NASA TECHNICAL MEMORANDUM

NASA TM X-64608

MATHEMATICAL CONCEPTS AND HISTORICAL DEVELOPMENT OF THE MASCOT GUIDANCE TECHNIQUE FOR SPACE VEHICLES

By C. D. Baker, W. E. Causey and H. L. Ingram
Aero-Astrodynamics Laboratory

July 20, 1971

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. NASA TM X-64608	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE MATHEMATICAL CONCEPTS AND HISTORICAL DEVELOPMENT OF THE MASCOT GUIDANCE TECHNIQUE FOR SPACE VEHICLES		5. REPORT DATE July 20, 1971
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR (S) C. D. Baker, W. E. Causey and H. L. Ingram		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS NASA Washington, DC 20546		13. TYPE OF REPORT & PERIOD COVERED TECHNICAL MEMORANDUM
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The recent development of improved integration routines, improved trajectory computation algorithms, and faster, lighter, more flexible flight-worthy digital computers has opened up new possibilities for improved guidance concepts and effective application of optimal guidance schemes to meet the challenges of the post-Apollo space vehicles.

This report documents one such guidance concept which permits practical realization of many heretofore unrealizable optimal guidance tasks, namely, on-board optimization of ascent trajectories through the atmosphere, self-targeting, optimal rendezvous, optimal coast-burn-coast-burn orbital transfer, and reentry for high lift-to-drag-ratio type of vehicles.

This collection of techniques combined into one guidance program has been called MASCOT (Manned Shuttle Comprehensive Optimization and Targeting).

17. KEY WORDS Trajectory Optimization Guidance and Control Calculus of Variations Space Vehicle Guidance Mathematics	18. DISTRIBUTION STATEMENT Unclassified-Unlimited E. D. Geissler E. D. Geissler Director, Aero-Astrodynamics Laboratory

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
UNCLASSIFIED	UNCLASSIFIED	248	$3.00

MSFC - Form 3292 (May 1969)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

MATHEMATICAL CONCEPTS AND HISTORICAL DEVELOPMENT OF THE MASCOT GUIDANCE TECHNIQUE FOR SPACE VEHICLES

SUMMARY

The recent development of improved integration routines, improved trajectory computation algorithms, and faster, lighter, more flexible flight-worthy digital computers has opened up new possibilities for improved guidance concepts and effective application of optimal guidance schemes to meet the challenges of the post-Apollo space vehicles.

This report documents one such guidance concept which permits practical realization of many heretofore unrealizable optimal guidance tasks, namely, on-board optimization of ascent trajectories through the atmosphere, self-targeting, optimal rendezvous, optimal coast-burn-coast-burn orbital transfer, and reentry for high lift-to-drag-ratio type of vehicles.

This collection of techniques combined into one guidance program has been called MASCOT (Manned Shuttle Comprehensive Optimization and Targeting).

I. INTRODUCTION

The advent of a new generation of space vehicles (specifically NASA's post-Apollo space shuttle) with advanced features such as completely reusable stages, sophisticated on-board digital computers, and airplane-type landing characteristics for both booster and orbiter has required a re-evaluation of the space vehicle guidance concepts used in the past. When re-examined, these traditional guidance concepts have been found to be inadequate for the new generation of space vehicles. In response to this need, new concepts, procedures, and techniques have recently been developed which provide a significant improvement in optimal guidance applications. In particular, this new approach yields a physically realizable optimal guidance scheme which results in nearly optimal performance for the boost phase, the rendezvous phase, and the reentry phase of the post-Apollo shuttle vehicle flight path. This new system and concept has been given the name MASCOT.

The MASCOT concept is made possible by the development of new mathematical techniques and the significant improvement of others. It also takes advantage of the improved speed, memory capacity, and reliability of the new flight-worthy digital computers.

In this report, the evolution and mathematical theory of the MASCOT guidance technique are explained. In addition, some computer-simulated trajectories obtained by means of the MASCOT program are presented to demonstrate the accuracy, flexibility, and optimality of the MASCOT system. Some comparisons will be made, whenever practical, with results obtained from the present Saturn Iterative Guidance Mode (IGM).

II. SOME BACKGROUND ON GUIDANCE, NAVIGATION, AND CONTROL

The operation of a guidance system involves three interrelated divisions of effort, navigation, guidance signal generation, and control. Navigation is concerned with the determination of the current position and velocity of the vehicle. Navigation is normally an open-loop process for short flights but must be made closed-loop by navigation update in some instances, i.e., long flight times.

With an accurate knowledge of all physical parameters of vehicle and environment, current position and velocity, and an accurate knowledge of the desired terminal conditions, it is possible to determine the proper directions of the engines thrust to obtain the desired end conditions. This closed-loop process of thrust-direction determination is referred to as guidance signal generation.

The control system implements the guidance signals in addition to employing such maneuvers that may be required to preserve the structural integrity of the vehicle. Thus, the control system may temporarily ignore or minimize the influence of the guidance signal in order to protect the vehicle from winds, wind gusts, wind shears, vibrational disturbances, or fuel sloshing problems. Control, too, is a closed-loop process.

III. THE GENERAL CONCEPT OF GUIDANCE

Implementation of the guidance signal will determine the vehicle flight path to reach a desired destination or set of terminal conditions. Perfect operation of the navigation system, exact generation of the guidance signal, and exact implementation of the control system, together with an exact knowledge of the vehicle physical parameters and an exact knowledge of the physical environment during the entire flight to the desired end conditions, would make it possible to solve for the guidance signal only once. This signal would, of course, be a function of time or some other convenient variable so that the guidance signal would change continuously during the flight.

In practice, perfect operation of the three systems cannot be achieved. Thus, a practical guidance system may make the computations at the initiation of guidance, and predict the required guidance signal or function to guide to the required end conditions. Since the initial information will have some inaccuracies, the process must be repeated periodically during the flight, treating each instant at which the new computations occur as a new set of initial conditions.

IV. OPTIMAL GUIDANCE

Optimal guidance, a subclass of the broad class of guidance concepts, is characterized usually by the deliberate maximization or minimization of some aspect of vehicle performance, for example, maximum payload to a given orbit or equivalently minimum fuel required for a given payload.

To accomplish optimal guidance of a vehicle, a mathematical model of the vehicle motions must first be chosen. Appearing in these equations of motion are the so-called control variables. These variables are the equation parameters which can be given an arbitrary (within prescribed limits that depend on the problem) value at any instant along the vehicle's flight path. This large amount of freedom of selection for the control variables allows a time history for the control variables to be chosen which achieves a desired destination and also optimizes some specified aspect of the vehicle performance. For a typical rocket-powered vehicle, the control variable is usually the thrust direction, and a time history of this thrust direction is determined (as described previously) to maximize the payload delivered to a particular destination.

A. Mathematical Techniques of Optimal Guidance

The different mathematical techniques used to select the optimum control variable are usually grouped into a body of knowledge known as optimization theory or calculus-of-variations theory.

When some type of optimization theory is applied to the differential equations simulating the motion of a rocket-powered vehicle, a two-point boundary value problem is produced. This means that not all of the initial conditions for the differential equations involved are known at the initial time. The unknown initial conditions must be determined so that they cause the results of the integration of the differential equations to satisfy some pre-specified conditions at the final time or destination. To accomplish this, in practice, one usually attempts to discover, numerically, some mathematical relations which connect the initial conditions with the final conditions. Then, the desired conditions at the destination are placed in these relations, and the resulting equations are solved, hopefully, to yield values for the missing initial conditions. These initial conditions and the relations connecting the initial conditions with the final conditions yield the time history of the control variables that optimize the chosen criterion of the vehicle's performance. In practice, there may be additional relations or constraints to be satisfied by a particular vehicle's trajectory which produce a multi-point boundary value problem instead of the simple two-point boundary value problem described above. These aspects of optimization theory are examined in more detail in the section on mathematical development.

B. The Philosophy of Optimal Guidance: Old and New

In the past, computer technology and mathematical techniques were inadequate to allow the consideration of a realistic computational algorithm for trajectory optimization as a practical on-board guidance signal generator. Thus, older techniques for on-board guidance signal generation relaxed the reality of the mathematical simulation of the vehicle's motion or degraded the optimality of the solution path in order to solve the resultant boundary value problem rapidly enough to control a particular vehicle's flight. The new MASCOT concept (which is a realistic computational algorithm for trajectory optimization) can be considered as a guidance signal generator for all phases of a vehicle's flight (boost phase, rendezvous phase, and reentry phase). This advance is possible at the present time because of improvements in computer technology and mathematical techniques for the solution of optimal trajectory problems.

Before going directly into the explanation and results associated with MASCOT, we briefly outline the historical developments which led to the present form of the MASCOT guidance technique. For readers not familiar with some of the ideas and terminology contained in this historical development, an extensive list of references and a bibliography are included at the end of the report.

V. HISTORICAL BACKGROUND

A. Delta Minimum Guidance

Beginning with the V-2 rockets in the mid-1940's and continuing through the Redstone, Jupiter, and Pershing missiles, the "delta-minimum" guidance concept was used successfully to guide rocket flights. The delta-minimum concept required that both nominal and perturbed trajectories follow essentially the same geometrical trajectory regardless of other considerations. On-board flight computations were simple, and analog computation was used for the execution of the delta-minimum concept.

B. Iterative Guidance Mode

In 1960, research work was begun to develop new guidance concepts for the Saturn space vehicles [1,2,3]. This work was motivated by the development of new mathematical techniques for maximization of payload through optimization methods and by the development of digital computers to replace analog computers as on-board hardware. It was also obvious that space trajectories would require greater flexibility to cope with sudden changes, such as engine out, and that more options must be permitted in the selection of flight profiles. The guidance law which resulted from the research work begun in 1960 and which has been flown on Saturn vehicles was given the name IGM, Iterative Guidance Mode.

IGM is essentially an approximate formulation of the calculus-of-variations problem that allows analytic construction of major parts of the solution, so that only a simple iterative numerical process is required for solution. This approach avoids the time-consuming numerical integration procedures that have been required to compute a general solution to the fundamental calculus-of-variations problems. The speed needed for real-time application has been the primary motivation for the derivation of semi-explicit methods of this type.

However, as a result of the approximations, the optimality and flexibility of such flight schemes are limited, primarily in that they are nearly optimal only for short arcs of powered flights and for specialized mission (boundary value) conditions in a restricted coordinate system. This limitation can be relaxed somewhat in practice by use of special purpose adjustments, but only at the expense of additional preflight analysis and simulation.

The basic simplifications made in the Iterative Guidance Mode to obtain analytic construction of major parts of the solution were (1) to assume a uniform gravitational field rather than an inverse square law and (2) to apply the same transversality condition at engine cutoff regardless of the mission flown. There were, incidentally, some small-angle approximations and ingenious special purpose adjustments made to improve the optimality of the scheme and to reduce the computational effort required for on-board mechanization. However, the basic concept of the simplifications is best seen in view of the assumption concerning the gravitational field and the assumption of the adequacy of a single transversality condition.

C. QUOTA

Next came the QUasi Optimal Trajectory Analysis, QUOTA [4], which belongs in the same category with IGM since it too is an approximation to the calculus-of-variations (COV) solution.

The fundamental approximation in QUOTA may be viewed in at least two different ways. The first way may be said to be an approximation to the COV in the sense that the Euler-Lagrange equations are replaced by a slightly different set of equations, the purpose of which is to allow analytic integration of both the "state" and "co-state" equations. Of course, the "co-state" variables must be interpreted in a generalized sense because they are not obtained from the Euler-Lagrange equations.

A second manner of viewing the approximations to achieve the solutions will be mentioned. From many observations of the behavior of the Lagrange multipliers (λ's) in the calculus of variations, it has been noted that for rocket flights in a wide variety of missions, these λ's are very nearly linear functions of time. The QUOTA equations may be derived by assuming linear λ's and by expanding the gravity term in series.

The advantage of this approach is a very rapid computational scheme which is much more flexible than IGM and also leads to a smaller loss of optimality. Even this small loss of optimality may be regained by making the assumption that the λ's are linear only for a portion of the flight; thus, the λ versus time curve is represented by a series of connecting straight lines where the slopes of the linear λ segments are determined from the Euler-Lagrange equations. For an Apollo-type mission, the λ's may be assumed to be linear for the entire flight with only a negligible loss in payload.

With either of the viewpoints mentioned above, the true gravitational field may be accurately represented and transversality conditions may be fitted to the particular end conditions. Needless to say, the optimality of the solution must be checked because of the substitution of approximate equations for the Euler-Lagrange equations.

Computationally, QUOTA offered much more flexibility than IGM, required less preflight analysis and only slightly increased the amount of on-board computation required. Because IGM was entirely adequate for all Saturn flights, there has been no need to change from IGM to QUOTA and, therefore, QUOTA has never been tested on any actual flights. It is still available for any mission which requires flexibility beyond IGM capability and for which the same computational equipment must be used.

D. OPGUID AND SWITCH

Before 1965, general (flexible) numerical procedures for computing precise optimal trajectories were too unreliable in convergence and costly in computational requirements to be considered for real-time guidance. However, an indirect method for computing optimal trajectories [5,6] was developed in 1965 incorporating improved techniques to obtain a substantial gain in speed, convergence, and flexibility. A simple scaling rule for the amount of the Newton correction that was permitted per iteration resulted in an extremely large region of convergence that was surprisingly insensitive to accurate initialization of the boundary value problem.

The indirect approach is particularly well suited for real-time use, where the continual adjustment of the guidance scheme to accommodate perturbations in initial conditions is readily accomplished by a single Newton iteration on the boundary value problem. In 1966, the feasibility of this approach as a real-time guidance scheme for optimizing single-burn-arc orbital injection missions was demonstrated [7] and named OPGUID (OPtimal GUIDance).

However, many orbit transfer problems require the use of several burn arcs separated by relatively long optimal coast arcs. A multi-burn-arc version of OPGUID, developed in 1967 [8], demonstrated that the attractive fundamental approach of OPGUID could successfully converge a general formulation of this problem, with variable boundary conditions. A sophisticated version of the multi-burn program (SWITCH) has been developed [9] that has successfully converged a variety of orbital transfer problems with an efficiency and reliability comparable to that of the original OPGUID.

As a result, the indirect method of SWITCH is not only feasible but considerably superior to existing implementations of quasilinearization in convergence as well as efficiency. A principal feature of SWITCH is the use of classical two-body theory to render the computations for coast arcs explicit. Since high-thrust multi-burn orbit transfers usually involve coast arcs many times longer in duration than burn arcs, the explicit method results in a substantial savings in computation per iteration. A universal variable formulation of the two-body problem with closed-form expressions for the state transition matrix is used. This formulation was adapted from the work in references 8, 10, 11 and 12 in a novel way to avoid the cumbersome computation of the three-dimensional tensor of second partial derivatives of final state with respect to initial state that is required when computing the partial derivative of final co-state with respect to initial state.

Since all the partial derivatives are available at each iteration, as was the case for the original OPGUID, the SWITCH algorithm is appropriate for computing real-time corrections to in-flight perturbations.

Unlike the OPGUID algorithm, the SWITCH algorithm does require reasonable initialization. That is, it is not possible with SWITCH as it was with OPGUID to misalign the thrust direction by 90 or 180 degrees and retain convergence. However, rough estimates of impulsive solutions have proved more than adequate as initialization in every trial case.

E. MASCOT

With the advent of the space shuttle with its high aerodynamic lifting characteristics both on ascent and descent, it has become imperative that optimal guidance laws be devised to optimally steer the vehicle through the atmospheric portions of flight.

This has been accomplished essentially by introducing into the SWITCH program the aerodynamic effects of both lift and drag [13]. Additionally, the effect on thrust of pressure variation with altitude has been included in the propulsion computations.

These changes have recently been carried out, and some of the observed results may be summarized as follows:

1. Maximum payload and maximum sensitivity to convergence occur when atmospheric effects are introduced into both the state and co-state equations.

2. Approximately two-thirds of the payload increases obtained under (1) may be kept by introducing the atmospheric effects into the state equations only. In this case, convergence is far easier.

3. Extremely difficult convergence cases may be approached gradually by multiplying the atmospheric model by $0 \leqq K \leqq 1$ where K starts at zero and gradually increases to 1. For each value of K, the case is converged before increasing the value of K.

When the atmospheric effects, together with changes to be described later, were added to the SWITCH concept, the name MASCOT was chosen for the overall scheme to handle multiple burn-coast-burn optimal trajectories both in and out of the atmosphere.

VI. MATHEMATICAL DEVELOPMENT FOR MASCOT

A. The Choice of a Physical Model Common to All Flight Phases

The first step in the development of an optimal guidance technique for a rocket-powered vehicle is the mathematical modeling of the vehicle's trajectory. To do this, a second order three-dimensional vector of ordinary differential equations is usually used which consists of the sums of the vector accelerations produced by all the forces to be considered acting on the vehicle. For the MASCOT scheme, this sum of vector accelerations must consist of terms produced by forces acting during the boost phase, the rendezvous phase, and the reentry phase. During the computation of a trajectory for a particular phase, all of the terms in the sum for all of the phases do not have to be considered and the unneeded terms can be easily ignored with the logic of the computer program. The next section develops in detail the general mathematical model, and then the terms to be ignored in particular phases are pointed out specifically.

B. Mathematical Modeling of Vehicle's Motion

1. Comments on Coordinate Transformation

A three-dimensional Cartesian coordinate system with an origin at the earth's center will be used. The orientation of this coordinate system will be assumed to remain fixed with respect to time and the initial orientation is completely arbitrary. To compare trajectories in this arbitrarily oriented coordinate system with any other coordinate system, their relative orientations at comparison times must be known so that a coordinate transformation can be performed on one of the coordinate systems. Some coordinate systems of interest do not always have their origin at the earth's center, but this is a simple translation if relative orientations are the same. For example, in booster work, an inertial coordinate system with origin at the earth's center could be defined to have the z-axis perpendicular to the earth's equatorial plane and pointing northward, the x-axis in the equatorial plane and pointing toward the Greenwich Meridian at some reference time (usually launch time), and the y-axis placed in the equatorial plane to form a right-hand system. Then, any other coordinate system can be oriented with respect to this coordinate system with the aid of the standard Euler angle rotation matrices. That is, for a given angle α, the Euler angle rotation matrices for rotations about the x, y, and z axis are written as follows:

$$(\alpha)_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha \\ 0 & -\sin\alpha & \cos\alpha \end{bmatrix}$$

$$(\alpha)_2 = \begin{bmatrix} \cos\alpha & 0 & -\sin\alpha \\ 0 & 1 & 0 \\ \sin\alpha & 0 & \cos\alpha \end{bmatrix}$$

$$(\alpha)_3 = \begin{bmatrix} \cos\alpha & \sin\alpha & 0 \\ -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Then coordinates in the equatorial coordinate system just defined (denoted by $\bar{x}_e$) can be transformed to coordinates in the standard Apollo coordinate system (denoted by $\bar{x}_p$) in the following manner:

$$\bar{x}_p = (-A_{Z_o})_1(-\varphi_d)_2(-\lambda_o)_3\bar{x}_e,$$

where

λ_o is the longitude of the launch site measured positive west

φ_d is the geodetic latitude of the launch site

A_{Z_o} is the launch azimuth of firing direction and is measured clockwise from a line perpendicular to the plumbline at the launch site and pointing northward parallel to the launch site meridian around to the firing direction.

Note that the inverse transformation to obtain equatorial coordinates from plumbline coordinates is easily remembered due to its mnemonic form. That is,

$$\bar{x}_e = (\lambda_o)_3(\varphi_d)_2(A_{Z_o})_1\bar{x}_p.$$

Also, the transformation matrix, $[A] = (\lambda_o)_3(\varphi_d)_2(A_{Z_o})_1$, remains constant with time.

For reentry work, a more interesting coordinate system might be a coordinate system with the origin at the reentry point with its x-axis pointed radially away from the earth's apparent gravitational center, its z-axis parallel to a projection of the instantaneous velocity vector in the local horizontal plane, and the y-axis finishing a right-handed coordinate system. A transformation from this coordinate system (denoted by x_r, y_r, z_r) to the equatorial coordinate system can be written as

$$\bar{x}_e = (\lambda_r)_3(\varphi_{d_r})_2(A_{Z_r})_1 \left\{ \bar{x}_r + R_r \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \right\},$$

where

λ_r is the longitude of the reentry point measured positive west,

φ_{d_r} is the geodetic latitude at the reentry point,

A_{Z_r} is the instantaneous reentry flight direction measured as is A_{Z_o},

R_r is the reentry point altitude.

Thus, the equations of motion for a point mass in a three-dimensional inertial Cartesian coordinate system whose orientation to the standard equatorial coordinate system is known can be written as will be shown in the following paragraphs.

2. Acceleration of a Point Mass in an Earth-Centered Arbitrarily Oriented Inertial Coordinate System

In an arbitrarily oriented earth-centered Cartesian coordinate system, the differential equations to be used for simulating the motion of a point mass subject to gravitational, aerodynamic, and thrusting forces can be written as follows:

$$\ddot{\bar{x}} = (F/m)\bar{u} + \frac{\bar{L} + \bar{D}}{m} - \frac{(GM)\bar{x}}{R^3} + \bar{g}(\bar{x}). \qquad (1)$$

In the above vector differential equation, the first term on the right is the thrusting term, where F is the instantaneous magnitude of the thrust, m is the instantaneous mass, and $\bar{u}$ is a unit vector which is considered to be a control variable for the direction of the thrust. In the second term, $\bar{L}$ is a vector of aerodynamic forces due to lift and $\bar{D}$ is a vector of aerodynamic forces due to drag. The determination and control of the thrusting force and the aerodynamic forces will be explained in the paragraphs to follow. The third term in equation (1) is the gravitational force term for a spherical central body, where GM is the gravitational constant and R is the magnitude of the position vector of the point mass under consideration. The fourth term which is considered to be a function of the position vector is a symbolic representation of corrections to the gravitational force expression which are needed when a nonspherical shape for the central body is considered. For simplicity in the rest of this development, the fourth term on the right-hand side of equation (1) will be ignored, and no further explanation of the derivation of the third term will be attempted since this expression is a very standard representation of the gravitational force due to a spherical central body.

To begin an explanation of the first term (the term due to thrust) in equation (1), the thrust force F will be assumed to be constant for vacuum flight and to have the following form for atmospheric flight:

$$F = F_s + A_e(P_o - P), \tag{2}$$

where

F_s is the vehicle's thrust measured at sea level ($P = P_o$)

A_e is the exit area of the engine

P_o,P are the atmospheric pressure at sea level and at any altitude, respectively.

For atmospheric flight, the mass flow rate $\dot{m}$ is given by the relation

$$\dot{m} = \frac{-F_s}{g_o I_{sp_s}}, \tag{3}$$

where I_{sp_s} is a constant (measured to correspond with F_s) indicating the efficiency of a particular set of engines and $g_o \doteq GM/R_o^2$ is a constant giving the acceleration due to gravity at the assumed R_o (radius of the spherical central body). For vacuum flight the mass flow rate is assumed to be the same as for atmospheric flight and the force F_V and efficiency I_{sp_V} for vacuum flight are related to F_s and I_{sp_s} as follows:

$$F_V = F_s + A_e P_o$$

$$I_{sp_V} = (F_V/F_s)\, I_{sp_s}.$$

In either case, the mass at any time t referenced to an initial time t_o is given by

$$m(t) = m(t_o) + \dot{m}(t - t_o). \tag{4}$$

To explain how the unit vector $\bar{u}$ and the aerodynamic force vectors $\bar{L}$ and $\bar{D}$ are to be determined, a missile-fixed or vehicle-fixed coordinate system (denoted by x_m, y_m, z_m) must be introduced. In this coordinate system, $\bar{u}$ will be denoted by $\bar{u}_m$ and another unit vector $\bar{a}_m$ ($\bar{a}_m$ is the vehicle axis which when aligned with the air stream allows no aerodynamic lifting force to be produced) will be introduced. Figure 1 illustrates the angles to be used to locate $\bar{u}_m$ and $\bar{a}_m$ in the missile-fixed coordinate system.

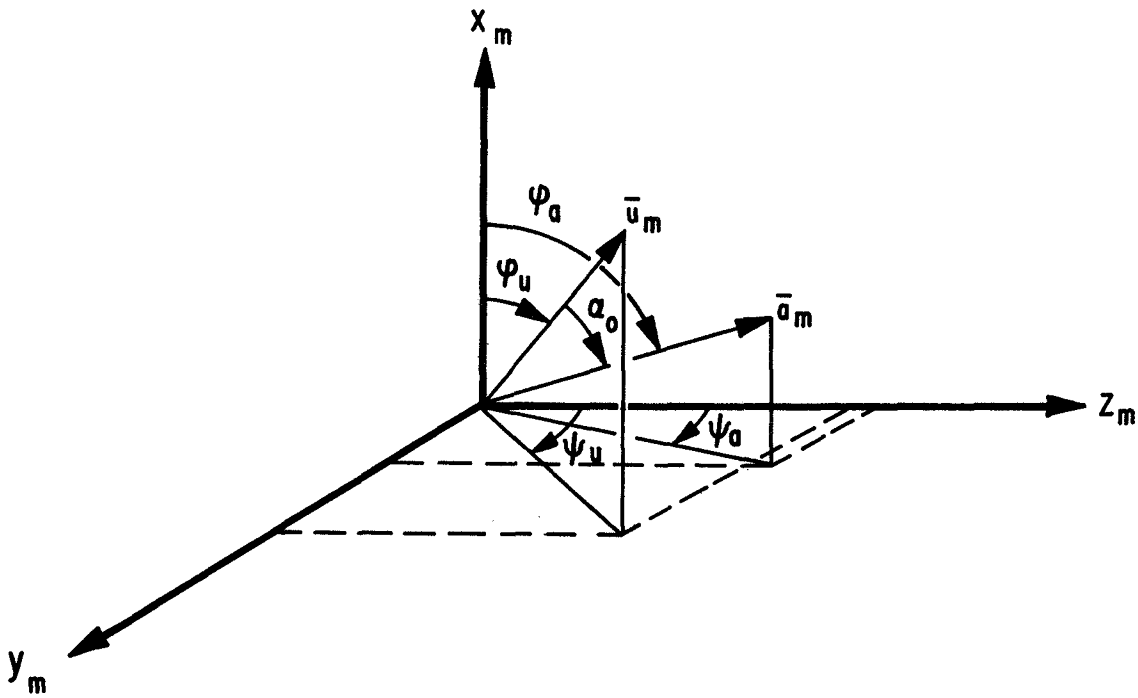

Figure 1. Angles used to Locate $\bar{u}_m$ and $\bar{a}_m$ in the Missile-Fixed Coordinate System

In the missile-fixed coordinate system, the angles φ_u and ψ_u are measured on the ground as a function of trajectory time or burning time to locate $\bar{u}_m$, which is the thrust direction produced by the unswiveled engines. Similarly, the angles φ_a and ψ_a are measured on the ground as a function of trajectory time to locate $\bar{a}_m$. These angles locating $\bar{u}_m$ and $\bar{a}_m$ in a missile-fixed coordinate system need to be determined only once before the initial flight of each vehicle. Then the angle α_o shown in figure 1 can also be computed as a function of trajectory time. The angle α_o and the unit vector $\bar{a}$ or $\bar{a}_m$ will be used later in the determination of $\bar{L}$ and $\bar{D}$, but for now only the unit vector $\bar{u}$ or $\bar{u}_m$ is of interest.

As shown in figure 2, the angles χ_p and χ_y will be used to locate $\bar{u}$ or $\bar{u}_m$ in the original inertial Cartesian coordinate system (x,y,z). The prime coordinate system (x',y',z') with the x' coordinate aligned with $\bar{u}$ will be shown again in figure 5 and used to help define the aerodynamic forces. It will be assumed that the vehicle's control system acts instantaneously so that the angles χ_p and χ_y, and thus the direction of $\bar{u}$ in the inertial coordinate system, can be changed instantaneously. As the angle χ_p and χ_y or the direction of $\bar{u}$ change with respect to the inertial coordinate system shown in figure 2, the orientation of the

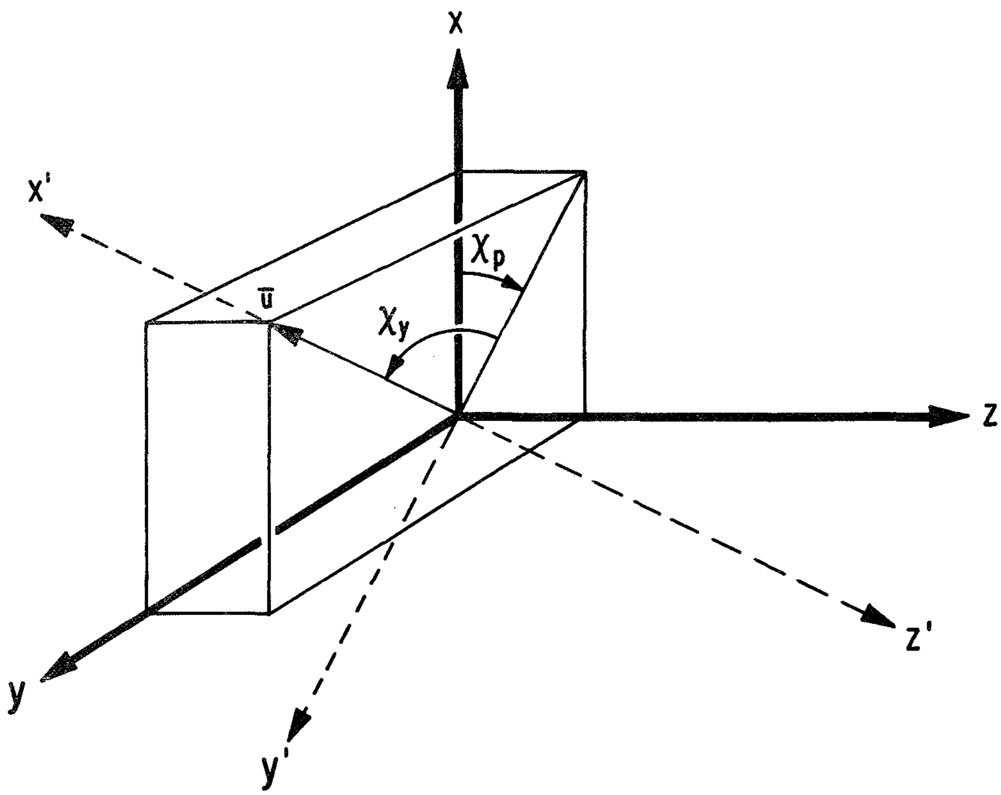

Figure 2. Angles Used to Locate $\bar{u}$ in the Inertial Coordinate System

missile-fixed coordinate system will also be changed with respect to the inertial coordinate system, since the angles φ_u and ψ_u cannot be changed by the vehicle's control system.

Often the vehicle's control system may be given a time history of the angles X_p and X_y to follow. In this case, $\bar{u}$ must be computed in terms of X_p and X_y so that it can be used in equation (1) for simulation purposes. As shown in figure 2,

$$\bar{u} = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} \cos X_y \quad \cos X_p \\ \sin X_y \\ \cos X_y \quad \sin X_p \end{bmatrix}. \tag{6}$$

If optimization theory is used to obtain $\bar{u}$, then the components of $\bar{u}$ in the inertial coordinate system may be determined directly by the optimization theory. In this case, for the information of the vehicle's control system, the angles X_p and X_y can be computed in terms of the components of $\bar{u}$ as follows:

$$X_y = \arctan\left(\frac{u_2}{\sqrt{u_1^2 + u_2^2}}\right) \qquad \left(-\frac{\pi}{2} < X_y < \frac{\pi}{2}\right) \tag{7}$$

$$X_p = \arctan\,(u_1/u_3) \qquad (0 \leqq X_p \leqq 2\pi). \tag{8}$$

This completes the present discussion of $\bar{u}$ which appears in the first term of equation (1). In section IV-C, how $\bar{u}$ is determined by optimization theory is discussed.

Now to explain how the expressions for $\bar{L}$ and $\bar{D}$ are obtained in the second term of equation (1), the unit vector $\bar{a}$ or $\bar{a}_m$ introduced in figure 1 will be used. First, it will be assumed that $\bar{a} \neq \bar{u}$ so that the unit vectors $\bar{a}$ and $\bar{u}$ define a plane in the reference coordinate system (see figure 3).

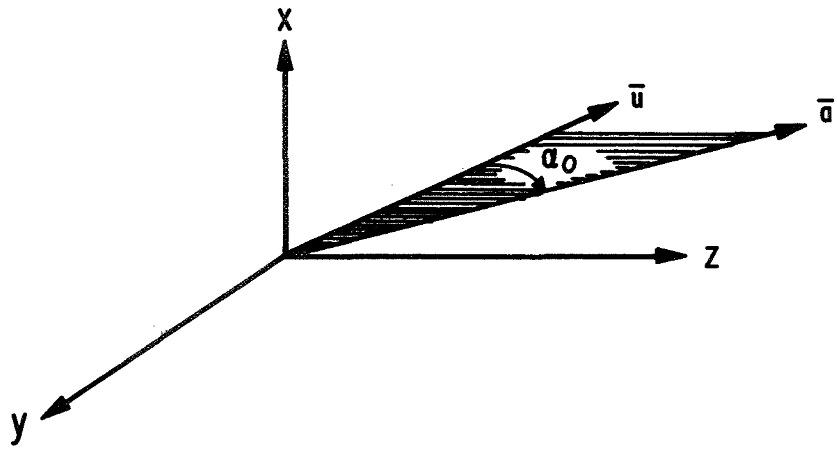

Figure 3. The Plane Formed by $\bar{u}$ and $\bar{a}$ in the Inertial Coordinate System

In a later section, the simplifying assumption $\bar{a} = \bar{u}$ is made and the results of this assumption are treated. As mentioned previously, the unit vector $\bar{a}$ is defined to lie along the instantaneous zero lift axis of the vehicle. Thus, if $\bar{a}$ and the relative velocity vector $\bar{V}_r$ of the point mass are aligned, $\bar{L}$ will be zero. The relative velocity vector in the reference coordinate system is given by

$$\bar{V}_r = \dot{\bar{x}} - \bar{\omega} \times \bar{x} - \bar{W}, \tag{9}$$

where $\bar{\omega}$ is the rotational velocity vector of the central body in the reference coordinate system and $\bar{W}$ is an arbitrary vector function describing winds in the reference coordinate system. Since $\bar{a}$ is a unit vector in the zero lift direction, a lift force (denoted by $\bar{L}$) will be produced when there is an angle α between $\bar{a}$ and $\bar{V}_r$ as shown in figure 4. Figure 4 shows that the lifting force $\bar{L}$ which occurs when there is an angle α between $\bar{a}$ and $\bar{V}_r$ lies in the plane formed by the vectors $\bar{a}$ and $\bar{V}_r$. Naturally, the vector $\bar{D}$ is in a direction opposite to $\bar{V}_r$.

To explain further how the unit vector $\bar{a}$ is to be defined, it will be assumed that the directions of $\bar{u}$ and $\bar{a}$ in the missile-fixed coordinate system are determined as shown in figure 1. It will also be assumed that these directions in the missile-fixed coordinate system depend only on the vehicle characteristics such as the position of the center of gravity and the center of pressure as functions of trajectory time. Thus, the angle α_o between $\bar{u}$ and $\bar{a}$ (as shown in figures 1 and 3) can be determined

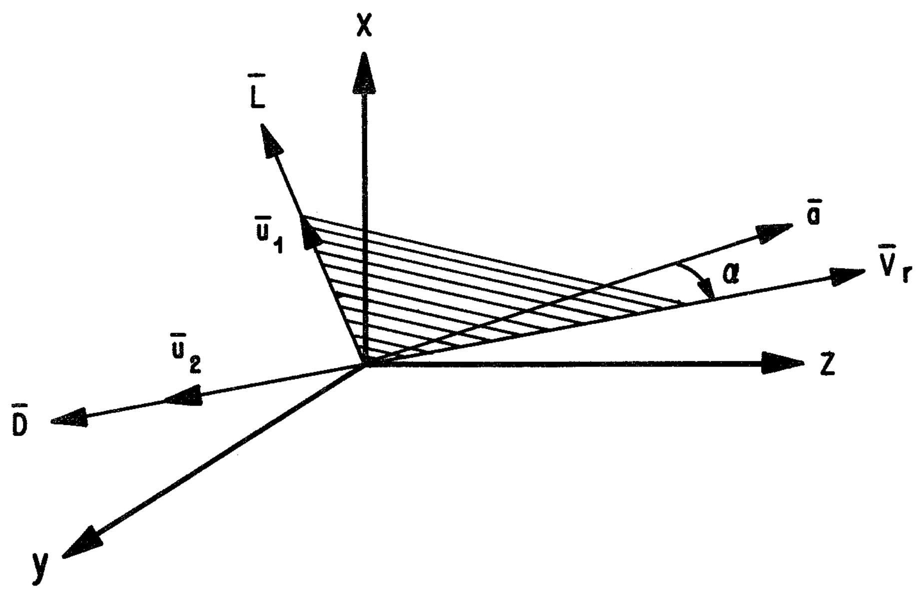

Figure 4. The Lift and Drag Force in the Inertial Coordinate System

as a function of trajectory time. Since α_o depends on the vehicle characteristics, it cannot be used as a control variable and varied by the vehicle's control system. Although the angle α_o is not considered to be a control variable, it will be assumed that the vehicle's engines can roll the vehicle about $\bar{u}$ (as shown in figure 3) so that the orientation of the plane formed by the vectors $\bar{a}$ and $\bar{u}$ is a control variable. Also, as the direction of $\bar{u}$ is changed (with the control variables χ_p and χ_y), the direction of $\bar{a}$ will change because the angle between $\bar{a}$ and $\bar{u}$ (denoted by α_o) is predetermined and cannot be varied.

To write expressions for the components of $\bar{a}$ in the reference coordinate system, a new coordinate system whose orientation changes with trajectory time (denoted by x',y',z') will be introduced. This new coordinate system is obtained by performing in succession the Euler angle rotations $(\chi_p)_2$ and $(\chi_y)_3$ so that the x' axis lies along $\bar{u}$ as shown in figure 2. In the prime coordinate system, the angles α_o and χ_R (which orient the plane formed by $\bar{u}$ and $\bar{a}$) can be depicted as in figure 5. The symbol $\bar{a}'$ will be used to denote the unit vector $\bar{a}$ with its components in the prime coordinate system. These components (see figure 5) are given by the following equation:

$$\bar{a}' = \begin{bmatrix} \cos\alpha_o \\ \sin\alpha_o \quad \cos\chi_R \\ \sin\alpha_o \quad \sin\chi_R \end{bmatrix} . \tag{10}$$

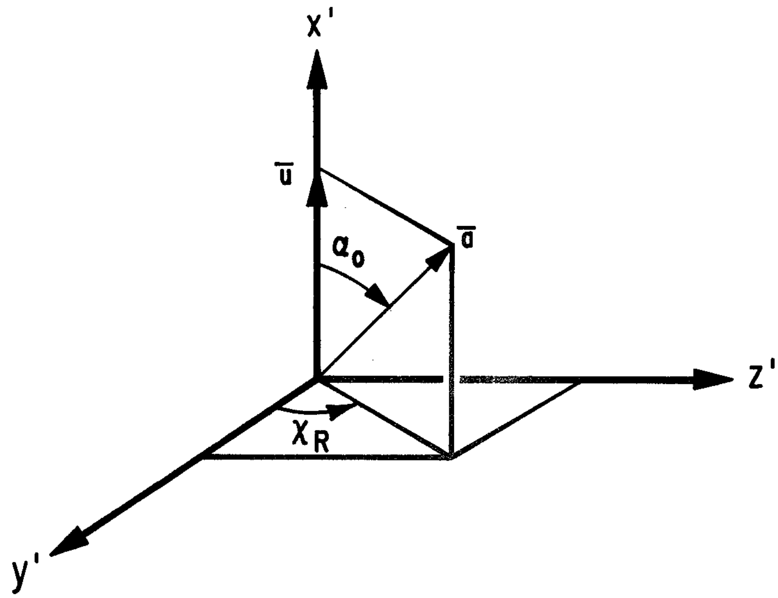

Figure 5. The Orientation of the Plane Formed by $\bar{u}$ and $\bar{a}$

Then, $\bar{a}$ with components in the reference coordinate system is obtained as follows:

$$\bar{a} = (\chi_p)_2(-\chi_y)_3\bar{a}'. \tag{11}$$

Notice that the successive Euler angle rotations $(-\chi_y)_3$ and $(\chi_p)_2$ are the inverse of the Euler angle rotations used to obtain the prime coordinate system. With $\bar{a}$ determined by equation (11) in terms of χ_p, χ_y, χ_R, and α_o, unit vectors in the direction of $\bar{L}$ and $\bar{D}$ can be written as:

$$\bar{u}_1 = \frac{(\bar{V}_r \times \bar{a}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{a}) \times \bar{V}_r|} \tag{12}$$

$$\bar{u}_2 = -\frac{\bar{V}_r}{|\bar{V}_r|} . \tag{13}$$

Figure 4 will aid the reader in visualization of the construction of the vectors $\bar{u}_1$ and $\bar{u}_2$ which are written in the reference coordinate system (since $\bar{a}$ and $\bar{V}_r$ are in the reference coordinate system). Now the following expressions for $\bar{L}$ and $\bar{D}$ can be written:

$$\bar{L} = \frac{1}{2} \rho A_r (\bar{V}_r \cdot \bar{V}_r) C_L \bar{u}_1 \tag{14}$$

$$\bar{D} = \frac{1}{2} \rho A_r (\bar{V}_r \cdot \bar{V}_r) C_D \bar{u}_2, \tag{15}$$

where

- ρ is the atmospheric density
- A_r is the reference area of the vehicle
- C_L is the lift coefficient of the vehicle
- C_D is the drag coefficient of the vehicle.

The atmospheric density ρ is usually considered to be a function of instantaneous altitude and the quantities A_r, C_L, and C_D must be measured on the ground. In the measurement of A_r, C_L, and C_D, a vehicle-fixed coordinate system is used (denoted by x_v, y_v, z_v). For simplicity, it will be assumed that the instantaneous orientation of this vehicle-fixed coordinate system is defined so that the x_v-axis lies along $\bar{a}$, the z_v-axis defines the plane of the vehicle where the relative velocity vector $\bar{V}_r$ would produce the maximum values for C_L and C_D for a given angle α between $\bar{V}_r$ and $\bar{a}$, and the y_v-axis completes a right-handed coordinate system. This coordinate system, with $\bar{u}$ and two possible locations for $\bar{V}_r$, is depicted in figure 6.

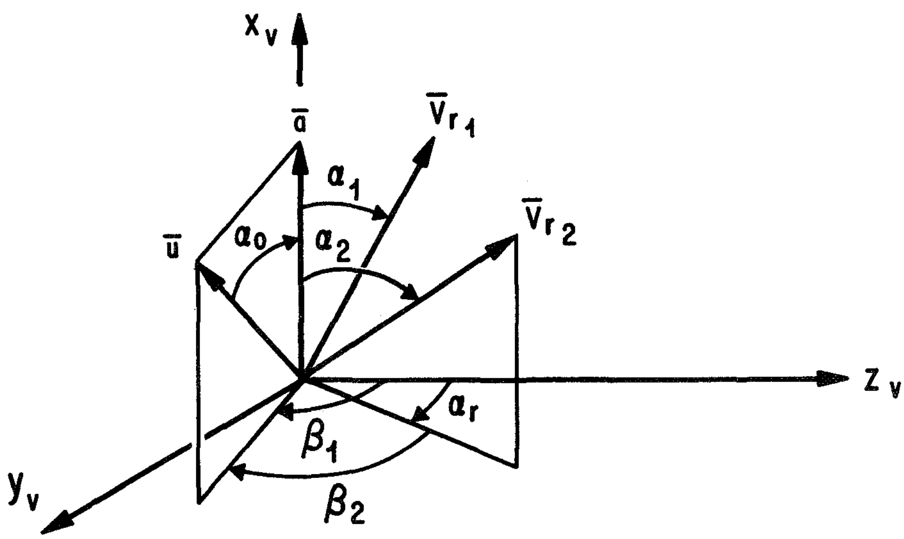

Figure 6. Coordinate System Used to Measure the Lift and Drag Coefficients

The reference area A_R will be taken to be the area of the (y_v, z_v)-plane obscured by the vehicle if a sighting along the x_v axis is made at an infinite distance from the origin. If $\bar{V}_r$ lies in the (x_v, z_v)-plane as depicted by $\bar{V}_{r_1}$ in figure 6, then the lift coefficient C_L and the drag coefficient C_D can be measured to depend only on the instantaneous value of the angle α between $\bar{a}$ and $\bar{V}_r$ and the Mach number M of the vehicle. If $\bar{V}_r$ is not in the (x_v, z_v)-plane as depicted by $\bar{V}_{r_2}$, then C_L and C_D must also depend on the angle α_r as shown in figure 6. As mentioned previously, the orientation of $\bar{u}$ with respect to a vehicle-fixed coordinate system can be determined or measured before the vehicle is flown. Thus, the angles α_o and β_1 can be determined using the angles measured in figure 1. The angles α_o and β_1 are needed in relating the vehicle-fixed coordinate system to the original reference coordinate system so that the angles α and α_R can be computed and used to obtain corresponding values for C_L and C_D. Figure 6 shows that the following equation will determine α for either position of $\bar{V}_r$ (i.e., $\bar{V}_{r_1}$ or $\bar{V}_{r_2}$).

$$\alpha = \arctan\left\{ \frac{\left[\dfrac{(\bar{a} \times \bar{V}_r) \times \bar{a}}{|(\bar{a} \times \bar{V}_r) \times \bar{a}|}\right] \cdot \bar{V}_r}{(\bar{V}_r \cdot \bar{a})} \right\} \quad (-\pi \leq \alpha \leq \pi). \tag{16}$$

To determine α_R, the angle β_2 shown in figure 6 must be determined. The following equation can be used to obtain β_2:

$$\beta_2 = \arctan\left\{ \frac{[\bar{a} \times (\bar{u} \times \bar{a})] \cdot (\bar{V}_r \times \bar{a})}{(\bar{u} \times \bar{a}) \cdot (\bar{V}_r \times \bar{a})} \right\} \quad (0 \leq \beta_2 \leq 2\pi). \tag{17}$$

Then α_R is given by

$$\alpha_R = \beta_1 - \beta_2. \tag{18}$$

With α and α_R computed as shown in equations (16) and (18), values for C_L and C_D can be obtained. Thus, enough information is available to compute $\bar{L}$ and $\bar{D}$ as given in equations (14) and (15). This completes a general explanation of the equations of motion given by equation (1).

To re-emphasize the concepts discussed previously, an outline will now be given of the order of the computations to be performed to obtain a value for $\ddot{\bar{x}}$ (as given by equation (1)) at a particular instant of trajectory time. At a particular instant of trajectory time (t), the position vector ($\bar{x}$) of the point mass (m) is known along with the velocity vector $\dot{\bar{x}}$. Thus, the altitude (h) of the point mass can be computed as follows:

$$h = R - R_o, \tag{19}$$

where $R = \sqrt{\bar{x} \cdot \bar{x}}$ and R_o is the radius of the spherical central body. With a value of h as obtained from equation (19), atmospheric tables can be used to obtain corresponding values of pressure (P), density (ρ), and velocity of sound (V_s). Since the gravitational constant of the central body (GM) is assumed known, the third term in equation (1) due to gravity can be computed immediately. To compute values for the first term in equation (1), equation (2) is used to obtain a value for F, since A_e, F_s, and P_o are known constants and P has been obtained as described. Also, m and $\bar{u}$ are assumed to be known at each instant of trajectory time. The unit vector $\bar{u}$ may be known directly in terms of its three components, or it may be known in terms of the angles χ_p and χ_y, in which case equation (6) is used to compute $\bar{u}$. Then, the first term in equation (1) can be computed. To compute values for the second term in equation (1), $\bar{V}_r$ must be computed by equation (9). The vector constant $\bar{\omega}$ needed in equation (9) and the wind function $\bar{W}$ are assumed known. With a value for the vector $\bar{V}_r$ available, the following equation can be used to compute Mach number M:

$$M = \frac{\sqrt{\bar{V}_r \cdot \bar{V}_r}}{V_s} . \tag{20}$$

Also, equations (16) and (18) can be used to compute α and α_R if values of $\bar{a}$ are available. The unit vector $\bar{a}$ may be assumed to be known directly in terms of its components, or it can be specified in terms of χ_p, χ_y, α_o, and χ_R as shown in equations (10) and (11). With values for α, α_R, and M obtained, a curve fit or table look-up can be used to obtain values of C_L and C_D, which depend on α, α_R, and M. Then equations (14) and (15) can be used to compute $\bar{L}$ and $\bar{D}$ since the quantities needed are now all available. Thus, the third term in equation (1) can be computed to complete the computation of equation (1).

The previous discussion shows how values of $\ddot{\bar{x}}$ can be obtained at each instant of trajectory time when the control variables X_p, X_y, and X_R are known. Thus, numerical integration of equation (1) could be used to obtain a trajectory for prespecified control functions X_p, X_y, and X_R.

Also, optimization theory could be applied directly to the equations of motion (equation (1)) in its present form to determine the correct time histories for $\bar{u}$ and $\bar{a}$, but the resulting computer program would be much too complicated to consider for guidance purposes.

For this reason, some simplifying assumptions and approximations to these differential equations will now be made that will result in a much more compact and efficient computer program for the application of optimization theory.

3. Simplifications to General Three-Dimensional Equations of Motion with Atmospheric Effects

The original equations of motion (equation (1)) are completely accurate representations of the ascent phase of the shuttle vehicle's flight. For the vacuum phase of a shuttle vehicle's flight, an accurate representation is obtained by leaving out the term

$$\frac{\bar{L} + \bar{D}}{m},$$

and for the reentry phase, an accurate representation is obtained by leaving out the term

$$(F/m)\ \bar{u}.$$

The only simplifications to be made to equation (1) before optimization theory is applied are simplifications of the expressions for $\bar{L}$ and $\bar{D}$ which will be used in both the ascent and the reentry phases. Also, the expression $\bar{g}(\bar{x})$ accounting for oblateness effects will be neglected in all three phases, at least in illustrating the application of optimization theory to the equations of motion (equation (1)).

The first simplification to be made in the development of new expressions for $\bar{L}$ and $\bar{D}$ is to assume that $\bar{a} = \bar{u}$. For most vehicles, α_o (the angle between $\bar{u}$ and $\bar{a}$ as shown in figure 2) is not very large because of the usual aerodynamic symmetry about the thrust vector direction. Thus, the assumption $\bar{a} = \bar{u}$ is not very restrictive as will be seen. With the assumption that $\bar{a} = \bar{u}$, the vehicle-fixed coordinate system shown in figure 6 does not have to be introduced. Instead $\bar{V}_r$ can be pictured immediately in the prime coordinate system of figure 7.

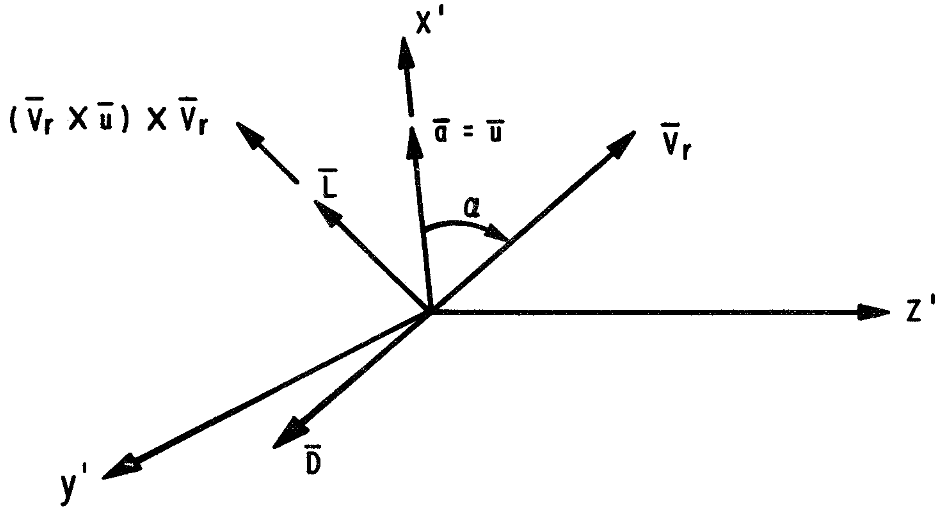

Figure 7. The Lift and Drag Forces with $\bar{a} = \bar{u}$

Then, the new expressions for $\bar{L}$ and $\bar{D}$ become

$$\bar{L} = \frac{1}{2} \rho \; A_r (\bar{V}_r \cdot \bar{V}_r) \left\{ C_L \left[\frac{(\bar{V}_r \times \bar{u}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{u}) \times \bar{V}_r|} \right] \right\} \tag{21}$$

$$\bar{D} = \frac{1}{2} \rho \; A_r (\bar{V}_r \cdot \bar{V}_r) \left\{ C_D \left[- \frac{\bar{V}_r}{|\bar{V}_r|} \right] \right\} . \tag{22}$$

Now the coefficients C_L and C_D will depend only on Mach number and the angle α defined by the equation

$$\alpha = \arctan\left\{\frac{\left[\frac{(\bar{V}_r \times \bar{u}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{u}) \times \bar{V}_r|}\right] \cdot \bar{u}}{\left[\frac{\bar{V}_r}{|\bar{V}_r|}\right] \cdot \bar{u}}\right\} \quad \text{(defined for } -\pi < \alpha < \pi). \quad (23)$$

Also, the following additional approximating equations for C_L and C_D will be used.

$$C_L \approx C_{L_\alpha} \sin \alpha \quad (24)$$

$$C_D \approx C_A + 2\eta\, C^2_{L_\alpha}(1-\cos \alpha) \quad (25)$$

where C_{L_α}, C_A, and η are all now considered to depend only on Mach number. These approximations have been found to closely represent most C_L and C_D tables in the range of Mach and alpha of interest and are used mainly because of their simplifcation of the optimization equations.

Substituting the above approximations into the expressions for $\bar{L}$ and $\bar{D}$ gives

$$\bar{L} = \frac{1}{2}\, \rho\, A_r(\bar{V}_r \cdot \bar{V}_r)\left\{(C_{L_\alpha} \sin \alpha)\left[\frac{(\bar{V}_r \times \bar{u}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{u}) \times \bar{V}_r|}\right]\right\} \quad (26)$$

$$\bar{D} = \frac{1}{2}\, \rho\, A_r(\bar{V}_r \cdot \bar{V}_r)\left\{[C_A + 2\eta\, C^2_{L_\alpha}(1 - \cos \alpha)]\left[\frac{-\bar{V}_r}{|\bar{V}_r|}\right]\right\}. \quad (27)$$

Notice that

$$|(\bar{V}_r \times \bar{u}) \times \bar{V}_r| = |\bar{V}_r|^2 \sin\alpha = (\bar{V}_r \cdot \bar{V}_r) \sin\alpha$$

because α is the angle between $\bar{V}_r$ and $\bar{u}$. Also,

$$\bar{V}_r \cdot \bar{u} = |\bar{V}_r| \cos\alpha.$$

Thus,

$$\bar{L} = \frac{1}{2} \rho A_r C_{L\alpha} [(\bar{V}_r \times \bar{u}) \times \bar{V}_r] \tag{28}$$

$$\bar{D} = -\frac{1}{2} \rho A_r [|\bar{V}_r| (C_A + 2\eta C_{L\alpha}^2) - 2\eta C_{L\alpha}^2 (\bar{V}_r \cdot \bar{u})] \bar{V}_r. \tag{29}$$

Now the following identity will be used:

$$(\bar{V}_r \times \bar{u}) \times \bar{V}_r = |\bar{V}_r|^2 \bar{u} - (\bar{V}_r \cdot \bar{u}) \bar{V}_r.$$

Then the final form of the lift and drag equations to be used is

$$\bar{L} = \frac{1}{2} \rho A_r C_{L\alpha} [|\bar{V}_r|^2 \bar{u} - (\bar{V}_r \cdot \bar{u}) \bar{V}_r] \tag{30}$$

$$\bar{D} = -\frac{1}{2} \rho A_r [|\bar{V}_r| (C_A + 2\eta C_{L\alpha}^2) - 2\eta C_{L\alpha}^2 (\bar{V}_r \cdot \bar{u})] \bar{V}_r. \tag{31}$$

These are the expressions for $\bar{L}$ and $\bar{D}$ that will be used in equation (1) for the application of optimization theory. At this point, it will be mentioned again that equation (1) can be integrated numerically to yield a trajectory (without any optimization considerations) if $\bar{a} = \bar{u}$ is known directly in terms of its components or if χ_p and χ_y are known and equation (6) is used to obtain $\bar{u}$. Appendix I is a computer program listing and a sample printout which uses the above equations for $\bar{L}$ and $\bar{D}$ and assumes the following time history for $\bar{a} = \bar{u}$:

$$\bar{u} = \frac{\bar{u}_o + \dot{\bar{u}}_o(t - t_o)}{|\bar{u}_o + \dot{\bar{u}}_o(t - t_o)|} . \qquad (32)$$

The values, $\bar{u}_o$, $\dot{\bar{u}}_o$, and the flight time, t_f, are parameters in this program which can be varied to satisfy specified end conditions and minimize desired quantities. In determining how to vary the parameters $\bar{u}_o$ and $\dot{\bar{u}}_o$ to satisfy the end conditions, variational differential equations for the matrices

$$\frac{\partial\bar{x}(t)}{\partial\bar{u}_o}, \quad \frac{\partial\dot{\bar{x}}(t)}{\partial\bar{u}_o}, \quad \frac{\partial\bar{x}(t)}{\partial\dot{\bar{u}}_o}, \text{ and } \frac{\partial\dot{\bar{x}}(t)}{\partial\dot{\bar{u}}_o}$$

were developed, as explained in reference 14, and an iterative algorithm constructed. The program is mentioned at this time so that the interested reader can examine the listing to see a sample set of data and how the atmospheric and aerodynamic quantities are determined for the numerical integration. Other references to this listing and further explanations of the technique will also be given in some of the following sections.

4. Alternate Determination of $\bar{a}$ and $\bar{u}$

Often it is more desirable to determine $\bar{a}$ and $\bar{u}$ in terms of angle of attack α, bank angle β, β_r (to be defined), and α_o, mentioned previously, instead of using the inertial angles X_p, X_y, X_R, and α_o. How this can be done will be explained at this point before discussing the application of optimization theory to equation (1). To begin, a new coordinate system denoted by x", y", z" will be defined as shown in figure 8. Note that, in this coordinate system, the origin is at the point mass (m) and $\bar{r}$ is the position vector of the point mass (i.e., $\bar{r} = \bar{x}$ in the reference coordinate system). As can be seen from figure 8, the $\bar{V}_r$ vector is defined to lie along the z" axis, the $\bar{V}_r \times \bar{r}$ vector lies along the y" axis, and the $(\bar{V}_r \times \bar{r}) \times \bar{V}_r$ vector lies along the x" axis. Thus, the $\bar{x}''$ coordinate system is transformed to the original x,y,z coordinate system as follows:

$$\bar{x} = \left[\frac{(\bar{V}_r \times \bar{r}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{r}) \times \bar{V}_r|}, \quad \frac{\bar{V}_r \times \bar{r}}{|\bar{V}_r \times \bar{r}|}, \quad \frac{\bar{V}_r}{|\bar{V}_r|}\right] \bar{x}'' = [B]\bar{x}''. \qquad (33)$$

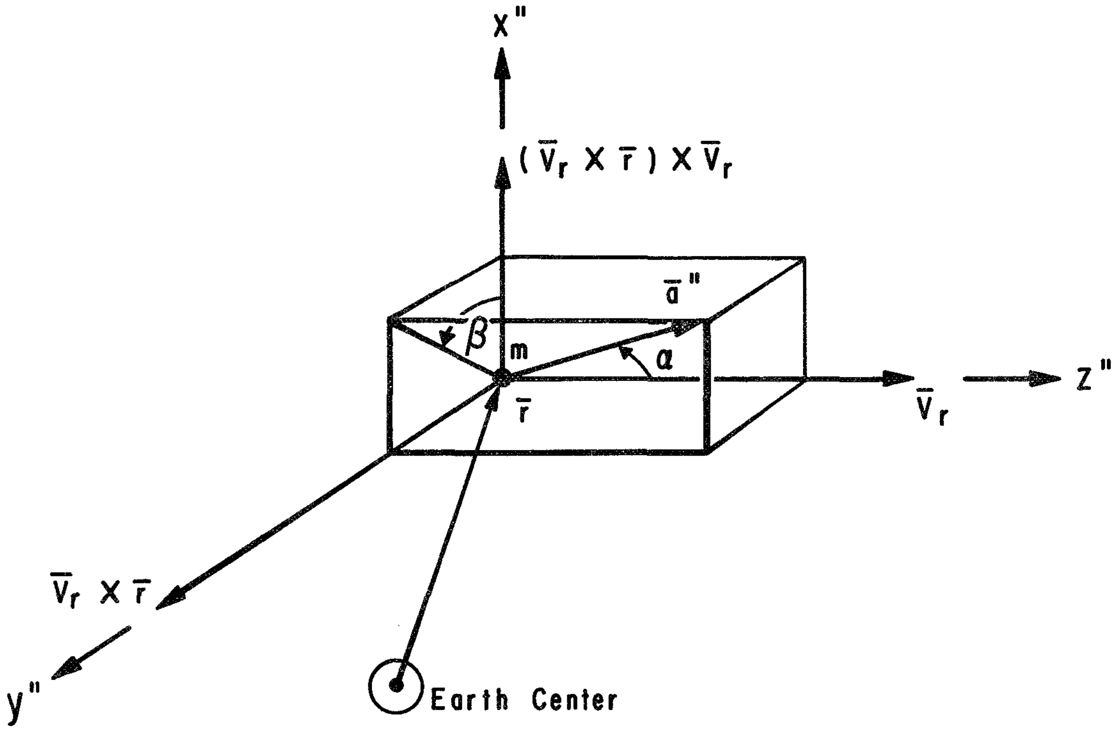

Figure 8. The Location of the Zero Lift Vector with an Angle of Attack and a Bank Angle

Then, as seen in figure 8,

$$\bar{a}'' = \begin{bmatrix} \sin\alpha \quad \cos\beta \\ \sin\alpha \quad \sin\beta \\ \cos\alpha \end{bmatrix}$$

and

$$\bar{a} = \left[\frac{(\bar{V}_r \times \bar{r}) \times \bar{V}_r}{|(\bar{V}_r \times \bar{r}) \times \bar{V}_r|}, \quad \frac{\bar{V}_r \times \bar{r}}{|\bar{V}_r \times \bar{r}|}, \quad \frac{\bar{V}_r}{|\bar{V}_r|} \right] \bar{a}'' = [B]a''.$$

The inverse transformation is given by

$$\bar{a}'' = [B]^T \bar{a}$$

and then

$$\alpha = \arctan \left[\frac{\sqrt{(a_1'')^2 + (a_2'')^2}}{a_3''} \right] \quad \text{(defined for } 0 < \alpha < \pi\text{)} \tag{34}$$

$$\beta = \arctan [(a_2''/a_1'')] \quad \text{(defined for } 0 \leqq \beta \leqq 2\pi\text{).} \tag{35}$$

When $\bar{u}$ is not the same as $\bar{a}$ and is allowed to be oriented with respect to $\bar{a}$ and V_r, then another coordinate system must be defined (denoted by x''', y''', z'''). To visualize this orientation see figure 9.

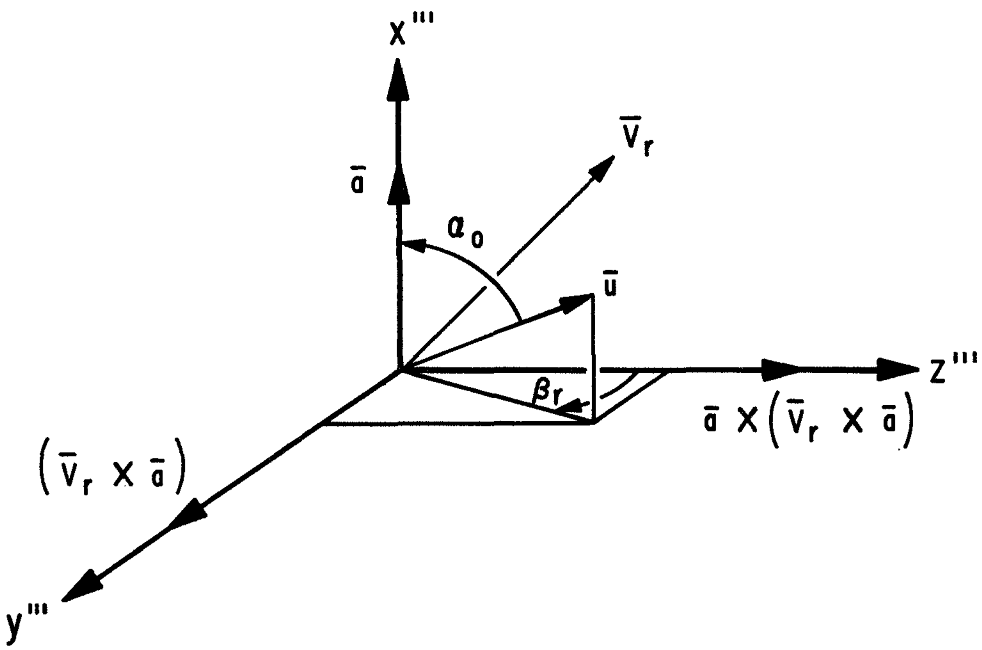

Figure 9. The Location of $\bar{u}$ with Respect to $\bar{a}$

The transformation from a vector $\bar{x}'''$ in this coordinate system to the original $\bar{x}$ coordinate system is obtained as follows:

$$\bar{x} = \left[\bar{a}, \quad \frac{\bar{V}_r \times \bar{a}}{|\bar{V}_r \times \bar{a}|}, \quad \frac{\bar{a} \times (\bar{V}_r \times \bar{a})}{|\bar{a} \times (\bar{V}_r \times \bar{a})|} \right] \bar{x}''' = [C]\bar{x}''' . \tag{36}$$

Thus,

$$\bar{u} = [C]\bar{u}'''.$$

Therefore,

$$\bar{u} = [C] \begin{bmatrix} \cos \alpha_o \\ -\sin \alpha_o \quad \sin \beta_r \\ -\sin \alpha_o \quad \cos \beta_r \end{bmatrix}.$$

Then the inverse transformation is given by

$$\bar{u}''' = [C]^T \bar{u}$$

and thus

$$\alpha_o = \arctan \frac{\sqrt{(u_2''')^2 + (u_3''')^2}}{u_1'''} \quad (\text{defined for } 0 < \alpha_o < \pi) \tag{37}$$

$$\beta_r = \arctan [u_2''' / u_3'''] \quad (\text{defined for } 0 \leq \beta_r \leq 2\pi). \tag{38}$$

The preceding equations show how to compute $\bar{a}$ and $\bar{u}$ with the angles α, β, α_o, and β_r or conversely how to compute α, β, α_o, and β_r when the unit vectors $\bar{a}$ and $\bar{u}$ are given. If it is assumed that $\bar{a} = \bar{u}$, then the triple prime coordinate system does not have to be introduced, and only the angles α and β are needed to compute $\bar{a}$ and thus $\bar{u}$. Conversely, α and β can be computed when $\bar{u} = \bar{a}$ is known or given.

In the next section, optimization theory will be applied to the equations of motion (equation (1)) with $\bar{L}$ and $\bar{D}$ given by the simplified expressions which resulted from assuming $\bar{a} = \bar{u}$. One of the results of the application of optimization theory will be a time history for $\bar{u}$, and thus $\bar{a}$ that will produce an optimum trajectory to the desired destination. This time history ($\bar{u} = \bar{a}$ as a function of time) can be used to compute X_p and X_y or α and β as functions of time for guidance purposes.

C. Application of Optimization Theory to Equations of Motion

1. Equations of Motion

The simplified equations of motion discussed in the previous section will be used here to illustrate the application of optimization theory. These equations with the simplified $\bar{L}$ and $\bar{D}$ should adequately represent the motion of most space shuttle type of vehicles during atmospheric flight. If it is found that they are not adequate, the reader should remember that they are used here only to illustrate the approach, and whatever corrections are needed can be added to the equations without changing the philosophy of the approach.

The simplified equations for $\bar{L}$ and $\bar{D}$ can be substituted into equation (1) of the previous section to give the following form for the equations of motion:

$$\ddot{\bar{x}} = (F/m)\bar{u} - \frac{GM\bar{x}}{R^3} + g(\bar{x}) + (\rho A_r/2m)\Big\{C_{L_\alpha}[\bar{V}_r \cdot \bar{V}_r)\bar{u} - (\bar{V}_r \cdot \bar{u})\bar{V}_r]$$

$$- [(\bar{V}_r \cdot \bar{V}_r)^{1/2}(C_A + 2\eta\, C_{L_\alpha}^2) - 2\eta\, C_{L_\alpha}^2 (\bar{V}_r \cdot \bar{u})]\, \bar{V}_r\Big\} . \tag{39}$$

In equation (39), F is given by equation (2) and m by equations (3) and (4). Typical values of the constants needed to use equations (2), (3), and (4) can be found in the computer program listing and sample case printout of Appendix I. The constant GM needed to compute the second term of equation (39) and the form of the equations for $g(\bar{x})$ can also be found in Appendix I. The atmospheric subroutine shown in Appendix I shows how the atmospheric density ρ, the atmospheric pressure P, and the velocity of sound V_s are obtained as functions of altitude for use in equation (39). With a value for V_s, equation (20) can be used to compute the Mach number. Then the aerodynamic subroutine of Appendix I shows how values of C_{L_α}, C_A, and η are obtained as functions of Mach number. If it is noted that $\bar{V}_r$ is given by equation (9) and that the instantaneous radius of the oblate earth's surface is determined in the differential equation subroutine of Appendix I, then the computation of all the terms in equation (39) has been explained.

A transition to state vector notation will be made to facilitate the explanation of the application of optimization theory to equation (39). To do this, let

$$X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \\ m \end{bmatrix}. \tag{40}$$

Then

$$\dot{X} = \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \\ \dot{x}_5 \\ \dot{x}_6 \\ \dot{x}_7 \end{bmatrix} = \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ \ddot{x} \\ \ddot{y} \\ \ddot{z} \\ \dot{m} \end{bmatrix} = \begin{bmatrix} f_1(x_1,x_2,\ \ldots,\ x_7) \\ f_2(x_1,x_2,\ \ldots,\ x_7) \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ f_7(x_1,x_2,\ \ldots,\ x_7) \end{bmatrix} \tag{41}$$

where

$$f_1 = x_4$$

$$f_2 = x_5$$

$$f_3 = x_6$$

$$\begin{bmatrix} f_4 \\ f_5 \\ f_6 \end{bmatrix} = (F/x_7)\bar{u} - \frac{GM \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}}{(x_1^2 + x_2^2 + x_3^2)^{3/2}} + \bar{g}(x_1,x_2,x_3)$$

$$+ \frac{\rho A_r}{2x_7} \Big\{ C_{L\alpha} \, [(\bar{V}_r \cdot \bar{V}_r)\bar{u} - (\bar{V}_r \cdot \bar{u})\bar{V}_r]$$

$$- [(\bar{V}_r \cdot \bar{V}_r)^{1/2}(C_A + 2\eta \, C_{L\alpha}^2) - 2\eta \, C_{L\alpha}^2 \, (\bar{V}_r \cdot \bar{u})]\bar{V}_r \Big\} \qquad (42)$$

$f_7 = \dot{m}$ (a constant developed in equation (3)).

Note that, in the previous expressions for f_4, f_5, and f_6; F depends on x_1,x_2,x_3; ρ depends on x_1,x_2,x_3; $\bar{V}_r$ depends on $x_1,x_2,x_3,x_4,$ x_5,x_6; and the aerodynamic coefficients $C_{L\alpha}$, C_A, and η all depend on x_1,x_2,x_3,x_4,x_5,x_6. This dependence can also be seen by referring to the differential equation subroutine of Appendix I. The preceding transition to state vector notation now allows the equations of motion to be written in standard first order form which is usually seen when optimization theory is developed. That is,

$$\dot{X} = f(X,\bar{u}), \qquad (43)$$

where $\dot{X}$, f, and X are all vectors of dimension 7, and $\bar{u}$ is a vector of dimension 3.

Before applying optimization theory to this system of equations, the optimization criteria and the boundary conditions must be discussed. Such a discussion appears in the next two sections.

2. Definition of Optimization Criteria

The optimization criteria selected for discussion in this section were chosen mainly for illustration, and some approximations were made to keep the equations as simple as possible while maintaining as much physical realism as possible. Again it must be emphasized that, if this particular selection of an optimization criteria is found to be unsatisfactory, then whatever criteria that can be selected which are satisfactory can be used without changing the basic philosophy of the MASCOT technique.

The selected criteria are given as:

$$x_8(t_f) = k_1 x_7(t_f) + k_2 \left[\int_{t_o}^{t_f} \dot{Q}\, dt\right] + k_3 \left[\int_{t_o}^{t_f} D^2\, dt\right]. \tag{44}$$

That is, $x_8(t_f)$ is to be minimized where the constants or weighting factors k_1, k_2, and k_3 can be selected to achieve different ratios of values among the three terms in the expression for $x_8(t_f)$. For example, in reentry, k_1 could be zero with k_2 and k_3 equal to .5, or in ascent, k_1 could be minus one and k_2 and k_3 zero. In equation (44) $\dot{Q}$, the convective heating rate per unit area of the vehicle, is given by

$$\dot{Q} = \frac{e}{\sqrt{\sigma}} \rho^{1/2} |\bar{V}_r|^3 \tag{45}$$

where e is a constant and σ is the radius of curvature of the vehicle's nose. Values for these constants are given in Appendix I. Also, in equation (44)

$$D^2 \approx \frac{|\bar{L}|^2 + |\bar{D}|^2}{m^2} .$$

The following steps are needed to derive the exact expression for D^2. From the simplified equation for $\bar{L}$ and $\bar{D}$ (equations (30) and (31)), it can be seen that

$$|\bar{L}|^2 = \bar{L} \cdot \bar{L} = (\tfrac{1}{2} \rho A_r C_{L_\alpha})^2 [(\bar{V}_r \cdot \bar{V}_r)^2 - (\bar{V}_r \cdot \bar{V}_r)(\bar{V}_r \cdot \bar{u})^2] \tag{46}$$

$$|\bar{D}|^2 = \bar{D} \cdot \bar{D} = (\frac{1}{2}\rho A_r)^2 \; [(\bar{V}_r \cdot \bar{V}_r)^{1/2}(C_A + 2\eta\; C^2_{L\alpha})$$

$$- 2\eta\; C^2_{L_\alpha}\; (\bar{V}_r \cdot \bar{u})]^2 \; (\bar{V}_r \cdot \bar{V}_r)$$

$$= (\frac{1}{2}\;\rho\; A_r)^2[(\bar{V}_r \cdot \bar{V}_r)(C_A + 2\eta\; C^2_{L\alpha})^2$$

$$- 4\eta\; C^2_{L_\alpha}\; (\bar{V}_r \cdot \bar{V}_r)^{1/2}(\bar{V}_r \cdot \bar{u})(C_A + 2\eta\; C^2_{L_\alpha})$$

$$+ 4(\eta\; C^2_{L_\alpha})^2\; (\bar{V}_r \cdot \bar{u})^2](\bar{V}_r \cdot \bar{V}_r). \tag{47}$$

Now note that $(\bar{V}_r \cdot \bar{u}) = |\bar{V}_r|\cos\alpha$ so that

$$(\bar{V}_r \cdot \bar{u})^2 = (\bar{V}_r \cdot \bar{V}_r)\;\cos^2\alpha = (\bar{V}_r \cdot \bar{V}_r)(1 - \sin^2\alpha). \tag{48}$$

In equation (48), $\sin^2\alpha$ will be approximated by $2(1 - \cos\alpha)$ to give

$$(\bar{V}_r \cdot \bar{u})^2 = (\bar{V}_r \cdot \bar{V}_r)[1 - 2(1 - \cos\alpha)]$$

$$= (\bar{V}_r \cdot \bar{V}_r)[2\cos\alpha - 1] \tag{49}$$

$$= 2(\bar{V}_r \cdot \bar{V}_r)^{1/2}(\bar{V}_r \cdot \bar{u}) - (\bar{V}_r \cdot \bar{V}_r).$$

The substitution of the final form of equation (49) into equations (46) and (47) gives

$$|\bar{L}|^2 \approx (\frac{1}{2}\;\rho\; A_r)^2(2C^2_{L\alpha})[(\bar{V}_r \cdot \bar{V}_r)^2 - (\bar{V}_r \cdot \bar{V}_r)^{3/2}(\bar{V}_r \cdot \bar{u})] \tag{50}$$

$$|\bar{D}|^2 \approx (\frac{1}{2}\;\rho\; A_r)^2[(\bar{V}_r \cdot \bar{V}_r)(C^2_A + 4\eta\; C_A\; C^2_{L_\alpha})$$

$$- 4\eta\; C_A\; C^2_{L\alpha}(\bar{V}_r \cdot \bar{u})(\bar{V}_r \cdot \bar{V}_r)^{1/2}](\bar{V}_r \cdot \bar{V}_r). \tag{51}$$

Adding equations (50) and (51) and dividing by m^2 gives the final form to be used for D^2. That is,

$$D^2 = (\rho A_r/2m)^2[(\bar{V}_r \cdot \bar{V}_r)^2(C_A^2 + 4\eta\ C_A\ C_{L\alpha}^2 + 2C_{L\alpha}^2)$$

$$- 2(\bar{V}_r \cdot \bar{u})(\bar{V}_r \cdot \bar{V}_r)^{3/2}(C_{L\alpha}^2 + 2\eta\ C_A\ C_{L\alpha}^2)]. \qquad (52)$$

With the preceding explanation of $\dot{Q}$ and D^2 and using equation (44), it can be seen that

$$\dot{x}_8 = k_1\dot{x}_7 + k_2\dot{Q} + k_3D^2 = f_8(x_1,x_2,\ldots,x_7). \qquad (53)$$

Thus, $x_8(t)$ as defined by equation (53) is a new variable which is added to the seven variables of the preceding section so that $x_8(t_f)$ is the quantity selected to be minimized at the final time with $x_8(t_o) = k_1m_o$.

3. Definition and Explanation of Some Example Boundary or Mission Conditions

The previous two sections have put the illustrative problem being solved in this report in the form:

(a) $X(t_o)$ and t_o are given

(b) $X(t)$ is defined by $\dot{X}(t) = f[X(t),\bar{u}(t)]$ where $t_o \leqq t \leqq t_f$ (54)

(c) $x_8(t_f)$ is to be minimized by the choice of $\bar{u}(t)$.

In equation (54), X is now an eight-dimensional vector and $\bar{u}$ is a three-dimensional vector. The only thing missing from equation (54) is some additional constraints which are usually placed on some of the values of $x_1(t_f)$, $x_2(t_f)$, ..., $x_7(t_f)$. These functional constraints are called the boundary (or end or mission) conditions.

The first set of boundary conditions to be discussed is an example set of reentry boundary conditions. For example, on a reentry trajectory a desired value for the magnitude of the radius vector, Mach number, the path angle, down range, and cross range could be specified for the end of the trajectory. In functional form the preceding specifications result in five equations as follows:

$$G_1 = \frac{x_1^2 + x_2^2 + x_3^2}{R_c^2} - 1 = 0 \tag{54}$$

$$G_2 = \frac{\bar{V}_r \cdot \bar{V}_r}{V_s^2 \, M_c^2} - 1 = 0 \tag{55}$$

$$G_3 = \frac{x_1 x_4 + x_2 x_5 + x_3 x_6}{R_c \sqrt{x_4^2 + x_5^2 + x_6^2}} - \cos \vartheta_c = 0 \tag{56}$$

$$G_4 = \left\{ \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \cdot \left[\frac{\bar{x}_o}{|\bar{x}_o|} \tan \varphi_{DR} - \frac{\bar{x}_o \times (\dot{\bar{x}}_o \times \bar{x}_o)}{|\bar{x}_o \times (\dot{\bar{x}}_o \times \bar{x}_o)|} \right] \right\} \Big/ R_c = 0 \tag{57}$$

$$G_5 = \left\{ \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \cdot \left[\frac{\dot{\bar{x}}_o \times \bar{x}_o}{|\dot{\bar{x}}_o \times \bar{x}_o|} \right] \right\} \Big/ R_c - \sin \varphi_{CR} = 0. \tag{58}$$

In all of these equations, the values of x_1, x_2, x_3, x_4, x_5, and x_6 are used at the final time. In equation (54), R_c is the desired value of the magnitude of the radius vector at the final time, and when $G_1 = 0$, it can be seen that $x_1^2 + x_2^2 + x_3^2$ will be equal to R_c^2. Similarly, in equation (55), M_c is the desired value of Mach number at the final time; in equation (56), ϑ_c is the desired value of the angle between the inertial position vector and the inertial velocity vector (path angle); in equation (57), φ_{DR} is the desired value of the down range angle; and in equation (58), φ_{CR} is the desired value of the cross range angle. In order to better understand equations (57) and (58), figure 10 is used.

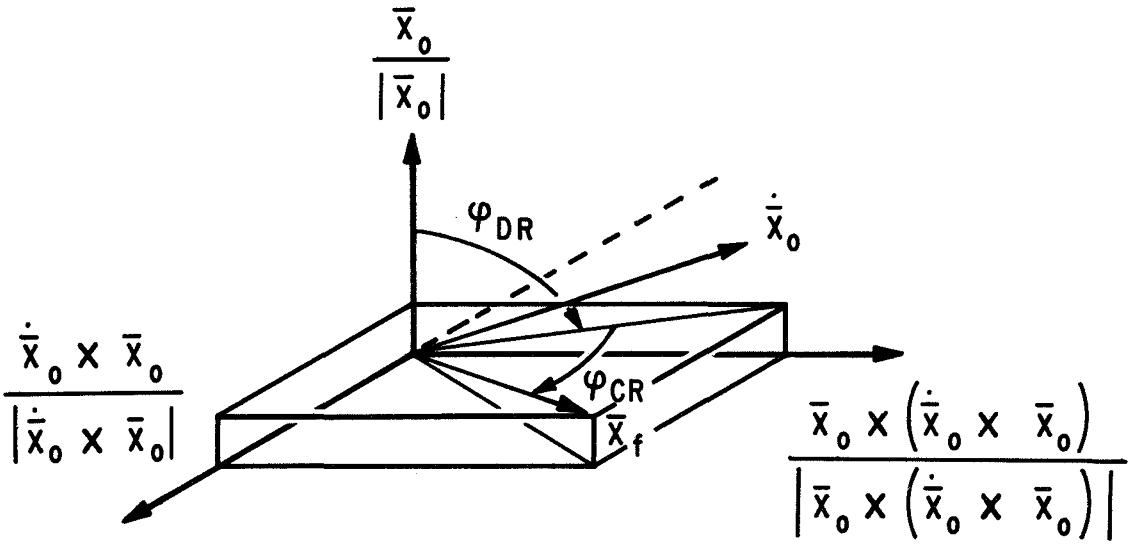

Figure 10. A Definition of the Down Range and Cross Range Angles

In this figure a coordinate system is defined using the position and velocity vector at the initial time ($\bar{x}_o$ and $\dot{\bar{x}}_o$), and then the angles φ_{DR} and φ_{CR} are used to locate the final position vector $\bar{x}_f$ with respect to the coordinate system defined by $\bar{x}_o$ and $\dot{\bar{x}}_o$. The figure shows that

$$\tan \varphi_{DR} = \frac{\bar{x}_f \cdot \left[\dfrac{\bar{x}_o \times (\dot{\bar{x}}_o \times \bar{x}_o)}{|\bar{x}_o \times (\dot{\bar{x}}_o \times \bar{x}_o)|}\right]}{\bar{x}_f \cdot \left[\dfrac{\bar{x}_o}{|\bar{x}_o|}\right]} \tag{59}$$

$$\sin \varphi_{CR} = \frac{\bar{x}_f \cdot \left[\dfrac{\dot{\bar{x}}_o \times \bar{x}_o}{|\dot{\bar{x}}_o \times \bar{x}_o|}\right]}{|\bar{x}_f|} . \tag{60}$$

Since $|\bar{x}_f|$ is to be equal to R_c, it can be seen that equations (57) and (58) follow from equations (59) and (60).

The computer program for computing equations (54), (55), (56), (57), and (58) is called subroutine BOUND in Appendix I. Notice that all of the equations are normalized so that $G_1^2 + G_2^2 + G_3^2 + G_4^2 + G_5^2$ will have a magnitude near the value of one. The preceding sum of squares is usually used as an error check to determine when the boundary conditions are satisfied. That is, it must be less than some tolerance (for example, $.5 \times 10^{-10}$).

With the preceding definition of an example set of boundary conditions, the complete trajectory optimization problem being solved in this paper can now be stated in functional notation. That is,

(a) $X(t_o)$ and t_o are given

(b) $X(t)$ is defined by $\dot{X}(t) = f[X(t),\bar{u}(t)]$ where $t_o \leqq t \leqq t_f$ (61)

(c) $x_8(t_f)$ is to be minimized and $G[X_f(t_f),t_f]$ is to be made equal to zero by the choice of $\bar{u}(t)$.

Appendix I is a computer program listing which solves the problem stated in equation (61) with the assumption that

$$\bar{u}(t) = \frac{\bar{u}_o + \dot{\bar{u}}_o(t - t_o)}{|\bar{u}_o + \dot{\bar{u}}_o(t - t_o)|}$$

where the vector constants $\bar{u}_o$ and $\dot{\bar{u}}_o$ are assumed to be unknown parameters which the program must select along with t_f to satisfy condition (c) of equation (61). This approach to trajectory optimization is called parameter optimization particularly when the time interval t_o to t_f is broken into n segments (at the times $t_1, t_2, \ldots, t_n$) and $u(t)$ is defined by

$$u(t) = \frac{\bar{u}_o + \dot{\bar{u}}_o(t - t_o)}{|\bar{u}_o + \dot{\bar{u}}_o(t - t_o)|} \qquad \text{for } t_o \leqq t \leqq t_1$$

$$u(t) = \frac{\bar{u}(t_1) + \dot{\bar{u}}_1(t - t_1)}{|\bar{u}(t_1) + \dot{\bar{u}}_1(t - t_1)|} \qquad \text{for } t_1 \leqq t \leqq t_2 \qquad (62)$$

$$\vdots$$

$$u(t) = \frac{\bar{u}(t_n) + \dot{\bar{u}}_n(t - t_n)}{|\bar{u}(t_n) + \dot{\bar{u}}_n(t - t_n)|} \qquad \text{for } t_n \leqq t \leqq t_f.$$

Then the parameters the program must select to satisfy condition (c) of equation (61) are $\bar{u}_o$, $\dot{\bar{u}}_o$, $\bar{u}_1$, $\bar{u}_2$, ..., $\bar{u}_n$, and t_f. As stated previously, the computer program listed in Appendix I and the sample case are a solution of the problem stated by equation (61) using only the parameters $\bar{u}_o$, $\dot{\bar{u}}_o$, and t_f with the boundary conditions given by equations (54), (55), (56), (57), and (58). Before explaining in more detail how this computer program works, a set of example boundary conditions for a rendezvous mission and an ascent mission will be given, and it will be noted here that the computer program of Appendix I has been used to solve these problems when the subroutines BOUND and PBOUND are replaced with the appropriate new subroutines for ascent and rendezvous.

For an ascent mission, the magnitude of the radius vector, the magnitude of the velocity vector, the angle between the radius vector and the velocity vector, and the angle between the plane containing the position and velocity vector and the equatorial plane could be specified. This yields the following set of boundary conditions (note that all values of x_1, x_2, x_3, x_4, x_5, and x_6 are used at t_f):

$$G_1 = \frac{x_1^2 + x_2^2 + x_3^2}{R_c^2} - 1 = 0 \tag{63}$$

$$G_2 = \frac{x_4^2 + x_5^2 + x_6^2}{V_c^2} - 1 = 0 \tag{64}$$

$$G_3 = \frac{x_1 x_4 + x_2 x_5 + x_3 x_6}{R_c V_c} - \cos \vartheta_c = 0 \tag{65}$$

$$G_4 = \frac{\left\{ \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \times \begin{bmatrix} x_4 \\ x_5 \\ x_6 \end{bmatrix} \right\} \cdot \bar{A}}{R_c \; V_c} - \sin \varphi_c \cos i_c = 0. \tag{66}$$

In equation (63), R_c is the specified radius vector magnitude; in equation (64), V_c is the specified velocity vector magnitude; in equation (65), ϑ_c is the specified angle between the radius vector and the velocity vector; and in equation (66), i_c is the specified inclination of the flight plane to the equatorial plane. Also, in equation (66), $\bar{A}$ is a unit vector perpendicular to the equatorial plane. Figure 11 shows $\bar{A}$ and a plumbline coordinate system oriented, with respect to the equatorial coordinate system, by the azimuth Az and the geodetic latitude φ_d of some point such as the launch site.

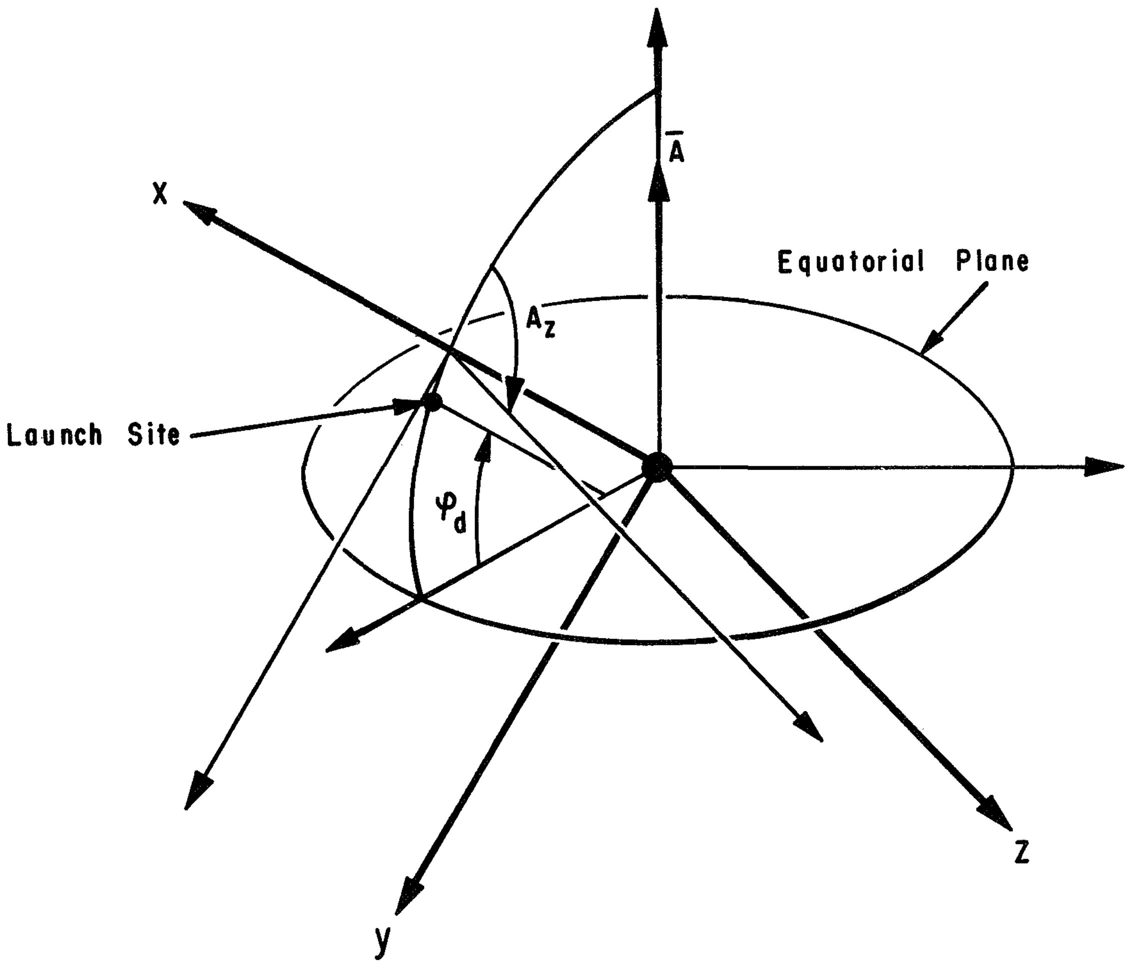

Figure 11. The Orientation of the Plumbline Coordinate System and the Unit North Vector $\bar{A}$

Figure 11 shows that

$$\bar{A} = \begin{bmatrix} \sin \varphi_d \\ \cos \varphi_d \quad \sin A_z \\ \cos \varphi_d \quad \cos A_z \end{bmatrix}. \tag{67}$$

This completes the explanation of an example set of ascent boundary conditions.

For a rendezvous mission, let the coordinates of the target vehicle (in the same coordinate system as the pursuit vehicle) be given by the six-dimensional vector Y, where

$$Y = \begin{bmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \end{bmatrix} . \tag{68}$$

Then the boundary conditions can be written in the form:

$$G_1 = \frac{x_1}{y_1} - 1 = 0 \tag{69}$$

$$G_2 = \frac{x_2}{y_2} - 1 = 0 \tag{70}$$

$$G_3 = \frac{x_3}{y_3} - 1 = 0 \tag{71}$$

$$G_4 = \frac{x_4}{y_4} - 1 = 0 \tag{72}$$

$$G_5 = \frac{x_5}{y_5} - 1 = 0 \tag{73}$$

$$G_6 = \frac{x_6}{y_6} - 1 = 0. \tag{74}$$

Note that in the above equations the values of x_1, x_2, x_3, x_4, x_5, and x_6 are all taken at the final time and the values of $y_1, y_2, \ldots, y_6$ depend only on the final time so that equations (69), (70), ..., (74) form a set of boundary conditions in the form $G[X(t_f), t_f] = 0$ where G is a six-dimensional vector.

The preceding discussion completes the explanation of all three sets of boundary conditions. Now the operation of the computer program in Appendix I will be explained in more detail. The starting point will be the problem statement of equation (61) with the five-dimensional

$G[X(t_f),t_f]$ vector given by equations (54), (55), (56), (57), and (58). As stated before, $\bar{u}(t)$ is assumed to have the form

$$\bar{u}(t) = \frac{\bar{u}_o + \dot{\bar{u}}_o(t - t_o)}{|\bar{u}_o + \dot{\bar{u}}_o(t - t_o)|}$$

and the parameters $\bar{u}_o$ and $\dot{\bar{u}}_o$ (appearing in the $\bar{u}(t)$ expression) and t_f are used to satisfy condition (c) of equation (61). With the preceding form for $\bar{u}(t)$ and the fixed initial conditions of condition (a) in equation (61), it can be stated that $X(t_f)$ depends only on α, β, $\dot{\bar{u}}_o$, and t_f, where α and β are shown in figure 8, and define a unit vector for $\bar{u}_o$ as shown in the explanation following equation (33). That is,

$$\bar{u}_o = (\sin\alpha\cos\beta)\left[\frac{(\bar{V}_{r_o} \times \bar{x}_o) \times \bar{V}_{r_o}}{|(\bar{V}_{r_o} \times \bar{x}_o) \times \bar{V}_{r_o}|}\right] + \sin\alpha\sin\beta\left[\frac{\bar{V}_{r_o} \times \bar{x}_o}{|\bar{V}_{r_o} \times \bar{x}_o|}\right]$$

$$+ \cos\alpha\left[\frac{\bar{V}_{r_o}}{|\bar{V}_{r_o}|}\right]. \tag{75}$$

It might also seem that $X(t_f)$ should depend on the magnitude of $\bar{u}_o$, but the definition of $\bar{u}(t)$ as a unit vector tends to eliminate this possibility because the magnitude of $\dot{\bar{u}}_o$ must also be considered. That is, any arbitrary initial magnitude of $\bar{u}_o$ will produce the same $X(t_f)$ that an initial magnitude of $\bar{u}_o$ equal to one would produce, when α and β are kept the same and the magnitude of $\dot{\bar{u}}_o$ is adjusted with the ratio of the two different $\bar{u}_o$ magnitudes.

Now it can be stated that $G[X(t_f),t_f]$ and $x_8(t_f)$ depend on α, β, $\dot{\bar{u}}_o$, and t_f. Thus, two new vectors (F and z) can now be defined. That is,

$$F(z) = F(\alpha,\beta,\dot{\bar{u}}_o,t_f) = \begin{bmatrix} G[X(t_f),t_f] \\ W_1 x_8(t_f) \end{bmatrix} \tag{76}$$

where

$$z = \begin{bmatrix} \alpha \\ \beta \\ \dot{u}_o \\ t_f \end{bmatrix}.$$

In equation (76), notice that F is a six-dimensional vector and z is a six-dimensional vector. The fact that F and z are of the same dimension is somewhat coincidental, since, for the following development, it is required only that the dimension of z be greater than or equal to the dimension of F. Note also the arbitrary weighting factor W_1 whose use will be explained later.

The preceding discussion allows condition (c) of equation (61) to be stated in the following form: Determine the parameters α, β, $\dot{u}$, and t_f to minimize $F^T F$ with a choice of the weighting factor W_1 which allows $G^T G$ to be zero. Note that F^T means F transpose so that $F^T F$ is a scalar, and similarly for $G^T G$. To determine the vector of unknown parameters z, which minimizes $F^T F$, a Taylor series expansion of F about an arbitrarily guessed vector z^* is made. That is,

$$F(z) = F(z^*) + (\partial F/\partial z)_*(z - z^*) + \dots \quad (77)$$

The notation $(\partial F/\partial z)_*$ means the matrix of partial derivatives of the vector F with respect to the vector z evaluated at the star point. Its determination will be explained later. If $(\partial F/\partial z)_*$ in equation (77) is not zero, then a vector z can be determined such that $F(z) = KF(z^*)$ where K is a scalar such that $0 \leq K < 1$. Also, if all the terms of order greater than one are neglected in equation (77), then the difference in this linear approximation to F(z) and $KF(z^*)$ will depend on z. That is,

$$\begin{aligned} \epsilon(z) &= F(z) - KF(z^*) \\ &= (1 - K)F(z^*) + (\partial F/\partial z)_*(z - z^*). \end{aligned} \quad (78)$$

Equation (77) shows that $\epsilon^T(z)\epsilon(z)$ is a minimum when the vector z satisfies the following equation:

$$(\partial F/\partial z)_*^T\ (\partial F/\partial z)_*\ (z - z^*) = -(1 - K)^2\ (\partial F/\partial z)_*^T\ F(z^*). \qquad (79)$$

Notice that, if the function F(z) satisfies appropriate continuity conditions, then a value of K close enough to one can be chosen so that the value of z obtained from equation (79) will produce a value of F(z), using equation (77), that will be equal to $KF(z^*)$ within any desired degree of accuracy. The computer program of Appendix I uses equation (79) and some logic for choosing a sequence of W_1's and a sequence of K's to determine a vector z which minimizes F(z). Since the program listing is self-explanatory, an explanation of the logic is not included here. The only other aspect of the listing in Appendix I to be explained is the determination of $(\partial F/\partial z_*)$ which appears in equations (77), (78), and (79).

Since the vector F depends on $X(t_f)$ and t_f in its original form, $(\partial F/\partial z)_*$ is obtained using the chain rule. That is,

$$(\partial F/\partial z) = \frac{F[X(t_f),t_f]}{\partial\alpha,\beta,\dot{u}_o,t_f} = \frac{F[X(t_f),t_f]}{X(t_f)}\left(\frac{\partial X(t_f)}{\partial z}\right) + \frac{\partial F[X(t_f),t_f]}{\partial t_f}\left(\frac{\partial t_f}{\partial z}\right). \qquad (80)$$

On the right-hand side of equation (80), it can be seen that

$$\frac{\partial F[X(t_f),t_f]}{\partial X(t_f)} \quad \text{and} \quad \frac{\partial F[X(t_f),t_f]}{\partial t_f}$$

are obtained by explicit partial differentiation of the expression for $F[X(t_f),t_f]$ with respect to the variables $X(t_f)$ and t_f. Also, to further explain the other two terms on the far right-hand side of equation (80), the following definitions are repeated:

$$\frac{\partial t_f}{\partial z} = \begin{bmatrix} \frac{\partial t_f}{\partial \alpha} \\ \frac{\partial t_f}{\partial \beta} \\ \frac{\partial t_f}{\partial \dot{\bar{u}}_o} \\ \frac{\partial t_f}{\partial t_f} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}. \tag{81}$$

and

$$\frac{\partial X(t_f)}{\partial z} = \left[\frac{\partial X(t_f)}{\partial \alpha}, \quad \frac{\partial X(t_f)}{\partial \beta}, \quad \frac{\partial X(t_f)}{\partial \dot{\bar{u}}_o}, \quad \dot{X}(t_f)\right]. \tag{82}$$

In equation (82), the chain rule is again applied to the first two columns of the matrix for $\partial X(t_f)/\partial z$ to give

$$\frac{\partial X(t_f)}{\partial \alpha} = \frac{\partial X(t_f)}{\partial \bar{u}_o} (\partial \bar{u}_o/\partial \alpha) + \frac{\partial X(t_f)}{\partial \dot{\bar{u}}_o} (\partial \dot{\bar{u}}_o/\partial \alpha) \tag{83}$$

and

$$\frac{\partial X(t_f)}{\partial \beta} = \frac{\partial X(t_f)}{\partial \bar{u}_o} (\partial \bar{u}_o/\partial \beta) + \frac{\partial X(t_f)}{\partial \dot{\bar{u}}_o} (\partial \dot{\bar{u}}_o/\partial \beta). \tag{84}$$

Since $\dot{\bar{u}}_o$, α, and β are assumed to be independent parameters, $\partial \dot{\bar{u}}_o/\partial \alpha$ and $\partial \dot{\bar{u}}_o/\partial \beta$ are zero. Equation (75) gives the relation between α, β, and $\bar{u}_o$ so that

$$\frac{\partial \bar{u}_o}{\partial \alpha} = \cos \alpha \left\{\cos \beta \left[\frac{(\bar{V}_{r_o} \times \bar{x}_o) \times \bar{V}_{r_o}}{|(\bar{V}_{r_o} \times \bar{x}_o) \times \bar{V}_{r_o}|}\right] + \sin \beta \left[\frac{\bar{V}_{r_o} \times \bar{x}_o}{|\bar{V}_{r_o} \times \bar{x}_o|}\right]\right\}$$
$$- \sin \alpha \left[\frac{\bar{V}_{r_o}}{|\bar{V}_{r_o}|}\right] \tag{85}$$

and

$$\frac{\partial \bar{u}_o}{\partial \beta} = \sin \alpha \left\{ \cos \beta \left[\frac{\bar{V}_{r_o} \times \bar{x}_o}{|\bar{V}_{r_o} \times \bar{x}_o|} \right] - \sin \beta \left[\frac{\bar{V}_{r_o} \times \bar{x}_o \times \bar{V}_{r_o}}{|(\bar{V}_{r_o} \times \bar{x}_o) \times \bar{V}_{r_o}|} \right] \right\} . \tag{86}$$

Now the only undetermined matrices needed for $\partial F/\partial z$, as given by equation (80), are the matrices $\partial X(t_f)/\partial \bar{u}_o$ and $\partial X(t_f)/\partial \dot{\bar{u}}_o$ which appear in equations (82), (83), and (84). These matrices must be determined by numerical integration of the variational equations. Equation (61) shows that $X(t_o)$ and t_o are fixed and $\dot{X} = f(X,u)$. Thus,

$$\frac{\partial X(t_o)}{\partial \bar{u}_o} = 0 \tag{87}$$

$$\frac{\partial X(t_o)}{\partial \dot{\bar{u}}_o(t_o)} = 0 \tag{88}$$

and

$$\frac{d}{dt}\left[\frac{\partial X(t)}{\partial \bar{u}_o, \dot{\bar{u}}_o}\right] = \left[\frac{\partial f(X,\bar{u})}{\partial \bar{u}_o, \dot{\bar{u}}_o}\right] = \left[\frac{\partial f(X,\bar{u})}{\partial X}\right]\left[\frac{\partial X(t)}{\partial \bar{u}_o, \dot{\bar{u}}_o}\right] + \left[\frac{\partial f(X,\bar{u})}{\partial \bar{u}}\right]\left[\frac{\partial \bar{u}(t)}{\partial \bar{u}_o, \dot{\bar{u}}_o}\right]. \tag{89}$$

The initial condition matrices given by equations (87) and (88) allow equation (89) to be integrated numerically from t_o to t_f to determine the matrices $\partial X(t_f)/\partial \bar{u}_o$ and $\partial X(t_f)/\partial \dot{\bar{u}}_o$. Notice that the matrices

$$\left[\frac{\partial f(X,\bar{u})}{\partial X}\right], \quad \left[\frac{\partial f(X,\bar{u})}{\partial \bar{u}}\right], \quad \text{and} \quad \left[\frac{\partial \bar{u}}{\partial \bar{u}_o, \dot{\bar{u}}_o}\right]$$

are obtained by explicit partial differentiation of the expressions for $f(X,\bar{u})$ and $\bar{u}(t)$.

The preceding discussion completes an explanation and brief derivation of the basic ideas included in the computer program of Appendix I. For the actual expressions of all the partial derivatives and any other equations of interest, the reader is referred to Appendix I.

4. Derivation of Optimization Conditions

In the previous section of this report, the optimization problem described by equation (61) was solved using the parameter t_f and the parameters $\bar{u}_o$ and $\dot{\bar{u}}_o$ appearing in a particular form of $\bar{u}(t)$. In this section, the optimization conditions needed to determine $\bar{u}(t)$ satisfying equation (61) will be derived without assuming a specified form for $\bar{u}(t)$ (i.e., the optimization conditions will determine the form for $\bar{u}(t)$). The derivation used here is rather informal, and is included mainly to give the reader an idea about the basis for optimization conditions and their form. A more precise derivation for similar problems can be found in references 15 and 16.

The first step in this derivation is the definition of an optimization criteria (J) with the constraints adjoined to J with vectors of "Lagrangian" multipliers (p and λ). That is,

$$J = x_8(t_f) + p^T G[X(t_f),t_f] + \int_{t_o}^{t_f} \left\{ \lambda(t)^T \left[\dot{X}(t) - f[X(t),\bar{u}(t)] \right] \right\} dt. \tag{90}$$

In equation (90) p is the vector of multipliers associated with the constraints of condition (c) in equation (61), and $\lambda(t)$ is the vector of multipliers associated with the constraints of condition (b) in equation (61). Since p is defined to have the same dimension as G and λ the same dimension as X, it can be seen that J is a scalar. For a given set of $X(t_o)$ and t_o, a minimization of J, a satisfaction of conditions (b) of equation (61), and a satisfaction of the condition $g[X(t_f),t_f] = 0$ by the selection of $\bar{u}(t)$ will produce a minimum of $x_8(t_f)$ and thus solve the problem stated in equation (61).

To minimize J as given in equation (90), with the proper selection of a $\bar{u}(t)$, consider the class C of all u(t) (where $t_o \leqq t \leqq t_f$) which satisfy the differential equations $\dot{X} = f(X,\bar{u})$ and the boundary conditions $G[X(t_f),t_f] = 0$. Let $\bar{u}^*(t)$ denote a particular control function in this class and $\delta u(t)$ a small variation in $\bar{u}^*(t)$ such that $\bar{u}(t)$ equal to $\bar{u}^*(t) + \delta\bar{u}(t)$ is in C. Then $\bar{u}^*(t)$ will be at least a local minimum of J if $\delta J = 0$ and $\delta^2 J > 0$. The computer program in Appendix I can be used to show that the class C is not empty and that variations in $\bar{u}^*(t)$ (produced by a $\delta\bar{u}(t)$) are also in C at least for some of the $\bar{u}^*(t)$ in C. Thus, the computer program in Appendix I can be used to show the existence of a nonempty subclass C^* contained in C such that every element u(t) in C^* is continuous with respect to t and has variations $\delta\bar{u}(t)$ which produce continuous variations in the trajectory given by X(t). This is the class of control functions to be considered here in the examination of δJ and $\delta^2 J$. Thus, for a particular $\bar{u}^*(t)$ in C^*, a small variation $\delta\bar{u}(t)$ will give

$$\delta J = \delta x_8(t_f) + p^T \left\{\frac{\partial G[X(t_f;t_f)]}{\partial X(t_f)}\right\}_* \delta X(t_f) + p^T \dot{G}^*[X(t_f);t_f]\, \delta t_f$$

$$+ \int_{t_o}^{t_f} \lambda^T \left\{\delta\dot{X}(t) - \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial X(t)}\right] \delta X(t) - \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial \bar{u}(t)}\right] \delta\bar{u}(t)\right\} dt. \qquad (91)$$

In equation (91) the term

$$\int_{t_o}^{t_f} \lambda^T \delta\dot{X}$$

can be integrated by parts to give

$$\int_{t_o}^{t_f} \lambda^T \delta\dot{X} = [\lambda^T \delta X]_{t_o}^{t_f} - \int_{t_o}^{t_f} \dot{\lambda}^T(t)\, \delta X(t). \qquad (92)$$

Substitution of equation (92) into equation (91) and noting that, since $X(t_o)$ is fixed, $\delta X(t_o)$ is zero gives

$$\delta J = \left\{[0,0,0,0,0,0,0,1] + p^T \left[\frac{\partial G[X(t_f),t_f]}{\partial X(t_f)}\right]_* + \lambda^T(t_f)\right\} \delta X(t_f)$$

$$+ \left\{p^T \dot{G}^*[X(t_f),t_f]\right\} \delta t_f$$

$$- \int_{t_o}^{t_f} \left[\left\{\dot{\lambda}^T(t) + \lambda^T(t) \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial X(t)}\right]_*\right\} \delta X(t)\right.$$

$$\left. + \lambda^T(t) \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial \bar{u}(t)}\right]_* \delta\bar{u}(t)\right] dt. \tag{93}$$

From equation (93), the list of necessary conditions are obtained by requiring that $\delta J = 0$. This gives

$$\text{(a)}\quad \lambda^T(t_f) = -[0,0,0,0,0,0,0,1] - p^T \left[\frac{\partial G[X(t_f),t_f]}{\partial X(t_f)}\right]_*$$

$$\text{(b)}\quad p^T \dot{G}^*[X(t_f),t_f] = 0 \tag{94}$$

$$\text{(c)}\quad \dot{\lambda}^T(t) = -\lambda^T(t) \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial X(t)}\right]_*$$

$$\text{(d)}\quad \lambda^T(t) \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial \bar{u}(t)}\right] = 0.$$

Thus, any candidate trajectory for the minimization of J must satisfy conditions (a), (b), (c), and (d) of equation (94). Conditions (a) and (b) are called transversality conditions, condition (c) is the defining differential equation for $\lambda(t)$, and condition (d) is used to define $\bar{u}(t)$. The next section of this report will explain more about how equation (94) is used to obtain candidate trajectories for the minimization of J.

At this point $\delta^2 J$ could be developed and examined to obtain the conditions which assure that $\delta^2 J > 0$, but this has already been done and explained very well in chapter 6 of reference 16. Thus, it will not be done again here, but the reader is urged to examine this material to understand the following sufficiency conditions which will be given. That is, $\delta^2 J > 0$, if

(a) $\dfrac{\partial^2\{\lambda^T f[X(t),\bar{u}(t)]\}}{\partial\bar{u}(t)\ \partial\bar{u}(t)}$ is negative definite, (95)

(b) the normality condition is satisfied on a trajectory which satisfies equations (94) and (a) above,

(c) no conjugate points occur on a trajectory which satisfies equations (94) and (a) above.

In equation (95), condition (a) is usually called the strengthened Legendre-Clebsch condition and can be combined with condition (d) of equation (94) to say that

$$H(t) = \lambda^T f[X(t),\bar{u}(t)] \tag{96}$$

must be a local maximum with respect to $\bar{u}(t)$ for $t_o \leqq t \leqq t_f$. An explanation of the meaning of conditions (b) and (c) of equation (95) will be deferred until section 6 on the solution of the boundary value problem resulting from an application of the other optimization conditions just developed. This completes the derivation and explanation of the optimization conditions which will be used in the next section.

5. Application of Optimization Equations

The complete set of differential equations in first order form to be used for this illustration is given by

$$\dot{x}_1 = x_4$$
$$\dot{x}_2 = x_5$$
$$\dot{x}_3 = x_6$$

$$\begin{bmatrix} \dot{x}_4 \\ \dot{x}_5 \\ \dot{x}_6 \end{bmatrix} = (F/x_7)\bar{u} - \frac{GM \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}}{(x_1^2 + x_2^2 + x_3^2)^{3/2}} + \bar{g}(x_1,x_2,x_3)$$

$$+ (\rho A_r/2x_7) \Big\{ C_{L_\alpha} [(\bar{V}_r \cdot \bar{V}_r)\bar{u} - (\bar{V}_r \cdot \bar{u}) \bar{V}_r]$$

$$- [(\bar{V}_r \cdot \bar{V}_r)^{1/2}(C_A + 2\eta\ C_{L_\alpha}^2) - 2\eta\ C_{L_\alpha}^2(\bar{V}_r \cdot \bar{u})]\ \bar{V}_r \Big\} \tag{97}$$

$$\dot{x}_7 = \dot{m}$$

$$\dot{x}_8 = k_1\dot{m} + k_2(e/\sqrt{\sigma})\rho^{1/2}|\bar{V}_r|^3$$

$$+ k_3(\rho A_r/2x_7)^2[(\bar{V}_r \cdot \bar{V}_r)^2(C_A^2 + 4\eta\ C_A\ C_{L_\alpha}^2 + 2C_{L_\alpha}^2)$$

$$- 2(\bar{V}_r \cdot \bar{u})(\bar{V}_r \cdot \bar{V}_r)^{3/2}(C_{L_\alpha}^2 + 2\eta\ C_A\ C_{L_\alpha}^2)].$$

With these differential equations the Hamiltonian H(t) defined by equation (96) can be written as

$$H(t) = \lambda_1 x_4 + \lambda_2 x_5 + \lambda_3 x_6 + [\lambda_4,\lambda_5,\lambda_6] \Bigg[(F/x_7)\bar{u} - \frac{GM \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}}{(x_1^2 + x_2^2 + x_3^2)^{3/2}}$$

$$+ \bar{g}(x_1,x_2,x_3) + (\rho A_r/2x_7) \Big\{ C_{L_\alpha}[(\bar{V}_r \cdot \bar{V}_r)\bar{u} - (\bar{V}_r \cdot \bar{u})\bar{V}_r] \tag{98}$$

$$-[(\bar{V}_r \cdot \bar{V}_r)^{1/2}(C_A + 2\eta\ C_{L_\alpha}^2) - 2\eta\ C_{L_\alpha}^2(\bar{V}_r \cdot \bar{u})]\ \bar{V}_r \Big\} \Bigg]$$

(equation (98) continued on next page)

$$+ \lambda_7 \dot{m}$$

$$+ \lambda_8 \Big\{ k_1 \dot{m} + k_2 (e/\sqrt{\sigma}) \rho^{1/2} |\bar{V}_r|^3 + k_3 (\rho A_r / 2x_7)^2 [(\bar{V}_r \cdot \bar{V}_r)^2 (C_A^2 + 4\eta \; C_A \; C_{L_\alpha}^2 + 2C_{L_\alpha}^2)$$

$$-2(\bar{V}_r \cdot \bar{u})(\bar{V}_r \cdot \bar{V}_r)^{3/2}(C_{L_\alpha}^2 + 2\eta \; C_A \; C_{L_\alpha}^2)] \Big\} .$$

To maximize H(t) with respect to $\bar{u}(t)$, only the terms involving $\bar{u}(t)$ need to be considered. That is,

$$H'(t) = [\lambda_4, \lambda_5, \lambda_6] \Big[(F/x_7)\bar{u} + (\rho A_r / 2x_7) \Big\{ C_{L_\alpha} [(\bar{V}_r \cdot \bar{V}_r)\bar{u} - (\bar{V}_r \cdot \bar{u})\bar{V}_r]$$

$$+ 2\eta \; C_{L_\alpha}^2 \; (\bar{V}_r \cdot \bar{u})\bar{V}_r \Big\} \Big] \qquad (99)$$

$$-\lambda_8 k_3 (\rho A_r / 2x_7)^2 [2(\bar{V}_r \cdot \bar{u})(\bar{V}_r \cdot \bar{V}_r)^{3/2}(C_{L_\alpha}^2 + 2\eta \; C_A \; C_{L_\alpha}^2)].$$

Then H(t) can be written as

$$H(t) = \bar{z}(t) + H'(t) = \bar{z}(t) + \bar{h}^T(t) \; \bar{u}(t), \qquad (100)$$

where

$$\bar{z}(t) = \lambda_1 x_4 + \lambda_2 x_5 + \lambda_3 x_6 + [\lambda_4, \lambda_5, \lambda_6] \left[- \frac{GM \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}}{(x_1^2 + x_2^2 + x_3^2)^{3/2}} + \bar{g}(x_1, x_2, x_3) \right.$$

$$\left. -(\rho A_r/2x_7)(C_A + 2\eta\, C_{L\alpha}^2)(\bar{V}_r \cdot \bar{V}_r)^{1/2} \right]$$

$$+\lambda_7 \dot{m} + \lambda_8 [k_1 \dot{m} + k_2 (e/\sqrt{\sigma}) \rho^{1/2} |\bar{V}_r|^3 \tag{101}$$

$$+ k_3 (\rho A_r/2x_7)^2 (\bar{V}_r \cdot \bar{V}_r)^2 (C_A^2 + 4\eta\, C_A\, C_{L\alpha}^2 + 2C_{L\alpha}^2]$$

and

$$\bar{h}^T = [\lambda_4, \lambda_5, \lambda_6] \left\{ \left[(F/x_7) + (\rho A_r/2x_7)\, C_{L\alpha} (\bar{V}_r \cdot \bar{V}_r) \right] \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \right.$$

$$\left. + (\rho A_r/2x_7)[(2\eta\, C_{L\alpha} - 1)\, C_{L\alpha} (\bar{V}_r\, \bar{V}_r^T)] \right\} \tag{102}$$

$$-\lambda_8 k_3 (\rho A_r/2x_7)^2\, 2 (\bar{V}_r \cdot \bar{V}_r)^{3/2} (C_{L\alpha}^2 + 2\eta\, C_A\, C_{L\alpha}^2)\, \bar{V}_r^T.$$

Since $\bar{u}(t)$ has been assumed to be a unit vector throughout this report, it can be written as

$$\bar{u}(t) = \frac{\bar{p}(t)}{|\bar{p}(t)|}, \tag{103}$$

so that $\bar{p}(t)$ becomes the actual control variable which is used to maximize $H(t)$. Applying condition (d) of equation (94) to equation (100) with

$$\bar{u} = \frac{\bar{p}(t)}{|\bar{p}(t)|}$$

gives

$$\frac{\partial H(t)}{\partial \bar{p}(t)} = \bar{h}^T \left\{ \frac{\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}}{|\bar{p}|} - \frac{\bar{p}\,\bar{p}^T}{|\bar{p}|^3} \right\} . \tag{104}$$

As can be seen in equation (104),

$$\frac{\partial H(t)}{\partial \bar{p}(t)} = 0,$$

when $\bar{p}(t) = \pm\bar{h}(t)$. Also, condition (a) of equation (95) applied to equation (100) will show that

$$\frac{\partial^2 H(t)}{\partial \bar{p}(t)\ \partial \bar{p}(t)}$$

will be a negative definite matrix only if $\bar{p}(t) = \bar{h}(t)$. Thus, the optimal control $\bar{u}(t)$ for $t_o \leqq t \leqq t_f$ is determined by

$$\bar{u}(t) = \frac{\bar{h}(t)}{|\bar{h}(t)|} , \tag{105}$$

where $\bar{h}(t)$ is given by equation (102). As can be seen in equation (102), the values of some of the multipliers $\lambda_1, \lambda_2, \ldots, \lambda_8$ are needed at each t to determine $\bar{u}(t)$. Thus, the differential equations for these multipliers given by condition (c) of equation (94) must be used. This equation can be written in the form

$$\dot{\lambda} = - \frac{\partial H}{\partial X} \tag{106}$$

where H is given in equation (98). To take the partial derivatives indicated in equation (106) and write explicit equations for the $\dot{\lambda}$'s is a rather lengthy task and thus will not be included here. The Fortran expressions for these differential equations can be found in the differential equation subroutine (DEQ) of the computer program listing in Appendix II. For a given set of initial conditions ($X(t_o)$, $\lambda(t_o)$, and t_o), this computer program integrates numerically the differential equations given by equations (97) and (106) and uses equation (105) to yield at each t (where $t_o \leqq t \leqq t_f$) a value for $X(t)$, $\lambda(t)$, and $\bar{u}(t)$. The numerical integration of the differential equations stops at a given time (t_f). At this time t_f conditions (a) and (b) of equation (94) can be applied to any of the three sets of boundary conditions (G's) described in section (3) to give the transversality conditions which complete the boundary value problem. As an example, equations (54), (55), (56), (57), and (58) are used, and the result is the equations listed in subroutine BOUND of Appendix II. As can be seen in this subroutine, or in conditions (a) and (b) of equation (94), values for the end condition multipliers (p's) must be given to evaluate the transversality conditions.

This completes the discussion of the application of the optimization conditions developed in the previous section. To reiterate the steps in the calculation of a candidate optimal trajectory, the following steps are listed and called equation (107):

(a) Values of $X(t_o)$ and t_o are given as fixed values.

(b) Values of $\lambda(t_o)$, p, and t_f must be known or determined.

(c) The differential equations

$$\dot{X}(t)\ f[X(t),\bar{u}(t)] \tag{107}$$

$$\dot{\lambda}(t) = \left[\frac{\partial f[X(t),\bar{u}(t)]}{\partial X(t)}\right]^T \lambda(t)$$

with

$$\bar{u}(t) = \frac{\bar{h}(t)}{|\bar{h}(t)|}$$

(where $\bar{h}(t)$ is defined by equation (102)) must be integrated numerically to t_f with the initial conditions given in conditions (a) and (b).

(equation (107) continued on next page)

(d) The known or determined values of $\lambda(t_o)$, p, and t_f as given in (b) must cause the following boundary condition to be satisfied:

$$G[X(t_f),t_f] = 0$$

$$\lambda^T(t_f) = -[0,0,0,0,0,0,0,1] - p^T \left[\frac{\partial G[X(t_f),t_f]}{\partial X(t_f)}\right]$$

$$p^T \dot{G}[X(t_f),t_f] = 0.$$

The determination of $\lambda(t_o)$, p, and t_f to satisfy the boundary conditions of condition (d) subject to the initial conditions (condition (a)) and the differential equation constraints of condition (c) is the boundary value problem to be solved. Methods for its solution are discussed below.

6. Solution of Boundary Value Problem

As can be seen in equation (107), the values of $\lambda(t_o)$ are the only variables that can be used to change the values of X(t) and $\lambda(t)$, because, by condition (a), $X(t_o)$ and t_o are fixed, and, by condition (c), the differential equations and optimal u(t) relation must hold. Thus, the boundary conditions given in (d) of equation (107) can be written as

$$F[\lambda(t_o),p,t_f] = 0, \tag{108}$$

where the dimension of F is equal to the dimension of G, plus the dimension of λ, plus one. Actually F has the form

$$F[X(t_f),\lambda(t_f),p,t_f] = \begin{bmatrix} G[X(t_f),t_f] \\ \lambda^T(t_f)+[0,0,0,0,0,0,0,1]+p^T\dfrac{\partial G[X(t_f),t_f]}{\partial X(t_f)} \\ p^T \dot{G}[X(t_f),t_f] \end{bmatrix}; \tag{109}$$

but $X(t_f)$ and $\lambda(t_f)$ appearing in the right-hand side of the above equation depend implicitly on $\lambda(t_o)$ which leads to the functional form given in equation (108). Now for a guessed set of $\lambda(t_o)$, p, and t_f (denoted by λ_o^*, p^*, t_f^*), a Taylor series expansion can be written:

$$F[\lambda(t_o),p,t_f] = F[\lambda_o^*,p^*,t_f^*] + \left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial \lambda(t_o),p,t_f}\right]_{\lambda_o^*,p^*,t_f^*} \begin{bmatrix} \Delta\lambda(t_o) \\ \Delta p \\ \Delta t_f \end{bmatrix}_* + \ldots \quad (110)$$

The higher order terms in the above expression can be neglected, a fudge factor K (where $0 < K \leqq 1$) can be chosen, and the above equation solved to yield the corrections ($\Delta\lambda(t_o)$, p, and Δt_f) which, when added to λ_o^*, p^* and t_f^* and used to generate a new trajectory, will produce a decrease in the error term $F^T F$. That is,

$$\begin{bmatrix} \Delta\lambda(t_o) \\ \Delta p \\ \Delta t_f \end{bmatrix} = -K \left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial \lambda(t_o),p,t_f}\right]^{-1}_{\lambda_o^*,p^*,t_f^*} F[\lambda_o^*,p^*,t_f]. \quad (111)$$

It can be seen that, as long as the matrix which must be inverted in the above equation is nonsingular, a value for K can be chosen as close to zero as necessary to give a set of corrections ($\Delta\lambda(t_o)$, Δp, and Δt_f) which, when used to generate a new trajectory, will make the square root of the error term ($\sqrt{F^T F}$) less than or equal to $1 - K$ times the square root of the original error ($\sqrt{F^T(\lambda_o^*,p^*,t_f^*) F(\lambda_o^*,p^*,t_f^*)}$). Thus, if equation (111) is used iteratively and the matrix inverse continues to exist, a set of values for $\lambda(t_o)$, p, and t_f can be found which will make $F[\lambda(t_o),p,t_f] = 0$.

To obtain numerical values for the matrices

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial \lambda(t_o)}\right]_{\lambda_o^*,p^*,t_f^*} \text{ and } \left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial t_f}\right]_{\lambda_o^*,p^*,t_f^*},$$

the chain rule is used on the form of F given in equation (109) and results in the following equation:

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial\lambda(t_o)}\right]_{\lambda_o^*,p^*,t_f^*} = \left[\frac{\partial F[X(t_f),\lambda(t_f),p,t_f]}{\partial X(t_f)}\right]_* \left(\frac{\partial X(t_f)}{\partial\lambda(t_o)}\right)_* + \left[\frac{\partial F[X(t_f),\lambda(t_f),p,t_f]}{\partial\lambda(t_f)}\right]_* \left(\frac{\partial\lambda(t_f)}{\partial\lambda(t_o)}\right)_* \tag{112}$$

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial t_f}\right]_{\lambda_o^*,p^*,t_f^*} = \dot{F}[\lambda(t_o),p,t_f]_{\lambda_o^*,p^*,t_f^*} \; . \tag{113}$$

The matrix

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial p}\right]_{\lambda_o^*,p^*,t_f}$$

is obtained by explicit partial differentiation of the expression for $F[\lambda(t_o),p,t_f]$ given by equation (109). Thus, the expression for

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial\lambda(t_o),p,t_f}\right]_{\lambda_o^*,p^*,t_f^*}$$

can be written by combining the expressions in equations (112) and (113) with the expressions for

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial p}\right]_{\lambda_o^*,p^*,t_f} .$$

In equation (112) the matrices

$$\left[\frac{\partial F[X(t_f),\lambda(t_f),p,t_f]}{\partial X(t_f)}\right]_* \quad \text{and} \quad \left[\frac{\partial F[X(t_f),\lambda(t_f),p,t_f]}{\partial \lambda(t_f)}\right]_*$$

can be obtained by explicit partial differentiation, but the matrices

$$\left(\frac{\partial X(t_f)}{\partial \lambda(t_o)}\right)_* \quad \text{and} \quad \left(\frac{\partial \lambda(t_f)}{\partial \lambda(t_o)}\right)_*$$

must be obtained from the numerical integration of the following set of matrix differential equations:

$$\text{(a)} \quad \frac{d}{dt}\left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right) = \frac{\partial \dot{X}(t)}{\partial \lambda(t_o)} = \left[\frac{\partial f(X(t),\bar{u}(t))}{\partial X(t)}\right]\left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right) + \left[\frac{\partial f(X(t),\bar{u}(t))}{\partial \bar{u}(t)}\right]\left(\frac{\partial \bar{u}(t)}{\partial \lambda(t_o)}\right).$$

$$\text{(b)} \quad \frac{d}{dt}\left(\frac{\partial \lambda(t)}{\partial \lambda(t_o)}\right) = \frac{\partial \dot{\lambda}(t)}{\partial \lambda(t_o)} = \left[\frac{\partial^2 \lambda^T f(X(t),\bar{u}(t))}{\partial X(t)\ \partial X(t)}\right]\left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right) + \left[\frac{\partial f(X(t),\bar{u}(t))}{\partial X(t)}\right]^T\left(\frac{\partial \lambda(t)}{\partial \lambda(t_o)}\right) + \left[\frac{\partial^2 \lambda^T f(X(t),\bar{u}(t))}{\partial X\ \partial \bar{u}(t)}\right]\left(\frac{\partial \bar{u}(t)}{\partial \lambda(t_o)}\right)$$

$$\text{(c)} \quad [0] = \left[\frac{\partial^2 \lambda^T f(X(t),\bar{u}(t))}{\partial \bar{u}(t)\ \partial X(t)}\right]\left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right) + \left[\frac{\partial f(X(t),\bar{u}(t))}{\partial \bar{u}(t)}\right]^T\left(\frac{\partial \lambda(t)}{\partial \lambda(t_o)}\right) + \left[\frac{\partial^2 \lambda^T f(X(t),\bar{u}(t))}{\partial \bar{u}(t)\ \partial \bar{u}(t)}\right]\frac{\partial \bar{u}(t)}{\partial \lambda(t_o)} \quad . \tag{114}$$

Note that condition (c) above allows

$$\frac{\partial \bar{u}(t)}{\partial \lambda(t_o)}$$

to be determined at each instant of time because the strengthened Legendre Clebsch condition requires the matrix

$$\left[\frac{\partial^2 \lambda^T f(X(t),\bar{u}(t))}{\partial \bar{u}(t)\ \partial \bar{u}(t)}\right]$$

to be negative definite. Thus, the above system can be integrated numerically along with the system given in equation (107), using the guessed values $(\lambda_o^*, p^*, t_f^*)$ and the initial conditions

$$\frac{\partial X(t_o)}{\partial \lambda(t_o)} = [0] \quad \text{and} \quad \frac{\partial \lambda(t_o)}{\partial \lambda(t_o)} = [I].$$

This completes the explanation of Newton's method for the solution of the boundary value problem.

When a solution of the boundary value problem by Newton's method is obtained as discussed previously, the sufficiency conditions given by conditions (b) and (c) of equation (95) can be checked very easily. The normality condition will be satisfied if the matrix

$$\left[\frac{\partial F[\lambda(t_o),p,t_f]}{\partial \lambda(t_o),p,t_f}\right]$$

is positive definite when evaluated for values of $\lambda(t_o)$,p, and t_f which satisfy equation (107). Reference 17 gives a very good explanation and a computer program listing for determining the definiteness of a matrix. The proof of this normality condition's contribution to the sufficiency conditions requires a detailed and difficult examination of the second variation as shown in reference 16, and will not be attempted here.

The easiest way to check a trajectory satisfying equation (107) for conjugate points is to generate the feedback guidance matrix. To do this the differential equation for the transition matrices

$$\left(\frac{\partial X(t)}{\partial X(t_o)}\right) \quad \text{and} \quad \left(\frac{\partial \lambda(t)}{\partial X(t_o)}\right)$$

are needed. These are obtained as equations (114) were obtained. That is,

$$\text{(a)} \quad \frac{d}{dt}\left(\frac{\partial X(t)}{\partial X(t_o)}\right) = \frac{\partial \dot{X}(t)}{\partial X(t_o)} = \text{same as (114) with } \lambda(t_o) \text{ replaced by } X(t_o).$$

$$\text{(b)} \quad \frac{d}{dt}\left(\frac{\partial \lambda(t)}{\partial X(t_o)}\right) = \frac{\partial \dot{\lambda}(t)}{\partial X(t_o)} = \text{same as (114) with } \lambda(t_o) \text{ replaced by } X(t_o). \qquad (115)$$

$$\text{(c)} \quad [0] = \text{same as (114) with } \lambda(t_o) \text{ replaced by } X(t_o).$$

The initial conditions for these equations are

$$\left(\frac{\partial X(t_o)}{\partial X(t_o)}\right) = I \quad \text{and} \quad \left(\frac{\partial \lambda(t_o)}{\partial X(t_o)}\right) = [0].$$

Thus, for values of $\lambda(t_o)$, p, and t_f which satisfy equations (107), the transition matrices

$$\left(\frac{\partial X(t)}{\partial X(t_o)}\right), \quad \left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right), \quad \left(\frac{\partial \lambda(t)}{\partial X(t_o)}\right), \quad \text{and} \quad \left(\frac{\partial \lambda(t)}{\partial \lambda(t_o)}\right)$$

where ($t_o \leqq t \leqq t_f$) can be obtained by numerically integrating equations (114) and (115). Also needed are the vectors

$$\frac{\partial X(t)}{\partial t_o} \quad \text{and} \quad \frac{\partial \lambda(t)}{\partial t_o}$$

which are defined by differential equations similar to equations (114) and (115). That is

$$\text{(a)} \quad \frac{d}{dt}\left(\frac{\partial X(t)}{\partial t_o}\right) = \frac{\partial \dot{X}(t)}{\partial t_o} = \text{same as (114) with } \lambda(t_o) \text{ replaced by } t_o.$$

$$\text{(b)} \quad \frac{d}{dt}\left(\frac{\partial \lambda(t)}{\partial t_o}\right) = \frac{\partial \dot{\lambda}(t)}{\partial t_o} = \text{same as (114) with } \lambda(t_o) \text{ replaced by } t_o. \tag{116}$$

$$\text{(c)} \quad [0] = \text{same as (114) with } \lambda(t_o) \text{ replaced by } t_o.$$

Note that $\partial X(t_o)/\partial t_o = \dot{X}_o$ and $\partial\lambda(t_o)/\partial t_o = \dot{\lambda}_o$.

With all of these transition matrices, a set of trajectories about the trajectory-satisfying equation (107) can be represented by

$$\Delta X(t) = \left(\frac{\partial X(t)}{\partial X(t_o)}\right) \Delta X(t_o) + \left(\frac{\partial X(t)}{\partial \lambda(t_o)}\right) \Delta\lambda(t_o) + \left(\frac{\partial X(t)}{\partial t_o}\right) \Delta t_o. \tag{117}$$

$$\Delta\lambda(t) = \left(\frac{\partial \lambda(t)}{\partial X(t_o)}\right) \Delta X(t_o) + \left(\frac{\partial \lambda(t)}{\partial \lambda(t_o)}\right) \Delta\lambda(t_o) + \left(\frac{\partial \lambda(t)}{\partial t_o}\right) \Delta t_o. \tag{118}$$

Equations (117) and (118) state that small changes in the initial conditions which satisfy equations (107) are mapped by the transition matrices into small changes ΔX and $\Delta\lambda$ at any time t where $t_o \leqq t \leqq t_f$. In the set of trajectories defined by equations (117) and (118), a subset can be defined (all of which satisfy equation (107)) by requiring the $\Delta X(t_f)$ and $\Delta\lambda(t_f)$ produced by $\Delta X(t_o)$, $\Delta\lambda(t_o)$, and Δt_o to satisfy condition (d) of equation (107). Thus, ΔF produced by substituting $\Delta X(t_f)$ and $\Delta\lambda(t_f)$ into equation (109) must be zero. That is,

$$\Delta F = (\partial F/\partial X_f)\ \Delta X_f + (\partial F/\partial \lambda_f)\ \Delta\lambda_f + (\partial F/\partial p)\ \Delta p + \dot{F}\ \Delta t_f = 0. \tag{119}$$

Substituting equations (117) and (118) (evaluated at t_f) into (119) gives

$$\left(\frac{\partial F}{\partial X_f}\right)\left[\left(\frac{\partial X_f}{\partial X_o}\right)\Delta X_o + \left(\frac{\partial X_f}{\partial \lambda_o}\right)\Delta\lambda_o + \left(\frac{\partial X_f}{\partial t_o}\right)\Delta t_o\right] + \left(\frac{\partial F}{\partial \lambda_f}\right)\left[\left(\frac{\partial \lambda_f}{\partial X_o}\right)\Delta X_o\right.$$

$$\left. + \left(\frac{\partial \lambda_f}{\partial \lambda_o}\right)\Delta\lambda_o + \left(\frac{\partial \lambda_f}{\partial t_o}\right)\Delta t_o\right] + \left(\frac{\partial F}{\partial p}\right)\Delta p + \dot{F}\,\Delta t_f = 0. \tag{120}$$

Equation (120) can be written as

$$[A]\begin{bmatrix}\Delta\lambda_o\\ \Delta p\\ \Delta t_f\end{bmatrix} + B\begin{bmatrix}\Delta x_o\\ \Delta t_o\end{bmatrix} = 0, \tag{121}$$

where

$$A = \left\{\left[\frac{\partial F}{\partial X_f}\left(\frac{\partial X_f}{\partial \lambda_o}\right) + \left(\frac{\partial F}{\partial \lambda_f}\right)\left(\frac{\partial \lambda_f}{\partial \lambda_o}\right)\right],\ \frac{\partial F}{\partial p},\ \dot{F}\right\}$$

$$B = \left\{\left[\frac{\partial F}{\partial X_f}\left(\frac{\partial X_f}{\partial X_o}\right) + \left(\frac{\partial F}{\partial \lambda_f}\right)\left(\frac{\partial \lambda_f}{\partial X_o}\right)\right],\ \left[\frac{\partial F}{\partial X_f}\left(\frac{\partial X_f}{\partial t_o}\right) + \frac{\partial F}{\partial \lambda_f}\left(\frac{\partial \lambda_f}{\partial t_o}\right)\right]\right\}.$$

Note that A is the same matrix which appears in equations (110) and (111) and must be positive definite from the normality condition. Thus, A is nonsingular so that

$$\begin{bmatrix}\Delta\lambda_o\\ \Delta p\\ \Delta t_f\end{bmatrix} = A^{-1}\,B\begin{bmatrix}\Delta X_o\\ \Delta t_o\end{bmatrix}. \tag{122}$$

Equation (122) can be partitioned to give

$$
\begin{aligned}
&(a) \quad \Delta\lambda_o = D_1\,\Delta X_o + D_2\,\Delta t_o \\
&(b) \quad \Delta p = D_3\,\Delta X_o + D_4\,\Delta t_o \\
&(c) \quad \Delta t_f = D_5\,\Delta X_o + D_6\,\Delta t_o
\end{aligned}
\tag{123}
$$

where

$$
A^{-1}\,B = \begin{bmatrix} D_1 & D_2 \\ D_3 & D_4 \\ D_5 & D_6 \end{bmatrix}.
$$

Now either Δt_f or Δt_o can be chosen to be zero. Usually, for purposes of comparison, it is better to choose Δt_f to be zero. Then, from equation (123) part (c), it can be seen that

$$
\Delta t_o = -(1/D_6)\,D_5\,\Delta X_o. \tag{124}
$$

Equation (124) can be substituted into parts (a) and (b) of equation (123) to give

$$
\begin{aligned}
&(a) \quad \Delta\lambda_o = [D_1 - (1/D_6)D_2D_5]\Delta X_o = D_7\,\Delta X_o \\
&(b) \quad \Delta p = [D_3 - (1/D_6)D_4D_5]\Delta X_o = D_8\,\Delta X_o.
\end{aligned}
\tag{125}
$$

Now part (a) of equation (125) and equation (124) can be substituted into equations (117). That is,

$$
\Delta X(t) = \left(\frac{\partial X(t)}{\partial X_o}\right)\Delta X(t_o) + \left(\frac{\partial X(t)}{\partial \lambda_o}\right)[D_7\,\Delta X_o] + \left(\frac{\partial X(t)}{\partial t_o}\right)[-(1/D_6)\,D_5\,\Delta X_o] \tag{126}
$$

$$
\Delta\lambda(t) = \left(\frac{\partial \lambda(t)}{\partial X_o}\right)\Delta X(t_o) + \left(\frac{\partial \lambda(t)}{\partial \lambda_o}\right)[D_7\,\Delta X_o] + \left(\frac{\partial \lambda(t)}{\partial t_o}\right)[-(1/D_6)\,D_5\,\Delta X_o]. \tag{127}
$$

Equations (126) and (127) can be rewritten to give

$$\Delta X(t) = P(t)\ \Delta X(t_o) \tag{128}$$

$$\Delta\lambda(t) = Q(t)\ \Delta X(t_o), \tag{129}$$

where

$$P(t) = \left(\frac{\partial X(t)}{\partial X_o}\right) + \left(\frac{\partial X(t)}{\partial \lambda_o}\right) D_7 - \left(\frac{\partial X(t)}{\partial t_o}\right) (1/D_6)\ D_5$$

$$Q(t) = \left(\frac{\partial \lambda(t)}{\partial X_o}\right) + \left(\frac{\partial \lambda(t)}{\partial \lambda_o}\right) D_7 - \left(\frac{\partial \lambda(t)}{\partial t_o}\right) (1/D_6)\ D_5.$$

The matrix P(t) which appears in equation (128) is the matrix which must be nonsingular for all t (where $t_o \leqq t < t_f$) in order to state that no conjugate points exist on the trajectory satisfying equation (107). Thus, this matrix can be computed at each time t and inverted if it is nonsingular (i.e., its determinant is nonzero). If there are no conjugate points on an optimal trajectory, then linear feedback guidance can be accomplished by solving equations (128) for ΔX_o and substituting the result into equation (129). That is,

$$\Delta\lambda(t) = [Q(t)\ P^{-1}(t)]\ \Delta X(t). \tag{130}$$

Also, the solution of equation (128) for $\Delta X(t_o)$ must be substituted into equations (124) and part (b) of (125) to give

$$\Delta p = [D_8\ P^{-1}(t)]\ \Delta X(t) \tag{131}$$

$$\Delta t_o = [-(1/D_6)\ D_5\ P^{-1}(t)]\ \Delta X(t). \tag{132}$$

Then equations (130), (131), and (132) are the linear feedback guidance equations. That is, for a measured or given value of $\Delta X(t)$ (where $t_o \leqq t < t_f$), $\Delta\lambda(t)$, Δp, and Δt_o can be computed. Note that, with values for $\Delta X(t)$ and $\Delta\lambda(t)$, equation (105) can be used to compute $\bar{u}(t)$ directly, or if equation (105) is linearized, then $\Delta\bar{u}(t)$ can be computed, which is the usual form of feedback guidance. In the present MASCOT implementations, equations (130), (131), and (132) are not used, but they are now being examined for use in improving the computational speed of the atmospheric portion of MASCOT.

The preceding discussion completes the solution of the boundary value problem by Newton's method and shows how the complete set of sufficient conditions can also be checked with little additional effort. As can be seen, this approach differs from the "sweep" method explained in chapter 6 of reference 16. After examining the computational aspects and flexibility of both procedures, Newton's method (as explained here) has been selected as the most favorable approach for solving the boundary value problem and also for performing the sufficient condition checks. More support for this viewpoint can be found in some of the statements and numerical results of reference 15.

A considerable amount of effort is involved in establishing a computer program to perform a solution of the boundary value problem and make the sufficiency condition checks by Newton's method. Thus, simpler methods are usually used for problems which are in an early and formulative stage of development. One of the most effective examples of these simpler approaches for solving the boundary value problem is a modification of the secant method, which will be explained next.

As before, the boundary values as given by equation (108) must be satisfied. To simplify the notation, a new vector will be defined as

$$X = \begin{bmatrix} \lambda(t_o) \\ p \\ t_f \end{bmatrix}. \tag{133}$$

Note that this X as defined above has no relation to any previous definition of X. Then the solution of the boundary value problem is a vector $X = (x_1, x_2, \ldots, x_n)$ that will satisfy equation (108) written in the following form:

$$F(X) = \begin{matrix} f_1(x_1, x_2, \ldots, x_n) = 0 \\ f_2(x_1, x_2, \ldots, x_n) = 0 \\ \vdots \\ f_n(x_1, x_2, \ldots, x_n) = 0. \end{matrix} \tag{134}$$

In the explanation to follow, for a given set of values of the X's, the f's can be evaluated only by numerically integrating the differential equations with their given initial conditions and the given set of values of the X's completing the initial conditions. If a coasting phase occurs at any point during this numerical integration procedure, very rapid closed-form solutions are available [8, 9, 10, 11] to obtain the trajectory across this coasting arc without the need for time-consuming numerical integration. Then after the integration is complete, the f's can be evaluated. There are many techniques available for numerically integrating ordinary nonlinear differential equations (such as Runge-Kutta and Shanks formulas), but the most effective yet developed are given in references 18 and 19. Thus, with a given numerical integration technique, the functions f can be evaluated for each set of X's. As can be seen in the explanation to follow, the transition matrix differential equations (113) are not needed for this approach, which accounts for most of its simplicity.

This method begins with a reasonable but nonetheless arbitrary first choice of $x_1, x_2, \ldots, x_n$. A variation in each of the x's must be made. One possibility is to define

$$y_i = k_i x_i, \quad i = 1, \ldots, n \quad \text{and} \quad 0 \leqq k_i < 1 \tag{135}$$

and then set up the matrix [X]:

$$[X] = \begin{bmatrix} x_1 & x_2 & \cdots & x_n \\ y_1 & x_2 & \cdots & x_n \\ x_1 & y_2 & \cdots & x_n \\ \vdots & & & \\ x_1 & x_2 & \cdots & y_n \end{bmatrix} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & & & \\ x_{j1} & x_{j2} & \cdots & x_{jn} \end{bmatrix}. \tag{136}$$

Note that $j = n + 1$, and hence [X] is an $n + 1 \times n$ matrix.

Now, for each of the j rows of [X], X_i, evaluate the n f's. This results in a $j \times n$ matrix of f values. Set

$$[F] = \begin{bmatrix} f_1(X_1) & f_2(X_1) & \cdots & f_n(X_1) \\ f_1(X_2) & f_2(X_2) & \cdots & f_n(X_2) \\ \vdots & & & \\ f_1(X_j) & f_2(X_j) & \cdots & f_n(X_j) \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ & & & \\ f_{j1} & f_{j2} & \cdots & f_{jn} \end{bmatrix}. \tag{137}$$

In order to make [X] square (for reasons to be seen), make U the jth column of [X], where U is a column vector of j 1's, and define

$$[X] = \left[[X] \,\vdots\, U \right] = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} & 1 \\ x_{21} & x_{22} & \cdots & x_{2n} & 1 \\ \vdots & & & & \\ x_{j1} & x_{j2} & \cdots & x_{jn} & 1 \end{bmatrix}. \tag{138}$$

The next step in the procedure is to try to replace the row of [X] which resulted in the "worst" row of [F] (for example, the one having the maximum sum of the squares of the f_i, assuming proper normalization) by an X_{new} which results in an improved F. To do this, first note that a matrix [A] exists which has the property

$$[X][A] = [F], \tag{139}$$

and set

$$\left[X_{new} \,\vdots\, 1 \right][A] = F_{new}, \tag{140}$$

where X_{new} is a vector of the unknowns that should produce F_{new} and

$$F_{new} = C \cdot F_{old}, \quad 0 \leq C < 1 \tag{141}$$

and F_{old} is a row of [F] selected by virtue of its having the minimum sum of squares of the f_i. Note here that an X_{new} is desired which will lead to the "worst" row of F being replaced by one better than the "best" row of [F].

From (139),

$$[A] = [X]^{-1} [F], \tag{142}$$

and therefore (140) becomes

$$\left[X_{new} \,\vdots\, 1\right] [X]^{-1} [F] = F_{new}. \tag{143}$$

The solution for X_{new} proceeds as follows: Let

$$P^T = \left[X_{new} \,\vdots\, 1\right] [X]^{-1}, \tag{144}$$

where P is a j = n + 1 column vector. Then, using (144) in (143),

$$P^T[F] = F_{new} \quad \text{or} \quad [F]^T P = F^T_{new}. \tag{145}$$

Equations (145) are a set of n equations in j = n + 1 unknowns. However, from (144)

$$P^T[X] = \left[X_{new} \,\vdots\, 1\right] \quad \text{or} \quad [X]^T P = \begin{bmatrix} X^T_{new} \\ \hline 1 \end{bmatrix}. \tag{146}$$

Looking back at (138), note that $[X]^T$ has a bottom row of 1's, so that from (146), the following equation is obtained:

$$\sum_{i=1}^{j} P_i = 1. \tag{147}$$

This provides the jth equation needed to solve for the j unknowns above, as a system of simultaneous equations; i.e.,

$$[F]^T P = F^T_{new} \quad \text{and} \quad \sum_{i=1}^{j} P_i = 1 \tag{148}$$

are sufficient to obtain the j components of P.

This may also be written

$$\begin{bmatrix} F^T \\ \hdashline U^T \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_j \end{bmatrix} = \begin{bmatrix} F^T_{new} \\ \hdashline 1 \end{bmatrix} , \tag{149}$$

where U^T is a row of vector of j 1's.

The nonexistence of the inverse in (149) does not necessarily imply that the solution as a set of simultaneous equations does not exist, since the rank of the augmented matrix may be the same as the original one.

Once P is known, (147) gives X_{new}, since from (146)

$$[X]^T P = \begin{bmatrix} X^T_{new} \\ \hdashline 1 \end{bmatrix} . \tag{150}$$

This completes the discussion of the methods for solving the boundary value problem as given by equation (107). Several computer programs are available from the authors for solving the boundary value problem as given by equation (107). The listing of these computer programs are not included here because they are almost constantly being modified. Some preliminary results on space shuttle type vehicles have been obtained with the secant method (as explained here) and they are discussed in the Results section of this report. In reference 9, a computer program listing for a Newton's method solution of the Vacuum Trajectory Optimization problem is given. This program, called SWITCH, is available for use. In reference 8 some examples of the application of feedback guidance associated with Newton's method are given to show that feedback guidance matrices can be used for guidance and to check for the satisfaction of sufficiency conditions.

D. Conclusion of Mathematical Development

The mathematical development presented here for the MASCOT concept has of necessity been rather complicated. It is hoped that the reader is able to spend enough time studying the ideas presented so that he can understand them. This understanding of the general idea and the numerical results presented in the next section should convince most readers that the MASCOT concept as outlined here can be developed into an efficient, effective, and flexible guidance scheme for vehicles of the space shuttle type.

To reiterate and emphasize the key mathematical ideas discussed in this section which now make the onboard solution of the trajectory optimization problem (MASCOT) an attractive guidance scheme for space shuttle type vehicles, the following statements are listed:

First, the unified set of guidance equations and performance criteria will reduce the computer storage requirements for onboard implementation.

Second, the techniques for obtaining a solution of the boundary-value problem have been carefully studied and the so-called "shooting method" selected because of its speed and reliability. The shooting method algorithm is easy to program and is compact in size. The alternatives to the shooting method, such as steepest descent and quasi-linearization, must use stored time functions so that the size and complexity of the algorithms are increased.

Third, the development of the Fehlberg-type, Runge-Kutta numerical integration routines has significantly speeded up the numerical integration process. Further improvements to numerical integration techniques, such as the variation of parameters method of reference 20, can also be easily incorporated into the technique.

Fourth, since the boundary value problem can be considered as the problem of finding the solution to a system of simultaneous nonlinear equations, any improvements in these techniques which may occur in the future can again be incorporated easily into the technique.

Finally, the many improvements in computational hardware which have resulted in flight-worthy high-speed digital computers also adds to the attractiveness of the concept.

VII. NUMERICAL RESULTS

The resources for developing the OPGUID, SWITCH, and MASCOT algorithms have been limited. To obtain the maximum benefit from available funds and manpower, the effort has been concentrated in the area of problem formulation and improving the numerical techniques needed to solve the resulting boundary value problem rather than in performing detailed guidance simulations. Therefore, only limited results are available at this time. These will be discussed in the following paragraphs. The results of the detailed guidance simulation studies now being performed will be published at a later date.

A. OPGUID

The feasibility of solving the trajectory optimization problem in real time for onboard guidance was demonstrated in 1966 by Brown and Johnson [7] for an ascent to orbit mission (vacuum). Since these results can be found in the literature, they will only be summarized here.

The mission selected was ascent to a circular orbit with the S-IVB stage of the AS-204 vehicle. To evaluate the stability and optimality characteristics of the real-time optimal guidance scheme (OPGUID) under realistic conditions, a number of simulations were made and compared to results obtained, making the same simulations with the IGM equations. These included thrust and mass rate variations of ±5 percent and engine mixture ratio shift times of ±30 seconds from nominal. OPGUID used a variable cycle time ranging from 10 seconds initially to one second near the end. In all cases, the OPGUID scheme delivered more payload to orbit than the IGM scheme; however, these differences in all cases were small (2 to 70 kg), and the main point to be made from this study was that it demonstrated the feasibility of using OPGUID as an onboard guidance scheme. The computer speed and storage requirements for OPGUID can be met by the Saturn Launch Vehicle Digital Computer; thus, OPGUID could serve as an onboard guidance scheme for the Saturn V vehicle.

B. SWITCH

Recently, under NASA contract NAS8-21315, a sophisticated multi-burn optimization program, SWITCH [9], was developed which appears to have the speed and reliability needed for onboard guidance signal generations. The convergence properties of the SWITCH program were demonstrated by applying it to a multi-burn rendezvous mission. The target vehicle was located in a synchronous orbit with an altitude of 19,300 n.mi., and the pursuit vehicle was assumed to be in a 100 n.mi. circular orbit. The number of separate burn arcs was set at two (coast-burn-coast-burn) and the initial values of the co-state vector and the lengths of arcs were chosen to correspond to values obtained in a previous study. The initial values of independent variables were extremely close to the required values, and the SWITCH algorithm converged to the solution in one iteration. Since the initialization was essentially equal to the converged solutions, the convergence properties were evaluated by deforming the final orbit into an ellipse with the eccentricity magnitude varying from 0 to .5. The pursuit vehicle orbit, vehicle parameters, and initial estimates of co-state and arc times were fixed. The results are taken from reference 9 and are shown in Table 1. Notice that the worst case required only five iterations.

Table 1. Low Altitude to Coplanar Synchronous Rendezvous Mission

Target Orbit Eccentricity	1st Coast Arc (sec)	1st Burn Arc (sec)	2nd Coast Arc (sec)	2nd Burn Arc (sec)	Number of Iterations to Converge
0	399.83	255.82	18,729.51	129.11	1
.05	401.16	253.47	17,572.70	134.87	3
.1	402.48	251.14	16,541.83	140.57	3
.5	412.62	232.95	11,155.52	184.04	5
First iteration specifications for all cases	400	255.82	18,727.46	129.11	

Although the SWITCH algorithm has not been subjected to the stringent guidance simulations that are necessary to prove the flight worthiness of an onboard guidance scheme, it is felt that the excellent convergence properties of the SWITCH algorithm and the speed per iteration (one quarter second per iteration on a CDC 6600 computer) of the algorithm make it applicable for onboard guidance. The computer requirements for SWITCH are greater in terms of speed and storage than for OPGUID; however, they are not considered to be excessive. It is estimated that the SWITCH algorithm would require 7,000 storage locations for onboard implementation.

Assuming a state-of-the-art type of flight computer, the guidance cycle time (time for complete converged computation of new optimal guidance command time history) would be approximately 2 seconds.

C. MASCOT

The MASCOT guidance algorithm is an extension of the SWITCH and OPGUID formulations. It can be reduced to the SWITCH algorithm by eliminating the aerodynamic forces, and it can be reduced to the OPGUID algorithm by eliminating both the aerodynamic forces and the multi-burn logic. Therefore, the results presented for OPGUID for ascent to orbit (vacuum), and the orbit transfer and rendezvous results obtained with SWITCH are indicative of MASCOT for these types of missions. Results for atmospheric flight are preliminary and it remains to be shown that the MASCOT scheme possesses the speed and reliability for onboard guidance for atmospheric flight. As mentioned earlier, studies to determine the properties of MASCOT are underway and will be documented as soon as results are available.

The need for a shuttle guidance scheme with the sophistication of MASCOT is demonstrated by the performance results presented in Table 2.

TABLE 2

Case	Time of Max Q (sec)	Max Q (kg/m^2)	Angle of Attack at Max Q (deg)	Cutoff Weight (kg)	Δ Cutoff Weight (kg)
A IGM from Staging*	63	2310	0	122,259	-
B Optimal from 12 sec.	46	4087	8.0	123,380	1121
C Optimal from 70 sec.	63	2310	0	122,519	260
D IGM from 70 sec.	63	2310	0	119,706	-2553

*All trajectories are zero angle of attack until initiation of IGM on optimal shaping.

The data shown in Table 2 indicate the effects on payload of optimally shaping the space shuttle trajectory during the atmospheric region of flight. Case A represents trajectory and vehicle data for a shuttle vehicle that was flown through the atmospheric portion of flight with a zero angle of attack, and the IGM steering logic was used to shape the remaining portion of the trajectory. Case B represents data obtained by shaping the trajectory with the MASCOT logic from 12 sec after lift-off through orbit insertion. This gain in payload of 1121 kg may not be fully obtainable because shaping the trajectory during the atmospheric portion of flight will result in increased structural loads. Case C represents data that were obtained by shaping the trajectory with the MASCOT logic from 70 seconds (7 sec after maximum dynamic pressure) after lift-off through orbit insertion. This increase in cutoff weight of 260 kg is potential payload since the maximum dynamic pressure is the same as in case A. More important than the 260 kg increase in payload is the fact that using MASCOT to guide the vehicle from 70 sec (or earlier) provides closed-loop guidance early in flight, and thus the effects on payload of perturbations (winds, thrust variations, etc.) during the first 70 seconds of flight can be minimized. The results of using IGM for closed-loop guidance at 70 sec is shown in Table 2 as case D. This loss in payload of 2553 kg is due to the following: (1) atmospheric forces are not modeled in IGM, and (2) the optimal steering angle during the atmospheric portion of flight is nonlinear (IGM is a linear steering law). Shown in figure 12 is the optimal steering angle versus time for case B. Notice the nonlinearity from 12 sec to approximately 130 sec. This indicates that linear steering laws are far from optimal and should not be used for guidance in this region of flight even if atmospheric forces are included in the guidance equations.

There are no significant results to report for the reentry phase. Early computations have shown a very high sensitivity of the reentry trajectories to the choice of the initial values of the Lagrange multipliers and consequently a very poor convergence rate. However, recently the approach outlined on pages 25 and 26 has been implemented in order to eliminate this high sensitivity and poor convergence. This method assumes that $\bar{u}(t)$ could adequately be represented as a linear function of time during the atmospheric portions of flight.

Studies are currently underway to determine whether it will be necessary to use the solutions so obtained as first approximations to the true optimum. Presently, no further corrections appear to be necessary.

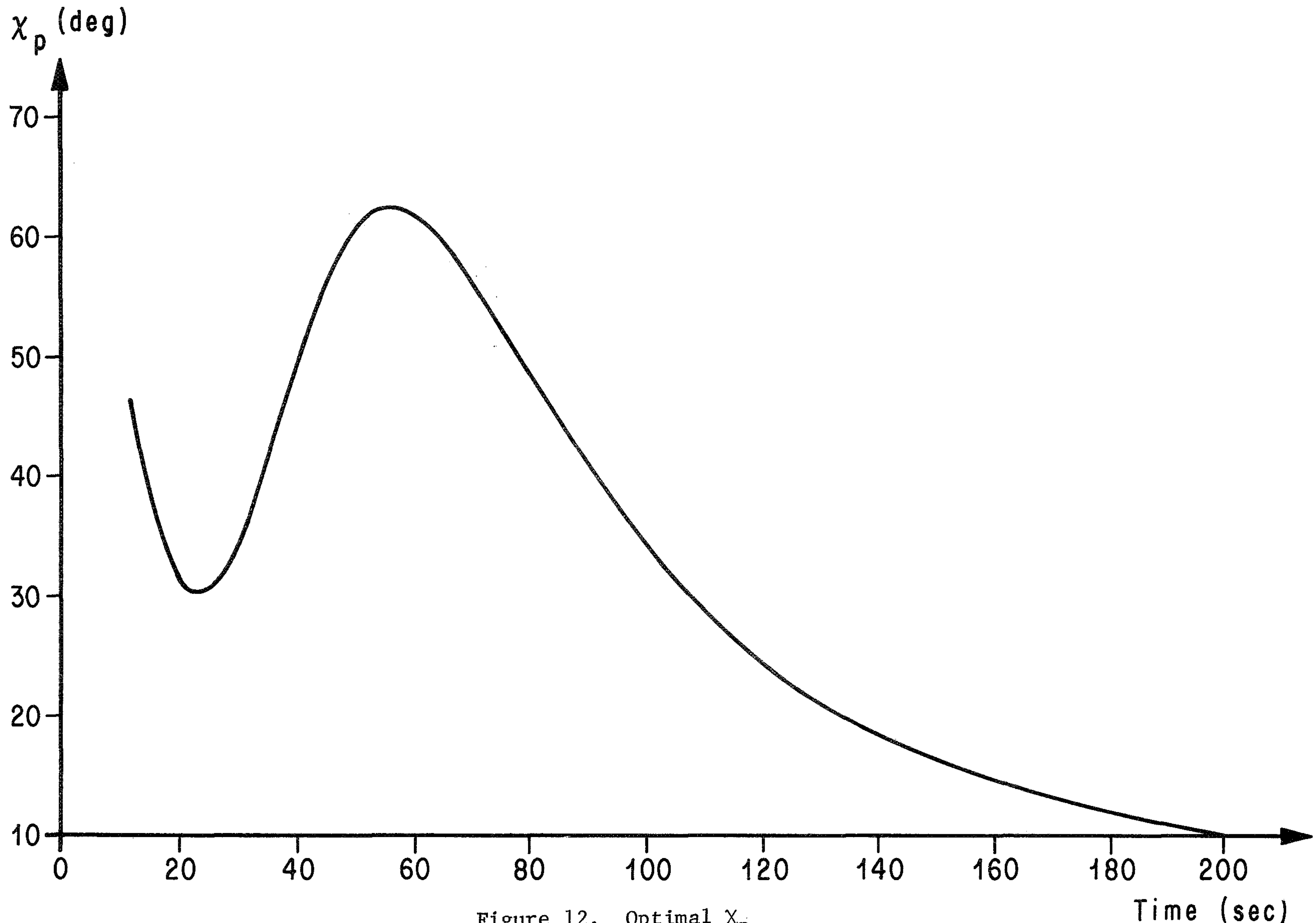

Figure 12. Optimal χ_p

VIII. CONCLUSIONS

Fast, efficient, compact trajectory algorithms for a total trajectory from lift-off to landing have been developed using a numerical solution of the optimization boundary value problem. These algorithms use a rapid numerical integration routine and an efficient iterative solution of the simultaneous nonlinear equations involved. The implementation of one of these algorithms (using the available vastly improved on-board flight computers) would accomplish a major advance in guidance techniques. That is, preflight analysis would be reduced to a minimum, thus making it possible to achieve Shuttle launches with airline type of turnaround times. Also, special tuning constants and functions (which have heretofore been necessary to account for approximations introduced to simplify onboard computations) would be eliminated. Thus, this proposed guidance system would produce (on board the vehicle) optimal trajectories for an extremely wide variety of missions and vehicle characteristics.

REFERENCES

1. Smith, I. E., Hart, J. J., and Chandler, D. C., "Procedures for Implementing a Simplified Path Adaptive Scheme," Marshall Space Flight Center, NASA TM X-53414, September 16, 1966.

2. Horn, H. J., Martin, D. T., and Chandler, D. C., "An Iterative Guidance Scheme and Its Application to Lunar Landing," Marshall Space Flight Center, NASA TN D-2869, July 1965.

3. Smith, I. E. and Deaton, E. T., Jr., "An Iterative Guidance Scheme for Ascent to Orbit (Suborbital Start of the Third Stage)," Marshall Space Flight Center Report MTP-AERO-63-44, NASA Accession No. N64-13495, May 29, 1963.

4. Burrows, Roger R. and McDaniel, Gary, "A Method of Trajectory Analysis with Multi-Mission Capability and Guidance Application," Presented at AIAA Guidance, Control, and Flight Dynamics Conference, Pasadena, California, August 14, 1968, AIAA Paper No. 68-844.

5. Ingram, Hugo L., "Boundary Value Problems Associated with Optimization Theory," NASA TM X-53365, December 3, 1965.

6. Brown, K. R. and Johnson, G. W., "Optimal Guidance for Orbital Transfer," IBM Report #65-221-0003H, Huntsville, Alabama, August 30, 1965.

7. Brown, K. R. and Johnson, G. W., "Real-Time Optimal Guidance," IEEE Transactions on Automatic Control, Vol. AC-12, No. 5, October 1967.

8. Ingram, Hugo L., "Optimal Guidance with Transition Partial Derivative Matrices," proceedings of the 19th Congress of the International Astronautical Federation, Vol. 2, Astrodynamics and Astrionics, Pergamon Press, Inc., New York, 1970.

9. Brown, K. R., Harrold, E. F., and Johnson, G. W., "Rapid Optimization of Multiple-Burn Rocket Trajectories," NASA Contractor Report CR-1430, September 1969, and presented at the 20th Congress of the I.A.F. at Mar Del Plata, Argentina, October 1969.

10. Pittkin, Edward T., "Second Transition Partial Derivatives via Universal Variables," The Journal of Astronautical Sciences, October-November 1966.

11. Goodyear, W. H., "A General Method for the Computation of Cartesian Coordinates and Partial Derivatives of the Two-Body Problem," NASA CR-522, September 1966.

12. Richman, Jack, "Two-Point Boundary-Value Problems of the Calculus of Variation for Optimum Orbits," paper published in Marshall Space Flight Center MTP-AERO-63-12, entitled "Progress Report No. 3 on Studies in the Field of Space Flight And Guidance Theory," February 1963, NASA Accession No. N63-16801.

13. Brown, K. R., Harrold, E. F., and Johnson, G. W., "Some New Results on Space Shuttle Atmospheric Ascent Optimization," presented at AIAA Guidance, Control, and Flight Mechanics Conference, Santa Barbara, California, August 17-19, 1970, AIAA Paper No. 70-978.

14. Keller, Herbert B., Numerical Methods for Two-Point Boundary-Value Problems, Blaisdell Publishing Co. (a division of Guin & Co.), Waltham, Mass., 1968.

15. Luenberger, David G., Optimization by Vector Space Methods, John Wiley & Sons, Inc., New York, 1969.

16. Bryson, Arthur E., Jr. and Ho, Yu-Chi, Applied Optimal Control, Blaisdell Publishing Co. (a division of Guin & Co.), Waltham, Mass., 1968.

17. Hayes, Russell M., Jr., "An Algorithm for the Determination of the Definiteness of a Real Square Matrix," NASA TM X-53644, August 8, 1967.

18. Fehlberg, Erwin, "Classical Fifth-, Sixth-, Seventh-, and Eighth-Order Runge-Kutta Formulas with Stepsize Control," NASA TR R-287, October 1968.

19. Fehlberg, Erwin, "Low-Order Classical Runge-Kutta Formulas with Stepsize Control and Their Application to Some Heat Transfer Problems," NASA TR R-315, July 1969.

20. Ward, D. E., "Improved Integration Methods for Lunar Trajectory," LMSC/HREC D162381, HREC-3969-1, June 1970.

BIBLIOGRAPHY

Baker, C. D., "A Minimum Fuel Reserve Guidance System," Aero-Internal Note 3-64 (Limited Distribution), Marshall Space Flight Center, January 14, 1964.

Burrows, Roger R., "Variational Problems and Their Solution by the Adjoint Method," NASA TM X-53459, May 6, 1966.

Burrows, Roger R., "The Classical Sphere of Influence," NASA TM X-53485, June 29, 1966.

Burrows, Roger R. and Wood, Gordon A., "Optimal Continuous Low-Thrust Trajectories for Co-Altitude Rendezvous," AIAA Journal, Vol. 7, No. 5, May 1969.

Hoelker, R. F., "The Evolution of Guidance Theory and Trajectory Analysis into a Single Scientific Discipline," prepared for presentation at the Meeting of the Institute of Navigation in Williamsburg, Virginia, June 1961, Marshall Space Flight Center, Alabama.

Ingram, Hugo L., "Path-Adaptive Guidance Applied to Saturn C-1 Block II: Three-Dimensional Steering Functions and Cutoff Functions for a Circular Orbit Mission," Aeroballistics Internal Note #7-63, Marshall Space Flight Center, February 15, 1963.

Ingram, Hugo L., "An Orthonormalization Procedure for Multivariable Function Approximation," Aero-Astrodynamics Research Review No. 2, NASA TM X-53295, April 1, 1965.

Ingram, Hugo L., "The Pontryagin Maximum Principle," presented August 2, 1966 at the Optimization Theory Symposium held by MSFC Astrodynamics and Guidance Theory Division.

Ingram, Hugo L., "The Automation of Optimization Problems," The American Astronautical Society of Science and Technology Series, Vol. II, Space Flight Mechanics Specialist Symposium, 1967.

Ingram, Hugo L., "The Mathematical and Numerical Analysis Associated with Optimal Guidance Concepts," Astrodynamics, Guidance and Control Review #1, NASA TM X-53709, 1968.

Ingram, Hugo L., "Optimal Guidance," Research Achievements Review, Vol. III, Report No. 2, NASA TM X-53777, 1968.

Miner, W. E., Schmieder, D. H., Braud, N. J., "The Path-Adaptive Mode for Guiding Space Flight Vehicles," ARS Guidance, Control and Navigation Conference, Stanford, California, August 1961. Revised March 1962, reprint from Progress in Astronautics and Rocketry, 1962, Academic Press, New York, New York.

Preston, Edward L., "A Computer Program for State Transition," MSFC Fall 1967 Co-op Report.

Preston, Edward L., "Formulation and Solution of a Rendezvous Boundary Value Problem," MSFC Summer 1968 Co-op Report.

Preston, Edward L., "A Variation of Parameters Solution of the N-Body Problem," S&E-AERO-G Branch Working Paper, Marshall Space Flight Center, 1969.

Silber, Robert and Ingram, Hugo L., "The Calculus of Variations," Status Report #2 on Theory of Space Flight and Adaptive Guidance," MTP-AERO-63-15, February 14, 1963.

APPENDIX I

COMPUTER PROGRAM LISTING

FOR PARAMETER OPTIMIZATION DECK

```
MAIN PROGRAM

STORAGE USED: CODE(1) 003010; DATA(0) 002321; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   ATMO    000112
 0004   ENDCDN  000054
 0005   RKINTG  000554
 0006   DIFEQ   000070
 0007   CONST   000103
 0010   AERO    000156

EXTERNAL REFERENCES (BLOCK, NAME)

 0011   TANGL
 0012   DEQ
 0013   PRINT
 0014   RK713
 0015   BOUND
 0016   PBOUND
 0017   SIMEQ
 0020   NINTRS
 0021   NRDCS
 0022   NI02S
 0023   NI01S
 0024   DSQRT
 0025   DCOS
 0026   DSIN
 0027   NPRTS
 0030   NSTOPS

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000002 10L      0001   001272 100L     0001   001765 1004G    0001   001766 1007G    0001   002003 1015G
 0001   002025 1023G    0001   002027 1026G    0001   002032 1032G    0001   002054 1041G    0001   002065 1044G
 0001   002077 1056G    0001   002100 1060G    0001   002126 1067G    0001   002151 1076G    0001   002177 1111G
 0001   002210 1117G    0001   002212 1122G    0001   002215 1126G    0001   002236 1135G    0001   002245 1142G
 0001   002251 1146G    0001   002300 1160G    0001   002315 1170G    0001   002332 1200G    0001   002342 1205G
 0001   002346 1211G    0001   002372 1222G    0001   002403 1230G    0001   002510 1274G    0001   002515 1301G
 0001   002522 1306G    0001   000015 132G     0001   002662 1361G    0001   002671 1366G    0001   002675 1372G
 0001   002721 1404G    0001   002731 1411G    0001   002737 1415G    0001   002773 1430G    0001   000071 171G
 0001   001616 190L     0001   001626 210L     0001   000123 214G     0001   001720 230L     0001   000345 314G
 0001   000346 317G     0001   002156 320L     0001   002204 350L     0001   000145 40L      0001   002473 420L
 0001   002474 430L     0001   002554 480L     0001   002556 490L     0001   002561 500L     0001   002573 520L
 0001   001042 536G     0001   002633 540L     0001   001146 553G     0001   001214 564G     0001   003000 580L
 0000   001333 590F     0000   001340 600F     0000   001346 610F     0001   001304 613G     0000   001370 620F
 0001   001331 624G     0000   001400 630F     0000   001411 640F     0001   001451 645G     0000   001416 650F
 0000   001426 660F     0000   001433 670F     0001   001546 671G     0000   001437 680F     0000   001443 690F
 0000   001446 700F     0000   001454 710F     0000   001457 720F     0000   001464 730F     0001   001633 736G
```

```
0000    001475 740F       0000    001511 750F       0000    001517 760F       0000    001525 770F       0001    001737 776G
0000    001552 780F       0000    001560 790F       0000    001562 800F       0000    001567 810F       0007 D 000016 AA
0007 D 000072 AB          0010 D 000050 ACA         0006 D 000044 ACH         0010 D 000000 ACLA        0000 D 000610 ACM
0010 D 000120 AETA        0000 D 001313 AFGRS       0000 D 001246 AK          0000 D 001244 AKL         0000 D 001242 AKU
0000 D 001307 AK2         0006 D 000034 ALB         0006 D 000054 ALFA        0000 D 001177 ALFG        0000 D 001236 ALFGR
0000 D 001124 ALMF        0000 D 001142 ALMO        0005 D 000470 ALPH        0006 D 000050 ALT         0000 D 000500 AM
0004 D 000002 AMC         0007 D 000010 AREA        0007 D 000004 AZ          0003 D 000000 A0          0003 D 000002 A1
0003 D 000024 A10         0003 D 000026 A11         0003 D 000030 A12         0003 D 000032 A13         0003 D 000034 A14
0003 D 000036 A15         0003 D 000040 A16         0003 D 000042 A17         0003 D 000044 A18         0003 D 000046 A19
0003 D 000004 A2          0003 D 000050 A20         0003 D 000052 A21         0003 D 000054 A22         0003 D 000056 A23
0003 D 000006 A3          0003 D 000010 A4          0003 D 000012 A5          0003 D 000014 A6          0003 D 000016 A7
0003 D 000020 A8          0003 D 000022 A9          0000 D 000344 B           0000 D 001074 BBM         0007 D 000012 BE
0006 D 000056 BEDA        0005 D 000000 BETA        0000 D 001201 BETG        0000 D 001240 BETGR       0000 D 000734 BM
0000 D 001315 BTGRS       0000 D 001252 BTOL        0003 D 000060 B0          0003 D 000062 B1          0003 D 000064 B2
0003 D 000066 B3          0003 D 000070 B4          0003 D 000072 B5          0003 D 000074 B6          0003 D 000076 B7
0003 D 000100 B8          0006 D 000042 CA          0000 D 001264 CB          0005 D 000522 CH          0007 D 000062 CK1
0007 D 000064 CK2         0007 D 000066 CK3         0006 D 000060 CLA         0000 D 001274 CNAL        0000 D 001272 CNBE
0000 D 001220 COA         0000 D 001224 COP         0004 D 000052 CRAD        0000 D 001266 CSA         0004 D 000004 CTHC
0006 D 000014 DB          0000 D 001173 DTP         0000 D 000356 DU          0000 D 000144 DX          0003 D 000102 D1
0003 D 000104 D2          0003 D 000106 D3          0003 D 000110 D4          0000 D 001303 ERR         0000 D 001305 ERRP
0006 D 000022 ETA         0007 D 000032 EXA         0006 D 000062 F           0007 D 000024 FD          0007 D 000022 FH
0007 D 000020 FJ          0000 D 001175 FPT         0007 D 000052 FS          0007 D 000000 GM          0007 D 000060 HEATC
0000 I 001170 I           0007 I 000102 ICNVG       0000 I 001211 J           0000 I 001327 K           0000 I 001330 LCH
0000 I 001302 M           0000 I 001254 MAXNT       0000 I 001255 NT          0007 D 000014 OM          0000 D 000750 PBU
0000 D 000372 PBUAT       0007 D 000002 PHIL        0006 D 000010 PRES        0000 D 000310 PT          0000 D 000720 PUWU
0007 D 000054 PO          0006 D 000064 QQ          0006 D 000000 R           0000 D 001205 RAD         0000 D 001214 RAZ
0004 D 000000 RC          0007 D 000006 RCONV       0004 D 000006 RCTHC       0007 D 000070 RCURV       0006 D 000024 RE
0006 D 000052 RHO         0007 D 000026 RISP        0007 D 000100 RLGO        0007 D 000030 RMD         0000 D 001212 RPHIL
0004 D 000030 RVR         0000 D 001230 RXVO        0004 D 000022 RXVOB       0000 D 001226 RO          0004 D 000014 ROB
0000 D 001260 SA          0000 D 001262 SB          0004 D 000012 SCRAD       0000 D 001216 SIA         0000 D 001222 SIP
0000 D 001276 SNAL        0000 D 001270 SNBE        0004 D 000010 SRAD        0000 D 001331 STEP        0000 D 001300 T
0000 D 001171 TF          0000 D 001311 TFS         0000 D 001203 THC         0000 D 001166 TI          0000 D 001256 TOL
0007 D 000050 TO          0006 D 000026 U           0004 D 000036 UXE         0004 D 000044 UYE         0007 D 000034 UO
0007 D 000042 UOD         0000 D 001160 UODS        0000 D 001317 VPR1        0000 D 001321 VPR2        0000 D 001323 VPR3
0000 D 001325 VPR4        0006 D 000002 VR          0006 D 000012 VRM         0000 D 001232 VRMO        0000 D 000336 VRVO
0000 D 000322 VRO         0006 D 000066 VS          0000 D 001234 VXRMO       0000 D 000330 VXRO        0000 D 001250 WF
0006 D 000046 WKG         0007 D 000056 WKGO        0000 D 000000 X           0000 D 001110 XI          0000 D 001207 XRAD
```

```
00100      1*    C      MAIN ROUTINE                                                         A    1
00101      2*           IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00103      3*           DIMENSION X(50), DX(50), ALPH(13), BETA(13,12), CH(13), AB(3)       A    2
00104      4*           DIMENSION PT(5)                                                      A    3
00105      5*           DIMENSION VR(3), U(3), ALB(3), DB(3), UO(3), UOD(3)                  A    4
00106      6*           DIMENSION ROB(3), RXVOB(3), RVR(3)                                   A    5
00107      7*           DIMENSION VRO(3), VXRO(3), VRVO(3)                                   A    6
00110      8*           DIMENSION B(5), DU(6), PBUAT(5,7), AM(6,6), ACM(6,6), PUWU(3,2), B  A    7
00110      9*          1M(6)                                                                 A    8
00111     10*           DIMENSION PBU(6,7), BBM(6)                                           A    9
00112     11*           DIMENSION XI(6), UXE(3), UYE(3)                                      A   10
00113     12*           DIMENSION ALMF(7), ALMO(7)                                           A   11
00114     13*           DIMENSION AETA(15), ACLA(20), ACA(20)                                A   12
00115     14*           DIMENSION UODS(3)                                                    A   13
00116     15*           COMMON /ATMO/ A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A1  A   14
```

```
00116           15,A16,A17,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2
00116           2,D3,D4
00117            COMMON /ENDCDN/ RC,AMC,CTHC,RCTHC,SRAD,SCRAD,ROB,RXVOB,RVR,UXE,UYE
00117           1,CRAD
00120            COMMON /RKINTG/ BETA,ALPH,CH
00121            COMMON /DIFEQ/ R,VR,PRES,VRM,DB,ETA,RE,U,ALB,CA,ACH,WKG,ALT,RHO,AL
00121           1FA,BEDA,CLA,F,QQ,VS
00122            COMMON /CONST/ GM,PHIL,AZ,RCONV,AREA,BE,OM,AA,FJ,FH,FD,RISP,RMD,EX
00122           1A,U0,UOD,T0,FS,P0,WKG0,HEATC,CK1,CK2,CK3,RCURV,AB,RLGO,ICNVG
00123            COMMON /AERO/ ACLA,ACA,AETA
00124         10 READ 790, GM,TI
00130            READ 790, (XI(I),I=1,6)
00136            READ 790, TF,DTP,FPT
00136      C     RLGO SHOULD BE THE LONGITUDE OF THE LAUNCH SITE WHEN TI IS REFEREN
00136      C     TO THE LAUNCH TIME BUT IF TI IS ARBITRARILY SET TO ZERO THEN RLGO
00136      C     SHOULD BE THE INSTANTANEOUS LONGITUDE
00143            READ 790, PHIL,AZ,RLGO
00150            READ 790, FS,RISP,RCURV
00150      C     FS MUST BE IN NEWTONS=KG.M./SEC2
00155            READ 790, WKG0,AREA,EXA
00162            READ 790, ALFG,BETG,HEATC
00167            READ 790, U0D
00175            READ 790, CK1,CK2,CK3
00202            READ 790, RC,AMC,THC
00207            READ 790, RAD,XRAD
00207      C     PRELIMINARY COMPUTATIONS AND DEFINITION OF CONSTANTS
00213            DO 20 I=1,6
00216         20 X(I)=XI(I)
00220            HEATC=HEATC/SQRT(RCURV)
00221            WKG=WKG0
00222            RMD=0.
00223            IF (RISP) 30,40,30
00226         30 RMD=FS/RISP
00227         40 CONTINUE
00230            T0=TI
00231            RCONV=.1745329252E-01
00232            CTHC=COS(THC*RCONV)
00233            RCTHC=RC*CTHC
00234            SRAD=SIN(RAD*RCONV)
00235            CRAD=COS(RAD*RCONV)
00236            SCRAD=SIN(XRAD*RCONV)
00237            BE=6356784.
00240            OM=.729211506E-04
00241            AA=.6378166E+07
00242            FJ=1.62345E-03
00243            FH=-5.75E-06
00244            FD=7.875E-06
00245            P0=1.01325E+05
00245      C     CONSTANTS FOR ATMOSPHERIC SUBROUTINE
00246            A0=-1.0902039E-07
00247            A1=6356.77
00250            A2=1.7870260E-04
00251            A3=21.680485
00252            A4=1.3949832E-05
00253            A5=284.01768
00254            A6=1.3327563E-04
```

```
00255     72*           A7=29.895060                                       A  71
00256     73*           A8=924.13600                                       A  72
00257     74*           A9=8.3168074E-04                                   A  73
00260     75*           A10=0.037777365                                    A  74
00261     76*           A11=0.56467830                                     A  75
00262     77*           A12=1.6002310E-04                                  A  76
00263     78*           A13=189.52010                                      A  77
00264     79*           A14=9665.295                                       A  78
00265     80*           A15=1.1637071E-03                                  A  79
00266     81*           A16=0.038184967                                    A  80
00267     82*           A17=3.6184094                                      A  81
00270     83*           A18=5.5628920E-05                                  A  82
00271     84*           A19=420.11368                                      A  83
00272     85*           A20=45675.466                                      A  84
00273     86*           A21=1.2844040E-04                                  A  85
00274     87*           A22=0.025387008                                    A  86
00275     88*           A23=5.3327146                                      A  87
00276     89*           B0=2.824793081E+02                                 A  88
00277     90*           B1=-5.240572992                                    A  89
00300     91*           B2=-1.266010595E-01                                A  90
00301     92*           B3=1.873293836E-02                                 A  91
00302     93*           B4=-5.104746533E-04                                A  92
00303     94*           B5=6.050186406E-06                                 A  93
00304     95*           B6=-3.550162735E-08                                A  94
00305     96*           B7=1.014102927E-10                                 A  95
00306     97*           B8=1.124449619E-13                                 A  96
00307     98*           D1=3483.6763560                                    A  97
00310     99*           D2=+.2021698826IE-01                               A  98
00311    100*           D3=+.58033445891E+01                               A  99
00312    101*           D4=.40187430086E+03                                A 100
00312    102*     C     CONSTANTS FOR INTEGRATION SUBROUTINE               A 101
00313    103*           DO 60 I=1,13                                       A 102
00316    104*           DO 50 J=1,12                                       A 103
00321    105*        50 BETA(I,J)=0.                                       A 104
00323    106*           ALPH(I)=0.                                         A 105
00324    107*        60 CH(I)=0.                                           A 106
00326    108*           CH(6)=34./105.                                     A 107
00327    109*           CH(7)=9./35.                                       A 108
00330    110*           CH(8)=CH(7)                                        A 109
00331    111*           CH(9)=9./280.                                      A 110
00332    112*           CH(10)=CH(9)                                       A 111
00333    113*           CH(12)=41./840.                                    A 112
00334    114*           CH(13)=CH(12)                                      A 113
00335    115*           ALPH(2)=2./27.                                     A 114
00336    116*           ALPH(3)=1./9.                                      A 115
00337    117*           ALPH(4)=1./6.                                      A 116
00340    118*           ALPH(5)=5./12.                                     A 117
00341    119*           ALPH(6)=.5                                         A 118
00342    120*           ALPH(7)=5./6.                                      A 119
00343    121*           ALPH(8)=1./6.                                      A 120
00344    122*           ALPH(9)=2./3.                                      A 121
00345    123*           ALPH(10)=1./3.                                     A 122
00346    124*           ALPH(11)=1.                                        A 123
00347    125*           ALPH(13)=1.                                        A 124
00350    126*           BETA(2,1)=2./27.                                   A 125
00351    127*           BETA(3,1)=1./36.                                   A 126
```

```
00352    128*          BETA(4,1)=1./24.                                    A 127
00353    129*          BETA(5,1)=5./12.                                    A 128
00354    130*          BETA(6,1)=.05                                       A 129
00355    131*          BETA(7,1)=-25./108.                                 A 130
00356    132*          BETA(8,1)=31./300.                                  A 131
00357    133*          BETA(9,1)=2.                                        A 132
00360    134*          BETA(10,1)=-91./108.                                A 133
00361    135*          BETA(11,1)=2383./4100.                              A 134
00362    136*          BETA(12,1)=3./205.                                  A 135
00363    137*          BETA(13,1)=-1777./4100.                             A 136
00364    138*          BETA(3,2)=1./12.                                    A 137
00365    139*          BETA(4,3)=1./8.                                     A 138
00366    140*          BETA(5,3)=-25./16.                                  A 139
00367    141*          BETA(5,4)=-BETA(5,3)                                A 140
00370    142*          BETA(6,4)=.25                                       A 141
00371    143*          BETA(7,4)=125./108.                                 A 142
00372    144*          BETA(9,4)=-53./6.                                   A 143
00373    145*          BETA(10,4)=23./108.                                 A 144
00374    146*          BETA(11,4)=-341./164.                               A 145
00375    147*          BETA(13,4)=BETA(11,4)                               A 146
00376    148*          BETA(6,5)=.2                                        A 147
00377    149*          BETA(7,5)=-65./27.                                  A 148
00400    150*          BETA(8,5)=61./225.                                  A 149
00401    151*          BETA(9,5)=704./45.                                  A 150
00402    152*          BETA(10,5)=-976./135.                               A 151
00403    153*          BETA(11,5)=4496./1025.                              A 152
00404    154*          BETA(13,5)=BETA(11,5)                               A 153
00405    155*          BETA(7,6)=125./54.                                  A 154
00406    156*          BETA(8,6)=-2./9.                                    A 155
00407    157*          BETA(9,6)=-107./9.                                  A 156
00410    158*          BETA(10,6)=311./54.                                 A 157
00411    159*          BETA(11,6)=-301./82.                                A 158
00412    160*          BETA(12,6)=-6./41.                                  A 159
00413    161*          BETA(13,6)=-289./82.                                A 160
00414    162*          BETA(8,7)=13./900.                                  A 161
00415    163*          BETA(9,7)=67./90.                                   A 162
00416    164*          BETA(10,7)=-19./60.                                 A 163
00417    165*          BETA(11,7)=2133./4100.                              A 164
00420    166*          BETA(12,7)=-3./205.                                 A 165
00421    167*          BETA(13,7)=2193./4100.                              A 166
00422    168*          BETA(9,8)=3.                                        A 167
00423    169*          BETA(10,8)=17./6.                                   A 168
00424    170*          BETA(11,8)=45./82.                                  A 169
00425    171*          BETA(12,8)=-3./41.                                  A 170
00426    172*          BETA(13,8)=51./82.                                  A 171
00427    173*          BETA(10,9)=-1./12.                                  A 172
00430    174*          BETA(11,9)=45./164.                                 A 173
00431    175*          BETA(12,9)=3./41.                                   A 174
00432    176*          BETA(13,9)=33./164.                                 A 175
00433    177*          BETA(11,10)=18./41.                                 A 176
00434    178*          BETA(12,10)=6./41.                                  A 177
00435    179*          BETA(13,10)=12./41.                                 A 178
00436    180*          BETA(13,12)=1.                                      A 179
00436    181*    C     COEFICCIENTS FOR AERODYNAMIC SUBROUTINE             A 180
00437    182*          AETA(1)=+.52824387840394170+00                      A 181
00440    183*          AETA(2)=-.27996093668012940+00                      A 182
```

```
00441    184*         AETA(3)=+.2634628613227735D-01                    A 183
00442    185*         AETA(4)=+.1002414720044129D+00                    A 184
00443    186*         AETA(5)=+.5419612944522060D-01                    A 185
00444    187*         AETA(6)=-.2636214482473858D-01                    A 186
00445    188*         AETA(7)=-.1460511365504975D-01                    A 187
00446    189*         AETA(8)=+.1985394233336290D-02                    A 188
00447    190*         AETA(9)=+.1102573887228908D-02                    A 189
00450    191*         AETA(10)=-.1053706608764938D+00                   A 190
00451    192*         ACLA(1)=+.1362968139235900D+01                    A 191
00452    193*         ACLA(2)=-.2161928050060222D+01                    A 192
00453    194*         ACLA(3)=+.1366240331189764D+01                    A 193
00454    195*         ACLA(4)=-.4047533602827794D+00                    A 194
00455    196*         ACLA(5)=+.5772563039573856D-01                    A 195
00456    197*         ACLA(6)=-.2906122591428341D-02                    A 196
00457    198*         ACLA(7)=-.1202658432132724D-03                    A 197
00460    199*         ACLA(8)=+.1261738360577320D-04                    A 198
00461    200*         ACLA(9)=-.1578691948483076D+01                    A 199
00462    201*         ACLA(10)=+.9157555148335584D+00                   A 200
00463    202*         ACLA(11)=-.1980722779428976D+00                   A 201
00464    203*         ACLA(12)=+.7212951895259629D-02                   A 202
00465    204*         ACLA(13)=-.1229475340782184D-02                   A 203
00466    205*         ACLA(14)=+.8763862599198162D-04                   A 204
00467    206*         ACLA(15)=-.3231936950766492D-05                   A 205
00470    207*         ACLA(16)=+.9928256601317429D-07                   A 206
00471    208*         ACLA(17)=-.1968602403590581D-08                   A 207
00472    209*         ACLA(18)=-.1728970917969919D-10                   A 208
00473    210*         ACLA(19)=-.1164022015904538D-12                   A 209
00474    211*         ACA(1)=+.1690054731875374D-01                     A 210
00475    212*         ACA(2)=-.4369802355589601D-01                     A 211
00476    213*         ACA(3)=+.4406563228231939D-01                     A 212
00477    214*         ACA(4)=-.2260835708215322D-01                     A 213
00500    215*         ACA(5)=+.7095634473294292D-02                     A 214
00501    216*         ACA(6)=-.1385831579493185D-02                     A 215
00502    217*         ACA(7)=+.1624012522715024D-03                     A 216
00503    218*         ACA(8)=-.1039850925399231D-04                     A 217
00504    219*         ACA(9)=+.2789363503859551D-06                     A 218
00505    220*         ACA(10)=-.2671139256070927D+01                    A 219
00506    221*         ACA(11)=+.2866995359711730D+01                    A 220
00507    222*         ACA(12)=-.1627281057493057D+01                    A 221
00510    223*         ACA(13)=+.5485606506388702D+00                    A 222
00511    224*         ACA(14)=-.1112504066814775D+00                    A 223
00512    225*         ACA(15)=+.1326927044763584D-01                    A 224
00513    226*         ACA(16)=-.8560501350938220D-03                    A 225
00514    227*         ACA(17)=+.2298678760945622D-04                    A 226
00515    228*         ACA(18)=+.3579775134987575D-08                    A 227
00516    229*         ACA(19)=-.2146523703958381D-10                    A 228
00516    230*   C     COMPUTATION OF UNIT NORTH VECTOR                  A 229
00517    231*         RPHIL=PHIL*RCONV                                  A 230
00520    232*         RAZ=AZ*RCONV                                      A 231
00521    233*         SIA=SIN(RAZ)                                      A 232
00522    234*         COA=COS(RAZ)                                      A 233
00523    235*         SIP=SIN(RPHIL)                                    A 234
00524    236*         COP=COS(RPHIL)                                    A 235
00525    237*         AB(1)=SIP                                         A 236
00526    238*         AB(2)=-COP*SIA                                    A 237
00527    239*         AB(3)=COP*COA                                     A 238
```

```
00527   C      VECTORS NEEDED FOR DOWN RANGE AND CROSS RANGE IN PRINT SUBROUTINE
00530          RO=SQRT(X(1)*X(1)+X(2)*X(2)+X(3)*X(3))
00531          RXVOB(1)=X(2)*X(6)-X(3)*X(5)
00532          RXVOB(2)=X(4)*X(3)-X(6)*X(1)
00533          RXVOB(3)=X(1)*X(5)-X(4)*X(2)
00534          RXVO=SQRT(RXVOB(1)**2+RXVOB(2)**2+RXVOB(3)**2)
00535          DO 70 I=1,3
00540          ROB(I)=X(I)/RO
00541       70 RXVOB(I)=RXVOB(I)/RXVO
00543          RVR(1)=RXVOB(2)*ROB(3)-RXVOB(3)*ROB(2)
00544          RVR(2)=RXVOB(3)*ROB(1)-RXVOB(1)*ROB(3)
00545          RVR(3)=RXVOB(1)*ROB(2)-RXVOB(2)*ROB(1)
00545   C      COMPUTATION OF UO BAR IN TERMS OF ALFG AND BETG
00546          VRO(1)=X(4)-OM*(AB(2)*X(3)-AB(3)*X(2))
00547          VRO(2)=X(5)-OM*(AB(3)*X(1)-AB(1)*X(3))
00550          VRO(3)=X(6)-OM*(AB(1)*X(2)-AB(2)*X(1))
00551          VRMO=SQRT(VRO(1)*VRO(1)+VRO(2)*VRO(2)+VRO(3)*VRO(3))
00552          DO 80 I=1,3
00555       80 VRO(I)=VRO(I)/VRMO
00557          VXRO(1)=VRO(2)*X(3)-VRO(3)*X(2)
00560          VXRO(2)=VRO(3)*X(1)-VRO(1)*X(3)
00561          VXRO(3)=VRO(1)*X(2)-VRO(2)*X(1)
00562          VXRMO=SQRT(VXRO(1)*VXRO(1)+VXRO(2)*VXRO(2)+VXRO(3)*VXRO(3))
00563          DO 90 I=1,3
00564       90 VXRO(I)=VXRO(I)/VXRMO
00570          VRVO(1)=VXRO(2)*VRO(3)-VXRO(3)*VRO(2)
00571          VRVO(2)=VXRO(3)*VRO(1)-VXRO(1)*VRO(3)
00572          VRVO(3)=VXRO(1)*VRO(2)-VXRO(2)*VRO(1)
00573          ALFGR=ALFG*RCONV
00574          BETGR=BETG*RCONV
00574   C      TEMPORARY END OF UO BAR COMPUTATIONS
00575          AKU=1.
00576          AKL=.01
00577          AK=.1
00600          WF=1.E-25
00601          BTOL=.5E-04
00602          MAXNT=40
00603          NT=0
00604          ICNVG=0
00605          TOL=.05
00605   C      START OF TRIAL INTEGRATION
00606      100 NT=NT+1
00607          PRINT 590, NT
00612          DO 110 I=7,50
00615      110 X(I)=0.
00615   C      CONTINUATION OF UO BAR COMPUTATIONS
00617          SA=SIN(ALFGR)
00620          SB=SIN(BETGR)
00621          CB=COS(BETGR)
00622          CSA=COS(ALFGR)
00623          DO 120 I=1,3
00626      120 UO(I)=SA*(CB*VRVO(I)+SB*VXRO(I))+CSA*VRO(I)
00630          SNBE=UO(1)*VXRO(1)+UO(2)*VXRO(2)+UO(3)*VXRO(3)
00631          CNBE=UO(1)*VRVO(1)+UO(2)*VRVO(2)+UO(3)*VRVO(3)
00632          CNAL=UO(1)*VRO(1)+UO(2)*VRO(2)+UO(3)*VRO(3)
00633          SNAL=SQRT(1.-CNAL*CNAL)
```

```
00634   296*          CALL TANGL (SNBE,CNBE,BETGR)                                  A 295
00635   297*          CALL TANGL (SNAL,CNAL,ALFGR)                                  A 296
00636   298*          ALFGR=ALFGR*RCONV                                             A 297
00637   299*          BETGR=BETGR*RCONV                                             A 298
00640   300*          SA=SIN(ALFGR)                                                 A 299
00641   301*          SB=SIN(BETGR)                                                 A 300
00642   302*          CSA=COS(ALFGR)                                                A 301
00643   303*          CB=COS(BETGR)                                                 A 302
00643   304*    C     END OF UO BAR COMPUTATIONS                                    A 303
00644   305*          DO 130 I=1,6                                                  A 304
00647   306*      130 X(I)=XI(I)                                                    A 305
00651   307*          CALL DEQ (X,TI,DX)                                            A 306
00652   308*          PRINT 800                                                     A 307
00654   309*          CALL PRINT (TI,X,DX)                                          A 308
00655   310*          T=TI                                                          A 309
00656   311*          CALL RK713 (T,TF,DTP,TOL,X,X,50,300,M)                        A 310
00657   312*          CALL DEQ (X,TF,DX)                                            A 311
00660   313*          PRINT 810, M                                                  A 312
00663   314*          CALL PRINT (TF,X,DX)                                          A 313
00663   315*    C     END OF TRIAL INTEGRATION                                      A 314
00663   316*    C     START OF NEWTONS ITERATION WITH LOGIC FOR WEIGHTING FACTORS   A 315
00664   317*          CALL BOUND (X,TF,DX,B,ERR)                                    A 316
00665   318*          PRINT 600                                                     A 317
00667   319*          PRINT 610, B,ERR                                              A 318
00676   320*          PRINT 620, RC,AMC,THC,RAD,XRAD                                A 319
00705   321*          IF (ERR-BTOL) 430,430,140                                     A 320
00710   322*      140 IF (NT-MAXNT) 150,580,580                                     A 321
00713   323*      150 IF (NT-1) 230,230,160                                         A 322
00716   324*      160 IF (ERR-ERRP) 170,190,190                                     A 323
00721   325*      170 AK=2.*AK                                                      A 324
00722   326*          IF (AK-AKU) 230,230,180                                       A 325
00725   327*      180 AK=AKU                                                        A 326
00726   328*          GO TO 230                                                     A 327
00727   329*      190 AK=.5*AK                                                      A 328
00730   330*          IF (AK-AKL) 200,210,210                                       A 329
00733   331*      200 AK=AKL                                                        A 330
00734   332*      210 AK2=AK*AK                                                     A 331
00735   333*          DO 220 I=1,3                                                  A 332
00740   334*      220 UOD(I)=UODS(I)-DU(I+2)*AK2                                    A 333
00742   335*          TF=TFS-DU(6)*AK2                                              A 334
00743   336*          ALFGR=AFGRS-DU(1)*AK2                                         A 335
00744   337*          BETGR=BTGRS-DU(2)*AK2                                         A 336
00745   338*          PRINT 630, AK,TOL,WF                                          A 337
00752   339*          VPR1=AFGRS/RCONV                                              A 338
00753   340*          VPR2=ALFGR/RCONV                                              A 339
00754   341*          VPR3=BTGRS/RCONV                                              A 340
00755   342*          VPR4=BETGR/RCONV                                              A 341
00756   343*          PRINT 700                                                     A 342
00760   344*          PRINT 710, VPR1,VPR2,VPR3,VPR4                                A 343
00766   345*          GO TO 100                                                     A 344
00767   346*      230 PRINT 630, AK,TOL,WF                                          A 345
00774   347*          CALL PBOUND (X,TF,DX,PBUAT)                                   A 346
00775   348*          DO 240 I=1,3                                                  A 347
01000   349*          PUWU(I,1)=CSA*(CB*VRVO(I)+SB*VXRO(I))-SA*VRO(I)               A 348
01001   350*      240 PUWU(I,2)=SA*(CB*VXRO(I)-SB*VRVO(I))                          A 349
01003   351*          DO 250 I=1,5                                                  A 350
```

```
01006          DO 250 J=1,7
01011      250 PBU(I,J)=PBUAT(I,J)
01014          DO 260 I=1,6
01017      260 PBU(6,I)=X(44+I)*WF
01021          PBU(6,7)=(CK1*RMD+CK2*DX(7)+CK3*DX(8))*WF
01022          DO 270 I=1,6
01025          DO 270 J=1,2
01030          ACM(I,J)=0.
01031          DO 270 K=1,3
01034      270 ACM(I,J)=ACM(I,J)+PBU(I,K)*PUWU(K,J)
01040          DO 290 I=1,6
01043          DO 280 J=1,3
01046      280 ACM(I,J+2)=PBU(I,J+3)
01050      290 ACM(I,6)=PBU(I,7)
01052          PRINT 640
01054          PRINT 690, ((ACM(I,J),J=1,6),I=1,5)
01065          BBM(6)=(CK1*WKG+CK2*X(7)+CK3*X(8))*WF
01066          DO 320 I=1,5
01071          IF (ABS(B(I))-.1) 320,320,300
01074      300 B(I)=.1*B(I)/ABS(B(I))
01075          DO 310 J=1,6
01100      310 ACM(I,J)=ACM(I,J)/ABS(B(I))*.1
01102      320 CONTINUE
01104          IF (ABS(BBM(6))-.1) 350,350,330
01107      330 BBM(6)=.1*BBM(6)/ABS(BBM(6))
01110          DO 340 J=1,6
01113      340 ACM(6,J)=ACM(6,J)/ABS(BBM(6))*.1
01115      350 CONTINUE
01116          DO 360 I=1,6
01121          DO 360 J=1,6
01124          AM(I,J)=0.
01125          DO 360 K=1,6
01130      360 AM(I,J)=AM(I,J)+ACM(K,I)*ACM(K,J)
01134          DO 370 I=1,5
01137      370 BBM(I)=B(I)
01141          DO 380 I=1,6
01144          BM(I)=0.
01145          DO 380 J=1,6
01150      380 BM(I)=BM(I)+ACM(J,I)*BBM(J)
01153          CALL SIMEQ (AM,DU,BM,6)
01154          PRINT 650
01156          PRINT 690, AM
01164          PRINT 660
01166          PRINT 690, BM
01174          PRINT 670
01176          PRINT 690, DU
01204          DO 390 I=1,6
01207          BM(I)=0.
01210          DO 390 J=1,6
01213      390 BM(I)=BM(I)+AM(I,J)*DU(J)
01216          PRINT 680
01220          PRINT 690, BM
01226          AK2=AK*AK
01226    C     THE COMPUTED CORRECTIONS ARE ADDED HERE AND THEN A NEW TRIAL START
01226    C     AT 100
01227          DO 400 I=1,3
```

```
01232    408*          UODS(I)=UOD(I)                                                     A 407
01233    409*      400 UOD(I)=UOD(I)-DU(I+2)*AK2                                          A 408
01235    410*          AFGRS=ALFGR                                                        A 409
01236    411*          BTGRS=BETGR                                                        A 410
01237    412*          TFS=TF                                                             A 411
01240    413*          TF=TF-DU(6)*AK2                                                    A 412
01241    414*          ALFGR=ALFGR-DU(1)*AK2                                              A 413
01242    415*          BETGR=BETGR-DU(2)*AK2                                              A 414
01243    416*          ERRP=ERR                                                           A 415
01244    417*          VPR1=AFGRS/RCONV                                                   A 416
01245    418*          VPR2=ALFGR/RCONV                                                   A 417
01246    419*          VPR3=BTGRS/RCONV                                                   A 418
01247    420*          VPR4=BETGR/RCONV                                                   A 419
01250    421*          PRINT 700                                                          A 420
01252    422*          PRINT 710, VPR1,VPR2,VPR3,VPR4                                     A 421
01260    423*          IF (ERR-.05) 410,410,420                                           A 422
01263    424*      410 TOL=.5E-06                                                         A 423
01264    425*      420 CONTINUE                                                           A 424
01265    426*          GO TO 100                                                          A 425
01266    427*      430 PRINT 720                                                          A 426
01266    428*   C      A FULL PRINT OF THE CONVERGED CASE BEGINS HERE                     A 427
01266    429*   C      ALSO THE MATRIX  PARTIAL OF X WITH RESPECT TO X0 IS OBTAINED BY    A 428
01266    430*   C      NUMERICAL INTEGRATION SO THAT SOME LAMBDAS CAN BE COMPUTED WHICH C A 429
01266    431*   C      BE USED AS FIRST GUESSES FOR AN OPTIMIZATION PROGRAM               A 430
01270    432*          PRINT 730                                                          A 431
01272    433*          ICNVG=1                                                            A 432
01273    434*          DO 440 I=1,6                                                       A 433
01276    435*      440 X(I)=XI(I)                                                         A 434
01300    436*          DO 450 I=7,50                                                      A 435
01303    437*      450 X(I)=0.                                                            A 436
01305    438*          DO 460 I=1,6                                                       A 437
01310    439*      460 X(2+7*I)=1.                                                        A 438
01312    440*          CALL DEQ (X,TI,DX)                                                 A 439
01313    441*          PRINT 800                                                          A 440
01315    442*          CALL PRINT (TI,X,DX)                                               A 441
01316    443*          T=TI                                                               A 442
01317    444*          LCH=0                                                              A 443
01320    445*          IF (TF-FPT) 470,480,490                                            A 444
01323    446*      470 FPT=TF                                                             A 445
01324    447*      480 LCH=1                                                              A 446
01325    448*      490 CONTINUE                                                           A 447
01326    449*          STEP=FPT                                                           A 448
01327    450*          GO TO 520                                                          A 449
01330    451*      500 STEP=T+DTP                                                         A 450
01331    452*          IF (TF-STEP) 510,510,520                                           A 451
01334    453*      510 LCH=1                                                              A 452
01335    454*          STEP=TF                                                            A 453
01336    455*      520 CALL RK713 (T,STEP,DTP,TOL,X,X,50,100,M)                           A 454
01337    456*          IF (LCH) 530,530,540                                               A 455
01342    457*      530 T=STEP                                                             A 456
01343    458*          CALL DEQ (X,T,DX)                                                  A 457
01344    459*          PRINT 740, M                                                       A 458
01347    460*          CALL PRINT (T,X,DX)                                                A 459
01350    461*          GO TO 500                                                          A 460
01351    462*      540 CONTINUE                                                           A 461
01352    463*          CALL DEQ (X,TF,DX)                                                 A 462
```

```
01353          PRINT 810, M
01356          CALL PRINT (TF,X,DX)
01356   C      THIS IS THE COMPUTATIONS FOR LAMBDA AT TO USING THE PARTIAL OF X W
01356   C      RESPECT TO XO
01357          CALL PBOUND (X,TF,DX,PBUAT)
01360          DO 550 I=1,5
01363      550 PT(I)=-1.E+04
01365          DO 560 I=1,6
01370          ALMF(I)=0.
01371          DO 560 J=1,5
01374      560 ALMF(I)=ALMF(I)-PT(J)*PBUAT(J,I)
01377          ALMF(7)=1.
01400          PRINT 750
01402          PRINT 770, ALMF
01410          DO 570 I=1,6
01413          ALMO(I)=0.
01414          DO 570 J=1,7
01417          M=6*J+I+2
01420      570 ALMO(I)=ALMO(I)+ALMF(J)*X(M)
01423          ALMO(7)=ALMF(7)
01424          PRINT 760
01426          PRINT 770, ALMO
01426   C      END OF THIS CASE
01434          GO TO 10
01435      580 PRINT 780, NT
01435   C      END OF THIS CASE
01440          GO TO 10
01440   C
01441      590 FORMAT (1H1,50X,13HTRIAL NUMBER I2,/)
01442      600 FORMAT (1H0,50X,19HBOUNDARY CONDITIONS)
01443      610 FORMAT (1H0,5HB1  =E18.11,2X,5HB2  =E18.11,2X,5HB3  =E18.11,2X,5HB
01443         14  =E18.11,/,6H B5  =E18.11,2X,5HERR =E18.11)
01444      620 FORMAT (1H0,50X,14HDESIRED VALUES,//,1X,5(E15.8,2X))
01445      630 FORMAT (1H0,5HAK  =F6.3,14X,5HTOL =E18.11,2X,5HWF  =E18.11)
01446      640 FORMAT (1H0,50X,11HPBWU MATRIX,/)
01447      650 FORMAT (1H0,50X,28HSIMULTANEOUS EQUATION MATRIX,/)
01450      660 FORMAT (1H0,50X,15HRIGHT HAND SIDE,/)
01451      670 FORMAT (1H0,50X,6HANSWER,/)
01452      680 FORMAT (1H0,50X,5HCHECK,/)
01453      690 FORMAT (6(E15.8,2X))
01454      700 FORMAT (1H0,50X,20HITERATION PARAMETERS,/)
01455      710 FORMAT (4(E15.8,2X))
01456      720 FORMAT (1H0,50X,14HCASE CONVERGED)
01457      730 FORMAT (1H1,25X,38HTHIS IS A FULL PRINT OF CONVERGED CASE)
01460      740 FORMAT (1H0,50X,19HINTERMEDIATE VALUES,1X,I4,1X,23HINTEGRATION STE
01460         1PS TAKEN)
01461      750 FORMAT (1H0,50X,18HFINAL LAMDA VALUES)
01462      760 FORMAT (1H0,50X,20HINITIAL LAMDA VALUES)
01463      770 FORMAT (1H0,5HLAM1=E18.11,2X,5HLAM2=E18.11,2X,5HLAM3=E18.11,/,6H L
01463         1AM4=E18.11,2X,5HLAM5=E18.11,2X,5HLAM6=E18.11,2X,5HLAM7=E18.11)
01464      780 FORMAT (1H0,50X,I4,19H TRIALS IS TOO MANY)
01465      790 FORMAT (3D18.11)
01466      800 FORMAT (1H0,/,51X,14HINITIAL VALUES)
01467      810 FORMAT (1H0,50X,12HFINAL VALUES,1X,I4,1X,23HINTEGRATION STEPS TAKE
01467         1N)
01470          END
        END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE PRINT      ENTRY POINT 001201

STORAGE USED: CODE(1) 001220; DATA(0) 000556; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   DIFEQ  000070
 0004   ENDCDN 000054
 0005   CONST  000103

EXTERNAL REFERENCES (BLOCK, NAME)

 0006   TANGL
 0007   DSQRT
 0010   DATAN
 0011   DSIN
 0012   DCOS
 0013   NPRT$
 0014   NI01$
 0015   NI02$
 0016   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000222 110L      0001   000306 130L      0001   000104 137G      0001   000361 150L      0001   000443 170L
 0001   000466 190L      0001   000033 20L       0001   000655 210L      0001   000663 230L      0001   000674 250L
 0001   000707 270L      0001   000623 275G      0000   000127 280F      0000   000205 290F      0000   000353 300F
 0000   000415 310F      0000   000457 320F      0000   000473 330F      0001   000735 337G      0000   000500 340F
 0001   000745 344G      0000   000503 350F      0001   000755 351G      0001   000771 361G      0001   001000 366G
 0001   001007 373G      0001   000064 40L       0001   001016 400G      0001   001041 421G      0001   001064 440G
 0001   001073 445G      0001   001141 501G      0001   001157 511G      0001   000120 70L       0001   000171 90L
 0005 D 000016 AA        0005 D 000072 AB        0003 D 000044 ACH       0000 D 000067 AJ        0003 D 000034 ALB
 0003 D 000054 ALFA      0003 D 000050 ALT       0004 D 000002 AMC       0005 D 000010 AREA      0005 D 000004 AZ
 0005 D 000012 BE        0003 D 000056 BEDA      0003 D 000042 CA        0000 D 000014 CCHI      0000 D 000020 CCHI2
 0000 D 000053 CD        0000 D 000016 CHIP      0000 D 000022 CHIY      0005 D 000062 CK1       0005 D 000064 CK2
 0005 D 000066 CK3       0000 D 000051 CL        0003 D 000060 CLA       0000 D 000123 CLAT      0000 D 000115 CLNG
 0000 D 000077 COA       0000 D 000103 COP       0004 D 000052 CRAD      0004 D 000004 CTHC      0000 D 000107 CWT
 0003 D 000014 DB        0000 D 000024 DCEL      0003 D 000022 ETA       0005 D 000032 EXA       0003 D 000062 F
 0005 D 000024 FD        0005 D 000022 FH        0005 D 000020 FJ        0005 D 000052 FS        0005 D 000000 GM
 0005 D 000060 HEATC     0000 I 000026 I         0005   000102 ICNVG     0000   000524 INJPS     0005 D 000014 OM
 0000 D 000055 PANG      0000 D 000061 PHIC      0005 D 000002 PHIL      0000 D 000057 PHIR      0003 D 000010 PRES
 0005 D 000054 PO        0003 D 000064 QQ        0003 D 000000 R         0000 D 000065 RANG      0000 D 000073 RAZ
 0004 D 000000 RC        0005 D 000006 RCONV     0004 D 000006 RCTHC     0005 D 000070 RCURV     0003 D 000024 RE
 0003 D 000052 RHO       0005 D 000026 RISP      0000 D 000125 RLAT      0005 D 000100 RLGO      0000 D 000121 RLNG
 0005 D 000030 RMD       0000 D 000071 RPHIL     0004 D 000030 RVR       0004 D 000022 RXVOB     0004 D 000014 ROB
 0000 D 000041 R2        0000 D 000012 SCHI      0004 D 000012 SCRAD     0000 D 000075 SIA       0000 D 000101 SIP
 0000 D 000111 SIWT      0000 D 000113 SLAT      0000 D 000117 SLNG      0004 D 000010 SRAD      0005 D 000050 TO
 0003 D 000026 U         0000 D 000047 UP3       0004 D 000036 UXE       0004 D 000044 UYE       0005 D 000034 UO
 0005 D 000042 UOD       0000 D 000010 V         0000 D 000037 VDX       0003 D 000002 VR        0003 D 000012 VRM
```

```
0000 D 000027 VRM2     0000 D 000031 VRM4     0003 D 000066 VS       0000 D 000000 VXR     0000 D 000035 VXRM
0000 D 000033 VXRM2    0000 D 000045 VXRXV    0000 D 000043 VXR2X    0000 D 000006 V2      0003 D 000046 WKG
0005 D 000056 WKGO     0000 D 000105 WT       0000 D 000063 XRNG


00101      1*         SUBROUTINE PRINT (T,X,DX)                                              B   1
00103      2*         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*         DIMENSION X(50), DX(50)                                                B   2
00105      4*         DIMENSION VR(3), VXR(3), U(3), ALB(3), DB(3), AB(3), UO(3), UOD(3)     B   3
00106      5*         DIMENSION ROB(3), RXVOB(3), RVR(3), UXE(3), UYE(3)                     B   4
00107      6*         COMMON /DIFEQ/ R,VR,PRES,VRM,DB,ETA,RE,U,ALB,CA,ACH,WKG,ALT,RHO,AL     B   5
00107      7*        1FA,BEDA,CLA,F,QQ,VS                                                    B   6
00110      8*         COMMON /ENDCDN/ RC,AMC,CTHC,RCTHC,SRAD,SCRAD,ROB,RXVOB,RVR,UXE,UYE     B   7
00110      9*        1,CRAD                                                                  B   8
00111     10*         COMMON /CONST/ GM,PHIL,AZ,RCONV,AREA,BE,OM,AA,FJ,FH,FD,RISP,RMD,EX     B   9
00111     11*        1A,UO,UOD,TO,FS,PO,WKGO,HEATC,CK1,CK2,CK3,RCURV,AB,RLGO,ICNVG           B  10
00112     12*         V2=(X(4)**2+X(5)**2+X(6)**2)                                           B  11
00113     13*         IF (V2) 10,20,20                                                       B  12
00116     14*      10 V2=0.                                                                  B  13
00117     15*      20 CONTINUE                                                               B  14
00120     16*         V=SQRT(V2)                                                             B  15
00121     17*         SCHI=U(3)                                                              B  16
00122     18*         CCHI=U(1)                                                              B  17
00123     19*         CALL TANGL (SCHI,CCHI,CHIP)                                            B  18
00124     20*         SCHI=U(2)                                                              B  19
00125     21*         CCHI2=(U(1)*U(1)+U(3)*U(3))                                            B  20
00126     22*         IF (CCHI2) 30,40,40                                                    B  21
00131     23*      30 CCHI2=0.                                                               B  22
00132     24*      40 CONTINUE                                                               B  23
00133     25*         CCHI=SQRT(CCHI2)                                                       B  24
00134     26*         CHIY=ATAN(SCHI/CCHI)/RCONV                                             B  25
00135     27*         DCEL=0.                                                                B  26
00136     28*         DO 50 I=1,3                                                            B  27
00141     29*      50 DCEL=DCEL+ALB(I)*ALB(I)+DB(I)*DB(I)                                    B  28
00143     30*         IF (DCEL) 60,70,70                                                     B  29
00146     31*      60 DCEL=0.                                                                B  30
00147     32*      70 CONTINUE                                                               B  31
00150     33*         DCEL=SQRT(DCEL)/WKG                                                    B  32
00151     34*         VRM2=VRM*VRM                                                           B  33
00152     35*         VRM4=VRM2*VRM2                                                         B  34
00153     36*         VXR(1)=VR(2)*X(3)-VR(3)*X(2)                                           B  35
00154     37*         VXR(2)=VR(3)*X(1)-VR(1)*X(3)                                           B  36
00155     38*         VXR(3)=VR(1)*X(2)-VR(2)*X(1)                                           B  37
00156     39*         VXRM2=(VXR(1)*VXR(1)+VXR(2)*VXR(2)+VXR(3)*VXR(3))                      B  38
00157     40*         IF (VXRM2) 80,90,90                                                    B  39
00162     41*      80 VXRM2=0.                                                               B  40
00163     42*      90 CONTINUE                                                               B  41
00164     43*         VXRM=SQRT(VXRM2)                                                       B  42
00165     44*         VDX=VR(1)*X(1)+VR(2)*X(2)+VR(3)*X(3)                                   B  43
00166     45*         R2=R*R                                                                 B  44
00167     46*         VXR2X=(VRM4*R2-VDX*VDX*VRM2)                                           B  45
00170     47*         IF (VXR2X) 100,110,110                                                 B  46
00173     48*     100 VXR2X=0.                                                               B  47
00174     49*     110 CONTINUE                                                               B  48
```

```
      VXRXV=SQRT(VXR2X)
      UP3=U(1)*VR(1)+U(2)*VR(2)+U(3)*VR(3)
      SCHI=(U(1)*VXR(1)+U(2)*VXR(2)+U(3)*VXR(3))/VXRM
      CCHI=((U(1)*X(1)+U(2)*X(2)+U(3)*X(3))*VRM2-VDX*UP3)/VXRXV
      CALL TANGL (SCHI,CCHI,BEDA)
      SCHI=(SCHI*SCHI+CCHI*CCHI)
      IF (SCHI) 120,130,130
  120 SCHI=0.
  130 CONTINUE
      SCHI=SQRT(SCHI)
      CCHI=UP3/VRM
      CL=CLA*SCHI
      CD=CA+2.*ETA*CLA*(1.-CCHI)*CLA
      CALL TANGL (SCHI,CCHI,ALFA)
      CCHI=(X(1)*DX(1)+X(2)*DX(2)+X(3)*DX(3))/(R*V)
      SCHI=(1.-CCHI*CCHI)
      IF (SCHI) 140,150,150
  140 SCHI=0.
  150 CONTINUE
      SCHI=SQRT(SCHI)
      CALL TANGL (SCHI,CCHI,PANG)
C     RANGE WILL BE WRONG IF RANGE ANGLE > 180 DEGREES
      SCHI=RVR(1)*X(1)+RVR(2)*X(2)+RVR(3)*X(3)
      CCHI=ROB(1)*X(1)+ROB(2)*X(2)+ROB(3)*X(3)
      CALL TANGL (SCHI,CCHI,PHIR)
      CCHI=-(X(1)*RXVOB(1)+X(2)*RXVOB(2)+X(3)*RXVOB(3))/R
      SCHI=(1.-CCHI*CCHI)
      IF (SCHI) 160,170,170
  160 SCHI=0.
  170 CONTINUE
      SCHI=SQRT(SCHI)
      PHIC=ATAN(CCHI/SCHI)
      XRNG=PHIC*RE
      IF ((PHIR-360.)+.5E-04) 190,180,180
  180 PHIR=0.
  190 CONTINUE
      RANG=RCONV*RE*PHIR
      AJ=CK1*WKG+CK2*X(7)+CK3*X(8)
C     COMPUTATION OF VECTORS NEEDED FOR LONGITUDE
      RPHIL=PHIL*RCONV
      RAZ=AZ*RCONV
      SIA=SIN(RAZ)
      COA=COS(RAZ)
      SIP=SIN(RPHIL)
      COP=COS(RPHIL)
      WT=OM*(T-TO)
      CWT=COS(WT)
      SIWT=SIN(WT)
      UXE(1)=COP*CWT
      UXE(2)=COA*SIWT+SIA*SIP*CWT
      UXE(3)=SIA*SIWT-COA*SIP*CWT
      UYE(1)=-COP*SIWT
      UYE(2)=COA*CWT-SIA*SIP*SIWT
      UYE(3)=SIA*CWT+COA*SIP*SIWT
      SLAT=0.
      CLNG=0.
```

```
00273          SLNG=0.
00274          DO 200 I=1,3
00277          SLAT=SLAT+X(I)*AB(I)
00300          CLNG=CLNG+X(I)*UXE(I)
00301      200 SLNG=SLNG+X(I)*UYE(I)
00303          CALL TANGL (SLNG,CLNG,RLNG)
00304          RL''G=RLGO+360.-(RLNG+RCONV*OM*TO)
00305      210 I+ (RLNG) 220,230,230
00310      220 RLNG=360.+RLNG
00311          GO TO 210
00312      230 IF (RLNG-360.) 250,250,240
00315      240 RLNG=RLNG-360.
00316          GO TO 230
00317      250 CONTINUE
00320          SLAT=SLAT/R
00321          CLAT=(1.-SLAT*SLAT)
00322          IF (CLAT) 260,270,270
00325      260 CLAT=0.
00326      270 CONTINUE
00327          CLAT=SQRT(CLAT)
00330          RLAT=ATAN(SLAT/CLAT)/RCONV
00331          PRINT 280, T,R,V,GM,(X(I),I=1,3),PHIL,(X(I),I=4,6),AZ,(DX(I),I=4,6
00331         1),ALT
00356          PRINT 290, WKG,(VR(I),I=1,3),VRM,(U(I),I=1,3),ALFA,(ALB(I),I=1,3),
00356         1BEDA,(DB(I),I=1,3),AREA,CL,CD,ETA,RHO,QQ,AA,BE,OM,FJ,FH,FD,F,(AB(I
00356         2),I=1,3),RISP,RMD,CHIP,CHIY
00431          PRINT 300, RANG,XRNG,PANG,DCEL,PRES,UO,ACH,UOD
00451          PRINT 310, CA,CLA,EXA,HEATC,CK1,CK2,CK3,RCURV,AJ,X(7),DX(7),X(8)
00467          PRINT 320, DX(8),RLAT,RLNG,RLGO
00475          PRINT 330
00477          PRINT 340, (X(I),I=9,50)
00505          PRINT 350
00507          PRINT 340, (DX(I),I=9,50)
00515          RETURN
00515    C
00516      280 FORMAT (1HO,5HT    =E18.11,2X,5HR    =E18.11,2X,5HV    =E18.11,2X,5HG
00516         1M  =E18.11,/,6H X   =E18.11,2X,5HY    =E18.11,2X,5HZ    =E18.11,2X,5
00516         2HPHI =E18.11,/,6H DX  =E18.11,2X,5HDY   =E18.11,2X,5HDZ   =E18.11,2X
00516         3,5HAZ  =E18.11,/,6H DDX =E18.11,2X,5HDDY  =E18.11,2X,5HDDZ  =E18.11,
00516         42X,5HALT =E18.11)
00517      290 FORMAT (6H WKG =E18.11,2X,5HVRX =E18.11,2X,5HVRY =E18.11,2X,5HVRZ
00517         1=E18.11,/,6H VR  =E18.11,2X,5HUX  =E18.11,2X,5HUY  =E18.11,2X,5HUZ
00517         2  =E18.11,/,6H ALFA=E18.11,2X5HLFX =E18.11,2X,5HLFY =E18.11,2X,5HL
00517         3FZ =E18.11,/,6H BETA=E18.11,2X,5HDFX =E18.11,2X,5HDFY =E18.11,2X,5
00517         4HDFZ =E18.11,/,6H AREA=E18.11,2X,5HCL   =E18.11,2X,5HCD   =E18.11,2X
00517         5,5HETA =E18.11,/,6H RHO =E18.11,2X,5HQ    =E18.11,2X,5HAE   =E18.11,
00517         62X,5HBE  =E18.11,/,6H OM  =E18.11,2X,5HFJ  =E18.11,2X,5HFH  =E18.1
00517         71,2X,5HFD  =E18.11,/,6H F    =E18.11,2X,5HOMX =E18.11,2X,5HOMY =E18
00517         8.11,2X,5HOMZ =E18.11,/,6H ISP =E18.11,2X,5HMD   =E18.11,2X,5HCHIP=E
00517         918.11,2X,5HCHIY=E18.11)
00520      300 FORMAT (6H DRNG=E18.11,2X,5HXRNG=E18.11,2X,5HPANG=E18.11,2X,5HDCEL
00520         1=E18.11,/,6H PRES=E18.11,2X,5HUOX =E18.11,2X,5HUOY =E18.11,2X,5HUO
00520         2Z =E18.11,/,6H MACH=E18.11,2X,5HUODX=E18.11,2X,5HUODY=E18.11,2X,5H
00520         3UODZ=E18.11)
00521      310 FORMAT (6H CDO =E18.11,2X,5HCLA =E18.11,2X,5HEXA =E18.11,2X,5HHTC
00521         1=E18.11,/,6H CK1 =E18.11,2X,5HCK2 =E18.11,2X,5HCK3 =E18.11,2X,5HRC
```

```
00521    162*        2RV=E18.11,/,6H J    =E18.11,2X,5HHT1 =E18.11,2X,5HDHT1=E18.11,2X,5H  B 161
00521    163*        3DCLI=E18.11)                                                              B 162
00522    164*     320 FORMAT (6H D2  =E18.11,2X,5HLAT =E18.11,2X,5HLONG=E18.11,2X,5HLNGO  B 163
00522    165*        1=E18.11)                                                                  B 164
00523    166*     330 FORMAT (1H0,50X,14HPXF/PUO MATRIX)                                        B 165
00524    167*     340 FORMAT (6(E15.8,2X))                                                      B 166
00525    168*     350 FORMAT (1H0,50X,15HDPXF/PUO MATRIX)                                       B 167
00526    169*         END                                                                       B 168-

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE RK713     ENTRY POINT 000336

STORAGE USED: CODE(1) 000375; DATA(0) 003033; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   RKINTG 000554

EXTERNAL REFERENCES (BLOCK, NAME)

 0004   DEQ
 0005   NEXPAS
 0006   NERR3S

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000177 110L     0001   000024 112G     0001   000037 120G     0001   000201 120L     0001   000047 125G
 0001   000054 130G     0001   000076 136G     0001   000226 140L     0001   000077 141G     0001   000130 151G
 0001   000146 160G     0001   000154 165G     0001   000156 170G     0001   000273 170L     0001   000172 176G
 0001   000274 180L     0001   000027 20L      0001   000303 200L     0001   000220 212G     0001   000313 220L
 0001   000315 230L     0001   000300 241G     0000 D 002747 A       0000 D 002755 AK      0003 D 000470 ALPH
 0003 D 000000 BETA     0003 D 000522 CH      0000 D 002736 DT      0000 D 002753 DTI     0000 D 002751 ER
 0000 D 000000 F        0000 I 002740 I       0000   002775 INJPS   0000 I 002743 J       0000 I 002741 K
 0000 I 002746 L        0000 I 002742 NN      0000 D 002734 T       0000 D 002744 TDUM    0000 D 002570 TE
 0000 D 002424 XDUM


00101      1*          SUBROUTINE RK713 (TI,TF,DTG,TOL,XI,X,N,KT,M)                       C   1
00103      2*          IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00103      3*    C     SEVENTH ORDER RUNGE-KUTTA INTEGRATION WITH STEPSIZE CONTROL        C   2
00103      4*    C     TF CAN BE GREATER THAN TI OR LESS THAN TI AND RK713 WILL WORK      C   3
00103      5*    C     M IS THE NUMBER OF STEPS NEEDED                                    C   4
00103      6*    C     N IS THE NUMBER OF DIFFERENTIAL EQUATIONS                          C   5
00103      7*    C     KT IS MAX NUMBER OF ITERATIONS                                     C   6
00103      8*    C     ARRAY F STORES THE 13 EVALUATIONS OF THE DIFFERENTIAL EQUATIONS    C   7
00103      9*    C     SUBSCRIPTS FOR ALPHA,BETA, AND CH ARE +1 GREATER THAN FEHLBERGS    C   8
00103     10*    C     F(0) IN FEHLBERGS REPORT IS IN F(1,J)                              C   9
00103     11*    C     F(I) IS IN F(I+1,J)                                                C  10
00103     12*    C     PARAMETERS FOR DEQ SUBROUTINE MUST BE STORED IN COMMON             C  11
00103     13*    C     DIMENSIONS MUST AGREE WITH NUMBER OF DIFFERENTIAL EQUATIONS AND    C  12
00103     14*    C     NUMBER OF CONSTANTS IN THE PARTICULAR FEHLBERG FORMULA USED        C  13
00104     15*          DIMENSION F(13,50), XDUM(50), TE(50), XI(50), ALPH(13), BETA(13,12 C  14
00104     16*         1), X(50), CH(13)                                                   C  15
00105     17*          COMMON /RKINTG/ BETA,ALPH,CH                                       C  16
00106     18*          T=TI                                                               C  17
00107     19*          DT=DTG                                                             C  18
00110     20*          M=0                                                                C  19
```

```
00111    21*        DO 10 I=1,N                                             C  20
00114    22*     10 X(I)=XI(I)                                              C  21
00116    23*     20 CALL DEQ (X,T,TE)                                       C  22
00117    24*        DO 30 I=1,N                                             C  23
00122    25*     30 F(1,I)=TE(I)                                            C  24
00124    26*        DO 70 K=2,13                                            C  25
00127    27*        DO 40 I=1,N                                             C  26
00132    28*     40 XDUM(I)=X(I)                                            C  27
00134    29*        NN=K-1                                                  C  28
00135    30*        DO 50 I=1,N                                             C  29
00140    31*        DO 50 J=1,NN                                            C  30
00143    32*     50 XDUM(I)=XDUM(I)+DT*BETA(K,J)*F(J,I)                     C  31
00146    33*        TDUM=T+ALPH(K)*DT                                       C  32
00147    34*        CALL DEQ (XDUM,TDUM,TE)                                 C  33
00150    35*        DO 60 I=1,N                                             C  34
00153    36*     60 F(K,I)=TE(I)                                            C  35
00155    37*     70 CONTINUE                                                C  36
00157    38*        DO 80 I=1,N                                             C  37
00162    39*     80 XDUM(I)=X(I)                                            C  38
00164    40*        DO 90 I=1,N                                             C  39
00167    41*        DO 90 L=1,13                                            C  40
00172    42*     90 X(I)=X(I)+DT*CH(L)*F(L,I)                               C  41
00175    43*        DO 120 I=1,N                                            C  42
00200    44*        IF (X(I)) 110,100,110                                   C  43
00203    45*    100 A=1.                                                    C  44
00204    46*        GO TO 120                                               C  45
00205    47*    110 A=X(I)                                                  C  46
00206    48*    120 TE(I)=DT*(F(1,I)+F(11,I)-F(12,I)-F(13,I))*41./840./A    C  47
00210    49*        ER=ABS(TE(1))                                           C  48
00211    50*        DO 140 I=2,N                                            C  49
00214    51*        IF (ABS(TE(I))-ER) 140,140,130                          C  50
00217    52*    130 ER=ABS(TE(I))                                           C  51
00220    53*    140 CONTINUE                                                C  52
00222    54*        DT1=DT                                                  C  53
00223    55*        M=M+1                                                   C  54
00224    56*        AK=.8                                                   C  55
00225    57*        DT=AK*DT1*(TOL/ER)**.125                                C  56
00226    58*        IF (ER-TOL) 150,150,180                                 C  57
00231    59*    150 T=T+DT1                                                 C  58
00232    60*        IF (ABS(DT)-ABS(TF-T)) 170,170,160                      C  59
00235    61*    160 DT=TF-T                                                 C  60
00236    62*    170 CONTINUE                                                C  61
00237    63*        GO TO 200                                               C  62
00240    64*    180 DO 190 I=1,N                                            C  63
00243    65*    190 X(I)=XDUM(I)                                            C  64
00245    66*    200 IF (M-KT) 210,220,220                                   C  65
00250    67*    210 IF (T-TF) 20,230,20                                     C  66
00253    68*    220 TF=T                                                    C  67
00254    69*    230 RETURN                                                  C  68
00255    70*        END                                                     C  69

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE DEQ        ENTRY POINT 002130

STORAGE USED: CODE(1) 002157; DATA(0) 000556; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   DIFEQ  000070
 0004   CONST  000103

EXTERNAL REFERENCES (BLOCK, NAME)

 0005   ATMOS
 0006   AEROD
 0007   DSQRT
 0010   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000534 120L     0001   000204 147G     0001   000362 176G     0001   000033 20L      0001   000406 201G
 0001   000430 207G     0001   000511 226G     0001   000545 242G     0001   000712 272G     0001   001372 280L
 0001   000727 300G     0001   001421 300L     0001   000731 303G     0001   000764 313G     0001   000774 320G
 0001   000776 323G     0001   001002 330G     0001   001035 341G     0001   001052 344G     0001   001120 356G
 0001   001164 372G     0001   000150 40L      0001   001216 401G     0001   001222 405G     0001   001246 415G
 0001   001250 420G     0001   001271 427G     0001   001276 432G     0001   001325 444G     0001   001361 457G
 0001   001362 462G     0001   001437 506G     0001   001444 513G     0001   001466 522G     0001   001470 525G
 0001   001471 530G     0001   001515 540G     0001   001516 543G     0001   001537 555G     0001   001545 560G
 0001   001561 565G     0001   001726 604G     0001   001752 612G     0001   001756 616G     0001   001772 624G
 0001   002006 632G     0001   002012 635G     0001   002077 651G     0001   000500 90L      0000 D 000312 A
 0004 D 000016 AA       0004 D 000072 AB       0003 D 000044 ACH      0003 D 000034 ALB      0003 D 000054 ALFA
 0003 D 000050 ALT      0004 D 000010 AREA     0004 D 000004 AZ       0000 D 000306 B        0000 D 000310 BB
 0004 D 000012 BE       0003 D 000056 BEDA     0000 D 000314 BE2      0003 D 000042 CA       0000 D 000361 CC1
 0000 D 000422 CC10     0000 D 000363 CC2      0000 D 000365 CC3      0004 D 000062 CK1      0004 D 000064 CK2
 0004 D 000066 CK3      0003 D 000060 CLA      0000 D 000420 CLA2     0000 D 000322 C1       0000 D 000355 C10
 0000 D 000357 C11      0000 D 000336 C12      0000 D 000340 C13      0000 D 000324 C2       0000 D 000326 C3
 0000 D 000330 C4       0000 D 000332 C5       0000 D 000334 C6       0000 D 000347 C7       0000 D 000351 C8
 0000 D 000353 C9       0003 D 000014 DB       0000 D 000410 DCA      0000 D 000406 DCLA     0000 D 000412 DETA
 0000 D 000404 DPRES    0000 D 000402 DRHO     0000 D 000400 DVS      0003 D 000022 ETA      0004 D 000032 EXA
 0000 D 000316 E2       0000 D 000320 E4       0003 D 000062 F        0004 D 000024 FD       0004 D 000022 FH
 0004 D 000020 FJ       0004 D 000052 FS       0004 D 000000 GM       0000 D 000345 GP       0000 D 000343 GR
 0004 D 000060 HEATC    0000 I 000342 I        0004 I 000102 ICNVG    0000   000501 INJPS    0000 I 000367 J
 0000 I 000424 K        0000 I 000425 L        0000 I 000427 L1       0000 I 000426 M        0000 I 000430 M1
 0004 D 000014 OM       0000 D 000000 P        0000 D 000220 PAXB     0000 D 000110 PHI      0004 D 000002 PHIL
 0000 D 000250 PJXB     0000 D 000264 PMXB     0003 D 000010 PRES     0000 D 000226 PVXB     0004 D 000054 PO
 0003 D 000064 QQ       0003 D 000000 R        0004 D 000006 RCONV    0004 D 000070 RCURV    0003 D 000024 RE
 0003 D 000052 RHO      0000 D 000302 RI       0004 D 000026 RISP     0004 D 000100 RLGO     0004 D 000030 RMD
 0000 D 000300 R2       0000 D 000304 R2I      0000 D 000376 TEMP     0004 D 000050 TO       0003 D 000026 U
 0000 D 000374 UM       0000 D 000372 UM2      0004 D 000034 UO       0004 D 000042 UOD      0000 D 000416 VDU
 0003 D 000002 VR       0003 D 000012 VRM      0000 D 000370 VRM2     0003 D 000066 VS       0003 D 000046 WKG
 0000 D 000414 WKGI     0004 D 000056 WKGO
```

```
      SUBROUTINE DEQ (X,T,DX)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION X(50), DX(50), AB(3)
      DIMENSION VR(3), U(3), ALB(3), DB(3), UO(3), UOD(3)
      DIMENSION P(6,6), PHI(6,6), PAXB(3), PVXB(3,3), PJXB(6), PMXB(6)
      COMMON /DIFEQ/ R,VR,PRES,VRM,DB,ETA,RE,U,ALB,CA,ACH,WKG,ALT,RHO,AL
     1FA,BEDA,CLA,F,QQ,VS
      COMMON /CONST/ GM,PHIL,AZ,RCONV,AREA,BE,OM,AA,FJ,FH,FD,RISP,RMD,EX
     1A,UO,UOD,TO,FS,PO,WKGO,HEATC,CK1,CK2,CK3,RCURV,AB,RLGO,ICNVG
      R2=X(1)*X(1)+X(2)*X(2)+X(3)*X(3)
      IF (R2) 10,20,20
   10 R2=0.
   20 CONTINUE
      R=SQRT(R2)
      RI=1./R
      R2I=1./R2
      B=AA*AA*R2I
      BB=AA*RI
      A=(AB(1)*X(1)+AB(2)*X(2)+AB(3)*X(3))*RI
      BE2=BE*BE
      E2=A*A
      E4=E2*E2
      C1=3.*FD*(1./7.-2.*E2+3.*E4)*B
      C2=FH*BB*A*(3.-7.*E2)
      C3=4.*FD*A*(3./7.-E2)*B
      C4=FH*BB*(E2-1./5.)
      C5=AA*AA-BE2
      C6=BE2+C5*E2
      IF (C6) 30,40,40
   30 C6=0.
   40 CONTINUE
      RE=AA*BE/SQRT(C6)
      C12=RE*A*C5/C6*RI
      C13=C12*A*RI
      DO 50 I=1,3
      PVXB(I,I)=0.
   50 PAXB(I)=(RI-C13)*X(I)+C12*AB(I)
      PVXB(1,2)=OM*AB(3)
      PVXB(1,3)=-OM*AB(2)
      PVXB(2,3)=OM*AB(1)
      PVXB(2,1)=-PVXB(1,2)
      PVXB(3,1)=-PVXB(1,3)
      PVXB(3,2)=-PVXB(2,3)
      GR=B*(FJ*(1.-5.*E2)+C1+C2)
      GP=B*(2.*FJ*A+C3+3.*C4)
      C7=(2.5*GR+1.5+B*(C1+.5*C2))*RI
      C8=2.*GP+B*(C3+1.5*C4)
      C9=(12.*FD*A*(3.*E2-1.)*B+3.*FH*BB*(1.-7.*E2)-10.*FJ*A)*R2I
      C10=(2.*FJ+12.*FD*(1./7.-E2)*B+6.*FH*A*BB)*RI
      C11=(1.+GR)*RI
      C12=A*RI
      CC1=GM*R2I
      CC2=CC1*C11
      CC3=CC1*GP
      DO 60 I=1,3
```

```
00200           DO 60 J=1,3
00203        60 P(I+3,J)=CC1*(2.*R2I*(C7*X(I)+C8*AB(I))*X(J)-B*(C9*X(I)+C10*AB(I))
00203          1*(AB(J)-C12*X(J)))
00206           DO 70 I=1,3
00211        70 P(I+3,I)=P(I+3,I)-CC2
00213           VR(1)=X(4)-OM*(AB(2)*X(3)-AB(3)*X(2))
00214           VR(2)=X(5)-OM*(AB(3)*X(1)-AB(1)*X(3))
00215           VR(3)=X(6)-OM*(AB(1)*X(2)-AB(2)*X(1))
00216           VRM2=VR(1)*VR(1)+VR(2)*VR(2)+VR(3)*VR(3)
00217           IF (VRM2) 80,90,90
00222        80 VRM2=0.
00223        90 CONTINUE
00224           VRM=SQRT(VRM2)
00225           DO 100 I=1,3
00230       100 U(I)=U0(I)+(T-T0)*U0D(I)
00232           UM2=U(1)*U(1)+U(2)*U(2)+U(3)*U(3)
00233           IF (UM2) 110,120,120
00236       110 UM2=0.
00237       120 CONTINUE
00240           UM=SQRT(UM2)
00241           DO 130 I=1,3
00244       130 U(I)=U(I)/UM
00246           ALT=R-RE
00247           CALL ATMOS (ALT,TEMP,PRES,RHO,VS,DVS,DRHO,DPRES)
00250           ACH=VRM/VS
00251           CALL AEROD (ACH,CLA,CA,ETA,DCLA,DCA,DETA)
00252           F=FS+EXA*(P0-PRES)
00253           WKG=WKG0-RMD*(T-T0)
00254           WKGI=1./WKG
00255           VDU=VR(1)*U(1)+VR(2)*U(2)+VR(3)*U(3)
00256           QQ=.5*RHO*AREA*VRM2
00257           CLA2=CLA*CLA
00260           C1=QQ*CLA
00261           C2=-C1*VDU/VRM2
00262           C3=CA+2.*ETA*CLA2
00263           C4=-2.*ETA*CLA2
00264           C5=QQ*(C3/VRM+C4*VDU/VRM2)
00265           C6=QQ/VRM2
00266           C7=C6*CLA
00267           C8=C6*C3/VRM
00270           C9=C6*C4
00271           DO 140 I=1,3
00274           ALB(I)=C1*U(I)+C2*VR(I)
00275       140 DB(I)=C5*VR(I)
00277           DO 150 I=1,3
00302           DO 150 J=1,3
00305           P(I,J)=(U(I)*VR(J)*2.-VR(I)*U(J))*C7
00306       150 P(I,J+3)=VR(I)*(C8*VR(J)+C9*U(J))
00311           CC10=C7*VDU
00312           DO 160 I=1,3
00315       160 P(I,I)=P(I,I)-CC10
00317           DO 170 I=1,3
00322           DO 170 J=1,3
00325           PHI(I,J+3)=0.
00326           P(I+3,J+3)=0.
00327           DO 170 K=1,3
```

```
00332              PHI(I,J+3)=PHI(I,J+3)+P(I,K)*PVXB(K,J)
00333          170 P(I+3,J+3)=P(I+3,J+3)+P(I,K+3)*PVXB(K,J)
00337              C10=-EXA*DPRES
00340              DO 180 I=1,3
00343              DO 180 J=1,3
00346              P(I+3,J)=P(I+3,J)+WKGI*(PHI(I,J+3)-P(I+3,J+3)+((ALB(I)-DB(I))/RHO*
00346             1DRHO+C10*U(I))*PAXB(J)-C5*PVXB(I,J))
00347              P(I+3,J+3)=(P(I,J)-P(I,J+3))*WKGI
00350          180 PHI(I+3,J)=-WKGI*(C7+C9)*VR(I)*VR(J)
00353              C11=(C1+F)*WKGI
00354              C12=C5*WKGI
00355              DO 190 I=1,3
00360              P(I+3,I+3)=P(I+3,I+3)-C12
00361          190 PHI(I+3,I)=PHI(I+3,I)+C11
00363              C7=VRM-VDU
00364              C8=C6*C7*2.
00365              C9=C8*ETA*2.*CLA
00366              C10=C8*CLA2
00367              C11=C6*VRM
00370              C12=C9*DCLA+C10*DETA+C11*DCA
00371              DO 200 I=1,3
00374          200 DX(I+3)=WKGI*(ALB(I)/CLA*DCLA-C12*VR(I))
00376              C7=1./(VS*VRM)
00377              C8=VRM/VS*DVS/VS
00400              DO 220 I=1,3
00403              DX(I)=0.
00404              DO 210 J=1,3
00407          210 DX(I)=DX(I)+VR(J)*PVXB(J,I)
00411              PMXB(I+3)=C7*VR(I)
00412          220 PMXB(I)=C7*DX(I)-C8*PAXB(I)
00414              DO 230 I=1,3
00417              DO 230 J=1,3
00422              P(I+3,J)=P(I+3,J)+DX(I+3)*PMXB(J)
00423          230 P(I+3,J+3)=P(I+3,J+3)+DX(I+3)*PMXB(J+3)
00426              DO 240 I=1,3
00431              DO 240 J=1,3
00434              P(I,J)=0.
00435              P(I,J+3)=0.
00436              PHI(I,J)=0.
00437              PHI(I,J+3)=-1./UM*U(I)*U(J)
00440          240 PHI(I+3,J+3)=(T-TO)*PHI(I,J+3)
00443              DO 250 I=1,3
00446              P(I,I+3)=1.
00447              PHI(I,I+3)=PHI(I,I+3)+1./UM
00450              PHI(I+3,I+3)=PHI(I+3,I+3)+(T-TO)/UM
00451          250 DX(I+3)=-CC2*X(I)-CC3*AB(I)+(ALB(I)-DB(I)+F*U(I))*WKGI
00451        C     ON A CONVERGED CASE INTEGRATION PARTIAL OF DX WITH RESPECT TO UO A
00451        C     UOD BAR ARE SET EQUAL TO ZERO SO THAT X9 THROUGH X50 WILL BE PARTI
00451        C     OF X WITH RESPECT TO XO AND NOT PARTIAL OF X WITH RESPECT TO UO AN
00451        C     UOD BAR AS IN THE ITERATION LOOP
00453              IF (ICNVG) 280,280,260
00456          260 DO 270 I=1,3
00461              DO 270 J=1,3
00464              PHI(I,J+3)=0.
00465          270 PHI(I+3,J+3)=0.
00470          280 CONTINUE
```

```
00471         C3=1.+2.*ETA*CA
00472         C4=CA*CA
00473         C5=CLA2*C3*2.
00474         C6=C4+C5
00475         C7=QQ*QQ*WKGI*WKGI
00476         IF (RHO) 290,300,300
00501     290 RHO=0.
00502     300 CONTINUE
00503         C8=SQRT(RHO)
00504         C9=-C5/VRM*C7*CK3
00505         DO 310 I=1,3
00510         DX(I+44)=0.
00511         DX(I+47)=0.
00512         DO 310 J=1,3
00515         DX(I+44)=DX(I+44)+C9*VR(J)*PHI(J,I+3)
00516     310 DX(I+47)=DX(I+47)+C9*VR(J)*PHI(J+3,I+3)
00521         DO 320 I=1,3
00524         DO 320 J=1,3
00527         DO 320 K=1,3
00532         PHI(I,J)=PHI(I,J)+PHI(I+3,K)*PHI(K,J+3)
00533     320 P(I,J)=P(I,J)+PHI(I+3,K)*PHI(K+3,J+3)
00537         DO 330 I=1,3
00542         DO 330 J=1,3
00545         PHI(I+3,J)=PHI(I,J)
00546         PHI(I+3,J+3)=P(I,J)
00547         P(I,J)=0.
00550         PHI(I,J)=0.
00551     330 PHI(I,J+3)=0.
00554         DO 340 I=1,6
00557         DO 340 J=1,6
00562         L=6*I+J+2
00563         DX(L)=PHI(I,J)
00564         DO 340 K=1,6
00567         M=6*K+J+2
00570     340 DX(L)=DX(L)+P(I,K)*X(M)
00574         DX(7)=HEATC*C8*VRM2*VRM
00575         DX(8)=C7*C6+VDU*C9/CK3
00576         C10=DRHO*(.5*CK2*HEATC/C8*VRM2*VRM*2.*CK3*DX(8)/RHO)
00577         C11=C7/VRM2/VRM2
00600         C12=VRM*(CK3*C11*(C6*4.*VRM-3.*VDU*C5)+CK2*3.*HEATC*C8)
00601         C1=2.*CLA*(DCLA+CLA*(DETA*CA+ETA*DCA)+2.*ETA*CA*DCLA)
00602         C2=CK3*C7*2.*(CA*DCA+C1-VDU/VRM*C1)
00603         DO 350 I=1,3
00606         PJXB(I)=C10*PAXB(I)+C12*DX(I)+C2*PMXB(I)
00607     350 PJXB(I+3)=C12*VR(I)+C2*PMXB(I+3)
00611         DO 360 I=1,3
00614         DX(I)=0.
00615         DO 360 J=1,3
00620     360 DX(I)=DX(I)+U(J)*PVXB(J,I)
00623         DO 370 I=1,3
00626         PJXB(I)=PJXB(I)+C9*DX(I)
00627     370 PJXB(I+3)=PJXB(I+3)+C9*U(I)
00631         DO 380 I=1,3
00634         DO 380 J=1,3
00637         K=6*J
00640         L=K+2+I
```

```
00641    224*          M=K+20+I                                              D 223
00642    225*          L1=K+5+I                                              D 224
00643    226*          M1=K+23+I                                             D 225
00644    227*          DX(I+44)=DX(I+44)+PJXB(J)*X(L)+PJXB(J+3)*X(M)         D 226
00645    228*      380 DX(I+47)=DX(I+47)+PJXB(J)*X(L1)+PJXB(J+3)*X(M1)       D 227
00650    229*          DO 390 I=1,3                                          D 228
00653    230*      390 DX(I)=X(I+3)                                          D 229
00655    231*          RETURN                                                D 230
00656    232*          END                                                   D 231-

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE ATMOS      ENTRY POINT 000427

STORAGE USED: CODE(1) 000512; DATA(0) 000117; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003    ATMO    000112

EXTERNAL REFERENCES (BLOCK, NAME)

 0004    DLOG
 0005    DATAN
 0006    DEXP
 0007    DSQRT
 0010    NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000007 20L        0001     000015 40L        0001     000375 60L        0001     000413 80L        0000 D 000020 A
 0000 D 000022 AAB        0000 D 000024 AAC        0000 D 000026 AAD        0003 D 000000 A0         0003 D 000002 A1
 0003 D 000024 A10        0003 D 000026 A11        0003 D 000030 A12        0003 D 000032 A13        0003 D 000034 A14
 0003 D 000036 A15        0003 D 000040 A16        0003 D 000042 A17        0003 D 000044 A18        0003 D 000046 A19
 0003 D 000004 A2         0003 D 000050 A20        0003 D 000052 A21        0003 D 000054 A22        0003 D 000056 A23
 0003 D 000006 A3         0003 D 000010 A4         0003 D 000012 A5         0003 D 000014 A6         0003 D 000016 A7
 0003 D 000020 A8         0003 D 000022 A9         0003 D 000060 B0         0003 D 000062 B1         0003 D 000064 B2
 0003 D 000066 B3         0003 D 000070 B4         0003 D 000072 B5         0003 D 000074 B6         0003 D 000076 B7
 0003 D 000100 B8         0000 D 000030 DA         0000 D 000032 DTEMP      0003 D 000102 D1         0003 D 000104 D2
 0003 D 000106 D3         0003 D 000110 D4         0000 D 000004 E1         0000 D 000006 E2         0000 D 000010 E3
 0000 D 000012 E4         0000 D 000014 E5         0000 D 000016 E6         0000     000072 INJP$     0000 D 000000 Z
 0000 D 000002 Z2


00101      1*          SUBROUTINE ATMOS (ALT,TEMP,PRES,RHO,VS,DVS,DRHO,DPRES)              E    1
00103      2*          IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*          COMMON /ATMO/ A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A1  E    2
00104      4*         15,A16,A17,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2  E    3
00104      5*         2,D3,D4                                                              E    4
00104      6*    C     NOTE THAT FORMULAS ARE NOT ACCURATE FOR ALTITUDE OUTSIDE 0 TO 200   E    5
00104      7*    C     ALT MUST BE IN METERS                                               E    6
00104      8*    C     TEMP IS IN DEGREES KELVIN                                           E    7
00104      9*    C     PRES IS IN NEWTONS/M2                                               E    8
00104     10*    C     RHO IS IN KG/M3                                                     E    9
00104     11*    C     VS IS IN METERS PER SECOND                                          E   10
00104     12*    C     DRHO, DPRES, AND DVS ARE IN SAME UNITS AS RHO, PRES, AND DVS OVER   E   11
00105     13*          Z=ALT*.001                                                          E   12
00106     14*          IF (Z) 10,20,20                                                     E   13
00111     15*       10 Z=0.                                                                E   14
```

```
00112     16*      20 CONTINUE                                                             E  15
00113     17*         IF (Z-200.) 40,40,30                                                 E  16
00116     18*      30 Z=200.                                                               E  17
00117     19*      40 CONTINUE                                                             E  18
00120     20*         Z2=Z*Z                                                               E  19
00121     21*         E1=Z+A1                                                              E  20
00122     22*         E2=Z+A3                                                              E  21
00123     23*         E3=Z-A5                                                              E  22
00124     24*         E4=Z2-A7*Z+A8                                                        E  23
00125     25*         E5=Z2-A13*Z+A14                                                      E  24
00126     26*         E6=Z2-A19*Z+A20                                                      E  25
00127     27*         A=A0/E1+A2*LOG(E2)-A4*LOG(-E3)+A6*LOG(E4)+A9*ATAN(A10*Z-A11)-A12*L   E  26
00127     28*        1OG(E5)+A15*ATAN(A16*Z-A17)-A18*LOG(E6)+A21*ATAN(A22*Z-A23)           E  27
00130     29*         AAB=.018031036                                                       E  28
00131     30*         AAC=-.060803123                                                      E  29
00132     31*         AAD=-.028429767                                                      E  30
00133     32*         DA=-A0/(E1*E1)+A2/E2-A4/E3+(2.*A6*Z+AAB)/E4-(2.*A12*Z+AAC)/E5-(2.*   E  31
00133     33*        1A18*Z+AAD)/E6                                                        E  32
00134     34*         DA=DA*.001                                                           E  33
00135     35*         TEMP=B0+Z*(B1+Z*(B2+Z*(B3+Z*(B4+Z*(B5+Z*(B6+Z*(B7-B8*Z)))))))        E  34
00136     36*         DTEMP=B1+Z*(2.*B2+Z*(3.*B3+Z*(4.*B4+Z*(5.*B5+Z*(6.*B6+Z*(7.*B7-8.*   E  35
00136     37*        1B8*Z))))))                                                           E  36
00137     38*         DTEMP=DTEMP*.001                                                     E  37
00140     39*         PRES=EXP(-D1*A)                                                      E  38
00141     40*         RHO=D2*PRES/TEMP                                                     E  39
00142     41*         PRES=D3*PRES                                                         E  40
00143     42*         VS=SQRT(D4*TEMP)                                                     E  41
00144     43*         DRHO=-RHO*(D1*DA+DTEMP/TEMP)                                         E  42
00145     44*         DVS=.5*D4*DTEMP/VS                                                   E  43
00146     45*         DPRES=-D1*PRES*DA                                                    E  44
00147     46*         IF (ALT-200./.001) 60,60,50                                          E  45
00152     47*      50 A=ALT-200./.001                                                      E  46
00153     48*         RHO=RHO+DRHO*A                                                       E  47
00154     49*         PRES=DPRES*A+PRES                                                    E  48
00155     50*         VS=VS+DVS*A                                                          E  49
00156     51*      60 IF (ALT) 70,80,80                                                    E  50
00161     52*      70 RHO=RHO+DRHO*ALT                                                     E  51
00162     53*         PRES=PRES+DPRES*ALT                                                  E  52
00163     54*         VS=VS+DVS*ALT                                                        E  53
00164     55*      80 CONTINUE                                                             E  54
00165     56*         RETURN                                                               E  55
00166     57*         END                                                                  E  56-

       END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE TANGL     ENTRY POINT 000124

STORAGE USED: CODE(1) 000154; DATA(0) 000031; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

 0003   DATAN
 0004   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000063 100L      0001   000077 110L      0001   000103 120L      0001   000112 130L      0001   000011 20L
 0001   000015 30L       0001   000021 40L       0001   000033 50L       0001   000037 60L       0001   000055 70L
 0001   000060 80L       0001   000060 90L       0000   000016 INJP$     0000 D 000000 PI


00101      1*         SUBROUTINE TANGL (SINA,COSA,A)                                         F   1
00103      2*         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*         PI=3.1415927                                                           F   2
00105      4*         IF (SINA) 10,20,30                                                     F   3
00110      5*      10 IF (COSA) 40,50,60                                                     F   4
00113      6*      20 IF (COSA) 70,80,90                                                     F   5
00116      7*      30 IF (COSA) 100,110,120                                                  F   6
00121      8*      40 A=ATAN(-SINA/(-COSA))                                                  F   7
00122      9*         A=A+PI                                                                 F   8
00123     10*         GO TO 130                                                              F   9
00124     11*      50 A=1.5*PI                                                               F  10
00125     12*         GO TO 130                                                              F  11
00126     13*      60 A=ATAN(-SINA/COSA)                                                     F  12
00127     14*         A=2.*PI-A                                                              F  13
00130     15*         GO TO 130                                                              F  14
00131     16*      70 A=PI                                                                   F  15
00132     17*         GO TO 130                                                              F  16
00133     18*      80 CONTINUE                                                               F  17
00134     19*      90 A=0.                                                                   F  18
00135     20*         GO TO 130                                                              F  19
00136     21*     100 A=ATAN(SINA/(-COSA))                                                   F  20
00137     22*         A=PI-A                                                                 F  21
00140     23*         GO TO 130                                                              F  22
00141     24*     110 A=.5*PI                                                                F  23
00142     25*         GO TO 130                                                              F  24
00143     26*     120 A=ATAN(SINA/COSA)                                                      F  25
00144     27*     130 A=A*57.29577951                                                        F  26
00145     28*         RETURN                                                                 F  27
00146     29*         END                                                                    F  28*
     END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE AEROD     ENTRY POINT 000437

STORAGE USED: CODE(1) 000510; DATA(0) 000171; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   AERO   000156

EXTERNAL REFERENCES (BLOCK, NAME)

 0004   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000024 120G      0001     000057 131G      0001     000233 152G      0001     000306 161G      0001     000013 20L
 0001     000421 80L       0003 D 000050 ACA       0003 D 000000 ACLA      0003 D 000120 AETA      0000 D 000064 A1
 0000 D 000066 A2        0000 D 000074 B1        0000 D 000076 B2        0000 D 000056 C1        0000 D 000054 C2
 0000 D 000070 DA1       0000 D 000072 DA2       0000 D 000100 DB1       0000 D 000102 DB2       0000 D 000060 DC1
 0000 D 000062 DC2       0000 D 000000 G         0000 I 000053 I         0000   000144 INJPS     0000 I 000050 NMC
 0000 D 000051 XS


00101      1*          SUBROUTINE AEROD (ACH,CLA,CA,ETA,DCLA,DCA,DETA)                  G   1
00103      2*          IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00103      3*    C     THESE FUNCTIONS CAN BE CHANGED FOR EACH VEHICLE OR TO IMPROVE    G   2
00103      4*    C     SIMULATION OF SAME VEHICLE                                       G   3
00104      5*          DIMENSION G(20), AETA(15), ACLA(20), ACA(20)                     G   4
00105      6*          COMMON /AERO/ ACLA,ACA,AETA                                      G   5
00106      7*          NMC=0                                                            G   6
00107      8*          IF (ACH-23.0) 20,10,10                                           G   7
00112      9*       10 XS=ACH                                                           G   8
00113     10*          ACH=23.0                                                         G   9
00114     11*          NMC=1                                                            G  10
00115     12*       20 G(1)=1.0                                                         G  11
00116     13*          G(2)=ACH                                                         G  12
00117     14*          DO 30 I=3,20                                                     G  13
00122     15*       30 G(I)=G(I-1)*G(2)                                                 G  14
00124     16*          C2=1.+ACA(19)*G(11)+ACA(18)*G(10)                                G  15
00125     17*          C1=ACA(9)*G(9)                                                   G  16
00126     18*          DC1=0.                                                           G  17
00127     19*          DC2=10.*ACA(19)*G(10)+9.*ACA(18)*G(9)                            G  18
00130     20*          DO 40 I=1,8                                                      G  19
00133     21*          C2=C2+ACA(I+9)*G(I+1)                                            G  20
00134     22*          C1=C1+ACA(I)*G(I)                                                G  21
00135     23*          DC1=DC1+I*ACA(I+1)*G(I)                                          G  22
00136     24*       40 DC2=DC2+I*ACA(I+9)*G(I)                                          G  23
00140     25*          CA=C1/C2                                                         G  24
```

```
00141    26*        DCA=DC1/C2-(C1*DC2/(C2*C2))                                      G  25
00142    27*        A1=AETA(1)+AETA(10)*G(2)+AETA(8)*G(4)+AETA(6)*G(5)+AETA(8)*G(6)  G  26
00143    28*        A2=1.+AETA(2)*G(2)+AETA(3)*G(3)+AETA(5)*G(4)+AETA(7)*G(5)+AETA(9)*  G  27
00143    29*       1G(6)                                                             G  28
00144    30*        DA1=AETA(10)+3.*AETA(4)*G(3)+4.*AETA(6)*G(4)+5.*AETA(8)*G(5)     G  29
00145    31*        DA2=AETA(2)+2.*AETA(3)*G(2)+3.*AETA(5)*G(3)+4.*AETA(7)*G(4)+5.*AET  G  30
00145    32*       1A(9)*G(5)                                                        G  31
00146    33*        ETA=A1/A2                                                        G  32
00147    34*        DETA=DA1/A2-(A1*DA2/(A2*A2))                                     G  33
00150    35*        B1=ACLA(18)*G(12)                                                G  34
00151    36*        DO 50 I=1,8                                                      G  35
00154    37*     50 B1=B1+ACLA(I)*G(I)                                               G  36
00156    38*        B2=1.+ACLA(9)*G(2)+ACLA(10)*G(3)+ACLA(11)*G(4)+ACLA(12)*G(6)+ACLA(  G  37
00156    39*       113)*G(7)+ACLA(14)*G(8)+ACLA(15)*G(9)+ACLA(16)*G(10)+ACLA(17)*G(11)  G  38
00156    40*       2+ACLA(19)*G(13)                                                  G  39
00157    41*        DB1=11.*ACLA(18)*G(11)                                           G  40
00160    42*        DO 60 I=1,7                                                      G  41
00163    43*     60 DB1=DB1+I*ACLA(I+1)*G(I)                                         G  42
00165    44*        DB2=ACLA(9)+2.*ACLA(10)*G(2)+3.*ACLA(11)*G(3)+5.*ACLA(12)*G(5)+6.*  G  43
00165    45*       1ACLA(13)*G(6)+7.*ACLA(14)*G(7)+8.*ACLA(15)*G(8)+9.*ACLA(16)*G(9)+1  G  44
00165    46*       20.*ACLA(17)*G(10)+12.*ACLA(19)*G(12)                             G  45
00166    47*        CLA=B1/B2                                                        G  46
00167    48*        DCLA=DB1/B2-(B1*DB2/(B2*B2))                                     G  47
00170    49*        IF (NMC) 70,80,70                                                G  48
00173    50*     70 CLA=CLA+DCLA*(XS-ACH)                                            G  49
00174    51*        CA=CA+DCA*(XS-ACH)                                               G  50
00175    52*        ETA=ETA+DETA*(XS-ACH)                                            G  51
00176    53*        ACH=XS                                                           G  52
00177    54*     80 RETURN                                                           G  53
00200    55*        END                                                              G  54

          END OF COMPILATION:         NO  DIAGNOSTICS.
```

```
SUBROUTINE SIMEQ     ENTRY POINT 000447

STORAGE USED: CODE(1) 000500; DATA(0) 000231; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

 0003   NPRTS
 0004   NI02S
 0005   NERR3S

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000043 106G      0001   000044 111G      0001   000070 121G      0001   000116 125G      0001   000324 140L
 0001   000137 142G      0001   000151 152G      0001   000152 155G      0001   000213 165G      0001   000334 170L
 0001   000340 180L      0001   000274 200G      0001   000413 200L      0001   000275 203G      0000   000135 210F
 0001   000347 225G      0001   000375 232G      0001   000130 40L       0001   000164 90L       0000 D 000000 D
 0000 D 000127 DENOM     0000 D 000110 E         0000 I 000124 I         0000   000154 INJPS     0000 I 000133 IP1
 0000 I 000125 J         0000 I 000132 L         0000 I 000131 MR        0000 I 000134 NMJP1     0000 I 000126 NM1


00101      1*          SUBROUTINE SIMEQ (A,B,C,N)                                          H   1
00103      2*          IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*          DIMENSION A(6,6), B(6), C(6), D(6,6), E(6)                          H   2
00104      4*    C     THE EQUATION TO BE SOLVED MUST BE IN THE FORM AB=C WHERE B IS THE   H   3
00104      5*    C     ANSWER RETURNED                                                     H   4
00104      6*    C     N IS THE DIMENSION OF THE SQUARE MATRIX A AND THE VECTORS B AND C   H   5
00104      7*    C     THE ROUTINE WORKS WHEN A IS SINGULAR IF THE SYSTEM IS CONSISTENT    H   6
00105      8*          DO 20 I=1,N                                                         H   7
00110      9*          DO 10 J=1,N                                                         H   8
00113     10*       10 D(I,J)=A(I,J)                                                       H   9
00115     11*       20 E(I)=C(I)                                                           H  10
00117     12*          NM1=N-1                                                             H  11
00120     13*          DO 130 I=1,NM1                                                      H  12
00123     14*          DENOM=0.                                                            H  13
00124     15*          DO 40 J=I,N                                                         H  14
00127     16*          IF (ABS(D(J,I))-ABS(DENOM)) 40,40,30                                H  15
00132     17*       30 DENOM=D(J,I)                                                        H  16
00133     18*          MR=J                                                                H  17
00134     19*       40 CONTINUE                                                            H  18
00136     20*          IF (DENOM) 90,50,90                                                 H  19
00141     21*       50 DO 60 J=I,N                                                         H  20
00144     22*          IF (E(I)) 200,60,200                                                H  21
00147     23*       60 CONTINUE                                                            H  22
00151     24*          DO 80 J=I,N                                                         H  23
00154     25*          DO 70 L=I,N                                                         H  24
00157     26*       70 D(J,L)=0.                                                           H  25
00161     27*       80 D(J,J)=1.                                                           H  26
```

```
00163            GO TO 140                                              H  27
00164         90 DO 100 J=I,N                                           H  28
00167            B(J)=D(MR,J)/DENOM                                     H  29
00170            D(MR,J)=D(I,J)                                         H  30
00171        100 D(I,J)=B(J)                                            H  31
00173            DENOM=E(MR)/DENOM                                      H  32
00174            E(MR)=E(I)                                             H  33
00175            E(I)=DENOM                                             H  34
00176            IP1=I+1                                                H  35
00177            DO 120 J=IP1,N                                         H  36
00202            DO 110 L=IP1,N                                         H  37
00205        110 D(J,L)=D(J,L)-D(J,I)*D(I,L)                            H  38
00207        120 E(J)=E(J)-D(J,I)*E(I)                                  H  39
00211        130 CONTINUE                                               H  40
00213        140 IF (D(N,N)) 170,150,170                                H  41
00216        150 IF (E(N)) 200,160,200                                  H  42
00221        160 B(N)=0.                                                H  43
00222            GO TO 180                                              H  44
00223        170 B(N)=E(N)/D(N,N)                                       H  45
00224        180 DO 190 J=1,NM1                                         H  46
00227            NMJP1=N-J+1                                            H  47
00230            B(N-J)=E(N-J)                                          H  48
00231            DO 190 L=NMJP1,N                                       H  49
00234        190 B(N-J)=B(N-J)-D(N-J,L)*B(L)                            H  50
00237            RETURN                                                 H  51
00240        200 PRINT 210                                              H  52
00242            RETURN                                                 H  53
00242      C                                                            H  54
00243        210 FORMAT (1H0,50X,22HNO SOLUTION FROM SIMEQ)             H  55
00244            END                                                    H  56-

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE BOUND      ENTRY POINT 000171

STORAGE USED: CODE(1) 000213; DATA(0) 000035; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   DIFEQ  000070
 0004   ENDCDN 000054

EXTERNAL REFERENCES (BLOCK, NAME)

 0005   DSQRT
 0006   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000047 121G      0001     000072 130G      0001     000113 137G      0001     000147 50L       0003 D 000044 ACH
 0003 D 000034 ALB         0003 D 000054 ALFA        0003 D 000050 ALT         0004 D 000002 AMC         0000 D 000002 AMC2
 0003 D 000056 BEDA        0003 D 000042 CA          0003 D 000060 CLA         0004 D 000052 CRAD        0004 D 000004 CTHC
 0003 D 000014 DB          0003 D 000022 ETA         0003 D 000062 F           0000 I 000006 I           0000   000015 INJP$
 0003 D 000010 PRES        0003 D 000064 QQ          0003 D 000000 R           0004 D 000000 RC          0004 D 000006 RCTHC
 0000 D 000000 RC2         0003 D 000024 RE          0003 D 000052 RHO         0004 D 000030 RVR         0004 D 000022 RXVOB
 0004 D 000014 ROB         0004 D 000012 SCRAD       0004 D 000010 SRAD        0003 D 000026 U           0004 D 000036 UXE
 0004 D 000044 UYE         0003 D 000002 VR          0003 D 000012 VRM         0003 D 000066 VS          0000 D 000004 V2
 0003 D 000046 WKG


00101      1*        SUBROUTINE BOUND (X,TF,DX,B,ERR)                                     1
00103      2*        IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*        DIMENSION X(50), DX(50)                                            I  2
00105      4*        DIMENSION VR(3), U(3), ALB(3), DB(3)                               I  3
00106      5*        DIMENSION ROB(3), RXVOB(3), RVR(3)                                 I  4
00107      6*        DIMENSION B(5), UXE(3), UYE(3)                                     I  5
00110      7*        COMMON /DIFEQ/ R,VR,PRES,VRM,DB,ETA,RE,U,ALB,CA,ACH,WKG,ALT,RHO,AL I  6
00110      8*       1FA,BEDA,CLA,F,QQ,VS                                                I  7
00111      9*        COMMON /ENDCDN/ RC,AMC,CTHC,RCTHC,SRAD,SCRAD,ROB,RXVOB,RVR,UXE,UYE I  8
00111     10*       1,CRAD                                                              I  9
00112     11*        RC2=RC*RC                                                          I 10
00113     12*        AMC2=AMC*AMC                                                       I 11
00114     13*        B(1)=R*R/RC2-1.                                                    I 12
00115     14*        B(2)=VRM*VRM/VS/VS/AMC2-1.                                         I 13
00116     15*        V2=X(4)*X(4)+X(5)*X(5)+X(6)*X(6)                                   I 14
00117     16*        B(3)=0.                                                            I 15
00120     17*        DO 10 I=1,3                                                        I 16
00123     18*     10 B(3)=B(3)+X(I)*X(I+3)                                              I 17
00125     19*        B(3)=B(3)/RC/SQRT(V2)-CTHC                                         I 18
00126     20*        B(4)=0.                                                            I 19
```

```
00127     21*          DO 20 I=1,3                                              I  20
00132     22*       20 B(4)=B(4)+X(I)*(ROB(I)*SRAD-RVR(I)*CRAD)                 I  21
00134     23*          B(4)=B(4)/RC                                             I  22
00135     24*          B(5)=0.                                                  I  23
00136     25*          DO 30 I=1,3                                              I  24
00141     26*       30 B(5)=B(5)-X(I)*RXVOB(I)                                  I  25
00143     27*          B(5)=B(5)/RC-SCRAD                                       I  26
00144     28*          ERR=(B(1)*B(1)+B(2)*B(2)+B(3)*B(3)+B(4)*B(4)+B(5)*B(5))  I  27
00145     29*          IF (ERR) 40,50,50                                        I  28
00150     30*       40 ERR=-ERR                                                 I  29
00151     31*       50 ERR=SQRT(ERR)                                            I  30
00152     32*          RETURN                                                   I  31
00153     33*          END                                                      I  32-

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
SUBROUTINE PBOUND    ENTRY POINT 000505

STORAGE USED: CODE(1) 000533; DATA(0) 000261; BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003   DIFEQ  000070
 0004   ENDCON 000054
 0005   CONST  000103

EXTERNAL REFERENCES (BLOCK, NAME)

 0006   ATMOS
 0007   DSQRT
 0010   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000370 110L      0001   000111 136G      0001   000460 140L      0001   000170 156G      0001   000171 161G
 0001   000063 20L       0001   000262 201G      0001   000270 205G      0001   000351 224G      0001   000354 230G
 0001   000374 240G      0001   000401 244G      0001   000420 252G      0001   000422 255G      0001   000427 261G
 0001   000214 60L       0000 D 000132 A         0005 D 000016 AA        0005 D 000072 AB        0003 D 000044 ACH
 0003 D 000034 ALB       0003 D 000054 ALFA      0003 D 000050 ALT       0004 D 000002 AMC       0000 D 000163 AMC2
 0005 D 000010 AREA      0005 D 000004 AZ        0000 D 000130 BB        0005 D 000012 BE        0003 D 000056 BEDA
 0000 D 000134 BE2       0003 D 000042 CA        0005 D 000062 CK1       0005 D 000064 CK2       0005 D 000066 CK3
 0003 D 000060 CLA       0004 D 000052 CRAD      0004 D 000004 CTHC      0000 D 000174 C1        0000 D 000144 C12
 0000 D 000146 C13       0000 D 000176 C3        0000 D 000200 C4        0000 D 000140 C5        0000 D 000142 C6
 0003 D 000014 DB        0000 D 000157 DPRES     0000 D 000155 DRHO      0000 D 000153 DVS       0003 D 000022 ETA
 0005 D 000032 EXA       0000 D 000136 E2        0003 D 000062 F         0005 D 000024 FD        0005 D 000022 FH
 0005 D 000020 FJ        0005 D 000052 FS        0005 D 000000 GM        0005 D 000060 HEATC     0000 I 000150 I
 0005 I 000102 ICNVG     0000   000221 INJP$     0000 I 000167 J         0000 I 000202 K         0000 I 000203 L
 0005 D 000014 OM        0000 D 000022 PAXB      0000 D 000030 PBXAT     0005 D 000002 PHIL      0003 D 000010 PRES
 0000 D 000000 PVXB      0005 D 000054 PO        0003 D 000064 QQ        0003 D 000000 R         0004 D 000000 RC
 0005 D 000006 RCONV     0004 D 000006 RCTHC     0005 D 000070 RCURV     0000 D 000161 RC2       0003 D 000024 RE
 0003 D 000052 RHO       0000 D 000126 RI        0005 D 000026 RISP      0005 D 000100 RLGO      0005 D 000030 RMD
 0004 D 000030 RVR       0004 D 000022 RXVOB     0004 D 000014 ROB       0000 D 000124 R2        0004 D 000012 SCRAD
 0004 D 000010 SRAD      0000 D 000151 TEMP      0005 D 000050 TO        0003 D 000026 U         0004 D 000036 UXE
 0004 D 000044 UYE       0005 D 000034 UO        0005 D 000042 UOD       0000 D 000172 VI        0003 D 000002 VR
 0003 D 000012 VRM       0000 D 000165 VRM2      0003 D 000066 VS        0000 D 000170 V2        0003 D 000046 WKG
 0005 D 000056 WKGO


00101      1*        SUBROUTINE PROUND (X,TF,DX,PBUAT)                           J    1
00103      2*        IMPLICIT DOUBLE PRECISION(A-H,O-Z)
00104      3*        DIMENSION X(50), DX(50), AB(3)                              J    2
00105      4*        DIMENSION VR(3), U(3), ALB(3), DB(3), UO(3), UOD(3)         J    3
00106      5*        DIMENSION ROB(3), RXVOB(3), RVR(3)                          J    4
```

```
      DIMENSION PBUAT(5,7)
      DIMENSION PVXB(3,3), PAXB(3)
      DIMENSION PBXAT(5,6), UXE(3), UYE(3)
      COMMON /DIFEQ/ R,VR,PRES,VRM,DB,ETA,RE,U,ALB,CA,ACH,WKG,ALT,RHO,AL
     1FA,BEDA,CLA,F,QQ,VS
      COMMON /ENDCDN/ RC,AMC,CTHC,RCTHC,SRAD,SCRAD,ROB,RXVOB,RVR,UXE,UYE
     1,CRAD
      COMMON /CONST/ GM,PHIL,AZ,RCONV,AREA,BE,OM,AK,FJ,FH,FD,RISP,RMD,EX
     1A,UD,UOD,TO,FS,PO,WKGO,HEATC,CK1,CK2,CK3,RCURV,AB,RLGO,ICNVG
      R2=R*R
      RI=1./R
      BB=AA*RI
      A=(AB(1)*X(1)+AB(2)*X(2)+AB(3)*X(3))*RI
      BE2=BE*BE
      E2=A*A
      C5=AA*AA-BE2
      C6=BE2+C5*E2
      IF (C6) 10,20,20
   10 C6=0.
   20 CONTINUE
      RE=AA*BE/SQRT(C6)
      C12=RE*A*C5/C6*RI
      C13=C12*A*RI
      DO 30 I=1,3
      PVXB(I,I)=0.
   30 PAXB(I)=(RI-C13)*X(I)+C12*AB(I)
      PVXB(1,2)=OM*AB(3)
      PVXB(1,3)=-OM*AB(2)
      PVXB(2,3)=OM*AB(1)
      PVXB(2,1)=-PVXB(1,2)
      PVXB(3,1)=-PVXB(1,3)
      PVXB(3,2)=-PVXB(2,3)
      CALL ATMOS (ALT,TEMP,PRES,RHO,VS,DVS,DRHO,DPRES)
      RC2=RC*RC
      AMC2=AMC*AMC
      VRM2=VRM*VRM
      DO 40 I=1,5
      DO 40 J=1,6
   40 PBXAT(I,J)=0.
      V2=X(4)*X(4)+X(5)*X(5)+X(6)*X(6)
      IF (V2) 50,60,60
   50 V2=0.
   60 CONTINUE
      VI=1./SQRT(V2)
      C1=X(1)*X(4)+X(2)*X(5)+X(3)*X(6)
      C3=1./(VS*VS*AMC2)
      C4=1./RC*VI
      DO 80 I=1,3
      PBXAT(1,I)=2.*X(I)/RC2
      DO 70 J=1,3
   70 PBXAT(2,I)=PBXAT(2,I)+2.*VR(J)*PVXB(J,I)
      PBXAT(2,I)=(PBXAT(2,I)-2.*VRM2*DVS*PAXB(I)/VS)*C3
      PBXAT(2,I+3)=2.*VR(I)*C3
      PBXAT(3,I)=X(I+3)*C4
      PBXAT(3,I+3)=C4*(X(I)-C1*X(I+3)/V2)
      PBXAT(4,I)=(ROB(I)*SRAD-RVR(I)*CRAD)/RC
```

```
00216          80 PBXAT(5,I)=-RXVOB(I)/RC
00216     C       THIS PART IS USED ONLY FOR THE CONVERGED CASE PRINT OUT
00220             IF (ICNVG) 110,110,90
00223          90 DO 100 I=1,5
00226             PBUAT(I,7)=0.
00227             DO 100 J=1,6
00232         100 PBUAT(I,J)=PBXAT(I,J)
00235             GO TO 140
00236         110 CONTINUE
00237             DO 120 I=1,5
00242             PBUAT(I,7)=0.
00243             DO 120 J=1,6
00246         120 PBUAT(I,7)=PBUAT(I,7)+PBXAT(I,J)*DX(J)
00251             DO 130 I=1,5
00254             DO 130 J=1,6
00257             PBUAT(I,J)=0.
00260             DO 130 K=1,6
00263             L=6*K+J+2
00264         130 PBUAT(I,J)=PBUAT(I,J)+PBXAT(I,K)*X(L)
00270         140 RETURN
00271             END

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
                                              TRIAL NUMBER  1

                                              INITIAL VALUES

T    =   .00000000000      R    =   .65000732772+07  V    =   .79182741874+04  GM   =   .39860319000+15
X    =   .10416416000+07   Y    =  -.62981421000+07  Z    =   .12244760000+07  PHI  =   .28608000000+02
DX   =  -.50566950000+04   DY   =  -.17567557000+04  DZ   =  -.58346132000+04  AZ   =   .90000000000+02
DDX  =  -.15169824303+01   DDY  =   .91182854077+01  DDZ  =  -.17679795558+01  ALT  =   .14030918566+06
WKG  =   .13280731000+06   VRX  =  -.49783056909+04  VRY  =  -.17140022624+04  VRZ  =  -.56813936515+04
VR   =   .77459386217+04   UX   =  -.60406856667+00  UY   =   .39419351810+00  UZ   =  -.69261290564+00
ALFA=    .36000000322+02   LFX  =  -.39584924713+01  LFY  =   .26975804219+02  LFZ  =  -.46696295822+01
BETA=    .18000000491+03   DFX  =  -.16281736040+02  DFY  =  -.56057088778+01  DFZ  =  -.18581211664+02
AREA=    .65821803840+03   CL   =   .44671309365+00  CD   =   .40911289286+00  ETA  =   .17999863636+01
RHO  =   .31358995814-08   Q    =   .61922721324+02  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04   FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000      OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03   MD   =   .00000000000     CHIP=    .22890640185+03  CHIY=    .23215685211+02
DRNG=    .00000000000      XRNG=    .88986254448-12  PANG=    .91500003418+02  DCEL=    .28243418797-03
PRES=    .68513884435-03   UOX  =  -.60406856667+00  UOY  =   .39419351810+00  UOZ  =  -.69261290564+00
MACH=    .14005598208+02   UODX=    .00000000000     UODY=    .00000000000     UODZ=    .00000000000
CDO  =   .12000053346-01   CLA  =   .75999370475+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000      CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .00000000000      HT1  =   .00000000000     DHT1=    .15884027431+00  DCLI=    .00000000000
D2   =   .50065665039-07   LAT  =   .68028973356+02  LONG=    .21023191184+03  LNGO=    .00000000000

                                              PXF/PUO MATRIX
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000

                                              DPXF/PUO MATRIX
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .28593413-03      .29794305-03     -.79808798-04      .00000000         .00000000         .00000000
   .10534060-03      .37282087-03      .12031342-03      .00000000         .00000000         .00000000
  -.78775209-04      .34047305-03      .26248124-03      .00000000         .00000000         .00000000
   .20172334-07      .70759961-07      .22678822-07      .00000000         .00000000         .00000000

                                              FINAL VALUES   57 INTEGRATION STEPS TAKEN

T    =   .18000000000+04   R    =   .64006975189+07  V    =   .51927943219+03  GM   =   .39860319000+15
X    =  -.36218648787+07   Y    =  -.21710741984+07  Z    =  -.48101414068+07  PHI  =   .28608000000+02
DX   =   .35047913826+03   DY   =   .30124140363+03  DZ   =  -.23678918701+03  AZ   =   .90000000000+02
DDX  =   .59853767322-01   DDY  =  -.19404975543+01  DDZ  =  -.13873012302+00  ALT  =   .22547004427+05
WKG  =   .13280731000+06   VRX  =   .42540360329+02  VRY  =   .13329194595+03  VRZ  =   .70882304040+02
VR   =   .15684618624+03   UX   =  -.60406856667+00  UY   =   .39419351810+00  UZ   =  -.69261290564+00
ALFA=    .98154856684+02   LFX  =  -.38896854264+06  LFY  =   .35399457330+06  LFZ  =  -.43223430706+06
BETA=    .31419010356+00   DFX  =   .33536416500+06  DFY  =   .10507983903+07  DFZ  =   .55879603567+06
AREA=    .65821803840+03   CL   =   .13796266811+01  CD   =   .25058584696+01  ETA  =   .56094991693+00
```

```
RHO  =   .60945999612-01   Q    =   .49343836744+06   AE   =   .63781660000+07   BE   =   .63567840000+07
OM   =   .72921150604-04   FJ   =   .16234500072-02   FH   =  -.57500000139-05   FD   =   .78750000512-05
F    =   .00000000000      OMX  =   .47881444528+00   OMY  =  -.87791612754+00   OMZ  =  -.77140676824-08
ISP  =   .40000000000+03   MD   =   .00000000000      CHIP=    .22890640185+03   CHIY=    .23215685211+02
DRNG=    .94015968698+07   XRNG=   -.41393527356+06   PANG=    .10365077390+03   DCEL=    .10628186221+02
PRES=    .37375288894+04   UDX  =  -.60406856667+00   UDY  =   .39419351810+00   UDZ  =  -.69261290564+00
MACH=    .53529121997+00   UDDX=    .00000000000      UDDY=    .00000000000      UDDZ=    .00000000000
CDO  =   .17496636227-01   CLA  =   .13937195411+01   EXA  =   .00000000000      HTC  =   .61031971743-08
CK1  =   .00000000000      CK2  =   .50000000000+00   CK3  =   .50000000000+00   RCRV=    .73152000000+00
J    =   .71700196876+05   HT1  =   .42437468370+05   DHT1=    .58136902968-02   DCLI=    .10096292538+06
D2   =   .62442903258+02   LAT  =   .15382285837+01   LONG=    .13877628250+03   LNGO=    .00000000000

                                                       PXF/PUO MATRIX

   .13695268+08       .38266040+08       .98342724+07       .72084181+10       .17365993+11       .35967896+10
  -.40279997+08      -.14281580+09      -.46151582+08      -.18245510+11      -.64850344+11      -.20995922+11
   .83156542+07       .37225354+08       .13933855+08       .29902261+10       .16830305+11       .69708424+10
  -.14075018+04      -.54166490+04      -.18552648+04      -.53726562+06      -.25436544+07      -.97911375+06
  -.39367513+04      -.14151708+05      -.46208261+04      -.14710174+07      -.52887019+07      -.17270493+07
  -.21151182+04      -.81824095+04      -.28122149+04      -.94781769+06      -.36989493+07      -.12785713+07
   .78973643+06       .27568889+07       .88027928+06       .36892560+09       .12893687+10       .41206917+09

                                                       DPXF/PUO MATRIX

  -.14075018+04      -.54166490+04      -.18552648+04      -.53726562+06      -.25436544+07      -.97911375+06
  -.39367513+04      -.14151708+05      -.46208261+04      -.14710174+07      -.52887019+07      -.17270493+07
  -.21151182+04      -.81824095+04      -.28122149+04      -.94781769+06      -.36989493+07      -.12785713+07
  -.24141825+02      -.83871419+02      -.26679047+02      -.10191265+05      -.29566947+05      -.79393209+04
   .95417891+02       .33693908+03       .10854584+03       .38285553+05       .13349536+06       .42586425+05
  -.18172865+02      -.65082406+02      -.21191355+02      -.50230884+04      -.20986251+05      -.75631773+04
   .90035899+02       .32021606+03       .10372206+03       .44348671+05       .16218429+06       .53626427+05

                                                       BOUNDARY CONDITIONS

B1   =   .21798652271-03   B2   =  -.92836582746+00   B3   =  -.62380817150-01   B4   =  -.41316465966+00
B5   =  -.47408063910-01   ERR  =   .10191698013+01

                                                       DESIRED VALUES

    .64000000+07       .20000000+01       .10000000+03       .60000000+02      -.10000000+01

AK   =   .100              TOL  =   .49999999814-01

                                                       PBWU MATRIX

  -.40325544+00       .48479575-03      -.42918537+02      -.14934156+03      -.47564427+02      -.38301565-04
  -.13835402+02       .15792695-01      -.14256861+04      -.49256536+04      -.15599601+04      -.15362578-02
   .12765253+02      -.63789113-02       .14553857+04       .49265892+04       .15345900+04       .10198166-02
   .23689026+02      -.31095901-01       .28006736+04       .98790505+04       .31799275+04      -.28279817-04
  -.83272875+00      -.43977925+00      -.55202111+03      -.35260547+03       .28076839+03      -.65513950-04

                                                       SIMULTANEOUS EQUATION MATRIX

   .91639606+03      -.67053699+00       .10512553+06       .36541649+06       .11628687+06       .33673040-01
  -.67053699+00       .19466308+00       .12385795+03      -.26141742+03      -.25680687+03      -.10944760-05
   .10512553+06       .12385795+03       .12301070+08       .42061574+08       .13210424+08       .36330542+01
   .36541649+06      -.26141742+03       .42061574+08       .14627562+09       .46566884+08       .12340734+02
   .11628687+06      -.25680687+03       .13210424+08       .46566884+08       .14981474+08       .38550009+01
```

.33673040-01 -.10944760-05 .36330542+01 .12340734+02 .38550009+01 .34066726-05

RIGHT HAND SIDE

-.17422791+01 .22777431-01 -.20212599+03 -.78598056+03 -.27104676+03 .95934308-04

ANSWER

.40884972+00 -.14792876+01 -.64402471-03 .27553783-04 -.26142098-02 -.46830849+03

CHECK

-.17422791+01 .22777431-01 -.20212599+03 -.78598056+03 -.27104676+03 .95934308-04

ITERATION PARAMETERS

.36000000+02 .35765747+02 .18000000+03 .18084757+03

```
                                        TRIAL NUMBER  2

                                        INITIAL VALUES

T    =   .00000000000     R    =   .65000732772+07  V    =   .79182741874+04  GM   =   .39860319000+15
X    =   .10416416000+07  Y    =  -.62981421000+07  Z    =   .12244760000+07  PHI  =   .28608000000+02
DX   =  -.50566950000+04  DY   =  -.17567557000+04  DZ   =  -.58346132000+04  AZ   =   .90000000000+02
DDX  =  -.15169814464+01  DDY  =   .91182837159+01  DDZ  =  -.17679830751+01  ALT  =   .14030918566+06
WKG  =   .13280731000+06  VRX  =  -.49783056909+04  VRY  =  -.17140022624+04  VRZ  =  -.56813936515+04
VR   =   .77459386217+04  UX   =  -.59861842302+00  UY   =   .39033991285+00  UZ   =  -.69949319943+00
ALFA=    .35765747008+02  LFX  =  -.36295228794+01  LFY  =   .26819404981+02  LFZ  =  -.49107046826+01
BETA=    .18084757916+03  DFX  =  -.16083431047+02  DFY  =  -.55374335996+01  DFZ  =  -.18354899984+02
AREA=    .65821803840+03  CL   =   .44419556693+00  CD   =   .40413006247+00  ETA  =   .17999863636+01
RHO  =   .31358995814-08  Q    =   .61922721324+02  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .22944346404+03  CHIY=    .22975651294+02
DRNG=    .00000000000     XRNG=    .88986254448-12  PANG=    .91500003418+02  DCEL=    .28000092559-03
PRES=    .68513884435-03  UDX  =  -.59861842302+00  UDY  =   .39033991285+00  UDZ  =  -.69949319943+00
MACH=    .14005598208+02  UDDX=    .64402470129-05  UDDY=   -.27553783201-06  UDDZ=    .26142098171-04
CDO  =   .12000053346-01  CLA  =   .75999370475+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .00000000000     HT1  =   .00000000000     DHT1=    .15884027431+00  DCLI=    .00000000000
D2   =   .49437851727-07  LAT  =   .68028973356+02  LONG=    .21023191184+03  LNGO=    .00000000000

                                        PXF/PUO MATRIX
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000

                                        DPXF/PUO MATRIX
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .00000000         .00000000         .00000000         .00000000         .00000000         .00000000
   .28943293-03      .29550156-03     -.82793988-04      .00000000         .00000000         .00000000
   .10416677-03      .37359514-03      .11933346-03      .00000000         .00000000         .00000000
  -.77554881-04      .33949434-03      .25581946-03      .00000000         .00000000         .00000000
   .20562000-07      .70474107-07      .21730111-07      .00000000         .00000000         .00000000

                                        FINAL VALUES   47 INTEGRATION STEPS TAKEN

T    =   .18046830848+04  R    =   .64007901936+07  V    =   .51953324044+03  GM   =   .39860319000+15
X    =  -.36254357682+07  Y    =  -.21698500486+07  Z    =  -.48081265956+07  PHI  =   .28608000000+02
DX   =   .34820831372+03  DY   =   .30447409241+03  DZ   =  -.23656137730+03  AZ   =   .90000000000+02
DDX  =   .10634522489+00  DDY  =  -.19755461218+01  DDZ  =  -.12870325450+00  ALT  =   .22639180916+05
WKG  =   .13280731000+06  VRX  =   .40398521287+02  VRY  =   .13659498327+03  VRZ  =   .71295975250+02
VR   =   .15929013172+03  UX   =  -.61130268228+00  UY   =   .40598561849+00  UZ   =  -.67932665796+00
ALFA=    .96370136858+02  LFX  =  -.40782182667+06  LFY  =   .35045245696+06  LFZ  =  -.44034251077+06
BETA=    .35211251475+00  DFX  =   .31102764919+06  DFY  =   .10516428618+07  DFZ  =   .54890671421+06
AREA=    .65821803840+03  CL   =   .13862786010+01  CD   =   .24461477114+01  ETA  =   .56176923634+00
```

```
RHO =   .60037444046-01  Q    =   .50134850234+06  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  MD   =   .00000000000     CHIP=   .22801704669+03  CHIY=   .23952905689+02
DRNG=   .94030150436+07  XRNG=  -.40991399511+06  PANG=   .10366570591+03  DCEL=   .10614018941+02
PRES=   .36832361630+04  UOX  =  -.59861842302+00  UOY  =   .39033991285+00  UOZ  =  -.69949319943+00
MACH=   .54352687077+00  UODX=   .64402470129-05  UODY=  -.27553783201-06  UODZ=   .26142098171-04
CDO =   .17507191005-01  CLA  =   .13948908104+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=   .73152000000+00
J   =   .72274054971+05  HT1  =   .42657163831+05  DHT1=   .60441483102-02  DCLI=   .10189094611+06
D2  =   .62824726378+02  LAT  =   .15132724550+01  LONG=   .13882490366+03  LNGO=   .00000000000

                                          PXF/PUO MATRIX

   .13939542+08     .38943146+08     .99986906+07     .73446418+10     .17669323+11     .36334454+10
  -.41209776+08    -.14603915+09    -.47176280+08    -.18660900+11    -.66368177+11    -.21483162+11
   .85426812+07     .38151877+08     .14268287+08     .30682794+10     .17274407+11     .71598943+10
  -.13534443+04    -.52337965+04    -.18026389+04    -.51540632+06    -.24944428+07    -.97691823+06
  -.40720922+04    -.14659737+05    -.47731575+04    -.15005869+07    -.54419514+07    -.17586751+07
  -.21805343+04    -.84121101+04    -.28847123+04    -.98084243+06    -.38127823+07    -.13119069+07
   .81599307+06     .28453258+07     .90838790+06     .38165332+09     .13328147+10     .42631293+09

                                          DPXF/PUO MATRIX

  -.13534443+04    -.52337965+04    -.18026389+04    -.51540632+06    -.24944428+07    -.97691823+06
  -.40720922+04    -.14659737+05    -.47731575+04    -.15005869+07    -.54419514+07    -.17586751+07
  -.21805343+04    -.84121101+04    -.28847123+04    -.98084243+06    -.38127823+07    -.13119069+07
  -.27487910+02    -.95752518+02    -.30338251+02    -.11427889+05    -.33875908+05    -.90228341+04
   .96244388+02     .34025156+03     .10939777+03     .38290289+05     .13436969+06     .42587254+05
  -.19552160+02    -.70342056+02    -.22860434+02    -.53054345+04    -.22553772+05    -.80228849+04
   .11004898+03     .39039539+03     .12645838+03     .52794531+05     .19172874+06     .63500719+05

                                          BOUNDARY CONDITIONS

B1  =   .24695075417-03  B2   =  -.92614463519+00  B3   =  -.62637508931-01  B4   =  -.41338938148+00
B5  =  -.46779757558-01  ERR  =   .10172249162+01

                                          DESIRED VALUES

   .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK  =   .200             TOL  =   .49999999814-01

                                          PBWU MATRIX

  -.41119337+00     .33210501-02    -.43400756+02    -.15173531+03    -.48010799+02    -.38361960-04
  -.14457181+02     .11563472+00    -.14723049+04    -.51154356+04    -.16041626+04    -.15844952-02
   .12692883+02    -.92286848-01     .14476952+04     .49073449+04     .15189638+04     .97305309-03
   .24214451+02    -.19890311+00     .28632732+04     .10107072+05     .32526422+04    -.28784198-04
  -.82657845+00    -.43973005+00    -.56027419+03    -.34354390+03     .29560428+03    -.65221283-04

                                          SIMULTANEOUS EQUATION MATRIX

   .95731129+03    -.72973621+01     .10947435+06     .38132669+06     .12100805+06     .34630874-01
  -.72973621+01     .25482425+00    -.62714148+03    -.29041708+04    -.11027835+04    -.23874504-03
   .10947435+06    -.62714148+03     .12777627+08     .43774193+08     .13710481+08     .36973342+01
   .38132669+06    -.29041708+04     .43774193+08     .15254367+09     .48440491+08     .12617794+02
   .12100805+06    -.11027835+04     .13710481+08     .48440491+08     .15549957+08     .39087579+01
```

```
 .34630874-01  -.23874504-03   .36973342+01   .12617794+02   .39087579+01   .34640114-05
                                              RIGHT HAND SIDE
-.17322119+01   .34678743-01  -.20357807+03  -.79051408+03  -.27383222+03   .10341988-03
                                              ANSWER
 .34929550+00  -.14130187+01  -.32362240-04  -.29268690-03  -.17834832-02  -.44642429+03
                                              CHECK
-.17322119+01   .34678743-01  -.20357807+03  -.79051408+03  -.27383222+03   .10341988-03
                                              ITERATION PARAMETERS
 .3765747+02    .34965221+02   .18084758+03   .18408598+03
```

TRIAL NUMBER 3

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169772523+01	DDY =	.91182775223+01	DDZ =	-.17679955706+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.57776010798+00	UY =	.37596755030+00	UZ =	-.72445956323+00
ALFA=	.34965221007+02	LFX =	-.24033227308+01	LFY =	.26227239752+02	LFZ =	-.58065107028+01
BETA=	.18408598431+03	DFX =	-.15414244730+02	DFY =	-.53070365664+01	DFZ =	-.17591204235+02
AREA=	.65821803840+03	CL =	.43553650623+00	CD =	.38731534754+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23142746919+03	CHIY=	.22084125855+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.27175601682-03
PRES=	.68513884435-03	UDX =	-.57776010798+00	UDY =	.37596755030+00	UDZ =	-.72445956323+00
MACH=	.14005598208+02	UDDX=	.77347366038-05	UDDY=	.11431938207-04	UDDZ=	.97481427565-04
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.47319276334-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.30297191-03	.28626542-03	-.93060506-04	.00000000	.00000000	.00000000
.10000698-03	.37632433-03	.11554225-03	.00000000	.00000000	.00000000
-.71967963-04	.33536808-03	.23143836-03	.00000000	.00000000	.00000000
.22166982-07	.69344750-07	.18309066-07	.00000000	.00000000	.00000000

FINAL VALUES 47 INTEGRATION STEPS TAKEN

T =	.18225400562+04	R =	.64020328194+07	V =	.52657613591+03	GM =	.39860319000+15
X =	-.36665593875+07	Y =	-.20808978895+07	Z =	-.48179072690+07	PHI =	.28608000000+02
DX =	.33879782708+03	DY =	.33039914465+03	DZ =	-.23094342271+03	AZ =	.90000000000+02
DDX =	.44399773215+00	DDY =	-.23356698047+01	DDZ =	.15850313214-01	ALT =	.23869481379+05
WKG =	.13280731000+06	VRX =	.30361889046+02	VRY =	.16217853643+03	VRZ =	.76440781669+02
VR =	.18184310569+03	UX =	-.64062806983+00	UY =	.45098374250+00	UZ =	-.62145743229+00
ALFA=	.88050985834+02	LFX =	-.48591352368+06	LFY =	.31625889314+06	LFZ =	-.47797983136+06
BETA=	.54982535361+00	DFX =	.19601021167+06	DFY =	.10469918129+07	DFZ =	.49348621796+06
AREA=	.65821803840+03	CL =	.14059374212+01	CD =	.21965631969+01	ETA =	.56970819501+00

RHO =	.49109960147-01	Q =	.53444503413+06	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.22412976812+03	CHIY=	.26806817232+02
DRNG=	.94981208952+07	XRNG=	-.38499401644+06	PANG=	.10402677658+03	DCEL=	.10495062049+02
PRES=	.30317452425+04	UDX =	-.57776010798+00	UDY =	.37596755030+00	UDZ =	-.72445956323+00
MACH=	.61854473166+00	UDDX=	.77347366038-05	UDDY=	.11431938207-04	UDDZ=	.97481427565-04
CD0 =	.17639245764-01	CLA =	.14067512448+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.73435100618+05	HT1 =	.43238408736+05	DHT1=	.81326617914-02	DCL1=	.10363179250+06
D2 =	.63165369020+02	LAT =	.63769397430+00	LONG=	.13879811464+03	LNGO=	.00000000000

PXF/PUO MATRIX

.14039499+08	.38834145+08	.97698063+07	.74371375+10	.17571968+11	.33904709+10
-.43442009+08	-.15385712+09	-.49560568+08	-.19611029+11	-.70056702+11	-.22628249+11
.85494708+07	.38572722+08	.14503513+08	.29941704+10	.17545814+11	.73954453+10
-.73017974+03	-.30210995+04	-.11257959+04	-.27894944+06	-.17367466+07	-.81671920+06
-.48904411+04	-.17752561+05	-.56990824+04	-.17008802+07	-.64474798+07	-.19799338+07
-.22022003+04	-.84639373+04	-.28896136+04	-.10335427+07	-.39506797+07	-.13379759+07
.77250344+06	.26778358+07	.85132009+06	.36112662+09	.12555114+10	.40154465+09

DPXF/PUO MATRIX

-.73017974+03	-.30210995+04	-.11257959+04	-.27894944+06	-.17367466+07	-.81671920+06
-.48904411+04	-.17752561+05	-.56990824+04	-.17008802+07	-.64474798+07	-.19799338+07
-.22022003+04	-.84639373+04	-.28896136+04	-.10335427+07	-.39506797+07	-.13379759+07
-.56584765+02	-.19981157+03	-.62552222+02	-.22227359+05	-.72746940+05	-.19313893+05
.96493151+02	.34359340+03	.10950605+03	.37200305+05	.13508612+06	.41757678+05
-.43203972+02	-.15693634+03	-.50318079+02	-.12980879+05	-.53827211+05	-.17400459+05
.31019691+03	.11004274+04	.35262066+03	.13015889+06	.46903817+06	.14961861+06

BOUNDARY CONDITIONS

B1 =	.63535696360-03	B2 =	-.90435060373+00	B3 =	-.68804062680-01	B4 =	-.42707296174+00
B5 =	-.42891373138-01	ERR =	.10034019144+01				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .400 TOL = .49999999814-01

PBWU MATRIX

-.42713388+00	.14494849-01	-.43251651+02	-.15536746+03	-.47600462+02	-.39896740-04
-.18704446+02	.63173888+00	-.18010441+04	-.64689004+04	-.19293414+04	-.20595893-02
.89130836+01	-.28474173+00	.10858093+04	.36350362+04	.10957337+04	.47230793-03
.25143339+02	-.85405717+00	.29699531+04	.10534924+05	.33828159+04	-.31888485-04
-.80260690+00	-.43465976+00	-.57910943+03	-.30556531+03	.34799963+03	-.63526085-04

SIMULTANEOUS EQUATION MATRIX

.10623135+04	-.35485432+02	.11852325+06	.41859134+06	.13064994+06	.41999441-01
-.35485432+02	.13987247+01	-.37323859+04	-.13988565+05	-.45719106+04	-.13813399-02
.11852325+06	-.37323859+04	.13580602+08	.47069636+08	.14511920+08	.41660542+01
.41859134+06	-.13988565+05	.47069636+08	.16616229+09	.52002515+08	.14729802+02
.13064994+06	-.45719106+04	.14511920+08	.52002515+08	.16489803+08	.43630938+01

.41999441-01	-.13813399-02	.41660542+01	.14729802+02	.43630938+01	.44716270-05

RIGHT HAND SIDE

-.12229921+01	.60475579-01	-.16678768+03	-.64370019+03	-.23569480+03	.17935044-03

ANSWER

.14935571+00	-.13939971+01	-.13304343-03	.10707028-03	-.17115697-02	-.35204379+03

CHECK

-.12229921+01	.60475579-01	-.16678768+03	-.64370019+03	-.23569480+03	.17935044-03

ITERATION PARAMETERS

.34965221+02	.33596029+02	.18408598+03	.19686521+03

TRIAL NUMBER 4

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169515807+01	DDY =	.91182599408+01	DDZ =	-.17680305521+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.49029720814+00	UY =	.33152231170+00	UZ =	-.80604069657+00
ALFA=	.33596029022+02	LFX =	.21198548291+01	LFY =	.24275768845+02	LFZ =	-.91811994171+01
BETA=	.19686521351+03	DFX =	-.14300445912+02	DFY =	-.49235619844+01	DFZ =	-.16320103196+02
AREA=	.65821803840+03	CL =	.42053021930+00	CD =	.35932880757+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23868875491+03	CHIY=	.19361199573+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.25790657133-03
PRES=	.68513884435-03	UDX =	-.49029720814+00	UDY =	.33152231170+00	UDZ =	-.80604069657+00
MACH=	.14005598208+02	UDDX=	.29021685945-04	UDDY=	-.56993062631-05	UDDZ=	.37133257375-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.43793103267-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUQ MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUQ MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.36180230-03	.25425547-03	-.11550198-03	.00000000	.00000000	.00000000
.89490872-04	.38311643-03	.10313936-03	.00000000	.00000000	.00000000
-.34326874-04	.31912185-03	.15213423-03	.00000000	.00000000	.00000000
.30691484-07	.65158160-07	.81304021-08	.00000000	.00000000	.00000000

FINAL VALUES 47 INTEGRATION STEPS TAKEN

T =	.18788670624+04	R =	.64143323462+07	V =	.11501302546+04	GM =	.39860319000+15
X =	-.40584076151+07	Y =	-.40711464660+06	Z =	-.49504792436+07	PHI =	.28608000000+02
DX =	-.97590479382+02	DY =	.11433188995+04	DZ =	.78087097328+02	AZ =	.90000000000+02
DDX =	.23705567745+01	DDY =	-.76770347385+01	DDZ =	-.10196791791+01	ALT =	.37479460788+05
WKG =	.13280731000+06	VRX =	-.41451349775+03	VRY =	.97046944777+03	VRZ =	.35211558384+03
VR =	.11124827069+04	UX =	-.78962685661+00	UY =	.58132456158+00	UZ =	-.19634454773+00
ALFA=	.42337794733+02	LFX =	-.92203196184+06	LFY =	-.11386696001+06	LFZ =	-.77159404527+06
BETA=	.10212065351+02	DFX =	-.42138477933+06	DFY =	.98655666539+06	DFZ =	.35795251156+06
AREA=	.65821803840+03	CL =	.51710341555+00	CD =	.48424226138+00	ETA =	.14726619973+01

RHO =	.57338248897-02	Q =	.23354509330+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.19396368670+03	CHIY=	.35543759070+02
DRNG=	.11205558625+08	XRNG=	-.17202557780+06	PANG=	.93543531565+02	DCEL=	.12458091850+02
PRES=	.40544757882+03	UOX =	-.49029720814+00	UOY =	.33152231170+00	UOZ =	-.80604069657+00
MACH=	.35357696167+01	UODX=	.29021685945-04	UODY=	-.56993062631-05	UODZ=	.37133257375-03
CDO =	.31405567840-01	CLA =	.76778503038+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.55495689654+05	HT1 =	.39538479184+05	DHT1=	.63629633234+00	DCLI=	.71452900124+05
D2 =	.10419108337+03	LAT =	-.14313623563+02	LONG=	.13505191895+03	LNGO=	.00000000000

PXF/PUD MATRIX

.40911574+07	.24492481+06	-.40852214+07	.28674307+10	-.63104255+09	-.39182770+10
-.35608696+08	-.12673737+09	-.38799701+08	-.14215110+11	-.55685090+11	-.17831818+11
-.23989252+06	.10938126+08	.67571009+07	-.11446476+10	.53414745+10	.47566769+10
.18642205+04	.88623785+04	.13732333+04	-.25950661+05	.13409748+07	-.24473382+07
-.15392506+05	-.61531650+05	-.18264479+05	-.14088273+07	-.18526686+08	-.52093566+07
-.90421476+04	-.32742195+05	-.89049634+04	-.35215524+07	-.13222896+08	-.19645308+07
.50692844+06	.16919127+07	.50187870+06	.21327929+09	.75988039+09	.24321732+09

DPXF/PUD MATRIX

.18642205+04	.88623785+04	.13732333+04	-.25950661+05	.13409748+07	-.24473382+07
-.15392506+05	-.61531650+05	-.18264479+05	-.14088273+07	-.18526686+08	-.52093566+07
-.90421476+04	-.32742195+05	-.89049634+04	-.35215524+07	-.13222896+08	-.19645308+07
.31608194+02	.13095944+03	.40482353+02	-.11855435+04	.38147708+05	.13367204+05
.80734030+02	.28407429+03	.91917897+02	.28558074+05	.12106487+06	.52129691+05
.10922502+02	.24533844+02	.17039311+01	.10015135+05	.13186779+05	-.43634938+04
-.55701916+02	-.30005137+03	-.66553209+02	.46507945+05	.53900677+04	.46318626+05

BOUNDARY CONDITIONS

B1 =	.44838732216-02	B2 =	.21254166956+01	B3 =	.11170296443+00	B4 =	-.65307580671+00
B5 =	-.95812900516-02	ERR =	.22263183955+01				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .200 TOL = .49999999814-01

ITERATION PARAMETERS

.34965221+02	.34622923+02	.18408598+03	.18728079+03

TRIAL NUMBER 5

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169706557+01	DDY =	.91182739768+01	DDZ =	-.17680047873+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.55534081266+00	UY =	.36727154758+00	UZ -	-.74612880398+00
ALFA=	.34622923246+02	LFX =	-.12451407462+01	LFY =	.25853498499+02	LFZ =	-.67086116528+01
BETA=	.18728079532+03	DFX =	-.15132139548+02	DFY =	-.52099093610+01	DFZ =	-.17269257234+02
AREA=	.65821803840+03	CL =	.43180792096+00	CD =	.38022686099+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23333983508+03	CHIY=	.21547444532+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.26826381062-03
PRES=	.68513884435-03	UDX =	-.55534081266+00	UDY =	.36727154758+00	UDZ =	-.74612880398+00
MACH=	.14005598208+02	UDDX=	.13056473939-04	UDDY=	.71491270897-05	UDDZ=	.16594421411-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.46426160201-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.31848887-03	.27924489-03	-.99595625-04	.00000000	.00000000	.00000000
.97552027-04	.37781500-03	.11336659-03	.00000000	.00000000	.00000000
-.63041496-04	.33330538-03	.21098649-03	.00000000	.00000000	.00000000
.24325649-07	.68575263-07	.15649734-07	.00000000	.00000000	.00000000

FINAL VALUES 52 INTEGRATION STEPS TAKEN

T =	.18366218078+04	R =	.64031746432+07	V =	.53073714298+03	GM =	.39860319000+15
X =	-.37041424685+07	Y =	-.19906180161+07	Z =	-.48288108265+07	PHI =	.28608000000+02
DX =	.32411673874+03	DY =	.35551029281+03	DZ =	-.22414880395+03	AZ =	.90000000000+02
DDX =	.89123208073+00	DDY =	-.25974751666+01	DDZ =	.20819664089+00	ALT =	.25008997581+05
WKG =	.13280731000+06	VRX =	.14982769578+02	VRY =	.18690897922+03	VRZ =	.82489233689+02
VR =	.20485097894+03	UX =	-.67382911546+00	UY =	.48239482776+00	UZ =	-.55968701371+00
ALFA=	.80474538583+02	LFX =	-.54862577506+06	LFY =	.26506432700+06	LFZ =	-.50094984965+06
BETA=	.81082742245+00	DFX =	.81126965050+05	DFY =	.10120530884+07	DFZ =	.44665314670+06
AREA=	.65821803840+03	CL =	.14013556949+01	CD =	.19705820406+01	ETA =	.57944402074+00

RHO =	.40756865903-01	W =	.56288108140+06	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FO =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.21971325509+03	CHIY=	.28841928987+02
DRNG=	.95939175056+07	XRNG=	-.36349549825+06	PANG=	.10406499116+03	DCEL=	.10248513985+02
PRES=	.25348987390+04	UDX =	-.55534081266+00	UDY =	.36727154758+00	UDZ =	-.74612880398+00
MACH=	.69421494667+00	UDDX=	.13056473939-04	UDDY=	.71491270897-05	UDDZ=	.16594421411-03
CDO =	.17901363643-01	CLA =	.14209474936+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.73211736038+05	HT1 =	.43593837496+05	DHT1=	.10591852449-01	DCL1=	.10282963458+06
D2 =	.61796957449+02	LAT =	-.23266029152+00	LONG=	.13872379484+03	LNGO=	.00000000000

PXF/PUO MATRIX

.13882347+08	.37685578+08	.91624136+07	.73923163+10	.16935250+11	.29367928+10
-.44980321+08	-.15917088+09	-.51112566+08	-.20179283+11	-.72442459+11	-.23355207+11
.83605424+07	.38380491+08	.14569193+08	.28213662+10	.17515239+11	.75647530+10
.18999976+03	.31366111+03	-.12767179+03	.33690978+05	-.61974637+06	-.60835513+06
-.54113396+04	-.19859392+05	-.62940763+04	-.17278579+07	-.69478569+07	-.20206112+07
-.20899697+04	-.79992466+04	-.27292706+04	-.10527991+07	-.39131413+07	-.13101743+07
.87875518+06	.30338576+07	.96229032+06	.41258585+09	.14312481+10	.45878359+09

DPXF/PUO MATRIX

.18999976+03	.31366111+03	-.12767179+03	.33690978+05	-.61974637+06	-.60835513+06
-.54113396+04	-.19859392+05	-.62940763+04	-.17278579+07	-.69478569+07	-.20206112+07
-.20899697+04	-.79992466+04	-.27292706+04	-.10527991+07	-.39131413+07	-.13101743+07
-.87349717+02	-.31144850+03	-.96262025+02	-.32400347+05	-.11214909+06	-.28453875+05
.87806529+02	.31469033+03	.99654664+02	.32637811+05	.12302523+06	.37574686+05
-.68519023+02	-.25153784+03	-.79796713+02	-.19979238+05	-.85657672+05	-.26117855+05
.52109124+03	.18600428+04	.58925099+03	.20255942+06	.74705514+06	.22847482+06

BOUNDARY CONDITIONS

B1 =	.99232206308-03	B2 =	-.87951640196+00	B3 =	-.69494654863-01	B4 =	-.44074550527+00
B5 =	-.39535604200-01	ERR =	.98701532788+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .400 TOL = .49999999814-01

PBWU MATRIX

-.42547815+00	.25243130-01	-.40858953+02	-.15151807+03	-.44715052+02	-.40326543-04
-.22468714+02	.13282630+01	-.20058701+04	-.75055644+04	-.20950268+04	-.25262944-02
.28434687+01	-.14069680+00	.56259708+03	.16402834+04	.50997402+03	-.25074085-03
.25578945+02	-.15107579+01	.30159956+04	.10753727+05	.34457526+04	-.35180095-04
-.71550905+00	-.44574777+00	-.59168519+03	-.23430606+03	.41865498+03	-.61088226-04

SIMULTANEOUS EQUATION MATRIX

.11679039+04	-.66580395+02	.12425578+06	.44860559+06	.13638085+06	.55210610-01
-.66580395+02	.42658523+01	-.70373194+04	-.26346136+05	-.82480417+04	-.32408942-02
.12425578+06	-.70373194+04	.13788020+08	.48556026+08	.14635751+08	.48580418+01
.44860559+06	-.26346136+05	.48556026+08	.17474453+09	.53524226+08	.18192085+02
.13638085+06	-.82480417+04	.14635751+08	.53524226+08	.16699694+08	.50197895+01

.55210610-01	-.32408942-02	.48560418+01	.18192085+02	.50197895+01	.64516298-05

RIGHT HAND SIDE

-.48076311+00	.45689019-01	-.11675796+03	-.42969413+03	-.18710920+03	.27594774-03

ANSWER

.54110942-01	-.14318742+01	.40348805-03	-.11273035-03	-.10628926-02	-.29852421+03

CHECK

-.48076311+00	.45689019-01	-.11675796+03	-.42969413+03	-.18710920+03	.27594774-03

ITERATION PARAMETERS

.34622923+02	.34126871+02	.18728080+03	.20040725+03

TRIAL NUMBER 6

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169388167+01	DDY =	.91182597192+01	DDZ =	-.17680348461+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.46003641316+00	UY =	.32891394984+00	UZ =	-.82473153945+00
ALFA=	.34126870979+02	LFX =	.33878162102+01	LFY =	.24099259549+02	LFZ =	-.10238996570+02
BETA=	.20040725574+03	DFX =	-.14727633283+02	DFY =	-.50706401605+01	DFZ =	-.16807622399+02
AREA=	.65821803840+03	CL =	.42637720161+00	CD =	.37006278955+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24084716449+03	CHIY=	.19202869820+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.26323828562-03
PRES=	.68513884435-03	UOX =	-.46003641316+00	UOY =	.32891394984+00	UOZ =	-.82473153945+00
MACH=	.14005598208+02	UODX=	-.51501613443-04	UODY=	.25185983385-04	UODZ=	.33600702405-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.45145534765-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38289694-03	.24874508-03	-.11437759-03	.00000000	.00000000	.00000000
.89264976-04	.38320000-03	.10303315-03	.00000000	.00000000	.00000000
-.16286407-04	.31680892-03	.13622984-03	.00000000	.00000000	.00000000
.34304346-07	.64651143-07	.66467266-08	.00000000	.00000000	.00000000

FINAL VALUES 42 INTEGRATION STEPS TAKEN

T =	.18843856815+04	R =	.64127852883+07	V =	.91448950892+03	GM =	.39860319000+15
X =	-.39791878136+07	Y =	-.37110247858+06	Z =	-.50151931616+07	PHI =	.28608000000+02
DX =	.25350205185+02	DY =	.91390860629+03	DZ =	.20481414922+02	AZ =	.90000000000+02
DDX =	.27820220272+01	DDY =	-.75211512206+01	DDZ =	-.95233975646+00	ALT =	.35922595681+05
WKG =	.13280731000+06	VRX =	-.29571571113+03	VRY =	.73879962280+03	VRZ =	.28818096629+03
VR =	.84635745037+03	UX =	-.79689517927+00	UY =	.53839270647+00	UZ =	-.27402804033+00
ALFA=	.49072738403+02	LFX =	-.84016894110+06	LFY =	-.49485884007+05	LFZ =	-.73527063976+06
BETA=	.86822880379+01	DFX =	-.40949533881+06	DFY =	.10230602922+07	DFZ =	.39906152425+06
AREA=	.65821803840+03	CL =	.65584164418+00	CD =	.68778706670+00	ETA =	.12479132266+01

```
RHO  =   .72281466117-02  W    =   .17040187941+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .19897654085+03  CHIY=    .32574290119+02
DRNG=    .11241387818+08  XRNG=   -.27372814251+06  PANG=    .95310255866+02  DCEL=    .12193810843+02
PRES=    .50279200646+03  UOX  =  -.46003641316+00  UOY  =   .32891394984+00  UOZ  =  -.82473153945+00
MACH=    .27121203006+01  UODX=   -.51501613443-04  UODY=    .25185983385-04  UODZ=    .33600702405-03
CDO  =   .39170123156-01  CLA  =   .86804171278+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .55129857608+05  HT1  =   .38120602586+05  DHT1=    .31458089383+00  DCLI=    .72139112630+05
D2   =   .94185293874+02  LAT  =  -.14258918756+02  LONG=    .13407693679+03  LNGO=    .00000000000

                                                   PXF/PUD MATRIX
  .36266498+07    -.85343117+06    -.39966184+07     .25534805+10    -.10857716+10    -.35361948+10
 -.33234326+08    -.11564275+09    -.34815360+08    -.13463022+11    -.50808328+11    -.16010144+11
 -.22152969+06     .99650972+07     .59644229+07    -.98410629+09     .48714737+10     .40656905+10
  .32733460+04     .12868061+05     .30309472+04     .73226835+06     .33966928+07    -.81767535+06
 -.13910766+05    -.52344729+05    -.15385718+05    -.24508203+07    -.16553370+08    -.47050874+07
 -.69652952+04    -.24771876+05    -.69201689+04    -.28195431+07    -.10139592+08    -.19451700+07
  .45650738+06     .14738316+07     .42532035+06     .19654377+09     .66580037+09     .20646844+09

                                                   DPXF/PUD MATRIX
  .32733460+04     .12868061+05     .30309472+04     .73226835+06     .33966928+07    -.81767535+06
 -.13910766+05    -.52344729+05    -.15385718+05    -.24508203+07    -.16553370+08    -.47050874+07
 -.69652952+04    -.24771876+05    -.69201689+04    -.28195431+07    -.10139592+08    -.19451700+07
  .10128778+02     .40012223+02     .14294014+02    -.20327028+04     .11124402+05     .86393601+04
  .98462055+02     .34841937+03     .10657801+03     .29441747+05     .13543975+06     .49699858+05
  .99954677+01     .23379742+02     .17352633+01     .88578064+04     .12484267+05    -.45200103+04
 -.39023492+02    -.19557362+03    -.42830730+02     .28550970+05     .16030681+05     .36063186+05

                                                   BOUNDARY CONDITIONS

B1   =   .39993934011-02  B2   =   .83889913126+00  B3   =   .80914546118-01  B4   =  -.65680735780+00
B5   =  -.25545343602-01  ERR  =   .10688140068+01

                                                   DESIRED VALUES

   .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK   =   .200             TOL  =   .49999999814-01

                                                   ITERATION PARAMETERS

  .34622923+02     .34498910+02     .18728080+03     .19056241+03
```

TRIAL NUMBER 7

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169625903+01	DDY =	.91182713243+01	DDZ =	-.17680126773-01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.53121027094+00	UY =	.36025770161+00	UZ =	-.76683116556+00
ALFA=	.34498910411+02	LFX =	-.72398937418-01	LFY =	.25536206913+02	LFZ =	-.76405007369+01
BETA=	.19056241416+03	DFX =	-.15030533454+02	DFY =	-.51749269620+01	DFZ =	-.17153301273+02
AREA=	.65821803840+03	CL =	.43045326218+00	CD =	.37767379397+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23528832949+03	CHIY=	.21116023083+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.26700351372-03
PRES=	.68513884435-03	UOX =	-.53121027094+00	UOY =	.36025770161+00	UOZ =	-.76683116556+00
MACH=	.14005598208+02	UODX=	-.30830479064-05	UODY=	.11658341164-04	UODZ=	.20845991660-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.46104485704-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.33537246-03	.27267718-03	-.10422013-03	.00000000	.00000000	.00000000
.95705448-04	.37889776-03	.11170793-03	.00000000	.00000000	.00000000
-.51893398-04	.33168923-03	.19177612-03	.00000000	.00000000	.00000000
.26841344-07	.67877153-07	.13294804-07	.00000000	.00000000	.00000000

FINAL VALUES 54 INTEGRATION STEPS TAKEN

T =	.18485627762+04	R =	.64041288293+07	V =	.53156636624+03	GM =	.39860319000+15
X =	-.37385475411+07	Y =	-.18929096433+07	Z =	-.48428319635+07	PHI =	.28608000000+02
DX =	.30655153419+03	DY =	.37664290610+03	DZ =	-.21616910023+03	AZ =	.90000000000+02
DDX =	.13694712828+01	DDY =	-.27579785989+01	DDZ =	.40390508915+00	ALT =	.25971448351+05
WKG =	.13280731000+06	VRX =	-.34800493442+01	VRY =	.20755203467+03	VRZ =	.89259947602+04
VR =	.22595861587+03	UX =	-.70525406429+00	UY =	.50152264605+00	UZ =	-.50109055099+00
ALFA=	.74122250844+02	LFX =	-.58895188762+06	LFY =	.21021529831+06	LFZ =	-.51176586746+06
BETA=	.10837236683+01	DFX =	-.16072216590+05	DFY =	.95855573443+06	DFZ =	.41223703138+06
AREA=	.65821803840+03	CL =	.13810043124+01	CD =	.17834926558+01	ETA =	.58935632005+00

RHO =	.34821731231-01	Q =	.58512405792+06	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.21539420488+03	CHIY=	.30100788517+02
DRNG=	.96967709084+07	XRNG=	-.34643344467+06	PANG=	.10380204179+03	DCEL=	.99380307313+01
PRES=	.21818094613+04	UDX =	-.53121027094+00	UDY =	.36025770161+00	UDZ =	-.76683116556+00
MACH=	.76292440671+00	UDDX=	-.30830479064-05	UDDY=	.11658341164-04	UDDZ=	.20845991660-03
CDO =	.18390550639-01	CLA =	.14357828331+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.73006841811+05	HT1 =	.43691696713+05	DHT1=	.13139211324-01	DCLI=	.10232198691+06
D2 =	.59402610159+02	LAT =	-.11475315727+01	LONG=	.13857940348+03	LNGO=	.00000000000

PXF/PUO MATRIX

.13224613+08	.35061470+08	.81588318+07	.70644546+10	.15620576+11	.23505826+10
-.45282117+08	-.15999724+09	-.51190163+08	-.20182775+11	-.72761614+11	-.23420542+11
.79319975+07	.37064341+08	.14207630+08	.25916648+10	.16981394+11	.75108580+10
.11887924+04	.40425479+04	.98055664+03	.33159147+06	.62915994+06	-.38017642+06
-.55828969+04	-.20715240+05	-.64963869+04	-.16405776+07	-.70418074+07	-.19546279+07
-.19012667+04	-.72237529+04	-.24698750+04	-.10425844+07	-.37485210+07	-.12522774+07
.86377034+06	.29595031+07	.93354495+06	.40575846+09	.13993625+10	.44837395+09

DPXF/PUO MATRIX

.11887924+04	.40425479+04	.98055664+03	.33159147+06	.62915994+06	-.38017642+06
-.55828969+04	-.20715240+05	-.64963869+04	-.16405776+07	-.70418074+07	-.19546279+07
-.19012667+04	-.72237529+04	-.24698750+04	-.10425844+07	-.37485210+07	-.12522774+07
-.10734476+03	-.38599536+03	-.11796373+03	-.37962780+05	-.13754086+06	-.33275705+05
.78441234+02	.28223753+03	.89078709+02	.28436434+05	.11075179+06	.34037072+05
-.83131054+02	-.30849596+03	-.97030240+02	-.22899869+05	-.10338316+06	-.30188831+05
.63034796+03	.22634047+04	.70990526+03	.23241624+06	.88162462+06	.26026141+06

BOUNDARY CONDITIONS

B1 =	.12906753354-02	B2 =	-.85448658741+00	B3 =	-.65073722883-01	B4 =	-.45527980991+00
B5. =	-.36871513881-01	ERR =	.97109360886+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .400 TOL = .49999999814-01

PBWU MATRIX

-.40351195+00	.34619181-01	-.36993483+02	-.14185280+03	-.40459878+02	-.39655168-04
-.25274515+02	.21643132+01	-.21021927+04	-.82379889+04	-.21450668+04	-.29596055-02
-.39925133+01	.38017787+00	.24242566+02	-.55742680+03	-.62107859+02	-.10589769-02
.25203702+02	-.21410366+01	.29740264+04	.10651571+05	.34068234+04	-.38134479-04
-.56479744+00	-.45531117+00	-.57644925+03	-.13371569+03	.48236784+03	-.58189851-04

SIMULTANEOUS EQUATION MATRIX

.12904497+04	-.10993869+03	.12833209+06	.47902850+06	.14007194+06	.78118309-01
-.10993869+03	.96213311+01	-.10646903+05	-.40790941+05	-.12181370+05	-.67013436-02
.12833209+06	-.10646903+05	.13598297+08	.49064708+08	.14363257+08	.61175861+01
.47902850+06	-.40790941+05	.49064708+08	.18166915+09	.53934918+08	.24578713+02
.14007194+06	-.12181370+05	.14363257+08	.53934918+08	.16445931+08	.62579403+01

```
.78118309-01   -.67013436-02   .61175861+01   .24578713+02   .62579403+01   .98871093-05
                                              RIGHT HAND SIDE
.28719314+00   -.10234551-01   -.67554114+02  -.20033715+03  -.13997192+03  .37077993-03
                                              ANSWER
-.17432891-01  -.14057539+01   .48103374-03   -.95805157-04  -.90716546-03  -.26285163+03
                                              CHECK
.28719314+00   -.10234551-01   -.67554114+02  -.20033715+03  -.13997192+03  .37077993-03
                                              ITERATION PARAMETERS
.34498910+02   .34658723+02    .19056241+03   .20344942+03
```

```
                                        TRIAL NUMBER  8


                                        INITIAL VALUES

T    =   .00000000000     R    =   .65000732772+07  V    =   .79182741874+04  GM   =   .39860319000+15
X    =   .10416416000+07  Y    =  -.62981421000+07  Z    =   .12244760000+07  PHI  =   .28608000000+02
DX   =  -.50566950000+04  DY   =  -.17567557000+04  DZ   =  -.58346132000+04  AZ   =   .90000000000+02
DDX  =  -.15169271601+01  DDY  =   .91182593903+01  DDZ  =  -.17680380302+01  ALT  =   .14030918566+06
WKG  =   .13280731000+06  VRX  =  -.49783056909+04  VRY  =  -.17140022624+04  VRZ  =  -.56813936515+04
VR   =   .77459386217+04  UX   =  -.43299106585+00  UY   =   .32597155814+00  UZ   =  -.84039352697+00
ALFA=    .34658723692+02  LFX  =   .45020031848+01  LFY  =   .23906186094+02  LFZ  =  -.11157052127+02
BETA=    .20344942194+03  DFX  =  -.15161530903+02  DFY  =  -.52200286368+01  DFZ  =  -.17302799540+02
AREA=    .65821803840+03  CL   =   .43219861246+00  CD   =   .38096538065+00  ETA  =   .17999863636+01
RHO  =   .31358995814-08  Q    =   .61922721324+02  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .24274138561+03  CHIY=    .19024446824+02
DRNG=    .00000000000     XRNG=    .88986254448-12  PANG=    .91500003418+02  DCEL=    .26862812339-03
PRES=    .68513884435-03  UDX  =  -.43299106585+00  UDY  =   .32597155814+00  UDZ  =  -.84039352697+00
MACH=    .14005598208+02  UDDX=   -.80048445393-04  UDDY=    .26987166123-04  UDDZ=    .35360638906-03
CD0  =   .12000053346-01  CLA  =   .75999370475+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .00000000000     HT1  =   .00000000000     DHT1=    .15884027431+00  DCLI=    .00000000000
D2   =   .46519210222-07  LAT  =   .68028973356+02  LONG=    .21023191184+03  LNG0=    .00000000000

                                        PXF/PUO MATRIX
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000

                                        DPXF/PUO MATRIX
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .00000000        .00000000        .00000000        .00000000        .00000000        .00000000
   .40120415-03     .24350273-03    -.11226032-03     .00000000        .00000000        .00000000
   .89017766-04     .38331863-03     .10281739-03     .00000000        .00000000        .00000000
   .34004789-06     .31788800-03     .12312709-03     .00000000        .00000000        .00000000
   .37534390-07     .64108196-07     .55276402-08     .00000000        .00000000        .00000000

                                        FINAL VALUES   43 INTEGRATION STEPS TAKEN

T    =   .18906190373+04  R    =   .64120223598+07  V    =   .84249998911+03  GM   =   .39860319000+15
X    =  -.39521756800+07  Y    =  -.37590681493+06  Z    =  -.50351794609+07  PHI  =   .28608000000+02
DX   =   .19416436495+02  DY   =   .84166960081+03  DZ   =   .31961175185+02  AZ   =   .90000000000+02
DDX  =   .29372554814+01  DDY  =  -.70554888725+01  DDZ  =  -.11639475047+01  ALT  =   .35131827646+05
WKG  =   .13280731000+06  VRX  =  -.30292897580+03  VRY  =   .66586278170+03  VRZ  =   .29809919288+03
VR   =   .78993818570+03  UX   =  -.81575008684+00  UY   =   .52629806318+00  UZ   =  -.23992112143+00
ALFA=    .48246987923+02  LFX  =  -.84126097807+06  LFY  =  -.52583390176+05  LFZ  =  -.73743575718+06
BETA=    .86064119893+01  DFX  =  -.43634488264+06  DFY  =   .95912190825+06  DFZ  =   .42938796788+06
AREA=    .65821803840+03  CL   =   .66959556635+00  CD   =   .68029085919+00  ETA  =   .11881097911+01
```

RHO =	.81444458945-02	Q =	.16725824793+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.19638919685+03	CHIY=	.31755669223+02
DRNG=	.11236587264+08	XRNG=	-.30712723096+06	PANG=	.95886763349+02	DCEL=	.12021576552+02
PRES=	.56166061025+03	UOX =	-.43299106585+00	UOY =	.32597155814+00	UOZ =	-.84039352697+00
MACH=	.25422761860+01	UODX=	-.80048445393-04	UODY=	.26987166123-04	UODZ=	.35360638906-03
CDO =	.40766139973-01	CLA =	.89755427797+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.56117755345+05	HT1 =	.37616599315+05	DHT1=	.27149853883+00	DCLI=	.74618911375+05
D2 =	.93909059620+02	LAT =	-.14102572360+02	LONG=	.13383501320+03	LNGO=	.00000000000

PXF/PUO MATRIX

.32317709+07	-.22635608+07	-.44018923+07	.23142642+10	-.18245336+10	-.37545848+10
-.32263554+08	-.11037794+09	-.32921370+08	-.12931755+11	-.48282245+11	-.15239639+11
.56307365+05	.10693862+08	.61117606+07	-.81249986+09	.52584137+10	.41510015+10
.34572376+04	.13603658+05	.32443788+04	.62670570+06	.35236814+07	-.72347394+06
-.11902036+05	-.44382895+05	-.12928482+05	-.17339391+07	-.13241295+08	-.37679764+07
-.68067188+04	-.24015350+05	-.66408845+04	-.25911065+07	-.96153688+07	-.18319978+07
.44565221+06	.13985820+07	.39695248+06	.19145508+09	.63020881+09	.19507540+09

DPXF/PUO MATRIX

.34572376+04	.13603658+05	.32443788+04	.62670570+06	.35236814+07	-.72347394+06
-.11902036+05	-.44382895+05	-.12928482+05	-.17339391+07	-.13241295+08	-.37679764+07
-.68067188+04	-.24015350+05	-.66408845+04	-.25911065+07	-.96153688+07	-.18319978+07
.37787650+01	.14885248+02	.66966842+01	-.31475919+04	.23720839+04	.59271513+04
.81705601+02	.28194057+03	.86750515+02	.23755816+05	.10889915+06	.43382973+05
-.18902410+00	-.14650921+02	-.88685208+01	.70950954+04	.19146385+04	-.63427274+04
.68459417+02	.20261984+03	.69147470+02	.48336535+05	.13606915+06	.61939607+05

BOUNDARY CONDITIONS

B1 =	.37605161625-02	B2 =	.61579205150+00	B3 =	.70892852161-01	B4 =	-.65599794908+00
B5 =	-.30781951544-01	ERR =	.90306180652+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .800 TOL = .49999999814-01

PBWU MATRIX

-.16965371+00	.32697540-01	-.94805270+01	-.54519277+02	-.16287811+02	-.27053553-04
-.19622283+03	.37261557+02	-.96097867+04	-.58841326+05	-.12149260+05	-.29265451-01
-.71921326+01	.14051808+01	-.15541220+03	-.18405956+04	-.33364355+03	-.12992825-02
.13464347+02	-.24560617+01	.15434023+04	.57023554+04	.17793472+04	-.90065015-04
.10274135+01	-.80505874+00	-.36096115+03	.73657477+03	.86277011+03	.12671227-05

SIMULTANEOUS EQUATION MATRIX

.38737498+05	-.73555764+04	.19071889+07	.11636794+08	.24112086+07	.57506875+01
-.73555764+04	.13970796+04	-.36179441+06	-.22097059+07	-.45823446+06	-.10920827+01
.19071889+07	-.36179441+06	.94884627+08	.57427432+09	.11923862+09	.28129746+03
.11636794+08	-.22097059+07	.57427432+09	.34987518+10	.72627550+09	.17238983+04
.24112086+07	-.45823446+06	.11923862+09	.72627550+09	.15162654+09	.35582834+03

.57506875+01	-.10920827+01	.28129746+03	.17238983+04	.35582834+03	.85816363-03

RIGHT HAND SIDE

-.21510852+02	.40962834+01	-.11152611+04	-.66077314+04	-.14431326+04	-.30097892-02

ANSWER

-.39124867+00	-.89724252+00	-.18533670-03	.98544597-03	-.13259974-02	.10747320+03

CHECK

-.21510852+02	.40962834+01	-.11152611+04	-.66077314+04	-.14431326+04	-.30097892-02

ITERATION PARAMETERS

.34658724+02	.49005538+02	.20344942+03	.23635068+03

TRIAL NUMBER 9

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15167109099+01	DDY =	.91182588562+01	DDZ =	-.17680071879+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.85655998302-02	UY =	.26048084878+00	UZ =	-.96544101732+00
ALFA=	.49005538395+02	LFX =	.19437831481+02	LFY =	.19089578722+02	LFZ =	-.22791423398+02
BETA=	.23635068113+03	DFX =	-.28945299302+02	DFY =	-.99657014996+01	DFZ =	-.33033254666+02
AREA=	.65821803840+03	CL =	.57362272213+00	CD =	.72731157803+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.26949167709+03	CHIY=	.15098595830+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.43189488938-03
PRES=	.68513884435-03	UDX =	-.85655998302-02	UDY =	.26048084878+00	UDZ =	-.96544101732+00
MACH=	.14005598208+02	UDDX=	.38567041930-04	UDDY=	-.60369825205-03	UDDZ=	.12022446900-02
CD0 =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.90157210294-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNG0=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.60619968-03	.15582783-03	.36664800-04	.00000000	.00000000	.00000000
.87508410-04	.38368995-03	.10274509-03	.00000000	.00000000	.00000000
.28451258-03	.26604586-03	.69256257-04	.00000000	.00000000	.00000000
.83452151-07	.51368292-07	.13119018-07	.00000000	.00000000	.00000000

FINAL VALUES 113 INTEGRATION STEPS TAKEN

T =	.18218361906+04	R =	.63649668035+07	V =	.33299936288+03	GM =	.39860319000+15
X =	-.20337875315+07	Y =	-.49211157825+07	Z =	-.34869944280+07	PHI =	.28608000000+02
DX =	.23154871618+03	DY =	.85282963610+02	DZ =	-.22360810323+03	AZ =	.90000000000+02
DDX =	.79532887388-02	DDY =	-.40576738564-02	DDZ =	.25492698187-01	ALT =	-.72668729163+04
WKG =	.13280731000+06	VRX =	.83160286277+01	VRY =	-.36467889844+02	VRZ =	.78416441058+02
VR =	.86880386451+02	UX =	.41515283525-01	UY =	-.56479364501+00	UZ =	.82418724802+00
ALFA=	.99565079206+01	LFX =	-.39047801961+06	LFY =	-.11202446525+07	LFZ =	-.47956438329+06
BETA=	.85129644032-01	DFX =	.24651690378+05	DFY =	-.10810390024+06	DFZ =	.23245444575+06
AREA=	.65821803840+03	CL =	.23635777815+00	CD =	.47571249540-01	ETA =	.53937792790+00

```
RHO  =   .21793382503+01  Q    =   .54138711290+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=   .87116381495+02  CHIY=  -.34387962686+02
DRNG=   .59171538191+07  XRNG=  -.75841127427+06  PANG=   .92998931571+02  DCEL=   .98283069135+01
PRES=   .19037508467+06  UOX  =  -.85655998302-02  UOY  =   .26048084878+00  UOZ  =  -.96544101732+00
MACH=   .24157554129+00  UODX=   .38567041930-04  UODY=  -.60369825205-03  UODZ=   .12022446900-02
CDO  =   .17210272928-01  CLA  =   .13670155365+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=   .73152000000+00
J    =   .64537632230+05  HT1  =   .74696256731+04  DHT1=   .59086049447-02  DCL1=   .12160563879+06
D2   =   .95768197299+02  LAT  =   .31720215196+02  LONG=   .14751760615+03  LNGO=   .00000000000

                                        PXF/PUO MATRIX

  .71517443+07     .43239224+07     .54167745+06     .36081838+10     .17401648+10     .30717132+09
 -.69424621+07    -.26022359+07    -.12851397+07    -.35422517+10    -.10580041+10    -.93530157+09
  .57418473+07     .11821640+07     .15142825+07     .29516003+10     .48221473+09     .11482516+10
 -.32908246+03    -.85594779+02    -.10142589+03    -.95146473+05    -.35105750+05    -.79823573+05
  .15121630+03    -.28113260+02    -.32461123+02     .62008007+04    -.15306929+06    -.95960404+05
 -.18551019+03     .24153706+03     .97189711+01    -.23051047+05     .34756850+06     .12941943+06
  .32113251+05     .77221498+05     .32131165+05     .25699070+08     .47925755+08     .32541337+08

                                        DPXF/PUO MATRIX

 -.32908246+03    -.85594779+02    -.10142589+03    -.95146473+05    -.35105750+05    -.79823573+05
  .15121630+03    -.28113260+02    -.32461123+02     .62008007+04    -.15306929+06    -.95960404+05
 -.18551019+03     .24153706+03     .97189711+01    -.23051047+05     .34756850+06     .12941943+06
 -.92348016-02    -.31741222-03     .79882936-02    -.50723629+01    -.97118174+01     .17038323+01
 -.19013799+00     .91820766-01     .77631415-01    -.35670508+02     .18108146+03     .13316475+03
  .99947103-01    -.14162448+00    -.11735043+00     .17969762+02    -.13863740+03    -.13303161+03
 -.55183554+01     .12569087+01     .61616795+00    -.12557120+04     .48081164+04     .26378039+04

                                        BOUNDARY CONDITIONS

B1   =  -.10917909936-01  B2   =  -.98541031446+00  B3   =   .12161729752+00  B4   =   .11685537155+00
B5   =  -.10063496389+00  ERR  =   .10048512474+01

                                        DESIRED VALUES

   .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK   =  .400              TOL  =   .49999999814-01

                                        ITERATION PARAMETERS

  .34658724+02     .38245427+02     .20344942+03     .21167474+03
```

TRIAL NUMBER 10

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15168779112+01	DDY =	.91182690075+01	DDZ =	-.17680349311+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.33549939052+00	UY =	.33882676375+00	UZ =	-.87899748755+00
ALFA=	.38245427600+02	LFX =	.79652717768+01	LFY =	.24123909645+02	LFZ =	-.14257416137+02
BETA=	.21167474058+03	DFX =	-.18238867276+02	DFY =	-.62795380028+01	DFZ =	-.20814749272+02
AREA=	.65821803840+03	CL =	.47045987174+00	CD =	.45828993517+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FM =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24910894234+03	CHIY=	.19805410186+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30623094480-03
PRES=	.68513884435-03	UDX =	-.33549939052+00	UDY =	.33882676375+00	UDZ =	-.87899748755+00
MACH=	.14005598208+02	UDDX=	-.50394573562-04	UDDY=	-.13068418842-03	UDDZ=	.56576596430-03
CDQ =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971745-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.56261742235-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGD=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.46438965-03	.23296881-03	-.87447776-04	.00000000	.00000000	.00000000
.91898675-04	.38001449-03	.11140775-03	.00000000	.00000000	.00000000
.66594316-04	.32543709-03	.10002809-03	.00000000	.00000000	.00000000
.49673201-07	.63842800-07	.56499829-08	.00000000	.00000000	.00000000

FINAL VALUES 44 INTEGRATION STEPS TAKEN

T =	.18734233256+04	R =	.64050807571+07	V =	.46491055177+03	GM =	.39860319000+15
X =	-.38463119954+07	Y =	-.54253737370+06	Z =	-.50927985172+07	PHI =	.28608000000+02
DX =	-.21575045739+03	DY =	.36100920422+03	DZ =	.19815629122+03	AZ =	.90000000000+02
DDX =	.28495641192+01	DDY =	-.15424729029+01	DDZ =	-.19679937203+01	ALT =	.27891064524+05
WKG =	.13280731000+06	VRX =	-.54178456404+03	VRY =	.18319057547+03	VRZ =	.46333508095+03
VR =	.73604938558+03	UX =	-.90354062584+00	UY =	.19755955258+00	UZ =	.38024276539+00
ALFA=	.17522649762+02	LFX =	-.83680771689+06	LFY =	-.16508021006+06	LFZ =	-.91322324339+06
BETA=	.39852763927+01	DFX =	-.43898093313+06	DFY =	.14843016043+06	DFZ =	.37541724089+06
AREA=	.65821803840+03	CL =	.27512564412+00	CD =	.13130748833+00	ETA =	.11591275256+01

```
RHO  =    .25473158449-01  Q    =    .45418887288+07  AE   =    .63781660000+07  BE   =    .63567840000+07
OM   =    .72921150604-04  FJ   =    .16234500072-02  FH   =   -.57500000139-05  FD   =    .78750000512-05
F    =    .00000000000     OMX  =    .47881444528+00  OMY  =   -.87791612754+00  OMZ  =   -.77140676824-08
ISP  =    .40000000000+03  MD   =    .00000000000     CHIP=     .15717687497+03  CHIY=     .11394284404+02
DRNG=     .11069862766+08  XRNG=    -.42527552652+06  PANG=     .97238239995+02  DCEL=     .10425718058+02
PRES=     .16237078087+04  UDX  =   -.33549939052+00  UDY  =    .33882676375+00  UDZ  =   -.87899748755+00
MACH=     .24639406753+01  UDDX=    -.50394573562-04  UDDY=    -.13068418842-03  UDDZ=     .56576596430-03
CDO  =    .41484364110-01  CLA  =    .91378734267+00  EXA  =    .00000000000     HTC  =    .61031971743-08
CK1  =    .00000000000     CK2  =    .50000000000+00  CK3  =    .50000000000+00  RCRV=     .73152000000+00
J    =    .64000238746+05  HT1  =    .28394960638+05  DHT1=     .38843616958+00  DCLI=     .99605516854+05
D2   =    .10136199308+03  LAT  =   -.12308153667+02  LONG=     .13335604129+03  LNGO=     .00000000000

                                                     PXF/PUO MATRIX

   .17605141+07     -.86988940+07     -.63937184+07      .77056174+09     -.63672131+10     -.50820570+10
  -.24578995+08     -.63079481+08     -.17851047+08     -.90024588+10     -.24476945+11     -.10988062+11
   .13260268+07      .13317071+08      .67547594+07      .36751310+09      .73030642+10      .50251053+10
   .13689899+04      .65399835+04      .84407188+03     -.29206160+07     -.45881885+07     -.31134358+07
   .11286775+03      .86076032+03     -.33090207+03      .14212295+07      .50778051+07      .33683086+06
  -.28958188+04     -.87612847+04     -.14580245+04      .13451910+07      .15701941+07      .17470161+07
   .26812045+06      .54059275+06      .16131583+06      .12286566+09      .21089969+09      .14553046+09

                                                     DPXF/PUO MATRIX

   .13689899+04      .65399835+04      .84407188+03     -.29206160+07     -.45881885+07     -.31134358+07
   .11286775+03      .86076032+03     -.33090207+03      .14212295+07      .50778051+07      .33683086+06
  -.28958188+04     -.87612847+04     -.14580245+04      .13451910+07      .15701941+07      .17470161+07
  -.66528684+01     -.10497266+02     -.52869583+01     -.20892449+04      .61359803+04     -.46413409+04
   .65274104+01     -.84617237+00      .71640014+01     -.23795574+04     -.24849145+05      .95560364+04
   .12148262+02      .13069717+02      .31044719+01      .11975140+05      .13859589+05      .84679865+04
  -.52377022+01     -.17819539+02     -.57180784+01     -.25875944+05     -.74489374+05     -.20828889+05

                                                     BOUNDARY CONDITIONS

B1   =    .15883668198-02  B2   =    .51775091288+00  B3   =    .47552869757-01  B4   =   -.63459025741+00
B5   =   -.49238058821-01  ERR  =    .82186311960+00

                                                     DESIRED VALUES

   .64000000+07      .20000000+01      .10000000+03      .60000000+02     -.10000000+01

AK   =    .800             TOL  =    .49999999814-01

                                                     PBWU MATRIX

  -.11456719-01     -.16897517-03      .23769197+01      .28169482+02     -.40643414+01     -.18319701-04
  -.33552190+02      .86126285+01      .14508458+05      .24401446+05      .15718111+05     -.14520539-01
  -.13233121+01      .33678836+00      .91263008+03      .21243786+04      .10078289+04     -.87228934-03
   .79044386+01     -.16932413+01      .10917047+04      .28864614+04      .12817348+04     -.39347439-04
   .19149266+01     -.12112276+01     -.56560553+02      .14905611+04      .11104534+04      .45877396-04

                                                     SIMULTANEOUS EQUATION MATRIX

   .11936478+04     -.30512176+03     -.47947727+06     -.79586334+06     -.51645286+06      .48812725+00
  -.30512176+03      .78624934+02      .12348331+06      .20418317+06      .13219838+06     -.12534273+00
  -.47947727+06      .12348331+06      .21252328+09      .35903306+09      .23030180+09     -.21151231+03
  -.79586334+06      .20418317+06      .35903306+09      .61049779+09      .39104043+09     -.35622094+03
  -.51645286+06      .13219838+06      .23030180+09      .39104043+09      .25095072+09     -.22911399+03
```

```
.48812725+00   -.12534273+00   -.21151231+03   -.35622094+03   -.22911399•03   .21161094-03
                                               RIGHT HAND SIDE
-.43028956+01   .11062404+01    .13878622+04    .21791712+04    .14368798+0'   -.14918871-02
                                               ANSWER
.33614553-01    .25950372+00   -.24809465-03    .11290472-03    .15405960-04    .27883775+02
                                               CHECK
-.43028956+01   .11062404+01    .13878622+04    .21791712+04    .14368798+04   -.14918871-02
                                               ITERATION PARAMETERS
.38245428+02    .37012806+02    .21167474+03    .20215892+03
```

TRIAL NUMBER 11

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169137873+01	DDY =	.91182769245+01	DDZ =	-.17680232446+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.42208860854+00	UY =	.36621411167+00	UZ =	-.82929393520+00
ALFA=	.37012805856+02	LFX =	.42875772932+01	LFY =	.25549560151+02	LFZ =	-.11464946514+02
BETA=	.20215892650+03	DFX =	-.17151953315+02	DFY =	-.59053197236+01	DFZ =	-.19574330048+02
AREA=	.65821803840+03	CL =	.45751127402+00	CD =	.43097893381+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24302511763+03	CHIY=	.21482320204+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.29306183039-03
PRES=	.68513884435-03	UDX =	-.42208860854+00	UDY =	.36621411167+00	UDZ =	-.82929393520+00
MACH=	.14005598208+02	UDDX=	.10838600005-03	UDDY=	-.20294320973-03	UDDZ=	.55590615001-03
CD0 =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.52820683872-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNG0=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.41206688-03	.25786679-03	-.95857786-04	.00000000	.00000000	.00000000
.96380083-04	.37675469-03	.11731902-03	.00000000	.00000000	.00000000
.13873797-04	.33939251-03	.14281348-03	.00000000	.00000000	.00000000
.40038995-07	.67290395-07	.93364827-08	.00000000	.00000000	.00000000

FINAL VALUES 59 INTEGRATION STEPS TAKEN

T =	.18555777100+04	R =	.63956258333+07	V =	.24881858855+03	GM =	.39860319000+15
X =	-.39019278346+07	Y =	-.72680086638+06	Z =	-.50150522903+07	PHI =	.28608000000+02
DX =	-.90375855348+02	DY =	.16270456487+03	DZ =	.16513666870+03	AZ =	.90000000000+02
DDX =	.33355886039+01	DDY =	-.39255854832+00	DDZ =	-.26490488340+01	ALT =	.18254822520+05
WKG =	.13280731000+06	VRX =	-.41143275307+03	VRY =	-.12399499952+02	VRZ =	.44030959848+03
VR =	.60274638151+03	UX =	-.73724943362+00	UY =	-.34574641077-01	UZ =	.67473540504+00
ALFA=	.45464876380+01	LFX =	-.86519639500+06	LFY =	-.21428191525+06	LFZ =	-.81448854301+06
BETA=	.34338134471+01	DFX =	-.51718559012+06	DFY =	-.15586612034+05	DFZ =	.55348481089+06
AREA=	.65821803840+03	CL =	.83253557843-01	CD =	.52242638506-01	ETA =	.99978293045+00

```
RHO  =   .12129644019+00  Q    =   .14502973830+08  AE   =   .63781660000+07  BE   =  .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =  .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  = -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .13753505395+03  CHIY= -.19813758926+01
DRNG=    .10884726086+08  XRNG=  -.33349065501+06  PANG=    .11190886902+03  DCEL=   .10733311178+02
PRES=    .74132937334+04  UOX  =  -.42208860854+00  UOY  =   .36621411167+00  UOZ  = -.82929393520+00
MACH=    .20605771000+01  UODX=    .10838600005-03  UODY=   -.20294320973-03  UODZ=   .55590615001-03
CDO  =   .45302068372-01  CLA  =   .10502804485+01  EXA  =   .00000000000     HTC  =  .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=   .73152000000+00
J    =   .68030834481+05  HT1  =   .29400048888+05  DHT1=    .46546310687+00  DCLI=   .10666162007+06
D2   =   .11475975819+03  LAT  =  -.11090238136+02  LONG=    .13471231113+03  LNGO=   .00000000000

                                              PXF/PUO MATRIX

  .34619250+07    -.67960261+07    -.62745318+07     .17137424+10    -.65747659+10    -.49890456+10
 -.26959995+08    -.78968011+08    -.25233603+08    -.10445648+11    -.31016818+11    -.15378263+11
  .13329275+07     .16527597+08     .85893255+07     .39582897+09     .94588265+10     .63135696+10
  .33177332+04     .12911285+04     .22038094+04     .18023302+07    -.72528428+07     .19569691+07
  .89945730+02     .22637642+04    -.54559710+02    -.21628017+06     .34526849+07    -.20176550+06
 -.33161096+04    -.46159460+04    -.24550798+04    -.46869443+06     .52978230+07    -.11140248+07
  .25894312+06     .43663061+06     .18542816+06     .17390353+09     .20279259+09     .22571754+09

                                              DPXF/PUO MATRIX

  .33177332+04     .12911285+04     .22038094+04     .18023302+07    -.72528428+07     .19569691+07
  .89945730+02     .22637642+04    -.54559710+02    -.21628017+06     .34526849+07    -.20176550+06
 -.33161096+04    -.46159460+04    -.24550798+04    -.46869443+06     .52978230+07    -.11140248+07
  .13583245+02    -.54636443+02    -.58948245+00     .59817006+05     .52409514+05     .52897317+05
  .17765065+01    -.27230301+02     .12188320+01     .39442112+04    -.37449429+05     .66650262+04
 -.21769057+02     .38985680+02    -.16566779+02    -.59155501+05    -.25173916+05    -.64582041+05
  .22061248+03    -.28796280+03     .12035592+03     .48003835+06     .13503543+06     .49245647+06

                                              BOUNDARY CONDITIONS

B1   =  -.13664599630-02  B2   =   .61494496284-01  B3   =  -.19922813270+00  B4   = -.61152563236+00
B5   =  -.34780850697-01  ERR  =   .64703059877+00

                                              DESIRED VALUES

   .64000000+07     .20000000+01     .10000000+03     .60000000*02    -.10000000+01

AK   = 1.000              TOL  =   .49999999814-01

                                              PBWU MATRIX

  .26403645-01    -.20321069-01    -.52739051+02     .37148574+02    -.49758325+02    -.28993300-04
 -.16839178+02    -.15820154+01    -.54759306+04     .33472344+05    -.68634485+04    -.15111063-01
 -.20311512+01    -.19237066+01    -.56240689+04     .10296656+05    -.41989609+04    -.44474803-02
  .10362819+02    -.16591945+01     .13225988+04     .37810374+04     .18856968+04    -.10974225-04
  .21516461+01    -.12079321+01    -.16558079+03     .17332872+04     .12297188+04     .27621392-04

                                              SIMULTANEOUS EQUATION MATRIX

  .39970178+03     .10753666+02     .11698169+06    -.54164821+06     .14628929+06     .26343631+00
  .10753666+02     .10415859+02     .17488699+05    -.81129435+05     .14322507+05     .32447014-01
  .11698169+06     .17488699+05     .63395432+08    -.23648950+09     .63492040+08     .10774251+03
 -.54164821+06    -.81129435+05    -.23648950+09     .12437209+10    -.26371147+09    -.55159155+03
  .14628929+06     .14322507+05     .63492040+08    -.26371147+09     .69808735+08     .12240351+03
```

```
.26343631+00     .32447014-01     .10774251+03    -.55159155+03     .12240351+03     .24812602-03
                                           RIGHT HAND SIDE
-.19435557+01     .30304555+00     .99238522+02     .59025967+03    -.23344057+03    -.48432280-03
                                           ANSWER
-.15449281-01    -.19920304-01     .38966403-04     .54837643-05    -.23842875-04     .24087942+02
                                           CHECK
-.19435557+01     .30304555+00     .99238522+02     .59025967+03    -.23344057+03    -.48432280-03
                                           ITERATION PARAMETERS
.37012806•02     .37897984+02     .20215893+03     .20330028+03
```

```
                                          TRIAL NUMBER 12

                                          INITIAL VALUES

T    =   .00000000000      R    =   .65000732772+07   V    =   .79182741874+04   GM   =   .39860319000+15
X    =   .10416416000+07   Y    =  -.62981421000+07   Z    =   .12244760000+07   PHI  =   .28608000000+02
DX   =  -.50566950000+04   DY   =  -.17567557000+04   DZ   =  -.58346132000+04   AZ   =   .90000000000+02
DDX  =  -.15169040258+01   DDY  =   .91182812113+01   DDZ  =  -.17680206727+01   ALT  =   .14030918566+06
WKG  =   .13280731000+06   VRX  =  -.49783056909+04   VRY  =  -.17140022624+04   VRZ  =  -.56813936515+04
VR   =   .77459386217+04   UX   =  -.40502357517+00   UY   =   .37470279903+00   UZ   =  -.83399863066+00
ALFA =   .37897984812+02   LFX  =   .48065030194+01   LFY  =   .25851207215+02   LFZ  =  -.12010656746+02
BETA =   .20330028095+03   DFX  =  -.17929429376+02   DFY  =  -.61730002982+01   DFZ  =  -.20461609342+02
AREA =   .65821803840+03   CL   =   .46683179097+00   CD   =   .45051465652+00   ETA  =   .17999863636+01
RHO  =   .31358995814-08   Q    =   .61922721324+02   AE   =   .63781660000+07   BE   =   .63567840000+07
OM   =   .72921150604-04   FJ   =   .16234500072-02   FH   =  -.57500000139-05   FD   =   .78750000512-05
F    =   .00000000000      OMX  =   .47881444528+00   OMY  =  -.87791612754+00   OMZ  =  -.77140676824-08
ISP  =   .40000000000+03   MD   =   .00000000000      CHIP =   .24409691333+03   CHIY =   .22005945075+02
DRNG =   .00000000000      XRNG =   .88986254448-12   PANG =   .91500003418+02   DCEL =   .30249286244-03
PRES =   .68513884435-03   UOX  =  -.40502357517+00   UOY  =   .37470279903+00   UOZ  =  -.83399863066+00
MACH =   .14005598208+02   UODX =   .69419597502-04   UODY =  -.20842697400-03   UODZ =   .57974902527-03
CDO  =   .12000053346-01   CLA  =   .75999370475+00   EXA  =   .00000000000      HTC  =   .61031971743-08
CK1  =   .00000000000      CK2  =   .50000000000+00   CK3  =   .50000000000+00   RCRV =   .73152000000+00
J    =   .00000000000      HT1  =   .00000000000      DHT1 =   .15884027431+00   DCLI =   .00000000000
D2   =   .55282093511-07   LAT  =   .68028973356+02   LONG =   .21023191184+03   LNGO =   .00000000000

                                          PXF/PUO MATRIX

   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000

                                          DPXF/PUO MATRIX

   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .00000000          .00000000          .00000000          .00000000          .00000000          .00000000
   .42396018-03       .25815855-03      -.89905587-04       .00000000          .00000000          .00000000
   .97756642-04       .37496945-03       .12099343-03       .00000000          .00000000          .00000000
   .26078376-04       .34398158-03       .14188093-03       .00000000          .00000000          .00000000
   .42322410-07       .67717137-07       .98707919-08       .00000000          .00000000          .00000000

                                          FINAL VALUES   48 INTEGRATION STEPS TAKEN

T    =   .18314897676+04   R    =   .63987587438+07   V    =   .20991752038+03   GM   =   .39860319000+15
X    =  -.39899521665+07   Y    =  -.15584129631+07   Z    =  -.47534981021+07   PHI  =   .28608000000+02
DX   =  -.70386193035+02   DY   =   .17721842740+03   DZ   =   .87776865872+02   AZ   =   .90000000000+02
DDX  =   .23873946405+01   DDY  =  -.53570455436+00   DDZ  =  -.20121197588+01   ALT  =   .20747089264+05
WKG  =   .13280731000+06   VRX  =  -.37469874318+03   VRY  =   .11246710158+02   VRZ  =   .39762131364+03
VR   =   .54646897962+03   UX   =  -.77319859776+00   UY   =  -.19558165775-01   UZ   =   .63386229307+00
ALFA =   .77061345705+01   LFX  =  -.87863622898+06   LFY  =  -.37456997407+06   LFZ  =  -.81738880596+06
BETA =   .32824864451+01   DFX  =  -.38807369095+06   DFY  =   .11648163763+05   DFZ  =   .41181448722+06
AREA =   .65821803840+03   CL   =   .15676783345+00   CD   =   .70577614439-01   ETA  =   .92208213473+00
```

RHO =	.81594275674-01	Q =	.80191900135+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.14065536599+03	CHIY=	-.11206718023+01
DRNG=	.10043331901+08	XRNG=	-.98075989691+05	PANG=	.10788853547+03	DCEL=	.10381050293+02
PRES=	.49785539485+04	UDX =	-.40502357517+00	UDY =	.37470279903+00	UDZ =	-.83399863066+00
MACH=	.18697329638+01	UDDX=	.69419597502-04	UDDY=	-.20842697400-03	UDDZ=	.57974902527-03
CDO =	.47813589581-01	CLA =	.11691040303+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.73164230752+05	HT1 =	.34521353939+05	DHT1=	.28450099471+00	DCL1=	.11180710757+06
D2 =	.10628329563+03	LAT =	-.48616132519+01	LONG=	.13944483543+03	LNGO=	.00000000000

PXF/PUO MATRIX

.50478206+07	.37262862+06	-.39845548+07	.21720861+10	-.37190983+10	-.40434698+10
-.28663020+08	-.91715645+08	-.30531071+08	-.11587239+11	-.37997087+11	-.16940430+11
.52441439+07	.29675744+08	.13382413+08	.20870639+10	.15462483+11	.90439949+10
.13969068+04	.35319278+04	.13644317+04	-.11854584+07	-.59937772+07	-.13569314+07
-.11984271+03	.17001584+04	-.19818109+03	-.29782404+06	.29012383+07	-.38896978+06
-.22100786+04	-.79786576+04	-.23292432+04	.14967772+07	.35242085+07	.13497914+07
.39207467+06	.97553748+06	.31983367+06	.20312372+09	.43843933+09	.23680164+09

DPXF/PUO MATRIX

.13969068+04	.35319278+04	.13644317+04	-.11854584+07	-.59937772+07	-.13569314+07
-.11984271+03	.17001584+04	-.19818109+03	-.29782404+06	.29012383+07	-.38896978+06
-.22100786+04	-.79786576+04	-.23292432+04	.14967772+07	.35242085+07	.13497914+07
.44573870+01	-.22729858+02	-.32762806+01	.19040690+05	.19349301+05	.17768023+05
-.20397436+00	-.18023271+02	-.27070218+00	-.12429393+04	-.29227790+05	.75794004+03
-.18425767+01	.15423764+02	-.41766000+01	-.11744563+05	-.67045737+04	-.18268257+05
.39446780+02	-.58900169+02	.20573959+02	.88792335+05	.57682910+05	.10532891+06

BOUNDARY CONDITIONS

B1 =	-.38785493462-03	B2 =	-.12602466098+00	B3 =	-.13345838170+00	B4 =	-.50320300037+00
B5 =	.20787902458-02	ERR =	.53564081828+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = 1.000 TOL = .49999999814-01

PBWU MATRIX

.45591685-02	-.11226690-01	-.25862826+02	.27016265+02	-.22323037+02	-.20145953-04
-.23989969+02	.45041052+01	.65046391+04	.22959898+05	.69200398+04	-.98902097-02
-.29333694+00	-.92612009+00	-.18063730+04	.68383079+04	-.71566513+03	-.23804270-02
.13338875+02	-.26057784+01	.16227344+04	.52613368+04	.23535047+04	-.17569209-04
.26780410+01	-.13434768+01	-.47151545+02	.20075469+04	.13967282+04	.17353252-04

SIMULTANEOUS EQUATION MATRIX

.76070219+03	-.14613777+03	-.13399716+06	-.47725645+06	-.13066811+06	.23777612+00
-.14613777+03	.29739799+02	.26805648+05	.80673428+05	.23822446+05	-.42319290-01
-.13399716+06	.26805648+05	.48209473+08	.14543571+09	.50058952+08	-.60061113+02
-.47725645+06	.80673428+05	.14543571+09	.60563202+09	.16917545+09	-.24341445+03
-.13066811+06	.23822446+05	.50058952+08	.16917545+09	.55889459+08	-.66753718+02

.23777612+00	-.42319290-01	-.60061113+02	-.24341445+03	-.66753718+02	.10348370-03

RIGHT HAND SIDE

.11000084+01	-.10000912+00	-.63218803+03	-.35017915+04	-.85287577+03	.12288645-02

ANSWER

.17169418-01	.76800960-01	-.87118683-04	-.44953432-04	.10516412-03	-.84632800+02

CHECK

.11000084+01	-.10000912+00	-.63218803+03	-.35017915+04	-.85287577+03	.12288645-02

ITERATION PARAMETERS

.37897985+02	.36914250+02	.20330028+03	.19889991+03

TRIAL NUMBER 13

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169236446+01	DDY =	.91182804430+01	DDZ =	-.17680170359+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.44875208100+00	UY =	.37654086004+00	UZ =	-.81045576716+00
ALFA=	.36914249932+02	LFX =	.30640549460+01	LFY =	.26046316933+02	LFZ =	-.10542703428+02
BETA=	.19889991517+03	DFX =	-.17066361408+02	DFY =	-.58758509181+01	DFZ =	-.19476649964+02
AREA=	.65821803840+03	CL =	.45646672978+00	CD =	.42882825696+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24102655777+03	CHIY=	.22119579331+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.29202000367-03
PRES=	.68513884435-03	UDX =	-.44875208100+00	UDY =	.37654086004+00	UDZ =	-.81045576716+00
MACH=	.14005598208+02	UDDX=	.15653828013-03	UDDY=	-.16347354199-03	UDDZ=	.47458490507-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.52549708654-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.39523802-03	.26638305-03	-.95082033-04	.00000000	.00000000	.00000000
.98521091-04	.37521213-03	.11977354-03	.00000000	.00000000	.00000000
-.78162776-06	.34380979-03	.16016814-03	.00000000	.00000000	.00000000
.37189276-07	.68421558-07	.11197091-07	.00000000	.00000000	.00000000

FINAL VALUES 61 INTEGRATION STEPS TAKEN

T =	.19161225673+04	R =	.63936971567+07	V =	.32118715296+03	GM =	.39860319000+15
X =	-.33756689366+07	Y =	-.28998212124+07	Z =	-.45907798355+07	PHI =	.28608000000+02
DX =	.71080340123+02	DY =	.28767595499+03	DZ =	-.12390043338+03	AZ =	.90000000000+02
DDX =	.76755413941+00	DDY =	-.75285949919+00	DDZ =	.11425140490+00	ALT =	.15985272674+05
WKG =	.13280731000+06	VRX =	-.22281520483+03	VRY =	.12738566033+03	VRZ =	.19345463711+03
VR =	.32140071341+03	UX =	-.78500176723+00	UY =	.33395893393+00	UZ =	.52176973455+00
ALFA=	.78476412895+01	LFX =	-.87397679795+06	LFY =	-.52203336758+06	LFZ =	-.66287247452+06
BETA=	.43223641677+01	DFX =	-.29151872293+06	DFY =	.16666414237+06	DFZ =	.25310502844+06
AREA=	.65821803840+03	CL =	.20772975053+00	CD =	.71905175652-01	ETA =	.65546206155+00

```
RHO =   .17201838143+00  Q    =   .58480127937+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  MD   =   .00000000000     CHIP=    .14638907754+03  CHIY=    .19509243583+02
DRNG=   .86023959793+07  XRNG=  -.45851660936+06  PANG=    .10424594684+03  DCEL=    .96796309671+01
PRES=   .10630828595+05  UOX  =  -.44875208100+00  UOY  =   .37654086004+00  UOZ  =  -.81045576716+00
MACH=   .10926637635+01  UODX=   .15653828013-03  UODY=   -.16347354199-03  UODZ=    .47458490507-03
CDO =   .43487837525-01  CLA  =   .15213913220+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J   =   .11072638672+06  HT1  =   .43195196074+05  DHT1=    .84039863544-01  DCLI=    .17825757737+06
D2  =   .92523087185+02  LAT  =   .83589686328+01  LONG=    .14147641615+03  LNGO=    .00000000000
```

PXF/PUO MATRIX

```
  .24960868+08     .72584743+08     .18768153+08     .11913315+11     .30125512+11     .45107039+10
 -.59190950+08    -.20802229+09    -.68448767+08    -.25405169+11    -.93322255+11    -.31578559+11
  .19666391+08     .79821399+08     .30105259+08     .77188198+10     .37660041+11     .17102158+11
  .17745976+04     .71001689+04     .18272462+04    -.81990314+05     .74756737+06    -.55038633+06
 -.21567065+04    -.75972485+04    -.34447177+04    -.26451827+06    -.74913872+06    -.20649634+07
 -.32973143+04    -.14824232+05    -.39303752+04    -.27580168+06    -.62848345+07    -.14196329+06
  .15231274+07     .50803362+07     .16534211+07     .70638033+09     .23641415+10     .81434548+09
```

DPXF/PUO MATRIX

```
  .17745976+04     .71001689+04     .18272462+04    -.81990314+05     .74756737+06    -.55038633+06
 -.21567065+04    -.75972485+04    -.34447177+04    -.26451827+06    -.74913872+06    -.20649634+07
 -.32973143+04    -.14824232+05    -.39303752+04    -.27580168+06    -.62848345+07    -.14196329+06
 -.15924631+03    -.63502446+03    -.18099384+03    -.16715016+05    -.17054390+06    -.90601914+04
  .49610394+02     .19465033+03     .60248432+02     .60522472+04     .54563673+05     .12157916+05
  .69225323+02     .25342554+03     .70283482+02     .19535489+05     .79170291+05     .52378143+04
  .11102306+03     .44119838+03     .14599584+03     .11522700+05     .13956195+06     .48519719+05
```

BOUNDARY CONDITIONS

```
B1  =  -.19686686750-02  B2   =  -.70152147498+00  B3   =  -.72194130097-01  B4   =  -.29601216691+00
B5  =  -.54308526602-01  ERR  =   .76675998002+00
```

DESIRED VALUES

```
   .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK  =  .500              TOL  =   .49999999814-01
```

ITERATION PARAMETERS

```
  .37897985+02     .37652051+02     .20330028+03     .20220019+03
```

TRIAL NUMBER 14

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169089787+01	DDY =	.91182811530+01	DDZ =	-.17680197907+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.41606714564+00	UY =	.37554827136+00	UZ =	-.82816159425+00
ALFA=	.37652051347+02	LFX =	.43663095245+01	LFY =	.25918376451+02	LFZ =	-.11645202478+02
BETA=	.20220019334+03	DFX =	-.17711847963+02	DFY =	-.60980882581+01	DFZ =	-.20213298825+02
AREA=	.65821803840+03	CL =	.46425331093+00	CD =	.44504746547+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24332511915+03	CHIY=	.22058203280+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.29985926359-03
PRES=	.68513884435-03	UDX =	-.41606714564+00	UDY =	.37554827136+00	UDZ =	-.82816159425+00
MACH=	.14005598208+02	UDDX=	.91199268159-04	UDDY=	-.19718861600-03	UDDZ=	.55345799522-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.54593253024-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.41686915-03	.26040369-03	-.91348597-04	.00000000	.00000000	.00000000
.98012521-04	.37496990-03	.12079709-03	.00000000	.00000000	.00000000
.19249751-04	.34420121-03	.14641464-03	.00000000	.00000000	.00000000
.41037576-07	.67933877-07	.10188909-07	.00000000	.00000000	.00000000

FINAL VALUES 62 INTEGRATION STEPS TAKEN

T =	.18526479675+04	R =	.63988334258+07	V =	.23164442906+03	GM =	.39860319000+15
X =	-.39366578846+07	Y =	-.17667969232+07	Z =	-.47250632316+07	PHI =	.28608000000+02
DX =	-.73186964180+02	DY =	.20709960773+03	DZ =	.73570118020+02	AZ =	.90000000000+02
DDX =	.23819056823+01	DDY =	-.78688086552+00	DDZ =	-.18539366894+01	ALT =	.20725915186+05
WKG =	.13280731000+06	VRX =	-.37567915207+03	VRY =	.42120713938+02	VRZ =	.38727860947+03
VR =	.54119654581+03	UX =	-.78120696378+00	UY =	.32332334316-01	UZ =	.62343427873+00
ALFA=	.77227964464+01	LFX =	-.87118969709+06	LFY =	-.41805724374+06	LFZ =	-.79962830258+06
BETA=	.39028172553+01	DFX =	-.39074845199+06	DFY =	.43810266494+05	DFZ =	.40281318862+06
AREA=	.65821803840+03	CL =	.15892567654+00	CD =	.71325423440-01	ETA =	.91480860160+00

```
RHO =   .81873058082-01  Q    =  .78920681819+07  AE   =  .63781660000+07  BE   =  .63567840000+07
OM  =   .72921150604-04  FJ   =  .16234500072-02  FH   = -.57500000139-05  FD   =  .78750000512-05
F   =   .00000000000     OMX  =  .47881444528+00  OMY  = -.87791612754+00  OMZ  = -.77140676824-08
ISP =   .40000000000+03  MD   =  .00000000000     CHIP =  .14140874214+03  CHIY =  .18528292018+01
DRNG=   .98283088604+07  XRNG= -.12014977092+06  PANG=  .10667873918+03  DCEL=  .10351664246+02
PRES=   .49954152712+04  UOX  = -.41606714564+00  UOY  =  .37554827136+00  UOZ  = -.82816159425+00
MACH=   .18517210231+01  UODX=  .91199268159-04  UODY= -.19718861600-03  UODZ=  .55345799522-03
CDO =   .48114499780-01  CLA  =  .11826546561+01  EXA  =  .00000000000     HTC  =  .61031971743-08
CK1 =   .00000000000     CK2  =  .50000000000+00  CK3  =  .50000000000+00  RCRV=  .73152000000+00
J   =   .76800693035+05  HT1  =  .37915603030+05  DHT1=  .27681712582+00  DCLI=  .11568578304+06
D2  =   .10566079878+03  LAT  = -.29904960653+01  LONG=  .14005738527+03  LNGO=  .00000000000
```

PXF/PUO MATRIX

```
  .73220895+07   .91841052+07  -.15501162+07   .31486616+10   .33631347+08  -.35537739+10
 -.33539738+08  -.11210068+09  -.37124732+08  -.13531264+11  -.47172253+11  -.19276320+11
  .65710570+07   .34355825+08   .15256243+08   .25719555+10   .17574375+11   .10293953+11
  .20619943+04   .79822221+04   .23450940+04  -.15447200+07  -.47636430+07  -.17998181+07
 -.38904310+03   .74496022+03  -.61812709+03  -.15160919+06   .33981054+07  -.48721195+06
 -.31399208+04  -.13815448+05  -.36561281+04   .17783333+07   .12876133+07   .17089009+07
  .54104295+06   .15278520+07   .48707183+06   .26363392+09   .69581464+09   .30330344+09
```

DPXF/PUO MATRIX

```
  .20619943+04   .79822221+04   .23450940+04  -.15447200+07  -.47636430+07  -.17998181+07
 -.38904310+03   .74496022+03  -.61812709+03  -.15160919+06   .33981054+07  -.48721195+06
 -.31399208+04  -.13815448+05  -.36561281+04   .17783333+07   .12876133+07   .17089009+07
  .56719472+01  -.25928919+02  -.20057414+01   .22392409+05   .20383251+05   .22429105+05
  .17237192+01  -.67600375+01   .33717659+01  -.34932843+04  -.30768829+05   .54131017+03
 -.33838948+00   .23975553+02  -.36175974+01  -.11812970+05  -.27051608+04  -.20953384+05
  .41020449+02  -.65403268+02   .27135695+02   .10135729+06   .83233830+05   .12877425+06
```

BOUNDARY CONDITIONS

```
B1  =  -.36452122307-03  B2  = -.14278231319+00  B3  = -.11330451666+00  B4  = -.47375804241+00
B5  =  -.13808861672-02  ERR =  .50761543015+00
```

DESIRED VALUES

```
  .64000000+07    .20000000+01    .10000000+03    .60000000+02   -.10000000+01

AK  = 1.000             TOL =  .49999999814-01
```

PBWU MATRIX

```
 -.35632504-01  -.26336123-02  -.31292029+02   .83672864+01  -.28918214+02  -.20772186-04
 -.45846900+02   .94717317+01   .77898861+04   .15623465+05   .85092236+04  -.95709152-02
 -.14488648+01  -.55376206+00  -.21670900+04   .49109203+04  -.12560900+04  -.19751786-02
  .16751172+02  -.31987266+01   .19497528+04   .67291197+04   .27528974+04  -.22284056-04
  .21444413+01  -.12135503+01  -.11359483+03   .17770539+04   .14659087+04   .16241494-04
```

SIMULTANEOUS EQUATION MATRIX

```
  .23892391+04  -.48963192+03  -.32158415+06  -.60687158+06  -.33904278+06   .44132085+00
 -.48963192+03   .10172492+03   .68884973+05   .12158061+06   .70708013+05  -.89507736-01
 -.32158415+06   .68884973+05   .69194024+08   .12398060+09   .74209797+08  -.70320593+02
 -.60687158+06   .12158061+06   .12398060+09   .31664884+09   .14790433+09  -.15935207+03
 -.33904278+06   .70708013+05   .74209797+08   .14790433+09   .83712817+08  -.78996992+02
```

```
 .44132085+00   -.89507736-01   -.70320593+02   -.15935207+03   -.78996992+02    .95504940-04
                                                RIGHT HAND SIDE
 .30515111+01   -.57024756+00   -.75708662+03   -.27288075+04   -.10026168+04    .11568229-02
                                                ANSWER
-.50237477-02   -.24594288-01    .72384085-05   -.21274615-04    .12481750-04   -.75660532+01
                                                CHECK
 .30515111+01   -.57024756+00   -.75708662+03   -.27288075+04   -.10026168+04    .11568229-02
                                                ITERATION PARAMETERS
 .37652051+02    .37939891+02    .20220019+03    .20360934+03
```

TRIAL NUMBER 15

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169028334+01	DDY =	.91182810306+01	DDZ =	-.17680210689+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.40215994202+00	UY =	.37402015612+00	UZ =	-.83568911914+00
ALFA=	.37939891224+02	LFX =	.49276730942+01	LFY =	.25814400753+02	LFZ =	-.12105727665+02
BETA=	.20360934734+03	DFX =	-.17966624752+02	DFY =	-.61858064541+01	DFZ =	-.20504057835+02
AREA=	.65821803840+03	CL =	.46727030079+00	CD =	.45144926864+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24430167809+03	CHIY=	.21963765324+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30294264271-03
PRES=	.68513884435-03	UOX =	-.40215994202+00	UOY =	.37402015612+00	UOZ =	-.83568911914+00
MACH=	.14005598208+02	UODX=	.83960859630-04	UODY=	-.17591400131-03	UODZ=	.54097624496-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55399850265-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.42574411-03	.25740161-03	-.89679086-04	.00000000	.00000000	.00000000
.97611325-04	.37505436-03	.12088529-03	.00000000	.00000000	.00000000
.27784874-04	.34368499-03	.14044834-03	.00000000	.00000000	.00000000
.42642092-07	.67624553-07	.97452565-08	.00000000	.00000000	.00000000

FINAL VALUES 53 INTEGRATION STEPS TAKEN

T =	.18602140207+04	R =	.63981629237+07	V =	.27324490832+03	GM =	.39860319000+15
X =	-.37069171719+07	Y =	-.26477788518+07	Z =	-.44927186682+07	PHI =	.28608000000+02
DX =	-.71449520651+02	DY =	.26349178016+03	DZ =	-.11394196272+02	AZ =	.90000000000+02
DDX =	.24698308242+01	DDY =	-.11847068841+01	DDZ =	-.14768423917+01	ALT =	.20155488545+05
WKG =	.13280731000+06	VRX =	-.35906732179+03	VRY =	.10662535964+03	VRZ =	.31836670492+03
VR =	.49158485300+03	UX =	-.81178890045+00	UY =	.15439585452+00	UZ =	.56317022401+00
ALFA=	.76198180535+01	LFX =	-.82983898555+06	LFY =	-.57259947638+06	LFZ =	-.74415740019+06
BETA=	.43367416029+01	DFX =	-.40763896352+06	DFY =	.12104875173+06	DFZ =	.36143270562+06
AREA=	.65821803840+03	CL =	.17559208380+00	CD =	.78201732965-01	ETA =	.84777015256+00

```
RHO =   .89731546364-01  Q    =   .71364449781+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  MD   =   .00000000000     CHIP =   .14524942127+03  CHIY =   .88817594376+01
DRNG=   .88907893579+07  XRNG =  -.14365379459+06  PANG =   .10260830852+03  DCEL =   .10328944490+02
PRES=   .54719990322+04  UOX  =  -.40215994202+00  UOY  =   .37402015612+00  UOZ  =  -.83568911914+00
MACH=   .16824179624+01  UODX =   .83960859630-04  UODY =  -.17591400131-03  UODZ =   .54097624496-03
CDO =   .51946873318-01  CLA  =   .13242315123+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV =   .73152000000+00
J   =   .95573003067+05  HT1  =   .42534693291+05  DHT1 =   .21718281351+00  DCL1 =   .14861131284+06
D2  =   .10509151564+03  LAT  =   .49277812985+01  LONG =   .14295920954+03  LNGO =   .00000000000

                                        PXF/PUO MATRIX

  .16866021+08    .45093890+08    .10116863+08    .75688964+10    .16799305+11    .12775219+10
 -.47293474+08   -.16373396+09   -.54218895+08   -.20215460+11   -.72645118+11   -.26196836+11
  .14289684+08    .60126605+08    .23921849+08    .59020564+10    .29306150+11    .14620282+11
  .59594448+04    .23612576+05    .69602513+04   -.85722822+05    .27419065+07   -.23806199+06
 -.25568909+04   -.80971146+04   -.33843564+04   -.44437899+06    .34687503+06   -.13489211+07
 -.70715365+04   -.29340567+05   -.82789618+04   -.22422799+06   -.76407391+07   -.21045350+06
  .12222455+07    .39379304+07    .12621934+07    .57863934+09    .18512397+10    .64799524+09

                                        DPXF/PUO MATRIX

  .59594448+04    .23612576+05    .69602513+04   -.85722822+05    .27419065+07   -.23806199+06
 -.25568909+04   -.80971146+04   -.33843564+04   -.44437899+06    .34687503+06   -.13489211+07
 -.70715365+04   -.29340567+05   -.82789618+04   -.22422799+06   -.76407391+07   -.21045350+06
  .16505370+02    .22332409+02    .12394242+02    .19557346+05    .24638874+05    .20952921+05
  .21334200+02    .79008190+02    .28376403+02   -.22847651+04   -.26553612+04    .45615165+04
  .10657541+02    .64008129+02    .73783174+01   -.73929030+04    .13076465+05   -.19533698+05
 -.11510128+03   -.70538210+03   -.15832912+03    .10911094+06   -.12424786+05    .13656299+06

                                        BOUNDARY CONDITIONS

B1  =  -.57400393573-03  B2   =  -.29236744997+00  B3   =  -.44573851233-01  B4   =  -.33968605171+00
B5  =  -.50625276510-02  ERR  =   .45041994451+00

                                        DESIRED VALUES

   .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK  =  1.000             TOL  =   .49999999814-01

                                        PBWU MATRIX

 -.20124638+00    .33651062-01   -.51146671+02   -.77622668+02   -.51613959+02   -.18633769-04
 -.11165239+03    .24759485+02   -.71940329+03   -.20310716+05   -.78138458+03   -.86751023-02
 -.47778634+00   -.50779166+00   -.22798829+04    .14183830+04   -.19890455+04   -.98378284-03
  .27363636+02   -.57764936+01    .32873718+04    .11741707+05    .42286094+04   -.35490268-04
  .50233028+00   -.84275481+00   -.29748425+03    .98757836+03    .13352673+04    .73662321-05

                                        SIMULTANEOUS EQUATION MATRIX

  .13215545+05   -.29227089+04    .17122769+06    .25888698+07    .20458505+06    .96810223+00
 -.29227089+04    .64736918+03   -.35394847+05   -.57226390+06   -.43890234+05   -.21409333+00
  .17122769+06   -.35394847+05    .16613333+08    .49687386+08    .18603352+08    .83658989+01
  .25888698+07   -.57226390+06    .49687386+08    .55338601+09    .64023031+08    .17439416+03
  .20458505+06   -.43890234+05    .18603352+08    .64023031+08    .24233604+08    .85961032+01
```

.96810223+00	-.21409333+00	.83658989+01	.17439416+03	.85961032+01	.76226890-04

RIGHT HAND SIDE

.84477444+01	-.18714177+01	-.15363831+03	.78872304+03	-.26279326+03	.91488365-03

ANSWER

-.32222317-02	.20436015-01	-.10196012-04	.12833431-04	-.18982926-05	.82294966+02

CHECK

.84477444+01	-.18714177+01	-.15363831+03	.78872304+03	-.26279326+03	.91488365-03

ITERATION PARAMETERS

.37939891+02	.38124511+02	.20360935+03	.20243845+03

TRIAL NUMBER 16

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62961421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169047902+01	DDY =	.91182839786+01	DDZ =	-.17680176196+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.40989705383+00	UY =	.38157691120+00	UZ =	-.82848262873+00
ALFA=	.38124511840+02	LFX =	.45035125020+01	LFY =	.26149355026+02	LFZ =	-.11835109432+02
BETA=	.20243845502+03	DFX =	-.18130906127+02	DFY =	-.62423675945+01	DFZ =	-.20691540729+02
AREA=	.65821803840+03	CL =	.46919919631+00	CD =	.45557718401+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24367580723+03	CHIY=	.22431394296+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30492771216-03
PRES=	.68513884435-03	UOX =	-.40989705383+00	UOY =	.38157691120+00	UOZ =	-.82848262873+00
MACH=	.14005598208+02	UODX=	.94156871838-04	UODY=	-.18874743185-03	UODZ=	.54287453755-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CKI =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55919948284-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.42142701-03	.26158135-03	-.88026332-04	.00000000	.00000000	.00000000
.99014565-04	.37373915-03	.12314616-03	.00000000	.00000000	.00000000
.24154452-04	.34729551-03	.14800444-03	.00000000	.00000000	.00000000
.41949384-07	.68305993-07	.10705186-07	.00000000	.00000000	.00000000

FINAL VALUES 52 INTEGRATION STEPS TAKEN

T =	.17779190548+04	R =	.63993663431+07	V =	.30490504769+03	GM =	.39860319000+15
X =	-.35124752862+07	Y =	-.32617970520+07	Z =	-.42397036393+07	PHI =	.28608000000+02
DX =	-.10987105642+03	DY =	.28101017482+03	DZ =	-.43917202939+02	AZ =	.90000000000+02
DDX =	.25083240533+01	DDY =	-.14610468517+01	DDZ =	-.11262665890+01	ALT =	.21933077446+05
WKG =	.13280731000+06	VRX =	-.38129117558+03	VRY =	.13297795132+03	VRZ =	.29483466586+03
VR =	.49999357626+03	UX =	-.85945727757+00	UY =	.16303262979+00	UZ =	.48451372494+00
ALFA=	.10106926040+02	LFX =	-.78394562585+06	LFY =	-.71254950016+06	LFZ =	-.69244970207+06
BETA=	.56052597851+01	DFX =	-.40697207975+06	DFY =	.14193434539+06	DFZ =	.31469251016+06
AREA=	.65821803840+03	CL =	.22840920529+00	CD =	.96312775034-01	ETA =	.85783487099+00

RHO =	.67347232822-01	W =	.55410030565+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.15058814272+03	CHIY=	.93829649057+01
DRNG=	.82000356558+07	XRNG=	-.12642261044+06	PANG=	.10016883492+03	DCEL=	.10342283867+02
PRES=	.41207265845+04	UOX =	-.40989705383+00	UOY =	.38157691120+00	UOZ =	-.82848262873+00
MACH=	.17083357786+01	UODX=	.94156871838-04	UODY=	-.18874743185-03	UODZ=	.54287453755-03
CDO =	.51208912062-01	CLA =	.13015827623+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.10650648426+06	HT1 =	.42744274287+05	DHT1=	.19797509178+00	DCL1=	.17026869423+06
D2 =	.10413170411+03	LAT =	.10641796494+02	LONG=	.14504293287+03	LNGO=	.00000000000

PXF/PUO MATRIX

.25879958+08	.77635084+08	.21490485+08	.12073083+11	.32934965+11	.71259237+10
-.53798055+08	-.18701951+09	-.62516284+08	-.23918636+11	-.85140843+11	-.30027205+11
.20475028+08	.81169876+08	.30854382+08	.86914646+10	.38930031+11	.17521553+11
.10495219+05	.40108634+05	.12257036+05	.17602118+07	.98734159+07	.15657730+07
-.53725499+04	-.18037144+05	-.67025560+04	-.15776675+07	-.38554664+07	-.26741855+07
-.10488500+05	-.41356137+05	-.12039799+05	-.20826375+07	-.13937171+08	-.17092954+07
.18008373+07	.60098251+07	.19614644+07	.85289078+09	.28484269+10	.97133738+09

DPXF/PUO MATRIX

.10495219+05	.40108634+05	.12257036+05	.17602118+07	.98734159+07	.15657730+07
-.53725499+04	-.18037144+05	-.67025560+04	-.15776675+07	-.38554664+07	-.26741855+07
-.10488500+05	-.41356137+05	-.12039799+05	-.20826375+07	-.13937171+08	-.17092954+07
.94527651+01	.30298115+02	.10381228+02	.41496435+04	.14832571+05	.61214121+04
.51797258+02	.18181850+03	.63527788+02	.12815621+05	.46271206+05	.22127330+05
.23036377+02	.78044192+02	.15999500+02	.11682822+05	.38125991+05	-.18159742+04
-.32386765+03	-.12918546+04	-.37483090+03	-.37892963+05	-.31969384+06	-.13124435+05

BOUNDARY CONDITIONS

B1 =	-.19800796966-03	B2 =	-.27039721685+00	B3 =	-.28836476671-02	B4 =	-.23626468801+00
B5 =	-.23677639287-02	ERR =	.35909555639+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = 1.000 TOL = .49999999814-01

PBWU MATRIX

-.35271361+00	.65654815-01	-.60444627+02	-.14760220+03	-.67049429+02	-.16820452-04
-.18291784+03	.38181156+02	-.92419438+04	-.51102133+05	-.90831984+04	-.85259728-02
-.48761671+00	-.23257347+00	-.13615621+04	.10070571+04	-.13653804+04	-.78714352-03
.34421519+02	-.69803857+01	.42530096+04	.15084354+05	.53135122+04	-.42876188-04
-.12195093+01	-.43815684+00	-.54555509+03	.61444956+02	.93980414+03	.85847126-05

SIMULTANEOUS EQUATION MATRIX

.34645626+05	-.72236653+04	.18382620+07	.98662040+07	.18439215+07	.15584559+01
-.72236653+04	.15067768+04	-.38200401+06	-.20567039+07	-.38399601+06	-.32505400+00
.18382620+07	-.38200401+06	.10565675+09	.53504117+09	.10789522+09	.79682287+02
.98662040+07	-.20567039+07	.53504117+09	.28400054+10	.54301434+09	.43425895+03
.18439215+07	-.38399601+06	.10789522+09	.54301434+09	.11348990+09	.78299226+02

```
 .15584559+01   -.32505400+00   .79682287+02   .43425895+03   .78299226+02   .73314003-04
                                        RIGHT HAND SIDE
 .14853995+02   -.31183819+01   .50412341+03   .35987576+04   .37869393+03   .85913775-03
                                        ANSWER
-.78397851-03    .50072063-01  -.39761331-04   .32102084-04  -.63795715-05   .11026857+03
                                        CHECK
 .14853995+02   -.31183819+01   .50412341+03   .35987576+04   .37869393+03   .85913775-03
                                        ITERATION PARAMETERS
 .38124512+02    .38169430+02   .20243846+03   .19956954+03
```

TRIAL NUMBER 17

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169127205+01	DDY =	.91182881477+01	DDZ =	-.17680112883+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.43281705870+00	UY =	.39315621626+00	UZ =	-.81123213898+00
ALFA=	.38169430841+02	LFX =	.34102302641+01	LFY =	.26689244526+02	LFZ =	-.11040001464+02
BETA=	.19956954223+03	DFX =	-.18170978797+02	DFY =	-.62561643866+01	DFZ =	-.20737272878+02
AREA=	.65821803840+03	CL =	.46966776893+00	CD =	.45658409421+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24191872445+03	CHIY=	.23151031376+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30541156118-03
PRES=	.68513884435-03	UDX =	-.43281705870+00	UDY =	.39315621626+00	UDZ =	-.81123213898+00
MACH=	.14005598208+02	UDDX=	.13391820264-03	UDDY=	-.22084951584-03	UDDZ=	.54925410910-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.56046814258-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.40753711-03	.26998241-03	-.86588965-04	.00000000	.00000000	.00000000
.10146385-03	.37177427-03	.12604294-03	.00000000	.00000000	.00000000
.12030810-04	.35231567-03	.16432775-03	.00000000	.00000000	.00000000
.39614994-07	.69474270-07	.12534262-07	.00000000	.00000000	.00000000

FINAL VALUES 48 INTEGRATION STEPS TAKEN

T =	.16676504841+04	R =	.64005094481+07	V =	.32751201955+03	GM =	.39860319000+15
X =	-.33263188961+07	Y =	-.37210633629+07	Z =	-.40069703325+07	PHI =	.28608000000+02
DX =	-.16280718494+03	DY =	.28164073778+03	DZ =	-.37900373354+02	AZ =	.90000000000+02
DDX =	.27579656660+01	DDY =	-.18648397303+01	DDZ =	-.84441076308+00	ALT =	.23813104861+05
WKG =	.13280731000+06	VRX =	-.41932803077+03	VRY =	.14173456077+03	VRZ =	.30496961875+03
VR =	.53752316365+03	UX =	-.88945329375+00	UY =	.10553629570+00	UZ =	.44467395756+00
ALFA=	.13096123010+02	LFX =	-.73347620126+06	LFY =	-.85600451417+06	LFZ =	-.61068937956+06
BETA=	.85205678168+01	DFX =	-.42801189346+06	DFY =	.14466974128+06	DFZ =	.31128523350+06
AREA=	.65821803840+03	CL =	.27201951988+00	CD =	.11641033548+00	ETA =	.90554296312+00

RHO =	.49564806591-01	Q =	.47131101088+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.15343766797+03	CHIY=	.60580656866+01
DRNG=	.76534254602+07	XRNG=	-.11584425299+06	PANG=	.99738658194+02	DCEL=	.10500348747+02
PRES=	.30588181395+04	UOX =	-.43281705870+00	UOY =	.39315621626+00	UOZ =	-.81123213898+00
MACH=	.18287018575+01	UODX=	.13391820264-03	UODY=	-.22084951584-03	UODZ=	.54925410910-03
CDO =	.48522187590-01	CLA =	.12005165329+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.11351367176+06	HT1 =	.42048231059+05	DHT1=	.21102585572+00	DCLI=	.18497911247+06
D2 =	.10568074811+03	LAT =	.15162413190+02	LONG=	.14653001669+03	LNGO=	.00000000000

PXF/PUO MATRIX

.32753026+08	.10171290+09	.30104418+08	.15609704+11	.45028265+11	.11766373+11
-.55812307+08	-.19392606+09	-.65347590+08	-.25362647+11	-.89408746+11	-.31451210+11
.25369068+08	.97995780+08	.36507252+08	.10963980+11	.46695181+11	.19868223+11
.15899266+05	.56719768+05	.18099511+05	.46912169+07	.16916486+08	.43193256+07
-.84168632+04	-.27065339+05	-.10132701+05	-.33027688+07	-.78032902+07	-.45572359+07
-.14009937+05	-.52712192+05	-.15607373+05	-.40545190+07	-.19466446+08	-.31988792+07
.22802644+07	.77196895+07	.25511908+07	.10821260+10	.36675907+10	.12500054+10

DPXF/PUO MATRIX

.15899266+05	.56719768+05	.18099511+05	.46912169+07	.16916486+08	.43193256+07
-.84168632+04	-.27065339+05	-.10132701+05	-.33027688+07	-.78032902+07	-.45572359+07
-.14009937+05	-.52712192+05	-.15607373+05	-.40545190+07	-.19466446+08	-.31988792+07
-.16236894+02	-.49458524+02	-.18076605+02	-.98843172+04	-.23925682+05	-.11301303+05
.78494712+02	.26158435+03	.96403646+02	.30229521+05	.93831569+05	.47355943+05
-.11227494+02	-.54458560+02	-.26753781+02	.75229033+04	.77578386+04	-.80953339+04
-.20475287+03	-.72262100+03	-.23046515+03	-.70672889+05	-.25196107+06	-.68564666+05

BOUNDARY CONDITIONS

B1 =	.15920885401-03	B2 =	-.16396237907+00	B3 =	.44803770339-02	B4 =	-.15241089957+00
B5 =	-.71485369403-03	ERR =	.22390478825+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = 1.000 TOL = .49999999814-01

PBWU MATRIX

-.48764335+00	.82187551-01	-.72225642+02	-.20453941+03	-.83893715+02	-.17313903-04
-.27071666+03	.47781380+02	-.21971799+05	-.84981549+05	-.20755872+05	-.94354376-02
-.93182879+00	-.80049454-01	-.10783095+04	.12193682+04	-.10902773+04	-.88673602-03
.38934082+02	-.69036928+01	.48543949+04	.17065417+05	.59974577+04	-.46221646-04
-.23771095+01	-.23923743+00	-.73141044+03	-.57441899+03	.63114730+03	.15453505-04

SIMULTANEOUS EQUATION MATRIX

.74810130+05	-.13203401+05	.61399121+07	.23670676+08	.58520224+07	.25533286+01
-.13203401+05	.23307916+04	-.10831007+07	-.41783270+07	-.10332194+07	-.45045326+00
.61399121+07	-.10831007+07	.50802802+09	.19491598+10	.48587795+09	.20803528+03
.23670676+08	-.41783270+07	.19491598+10	.75149508+10	.18645404+10	.79996271+03
.58520224+07	-.10332194+07	.48587795+09	.18645404+10	.46836980+09	.19654151+03

.25533286+01	-.45045326+00	.20803528+03	.79996271+03	.19654151+03	.89816458-04

RIGHT HAND SIDE

.23175705+02	-.40879432+01	.17074205+04	.67974544+04	.14704920+04	.94417920-03

ANSWER

-.13075632-02	.36922050-01	-.40356239-04	.29033506-04	-.14860026-04	.10025876+03

CHECK

.23175705+02	-.40879432+01	.17074205+04	.67974544+04	.14704920+04	.94417920-03

ITERATION PARAMETERS

.38169431+02	.38244349+02	.19956954+03	.19745406+03

TRIAL NUMBER 18

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169183217+01	DDY =	.91182911899+01	DDZ =	-.17680062291+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.44952591872+00	UY =	.40143086464+00	UZ =	-.79798478013+00
ALFA=	.38244349036+02	LFX =	.25994356512+01	LFY =	.27070234970+02	LFZ =	-.10444484737+02
BETA=	.19745406967+03	DFX =	-.18237902987+02	DFY =	-.62792060033+01	DFZ =	-.20813648795+02
AREA=	.65821803840+03	CL =	.47044863581+00	CD =	.45826570535+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.24060629333+03	CHIY=	.23667659124+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30621930907-03
PRES=	.68513884435-03	UDX =	-.44952591872+00	UDY =	.40143086464+00	UDZ =	-.79798478013+00
MACH=	.14005598208+02	UDDX=	.17427444171-03	UDDY=	-.24988302162-03	UDDZ=	.56411413463-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	OHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.56258689392-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNG0=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.39726315-03	.27607189-03	-.84909266-04	.00000000	.00000000	.00000000
.10337116-03	.37028573-03	.12804267-03	.00000000	.00000000	.00000000
.35749013-05	.35559860-03	.17687210-03	.00000000	.00000000	.00000000
.37941872-07	.70283899-07	.13983063-07	.00000000	.00000000	.00000000

FINAL VALUES 46 INTEGRATION STEPS TAKEN

T =	.15673917218+04	R =	.64001274606+07	V =	.33414252636+03	GM =	.39860319000+15
X =	-.30856154477+07	Y =	-.41839618957+07	Z =	-.37329708913+07	PHI =	.28608000000+02
DX =	-.19580329435+03	DY =	.26767315334+03	DZ =	-.40784565984+02	AZ =	.90000000000+02
DDX =	.30987807153+01	DDY =	-.21915564147+01	DDZ =	-.44588910010+00	ALT =	.24489355522+05
WKG =	.13280731000+06	VRX =	-.43478306446+03	VRY =	.13733385883+03	VRZ =	.30283834173+03
VR =	.54736456146+03	UX =	-.89731901003+00	UY =	.49688116562-01	UZ =	.43857688643+00
ALFA=	.14562095870+02	LFX =	-.66222061307+06	LFY =	-.99528532787+06	LFZ =	-.49939493104+06
BETA=	.11834057207+02	DFX =	-.45096620990+06	DFY =	.14244558924+06	DFZ =	.31411034685+06
AREA=	.65821803840+03	CL =	.29610238376+00	CD =	.12975560992+00	ETA =	.91745417756+00

```
RHO =   .44374020452-01  Q    =   .43754418414+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  ND   =   .00000000000     CHIP=   .15395230168+03  CHIY=   .28480921226+01
DRNG=   .70648193992+07  XRNG=  -.11947573501+06  PANG=   .99786699786+02  DCEL=   .10650877342+02
PRES=   .27499984735+04  UOX  =  -.44952591872+00  UOY  =   .40143086464+00  UOZ  =  -.79798478013+00
MACH=   .18582779469+01  UODX=   .17427444171-03  UODY=  -.24988302162-03  UODZ=   .56411413463-03
CDO =   .48003208411-01  CLA  =   .11776774011+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=   .73152000000+00
J   =   .12536583907+06  HT1  =   .40844054241+05  DHT1=   .21083942278+00  DCL1=   .20988762390+06
D2  =   .10774032737+03  LAT  =   .20064394344+02  LONG=   .14816297705+03  LNGO=   .00000000000

                                            PXF/PUO MATRIX
  .40849958+08    .13028032+09    .40369072+08    .19654077+11    .59412380+11    .17194078+11
 -.56429090+08   -.19567301+09   -.66414360+08   -.26084010+11   -.91319370+11   -.32064761+11
  .30549271+08    .11513967+09    .42291616+08    .13522561+11    .54868996+11    .22361314+11
  .25934109+05    .88629210+05    .29425960+05    .10144403+08    .32247434+08    .10372365+08
 -.12759722+05   -.40626998+05   -.15176606+05   -.57758433+07   -.14696902+08   -.74515409+07
 -.19196965+05   -.69982595+05   -.21268195+05   -.68744560+07   -.28399408+08   -.60387492+07
  .28777234+07    .98082830+07    .32771825+07    .13714555+10    .46771354+10    .15974295+10

                                            DPXF/PUO MATRIX
  .25934109+05    .88629210+05    .29425960+05    .10144403+08    .32247434+08    .10372365+08
 -.12759722+05   -.40626998+05   -.15176606+05   -.57758433+07   -.14696902+08   -.74515409+07
 -.19196965+05   -.69982595+05   -.21268195+05   -.68744560+07   -.28399408+08   -.60387492+07
 -.42756639+02   -.14375386+03   -.50660684+02   -.21686585+05   -.72377796+05   -.28799141+05
  .13428173+03    .45501375+03    .16625147+03    .56729589+05    .19043982+06    .85220090+05
 -.72376163+02   -.26000660+03   -.10053999+03   -.18342495+05   -.73476991+05   -.41753413+05
 -.31185287+03   -.10988383+04   -.37214290+03   -.12540213+06   -.47021066+06   -.16253093+06

                                            BOUNDARY CONDITIONS

B1  =   .39831832300-04  B2   =  -.13670076801+00  B3   =   .36641151709-02  B4   =  -.60851374269-01
B5  =  -.12862859449-02  ERR  =   .14968323748+00

                                            DESIRED VALUES

   .64000000+07    .20000000+01    .10000000+03    .60000000+02   -.10000000+01

AK  = 1.000              TOL  =   .49999999814-01

                                            PBWU MATRIX

 -.68482822+00    .10519256+00   -.97155593+02   -.29645316+03   -.11575717+03   -.17749659-04
 -.40799618+03    .63301230+02   -.43040785+05   -.14637223+06   -.43728217+05   -.99380167-02
 -.43476244+01    .41023984+00   -.16101170+04    .43431768+02   -.16140245+04   -.11420450-02
  .43136455+02   -.68508701+01    .54348343+04    .18980005+05    .66590127+04   -.47250162-04
 -.40769471+01    .30597414-01   -.94773770+03   -.14382780+04    .24474997+03    .19051432-04

                                            SIMULTANEOUS EQUATION MATRIX

  .16835763+06   -.26124163+05    .17805846+08    .60543921+08    .18134291+08    .40575343+01
 -.26124163+05    .40541604+04   -.27624677+07   -.93956293+07   -.28143368+07   -.62923477+00
  .17805846+08   -.27624677+07    .18855467+10    .64044510+10    .19206655+10    .42930574+03
  .60543921+08   -.93956293+07    .64044510+10    .21787230+11    .65265971+10    .14536811+04
  .18134291+08   -.28143368+07    .19206655+10    .65265971+10    .19591778+10    .43610712+03
```

.40575343+01	-.62923477+00	.42930574+03	.14536811+04	.43610712+03	.10007135-03

RIGHT HAND SIDE

.38163992+02	-.59117701+01	.39686769+04	.13484261+05	.39613782+04	.99246710-03

ANSWER

.33014589-02	.47285006-01	-.46022117-04	.22541456-04	-.80097816-05	.78270616+02

CHECK

.38163992-02	-.59117701-01	.39686769+04	.13484261+05	.39613782-04	.99246710-03

ITERATION PARAMETERS

.38244349+02	.38055189+02	.19745407-03	.19474484+03

TRIAL NUMBER 19

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169275523+01	DDY =	.91182927255+01	DDZ =	-.17680012997+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47329988103+00	UY =	.40654756042+00	UZ =	-.78147700142+00
ALFA=	.38055189715+02	LFX =	.15422948280+01	LFY =	.27332268178+02	LFZ =	-.95972199707+01
BETA=	.19474484347+03	DFX =	-.18069141725+02	DFY =	-.62211024634+01	DFZ =	-.20621053318+02
AREA=	.65821803840+03	CL =	.46847549662+00	CD =	.45402522341+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23879889982+03	CHIY=	.23988141518+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30418167315-03
PRES=	.68513884435-03	UDX =	-.47329988103+00	UDY =	.40654756042+00	UDZ =	-.78147700142+00
MACH=	.14005598208+02	UDDX=	.22029655906-03	UDDY=	-.27242447738-03	UDDZ=	.57212391619-03
CD0 =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55724408511-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNG0=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38172543-03	.28222839-03	-.84367598-04	.00000000	.00000000	.00000000
.10493822-03	.36948061-03	.12865919-03	.00000000	.00000000	.00000000
-.92389171-05	.35685450-03	.19124184-03	.00000000	.00000000	.00000000
.35369618-07	.70918900-07	.15472586-07	.00000000	.00000000	.00000000

FINAL VALUES 43 INTEGRATION STEPS TAKEN

T =	.14891211058+04	R =	.64013426500+07	V =	.40725547785+03	GM =	.39860319000+15
X =	-.29976179968+07	Y =	-.43612254022+07	Z =	-.36015534230+07	PHI =	.28608000000+02
DX =	-.28255565557+03	DY =	.29328866187+03	DZ =	-.10423859067+01	AZ =	.90000000000+02
DDX =	.37012152563+01	DDY =	-.29796286119+01	DDZ =	.37808298315+00	ALT =	.26178920885+05
WKG =	.13280731000+06	VRX =	-.51312225612+03	VRY =	.16753790034+03	VRZ =	.34313632289+03
VR =	.63961389436+03	UX =	-.89965553655+00	UY =	.54165867170-02	UZ =	.43656680605+00
ALFA=	.16791369924+02	LFX =	-.60009635648+06	LFY =	-.11186067424+07	LFZ =	-.35121251632+06
BETA=	.18700502414+02	DFX =	-.48714445799+06	DFY =	.15905597288+06	DFZ =	.32576438858+06
AREA=	.65821803840+03	CL =	.29060953798+00	CD =	.13398204609+00	ETA =	.10392386562+01

```
RHO =   .33661435655-01  Q    =   .45321909331+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  MD   =   .00000000000     CHIP=    .15411456179+03  CHIY=    .31034907411+00
DRNG=   .68284013121+07  XRNG=  -.10042123124+06  PANG=    .99457082231+02  DCEL=    .10920612420+02
PRES=   .21127168764+04  UOX  =  -.47329988103+00  UOY  =   .40654756042+00  UOZ  =  -.78147700142+00
MACH=   .21577413765+01  UODX=   .22029655906-03  UODY=   -.27242447738-03  UODZ=    .57212391619-03
CDO =   .44302451375-01  CLA  =   .10059605876+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J   =   .12786438592+06  HT1  =   .40387829772+05  DHT1=    .29300658871+00  DCLI=    .21534094207+06
D2  =   .11203608859+03  LAT  =   .21956586748+02  LONG=    .14887580692+03  LNGO=    .00000000000

                                                  PXF/PUO MATRIX

  .43133969+08    .13795602+09    .43151522+08    .20886870+11    .63522626+11    .18798995+11
 -.55606678+08   -.19250896+09   -.65527325+08   -.25864538+11   -.90253813+11   -.31727674+11
  .32765838+08    .12268327+09    .44969277+08    .14591832+11    .58449224+11    .23565538+11
  .31346237+05    .10405453+06    .35284771+05    .13277606+08    .39061571+08    .13674676+08
 -.16155834+05   -.50216115+05   -.19407363+05   -.78041424+07   -.19321052+08   -.10385905+08
 -.19215914+05   -.70006210+05   -.20522082+05   -.70454019+07   -.29102270+08   -.53269310+07
  .31283766+07    .10672449+08    .35838583+07    .14968693+10    .51011544+10    .17521191+10

                                                  DPXF/PUO MATRIX

  .31346237+05    .10405453+06    .35284771+05    .13277606+08    .39061571+08    .13674676+08
 -.16155834+05   -.50216115+05   -.19407363+05   -.78041424+07   -.19321052+08   -.10385905+08
 -.19215914+05   -.70006210+05   -.20522082+05   -.70454019+07   -.29102270+08   -.53269310+07
 -.12248317+03   -.43270925+03   -.14485157+03   -.52049757+05   -.19963113+06   -.66717327+05
  .17425908+03    .61074473+03    .22497175+03    .71889622+05    .27339016+06    .11995899+06
 -.14116890+03   -.48988209+03   -.18976719+03   -.48200052+05   -.17037065+06   -.90449604+05
 -.21735960+03   -.93286423+03   -.33075723+03   -.53495842+05   -.47380016+06   -.17372386+06

                                                  BOUNDARY CONDITIONS

B1  =   .41962212480-03  B2   =   .16396196200+00  B3   =   .93050035851-02  B4   =  -.23896472430-01
B5  =   .16978080414-02  ERR  =   .16596447844+00

                                                  DESIRED VALUES

   .64000000+07    .20000000+01    .10000000+03    .60000000+02   -.10000000+01

AK  =   .500             TOL  =   .49999999814-01

                                                  ITERATION PARAMETERS

  .38244349+02    .38197059+02    .19745407+03    .19677676+03
```

TRIAL NUMBER 20

INITIAL VALUES

```
T    =  .00000000000      R    =  .65000732772+07   V    =  .79182741874+04   GM   =  .39860319000+15
X    =  .10416416000+07   Y    = -.62981421000+07   Z    =  .12244760000+07   PHI  =  .28608000000+02
DX   = -.50566950000+04   DY   = -.17567557000+04   DZ   = -.58346132000+04   AZ   =  .90000000000+02
DDX  = -.15169206326+01   DDY  =  .91182916190+01   DDZ  = -.17680050086+01   ALT  =  .14030918566+06
WKG  =  .13280731000+06   VRX  = -.49783056909+04   VRY  = -.17140022624+04   VRZ  = -.56813936515+04
VR   =  .77459386217+04   UX   = -.45547777818+00   UY   =  .40283791649+00   UZ   = -.79389017289+00
ALFA =  .38197059462+02   LFX  =  .23347808139+01   LFY  =  .27141769656+02   LFZ  = -.10234162738+02
BETA =  .19677676692+03   DFX  = -.18195646418+02   DFY  = -.62646573077+01   DFZ  = -.20765424316+02
AREA =  .65821803840+03   CL   =  .46995583357+00   CD   =  .45720392011+00   ETA  =  .17999863636+01
RHO  =  .31358995814-08   Q    =  .61922721324+02   AE   =  .63781660000+07   BE   =  .63567840000+07
OM   =  .72921150604-04   FJ   =  .16234500072-02   FH   = -.57500000139-05   FD   =  .78750000512-05
F    =  .00000000000      OMX  =  .47881444528+00   OMY  = -.87791612754+00   OMZ  = -.77140676824-08
ISP  =  .40000000000+03   MD   =  .00000000000      CHIP =  .24015586269+03   CHIY =  .23755710509+02
DRNG =  .00000000000      XRNG =  .88986254448-12   PANG =  .91500003418+02   DCEL =  .30570933499-03
PRES =  .68513884435-03   UOX  = -.45547777818+00   UOY  =  .40283791649+00   UOZ  = -.79389017289+00
MACH =  .14005598208+02   UODX =  .18577997105-03   UODY = -.25551838556-03   UODZ =  .56611658002-03
CDO  =  .12000053346-01   CLA  =  .75999370475+00   EXA  =  .00000000000      HTC  =  .61031971743-08
CK1  =  .00000000000      CK2  =  .50000000000+00   CK3  =  .50000000000+00   RCRV =  .73152000000+00
J    =  .00000000000      HT1  =  .00000000000      DHT1 =  .15884027431+00   DCLI =  .00000000000
D2   =  .56124909421-07   LAT  =  .68028973356+02   LONG =  .21023191184+03   LNGO =  .00000000000
```

PXF/PUO MATRIX

```
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
```

DPXF/PUO MATRIX

```
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .39341442-03  .27766386-03 -.84820292-04  .00000000     .00000000     .00000000
 .10377697-03  .37006314-03  .12823860-03  .00000000     .00000000     .00000000
 .33876748-06  .35600338-03  .18044984-03  .00000000     .00000000     .00000000
 .37299090-07  .70455600-07  .14351205-07  .00000000     .00000000     .00000000
```

FINAL VALUES   44 INTEGRATION STEPS TAKEN

```
T    =  .15478240678+04   R    =  .64001536539+07   V    =  .34101146299+03   GM   =  .39860319000+15
X    = -.30492265470+07   Y    = -.42507752149+07   Z    = -.36871526049+07   PHI  =  .28608000000+02
DX   = -.20764348192+03   DY   =  .26807081542+03   DZ   = -.36208289450+02   AZ   =  .90000000000+02
DDX  =  .31899021775+01   DDY  = -.23145745373+01   DDZ  = -.31266804359+00   ALT  =  .24693626656+05
WKG  =  .13280731000+06   VRX  = -.44369002695+03   VRY  =  .13933129848+03   VRZ  =  .30741788364+03
VR   =  .55747628285+03   UX   = -.89713818639+00   UY   =  .39216540116-01   UZ   =  .44005838804+00
ALFA =  .14880291267+02   LFX  = -.64771083643+06   LFY  = -.10243523702+07   LFZ  = -.47055978305+06
BETA =  .12964156563+02   DFX  = -.45598336029+06   DFY  =  .14319175509+06   DFZ  =  .31593552048+06
AREA =  .65821803840+03   CL   =  .29619057700+00   CD   =  .13052419528+00   ETA  =  .93081786912+00
```

```
RHO =   .42915297111-01  Q    =  .43893953476+07  AE   =  .63781660000+07  BE   =  .63567840000+07
OM  =   .72921150604-04  FJ   =  .16234500072-02  FH   = -.57500000139-05  FD   =  .78750000512-05
F   =   .00000000000     OMX  =  .47881444528+00  OMY  = -.87791612754+00  OMZ  = -.77140676824-08
ISP =   .40000000000+03  MD   =  .00000000000     CHIP=   .15387413509+03  CHIY=   .22475185647+01
DRNG=   .69761675993+07  XRNG= -.11714909554+06  PANG=   .99836361133+02  DCEL=   .10697731789+02
PRES=   .26632505723+04  UOX  = -.45547777818+00  UOY  =  .40283791649+00  UOZ  = -.79389017289+00
MACH=   .18913080738+01  UODX=   .18577997105-03  UODY= -.25551838556-03  UODZ=   .56611658002-03
CDO =   .47472007194-01  CLA  =  .11533884766+01  EXA  =  .00000000000     HTC  =  .61031971743-08
CK1 =   .00000000000     CK2  =  .50000000000+00  CK3  =  .50000000000+00  RCRV=   .73152000000+00
J   =   .12715451457+06  HT1  =  .40657472834+05  DHT1=   .21904969325+00  DCLI=   .21365155632+06
D2  =   .10854101902+03  LAT  =  .20791106591+02  LONG=   .14842540199+03  LNGO=   .00000000000
```

PXF/PUO MATRIX

```
  .42222419+08   .13506226+09   .42069949+08   .20343514+11   .61838276+11   .18094316+11
 -.56503496+08  -.19583818+09  -.66533681+08  -.26180383+11  -.91560572+11  -.32143729+11
  .31376942+08   .11788325+09   .43236273+08   .13932541+11   .56184045+11   .22780076+11
  .28183402+05   .95761086+05   .31972390+05   .11348285+08   .35643856+08   .11733731+08
 -.13839402+05  -.43966309+05  -.16460605+05  -.63741422+07  -.16326098+08  -.82095942+07
 -.20194111+05  -.73398665+05  -.22316432+05  -.73833717+07  -.30169710+08  -.65079042+07
  .29868820+07   .10187702+08   .34097471+07   .14247742+10   .48616556+10   .16621634+10
```

DPXF/PUO MATRIX

```
  .28183402+05   .95761086+05   .31972390+05   .11348285+08   .35643856+08   .11733731+08
 -.13839402+05  -.43966309+05  -.16460605+05  -.63741422+07  -.16326098+08  -.82095942+07
 -.20194111+05  -.73398665+05  -.22316432+05  -.73833717+07  -.30169710+08  -.65079042+07
 -.57299323+02  -.19635961+03  -.67988532+02  -.27354459+05  -.95915427+05  -.36033486+05
  .14359154+03   .48893254+03   .17918791+03   .61152058+05   .20961586+06   .93439401+05
 -.94100298+02  -.33332878+03  -.12699868+03  -.27711863+05  -.10393888+06  -.54434220+05
 -.26631093+03  -.95536137+03  -.32999638+03  -.10728064+06  -.43567514+06  -.15865323+06
```

BOUNDARY CONDITIONS

```
B1  =   .48017434991-04  B2   = -.10573844245+00  B3   =  .28093224580-02  B4   = -.47000136875-01
B5  =  -.92200333870-03  ERR  =  .11575135320+00
```

DESIRED VALUES

```
  .64000000+07   .20000000+01   .10000000+03   .60000000+02  -.10000000+01

AK  = 1.000           TOL  =  .49999999814-01
```

PBWU MATRIX

```
 -.73351006+00   .10848245+00  -.10334282+03  -.31809816+03  -.12360926+03  -.18205629-04
 -.44450441+03   .66032084+02  -.48181296+05  -.16182307+06  -.49328284+05  -.10181699-01
 -.66788414+01   .71947920+00  -.19282414+04  -.79114343+03  -.19231774+04  -.12351307-02
  .43865306+02  -.66928953+01   .55286430+04   .19288595+05   .67666246+04  -.47759992-04
 -.43789908+01   .56761163-01  -.98728261+03  -.15904322+04   .18120786+03   .20918253-04
```

SIMULTANEOUS EQUATION MATRIX

```
  .19957265+06  -.29650272+05   .21676592+08   .72789649+08   .22235601+08   .45318862+01
 -.29650272+05   .44055637+04  -.32199686+07  -.10815305+08  -.33039245+07  -.67288861+00
  .21676592+08  -.32199686+07   .23567067+10   .79066136+10   .24176531+10   .49266628+03
  .72789649+08  -.10815305+08   .79066136+10   .26562012+11   .81142456+10   .16476623+04
  .22235601+08  -.33039245+07   .24176531+10   .81142456+10   .24828135+10   .50430399+03
```

```
.45318862+01  -.67288861+00  .49266628+03  .16476623+04  .50430399+03  .10519560-03
                                   RIGHT HAND SIDE
.42374004+02  -.62866673+01  .45537709+04  .15274969+05  .46092202+04  .10169246-02
                                   ANSWER
.62122449-02  .53995277-01  -.48199403-04  .16122354-04  .39773941-07  .60444659+02
                                   CHECK
.42374004+02  .62866673+01  .45537709+04  .15274969+05  .46092202+04  .10169246-02
                                   ITERATION PARAMETERS
.38197059+02  .37841124+02  .19677677+03  .19368307+03
```

TRIAL NUMBER 21

INITIAL VALUES

```
T    =  .00000000000      R    =  .65000732772+07   V    =  .79182741874+04   GM   =  .39860319000+15
X    =  .10416416000+07   Y    = -.62981421000+07   Z    =  .12244760000+07   PHI  =  .28608000000+02
DX   = -.50566950000+04   DY   = -.17567557000+04   DZ   = -.58346132000+04   AZ   =  .90000000000+02
DDX  = -.15169321201+01   DDY  =  .91182922274+01   DDZ  = -.17680001838+01   ALT  =  .14030918566+06
WKG  =  .13280731000+06   VRX  = -.49783056909+04   VRY  = -.17140022624+04   VRZ  = -.56813936515+04
VR   =  .77459386217+04   UX   = -.48362690997+00   UY   =  .40602444362+00   UZ   = -.77540258133+00
ALFA =  .37841124389+02   LFX  =  .11257869277+01   LFY  =  .27331575250+02   LFZ  = -.92320470118+01
BETA =  .19368307047+03   DFX  = -.17879016947+02   DFY  = -.61556435861+01   DFZ  = -.20404077146+02
AREA =  .65821803840+03   CL   =  .46623640271+00   CD   =  .44924793810+00   ETA  =  .17999863636+01
RHO  =  .31358995814-08   Q    =  .61922721324+02   AE   =  .63781660000+07   BE   =  .63567840000+07
OM   =  .72921150604-04   FJ   =  .16234500072-02   FH   = -.57500000139-05   FD   =  .78750000512-05
F    =  .00000000000      OMX  =  .47881444528+00   OMY  = -.87791612754+00   OMZ  = -.77140676824-08
ISP  =  .40000000000+03   MD   =  .00000000000      CHIP =  .23804777148+03   CHIY =  .23955339858+02
DRNG =  .00000000000      XRNG =  .88986254448-12   PANG =  .91500003418+02   DCEL =  .30188305693-03
PRES =  .68513884435-03   UOX  = -.48362690997+00   UOY  =  .40602444362+00   UOZ  = -.77540258133+00
MACH =  .14005598208+02   UODX =  .23397937407-03   UODY = -.27164073996-03   UODZ =  .56607680608-03
CDO  =  .12000053346-01   CLA  =  .75999370475+00   EXA  =  .00000000000      HTC  =  .61031971743-08
CK1  =  .00000000000      CK2  =  .50000000000+00   CK3  =  .50000000000+00   RCRV =  .73152000000+00
J    =  .00000000000      HTI  =  .00000000000      DHTI =  .15884027431+00   DCLI =  .00000000000
D2   =  .55122492919-07   LAT  =  .68028973356+02   LONG =  .21023191184+03   LNGO =  .00000000000
```

PXF/PUO MATRIX

```
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
 .00000000    .00000000    .00000000    .00000000    .00000000    .00000000
```

DPXF/PUO MATRIX

```
 .00000000      .00000000      .00000000     .00000000    .00000000    .00000000
 .00000000      .00000000      .00000000     .00000000    .00000000    .00000000
 .00000000      .00000000      .00000000     .00000000    .00000000    .00000000
 .37456945-03   .28383243-03  -.84999666-04  .00000000    .00000000    .00000000
 .10507819-03   .36970215-03   .12804893-03  .00000000    .00000000    .00000000
-.15227928-04   .35607071-03   .19594731-03  .00000000    .00000000    .00000000
 .34158884-07   .70987139-07   .15865769-07  .00000000    .00000000    .00000000
```

FINAL VALUES   40 INTEGRATION STEPS TAKEN

```
T    =  .14873794084+04   R    =  .64019820763+07   V    =  .45267834778+03   GM   =  .39860319000+15
X    = -.30306441157+07   Y    = -.43169368848+07   Z    = -.36283090665+07   PHI  =  .28608000000+02
DX   = -.32436322288+03   DY   =  .31505200579+03   DZ   =  .21175925962+02   AZ   =  .90000000000+02
DDX  =  .38904257063+01   DDY  = -.33221972750+01   DDZ  =  .76951713268+00   ALT  =  .26682220905+05
WKG  =  .13280731000+06   VRX  = -.55664268375+03   VRY  =  .18836705221+03   VRZ  =  .36592255785+03
VR   =  .69226623641+03   UX   = -.89760054150+00   UY   =  .13182295340-01   UZ   =  .44061263599+00
ALFA =  .16616903154+02   LFX  = -.58869669995+06   LFY  = -.11466838727+07   LFZ  = -.30524559819+06
BETA =  .21626230195+02   DFX  = -.49433973014+06   DFY  =  .16728382583+06   DFZ  =  .32496620144+06
AREA =  .65821803840+03   CL   =  .27085707756+00   CD   =  .12571019274+00   ETA  =  .11079352278+01
```

RHO =	.31007416575-01	Q =	.48904820489+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.15385458378+03	CHIY=	.75531175961+00
DRNG=	.68892168209+07	XRNG=	-.92890253125+05	PANG=	.99010208573+02	DCEL=	.10995900830+02
PRES=	.19545357569+04	UOX =	-.48362690997+00	UOY =	.40602444362+00	UOZ =	-.77540258133+00
MACH=	.23303436287+01	UODX=	.23397937407-03	UODY=	-.27164073996-03	UODZ=	.56607680608-03
CDO =	.42694687730-01	CLA =	.94714851243+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.12553822346+06	HT1 =	.40669176509+05	DHT1=	.35654113626+00	DCLI=	.21040727042+06
D2 =	.11368641556+03	LAT =	.21427472110+02	LONG=	.14870945363+03	LNGO=	.00000000000

PXF/PUD MATRIX

.42407184+08	.13517753+09	.42061858+08	.20568025+11	.62151330+11	.18211465+11
-.56134813+08	-.19438367+09	-.66130966+08	-.26077012+11	-.91043822+11	-.32030341+11
.32675464+08	.12265915+09	.45059778+08	.14496374+11	.58392436+11	.23688486+11
.30724407+05	.10141629+06	.34502486+05	.12907807+08	.37083361+08	.13228180+08
-.16399570+05	-.50365543+05	-.19933158+05	-.79916764+07	-.19098390+08	-.11051269+08
-.17676754+05	-.65247523+05	-.18415682+05	-.61503733+07	-.26824194+08	-.38579837+07
.30670233+07	.10456234+08	.35122407+07	.14706532+10	.50019689+10	.17238738+10

DPXF/PUD MATRIX

.30724407+05	.10141629+06	.34502486+05	.12907807+08	.37083361+08	.13228180+08
-.16399570+05	-.50365543+05	-.19933158+05	-.79916764+07	-.19098390+08	-.11051269+08
-.17676754+05	-.65247523+05	-.18415682+05	-.61503733+07	-.26824194+08	-.38579837+07
-.13216346+03	-.47406859+03	-.15551122+03	-.53292605+05	-.21567730+06	-.67368144+05
.20110948+03	.71381891+03	.26011653+03	.79679099+05	.31560017+06	.13463837+06
-.13487707+03	-.47359719+03	-.18906565+03	-.43117448+05	-.16252002+06	-.94684337+05
-.46273258+03	-.18578377+04	-.63516829+03	-.12712135+06	-.83935555+06	-.28305862+06

BOUNDARY CONDITIONS

B1 =	.61949476623-03	B2 =	.35762535701+00	B3 =	.16989305613-01	B4 =	-.33413649729-01
B5 =	.28780750332-02	ERR =	.35959653997+00				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = .500 TOL = .49999999814-01

ITERATION PARAMETERS

.38197059+02	.38108076+02	.19677677+03	.19600334+03

TRIAL NUMBER 22

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169235158+01	DDY =	.91182918319+01	DDZ =	-.17680038146+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.46254390458+00	UY =	.40380721553+00	UZ =	-.78929897315+00
ALFA=	.38108075950+02	LFX =	.20312610351+01	LFY =	.27197376568+02	LFZ =	-.99849802390+01
BETA=	.19600334661+03	DFX =	-.18116253509+02	DFY =	-.62373227819+01	DFZ =	-.20674818717+02
AREA=	.65821803840+03	CL =	.46902767322+00	CD =	.45520900615+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23962890677+03	CHIY=	.23816402569+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30475075688-03
PRES=	.68513684435-03	UDX =	-.46254390458+00	UDY =	.40380721553+00	UDZ =	-.78929897315+00
MACH=	.14005596208+02	UDDX=	.19782982180-03	UDDY=	-.25954897416-03	UDDZ=	.56610663654-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.55873559597-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38874486-03	.27928573-03	-.84928492-04	.00000000	.00000000	.00000000
.10412822-03	.36994250-03	.12824238-03	.00000000	.00000000	.00000000
-.36023038-05	.35613760-03	.18431185-03	.00000000	.00000000	.00000000
.36513538-07	.70606133-07	.14724650-07	.00000000	.00000000	.00000000

FINAL VALUES 45 INTEGRATION STEPS TAKEN

T =	.15327129029+04	R =	.64002387183+07	V =	.35283448879+03	GM =	.39860319000+15
X =	-.30245966314+07	Y =	-.42967218458+07	Z =	-.36541828428+07	PHI =	.28608000000+02
DX =	-.22270655598+03	DY =	.27204576977+03	DZ =	-.29750051384+02	AZ =	.90000000000+02
DDX =	.32771087946+01	DDY =	-.24625164796+01	DDZ =	-.14525067441+00	ALT =	.24904143047+05
WKG =	.13280731000+06	VRX =	-.45664242119+03	VRY =	.14445741518+03	VRZ =	.31390360645+03
VR =	.57264798941+03	UX =	-.89678989915+00	UY =	.33733015569-01	UZ =	.44116885706+00
ALFA=	.15102369836+02	LFX =	-.63556116773+06	LFY =	-.10507636751+07	LFZ =	-.44100667574+06
BETA=	.14258721147+02	DFX =	-.46046113162+06	DFY =	.14566545239+06	DFZ =	.31652865161+06
AREA=	.65821803840+03	CL =	.29159509124+00	CD =	.12904387279+00	ETA =	.95115933218+00

RHO =	.41462149142-01	Q =	.44747324582+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.15380548096+03	CHIY=	.19331261524+01
DRNG=	.69146432093+07	XRNG=	-.11429816235+06	PANG=	.99857272548+02	DCEL=	.10743923366+02
PRES=	.25768389185+04	UOX =	-.46254390458+00	UOY =	.40380721553+00	UOZ =	-.78929897315+00
MACH=	.19413589538+01	UODX=	.19782982180-03	UODY=	-.25954897416-03	UODZ=	.56610663654-03
CDO =	.46747808385-01	CLA =	.11191760232+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.12834329898+06	HTI =	.40551949170+05	DHTI=	.23337080605+00	DCLI=	.21613464878+06
D2 =	.10943950160+03	LAT =	.21290836412+02	LONG=	.14861397509+03	LNGO=	.00000000000

PXF/PUO MATRIX

.43248109+08	.13860143+09	.43307462+08	.20867026+11	.63646325+11	.18741424+11
-.56676048+08	-.19636060+09	-.66750412+08	-.26305032+11	-.91928187+11	-.32264789+11
.32075975+08	.12023134+09	.44057331+08	.14270595+11	.57305144+11	.23159971+11
.29885130+05	.10109465+06	.33892851+05	.12255566+08	.38135119+08	.12763398+08
-.14829401+05	-.46994980+05	-.17670131+05	-.69156396+07	-.17752388+08	-.89538744+07
-.20679880+05	-.75151041+05	-.22749526+05	-.76237731+07	-.31163841+08	-.66336101+07
.30810366+07	.10515836+08	.35247469+07	.14705942+10	.50206576+10	.17187617+10

DPXF/PUO MATRIX

.29885130+05	.10109465+06	.33892851+05	.12255566+08	.38135119+08	.12763398+08
-.14829401+05	-.46994980+05	-.17670131+05	-.69156396+07	-.17752388+08	-.89538744+07
-.20679880+05	-.75151041+05	-.22749526+05	-.76237731+07	-.31163841+08	-.66336101+07
-.75542705+02	-.26252223+03	-.89337389+02	-.34264802+05	-.12463608+06	-.44192949+05
.15180381+03	.52048267+03	.19130163+03	.64681540+05	.22772231+06	.10129646+06
-.11342395+03	-.39916337+03	-.15136880+03	-.35856582+05	-.13177235+06	-.66880736+05
-.21461290+03	-.79934657+03	-.28328848+03	-.83899933+05	-.39491885+06	-.15189392+06

BOUNDARY CONDITIONS

B1 =	.74600866831-04	B2 =	-.57781353085-01	B3 =	.24474419789-02	B4 =	-.37382097303-01
B5 =	-.47548434085-03	ERR =	.68864559724-01				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = 1.000 TOL = .49999999814-01

PBWU MATRIX

-.77867552+00	.10985519+00	-.10919413+03	-.33779718+03	-.13101538+03	-.18876727-04
-.47759359+03	.67358462+02	-.52601783+05	-.17516062+06	-.54058960+05	-.10485573-01
-.10037989+02	.11369812+01	-.23633166+04	-.20228561+04	-.23515784+04	-.13326259-02
.44519407+02	-.64708787+01	.56078402+04	.19551248+05	.68576887+04	-.48743789-04
-.45695699+01	.55350256-01	-.10145931+04	-.16894815+04	.14357775+03	.23359501-04

SIMULTANEOUS EQUATION MATRIX

.23019987+06	-.32469801+05	.25400377+08	.84554288+08	.26146564+08	.50189572+01
-.32469801+05	.45803425+04	-.35822180+07	-.11927494+08	-.36883838+07	-.70749260+00
.25400377+08	-.35822180+07	.28050221+10	.93299328+10	.28874807+10	.55441426+03
.84554288+08	-.11927494+08	.93299328+10	.31070554+11	.96076359+10	.18383691+04
.26146564+08	-.36883838+07	.28874807+10	.96076359+10	.29749668+10	.56964450+03

.50189572+01	-.70749260+00	.55441426+03	.18383691+04	.56964450+03	.11172641-03

RIGHT HAND SIDE

.25909322+02	-.36474035+01	.28244596+04	.93859782+04	.28614117+04	.60441870-03

ANSWER

.90825529-03	.20708640-01	-.23870473-04	.12772809-04	-.83701639-05	.46704679+02

CHECK

.25909322+02	-.36474035+01	.28244596+04	.93859782+04	.28614117+04	.60441870-03

ITERATION PARAMETERS

.38108076+02	.38056037•02	.19600335+03	.19481683+03

TRIAL NUMBER 23

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169273367+01	DDY =	.91182926621+01	DDZ =	-.17680014575+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47270147786+00	UY =	.40636520383+00	UZ =	-.78193390638+00
ALFA=	.38056037096+02	LFX =	.15701804633+01	LFY =	.27323591380+02	LFZ =	-.96190370060+01
BETA=	.19481683398+03	DFX =	-.18069896147+02	DFY =	-.62213622063+01	DFZ =	-.20621914287+02
AREA=	.65821803840+03	CL =	.46848434714+00	CD =	.45404417983+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23884583851+03	CHIY=	.23976706032+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30419078768-03
PRES=	.68513884435-03	UOX =	-.47270147786+00	UOY =	.40636520383+00	UOZ =	-.78193390638+00
MACH=	.14005598208+02	UODX=	.22170029484-03	UODY=	-.27232178286-03	UODZ=	.57447680046-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55726796931-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38211402-03	.28205341-03	-.84417841-04	.00000000	.00000000	.00000000
.10488619-03	.36951309-03	.12862648-03	.00000000	.00000000	.00000000
-.89351996-05	.35680333-03	.19082961-03	.00000000	.00000000	.00000000
.35431905-07	.70699605-07	.15426392-07	.00000000	.00000000	.00000000

FINAL VALUES 43 INTEGRATION STEPS TAKEN

T =	.14860082238+04	R =	.64002054858+07	V =	.37159167240+03	GM =	.39860319000+15
X =	-.29333550531+07	Y =	-.44509303125+07	Z =	-.35422136788+07	PHI =	.28608000000+02
DX =	-.25145062127+03	DY =	.27288708238+03	DZ =	-.19636606964+02	AZ =	.90000000000+02
DDX =	.35521113373+01	DDY =	-.27588122434+01	DDZ =	.24801914260+00	ALT =	.25323753433+05
WKG =	.13280731000+06	VRX =	-.47821837121+03	VRY =	.14920820961+03	VRZ =	.32356018443+03
VR =	.59636154582+03	UX =	-.89408539777+00	UY =	.10565245302-01	UZ =	.44777190297+00
ALFA=	.15730751241+02	LFX =	-.59398426096+06	LFY =	-.11190082077+07	LFZ =	-.36187695594+06
BETA=	.17306733191+02	DFX =	-.47398735489+06	DFY =	.14788809644+06	DFZ =	.32069749972+06
AREA=	.65821803840+03	CL =	.29078510111+00	CD =	.13045282127+00	ETA =	.98268669434+00

```
RHO =    .38711286786-01  Q    =   .45310270575+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =    .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =    .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =    .40000000000+03  MD   =   .00000000000     CHIP=    .15339758110+03  CHIY=    .60535522437+00
DRNG=    .67036960645+07  XRNG=  -.11033882195+06  PANG=    .99864734449+02  DCEL=    .10873410107+02
PRES=    .24132455442+04  UDX  =  -.47270147786+00  UDY  =   .40636520383+00  UDZ  =  -.78193390638+00
MACH=    .20186615588+01  UDDX=    .22170029484-03  UDDY=  -.27232178286-03  UDDZ=    .57447680046-03
CDO =    .45775044795-01  CLA  =   .10725443318+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =    .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J   =    .13286888687+06  HT1  =   .40025891864+05  DHT1=    .25468601612+00  DCLI=    .22571188188+06
D2  =    .11176316924+03  LAT  =   .23021895678+02  LONG=    .14924220935+03  LNGO=    .00000000000

                                        PXF/PUD MATRIX

   .46075376+08    .14848295+09    .46876964+08    .22293124+11    .68758069+11    .20676573+11
  -.56133790+08   -.19422687+09   -.66169034+08   -.26192952+11   -.91330859+11   -.32049500+11
   .33837625+08    .12593317+09    .46013388+08    .15175408+11    .60099876+11    .24024954+11
   .35816752+05    .11999049+06    .40680039+05    .15448058+08    .47378943+08    .16462374+08
  -.17346266+05   -.54848024+05   -.20727067+05   -.83328960+07   -.21818124+08   -.10814395+08
  -.22666329+05   -.82058638+05   -.24795142+05   -.86600184+07   -.34906888+08   -.75595251+07
   .32946351+07    .11247101+08    .37825664+07    .15765619+10    .53790565+10    .18451146+10

                                        DPXF/PUD MATRIX

   .35816752+05    .11999049+06    .40680039+05    .15448058+08    .47378943+08    .16462374+08
  -.17346266+05   -.54848024+05   -.20727067+05   -.83328960+07   -.21818124+08   -.10814395+08
  -.22666329+05   -.82058638+05   -.24795142+05   -.86600184+07   -.34906888+08   -.75595251+07
  -.11749710+03   -.41609090+03   -.13981327+03   -.50932568+05   -.19624413+06   -.66026531+05
   .17875213+03    .62337108+03    .22837034+03    .75686597+05    .28143699+06    .12117509+06
  -.16367351+03   -.56893860+03   -.21473292+03   -.58865411+05   -.20850617+06   -.10062914+06
  -.23916406+03   -.96828132+03   -.34362093+03   -.75796881+05   -.49130738+06   -.18322017+06

                                        BOUNDARY CONDITIONS

B1  =    .64215352523-04  B2   =   .18748622207-01  B3   =   .23200161353-02  B4   =  -.43815794668-02
B5  =    .14434342949-03  ERR  =   .19393723386-01

                                        DESIRED VALUES

    .64000000+07    .20000000+01    .10000000+03    .60000000+02   -.10000000+01

AK  = 1.000               TOL  =   .49999999874-06

                                        PBWU MATRIX

  -.90159816+00    .11843059+00   -.12525308+03   -.39409892+03   -.15152156+03   -.19895038-04
  -.57299407+03    .74446911+02   -.66270625+05   -.21678837+06   -.69293226+05   -.11121523-01
  -.18080193+02    .20459887+01   -.34781216+04   -.51777994+04   -.34817379+04   -.15777878-02
   .45700192+02   -.61537009+01    .57717626+04    .20079864+05    .70430573+04   -.50049996-04
  -.51926294+01    .10639411+00   -.10904773+04   -.20072852+04    .35228042+01    .27789593-04

                                        SIMULTANEOUS EQUATION MATRIX

   .33076539+06   -.42976515+05    .38305107+08    .12524050+09    .40089546+08    .63986801+01
  -.42976515+05    .55844220+04   -.49764081+07    .16273644+08   -.52091487+07    .83088261+00
   .38305107+08   -.49764081+07    .44384111+10    .14502844+11    .46448813+10    .74220136+03
   .12524050+09   -.16273644+08    .14502844+11    .47431394+11    .15181470+11    .24181335+04
   .40089546+08   -.52091487+07    .46448813+10    .15181470+11    .48633013+10    .77579029+03
```

.63986801+01	-.83088261+00	.74220136+03	.24181335+04	.77579029+03	.12618137-03

RIGHT HAND SIDE

-.10985842+02	.14275096+01	-.12760071+04	-.41647924+04	-.13380991+04	-.21195170-03

ANSWER

-.49336176-03	-.22409045-02	.20524217-06	.10088733-05	-.24032672-05	.28173243+01

CHECK

-.10985842+02	.14275096+01	-.12760071+04	-.41647924+04	-.13380991+04	-.21195170-03

ITERATION PARAMETERS

.38056037+02	.38084305+02	.19481683+03	.19494523+03

TRIAL NUMBER 24

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169267654+01	DDY =	.91182927327+01	DDZ =	-.17680015772+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47142866366+00	UY =	.40644744390+00	UZ =	-.78265924285+00
ALFA=	.38084304983+02	LFX =	.16208786853+01	LFY =	.27324293635+02	LFZ =	-.96636730458+01
BETA=	.19494523339+03	DFX =	-.18095071140+02	DFY =	-.62300298129+01	DFZ =	-.20650644753+02
AREA=	.65821803840+03	CL =	.46877953383+00	CD =	.45467675452+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23893767582+03	CHIY=	.23981863138+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30449491016-03
PRES=	.68513884435-03	UDX =	-.47142866366+00	UDY =	.40644744390+00	UDZ =	-.78265924285+00
MACH=	.14005598208+02	UDDX=	.22149505267-03	UDDY=	-.27333065615-03	UDDZ=	.57688006765-03
CD0 =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCL1=	.00000000000
D2 =	.55806498383-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38299278-03	.28186058-03	-.84318002-04	.00000000	.00000000	.00000000
.10487259-03	.36948139-03	.12870840-03	.00000000	.00000000	.00000000
-.81867943-05	.35690402-03	.19027721-03	.00000000	.00000000	.00000000
.35581974-07	.70891891-07	.15382768-07	.00000000	.00000000	.00000000

FINAL VALUES 118 INTEGRATION STEPS TAKEN

T =	.14831908995+04	R =	.64000165865+07	V =	.36497034494+03	GM =	.39860319000+15
X =	-.29205590074+07	Y =	-.44701504863+07	Z =	-.35282151325+07	PHI =	.28608000000+02
DX =	-.24828758503+03	DY =	.26687391346+03	DZ =	-.18301423872+02	AZ =	.90000000000+02
DDX =	.35497737020+01	DDY =	-.26952909752+01	DDZ =	.21172241108+00	ALT =	.25195640507+05
WKG =	.13280731000+06	VRX =	-.47415916687+03	VRY =	.14368380974+03	VRZ =	.32474726772+03
VR =	.59239576349+03	UX =	-.89061384687+00	UY =	.65180885519-02	UZ =	.45471363548+00
ALFA=	.15483460379+02	LFX =	-.58778992909+06	LFY =	-.11199808946+07	LFZ =	-.36269084608+06
BETA=	.17113050522+02	DFX =	-.47003583129+06	DFY =	.14243432095+06	DFZ =	.32192323298+06
AREA=	.65821803840+03	CL =	.28820117756+00	CD =	.12862220388+00	ETA =	.97759880243+00

RHO =	.39531121887-01	Q =	.45656520640+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.15295287185+03	CHIY=	.37346160691+00
DRNG=	.66767390648+07	XRNG=	-.11089287507+06	PANG=	.99941386636+02	DCEL=	.10849714941+02
PRES=	.24620050585+04	UDX =	-.47142866366+00	UDY =	.40644744390+00	UDZ =	-.78265924285+00
MACH=	.20061937684+01	UDDX=	.22149505267-03	UDDY=	-.27333065615-03	UDDZ=	.57688006765-03
CDO =	.45922234842-01	CLA =	.10795661156+01	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.13363906369+06	HT1 =	.39932322523+05	DHT1=	.25226837095+00	DCL1=	.22734580487+06
DZ =	.11144754930+03	LAT =	.23246532734+02	LONG=	.14932751603+03	LNGO=	.00000000000

PXF/PUO MATRIX

.46394484+08	.14963621+09	.47312047+08	.22446207+11	.69343240+11	.20911721+11
-.55956287+08	-.19358715+09	-.65979314+08	-.26126785+11	-.91076530+11	-.31969847+11
.33960968+08	.12628054+09	.46132112+08	.15252989+11	.60292339+11	.24079140+11
.36185088+05	.12117347+06	.41127304+05	.15678602+08	.48076840+08	.16753651+08
-.17160123+05	-.54169823+05	-.20481426+05	-.82856775+07	-.21616819+08	-.10705635+08
-.23072044+05	-.83485614+05	-.25317999+05	-.88402709+07	-.35560395+08	-.78375813+07
.32886191+07	.11224100+08	.37760283+07	.15737242+10	.53671498+10	.18411461+10

DPXF/PUO MATRIX

.36185088+05	.12117347+06	.41127304+05	.15678602+08	.48076840+08	.16753651+08
-.17160123+05	-.54169823+05	-.20481426+05	-.82856775+07	-.21616819+08	-.10705635+08
-.23072044+05	-.83485614+05	-.25317999+05	-.88402709+07	-.35560395+08	-.78375813+07
-.12154144+03	-.42952264+03	-.14489422+03	-.52820635+05	-.20208122+06	-.68745697+05
.18609299+03	.64614350+03	.23658642+03	.79657388+05	.29164670+06	.12540737+06
-.17050494+03	-.59044743+03	-.22249508+03	-.62863708+05	-.21966546+06	-.10513485+06
-.27765005+03	-.10885187+04	-.38623312+03	-.95578510+05	-.54174171+06	-.20395906+06

BOUNDARY CONDITIONS

B1 =	.51832804429-05	B2 =	.62033591143-02	B3 =	.10071699659-02	B4 =	-.16344440868-03
B5 =	.57789376149-04	ERR =	.62869814851-02				

DESIRED VALUES

.64000000+07	.20000000+01	.10000000+03	.60000000+02	-.10000000+01

AK = 1.000 TOL = .49999999874-06

PBWU MATRIX

-.90432311+00	.11988704+00	-.12600767+03	-.39646367+03	-.15235716+03	-.19690266-04
-.57547851+03	.75522474+02	-.66785974+05	-.21867814+06	-.70016481+05	-.10989471-01
-.18459408+02	.21073350+01	-.35858697+04	-.53833855+04	-.35938107+04	-.16227001-02
.45726506+02	-.62146175+01	.57816904+04	.20109049+05	.70553914+04	-.49041950-04
-.52988063+01	.13070669+00	-.11006032+04	-.20566381+04	-.18685213+02	.27550419-04

SIMULTANEOUS EQUATION MATRIX

.33363608+06	-.43785435+05	.38770408+08	.12687472+09	.40682175+08	.63517877+01
-.43785435+05	.57467378+04	-.50874885+07	-.16651745+08	-.53392585+07	-.83306558+00
.38770408+08	-.50874885+07	.45078799+10	.14742514+11	.47298376+10	.73944991+03
.12687472+09	-.16651745+08	.14742514+11	.48257871+11	.15472397+11	.24108576+04
.40682175+08	-.53392585+07	.47298376+10	.15472397+11	.49650252+10	.77493223+03

```
 .63517877+01   -.83306558+00    .73944991+03    .24108576+04    .77493223+03    .12340518-03
                                            RIGHT HAND SIDE
-.35962763+01    .47163939+00   -.41891820+03   -.13653686+04   -.43911199+03   -.69796463-04
                                            ANSWER
-.16830975-02   -.90478324-02    .55028273-05    .83291191-06   -.39634788-05    .63023659+00
                                            CHECK
-.35962763+01    .47163939•00   -.41891820+03   -.13653686+04   -.43911199+03   -.69796463-04
                                            ITERATION PARAMETERS
 .38084305+02    .38180739+02    .19494523+03    .19546364+03
```

TRIAL NUMBER 25

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169245778+01	DDY =	.91182928836+01	DDZ =	-.17680021659+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.46641481656+00	UY =	.40647409587+00	UZ =	-.78564370314+00
ALFA=	.38180739710+02	LFX =	.18254004968+01	LFY =	.27314725272+02	LFZ =	-.98399980750+01
BETA=	.19546364105+03	DFX =	-.18181073850+02	DFY =	-.62596400554+01	DFZ =	-.20748793658+02
AREA=	.65821803840+03	CL =	.46978569194+00	CD =	.45683775365+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23930357789+03	CHIY=	.2398353447[illegible]+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.3055334294. 03
PRES=	.68513884435-03	UOX =	-.46641481656+00	UOY =	.40647409587+00	UOZ =	-.78564370314+00
MACH=	.14005598208+02	UODX=	.21599222539-03	UODY=	-.27416356806-03	UODZ=	.58084354647-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.56078774160-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38641090-03	.28098414-03	-.84026634-04	.00000000	.00000000	.00000000
.10475802-03	.36941906-03	.12893706-03	.00000000	.00000000	.00000000
-.52902337-05	.35716014-03	.18792716-03	.00000000	.00000000	.00000000
.36162419-07	.70839302-07	.15182013-07	.00000000	.00000000	.00000000

FINAL VALUES 127 INTEGRATION STEPS TAKEN

T =	.14825606629+04	R =	.64000633646+07	V =	.36243079193+03	GM =	.39860319000+15
X =	-.29233034309+07	Y =	-.44662433176+07	Z =	-.35309741928+07	PHI =	.28608000000+02
DX =	-.24853067334+03	DY =	.26344233854+03	DZ =	-.13664465425+02	AZ =	.90000000000+02
DDX =	.35534730450+01	DDY =	-.26491992549+01	DDZ =	.13759686403+00	ALT =	.25229826587+05
WKG =	.13280731000+06	VRX =	-.47457888650+03	VRY =	.14015590030+03	VRZ =	.32942349894+03
VR =	.59446500112+03	UX =	-.88852771109+00	UY =	.60623622932-04	UZ =	.45882295362+00
ALFA=	.15504517425+02	LFX =	-.58650032767+06	LFY =	-.11170690731+07	LFZ =	-.36966655748+06
BETA=	.16828152671+02	DFX =	-.46869177984+06	DFY =	.13841727947+06	DFZ =	.32533703127+06
AREA=	.65821803840+03	CL =	.28756060773+00	CD =	.12841108464+00	ETA =	.98035470293+00

```
RHO =   .39310659902-01  Q    =  .45719629273+07  AE   =  .63781660000+07  BE   =  .63567840000+07
OM  =   .72921150604-04  FJ   =  .16234500072-02  FH   = -.57500000139-05  FD   =  .78750000512-05
F   =   .00000000000     OMX  =  .47881444528+00  OMY  = -.87791612754+00  OMZ  = -.77140676824-08
ISP =   .40000000000+03  MD   =  .00000000000     CHIP =  .15268882285+03  CHIY =  .34734777155-02
DRNG=   .66822387078+07  XRNG= -.11061577484+06  PANG =  .99975607145+02  DCEL =  .10841612684+02
PRES=   .24488935948+04  UOX  = -.46641481656+00  UOY  =  .40647409587+00  UOZ  = -.78564370314+00
MACH=   .20129469709+01  UODX =  .21599222539-03  UODY = -.27416356806-03  UODZ =  .58084354647-03
CDO =   .45842104633-01  CLA  =  .10757395062+01  EXA  =  .00000000000     HTC  =  .61031971743-08
CK1 =   .00000000000     CK2  =  .50000000000+00  CK3  =  .50000000000+00  RCRV =  .73152000000+00
J   =   .13329256653+06  HT1  =  .39906251978+05  DHT1 =  .25420930329+00  DCLI =  .22667888109+06
D2  =   .11127702675+03  LAT  =  .23200135951+02  LONG =  .14930653143+03  LNGO =  .00000000000

                                                  PXF/PUO MATRIX

  .45852910+08    .14776285+09    .46700016+08    .22178869+11    .68416422+11    .20627081+11
 -.55502108+08   -.19203990+09   -.65472097+08   -.25910518+11   -.90327170+11   -.31735652+11
  .33682633+08    .12534837+09    .45817635+08    .15128311+11    .59858600+11    .23928992+11
  .35366948+05    .11827871+06    .40172895+05    .15331950+08    .46744123+08    .16327928+08
 -.16415923+05   -.51572447+05   -.19567321+05   -.79701241+07   -.20487530+08   -.10264654+08
 -.22935988+05   -.82909726+05   -.25211479+05   -.87939861+07   -.35221491+08   -.78528634+07
  .32613858+07    .11128848+08    .37434015+07    .15606598+10    .53212285+10    .18255287+10

                                                  DPXF/PUO MATRIX

  .35366948+05    .11827871+06    .40172895+05    .15331950+08    .46744123+08    .16327928+08
 -.16415923+05   -.51572447+05   -.19567321+05   -.79701241+07   -.20487530+08   -.10264654+08
 -.22935988+05   -.82909726+05   -.25211479+05   -.87939861+07   -.35221491+08   -.78528634+07
 -.12046551+03   -.42427434+03   -.14375346+03   -.52424198+05   -.19836209+06   -.68400187+05
  .17883327+03    .61892373+03    .22746300+03    .76798373+05    .27860938+06    .12109213+06
 -.16261270+03   -.56111115+03   -.21214158+03   -.60184394+05   -.20710634+06   -.10022868+06
 -.24165609+03   -.95762657+03   -.34304451+03   -.81260559+05   -.48258092+06   -.18546613+06

                                                  BOUNDARY CONDITIONS

B1  =   .19801549000-04  B2   =  .12988876868-01  B3   =  .41764050036-03  B4   = -.10239672857-02
B5  =   .10115830309-03  ERR  =  .13036275541-01

                                                  DESIRED VALUES

   .64000000+07    .20000000+01    .10000000+03    .60000000+02   -.10000000+01

AK  =  .500              TOL  =  .49999999874-06

                                                  ITERATION PARAMETERS

  .38084305+02    .38108414+02    .19494523+03    .19507483+03
```

TRIAL NUMBER 26

INITIAL VALUES

```
T    =  .00000000000      R    =  .65000732772+07   V    =  .79182741874+04   GM   =  .39860319000+15
X    =  .10416416000+07   Y    = -.62981421000+07   Z    =  .12244760000+07   PHI  =  .28608000000+02
DX   = -.50566950000+04   DY   = -.17567557000+04   DZ   = -.58346132000+04   AZ   =  .90000000000+02
DDX  = -.15169262191+01   DDY  =  .91182927722+01   DDZ  = -.17680017247+01   ALT  =  .14030918566+06
WKG  =  .13280731000+06   VRX  = -.49783056909+04   VRY  = -.17140022624+04   VRZ  = -.56813936515+04
VR   =  .77459386217+04   UX   = -.47017673102+00   UY   =  .40645924435+00   UZ   = -.78340584903+00
ALFA =  .38108413920+02   LFX  =  .16719434118+01   LFY  =  .27322145465+02   LFZ  = -.97077702982+01
BETA =  .19507483909+03   DFX  = -.18116554756+02   DFY  = -.62374264995+01   DFZ  = -.20675162509+02
AREA =  .65821803840+03   CL   =  .46903120063+00   CD   =  .45521657561+00   ETA  =  .17999863636+01
RHO  =  .31358995814-08   W    =  .61922721324+02   AE   =  .63781660000+07   BE   =  .63567840000+07
OM   =  .72921150604-04   FJ   =  .16234500072-02   FH   = -.57500000139-05   FD   =  .78750000512-05
F    =  .00000000000      OMX  =  .47881444528+00   OMY  = -.87791612754+00   OMZ  = -.77140676824-08
ISP  =  .40000000000+03   MD   =  .00000000000      CHIP =  .23902908384+03   CHIY =  .23982603138+02
DRNG =  .00000000000      XRNG =  .88986254448-12   PANG =  .91500003418+02   DCEL =  .30475439514-03
PRES =  .68513884435-03   UDX  = -.47017673102+00   UDY  =  .40645924435+00   UDZ  = -.78340584903+00
MACH =  .14005598208+02   UDDX =  .22011934585-03   UDDY = -.27353888413-03   UDDZ =  .57787093735-03
CD0  =  .12000053346-01   CLA  =  .75999370475+00   EXA  =  .00000000000      HTC  =  .61031971743-08
CK1  =  .00000000000      CK2  =  .50000000000+00   CK3  =  .50000000000+00   RCRV =  .73152000000+00
J    =  .00000000000      HT1  =  .00000000000      DHT1 =  .15884027431+00   DCL1 =  .00000000000
D2   =  .55874513314-07   LAT  =  .680289733 6+02   LONG =  .21023191184+03   LNG0 =  .00000000000
```

PXF/PUD MATRIX

```
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
```

DPXF/PUD MATRIX

```
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .00000000     .00000000     .00000000     .00000000     .00000000     .00000000
 .38384834-03  .28164419-03 -.84247107-04  .00000000     .00000000     .00000000
 .10484499-03  .36946489-03  .12876690-03  .00000000     .00000000     .00000000
-.74643005-05  .35697140-03  .18968950-03  .00000000     .00000000     .00000000
 .35727043-07  .70879285-07  .15332431-07  .00000000     .00000000     .00000000
```

FINAL VALUES 124 INTEGRATION STEPS TAKEN

```
T    =  .14830333403+04   R    =  .64000164695+07   V    =  .36379245598+03   GM   =  .39860319000+15
X    = -.29205889580+07   Y    = -.44700411317+07   Z    = -.35283286736+07   PHI  =  .28608000000+02
DX   = -.24780404280+03   DY   =  .26576609307+03   DZ   = -.17506889267+02   AZ   =  .90000000000+02
DDX  =  .35488918481+01   DDY  = -.26808396644+01   DDZ  =  .19023650837+00   ALT  =  .25195231639+05
WKG  =  .13280731000+06   VRX  = -.47368289338+03   VRY  =  .14257202499+03   VRZ  =  .32553990153+03
VR   =  .59218113216+03   UX   = -.89009049007+00   UY   =  .49043600652-02   UZ   =  .45575746482+00
ALFA =  .15484304390+02   LFX  = -.58750659475+06   LFY  = -.11191220526+07   LFZ  = -.36473662943+06
BETA =  .17016961301+02   DFX  = -.46962919861+06   DFY  =  .14135191871+06   DFZ  =  .32275398839+06
AREA =  .65821803840+03   CL   =  .28832687926+00   CD   =  .12867816256+00   ETA  =  .97730341121+00
```

```
RHO =   .39533766141-01  W    =   .45626494711+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM  =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F   =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP =   .40000000000+03  MD   =   .00000000000     CHIP=    .15288596954+03  CHIY=    .28100025786+00
DRNG=   .66768907844+07  XRNG=  -.11094411983+06  PANG=    .99954537524+02  DCEL=    .10847306765+02
PRES=   .24621623175+04  UDX  =  -.47017673102+00  UDY  =   .40645924435+00  UDZ  =  -.78340584903+00
MACH=   .20054699270+01  UDDX=    .22011934585-03  UDDY=   -.27353888413-03  UDDZ=    .57787093735-03
CDO =   .45930881724-01  CLA  =   .10799795487+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1 =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J   =   .13360250830+06  HT1  =   .39921969075+05  DHT1=    .25200269954+00  DCLI=    .22728304753+06
D2  =   .11139608372+03  LAT  =   .23245458046+02  LONG=    .14932582033+03  LNGO=    .00000000000

                                                   PXF/PUO MATRIX

  .46290202+08     .14927961+09     .47198657+08     .22394180+11     .69166947+11     .20860469+11
 -.55848032+08    -.19321773+09    -.65858769+08    -.26075913+11    -.90899693+11    -.31914125+11
  .33900475+08     .12607408+09     .46061504+08     .15226830+11     .60197307+11     .24044600+11
  .36024658+05     .12060794+06     .40941131+05     .15613088+08     .47825837+08     .16672838+08
 -.16988773+05    -.53579016+05    -.20268645+05    -.82126035+07    -.21364239+08    -.10598927+08
 -.23078477+05    -.83479158+05    -.25341401+05    -.88484522+07    -.35540866+08    -.78681628+07
  .32834129+07     .11205694+08     .37698024+07     .15712018+10     .53583348+10     .18381114+10

                                                   DPXF/PUO MATRIX

  .36024658+05     .12060794+06     .40941131+05     .15613068+08     .47825837+08     .16672838+08
 -.16988773+05    -.53579016+05    -.20268645+05    -.82126035+07    -.21364239+08    -.10598927+08
 -.23078477+05    -.83479158+05    -.25341401+05    -.88484522+07    -.35540866+08    -.78681628+07
 -.12093446+03    -.42700840+03    -.14423779+03    -.52608145+05    -.20071639+06    -.68561068+05
  .18452898+03     .64011719+03     .23456075+03     .79082314+05     .28873179+06     .12443568+06
 -.16882714+03    -.58411987+03    -.22021056+03    -.62335064+05    -.21697623+06    -.10400625+06
 -.27083792+03    -.10625142+04    -.37769320+03    -.93164336+05    -.52972601+06    -.20031019+06

                                                   BOUNDARY CONDITIONS

B1  =   .51467244023-05  B2   =   .54774070704-02  B3   =   .78109716659-03  B4   =  -.18719270421-03
B5  =   .49753068399-04  ERR  =   .55362120591-02

                                                   DESIRED VALUES

  .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

AK  = 1.000              TOL  =   .49999999874-06

                                                   PBNU MATRIX

 -.89986713+00     .12036078+00    -.12544202+03    -.39446973+03    -.15159450+03    -.19652420-04
 -.57284666+03     .75874877+02    -.66518528+05    -.21767988+06    -.69702136+05    -.10988924-01
 -.18492277+02     .21309231+01    -.35852058+04    -.53901215+04    -.35819286+04    -.16199246-02
  .45618936+02    -.62565786+01     .57701326+04     .20068858+05     .70426534+04    -.48817944-04
 -.52758536+01     .13414936+00    -.10971151+04    -.20454709+04    -.16144173+02     .27574175-04

                                                   SIMULTANEOUS EQUATION MATRIX

  .33060499+06    -.43790310+05     .38440344+08     .12572354+09     .40316374+08     .63225700+01
 -.43790310+05     .58007151+04    -.50909885+07    -.16653805+08    -.53403571+07    -.83692846+00
  .38440344+08    -.50909885+07     .44720821+10     .14617164+11     .46899992+10     .73646537+03
  .12572354+09    -.16653805+08     .14617164+11     .47820684+11     .15333491+11     .23997710+04
  .40316374+08    -.53403571+07     .46899992+10     .15333491+11     .49208401+10     .77141269+03
```

.63225700+01	-.83692846+00	.73646537+03	.23997710+04	.77141269+03	.12338415-03

RIGHT HAND SIDE

-.31609653+01	.41844053+00	-.36828481+03	-.12003921+04	-.38590472+03	-.61445722-04

ANSWER

-.13346040-04	.27534287-03	-.32221203-06	.20223005-06	-.71927719-08	.88492948-01

CHECK

-.31609653+01	.41844053+00	-.36828481+03	-.12003921+04	-.38590472+03	-.61445722-04

ITERATION PARAMETERS

.38108414+02	.38109179+02	.19507484+03	.19505906+03

TRIAL NUMBER 27

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169262598+01	DDY =	.91182927929+01	DDZ =	-.17680016844+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47030060945+00	UY =	.40651459461+00	UZ =	-.78330276466+00
ALFA=	.36109176933+02	LFX =	.16658643488+01	LFY =	.27324664486+02	LFZ =	-.97032034917+01
BETA=	.19505906815+03	DFX =	-.18117236652+02	DFY =	-.62376612724+01	DFZ =	-.20675940709+02
AREA=	.65821803840+03	CL =	.46903918503+00	CD =	.45523370968+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23901909617+03	CHIY=	.23986074175+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30476263059-03
PRES=	.68513884435-03	UUX =	-.47030060945+00	UDY =	.40651459461+00	UDZ =	-.78330276466+00
MACH=	.14005598208+02	UDDX=	.22044155739-03	UDDY=	-.27374111417-03	UDDZ=	.57787813012-03
CD0 =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55876672127-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUD MATRIX

.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.38377006-03	.28168715-03	-.84229698-04	.00000000	.00000000	.00000000
.10485931-03	.36945442-03	.12877934-03	.00000000	.00000000	.00000000
-.75237404-05	.35699006-03	.18978624-03	.00000000	.00000000	.00000000
.35714783-07	.70884551-07	.15343901-07	.00000000	.00000000	.00000000

FINAL VALUES 119 INTEGRATION STEPS TAKEN

T =	.14829448474+04	R =	.64000000744+07	V =	.36189332469+03	GM =	.39860319000+15
X =	-.29197947462+07	Y =	-.44708789901+07	Z =	-.35278946481+07	PHI =	.28608000000+02
DX =	-.24620383031+03	DY =	.26465067905+03	DZ =	-.17620172379+02	AZ =	.90000000000+02
DDX =	.35494248640+01	DDY =	-.26779945929+01	DDZ =	.18172366166+00	ALT =	.25181807172+05
WKG =	.13280731000+06	VRX =	-.47205489516+03	VRY =	.14147176527+03	VRZ =	.32540502847+03
VR =	.59054086816+03	UX =	-.88950633705+00	UY =	.35457933829-02	UZ =	.45690907597+00
ALFA=	.15494627081+02	LFX =	-.58709355729+06	LFY =	-.11195827077+07	LFZ =	-.36493303800+06
BETA=	.17005872338+02	DFX =	-.46944387024+06	DFY =	.14068925817+06	DFZ =	.32360515170+06
AREA=	.65821803840+03	CL =	.28935237319+00	CD =	.12914555112+00	ETA =	.97507692102+00

```
RHO  =   .39620684537-01  Q    =   .45473844807+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .15281198383+03  CHIY=    .20315942044+00
DRNG=    .66757007875+07  XRNG=   -.11126135424+06  PANG=    .10000012545+03  DCEL=    .10849602784+02
PRES=    .24673315027+04  UOX  =  -.47030060945+00  UOY  =   .40651459461+00  UOZ  =  -.78330276466+00
MACH=    .20000139611+01  UODX=    .22044155789-03  UODY=   -.27374111417-03  UODZ=    .57787813012-03
CDO  =   .45996428705-01  CLA  =   .10831163360+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .13363555967+06  HT1  =   .39917053348+05  DHT1=    .25018902962+00  DCLI=    .22735406599+06
D2   =   .11142490064+03  LAT  =   .23256393721+02  LONG=    .14932710295+03  LNGO=    .00000000000

                                                     PXF/PUO MATRIX
   .46297186+08     .14929584+09     .47205419+08     .22398198+11     .69171923+11     .20863391+11
  -.55839099+08    -.19318375+09    -.65848836+08    -.26072216+11    -.90882547+11    -.31909171+11
   .33907944+08     .12610096+09     .46071486+08     .15230504+11     .60210766+11     .24049524+11
   .35983642+05     .12043037+06     .40883503+05     .15599331+08     .47729511+08     .16642568+08
  -.16941860+05    -.53403348+05    -.20206591+05    -.81949214+07    -.21282658+08    -.10565970+08
  -.23131286+05    -.83651644+05    -.25404841+05    -.88682773+07    -.35594646+08    -.78935446+07
   .32845676+07     .11209850+08     .37712114+07     .15717614+10     .53602026+10     .18387840+10

                                                     DPXF/PUO MATRIX
   .35983642+05     .12043037+06     .40883503+05     .15599331+08     .47729511+08     .16642568+08
  -.16941860+05    -.53403348+05    -.20206591+05    -.81949214+07    -.21282658+08    -.10565970+08
  -.23131286+05    -.83651644+05    -.25404841+05    -.88682773+07    -.35594646+08    -.78935446+07
  -.12018578+03    -.42436486+03    -.14348934+03    -.52316155+05    -.19969048+06    -.68421643+05
   .18544015+03     .64298212+03     .23562124+03     .79514325+05     .28984575+06     .12495404+06
  -.16924151+03    -.58527055+03    -.22058650+03    -.62510502+05    -.21714044+06    -.10403531+06
  -.28040112+03    -.10945173+04    -.38878332+03    -.97545557+05    -.54350895+06    -.20549017+06

                                                     BOUNDARY CONDITIONS

B1   =   .23244205746-07  B2   =   .13961189771-04  B3   =  -.20861388009-05  B4   =  -.10369994727-05
B5   =   .33418654874-07  ERR  =   .14154286274-04

                                                     DESIRED VALUES

    .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

                                                     CASE CONVERGED
```

THIS IS A FULL PRINT OF CONVERGED CASE

INITIAL VALUES

T =	.00000000000	R =	.55000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	-.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169262597+01	DDY =	.91182927929+01	DDZ =	-.17680016844+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	-.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47030056530+00	UY =	.40651458587+00	UZ =	-.78330279570+00
ALFA=	.38109179274+02	LFX =	.16658663157+01	LFY =	.27324664037+02	LFZ =	-.97032050795+01
BETA=	.19505907320+03	DFX =	-.18117236956+02	DFY =	-.62376613771+01	DFZ =	-.20675941056+02
AREA=	.65821803840+03	CL =	.46903918959+00	CD =	.45523371732+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23901909955+03	CHIY=	.23986073627+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30476263426-03
PRES=	.68513884435-03	UDX =	-.47030056530+00	UDY =	.40651458587+00	UDZ =	-.78330279570+00
MACH=	.14005598208+02	UDDX=	.72044155789-03	UDDY=	-.27374111417-03	UDDZ=	.57787813012-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCPV=	.73152000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15884027431+00	DCLI=	.00000000000
D2 =	.55876673089-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000

PXF/PUO MATRIX

.10000000+01	.00000000	.00000000	.00000000	.00000000	.00000000
.00000000	.10000000+01	.00000000	.00000000	.00000000	.00000000
.00000000	.00000000	.10000000+01	.00000000	.00000000	.00000000
.00000000	.00000000	.00000000	.10000000+01	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.10000000+01	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.10000000+01
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

DPXF/PUO MATRIX

.00000000	.00000000	.00000000	.10000000+01	.00000000	.00000000
.00000000	.00000000	.00000000	.00000000	.10000000+01	.00000000
.00000000	.00000000	.00000000	.00000000	.00000000	.10000000+01
-.13330720-05	-.66809964-06	.12968910-06	-.63733287-07	-.29130168-07	.12197047-07
-.68083129-06	.26396727-05	-.79115004-06	-.33544894-07	-.84936214-07	-.33949331-07
.13069245-06	-.78239069-05	-.12925011-05	.14112107-07	-.28251769-07	-.32929763-07
-.44129601-06	.26442963-05	-.51261927-06	-.19769039-04	-.68063771-05	-.22561024-04

INTERMEDIATE VALUES 1 INTEGRATION STEPS TAKEN

T =	.10000000000+03	R =	.54805373375+07	V =	.79418704793+04	GM =	.39860319000+15
X =	.52959530430+06	Y =	-.64277122901+07	Z =	.63356744889+06	PHI =	.28508000000+02
DX =	-.51720114713+04	DY =	-.93007721726+03	DZ =	-.59694703170+04	AZ =	.90000000000+02
DDX =	-.78389571556+00	DDY =	.93924642678+01	DDZ =	-.92295398058+00	ALT =	.12008877293+06
WKG =	.13280731000+06	VRX =	-.51314513323+04	VRY =	-.80795576581+03	VRZ =	-.57789462198+04
VR =	.77705085517+04	UX =	-.48029066245+00	UY =	.40623541743+00	UZ =	-.77736327749+00
ALFA=	.31453954794+02	LFX =	.25489098794+02	LFY =	.15190362854+03	LFZ =	-.43870884560+02
BETA=	.19729303410+03	DFX =	-.34683457994+02	DFY =	-.13333554919+02	DFZ =	-.95368954663+02
AREA=	.65821803840+03	CL =	.39657781039+00	CD =	.31754150071+00	ETA =	.18000013154+01
RHO =	.20322102803-07	Q =	.40383813251+03	AE =	.63781660000+07	BE =	.63567840000+07

```
OM   =  .72921150604-04  FJ   =  .16234500072-02  FH   = -.57500000139-05  FD   =  .78750000512-05
F    =  .00000000000     OMX  =  .47881444528+00  OMY  = -.87791612754+00  OMZ  = -.77140676824-08
ISP  =  .40000000000+03  MD   =  .00000000000     CHIP =  .23829033117+03  CHIY =  .23968567814+02
DRNG =  .77695134250+06  XRNG =  .47832888050+02  PANG =  .91320019548+02  DCEL =  .15448448511-02
PRES =  .22943646649-02  UDX  = -.47030056530+00  UDY  =  .40651458587+00  UDZ  = -.78330279570+00
MACH =  .19545121802+02  UDDX =  .22044155789-03  UDDY = -.27374111417-03  UDDZ =  .57787813012-03
CDG  =  .12000000427-01  CLA  =  .75999960681+00  EXA  =  .00000000000     HTC  =  .61031971743-08
CK1  =  .00000000000     CK2  =  .50000000000+00  CK3  =  .50000000000+00  RCRV =  .73152000000+00
J    =  .12732169726+02  HT1  =  .25464297978+02  DHT1 =  .40821604223+00  DCLI =  .41473702421-04
D2   =  .16386593894-05  LAT  =  .65490027419+02  LONG =  .19404843730+03  LNGO =  .00000000000

                                   PXF/PUD MATRIX
  .99315564+00   -.27638476-02    .45770375-03    .99768178+02   -.82026107-01    .12366917-01
 -.29074001-02    .10137523+01   -.33831182-02   -.88660045-01    .10046616+03   -.10321892+00
  .46730461-03   -.32920706-02    .99330813+00    .12806466-01   -.99156128-01    .99772791+02
 -.13842429-03   -.48667070-04    .74302415-05    .99296738+00   -.21088088-02    .28808180-03
 -.53120440-04    .28142946-03   -.61867649-04   -.24025666-02    .10143001+01   -.28002243-02
  .77005215-05   -.59147918-04   -.13578377-03    .30585510-03   -.26275654-02    .99308640+00
 -.70462488-04    .61250716-03   -.81895045-04   -.72280414-02    .37389928-01   -.83055254-02

                                   DPXF/PUD MATRIX
 -.13842429-03   -.48667070-04    .74302415-05    .99296738+00   -.21088088-02    .28808180-03
 -.53120440-04    .28142946-03   -.61867649-04   -.24025666-02    .10143001+01   -.28002243-02
  .77005215-05   -.59147918-04   -.13578877-03    .30585510-03   -.26275654-02    .99308640+00
 -.14256595-05   -.26046330-06    .25810215-07   -.14365518-03   -.26246063-04    .26547781-05
 -.38017497-06    .30378100-05   -.44462481-06   -.37759243-04    .30045683-03   -.44143322-04
  .31871075-07   -.37620303-06   -.14096708-05    .32617476-05   -.37768702-04   -.14187440-03
 -.10661824-05    .12531877-04   -.12404846-05   -.15694320-03    .12330605-02   -.18064601-03

                                   INTERMEDIATE VALUES     5 INTEGRATION STEPS TAKEN

T    =  .20000000000+03  R    =  .64635639144+07  V    =  .79624354856+04  GM   =  .39860319000+15
X    =  .97368784346+04  Y    = -.54634699942+07  Z    =  .33455981199+05  PHI  =  .28608000000+02
DX   = -.52123644617+04  DY   =  .11729859131+03  DZ   = -.60181289967+04  AZ   =  .90000000000+02
DDX  = -.15117923398-01  DDY  =  .95366298225+01  DDZ  = -.45001651469-01  ALT  =  .10192334810+06
WKG  =  .13280731000+06  VRX  = -.52102226512+04  VRY  =  .11846673032+03  VRZ  = -.57930757575+04
VR   =  .77923155206+04  UX   = -.49173593354+00  UY   =  .40584511450+00  UZ   = -.77038011053+00
ALFA =  .24812011315+02  LFX  =  .61249014963+03  LFY  =  .20848086548+04  LFZ  = -.50823253653+03
BETA =  .20074323112+03  DFX  = -.95416494719+03  DFY  =  .21595195973+02  DFZ  = -.10609047241+04
AREA =  .65821803840+03  CL   =  .31892917837+00  CD   =  .20394773441+00  ETA  =  .17999986689+01
RHO  =  .35014020084-06  Q    =  .69970474569+04  AE   =  .63781660000+07  BE   =  .63567840000+07
OM   =  .72921150604-04  FJ   =  .16234500072-02  FH   = -.57500000139-05  FD   =  .78750000512-05
F    =  .00000000000     OMX  =  .47881444528+00  OMY  = -.87791612754+00  OMZ  = -.77140676824-08
ISP  =  .40000000000+03  MD   =  .00000000000     CHIP =  .23744979197+03  CHIY =  .23944097076+02
DRNG =  .15586260125+07  XRNG =  .18510789427+03  PANG =  .91124769168+02  DCEL =  .19944899104-01
PRES =  .20525930657-01  UDX  = -.47030056530+00  UDY  =  .40651458587+00  UDZ  = -.78330279570+00
MACH =  .27200189054+02  UDDX =  .22044155789-03  UDDY = -.27374111417-03  UDDZ =  .57787813012-03
CDG  =  .11999999168-01  CLA  =  .76000231834+00  EXA  =  .00000000000     HTC  =  .61031971743-08
CK1  =  .00000000000     CK2  =  .50000000000+00  CK3  =  .50000000000+00  RCRV =  .73152000000+00
J    =  .56557417931+02  HT1  =  .11310944573+03  DHT1 =  .17087478343+01  DCLI =  .53901277891-02
D2   =  .30919029823-03  LAT  =  .61476900193+02  LONG =  .18145669212+03  LNGO =  .00000000000

                                   PXF/PUD MATRIX
  .97209172+00   -.69980303-02    .11927652-02    .19808710+03   -.17172313+00    .40512519-01
 -.96361600-02    .10593300+01   -.11235894-01   -.50481867+00    .20422568+03   -.59019196+00
  .12936498-02   -.98934989-02    .97258536+00    .51256256-01   -.43455328+00    .19811638+03
```

-.28351984-03	.19851725-05	.60692855-05	.97077547+00	.69256351-02	.14308189-03
-.76631949-04	.67632581-03	-.89650990-04	-.55135187-02	.10741449+01	-.64828109-02
.80417896-05	-.54506091-04	-.27923566-03	.39422681-03	-.12794952-02	.97121566+00
-.20865924-03	.43809667-02	-.24406320-03	-.36579877-01	.64290674+00	-.42169382-01

DPXF/PUO MATRIX

-.28351984-03	.19851725-05	.60692855-05	.97077547+00	.69256351-02	.14308189-03
-.76631949-04	.67632581-03	-.89650990-04	-.55135187-02	.10741449+01	-.64828109-02
.80417896-05	-.54506091-04	-.27923566-03	.39422681-03	-.12794952-02	.97121566+00
-.14582148-05	.23526412-05	-.38349941-07	-.30016730-03	.44955106-03	-.24148934-05
-.81440390-07	.62178511-05	-.10183676-06	-.10865639-04	.11929963-02	-.13961531-04
-.12515123-07	.82121333-06	-.14405468-05	.42194662-06	.15362673-03	-.29512062-03
-.10384349-05	.85525858-04	-.12585298-05	-.31970942-03	.16488248-01	-.37034719-03

INTERMEDIATE VALUES 4 INTEGRATION STEPS TAKEN

T =	.30000000000+03	R =	.64491226368+07	V =	.79756196417+04	GM =	.39860319000+15
X =	-.51014832046+06	Y =	-.64038555344+07	Z =	-.56706769507+06	PHI =	.28608000000+02
DX =	-.51696057651+04	DY =	.10778997750+04	DZ =	-.59769404362+04	AZ =	.90000000000+02
DDX =	.94360336059+00	DDY =	.97243577742+01	DDZ =	.87928488141+00	ALT =	.85847455615+05
WKG =	.13280731000+06	VRX =	-.52059086721+04	VRY =	.10581002090+04	VRZ =	-.57206863269+04
VR =	.78068760209+04	UX =	-.50497023840+00	UY =	.40529777950+00	UZ =	-.76206218136+00
ALFA=	.18179327684+02	LFX =	.14877887137+05	LFY =	.31996714006+05	LFZ =	-.76209722751+04
BETA=	.20658333244+03	DFX =	-.11755741582+05	DFY =	.23893528312+04	DFZ =	-.12918188613+05
AREA=	.65821803840+03	CL =	.23711501676+00	CD =	.11579262092+00	ETA =	.17999972443+01
RHO =	.75902404648-05	Q =	.15224739980+06	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23647009476+03	CHIY=	.23909788746+02
DRNG=	.23444464190+07	XRNG=	.28571833300+03	PANG=	.90975985176+02	DCEL=	.30250367952+00
PRES=	.38850713604+00	UDX =	-.47030056530+00	UDY =	.40651458587+00	UDZ =	-.78330279570+00
MACH=	.29163616824+02	UDDX=	.22044155789-03	UDDY=	-.27374111417-03	UDDZ=	.57787813012-03
CDO =	.11999998790-01	CLA =	.76000315654+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.26586630674+03	HT1 =	.53017601804+03	DHT1=	.80004979034+01	DCLI=	.15565954335+01
D2 =	.79242177627-01	LAT =	.56499190676+02	LONG=	.17208673107+03	LNGO=	.00000000000

PXF/PUO MATRIX

.93754996+00	.37285258-01	.27437922-02	.29370952+03	.10895000+02	.47802551+00
-.15958834-01	.11958139+01	-.18717039-01	-.57135135+00	.32754562+03	-.69342068+00
.23053550-02	-.25615157-02	.93785117+00	.21357066+00	.23663471+01	.29359861+03
-.37683454-03	.15051944-02	.57888266-04	.94863185+00	.38407628+00	.21557972-01
-.11399170-04	.27466129-02	-.16096473-04	.17605002-01	.15857779+01	.19746275-01
.18723242-04	.33421861-03	-.40673533-03	.58238929-02	.93653724-01	.93816581+00
.39853223-03	.26880559-01	.43882870-03	.14468998+00	.61713677+01	.16617492+00

DPXF/PUO MATRIX

-.37683454-03	.15051944-02	.57888266-04	.94863185+00	.38407628+00	.21557972-01
-.11399170-04	.27466129-02	-.16096473-04	.17605002-01	.15857779+01	.19746275-01
.18723242-04	.33421861-03	-.40673533-03	.58238929-02	.93653724-01	.93816581+00
.65808994-06	.42469161-04	.22592025-05	.23472913-03	.11613408-01	.92289553-03
.24998446-05	.50235180-04	.28470320-05	.91705257-03	.13687037-01	.10459364-02
.40264411-06	.87987869-05	-.88646293-06	.19576488-03	.23650805-02	-.29921007-03
.21008145-04	.43818158-03	.23865029-04	.70714559-02	.12032044+00	.81474265-02

INTERMEDIATE VALUES 5 INTEGRATION STEPS TAKEN

```
T    =   .40000000000+03  R    =   .64342325319+07  V    =   .79590794785+04  GM   =   .39860319000+15
X    =  -.10196407475+07  Y    =  -.62463437690+07  Z    =  -.11588229119+07  PHI  =   .28608000000+02
DX   =  -.49828819904+04  DY   =   .20890902726+04  DZ   =  -.58441025870+04  AZ   =   .90000000000+02
DDX  =   .32974219246+01  DDY  =   .10772812768+02  DDZ  =   .16909364970+01  ALT  =   .68981355708+05
WKG  =   .13280731000+06  VRX  =  -.50570682701+04  VRY  =   .20486291586+04  VRZ  =  -.55607310918+04
VR   =   .77905424197+04  UX   =  -.52043396508+00  UY   =   .40452405976+00  UZ   =  -.75200317358+00
ALFA=    .11196040472+02  LFX  =   .17223274617+06  LFY  =   .21697614562+06  LFZ  =  -.76696589020+05
BETA=    .21874680075+03  DFX  =  -.65211406986+05  DFY  =   .26417280227+05  DFZ  =  -.71706189919+05
AREA=    .65821803840+03  CL   =   .14756690510+00  CD   =   .51573348565-01  ETA  =   .17999998088+01
RHO  =   .97519606917-04  Q    =   .19479020723+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .23531430882+03  CHIY=    .23861305583+02
DRNG=    .31326834594+07  XRNG=  -.14931211848+04  PANG=    .91338406648+02  DCEL=    .22927591539+01
PRES=    .64361786197+01  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
MACH=    .25629224020+02  UDDX=    .22044155789-03  UDDY=  -.27374111417-03  UDDZ=    .57787813012-03
CDD  =   .11999999470-01  CLA  =   .76000164769+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .11370334982+04  HT1  =   .21496304629+04  DHT1=    .28497480281+02  DCLI=    .12443653358+03
D2   =   .49648536285+01  LAT  =   .50932262463+02  LONG=    .16506640080+03  LNGO=    .00000000000

                                               PXF/PUD MATRIX
   .92905451+00     .72221451+00     .48606248-01     .40014668+03     .20991792+03     .20775749+02
   .19245028-01     .20103056+01     .21228300-01     .16313075+02     .64698995+03     .18560592+02
   .75139591-02     .87656166-01     .89479616+00     .27832333+01     .27908216+02     .38607017+03
   .71996873-03     .18241617-01     .14314053-02     .14031733+01     .55629027+01     .66685652+00
   .11330139-02     .18357493-01     .12939221-02     .51550274+00     .63744626+01     .58883380+00
   .76235208-04     .13026602-02     .45524152-03     .49349920-01     .36683913+00     .89927178+00
   .90961053-02     .14726307+00     .10347005-01     .37937163+01     .43359170+02     .44184635+01

                                               DPXF/PUD MATRIX
   .71996873-03     .18241617-01     .14314053-02     .14031733+01     .55629027+01     .66685652+00
   .11330139-02     .18357493-01     .12939221-02     .51550274+00     .63744626+01     .58883380+00
   .76235208-04     .13026602-02    -.45524152-03     .49349920-01     .36683913+00     .89927178+00
   .35637666-04     .45416451-03     .41302816-04     .15668999-01     .14559072+00     .20364122-01
   .29750905-04     .36465716-03     .34114172-04     .13776816-01     .11627716+00     .15755327-01
  -.95345429-06    -.10353267-04    -.17976992-05     .74556337-04    -.36908492-02    -.15032898-02
   .25359666-03     .31457189-02     .28876678-03     .11438054+00     .10086524+01     .13425695+00

                                               INTERMEDIATE VALJES   17 INTEGRATION STEPS TAKEN

T    =   .50000000000+03  R    =   .64016959422+07  V    =   .76649731198+04  GM   =   .39860319000+15
X    =  -.14839846702+07  Y    =  -.59800660527+07  Z    =  -.17373285355+07  PHI  =   .28608000000+02
DX   =  -.39836306857+04  DY   =   .31368802948+04  DZ   =  -.57749009021+04  AZ   =   .90000000000+02
DDX  =   .18259967790+02  DDY  =  -.42133836455+01  DDZ  =   .46573275462+01  ALT  =   .34308226116+05
WKG  =   .13280731000+06  VRX  =  -.40948521170+04  VRY  =   .30762202515+04  VRZ  =  -.54711000068+04
VR   =   .74942564795+04  UX   =  -.53871762763+00  UY   =   .40341612330+00  UZ   =  -.73962067923+00
ALFA=    .81163345661+00  LFX  =   .98922593888+06  LFY  =  -.91055115857+06  LFZ  =  -.12523605556+07
BETA=    .30160073301+03  DFX  =  -.11385332892+07  DFY  =   .85531273445+06  DFZ  =  -.15211854564+07
AREA=    .65821803840+03  CL   =   .10765568647-01  CD   =   .12208625744-01  ETA  =   .18000008244+01
RHO  =   .92336284328-02  Q    =   .17067475287+09  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .23393152663+03  CHIY=    .23791911160+02
DRNG=    .39150459848+07  XRNG=  -.28374400474+05  PANG=    .93279279850+02  DCEL=    .20918360064+02
PRES=    .63098068754+03  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
```

MACH=	.24229393846+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.11999999740-01	CLA =	.76000105010+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCPV=	.73152000000+00
J =	.11044663666+05	HT1 =	.10637106463+05	DHT1=	.24684779613+03	DCLI=	.11452220869+05
D2 =	.43751550667+03	LAT =	.45161742757+02	LONG=	.15945241180+03	LNGO=	.00000000000

PXF/PUO MATRIX

.18061891+01	.12028746+02	.11050310+01	.92118888+03	.38564467+04	.55703357+03
.32656682+00	.60385167+01	.37358871+00	.15869183+03	.19888448+04	.17999618+03
-.74688822-01	-.80869777+00	.75217512+00	-.27585582+02	-.27578593+03	.41483217+03
.24429996-01	.29168388+00	.28173140-01	.12634602+02	.94881061+02	.14595294+02
-.80885580-02	-.95783258-01	-.93301260-02	-.42632284+01	-.31063784+02	-.50221781+01
.50121462-02	.61479372-01	.55794034-02	.28560708+01	.19784953+02	.34917191+01
.51591970+00	.59999279+01	.58444769+00	.24904661+03	.19555288+04	.29988529+03

DPXF/PUO MATRIX

.24429996-01	.29168389+00	.28173140-01	.12634602+02	.94881061+02	.14595294+02
-.80885580-02	-.95783258-01	-.93301260-02	-.42632284+01	-.31063784+02	-.50221781+01
.50121462-02	.61479372-01	.55794034-02	.28560708+01	.19784953+02	.34917191+01
-.16953756-03	-.23399909-02	-.20642378-03	-.95425630-01	-.74813124+00	-.94365849-01
-.13579009-02	-.16065917-01	-.15656310-02	-.68408680+00	-.52420045+01	-.79385336+00
.14831563-02	.17496990-01	.17192832-02	.75108705+00	.57028239+01	.85845003+00
.24014535-01	.27792335+00	.27517909-01	.11919946+02	.90763468+02	.14047914+02

INTERMEDIATE VALUES 36 INTEGRATION STEPS TAKEN

T =	.60000000000+03	R =	.63961800026+07	V =	.42964438719+04	GM =	.39860319000+15
X =	-.17813912374+07	Y =	-.57422099146+07	Z =	-.21828397060+07	PHI =	.28608000000+02
DX =	-.21483773344+04	DY =	.17619160061+04	DZ =	-.32771262962+04	AZ =	.90000000000+02
DDX =	.77289855760+01	DDY =	-.50964590498+01	DDZ =	.11484258855+02	ALT =	.27208221489+05
WKG =	.13280731000+06	VRX =	-.22881197914+04	VRY =	.16857006282+04	VRZ =	-.29625907464+04
VR =	.41053651138+04	UX =	-.56062651797+00	UY =	.40180066212+00	UZ =	-.72405395881+00
ALFA=	.55599971820+00	LFX =	-.39642556793+06	LFY =	-.10545298109+07	LFZ =	-.29384834135+06
BETA=	.59379298522+01	DFX =	-.10644861090+07	DFY =	.78422681775+06	DFZ =	-.13782655559+07
ARFA=	.65821803840+03	CL =	.73748709817-02	CD =	.12097966451-01	ETA =	.17999888497+01
RHO =	.28461467784-01	Q =	.15787037934+09	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23224980403+03	CHIY=	.23690794790+02
DRNG=	.44958347748+07	XRNG=	-.94364400142+05	PANG=	.88199881978+02	DCEL=	.16842475485+02
PRES=	.18025456817+04	UCX =	-.47030056530+00	UCY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.13787106422+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.12000065053-01	CLA =	.75999249844+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCPV=	.73152000000+00
J =	.91332940201+05	HT1 =	.32484247355+05	DHT1=	.71242870549+02	DCLI=	.15018163305+06
D2 =	.28365724616+03	LAT =	.40904536016+02	LONG=	.15566450202+03	LNGO=	.00000000000

PXF/PUO MATRIX

.95017668+01	.10012613+03	.10006961+02	.48200818+04	.32552124+05	.51018211+04
-.55144256+01	-.60769534+02	-.63898607+01	-.28001491+04	-.19772143+05	-.32732441+04
.10003061+02	.11444599+03	.12408973+02	.50785302+04	.37264636+05	.63688065+04
.12044250+00	.13622855+01	.13955790+00	.60927637+02	.44369564+03	.71123068+02
-.92027625-01	-.10400539+01	-.10670671+00	-.46557566+02	-.33873521+03	-.54388850+02
.15794893+00	.17859843+01	.18300935+00	.79903243+02	.58168835+03	.93270973+02
.78096836+01	.87833728+02	.90490645+01	.39188941+04	.28621232+05	.45836738+04

```
                                                         DPXF/PUO MATRIX
  .12044250+00       .13622855+01       .13955790+00       .60927637+02       .44369564+03       .71123068+02
 -.92027625-01      -.10400538+01      -.10670671+00      -.46557566+02      -.33873521+03      -.54388850+02
  .15794893+00       .17859847+01       .18300935+00       .79903243+02       .58168835+03       .93270973+02
  .51305546-03       .56340327-02       .59661012-03       .26001829+00       .18333833+01       .30485337+00
 -.49802751-03      -.54863926-02      -.57874691-03      -.25241034+00      -.17854617+01      -.29573199+00
  .60836305-03       .66571765-02       .70739009-03       .30839192+00       .21660930+01       .36157129+00
  .12189268-01       .13268618+00       .14183565-01       .61820947+01       .43165171+02       .72547911+01

                                                         INTERMEDIATE VALUES    11 INTEGRATION STEPS TAKEN

T    =   .70000000000+03  R    =   .64110712354+07  V    =   .37251820030+04  GM   =   .39860319000+15
X    =  -.19758285536+07  Y    =  -.55729501674+07  Z    =  -.24779350966+07  PHI  =   .28608000000+02
DX   =  -.18256251043+04  DY   =   .17385024216+04  DZ   =  -.27425687347+04  AZ   =   .90000000000+02
DDX  =   .17485959373+01  DDY  =   .21917313538+01  DDZ  =   .32760956757+01  ALT  =   .41033068924+05
WKG  =   .13280731000+06  VRX  =  -.19842591711+04  VRY  =   .16519835813+04  VRZ  =  -.24214953921+04
VR   =   .35397703521+04  UX   =  -.58727653040+00  UY   =   .39938819047+00  UZ   =  -.70398533376+00
ALFA=   .43037880235+01  LFX  =  -.30485632010+06  LFY  =  -.71095337388+06  LFZ  =  -.23521389037+06
BETA=   .65352158759+01  DFX  =  -.14193840938+06  DFY  =   .11817000787+06  DFZ  =  -.17321437500+06
AREA=   .65821803840+03  CL   =   .57042568352-01  CD   =   .17864077381-01  ETA  =   .18001834470+01
RHO  =   .34372100548-02  Q    =   .14174117673+08  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=   .23016456588+03  CHIY=   .23539936750+02
DRNG=   .48835745065+07  XRNG=  -.13965671394+06  PANG=   .88285741401+02  DCFL=   .53795396079+01
PRES=   .25125354373+03  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
MACH=   .11065164139+02  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDC  =   .11998271909-01  CLA  =   .76011501777+00  EXA  =   .00000000000     HTC  =   .61031971743-08
CKI  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=   .73152000000+00
J    =   .97724883908+05  HT1  =   .35851097244+05  DHT1=   .15870320614+02  DCLI=   .15959867057+06
D2   =   .40358930265+02  LAT  =   .37994080147+02  LONG=   .15355467938+03  LNGO=   .00000000000

                                                         PXF/PUO MATRIX
  .23056943+02       .25305802+03       .25719230+02       .11678599+05       .82357969+05       .13111656+05
 -.17506550+02      -.19584194+03      -.20297324+02      -.88690910+04      -.63758898+05      -.10365184+05
  .27588720+02       .31277047+03       .32789292+02       .13976692+05       .10185280+06       .16758794+05
  .14055010+00       .15846975+01       .16295046+00       .71118750+02       .51608251+03       .83077107+02
 -.14995566+00      -.16872004+01      -.17390044+00      -.75900028+02      -.54941987+03      -.88695487+02
  .18217619+00       .20528401+01       .21112597+00       .92186283+02       .66852873+03       .10764414+03
  .93456016+01       .93763310+02       .96703587+01       .41905702+04       .30551060+05       .49017477+04

                                                         DPXF/PUO MATRIX
  .14055010+00       .15846975+01       .16295046+00       .71118750+02       .51608251+03       .83077107+02
 -.14995566+00      -.16872004+01      -.17390044+00      -.75900028+02      -.54941987+03      -.88695487+02
  .18217619+00       .20528401+01       .21112597+00       .92186283+02       .66852873+03       .10764414+03
 -.48891312-04      -.54997025-03      -.56038567-04      -.24741788-01      -.17909835+00      -.28562058-01
 -.60527755-03      -.58355241-02      -.70151311-03      -.30543049+00      -.22160594+01      -.35789896+00
 -.42987073-04      -.49085650-03      -.50210896-04      -.21735309-01      -.15991157+00      -.25580430-01
  .35500428-02       .39855315-01       .41149207-02       .17977092+01       .12977131+02       .21000748+01

                                                         INTERMEDIATE VALUES     5 INTEGRATION STEPS TAKEN

T    =   .80000000000+03  R    =   .64151301334+07  V    =   .35072628288+04  GM   =   .39860319000+15
X    =  -.21503457882+07  Y    =  -.53891491662+07  Z    =  -.27362344352+07  PHI  =   .28608000000+02
DX   =  -.16736050835+04  DY   =   .19015501576+04  DZ   =  -.24257051703+04  AZ   =   .90000000000+02
DDX  =   .12236711422+01  DDY  =   .23653411919+00  DDZ  =   .31181082152+01  ALT  =   .44107048899+05
```

```
WKG =    .13280731000+06  VRX =  -.18487751264+04  VRY =   .18060126149+04  VRZ =  -.20998770099+04
VR  =    .33300352085+04  UX  =  -.62023230090+00  UY  =   .39567298136+00  UZ  =  -.67731439136+00
ALFA=    .95859744449+01  LFX =  -.45403650692+06  LFY =  -.86747021076+06  LFZ =  -.34633016114+06
BETA=    .79210762978+01  DFX =  -.18697601236+06  DFY =   .18265122252+06  DFZ =  -.21237122035+06
AREA=    .65821803840+03  CL  =   .12656156504+00  CD  =   .41041440993-01  ETA =   .18003101587+01
RHO =    .22484981005-02  Q   =   .82059341666+07  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =    .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   =    .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =    .40000000000+03  MD  =   .00000000000     CHIP=   .22751895422+03  CHIY=   .23307952664+02
DRNG=    .52421245999+07  XRNG=  -.17607246057+06  PANG=   .90029568279+02  DCEL=   .82209126407+01
PRES=    .16804846703+03  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=    .10294675891+02  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDO =    .12001635529-01  CLA =   .76000455442+00  EXA =   .00000000000     HTC =   .61031971743-08
CK1 =    .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73152000000+00
J   =    .10066731842+06  HT1 =   .37078791765+05  DHT1=   .10686836709+02  DCLI=   .16425584508+06
D2  =    .64793767120+02  LAT =   .35240626098+02  LONG=   .15186015094+03  LNGO=   .00000000000

                                                   PXF/PUO MATRIX
   .36730434+02      .40723410+03      .41575170+02      .18597412+05      .13256797+06      .21195540+05
  -.35037214+02     -.39314167+03     -.40624603+02     -.17742060+05     -.12800814+06     -.20732503+05
   .45330434+02      .51267512+03      .53348508+02      .22954505+05      .16695371+06      .27241037+05
   .13360143+00      .15064368+01      .15495446+00      .67603043+02      .49059567+03      .79002196+02
  -.19248538+00     -.21673456+01     -.22316867+00     -.97418816+02     -.70579275+03     -.11381100+03
   .17149954+00      .19322680+01      .19872069+00      .86783600+02      .62926143+03      .10131861+03
   .86132464+01      .96783075+02      .99804302+01      .43260083+04      .31534504+05      .50598417+04

                                                   DPXF/PUO MATRIX
   .13360143+00      .15064368+01      .15495446+00      .67603043+02      .49059567+03      .79002196+02
  -.19248538+00     -.21673456+01     -.22316867+00     -.97418816+02     -.70579275+03     -.11381100+03
   .17149954+00      .19322680+01      .19872069+00      .86783600+02      .62926143+03      .10131861+03
  -.19387739-04     -.21946573-03     -.22074653-04     -.97910765-02     -.71497150-01     -.11216288-01
  -.12284583-03     -.14342035-02     -.14211600-03     -.62023464-01     -.45755692+00     -.72232569-01
  -.12307423-03     -.13874559-02     -.14276605-03     -.62279688-01     -.45184253+00     -.72793927-01
   .94746402-03      .10814893-01      .10965726-02      .47850451+00      .35237824+01      .55758200+00

                                                   INTERMEDIATE VALUES     5 INTEGRATION STEPS TAKEN

T   =    .90000000000+03  R   =   .64163733340+07  V   =   .32073001493+04  GM  =   .39860319000+15
X   =   -.23118505507+07  Y   =  -.52006535402+07  Z   =  -.29628358961+07  PHI =   .28608000000+02
DX  =   -.15532932392+04  DY  =   .18616278122+04  DZ  =  -.20996181200+04  AZ  =   .90000000000+02
DDX =    .13640656525+01  DDY =  -.35960295562+00  DDZ =   .34916392600+01  ALT =   .44442793206+05
WKG =    .13280731000+06  VRX =  -.17429700028+04  VRY =   .17581783208+04  VRZ =  -.17700320989+04
VR  =    .30433779045+04  UX  =  -.66168555721+00  UY  =   .38972456783+00  UZ  =  -.64053648187+00
ALFA=    .12409582035+02  LFX =  -.50649785405+06  LFY =  -.86340794462+06  LFZ =  -.35887177670+06
BETA=    .97453481334+01  DFX =  -.22577019591+06  DFY =   .22774015806+06  DFZ =  -.22927560033+06
AREA=    .65821803840+03  CL  =   .16235511312+00  CD  =   .60187348036-01  ETA =   .18002962272+01
RHO =    .21487001870-02  Q   =   .65497899474+07  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =    .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   =    .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =    .40000000000+03  MD  =   .00000000000     CHIP=   .22406955886+03  CHIY=   .22937362167+02
DRNG=    .55758740875+07  XRNG=  -.20169914725+06  PANG=   .89637711136+02  DCEL=   .85395211112+01
PRES=    .16091078396+03  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=    .93991169269+01  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDO =    .12172105173-01  CLA =   .75549616246+00  EXA =   .00000000000     HTC =   .61031971743-08
CK1 =    .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73152000000+00
J   =    .10475301882+06  HT1 =   .38026571881+05  DHT1=   .79746744209+01  DCLI=   .17147946577+06
```

D2 =	.68073727345+02	LAT =	.32619459561+02	LONG=	.15051423441+03	LNGO=	.00000000000

PXF/PUO MATRIX

.50072554+02	.55768579+03	.57051263+02	.25348600+05	.18156508+06	.29085927+05
-.54435507+02	-.61160209+03	-.63114535+02	-.27559341+05	-.19915006+06	-.32201232+05
.61807201+02	.69832429+03	.72440050+02	.31292159+05	.22741223+06	.36974847+05
.13222190+00	.14912517+01	.15338616+00	.66904060+02	.48565370+03	.78201739+02
-.19733197+00	-.22222427+01	-.22878018+00	-.99867203+02	-.72367615+03	-.11666545+03
.15681751+00	.17670576+01	.18169880+00	.79352512+02	.57546200+03	.92637261+02
.86726216+01	.97451266+02	.10049266+02	.43560435+04	.31752109+05	.50949222+04

DPXF/PUO MATRIX

.13222190+00	.14912517+01	.15338616+00	.66904060+02	.48565370+03	.78201739+02
-.19733197+00	-.22222427+01	-.22878018+00	-.99867203+02	-.72367615+03	-.11666545+03
.15681751+00	.17670576+01	.18169880+00	.79352512+02	.57546200+03	.92637261+02
-.63682060-04	-.71149557-03	-.73444246-04	-.32253988-01	-.23163915+00	-.37485281-01
-.16854625-03	-.18945077-02	-.19531867-03	-.85318996-01	-.61690673+00	-.99631683-01
-.18976590-03	-.21350448-02	-.21999545-03	-.96051972-01	-.69525398+00	-.11220741+00
.19174841-02	.21528769-01	.22226973-02	.97083414+00	.70100493+01	.11341120+01

INTERMEDIATE VALUES 5 INTEGRATION STEPS TAKEN

T =	.10000000000+04	R =	.64166216053+07	V =	.28664769811+04	GM =	.39860319000+15
X =	-.24600060011+07	Y =	-.50169028932+07	Z =	-.31546931167+07	PHI =	.28608000000+02
DX =	-.14091351815+04	DY =	.17969843043+04	DZ =	-.17325922006+04	AZ =	.90000000000+02
DDX =	.14205658593+01	DDY =	-.12762335235+01	DDZ =	.37948828345+01	ALT =	.43882375856+05
WKG =	.13280731000+06	VRX =	-.16110943862+04	VRY =	.16868359836+04	VRZ =	-.13999372494+04
VR =	.27204530982+04	UX =	-.71459020134+00	UY =	.37972864319+00	UZ =	-.58750915030+00
ALFA=	.16059431353+02	LFX =	-.58969093543+06	LFY =	-.87603313230+06	LFZ =	-.37692864801+06
BETA=	.12104779297+02	DFX =	-.28663566540+06	DFY =	.30011112863+06	DFZ =	-.24906793074+06
AREA=	.65821803840+03	CL =	.19859130361+00	CD =	.85723681497-01	ETA =	.17987463959+01
RHO =	.23180745672-02	Q =	.56461143828+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.21942575901+03	CHIY=	.22316875084+02
DRNG=	.58785907349+07	XRNG=	-.21479808602+06	PANG=	.90258611522+02	DCEL=	.91958218416+01
PRES=	.17300977759+03	UOX =	-.47030056530+00	UOY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.84159947073+01	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.13372059879-01	CLA =	.71788388398+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.10855667510+06	HT1 =	.38707911491+05	DHT1=	.59162270189+01	DCLI=	.17840543872+06
D2 =	.76520361915+02	LAT =	.30188066801+02	LONG=	.14951270312+03	LNGO=	.00000000000

PXF/PUO MATRIX

.62851167+02	.70183622+03	.71877764+02	.31814438+05	.22851062+06	.36644865+05
-.75003215+02	-.84323680+03	-.86959270+02	-.37968329+05	-.27458235+06	-.44360627+05
.76382975+02	.86258044+03	.89327908+02	.38667651+05	.28090426+06	.45584756+05
.12234522+00	.13803654+01	.14197823+00	.61904498+02	.44954660+03	.72383386+02
-.21201797+00	-.23881200+01	-.24579128+00	-.10729657+03	-.77770051+03	-.12533511+03
.13299196+00	.14988145+01	.15408275+00	.67294293+02	.48810909+03	.78554050+02
.89087472+01	.10011132+03	.10322905+02	.44755412+04	.32618368+05	.52344569+04

DPXF/PUO MATRIX

.12234522+00	.13803654+01	.14197823+00	.61904498+02	.44954660+03	.72383386+02
-.21201797+00	-.23881200+01	-.24579128+00	-.10729657+03	-.77770051+03	-.12533511+03
.13299196+00	.14988145+01	.15408275+00	.67294293+02	.48810909+03	.78554050+02

-.12841876-03	-.14443873-02	-.14850493-03	-.64990535-01	-.47035605+00	-.75721332-01
-.11619018-03	-.13180749-02	-.13465339-03	-.58734525-01	-.42935986+00	-.68557511-01
-.28805952-03	-.32441262-02	-.33382555-03	-.14577801+00	-.10564601+01	-.17022188+00
.28162831-02	.31770416-01	.32645132-02	.14248985+01	.10346804+02	.16641011+01

INTERMEDIATE VALUES   5 INTEGRATION STEPS TAKEN

T =	.11000000000+04	R =	.64153256980+07	V =	.24480942392+04	GM =	.39860319000+15
X =	-.25938762077+07	Y =	-.48457622829+07	Z =	-.33085945547+07	PHI =	.28608000000+02
DX =	-.12666204794+04	DY =	.16097001951+04	DZ =	-.13407845760+04	AZ =	.90000000000+02
DDX =	.15169963992+01	DDY =	-.22514240864+01	DDZ =	.40698837354+01	ALT =	.41892076862+05
WKG =	.13280731000+06	VRX =	-.14784322472+04	VRY =	.14941782878+04	VRZ =	-.10055349286+04
VR =	.23301139796+04	UX =	-.78229509516+00	UY =	.36193163875+00	UZ =	-.50697127430+00
ALFA=	.18697690953+02	LFX =	-.67369352323+06	LFY =	-.91219095310+06	LFZ =	-.36494575327+06
BETA=	.15193499850+02	DFX =	-.35611775242+06	DFY =	.35991058406+06	DFZ =	-.24220848771+06
AREA=	.65821803840+03	CL =	.21874200687+00	CD =	.10305968817+00	ETA =	.17868082488+01
RHO =	.30477997090-02	Q =	.54460363834+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.21294551372+03	CHIY=	.21218871933+02
DRNG=	.61438933048+07	XRNG=	-.21401810987+06	PANG=	.90286952716+02	DCEL=	.99156855651+01
PRES=	.22432733393+03	UDX =	-.47030056530+00	UDY =	.40651458587+00	UDZ =	-.78330279570+00
MACH=	.72588047257+01	UDDX=	.22044155789-03	UDDY=	-.27374111417-03	UDDZ=	.57787813012-03
CDD =	.15247137119-01	CLA =	.68234307905+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.11301150537+06	HT1 =	.39219405783+05	DHT1=	.42626738897+01	DCLI=	.18680360495+06
D2 =	.87534859935+02	LAT =	.28003788057+02	LONG=	.14885473685+03	LNGO=	.00000000000

PXF/PUO MATRIX

.74597363+02	.83438666+03	.85511212+02	.37757729+05	.27167883+06	.43595400+05
-.96664335+02	-.10872575+04	-.11207125+03	-.48930181+05	-.35404911+06	-.57165453+05
.88255861+02	.99640010+03	.10308352+03	.44675272+05	.32448460+06	.52597457+05
.11566898+00	.13055026+01	.13427460+00	.58524903+02	.42517026+03	.68454326+02
-.21380028+00	-.24087531+01	-.24786562+00	-.10819451+03	-.78442716+03	-.12638661+03
.10516765+00	.11854938+01	.12184525+00	.53213334+02	.38607536+03	.62115977+02
.91172312+01	.10246105+03	.10564632+02	.45810363+04	.33383590+05	.53576999+04

DPXF/PUO MATRIX

.11566898+00	.13055026+01	.13427460+00	.58524903+02	.42517026+03	.68454326+02
-.21380028+00	-.24087531+01	-.24786562+00	-.10819451+03	-.78442716+03	-.12638661+03
.10516765+00	.11854938+01	.12184525+00	.53213334+02	.38607536+03	.62115977+02
.25606652-04	.29307639-03	.30122108-04	.12941757-01	.95487242-01	.15341281-01
.25732203-03	.28962399-02	.29828453-03	.13023677+00	.94314513+00	.15212282+00
-.26268449-03	-.29580079-02	-.30429445-03	-.13293451+00	-.96328461+00	-.15515809+00
-.29599905-03	-.33531305-02	-.34378965-03	-.14968109+00	-.10921927+01	-.17513541+00

INTERMEDIATE VALUES   5 INTEGRATION STEPS TAKEN

T =	.12000000000+04	R =	.64132517660+07	V =	.19687568850+04	GM =	.39860319000+15
X =	-.27124632777+07	Y =	-.46971443113+07	Z =	-.34218673995+07	PHI =	.28608000000+02
DX =	-.11005172491+04	DY =	.13477396927+04	DZ =	-.92112060959+03	AZ =	.90000000000+02
DDX =	.18022277581+01	DDY =	-.31350110409+01	DDZ =	.42822278729+01	ALT =	.39251296696+05
WKG =	.13280731000+06	VRX =	-.13195805921+04	VRY =	.12282627947+04	VRZ =	-.58346827818+03
VR =	.18948239136+04	UX =	-.86566567832+00	UY =	.32824780861+00	UZ =	-.37798982728+00
ALFA=	.21246289280+02	LFX =	-.74557687295+06	LFY =	-.94980357910+06	LFZ =	-.31322975707+06
BETA=	.19171465358+02	DFX =	-.44141052980+06	DFY =	.41086397769+06	DFZ =	-.19517492402+06

```
AREA=  .65821803840+03  CL  =  .23832948690+00  CD  =  .12109639693+00  ETA =  .17394291576+01
RHO =  .44296244406-02  Q   =  .52341287970+07  AE  =  .63781660000+07  BE  =  .63567840000+07
OM  =  .72921150604-04  FJ  =  .16234500072-02  FH  = -.57500000139-05  FD  =  .78750000512-05
F   =  .00000000000     OMX =  .47881444528+00  OMY = -.87791612754+00  OMZ = -.77140676824-08
ISP =  .40000000000+03  MD  =  .00000000000     CHIP=  .20358831987+03  CHIY=  .19162458959+02
DRNG=  .63639222726+07  XRNG= -.19835409307+06  PANG=  .90877946596+02  DCEL=  .10535859728+02
PRES=  .31872861626+03  UOX = -.47030056530+00  UOY =  .40651458587+00  UOZ = -.78330279570+00
MACH=  .59700451485+01  UODX=  .22044155789-03  UODY= -.27374111417-03  UODZ=  .57787813012-03
CDO =  .18819361707-01  CLA =  .55768258639+00  EXA =  .00000000000     HTC =  .61031971743-08
CK1 =  .00000000000     CK2 =  .50000000000+00  CK3 =  .50000000000+00  RCRV=  .73152000000+00
J   =  .11774176087+06  HT1 =  .39566976821+05  DHT1=  .27634233662+01  DCLI=  .19591654492+06
D2  =  .97860103969+02  LAT =  .26134740098+02  LONG=  .14854912683+03  LNGO=  .00000000000

                                             PXF/PUO MATRIX
  .86232801+02    .96573077+03    .99020518+02    .43644835+05    .31445458+06    .50482503+05
 -.11679756+03   -.13141072+04   -.13541257+03   -.59118553+05   -.42792455+06   -.69066985+05
  .97309399+02    .10984679+04    .11357285+03    .49256147+05    .35772481+06    .57944719+05
  .11585724+00    .13080428+01    .13454159+00    .58618952+02    .42600129+03    .68589459+02
 -.19245772+00   -.21687991+01   -.22313051+00   -.97391006+02   -.70629059+03   -.11376958+03
  .74011088-01    .83450344+00    .85746851-01    .37446975+02    .27177256+03    .43710711+02
  .91630882+01    .10297786+03    .10617721+02    .46042404+04    .33551896+05    .53847652+04

                                             DPXF/PUO MATRIX
  .11585724+00    .13080428+01    .13454159+00    .58618952+02    .42600129+03    .68589459+02
 -.19245772+00   -.21687991+01   -.22313051+00   -.97391006+02   -.70629059+03   -.11376958+03
  .74011088-01    .83450344+00    .85746851-01    .37446975+02    .27177256+03    .43710711+02
 -.19339809-04   -.21391040-03   -.21911350-04   -.97962039-02   -.69627522-01   -.11177468-01
  .12087376-03    .13552957-02    .13990145-03    .61206816-01    .44128331+00    .71391694-01
 -.36651294-03   -.41302902-02   -.42472508-03   -.18546176+00   -.13450775+01   -.21654213+00
  .17075157-02    .19254627-01    .19796783-02    .86397233+00    .62706301+01    .10092447+01

                                             INTERMEDIATE VALUES    5 INTEGRATION STEPS TAKEN

T   =  .13000000000+04  R   =  .64097577938+07  V   =  .14117767622+04  GM  =  .39860319000+15
X   = -.28126336581+07  Y   = -.45799714399+07  Z   = -.34925561541+07  PHI =  .28608000000+02
DX  = -.89035909708+03  DY  =  .97765416573+03  DZ  = -.49453678998+03  AZ  =  .90000000000+02
DDX =  .25676416989+01  DDY = -.42097953961+01  DDZ =  .41500376726+01  ALT =  .35328828219+05
WKG =  .13280731000+06  VRX = -.11139478390+04  VRY =  .85570912028+03  VRZ = -.15456285850+03
VR  =  .14131551804+04  UX  = -.95067698469+00  UY  =  .26208990061+00  UZ  = -.16589802525+00
ALFA=  .22144118003+02  LFX = -.77880107773+06  LFY = -.10550277456+07  LFZ = -.22808252141+06
BETA=  .23533692182+02  DFX = -.55512456921+06  DFY =  .42643393174+06  DFZ = -.77024827584+05
AREA=  .65821803840+03  CL  =  .25619229365+00  CD  =  .13554834695+00  ETA =  .16282769960+01
RHO =  .79049973569-02  Q   =  .51954267142+07  AE  =  .63781660000+07  BE  =  .63567840000+07
OM  =  .72921150604-04  FJ  =  .16234500072-02  FH  = -.57500000139-05  FD  =  .78750000512-05
F   =  .00000000000     OMX =  .47881444528+00  OMY = -.87791612754+00  OMZ = -.77140676824-08
ISP =  .40000000000+03  MD  =  .00000000000     CHIP=  .18989873655+03  CHIY=  .15194105578+02
DRNG=  .65304023620+07  XRNG= -.16890584159+06  PANG=  .91558893656+02  DCEL=  .11338593007+02
PRES=  .54632941048+03  UOX = -.47030056530+00  UOY =  .40651458587+00  UOZ = -.78330279570+00
MACH=  .45430682672+01  UODX=  .22044155789-03  UODY= -.27374111417-03  UODZ=  .57787813012-03
CDO =  .24584804936-01  CLA =  .67966768569+00  EXA =  .00000000000     HTC =  .61031971743-08
CK1 =  .00000000000     CK2 =  .50000000000+00  CK3 =  .50000000000+00  RCRV=  .73152000000+00
J   =  .12316121554+06  HT1 =  .39780449112+05  DHT1=  .15313618729+01  DCLI=  .20654198197+06
D2  =  .11356665268+03  LAT =  .24657448018+02  LONG=  .14859388407+03  LNGO=  .00000000000

                                             PXF/PUO MATRIX
  .98002208+02    .10986280+04    .11269054+03    .49599626+05    .35773651+06    .57451478+05
```

-.13506021+03	-.15199416+04	-.15658750+03	-.68359979+05	-.49495690+06	-.79863391+05
.10275570+03	.11598839+04	.11988186+03	.52011700+05	.37772627+06	.61160687+05
.12320016+00	.13912979+01	.14311888+00	.62333515+02	.45311852+03	.72962105+02
-.16737288+00	-.18867741+01	-.19408522+00	-.84693820+02	-.61445372+03	-.98955491+02
.33438275-01	.37710935+00	.38716580-01	.16917164+02	.12281502+03	.19733649+02
.92050099+01	.10345081+03	.10666336+02	.46254504+04	.33705921+05	.54095468+04

DPXF/PUO MATRIX

.12320016+00	.13912979+01	.14311888+00	.62333515+02	.45311852+03	.72962105+02
-.16737288+00	-.18867741+01	-.19408522+00	-.84693820+02	-.61445372+03	-.98955491+02
.33438275-01	.37710935+00	.38716580-01	.16917164+02	.12281502+03	.19733649+02
.18190925-03	.20567370-02	.21177329-03	.92036695-01	.66985497+00	.10796947+00
.44172769-03	.49719008-02	.51169534-03	.22355625+00	.16190864+01	.26093415+00
-.46252236-03	-.52163786-02	-.53634436-03	-.23402838+00	-.16988163+01	-.27343211+00
-.16466034-02	-.18565442-01	-.19102071-02	-.83321170+00	-.60461109+01	-.97394490+00

INTERMEDIATE VALUES 9 INTEGRATION STEPS TAKEN

T =	.14000000000+04	R =	.64052168656+07	V =	.79781567128+03	GM =	.39860319000+15
X =	-.28864312566+07	Y =	-.45038279855+07	Z =	-.35229037985+07	PHI =	.28608000000+02
DX =	-.56289097114+03	DY =	.54846144610+03	DZ =	-.13730856525+03	AZ =	.90000000000+02
DDX =	.38568387995+01	DDY =	-.40254645876+01	DDZ =	.26460671846+01	ALT =	.30512884444+05
WKG =	.13280731000+06	VRX =	-.78842252851+03	VRY =	.42545679135+03	VRZ =	.20473118714+03
VR =	.91898771686+03	UX =	-.97774312039+00	UY =	.14076333775+00	UZ =	.15557658333+00
ALFA=	.20172674729+02	LFX =	-.66002479833+06	LFY =	-.11245025815+07	LFZ =	-.20490849864+06
BETA=	.24284973613+02	DFX =	-.59140125014+06	DFY =	.31913811337+06	DFZ =	.15357029466+06
AREA=	.65821803840+03	CL =	.28417470111+00	CD =	.14841524555+00	ETA =	.13488858971+01
RHO =	.16710721717-01	Q =	.46446650956+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.17095900414+03	CHIY=	.80920196640+01
DRNG=	.66343369734+07	XRNG=	-.13309754904+06	PANG=	.94058863945+02	DCEL=	.11212221976+02
PRES=	.10945094916+04	UDX =	-.47030056530+00	UDY =	.40651458587+00	UDZ =	-.78330279570+00
MACH=	.30348230767+01	UDDX=	.22044155789-03	UDDY=	-.27374111417-03	UDDZ=	.57787813012-03
CDO =	.36038895399-01	CLA =	.82405169250+00	EXA =	.00000000000	HTC =	.61031971743-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73152000000+00
J =	.12896054038+06	HT1 =	.39883180663+05	DHT1=	.61232800759+00	DCLI=	.21803790010+06
D2 =	.11339329544+03	LAT =	.23674169012+02	LONG=	.14894035776+03	LNGO=	.00000000000

PXF/PUO MATRIX

.11101399+03	.12455873+04	.12780914+03	.56182969+05	.40559838+06	.65158999+05
-.14865949+03	-.16732707+04	-.17235894+03	-.75241352+05	-.54489088+06	-.87904399+05
.10347097+03	.11679390+04	.12070404+03	.52373440+05	.38034966+06	.61579417+05
.13043716+00	.14734296+01	.15159628+00	.65994803+02	.47987000+03	.77284764+02
-.98406169-01	-.11096942+01	-.11413487+00	-.49793612+02	-.36139112+03	-.58189999+02
-.21846329-01	-.24673547+00	-.25436854-01	-.11055142+02	-.80355167+02	-.12971886+02
.88608359+01	.99567238+02	.10266765+02	.44513014+04	.32441152+05	.52058297+04

DPXF/PUO MATRIX

.13043716+00	.14734296+01	.15159628+00	.65994803+02	.47987000+03	.77284764+02
-.98406169-01	-.11096942+01	-.11413487+00	-.49793612+02	-.36139112+03	-.58189999+02
-.21846329-01	-.24673547+00	-.25436854-01	-.11055142+02	-.80355167+02	-.12971886+02
-.18758523-03	-.21132554-02	-.21706738-03	-.94914855-01	-.68820867+00	-.11065363+00
.77380639-03	.87231714-02	.89736285-03	.39156187+00	.28408194+01	.45752891+00
-.61240184-03	-.69139244-02	-.71113586-03	-.30985009+00	-.22517147+01	-.36253766+00
-.32572783-02	-.36772703-01	-.37837075-02	-.16481062+01	-.11976003+02	-.19290529+01

```
                                                    FINAL VALUES    7 INTEGRATION STEPS TAKEN

T    =   .14829448474+04  R    =   .64000000917+07  V    =   .36189408358+03  GM   =   .39860319000+15
X    =  -.29197955092+07  Y    =  -.44708776756+07  Z    =  -.35278957139+07  PHI  =   .28608000000+02
DX   =  -.24620459514+03  DY   =   .26465103983+03  DZ   =  -.17619653197+02  AZ   =   .90000000000+02
DDX  =   .35494278452+01  DDY  =  -.26779995581+01  DDZ  =   .18172834836+00  ALT  =   .25181820492+05
WKG  =   .13280731000+06  VRY  =  -.47205572823+03  VRY  =   .14147208884+03  VRZ  =   .32540555060+03
VR   =   .59054189930+03  UX   =  -.88950635831+00  UY   =   .35457403627-02  UZ   =   .45690903498+00
ALFA=    .15494635701+02  LFX  =  -.58709345648+06  LFY  =  -.11195829779+07  LFZ  =  -.36493257847+06
BETA=    .17005912681+02  DFX  =  -.46944401464+06  DFY  =   .14068937494+06  DFZ  =   .32360519940+06
AREA=    .65821803840+03  CL   =   .28935200589+00  CD   =   .12914541885+00  ETA  =   .97507830610+00
RHO  =   .39620598199-01  Q    =   .45473904518+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .15281198648+03  CHIY=    .20315638259+00
DRNG=    .66757026373+07  XRNG=  -.11126147144+06  PANG=    .10000012074+03  DCEL=    .10849603700+02
PRES=    .24673263681+04  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
MACH=    .20000173553+01  UDDX=    .22044155789-03  UDDY=  -.27374111417-03  UDDZ=    .57787813012-03
CDO  =   .45996387722-01  CLA  =   .10831143733+01  EXA  =   .00000000000     HTC  =   .61031971743-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73152000000+00
J    =   .13363548692+06  HT1  =   .39917058410+05  DHT1=    .25019006760+00  DCLI=    .22735391543+06
D2   =   .11142491923+03  LAT  =   .23256378849+02  LONG=    .14932709488+03  LNGO=    .00000000000

                                                    PXF/PUO MATRIX
   .12074966+03      .13555788+04      .13912693+03      .61108724+05      .44142079+06      .70928910+05
  -.15445198+03     -.17385986+04     -.17907787+03     -.78172325+05     -.56616612+06     -.91329905+05
   .99639947+02      .11246720+04      .11624854+03      .50434960+05      .36625860+06      .59307651+05
   .10201838+00      .11527467+01      .11862722+00      .51616073+02      .37543154+03      .60477724+02
  -.45304248-01     -.51105976+00     -.52563610-01     -.22923396+02     -.16643715+03     -.26798195+02
  -.69021755-01     -.77961097+00     -.80261059-01     -.34923607+02     -.25390316+03     -.40921571+02
   .87175413+01      .97949867+02      .10100376+02      .43787977+04      .31914414+05      .51210005+04

                                                    DPXF/PUO MATRIX
   .10201838+00      .11527467+01      .11862722+00      .51616073+02      .37543154+03      .60477724+02
  -.45304248-01     -.51105976+00     -.52563610-01     -.22923396+02     -.16643715+03     -.26798195+02
  -.69021755-01     -.77961097+00     -.80261059-01     -.34923607+02     -.25390316+03     -.40921571+02
  -.33630134-03     -.37972713-02     -.39045730-03     -.17014899+00     -.12366971+01     -.19904534+00
   .52108640-03      .58750927-02      .60412052-03      .26366826+00      .19133211+01      .30799411+00
  -.50741078-03     -.57351426-02     -.59032066-03     -.25672282+00     -.18678577+01     -.30095739+00
  -.85056734-03     -.95912280-02     -.98570665-03     -.43036101+00     -.31235738+01     -.50249018+00

                                                    FINAL LAMDA VALUES

LAM1=  -.29306736668+00  LAM2=  -.48740628019+00  LAM3=  -.39141033909+00
LAM4=   .42943398168+03  LAM5=   .76807949433+02  LAM6=  -.31965965069+02  LAM7=   .10000000000+01

                                                    INITIAL LAMDA VALUES

LAM1=   .52147295108+02  LAM2=   .58856570851+03  LAM3=   .60580489990+02
LAM4=   .26352105840+05  LAM5=   .19169952861+06  LAM6=   .30856165926+05  LAM7=   .10000000000+01
```

APPENDIX II

COMPUTER PROGRAM LISTING

FOR OPTIMAL TRAJECTORY TRIAL DECK

```
ΔASSIGN S=MT0,B0=MT1,SI=CR,L0=LP.
ΔREWIND MT1.
Δ FORTRAN B0, L0.
C     MAIN ROUTINE
      DIMENSION AETA[15], ACLA[20], ACA[20]
      DIMENSION RLMI[7]
      DIMENSION X[15], DX[15], ALPH[13], BETA[13,12], CH[13], AB[3]
      DIMENSION VR[3], U[3], ALB[3], DB[3], U0[3], UOD[3]
      DIMENSION ROB[3], RXVOB[3], RVR[3]
      DIMENSION PB[5], B[13]
      DIMENSION VXR[3], VXRXV[3], UXE[3], UYE[3]
      COMMON A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      COMMON GM,PHIL,AZ,BETA,ALPH,CH,AB,ALFA,BEDA,RCONV,CLA,CA,ETA,AREA,
     1WKG,R,RE,VR,VRM,U,ALT,RHO,QQ,ALB,DB,BE,OM,AA,FJ,FH,FD,F,RISP,RMD,E
     2XA,U0,UOD,VS,ACH,TO,FS,P0,WKG0,PRES,HEATC,CK1,CK2,CK3,RCURV,ROB,RX
     3VOB,RVR,RLGO,UXE,UYE,POPU,PB
      COMMON ACLA,ACA,AETA
      COMMON RC,AMC,CTHC,RCTHC,SRAD,SCRAD,CRAD
   10 READ 250, GM,TI
      READ 250, [X[I],I=1,6]
      READ 250, TF,DTP,FPT
      READ 250, PHIL,AZ,RLGO
C     FS MUST BE IN NEWTONS=KG.M./SEC2
      READ 250, FS,RISP,RCURV
      READ 250, WKG0,AREA,EXA
      READ 250, ALFG,BETG,HEATC
      READ 250, UOD
      READ 250, CK1,CK2,CK3
      READ 250, RLMI,POPU
      READ 250, PB
      READ 250, RC,AMC,THC
      READ 250, RAD,XRAD
C     PRELIMINARY COMPUTATIONS AND DEFINITION OF CONSTANTS
      HEATC=HEATC/SQRT[RCURV]
      WKG=WKG0
      DO 20 I=1,7
   20 X[I+8]=RLMI[I]
      RMD=0.
      IF [RISP] 30,40,30
   30 RMD=FS/RISP
   40 CONTINUE
      TO=TI
      RCONV=.1745329252E-01
      CTHC=COS[THC*RCONV]
      RCTHC=RC*CTHC
      SRAD=SIN[RAD*RCONV]
      CRAD=COS[RAD*RCONV]
      SCRAD=SIN[XRAD*RCONV]
      BE=6356784.
      OM=.729211506E-04
      AA=.6378166E+07
      FJ=1.62345E-03
```

```
      FH=-5.75E-06
      FD=7.875E-06
      P0=1.01325E+05
C     CONSTANTS FOR INTEGRATION SUBROUTINE
      DO 60 I=1,13
      DO 50 J=1,12
   50 BETA[I,J]=0.
      ALPH[I]=0.
   60 CH[I]=0.
      CH[6]=34./105.
      CH[7]=9./35.
      CH[8]=CH[7]
      CH[9]=9./280.
      CH[10]=CH[9]
      CH[12]=41./840.
      CH[13]=CH[12]
      ALPH[2]=2./27.
      ALPH[3]=1./9.
      ALPH[4]=1./6.
      ALPH[5]=5./12.
      ALPH[6]=.5
      ALPH[7]=5./6.
      ALPH[8]=1./6.
      ALPH[9]=2./3.
      ALPH[10]=1./3.
      ALPH[11]=1.
      ALPH[13]=1.
      BETA[2,1]=2./27.
      BETA[3,1]=1./36.
      BETA[4,1]=1./24.
      BETA[5,1]=5./12.
      BETA[6,1]=.05
      BETA[7,1]=-25./108.
      BETA[8,1]=31./300.
      BETA[9,1]=2.
      BETA[10,1]=-91./108.
      BETA[11,1]=2383./4100.
      BETA[12,1]=3./205.
      BETA[13,1]=-1777./4100.
      BETA[3,2]=1./12.
      BETA[4,3]=1./8.
      BETA[5,3]=-25./16.
      BETA[5,4]=-BETA[5,3]
      BETA[6,4]=.25
      BETA[7,4]=125./108.
      BETA[9,4]=-53./6.
      BETA[10,4]=23./108.
      BETA[11,4]=-341./164.
      BETA[13,4]=BETA[11,4]
      BETA[6,5]=.2
      BETA[7,5]=-65./27.
      BETA[8,5]=61./225.
      BETA[9,5]=704./45.
      BETA[10,5]=-976./135.
```

```
      BETA[11,5]=4496./1025.
      BETA[13,5]=BETA[11,5]
      BETA[7,6]=125./54.
      BETA[8,6]=-2./9.
      BETA[9,6]=-107./9.
      BETA[10,6]=311./54.
      BETA[11,6]=-301./82.
      BETA[12,6]=-6./41.
      BETA[13,6]=-289./82.
      BETA[8,7]=13./900.
      BETA[9,7]=67./90.
      BETA[10,7]=-19./60.
      BETA[11,7]=2133./4100.
      BETA[12,7]=-3./205.
      BETA[13,7]=2193./4100.
      BETA[9,8]=3.
      BETA[10,8]=17./6.
      BETA[11,8]=45./82.
      BETA[12,8]=-3./41.
      BETA[13,8]=51./82.
      BETA[10,9]=-1./12.
      BETA[11,9]=45./164.
      BETA[12,9]=3./41.
      BETA[13,9]=33./164.
      BETA[11,10]=18./41.
      BETA[12,10]=6./41.
      BETA[13,10]=12./41.
      BETA[13,12]=1.
C     CONSTANTS FOR ATMOSPHERIC SUBROUTINE
      A0=-1.0902039E-07
      A1=6356.77
      A2=1.7870260E-04
      A3=21.680485
      A4=1.3949832E-05
      A5=284.01768
      A6=1.3327563E-04
      A7=29.895060
      A8=924.13600
      A9=8.3168074E-04
      A10=0.037777365
      A11=0.56467830
      A12=1.6002310E-04
      A13=189.52010
      A14=9665.295
      A15=1.1637071E-03
      A16=0.038184967
      A17=3.6184094
      A18=5.5628920E-05
      A19=420.11368
      A20=45675.466
      A21=1.2844040E-04
      A22=0.025387008
      A23=5.3327146
      B0=2.824793081E+02
```

```
      B1=-5.240572992
      B2=-1.266010595E-01
      B3=1.873293836E-02
      B4=-5.104746533E-04
      B5=6.050186406E-06
      B6=-3.550162735E-08
      B7=1.014102927E-10
      B8=1.124449619E-13
      D1=3483.6763560
      D2=+.20216988261E-01
      D3=+.58033445891E+01
      D4=.40187430086E+03
C     COEFICCIENTS FOR AERODYNAMIC SUBROUTINE
      AETA[1]=+.52824387840E+00
      AETA[2]=-.27996093668E+00
      AETA[3]=+.26346286132E-01
      AETA[4]=+.10024147200E+00
      AETA[5]=+.54196129445E-01
      AETA[6]=-.26362144824E-01
      AETA[7]=-.14605113655E-01
      AETA[8]=+.19853942333E-02
      AETA[9]=+.11025738872E-02
      AETA[10]=-.10537066087E+00
      ACLA[1]=+.13629681392E+01
      ACLA[2]=-.21619280500E+01
      ACLA[3]=+.13662403311E+01
      ACLA[4]=-.40475336028E+00
      ACLA[5]=+.57725630395E-01
      ACLA[6]=-.29061225914E-02
      ACLA[7]=-.12026584321E-03
      ACLA[8]=+.12617383605E-04
      ACLA[9]=-.15786919484E+01
      ACLA[10]=+.91575551483E+00
      ACLA[11]=-.19807227794E+00
      ACLA[12]=+.72129518952E-02
      ACLA[13]=-.12294753407E-02
      ACLA[14]=+.87638625991E-04
      ACLA[15]=-.32319369507E-05
      ACLA[16]=+.99282566013E-07
      ACLA[17]=-.19686024035E-08
      ACLA[18]=-.17289709179E-10
      ACLA[19]=-.11640220159E-12
      ACA[1]=+.16900547318E-01
      ACA[2]=-.43698023555E-01
      ACA[3]=+.44065632282E-01
      ACA[4]=-.22608357082E-01
      ACA[5]=+.70956344732E-02
      ACA[6]=-.13858315794E-02
      ACA[7]=+.16240125227E-03
      ACA[8]=-.10398509253E-04
      ACA[9]=+.27893635038E-06
      ACA[10]=-.26711392560E+01
      ACA[11]=+.28669953597E+01
      ACA[12]=-.16272810574E+01
```

```
      ACA[13]=+.54856065063E+00
      ACA[14]=-.11125040668E+00
      ACA[15]=+.13269270447E-01
      ACA[16]=-.85605013509E-03
      ACA[17]=+.22986787609E-04
      ACA[18]=+.35797751349E-08
      ACA[19]=-.21465237039E-10
C     COMPUTATION OF UNIT NORTH VECTOR
      RPHIL=PHIL*RCONV
      RAZ=AZ*RCONV
      SIA=SIN[RAZ]
      COA=COS[RAZ]
      SIP=SIN[RPHIL]
      COP=COS[RPHIL]
      AB[1]=SIP
      AB[2]=-COP*SIA
      AB[3]=COP*COA
C     COMPUTATION OF UO BAR IN TERMS OF ALFG AND BETG
      VR[1]=X[4]-OM*[AB[2]*X[3]-AB[3]*X[2]]
      VR[2]=X[5]-OM*[AB[3]*X[1]-AB[1]*X[3]]
      VR[3]=X[6]-OM*[AB[1]*X[2]-AB[2]*X[1]]
      VRM=SQRT[VR[1]*VR[1]+VR[2]*VR[2]+VR[3]*VR[3]]
      DO 70 I=1,3
   70 VR[I]=VR[I]/VRM
      VXR[1]=VR[2]*X[3]-VR[3]*X[2]
      VXR[2]=VR[3]*X[1]-VR[1]*X[3]
      VXR[3]=VR[1]*X[2]-VR[2]*X[1]
      VXRM=SQRT[VXR[1]*VXR[1]+VXR[2]*VXR[2]+VXR[3]*VXR[3]]
      DO 80 I=1,3
   80 VXR[I]=VXR[I]/VXRM
      VXRXV[1]=VXR[2]*VR[3]-VXR[3]*VR[2]
      VXRXV[2]=VXR[3]*VR[1]-VXR[1]*VR[3]
      VXRXV[3]=VXR[1]*VR[2]-VXR[2]*VR[1]
      ALFGR=ALFG*RCONV
      BETGR=BETG*RCONV
      SA=SIN[ALFGR]
      CA=COS[ALFGR]
      SB=SIN[BETGR]
      CB=COS[BETGR]
      DO 90 I=1,3
   90 UO[I]=SA*[CB*VXRXV[I]+SB*VXR[I]]+CA*VR[I]
C     VECTORS NEEDED FOR DOWN RANGE AND CROSS RANGE IN PRINT SUBROUTINE
      RO=SQRT[X[1]*X[1]+X[2]*X[2]+X[3]*X[3]]
      RXVOB[1]=X[2]*X[6]-X[3]*X[5]
      RXVOB[2]=X[4]*X[3]-X[6]*X[1]
      RXVOB[3]=X[1]*X[5]-X[4]*X[2]
      RXVO=SQRT[RXVOB[1]**2+RXVOB[2]**2+RXVOB[3]**2]
      DO 100 I=1,3
      ROB[I]=X[I]/RO
  100 RXVOB[I]=RXVOB[I]/RXVO
      RVR[1]=RXVOB[2]*ROB[3]-RXVOB[3]*ROB[2]
      RVR[2]=RXVOB[3]*ROB[1]-RXVOB[1]*ROB[3]
      RVR[3]=RXVOB[1]*ROB[2]-RXVOB[2]*ROB[1]
C     START OF TRIAL INTEGRATION
```

```
      TOL=.05
      CALL DEQ [X,TI,DX]
      PRINT 260
      CALL PRINT [TI,X,DX]
      T=TI
      LCH=0
      IF [TF-FPT] 110,120,130
  110 FPT=TF
  120 LCH=1
  130 CONTINUE
      STEP=FPT
      GO TO 160
  140 STEP=T+DTP
      IF [TF-STEP] 150,150,160
  150 LCH=1
      STEP=TF
  160 CALL RK713 [T,STEP,TOL,X,X,15,1000,M]
      IF [LCH] 170,170,180
  170 T=STEP
      CALL DEQ [X,T,DX]
      PRINT 190, M
      CALL PRINT [T,X,DX]
      GO TO 140
  180 CONTINUE
      CALL DEQ [X,TF,DX]
      PRINT 270, M
      CALL PRINT [TF,X,DX]
      CALL BOUND [TF,X,DX,B,ERR]
      PRINT 200, PB
      PRINT 210
      PRINT 220, [B[I],I=1,12]
      PRINT 230, RC,AMC,THC,RAD,XRAD
      PRINT 240, ERR
      GO TO 10
C
  190 FORMAT [1H0,50X,19HINTERMEDIATE VALUES,1X,I4,1X,23HINTEGRATION STE
     1PS TAKEN]
  200 FORMAT [1H0,50X,25HEND CONDITION MULTIPLIERS,/,5[E15.8,2X]]
  210 FORMAT [1H0,50X,19HBOUNDARY CONDITIONS]
  220 FORMAT [/,6[E15.8,2X],/,6[E15.8,2X]]
  230 FORMAT [1H0,50X,14HDESIRED VALUES,/,5[E15.8,2X]]
  240 FORMAT [1H0,5HERR =E18.11]
  250 FORMAT [3E18.11]
  260 FORMAT [1H1,/,51X,14HINITIAL VALUES]
  270 FORMAT [1H0,50X,12HFINAL VALUES,1X,I4,1X,23HINTEGRATION STEPS TAKE
     1N]
      END

COMMON ALLOCATION

  77776 A0      77774 A1      77772 A2      77770 A3
  77766 A4      77764 A5      77762 A6      77760 A7
  77756 A8      77754 A9      77752 A10     77750 A11
```

```
77746 A12        77744 A13        77742 A14        77740 A15
77736 A16        77734 A17        77732 A18        77730 A19
77726 A20        77724 A21        77722 A22        77720 A23
77716 BO         77714 B1         77712 B2         77710 B3
77706 B4         77704 B5         77702 B6         77700 B7
77676 B8         77674 D1         77672 D2         77670 D3
77666 D4         77664 GM         77662 PHIL       77660 AZ
77170 BETA       77136 ALPH       77104 CH         77076 AB
77074 ALFA       77072 BEDA       77070 RCØNV      77066 CLA
77064 CA         77062 ETA        77060 AREA       77056 WKG
77054 R          77052 RE         77044 VR         77042 VRM
77034 U          77032 ALT        77030 RHØ        77026 QQ
77020 ALB        77012 DB         77010 BE         77006 ØM
77004 AA         77002 FJ         77000 FH         76776 FD
76774 F          76772 RISP       76770 RMD        76766 EXA
76760 UO         76752 UOD        76750 VS         76746 ACH
76744 TO         76742 FS         76740 PO         76736 WKGO
76734 PRES       76732 HEATC      76730 CK1        76726 CK2
76724 CK3        76722 RCURV      76714 ROB        76706 RXVOR
76700 RVR        76676 RLGO       76670 UXE        76662 UYE
76660 PØPU       76646 PB         76576 ACLA       76526 ACA
76470 AETA       76466 RC         76464 AMC        76462 CTHC
76460 RCTHC      76456 SRAD       76454 SCRAD      76452 CRAD

PRØGRAM ALLØCATIØN

 00015 RLMI       00033 X          00071 DX         00127 B
 00161 VXR        00167 VXRXV      00175 I          00176 J
 00177 LCH        00200 M          00201 TI         00203 TF
 00205 DTP        00207 FPT        00211 ALFG       00213 BETG
 00215 THC        00217 RAD        00221 XRAD       00223 RPHIL
 00225 RAZ        00227 SIA        00231 CØA        00233 SIP
 00235 CØP        00237 VXRM       00241 ALFGR      00243 BETGR
 00245 SA         00247 SB         00251 CB         00253 RC
 00255 RXVO       00257 TØL        00261 T          00263 STEP
 00265 ERR

SUBPRØGRAMS REQUIRED

 SQRT      CØS       SIN       DEQ       PRINT     RK713
 BØUND
THE END
```

```
      SUBROUTINE PRINT [T,X,DX]
      DIMENSION X[15], DX[15], ALPH[13], BETA[13,12], CH[13]
      DIMENSION VR[3], VXR[3], U[3], ALB[3], DB[3], AB[3], UO[3], UOD[3]
      DIMENSION ROB[3], RXVOB[3], RVR[3]
      DIMENSION UXE[3], UYE[3], PB[5]
      COMMON AO,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,BO,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      COMMON GM,PHIL,AZ,BETA,ALPH,CH,AB,ALFA,BEDA,RCONV,CLA,CA,ETA,AREA,
     1WKG,R,RE,VR,VRM,U,ALT,RHO,QQ,ALB,DB,BE,OM,AA,FJ,FH,FD,F,RISP,RMD,E
     2XA,UO,UOD,VS,ACH,TO,FS,PO,WKGO,PRES,HEATC,CK1,CK2,CK3,RCURV,ROB,RX
     3VOB,RVR,RLGO,UXE,UYE,POPU,PB
      V=SQRT[X[4]**2+X[5]**2+X[6]**2]
      SCHI=U[3]
      CCHI=U[1]
      CALL TANGL [SCHI,CCHI,CHIP]
      SCHI=U[2]
      CCHI=SQRT[U[1]*U[1]+U[3]*U[3]]
      CHIY=ATAN[SCHI/CCHI]/RCONV
      DCEL=0.
      DO 10 I=1,3
   10 DCEL=DCEL+ALB[I]*ALB[I]+DB[I]*DB[I]
      DCEL=SQRT[DCEL]/WKG
      VRM2=VRM*VRM
      VRM4=VRM2*VRM2
      VXR[1]=VR[2]*X[3]-VR[3]*X[2]
      VXR[2]=VR[3]*X[1]-VR[1]*X[3]
      VXR[3]=VR[1]*X[2]-VR[2]*X[1]
      VXRM=SQRT[VXR[1]*VXR[1]+VXR[2]*VXR[2]+VXR[3]*VXR[3]]
      VDX=VR[1]*X[1]+VR[2]*X[2]+VR[3]*X[3]
      R2=R*R
      VXRXV=SQRT[VRM4*R2-VDX*VDX*VRM2]
      UP3=U[1]*VR[1]+U[2]*VR[2]+U[3]*VR[3]
      SCHI=[U[1]*VXR[1]+U[2]*VXR[2]+U[3]*VXR[3]]/VXRM
      CCHI=[[U[1]*X[1]+U[2]*X[2]+U[3]*X[3]]*VRM2-VDX*UP3]/VXRXV
      CALL TANGL [SCHI,CCHI,BEDA]
      SCHI=SQRT[SCHI*SCHI+CCHI*CCHI]
      CCHI=UP3/VRM
      CL=CLA*SCHI
      CD=CA+2.*ETA*CLA*[1.-CCHI]*CLA
      CALL TANGL [SCHI,CCHI,ALFA]
      CCHI=[X[1]*DX[1]+X[2]*DX[2]+X[3]*DX[3]]/[R*V]
      SCHI=SQRT[1.-CCHI*CCHI]
      CALL TANGL [SCHI,CCHI,PANG]
C     RANGE WILL BE WRONG IF RANGE ANGLE > 180 DEGREES
      SCHI=RVR[1]*X[1]+RVR[2]*X[2]+RVR[3]*X[3]
      CCHI=ROB[1]*X[1]+ROB[2]*X[2]+ROB[3]*X[3]
      CALL TANGL [SCHI,CCHI,PHIR]
      CCHI=-[X[1]*RXVOB[1]+X[2]*RXVOB[2]+X[3]*RXVOB[3]]/R
      SCHI=SQRT[1.-CCHI*CCHI]
      PHIC=ATAN[CCHI/SCHI]
      XRNG=PHIC*RE
      IF [[PHIR-360.]+.5E-04] 30,20,20
   20 PHIR=0.
```

```
   30 CONTINUE
      RANG=RCONV*RE*PHIR
      AJ=CK1*WKG+CK2*X[7]+CK3*X[8]
C     COMPUTATION OF VECTORS NEEDED FOR LONGITUDE
      RPHIL=PHIL*RCONV
      RAZ=AZ*RCONV
      SIA=SIN[RAZ]
      COA=COS[RAZ]
      SIP=SIN[RPHIL]
      COP=COS[RPHIL]
      WT=OM*[T-TO]
      CWT=COS[WT]
      SIWT=SIN[WT]
      UXE[1]=COP*CWT
      UXE[2]=COA*SIWT+SIA*SIP*CWT
      UXE[3]=SIA*SIWT-COA*SIP*CWT
      UYE[1]=-COP*SIWT
      UYE[2]=COA*CWT-SIA*SIP*SIWT
      UYE[3]=SIA*CWT+COA*SIP*SIWT
      SLAT=0.
      CLNG=0.
      SLNG=0.
      DO 40 I=1,3
      SLAT=SLAT+X[I]*AB[I]
      CLNG=CLNG+X[I]*UXE[I]
   40 SLNG=SLNG+X[I]*UYE[I]
      CALL TANGL [SLNG,CLNG,RLNG]
      RLNG=RLGO+360.-[RLNG+RCONV*OM*TO]
   50 IF [RLNG] 60,70,70
   60 RLNG=360.+RLNG
      GO TO 50
   70 IF [RLNG-360.] 90,90,80
   80 RLNG=RLNG-360.
      GO TO 70
   90 CONTINUE
      SLAT=SLAT/R
      CLAT=SQRT[1.-SLAT*SLAT]
      RLAT=ATAN[SLAT/CLAT]/RCONV
      PRINT 100, T,R,V,GM,[X[I],I=1,3],PHIL,[X[I],I=4,6],AZ,[DX[I],I=4,6
     1],ALT
      PRINT 110, WKG,[VR[I],I=1,3],VRM,[U[I],I=1,3],ALFA,[ALB[I],I=1,3],
     1BEDA,[DB[I],I=1,3],AREA,CL,CD,ETA,RHO,QQ,AA,BE,OM,FJ,FH,FD,F,[AB[I
     2],I=1,3],RISP,RMD,CHIP,CHIY
      PRINT 120, RANG,XRNG,PANG,DCEL,PRES,UO,ACH,UOD
      PRINT 130, CA,CLA,EXA,HEATC,CK1,CK2,CK3,RCURV,AJ,X[7],DX[7],X[8]
      PRINT 140, DX[8],RLAT,RLNG,RLGO
      HAM=X[9]*DX[1]+X[10]*DX[2]+X[11]*DX[3]+X[12]*DX[4]+X[13]*DX[5]+X[1
     14]*DX[6]+X[15]*[CK1*RMD+CK2*DX[7]+CK3*DX[8]]
      PRINT 150, X[9],X[10],X[11],HAM,X[12],X[13],X[14],X[15],DX[9],DX[1
     10],DX[11],POPU,DX[12],DX[13],DX[14],DX[15]
      RETURN
C
  100 FORMAT [1HO,5HT    =E18.11,2X,5HR    =E18.11,2X,5HV    =E18.11,2X,5HG
     1M  =E18.11,/,6H X    =E18.11,2X,5HY    =E18.11,2X,5HZ    =E18.11,2X,5
```

```
      2HPHI =E18.11,/,6H DX   =E18.11,2X,5HDY   =E18.11,2X,5HDZ   =E18.11,2X
      3,5HAZ  =E18.11,/,6H DDX =E18.11,2X,5HDDY =E18.11,2X,5HDDZ =E18.11,
      42X,5HALT =E18.11]
  110 FØRMAT [6H WKG =E18.11,2X,5HVRX =E18.11,2X,5HVRY =E18.11,2X,5HVRZ
      1=E18.11,/,6H VR   =E18.11,2X,5HUX   =E18.11,2X,5HUY   =E18.11,2X,5HUZ
      2  =E18.11,/,6H ALFA=E18.11,2X5HLFX =E18.11,2X,5HLFY =E18.11,2X,5HL
      3FZ =E18.11,/,6H BETA=E18.11,2X,5HDFX =E18.11,2X,5HDFY =E18.11,2X,5
      4HDFZ =E18.11,/,6H AREA=E18.11,2X,5HCL   =E18.11,2X,5HCD   =E18.11,2X
      5,5HETA =E18.11,/,6H RHØ =E18.11,2X,5HQ    =E18.11,2X,5HAE   =E18.11,
      62X,5HBE   =E18.11,/,6H ØM   =E18.11,2X,5HFJ   =E18.11,2X,5HFH   =E18.1
      71,2X,5HFD   =E18.11,/,6H F    =E18.11,2X,5HØMX =E18.11,2X,5HØMY =E18
      8.11,2X,5HØMZ =E18.11,/,6H ISP =E18.11,2X,5HMD   =E18.11,2X,5HCHIP=E
      918.11,2X,5HCHIY=E18.11]
  120 FØRMAT [6H DRNG=E18.11,2X,5HXRNG=E18.11,2X,5HPANG=E18.11,2X,5HDCEL
      1=E18.11,/,6H PRES=E18.11,2X,5HUØX =E18.11,2X,5HUØY =E18.11,2X,5HUØ
      2Z =E18.11,/,6H MACH=E18.11,2X,5HU0DX=E18.11,2X,5HU0DY=E18.11,2X,5H
      3U0DZ=E18.11]
  130 FØRMAT [6H CD0 =E18.11,2X,5HCLA =E18.11,2X,5HEXA =E18.11,2X,5HHTC
      1=E18.11,/,6H CK1 =E18.11,2X,5HCK2 =E18.11,2X,5HCK3 =E18.11,2X,5HRC
      2RV=E18.11,/,6H J    =E18.11,2X,5HHT1 =E18.11,2X,5HDHT1=E18.11,2X,5H
      3DCLI=E18.11]
  140 FØRMAT [6H D2   =E18.11,2X,5HLAT =E18.11,2X,5HLØNG=E18.11,2X,5HLNG0
      1=E18.11]
  150 FØRMAT [6H LAM1=E18.11,2X,5HLAM2=E18.11,2X,5HLAM3=E18.11,2X,5HHAM
      1=E18.11,/,6H LAM4=E18.11,2X,5HLAM5=E18.11,2X,5HLAM6=E18.11,2X,5HLA
      2M7=E18.11,/,6H DLM1=E18.11,2X,5HDLM2=E18.11,2X,5HDLM3=E18.11,2X,5H
      3PØPU=E18.11,/,6H DLM4=E18.11,2X,5HDLM5=E18.11,2X,5HDLM6=E18.11,2X,
      45HDLM7=E18.11]
       END
```

CØMMØN ALLØCATIØN

77776 A0	77774 A1	77772 A2	77770 A3
77766 A4	77764 A5	77762 A6	77760 A7
77756 A8	77754 A9	77752 A10	77750 A11
77746 A12	77744 A13	77742 A14	77740 A15
77736 A16	77734 A17	77732 A18	77730 A19
77726 A20	77724 A21	77722 A22	77720 A23
77716 B0	77714 B1	77712 B2	77710 B3
77706 B4	77704 B5	77702 B6	77700 B7
77676 B8	77674 D1	77672 D2	77670 D3
77666 D4	77664 GM	77662 PHIL	77660 AZ
77170 BETA	77136 ALPH	77104 CH	77076 AB
77074 ALFA	77072 BEDA	77070 RCØNV	77066 CLA
77064 CA	77062 ETA	77060 AREA	77056 WKG
77054 R	77052 RE	77044 VR	77042 VRM
77034 U	77032 ALT	77030 RHØ	77026 QQ
77020 ALB	77012 DB	77010 BE	77006 ØM
77004 AA	77002 FJ	77000 FH	76776 FD
76774 F	76772 RISP	76770 RMD	76766 EXA
76760 U0	76752 U0D	76750 VS	76746 ACH
76744 T0	76742 FS	76740 P0	76736 WKG0
76734 PRES	76732 HEATC	76730 CK1	76726 CK2

```
  76724 CK3          76722 RCURV        76714 ROB          76706 RXVOB
  76700 RVR          76676 RLGO         76670 UXE          76662 UYE
  76660 PØPU         76646 PB

PRØGRAM ALLØCATIØN

  DUMMY X            DUMMY DX           00033 VXR          00041 I
  00042 PRINT        00044 V            00046 SCHI         00050 CCHI
  00052 CHIP         00054 CHIY         00056 DCEL         00060 VRM2
  00062 VRM4         00064 VXRM         00066 VDX          00070 R2
  00072 VXRXV        00074 UP3          00076 CL           00100 CD
  00102 PANG         00104 PHIR         00106 PHIC         00110 XRNG
  00112 RANG         00114 AJ           00116 RPHIL        00120 RAZ
  00122 SIA          00124 CØA          00126 SIP          00130 CØP
  00132 WT           DUMMY T            00134 CWT          00136 SIWT
  00140 SLAT         00142 CLNG         00144 SLNG         00146 RLNG
  00150 CLAT         00152 RLAT         00154 HAM

SUBPRØGRAMS REQUIRED

  SQRT      TANGL      ATAN      SIN      CØS
THE END
```

```
      SUBROUTINE RK713 [TI,TF,TOL,XI,X,N,KT,M]
C     SEVENTH ORDER RUNGE-KUTTA INTEGRATION WITH STEPSIZE CONTROL
C     M IS THE NUMBER OF STEPS NEEDED
C     N IS THE NUMBER OF DIFFERENTIAL EQUATIONS
C     KT IS MAX NUMBER OF ITERATIONS
C     ARRAY F STORES THE 13 EVALUATIONS OF THE DIFFERENTIAL EQUATIONS
C     SUBSCRIPTS FOR ALPHA,BETA, AND CH ARE +1 GREATER THAN FEHLBERGS
C     F[0] IN FEHLBERGS REPORT IS IN F[1,J]
C     F[I] IS IN F[I+1,J]
C     PARAMETERS FOR DEQ SUBROUTINE MUST BE STORED IN COMMON
C     DIMENSIONS MUST AGREE WITH NUMBER OF DIFFERENTIAL EQUATIONS AND
C     NUMBER OF CONSTANTS IN THE PARTICULAR FEHLBERG FORMULA USED
      DIMENSION F[13,15], XDUM[15], TE[15], XI[15], ALPH[13], BETA[13,12
     1], X[15], CH[13]
      COMMON A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      COMMON GM,PHIL,AZ,BETA,ALPH,CH
      T=TI
      DT=TF-T
      M=0
      DO 10 I=1,N
   10 X[I]=XI[I]
   20 CALL DEQ [X,T,TE]
      DO 30 I=1,N
   30 F[1,I]=TE[I]
      DO 70 K=2,13
      DO 40 I=1,N
   40 XDUM[I]=X[I]
      NN=K-1
      DO 50 I=1,N
      DO 50 J=1,NN
   50 XDUM[I]=XDUM[I]+DT*BETA[K,J]*F[J,I]
      TDUM=T+ALPH[K]*DT
      CALL DEQ [XDUM,TDUM,TE]
      DO 60 I=1,N
   60 F[K,I]=TE[I]
   70 CONTINUE
      DO 80 I=1,N
   80 XDUM[I]=X[I]
      DO 90 I=1,N
      DO 90 L=1,13
   90 X[I]=X[I]+DT*CH[L]*F[L,I]
      DO 120 I=1,N
      IF [X[I]] 110,100,110
  100 A=1.
      GO TO 120
  110 A=X[I]
  120 TE[I]=DT*[F[1,I]+F[11,I]-F[12,I]-F[13,I]]*41./840./A
      ER=ABS[TE[1]]
      DO 140 I=2,N
      IF [ABS[TE[I]]-ER] 140,140,130
  130 ER=ABS[TE[I]]
  140 CONTINUE
```

```
      DT1=DT
      M=M+1
      AK=.8
      DT=AK*DT1*[T0L/ER]**.125
      IF [ABS[DT]-10.*ABS[DT1]] 160,160,150
  150 DT=10.*DT1
  160 IF [ABS[DT]-.1*ABS[DT1]] 170,180,180
  170 DT=.1*DT1
  180 C0NTINUE
      IF [ER-T0L] 190,190,220
  190 T=T+DT1
      IF [ABS[DT]-ABS[TF-T]] 210,210,200
  200 DT=TF-T
  210 C0NTINUE
      G0 T0 240
  220 D0 230 I=1,N
  230 X[I]=XDUM[I]
  240 IF [M-KT] 250,260,260
  250 IF [T-TF] 20,270,20
  260 TF=T
  270 RETURN
      END

C0MM0N ALL0CATI0N

  77776 A0        77774 A1        77772 A2        77770 A3
  77766 A4        77764 A5        77762 A6        77760 A7
  77756 A8        77754 A9        77752 A10       77750 A11
  77746 A12       77744 A13       77742 A14       77740 A15
  77736 A16       77734 A17       77732 A18       77730 A19
  77726 A20       77724 A21       77722 A22       77720 A23
  77716 B0        77714 B1        77712 B2        77710 B3
  77706 B4        77704 B5        77702 B6        77700 B7
  77676 B8        77674 D1        77672 D2        77670 D3
  77666 D4        77664 GM        77662 PHIL      77660 AZ
  77170 BETA      77136 ALPH      77104 CH

PR0GRAM ALL0CATI0N

  00032 F         00640 XDUM      00676 TE        DUMMY XI
  DUMMY X         DUMMY M         00734 I         DUMMY N
  00735 K         00736 NN        00737 J         00740 L
  DUMMY KT        00741 RK713     00743 T         DUMMY TI
  00745 DT        DUMMY TF        00747 TDUM      00751 A
  00753 ER        00755 DT1       00757 AK        DUMMY T0L

SUBPR0GRAMS REQUIRED

  DEQ       ABS
THE END
```

```
      SUBRØUTINE DEQ [X,T,DX]
      DIMENSIØN X[15], DX[15], ALPH[13], BETA[13,12], CH[13], AB[3]
      DIMENSIØN VR[3], U[3], ALB[3], DB[3], UO[3], UOD[3]
      DIMENSIØN P[6,6], PHI[6,6], PAXB[3], PVXB[3,3], PMXB[6], PJXB[6]
      DIMENSIØN ROB[3], RXVOB[3], RVR[3]
      DIMENSIØN UXE[3], UYE[3]
      DIMENSIØN UØPT[3], PB[5]
      DIMENSIØN HTM[3,3]
      CØMMØN AO,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      CØMMØN GM,PHIL,AZ,BETA,ALPH,CH,AB,ALFA,BEDA,RCØNV,CLA,CA,ETA,AREA,
     1WKG,R,RE,VR,VRM,U,ALT,RHØ,QQ,ALB,DB,BE,ØM,AA,FJ,FH,FD,F,RISP,RMD,E
     2XA,UO,UOD,VS,ACH,TO,FS,PO,WKGO,PRES,HEATC,CK1,CK2,CK3,RCURV,ROB,RX
     3VOB,RVR,RLGO,UXE,UYE,PØPU,PB
      R2=X[1]*X[1]+X[2]*X[2]+X[3]*X[3]
      IF [R2] 10,20,20
   10 R2=0.
   20 CØNTINUE
      R=SQRT[R2]
      RI=1./R
      R2I=1./R2
      B=AA*AA*R2I
      BB=AA*RI
      A=[AB[1]*X[1]+AB[2]*X[2]+AB[3]*X[3]]*RI
      BE2=BE*BE
      E2=A*A
      E4=E2*E2
      C1=3.*FD*[1./7.-2.*E2+3.*E4]*B
      C2=FH*BB*A*[3.-7.*E2]
      C3=4.*FD*A*[3./7.-E2]*B
      C4=FH*BB*[E2-1./5.]
      C5=AA*AA-BE2
      C6=BE2+C5*E2
      IF [C6] 30,40,40
   30 C6=0.
   40 CØNTINUE
      RE=AA*BE/SQRT[C6]
      C12=RE*A*C5/C6*RI
      C13=C12*A*RI
      DØ 50 I=1,3
      PVXB[I,I]=0.
   50 PAXB[I]=[RI-C13]*X[I]+C12*AB[I]
      PVXB[1,2]=ØM*AB[3]
      PVXB[1,3]=-ØM*AB[2]
      PVXB[2,3]=ØM*AB[1]
      PVXB[2,1]=-PVXB[1,2]
      PVXB[3,1]=-PVXB[1,3]
      PVXB[3,2]=-PVXB[2,3]
      GR=B*[FJ*[1.-5.*E2]+C1+C2]
      GP=B*[2.*FJ*A+C3+3.*C4]
      C7=[2.5*GR+1.5+B*[C1+.5*C2]]*RI
      C8=2.*GP+B*[C3+1.5*C4]
      C9=[12.*FD*A*[3.*E2-1.]*B+3.*FH*BB*[1.-7.*E2]-10.*FJ*A]*R2I
```

```
      C10=[2.*FJ+12.*FD*[1./7.-E2]*B+6.*FH*A*BB]*RI
      C11=[1.+GR]*RI
      C12=A*RI
      CC1=GM*R2I
      CC2=CC1*C11
      CC3=CC1*GP
      DØ 60 I=1,3
      DØ 60 J=1,3
   60 P[I+3,J]=CC1*[2.*R2I*[C7*X[I]+C8*AB[I]]*X[J]-B*[C9*X[I]+C10*AB[I]]
     1*[AB[J]-C12*X[J]]]
      DØ 70 I=1,3
   70 P[I+3,I]=P[I+3,I]-CC2
      VR[1]=X[4]-ØM*[AB[2]*X[3]-AB[3]*X[2]]
      VR[2]=X[5]-ØM*[AB[3]*X[1]-AB[1]*X[3]]
      VR[3]=X[6]-ØM*[AB[1]*X[2]-AB[2]*X[1]]
      VRM2=VR[1]*VR[1]+VR[2]*VR[2]+VR[3]*VR[3]
      IF [VRM2] 80,90,90
   80 VRM2=0.
   90 CØNTINUE
      VRM=SQRT[VRM2]
      DØ 100 I=1,3
  100 U[I]=UO[I]+[T-TO]*UOD[I]
      UM2=U[1]*U[1]+U[2]*U[2]+U[3]*U[3]
      IF [UM2] 110,120,120
  110 UM2=0.
  120 CØNTINUE
      UM=SQRT[UM2]
      DØ 130 I=1,3
  130 U[I]=U[I]/UM
      ALT=R-RE
      CALL ATMØS [ALT,TEMP,PRES,RHØ,VS,DVS,DRHØ,DPRES]
      ACH=VRM/VS
      CALL AERØD [ACH,CLA,CA,ETA,DCLA,DCA,DETA]
      F=FS+EXA*[PO-PRES]
      WKG=WKGO-RMD*[T-TO]
      WKGI=1./WKG
      QQ=.5*RHØ*AREA*VRM2
      CLA2=CLA*CLA
      C1=QQ*CLA
      C3=CA+2.*ETA*CLA2
      C4=-2.*ETA*CLA2
      C6=QQ/VRM2
      C7=C6*CLA
      C8=C6*C3/VRM
      C9=C6*C4
      DØ 150 I=1,3
      DØ 140 J=1,3
  140 HTM[I,J]=-WKGI*[C7+C9]*VR[I]*VR[J]
  150 HTM[I,I]=HTM[I,I]+[F+C7*VRM2]*WKGI
      C10=2.*CLA2*[1.-2.*ETA*CA]
      C11=QQ*QQ*WKGI*WKGI
      C12=-C10/VRM*C11*CK3
      DØ 170 I=1,3
      UØPT[I]=0.
```

```
      DØ 160 J=1,3
  160 UØPT[I]=X[J+11]*HTM[J,I]+UØPT[I]
  170 UØPT[I]=UØPT[I]+X[15]*C12*VR[I]
      UØPTM=UØPT[1]*UØPT[1]+UØPT[2]*UØPT[2]+UØPT[3]*UØPT[3]
      UØPTM=SQRT[UØPTM]
      DØ 180 I=1,3
  180 UØPT[I]=UØPT[I]/UØPTM
      DØ 190 I=1,3
  190 U[I]=U[I]+PØPU*[UØPT[I]-U[I]]
      UM2=U[1]*U[1]+U[2]*U[2]+U[3]*U[3]
      UM=SQRT[UM2]
      DØ 200 I=1,3
  200 U[I]=U[I]/UM
      VDU=VR[1]*U[1]+VR[2]*U[2]+VR[3]*U[3]
      C2=-C1*VDU/VRM2
      C5=QQ*[C3/VRM+C4*VDU/VRM2]
      DØ 210 I=1,3
      ALB[I]=C1*U[I]+C2*VR[I]
  210 DB[I]=C5*VR[I]
      DØ 220 I=1,3
      DØ 220 J=1,3
      P[I,J]=[U[I]*VR[J]*2.-VR[I]*U[J]]*C7
  220 P[I,J+3]=VR[I]*[C8*VR[J]+C9*U[J]]
      CC10=C7*VDU
      DØ 230 I=1,3
  230 P[I,I]=P[I,I]-CC10
      DØ 240 I=1,3
      DØ 240 J=1,3
      PHI[I,J+3]=0.
      P[I+3,J+3]=0.
      DØ 240 K=1,3
      PHI[I,J+3]=PHI[I,J+3]+P[I,K]*PVXB[K,J]
  240 P[I+3,J+3]=P[I+3,J+3]+P[I,K+3]*PVXB[K,J]
      C10=-EXA*DPRES
      DØ 250 I=1,3
      DØ 250 J=1,3
      P[I+3,J]=P[I+3,J]+WKGI*[PHI[I,J+3]-P[I+3,J+3]+[[ALB[I]-DB[I]]/RHØ*
     1DRHØ+C10*U[I]]*PAXB[J]-C5*PVXB[I,J]]
      P[I+3,J+3]=[P[I,J]-P[I,J+3]]*WKGI
  250 PHI[I+3,J]=-WKGI*[C7+C9]*VR[I]*VR[J]
      C11=[C1+F]*WKGI
      C12=C5*WKGI
      DØ 260 I=1,3
      P[I+3,I+3]=P[I+3,I+3]-C12
  260 PHI[I+3,I]=PHI[I+3,I]+C11
      C7=VRM-VDU
      C8=C6*C7*2.
      C9=C8*ETA*2.*CLA
      C10=C8*CLA2
      C11=C6*VRM
      C12=C9*DCLA+C10*DETA+C11*DCA
      DØ 270 I=1,3
  270 DX[I+3]=WKGI*[ALB[I]/CLA*DCLA-C12*VR[I]]
      C7=1./[VS*VRM]
```

```
      C8=VRM/VS*DVS/VS
      DΘ 290 I=1,3
      DX[I]=0.
      DΘ 280 J=1,3
  280 DX[I]=DX[I]+VR[J]*PVXB[J,I]
      PMXB[I+3]=C7*VR[I]
  290 PMXB[I]=C7*DX[I]-C8*PAXB[I]
      DΘ 300 I=1,3
      DΘ 300 J=1,3
      P[I+3,J]=P[I+3,J]+DX[I+3]*PMXB[J]
  300 P[I+3,J+3]=P[I+3,J+3]+DX[I+3]*PMXB[J+3]
      DΘ 310 I=1,3
      DΘ 310 J=1,3
      P[I,J]=0.
      P[I,J+3]=0.
      PHI[I,J]=0.
      PHI[I,J+3]=-1./UM*U[I]*U[J]
  310 PHI[I+3,J+3]=[T-TO]*PHI[I,J+3]
      DΘ 320 I=1,3
      P[I,I+3]=1.
      PHI[I,I+3]=PHI[I,I+3]+1./UM
      PHI[I+3,I+3]=PHI[I+3,I+3]+[T-TO]/UM
  320 DX[I+3]=-CC2*X[I]-CC3*AB[I]+[ALB[I]-DB[I]+F*U[I]]*WKGI
      C3=1.+2.*ETA*CA
      C4=CA*CA
      C5=CLA2*C3*2.
      C6=C4+C5
      C7=QQ*GQ*WKGI*WKGI
      IF [RHΘ] 330,340,340
  330 RHΘ=0.
  340 CΘNTINUE
      C8=SQRT[RHΘ]
      C9=-C5/VRM*C7*CK3
      DΘ 350 I=1,3
      DX[I+44]=0.
      DX[I+47]=0.
      DΘ 350 J=1,3
      DX[I+44]=DX[I+44]+C9*VR[J]*PHI[J,I+3]
  350 DX[I+47]=DX[I+47]+C9*VR[J]*PHI[J+3,I+3]
      DΘ 360 I=1,3
      DΘ 360 J=1,3
      DΘ 360 K=1,3
      PHI[I,J]=PHI[I,J]+PHI[I+3,K]*PHI[K,J+3]
  360 P[I,J]=P[I,J]+PHI[I+3,K]*PHI[K+3,J+3]
      DΘ 370 I=1,3
      DΘ 370 J=1,3
      PHI[I+3,J]=PHI[I,J]
      PHI[I+3,J+3]=P[I,J]
      P[I,J]=0.
      PHI[I,J]=0.
  370 PHI[I,J+3]=0.
      DX[7]=HEATC*C8*VRM2*VRM
      DX[8]=C7*C6+VDU*C9/CK3
      C10=DRHΘ*[.5*CK2*HEATC/C8*VRM2*VRM+2.*CK3*DX[8]/RHΘ]
```

```
      C11=C7/VRM2/VRM2
      C12=VRM*[CK3*C11*[C6*4.*VRM-3.*VDU*C5]+CK2*3.*HEATC*C8]
      C1=2.*CLA*[DCLA+CLA*[DETA*CA+ETA*DCA]+2.*ETA*CA*DCLA]
      C2=CK3*C7*2.*[CA*DCA+C1-VDU/VRM*C1]
      DØ 380 I=1,3
      PJXB[I]=C10*PAXB[I]+C12*DX[I]+C2*PMXB[I]
  380 PJXB[I+3]=C12*VR[I]+C2*PMXB[I+3]
      DØ 390 I=1,3
      DX[I]=0.
      DØ 390 J=1,3
  390 DX[I]=DX[I]+U[J]*PVXB[J,I]
      DØ 400 I=1,3
      PJXB[I]=PJXB[I]+C9*DX[I]
  400 PJXB[I+3]=PJXB[I+3]+C9*U[I]
      DØ 420 I=1,6
      DX[I+8]=0.
      DØ 410 J=1,6
  410 DX[I+8]=DX[I+8]-X[J+8]*P[J,I]
  420 DX[I+8]=DX[I+8]-X[15]*PJXB[I]
      DX[15]=0.
      DØ 430 I=1,3
  430 DX[I]=X[I+3]
      RETURN
      END
```

CØMMØN ALLØCATIØN

77776 A0	77774 A1	77772 A2	77770 A3
77766 A4	77764 A5	77762 A6	77760 A7
77756 A8	77754 A9	77752 A10	77750 A11
77746 A12	77744 A13	77742 A14	77740 A15
77736 A16	77734 A17	77732 A18	77730 A19
77726 A20	77724 A21	77722 A22	77720 A23
77716 B0	77714 B1	77712 B2	77710 B3
77706 B4	77704 B5	77702 B6	77700 B7
77676 B8	77674 D1	77672 D2	77670 D3
77666 D4	77664 GM	77662 PHIL	77660 AZ
77170 BETA	77136 ALPH	77104 CH	77076 AB
77074 ALFA	77072 BEDA	77070 RCØNV	77066 CLA
77064 CA	77062 ETA	77060 AREA	77056 WKG
77054 R	77052 RE	77044 VR	77042 VRM
77034 U	77032 ALT	77030 RHØ	77026 QQ
77020 ALB	77012 DB	77010 BE	77006 ØM
77004 AA	77002 FJ	77000 FH	76776 FD
76774 F	76772 RISP	76770 RMD	76766 EXA
76760 U0	76752 UOD	76750 VS	76746 ACH
76744 T0	76742 FS	76740 P0	76736 WKG0
76734 PRES	76732 HEATC	76730 CK1	76726 CK2
76724 CK3	76722 RCURV	76714 RØB	76706 RXVØB
76700 RVR	76676 RLG0	76670 UXE	76662 UYE
76660 PØPU	76646 PB		

PRØGRAM ALLØCATIØN

```
DUMMY  X          DUMMY  DX         00035  P          00145  PHI
00255  PAXB       00263  PVXB       00305  PMXB       00321  PJXB
00335  UØPT       00343  HTM        00365  I          00366  J
00367  K          00370  DEQ        00372  R2         00374  RI
00376  R2I        00400  B          00402  BB         00404  A
00406  BE2        00410  E2         00412  E4         00414  C1
00416  C2         00420  C3         00422  C4         00424  C5
00426  C6         00430  C12        00432  C13        00434  GR
00436  GP         00440  C7         00442  C8         00444  C9
00446  C10        00450  C11        00452  CC1        00454  CC2
00456  CC3        00460  VRM2       DUMMY  T          00462  UM2
00464  UM         00466  TEMP       00470  DVS        00472  DRHØ
00474  DPRES      00476  DCLA       00500  DCA        00502  DETA
00504  WKGI       00506  CLA2       00510  UØPTM      00512  VDU
00514  CC10

SUBPRØGRAMS REQUIRED

  SQRT       ATMØS       AERØD
THE END
```

```
      SUBROUTINE ATMOS [ALT,TEMP,PRES,RHO,VS,DVS,DRHO,DPRES]
      COMMON A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
C     NOTE THAT FORMULAS ARE NOT ACCURATE FOR ALTITUDE OUTSIDE 0 TO 200
C     ALT MUST BE IN METERS
C     TEMP IS IN DEGREES KELVIN
C     PRES IS IN NEWTONS/M2
C     RHO IS IN KG/M3
C     VS IS IN METERS PER SECOND
C     DRHO, DPRES, AND DVS ARE IN SAME UNITS AS RHO, PRES, AND DVS OVER
      Z=ALT*.001
      IF [Z] 10,20,20
   10 Z=0.
   20 CONTINUE
      IF [Z-200.] 40,40,30
   30 Z=200.
   40 CONTINUE
      Z2=Z*Z
      E1=Z+A1
      E2=Z+A3
      E3=Z-A5
      E4=Z2-A7*Z+A8
      E5=Z2-A13*Z+A14
      E6=Z2-A19*Z+A20
      A=A0/E1+A2*ALOG[E2]-A4*ALOG[-E3]+A6*ALOG[E4]+A9*ATAN[A10*Z-A11]
     1-A12*ALOG[E5]+A15*ATAN[A16*Z-A17]-A18*ALOG[E6]+A21*ATAN[A22*Z-A23]
      AAB=.018031036
      AAC=-.060803123
      AAD=-.028429767
      DA=-A0/[E1*E1]+A2/E2-A4/E3+[2.*A6*Z+AAB]/E4-[2.*A12*Z+AAC]/E5-[2.*
     1A18*Z+AAD]/E6
      DA=DA*.001
      TEMP=B0+Z*[B1+Z*[B2+Z*[B3+Z*[B4+Z*[B5+Z*[B6+Z*[B7-B8*Z]]]]]]]
      DTEMP=B1+Z*[2.*B2+Z*[3.*B3+Z*[4.*B4+Z*[5.*B5+Z*[6.*B6+Z*[7.*B7-8.*
     1B8*Z]]]]]]
      DTEMP=DTEMP*.001
      PRES=EXP[-D1*A]
      RHO=D2*PRES/TEMP
      PRES=D3*PRES
      VS=SQRT[D4*TEMP]
      DRHO=-RHO*[D1*DA+DTEMP/TEMP]
      DVS=.5*D4*DTEMP/VS
      DPRES=-D1*PRES*DA
      IF [ALT-200./.001] 60,60,50
   50 A=ALT-200./.001
      RHO=RHO+DRHO*A
      PRES=DPRES*A+PRES
      VS=VS+DVS*A
   60 IF [ALT] 70,80,80
   70 RHO=RHO+DRHO*ALT
      PRES=PRES+DPRES*ALT
      VS=VS+DVS*ALT
   80 CONTINUE
```

```
=     54         RETURN
=     55         END

COMMON ALLOCATION

  77776 A0        77774 A1        77772 A2        77770 A3
  77766 A4        77764 A5        77762 A6        77760 A7
  77756 A8        77754 A9        77752 A10       77750 A11
  77746 A12       77744 A13       77742 A14       77740 A15
  77736 A16       77734 A17       77732 A18       77730 A19
  77726 A20       77724 A21       77722 A22       77720 A23
  77716 B0        77714 B1        77712 B2        77710 B3
  77706 B4        77704 B5        77702 B6        77700 B7
  77676 B8        77674 D1        77672 D2        77670 D3
  77666 D4

PROGRAM ALLOCATION

  00054 ATMOS     00056 Z         DUMMY ALT       00060 Z2
  00062 E1        00064 E2        00066 E3        00070 E4
  00072 E5        00074 E6        00076 A         00100 AAB
  00102 AAC       00104 AAD       00106 DA        DUMMY TEMP
  00110 DTEMP     DUMMY PRES      DUMMY RHO       DUMMY VS
  DUMMY DRHO      DUMMY DVS       DUMMY DPRES

SUBPROGRAMS REQUIRED

  ALOG      ATAN      EXP       SQRT
THE END
```

```
=          SUBRØUTINE TANGL [SINA,CØSA,A]
=          PI=3.1415927
=          IF [SINA] 10,20,30
=       10 IF [CØSA] 40,50,60
=       20 IF [CØSA] 70,80,90
=       30 IF [CØSA] 100,110,120
=       40 A=ATAN[-SINA/[-CØSA]]
=          A=A+PI
=          GØ TØ 130
=       50 A=1.5*PI
=          GØ TØ 130
=       60 A=ATAN[-SINA/CØSA]
=          A=2.*PI-A
=          GØ TØ 130
=       70 A=PI
=          GØ TØ 130
=       80 CØNTINUE
=       90 A=0.
=          GØ TØ 130
=      100 A=ATAN[SINA/[-CØSA]]
=          A=PI-A
=          GØ TØ 130
=      110 A=.5*PI
=          GØ TØ 130
=      120 A=ATAN[SINA/CØSA]
=      130 A=A*57.29577951
=          RETURN
=          END

PRØGRAM ALLØCATIØN

  00011 TANGL     00013 PI        DUMMY SINA      DUMMY CØSA
  DUMMY A

SUBPRØGRAMS REQUIRED

  ATAN
THE END
```

```
      SUBROUTINE AEROD [ACH,CLA,CA,ETA,DCLA,DCA,DETA]
C     THESE FUNCTIONS CAN BE CHANGED FOR EACH VEHICLE OR TO IMPROVE
C     SIMULATION OF SAME VEHICLE
      DIMENSION G[20], AETA[15], ACLA[20], ACA[20]
      DIMENSION RLMI[7]
      DIMENSION X[15], DX[15], ALPH[13], BETA[13,12], CH[13], AB[3]
      DIMENSION VR[3], U[3], ALB[3], DB[3], UO[3], UOD[3]
      DIMENSION ROB[3], RXVOB[3], RVR[3]
      DIMENSION PB[5], B[13]
      DIMENSION VXR[3], VXRXV[3], UXE[3], UYE[3]
      COMMON AO,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      COMMON GM,PHIL,AZ,BETA,ALPH,CH,AB,ALFA,BEDA,RCONV,CLA,CA,ETA,AREA,
     1WKG,R,RE,VR,VRM,U,ALT,RHO,QQ,ALB,DB,BE,OM,AA,FJ,FH,FD,F,RISP,RMD,E
     2XA,UO,UOD,VS,ACH,TO,FS,PO,WKGO,PRES,HEATC,CK1,CK2,CK3,RCURV,ROB,RX
     3VOB,RVR,RLGO,UXE,UYE,POPU,PB
      COMMON ACLA,ACA,AETA
      COMMON RC,AMC,CTHC,RCTHC,SRAD,SCRAD,CRAD
      NMC=0
      IF [ACH-23.0] 20,10,10
   10 XS=ACH
      ACH=23.0
      NMC=1
   20 G[1]=1.0
      G[2]=ACH
      DO 30 I=3,20
   30 G[I]=G[I-1]*G[2]
      C2=1.+ACA[19]*G[11]+ACA[18]*G[10]
      C1=ACA[9]*G[9]
      DC1=0.
      DC2=10.*ACA[19]*G[10]+9.*ACA[18]*G[9]
      DO 40 I=1,8
      C2=C2+ACA[I+9]*G[I+1]
      C1=C1+ACA[I]*G[I]
      DC1=DC1+I*ACA[I+1]*G[I]
   40 DC2=DC2+I*ACA[I+9]*G[I]
      CA=C1/C2
      DCA=DC1/C2-[C1*DC2/[C2*C2]]
      A1=AETA[1]+AETA[10]*G[2]+AETA[4]*G[4]+AETA[6]*G[5]+AETA[8]*G[6]
      A2=1.+AETA[2]*G[2]+AETA[3]*G[3]+AETA[5]*G[4]+AETA[7]*G[5]+AETA[9]*
     1G[6]
      DA1=AETA[10]+3.*AETA[4]*G[3]+4.*AETA[6]*G[4]+5.*AETA[8]*G[5]
      DA2=AETA[2]+2.*AETA[3]*G[2]+3.*AETA[5]*G[3]+4.*AETA[7]*G[4]+5.*AET
     1A[9]*G[5]
      ETA=A1/A2
      DETA=DA1/A2-[A1*DA2/[A2*A2]]
      B1=ACLA[18]*G[12]
      DO 50 I=1,8
   50 B1=B1+ACLA[I]*G[I]
      B2=1.+ACLA[9]*G[2]+ACLA[10]*G[3]+ACLA[11]*G[4]+ACLA[12]*G[6]+ACLA[
     113]*G[7]+ACLA[14]*G[8]+ACLA[15]*G[9]+ACLA[16]*G[10]+ACLA[17]*G[11]
     2+ACLA[19]*G[13]
      DB1=11.*ACLA[18]*G[11]
```

```
      DO 60 I=1,7
   60 DB1=DB1+I*ACLA[I+1]*G[I]
      DB2=ACLA[9]+2.*ACLA[10]*G[2]+3.*ACLA[11]*G[3]+5.*ACLA[12]*G[5]+6.*
     1ACLA[13]*G[6]+7.*ACLA[14]*G[7]+8.*ACLA[15]*G[8]+9.*ACLA[16]*G[9]+1
     20.*ACLA[17]*G[10]+12.*ACLA[19]*G[12]
      CLA=B1/B2
      DCLA=DB1/B2-[B1*DB2/[B2*B2]]
      IF [NMC] 70,80,70
   70 CLA=CLA+DCLA*[XS-ACH]
      CA=CA+DCA*[XS-ACH]
      ETA=ETA+DETA*[XS-ACH]
      ACH=XS
   80 RETURN
      END
```

COMMON ALLOCATION

77776 A0	77774 A1	77772 A2	77770 A3
77766 A4	77764 A5	77762 A6	77760 A7
77756 A8	77754 A9	77752 A10	77750 A11
77746 A12	77744 A13	77742 A14	77740 A15
77736 A16	77734 A17	77732 A18	77730 A19
77726 A20	77724 A21	77722 A22	77720 A23
77716 B0	77714 B1	77712 B2	77710 B3
77706 B4	77704 B5	77702 B6	77700 B7
77676 B8	77674 D1	77672 D2	77670 D3
77666 D4	77664 GM	77662 PHIL	77660 AZ
77170 BETA	77136 ALPH	77104 CH	77076 AB
77074 ALFA	77072 BEDA	77070 RCONV	DUMMY CLA
DUMMY CA	DUMMY ETA	77060 AREA	77056 WKG
77054 R	77052 RE	77044 VR	77042 VRM
77034 U	77032 ALT	77030 RHO	77026 QQ
77020 ALB	77012 DB	77010 BE	77006 OM
77004 AA	77002 FJ	77000 FH	76776 FD
76774 F	76772 RISP	76770 RMD	76766 EXA
76760 U0	76752 UOD	76750 VS	DUMMY ACH
76744 T0	76742 FS	76740 P0	76736 WKG0
76734 PRES	76732 HEATC	76730 CK1	76726 CK2
76724 CK3	76722 RCURV	76714 ROB	76706 RXVOB
76700 RVR	76676 RLGO	76670 UXE	76662 UYE
76660 POPU	76646 PB	76576 ACLA	76526 ACA
76470 AETA	76466 RC	76464 AMC	76462 CTHC
76460 RCTHC	76456 SRAD	76454 SCRAD	76452 CRAD

PROGRAM ALLOCATION

00040 G	00110 RLMI	00126 X	00164 DX
00222 B	00254 VXR	00262 VXRXV	00270 NMC
00271 I	00272 AEROD	DUMMY ACH	00274 XS
00276 C2	00300 C1	00302 DC1	00304 DC2
DUMMY CA	DUMMY DCA	00306 DA1	00310 DA2
DUMMY ETA	DUMMY DETA	00312 DB1	00314 DB2
	DUMMY CLA	DUMMY DCLA	

THE END

```
      SUBRØUTINE BØUND [TF,X,DX,B,ERR]
      DIMENSIØN X[15], DX[15], ALPH[13], BETA[13,12], CH[13], AB[3]
      DIMENSIØN VR[3], U[3], ALB[3], DB[3], UO[3], UOD[3]
      DIMENSIØN ROB[3], RXVOB[3], RVR[3]
      DIMENSIØN PBXAT[5,6], PVXB[3,3], PAXB[3], PB[5]
      DIMENSIØN B[13]
      DIMENSIØN VXR[3], VXRXV[3], UXE[3], UYE[3]
      DIMENSIØN AETA[15], ACLA[20], ACA[20]
      DIMENSIØN RLMI[7]
      CØMMØN A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A
     117,A18,A19,A20,A21,A22,A23,B0,B1,B2,B3,B4,B5,B6,B7,B8,D1,D2,D3,D4
      CØMMØN GM,PHIL,AZ,BETA,ALPH,CH,AB,ALFA,BEDA,RCØNV,CLA,CA,ETA,AREA,
     1WKG,R,RE,VR,VRM,U,ALT,RHØ,QQ,ALB,DB,BE,ØM,AA,FJ,FH,FD,F,RISP,RMD,E
     2XA,UO,UOD,VS,ACH,TO,FS,PO,WKGO,PRES,HEATC,CK1,CK2,CK3,RCURV,ROB,RX
     3VOB,RVR,RLGO,UXE,UYE,PØPU,PB
      CØMMØN ACLA,ACA,AETA
      CØMMØN RC,AMC,CTHC,RCTHC,SRAD,SCRAD,CRAD
      RC2=RC*RC
      AMC2=AMC*AMC
      B[1]=R*R/RC2-1.
      B[2]=VRM*VRM/VS/VS/AMC2-1.
      V2=X[4]*X[4]+X[5]*X[5]+X[6]*X[6]
      B[3]=0.
      DØ 10 I=1,3
   10 B[3]=B[3]+X[I]*X[I+3]
      B[3]=B[3]/RC/SQRT[V2]-CTHC
      B[4]=0.
      DØ 20 I=1,3
   20 B[4]=B[4]+X[I]*[ROB[I]*SRAD-RVR[I]*CRAD]
      B[4]=B[4]/RC
      B[5]=0.
      DØ 30 I=1,3
   30 B[5]=B[5]-X[I]*RXVOB[I]
      B[5]=B[5]/RC-SCRAD
      R2=R*R
      RI=1./R
      BB=AA*RI
      A=[AB[1]*X[1]+AB[2]*X[2]+AB[3]*X[3]]*RI
      BE2=BE*BE
      E2=A*A
      C5=AA*AA-BE2
      C6=BE2+C5*E2
      RE=AA*BE/SQRT[C6]
      C12=RE*A*C5/C6*RI
      C13=C12*A*RI
      DØ 40 I=1,3
      PVXB[I,I]=0.
   40 PAXB[I]=[RI-C13]*X[I]+C12*AB[I]
      PVXB[1,2]=ØM*AB[3]
      PVXB[1,3]=-ØM*AB[2]
      PVXB[2,3]=ØM*AB[1]
      PVXB[2,1]=-PVXB[1,2]
      PVXB[3,1]=-PVXB[1,3]
```

```
=         PVXB[3,2]=-PVXB[2,3]
=         CALL ATMOS [ALT,TEMP,PRES,RHO,VS,DVS,DRHO,DPRES]
=         RC2=RC*RC
=         AMC2=AMC*AMC
=         VRM2=VRM*VRM
=         DO 50 I=1,5
=         DO 50 J=1,6
=      50 PBXAT[I,J]=0.
=         V2=X[4]*X[4]+X[5]*X[5]+X[6]*X[6]
=         VI=1./SQRT[V2]
=         C1=X[1]*X[4]+X[2]*X[5]+X[3]*X[6]
=         C3=1./[VS*VS*AMC2]
=         C4=1./RC*VI
=         DO 70 I=1,3
=         PBXAT[1,I]=2.*X[I]/RC2
=         DO 60 J=1,3
=      60 PBXAT[2,I]=PBXAT[2,I]+2.*VR[J]*PVXB[J,I]
=         PBXAT[2,I]=[PBXAT[2,I]-2.*VRM2*DVS*PAXB[I]/VS]*C3
=         PBXAT[2,I+3]=2.*VR[I]*C3
=         PBXAT[3,I]=X[I+3]*C4
=         PBXAT[3,I+3]=C4*[X[I]-C1*X[I+3]/V2]
=         PBXAT[4,I]=[ROB[I]*SRAD-RVR[I]*CRAD]/RC
=      70 PBXAT[5,I]=-RXVOB[I]/RC
=         DO 90 I=1,6
=         B[I+5]=0.
=         DO 80 J=1,5
=      80 B[I+5]=B[I+5]+PB[J]*PBXAT[J,I]
=      90 B[I+5]=X[I+8]+B[I+5]
=         B[12]=X[15]-1.
=         HAM=X[9]*DX[1]+X[10]*DX[2]+X[11]*DX[3]+X[12]*DX[4]+X[13]*DX[5]+X[1
=        14]*DX[6]+X[15]*[CK1*RMD+CK2*DX[7]+CK3*DX[8]]
=         B[13]=HAM
=         ERR=0.
=         DO 100 I=1,13
=     100 ERR=ERR+B[I]*B[I]
=         RETURN
=         END
```

COMMON ALLOCATION

77776 A0	77774 A1	77772 A2	77770 A3
77766 A4	77764 A5	77762 A6	77760 A7
77756 A8	77754 A9	77752 A10	77750 A11
77746 A12	77744 A13	77742 A14	77740 A15
77736 A16	77734 A17	77732 A18	77730 A19
77726 A20	77724 A21	77722 A22	77720 A23
77716 B0	77714 B1	77712 B2	77710 B3
77706 B4	77704 B5	77702 B6	77700 B7
77676 B8	77674 D1	77672 D2	77670 D3
77666 D4	77664 GM	77662 PHIL	77660 AZ
77170 BETA	77136 ALPH	77104 CH	77076 AB
77074 ALFA	77072 BEDA	77070 RCONV	77066 CLA
77064 CA	77062 ETA	77060 AREA	77056 WKG

```
  77054 R          77052 RE         77044 VR         77042 VRM
  77034 U          77032 ALT        77030 RHØ        77026 QQ
  77020 ALB        77012 DB         77010 BE         77006 ØM
  77004 AA         77002 FJ         77000 FH         76776 FD
  76774 F          76772 RISP       76770 RMD        76766 EXA
  76760 UO         76752 UOD        76750 VS         76746 ACH
  76744 TO         76742 FS         76740 PO         76736 WKGO
  76734 PRES       76732 HEATC      76730 CK1        76726 CK2
  76724 CK3        76722 RCURV      76714 ROB        76706 RXVOB
  76700 RVR        76676 RLGO       76670 UXE        76662 UYE
  76660 PØPU       76646 PB         76576 ACLA       76526 ACA
  76470 AETA       76466 RC         76464 AMC        76462 CTHC
  76460 RCTHC      76456 SRAD       76454 SCRAD      76452 CRAD

PRØGRAM ALLØCATIØN

  DUMMY X          DUMMY DX         00034 PBXAT      00130 PVXB
  00152 PAXB       DUMMY B          00160 VXR        00166 VXRXV
  00174 RLMI       00212 I          00213 J          00214 BØUND
  00216 RC2        00220 AMC2       00222 V2         00224 R2
  00226 RI         00230 BB         00232 A          00234 BE2
  00236 E2         00240 C5         00242 C6         00244 C12
  00246 C13        00250 TEMP       00252 DVS        00254 DRHØ
  00256 DPRES      00260 VRM2       00262 VI         00264 C1
  00266 C3         00270 C4         00272 HAM        DUMMY ERR

SUBPRØGRAMS REQUIRED

  SQRT      ATMØS
THE END
```

INITIAL VALUES

T =	.00000000000	R =	.65000732772+07	V =	.79182741874+04	GM =	.39860319000+15
X =	.10416416000+07	Y =	-.62981421000+07	Z =	.12244760000+07	PHI =	.28608000000+02
DX =	-.50566950000+04	DY =	-.17567557000+04	DZ =	.58346132000+04	AZ =	.90000000000+02
DDX =	-.15169262597+01	DDY =	.91182927929+01	DDZ =	.17680016844+01	ALT =	.14030918566+06
WKG =	.13280731000+06	VRX =	-.49783056909+04	VRY =	.17140022624+04	VRZ =	-.56813936515+04
VR =	.77459386217+04	UX =	-.47030056530+00	UY =	.40651458587+00	UZ =	-.78330279570+00
ALFA=	.38109179274+02	LFX =	.16658663157+01	LFY =	.27324664037+02	LFZ =	-.97032050795+01
BETA=	.19505907320+03	DFX =	-.18117236956+02	DFY =	-.62376613771+01	DFZ =	-.20675941056+02
AREA=	.65821803840+03	CL =	.46903918859+00	CD =	.45523371732+00	ETA =	.17999863636+01
RHO =	.31358995814-08	Q =	.61922721324+02	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23901909955+03	CHIY=	.23986073627+02
DRNG=	.00000000000	XRNG=	.88986254448-12	PANG=	.91500003418+02	DCEL=	.30476263426-03
PRES=	.68513884435-03	UOX =	-.47030056530+00	UOY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.14005598208+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.12000053346-01	CLA =	.75999370475+00	EXA =	.00000000000	HTC =	.61073730421-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73052000000+00
J =	.00000000000	HT1 =	.00000000000	DHT1=	.15894895440+00	DCLI=	.00000000000
D2 =	.55876673089-07	LAT =	.68028973356+02	LONG=	.21023191184+03	LNGO=	.00000000000
LAM1=	.52147295108+02	LAM2=	.58856570851+03	LAM3=	.60580489990+02	HAM =	.23216986778+04
LAM4=	.26352105840+05	LAM5=	.19169952861+06	LAM6=	.30856165926+05	LAM7=	.10000000000+01
DLM1=	.16161206463+00	DLM2=	-.46427924821+00	DLM3=	.18812765169+00	POPU=	.00000000000
DLM4=	-.52139600593+02	DLM5=	-.58854778008+03	DLM6=	-.60573264674+02	DLM7=	.00000000000

INTERMEDIATE VALUES 10 INTEGRATION STEPS TAKEN

T =	.10000000000+03	R =	.64805373374+07	V =	.79418704794+04	GM =	.39860319000+15
X =	.52959530431+06	Y =	-.64277122900+07	Z =	.63356744889+06	PHI =	.28608000000+02
DX =	-.51720114713+04	DY =	-.83007721734+03	DZ =	-.59694703170+04	AZ =	.90000000000+02
DDX =	-.78389571559+00	DDY =	.93924642679+01	DDZ =	-.92295398060+00	ALT =	.12008877289+06
WKG =	.13280731000+06	VRX =	-.51314513323+04	VRY =	-.80795576590+03	VRZ =	-.57789462198+04
VR =	.77705086518+04	UX =	-.48029066245+00	UY =	.40623541743+00	UZ =	-.77736327749+00
ALFA=	.31453954794+02	LFX =	.25489098925+02	LFY =	.15190362932+03	LFZ =	-.43870884789+02
BETA=	.19729303410+03	DFX =	.84683458435+02	DFY =	-.13333554990+02	DFZ =	-.95368955157+02
AREA=	.65821803840+03	CL =	.39657781039+00	CD =	.31754150073+00	ETA =	.18000013154+01
RHO =	.20322102908-07	Q =	.40383813459+03	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23829033117+03	CHIY=	.23968567814+02
DRNG=	.77695134248+06	XRNG=	.47832879956+02	PANG=	.91320019547+02	DCEL=	.15448448591-02
PRES=	.22943646730-02	UOX =	.47030056530+00	UOY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.19545121817+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.12000000427-01	CLA =	.75999960681+00	EXA =	.00000000000	HTC =	.61073730421-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73052000000+00
J =	.12740880864+02	HT1 =	.25481720258+02	DHT1=	.40849534874+00	DCLI=	.41469047409-04
D2 =	.16386594064-05	LAT =	.65490027419+02	LONG=	.19404843730+03	LNGO=	.00000000000
LAM1=	.63960890321+02	LAM2=	.54589222069+03	LAM3=	.74361517654+02	HAM =	.23213750478+04
LAM4=	.20479423468+05	LAM5=	.13504361332+06	LAM6=	.24030865850+05	LAM7=	.10000000000+01
DLM1=	.79144185285-01	DLM2=	-.39000281212+00	DLM3=	.92664419706-01	POPU=	.00000000000
DLM4=	-.63929460915+02	DLM5=	-.54582614493+03	DLM6=	-.74331304179+02	DLM7=	.00000000000

INTERMEDIATE VALUES 10 INTEGRATION STEPS TAKEN

```
T    =   .20000000000+03  R    =   .64635639143+07  V    =   .79624354856+04  GM   =   .39860319000+15
X    =   .97368784410+04  Y    =  -.64634699941+07  Z    =   .33455981201+05  PHI  =   .28608000000+02
DX   =  -.52123644617+04  DY   =   .11729859123+03  DZ   =  -.60181289967+04  AZ   =   .90000000000+02
DDX  =  -.15117923313-01  DDY  =   .95366298227+01  DDZ  =  -.45001651439-01  ALT  =   .10192334805+06
WKG  =   .13280731000+06  VRX  =  -.52102226512+04  VRY  =   .11846673025+03  VRZ  =  -.57930757575+04
VR   =   .77923155207+04  UX   =  -.49173593354+00  UY   =   .40584511450+00  UZ   =  -.77038011053+00
ALFA=    .24812011316+02  LFX  =   .61249015459+03  LFY  =   .20848086717+04  LFZ  =  -.50823254067+03
BETA=    .20074323112+03  DFX  =  -.95416495495+03  DFY  =   .21695196137+02  DFZ  =  -.10609047327+04
AREA=    .65821803840+03  CL   =   .31892917838+00  CD   =   .20394773442+00  ETA  =   .17999986689+01
RHO  =   .35014020367-06  Q    =   .69970475135+04  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .23744979197+03  CHIY=    .23944097076+02
DRNG=    .15586260125+07  XRNG=    .18510789082+03  PANG=    .91124768168+02  DCEL=    .19944899266-01
PRES=    .20525930799-01  UOX  =  -.47030056530+00  UOY  =   .40651458587+00  UOZ  =  -.78330279570+00
MACH=    .27200189070+02  UODX=    .22044155789-03  UODY=   -.27374111417-03  UODZ=    .57787813012-03
CDO  =   .11999999168-01  CLA  =   .76000231834+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =   .56596113068+02  HT1  =   .11318683601+03  DHT1=    .17099169834+01  DCLI=    .53901228658-02
D2   =   .30919030324-03  LAT  =   .61476900193+02  LONG=    .18145669212+03  LNGO=    .00000000000
LAM1=    .68932001776+02  LAM2=    .50498719147+03  LAM3=    .80217826964+02  HAM  =   .23188284803+04
LAM4=    .13799766890+05  LAM5=    .82427866813+05  LAM6=    .16259395019+05  LAM7=    .10000000000+01
DLM1=    .22680102243-01  DLM2=   -.52709393840+00  DLM3=    .27272257098-01  POPU=    .00000000000
DLM4=   -.68649537193+02  DLM5=   -.50442296376+03  DLM6=   -.79938251107+02  DLM7=    .00000000000

                                              INTERMEDIATE VALUES    10 INTEGRATION STEPS TAKEN

T    =   .30000000000+03  R    =   .64491226368+07  V    =   .79756196417+04  GM   =   .39860319000+15
X    =  -.51014832046+06  Y    =  -.64038555343+07  Z    =  -.56706769507+06  PHI  =   .28608000000+02
DX   =  -.51696057650+04  DY   =   .10778997750+04  DZ   =  -.59769404362+04  AZ   =   .90000000000+02
DDX  =   .94360336221+00  DDY  =   .97243577761+01  DDZ  =   .87928488174+00  ALT  =   .85847455570+05
WKG  =   .13280731000+06  VRX  =  -.52059086721+04  VRY  =   .10581002090+04  VRZ  =  -.57206863268+04
VR   =   .78068760208+04  UX   =  -.50497023840+00  UY   =   .40529777950+00  UZ   =  -.76206218136+00
ALFA=    .18179327684+02  LFX  =   .14877887256+05  LFY  =   .31996714262+05  LFZ  =  -.76209723362+04
BETA=    .20658333244+03  DFX  =  -.11755741676+05  DFY  =   .23893528504+04  DFZ  =  -.12918188717+05
AREA=    .65821803840+03  CL   =   .23711501676+00  CD   =   .11579262091+00  ETA  =   .17999972443+01
RHO  =   .75902405256-05  Q    =   .15224740102+06  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .23647009476+03  CHIY=    .23909788746+02
DRNG=    .23444464190+07  XRNG=    .28571833348+03  PANG=    .90975985176+02  DCEL=    .30250368194+00
PRES=    .38850713931+00  UOX  =  -.47030056530+00  UOY  =   .40651458587+00  UOZ  =  -.78330279570+00
MACH=    .29163616818+02  UODX=    .22044155789-03  UODY=   -.27374111417-03  UODZ=    .57787813012-03
CDO  =   .11999998790-01  CLA  =   .76000315654+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =   .26604768331+03  HT1  =   .53053877116+03  DHT1=    .80059719552+01  DCLI=    .15565954640+01
D2   =   .79242178895-01  LAT  =   .56499190676+02  LONG=    .17208673107+03  LNGO=    .00000000000
LAM1=    .65275949102+02  LAM2=    .39530910922+03  LAM3=    .76124056283+02  HAM  =   .22904343335+04
LAM4=    .70612972513+04  LAM5=    .36462788139+05  LAM6=    .03959178199+04  LAM7=    .10000000000+01
DLM1=   -.13609348494+00  DLM2=   -.18546884231+01  DLM3=   -.15547819771+00  POPU=    .00000000000
DLM4=   -.63056480665+02  DLM5=   -.39075039481+03  DLM6=   -.73844406451+02  DLM7=    .00000000000

                                              INTERMEDIATE VALUES    10 INTEGRATION STEPS TAKEN

T    =   .40000000000+03  R    =   .64342325319+07  V    =   .79590794782+04  GM   =   .39860319000+15
X    =  -.10196407475+07  Y    =  -.62463437689+07  Z    =  -.11588229119+07  PHI  =   .28608000000+02
```

DX =	-.49828819897+04	DY =	.20890902733+04	DZ =	-.58441025869+04	AZ =	.9000000
DDX =	.32974219418+01	DDY =	.10772812782+02	DDZ =	.16909364966+01	ALT =	.68981355629+05
WKG =	.13280731000+06	VRX =	-.50570682694+04	VRY =	.20486291593+04	VRZ =	-.55607310917+04
VR =	.77905424194+04	UX =	-.52043396508+00	UY =	.40452405976+00	UZ =	-.75200317358+00
ALFA=	.11196040465+02	LFX =	.17223274986+06	LFY =	.21697614768+06	LFZ =	-.76696589748+05
BETA=	.21874680076+03	DFX =	-.65211407484+05	DFY =	.26417280482+05	DFZ =	-.71706190586+05
AREA=	.65821803840+03	CL =	.14756690501+00	CD =	.51573348517-01	ETA =	.17999998088+01
RHO =	.97519607922-04	Q =	.19479020922+07	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23531430882+03	CHIY=	.23861305583+02
DRNG=	.31326834594+07	XRNG=	-.14931212010+04	PANG=	.91338406654+02	DCEL=	.22927591759+01
PRES=	.64361786937+01	UOX =	-.47030056530+00	UOY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.25629224004+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.11999999470-01	CLA =	.76000164769+00	EXA =	.00000000000	HTC =	.61073730421-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73052000000+00
J =	.11377689031+04	HT1 =	.21511012705+04	DHT1=	.28516978681+02	DCLI=	.12443653576+03
D2 =	.49648537238+01	LAT =	.50932262464+02	LONG=	.16506640080+03	LNGO=	.00000000000
LAM1=	.39950274471+02	LAM2=	.17919321676+03	LAM3=	.47062754244+02	HAM =	.21581111463+04
LAM4=	.20149957919+04	LAM5=	.84575825297+04	LAM6=	.24491673804+04	LAM7=	.10000000000+01
DLM1=	-.32064029710+00	DLM2=	-.20086625379+01	DLM3=	-.36881101966+00	POPU=	.00000000000
DLM4=	-.34882827296+02	DLM5=	-.16692510780+03	DLM6=	-.41514711893+02	DLM7=	.00000000000

INTERMEDIATE VALUES 14 INTEGRATION STEPS TAKEN

T =	.50000000000+03	R =	.64016959419+07	V =	.76849731107+04	GM =	.39860319000+15
X =	-.14839846698+07	Y =	-.59800660524+07	Z =	-.17373285355+07	PHI =	.28608000000+02
DX =	-.39836306746+04	DY =	.31368802909+04	DZ =	-.57749008997+04	AZ =	.90000000000+02
DDX =	.18259967734+02	DDY =	-.42133842381+01	DDZ =	.46573283199+01	ALT =	.34308225798+05
WKG =	.13280731000+06	VRX =	-.40948521059+04	VRY =	.30762202476+04	VRZ =	-.54711000044+04
VR =	.74942564701+04	UX =	-.53871762763+00	UY =	.40341612330+00	UZ =	-.73962067923+00
ALFA=	.81163340845+00	LFX =	.98922588284+06	LFY =	-.91055119964+06	LFZ =	-.12523605346+07
BETA=	.30160073516+03	DFX =	-.11385333379+07	DFY =	.85531277221+06	DFZ =	-.15211855248+07
AREA=	.65821803840+03	CL =	.10765568008-01	CD =	.12208625719-01	ETA =	.18000008244+01
RHO =	.92336288826-02	Q =	.17067476075+09	AE =	.63781660000+07	BE =	.63567840000+07
OM =	.72921150604-04	FJ =	.16234500072-02	FH =	-.57500000139-05	FD =	.78750000512-05
F =	.00000000000	OMX =	.47881444528+00	OMY =	-.87791612754+00	OMZ =	-.77140676824-08
ISP =	.40000000000+03	MD =	.00000000000	CHIP=	.23393152663+03	CHIY=	.23791911160+02
DRNG=	.39150459846+07	XRNG=	-.28374400841+05	PANG=	.93279279851+02	DCEL=	.20918360463+02
PRES=	.63098071603+03	UOX =	-.47030056530+00	UOY =	.40651458587+00	UOZ =	-.78330279570+00
MACH=	.24229393859+02	UODX=	.22044155789-03	UODY=	-.27374111417-03	UODZ=	.57787813012-03
CDO =	.11999999740-01	CLA =	.76000105010+00	EXA =	.00000000000	HTC =	.61073730421-08
CK1 =	.00000000000	CK2 =	.50000000000+00	CK3 =	.50000000000+00	RCRV=	.73052000000+00
J =	.11048302909+05	HT1 =	.10644384606+05	DHT1=	.24701669693+03	DCLI=	.11452221211+05
D2 =	.43751552340+03	LAT =	.45161742760+02	LONG=	.15945241180+03	LNGO=	.00000000000
LAM1=	.17586679205+02	LAM2=	.61468151918+02	LAM3=	.21319905470+02	HAM =	.17763485723+04
LAM4=	.12977719640+03	LAM5=	.32824965377+03	LAM6=	.17356275134+03	LAM7=	.10000000000+01
DLM1=	.49082732263-01	DLM2=	.20379827292+00	DLM3=	.61690633735-01	POPU=	.00000000000
DLM4=	-.40223817778+01	DLM5=	-.15476486247+02	DLM6=	-.60918551902+01	DLM7=	.00000000000

INTERMEDIATE VALUES 92 INTEGRATION STEPS TAKEN

T =	.60000000000+03	R =	.63961800021+07	V =	.42964437763+04	GM =	.39860319000+15
X =	-.17813912335+07	Y =	-.57422099169+07	Z =	-.21828397015+07	PHI =	.28608000000+02
DX =	-.21483772831+04	DY =	.17619159636+04	DZ =	-.32771262273+04	AZ =	.90000000000+02
DDX =	.77289861254+01	DDY =	-.50964577714+01	DDZ =	.11484259158+02	ALT =	.27208221017+05

```
WKG =   .13280731000+06  VRX =  -.22881197398+04  VRY =   .16857005858+04  VRZ =  -.29625906776+04
VR  =   .41053650181+04  UX  =  -.56062651797+00  UY  =   .40180066212+00  UZ  =  -.72405395881+00
ALFA=   .55599966960+00  LFX =  -.39642552569+06  LFY =  -.10545297536+07  LFZ =  -.29384833999+06
BETA=   .59379286215+01  DFX =  -.10644861404+07  DFY =   .78422683885+06  DFZ =  -.13782655956+07
AREA=   .65821803840+03  CI  =   .73748703372-02  CD  =   .12097966434-01  ETA =   .17999888497+01
RHO =   .28461469969-01  Q   =   .15787038410+09  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =   .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   -   .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =   .40000000000+03  MD  =   .00000000000     CHIP=   .23224980403+03  CHIY=   .23690794790+02
DRNG=   .44958347685+07  XRNG=  -.94364400183+05  PANG=   .88199881989+02  DCEL=   .16842475576+02
PRES=   .18025458123+04  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=   .13787106130+02  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDO =   .12000065054-01  CLA =   .75999249844+00  EXA =   .00000000000     HTC =   .61073730421-08
CK1 =   .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73052000000+00
J   =   .91344056582+05  HT1 =   .32506473427+05  DHT1=   .71291613375+02  DCLI=   .15018163974+06
D2  =   .28365724924+03  LAT =   .40904536066+02  LONG=   .15566450206+03  LNGO=   .00000000000
LAM1=   .16758220930+14  LAM2=   .55546745104+14  LAM3=   .21408015329+14  HAM =   .10529749774+16
LAM4=   .25141783108+16  LAM5=   .92176220852+16  LAM6=   .30287761456+16  LAM7=   .10000000000+01
DLM1=   .39946517869+13  DLM2=   .13149816070+14  DLM3=   .50935794977+13  POPU=   .00000000000
DLM4=   .54568796049+15  DLM5=   .20056068864+16  DLM6=   .65605661036+15  DLM7=   .00000000000

                                            INTERMEDIATE VALUES    25 INTEGRATION STEPS TAKEN

T   =   .70000000000+03  R   =   .64110712343+07  V   =   .37251818845+04  GM  =   .39860319000+15
X   =  -.19758285438+07  Y   =  -.55729501751+07  Z   =  -.24779350845+07  PHI =   .28608000000+02
DX  =  -.18256250427+04  DY  =   .17385023578+04  DZ  =  -.27425686552+04  AZ  =   .90000000000+02
DDX =   .17485959140+01  DDY =   .21917311000+01  DDZ =   .32760956529+01  ALT =   .41033067913+05
WKG =   .13280731000+06  VRX =  -.19842591088+04  VRY =   .16519835179+04  VRZ =  -.24214953130+04
VR  =   .35397702334+04  UX  =  -.58727653040+00  UY  =   .39938819047+00  UZ  =  -.70398533376+00
ALFA=   .43037878741+01  LFX =  -.30485632916+06  LFY =  -.71095340403+06  LFZ =  -.23521390044+06
BETA=   .65352156707+01  DFX =  -.14193841713+06  DFY =   .11817001349+06  DFZ =  -.17321488423+06
AREA=   .65821803840+03  CL  =   .57042566378-01  CD  =   .17864076974+01  ETA =   .18001834470+01
RHO =   .34372105538-02  Q   =   .14174118739+08  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =   .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   =   .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =   .40000000000+03  MD  =   .00000000000     CHIP=   .23016456588+03  CHIY=   .23539936750+02
DRNG=   .48835744892+07  XRNG=  -.13965671345+06  PANG=   .88285741411+02  DCEL=   .63795398739+01
PRES=   .25125357737+03  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=   .11065163815+02  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDO =   .11998271909-01  CLA =   .76011501781+00  EXA =   .00000000000     HTC =   .61073730421-08
CK1 =   .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73052000000+00
J   =   .97737152287+05  HT1 =   .35875626844+05  DHT1=   .15881178777+02  DCLI=   .15959867773+06
D2  =   .40358933654+02  LAT =   .37994080283+02  LONG=   .15355467947+03  LNGO=   .00000000000
LAM1=   .10579507330+18  LAM2=   .31449145572+18  LAM3=   .13380988228+18  HAM =  -.20502497852+19
LAM4=   .59177347574+18  LAM5=   .47124251237+19  LAM6=  -.99521861551+16  LAM7=   .10000000000+01
DLM1=   .12893438134+16  DLM2=   .36829105642+16  DLM3=   .16334596652+16  POPU=   .00000000000
DLM4=  -.74803374904+17  DLM5=  -.21185500928+18  DLM6=  -.11406236323+18  DLM7=   .00000000000

                                            INTERMEDIATE VALUES    11 INTEGRATION STEPS TAKEN

T   =   .80000000000+03  R   =   .64151301321+07  V   =   .35072626987+04  GM  =   .39860317000+15
X   =  -.21503457724+07  Y   =  -.53891491810+07  Z   =  -.27362344154+07  PHI =   .28608000000+02
DX  =  -.16736050309+04  DY  =   .19015500549+04  DZ  =  -.24257050989+04  AZ  =   .90000000000+02
DDX =   .12236711203+01  DDY =   .23653397706+00  DDZ =   .31181081606+01  ALT =   .44107047652+05
WKG =   .13280731000+06  VRX =  -.18487750726+04  VRY =   .18060125129+04  VRZ =  -.20998769391+04
VR  =   .33300350787+04  UX  =  -.62023230090+00  UY  =   .39567298136+00  UZ  =  -.67731439136+00
```

```
ALFA=   .95859737903+01  LFX =  -.45403650768+06  LFY =  -.86747023749+06  LFZ =  -.39633016969+06
BETA=   .79210760480+01  DFX =  -.18697601313+06  DFY =   .18265121828+06  DFZ =  -.21237122025+06
AREA=   .65821803840+03  CL  =   .12656155643+00  CD  =   .41041437024-01  ETA =   .18003101588+01
RHO =   .22484884804-02  Q   =   .82059349130+07  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =   .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   =   .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =   .40000000000+03  MD  =   .00000000000     CHIP=   .22751895422+03  CHIY=   .23307952664+02
DRNG=   .52421245707+07  XRNG=  -.17607245960+06  PANG=   .90029567917+02  DCEL=   .82209128068+01
PRES=   .16804849415+03  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=   .10294675529+02  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDD =   .12001635538-01  CLA =   .76000455414+00  EXA =   .00000000000     HTC =   .61073730421-08
CK1 =   .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73052000000+00
J   =   .10068000704+06  HT1 =   .37104161329+05  DHT1=   .10694148401+02  DCLI=   .16425585275+06
D2  =   .64793770109+02  LAT =   .35240626331+02  LONG=   .15186015108+03  LNGD=   .00000000000
LAM1=  -.28041511843+18  LAM2=  -.69734049023+18  LAM3=  -.36032471775+18  HAM =  -.30406873359+19
LAM4=  -.66135950225+18  LAM5=  -.16371026945+20  LAM6=  -.50276983760+19  LAM7=   10000000000+01
DLM1=  -.60944329981+16  DLM2=  -.15452852178+17  DLM3=  -.78209664445+16  POPU=   .00000000000
DLM4=   .26323231913+18  DLM5=   .43705296389+18  DLM6=   .28163923019+18  DLM7=   .00000000000

                                                  INTERMEDIATE VALUES    11 INTEGRATION STEPS TAKEN

T   =   .90000000000+03  R   =   .64163733321+07  V   =   .32073000125+04  GM  =   .39860319000+15
X   =  -.23118505290+07  Y   =  -.52006535629+07  Z   =  -.29628358691+07  PHI =   .28608000000+02
DX  =  -.15532931929+04  DY  =   .18616276855+04  DZ  =  -.20996180575+04  AZ  =   .90000000000+02
DDX =   .13640655468+01  DDY =  -.35960336108+00  DDZ =   .34916391480+01  ALT =   .44442791400+05
WKG =   .13280731000+06  VRX =  -.17429699548+04  VRY =   .17581781950+04  VRZ =  -.17700320370+04
VR  =   .30433777683+04  UX  =  -.66168555721+00  UY  =   .38972456783+00  UZ  =  -.64053640187+00
ALFA=   .12409580936+02  LFX =  -.50649786933+06  LFY =  -.86340800871+06  LFZ =  -.35887179024+06
BETA=   .97453478248+01  DFX =  -.22577020110+06  DFY =   .22774015327+06  DFZ =  -.22927560389+06
AREA=   .65821803840+03  CL  =   .16235509783+00  CD  =   .60187339100-01  ETA =   .18002962270+01
RHO =   .21487007106-02  Q   =   .65497709576+07  AE  =   .63781660000+07  BE  =   .63567840000+07
OM  =   .72921150604-04  FJ  =   .16234500072-02  FH  =  -.57500000139-05  FD  =   .78750000512-05
F   =   .00000000000     OMX =   .47881444528+00  OMY =  -.87791612754+00  OMZ =  -.77140676824-08
ISP =   .40000000000+03  MD  =   .00000000000     CHIP=   .22406955886+03  CHIY=   .22937362167+02
DRNG=   .55758740463+07  XRNG=  -.20169914608+06  PANG=   .89637710468+02  DCEL=   .85395215681+01
PRES=   .16091082149+03  UDX =  -.47030056530+00  UDY =   .40651458587+00  UDZ =  -.78330279570+00
MACH=   .93991165556+01  UDDX=   .22044155789-03  UDDY=  -.27374111417-03  UDDZ=   .57787813012-03
CDD =   .12172105383-01  CLA =   .75549615719+00  EXA =   .00000000000     HTC =   .61073730421-08
CK1 =   .00000000000     CK2 =   .50000000000+00  CK3 =   .50000000000+00  RCRV=   .73052000000+00
J   =   .10476603180+06  HT1 =   .38052589879+05  DHT1=   .79801306734+01  DCLI=   .17147947372+06
D2  =   .68073735511+02  LAT =   .32619459893+02  LONG=   .15051423460+03  LNGD=   .00000000000
LAM1=   .68849491243+18  LAM2=   .15617498403+19  LAM3=   .88695747099+18  HAM =  -.17581168673+20
LAM4=   .10966316338+20  LAM5=   .29587814408+20  LAM6=   .69009914778+18  LAM7=   .10000000000+01
DLM1=   .12912076807+17  DLM2=   .29307066339+17  DLM3=   .16631135117+17  POPU=   .00000000000
DLM4=  -.55656643058+18  DLM5=  -.11082431757+19  DLM6=  -.89496582440+18  DLM7=   .00000000000

                                                  INTERMEDIATE VALUES    12 INTEGRATION STEPS TAKEN

T   =   .10000000000+04  R   =   .64166216039+07  V   =   .28664768601+04  GM  =   .39860319000+15
X   =  -.24600059742+07  Y   =  -.50169029255+07  Z   =  -.31546930835+07  PHI =   .28608000000+02
DX  =  -.14091351306+04  DY  =   .17969842056+04  DZ  =  -.17325921442+04  AZ  =   .90000000000+02
DDX =   .14205657926+01  DDY =  -.12762336191+01  DDZ =   .37948827074+01  ALT =   .43882374571+05
WKG =   .13280731000+06  VRX =  -.16110943332+04  VRY =   .16868358861+04  VRZ =  -.13999371936+04
VR  =   .27204529776+04  UX  =  -.71459020134+00  UY  =   .37972864319+00  UZ  =  -.58750915030+00
ALFA=   .16059430731+02  LFX =  -.58969093795+06  LFY =  -.87603316086+06  LFZ =  -.37692865584+06
BETA=   .12104778890+02  DFX =  -.28663566418+06  DFY =   .30011111987+06  DFZ =  -.24906792794+06
```

```
AREA=   .65821803840+03  CL   =   .19859129120+00  CD   =   .85723672785-01  ETA  =   .17987463997+01
RHO  =  .23180749719-02  Q    =   .56461148681+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =  .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =  .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =  .40000000000+03  MD   =   .00000000000     CHIP=    .21942575901+03  CHIY=    .22316875084+02
DRNG=   .58785906815+07  XRNG=   -.21479808482+06  PANG=    .90258611413+02  DCEL=    .91958220006+01
PRES=   .17300980641+03  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
MACH=   .84159943681+01  UDDX=    .22044155789-03  UDDY=   -.27374111417-03  UDDZ=    .57787813012-03
CDO  =  .13372060375-01  CLA  =   .71788386620+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =  .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =  .10856992096+06  HT1  =   .38734395621+05  DHT1=    .59202746896+01  DCLI=    .17840544631+06
D2   =  .76520365576+02  LAT  =   .30188067235+02  LONG=    .14951270335+03  LNGO=    .00000000000
LAM1=  -.16448880756+19  LAM2=   -.33762257893+19  LAM3=   -.21285749362+19  HAM  =  -.57335415739+20
LAM4=   .21742088078+20  LAM5=   -.65926996672+20  LAM6=   -.29291313665+20  LAM7=    .10000000000+01
DLM1=  -.29422668534+17  DLMZ=   -.60689094188+17  DLM3=   -.38029414993+17  POPU=    .00000000000
DLM4=   .18599705034+19  DLM5=    .23748356703+19  DLM6=    .17544110327+19  DLM7=    .00000000000

                                                   INTERMEDIATE VALUES    14 INTEGRATION STEPS TAKEN

T    =  .11000000000+04  R    =   .64153256958+07  V    =   .24480941015+04  GM   =   .39860319000+15
X    = -.25938761754+07  Y    =  -.48457623235+07  Z    =  -.33085945163+07  PHI  =   .28608000000+02
DX   = -.12666204441+04  DY   =   .16097000364+04  DZ   =  -.13407845364+04  AZ   =   .90000000000+02
DDX  =  .15169963285+01  DDY  =  -.22514244137+01  DDZ  =   .40698835998+01  ALT  =   .41892074842+05
WKG  =  .13280731000+06  VRX  =  -.14784322094+04  VRY  =   .14941781405+04  VRZ  =  -.10055348898+04
VR   =  .23301138444+04  UX   =  -.78229509516+00  UY   =   .36193163875+00  UZ   =  -.50697127430+00
ALFA=   .18697688996+02  LFX  =  -.67369352941+06  LFY  =  -.91219103917+06  LFZ  =  -.36494576294+06
BETA=   .15193499308+02  DFX  =  -.35611775520+06  DFY  =   .35991056057+06  DFZ  =  -.24220848642+06
AREA=   .65821803840+03  CL   =   .21874198262+00  CD   =   .10305966860+00  ETA  =   .17868082414+01
RHO  =  .30478005663-02  Q    =   .54460372830+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =  .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =  .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =  .40000000000+03  MD   =   .00000000000     CHIP=    .21294551372+03  CHIY=    .21218871933+02
DRNG=   .61438932405+07  XRNG=   -.21401810932+06  PANG=    .90286951490+02  DCEL=    .99156859614+01
PRES=   .22432739353+03  UDX  =  -.47030056530+00  UDY  =   .40651458587+00  UDZ  =  -.78330279570+00
MACH=   .72588043610+01  UDDX=    .22044155789-03  UDDY=   -.27374111417-03  UDDZ=    .57787813012-03
CDO  =  .15247137877-01  CLA  =   .68234307127+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =  .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =  .11302492669+06  HT1  =   .39246239860+05  DHT1=    .42655903105+01  DCLI=    .18480361351+06
D2   =  .87534869285+02  LAT  =   .28003788585+02  LONG=    .14885473711+03  LNGO=    .00000000000
LAM1=   .42446406367+19  LAM2=    .79996588204+19  LAM3=    .54240374109+19  HAM  =  -.23220340163+21
LAM4=   .42274782031+20  LAM5=    .86074558920+20  LAM6=   -.81275230601+20  LAM7=    .10000000000+01
DLM1=   .47960570841+17  DLM2=    .90190105332+17  DLM3=    .61219957167+17  POPU=    .00000000000
DLM4=  -.34710969726+19  DLM5=   -.66129777382+19  DLM6=   -.63765088257+19  DLM7=    .00000000000

                                                   INTERMEDIATE VALUES    12 INTEGRATION STEPS TAKEN

T    =  .12000000000+04  R    =   .64132517645+07  V    =   .19687567687+04  GM   =   .39860319000+15
X    = -.27124632406+07  Y    =  -.46971443614+07  Z    =  -.34218673573+07  PHI  =   .28608000000+02
DX   = -.11005172069+04  DY   =   .13477395771+04  DZ   =  -.92112058063+03  AZ   =   .90000000000+02
DDX  =  .18022278305+01  DDY  =  -.31350107773+01  DDZ  =   .42822277468+01  ALT  =   .39251295355+05
WKG  =  .13280731000+06  VRX  =  -.13195805472+04  VRY  =   .12282626805+04  VRZ  =  -.58346824985+03
VR   =  .18948237996+04  UX   =  -.86566567832+00  UY   =   .32824780861+00  UZ   =  -.37798982728+00
ALFA=   .21246287678+02  LFX  =  -.74557683874+06  LFY  =  -.94980359527+06  LFZ  =  -.31322975522+06
BETA=   .19171464579+02  DFX  =  -.44141051232+06  DFY  =   .41086393721+06  DFZ  =  -.19517491346+06
AREA=   .65821803840+03  CL   =   .23832946793+00  CD   =   .12109638016+00  ETA  =   .17394291403+01
RHO  =  .44296252957-02  Q    =   .52341291775+07  AE   =   .63781660000+07  BE   =   .63567840000+07
```

```
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .20358831987+03  CHIY=    .19162458959+02
ORNG=    .63639221976+07  XRNG=  -.17835409366+06  PANG=    .90877945821+02  OCEL=    .10535859528+02
PRES=    .31872867378+03  UOX  =  -.47030056530+00  UOY  =   .40651458587+00  UOZ  =  -.78330279570+00
MACH=    .59700448268+01  UODX=    .22044155789-03  UODY=   -.27374111417-03  UODZ=    .57787813012-03
COD  =   .18819362783-01  CLA  =   .65768258133+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =   .11775530087+06  HT1  =   .39594048677+05  DHT1=    .27653138955+01  OCLI=    .19591655305+06
D2   =   .97860102542+02  LAT  =   .26134740719+02  LONG=    .14854912712+03  LNGO=    .00000000000
LAM1=   -.11390625598+20  LAM2=   -.20122538823+20  LAM3=   -.14559630497+20  HAM  =  -.11589852649+22
LAM4=    .37029017793+21  LAM5=   -.12409213350+21  LAM6=   -.24337227463+21  LAM7=    .10000000000+01
DLM1=   -.38167010790+17  DLM2=   -.68109227347+17  DLM3=   -.49687857216+17  POPU=    .00000000000
DLM4=    .13784185672+20  DLM5=    .19046603340+20  DLM6=    .94243282898+19  DLM7=    .00000000000

                                                     INTERMEDIATE VALUES    13 INTEGRATION STEPS TAKEN

T    =   .13000000000+04  R    =   .64097577928+07  V    =   .14117766677+04  GM   =   .39860319000+15
X    =  -.28126336160+07  Y    =  -.45799714984+07  Z    =  -.34925561096+07  PHI  =   .28608000000+02
DX   =  -.89035904569+03  DY   =   .97765408307+03  DZ   =  -.49453677638+03  AZ   =   .90000000000+02
DDX  =   .25676418810+01  DDY  =  -.42097946934+01  DDZ  =   .41500375236+01  ALT  =   .35328827494+05
WKG  =   .13280731000+06  VRX  =  -.11139477848+04  VRY  =   .85570903918+03  VRZ  =  -.15456284555+03
VR   =   .14131550871+04  UX   =  -.95067698469+00  UY   =   .26208990061+00  UZ   =  -.16589802525+00
ALFA=    .22144116774+02  LFX  =  -.77880101281+06  LFY  =  -.10550277090+07  LFZ  =  -.22808252530+06
BETA=    .23533690976+02  DFX  =  -.55512453676+06  DFY  =   .42643388716+06  DFZ  =  -.77024820379+05
AREA=    .65821803840+03  CL   =   .25619228659+00  CD   =   .13554833970+00  ETA  =   .16282769647+01
RHO  =   .79049982245-02  Q    =   .51954265985+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
ISP  =   .40000000000+03  MD   =   .00000000000     CHIP=    .18989873655+03  CHIY=    .15194105578+02
ORNG=    .65304022776+07  XRNG=  -.16890584441+06  PANG=    .91558893318+02  OCEL=    .11338592377+02
PRES=    .54632946610+03  UOX  =  -.47030056530+00  UOY  =   .40651458587+00  UOZ  =  -.78330279570+00
MACH=    .45430679854+01  UODX=    .22044155789-03  UODY=   -.27374111417-03  UODZ=    .57787813012-03
COD  =   .24584806397-01  CLA  =   .67966770279+00  EXA  =   .00000000000     HTC  =   .61073730421-08
CK1  =   .00000000000     CK2  =   .50000000000+00  CK3  =   .50000000000+00  RCRV=    .73052000000+00
J    =   .12317482835+06  HT1  =   .39807667003+05  DHT1=    .15324094265+01  OCLI=    .20654198971+06
D2   =   .11356664138+03  LAT  =   .24657448726+02  LONG=    .14859388437+03  LNGO=    .00000000000
LAM1=    .33509983795+20  LAM2=    .55425685729+20  LAM3=    .41617428569+20  HAM  =  -.73037088085+22
LAM4=   -.12967676609+21  LAM5=   -.20862262840+21  LAM6=   -.27997061430+22  LAM7=    .10000000000+01
DLM1=   -.36696058435+18  DLM2=   -.60545790012+18  DLM3=   -.46544704580+18  POPU=    .00000000000
DLM4=   -.24880979005+20  DLM5=   -.65567217412+20  DLM6=   -.99116815457+20  DLM7=    .00000000000

                                                     INTERMEDIATE VALUES    13 INTEGRATION STEPS TAKEN

T    =   .14000000000+04  R    =   .64052168646+07  V    =   .79781560526+03  GM   =   .39860319000+15
X    =  -.28864312089+07  Y    =  -.45938280497+07  Z    =  -.35229037536+07  PHI  =   .28608000000+02
DX   =  -.56289091529+03  DY   =   .59846140511+03  DZ   =  -.13730857429+03  AZ   =   .90000000000+02
DDX  =   .39568387107+01  DDY  =  -.40254643295+01  DDZ  =   .26460669027+01  ALT  =   .30512883611+05
WKG  =   .13280731000+06  VRX  =  -.78842246978+03  VRY  =   .42545675193+03  VRZ  =   .20473117729+03
VR   =   .91898764604+03  UX   =  -.97774312039+00  UY   =   .14076333775+00  UZ   =   .15557658333+00
ALFA=    .20172674371+02  LFX  =  -.66002479058+06  LFY  =  -.11245025719+07  LFZ  =  -.20490852591+06
BETA=    .24284971762+02  DFX  =  -.59140124000+06  DFY  =   .31913810210+06  DFZ  =   .15357029607+06
AREA=    .65821803840+03  CL   =   .28417470554+00  CD   =   .14891524582+00  ETA  =   .13488858340+01
RHO  =   .16710723932-01  Q    =   .46446649953+07  AE   =   .63781660000+07  BE   =   .63567840000+07
OM   =   .72921150604-04  FJ   =   .16234500072-02  FH   =  -.57500000139-05  FD   =   .78750000512-05
F    =   .00000000000     OMX  =   .47881444528+00  OMY  =  -.87791612754+00  OMZ  =  -.77140676824-08
```

```
ISP =   .40000000000+03   MD   =   .00000000000      CHIP=   .17095900414+03   CHIY=   .80920196640+01
DRNG=   .66343368821+07   XRNG=  -.13309755586+06    PANG=   .94058864428+02   DCEL=   .11212221876+02
PRES=   .10945096267+04   UDX =  -.47030056530+00    UDY =   .40651458587+00   UDZ =  -.78330279570+00
MACH=   .30348228566+01   UDDX=   .22044155789-03    UDDY=  -.27374111417-03   UDDZ=   .57787813012-03
CDD =   .34038897539-01   CLA =   .82405171940+00    EXA =   .00000000000      HTC =   .61073730421-08
CK1 =   .00000000000      CK2 =   .50000000000+00    CK3 =   .50000000000+00   RCRV=   .73052000000+00
J   =   .12897418806+06   HT1 =   .39910468830+05    DHT1=   .61274686741+00   DCLI=   .21803790730+06
D2  =   .11339329423+03   LAT =   .23674169789+02    LONG=   .14894035804+03   LNGD=   .00000000000
LAM1=  -.16502551209+21   LAM2=  -.26531392913+21    LAM3=  -.20815910516+21   HAM =  -.10608892163+24
LAM4=   .59986951960+22   LAM5=   .93719470505+22    LAM6=  -.25493468814+23   LAM7=   .10000000000+01
DLM1=   .26122762179+19   DLM2=   .40460844862+19    DLM3=   .30900536491+19   POPU=   .00000000000
DLM4=   .86806903766+20   DLM5=   .65364683800+21    DLM6=  -.63576646824+21   DLM7=   .00000000000

                                                     FINAL VALUES    11 INTEGRATION STEPS TAKEN

T   =   .14829448474+04   R   =   .64000000908+07    V   =   .36189403930+03   GM  =   .39860319000+15
X   =  -.29197954573+07   Y   =  -.44708777423+07    Z   =  -.35278956707+07   PHI =   .28608000000+02
DX  =  -.24620455087+03   DY  =   .26465101856+03    DZ  =  -.17619681832+02   AZ  =   .90000000000+02
DDX =   .35494276652+01   DDY =  -.26779992234+01    DDZ =   .18172805497+00   ALT =   .25181819794+05
WKG =   .13280731000+06   VRX =  -.47205568119+03    VRY =   .14147206908+03   VRZ =   .32540552097+03
VR  =   .59054184064+03   UX  =  -.88950635831+00    UY  =   .35457403627-02   UZ  =   .45690903498+00
ALFA=   .15494635309+02   LFX =  -.58709346161+06    LFY =  -.11195829554+07   LFZ =  -.36493261201+06
BETA=   .17005910127+02   DFX =  -.46944400617+06    DFY =   .14068936677+06   DFZ =   .32360519634+06
AREA=   .65821803840+03   CL  =   .28935202865+00    CD  =   .12914542746+00   ETA =   .97507822713+00
RHO =   .39620602729-01   Q   =   .45473900683+07    AE  =   .63781660000+07   BE  =   .63567840000+07
OM  =   .72921150604-04   FJ  =   .16234500072-02    FH  =  -.57500000139-05   FD  =   .78750000512-05
F   =   .00000000000      OMX =   .47881444528+00    OMY =  -.87791612754+00   OMZ =  -.77140676824-08
ISP =   .40000000000+03   MD  =   .00000000000       CHIP=   .15281198648+03   CHIY=   .20315638259+00
DRNG=   .64757025432+07   XRNG=  -.11126148251+06    PANG=   .10000012108+03   DCEL=   .10849603616+02
PRES=   .24673266375+04   UDX =  -.47030056530+00    UDY =   .40651458587+00   UDZ =  -.78330279570+00
MACH=   .20000171618+01   UDDX=   .22044155789-03    UDDY=  -.27374111417-03   UDDZ=   .57787813012-03
CDD =   .45996390058-01   CLA =   .10831144852+01    EXA =   .00000000000      HTC =   .61073730421-08
CK1 =   .00000000000      CK2 =   .50000000000+00    CK3 =   .50000000000+00   RCRV=   .73052000000+00
J   =   .13364914615+06   HT1 =   .39944369749+05    DHT1=   .25036118982+00   DCLI=   .22735392255+06
D2  =   .11142491745+03   LAT =   .23256379665+02    LONG=   .14932709513+03   LNGD=   .00000000000
LAM1=   .87481578884+21   LAM2=   .13093098518+22    LAM3=   .94297092338+21   HAM =  -.35690196666+25
LAM4=  -.50265472397+24   LAM5=   .62826842846+24    LAM6=  -.11934999779+25   LAM7=   .10000000000+01
DLM1=  -.43549581236+20   DLM2=  -.69947911211+20    DLM3=  -.60803334937+20   POPU=   .00000000000
DLM4=  -.40787025184+23   DLM5=   .41198259058+23    DLM6=  -.79309227558+23   DLM7=   .00000000000

                                                     END CONDITION MULTIPLIERS

  .10000000+01     .10000000+01     .10000000+01     .10000000+01     .10000000+01

                                                     BOUNDARY CONDITIONS

  .28381782-07     .17161867-04    -.20114871-05    -.13117416-05     .13265819-07     .87481579+21
  .13093099+22     .94297092+21    -.50265472+24     .62826843+24    -.11935000+25     .00000000

                                                     DESIRED VALUES

  .64000000+07     .20000000+01     .10000000+03     .60000000+02    -.10000000+01

ERR =******************
```

APPROVAL

MATHEMATICAL CONCEPTS AND HISTORICAL DEVELOPMENT OF THE MASCOT GUIDANCE TECHNIQUE FOR SPACE VEHICLES

by C. D. Baker, W. E. Causey, and H. L. Ingram

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

E. D. Geissler

E. D. Geissler
Director, Aero-Astrodynamics Laboratory

DISTRIBUTION

DIR
DEP-T
A&TS-PAT
A&TS-MS-H
A&TS-MS-IP
A&TS-MS-IL (8)
A&TS-TU, Mr. Wiggins (6)
PM-PR-M, Mr. Goldston

S&E-DIR
Dr. Weidner

PD-DIR

PD-DO
Mr. Goerner
Mr. Carlile
Mr. Goldsby (3)

PD-RV
Mr. Jean

S&E-CSE
Dr. Haeussermann
Mr. McNair
Mr. Hammers
Mr. Mack

S&E-AERO
Dr. Geissler
Mr. Horn
Mr. Lindberg
Mr. W. Vaughan
Mr. Dahm
Dr. Lovingood
Mr. Baker (100)
Mr. Sims
Dr. Blair
Mr. Buckelew
Mr. Hardage
Mrs. Brandon
Mr. Redus
Mr. McAnnally
Mr. Nunley
Mr. Ingram (20)
Mr. Foy
Mr. Phillips

S&E-AERO
Mr. Burrows
Mr. Galloway
Mr. Hooker
Mr. W. Deaton
Mr. Wood
Mr. McLeish
Mr. Schwaniger
Mr. Causey (20)

S&E-ASTR
Mr. Moore
Mr. M. Brooks (2)
Mr. Gassaway
Mr. Scofield
Mr. H. Brown
Mr. Ellsworth
Mr. George
Mr. L. Wood
Mr. Wojtalik

Sci. & Tech. Info. Facility (25)
P. O. Box 33
Attn: NASA Rep. (S-AK/RKT)
College Park, Md. 20740

Dr. Benjamin Lange
Dept. of Aero. & Astro.
Stanford University
Stanford, California

Mr. K. Phelps (3)
Honeywell Research Dept.
2345 Walnut Street
St. Paul, Minn. 55113

Mr. W. Geissler (3)
Dept. E238, Bl. 106, Mail Stop 406
P. O. Box 516
MDAC
St. Louis, MO 63166

Mr. Ted Michaels
NASA Hdqs.
Code REG
Washington, DC 20546

Mr. Richard Carley
NASA Hdqs.
Mail Code MH
Washington, DC 20546

Mr. Ralph Wittman
Aerodynamics
Grumman Aerospace Corp.
Bethpage, New York 11714

Mr. Wm. Klabunde
Northrop
Huntsville, Alabama

Mr. Robert Wells
Northrop
Huntsville, Alabama

Dr. Theodore Bettwy
Guidance and Navigation Laboratory
Systems Group of TRW, Inc.
One Space Park
Redondo Beach, CA 90278

Mr. Robert Ratner
Stanford Research Inst.
Menlo Park, CA

Dr. H. E. Tsou
TRW, Inc.
Systems Technology Drive
One Space Park
Redondo Beach, CA 90278

Dr. Kenneth Kimble
University of Tennesse Space Inst.
Tullahoma, TN

Mr. P. Rosati
McDonnell Douglas
Dept A 833, Mail St. 14
Huntington Beach, CA

Mr. W. Hayes
McDonnell Douglas
Dept A 3830, Mail Station 14
Huntington Beach, CA

Mr. L. Fortenberry (3)
McDonnell-Douglas - HO
16915 El Camino Real
Houston, Texas 77058

Mr. Butler
P. O. Box 516
McDonnell-Douglas
St. Louis, MO 63166

Mr. John Callahan
McDonnell-Douglas
P. O. Box 516
St. Louis, MO 63166

Mr. John Miller
INTERMETRICS, Inc.
380 Green Street
Cambridge, Mass. 02139

Mr. William Widnall
INTERMETRICS, Inc.
380 Green Street
Cambridge, Mass. 02139

Mr. John Hardtla
The Boeing Company
8H-40, 773-2300
Seattle, Washington

Mr. John Shaul
Aero Space Corp.
Bl A-2
2350 East El Segundo Blvd.
El Segundo, CA

Mr. David Engels (2)
Space Division
Mail Code AE55
North American Rockwell
12214 Lakewood Blvd.
Downey, CA 90241

Mr. John Rupert
A-3340
Honeywell
Systems & Research Division
Research Department
2345 Walnut Street
St. Paul, Minnesota 55113

Mr. James S. Farrior
Lockheed
Huntsville, AL

Mr. William Green
Lockheed
Huntsville, AL

Dr. Reynolds Beal
Lockheed
Huntsville, AL

Dr. Carroll D. Johnson
University of Alabama
Huntsville, Alabama

Mr. Lynn Small
IBM
Dept. 228, Bl 53
Sparkman Drive
Huntsville, AL

Mr. Dave Riggs (3)
IBM
Huntsville, Alabama

Dr. G. W. Johnson
IBM
1730 Cambridge Street
Cambridge, Massachusetts 02138

Mr. Ken Brown
IBM
1730 Cambridge Street
Cambridge, Massachusetts 02138

Lt. Col. Bowles
Hq. Space & Missile System Org.
A. F. Base P. O.
Los Angeles, CA 90045

Manned Spacecraft Center
Houston, TX
ATTN: Mr. John Mayer
Mr. Ken Cox (2)
Mr. Paul Thomas
Mr. John McAnulty
Mr. Paul Crammer
Mr. D. Cheatham
Mr. R. Abel
Mr. R. Nobles

Dr. William F. Powers (3)
Department of Aerospace Engineering
University of Michigan
Ann Arbor, Michigan

☆ U. S. GOVERNMENT PRINTING OFFICE: 1971 — 748-000 / 4012, REGION NO. 4