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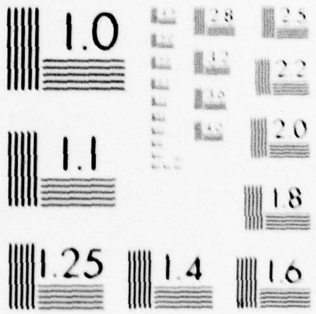
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(10) B.N. Tomlinson

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SESAME - A SYSTEM OF EQUATIONS FOR THE SIMULATION OF AIRCRAFT IN A MODULAR ENVIRONMENT

by

B. N. Tomlinson

SUMMARY

A system of equations has been developed for the simulation of an aircraft's motion in real time using a digital computer. Those parts of the mathematical model common to all aircraft have been created as a set of Fortran subroutines, leaving the user to create only a small group of routines specifically to describe his aircraft. The equations employed are defined and the computer implementation described in detail. The Report can be used as a handbook and 'user guide' but as the routines described are not specific to real-time simulation they could be used as a basis for a general mathematical model of an aircraft for use on any computer which supports Fortran.

Departmental Reference: FS 91

LIST OF CONTENTS

LIST OF CONTENTS (concluded)

1 INTRODUCTION

This Report describes a system of equations for the simulation of an aircraft's 'rigid-body' motion in real time using a digital computer. Known as SESAME - a System of Equations for the Simulation of Aircraft in a Modular Environment - it may be described as opening the door to flexible use of the simulator. Those parts of the mathematical model which are common to all aircraft, such as the equations of motion and axis transformations, have been created as a set of standard modules (written in Fortran), leaving the user to create only a small group of routines specifically to describe his aircraft. The two sets of modules are then linked together to produce a complete model program.

The simulator for which SESAME has been created changed from pure analogue to hybrid computing[1] in 1974. The computer system consists of a Xerox Sigma 8 digital computer linked to an Applied Dynamics AD4 analogue computer. This Report is concerned mainly with the digital computer aspects. In the early days of using this new computing facility, the aircraft's mathematical model, computed entirely digitally, was coded using SL1, a simulation language for solving sets of ordinary differential equations. With increasing experience and increasingly complex simulations, the single large program imposed by the SL1 language was found to be more and more inconvenient and the decision was taken to restructure the program into small, self-contained modules.

Such restructuring became feasible largely because a newly-created software package, for on-line parameter variation and inspection, provided the means to access and change, on-line, variables contained in subroutines.

Although the basic modules are themselves coded in Fortran, SL1 itself has been retained to provide the overall framework in which the modules sit. This is because SL1 provides facilities for numerical integration and for synchronisation with real-time.

The structure of the Report is as follows. After a discussion, in section 2, of the objectives to be achieved by the modular nature of SESAME, section 3 gives a brief theoretical background to the system equations, including such topics as choice of axes and definition of the equations of motion. This is followed in section 4 by an outline of how the equations to be solved are distributed among the specific routines. This is supplemented (in Appendix A) by a detailed definition of each routine and, as the ultimate specification for reference purposes, by a listing of the routines (Appendix B). Section 5 then describes the overall program structure in which the routines are embedded. Section 6 discusses how communication among routines is achieved using the Fortran named COMMON facility, and how the user should adopt the same technique for his routines. Hybrid input/output (analogue to digital and digital to analogue conversion, and single bit discretes) is also described in section 6 in terms of what the user receives and must provide, while section 7 is a general "User's Guide", summarising what the system expects from the user, defining the set of routines and the data the user must provide, and outlining the choices the user may make regarding the atmosphere, turbulence and other features.

The Report has been written with three principal aims: to provide primary simulator users with a description of the standard computer model and an outline of how to build it into a full simulation; to provide simulator customers with an idea of how the model is formulated and what must be done to represent an individual aircraft, so that they can, if necessary, contribute to the creation of a complete simulation model; and to provide a general description of a computer model for others interested in doing something similar.

2 OBJECTIVES

Specific objectives to be achieved by the modular system of equations concern size, testing, transferability, communication and execution time, and are intended to overcome detailed weaknesses of the simulation language SL1. However, as explained later in section 5.1, SL1 is retained as the appropriate language for the overall program, containing the individual modules.

2.1 Size

A complete model program is large, often exceeding 20000 words of computer storage. If coded entirely in SL1 source language this means many lines of code. The process of translating the SL1 source code into Fortran and then compiling is slow and tedious and must be repeated in its entirety whenever a change is made at source level. The present scheme drastically cuts the size of the SL1 source program, which in itself will speed up the translation/compilation process. In addition, changes at SL1 level will be rare, since the detail of a simulation is relegated to a lower level of routine. The existence of subroutines also provides the potential ability to create overlays, in order to reduce main store occupancy.

2.2 Creation and testing

Creation and checking of modules will be easier than handling a large SL1 program since routines, such as for the generation of the aircraft's aerodynamic forces, can be defined, created and tested in isolation before being included in the main program. Work could proceed in parallel on several routines, and be done by external users of the simulator, *ie* people who are not specialists in simulation as such.

Modifications will also be easier, since they should involve only revision of a single subroutine, its compilation and then creation of a new load module without having to repeat the SL1 translation.

Using Fortran rather than SL1 as the primary medium does not mean that all the useful SL1 facilities, such as function generation by table look-up, must be discarded. These can still be used at the Fortran level, since each one involves a Fortran-callable subroutine or function. However, the calling sequence will, in general, be more complicated in Fortran than in SL1. SL1 operators involving integration are not usable in subroutines without considerable effort.

2.3 Transferability

Having a modular structure means that simulation of a new aircraft requires only the creation of the routines specific to that aircraft. The standard parts can be picked up from libraries and special facilities, such as simulation of guidance beams, can readily be moved from simulation to simulation in subroutine form. With SL1 the only way of transferring across an existing piece of code is by explicit inclusion of the source lines and punching of the necessary cards.

None of the modules includes any compromising feature which limits its employment to real-time simulation. Hence the routines described could also form the basis for a conventional digital model of aircraft dynamics for use in non-real-time studies.

2.4 Communication

A defect of the SL1 language is the way most of the significant variables are lumped into one large block of labelled COMMON, the name of which is not fixed and the contents of which can change if the SL1 source code is varied.

In this new system communication of variables among all the modules is achieved by using Fortran labelled COMMON, but under *user* control. This retains the advantage of using COMMON storage, that variables are conveniently accessible by any subroutine without using arguments, thus saving execution time.

2.5 Execution time

The aircraft's motion is computed by repeatedly integrating the differential equations. If a multi-pass integration technique is used, such as Runge-Kutta fourth order, there are some sections of the equations which are not part of the dynamic loop and so need only be executed once per time step. Examples are calculation of ILS guidance and TV position signals. By having these elements as subroutines, it is easy to arrange that they are executed only as often as necessary and so save time for more important functions.

To date, aircraft model programs have been solved with only one basic loop or frame. SL1 does provide a means to execute one part at a different iteration rate from another. Should circumstances arise where more than one frame time is necessary, recasting of the model program (at SL1 skeleton level) will be aided by the simplicity of merely moving subroutine calls from one 'derivative' section to another, rather than blocks of code which would be necessary in a program coded completely in SL1. Communication between 'derivative' sections is also no problem when variables are in COMMON areas controlled by the user rather than by the SL1 translator.

2.6 Data logging

Access to variables for data logging purposes is easy and convenient. A self-contained data logging routine can be written knowing that all variables may be accessed without special action and without run-time inefficiencies.

3 SYSTEM EQUATIONS

3.1 Choice of axes

The first requirement is to choose sets of axes in which to solve the fundamental equations of motion. In classic texts[2-4] a set of axes fixed in the aircraft is generally chosen but, being a rotating frame of reference, such body axes result in the translational accelerations including angular velocity terms, as in

$$X - mg \sin \theta = m(\dot{u} + qw - rv) .$$

For efficient computer solution of the equations of motion, it is desirable to uncouple translational motion from rotational motion, a point which was made many years ago by Howe[5] and reiterated recently[6]. This may be achieved by suitable choice of axes. Then, since rotational motion of aircraft is intrinsically more rapid than translational motion, solution of the rotational equations may be performed more frequently than the translational equations without an excessive computing load, and while maintaining overall accuracy.

Body-fixed axes still provide a natural frame for the solution of rotational equations of motion, with the advantage of constant moments of inertia. Choice of axes therefore reduces to selecting an appropriate frame for the translational equations of motion.

So-called 'flight path axes' could be a suitable choice, with the origin at the aircraft's centre of gravity and the x axis aligned with the aircraft's velocity vector with respect to the ground. However, in the presence of winds and turbulence this introduces complications, so that, following Ref 7, the choice falls on earth-based axes.

3.2 Definition of axes

All axes systems used are orthogonal, right-handed triads.

3.2.1 Earth axes

Earth axes are an inertial frame assuming a flat, non-rotating earth. (See McFarland[7] for the case of a spherical, rotating earth.)

The origin is at a datum point on the visual model* in use, typically at the runway threshold and on the centreline. The x-axis points northward (suffix N), the y-axis points eastward (suffix E), the xy plane being parallel to the earth's surface, and the z-axis (suffix D) points down to the centre of the earth.

3.2.2 Geometric body axes

Geometric body axes have their origin at the aircraft's centre of gravity and are located with respect to the aircraft by some geometric feature such as the longitudinal fuselage datum line. Once defined they are fixed in the aircraft. The x-axis points forward, the y-axis to starboard and the z-axis 'down'.

3.3 Aircraft attitude

Aircraft angular orientation with respect to the earth is defined[8] by a conventional trio of Euler angles ψ, θ, ϕ . The heading angle ψ is measured from north and lies in the range 0, 360°; the elevation angle or pitch attitude θ is measured from the horizontal plane and lies in the range -90, +90°; the roll (or bank) angle is measured from the horizontal plane and lies in the range -180, +180°.

Rates of change of these angles may be related to the components of angular velocity of the aircraft by

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08

* Outside world cues are provided by a closed-circuit TV system viewing a physical model of an appropriate terrain.

$$\left.\begin{aligned} \dot{\theta} &= q \cos \phi - r \sin \phi \\ \dot{\phi} &= p + (q \sin \phi + r \cos \phi) \tan \theta = p + \dot{\psi} \sin \theta \\ \dot{\psi} &= (q \sin \phi + r \cos \phi) \sec \theta \end{aligned}\right\} \quad (1)$$

and the angles themselves obtained by integration. However, a singularity occurs at $\theta = 90^o$. If all-attitude manoeuvring is desired, an alternative formulation of equations is necessary. No provision has yet been made for multiple rolls or turns.

3.4 Transformation from earth to body axes

Transformation of a set of variables from earth axes to body axes (or vice versa) is most conveniently achieved through the direction cosine matrix[4,9]. For example, the components of airspeed in body axes (u_B, v_B, w_B) are related to the components in earth axes (V_N, V_E, V_D) by

$$\left.\begin{aligned} u_B &= \ell_1 V_N + \ell_2 V_E + \ell_3 V_D \\ v_B &= m_1 V_N + m_2 V_E + m_3 V_D \\ w_B &= n_1 V_N + n_2 V_E + n_3 V_D \end{aligned}\right\} \quad (2)$$

where ℓ_1 etc are the direction cosines, given by

$$\left.\begin{aligned} \ell_1 &= S_{11} = \cos \theta \cos \psi \\ \ell_2 &= S_{12} = \cos \theta \sin \psi \\ \ell_3 &= S_{13} = - \sin \theta \\ m_1 &= S_{21} = \sin \phi \sin \theta \cos \psi - \cos \phi \sin \psi \\ m_2 &= S_{22} = \sin \phi \sin \theta \sin \psi + \cos \phi \cos \psi \\ m_3 &= S_{23} = \sin \phi \cos \theta \\ n_1 &= S_{31} = \cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi \\ n_2 &= S_{32} = \cos \phi \sin \theta \sin \psi - \sin \phi \cos \psi \\ n_3 &= S_{33} = \cos \phi \cos \theta \ . \end{aligned}\right\} \quad (3)$$

In matrix form, equations (2) may be written

$$\left\{u_B\right\} = S\left\{V_N\right\} \tag{4}$$

where $\left\{u_B\right\}$, $\left\{V_N\right\}$ are column matrices (after Hopkin[4]) and S, the transformation matrix, is orthogonal, its transpose S^T being the same as its inverse.

The inverse relationship, for earth axes variables in terms of body axis variables, is then given by

$$\left\{V_N\right\} = S^T\left\{u_B\right\} . \tag{5}$$

Thus, for example, the total forces (suffix T) applied in body axes (suffix X, Y, Z) may be transformed to earth axes (suffix N, E, D) by

$$\left\{F_{TN}\right\} = S^T\left\{F_{TX}\right\} \tag{6}$$

which, expanded, is

$$\left.\begin{aligned} F_{TN} &= S_{11}F_{TX} + S_{21}F_{TY} + S_{31}F_{TZ} \\ F_{TE} &= S_{12}F_{TX} + S_{22}F_{TY} + S_{32}F_{TZ} \\ F_{TD} &= S_{13}F_{TX} + S_{23}F_{TY} + S_{33}F_{TZ} . \end{aligned}\right\} \tag{7}$$

Other vector components are related in the same way.

3.5 Equations of motion - translation

The components of acceleration with respect to the earth are obtained from

$$\left.\begin{aligned} \dot{V}_{KN} &= F_{TN}/m \\ \dot{V}_{KE} &= F_{TE}/m \\ \dot{V}_{KD} &= F_{TD}/m + g \end{aligned}\right\} \tag{8}$$

where the acceleration due to gravity, g, is assumed constant, and the forces F_{TN} etc in earth axes are obtained from the total forces in body axes F_{TX}, F_{TY}, F_{TZ} by the equations (7).

Integration of equations (8) yields the velocity components (V_{KN}, V_{KE}, V_{KD}) of the vehicle relative to the earth. Relative to the air mass, the velocity components of the aircraft are

)8

$$\left.\begin{aligned} V_N &= V_{KN} - V_{WN} \\ V_E &= V_{KE} - V_{WE} \\ V_D &= V_{KD} - V_{WD} \end{aligned}\right\} \qquad (9)$$

where V_{WN}, V_{WE}, V_{WD} are the components of the wind velocity relative to the ground.

The body-axes components of the velocity vector relative to the air may then be derived using equations (2) and (9), from which the velocity (or True Airspeed, TAS) is

$$V_T = \left(u_B^2 + v_B^2 + w_B^2\right)^{\frac{1}{2}} \qquad (10)$$

and equivalent airspeed is derived using the atmospheric density ratio

$$V = V_T\sigma^{\frac{1}{2}} \quad . \qquad (11)$$

Angles of attack and sideslip are computed from[10]

$$\alpha = \tan^{-1} w_B/u_B \qquad (12)$$

(α being in the range −180, +180°) and

$$\beta = \tan^{-1} v_B\Big/\left(u_B^2 + v_B^2\right)^{\frac{1}{2}} \qquad (13)$$

(β being in the range −90, +90° and taking the sign of v_B).

Derivatives of these angles with respect to time, needed to calculate the aerodynamic forces and moments, are created by simple difference equations. Flight path angles defining climb (γ) and track (χ) are derived from the velocity vector components relative to the ground, having first obtained the ground speed (V_K) as the horizontal component

$$V_K = \left(V_{KN}^2 + V_{KE}^2\right)^{\frac{1}{2}} \qquad (14)$$

$$\gamma = \tan^{-1}\left(-V_{KD}/V_K\right) \qquad (15)$$

$$\chi = \tan^{-1}\left(V_{KE}/V_{KN}\right) \quad . \qquad (16)$$

Positional coordinates x, y, h of the aircraft's centre of gravity are found by integrating the velocities

$$\left.\begin{aligned}\dot{x} &= V_{KN}\\ \dot{y} &= V_{KE}\\ \dot{h} &= -V_{KD}\ .\end{aligned}\right\}\qquad(17)$$

A block diagram of the translation equations is illustrated in Fig 1.

3.6 Equations of motion - rotation

It is assumed that the x and z body axes lie in a plane of mass symmetry so that products of inertia I_{yz} and I_{xy} are zero. Then the classical equations (Hopkin[4], section 10.1) may be manipulated to give

$$\left.\begin{aligned}\dot{p} &= \left\{L + \frac{I_{zx}}{I_z}N + \left[\frac{I_{zx}}{I_z}(I_z + I_x - I_y)\right]pq \right.\\ &\qquad \left. + \left[(I_y - I_z) - \frac{I_{zx}^2}{I_z}\right]qr\right\}\Bigg/\left\{I_x\left(1 - \frac{I_{zx}^2}{I_xI_z}\right)\right\}\\ \dot{q} &= \left\{M + I_{zx}(r^2 - p^2) + (I_z - I_x)rp\right\}\Big/ I_y\\ \dot{r} &= \left\{N + \frac{I_{zx}}{I_x}L + \left[(I_x - I_y) + \frac{I_{zx}^2}{I_x}\right]pq \right.\\ &\qquad \left. + \left[\frac{I_{zx}}{I_x}(-I_x + I_y - I_z)\right]qr\right\}\Bigg/\left\{I_z\left(1 - \frac{I_{zx}^2}{I_xI_z}\right)\right\}\end{aligned}\right\}\qquad(18)$$

or

$$\left.\begin{aligned}\dot{p} &= CI_1L + CI_2N + (CI_3p + CI_4r)q\\ \dot{q} &= CI_5M + CI_6(r^2 - p^2) + CI_7rp\\ \dot{r} &= CI_8N + CI_2L + (CI_9p + CI_{10}r)q\end{aligned}\right\}\qquad(19)$$

where CI_1 etc are constants evaluated during initialisation.

$$\left.\begin{aligned}
CI_1 &= I_z\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_2 &= I_{zx}\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_3 &= I_{zx}\left(I_x - I_y + I_z\right)\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_4 &= \left(I_z(I_y - I_z) - I_{zx}^2\right)\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_5 &= 1/I_y \\
CI_6 &= I_{zx}/I_y \\
CI_7 &= \left(I_z - I_x\right)\Big/I_y \\
CI_8 &= I_x\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_9 &= \left(I_x(I_x - I_y) + I_{zx}^2\right)\Big/\left(I_xI_z - I_{zx}^2\right) \\
CI_{10} &= -I_{zx}\left(I_x - I_y + I_z\right)\Big/\left(I_xI_z - I_{zx}^2\right) \quad .
\end{aligned}\right\} \qquad (20)$$

No terms are included in these equations (18) and (19) to allow for engine gyroscopic effects, but they could easily be added by the user when he provides the total moments L, M, N . It would also be straightforward to extend the equations to allow for a non-symmetric mass distribution.

Solution of the equations of rotational motion therefore consists in calculating the angular acceleration components from equations (19) given the total moments L, M, N ; integrating to obtain angular velocity components; transforming, using equations (1), to attitude rates; integrating again to attitude angles and calculating the direction cosines according to equations (3). This total process is illustrated in Fig 2.

3.7 Centre of gravity location

An aircraft's centre of gravity location is usually defined, in a fore-and-aft sense, in terms of a reference length such as the mean chord $\bar{c}$. Thus if the centre of gravity is quoted as being at $0.1\bar{c}$, then it is 10% of the reference chord *aft* of the origin. This convention is in a direction contrary to the normal positive sense of x, but will be retained here. The vertical location of the centre of gravity, however, is defined as being measured in the positive z direction (*ie* downwards) from some origin.

Aerodynamic moment data may often be quoted relative to some reference centre of gravity position, so that for an actual operational centre of gravity position, some correction is necessary. This is provided for as follows. If the moment reference position of the centre of gravity is $x_{cg\,ref}, z_{cg\,ref}$ and the actual centre of gravity position is x_{cg}, z_{cg}, all defined as fractions of some reference length c_{ref} then the differences are calculated as

$$\left.\begin{aligned} \Delta x_{cg} &= x_{cg} - x_{cg\,ref} \\ \Delta z_{cg} &= z_{cg} - z_{cg\,ref} \ . \end{aligned}\right\} \qquad (21)$$

Then differences are then available to correct aerodynamic moments to the current centre of gravity position.

3.8 Pilot position and positional rates

Given the coordinates x, y, h of the aircraft's centre of gravity, the pilot's position, needed to drive outside world displays, is obtained from

$$\left.\begin{aligned} x_{TV} &= x + (x_{pcg} \cos\theta + z_{pcg} \sin\theta) \cos\psi \\ y_{TV} &= y + (x_{pcg} \cos\theta + z_{pcg} \sin\theta) \sin\psi \\ h_{TV} &= h + (x_{pcg} \sin\theta - z_{pcg} \cos\theta) \end{aligned}\right\} \qquad (22)$$

where

$$\left.\begin{aligned} x_{pcg} &= x_p + \Delta x_{cg} c_{ref} \\ z_{pcg} &= z_p - \Delta z_{cg} c_{ref} \end{aligned}\right\} \qquad (23)$$

and x_p, z_p are the ooordinates of the pilot's eye point, assumed to be on the aircraft centre line, and defined relative to the reference centre of gravity position.

If we put

$$\left.\begin{aligned} R_{xp} &= x_{pcg} \cos\theta + z_{pcg} \sin\theta \\ R_{hp} &= x_{pcg} \sin\theta - z_{pcg} \cos\theta \end{aligned}\right\} \qquad (24)$$

then

$$\left.\begin{aligned} \dot{x}_{TV} &= \dot{x} - R_{xp}\dot{\psi}\sin\psi - R_{hp}\dot{\theta}\cos\psi \\ \dot{y}_{TV} &= \dot{y} + R_{xp}\dot{\psi}\cos\psi - R_{hp}\dot{\theta}\sin\psi \\ \dot{h}_{TV} &= \dot{h} + R_{xp}\dot{\theta} . \end{aligned}\right\} \quad (25)$$

3.9 Accelerations in body axes

Linear accelerations at the aircraft's centre of gravity, at the pilot's head and elsewhere (*eg* for accelerometers) are needed.

Referred to body axes, the components (in units of g) of the acceleration of the aircraft's centre of gravity are

$$\left.\begin{aligned} a_{xcg} &= F_{TX}/W \\ a_{ycg} &= F_{TY}/W \\ a_{zcg} &= F_{TZ}/W . \end{aligned}\right\} \quad (26)$$

These are referred to as the 'specific' accelerations and are the acceleration components that would be measured by a set of orthogonal, body-fixed, accelerometers aligned with the body axes and located at the centre of gravity of the aircraft. 'Absolute' accelerations, including the gravity components, are then

$$\begin{aligned} a_{xacg} &= a_{xcg} - \sin\theta &&= a_{xcg} + S_{13} \\ a_{yacg} &= a_{ycg} + \sin\phi\cos\theta &&= a_{ycg} + S_{23} \\ a_{zacg} &= a_{zcg} + \cos\phi\cos\theta &&= a_{zcg} + S_{33} . \end{aligned}$$

It should be remembered that a_{xacg} is not equal to $\dot{u}_b$ because the body axis system is rotating, as explained in any text, such as Etkin[3], Chapter 4.

At an arbitrary location $L(x_L, y_L, z_L)$, the components of specific acceleration are

$$\left.\begin{aligned} a_{x_L} &= a_{xcg} - \left[x_L(q^2 + r^2) - y_L(pq - \dot{r}) - z_L(pr + \dot{q})\right]\Big/ g \\ a_{y_L} &= a_{ycg} + \left[x_L(pq + \dot{r}) - y_L(p^2 + r^2) + z_L(qr - \dot{p})\right]\Big/ g \\ a_{z_L} &= a_{zcg} + \left[x_L(pr - \dot{q}) + y_L(qr + \dot{p}) - z_L(p^2 + q^2)\right]\Big/ g . \end{aligned}\right\} \quad (27)$$

The indication of an accelerometer or a 'g' meter may then be derived from equations (27) given the location of the device. Similarly the linear acceleration components at the pilot's station (x_p, z_p) may be derived for use in driving motion systems. Further details of the accelerations computed are given in the description of the SACCBOD routine in Appendix A.

3.10 Wind, wind shear and turbulence

Wind

A datum mean wind is defined in speed and direction by V_{WKTO} and ψ_W, from which the components in earth axes are obtained as

$$\left.\begin{aligned} V_{WNLO} &= -V_{WKTO} \cos \psi_W \\ V_{WELO} &= -V_{WKTO} \sin \psi_W \end{aligned}\right\} \qquad (28)$$

bearing in mind the convention that when ψ_W is zero, the wind is *from* the north. The vertical component of mean wind, V_{WDLO}, is normally assumed to be zero.

Wind shear

Wind shear is obtained as a multiplying factor f according to altitude, and the wind components at height are then

$$\left.\begin{aligned} V_{WNL} &= fV_{WNLO} \\ V_{WEL} &= fV_{WELO} \; . \end{aligned}\right\} \qquad (29)$$

This shear is effective only in magnitude, not in direction. Three choices are available: no shear (f = 1.0), logarithmic profile and linear profile. The initialisation process allows for actual wind at the initial height and sets up the aircraft's track to give a desired initial heading.

Turbulence

Turbulence in three orthogonal directions can be added to the components of the mean wind to give total wind components. Gust velocity components u_G, v_G, w_G are calculated by a new technique[12], based on the Statistical Discrete Gust theory of J.G. Jones[13], which allows the intermittent character of the generated turbulence to be controlled. Scaled components of turbulence u_T, v_T, w_T are obtained by

08

$$\left.\begin{aligned} u_T &= u_{sig} u_G \\ v_T &= v_{sig} v_G \\ w_T &= w_{sig} w_G \end{aligned}\right\} \qquad (30)$$

where u_{sig}, v_{sig}, w_{sig} are desired root-mean-square intensities. These turbulence components are considered to be along the wind, across the wind and vertical, so that the total fluctuating wind components, in earth axes, are

$$\left.\begin{aligned} V_{WN} &= V_{WNL} - (u_T \cos \psi_W - v_T \sin \psi_W) \\ V_{WE} &= V_{WEL} - (v_T \cos \psi_W + u_T \sin \psi_W) \\ V_{WD} &= V_{WDL} - w_T \quad . \end{aligned}\right\} \qquad (31)$$

3.11 Properties of the atmosphere

The properties of the ICAO International Standard Atmosphere[11] are calculated up to a maximum height of 65616 ft by the routine SATMOS (see description of SVELOC2 in Appendix A). Given altitude, it returns the density ratio, speed of sound ratio, temperature ratio and pressure ratio for a standard day. A routine ATMOS is also available for hot days but this is not integrated into SESAME. Strictly the altitude input should be 'geopotential' but below 65616 ft it is adequate to treat geometric and geopotential altitude as interchangeable.

The user may optionally choose to use constant atmospheric properties (as in many classical studies) or else allow standard variation with altitude. A software flag KISA controls this option.

4 TECHNICAL IMPLEMENTATION

Section 3 has defined a set of equations which compose the standard processes of any aircraft simulation. These equations are distributed among a series of modules for solution by digital computer. This section briefly describes the routines and their functions. Full details of each routine are given in Appendix A and listings are given in Appendix B. In general, system routines have names beginning with S . The routines fall into four categories:

Initialisation - SINIT, SYSCOM
Rotational motion - SDCOS, SEULER, SACCROT
Translational motion - SVELOC1, SALFBET, SACCLIN, SPATH, SVELOC2
Utility functions - STV, SILS, SWIND, SACCBOD, SATMOS, SCOUNT .

All the subroutines described in this Report are coded in Fortran. The particular dialect used is Xerox Extended Fortran IV, designed for the Xerox Sigma range of computers. It was not intended to use only those features of the language embodied in Standard Fortran IV and a few non-standard features have in fact been used. These include

variable names of up to 8 characters,
initialisation of COMMON variables within subroutines,
use of the NAMELIST feature (in SYSCOM only).

Conversion of the subroutines to run on another computer should, however, pose few problems.

4.1 Initialisation

Two routines (SINIT, SYSCOM) are specifically concerned with performing certain start-up, or initialisation, functions. Other initialisation functions may be performed internally in the other routines.

SINIT calculates various aircraft related constants, sets up initial height, derives initial values of atmospheric properties and initialises speeds and attitudes allowing for wind.

SYSCOM sets up communication with system variables by creating a NAMELIST table and reads 'semi-permanent' data changes from a file.

Execution of most routines during an initialisation pass is organised intrinsically by the SL1 model program (see section 5.2). Many routines may need to perform preliminary calculations. If their nature is such that they must be performed *once only* (otherwise errors will result) then a local flag must be created and the routine structured as in Fig 3a, with the flag set 'off' on entry (*eg* by a DATA statement). However, if there are no reasons why initial calculations should not be performed more than once there is a standard flag available in the system COMMON, JJCOMP, which takes the value 0 until the 'compute' button is pressed, and thereafter is 1. In this case the structure in Fig 3b can be used.

4.2 Rotational motion

A diagram of the information flow is shown in Fig 4. Rotational motion is calculated first, principally to provide the direction cosines required by the translational motion.

SACCROT calculates the three components of angular acceleration, in body axes, using equations (19), given total moments (supplied by the user) and inertia constants, equations (20), (calculated by SINIT).

SEULER calculates the rate of change of body attitude angles from the angular velocity components, using equations (1).

SDCOS calculates the nine direction cosines S_{11} etc from the three attitude angles ψ, θ, ϕ using equations (3).

4.3 Translational motion

A diagram of the information flow is shown in Fig 5.

SVELOC1 derives components of velocity, relative to the air, in earth axes using equations (9) and transforms to body axes, using equations (2).

SALFBET takes the body axes velocity components and calculates α, β, $\dot{\alpha}$, $\dot{\beta}$ using equations (12) and (13).

SACCLIN transforms total force components in body frame to inertial (earth) frame, using equations (7), then calculates the translational acceleration using equations (8). It may sometimes be desirable to separate the vertical from the two horizontal components so that vertical motion can be solved more frequently for better simulation of undercarriage dynamics.

SPATH calculates flight path angles from velocities in earth axes, using equations (15) and (16).

SVELOC2 calculates resultant airspeed, dynamic pressure, Mach number etc, using SATMOS for atmospheric properties. Some features are at present only valid for Mach number less than 1.0, as indicated in the routine.

4.4 Utility functions

Fig 6 shows the flow of information among the utility routines, all of which have something to do with the simulation environment, *eg* visual display, motion cues, wind etc.

STV calculates, from equations (22) to (25), positions and velocities to drive the TV visual system, and also handles the logic of belt positioning.

SILS calculates one or two segment ILS guidance beams.

SWIND controls the generation of turbulence and adds it to wind, modified by shear effects (if any).

SACCBOD calculates accelerations in body axes of the aircraft centre of gravity, from equations (26), and pilot station, accelerometers etc, from equations (27).

SATMOS calculates the properties (in ratio form) of the ICAO international standard atmosphere. It is an existing library subroutine and is not otherwise described in this Report.

A further utility routine, SCOUNT, not included in Fig 6, has nothing to do with the simulation of aircraft, but assists in the management of the calculation process, by setting an 'initialisation complete' flag, by keeping track of the sub-steps (if any) of the integration routine, and by picking up the current run number from the data logging system.

4.5 Units

With Aeronautics still retaining the use of such units as knots, it is difficult at present to make a wholehearted conversion to SI units. However, the equations set up are self-consistent so that a force in newtons acting on a mass in kilograms will produce an acceleration in m/s^2 and likewise, a force in pounds and mass in slugs will yield ft/s^2. The routines as set up are intrinsically in the feet, pound, second system but alteration of a few conversion constants (gravity, etc) and datum values (air density, etc), would enable the whole system to work in SI units.

5 OVERALL PROGRAM STRUCTURE

5.1 Introduction

The program which provides the general framework for all the system routines is written in the simulation language SL1[14].

The basic structure (Fig 7) consists of an INITIAL region, for start-up calculations, a DYNAMIC region and a TERMINAL region. (The TERMINAL region, however, has no relevance to real-time simulation.) This is a common form for continuous system simulation languages, like SL1 or CSMP. The DYNAMIC region contains one or more DERIVATIVE sections. These DERIVATIVE sections, each of which can have its own integration algorithm and step size, contain the routines which are the core of a simulation. During real-time operation, the code generated from each DERIVATIVE section is executed repetitively to produce the desired solution as a function of time. A listing of an aircraft simulation program with one DERIVATIVE section, or loop, is given in Appendix C, and corresponding flow charts of the execution sequence are shown in Fig 8. The reason for using SL1 is that two major facilities are provided by the language. These are synchronisation with real-time and a centralised integration scheme with a choice of five algorithms. Further details are contained in the Reference Manuals[14-16] and in Ref 1.

The SL1 program is translated into a series of Fortran modules. Communication is organised using Fortran labelled COMMON. To permit system COMMON to handle the main variables, however, some duplication of variables is necessary in order for SESAME routines to communicate with the integration operators.

This duplication is arranged through PROCEDURAL blocks, with the subterfuge that only those variables to be exchanged with the integration processes are contained in the argument list. Other variables thus remain invisible to the SL1 translator and so may be placed in system COMMON. If they were visible to the SL1 translator they would be placed in a separate COMMON area, no longer under control of the user.

For example, a PROCEDURAL block

```
PROCEDURAL (=VV)
        V  =  VV
END
```

picks up VV from the SL1 labelled COMMON and places its value in V . In the opposite direction

```
PROCEDURAL (VVDOT=)
        VVDOT  =  VDOT
END
```

transfers VDOT to VVDOT , for use in the integration statement

```
VV  =  INTEG (VVDOT, VVIC).
```

5.2 Initialisation

In the normal course of events, the code generated by the SL1 translator causes the DERIVATIVE section(s) to be executed just once at the end of INITIAL to calculate the initial values of all the derivatives. This has been augmented by explicit code (see near the 'END' of the INITIAL region in the SL1 listing in Appendix C) to force these calculations to be done twice. This is necessary because routines at the end of the sequence (such as SVELOC2) produce variables, such as dynamic pressure, needed early on. Once the whole system is running, there is no problem. This slight idiosyncracy needs to be remembered by the user. The other important point about initialisation is that at the start of a 008
new run, a *fresh copy* of the program is loaded into main store from a disc file,

so all parameter values are restored to their datum values. However, the 'retained changes' facility (see section 7.7) permits revised parameter values to be retained from run to run.

5.3 PV100 - operator dialogue

A set of programs and routines, collectively known as the parameter variation package, exists to enable the user to interact on-line with the parameters of the simulation. The principal item is PV100, the operator dialogue routine, which provides a wider range of facilities than the 'interpreter' inherent in SL1. PV100 enables the user, on-line and during any phase of a simulation flight, to access, display and amend any variable within the scope of the model program and its subroutines. Variables may be referred to by name (the principal function of routines SYSCOM and USERCOM is to provide tables of names for use by PV100), and in addition the contents of *any* memory location may also be displayed. A display may be in alternative styles, *eg* binary, hexadecimal, integer or 'real' format. Selected changes may be 'retained' to operate for subsequent runs, otherwise the change vanishes at the end of the current run. A readable memory dump may be printed, such as all the parameters in system COMMON. There is also a facility for forcing an 'automatic hold' or freeze if a variable falls within defined limits. A description of the full facilities is given elsewhere[17].

During initialisation there are four explicit calls to PV100 inserted at strategic points in the INITIAL region, as can be seen by inspection of the SL1 listing in Appendix C. These calls to PV100 are only executed if a switch (Desk Switch 1) on the simulator control desk is set on. These individual calls to PV100 may be identified by reference to the indicator ITP, as follows.

ITP = 1 After initial conditions or retained changes have been input, but before SINIT. Enables IC values to be altered, and other changes to be inserted before the main initialisation calculations of SINIT. In particular, if the frame time is to be altered, it should be done here, using FRAMET1, DELT1 for Loop 1 and similar variables for Loop 2 (if present).

ITP = 2 After SINIT but before the integrator IC values are actually set up.

ITP = 3 At end of INITIAL but before analogue to digital converter (ADC) read and DERIVATIVE section(s) initialised.

ITP = 4 After DERIVATIVE section(s) initialised and ADC read. DAC values are calculated but not yet set.

6 COMMUNICATION

6.1 Introduction

Communication among all the routines which comprise the aircraft model program is achieved by Fortran labelled COMMON. Labelled COMMON designates a block of contiguous memory locations which may be accessed by any subroutine in which the COMMON block is declared. This technique provides flexibility and also avoids the time penalty associated with using arguments in subroutine calls.

Two large blocks of labelled COMMON are employed. One, named SYSTEM, is an inherent part of the standard subroutines and contains all the state variables and other parameters common to any aircraft simulation. This is of fixed size and has its variables in predefined locations. The other, named USER, is set up, in terms of size and content, by the user to handle variables specific to his particular simulation, *eg* the aerodynamic force coefficients, engine forces etc.

6.2 System COMMON

This is defined as

```
COMMON / SYSTEM / A(1000), L(400)
```

where the array A contains real variables and L contains integer variables. An index to all the variables, in numerical and alphabetical order, is provided in Appendices D and E.

If the user wishes to pick up the current value of angle of attack (say) he needs to include in his routine

```
COMMON / SYSTEM / A(1000), L(400)
EQUIVALENCE (ALFAD , A(112))
```

and then ALFAD can be used freely in his routine. System variables must *not* be altered by the user.

6.3 User COMMON

This is defined for example as

```
COMMON / USER / B(1000), M(100)
```

where the array B is for real variables and M for integer variables. Names and sizes of these arrays are defined by the user, but the COMMON name USER must be employed. Sizes should be kept as small as possible, in order to avoid sterilising areas of core unnecessarily. However, if the size is too small, the user will have to increase it frequently, with consequent work updating *all* routines in which the COMMON statement appears.

The user will choose his own variable names and allocate space in the COMMON arrays. This will normally be done by EQUIVALENCE techniques, for flexibility. (Routines could, in fact, be created and checked in the first place without considering inter-routine communication.)

6.4 Documentation aids

A utility program has been created, called COMMLIST, to assist the user in keeping track of his variable names and locations. As he creates a variable, the user punches a card defining the variable name, its meaning and the routine in which it is calculated. This is similar to a scheme described by Bean[18]. The program COMMLIST can then produce an index of names in alphabetical order, of locations in numerical order or of names according to the routine in which they are created or used. A brief guide to the program COMMLIST is given in Appendix F. The lists in Appendices D and E, G and H have been produced by this program.

6.5 Access to variables at run-time

In order to be able to access his variables at run-time, to inspect and change values via PV100[17], the user must create a NAMELIST table of his variable names. This is achieved in the routine USERCOM, which must be written by the user. The bulk of this routine will be COMMON (or EQUIVALENCE) statements, referencing the variables by name. Its structure will be identical to the routine SYSCOM which does the same job for system variables. A listing of SYSCOM is included in Appendix B.

6.6 Hybrid input/output (ADC, DAC)

6.6.1 Introduction

Hybrid input/output, that is analogue to digital conversion (ADC) and digital to analogue conversion (DAC), is integrated into SESAME so that the user merely has to define entries in a set of tables incorporated in system COMMON. Conversion and scaling then occurs automatically. The general form of conversion required is of the form

$$y = ax + b$$

where a is a scale factor and b is a bias. For ADC, x would be a scaled value and y a value in 'engineering' units whereas, for DAC, x would be in engineering units and y a value scaled appropriately for output. The present implementation does not include any bias.

Data transfer in both directions employs a special piece of hardware known as the DMS12 (Direct Memory Sub System) which is a processor capable of operating in parallel with the computer's central processor. Use of this device provides for an element of parallel operation which is exploited in the software to save execution time.

Overall, the software scheme offers the user convenience - because he only has to set up data tables; flexibility - because the tables can be changed on line; and speed - because the hardware is fully exploited. The operating routines, coded in assembler, are not described in this Report.

6.6.2 Analogue to digital conversion

Analogue to digital conversion, and scaling, are executed prior to entry into the Derivative Section of the SL1 model program, where the dynamic equations are solved. The main scaling calculation performed is of the form

```
YADC(I) = ADC(NADC(I)) * AADC(I)
```

where ADC is the array of raw converted values, nominally in the range ±1.0, held in the SL1 labelled COMMON Z99999.

NADC is the array of ADC channel numbers

AADC is the array of scaling factors, set up by the user

YADC is the array of input values in engineering units (degrees etc) ready for use.

All 32 channels are read in raw form into the array ADC, but scaling and transfer to YADC stops when the first zero element in NADC is reached. Because of the parallel nature of the hardware (DMS12, mentioned above) scaling is begun as soon as the first raw converted value is available. Conversion of further channels then proceeds concurrently with scaling. To avoid the danger of scaling a channel before it has been converted, it is important, therefore, that ADC channels are kept in numeric order and are used, as far as possible, without large gaps. For example, to use channels 1, 3, 7, 9 is better than 1, 17, 24, 30. To use 1, 2, 3, 4 is best of all. Thus, for simplicity, NADC(I) = I.

The data structure being in table form allows considerable operational flexibility. For example, in the event of failure of ADC channel 2, the variable being input on this channel can be redirected to channel 9 (say) simply by repatching on the analogue computer and by changing the contents of NADC(2) from 2 to 9 via the keyboard. The scaling AADC(2) would not need to be altered. The necessary changes can all be achieved on-line and no program changes are necessary. However, the warning of the previous paragraph should not be overlooked.

At present 32 ADC channels are available and supported by software. Provision has been made for enlargement, however, by reserving 64 contiguous locations for each of the arrays AADC, YADC, NADC in the COMMON storage area.[1]

The SL1 model program includes in its source code (Appendix C) a sequence of the form

```
PROCEDURAL (=ADC(1))
END
```

in order to ensure that the key driving routine Z9991 is called. No special code has to be created by the user.

The user does, of course, wish to use the result of the conversion and scaling processes, as held in YADC. To do so he may either use an element of YADC directly, as in the following example

```
CL  =  CLETA*YADC(7) + .......
```

or may give the element of YADC his own names via the usual EQUIVALENCE declarations *viz*

```
DIMENSION YADC(32)
EQUIVALENCE (YADC(1), A(401))
EQUIVALENCE (ETAD    , YADC(7))
```

and then

```
CL  =  CLETA * ETAD + ......
```

To make his variable names accessible via PV100, the user could include them in subroutine USERCOM.

6.6.3 Digital to analogue conversion

Digital to analogue conversion occurs once per frame, *after* the main integration loop. The DAC software scales output variables to be in the settable range for DACs and DCUs (otherwise known as vari-DACs).

In principle, the same calculation technique is adopted as for ADC. The special difficulty for variables to be output to DACs is that they must be selected from any location in the system or user COMMON arrays (A or B) and must be routed either to proper, four-quadrant DACs (the first 32) or to two-quadrant vari-DACs (the next 16). An additional requirement is that it should be possible to set DACs from either of two loops. (This description refers for completeness to two loops. For the moment, however, only Loop 1 is operational.)

To achieve these objectives, data for four arrays must be defined by the user.

ADAC	array of scaling factors. A variable in engineering units is multiplied by the scaling factor in the appropriate element to give a result in the desired range (nominally ±1.0).
NADC	is the array of pointers defining which variables are to be converted. The pointers may refer to the 'A' or 'B' arrays in any sequence. Distinction between the source arrays is controlled by arrays L1DAC, L2DAC below.
L1DAC	defines the source of data for each channel to be converted in Loop 1.
L2DAC	defines the source of data for each channel to be converted in Loop 2. Each element of L1DAC, L2DAC can take the value 0, 1 or 2: 1 means that the data for scaling is to be taken from array A and 2 that it comes from array B. If 0 is set, no scaling is performed.

As an example, if NDAC(6) = 112, L1DAC(6) = 1, ADAC(6) = 0.1 then DAC channel 6 is to be used to output, at the end of Loop 1, variable A(112), *ie* ALFAD, angle of attack in degrees, scaled to ±10.0.

This structure provides flexibility by enabling changes to be introduced on-line. For example, by changing NDAC(6) from 112 to 241 (say), and changing the scaling ADAC(6) to suit, a different variable from the same array can be output on a given DAC. The source array (A or B) can also be easily changed, via L1DAC.

Operational considerations

(1) Of the 48 DAC channels available, the first 32 are true DACs, while the rest are only two-quadrant devices. The user needs to remember this when allocating channels, so that 33-48 are only used for variables which do not change sign, *eg* airspeed. Provision has been made for expansion to 64 channels by reserving extra space for ADAC, NDAC in the COMMON area.

(2) For those DAC channels not used, the corresponding elements of ADAC should be set to zero.

(3) A set of default hardware addresses associated with channel numbers is defined in the table IDACAD. DAC addresses can be reassigned during initialisation.

(4) Timing tests have given the following results:

Convert and scale 32 ADC channels	1.2 ms
Scale and convert 48 DAC channels	3.8 ms .

All channels are converted, but only those specified are scaled and stored, 008
so that time can be saved if fewer channels are needed.

6.6.4 User summary of system COMMON relevant to ADC/DAC

A	301 364		401 464		501 564
	1 AADC 64		1 YADC 64		1 ADAC 64

A	System COMMON array (real)
AADC*	Array of scaling factors for ADC
YADC	Array of converted variables
ADAC*	Array of scaling factors for DAC

L	11 74	82 144		305 352	353 400
	1 NDAC 64	1 NADC 64		1 L1DAC 48	1 L2DAC 48

L	System COMMON array (integer)
NDAC*	Array of pointers defining variables in 'A' array and user's 'B' array to be converted
NADC*	Array of ADC channel numbers
L1DAC*	Array of DAC source pointers for Loop 1
L2DAC*	Array of DAC source pointers for Loop 2

6.7 Hybrid input/output (discretes)

6.7.1 Introduction

Discretes are single-bit logic lines enabling on/off information to be communicated into and out of the computer. These lines are read and set automatically and so are conveniently available to the user.

6.7.2 Summary of lines available

A number of lines are available in each direction

(a) between the digital computer (Sigma 8) and the analogue computer (AD4) and

(b) between the digital computer and other external hardware, such as the simulator cockpits and the control desk. The numbers and types are summarised in the table below, together with the relevant driving routine.

---

* These items must have values supplied by the user. It is recommended that, for convenience, all such data be located in one routine, such as OUTSR, or a self-contained 'information' routine.

	Type	Location	Number	Direction	Subroutine
(1)	AD4 sense lines	AD4 logic patch panel	16	To Sigma 8	READSLR
(2)	AD4 control lines	AD4 logic patch panel	16	From Sigma 8	SETCLR
(3)	Patchable sense lines	Rack N logic patch panel	32	To Sigma 8	READSCR
(4)	Desk switches	Bay 5 of control desk	32	To Sigma 8	
(5)	Relay change-overs	Rack N logic patch panel	32	From Sigma 8	SETDSCR

The driver routines READSLR etc are themselves executed by one of two supervisor routines DSCRT1 and DSCRT2. DSCRT2 is only relevant if the model program is structured to have two iteration loops.

6.7.3 Software interface

Discrete information to be input or output is communicated via the labelled COMMON system, *viz*

COMMON/SYSTEM/A(1000), L(400).

The basic routines which handle the hardware are called implicitly and convert from bit patterns in 32-bit words to arrays of integers, as defined below. Each integer can take the value 0 or 1. Thus no coding or decoding (packing or unpacking) of bits is necessary by the user.

The layout of the relevant parts of L is

L	150	151 166	170	171 186	190	191 222	223 254	270	271 302
		1 ISLR 16		1 ICLR 16		1 IP 32	1 IDS 32		1 ICO 32
	IAD4SL		IAD4CL		IDSCFL			IPCOFL	

where ISLR(16)	is the AD4 sense line array, ISLR(1) corresponding to DGS00 on the AD4 patch panel (remember the AD4 is marked in octal!)
ICLR(16)	is the AD4 control line array, ICLR(1) corresponding to DGC00 on the AD4 patch panel
IP(32)	is the array of patchable sense lines
IDS(32)	is the array of desk switches
ICO(32)	is the array of relay change-overs

IAD4SL, IAD4CL, IDSCFL, IPCOFL are flags, defined in detail in section 7.4.1 below, which control in which iteration loop, if any, the discretes routines are executed.

All these names are defined in SYSCOM, to be accessible by PV100. For the user to obtain access to ISLR(3), for example, he will include in his routine

```
COMMON/SYSTEM/A(1000), L(400)
```

and either

```
EQUIVALENCE (ISLR(1), L(151))
DIMENSION ISLR(16)
```

or

```
EQUIVALENCE (ISLR(3), L(153))
```

The former is more general. Discrete information is then available for use in such constructs as

```
IF (ISLR(3).EQ.1) CALL XYZ
```

6.7.4 Dedicated functions

Some of these discrete lines are dedicated to certain functions within SESAME, as summarised in the following list.

Line	Purpose	Routine
ISLR(4)	Slew forward	STV
ISLR(5)	Slew back	STV
ICLR(16)	TV Desync	STV
IDS(1)	PV100 select	SL1
IDS(5)	TV cycle	STV
IDS(6)	X TV reset	STV
IDS(7)	Y TV reset	STV
IDS(8)	Turbulence	SWIND

7 USER'S GUIDE

7.1 What the system expects from the user

The user is required to provide the three components of total force (FTX, FTY, FTZ) and the three components of total moment (XLLTOT, XMMTOT, XNNTOT), all in body axes. Thereafter the appropriate integrations, resolutions etc occur, with the system providing back to the user all the state variables from which the forces etc are generated. Various constants must also be provided. These are described in section 7.3.

7.2 Typical user routines

The user is required to create the following set of routines, which may perform some or all of the tasks indicated.

'Input'

CONTROLS	takes the raw control inputs from the pilot, applies any non-linear gearings, computes autostabiliser contributions and finishes up with the total control surface deflections, for use by the aerodynamics routines. It may also organise the computation of engine performance, including dynamics, and total thrust, momentum drag etc.

'Calculation loop'

TOTF	computes aerodynamic force coefficients etc, finishing up with three components of total force from all sources.
TOTM	computes aerodynamic moment coefficients etc, finishing up with three components of total moment from all sources.

'Output'

OUTSR	computes miscellaneous functions, *eg* scalings of non-linear instruments, navigation and guidance and handles data logging.

'Initial'

USERCOM	contains the names of all the variables the user may wish to access via PV100, and also reads semi-permanent data changes from a file.

* These routines are actually called at SL1 level. All are executed in a DERIVATIVE section, except USERCOM, which is executed in INITIAL.

* All these routines are likely to be umbrella routines, in the sense that they are likely merely to organise the calling of other, more detailed, routines. For example, TOTF may call a routine to compute all ground reactions, tyre forces etc.

* Ideally, TOTF and TOTM should be kept separate, so that they can, if necessary, be executed in different loops at different frame times.

* Routines in the calculation loop may be executed up to four times per frame, depending on the integration technique employed, *eg* Trapezoidal, Runge-Kutta fourth order. All other routines are only executed once per frame (see section 5.4).

* Each routine should, as far as possible, contain its own constants.

* The method for communication of variables other than by lengthy argument lists has been described in section 6.

7.3 Data the user must provide

In addition to the primary forces and moments (FTX, XLLTOT, etc) and initial values (section 7.5), the user must provide values for a number of constants and parameters. These fall into such categories as basic data, hybrid input/output and external environment. They are described briefly below and listed in full in Appendices G and H. Typically the values will be provided by DATA statements in appropriate subroutines (*eg* TOTM, TOTF), unless default values are already provided, in which case new values should be provided in the SYSCHNG file (section 7.7). Zero values should be set up if the parameter is not relevant.

Aircraft basic data

Moments of inertia	XIX, XIY, XIZ, XIZX
Centre of gravity	XCGREF, ZCGREF, ZCG
Span, wing area etc	SPAN, SWREF, STAIL, XLTAIL, CREF
Pilot location	XP, ZP
Coordinates of slip ball	X1, Y1, Z1
Coordinates of g meter	X2, Y2, Z2
Coordinates of accelerometer (AX3)	X3, Y3, Z3
Coordinates of accelerometer (AY4)	X4, Y4, Z4
Coordinates of accelerometer (AZ5)	X5, Y5, Z5

Timing

Frame time	FRAMET1, FRAMET2
Step size	DELT1, DELT2

Hybrid input/output

Scaling factors for analogue to digital conversion etc, (for full details refer to section 6.6)	AADC, ADAC L1DAC, L2DAC, NDAC, NADC
Output discretes (see section 6.7)	ICLR, ICO

External environment

Turbulence rms	USIG, VSIG, WSIG
Turbulence character	NG, SFRACG, SRDECAY
Ship speed	VSHIPKT

Additional integer parameters which can take one of several specific values and thereby select alternative functions are described in the next section.

7.4 Options available

A number of choices may be made by software flags or hardware switches. These are summarised below, with default values where relevant.

7.4.1 Software flags

(a) Variation of atmospheric properties

KISA	default 0 set in SINIT
0	constant sea level conditions at all times
1	standard atmosphere as function of current height
-1	constant properties appropriate to initial height (HIC).

FOR KISA = 1, SATMOS is called within SVELOC2 to calculate the new properties. Otherwise, constant values are set up within SINIT.

(b) Selection of constants for TV belt in use

NTVB	no default
1	700:1 model
2	2000:1 model
3	5000:1 model

(c) ILS on/off

LSILS	no default
0	ILS off
1	ILS on

(d) Type of ILS beam

ILSFLG	no default, value obtained from XILSFLG (see section 7.5.2)
1	3° straight beam
2	6° straight beam
3	6° changing to 3° at height HKINK (qv)

(e) Discretes in and out (see also section 6.7)

IAD4SL	AD4 sense lines (default 1 set in DSCRT1)
IAD4CL	AD4 control lines (default 1 set in DSCRT1)
IDSCFL	discretes in to Sigma (default 1 set in DSCRT1)
IPCOFL	discretes out from Sigma (default 0 set in DSCRT1)
0	do not execute at all
1	execute in DSCRT1, *ie* in fast loop
2	execute in DSCRT2, *ie* in slow loop (if any)

(f) Wind shear

ISHR	default 1, set in SINIT
1	no shear
2	logarithmic profile
3	linear profile

The value of ISHR is obtained from XISHR set up in the Initial Conditions file.

(g) Control of random number generation for turbulence

LSEED default 0, set in SWIND

0	seeds for random number generation derived from time of day
1	constant seeds employed, enabling a repeatable turbulence sequence to be obtained

7.4.2 External switches

Desk switch	Name	Purpose when set on
1		Calls PV100 during INITIAL
5	LCYCLE	TV belt cycles continually
6	LXTVIC	Resets TV x position
7	LYTVIC	Resets TV y position
8	LTURB	Turbulence
TV slew	LFWD	TV belt (and x position) moves forward at maximum rate
TV slew	LBACK	TV belt (and x position) moves backward at maximum rate

7.5 Initial conditions and initial values

7.5.1 Initial conditions

The standard SL1 model embodies 12 integrations, each of which requires an initial condition. These are given in the table below as 'SL1 names'. Many of these variables do not form a natural or convenient set for the user, who is more interested, for example, in specifying an initial airspeed rather than components of speed relative to the ground, or an initial angle of attack rather than pitch attitude. Hence SINIT performs various calculations to transform a user's initial values into those that the system requires.

One particular feature is that, regardless of the wind, the ground speed components are derived implicitly to satisfy the specified initial *heading* PSIDIC so that any datum wind or wind shear conditions are not revealed inadvertently to the pilot. More detail is given in the description of the SINIT routine in Appendix A.

SL1 names	Source	Definition
VVKNIC	Calculation	Velocity comp rel to ground, north
VVKEIC	Calculation	Velocity comp rel to ground, east
VVKDIC	Calculation	Velocity comp rel to ground, down
SXIC	XIC	X position
SYIC	YIC	Y position
SHIC	HIC	Height
PPIC	PDIC, default zero	Rate of roll, body axes
QQIC	QDIC, default zero	Rate of pitch, body axes
RRIC	RDIC, default zero	Rate of yaw, body axes
PPHIC	PHIDIC, default zero	Roll attitude angle
TTHIC	Calculation	Pitch attitude angle
PPSIC	PSIDIC	Heading angle

008

7.5.2 Initial values

Initial values are parameters relevant to the current 'run' and are not in general true initial conditions for integration. However, those initial conditions listed above that are not calculated are obtained from a set of initial values created by the user in a file. This file is read, during the INITIAL phase, by the routine RDICFILE and its contents stored in a 20-element array (A(191) - A(210)) which is part of system COMMON.

At present only 14 elements are actually used (as defined by the value of NVALS). These are

Name	Element	Definition	Units
BETADIC	A(191)	Sideslip angle	degrees
ALFADIC	A(192)	Angle of attack	degrees
GAMDIC	A(193)	Climb angle	degrees
VKTIC	A(194)	Airspeed	knots
XIC	A(195)	X position	feet
YIC	A(196)	Y position	feet
HIC	A(197)	Height	feet
W	A(198)	Aircraft weight	pound
XCG	A(199)	Aircraft centre of gravity	fraction of ref chord
XILSFLG	A(200)	ILS flag (actually used in integer form, ILSFLG)	
XISHR	A(201)	Wind shear flag (actually used in integer form, ISHR)	
VWKT0	A(202)	Datum wind speed	knots
PSIWD	A(203)	Wind direction	degrees
PSIDIC	A(204)	Aircraft heading	degrees
Spare	A(205) - A(210)		

Additional items could be read by increasing NVALS, *eg* by inputting a new value from the semi-permanent changes file (see section 7.7) read in SYSCOM.

7.6 Modification status

To keep track of the modification status of each routine, it is recommended that the user allocate an identifier per routine and assign a value to identify the version. For example, with the routine TOTF

```
DATA MTOTF / 1 /
```

to indicate version 1, or

DATA MTOTF / 171176/

to indicate the date of the current version. These values should be changed whenever the routine is modified. By placing these status identifiers in user COMMON, the current versions of each routine can be readily checked on-line.

This technique has been adopted for all the SESAME routines. The name of the version identifier is the routine name preceded by K , *eg* for routine SALFBET, the identifier is KSALFBET and contains the date in integer form. These identifiers are held in system COMMON (see Appendix E).

Identification of a new version of the executable program, or load module, is desirable. The SL1 model program has a version number (IVERSION) for its *source* code, but this is not changed if a new load module is built without changing the SL1 source. Identifying individual routines as above will help but a global load module identifier could also be created in a 'history' routine, the only purpose of which is to set a version number for the load module, *eg*

DATA LHARRIER / 240776 /

and perhaps also to include a modification history in 'comment' form.

A recent modification to the loader utility in the RBM operating system now places the date and time of load module creation into the program header. This information can be inspected from the keyboard.

7.7 Changes to parameters

It is possible to introduce lasting parameter changes into a completed and working aircraft model program without recoding.

On-line changes can be achieved from a keyboard, during any mode of a simulation, through the program PV100[17]. The user has the option, at the time of making the changes, of declaring that the changes be 'retained', in which case they are automatically copied into a file and read back again (by PV300) at the start of each subsequent run. These changes are initially name-orientated, but PV300 relies on absolute address so that if alternative aircraft model programs are used, the retained changes file needs to be reset.

Semi-permanent changes to a user's parameters held in USER COMMON may be achieved by creating (from cards) a file called USERCHNG which is read each time the routine USERCOM is executed. Changes to parameters in SYSTEM COMMON may be achieved by a similar process, via the file SYSCHNG. All these changes work only by parameter name, as explained in the description of SYSCOM in Appendix A.

)08

7.8 Operational considerations

The binary versions of all SESAME routines, in relocatable form (ROM), are held in files on disc and may be incorporated when building, via OLOAD, the final executable program. To ensure that the size of user defined COMMON is correctly set up, it is essential that a user ROM containing the definition of USER COMMON be loaded *before* SDAC.

If data logging is in use, the correct run number may be obtained by inspecting the variable NRUN.

8 CONCLUSIONS

A system of equations and associated computer subroutines has been developed to make it easy to create an aircraft model program for real-time flight simulation. Several simulations have been completed and it has been found to be very useful. The objectives of the scheme have been achieved. In particular, the resulting model program is more efficient during execution in terms of time required and the modular structure has also given the desired benefits at the program development stage.

The facilities of SESAME are described as they exist at the time of publication of this Report. Extensions and enhancements may easily be added as new needs arise.

Furthermore, the routines as described in this Report are not specific either to real-time simulation or to the computer on which they have been developed. They are written in Fortran and, supplemented by appropriate integration techniques, could be used on other computers for general purpose calculations of aircraft dynamics in six degrees of freedom.

Appendix A

DESCRIPTION OF INDIVIDUAL SESAME ROUTINES

Section	Routine	Source file	Binary file (ROM)
A.1	SACCBOD	SACBS	SACBR
A.2	SACCLIN	SACLS	SACLR
A.3	SACCROT	SACRS	SACRR
A.4	SALFBET	SALFS	SALFR
A.5	SCOUNT	SCNTS	SCNTR
A.6	SDCOS	SDCSS	SDCSR
A.7	SEULER	SEULS	SEULR
A.8	SILS	SILSS	SILSR
A.9	SINIT	SINTS	SINTR
A.10	SPATH	SPTHS	SPTHR
A.11	STV	STVVS	STVVR
A.12	SVELOC1	SVL1S	SVL1R
A.13	SVELOC2	SVL2S	SVL2R
A.14	SWIND	SWNDS	SWNDR
A.15	SYSCOM	SYSCS	SYSCR
A.16	DSCRT1	SCR1S	SCR1R
A.16	DSCRT2	SCR2S	SCR2R
A.17	ISDSCR	ISDCS	ISDCR

A.1	Subroutine	SACCBOD
A.1.1	Purpose	Calculates accelerations, in body axes, of aircraft centre of gravity (cg), pilot and various accelerometer locations.
A.1.2	Call	CALL SACCBOD
A.1.3	Inputs	P,Q,R PDOT, QDOT, RDOT RG, W FTX, FTY, FTZ S13, S23, S33 XP, ZP X1, Y1, Z1; X2, Y2, Z2; X3, Y3, Z3; X4, Y4, Z4; X5, Y5, Z5
A.1.4	Outputs	AXCG, AYCG, AZCG AXACG, AYACG, AZACG AXP, AYP, AZP AZAP, AZCG1 AY1, AZ2, AX3, AY4, AZ5
A.1.5	Data required	XP, ZP X1, Y1, Z1; X2, Y2, Z2; X3, Y3, Z3; X4, Y4, Z4; X5, Y5, Z5

A.1.6 Description (NB all accelerations in units of g) - see also section 3.9

A.1.6.1 Specific accelerations at aircraft centre of gravity (as measured by an accelerometer).

$$a_{xcg} = F_{TX}/W$$

$$a_{ycg} = F_{TY}/W$$

$$a_{zcg} = F_{TZ}/W$$

Note that in steady level flight, with $\theta = 0$, a 'normal' accelerometer at the centre of gravity registers -1 g and in a pull-up, for example, registers -1.5 g.

A.1.6.2 Absolute accelerations at aircraft centre of gravity

$$a_{xacg} = a_{xcg} + S_{13}$$

$$a_{yacg} = a_{ycg} + S_{23}$$

$$a_{zacg} = a_{zcg} + S_{33}$$

S_{13}, S_{23}, S_{33} are direction cosines, *eg* $S_{13} = - \sin \theta$.

A.1.6.3 Accelerations at pilot

$$a_{xp} = a_{xcg} - \left[x_p(q^2 + r^2) - z_p(pr + \dot{q})\right] / g$$

$$a_{yp} = a_{ycg} + \left[x_p(pq + \dot{r}) + z_p(qr - \dot{p})\right] / g$$

$$a_{zp} = a_{zcg} + \left[x_p(pr - \dot{q}) - z_p(p^2 + q^2)\right] / g$$

A.1.6.4 Absolute normal acceleration at pilot (or 'manoeuvre g' used for motion cues)

$$a_{zap} = a_{zp} + S_{33}$$

A.1.6.5 Acceleration relative to 1 g for recording

$$a_{zcg1} = a_{zcg} + 1.0$$

A.1.6.6 Acceleration for slip ball (located at x_1, y_1, z_1)

$$a_{y_1} = a_{ycg} + \left[x_1(pq - \dot{r}) - y_1(p^2 + r^2) + z_1(qr - \dot{p})\right] / g$$

A.1.6.7 Accelerations for g meter (located at x_2, y_2, z_2)

$$a_{z_2} = a_{zcg} + \left[x_2(pr - \dot{q}) + y_2(qr - \dot{p}) - z_2(p^2 + q^2)\right] / g$$

A.1.6.8 Accelerations for three independent accelerometers

$$a_{x_3} = a_{xcg} - \left[x_3(p^2 + r^2) - y_3(pq - \dot{r}) - z_3(pr + \dot{q})\right] / g$$

$$a_{y_4} = a_{ycg} + \left[x_4(pq + \dot{r}) - y_4(p^2 + r^2) + z_4(qr - \dot{p})\right] / g$$

$$a_{z_5} = a_{zcg} + \left[x_5(pr - \dot{q}) + y_5(qr + \dot{p}) - z_5(p^2 + q^2)\right] / g$$

A.1.7 Initialisation

Nil

A.1.8 Subroutines used

Nil

A.1.9 Remarks

A.1.9.1 See Etkin[9] (Dynamics of Atmospheric Flight) pp 122-124 for derivation of acceleration at an arbitrary point.

A.1.9.2 'Flat earth' is assumed.

A.2 Subroutine SACCLIN

A.2.1 Purpose To compute linear accelerations in earth axes

A.2.2 Call CALL SACCLIN

A.2.3 Inputs FTX, FTY, FTZ
RXMASS, G
$S_{11} - S_{33}$

A.2.4 Outputs FTN, FTE, FTD
VKNDOT, VKEDOT, VKDDOT

A.2.5 Description

A.2.5.1 Transforms total forces in body axes (FTX, FTY, FTZ) to earth axes (FTN, FTE, FTD), using direction cosines S_{11} etc.

$$F_{TN} = S_{11}F_{TX} + S_{21}F_{TY} + S_{31}F_{TZ}$$

$$F_{TE} = S_{12}F_{TX} + S_{22}F_{TY} + S_{32}F_{TZ}$$

$$F_{TD} = S_{13}F_{TX} + S_{23}F_{TY} + S_{33}F_{TZ}$$

A.2.5.2 Calculates accelerations in earth axes

$$\dot{V}_{KN} = F_{TN}/m$$

$$\dot{V}_{KE} = F_{TE}/m$$

$$\dot{V}_{KD} = F_{TD}/m + g$$

A.2.6 Initialisation

Nil

A.2.7 Subroutines used

Nil

A.2.8 Remarks

User must supply total forces in body axes (FTX, FTY, FTZ).

A.3 Subroutine SACCROT

A.3.1 Purpose Calculates angular accelerations in body axes

A.3.2 Call CALL SACCROT

A.3.3 Inputs XLLTOT, XMMTOT, XNNTOT
P, Q, R
CI1 - CI10

A.3.4 Outputs PDOT, QDOT, RDOT

A.3.5 Description

Given total moments, angular velocity components and inertia coefficients, calculates angular acceleration components in body axes.

$$\dot{p} = CI_1L + CI_2N + CI_3pq + CI_4qr$$

$$\dot{q} = CI_5M + CI_6(r^2 - p^2) + CI_7rp$$

$$\dot{r} = CI_8N + CI_2L + CI_9pq + CI_{10}qr$$

A.3.6 Initialisation

Nil

A.3.7 Subroutines used

Nil

A.3.8 Remarks

A.3.8.1 CI1 etc are calculated in SINIT from inertia information supplied by the user.

A.3.8.2 The user must provide the total moments in body axes (XLLTOT, XMMTOT, XNNTOT).

A.3.8.3 An xz plane of symmetry is assumed.

A.4 Subroutine SALFBET

A.4.1 Purpose Calculates angles of attack and sideslip

A.4.2 Call CALL SALFBET(DT)

A.4.3 Inputs UB, VB, WB, RADTOD

A.4.4 Outputs ALFAR, ALFAD, SALFA, CALFA, ALFADOT,
BETAR, BETAD, SBETA, CBETA, BETADOT

A.4.5 Argument DT is frame time of loop in which SALFBET is used.

A.4.6 Description

A.4.6.1 Given the body axes components of airspeed, calculates α and β from (see Hopkin[4] section 6.2)

$\alpha = \tan^{-1} WB/UB$, with α taking the sign of WB and being in the range $-\pi$ to $+\pi$.

$\beta = \tan^{-1} VB/(UB^2 + WB^2)^{\frac{1}{2}}$
being in the range $-\pi/2$ to $+\pi/2$, and taking the sign of VB.

A.4.6.2 Calculates the sine and cosine of α and β.

A.4.6.3 Converts α and β to degrees and stores.

A.4.6.4 Estimates the rate of change of the incidence angles ($\dot{\alpha}$ and $\dot{\beta}$) from the present and two preceding values, *eg*

$$\dot{a} = (a_2 - 4a_1 + 3a)/(2DT)$$

where DT is the time step.

A.4.7 Initialisation

During the first entry to the routine the two preceding values of α and β used in estimating $\dot{\alpha}$, $\dot{\beta}$ are set to the current values of α and β, thus making $\dot{\alpha} = \dot{\beta} = 0.0$ for two time steps after 'compute'.

A.4.8 Subroutines used

Library mathematical functions.

A.4.9 Remarks

For $UB = WB = 0.0$, $\alpha = 0.0$.
If VB is zero as well, then $\beta = 0.0$.

A.5	Subroutine	SCOUNT
A.5.1	Purpose	Resets pass count for derivative section
A.5.2	Call	CALL SCOUNT
A.5.3	Inputs	JCOMP (from COMMON 'CONTROL')
A.5.4	Outputs	NCPASS, JJCOMP, NRUN

A.5.5 Description

A.5.5.1 Resets pass count NCPASS to zero. NCPASS is used in the derivative section to keep track of sub-steps of integration routine.

A.5.5.2 Picks up JCOMP from COMMON 'CONTROL' and reassigns to JJCOMP in COMMON 'SYSTEM' to enable JJCOMP to be used as an 'initialisation complete' flag. JCOMP (and hence JJCOMP) gets set to 1 once 'compute' is pressed.

A.5.5.3 Calls DLRUN to pick up current run number held in mailbox.

A.5.6 Initialisation

Nil

A.5.7 Subroutines used

DLRUN

A.5.8 Remarks

A.5.8.1 Since DLRUN accesses the foreground mailbox, any program using SCOUNT or DLRUN must be run in the foreground.

A.5.8.2 Run number is only obtained if data logging is *not* inhibited.

A.5.8.3 Because SCOUNT is not called during initialisation, the run number is not obtained until after 'compute' is pressed.

A.6	Subroutine	SDCOS
A.6.1	Purpose	Calculates direction cosines from Euler angles
A.6.2	Call	CALL SDCOS
A.6.3	Inputs	PSIR, THETAR, PHIR, RADTOD
A.6.4	Outputs	PSID, THETAD, PHID, SPSI, CPSI, STHETA, CTHETA, SPHI, CPHI

A.6.5 Description

A.6.5.1 Calculates sines and cosines of the three Euler angles

ψ - heading $0\text{-}360^{\circ}$ (or ± 180)

θ - pitch $\pm 90^{\circ}$

ϕ - bank $\pm 180^{\circ}$

A.6.5.2 Calculates nine direction cosines used in transformation from earth to body axes and vice versa (see Hopkin[4] section 5.6).

$\text{S11} = \cos\theta \cos\psi = \ell_1$

$\text{S12} = \cos\theta \sin\psi = \ell_2$

$\text{S13} = -\sin\theta = \ell_3$

$\text{S21} = \sin\phi \sin\theta \cos\psi - \cos\phi \sin\psi = m_1$

$\text{S22} = \sin\phi \sin\theta \sin\psi + \cos\phi \cos\psi = m_2$

$\text{S23} = \sin\phi \cos\theta = m_3$

$\text{S31} = \cos\phi \sin\theta \cos\psi + \sin\phi \sin\psi = n_1$

$\text{S32} = \cos\phi \sin\theta \sin\psi - \sin\phi \cos\psi = n_2$

$\text{S33} = \cos\phi \cos\theta = n_3$

A.6.5.3 Calculates sec θ and tan θ .

A.6.5.4 Converts input angles (ψ, θ, ϕ) from radians to degrees and stores.

A.6.6 Initialisation

Nil

A.6.7 Subroutines used

Library mathematical functions, *eg* sine, cosine

A.6.8 Remarks

Makes no provision yet for $\theta = 90^{\circ}$, nor for large angles, *ie* multiple turns.

A.7	Subroutine	SEULER
A.7.1	Purpose	Calculates Euler attitude rates.
A.7.2	Call	CALL SEULER
A.7.3	Inputs	P, Q, R SPHI, CPHI, TANTHT, SECTHT RADTOD
A.7.4	Outputs	PHIDT, THETDT, PSIDT PD, QD, RD

A.7.5 Description

A.7.5.1 Calculates Euler attitude rates from body rates and Euler angles

$$\dot{\phi} = p + (q \sin \phi + r \cos \phi) \tan \theta$$

$$\dot{\theta} = q \cos \phi - r \sin \phi$$

$$\dot{\psi} = (q \sin \phi + r \cos \phi) \sec \theta$$

A.7.5.2 Converts body rates to degrees/s and stores.

A.7.6 Initialisation

Nil

A.7.7 Subroutines used

Library mathematical functions.

A.8	Subroutine	SILS
A.8.1	Purpose	To calculate glide slope and localiser indications for conventional instrument landing system (ILS).

A.8.2	Call	CALL SILS
A.8.3	Inputs	JJCOMP, LSILS, ILSFLG X, Y, H, RADTOD, DEGTOR
A.8.4	Outputs	EGS, ELOC, HSLOPE, RGS, RLOC, RKINK XGS, XLOC, YLOC, SGS, SLOC, USLOPE, BSLOPE, HKINK, CILS1, CILS2, CILS3, CILS4, XKINK

A.8.5 User options

LSILS	ILS on/off flag
0	off, glide slope and localiser indications set to zero
1	on
ILSFLG	select beam type
1	3° straight beam
2	6° straight beam
3	6° changing to 3° at height defined by HKINK

A.8.6 Description

A.8.6.1 If ILS is required (set by LSILS), calculates conventional angular ILS beam, with no beam noise, assuming *receiver in aircraft is at centre of* gravity.

A.8.6.2 If ILS is not required, glide slope and localiser indications are set to zero and no other calculations are performed.

A.8.6.3 Localiser model

Beam origin is at XLOC, YLOC. (X = 0 is at runway threshold, Y = 0 on runway centre line).

RLOC is range from transmitter.

Angular error ELOC is returned scaled to ±1.0, *ie* as a fraction of the defined beam width.

Beam width is ±SLOC degrees.

A.8.6.4 Glide slope model

Glide path origin is at XGS.

RGS is range from transmitter.

HSLOPE is height of beam centre line at range RGS.

Angular error EGS is returned scaled to ±1.0, *ie* as a fraction of the defined beam width.

Beam width is ±SGS degrees.

USLOPE is upper segment slope (if applicable) in degrees.

BSLOPE is lower segment slope in degrees.

For a single segment beam, USLOPE = BSLOPE.

If a 2-segment slope is used (selected by ILSFLG), the kink occurs at the defined height HKINK.

Range and position from kink (RKINK, XKINK) are derived.

A.8.7 Initialisation

A.8.7.1 During initialisation (when JJCOMP = 0) beam constants are set up according to the choice of beam defined by ILSFLG. Initialisation occurs regardless of the state of the ILS on/off flag.

A.8.8 Subroutines used

BOUND

Library mathematical routines.

A.8.9 Remarks

A.8.9.1 SILS is used by SINIT, if requested, to place the aircraft exactly on the beam as an initial condition.

A.8.9.2 If the user wishes to create his own ILS routine (or similar guidance) he could use the same name and ensure that it will interface correctly to SINIT, *ie* receive a value X and return a value HSLOPE.

A.9 Subroutine SINIT

A.9.1 Purpose Various initialisation calculations

A.9.2 Call CALL SINIT

A.9.3 Inputs

XIX, XIY, XIZ, XIZX
HIC, XIC, HSLOPE
DENR, SPSNDR, TEMPR, PRESSR
SPSL, RHOSL, TEMPSL, PRESSL
VWKT0, PSIWD, SHRFAC
PSIDIC, GAMDIC, VKTIC, BETADIC, ALFADIC
SWREF, SPAN, W, XCG, ZCG, XCGREF, ZCGREF
KISA, ISHR

A.9.4 Outputs

CI1 - CI10
X
ROOTSIG, SPSOND, RHO, TALPHA, PALPHA
CPSIW, SPSIW, VWNL0, VWEL0, VWN, VWE, VWD
VKNIC, VKEIC, VKDIC, VN, VE, VD, VK, VT
THETADIC, PHIDIC
SB2, XMASS, RXMASS, DXCG, DZCG
PDIC, QDIC, RDIC
RADTOD, DEGTOR, FPSTKT, XK2FPS, G, RG

A.9.5 Data to be supplied by user

SWREF, SPAN, XCGREF, ZCGREF, ZCG, XIX, XIY, XIZ, XIZX

A.9.6 User options

KISA	flag to control variation of atmospheric properties with height
0	sea level conditions at all times
1	standard atmosphere
-1	fixed values appropriate to initial height (HIC)
ISHR	wind shear selection flag (see SWIND for full description)

A.9.7 Description

A.9.7.1 Calculates inertia coefficients, according to equations (20)

```
CI0   =  1.0/(XIZ*XIX - XIZX*XIZX)
CI1   =  XIZ*CI0
CI2   =  XIZX*CI0
CI3   =  XIZX*(XIX - XIY + XIZ)*CI0
CI4   =  (XIZ*(XIY - XIZ) - XIZX*XIZX)*CI0
CI5   =  1.0/XIY
CI6   =  XIZX*CI5
CI7   =  (XIZ - XIX)*CI5
CI8   =  XIX*CI0
CI9   =  (XIX*(XIX - XIY) + XIZX*XIZX)*CI0
CI10  =  -XIZX(XIX - XIY + XIZ)*CI0
```

A.9.7.2 If HIC is set negative, calculates initial height to put aircraft exactly on ILS beam.

A.9.7.3 Sets up initial values of atmospheric properties. If KISA = 0, sets up sea level conditions. Otherwise uses SATMOS to derive properties appropriate to HIC.

A.9.7.4 Calculates local true wind components from datum wind speed (V_{WKT0}) and direction (ψ_W)

$$V_{WNL0} = - V_{WKT0} \cos \psi_W$$

$$V_{WEL0} = - V_{WKT0} \sin \psi_W$$

and allows for wind shear to give initial values for V_{WN}, V_{WE}.

A.9.7.5 If initial condition is not at rest derives velocity relative to ground, and then components for IC values, given wind speed and direction, desired initial airspeed and heading. (Note that VK in this routine is resultant velocity relative to ground, whereas VK obtained in SPATH is truly the ground speed, *ie* in the horizontal plane.)

An iteration technique is used to ensure that the initial track and heading are compatible with the specified wind. The initial heading will thus not reveal to the pilot anything about the applied wind.

A.9.7.6 If initial condition *is* at rest (defined by VKTIC < 1.0) then *ground* speed is set to zero.

A.9.7.7 An initial value for θ is calculated, assuming $\phi = 0$, from

$$\theta = \gamma + \alpha .$$

A.9.7.8 Aircraft related constants are calculated from data supplied by the user

SB2 = SWREF*SPAN*SPAN
XMASS = W/G
RXMASS = 1.0/XMASS
DXCG = XCG - XCGREF
DZCG = ZCG - ZCGREF

A.9.7.9 Various system constants are given default values via DATA statements, as detailed below.

Default values

RADTOD	57.295780
DEGTOR	0.0174533
FPSTKT	0.5921053
XK2FPS	1.688889
G	32.174
RHOSL	0.0023769
SPSL	1116.45
RG	0.03108
TEMPSL	288.15
PRESSL	14.69597
DENR	1.0
SPSNDR	1.0
TEMPR	1.0
PRESSR	1.0
PDIC	0.0

QDIC	0.0
RDIC	0.0
PHIDIC	0.0
KISA	0
ISHR	1

A.9.7.10 A software switch is also set on (IHSHIO = 1) to enable the high speed hybrid input/output. It is communicated via labelled COMMON HSHIO.

A.9.8 Initialisation

Whole routine is for initialisation only.

A.9.9 Subroutines used

SATMOS, SILS, WSHEAR and library functions.

A.9.10 Remarks

Will not initialise correctly if initial ϕ is non-zero.

A.10 Subroutine SPATH

A.10.1 Purpose — Calculates velocity over ground and flight path angles

A.10.2 Call — CALL SPATH

A.10.3 Inputs — VKN, VKE, VKD
RADTOD, FPSTKT

A.10.4 Outputs — VK, VKKT,
PSIKR, PSIKD,
GAMMAR, GAMMAD

A.10.5 Description

A.10.5.1 Calculates velocity over ground (ground speed)

$$VK = (VKN^2 + VKE^2)^{\frac{1}{2}}$$

A.10.5.2 Converts VK to knots and stores.

A.10.5.3 Calculates climb angle

$$\gamma = \tan^{-1}(-VKD/VK)$$

in the range $-\pi/2$ to $+\pi/2$.

A.10.5.4 Calculates track

$$\chi(= \psi_k) = \tan^{-1}(V_{KE}/V_{KN})$$

in the range 0 to 2π.

A.10.5.5 Converts γ and χ to degrees and stores.

A.10.6 Initialisation

None

A.10.7 Subroutines used

Library mathematical functions.

A.10.8 Remarks

A.10.8.1 If VKD = VK = 0.0 , $\gamma = 0.0$.

A.10.8.2 If VKE = VKN = 0.0 , $\chi = 0.0$.

A.10.8.3 For $V_{KE} = 0.0$, $\chi = 0$ for V_{KN} positive but $\chi = 180^{\circ}$ for V_{KN} negative.

A.11 Subroutine STV

A.11.1 Purpose Computes TV positions and rates, and controls belt logic.

A.11.2 Call CALL STV

A.11.3 Inputs
VKN, VKE, VKD, VSHIPKT, XK2FPS
X, Y, H, XIC
XP, ZP, CTHETA, STHETA, CPSI, SPSI, PSIDT, THETDT
JJCOMP, NTVB
LFWD, LBACK, LYTVIC, LXTVIC, LCYCLE

A.11.4 Outputs
XTV, YTV, HTV, XIC, XIHX, XIHY
XDOTM, XDTV, YDTV, HDTV
SXPL, SXMIN, SXPLUS, SXMINUS, SYPL, SYMIN, HTVLIM,
XDTMX
IDSYNC

A.11.5 Data to be supplied by user

NTVB	TV belt flag
1	700:1 model
2	2000:1 model
3	5000:1 model

VSHIPKT ship velocity, knots.

A.11.6 Description

A.11.6.1 Initialisation.

A.11.6.2 Belt slew control.

If forward slew is selected, X rate is forced to maximum positive value.

If backward slew is selected, X rate is forced to maximum negative value.

In both cases, the aircraft's position keeps in step. Positional calculations can also be referred to a ship moving at constant velocity VSHIPKT.

A.11.6.3 Integration control for X and Y (belt logic).

(a) If Y reset is selected, Y position resets to YIC.

(b) If X reset is selected, X position resets to XIC as originally defined in ICFILE.

(c) If X reset is not selected, additional logic is invoked to control the belt (x):

- if X is not near the belt join (defined by SXMIN, SXPL - see belt diagram), the program continues to the position module.
- If X is near the join but 'LCYCLE' is not set, the program continues to the position module.
- If 'LCYCLE' is not set, the program continues to the position module.
- If 'LCYCLE' is set, X is forced to cycle between SXMINUS and SXPLUS. IDSYNC is set to 1 to uncouple the belt position feedback.
- If 'LCYCLE' is set, but the demanded X position is less than the negative cycle limit SXMINUS (as can happen if X had been previously reset), the X integrator is reset and XIC is set to SXMINUS. This will force the belt to start to move.
- If X is between SXMINUS and SXPLUS, the program continues to the position module.
- When X reaches SXPLUS, it resets to SXMINUS, before going on to the position module.

A.11.6.4 Position module - TV positions and rates in three axes (equations (22) to (25)).

(a) Calculates pilot position, and rate of change of his position, allowing for his location away from the aircraft's centre of gravity.

(b) If TV belt is trying to position before minimum X possible on the belt (SXMIN), or if X reset is demanded, then $\dot{X}_{TV}$ is set to zero to stop hunting. This is not done if LCYCLE is set.

)08

(c) If H is above the ceiling for the model, $\dot{h}_{TV}$ is set to zero to stop bouncing.

(d) Limits are finally applied to x_{TV}, y_{TV} and h_{TV} to keep within model confines. These limits do not affect computed aircraft position and navigation.

A.11.7 Initialisation

A.11.7.1 During initialisation, the set of TV constants appropriate to the particular belt are selected from the array TVCON (8,3). These constants define the limit of movement as follows:

SXPL	TVCON (1, NTVB)	Maximum value of x_{TV} allowed, also determines when 'near belt join'.
SXMIN	TVCON (2, NTVB)	Minimum value of x_{TV} allowed, also determines when 'near belt join'.
SXPLUS	TVCON (3, NTVB)	x cycles between these two values if
SXMINUS	TVCON (4, NTVB)	'cycle' mode is selected
SYPL	TVCON (5, NTVB)	Maximum value of y_{TV} allowed
SYMIN	TVCON (6, NTVB)	Minimum value of y_{TV} allowed
HTVLIM	TVCON (7, NTVB)	Ceiling for TV height
XDTMX	TVCON (8, NTVB)	Belt velocity when slewing.

The x-related quantities are illustrated in Fig A4.

STV holds three values of each parameter in TVCON, the appropriate one being selected according to the TV belt in use. Because of this, on-line permanent changes to SXPL etc can only be achieved by changing the associated element of TVCON.

A.11.7.2 The initial value of X obtained from the IC file is stored in a temporary location (XICF) so that a demand to reset X will reset X to this value regardless of whether cycle has previously been selected.

A.11.8 Subroutines used

BOUND

A.11.9 Remarks

A.11.9.1 The array of TV constants is accessible to PV100 and so can be overwritten if new values are found to be more appropriate to the hardware. Alterations can also be made via the semi-permanent changes file (see SYSCOM).

A.11.9.2 The logical controls are set via special buttons etc on the control desk and so are hardware dependent.

LCYCLE	desk switch 5
LXTVIC	desk switch 6
LYTVIC	desk switch 7
LFWD	slew toggle patched to AD4 sense line DGS03 (line 4)
LBACK	slew toggle patched to AD4 sense line DGS04 (line 5)
IDSYNC	software flag controls AD4 control line DGC17 (line 16)

A.11.9.3 To start the aircraft at some position outside the limits of the TV model, set up XIC, YIC to suit. When the aircraft position comes within the confines of the belt, it will begin to move with the aircraft. X and Y positions can be reset using their appropriate buttons without having to reset the whole computation.

A.11.9.4 If, after a reset to some distant location, immediate movement of the belt is required, put 'X reset' off and 'cycle' on.

A.11.9.5 No provision has been made for large bank angles (>1 rev), nor for cloud or visibility control.

A.11.9.6 Successful use of this routine to drive the TV model is dependent on analogue computer circuitry incorporating position feedbacks.

A.11.9.7 Do not initialise with 'CYCLE' on if, subsequently in the run, you may want to reset X outside the confines of the belt. This is because initialisation occurs twice and so XIC is overwritten.

A.12	<u>Subroutine</u>	SVELOC1
A.12.1	<u>Purpose</u>	Calculates body axes velocity components
A.12.2	<u>Call</u>	CALL SVELOC1
A.12.3	<u>Inputs</u>	VKN, VKE, VKD VWN, VWE, VWD $S_{11} - S_{33}$
A.12.4	<u>Outputs</u>	UB, VB, WB VN, VE, VD

A.12.5 <u>Description</u>

A.12.5.1 Given the components of velocity relative to ground (VKN, VKE, VKD) and the components of total wind speed, including turbulence (VWN, VWE, VWD), calculates components of velocity relative to the air in earth axes (VN, VE, VD), then resolves to body axes.

A.12.6 Initialisation

None

A.12.7 Subroutines used

None

A.12.8 Remarks

A.12.8.1 Assumes wind velocity component is positive in the *same* direction as the component relative to the air. Thus, for a head wind and for the aircraft on a northerly heading ($\psi = 0$) , VWN is negative.

A.12.8.2 VN, VE, VD are initially calculated in SINIT.

A.13 Subroutine SVELOC2

A.13.1 Purpose

Calculates total airspeed, equivalent airspeed, Mach number etc using appropriate atmospheric properties.

A.13.2 Call

CALL SVELOC2

A.13.3 Inputs

UB, VB, WB
H
SWREF, CREF, SPAN, SB2
KISA
FPSTKT, RHOSL, SPSL, TEMPSL, PRESSL

A.13.4 Outputs

VT, VTKT, VEAS, VEASKT, XMACH
QDYN, HLFROV, QDYNS, QSCREF, QSSPAN, QSB2IV
ROOTSIG, RHO, SPSOND, DENR, SPSNDR, TEMPR, PRESSR
TRATIO, ARATIO, DRATIO, PRATIO, TALPHA, PALPHA

A.13.5 Data to be supplied by user

Note that certain geometric parameters for the aircraft must be supplied by the user.

SWREF	reference wing area
CREF	reference chord
SPAN	reference wing span

SB2 is a combination (SWREF*SPAN*SPAN) calculated in SINIT.

A.13.6 User options

The flag KISA selects the way in which atmospheric properties vary. It must only be changed in INITIAL, before SINIT is executed.

KISA = 1 standard atmosphere
= 0 fixed values appropriate to sea level 008
= -1 fixed values appropriate to initial height HIC

A.13.7 Description

A.13.7.1 Calculates total airspeed, converts to knots and stores.

$$V_T = \left(u_B^2 + v_B^2 + w_B^2\right)^{\frac{1}{2}}$$

A.13.7.2 If the flag KISA is set to 1, obtains, for the current height, new properties (density ratio, speed of sound ratio, temperature ratio and pressure ratio) of a standard atmosphere, using the routine SATMOS.

If KISA is not set to 1, atmospheric properties are kept constant, as set up by SINIT.

A.13.7.3 Calculates properties of the atmosphere

air density $\rho = \rho_{SL}\sigma$

speed of sound $a = a_{SL}a_r$

ambient temperature $T_\alpha = T_{SL}T_r$

ambient pressure $P_\alpha = P_{SL}P_r$

A.13.7.4 Calculates equivalent airspeed, converts to knots and stores.

$$V_{EAS} = V_T\sigma^{\frac{1}{2}} .$$

A.13.7.5 Calculates dynamic pressure and related terms

$$\mathrm{QDYN} = \tfrac{1}{2}\rho V_T^2$$

$$\mathrm{QDYNS} = \tfrac{1}{2}\rho V_T^2 S_W$$

$$\mathrm{QSCREF} = \tfrac{1}{2}\rho V_T^2 S_W c_{ref}$$

$$\mathrm{QSSPAN} = \tfrac{1}{2}\rho V_T^2 S_W b$$

$$\mathrm{QSB2IV} = \tfrac{1}{2}\rho V_T (S_W b^2)$$

A.13.7.6 Calculates Mach number

$$M = V_T/a$$

A.13.7.7 Calculates compressible adiabetic flow relationships for Mach number <1.0. For initialisation purposes, these ratios are given datum values of 1.0.

$$T_{ratio} = (1 + 0.2M^2)^{-1}$$

$$a_{ratio} = (T_{ratio})^{\frac{1}{2}}$$

$$\rho_{ratio} = (a_{ratio})^5$$

$$P_{ratio} = a_{ratio}\ T_{ratio}$$

A.13.8 Initialisation

In addition to those items mentioned above, datum values of atmospheric properties are provided in SINIT (qv).

A.13.9 Subroutines used

SATMOS

A.13.10 Remarks

Subroutine ATMOS, an alternative to SATMOS, is available to calculate atmospheric properties for hot days. It is not included as an option, however, as it is very much larger than SATMOS, the subroutine for 'standard' days.

A.14 Subroutine SWIND

A.14.1 Purpose

Controls turbulence, wind and wind shear

A.14.2 Call

CALL SWIND

A.14.3 Inputs

H, HIC, VKTIC,
XK2FPS, FRAMET1, SFRACG, SRDECAY
VWNL0, VWEL0, VWDL0, CPSIW, SPSIW
USIG, VSIG, WSIG
ISHR, JJCOMP, NG, LTURB, LSEED

A.14.4 Outputs

UTURB, VTURB, WTURB
VWN, VWE, VWD
VWNL, VWEL, VWDL
SHRFAC

A.14.5 User options

LTURB	Turbulence switch
0	no turbulence calculated or output
1	turbulence calculated and output
ISHR	wind shear selection
1 (default)	no shear applied. Returns immediately with SHRFAC = 1.0. Time overhead is minimal.
2	ARB mean shear profile (logarithmic)
3	linear shear up to 333 ft, thereafter constant
LSEED	random number seed selector
0 (default)	seeds in GUSTS routine obtained from time of day
1	constant seeds enable a repeatable turbulence sequence to be obtained
USIG, VSIG, WSIG	rms settings for each component (never exactly achieved - it is a random process!). Can be changed in flight.
VWKT0	datum wind speed, true (knots)

PSIWD	datum wind direction (degrees). PSIWD = 0.0 is a wind from the north. VWKT0 and PSIWD are set as initial conditions and are used by SINIT (qv) to calculate VWNL0, CPSIW etc.

For the remaining parameters (except for VWDL) changes are only effective if applied during initialisation.

VWDL	wind component in 'down' sense (default = 0.0)
SRDECAY	decay parameter, should not be changed (default = 0.7)
SFRACG	intermittency parameter, in range 0.0 to 0.99 (default = 0.0). Should never be set equal to 1.0. For minimum intermittency, set SFRACG = 0.0. A value of 0.7 is probably as extreme as will ever be needed. Refer to Ref 12 for discussion.
NG	Controls the three gust ramp lengths used in the turbulence generation routine GUSTS[12], via $\text{NGUSTS} = \text{NG}^* \dfrac{\text{Initial speed (ft/s)}}{200}$. NGUSTS, an important parameter, required by the GUSTS routine, defines the number of gusts per second. Thus, if the initialisation speed is 200 ft/s (118 kn), NGUSTS = NG = 4 (the default value for NG) and so the shortest gust gradient distance is 200/4 = 50 ft and the longest, determined in the GUSTS subroutine, is 16 times the shortest, or 800 ft. Initialisation at speeds much below 100 kn may require NG to be increased. If the initial speed is zero, NGUSTS takes a minimum value of 1. A further limitation is that NGUSTS must be less than the repetition rate of the simulation, *eg* for a frame time of 50 ms (20 solutions/s) and NG = 4, the *maximum* initial speed must not exceed 1000 ft/s (592 kn). This constraint is checked and imposed in SWIND.

A.14.6 Description

(a) Derives shear factor (SHRFAC) according to height, using WSHEAR subroutine.

(b) Calculates local wind velocity components VWNL, VWEL at height, including shear effects.

VWNL = VWNL0 * SHRFAC
VWEL = VWEL0 * SHRFAC
VWNL0, VWEL0 are calculated in SINIT.

(c) If turbulence is required (set by LTURB), calculates three raw components of turbulence (using GUSTS subroutine). The gust velocities obtained are scaled by nominal rms values for each component (USIG, VSIG, WSIG), set by the user, to give turbulence components UTURB, VTURB, WTURB.

(d) If turbulence is not required, turbulence components are set to zero.

(e) The calculated turbulence components are added to the mean wind components to provide three components of total wind (VWN, VWE, VWD) in earth axes.

```
VWN  =  VWNL - (UTURB * CPSIW - VTURB * SPSIW)
VWE  =  VWEL - (VTURB * CPSIW + UTURB * SPSIW)
VWD  =  VWDL - WTURB
```

(f) A flow chart is shown in Fig A9.

A.14.7 Initialisation

During initialisation, the gust generation routine GUSTS is called regardless of whether the turbulence switch LTURB is set on or off. This is necessary to perform the required preliminary calculations. However, the turbulence components returned are set to zero. GUSTS uses its own flag (IFLAG) to control initialisation, but this is tied to the system flag JJCOMP in SWIND.

A.14.8 Subroutines used

WSHEAR, GUSTS, FDC, RANDU, VSTEP, SEEDVAL
Library mathematical functions.

A.14.9 Remarks

A.14.9.1 The calculated turbulence components are added to the mean wind components, which only later become resolved into body axes. UTURB is *along* the datum wind, a positive gust increasing the wind (crudely, increasing the airspeed); VTURB is across the wind (a positive gust, crudely, increasing the sideslip); WTURB is vertical, positive up (to increase incidence).

A.14.9.2 Wind shear and attenuation of vertical turbulence with height work from altitude rather than height above local terrain.

A.14.9.3 Details of the gust generation process are contained in Ref 12.

A.14.9.4 Wind shear is only in magnitude, not in direction.

A.14.9.5 The turbulence control, LTURB, is set by a desk switch (currently number 8).

A.15 Subroutine SYSCOM

A.15.1 Purpose Sets up communication with system variables.

A.15.2 Call CALL SYSCOM

008

A.15.3 Inputs

As set up in 'changes' file.

A.15.4 Outputs

Nil

A.15.5 Description

A.15.5.1 Includes in the labelled common area SYSTEM *all* the names of system variables so that they are set up in the Namelist table.

A.15.5.2 Calls PV200 in the defined way to set up the Namelist table address. The defined way is

```
      DIMENSION NAME (2)
      DATA NAME/'SYSCOM'/
      NAMELIST
      CALL PV200(NAME)
      GO TO 3
2     INPUT 101
3     CONTINUE
```

A.15.5.3 Provides for 'semi-permanent' changes to be read from a file, using the self-identified input facility

```
      DATA ISYS/50/
      REWIND ISYS
      INPUT (ISYS)
      REWIND ISYS
```

A.15.6 Initialisation

This routine is only called in the INITIAL region, so it is all initialisation.

A.15.7 Subroutines used

PV200 plus library routines. Note that to test SYSCOM in the background, a dummy PV200 should be supplied.

A.15.8 Remarks

A.15.8.1 Unit 50 used for inputting semi-permanent changes should be assigned at model load time to a file in the user's area, *eg*

```
:ASSIGN (F:50, D3, SYSCHNG)
```

A.15.8.2 Prior to running the aircraft model program, the 'changes' file should be filled with the desired changes in the form

```
X1    = 23.0
SWREF = 560.0
*
```

The concluding asterisk (*) is essential. If no changes are required the file *must contain* an asterisk otherwise a run-time error occurs.

A.15.8.3 The positioning of SYSCOM means that IC values cannot be overwritten since they are read after SYSCOM is executed. However, changes introduced through SYSCOM can be altered on-line since retained changes are applied (by PV300) after SYSCOM.

A.16	Subroutine	DSCRT1/DSCRT2
A.16.1	Purpose	To control execution of routines for discrete input/output.
A.16.2	Call	CALL DSCRT1 (CALL DSCRT2)
A.16.3	Inputs	IAD4SL, IAD4CL, IDSCFL, IPCOFL
A.16.4	Outputs	By calling other routines, the arrays ISLR(16), ICLR(16), IP(32), IDS(32), ICO(32) are filled.

A.16.5 Data to be supplied by user

Four flags must be set to control which of the basic routines, if any, is executed in which real time loop.

IAD4SL	Execution control flag for AD4 sense lines (READSLR)
IAD4CL	Execution control flag for AD4 control lines (SETCLR)
IDSCFL	Execution control flag for discretes in to the Sigma (READSCR)
IPCOFL	Execution control flag for discretes out from Sigma (SETDSCR)

Each flag can take the values:

0	Do not execute
1	Execute in DSCRT1, *ie* in the fastest loop
2	Execute in DSCRT2, *ie* in the second loop.

Default values (set in DSCRT1) and typical values are

Flag	Routine	Default	Typical	(possible)
IAD4SL	READSLR	1	1	(2)
IAD4CL	SETCLR	1	1	(2)
IDSCFL	READSCR	1	2	
IPCOFL	SETDSCR	0	2	(1)

A.16.6 Description

Calls appropriate routines, according to flag settings. Routines which are called by DSCRT1 are not then called by DSCRT2, and *vice versa*.

A.16.7 Initialisation

Nil

A.16.8 Subroutines used

READSLR, SETCLR, READSCR, SETDSCR

A.16.9 Remarks

Execution timings are

SETCLR	0.16 ms
READSLR	0.22 ms
SETDSCR	0.34 ms
READSCR	0.87 ms
Total	1.59 ms

Hence a millisecond or more could be saved in the main loop by executing READSCR and SETDSCR in the second loop.

A.17 Function subroutine ISDSCR

A.17.1 **Purpose** To read a single specified Sigma 8 sense line

A.17.2 **Call** I = ISDSCR (ISET, LINE)
ISDSCR is returned with a value 0 or 1, depending on whether the specified line LINE is off or on.

A.17.3 Description

This function tests the status of an individual sense line, either from the logic patch panel in rack N(ISET = 0) or from the control desk switches (ISET = 1).

A.17.4 Initialisation

Nil

A.17.5 Subroutines used

READSCR

A.17.6 Remarks

This function is intended for use during the INITIAL region only, when time is not critical. It is not a fast routine.

Appendix B

LISTING OF SESAME ROUTINES

```
      SUBROUTINE SACCBOD
C
C
C                ***************************************************
C                *                                                 *
C                *   WRITTEN BY : A.J.SPENCER                      *
C                *   DATE :  24.02.78                              *
C                *   DESCRIPTION : SACCBOD CALCULATES ACCELERATIONS *
C                *     OF THE AIRCRAFT C.G. AND OF THE PILOT , IN  *
C                *     THE BODY AXES , FOR USE BY MOTION , AUTOSTAB *
C                *     ETC..                                       *
C                *                                                 *
C                ***************************************************

      COMMON/SYSTEM/A(1000),L(400)
C
C     VERSION IDENTIFIER
C
      DATA KSACCBOD/240278/
C     12-8-76       SYSTEM COMMON ENLARGED
C  24.2.78 XP,ZP REPLACED BY XPCG,ZPCG
      EQUIVALENCE(KSACCBOD,L(255))
C
C     *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(AXCG          ,A(241)),(AYCG          ,A(242)),(AZCG          ,A(243)),
     1           (AZCG1         ,A(244)),(AXACG         ,A(245)),(AYACG         ,A(246)),
     2           (AZACG         ,A(247)),(AXP           ,A(248)),(AYP           ,A(249)),
     3           (AZP           ,A(250)),(AZAP          ,A(251)),(AY1           ,A(252)),
     4           (AZ2           ,A(253)),(AX3           ,A(254)),(AY4           ,A(255)),
     5           (AZ5           ,A(256))
C
C     *** VARIABLE INPUTS ***
C
      EQUIVALENCE(X1            ,A(257)),(Y1            ,A(258)),(Z1            ,A(259)),
     1           (X2            ,A(260)),(Y2            ,A(261)),(Z2            ,A(262)),
     2           (X3            ,A(263)),(Y3            ,A(264)),(Z3            ,A(265)),
     3           (X4            ,A(266)),(Y4            ,A(267)),(Z4            ,A(268)),
     4           (X5            ,A(269)),(Y5            ,A(270)),(Z5            ,A(271)),
     5           (S13           ,A( 19)),(S23           ,A( 22)),(S33           ,A( 25)),
     6           (P             ,A( 26)),(Q             ,A( 27)),(R             ,A( 28)),
     7           (PDOT          ,A( 45)),(QDOT          ,A( 46)),(RDOT          ,A( 47)),
     8           (XPCG          ,A(280)),(ZPCG          ,A(281)),(FTX           ,A(134)),
     9           (FTY           ,A(135)),(FTZ           ,A(136)),(W             ,A(198))    240278
C
C     **** CONSTANTS ****
C
      EQUIVALENCE(RG            ,A(146))
C
C  EVALUATING COMMON SUB-EXPRESSIONS
C
      P2 = P*P
      Q2 = Q*Q
      R2 = R*R
      PQ = P*Q
      PR = P*R
      QR = Q*R

C  THESE INCLUDE DIVISION BY 'G'
      Q2R2   = (Q2 + R2)*RG
      PQRDTB = (PQ-RDOT)*RG
      PRQDT  = (PR+QDOT)*RG
      PQRDT  = (PQ+RDOT)*RG
      P2R2   = (P2+R2)*RG
      QRPDTB = (QR-PDOT)*RG
      PRQDTB = (PR-QDOT)*RG
      QRPDT  = (QR+PDOT)*RG
      P2Q2   = (P2+Q2)*RG

      RW = 1.0/W
C
C  CALCULATING ACCELERATIONS IN 'G'UNITS
C
C  SPECIFIC ACCNS AT AIRCRAFT C.G.
C
      AXCG = FTX*RW
```

```
          AYCG = FTY*RM
          AZCG = FTZ*RM
C
C  ABSOLUTE ACCNS AT AIRCRAFT C.G.
C
          AXACG = AXCG+S13
          AYACG = AYCG+S23
          AZACG = AZCG+S33
C
C  SPECIFIC ACCNS AT PILOT
C
          AXP = AXCG-XPCG*Q2R2 + ZPCG*PRQDT                              240278
          AYP = AYCG+XPCG*PQRDT + ZPCG*QRPDTB                            240278
          AZP = AZCG+XPCG*PRQDTA - ZPCG*P2Q2                             240278
C
C  ABSOLUTE (OR 'MANUEUVRE G') ACCNS AT PILOT
C
          AZAP = AZP+S33
C
C  ACCNS FOR RECORDERS RELATIVE TO 1.0 G
C
          AZCG1 = AZCG+1.0
C
C  ACCNS FOR SLIP BALL (LOCATED AT X1,Y1,Z1)
C
          AY1 = AYCG+X1*PQRDT-Y1*P2R2+Z1*QRPDTB
C
C  ACCNS FOR 'G' METER (AT X2,Y2,Z2)
C
          AZ2 = AZCG+X2*PRQDTB+Y2*QRPDT-Z2*P2Q2
C
C ACCNS FOR THREE INDEPENDANT ACCELEROMETERS (FOR USE BY AUTOSTAB)
C              X-ACCELEROMETER AT X3,Y3,Z3
C              Y-ACCELEROMETER AT X4,Y4,Z4
C              Z-ACCELEROMETER AT X5,Y5,Z5
C
          AX3 = AXCG-X3*Q2R2+Y3*PQRDTB+Z3*PRQDT
          AY4 = AYCG+X4*PQRDT-Y4*P2R2+Z4*QRPDTB
```

```
          AZ5 = AZCG+X5*PRQDTB+Y5*QRPDT-Z5*P2Q2
          RETURN
          END
!ASSIGN (MISI,D3,SACLS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
      SUBROUTINE SACCLIN
C
C        ****************************************************
C        *                                                  *
C        *    WRITTEN BY: D.OLDFIELD                        *
C        *    DATE:12-8-76                                  *
C        *    DESCRIPTION: THIS SUBROUTINE CALCULATES THE TOTAL *
C        *        FORCE COMPONENTS TO THE EARTH AXES GIVEN THE  *
C        *        COMPONENTS TO THE BODY AXES AND THE DIRECTION *
C        *        COSINES. THE ACCELERATION IS ALSO CALCULATED  *
C        *        FROM THIS INFORMATION AND THE AIRCRAFT MASS   *
C        *                                                  *
C        ****************************************************
C
C     12-8-76     SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KSACCLIN/120876/
      EQUIVALENCE(KSACCLIN,L(256))
C
C             *** VARIABLE INPUTS ***
C
      EQUIVALENCE(S11      ,A( 17)),(S12      ,A( 18)),(S13      ,A( 19)),
     1           (S21      ,A( 20)),(S22      ,A( 21)),(S23      ,A( 22)),
     2           (S31      ,A( 23)),(S32      ,A( 24)),(S33      ,A( 25)),
     3           (FTX      ,A(134)),(FTY      ,A(135)),(FTZ      ,A(136)),
     4           (RXMASS   ,A(  1))
C
C             *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(FTN      ,A(137)),(FTE      ,A(138)),(FTD      ,A(139)),
     1           (VKNDOT   ,A(238)),(VKEDOT   ,A(239)),(VKDDOT   ,A(240))
C
C             *** CONSTANTS ***
C
      EQUIVALENCE(G        ,A(145))
C
C         CALCULATE TOTAL FORCES TO EARTH AXES
      FTN = S11*FTX+S21*FTY+S31*FTZ
      FTE = S12*FTX+S22*FTY+S32*FTZ
      FTD = S13*FTX+S23*FTY+S33*FTZ
C         CALCULATE ACCELERATION
      VKNDOT= FTN*RXMASS
      VKEDOT= FTE*RXMASS
      VKDDOT= FTD*RXMASS+G
      RETURN
      END.
IASSIGN (MISI,D3,SACRS)

IFORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SACCROT
C
C         ****************************************************
C         *    WRITTEN BY : D.BLUFIELD                       *
C         *    DATE : 12-8-76                                *
C         *    DESCRIPTION : THIS SUBROUTINE CALCULATES      *
C         *      THE ANGULAR ACCELERATIONS IN THE BODY       *
C         *      AXES GIVEN THE TOTAL MOMENTS,ANGULAR        *
C         *      VELOCITY COMPONENTS IN THE BODY AXES AND    *
C         *      THE INERTIA COEFFICIENTS.                   *
C         *                                                  *
C         ****************************************************
C
C     12-8-76    SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KSACCROT/120876/
      EQUIVALENCE(KSACCROT,L(257))
C
C              *** VARIABLE INPUTS ***
C
      EQUIVALENCE(XLLTOT  ,A(131)),(XMMTOT  ,A(132)),(XNNTOT  ,A(133)),
    1           (P       ,A( 26)),(Q       ,A( 27)),(R       ,A( 28)),
    2           (CI1     ,A( 35)),(CI2     ,A( 36)),(CI3     ,A( 37)),
    3           (CI4     ,A( 38)),(CI5     ,A( 39)),(CI6     ,A( 40)),
    4           (CI7     ,A( 41)),(CI8     ,A( 42)),(CI9     ,A( 43)),
    5           (CI10    ,A( 44))
C
C              *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(PDOT    ,A( 45)),(QDOT    ,A( 46)),(RDOT    ,A( 47))
C
C         CALCULATE ANGULAR ACCELERATIONS
      PDOT = CI1*XLLTOT+CI2*XNNTOT+(CI3*P+CI4*R)*Q
      QDOT = CI5*XMMTOT+CI6*(R*R-P*P)+CI7*R*P
      RDOT = CI8*XNNTOT+CI2*XLLTOT+(CI9*P+CI10*R)*Q
C
      RETURN
      END
!ASSIGN (M:SI,D3,SALFS)

!FORTRAN LS,NB
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SALFBLT(DT)
C
C         ***************************************************
C         *                                                 *
C         *    WRITTEN BY : D.OLDFIELD                      *
C         *    DATE : 21-3-78                               *
C         *    DESCRIPTION : THIS SUBROUTINE CALCULATES     *
C         *      THE ANGLE OF ATTACK AND SIDE SLIP. THE     *
C         *       SINE AND COSINE OF THE ANGLES ARE ALSO    *
C         *       CALCULATED. THE DERIVATIVES OF THE ANGLES *
C         *       ARE DERIVED FROM THE ASSUMPTION OF A      *
C         *       QUADRATIC FIT TO THE DATA USING THE       *
C         *       TIME INTERVAL IS PASSED AS A PARAMETER    *
C         *                                                 *
C         ***************************************************
C
C     12-8-78     SYSTEM COMMON ENLARGED
C     21.3.78     TEMP VARIABLE NAME CHANGED
C      9.8.79     EVALUATION OF DERIVATIVES CORRECTED
      COMMON/SYSTEM/A(1000),C(400)
C
C   VERSION IDENTIFIER
C
      DATA KSALFBLT/090879/
      EQUIVALENCE(KSALFBLT,C(250))
      DATA I/0/
C
C              *** VARIABLE INPUTS ***
C
      EQUIVALENCE(UB      ,A( 88)),(VB      ,A( 89)),(WB      ,A( 90))
      EQUIVALENCE(NCPASS  ,C( 21)),(NIPASS  ,C( 33))                  090879
C
C              *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(ALFAR   ,A(111)),(ALFAD   ,A(112)),(ALFADOT ,A(120)),
     1            (SALFA  ,A(116)),(CALFA   ,A(117)),(BETAR   ,A(113)),
     2            (BETAD  ,A(114)),(BETADOT ,A(121)),(SBETA   ,A(118)),
     3            (CBETA  ,A(119))
C
C              *** CONSTANTS ***
C
      EQUIVALENCE(RADTOD  ,A(145))
C
C          CALCULATE ANGLE OF ATTACK,IN RANGE +/- 180 DEG.
      ALFAR = 0.0
      IF(WB.EQ.0.0.AND.UB.EQ.0.0) GO TO 7
      ALFAR = ATAN2(WB,UB)
    7 ALFAD = ALFAR*RADTOD
      SALFA = SIN(ALFAR)
      CALFA = COS(ALFAR)
C          CALCULATE ANGLE OF SIDESLIP,IN RANGE +/- 90 DEG.
      V = SQRT(UB*UB+WB*WB)
      BETAR = 0.0
      IF(V.EQ.0.0.AND.VB.EQ.0.0) GO TO 8
      BETAR = ATAN2(VB,V)
    8 BETAD = BETAR*RADTOD
      SBETA = SIN(BETAR)
      CBETA = COS(BETAR)
C          SET UP PREVIOUS VALUES FOR FIRST ENTRY
      IF(I.GT.0) GO TO 10
      ALFARM1 = ALFAR
      ALFARM2 = ALFAR
      BETARM1 = BETAR
      BETARM2 = BETAR
      I = 1
   10 CONTINUE
C          CALCULATE DERIVATIVE OF ALFA AND BETA,THEN SET UP PREVIOUS VALUES
C          FOR NEXT ENTRY.
C
C   EVALUATE DERIVATIVES ONLY DURING LAST PASS OF INTEGRATION STEP
C   (AND DURING INITIALISATION)
C
      IF(NCPASS.LT.NIPASS-1)RETURN                                    090879
C
      RT = 0.5/DT                                                     210378
      ALFADOT = (ALFARM2-4.0*ALFARM1+3.0*ALFAR)*RT                    210378
      BETADOT = (BETARM2-4.0*BETARM1+3.0*BETAR)*RT                    210378
      ALFARM2 = ALFARM1
      ALFARM1 = ALFAR
      BETARM2 = BETARM1
      BETARM1 = BETAR
      RETURN
      END
ICC
IFIN
```

```
      SUBROUTINE SCOUNT
C
C         *********************************************************
C         *                                                       *
C         *    DESCRIPTION : THIS ROUTINE SETS PASS COUNT FOR     *
C         *      DERIVATIVE SECTION.                              *
C         *    WRITTEN BY : B.N.TOMLINSON                         *
C         *    DATE :12-8-76                                      *
C         * MODIFIED: 31-5-77 TO INCLUDE DLRUN                    *
C         *                                                       *
C         *********************************************************
C
C
C   VERSION IDENTIFIER
C
      DATA KSCOUNT/310577/                                              310577
      EQUIVALENCE(KSCOUNT ,L(259))
C     12-8-76      SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A(1000),L(400)
C  PICK UP JCOMP (SET IN SWAIT)
      COMMON/CONTROL/JCOMP
C  JCOMP = 1 AFTER COMPUTE PRESSED
C
C              *** VARIABLE INPUTS ***
C
C
C              *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE (NRUN    ,L(169))                                     310577
      EQUIVALENCE(NCPASS  ,L(. 2)),(JJCOMP  ,L(  8))
C     NCPASS IS COUNT OF NUMBER OF PASSES THROUGH DERIVATIVE SECTION
C     EXECUTED SO FAR IN ONE INTEGRATION STEP. SET TO ZERO IN THIS
C     ROUTINE PRIOR TO DOING INTEGRATION.
      NCPASS = 0
C  SET JJCOMP,IN SYSTEM COMMON,TO ENABLE STATUS TO BE
C      USED,E.G. IN SIL6,STV
      JJCOMP = JCOMP




C  PICK UP RUN NUMBER FROM MAILBOX
      CALL DLRUN (NRUN)                                                 310577
      RETURN
      END
IASSIGN (MISI,D3,SDCSS)

IFORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SDCOS
C
C     ****************************************************
C     *                                                  *
C     *     WRITTEN BY : D.OLDFIELD                      *
C     *     DATE : 12-8-76                               *
C     *     DESCRIPTION : THIS SUBROUTINE  CALCULATES    *
C     *        THE DIRECTION COSINES,SINES AND DEGREE    *
C     *        VALUE OF THREE INPUT ANGLES IN RADIANS.   *
C     *        SEC THETA AND TAN THETA ARE ALSO          *
C     *        CALCULATED.                               *
C     *                                                  *
C     ****************************************************
C
C   12-8-76     SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KSDCOS  /120876/
      EQUIVALENCE(KSDCOS   ,L(260))
C
C             *** VARIABLE INPUTS ***
C
      EQUIVALENCE(PSIR        ,A(  3)),(THETAR  ,A(  5)),(PHIR      ,A(  7))
C
C             *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(PSID        ,A(  4)),(THETAD  ,A(  6)),(PHID      ,A(  8)),
     1            (SPSI       ,A(  9)),(CPSI    ,A( 10)),(STHETA    ,A( 11)),
     2            (CTHETA     ,A( 12)),(SPHI    ,A( 13)),(CPHI      ,A( 14)),
     3            (SECTHT     ,A( 15)),(TANTHT  ,A( 16)),(S11       ,A( 17)),
     4            (S12        ,A( 18)),(S13     ,A( 19)),(S21       ,A( 20)),
     5            (S22        ,A( 21)),(S23     ,A( 22)),(S31       ,A( 23)),
     6            (S32        ,A( 24)),(S33     ,A( 25))
C
C             *** CONSTANTS ***
C
      EQUIVALENCE(RADTOD   ,A(141))
C
C          CALCULATE SINE,COSINE AND TANGENTS
      STHETA = SIN(THETAR)
      CTHETA = COS(THETAR)
      SPSI   = SIN(PSIR)
      CPSI   = COS(PSIR)
      SPHI   = SIN(PHIR)
      CPHI   = COS(PHIR)
C
C          CALCULATE DIRECTION COSINES
      S11 = CTHETA*CPSI
      S12 = CTHETA*SPSI
      S13 = -STHETA
      S21 = SPHI*STHETA*CPSI-CPHI*SPSI
      S22 = SPHI*STHETA*SPSI+CPHI*CPSI
      S23 = SPHI*CTHETA
      S31 = CPHI*STHETA*CPSI+SPHI*SPSI
      S32 = CPHI*STHETA*SPSI-SPHI*CPSI
      S33 = CPHI*CTHETA
C
C          CALCULATE SEC THETA AND TAN THETA
      SECTHT = 1.0/CTHETA
      TANTHT = STHETA*SECTHT
C
C          CALCULATE ANGLES IN DEGREES
      PSID   = PSIR*RADTOD
      THETAD = THETAR*RADTOD
      PHID   = PHIR*RADTOD
      RETURN
      END
IASSIGN (M;SI/D3,SEOLS)

IFORTRAN LS,NB
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SEULER
C
C         ************************************************
C         *                                              *
C         *    WRITTEN BY : D.BLUFIELD                   *
C         *    DATE : 12-8-76                            *
C         *    DESCRIPTION : THIS SUBROUTINE CALCULATES  *
C         *       THE ALTITUDE RATES GIVEN THE COMPONENTS *
C         *        OF THE ANGULAR VELOCITY IN THE BODY AXIS *
C         *                                              *
C         ************************************************
C
C     12-8-76     SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KSEULER /120876/
      EQUIVALENCE(KSEULER ,L(261))
C
C              *** VARIABLE INPUTS ***
C
      EQUIVALENCE(SPHI    ,A( 13)),(CPHI    ,A( 14)),(SECTHT  ,A( 15)),
     1           (TANTHT  ,A( 16)),(P       ,A( 26)),(Q       ,A( 27)),
     2           (R       ,A( 28))
C
C              *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(PHIDT   ,A( 29)),(THETDT  ,A( 30)),(PSIDT   ,A( 31)),
     1           (PD      ,A( 32)),(QD      ,A( 33)),(RD      ,A( 34))
C
C              *** CONSTANTS ***
C
      EQUIVALENCE(RADTOD  ,A(141))
C
C         CALCULATE ATTITUDES
      PHIDT = P+TANTHT*(Q*SPHI+R*CPHI)
      THETDT = Q*CPHI-R*SPHI
      PSIDT = SECTHT*(Q*SPHI+R*CPHI)
C         CALCULATE ANGULAR VELOCITY IN DEGREES
      PD = P*RADTOD
      QD = Q*RADTOD
      RD = R*RADTOD
C
      RETURN
      END
!ASSIGN (M1SI,D3,SILSS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE [illegible]
C
C       ****************************************************************
C       *                                                              *
C       *    WRITTEN BY : [illegible]                                  *
C       *    DATE       : [illegible]                                  *
C       *    DESCRIPTION: CALCULATES CONVENTIONAL ANGULAR TYPE ILS     *
C       *       BEAM WITH CHOICE OF 3 BEAM CHARACTERISTICS SET         *
C       *       BY ILSFLG                                              *
C       *            1  3 DEG SLOPE                                    *
C       *            2  6 DEG SLOPE                                    *
C       *            3  TWO SEGMENT[illegible]                         *
C       *                                                              *
C       ****************************************************************
C
C     EGS       GLIDE SLOPE [illegible] AT RUNWAY THRESHOLD)
C     ELOC      LOCALIZER ERROR[illegible]
C     YLOC      LOCALIZER ERROR [illegible]
C     RKINK     RANGE FROM BEAM KINK
C     XKINK     DISTANCE OF BEAM KINK FROM R/W THRESHOLD (NEG ON APPROACH)
C     RGS       RANGE FROM GS TRANSMITTER
C     RLOC      RANGE FROM LOC TRANSMITTER
C     HSLOPE    HEIGHT OF ILS BEAM AT RANGE RGS
C     XGS       GLIDE SLOPE ANGULAR ERROR (FRACTION OF FULL SCALE)
C     XLOC      LOCALIZER   ANGULAR ERROR
C     SGS       GLIDE SLOPE SENSITIVITY (DEG)
C     SLOC      LOCALIZER   SENSITIVITY (DEG)
C   ILS PARAMETERS
C     USLOPE    SLOPE OF UPPER SEGMENT
C     BSLOPE    SLOPE OF BASIC SEGMENT
C     HKINK     HEIGHT OF KINK OF UPPER AND LOWER BEAM SEGMENTS
C
C     LEVEL 2      SYSTEM COMMON ENLARGED
      COMMON/SYSTEM/A([illegible]),L([illegible])
C
C    VERSION IDENTIFIER
C

      DATA KSILS    /2155974/
      EQUIVALENCE(KSILS    ,L(262))
C
C              *** VARIABLE INPUTS ***
C
      EQUIVALENCE(X        ,A(149)),(Y        ,A(150)),(H        ,A(151))
C
      EQUIVALENCE(ILSFLG  ,L(  4)),(JJCOMP  ,L(  8)),(LSILS   ,L(148))
C
C              *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(EGS      ,A(171)),(ELOC     ,A(172)),(HSLOPE   ,A(173)),
     1            (RGS      ,A(174)),(RLOC     ,A(175)),(RKINK    ,A(176))
C
C              *** INTERNALLY GENERATED PARAMETERS ***
C
      EQUIVALENCE(XGS      ,A(177)),(XLOC     ,A(178)),(YLOC     ,A(179)),
     1            (SGS      ,A(180)),(SLOC     ,A(181)),(HKINK    ,A(182)),
     2            (BSLOPE   ,A(183)),(USLOPE   ,A(184)),(XKINK    ,A(185)),
     3            (CILS1    ,A(186)),(CILS2    ,A(187)),(CILS3    ,A(188)),
     4            (CILS4    ,A(189))
C
C              *** CONSTANTS ***
C
      EQUIVALENCE(RADTOD  ,A(141)),(DEGTOR  ,A(142))
C
      IF(JJCOMP.EQ.0)GO TO 99
      IF(LSILS.EQ.1)GO TO 20
C  NO ILS REQUIRED
      EGS=ELOC=0.0
      GO TO 30
   99 CONTINUE
C EXECUTE ONLY IF INITIALISATION NOT COMPLETE
      GO TO (1,2,3)ILSFLG
C     ILSFLG
C       1      MAIN RUNWAY,3 DEG SLOPE
C       2      MAIN RUNWAY,6 DEG SLOPE
C       3      MAIN RUNWAY,2 SEGMENT
```

```
    1 CONTINUE
C   ILS CONSTANTS FOR MAIN RUNWAY,3 DEG GLIDE SLOPE
      XGS       = 1000.0
      XLOC      =11000.0
      YLOC      =     0.0
      SGS       =     0.75
      SLOC      =     2.0
      USLOPE    =     3.0
      BSLOPE    =     3.0
      HKINK     =     0.0
      GO TO 10
    2 CONTINUE
C   ILS CONSTANTS FOR MAIN RUNWAY,6 DEG GLIDE SLOPE
      XGS     =  1000.0
      XLOC    = 11000.0
      YLOC    =     0.0
      SGS     =     0.75
      SLOC    =     2.0
      USLOPE  =     6.0
      BSLOPE  =     6.0
      HKINK   =     0.0
      GO TO 10
    3 CONTINUE
C   ILS CONSTANTS FOR2 SEGMENT (6/3) TO MAIN RUNWAY
      XGS     =  1000.0
      XLOC    = 11000.0
      YLOC    =     0.0
      SGS     =     0.75
      SLOC    =     2.0
      USLOPE  =     6.0
      BSLOPE  =     3.0
      HKINK   =   500.0
   10 CONTINUE
C   COLLECTIVE CONSTANTS
      CILS1 = RADTOD/SGS
      CILS2 = RADTOD/SLOC
      CILS3 = TAN(BSLOPE*DEGTOR)
      CILS4 = TAN(USLOPE*DEGTOR)- CILS3


      XKINK = XGS - HKINK/CILS3
C    MAIN ROUTINE
   20 CONTINUE
C   HERE IMMEDIATELY IF IN 'COMPUTE'
      RKINK = -(X - XKINK)
      RGS   = -(X - XGS)
      RLOC  = -(X - XLOC)
      HSLOPE=RGS*CILS3 + 0.5*(RKINK + ABS(RKINK))*CILS4
      EGS   =BOUND(-1.0,1.0,CILS1*(H - HSLOPE)/RGS)
      ELOC  =BOUND(-1.0,1.0,CILS2*(Y - YLOC)/RLOC)
   30 CONTINUE
      RETURN
      END
IASSIGN (MISI,03,SINTS)

IFORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SINIT
C
C         ******************************************************
C         *                                                    *
C         *    WRITTEN BY : D.OLDFIELD                         *
C         *    DATE   17.10.77                                 *
C         *    DESCRIPTION : THIS SUBROUTINE CALCULATES        *
C         *      THE INITIAL VALUES OF THE INERTIA COEFFICIENTS *
C         *      GIVEN IX,IY,IZ,IZX                            *
C         *      THE INITIAL VALUES OF VARIABLES LISTED BELOW  *
C         *      FROM THE STATED INPUT VARIABLES FROM THE USER *
C         *                                                    *
C         *      USER PROVIDED INFORMATION:-                   *
C         *           BETADIC,ALFADIC,GAMDIC,VKTIC,XIC,YIC,    *
C         *           HIC,ISHR,VWKTO,PSIWD,PSIKDIC,SWREF,SPAN,W *
C         *                                                    *
C         *      INITIAL VALUES OUTPUT:-                       *
C         *           HSLOPE,CPSIW,SPSIW,VWNLO,VWELO,SHRFAC,   *
C         *           VWN,VWE,VWD,DENR,SPSNDR,TEMPR,PRESSR,    *
C         *           ROOTSIG,VT,VK,VKNIC,VKEIC,VKDIC,VN,VE,   *
C         *           VD,PSIDIC,THETADIC,RADTOD,DEGTOR,        *
C         *           FPSTKT,KTOFPS,G,RHOSL,SPSL,PDIC,QDIC,    *
C         *           RDIC,PHIDIC,XMASS,RXMASS,SB2             *
C         *    N.B                                             *
C         *    HIC NEGATIVE PLACES AIRCRAFT ON ILS BEAM        *
C         *           AT SPECIFIED RANGE XIC                   *
C         *    KISA = 0 (DEFAULT) SELECTS SEA LEVEL ATMOSPHERE *
C         *    VKTIC= 0.0 SETS SYSTEM UP FOR ZERO GROUND SPEED *
C         *           OTHERWISE SETS UP FOR AIRSPEED(EAS)=VKTIC*
C         *                                                    *
C         ******************************************************
C
C      12-8-76     SYSTEM COMMON ENLARGED
C    17.10.77  CI3 CORRECTED
C    8. 2.78 FLAG FOR HIGH SPEED DAC CONTROL ADDED
C    5.6.78 COMMON HSHIO ENLARGED TO 2 WORDS
      COMMON/SYSTEM/A(1000),L(400)


      COMMON/HSHIO/IHSHIO,IDUM
C
C  VERSION IDENTIFIER
C
      DATA KSINIT  /050678/
      EQUIVALENCE(KSINIT  ,L(263))
C
C         ***     INPUT VARIABLES     ***
C
      EQUIVALENCE(XIX     ,A( 48)),(XIY     ,A( 49)),(XIZ     ,A( 50)),
     1           (XIZX    ,A( 51)),(ZCG     ,A( 98)),(XCGREF  ,A( 99)),
     2           (ZCGREF  ,A(100)),(SPAN    ,A(103)),(SWREF   ,A(106)),
     3           (HSLOPE  ,A(173)),(BETADIC ,A(191)),(ALFADIC ,A(192)),
     4           (GAMDIC  ,A(193)),(VKTIC   ,A(194)),(XIC     ,A(195)),
     5           (HIC     ,A(197)),(XCG     ,A(199)),(VWKTO   ,A(202)),
     6           (PSIWD   ,A(203)),(PSIDIC  ,A(204)),(SHRFAC  ,A(228)),
     7           (W       ,A(198))
      EQUIVALENCE                  (ISHR    ,L(  5)),(KISA    ,L(  1))
C
C         ***     OUTPUT VARIABLES     ***
C
      EQUIVALENCE(RXMASS  ,A(  1)),(XMASS   ,A(  2)),(CI1     ,A( 35)),
     1           (CI2     ,A( 36)),(CI3     ,A( 37)),(CI4     ,A( 38)),
     2           (CI5     ,A( 39)),(CI6     ,A( 40)),(CI7     ,A( 41)),
     3           (CI8     ,A( 42)),(CI9     ,A( 43)),(CI10    ,A( 44)),
     4           (VWN     ,A( 55)),(VWE     ,A( 56)),(VWD     ,A( 57)),
     5           (RHOSL   ,A( 79)),(SPSL    ,A( 80)),(DXCG    ,A(101)),
     6           (DZCG    ,A(102)),(SB2     ,A(108)),(X       ,A(149)),
     7           (VKNIC   ,A(211)),(VKEIC   ,A(212)),(VKDIC   ,A(213)),
     8           (PHIDIC  ,A(214)),(THETADIC,A(215)),
     9           (VN      ,A(217)),(VE      ,A(218)),(VD      ,A(219))
C
      EQUIVALENCE(PDIC    ,A(220)),(QDIC    ,A(221)),(RDIC    ,A(222)),
     1           (CPSIW   ,A(224)),(SPSIW   ,A(225)),(VWNLO   ,A(226)),
     2           (VWELO   ,A(227)),(RHO     ,A( 72)),(SPSOND  ,A( 73)),
     3           (ROOTSIG ,A( 71)),(VT      ,A( 67)),(VK      ,A( 65)),
     4           (TALPHA  ,A( 88)),(PALPHA  ,A( 86))
C
```

```
C          ***    CONSTANTS DERIVED    ***
C
      EQUIVALENCE(RADTOD  ,A(141)),(DEGTOR  ,A(142)),(FPSTKT  ,A(143)),
     1            (XK2FPS  ,A(144)),(G       ,A(145)),(DENR    ,A( 78)),
     2            (SPSNDR  ,A( 84)),(TEMPR   ,A( 81)),(PRESSR  ,A( 82)),
     3            (TEMPSL  ,A( 76)),(PRESSL  ,A( 77)),(RG      ,A(146))
C
C          INITIALISE CONSTANTS
      DATA RADTOD,DEGTOR/57.295780,0.0174533/
      DATA FPSTKT,XK2FPS/0.5921053,1.688889/
      DATA G,RHOSL,SPSL/32.174,0.0023769,1116.45/
      DATA RG/0.03108/
      DATA TEMPSL,PRESSL/288.15,14.69597/
      DATA DENR,SPSNDR,TEMPR,PRESSR/1.0,1.0,1.0,1.0/
      DATA PDIC,QDIC,RDIC,PHIDIC/0.0,0.0,0.0,0.0/
      DATA KISA/0/
      DATA ISHR/1/
C
C  SET FLAG FOR HIGH SPEED HYBRID OUTPUT
      DATA IHSHIO/1/
C
      CI0 = 1.0/(XIZ*XIX-XIZX*XIZX)
C          CALCULATE INITIAL VALUES OF INERTIA COEFFICIENTS
      CI1 = CI0*XIZ
      CI2 = CI0*XIZX
      CI3 = CI0*(XIX-XIY+XIZ)*XIZX                                      171077
      CI4 = CI0*(XIZ*(XIY-XIZ)-XIZX*XIZX)
      CI5 = 1.0/XIY
      CI6 = CI5*XIZX
      CI7 = CI5*(XIZ-XIX)
      CI8 = CI0*XIX
      CI9 = CI0*((XIX-XIY)*XIX+XIZX*XIZX)
      CI10 = CI0*XIZX*(-XIX+XIY-XIZ)
C
C         ADJUST H FOR A/C ON BEAM (H<0)
      IF (HIC.GT.0.0) GO TO 10
      X = XIC
      CALL SILS

      HIC = HSLOPE
   10 CONTINUE
C
      IF (KISA.EQ.0) GO TO 24
C         SET UP INITIAL ATMOSPHERIC VALUES
      CALL SATMOS(HIC,DENR,SPSNDR,TEMPR,PRESSR)
   24 ROOTSIG = SQRT(DENR)
      SPSOND = SPSL*SPSNDR
      RHO    = RHOSL*DENR
      TALPHA = TEMPSL*TEMPR
      PALPHA = PRESSL*PRESSR
C
C
C         CALCULATE LOCAL TRUE WIND COMPONENTS GIVEN DATUM WIND
C         SPEED AND DIRECTION
C
      CPSIW = COS(PSIWD*DEGTOR)
      SPSIW = SIN(PSIWD*DEGTOR)
      VWNLO = -VWKTO*XK2FPS*CPSIW
      VWELO = -VWKTO*XK2FPS*SPSIW
C         ALLOWANCE FOR WIND SHEAR
      CALL WSHEAR(ISHR,HIC,SHRFAC)
      VWN = VWNLO*SHRFAC
      VWE = VWELO*SHRFAC
      VWD = 0.0
C
C  SET STARTING VALUE OF TRACK EQUAL TO HEADING
      PSIRDIC = PSIDIC
C  AND STORE DESIRED HEADING FOR REFERENCE
      PSIDICO = PSIDIC
C
C         CALCULATE SIN AND COS OF GAMMA
      CGV = COS(GAMDIC*DEGTOR)
      CGH = COS(PSIRDIC*DEGTOR)
      SGV = SIN(GAMDIC*DEGTOR)
      SGH = SIN(PSIRDIC*DEGTOR)
      IF (VKTIC.LE.1.0) GO TO 20
C
```

```
C         SET UP VELOCITIES FOR DESIRED AIRSPEED
C         AND ITERATE TO GET DESIRED HEADING
C   INITIALISE LOOP COUNT
       I = 0
C   LOOP
    30 CONTINUE
       I = I + 1
       CGH = COS(PSIKDIC*DEGTOR)
       SGH = SIN(PSIKDIC*DEGTOR)
C
       VT = VKTIC*KK2FPS/ROOTSIG
C          SOLVE QUADRATIC FOR VK
       B =-2.0*((VWN*CGH+VWE*SGH)*CGV-VWD*SGV)
       C = VWN*VWN+VWE*VWE+VWD*VWD-VT*VT
       VK = (-B+SQRT(B*B-4.0*C))*0.5
C          CALCULATE GROUND SPEED COMPONENTS
       VKNIC = VK*CGV*CGH
       VKEIC = VK*CGV*SGH
       VKDIC = -VK*SGV
C      CALCULATE COMPONENTS OF AIRSPEED IN EARTH AXES
       VN = VKNIC-VWN
       VE = VKEIC-VWE
       VD = VKDIC-VWD
C      CALCULATE INITIAL HEADING
       PSIAD = 0.0
       IF (VE.EQ.0.0.AND.VN.EQ.0.0) GO TO 16
       PSIAD = ATAN2(VE,VN)*RADTOD
    16 PSIDIC = PSIAD-BETADIC
       DP = PSIDICO - PSIDIC
C   LIMIT NUMBER OF ITERATIONS FOR SAFETY
       IF(I.GE.10) GO TO 26
C   TEST FOR HEADING GOOD ENOUGH
       IF(ABS(DP).LT.0.1) GO TO 26
       PSIKDIC = PSIKDIC + DP
       GO TO 30
C
C         SET UP VALUES FOR ZERO GROUND SPEED
C
    20 VK = 0.0
       VKNIC = 0.0
       VKEIC = 0.0
       VKDIC = 0.0
       VN = -VWN
       VE = -VWE
       VD = -VWD
       VT = SQRT(VN*VN+VE*VE+VD*VD)
C
    26 GAMD = 0.0
       IF (VN.EQ.0.0.AND.VE.EQ.0.0.AND.VD.EQ.0.0) GO TO 18
       GAMD = ATAN2(-VD,SQRT(VN*VN+VE*VE))*RADTOD
    18 THETADIC = GAMD+ALFADIC
C
C         AIRCRAFT RELATED CONSTANTS
C
       SB2 = SWREF*SPAN*SPAN
       XMASS = W/G
       RXMASS = 1.0/XMASS
       DXCG = XCG-XCGREF
       DZCG = ZCG-ZCGREF
       RETURN
       END
!ASSIGN (M1S1,D3,SPTHS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
          SUBROUTINE SPATH
    C
    C           *****************************************************
    C           *                                                   *
    C           *    WRITTEN BY : D.OLDFIELD                        *
    C           *    DATE : 12-8-76                                 *
    C           *    DESCRIPTION : THIS SUBROUTINE CALCULATES THE   *
    C           *      ANGLE OF ELEVATION AND TRACK AND THE VELOCITY *
    C           *      OVER THE GROUND                              *
    C           *                                                   *
    C           *****************************************************
    C
    C     12-8-76      SYSTEM COMMON ENLARGED
          COMMON/SYSTEM/A(1000),L(400)
    C
    C   VERSION IDENTIFIER
    C
          DATA KSPATH  /120R76/
          EQUIVALENCE(KSPATH  ,L(264))
    C
    C              *** VARIABLE INPUTS ***
    C
          EQUIVALENCE(VKN     ,A( 52)),(VKE     ,A( 53)),(VKD     ,A( 54))
    C
    C              *** VARIABLE OUTPUTS ***
    C
          EQUIVALENCE(GAMMAR  ,A( 61)),(GAMMAD  ,A( 62)),(PSIKR   ,A( 63)),
         1            (PSIKD   ,A( 64)),(VK      ,A( 65)),(VKKT    ,A( 66))
    C
    C              *** CONSTANTS ***
    C
          EQUIVALENCE(FPSTKT  ,A(143)),(RADTOD  ,A(141))
    C
    C          CALCULATE VELOCITY OVER GROUND
          VK = SQRT(VKN*VKN+VKE*VKE)
          VKKT = VK*FPSTKT
    C



    C              *** CALCULATE FLIGHT PATH ANGLES ***
    C
    C          INITIALISE ANGLES TO ZERO
          PSIKR = 0.0
          GAMMAR = 0.0
    C          CALCULATE ANGLE OF ELEVATION
    C              RANGE +90 TO -90
          IF(VKD.EQ.0.0.AND.VK.EQ.0.0) GO TO 4
          GAMMAR = ATAN2(-VKD,VK)
        4 GAMMAD = GAMMAR*RADTOD
    C          CALCULATE ANGLE OF TRACK
    C              RANGE  0(NORTH) TO 360
          IF(VKE.EQ.0.0.AND.VKN.EQ.0.0) GO TO 5
          PSIKR = ATAN2(VKE,VKN)
    C          ADJUST FOR RANGE
          IF(VKE.LT.0.0) PSIKR = 6.283185+PSIKR
        5 PSIKD = PSIKR*RADTOD
    C
          RETURN
          END
IASSIGN (MISI,D3,STVVS)

IFORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```

      SUBROUTINE STV
C
C     *****************************************************************
C     *                                                               *
C     *    WRITTEN BY : B.N.TOMLINSON                                 *
C     *    DATE       : 12-8-76                                       *
C     *    REVISED    : 2.9.76 TO USE SYSTEM DISCRETES                *
C     *                 6.9.76 WITH NEW TV CONSTANTS                  *
C     *                        FOR 700 MODEL                          *
C     *                        AND SHIP MOTION                        *
C     *                 8.9.76 HEIGHT AND BELT PROTECTION             *
C     *                 5.10.76 TVCONS INCLUDED IN                    *
C     *                        SYSTEM COMMON AND                      *
C     *                        CYCLE LOGIC REVISED                    *
C     *                 24.2.78 PILOT LOCATION CORRECTED              *
C     *    DESCRIPTION: HANDLES TV SLEW AND RESET LOGIC               *
C     *                 ALSO CALCULATES TV POSITIONS                  *
C     *                 N.B.                                          *
C     *                   NTVB MUST BE PROVIDED BY USER TO            *
C     *                        SELECT APPROPRIATE                     *
C     *                        TV CONSTANTS                           *
C     *****************************************************************
C
C     LOGIC INPUTS
C       BELT CYCLE      LCYCLE = 1
C       BX RESET        LXTVIC = 1
C       BY RESET        LYTVIC = 1
C       FORWARD SLEW    LFWD   = 1
C       BACKWARD SLEW   LBACK  = 1
C     LOGIC OUTPUTS
C       IDSYNC
C     CONTROL OUTPUTS
C       XIHX
C       XIHY
C       12-8-76         SYSTEM COMMON ENLARGED

      COMMON/SYSTEM/A(1000),L(400)
C
C     VERSION IDENTIFIER
C
      DATA KSTV    /240278/
      EQUIVALENCE(KSTV        ,L(265))
      DIMENSION TVCON(8,3)
      DIMENSION IDS(32),ISLR(16),IP(32)
C
C           ***  VARIABLE INPUTS  ***
C
      EQUIVALENCE(X           ,A(149)),(Y          ,A(150)),(H          ,A(151)),
     1           (STHETA      ,A( 11)),(CTHETA     ,A( 12)),(SPSI       ,A(  9)),
     2           (CPSI        ,A( 10)),(PSIDT      ,A( 31)),(THETDT     ,A( 30)),
     3           (VKN         ,A( 52)),(VKE        ,A( 53)),(VKD        ,A( 54)),
     4           (DXCG        ,A(101)),(DZCG       ,A(102)),(CREF       ,A(107))      240278
C     EQUIVALENCE          (VSHIPKT     ,A( 169))
      EQUIVALENCE(JJCOMP      ,L(  8))
      EQUIVALENCE(IDS(1)      ,L(223)),(IP(1)      ,L(191))
      EQUIVALENCE(LCYCLE      ,IDS(5)),(LXTVIC     ,IDS(6)),(LYTVIC     ,IDS(7))
      EQUIVALENCE(LFWD        ,ISLR(4)),(LBACK     ,ISLR(5))
C
C           ***  VARIABLE OUTPUTS  ***
C
      EQUIVALENCE(XTV         ,A(152)),(YTV        ,A(153)),(HTV        ,A(154)),
     1           (XDTV        ,A(155)),(YDTV       ,A(156)),(HDTV       ,A(157)),
     2           (XIHX        ,A(159)),(XIHY       ,A(160)),(XDOTM      ,A(158)),
     3           (XIC         ,A(195)),(XPCG       ,A(280)),(ZPCG       ,A(281)),     240278
     4           (RXP         ,A(282)),(RHP        ,A(283)),(XICF       ,A(284))      240278
C
      EQUIVALENCE(IDSYNC,ICLR(16))
C
      EQUIVALENCE(ISLR(1)     ,L(151)),(ICLR(1)    ,L(171))
C
C           ***  CONSTANTS  ***
C
      EQUIVALENCE(XP          ,A(109)),(ZP         ,A(110)),(XK2FPS     ,A(144))
```

```
C
      EQUIVALENCE(NTVB     ,LI   2))
C
C         ***  INTERNALLY GENERATED PARAMETERS  ***
C
      EQUIVALENCE(SXPL     ,A(161)),(SXMIN    ,A(162)),(SXPLUS  ,A(163)),
     1            (SXMINUS ,A(164)),(SYPL     ,A(165)),(SYMIN   ,A(166)),
     2            (HTVLIM  ,A(167)),(XDTMX    ,A(168))
C
      EQUIVALENCE(TVCON (1,1),A(365))
C
C     NTVB = 1(700),2(2000) OR 3(5000),ACCORDING TO BELT USED
C
C  SXPL - TV X TRAVEL LIMIT,POSITIVE,AND 'NEAR BELT JOIN'
      DATA TVCON(1,1),TVCON(1,2),TVCON(1,3)/ 11590.0, 33000.0, 77500.0/
C  SXMIN - TV X TRAVEL LIMIT,NEGATIVE,AND 'NEAR BELT JOIN'
      DATA TVCON(2,1),TVCON(2,2),TVCON(2,3)/-11590.0,-33000.0,-77500.0/
C  SXPLUS - X CYCLE LIMIT
      DATA TVCON(3,1),TVCON(3,2),TVCON(3,3)/ 12800.0, 34500.0, 89600.0/
C  SXMINUS - X CYCLE LIMIT
      DATA TVCON(4,1),TVCON(4,2),TVCON(4,3)/-12800.0, 34500.0,-89600.0/
C  SYPL - TV Y TRAVEL LIMIT,POSITIVE(RIGHT)
      DATA TVCON(5,1),TVCON(5,2),TVCON(5,3)/  2700.0,  7650.0, 54650.0/
C  SYMIN - TV Y TRAVEL LIMIT,NEGATIVE(LEFT)
      DATA TVCON(6,1),TVCON(6,2),TVCON(6,3)/ -2700.0, -7650.0,-54650.0/
C  HTVLIM - CEILING FOR TV OPERATION
      DATA TVCON(7,1),TVCON(7,2),TVCON(7,3)/   600.0,  1480.0,  4285.7/
C  XDTMX - TV SLEW VELOCITY
      DATA TVCON(8,1),TVCON(8,2),TVCON(8,3)/   389.0,   368.0,  2727.3/
C
C
      IF(JJCOMP.EQ.1)GO TO 5
C  EXECUTE ONLY IF INITIALISATION NOT COMPLETE
      SXPL    = TVCON(1,NTVB)
      SXMIN   = TVCON(2,NTVB)
      SXPLUS  = TVCON(3,NTVB)
      SXMINUS = TVCON(4,NTVB)
      SYPL    = TVCON(5,NTVB)

      SYMIN   = TVCON(6,NTVB)
      HTVLIM  = TVCON(7,NTVB)
      XDTMX   = TVCON(8,NTVB)
C  STORE XIC FROM ICFILE FOR FUTURE USE
      XICF = XIC
C  ACTUAL PILOT LOCATION RELATIVE TO CG
      XPCG = XP + DXCG*CREF                                             240278
      ZPCG = ZP - DZCG*CREF                                             240278
C
    5 CONTINUE
C  HERE IMMEDIATELY IF IN 'COMPUTE'
C
C   ************************************
C   *                                  *
C   *      SLEW                        *
C   *                                  *
C   ************************************
C   CHECK FOR SLEW DEMAND ON BELT DRIVE
C   IF LFWD = 1,FORWARD SLEW AT XDTMX FT/SEC
      IF(LFWD.EQ.0)GO TO 10
      XDOTM = XDTMX
      GO TO 14
C   IF LBACK = 1,BACKWARD SLEW AT XDTMX FT/SEC
   10 CONTINUE
      IF(LBACK.EQ.0)GO TO 12
      XDOTM =-XDTMX
      GO TO 14
   12 XDOTM = VKN
C  ALLOW FOR SHIP VELOCITY
      XDOTM = XDOTM - VSHIPKT*XK2FPS
   14 CONTINUE
C   ************************************
C   *                                  *
C   *      TV INTEGRATION CONTROL      *
C   *                                  *
C   ************************************
C
C   TEST TO DETERMINE INTEGRATION STATE OF SX AND SY
```

```
      C   PUT SX AND SY IN COMPUTE,DESYNC TO ZERO
            XIMX = XIMY = 1.0
            IDSYNC = 0
      C  IF LYTVIC = 1,SY RESETS
            IF(LYTVIC.EQ.0)GO TO 20
            XIMY = 0.0
         20 CONTINUE
      C  IF LXTVIC = 1,SX RESETS
            IF(LXTVIC.EQ.0)GO TO 22
            XIMX = 0.0
            XIC = XICF
            GO TO 24
      C   CHECK FOR TV NEAR BELT JOIN
         22 IF(SXMIN.LT. X.LT.SXPL)GO TO 24
      C   TV NEAR BELT JOIN
      C   IF LCYCLE = 1,X COMPUTATION CYCLES BETWEEN SXMINUS AND SXPLUS
            IF(LCYCLE.EQ.0)GO TO 24
            IDSYNC = 1
      C   IDSYNC = 1 TO DISCONNECT POSITION ERROR DRIVE TO TV
      C  COMMAND IMMEDIATE MOVEMENT IF X SITTING WAY OUT
            IF(X.LT.SXMINUS)GO TO 23
      C   WHEN SX REACHES SXPLUS,RESET SX TO SXMINUS
            IF( X.LT.SXPLUS)GO TO 24
         23 CONTINUE
            XIMX = 0.0
             XIC = SXMINUS
         24 CONTINUE
      C
      C  TV POSITION
      C
      C  PILOT AT XP,ZP = RH ZP NORMALLY NEGATIVE(!) IF EYE ABOVE DATUM LINE
            RXP    = XPCG*CTHETA + ZPCG*STHETA                              2*0278
            RHP    = XPCG*STHETA - ZPCG*CTHETA                              2*0278
            XTV    = X + RXP*CPSI
            YTV    = Y + RXP*SPSI
            HTV    = H + RHP
      C  TV RATES
            XDTV   = XDOTM -RXP*SPSI*PSIDT -RHP*CPSI*THETDT
            YDTV   = VKE +  RXP*CPSI*PSIDT -RHP*SPSI*THETDT
            HDTV   =-VKD +  RXP*THETDT
      C  ON LIMITS,PUT RATES TO ZERO TO KEEP TV DRIVE QUIESCENT
            IF(LCYCLE.EQ.1)GO TO 30
            IF((XTV.LT.SXMIN).OR.(LXTVIC.EQ.1))XDTV = 0.0
         30 CONTINUE
      C   IF TV ABOVE CEILING,SET HDTV TO ZERO
            IF(HTV.GT.HTVLIM) HDTV = 0.0
      C   KEEP TV POSITION WITHIN LIMITS
            XTV = BOUND(SXMIN,SXPL,XTV)
            YTV = BOUND(SYMIN,SYPL,YTV)
            HTV = BOUND(0.0,HTVLIM,HTV)
      C
            RETURN
            END
IASSIGN (MIS1,D3,SVLIS)

IFORTRAN LS,NB
EXT. FORTRAN IV, VERSION E00
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```
              SUBROUTINE SVELOC1
      C
      C          ****************************************************
      C          *                                                  *
      C          *    WRITTEN BY : D.OLUFIELD                       *
      C          *      DATE : 12-8-76                              *
      C          *    REVISED: 22-12-76                             *
      C          *    DESCRIPTION : THIS SUBROUTINE CALCULATES THE  *
      C          *      VELOCITY RELATIVE TO BODY AXES GIVEN THE    *
      C          *      VELOCITIES RELATIVE TO THE GROUND AND OF    *
      C          *      THE WIND                                    *
      C          *                                                  *
      C          ****************************************************
      C
      C       12-8-76     SYSTEM COMMON ENLARGED
              COMMON/SYSTEM/A(1000),L(400)
      C
      C   VERSION IDENTIFIER
      C
              DATA KSVELOC1/221276/
              EQUIVALENCE(KSVELOC1,L(266))
      C
      C                 *** VARIABLE INPUTS ***
      C
              EQUIVALENCE(VKN      ,A( 52)),(VKE      ,A( 53)),(VKD      ,A( 54)),
             1           (VWN      ,A( 55)),(VWE      ,A( 56)),(VWD      ,A( 57)),
             2           (S11      ,A( 17)),(S12      ,A( 18)),(S13      ,A( 19)),
             3           (S21      ,A( 20)),(S22      ,A( 21)),(S23      ,A( 22)),
             4           (S31      ,A( 23)),(S32      ,A( 24)),(S33      ,A( 25))
      C
      C                 *** VARIABLE OUTPUTS ***
      C
              EQUIVALENCE(UB       ,A( 58)),(VB       ,A( 59)),(WB       ,A( 60)),
             1           (VN       ,A(217)),(VE       ,A(218)),(VD       ,A(219))
      C
      C            CALCULATE VELOCITY RELATIVE TO THE AIR
              VN = VKN-VWN
              VE = VKE-VWE
              VD = VKD-VWD
      C            CALCULATE VELOCITY RELATIVE TO BODY AXES
              UB = S11*VN+S12*VE+S13*VD
              VB = S21*VN+S22*VE+S23*VD
              WB = S31*VN+S32*VE+S33*VD
              RETURN
              END
!ASSIGN (MISI,03,SVL2S)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
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```
      SUBROUTINE SVELOC2
C
C         *************************************************************
C         *                                                           *
C         *     WRITTEN BY : D.DUFIELD                                *
C         *     DATE : 21.3.78                                        *
C         *     DESCRIPTION : THIS SUBROUTINE CALCULATES THE          *
C         *        RESULTANT AIR SPEED AND THE EQUIVALENT AIR         *
C         *        SPEED,DYNAMIC PRESSURE AND MACH NO.                *
C         *        USING ATMOSPHERIC PROPERTIES APPROPRIATE TO        *
C         *        SPECIFIED VALUE OF KISA                            *
C         *                                                           *
C         *          -1 FIXED VALUES APPROPRIATE TO MIC               *
C         *           0 FIXED(SEA LEVEL) VALUES - DEFAULT             *
C         *           1 VALUES VARY WITH HEIGHT                       *
C         *                                                           *
C         *************************************************************
C
C     12-8-76      SYSTEM COMMON ENLARGED
C     21.3.78      TRATIO ETC GIVEN DATA VALUES
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KSVELOC2/210378/
      EQUIVALENCE(KSVELOC2,L(267))
C
C               *** VARIABLE INPUTS ***
C
      EQUIVALENCE(UB       ,A( 58)),(VB       ,A( 59)),(WB       ,A( 60)),
     1           (H        ,A(151)),(SWREF    ,A(106)),(CREF     ,A(107)),
     2           (SPAN     ,A(103)),(SBZ      ,A(108))
      EQUIVALENCE(KISA     ,L(  1))
C
C               *** VARIABLE OUTPUTS ***
C
      EQUIVALENCE(VT       ,A( 67)),(VTKT     ,A( 68)),(VEAS     ,A( 69)),
     1           (VEASKT   ,A( 70)),(QDYN     ,A(125)),(XMACH    ,A( 75)),
     2           (ROOTSIG  ,A( 71)),(RHO      ,A( 72)),(SPSOND   ,A( 73)),
     3           (DENR     ,A( 78)),(SPSNDR   ,A( 84)),(HLFRHOV  ,A(124)),
     4           (TEMPR    ,A( 81)),(PRESSR   ,A( 82)),(QDYNS    ,A(126)),
     5           (QSCREF   ,A(127)),(QSSPAN   ,A(128)),(QSBZIV   ,A(129)),
     6           (TRATIO   ,A( 89)),(ARATIO   ,A( 85)),(DRATIO   ,A( 83)),
     7           (PRATIO   ,A( 87)),(TALPHA   ,A( 88)),(PALPHA   ,A( 86))
C
C               *** CONSTANTS ***
C
      EQUIVALENCE(FPSTKT   ,B(143)),(RHOSL    ,A( 79)),(SPSL     ,A( 80)),
     1           (TEMPSL   ,A( 76)),(PRESSL   ,A( 77))
C
C         DATA TRATIO,ARATIO,DRATIO,PRATIO TO AVOID PROBLEMS
C         DURING INITIALISATION
      DATA TRATIO,ARATIO,DRATIO,PRATIO/4*1.0/                           210378
C
C         *****
C
C         CALCULATE TOTAL AIR SPEED
      VT = SQRT(UB*UB+VB*VB+WB*WB)
      VTKT = VT*FPSTKT
C         SET VALUES OF ROOTSIG,RHO AND SPSOND
      IF (KISA.NE.1) GO TO 3
C         CALL SATMOS TO AMMEND RHO,ROOTSIG,SPSOND
      CALL SATMOS(H,DENR,SPSNDR,TEMPR,PRESSR)
      RHO = RHOSL * DENR
      SPSOND = SPSL * SPSNDR
      ROOTSIG = SQRT(DENR)
      TALPHA = TEMPSL*TEMPR
      PALPHA = PRESSL*PRESSR
    3 CONTINUE
C         CALCULATE EQUIVALENT AIRSPEED
      VEAS = VT*ROOTSIG
      VEASKT = VEAS*FPSTKT
C         CALCULATE DYNAMIC PRESSURE
      HLFRHOV = 0.5*RHO*VT
      QDYN = HLFRHOV*VT
```

```
            QDYNS = QDYN*SWREF
            QSCREF = QDYNS*CREF
            QSSPAN = QDYNS*SPAN
            QSB2IV = HLFRHOV*SB2
      C          CALCULATE MACH NO.
            XMACH = VT/SPSOND
      C  CALCULATE COMPRESSIBLE ADIABATIC FLOW RELATIONSHIPS
      C  MACH NUMBER < 1.0
            XX = 1.0 + 0.2*XMACH*XMACH
      C  ADIABATIC STATIC/TOTAL TEMPERATURE
            TRATIO = 1.0/XX
      C  ADIABATIC SPEED OF SOUND RATIO
            ARATIO = SQRT(TRATIO)
      C  ADIABATIC DENSITY RATIO
            DRATIO = ARATIO**5
      C  ADIABATIC STATIC/TOTAL PRESSURE
            PRATIO = DRATIO*TRATIO
            RETURN
            END
1ASSIGN (MISI,03,SWNDS)

1FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
            SUBROUTINE SWIND
      C
      C        **********************************************************
      C        *                                                        *
      C        * WRITTEN BY : B.N.TOMLINSON                             *
      C        * DATE       : 20.9.76                                   *
      C        * REVISED    : 22.12.76 TO IMPROVE COMM'N WITH GUSTS     *
      C        *              24.02.78 VWE CORRECTED + FRACG,NGUSTS PROTECTED
      C        * DESCRIPTION: THIS SUBROUTINE CALCULATES TOTAL WIND     *
      C        *    COMPONENTS, INCLUDING TURBULENCE AND WIND SHEAR     *
      C        *                                                        *
      C        **********************************************************
      C
            COMMON/SYSTEM/A(1000),L(400)
      C  COMMON 'FRN' AND 'INITGUST' COMMUNICATE WITH S/R GUSTS ONLY
            COMMON/FRN/FRACG,RDECAY,NGUSTS
            COMMON/INITGUST/IFLAG,ISR
            EQUIVALENCE(KSWIND  ,L(268))
      C
      C   VERSION IDENTIFIER
      C
            DATA KSWIND/240278/
      C
      C       *** INPUT VARIABLES ***
      C
            EQUIVALENCE(W         ,A(151)),(HIC      ,A(197)),(VKTIC     ,A(194)),
           1           (VWNLO     ,A(226)),(VWELO    ,A(227)),(VWDLO     ,A(223)),
           2           (CPSIW     ,A(224)),(SPSIW    ,A(225)),(FRAMET1   ,A( 92)),
           3           (USIG      ,A(235)),(VSIG     ,A(236)),(WSIG      ,A(237)),
           4           (SFRACG    ,A(278)),(SRDECAY  ,A(279))
      C
            DIMENSION IDS(32)
            EQUIVALENCE(ISHR      ,L(  5)),(JJCOMP   ,L(  8)),(NG        ,L(167)),
           1           (LTURB     ,IDS(8)),(IDS(1)   ,L(223)),(LSEED     ,L(168))
      C
      C       *** OUTPUT VARIABLES ***
      C
```

```
      EQUIVALENCE(UTURB   ,A(232)),(VTURB   ,A(233)),(WTURB   ,A(234)),
     1            (VWN    ,A( 55)),(VWE     ,A( 56)),(VWD     ,A( 57)),
     2            (VWNL   ,A(229)),(VWEL    ,A(230)),(VWDL    ,A(231)),
     3            (SHRFAC ,A(228))
C
C        *** CONSTANTS ***
C
      EQUIVALENCE(XK2FPS  ,A(144))
C
      DATA NG/4/
      DATA VWDL/0.0/
C  SET UP FRACG,RDECAY
      DATA SFRACG,SRDECAY/0.0,0.7/
      DATA LSEED/0/
C  CALCULATE WIND AT HEIGHT
      CALL WSHEAR(ISHR,H,SHRFAC)
      VWNL = VWNLO*SHRFAC
      VWEL = VWELO*SHRFAC
C
      IFLAG = JJCOMP
      IF(JJCOMP.EQ.0)GO TO 10
C  INITIALISATION COMPLETE
      IF(LTURB.EQ.1) GO TO 20
C  TURBULENCE IS NOT REQUIRED
      GO TO 30
   10 CONTINUE
C  INITIALISATION
      H = HIC
C  PICK UP TURB PARAMETERS FROM SYSTEM VARIABLES
      FRACG = SFRACG
C  CHECK ON RANGE
      IF(FRACG.GT.0.99)FRACG = 0.99                                     240278
      RDECAY = SRDECAY
      ISR = LSEED
C  SET UP NGUSTS ACCORDING TO INITIAL SPEED
      NGUSTS = NG*(VKTIC*XK2FPS/200.0)
C  CHECK ON RANGE
      IF(NGUSTS.LT.1)NGUSTS = 1                                         240278

      NMAX = 1000.0/FRAMETI                                             240278
      IF(NGUSTS.GT.NMAX)NGUSTS = NMAX                                   240278
   20 CONTINUE
C  TURB IS REQUIRED
      CALL GUSTS(UG,VG,WG,FRAMETI,H)
      IF(JJCOMP.EQ.0) GO TO 30
C  INITIALISATION IS COMPLETE,SO LET TURBULENCE OUT
      UTURB = USIG*UG
      VTURB = VSIG*VG
      WTURB = WSIG*WG
      GO TO 40
   30 CONTINUE
C  TURBULENCE OUTPUTS SET TO ZERO(INITIALISATION,OR NOT REQUIRED)
      UTURB = VTURB = WTURB = 0.0
   40 CONTINUE
C     CALCULATE TOTAL WIND COMPONENTS
      VWN = VWNL - (UTURB*CPSIW - VTURB*SPSIW)
      VWE = VWEL - (VTURB*CPSIW + UTURB*SPSIW)                          240278
      VWD = VWDL - WTURB
C
      RETURN
      END
!ASSIGN (M:SI,D3,SYSCS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
      SUBROUTINE SYSCOM
C
C         *****************************************************
C         *                                                   *
C         *     WRITTEN BY : B.N.TOMLINSON                    *
C         *     DATE : 24.2.78                                *
C         *       THIS ROUTINE CALLS PV200 TO PROVIDE ACCESS  *
C         *       TO SYSTEM COMMON VARIABLES                  *
C         *     REVISED:21.9.76 TO INCLUDE INPUT FROM CHANGES FILE*
C         *              8.10.76 TVCON(8,3) ADDED             *
C         *             29.11.76 DISCRETES NAMES ADDED        *
C         *             22.12.76 FRAMETIME VARIABLES ADDED    *
C         *             31.5.77 NRUN ADDED                    *
C         *             18.10.77 LIDACA ETC.                  *
C         *              8. 2.78 DUMMY 'A' VARIABLES REPLACED BY ARRAYS
C         *              24.2.78 LIDAC REVISED                *
C         *                                                   *
C         *****************************************************
C
C
C   VERSION IDENTIFIER
C
      DATA KSYSCOM/240278/
C  SET UP COMMUNICATION WITH DAC HARDWARE ADDRESSES
      COMMON/DACNOS/IDACAD(50)                                          080278
C
      COMMON/SYSTEM/
     X RXMASS,XMASS,PSIR,PSID,THETAR,THETAD,PHIR,PHID,SPSI,
     1 CPSI,STHETA,CTHETA,SPHI,CPHI,SECTHT,TANTHT,S11(9),               080278
     2                          P,Q,R,PHIDT,                            080278
     3 THETDT,PSIDT,PD,QD,RD,C11(10),                                   080278
     4                          PDOT,QDOT,RDOT,XIX,XIY,                 080278
     5 XIZ,XIZX,VKN,VKE,VKD,VWN,VWE,VWD,UB,VB,
     6 WB,GAMMAR,GAMMAD,PSIKR,PSIKD,VK,VKKT,VT,VTKT,VEAS,
     7 VEASKT,ROOTSIG,RHO,SPSOND,A74,XMACH,TEMPSL,PRESSL,DENR,RHOSL,
     8 SPSL,TEMPR,PRESSR,DRATIO,SPSNDR,ARATIO,PALPHA,PRATIO,TALPHA,
     C                                                   TRATIO,
     9 A90,DELT1,FRAMET1,A93,TIME,DELT2,FRAMET2,A97,ZCG,XCGREF
C  100
      COMMON/SYSTEM/
     X ZCGREF,DXCG,DZCG,SPAN,XLTAIL,STAIL,SWREF,CREF,SB2,XP,
     1 ZP,ALFAR,ALFAD,BETAR,BETAD,A115,SALFA,CALFA,SBETA,CBETA,
     2 ALFADOT,BETADOT,A122,A123,HLFRHOV,QDYN,QDYNS,QSCREF,QSSPAN,
     C                                                   QSB2IV,
     3 A130,XLLTOT,XMMTOT,XNNTOT,FTX,FTY,FTZ,FTN,FTE,FTD,
     4 A140,RADTOD,DEGTOR,FPSTKT,XK2FPS,G,RG   ,A147,A148,X,
     5 Y,H,XTV,YTV,HTV,XDTV,YDTV,HDTV,XDOTM,XIMX,
     6 XIMY,SXPL,SXMIN,SXPLUS,SXMINUS,SYPL,SYMIN,HTVLIM,XDTMX,VSHIPKT,
     7 A170,EGS,ELOC,HSLOPE,RGS,RLOC,RKINK,XGS,XLOC,YLOC,
     8 SGS,SLOC,HKINK,HSLOPE,USLOPE,XKINK,CILS1,CILS2,CILS3,CILS4,
     9 A190,BETADIC,ALFADIC,GAMDIC,VKTIC,XIC,YIC,HIC,W,XCG
C  200
      COMMON/SYSTEM/
     X XILSFLAG,XISHR,VWKTO,PSIWD,PSIDIC ,A205T210(6),                  080278
     1        VKNIC,VKEIC,VKDIC,PHIDIC,THETADIC,A216   ,VN,VE,VD,       080278
     2 PDIC,QDIC,RDIC,VWDLO,CPSIW,SPSIW,VWNLO,VWELO,SHRFAC,VWNL,
     3 VWEL,VWDL,UTURB,VTURB,WTURB,USIG,VSIG,WSIG,VKNDOT,VKEDOT,
     4 VKDDOT,AXCG,AYCG,AZCG,AZCG1,AXACG,AYACG,AZACG,AXP,AYP,
     5 AZP,AZAP,AY1,AZ2,AX3,AY4,AZ5,X1,Y1,Z1,
     6 X2,Y2,Z2,X3,Y3,Z3,X4,Y4,Z4,X5,
     7 Y5   ,Z5   ,A272T277(6),                   SFRACG,SRDECAY,       080278
     8 A280T299(20)                                                     080278
C  300
      COMMON/SYSTEM/
     X A300,AADC(64),
     6 TVCON(8,3),
     8 A389T399(11)                                                     080278
C  400
      COMMON/SYSTEM/
     X A400,YADC(64),
     6 A465T499(35)                                                     080278
C   500
      COMMON/SYSTEM/
     X A500,ADAC(64),
     6 A(565:1000)
```

```
      C
            COMMON/SYSTEM/
           X KISA,NCPASS,NIPASS,ILSFLG ,ISHR,L6     ,NTVB,JJCOMP,NUMD,
           1 NUMV,NDAC(64),
           7 KSADC,KSDAC,KDSCRT1,KDSCRT2,KISDSCR,
           8 L80,NADC(64)
      C  100
            COMMON/SYSTEM/
           4 L145,L146,L147,LSILS,L149,
           5 IAD4SL,ISLR(16),
           6 NG,LSEED,NRUN,                                               310577
           7 IAD4CL,ICLR(16),
           8 L187,L188,L189,
           9 IDSCFL,IP(32)
      C  200
            COMMON/SYSTEM/
           2 IDS(32),
           5 KSACCBOD,KSACCLIN,KSACCROT,KSALFBET,KSCOUNT,
           6 KSDCOS,KSEULER,KSILS,KSINIT,KSPATH,KSTV,KSVELOC1,KSVELOC2,
           C                                        KSWIND,KSYSCOM,
           7 IPCOFL,ICO(32)
      C  300
            COMMON/SYSTEM/
           X L303,L304,L1DAC(48),                                          240278
           5 L2DAC(48)                                                     240278
      C
      C
      C   EQUIVALENCES  -  DISCRETES
      C
      C
            EQUIVALENCE(LFWD    ,ISLR( 4)),
           5            (LBACK   ,ISLR( 5))
      C
            EQUIVALENCE(IDSYNC  ,ICLR(16))
      C
            EQUIVALENCE(LCYCLE  ,IDS( 5)),
           6            (LXTVIC  ,IDS( 6)),
           7            (LYTVIC  ,IDS( 7)),
           8            (LTJRB   ,IDS( 8))
      C
      C         FOR CALL TO PV200
            DIMENSION NAME(2)
            DATA NAME/'SYSCOM'/
            NAMELIST
      C  DEFINE INPUT UNIT FOR SYSTEM CHANGES FILE
            DATA ISYS/50/
      C
      C
            CALL PV200(NAME)
            GO TO 3
          2 INPUT(101)
          3 CONTINUE
      C  INPUT SEMI-PERMANENT CHANGES FROM SYSTEM INPUT FILE-UNIT ISYS
            REWIND ISYS
            INPUT (ISYS)
            REWIND ISYS
            RETURN
            END
!ASSIGN (MIS1,03,SCRIS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
      SUBROUTINE DSCRT1
C
C     *****************************************************
C     *                                                   *
C     *  AUTHOR  : B.N.TOMLINSON                          *
C     *  DATE    : 21.9.76                                *
C     *  PURPOSE : THIS ROUTINE HANDLES DISCRETES IN FRAME 1. *
C     *            THE FLAGS IAD4SL,IAD4CL,IDSCFL,IPCOFL  *
C     *            ARE SET EXTERNALLY AND DETERMINE WHICH *
C     *            ROUTINES ARE TO BE EXECUTED            *
C     *                                                   *
C     *****************************************************
C
      COMMON/SYSTEM/A(1000),L(400)
C
C   VERSION IDENTIFIER
C
      DATA KDSCRT1 /210976/
      EQUIVALENCE(KDSCRT1 ,L( 77))
C
      EQUIVALENCE(IAD4SL  ,L(150)),(IAD4CL  ,L(170)),
     1           (IDSCFL  ,L(190)),(IPCOFL  ,L(270))
      DATA IAD4SL,IAD4CL,IDSCFL,IPCOFL/1,1,1,0/
C
      IF(IAD4SL.EQ.1)CALL READSLR
      IF(IAD4CL.EQ.1)CALL SETCLR
      IF(IDSCFL.EQ.1)CALL READSCR
      IF(IPCOFL.EQ.1)CALL SETDSCR
      RETURN
      END
!ASSIGN (MISI,03,SCR2S)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
      SUBROUTINE DSCRT2
C
C     *****************************************************
C     *                                                   *
C     *  AUTHOR  : B.N.TOMLINSON                          *
C     *  DATE    : 24-8-76                                *
C     *  PURPOSE : THIS ROUTINE HANDLES DISCRETES IN FRAME 2. *
C     *            THE FLAGS IAD4SL,IAD4CL,IDSCFL,IPCOFL  *
C     *            ARE SET EXTERNALLY AND DETERMINE WHICH *
C     *            ROUTINES ARE TO BE EXECUTED            *
C     *                                                   *
C     *****************************************************
C
      COMMON/SYSTEM/A(1000),L(400)
C
C VERSION IDENTIFIER
C
.     DATA KDSCRT2 /240876/
      EQUIVALENCE(KDSCRT2 ,L( 78))
C
      EQUIVALENCE(IAD4SL  ,L(150)),(IAD4CL  ,L(170)),
     1           (IDSCFL  ,L(190)),(IPCOFL  ,L(270))
C
      IF(IAD4SL.EQ.2)CALL READSLR
      IF(IAD4CL.EQ.2)CALL SETCLR
      IF(IDSCFL.EQ.2)CALL READSCR
      IF(IPCOFL.EQ.2)CALL SETDSCR
      RETURN
      END
!ASSIGN (MISI,03,ISDCS)

!FORTRAN LS,NS
EXT. FORTRAN IV, VERSION E00
```

```
      FUNCTION ISDSCR(ISET,LINE)
C
C     ****************************************************************
C     *
C     *  AUTHOR  : B.N.TOMLINSON                                     *
C     *  DATE    :  19-8-76                                          *
C     *  PURPOSE : THIS FUNCTION READS SIGMA DISCRETES IN I.E.       *
C     *            PATCHABLE AND DEDICATED DESK SWITCHES.            *
C     *            IT IS INTENDED FOR EXECUTION DURING 'INITIAL'.    *
C     *  ARGUMENTS :                                                 *
C     *            ISET  SELECTS PATCHABLE DISCRETES(0) OR           *
C     *                        DEDICATED DESK SWITCHES(1).           *
C     *            LINE  DEFINES ELEMENT IN ARRAY                    *
C     *            ISDSCR IS RETURNED 0 OR 1                         *
C     *                                                              *
C     ****************************************************************
      COMMON/SYSTEM/A(1000),L(400)
C
C  VERSION IDENTIFIER
C
      DATA KISDSCR /190876/
      EQUIVALENCE(KISDSCR ,L( 79))
      DIMENSION IP(32),IDS(32)
      EQUIVALENCE(ISCR(1) ,L(151)),(ICLR(1) ,L(171)),
     1           (IP(1)   ,L(191)),(IDS(1)  ,L(223)),(ICP(1)  ,L(271))
C
      CALL READSCR
C
      ISDSCR= IP(LINE)
      IF(ISET.EQ.1)ISDSCR= IDS(LINE)
      RETURN
      END
IFIN
```

Appendix C

LISTING OF SL1 PROGRAM - SINGLE LOOP

```
 PROGRAM GENERAL MODEL
C  SET VERSION NUMBER
      DATA IVERSION/080278/
C  12.8.76 SYSTEM COMMON ENLARGED
C  25.8.76 DISCRETES INCLUDED
C  5.10.76 FRAME TIME VARIABLES TIDIED UP
C  21.12.76 TOTM AND TOTF SEPARATED AND SOURCE CLEANED UP
C  8. 2.78 SHORT NAME LIST SPECIFIED TO CUT STORAGE
C
   CONTROL
      MODE = REALT
   ENDC
 INITIAL
C
C  DIMENSION,COMMON,DATA DECLARATIONS
C
      COMMON/SYSTEM/A(1000),L(400)
      DIMENSION RICVALS(20)
      DATA NIPASS/1/
      EQUIVALENCE(RICVALS(1),A(191))
C
C     COMMUNICATION BETWEEN 'INITIAL' AND SYSTEM COMMON
C
      EQUIVALENCE(VKNIC   ,A(211)),(VKEIC   ,A(212)),(VKDIC  ,A(213)),..
                 (XIC     ,A(195)),(YIC     ,A(196)),(HIC    ,A(197)),..
                 (PDIC    ,A(220)),(QUIC    ,A(221)),(RDIC   ,A(222)),..
                 (PHIDIC  ,A(214)),(THETADIC,A(215)),(PSIDIC ,A(204)),..
                 (FRAMET1 ,A( 92)),..
                 (DEGTOR  ,A(142)),(DELT1   ,A( 91))
      EQUIVALENCE(NCPASS  ,L(  2)),(NIPASS  ,L(  3)),(ILSFLG ,L(  4)),..
                 (ISHR    ,L(  5))                                      080278
C
C  REAL TIME PARAMETERS
      DATA FRAMET1/50.0/
      DATA TIMLEFT1/0.0/
      DATA DELT1/0.050/
C  NUMBER OF IC VALUES
      DATA NVALS/14/

C
C  SET UP COMMUNICATION,TO ENABLE VARIABLES IN SL1 LABELLED
C  COMMON TO BE ACCESSED
C
      DIMENSION NAME(2)
      DATA NAME/'MODEL'/
      NAMELIST CINT1,IALG1,JALG1,IHX,IHY,ITP,IVERSION,MODE,..           080278
         NS1,NVALS,SX,SY,HH,SX1C,SYIC,SHIC,T,TIMLEFT1                   080278
 LABC:CALL PV200(NAME)
      GO TO LABO
 LABB:INPUT(101)
 LABO:CONTINUE
      CALL SYSCOM
      CALL USERCOM
C
C  CHECK ACCESS 'ON' AND INITIALISE AD4
      CALL INTLAD4
C  READ IC CONDITIONS FROM MASTER FILE(F:1),PLACE IN SYSTEM COMMON
      CALL RDICFILE(NVALS,RICVALS)
      ILSFLG = RICVALS(10)
      ISHR   = RICVALS(11)
C   ***************************
C   *  INPUT RETAINED CHANGES  *
C   ***************************
      CALL PV300
C  INTERPRETER
C  ***********
      ITP = 1
C  CALL PV100 IF DESK SWITCH 1 ON
      IF(ISDSCR(1,1).EQ.1)CALL PV100
C
C  STEP SIZE (FOR REAL TIME, = FRAMET1/1000.0)
C  SL1 CALCULATES INTEGRATION STEP FROM CINT/NS.
C  FOR USER ACCESS,SET CINT FROM DELT
      CINT1 = DELT1
C   INITIALISE SYSTEM FUNCTIONS.
      CALL SINIT
C  INTERPRETER
```

```
C  ***********
       ITP = 2
C  CALL PV100 IF DESK SWITCH 1 ON
       IF(ISDSCR(1,1).EQ.1)CALL PV100
C
C  SET UP INITIAL VALUES FOR INTEGRATIONS
C
       VVKNIC = VKNIC
       VVKEIC = VKEIC
       VVKDIC = VKDIC
       SXIC   = XIC
       SYIC   = YIC
       SHIC   = HIC
       PPIC   = PDIC*DEGTOR
       QQIC   = QDIC*DEGTOR
       RRIC   = RDIC*DEGTOR
       PPHIC  = PHIDIC*DEGTOR
       TTHIC  = THETADIC*DEGTOR
       PPSIC  = PSIDIC*DEGTOR
C
C   FOR CONTROL OF 'POST-INTEGRATION' CALCULATIONS,SET UP VALUE OF NIPASS TO
C   SUIT INTEGRATION ALGORITHM IALGOR.DEFAULT IS NIPASS=1
       IF(IALG1.EQ.4)NIPASS = 2
       IF(IALG1.EQ.5)NIPASS = 4
C  TO ENSURE THAT SUCH 'POST-INTEGRATION' ROUTINES ARE CALLED DURING THE
C  INITIALISATION PASS THROUGH 'Z0001'
       NCPASS=4
C
C  INTERPRETER
C  ***********
       ITP = 3
C  CALL PV100 IF DESK SWITCH 1 ON
       IF(ISDSCR(1,1).EQ.1)CALL PV100
C
       INIT = 0
  INIT2:CONTINUE
       INIT = INIT + 1
  END
```

```
C  INITIALISE TWICE SO THAT 'QDYN' ETC SET UP CORRECTLY
       IF(INIT.EQ.1) GO TO INIT2
C
C  INTERPRETER
C  ***********
       ITP = 4
C  CALL PV100 IF DESK SWITCH 1 ON
       IF(ISDSCR(1,1).EQ.1)CALL PV100
C
C  START CLOCK FOR REAL TIME
       IF(MODE) CALL STARTC
  DYNAMIC
C
C      *****************************    DYNAMIC     *******************
C
       IF(MODE) CALL EXITS
  DERIVATIVE LOOP1
C
C      *****************************    DERIVATIVE  *******************
C
C
C   *************************
C   *                       *
C   *   SYSTEM FUNCTIONS    *
C   *                       *
C   *************************
C  COMMON STATEMENT TO ALLOW CONTROL PARAMETER 'MODE'
C  TO BE ACCESSED BY THE DERIVATIVE SECTION
       COMMON/Z9980/MODE
       DECLARE LOGICAL MODE
C  INTEGRATION CONTROL STATEMENTS
       VARIABLE     T = 0.0
       CINTERVAL CINT1 = 0.05
       NSTEPS    NS1   = 1
       ALGORITHM IALG1 = 5 , JALG1 = 5
       RT(MIL,FRAMET1,IFLAG1,TIMLEFT1,1.0,1)
      PROCEDURAL
C      12-8-76      SYSTEM COMMON ENLARGED
```

```
            COMMON/SYSTEM/A(1000),L(400)
      C
      C         ** INPUT VARIABLES **
      C
            EQUIVALENCE(PHIDT    ,A( 29)),(THETDT   ,A( 30)),(PSIDT,A( 31)),...
                       (PDOT     ,A( 45)),(QDOT     ,A( 46)),(RDOT ,A( 47)),...
                       (VKNDOT   ,A(238)),(VKEDOT   ,A(239)),(VKDDOT,A(240)),...
                       (XIC      ,A(195)),(XDOTM    ,A(158)),(DELT1,A( 91)),...
                       (XIHX     ,A(159)),(XIHY     ,A(160))
      C
            EQUIVALENCE(NCPASS   ,L(  2)),(NIPASS   ,L(  3))
      C
      C         ** OUTPUT VARIABLES **
      C
            EQUIVALENCE(PHIR     ,A(  7)),(THETAR   ,A(  5)),(PSIR ,A(  3)),...
                       (P        ,A( 26)),(Q        ,A( 27)),(R    ,A( 28)),...
                       (VKN      ,A( 52)),(VKE      ,A( 53)),(VKD  ,A( 54)),...
                       (X        ,A(149)),(Y        ,A(150)),(H    ,A(151)),...
                       (TIME     ,A( 94))
          END
      C                     ********************
      C                     *                  *
      C                     *PRE-INTEGRAL CALLS *
      C                     *                  *
      C                     ********************
      C
      C  READ AND WRITE DISCRETE LINES
            CALL DSCRT1
      C
            CALL SCOUNT
      C
       PROCEDURAL
            DATA IFIRST/1/
            IF(IFIRST.NE.1) GO TO NOTF
      C   INSERT CALLS HERE FOR ROUTINES TO BE EXECUTED AFTER ADC BUT BEFORE INTEG
      C   -RATION ,AND WHICH ARE NOT PART OF EVALUATION LOOP FOR DERIVATIVES.
      C  ONLY EXECUTE THESE ROUTINES ONCE PER FRAME
      C       1) PRE DERIVATIVE S/R CALLS
```

```
      C
            CALL CONTROLS
      C  CALCULATE WIND
            CALL SWIND
      C
      C  RESET FLAG
            IFIRST = 0
       NOTF:CONTINUE
            END
```

```
      C
           PROCEDURAL( = ADC(1))
          END
      C
      C                     *******************
      C                     *                 *
      C                     *  ANGULAR MOTION *
      C                     *                 *
      C                     *******************
      C
      C  ATTITUDE ANGLES
            PPSI = INTEG(PPSIDT,PPSIC)
            TTHET = INTEG(TTHDT,TTHIC)
            PPHI = INTEG(PPHIDT,PPHIC)
      C
           PROCEDURAL(=PPSI,TTHET,PPHI)
      C    EQUATE VARIABLES
            PSIR = PPSI
            THETAR = TTHET
            PHIR = PPHI
      C    CALCULATE DIRECTION COSINES
      C
            CALL SDCOS
      C
           END
      C
            PP = INTEG(PPDOT,PPIC)
```

```
         QQ = INTEG(QQDOT,QQIC)
         RR = INTEG(RRDOT,RRIC)
   C
       PROCEDURAL(PPSIDT,TTHDT,PPHIDT=PP,QQ,RR)
   C   EQUATE VARIABLES
         P = PP
         Q = QQ
         R = RR
   C  CALCJLATE ATTITUDE RATES
         CALL SEULER
         PPSIDT = PSIDT
         TTHDT = THETDT
         PPHIDT = PHIDT
       END
   C
   C                   ********************
   C                   *                  *
   C                   *   LINEAR MOTION  *
   C                   *                  *
   C                   ********************
   C
   C   VELOCITIES
         VVKN = INTEG(VVKNDT,VVKNIC)
         VVKE = INTEG(VVKEDT,VVKEIC)
         VVKD = INTEG(VVKDDT,VVKDIC)
   C
       PROCEDURAL(=VVKN,VVKE,VVKD)
   C   EQUATE VARIABLES
         VKN = VVKN
         VKE = VVKE
         VKD = VVKD
   C   CALCULATE BODY AXES VELOCITIES
         CALL SVELOC1
   C   CALCULATE ALPHA AND BETA AND ASSOCIATED SINES/COSINES
         CALL SALFBET(DELT1)
       END
       PROCEDURAL(HHDOT,SYDOT=)
   C
```

```
   C   EQUATE VARIABLES
         HHDOT = -VKD
         SYDOT = VKE
         SXDOTM = XDOTM
       END
   C
   C   CALCULATE POSITIONS
         SX = MODINT(SXDOTM,SXIC,1.0,IHX,T)
         SY = MODINT(SYDOT,SYIC,1.0,IHY,T)
         HH = INTEG(HHDOT,SHIC)
   C
       PROCEDURAL
   C   USERS ROUTINES
   C   CALCULATE TOTAL FORCES IN BODY AXES
   C
         CALL TOTF
   C
       END
   C
       PROCEDURAL(PPDOT,QQDOT,RRDOT = PP,QQ,RR)
   C  USER'S ROUTINE TO CALCULATE MOMENTS
         CALL TOTM                                                   080278
   C
   C  CALCULATE ANGULAR ACCELERATIONS
         CALL SACCROT                                                080278
   C  EQUATE VARIABLES
         PPDOT = PDOT                                                080278
         QQDOT = QDOT                                                080278
         RRDOT = RDOT                                                080278
       END
   C
   C
       PROCEDURAL(VVKNDT,VVKEDT,VVKDDT=)
   C   CALCULATE LINEAR ACCELERATIONS
         CALL SACCLIN
   C   EQUATE VARIABLES
         VVKNDT = VKNDOT
         VVKEDT = VKEDOT
```

```
     VVKDDT = VKDDOT
   END
 PROCEDURAL( = SX,SY,HH)
C               ********************
C               *                  *
C               *POST-INTEGRAL CALLS*
C               *                  *
C               ********************
     NCPASS=NCPASS+1
C  NCPASS = COUNT OF NUMBER OF PASSES EXECUTED SO FAR IN ONE INTEGRATION STEP
C  NIPASS = CONSTANT,SET UP IN INITIAL,FOR NUMBER OF PASSES USED BY
C  INTEGRATION ROUTINE.
     IF(NCPASS.LT.NIPASS)GO TO SKPASS
C  INSERT HERE CALLS TO 'POST-INTEGRATION' ROUTINES,TO BE EXECUTED ONLY
C  ONCE PER STEP.
C
C FIRST PICK UP TIME
     TIME = T
C  EQUATE VARIABLES
     X = SX
     Y = SY
     H = HH
C  CALCULATE BODY AXES ACCELERATIONS FOR MOTION ('OUTPUT' ONLY)
     CALL SACCBOD
C
C  CALCULATE INSTRUMENT READINGS ('OUTPUT' ONLY)
C  CALCULATE ILS ('OUTPUT' ONLY)
     CALL SILS
C
C  LOGIC AND POSITION FOR VFA CONTROL ('OUTPUT' ONLY)
     CALL STV
C EQUATE VARIABLES
     SXIC = XIC
     IMX = XIMX
     IMY = XIMY
     SXDOTM = XDOTM
C  CALCULATE EAS,MACH,DYNAMIC PRESSURE ETC.
     CALL SVELOC2
C  CALCULATE FLIGHT PATH ANGLES
     CALL SPATH
C
C    3) POST DERIVATIVE S/R CALLS
C
C    S/R 'OUTSR' HANDLES OUTPUT FUNCTIONS
C
     CALL OUTSR
C
     CALL SDAC
C
C SET 'FIRST TIME' FLAG ON,READY FOR NEXT TIME ROUND
     IFIRST = 1
   SKPASS : CONTINUE
   END
C
   PROCEDURAL(DAC( 1),DAC( 2),DAC( 3),DAC( 4),DAC( 5),...
              DAC( 6),DAC( 7),DAC( 8),DAC( 9),DAC(10),...
              DAC(11),DAC(12),DAC(13),DAC(14),DAC(15),...
              DAC(16),DAC(17),DAC(18),DAC(19),DAC(20),...
              DAC(21),DAC(22),DAC(23),DAC(24),DAC(25),...
              DAC(26),DAC(27),DAC(28),DAC(29),DAC(30),...
              DAC(31),DAC(32),DAC(33),DAC(34),DAC(35),...
              DAC(36),DAC(37),DAC(38),DAC(39),DAC(40),...
              DAC(41),DAC(42),DAC(43),DAC(44),DAC(45),...
              DAC(46),DAC(47),DAC(48)=)
   END
C
C PROCESS AUTOMATIC HOLD
     CALL PV700
     IF(MODE) CALL TERMNATE('AIRCRAFT')
 END
 END
 TERMINAL
 END
 END
```

Appendix D

INDEX TO SYSTEM COMMON, REAL VARIABLES

D.1 Numeric order

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78

 NUMERIC ORDER                                     10:45 MAR 13,'79                                PAGE  1

  ELEMENT     FORTRAN    QUANTITY           DESCRIPTION                  UNITS     CALCULATED     USED
    NO.        NAME                                                                    IN           IN

     1      RXMASS                  1/XMASS                                          SINIT        SACCLIN

     2      XMASS                   AIRCRAFT MASS                      SLUG          SINIT        SINIT

     3      PSIR                    HEADING ANGLE                      RADIANS       DER'TIVE     SDCOS

     4      PSID                    HEADING ANGLE                      DEGREES       SDCOS

     5      THETAR                  PITCH ATTITUDE                     RADIANS       DER'TIVE     SDCOS

     6      THETAD                  PITCH ATTITUDE                     DEGREES       SDCOS

     7      PHIR                    BANK ANGLE                         RADIANS       DER'TIVE     SDCOS

     8      PHID                    BANK ANGLE                         DEGREES       SDCOS

     9      SPSI                    SIN(PSIR)                                        SDCOS        STV
                                                                                                  SDCOS

    10      CPSI                    COS(PSIR)                                        SDCOS        STV
                                                                                                  SDCOS

    11      STHETA                  SIN(THETAR)                                      SDCOS        STV
                                                                                                  SDCOS

    12      CTHETA                  COS(THETAR)                                      SDCOS        STV
                                                                                                  SDCOS
```

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78

 NUMERIC ORDER                                     10:45 MAR 13,'79                                PAGE  2

  ELEMENT     FORTRAN    QUANTITY           DESCRIPTION                  UNITS     CALCULATED     USED
    NO.        NAME                                                                    IN           IN

    13      SPHI                    SIN(PHIR)                                        SDCOS        SEULER
                                                                                                  SDCOS

    14      CPHI                    COS(PHIR)                                        SDCOS        SEULER
                                                                                                  SDCOS

    15      SECTHT                  SEC(THETAR)                                      SDCOS        SEULER
                                                                                                  SDCOS

    16      TANTHT                  TAN(THETAR)                                      SDCOS        SEULER

    17      B11                     DIRECTION COSINE                                 SDCOS        SVELOC1
                                                                                                  SACCLIN

    18      B12                     DIRECTION COSINE                                 SDCOS        SVELOC1
                                                                                                  SACCLIN

    19      B13                     DIRECTION COSINE                                 SDCOS        SVELOC1
                                                                                                  SACCLIN
                                                                                                  SACCBOD

    20      B21                     DIRECTION COSINE                                 SDCOS        SVELOC1
                                                                                                  SACCLIN

    21      B22                     DIRECTION COSINE                                 SDCOS        SVELOC1
                                                                                                  SACCLIN

    22      B23                     DIRECTION COSINE                                 SDCOS        SVELOC1
```

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                          10:45 MAR 13,'79                                  PAGE  3

 ELEMENT      FORTRAN     QUANTITY               DESCRIPTION                  UNITS        CALCULATED     USED
   NO.          NAME                                                                            IN           IN

                                                                                                          SACCLIN
                                                                                                          SACCBOD

   23      S31                          DIRECTION COSINE                                   SDCOS          SVELOC1
                                                                                                          SACCLIN

   24      S32                          DIRECTION COSINE                                   SDCOS          SVELOC1
                                                                                                          SACCLIN

   25      S33                          DIRECTION COSINE                                   SDCOS          SVELOC1
                                                                                                          SACCLIN
                                                                                                          SACCBOD

   26      P                            ANG VEL,ROLL,BODY AXES              RADS/SEC       DER'TIVE       SEULER
                                                                                                          SACCROT
                                                                                                          SACCBOD

   27      Q                            ANG VEL,PITCH,BODY AXES             RADS/SEC       DER'TIVE       SEULER
                                                                                                          SACCROT
                                                                                                          SACCBOD

   28      R                            ANG VEL,YAW,BODY AXES               RADS/SEC       DER'TIVE       SEULER
                                                                                                          SACCROT
                                                                                                          SACCBOD

   29      PHIDT                        ATTITUDE RATE,BANK                  RAD/SEC        SEULER         DER'TIVE

   30      THETDT                       ATTITUDE RATE,PITCH                 RAD/SEC        SEULER         STV
```

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                          10:45 MAR 13,'79                                  PAGE  4

 ELEMENT      FORTRAN     QUANTITY               DESCRIPTION                  UNITS        CALCULATED     USED
   NO.          NAME                                                                            IN           IN

                                                                                                          DER'TIVE

   31      PSIDT                        ATTITUDE RATE,HEADING               RAD/SEC        SEULER         STV
                                                                                                          DER'TIVE

   32      PD                           ANG VEL,ROLL,BODY AXES              DEGS/SEC       SEULER

   33      QD                           ANG VEL,PITCH,BODY AXES             DEGS/SEC       SEULER

   34      RD                           ANG VEL,YAW,BODY AXES               DEGS/SEC       SEULER

   35      CI1                          INERTIA COEFFICIENT                                SINIT          SACCROT

   36      CI2                          INERTIA COEFFICIENT                                SINIT          SACCROT

   37      CI3                          INERTIA COEFFICIENT                                SINIT          SACCROT

   38      CI4                          INERTIA COEFFICIENT                                SINIT          SACCROT

   39      CI5                          INERTIA COEFFICIENT                                SINIT          SACCROT
                                                                                                          SINIT

   40      CI6                          INERTIA COEFFICIENT                                SINIT          SACCROT

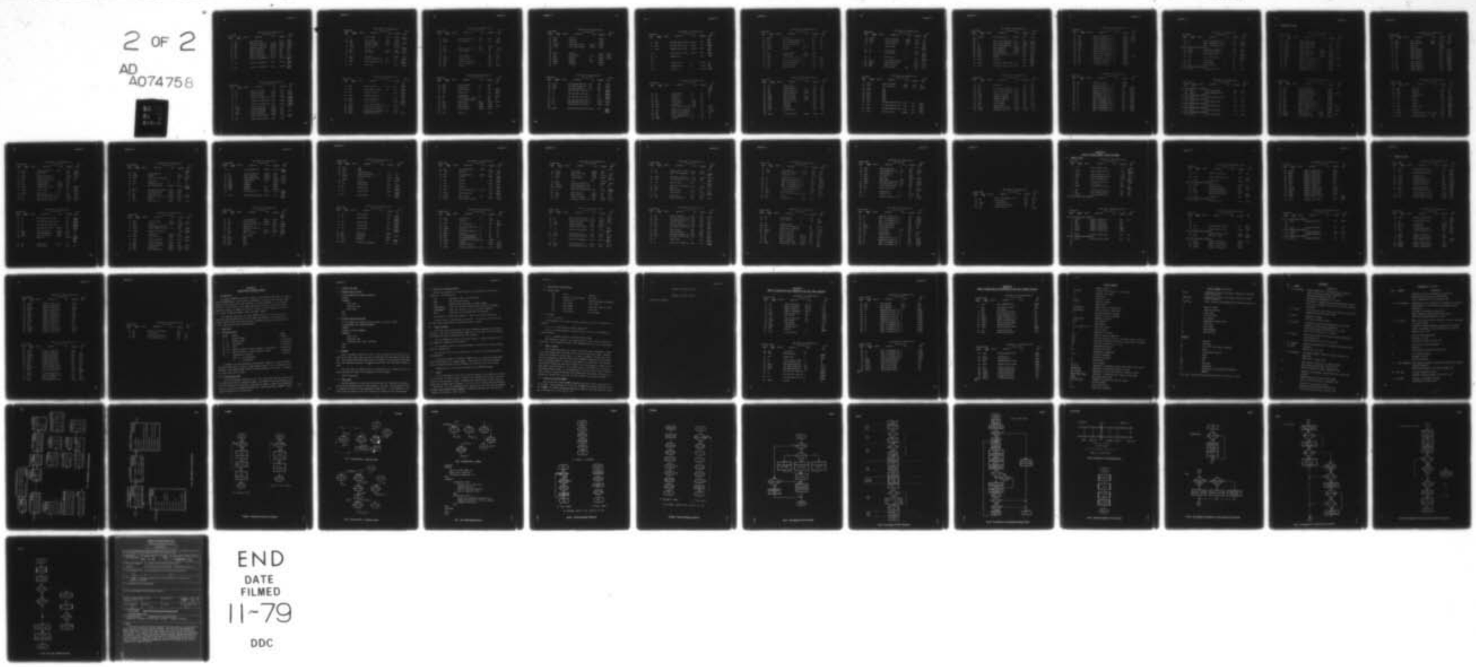
   41      CI7                          INERTIA COEFFICIENT                                SINIT          SACCROT

   42      CI8                          INERTIA COEFFICIENT                                SINIT          SACCROT

   43      CI9                          INERTIA COEFFICIENT                                SINIT          SACCROT
```

AD-A074 758 ROYAL AIRCRAFT ESTABLISHMENT FARNBOROUGH (ENGLAND) F/G 9/2
SESAME-A SYSTEM OF EQUATIONS FOR THE SIMULATION OF AIRCRAFT IN --ETC(U)
JAN 79 B N TOMLINSON
UNCLASSIFIED RAE-TR-79008 DRIC-BR-68659 NL

2 OF 2
AD
A074758



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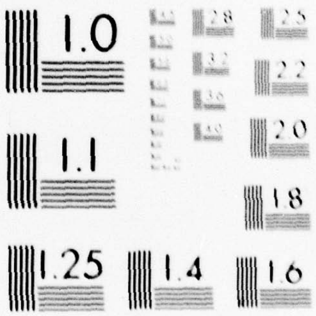

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                            10:45 MAR 13,'79                           PAGE  5

  ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS       CALCULATED     USED
   NO.         NAME                                                                          IN           IN

     44     C110                      INERTIA COEFFICIENT                                 SINIT       SACCROT

     45     PDOT                      ANGULAR ACCN. IN BODY AXES       RADS/SEC2         SACCROT     SACCBOD

     46     QDOT                      ANGULAR ACCN.IN BODY AXES        RADS/SEC2         SACCROT     SACCBOD

     47     RDOT                      ANGULAR ACCN. IN BODY AXES       RADS/SEC2         SACCROT     SACCBOD

     48     XIX                       MOMENT OF INERTIA,ROLL           SLUG FT2          USER        SINIT

     49     XIY                       MOMENT OF INERTIA,PITCH          SLUG FT2          USER        SINIT

     50     XIZ                       MOMENT OF INERTIA,YAW            SLUG FT2          USER        SINIT

     51     XIZX                      MOMENT OF INERTIA,PRODUCT        SLUG FT2          USER        SINIT

     52     VKN                       VELOCITY REL TO GROUND,NORTH     FT/SEC            DER'TIVE    SVELOC1
                                                                                                      SPATH
                                                                                                      STV

     53     VKE                       VELOCITY REL TO GROUND,EAST      FT/SEC            DER'TIVE    SVELOC1
                                                                                                      SPATH
                                                                                                      STV

     54     VKD                       VELOCITY REL TO GROUND,DOWN      FT/SEC            DER'TIVE    SVELOC1
                                                                                                      SPATH
                                                                                                      STV
```

```
                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                            10:45 MAR 13,'79                           PAGE  6

  ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS       CALCULATED     USED
   NO.         NAME                                                                          IN           IN

     55     VWN                       VELOCITY OF WIND,NORTH           FT/SEC            SWIND       SVELOC1

     56     VWE                       VELOCITY OF WIND,EAST            FT/SEC            SWIND       SVELOC1

     57     VWD                       VELOCITY OF WIND,DOWN            FT/SEC            SWIND       SVELOC1

     58     UB                        VEL COMP REL TO AIR,BODY AXES    FT/SEC            SVELOC1     SVELOC2
                                                                                                      SALFBET

     59     VB                        VEL COMP REL TO AIR,BODY AXES    FT/SEC            SVELOC1     SVELOC2
                                                                                                      SALFBET

     60     WB                        VEL COMP REL TO AIR,BODY AXES    FT/SEC            SVELOC1     SVELOC2
                                                                                                      SALFBET

     61     GAMMAR                    FLIGHT PATH ANGLE,CLIMB          RADIANS           SPATH       SPATH

     62     GAMMAD                    FLIGHT PATH ANGLE,CLIMB          DEGREES           SPATH

     63     PSIKR                     FLIGHT PATH ANGLE,TRACK .        RADIANS           SPATH       SPATH

     64     PSIKD                     FLIGHT PATH ANGLE,TRACK          DEGREES           SPATH

     65     VK                        VELOCITY RELATIVE TO GROUND      FT/SEC            SPATH       SINIT
                                                                                                      SPATH

     66     VKKT                      VELOCITY RELATIVE TO GROUND      KNOTS             SPATH
```

```
                                  SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                 10:45 MAR 13,'79                        PAGE  7

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                UNITS      CALCULATED    USED
  NO.        NAME                                                                 IN          IN

   67     VT                      TOTAL AIR SPEED                  FT/SEC      $VELOC2     $INIT
                                                                                           $VELOC2

   68     VTKT                    TOTAL AIR SPEED                  KNOTS       $VELOC2

   69     VEAS                    EQUIVALENT AIR SPEED             FT/SEC      $VELOC2     $VELOC2

   70     VEASKT                  EQUIVALENT AIR SPEED             KNOTS       $VELOC2

   71     ROOTSIG                 SQRT(DENSITY RATIO)                          $VELOC2     $INIT
                                                                                           $VELOC2

   72     RHO                     AIR DENSITY                      SLUG/FT3    $VELOC2     $VELOC2

   73     SPSOND                  SPEED OF SOUND                   FT/SEC      $VELOC2     $VELOC2

   74

   75     XMACH                   MACH NUMBER                                  $VELOC2     $VELOC2

   76     TEMPSL                  AMB TEMP AT SL(STANDARD DAY)     DEG. R      $INIT       $VELOC2
                                                                                           $INIT

   77     PRESSL                  AMBIENT PRESSURE AT SEA LEVEL    LB/IN 2     $INIT       $VELOC2
                                                                                           $INIT

   78     DENR                    DENSITY RATIO                                $INIT       $VELOC2
```

```
                                  SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                 10:45 MAR 13,'79                        PAGE  8

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                UNITS      CALCULATED    USED
  NO.        NAME                                                                 IN          IN

                                                                                           $INIT

   79     RHOSL                   DENSITY AT SEA LEVEL             SLUG /FT3   $INIT       $VELOC2
                                                                                           $INIT

   80     SPSL                    SPEED OF SOUND AT SEA LEVEL      FT/SEC      $INIT       $VELOC2
                                                                                           $INIT

   81     TEMPR                   ATMOSPHERIC TEMP RATIO                       $ATMOS      $VELOC2
                                                                                           $INIT

   82     PRESSR                  ATMOSPHERIC PRESSURE RATIO                   $ATMOS      $VELOC2
                                                                                           $INIT

   83     DRATIO                  ADIABATIC DENSITY RATIO                      $VELOC2     $VELOC2

   84     SPSNDR                  SPEED OF SOUND RATIO                         $ATMOS      $VELOC2
                                                                                           $INIT

   85     ARATIO                  ADIABATIC SPEED OF SOUND RATIO               $VELOC2     $VELOC2

   86     PALPHA                  FREE STREAM STATIC PRESSURE      LB/IN 2     $VELOC2

   87     PRATIO                  ADIABATIC STATIC/TOTAL PRESS                 $VELOC2

   88     TALPHA                  FREE STREAM STATIC TEMPERATURE   DEG. R      $VELOC2

   89     TRATIO                  ADIABATIC STATIC/TOTAL TEMP                  $VELOC2     $VELOC2
```

```
                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                  10:45 MAR 13,'79                                PAGE  9

 ELEMENT     FORTRAN     QUANTITY            DESCRIPTION                 UNITS     CALCULATED     USED
   NO.         NAME                                                                    IN           IN

   90

   91     DELT1                      INTEG. STEP LENGTH NO. 1           SECS        USER          INITIAL

   92     FRAMET1                    FRAME TIME,LOOP 1                  MSEC        USER          INITIAL
                                                                                                  SWIND

   93

   94     TIME                       TIME                               SEC         DER'TIVE

   95     DELT2                      INTEG. STEP LENGTH NO. 2           SECS        USER          INITIAL

   96     FRAMET2                    FRAME TIME,LOOP 2                  MSEC        USER          INITIAL

   97

   98     ZCG                        Z C.G. LOCATION                                USER          SINIT

   99     XCGREF                     X LOCATION OF REF PT                           USER          SINIT

  100     ZCGREF                     Z LOCATION OF REF PT                           USER          SINIT

  101     DXCG                       DIST OF C.G. AHEAD OF M.R.C.                   SINIT         STV

  102     DZCG                       DIST OF C.G. BELOW M.R.C.                      SINIT         STV

  103     SPAN                       WING SPAN                          FT          USER          SVELOC2
```

```
                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                  10:45 MAR 13,'79                                PAGE 10

 ELEMENT     FORTRAN     QUANTITY            DESCRIPTION                 UNITS     CALCULATED     USED
   NO.         NAME                                                                    IN           IN
                                                                                                  SINIT

  104     XLTAIL                     TAIL ARM FROM M.R.C.               FT          USER

  105     STAIL                      TAIL PLANE AREA                    FT2         USER

  106     SWREF                      WING REFERENCE AREA                FT2         USER          SVELOC2
                                                                                                  SINIT

  107     CREF                       REFERENCE CHORD                    FT          USER          SVELOC2
                                                                                                  STV

  108     SS2                        SWREF*SPAN*SPAN                    FT4         SINIT         SVELOC2

  109     XP                         X LOC OF PILOT REL TO REFCG        FT          USER          STV

  110     ZP                         Z LOC OF PILOT REL TO REFCG        FT          USER          STV

  111     ALFAR                      ANGLE OF ATTACK                    RADIANS     SALFBET       SALFBET

  112     ALFAD                      ANGLE OF ATTACK                    DEGREES     SALFBET

  113     BETAR                      ANGLE OF SIDESLIP                  RADIANS     SALFBET       SALFBET

  114     BETAD                      ANGLE OF SIDESLIP                  DEGREES     SALFBET

  115

  116     SALFA                      SINE OF ALFA                                   SALFBET
```

```
                                          SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                    10:45 MAR 13,'79                      PAGE 11
  ELEMENT    FORTRAN    QUANTITY            DESCRIPTION                 UNITS     CALCULATED    USED
    NO.        NAME                                                                   IN          IN

    117     CALFA                        COS OF ALFA                                SALFBET
    118     SBETA                        SINE OF BETA                               SALFBET
    119     CBETA                        COS OF BETA                                SALFBET
    120     ALFADOT                      RATE OF ANGLE OF ATTACK      RADS/SEC      SALFBET
    121     BETADOT                      RATE OF ANGLE OF SIDESLIP    RADS/SEC      SALFBET
    122
    123
    124     MLFRHOV                      0.5*RHO*VT                                 SVELOC2     SVELOC2
    125     QDYN                         DYNAMIC PRESSURE             LB/FT2        SVELOC2     SVELOC2
    126     QDYNS                        QDYN*SWREF                   LB            SVELOC2     SVELOC2
    127     QSCREF                       QDYNS*CREF                   LB-FT         SVELOC2
    128     QSSPAN                       QDYNS*SPAN                   LB-FT         SVELOC2
    129     QSB21V                       MLFRHOV*SB2                                SVELOC2
    130
```

```
                                          SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                    10:45 MAR 13,'79                      PAGE 12
  ELEMENT    FORTRAN    QUANTITY            DESCRIPTION                 UNITS     CALCULATED    USED
    NO.        NAME                                                                   IN          IN

    131     XLLTOT                       TOTAL MOMENT,ROLL,BODY AXES      LB-FT     USER        SACCROT
    132     XMMTOT                       TOTAL MOMENT,PITCH,BODY AXES     LB-FT     USER        SACCROT
    133     XNNTOT                       TOTAL MOMENT,YAW,BODY AXES       LB-FT     USER        SACCROT
    134     FTX                          TOTAL FORCE COMP. IN BODY AXES   LB        USER        SACCLIN
                                                                                                SACCBOD
    135     FTY                          TOTAL FORCE COMP. IN BODY AXES   LB        USER        SACCLIN
                                                                                                SACCBOD
    136     FTZ                          TOTAL FORCE COMP. IN BODY AXES   LB        USER        SACCLIN
                                                                                                SACCBOD
    137     FTN                          TOTAL FORCE COMP IN EARTH AXES   LB        SACCLIN     SACCLIN
    138     FTE                          TOTAL FORCE COMP IN EARTH AXES   LB        SACCLIN     SACCLIN
    139     FTD                          TOTAL FORCE COMP IN EARTH AXES   LB        SACCLIN     SACCLIN
    140
    141     RADTOD                       CONVERSION RADIANS TO DEGREES    CONSTANT  SINIT       SDCOS
                                                                                                SPATH
                                                                                                SALFBET
                                                                                                SEULER
```

```
                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                10:45 MAR 13,'79                         PAGE 13
 ELEMENT     FORTRAN    QUANTITY              DESCRIPTION                UNITS      CALCULATED    USED
   NO.         NAME                                                                     IN          IN
                                                                                                  SILS
                                                                                                  SINIT
   142     DEGTOR                   CONVERSION DEGREES TO RADIANS   CONSTANT     SINIT        SILS
                                                                                                  SINIT
   143     FPSTKT                   CONVERSION FT/SEC TO KNOTS      CONSTANT     SINIT        SVELOC2
                                                                                                  SPATH
   144     KK2FPS                   CONVERSION KNOTS TO FT/SEC      CONSTANT     SINIT        SWIND
                                                                                                  STV
                                                                                                  SINIT
   145     G                        ACCELERATION DUE TO GRAVITY     CONSTANT     SINIT        SACCLIN
                                                                                                  SINIT
   146     RG                       RECIPROCAL OF G                              SINIT        SACCBOD
   147
   148
   149     X                        X POSITION OF C.G.              FT           DER'TIVE     STV
                                                                                                  SILS
   150     Y                        Y POSITION OF C.G.              FT           DER'TIVE     STV
                                                                                                  SILS
   151     H                        HEIGHT OF CG                    FT           DER'TIVE     SATMOS
```

```
                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                10:45 MAR 13,'79                         PAGE 14
 ELEMENT     FORTRAN    QUANTITY              DESCRIPTION                UNITS      CALCULATED    USED
   NO.         NAME                                                                     IN          IN
                                                                                                  SVELOC2
                                                                                                  STV
                                                                                                  SILS
                                                                                                  SWIND
   152     XTV                      X POSITION FOR TV               FT           STV          STV
   153     YTV                      Y POSITION FOR TV               FT           STV          STV
   154     HTV                      HEIGHT FOR TV                   FT           STV          STV
   155     XDTV                     X VELOCITY FOR TV               FT/SEC       STV
   156     YDTV                     Y VELOCITY FOR TV               FT/SEC       STV
   157     HDTV                     H VELOCITY FOR TV               FT/SEC       STV
   158     XDOTH                    RATE OF CHANGE OF A/C'S X POSN  FT/SEC       STV          DER'TIVE
                                                                                                  STV
   159     XIMX                     CONTROL VAR FOR X INTEGRATION                STV          DER'TIVE
   160     XIMY                     CONTROL VAR FOR Y INTEGRATION                STV          DER'TIVE
   161     SXPL                     NEAR BELT JOIN(POS)AND LIMIT    FT           STV          STV
   162     SXMIN                    NEAR BELT JOIN(NEG)AND LIMIT    FT           STV          STV
   163     SXPLUS                   CYCLE LIMIT                     FT           STV          STV
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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                   10:45 MAR 13,'79                                PAGE 15

ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                  UNITS      CALCULATED     USED
  NO.        NAME                                                                    IN           IN

  164      SXMINUS                 CYCLE LIMIT                        FT           STV          STV
  165      SYPL                    LIMIT FOR SIDEWAYS(POSITIVE)       FT           STV          STV
  166      SYMIN                   LIMIT FOR SIDEWAYS(NEGATIVE)       FT           STV          STV
  167      HTVLIM                  CEILING AND HEIGHT LIMIT           FT           STV          STV
  168      XDTMX                   SLEW RATE                          FT/SEC       STV          STV
  169      VSHIPKT                 SHIP SPEED                         KT           USER         STV
  170
  171      EGS                     GLIDE SLOPE ERROR                  DEGREES      SILS
  172      ELOC                    LOCALISER ERROR                    DEGREES      SILS
  173      HSLOPE                  HT OF ILS BEAM AT GIVEN RANGE      FT           SILS         SINIT
                                                                                                SILS
  174      RGS                     RANGE FROM G/S TRANSMITTER         FT           SILS         SILS
  175      RLOC                    RANGE FROM LOC TRANSMITTER         FT           SILS         SILS
  176      RKINK                   RANGE FROM BEAM KINK               FT           SILS         SILS
  177      XGS                     GLIDE SLOPE ORIGIN                 FT           SILS         SILS
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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                   10:45 MAR 13,'79                                PAGE 16

ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                  UNITS      CALCULATED     USED
  NO.        NAME                                                                    IN           IN

  178      XLOC                    LOCALISER ORIGIN (X)               FT           SILS         SILS
  179      YLOC                    LOCALISER ORIGIN (Y)               FT           SILS         SILS
  180      SGS                     GLIDE SLOPE SENSITIVITY            DEGREES      SILS         SILS
  181      SLOC                    LOCALISER SENSITIVITY              DEGREES      SILS         SILS
  182      HKINK                   HEIGHT OF BEAM KINK                FT           SILS         SILS
  183      BSLOPE                  SLOPE OF LOWER BEAM                DEGREES      SILS         SILS
  184      USLOPE                  SLOPE OF UPPER BEAM                DEGREES      SILS         SILS
  185      XKINK                   POSITION OF BEAM KINK              FT           SILS         SILS
  186      CILS1                   RADTOD/SGS                                      SILS         SILS
  187      CILS2                   RADTOD/SLOC                                     SILS         SILS
  188      CILS3                   TAN(BSLOPE)                                     SILS         SILS
  189      CILS4                   TAN(USLOPE)-CILS3                               SILS         SILS
  190
  191      BETADIC                 INITIAL VALUE OF BETA              DEGREES      ICFILE       SINIT
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                                     SYSTEM COMMON - REAL VARIABLES 15.3.79

NUMERIC ORDER                                 10:45 MAR 13,'79                                  PAGE 17

ELEMENT      FORTRAN      QUANTITY              DESCRIPTION                 UNITS      CALCULATED      USED
  NO.          NAME                                                                        IN            IN

  192     ALFADIC                      INITIAL VALUE OF ALFA            DEGREES      ICFILE        SINIT

  193     GAMDIC                       INITIAL VALUE OF GAMMA           DEGREES      ICFILE        SINIT

  194     VKTIC                        INITIAL AIR SPEED                KNOTS        ICFILE        SINIT
                                                                                                   SWIND

  195     XIC                          INITIAL POSITION                 FT           ICFILE        SINIT
                                                                                                   INITIAL
                                                                                                   STV

  196     YIC                          INITIAL POSITION                 FT           ICFILE        INITIAL

  197     HIC                          INITIAL POSITION                 FT           ICFILE        SINIT
                                                                                                   SWIND
                                                                                                   INITIAL

  198     W                            AIRCRAFT WEIGHT                  LB           ICFILE        SINIT
                                                                                                   SACCBOD

  199     XCG                          X C.G. LOCATION IN AIRCRAFT                   ICFILE        SINIT

  200     XILSFLAG                     ILSFLAG IN 'REAL' FORM                        ICFILE        INITIAL

  201     XISHR                        ISHR IN 'REAL' FORM                           ICFILE        INITIAL

  202     VWKTO                        DATUM WIND SPEED                 KNOTS        ICFILE        SINIT



                                     SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                 10:45 MAR 13,'79                                  PAGE 18

ELEMENT      FORTRAN      QUANTITY              DESCRIPTION                 UNITS      CALCULATED      USED
  NO.          NAME                                                                        IN            IN

  203     PSIWD                        DATUM WIND DIRECTION             DEGREES      ICFILE        SINIT

  204     PSIDIC                       INITIAL VALUE OF PSI             DEGREES      ICFILE        INITIAL
                                                                                                   SINIT

  205     RIC15                        SPARE

  206     RIC16                        SPARE

  207     RIC17                        SPARE

  208     RIC18                        SPARE

  209     RIC19                        SPARE

  210     RIC20                        SPARE

  211     VKNIC                        INIT GROUND SPEED COMP (NORTH)   FT/SEC       SINIT         INITIAL
                                                                                                   SINIT

  212     VKEIC                        INIT GROUND SPEED COMP (EAST)    FT/SEC       SINIT         INITIAL
                                                                                                   SINIT

  213     VKDIC                        INIT GROUND SPEED COMP (DOWN)    FT/SEC       SINIT         INITIAL
                                                                                                   SINIT

  214     PHIDIC                       INITIAL VALUE OF PHI             DEGREES      SINIT         INITIAL
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                                                SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                        10:45 MAR 13,'79                                PAGE 19

ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS      CALCULATED      USED
  NO.         NAME                                                                         IN           IN

  215     THETADIC                     INITIAL VALUE OF THETA             DEGREES       SINIT         INITIAL
  216
  217     VN                           COMP. OF TRUE AIR SPEED(NORTH)     FT/SEC        SVELOC1       SVELOC1
  218     VE                           COMP. OF TRUE AIR SPEED(EAST)      FT/SEC        SVELOC1       SVELOC1
  219     VD                           COMP. OF TRUE AIR SPEED(DOWN)      FT/SEC        SVELOC1       SVELOC1
  220     PDIC                         INITIAL ANGULAR RATE               RADS/SEC      SINIT         INITIAL
  221     QDIC                         INITIAL ANGULAR RATE               RADS/SEC      SINIT         INITIAL
  222     RDIC                         INITIAL ANGULAR RATE               RADS/SEC      SINIT         INITIAL
  223     VWDLO                        WIND VELOCITY(DOWN)AT HEIGHT       FT/SEC        SWIND         SWIND
  224     CPSIW                        COS(PSIWD)                                       SINIT         SWIND
                                                                                                      SINIT
  225     SPSIW                        SIN(PSIWD)                                       SINIT         SWIND
                                                                                                      SINIT
  226     VWNLO                        WIND VELOCITY (NORTH)AT HEIGHT     FT/SEC        SINIT         SWIND
                                                                                                      SINIT
  227     VWELO                        WIND VELOCITY (EAST)AT HEIGHT      FT/SEC        SINIT         SWIND
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                                                SYSTEM COMMON - REAL VARIABLES 15.3.78

NUMERIC ORDER                                        10:45 MAR 13,'79                                PAGE 20

ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS      CALCULATED      USED
  NO.         NAME                                                                         IN           IN
                                                                                                      SINIT
  228     SHRFAC                       SHEAR FACTOR                                     WSHEAR        SINIT
                                                                                                      SWIND
  229     VWNL                         MEAN WIND COMP AT HEIGHT(NTH)      FT/SEC        SWIND         SWIND
  230     VWEL                         MEAN WIND COMP AT HEIGHT(EAST)     FT/SEC        SWIND         SWIND
  231     VWDL                         MEAN WIND COMP AT HEIGHT(DOWN)     FT/SEC        SWIND         SWIND
  232     UTURB                        COMPONENT OF TURBULENCE            FT/SEC        SWIND         SWIND
  233     VTURB                        COMPONENT OF TURBULENCE            FT/SEC        SWIND         SWIND
  234     WTURB                        COMPONENT OF TURBULENCE            FT/SEC        SWIND         SWIND
  235     USIG                         RMS OF TURBULENCE                  FT/SEC        USER          SWIND
  236     VSIG                         RMS OF TURBULENCE                  FT/SEC        USER          SWIND
  237     WSIG                         RMS OF TURBULENCE                  FT/SEC        USER          SWIND
  238     VKNDOT                       ACCELERATION IN EARTH AXES         FT/SEC2       SACCLIN       DER'TIVE
  239     VKEDOT                       ACCELERATION IN EARTH AXES         FT/SEC2       SACCLIN       DER'TIVE
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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                10:45 MAR 13,'79                                PAGE 21

ELEMENT    FORTRAN    QUANTITY            DESCRIPTION                UNITS     CALCULATED     USED
  NO.        NAME                                                                  IN           IN

  241      AXCG                   SPECIFIC ACCELERATION AT CG(X)  G             SACCBOD      SACCBOD
  242      AYCG                   SPECIFIC ACCELERATION AT CG(Y)  G             SACCBOD      SACCBOD
  243      AZCG                   SPECIFIC ACCELERATION AT CG(Z)  G             SACCBOD      SACCBOD
  244      AZCG1                  Z ACCEL'N AT CG,REL. TO 1.0     G             SACCBOD
  245      AXACG                  ABSOLUTE ACCELERATION AT CG(X)  G             SACCBOD
  246      AYACG                  ABSOLUTE ACCELERATION AT CG(Y)  G             SACCBOD
  247      AZACG                  ABSOLUTE ACCELERATION AT CG(Z)  G             SACCBOD
  248      AXP                    SPECIFIC ACCEL'N AT PILOT (X)   G             SACCBOD
  249      AYP                    SPECIFIC ACCEL'N AT PILOT (Y)   G             SACCBOD
  250      AZP                    SPECIFIC ACCEL'N AT PILOT (Z)   G             SACCBOD      SACCBOD
  251      AZAP                   ABSOLUTE ACCEL'N AT PILOT (Z)   G             SACCBOD
  252      AY1                    ACCELERATION AT SLIP BALL       G             SACCBOD
  253      AZ2                    ACCELERATION AT G METER         G             SACCBOD
  254      AX3                    X ACCEL'N AT (X3,Y3,Z3)         G             SACCBOD
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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
NUMERIC ORDER                                10:45 MAR 13,'79                                PAGE 22

ELEMENT    FORTRAN    QUANTITY            DESCRIPTION                UNITS     CALCULATED     USED
  NO.        NAME                                                                  IN           IN

  255      AY4                    Y ACCEL'N AT (X4,Y4,Z4)         G             SACCBOD
  256      AZ5                    Z ACCEL'N AT (X5,Y5,Z5)         G             SACCBOD
  257      X1                     COORDINATES OF SLIP BALL (AY1)  FT            USER         SACCBOD
  258      Y1                     COORDINATES OF SLIP BALL (AY1)  FT            USER         SACCBOD
  259      Z1                     COORDINATES OF SLIP BALL (AY1)  FT            USER         SACCBOD
  260      X2                     COORDINATES OF G METER (AZ2)    FT            USER         SACCBOD
  261      Y2                     COORDINATES OF G METER (AZ2)    FT            USER         SACCBOD
  262      Z2                     COORDINATES OF G METER (AZ2)    FT            USER         SACCBOD
  263      X3                     COORD.  OF ACCELEROMETER (AX3)  FT            USER         SACCBOD
  264      Y3                     COORD.  OF ACCELEROMETER (AX3)  FT            USER         SACCBOD
  265      Z3                     COORD.  OF ACCELEROMETER (AX3)  FT            USER         SACCBOD
  266      X4                     COORD.  OF ACCELEROMETER (AY4)  FT            USER         SACCBOD
  267      Y4                     COORD.  OF ACCELEROMETER (AY4)  FT            USER         SACCBOD
  268      Z4                     COORD.  OF ACCELEROMETER (AY4)  FT            USER         SACCBOD
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                                            SYSTEM COMMON - REAL VARIABLES 15.3.78
  NUMERIC ORDER                                   10:45 MAR 13,'79                                 PAGE 23

   ELEMENT      FORTRAN    QUANTITY            DESCRIPTION                  UNITS      CALCULATED      USED
     NO.          NAME                                                                     IN            IN

     269     XS                       COORD.  OF ACCELEROMETER (AZS)  FT              USER          SACCBOD

     270     YS                       COORD.  OF ACCELEROMETER (AZS)  FT              USER          SACCBOD

     271     ZS                       COORD.  OF ACCELEROMETER (AZS)  FT              USER          SACCBOD

******** NOTE MISSING ELEMENT NUMBERS *****

     278     SFRACG                   INTERMITTENCY FOR TURBULENCE                    USER          SWIND

     279     SRDECAY                  DECAY FACTOR FOR TURBULENCE                     USER          SWIND

     280     XPCG                     XLOC OF PILOT REL TO CG                         STV           STV
                                                                                                    SACCBOD

     281     ZPCG                     Z LOC OF PILOT REL TO CG                        STV           STV
                                                                                                    SACCBOD

     282     RXP                      PILOT X RADIUS                  FT              STV           STV

     283     RHP                      PILOT H RADIUS                  FT              STV           STV

     284     XICF                     EXTRA STORE FOR XIC             FT              STV           STV

******** NOTE MISSING ELEMENT NUMBERS *****

     301     AADC(1)                  ARRAY OF SCALING FACTORS                        USER          SADC
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                                            SYSTEM COMMON - REAL VARIABLES 15.3.78
  NUMERIC ORDER                                   10:45 MAR 13,'79                                 PAGE 24

   ELEMENT      FORTRAN    QUANTITY            DESCRIPTION                  UNITS      CALCULATED      USED
     NO.          NAME                                                                     IN            IN

******** NOTE MISSING ELEMENT NUMBERS *****

     364     AADC(64)                 ARRAY OF SCALING FACTORS                        USER          SADC

     365     TVCON(1,1)               ARRAY OF CONSTANTS FOR TV BELT                  STV           STV

******** NOTE MISSING ELEMENT NUMBERS *****

     388     TVCON(8,3)               ARRAY OF CONSTANTS FOR TV BELT                  STV           STV

******** NOTE MISSING ELEMENT NUMBERS *****

     401     YADC(1)                  ARRAY OF DESCALED INPUTS                        SADC          USER

******** NOTE MISSING ELEMENT NUMBERS *****

     464     YADC(64)                 ARRAY OF DESCALED INPUTS                        SADC          USER

******** NOTE MISSING ELEMENT NUMBERS *****

     501     ADAC(1)                  ARRAY OF SCALING FACTORS                        USER          SDAC

******** NOTE MISSING ELEMENT NUMBERS *****

     564     ADAC(64)                 ARRAY OF SCALING FACTORS                        USER          SDAC
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D.2 Alphabetical order

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                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                         10:45 MAR 13,'79                                    PAGE  1

ELEMENT   FORTRAN    QUANTITY            DESCRIPTION                  UNITS      CALCULATED   USED
  NO.       NAME                                                                     IN        IN


  301    AADC(1)                ARRAY OF SCALING FACTORS                          USER       SADC

  364    AADC(64)               ARRAY OF SCALING FACTORS                          USER       SADC

  501    ADAC(1)                ARRAY OF SCALING FACTORS                          USER       SDAC

  564    ADAC(64)               ARRAY OF SCALING FACTORS                          USER       SDAC

  112    ALFAD                  ANGLE OF ATTACK                 DEGREES           SALFBET

  192    ALFADIC                INITIAL VALUE OF ALFA           DEGREES           ICFILE     SINIT

  120    ALFADOT                RATE OF ANGLE OF ATTACK         RADS/SEC          SALFBET

  111    ALFAR                  ANGLE OF ATTACK                 RADIANS           SALFBET    SALFBET

   85    ARATIO                 ADIABATIC SPEED OF SOUND RATIO                    SVELOC2    SVELOC2

  254    AX3                    X ACCEL'N AT (X3,Y3,Z3)         G                 SACCBOD

  245    AXACG                  ABSOLUTE ACCELERATION AT CG(X)  G                 SACCBOD

  241    AXCG                   SPECIFIC ACCELERATION AT CG(X)  G                 SACCBOD    SACCBOD

  248    AXP                    SPECIFIC ACCEL'N AT PILOT (X)   G                 SACCBOD

  252    AY1                    ACCELERATION AT SLIP BALL       G                 SACCBOD
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                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                         10:45 MAR 13,'79                                    PAGE  2

ELEMENT   FORTRAN    QUANTITY            DESCRIPTION                  UNITS      CALCULATED   USED
  NO.       NAME                                                                     IN        IN


  255    AY4                    Y ACCEL'N AT (X4,Y4,Z4)         G                 SACCBOD

  246    AYACG                  ABSOLUTE ACCELERATION AT CG(Y)  G                 SACCBOD

  242    AYCG                   SPECIFIC ACCELERATION AT CG(Y)  G                 SACCBOD    SACCBOD

  249    AYP                    SPECIFIC ACCEL'N AT PILOT (Y)   G                 SACCBOD

  253    AZ2                    ACCELERATION AT G METER         G                 SACCBOD

  256    AZ5                    Z ACCEL'N AT (X5,Y5,Z5)         G                 SACCBOD

  247    AZACG                  ABSOLUTE ACCELERATION AT CG(Z)  G                 SACCBOD

  251    AZAP                   ABSOLUTE ACCEL'N AT PILOT (Z)   G                 SACCBOD

  243    AZCG                   SPECIFIC ACCELERATION AT CG(Z)  G                 SACCBOD    SACCBOD

  244    AZCG1                  Z ACCEL'N AT CG,REL. TO 1.0     G                 SACCBOD

  250    AZP                    SPECIFIC ACCEL'N AT PILOT (Z)   G                 SACCBOD    SACCBOD

  114    BETAD                  ANGLE OF SIDESLIP               DEGREES           SALFBET

  191    BETADIC                INITIAL VALUE OF BETA           DEGREES           ICFILE     SINIT

  121    BETADOT                RATE OF ANGLE OF SIDESLIP       RADS/SEC          SALFBET
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                                                 SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                                     10:45 MAR 13,'79                          PAGE  3

ELEMENT     FORTRAN     QUANTITY          DESCRIPTION                    UNITS      CALCULATED     USED
  NO.         NAME                                                                      IN          IN

  113       BETAR                     ANGLE OF SIDESLIP               RADIANS       SALFBET     SALFBET

  183       BSLOPE                    SLOPE OF LOWER BEAM             DEGREES       SILS        SILS

  117       CALFA                     COS OF ALFA                                   SALFBET

  119       CBETA                     COS OF BETA                                   SALFBET

   35       C11                       INERTIA COEFFICIENT                           SINIT       SACCROT

   36       C12                       INERTIA COEFFICIENT                           SINIT       SACCROT

   37       C13                       INERTIA COEFFICIENT                           SINIT       SACCROT

   38       C14                       INERTIA COEFFICIENT                           SINIT       SACCROT

   39       C15                       INERTIA COEFFICIENT                           SINIT       SACCROT
                                                                                                SINIT

   40       C16                       INERTIA COEFFICIENT                           SINIT       SACCROT

   41       C17                       INERTIA COEFFICIENT                           SINIT       SACCROT

   42       C18                       INERTIA COEFFICIENT                           SINIT       SACCROT

   43       C19                       INERTIA COEFFICIENT                           SINIT       SACCROT

   44       C110                      INERTIA COEFFICIENT                           SINIT       SACCROT
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                                                 SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                                     10:45 MAR 13,'79                          PAGE  4

ELEMENT     FORTRAN     QUANTITY          DESCRIPTION                    UNITS      CALCULATED     USED
  NO.         NAME                                                                      IN          IN

  186       CILS1                     RADTOD/SGB                                    SILS        SILS

  187       CILS2                     RADTOD/SLGL                                   SILS        SILS

  188       CILS3                     TAN(BSLOPE)                                   SILS        SILS

  189       CILS4                     TAN(USLOPE)-CILS3                             SILS        SILS

   14       CPHI                      COS(PHIR)                                     SOCOS       SEULER
                                                                                                SOCOS

   10       CPSI                      COS(PSIR)                                     SOCOS       STV
                                                                                                SOCOS

  224       CPSIW                     COS(PSIW0)                                    SINIT       SWIND
                                                                                                SINIT

  107       CREF                      REFERENCE CHORD                 FT            USER        SVELOC2
                                                                                                STV

   12       CTHETA                    COS(THETAR)                                   SOCOS       STV
                                                                                                SOCOS

  142       DEGTOR                    CONVERSION DEGREES TO RADIANS   CONSTANT      SINIT       SILS
                                                                                                SINIT

   91       DELT1                     INTEG. STEP LENGTH NO. 1        SECS          USER        INITIAL
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                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                          10:45 MAR 13,'79                               PAGE  5

 ELEMENT     FORTRAN     QUANTITY           DESCRIPTION                 UNITS      CALCULATED     USED
   NO.        NAME                                                                    IN           IN

    95     DELT2                    INTEG. STEP LENGTH NO. 2           SECS         USER         INITIAL
    78     DENR                     DENSITY RATIO                                   SINIT        SVELOC2
                                                                                                 SINIT
    83     DRATIO                   ADIABATIC DENSITY RATIO                         SVELOC2      SVELOC2
   101     DXCG                     DIST OF C.G. AHEAD OF M.R.C.                    SINIT        STV
   102     DZCG                     DIST OF C.G. BELOW M.R.C.                       SINIT        STV
   171     EGS                      GLIDE SLOPE ERROR                  DEGREES      SILS
   172     ELOC                     LOCALISER ERROR                    DEGREES      SILS
   143     FPSTKT                   CONVERSION FT/SEC TO KNOTS         CONSTANT     SINIT        SVELOC2
                                                                                                 SPATH
    92     FRAMET1                  FRAME TIME,LOOP 1                  MSEC         USER         INITIAL
                                                                                                 SWIND
    96     FRAMET2                  FRAME TIME,LOOP 2                  MSEC         USER         INITIAL
   139     FTD                      TOTAL FORCE COMP IN EARTH AXES     LB           SACCLIN      SACCLIN
   138     FTE                      TOTAL FORCE COMP IN EARTH AXES     LB           SACCLIN      SACCLIN
   137     FTN                      TOTAL FORCE COMP IN EARTH AXES     LB           SACCLIN      SACCLIN




                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                          10:45 MAR 13,'79                               PAGE  6

 ELEMENT     FORTRAN     QUANTITY           DESCRIPTION                 UNITS      CALCULATED     USED
   NO.        NAME                                                                    IN           IN

   134     FTX                      TOTAL FORCE COMP. IN BODY AXES     LB           USER         SACCLIN
                                                                                                 SACCBOD
   135     FTY                      TOTAL FORCE COMP. IN BODY AXES     LB           USER         SACCLIN
                                                                                                 SACCBOD
   136     FTZ                      TOTAL FORCE COMP. IN BODY AXES     LB           USER         SACCLIN
                                                                                                 SACCBOD
   145     G                        ACCELERATION DUE TO GRAVITY        CONSTANT     SINIT        SACCLIN
                                                                                                 SINIT
   193     GAMDIC                   INITIAL VALUE OF GAMMA             DEGREES      ICFILE       SINIT
    62     GAMMAD                   FLIGHT PATH ANGLE,CLIMB            DEGREES      SPATH
    61     GAMMAR                   FLIGHT PATH ANGLE,CLIMB            RADIANS      SPATH        SPATH
   151     H                        HEIGHT OF CG                       FT           DER'TIVE     SATMOS
                                                                                                 SVELOC2
                                                                                                 STV
                                                                                                 SILS
                                                                                                 SWIND
   157     HDTV                     H VELOCITY FOR TV                  FT/SEC       STV
   197     HIC                      INITIAL POSITION                   FT           ICFILE       SINIT
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                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                                    10:45 MAR 13,'79                         PAGE  7

ELEMENT    FORTRAN     QUANTITY          DESCRIPTION                     UNITS      CALCULATED    USED
  NO.        NAME                                                                       IN          IN

                                                                                                SWIND
                                                                                                INITIAL

  182     HKINK                     HEIGHT OF BEAM KINK               FT          SILS         SILS

  124     HLFRHOV                   0.5*RHO*VT                                    SVELOC2      SVELOC2

  173     HSLOPE                    HT OF ILS BEAM AT GIVEN RANGE     FT          SILS         SINIT
                                                                                                SILS

  184     HTV                       HEIGHT FOR TV                     FT          STV          STV

  167     HTVLIM                    CEILING AND HEIGHT LIMIT          FT          STV          STV

   26     P                         ANG VEL,ROLL,BODY AXES            RADS/SEC    DER'TIVE     SEULER
                                                                                                SACCROT
                                                                                                SACCBOD

   86     PALPHA                    FREE STREAM STATIC PRESSURE       LB/IN 2     SVELOC2

   32     PD                        ANG VEL,ROLL,BODY AXES            DEGS/SEC    SEULER

  220     PDIC                      INITIAL ANGULAR RATE              RADS/SEC    SINIT        INITIAL

   45     PDOT                      ANGULAR ACCN. IN BODY AXES        RADS/SEC2   SACCROT      SACCBOD

    8     PHID                      BANK ANGLE                        DEGREES     SDCOS

  214     PHIDIC                    INITIAL VALUE OF PHI              DEGREES     SINIT        INITIAL
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                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                                    10:45 MAR 13,'79                         PAGE  8

ELEMENT    FORTRAN     QUANTITY          DESCRIPTION                     UNITS      CALCULATED    USED
  NO.        NAME                                                                       IN          IN

   29     PHIDT                     ATTITUDE RATE,BANK                RAD/SEC     SEULER       DER'TIVE

    7     PHIR                      BANK ANGLE                        RADIANS     DER'TIVE     SDCOS

   87     PRATIO                    ADIABATIC STATIC/TOTAL PRESS                  SVELOC2

   77     PRESSL                    AMBIENT PRESSURE AT SEA LEVEL     LB/IN 2     SINIT        SVELOC2
                                                                                                SINIT

   82     PRESSR                    ATMOSPHERIC PRESSURE RATIO                    SATMOS       SVELOC2
                                                                                                SINIT

    4     PSID                      HEADING ANGLE                     DEGREES     SDCOS

  204     PSIDIC                    INITIAL VALUE OF PSI              DEGREES     ICFILE       INITIAL
                                                                                                SINIT

   31     PSIDT                     ATTITUDE RATE,HEADING             RAD/SEC     SEULER       STV
                                                                                                DER'TIVE

   64     PSIKD                     FLIGHT PATH ANGLE,TRACK           DEGREES     SPATH

   63     PSIKR                     FLIGHT PATH ANGLE,TRACK           RADIANS     SPATH        SPATH

    3     PSIR                      HEADING ANGLE                     RADIANS     DER'TIVE     SDCOS

  203     PSIWD                     DATUM WIND DIRECTION              DEGREES     ICFILE       SINIT
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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                              10:45 MAR 13,'79                                 PAGE  9

ELEMENT     FORTRAN    QUANTITY            DESCRIPTION                    UNITS      CALCULATED      USED
  NO.         NAME                                                                       IN            IN

  27     Q                           ANG VEL,PITCH,BODY AXES          RADS/SEC     DER'TIVE      SEULER
                                                                                                  SACCROT
                                                                                                  SACCBOD

  33     QD                          ANG VEL,PITCH,BODY AXES          DEGS/SEC     SEULER

 221     QDIC                        INITIAL ANGULAR RATE             RADS/SEC     SINIT         INITIAL

  46     QDOT                        ANGULAR ACCN.IN BODY AXES        RADS/SEC2    SACCROT       SACCBOD

 125     QDYN                        DYNAMIC PRESSURE                 LB/FT2       SVELOC2       SVELOC2

 126     QDYNS                       QDYN*SWREF                       LB           SVELOC2       SVELOC2

 129     QSB21V                      HLFRHOV*SW2                                   SVELOC2

 127     QSCREF                      QDYNS*CREF                       LB-FT        SVELOC2

 128     QSSPAN                      QDYNS*SPAN                       LB-FT        SVELOC2

  28     R                           ANG VEL,YAW,BODY AXES            RADS/SEC     DER'TIVE      SEULER
                                                                                                  SACCROT
                                                                                                  SACCBOD

 141     RADTOD                      CONVERSION RADIANS TO DEGREES    CONSTANT     SINIT         SDCOS
                                                                                                  SPATH
                                                                                                  SALFBET
```

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                                        SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                              10:45 MAR 13,'79                                 PAGE 10

ELEMENT     FORTRAN    QUANTITY            DESCRIPTION                    UNITS      CALCULATED      USED
  NO.         NAME                                                                       IN            IN

                                                                                                  SEULER
                                                                                                  SILS
                                                                                                  SINIT

  34     RD                          ANG VEL,YAW,BODY AXES            DEGS/SEC     SEULER

 222     RDIC                        INITIAL ANGULAR RATE             RADS/SEC     SINIT         INITIAL

  47     RDOT                        ANGULAR ACCN. IN BODY AXES       RADS/SEC2    SACCROT       SACCBOD

 146     RG                          RECIPROCAL OF G                               SINIT         SACCBOD

 174     RGS                         RANGE FROM G/S TRANSMITTER       FT           SILS          SILS

  72     RHO                         AIR DENSITY                      SLUG/FT3     SVELOC2       SVELOC2

  73     RHOSL                       DENSITY AT SEA LEVEL             SLUG /FT3    SINIT         SVELOC2
                                                                                                  SINIT

 283     RHP                         PILOT H RADIUS                   FT           STV           STV

 205     RIC15                       SPARE

 206     RIC16                       SPARE

 207     RIC17                       SPARE

 208     RIC18                       SPARE
```

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                                            SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                                   10:45 MAR 13,'79                                    PAGE 11

 ELEMENT     FORTRAN     QUANTITY           DESCRIPTION                     UNITS     CALCULATED      USED
   NO.         NAME                                                                       IN            IN

   209       RIC19                          SPARE

   210       RIC20                          SPARE

   176       RKINK                          RANGE FROM BEAM KINK             FT         SILS          SILS

   175       RLOC                           RANGE FROM LOC TRANSMITTER       FT         SILS          SILS

    71       ROOTSIG                        SQRT(DENSITY RATIO)                         SVELOC2       SINIT
                                                                                                      SVELOC2

     1       RXMASS                         1/XMASS                                     SINIT         SACCLIN

   282       RXP                            PILOT X RADIUS                   FT         STV           STV

    17       S11                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN

    18       S12                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN

    19       S13                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN
                                                                                                      SACCBOD

    20       S21                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN
```

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                                            SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                                   10:45 MAR 13,'79                                    PAGE 12

 ELEMENT     FORTRAN     QUANTITY           DESCRIPTION                     UNITS     CALCULATED      USED
   NO.         NAME                                                                       IN            IN

    21       S22                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN

    22       S23                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN
                                                                                                      SACCBOD

    23       S31                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN

    24       S32                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN

    25       S33                            DIRECTION COSINE                            SDCOS         SVELOC1
                                                                                                      SACCLIN
                                                                                                      SACCBOD

   116       SALFA                          SINE OF ALFA                                SALFBET

   108       SB2                            SWREF*SPAN*SPAN                  FT4        SINIT         SVELOC2

   118       SBETA                          SINE OF BETA                                SALFBET

    15       SECTHT                         SEC(THETAR)                                 SDCOS         SEULER
                                                                                                      SDCOS

   278       SFRACG                         INTERMITTENCY FOR TURBULENCE                USER          SWIND
```

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                                       SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                            10:45 MAR 13,'79                                  PAGE 13

ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS      CALCULATED     USED
  NO.         NAME                                                                          IN           IN

  180      SGS                       GLIDE SLOPE SENSITIVITY          DEGREES      SILS          SILS
  228      SHRFAC                    SHEAR FACTOR                                  WSHEAR        SINIT
                                                                                                 SWIND
  181      SLOC                      LOCALISER SENSITIVITY            DEGREES      SILS          SILS
  103      SPAN                      WING SPAN                        FT           USER          SVELOC2
                                                                                                 SINIT
   13      SPHI                      SIN(PHIR)                                     SDCOS         SEULER
                                                                                                 SDCOS
    9      SPSI                      SIN(PSIR)                                     SDCOS         STV
                                                                                                 SDCOS
  225      SPSIW                     SIN(PSIWD.                                    SINIT         SWIND
                                                                                                 SINIT
   80      SPSL                      SPEED OF SOUND AT SEA LEVEL      FT/SEC       SINIT         SVELOC2
                                                                                                 SINIT
   84      SPSNDR                    SPEED OF SOUND RATIO                          SATMOS        SVELOC2
                                                                                                 SINIT
   73      SPSOND                    SPEED OF SOUND                   FT/SEC       SVELOC2       SVELOC2
  279      SRDECAY                   DECAY FACTOR FOR TURBULENCE                   USER          SWIND


                                       SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                            10:45 MAR 13,'79                                  PAGE 14

ELEMENT     FORTRAN     QUANTITY              DESCRIPTION                   UNITS      CALCULATED     USED
  NO.         NAME                                                                          IN           IN

  105      STAIL                     TAIL PLANE AREA                  FT2          USER
   11      STHETA                    SIN(THETAR)                                   SDCOS         STV
                                                                                                 SDCOS
  106      SWREF                     WING REFERENCE AREA              FT2          USER          SVELOC2
                                                                                                 SINIT
  162      SXMIN                     REAR BELT JOIN(NEG)AND LIMIT     FT           STV           STV
  164      SXMINUS                   CYCLE LIMIT                      FT           STV           STV
  161      SXPL                      REAR BELT JOIN(POS)AND LIMIT     FT           STV           STV
  163      SXPLUS                    CYCLE LIMIT                      FT           STV           STV
  166      SYMIN                     LIMIT FOR SIDEWAYS(NEGATIVE)     FT           STV           STV
  165      SYPL                      LIMIT FOR SIDEWAYS(POSITIVE)     FT           STV           STV
   88      TALPHA                    FREE STREAM STATIC TEMPERATURE   DEG. K       SVELOC2
   16      TANTHT                    TAN(THETAR)                                   SDCOS         SEULER
   81      TEMPR                     ATMOSPHERIC TEMP RATIO                        SATMOS        SVELOC2
                                                                                                 SINIT
   76      TEMPSL                    AMB TEMP AT SL(STANDARD DAY)     DEG. K       SINIT         SVELOC2
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                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                               10:45 MAR 13,'79                                PAGE 15

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                   UNITS      CALCULATED     USED
  NO.        NAME                                                                    IN          IN

                                                                                              SINIT

     6    THETAD                    PITCH ATTITUDE                  DEGREES      SDCOS

   216    THETADIC                  INITIAL VALUE OF THETA          DEGREES      SINIT         INITIAL

     5    THETAR                    PITCH ATTITUDE                  RADIANS      DER'TIVE      SDCOS

    30    THETDT                    ATTITUDE RATE,PITCH             RAD/SEC      SEULER        STV
                                                                                               DER'TIVE

    94    TIME                      TIME                            SEC          DER'TIVE

    89    TRATIO                    ADIABATIC STATIC/TOTAL TEMP                  SVELOC2       SVELOC2

   365    TVCON(1,1)                ARRAY OF CONSTANTS FOR TV BELT               STV           STV

   388    TVCON(8,3)                ARRAY OF CONSTANTS FOR TV BELT               STV           STV

    58    UB                        VEL COMP REL TO AIR,BODY AXES   FT/SEC       SVELOC1       SVELOC2
                                                                                               SALFBET

   235    USIG                      RMS OF TURBULENCE               FT/SEC       USER          SWIND

   184    USLOPE                    SLOPE OF UPPER BEAM             DEGREES      SILS          SILS

   232    UTURB                     COMPONENT OF TURBULENCE         FT/SEC       SWIND         SWIND

    59    VB                        VEL COMP REL TO AIR,BODY AXES   FT/SEC       SVELOC1       SVELOC2
```

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                                         SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                               10:45 MAR 13,'79                                PAGE 16

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                   UNITS      CALCULATED     USED
  NO.        NAME                                                                    IN          IN

                                                                                              SALFBET

   219    VD                        COMP. OF TRUE AIR SPEED(DOWN)   FT/SEC       SVELOC1       SVELOC1

   218    VE                        COMP. OF TRUE AIR SPEED(EAST)   FT/SEC       SVELOC1       SVELOC1

    69    VEAS                      EQUIVALENT AIR SPEED            FT/SEC       SVELOC2       SVELOC2

    70    VEASKT                    EQUIVALENT AIR SPEED            KNOTS        SVELOC2

    65    VK                        VELOCITY RELATIVE TO GROUND     FT/SEC       SPATH         SINIT
                                                                                               SPATH

    64    VKD                       VELOCITY REL TO GROUND,DOWN     FT/SEC       DER'TIVE      SVELOC1
                                                                                               SPATH
                                                                                               STV

   240    VKDDOT                    ACCELERATION IN EARTH AXES      FT/SEC2      SACCLIN       DER'TIVE

   213    VKDIC                     INIT GROUND SPEED COMP (DOWN)   FT/SEC       SINIT         INITIAL
                                                                                               SINIT

    63    VKE                       VELOCITY REL TO GROUND,EAST     FT/SEC       DER'TIVE      SVELOC1
                                                                                               SPATH
                                                                                               STV

   239    VKEDOT                    ACCELERATION IN EARTH AXES      FT/SEC2      SACCLIN       DER'TIVE

   212    VKEIC                     INIT GROUND SPEED COMP (EAST)   FT/SEC       SINIT         INITIAL
```

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                                   SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                              10:45 MAR 13,'79                                  PAGE 17

ELEMENT     FORTRAN    QUANTITY           DESCRIPTION                    UNITS      CALCULATED    USED
  NO.        NAME                                                                      IN          IN

                                                                                                 SINIT

   66      VKKT                   VELOCITY RELATIVE TO GROUND        KNOTS       SPATH

   52      VKN                    VELOCITY REL TO GROUND,NORTH       FT/SEC      DER'TIVE      SVELOC1
                                                                                               SPATH
                                                                                               STV

  238      VKNDOT                 ACCELERATION IN EARTH AXES         FT/SEC2     SACCLIN       DER'TIVE

  211      VKNIC                  INIT GROUND SPEED COMP (NORTH)     FT/SEC      SINIT         INITIAL
                                                                                               SINIT

  194      VKTIC                  INITIAL AIR SPEED                  KNOTS       ICFILE        SINIT
                                                                                               SWIND

  217      VN                     COMP. OF TRUE AIR SPEED(NORTH)     FT/SEC      SVELOC1       SVELOC1

  169      VSHIPKT                SHIP SPEED                         KT          USER          STV

  236      VSIG                   RMS OF TURBULENCE                  FT/SEC      USER          SWIND

   67      VT                     TOTAL AIR SPEED                    FT/SEC      SVELOC2       SINIT
                                                                                               SVELOC2

   68      VTKT                   TOTAL AIR SPEED                    KNOTS       SVELOC2

  233      VTURB                  COMPONENT OF TURBULENCE            FT/SEC      SWIND         SWIND
```

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                                   SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                              10:45 MAR 13,'79                                  PAGE 18

ELEMENT     FORTRAN    QUANTITY           DESCRIPTION                    UNITS      CALCULATED    USED
  NO.        NAME                                                                      IN          IN

   57      VWD                    VELOCITY OF WIND,DOWN              FT/SEC      SWIND         SVELOC1

  231      VWDL                   MEAN WIND COMP AT HEIGHT(DOWN)     FT/SEC      SWIND         SWIND

  223      VWDLO                  WIND VELOCITY(DOWN)AT HEIGHT       FT/SEC      SWIND         SWIND

   56      VWE                    VELOCITY OF WIND,EAST              FT/SEC      SWIND         SVELOC1

  230      VWEL                   MEAN WIND COMP AT HEIGHT(EAST)     FT/SEC      SWIND         SWIND

  227      VWELO                  WIND VELOCITY (EAST)AT HEIGHT      FT/SEC      SINIT         SWIND
                                                                                               SINIT

  202      VWKTO                  DATUM WIND SPEED                   KNOTS       ICFILE        SINIT

   55      VWN                    VELOCITY OF WIND,NORTH             FT/SEC      SWIND         SVELOC1

  229      VWNL                   MEAN WIND COMP AT HEIGHT(NTH)      FT/SEC      SWIND         SWIND

  226      VWNLO                  WIND VELOCITY (NORTH)AT HEIGHT     FT/SEC      SINIT         SWIND
                                                                                               SINIT

  198      W                      AIRCRAFT WEIGHT                    LB          ICFILE        SINIT
                                                                                               SACCBOD

   60      WB                     VEL COMP REL TO AIR,BODY AXES      FT/SEC      SVELOC1       SVELOC2
                                                                                               SALFBET
```

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                                      SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                            10:45 MAR 13,'79                              PAGE 19

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                   UNITS     CALCULATED     USED
  NO.        NAME                                                                   IN          IN

  237     WSIG                  RMS OF TURBULENCE                FT/SEC     USER         SWIND

  234     WTURB                 COMPONENT OF TURBULENCE          FT/SEC     SWIND        SWIND

  149     X                     X POSITION OF C.G.               FT         DER'TIVE     STV
                                                                                         SILS

  257     X1                    COORDINATES OF SLIP BALL (AY1)   FT         USER         SACCBOD

  260     X2                    COORDINATES OF G METER (AZ2)     FT         USER         SACCBOD

  263     X3                    COORD.  OF ACCELEROMETER (AX3)   FT         USER         SACCBOD

  266     X4                    COORD.  OF ACCELEROMETER (AY4)   FT         USER         SACCBOD

  269     X5                    COORD.  OF ACCELEROMETER (AZ5)   FT         USER         SACCBOD

  199     XCG                   X C.G. LOCATION IN AIRCRAFT                 ICFILE       SINIT

   99     XCUREF                X LOCATION OF REF PT                        USER         SINIT

  158     XDOTM                 RATE OF CHANGE OF A/C'S X POSN   FT/SEC     STV          DER'TIVE
                                                                                         STV

  168     XDTMX                 SLEW RATE                        FT/SEC     STV          STV

  165     XDTV                  X VELOCITY FOR TV                FT/SEC     STV
```

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                                      SYSTEM COMMON - REAL VARIABLES 15.3.78

ALPHABETIC ORDER                            10:45 MAR 13,'79                              PAGE 20

ELEMENT    FORTRAN    QUANTITY          DESCRIPTION                   UNITS     CALCULATED     USED
  NO.        NAME                                                                   IN          IN

  177     XGS                   GLIDE SLOPE ORIGIN               FT         SILS         SILS

  195     XIC                   INITIAL POSITION                 FT         ICFILE       SINIT
                                                                                         INITIAL
                                                                                         STV

  284     XICF                  EXTRA STORE FOR XIC              FT         STV          STV

  159     XINX                  CONTROL VAR FOR X INTEGRATION               STV          DER'TIVE

  160     XINY                  CONTROL VAR FOR Y INTEGRATION               STV          DER'TIVE

  200     XILSFLAG              ILSFLAG IN 'REAL' FORM                      ICFILE       INITIAL

  201     XISMR                 ISMR IN 'REAL' FORM                         ICFILE       INITIAL

   48     XIX                   MOMENT OF INERTIA,ROLL           SLUG FT2   USER         SINIT

   49     XIY                   MOMENT OF INERTIA,PITCH          SLUG FT2   USER         SINIT

   50     XIZ                   MOMENT OF INERTIA,YAW            SLUG FT2   USER         SINIT

   51     XIZX                  MOMENT OF INERTIA,PRODUCT        SLUG FT2   USER         SINIT

  144     XK2FPS                CONVERSION KNOTS TO FT/SEC       CONSTANT   SINIT        SWIND
                                                                                         STV
                                                                                         SINIT
```

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                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                         10:45 MAR 13,'79                               PAGE 21
 ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                 UNITS     CALCULATED     USED
   NO.        NAME                                                                  IN           IN

   180     XKINK                  POSITION OF BEAM KINK            FT         SILS          SILS
   131     XLLTOT                 TOTAL MOMENT,ROLL,BODY AXES      LB-FT      USER          SACCROT
   178     XLOC                   LOCALISER ORIGIN (X)             FT         SILS          SILS
   104     XLTAIL                 TAIL ARM FROM M.N.C.             FT         USER
    70     XMACH                  MACH NUMBER                                 SVELOC2       SVELOC2
     2     XMASS                  AIRCRAFT MASS                    SLUG       SINIT         SINIT
   132     XMMTOT                 TOTAL MOMENT,PITCH,BODY AXES     LB-FT      USER          SACCROT
   133     XNNTOT                 TOTAL MOMENT,YAW,BODY AXES       LB-FT      USER          SACCROT
   103     XP                     X LOC OF PILOT REL TO REFCG      FT         USER          STV
   280     XPCG                   XLOC OF PILOT REL TO CG                     STV           STV
                                                                                            SACCBOD
   152     XTV                    X POSITION FOR TV                FT         STV           STV
   150     Y                      Y POSITION OF C.G.               FT         DER'TIVE      STV
                                                                                            SILS
   258     Y1                     COORDINATES OF SLIP BALL (AY1)   FT         USER          SACCBOD
```

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                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                         10:45 MAR 13,'79                               PAGE 22
 ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                 UNITS     CALCULATED     USED
   NO.        NAME                                                                  IN           IN

   261     Y2                     COORDINATES OF G METER (AZ2)     FT         USER          SACCBOD
   264     Y3                     COORD.  OF ACCELEROMETER (AX3)   FT         USER          SACCBOD
   267     Y4                     COORD.  OF ACCELEROMETER (AY4)   FT         USER          SACCBOD
   270     Y5                     COORD.  OF ACCELEROMETER (AZ5)   FT         USER          SACCBOD
   401     YADC(1)                ARRAY OF UNSCALED INPUTS                    SADC          USER
   464     YADC(64)               ARRAY OF UNSCALED INPUTS                    SADC          USER
   156     YDTV                   Y VELOCITY FOR TV                FT/SEC     STV
   196     YIC                    INITIAL POSITION                 FT         ICFILE        INITIAL
   179     YLOC                   LOCALISER ORIGIN (Y)             FT         SILS          SILS
   153     YTV                    Y POSITION FOR TV                FT         STV           STV
   259     Z1                     COORDINATES OF SLIP BALL (AY1)   FT         USER          SACCBOD
   262     Z2                     COORDINATES OF G METER (AZ2)     FT         USER          SACCBOD
   265     Z3                     COORD.  OF ACCELEROMETER (AX3)   FT         USER          SACCBOD
   268     Z4                     COORD.  OF ACCELEROMETER (AY4)   FT         USER          SACCBOD
```

```
                                        SYSTEM COMMON - REAL VARIABLES 15.3.78
ALPHABETIC ORDER                               10:45 MAR 13,'79                              PAGE 23

ELEMENT    FORTRAN    QUANTITY              DESCRIPTION                UNITS     CALCULATED    USED
  NO.        NAME                                                                    IN          IN

  271     ZB                        COORD. OF ACCELEROMETER (AZB)  FT              USER        SACCBOD
   98     ZCG                       Z C.G. LOCATION                                USER        SINIT
  100     ZCGREF                    Z LOCATION OF REF PT                           USER        SINIT
  110     ZP                        Z LOC OF PILOT REL TO REFCG     FT             USER        STV
  281     ZPCG                      Z LOC OF PILOT REL TO CG                       STV         STV
                                                                                               SACCBOD
```

Appendix E

INDEX TO SYSTEM COMMON, INTEGER VARIABLES

E.1 Numeric order

```
                                              SYSTEM COMMON - INTEGER VARIABLES 16.03.78

NUMERIC ORDER                                  10:50 MAR 13,'79                              PAGE  1

ELEMENT    FORTRAN     QUANTITY              DESCRIPTION                 UNITS     CALCULATED      USED
  NO.       NAME                                                                       IN            IN

    1     KISA                      SELECT ATMOSPHERE VARIATION                    USER          SVELOC2
                                                                                                 SINIT

    2     NCPASS                    COUNT OF PASSES THRO DER'TIVE                  INITIAL       DER'TIVE
                                                                                                 SCOUNT

    3     NIPASS                    COUNT OF PASSES TO SUIT INTEG                  INITIAL       DER'TIVE

    4     ILSFLG                    SELECTS ILS BEAM(SEE XILSFLG)                  INITIAL       SILS

    5     ISHR                      WIND SHEAR SHAPE(SEE XISHR)                    INITIAL       SWIND
                                                                                                 SINIT

    6     ISYS                      UNIT NO FOR SYSTEM CHANGES                     USER          SYSCOM

    7     NTVS                      TV BELT SELECT                                 USER          STV

    8     JJCOMP                    INITIALISATION COMPLETE FLAG                   SCOUNT        SILS
                                                                                                 STV
                                                                                                 SWIND

    9     NUMD                      NO. OF DACS TO BE SET FROM 'A'                 USER          SDAC

   10     NUMV                      NO.OF VARIDACS BE SET FROM 'A'                 USER          SDAC

   11     NDAC(1)                   POINTER TO VARIABLE FOR DAC 1                  USER          SDAC

******** NOTE MISSING ELEMENT NUMBERS *****
```

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                                              SYSTEM COMMON - INTEGER VARIABLES 16.03.78

NUMERIC ORDER                                  10:50 MAR 13,'79                              PAGE  2

ELEMENT    FORTRAN     QUANTITY              DESCRIPTION                 UNITS     CALCULATED      USED
  NO.       NAME                                                                       IN            IN

******** NOTE MISSING ELEMENT NUMBERS *****

   74     NDAC(64)                  POINTER TO VARIABLE FOR DAC 64                 USER          SDAC

   75     KSADC                     VERSION ID - ROUTINE SADC                      SADC

   76     KSDAC                     VERSION ID - ROUTINE SDAC                      SDAC

   77     KDSCRT1                   VERSION ID - ROUTINE DSCRT1                    DSCRT1

   78     KDSCRT2                   VERSION ID - ROUTINE DSCRT2                    DSCRT2

   79     KISDSCR                   VERSION ID - ROUTINE ISDSCR                    ISDSCR

   80

   81     NADC(1)                   ARRAY OF ADC CHANNEL NUMBERS                   USER          SADC

******** NOTE MISSING ELEMENT NUMBERS *****

  144     NADC(64)                  ARRAY OF ADC CHANNEL NUMBERS                   USER          SADC

  145

  146

  147
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                                          SYSTEM COMMON - INTEGER VARIABLES 16.03.78
  NUMERIC ORDER                                  10:50 MAR 13,'79                       PAGE  3

   ELEMENT     FORTRAN    QUANTITY          DESCRIPTION               UNITS    CALCULATED    USED
     NO.        NAME                                                              IN          IN

     148    LSILS                    CONTROLS EXECUTION OF SILS                   USER        SILS

     149

     150    IAD4SL                   CONTROLS EXECUTION OF READSLR                USER        DSCRT1
                                                                                              DSCRT2

     151    ISLR(1)                  AD4 SENSE LINE 1                             READSLR     USER

******** NOTE MISSING ELEMENT NUMBERS *****

     166    ISLR(16)                 AD4 SENSE LINE 16                            READSLR     USER

     167    NG                       SCALE FACTOR IN NGUSTS                       USER        SWIND

     168    LSEED                    CONTROLS RANDOM NUMBER SEED                  USER        SWIND

     169    NRUN                     CURRENT RUN NO. FROM MAILBOX                 SCOUNT

     170    IAD4CL                   CONTROLS EXECUTION OF SETCLR                 USER        DSCRT1
                                                                                              DSCRT2

     171    ICLR(1)                  AD4 CONTROL LINE 1                           USER        SETCLR

******** NOTE MISSING ELEMENT NUMBERS *****

     186    ICLR(16)                 AD4 CONTROL LINE 16                          USER        SETCLR
```

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                                          SYSTEM COMMON - INTEGER VARIABLES 16.03.78
  NUMERIC ORDER                                  10:50 MAR 13,'79                       PAGE  4

   ELEMENT     FORTRAN    QUANTITY          DESCRIPTION               UNITS    CALCULATED    USED
     NO.        NAME                                                              IN          IN

     187

     188

     189

     190    IDSCFL                   CONTROLS EXECUTION OF READSCR                USER        DSCRT1
                                                                                              DSCRT2

     191    IP(1)                    PATCHABLE DISCRETE 1 TO SIGMA                READSCR     ISDSCR

******** NOTE MISSING ELEMENT NUMBERS *****

     222    IP(32)                   PATCHABLE DISCRETE 32 TO SIGMA               READSCR     ISDSCR

     223    IDS(1)                   DESK SWITCH 1 TO SIGMA                       READSCR     INITIAL
                                                                                              ISDSCR

******** NOTE MISSING ELEMENT NUMBERS *****

     254    IDS(32)                  DESK SWITCH 32 TO SIGMA                      READSCR     ISDSCR

     255    KSACCBOD                 VERSION ID - ROUTINE SACCBOD                 SACCBOD

     256    KSACCLIN                 VERSION ID - ROUTINE SACCLIN                 SACCLIN

     257    KSACCROT                 VERSION ID - ROUTINE SACCROT                 SACCROT
```

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                                          SYSTEM COMMON - INTEGER VARIABLES 16.03.78
NUMERIC ORDER                                  10:50 MAR 13,'79                          PAGE  5

 ELEMENT     FORTRAN     QUANTITY            DESCRIPTION                UNITS     CALCULATED     USED
   NO.        NAME                                                                    IN          IN

   258     KSALFBET                 VERSION ID - ROUTINE SALFBET                      SALFBET

   259     KSCOUNT                  VERSION ID - ROUTINE SCOUNT                       SCOUNT

   260     KSDCOS                   VERSION ID - ROUTINE SDCOS                        SDCOS

   261     KSEULER                  VERSION ID - ROUTINE SEULER                       SEULER

   262     KSILS                    VERSION ID - ROUTINE SILS                         SILS

   263     KSINIT                   VERSION ID - ROUTINE SINIT                        SINIT

   264     KSPATH                   VERSION ID - ROUTINE SPATH                        SPATH

   265     KSTV                     VERSION ID - ROUTINE STV                          STV

   266     KSVELOC1                 VERSION ID - ROUTINE SVELOC1                      SVELOC1

   267     KSVELOC2                 VERSION ID - ROUTINE SVELOC2                      SVELOC2

   268     KSWIND                   VERSION ID - ROUTINE SWIND                        SWIND

   269     KSYSCOM                  VERSION ID - ROUTINE SYSCOM                       SYSCOM

   270     IPCOFL                   CONTROLS EXECUTION OF SETDSCR                     USER          DSCRT1
                                                                                                    DSCRT2

   271     ICO(1)                   CHANGE OVER 1 OUT OF SIGMA                        USER          SETDSCR
```

```
                                          SYSTEM COMMON - INTEGER VARIABLES 16.03.78
NUMERIC ORDER                                  10:50 MAR 13,'79                          PAGE  6

 ELEMENT     FORTRAN     QUANTITY            DESCRIPTION                UNITS     CALCULATED     USED
   NO.        NAME                                                                    IN          IN

******** NOTE MISSING ELEMENT NUMBERS *****

   302     ICO(32)                  CHANGE OVER 32OUT OF SIGMA                        USER          SETDSCR

   303

   304

   305     L1DAC(1)                 DAC SOURCE POINTERS,LOOP1                         USER          SDACN

******** NOTE MISSING ELEMENT NUMBERS *****

   352     L1DAC(48)                DAC SOURCE POINTERS,LOOP1                         USER          SDACN

   353     L2DAC(1)                 DAC SOURCE POINTERS,LOOP2                         USER          SDACN

******** NOTE MISSING ELEMENT NUMBERS *****

   400     L2DAC(48)                DAC SOURCE POINTERS,LOOP2                         USER          SDACN
```

E.2 Alphabetic order

```
                                         SYSTEM COMMON - INTEGER VARIABLES 16.03.78

ALPHABETIC ORDER                              10:50 MAR 13,'79                          PAGE  1

ELEMENT   FORTRAN   QUANTITY          DESCRIPTION                UNITS   CALCULATED    USED
  NO.       NAME                                                              IN          IN


  170     IAD4CL               CONTROLS EXECUTION OF SETCLR                 USER        DSCRT1
                                                                                        DSCRT2

  150     IAD4SL               CONTROLS EXECUTION OF READSLR                USER        DSCRT1
                                                                                        DSCR[illegible]

  171     ICLR(1)              AD4 CONTROL LINE 1                           USER        SETCLR

  186     ICLR(16)             AD4 CONTROL LINE 16                          USER        SETCLR

  271     ICO(1)               CHANGE OVER 1 OUT OF SIGMA                   USER        SETDSCR

  302     ICO(32)              CHANGE OVER 32OUT OF SIGMA                   USER        SETDSCR

  223     IDS(1)               DESK SWITCH 1 TO SIGMA                       READSCR     INITIAL
                                                                                        ISDSCR

  254     IDS(32)              DESK SWITCH 32 TO SIGMA                      READSCR     ISDSCR

  190     IDSCFL               CONTROLS EXECUTION OF READSCR                USER        DSCRT1
                                                                                        DSCRT2

    4     ILSFLG               SELECTS ILS BEAM(SEE XILSFLG)                INITIAL     SILS

  191     IP(1)                PATCHABLE DISCRETE 1 TO SIGMA                READSCR     ISDSCR

  222     IP(32)               PATCHABLE DISCRETE 32 TO SIGMA               READSCR     ISDSCR
```

```
                                         SYSTEM COMMON - INTEGER VARIABLES 16.03.78

ALPHABETIC ORDER                              10:50 MAR 13,'79                          PAGE  2

ELEMENT   FORTRAN   QUANTITY          DESCRIPTION                UNITS   CALCULATED    USED
  NO.       NAME                                                              IN          IN


  270     IPCOFL               CONTROLS EXECUTION OF SETDSCR                USER        DSCRT1
                                                                                        DSCRT2

    5     ISHR                 WIND SHEAR SHAPE(SEE XISHR)                  INITIAL     SWIND
                                                                                        SINIT

  151     ISLR(1)              AD4 SENSE LINE 1                             READSLR     USER

  166     ISLR(16)             AD4 SENSE LINE 16                            READSLR     USER

    6     ISYS                 UNIT NO FOR SYSTEM CHANGES                   USER        SYSCOM

    8     JJCOMP               INITIALISATION COMPLETE FLAG                 SCOUNT      SILS
                                                                                        STV
                                                                                        SWIND

   77     KDSCRT1              VERSION ID - ROUTINE DSCRT1                  DSCRT1

   78     KDSCRT2              VERSION ID - ROUTINE DSCRT2                  DSCRT2

    1     KISA                 SELECT ATMOSPHERE VARIATION                  USER        SVELOC2
                                                                                        SINIT

   79     KISDSCR              VERSION ID - ROUTINE ISDSCR                  ISDSCR

  255     KSACCBOD             VERSION ID - ROUTINE SACCBOD                 SACCBOD

  256     KSACCLIN             VERSION ID - ROUTINE SACCLIN                 SACCLIN
```

```
                                            SYSTEM COMMON - INTEGER VARIABLES 16.03.78

ALPHABETIC ORDER                                  10:50 MAR 13,'79                          PAGE  3

ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                   UNITS    CALCULATED    USED
  NO.        NAME                                                                   IN          IN

  257     KSACCROT                 VERSION ID - ROUTINE SACCROT                  SACCROT

   75     KSADC                    VERSION ID - ROUTINE SADC                     SADC

  258     KSALFBET                 VERSION ID - ROUTINE SALFBET                  SALFBET

  259     KSCOUNT                  VERSION ID - ROUTINE SCOUNT                   SCOUNT

   76     KSDAC                    VERSION ID - ROUTINE SDAC                     SDAC

  260     KSDCOS                   VERSION ID - ROUTINE SDCOS                    SDCOS

  261     KSEULER                  VERSION ID - ROUTINE SEULER                   SEULER

  262     KSILS                    VERSION ID - ROUTINE SILS                     SILS

  263     KSINIT                   VERSION ID - ROUTINE SINIT                    SINIT

  264     KSPATH                   VERSION ID - ROUTINE SPATH                    SPATH

  265     KSTV                     VERSION ID - ROUTINE STV                      STV

  266     KSVELOC1                 VERSION ID - ROUTINE SVELOC1                  SVELOC1

  267     KSVELOC2                 VERSION ID - ROUTINE SVELOC2                  SVELOC2

  268     KSWIND                   VERSION ID - ROUTINE SWIND                    SWIND
```

```
                                            SYSTEM COMMON - INTEGER VARIABLES 16.03.78

ALPHABETIC ORDER                                  10:50 MAR 13,'79                          PAGE  4

ELEMENT    FORTRAN    QUANTITY           DESCRIPTION                   UNITS    CALCULATED    USED
  NO.        NAME                                                                   IN          IN

  269     KSYSCOM                  VERSION ID - ROUTINE SYSCOM                   SYSCOM

  305     L1DAC(1)                 DAC SOURCE POINTERS,LOOP1                     USER        SDACN

  352     L1DAC(48)                DAC SOURCE POINTERS,LOOP1                     USER        SDACN

  353     L2DAC(1)                 DAC SOURCE POINTERS,LOOP2                     USER        SDACN

  400     L2DAC(48)                DAC SOURCE POINTERS,LOOP2                     USER        SDACN

  168     LSEED                    CONTROLS RANDOM NUMBER SEED                   USER        SWIND

  148     LSILS                    CONTROLS EXECUTION OF SILS                    USER        SILS

   81     NADC(1)                  ARRAY OF ADC CHANNEL NUMBERS                  USER        SADC

  144     NADC(64)                 ARRAY OF ADC CHANNEL NUMBERS                  USER        SADC

    2     NCPASS                   COUNT OF PASSES THRO DER'TIVE                 INITIAL     DER'TIVE
                                                                                             SCOUNT

   11     NDAC(1)                  POINTER TO VARIABLE FOR DAC 1                 USER        SDAC

   74     NDAC(64)                 POINTER TO VARIABLE FOR DAC 64                USER        SDAC

  167     NG                       SCALE FACTOR IN NGUSTS                        USER        SWIND

    3     NIPASS                   COUNT OF PASSES TO SUIT INTEG                 INITIAL     DER'TIVE
```

```
                                              SYSTEM COMMON - INTEGER VARIABLES 16.03.78
ALPHABETIC ORDER                                    10:50 MAR 13,'79                                  PAGE  5
ELEMENT     FORTRAN     QUANTITY            DESCRIPTION                    UNITS    CALCULATED    USED
  NO.         NAME                                                                      IN         IN

  169     NRUN                         CURRENT RUN NO. FROM MAILBOX                  SCOUNT
    7     NTVB                         TV BELT SELECT                                USER         STV
    9     NUMD                         NO. OF DACS TO BE SET FROM 'A'                USER         SDAC
   10     NUMV                         NO.OF VARIDACS BE SET FROM 'A'                USER         SDAC
```

Appendix F

DESCRIPTION OF PROGRAM COMMLIST

F.1 Introduction

The program COMMLIST produces an index to the variable names used in a large labelled COMMON area. A data record is prepared on cards for each variable name, giving a brief definition of the variable, its units and where it is calculated and used. A collection of such cards (which may be held on a disc file) may be sorted according to a number of criteria, of which the most important are alphabetic order of name and numeric order of element number.

For simulator purposes, two large COMMON areas are in current use, one defining system variables which are the same from simulation to simulation, *eg* height, speed and the other defining user variables which are entirely specific to the particular aircraft being simulated.

F.2 Input data

F.2.1 Main data record

Column	Purpose	Length
1 - 4	Element number	4 digits
5 - 16	Variable name	12 characters
18 - 47	Description	30 characters
49 - 58	Units	10 characters
60 - 67	Name of routine in which variable is calculated	8 characters
69 - 76	Name of routine in which variable is used	8 characters
78	Continuation indicator blank = no continuation C = continuation .	1 character

In general, no field delimiters are required. However, it may help human reading of data cards to insert a comma between fields. This is allowed, but is optional. The element number should be right justified in its field. A minimum of 2 data cards must be input.

F.2.2 Continuation cards

If the continuation indicator is set (C in column 78), the next card is read for additional 'used in' subroutine names. The format of this continuation card is up to 8 fields of 8 characters, separated by commas, a blank field signifying the end of the list of subroutine names and a field containing Cbbbbbbb signifying continuation on the next card.

F.3 Complete job deck

F.3.1 Original data on cards

```
!JOB SIM,BARRY LIST COMMON VARIABLES
!ATTEND
!COMMLIST
      Title card
      Selection card
      Data cards
!EOD
!FIN
```

F.3.2 Original data on disc file

It is assumed data cards have been copied to a file by :COPY

```
!JOB SIM,BARRY LIST COMMON VARIABLES
!ATTEND
!ASSIGN (F:100,DC,RCOMMON)
!COMMLIST
      Title card
      Selection card
      Additional data cards (optional)
!EOD
!FIN
```

F.3.3 Remarks

Note, in example section F.3.2 above, that although the main input file is taken to be a disc file, data can still be read from the card reader in the same run. This enables additional data cards to be added to and merged with the main file, thus avoiding the need to recreate the main file for every small change in data.

Note also that if original data is on cards only, as in example section F.3.1, device 100 does *not* need to be assigned to the card reader.

!EOD is essential.

F.3.4 Title card

The 80 characters on this card are printed out as a heading on each page of the output listing exactly as they appear on the card. This enables the user to identify the nature of the information being listed. If the contents of the title card are centred on the card, they will be centred on the listing page.

F.3.5 Selection of listing options

Options are specified on a selection card, containing up to 20 words of 4 characters. The options are

Abbb	Alphabetic order of variable name
Dbbb	Data listed as stored
Nbbb	Numeric order according to element number
CbbbSSSSSSSS	Lists all variables calculated in subroutine SSSSSSSS
UbbbSSSSSSSS	Lists all variables used in subroutine SSSSSSSS
Xbbb	Read next card for additional instructions.

The blanks (b = blank) are essential. There are no field separators.

As many options as desired may be specified. If they will not fit on one selection card, continuation is indicated by the X option.

F.4 Output listings

The output listing reproduces the input information spaced out for better legibility. An extra column labelled 'quantity' is left blank for the insertion of mathematical symbols associated with the variable.

For the alphabetical option, all blank records (*ie* those with only an element number) are ignored and not printed.

For the numeric option, a warning message is output when an unused element number is encountered.

For options C and U the 'calculated in' or 'used in' columns are omitted, as appropriate.

In the early stages of building a COMMON list, it is worth including data cards containing only an element number. These will be listed by the numeric option and enable details of new variables to be written in on the listing.

Appendices D, E, G and H were produced by the COMMLIST program.

F.5 Arrays

It is recommended that the first and last elements of an array are included as data items, in order to make it clear in the listings which items in the complete list are genuinely unused. COMMLIST will handle arrays of more than one dimension, provided that an element, *eg* X(12,10) can be fitted into the allowable 12 characters. If this recommendation is adopted, the user will find the warning message 'NOTE MISSING ELEMENT NUMBERS' interspersed between the first and last elements in the numeric order listing.

F.6 Operational considerations

F.6.1 Devices used

DCB	Device	Purpose
100	defaults to card reader	data file
101	console TTY	opening message (!!COMMLIST)
105	card reader	title card
105	card reader	selection (control) cards
105	card reader	extra data
108	line printer	all listings

F.6.2 Messages

F.6.2.1 !!COMMLIST

This message on the console teletype announces the start of execution of COMMLIST.

F.6.2.2 *** NOTE MISSING ELEMENT NUMBERS ***

This is a warning message to draw attention to gaps in the sequence of element numbers.

F.6.2.3 COMMLIST ABORTED - TOO MANY INPUT RECORDS

This message is output on the teletype when too many input records have been read. It is repeated on device 108, supplemented by the last record read.

F.7 Limits on data

This program uses many (23) arrays to hold the input information. These arrays are dimensioned at present to cater for 500 input data cards. However, since the DO loops are in the range 1 to 1000, the number of input data cards could be increased to 1000 by altering the DIMENSION statements in the program and by increasing JMAX, the limit on the number of records read. Any increase will greatly enlarge the core store needed to run the program, so should not be made unless really necessary. This present limit of 500 applies, of course, to individual variable names, so the program will cope with a user array of 2000 or more locations if many constituents are themselves large arrays, for which it is adequate to include only the first and last elements, as already discussed.

F.8 Location of system COMMON

The raw data for system COMMON variables are held in files on the DC area of the disc. Real variables are in file DC, RCOMMON and integer variables in file DC, ICOMMON. An index listing may therefore be made at any time using the technique of section F.3.2, with the job card

```
!ASSIGN (F:100,DC,RCOMMON)
```

or

```
!ASSIGN (F:100,DC,ICOMMON)
```

included as required.

Appendix G

INDEX TO SYSTEM DATA TO BE PROVIDED BY THE USER, REAL VARIABLES

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78
CALCULATED IN USER                                10:45 MAR 13,'79                           PAGE  1

ELEMENT      FORTRAN      QUANTITY          DESCRIPTION                 UNITS                USED
  NO.         NAME                                                                            IN

   48      XIX                           MOMENT OF INERTIA,ROLL        SLUG FT2             SINIT

   49      XIY                           MOMENT OF INERTIA,PITCH       SLUG FT2             SINIT

   50      XIZ                           MOMENT OF INERTIA,YAW         SLUG FT2             SINIT

   51      XIZX                          MOMENT OF INERTIA,PRODUCT     SLUG FT2             SINIT

   91      DELT1                         INTEG. STEP LENGTH NO. 1      SECS                 INITIAL

   92      FRAMET1                       FRAME TIME,LOOP 1             MSEC                 INITIAL
                                                                                            SWIND

   95      DELT2                         INTEG. STEP LENGTH NO. 2      SECS                 INITIAL

   96      FRAMET2                       FRAME TIME,LOOP 2             MSEC                 INITIAL

   98      ZCG                           Z C.G. LOCATION                                    SINIT

   99      XCGREF                        X LOCATION OF REF PT                               SINIT

  100      ZCGREF                        Z LOCATION OF REF PT                               SINIT

  103      SPAN                          WING SPAN                     FT                   SVELOC2
                                                                                            SINIT

  104      XLTAIL                        TAIL ARM FROM M.R.C.          FT
```

```
                                              SYSTEM COMMON - REAL VARIABLES 15.3.78
CALCULATED IN USER                                10:45 MAR 13,'79                           PAGE  2

ELEMENT      FORTRAN      QUANTITY          DESCRIPTION                 UNITS                USED
  NO.         NAME                                                                            IN

  105      STAIL                         TAIL PLANE AREA               FT2

  106      SWREF                         WING REFERENCE AREA           FT2                  SVELOC2
                                                                                            SINIT

  107      CREF                          REFERENCE CHORD               FT                   SVELOC2
                                                                                            STV

  109      XP                            X LOC OF PILOT REL TO REFCG   FT                   STV

  110      ZP                            Z LOC OF PILOT REL TO REFCG   FT                   STV

  131      XLLTOT                        TOTAL MOMENT,ROLL,BODY AXES   LB-FT                SACCROT

  132      XMMTOT                        TOTAL MOMENT,PITCH,BODY AXES  LB-FT                SACCROT

  133      XNNTOT                        TOTAL MOMENT,YAW,BODY AXES    LB-FT                SACCROT

  134      FTX                           TOTAL FORCE COMP. IN BODY AXES LB                  SACCLIN
                                                                                            SACCBOD

  135      FTY                           TOTAL FORCE COMP. IN BODY AXES LB                  SACCLIN
                                                                                            SACCBOD

  136      FTZ                           TOTAL FORCE COMP. IN BODY AXES LB                  SACCLIN
                                                                                            SACCBOD

  169      VSHIPKT                       SHIP SPEED                    KT                   STV
```

```
                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
 CALCULATED IN USER                                 10:45 MAR 13,'79                           PAGE  3
  ELEMENT     FORTRAN     QUANTITY          DESCRIPTION                       UNITS                 USED
    NO.         NAME                                                                                 IN

    235     USIG                        RMS OF TURBULENCE              FT/SEC                  SWIND
    236     VSIG                        RMS OF TURBULENCE              FT/SEC                  SWIND
    237     WSIG                        RMS OF TURBULENCE              FT/SEC                  SWIND
    257     X1                          COORDINATES OF SLIP BALL (AY1)  FT                     SACCBOD
    258     Y1                          COORDINATES OF SLIP BALL (AY1)  FT                     SACCBOD
    259     Z1                          COORDINATES OF SLIP BALL (AY1)  FT                     SACCBOD
    260     X2                          COORDINATES OF G METER (AZ2)    FT                     SACCBOD
    261     Y2                          COORDINATES OF G METER (AZ2)    FT                     SACCBOD
    262     Z2                          COORDINATES OF G METER (AZ2)    FT                     SACCBOD
    263     X3                          COORD.  OF ACCELEROMETER (AX3)  FT                     SACCBOD
    264     Y3                          COORD.  OF ACCELEROMETER (AX3)  FT                     SACCBOD
    265     Z3                          COORD.  OF ACCELEROMETER (AX3)  FT                     SACCBOD
    266     X4                          COORD.  OF ACCELEROMETER (AY4)  FT                     SACCBOD
    267     Y4                          COORD.  OF ACCELEROMETER (AY4)  FT                     SACCBOD
```

```
                                                    SYSTEM COMMON - REAL VARIABLES 15.3.78
 CALCULATED IN USER                                 10:45 MAR 13,'79                           PAGE  4
  ELEMENT     FORTRAN     QUANTITY          DESCRIPTION                       UNITS                 USED
    NO.         NAME                                                                                 IN

    268     Z4                          COORD.  OF ACCELEROMETER (AY4)  FT                     SACCBOD
    269     X5                          COORD.  OF ACCELEROMETER (AZ5)  FT                     SACCBOD
    270     Y5                          COORD.  OF ACCELEROMETER (AZ5)  FT                     SACCBOD
    271     Z5                          COORD.  OF ACCELEROMETER (AZ5)  FT                     SACCBOD
    278     SFRACG                      INTERMITTENCY FOR TURBULENCE                           SWIND
    279     SRDECAY                     DECAY FACTOR FOR TURBULENCE                            SWIND
    301     AADC(1)                     ARRAY OF SCALING FACTORS                               SADC
    364     AADC(64)                    ARRAY OF SCALING FACTORS                               SADC
    501     ADAC(1)                     ARRAY OF SCALING FACTORS                               SDAC
    564     ADAC(64)                    ARRAY OF SCALING FACTORS                               SDAC
*STOP* 0
IFIN
```

Appendix H

INDEX TO SYSTEM DATA TO BE PROVIDED BY THE USER, INTEGER VARIABLES

```
                                                        SYSTEM COMMON - INTEGER VARIABLES 16.03.78

CALCULATED IN USER                                      10:50 MAR 13,'79                              PAGE  1

ELEMENT     FORTRAN    QUANTITY            DESCRIPTION                  UNITS                  USED
  NO.        NAME                                                                               IN

    1     KISA                      SELECT ATMOSPHERE VARIATION                                SVELOC2
                                                                                               SINIT

    6     ISYS                      UNIT NO FOR SYSTEM CHANGES                                 SYSCOM

    7     NTVS                      TV BELT SELECT                                             STV

    9     NUMD                      NO. OF DACS TO BE SET FROM 'A'                             SDAC

   10     NUMV                      NO.OF VARIDACS BE SET FROM 'A'                             SDAC

   11     NDAC(1)                   POINTER TO VARIABLE FOR DAC 1                              SDAC

   74     NDAC(64)                  POINTER TO VARIABLE FOR DAC 64                             SDAC

   81     NADC(1)                   ARRAY OF ADC CHANNEL NUMBERS                               SADC

  144     NADC(64)                  ARRAY OF ADC CHANNEL NUMBERS                               SADC

  148     LSILS                     CONTROLS EXECUTION OF SILS                                 SILS

  150     IAD4SL                    CONTROLS EXECUTION OF READSLR                              DSCRT1
                                                                                               DSCRT2

  167     NG                        SCALE FACTOR IN NGUSTS                                     SWIND

  168     LSEED                     CONTROLS RANDOM NUMBER SEED                                SWIND
```

```
                                                        SYSTEM COMMON - INTEGER VARIABLES 16.03.78

CALCULATED IN USER                                      10:50 MAR 13,'79                              PAGE  2

ELEMENT     FORTRAN    QUANTITY            DESCRIPTION                  UNITS                  USED
  NO.        NAME                                                                               IN

  170     IAD4CL                    CONTROLS EXECUTION OF SETCLR                               DSCRT1
                                                                                               DSCRT2

  171     ICLR(1)                   AD4 CONTROL LINE 1                                         SETCLR

  186     ICLR(16)                  AD4 CONTROL LINE 16                                        SETCLR

  190     IDSCFL                    CONTROLS EXECUTION OF READSCR                              DSCRT1
                                                                                               DSCRT2

  270     IPCOFL                    CONTROLS EXECUTION OF SETDSCR                              DSCRT1
                                                                                               DSCRT2

  271     ICO(1)                    CHANGE OVER 1 OUT OF SIGMA                                 SETDSCR

  302     ICO(32)                   CHANGE OVER 32OUT OF SIGMA                                 SETDSCR

  305     L1DAC(1)                  DAC SOURCE POINTERS,LOOP1                                  SDACN

  352     L1DAC(48)                 DAC SOURCE POINTERS,LOOP1                                  SDACN

  353     L2DAC(1)                  DAC SOURCE POINTERS,LOOP2                                  SDACN

  400     L2DAC(48)                 DAC SOURCE POINTERS,LOOP2                                  SDACN
*STOP* 0
IFIN
```

LIST OF SYMBOLS

a	speed of sound
a_x, a_y, a_z	accelerations along x, y, z body axes
b	reference wing span
$\bar{c}$	mean chord
c_{ref}	reference chord
CI_1 etc	inertia constants
f	shear factor
F_{TN}, F_{TE}, F_{TD}	applied forces in earth axes
F_{TX}, F_{TY}, F_{TZ}	applied forces in body axes
g	acceleration due to gravity
h	height of centre of gravity
I_x, I_y, I_z, I_{zx}	moments of inertia
L, M, N	total moments
M	Mach number
$\ell_1, \ell_2, \ell_3, m_1, n_1$, etc	direction cosines
m	aircraft mass
P	atmospheric pressure
p, q, r	angular velocity components
R_{hp}	vertical distance of pilot's eye above centre of gravity
R_{xp}	horizontal distance of pilot's eye from centre of gravity
S_{ij}	direction cosines ($S_{11} = \ell_1$ etc)
S	transformation matrix
S_W	reference wing area
T	atmospheric temperature
u, v, w	velocity components
V	equivalent airspeed
V_K	ground speed
V_T	true airspeed
V_N, V_E, V_D	components of airspeed in earth axes (north, east, down)
V_{KN}, V_{KE}, V_{KD}	components of velocity relative to earth
V_{WN}, V_{WE}, V_{WD}	components of total wind velocity relative to earth
$V_{WNL0}, V_{WEL0}, V_{WDL0}$	components of datum mean wind speed in earth axes
V_{WKT0}	datum mean wind speed
$V_{WNL}, V_{WEL}, V_{WDL}$	components of mean wind speed at height
W	aircraft weight
X	force along x-axis
x, y, z	positional coordinates

LIST OF SYMBOLS (concluded)

x_p, z_p	coordinates of pilot's eye point, relative to reference centre of gravity
x_{pcg}, z_{pcg}	coordinates of pilot's eye point, relative to actual centre of gravity
$\Delta x_{cg}, \Delta z_{cg}$	centre of gravity displacements from reference position
α	angle of attack
β	angle of sideslip
γ	climb angle
θ	pitch attitude
ρ	air density
σ	atmospheric density ratio
ϕ	bank angle
χ	track angle
ψ	heading angle
ψ_W	wind direction

Suffices

a	absolute
B	body axes
cg	at, or of, the centre of gravity
G	gusts
L	at arbitrary location
p	pilot
r	ratio
SIG	rms
SL	sea level
T	turbulence
TV	television (for outside world display)
α	ambient

A dot over a variable denotes differentiation with respect to time.

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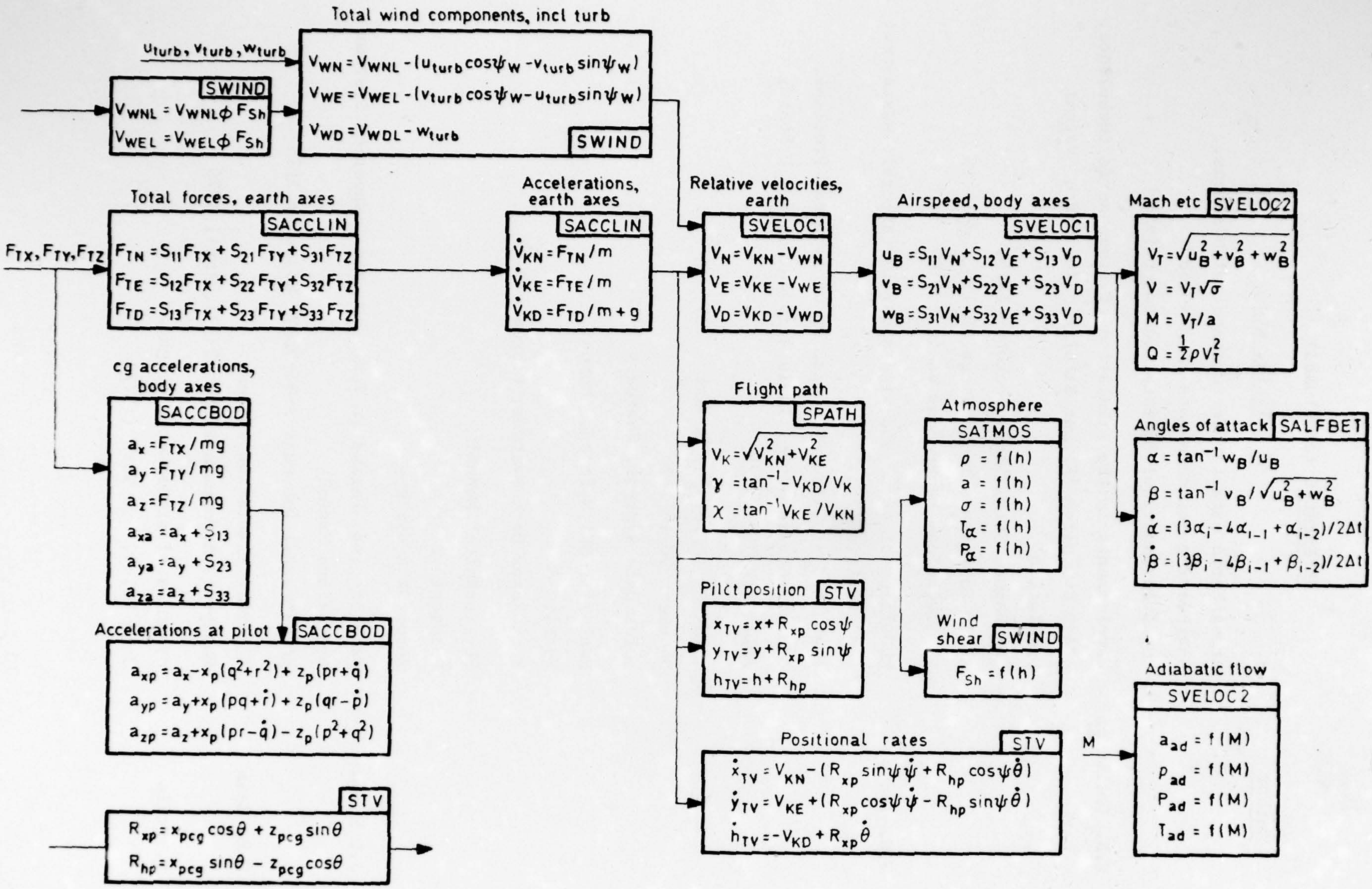


Fig 1 Block diagram of translational equations

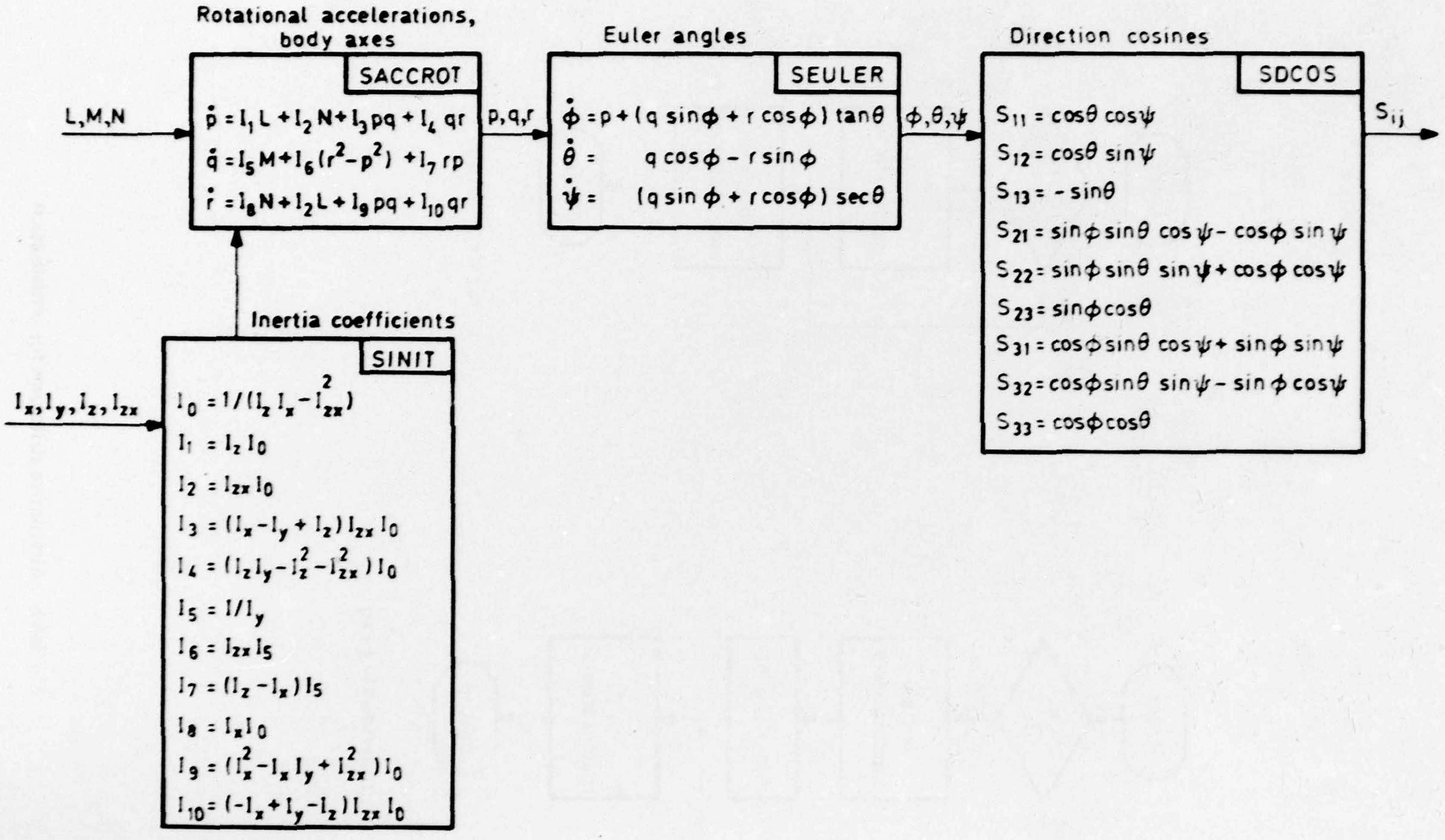
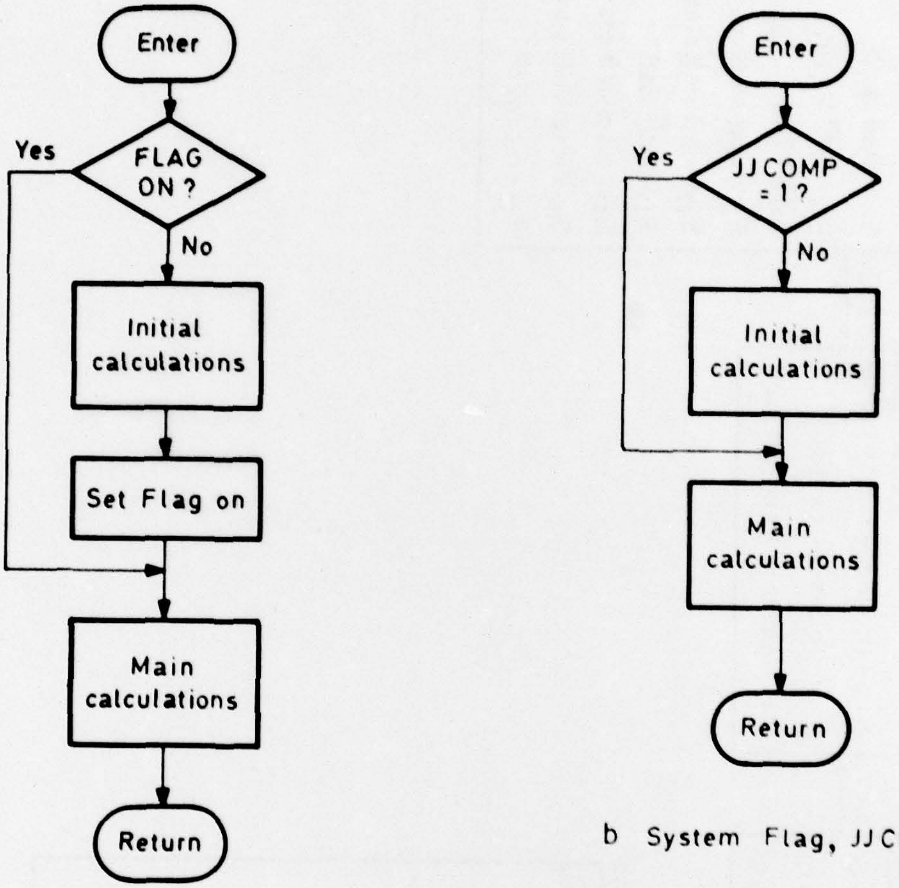


Fig 2 Block diagram of rotational equations



b System Flag, JJCOMP

a Individual Flag

Fig 3a&b Alternative structures for initialisation

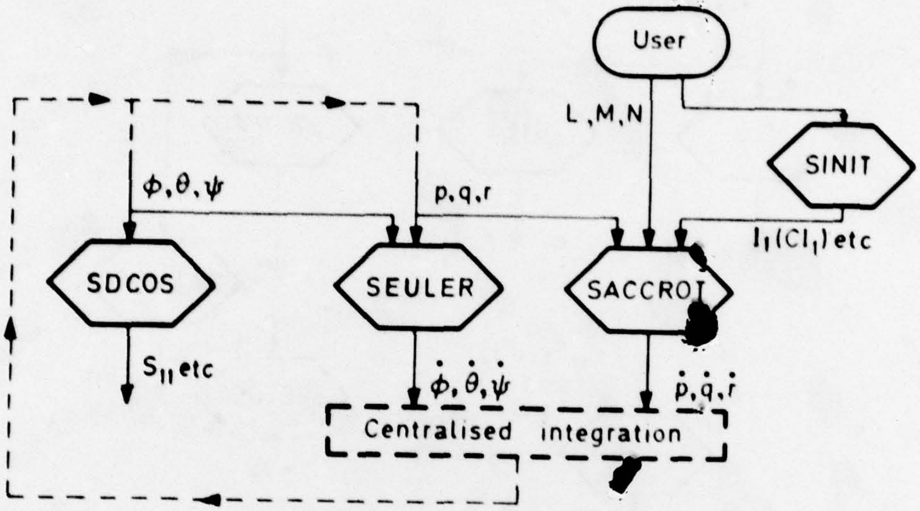


Fig 4 Information flow – rotational motion

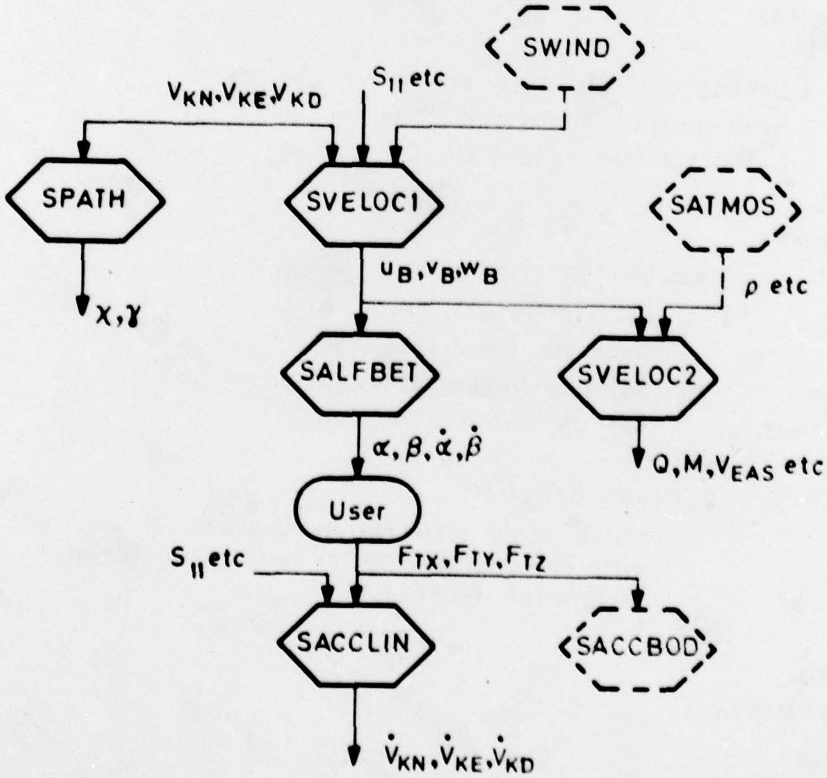


Fig 5 Information flow – translational motion

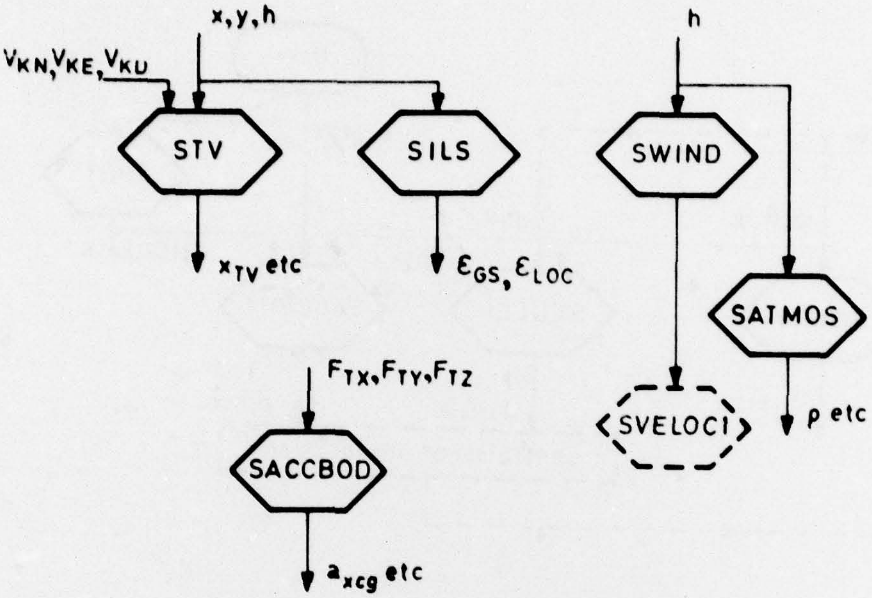
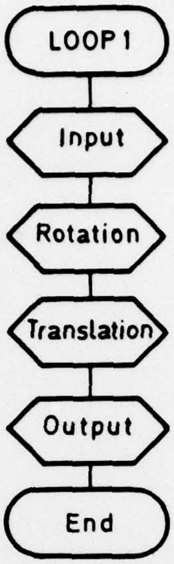


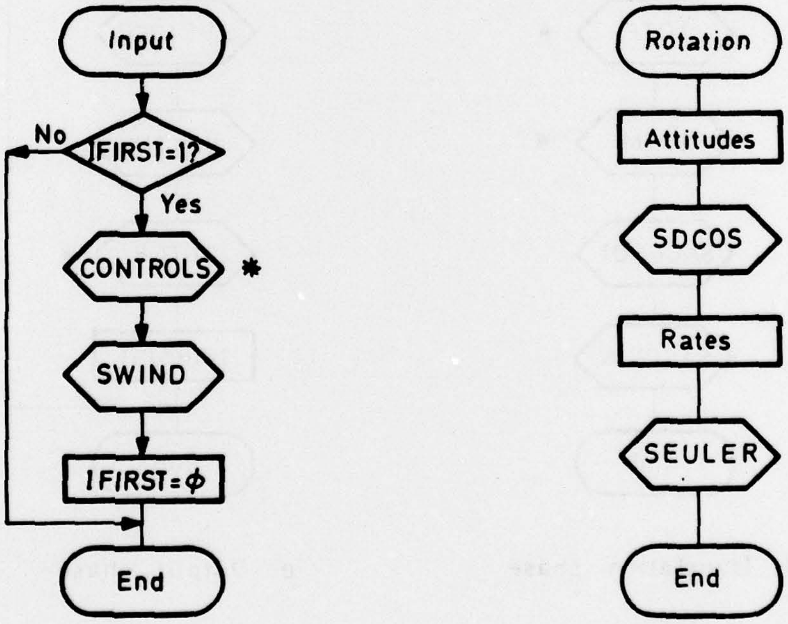
Fig 6 Information flow – utilities

```
PROGRAM
INITIAL
        Set up aircraft data etc
        Read initial conditions
        Calculate consequential ICs
END
DYNAMIC
             DERIVATIVE LOOP 1
                   Receive inputs from ADC
                   Generate functions
                   Solve differential equations
                   Set up outputs for DAC
             END
             DERIVATIVE LOOP 2
                   Solve other differential equations at a
                   different frame rate or with a different
                   integration technique
             END
END
TERMINAL
END
END
```

Fig 7 SL1 model program structure



a Phases of calculation



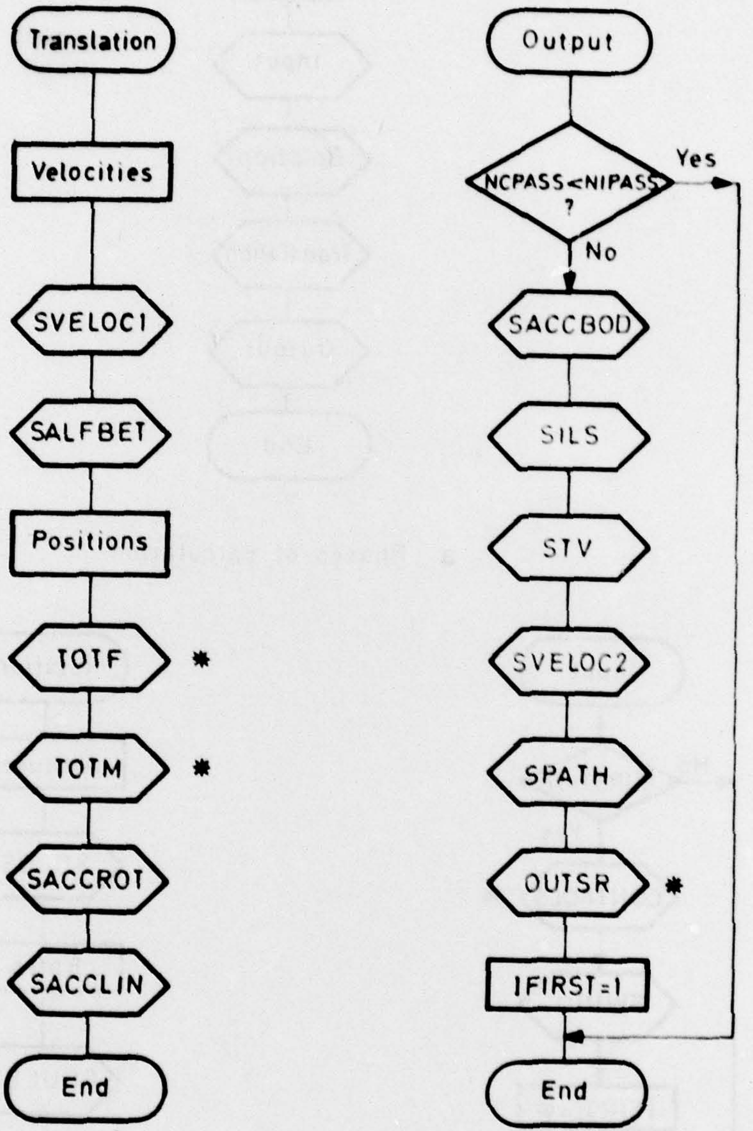
b Input phase

c Rotation phase

* Indicates routine to be supplied by User

Fig 8a-c Execution sequence, single loop

Fig 8d&e



d Translation phase

e Output phase

* Indicates routine to be supplied by User

Fig 8d&e Execution sequence, single loop

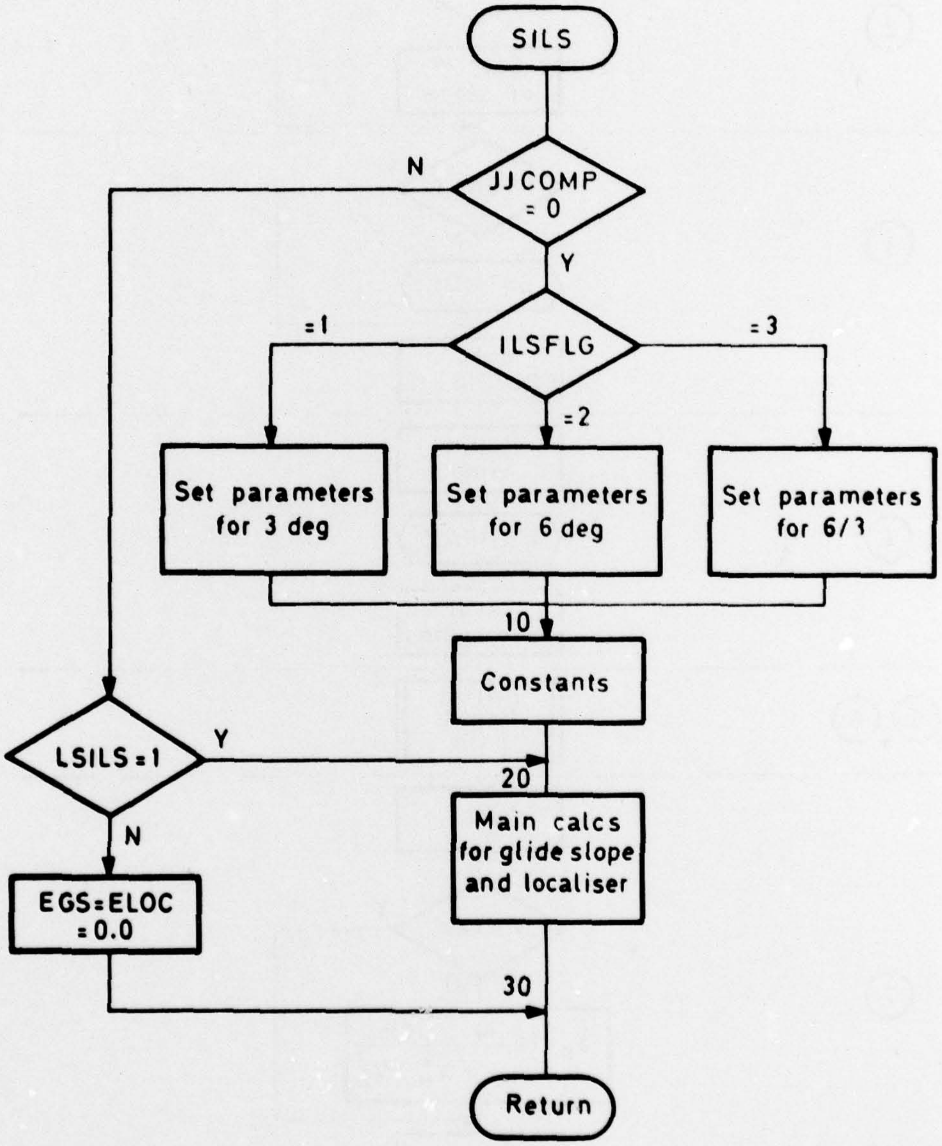


Fig A1 Flow diagram for SILS subroutine

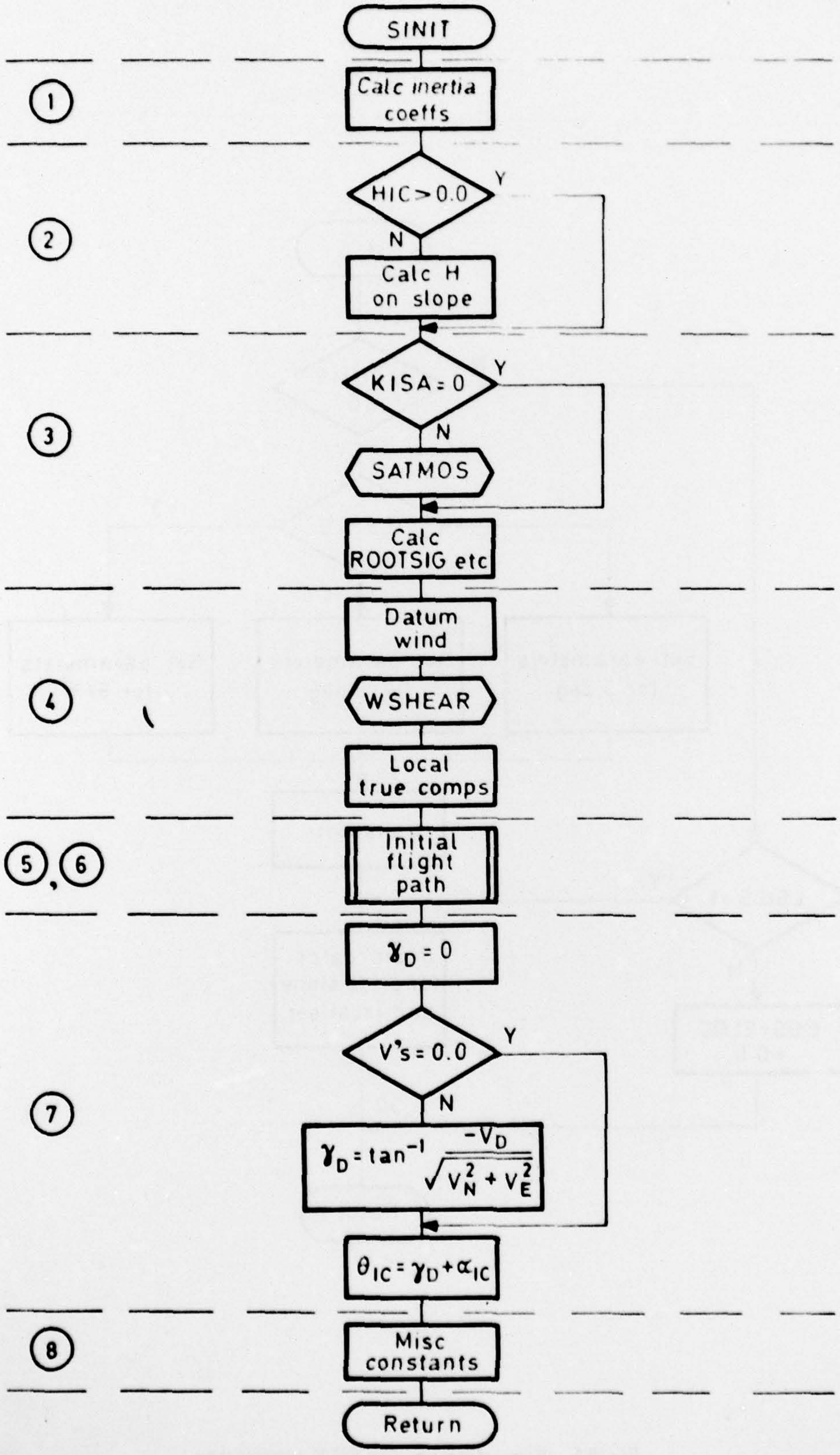


Fig A2 Flow diagram for SINIT subroutine

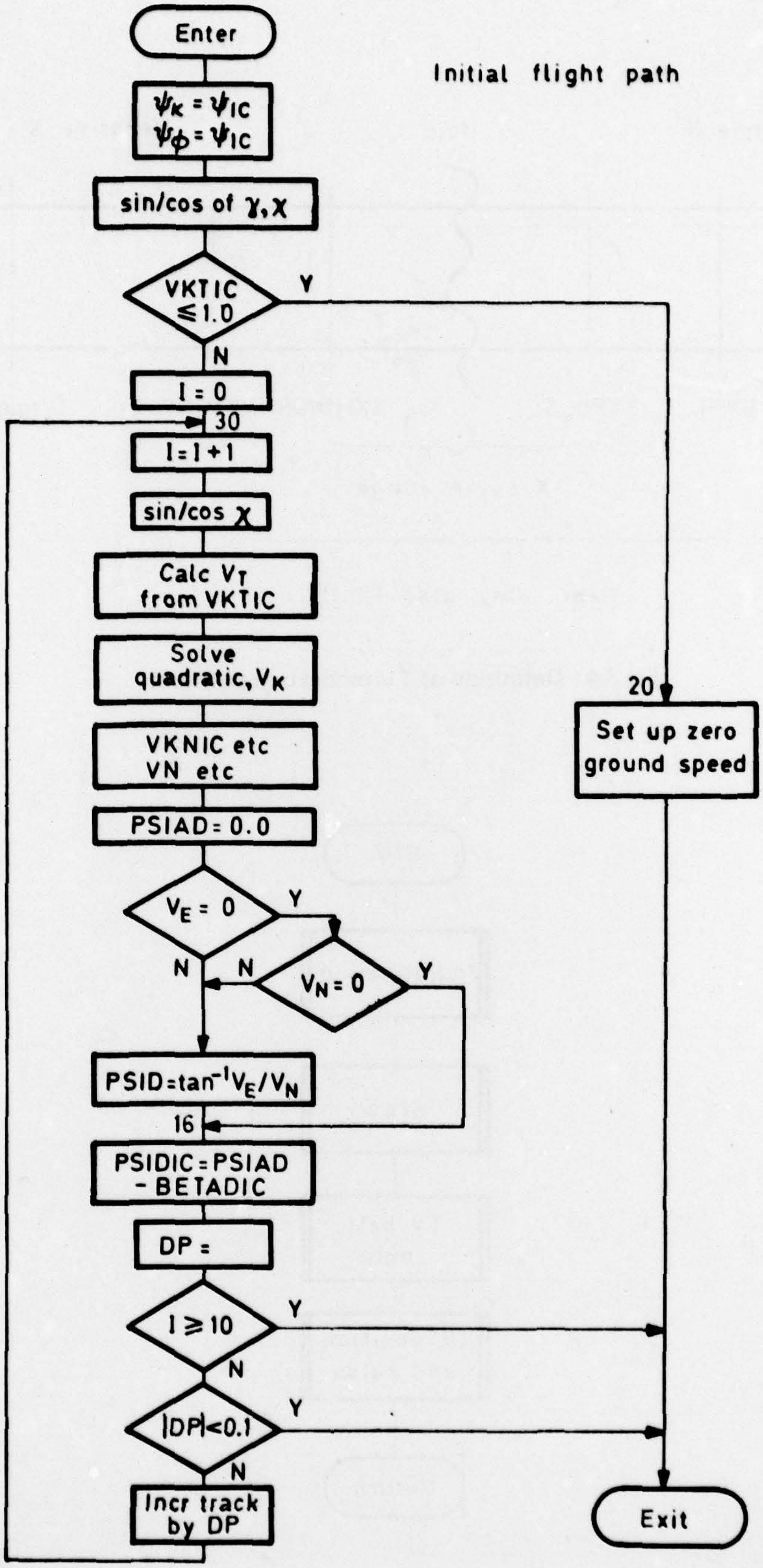


Fig A3 Flow diagram for 'initial flight path' phase of SINIT

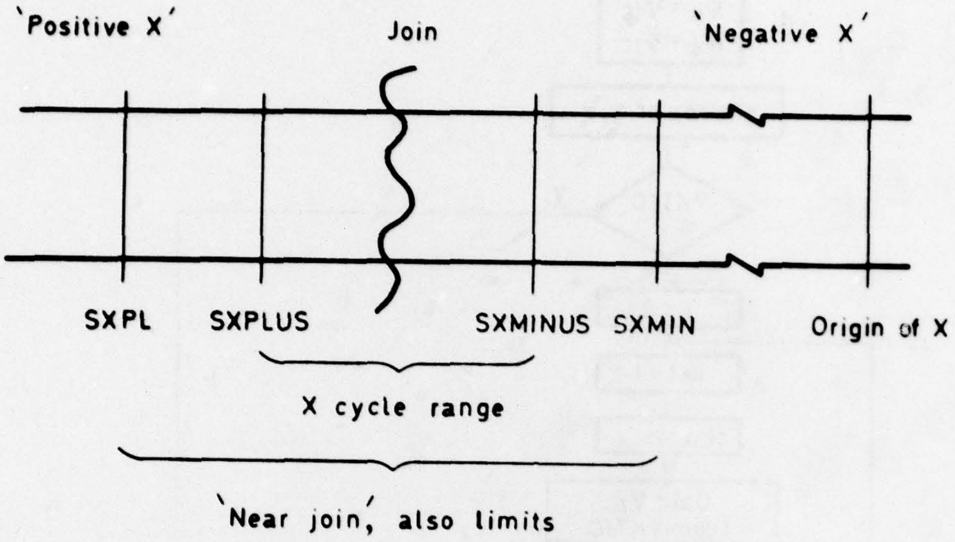


Fig A4 Definition of TV model belt positions

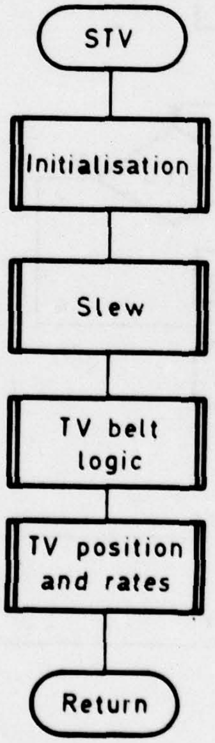


Fig A5 Overall flow diagram of STV subroutine

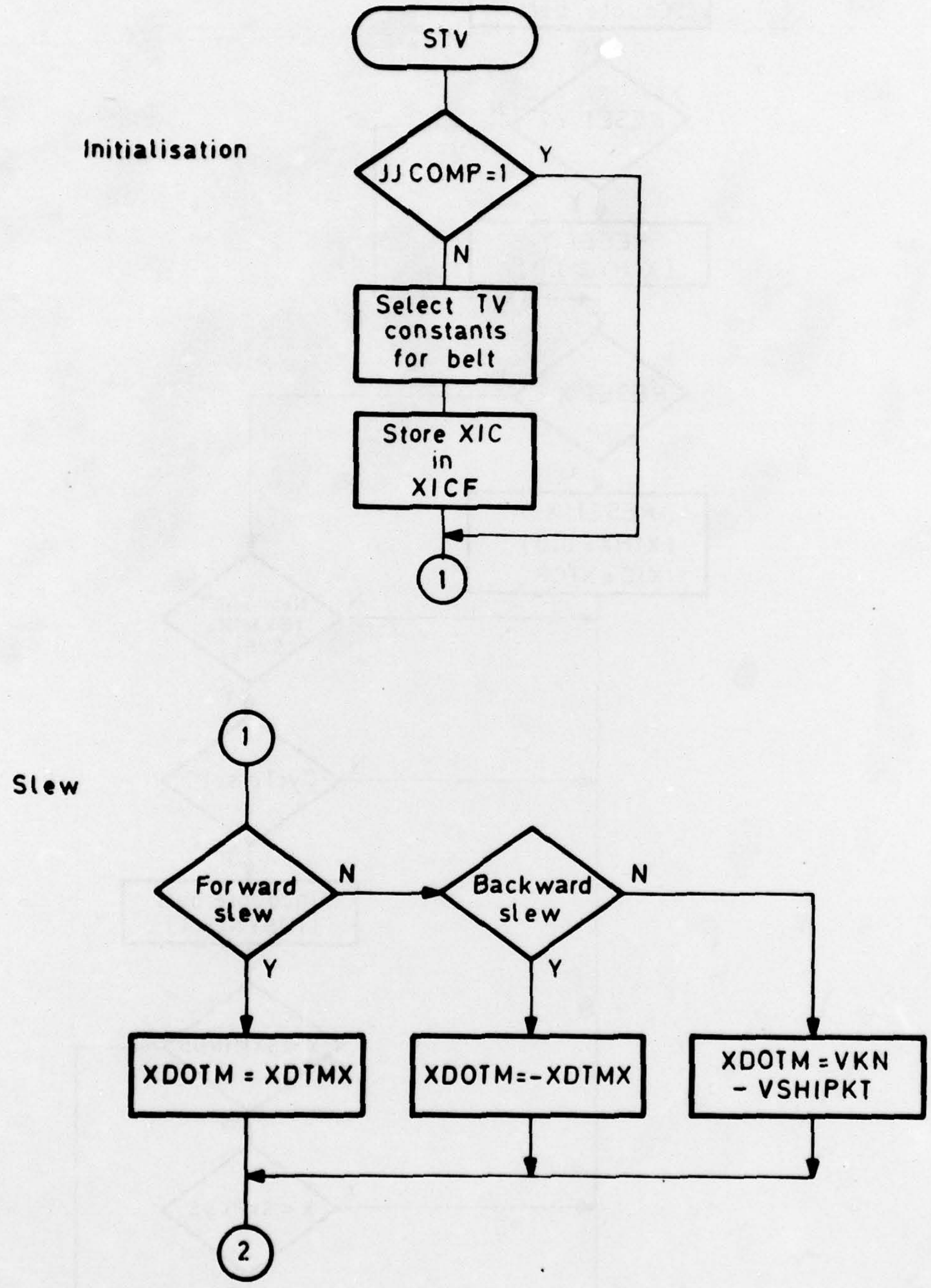


Fig A6 Flow diagrams of 'initialisation' and 'slew' phase of STV subroutine

Fig A7

TV belt logic

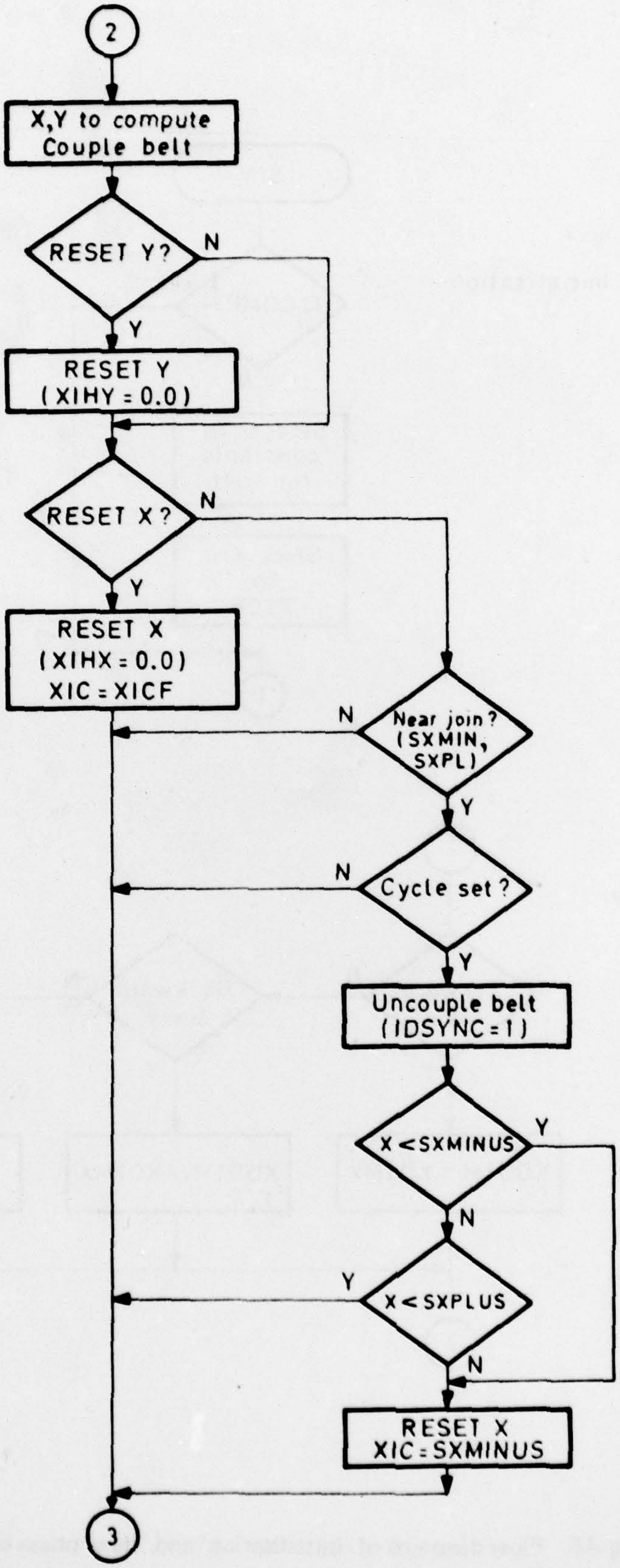


Fig A7 Flow diagram of TV belt logic in STV subroutine

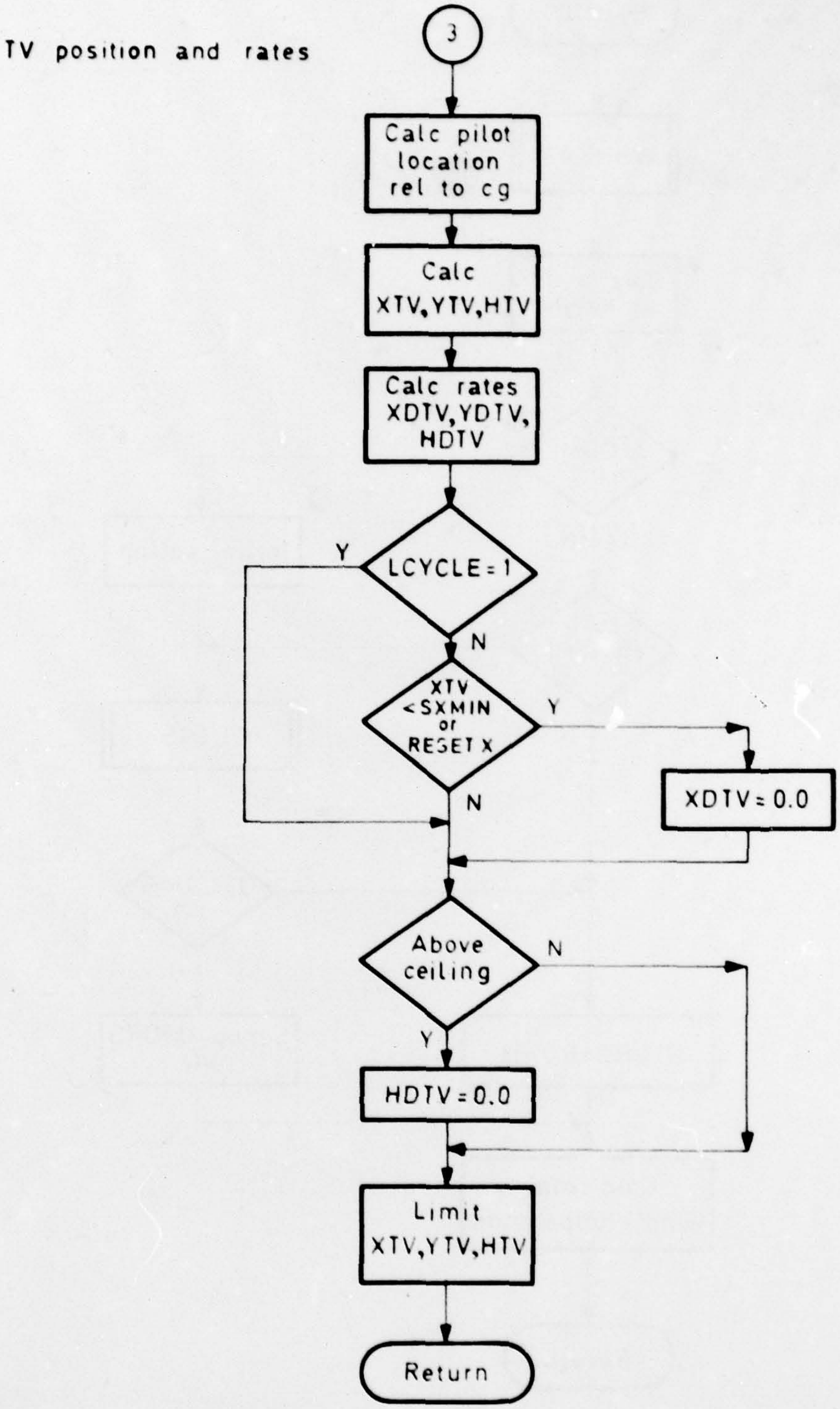


Fig A8 Flow diagram of TV position and rate control, STV subroutine

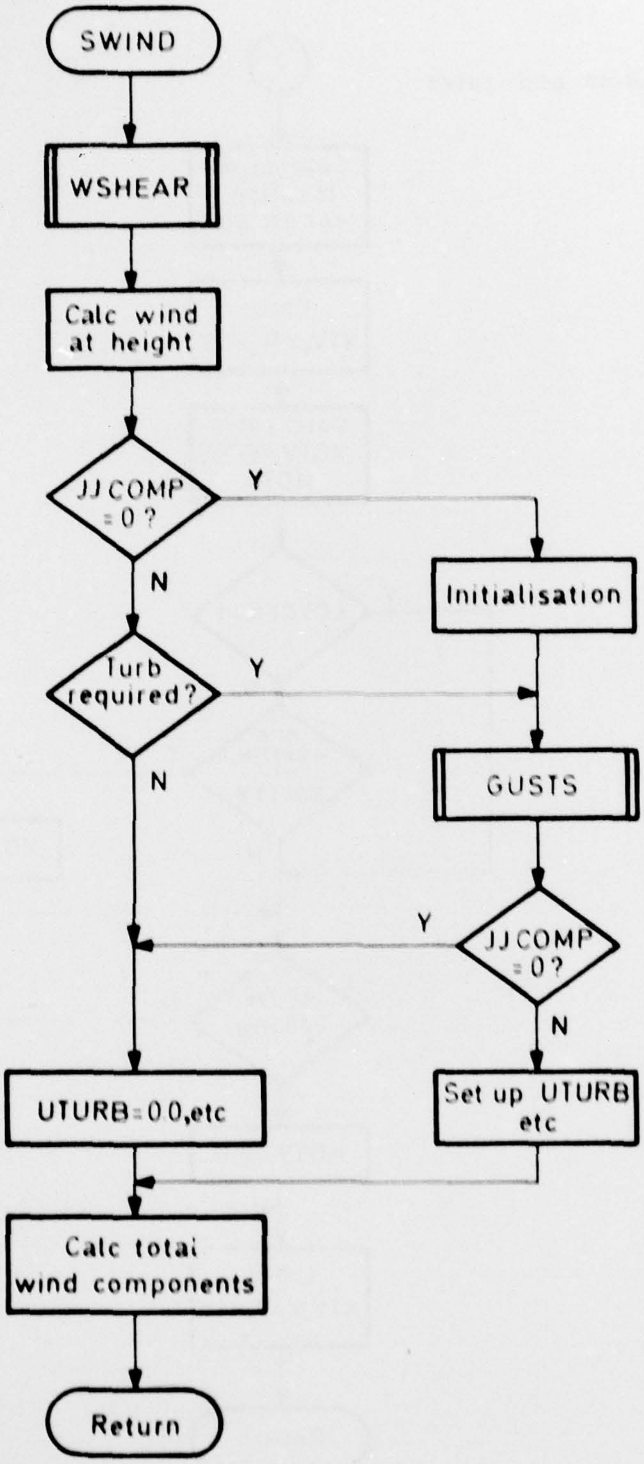


Fig A9 Flow chart of SWIND subroutine

TR 79006

REPORT DOCUMENTATION PAGE

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15\. Distribution statement

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16\. Descriptors (Keywords) (Descriptors marked * are selected from TEST)

Simulation. Mathematical modelling. Software. Computer programs

17\. Abstract

A system of equations has been developed for the simulation of an aircraft's motion in real time using a digital computer. Those parts of the mathematical model common to all aircraft have been created as a set of Fortran subroutines, leaving the user to create only a small group of routines specifically to describe his aircraft. The equations employed are defined and the computer implementation described in detail. The Report can be used as a handbook and "user guide" but as the routines described are not specific to real-time simulation they could be used as a basis for a general mathematical model of an aircraft for use on any computer which supports Fortran.

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