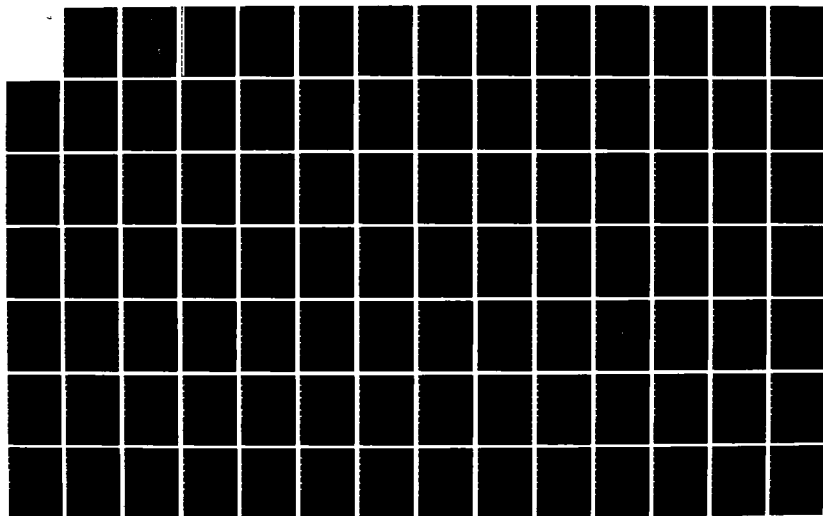
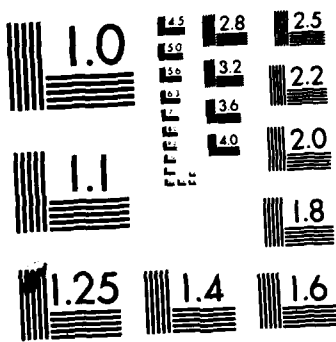


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**A GENERALIZED ESCAPE SYSTEM SIMULATION (GESS)
COMPUTER PROGRAM: GESS USER'S GUIDE
VERSION II - VOLUME I**

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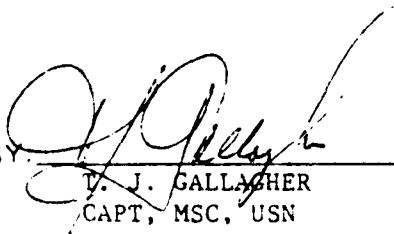
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are provided to simulate the performance of all conventional escape system designs under most environmental conditions and aircraft attitudes or trajectories. This GESS User's Guide describes the elements and events occurring in typical escape systems, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize this and the related ACT and DRAS programs. The GESS Programmer's Manual, a companion guide, lists the annotated FORTRAN-IV program code, and represents the second of two volumes of GESS documentation.

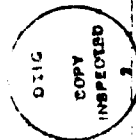
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FOREWORD

This final report describes the elements and events occurring in a typical ejection with a state-of-the-art escape system, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize the Generalized Escape System Simulation (GESS) Computer Program and the related ACT and DRAS programs. The GESS Programmer's Manual, a companion guide, lists the annotated FORTRAN-IV program code and represents the second of two volumes of GESS documentation. A portion of this work was performed by Ketron, Inc., in accordance with NADC Contract N62269-81-C-0206, Task No. 630-1944.

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ABSTRACT

The Generalized Escape System Simulation (GESS) program is a computerized mathematical model for dynamically simulating the performance of existing or developmental aircraft ejection seat systems. The program generates six-dimensional trajectory predictions of the aircraft, seat/occupant, occupant alone, and seat alone by calculating the forces and moments imposed on these elements by the seat catapults, rails, rockets, stabilization, and recovery systems included in most escape system configurations. User options are provided to simulate the performance of all conventional escape system designs under most environmental conditions and aircraft attitudes or trajectories. This *GESS User's Guide* describes the elements and events occurring in typical escape systems, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize this and the related ACT and DRAS programs. The *GESS Programmer's Manual*, a companion guide, lists the annotated FORTRAN IV program code, and represents the second of two volumes of GESS documentation.

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1.0 INTRODUCTION

Designing ejection seat systems enabling the safe escape of crewmembers from high-speed military aircraft is a formidable task. As an adjunct to the Navy's on-going escape systems program of system engineering, testing, and incident review, a mathematical model has been formulated and developed to simulate the operation of any ejection seat-based escape system under most realistic conditions from any aircraft. This User's Guide describes the preparation and use of the Generalized Escape System Simulation (GESS) program.

Originally in February 1972, the Naval Aerospace Recovery Facility, El Centro, contracted Vought Aeronautics Company to develop a simulation model of the SIIIS-3 (now SEU-3/A) Escape System, made by Stencel Aero Engineering Corporation^{(1)*}. This program was a reformulation of an earlier program which Vought produced for the Air Force in 1970⁽²⁾. This Navy program, named ICARUS⁽³⁾ provided greater detail in the modeling of the individual system elements than did its predecessor. These enhancements allowed greater flexibility in studying hardware modifications and occupant physiological effects. The completed program provided engineers, civilian management, and Navy personnel with greater ability to:

- . establish escape system performance requirements,
- . evaluate competitive escape system proposals,
- . evaluate escape system design modifications,
- . monitor escape system test programs,
- . prepare fleet information on escape systems, and
- . investigate in-flight escape incidents.

* All references may be found in Section 7.0.

The ICARUS program results were compared with test data, and then modified to achieve acceptable results^(4,5).

In 1976, the ICARUS program was obtained by the Naval Air Development Center (NADC), Warminster, for use in the F-18 escape system development program. This effort required a substantial reprogramming of the model due to the incorporation of the Martin-Baker escape system in the F-18 aircraft. As this difficult task continued, it became clear that a more flexible model, which could be easily configured by the user to simulate a wide variety of escape systems and aircraft designs, was critically needed.

In 1980, NADC contracted the Computer Sciences Corporation to reformulate and code the simulation model which was to become known as GESS. This program, later revised and documented by KETRON, INC., provides the user with a greatly enhanced capability to describe escape system parameters without code modification, and to execute simulation runs with significantly improved computational efficiency. The capability to produce graphics output through the use of the DRAS program has also been added.

This *GESS User's Guide* is Volume I of two volumes of GESS documentation. Volume II is the *GESS Programmer's Manual*, which includes the annotated GESS program listing.

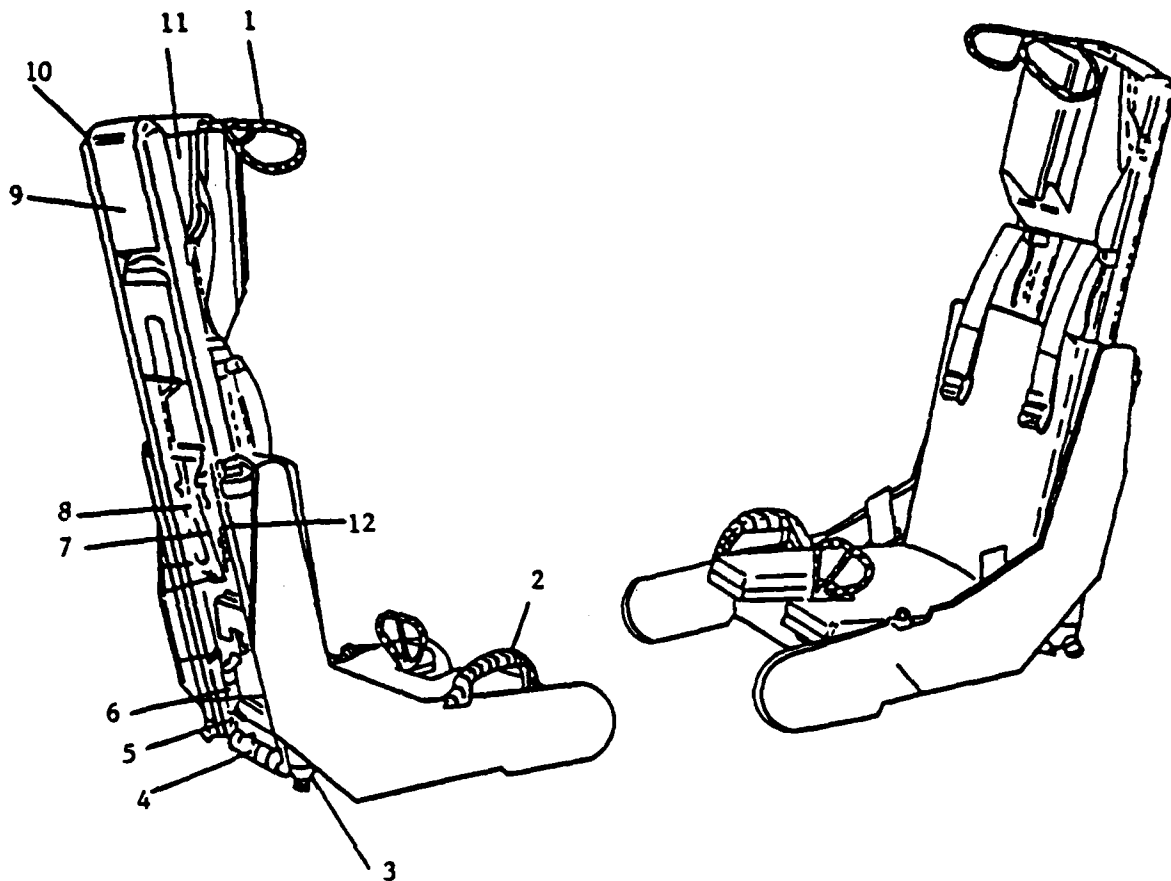
2.0 ESCAPE SYSTEM OPERATION

Following an aircraft failure requiring emergency egress, a typical sequence of escape system events could be:

- (1) trigger mechanism initiation
- (2) catapult(s) ignition
- (3) seat first motion
- (4) drogue gun/container deployment
- (5) catapult(s) separation
- (6) rail(s) separation
- (7) rocket(s) ignition
- (8) seat separation from aircraft
- (9) stabilization system operation
- (10) rocket(s) burnout
- (11) recovery chute deployment
- (12) recovery chute line stretch
- (13) seat/occupant separation
- (14) recovery chute full inflation

Although every supplier of escape systems incorporates somewhat different configurations and mechanisms for accomplishing these tasks, the general functional sequence includes most or all of these events.

The components of a typical ejection seat system are shown in Figure 2-1.



- 1 - FACE CURTAIN EJECTION HANDLE
- 2 - EMERGENCY RELEASE HANDLE
- 3 - SEAT BACK ROCKET (SBR)(2)
- 4 - CATAPULT CARTRIDGE
- 5 - CATAPULT OUTER TUBE/GUIDE RAIL
- 6 - TIME DELAY INITIATORS (2)
- 7 - WORD
- 8 - DROGUE BRIDLE
- 9 - DROGUE CONTAINER
- 10 - CANOPY BREAKER
- 11 - PARACHUTE CONTAINER/HEADREST
- 12 - ANEROIDS (2)

Figure 2-1. SIIIS-3 Escape System Components

Upon catapult ignition, pressure is rapidly created within the catapult tubes providing thrust to initiate seat motion along a prescribed path out of the aircraft. When the seat headbox enters the airstream, after either canopy jettison or penetration, the drogue parachute is deployed from the seat. Prior to or at the time of seat separation from the aircraft, the rockets located on the seat are ignited, providing additional thrust to move the seat and its occupant away from the aircraft.

As the seat continues its trajectory from the aircraft, it must be stabilized through the use of a system such as the Directional Automatic Realignment of Trajectory (DART) system. This system consists of a brake attached to the seat through which one or two aircraft-attached lines are played out, producing a moment designed to correct any adverse seat attitude. These lines break when the seat reaches a specific distance from the aircraft.

Deployment of the recovery system is usually accomplished either by a drogue parachute, a Wind Oriented Rocket Deployment (WORD) system, mortar deployment, or a combination of these. The time of deployment of the recovery system is controlled by the seat sequencing mechanism, which senses seat air-speed and altitude.

As the parachute deploys, the risers and suspension lines develop tension from the differential momentum between the inflating parachute canopy and the seat/occupant. This causes the seat and occupant to separate. The seat moves away from the occupant as the occupant/parachute system decelerates further under the action of the inflating parachute canopy.

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3.0 FORMULATION

3.1 Coordinate Systems

Trajectories generated by the Generalized Escape System Simulation (GESS) program are calculated with respect to specific, "right hand rule," coordinate systems coinciding with center of gravities or other specified reference points of the various system elements. Each of the program coordinate systems is defined by six (6) degrees of freedom:

A. Linear:

1. X - forward positive displacement
2. Y - left positive displacement
3. Z - upward positive displacement

B. Angular:

4. Yaw (R) - leftward positive rotation
5. Pitch (Q) - nose downward positive rotation
6. Roll (P) - right wing downward positive rotation

These coordinate systems, illustrated in Figure 3-1, are defined as follows:

• Earth-Fixed Coordinate System (EFCS)

The EFCS is a 3-axis orthogonal coordinate system with origin at a fixed point located on or near the surface of the earth. Since all simulated distances are relatively small compared to the earth's radius, the errors associated with neglecting the curvature of the earth's surface are considered negligible. The movements and rotations of all simulated system elements can be described with respect to (wrt) this fixed coordinate system.

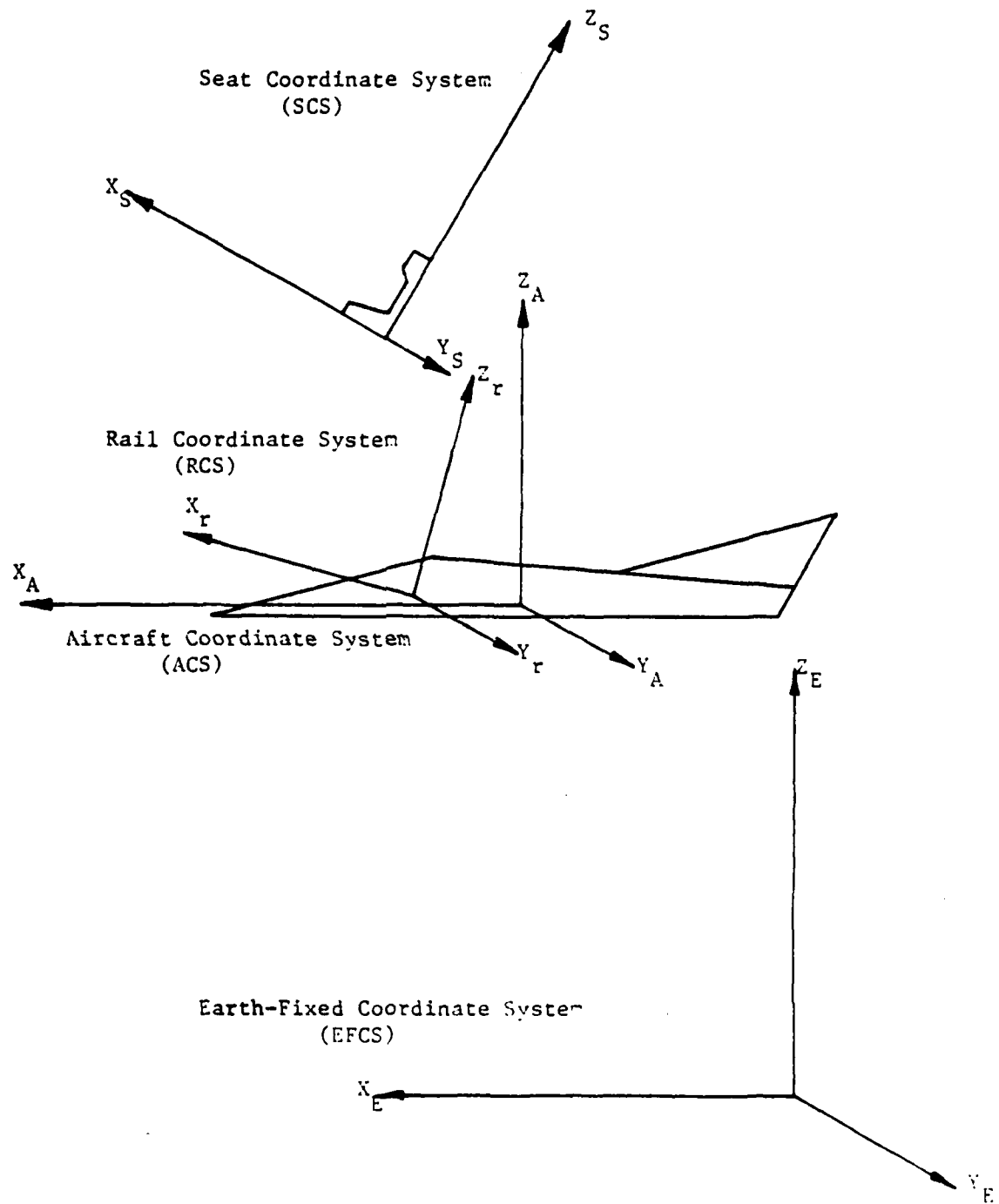


Figure 3-1. Coordinate Systems

- Aircraft Coordinate System (ACS)

The ACS is a 3-axis orthogonal coordinate system with origin at a fixed point, usually the aircraft's center of gravity. All linear and angular movements of the aircraft are determined by establishing the position of this coordinate system wrt the EFCS. The position of all other system elements, prior to and, optionally, after the separation of the seat from the aircraft, is determined wrt to the ACS.

- Rail Coordinate System (RCS)

The RCS is a 3-axis orthogonal coordinate system which is defined and fixed wrt the ACS. Its origin coincides with the mid-point between the rails of the lateral (Y) axis defined by the two lowest rail points in the ACS, and its vertical (Z) axis is parallel to the rails. The rail system serves to restrict the motion of the seat to a specific path as it moves out of the aircraft cockpit.

- Seat Coordinate System (SCS)

The SCS is a 3-axis orthogonal coordinate system with origin usually corresponding to the initial location of the RCS origin wrt the seat. The center of gravity (CG) of either the seat/occupant (S/O) combination or the seat/alone (S/A) is referenced wrt the SCS, allowing the trajectories of these system elements to be tracked wrt either the ACS or the EFCS. Points of application of the various forces acting on the S/O or S/A are also referenced wrt the SCS, allowing the calculation of moments and rotation around the respective CGs.

- Occupant Alone Coordinate System (OACS)

The OACS is a 3-axis orthogonal coordinate system with origin at the center of gravity of the seat occupant after the occupant separates from the seat. The OACS is currently defined only by the three linear degrees of freedom because the disjointed non-rigidity of the occupant alone makes any angular determination difficult, if not irrelevant. Provisions have been made for the future incorporation of OACS angular degrees of freedom if such information is necessary at a later date.

- Thrust Vector Control Coordinate System (TVCCS)

The TVCCS is a 3-axis orthogonal coordinate system with origin at the common intersection of the rocket line of thrust and the centerlines of its gimbals. This coordinate system establishes the orientation of the rocket line of thrust, which is modified dynamically as part of the vertical-seeking maneuver.

Coordinate systems and vector directions should be carefully considered when preparing simulation inputs. All output reports are referenced accordingly.

3.1.2 Notation and Variable Identification. For brevity, vector notation is used in the formulation wherever possible. Individual component equations are occasionally used for clarity. Position vectors are denoted by the symbol $\vec{r}$. Hence, $\vec{r}_{ASO}$ represents the position vector from the aircraft CG to the seat/occupant CG, while $\vec{r}_{SA}$ represents the position vector of the seat alone with respect to the EFCS. Direction cosine matrices are denoted by the symbol D_{ij} . Hence, D_{AE} represents the direction cosine matrix which transforms components of a vector presented in the AFCS to components presented in the EFCS.

Several naming conventions are used to identify variables used in the formulation. Refer to Section 4.0 for specific variable descriptions. These naming conventions are summarized below.

SA	- seat alone
OA	- occupant alone
SO	- seat/occupant
NPTS	- number of points
RK	- rocket
WGHT	- weight
X	- X axis
Y	- Y axis
Z	- Z axis
P	- roll rotation
Q	- pitch rotation
R	- yaw rotation
VEL	- velocity
PORO	- porosity
REC	- recovery parachute

DRO/DR	-	drogue parachute
DRT	-	DART
POS	-	position
IGN	-	ignition
CAT	-	catapult
TVC	-	thrust vector control
CG	-	center of gravity

The variable names used in the formulation have been selected to facilitate the user's understanding. There is limited correlation between these variable names and the coded variable names used in the actual program.

3.1.3. Units of Measure. Either English or metric units of measure may be used in the GESS program. The specific units required for either system of measure selected by the user are detailed for each input variable in Section 4.0. No units of measure are referenced in the formulation.

3.2 Vector Mathematics

3.2.1 Position Vectors. A position vector is a representation of the location of a specified external point, with reference to a stated initial point, characterized by both distance or magnitude and direction components. By stating the location of a point, denoted (2), in terms of the origin of a specified coordinate axis (1), the position vector ($\vec{r}_{12}$) from the origin of the coordinate system to the point is defined. The calculation of the position vector $\vec{r}_{23}$, between the two points, (2) and (3), is facilitated by vector subtraction. These principles are illustrated in Figure 3-2.

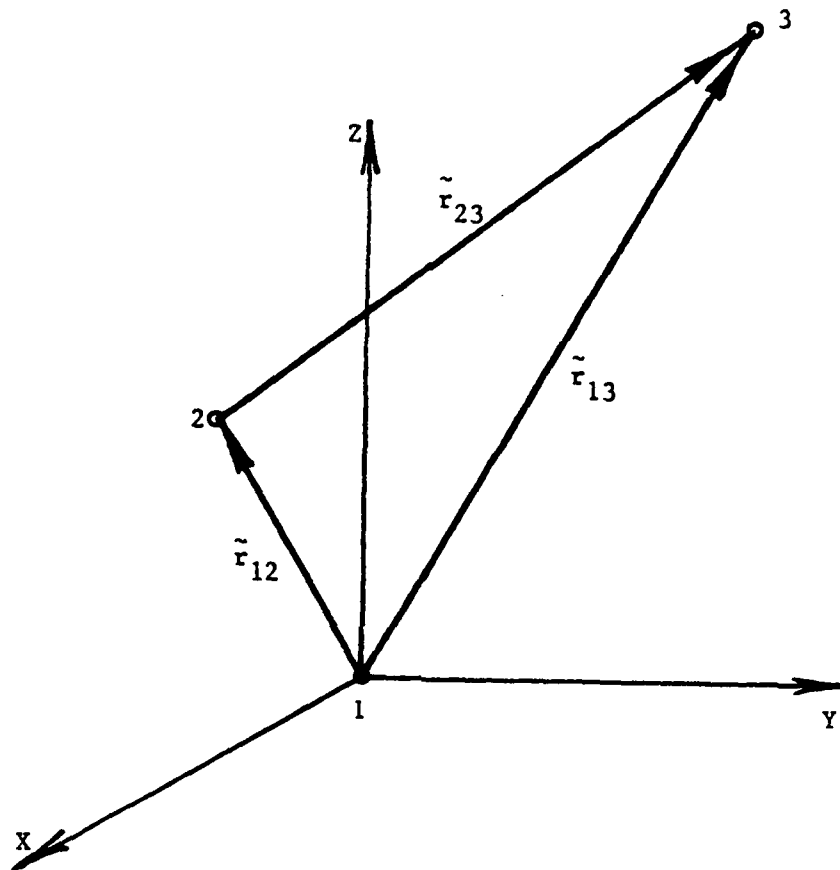


Figure 3-2. Generalized Position Vectors

The definitions of the position vectors used in GESS are given in conjunction with discussions of the formulation in which they are used.

3.2.2 Direction Cosine Matrices. Direction cosine matrices (DCMs) are used to transpose position vectors from one coordinate system to the orientation of another coordinate system. Such transformations are necessary prior to vector addition or subtraction operations intended to determine resultant vectors. Hence, the addition of the position vectors $\vec{r}_{12}$ and $\vec{r}_{23}$ will yield the new position vector $\vec{r}_{13}$ after $\vec{r}_{23}$ has been transposed into the $\vec{r}_{12}$ coordinate system. Further, given position vectors $\vec{r}_{12}$ and $\vec{r}_{34}$, the vector $\vec{r}_{24}$ can be found by subtracting $\vec{r}_{12}$ from the addition of $\vec{r}_{13}$ and the transposition of $\vec{r}_{34}$ into the $\vec{r}_{12}$ coordinate system. These principles are illustrated in Figures 3-3 and 3-4.

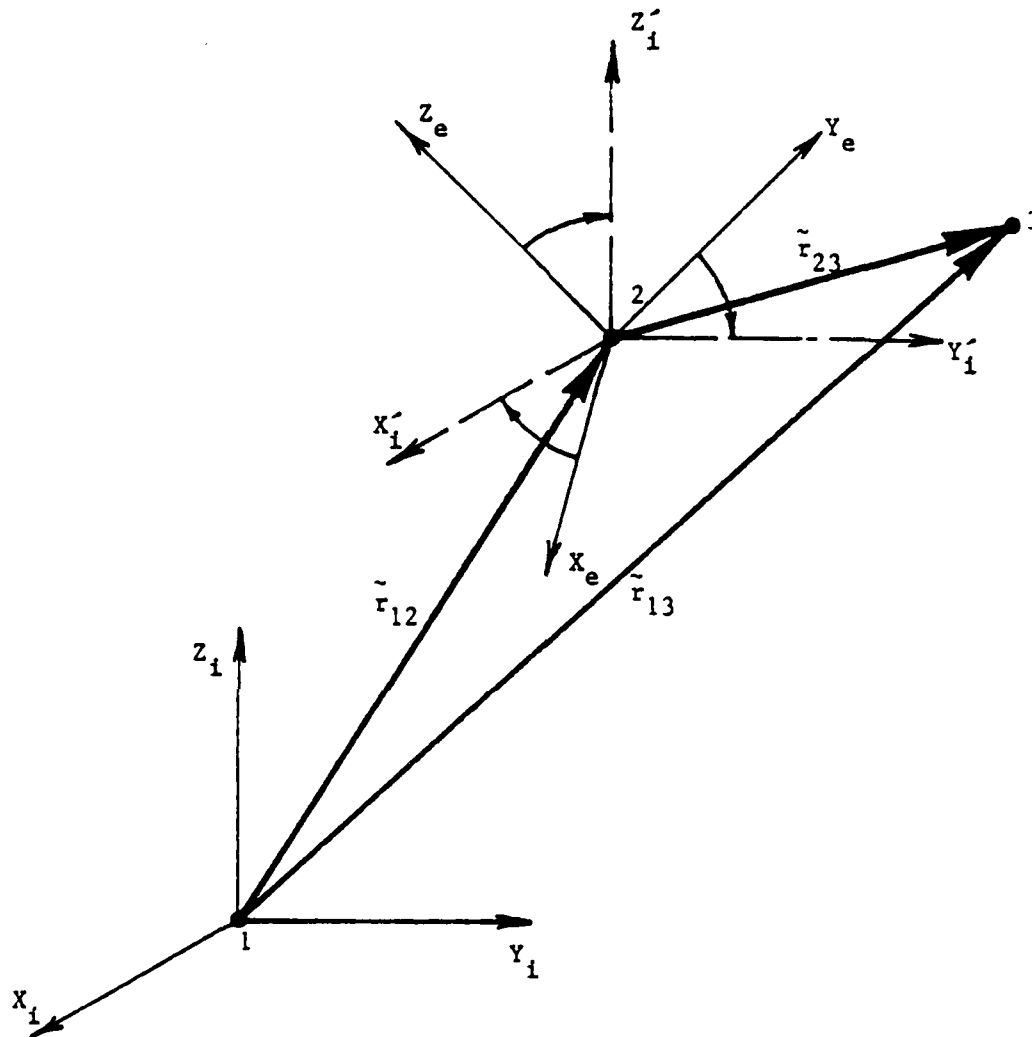


Figure 3-3. Vector Addition Using Transformation

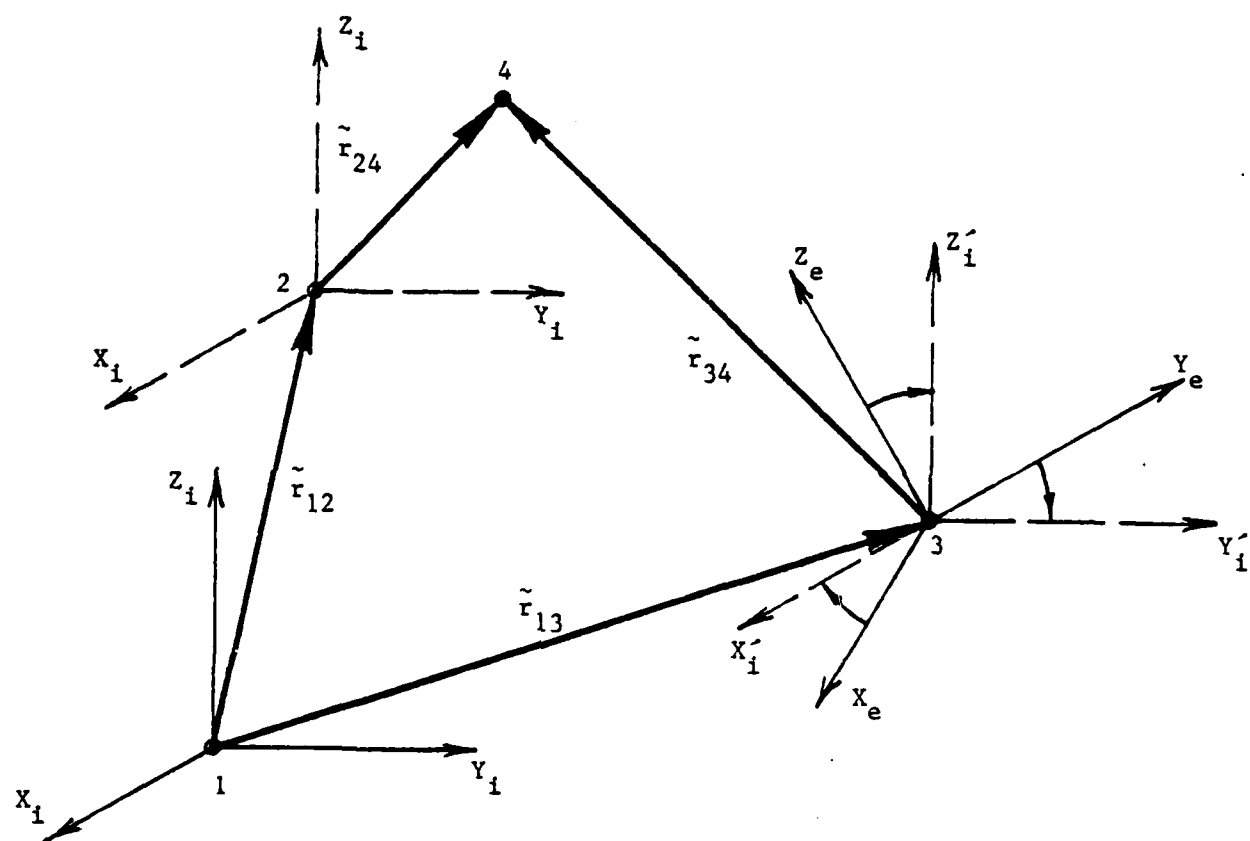


Figure 3-4. Vector Subtraction Using Transformation

The generalized DCM, D_{21} , which transforms a vector in the initial coordinate system to the coordinates of an external coordinate system is given by:

$$D_{21} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \quad (1)$$

where:

$$d_{11} = \cos \beta \cos \gamma \quad (1.a)$$

$$d_{12} = \cos \beta \sin \gamma \quad (1.b)$$

$$d_{13} = -\sin \beta \quad (1.c)$$

$$d_{21} = -\sin \gamma \cos \alpha + \sin \alpha \sin \beta \cos \gamma \quad (1.d)$$

$$d_{22} = \cos \gamma \cos \alpha + \sin \alpha \sin \beta \sin \gamma \quad (1.e)$$

$$d_{23} = \cos \beta \sin \alpha \quad (1.f)$$

$$d_{31} = \sin \alpha \sin \gamma + \sin \beta \cos \alpha \cos \gamma \quad (1.g)$$

$$d_{32} = -\sin \alpha \cos \gamma + \sin \beta \cos \alpha \sin \gamma \quad (1.h)$$

$$d_{33} = \cos \alpha \cos \beta \quad (1.i)$$

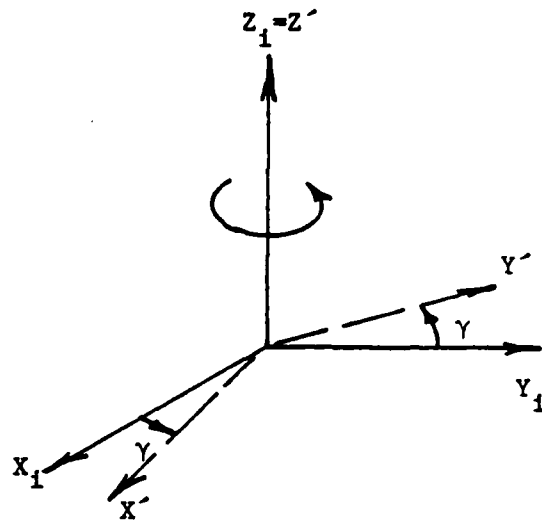
and where the modified Euler angles are:

$\alpha \equiv$ positive rotation to right about the X'' axis (Roll)

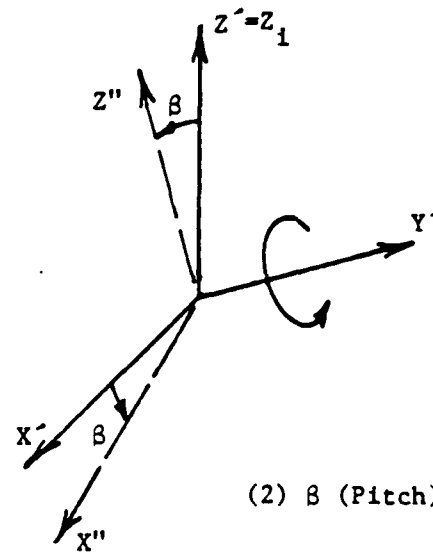
$\beta \equiv$ positive rotation nose downward about the Y' axis (Pitch)

$\gamma \equiv$ positive rotation to left about the Z_1 axis (Yaw)

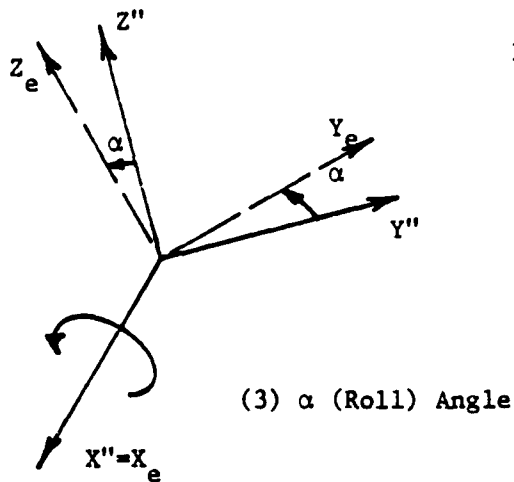
These angles are illustrated in Figure 3-5.



(1) γ (Yaw) Angle



(2) β (Pitch) Angle



(3) α (Roll) Angle

Figure 3-5. Modified Euler Angles For Direction Cosine Matrices

Thus, the position vector resulting from the addition of the position vector to the external coordinate system origin to a position vector in that external coordinate system, as in Figure 3-3, is given by:

$$\mathbf{r}_{13} = \mathbf{r}_{12} + D_{21} \mathbf{r}_{23}$$

And, the position vector found by subtracting two separately coordinated position vectors, as in Figure 3-4, is given by:

$$\mathbf{r}_{24} = \mathbf{r}_{13} + D_{21} \mathbf{r}_{34} - \mathbf{r}_{12}$$

A final principle involves the use of the transpose of the DCM, which is defined as:

$$D_{21}^T = \begin{bmatrix} d_{11} & d_{21} & d_{31} \\ d_{12} & d_{22} & d_{32} \\ d_{13} & d_{23} & d_{33} \end{bmatrix} = D_{12} \quad (2)$$

If the DCM which transforms the first coordinate system into the second is used, then Figure 3-3 can be represented as:

$$\mathbf{r}_{13} = \mathbf{r}_{23} + D_{21}^T \mathbf{r}_{12}$$

and Figure 3-4 is represented as:

$$\mathbf{r}_{24} = \mathbf{r}_{31} + D_{21}^T \mathbf{r}_{12} - \mathbf{r}_{34}$$

This is possible since all DCMs are orthogonal matrices; for this class of matrices, $D_{21}^T = D_{21}^{-1}$, where: $D_{21}^{-1} \equiv$ inverse of D_{21} . Thus, a single DCM is used to enable position vector transformation in either direction between two separate coordinate systems.

The definitions of the specific modified Euler angles describing the relative orientations of the various program coordinate systems, and their respective DCMs, are described in conjunction with the discussion of the formulation in which they are used.

3.2.3 Quaternions. Calculating the components of the DCMs for each of the coordinate system pairs using the modified Euler angles involves a considerable use of trigonometric functions. The cost of using these functions, in terms of computer time and CPU memory, is excessive in a large iterative program. This problem has been substantially resolved in GESS through the use of unit quaternions.

Quaternions are represented symbolically as the sum of a vector and a scalar, and may be interpreted geometrically by considering them as operators on vectors. In GESS, unit quaternions are used to update DCMs during integration of each system element's equations of motion. During program initiation, quaternion components are initiated for each DCM as:

$$\lambda_0 = (1/2)[|(1 + d_{11} + d_{22} + d_{33})|]^{1/2} \quad (3.a)$$

$$\lambda_1 = (d_{23} - d_{32})/4\lambda_0 \quad (3.b)$$

$$\lambda_2 = (d_{31} - d_{13})/4\lambda_0 \quad (3.c)$$

$$\lambda_3 = (d_{12} - d_{21})/4\lambda_0 \quad (3.d)$$

where the DCM components indicated have been initialized by the trigonometric calculations used in equation (1).

Following initiation, the quaternion is updated during every integration time step by the matrix differential equation:

$$\begin{bmatrix} \dot{\lambda}_0 \\ \dot{\lambda}_1 \\ \dot{\lambda}_2 \\ \dot{\lambda}_3 \end{bmatrix} = \begin{bmatrix} 0 & p & q & r \\ -p & 0 & -r & q \\ -q & r & 0 & -p \\ -r & -q & p & 0 \end{bmatrix} \begin{bmatrix} \lambda_0 \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} \quad (4)$$

where:

$p \equiv$ angular velocity of roll angle, α

$q \equiv$ angular velocity of pitch angle, β

$r \equiv$ angular velocity of yaw angle, γ

The new orientation of the system element with respect to the DCM reference coordinate system is then obtained by integrating:

$$\lambda_i = \int \dot{\lambda}_i dt \quad (i = 0, 1, 2, 3) \quad (5)$$

And, the new DCM, $D_{21}^{\sim}$ is found from:

$$D_{21}^{\sim} = \begin{bmatrix} d_{11}^{\sim} & d_{12}^{\sim} & d_{13}^{\sim} \\ d_{21}^{\sim} & d_{22}^{\sim} & d_{23}^{\sim} \\ d_{31}^{\sim} & d_{32}^{\sim} & d_{33}^{\sim} \end{bmatrix} \quad (6)$$

where

$$d_{11}^{\sim} = 2(\lambda_0^2 + \lambda_1^2) - 1 \quad (6.a)$$

$$d_{12}^{\sim} = 2(\lambda_1\lambda_2 + \lambda_0\lambda_3) \quad (6.b)$$

$$d_{13}^{\sim} = 2(\lambda_1\lambda_3 - \lambda_0\lambda_2) \quad (6.c)$$

$$d_{21}^{\sim} = 2(\lambda_1\lambda_2 - \lambda_0\lambda_3) \quad (6.d)$$

$$d_{22}^{\sim} = 2(\lambda_0^2 + \lambda_2^2) - 1 \quad (6.e)$$

$$d_{23}^{\sim} = 2(\lambda_2\lambda_3 + \lambda_0\lambda_1) \quad (6.f)$$

$$d_{31}^{\sim} = 2(\lambda_1\lambda_3 + \lambda_0\lambda_2) \quad (6.g)$$

$$d_{32}^{\sim} = 2(\lambda_2\lambda_3 - \lambda_0\lambda_1) \quad (6.h)$$

$$d_{33}^{\sim} = 2(\lambda_0^2 + \lambda_3^2) - 1 \quad (6.i)$$

Finally, the new modified Euler angles can be found from:

$$\alpha' = \tan^{-1} (d'_{23}/d'_{33}) \quad (7.a)$$

$$\beta' = \sin^{-1} (d'_{13}) \quad (7.b)$$

$$\gamma' = \tan^{-1} (d'_{12}/d'_{11}) \quad (7.c)$$

A more detailed discussion of the theory and use of quaternions can be found in most linear algebra texts.

3.3 Equations of Motion

3.3.1 Aircraft. The aircraft equations of motion are based upon linear and angular input values of position, velocity, and acceleration for each of six degrees of freedom with respect to the EFCS. No external forces, such as gravity, thrust, or moments are considered, although the linear and angular acceleration input can be structured as a function of time to represent nearly any aircraft maneuver. The input values are then integrated over the simulation time increment to determine the linear and angular time history of the aircraft with respect to the earth.

The aircraft equations of motions are:

$$\tilde{s}_{AC} = \int \tilde{\dot{s}}_{AC} dt \quad (8.a)$$

$$\tilde{v}_{AC} = \int \tilde{\dot{v}}_{AC} dt \quad (8.b)$$

$$\tilde{\theta}_{AC} = \int \tilde{\dot{\theta}}_{AC} dt \quad (8.c)$$

$$\tilde{\omega}_{AC} = \int \tilde{\dot{\omega}}_{AC} dt \quad (8.d)$$

where:

$$\begin{aligned}\tilde{s}_{AC} &\equiv \text{linear displacement vector wrt EFCS} \\ \tilde{v}_{AC} &\equiv \text{linear velocity vector wrt EFCS} \\ \tilde{\theta}_{AC} &\equiv \text{angular displacement vector wrt EFCS} \\ \tilde{\omega}_{AC} &\equiv \text{angular velocity vector wrt EFCS}\end{aligned}$$

3.3.2 Seat/Occupant and Seat Alone. Both the seat/occupant and seat alone configurations are considered as rigid bodies. Consequently, the equations of motion for both of these configurations are given by:

$$m_s (\ddot{\tilde{V}}_s + \tilde{\omega}_s \times \tilde{V}_s) = \tilde{\Sigma F}_s \quad (9.a)$$

and

$$[I_s] \ddot{\tilde{\omega}}_s + \tilde{\omega}_s \times [I_s] \tilde{\omega}_s = \tilde{\Sigma M}_s \quad (9.b)$$

where:

$$\begin{aligned}\tilde{\Sigma F}_s &\equiv \text{summation of the external forces acting on the S/O or S/A} \\ \tilde{\Sigma M}_s &\equiv \text{summation of the external moments acting on the S/O or S/A} \\ m_s &\equiv \text{mass of the S/O or S/A} \\ [I_s] &\equiv \text{moment of inertia matrix for the S/O or S/A} \\ \ddot{\tilde{V}}_s &\equiv \text{linear acceleration vector for the S/O or S/A} \\ \tilde{V}_s &\equiv \text{linear velocity vector for the S/O or S/A} \\ \tilde{\omega}_s &\equiv \text{angular velocity vector for the S/O or S/A} \\ \ddot{\tilde{\omega}}_s &\equiv \text{angular acceleration vector for the S/O or S/A}\end{aligned}$$

The possible external forces acting on the S/O are given by:

$$\tilde{F}_{so} = \tilde{F}_c + \tilde{F}_R + \tilde{F}_r + \tilde{F}_A + \tilde{F}_D + \tilde{F}_{DC} + \tilde{F}_{RC} + \tilde{F}_g \quad (10.a)$$

where:

$\tilde{F}_c$	$\equiv$	catapult forces
$\tilde{F}_R$	$\equiv$	rocket forces
$\tilde{F}_r$	$\equiv$	rail forces
$\tilde{F}_A$	$\equiv$	aerodynamic forces
$\tilde{F}_D$	$\equiv$	DART forces
$\tilde{F}_{DC}$	$\equiv$	drogue parachute forces
$\tilde{F}_{RC}$	$\equiv$	recovery parachute forces
$\tilde{F}_g$	$\equiv$	gravitational forces

The possible external moments acting on the S/O are:

$$\tilde{M}_{so} = \tilde{M}_c + \tilde{M}_R + \tilde{M}_r + \tilde{M}_A + \tilde{M}_D + \tilde{M}_{DC} + \tilde{M}_{RC} \quad (10.b)$$

where:

$\tilde{M}_c$	$\equiv$	catapult moments
$\tilde{M}_R$	$\equiv$	rocket moments
$\tilde{M}_r$	$\equiv$	rail moments
$\tilde{M}_A$	$\equiv$	aerodynamic moments
$\tilde{M}_D$	$\equiv$	DART moments
$\tilde{M}_{DC}$	$\equiv$	drogue parachute moments
$\tilde{M}_{RC}$	$\equiv$	recovery parachute moments

The external forces and moments acting on the S/A are:

$$\tilde{\Sigma F}_{SA} = \tilde{F}_A + \tilde{F}_g \quad (11.a)$$

$$\tilde{\Sigma M}_{SA} = \tilde{M}_A \quad (11.b)$$

The new positions and orientations of the S/O or S/A with respect to the EFCS are obtained by integrating twelve (12) differential equations. These equations are:

$$u_s = \int \dot{u}_s dt \quad (12.a)$$

$$v_s = \int \dot{v}_s dt \quad (12.b)$$

$$w_s = \int \dot{w}_s dt \quad (12.c)$$

$$x_s = \int \dot{x}_s dt \quad (12.d)$$

$$y_s = \int \dot{y}_s dt \quad (12.e)$$

$$z_s = \int \dot{z}_s dt \quad (12.f)$$

$$p_s = \int \dot{p}_s dt \quad (12.g)$$

$$q_s = \int \dot{q}_s dt \quad (12.h)$$

$$r_s = \int \dot{r}_s dt \quad (12.i)$$

$$\dot{p}_s = \int \ddot{p}_s dt \quad (12.j)$$

$$\dot{q}_s = \int \ddot{q}_s dt \quad (12.k)$$

$$\dot{r}_s = \int \ddot{r}_s dt \quad (12.l)$$

where:

$$\begin{bmatrix} \dot{x}_s \\ \dot{y}_s \\ \dot{z}_s \end{bmatrix} = [D_{SE}]^T \begin{bmatrix} u_s \\ v_s \\ w_s \end{bmatrix} \quad (13)$$

It should be noted that all u , v , w , $\dot{p}$, $\dot{q}$, and $\dot{r}$ terms refer to the SCS, while the x , y , z , p , q and r terms refer to the EFCS.

3.3.3 Occupant Alone. The occupant alone (O/A) configuration cannot be considered as a rigid body because of the numerous degrees of freedom of the various body elements. Consequently, any singular consideration of angular orientation, velocity, or acceleration is meaningless. Therefore, the equation of motion for the O/A is based on only the three (3) linear degrees of freedom, and is given by:

$$m_{OA} \ddot{\tilde{V}}_{OA} = \Sigma \tilde{F}_{OA} \quad (14)$$

where:

$m_{OA} \equiv$ mass of the O/A

$\ddot{\tilde{V}}_{OA} \equiv$ linear acceleration vector of the O/A

$\Sigma \tilde{F}_{OA} \equiv$ summation of the external force vector acting on the O/A

The external forces acting on the O/A are:

$$\Sigma \tilde{F}_{OA} = \tilde{F}_{RC} + \tilde{F}_A + \tilde{F}_g \quad (15)$$

The new position of the O/A with respect to the EFCS is obtained by integrating the same twelve (12) equations as the S/O and S/A (equations 12.a-1). However, all angular terms are set equal to zero. This causes the DCM to be a unity matrix, and there is no relevant distinction between the OACS and EFCS position and velocity terms. These equations become:

$$u_{OA} = \int \dot{u}_{OA} dt \quad (15.a)$$

$$v_{OA} = \int \dot{v}_{OA} dt \quad (15.b)$$

$$w_{OA} = \int \dot{w}_{OA} dt \quad (15.c)$$

$$x_{OA} = \int \dot{x}_{OA} dt \quad (15.d)$$

$$y_{OA} = \int \dot{y}_{OA} dt \quad (15.e)$$

$$z_{OA} = \int \dot{z}_{OA} dt \quad (15.f)$$

$$p_{OA} = 0 \quad (15.g)$$

$$q_{OA} = 0 \quad (15.h)$$

$$r_{OA} = 0 \quad (15.i)$$

$$\dot{p}_{OA} = 0 \quad (15.j)$$

$$\dot{q}_{OA} = 0 \quad (15.k)$$

$$\dot{r}_{OA} = 0 \quad (15.l)$$

3.4 Forces and Moments

The various forces and moments acting on the individual system elements result in changes to the trajectories of these elements. These forces and moments are dependent upon a wide variety of independent variables, and will be separately discussed in association with their sources.

3.4.1 Aircraft. Prior to the unlocking of the catapult tubes at ejection initiation, the seat/occupant (S/O) is located by a fixed position vector from the aircraft center of gravity (CG). Thus, the forces and moments created by the aircraft's trajectory are directly translated to the S/O. However, since these forces and moments do not affect the S/O trajectory relative to the aircraft, the GESS program translates the aircraft accelerations and velocities directly to the S/O, but does not calculate specific forces and moments exerted on the S/O by the aircraft. The linear and angular aircraft accelerations in

the ACS are entered as input time tables (refer to Sections 4.3.4.1. and 4.3.4.2.), allowing the user to simulate the forces and moments of any aircraft maneuver (also refer to Section 3.3.1).

3.4.2 Catapults and Catapult Tube. The GESS program allows the simulation of either one or two seat catapults. Input variables allow the seat-to-catapult moment arm vector(s), $\tilde{r}_{SCi}$, to be specified according to seat geometry. If two catapults are specified, the right ($i = 1$) and left ($i = 2$) catapult thrust time histories are input and tabulated separately to allow greater flexibility in simulating catapult system anomalies. The input catapult thrust versus time tables are linearly interpolated to determine thrust magnitudes between intermediate time points.

In the RCS, the right, left, and total catapult thrust vectors ($\tilde{F}_{C1}$, $\tilde{F}_{C2}$, and $\tilde{F}_C$, respectively) are given by:

$$\tilde{F}_{C1} = (0, 0, T_{C1})^T \quad (16.a)$$

$$\tilde{F}_{C2} = (0, 0, T_{C2})^T \quad (16.b)$$

$$\tilde{F}_C = \tilde{F}_{C1} + \tilde{F}_{C2} \quad (16.c)$$

where T_{C1} and T_{C2} are the right and left thrust table values, respectively.

The corresponding catapult moment vector, $\tilde{M}_C$, is formed to be:

$$\tilde{M}_C = \tilde{r}_{SC1} \times \tilde{F}_{C1} + \tilde{r}_{SC2} \times \tilde{F}_{C2} \quad (16.d)$$

where: $\tilde{r}_{SC1}$ = vector moment arm from catapult 1 line of thrust to S/O CG

Figure 3-6 illustrates the forces and moments on the seat/occupant due to catapult thrust.

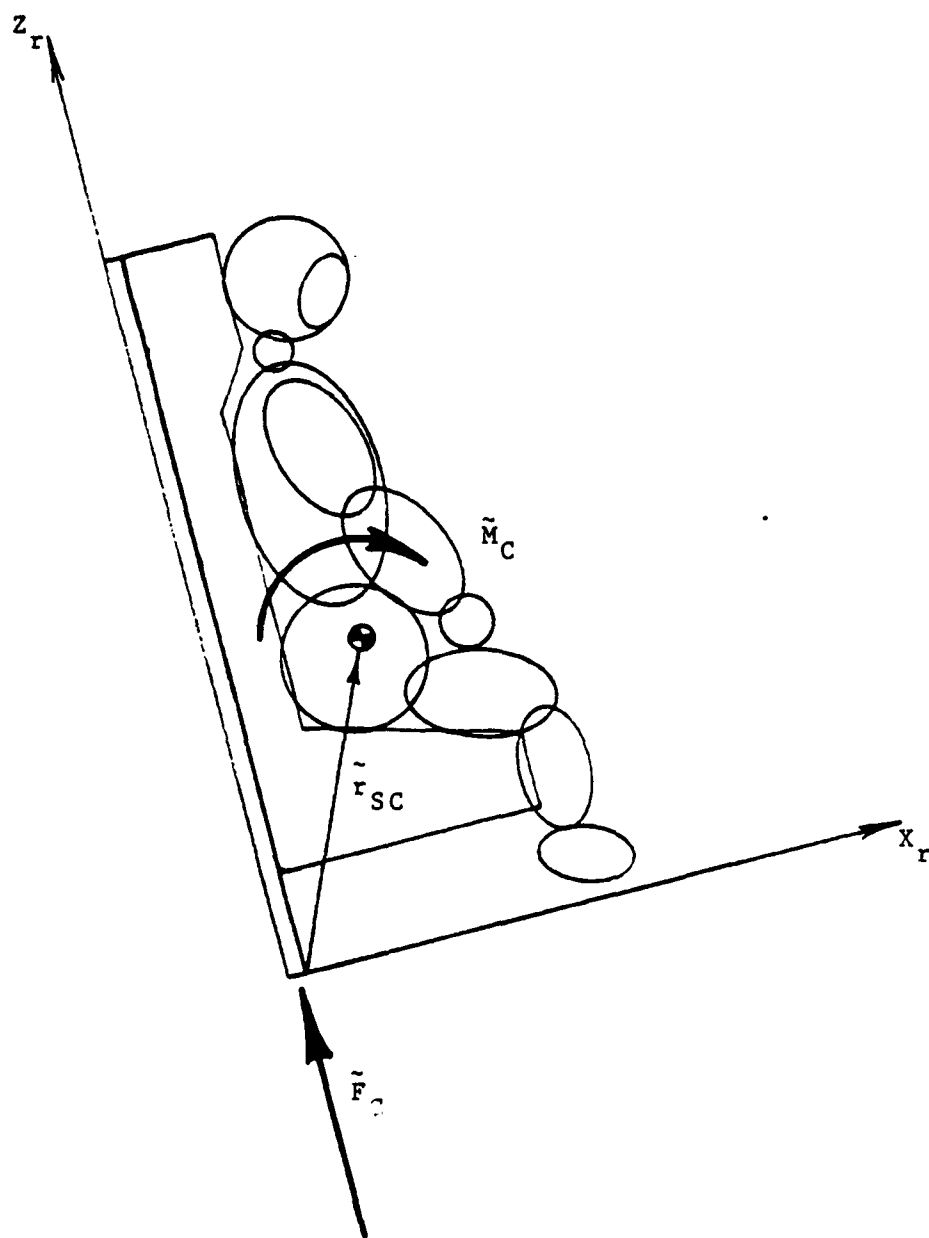


Figure 3-6. Catapult Forces and Moments

An additional force and moment source sometimes encountered in ejection seat systems is that of the bending catapult tube. As the seat moves out of the cockpit, it will, in some designs, remain attached to a single extended catapult tube until the tube extension length has been achieved. As the extension of the tube progresses, the aerodynamic forces acting on the seat/occupant cause the tube to deflect. This deflection results in a countering force on the S/O. Figure 3-7 illustrates the tube bending forces and moments.

In the RCS, the bending length, L_b , is found from:

$$L_b = [(\Delta X)^2 + (\Delta Y)^2 + (\Delta Z - L_i)^2]^{1/2} \quad (17.a)$$

where:

$\Delta X \equiv$ change in X-axis position of catapult tube end

$\Delta Y \equiv$ change in Y-axis position of catapult tube end

$\Delta Z \equiv$ change in Z-axis position of catapult tube end

$L_i \equiv$ initial catapult length

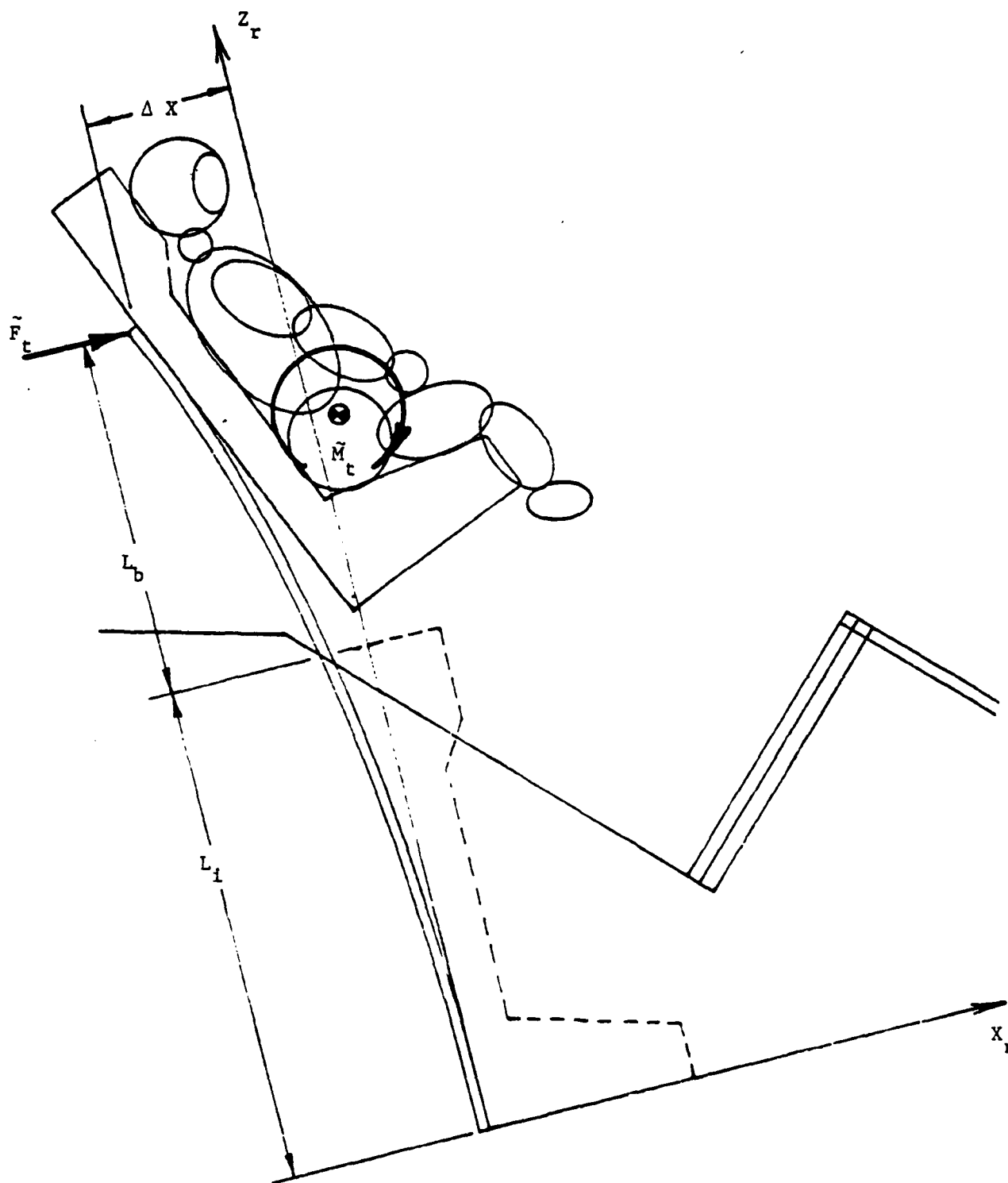


Figure 3-7. Catapult Tube Bending Forces and Moments

The catapult tube deflection, δ , is found from:

$$\delta = [(\Delta X)^2 + (\Delta Y)^2]^{1/2} \quad (17.b)$$

The total tube bending force, F_t , exerted on the S/O is:

$$F_t = K_t \delta \left(1 - \frac{L_b}{L_{mx}}\right)^2 \quad (18)$$

where:

$K_t \equiv$ catapult tube stiffness constant

$L_{mx} \equiv$ maximum catapult tube extension length

This yields the orthogonal force components:

$$F_{tx} = -F_t \Delta X / \delta \quad (19.a)$$

$$F_{ty} = -F_t \Delta Y / \delta \quad (19.b)$$

$$F_{tz} = -\mu_t F_t \quad (19.c)$$

where:

$\mu_t \equiv$ catapult tube friction coefficient

And, the corresponding tube bending moments are:

$$\tilde{M}_t = \tilde{F}_t \times \tilde{r}_{SC} \quad (20)$$

where:

$\tilde{r}_{SC} \equiv$ position vector from S/O CG to catapult attachment point

3.4.3 Sustainer Rockets. The sustainer rocket thrusts are handled similarly to the catapult thrusts in that each of up to six rockets have separate data inputs and thrust vs time tables, and are computed separately within the program. The multiple inputs may be used to investigate sustainer rocket anomalies or intentionally introduced asymmetry to achieve divergence in multi-seat aircraft. The unit vectors for each rocket's line of thrust, as seen in the SCS, are given by:

$$\tilde{U}_{Ri} = (\cos \alpha_{Ri}, \cos \beta_{Ri}, \cos \gamma_{Ri})^T, \quad (i = 1 \text{ to } n, n \leq 6)$$

Figure 3-8 illustrates the modified Euler angles specifying the rocket thrust line orientation with respect to the RCS, and the unit vector components in the SCS.

The sustainer rocket thrust vector, F_R , in the SCS is given by:

$$\tilde{F}_R = \sum_{i=1}^n T_{Ri} \tilde{U}_{Ri}, \quad (n \leq 6) \quad (21)$$

where:

$T_{Ri} \equiv$ rocket i total thrust.

The corresponding rocket moments are:

$$\tilde{M}_R = \sum_{i=1}^n (\tilde{r}_{Ri} \times T_{Ri} \tilde{U}_{Ri}), \quad (n \leq 6) \quad (22)$$

The effect of rocket fuel burnoff on the S/O mass, m_{SO} , is computed as a linear function of rocket i burn time, θ_{Rbi} , from:

$$m_{SO} = m_{SO_0} - \sum_{i=1}^n \left(\frac{\theta_{Rbi}}{\theta_{TRbi}} \times m_{RFi} \right) \quad (23)$$

where:

$m_{SO_0} \equiv$ initial S/O mass, including rocket fuel

$\theta_{TRbi} \equiv$ total rocket i burn time

$m_{RFi} \equiv$ initial mass of rocket i fuel

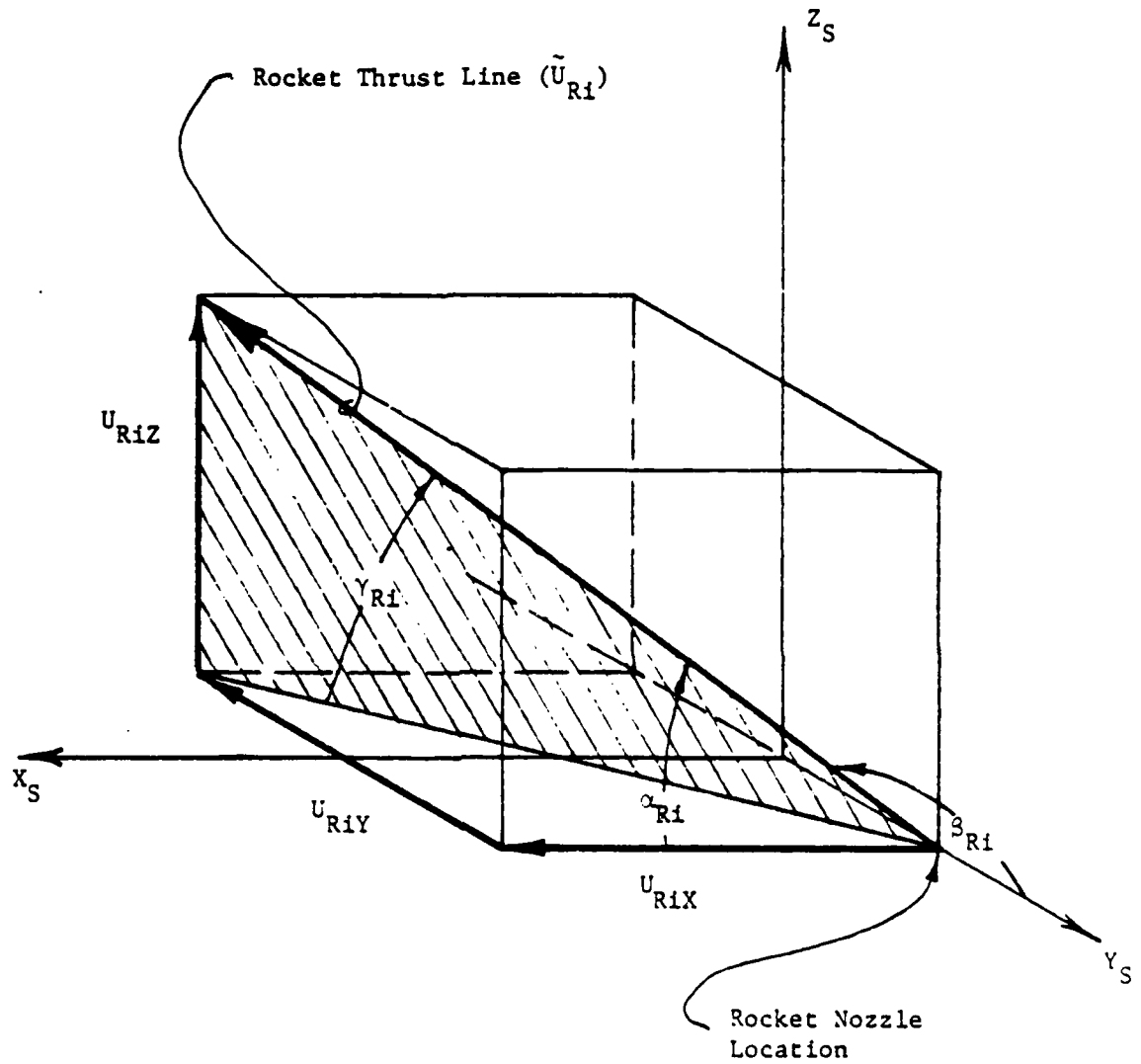


Figure 3-8. Rocket Thrust Line Unit Vectors and Direction Cosine Angles

3.4.4 Rail System. Several different rail system configurations are used for directing the seat/occupant out of the aircraft. The rail can be permanently mounted in the aircraft with either rollers or slider blocks (slippers) attached to the seat, or the rail may be mounted on the seat with slippers attached to the aircraft. There are also "rail-within-a-rail" systems in which both the seat and the aircraft are provided rails which contact each other. The GESS program allows the user to specify either type of system.

The program determines the displacement of each slipper from the rail, perpendicular to the RCS Z-axis, at each integration time step. For the rail-within-a-rail option, four slippers, each pair separated by the rail length, are assumed. Based on this displacement, a restoring force is computed, constraining the slider blocks to the rails.

Up to six slippers can be specified; they are numbered consecutively in the order in which their initial positions are entered in input. The deflection vector from the i th slipper to its respective rail, $\tilde{r}_{SSBi}$, which is perpendicular to the RCS Z-axis, is denoted as:

$$\tilde{\delta}_{SSBi} = (\delta_{SSBi x}, \delta_{SSBi y}, 0) = \tilde{r}_{SSBi} - \tilde{\delta}_{SSBi z} \quad (24.a)$$

and is illustrated in Figure 3-9. Solving for $\tilde{\delta}_{SSBi}$, we obtain, in the RCS:

$$\tilde{\delta}_{SSBi} = \begin{bmatrix} r_{Sx} \\ r_{Sy} \\ 0 \end{bmatrix} + D_{Sr} \begin{bmatrix} r_{SSBi x} \\ r_{SSBi y} \\ 0 \end{bmatrix} - \begin{bmatrix} r_{SBi ox} \\ r_{SBi oy} \\ 0 \end{bmatrix} \quad (24.b)$$

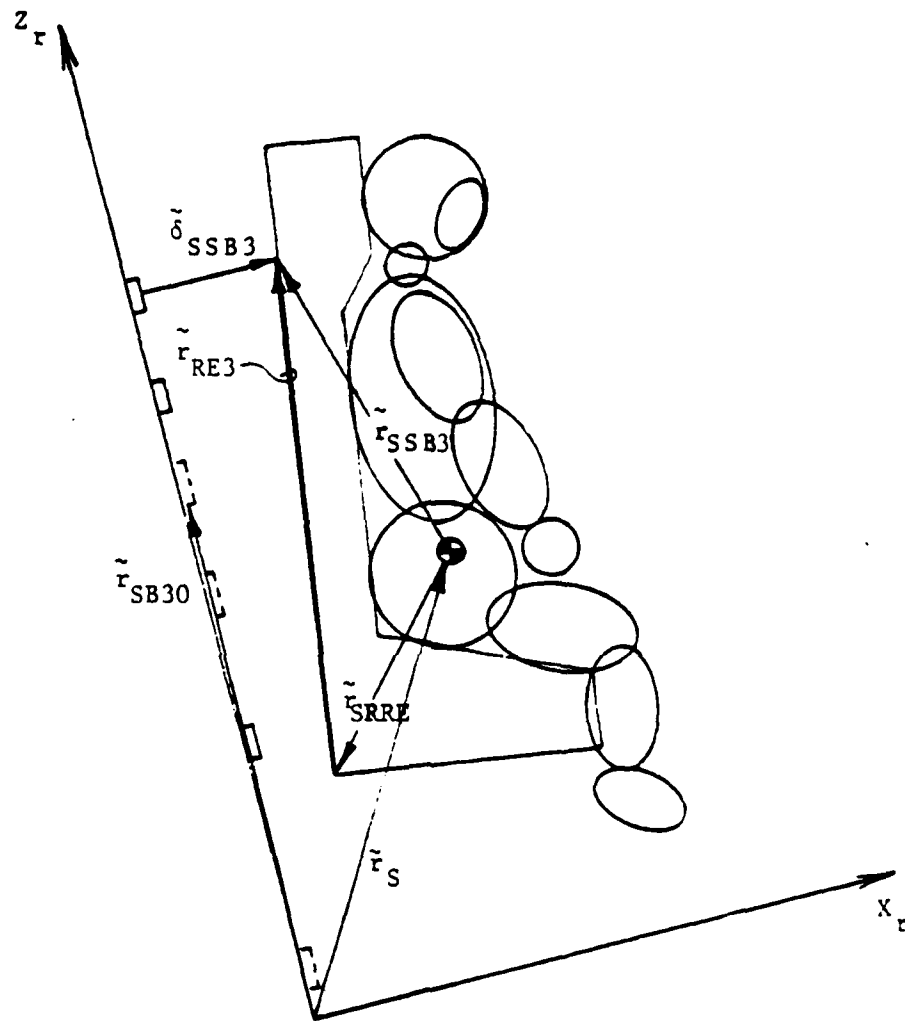


Figure 3-9. Rail to Slipper Deflection Vector

where:

- $\tilde{r}_{Sj} \equiv$ vector components of S/O CG position in RCS
- $D_{Sr} \equiv$ SCS to RCS DCM
- $\tilde{r}_{SSBij} \equiv$ components of vector from S/O CG to slipper i in SCS
- $\tilde{r}_{SBioj} \equiv$ vector components of slipper i initial position in RCS

The reaction forces at slipper i are computed by:

$$F_{SBix} = -k_x \delta_{SSBix} \quad (25.a)$$

$$F_{SBiy} = -k_y \delta_{SSBiy} \quad (25.b)$$

where:

$$k_j \equiv \text{slipper i spring constant in j direction}$$

and, the frictional force at slipper i, F_{SBiz} , is computed by:

$$F_{SBiz} = -\mu_f (F_{SBix}^2 + F_{SBiy}^2)^{1/2} \quad (25.c)$$

where: $\mu_f \equiv$ linear coefficient of friction between rail and slipper.

The summation of the rail/slipper forces acting on the S/O in the SCS then becomes:

$$\tilde{F}_r = D_{Sr} \sum_{i=1}^6 \tilde{F}_{SBi} \quad (26)$$

The vector from the S/O CG to the rail/slipper contact point i, $\tilde{r}_{SSBi}$, is found from: (refer to Figure 3-9 for vector definitions)

$$\tilde{r}_{SSBi} = D_{Sr}^T [\tilde{r}_{SRRE} + \tilde{r}_{REi}] \quad (27)$$

The vector slipper moment about the S/O CG, $\tilde{M}_{SBi}$, is then given by:

$$\tilde{M}_{SBi} = \tilde{r}_{SSBi} \times \tilde{F}_r \quad (28)$$

An additional pitching moment, M_T , caused by the torsional bending of the rail as the S/O angular position varies relative to the RCS, is given by:

$$M_T = -K_T(\theta_{Sr} - \theta_{Sr0}) \quad (29)$$

where:

K_T $\equiv$ torsional bending constant

θ_{Sr} $\equiv$ pitch angle of seat to rail

θ_{Sr0} $\equiv$ initial pitch angle of seat to rail

Therefore, the rail/slipper moment vector acting on the S/O in the SCS, is:

$$\tilde{M}_T = D_{Sr} \sum_{i=1}^6 \tilde{M}_{SBi} + \tilde{M}_T \quad (30)$$

3.4.5 Aerodynamic Drag. The forces acting on the seat/occupant and seat alone due to aerodynamic drag are based upon tabular data similar to that found in Reference 6. These data, in the form of drag coefficients, are functions of the angles of attack and sideslip and of Mach number. The coefficients are modified, when appropriate, to compensate for the partial wind exposure encountered as the S/O begins to emerge from the aircraft.

First, the velocity of the S/O or S/A with respect to the air, $\tilde{U}_{SA}$, found from:

$$\tilde{U}_{SA} = \tilde{U}_S - D_{SE}\tilde{W}_E \quad (31)$$

and its scalar magnitude, V_{SA} , is:

$$V_{SA} = (u_{SA}^2 + v_{SA}^2 + w_{SA}^2)^{1/2} \quad (32)$$

where:

$\tilde{U}_S \equiv$ S/O or S/A velocity vector wrt EFCS

$D_{SE} \equiv$ SCS to EFCS DCM

$\tilde{W}_E \equiv$ wind velocity vector

$u_{SA}, v_{SA}, w_{SA} \equiv$ vector components of $\tilde{U}_{SA}$

The angles of attack, α_s , and sideslip, β_s , as shown in Figure 3-10, are determined by:

$$\alpha_s = -\tan^{-1} (w_{SA}/u_{SA}) \quad (33)$$

$$\beta_s = \sin^{-1} (v_{SA}/V_{SA}) \quad (34)$$

The Mach number is found from:

$$N_M = \frac{V_{SA}}{V_x} \quad (35)$$

where:

$$V_x = 49.0212 \times T_{amb}^{1/2} \quad (36)$$

$T_{amb} \equiv$ ambient air temperature

The aerodynamic force vector, $\tilde{F}_A$ is then given by:

$$\tilde{F}_A = \rho_{amb} V_{SA}^2 S f_x \tilde{C}_{FS}/2 \quad (37)$$

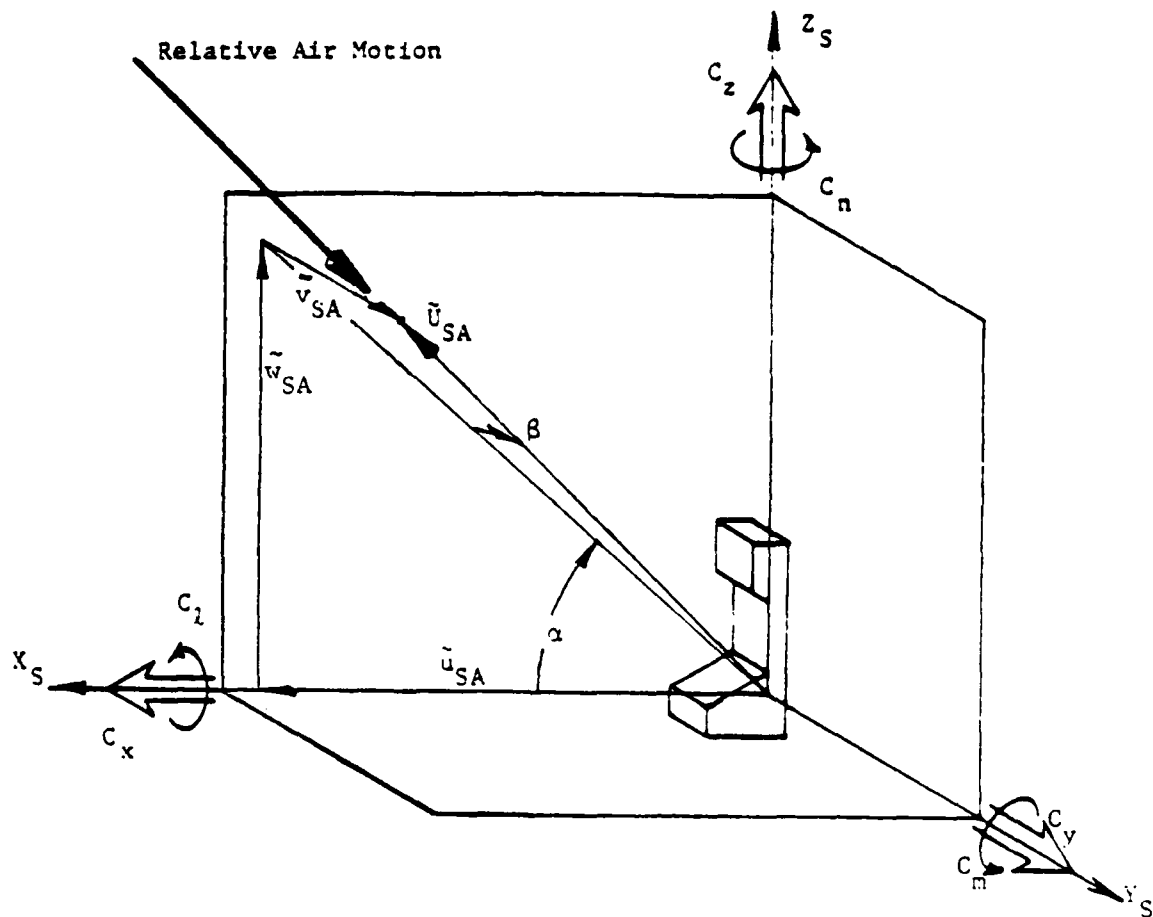


Figure 3-10. Seat/Occupant Aerodynamic Force and Moment Angles and Coefficients

where:

- ρ_{amb} $\equiv$ ambient air density
 f_x $\equiv$ fraction of S/O exposed to the air stream
 A_S $\equiv$ aerodynamic reference area of S/O or S/A
 $\tilde{C}_{FS}$ $\equiv$ vector of S/O or S/A aerodynamic force coefficients, functions of α_s , β_s , and M_u

The aerodynamic moment vector, $\tilde{M}_A$, is given by:

$$\tilde{M}_A = (\rho_{amb} v^2 \tilde{r}_{SSCG} \times \tilde{C}_{FS} + L_{RS} \tilde{C}_{MS}) / 2 \quad (38)$$

where:

- $\tilde{r}_{SSCG}$ $\equiv$ vector location of the seat center of gravity in SCS
 $\tilde{C}_{MS}$ $\equiv$ vector of S/O or S/A aerodynamic moment coefficients, functions of α_s , β_s , and N_M
 L_{RS} $\equiv$ aerodynamic reference length of S/O or S/A

As the S/O moves from the cockpit into the airstream, the reference area, reference length, and center of aerodynamic forces are modified to account for the partial wind exposure. Hence, if we define ψ as the fraction of the S/O exposed:

$$\psi = \frac{|z_{RSB}| + z_{SA} - z_{CPH}}{z_{SA}}$$

then:

$$A_S = \begin{cases} \psi A_{SF}, & (|z_{RSB}| + z_{SA}) < z_{CP} \\ A_{SF}, & (|z_{RSB}| + z_{SA}) > z_{CP} \end{cases} \quad (39.a)$$

$$(39.b)$$

Similarly:

$$L_{RS} = \begin{cases} \forall L_{RSF}, & (|Z_{RSB}| + Z_S) < Z_{CP} \end{cases} \quad (40.a)$$

$$L_{RSF}, \quad (|Z_{RSB}| + Z_S) > Z_{CP} \quad (40.b)$$

where:

A_{SF} $\equiv$ aerodynamic reference area of S/O fully out of aircraft

L_{RSF} $\equiv$ aerodynamic reference length of S/O fully out of aircraft

Z_{RSB} $\equiv$ travel of RCS Z-position of seat bottom

Z_{SA} $\equiv$ S/A height in RCS

Z_{CPH} $\equiv$ cockpit height in RCS

The partially exposed aerodynamic reference point (center of aerodynamic forces), Z_{SRP} , is found from:

$$Z_{SRP} = Z_{SSRP} + (Z_{SBOT} - Z_{SSRP} + Z_{SA}) (1 - \psi) \quad (41)$$

where:

Z_{SSRP} $\equiv$ fully exposed aerodynamic reference point

Z_{SBOT} $\equiv$ SCS Z-position of seat bottom

As the fully-exposed S/O or S/A rotates, a retarding moment tends to oppose this rotation due to aerodynamic damping. GESS has incorporated this moment in the form of a damping factor, f_D , such that:

$$\tilde{\omega}_{SD} = \tilde{\omega}_S f_D \quad (42)$$

where:

$$f_D = \exp(-10 C_D \Delta t_1) \quad (43)$$

and

- $\tilde{\omega}_{Sd} \equiv$ dampened rotational velocity of S/O or S/A
 $\tilde{\omega}_S \equiv$ calculated rotational velocity of S/O or S/A
 $C_D \equiv$ input damping coefficient ($0 < C_D < 1$)
 $\Delta t_i \equiv$ integration time step for simulation phase i

In the OACS, the aerodynamic forces are computed based upon a fixed, multidimensional, aerodynamic reference area where no rotational effects are assumed. First, the O/A velocity with respect to the air, U_{OA} , is found from:

$$\tilde{U}_{OA} = \tilde{U}_O - \tilde{W}_E \quad (44)$$

and its scalar magnitude, V_{OA} , is:

$$V_{OA} = (u_{OA}^2 + v_{OA}^2 + w_{OA}^2)^{1/2} \quad (45)$$

where:

$$\begin{aligned} \tilde{U}_O &\equiv \text{O/A velocity vector wrt EFCS} \\ u_{OA}, v_{OA}, w_{OA} &\equiv \text{vector components of } \tilde{U}_{OA} \end{aligned}$$

The O/A angles of attack, α_{OA} , and sideslip, β_{OA} , are found from:

$$\alpha_{OA} = \sin^{-1}(w_{OA}/V_{OA}) \quad (46)$$

$$\beta_{OA} = \tan^{-1}(v_{OA}/u_{OA}) \quad (47)$$

The vector components of the aerodynamic force coefficient, C_F , are determined from:

$$C_{FX} = -\text{SIGN}[(\cos\alpha_{OA}\cos\beta_{OA}), u_{OA}] \quad (48.a)$$

$$C_{FY} = -\text{SIGN}[(\cos\alpha_{OA}\sin\beta_{OA}), v_{OA}] \quad (48.b)$$

$$C_{FZ} = -\text{SIGN}[(\sin\alpha_{OA}), w_{OA}] \quad (48.c)$$

where the SIGN function assigns the first argument the sign of the second. Therefore, the total vector OA aerodynamic force, F_{AO} , is

$$\tilde{F}_{AO} = \rho_{amb} V_{OA}^2 A_{OA} \tilde{C}_F / 2 \quad (49)$$

3.4.6 Stabilization. Various mechanisms are used to stabilize the S/O during sustainer rocket burn. The GESS program includes provisions for simulating a Directional Automatic Realignment of Trajectory (DART) system. As the seat moves away from the aircraft, the DART lines play out through a brake mechanism in the DART frame. The brake force is assumed to act along each DART line from the time that the DART line first becomes stretched to the time that the lines separate from the seat (see Figure 3-11).

The vector DART force, F_{D1} , for a given DART line i , presented in the SCS, is given by:

$$\tilde{F}_{D1} = \frac{1}{2} \frac{K_{DF}}{L_{DL1}} \tilde{r}_{DCAP1} \quad (50)$$

where

$$\begin{aligned} K_{DF} &\equiv \text{DART force constant} \\ L_{DL1} &\equiv \text{length of dart line } i \text{ from confluence to attachment points} \\ \tilde{r}_{DCAP1} &\equiv \text{vector from confluence to attachment points of dart line } i. \end{aligned}$$

The total DART force, $\tilde{F}_D$, then becomes:

$$\tilde{F}_D = \sum_{i=1}^2 \tilde{F}_{D1} \quad (51)$$

The vector DART moment, M_{D1} , for a given DART line i , in the SCS, is given by:

$$\tilde{M}_{D1} = \tilde{r}_{SCP1} \times \tilde{F}_{D1} \quad (52)$$

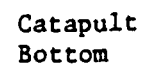


Figure 3-11. DART Forces and Moments

where:

$\tilde{r}_{SCP_i} \equiv$ vector from the seat center of gravity to the aircraft confluence point for DART line i

The total DART moment, $\tilde{M}_D$, then becomes:

$$\tilde{M}_D = \sum_{i=1}^2 \tilde{M}_{Di} \quad (53)$$

3.4.7 Drogue Slug/Container. The aerodynamic drag force applied to the drogue slug/container, F_{DSC} , after its deployment is used to determine the drogue parachute acceleration. This force magnitude is determined by:

$$F_{DSC} = \rho_{amb} C_{DSC} A_{DSC} V_{DA}^2 / 2 \quad (54)$$

where:

$C_{DSC} \equiv$ drogue slug/container drag coefficient

$A_{DSC} \equiv$ drogue slug/container effective drag area

$V_{DA} \equiv$ velocity magnitude of the drogue parachute being deployed by the slug/container relative to the air
 $= (u_{DA}^2 + v_{DA}^2 + w_{DA}^2)^{1/2}$

$u_{DA}, v_{DA}, w_{DA} \equiv$ components of vector $\tilde{U}_{DA}$

$\tilde{U}_{DA} \equiv D_{SE} \tilde{U}_D - \tilde{W}$

$D_{SE} \equiv$ SCS to EFCS DCM

$\tilde{U}_D \equiv$ drogue parachute velocity vector in EFCS

$\tilde{W} \equiv$ wind vector in EFCS

The axial components of $\tilde{F}_{DSC}$ are found from:

$$\tilde{F}_{DSC} = \frac{F_{DSC}}{V_{DA}} \tilde{U}_{DA} \quad (55.a)$$

and the initial slug/container acceleration, $\tilde{a}_{DSC_0}$, becomes:

$$\tilde{a}_{DSC_0} = \frac{1}{m_{DSC}} \tilde{F}_{DSC} \quad (55.b)$$

where:

$m_{DSC} \equiv$ mass of the drogue slug/container

3.4.8 Parachutes. Both drogue and recovery parachute forces and moments are calculated similarly. Parachute release or deployment occurs at the time the parachute begins to leave the seat. After deployment, the parachute begins to develop or play out, but will not exert any force until the suspension line is fully extended (line stretch). Upon achieving line stretch, the parachute begins to fill and exert force. The total time required to completely fill the parachute is nearly always a function of the velocity of the S/O, and is determined by linear extrapolation from a user provided data table. The partially inflated diameter of the parachute, d_η , as a function of time, t , is calculated as:

$$d_\eta = d_{full} \frac{t - t_{1s}}{\Delta t_{ft}}, \quad (t_{1s} < t < t_{1s} + \Delta t_{ft}) \quad (56)$$

where:

$d_{full} \equiv$ fully inflated parachute projected diameter

$t_{1s} \equiv$ time at which parachute line stretch is achieved

$\Delta t_{ft} \equiv$ total time required for parachute fill

The total force magnitude exerted by the parachute on the S/O or O/A is found from:

$$F_p = \rho_{\text{amp}} V_{SA}^2 C_{DP} d_{\eta}^2 / 8 \quad (57)$$

where

$$\begin{aligned} V_{SA} &\equiv \text{total resultant velocity of S/O wrt air} \\ &= (u_{SA}^2 + v_{SA}^2 + w_{SA}^2)^{1/2} \end{aligned}$$

$$C_{DP} \equiv \text{parachute drag coefficient}$$

The parachute force vector, $\tilde{F}_p$, is componentized as:

$$F_{Px} = F_p \cos \alpha_p \cos \beta_p \quad (58.a)$$

$$F_{Py} = F_p \cos \alpha_p \sin \beta_p \quad (58.b)$$

$$F_{Pz} = F_p \sin \alpha_p \quad (58.c)$$

where:

$$\begin{aligned} \alpha_p &\equiv \text{parachute angle of attack wrt air} \\ &= \sin^{-1} (w_{SA} / V_{SA}) \end{aligned}$$

$$\begin{aligned} \beta_p &\equiv \text{parachute angle of sideslip wrt air} \\ &= \tan^{-1} (v_{SA} / u_{SA}) \end{aligned}$$

The moment, $\tilde{M}_p$, exerted on the S/O by the parachute is found from:

$$\tilde{M}_p = \tilde{r}_{SP} \times \tilde{F}_p \quad (59)$$

where

$$\tilde{r}_{SP} \equiv \text{position vector from S/O center of gravity to parachute confluence point}$$

3.4.8.1. The drogue parachute (drogue) is deployed from the seat by the drogue slug/container until the drogue suspension line is completely extended (line stretch). The total time required to achieve line stretch may be specified on input as either extrapolation table values based on S/O linear velocity, or it may be calculated based upon the acceleration provided by the slug/container. At this time the drogue begins to fill. The total time required to completely fill the drogue is also determined by linearly extrapolating input table values based on S/O velocity.

An option is provided to allow the simulation of a duplex VELCON drogue system. The VELCON drogue consists of two tandem drogues, a relatively small one preceded by a larger one. The two drogues are connected by a velocity-calibrated breakaway bridle. At high speeds, the force generated by the large drogue causes the bridle to fail, separating it from the system and limiting the force imposed on the S/O. At low speeds, the forces of the two drogues are additive. The speed at which the large drogue separates is part of the program input, along with the descriptions of the two drogues.

3.4.8.2. The recovery parachute (chute) is deployed from the seat by various mechanisms, depending upon such variables as the ejection altitude, velocity, drogue force, and others. The GESS program allows the user to specify either a fixed time of deployment or to use an extrapolated time of deployment based on table values that are functions of the S/O velocity. The user can also specify one altitude above which the chute will not deploy (CHALT2), and the altitude below which the parachute will deploy at the specified deployment time (CHALT1). Between these two altitudes the user can specify an additional fixed time delay,

or a variable delay based upon the seat vertical deceleration. The latter option determines a time of deployment, t_{deploy} , based on:

$$t_{\text{deploy}} = t_{\text{delay}} + i\Delta t \quad (60)$$

where:

$t_{\text{delay}} \equiv$ fixed deployment time delay

$i \equiv$ number of time steps during which the vertical acceleration exceeds a specified acceleration limit

$\Delta t \equiv$ integration step time increment

The total time required to achieve line stretch is specified in input as linear extrapolation table values, based upon S/O linear velocity. The user has the option of determining parachute fill time by extrapolation tables based on S/O velocity or by calculations based on theory. The latter approach calculates the area under the curve representing current parachute volume, and then compares this volume to the actual parachute volume at full inflation. If the two volumes vary by more than a given tolerance limit, a new value for parachute filling time is assumed, and the area under the new volume curve is calculated. The proper value for parachute filling time is determined when the two volumes are within the tolerance limit. A more detailed discussion can be found in Reference 7.

The maximum parachute volume, V_{max} , is found from:

$$V_{\text{max}} = \frac{\pi}{12} D_p^3 \quad (61)$$

where:

$D_p \equiv$ projected parachute diameter

The projected parachute area, A_p , is found from:

$$A_p = \sum_{i=1}^{10} A_{pi} \quad (62)$$

where:

$$A_{pi} = \frac{Z_i R_{1i}}{3(P_2 R_{2i} + P_{3i}/A)} \quad (63.a)$$

$$Z_i = \begin{cases} .1, & T_{Di} = 1. \\ .4, & T_{Di} = .1, .3, .5, .7, .9 \\ .2, & T_{Di} = .2, .4, .6, .8 \end{cases} \quad (63.b)$$

$$R_{1i} = T_{Di} (P_{1i} T_{Di}^{1/3} - 2.2p) \quad (63.c)$$

$$R_{2i} = P_{3i} \log_e (P_{3i}/A) - 11.25 T_{Di} \quad (63.d)$$

$$P_{1i} = 1 + T_{Di} (2.2p - 1) \quad (63.e)$$

$$P_{2i} = BV_0/253.125 \quad (63.f)$$

$$P_{3i} = 11.25 T_{Di} + A \quad (63.g)$$

$$T_{Di} = \text{fraction of total chute filling time} \\ = 0. \text{ to } 1.0$$

$$A = \frac{5000 W_{OA}}{g(\rho/\rho_0) D_{ODC}^2} \quad (63.h)$$

$$B = \frac{120 T_{FP} C_D S_p}{D_{ODC}^3} \quad (63.i)$$

$W_{OA} \equiv$ weight of the occupant alone after seat separation

$g \equiv$ gravitational acceleration constant

$\rho \equiv$ localized air density

$\rho_0 \equiv$ air density at sea level

D_{ODC} $\equiv$ parachute flattened diameter $= \pi/D_p$
 D_p $\equiv$ parachute projected diameter
 T_{FP} $\equiv$ estimated parachute filling times, initially $= 1.0$ sec
 C_D $\equiv$ parachute drag coefficient
 S_p $\equiv$ parachute projected area $= \pi D_p^2/4$
 p $\equiv$ parachute porosity
 V_0 $\equiv$ free stream air velocity

The calculated parachute volume becomes:

$$Vol = \frac{T_{FP}^2 V_0^2 D_{ODC} A_C}{\pi} \quad (64)$$

This volume is then compared with the actual volume:

$$\frac{|V_{max} - V_0|}{V_{max}} < 0.01 \quad (65)$$

If the tolerance condition is not met, then T_{FP} is incremented or decremented by half of the difference between the current value and either its closest previously tried value or zero.

3.5 Special Features

3.5.1 Dynamic Response Index. The user is offered the option of having the program determine the maximum value of the Dynamic Response Index (DRI) during the time period of seat motion prior to rail separation. The DRI is a standard measure of the acceleration stress applied to the seat occupant during ejection.

The DRI is determined at every integration time step during in aircraft acceleration by first numerically integrating the following second order equation given in Section 6.5.1 of MIL-S-9479B(USAF):

$$dS_Z = V_Z \quad (66.a)$$

$$dV_Z = A_Z - 23.7 V_Z - 2798.41 S_Z \quad (66.b)$$

$$A_Z = \ddot{Z}_s - (\ddot{Z}_s - \ddot{Z}_{s-1})[(t-t_{-1})/\Delta t] \quad (66.c)$$

where:

A_Z $\equiv$ vertical acceleration in SCS during time step

$\ddot{Z}_s$ $\equiv$ vertical acceleration in SCS at time t

$\ddot{Z}_{s-1}$ $\equiv$ vertical acceleration in SCS at time t_{-1}

Δt $\equiv$ length of integration time step

Hence, the time step value of DRI, I_{DR} , is taken from:

$$I_{DR} = C_{DRI} S_Z \quad (67.a)$$

where:

C_{DRI} $\equiv$ dynamic response index constant

and

$$S_Z = \int dS_Z \quad (67.b)$$

$$= \iint dV_Z \quad (67.c)$$

When selected, the DRI option will save the maximum DRI value calculated over the pre-separation period and the time at which this value occurred.

3.5.2 Dynamic Center of Gravity. Previous ejection seat tests have demonstrated a considerable oscillatory motion between the occupant and the seat prior to seat/occupant separation. Since the relationship between the S/O center of mass and the rocket thrust line can be critical to the accurate determination of the S/O trajectory, a user-optional routine has been included in GESS to approximate the shifting of the S/O center of gravity (CG) location throughout this phase of the simulation. The development, methodology, and evaluation of this dynamic CG mathematical model used for this routine is described in Reference 8.

The dynamic CG model is represented by an orthogonal three degrees of freedom spring and damper system. A two-dimensional representation of this system is shown in Figure 3-12. The general equation of motion for such a system is given by:

$$\ddot{\delta} + 2c\omega_0\dot{\delta} + \omega_0^2\delta = A(t) \quad (68)$$

where

δ $\equiv$ deflection vector of occupant relative to seat

$\dot{\delta}, \ddot{\delta}$ $\equiv$ first and second time derivatives of deflection vector

$$c = \frac{b}{2m\omega_0}$$

b $\equiv$ damping constant

m $\equiv$ mass of occupant

$$\omega_0 = (K/m)^{1/2}$$

K $\equiv$ spring constant

$A(t)$ $\equiv$ time dependent external acceleration

A major feature of the dynamic CG model is its use of non-linear spring constants. The spring constants of all three axes incorporate different values

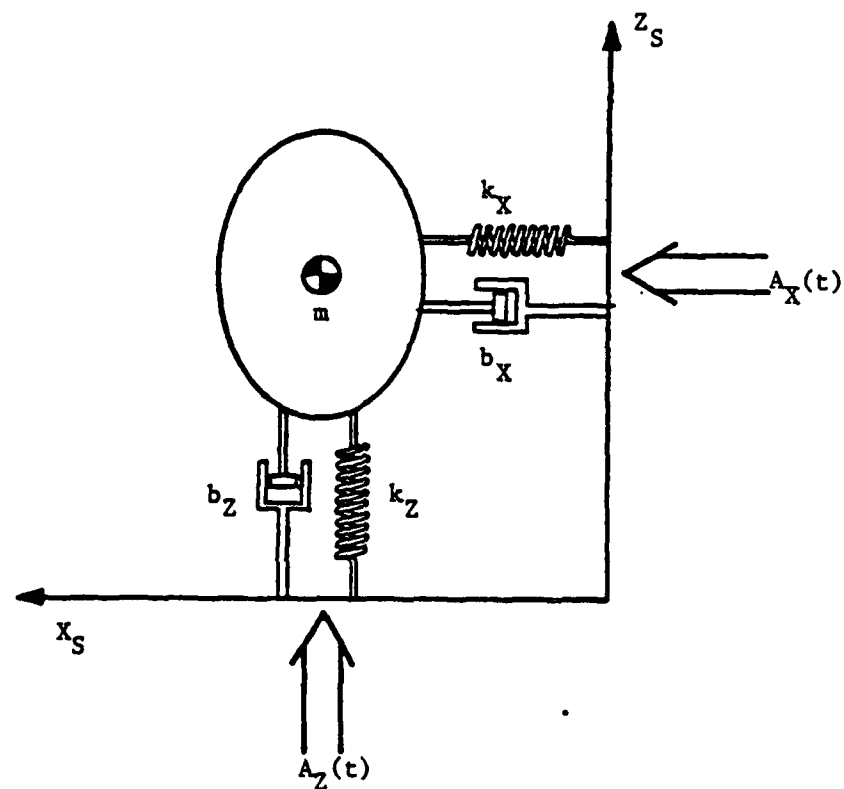


Figure 3-12. Dynamic CG Model

between the positive and negative displacement directions. Both the SCS X and Z axes incorporate a positive "slack" displacement zone in which there is no spring force exerted on the occupant. Further, the Z-axis incorporates two separate spring constant values in the negative direction; this simulates the effects of the initial compression of the seat cushion before reaching the "bottoming" displacement corresponding to the cushion thickness. Hence, the vertical (Z-axis) spring constant can be represented as:

$$K_Z = 0, \quad Z = 0 \text{ to } Z_{\text{slack}}$$

$$K_Z = K_p, \quad Z = Z_{\text{slack}} \text{ to } +\infty$$

$$K_Z = K_{n1}, \quad Z = 0 \text{ to } Z_{\text{bottom}}$$

$$K_Z = K_{n2}, \quad Z = Z_{\text{bottom}} \text{ to } -\infty$$

Typical dynamic CG spring constant curves are presented in Figures 4-16, 4-17, and 4-18 on pages 4-35 to 4-37.

The displacement of the occupant CG relative to the seat is determined by numerically integrating Equation 68 at each time step until seat/occupant separation. This displacement is then used to update the S/O CG location in the SCS, upon which the remaining position vectors are similarly updated.

3.5.3 Thrust Vector Control. The user-optional Thrust Vector Control (TVC) feature simulates the vertical-seeking maneuver incorporated into the developmental Maximum Performance Ejection Seat (MPES). In this maneuver, a single seat booster rocket (SBR), located on the seat bottom, can be gimballed to control the roll and pitch movement of the S/O in a manner which attempts to bring the S/O to an upright orientation. An on-board microprocessor updates the direction cosine matrix (DCM) from sensor data identifying the current seat orientation at fixed time intervals from catapult ignition to rocket

burnout. A series of TVC thrust signal transfer equations are numerically integrated to produce the orientation instruction given to the rocket nozzle rotation actuators. The development of the vertical-seeking maneuver algorithm upon which the TVC routine is based was conducted at the Naval Weapons Center, China Lake, CA. The brief formulation that follows has been included for completeness only. A more detailed analysis than that which follows can be found in Reference 9.

The equations governing the TVC pitch rate compensation are as follows:

$$\dot{X}_3 = 500(\dot{\theta}_{ST} - X_3) \quad (69)$$

$$\dot{X}_4 = X_5 \quad (70)$$

$$\dot{X}_5 = 250000(X_3 - X_4) - 500X_5 \quad (71)$$

$$\dot{X}_6 = C_{29}\xi_2 - C_{30} X_4 - 100X_6 \quad (72)$$

$$\theta_T = 5(\dot{X}_6 + 20 X_6), |\theta_T| < \theta_{limit} \quad (73)$$

where:

X_i $\equiv$ signal transfer variables

$\dot{X}_i$ $\equiv$ time derivative of X_i

$\dot{\theta}_{ST}$ $\equiv$ pitch rate of the TVC coordinate system (TVCCS) wrt the SCS

ξ_i $\equiv$ rocket command angles

C_i $\equiv$ fixed constants

θ_T $\equiv$ intermediate value of rocket pitch wrt TVCCS

θ_{limit} $\equiv$ rocket pitch angle limit

The corresponding TVC roll compensation equations are:

$$\dot{x}_7 = 500(\dot{\phi}_{ST} - x_7) \quad (74)$$

$$\dot{x}_8 = x_9 \quad (75)$$

$$\dot{x}_9 = 250000(x_7 - x_8) - 500x_9 \quad (76)$$

$$\dot{x}_{10} = C_{31}\xi_1 - C_{32}x_8 - 100x_{10} \quad (77)$$

$$\phi_T = 5(\dot{x}_{10} + 20x_{10}), \quad |\phi_T| < \phi_{limit} \quad (78)$$

where

$$\dot{\phi}_{ST} \equiv \text{roll rate of the TVCCS wrt the SCS}$$

$$\phi_T \equiv \text{intermediate value of rocket roll wrt TVCCS}$$

$$\phi_{limit} \equiv \text{rocket roll angle limit}$$

The equations governing control of the rocket pitch angle are then:

$$\dot{x}_{11} = 2861000 \theta_T - 31.45x_{11} \quad (79)$$

$$\dot{x}_1 = \begin{cases} 0.0, & x_1 < (\theta_{limit} + 0.25) \\ x_{12}, & (\theta_{limit} + 0.25) < x_1 \end{cases} \quad (80)$$

$$\dot{x}_{12} = x_{11} - 48.26x_{12} - 90992x_1 \quad (81)$$

$$\Omega_1 = x_1 + \theta_{RT} \quad (82)$$

and the corresponding rocket roll angle control equations are:

$$\dot{x}_{13} = 2861000\phi_T - 31.45x_{13} \quad (83)$$

$$\dot{x}_2 = \begin{cases} 0.0, & x_2 < (\phi_{limit} + 0.25) \\ x_{14}, & (\phi_{limit} + 0.25) < x_2 \end{cases} \quad (84)$$

$$\dot{x}_{14} = x_{13} - 48.26x_{14} - 90992x_2 \quad (85)$$

$$\Omega_2 = x_2 \quad (86)$$

where:

$\Omega_1 \equiv$ rocket thrust line angles, generated by the signal transfer equations, wrt TVCCS

$\Theta_{RT} \equiv$ initial angle of rocket wrt TVCCS

We now find the TVC Euler angles to be:

$$\alpha_{TVC} = \sin \Omega_1 \cos \Omega_2 \quad (87.a)$$

$$\beta_{TVC} = \sin \Omega_2 \quad (87.b)$$

$$\gamma_{TVC} = \cos \Omega_1 \cos \Omega_2 \quad (87.c)$$

Next, the TVC microprocessor code is simulated by integrating the angular rate data as follows:

$$d_{i,j} = \dot{\lambda}_i \delta_{tj} \quad (i=1,2,3; j=1,2) \quad (88)$$

$$T_{di} = \sum_{j=1}^2 d_{i,j} \quad (89)$$

$$\Delta \zeta = \zeta_s \delta_t \quad (90)$$

$$\text{If } |T_{di}| > \Delta \zeta, \text{ then } d_{i,2} = .007812 T_{di} / |T_{di}| \quad (91.a)$$

$$\text{and } d_{i,1} = T_{di} - .0078125 T_{di} / |T_{di}| \quad (91.b)$$

$$\text{If } |T_{di}| < \Delta \zeta, \text{ then } d_{i,2} = T_{di} \quad (92.a)$$

$$\text{and } d_{i,1} = 0 \quad (92.b)$$

where:

$d_{i,j} \equiv$ angular displacement matrix

$\dot{\lambda}_i \equiv$ vector time derivative of TVC angular velocity wrt SCS

$\delta_{tj} \equiv$ integration time step length for increment j

$T_{di} \equiv$ as defined

$\Delta \zeta \equiv$ as defined

$\zeta_s \equiv$ TVC processor sampling rate

Using the Crowder-Hession algorithm, the direction cosine matrices are updated as follows:

$$d_2' = d_2 - d_{3,2} d_1 \quad (93.a)$$

$$d_3' = d_3 + d_{2,2} d_1 \quad (93.b)$$

$$d_1' = d_1 + d_{3,2} d_2' \quad (93.c)$$

$$d_3 = d_3' - d_{1,2} d_2' \quad (93.d)$$

$$d_1 = d_1' - d_{2,2} d_3 \quad (93.e)$$

$$d_2 = d_2' + d_{1,2} d_3 \quad (93.f)$$

Finally, the rocket commands are updated, depending upon the DCM values, as follows:

If $d_3 > 0$:

$$\xi_1 = -d_2 \quad (94.a)$$

$$\xi_2 = d_1 \quad (94.b)$$

If $d_3 < 0$, $d_1 = d_2 = 0$, and $\dot{\theta}_{ST} = 0$:

$$\xi_1 = 2 \quad (95.a)$$

$$\xi_2 = 0 \quad (95.b)$$

If $d_3 < 0$, $d_1 = d_2 = 0$, and $\dot{\theta}_{ST} \neq 0$:

$$\xi_1 = 2 \dot{\theta}_{ST} / |\dot{\theta}_{ST}| \quad (96.a)$$

$$\xi_2 = 0 \quad (96.b)$$

If $d_3 < 0$, and $|d_1| < |d_2|$:

$$\xi_1 = (|d_2| - 2)d_2 / |d_2| \quad (97.a)$$

$$\xi_2 = d_1 \quad (97.b)$$

If $d_3 < 0$, and $|d_1| > |d_2|$:

$$\xi_1 = -d_2 \quad (98.a)$$

$$\xi_2 = (2 - |d_1|) d_1 / |d_1| \quad (98.b)$$

3.6 Numerical Integration

Solution of the various differential equations found in all sections of the GESS program requires numerical integration techniques. Two different types of integration methods are used: the Runge-Kutta method, and the predictor-corrector method. The Runge-Kutta method is well known for its accuracy, but is not computationally efficient for programs with numerous time steps and large arrays. The predictor-corrector method yields reasonable accuracy with excellent computational efficiency.

3.6.1 Runge-Kutta. Runge-Kutta formulas involve the computation of the value of a multivariate function at specified points without the prior calculation of the higher derivatives of the function. If we assume such functions as:

$$\frac{dx}{dt} = f(t, x, y) \quad (99.a)$$

and

$$\frac{dy}{dt} = g(t, x, y) \quad (99.b)$$

we will seek solutions:

$$x(t+h) = x(t) + \Delta x \quad (100.a)$$

and

$$y(t+h) = y(t) + \Delta y \quad (100.b)$$

where:

$$h \equiv \text{time step interval} = \Delta t$$

$$\Delta x = ak_1 + bk_2 + ck_3 + dk_4 \quad (101.a)$$

$$\Delta y = al_1 + bl_2 + cl_3 + dl_4 \quad (101.b)$$

and the general form of the solution is found from:

$$k_1 = hf(t, x, y) \quad (102.a)$$

$$k_2 = hf(t + mh, x + mk_1, y + ml_1) \quad (102.b)$$

$$k_3 = hf[t + nh, x + nk_2 + (n - r)k_1, \\ y + nl_2 + (n - r)l_1] \quad (102.c)$$

$$k_4 = hf[t + ph, x + sk_2 + tk_3 + (p-s-t)k_1, \\ y + sl_2 + tl_3 + (p-s-t)l_1] \quad (102.d)$$

and similarly;

$$l_1 = hg(t, x, y) \quad (102.e)$$

$$l_2 = hg(t + mh, x + mk_1, y + ml_1) \quad (102.f)$$

$$l_3 = hg[t + nh, x + nk_2 + (n-r)k_1, y + nl_2 + (n-r)l_1] \quad (102.g)$$

$$l_4 = hg[t + ph, x + sk_2 + tk_3 + (p-s-t)k_1, \\ y + sl_2 + tl_3 + (p-s-t)l_1] \quad (102.h)$$

The method may be extended for as many first-degree differential equations as are required. A more detailed discussion of Runge-Kutta methods can be found in any numerical methods textbook.

There are several variations of the Runge-Kutta method, each with its own advantages and disadvantages. In GESS, two variations are used. The first, the Kutta-Simpson one-third rule variation, is used for integrations involving relatively small arrays and short simulated time periods, such as in the calculations of the DRI (Section 3.5.1) and dynamic CG (Section 3.5.2). This method assumes constant values of:

$$m = n = r = 1/2 \quad (103.a)$$

$$p = t = 1 \quad (103.b)$$

$$s = 0 \quad (103.c)$$

$$a = d = 1/6 \quad (103.d)$$

$$b = c = 1/3 \quad (103.e)$$

GESS uses the Gill variation for integrating the very large trajectory arrays during the initial four time steps, since it minimizes the number of memory locations. This method assumes constant values of:

$$m = n = 1/2 \quad (104.a)$$

$$p = 1 \quad (104.b)$$

$$r = 1/\sqrt{2} \quad (104.c)$$

$$s = -1/\sqrt{2} \quad (104.d)$$

$$t = 1 + 1/\sqrt{2} \quad (104.e)$$

$$a = d = 1/6 \quad (104.f)$$

$$b = (1 - 1/\sqrt{2})/3 \quad (104.g)$$

$$c = (1 + 1/\sqrt{2})/3 \quad (104.h)$$

3.6.2 Predictor-Corrector. Predictor-Corrector forward integration methods involve the use of an initial prediction formula for the next time step value of a function, followed by the application of a more accurate corrector formula. By iterating these formulas until the solution converges, this procedure achieves successive improvements in both the function value and its subsequently calculated derivative. However, the Hamming variation of applying the predictor-corrector method eliminates the need for iteration by further modifying each of the two equations based on a previously-derived error estimate⁽¹⁰⁾. Thus, the two-pass equations used in GESS based on previously-determined values of the function and derivative at equally spaced time intervals, become:

- Predictor:
$$p_{+1} = y_{-3} + \frac{4}{3}h(2y'_0 - y'_{-1} + 2y'_{-2}) \quad (105.a)$$

- Modifier:
$$y_p = p_{+1} - \frac{112}{121}(p_0 - c_0) \quad (105.b)$$

- Corrector:
$$c_{+1} = \frac{1}{8}[9y_0 - y_{-2} + 3h(y'_{+1} + 2y'_0 - y'_{-1})] \quad (105.c)$$

- Final Value:
$$y_{+1} = c_{+1} + \frac{9}{121}(p_{+1} - c_{+1}) \quad (105.d)$$

where:

$y_k \equiv$ value of function at time step k

$y'_k \equiv$ value of function derivative at time step k

$p_k \equiv$ predicted value of function at time step k

$c_k \equiv$ corrected value of function at time step k

$h \equiv$ time step interval

3.6.3 Integration Arrays. The large number of equations and saved values associated with many of the trajectory integrations in GESS resulted in the development of a highly structured integration array logic. This logic maintains the current value of each integration equation, in addition to all intermediate or previous equation values for both the Runge-Kutta and predictor-corrector methods. Thus, the initial four time steps can be integrated by the Runge-Kutta routine, and subsequent integrations performed by the predictor-corrector routine.

The first value of each array indicates the number of equations involved in the integration. The remaining array values are then ordered, in accordance with the number of equations, as described in Table 3-1.

Table 3-1. Integration Array Values

<u>Array Location</u>	<u>Description</u>
1	number of equations (N)
2 -- (1+N)	results of integrations - equation values
(2+N) -- (1+2N)	equation derivatives
(2+2N) -- (1+3N)	current Runge-Kutta K-values
(2+3N) -- (1+4N)	intermediate Runge-Kutta K-value summations
(2+4N) -- (1+5N)	intermediate equation values
(2+5N) -- (1+6N)	equation values at (time- Δt)
(2+6N) -- (1+7N)	equation values at (time- $2\Delta t$)
(2+7N) -- (1+8N)	equation values at (time- $3\Delta t$)
(2+8N) -- (1+9N)	equation values at (time- $4\Delta t$)
(2+9N) --(1+10N)	equation derivatives at (time- Δt)
(2+10N)--(1+11N)	equation derivatives at (time- $2\Delta t$)
(2+11N)--(1+12N)	equation derivatives at (time- $3\Delta t$)
(2+12N)--(1+13N)	predictor values at current time
(2+13N)--(1+14N)	predictor values at (time+ Δt)
(2+14N)--(1+15N)	corrector values at current time
(2+15N)--(1+16N)	corrector values at (time+ Δt)

4.0 INPUT PREPARATION

4.1 General Procedures

The GESS program has been developed to use a series of specific steps or procedures for its proper execution. The program was developed using the Control Data Corporation computers located at the Naval Air Development Center with the KRONOS operating system, and was programmed using the ASCII FORTRAN IV language^(11,12,13). Slight modifications may be necessary if the program is to be used on other computer systems.

The first step in the execution of the program is to create a series of aerodynamic coefficient tables using a pre-processing program called ACT⁽¹⁴⁾. This routine analyzes a file of raw data from wind tunnel tests consisting of aerodynamic forces and moments acting on the seat/occupant, occupant alone, or seat alone. The program generates a random access file of numerically smoothed, tabular, aerodynamic coefficients which are used in subsequent runs of the GESS program. Once a table has been generated for a specific seat or occupant configuration, it may be reused for all subsequent GESS runs relevant to that configuration. The procedure for generating the ACT file is generally discussed in Section 4.2 and detailed in Appendix A. A description of the theoretical concepts involved can be found in Reference 14.

Next, the GESS input file is created. All program variables are listed in a specific format, which is detailed in Section 4.3. If a previous input file exists for the specific seat and occupant configuration, a relatively few variable changes can usually produce the new input file with minimum effort.

Finally, the simulation job stream file is created. This is the list of commands to the computer which will control the program execution and assemble the output report data. The job stream is detailed for the KRONOS operating system in Section 4.4.

After the submission of the job stream and subsequent program execution, a series of simulation reports, detailed in Section 5.1, are available from the output file. These reports may be reviewed and analyzed according to the user's specific needs. Also, two plotting files may be created at the user's option for further analysis using post-processing routines, such as the DRAS utility program. This program, discussed in Section 5.2, and detailed in Reference 15, performs various data manipulation and graphic function routines using the data from the program plotting files. The CALCOMP-type plots generated can greatly enhance the interpretation of program output.

4.2 Aerodynamic Coefficient Tables

During the execution of the GESS program, equally spaced aerodynamic coefficients are required for computing the aerodynamic forces acting upon the seat/occupant system. These coefficients are usually derived through wind tunnel experiments using the subject ejection seat⁽⁶⁾. The forces and moments data produced by these tests are used as input for the Aerodynamic Coefficient Table (ACT) program⁽¹⁴⁾, which creates the necessary coefficient tables as functions of the seat orientation and velocity. The ACT program provides an efficient method for creating, modifying, and storing these aerodynamic coefficient tables on random access files for retrieval by GESS during simulation execution. The ACT program was closely modeled after the RFWTHR program ⁽⁴⁾.

Detailed instructions for using the ACT program are given in Appendix A. These instructions have been extracted from Reference 14 because of the importance of having proper aerodynamic coefficient tables for the successful execution of GESS.

4.3 Simulation Input Variables

Prior to running the GESS program, an 80 column card image input file must be created. This file consists of START and STOP cards, a three card headers, and fifteen data sections. A sample listing of a typical input file is given in Appendix B.

The program can be run against several sets of data without the user having to resubmit the job. This is accomplished by placing the START card at the beginning of each input set so that the input sets are separated by START cards. A STOP or blank card is placed at the end of the entire input file. The job is terminated when the program reaches this instruction.

The three line header is used to identify the input file, as well as all subsequent output reports. Any alphanumeric data may be entered, but the third line serves to identify the seat to be simulated. If three lines (or records) of description are not necessary, then blank records must be inserted to complete the mandatory three lines. Each of the fifteen data sections contain a specific number of variables or arrays depending upon the section requirements. Each variable occupies a 20 column field comprised of a 10 column alphanumeric descriptor space and a 10 column integer or floating point data space. The descriptor space is provided for the user's convenience, and is usually used to enter the variable name. The descriptor is typically left-justified with any

remaining spaces filled with blanks. The data space is always located to the right of its descriptor space, and should be right-justified in the designated format.

The variable fields are arranged within the data sections in records (or lines) of from one to four fields per record. The individual section requirements for field arrangement are discussed in each of the following subsections.

The GESS program performs a series of checks on the input variables to ensure that the data given will be compatible with the program logic. When problems with the given data are determined, descriptive error messages are printed. These messages will describe the problem as either a "Warning" or a "Fatal Error". Warning messages allow the program to continue, but fatal errors will halt execution, and must be corrected and resubmitted. Both types of messages include a description of the problem encountered.

4.3.1 Program Controls. The Program Control section allows the user to control the execution of the simulation. Variable fields are arranged as shown in Figure 4-1.

DOWHAT			
[HEADER]			
TSTART,	TSTOP,	ESTOP,	IRESTRT
IUNITS,	ISEATTR,	ISOSEP,	IPLOT
IDRIFLC			

Figure 4-1. Program Control Variable Fields

These variables are described in Table 4-1.

Table 4-1. Program Control Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
DOWHAT	Input delimiter variable ("START"-beginning of new input deck) ("STOP"-end of job) ([blank card]-same as "STOP")	A5	N/A
HEADER	Simulation identifier (any relevant 3 lines of alphanumerics)	3(8A10)	N/A
TSTART	Time at which simulation starts (0.0-normal start) (>0.0-restart)	F10.4	sec
TSTOP	Time at which simulation stops (0.0-stop at event ESTOP) (>0.0-stop at time TSTOP)	F10.4	sec
ESTOP	Event at which simulation stops (0-stops a time TSTOP) (1-catapult 1 ignition) (2-catapult 2 ignition) (3-catapult 1 separation) (4-catapult 2 separation) (5-rail separation) (6-rocket 1 ignition) (7-rocket 2 ignition) (8-rocket 3 ignition) (9-rocket 4 ignition) (10-rocket 5 ignition) (11-rocket 6 ignition) (12-rocket 1 burnout) (13-rocket 2 burnout) (14-rocket 3 burnout) (15-rocket 4 burnout) (16-rocket 5 burnout) (17-rocket 6 burnout) (18-drogue chute 1 deployment) (19-drogue chute 1 line stretch) (10-drogue chute 1 full inflation) (21-drogue chute 2 deployment) (22-drogue chute 2 line stretch) (23-drogue chute 2 full inflation) (24-recovery chute deployment) (25-recovery chute line stretch) (26-recovery chute full inflation) (27-peak trajectory) (28-seat/occupant separation) (29-seat/occupant impact) (30-occupant impact)	I2	N/A

(Continued)

Table 4-1. Program Control Variable Descriptions (Continued)

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
ESTOP (Continued)			
	(31-seat impact) (32-aircraft impact) (33-DART right line start) (34-DART left line start) (35-DART right line broken) (36-DART left line broken) (37-seat separation from aircraft) (38-seat first motion)		
IRESTR	Instantaneous restart flag, to create a data base of all trajectory information at a specified time from which multiple continuations can be made (0-restart file not created) (1-not implemented)	I2	N/A
IUNITS	Flag controlling units of measure (0-metric units) (1-English units)	I2	N/A
ISEATTR	Flag controlling seat alone trajectory (0-trajectory not generated) (1-trajectory generated)	I2	N/A
ISOSEP	Flag controlling seat/occupant separation (0-separation suppressed) (1-separation based on time) (2-separation based on force)	I2	N/A
IPLOT	Flag controlling plot file generation (0-plot file not generated) (1-plot file generated)	I2	N/A
IDRIFLG	Flag controlling Dynamic Response Index Calculation (0-DRI not generated) (1-DRI generated)	I2	N/A

4.3.2 Report Flags. The Report Flags section allows the user to select the output reports that will be required for the specific analyses to be conducted. Variable fields are arranged as shown in Figure 4-2.

IREPTS(1),	IREPTS(2),	IREPTS(3),	IREPTS(4)
IREPTS(5),	IREPTS(6),	IREPTS(7),	IREPTS(8)
		.	
		.	
		.	
IREPTS(29),	IREPTS(30),	IREPTS(31)	

Figure 4-2. Report Flag Variable Fields

These variables are described in Table 4-2.

Table 4-2. Report Flags Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IREPTS(i)	Flag controlling report i generator (0-report i not generated) (1-report i generated)	I2	N/A

Refer to Table 5-1 for report titles.

4.3.3 Integration Time Steps. The Integration Time Steps section allows the user to adjust the time increments between trajectory phases. The precision of the trajectory is inversely affected by the size of the time steps; hence, a larger time step, although more economical in terms of computer time, can result in greater inaccuracies in the integration calculations. The simulation has been categorized into three phases:

- . Phase I - from Time = 0 to Seat/Aircraft Separation
- . Phase II - from S/A Separation to Seat/Occupant Separation
- . Phase III - from S/O Separation to Occupant Impact

It is recommended that the earlier phases have very small time increments, since this period is characterized by very complex forces and moments, while later phases have larger time increments to conserve computer time. The variable fields in this section are arranged as shown in Figure 4-3.

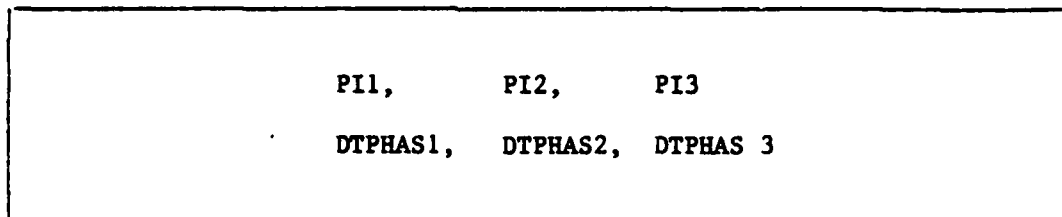


Figure 4-3. Integration Time Step Variable Fields

These variables are described in Table 4-3.

Table 4-3. Integration Time Step Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
PI1	Print frequency - Phase 1	I4	N/A
PI2	Print frequency - Phase 2	I4	N/A
PI3	Print frequency - Phase 3 (PI1 > 0)	I4	N/A
DTPHAS1	Integration time step - Phase 1	F10.4	sec
DTPHAS2	Integration time step - Phase 2	F10.4	sec
DTPHAS3	Integration time step - Phase 3 (DTPHAS1 > 0)	F10.4	sec

4.3.4 Initial Conditions

The Initial Conditions section allows the user to create the precise escape scenario required for analysis. Variable fields are arranged as shown in Figure 4-4.

TEMP,	PRESSUR,	DENSITY	
XPOS,	YPOS,	ZPOS	
YAW,	PITCH,	ROLL	
RVEL,	QVEL,	PVEL	
WINDX,	WINDY,	WINDZ	
XACVEL,	ZACVEL,	CKPITHT	
NPTSAAT,			
AAT(1,1),	AAT(1,2),	AAT(1,3),	AAT(1,4)
	.		
	.		
AAT(50,1),	AAT(50,2),	AAT(50,3),	AAT(50,4)
NPTSLAT			
LAT(1,1),	LAT(1,2),	LAT(1,3),	LAT(1,4)
	.		
	.		
LAT(50,1),	LAT(50,2),	LAT(50,3),	LAT(50,4)

See Section
4.3.4.1

See Section
4.3.4.2

Figure 4-4. Initial Condition Variable Fields

These variables are described in Table 4-4.

Table 4-4. Initial Conditions Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u> Engl.(metr.)
TEMP	Air temperature	F10.4	°F(°C)
PRESSUR	Barometric pressure(>0.0)	F10.4	millibars
DENSITY	Atmospheric density or mass/unit volume (>0.0) (0.0-effective density calculated from TEMP)	F10.4	slugs/ft ³
XPOS	Initial aircraft X-position in EFCS	F10.4	ft(m)
YPOS	Initial aircraft Y-position in EFCS	F10.4	ft(m)
ZPOS	Initial aircraft Z-position in EFCS	F10.4	ft(m)
YAW	Initial aircraft yaw in EFCS	F10.4	deg
PITCH	Initial aircraft pitch in EFCS	F10.4	deg
ROLL	Initial aircraft roll in EFCS	F10.4	deg
RVEL	Initial angular velocity about aircraft Z-Axis, or yaw velocity	F10.4	deg/sec
QVEL	Initial angular velocity about aircraft Y-Axis, or pitch velocity	F10.4	deg/sec
PVEL	Initial angular velocity about aircraft X-Axis, or roll velocity	F10.4	deg/sec
WINDX	Wind X-velocity in EFCS	F10.4	ft/sec (m/sec)
WINDY	Wind Y-velocity in EFCS	F10.4	ft/sec (m/sec)
WINDZ	Wind Z-velocity in EFCS	F10.4	ft/sec (m/sec)
XACVEL	Initial aircraft X-velocity in EFCS (>0.0)	F10.4	ft/sec (m/sec)
ZACVEL	Initial vertical rate of climb in EFCS or sink rate	F10.4	ft/sec (m/sec)
CKPITHT	Aircraft cockpit screen height in ACS or protected height of seat/occupant (>0.0)	F10.4	ft/sec (m/sec)
NPTSAAT	Number of points in aircraft angular acceleration table (0-50)	I3	N/A
AAT(1,j)	Aircraft angular acceleration table array (See Section 4.3.4.1)	1(4F10.4)	sec,deg/ sec ²
NPTSLAT	Number of points in aircraft linear acceleration table (0-50)	I3	N/A
LAT(1,j)	Aircraft linear acceleration table array	1(4F10.4)	sec,ft/sec ² (sec,m/sec ²)

4.3.4.1. If NPTSAAT = 0, no AAT values are given. When $1 < \text{NPTSAAT} < 50$, NPTSAAT lines of AAT values must be entered. Each line of AAT data consists of the time at which that line of data is initialized (AAT(i,1)), followed by the X, Y, and Z values of the angular acceleration (AAT(i,2), AAT(i,3), and AAT(i,4), respectively). The GESS program linearly interpolates the values between points based on the time value. Hence, a typical aircraft angular acceleration table could be set up as follows:

NPTSAAT	5						
AAT(1,1)	0.000	AAT(1,2)	0.0	AAT(1,3)	5.0	AAT(1,4)	0.0
AAT(2,1)	2.999	AAT(2,2)	0.0	AAT(2,3)	5.0	AAT(2,4)	0.0
AAT(3,1)	3.000	AAT(3,2)	0.0	AAT(3,3)	-5.0	AAT(3,4)	0.0
AAT(4,1)	5.999	AAT(4,2)	0.0	AAT(4,3)	-5.0	AAT(4,4)	0.0
AAT(5,1)	6.000	AAT(5,2)	0.0	AAT(5,3)	0.0	AAT(5,4)	0.0

4.3.4.2. The LAT array is set up identically to the AAT array, based on NPTSLAT. Hence, a typical aircraft linear acceleration table could be set up as follows:

NPTSLAT	2						
LAT(1,1)	0.000	LAT(1,2)	0.0	LAT(1,3)	0.0	LAT(1,4)	-32.2
LAT(2,1)	30.000	LAT(2,2)	0.0	LAT(2,3)	0.0	LAT(2,4)	-32.2

4.3.5 Seat Alone Descriptors. The Seat Alone section allows the user to fully describe all aspects of the various escape system ejection seats. Variable fields are arranged as shown in Figure 4-5.

XPOSSRP,	YPOSSRP,	ZPOSSRP
XCGSA,	YCGSA,	ZCGSA
IXXSA,	IXYSA,	IXZSA
IYYSA,	IYZSA,	IZZSA
PHISA,	PSISA,	THESA
AREASA,	HGHTSA,	WGHTSA
XPOSBOT,	YPOSBOT,	ZPOSBOT
XPOSSCS,	YPOSSCS,	ZPOSSCS

Figure 4-5. Seat Alone Variable Fields

These variables are described in Table 4-5.

Table 4-5. Seat Alone Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
XPOSSRP	X position of seat alone aerodynamics reference point	F10.4	ft(m)
YPOSSRP	Y position of seat alone aerodynamics reference point	F10.4	ft(m)
ZPOSSRP	Z position of seat alone aerodynamics reference point	F10.4	ft(m)
XCGSA	X position of seat alone center of gravity in SCS	F10.4	ft(m)
YCGSA	Y position of seat alone center of gravity in SCS	F10.4	ft(m)
ZCGSA	Z position of seat alone center of gravity in SCS	F10.4	ft(m)
IXXSA	Seat alone moment of inertia about X-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXYSA	Seat alone moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXZSA	Seat alone moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYYSA	Seat alone moment of inertia about Y-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYZSA	Seat alone moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IZZSA	Seat alone moment of inertia about Z-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
PHISA	Angular position of seat alone about ACS X-axis	F10.4	deg
PSISA	Angular position of seat alone about ACS Y-axis	F10.4	deg
THESA	Angular position of seat alone about ACS Z-axis	F10.4	deg
AREASA	Aerodynamic reference area of seat alone (>0.0)	F10.4	ft ² (m ²)
HGHTSA	Height or vertical length of seat alone (>0.0)	F10.4	ft(m)
WGHTSA	Weight of seat alone after occupant separation (>0.0)	F10.4	lbs(kg)
XPOSBOT	X-position of seat bottom in RCS	F10.4	ft(m)
YPOSBOT	Y-position of seat bottom in RCS	F10.4	ft(m)
ZPOSBOT	Z-position of seat bottom in RCS	F10.4	ft(m)
XPOSSCS	X-position of SCS origin in RCS	F10.4	ft(m)
YPOSSCS	Y-position of SCS origin in RCS	F10.4	ft(m)
ZPOSSCS	Z-position of SCS origin in RCS	F10.4	ft(m)

4.3.6 Seat/Occupant Descriptors. The Seat/Occupant section allows the user to fully describe all aspects of the seat/occupant combination. Variable fields are arranged as shown in Figure 4-6.

XCGSO,	YCGSO,	ZCGSO
IXXSO,	IXYSO,	IXZSO
IYYSO,	IYZSO,	IZZSO
AREASO,	WGHTSO	

Figure 4-6. Seat/Occupant Variable Fields

These variables are described in Table 4-6.

Table 4-6. Seat/Occupant Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
XCGSO	X-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
YCGSO	Y-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
ZCGSO	Z-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
IXXSO	Seat/occupant moment of inertia about X-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXYSO	Seat/occupant moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXZSO	Seat/occupant moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYYSO	Seat/occupant moment of inertia about Y-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYZSO	Seat/occupant moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IZZSO	Seat/occupant moment of inertia about Z-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
AREASO	Aerodynamic reference area of seat/occupant (>0.0)	F10.4	ft ² (m ²)
WGHTSO	Weight of seat/occupant combination (>0.0)	F10.4	lbs(kg)

4.3.7 Occupant Alone Descriptors. The Occupant Alone section allows the user to fully describe the basic features of the occupant before and after separation from the ejection seat. Variable fields are arranged as shown in Figure 4-7.

LXXOA,	IXOYA,	IXZOA
IYYOA,	IYZOA,	IZZOA
AREAOAA,	WGHTOAB,	WGHTOAA
SOSEP,	DMPGC	

Figure 4-7. Occupant Alone Variable Fields

These variables are described in Table 4-7.

Table 4-7. Occupant Alone Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IXXOA*	Occupant alone moment of inertia about X-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXYOA*	Occupant alone moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IXZOA*	Occupant alone moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYYOA*	Occupant alone moment of inertia about Y-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IYZOA*	Occupant alone moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft ² (kg-m ²)
IZZOA*	Occupant alone moment of inertia about Z-axis (>0.0)	F10.4	slug-ft ² (kg-m ²)

(continued)

* - Input required, although not currently used in program.

Table 4-7. Occupant Alone Variable Descriptions
(Continued)

AREAOAA	Aerodynamic reference area of occupant alone after separation from seat (>0.0)	F10.4	ft ² (m ²)
WGHTOAB	Weight of occupant alone before separation from seat (>0.0) see Section 4.3.7.1	F10.4	lbs(kg)
WGHTOAA	Weight of occupant alone after separation from seat (>0.0) see Section 4.3.7.1	F10.4	lbs(kg)
SOSEP	Seat/occupant separation parameter (>0.0) see Section 4.3.7.2	F10.4	sec;lbs (sec;kg)
DMPGC	Aerodynamic angular damping coefficient (0.0<DMPGC<1.0)	F10.4	N/A

4.3.7.1. After seat/occupant separation, the weight of the occupant alone includes the weight of the parachute pack and all emergency gear. Before separation, this extra weight is considered part of the seat.

4.3.7.2. SOSEP determines the point at which seat/occupant separation occurs. It does this conditionally, depending upon the means being used to determine separation dictated by ISOSEP in Section 1. Hence, if ISOSEP=1, then SOSEP will be the time at which separation occurs. Alternately, if ISOSEP=2, then SOSEP will be the recovery chute force required to produce separation.

4.3.8 Rail Data. The Rail Data section allows the user to fully describe all aspects of the seat/aircraft rail system. Variable fields are arranged as shown in Figure 4-8.

RAILNTH,	RAILANG		
ISTRN,	NSLBKS		
KXSB,	KYSB,	MUSB	
YKTOR,			
XPOSRE,	YPOSRE,	ZPOSRE	
XPOSSLRE,	YPOSSLRE,	ZPOSSLRE	
XPOSSB(1),	YPOSSB(1),	ZPOSSB(1)	See Section 4.3.8.1
.	.	.	
.	.	.	
.	.	.	
XPOSSB(6),	YPOSSB(6)	ZPOSSB(6)	

Figure 4-8. Rail Data Variable Fields

These variables are described in Table 4-8.

Table 4-8. Rail Data Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
RAILNTH	Length of rails (>0.0)	F10.4	ft(m)
RAILANG	Pitch angle of rails WRT ACS X-Axis	F10.4	deg
ISTR	Slider block flag (0-slipper/slider blocks are on seat) (1-slipper/slider blocks are on aircraft)	I3	N/A
NSLBKS	Number of slipper/slider blocks (0-6)	I3	N/A
KXSB	Effective rail spring constant along RCS X-axis(>0.0)	F10.6	lbs/ft (N/m)
KYSB	Effective rail spring constant along RCS Y-axis(>0.0)	F10.6	lbs/ft (N/m)
MUSB	Rail to slider block coefficient of friction (>0.0)	F10.6	N/A
YKTOR	Effective torsional spring constant along RCS Y-axis(>0.0)	F10.6	ft-lbs/deg (N-m/deg)
XPOSRRE	Right rail attachment point along ACS X-axis	F10.4	ft(m)
YPOSRRE	Right rail attachment point along ACS Y-axis	F10.4	ft(m)
ZPOSRRE	Right rail attachment point along ACS Z-axis	F10.4	ft(m)
XPOSLRE	Left rail attachment point along ACS X-axis	F10.4	ft(m)
YPOSLRE	Left rail attachment point along ACS Y-axis	F10.4	ft(m)
ZPOSLRE	Left rail attachment point along ACS Z-axis	F10.4	ft(m)
XPOSSB(i)	Slipper/Slider block i X-position in SCS	F10.4	ft(m)
YPOSSB(i)	Slipper/Slider block i Y-position in SCS	F10.4	ft(m)
ZPOSSB(i)	Slipper/Slider block i Z-position in SCS (see Section 4.3.8.1)	F10.4	ft(m)

4.3.8.1. If NSLBKS = 0, then the GESS program assumes that a continuous "rail within a rail", with no slippers or slider blocks, is being used; the KPOSSB, YPOSSB, and ZPOSSB arrays are not inputted. Otherwise, each of the NSLBKBS slider blocks is located by a separate line of XPOSSB, YPOSSB, and ZPOSSB data.

4.3.9 Catapult Data. The Catapult section allows the user to fully describe all aspects of the in-aircraft catapult seat launching system. Variable fields are arranged as shown in Figure 4-9.

INCAT			
See Section 4.3.9.1	CATLNT(1),	CATSTK(1),	TCI(1)
	XPOSAP(1),	YPOSAP(1),	ZPOSAP(1)
	NPTSCT(1)		
	CATHRST(1,1,1),CATHRST(1,1,2),CATHRST(1,2,1),CATHRST(1,2,2)		
	.		
			See Section 4.3.9.2
			.
			.
	CATHRST(1,25,1),CATHRST(1,25,2)		
See Section 4.3.9.1	CATLNT(2),	CATSTK(2),	TCI(2)
	XPOSAP(2),	YPOSAP(2),	ZPOSAP(2)
	NPTSCT(2)		
	CATHRST(2,1,1),CATHRST(2,1,2),CATHRST(2,2,1),CATHRST(2,2,2)		
	.		
			See Section 4.3.9.2
			.
			.
	CATHRST(2,25,1),CATHRST(2,25,2)		
	ITUBEND		
	KTUBE,	CTUBE,	PTUBE
	MUTUBE,	EXTLNGT	
			See Section 4.3.9.3

Figure 4-9. Catapult Variable Fields

These variables are described in Table 4-9.

Table 4-9. Catapult Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
INCAT	Number of catapults (0-2)	I3	N/A
CATLNT(i)	Length of catapult i tube (>0.0)	F10.4	ft(m)
CATSTK(i)	Length of catapult i stroke (>0.0)	F10.4	ft(m)
TCI(i)	Catapult i time of ignition (>0.0)	F10.4	sec
XPOSAP(i)	Catapult i attachment point on SCS X-axis	F10.4	ft(m)
YPOSAP(i)	Catapult i attachment point on SCS Y-axis	F10.4	ft(m)
ZPOSAP(i)	Catapult i attachment point on SCS Z-axis	F10.4	ft(m)
NPTSCT(i)	Number of points in catapult i thrust table	I3	N/A
CATHRST(i,j,1)	Catapult i thrust table point; time (>0.0)	F10.4	sec
CATHRST(i,j,2)	Catapult i thrust table point; thrust (>0.0)	F10.4	lbs(N)
ITUBEND	Flag to simulate catapult tube bending (0-no tube bending) (1-tube bending using default values) (2-tube bending using input values)	I3	N/A
KTUBE	Tube spring stiffness constant K (>0.0)	F10.4	lb/ft (N/m)
CTUBE	Tube spring damping coefficient K (>0.0)	F10.4	lb-sec/ft (N-sec/m)
PTUBE	Empirical tube bending constant (>0.0)	F10.4	N/A
MUTUBE	Coefficient of friction (>0.0)	F10.4	N/A
EXTLNGT	External length of catapult tube (>0.0)	F10.4	ft(m)

4.3.9.1. Should INCAT=0, then catapults will not be simulated, and no further data is required in this section. If INCAT=1, then one catapult will be simulated, requiring only that catapult's data subsection and the tube bending subsection, if applicable. If INCAT=2, then applicable all data subsections will be required.

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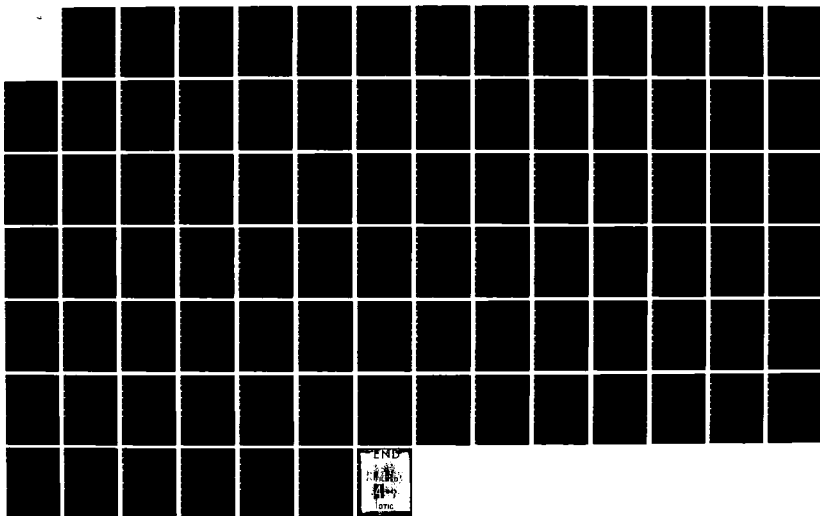
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WARMINSTER PA AIRCRAFT AND CREW S.

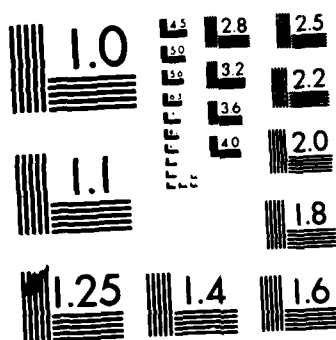
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4.3.9.2. If NPTSCT(1) = 0, then no CATHRST data is required. Otherwise, two CATHRST array values (time and thrust) will be required for each NPTSCT(1) point, arranged in lines of four values each.

4.3.9.3. If ITUBEND=0 or 1, then no further tube bending data is required. If ITUBEND=2, then the five tube bending variables must be entered as indicated.

4.3.10 Rocket Data. The Rocket section allows the user to fully describe all aspects of the ejection seat booster rockets. Variable fields are arranged as shown in Figure 4-10.

4.3.10.1. If INRKT=0, then rockets will not be simulated, and no further data is required in this section.

4.3.10.2. If INRKT > 0, then INRKT represents the number of rocket data subsections required, each describing one of up to six rockets.

4.3.10.3. At least two rocket thrust table points must be given for each rocket subsection. Each point consists of a time value and the thrust at that time. The GESS program linearly interpolates between points based on time.

4.3.10.4. The rocket thrust angles are the direction cosines of the thrust vector with respect to the seat coordinate system. The thrust in each direction is computed by the program based on the total thrust multiplied by the cosines of the rocket angles.

INRKT				
RKIGN(1),	RKWGHT(1),	RKBURN(1),	RKDELY(1)	See Section 4.3.10.1
XPOSRK(1),	YPOSRK(1),	ZPOSRK(1)		
RKALPH(1),	RKBETA(1),	RKGAMA(1)		
RKNPTS(1)				See Section 4.3.10.2
RKTHRST(1,1,1),	RKTHRST(1,1,2),	RKTHRST(1,2,1),	RKTHRST(1,2,2)	See Section 4.3.10.3
.	.	.	.	
.	.	.	.	
RKTHRST(1,25,1),	RKTHRST(1,25,2)			
.	.	.	.	
RKIGN(6),	RKWGHT(6),	RKBURN(6),	RKDELY(6)	See Section 4.3.10.2
XPOSRK(6),	YPOSRK(6),	ZPOSRK(6)		
RKALPH(6),	RKBETA(6),	RKGAMA(6)		
RKNPTS(6)				
RKTHRST(6,1,1),	RKTHRST(6,1,2),	RKTHRST(6,2,1),	RKTHRST(6,2,2)	See Section 4.3.10.3
.	.	.	.	
.	.	.	.	
RKTHRST(6,25,1),	RKTHRST(6,25,2)			

Figure 4-10. Rocket Variable Fields

These variables are described in Table 4-10.

Table 4-10. Rocket Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
INKRT	Number of booster rockets on seat (0-6)	I3	N/A
RKIGN(1)	Seat travel on rail prior to rocket 1 ignition (>0.0)	F10.4	ft(m)
RKWGHT(1)	Weight of fuel in rocket 1 (>0.0)	F10.4	lbs(kg)
RKBURN(1)	Burn time for rocket 1 (>0.0)	F10.4	sec
RKDLY(1)	Delay time for rocket 1 ignition after RKIGN(1)(>0.0)	F10.4	sec
XPOSRK(1)	Position of rocket 1 in SCS X-axis	F10.4	ft(m)
YPOSRK(1)	Position of rocket 1 in SCS Y-axis	F10.4	ft(m)
ZPOSRK(1)	Position of rocket 1 in SCS Z-axis	F10.4	ft(m)
RKALPH(1)	Thrust angle of rocket 1 WRT SCS X-axis	F10.4	deg*
RKBETA(1)	Thrust angle of rocket 1 WRT SCS Y-axis	F10.4	deg*
RKGAMA(1)	Thrust angle of rocket 1 WRT SCS Z-axis	F10.4	deg*
RKNPTS(1)	Number of points in rocket 1 thrust table (2-25)	I3	N/A
RKTHRST(1,j,1)	Rocket 1 thrust table point j time (>0.0)	F10.4	sec
RKTHRST(1,j,2)	Rocket 1 thrust table point j thrust (>0.0)	F10.4	lbs(N)

* See Section 4.3.10.4.

4.3.11 Drogue Chute Data. The Drogue Chute section allows the user to describe the drogue chute system. Variable fields are arranged as shown in Figure 4-11.

4.3.11.1. If IDROGUE=0, then no further information is required in this section.

4.3.11.2. If IDROGLS=1, then this subsection is not required.

4.3.11.3. If IDROGLS=0, then this subsection is not required.

4.3.11.4. Two values are required for each line stretch table point specified by NPTSDLS. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

4.3.11.5. If IFTDRO1=0, then no further information is required in this subsection.

4.3.11.6. Two values are required for each line stretch table point specified by NPTDRO1. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

4.3.11.7. If IDROGUE < 3, then no information is required in this subsection.

4.3.11.8. If IFTDRO2=0, then no further information is required in this subsection.

4.3.11.9. Two values are required for each line stretch table point specified by NPTDRO2. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

IDROGUE					
TDDPLOY,	DISPLOY,	DROGLL			See Section 4.3.11.1
DRDRAG1,	DROGPD1,	POROSD1			
AREADC,	WGHTDC,	CDDC			
XDROGAP,	YDROGAP,	ZDROGAP			
IDROGLS					
DROVELX,	DROVELY,	DROVELZ			See Section 4.3.11.2
NPTSDLS					
DROGLS(1,1),	DROGLS(1,2),	DROGLS(2,1),	DROGLS(2,2)		See Section 4.3.11.3
.	.	.	.		
DROGLS(25,1),	DROGLS(25,2)				See Section 4.3.11.4
IFTDRO1					
NPTDFT1					
DROGFT1(1,1),	DROGFT1(1,2),	DROGFT1(2,1),	DROGFT1(2,2)		See Section 4.3.11.5
.	.	.	.		
DROGFT1(25,1),	DROGFT1(25,2)				See Section 4.3.11.6
VELCON					
DRDRAG2	DROGPD2,	POROSD2			
IFTDRO2					See Section 4.3.11.7
NPTDFT2					
DROGFT2(1,1),	DROGFT2(1,2),	DROGFT2(2,1),	DROGFT2(2,2)		See Section 4.3.11.8
.	.	.	.		
DROGFT2(25,1),	DROGFT2(25,2)				See Section 4.3.11.9

Figure 4-11. Drogue Chute Variable Fields

These variables are described in Table 4-11.

Table 4-11. Drogue Chute Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IDROGUE	Drogue chute control flag (0-do not simulate drogue chute) (1-simulate standard single drogue chute) (2-simulate VELCON/duplex drogue system)	I3	N/A
TDDPLOY	Time of drogue chute deployment (>0.0)	F10.4	sec
DISPLOY	Seat rail travel required for drogue chute deployment (>0.0)	F10.4	ft(m)
DROGLL	Drogue chute line length (>0.0)	F10.4	ft(m)
DRDRAG1	Drogue chute 1 drag coefficient (>0.0)	F10.4	N/A
DROGPD1	Drogue chute 1 projected diameter (>0.0)	F10.4	ft(m)
POROSD1	Drogue chute 1 effective porosity (>0.0)	F10.4	N/A
AREADC	Drogue container/slug reference area (>0.0)	F10.4	ft ² (m ²)
WGHTDC	Drogue container/slug weight (>0.0)	F10.4	lb(kg)
CDDC	Drogue container/slug drag coefficient (>0.0)	F10.4	N/A
XDROGAP	Drogue chute attachment point along SCS X-axis	F10.4	ft(m)
YDROGAP	Drogue chute attachment point along SCS Y-axis	F10.4	ft(m)
ZDROGAP	Drogue chute attachment point along SCS Z-axis	F10.4	ft(m)
IDROGLS	Drogue chute time of line stretch control flag (0-use slug/container projection velocity)* (1-use input table data)	I3	N/A
DROVELX	Drogue container/slug projection velocity in SCS X-axis	F10.4	ft/sec (m/sec)
DROVELY	Drogue container/slug projection velocity in SCS Y-axis	F10.4	ft/sec (m/sec)
DROVELZ	Drogue container/slug projection velocity in SCS Z-axis	F10.4	ft/sec (m/sec)
NPTSDLS	Number of points in drogue chute line stretch table (2-25)	I3	N/A

(continued)

*See Section 4.3.11.2 and 4.3.11.3

Table 4-11. Drogue Chute Variable Descriptions
(Continued)

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
DROGLS(i,1)	Drogue chute line stretch table point i velocity (>0.0)	F10.4	ft/sec (m/sec)
DROGLS(i,2)	Drogue chute line stretch table point i time (>0.0)	F10.4	sec
IFTDRO1	Drogue chute i fill time control flag (0-use default table data) (1-use input table data)	I3	N/A
NPTDFT1	Number of points in drogue i fill time table (2-25)	I3	N/A
DROGFT1(j,1)	Drogue chute i fill time table point j velocity (>0.0)	F10.4	ft/sec (m/sec)
DROGFT1(j,2)	Drogue chute i fill time table point j time (>0.0)	F10.4	sec
VELCON	Seat velocity at which VELCON drogue chute disengages (>0.0)	F10.4	ft/sec (m/sec)

4.3.12 Recovery Chute Data. The Recovery Chute section allows the user to describe the recovery parachute system. Variable fields are arranged as shown in Figure 4-12.

4.3.12.1. If IRECOV=0, then the recovery chute deployment is to be suppressed, and no further information is required in this section.

4.3.12.2. If NPTSRDT=1, then only the value of TRDPLOY is entered. If $1 < \text{NPTSRDT} < 25$, then only the deployment time table array, RECOVDT, is entered.

4.3.12.3. Two values are required for each line stretch table point specified by NPTSRLS. These points are arranged in the order of ascending velocities, with up to two points (or four values) per line.

4.3.12.4. If IFTRECV=0 or 1, then no further information is required by this section.

4.3.12.5. Two values are required for each full inflation table point specified by IFTRECV. These points are arranged in the order of ascending velocities, with up to two points (or four values) per line.

4.3.13 DART Data. The Directional Automatic Realignment of Trajectory (DART) sections allows the user to fully describe all aspects of the DART stabilization system. Variable fields are arranged as shown in Figure 4-13.

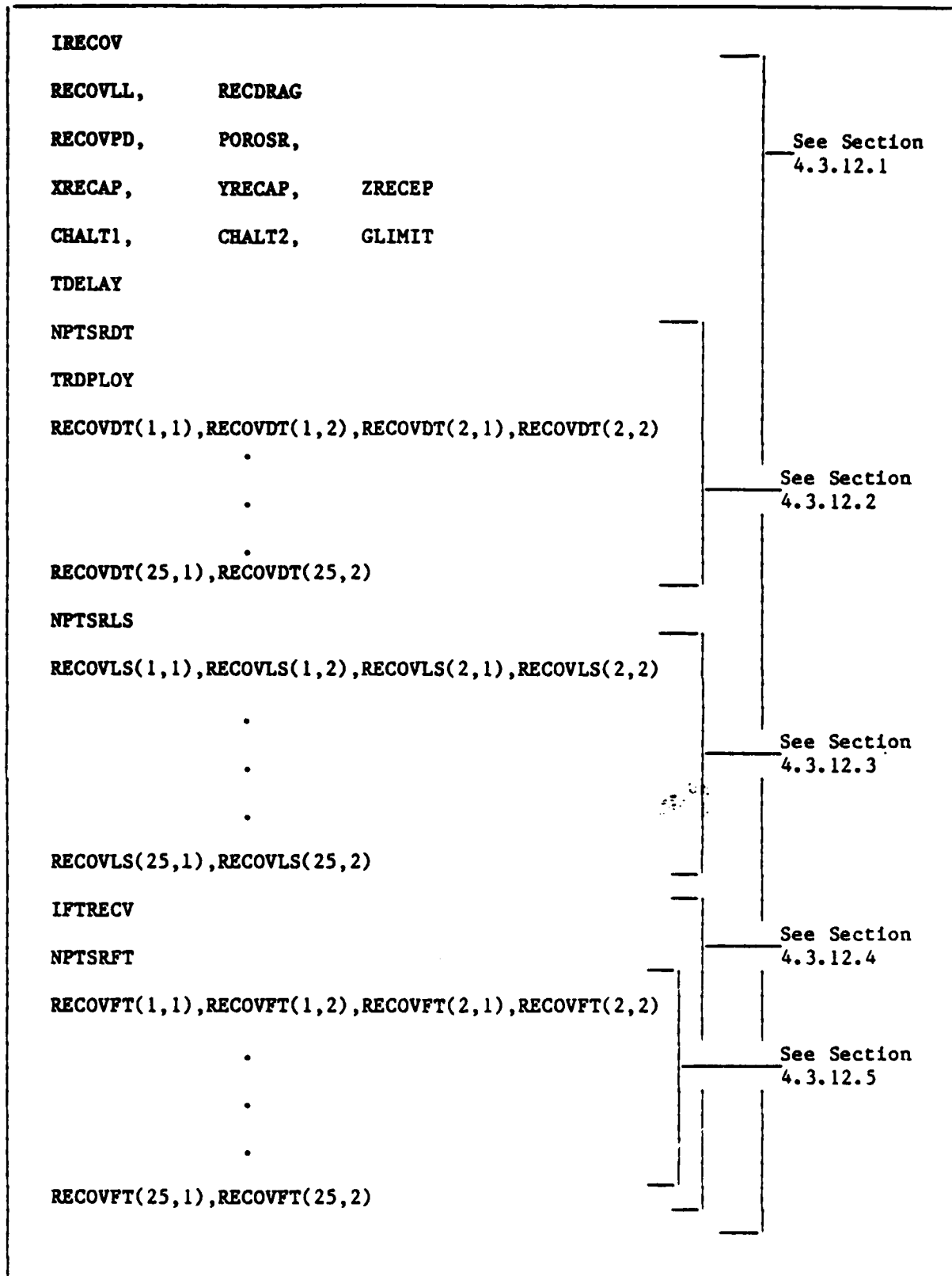


Figure 4-12. Recovery Chute Variable Fields

These variables are described in Table 4-12.

Table 4-12. Recovery Chute Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IRECOV	Recovery chute control flag (0-do not simulate recovery chute) (1-simulate recovery chute with fixed time delay) (2-simulate recovery chute with time delay extended for exceeding GLIMIT)	I3	N/A
RECOVLL	Recovery chute line length (>0.0)	F10.4	ft(m)
RECDRAG	Recovery chute drag coefficient (>0.0)	F10.4	N/A
RECOVPD	Recovery chute projected diameter (>0.0)	F10.4	ft(m)
POROSR	Recovery chute effective porosity (>0.0)	F10.4	N/A
XRECAP	Recovery chute attachment point along SCS X-axis	F10.4	ft(m)
YRECAP	Recovery chute attachment point along SCS Y-axis	F10.4	ft(m)
ZRECAP	Recovery chute attachment point along SCS Z-axis	F10.4	ft(m)
CHALT1	Lower chute deployment altitude (>0.0)	F10.4	ft(m)
CHALT2	Upper chute deployment altitude (>CHALT1)	F10.4	ft(m)
GLIMIT	Acceleration limit in SCS Z-axis for chute deployment delay (>0.0)	F10.4	G
TDELAY	Recovery chute deployment delay time between CHALT1 and CHALT2 (>0.0)	F10.4	sec
NPTSRTD	Number of points in recovery chute deployment time table (1-25)	I3	N/A
TRDPLOY	Time at which recovery chute is deployed (>0.0)	F10.4	sec
NPTSRLS	Number of points in recovery chute line stretch table (2-25)	I3	N/A
RECOVLS(1,1)	Recovery chute line stretch table point 1 velocity (>0.0)	F10.4	ft/sec (m/sec)
RECOVLS(1,2)	Recovery chute line stretch table point 1 time (>0.0)	F10.4	sec
IFTRECV	Recovery chute fill time control flag (0-use default table data) (1-use input table data)	I3	N/A
NPTSRTF	Number of points in recovery chute fill time table (2-25)	I3	N/A
RECOVFT(1,1)	Recovery chute fill time table point 1 velocity (>0.0)	F10.4	ft/sec (m/sec)
RECOVFT(1,2)	Recovery chute fill time table point 1 time (>0.0)	F10.4	sec

IDART			See Section 4.3.13.1
DRTFRCE,	DRTSTRT,	DRSTOP	
XDRTAP(1),	YDRTAP(1),	ZDRTAP(1)	
XDRTCP(1),	YDRTCP(1),	ZDRTCP(1)	
XDRTAP(2),	YDRTAP(2),	ZDRTAP(2)	
XDRTCP(2),	YDRTCP(2),	ZDRTCP(2)	

Figure 4-13. DART Variable Ends

These variables are described in Table 4-13.

Table 4-13. DART Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IDART	DART system flag (0-no DART system) (1-DART system)	I3	N/A
DRTFRCE	Force which the DART lines exert on the seat (>0.0)	F10.4	lbs(N)
DRTSTRT	Distance between seat and aircraft at which the DART initiates stabilization (>0.0)	F10.4	ft(m)
DRTSTOP	Distance between seat and aircraft at which the DART lines break (>DRTSTRT)	F10.4	ft(m)
XDRTAP(1)	DART line 1 cockpit attachment point along SCS X-axis	F10.4	ft(m)
YDRTAP(1)	DART line 1 cockpit attachment point along SCS Y-axis	F10.4	ft(m)
ZDRTAP(1)	DART line 1 cockpit attachment point along SCS Z-axis	F10.4	ft(m)
XDRTCP(1)	DART line 1 confluence point along SCS X-axis	F10.4	ft(m)
YDRTCP(1)	DART line 1 confluence point along SCS Y-axis	F10.4	ft(m)
ZDRTCP(1)	DART line 1 confluence point along SCS Z-axis	F10.4	ft(m)

4.3.13.1. If IDART=0, no further information is required in this section.

4.3.14 TVC Data. The Thrust Vector Control (TVC) section allows the user to implement and describe the response of a gimbale booster rocket. Variable fields are arranged as shown in Figure 4-14.

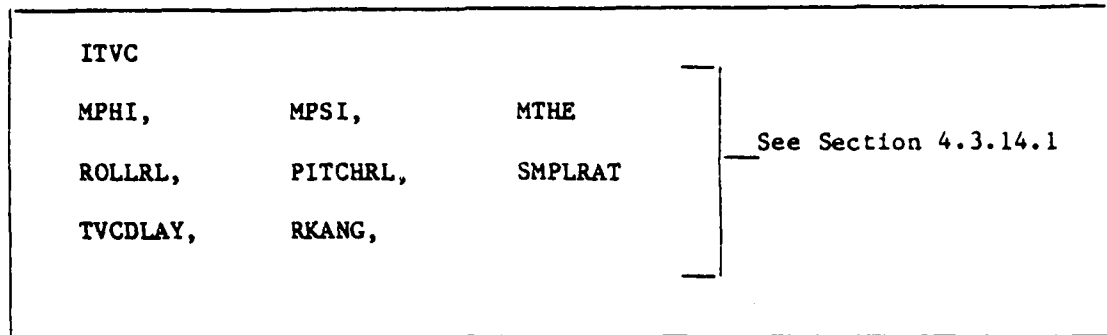


Figure 4-14. TVC Variable Fields

These variables are described in Table 4-14.

Table 4-14. TVC Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
ITVC	Thrust vector control (TVC) flag (0-do not simulate TVC) (1-simulate TVC)	I3	N/A
MPHI	TVC coordinate system rotation about SCS X-axis	F10.4	deg
MPSI	TVC coordinate system rotation about SCS Y-axis	F10.4	deg
MTHE	TVC coordinate system rotation about SCS Z-axis	F10.4	deg
ROLLRL	Rocket rotation limit about TVCCS X-axis	F10.4	deg
PITCHRL	Rocket rotation limit about TVCCS Y-axis	F10.4	deg
SMPLRAT	Gyroscope maximum sampling rate (>0.0)	F10.4	deg/ sec
TVCDLAY	TVC gimbaling time delay after rocket ignition (>0.0)	F10.4	sec
RKANG	Neutral rocket pitch angle in TVCCS	F10.4	deg

4.3.14.1. If ITVC=0, then no further information is required in this section.

4.3.15 Dynamic CG Data. The Dynamic Center of Gravity (CG) section allows the user to implement and describe the response of an occupant modeled as a single mass connected to the seat by a three-dimensional spring-damper system. Variable fields are arranged as shown in Figure 4-15.

IDYNCG			
CX,	XSLACK,	SXP	See Section 4.3.15.1
SXN,	CY,	SY	
CZ,	ZSLACK,	SZP	
ZBOT,	SZNI,	SZN2	

Figure 4-15. Dynamic CG Variable Fields

These variables are described in Table 4-15. Typical dynamic CG X, Y, and Z-axis spring constants are shown in Figures 4-16, -17, and -18.

Tz 4-15. Dynamic CG Variable Descriptions

<u>Variable</u>	<u>Definition (Legal Values)</u>	<u>Format</u>	<u>Units</u>
IDYNCG	Dynamic CG flag (0-do not simulate dynamic CG) (1-simulate dynamic CG using default values) (2-simulate dynamic CG using input values)	I3	N/A
CX	Damping constant along SCS X-axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
XSLACK	No-response distance along SCS X-axis (>0.0)	F10.4	ft(m)
SXP	Spring constant along SCS positive X-axis (>0.0)	F10.4	lbs/ft (N/m)
SXN	Spring constant along SCS negative X-axis (>0.0)	F10.4	lbs/ft (N/m)
CY	Damping constant along SCS Y-axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
SY	Spring constant along SCS Y-axis (>0.0)	F10.4	lbs/ft (N/m)
CZ	Damping constant along SCS Z-Axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
ZSLACK	No-response distance along SCS Z-axis (>0.0)	F10.4	ft(m)
SZP	Spring constant along SCS positive Z-axis (>0.0)	F10.4	lbs/ft (N/m)
ZBOT	Absolute value of bottoming distance along SCS Z-axis (>0.0)	F10.4	ft(m)
SZN1	Spring constant below ZBOT (>0.0)	F10.4	lbs/ft (N/m)
SZN2	Spring constant above ZBOT (>SZN1)	F10.4	lbs/ft (N/m)

4.3.15.1. If IDYNCG=0 or 1, then no further information is required in this section.

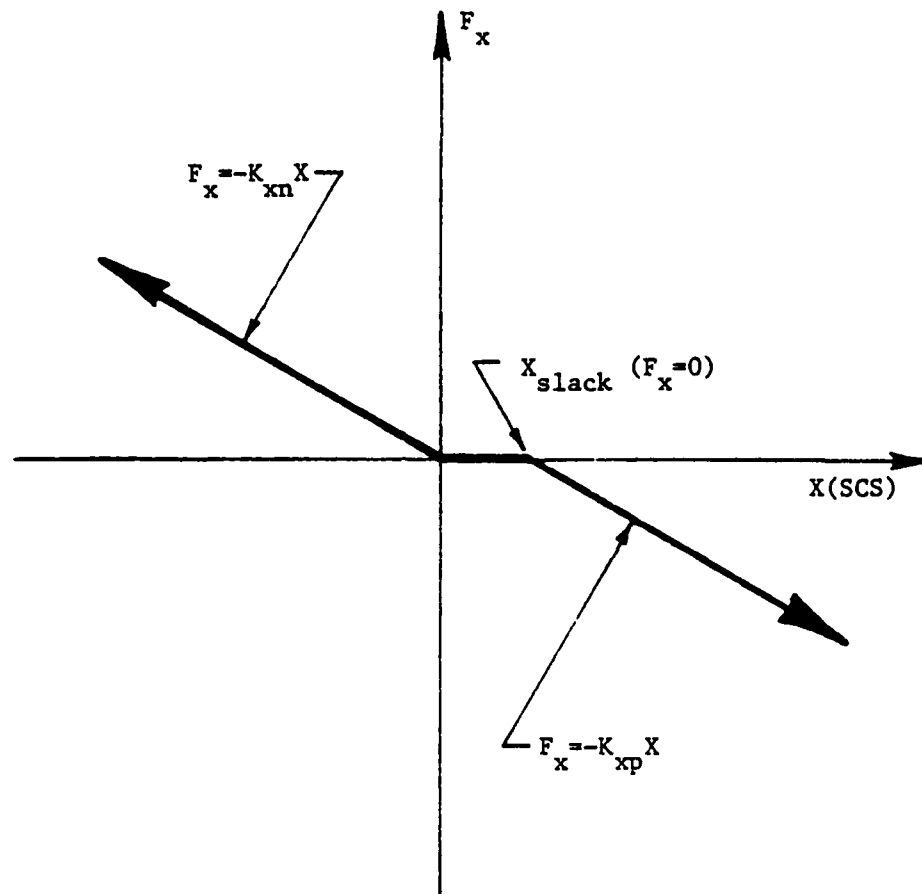


Figure 4-16. Dynamic CG X-Axis Spring Constants

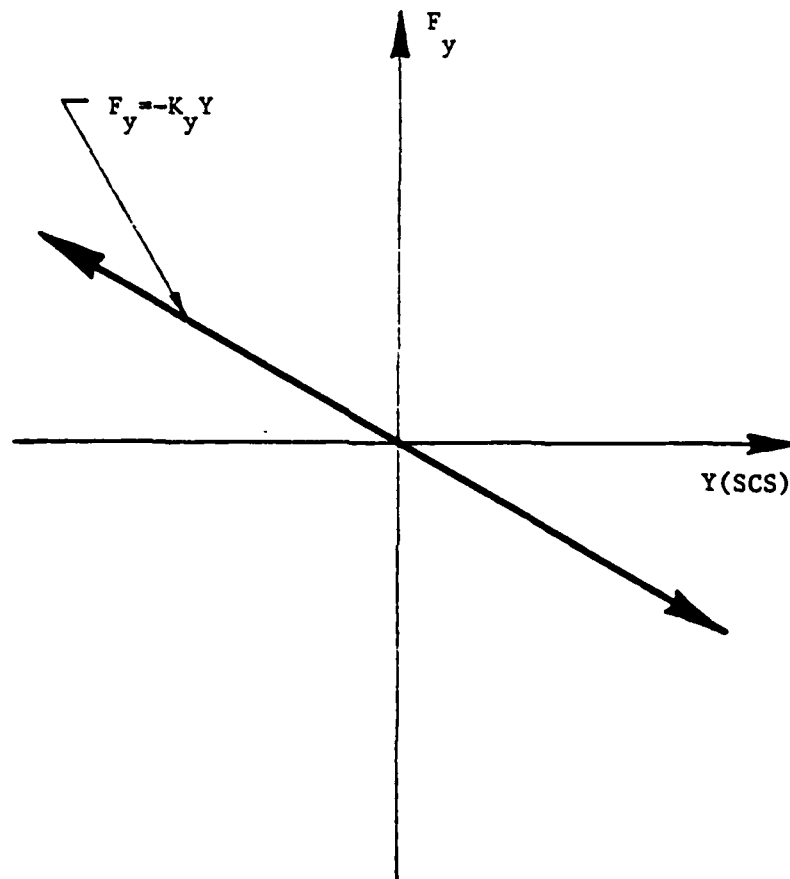


Figure 4-17. Dynamic CG Y-Axis Spring Constants

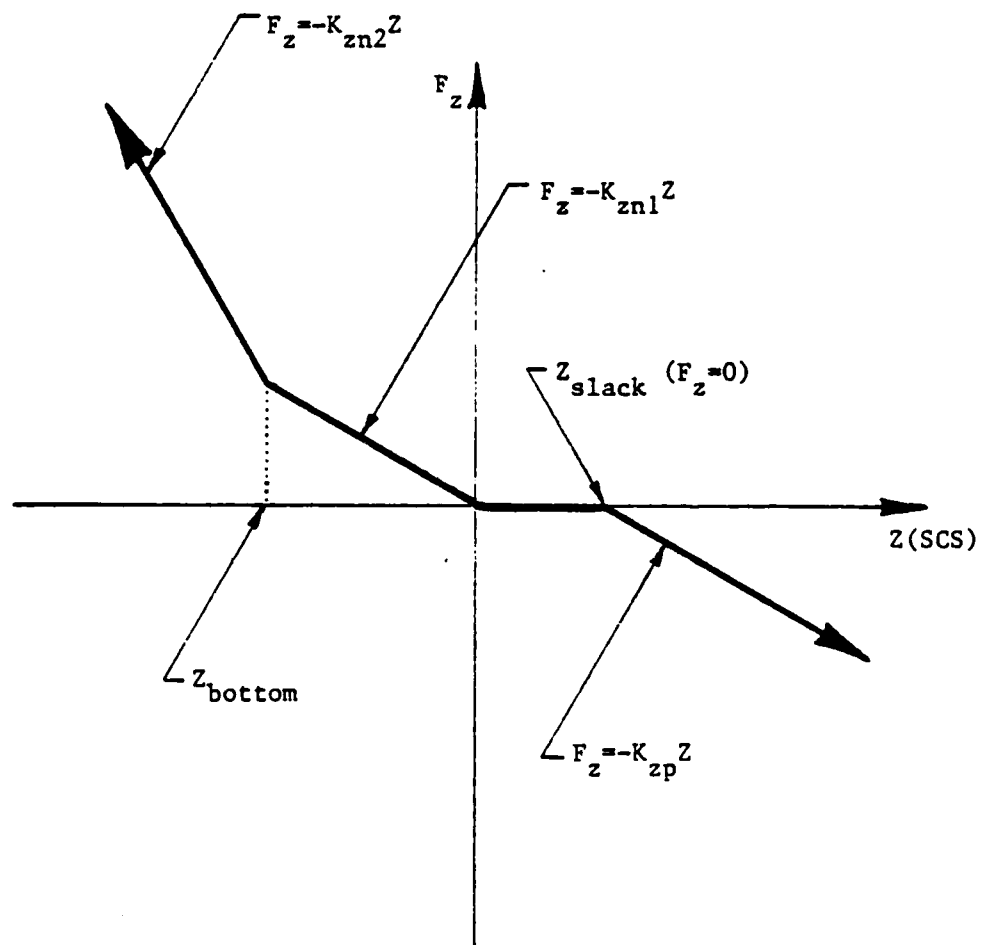


Figure 4-18. Dynamic CG Z-Axis Spring Constants

4.4 Execution Job Stream

The GESS program is executed by submitting to the computer a series of operating system commands known as the "job stream". The job stream can be entered line-by-line interactively. However, it is usually more convenient to prepare a job stream, or "submit file", in advance of execution and "batch" submit this file to the computer for execution. The interactive commands to batch submit a job stream are:

GET,filename

SUBMIT,filename

Another print site can be specified if the main computer center printer is not desired.

SUBMIT,filename, EI=print site identifier

If no printed output is desired:

SUBMIT,filename,N

Figure 4-18 presents a recommended job stream for GESS execution using the CDC KRONOS operating system. This job stream provides for:

- the loading of the prepared input file (GESSI)
- the loading of the ACT program-generated aerodynamic coefficient tables (AERO4)
- the loading and execution of the pre-compiled program binary code (GESSB)
- the optional creation or replacement of program-generated plotting data files (GESST and GESSZ)
- the creation of a single, inclusive, indirect access output file containing a mirror copy of the original input file and all requested program-generated reports (GESSO)

- . A "day file" record of the submitted job execution (GESSDAY)
- . An error recovery logic that saves the day file and any prior output, in the eventuality of an execution error

The recommended job stream is intended for execution runs generating a nominal number of output reports and/or simulating a relatively few seconds of simulated trajectory. Should a large number of reports and/or a long simulation period be desired, the output (and, possibly, the plotting files) should be created either as a direct access file, or as several indirect files. Refer to Reference 12 for details on direct file creation on the KRONOS system.

```

/JOB
GESS(CB200000,T75)
ACCOUNT(XXXXXX,YYYYYY)
ASSIGN,MS,OUTPUT
GET(TAPE1=KGESI)
GET(TAPE2=AERO4)
GET(GESSB)
MAP(OFF)
GESSB.
REPLACE(TAPE42=KGEST)
REPLACE(TAPE41=KGESZ)
GOTO,1.
EXIT.
1,REWIND,*
SKIPF(DAYFILE)
COPYSBF(TAPE1,OUTPUT)
COPYBF(TAPE5,OUTPUT)
COPYBF(TAPE6,OUTPUT)
COPYBF(TAPE7,OUTPUT)
.
.
.
COPYBF(TAPE40,OUTPUT)
REWIND,OUTPUT.
REPLACE(OUTPUT=KGESO)
GOTO,2.
EXIT.
2,DAYFILE,GESSDAY.
REPLACE,GESSDAY.
EXIT.
/EOR
/EOI

```

Figure 4-19. GESS Execution Job Stream for CDC KRONOS/OS

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5.0 OUTPUT INTERPRETATION

5.1 Report Descriptions

The GESS program can, at the user's option, generate up to 31 different output reports. Each of these reports, listed in Table 5.1, describes a different aspect of ejection seat escape simulated performance. The reports show specific performance variables in relation to the simulated time of occurrence, and also show the times at which specific sequential events occur. An example series of output reports is presented in Appendix B.

Table 5-1. GESS Report Titles

<u>Report Number</u>	<u>Report Title</u>
1	Input Validation
2	Seat/Occupant Linear Time History
3	Seat/Occupant Angular Time History
4	Occupant Alone Linear Time History
5	Seat Alone Linear Time History
6	Seat Alone Angular Time History
7	Seat/Occupant Linear Time History WRT Aircraft
8	Seat/Occupant Angular Time History WRT Aircraft
9	Occupant Alone Linear Time History WRT Aircraft
10	Seat Alone Linear Time History WRT Aircraft
11	Seat Alone Angular Time History WRT Aircraft
12	Catapult Forces and Moments
13	Rocket 1 Forces and Moments
14	Rocket 2 Forces and Moments

(continued)

Table 5-1. GESS Report Titles (Cont'd)

<u>Report Number</u>	<u>Report Title</u>
15	Rocket 3 Forces and Moments
16	Rocket 4 Forces and Moments
17	Rocket 5 Forces and Moments
18	Rocket 6 Forces and Moments
19	DART Forces and Moments
20	Drogue Forces and Moments
21	Recovery Chute Forces and Moments
22	Thrust Vector Control Microprocessor Data
23	Rail Forces And Moments
24	Seat/Occupant Aerodynamic Forces and Moments
25	Occupant Alone Aerodynamic Forces and Moments
26	Seat Alone Aerodynamic Forces and Moments
27	Occupant Alone Angular Time History (not currently implemented)
28	Aircraft Linear Time History
29	Aircraft Angular Time History
30	Aerodynamic Coefficients Time History
31	Dynamic Center of Gravity Data

5.2 Plotting Files

The user has the option of creating up to two sequential files of simulated trajectory data which can be used for generating trajectory plots on a Calcomp-type plotter. When the IPLOT flag is set equal to 1 (see Section 4.3.1), an EFCS-based plotting file is generated as TAPE42, and an ACS-based plotting file is generated as TAPE41 (see Section 4.4). The contents of either of these

files is described in Figure 5-1. The trajectory variables that are recorded in each of these files are listed in Table 5-2.

The plotting files have been specifically designed to be compatible with the Data Reduction and Analysis System (DRAS). This program has three primary capabilities. First, data reduction routines are provided, such as frequency filtering, moving average calculation, interpolation, integration, differentiation, and others. Second, a simplified plot-generation instruction set are provided. Third, output data files may be provided for generating input files for additional analysis.

An example of a DRAS-generated plot, comparing a GESS-calculated trajectory with the trajectory of an ejection seat during field performance testing, is shown in Figure 5-2. The use of the DRAS program in conjunction with GESS plotting files is detailed in Reference 15. Users desiring to access GESS-generated plotting files with other analysis routines should review subroutines PLOTBIN and PLOTWAC, as given in the Volume II GESS Programmer's Manual.

<u>Record No.</u>	<u>File Section</u>
1	Header
1	General Data
2,3	Variable Names
4	Simulation Data
5-n*	Trajectory Data
* one record per time point	

Figure 5-1. Plotting File Structure

Table 5-2. TAPE42 Plotting File Trajectory Variables

- . TAPE42 Trajectory Variables are in the EPCS.
- . TAPE41 Trajectory Variables are in the ACS.

<u>Variable No.</u>	<u>Variable Name</u>
1	time
2	S0/OA x-acceleration
3	S0/OA y-acceleration
4	S0/OA z-acceleration
5	S0/OA total acceleration
6	S0/OA x-velocity
7	S0/OA y-velocity
8	S0/OA z-velocity
9	S0/OA total velocity
10	S0/OA x-position
11	S0/OA y-position
12	S0/OA z-position
13	S0/OA roll rate
14	S0/OA pitch rate
15	S0/OA yaw rate
16	S0/OA roll angle
17	S0/OA pitch angle
18	S0/OA yaw angle
19	S0/SA x-acceleration
20	S0/SA y-acceleration
21	S0/SA z-acceleration
22	S0/SA total acceleration
23	S0/SA x-velocity
24	S0/SA y-velocity
25	S0/SA z-velocity
26	S0/SA total velocity
27	S0/SA x-position
28	S0/SA y-position
29	S0/SA z-position
30	S0/SA roll rate
31	S0/SA pitch rate
32	S0/SA yaw rate
33	S0/SA roll angle
34	S0/SA pitch angle
35	S0/SA yaw angle

97'02'23

CESS PROGRAM VALIDATION - RUN NO. 4 - 28 MARCH 1983

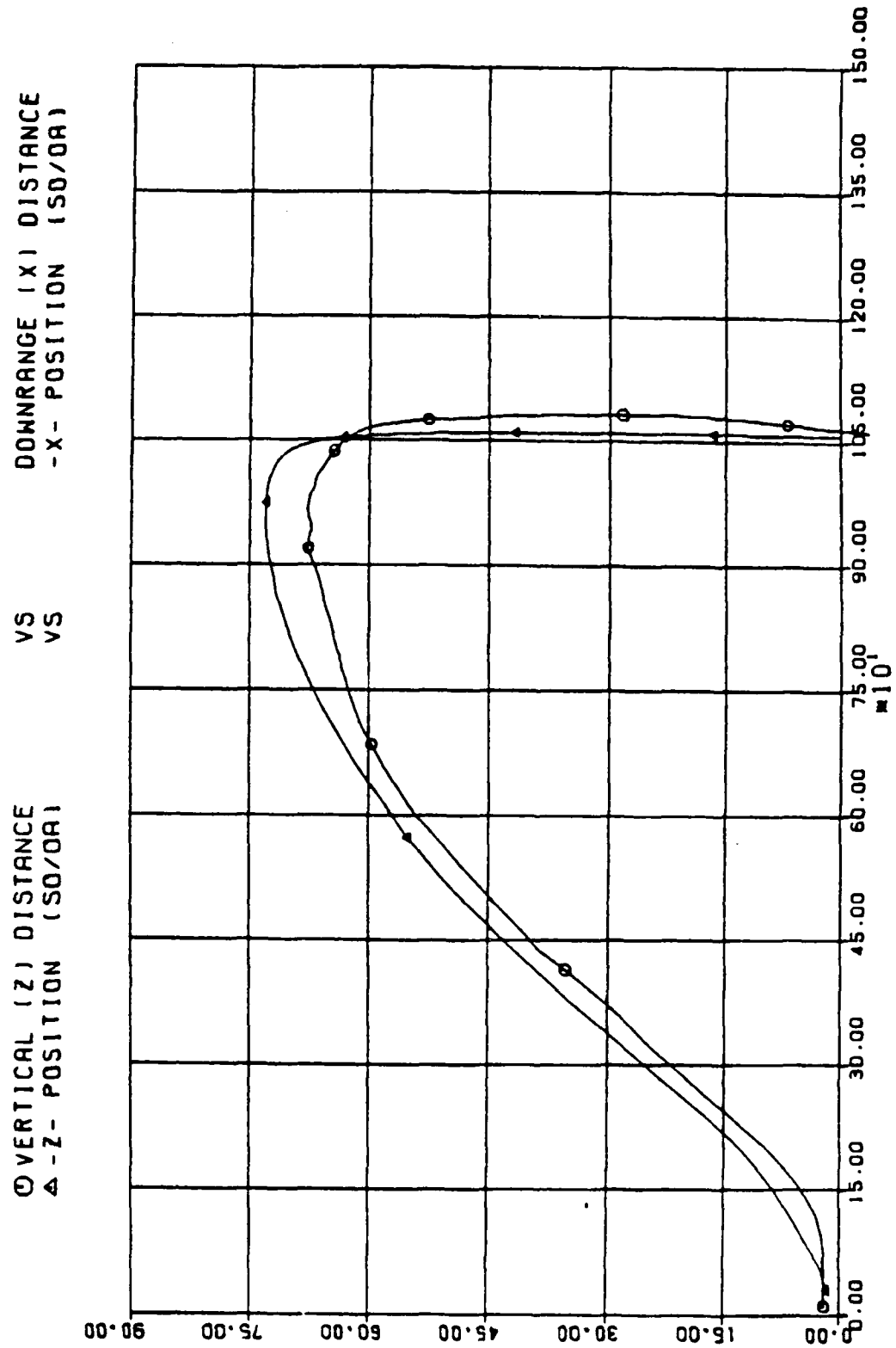


Figure 5-2. Sample DRAS-Generated Trajectory Plots

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6.0 PERFORMANCE ASSESSMENT

A series of simulations has been performed using input variables extracted from ejection sled test data obtained at the Naval Weapons Center Supersonic Naval Ordinance Research Track (NWC/SNORT) facility at China Lake, CA during the ESCAPAC Replacement Test Program. A summary of the input variables describing these simulations are listed in Table 6-1 while the complete input listings of these simulations are presented in Appendix D. The sled tests chosen for these simulations were selected based upon dummy size (3 and 98 percentile) and sled downrange velocity (zero, low, and high speeds).

To enhance the interpretation of the simulation and test data comparisons, a series of plots was generated, comparing each of the simulation trajectories to the photometric trajectory data taken from the corresponding sled test. Four types of comparison plots were generated for each of four simulation/test data sets, and the four plots of each type are presented in Figures 6-1 through 6-4. These figures are discussed in detail below.

Figure 6-1 illustrates the seat/occupant (S/O) and occupant alone (O/A) trajectories in the X-Z plane. It can be seen that, despite the wide variations in wind, aircraft velocity, and dummy weight, the simulated trajectories closely parallel their corresponding test (actual) trajectories. It should be noted that three of the four simulations exhibited higher trajectory apogee than test apogee. In simulation 2, predicted apogee is approximately 50 percent higher than actual. However, the downrange distance at impact, in all cases, shows excellent agreement.

Figure 6-2 illustrates the downrange velocity time histories of the S/O-O/A. Despite a wide variation in the initial ejection velocities, and

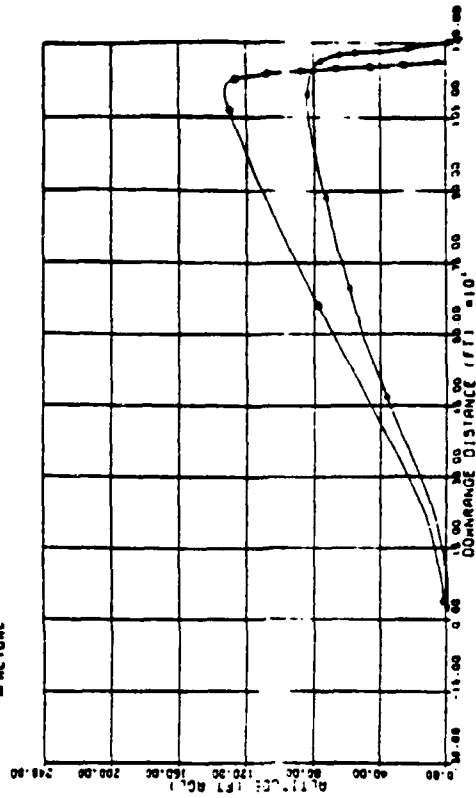
Table 6-1. Test Data Used as Simulation Input

<u>Simulation Number</u>	1	2	3	4
ER A-7 Test System	SRT	DVT	DVT	DVT
Test Number	P1	3	2	1
Test Date*	5/20	4/19	3/27	3/13
Dummy Percentile (%)	98	3	98	3
Dummy Weight (lbs)	250.7	174.2	255.5	169
Total Ejected Weight (lbs)	414.2	341.2	418.5	333
S/O CG Location, X Axis (in)	10.7	8.58	10.22	8.57
S/O CG Location, Z Axis (in)	12.3	11.62	12.43	11.47
X Velocity at Ejection (KEAS)	0	442	201	0
Air Density (slug/ft ³ x 10 ⁻⁵)	212	211	216	219
Wind Vector (deg wrt traj. vector)	220	230	30	10
Wind Velocity (ft/sec)	6.7	7.0	21.9	23.6
Air Temperature (deg F)	71.5	75	59	56
Barometric Pressure (in Hg)	27.4	27.4	27.3	27.5
Time of Seat First Motion (sec)	0.031	0.020	0.026	0.018
Time of Drogue Projection (sec)	0.166	0.155	0.158	0.148
Time of Drogue Inflation (sec)	1.700	0.286	0.394	0.629
Time of Booster Rocket Ignition (sec)	0.187	0.179	0.188	0.180
Time of Booster Rocket Burnout (sec)	0.423	0.415	0.436	0.427
Time of Parachute Deployment (sec)	0.289	1.417	0.333	1.585
Time of Parachute Line Stretch (sec)	0.697	1.685	0.581	2.098
Time of Seat/Occupant Separation (sec)	0.968	1.920	0.768	2.484
Time of Parachute Full Inflation (sec)	3.520	2.668	1.572	3.760

* All tests conducted during 1981.

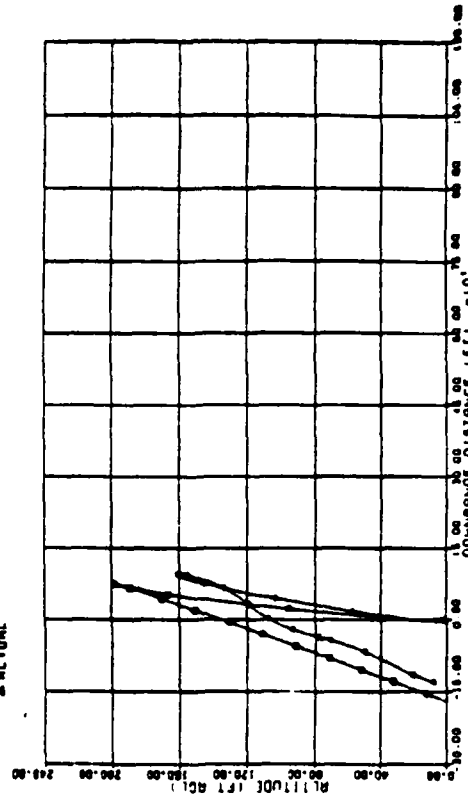
SIMULATION 2 - DVT/3 - 3XILE - 442 KEAS

○ SIMULATION
▲ ACTUAL



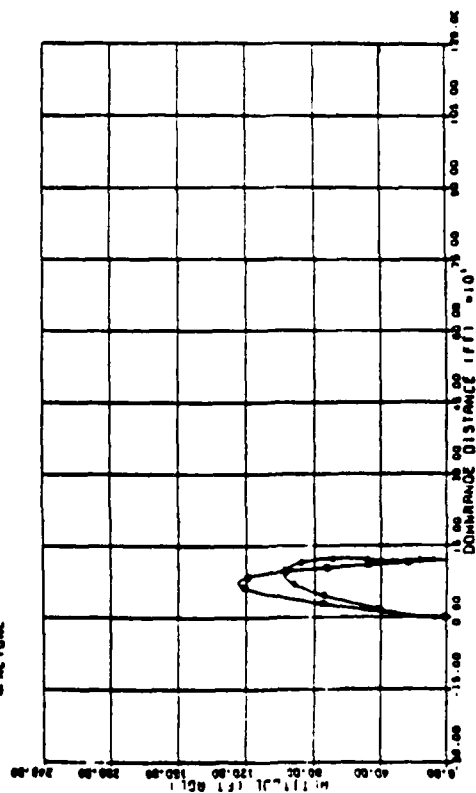
SIMULATION 4 - DVT/1 - 3XILE - 0 KEAS

○ SIMULATION
▲ ACTUAL



SIMULATION 1 - PSRT/1 - 98XILE - 0 KEAS

○ SIMULATION
▲ ACTUAL



SIMULATION 3 - DVT/2 - 98XILE - 201 KEAS

○ SIMULATION
▲ ACTUAL

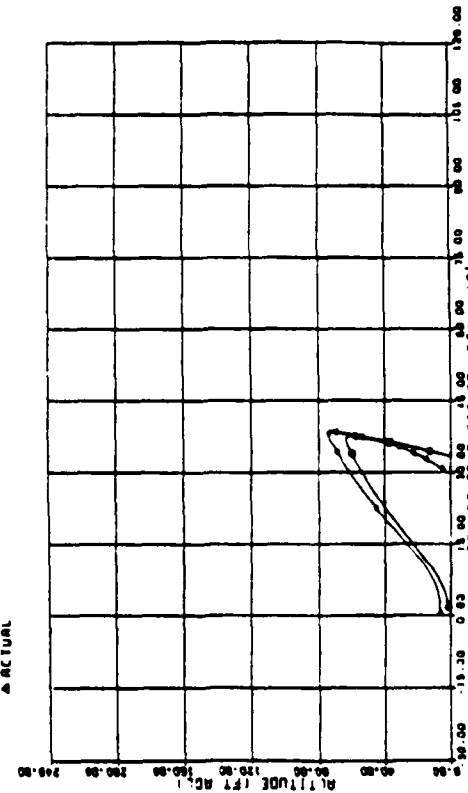
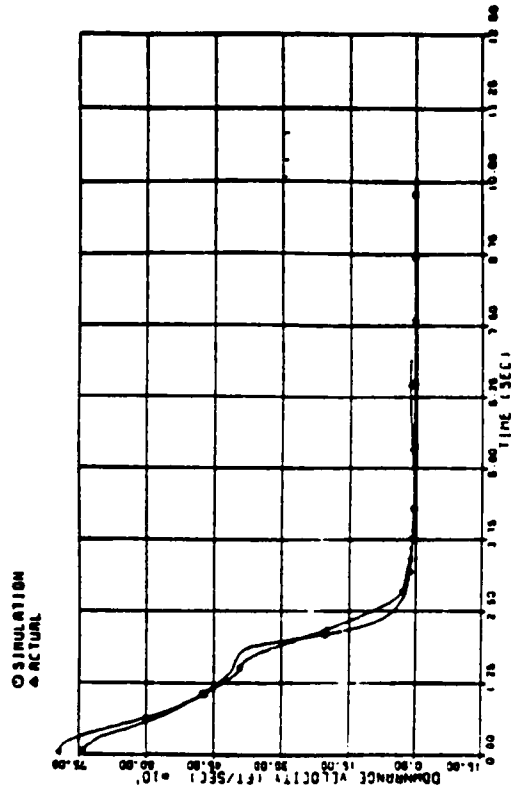
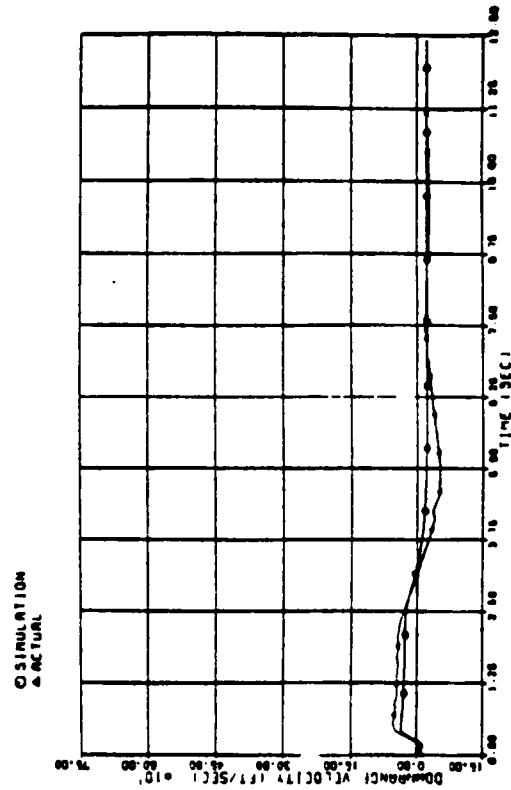


FIGURE 6-1. Seat/Occupant - Occupant Alone Altitude (Z-Axis) vs Downrange (X-Axis) Distance

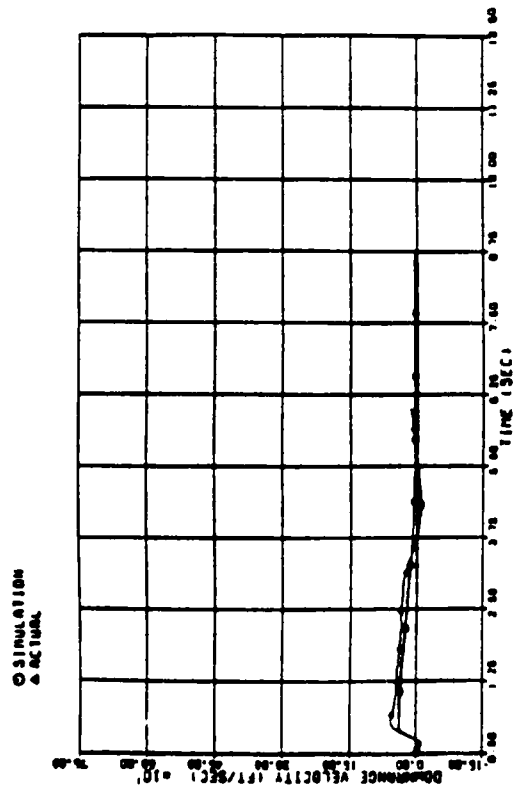
SIMULATION 2 - DV1/2 - 3ZILE - 442 HEARS



SIMULATION 4 - DV1/1 - 3ZILE - 0 HEARS



SIMULATION 1 - 98Z1/1 - 98ZILE - 0 HEARS



SIMULATION 3 - DV1/2 - 98ZILE - 201 HEARS

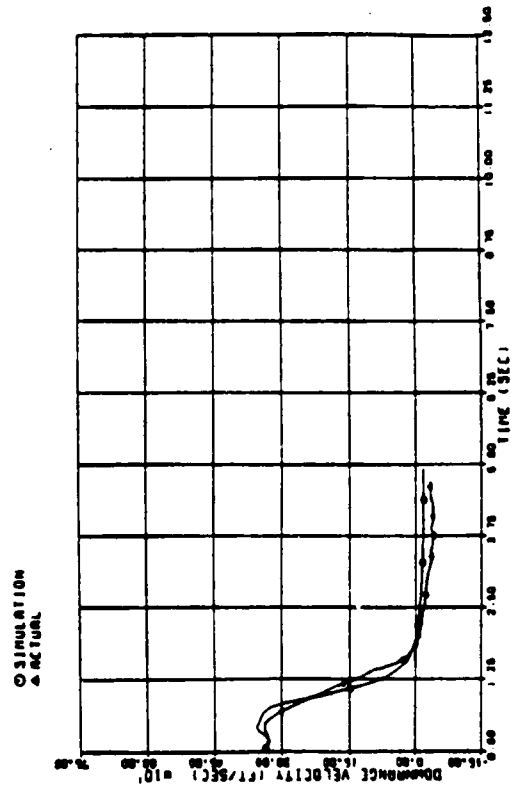


FIGURE 6-2. Seat/Occupant - Occupant Alone Downrange (X-Axis) Velocity vs Time

the distinctive changes in the deceleration rates, the simulation curves show exceptionally close comparisons with the actual data.

Figure 6-3 illustrates the vertical velocity time histories of the S/O-O/A. Here, all plots show an extended vertical acceleration for the simulated curve relative to the actual curve. This could possibly be due to a shorter actual rocket thrust period or a stronger than anticipated DART braking force. The extended acceleration could easily explain the higher predicted trajectory apogee tendency noted in Figure 6-1.

Finally, Figure 6-4 illustrates the total velocity time history of the S/O-O/A. It can be seen that in all cases the agreement between the simulated and actual time histories is again excellent.

Since "the purpose of all computation is insight, rather than numbers"(10), it is essential that the user know and understand the effective limits to the use of the GESS program. The foregoing brief analysis, while not intended as a complete validation study, suggests that the GESS program provides good representation of actual escape system performance. The model has not been designed to duplicate the intrinsic stochastic variability that exists in real world ejection situations, and should not be used with that intent. However, we conclude that when correctly used with reasonably accurate input data, the GESS program will provide highly reliable, detailed descriptions of escape system performance.

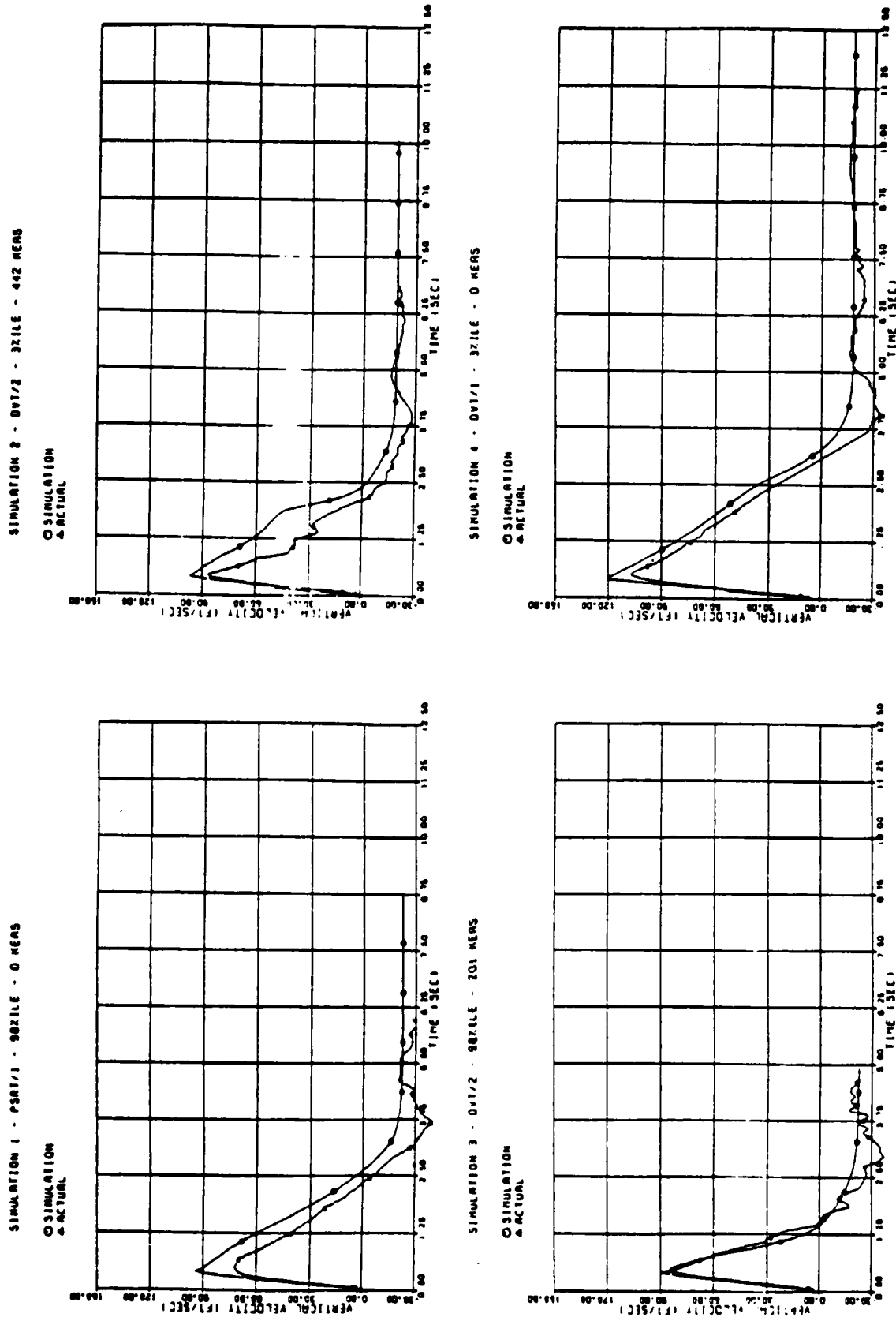
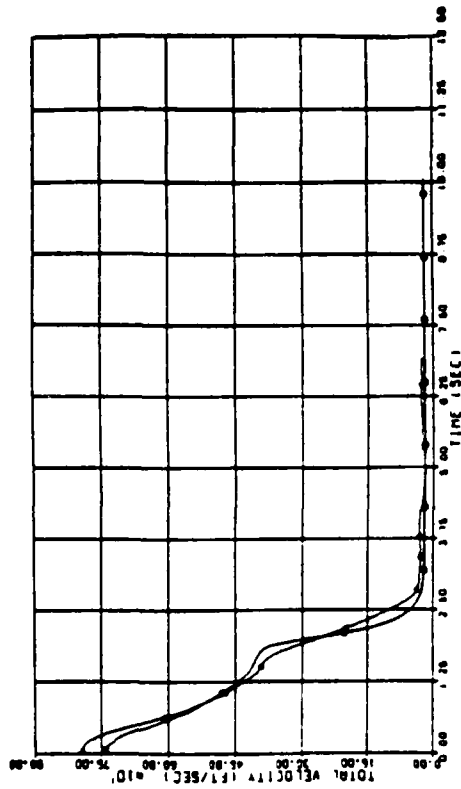


FIGURE 6-3. Seat/Occupant - Occupant Alone Vertical Velocity (Z-Axis) vs Time

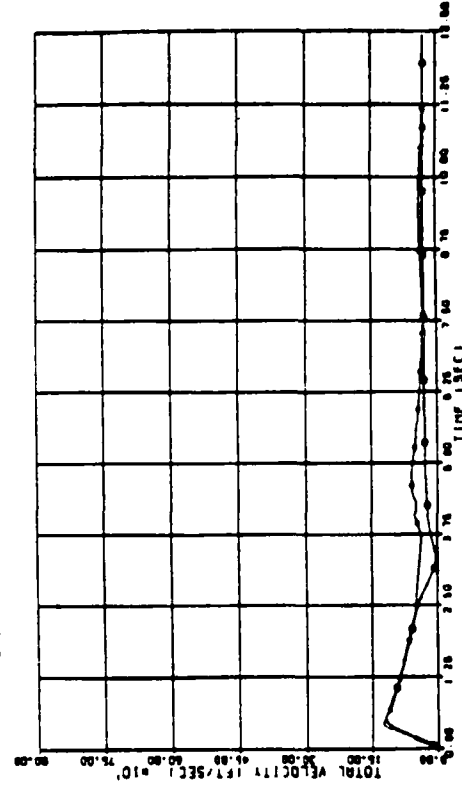
SIMULATION 2 - DVT/3 - 3XILE - 442 MEAS

○ SIMULATION
▲ ACTUAL



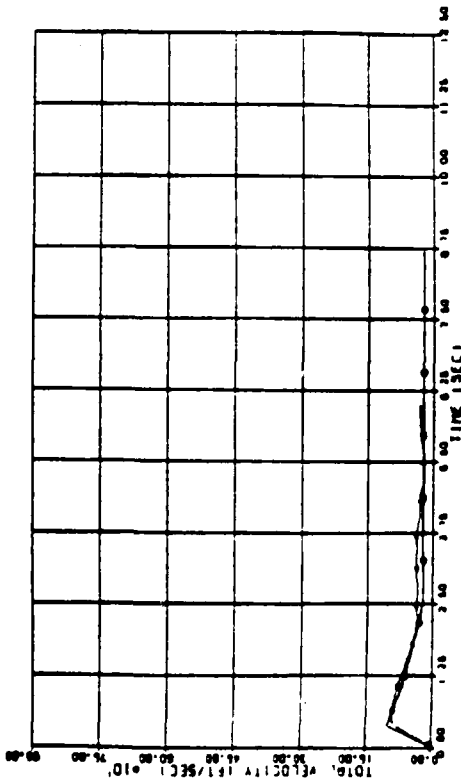
SIMULATION 4 - DVT/1 - 3XILE - 0 MEAS

○ SIMULATION
▲ ACTUAL



SIMULATION 1 - PRT/1 - 80XILE - 0 MEAS

○ SIMULATION
▲ ACTUAL



SIMULATION 3 - DVT/2 - 80XILE - 201 MEAS

○ SIMULATION
▲ ACTUAL

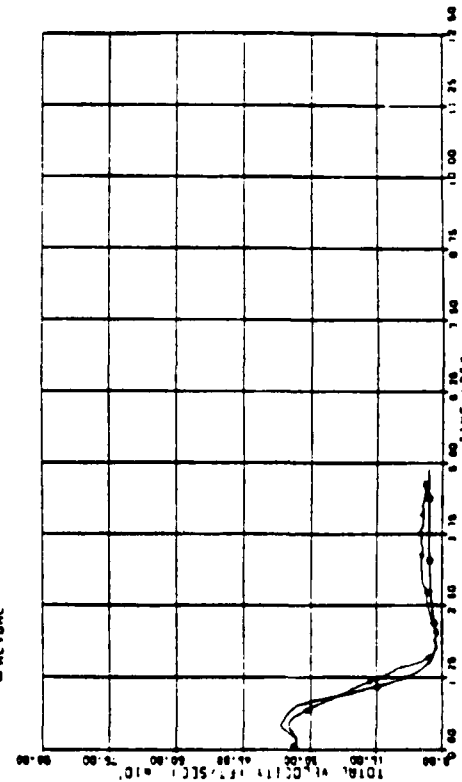


FIGURE 6-4. Seat/Occupant - Occupant Alone Total Velocity vs Time

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7.0 REFERENCES

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APPENDIX A

ACT Program Description

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APPENDIX A

AERODYNAMIC COEFFICIENT TABLES

The Aerodynamic Coefficient Tables (ACT) program creates aerodynamic coefficient tables that are functions of either two or three independent variables. The format in which the ACT tables are created is designed to be similar to the format in which the experimental data are received. A maximum of 500 entries are allowed in a table. For three-way tables, the coefficients are functions of the angle of attack (ALPHA), the angle of sideslip (BETA), and mach number (MACH). The two-way tables may be functions of BETA and MACH, BETA and ALPHA, or ALPHA and MACH.

By specifying the order in which the data must be read into memory, and through the use of variable dimensioned arrays, the user can easily store and reference the tables on random access files. As the coefficients are stored in consecutive locations in memory, it is necessary that the data be read as follows:

- ° For three-way data:

$$C(I,J,K)=F(((ALPHA(I),BETA(J),MACH(K)),I=1,L),J=1,M),K=1,N)$$

- ° For two-way data:

$$C(J,K)=F(((BETA(J),MACH(K)),J=1,M),K=1,N)$$

or $C(J,I)=F(((BETA(J),ALPHA(I)),J=1,M),I=1,L)$

or $C(I,K)=F(((ALPHA(I),MACH(K)),I=1,L),K=1,N)$

L, M, and N are the number of ALPHA, BETA, and MACH coordinates, respectively. Proper dimensioning of the coefficient array facilitates printout of the tables.

A.1 SEQUENCE NUMBERS

A sequence number is assigned to each table and is used to reference the disk address at which the table is stored. During creation runs the program assigns consecutive numbers to the tables as they are read. Three-way tables are assigned sequence numbers 1 to 20, and two-way tables are assigned sequence numbers 21 to 50. See Reference 13 for further information on random files and sequence numbers.

When the tables are extended, the program searches the appropriate info array (see Section A.3.2) to determine the sequence number of the last random file table. Each table that is added is assigned the next available sequence number. During this search, a check is made to ensure that the tables will not be extended beyond their limit. To replace a table, the user must specify the sequence number of the table he wishes to replace.

A.2 INFO ARRAYS

Associated with each table is an INFO array, containing information about that table. INFO3 is a 20 by 13 array associated with three-way tables, and INFO2 is a 30 by 10 array associated with two-way tables. These arrays are updated and written to a random file after creating, extending, or replacing tables. To facilitate referencing, the 20 by 13 INFO array is assigned disk address 51, and the 30 by 10 INFO array is assigned disk address 52.

During an extension run, the proper INFO array is interrogated to determine the number of tables already on random file. The new tables are assigned the next available sequence numbers, provided there is room to extend them. In the replacement mode, the first word in the INFO array for the given

sequence number is checked to be sure that a table with that sequence number already exists.

The contents of the INFO array, with J representing the sequence number of the current table being processed, are as shown below.

For two-way tables:

- INFO2(J,1) - table identifier
- INFO2(J,2) - number of BETAs
- INFO2(J,3) - number of MACHs
- INFO2(J,4) - BETA delta*
- INFO2(J,5) - MACH delta*
- INFO2(J,6) - minimum BETA
- INFO2(J,7) - minimum MACH
- INFO2(J,8) - maximum BETA
- INFO2(J,9) - maximum MACH
- INFO2(J,10) - type of two-way table

Depending on the type of two-way table being processed, either BETA or MACH, as used above, may be replaced by ALPHA.

For three-way tables:

- INFO3(J,1) - table identifier
- INFO3(J,2) - number of ALPHAs
- INFO3(J,3) - number of BETAs
- INFO3(J,4) - number of MACHs

* delta: increment between variable points

INFO3(J,5) - ALPHA delta*
 INFO3(J,6) - BETA delta*
 INFO3(J,7) - MACH delta*
 INFO3(J,8) - minimum ALPHA
 INFO3(J,9) - minimum BETA
 INFO3(J,10) - minimum MACH
 INFO3(J,11) - maximum ALPHA
 INFO3(J,12) - maximum BETA
 INFO3(J,13) - maximum MACH

A.3 COMMON VARIABLES

A.3.1 Externally Defined

The following common variables are user-defined through the program input.

ALMAX	BEMIN	DELMAC	ITYPE	MODE	NTYPE
ALMIN	DELALP	FMT	MAMAX	NCOEF	
BEMAX	DELBET	IDENT	MAMIN	NOFTAB	

The mnemonic definitions of the above are presented in Section 4.1.8 of this report.

A.3.2 Internally Defined

Table A-1 gives the definitions for the common variables which are initialized by the program.

* delta: increment between variable points

Table A-1. ACT VARIABLES DEFINITIONS

IBLNK	Hollerith word for blanking out the table name in the INFO array.
IC	The sequence number of the current table. Used in the ACT and INPUTT routines when referencing the INFO array.
IERTEST	Internal test work, set by the ERMSC subroutine, which will alter the flow of the program to compensate for an input error. = 1: ignore present case, read next type 1 card = 2: read excess tables into a dummy name = 3: disregard present table, read next table = 4: end program after present case
IJ, IK	In a list of extend run, they return the number of tables that have been written into the INFO array.
INFO2, INFO3	Two dimensional array which is equivalenced to the three dimensional array INFO3. The array INFO2 (30,10) contains the INFO array for two-way tables. INFO3 (20,13) contains the INFO array for the tables of three-way data. Detailed information concerning the contents of the INFO array may be found in Section A.2.
ISEQNO	The sequence number of the table to be replaced. (see Section A.7)
ITABNO	Position of table ISEQNO on the INFO array = ISEQNO-20: for two-way tables = ISEQNO : for three-way tables
I2NO I3NO	The number of two-way and three-way tables, respectively. Used as a counter when printing the file dictionary.
MTEST	A control word used in the PTOUT and WRINFO routines. = 0: read the INFO array from random file prior to processing the first table on a replacement or extension run = 1: do not read the INFO array again = 9: the PTOUT routine only prints the file dictionary
NAL NBE NMA	The number of ALPHA, BETA, and MACH numbers, respectively, that are contained in the present table. Computed by the program from the given maximum, minimum, and range values for each variable.

A.4 SYSTEM ROUTINES

Table A-2 lists the routines called by the ACT program which are available on the CDC system's library. A more complete description of these routines can be found in Reference 13.

Table A-2. System Routines Required by ACT

OPENMS	Informs the operating system that the mass storage file will be a random access file.
READMS	Transfers data from mass storage to central memory.
SECOND	Gives accumulated central processor time.
WRITMS	Transfers data from central memory to mass storage.

A.5 I/O REQUIREMENTS

The input/output requirements of the ACT program require that the following buffer areas be reserved.

TAPE10/INPUT	permanent file/ card reader	card images	coded
OUTPUT	printer	program output	coded
TAPE1	local	aerodynamic tables	random, binary

It should be recognized that TAPE1 is a random file which may be saved as a permanent file according to the procedures explained in Reference 12.

A.6 DECK SETUP

The object code for this program is saved as a permanent file. The program may be referenced under the filename ACTBIN. Loading of the program requires 50K octal locations of core memory.

A.6.1 Job Control for Creation Run

The following control cards are required to execute ACT, save the tables that are created, and store these tables on the random file.

° CASE1: (If input data are from cards)

JOBNAME, CB50000, T10.

ACCOUNT, NUMBER, PASSWORD.

GET, LGO=ACTBIN.

binary version of act

LGO.

SAVE, TAPE1=AERO4.

random aerodynamic co-efficient file

7/ } multi-punch
8/ }
9

data cards

6/ }
7/ } multi-punch
8/ }
9

° CASE2: (If input data are from a permanent file)

JOBNAME, CB50000, T10

ACCOUNT, NUMBER, PASSWORD

GET, LGO=ACTBIN

GET, CARDS

LGO, CARDS

SAVE, TAPE1=AERO4

/EOF

A.6.2 Job Control for Extension Run

Using the files generated in the creation run, the following control cards are necessary to add or replace tables. This setup can also be used to provide only a listing of the current tables.

° CASE1: (If input data is from cards)

JOBNAME, CB50000, T10.

ACCOUNT, NUMBER, PASSWORD.

GET, LGO=ACTBIN.

GET, TAPE1=AERO4.

LGO.

REPLACE, TAPE1=AERO4.

```
7/
 8/  } multi-punch
 9
```

data cards

```
6/
 7/  } multi-punch
 8/
 9
```

° CASE2: (If input data is from a permanent file)

JOBNAME, CB50000, T10

ACCOUNT, NUMBER, PASSWORD

GET, LGO=ACTBIN

GET, TAPE1=AERO4

GET, CARDS

LGO, CARDS

REPLACE, TAPE1=AERO4

/EOF

If the REPLACE card is not included in the above example, any new tables written to TAPE1 will be lost when the program ends. The REPLACE card will not otherwise affect program execution, and may remain in the deck even if no new tables are created.

A.7 CARD INPUT

The following are the five different card types that are recognized by the ACT program. Most runs will only require a subset of these, and, unless specified, they must be in the order shown. All integer data must be right-justified in their appropriate columns, while all alphanumeric data must be left-justified.

• Card type 1

<u>Format</u>	<u>Columns</u>	<u>Mnemonic</u>	<u>Description</u>
I5	1-5	ITYPE	Type of data = 1: Two-way data = 2: Three-way data
I5	6-10	MODE	Type of run = 1: Creation run = 2: Extension run = 3: Replacement run = 4: Short listing = 5: Long listing
I5	11-15	NOFTAB	Number of tables to be processed
I5	16-20	NTYP	Type of two-way table = 1: BETA vs MACH = 2: BETA vs ALPHA = 3: ALPHA vs MACH (Default is NTYP = 1)

On a list run (MODE = + or 5), NOFTAB and NTYP do not have to be defined.

• Card type 2

<u>Format</u>	<u>Columns</u>	<u>Mnemonic</u>	<u>Description</u>
8A10	1-80	FMT	The format under which the coefficients will be read

Card types 3, 4, and 5 must be repeated, in sequence, NOFTAB times.

• Card type 3

<u>Format</u>	<u>Columns</u>	<u>Mnemonic</u>	<u>Description</u>
A10	1-10	IDENT	Table name
I5	11-15	NCOEF	Number of coefficients
I5	16-20	ISEQNO	Sequence number of the table to be replaced (when MODE = 3)

• Card type 4

when ITYPE = 2:

<u>Format</u>	<u>Columns</u>	<u>Mnemonic</u>	<u>Description</u>
F8.0	1-8	ALMIN	Minimum ALPHA
F8.0	9-16	ALMAX	Maximum ALPHA
F8.0	17-24	DELALP	ALPHA Range
F8.0	25-32	BEMIN	Minimum BETA
F8.0	33-40	BEMAX	Maximum BETA
F8.0	41-48	DELBET	BETA Range
F8.0	49-56	MAMIN	Minimum MACH
F8.0	57-64	MAMAX	Maximum MACH
F8.0	65-72	DELMAC	MACH Range

when ITYPE = 1:

<u>Format</u>	<u>Columns</u>	<u>Mnemonic</u>	<u>Description</u>		
			<u>NTYP=1</u>	<u>NTYP=2</u>	<u>NTYP=3</u>
F8.0	25-32	BEMIN	Min. BETA	Min. BETA	Min. ALPHA
F8.0	33-40	BEMAX	Max. BETA	Max. BETA	Max. ALPHA
F8.0	41-48	DELBET	BETA Range	BETA Range	ALPHA Range
F8.0	49-56	MAMIN	Min. MACH	Min. ALPHA	Min. MACH
F8.0	57-64	MAMAX	Max. MACH	Max. ALPHA	Max. MACH
F8.0	65-72	DELMAC	MACH Range	ALPHA Range	MACH Range

° Card type 5

<u>Format</u>	<u>Columns</u>	<u>Description</u>
Specified by the user in Card Type 2.		TABLE COEFFICIENTS

See Section A.1 for a further description of how the table coefficients must be inputted.

A.8 EXECUTION ERRORS

Types of errors that may be found include:

1. Number of tables greater than 50
2. Number of coefficients greater than 500
3. Invalid use of replace mode
4. Read excess tables into dummy file
5. Two-way tables fully extended
6. Attempt to extend two-way tables beyond 30
7. Three-way tables fully extended
8. Attempt to extend three-way tables beyond 20
9. Error in number of coefficients defined

The ACT program provides a method of continuing execution of the program, despite the discovery of an input error. The user is informed of the error that has been found, which will enable him to correct it in a later run. In cases where a serious error causes the program to end, the INFO array for all previously created tables is written to the random file.

Under a LIST run (mode = 4 or 5), only card type 1 is recognized. For all other runs, all five card types are required. After each set of input is processed, the next card type 1 is read. The program will terminate upon reading an end of information card.

The program is designed to check for obvious input errors, and make the appropriate adjustments to compensate for them. The subroutine ERMSG handles the printing of the error messages, which indicate the source of the error and the action that will be taken by the program. An attempt is always made to save the INFO array before terminating the program due to an input error.

Figures A-1 and A-2 are provided as examples of the inputs needed to execute the ACT program.

三

25

1	2	2	1								
(14F5.1)											
CYS	50										
				0.	45.	5.	0.	1.2		.3	
0.0	-0.10	-0.15	-0.30	-0.35	-0.50	-0.60	-0.70	-0.85	-1.00		
0.0	-0.10	-0.15	-0.30	-0.35	-0.50	-0.60	-0.70	-0.85	-1.00		
0.0	-0.10	-0.15	-0.30	-0.35	-0.50	-0.60	-0.70	-0.85	-1.00		
0.0	-0.10	-0.20	-0.40	-0.50	-0.60	-0.80	-0.90	-1.00	-1.20		
0.0	-0.10	-0.30	-0.50	-0.60	-0.80	-0.90	-1.10	-1.20	-1.40		
CLS	50										
				0.	45.	5.	0.	1.2		.3	
0.0	+0.01	+0.02	+0.04	+0.05	+0.07	+0.09	+0.09	+0.09	+0.08		
0.0	+0.01	+0.02	+0.04	+0.05	+0.07	+0.09	+0.09	+0.09	+0.08		
0.0	+0.01	+0.02	+0.04	+0.05	+0.07	+0.09	+0.09	+0.09	+0.08		
0.0	+0.01	+0.02	+0.04	+0.05	+0.07	+0.09	+0.09	+0.09	+0.08		
0.0	+0.01	+0.02	+0.04	+0.05	+0.07	+0.09	+0.09	+0.09	+0.08		

1	3	1	1								
(14F5.1)											
CNS	50		23								
				0.	45.	5.	0.	1.2		.3	
0.0	-0.01	-0.03	-0.05	-0.07	-0.08	-0.10	-0.12	-0.13	-0.14		
0.0	-0.01	-0.03	-0.05	-0.07	-0.08	-0.10	-0.12	-0.13	-0.14		
0.0	-0.01	-0.03	-0.05	-0.07	-0.08	-0.10	-0.12	-0.13	-0.14		
0.0	-0.01	-0.03	-0.05	-0.06	-0.10	-0.12	-0.13	-0.14	-0.15		
0.0	-0.01	-0.03	-0.05	-0.08	-0.10	-0.12	-0.13	-0.14	-0.15		

Figure A-2. ACT Sample Input - Extension Run

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APPENDIX B

Sample GESS Input File Listing

[illegible]

RKIGN(2)	0.03	2200.0	0.25	2400.0
XPOSRK(2)	0.27	300.0	0.29	10.0
RKALPH(2)	0.31	0.0		
RKNPTS(2)	0.0	6.0	0.225	0.191
	0.0	RKBURN(2)	-0.0533	
	53.15	ZPOSRK(2)	45.0	
	7	112.0		
	0.0	0.0	0.02	2000.0
	0.03	2200.0	0.25	2400.0
	0.27	300.0	0.29	10.0
	0.31	0.0		
IDROGUE	1			
TDDPLY	0.163	DISPLY	14.00	
DRDRAG1	0.60	DRDGLL	0.05	
AREADC	0.50	POROSD1	1.00	
XDRGAP	0.00	CDCC	2.00	
IDROGLS	1	0.00		
NPTSLS	2	ZDRGAP		
	0.00	0.050	1500.00	0.050
IFTDR01	1			
NPTDFT1	2	0.110	1500.00	0.110
	0.00			
IRECOV	1			
RECOVLL	25.5	RECDRAG	0.75	
RECOVPD	28.00	POROSR	0.05	
XRECAP	0.2917	YRECAP	0.00	3.083
CHALT1	7000.00	CHALT2	0.00	0.00
TDELAY	.000	14000.00	GLIMIT	
NPTSROT	1			
TDDPLY	1.491			
NPTSRLS	2			
	0.00	0.271	1500.	0.271
IFTRECV	1			
NPTSRT	2	0.896	1500.	0.896
	0.00			
IDART	1			
DRIFRCE	900.0	DRISTRT	8.0	21.0
XDRTAP(1)	0.0417	YDRTAP(1)	-0.4167	-0.1917
XDRTCP(1)	0.6667	YDRTCP(1)	-0.4167	-1.6900
XDRTAP(2)	0.0417	YDRTAP(2)	0.4167	-0.1916
XDRTCP(2)	0.6667	YDRTCP(2)	0.4167	-1.6900
ITVC	0			
IDYNCG	1			
STOP				

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APPENDIX C

Sample GESS Output Reports

PAGE 1

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: STING-ER A-7 SRT #4 - 350 KEAS - 98 XOCUPANT - HIGH SPEED MODE

TEST CONDITIONS: ALTITUDE: 00 FT CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

X VELOCITY: 600.90 FT/SEC
YAW: 0.00 DEG
PITCH: 0.00 DEG
Z VELOCITY: 0.00 FT/SEC
ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

PROGRAM CONTROL VARIABLES

EJECTION SIMULATION START TIME = 0.0000(IF > 0 FROM RESTART FILE)

EJECTION SIMULATION STOP EVENT = SEAT/OCCUPANT SEPARATION

VARIABLE	VALUE	DEFINITION
IRESTRT	0	RESTART FILE CREATION SWITCH (0 = NOT CREATED, 1 = CREATED)
IUNITS	1	UNITS OF MEASUREMENT (0 = METRIC, 1 = ENGLISH)
ISEATTR	0	SEAT ALONE TRAJECTORY SWITCH (0 = TRAJ. NOT GENERATED, 1 = TRAJ. GENERATED)
IPLOT	0	PLOTTING FILE SWITCH (0 = NOT CREATED, 1 = CREATED WRT EFCS, 2 = CREATED WRT EFCS AND ACS)
ISOSEP	2	SEAT/OCCUPANT SEP. SWITCH (0 = WILL NOT OCCUR, 1 = WILL OCCUR BASED ON TIME, 2 = WILL OCCUR BASED ON FORCE)
IDRIFLG	0	DYNAMIC RESPONSE INDEX SWITCH (0 = NOT COMPUTED, 1 = COMPUTED)

PAGE 2

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE

TEST CONDITIONS: ALTITUDE:

X VELOCITY:

Z VELOCITY:

0.00 FT/SEC

YAW: 0.00 DEG

PITCH:

0.00 DEG

0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

OUTPUT REPORTS: THE FOLLOWING REPORTS WILL BE CREATED

REPORT NO.	TITLE
1	INPUT VALIDATION
2	SEAT/OCCUPANT LINEAR TIME HISTORY
3	SEAT/OCCUPANT ANGULAR TIME HISTORY

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENDEL SEAT - CATAPULT, ROCKET, DART, DROGUE CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: 0.00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
 YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

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INTEGRATION TIME STEPS AND PRINT FREQUENCIES

	INTEGRATION STEP (SEC)	PRINT FREQUENCY
PHASE 1 (INITIATION TO RAIL CLEARANCE)	DTPHAS1 = .00010	P11 = 100
PHASE 2 (RAIL CLEARANCE TO SEAT/OCCUPANT SEPARATION)	DTPHAS2 = .00100	P12 = 100
PHASE 3 (SEAT/OCCUPANT SEPARATION TO COMPLETION)	DTPHAS3 = .00500	P13 = 20

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DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

TEST CONDITIONS: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

ALTIITUDE:	0.00 FT	X VELOCITY:	600.90 FT/SEC	Z VELOCITY:	0.00 FT/SEC
YAW:	0.00 DEG	PITCH:	0.00 DEG	ROLL:	0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

AIRCRAFT INITIAL CONDITIONS

ATMOSPHERIC CONDITIONS

TEMPERATURE	(TEMP):	92.0000 DEG FARENHEIT
BAROM PRESSURE	(PRESSUR):	919.1000 MILLIBAR
AIR DENSITY	(DENSITY):	.0021 LB /FT**3
COCKPIT HEIGHT	(CKPHTHT):	3.5000 FT
WIND VELOCITY	(WINDX):	-2.9440 FT/SEC
	(WINDY):	-1.7000 FT/SEC
	(WINDZ):	0.0000 FT/SEC

POSITION (EFCS) (FT)	ORIENTATION (EFCS) (DEG)	LINEAR VELOCITY (EFCS) (FT/SEC)	ANGULAR VELOCITY (ACS) (DEG/SEC)
XPOS: 0.0000	YAW: 0.0000	XACVEL : 600.9000	YAW (RVEL): 0.0000
YPOS: 0.0000	PITCH: 0.0000	YACVEL : 0.0000	PITCH (QVEL): 0.0000
ZPOS: .0010	ROLL: 0.0000	ZACVEL : 0.0000	ROLL (PVEL): 0.0000

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

TEST CONDITIONS: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

ALTIITUDE: 0.00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC

PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

SEAT ALONE INITIAL CONDITIONS

REFERENCE AREA (AREASA): 6.0000 FT**2
 HEIGHT (HGTSA): 3.5000 FT
 WEIGHT (WGHTSA): 169.5000 LB

LOCATION OF SEAT BOTTOM (RCS)
(FT)

XPOSBOT: 0.0000
 YPOSBOT: 0.0000
 ZPOSBOT: 0.0000

ORIGIN OF SCS (RCS)
(FT)

XPOSSCS: 0.0000
 YPOSSCS: 0.0000
 ZPOSSCS: 0.0000

LOCATION OF SEAT REFERENCE POINT (SCS)
(FT)

XPOSSRP: .1650
 YPOSSRP: 0.0000
 ZPOSSRP: .5500

ORIENTATION (ACS)
(DEG)

ROLL (PHISA): 0.0000
 PITCH (PSISA): -15.0000
 YAW (THESA): 0.0000

LOCATION OF SEAT ALONE CG (SCS)
(FT)

XCGSA: .3628
 YCGSA: 0.0000
 ZCGSA: 1.4000

MOMENTS OF INERTIA
(SLUG-FT**2)

IXXSA: 4.0000
 IYXSA: 0.0000
 IXXZA: 0.0000
 IYXZA: 0.0000
 IYYSA: 5.0000
 IYYZA: 0.0000
 IZZSA: 1.0000

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DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
REPORT NO. 1: INPUT VALIDATION

SEAT/OCCUPANT, OCCUPANT ALONE INITIAL CONDITIONS

SEAT/OCCUPANT REFERENCE AREA (AREASO): 7.5000 FT**2
 OCCUPANT ALONE EFFECTIVE DRAG AREA (AREAOA): 9.6000 FT**2
 SEAT/OCCUPANT WEIGHT (WGHTSO): 427.5000 LB
 OCCUPANT ALONE WEIGHT BEFORE SEAT/OCC SEPARATION(WGHTOAB): 258.0000 LB
 OCCUPANT ALONE WEIGHT AFTER SEAT/OCC SEPARATION(WGHTOAA): 258.0000 LB
 SEAT/OCCUPANT SEPARATION OCCURS AT (SOSEP): 80.0000 LB PARACHUTE FORCE
 AERODYNAMIC DAMPING COEFFICIENT (DMPGCG): .4000

LOCATION OF SEAT/OCCUPANT C.G. (SCS)
(FT)

XCGSO: .8650
 YCGSO: 0.0000
 ZCGSO: .9850

SEAT/OCCUPANT MOMENTS OF INERTIA
(SLUG-FT**2)

IXXSO: 22.0000
 IXXSO: 0.0000
 IXXSO: 0.0000
 IXXSO: 22.0000
 IXXSO: 0.0000
 IXXSO: 6.3000

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

STIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCEL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE:

X VELOCITY: 600.90 FT/SEC

Z VELOCITY: 0.00 FT/SEC

ROLL: 0.00 DEG

YAW: 0.00 DEG

PITCH: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

RAIL INITIAL CONDITIONS

RAIL LENGTH (RAILNTH): 3.5000 FT
 RAIL ANGLE WRT AIRCRAFT (RAILANG): -17.5000 DEG
 X-DIRECTION SPRING CONSTANT(KXSB): 50000.0000 LB/FT
 Y-DIRECTION SPRING CONSTANT(KYSB): 50000.0000 LB/FT
 COEFFICIENT OF FRICTION(MUSB): .0500
 TORSIONAL SPRING CONSTANT(VKTOR): 500.0000 FT-LB/DEG

LOCATION OF RAIL ATTACHMENT POINTS (ACS) (FT)

	RIGHT	LEFT
XPOSRE:	0.0000	XPOSLE: 0.0000
YPOSRE:	-1.4167	YPOSLE: .4167
ZPOSRE:	0.0000	ZPOSLE: 0.0000

NUMBER OF SLIPPERS ON SEAT: 0

(PROGRAM ASSUMES A CONTINUOUS "RAIL WITHIN A RAIL")

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

TEST CONDITIONS: STENCIL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE

Z VELOCITY: 0.00 FT/SEC
ROLL: 0.00 DEG

X VELOCITY: 600.90 FT/SEC
PITCH: 0.00 DEG

YAW: 0.00 DEG
TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

CATAPULT PARAMETERS

NUMBER OF CATAPULTS: 2

LOCATION OF CATAPULT ATTACHMENT POINTS (SCS) (FT)

XPOSAP: 0.0000
YPOSAP: -.4167
ZPOSAP: 3.5000

XPOSAP: 0.0000
YPOSAP: .4167
ZPOSAP: 3.5000

CATAPULT 1:
LENGHT (CATLNT): 3.5000 FT
STROKE (CATSTK): 3.5000 FT
TIME OF IGNITION (TCI): 0.0000 SEC

CATAPULT 2:
LENGHT (CATLNT): 3.5000 FT
STROKE (CATSTK): 3.5000 FT
TIME OF IGNITION (TCI): 0.0000 SEC

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DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SITS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STINCEL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: 00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

CATAPULT 1 THRUST TABLE

TIME (SEC)	THRUST (LB)
0.0000	0.0000
.0100	2450.0000
.1600	2450.0000
.2000	0.0000

CATAPULT 2 THRUST TABLE

TIME (SEC)	THRUST (LB)
0.0000	0.0000
.0100	2450.0000
.1600	2450.0000
.2000	0.0000

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: 0.00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC

YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

ROCKET PARAMETERS

NUMBER OF ROCKETS: 2

ROCKET NOZZLE LOCATION (SCS)
(FT)

ROCKET THRUST LINE
DIRECTION COSINE ANGLES (SCS)
(DEG)

ROCKET 1:
IGNITION (RKIGN):
FUEL WT (RKWGT):
BURN TIME (RKBURN):
IGN DELAY (RKDELY):

XPOSRK : 0.0000
YPOSRK : -.5833
ZPOSRK : -.0533

0.0000 FT
6.0000 LB
.2250 SEC
.1910 SEC

RKALPH : 53.1500
RKBETA : 68.0000
RKGAMA : 45.0000

ROCKET 2:
IGNITION (RKIGN):
FUEL WT (RKWGT):
BURN TIME (RKBURN):
IGN DELAY (RKDELY):

XPOSRK : 0.0000
YPOSRK : -.5833
ZPOSRK : -.0533

0.0000 FT
6.0000 LB
.2250 SEC
.1910 SEC

RKALPH : 53.1500
RKBETA : 112.0000
RKGAMA : 45.0000

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DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: STIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC

ROLL: 0.00 DEG

PITCH: 0.00 DEG

YAW: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

ROCKET THRUST TABLES

ROCKET 1

NOMINAL		ADJUSTED	
TIME (SEC)	THRUST (LB)	TIME (SEC)	THRUST (LB)
0.0000	0.0000	0.0000	0.0000
.0200	2000.0000	.0145	2755.5556
.0300	2200.0000	.0218	3031.1111
.2500	2400.0000	.1815	3308.6667
.2700	300.0000	.1960	413.3333
.2900	10.0000	.2105	13.7778
.3100	0.0000	.2250	0.0000

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: STENCIL SEAT - CATAPULT,ROCKET,DART, DROGUE,CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

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ROCKET THRUST TABLES

ROCKET 2

NOMINAL		ADJUSTED	
TIME (SEC)	THRUST (LB)	TIME (SEC)	THRUST (LB)
0.0000	0.0000	0.0000	0.0000
.0200	2000.0000	.0145	2755.5556
.0300	2200.0000	.0218	3031.1111
.2500	2400.0000	.1815	3306.8667
.2700	300.0000	.1960	413.3333
.2900	10.0000	.2105	13.7778
.3100	0.0000	.2250	0.0000

DATE: 1 SEP 83
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
 SEAT DESCRIPTION: STENCIL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
 YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG
 TOTAL EJECTED WEIGHT: 427.50 LB
 COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
 REPORT NO. 1; INPUT VALIDATION

DART PARAMETERS

DART FORCE (DRIFRCE): 900.0000 LB
 DART START DISTANCE (DRTSTRT): 8.0000 FT
 DART STOP DISTANCE (DRTSTOP): 21.0000 FT

LEFT DART CONFLUENCE POINT (SCS)
 (FT)

XDRTCPL: .6667
 YDRTCPL: .4167
 ZDRTCPL: -1.6900

RIGHT DART CONFLUENCE POINT (SCS)
 (FT)

XDRTCPR: .6667
 YDRTCPR: -.4167
 ZDRTCPR: -1.6900

LEFT DART COCKPIT ATTACHMENT POINT (SCS)
 (FT)

XDRTAPL: .0417
 YDRTAPL: .4167
 ZDRTAPL: -.1916

RIGHT DART COCKPIT ATTACHMENT POINT (SCS)
 (FT)

XDRTAPR: .0417
 YDRTAPR: -.4167
 ZDRTAPR: -.1917

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DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCEL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE:

.00 FT

X VELOCITY:

600.90 FT/SEC

Z VELOCITY:

0.00 FT/SEC

YAW:

0.00 DEG

PITCH:

0.00 DEG

ROLL:

0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD

+Y= LEFT

+Z= UP

+YAW= TURN LEFT

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

DYNAMIC CG VARIABLES

DEFAULT VALUES USED:

DAMPING CONSTANT (CX): .3000

DAMPING CONSTANT (CY): .3000

DAMPING CONSTANT (CZ): .3000

X SPRING MODULUS CONSTANT (SXP): 18000.0000 LB/FT

X SPRING MODULUS CONSTANT (SXN): 18750.0000 LB/FT

Y SPRING MODULUS CONSTANT (SY): 12000.0000 LB/FT

Z SPRING MODULUS CONSTANT (SZN1): 12000.0000 LB/FT

Z SPRING MODULUS CONSTANT (SZN2): 25500.0000 LB/FT

X DIRECTION DEAD ZONE (XSLACK): .0830 FT

Z DIRECTION DEAD ZONE (ZSLACK): .0830 FT

Z DIRECTION BOTTOMING ZONE (ZBOT): -.0830 FT

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC

YAW: 0.00 DEG PITCH: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

Z VELOCITY: 0.00 FT/SEC
ROLL: 0.00 DEG

DROGUE CHUTE(S) PARAMETERS

DROGUE TYPE (IDROGUE = 1) :
SEAT TRAVEL TO DROGUE CONTAINER/SLUG RELEASE (DISPLOY) :
DROGUE CONTAINER/SLUG RELEASE DELAY (TDDPLOY) :
DROGUE CONTAINER/SLUG REFERENCE AREA (AREADC) :
DROGUE CONTAINER/SLUG WEIGHT (WGHTDC) :
DROGUE CONTAINER/SLUG DRAG COEFFICIENT (CDDC) :
DROGUE CHUTE DRAG COEFFICIENT (DRDRAG1) :
DROGUE CHUTE EFFECTIVE POROSITY (POROSD1) :
DROGUE CHUTE LINE LENGTH (DROGLL) :
DROGUE CHUTE PROJECTED DIAMETER (DROGPD1) :

STANDARD SINGLE DROGUE
0.0000 FT
.1830 SEC
.5000 FT
3.0000 LB
1.0000
.6000
.0500
14.0000 FT
3.2500 FT

DROGUE CHUTE ATTACHMENT POINT (SCS) (FT)

XDROGAP: 0.0000
YDROGAP: 0.0000
ZDROGAP: 2.0000

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
 SEAT DESCRIPTION: SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE
 TEST CONDITIONS: STENGEL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE
 ALTITUDE: 00 FT X VELOCITY: 600.90 FT/SEC
 YAW: 0.00 DEG PITCH: 0.00 DEG
 Z VELOCITY: 0.00 FT/SEC
 ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB
 COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
 REPORT NO. 1: INPUT VALIDATION

TABLE OF TIMES FROM
 DROGUE CONTAINER/SLUG DEPLOYMENT
 TO DROGUE CHUTE LINE STRETCH
 (DROGLES)

VELOCITY AT DROGUE DEPLOYMENT (FT/SEC) : 0.0 1500.0
 TIME TO DROGUE LINE STRETCH (SEC) : .0500 .0500

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TABLE OF TIMES FROM
 DROGUE CHUTE LINE STRETCH
 TO FULL INFLATION
 (DROGFT1)

VELOCITY AT DROGUE DEPLOYMENT (FT/SEC) : 0.0 1500.0
 TIME TO DROGUE LINE STRETCH (SEC) : .1100 .1100

DATE: 1 SEP 83

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENGE SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE

TEST CONDITIONS: ALTITUDE:

YAW:

0.00 DEG

PITCH:

0.00 DEG

X VELOCITY:

600.90 FT/SEC

Z VELOCITY:

0.00 FT/SEC

ROLL:

0.00 DEG

TOTAL EJECTED WEIGHT:

427.50 LB

COORDINATE CONVENTIONS:

+X= FORWARD

+Y= LEFT

+Z= UP

+YAW= TURN LEFT

+PITCH= NOSE DOWN

+ROLL= RIGHT WING DOWN

REPORT NO. 1: INPUT VALIDATION

RECOVERY PARACHUTE PARAMETERS

TYPE OF CONTROL (IRECOV = 1): FIXED TIME DELAY
 LINE LENGTH (RECOVLL): 25.5000 FT
 DRAG COEFFICIENT (RECDRAG): .7500
 PROJECTED DIAMETER (RECOVPD): 28.0000 FT
 EFFECTIVE POROSITY (POROSR): .0500
 LOWER ALTITUDE LIMIT (CHALT1): 7000.0000 FT
 UPPER ALTITUDE LIMIT (CHALT2): 14000.0000 FT
 UPPER ALTITUDE DELAY (TDELAY): 0.0000 SEC
 PARACHUTE RELEASE TIME (TRDPLY): 1.4910 SEC

RECOVERY CHUTE ATTACHMENT POINT (SCS)
(FT)

XRECAP: .2917
 YRECAP: 0.0000
 ZRECAP: 3.0830

TABLE OF TIMES FROM RECOVERY
PARACHUTE RELEASE TO LINE
STRETCH

VELOCITY (FT/SEC)	TIME (SEC)
0.0	.2710
1500.0	.2710

TABLE OF TIMES FROM RECOVERY
PARACHUTE LINE STRETCH TO FULL
INFLATION

VELOCITY (FT/SEC)	TIME (SEC)
0.0	.8980
1500.0	.8960

DATE: 1 SEP 83
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
 SITS-ER A-7 SRT #4 - 350 KEAS - 98 OCCUPANT - HIGH SPEED MODE
 SEAT DESCRIPTION: STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
 YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG
 TOTAL EJECTED WEIGHT: 427.50 LB
 COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
 REPORT NO. 2: SEAT/OCCUPANT LINEAR TIME HISTORY

TIME (SEC)	ACCELERATION (G/S)			X	VELOCITY(EFTS) (FT/SEC)			RES	Z	X	POSITION (EFTS) (FT)			RES
	X	Y	Z		X	Y	Z				X	Y	Z	
0.0000	***** CATAPULT 1 IGNITION													
0.0000	***** CATAPULT 2 IGNITION													
0.0000	***** SEAT FIRST MOTION													
0.0008	-0.00	0.00	0.00	600.90	0.00	-0.00	600.90	.58	0.00	1.18	1.31			
0.0008	-0.00	0.00	-0.05	600.90	.00	-0.00	600.90	1.06	.00	1.18	1.58			
0.0100	-0.95	0.00	10.39	600.42	.00	1.46	600.42	6.59	.00	1.18	6.69			
0.0200	-1.40	0.00	10.04	599.08	.00	4.49	599.10	12.58	.00	1.23	12.64			
0.0300	2.35	0.00	10.23	598.43	.00	7.68	598.48	18.55	.00	1.32	18.60			
0.0400	-0.06	0.00	10.15	598.17	.00	11.01	598.27	24.53	.00	1.44	24.57			
0.0500	-2.89	0.00	10.03	596.71	.00	13.98	596.87	30.50	.00	1.59	30.54			
0.0600	1.09	0.00	10.21	595.52	.00	17.03	595.77	36.45	.00	1.76	36.49			
0.0700	1.57	0.00	10.09	595.30	.00	20.36	595.65	42.40	.00	1.95	42.44			
0.0800	-1.85	0.00	9.78	594.42	.00	23.43	594.89	48.35	.00	2.16	48.40			
0.0900	-5.53	0.00	9.85	593.13	.00	26.35	593.71	54.28	.00	2.39	54.34			
0.1000	1.47	0.00	9.94	592.58	.00	29.51	593.32	60.21	.00	2.66	60.27			
0.1100	-1.06	0.00	9.74	591.91	.01	32.62	592.81	66.13	.00	2.96	66.20			
0.1200	-1.56	0.00	9.59	590.58	.01	35.47	591.64	72.04	.00	3.29	72.12			
0.1300	1.58	0.00	9.61	589.82	.01	38.47	591.07	77.94	.00	3.66	78.02			
0.1400	.68	0.00	9.41	589.57	.01	41.57	591.03	83.83	.00	4.08	83.93			
0.1484	***** CATAPULT 1 SEPARATION													
0.1484	***** CATAPULT 2 SEPARATION													
0.1484	***** RAIL SEPARATION													
0.1484	***** SEAT SEPARATION FROM AIRCRAFT													
0.1484	-4.89	.02	-2.09	588.85	.01	43.97	590.49	88.78	.00	4.42	88.89			
0.1590	-5.11	.01	-2.13	587.29	.02	42.87	588.85	95.05	.00	4.88	95.18			
0.1630	***** DROGUE GUN/CONTAIN. DEPLOYMENT													
0.1630	-5.11	.01	-2.14	586.71	.02	42.46	588.24	97.40	.00	5.04	97.53			
0.1910	***** ROCKET 1 IGNITION													
0.1910	-5.08	.01	-2.22	582.60	.03	39.62	583.95	113.74	.00	6.11	113.90			
0.2000	-.29	.01	3.40	581.81	.03	39.64	583.16	118.98	.00	6.43	119.15			
0.2130	***** DROGUE CHUTE LINE STRETCH													
0.2130	3.37	.01	7.71	582.28	.03	42.42	583.82	126.56	.00	6.94	126.75			
0.2720	***** DART START RIGHT LINE													
0.2720	2.54	.00	5.63	585.96	.02	57.65	588.79	161.18	.00	10.08	161.50			
0.3000	1.17	.00	5.81	587.13	.01	62.92	590.50	177.58	.00	11.77	177.97			
0.3230	***** DROGUE CHUTE FULL INFLATION													
0.3230	-.34	.00	6.34	586.84	.00	67.39	590.70	191.04	.00	13.21	191.50			
0.4000	-8.51	.00	-4.4	577.89	.08	77.64	583.08	235.88	.00	18.96	236.64			
0.4160	***** ROCKET 1 BURNOUT													
0.4160	***** ROCKET 2 BURNOUT													
0.4490	-8.19	.00	.44	574.34	.10	75.16	579.24	245.10	.00	20.13	249.93			
0.4490	***** DART STOP RIGHT LINE													
0.4490	-6.08	.00	3.68	567.33	.14	70.73	571.72	263.95	.00	22.52	264.91			

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RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SEAT DESCRIPTION: STIIIS-ER A-7 SRT #4 - 350 KEAS - 98 X OCCUPANT - HIGH SPEED MODE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC

YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 2: SEAT/OCCUPANT LINEAR TIME HISTORY

TIME (SEC)	ACCELERATION (G(S))			VELOCITY(EFCS) (FT/SEC)			POSITION (EFCS) (FT)		
	X	Y	Z	X	Y	Z	X	Y	Z
.5000	-4.93	.00	4.65	6.78	556.20	68.48	292.60	560.40	283.76
.6000	-4.07	.00	4.81	6.30	535.44	68.08	347.15	839.38	348.69
.7000	-4.21	.00	4.04	5.84	516.20	61.78	399.71	519.89	401.63
.8000	-4.71	.00	2.77	5.46	498.50	57.91	450.44	501.85	452.70
.9000	-4.89	.00	1.85	5.22	482.06	52.93	499.47	484.95	502.03
1.0000	-4.64	.00	1.59	4.91	466.59	47.68	546.90	469.02	549.73
1.1000	-4.21	.00	1.71	4.54	452.18	42.89	592.83	454.21	595.88
1.2000	-3.79	.00	1.88	4.23	438.71	38.72	637.37	440.41	640.60
1.3000	-3.49	.00	1.90	3.98	426.04	35.04	680.60	427.48	683.99
1.4000	-3.32	.00	1.77	3.76	414.08	31.60	722.60	415.29	726.12
1.4910	-1.67	.00	.30	1.70	403.78	28.48	759.81	404.78	763.42
1.5000	-1.67	.00	.29	1.70	403.37	28.22	763.45	404.36	767.06
1.6000	-1.75	.00	.05	1.75	398.84	25.05	803.58	399.63	807.26
1.7000	-1.90	.00	-.38	1.94	394.29	21.32	843.26	394.86	846.98
1.7620	-2.01	.00	-.75	2.14	391.36	18.49	867.63	391.80	871.35
1.7820	-2.01	.00	-.75	2.14	391.36	18.49	867.63	391.80	871.35

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DATE: 1 SEP 83

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RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT

SIIIS-ER A-7 SRT 44 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENGEL SEAT - CATAPULT,ROCKET,DART, DROGUE,CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 800.90 FT/SEC Z VELOCITY: 0.00 FT/SEC

ROLL: 0.00 DEG

PITCH: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 3: SEAT/OCCUPANT ANGULAR TIME HISTORY

TIME (SEC)	ACCELERATION (SCS)			RATE (EFCS)			ORIENTATION (EFCS)					
	X	Y	Z	X	Y	Z	RES	ROLL	PITCH	YAW	RES	
0.0000	CATAPULT 1 IGNITION											
0.0000	CATAPULT 2 IGNITION											
0.0000	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	-15.00	0.00	15.00	
0.0008	SEAT FIRST MOTION											
0.0008	-0.00	879.88	-0.00	-0.00	.35	-0.00	.35	-0.00	-15.00	.00	15.00	
0.0100	-19	6167.97	.03	-0.00	36.15	-0.00	36.15	-0.00	-14.86	.00	14.86	
0.0200	-64	-4550.51	1.03	-0.00	20.30	-0.00	20.30	-0.00	-14.49	.00	14.49	
0.0300	-60	-904.08	3.27	-0.01	-13.32	-0.02	13.32	-0.00	-14.50	.00	14.50	
0.0400	-70	-200.91	5.07	-0.01	-7.65	-0.05	7.65	-0.00	-14.61	.00	14.61	
0.0500	-52	-142.15	7.72	-0.01	-10.80	-0.09	10.80	-0.00	-14.70	.00	14.70	
0.0600	-44	3327.03	10.18	-0.01	8.64	-0.13	8.64	-0.00	-14.74	.00	14.74	
0.0700	-73	357.98	12.23	-0.01	24.44	-0.18	24.44	-0.00	-14.54	.00	14.54	
0.0800	-87	-2885.40	14.95	-0.02	1.21	-0.23	1.23	-0.00	-14.38	.01	14.38	
0.0900	-67	-626.90	17.21	-0.02	-15.10	-0.29	15.11	-0.00	-14.49	.01	14.49	
0.1000	-59	1263.76	19.52	-0.02	-5.20	-0.34	5.21	-0.00	-14.60	.01	14.60	
0.1100	-1.03	1770.72	21.90	-0.02	8.98	-0.40	8.99	-0.01	-14.58	.02	14.58	
0.1200	-1.93	2359.28	24.72	-0.02	23.65	-0.46	23.65	-0.01	-14.42	.02	14.42	
0.1300	-3.60	1841.78	28.22	-0.04	33.17	-0.53	33.17	-0.01	-14.13	.03	14.13	
0.1400	-8.02	3819.56	30.17	-0.06	42.81	-0.59	42.81	-0.01	-13.78	.03	13.78	
0.1484	CATAPULT 1 SEPARATION											
0.1484	CATAPULT 2 SEPARATION											
0.1484	RAIL SEPARATION											
0.1484	SEAT SEPARATION FROM AIRCRAFT											
0.1484	4.82	-192.76	-4.99	-0.10	72.28	.65	72.27	-0.01	-13.29	.04	13.29	
0.1590	4.51	-196.21	-4.75	-0.05	65.51	.55	65.52	-0.01	-12.56	.04	12.56	
0.1830	DROGUE GUN/CONTAIN. DEPLOYMENT											
0.1630	4.49	-173.28	-4.67	-0.03	63.72	.53	63.72	-0.01	-12.30	.05	12.30	
0.1910	ROCKET 1 IGNITION											
0.1910	ROCKET 2 IGNITION											
0.1910	4.70	135.83	-3.55	.10	56.08	.36	56.08	-0.01	-10.65	.06	10.65	
0.2000	5.93	697.56	-6.18	.14	57.91	.30	57.91	-0.01	-10.14	.06	10.14	
0.2130	DROGUE CHUTE LINE STRETCH											
0.2130	7.10	786.33	-7.94	.22	65.53	.19	65.53	-0.01	-9.34	.06	9.34	
0.2720	DART START RIGHT LINE											
0.2720	DART START LEFT LINE											
0.2720	-1.07	-3294.78	9.98	.52	26.91	.16	26.92	.02	-5.85	.06	5.85	
0.3000	-99	-4722.12	17.33	.44	-82.57	.61	82.57	.03	-8.57	.07	8.57	
0.3230	DROGUE CHUTE FULL INFLATION											
0.3230	-2.00	-5609.13	21.20	.37	-189.55	.89	189.56	.03	-9.68	.09	9.68	
0.4000	-6.41	-510.70	-3.33	.18	-320.95	1.19	320.95	.05	-32.10	.20	32.10	
0.4160	ROCKET 1 BURNOUT											
0.4160	ROCKET 2 BURNOUT											
0.4160	-3.88	1202.35	-6.80	.25	-295.56	1.03	295.56	.09	-37.06	.23	37.06	
0.4490	DART STOP RIGHT LINE											
0.4490	DART STOP LEFT LINE											
0.4490	-5.75	473.57	-7.97	.21	-190.45	.60	190.46	.18	-45.25	.32	45.26	

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APPENDIX D

GESS Performance Assessment

Input Listings

START
 GESS PROGRAM VALIDATION - RUN NO. 1 - 28 MARCH 1983
 SITS-ER A-7 (P)SRT #1 - O.O KEAS - 98% OCCUPANT - LOW SPEED MODE
 STENCIL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TSTART O.O TSTOP O.O ESTOP 30 IRESIRT 1 IPLOT 0
 IUNITS 1 ISEATTR 0 ISOSEP 1
 IORIFLG 1 IREPTS(2) 1 IREPTS(3) 0 IREPTS(4) 1
 IREPTS(5) 0 IREPTS(6) 0 IREPTS(7) 0 IREPTS(8) 0
 IREPTS(9) 0 IREPTS(10) 0 IREPTS(11) 0 IREPTS(12) 0
 IREPTS(13) 0 IREPTS(14) 0 IREPTS(15) 0 IREPTS(16) 0
 IREPTS(17) 0 IREPTS(18) 0 IREPTS(19) 0 IREPTS(20) 0
 IREPTS(21) 0 IREPTS(22) 0 IREPTS(23) 0 IREPTS(24) 0
 IREPTS(25) 0 IREPTS(26) 0 IREPTS(27) 0 IREPTS(28) 0
 IREPTS(29) 0 IREPTS(30) 0 IREPTS(31) 0
 P11 100 P12 100 P13 20
 DTPHAS1 .0001 DTPHAS2 .0001 DTPHAS3 .005
 TEMP 71.5 PRESSUR 915.8 DENSITY .00212
 XPOS 0.0 YPOS 0.0 ZPOS 0.001
 YAW 0.0 PITCH 0.0 ROLL 0.0
 RVEL 0.0 QVEL 0.0 PVEL 0.0
 WINDX 8.132 WINDY -4.307 WINDZ 0.0
 XACVEL 0.0 ZACVEL 0.0 CKPITHI 3.5
 NPTSAAT 0
 XPOSSRP .165 YPOSSRP 0.0 ZPOSSRP .55
 XCGSA .3825 YCGSA 0.0 ZCGSA 1.4000
 IXSA 4.0 IYSA 0.0 IZSA 0.0
 IVSA 5.0 IVZSA 0.0 IZSA 1.0
 PHISA 0.0 PSISA 0.0
 AREASA 6.0 HGHTSA 3.5 WHTSA 163.5
 XPOSBOT 0.0 YPOSBOT 0.0 ZPOSBOT 0.0
 XPOSSCS 0.0 YPOSSCS 0.0 ZPOSSCS 0.0
 XCGSO 0.8917 YCGSO 0.0 ZCGSO 1.025
 IXSO 22.0 IYSO 0.0 IZSO 0.0
 IVSO 22.0 IVZSO 0.0 IZSO 6.3
 AREASO 7.5 WHTSO 414.2
 AREAOAA 9.6 WHTOAB 250.7 WHTOAA 250.7
 SOSEP 0.968 DMPGC 0.40
 RAILNTH 3.5 RAILANG -17.5
 ISTRL 1 NSLBKS 0
 KXSB 50000.0 KYSB 50000.0 MUSB 0.050
 YKTOR 500.0
 XPOSRR 0.0 YPOSRR 0.0
 XPOSRLR 0.0 YPOSRLR .4167 ZPOSRLR 0.0
 INCAT 2
 CATLNT(1) 3.5 CATSTK(1) 3.5 TCI(1) 0.0302
 XPOSAP(1) 0.0 YPOSAP(1) -.4167 ZPOSAP(1) 3.5
 NPTSCT(1) 4
 0.0 0.0 0.01
 0.16 2450.0 0.20
 3.5 CATSTK(2) 3.5 TCI(2) 0.0302
 XPOSAP(2) 0.0 YPOSAP(2) .4167 ZPOSAP(2) 3.5
 NPTSCT(2) 4
 0.0 0.0 0.01
 0.16 2450.0 0.20
 ITUBEND 0
 INRKT 2
 RKIGN(1) 0.0 RKWGT(1) 6.0 RKBURN(1) 0.236 RKOELY(1) 0.187
 XPOSRK(1) 0.0 YPOSRK(1) -0.5833 ZPOSRK(1) -0.0533
 RKALPH(1) 53.15 RKBETA(1) 68.0 RKGAMA(1) 45.0
 RKNPTS(1) 7

NAME	UNIT	VALUE	UNIT	VALUE	UNIT	VALUE
AKIGN(2)	0.03	2200.0	0.25	2400.0		
XPOSRK(2)	0.27	300.0	0.28	10.0		
AKALPH(2)	0.31	0.0				
AKNPTS(2)	0.0	0.0				
	0.0	0.0	0.336	RKDELY(2)	0.187	
	0.0	0.5833	ZPOSRK(2)	-0.0533		
	53.150	112.0	RKGAMA(2)	45.0		
	7					
	0.0	0.0				
	0.03	2200.0	0.25	2400.0		
	0.27	300.0	0.28	10.0		
	0.31	0.0				
IDROQUE	1					
IDROQUE	0.166	DISPLY	14.00			
IDROQUE	0.60	DROGRD1	0.05			
IDROQUE	0.50	WGHTDC	1.00			
IDROQUE	0.00	YDROGAP	2.00			
IDROQUE	1					
IDROQUE	2					
IDROQUE	0.00	0.464	1500.00	0.464		
IDROQUE	1					
IDROQUE	2					
IDROQUE	0.00	1.070	1800.00	1.070		
IDROQUE	1					
IDROQUE	25.5	RECDRAG	0.75			
IDROQUE	28.00	POROSR	0.05			
IDROQUE	0.2917	YRECAP	0.00	ZRECAP	3.083	
IDROQUE	7000.00	CHALT1	14000.00	GLIMIT	0.00	
IDROQUE	.000	CHALT2				
IDROQUE	1					
IDROQUE	0.289					
IDROQUE	2					
IDROQUE	0.00					
IDROQUE	1					
IDROQUE	2					
IDROQUE	0.00					
IDROQUE	1					
IDROQUE	900.0	DRTSTRT	8.0	DRTSTOP	21.0	
IDROQUE	0.0417	YDRAP(1)	-0.4167	ZDRAP(1)	-0.1917	
IDROQUE	0.6667	YDRTCP(1)	-0.4167	ZDRTCP(1)	-1.8900	
IDROQUE	0.0417	YDRAP(2)	0.4167	ZDRAP(2)	-0.1916	
IDROQUE	0.6667	YDRTCP(2)	0.4167	ZDRTCP(2)	-1.8900	
IDROQUE	0					
IDROQUE	1					

GESS PROGRAM VALIDATION - RUN NO. 2 - 28 MARCH 1983									
S1115-ER A-7 DVT #3 - 440 KEAS - 3% OCCUPANT - HIGH SPEED MODE									
STENGEL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE									
TSTART O.O TSTOP O.O ESTOP O.O ISOSEP O ISOSEP									
IUNITS 1 ISEATTR 1 IREPTS(2) 1 IREPTS(3) 0 IREPTS(4)									
IDIRFLG 1 IREPTS(8) 0 IREPTS(7) 0 IREPTS(8)									
IREPTS(9) 0 IREPTS(10) 0 IREPTS(11) 0 IREPTS(12)									
IREPTS(13) 0 IREPTS(14) 0 IREPTS(15) 0 IREPTS(16)									
IREPTS(17) 0 IREPTS(18) 0 IREPTS(19) 0 IREPTS(20)									
IREPTS(21) 0 IREPTS(22) 0 IREPTS(23) 0 IREPTS(24)									
IREPTS(25) 0 IREPTS(26) 0 IREPTS(27) 0 IREPTS(28)									
IREPTS(29) 0 IREPTS(30) 0 IREPTS(31) 0									
100 P12 100 P13 20									
DTPHAS1 .0001 DTPHAS2 .001 DTPHAS3 .005									
TEMP 75.0 PRESSUR 915.8 DENSITY .00211									
XPOS 0.0 YPOS 0.0 ZPOS 0.001									
YAW 0.0 PITCH 0.0 ROLL 0.0									
RVEL 0.0 QVEL 0.0 PVEL 0.0									
WINDX 4.800 WINDY 746.1 ZACVEL -5.362 WINDZ 0.0									
XACVEL 746.1 ZACVEL -5.362 WINDZ 0.0 CKPITH 3.5									
NPTSAAAT 0									
NPTSLAT 0									
XPOSSRP .165 YPOSSRP 0.0 ZPOSSRP .55									
XCGSA .3625 YCGSA 0.0 ZCGSA 1.4000									
IXXA 4.0 IXYSA 0.0 IXZSA 0.0									
IYXA 5.0 IYZSA 0.0 IZZSA 1.0									
PHISA 0.0 PSISA 0.0 THESA 0.0									
AREASA 6.0 WHTSA 3.5 WHTSA 167.0									
XPOSBOT 0.0 YPOSBOT 0.0 ZPOSBOT 0.0									
XPOSSCS 0.0 YPOSSCS 0.0 ZPOSSCS 0.0									
XCGSO 0.7180 YCGSO 0.0 ZCGSO .9683									
IXXSO 22.0 IXYSO 0.0 IXZSO 0.0									
IYYSO 22.0 IYZSO 0.0 IZZSO 6.3									
AREASO 7.5 WHTSO 341.2									
AREADAA 8.6 WHTDAB 174.2 WHTDAA 174.2									
SOSEP 1.920 DMPGC 0.40									
RAILNTH 3.5 RAILANG -17.8									
ISTR 1 NSLBKS 0									
KXSB 50000.0 KYSB 50000.0 MUSB 0.050									
YKTOR 500.0									
XPOSRE 0.0 YPOSRE -.4167 ZPOSRE 0.0									
XPOSLE 0.0 YPOSLE .4167 ZPOSLE 0.0									
INCAT 2									
CATLNT(1) 3.5 CATSTK(1) 3.5 TCI(1) 0.0192									
XPOSAP(1) 0.0 YPOSAP(1) -.4167 ZPOSAP(1) 3.5									
NPTSCT(1) 4									
CATLNT(2) 0.0									
XPOSAP(2) 0.16									
CATSTK(2) 3.5									
XPOSAP(2) 3.5									
NPTSCT(2) 4									
CATLNT(2) 0.0									
XPOSAP(2) 0.16									
NPTSCT(2) 4									
ITUBEND 0									
INRKT 2									
RKIGN(1) 0.0 RKWGT(1) 6.0 RKBURN(1) 0.236 RKDELY(1) 0.179									
XPOSRK(1) 0.0 YPOSRK(1) -.0583 ZPOSRK(1) -0.0533									
RKALPH(1) 53.15 RKBETA(1) 68.0 RKGAMA(1) 45.0									
RKNPST(1) 7									
RKNPST(1) 0									

AKJH(2)	0.03	2200.0	0.25	2400.0
XPOSRK(2)	0.27	300.0	0.28	10.0
RKALPH(2)	0.31	0.0	0.238	0.178
RKNPTS(2)	0.0	0.0	-0.0533	
	53.15	0.5833	45.0	
	7	112.0		
	0.0	0.0	0.02	2000.0
	0.33	2200.0	0.28	2400.0
	0.27	300.0	0.28	10.0
	0.31	0.0		
IDROGUE	0.155	0.00	14.00	
TDDPLOY	0.60	0.00	0.05	
DRDRAG1	0.50	3.25	1.00	
AREADC	0.00	0.00	2.00	
XDRGAP	1			
IDROGLS	2			
NPTSCLS	0.00	0.039	1500.00	0.039
IFTOR01	1			
NPTDFT1	2	0.092	1800.00	0.092
IRECOV	0.00			
RECOVLL	25.5	0.75		
RECOVPD	28.00	0.05		
XRECAP	0.2917	0.00	3.083	
CHALT1	7000.00	14000.00	0.00	
TDELAY	.000			
NPTSROT	1			
TDDPLOY	1.417			
NPTSRLS	2			
JFTRECV	0.00	0.268	1500.	0.268
NPTSRT	1			
IOART	0.00	0.983	1500.	0.983
DRTRCE	800.0	8.0	21.0	
XDRTAP(1)	0.0417	-0.4167	-0.1917	
XDRTCP(1)	0.8667	-0.4167	-1.6900	
XDRTAP(2)	0.0417	0.4167	-0.1916	
XDRTCP(2)	0.8667	0.4167	-1.6900	
ITVC	0			
JOYMCQ	1			
STOP				

START	QEST PROGRAM VALIDATION - RUN NO. 3 - 28 MARCH 1983	30 IRESTR	1 IPLOT
1111-ER A-7 DVT #2 - 200 KEAS - 98% OCCUPANT - LOW SPEED MODE			
STENCIL SEAT - CATAPULT, ROCKET, DART, DROGUE, CHUTE OPERATE			
TSTART	O.O TSTOP	O.O ESTOP	
IUNITS	1 ISEATTR	O IPOSEP	
IDRTFLG	1		
IREPTS(1)	1 IREPTS(2)	1 IREPTS(3)	0 IREPTS(4)
IREPTS(5)	0 IREPTS(6)	0 IREPTS(7)	0 IREPTS(8)
IREPTS(9)	0 IREPTS(10)	0 IREPTS(11)	0 IREPTS(12)
IREPTS(13)	0 IREPTS(14)	0 IREPTS(15)	0 IREPTS(16)
IREPTS(17)	0 IREPTS(18)	0 IREPTS(19)	0 IREPTS(20)
IREPTS(21)	0 IREPTS(22)	0 IREPTS(23)	0 IREPTS(24)
IREPTS(25)	0 IREPTS(26)	0 IREPTS(27)	0 IREPTS(28)
IREPTS(29)	0 IREPTS(30)	0 IREPTS(31)	0 IREPTS(32)
P11	100 P12	100 P13	20
DTPHAS1	.0001 DTPHAS2	.001 DTPHAS3	.005
TEMP	59.0 PRESSUR	912.4 DENSITY	.00216
XPOS	O.O YPOS	O.O ZPOS	O.O01
RVEL	O.O PITCH	O.O ROLL	O.O
WINDX	O.O QVEL	O.O PVEL	O.O
XACVEL	-18.988 WINDY	10.980 WINDZ	O.O
NPTSAT	339.3 ZACVEL	O.O CKPITH	3.5
NPTSLAT	0		
XPOSSRP	.165 YPOSSRP	O.O ZPOSSRP	.55
XCGSA	.3826 YCGSA	O.O ZCGSA	1.4000
IXXA	4.0 IXYA	O.O IXZA	O.O
IYXA	5.0 IYZA	O.O IZZA	1.0
PHISA	O.O PSIA	-15.0 THESA	O.O
AREASA	6.0 HGHTSA	3.5 WHTSA	163.0
XPOSBOT	O.O XPOSBOT	O.O ZPOSBOT	O.O
XPOSSCS	O.O YPOSSCS	O.O ZPOSSCS	O.O
XCGSO	0.8517 YCGSO	O.O ZCGSO	1.038
IXXSO	22.0 IXYSO	O.O IXZSO	O.O
IYYSO	22.0 IYZSO	O.O IZZSO	6.3
AREASO	7.5 WHTSO	418.5	
AREAOA	9.6 WHTOAB	255.5 WHTOAA	255.5
SOSEP	0.768 DMPCG	O.40	
RAILNTH	3.5 RAILANG	-17.5	
ISTR	1 NSLBKS	O	
KXSB	50000.0 KYSB	50000. MUSB	O.050
XKTOR	500.0		
XPOSRRE	O.O YPOSRRE	-.4167 ZPOSRRE	O.O
XPOSIRE	O.O YPOSIRE	.4167 ZPOSIRE	O.O
INCAT	2		
CATLNT(1)	3.5 CATSTK(1)	3.5 TCI(1)	O.0252
XPOSAP(1)	O.O YPOSAP(1)	-.4167 ZPOSAP(1)	3.5
NPTSCT(1)	4		
	O.O	O.O	
	0.16	2450.0	2450.0
CATLNT(2)	3.5 CATSTK(2)	3.5 TCI(2)	O.020
XPOSAP(2)	O.O YPOSAP(2)	.4167 ZPOSAP(2)	O.0252
NPTSCT(2)	4		3.5
	O.O	O.O	
	0.16	2450.0	2450.0
ITUREAD	0		
INRKT	2		
RKGN(1)	O.O RKWGT(1)	6.0 RKBURN(1)	O.248
XPOSRK(1)	O.O YPOSRK(1)	-0.5833 ZPOSRK(1)	O.168
RKALPH(1)	3.15 RKBETA(1)	68.0 RKGAMA(1)	-0.0533
RKNPTS(1)	7		45.0
	O.O	O.O	
	0.0	O.O	O.02
			2000.0

RTNEN(2)	0.03	2200.0	0.25	2400.0
XPOSRK(2)	0.27	300.0	0.25	10.0
BKALPH(2)	0.31	0.0		
RKNPTS(2)	0.0	6.0	0.248	0.188
	0.0	0.5833	-0.0533	
	53.15	112.0	45.0	
	7			
	0.0	0.0	0.02	2000.0
	0.03	2200.0	0.25	2400.0
	0.27	300.0	0.25	10.0
	0.31	0.0		
IDROGUE	1	0.00	14.00	
TDDPLOY	0.158	0.00	0.05	
DROGPD1	0.80	3.25	1.00	
AREADC	0.50	3.00	2.00	
XDROGAP	0.00	0.00		
IDROGLS	1			
NPTSOLS	2			
IFTDRD1	0.00	0.071	1500.00	0.071
NPTDFT1	2	0.165	1500.00	0.165
IRECOV	1	0.75		
RECOVLL	25.5	0.05		
RECOVPD	28.00	0.00	3.083	
XRECAP	0.2917	14000.00	0.00	
CHALT1	7000.00			
TDELAY	.000			
NPTSROD1	1	0.248	1500.	0.248
TDDPLOY	0.333			
NPTSRLS	2			
IFTRECV	0.00			
NPTSRT1	2	0.991	1500.	0.991
IDART	1	8.0	21.0	
DRTRCE	900.0	-0.4167	-0.1917	
XDRTP(1)	0.0417	-0.4167	-1.6900	
XDRTCP(1)	0.8667	0.4167	-0.1916	
XDRTP(2)	0.0417	0.4167	-1.6900	
XDRTCP(2)	0.8667			
ITVC	0			
IDYNCG	1			
STOP				

30

WRTM(2)	0.03	2200.0	0.28	2400.0
XPOSRK(2)	0.37	300.0	0.39	10.0
RKALPH(2)	0.31	0.0		
RKAPTS(2)	0.0	0.0	0.247	0.180
	0.0	0.0	-0.0333	
	53.15	0.5833	45.0	
	7	112.0		
	0.0	0.0		
	0.03	2200.0	0.02	2000.0
	0.37	300.0	0.25	2400.0
	0.31	0.0	0.29	10.0
IDROGUE	0.148	0.0		
TDDPLOY	0.60	0.00	14.00	
DRORAI	0.50	3.25	0.05	
AREADC	0.50	3.00	1.00	
XDRGAP	0.00	0.00	2.00	
IDROGLS	1			
NPTSCLS	2			
	0.00	0.144	1500.00	0.144
IFTORO1	1			
NPTDFT1	2			
	0.00	0.337	1500.00	0.337
IRECOV	1			
RECOVLL	25.5	0.75		
RECOVPD	28.00	0.05		
XRECAP	0.2917	0.00	3.043	
CHALT1	7000.00	0.00	0.00	
TDELAY	.000	14000.00		
NPTSROT	1			
TDDPLOY	1.585			
NPTSRLS	2			
	0.00	0.513	1500.	0.513
IFTRECV	1			
NPTSRT	2			
	0.00	1.662	1500.	1.662
IDART	1			
ORTFRC	900.0	8.0	21.0	
XDRTCP(1)	0.0417	-0.4167	-0.1917	
XDRTCP(1)	0.8867	-0.4167	-1.6900	
XDRTCP(2)	0.0417	0.4167	-0.1916	
XDRTCP(2)	0.6667	0.4167	-1.6900	
ITVC	0			
IDYNG	1			
STOP				

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