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Computer Simulation of a Transport Aircraft Seat and Occupant(s) in a Crash Environment
Volume II - Program SOM-TA User Manuel

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FINAL REPORT

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16. Abstract

A mathematical model of a transport aircraft seat, occupants, and restraint system has been developed for use in analysis of transport aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model of the seat structure is included. The seat model can accommodate large plastic deformations and includes the capability for simulation of local buckling members. Because the program has been written for use primarily by engineers concerned with the design and analysis of seat and restraint systems, an effort has been made to minimize the input data required to describe the occupants. This report is Volume II of a two-volume document. Volume I discusses development of the mathematical model of the occupants, the finite element seat analysis, validation and organization of the computer program. Volume II contains instructions for preparing input data and operating the program, supported by detailed examples. Sample material properties and modeling parameters are also included.

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FOREWORD

This report was prepared by Simula Inc. under Contract No. DTFA3-83-C-00036 with the Federal Aviation Administration (FAA) Technical Center, where Mr. L. M. Neri acted as Technical Monitor. Under the same contract, computer simulation program SOM-TA (Seat/Occupant Simulation Model for Transport Aircraft) was developed.

The Simula Inc. Project Engineer has been Mr. Akif O. Bolukbasi. Dr. David H. Laananen of Arizona State University has provided consulting services during the development and validation of Program SOM-TA, and during the preparation of this report. Data for model validation have been provided by the Protection and Survival Laboratory, FAA Civil Aeromedical Institute, where the tests were conducted under the supervision of Mr. R. F. Chandler.

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1.0 INTRODUCTION

Program SOM-TA (Seat/Occupant Model - Transport Aircraft) combines a lumped parameter model of aircraft passengers with a finite element model of the seat structure. Its intent is to aid in the evaluation of the performance of aircraft seat and restraint systems in crash environments. Because the program has been written for use primarily by engineers concerned with the design and analysis of seats and restraint systems, an effort has been made to minimize the input required to describe the occupants. The program allows simulation of one, two, or three passengers, of the same or different sizes. Characteristics of two standard occupants, one dummy and one human, are included within the program, and an option is provided to simulate other occupants by providing additional input data. The structural model includes beam elements and has a maximum capacity of approximately 450 degrees of freedom, as determined by array dimensions within the program. The beam elements can accommodate large plastic deformations and include the capability for cross-section reduction due to local instabilities. As an option to reduce both modeling complexity and execution costs for cases where only the restraint system or cockpit configuration is of concern, or for cases where the details of the seat design may not yet be known, a rigid seat model, in which seat pan and back planes defined by input are maintained in fixed positions in the aircraft, is available.

The following sections of this report present instructions necessary for the use of Program SOM-TA and information to enable the user to operate the program most efficiently.

Sections 2.0 and 3.0 describe program input and output, respectively, including options available to the user. Section 4.0 outlines an efficient procedure for development of a mathematical model. Section 5.0 then provides detailed descriptions of the sample input case. Appendix A defines all input variables, line by line. Appendix B provides examples of material properties and occupant characteristics required as input data. Appendix C displays the complete set of output data for the input listed in Section 5.0 and Appendix A. Appendix D describes program organization and the functions of all subroutines.

2.0 PROGRAM INPUT DATA

Input data are read by Program SOM-TA in the following six blocks:

1. Simulation and output control information.
2. Cushion properties.
3. Restraint system description.
4. Crash conditions.
5. Occupant description.
6. Seat design information.

All input data, except those pertaining to the seat (Block 6), are read by subroutine INPT; the seat data are read by subroutines SEATIN and READIN.

The coordinate system that is fixed to the aircraft at the floor has the following positive directions:

X - Forward
Y - Left
Z - Upward

The basic input data deck consists of a minimum of 44 lines of data for execution of Program SOM-TA with three passengers. These are described in detail in Appendix A. The basic case makes use of a rigid seat model, specified by NSEAT = 0 on line 1. Modeling an actual seat with the finite element analysis would change lines 43 and 44, and require a number of additional lines. Requesting the storage of plot data on external files, unit 14 for the occupant and unit 20 for the seat, by setting NOPLOT > 0 or NSPLOT > 0 on line 3, requires additional lines following line 3. Modeling nonstandard occupant(s) requires an additional 12 data lines for each occupant, after line 41.

The following sections of this chapter present descriptions of each of the six input data blocks, including more detailed definitions of the above options. Line-by-line descriptions of input data are presented in Appendix A.

2.1 SIMULATION AND OUTPUT CONTROL INFORMATION

2.1.1 Systems of Units. The NUNIT parameter on line 2 permits the user to specify either the SI or English system of units for both input and output data. English units are presented throughout the input instructions in this report and are used in the sample input cases. In the SI system of units, all lengths are specified in meters, masses in kilograms, and forces or weights in newtons.

2.1.2 Seat Options. The NSEAT parameter on line 2 allows the user to select either a rigid seat model or a finite element seat model. The rigid seat model consists of two planes that represent the seat pan and seat back. The positions of these planes are specified by the X and Z coordinates of their intersection (a lateral line) and two angles which specify their positions relative to horizontal and vertical planes, respectively. The length of the seat pan and the height of the seat back are used to determine the limits of the surfaces within which the seat pan and back can apply forces to the occupant. Cushions, of input-specified thicknesses, are included on top of the seat pan and seat back surfaces.

The type of seat (single-, double-, or triple-occupant) is specified on line 2, along with identification of the positions that are occupied. Seat row pitch, used in plotting, is also specified in line 2.

2.1.3 Occupant Degrees of Freedom. The NDIM parameter on line 2 permits selection of either two- (NDIM = 2) or three-dimensional (NDIM = 3) occupant response. The three-dimensional occupant model consists of 12 rigid segments, illustrated in figure 1, with rotational springs and dampers at the joints. Each of the torso joints possesses three rotational degrees of freedom, or, in other words, is a ball-and-socket type joint. Because of the hinge-type motion at elbow and knee joints, the position of a forearm or lower leg relative to an upper arm or thigh, respectively, is described by one additional angular coordinate. In total, this occupant model possesses 29 degrees of freedom.

The two-dimensional occupant model, specified by NDIM = 2 on line 2, consists of 11 segments, as shown in figure 2. Beam elements in the torso and neck are capable of flexural and axial deformation. Although restricted to two-dimensional response, this occupant option does permit more direct evaluation of accident severity by output of forces and moments in the spine and neck. Restraint system forces on the ellipsoidal contact surfaces are computed three-dimensionally, but only the X- and Z-components are used. Therefore, the two-dimensional model should be reserved for cases in which both the impact conditions and the restraint system are symmetrical.

2.1.4 Output Control Data. Ten blocks of program output can be selected on line 3. The data include time histories of the following variables, which are stored during solution at predetermined print intervals:

1. Occupant segment positions (X, Y, Z, pitch and roll).*

2. Occupant segment velocities (X, Y, and Z).

3. Occupant segment accelerations (x, y, z, and resultants).*

4. Restraint system loads.

5. Cushion loads.

6. Aircraft displacement, velocity, and acceleration.

7. Injury criteria, including spinal forces and moments.

8. Details of contact between the occupants and the seat in front of them.

*Upper case X, Y, Z refer to inertial or aircraft-fixed coordinate system; lower case x, y, z refer to segment-fixed coordinates.

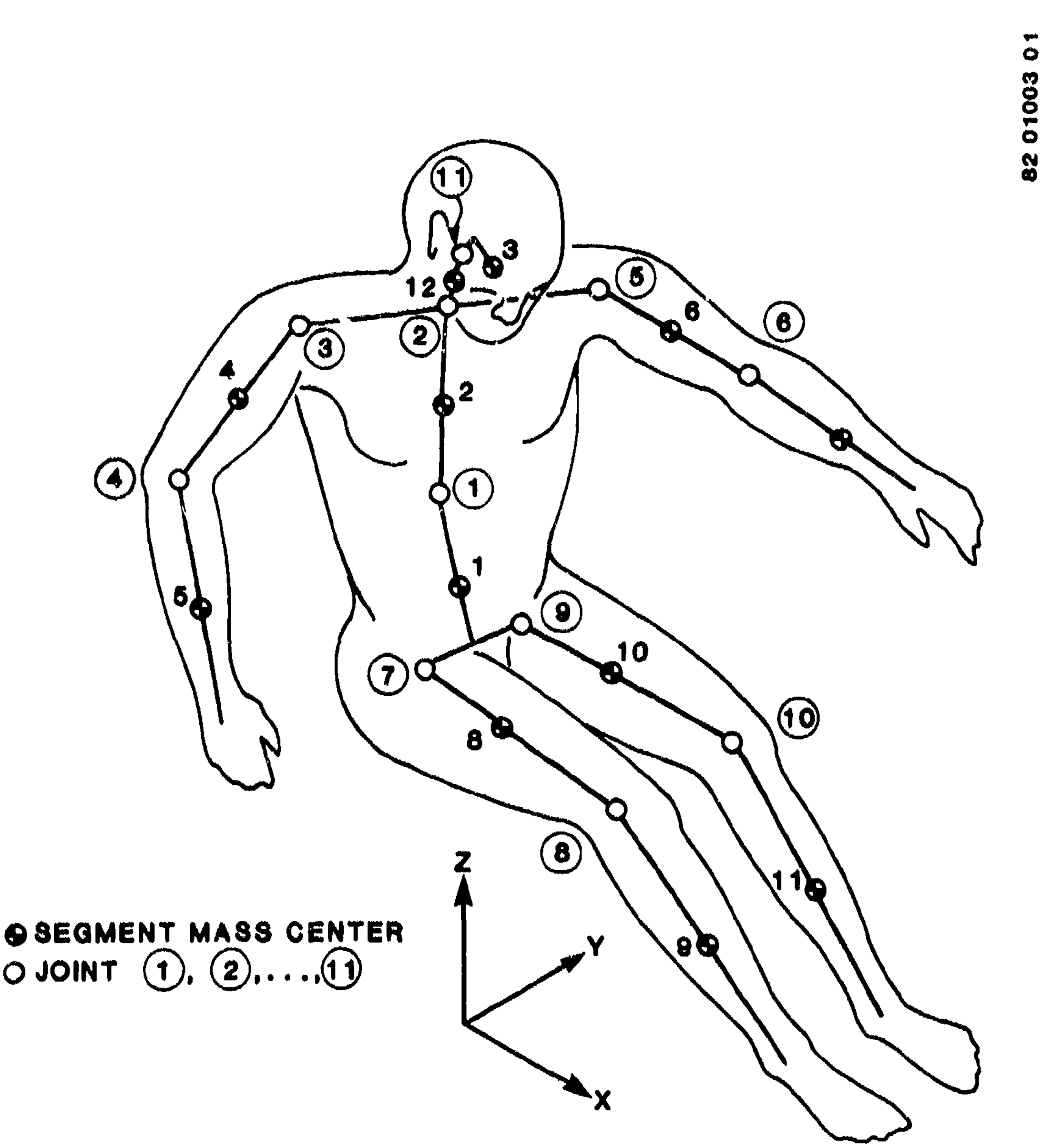


Figure 1. Twelve-segment (three-dimensional) occupant model.

9. Seat structure nodal forces.

10. Seat structure element stresses.

Printer plots are provided for occupant segment accelerations, restraint system loads, and cushion loads. The option of two different filters is also provided for the occupant segment accelerations and cushion loads. The particular occupant for which output data are displayed is specified in line 2.

If plots are requested for the occupant and/or seat on line 3, then additional lines must be included to specify plot times (up to eight) and viewing angles. As explained in the line-by-line input data descriptions, if plots are requested, the job control language must define external files 14 and 20 to be saved.

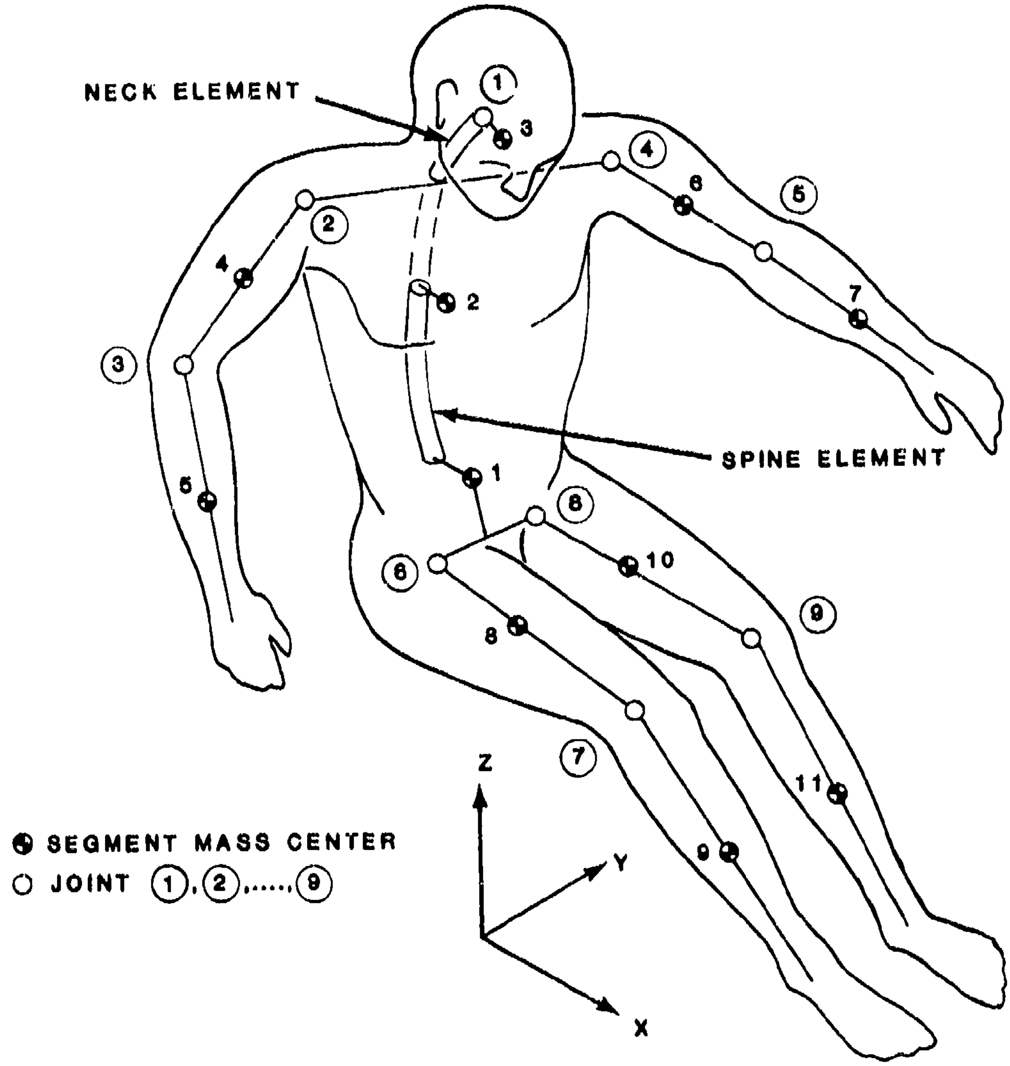


Figure 2. Eleven-segment (two-dimensional) occupant model.

Program output data are described further in Chapter 3.

2.1.5 Solution Control Data. The occupant model utilizes an Adams-Moulton predictor-corrector solution procedure with a variable time step. Data on line 4 control the step size and error bounds for the solution.

At every solution step, the system central processor time is checked and compared with the TMAX parameter on line 4. Allowing time for output, the solution will be terminated once system time reaches TMAX, whether or not the final solution time, TF, has been reached. Therefore, the permitted execution time in the job control language should be at least TMAX seconds, in order to ensure that the solution is terminated in time to permit printing of the output already computed and stored.

2.2 SECONDARY IMPACT OPTION

If secondary impact information is desired, it can be specified by input of IOUT(4) on line 3.

2.3 CUSHION PROPERTIES

Seat cushion forces applied to the occupant model are calculated from cushion deflections based on an exponential relationship:

$$F = C(e^{\beta\delta} - 1) \tag{1}$$

Lines 5 and 6, and 7A if a headrest is included on the seat, require input of the C and B coefficients for this equation, along with damping coefficients and thicknesses. The force-deflection relationship for the seat cushion also includes compliance of the occupant buttocks. Therefore, the relationship for an occupant sitting directly on a hard seat pan would be the force-deflection curve for the occupant buttocks. Several sample force-deflection curves with their appropriate coefficients are provided in Appendix B.

2.4 RESTRAINT SYSTEM DESCRIPTION

Several restraint system configurations are available in SOM-TA: lap belt only, lap with diagonal shoulder belt over either shoulder, and double shoulder belt. As specified on line 7, both the lap belt and shoulder harness can be attached to either the airframe or the seat.

The force-deflection characteristics of the restraint system webbing are provided by input of tables of forces and strains. Properties of representative webbing samples are included in Appendix B.

For a seat with a shoulder harness in which an inertia reel is mounted on the seat back and a length of inertia reel strap is passed along the seat back to a slot above the occupant shoulders, the XTRAL parameter on lines 11B, 11C, and 11D defines the length of the shoulder strap behind the seat back.

2.5 CRASH CONDITIONS

Six components of the acceleration of the aircraft coordinate system are provided on lines 12 through 35: X, Y, Z, yaw, pitch, and roll. All of these lines must be included, even if blank. For each acceleration component, two lines are included to allow up to 16 points on an acceleration-time history, and the subsequent two lines provide the corresponding points in time. Acceleration components are directed in the aircraft-fixed coordinate system.

2.6 OCCUPANT DESCRIPTION

The IMAN parameter on line 38 identifies the type of occupant being simulated. Initial positions for the three passengers are specified by data on lines 39 through 41. Data for the standard occupants, a 50th-percentile U.S. male and a 50th-percentile (Part 572) anthropomorphic dummy, are included within the program. For nonstandard occupants, additional data may be provided (for each occupant) following line 41 to define segment lengths, center of mass locations, weights, moments of inertia, contact surface radii, properties for the spine and neck, and compliances for the chest and abdomen under restraint system loading. Examples of these data are included in Appendix B.

The angular orientations of the torso, head, and arm segments are provided as input on lines 39 through 41, along with the X-coordinate of the heels. Static equilibrium is then used to seat the occupant in the cushions.

2.7 SEAT DESIGN INFORMATION

2.7.1 Rigid Seat Option. For cases where the details of seat response are not important or not worth the greater execution costs that would be incurred by the use of the finite element structural model, a rigid seat option is provided. Plane surfaces representing the seat pan and seat back support the cushions and remain fixed in the aircraft coordinate system, except where the energy-absorbing option is used.

2.7.2 Simplified Energy-Absorbing Seat Option. If the SEATM parameter on line 43 is greater than 0, a simplified, two-degree-of-freedom seat model is used. Intended for use in simulation of a guided energy-absorbing seat, this model permits the stroking of a rigid seat bucket in a prescribed direction. Because elastic bending of the supporting frame has been observed in testing of such seats and may influence occupant response, the second degree of freedom is added to simulate rotational elasticity of the frame.

Although the finite element analysis can provide a complete evaluation of a seat's crashworthy performance, the simple stroking seat model can prove useful in other aspects of seat design. For example, the two-degree-of-freedom model can aid in economically estimating the optimum energy absorber limit load for protection of occupants of various size, as well as in evaluating alternative restraint system configurations.

Input data for this seat model include the weight of the movable part of the seat, the direction along which it will stroke, the movement of inertia with respect to a lateral axis, force-deflection characteristics, and unloading slopes.

2.7.3 Finite Element Structural Analysis. The finite element seat model contained in Program SOM-TA uses beam elements. The beam elements can accommodate large, plastic deformations and localized buckling of elements with hollow cross sections. The program has a capacity for 150 nodes and 450 degrees of freedom. However, a more severe restriction is placed on the size, N, of the master stiffness matrix, given by:

$$N = MEQ + MUD * (2 * MEQ - MUD - 1)/2 \qquad (2)$$

where MUD is the length of the maximum upper diagonal of the banded stiffness matrix given by:

$$MUD = 6 * (J + 1) - 1 \tag{3}$$

MEQ equals the total number of degrees of freedom and J equals the maximum difference between node numbers across elements in the model, as illustrated in section 4.0.

As determined by array dimensions in Program SOM-TA, the quantity N is limited to 23,750.

The finite element seat model in SOM-TA uses an unconditionally stable solution algorithm. However, stability does not necessarily imply convergence to the correct solution, and solution accuracy will depend on the size of the time step, a smaller time step yielding more accurate results. Because the seat step size is governed by that for the occupant model, reducing DMAX and DMIN on line 4 will produce a more accurate solution. However, little improvement can be expected in reducing the seat step size below that normally required for stability in the occupant solution.

Material properties, including a three-slope approximation to the stress-strain curve, are provided on lines 45-47, which must be repeated for each material used. (The number of materials is specified as NUMMAT on line 43.) To assist in input of material properties, summaries of input data for metals typically used in seat frames are presented in Appendix B.

Beam cross sections can be either open or closed, but a plastic problem requires a closed cross section to generate all the terms required by the tangent stiffness matrix. If plastic deformation of an open "I" is anticipated, the cross section can be modeled as a closed "box" beam, which is equivalent for one bending direction, provided that the erroneous properties for other bending directions can be tolerated.

The NUMDIS parameter on line 43 specifies the number of nodes that are attached to the aircraft structure. Then, floor attachment conditions are specified on line 55, one of which must be inserted for each of the NUMDIS nodes. Element cross-sections are described by data on lines 48 and 49, which must be repeated for each cross-section, the number of which is specified by NSECT on line 43.

Nodal coordinates are provided on line 50, which is repeated for each node in the model (NNODE on line 43) and for each beam pointer node (NCOORD on line 43). As illustrated in Appendix A, the pointer node is required to specify the initial orientation of the y-axis of a beam cross section. A real node can be used as a pointer node, or (NCOORD) additional nodes can be added solely to serve as pointers.

3.0 PROGRAM OUTPUT DATA

Program SOM-TA output data are available from the following four sources:

1. Printer (unit 6)
2. Occupant position plots (unit 14)
3. Seat structure plots (unit 20)
4. Plots of other data (unit 26)

which are described further in the following sections.

3.1 PRINTED OUTPUT

Printed data can be selected from the ten blocks listed in section 2.1.4. The interval at which these data are printed is selected in subroutine INPT, based on the total solution time. The interval is sized to provide a maximum of 51 lines for each variable. For example, a solution time between 0.100 and 0.150 sec results in a print interval of 0.003 sec, a solution time between 0.250 and 0.300 sec, an interval of 0.006 sec, etc.

Accelerations, severity indices, vertebral forces and moments, and restraint system forces are printed in tabular and graphical formats. Other data are provided in tabular form only. Acceleration output data are computed each 0.001 sec, equivalent to a 1 KHz sampling rate. Input line 3 provides the option of applying Class 180 (300 Hz) or Class 60 (100 Hz) filter to the data prior to their printing.

3.2 OCCUPANT POSITION PLOTS

If specified in input line 3, data for up to eight plots of occupant position, can be stored on external file 14. The times for these plots are defined on input line 3A. Viewing angles, illustrated in figure 3, are defined on line 3B. The right-side view of figure 4 was obtained using an angle of zero degrees. The front view of figure 5 was obtained using an angle of 90 degrees.

The IOUT(4) parameter on line 3 can be used to draw the image of the seat in front of that being modeled. A value of 0 causes no seat to be drawn. A value of 1 or 2 respectively, produces a plot of the forward seat in its undeformed or deformed position and uses subroutine IMPACT for prediction of contact with the forward seat. The seat image is spaced according to the SPITCH parameter.

The job control language used in executing SOM-TA must define external file 14 as a permanent file to be saved. The occupant plotting program can then be executed using this same permanent file as input.

3.3 SEAT STRUCTURE PLOTS

Just as described in section 3.2 for occupant position, data for up to eight plots of the seat structure can be requested on line 3. As shown in figure 6,

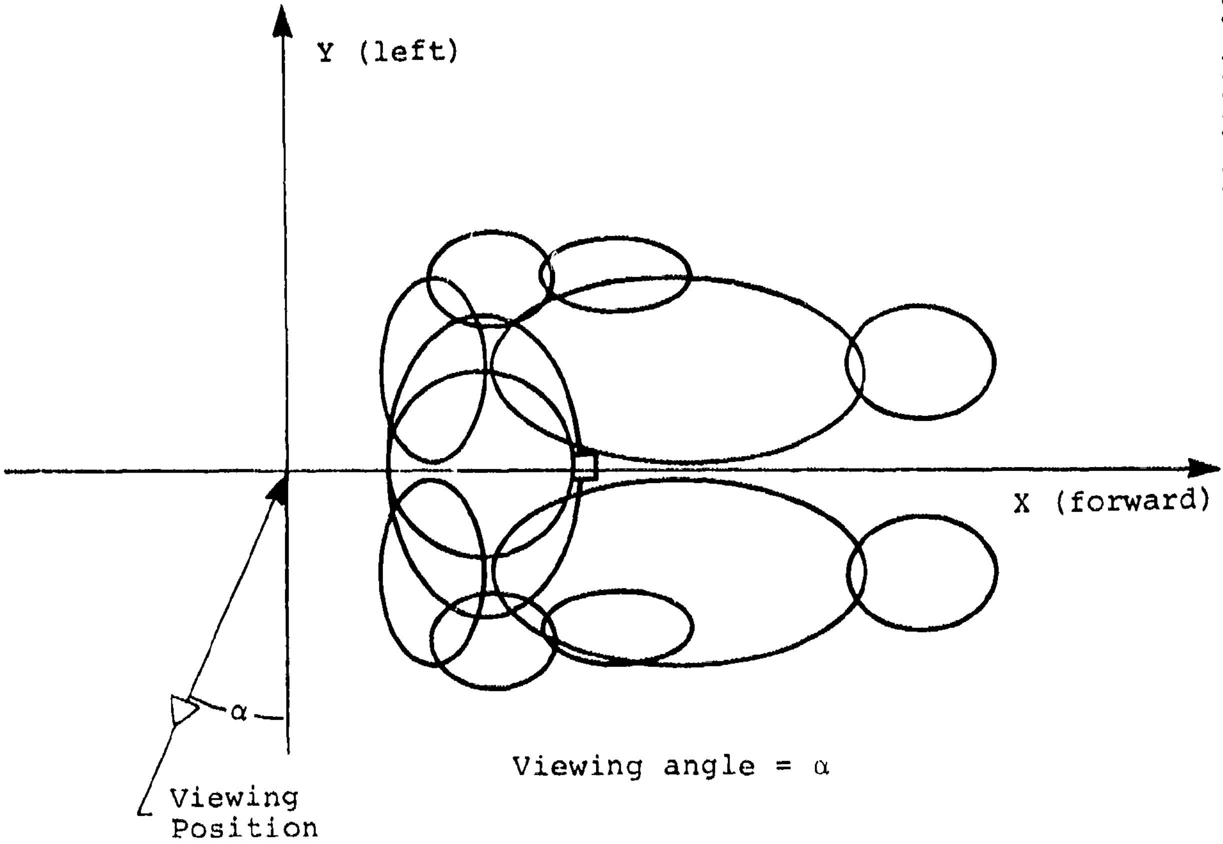


Figure 3. Definition of plot viewing angle.

nodes are indicated and numbered. The viewer position for the seat structure is defined by both elevation and azimuth angles, θ and ϕ, respectively, as shown in figure 7. The view of figure 6 was obtained with θ = 20 degrees and Φ = 45 degrees.

The job control language must save external file 20 as input to the seat plotting program.

3.4 ADDITIONAL DATA FOR PLOTTING

Although the printer plots of accelerations and forces are probably satisfactory output for most purposes, there may be cases where plots with a higher level of resolution are desired. Also, pen-drawn plots may be required for use in reports. To meet these needs, 32 variables are written on external file 26 at input-selected intervals. The input parameter DTPLT on line 3 specifies this interval in seconds, and is assumed to be 0.001 sec if DTPLT is left blank. The data are written in either F10.3 or F10.5 format and are arranged as illustrated in figure 8.

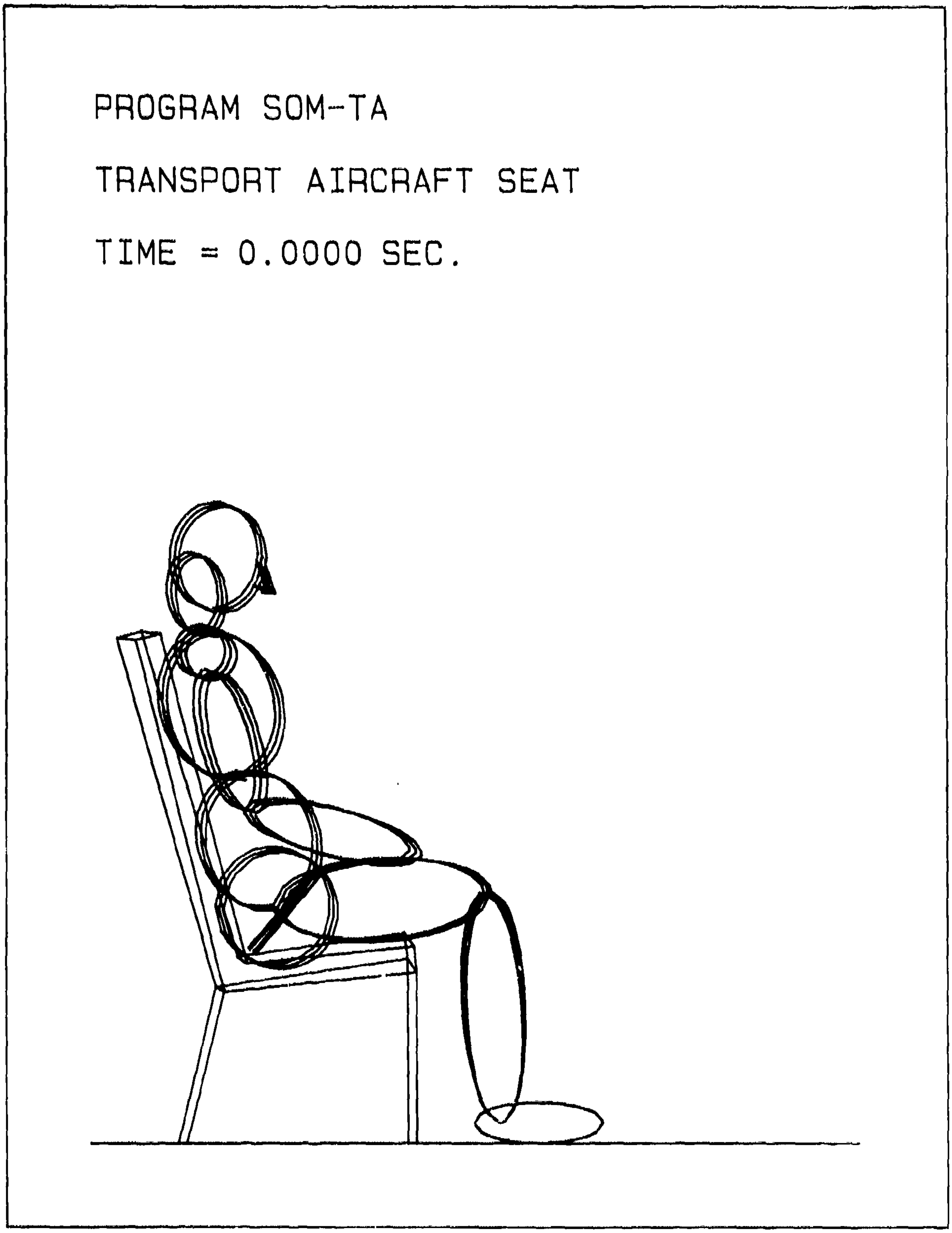


Figure 4. Sample case occupant plot (side view) at time = 0 sec.

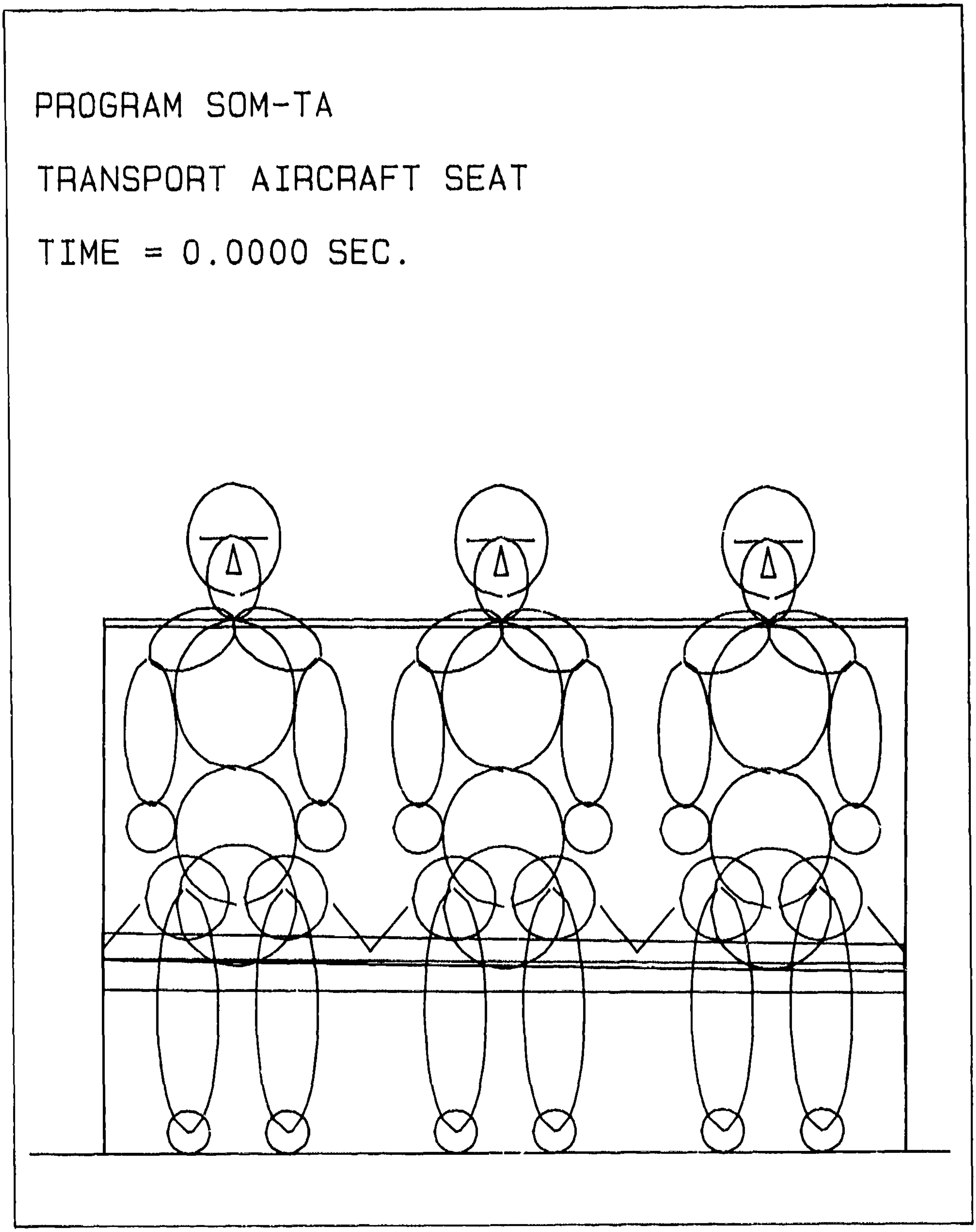


Figure 5. Sample case occupant plot (front view) at time = 0 sec.

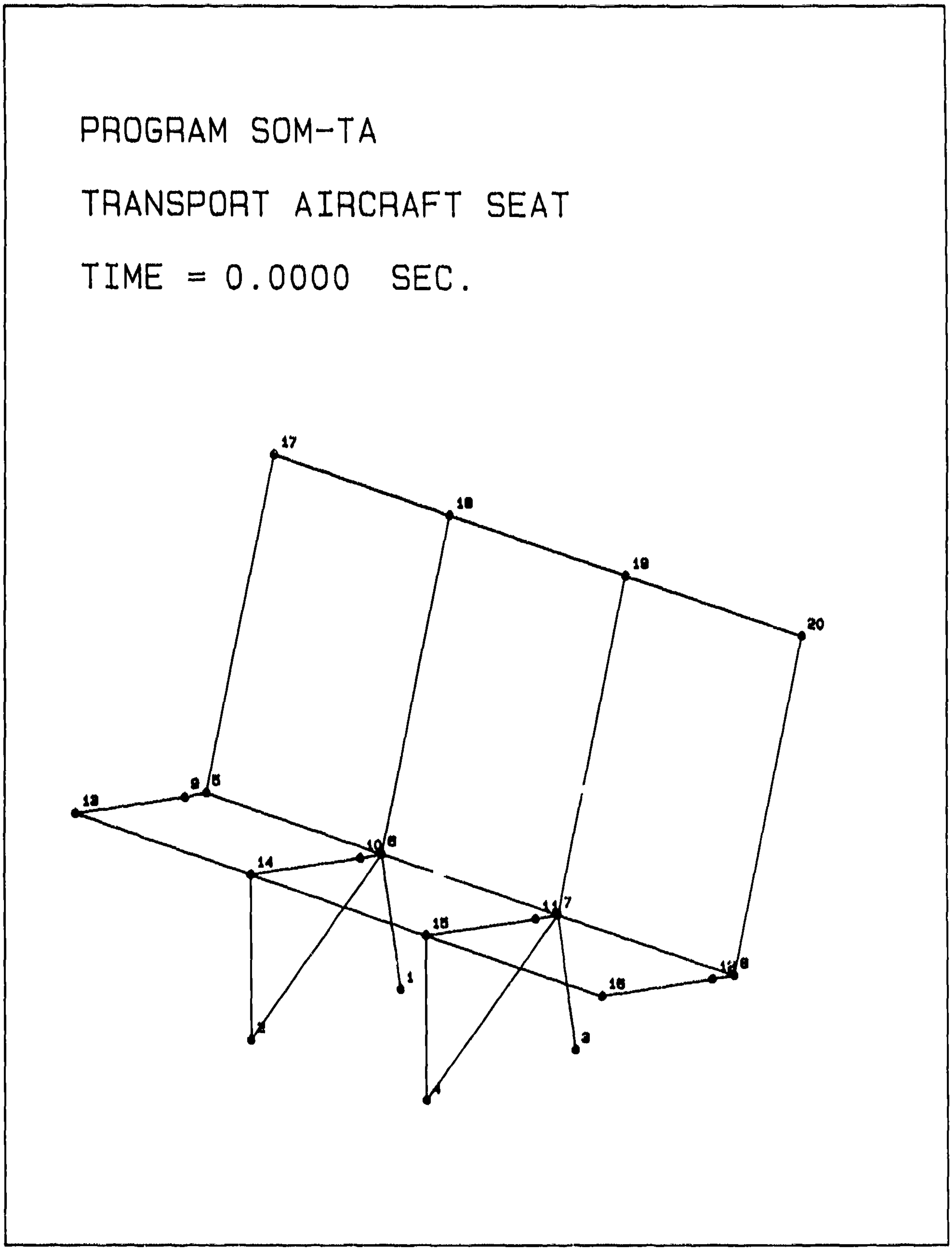
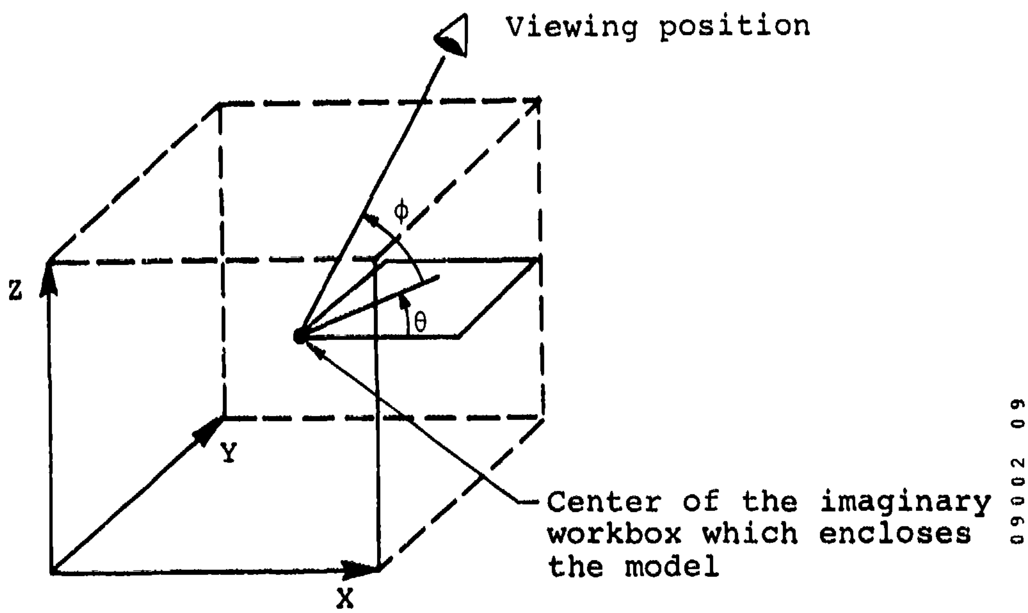


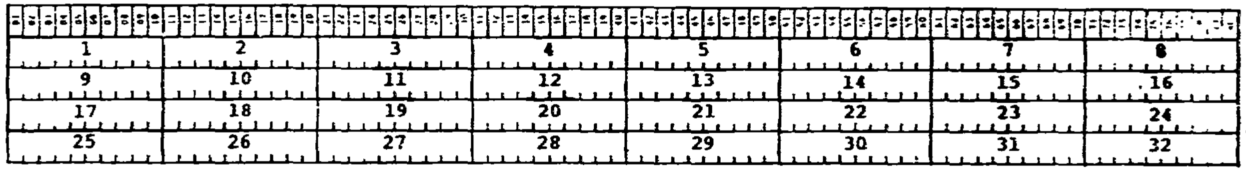
Figure 6. Sample case seat plot at time = 0 sec.



θ = Azimuth angle in X-Y plane in degrees ($-180° \leq \theta \leq +180°$)

ϕ = Elevation angle in degrees ($-90° \leq \phi \leq +90°$)

Figure 7. Angular coordinates for viewing seat plots.



Field	Format	Variable	Field	Format	Variable
1	F10.5	Time (sec)	17	F10.5	Pelvis x-accel (G)
2	F10.5	Aircraft X-accel (G)	18	F10.5	Pelvis z-accel (G)
3	F10.5	Aircraft Z-accel (G)	19	F10.5	Pelvis res. accel (G)
4	F10.5	Aircraft res. accel (G)	20	F10.3	Lumbar axial load (lb)
5	F10.5	Aircraft res. vel. (ft/sec)	21	F10.3	Lumbar y-moment (in.-lb)
6	F10.5	Aircraft res. displ. (in.)	22	F10.3	Neck axial load (lb)
7	F10.5	Seat X-accel (G)	23	F10.3	Neck y-moment (in.-lb)
8	F10.5	Seat Z-accel (G)	24	F10.3	Back cushion force (lb)
9	F10.5	Head x-accel (G)	25	F10.3	Right lap belt force (lb)
10	F10.5	Head z-accel (G)	26	F10.3	Left lap belt force (lb)
11	F10.5	Head res. accel (G)	27	F10.3	Right shoulder belt force (lb)
12	F10.5	Chest x-accel (G)	28	F10.3	Left shoulder belt force (lb)*
13	F10.5	Chest z-accel (G)	29	F10.3	Energy absorber force (lb)
14	F10.5	Chest res. accel (G)	30	F10.5	Seat displacement (in.)
15	F10.5	DRI	31	F10.3	Footrest X-force (lb)
16	F10.3	Seat cushion force (lb)	32	F10.3	Footrest Z-force (lb)

*Replaced by seat angular displacement (deg) for energy-absorbing seat model (with NSEAT = 0 and SEATM > 0).

Figure 8. Data format for external file 26.

4.0 INSTRUCTIONS FOR INPUT DATA PREPARATION

This chapter is intended to guide users of Program SOM-TA through an efficient process of preparing input data. The recommended procedure is summarized in table 1. It is suggested that, if time permits, the sample case described in detail in chapter 5 be run initially in order to be certain that the program runs properly on a particular computer system. Storage of plot data on permanent files and subsequent access of these files using the related occupant and seat plot programs should be attempted first with the sample case to assure that the plotting programs are compatible with the computer system and that the job control language is structured properly.

TABLE 1. SUMMARY OF INPUT DATA

1. On sketch of seat, locate aircraft fl... nd coordinate system.
2. Locate restraint system anchor points.
3. Locate footrest and/or heel position (at $Z = 0$).
4. Estimate initial position angles for occupant upper torso, head, and arms.
5. Prepare input data for and run rigid seat case for short time.
6. Plot occupant initial position and check whether it appears reasonable.
7. Add seat structure input.
8. Run short case with complete input data.
9. Check plot of seat structure at initial time.
10. Run complete case.

The essential starting point for any simulation case is a sketch of the seat of interest, on which the aircraft floor and aircraft coordinate axes can be located. On this sketch the restraint system anchor points, which can be fixed to either the seat or the aircraft structure, can be located, as can the position of a footrest or pedal, if applicable. The required seat design data for a rigid seat case, i.e., the locations and dimensions of the seat pan and back, can then be determined. Both the seat cushion and back cushion are assumed to be plane surfaces parallel to the seat pan and back surfaces. Using an average cushion thickness in the area of contact between the occupant and the seat, the cushion surfaces can now be added to the sketch.

Initial angular positions of the torso, head, and arm segments are required. The torso segments can be assumed parallel to, or one or two degrees forward of, the seat back. The position of the head, in a normal seated position, would range from vertical to several degrees forward of vertical, as illustrated in the section 5.0 sample case.

In order to be certain that the occupant initial position is reasonable for the configuration being studied, it is wise to run a short rigid seat case prior to adding the seat structure input. Starting with a small value of final time, TF, on line 4, such as 0.010 sec, the initial position and accelerations of the occupant segments and the external forces can be checked prior to initiating a more expensive case. The plot data saved on unit 14 by SOM-TA can then be input to the occupant plot program and the initial position of all the occupant segments reviewed. If the occupant's initial position, as calculated by subroutine INITIL, is geometrically impossible, the program will be stopped and informative messages printed. An example of this type of error, commonly encountered in initially running a case, is in attempting to locate the heel position beyond the reach of the legs. If the input parameters yield a geometrically feasible initial position and NOPLOT > 0 on line 3 and TPLOT = 0 on line 3A, then data for a plot of the initial position will be stored.

Once the desired initial position has been achieved for the occupant, the input data for the finite element seat structure model can be added. The NSEAT parameter on line 2 should then be changed from 0 to 1 to signify modeling a nonrigid seat. Once again, prior to running a complete simulation, a case with a small TF should be run in order to check the seat structure plot at the initial time.

When it has been determined that both the occupant initial position and the seat structure configuration are as desired, a complete simulation case can be run. The user should take care that the TMAX parameter in decimal seconds on line 4 corresponds to the time allotted for the run in the job control language (which may be an octal number). Within the program, an allowance is made for printing of the stored output data. Should the run be terminated at TMAX prior to the solution reaching completion at TF, the output data already generated will be printed, including the final generalized coordinates, which can be used in restarting the solution.

5.0 SAMPLE SIMULATION CASE

This section contains the description of input data for a sample simulation case. A simple airline seat model with three occupants was used to illustrate the capabilities of Program SOM-TA, including the preparation of input data and output data available from the program.

A complete line-by-line input data listing is discussed in Section 5.1. Output data are then discussed, and examples of plots presented, in Section 5.2. The contents of Appendix A show explicit input requirements for this case.

5.1 SAMPLE CASE INPUT DATA (DETAILED LISTING IN APPENDIX A)

Line 1: Descriptive title.

Line 2: NUNIT = 1 for English units; NSEAT = 1 for finite element seat; NDIM = 2 for two-dimensional simulation; NOCC = 3 for three occupants to be simulated; ITYPE = 3 for a three-occupant seat type; ISEAT (1) = 1, ISEAT (2) = 1 and ISEAT (3) = 1 to specify that all seat positions are occupied; IPASS = 2 to specify that the output data will be stored and printed for the center occupant.

Line 3: IOUT(1) = 1 and IOUT(2) = 1 request segment position and velocity data; IOUT(3) = 2 requests occupant segment acceleration, filtered with class 180 digital filter; IOUT(4) = 0 calls for no secondary impact simulation; IOUT(5) = 1 requests restraint system forces; IOUT(6) = 1 requests spinal loads and injury criteria; IOUT(7) = 1 requests seat external forces filtered with a class 60 digital filter; IOUT(8) = 1, IOUT(9) = 1, and IOUT(10) = 1 request seat structure deflection, support reactions, and beam loads and stresses, respectively; NOPLOT = 8 for eight occupant-position plots; NSPLOT = 8 for eight seat plots; DTPLT = 0.0005 determines the interval at which the data described in Section 3.4 are written in unit 26; TSEAT = 0.025 indicates the output data print interval for the seat.

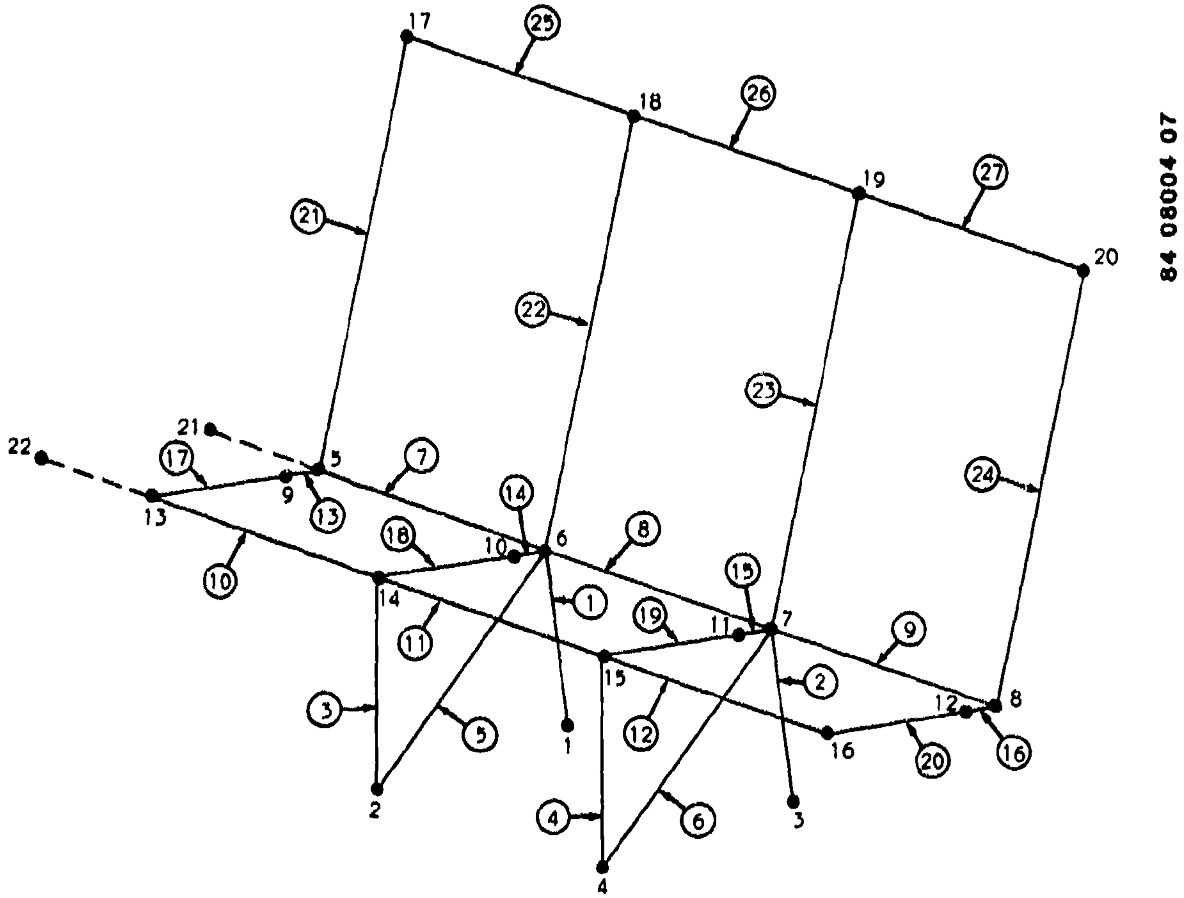
Line 3A: Occupant plot data to be stored at t = 0, 0.025, 0.050, 0.075, 0.100, 0.125, 0.150, and 0.175 sec.

Line 3B: Occupant plot data to be stored with viewing angle of 0 degrees for all plots, i.e., right-side view.

Line 3C: Seat structure plot data to be stored for all plots with +20-degrees elevation angle.

Line 3D: Seat structure plot data to be stored for all plots with +45-degrees azimuth angle, i.e., viewed from left-front quarter.

Line 3E: Nodal output data requested for nodes 1 through 20. (See figure 9 for node designations)



1, 2, ..., 22 Node numbers

1, 2, ..., 27 Beam element numbers

Figure 9. Sample case airline seat finite element model.

Line 3F: Beam loads and stress output data requested for elements 1 through 27 (See Figure 9 for beam element designations).

Line 4: TMAX = 300 to allow up to 300 sec central processor time; DMAX and DMIN set to 0.0005 sec for fixed-time step integration; integration error bonds, EUR, and ELR, set at 10 and 0.1 percent, respectively; TI = 0 and TF = 0.176 sec; initial time step size, DTI, is same as fixed step size (If DMAX is not the same as DMIN, DTI should be set equal to DMIN).

Line 5: Combined seat bottom cushion and occupant buttocks force-deflection relationship of the form $F = 760 (e^{0.5\delta} - 1)$, as shown in Figure 10; damping coefficient of 2.40 at zero load. A cushion thickness of 1.5 in. was used.

Line 6: Seat back cushion properties with same load-deflection curve as bottom cushion.

Line 7: IRSYS = 0 for lap-belt-only restraint system configuration; ILPBELT = 1 for lap belt attached to the seat; IHRST = 1 for headrest.

Line 7A: Headrest cushion properties with same load-deflection curve as seat back and seat bottom cushions.

Line 8: Forces and strains for 2.0-in. nylon webbing; zero damping; no slack.

Line 9: Lap belt anchor point coordinates for passenger No. 1.

Line 10: Lap belt anchor point coordinates for passenger No. 2.

Line 11: Lap belt anchor point coordinates for passenger No. 3.

Lines 12-35: The aircraft acceleration pulse is approximated by a series of straight lines through five points. Note that the accelerations in the coordinate directions are required so that the deceleration pulse of Figure 11 results in negative X values. Because there are no Y- or Z-accelerations, lines 16-23 are blank; the absence of vehicle rotations requires lines 24-35 to be blank.

Line 36: Initial velocity = 30 ft/sec in the X-direction.

Line 37: Initial position of "aircraft" in inertial coordinate system is assumed to be (0., 0., 0.).

Line 38: IMAN = 1 requests standard 50th-percentile (Part 572) dummy; seat cushion and floor friction coefficients are 0.18 and 0.25, respectively.

Line 39: Initial position for passenger No. 1. GAM(1,1) and GAM(2,1) = -16 degrees; GAM(3,1) = 7 degrees; GAM(4,1) = -16 degrees for upper arms; GAM(5,1) = 60 degrees at elbow; heels at 32 in. (these coordinates are illustrated in Figure A-6); YPASS(1) = -20 in. for y-coordinate of mid-plane for passenger No. 1.

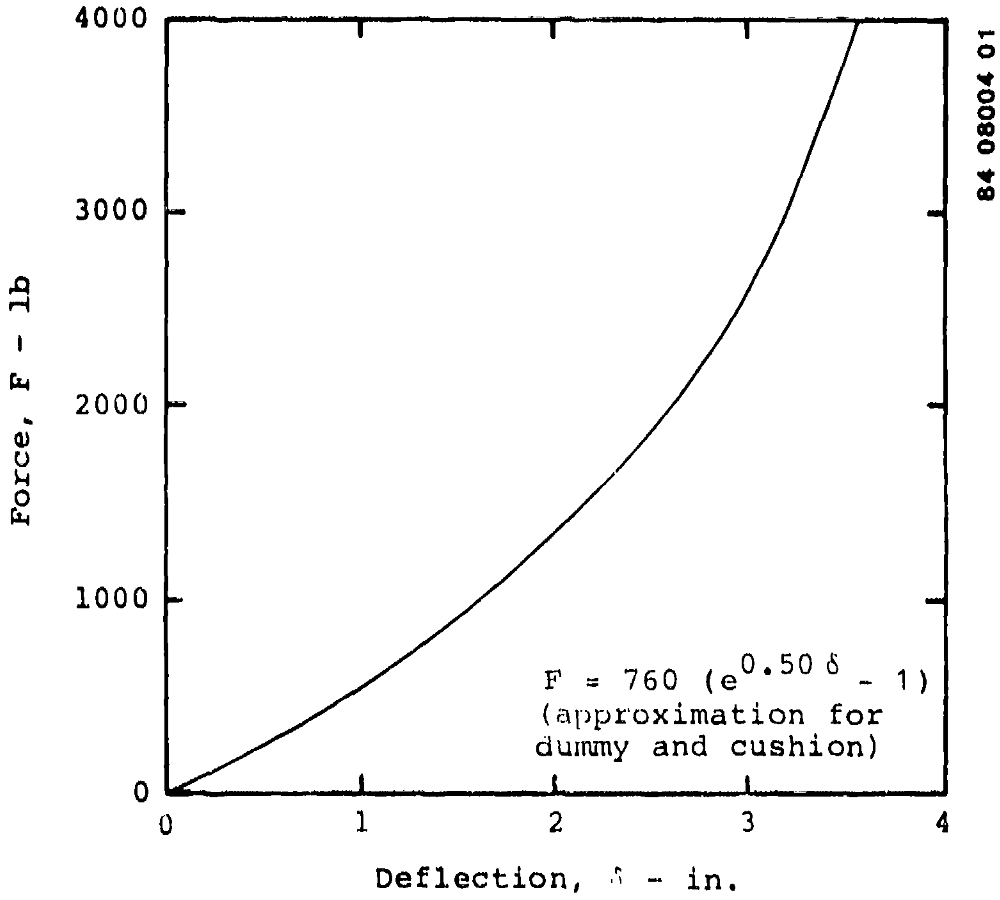


Figure 10. Exponential approximation of force-deflection characteristics for dummy and 1.5-in.-thick cushion.

Line 40: Initial position for passenger 2. Same as line 39 except YPASS(2) = 0 in.

Line 41: Initial position for passenger 3. Same as line 39 except YPASS(3) = 20 in.

Line 42: Coordinate system was located under the rear edge of the seat pan, so that XSEAT = 10 in.; the height of the seat pan is 12 in.; seat pan and back angles are 8 and 16 degrees, respectively. Seat pan length and width are 15.15 in. and 20 in. respectively. The height of the seat back is 39 in. The seat back is the same width as the seat pan. (These coordinates are illustrated in figure A-9).

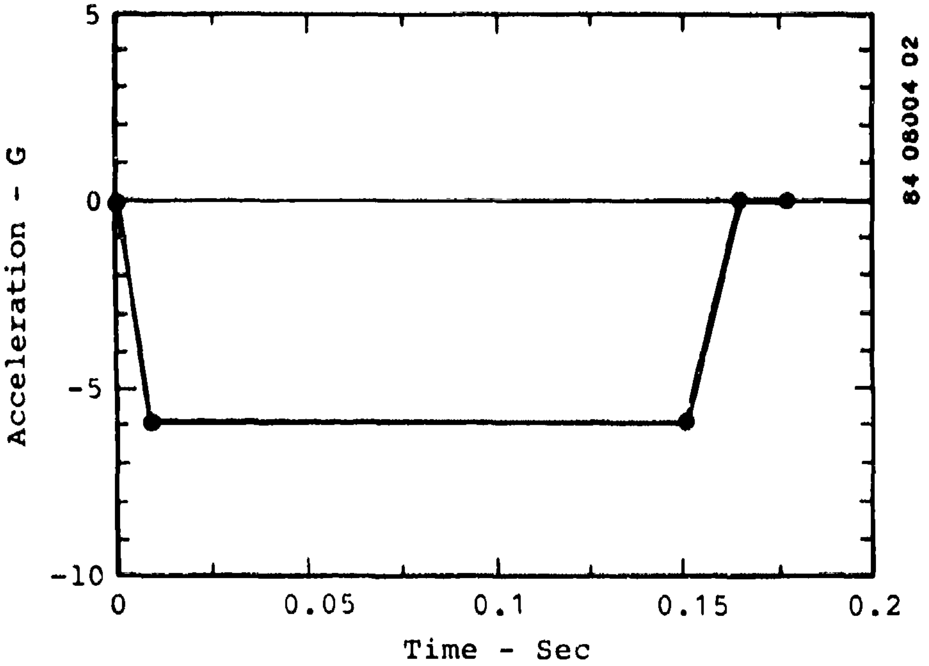


Figure 11. Approximation to sled acceleration.

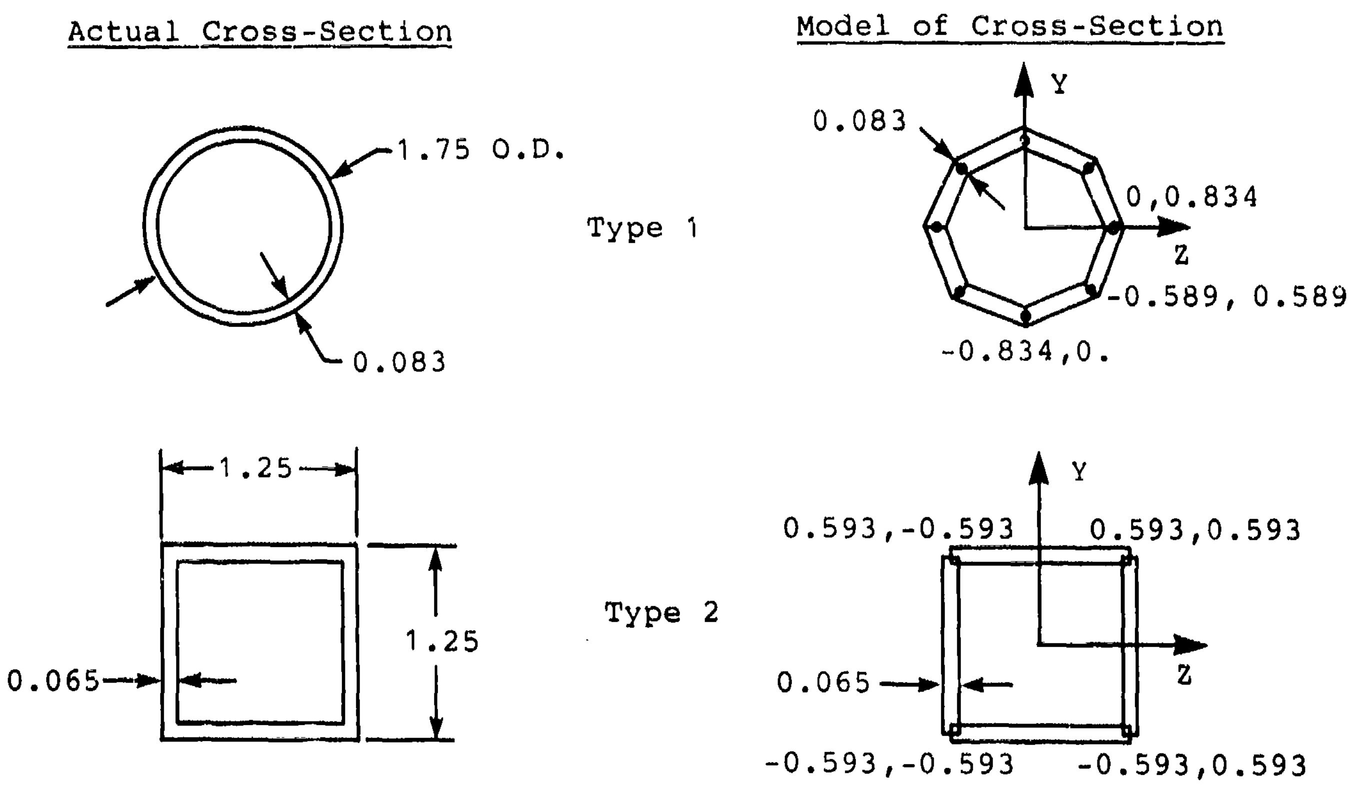
Line 43: The finite element seat model is illustrated in figure 9. NNODE = 20 (real nodes); NELE = 27; NUMMAT = 2 for two materials; NUMDIS = 4 (restrained nodes on the floor); NCOORD = 2 (beam pointer nodes, numbered 21 and 22); and NSECT = 2 for two beam element cross sections. The buckling coefficient has the standard value 0.5.

Line 44: KNTRL(1) = 5 indicates that up to 5 iterations will be used at each time step. KNTRL(2) = 5 indicates that 5 load increments will be used to enforce the floor warping.

Line 45-47: These are two groups of material properties corresponding to NUMMAT = 2. Material type No. 1 is 2024-T4 aluminum; material No. 2 is 4130 steel.

Lines 48-49: There are two groups of cross-section properties (NSECT = 2), shown in figure 12. The circular tubing cross section, defined first, is made up of eight segments; the square cross section is made up of four segments. The orientation of the cross section is specified by the beam pointer node, which locates the beam y-axis (beam coordinate system is illustrated in figure A-13).

Line 50: Twenty-two lines of nodal coordinate data corresponding to 20 real nodes (NNODE = 20) and 2 pointer nodes (NCOORD = 2). Node point locations and numbers are shown in figure 13.



Note: All dimensions in inches.

Figure 12. Element cross-section models used for seat structure beam elements.

Line 51: Twenty-seven lines of beam element data corresponding to NELE = 27. Beam element connectivity and numbers are shown in figure A-13.

Line 52: Seat pan cushion load is distributed on nodes (5, 6, 13, 14) for the first (right) occupant, (6, 7, 14, 15) for the second (middle) occupant, and (7, 8, 15, 16) for the third (left) occupant. The order in which the seat pan nodes are specified is shown in figure A-14.

Line 53: Back cushion load is distributed on nodes (5, 6, 17, 18) for the first (right) occupant, (6, 7, 18, 19) for the second (middle) occupant, and (7, 8, 19, 20) for the third (left) occupant. The order in which the seat back nodes are specified is shown in figure A-14.

Line 54: Lap belt loads are applied at nodes (9, 10) for the first (right) occupant, (10, 11) for the second (middle) occupant, and (11, 12) for the third (left) occupant.

Lines 55-55A: Five lines, which specify the constraint conditions at the bottom of the seat-leg elements. For nodes 1, 2, 3, and 4 all forces and only moments in Z-direction can be supported. In addition, for node 2 the node is moved down in Z-direction by 0.5 in., corresponding to user-specified (pitch) floor warping condition.

A complete listing of the input data for the sample case is presented in figure 13.

5.2 SAMPLE CASE OUTPUT DATA

A listing of the output data for the sample case described in 5.1 is presented in Appendix C. Examples of plots generated by this case are presented as figures 14, 15, and 16.

```
TRANSPORT AIRCRAFT SEAT
   1    1    2    3    3    1    1    1    2
   1    1    2    0    1    1    2    1    1    1    8    8.00050.025
      0.       .025      .050      .075      .100      .125      .150      .175
      0.        0.        0.        0.        0.        0.        0.        0.
     20.       20.       20.       20.       20.       20.       20.       20.
     45.       45.       45.       45.       45.       45.       45.       45.
   1   20
   1   27
    300.      .0005     .0005      0.1      0.001       0.       .176     .0005
    760.      0.50      2.40       1.5
    760.      0.50      2.40       1.5
   0    0    1    0    1
    760.      0.50      2.40       3.0
    550.     1300.     2750.     0.0403    0.1048    0.1613      0.        0.
    12.5     -30.0      15.0      12.5     -10.0      15.0
    12.5     -10.0      15.0      12.5      10.0      15.0
    12.5      10.0      15.0      12.5      30.0      15.0
      0.      -6.0      -6.0       0.0       0.0

      0.      .010      .155      .165      .175

     30.        0.        0.
      0.        0.        0.
   1          0.18      0.25
    -16.      -16.        7.      -16.       60.       32.      -20.
    -16.      -16.        7.      -16.       60.       32.        0.
    -16.      -16.        7.      -16.       60.       32.       20.
     10.       12.        8.       16.     15.15       20.       39.       20.
```

Figure 13. Listing of input data for sample case.

```
  20   27    2    4    6    2    2  0.5
   5    5
   12024-T4 AL
 .2588E-4    10.5E6     44000.      4.9E5        .1    62000.        .3
                        58000.      6.2E4
   24130 STEEL
7.324E-04    29.0E6    163000.      6.0E6        .1   180000.        .3
                       174000.      8.1E4
   8    0     .4347      .3028      .1514      .1514
      0.0       0.0        0.0        0.0
      0.0      .834       .083
    -0.59       .59       .083
   -0.834       0.0       .083
    -0.59     -0.59       .083
      0.0     -.834       .083
     0.59     -0.59       .083
     .834       0.0       .083
     .590       .59       .083
   4    0     .3081      .1082      .0723      .0723
      0.0       0.0        0.0        0.0
    -.593      .593       .065
    -.593     -.593       .065
     .593     -.593       .065
     .593      .593       .065
    1            8.       -10.         0.
    2           25.       -10.         0.
    3            8.        10.         0.
    4           25.        10.         0.
    5           10.       -30.        12.
    6           10.       -10.        12.
    7           10.        10.        12.
    8           10.        30.        12.
    9          12.5       -30.      12.33
   10          12.5       -10.      12.33
   11          12.5        10.      12.33
   12          12.5        30.      12.33
   13          25.0       -30.     14.108
   14          25.0       -10.     14.108
   15          25.0        10.     14.108
   16          25.0        30.     14.108
   17         2.258       -30.        39.
   18         2.258       -10.        39.
   19         2.258        10.        39.
   20         2.258        30.        39.
   21           10.       -40.        12.
   22           25.       -40.        14.
    1    1    6                        2    21    2    2
    2    3    7                        2    21    2    2
    3    2   14                        2    22    2    2
    4    4   15                        2    22    2    2
    5    2    6                        2    21    2    2  000  010  000  010
    6    4    7                        2    21    2    2  000  010  000  010
    7    5    6                        1    22    2    1
```

Figure 13 (contd). Listing of input data for sample case.

```
  8    6    7                             1   22    2    1
  9    7    8                             1   22    2    1
 10   13   14                             1   21    2    1
 11   14   15                             1   21    2    1
 12   15   16                             1   21    2    1
 13    5    9                             2   21    2    1
 14    6   10                             2   21    2    1
 15    7   11                             2   21    2    1
 16    8   12                             2   21    2    1
 17    9   13                             2   21    2    1
 18   10   14                             2   21    2    1
 19   11   15                             2   21    2    1
 20   12   16                             2   21    2    1
 21    5   17                             2   21    2    1
 22    6   18                             2   21    2    1
 23    7   19                             2   21    2    1
 24    8   20                             2   21    2    1
 25   17   18                             2   21    2    1
 26   18   19                             2   21    2    1
 27   19   20                             2   21    2    1
  5    6   13   14    6    7   14   15    7    8   15   16
  5    6   17   18    6    7   18   19    7    8   19   20



  9   10   10   11   11   12
1111001
2112001
    -.5
3111001
4111001
```

Figure 13 (contd). Listing of input data for sample case.

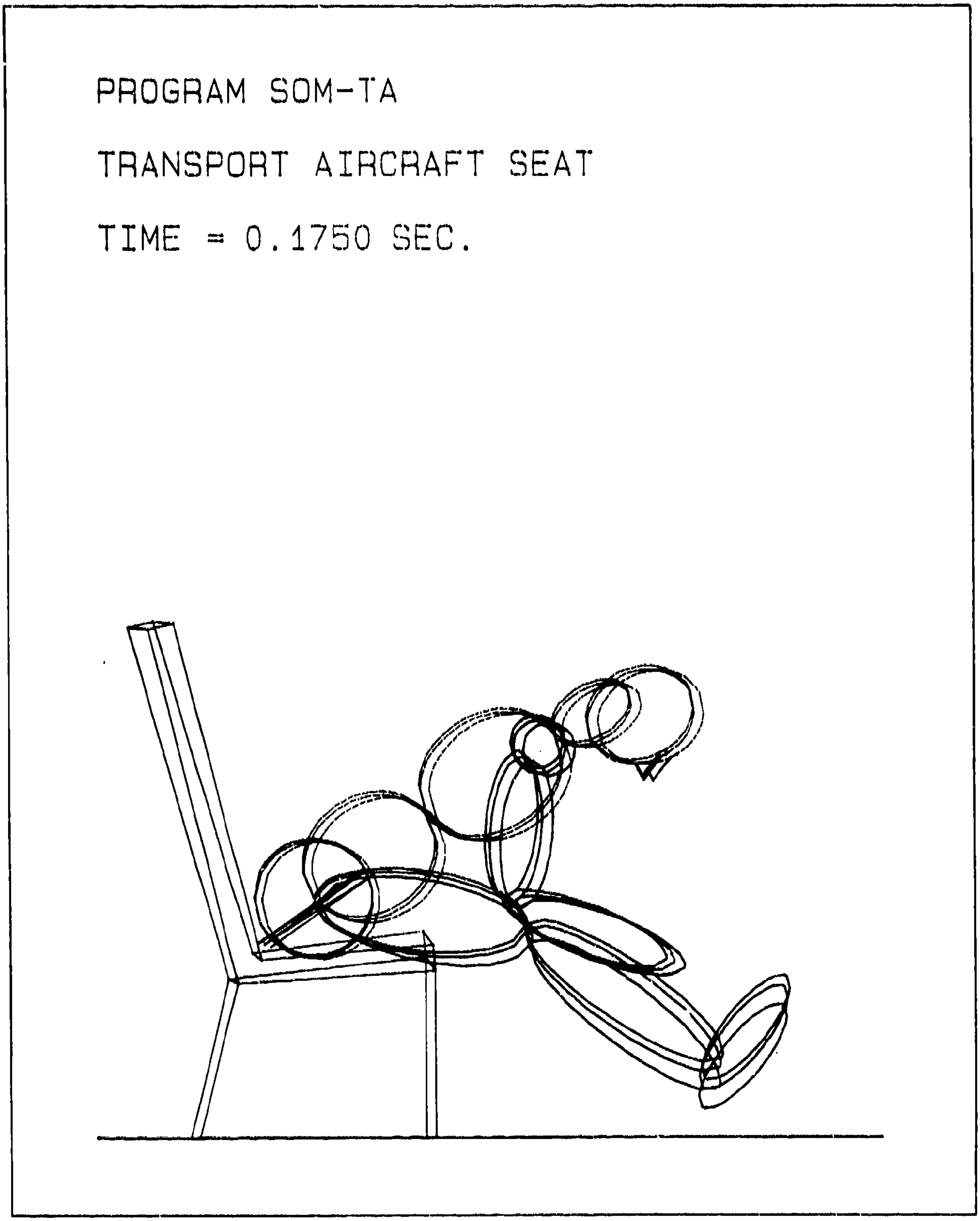


Figure 14. Sample case occupant plot (side view) at time = 0.175 sec.

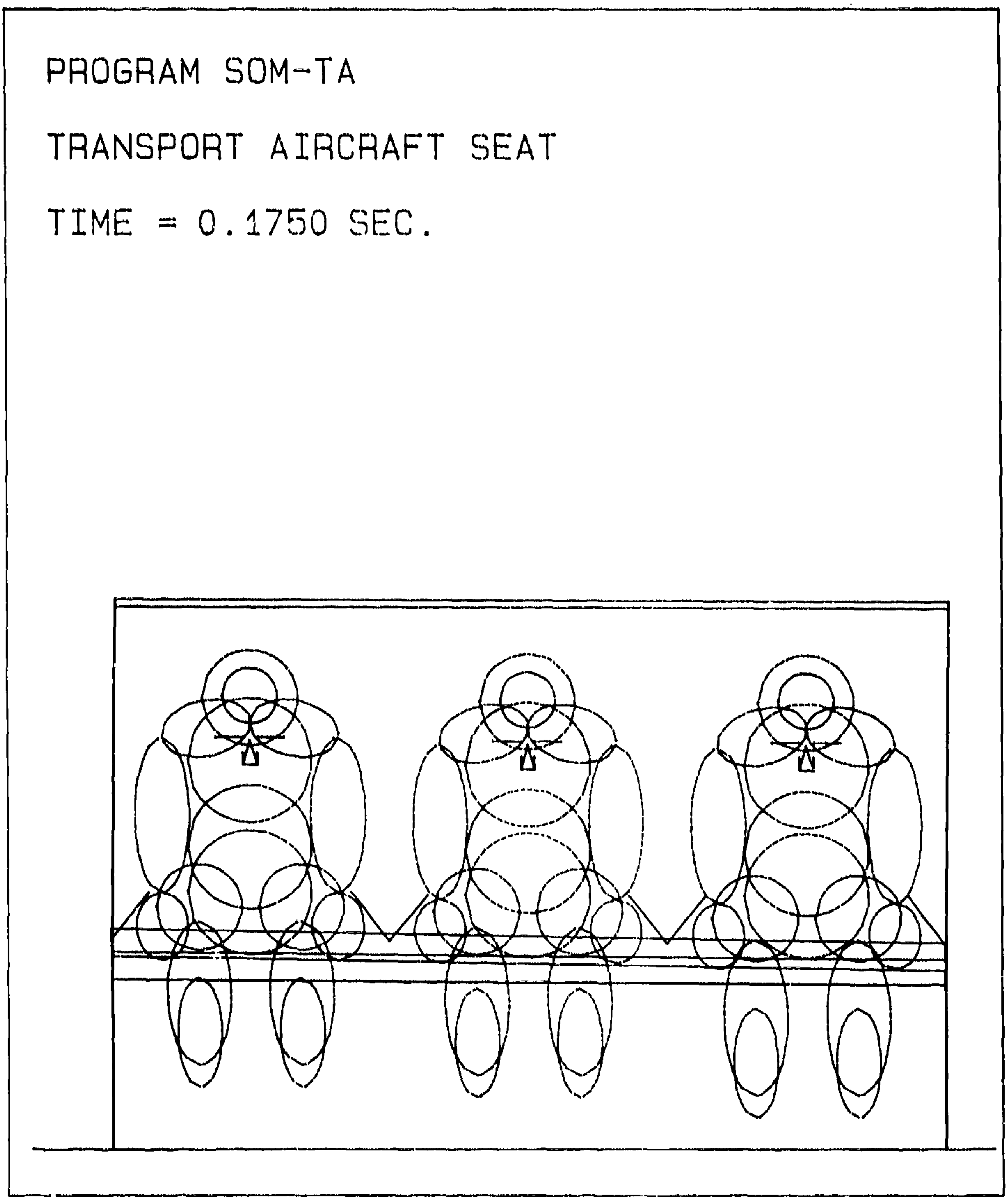


Figure 15. Sample case occupant plot (front view) at time = 0.175 sec.

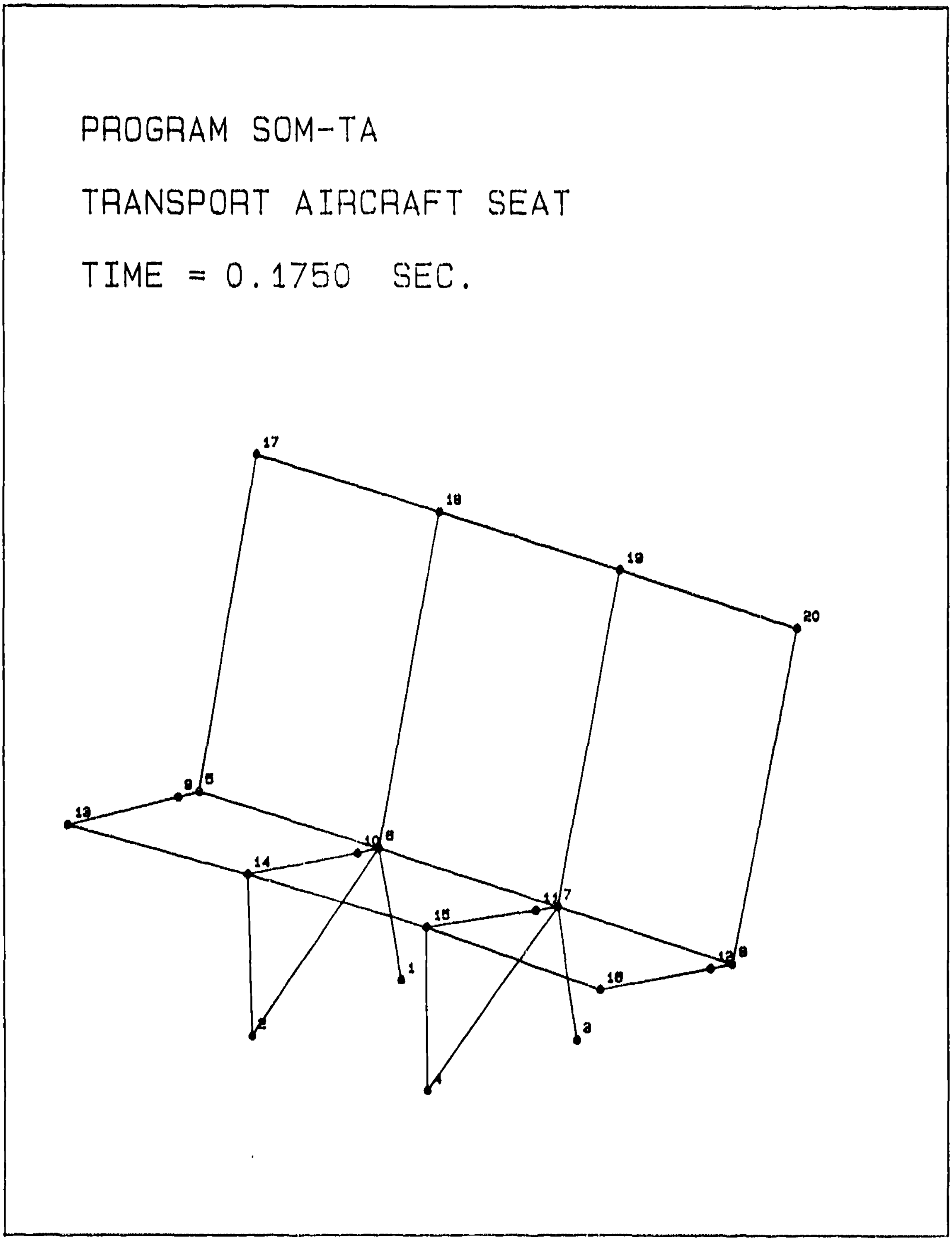


Figure 16. Sample case seat plot at time = 0.175 sec.

APPENDIX A

PROGRAM SOM-TA INPUT DATA REQUIREMENTS

In this Appendix a line-by-line description of input data required by Program SOM-TA is presented. As described in section 2, there are a number of optional lines of data, each of which is suffixed by an alphabetic character, such as line 6A, which is used only if the seat includes a headrest.

LINE 1: Case Identification

DESCRIPTION: Title and type of case.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NAME							
TRANSPORT	AIRCRAFT S	EAT					

FIELD	FORMAT	CONTENTS
NAME	6A10	Alphanumeric title of case to be centered at top of printed output and plots.

LINE 2: Seat Type and Occupant Location

DESCRIPTION: Seat pitch, type, and locations of passengers.

FORMAT AND EXAMPLE:

0 1234567890		2 1234567890		3 1234567890		4 1234567890		5 1234567890		6 1234567890	7 1234567890	8 1234567890
NUNIT	NSEAT	NDIM	NOCC	ITYPE	ISEAT(1)	ISEAT(2)	ISEAT(3)	IPASS				
1	1	2	3	3	1	1	1	2				

FIELD	FORMAT	CONTENTS
NUNIT	I5	System of units NUNIT = 0 : SI units NUNIT = 1 : English units.
NSEAT	I5	Seat model NSEAT = 0 : Rigid seat model NSEAT = 1 : Finite element seat model.
NDIM	I5	Definition of occupant degrees of freedom NDIM = 2 : Two-dimensional simulation NDIM = 3 or 0 : Three-dimensional simulation.
NOCC	I5	Number of occupants to be modeled
ITYPE	I5	Seat type in terms of occupant positions. ITYPE = 1 : Single seat ITYPE = 2 : Two-passenger seat ITYPE = 3 : Three-passenger seat.
ISEAT	3I5	Locations of occupants, specifying whether a given seat position is occupied (1) or empty (0) ISEAT(1) : Right-most position ISEAT(2) : Center position for three-passenger seat, left position for two-passenger seat ISEAT(3) : Left position for three-passenger seat

FIELD	FORMAT	CONTENTS
IPASS	I5	Identification of occupant for which output data (position, velocity, acceleration, belt loads, etc.) are stored and printed. IPASS = 1 : Right-most passenger IPASS = 2 : Center position for three-passenger seat or left position for two-passenger seat IPASS = 3 : Left position for three-passenger seat

The example specifies a three-passenger seat which is fully occupied. Output data are stored and printed for center passenger.

LINE 3: Output Selection

DESCRIPTION: Definition of output data to be stored for printing and number of plots.

FORMAT AND EXAMPLE:

0 … 1		2		3		4		5		6		7		8	
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	
IOUT(1)	IOUT(2)	IOUT(3)	IOUT(4)	IOUT(5)	IOUT(6)	IOUT(7)	IOUT(8)	IOUT(9)	IOUT(10)	NOPLOT	NSPLOT	DTPLT	TSEAT		
1	1	2	0	1	1	2	1	1	1	8	8	.0005	0.025		

FIELD	FORMAT	CONTENTS
IOUT	10I5	Vector of 0's, 1's, 2's and 3's indicating which output data are to be printed (1, 2, or 3) or not printed (0) IOUT(1) : Occupant segment position IOUT(2) : Occupant segment velocity IOUT(3) : Occupant segment acceleration (1) IOUT(4) : Secondary impact prediction (2) IOUT(5) : Restraint system forces IOUT(6) : Injury criteria IOUT(7) : Seat external loads (cushions, floor) (1) IOUT(8) : Seat structure deflections (3) IOUT(9) : Seat structure support reactions IOUT(10): Stresses in seat structure beam elements (4).
NOPLOT	I5	Number of requested occupant position plots (up to 8). Lines 3A and 3B must be inserted if NOPLOT 0.
NSPLOT	I5	Number of requested seat position plots (up to 8). Lines 3A, 3C, and 3D must be inserted if NSPLOT 0.

---

(1) For IOUT(3) and IOUT(7), an input value of 1 results in unfiltered output. A value of 2 or 3 results in application of a class 180 (300 Hz) or class 60 (100 Hz) filter, respectively.

(2) IOUT(4) = 0 : No secondary impact prediction and the forward seat is not plotted.
IOUT(4) = 1 : Subroutine IMPACT is called for prediction of contact with the seat back and occupant plots show the forward seat in its undeformed position.
IOUT(4) = 2 : Subroutine IMPACT is called for prediction of contact with the seat back and occupant plots show the forward seat deformation as the seat being modeled.

(3) If IOUT(8) = 1, line 3E must be included to select the nodes for seat structure deflections.

(4) If IOUT(10) = 1, line 3F must be included to select the beam elements for seat structure loads and stresses.

FIELD	FORMAT	CONTENTS
DTPLT	F5.0	Interval at which data are written on external file 26, as described in section 3. If left blank, 0.001 sec is assumed.
TSEAT	F5.0	Print frequency (in seconds) for data selected with IOUT(8), IOUT(9), and IOUT(10).

LINE 3A: Plot Times (only if NOPLOT > 0 or NSPLOT > 0)

DESCRIPTION: Times when plots of occupant or seat position are desired. The first NOPLOT fields are read, as defined on line 2.

Occupant and seat plot data are stored on external file numbers 14 and 20, respectively. Therefore, if plots are requested, the job control language must define files 14 and/or 20 as permanent files to be saved. These permanent files can then be used as input to occupant and seat plotting programs.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TPLOT(1)	TPLOT(2)	TPLOT(3)	TPLOT(4)	TPLOT(5)	TPLOT(6)	TPLOT(7)	TPLOT(8)
0.	0.025	0.050	0.075	0.100	0.125	0.150	0.175

FIELD	FORMAT	CONTENTS
TPLOT	8F10.0	Plot times, seconds.

LINE 3B: Occupant Plot Viewing Angles (only if NOPLOT > 0)

DESCRIPTION: Angles in degrees corresponding to TPLOT times on line 3A. The angle is measured in the horizontal plane, as illustrated in figure A-1. An angle of 0 degrees results in a right-side view; 90 degrees, a front view; and 180 degrees, a left-side view.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
ANGVU(1)	ANGVU(2)	ANGVU(3)	ANGVU(4)	ANGVU(5)	ANGVU(6)	ANGVU(7)	ANGVU(8)
0.	0.	0.	0.	0.	0.	0.	0.

FIELD	FORMAT	CONTENTS
ANGVU	8F10.0	NOPLOT occupant viewing angles, degrees.

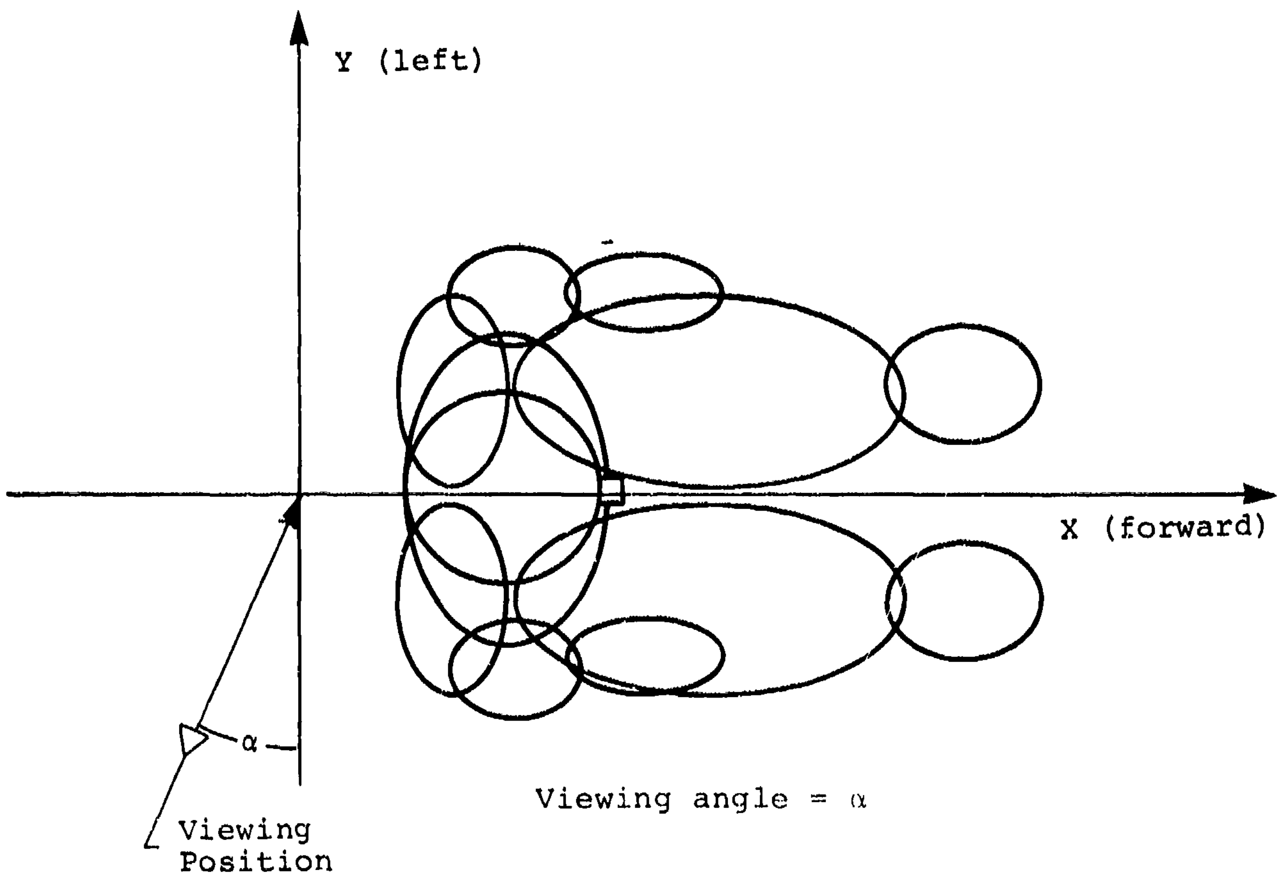


Figure A-1. Definition of occupant plot viewing angle.

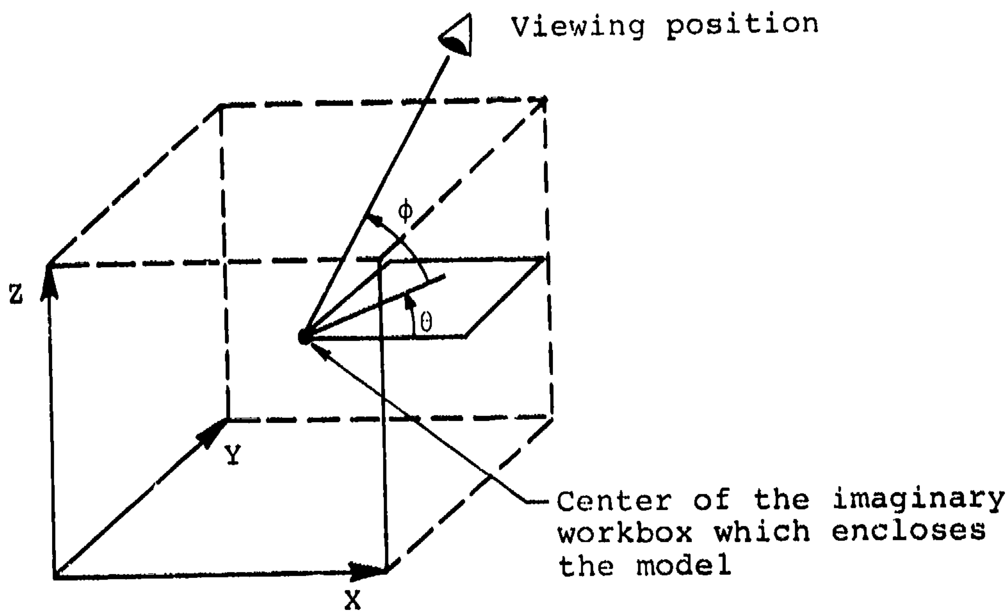
LINE 3C: Seat Structure Plot Viewing Elevation Angle (only if NSPLOT > 0)

DESCRIPTION: Angles in degrees corresponding to TPLOT times on line 3A. The viewing elevation angle, ϕ , is illustrated in figure A-2.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
PHI(1)	PHI(2)	PHI(3)	PHI(4)	PHI(5)	PHI(6)	PHI(7)	PHI(8)
20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

FIELD	FORMAT	CONTENTS
PHI	8F10.0	NSPLOT elevation angles, degrees.



θ = Azimuth angle in X-Y plane in degrees ($-180° \leq \theta \leq +180°$)

ϕ = Elevation angle in degrees ($-90° \leq \phi \leq +90°$)

Figure A-2. Angular coordinates for viewing of seat models.

LINE 3D: Seat Structure Plot Viewing Azimuth Angle (only if NSPLOT > 0)

DESCRIPTION: Angles in degrees corresponding to TPLOT times on line 3A. The viewing azimuth angle is illustrated in figure A-2.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
THE(1)	THE(2)	THE(3)	THE(4)	THE(5)	THE(6)	THE(7)	THE(8)
45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0

FIELD	FORMAT	CONTENTS
THE	8F10.0	Vector of NSPLOT azimuth angles, degrees.

LINE 3E: Nodal Output Selection (only if IOUT(8) > 0)

DESCRIPTION: Node numbers, in pairs, to specify which X, Y, Z displacements are to be printed. (The node numbers are defined on line 50.)

FORMAT AND EXAMPLE:

0	1		2		3		4		5	6	7	8
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	1234567890	1234567890	1234567890
KNODE(1)	KNODE(2)	KNODE(3)	KNODE(4)	KNODE(5)	KNODE(6)	KNODE(7)	KNODE(8)	KNODE(9)	KNODE(10)			
1	20											

FIELD	FORMAT	CONTENTS
KNODE	5(2I5)	Nodal displacements printed for nodes beginning with KNODE(I) through KNODE(I+1), inclusive. Up to 5 pairs of nodes are permitted.

LINE 3F: Beam load and stress Selection (only if IOUT(10) > 0)

DESCRIPTION: Element numbers, in pairs, to specify which stresses are to be printed. Maximum and minimum values of stress are printed at both ends of selected beams.

FORMAT AND EXAMPLE:

0	1		2		3		4		5	6	7	8
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	1234567890	1234567890	1234567890
KBEAM(1)	KBEAM(2)	KBEAM(3)	KBEAM(4)	KBEAM(5)	KBEAM(6)	KBEAM(7)	KBEAM(8)	KBEAM(9)	KBEAM(10)			
1	27											

FIELD	FORMAT	CONTENTS
KBEAM	5(2I5)	Loads and stresses printed for beam elements beginning with KBEAM(I) through KBEAM(I+1), inclusive. Up to 5 pairs of elements are permitted.

LINE 4: Simulation Control Data

DESCRIPTION: Parameters for control of solution duration, step size, and error bounds.

FORMAT AND EXAMPLE:

0 1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
TMAX	DMAX	DMIN	EUR	ELR	TI	TF	DTI
300.	0.0005	0.0005	0.10	0.001	0.	0.176	0.0005

FIELD	FORMAT	CONTENTS
TMAX	F10.0	The maximum time allotted for the run on the job card in decimal seconds. This will ensure that the solution is terminated in time to permit printing of the output already computed.
DMAX	F10.0	Maximum step size. A value of 0.001 sec has been used successfully.
DMIN	F10.0	Minimum step size. A value as large as 0.001 sec has been used successfully, but the use of very stiff restraint system webbing or seat cushions may require a smaller value, such as 0.00001. The solution can be accomplished with a fixed step size by setting DMIN = DMAX.
EUR	F10.0	Maximum bound on error between predictor and corrector. A value of 0.05 to 0.10 is suggested, corresponding to a range of 5 to 10 percent. If the error in any variable is larger than this value, the step size is halved, maintaining solution accuracy.
ELR	F10.0	Lower bound on error between predictor and corrector. A value of 0.001 is suggested, corresponding to 0.1 percent. If the error in all variables is smaller than this value, the step size is doubled, preventing the computer execution cost from becoming excessively high. Note: Because doubling the step size multiplies the truncation error in the Adams-Moulton integrator by a factor of 2^5, ELR should be chosen less than EUR/32 if the advantages of doubling are not to be short-lived.
TI	F10.0	Initial solution time in seconds. Normally taken as 0.
TF	F10.0	Final solution time in seconds.
DTI	F10.0	Initial step size, normally set equal to DMIN.

LINE 5: Combined Seat Cushion and Occupant Buttocks Properties

DESCRIPTION: Force-deflection characteristics and damping for seat cushion and buttocks combined; thickness for seat bottom cushion. The force, F, is computed from total deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CSC	BSC	DPSC	THSCE				
760.	0.50	2.40	1.50				

FIELD	FORMAT	CONTENTS
CSC	F10.0	Coefficient C in above equation (lb).
BSC	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPSC	F10.0	Damping coefficient at zero load (lb-sec/in.).
THSCE	F10.0	Unloaded thickness of cushion under buttocks (in.)

LINE 6: Back Cushion Properties

DESCRIPTION: Force-deflection characteristics, damping, and thickness for back cushion. These characteristics should be measured using an indenter with the form of the occupant torso. If a dummy torso is used in measurement, the deflection should be based on the chest accelerometer location. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CBC	BBC	DPBC	THBCE				
760.	0.50	2.45	1.50				

FIELD	FORMAT	CONTENTS
CBC	F10.0	Coefficient C in above equation (lb).
BBC	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPBC	F10.0	Damping coefficient at zero load (lb-sec/in.).
THBCE	F10.0	Unloaded thickness of cushion in center of seat back (in.).

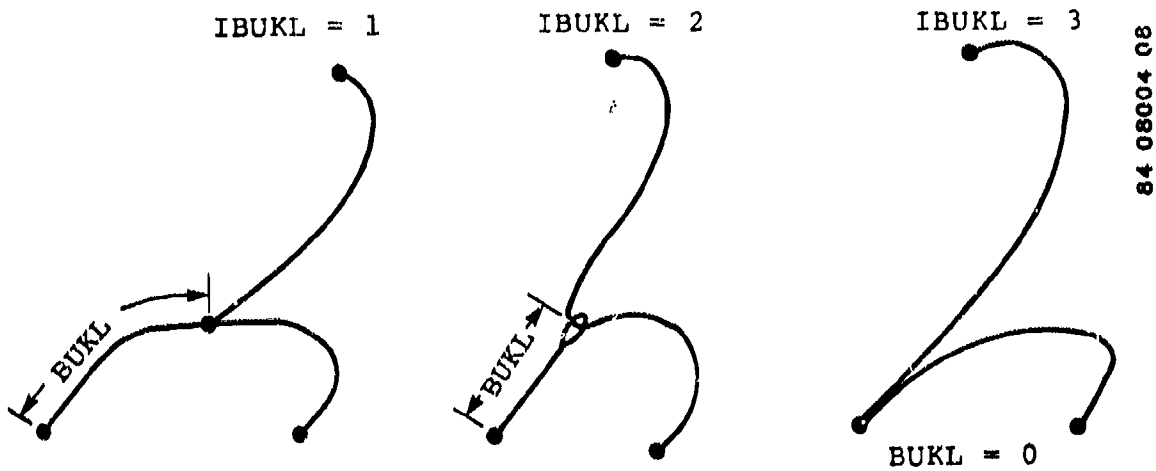
LINE 7: Restraint System Identification

DESCRIPTION: Integers defining configuration of restraint system and presence or absence of headrest.

FORMAT AND EXAMPLE:

IRSYS	IBUKL	ILPBLT	ISHRNS	IHRST
0	0	1	0	1

FIELD	FORMAT	CONTENTS
IRSYS	I5	Restraint system configuration. IRSYS = 0 : Lap belt only IRSYS = 1 : Diagonal shoulder belt over right shoulder IRSYS = 2 : Diagonal shoulder belt over left shoulder IRSYS = 3 : Double shoulder belt
IBUKL	I5	Buckle connection type (see figure A-3).
ILPBLT	I5	Lap belt attachment ILPBLT = 0 : Attached to airframe ILPBLT = 1 : Attached to seat.
ISHRNS	I5	Shoulder harness attachment ISHRNS = 0 : Attached to airframe ISHRNS = 1 : Attached to seat.
IHRST	I5	Headrest option IHRST = 0 : No headrest IHRST = 1 : Headrest included - requires line 7A.



1 = Shoulder belt fixed to buckle
2 = Shoulder belt and one side of lap belt are one length of webbing
3 = Shoulder belt and lap belt attached to fixed point

NOTE: BUKL parameter is defined on lines 11B, 11C, and 11D.

Figure A-3. Types of buckle connections specified by IBUKL on line 7.

LINE 7A: Headrest Cushion Properties (only if IHRST = 1)

DESCRIPTION: Force-deflection characteristics, damping, and thickness for headrest cushion. The measurement should be made using a headform. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CHR	BHR	DPHR	THHRE				
760.	0.50	2.40	3.0				

FIELD	FORMAT	CONTENTS
CHR	F10.0	Coefficient C in above equation (lb).
BHR	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPHR	F10.0	Damping coefficient (lb-sec/in.).
THHRE	F10.0	Unloaded thickness of cushion behind head (in.).

LINE 8: Lap Belt Properties

DESCRIPTION: Tables of forces and deflections define an approximation to force-deflection curve by three linear segments, as illustrated in figure A-4. The force and deflection at point 1 are assumed to be zero.

FORMAT AND EXAMPLE:

0 1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898
FFLB(2)	FFLB(3)	FFLB(4)	DDLB(2)	DDLB(3)	DDLB(4)	DPLB	SLAB
550.	1300.	2250.	0.0403	0.1048	0.1613	0.	0.

FIELD	FORMAT	CONTENTS
FFLB	3F10.0	Forces (lb).
DDLB	3F10.0	Strains corresponding to forces (in./in.).
DPLB	F10.0	Damping coefficient (lb-sec).
SLAB	F10.0	Slack in the total lap belt loop, the length that, if removed, would cause the belt to pass snugly over the occupant with zero load (in.).

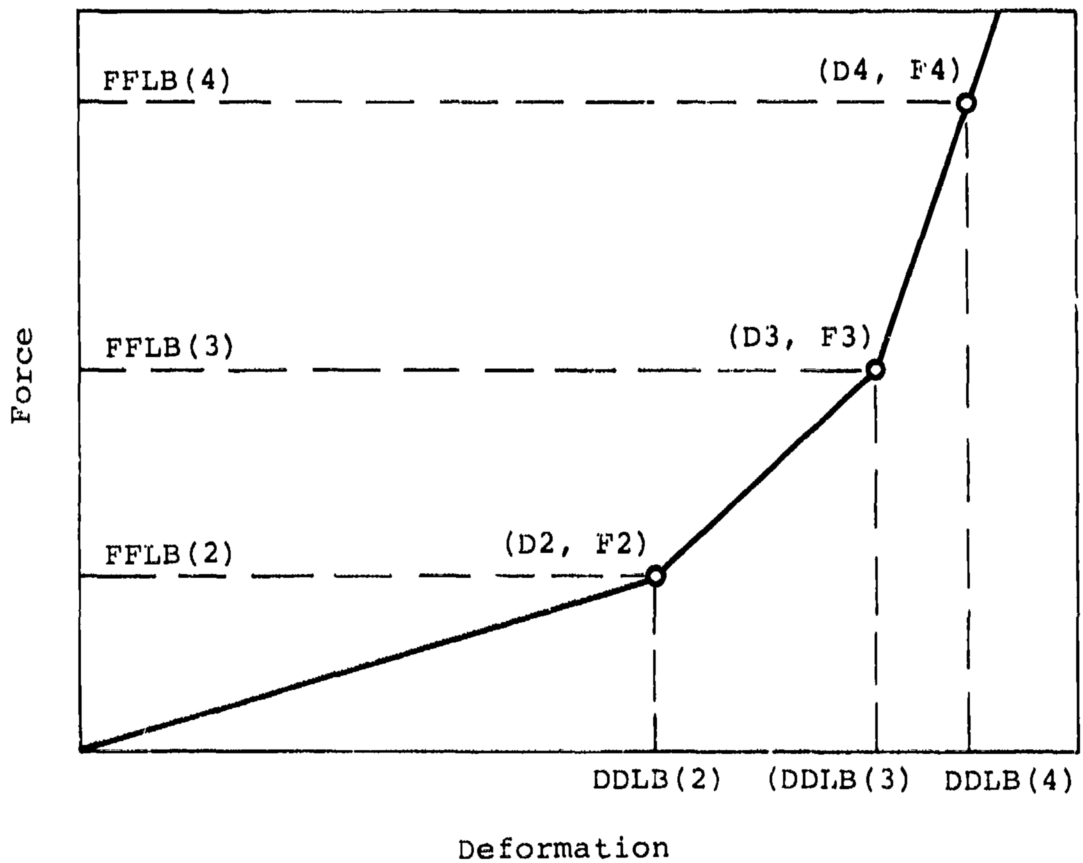


Figure A-4. Force-deflection model for restraint system webbing.

LINE 9: Lap Belt Anchor Points and Footrest, Passenger No. 1*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system; location of footrest.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,1)	YLB(1,1)	ZLB(1,1)	XLB(2,1)	YLB(2,1)	ZLB(2,1)		
12.5	-30.0	15.0	12.5	-10.0	15.0		

FIELD	FORMAT	CONTENTS
XLB(1,1) YLB(1,1) ZLB(1,1)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).
XLB(2,1) YLB(2,1) ZLB(2,1)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Used only if ISEAT(1) = 1 on line 2.

LINE 10: Lap Belt Anchor Points and Footrest, Passenger No. 2*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system; location of footrest.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,2)	YLB(1,2)	ZLB(1,2)	XLB(2,2)	YLB(2,2)	ZLB(2,2)		
12.5	-10.0	15.0	12.5	10.0	15.0		

FIELD	FORMAT	CONTENTS
XLB(1,2) YLB(1,2) ZLB(1,2)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).
XLB(2,2) YLB(2,2) ZLB(2,2)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Must be included. Used only if ITYPE > 1 and ISEAT(2) = 1 on line 2.

LINE 11: Lap Belt Anchor Points and Footrest, Passenger No. 3*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system; location of footrest.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,3)	YLB(1,3)	ZLB(1,3)	XLB(2,3)	YLB(2,3)	ZLB(2,3)		
12.5	10.0	15.0	12.5	30.0	15.0		

FIELD	FORMAT	CONTENTS
XLB(1,3) YLB(1,3) ZLB(1,3)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).
XLB(2,3) YLB(2,3) ZLB(2,3)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Must be included. Used only if ITYPE = 3 and ISEAT(3) = 1 on line 2.

LINE 11A: Shoulder Belt Properties (only if IRSYS > 0)*

DESCRIPTION: Tables of forces and deflections define an approximation to force-deflection curve by three linear segments, as illustrated in figure A-4. The force and deflection at point 1 are assumed to be zero.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFSH(2)	FFSH(3)	FFSH(4)	DDSH(2)	DDSH(3)	DDSH(4)	DPSH	SLSH

FIELD	FORMAT	CONTENTS
FFSH	3F10.0	Forces (lb).
DDSH	3F10.0	Strain corresponding to forces (in./in.).
DPSH	F10.0	Damping coefficient (lb-sec).
SLSH	F10.0	Shoulder belt slack (in.).

*Not present for sample case.

LINE 11B, 11C, 11D: Shoulder Belt Anchor Points (only if IRSYS > 0)*

DESCRIPTION: Coordinates of shoulder belt anchor point in aircraft coordinate system, along with other restraint system characteristics.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XSH(1)	YSH(1)	ZSH(1)	BUKL(1)	XTRAL(1)			

FIELD	FORMAT	CONTENTS
XSH(1) YSH(1) ZSH(1)	3F10.0	Coordinates of shoulder belt anchor point in aircraft coordinate system, or point from which belt passes to shoulder in a straight line.
BUKL(1)	F10.0	Length of lap belt webbing attached to buckle, illustrated in figure A-3 (in.).
XTRAL(1)	F10.0	Length of shoulder strap beyond ($XSH^{(1)}$, $YSH^{(1)}$, $ZSH^{(1)}$) if strap not in straight line, as shown in figure A-5 (in.).

Lines 11C and 11D repeat Line 11B for passengers 2 and 3.

*Not present for sample case.

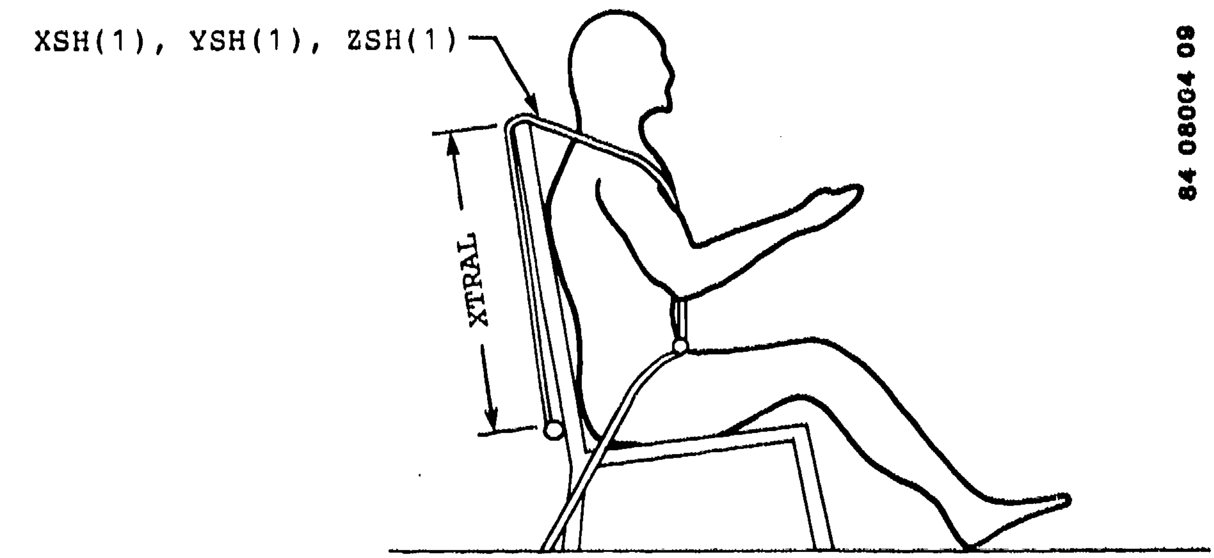


Figure A-5. XTRAL dimensions for shoulder belts on lines 11B, 11C, 11D.

LINE 12 - 35: Aircraft Acceleration

DESCRIPTION: The time variation of each of the six components of the acceleration of the aircraft coordinate system is approximated by up to 16 points in acceleration and time.

FORMAT AND EXAMPLE: (Lines 12 - 15)

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
AX(1)	AX(2)	AX(3)	AX(4)	AX(5)	AX(6)	AX(7)	AX(8)
0.	-6.0	-6.0	0.	0.			
AX(9)	AX(10)	AX(11)	AX(12)	AX(13)	AX(14)	AX(15)	AX(16)
TX(1)	TX(2)	TX(3)	TX(4)	TX(5)	TX(6)	TX(7)	TX(8)
0.	0.010	0.155	0.165	0.175			
TX(9)	TX(10)	TX(11)	TX(12)	TX(13)	TX(14)	TX(15)	TX(16)

FIELD	FORMAT	CONTENTS
Lines 12 and 13:		
AX(J), J = 1-8	8F10.0	X-acceleration (G).
AX(J), J = 9-16	8F10.0	
Lines 14 and 15:		
TX(J), J = 1-8	8F10.0	X-time corresponding to lines 12 and 13 (sec).
TX(J), J = 9-16	8F10.0	
Lines 16 and 17:		Y-acceleration (G).
Lines 18 and 19:		Y-time (sec).
Lines 20 and 21:		Z-acceleration (G).
Lines 22 and 23:		Z-time (sec).
Lines 24 and 25:		Yaw acceleration (rad/sec/sec).
Lines 26 and 27:		Yaw time (sec).
Lines 28 and 29:		Pitch acceleration (rad/sec/sec).
Lines 30 and 31:		Pitch time (sec).
Lines 32 and 33:		Roll acceleration (rad/sec/sec).
Lines 34 and 35:		Roll time (sec).

LINE 36: Aircraft Initial Velocity

DESCRIPTION: Components of aircraft initial velocity, in aircraft coordinate system, translation and rotation.

FORMAT AND EXAMPLE:

0 1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
VX	VY	VZ	DYAW	DPITCH	DROLL		
30.	0.	0.	0.	0.	0.		

FIELD	FORMAT	CONTENTS
VX VY VZ	3F10.0	Components of aircraft initial velocity in aircraft coordinate system (ft/sec).
DYAW DPITCH DROLL	3F10.0	Yaw, pitch, and roll rates (rad/sec).

LINE 37: Aircraft Initial Position

DESCRIPTION: Components of aircraft initial position, in earth-fixed coordinate system, and attitude.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XA	YA	ZA	YAW	PITCH	ROLL		
0.	0.	0.	0.	0.	0.		

FIELD	FORMAT	CONTENTS
XA YA ZA	3F10.0	Position of aircraft coordinate system in inertial system (earth-fixed system in which gravity acts in the -Z direction) (in.). These initial coordinates are normally taken as (0., 0., 0.) unless displacement from a specific point is desired. For example, if the simulation is to be initiated at some horizontal distance from a barrier, such as 60 in., the initial position could be specified as (-60., 0., 0.). If the simulation is to begin 10 in. above the ground in a vertical drop, the initial position could be specified as (0., 0., 10.). These coordinates are not used in the simulation but only in output of aircraft position.
YAW PITCH ROLL	3F10.0	Initial attitude of aircraft relative to earth-fixed system (deg).

LINE 38: Occupant Identification and Friction Coefficients

DESCRIPTION: Identification of type of occupant (human or dummy).

NOTE: IMAN = 2 or 3 requires additional lines for each passenger.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
IMAN	COEFFS	COEFFR					
1	0.18	0.25					

FIELD	FORMAT	CONTENTS
IMAN	I5	Identification of occupant
	5X	IMAN = 0 : Standard 50th-percentile male human IMAN = 1 : Standard 50th-percentile (Part 572) dummy IMAN = 2 : Nonstandard human IMAN = 3 : Nonstandard dummy.
COEFFS	F10.0	Seat cushion friction coefficient.
COEFFR	F10.0	Floor-foot friction coefficient.

LINE 39: Occupant Initial Position, Passenger No. 1

DESCRIPTION: Initial position angles and heel X-position, as illustrated in figure A-6. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,1), GAM(2,1), and GAM(3,1), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included.

FORMAT AND EXAMPLE:

0 1234567890 1	1234567890 2	1234567890 3	1234567890 4	1234567890 5	1234567890 6	1234567890 7	1234567890 8
GAM(1,1)	GAM(2,1)	GAM(3,1)	GAM(4,1)	GAM(5,1)	XHEEL(1)	YPASS(1)	
-16.	-16.	7.	-16.	60.	32.	-20.	

FIELD	FORMAT	CONTENTS
GAM(I,1)	5F10.0	Vector of initial position angular coordinates, as illustrated in figure A-6 (deg).
XHEEL(1)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(1)	F10.0	Y-coordinate of mid-place (plane of symmetry) for occupant.

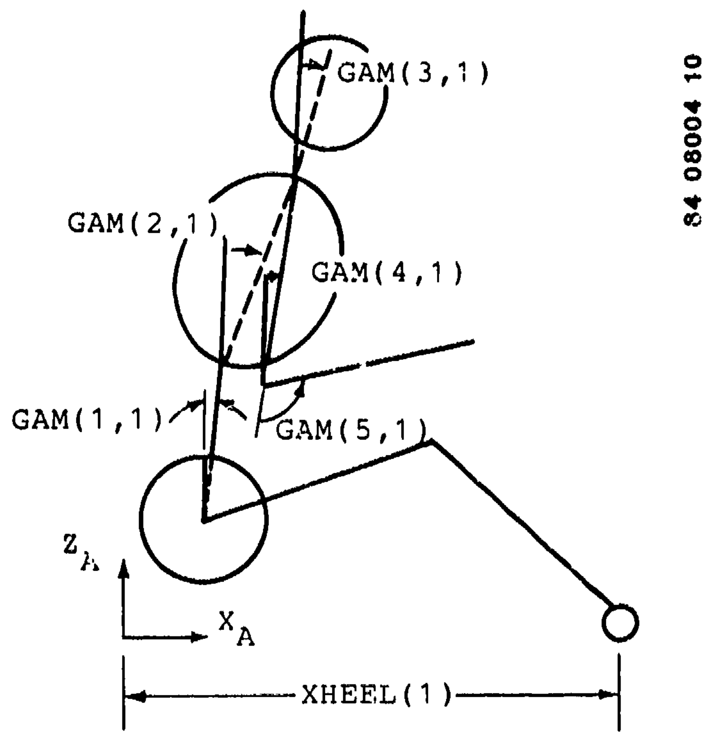


Figure A-6. Occupant initial position input data.

LINE 40: Occupant Initial Position, Passenger No. 2

DESCRIPTION: Initial position angles and heel X-position, as illustrated in figure A-6. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,2), GAM(2,2), and GAM(3,2), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
GAM(1,2)	GAM(2,2)	GAM(3,2)	GAM(4,2)	GAM(5,2)	XHEEL(2)	YPASS(2)	
-16.	-16.	7.	-16.	60.	32.	0.	

FIELD	FORMAT	CONTENTS
GAM(I,2)	5F10.0	Vector of initial position angular coordinate, as illustrated in figure A-6 (deg.).
XHEEL(2)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(2)	F10.0	Y-coordinate of mid-plane (plane of symmetry) for occupant.

LINE 41: Occupant Initial Position, Passenger No. 3

DESCRIPTION: Initial position angles and heel X-position, as illustrated in figure A-6. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,3), GAM(2,3), and GAM(3,3), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included.

FORMAT AND EXAMPLE:

0 1234567890 1	1234567890 2	1234567890 3	1234567890 4	1234567890 5	1234567890 6	1234567890 7	1234567890 8
GAM(1,3)	GAM(2,3)	GAM(3,3)	GAM(4,3)	GAM(5,3)	XHEEL(3)	YPASS(3)	
-16.	-16.	7.	-16.	60.	32.	20.	

FIELD	FORMAT	CONTENTS
GAM(I,3)	5F10.0	Vector of initial position angular coordinate, as illustrated in figure A-6 (deg).
XHEEL(3)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(3)	F10.0	Y-coordinate of mid-plane (plane of symmetry) for occupant.

LINES 39A - 39L: Nonstandard Occupant Input Data*

If nonstandard occupants are requested by setting IMAN = 2 (human) or IMAN = 3 (dummy) on line 38, then 12 additional lines must be inserted. The format for these 12 lines, referred to as 39A - 39L, is explained on the following 15 pages. If IMAN = 0 (standard 50th-percentile human) or IMAN = 1 (standard 50th-percentile dummy), skip this section and proceed to line 42.

*These lines must be provided for each occupant after the line specifying corresponding occupant initial position (lines 39, 40, and 41). They are not included in the sample case, but an example is provided in Appendix B.

LINE 39A: Segment Lengths (only if IMAN = 2 or 3)

DESCRIPTION: Lengths of the spine and segments 3, 4, 5, 8, and 9 as described in figure A-7. The lengths of segments 6, 7, 10, and 11 are obtained from these by symmetry (in.).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SPL	XL(3)	XL(4)	XL(5)	XL(8)	XL(9)		

FIELD	FORMAT	CONTENTS
SPL	F10.0	Spinal length.
XL(3)	F10.0	Head Length.
XL(4)	F10.0	Upper arm length.
XL(5)	F10.0	Lower arm length - elbow to mid-point of hand.
XL(8)	F10.0	Upper leg length.
XL(9)	F10.0	Lower leg length - knee to ankle.

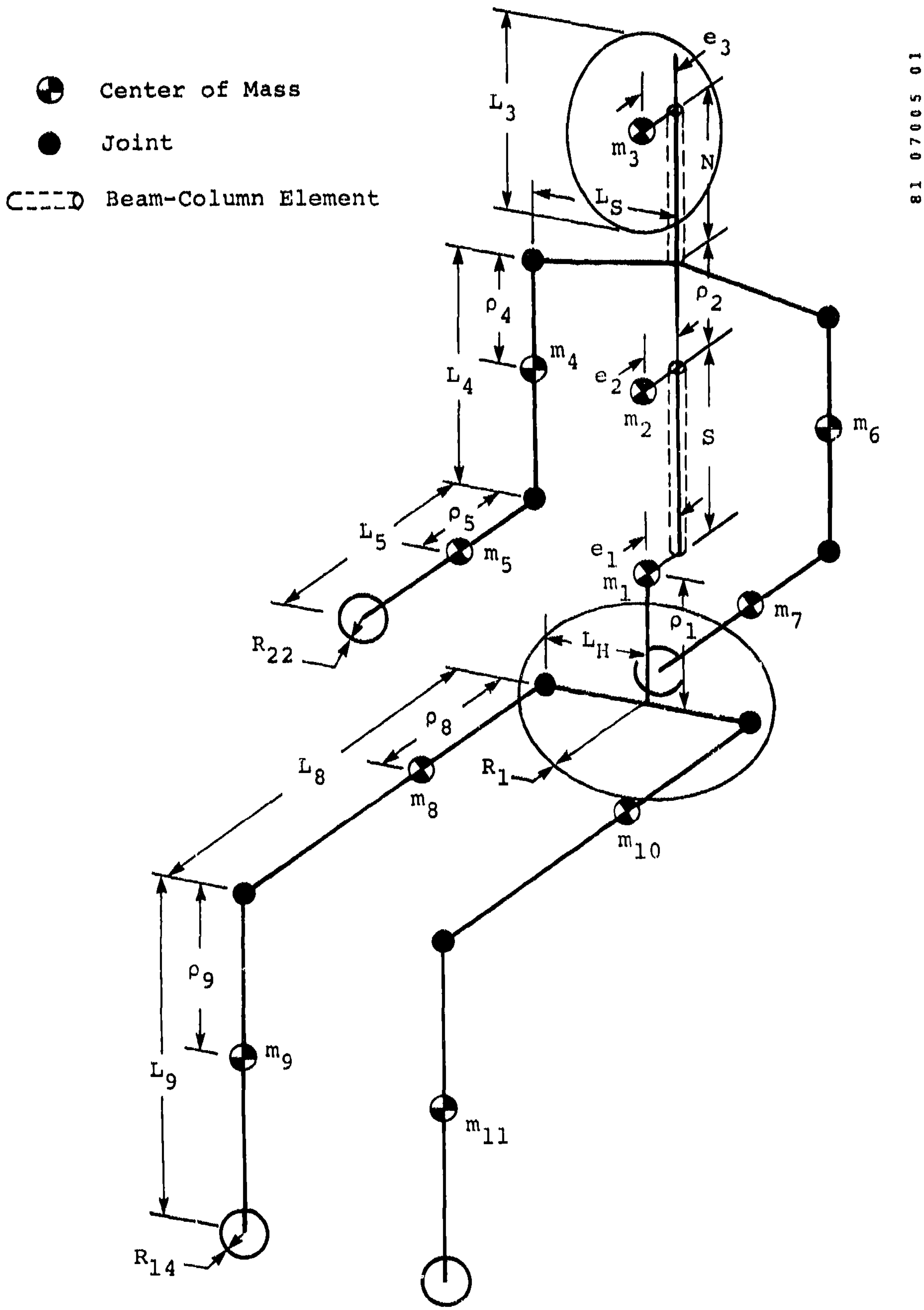


Figure A-7. Program SOM-LA body segment dimensions.

LINE 39B: Segment Center of Mass Location (only if IMAN = 2 or 3)

DESCRIPTION: Center of mass locations for segments 1, 2, 3, 4, 5, 8, and 9. See figure A-7 for datum plane description (in.).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
RHO(1)	RHO(2)	RHO(3)	RHO(4)	RHO(5)	RHO(8)	RHO(9)	

FIELD	FORMAT	CONTENTS
RHO(1)	F10.0	Lower torso center of mass vertical distance from hip pivot.
RHO(2)	F10.0	Upper torso center of mass distance from base of neck.
RHO(3)	F10.0	Head center of mass distance from base of neck.
RHO(4)	F10.0	Upper arm center of mass distance from shoulder pivot.
RHO(5)	F10.0	Lower arm center of mass distance from elbow pivot.
RHO(8)	F10.0	Upper leg center of mass distance from hip pivot.
RHO(9)	F10.0	Lower leg center of mass distance from knee pivot.

LINE 39C: Segment Weight (only if IMAN = 2 or 3)

DESCRIPTION: Weights of segments 1, 2, 3, 4, 5, 8, 9 and 12 (lb).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SW(1)	SW(2)	SW(3)	SW(4)	SW(5)	SW(8)	SW(9)	SW(12)

FIELD	FORMAT	CONTENTS
SW(1)	F10.0	Lower torso weight.
SW(2)	F10.0	Upper torso weight.
SW(3)	F10.0	Head weight.
SW(4)	F10.0	Upper arm weight.
SW(5)	F10.0	Lower arm weight.
SW(8)	F10.0	Upper leg weight.
SW(9)	F10.0	Lower leg weight.
SW(12)	F10.0	Neck weight.

LINE 39D: Segment Moment of Inertia with Respect to Local x-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to x-axis for segments 1, 2, 3, 4, 5, 8, and 9 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CIX(1)	CIX(2)	CIX(3)	CIX(4)	CIX(5)	CIX(8)	CIX(9)	

FIELD	FORMAT	CONTENTS
CIX(1)	F10.0	Lower torso x-axis moment of inertia.
CIX(2)	F10.0	Upper torso x-axis moment of inertia.
CIX(3)	F10.0	Head x-axis moment of inertia.
CIX(4)	F10.0	Upper arm x-axis moment of inertia.
CIX(5)	F10.0	Lower arm x-axis moment of inertia.
CIX(8)	F10.0	Upper leg x-axis moment of inertia.
CIX(9)	F10.0	Lower leg x-axis moment of inertia.

LINE 39E: Segment Moment of Inertia with Respect to Local y-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to y-axis for segments 1, 2, 3, 4, 5, 8, 9, and 12 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0
CIY(1)	CIY(2)	CIY(3)	CIY(4)	CIY(5)	CIY(8)	CIY(9)	CIY(12)

FIELD	FORMAT	CONTENTS
CIY(1)	F10.0	Lower torso y-axis moment of inertia.
CIY(2)	F10.0	Upper torso y-axis moment of inertia.
CIY(3)	F10.0	Head y-axis moment of inertia.
CIY(4)	F10.0	Upper arm y-axis moment of inertia.
CIY(5)	F10.0	Lower arm y-axis moment of inertia.
CIY(8)	F10.0	Upper leg y-axis moment of inertia.
CIY(9)	F10.0	Lower leg y-axis moment of inertia.
CIY(12)	F10.0	Neck y-axis moment of inertia.

LINE 39F: Segment Moment of Inertia with Respect to Local z-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to z-axis for segments 1, 2, 3, 4, 5, 8, and 9 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CIZ(1)	CIZ(2)	CIZ(3)	CIZ(4)	CIZ(5)	CIZ(8)	CIZ(9)	

FIELD	FORMAT	CONTENTS
CIZ(1)	F10.0	Lower torso z-axis moment of inertia.
CIZ(2)	F10.0	Upper torso z-axis moment of inertia.
CIZ(3)	F10.0	Head z-axis moment of inertia.
CIZ(4)	F10.0	Upper arm z-axis moment of inertia.
CIZ(5)	F10.0	Lower arm z-axis moment of inertia.
CIZ(8)	F10.0	Upper leg z-axis moment of inertia.
CIZ(9)	F10.0	Lower leg z-axis moment of inertia.

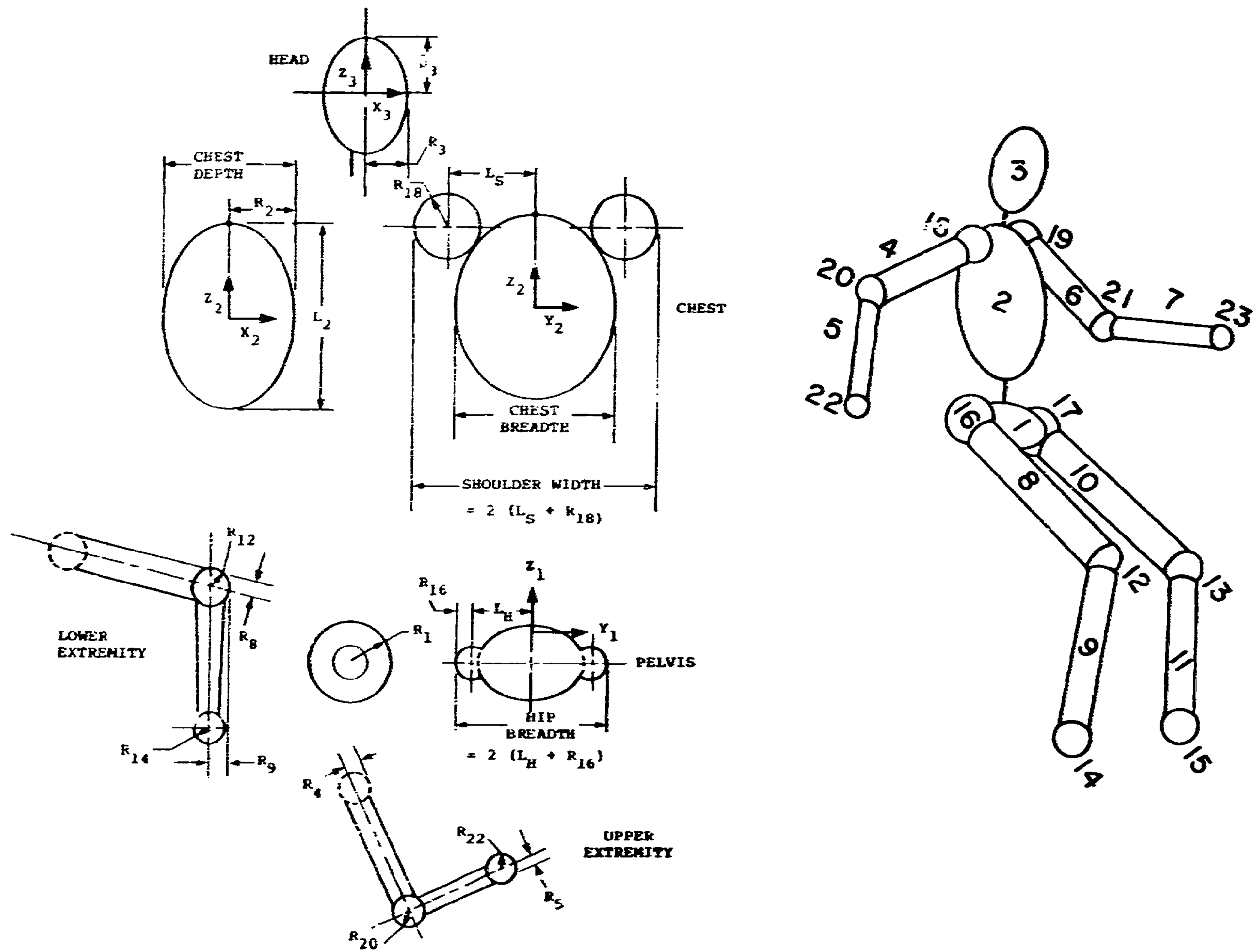
LINE 39G: Contact Surface Radii (only if IMAN = 2 or 3)

DESCRIPTION: Radii of contact surfaces 1, 2, 3, 4, 5, 8, 9, and 12 (in.). (See figure A-8 and table A-1 for human occupant.)

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XR(1)	XR(2)	XR(3)	XR(4)	XR(5)	XR(8)	XR(9)	XR(12)

FIELD	FORMAT	CONTENTS
XR(1)	F10.0	Radius of lower torso contact surface ellipsoid.
XR(2)	F10.0	Radius of upper torso in mid-saggital plane.
XR(3)	F10.0	Radius of head in mid-saggital plane.
XR(4)	F10.0	Radius of upper arm contact surface cylinder.
XR(5)	F10.0	Radius of lower arm contact surface cylinder.
XR(8)	F10.0	Radius of upper leg contact surface cylinder.
XR(9)	F10.0	Radius of lower leg contact surface cylinder.
XR(12)	F10.0	Radius of neck contact surface cylinder.



a) Body contact surface dimensions

b) Contact surface identification

Figure A-8. Body contact surfaces description.

TABLE A-1. STANDARD CONTACT SURFACE DIMENSIONS			
Surface	Symbol	Fraction of Stature (R_i/S)	Actual Dimension for 50th-Percentile Human Male (in.)
Pelvis	R_1	0.0579	4.00
Chest	R_2	0.0689	4.76
Head	R_3	0.0485	3.35
Arm	R_4, R_6	0.0263	1.82
Forearm	R_5, R_7	0.0243	1.68
Thigh	R_8, R_{10}	0.0466	3.22
Leg	R_9, R_{11}	0.0344	2.38
Knee	R_{12}, R_{13}	0.0373	2.58
Foot	R_{14}, R_{15}	0.0405	3.10
Hip	R_{16}, R_{17}	0.0515	3.56
Shoulder	R_{18}, R_{19}	0.0378	2.61
Elbow	R_{20}, R_{21}	0.0268	1.85
Hand	R_{22}, R_{23}	0.0339	2.34

LINE 39H: Contact Surface Radii Continued (only if IMAN = 2 or 3)

DESCRIPTION: Radii of contact surfaces 14, 16, 18, 20, and 22 (in.).

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XR(14)	XR(16)	XR(18)	XR(20)	XR(22)			

FIELD	FORMAT	CONTENTS
XR(14)	F10.0	Radius of foot contact surface sphere.
XR(16)	F10.0	Radius of hip contact surface sphere.
XR(18)	F10.0	Radius of shoulder contact surface sphere.
XR(20)	F10.0	Radius of elbow contact surface sphere.
XR(22)	F10.0	Radius of hand contact surface sphere.

LINE 39I: Spherical Joint and Center of Mass Offset Distances (only if IMAN = 2 or 3)

DESCRIPTION: Distances that spherical joints (shoulder and hip) are laterally offset from the mid-saggital plane, and the anterior offset of the major upper body segment (lower torso, upper torso, and head) center of masses from the spine. (See description of distances in figure A-7.) Dimensions are in inches.

FORMAT AND EXAMPLE;

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLH	XLS	EM(1)	EM(2)	EM(3)			

FIELD	FORMAT	CONTENTS
XLH	F10.0	Lateral distance of center of hip joint from mid-saggital plane.
XLS	F10.0	Lateral distance of shoulder joint from mid-saggital plane.
EM(1)	F10.0	Anterior offset distance of the lower torso center of mass from the spine.
EM(2)	F10.0	Anterior offset distance of the upper torso center of mass from the spine.
EM(3)	F10.0	Anterior offset distance of the head center of mass from the spine.

LINE 39J: Abdomen and Chest Compliance (only if IMAN = 2 or 3)

DESCRIPTION: Estimated force-deflection characteristics (compliance) of occupant chest and abdomen under restraint system loads. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CABD	BABD	CCHE	BCHE				

FIELD	FORMAT	CONTENTS
CABD	F10.0	Coefficient C for abdomen compliance (lb).
BABD	F10.0	Coefficient B for abdomen compliance ($in.^{-1}$).
CCHE	F10.0	Coefficient C for chest compliance (lb).
BCHE	F10.0	Coefficient B for chest compliance ($in.^{-1}$).

LINE 39K: Axial Stiffness and Damping Properties for Spine and Neck (only if IMAN = 2 or 3)

DESCRIPTION: Axial force-deflection characteristics for the two-dimensional spine and neck beam models and associated axial damping. The force, F, is computed from deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CAXS	BAXS	DMPS	CAXN	BAXN	DMPN		

FIELD	FORMAT	CONTENTS
CAXS	F10.0	Coefficient C in above equation for axial spinal stiffness (lb).
BAXS	F10.0	Coefficient B in above equation for axial spinal stiffness ($in.^{-1}$).
DMPS	F10.0	Axial damping in spine (lb-sec-$in.^{-1}$).
CAXN	F10.0	Coefficient C in above equation for axial neck stiffness (lb).
BAXN	F10.0	Coefficient B in above equation for axial neck stiffness ($in.^{-1}$).
DMPN	F10.0	Axial damping in neck (lb-sec-$in.^{-1}$).

LINE 39L: Rotational Stiffness and Damping Properties for Spine and Neck (only if IMAN = 2 or 3)

DESCRIPTION: Rotational moment-angle characteristics for the two-dimensional spine and neck beam models and associated rotational damping. The moment, M, is computed from angular deflection, δ, according to $M = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CROT(1)	BROT(1)	XJ(1)	CROT(2)	BROT(2)	XJ(2)		

FIELD	FORMAT	CONTENTS
CROT(1)	F10.0	Coefficient C in above equation for rotational spinal stiffness (in.-lb).
BROT(1)	F10.0	Coefficient B in above equation for rotational spinal stiffness (rad^{-1}).
XJ(1)	F10.0	Rotational damping in spine (lb-sec).
CROT(2)	F10.0	Coefficient C in above equation for rotational neck stiffness (in.-lb).
BROT(2)	F10.0	Coefficient B in above equation for rotational neck stiffness (rad^{-1}).
XJ(2)	F10.0	Rotational damping in neck (lb-sec).

LINE 42: Seat Geometry

DESCRIPTION: Dimensions of seat model as shown in figure A-9.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XSEAT	ZSEAT	ANGSP	ANGSB	XLPAN	XWPAN	SBHT	SBW
10.	12.	8.	16.	15.15	20.	39.	20.

FIELD	FORMAT	CONTENTS
XSEAT ZSEAT	2F10.0	X- and Z-coordinates (in aircraft-fixed system) of intersection of seat pan and seat back planes under the cushions (in.).
ANGSP ANGSB	2F10.0	Seat pan and seat back angles (in aircraft-fixed system), directions as defined in figure A-9 (deg).
XLPAN	F10.0	Seat pan length (in.).
XWPAN	F10.0	Seat pan width (in.).
SBHT	F10.0	Seat back height (in.).
SBW	F10.0	Seat back width at top (in.).

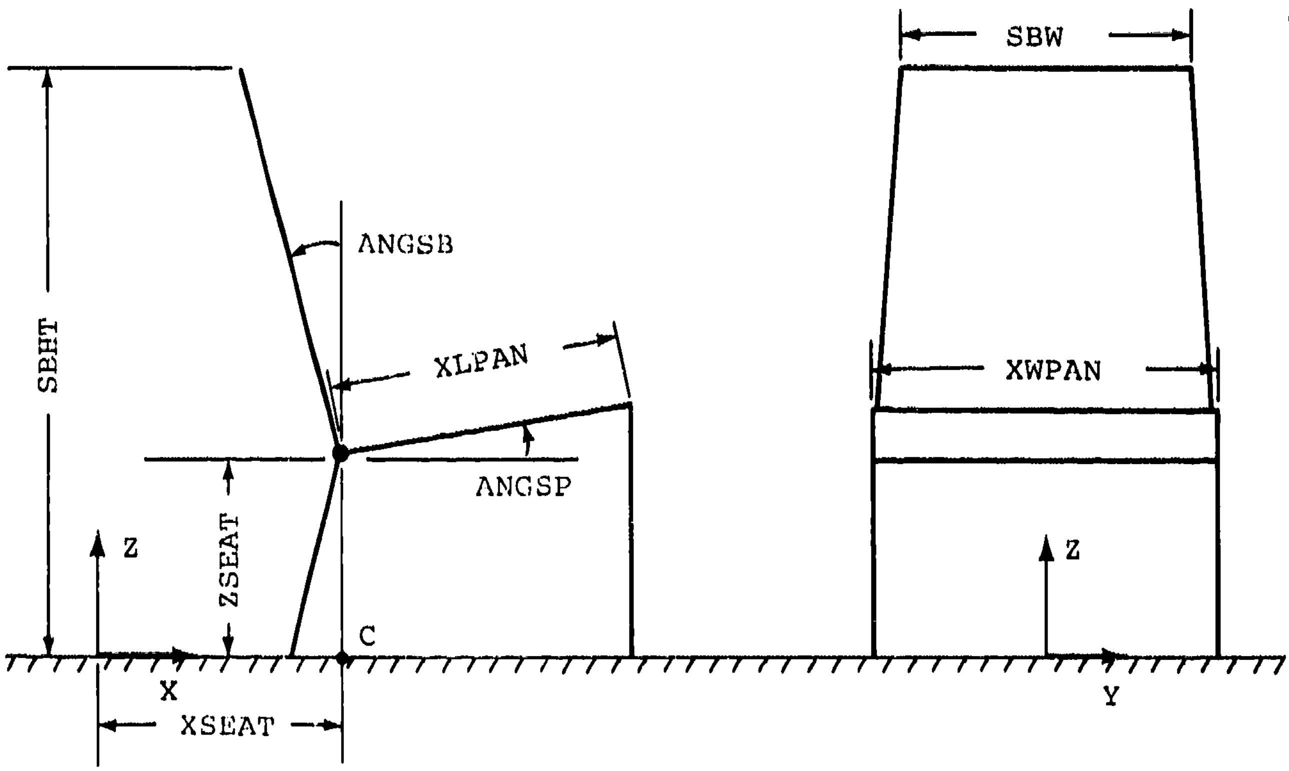


Figure A-9. Rigid seat model geometry.

A.1 RIGID SEAT INPUT

If a rigid seat is requested by setting NSEAT = 0 on line 1, then the input data for lines 42A and 42B following this page are required. If the stroking energy-absorbing seat option is utilized, line 42C is also required. If contact with the seat back is requested by IOUT(4) = 1 or 2 on line 3, the data described in section A.2 are required. If NSEAT = 1, signifying the use of the finite element model, lines 42A-C are omitted and the data of A.3 are used.

LINE 42A: Energy Absorber Data

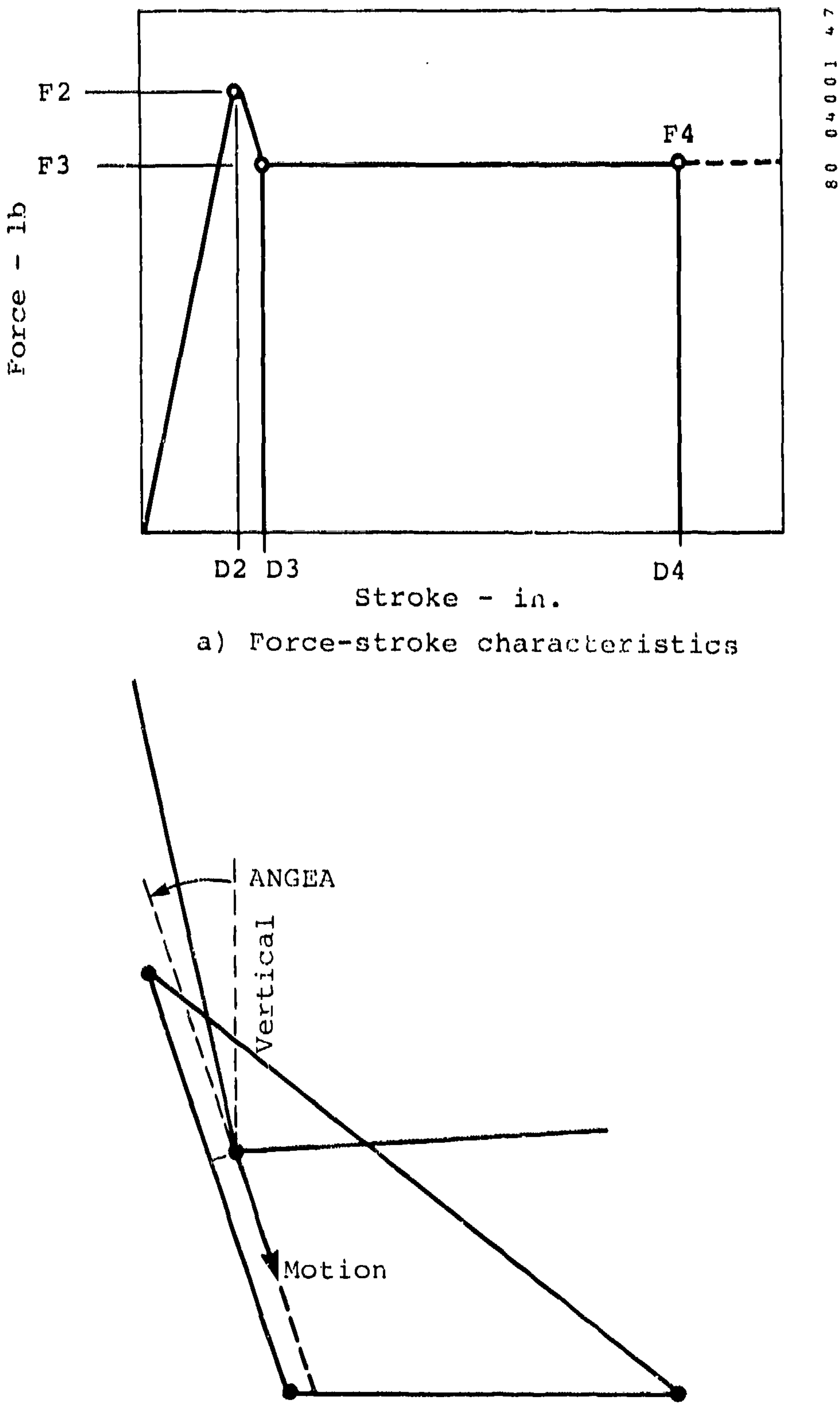
DESCRIPTION: Parameters for the two-degree-of-freedom (seat stroke and rigid-body rotation) energy-absorbing seat model. (See figure A-10 for a detailed description of the parameters.)

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
F2	F3	F4	D2	D3	D4	ANGEA	SEATM

FIELD	FORMAT	CONTENTS
F2 F3 F4	3F10.0	Energy absorber force (lb).
D2 D3 D4	3F10.0	Deflections corresponding to above forces (in.), see figure A-10a.
ANGEA	F10.0	Stroking angle for guided energy-absorbing seat (deg), see figure A-10b.
SEATM	F10.0	Weight of movable part of energy-absorbing seat (lb). NOTE: If SEATM $\leq$ 0 (or left blank) the energy-absorbing stroke of the seat will not be used, i.e., the seat will remain fixed in position. However, lines 42A and 42B must be included, even if blank.

*Line not present for sample case.



a) Force-stroke characteristics

b) Geometry

Figure A-10. Energy absorber data.

LINE 42B: Energy Absorber Data Continued

DESCRIPTION: Parameters for the two-degree-of-freedom (seat stroke and rigid-body rotation) energy-absorbing seat model.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SUNLOD	SDAMP	YISEAT	RUNLOD	RDAMP			

FIELD	FORMAT	CONTENTS
SUNLOD	F10.0	Energy absorber unloading slope (lb/in.)
SDAMP	F10.0	Damping coefficent for the energy absorber (lb-sec/in.).
YISEAT	F10.0	Mass moment of inertia of the seat about a lateral axis through point C (in figure A-9) with coordinates X = XSEAT, Z = 0 (lb-in.-sec^2).
RUNLOD	F10.0	Unloading slope for rotational deformation of seat (in.-lb/rad)
RDAMP	F10.0	Rotational damping coefficient for the seat (in.-lb-sec).

*Line not present for sample case.

LINE 42C: Rigid Seat Rotational Stiffness Parameters

DESCRIPTION: Applied moment versus seat rotational angle as shown in figure A-11.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFRT(2)	FFRT(3)	FFRT(4)	DDRT(2)	DDRT(3)	DDRT(4)		

FIELD	FORMAT	CONTENTS
FFRT(2) FFRT(3) FFRT(4)	3F10.0	Applied moment on rigid seat (in.-lb).
DDRT(2) DDRT(3) DDRT(4)	3F10.0	Angular seat displacement (rad).

*Line not present for sample case.

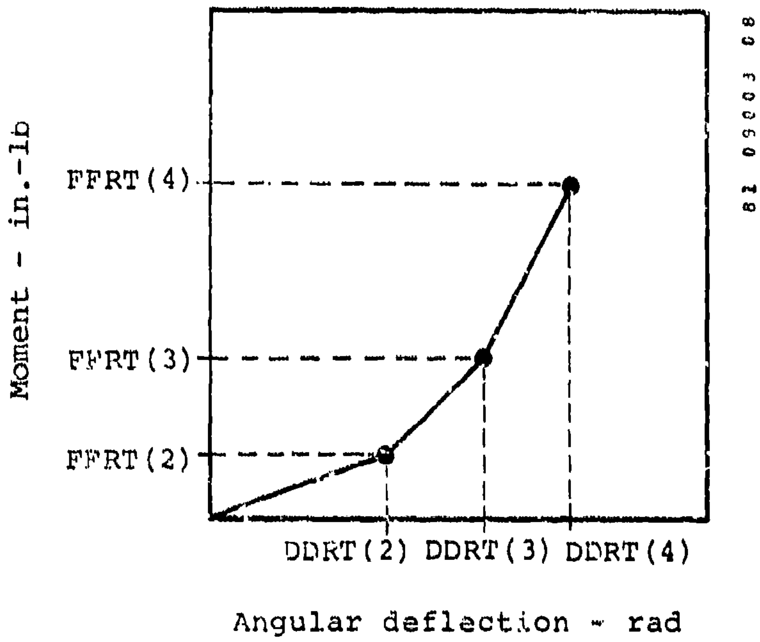


Figure A-11. Rigid seat model rotational stiffness.

A.2 SECONDARY IMPACT INPUT

If contact with the seat back is to be simulated (by IOUT(4) = 1 or 2), the following lines of input data are required to describe the surfaces on the seat back.

Line 42D: Seat Back Contact Surface Dimensions

Description: Dimensions of contact surfaces on seat back, as illustrated in figure A-12. Also, the seat row pitch is included.

Format and Example:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TTT	WTT	HTT	TAR	WAR	HAR	XLAR	SPITCH

Field	Format	Contents
TTT	F10.0	Distance from top of seat back to top edge of stowed tray table (in.).
WTT	F10.0	Width of tray table (in.).
HTT	F10.0	Height of tray table (in.)
TAR	F10.0	Distance from top of seat back to top of armrest (in.).
WAR	F10.0	Width of armrest (in.).
HAR	F10.0	Height of armrest (in.).
XLAR	F10.0	Length of armrest (in.).
SPITCH	F10.0	Seat row pitch (in.).

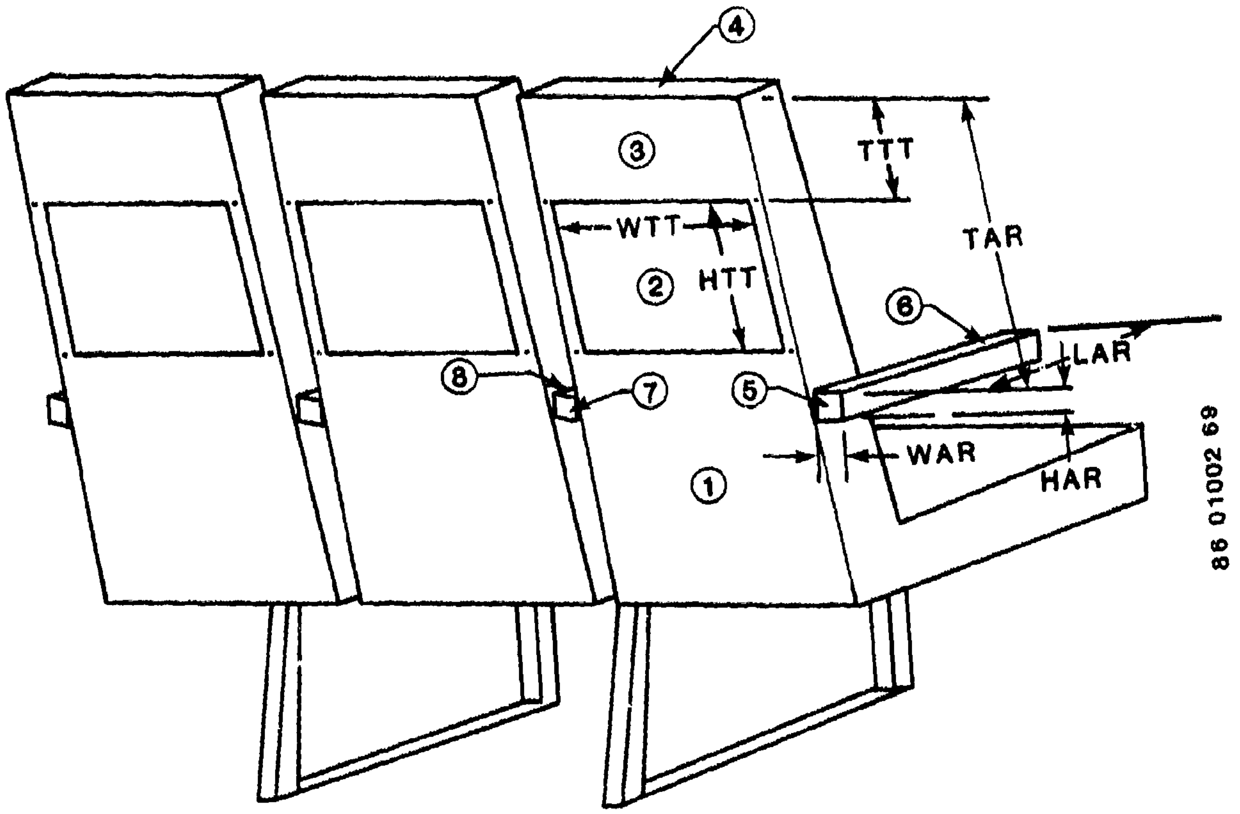


Figure A-12. Seat back contact surfaces.

Lines 42E,F,G: Seat Back Force-Deformation Properties

Description: Force-deflection characteristics and damping for seat back surfaces. The force is computed from deflection, δ, according to $F = C(e^{B\delta} - 1)$.

Format and Example:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CCON	BCON	DCON	FLIMIT				

Field	Format	Contents
CCON	F10.0	Coefficient C in above equation (lb).
BCON	F10.0	Coefficient B (in.$^{-1}$).
DCON	F10.0	Damping coefficient at zero load (lb-sec/in.).
FLIMIT	F10.0	Maximum longitudinal force that can be exerted to the surface.

Three lines of data are input in the above format. The first (42E) applies to the cushion surfaces (1, 3, and 4, in figure A-12). The second line (42F) applies to the tray table (2 in figure A-12). The third refers to the armrest surfaces (5-8 in figure A-12).

A.3 NONRIGID SEAT INPUT

If a nonrigid seat is requested by setting NSEAT = 1 on line 1, then the input data described on the following lines is required to define the finite element seat model.

LINE 43: Basic Seat Model Data

DESCRIPTION: Control line for finite element model describing the number of items in each segment of the model (used to control reading of input cards) and the integration parameters.

FORMAT AND EXAMPLE:

NNODE	NELE	NUMMAT	NUMDIS	NDGREE	NCOORD	NSECT	CBUK
20	27	2	4	6	7	2	.50

FIELD	FORMAT	CONTENTS
NNODE	I5	Number of real nodes.
NELE	I5	Number of elements.
NUMMAT	I5	Number of materials.
NUMDIS	I5	Number of displacement-specified node points (at which the aircraft displacement, velocity, and acceleration are applied).
NDGREE	I5	Number of degrees of freedom per node (= 6 this version).
NCOORD	I5	Number of inactive beam pointer nodes, which are used to orient beam cross sections. A real node can be used as a pointer node. Also, a single node can be used as a pointer node for more than one beam.
NSECT	I5	Number of different beam cross-section types.
CBUK	F5.0	Buckling coefficient for beams of closed cross-section.

LINE 44: Miscellaneous Control Flags

DESCRIPTION: Parameters for controlling execution of finite element seat simulation.

FORMAT AND EXAMPLE:

0 — 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
KNTRL(1)	KNTRL(2)						
5	5						

FIELD	FORMAT	CONTENTS
KNTRL (1)	I5	Maximum number of iterations for convergence within a time step (Default is 5).
KNTRL(2)	I5	Number of increments to enforce the floor warping. (See Lines 55 and 55A.) A value of 10 is recommended for cases where the floor warping produces plastic and/or large deformations of the seat finite element model.

LINE 45: Material Type Number

DESCRIPTION: Material type designation number. Repeat group 45 through 47 in sequence NUMMAT times, as specified on line 43, one sequence for each material.

FORMAT AND EXAMPLES:

0 … 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
MYTP MAT							
12024-T4 AL							

FIELD	FORMAT	CONTENTS
MYTP	I5	Material type designation number. The element data on line 51 specifies the material type by referring to this number.
MAT	A10	Material type description used as heading for material property output.

LINE 46: Material Properties

DESCRIPTION: Material physical properties as described in figure A-13.

FORMAT AND EXAMPLE:*

0 1234567890 1	1234567890 2	1234567890 3	1234567890 4	1234567890 5	1234567890 6	1234567890 7	1234567890 8
E(1)	E(2)	E(3)	E(4)	E(5)	E(6)	E(7)	E(8)
2.588E-4	10.5E6	44000.	4.9E5		62000.	.3	

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
E(1)	E10.4	Density (lb-sec^2/in.^{4})
E(2)	E10.4	Modulus of elasticity (lb/in.^{2}).
E(3)	E10.4	First yield stress; s_{y1} (lb/in.^{2}) = 0 if elastic.
E(4)	E10.4	First plastic modulus (lb/in.^{2}) = 0 if elastic.
E(5)	E10.4	Not used.
E(6)	E10.4	Ultimate stress; s_{ult} (lb/in.^{2}) = 0 if elastic.
E(7)	E10.4	Poisson's ratio.
E(8)	E10.4	Not used.

*Example for the first of two groups, determined by NUMMAT = 2 on line 43.

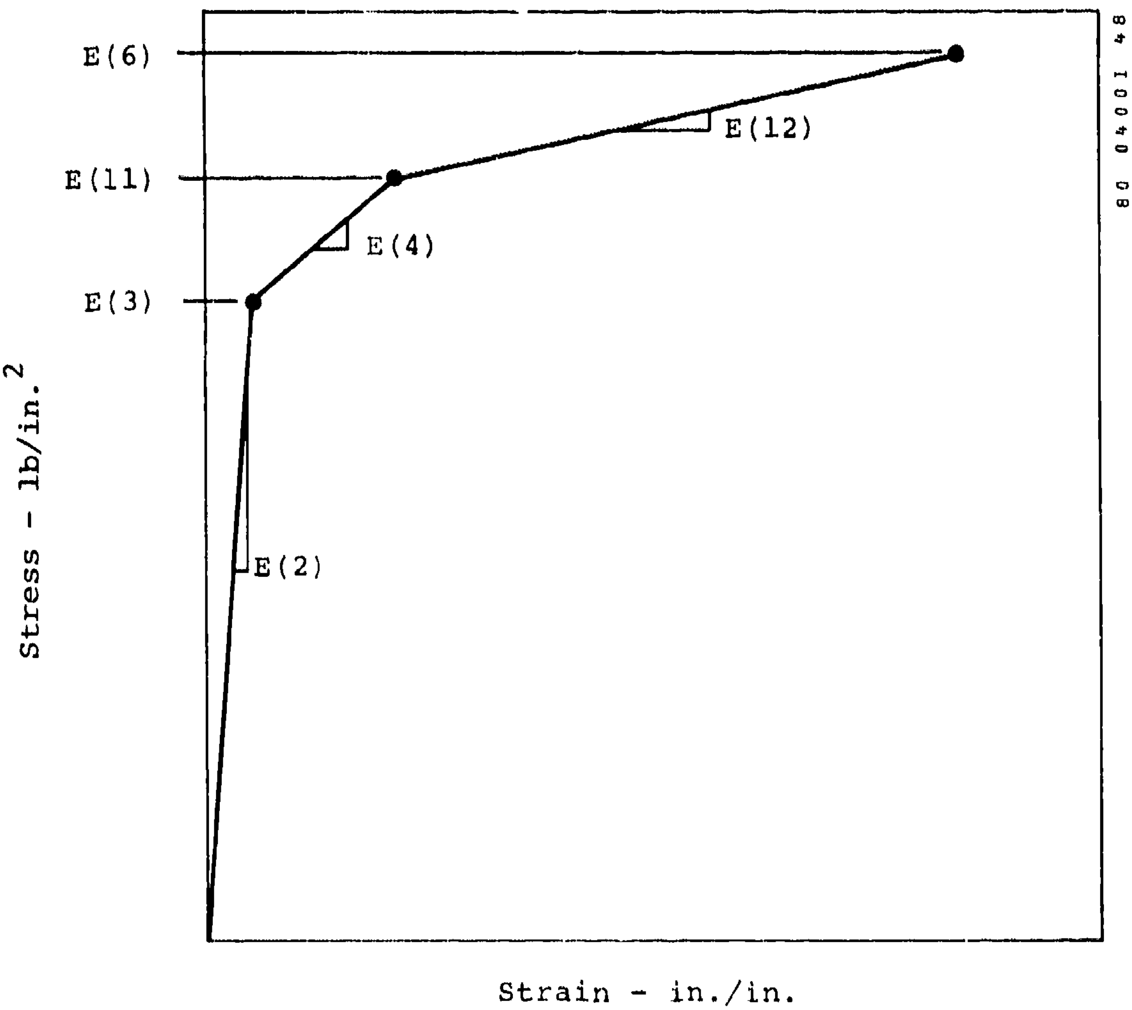


Figure A-13. Idealized stress-strain curve.

LINE 47: Material Properties (continued)

DESCRIPTION: Material physical properties as described in figure A-13.

FORMAT AND EXAMPLE:*

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
E(9)	E(10)	E(11)	E(12)	E(13)	E(14)	E(15)	E(16)
		58000.	6.2E4				

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
E(9)	E10.4	None.
E(10)	E10.4	None.
E(11)	E10.4	Second yield stress, s_{y2} (lb/in.^{2}).
E(12)	E10.4	Second plastic modulus (lb/in.^{2}).
E(13)	E10.4	Strain-rate coefficient = 0, no strain-rate effect considered.
E(14)	E10.4	Strain-rate exponent = 0, no strain-rate effect considered.
E(15)	E10.4	Explicit moment curvature flag 1, use explicit moment curvature option (plate) 0, ignored explicit moment curvature option (plate).
E(16)	E10.4	None.

*Example for the first of two groups determined by NUMMAT = 2 on line 43.

LINE 48: Beam Cross-Section Data (only if NSECT > 0 on line 43)

DESCRIPTION: Beam element cross-sectional properties as described in figure A-14. Repeat group 48 and 49 NSECT times, as specified on line 43, one sequence for each cross section.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NSEG	KLOS	ABM	FIXX	FIYY	FIZZ		
8	0	0.4347	0.3028	0.1514	0.1514		

FIELD	FORMAT	CONTENTS
NSEG	I5	Number of plate segments in beam cross section.
KLOS	I5	Flag for closed-wall sections. = 0; closed wall = 1; open wall.
ABM	E10.4	Cross-section area.
FIXX FIYY FIZZ	3E10.4	Cross-section moments of inertia about x, y, and z principal axes, respectively. The cross section for each beam element is oriented by specification of a pointer node in the element data on line 51.

*Example for the first of two groups, determined by NSECT = 2 on line 43.

Line 48A: Beam Cross-Section Data (only if NSECT > 0 on line 43)

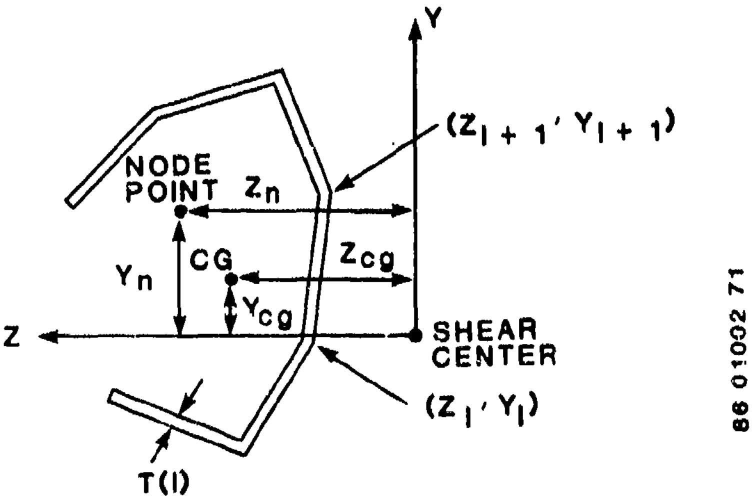
Description: Beam element cross-sectional properties as described in figure A-14.

Format and Example

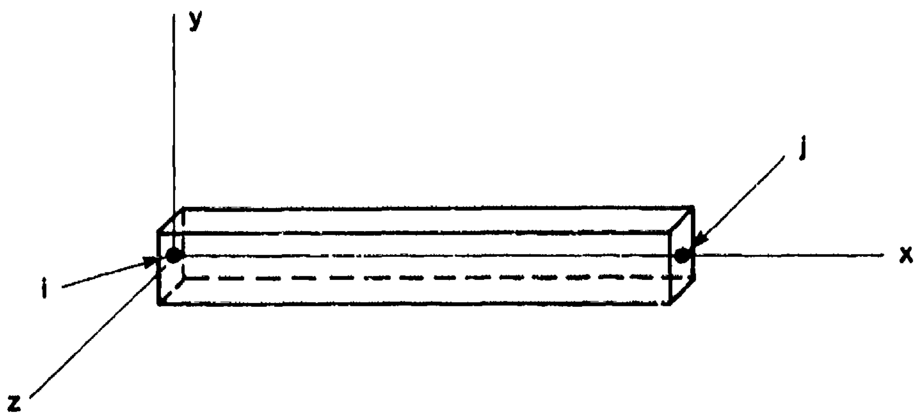
1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
YN	ZN	YCG	ZCG				
0.0	0.0	0.0	0.0				

Field	Format	Contents
YN ZN	2F10.0	Y and Z coordinates of the beam end node point. (see figure A-14a).
YCG ZCG	2F10.0	Y and Z coordinates of the cross-section centroid (see figure A-14a).

*Example for the first of two groups, determined by NSECT = 2 on line 43.



a) Cross-section geometry



b) Element coordinate system

Figure A-14. Beam element coordinate system and cross-section geometry.

LINE 49: Beam Cross-Section Data (only if NSECT > 0 on Line 43)

DESCRIPTION: Beam element cross-sectional properties as described in figure A-14.

NOTES: (1) Repeat line 49 NSEG + KLOS times, following line 48.
(2) Repeat the sequence of lines 48 and 49 NSECT times, as defined on line 40.

FORMAT AND EXAMPLE:*

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
Y(1)	Z(1)	T(1)					
.0	.834	.083					

FIELD	FORMAT	CONTENTS
Y(I) Z(I)	E10.0 E10.0	Cross-section coordinates of point at beginning of segment I (in.). (See figure A-14a.)
T(I)	E10.0	Segment thickness for segment between points I and I + 1 (in.).

*Example for the first of eight lines based on NSEG = 8 and KLOS = 0 on line 48.

LINE 50: Nodal Point Data

DESCRIPTION: Finite element node number and nodal coordinates in global system.

NOTES: Repeat line 50 NNODE + NCOORD times.

FORMAT AND EXAMPLE:*

0 12345	67890 1	1234567890 2	1234567890 3	1234567890 4	1234567890 5	1234567890 6	1234567890 7	1234567890 8
N		XC(N)	YC(N)	ZC(N)				
1		8.	10.	0.				

FIELD	FORMAT	CONTENTS
N	I5 5X	Node number.
XC(N)	E10.4	X
YC(N)	E10.4	Y coordinates of node point (in.).
ZC(N)	E10.4	Z

*Example for the first of 22 lines, based on NNODE = 20 and NCOORD = 2 on line 43.

LINE 51: Element Data

DESCRIPTION: Individual element property descriptions.

NOTE: Repeat line 51 NELE times.

FORMAT AND EXAMPLE:*

M	NODE(1)	NODE(2)	NODE(3)	NODE(4)	NODE(5)	NODE(6)	NODE(7)	NODE(8)	NODE(9)	NODE(10)	NODE(11)	NODE(12)	NODE(13)	
5	2	6				2	21	2	2	000	010	000	010	

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
M	I5	Element number.
NODE(1) NODE(2)	2I5	End nodes.
NODE(3) NODE(4)	2I5	Not used.
NODE(5)	I10	Stiffness flag = 0 Use plastic beam stiffness = 1 Use elastic beam stiffness
NODE(6)	I5	Cross-section type. The first set of lines 48 and 49 is assumed to be cross-section type no. 1; the second, no. 2, etc.
NODE(7)	I5	Pointer node for orientation of initial principal beam axis Y.
NODE(8)	I5	Beam element = 2
NODE(9)	I5	Material type (assumes 1 if left blank).
NODE(10)	I5	Beam-end conditions (forces), at end i, figure A-14(b) ABC (packed word, right justified) A = Force release in x-direction, if 1. B = Force release in y-direction, if 1. C = Force release in z-direction, if 1.
NODE(11)	I5	Beam-end conditions (moments), at end i, figure A-14(b). DEF (packed word, right justified) D = Moment release in x-direction, if 1. E = Moment release in y-direction, if 1. F = Moment release in z-direction, if 1.

*Example for the fifth of 27 lines, based on NELE = 27 on line 43.

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
NODE(12)	I5	Beam-end conditions (forces), at end j, figure A-14(b) OPQ (packed word, right justified) O = Force release in x-direction, if 1. P = Force release in y-direction, if 1. Q = Force release in z-direction, if 1.
NODE(13)	I5	Beam-end conditions (moments), at end j, figure A-14(b). RST (packed word, right justified) R = Moment release in x-direction, if 1. S = Moment release in y-direction, if 1. T = Moment release in z-direction, if 1.

LINE 52: Seat Pan Nodes

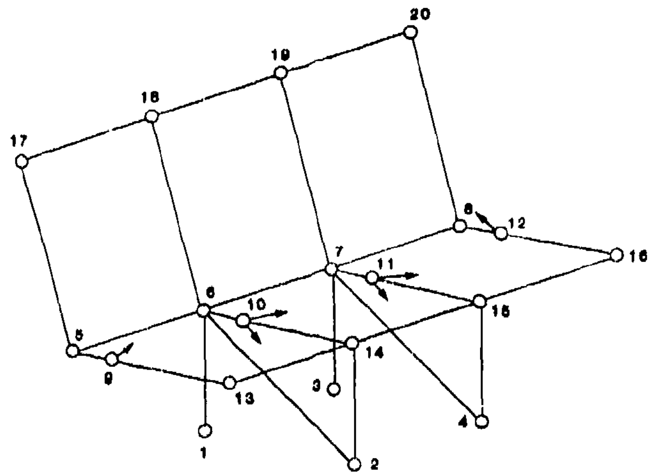
DESCRIPTION: Nodes on which seat cushion loads will be applied, and which are used to define the seat pan outline for the occupant plots.

FORMAT AND EXAMPLE:

0 ... 1		2		3		4		5		6		7	8
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	1234567890
NPAN(1)	NPAN(2)	NPAN(3)	NPAN(4)	NPAN(5)	NPAN(6)	NPAN(7)	NPAN(8)	NPAN(9)	NPAN(10)	NPAN(11)	NPAN(12)		
5	6	13	14	6	7	14	15	7	8	15	16		

FIELD	FORMAT	CONTENTS
NPAN	12I5	Nodes on which seat cushion loads are to be applied, input on rear edge first, then forward edge, and from right to left, as shown in figure A-15.

Note that in this example node 6 is used as NPAN(2) and NPAN(5), node 14 as NPAN(4) and NPAN(7), node 7 as NPAN(6) and NPAN(9), and node 15 as NPAN(8) and NPAN(11).



COLUMNS	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
LINE 52, NPAN	5	6	13	14	6	7	14	15	7	8	15	16
LINE 53, NBAK	5	6	17	18	6	7	18	19	7	8	19	20
LINE 54, NLBA	9	10	10	11	11	12						

Figure A-15. Illustration of seat pan, back, and lap belt node identification.

LINE 53: Seat Back Nodes

DESCRIPTION: Nodes on which back cushion loads are to be applied, and which are used to define the seat back outline for the occupant plots.

FORMAT AND EXAMPLE:

0	1		2		3		4		5		6	7	8
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	1234567890	1234567890
NBAK(1)	NBAK(2)	NBAK(3)	NBAK(4)	NBAK(5)	NBAK(6)	NBAK(7)	NBAK(8)	NBAK(9)	NBAK(10)	NBAK(11)	NBAK(12)		
5	6	17	18	6	7	18	19	7	8	19	20		

FIELD	FORMAT	CONTENTS
NBAK	12I5	Nodes on which back cushion loads are to be applied, input on lower edge first, then top, and from right to left, as shown in figure A-15.

Note that in this example node 6 is used as NBAK(2) and NBAK(5), node 7 as NBAK(6) and NBAK(9), etc.

LINE 54: Restraint System Anchor Point Nodes

DESCRIPTION: Nodal points on seat structure to which restraint system is attached as shown in figure A-15.

FORMAT AND EXAMPLE:

0	1		2		3		4		5		6	7	8
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	1234567890	1234567890
NLBA(1)	NLBA(2)	NLBA(3)	NLBA(4)	NLBA(5)	NLBA(6)	NSHA(1)	NSHA(2)	NSHA(3)	NSHA(4)	NSHA(5)	NSHA(6)		
9	10	10	11	11	12								

FIELD	FORMAT	CONTENTS
NLBA	6I5	Seat structure nodes at which lap belt is attached, right side first, then left, as shown in figure A-15. Not used if lap belt is attached to aircraft floor.
NSHA	6I5	Seat structure nodes at which shoulder harness load is to be applied (one node), or distributed (two nodes). Leave blank if shoulder harness is not used or not attached to seat.

Note that for this example node 10 is used as both NLBA(2) and NLBA(3), and node 11 is used as both NLBA(4) and NLBA(5), as common points of attachment for lap-belts usually found transport seats. Also, in this example no shoulder harness is used.

LINE 55: Node Constraint Data

DESCRIPTION: Packed (encoded) word for each nodal point that is constrained in at least one degree of freedom.

NOTE: (1) Repeat line 55 NUMDIS times. Omit if NUMDIS = 0.
(2) If any of the displacement/rotation codes is set to 2 to enforce floor warping, include line 55A immediately following the corresponding line 55 data.

FORMAT AND EXAMPLE:*

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NODDIS							
2112001							

FIELD	FORMAT	CONTENTS
NODDIS	I10	Packed word - NABCDEF (right justified)

N = Node number
A = Displacement code in X direction
B = Displacement code in Y direction
C = Displacement code in Z direction
D = Rotation code in X direction
E = Rotation code in Y direction
F = Rotation code in Z direction

A, B, C, D, E, or F = 0, no constraint
= 1, constrained for zero displacement/rotation
= 2, constrained for floor warp displacement/rotation.

*Example for the second of five lines, based on NUMDIS = 4 on line 43, and displacement/rotation codes set to 2 on line 55.

LINE 55A: Floor Warp Data

DESCRIPTION: Floor warp displacement/rotation.

NOTE: (1) Repeat line 55A for each displacement/rotation code set to 2 in. line 55, in the order from displacement in x-direction to rotation in z-direction.
(2) rotations are input in radians.

FORMAT AND EXAMPLE:*

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FWARP							
-0.5							

FIELD	FORMAT	CONTENTS
FWARP	E10.4	Floor warp displacement/rotation.

*Example for the third of five lines based on NUMDIS = 4 on line 43 and displacement/rotation codes set to 2 on line 55.

APPENDIX B

EXAMPLES OF OCCUPANT CHARACTERISTICS AND MATERIAL PROPERTIES

A significant problem encountered in mathematically modeling a physical system lies in determination of system characteristics and properties. In this appendix are presented examples of the following:

- Occupant dimensions and characteristics.
- Restraint system webbing load-elongation characteristics.
- Cushion load-deflection characteristics.
- Structural material stress-strain characteristics.

The characteristics and properties contained in this appendix are, of course, not intended to be all inclusive, but rather are intended to provide the SOM-LA program user with examples that may aid in setting up new input cases.

B.1 OCCUPANT MODELING CHARACTERISTICS

As described in chapter 2, dimensions and inertial properties for two standard occupants, a 50th-percentile civilian male and a 50th-percentile anthropomorphic (Part 572) dummy, are included within the program. If a nonstandard occupant is desired, additional data must be provided on lines 39A through 39L. The format for nonstandard occupant data is displayed in figure B-1, and parameters are defined on pages A-37 through A-52. In figure B-2 are presented the properties that are used in the program for the standard (Part 572 50th-percentile) dummy occupant. Figure B-3 presents a set of data for a 95th-percentile dummy, which have simply been scaled from the 50th-percentile data. The use of this scaling method is not suggested if measured properties can be obtained; however, to complete a partial set of properties or obtain a quick estimate of the solution, use of the scaling approach can be justified.

The scaling method is based on multiplying the 50th-percentile properties by the appropriate nondimensional scaling factor. All properties with length dimensions are multiplied by the ratio of nonstandard occupant sitting height to 50th-percentile sitting height. In this example:

$$\text{Length Factor} = \frac{\text{95th \% Sitting Height}}{\text{50th \% Sitting Height}} = \frac{37.8\ \text{in.}}{35.7\ \text{in.}} = 1.06$$

Similarly, occupant properties based on weight are scaled by the occupant weight ratio, i.e.:

$$\text{Weight Factor} = \frac{\text{95th \% Weight}}{\text{50th \% Weight}} = \frac{212\ \text{lb}}{164\ \text{lb}} = 1.29$$

The factor for scaling moments of inertia was derived from a dimensional analysis for the variables involved. The resulting scaling factor is:

$$\begin{array}{c}\text{Moment of}\\ \text{Inertia Factor}\end{array} = \frac{(\text{95th \% Weight})\ (\text{95th \% Sitting Height})^2}{(\text{50th \% Weight})\ (\text{50th \% Sitting Height})^2} = 1.45$$

Since there is no valid basis for scaling stiffnesses, the 50th-percentile spine and neck stiffness properties were retained.

B.2 WEBBING LOAD-ELONGATION CHARACTERISTICS

Figures B-4 and B-5 present static load-elongation characteristics for several types of nylon and polyester restraint system webbing, respectively. Very little dynamic data for webbing deformation exist; however, figures B-6 and B-7 present some dynamic results taken from reference B.1.

The damping coefficients for the restraint components are based on three assumptions: that the webbing damping coefficient is not a function of strain condition, that it is independent of strain rate, and that the Voigt-Kelvin model (shown in figure B-8) can be used to represent the webbing.

The first assumption allows the use of a linear approximation to the static and dynamic load-strain curves for the webbing material. The single slope approximation should be the best estimate for the expected range of webbing loads, and not for the entire curve. The second assumption indicates that the damping coefficient will be applicable to all possible strain rates encountered in the simulation. The accuracy of the damping coefficient can be maximized by basing the calculated value on dynamic webbing test data measured at an applicable strain rate. The procedure for calculating the damping coefficient for nylon webbing (MIL-W-4088 TYPE VII) is given below.

The static load/elongation curve for the nylon webbing sample is shown in figure B-9. A linear approximation to this curve is 11,000 lb/in./in. over the expected load range of 0 to 2000 lb. The slope of the dynamic test data, measured at a strain rate of 40.9 in./in./sec, is approximated as 26,000 lb/in./in. Based on the assumption of a parallel spring-damper model, the dynamic load at any elongation value must be equal to the static load plus the damper force, i.e.

$$P_{DYNAMIC} = P_{STATIC} + P_{DAMPING}$$

$$= K\varepsilon + C\dot{\varepsilon} \qquad \text{(B-1)}$$

Where:

- K is slope of the load/strain curve (lb/in./in.)
- C is the damping coefficient (lb-sec/in./in.)
- ε is the strain (in./in.)
- $\dot{\varepsilon}$ is the strain rate (in./in./sec)

Therefore, the damping coefficient can be calculated using

$$C = \frac{P_{DYNAMIC} - K\varepsilon}{\dot{\varepsilon}} \qquad \text{(B-2)}$$

Using as representative point a dynamic load of 2000 lb and 0.0825 in./in. strain, the damping coefficient for the nylon webbing is calculated as

$$C = \frac{2000\ \text{lb} - (11{,}00\ \text{lb/in./in.})(.0825\ \text{in./in.})}{40.9\ \text{in./in./sec}}$$

$$= 26.7\ \frac{\text{lb - sec}}{\text{in./in.}}$$

B.3 CUSHION LOAD-DEFLECTION-CHARACTERISTICS

The seat cushion represented in Program SOM-TA accounts for the stiffness and damping properties of the cushion combined with the occupant buttocks. This modeling approach is desirable in order to avoid the numerical problems associated with springs in a series configuration. An experiment was performed to develop load deflection properties for representative cushions. The experiment consisted of applying a known static load in the downward direction to the lower torso segment of an Alderson VIP-95 dummy. This downward load, which was applied at the spine base plate, caused both the buttocks and cushion to deform. The deflections of the combined system, buttocks and cushion, and the buttocks separately were measured for each applied load.

A description of the cushions used in load-deflection tests is given in table B1. The cushions were selected to provide a spectrum of the possible cushion configurations that the user may select. Combined load-deflection curves for the VIP-95 buttocks and cushions are presented in figures B-10 through B-14. The form that the load-deflection curves take is a linear slope followed by an exponential stiffening as the cushion and occupant "bottom out." These curves can be approximated by an expression of the form:

$$F = C(e^{B\delta} - 1) \qquad \text{(B-3)}$$

Representing the load-deflection curves with a smooth function alleviates a convergence problem encountered previously with the numerical integration around the slope-change points of a piecewise, linear representation. The exponential representation of the five load-deflection curves, developed with a least-squares approximation routine, is presented as the dashed line in each figure. Also presented in this section are the separate load-deflection curves (figure B-15) for the Alderson VIP-95 dummy buttocks when tested with each of the five cushion types. This is presented for the user who may want to synthesize a combined load-deflection curve by adding the desired cushion properties determined under a rigid indenter to an average deflection curve for the dummy buttocks. The indenter should be configured like the dummy.

B.4 STRUCTURAL MATERIAL STRESS-STRAIN CURVES

Figures B-16 through B-20 present approximated stress-strain curves for three steels and two aluminum alloys. From each of these curves, six characteristics are provided as input to the finite element seat model.

Type Number	Description
1	Contoured, multilayered cushion designed to minimize occupant rebound in crash situation.
2	Contoured, rigid foam cushion designed for negligible deflection.
3	Contoured furniture foam cushion approximately 1.5 in. thick (undeformed) over buttock contact area.
4	Furniture foam slab, 1.2 lb/ft^3 density, approximately 3.0 in. thick (undeformed).
5	Furniture foam slab, 1.4 lb/ft^3 density, approximately 3.0 in. thick (undeformed).

TABLE B-1. TYPE DESIGNATION AND DESCRIPTION OF CUSHIONS FOR LOAD-DEFLECTION CURVES

B.5 REFERENCES

B.1. Kourouklis, G., Glancy, J. L., and Desjardins, S. P., The Design, Development, and Testing of an Aircraft Restraint System for Army Aircraft, Dynamic Science, Division of Ultrasystems, Inc.; USAAMRDL Technical Report 72-26, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, June 1971, AD 746631.

SPL	XL(3)	XL(4)	XL(5)	XL(8)	XL(9)		
RHO(1)	RHO(2)	RHO(3)	RHO(4)	RHO(5)	RHO(8)	RHO(9)	
SW(1)	SW(2)	SW(3)	SW(4)	SW(5)	SW(8)	SW(9)	SW(12)
CIX(1)	CIX(2)	CIX(3)	CIX(4)	CIX(5)	CIX(8)	CIX(9)	
CIY(1)	CIY(2)	CIY(3)	CIY(4)	CIY(5)	CIY(8)	CIY(9)	CIY(12)
CIZ(1)	CIZ(2)	CIZ(3)	CIZ(4)	CIZ(5)	CIZ(8)	CIZ(9)	
XR(1)	XR(2)	XR(3)	XR(4)	XR(5)	XR(8)	XR(9)	XR(12)
XR(14)	XR(16)	XR(18)	XR(20)	XR(22)			
XLH	XLS	EM(1)	EM(2)	EM(3)			
CABD	BABD	CCHE	BCHE				
CAXS	BAXS	DMPS	CAXN	BAXN	DMPN		
CROT(1)	BROT(1)	XJ(1)	CROT(2)	BROT(2)	XJ(2)		

Figure B-1. Nonstandard occupant data format.

10.85	8.35	11.3	13.3	16.5	18.0		
4.67	6.55	6.33	4.72	6.26	8.35	10.96	
34.6	36.0	10.1	4.85	4.85	21.7	9.49	1.98
2.32	2.18	0.275	0.132	0.017	0.127	0.994	
0.760	0.926	0.266	0.135	0.185	1.22	0.994	0.0177
2.32	1.70	0.233	0.022	0.195	.873	0.505	
4.50	4.50	3.44	1.95	1.85	3.10	2.30	2.30
1.60	3.56	2.61	1.85	2.34			
3.70	6.34	0.20	0.20	2.00			
2000.	.050	2000.	0.380				
6000.	.238	1.0	3240.	.270	1.0		
375.	1.49	150.	375.	1.49	30.		

Figure B-2. Data for 50th-percentile standard dummy.

11.50	8.85	11.98	14.10	17.49	19.08		
4.95	6.94	6.71	5.00	6.64	8.85	11.62	
44.6	46.4	13.0	6.26	6.26	28.0	12.2	2.55
3.36	3.16	.379	.191	.025	.184	1.44	
1.10	1.34	.386	.196	.268	1.77	1.44	.026
3.36	2.47	.338	.032	.283	1.27	.732	
4.77	4.77	3.65	2.07	1.96	3.29	2.44	2.44
1.70	3.77	2.77	1.96	2.48			
3.92	6.72	0.21	0.21	2.12			
2000.	.050	2000.	.380				
6000.	.238	1.0	3240.	.270	1.0		
375.	1.49	150.	375.	1.49	30.		

Figure B-3. Data for 95th-percentile dummy.

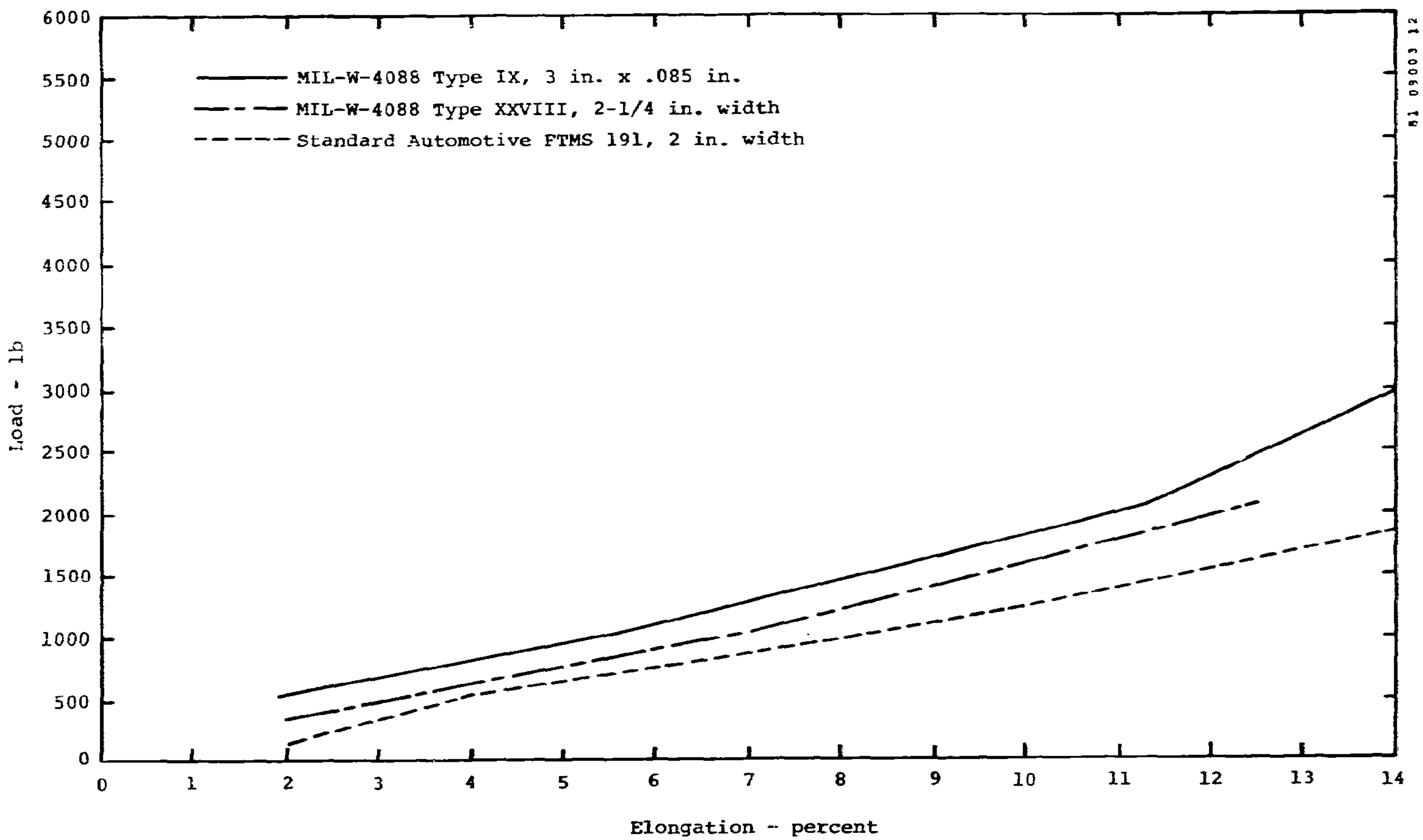


Figure B-4. Load-elongation characteristics for nylon webbing.

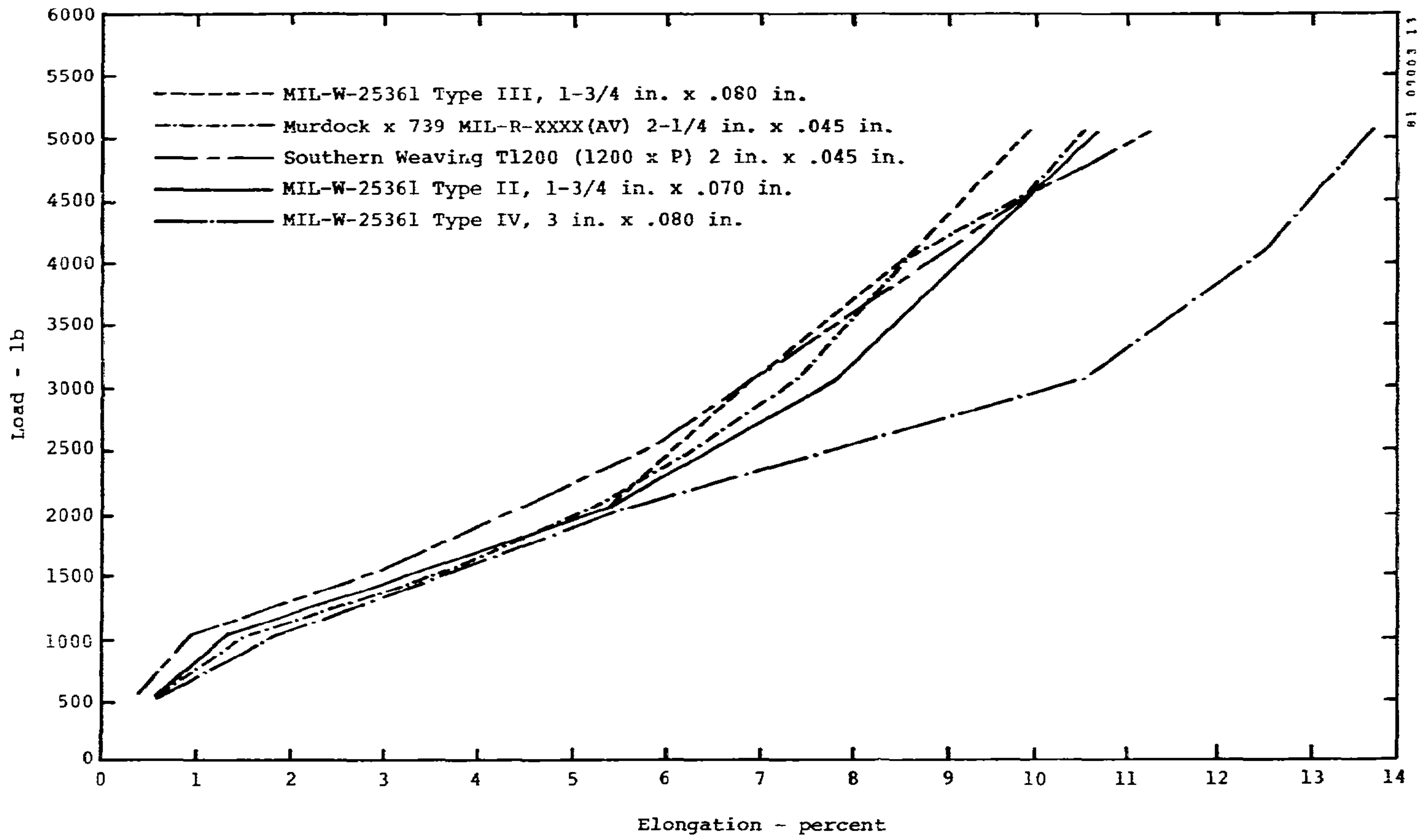


Figure B-5. Load-elongation characteristics for polyester webbing.

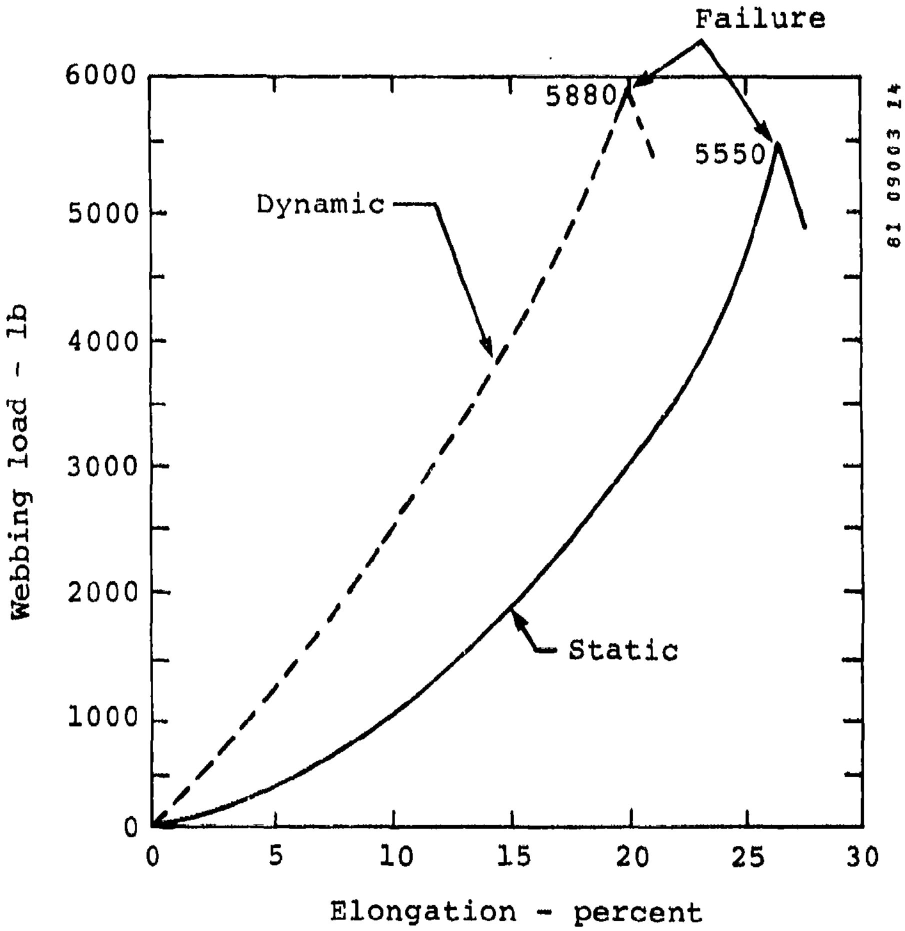


Figure B-6. Load-strain curves for MIL-W-4088 (Type VII) nylon webbing for static and rapid loading rates (from reference B-1).

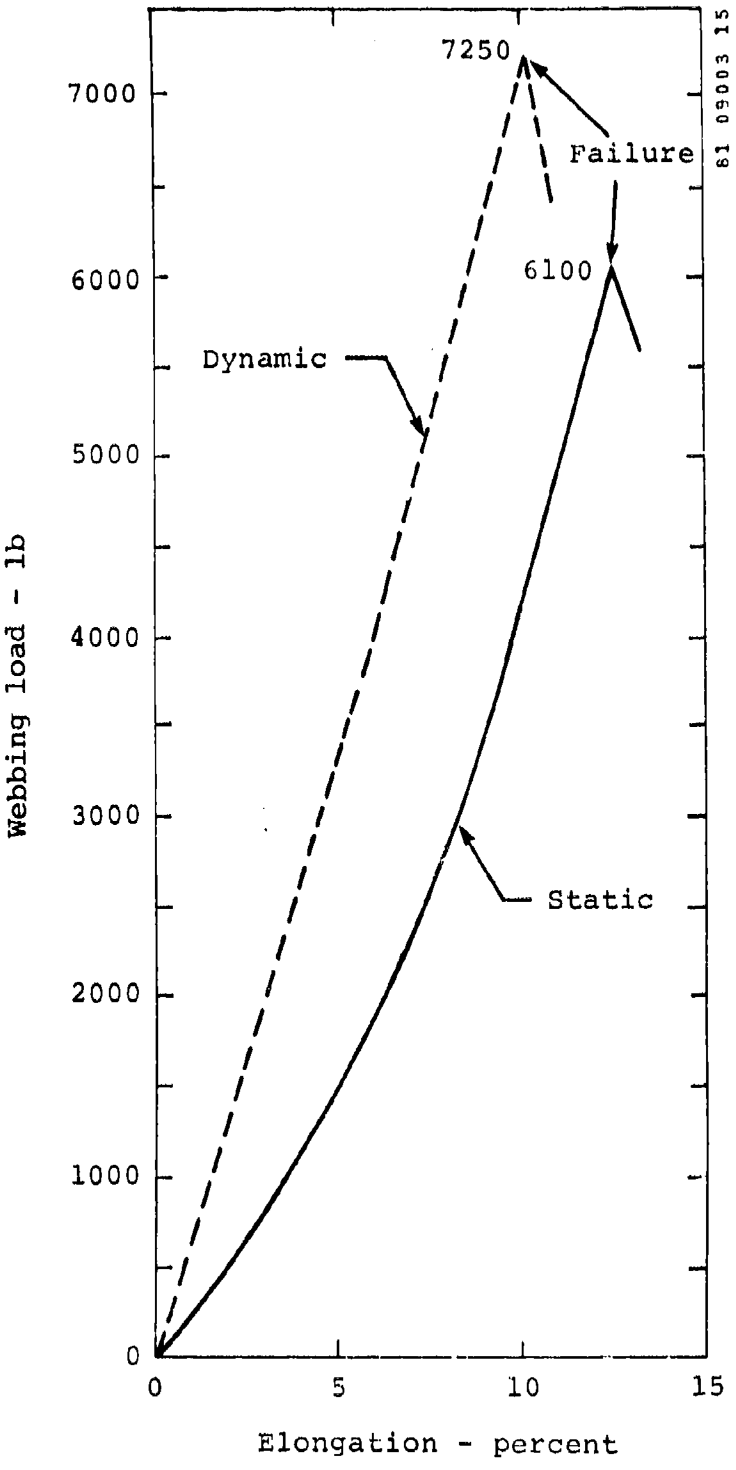


Figure B-7. Load-strain curves for MIL-W-25361 (Type II) polyester webbing for static and rapid loading rates (from reference B-1).

K (lb/in.in.)

C (lb-sec/in./in.)

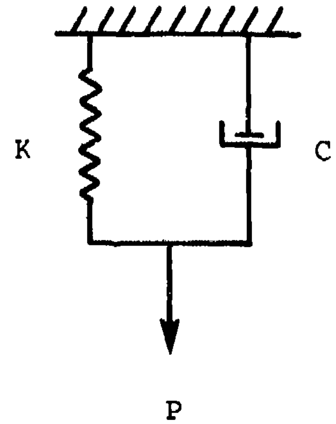


Figure B-8. Voigt-Kelvin model of restraint system webbing.

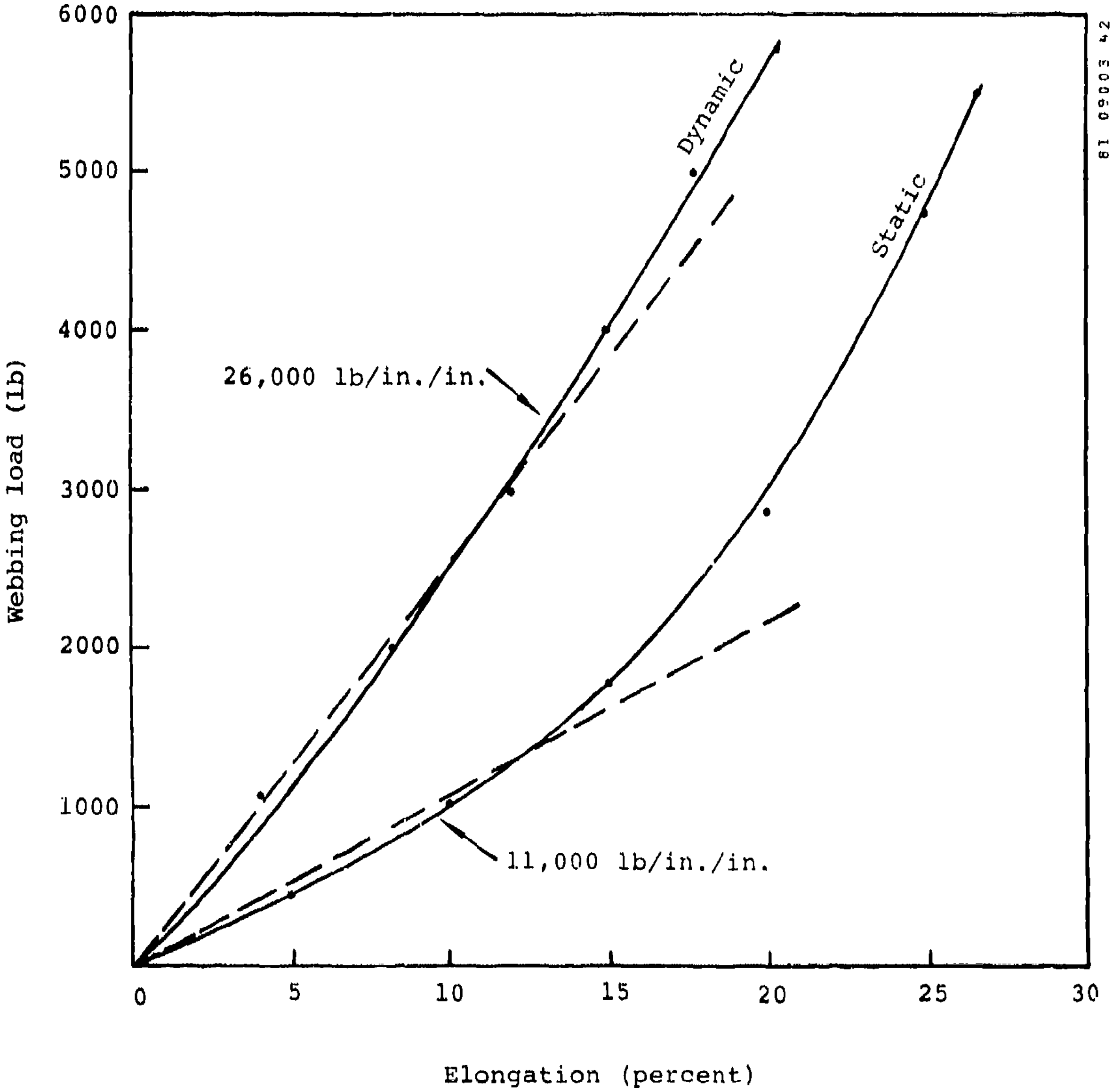


Figure B-9. Stress-strain curves for MIL-W-4088 (Type VII) nylon webbing for static and rapid loading rates with linear approximations.

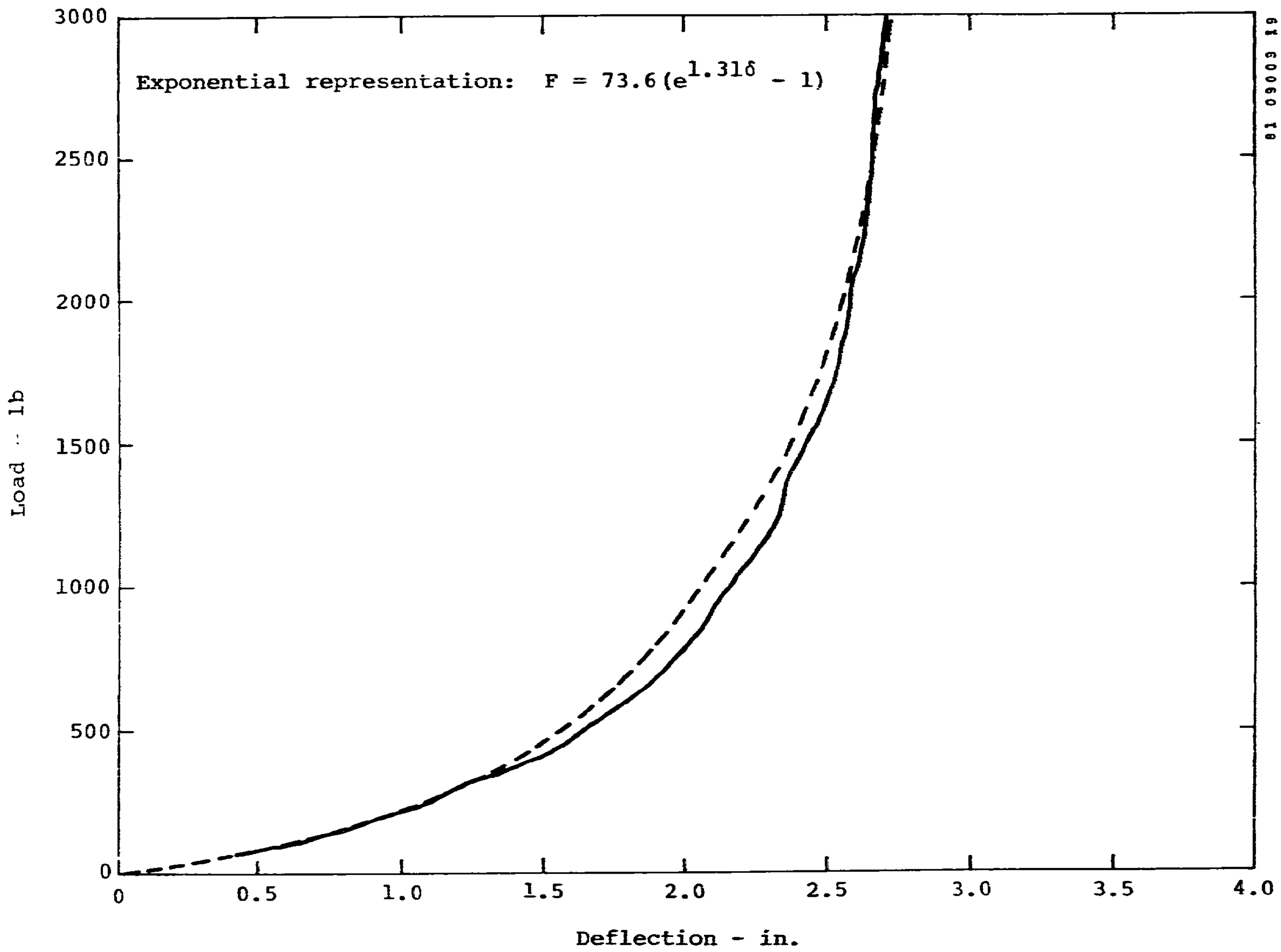


Figure B-10. Combined load-deflection curve and exponential representation for Type 1 cushion and VIP-95 dummy pelvis and buttocks.

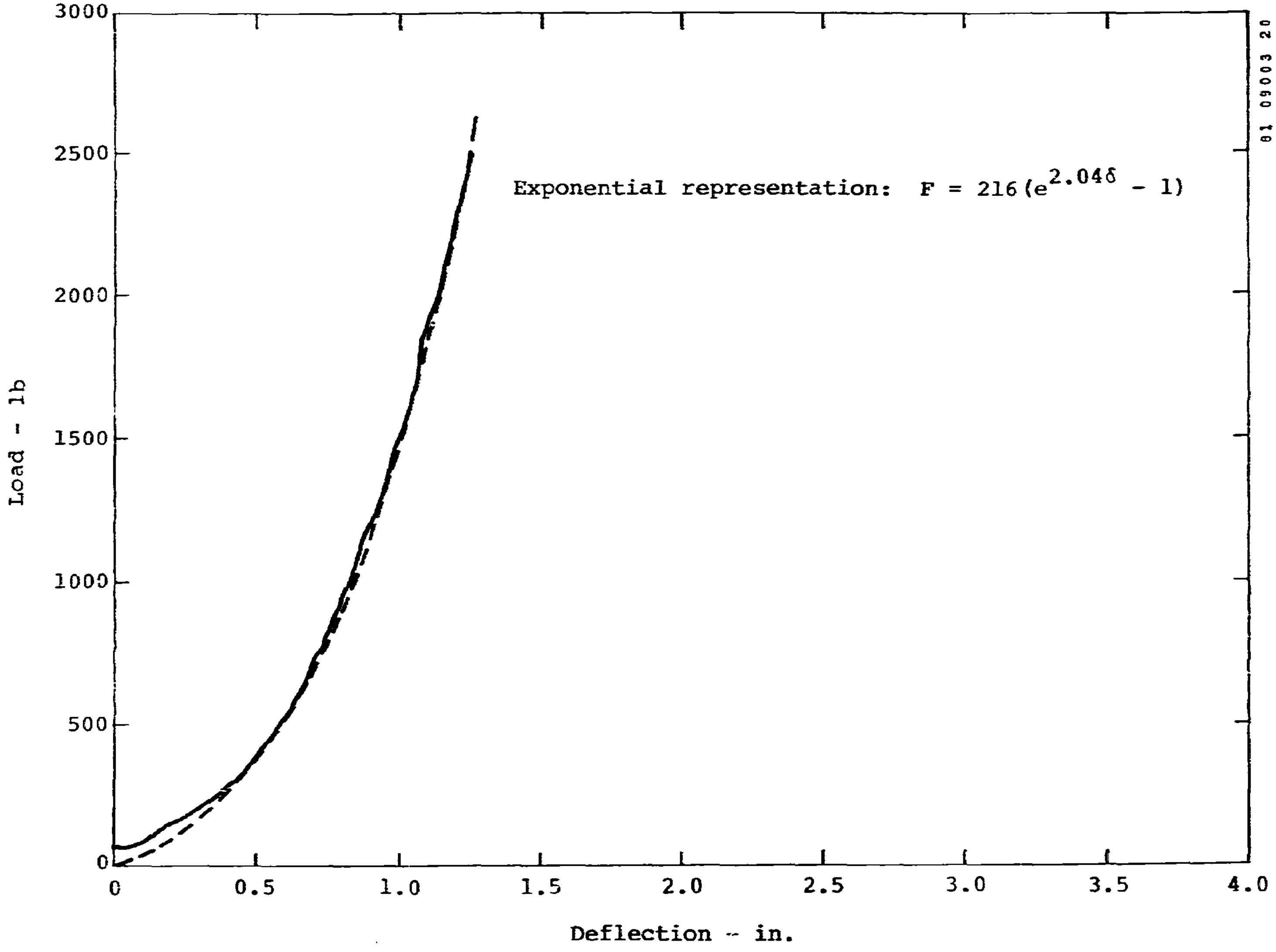


Figure B-11. Combined load-deflection curve and exponential representation for Type 2 cushion and VIP-95 dummy pelvis and buttocks.

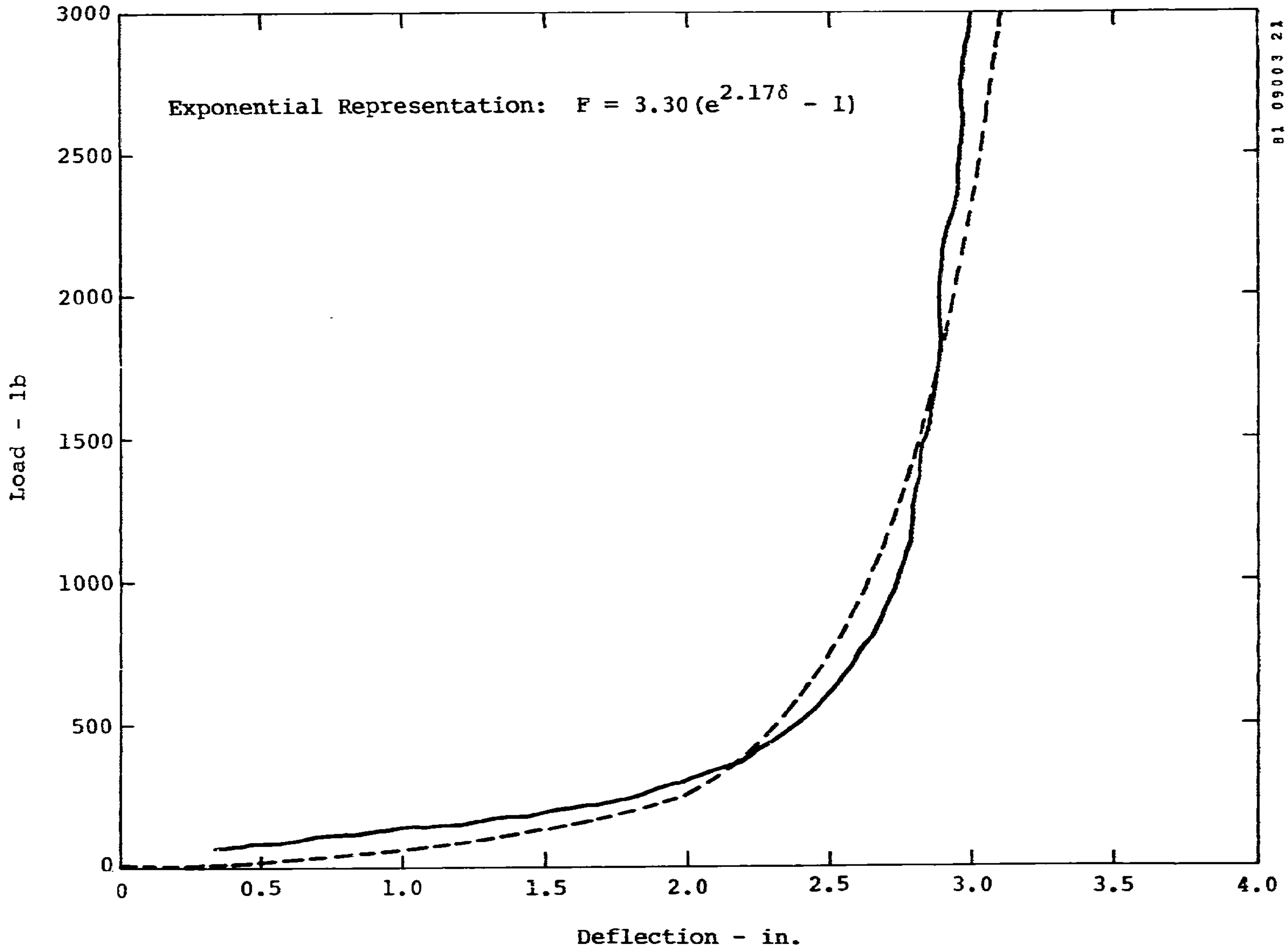


Figure B-12. Combined load-deflection curve and exponential representation for Type 3 cushion and VIP-95 dummy pelvis and buttocks.

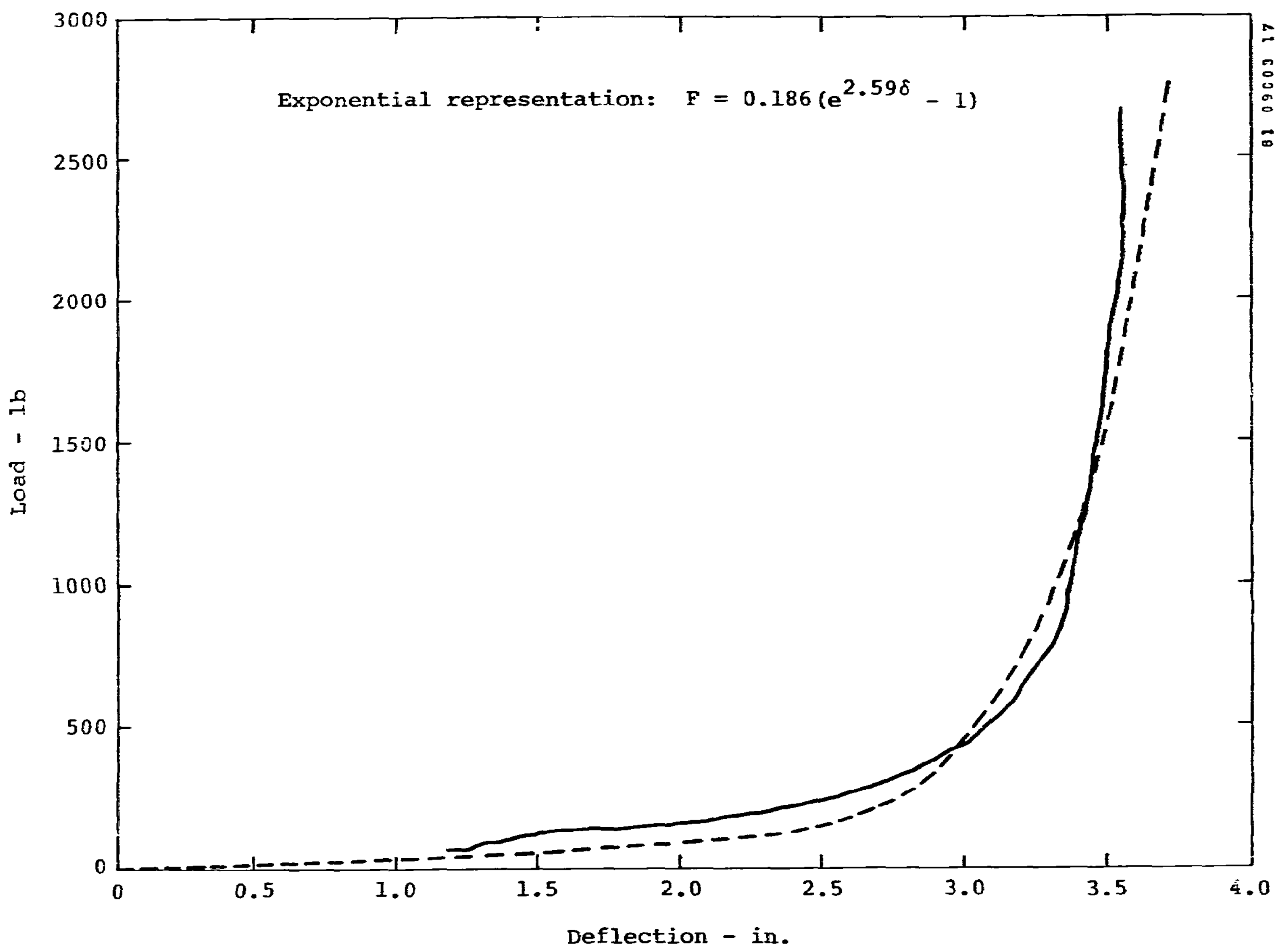


Figure B-13. Combined load-deflection curve and exponential representation for Type 4 cushion and VIP-95 dummy pelvis and buttocks.

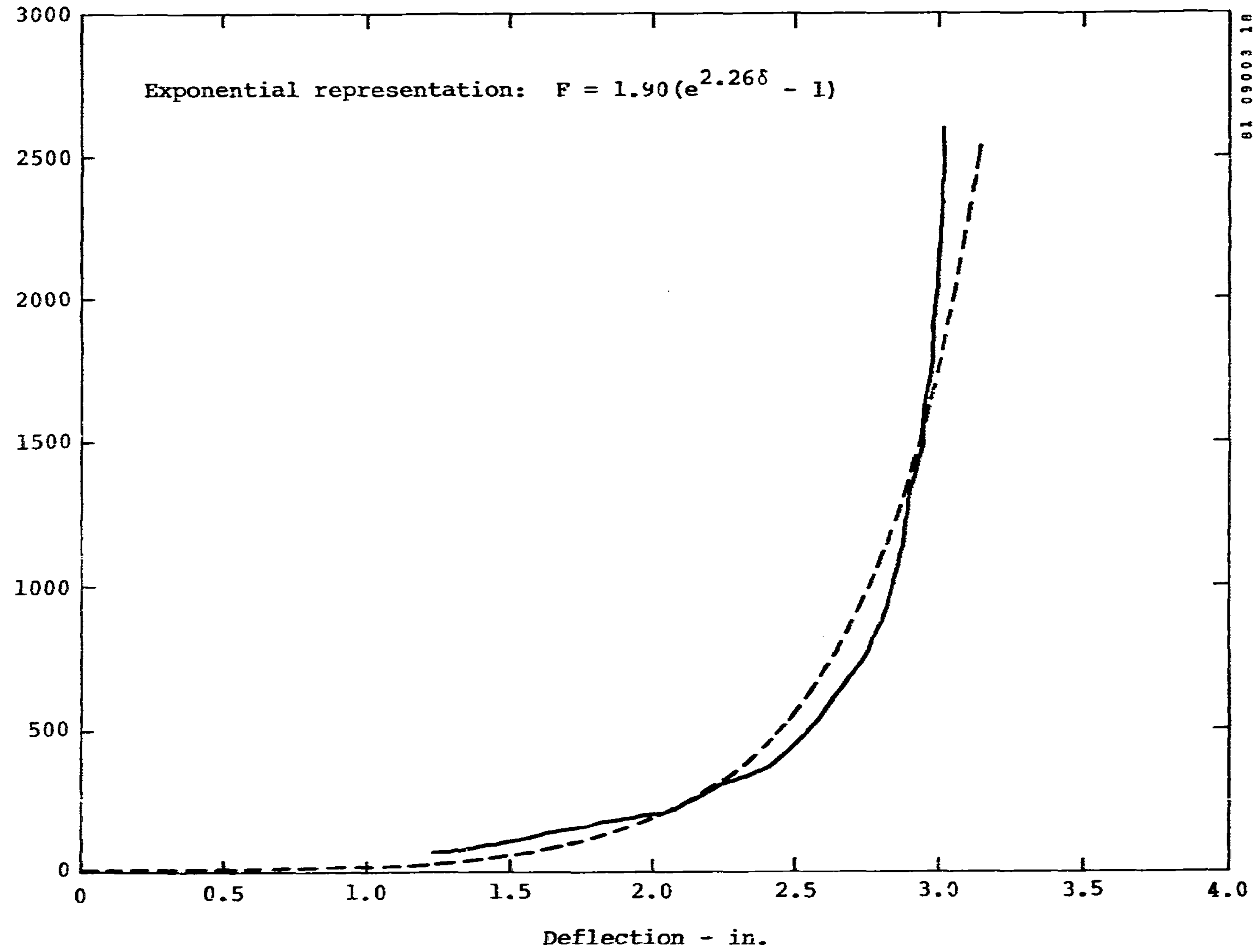


Figure B-14. Combined load-deflection curve and exponential representation for Type 5 cushion and VIP-95 dummy pelvis and buttocks.

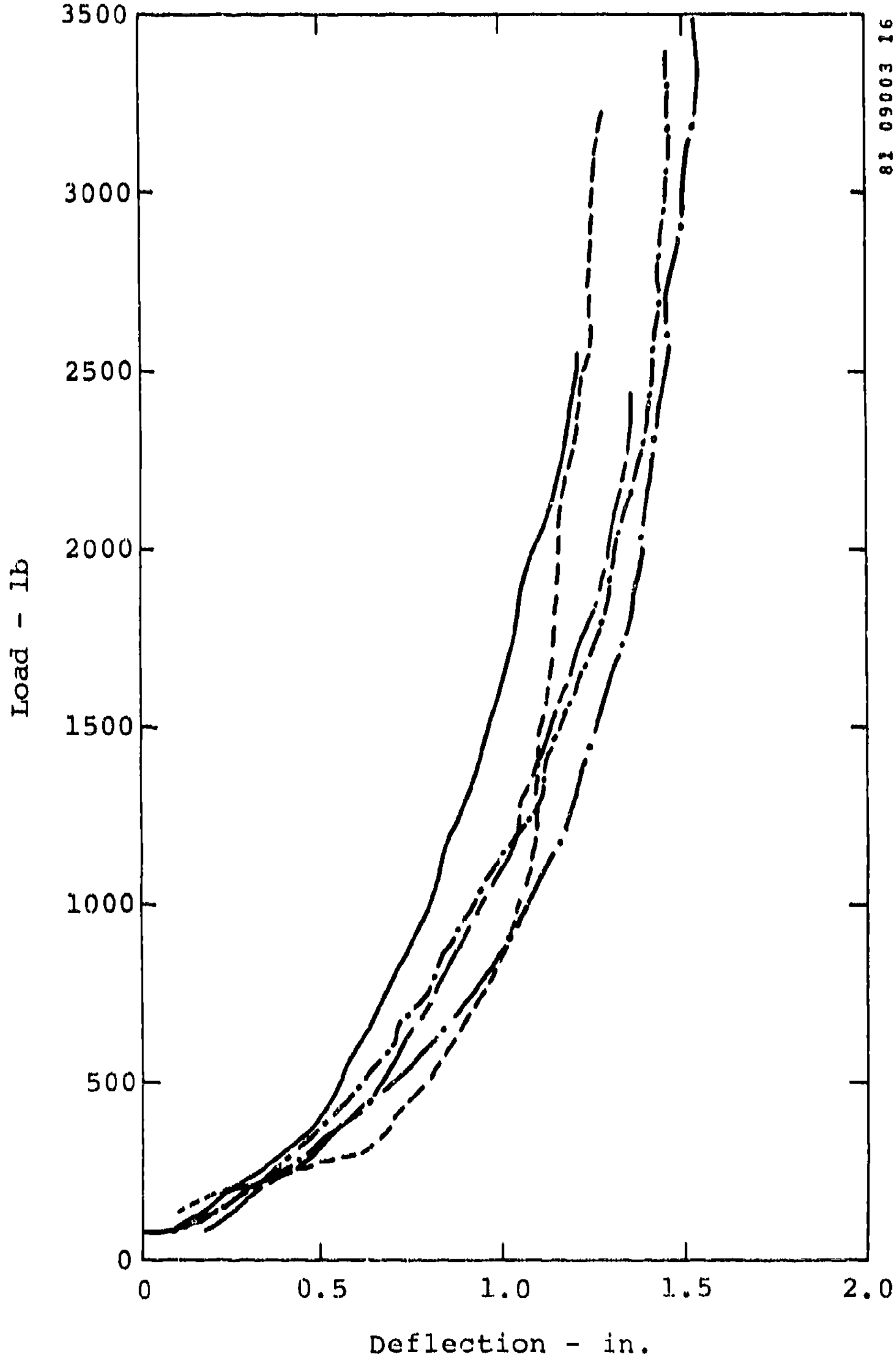


Figure B-15. Load-deflection curves for Alderson VIP-95 dummy pelvis and buttocks tested with five different cushions.

Approximate Material Properties

Modulus of elasticity, E(2) = 30 x 10^6 psi

First yield stress, E(3) = 58,700 psi

First plastic modulus, E(4) = 2.9 x 10^5 psi

Ultimate stress, E(6) = 67,000 psi

Second yield stress, E(11) = 62,500 psi

Second plastic modulus, E(12) = 75,000 psi

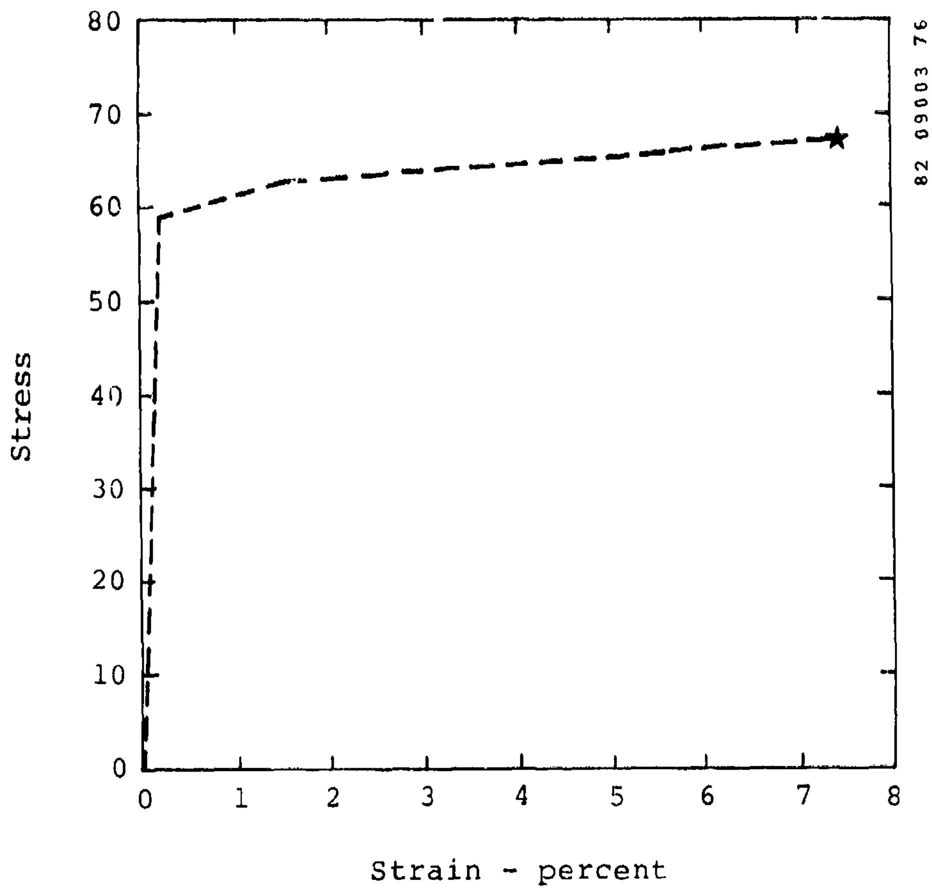
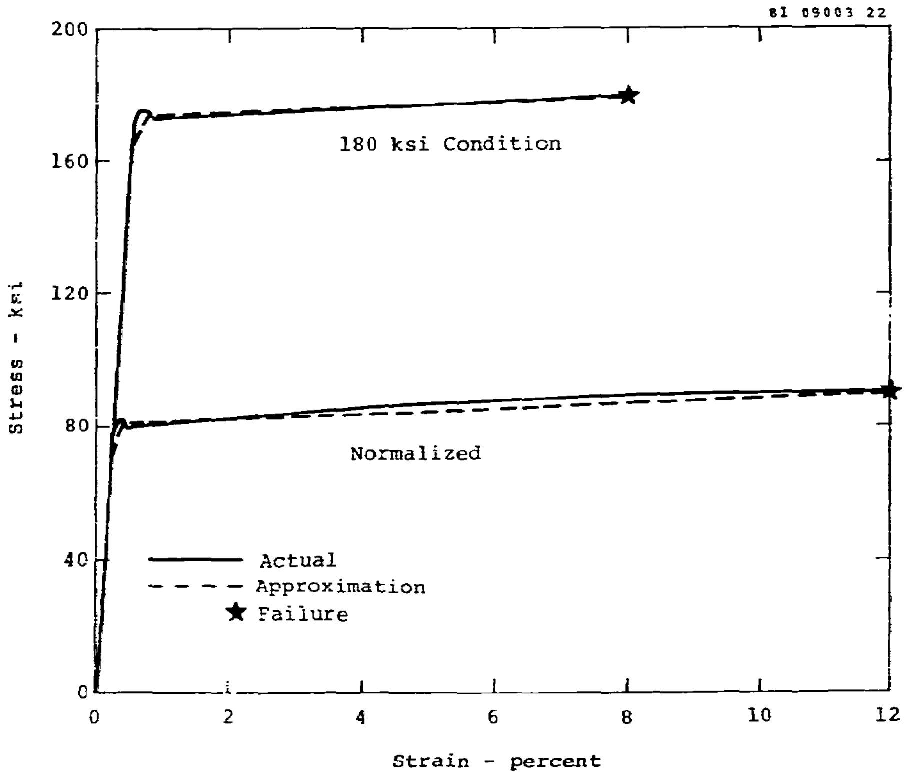


Figure B-16. Piecewise, linear approximation of stress-strain curve for 1010 cold-drawn steel.



<u>Approximated Material Properties</u>

Modulus of elasticity, E(2) = 29.0×10^6 psi

First yield stress, E(3) = 163,000 psi

First plastic modulus, E(4) = 6.0×10^6 psi

Ultimate stress, E(6) = 180,000 psi

Second yield stress, E(11) = 174,000 psi

Second Plastic modulus, E(12) = 8.1×10^4 psi

<u>Approximated Material Properties For Normalized State</u>

Modulus of Elasticity, E(2) = 29.0×10^6 psi

First yield stress, E(3) = 70,000 psi

First plastic modulus, E(4) = 7.0×10^6 psi

Ultimate stress, E(6) = 90,000 psi

Second yield stress, E(11) = 80,000 psi

Second plastic modulus, E(12) = 1.0×10^5 psi

Figure B-17. Typical tensile stress-strain curves for AISI 4130 steel heat treated to ksi and normalized state, and piecewise, linear approximation to curves.

Approximated Material Properties

Modulus of elasticity, E(2) = 29.1 X 10^6 psi

First yield stress, E(3) = 160,000 psi

First plastic modulus, E(4) = 7.8 X 10^6 psi

Ultimate stress, E(6) = 180,000 psi

Second yield stress, E(11) = 170,000 psi

Second plastic modulus, E(12) = 8.85 X 10^5 psi

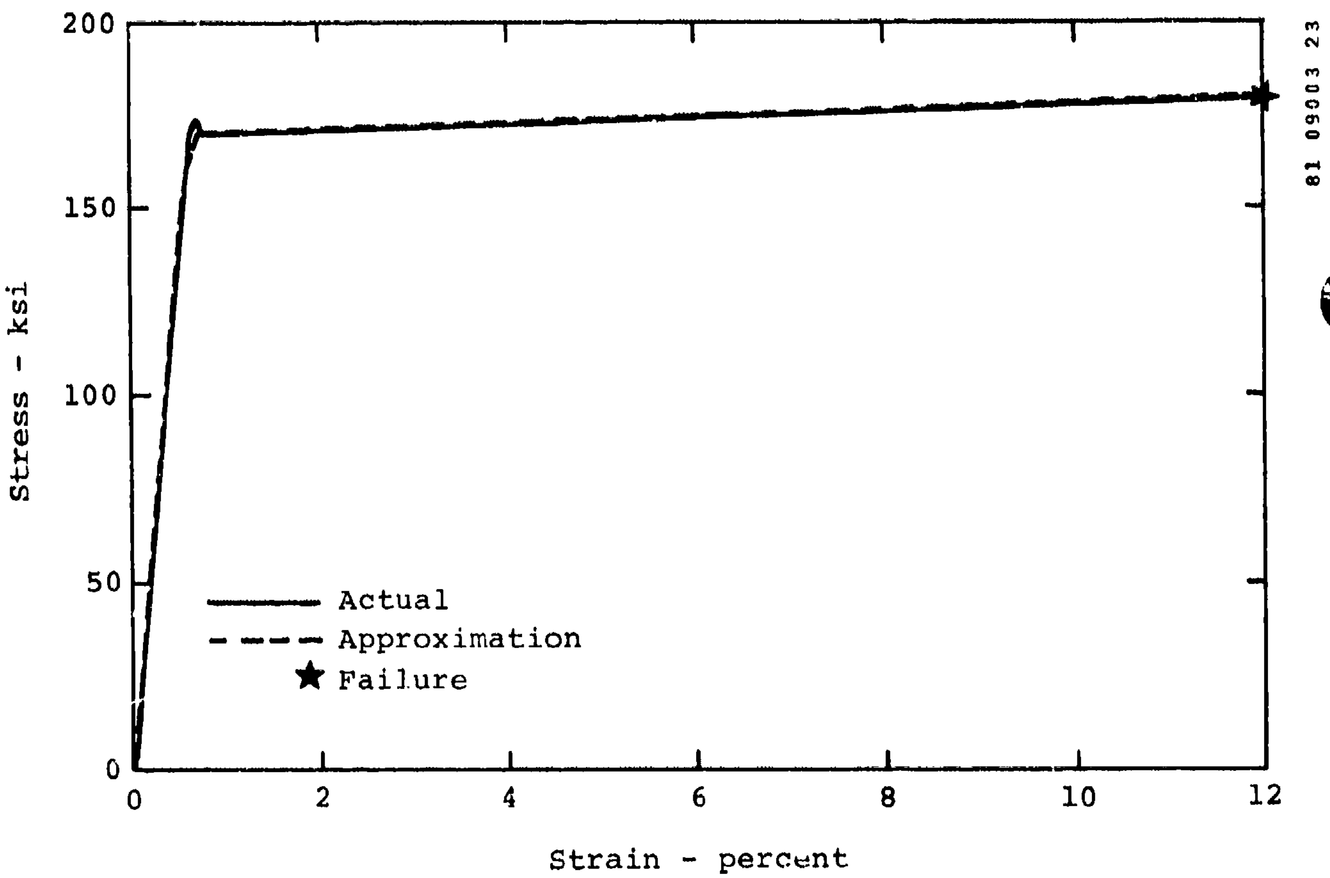


Figure B-18. Typical tensile stress-strain curve for AISI 4340 steel, heat treated to 180 ksi ultimate stress and piecewise, linear approximation to curve.

Approximated Material Properties

Modulus of elasticity, E(2) = 10.5 X 10^6 psi

First yield stress, E(3) = 44,000 psi

First plastic modulus, E(4) = 4.9 X 10^5 psi

Ultimate stress, E(6) = 62,000 psi

Second yield stress, E(11) = 58,000 psi

Second plastic modulus, E(12) = 6.2 X 10^4 psi

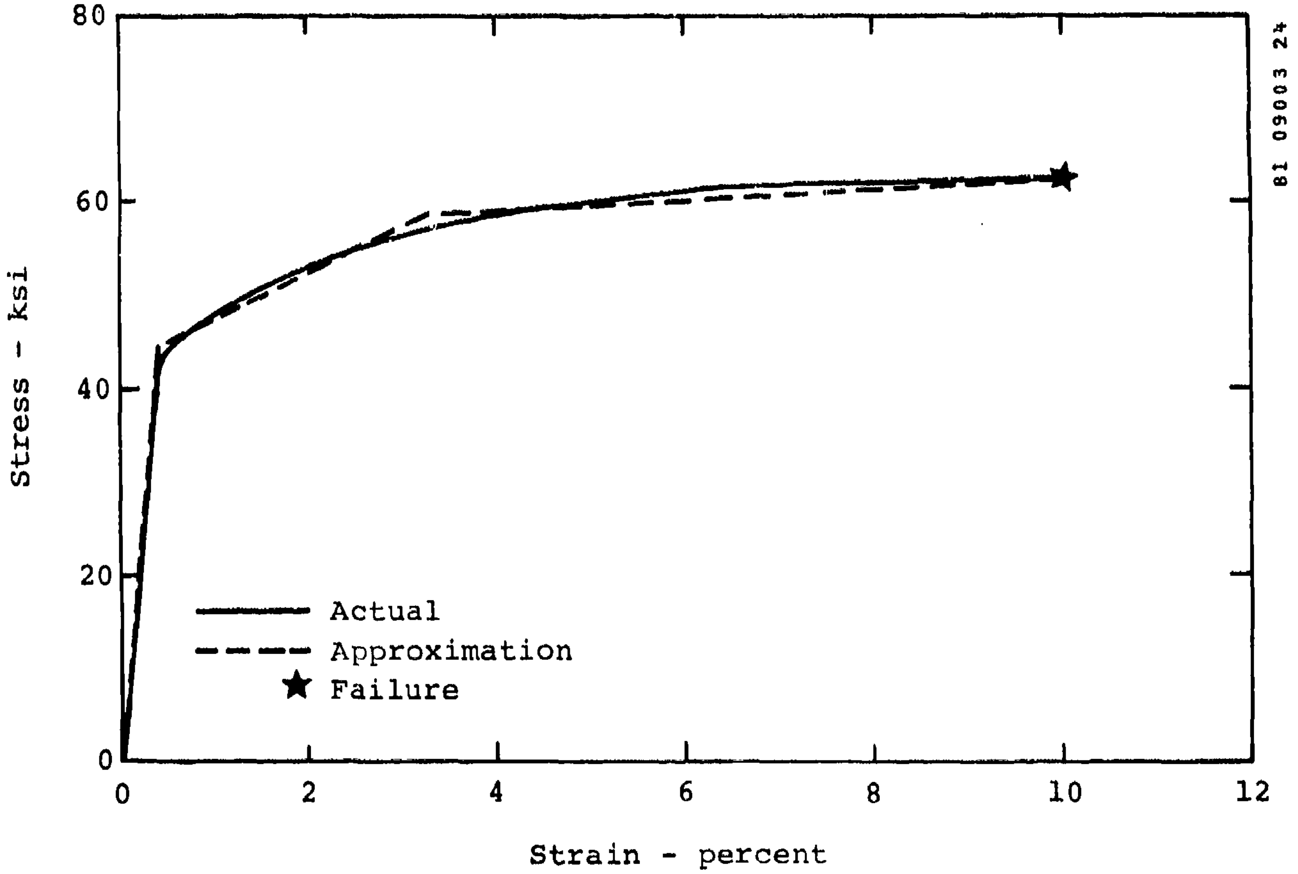


Figure B-19. Typical tensile stress-strain curve for 2024-T4 aluminum alloy and piecewise, linear approximation to curve.

Approximated Material Properties

Modulus of elasticity, E(2) = 9.9×10^6 psi

First yield stress, E(3) = 36,200 psi

First plastic modulus, E(4) = 1.1×10^5 psi

Ultimate stress, E(6) = 42,000 psi

Second yield stress, E(11) = 40,200 psi

Second plastic modulus, E(12) = 3.0×10^4 psi

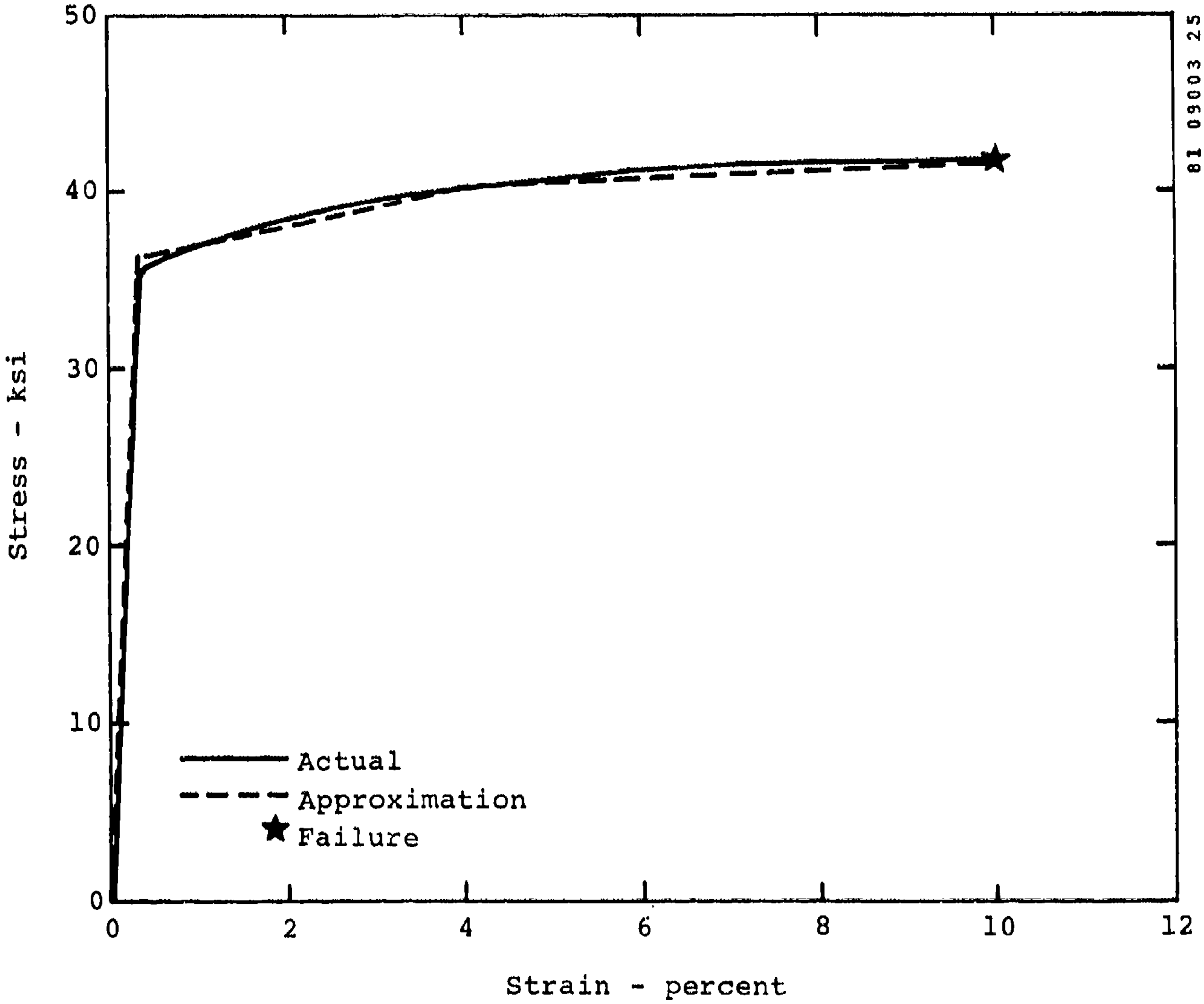


Figure B-20. Typical tensile stress-strain curve for 6061-T6 aluminum, alloy and piecewise, linear approximation to curve.

TRANSPORT AIRCRAFT SEAT

INPUT DATA

A 2-DIMENSIONAL SIMULATION OF A 3-PASSENGER SEAT WITH 3 OCCUPANTS

SIMULATION CONTROL DATA

TI=0.000000, TF =0.176000, DTI =0.000500, DMAX =0.000500, DMIN =0.000500
EUR =0.100000, ELR =0.001000

ACCELERATION FILTER CLASSES

HEAD	CHEST	PELVIS	SEAT
1000	180	180	180

FORCE-DEFLECTION CHARACTERISTICS

SEAT CUSHION		BACK CUSHION		HEAD REST	
C	B	C	B	C	B
760.000	0.500	760.000	0.500	760.000	0.500

F2	D2	F3	D3	F4	D4
LAP BELT					
550.00	0.04030	1300.00	0.10480	2250.00	0.16130

XLB(1)	YLB(1)	ZLB(1)	XLB(2)	YLB(2)	ZLB(2)
12.500	-30.000	15.000	12.500	-10.000	15.000
12.500	-10.000	15.000	12.500	10.000	15.000
12.500	10.000	15.000	12.500	30.000	15.000

	DAMPING COEFFICIENT	THICKNESS/SLACK
SEAT CUSHION	2.40000	1.50000
BACK CUSHION	2.40000	1.50000
HEAD REST	2.40000	3.00000
LAP BELT	0.00000	0.00000

CRASH CONDITIONS

X	Y	Z	PITCH	ROLL	YAW
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VX	VY	VZ	ANGVX	ANGVY	ANGVZ
30.00000	0.00000	0.00000	0.00000	0.00000	0.00000

TX	AX	TY	AY	TZ	AZ
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.01000	-6.00000	0.00000	0.00000	0.00000	0.00000
0.15500	-6.00000	0.00000	0.00000	0.00000	0.00000
0.16500	0.00000	0.00000	0.00000	0.00000	0.00000
0.17500	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

TX	ALFX	TY	ALFY	TZ	ALFZ
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

OCCUPANT PROPERTIES---PASSENGER NO. 1

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.089545	2.320000	0.760000	2.320000
2	11.560	6.550	0.093168	2.180000	0.926000	1.700000
3	8.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	13.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	13.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.873000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	3.56
17	3.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	6000.000	0.238	1.000
LUMBAR SPINE - FLEXURAL	375.000	1.490	150.000
NECK - AXIAL	3240.000	0.270	1.000
NECK - FLEXURAL	375.000	1.490	30.000

OCCUPANT PROPERTIES---PASSENGER NO. 2

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.089545	2.320000	0.760000	2.320000
2	11.560	6.550	0.093168	2.180000	0.926000	1.700000
3	8.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	13.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	13.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.873000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	3.56
17	3.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	6000.000	0.238	1.000
LUMBAR SPINE - FLEXURAL	375.000	1.490	150.000
NECK - AXIAL	3240.000	0.270	1.000
NECK - FLEXURAL	375.000	1.490	30.000

OCCUPANT PROPERTIES---PASSENGER NO. 3

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.089545	2.320000	0.760000	2.320000
2	11.560	6.550	0.093168	2.180000	0.926000	1.700000
3	8.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	13.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	13.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.873000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	3.56
17	3.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	6000.000	0.238	1.000
LUMBAR SPINE - FLEXURAL	375.000	1.490	150.000
NECK - AXIAL	3240.000	0.270	1.000
NECK - FLEXURAL	375.000	1.490	30.000

SEAT DESIGN DATA

XSEAT=	10.0000	ZSEAT=	12.0000	ANGSP=	8.0000	ANGSB=	16.0000
XL =	15.1500	XW =	20.0000	SBHT =	39.0000	SBW =	20.0000

NUMBER OF NODES	20
NUMBER OF ELEMENTS	27
NUMBER OF MATERIALS	2
NO. OF DISP. NODES	4
NO. OF COORD NODES	2
NO. OF BEAM XSECT	2
BUCKLING CONSTANT	0.50

MATERIAL DATA

MATERIAL NAME	2024-T4 AL
MATERIAL NO	1
FIRST YIELD STRESS	0.44000E+05
SECOND YIELD STRESS	0.58000E+05
ULTIMATE STRESS	0.62000E+05
MODULUS OF ELASTICITY	0.10500E+08
FIRST PLASTIC MODULUS	0.49000E+06
SECOND PLASTIC MODULUS	0.62000E+05
POISSONS RATIO (PLATES ONLY)	0.30000E+00
THICKNESS (PLATES ONLY)	0.10000E+00

MATERIAL NAME	4130 STEEL
MATERIAL NO	2
FIRST YIELD STRESS	0.16300E+06
SECOND YIELD STRESS	0.17400E+06
ULTIMATE STRESS	0.18000E+06
MODULUS OF ELASTICITY	0.29000E+08
FIRST PLASTIC MODULUS	0.60000E+07
SECOND PLASTIC MODULUS	0.81000E+05
POISSONS RATIO (PLATES ONLY)	0.30000E+00
THICKNESS (PLATES ONLY)	0.10000E+00

BEAM CROSS-SECTION DATA

N	NSEG	KLOS	AREA	FIXX	FIYY	FIZZ
1	8	0	0.43470E+00	0.30280E+00	0.15140E+00	0.15140E+00

YN	ZN	YCG	ZCG
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

I	Y	Z	T
1	0.00E+00	0.83E+00	0.83E-01
2	-0.59E+00	0.59E+00	0.83E-01
3	-0.83E+00	0.00E+00	0.83E-01
4	-0.59E+00	-0.59E+00	0.83E-01
5	0.00E+00	-0.83E+00	0.83E-01
6	0.59E+00	-0.59E+00	0.83E-01
7	0.83E+00	0.00E+00	0.83E-01
8	0.59E+00	0.59E+00	0.83E-01

N	NSEG	KLOS	AREA	FIXX	FIYY	FIZZ
2	4	0	0.30810E+00	0.10820E+00	0.72300E-01	0.72300E-01

YN	ZN	YCG	ZCG
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

I	Y	Z	T
1	-0.59E+00	0.59E+00	0.65E-01
2	-0.59E+00	-0.59E+00	0.65E-01
3	0.59E+00	-0.59E+00	0.65E-01
4	0.59E+00	0.59E+00	0.65E-01

NODE NO.	X	Y	Z
1	8.00000	-10.00000	0.00000
2	25.00000	-10.00000	0.00000
3	8.00000	10.00000	0.00000
4	25.00000	10.00000	0.00000
5	10.00000	-30.00000	12.00000
6	10.00000	-10.00000	12.00000
7	10.00000	10.00000	12.00000
8	10.00000	30.00000	12.00000
9	12.50000	-30.00000	12.33000
10	12.50000	-10.00000	12.33000
11	12.50000	10.00000	12.33000
12	12.50000	30.00000	12.33000
13	25.00000	-30.00000	14.10800
14	25.00000	-10.00000	14.10800
15	25.00000	10.00000	14.10800
16	25.00000	30.00000	14.10800
17	2.25800	-30.00000	39.00000
18	2.25800	-10.00000	39.00000
19	2.25800	10.00000	39.00000
20	2.25800	30.00000	39.00000
21	10.00000	-40.00000	12.00000
22	25.00000	-40.00000	14.00000

ELEMENT NO.	N1	N2	N3	N4	N5	N6	N7	N8	MTYP				
1	1	6	1	6	0	2	21	2	2	0	0	0	0
2	3	7	3	7	0	2	21	2	2	0	0	0	0
3	2	14	2	14	0	2	22	2	2	0	0	0	0
4	4	15	4	15	0	2	22	2	2	0	0	0	0
5	2	6	2	6	0	2	21	2	2	0	10	0	10
6	4	7	4	7	0	2	21	2	2	0	10	0	10
7	5	6	5	6	0	1	22	2	1	0	0	0	0
8	6	7	6	7	0	1	22	2	1	0	0	0	0
9	7	8	7	8	0	1	22	2	1	0	0	0	0
10	13	14	13	14	0	1	21	2	1	0	0	0	0
11	14	15	14	15	0	1	21	2	1	0	0	0	0
12	15	16	15	16	0	1	21	2	1	0	0	0	0
13	5	9	5	9	0	2	21	2	1	0	0	0	0
14	6	10	6	10	0	2	21	2	1	0	0	0	0
15	7	11	7	11	0	2	21	2	1	0	0	0	0
16	8	12	8	12	0	2	21	2	1	0	0	0	0
17	9	13	9	13	0	2	21	2	1	0	0	0	0
18	10	14	10	14	0	2	21	2	1	0	0	0	0
19	11	15	11	15	0	2	21	2	1	0	0	0	0
20	12	16	12	16	0	2	21	2	1	0	0	0	0
21	5	17	5	17	0	2	21	2	1	0	0	0	0
22	6	18	6	18	0	2	21	2	1	0	0	0	0
23	7	19	7	19	0	2	21	2	1	0	0	0	0
24	8	20	8	20	0	2	21	2	1	0	0	0	0
25	17	18	17	18	0	2	21	2	1	0	0	0	0
26	18	19	18	19	0	2	21	2	1	0	0	0	0
27	19	20	19	20	0	2	21	2	1	0	0	0	0

SEAT PAN NODES = 5 6 13 14 6 7 14 15 7 8 15 16

SEAT BACK NODES = 5 6 17 18 6 7 18 19 7 8 19 20

LAP BELT ANCHOR NODES = 9 10 10 11 11 12

DISPLACEMENT NODES

	NODE	CONDITION
1	1	1 1 1 0 0 1
2	2	1 1 2 0 0 1
		-0.5000
3	3	1 1 1 0 0 1
4	4	1 1 1 0 0 1

STRESS AND BAR STORAGE LSTRS 1056 LBAR 648

MUD 77 SIZE OF STIFF 6357

INITIAL CONDITIONS---PASSENGER NO. 1

SEGMENT	ANGLE
1	-14.776
2	-14.776
3	0.224
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-5.424
9	-1.959
10	-5.424
11	-1.959

GENERALIZED COORDINATES---PASSENGER NO. 1

J	Q(J)	QD(J)	QDD(J)
1	0.13768D+02	0.36000D+03	0.00000D+00
2	0.22545D+02	0.00000D+00	0.00000D+00
3	-0.25789D+00	0.00000D+00	0.00000D+00
4	0.10850D+02	0.00000D+00	0.00000D+00
5	-0.25789D+00	0.00000D+00	0.00000D+00
6	0.63300D+01	0.00000D+00	0.00000D+00
7	0.14353D+00	0.00000D+00	0.00000D+00
8	-0.27925D+00	0.00000D+00	0.00000D+00
9	0.24435D+00	0.00000D+00	0.00000D+00
10	-0.94670D-01	0.00000D+00	0.00000D+00
11	-0.34186D-01	0.00000D+00	0.00000D+00

INITIAL CONDITIONS---PASSENGER NO. 2

SEGMENT	ANGLE
1	-15.155
2	-15.155
3	7.845
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-4.624
9	-2.893
10	-4.624
11	-2.893

GENERALIZED COORDINATES---PASSENGER NO. 2

J	Q(J)	QD(J)	QDD(J)
12	0.13424D+02	0.36000D+03	0.00000D+00
13	0.22754D+02	0.00000D+00	0.00000D+00
14	-0.26451D+00	0.00000D+00	0.00000D+00
15	0.10850D+02	0.00000D+00	0.00000D+00
16	-0.26451D+00	0.00000D+00	0.00000D+00
17	0.63300D+01	0.00000D+00	0.00000D+00
18	0.13692D+00	0.00000D+00	0.00000D+00
19	-0.27925D+00	0.00000D+00	0.00000D+00
20	0.24435D+00	0.00000D+00	0.00000D+00
21	-0.80703D-01	0.00000D+00	0.00000D+00
22	-0.50488D-01	0.00000D+00	0.00000D+00

INITIAL CONDITIONS---PASSENGER NO. 3

SEGMENT	ANGLE
1	-15.535
2	-15.535
3	7.465
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-3.811
9	-3.839
10	-3.811
11	-3.839

GENERALIZED COORDINATES---PASSENGER NO. 3

J	Q(J)	QD(J)	QDD(J)
23	0.13081D+02	0.36000D+03	0.00000D+00
24	0.22962D+02	0.00000D+00	0.00000D+00
25	-0.27113D+00	0.00000D+00	0.00000D+00
26	0.10850D+02	0.00000D+00	0.00000D+00
27	-0.27113D+00	0.00000D+00	0.00000D+00
28	0.63300D+01	0.00000D+00	0.00000D+00
29	0.13030D+00	0.00000D+00	0.00000D+00
30	-0.27925D+00	0.00000D+00	0.00000D+00
31	0.24435D+00	0.00000D+00	0.00000D+00
32	-0.66513D-01	0.00000D+00	0.00000D+00
33	-0.67001D-01	0.00000D+00	0.00000D+00

NODAL DISPLACEMENT VECTOR (TIME = 0.025 SEC)

NODE	TRANSLATION X	Y	Z
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	-0.5000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.5627	-0.1811	-0.2722
6	0.3510	-0.1808	-0.0595
7	0.0047	-0.1806	0.0000
8	-0.1011	-0.1806	0.2309
9	0.5768	-0.1683	-0.3483
10	0.3620	-0.1673	-0.1270
11	0.0060	-0.1688	-0.0040
12	-0.1013	-0.1730	0.2323
13	0.6355	-0.1339	-0.7619
14	0.4125	-0.1343	-0.4992
15	0.0070	-0.1348	-0.0009
16	-0.1037	-0.1344	0.2440
17	1.2491	-0.5239	-0.0755
18	0.8138	-0.5219	0.0724
19	0.3552	-0.5202	0.1012
20	-0.0232	-0.5193	0.2526

SUPPORT STRUCTURE REACTIONS (TIME = 0.025 SEC)

NODE	FX	FY	FZ	MX	MY	MZ
1	6.	-251.	-773.	0.	0.	845.
2	-360.	255.	830.	0.	0.	2164.
3	126.	-256.	1461.	0.	0.	713.
4	957.	248.	-1409.	0.	0.	1992.

BEAM ELEMENT LOADS (TIME = 0.025 SEC)

BEAM	NODE	FX	FY	FZ	MX	MY	MZ	STATUS
1	1	761.	-252.	-133.	-833.	6.	139.	0
	6	-761.	252.	133.	833.	1616.	-3200.	0
2	3	-1467.	-230.	104.	-704.	13.	111.	0
	7	1467.	230.	-104.	704.	-1276.	-2914.	0
3	2	-509.	262.	-42.	-1136.	0.	525.	0
	14	509.	-262.	42.	1136.	594.	3178.	0
4	4	609.	263.	56.	-917.	-1.	624.	0
	15	-609.	-263.	-56.	917.	-790.	3094.	0
5	2	-515.	-8.	0.	-232.	0.	-1131.	0
	6	515.	8.	0.	232.	0.	985.	0
6	4	1288.	-32.	0.	-177.	0.	-1238.	0
	7	-1288.	32.	0.	177.	0.	626.	0
7	5	-68.	59.	11.	211.	-82.	696.	0
	6	68.	-59.	-11.	-211.	-128.	487.	0
8	6	-78.	381.	-266.	1427.	2652.	3710.	0
	7	78.	-381.	266.	-1427.	2668.	3909.	0
9	7	13.	-51.	15.	181.	-170.	-792.	0
	8	-13.	51.	-15.	-181.	-128.	-224.	0
10	13	118.	-42.	31.	301.	35.	-809.	0
	14	-118.	42.	-31.	-301.	-663.	-34.	0
11	14	117.	-290.	-422.	1567.	4177.	-2729.	0
	15	-117.	290.	422.	-1567.	4267.	-3074.	0
12	15	22.	64.	47.	151.	-901.	1081.	0
	16	-22.	-64.	-47.	-151.	-36.	201.	0
13	5	-66.	-72.	12.	83.	456.	-862.	0
	9	66.	72.	-12.	-83.	-487.	679.	0
14	6	111.	-265.	94.	-82.	432.	-1851.	0
	10	-111.	265.	-94.	82.	-668.	1185.	0
15	7	-750.	-151.	206.	-109.	-928.	-1270.	0
	11	750.	151.	-206.	109.	410.	888.	0
16	8	-39.	-19.	99.	27.	-323.	45.	0
	12	39.	19.	-99.	-27.	75.	-94.	0

17	9	37.	-118.	-63.	-37.	494.	-678.	0
	13	-37.	118.	63.	37.	298.	-810.	0
18	10	355.	-258.	-108.	-191.	674.	-1169.	0
	14	-355.	258.	108.	191.	686.	-2084.	0
19	11	-493.	-188.	82.	-166.	-421.	-874.	0
	15	493.	188.	-82.	166.	-618.	-1496.	0
20	12	59.	24.	18.	29.	-73.	94.	0
	16	-59.	-24.	-18.	-29.	-149.	204.	0
21	5	-28.	10.	3.	-179.	-252.	122.	0
	17	28.	-10.	-3.	179.	165.	159.	0
22	6	84.	-8.	37.	-217.	-829.	-45.	0
	18	-84.	8.	-37.	217.	-199.	-168.	0
23	7	-78.	-10.	-42.	-215.	944.	-67.	0
	19	78.	10.	42.	215.	235.	-201.	0
24	8	23.	7.	2.	-190.	142.	72.	0
	20	-23.	-7.	-2.	190.	-210.	115.	0
25	17	-10.	28.	-3.	163.	179.	162.	0
	18	10.	-28.	3.	-163.	-116.	399.	0
26	18	-3.	-56.	-39.	-32.	335.	-569.	0
	19	3.	56.	39.	32.	453.	-544.	0
27	19	7.	23.	2.	209.	-239.	343.	0
	20	-7.	-23.	-2.	-209.	192.	113.	0

STRESSES IN BEAM ELEMENTS (TIME = 0.025 SEC)

BEAM NO	NODE NO	S-MAX	S-MIN
1	1	0.000000E+00	-0.360796E+04
	6	0.370335E+05	-0.419695E+05
2	3	0.577302E+04	0.000000E+00
	7	0.391287E+05	-0.296106E+05
3	2	0.596260E+04	-0.266260E+04
	14	0.325881E+05	-0.292881E+05
4	4	0.314845E+04	-0.709571E+04
	15	0.298855E+05	-0.338328E+05
5	2	0.109445E+05	-0.760617E+04
	6	0.974985E+04	-0.641157E+04
6	4	0.598021E+04	-0.143319E+05
	7	0.963392E+03	-0.931507E+04
7	5	0.452304E+04	-0.420389E+04
	6	0.321116E+04	-0.289201E+04
8	6	0.283841E+05	-0.280171E+05
	7	0.293343E+05	-0.289674E+05
9	7	0.493249E+04	-0.499363E+04
	8	0.152655E+04	-0.158769E+04
10	13	0.478995E+04	-0.534453E+04
	14	0.387869E+04	-0.443327E+04
11	14	0.303349E+05	-0.308862E+05
	15	0.322648E+05	-0.328161E+05
12	15	0.873518E+04	-0.883726E+04
	16	0.120927E+04	-0.131135E+04
13	5	0.110258E+05	-0.105983E+05
	9	0.977400E+04	-0.934658E+04
14	6	0.183819E+05	-0.190998E+05
	10	0.148362E+05	-0.155542E+05
15	7	0.204598E+05	-0.155930E+05
	11	0.130790E+05	-0.821230E+04
16	8	0.314962E+04	-0.289962E+04
	12	0.150674E+04	-0.125674E+04

17	9	0.949012E+04	-0.972963E+04
	13	0.896875E+04	-0.920827E+04
18	10	0.139621E+05	-0.162618E+05
	14	0.215751E+05	-0.238748E+05
19	11	0.122208E+05	-0.902554E+04
	15	0.189397E+05	-0.157445E+05
20	12	0.118228E+04	-0.156341E+04
	16	0.270240E+04	-0.308353E+04
21	5	0.316367E+04	-0.298168E+04
	17	0.275315E+04	-0.257116E+04
22	6	0.689369E+04	-0.743541E+04
	18	0.273846E+04	-0.328019E+04
23	7	0.854127E+04	-0.803299E+04
	19	0.383197E+04	-0.332369E+04
24	8	0.167998E+04	-0.182811E+04
	20	0.259045E+04	-0.273857E+04
25	17	0.282889E+04	-0.276410E+04
	18	0.425910E+04	-0.419431E+04
26	18	0.742523E+04	-0.740356E+04
	19	0.818936E+04	-0.816770E+04
27	19	0.475820E+04	-0.480249E+04
	20	0.247918E+04	-0.252348E+04

NODAL DISPLACEMENT VECTOR (TIME = 0.175 SEC)

NODE	TRANSLATION X	Y	Z
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	-0.5000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.7935	-0.1744	-0.1285
6	0.3573	-0.1733	-0.0576
7	0.0112	-0.1714	0.0020
8	0.1576	-0.1677	0.3191
9	0.8218	-0.1477	-0.2399
10	0.3696	-0.1554	-0.1237
11	0.0134	-0.1642	-0.0008
12	0.1626	-0.1763	0.2848
13	0.9195	-0.1276	-0.9336
14	0.4222	-0.1296	-0.5005
15	0.0166	-0.1321	-0.0023
16	0.1937	-0.1346	0.0204
17	1.6444	-0.4828	0.1133
18	1.0292	-0.4807	0.1347
19	0.5674	-0.4792	0.1620
20	0.3823	-0.4794	0.3808

SUPPORT STRUCTURE REACTIONS (TIME = 0.175 SEC)

NODE	FX	FY	FZ	MX	MY	MZ
1	352.	-333.	1408.	0.	0.	1131.
2	946.	361.	-1113.	0.	0.	2762.
3	433.	-211.	3497.	0.	0.	381.
4	2361.	161.	-3448.	0.	0.	1278.

BEAM ELEMENT LOADS (TIME = 0.175 SEC)

BEAM	NODE	FX	FY	FZ	MX	MY	MZ	STATUS
1	1	-1446.	-333.	-116.	-1116.	0.	186.	0
	6	1446.	333.	116.	1116.	1409.	-4234.	0
2	3	-3525.	-147.	116.	-377.	7.	59.	0
	7	3525.	147.	-116.	377.	-1421.	-1847.	0
3	2	345.	340.	14.	-1649.	0.	413.	0
	14	-345.	-340.	-14.	1649.	-198.	4386.	0
4	4	1499.	173.	108.	-379.	-6.	643.	0
	15	-1499.	-173.	-108.	379.	-1517.	1803.	0
5	2	1229.	21.	0.	-373.	0.	-1127.	0
	6	-1229.	-21.	0.	373.	0.	1527.	0
6	4	3135.	-56.	0.	-55.	0.	-1110.	0
	7	-3135.	56.	0.	55.	0.	43.	0
7	5	-250.	304.	-98.	956.	822.	2781.	0
	6	250.	-304.	98.	-956.	1130.	3306.	0
8	6	-443.	386.	-236.	1432.	2218.	3243.	0
	7	443.	-386.	236.	-1432.	2510.	4476.	0
9	7	-152.	-311.	86.	-504.	-969.	-3820.	0
	8	152.	311.	-86.	504.	-760.	-2398.	0
10	13	449.	-292.	-79.	1390.	533.	-3194.	0
	14	-449.	292.	79.	-1390.	1055.	-2654.	0
11	14	557.	-296.	-435.	1577.	3796.	-1986.	0
	15	-557.	296.	435.	-1577.	4899.	-3926.	0
12	15	348.	315.	180.	-921.	-3062.	3710.	0
	16	-348.	-315.	-180.	921.	-538.	2588.	0
13	5	-359.	-225.	25.	91.	1819.	-3116.	0
	9	359.	225.	-25.	-91.	-1882.	2548.	0
14	6	-1536.	-454.	588.	-195.	-734.	-3191.	0
	10	1536.	454.	-588.	195.	-749.	2047.	0
15	7	-2381.	123.	687.	-64.	-2082.	168.	0
	11	2381.	-123.	-687.	64.	348.	142.	0
16	8	-333.	139.	182.	532.	956.	2270.	0
	12	333.	-139.	-182.	-532.	-1413.	-1920.	0

17	9	315.	-450.	-259.	-552.	1895.	-2479.	0
	13	-315.	450.	259.	552.	1375.	-3197.	0
18	10	13.	-447.	-88.	-338.	744.	-2031.	0
	14	-13.	447.	88.	338.	364.	-3612.	0
19	11	-883.	-15.	104.	-53.	-355.	-130.	0
	15	883.	15.	-104.	53.	-958.	-57.	0
20	12	300.	355.	-189.	515.	1443.	1902.	0
	16	-300.	-355.	189.	-515.	946.	2584.	0
21	5	2.	-9.	30.	-221.	-878.	-144.	0
	17	-2.	9.	-30.	221.	31.	-103.	0
22	6	36.	-11.	10.	-254.	-206.	-75.	0
	18	-36.	11.	-10.	254.	-66.	-236.	0
23	7	-73.	4.	-69.	-181.	1560.	102.	0
	19	73.	-4.	69.	181.	369.	0.	0
24	8	35.	17.	29.	-158.	-457.	215.	0
	20	-35.	-17.	-29.	158.	-344.	255.	0
25	17	9.	-1.	-30.	32.	222.	-101.	0
	18	-9.	1.	30.	-32.	379.	72.	0
26	18	20.	-38.	-40.	-31.	-125.	-309.	0
	19	-20.	38.	40.	31.	917.	-448.	0
27	19	16.	35.	29.	347.	-737.	451.	0
	20	-16.	-35.	-29.	-347.	158.	251.	0

S T R E S S E S I N B E A M E L E M E N T S (TIME = 0.175 SEC)

BEAM NO	NODE NO	S-MAX	S-MIN
1	1	0.621813E+04	0.000000E+00
	6	0.509831E+05	-0.416013E+05
2	3	0.119765E+05	0.000000E+00
	7	0.382400E+05	-0.153753E+05
3	2	0.227231E+04	-0.450744E+04
	14	0.364870E+05	-0.307221E+05
4	4	0.465845E+03	-0.101906E+05
	15	0.223737E+05	-0.320984E+05
5	2	0.526003E+04	-0.132332E+05
	6	0.853884E+04	-0.165120E+05
6	4	0.000000E+00	-0.192736E+05
	7	0.000000E+00	-0.105205E+05
7	5	0.180131E+05	-0.168318E+05
	6	0.213072E+05	-0.201259E+05
8	6	0.252494E+05	-0.231588E+05
	7	0.320099E+05	-0.299192E+05
9	7	0.242912E+05	-0.235762E+05
	8	0.153826E+05	-0.146676E+05
10	13	0.189547E+05	-0.210728E+05
	14	0.155722E+05	[illegible]902E+05
11	14	0.243147E+05	-0.269407E+05
	15	0.378031E+05	-0.404293E+05
12	15	0.291991E+05	-0.308412E+05
	16	0.153964E+05	-0.170386E+05
13	5	0.416467E+05	-0.393165E+05
	9	0.375062E+05	-0.351760E+05
14	6	0.371780E+05	-0.272131E+05
	10	0.279222E+05	-0.179574E+05
15	7	0.261777E+05	-0.107364E+05
	11	0.117436E+05	0.000000E+00
16	8	0.275360E+05	-0.253770E+05
	12	0.284218E+05	-0.262628E+05

17	9	0.348640E+05	-0.369040E+05
	13	0.364877E+05	-0.385277E+05
18	10	0.227165E+05	-0.228001E+05
	14	0.325727E+05	-0.326562E+05
19	11	0.684424E+04	-0.111529E+04
	15	0.111893E+05	-0.546033E+04
20	12	0.264675E+05	-0.284145E+05
	16	0.279819E+05	-0.299289E+05
21	5	0.837876E+04	-0.838937E+04
	17	0.109508E+04	-0.110568E+04
22	6	0.219433E+04	-0.242931E+04
	18	0.235809E+04	-0.259308E+04
23	7	0.138684E+05	-0.133975E+05
	19	0.326717E+04	-0.279631E+04
24	8	0.539849E+04	-0.562739E+04
	20	0.479485E+04	-0.502375E+04
25	17	0.261914E+04	-0.267906E+04
	18	0.366913E+04	-0.372905E+04
26	18	0.349647E+04	-0.362542E+04
	19	0.111334E+05	-0.112623E+05
27	19	0.969025E+04	-0.979679E+04
	20	0.330023E+04	-0.340677E+04

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME		PELVIS			CHEST	
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	13.42	-0.17	22.75	10.59	-0.17	33.23
0.004	13.43	-0.17	22.76	10.59	-0.17	33.23
0.008	13.44	-0.17	22.77	10.62	-0.17	33.22
0.013	13.49	-0.17	22.77	10.69	-0.17	33.21
0.016	13.56	-0.17	22.78	10.76	-0.17	33.20
0.021	13.69	-0.17	22.78	10.89	-0.17	33.19
0.025	13.83	-0.17	22.77	11.03	-0.17	33.19
0.029	13.99	-0.17	22.76	11.20	-0.17	33.18
0.032	14.16	-0.17	22.73	11.37	-0.17	33.17
0.037	14.39	-0.17	22.68	11.63	-0.17	33.16
0.041	14.61	-0.17	22.63	11.89	-0.17	33.14
0.045	14.84	-0.17	22.57	12.20	-0.17	33.12
0.049	15.06	-0.17	22.51	12.54	-0.17	33.09
0.053	15.29	-0.17	22.45	12.92	-0.17	33.05
0.057	15.51	-0.17	22.39	13.34	-0.17	33.00
0.061	15.72	-0.17	22.33	13.67	-0.17	32.93
0.064	15.89	-0.17	22.27	14.04	-0.17	32.88
0.069	16.10	-0.17	22.20	14.53	-0.17	32.83
0.073	16.27	-0.17	22.15	14.99	-0.17	32.79
0.077	16.42	-0.17	22.11	15.47	-0.17	32.77
0.081	16.56	-0.17	22.08	15.96	-0.17	32.77
0.085	16.69	-0.17	22.08	16.47	-0.17	32.78
0.089	16.81	-0.17	22.09	17.00	-0.17	32.82
0.093	16.93	-0.17	22.12	17.55	-0.17	32.87
0.097	17.05	-0.17	22.18	18.13	-0.17	32.94
0.101	17.17	-0.17	22.25	18.73	-0.17	33.02
0.105	17.29	-0.17	22.34	19.35	-0.17	33.09
0.109	17.42	-0.17	22.44	20.00	-0.17	33.16
0.113	17.57	-0.17	22.55	20.66	-0.17	33.20
0.117	17.72	-0.17	22.67	21.35	-0.17	33.23
0.121	17.89	-0.17	22.78	22.04	-0.17	33.21
0.125	18.07	-0.17	22.87	22.74	-0.17	33.15
0.128	18.24	-0.17	22.95	23.36	-0.17	33.06
0.132	18.44	-0.17	23.01	24.05	-0.17	32.91
0.136	18.64	-0.17	23.06	24.74	-0.17	32.70
0.140	18.85	-0.17	23.07	25.40	-0.17	32.43
0.144	19.05	-0.17	23.04	26.04	-0.17	32.11
0.148	19.25	-0.17	22.97	26.66	-0.17	31.73
0.152	19.44	-0.17	22.86	27.24	-0.17	31.29
0.156	19.62	-0.17	22.69	27.78	-0.17	30.80
0.160	19.79	-0.17	22.49	28.32	-0.17	30.20
0.164	19.93	-0.17	22.26	28.63	-0.17	29.73
0.168	20.03	-0.17	22.01	28.99	-0.17	29.09
0.172	20.09	-0.17	21.73	29.22	-0.17	28.47
0.176	20.13	-0.17	21.45	29.39	-0.17	27.83

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	PELVIS		CHEST	
(SEC)	PITCH (DEG) --	ROLL (DEG)	PITCH (DEG) --	ROLL (DEG)
0.000	-15.535	0.00	-15.53	0.00
0.004	-15.522	0.00	-15.55	0.00
0.008	-15.488	0.00	-15.57	0.00
0.013	-15.458	0.00	-15.57	0.00
0.016	-15.433	0.00	-15.56	0.00
0.021	-15.404	0.00	-15.52	0.00
0.025	-15.384	0.00	-15.45	0.00
0.029	-15.372	0.00	-15.32	0.00
0.032	-15.327	0.00	-15.18	0.00
0.037	-15.177	0.00	-14.95	0.00
0.041	-14.926	0.00	-14.68	0.00
0.045	-14.532	0.00	-14.35	0.00
0.049	-13.968	0.00	-13.93	0.00
0.053	-13.211	0.00	-13.43	0.00
0.057	-12.245	0.00	-12.81	0.00
0.061	-11.061	0.00	-12.07	0.00
0.064	-9.845	0.00	-11.31	0.00
0.069	-8.042	0.00	-10.15	0.00
0.073	-6.222	0.00	-8.94	0.00
0.077	-4.219	0.00	-7.55	0.00
0.081	-2.061	0.00	-5.98	0.00
0.085	0.233	0.00	-4.23	0.00
0.089	2.646	0.00	-2.32	0.00
0.093	5.162	0.00	-0.25	0.00
0.097	7.761	0.00	1.97	0.00
0.101	10.426	0.00	4.34	0.00
0.105	13.136	0.00	6.83	0.00
0.109	15.872	0.00	9.44	0.00
0.113	18.616	0.00	12.15	0.00
0.117	21.348	0.00	14.95	0.00
0.121	24.051	0.00	17.82	0.00
0.125	26.709	0.00	20.74	0.00
0.128	28.992	0.00	23.32	0.00
0.132	31.565	0.00	26.30	0.00
0.136	34.104	0.00	29.28	0.00
0.140	36.601	0.00	32.26	0.00
0.144	39.034	0.00	35.22	0.00
0.148	41.381	0.00	38.14	0.00
0.152	43.599	0.00	41.03	0.00
0.156	45.602	0.00	43.91	0.00
0.160	47.297	0.00	46.82	0.00
0.164	48.632	0.00	49.75	0.00
0.168	49.614	0.00	52.70	0.00
0.172	50.331	0.00	55.61	0.00
0.176	50.931	0.00	58.42	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	HEAD			NECK		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	10.26	-0.17	45.50	8.23	-0.17	41.89
0.004	10.27	-0.17	45.50	8.23	-0.17	41.89
0.008	10.29	-0.17	45.49	8.26	-0.17	41.88
0.013	10.35	-0.17	45.47	8.32	-0.17	41.87
0.016	10.43	-0.17	45.46	8.40	-0.17	41.87
0.021	10.57	-0.17	45.44	8.53	-0.17	41.86
0.025	10.73	-0.17	45.43	8.69	-0.17	41.85
0.029	10.93	-0.17	45.42	8.87	-0.17	41.85
0.032	11.14	-0.17	45.42	9.07	-0.17	41.85
0.037	11.45	-0.17	45.41	9.36	-0.17	41.85
0.041	11.77	-0.17	45.41	9.67	-0.17	41.84
0.045	12.14	-0.17	45.40	10.03	-0.17	41.83
0.049	12.57	-0.17	45.38	10.43	-0.17	41.82
0.053	13.04	-0.17	45.35	10.89	-0.17	41.80
0.057	13.57	-0.17	45.31	11.40	-0.17	41.77
0.061	14.05	-0.17	45.25	11.85	-0.17	41.73
0.064	14.56	-0.17	45.20	12.34	-0.17	41.70
0.069	15.29	-0.17	45.15	13.01	-0.17	41.68
0.073	15.99	-0.17	45.11	13.66	-0.17	41.67
0.077	16.75	-0.17	45.07	14.35	-0.17	41.68
0.081	17.56	-0.17	45.05	15.09	-0.17	41.71
0.085	18.44	-0.17	45.03	15.88	-0.17	41.75
0.089	19.37	-0.17	45.01	16.71	-0.17	41.80
0.093	20.35	-0.17	45.00	17.58	-0.17	41.86
0.097	21.39	-0.17	44.97	18.51	-0.17	41.92
0.101	22.48	-0.17	44.94	19.48	-0.17	41.97
0.105	23.61	-0.17	44.88	20.49	-0.17	42.00
0.109	24.78	-0.17	44.78	21.53	-0.17	42.01
0.113	25.98	-0.17	44.65	22.61	-0.17	41.98
0.117	27.20	-0.17	44.46	23.71	-0.17	41.89
0.121	28.44	-0.17	44.20	24.83	-0.17	41.75
0.125	29.67	-0.17	43.88	25.95	-0.17	41.55
0.128	30.74	-0.17	43.53	26.93	-0.17	41.31
0.132	31.95	-0.17	43.06	28.03	-0.17	40.97
0.136	33.13	-0.17	42.51	29.12	-0.17	40.55
0.140	34.27	-0.17	41.87	30.17	-0.17	40.05
0.144	35.36	-0.17	41.16	31.19	-0.17	39.48
0.148	36.41	-0.17	40.36	32.16	-0.17	38.84
0.152	37.40	-0.17	39.48	33.08	-0.17	38.13
0.156	38.32	-0.17	38.54	33.94	-0.17	37.35
0.160	39.23	-0.17	37.45	34.80	-0.17	36.44
0.164	39.90	-0.17	36.47	35.41	-0.17	35.64
0.168	40.57	-0.17	35.29	36.05	-0.17	34.65
0.172	41.10	-0.17	34.09	36.56	-0.17	33.66
0.176	41.52	-0.17	32.85	36.98	-0.17	32.65

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	HEAD		NECK	
(SEC)	PITCH (DEG) --	ROLL (DEG)	PITCH (DEG) --	ROLL (DEG)
0.000	7.465	0.00	-4.03	0.00
0.004	7.464	0.00	-4.04	0.00
0.008	7.457	0.00	-4.05	0.00
0.013	7.444	0.00	-4.06	0.00
0.016	7.456	0.00	-4.05	0.00
0.021	7.523	0.00	-4.00	0.00
0.025	7.652	0.00	-3.90	0.00
0.029	7.850	0.00	-3.74	0.00
0.032	8.077	0.00	-3.55	0.00
0.037	8.403	0.00	-3.27	0.00
0.041	8.687	0.00	-3.00	0.00
0.045	8.939	0.00	-2.70	0.00
0.049	9.149	0.00	-2.39	0.00
0.053	9.333	0.00	-2.05	0.00
0.057	9.523	0.00	-1.65	0.00
0.061	9.769	0.00	-1.15	0.00
0.064	10.071	0.00	-0.62	0.00
0.069	10.632	0.00	0.24	0.00
0.073	11.328	0.00	1.20	0.00
0.077	12.235	0.00	2.34	0.00
0.081	13.364	0.00	3.69	0.00
0.085	14.712	0.00	5.24	0.00
0.089	16.264	0.00	6.97	0.00
0.093	17.986	0.00	8.87	0.00
0.097	19.840	0.00	10.91	0.00
0.101	21.794	0.00	13.07	0.00
0.105	23.822	0.00	15.33	0.00
0.109	25.906	0.00	17.67	0.00
0.113	28.028	0.00	20.09	0.00
0.117	30.172	0.00	22.56	0.00
0.121	32.319	0.00	25.07	0.00
0.125	34.452	0.00	27.59	0.00
0.128	36.297	0.00	29.81	0.00
0.132	38.375	0.00	32.34	0.00
0.136	40.419	0.00	34.85	0.00
0.140	42.443	0.00	37.35	0.00
0.144	44.476	0.00	39.85	0.00
0.148	46.547	0.00	42.35	0.00
0.152	48.673	0.00	44.85	0.00
0.156	50.847	0.00	47.38	0.00
0.160	53.072	0.00	49.94	0.00
0.164	55.365	0.00	52.56	0.00
0.168	57.771	0.00	55.23	0.00
0.172	60.329	0.00	57.97	0.00
0.176	63.053	0.00	60.74	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	RIGHT UPPER ARM			RIGHT LOWER ARM		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	10.77	-6.51	32.06	18.66	-6.51	24.22
0.004	10.77	-6.51	32.06	18.66	-6.51	24.22
0.008	10.80	-6.51	32.06	18.69	-6.51	24.22
0.013	10.86	-6.51	32.05	18.76	-6.51	24.21
0.016	10.94	-6.51	32.04	18.83	-6.51	24.20
0.021	11.07	-6.51	32.03	18.96	-6.51	24.19
0.025	11.21	-6.51	32.02	19.09	-6.51	24.17
0.029	11.38	-6.51	32.01	19.24	-6.51	24.15
0.032	11.55	-6.51	32.01	19.40	-6.51	24.13
0.037	11.81	-6.51	32.00	19.63	-6.51	24.10
0.041	12.07	-6.51	31.98	19.87	-6.51	24.06
0.045	12.38	-6.51	31.96	20.15	-6.51	24.01
0.049	12.73	-6.51	31.93	20.46	-6.51	23.95
0.053	13.11	-6.51	31.90	20.80	-6.51	23.88
0.057	13.54	-6.51	31.85	21.18	-6.51	23.79
0.061	13.88	-6.51	31.79	21.47	-6.51	23.68
0.064	14.27	-6.51	31.74	21.79	-6.51	23.59
0.069	14.79	-6.51	31.69	22.23	-6.51	23.46
0.073	15.27	-6.51	31.66	22.63	-6.51	23.35
0.077	15.78	-6.51	31.64	23.03	-6.51	23.24
0.081	16.30	-6.51	31.64	23.43	-6.51	23.14
0.085	16.85	-6.51	31.66	23.84	-6.51	23.05
0.089	17.42	-6.51	31.70	24.26	-6.51	22.96
0.093	18.01	-6.51	31.75	24.68	-6.51	22.88
0.097	18.62	-6.51	31.81	25.10	-6.51	22.80
0.101	19.26	-6.51	31.87	25.54	-6.51	22.73
0.105	19.92	-6.51	31.93	25.98	-6.51	22.65
0.109	20.61	-6.51	31.97	26.44	-6.51	22.57
0.113	21.32	-6.51	31.99	26.92	-6.51	22.47
0.117	22.04	-6.51	31.98	27.42	-6.51	22.36
0.121	22.79	-6.51	31.92	27.93	-6.51	22.22
0.125	23.54	-6.51	31.82	28.48	-6.51	22.06
0.128	24.20	-6.51	31.69	28.98	-6.51	21.89
0.132	24.96	-6.51	31.47	29.57	-6.51	21.66
0.136	25.72	-6.51	31.20	30.19	-6.51	21.38
0.140	26.47	-6.51	30.86	30.84	-6.51	21.07
0.144	27.20	-6.51	30.45	31.51	-6.51	20.70
0.148	27.92	-6.51	29.98	32.20	-6.51	20.29
0.152	28.63	-6.51	29.44	32.92	-6.51	19.84
0.156	29.30	-6.51	28.84	33.66	-6.51	19.34
0.160	30.00	-6.51	28.11	34.46	-6.51	18.73
0.164	30.49	-6.51	27.51	35.10	-6.51	18.27
0.168	31.04	-6.51	26.72	35.84	-6.51	17.63
0.172	31.49	-6.51	25.94	36.51	-6.51	17.02
0.176	31.88	-6.51	25.15	37.15	-6.51	16.40

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	RIGHT UPPER ARM		RIGHT LOWER ARM	
(SEC)	PITCH (DEG) --	ROLL (DEG)	PITCH (DEG) --	ROLL (DEG)
0.000	-16.000	0.00	14.00	0.00
0.004	-16.004	0.00	14.00	0.00
0.008	-16.015	0.00	13.99	0.00
0.013	-16.025	0.00	13.99	0.00
0.016	-16.022	0.00	14.00	0.00
0.021	-15.990	0.00	14.03	0.00
0.025	-15.932	0.00	14.09	0.00
0.029	-15.839	0.00	14.18	0.00
0.032	-15.733	0.00	14.29	0.00
0.037	-15.558	0.00	14.46	0.00
0.041	-15.368	0.00	14.64	0.00
0.045	-15.140	0.00	14.85	0.00
0.049	-14.868	0.00	15.08	0.00
0.053	-14.550	0.00	15.33	0.00
0.057	-14.185	0.00	15.63	0.00
0.061	-13.773	0.00	15.98	0.00
0.064	-13.370	0.00	16.36	0.00
0.069	-12.781	0.00	16.95	0.00
0.073	-12.172	0.00	17.56	0.00
0.077	-11.471	0.00	18.26	0.00
0.081	-10.673	0.00	19.06	0.00
0.085	-9.774	0.00	19.95	0.00
0.089	-8.776	0.00	20.95	0.00
0.093	-7.682	0.00	22.03	0.00
0.097	-6.488	0.00	23.18	0.00
0.101	-5.199	0.00	24.36	0.00
0.105	-3.825	0.00	25.55	0.00
0.109	-2.382	0.00	26.73	0.00
0.113	-0.892	0.00	27.86	0.00
0.117	0.622	0.00	28.92	0.00
0.121	2.131	0.00	29.88	0.00
0.125	3.606	0.00	30.69	0.00
0.128	4.842	0.00	31.27	0.00
0.132	6.163	0.00	31.75	0.00
0.136	7.355	0.00	32.01	0.00
0.140	8.387	0.00	32.04	0.00
0.144	9.230	0.00	31.84	0.00
0.148	9.854	0.00	31.40	0.00
0.152	10.232	0.00	30.72	0.00
0.156	10.336	0.00	29.77	0.00
0.160	10.140	0.00	28.58	0.00
0.164	9.626	0.00	27.17	0.00
0.168	8.785	0.00	25.55	0.00
0.172	7.639	0.00	23.80	0.00
0.176	6.236	0.00	21.95	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	LEFT UPPER ARM			LEFT LOWER ARM		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	10.77	6.17	32.06	18.66	6.17	24.22
0.004	10.77	6.17	32.06	18.66	6.17	24.22
0.008	10.80	6.17	32.06	18.69	6.17	24.22
0.013	10.86	6.17	32.05	18.76	6.17	24.21
0.016	10.94	6.17	32.04	18.83	6.17	24.20
0.021	11.07	6.17	32.03	18.96	6.17	24.19
0.025	11.21	6.17	32.02	19.09	6.17	24.17
0.029	11.38	6.17	32.01	19.24	6.17	24.15
0.032	11.55	6.17	32.01	19.40	6.17	24.13
0.037	11.81	6.17	32.00	19.63	6.17	24.10
0.041	12.07	6.17	31.98	19.87	6.17	24.06
0.045	12.38	6.17	31.96	20.15	6.17	24.01
0.049	12.73	6.17	31.93	20.46	6.17	23.95
0.053	13.11	6.17	31.90	20.80	6.17	23.88
0.057	13.54	6.17	31.85	21.18	6.17	23.79
0.061	13.88	6.17	31.79	21.47	6.17	23.68
0.064	14.27	6.17	31.74	21.79	6.17	23.59
0.069	14.79	6.17	31.69	22.23	6.17	23.46
0.073	15.27	6.17	31.66	22.63	6.17	23.35
0.077	15.78	6.17	31.64	23.03	6.17	23.24
0.081	16.30	6.17	31.64	23.43	6.17	23.14
0.085	16.85	6.17	31.66	23.84	6.17	23.05
0.089	17.42	6.17	31.70	24.26	6.17	22.96
0.093	18.01	6.17	31.75	24.68	6.17	22.88
0.097	18.62	6.17	31.81	25.10	6.17	22.80
0.101	19.26	6.17	31.87	25.54	6.17	22.73
0.105	19.92	6.17	31.93	25.98	6.17	22.65
0.109	20.61	6.17	31.97	26.44	6.17	22.57
0.113	21.32	6.17	31.99	26.92	6.17	22.47
0.117	22.04	6.17	31.98	27.42	6.17	22.36
0.121	22.79	6.17	31.92	27.93	6.17	22.22
0.125	23.54	6.17	31.82	28.48	6.17	22.06
0.128	24.20	6.17	31.69	28.98	6.17	21.89
0.132	24.96	6.17	31.47	29.57	6.17	21.66
0.136	25.72	6.17	31.20	30.19	6.17	21.38
0.140	26.47	6.17	30.86	30.84	6.17	21.07
0.144	27.20	6.17	30.45	31.51	6.17	20.70
0.148	27.92	6.17	29.98	32.20	6.17	20.29
0.152	28.63	6.17	29.44	32.92	6.17	19.84
0.156	29.30	6.17	28.84	33.66	6.17	19.34
0.160	30.00	6.17	28.11	34.46	6.17	18.73
0.164	30.49	6.17	27.51	35.10	6.17	18.27
0.168	31.04	6.17	26.72	35.84	6.17	17.63
0.172	31.49	6.17	25.94	36.51	6.17	17.02
0.176	31.88	6.17	25.15	37.15	6.17	16.40

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	LEFT UPPER ARM PITCH (DEG)	LEFT UPPER ARM ROLL (DEG)	LEFT LOWER ARM PITCH (DEG)	LEFT LOWER ARM ROLL (DEG)
0.000	-16.000	0.00	14.00	0.00
0.004	-16.004	0.00	14.00	0.00
0.008	-16.015	0.00	13.99	0.00
0.013	-16.025	0.00	13.99	0.00
0.016	-16.022	0.00	14.00	0.00
0.021	-15.990	0.00	14.03	0.00
0.025	-15.932	0.00	14.09	0.00
0.029	-15.839	0.00	14.18	0.00
0.032	-15.733	0.00	14.29	0.00
0.037	-15.558	0.00	14.46	0.00
0.041	-15.368	0.00	14.64	0.00
0.045	-15.140	0.00	14.85	0.00
0.049	-14.868	0.00	15.08	0.00
0.053	-14.550	0.00	15.33	0.00
0.057	-14.185	0.00	15.63	0.00
0.061	-13.773	0.00	15.98	0.00
0.064	-13.370	0.00	16.36	0.00
0.069	-12.781	0.00	16.95	0.00
0.073	-12.172	0.00	17.56	0.00
0.077	-11.471	0.00	18.26	0.00
0.081	-10.673	0.00	19.06	0.00
0.085	-9.774	0.00	19.95	0.00
0.089	-8.776	0.00	20.95	0.00
0.093	-7.682	0.00	22.03	0.00
0.097	-6.488	0.00	23.18	0.00
0.101	-5.199	0.00	24.36	0.00
0.105	-3.825	0.00	25.55	0.00
0.109	-2.382	0.00	26.73	0.00
0.113	-0.892	0.00	27.86	0.00
0.117	0.622	0.00	28.92	0.00
0.121	2.131	0.00	29.88	0.00
0.125	3.606	0.00	30.69	0.00
0.128	4.842	0.00	31.27	0.00
0.132	6.163	0.00	31.75	0.00
0.136	7.355	0.00	32.01	0.00
0.140	8.387	0.00	32.04	0.00
0.144	9.230	0.00	31.84	0.00
0.148	9.854	0.00	31.40	0.00
0.152	10.232	0.00	30.72	0.00
0.156	10.336	0.00	29.77	0.00
0.160	10.140	0.00	28.58	0.00
0.164	9.626	0.00	27.17	0.00
0.168	8.785	0.00	25.55	0.00
0.172	7.639	0.00	23.80	0.00
0.176	6.236	0.00	21.95	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	RIGHT THIGH			RIGHT LOWER LEG		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	22.97	-3.87	18.92	31.65	-3.87	8.59
0.004	22.97	-3.87	18.92	31.65	-3.87	8.59
0.008	22.98	-3.87	18.92	31.66	-3.87	8.59
0.013	23.03	-3.87	18.92	31.70	-3.87	8.58
0.016	23.10	-3.87	18.93	31.76	-3.87	8.58
0.021	23.22	-3.87	18.92	31.88	-3.87	8.58
0.025	23.36	-3.87	18.92	32.01	-3.87	8.57
0.029	23.53	-3.87	18.91	32.18	-3.87	8.57
0.032	23.69	-3.87	18.89	32.35	-3.87	8.57
0.037	23.90	-3.87	18.87	32.60	-3.87	8.57
0.041	24.09	-3.87	18.84	32.84	-3.87	8.57
0.045	24.28	-3.87	18.80	33.09	-3.87	8.57
0.049	24.46	-3.87	18.76	33.35	-3.87	8.56
0.053	24.62	-3.87	18.71	33.63	-3.87	8.55
0.057	24.75	-3.87	18.66	33.91	-3.87	8.54
0.061	24.86	-3.87	18.61	34.19	-3.87	8.53
0.064	24.93	-3.87	18.56	34.44	-3.87	8.52
0.069	24.99	-3.87	18.48	34.77	-3.87	8.50
0.073	25.01	-3.87	18.41	35.06	-3.87	8.48
0.077	25.00	-3.87	18.34	35.36	-3.87	8.44
0.081	24.96	-3.87	18.27	35.65	-3.87	8.40
0.085	24.91	-3.87	18.19	35.94	-3.87	8.35
0.089	24.84	-3.87	18.12	36.23	-3.87	8.30
0.093	24.77	-3.87	18.06	36.50	-3.87	8.24
0.097	24.68	-3.87	18.01	36.77	-3.87	8.17
0.101	24.59	-3.87	17.96	37.03	-3.87	8.11
0.105	24.51	-3.87	17.93	37.27	-3.87	8.05
0.109	24.43	-3.87	17.90	37.49	-3.87	8.00
0.113	24.36	-3.87	17.89	37.71	-3.87	7.95
0.117	24.30	-3.87	17.89	37.92	-3.87	7.90
0.121	24.26	-3.87	17.89	38.12	-3.87	7.86
0.125	24.23	-3.87	17.89	38.31	-3.87	7.84
0.128	24.22	-3.87	17.89	38.49	-3.87	7.82
0.132	24.22	-3.87	17.90	38.68	-3.87	7.81
0.136	24.23	-3.87	17.90	38.89	-3.87	7.82
0.140	24.25	-3.87	17.90	39.09	-3.87	7.85
0.144	24.28	-3.87	17.89	39.32	-3.87	7.90
0.148	24.32	-3.87	17.86	39.55	-3.87	7.98
0.152	24.37	-3.87	17.82	39.81	-3.87	8.09
0.156	24.43	-3.87	17.77	40.08	-3.87	8.23
0.160	24.50	-3.87	17.69	40.38	-3.87	8.40
0.164	24.57	-3.87	17.59	40.68	-3.87	8.58
0.168	24.63	-3.87	17.47	40.98	-3.87	8.77
0.172	24.66	-3.87	17.33	41.25	-3.87	8.98
0.176	24.68	-3.87	17.19	41.49	-3.87	9.20

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	RIGHT THIGH PITCH (DEG)	RIGHT THIGH ROLL (DEG)	RIGHT LOWER LEG PITCH (DEG)	RIGHT LOWER LEG ROLL (DEG)
0.000	-3.811	0.00	-3.84	0.00
0.004	-3.794	0.00	-3.83	0.00
0.008	-3.763	0.00	-3.81	0.00
0.013	-3.724	0.00	-3.78	0.00
0.016	-3.703	0.00	-3.75	0.00
0.021	-3.698	0.00	-3.73	0.00
0.025	-3.721	0.00	-3.73	0.00
0.029	-3.763	0.00	-3.77	0.00
0.032	-3.835	0.00	-3.84	0.00
0.037	-3.990	0.00	-4.00	0.00
0.041	-4.173	0.00	-4.21	0.00
0.045	-4.363	0.00	-4.53	0.00
0.049	-4.542	0.00	-4.98	0.00
0.053	-4.712	0.00	-5.57	0.00
0.057	-4.882	0.00	-6.32	0.00
0.061	-5.054	0.00	-7.24	0.00
0.064	-5.186	0.00	-8.19	0.00
0.069	-5.277	0.00	-9.64	0.00
0.073	-5.253	0.00	-11.12	0.00
0.077	-5.121	0.00	-12.77	0.00
0.081	-4.873	0.00	-14.54	0.00
0.085	-4.495	0.00	-16.42	0.00
0.089	-3.976	0.00	-18.36	0.00
0.093	-3.313	0.00	-20.34	0.00
0.097	-2.509	0.00	-22.31	0.00
0.101	-1.577	0.00	-24.26	0.00
0.105	-0.539	0.00	-26.17	0.00
0.109	0.578	0.00	-28.01	0.00
0.113	1.747	0.00	-29.77	0.00
0.117	2.938	0.00	-31.45	0.00
0.121	4.122	0.00	-33.05	0.00
0.125	5.269	0.00	-34.58	0.00
0.128	6.225	0.00	-35.86	0.00
0.132	7.257	0.00	-37.27	0.00
0.136	8.214	0.00	-38.64	0.00
0.140	9.066	0.00	-39.99	0.00
0.144	9.776	0.00	-41.34	0.00
0.148	10.304	0.00	-42.73	0.00
0.152	10.619	0.00	-44.17	0.00
0.156	10.719	0.00	-45.68	0.00
0.160	10.616	0.00	-47.27	0.00
0.164	10.327	0.00	-48.95	0.00
0.168	9.874	0.00	-50.72	0.00
0.172	9.280	0.00	-52.57	0.00
0.176	8.591	0.00	-54.47	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	LEFT THIGH			LEFT LOWER LEG		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	22.97	3.53	18.92	31.65	3.53	8.59
0.004	22.97	3.53	18.92	31.65	3.53	8.59
0.008	22.98	3.53	18.92	31.66	3.53	8.59
0.013	23.03	3.53	18.92	31.70	3.53	8.58
0.016	23.10	3.53	18.93	31.76	3.53	8.58
0.021	23.22	3.53	18.92	31.88	3.53	8.58
0.025	23.36	3.53	18.92	32.01	3.53	8.57
0.029	23.53	3.53	18.91	32.18	3.53	8.57
0.032	23.69	3.53	18.89	32.35	3.53	8.57
0.037	23.90	3.53	18.87	32.60	3.53	8.57
0.041	24.09	3.53	18.84	32.84	3.53	8.57
0.045	24.28	3.53	18.80	33.09	3.53	8.57
0.049	24.46	3.53	18.76	33.35	3.53	8.56
0.053	24.62	3.53	18.71	33.63	3.53	8.55
0.057	24.75	3.53	18.66	33.91	3.53	8.54
0.061	24.86	3.53	18.61	34.19	3.53	8.53
0.064	24.93	3.53	18.56	34.44	3.53	8.52
0.069	24.99	3.53	18.48	34.77	3.53	8.50
0.073	25.01	3.53	18.41	35.06	3.53	8.48
0.077	25.00	3.53	18.34	35.36	3.53	8.44
0.081	24.96	3.53	18.27	35.65	3.53	8.40
0.085	24.91	3.53	18.19	35.94	3.53	8.35
0.089	24.84	3.53	18.12	36.23	3.53	8.30
0.093	24.77	3.53	18.06	36.50	3.53	8.24
0.097	24.68	3.53	18.01	36.77	3.53	8.17
0.101	24.59	3.53	17.96	37.03	3.53	8.11
0.105	24.51	3.53	17.93	37.27	3.53	8.05
0.109	24.43	3.53	17.90	37.49	3.53	8.00
0.113	24.36	3.53	17.89	37.71	3.53	7.95
0.117	24.30	3.53	17.89	37.92	3.53	7.90
0.121	24.26	3.53	17.89	38.12	3.53	7.86
0.125	24.23	3.53	17.89	38.31	3.53	7.84
0.128	24.22	3.53	17.89	38.49	3.53	7.82
0.132	24.22	3.53	17.90	38.68	3.53	7.81
0.136	24.23	3.53	17.90	38.89	3.53	7.82
0.140	24.25	3.53	17.90	39.09	3.53	7.85
0.144	24.28	3.53	17.89	39.32	3.53	7.90
0.148	24.32	3.53	17.86	39.55	3.53	7.98
0.152	24.37	3.53	17.82	39.81	3.53	8.09
0.156	24.43	3.53	17.77	40.08	3.53	8.23
0.160	24.50	3.53	17.69	40.38	3.53	8.40
0.164	24.57	3.53	17.59	40.68	3.53	8.58
0.168	24.63	3.53	17.47	40.98	3.53	8.77
0.172	24.66	3.53	17.33	41.25	3.53	8.98
0.176	24.68	3.53	17.19	41.49	3.53	9.20

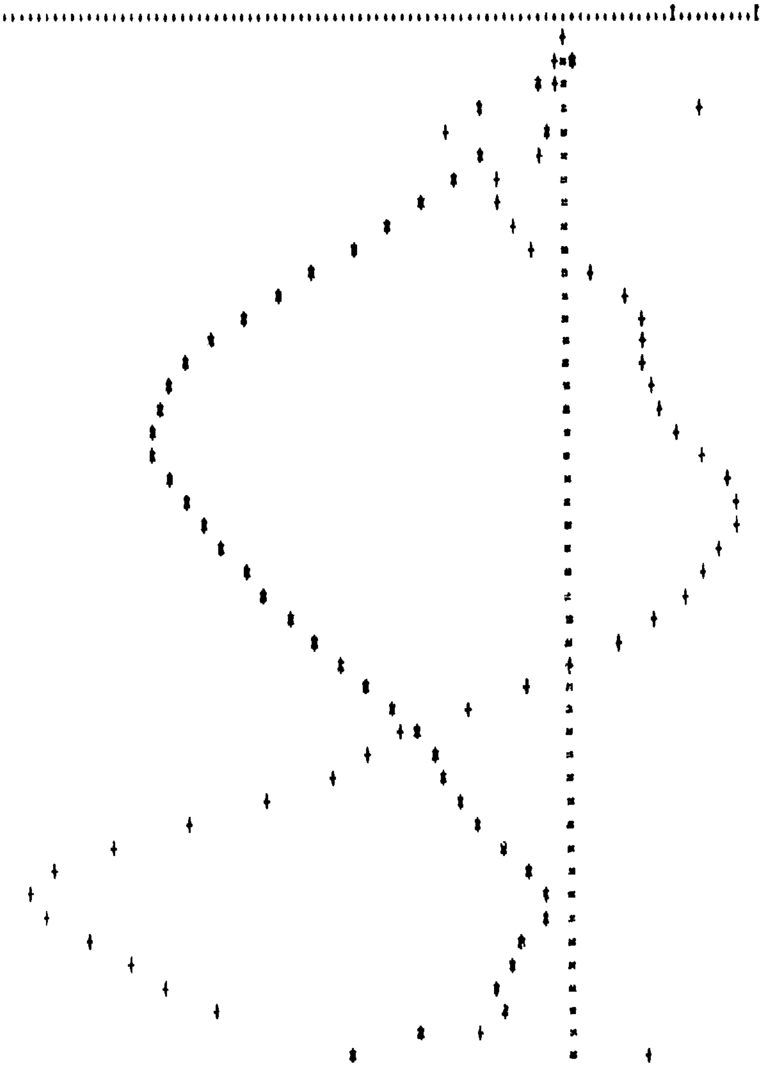
OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	LEFT THIGH PITCH (DEG)	LEFT THIGH ROLL (DEG)	LEFT LOWER LEG PITCH (DEG)	LEFT LOWER LEG ROLL (DEG)
0.000	-3.811	0.00	-3.84	0.00
0.004	-3.794	0.00	-3.83	0.00
0.008	-3.763	0.00	-3.81	0.00
0.013	-3.724	0.00	-3.78	0.00
0.016	-3.703	0.00	-3.75	0.00
0.021	-3.698	0.00	-3.73	0.00
0.025	-3.721	0.00	-3.73	0.00
0.029	-3.763	0.00	-3.77	0.00
0.032	-3.835	0.00	-3.84	0.00
0.037	-3.990	0.00	-4.00	0.00
0.041	-4.173	0.00	-4.21	0.00
0.045	-4.363	0.00	-4.53	0.00
0.049	-4.542	0.00	-4.98	0.00
0.053	-4.712	0.00	-5.57	0.00
0.057	-4.882	0.00	-6.32	0.00
0.061	-5.054	0.00	-7.24	0.00
0.064	-5.186	0.00	-8.19	0.00
0.069	-5.277	0.00	-9.64	0.00
0.073	-5.253	0.00	-11.12	0.00
0.077	-5.121	0.00	-12.77	0.00
0.081	-4.873	0.00	-14.54	0.00
0.085	-4.495	0.00	-16.42	0.00
0.089	-3.976	0.00	-18.36	0.00
0.093	-3.313	0.00	-20.34	0.00
0.097	-2.509	0.00	-22.31	0.00
0.101	-1.577	0.00	-24.26	0.00
0.105	-0.539	0.00	-26.17	0.00
0.109	0.578	0.00	-28.01	0.00
0.113	1.747	0.00	-29.77	0.00
0.117	2.938	0.00	-31.45	0.00
0.121	4.122	0.00	-33.05	0.00
0.125	5.269	0.00	-34.58	0.00
0.128	6.225	0.00	-35.86	0.00
0.132	7.257	0.00	-37.27	0.00
0.136	8.214	0.00	-38.64	0.00
0.140	9.066	0.00	-39.99	0.00
0.144	9.776	0.00	-41.34	0.00
0.148	10.304	0.00	-42.73	0.00
0.152	10.619	0.00	-44.17	0.00
0.156	10.719	0.00	-45.68	0.00
0.160	10.616	0.00	-47.27	0.00
0.164	10.327	0.00	-48.95	0.00
0.168	9.874	0.00	-50.72	0.00
0.172	9.280	0.00	-52.57	0.00
0.176	8.591	0.00	-54.47	0.00

OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

TIME (SEC)	PELVIS X (G) *	PELVIS Y (G) =	PELVIS Z (G) +
0.000	0.00	0.00	0.00
0.004	0.17	0.00	-0.19
0.008	-0.53	0.00	-0.15
0.013	-1.64	0.00	2.70
0.015	-0.25	0.00	-2.41
0.021	-1.72	0.00	-0.49
0.025	-2.16	0.00	-1.26
0.029	-2.81	0.00	-1.40
0.032	-3.46	0.00	-0.99
0.037	-4.25	0.00	-0.60
0.041	-4.99	0.00	0.50
0.045	-5.70	0.00	1.22
0.049	-6.38	0.00	1.48
0.053	-7.00	0.00	1.48
0.057	-7.52	0.00	1.46
0.061	-7.91	0.00	1.71
0.064	-8.09	0.00	1.85
0.069	-8.21	0.00	2.12
0.073	-8.13	0.00	2.77
0.077	-7.87	0.00	3.11
0.081	-7.55	0.00	3.36
0.085	-7.18	0.00	3.30
0.089	-6.79	0.00	3.07
0.093	-6.40	0.00	2.75
0.097	-5.96	0.00	2.29
0.101	-5.49	0.00	1.67
0.105	-5.01	0.00	0.94
0.109	-4.51	0.00	0.10
0.113	-3.99	0.00	-0.89
0.117	-3.46	0.00	-2.03
0.121	-2.92	0.00	-3.34
0.125	-2.66	0.00	-4.07
0.128	-2.51	0.00	-4.75
0.132	-2.24	0.00	-5.98
0.136	-1.85	0.00	-7.53
0.140	-1.37	0.00	-9.06
0.144	-0.86	0.00	-10.15
0.148	-0.44	0.00	-10.70
0.152	-0.55	0.00	-10.31
0.156	-0.93	0.00	-9.48
0.160	-1.22	0.00	-8.74
0.164	-1.49	0.00	-8.00
0.168	-1.39	0.00	-6.98
0.172	-3.07	0.00	-1.76
0.176	-4.29	0.00	1.44

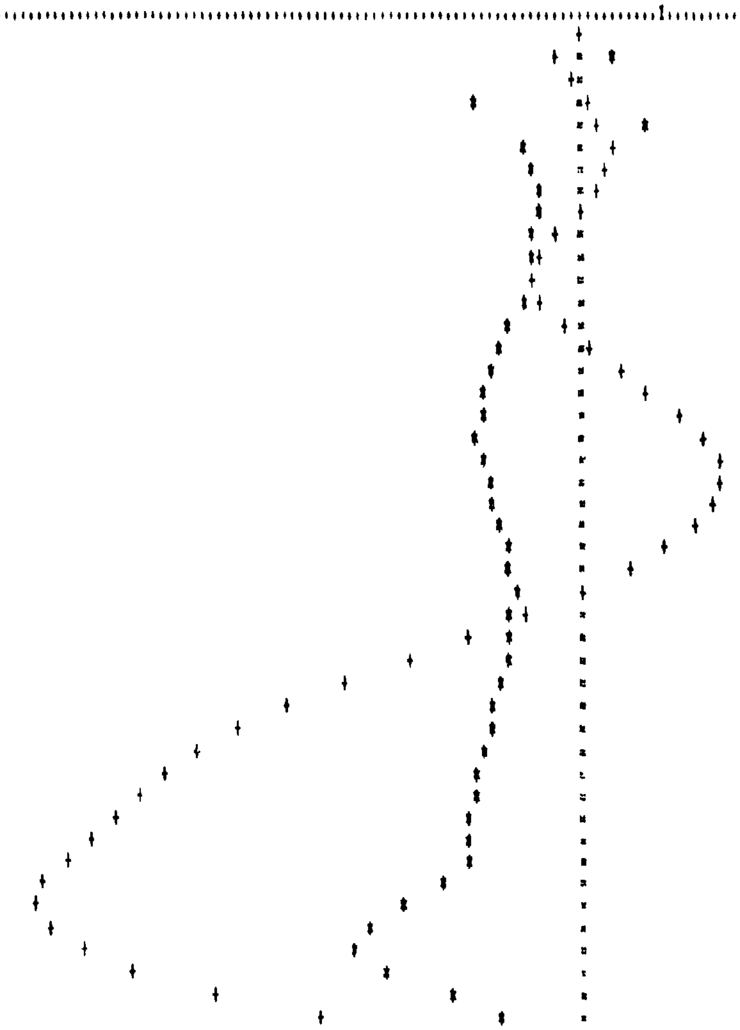
SCALE FACTOR = 0.167E+01



OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

SCALE FACTOR = 0.229E+01

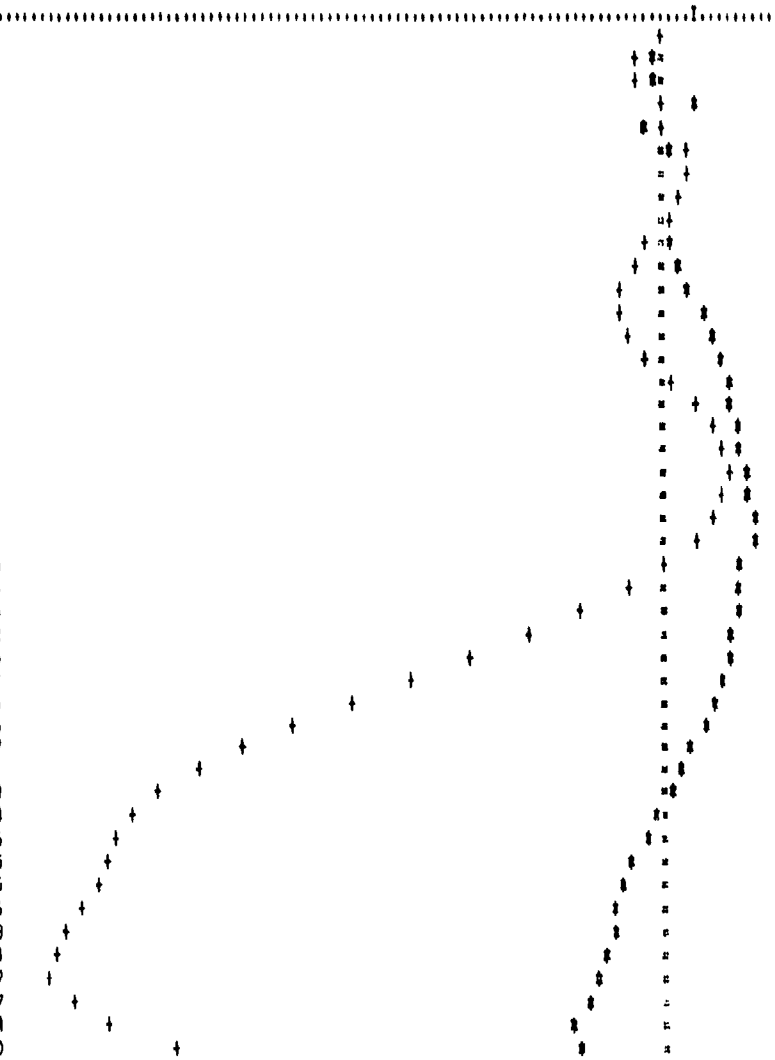
TIME (SEC)	CHEST X (G) *	CHEST Y (G) ¤	CHEST Z (G) +
0.000	0.00	0.00	0.00
0.004	0.84	0.00	-0.70
0.008	-0.36	0.00	-0.23
0.013	-3.15	0.00	0.09
0.016	1.81	0.00	0.29
0.021	-1.67	0.00	0.72
0.025	-1.37	0.00	0.59
0.029	-1.31	0.00	0.36
0.032	-1.31	0.00	-0.03
0.037	-1.36	0.00	-0.75
0.041	-1.43	0.00	-1.23
0.045	-1.57	0.00	-1.41
0.049	-1.78	0.00	-1.17
0.053	-2.07	0.00	-0.59
0.057	-2.37	0.00	0.23
0.061	-2.67	0.00	0.98
0.064	-2.81	0.00	1.64
0.069	-2.95	0.00	2.66
0.073	-2.96	0.00	3.30
0.077	-2.89	0.00	3.71
0.081	-2.70	0.00	3.80
0.085	-2.57	0.00	3.68
0.089	-2.36	0.00	3.10
0.093	-2.20	0.00	2.30
0.097	-2.08	0.00	1.17
0.101	-2.03	0.00	-0.18
0.105	-2.05	0.00	-1.69
0.109	-2.13	0.00	-3.33
0.113	-2.26	0.00	-5.02
0.117	-2.43	0.00	-6.68
0.121	-2.61	0.00	-8.27
0.125	-2.72	0.00	-9.75
0.128	-2.85	0.00	-10.96
0.132	-3.02	0.00	-11.86
0.136	-3.18	0.00	-12.55
0.140	-3.29	0.00	-13.19
0.144	-3.30	0.00	-13.89
0.148	-3.29	0.00	-14.61
0.152	-4.03	0.00	-15.20
0.156	-5.18	0.00	-15.44
0.160	-6.03	0.00	-15.05
0.164	-6.48	0.00	-14.18
0.168	-5.70	0.00	-12.67
0.172	-3.69	0.00	-10.48
0.176	-2.38	0.00	-7.41



OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

TIME (SEC)	HEAD X (G) ‡	HEAD Y (G) *	HEAD Z (G) +
0.000	0.00	0.00	0.00
0.004	-0.34	0.00	-1.06
0.008	-0.34	0.00	-0.88
0.013	1.01	0.00	-0.14
0.016	-0.69	0.00	-0.03
0.021	0.25	0.00	0.70
0.025	-0.03	0.00	0.84
0.029	-0.06	0.00	0.63
0.032	0.05	0.00	0.19
0.037	0.33	0.00	-0.49
0.041	0.64	0.00	-1.04
0.045	0.96	0.00	-1.41
0.049	1.29	0.00	-1.50
0.053	1.60	0.00	-1.24
0.057	1.90	0.00	-0.63
0.061	2.20	0.00	0.29
0.064	2.39	0.00	1.01
0.069	2.56	0.00	1.74
0.073	2.67	0.00	2.14
0.077	2.75	0.00	2.26
0.081	2.78	0.00	2.11
0.085	3.18	0.00	1.77
0.089	3.17	0.00	1.09
0.093	2.74	0.00	0.04
0.097	2.69	0.00	-1.26
0.101	2.58	0.00	-2.86
0.105	2.43	0.00	-4.72
0.109	2.23	0.00	-6.76
0.113	1.96	0.00	-8.87
0.117	1.65	0.00	-10.96
0.121	1.28	0.00	-12.96
0.125	0.86	0.00	-14.79
0.128	0.51	0.00	-16.21
0.132	0.13	0.00	-17.54
0.136	-0.25	0.00	-18.48
0.140	-0.65	0.00	-19.06
0.144	-1.09	0.00	-19.45
0.148	-1.56	0.00	-19.85
0.152	-1.79	0.00	-20.36
0.156	-1.89	0.00	-20.88
0.160	-2.15	0.00	-21.34
0.164	-2.37	0.00	-21.49
0.168	-2.80	0.00	-20.57
0.172	-3.21	0.00	-19.34
0.176	-3.06	0.00	-17.00

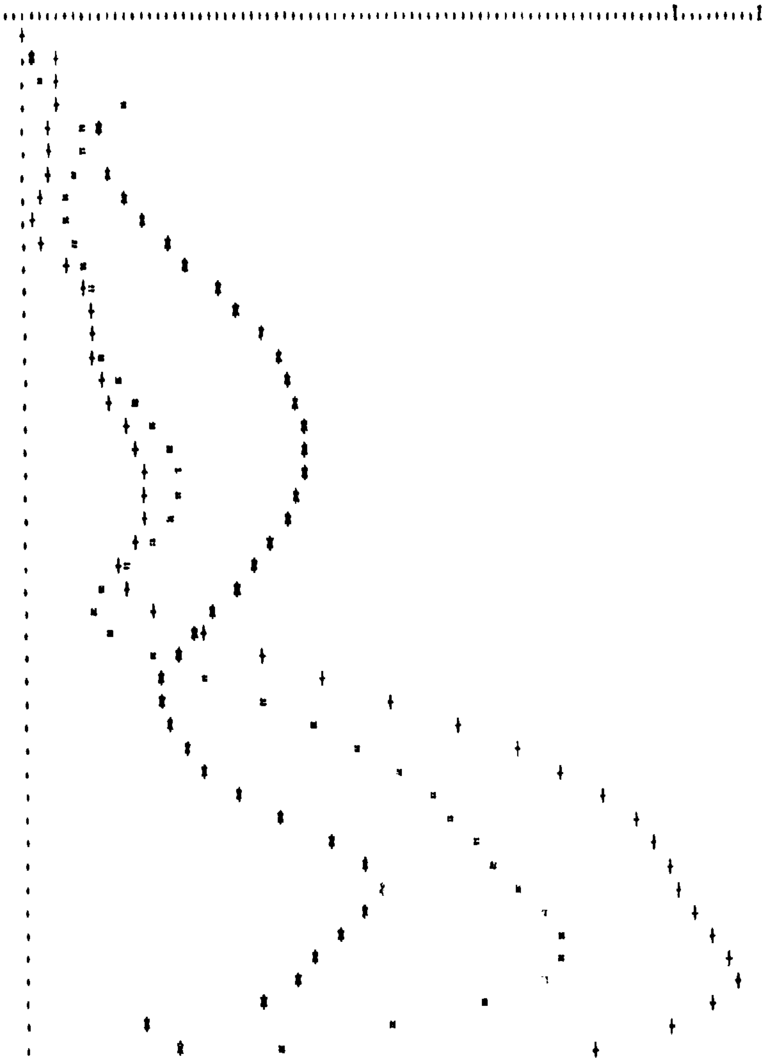
SCALE FACTOR = 0.294E+01



OCCUPANT SEGMENT ACCELERATION
(RESULTANTS)

SCALE FACTOR = 0.257E+01

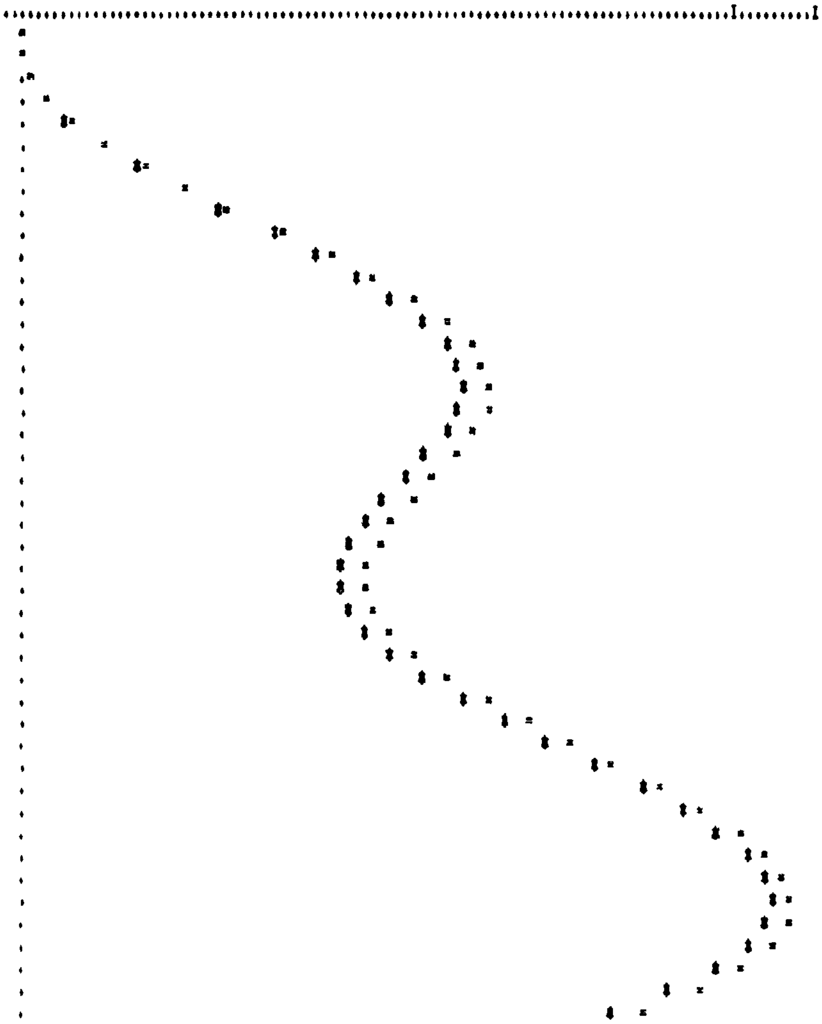
TIME (SEC)	PELVIS (G) *	CHEST (G) =	HEAD (G) +
0.000	0.00	0.00	0.00
0.004	0.26	1.10	1.11
0.008	0.55	0.42	0.95
0.013	3.16	3.15	1.02
0.016	2.42	1.83	0.69
0.021	1.79	1.82	0.74
0.025	2.50	1.50	0.84
0.029	3.14	1.36	0.63
0.032	3.60	1.31	0.20
0.037	4.30	1.55	0.60
0.041	5.01	1.89	1.22
0.045	5.83	2.10	1.71
0.049	6.55	2.13	1.98
0.053	7.16	2.15	2.03
0.057	7.66	2.38	2.00
0.061	8.09	2.84	2.22
0.064	8.30	3.25	2.59
0.069	8.48	3.97	3.10
0.073	8.59	4.44	3.42
0.077	8.47	4.70	3.56
0.081	8.27	4.66	3.49
0.085	7.90	4.49	3.64
0.089	7.45	3.89	3.36
0.093	6.97	3.18	2.74
0.097	6.38	2.39	2.96
0.101	5.74	2.04	3.86
0.105	5.09	2.66	5.31
0.109	4.51	3.95	7.12
0.113	4.09	5.50	9.08
0.117	4.01	7.11	11.08
0.121	4.44	8.68	13.02
0.125	4.86	10.12	14.82
0.128	5.37	11.33	16.22
0.132	6.38	12.24	17.54
0.136	7.76	12.95	18.48
0.140	9.16	13.60	19.07
0.144	10.23	14.27	19.48
0.148	10.71	14.98	19.91
0.152	10.33	15.73	20.44
0.156	9.53	16.29	20.97
0.160	8.82	16.21	21.45
0.164	8.14	15.59	21.62
0.168	7.12	13.90	20.76
0.172	3.54	11.11	19.61
0.176	4.52	7.78	17.27



RESTRAINT SYSTEM LOADS

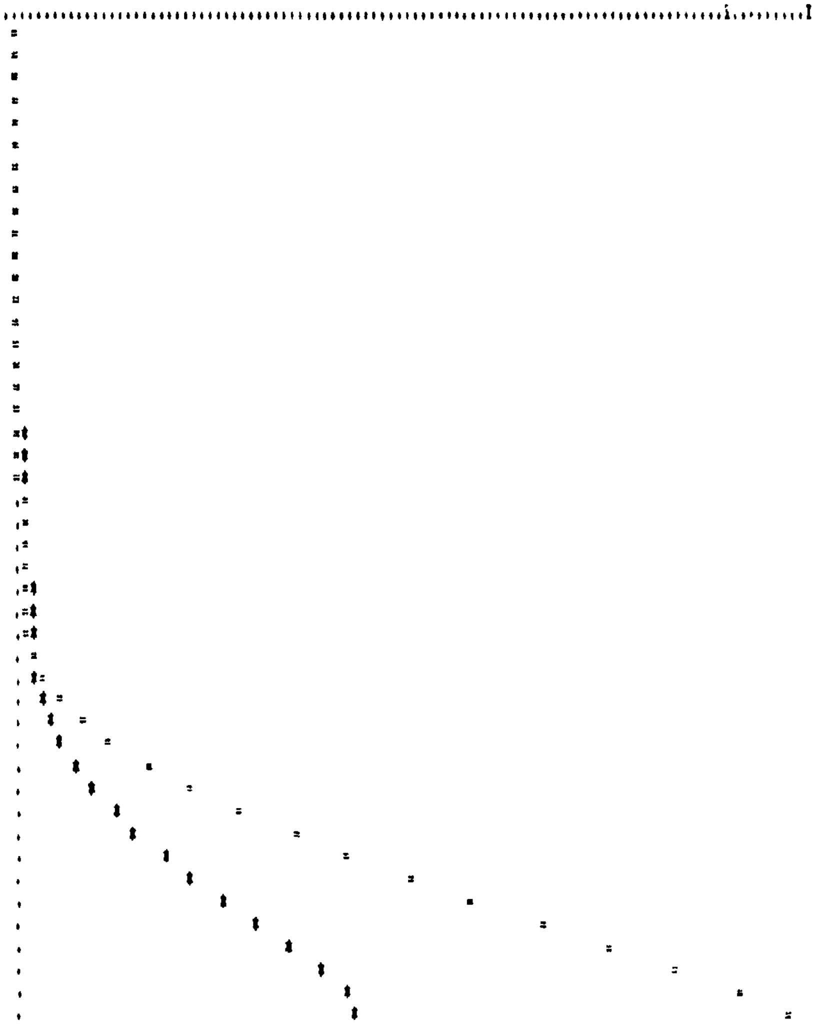
SCALE FACTOR = 0.895E+02

TIME (SEC)	RIGHT LAP (LB) $	LEFT LAP (LB) *
0.000	0.00	0.00
0.004	1.82	1.60
0.008	8.40	8.41
0.013	25.73	26.38
0.016	48.09	49.66
0.021	85.93	89.20
0.025	127.90	133.15
0.029	175.08	182.65
0.032	218.20	228.02
0.037	273.67	286.55
0.041	321.20	336.84
0.045	365.66	384.02
0.049	405.46	426.38
0.053	438.59	461.89
0.057	463.27	488.33
0.061	477.25	505.18
0.064	481.39	510.91
0.069	475.63	506.08
0.073	461.41	493.87
0.077	441.11	474.45
0.081	417.65	451.57
0.085	394.04	428.23
0.089	372.92	407.02
0.093	356.32	390.39
0.097	347.15	379.59
0.101	345.92	377.19
0.105	354.10	384.04
0.109	372.24	400.72
0.113	400.26	427.22
0.117	437.35	462.83
0.121	482.01	506.13
0.125	531.98	554.61
0.128	576.59	597.26
0.132	627.93	647.74
0.136	678.58	697.81
0.140	725.31	744.18
0.144	764.74	783.57
0.148	794.22	813.36
0.152	812.45	832.29
0.156	819.93	840.91
0.160	816.55	839.14
0.164	798.86	823.46
0.168	763.27	790.17
0.172	710.27	739.66
0.176	647.83	681.19



SEVERITY INDEX

SCALE FACTOR = 0.101E+02



TIME	CHEST *	HEAD =
0.000	0.00	0.00
0.004	0.03	0.01
0.008	0.05	0.01
0.013	0.09	0.02
0.016	0.12	0.02
0.021	0.15	0.02
0.025	0.16	0.03
0.029	0.17	0.03
0.032	0.18	0.03
0.037	0.19	0.03
0.041	0.20	0.03
0.045	0.22	0.04
0.049	0.25	0.06
0.053	0.27	0.08
0.057	0.30	0.11
0.061	0.34	0.13
0.064	0.40	0.17
0.069	0.50	0.22
0.073	0.63	0.29
0.077	0.81	0.39
0.081	1.00	0.48
0.085	1.17	0.58
0.089	1.32	0.65
0.093	1.44	0.71
0.097	1.49	0.76
0.101	1.52	0.85
0.105	1.55	1.03
0.109	1.63	1.42
0.113	1.82	2.17
0.117	2.23	3.47
0.121	2.93	5.50
0.125	4.03	8.41
0.128	5.12	11.22
0.132	6.94	15.81
0.136	9.12	21.25
0.140	11.61	27.32
0.144	14.43	33.81
0.148	[illegible].60	40.64
0.152	21.19	47.89
0.156	25.21	55.63
0.160	29.51	63.84
0.164	33.66	72.46
0.168	37.26	80.80
0.172	39.85	88.31
0.176	41.20	94.48

DYNAMIC RESPONSE INDEX AND HEAD INJURY CRITERION

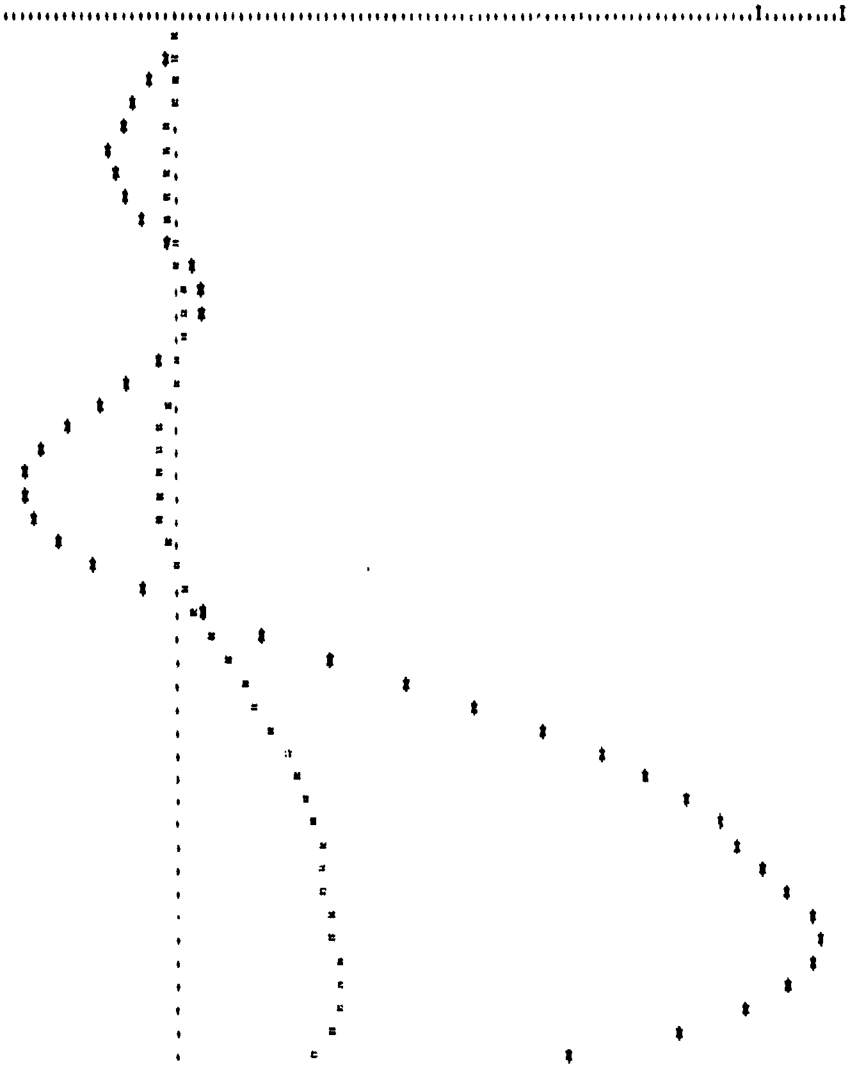
MAXIMUM DRI	HIC
0.0	87.5

BETWEEN 0.1165 AND 0.1755 SEC

AXIAL LOADS IN VERTEBRAL ELEMENTS

SCALE FACTOR = 0.131E+03

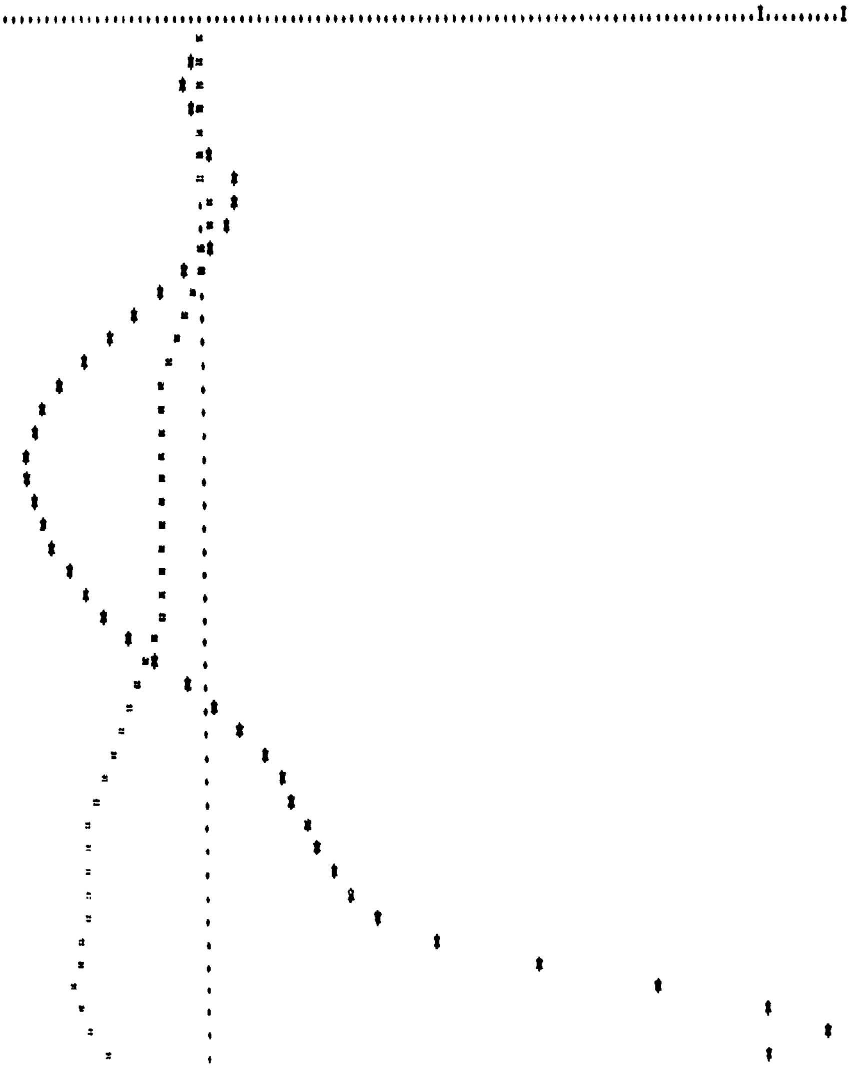
TIME (SEC)	LUMBAR (LB) $	NECK (LB) *
0.000	0.00	0.00
0.004	-12.26	-0.37
0.008	-35.69	-2.46
0.013	-65.57	-7.78
0.016	-87.07	-13.37
0.021	-101.19	-19.43
0.025	-99.83	-21.79
0.029	-82.25	-19.28
0.032	-55.62	-13.82
0.037	-14.75	-4.92
0.041	19.07	2.48
0.045	37.80	7.79
0.049	34.24	9.73
0.053	8.90	7.40
0.057	-32.22	0.85
0.061	-81.71	-8.40
0.064	-126.94	-16.41
0.069	-179.33	-24.72
0.073	-214.37	-29.16
0.077	-235.24	-30.48
0.081	-238.79	-28.72
0.085	-223.15	-23.88
0.089	-187.09	-15.86
0.093	-130.92	-4.41
0.097	-56.85	10.61
0.101	31.12	29.05
0.105	130.31	50.26
0.109	237.22	73.29
0.113	347.04	97.10
0.117	455.21	120.71
0.121	558.19	143.28
0.125	653.28	164.21
0.128	724.23	180.69
0.132	786.90	196.30
0.136	832.62	207.48
0.140	869.21	214.48
0.144	904.41	219.25
0.148	941.22	224.39
0.152	975.33	231.09
0.156	994.96	238.31
0.160	987.27	244.16
0.164	946.07	245.31
0.168	871.44	240.30
0.172	766.01	228.46
0.176	607.72	205.51



MOMENTS IN VERTEBRAL ELEMENTS

SCALE FACTOR = 0.202E+03

TIME (SEC)	LUMBAR (IN-LB) *	NECK (IN-LB) =
0.000	0.00	0.00
0.004	-20.11	1.60
0.008	-27.92	0.41
0.013	-24.76	0.05
0.016	9.31	0.04
0.021	27.89	5.20
0.025	78.40	8.67
0.029	79.28	14.70
0.032	58.08	15.43
0.037	14.75	8.56
0.041	-32.35	-5.19
0.045	-90.59	-23.60
0.049	-156.39	-43.83
0.053	-223.82	-63.17
0.057	-286.67	-79.14
0.061	-339.05	-90.01
0.064	-374.44	-95.05
0.069	-404.79	-97.79
0.073	-418.91	-97.51
0.077	-418.31	-95.30
0.081	-404.79	-92.50
0.085	-384.35	-89.10
0.089	-356.99	-87.06
0.093	-322.44	-87.46
0.097	-280.32	-91.49
0.101	-230.10	-100.32
0.105	-172.91	-113.92
0.109	-110.31	-131.77
0.113	-44.11	-152.89
0.117	23.98	-175.96
0.121	92.13	-199.43
0.125	152.09	-221.57
0.128	185.79	-239.22
0.132	213.18	-257.71
0.136	239.01	-273.10
0.140	269.02	-283.26
0.144	303.11	-286.84
0.148	337.30	-284.46
0.152	402.22	-282.89
0.156	554.35	-289.28
0.160	794.10	-300.53
0.164	1074.19	-309.31
0.168	1327.38	-303.66
0.172	1476.12	-279.18
0.176	1329.00	-236.26



FORCES APPLIED TO SEAT BY OCCUPANT

TIME	SEAT CUSHION (LB)			BACK CUSHION (LB)		
(SEC)	FSC(1)	FSC(2)	FSC(3)	FBC(1)	FBC(2)	FBC(3)
0.000	135.87	0.00	0.00	17.54	17.54	0.00
0.004	131.27	0.00	0.00	11.57	10.39	0.00
0.008	129.50	0.00	0.00	0.00	0.00	0.00
0.013	132.06	0.00	0.00	0.00	0.00	0.00
0.016	138.72	0.00	0.00	0.00	0.00	0.00
0.021	153.68	0.00	0.00	0.00	0.00	0.00
0.025	172.41	0.00	0.00	0.00	0.00	0.00
0.029	199.77	0.00	0.00	0.00	0.00	0.00
0.032	231.91	0.00	0.00	0.00	0.00	0.00
0.037	282.48	0.00	0.00	0.00	0.00	0.00
0.041	333.85	0.00	0.00	0.00	0.00	0.00
0.045	388.14	0.00	0.00	0.00	0.00	0.00
0.049	444.88	0.00	0.00	0.00	0.00	0.00
0.053	504.68	0.00	0.00	0.00	0.00	0.00
0.057	567.47	0.00	0.00	0.00	0.00	0.00
0.061	630.76	0.00	0.00	0.00	0.00	0.00
0.064	683.72	0.00	0.00	0.00	0.00	0.00
0.069	745.45	0.00	0.00	0.00	0.00	0.00
0.073	790.84	33.50	33.50	0.00	0.00	0.00
0.077	819.90	48.66	48.66	0.00	0.00	0.00
0.081	825.96	62.74	62.74	0.00	0.00	0.00
0.085	804.71	75.29	75.29	0.00	0.00	0.00
0.089	755.92	85.81	85.81	0.00	0.00	0.00
0.093	683.23	93.83	93.83	0.00	0.00	0.00
0.097	592.66	99.13	99.13	0.00	0.00	0.00
0.101	491.49	101.81	101.81	0.00	0.00	0.00
0.105	386.52	102.14	102.14	0.00	0.00	0.00
0.109	283.28	100.55	100.55	0.00	0.00	0.00
0.113	186.01	97.59	97.59	0.00	0.00	0.00
0.117	97.87	93.99	93.99	0.00	0.00	0.00
0.121	21.17	90.56	90.56	0.00	0.00	0.00
0.125	0.00	88.17	88.17	0.00	0.00	0.00
0.128	0.00	86.77	86.77	0.00	0.00	0.00
0.132	0.00	86.01	86.01	0.00	0.00	0.00
0.136	0.00	87.14	87.14	0.00	0.00	0.00
0.140	0.00	91.35	91.35	0.00	0.00	0.00
0.144	0.00	99.66	99.66	0.00	0.00	0.00
0.148	0.00	112.79	112.79	0.00	0.00	0.00
0.152	0.00	131.99	131.99	0.00	0.00	0.00
0.156	0.00	159.16	159.16	0.00	0.00	0.00
0.160	0.00	195.43	195.43	0.00	0.00	0.00
0.164	0.00	241.21	241.21	0.00	0.00	0.00
0.168	0.00	295.79	295.79	0.00	0.00	0.00
0.172	0.00	357.07	357.07	0.00	0.00	0.00
0.176	293.29	413.01	413.01	0.00	0.00	0.00

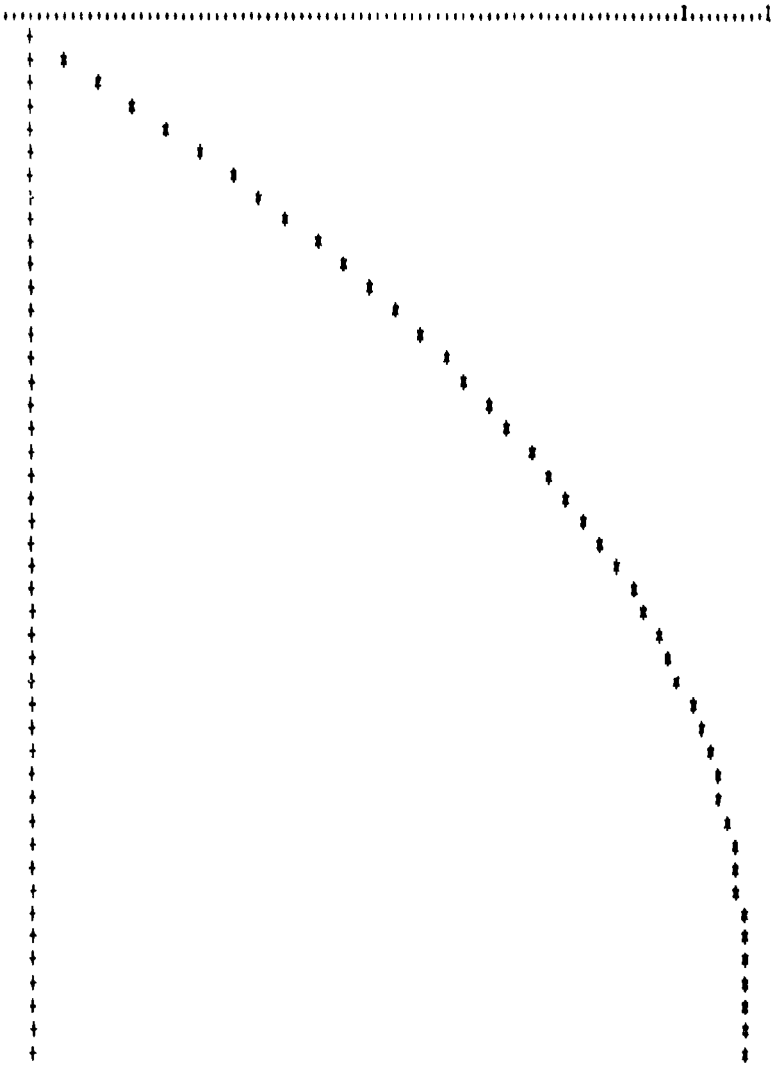
FORCES BETWEEN FEET AND FLOOR

TIME (SEC)	RIGHT X	RIGHT Y	RIGHT Z	LEFT X	LEFT Y	LEFT Z
0.000	0.00	0.00	0.00	0.00	0.00	0.00
0.004	0.00	0.00	6.57	0.00	0.00	6.57
0.008	-2.28	0.00	16.76	-2.28	0.00	16.76
0.013	-7.04	0.00	28.26	-7.04	0.00	28.26
0.016	-8.65	0.00	34.62	-8.65	0.00	34.62
0.021	-10.00	0.00	39.99	-10.00	0.00	39.99
0.025	-11.15	0.00	44.63	-11.15	0.00	44.63
0.029	-13.09	0.00	52.36	-13.09	0.00	52.36
0.032	-13.54	0.00	54.16	-13.54	0.00	54.16
0.037	-11.40	0.00	45.62	-11.40	0.00	45.62
0.041	-8.56	0.00	34.26	-8.56	0.00	34.26
0.045	-7.94	0.00	31.78	-7.94	0.00	31.78
0.049	-10.25	0.00	41.00	-10.25	0.00	41.00
0.053	-13.32	0.00	53.30	-13.32	0.00	53.30
0.057	-14.26	0.00	57.06	-14.26	0.00	57.06
0.061	-10.63	0.00	42.55	-10.63	0.00	42.55
0.064	-4.56	0.00	18.24	-4.56	0.00	18.24
0.069	0.00	0.00	0.00	0.00	0.00	0.00
0.073	0.00	0.00	0.00	0.00	0.00	0.00
0.077	0.00	0.00	0.00	0.00	0.00	0.00
0.081	0.00	0.00	0.00	0.00	0.00	0.00
0.085	0.00	0.00	0.00	0.00	0.00	0.00
0.089	0.00	0.00	0.00	0.00	0.00	0.00
0.093	0.00	0.00	0.00	0.00	0.00	0.00
0.097	0.00	0.00	0.00	0.00	0.00	0.00
0.101	0.00	0.00	0.00	0.00	0.00	0.00
0.105	0.00	0.00	0.00	0.00	0.00	0.00
0.109	0.00	0.00	0.00	0.00	0.00	0.00
0.113	0.00	0.00	0.00	0.00	0.00	0.00
0.117	0.00	0.00	0.00	0.00	0.00	0.00
0.121	0.00	0.00	0.00	0.00	0.00	0.00
0.125	0.00	0.00	0.00	0.00	0.00	0.00
0.128	0.00	0.00	0.00	0.00	0.00	0.00
0.132	0.00	0.00	0.00	0.00	0.00	0.00
0.136	0.00	0.00	0.00	0.00	0.00	0.00
0.140	0.00	0.00	0.00	0.00	0.00	0.00
0.144	0.00	0.00	0.00	0.00	0.00	0.00
0.148	0.00	0.00	0.00	0.00	0.00	0.00
0.152	0.00	0.00	0.00	0.00	0.00	0.00
0.156	0.00	0.00	0.00	0.00	0.00	0.00
0.160	0.00	0.00	0.00	0.00	0.00	0.00
0.164	0.00	0.00	0.00	0.00	0.00	0.00
0.168	0.00	0.00	0.00	0.00	0.00	0.00
0.172	0.00	0.00	0.00	0.00	0.00	0.00
0.176	0.00	0.00	0.00	0.00	0.00	0.00

AIRCRAFT DISPLACEMENT

SCALE FACTOR = 0.354E+01

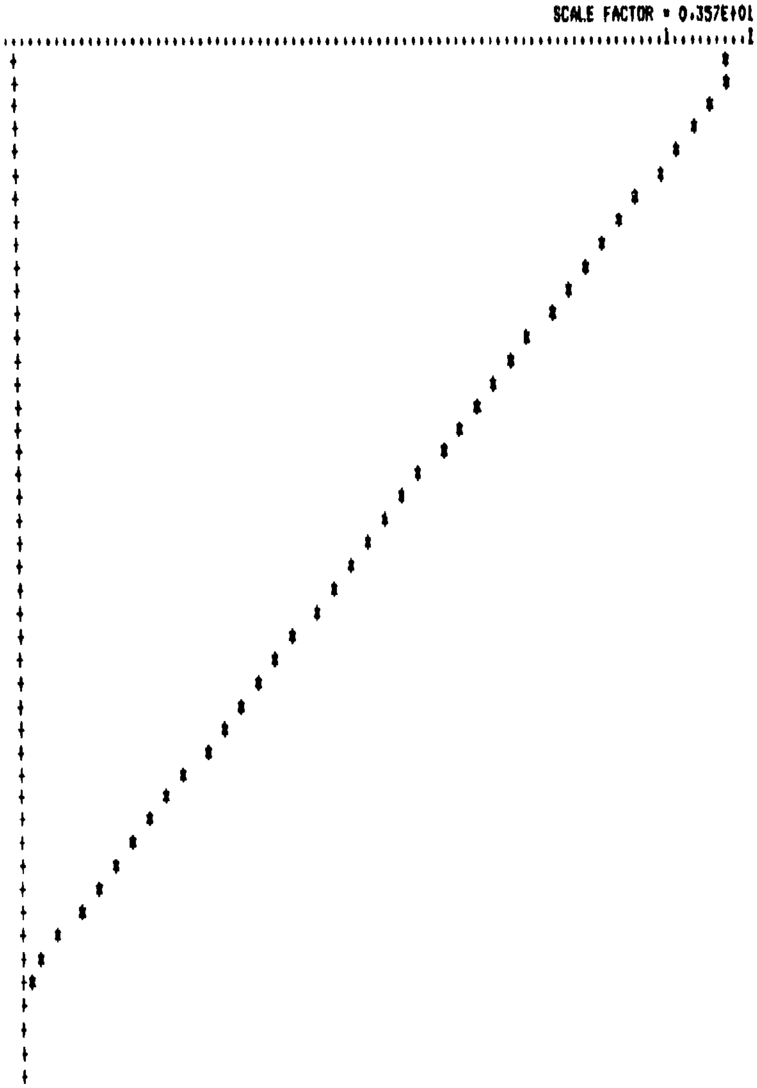
TIME (SEC)	X (IN) *	Y (IN) ×	Z (IN) +
0.000	0.00	0.00	0.00
0.004	1.44	0.00	0.00
0.008	2.86	0.00	0.00
0.013	4.43	0.00	0.00
0.016	5.61	0.00	0.00
0.021	7.09	0.00	0.00
0.025	8.37	0.00	0.00
0.029	9.61	0.00	0.00
0.032	10.67	0.00	0.00
0.037	11.98	0.00	0.00
0.041	13.11	0.00	0.00
0.045	14.20	0.00	0.00
0.049	15.26	0.00	0.00
0.053	16.27	0.00	0.00
0.057	17.26	0.00	0.00
0.061	18.20	0.00	0.00
0.064	19.00	0.00	0.00
0.069	19.98	0.00	0.00
0.073	20.81	0.00	0.00
0.077	21.60	0.00	0.00
0.081	22.36	0.00	0.00
0.085	23.08	0.00	0.00
0.089	23.77	0.00	0.00
0.093	24.42	0.00	0.00
0.097	25.03	0.00	0.00
0.101	25.60	0.00	0.00
0.105	26.13	0.00	0.00
0.109	26.63	0.00	0.00
0.113	27.09	0.00	0.00
0.117	27.52	0.00	0.00
0.121	27.91	0.00	0.00
0.125	28.26	0.00	0.00
0.128	28.53	0.00	0.00
0.132	28.81	0.00	0.00
0.136	29.06	0.00	0.00
0.140	29.26	0.00	0.00
0.144	29.43	0.00	0.00
0.148	29.57	0.00	0.00
0.152	29.66	0.00	0.00
0.156	29.72	0.00	0.00
0.160	29.75	0.00	0.00
0.164	29.75	0.00	0.00
0.168	29.76	0.00	0.00
0.172	29.76	0.00	0.00
0.176	29.76	0.00	0.00



AIRCRAFT VELOCITY

SCALE FACTOR = 0.357E+01

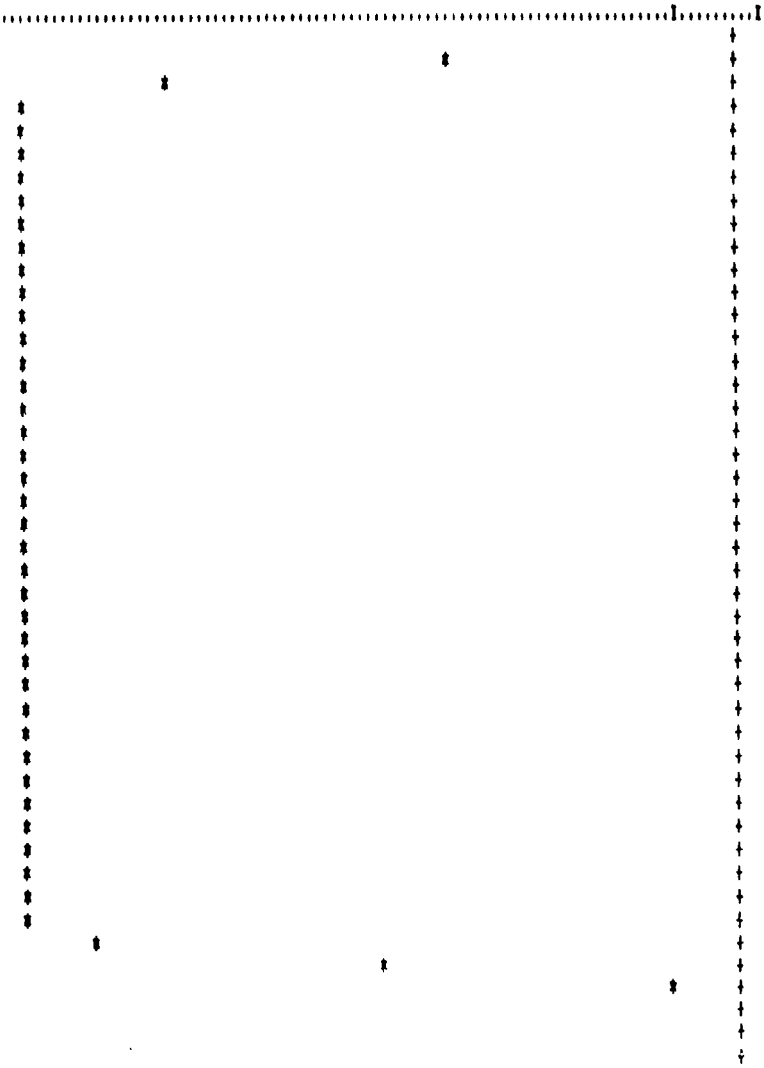
TIME (SEC)	X (FPS) *	Y (FPS) =	Z (FPS) +
0.000	30.00	0.00	0.00
0.004	29.85	0.00	0.00
0.008	29.38	0.00	0.00
0.013	28.55	0.00	0.00
0.016	27.87	0.00	0.00
0.021	27.01	0.00	0.00
0.025	26.23	0.00	0.00
0.029	25.46	0.00	0.00
0.032	24.78	0.00	0.00
0.037	23.91	0.00	0.00
0.041	23.14	0.00	0.00
0.045	22.37	0.00	0.00
0.049	21.60	0.00	0.00
0.053	20.82	0.00	0.00
0.057	20.05	0.00	0.00
0.061	19.28	0.00	0.00
0.064	18.60	0.00	0.00
0.069	17.73	0.00	0.00
0.073	16.96	0.00	0.00
0.077	16.19	0.00	0.00
0.081	15.41	0.00	0.00
0.085	14.64	0.00	0.00
0.089	13.87	0.00	0.00
0.093	13.09	0.00	0.00
0.097	12.32	0.00	0.00
0.101	11.55	0.00	0.00
0.105	10.78	0.00	0.00
0.109	10.00	0.00	0.00
0.113	9.23	0.00	0.00
0.117	8.46	0.00	0.00
0.121	7.69	0.00	0.00
0.125	6.91	0.00	0.00
0.128	6.24	0.00	0.00
0.132	5.46	0.00	0.00
0.136	4.69	0.00	0.00
0.140	3.92	0.00	0.00
0.144	3.15	0.00	0.00
0.148	2.37	0.00	0.00
0.152	1.60	0.00	0.00
0.156	0.84	0.00	0.00
0.160	0.30	0.00	0.00
0.164	0.06	0.00	0.00
0.168	0.05	0.00	0.00
0.172	0.05	0.00	0.00
0.176	0.05	0.00	0.00



AIRCRAFT ACCELERATION

SCALE FACTOR = 0.714E+00

TIME (SEC)	X (G) *	Y (R) ⁎	Z (G) +
0.000	0.00	0.00	0.00
0.004	-2.40	0.00	0.00
0.008	-4.80	0.00	0.00
0.013	-6.00	0.00	0.00
0.016	-6.00	0.00	0.00
0.021	-6.00	0.00	0.00
0.025	-6.00	0.00	0.00
0.029	-6.00	0.00	0.00
0.032	-6.00	0.00	0.00
0.037	-6.00	0.00	0.00
0.041	-6.00	0.00	0.00
0.045	-6.00	0.00	0.00
0.049	-6.00	0.00	0.00
0.053	-6.00	0.00	0.00
0.057	-6.00	0.00	0.00
0.061	-6.00	0.00	0.00
0.064	-6.00	0.00	0.00
0.069	-6.00	0.00	0.00
0.073	-6.00	0.00	0.00
0.077	-6.00	0.00	0.00
0.081	-6.00	0.00	0.00
0.085	-6.00	0.00	0.00
0.089	-6.00	0.00	0.00
0.093	-6.00	0.00	0.00
0.097	-6.00	0.00	0.00
0.101	-6.00	0.00	0.00
0.105	-6.00	0.00	0.00
0.109	-6.00	0.00	0.00
0.113	-6.00	0.00	0.00
0.117	-6.00	0.00	0.00
0.121	-6.00	0.00	0.00
0.125	-6.00	0.00	0.00
0.128	-6.00	0.00	0.00
0.132	-6.00	0.00	0.00
0.136	-6.00	0.00	0.00
0.140	-6.00	0.00	0.00
0.144	-6.00	0.00	0.00
0.148	-6.00	0.00	0.00
0.152	-6.00	0.00	0.00
0.156	-5.40	0.00	0.00
0.160	-3.00	0.00	0.00
0.164	-0.60	0.00	0.00
0.168	0.00	0.00	0.00
0.172	0.00	0.00	0.00
0.176	0.00	0.00	0.00



FINAL GENERALIZED COORDINATES

J	Q(J)	QD(J)	QDD(J)
1	5.0507D+01	5.3202D+00	-1.7772D+03
2	2.1433D+01	-7.1625D+01	-1.1514D+03
3	9.4279D-01	2.9192D+00	-1.3781D+02
4	1.1379D+01	-1.7507D+01	-1.3752D+03
5	1.0308D+00	1.2691D+01	-8.7898D+01
6	6.5941D+00	-4.0008D+00	-8.2087D+02
7	1.1085D+00	1.1538D+01	2.1560D+02
8	1.0246D-01	-6.7054D+00	-2.4398D+02
9	3.8030D-01	-8.2602D+00	-5.4270D+01
10	2.2110D-01	-2.6049D+00	-1.4543D+02
11	-8.8514D-01	-7.7[illegible]8D+00	-1.7876D+01

APPENDIX D

PROGRAM STRUCTURE

The overall organization of Program SOM-TA is illustrated in figure D-1. The main program controls the overall solution procedure by calling two individual sets of subroutines, one for the occupant segments of the program, and the other for the seat segment of the program. Detailed descriptions of the occupant subroutines are presented in section D.1, and the seat subroutines in section D.2.

At the start of execution, the main program calls subroutine INPT to read input data for the occupant model and subroutine READIN for seat input data. Subroutines CONST and INITIL calculate constants and determine initial values of generalized coordinates for the occupant, and subroutine ASSBLE performs preliminary calculations for the seat model. Then, a solution loop is entered at initial time and passed through for each time step. During each pass through the solution loop, subroutine RKAM advances the solution for the occupant equations of motion one time step and provides forces to be applied to the seat model by the occupant. After the call to RKAM, if the finite element seat model is being used, subroutine SOLVE advances the solution by the seat structural analysis to the same point in time that has been attained by RKAM. At time intervals selected by user input, subroutine ANSWER stores, in arrays, user-selected items of output data. Data for post-processing plot programs are written on external files 14 and 20 for the occupant and seat, respectively. Additional data are written on unit 26, as described in section 3.4. These files must be saved if plots are desired.

D.1 OCCUPANT SUBROUTINE DESCRIPTIONS

The relationship among the subroutines in the occupant segment of the program are illustrated in figure D-2. Individual subroutines are described below.

D.1.1 Subroutine AMATRX. Called by EQUATE; calculates elements of the inertia matrix [A] for three-dimensional occupant model.

D.1.2 Subroutine AMATX2. Called by EQUAT2; calculates elements of inertia matrix for two-dimensional occupant model.

D.1.3 Subroutine ANSWER. Called by MAIN; calculates accelerations AC(I, J) of body segments in the inertial coordinate system and tranforms accelerations to segment-fixed coordinate systems. Calculates severity indices and organizes position, velocity, and force data for output. Writes plot data on units 14 and 26. If data filtering is requested by user input, ANSWER writes occupant accelerations on unit 9 and seat accelerations on unit 10 for subsequent filtering by subroutine OUTPT.

D.1.4 Subroutine ARCRFT. Called initially by INPT, then by POSTON; calculates current acceleration components at aircraft floor (ACC(J), J = 1, 3) based on input acceleration pulses. Integrates acceleration to determine velocity (in aircraft coordinate system) and displacement (in inertial system). When time is greater than the input pulse duration, acceleration is set to zero, so that velocity then remains constant.

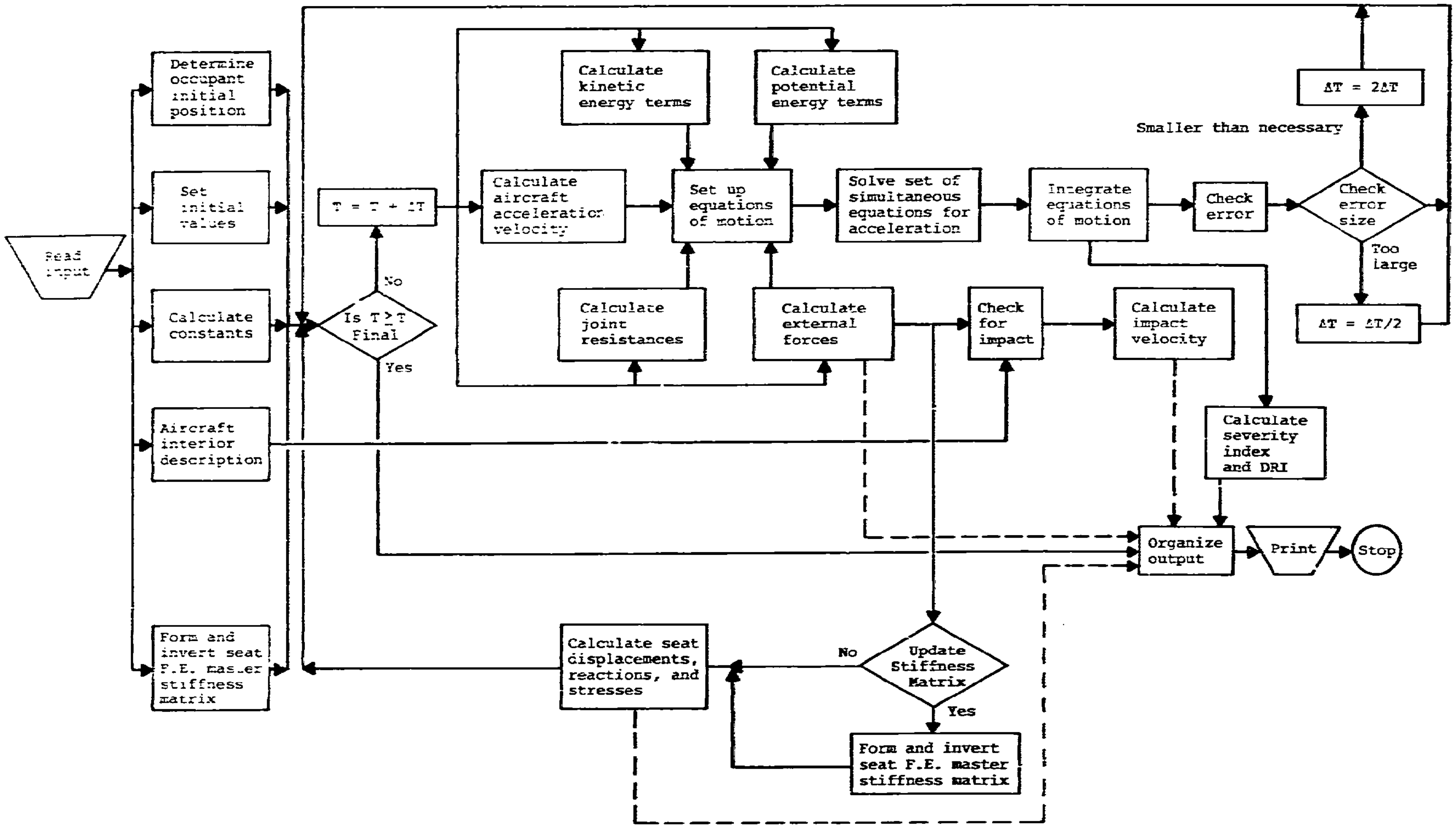


Figure D-1. Overall organization of Program SOM-TA.

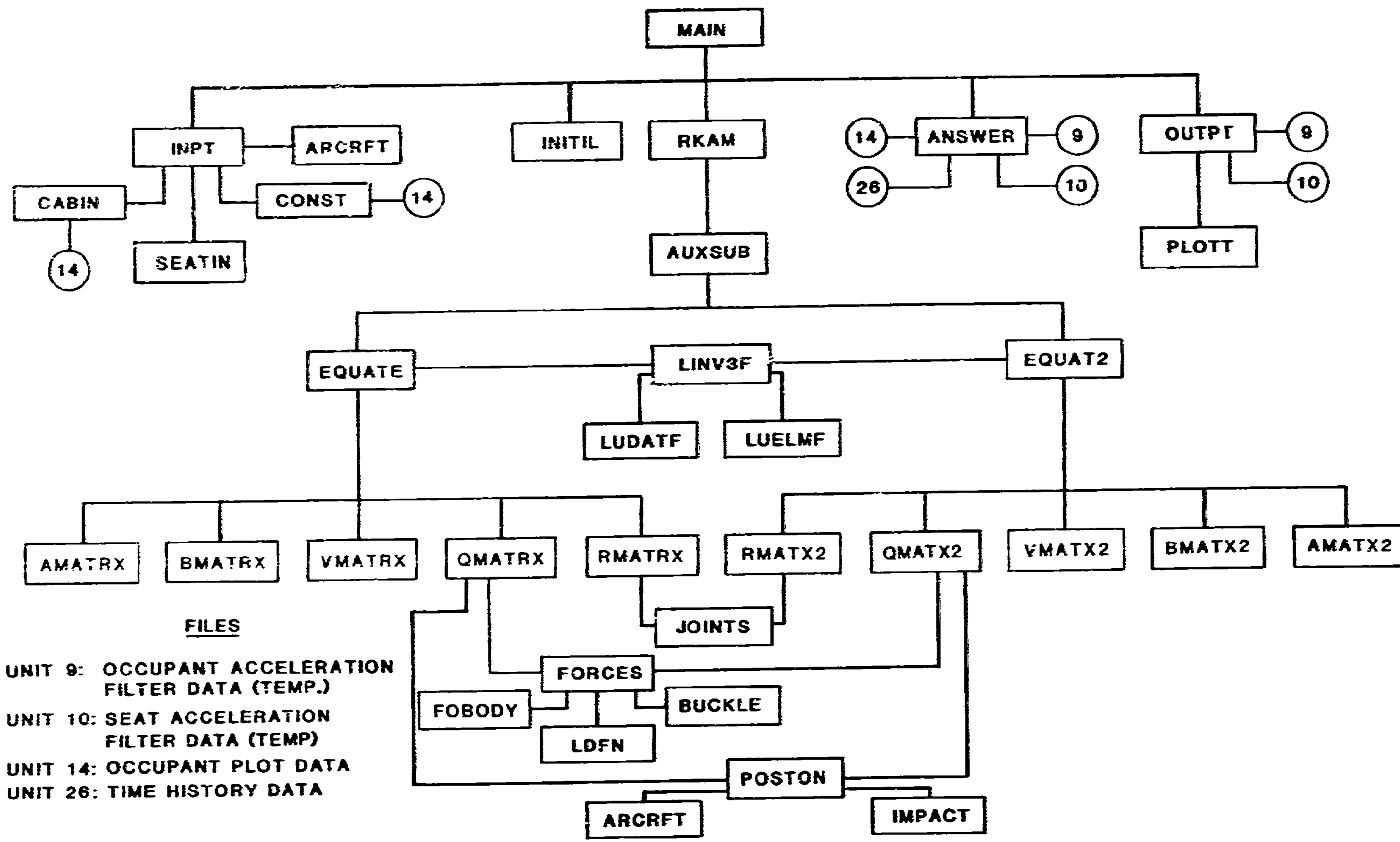


Figure D.2 SOM-TA Program Structure: Occupant Segment.

D.1.5 Subroutine AUXSUB. Called by RKAM (also initially by MAIN); calculates derivatives and forms two 1 x 2N arrays of variables and derivatives:

$$
\begin{array}{ll}
V(1) = Q(1) & DER(1) = QD(1) \\
\vdots & \vdots \\
V(N) = Q(N) & DER(N) = QD(N) \\
V(N+1) = QD(1) & DER(N+1) = QDD(1) \\
\vdots & \vdots \\
V(2N) = QD(N) & DER(2N) = QDD(N)
\end{array}
$$

where N is the number of degrees of freedom, either 12 for the two-dimensional model or 29 for the three-dimensional model. The velocity and acceleration of the DRI model are assigned to DER(2N+1) and DER (2N+2), respectively. If the two-degree-of-freedom energy-absorbing seat model is used, its velocities and accelerations are assigned to DER(2N+3) through DER(2N+6).

EQUATE is called to provide values of the derivatives (the generalized velocities, QD(J), and accelerations QDD(J)). RKAM then integrates the two systems of first-order equations.

D.1.6 Subroutine BMATRX. Called by EQUATE; calculates elements of velocity-dependent vector {B} for three-dimensional model.

D.1.7 Subroutine BMATX2. Called by EQUAT2; calculates elements of vector {B} for two-dimensional model.

D.1.8 Subroutine BUCKLE. Called by FORCES; determines position of point of intersection between abdominal contact surface and thigh contact surfaces (projected on X-Z plane).

D.1.9 Subroutine CABIN. Called by INPT; computes coordinates for image of seat in front of that being modeled. These coordinates are then available for use by passenger plot program.

D.1.10 Subroutine CONST. Called by INPT, once for each passenger; based on input data, calculates values of parameters that remain constant throughout program execution. These constants include functions of occupant dimensions used in the equations of motion and joint resistance parameters.

CONST also writes occupant dimensions on unit 14 for plotting.

D.1.11 Subroutine EQUATE. Called by AUXSUB for the three-dimensional occupant; uses latest values of generalized coordinates and velocities to calculate terms in occupant equations of motion. Solves equations of motion for accelerations QDD(J).

Calls AMATRX, BMATRX, VMATRX, RMATRX, AND QMATRX in setting up the equations of motion and calls LINV3F for their solution.

D.1.12 Subroutine EQUAT2. Called by AUXSUB for the two-dimensional occupant; uses latest values of generalized coordinates and velocities to calculate terms in occupant equations of motion. Solves equations of motion for accelerations QDD(J).

Calls AMATX2, BMATX2, VMATX2, RMATX2, and QMATX2 in setting up the equations of motion and calls LINV3F for their solution.

D.1.13 Subroutine FOBODY. Called by FORCES if IRSYS = 0 for lap belt only; checks for head/leg and chest/leg contact. If contact occurs, the force is calculated based on an exponential function. The components of the force are then added to the F array already computed by FORCES.

D.1.14 Subroutine FORCES. Called by QMATRX or QMATX2; calculates forces exerted on occupant by restraint system, cushions, and floor. Calculates deflection of each cushion or restraint system components and passes deflection to subroutine LDFN for computation of force.

The forces of the floor and seat cushions include frictional components whose directions oppose the current velocity of the occupant with respect to the floor or cushion.

The forces are placed in an array (F(I, J), I = 1, 11, J = 1, 3) for use in QMATRX or QMATX2.

If the two-degree-of-freedom energy-absorbing seat model is used, the translational and rotational accelerations are calculated.

D.1.15 Subroutine IMPACT. Called by FORCES; computes point of closest proximity between each contact surface on the occupant and seat in front. DELIMP(N,J) is the penetration of occupant surface N into the seat back in front. If DELIMP(N,J) $\geq$ 0 the impact velocity VELIMP(N,J) is calculated.

D.1.16 Subroutine INITIL. Called by MAIN, once for each passenger; calculates initial values of the generalized coordinates and velocities for the occupant and the initial deflections of the seat. INITIL first uses input values of GAM(J) to determine the position of the body segments 1 through 7. Based on the aircraft orientation, the occupant's weight is applied to the seat and restraint system, and the position of the lower torso segment (X_1, Y_1, Z_1) is determined. From the X and Z coordinates of segment 1 (computed here) and of the occupant's heels (from INPT) the position of the leg segments is calculated. Throughout these computations, the body is assumed to be symmetric with respect to the aircraft (X-Z) plane.

If the seat is initially warped so that the seat back angle is changed, the values of GAM(1), GAM(2), and GAM(3) are adjusted accordingly.

In the event that the input initial conditions impose unreasonable requirements on occupant geometry, a diagnostic message is provided and execution is stopped.

D.1.17 Subroutine INPT. Called by MAIN; reads occupant input data. A detailed description of input is presented in chapter 2 and appendix A.

D.1.18 Subroutine JOINTS. Called by RMATRX or RMATX2; fits a cubic curve into the transition region of the joint stopping moments.

D.1.19 Subroutine LDFN. Called by FORCES: uses linear interpolation in a table of force (Y) versus deflection (X) values. A description of the parameters in the calling sequence follows:

X	a table of the independent variable, x_i, such that $x_{i+1} \geq x_i$ (if II = 0)
Y	the table of the dependent variable, $y_i = y(x_i)$ (if II = 0)
N	the number of entries in each of the above tables; i = 1,...N
XA	the independent variable, x, for which interpolation is requested
XLAST YLAST	previous values of XA and YA
ICHK	index which is 0 or 1 depending on call during loading or unloading
XCURV YCURV	point on loading curve from which unloading started
C	unloading slope, used only if IUNLD = 2.
YA	the dependent variable, $y = y(x)$, being determined
IUNLD	index which is 2 if unloading slope, C, is to be used, 1 if unloading proceeds along basic loading function.

D.1.20 Subroutine LINV3F. Peforms matrix decomposition, matrix inversion, linear equation solution, and determinant evaluation:

A	Input/output matrix of dimensions N x N. See parameter IJOB.
B	Input/output vector of length N when IJOB = 2 or 3. On input, B contains the right-hand side of the equation AX = B. On output, the solution X replaces B. Otherwise, B is not used.
IJOB	Input option parameter. IJOB = I implies when I = 1, invert matrix A. A is replaced by its inverse. I = 2, solve the equation AX = B. A is replaced by the LU decomposition of a rowwise permutation of A, where U is upper triangular and L is lower triangular with unit diagonal. The unit diagonal of L is not stored.

I = 3, solve AX = B and invert matrix A. A is replaced by its inverse.

I = 4, compute the determinant of A. A is replaced by the LU decomposition of a rowwise permutation of A.

N — Order of A. (input)

IA — Row dimension of A as specified in the calling program. IA must be greater than or equal to N. (input)

D1,D2 — If D1 is non-negative on input, then D1 and D2 will be components of the determinant on output such that determinant (A) = D1*2**D2.

WKAREA — Work area of length at least 2*N when IJOB = 1 or 3. Work area of length at least N when IJOB = 2 or 4.

IER — Error parameter.
Warning with fix = 64+N.
N = 1 indicates that IJOB was less than 1 or greater than 4. IJOB is assumed to be 4.
Terminal error = 128+N.
N = 2 indicates that matrix A is algorithmically singular.

D.1.21 Subroutine LUDATF. Performs L-U decomposition by the Crout algorithm with optional accuracy test.

A — Input matrix of dimension N x N containing the matrix to be decomposed.

LU — Real output matrix of dimension N x N containing the L-U decomposition of a rowwise permutation of the input matrix.

N — Input scalar containing the order of the matrix A.

IA — Input scalar containing the row dimension of matrices A and LU in the calling program.

IDGT — Input option.
If IDGT is greater than zero, the non-zero elements of A are assumed to be correct to IDGT decimal places. LUDATF performs an accuracy test to determine if the computed decomposition is the exact decomposition of a matrix which differs from the given one by less than its uncertainty.

If IDGT is equal to zero, the accuracy test is bypassed.

D1 — Output scalar containing one of the two components of the determinant. See description of parameter D2, below.

D2 — Output scalar containing one of the two components of the determinant. The determinant may be evaluated as (D1)(2**D2).

IPVT Output vector of length N containing the permutation indices.

EQUIL Output vector of length N containing reciprocals of the absolute values of the largest (in absolute value) element in each row.

WA Accuracy test parameter, output only if IDGT is greater than zero. See element documentation for details.

IER Error parameter.
Terminal error = 128+N
N = 1 indicates that matrix A is algorithmically singular.
Warning error = 32+N
N = 2 indicates that the accuracy test failed. The computed solution may be in error bymore than can be accounted for by the uncertainty of the data. This warning can be produced only if IDGT is greater than 0 on input.

D.1.22 Subroutine LUELMF. Performs elimination part of solution of AX = B, in full-storage mode

A The result, LU, computed in the subroutine LUDATF, where L is a lower triangular matrix with ones on the main diagonal. Y is upper triangular. L and U are stored as a single matrix A, and the unit diagonal of L is not stored.

B B is a vector of length N on the right-hand side of the equation AX = B.

IPVT The permutation matrix returned from the subroutine LUDATF, stored as an N length vector.

N Order of A and number of rows in B.

IA Number of rows in the dimension statement for A in the calling program.

X The result X.

D.1.23 Subroutine OUTPT. Called by MAIN; writes output data, along with headings, on output file. The parameter IOUT(J) from input determines whether the output file receives data of Type J. For example, output category no. 1 is occupant segment position information. If IOUT(1) = 1, these data go to output; if IOUT(1) = 0, they do not. Also performs filtering of acceleration data if requested in input.

D.1.24 Subroutine PLOTT. Provides printer plots for up to three dependent, continuous, single-valued functions (Y1, Y2, Y3) against an even-incremental independent variable (X).

M	The number of dependent variables (1, 2, or 3).
NP	The number of points to be plotted for each dependent variable.
X	The independent variable.
Y1 Y2 Y3	The dependent variables.

D.1.25 Subroutine POSTON. Called by QMATRX or QMATX2; uses equations of the form

$$\begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix} = \begin{bmatrix} T^n \end{bmatrix} \begin{Bmatrix} x_n \\ y_n \\ z_n \end{Bmatrix}$$

to compute absolute positions of 29 points on body (XC, YC, ZC). Computes positions of same 29 points in aircraft coordinate system (XCA, YCA, ZCA). Calculates velocities (XCDA, YCDA, ZCDA) for output.

D.1.26 Subroutine QMATRX. Called by EQUATE for three-dimensional model; calculates elements of generalized force vector $\{Q_f\}$. Calls FORCES for computation of external forces acting on occupant.

D.1.27 Subroutine QMATX2. Called by EQUAT2 for two-dimensional model; calculates elements of generalized force vector $\{Q_f\}$. Calls FORCES for computation of external forces acting on occupant.

D.1.28 Subroutine RKAM. Called by MAIN; solves a set of N simultaneous, first-order, ordinary differential equations. Because of the importance of the integration scheme to the success of any dynamic analysis program, a detailed discussion of the method is provided along with the description of the FORTRAN subroutine.

Method - The user is allowed an option of using either the Runge-Kutta classical fourth-order method or the Adams-Moulton predictor-corrector method using the Runge-Kutta method for starting the process.

The system of equations to be solved is:

$$\begin{aligned} &y_i' = f_i(x, y_1, y_2 \ldots, y_N) \\ & \qquad\qquad\qquad\qquad i = 1, 2, \ldots, N \qquad\qquad (D.1) \\ &y_i(x_o) = y_{io} \end{aligned}$$

Let y_{in} be the value of y_i at $x = x_n$ and f_{in} the derivative of y_i at $x = x_n$, and let h be the increment (step size) of the independent variable x. The classical Runge-Kutta fourth-order method uses the formulas

$$
\begin{aligned}
k_{i1} &= hf_i(x_n, y_{in}), \\
k_{i2} &= hf_i(x_n + \tfrac{1}{2}h, y_{in} + \tfrac{1}{2}k_{i1}), \\
k_{i3} &= hf_i(x_n + \tfrac{1}{2}h, y_{in} + \tfrac{1}{2}k_{i2}), \\
k_{i4} &= hf_i(x_n + h, y_{in} + k_{i3}), \\
y_{i,n+1} &= y_n + \tfrac{1}{6}(k_{i1} + 2k_{i2} + 2k_{i3} + k_{i4})
\end{aligned}
\tag{D.2}
$$

The normal option is to continue the integration with Adams-Moulton predictor-corrector formulas once enough back values have been generated by the Runge-Kutta method.

The Adams-Moulton predictor-corrector formulas for the system (D.1) are

$$y^{(p)}_{i,n+1} = y_{i,n} + \frac{h}{24}(55f_{i,n} - 59f_{i,n-1} + 37f_{i,n-2} - 9f_{i,n-3}) \tag{D.3}$$

$$y^{(c)}_{i,n+1} = y_{i,n} + \frac{h}{24}(9f^{(p)}_{i,n+1} + 19F_{i,n} - 5f_{i,n-1} + f_{i,n-2}) \tag{D.4}$$

The corrector formula (D.4) is applied only once so that only two derivative evaluations are needed for each Adams-Moulton integration step. The starting values needed in (D.3) are obtained using the Runge-Kutta method.

The Adams-Moulton method may be used with either a fixed step size or a variable step size. The step size to be used in the variable mode is determined from the difference between the predicted and corrected values. The integration step size is thus controlled dynamically between prescribed error bounds so that execution speed and accuracy can be optimized.

Restrictions - An auxiliary routine must be provided for evaluation of the first-order derivatives. (See AUXSUB under Calling Sequence.)

Initial conditions for both variables and derivatives must be stored in their respective locations prior to entering RKAM.

Calling Sequence

XDP	=	x, the independent variable
HDP	=	h, the integration step size

VAR = N-dimensional vector of dependent variables ($y_1, y_2, \ldots, y_n$)

DER = N-dimensional vector of derivatives ($y_1', y_2', \ldots, y_n'$)

AUXSUB = Name of the auxiliary routine that computes derivatives and stores them in DER (1) to DER(N). The main program, which calls RKAM, must contain an EXTERNAL statement. No items are allowed in the calling sequence.

N = Number of equations

OPT = Option indicator, zero for AM, non-zero for RK only

EU = N-dimensional vector of upper bounds from main program

EL = N-dimensional vector of lower bounds from main program

HMAX = Absolute value of maximum allowable step size

HMIN = Absolute value of minimum allowable step size (HMIN > 0).

ICNT = Internal counter, set to zero initially in MAIN

TEMPS = A two-dimensional, (9,N) storage region. TEMP (1,I), I = 1, N must be set to zero initially or when restarting.

NH = Index of the equation that caused halving when step size has been reduced.

VAR, DER, and all other locations referred to in both the main program and the auxiliary subroutine must be assigned in COMMON statements. (If the step size were to be changed outside of RKAM, the restart flag, ICNT, should be set to zero.) This restriction does not apply in the "RK only" mode. HMAX, HMIN, EU, and EL are also irrelevant in this mode.

Functional Description - The subroutine employs the fourth-order Adams-Moulton predictor-corrector method using the classical fourth-order Runge-Kutta method to obtain starting values.

AM has the following advantages with respect to RK:

1. Only half as many derivative evaluations per integration step are required to attain the same order of accuracy.

2. The local truncation error may be estimated at the conclusion of each integration step thereby providing a means for step size control.

For each variable, the local truncation error is approximately one-fourteenth the difference between the predicted and corrected values, that is

$$e_i = \frac{1}{14}\left| y_i^{(c)} - y_i^{(p)} \right| \qquad (D.5)$$

In RKAM, the differences $D_i \equiv \left| y_i^{(c)} - y_i^{(p)} \right|$ are formed and compared with positive numbers EU_i and EL_i. If $D_i \geq EU_i$ for <u>any</u> i, the step size is halved provided $|h/2| \geq$ HMIN. If $D_i < EL_i$ for <u>all</u> i and for three successive steps, the step size is doubled provided $|2h| \leq$ HMAX. (Note that h may be held fixed either by setting HMIN = HMAX or by making EU_i and EL_i prohibitively large and small, respectively.) If halving is called for during the first AM step following the three initial RK steps, the step size is halved, the independent variable is set back to its initial value, and the three RK steps are repeated. This will continue until the first AM step is successfully taken. From this point on, halving is effected by interpolation of past data whereas doubling is accomplished by alternate selection of past data.

In selecting EU and EL, one should note the following:

1. The test is an absolute test. To control relative error EU_i and EL_i should be computed as functions of y_i prior to each integration step.

2. Although the local truncation error in y_i is not allowed to exceed EU_i, this does not imply that the cumulative error will not exceed EU_i. Therefore, EU_i and EL_i should depend upon the maximum allowable cumulative error and the number of integration steps.

3. Since doubling h will multiply the truncation error by a factor of 2^5, EL_i should be chosen less than $EU_i/32$ if the advantages of doubling are not to be short-lived.

D.1.29 <u>Subroutine RMATRX</u>. Called by EQUATE for three-dimensional model; calculates elements of joint resistance vector $\{R\}$. Input parameter IMAN determines whether human (IMAN = 0) or dummy (IMAN = 1) model is used.

D.1.30 <u>Subroutine RMATX2</u>. Called by EQUAT2 for two-dimensional model; calculates elements of joint resistance vector $\{R\}$.

D.1.31 <u>Subroutine SEATIN</u>. Called by INPT if NSEAT = 0; reads input data required for rigid seat model and energy-absorbing option.

D.1.32 <u>Subroutine VMATRX</u>. Called by EQUATE for three-dimensional model; calculates elements of force vector $\{F_p\}$ derived from system potential energy.

D.1.33 <u>Subroutine VMATX2</u>. Called by EQUAT2 for two-dimensional model; calculates elements of force vector $\{F_p\}$ derived from system potential energy.

D.2 <u>SEAT SUBROUTINE DESCRIPTIONS</u>

The relationships among the subroutines in the seat segment of the program are illustrated in figure D-3. Individual subroutines are described below.

D.2.1 <u>Subroutine ASSBLE</u>. Called by MAIN; initializes the element data storage. The mass matrix and the initial transformations $\underline{B}_o$ for the nodal coordinate systems are assembled, and the initial values of the pointing vectors $\overline{n}, \overline{\eta}$, and $\overline{\xi}$ and the normal components of the rigid links $\overline{\Delta}$ are generated.

D.2.2 <u>Subroutine ASSMBL</u>. Called by PLSTF and BMSTF; assembles the master stiffness matrix in a banded symmetric form. This subroutine calls subroutine

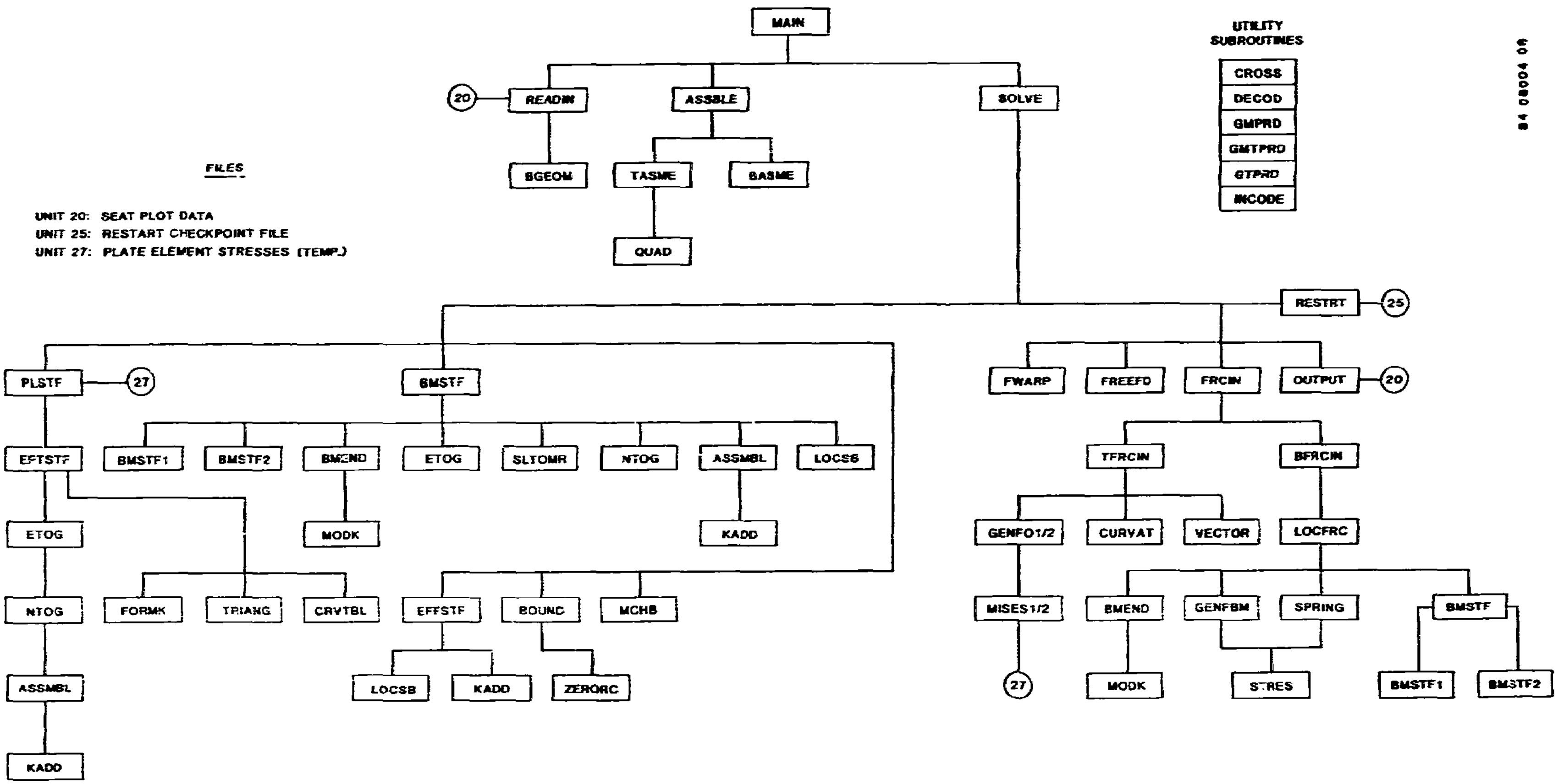


Figure D-3. SOM-TA Program Structure: Seat Segment.

KADD, which adds a particular element of the square element stiffness matrix to the banded master stiffness matrix.

D.2.3 Subroutine BASME. Called by ASSBLE; calculates the contributions to the lumped mass matrix for beam elements and forms the initial element coordinate system $\underline{E}$ for beam and spring elements.

D.2.4 Subroutine BFRCIN. Called by FRCIN: calculates the beam and spring element deformations and nodal forces in the element coordinate system. Performs the operations associated with the master-slave relations and transforms the forces to the nodal coordinate system.

D.2.5 Subroutine BGEOM. Called by READIN; reads the data describing the cross-section properties of beams and springs. Generates certain additional data, such as segment lengths and torsional constants.

D.2.6 Subroutine BMEND. Called by BMSTF; calls MODK to calcuate the reduced stiffness matrix due to axial force, shear, and moment discontinuity.

D.2.7 Subroutine BMSTF. Called by SOLVE; calculates beam or spring element stiffness matrix. The principal subroutines called include BMSTF1 for elastic material, BMSTF2 for inelastic material, BMEND for the modification of the stiffness due to special end conditions, and ASSMBL for assembly of element stiffness.

D.2.8 Subroutine BMSTF2. Called by BMSTF; calculates the elastic stiffness matrix for a beam or spring element.

D.2.9 Subroutine BMSTF2. Called by BMSTF; calculates the tangential stiffness matrix for a beam or spring element.

D.2.10 Subroutine BOUND. Called by SOLVE; applies the specified boundary conditions to the assembled master stiffness matrix by calling ZERORC, which deletes the appropriate rows and columns of the banded matrix.

D.2.11 Subroutine CROSS. Utility subroutine; calculates the cross product of two matrices.

D.2.12 Subroutine CRVTBL. Called by EPTSTF; contains plate bending curvature tables.

D.2.13 Subroutine CURVAT. Called by TFRCIN; provides algebraic expressions for curvature components at the midpoints of the three sides of the plate elements as functions of the nodal rotations.

D.2.14 Subroutine DECOD. Utility subroutine, decodes a packed word.

D.2.15 Subroutine EFFSTF. Called by SOLVE; generates the effective stiffness with a 3 x 3 rotational mass matrix. Calls KADD, which adds a particular element of the square matrix to the banded matrix.

D.2.16 Subroutine EPTSTF. Called by PLSTF; calculates plate element stiffness matrix. This subroutine calls TRIANG for the in-plane strain-displacement relationship, CRVTBL for curvature, and FORMK for calculation of appropriate elements in the stiffness matrix.

D.2.17 Subroutine ETOG. Called by EPTSTF; transforms appropriate variables from the element coordinate system to the global coordinate system.

D.2.18 Subroutine FORMK. Called by EPTSTF; calculates the products of three different matrices.

D.2.19 Subroutine FRCIN. Called by SOLVE; calculates internal nodal forces. The program updates the nodal coordinate transformations $\underline{B}$, and calls subroutines TFRCIN for plate forces and BFRCIN for beam forces.

D.2.20 Subroutine FREEFD. Called by SOLVE; calculates the external forces including restraint system forces and forces exerted by the occupants on the seat pan and seat back.

D.2.21 Subroutine FWARP. Called by SOLVE; modifies forces to account for specified floor warp displacements and rotations.

D.2.22 Subroutine GENFBM. Called by LOCFRC; numerically integrates stresses over the cross section of the beam to obtain internal forces and moments.

D.2.23 Subroutines GENF01/GENF02. Called by TFRCIN; computes moments and forces at a cross section of an elastic-plastic plate (with/without) integrating through the thickness

D.2.24 Subroutine GMPRD. Utility subroutine; performs general matrix multiplication.

D.2.25 Subroutine GMTPRD. Utility subroutine; calculates the product of a matrix with the transpose of another matrix.

D.2.26 Subroutine GTPRD. Utility subroutine; calculates the product of the transpose of a matrix with another matrix.

D.2.27 Subroutine INCODE. Utility subroutine; encodes a number into a packed word.

D.2.28 Subroutine KADD. Called by ASSMBL and EFFSTF; adds a particular element of the square matrix to the banded matrix.

D.2.29 Subroutine LOCFRC. Called by BFRCIN; calculates midplane strains, curvatures, nodal forces, and moments in the beam element coordinate system. Elongation and nodal forces are also calculated for the spring in the element coordinate system.

D.2.30 Subroutine LOCSB. Called by ASSMBL; computes the location of a particular element of a square matrix when assembled into the banded symmetric form.

D.2.31 Subroutine MCHB. Called by SOLVE; solves the linear system of equations $\underline{K}\,\overline{x} = \overline{F}$ for $\overline{x}$ (displacements). The master stiffness matrix $\underline{K}$ is assumed to be symmetric positive definite and stored in the compressed form, that is, main diagonal and upper codiagonals rowwise in successive storage locations.

$\overline{F}$ is the applied force vector. This is a two-step equation solver that uses Cholesky's method. In the first step the master stiffness matrix $\underline{K}$ is factored into an upper diagonal matrix $\underline{U}$ and a lower diagonal matrix $\underline{L}$.

$$\underline{K} = \underline{L}\,\underline{U} \tag{D.6}$$

and let

$$\underline{U}\,\overline{x} = \overline{v} \tag{D.7}$$

so that the linear system of equations $\underline{K}\,\overline{x} = \overline{F}$ is equivalent to

$$\underline{L}\,\overline{v} = \overline{F} \tag{D.8}$$

In the second step, equation (D.8) is solved by forward reduction for $\overline{v}$ and finally equation (D.7) is solved for $\overline{x}$ by back substituting for $\overline{v}$.

D.2.32 Subroutines MISES1/MISES2. Called by TFRCIN; computes biaxial elastic-plastic stress-strain relations using Von Mises yield criterion.

D.2.33 Subroutine MODK. Called by BMEND; modifies beam element stiffness matrix and forces and moments for specified beam end conditions.

D.2.34 Subroutine NTOG. Called by PLSTF and BMSTF; transforms appropriate variables from global coordinate system to nodal coordinate system.

D.2.35 Subroutine OUTPUT. Called by SOLVE; organizes and tabulates output for those quantities selected for output. Deformed seat model plot data are written onto file 20 at user-selected times.

D.2.36 Subroutine PLSTF. Called by SOLVE; calls EPTSTF to form the plate element stiffness matrix and then uses ASSMBL to assemble the element stiffness.

D.2.37 Subroutine QUAD. Called by TASME; provides an algorithm for lumping the plate rotational inertia at the three defining nodes based on the properties of three quadrilaterals formed in the triangle by extending perpendiculars from the centroid to three sides.

D.2.38 Subroutine READIN. Called by MAIN; reads all input data and, if required, initializes the data files. Undeformed seat model data and model parameters are written onto file 20 if requested.

D.2.39 Subroutine RESTRT. Called by SOLVE; generates checkpoint data files or reads files that contain sufficient information to restart the solution procedures at specified times.

D.2.40 Subroutine SLTGMR. Called by BMSTF; transforms the appropriate variables from a slave node to the corresponding master node.

D.2.41 Subroutine SOLVE. Called by MAIN; performs the main solution procedure. The principal subroutines called are BMSTF for beam or spring stiffness, PLSTF for plate stiffness, FREEFD for applied forces, MCHB for the solution of displacements and OUTPUT for printed output and plot of selected parameters.

D.2.42 Subroutine SPRING. Called from LOCRFC; calculates element forces for a spring element.

D.2.43 Subroutine STRES. Called from GENFBM and SPRING; provides an algorithm for uniaxial stress-strain relationship.

D.2.44 Subroutine TASME. Called from ASSBLE; calculates the contributions to the lumped mass matrix for plate elements. Forms the initial element coordinate system E for the plate elements.

D.2.45 Subroutine TFRCIN. Called from FRCIN; calculates plate element deformations and forces in element coordinate system. The forces are then transformed to the nodal coordinate system.

D.2.46 Subroutine TRIANG. Called from EPTSTF; contains algebraic expressions of the strain-displacement relationship for a plate element.

D.2.47 Subroutine VECTOR. Called from TFRCIN; calculates the deformed length of plate element sides. The components of a vector normal to the reference surface are defined by the displaced positions of the three node points.

D.2.48 Subroutine ZERORC. Called from BOUND; deletes appropriate rows and columns of a banded matrix to enforce the specified boundary conditions.

APPENDIX E

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