AFAMRL-TR-81-111
VOLUME II

ARTICULATED TOTAL BODY (ATB) "VIEW" PROGRAM SOFTWARE REPORT, PART II, USER'S GUIDE

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JUNE 1983

Summary report for June 1981 to June 1983

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WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6573

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFAMRL-TR-81-111 Volume II
6a. NAME OF PERFORMING ORGANIZATION: Systems Research Laboratories, Inc. / 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Modeling and Analysis Branch, Biodynamics & Bioengineering Division
6c. ADDRESS (City, State, and ZIP Code): 2800 Indian Ripple Road, Dayton OH 45440	7b. ADDRESS (City, State, and ZIP Code): AFAMRL/BBM, Wright-Patterson AFB OH 45433-6573
8a. NAME OF FUNDING/SPONSORING ORGANIZATION / 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: F33615-81-C-0500
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62202F	7231	15	02

11. TITLE (Include Security Classification)
ARTICULATED TOTAL BODY (ATB) "VIEW" PROGRAM SOFTWARE REPORT, PART II, USER'S GUIDE (UNCLASSIFIED)

12. PERSONAL AUTHOR(S)
Bruce D. Leetch, William L. Bowman

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Summary	FROM Jun 81 TO Jun 83	JUNE 1983	49

16. SUPPLEMENTARY NOTATION
Previously a limited document, AD-B075 162.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Computer Simulation, Human Body Model, Aerodynamic Forces, Mathematical, Ejection, Harness Restraint System, Three-Dimensional Dynamics, Computer Graphics, Crash Victim Simulation
20	11		
12	05		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Articulated Total Body Model (ATBM) is used by the AFAMRL to study the biomechanics of pilot-seat ejection. The VIEW program provides a graphical representation of the simulation output from the ATBM.

The VIEW input data consist of two files. The first file, output from the ATBM, consists of body element and contact plane information. The second file contains control data necessary for running VIEW and additional planar surfaces for visual enhancement of the plots

Object plot size and orientation are defined through a combination of plotting surface dimension, scale factor, viewpoint position, the direction from the observer position (viewpoint) to the object being viewed, and the distance from the viewpoint to the object.

(Continued on reverse)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL: ROY RASMUSSEN	22b. TELEPHONE (Include Area Code): (513) 255-3667 / 22c. OFFICE SYMBOL: AFAMRL/BBM

19. ABSTRACT (Continued)

VIEW output consists of two files. The first file is a listing file containing an echo of the input data and debug messages. The second file is the graphics output of VIEW. VIEW graphics can be output to four different devices: single color and multicolor Calcomp plotters and single color and multicolor graphics terminals.

This document is Part II of a two-part set (Part I being the Programmer's Guide). It contains all pertinent information necessary for running VIEW. It is designed for the experienced ATBM user attempting to evaluate the output of his/her simulation. The User's Guide describes the necessary concepts for linking and running VIEW, VIEW's input and output data structure, and explicitly documents the input control file.

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Section 1.0
INTRODUCTION

The VIEW program provides computer generated visual data displays for the users of the Articulated Total Body Model (ATBM) program. The ATBM provides a challenging task to any user interested in what the ATBM program has predicted because of the large amount of data available as output. The VIEW program aids in the perception and evaluation of the gross body dynamics of the ATBM by providing pictorial 3D representations of one or more selected ATBM program time steps, including time step zero. A representation of time step zero is particularly useful in verifying the initial alignment and position of the body segments. In addition, movies can be created by plotting each time step and exposing the result to motion picture film. This technique provides a medium that quickly demonstrates the capabilities of the ATBM program. The use of motion picture film is also helpful in studying the dynamic characteristics of the simulation events being modeled.

The VIEW program has the capability to plot two basic types of elements. The first is ellipsoids. Ellipsoids are elements used to represent the subject being simulated. In a typical case, the ellipsoids represent the pilot. The second type of element represented by VIEW is polygons. These elements are used to represent contact planes used in ATBM simulations. The VIEW program was designed to work with elements corresponding to those found in the ATBM program. Although the internal representation of elements used by VIEW is not the same as the ATBM program, the differences are compensated for by using subroutines that restructure data from ATBM to VIEW format.

The mathematics used within the VIEW program to represent ellipsoids can be generally described as a system of nonlinear vector equations. Since ellipsoids are quadratic surfaces, all equations dealing with ellipsoid projection and hidden line removal use a system of quadratic equations. Contours for 3D graphics can be represented by either lines or contour surfaces with shadowing. Calcomp plotting was selected for representing ellipsoids because of its capability to draw contour lines. Once the contour mesh has been generated, it is retained throughout all time step processing to allow for identification of rotation of ellipsoids.

Polygons are depicted as a set of linear vector equations. By restricting the allowable polygons to the class of convex polygons, implementation of fast and efficient algorithms was permitted. This restriction is not a limitation since any concave polygon can be constructed from a set of convex polygons. Polygons are supplied to the VIEW program in two ways. The first method reads polygon data generated by the ATBM program. These polygons should have corresponding contact cards in the ATBM program to assure proper attachment to the correct reference frame. If there is no defined contact in the ATBM program, the VIEW program attaches undefined plane systems to a user-supplied reference system. The second source of polygon data is from the user-supplied input control file and is called supplemental plane data. The polygon data contained within this file consists of the number of supplemental planes, the number of vertices for each plane, the position vectors of each of these vertices, and a reference system number for each plane.

A brief historical footnote for the VIEW program is as follows: An original VIEW program and several later versions were developed by AFAMRL (collectively called version 1.0). Several of these versions of the VIEW program are still in circulation at this time. A number of corrections have been made and new features added to version 1.0 and the enhanced version has been identified as 1.1. This User's Guide and the complementary Programmer's Guide addresses version 1.1 of VIEW. It is intended to implement software configuration control for version 1.1 of VIEW and to document all changes made to VIEW from version 1.1 forward. All users of VIEW will be notified of these changes when a new version of VIEW is ready for general usage. In this way, there will be only one current version of the program. Hopefully, this will eliminate any confusion about what version of VIEW any user possesses.

Section 2.0
GENERAL CONSIDERATIONS

2.1 INPUT/OUTPUT FILES USED BY VIEW

Four data files (two input and two output) are used by VIEW (Table 2.1). The first input file to VIEW is the ATB output file generated on the ATBM's FORTRAN unit no. 1. VIEW is formatted to automatically read this binary file from FORTRAN unit no. 1. (See ref. 1, Section 5.5 for further information on this file.)

TABLE 2.1. VIEW DATA FILES

FORTRAN Unit No.	Input or Output	Type	Description
1	input	unformatted	ATBM output file
5	input	formatted	control file
6	output	formatted	listing file
8	output	unformatted	graphics file

VIEW is a batch type program and needs a control file to select program options in order to run. The second input file is an input control file read from FORTRAN unit no. 5. This input file must be carefully thought out to avoid creating unwanted output. (See Section 3.0 for the format of the input control file.)

The first output file is the output listing file written to FORTRAN unit no. 6. This listing file contains two categories of data. The first category is a formatted listing of the input control file. The second category is debug messages controlled by card 5.0 of the input control file (see Section 3.0).

The second output file is the output graphics file written to FORTRAN unit no. 8. This data is generated by the graphics subroutines and is output either directly to the plotter/terminal or a file to be post-processed.

2.2 LINKING PHILOSOPHY FOR VIEW

The VIEW program has four output options (see Figure 2.1). Two are directed to the Calcomp plotter (single and multicolor) and the other two to a graphics terminal (also single and multicolor). The VIEW program must be linked with a different graphics subroutine library for each of the three output devices (Calcomp plotter, single and multicolor graphics terminal). The Calcomp subroutine library is able to accommodate both the single and multicolor plotters, while separate subroutine libraries may be needed for the single and multicolor graphics terminals. In this way, neither the FORTRAN source code nor the compiled object module for VIEW needs to be changed to direct the output to a different device. VIEW only needs its compiled object module to be linked with a different graphics subroutine library and the device flag changed in the input control file to enable output to a different device. You may need up to three different linked task files of the VIEW program if you wish to utilize all three of the output devices.

2.3 GRAPHICS SUBROUTINE LIBRARIES

The three subroutine libraries (Calcomp plotter, single and multicolor graphics terminal) fall into two categories (see Figure 2.1). The first is the standard Calcomp library consisting of the standard Calcomp subroutines (AXIS, PLOT, SCALE, SYMBOL, etc.) that operate the standard Calcomp plotters. The second category is what will be called in this discussion a Calcomp translator library. A two step process is contained within these translator libraries. The first step is to take the standard Calcomp calls and arguments and translate them into equivalent calls and arguments for the terminal graphics subroutines. The second step is for these terminal graphics subroutines (which are also contained within the library) to execute and perform the plotting on the terminal screen. An example of this second category of graphics subroutine library is the Tektronix Calcomp Preview Package. It takes the Calcomp calls, translates them into PLOT-10 calls, and then executes the PLOT-10 subroutines.

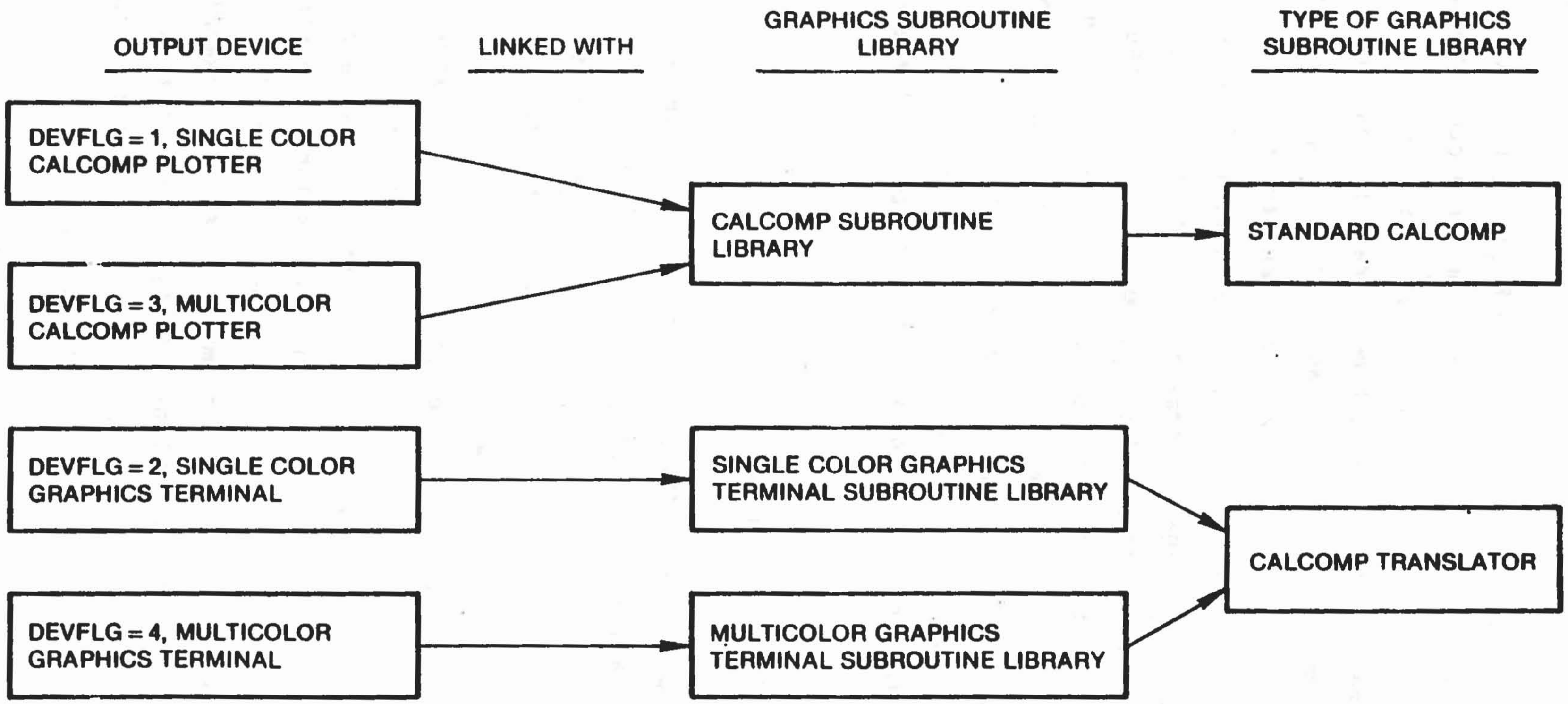


Figure 2.1. Output Device/Graphics Subroutine Library Linkage

2.4 VIEWPOINT SYSTEM DISCUSSION

This discussion will concern itself about the viewpoint, the focal point, and the scaling factor of the VIEW program. These variables interact in such a way that individual discussions about each are not sufficient to fully explain their function. A comprehensive discussion will be given to explain their use. Also refer to record 13.0 and 15.0 descriptions for additional information.

Figure 2.2 depicts the system used by the VIEW program to plot ATBM output. The viewpoint and the focal point are specified in the same coordinate system as an ATBM simulation segment. This segment may be a body segment, a vehicle segment, or the ground segment and is specified by variable IVP in record 15.0. The viewpoint is analogous to a location at which one would stand in a particular coordinate system to view an object (or more precisely, a point on the object) that exists in the same coordinate system. The focal point is the point on the object that is being viewed. Record 15.0 defines the viewpoint and the focal point. The VIEW program constructs an infinite plane (called the image plane) perpendicular to line D (a straight line between the viewpoint and the focal point). The intersection of this image plane with the surface of any object traces out a contour. A viewing plane is then placed between the viewpoint and the focal point centered on line D and a distance SFACTR from the viewpoint (see record 13.0 description for a definition of SFACTR). The X and Y dimensions of the viewing plane must be specified to limit which part of the infinite image is to be viewed. The X dimension of this viewing plane is defined in record 16.0 by the variables XMAX and XMIN and the Y dimension in record 13.0 by the variable PPD. The viewing plane corresponds to the Calcomp plotter paper or the graphics terminal screen. Straight lines are radiated from the viewpoint through each of the four corners of the viewing plane to project a rectangular border on the image plane. All contours on the image plane that fall outside this projected border will not be projected onto the viewing plane and, hence, not "seen."

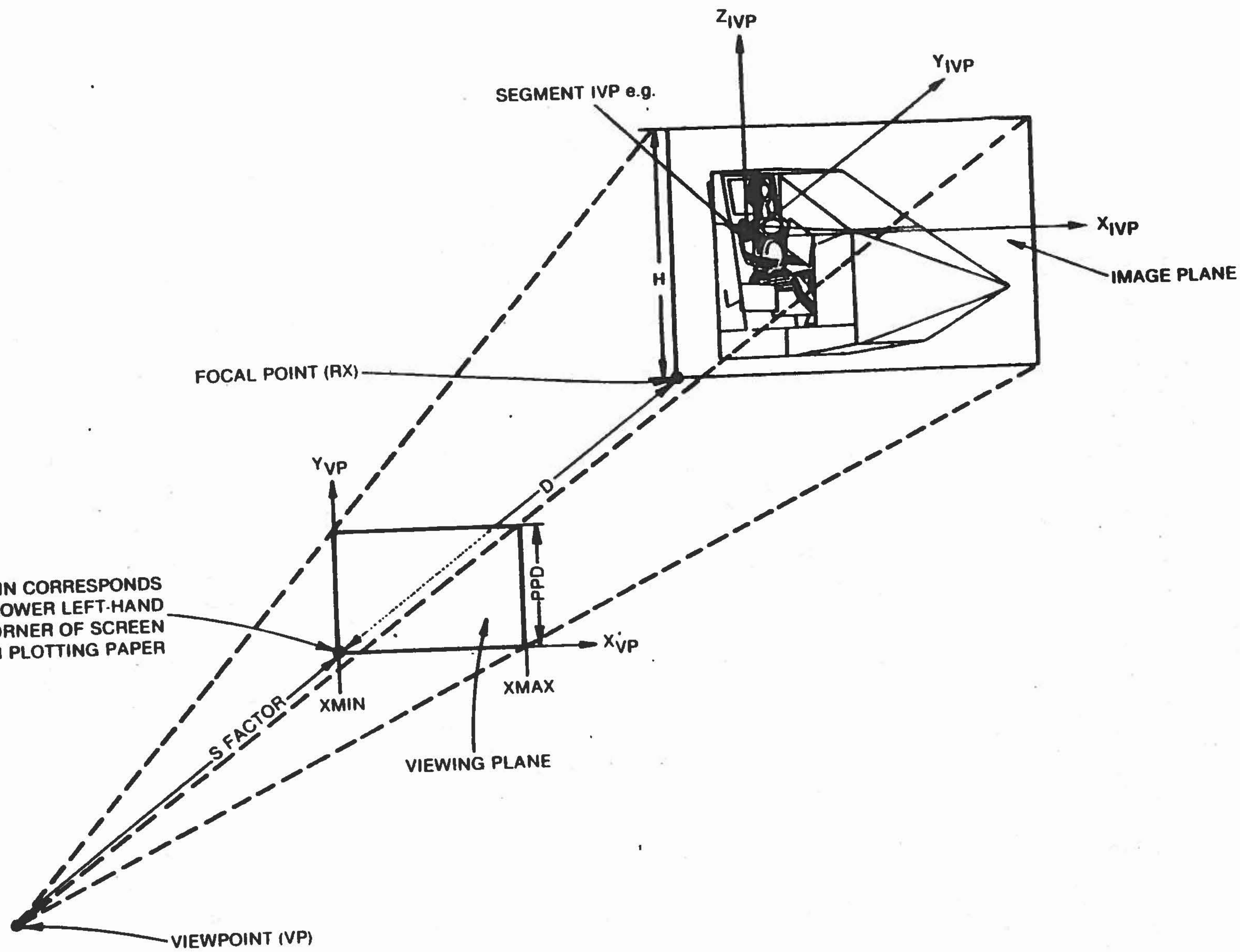


Figure 2.2. Viewpoint System

2.4.1 Viewpoint System Options

There are three methods in which to specify the necessary parameters for defining the viewpoint system for a VIEW run. These parameters are defined by the variables found in records 13.0, 15.0, 15.1, and 16.0.

A. The first method is specified by setting ICODE=2 in record 15.0. This method requires that the X, Y, and Z coordinates of the viewpoint (VP) and the focal point (RA); the height of the object to be plotted (H); the height (PPD) and width (XMAX-XMIN) of the viewing plane; and the distance between the viewpoint and the focal point (D) be specified. The VP is selected based on the desired size of the object and what perspective is to be taken. This value is arbitrary but it is suggested that the location of the viewpoint be such that the distance between the viewpoint and the focal point be approximately 1000 inches. The location of the center of the object is plotted (focal point) RA is provided by the output from the ATBM simulation. The nominal height of the object H is also provided by the output of the ATBM program. The height and width of the viewing plane (PPD and XMIN-XMAX) corresponds to the height and width of the Calcomp plotting paper or the graphics terminal screen. Given PPD, H, and D (calculated from the coordinates of the viewpoint and the focal point, see record 13.0 description), the scale factor SFACTR can be calculated by the formula:

$$SFACTR = (PPD/H) * D$$

from the law of similar triangles.

B. The second option for setting up a VIEW run is specified by setting ICODE=1 in record 15.0. It requires the X, Y, and Z coordinates of the viewpoint; the roll, pitch, and yaw angles of the viewpoint direction vector (i.e., $\vec{D}$); the height of the object to be plotted H; the X and Y dimensions of the viewing plane; and the distance from the viewing plane to the focal point D. Specifying

$|\vec{D}|$ and the orientation of $|\vec{D}|$ defines the focal point. Given the distance $|\vec{D}|$, the viewing plane height PPD, and the image height H, the scale factor SFACTR can be calculated in the same manner as above in A.

C. The last method for setting up a VIEW run is specified by setting ICODE=0 in record 15.0. It is similar to inputting the roll, pitch, and yaw angles except that the direction cosine matrix for the vector D is specified instead of the roll, pitch, and yaw angles. The first row of the direction cosine matrix is found in array RA in record 15.0 and the second and third rows in record 15.1.

2.4.2 Setting Up the Viewpoint System

When first setting up a particular VIEW run, it is common to make a series of runs to obtain the projected view that is the most aesthetically pleasing. The following order is suggested to minimize the number of iterations required to obtain an acceptable plot.

A. Keeping the scale factor constant (hence, the distance between the viewpoint and the focal point constant), vary the viewpoint until the desired perspective is obtained. This is done for ICODE=2 by keeping D constant, arbitrarily selecting two out of three direction components to remain constant, and calculating the third from the distance formula (see Section 3.0, record 13.0). For ICODE=1, the viewpoint and the roll, pitch, and yaw angles are varied to set the desired perspective. For ICODE=0, vary the direction cosine matrix rather than the roll, pitch, and yaw angles.

B. Once the desired perspective has been obtained, vary only the scale factor. This is analogous to sliding the viewing plane along the line between the viewpoint and the focal point. Decreasing the scale factor in effect moves the viewing plane closer to the viewpoint and results in a smaller image on the screen. Increasing the scale factor in effect moves the viewing plane closer to the focal point and results in a larger projected image.

C. After setting the perspective and scale factor, a series of ATBM runs may be run through VIEW which may have very minor differences in the size of the desired projected image. These differences can be overcome by the use of the offset option found on record 14.0 (variable OFSETX and OFSETY). The offset option slides the viewpoint and, hence, the viewing plane along two perpendicular axes which are both perpendicular to D. This allows different regions of the viewing plane to be viewed, holding the scale factor (i.e., the size of the image) and the perspective constant. A positive X offset, in effect, moves the focal point (and hence the image being viewed) to the right on the viewing plane (see Figure 2.2). A positive Y offset, in effect, moves the focal point (and hence the image being viewed) up on the viewing plane (see Figure 2.2).

Section 3.0

INPUT CONTROL FILE DESCRIPTION

This section contains a full summary of the input control file. As described in Section 2.0, the input control file selects program options and supplies data necessary for the operation of the VIEW program. The data contained in this file breaks down into the following ten basic categories:

1. Output device option (record 1.0).
2. Title frame and title strip data (2.0, 2.1, 3.0).
3. Time parameters for reading ATB input data (4.0).
4. Debug message flags (5.0).
5. Ellipsoid and polygon removal data (6.0, 6.1).
6. Supplemental polygon data (7.0, 7.1., 7.2).
7. Figure color data (8.0, 9.0, 10.0).
8. Plotting steps and vectors data (11.0, 12.0, 12.1).
9. Plotting parameters (13.0, 14.0, 16.0).
10. Viewpoint and focal point location data (15.0, 15.1).

The table contained in Appendix A describes the organization of the input control file. It is meant to be a brief overview and reference chart for the input control file. Following this introduction is a series of detailed summaries of all input control file record or record sets (record sets being two or more records). Each summary contains a list of FORTRAN variables read, the FORTRAN format of the records read, a discussion of the purpose of the record (set), and a detailed description of each variable. Two brief notes should be mentioned about the content of these summaries. First, in the variable lists, the range of the array locations used is given after the array name. In the variable descriptions, the actual dimension of the array is provided. Second, the FORTRAN format listed for a given record set is for a single record of that set. This format is executed repeatedly until all the records of the set have been read. For example, in record set 8.0, the format (8(5X, I5)) is given Since this record has four records in it, this format is executed four times.

3.1 INPUT CONTROL FILE RECORD AND RECORD SET SUMMARIES

RECORD 1.0

Variable List: DEVFLG   Format: (I1)

Discussion: This record directs the VIEW program output graphics file. Since the VIEW program is capable of generating pictorial plots on several output devices, the variable DEVFLG is needed to specify the device. (See Sections 2.2 and 2.3 for linking information.)

Variable	Description
DEVFLG	1. DEVFLG=1: This directs the output to a single color Calcomp plotter. When using this option, VIEW must be linked with the standard Calcomp library.
	2. DEVFLG=2: This directs the output to a single color graphics terminal. VIEW must be linked with a Calcomp translator subroutine library with this option.
	3. DEVFLG=3: This directs the output to the multicolor Calcomp plotter. Consult your system manual for the color numbering protocol used on your plotter. VIEW must be linked with the standard Calcomp library with this option.
	4. DEVFLG=4: This directs the output to the multicolor graphics terminal. Consult you system manual for the color numbering protocol used on your terminal. VIEW must be linked with a Calcomp translator subroutine library with this option.

RECORD 2.0

Variable List: NFRME* Format: (I2)

Discussion: VIEW has the capability for creating one or more title frames at the beginning of a plotting frame sequence. This record defines the number of these frames to make. NFRME may be set to zero if no title frame is desired. NFRME record set 2.1s must follow this record if NFRME is greater than zero.

Variable	Description
NFRME	Number of title frames.

RECORD SET 2.1

Variable List: ID (1-8, 1-20)*, ICOLOR (1-20)* Format: (7A4, A2, I2)

Discussion: Record set 2.1 is a series of 20 records that form the 20 lines of text for the title frame(s). There must be NFRME number of record set 2.1. Record set 2.1 is not read if NFRME=0.

Variable	Description
ID (10,20) ICOLOR (21)	Array ID contains the lines of text for the title frame. There are 30 characters per line. If the title frame is to be output to a multicolor plotter or multicolor graphics terminal, ICOLOR contains the color number for each line. On the one color plotter and the one color graphics terminal, ICOLOR is ignored.

*NOTE: These arrays are local to subroutine TITLE and are not to be confused with other arrays with the same names.

RECORD 3.0

Variable List: ID (1-10)* Format: (10A4)

Discussion: VIEW has the capability to print a title above the line containing the time in milliseconds of each time frame. If this title is not desired, a blank record may be inserted.

Variable	Description
ID (10)	ID contains the 40 character title strip.

RECORD 4.0

Variable List: STIME, DTIME, ETIME Format: (3D10.0)

Discussion: This record defines what time frames will be plotted from the ATBM input file.

Variable	Description
STIME	Start time for plotting ATBM input data (seconds) time.
DTIME	Increment for stepping through ATBM input data (seconds). The size of DTIME cannot be smaller than the DTIME of the ATBM run (reference page 29, card A.4 in Vol. 3 of ref. 1). It should be an integer multiple of this time step. VIEW will not plot more time frames than are in the ATBM input file. VIEW does not create or interpolate data from the ATBM input file; VIEW only plots existing ATBM data.
ETIME	End time for plotting ATBM input data (seconds). ETIME cannot be greater than DT*NSTEPS (reference same as above).

*NOTE: This array is local to the main program and should not be confused with any other arrays with this name.

RECORD 5.0

Variable List: IDEBUG (1-80) Format: (80I1)

Discussion: This record contains the debug flags that control the debug messages that are written to the output listing file. The flags can be turned on (set to 1) either individually or in combinations. Only the first four array positions in IDEBUG are presently being used.

Variable	Description
IDEBUG (80)	IDEBUG(1)=1 prints the NIE array. The NIE array contains the total number of overlapping ellipsoids and polygons for a given ellipsoid or polygon. Created in subroutine BUILDIE.

IDEBUG(2)=1 prints the IE array. The IE array contains the numbers of the overlapping ellipsoids or polygons as seen on the projection plane. IE is printed as an array with the row number indicating the ellipsoid or polygon number. The remaining entries in each row give the number of an overlapping object.

IDEBUG(3)=1 prints subroutine INPUT parameters. Some of them are read from the input control file and the remaining from the ATB input file. They are printed in the following order:

- Number of segments and planes
- Number of segments to be plotted
- NSTEPS array
- Offset in X and Y directions (OFSETX, OFSETY)
- SFACTR (scale factor) and INT (iteration factor)
- Viewpoint position vector (VP) and rotation of viewpoint vector (RA)
- Viewpoint direction cosine matrix (DVP)

- Segment initial position vector (SEG)
- Segment inertial direction cosine matrix (SEGLP)
- Segment ellipsoid generation matrices (A,D)

IDEBUG(4)=1 prints plane vectors in inertial reference frame. These are the position vectors of each vertex for each plane and are created in subroutine CONVREC. The reference segment number (ISG) is printed first. This number should never be zero and should be a body segment, vehicle segment, or ground segment number. Reference segment numbers are defined in the F cards (contact cards) of the ATB simulation input deck. If a particular plane is not used as a contact plane in the simulation, its reference segment number will be defined as zero. The VIEW program checks for zero reference segment numbers and sets them to a user assigned value specified in record 6.0.

RECORD 6.0

Variable List: NFAST, NPREM, NISG   Format: (3I2)

Discussion: This card contains the total number of segments and polygons to remove from plotting and the substitute coordinate system for the MPL array.

Variable	Description
NFAST	NFAST represents the total number of segments from the ATBM program output which are not to be plotted. Extremely small ellipsoids viewed at a relatively great distance should be avoided when using the VIEW program. NFAST can be used to do this by eliminating these ellipsoids if they are the last ones to have been defined in the input to the ATBM simulation. NFAST at one time represented the number of belt fasteners used in the ATBM simulation, but that feature is no longer used in the ATBM model.

NPREM — NPREM represents the total number of ATBM simulation polygons to be removed from plotting consideration. This variable is used in combination with record 6.1, IREMOV array. VIEW can only accurately plot ATBM simulation planes which are rectangular. ATBM simulation planes which are not rectangular but are parallelograms will be plotted as distorted planes.

NISG — NISG is a variable containing the number of the coordinate system that will be substituted for MPL array values which are zero. The MPL array connects the plane number to the segment number that defines the coordinate system for plotting the plane vectors. MPL is set to zero whenever a plane is defined in the input to the ATB simulation but there is no defined contact with that plane using the F cards. NISG allows the user of VIEW to arbitrarily define the reference frame for all unattached planes.

RECORD 6.1

Variable List: IREMOV (1-NPREM) Format: (30I2)

Discussion — This record contains the polygon numbers from the ATBM simulation to be removed from consideration for the output graphics file.

Variable	Description
IREMOV (30)	IREMOV is an array containing NPREM numbers identifying the numbers of the polygons to be removed from the output graphics file. The numbering of the polygons is as follows. The polygons that were read from the ATB input file are first (in the order that they were specified in the input to the ATB simulation) followed by the supplemental polygons read from record 7.0, 7.1, and 7.2 (in the order they were read from the input control file).

RECORD 7.0

Variable List: NSP Format: (I2)

Discussion: NSP defines the number of supplemental polygons that are to be added to the output plot. These polygons are purely cosmetic and do not affect the ellipsoids. These supplemental polygons must be convex. NSP groups of record set 7.1 and 7.2 must follow if NSP>0. If NSP=0, no 7.1 and 7.2 records are read.

Variable	Description
NSP	Number of supplemental polygons to be added to output plot.

RECORD SET 7.1

Variable List: NPPP ((30+NP+1)-(30+NP+NSP)), MPL ((NP+1)-(NP+NSP))

Format: (I1,I2)

Discussion: This record defines number of vertices per polygon and its coordinate system. If NSP>0, there should be NSP 7.1 records. If NSP=0, no 7.1 records are read.

Variable	Description
NPPP	NPPP defines number of points per polygon (number of vertices) for each input polygon. Due to the particular array dimensions associated with the polygon arrays, the maximum number of points per polygon is four.
MPL	MPL defines the local coordinate system that serves as a reference for the polygon position vectors. This number must be a body segment, vehicle segment, or a ground segment number as defined in the ATB simulation.

RECORD SET 7.2

Variable List: PO (1-3, 1-NSIDES, NP+1-NP+NSP) Format: (3F10.0)

Discussion: This record set defines the size and shape of the supplemental polygons. There should be NSP groups of 7.2 records with NSIDES number of records for each polygon.

Variable	Description
PO	The PO array contains the position vectors of the polygon vertices in reference to the MPL coodinate system. There are NSIDE records read for each polygon and there are NSP polygons. Each record read consists of an X, Y, and Z coordinate. These records must be read in either clockwise or counterclockwise order. Any vertex may be used as the starting point.

RECORD 8.0

Variable List: ICOLOR (1-30) Format: (8(5X,I5))

Discussion: This four record set contains 30 integer numbers that define the colors for the contours of the ellipsoids. These colors are used for the multicolor plotter and the multicolor graphics terminal (DEVFLG=3,4). For the one-color plotter and the one-color graphics terminal, record set 8.0 is still read but is ignored. The color numbers are the ones listed in your system's Calcomp manual for subroutine NEWPEN. Consult your multicolor graphics terminal manual for the color numbering system for it.

Variable	Description
ICOLOR (91)	Color numbers for ellipsoids. Position 1 of ICOLOR contains the color number for ellipsoid 1, position 2 represents ellipsoid 2, etc. The numbering of the ellipsoids is as

specified in the ATBM simulation, cards B2.A-N, and is unique for each ATBM simulation.

RECORD SET 9.0

Variable List: ICOLOR (31-90) Format: (8((5X,I5))

Discussion: This eight record set contains 60 integer numbers that define the colors for the contours of the polygons. As in record 8.0, these colors are used for the multicolor plotter and multicolor graphics terminal and are read but ignored for the one-color plotter and the one-color graphics terminal. The color numbers are the values for NEWPEN in the Calcomp library. Consult your multicolor graphics terminal manual for the color numbering system for it.

Variable	Description
ICOLOR (91)	Color numbers for polygons. Position 31 of ICOLOR represents that color number for polygon 1, position 32 represents polygon 2, etc.

RECORD 10.0

Variable List: ICOLOR (91) Format: (5X, I5)

Discussion: Array position 91 of ICOLOR represents the integer color number of the title strip from record 3.0 and the time of the time frame plot (msec) printed at the top of each time frame plot. It follows the same protocol for usage and coloring as records 8.0 and 9.0.

Variable	Description
ICOLOR (91)	Color number for title strip and time at the top of each time frame plot.

RECORD 11.0

Variable List: NSTEPS (1-NSEG) Format: (30I2)

Discussion: This record defines the number of steps used for plotting contour lines of ellipsoids. Subroutine ELIPSN, the ellipsoid contour generation routine, uses NSTEPS for each ellipsoid to generate an X-Y mesh having NSTEPS discrete units along each ellipsoid semiaxis. The Z value is then calculated from the ellipsoid equations.

Variable	Description
NSTEPS (90)	NSTEPS (1-NSEG, maximum of 30) contains the number of plot vectors for plotting contour lines of ellipsoids. Array position 1 represents number of plot vectors for ellipsoid 1, position 2 represents ellipsoid 3, etc. The values for NSTEPS are subjectively determined, although the larger the ellipsoid, the greater the number of plot vectors are needed. Suggested values for ellipsoids are in the range 7 to 15.

RECORD 12.0

Variable List: NSTEPS (31-NPLANE) Format: (30I2)

Discussion: This record defines the number of plot vectors used in plotting the contour lines of polygons. Subroutine PLPLN, the polygon contour line generation routine, divides each polygon side in NSTEPS pieces.

Variable	Description
NSTEPS (90)	NSTEPS (31-NPLANE or 60, whichever is smaller) contains the number of vectors used for plotting polygons. Array position 31 represents number of steps for polygon 1, position 32 represents polygon 2, etc. Again, the values for

NSTEPS are determined subjectively. A suggested value for larger polygons is 10.

RECORD 12.1

Variable List: NSTEPS (61-NPLANE)   Format: (30I2)

Discussion: Record 12.1 is a continuation of record 12.0. It is an optional record read only when NPLANE>30.

Variable	Description
NSTEPS (90)	Number of vectors used for plotting polygons 61 to NPLANE. Array position 61 represents polygon 31, position 62 represents polygon 32, etc.

RECORD 13.0

Variable List: INT, SFACTR   Format: (I3,7X,F10.2)

Discussion: This record defines INT, a variable that terminates the algorithm that removes gaps from hidden lines, and SFACTR, the scale factor for plotting.

Variable	Description
INT	INT is an interation count value used in subroutine EXTEND. This count is used to terminate an algorithm that removes gaps in contour lines when hidden lines are eliminated. The size of these gaps are related to the step size used to plot the contour lines (NSTEPS). EXTEND is called whenever a line segment is partially hidden. In these cases EXTEND, through an iterative process using a binary search technique, extends the previous visible line segment to the boundary of the overlapping object. A suggested value for INT is 4.

SFACTR

SFACTR is a scale factor used for drawing an object on the plotting area. It represents the physical distance between the viewing plane and the viewpoint and is based on the law of similar triangles (refer to Figure 2.2). SFACTR is calculated by the following equation:

SFACTR = (PPD/H) * D

where:

PPD = viewing plane Y dimension (inches)

D = distance from viewpoint to object, calculated by:

$$\sqrt{(VP(1) - RA(1))^2 + (VP(2) - RA(2))^2 + (VP(3) - RA(3))^2}$$

(See record 15.0 for information about VP and RA.)

H = Height of the object to be plotted as measured in the direction of the Y axis of the projection plane. This height can be found in the input to the ATB simulation.

For example, if the object is 1000 inches from the viewpoint, the height of the viewing plane is 11 inches, and the height of the object is 65 inches, SFACTR is calculated by the following equation:

SFACTR = (11.0/65.0) * 1000.0 = 169.2 (inches)

After calculating the value of SFACTR, it can be manipulated to vary the size of the object on the plotting region. Increasing the value of SFACTR has the effect of moving the viewing plane closer to the object, increasing its size on the plotting area. Decreasing SFACTR moves the plane away from the object. The size of the object may also be varied by keeping a constant scale factor and varying the location of the viewpoint. A viewpoint closer to the focal point results in a larger image. A viewpoint further from the focal point (for a constant SFACTR) results in a smaller image. Refer to the detailed description in section 2.4.

RECORD 14.0

Variable List: OFSETX, OFSETY   Format: (2F10.0)

Discussion: These offset variables will move the output plot figure around the defined plotting region. This capability is useful when the viewpoint is placed to maximize the viewing angle and some part of the figure falls outside the plotting region. Using these offset variables, the entire figure can be moved back onto the plotting region. Refer to Section 2.4.2 and Figure 2.2.

Variable	Description
OFSETX	OFSETX moves the figure on the plotting region in the X direction (inches).
OFSETY	OFSETY moves the figure on the plotting region in the Y direction (inches).

RECORD 15.0

Variable List: VP(1-3), RA(1-3), IVP, ICODE   Format: (6F10.0, 2I10)

Discussion: This record defines the viewpoint system. See Sections 2.4, 2.4.1, and 2.4.2 for a discussion of this system.

Variable	Description
VP(3)	Contains the X, Y, and Z coordinates of the viewpoint in the IVP segment number coordinate system.
RA(3)	ICODE=2, RA contains the X, Y, and Z coordinates of the focal point in the IVP segment number coordinate system.

ICODE=1, RA contains the roll, pitch, and yaw angle for the viewpoint direction vector $\vec{D}$.

ICODE=0, RA contains the first row of the direction cosine matrix for vector $\vec{D}$.

IVP	Body segment, vehicle segment, or ground segment number to which the viewpoint coordinate system is tied. Segment number is as defined in the input to the ATBM simulation.
ICODE	Defines the method of inputting the viewpoint location. Refer to Section 2.4.1.

RECORD 15.1

Variable List: DVP (1-3) Format: (6F10.0)

Discussion: This record read only when ICODE=1. Contains the second and third rows of the direction cosine matrix.

Variable	Description
DVP (3,3)	Contains second and third rows of the direction cosine matrix. First row loaded from array RA.

RECORD 16.0

Variable List: XMIN, XMAX Format: (2F10.2)

Discussion: This record defines the X axis limits of the plotting region (point X=0, Y=0, being the origin). See Figure 2.2.

Variable	Description
XMIN	Defines the minimum X axis value for the plotting region. A suggested value is 0. (inches).

XMAX Defines the maximum X axis value for the plotting region. A suggested value is 11. (inches).

Section 4.0

SAMPLE INPUT AND OUTPUT

4.1 SAMPLE INPUT CONTROL FILE

```
1
 126
                                               25
                                               25
                                               25
AIRCRAFT EJECTION SIMULATION                    1
EJECTION SEAT MODELED: ACES II                  2
ACCELERATION: 14 G PEAK ALONG                   3
  AXIS OF THE SEAT                              7
2000 DEG/SEC*2 YAW ACCEL.                       8
300 MPH WINDSTREAM                              4
BODY SIZE: 95 PERCENTILE MALE                   5
RESTRAINT: 4 BELT HARNESS                       6
                                               25
                                               25
                                               25
                                               25
                                               25
                                               25
                                               25
                                               25
                                               25


0.000      .010       0.000
1111
 2  20

15
320      TOP FRONT FUSELAGE
152.0      0.0        -10.0
84.0       12.0       -29.0
84.0      -12.0       -29.0
320      LEFT SIDE FUSELAGE
152.0      0.0        -10.0
84.0      -12.0        5.0
84.0      -12.0       -29.0
320      RIGHT SIDE FUSELAGE
152.0      0.0        -10.0
84.0       12.0        5.0
84.0       12.0       -29.0
320      BOTTOM FRONT FUSELAGE
152.0      0.0        -10.0
84.0       12.0        5.0
84.0      -12.0        5.0
420       WINDSHIELD FRONT
84.0      -12.0       -29.0
84.0       12.0       -29.0
40.0       12.0       -48.0
40.0      -12.0       -48.0
320       LEFT WINDSHIELD
84.0      -12.0       -32.0
40.0      -12.0       -48.0
84.0      -12.0       -29.0
```

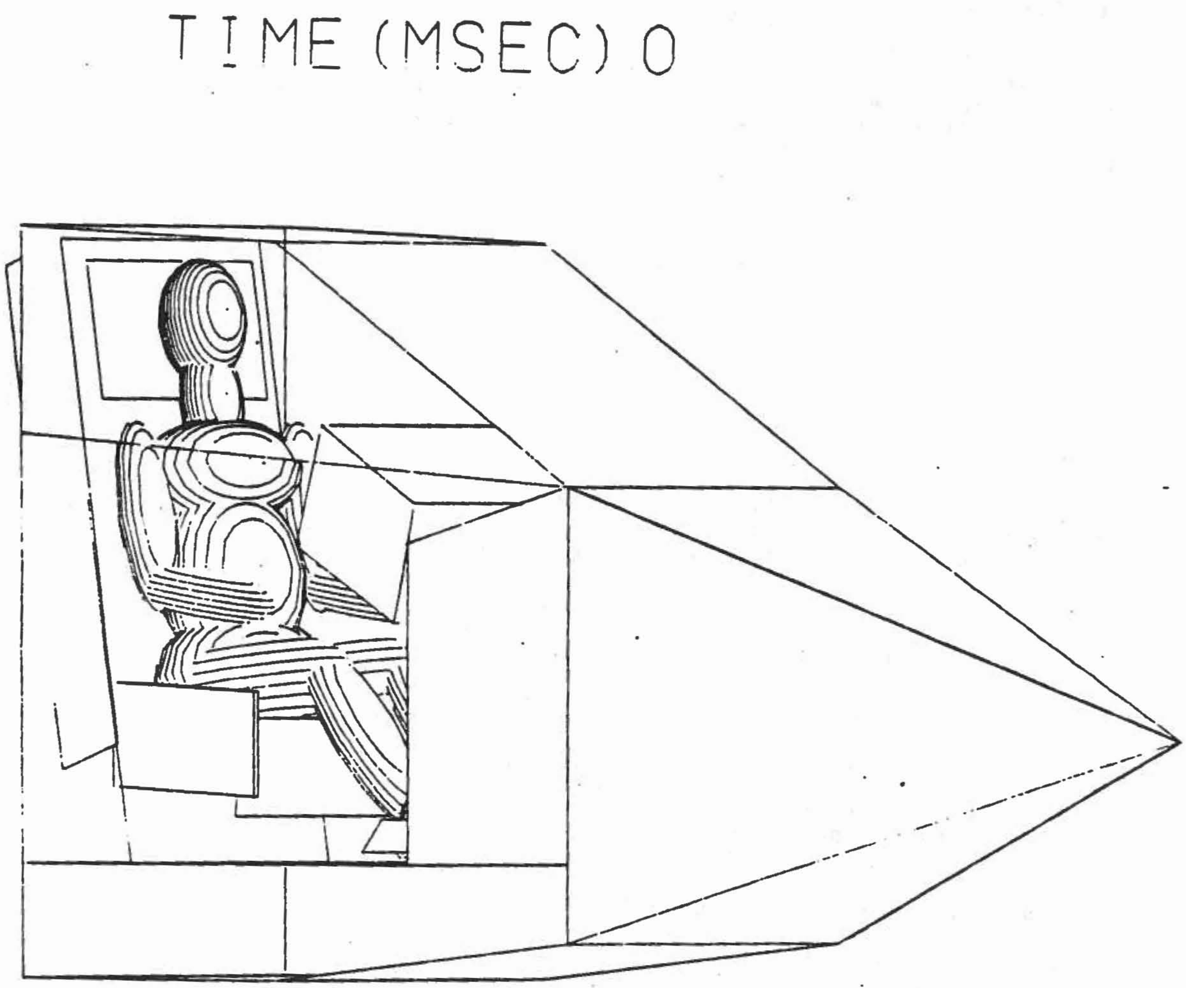
```
420      FUSELAGE TOP
60.0      12.0      -25.0
60.0      -12.0     -25.0
84.0      -12.0     -29.0
84.0      12.0      -29.0
420       INST TOP
47.0      12.0      -34.0
47.0      -12.0     -34.0
61.0      -12.0     -28.0
61.0      12.0      -28.0
420      INST BOTTOM
58.0      12.0      -19.0
43.0      12.0      -25.0
43.0      -12.0     -25.0
58.0      -12.0     -19.0
420       INST FRONT
43.0      12.0      -25.0
43.0      -12.0     -25.0
47.0      -12.0     -34.0
47.0      12.0      -34.0
420      INST BACK
58.0      12.0      -19.0
58.0      -12.0     -19.0
61.0      -12.0     -28.0
61.0      12.0      -28.0
420     MIDDLE BOTTOM FUSELAGE
84.0      12.0      5.0
40.0      12.0      8.0
40.0      -12.0     8.0
84.0      -12.0     5.0
420     REAR BOTTOM FUSELAGE
40.0      12.0      8.0
0.0       12.0      8.0
0.0       -12.0     8.0
40.0      -12.0     8.0
420     BACK
0.0       12.0      8.0
0.0       -12.0     8.0
0.0       -12.0     -50.0
0.0       12.0      -50.0
420      SIDE CANOPY
84.0      12.0      -29.0
0.0       12.0      -34.0
0.0       -12.0     -34.0
84.0      -12.0     -29.0
          1         2         3         4         5         6         7         8
          9         10        11        12        13        14        15        16
          17        18        19        20        21        22        23        24
          25        26        27        28        29        30
          31        32        33        34        35        36        37        38
          39        40        41        42        43        44        45        46
          47        48        49        50        51        52        53        54
          55        56        57        58        59        60        61        62
          63        64        65        66        67        68        69        70
          71        72        73        74        75        76        77        78
          79        80        81        82        83        84        85        86
          87        88        89        90
          91
 7 7 7 6 8 4 4 4 4 4 4 4 4 4 410
10101010101010101010101010101010101010101010101010101010101010
101010101010101010101010101010101010101010101010101010101010
 4        180.0
0.0              0.0
1735.05   1000.0    0.0       -75.0     0. 2      20.0                18        2
0.0       11.0
```

4.2 SAMPLE OUTPUT GRAPHICS FILE PLOT

4.2.1 Sample Title Frame Plot

AIRCRAFT EJECTION SIMULATION
EJECTION SEAT MODELED: ACES II
ACCELERATION: 14 G PEAK ALONG
  AXIS OF THE SEAT
2000 DEG/SEC*2 YAW ACCEL.
300 MPH WINDSTREAM
BODY SIZE: 95 PERCENTILE MALE
RESTRAINT: 4 BELT HARNESS

4.2.2 Sample Time Frame Plot



4.3 SAMPLE OUTPUT LISTING FILE (WITH ALL DEBUG FLAGS ON)

```
1
                                25
                                25
                                25
AIRCRAFT EJECTION SIMULATION     1
EJECTION SEAT MODELED: ACES II  2
ACCELERATION: 14 G PEAK ALONG    3
  AXIS OF THE SEAT               7
2000 DEG/SEC*2 YAW ACCEL.        8
300 MPH WINDSTREAM               4
BODY SIZE: 95 PERCENTILE MALE    5
RESTRAINT: 4 BELT HARNESS        6
                                25
                                25
                                25
                                25
                                25
                                25
                                25
                                25
                                25

111100000000000000000000000000000000000000000000000000000000000000000000000000000
 2 020

1NUMBER OF SEGMENTS = 17,  NUMBER OF PLANES = 31
 THE NUMBER OF SEGMENTS TO  BE PLOTTED = 15
          NUMBER OF DIVISIONS ALONG A RADIUS
    7  7  7  6  8  4  4  4  4  4  4  4  4  4  4
          NUMBER OF DIVISIONS ALONG A SIDE
   10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
          NUMBER OF DIVISIONS ALONG A SIDE
   10
  4          180.00
      0.         0.
 CFSETX=      0.000    OFSETY=      0.000
 SCALE FACTOR =     130.00   ITERATION NUMBER =    4
 *********************
 VIEWPOINT DIRECTION COSINE MATRIX
  -0.483571   0.875305   0.000000
  -0.008465  -0.004677  -0.999953
  -0.875264  -0.483548   0.009671

 *********************
 *********************
 SEGMENT #   1      SEGLP = (     14.008,      0.000,    -15.074,

 A MATRIX                                                 DIRECTION COSINE MATRIX

   0.03921    0.00000    0.00000                              0.974370    0.000000   -0.224951
   0.00000    0.01733    0.00000                              0.000000    1.000000    0.000000
   0.00000    0.00000    0.04182                              0.224951    0.000000    0.974370

 *********************
 *********************
 SEGMENT #   2      SEGLP = (     12.276,      0.000,    -22.577,

 A MATRIX                                                 DIRECTION COSINE MATRIX

   0.04340    0.00000    0.00000                              0.974370    0.000000   -0.224951
   0.00000    0.02653    0.00000                              0.000000    1.000000    0.000000
   0.00000    0.00000    0.01753                              0.224951    0.000000    0.974370
```

```
********************
********************
SEGMENT #    3      SEGLP = (     10.373,      0.000,    -30.920,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.04148    0.00000    0.00000                      0.974370   0.000000  -0.224951
  0.00000    0.02047    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.05391                      0.224951   0.000000   0.974370

********************
********************
SEGMENT #    4      SEGLP = (      9.104,      0.000,    -36.315,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.15747    0.00000    0.00000                      0.974370   0.000000  -0.224951
  0.00000    0.15747    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.04287                      0.224951   0.000000   0.974370

********************
********************
SEGMENT #    5      SEGLP = (      7.673,      0.000,    -42.512,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.06037    0.00000    0.00000                      0.974370   0.000000  -0.224951
  0.00000    0.09766    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.04287                      0.224951   0.000000   0.974370

********************
********************
SEGMENT #    6      SEGLP = (     22.994,      3.520,    -14.792,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.08500    0.00000    0.00000                     -0.069756   0.000000  -0.997564
  0.00000    0.08500    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.00613                      0.997564   0.000000  -0.069756

********************
********************
SEGMENT #    7      SEGLP = (     39.210,      3.520,    -10.491,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.15747    0.00000    0.00000                      0.631082   0.000000  -0.775716
  0.00000    0.15747    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.00887                      0.775716   0.000000   0.631082

********************
********************
SEGMENT #    8      SEGLP = (     48.988,      3.520,     -4.900,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.35431    0.00000    0.00000                     -0.642788   0.000000  -0.766044
  0.00000    0.21836    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.03258                      0.766044   0.000000  -0.642788

********************
********************
SEGMENT #    9      SEGLP = (     22.994,     -3.520,    -14.792,

A MATRIX                                          DIRECTION COSINE MATRIX

  0.08500    0.00000    0.00000                     -0.069756   0.000000  -0.997564
  0.00000    0.08500    0.00000                      0.000000   1.000000   0.000000
  0.00000    0.00000    0.00613                      0.997564   0.000000  -0.069756

********************
```

```
*********************
SEGMENT #  10      SEGLP = (     39.210,     -3.520,    -10.491,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.15747    0.00000    0.00000                        0.631082   0.000000  -0.775716
  0.00000    0.15747    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.00887                        0.775716   0.000000   0.631082

*********************
*********************
SEGMENT #  11      SEGLP = (     48.988,     -3.520,     -4.900,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.35431    0.00000    0.00000                       -0.642788   0.000000  -0.766044
  0.00000    0.21836    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.03258                        0.766044   0.000000  -0.642788

*********************
*********************
SEGMENT #  12      SEGLP = (     11.556,      7.280,    -27.423,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.19407    0.00000    0.00000                        0.955793   0.000000  -0.294040
  0.00000    0.19407    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.01682                        0.294040   0.000000   0.955793

*********************
*********************
SEGMENT #  13      SEGLP = (     21.098,      7.280,    -21.300,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.25508    0.00000    0.00000                        0.099493   0.000000  -0.995038
  0.00000    0.25508    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.00986                        0.995038   0.000000   0.099493

*********************
*********************
SEGMENT #  14      SEGLP = (     11.556,     -7.280,    -27.423,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.19407    0.00000    0.00000                        0.955793   0.000000  -0.294040
  0.00000    0.19407    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.01682                        0.294040   0.000000   0.955793

*********************
*********************
SEGMENT #  15      SEGLP = (     21.098,     -7.280,    -21.300,

A MATRIX                                           DIRECTION COSINE MATRIX

  0.25508    0.00000    0.00000                        0.099493   0.000000  -0.995038
  0.00000    0.25508    0.00000                        0.000000   1.000000   0.000000
  0.00000    0.00000    0.00986                        0.995038   0.000000   0.099493
```

```
*********************
MAIN - PROCESSING FRAME #    1
1PLANE INFORMATION
****************
ISG=16
********************************
  PLANE NUMBER =    1
    10.00        8.00     -10.00
    28.01        8.00     -11.89
    28.01       -8.00     -11.89
    10.00       -8.00     -10.00
ISG=16
********************************
  PLANE NUMBER =    2
     1.00        9.00     -48.97
    10.00        9.00     -10.00
    10.00       -9.00     -10.00
     1.00       -9.00     -48.97
ISG=20
********************************
  PLANE NUMBER =    3
     0.00       12.00      -0.75
    60.00       12.00      -0.75
    60.00      -12.00      -0.75
     0.00      -12.00      -0.75
ISG=16
********************************
  PLANE NUMBER =    4
     2.48        7.50     -47.26
     4.96        7.50     -36.55
     4.96       -7.50     -36.55
     2.48       -7.50     -47.26
ISG=16
********************************
  PLANE NUMBER =    5
    28.01        8.00     -11.89
    26.66        8.00      -4.40
    26.66       -8.00      -4.40
    28.01       -8.00     -11.89
ISG=20
********************************
  PLANE NUMBER =    6
     0.00       12.00     -50.00
     0.00      -12.00     -50.00
    40.00      -12.00     -48.00
    40.00       12.00     -48.00
ISG=20
********************************
  PLANE NUMBER =    7
    60.00       12.00     -25.00
    60.00      -12.00     -25.00
    60.00      -12.00      -0.75
    60.00       12.00      -0.75
ISG=16
********************************
  PLANE NUMBER =    8
     8.41        8.10      -6.66
     8.42        8.10     -14.73
    30.56        8.10     -13.93
    30.55        8.10      -5.86
ISG=16
********************************
  PLANE NUMBER =    9
     8.41       -8.10      -6.66
    30.55       -8.10      -5.86
    30.56       -8.10     -13.93
     8.42       -8.10     -14.73
ISG=20
```

```
********************************
  PLANE NUMBER =  10
     3.96        9.00      -34.00
    12.00        9.00       -0.75
    12.00       -9.00       -0.75
     3.96       -9.00      -34.00
ISG=20
********************************
  PLANE NUMBER =  11
    43.00        9.00       -1.69
    51.00        9.00       -4.21
    51.00       -9.00       -4.21
    43.00       -9.00       -1.69
ISG=16
********************************
  PLANE NUMBER =  12
     1.00       -9.00      -43.97
    10.00       -9.00      -10.00
     1.23       -9.00       -7.98
    -7.77       -9.00      -46.95
ISG=16
********************************
  PLANE NUMBER =  13
     1.00        9.00      -43.97
    -7.77        9.00      -46.95
     1.23        9.00       -7.98
    10.00        9.00      -10.00
ISG=16
********************************
  PLANE NUMBER =  14
     1.00        9.00      -43.97
    10.00        9.00      -10.00
    10.00       -9.00      -10.00
     1.00       -9.00      -43.97
ISG=16
********************************
  PLANE NUMBER =  15
     8.41        8.50       -6.66
    30.55        8.50       -5.86
    30.56        8.50      -13.93
     8.42        8.50      -14.73
ISG=16
********************************
  PLANE NUMBER =  16
     8.41       -8.50       -6.66
     8.42       -8.50      -14.73
    30.56       -8.50      -13.93
    30.55       -8.50       -5.86
ISG=20
********************************
  PLANE NUMBER =  17
   152.00        0.00      -10.00
    84.00       12.00      -29.00

    84.00      -12.00      -29.00
ISG=20
********************************
  PLANE NUMBER =  18
   152.00        0.00      -10.00
    84.00      -12.00        5.00
    84.00      -12.00      -29.00
ISG=20
********************************
  PLANE NUMBER =  19
   152.00        0.00      -10.00
    84.00       12.00        5.00
    84.00       12.00      -29.00
ISG=20
```

```
********************************
  PLANE NUMBER =  20
  152.00       0.00     -10.00
   84.00      12.00       5.00
   34.00     -12.00       5.00
ISG=20
********************************
  PLANE NUMBER =  21
   84.00     -12.00     -29.00
   84.00      12.00     -29.00
   40.00      12.00     -48.00
   40.00     -12.00     -48.00
ISG=20
********************************
  PLANE NUMBER =  22
   34.00     -12.00     -32.00
   40.00     -12.00     -48.00
   84.00     -12.00     -29.00
ISG=20
********************************
  PLANE NUMBER =  23
   60.00      12.00     -25.00
   60.00     -12.00     -25.00
   84.00     -12.00     -29.00
   84.00      12.00     -29.00
ISG=20
********************************
  PLANE NUMBER =  24
   47.00      12.00     -34.00
   47.00     -12.00     -34.00
   61.00     -12.00     -28.00
   61.00      12.00     -28.00
ISG=20
********************************
  PLANE NUMBER =  25
   58.00      12.00     -19.00
   43.00      12.00     -25.00
   43.00     -12.00     -25.00
   58.00     -12.00     -19.00
ISG=20
********************************
  PLANE NUMBER =  26
   43.00      12.00     -25.00
   43.00     -12.00     -25.00
   47.00     -12.00     -34.00
   47.00      12.00     -34.00
ISG=20
********************************
  PLANE NUMBER =  27
   58.00      12.00     -19.00
   58.00     -12.00     -19.00
   61.00     -12.00     -28.00
   61.00      12.00     -28.00
ISG=20
********************************
  PLANE NUMBER =  25
   84.00      12.00       5.00
   40.00      12.00       8.00
   40.00     -12.00       8.00
   84.00     -12.00       5.00
ISG=20
********************************
  PLANE NUMBER =  29
   40.00      12.00       8.00
    0.00      12.00       8.00
    0.00     -12.00       3.00
   40.00     -12.00       8.00
ISG=20
```

```
******************************
  PLANE NUMBER =  30
     0.00       12.00        8.00
     0.00      -12.00        3.00
     0.00      -12.00      -50.00
     0.00       12.00      -50.00
ISG=20
******************************
  PLANE NUMBER =  31
    84.00       12.00      -29.00
     0.00       12.00      -34.00
     0.00      -12.00      -34.00
    84.00      -12.00      -29.00
19 19 12 10  7 16 17  9 21 11  5  9  9 14 13  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
16 26  6  6 17  4 17 13 14 24  6 24  7 26 13 14  9  7 11  4  8  7 10  9  8 13  9  3  2 26
17  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

 1  2  6  7  9 13 14 15 31 32 35 38 39 40 42 44 45 46 60  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 2  1  3  6  7  9 12 13 14 15 32 38 40 42 44 45 55 56 60  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 3  2  4 12 14 32 40 42 44 56 60 61  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 4  3  5 32 34 40 42 44 60 61  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 5  4 32 34 42 44 60  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 6  1  2  7  9 31 32 35 38 39 40 42 44 45 46 60  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 7  1  2  6  8  9 31 32 35 37 39 40 41 42 44 46 60  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 8  7 10 33 35 37 39 41 46  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 9  1  2  6  7 10 15 31 32 35 37 38 39 40 42 44 45 46 55 57 60  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
10  8  9 11 15 31 35 37 39 41 46  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
11 10 33 37 41  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12  2  3 13 32 40 44 60 61  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
13  1  2 12 32 40 42 44 60  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
14  1  2  3 15 32 40 42 44 54 55 56 60 61  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
15  1  2  9 10 14 32 37 40 42 44 55 57  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	6	7	9	10	32	35	37	38	39	40	42	44	45	46	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	3	4	5	6	7	9	12	13	14	15	31	34	35	36	38	39	40	42	43	44	45	46	60	61	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	11	37	40	49	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	5	32	42	44	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1	6	7	8	9	10	31	32	37	38	39	40	42	44	45	46	60	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	42	44	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	8	9	10	11	15	31	33	35	39	41	46	49	53	55	56	57	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	6	9	31	32	35	40	42	43	44	45	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	6	7	8	9	10	31	32	35	37	40	42	44	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	2	3	4	6	7	9	12	13	14	15	31	32	33	35	38	39	42	43	44	45	46	60	61	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	8	10	11	37	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

XMIN,XMAX= 0.000 11.000

Appendix A
INPUT CONTROL FILE ORGANIZATION

Note: all records mandatory unless marked with an asterisk (*).

Record Set Number	Number Record	Variables	Description	Where Read
1.0	1	DEVFLG	Specifies device for output plot file	Main
2.0	1	NFRME	Number of title frames	TITLE
*2.1	NFRME*20	ID, ICOLOR (if NFRME>0)	Text and color for title frame(s)	TITLE
3.0	1	ID	Title strip for time frame plots	Main
4.0	1	STIME, DTIME, ETIME	Time parameters for reading ATB input file	Main
5.0	1	IDEBUG	Flags for controlling debug messages	Main
6.0	1	NFAST, NPREM, NISG	Number of ellipsoids and polygons removed, substitute coordinate system for MPL array	INPUT
6.1	1	IREMOV	Polygon numbers to be removed	INPUT
7.0	1	NSP	Number of supplemental polygons	INPUT
*7.1	NSP	NPPP, MPL (if NSP>0)	Number of vertices, substitute coordinate system	INPUT
*7.2	NSP*NSIDES	PO (if NSP>0)	X, Y, and Z coordinates of vertices for polygons	INPUT
8.0	4	ICOLOR (1-30)	Color numbers for ellipsoids	INPUT
9.0	8	ICOLOR (31-90)	Color numbers for polygons	INPUT

Record Set Number	Number Record	Variables	Description	Where Read
10.0	1	ICOLOR (91)	Color for title strip and time	INPUT
11.0	1	NSTEPS (1-30)	Number of steps for plotting ellipsoids	INPUT
12.0	1	NSTEPS (31-60)	Number of steps for plotting polygons	INPUT
*12.1	1	NSTEPS (61-90)	Continuation of 12.0, when NPLANE>30	INPUT
13.0	1	INT, SFACTR	Iteration count for EXTEND, scale factor	INPUT
14.0	1	OFSETX, OFSETY	Offset variables for moving figure on plotter	INPUT
15.0	1	VP, RA, IVP, ICODE	Locations for viewpoint and focal point	INPUT
*15.1	1	DVP (when ICODE=1)	Second and third rows of direction cosine matrix	INPUT
16.0	1	XMIN, XMAX	Defines X axis limits of plotting region	PNTPLT

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2. Leetch, Bruce D., November 1982, "Articulated Total Body (ATB) VIEW Program Software Report, Part I, Programmer's Guide," Report No. AFAMRL-TR-81-111.