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Wireframe Analysis of Driver Leg-Movement Space:

WIREFRAM User and Programmer Guides

Project Report

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16. Abstract

WIREFRAM is a computer program developed to compute planar contours of intersections of cutting planes with the envelope (the wireframe) of time samples of leg target data taken from seated subjects performing typical automobile driver leg movements. The cutting planes are program inputs and are normally specified as families of parallel planes. WIREFRAM also computes a histogram of the maximum excursion envelope of the wireframe "leg movement" in a selected direction parallel to the cutting planes. The maximum excursion histograms thus represent the surface of the wireframe as seen in a particular viewing direction. The wireframe itself is defined as a set of connected panels. In general, each panel is a warped (but straight-edged) quadrilateral in X-Y-Z space. The corner points of each panel (wireframe nodes) are the locations of sonic emitters ("sparkers") along the leg at each sample time.

This manual discusses WIREFRAM input data and also program output and the method of their calculation. Illustrative examples are given.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

WIREFRAM

User's Guide, Analysis, and Programmer's Guide

1.0 Introduction

WIREFRAM is a program that computes intersections of cutting planes with the envelope (the "wireframe") of time samples of leg target data taken from seated subjects doing typical driver leg movements. The cutting planes are program inputs and are normally specified as families of parallel planes. WIREFRAM also computes a histogram of the maximum excursion envelope of the wireframe "leg movement" in a selected direction parallel to the cutting planes. The "maximum excursion histograms" thus represent the surface of the wireframe as seen in a particular viewing direction. A leg-movement wireframe is illustrated in Figure 1. Plots of maximum excursion histograms are included in Appendix A.

Section 2.0 of this manual is the WIREFRAM User's Guide, which discusses WIREFRAM input and output and also, in general terms, some of methods used for calculation of primary outputs. Section 3.0 presents illustrative examples of program input and output in part and in summary. (Program output is much too extensive to include all input and output except for trivial test cases). Section 4.0 discusses the mathematical analysis upon which WIREFRAM is based. Finally, Section 5.0 is the WIREFRAM Programmer's Guide.

(Also see the manual Determination of Nth-Percentile Maximum Excursion Histograms, which describes use of the MXMXEX and PRCNTILE programs.)

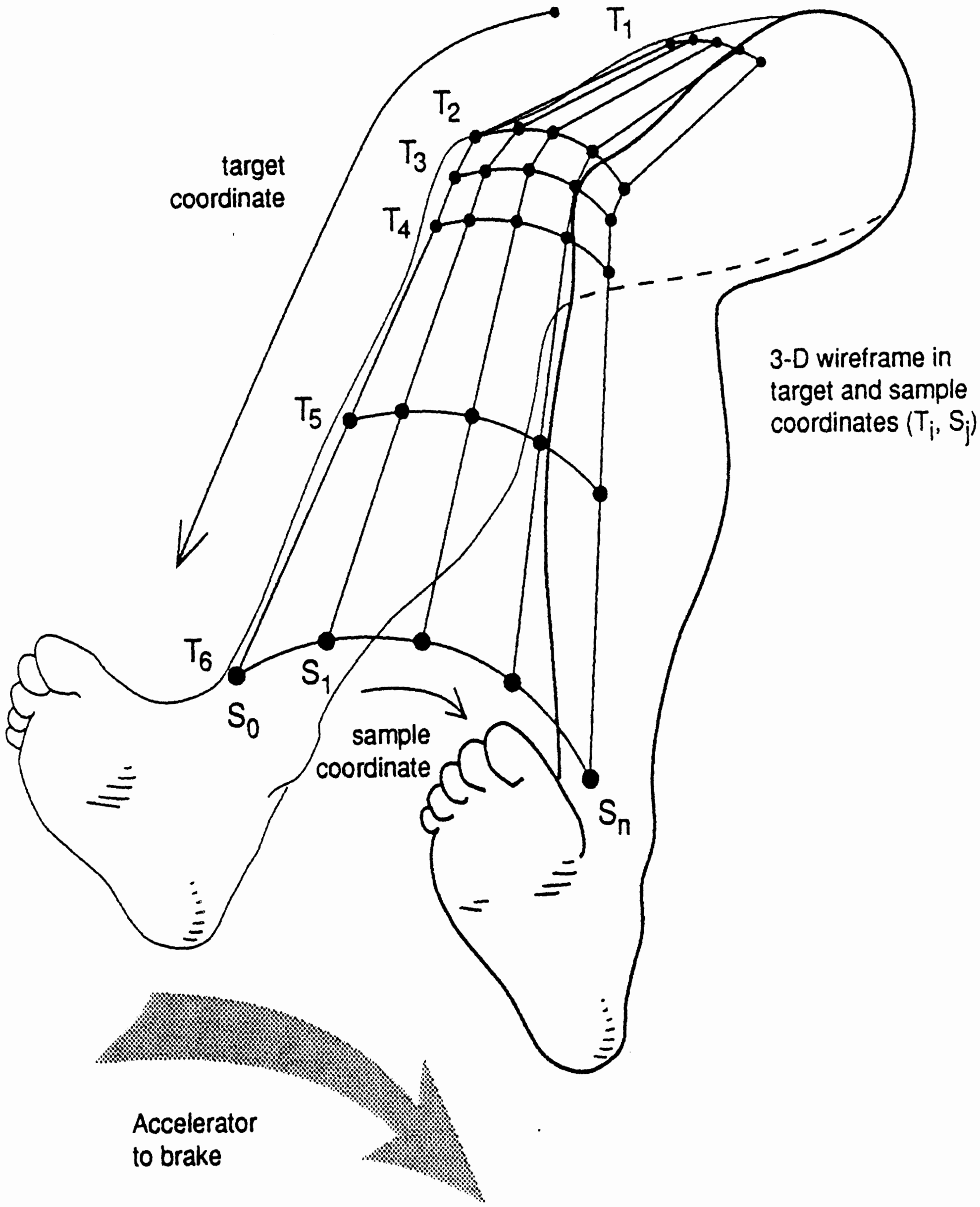


Figure 1. An Example Wireframe for Driver Leg Movement

2.0 WIREFRAM User's Guide

2.1 Program Input and Output

WIREFRAM asks for interactive instructions from the user and reads a leg target data file (i.e., "wireframe" node data) and a control file, which specifies cutting plane data and data processing and output parameters. The program produces an interactive summary of program activity and optionally produces one auxiliary file of detailed program function information (debugging output). Primary program outputs are a) files of cutting plane intersection data and b) files for three levels of maximum excursion histogram data.

A typical leg-motion data file contains all measurements for one subject. This file contains data for 45 leg-motion envelopes since data were obtained for three different vehicle seating packages (Taurus, Econoline, and Camaro), five types of leg movements, and three repetitions for each movement. With forty-five envelopes, WIREFRAM can produce 45 files of cutting plane intersection data and up to 63 histogram files. (Sections 2.2 and 3.0 include descriptions of histogram files and the algorithms used for determination of histogram values.)

Specifically, the following output files may be obtained for each subject:

- for each wireframe (45 total), a file containing three-dimensional coordinate data for the planar contours of intersection of the wireframe by all cutting planes

- for each wireframe (45 total), a maximum excursion histogram file that describes the three-dimensional surface of the wireframe in terms of distance measured along a coordinate direction (+ or -) parallel to the cutting planes and as a function of histogram "cell" position within a family of planes

- for each set of three repetitions of a particular leg movement for a particular seating package, a movement-maximum excursion histogram representing the maximum extent surface for the three repetitions combined (15 total)

- for each set of five movements for a particular seating package, a package-maximum excursion histogram representing the maximum extent surface for the five movements (and all repetitions) combined (3 total)

Table 1 gives a brief description of the five leg movements for which data where obtained and analyzed in the study.

Table 1 Description of Driver Leg Movements

Movement No.	Right/Left Leg	Movement
1	right	accelerator to brake
2	right	brake to accelerator
3	right	accelerator to brake, panic
4	left	floor to clutch
5	left	clutch to floor

2.2 Maximum Excursion Histograms

Figure 2 shows a portion of a "package-maximum excursion histogram" file (called 20103T00.ZMX). All maximum excursion histogram files have the same layout and are thus illustrated by Figure 2 (which is the same as Figure 12 in Section 3.0). This section describes the basic method of determination of a maximum excursion histogram, from which the 63 histogram files described in the preceding section derive.

There are two different algorithms that may be selected for determination of maximum excursion histograms. They are called the <u>Intersection Option</u> and the <u>Wireframe Option</u>. The user may select neither, either, or both options. Basically the same approach is used for the two options, and they give almost identical results. Differences that occur are consistent with the resolution implied by user-specified "cell" and "step" sizes. (If the user requests "both" options, the program will use the "maximum" of the two values determined for any cell if the two methods produce different results.) The Intersection Option is dependent on determination of the cut contours between planes and the wireframe. Determination of cut contours is a separate program option and, since it may not always be desired to obtain the cut contour files, it will not always be efficient to use the Intersection Option. The Wireframe Option for determination of maximum excursion histograms may be used whether or not cut contours are obtained. The general approach to determination of maximum excursion histograms is described below.

The wireframe is defined as a set of connected panels. In general each panel is a warped (but straight-edged), quadrilateral in X-Y-Z space. The corner points of each panel (wireframe nodes) are the locations of the sonic emitters ("sparkers") along the leg at each sample time. (See Figure 1.) The WIREFRAM program examines each panel of the wireframe in turn.

If the Wireframe Option was selected, panel edges ("wires") are subdivided as the user specifies, and this allows definition of a set of quadrilateral subpanels for each panel. The excursion value (W, in a user-specified direction perpendicular to the cutting planes) is determined at each subpanel corner point, (x,y,z). Also, the program determines which cell (with coordinates U-V in the transverse plane) of the Maximum Excursion Histogram contains the point. If the excursion value exceeds the value already residing in the cell, it replaces the value. For the wireframe of even a single package-movement-repetition, more than one point--and even several--can fall within a given histogram U-V cell because of "folds" in the wireframe and because of the fact that some wireframe panel edges may run nearly parallel to

Wire Frame Maximum Excursion File for Subject: 20103
Seat= Taurus, Movement= 0, Repetition= 0, No. Samples= 1
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 1, Z= -200.0
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 2, Z= -220.0

Beg Z-box No	Z-box values									
1	145	169	193	217	241	265	289	313	337	361
11	385	409	433	457	481	505	529	553	577	601

Y-box No.	Y-box Value	Beg Z-box No	Maximum excursion in -X direction									
1	199	1	-162	-184	-177	-125	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	223	1	-145	-172	-181	-153	-112	-64	-19	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	247	1	-232	-158	-100	-108	-95	-64	-25	6	38	74
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	271	1	-183	-123	-84	-49	-27	-7	13	30	40	68
		11	88	112	137	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	295	1	-144	-152	-138	-106	-75	-43	-12	17	40	62
		11	83	104	134	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	319	1	-157	-153	-145	-108	-54	23	60	106	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	343	1	-167	-153	-104	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
8	367	1	-170	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		* * *										
13	487	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	41	46	113	182	-9999	-9999	-9999	-9999
14	511	1	-9999	-9999	-239	-252	-216	-173	-141	-111	-83	-58
		11	-36	-19	1	22	40	87	137	-9999	-9999	-9999
15	535	1	-9999	-114	-132	-168	-170	-163	-131	-105	-79	-60
		11	-43	-30	-13	0	17	36	59	-9999	-9999	-9999
16	559	1	-126	-133	-129	-109	-89	-88	-84	-70	-60	-50
		11	-43	-27	-14	0	14	26	51	90	-9999	-9999
17	583	1	-139	-137	-124	-103	-82	-65	-54	-44	-35	-24
		11	-14	-5	6	16	-9999	-9999	-9999	-9999	-9999	-9999
18	607	1	-145	-131	-111	-94	-74	-60	-50	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
19	631	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
20	655	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 2 Example of Vehicle Package Maximum Excursion Histogram Output Resulting from Case in Figure 9

the excursion coordinate axis. [Note: It is unnecessary to calculate the excursions for points within subpanels since maximum excursion must occur for a corner point to within the desired resolution.]

In comparison, if the Intersection Option is selected, as each point of the intersection curve is computed, the line from the last intersection point of a panel edge to the current intersection point is examined in user-specified steps across the panel. Again, the excursion value is determined together with the proper histogram cell and the cell value is updated if the excursion value is larger than the value previously assigned for that cell.

The mathematical procedures for determining excursion values and for identifying histogram cells involve using a coordinate transformation (see Section 4.0) to find the coordinates (u,v,w) in a Maximum Excursion coordinate system of the point (x,y,z) in the laboratory system. The user specifies the direction in the laboratory system which defines "maximum excursion." (It need not be parallel to X, Y, or Z.) The program defines a W-axis for the Maximum Excursion coordinate system which is parallel to this. Additionally, the Maximum Excursion coordinate system is set up so that the first quadrant in the U-V plane, which is transverse to the W-axis, contains all histogram cells in the rectangular histogram space requested by the user, with the origin being the lower left corner point of the lowest and leftmost cell. When the point (x,y,z) in laboratory coordinates is transformed into U-V-W coordinates, the u and v values determine the histogram cell for the point and the w value is the excursion value. [It should be pointed out that if the (u,v) coordinates fall on the line between two cells or the corner between two or four cells, all the affected cells are updated. This expedient was adopted to avoid a complicated decision algorithm. The alternative would have been to develop an inverse coordinate transformation from the U-V-W system into laboratory coordinates. This transformation would in general be multiple-valued and would also require a decision algorithm based on nearby points already found in each of the "folds" of the wireframe. It was deemed that this is unnecessary provided only that histogram cells are sufficiently small.]

2.3 Input Data Format and Layout of Output Files

The remainder of this section is devoted to layouts of normal input and output:

Table 2 -- layout of interactive program input
Table 3 -- layout of the leg envelope data
Table 4 -- layout of cutting plane descriptions
Table 5 -- layout of intersection output data
Table 6 -- layout of histogram output data

Table 2 Layout of WIREFRAM Interactive Input

Program Request 1: Please enter Time Point Increment
(2 digits, default 1):?

User Response:

Field	Columns	Format	Description
1	1- 2	I2	Increment between samples to be used to create the wireframe envelope used by this program. (NI) Note: This parameter is normally specified as " 1". Responses must be right-adjusted within the first two characters typed.

There are two "hidden" responses to this request which are normally ignored (left blank):

Field	Columns	Format	Description
2	3- 4	I2	Switch which is non-zero to specify that detailed interactive output is to be produced. (JDEBUG)
3	5- 6	I2	Switch which can meaningfully be assigned values: 0, 1, 2, 3, 4, or 5. Each integer represents a level of debugging information and is inclusive of all lower levels. (IDEBUG)

WARNING---This output is extremely huge (as much as 10 MB from each envelope and possibly more); it must be used for a reduced case and must take advantage of the limiting controls provided in the cut plane family description file. The output is mostly not self-explanatory and must be understood from a WIREFRAM source listing. DO NOT USE except as a program debugging tool if that is your responsibility. This output is written to the file, "WIREFRAM.AUX", which will be created by the program. The program will acknowledge a request for debugging output with the words, "Debugging Printout requested at level=???". If you see this and did not plan for it, stop the run as explained below.

Table 2 Layout of WIREFRAM Interactive Input (continued)

Program Request 2: Please enter Intersection Curve Step Limit (8 digits, default 1.):?

User Response:

Field	Columns	Format	Description
1	1- 8	E8.0	Minimum step along each intersection curve to the next evaluated point. (Minimum of 1.) Typed with the decimal point in eight characters or less.

Program Request 3: Please enter File Name Stem (5 to 20 characters or <Return> to quit):

User Response:

Field	Columns	Format	Description
1	1-20	A20	Path and stem of file name containing the leg target sample or envelope data. Path is necessary when the data and resulting output files are on a different directory from the program. The stem is expected to be eight characters long with the first five characters being the subject number which is in the file.

Table 2 Layout of WIREFRAM Interactive Input (continued)

Program Request 4: Please enter file name containing cutting planes (Up to 24 characters, <Return> for bounding planes):

User Response:

Field	Columns	Format	Description
1	1-24	A24	Path and file name for Cutting Plane Family Description File. Path is necessary only when the file resides on a different directory from the program. The null response causes the program to set up the X-Z and Y-Z Coordinate Planes as two single member families with no maximum excursion.

Table 3 Layout of Leg Target Sample Data File

Record 1: Subject Number Identification

Field	Columns	Format	Description
1	1- 5	A5	Subject number (FILSBJ)

Typical Repetition Entry: Identification Record---Record 1

Field	Columns	Format	Description
1	1-10	A10	Package (seat) name (SEATCC) (Expected to be Camaro, Taurus, or Econoline.)
2	11-17	7X	7 arbitrary characters
3	18-18	I1	Movement number (1-5) (NMVTCC)
4	19-24	6X	6 arbitrary characters
5	25-25	I1	Repetition number (1-3) (NREPCC)
6	26-32	7X	7 arbitrary characters
7	33-34	I2	Number of samples (≤3) (NPTSCC)

Table 3 Layout of Leg Target Sample Data File (continued)

Typical Repetition Entry: Typical Sample Record---Record 2 to NPTSCC+1
(Exactly NPTSCC of these records)
Note: All coordinate information is W.R.T. Lab System and is in integral millimeters.

Field	Columns	Format	Description
1	1- 3	I3	Sample Number (ITS)
2	4- 6	3X	3 arbitrary characters
3	7- 11	E5.0	X-coordinate of target 1 (XYZINP(1,ITS,1))
4	12- 12	1X	1 arbitrary character
5	13- 17	E5.0	Y-coordinate of target 1 (XYZINP(2,ITS,1))
6	18- 18	1X	1 arbitrary character
7	19- 23	E5.0	Z-coordinate of target 1 (XYZINP(3,ITS,1))
8	24- 26	3X	3 arbitrary characters
9	27- 31	E5.0	X-coordinate of target 2 (XYZINP(1,ITS,2))
10	32- 32	1X	1 arbitrary character
11	33- 37	E5.0	Y-coordinate of target 2 (XYZINP(2,ITS,2))
12	38- 38	1X	1 arbitrary character
13	39- 43	E5.0	Z-coordinate of target 2 (XYZINP(3,ITS,2))
14	44- 46	3X	3 arbitrary characters
15	47- 51	E5.0	X-coordinate of target 3 (XYZINP(1,ITS,3))
16	52- 52	1X	1 arbitrary character
17	53- 57	E5.0	Y-coordinate of target 3 (XYZINP(2,ITS,3))
18	58- 58	1X	1 arbitrary character
19	59- 63	E5.0	Z-coordinate of target 3 (XYZINP(3,ITS,3))

Table 3 Layout of Leg Target Sample Data File (continued)

Typical Repetition Entry: Typical Sample Record (cont.)

Field	Columns	Format	Description
20	64- 66	3X	3 arbitrary characters
21	67- 71	E5.0	X-coordinate of target 4 (XYZINP(1,ITS,4))
22	72- 72	1X	1 arbitrary character
23	73- 77	E5.0	Y-coordinate of target 4 (XYZINP(2,ITS,4))
24	78- 78	1X	1 arbitrary character
25	79- 83	E5.0	Z-coordinate of target 4 (XYZINP(3,ITS,4))
26	84- 86	3X	3 arbitrary characters
27	87- 91	E5.0	X-coordinate of target 5 (XYZINP(1,ITS,5))
28	92- 92	1X	1 arbitrary character
29	93- 97	E5.0	Y-coordinate of target 5 (XYZINP(2,ITS,5))
30	98- 98	1X	1 arbitrary character
31	99-103	E5.0	Z-coordinate of target 5 (XYZINP(3,ITS,5))
32	104-106	3X	3 arbitrary characters
33	107-111	E5.0	X-coordinate of target 6 (XYZINP(1,ITS,6))
34	112-112	1X	1 arbitrary character
35	113-117	E5.0	Y-coordinate of target 6 (XYZINP(2,ITS,6))
36	118-118	1X	1 arbitrary character
37	119-123	E5.0	Z-coordinate of target 6 (XYZINP(3,ITS,6))
38	124-124	1X	1 arbitrary character

Table 4 Layout of Cutting Planes Description File

Record 1: Number of Cutting Plane Families

Field	Columns	Format	Description
1	1- 8	A8	File I.D.: "CUTTING" (required)
2	9-12	I4	Number of cutting plane families. (NPLN) (Max 10)

Typical Cutting Plane Family Description---Record 1:

Field	Columns	Format	Description
1	1- 4	I4	Cutting plane family number (IPLN)
2	5- 8	I4	Magnitude is number of planes in this family. Sign is negative if WFA output (wireframe cut contours) not desired. (NOINTS)
3	9-12	I4	Maximum excursion switch: (ISXCUR) <1 = No maximum excursion, 1 = Based on intersection curves for all plane instances, 2 = Based on wireframe surface, 3 = Based on both.
4	13-16	4X	Spaces
5	17-24	E8.0	Directed increment between plane instances (signed step size). Sign controls whether direction of step is with/against (P2 - P1) X (P3 - P1). (Note: All planes in the family will be parallel to first cutting plane, defined by P1, P2, and P3.) (PLNSTP)
6	25-44	A20	Cutting plane family title. (PLANTL)
7	45-48	I4	Plane family debug modification control: =2 Read two optional records immediately following this one which contain debug limiting controls (see below) =1 Do debugging for all instances =0 No debugging for this family <0 Apply debugging switch to the first "n" instances (planes) where "n" is given by the magnitude of this field. Note: This field limits the use of IDEBUG which is inputted in the interactive input (see Table 2) but does not change IDEBUG. Hence, if IDEBUG is set to zero, this field is irrelevant. (KNTLDB)

Table 4 Layout of Cutting Planes Description File (continued)

Typical Cutting Plane Family Description---Record 1 (cont.):

Field	Columns	Format	Description
8	49-52	I4	Cut plane and maximum excursion plane specification mode switch. Basic magnitude designations: =0 Use three points inputted, =1 This plane is X=constant, =2 This plane is Y=constant, or =3 This plane is Z=constant 3 is added to basic magnitudes above to interchange U and W as in Maximum Excursion Notes at the end of this table. (ISHORT) The sign of this field is applied to unity to form another quantity (FFAC) which multiplies the plane coeffs. (See note on Maximum Excursion for use of these special conventions)
9	53-60	E8.0	Value of the implied constant when basic ISHORT = 1, 2, or 3 (AVALUE). (This field is also multiplied by FFAC to retain the same plane.)
10	61-68	E8.0	Maximum step on intersection curves for evaluation of maximum excursion. (CRVSTP)
11	69-72	I4	Switch which is non-zero to require "repetition" maximum excursion output for this family of planes. (NREPSW) This switch is operational for each cut plane family separately.
12	73-76	I4	Switch which is non-zero to require "movement" maximum excursion output for this family of planes. (MMOVMT) This switch is operational for only the first cut plane family which has it set.
13	77-80	I4	Switch which is non-zero to require "seat" maximum excursion output for this family of planes. (MSEATW) This switch is operational for only the first cut plane family which has it set.

Table 4 Layout of Cutting Planes Description File (continued)

Typical Cutting Plane Family Description---Record 2 (Optional):
(These two records must be present if KNTLDB = 2 and absent otherwise.)

Field	Columns	Format	Description
I	2I-1 to 2I	I2	I-th value of NDEBUG Switch non-zero for the samples for which debugging output is requested.
	1-60	for I = 1 to 30 on one record	

Typical Cutting Plane Family Description---Record 3 (Optional):
(These two records must be present if KNTLDB = 2 and absent otherwise.)

Field	Columns	Format	Description
I	2I-1 to 2I	I2	I-th value of MDEBUG Switch non-zero for the targets for which debugging output is requested.
	1-12	for I = 1 to 6 on one record	

Note: If KNTLDB = 2, debugging output will be generated for only those panels for which both NDEBUG and MDEBUG are non-zerol.

Typical Cutting Plane Family Description---Record 4:

Field	Columns	Format	Description
1-3	1-24	3E8.0	X,Y,Z coordinates of 1st point (P1)
4-6	25-48	3E8.0	X,Y,Z coordinates of 2nd point (P2)
7-9	49-72	3E8.0	X,Y,Z coordinates of 3rd point (P3)

Note 1: The Maximum Excursion Direction is defined by vector P2-P1.

Note 2: Program FINDMNMX may be used to find the min and max values of X, Y, and Z for all reps for all movements for all seats for a subject's leg movement data file.

Note 3: This card is ignored if ISHORT is non-zero, but the card must be present.

Table 4 Layout of Cutting Planes Description File (continued)

Typical Cutting Plane Family Description---Record 5:

Field	Columns	Format	Description
1-3	1-24	3E8.0	U,V,W coordinates of first point (P1) (UUORG, VVORG, WWORG) (See note on Maximum Excursion below.)
4	25-32	E8.0	Length of U-axis for Maximum Excursion Magnitude is UAXLEN; UFAC is 1. with sign of this field applied. UFAC multiplies coefficients of U-axis.
5	33-40	E8.0	Length of each Maximum Excursion cell in U-direction (UUSTP).
6	41-48	E8.0	Length of V-axis for Maximum Excursion Magnitude is VAXLEN; VFAC is 1. with sign of this field applied. VFAC multiplies coefficients of V-axis.
7	49-56	E8.0	Length of each Maximum Excursion cell in V-direction (VVSTP).
8	57-64	E8.0	Step for Maximum Excursion Evaluation by Wireframe Method in Sample direction (SAMSTP).
9	65-72	E8.0	Step for Maximum Excursion Evaluation by Wireframe Method in Target direction (TARSTP).

(Values on this card are ignored if Maximum Excursion Evaluation is not requested, but the card must be present.)

Notes on Maximum Excursion:

1. In the case of cut planes X=const, Y=const, or Z=const, it is best to make U, V, or W zero or a multiple of cell size (cut step)--whichever one corresponds to the cutting plane variable. See the other notes.

2. If ISHORT = 0, the UVW system is defined as follows:

   a. The W-axis is parallel to P2-P1.
   b. The U-axis is parallel to the original plane and perpendicular to P2-P1 with signs chosen so that P3 has a positive U in the U-V-W system.
   c. The V-axis is parallel to the normal of the original plane ((P2-P1) X (P3-P1)).

Table 4 Layout of Cutting Planes Description File (continued)

Notes on Maximum Excursion (continued):

3. If ISHORT is not zero, the U-V-W system is defined using the following table:

ISHORT	Cutting Plane	U-axis	V-axis	W-axis	Maximum Excursion Direction
1	X=AVALUE	Z-axis	X-axis	Y-axis	+Y
2	Y=AVALUE	X-axis	Y-axis	Z-axis	+Z
3	Z=AVALUE	Y-axis	Z-axis	X-axis	+X
4	X=AVALUE	Y-axis	X-axis	-Z-axis	-Z
5	Y=AVALUE	Z-axis	Y-axis	-X-axis	-X
6	Z=AVALUE	X-axis	Z-axis	-Y-axis	-Y

FFAC multiplies the coefficients of both the V-axis and the W-axis.

4. The U-V-W-system resulting from either 1. or 2. above is further adjusted as follows:

U-axis = UFAC * U-axis + UORG
V-axis = VFAC * V-axis + VORG
W-axis = W-axis + WORG

In each equation above, each axis is represented by coefficients of X, Y, and Z together with a constant term. The indicated multiplication applies to all four coefficients while the indicated addition applies only to the constant term. The resulting system will be right-handed only if UFAC=VFAC.

** 5. Maximum excursion is carried out in the part of the <u>first quadrant of the U-V plane</u> bounded by U = 0, U = UAXLEN, V = 0, and V=VAXLEN using cells of size UUSTP by VVSTP. The Maximum Excursion variable is UAXLEN must be an integral multiple of UUSTP, and VAXLEN must be an integral multiple of VVSTP. The quantity tabulated in each cell is the maximum W encountered among the points falling within the cell.

Table 5 Layout of Intersection Curve Output File

Record 1 Subject and File Identification:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-48	A47	File I.D. Caption: "Wire Frame Intersection Curve File for Subject:"
3	49-49	1X	Space
4	50-54	A5	Subject I.D. (FILSBJ)

Typical Package, Movement, and Repetition Identification Entry:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 7	A6	Caption: "Seat= "
3	8-17	A10	Seat Type
4	18-28	A11	Caption: ", Movement="
5	29-33	I5	Movement Number
6	34-46	A13	Caption: ", Repetition="
7	47-51	I5	Repetition Number
8	52-65	A14	Caption: ", No. Samples="
9	66-70	I5	Number of Samples

Table 5 Layout of Intersection Curve Output File (continued)

Typical Cutting Plane Instance Identification Entry:

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Format A:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-25	A24	Caption: "Cutting Plane Family No."
3	26-28	I3	Current cutting plane family No. (KURPLN)
4	29-30	A2	Caption: " ("
5	31-50	A20	Cutting plane family title (PLANTL)
6	51-62	A12	Caption: "): plane no."
7	63-65	I3	Instance number (LPLN)
8	66-67	A2	Caption: ", "
9	68-68	A1	Axis identifier (NAXIS(2,_))
10	69-69	A1	Caption: "="
11	70-77	F8.1	Instance r.h.s. value (DDB)

Format B, record 1:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-16	A15	Caption: "Plane Instance:"
3	17-21	I5	Cutting plane family no. (KURPLN)
4	22-26	I5	Instance number (LPLN)
5	27-28	2X	Spaces
6	29-48	A20	Cutting plane family title (PLANTL)

Format B, record 2:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-20	G19.7	Plane X-coefficient (AA)
3	21-39	G19.7	Plane Y-coefficient (BB)
4	40-58	G19.7	Plane Z-coefficient (CC)
5	59-77	G19.7	Plane constant coefficient (DD)

Table 5 Layout of Intersection Curve Output File (continued)

Typical Intersection Curve Panel Entry--Record 1:
(Panel entries occur for each cutting plane family used.)

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 7	I6	Panel Lower Left Point Sample Number (N)
3	8-13	I6	Panel Lower Left Point Target Number (M)
4	14-19	I6	Cutting Plane Number (KURPLN)
5	20-25	I6	Cutting Plane Instance (LPLN)
6	26-32	7X	Spaces
7	33-39	I7	Number of points recorded in Intersection Curve (KOUNT)
8	40-46	I7	Beginning Edge Number (IISIDE(1))
9	47-53	I7	Ending Edge Number (IISIDE(2))

Typical Intersection Curve Panel Entry--Record for Points 2n-1 and 2n
(n=1 to [(KOUNT+1)/2])

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 8	I7	Point Number (2n-1)
3	9-15	I7	X-coordinate of Intersection Pt.
4	16-22	I7	Y-coordinate of Intersection Pt.
5	23-29	I7	Z-coordinate of Intersection Pt.
6	30-36	7X	Spaces
7	37-43	I7	Point Number (2n)
8	44-50	I7	X-coordinate of Intersection Pt.
9	51-57	I7	Y-coordinate of Intersection Pt.
10	58-64	I7	Z-coordinate of Intersection Pt.

Note: If an odd number of points is recorded, the last such record will record only Fields 1-6. Output units are mm.

Table 6 Layout of Maximum Excursion Output File

Record 1 Subject and File Identification:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-48	A47	File I.D.: "Wire Frame Maximum Excursion File for Subject:"
3	49-49	1X	Space
4	50-54	A5	Subject I.D.

Typical Seat, Movement, and Repetition Identification Entry:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 7	A6	Caption: "Seat= "
3	8-17	A10	Seat Type
4	18-28	A11	Caption: ", Movement="
5	29-33	I5	Movement Number
6	34-46	A13	Caption: ", Repetition="
7	47-51	I5	Repetition Number
8	52-65	A14	Caption: ", No. Samples="
9	66-70	I5	Number of Samples

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Cutting Plane Instance Identification Entry:

(This entry appears only for plane family instances that make contributions to maximum excursion.)

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Format A:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-25	A24	Caption: "Cutting Plane Family No."
3	26-28	I3	Current cutting plane family No. (KURPLN)
4	29-30	A2	Caption: " ("
5	31-50	A20	Cutting plane family title (PLANTL)
6	51-62	A12	Caption: "): plane no."
7	63-65	I3	Instance number (LPLN)
8	66-67	A2	Caption: ", "
9	68-68	A1	V-axis identifier (NAXIS(2,_))
10	69-69	A1	Caption: "="
11	70-77	F8.1	Instance r.h.s. value (DDB)

Format B, record 1:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-16	A15	Caption: "Plane Instance:"
3	17-21	I5	Cutting plane family no. (KURPLN)
4	22-26	I5	Instance number (LPLN)
5	27-28	2X	Spaces
6	29-48	A20	Cutting plane family title (PLANTL)

Format B, record 2:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-20	G19.7	Plane X-coefficient (AA)
3	21-39	G19.7	Plane Y-coefficient (BB)
4	40-58	G19.7	Plane Z-coefficient (CC)
5	59-77	G19.7	Plane constant coefficient (DD)

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Cell Definition Entry:

This entry occurs only if the cutting plane is not parallel to one of the coordinate planes (Format B).

Format B, record 1, Definition of U-axis:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-16	A15	Caption: "Cells: U-axis ="
3	17-31	F15.5	X Coefficient in U-axis definition
4	32-46	F15.5	Y Coefficient (COSCUR(1-3,1))
5	47-61	F15.5	Z Coefficient in U-axis definition
6	62-76	F15.5	Coefficient of constant term in U-axis definition (RHOCUR(1))

Format B, record 2, Definition of V-axis:

Field	Columns	Format	Description
1	1- 8	8X	Spaces
2	9-16	A8	Caption: "V-axis ="
3	17-31	F15.5	X Coefficient in V-axis definition
4	32-46	F15.5	Y Coefficient (COSCUR(1-3,2))
5	47-61	F15.5	Z Coefficient in V-axis definition
6	62-76	F15.5	Coefficient of constant term in V-axis definition (RHOCUR(2))

Format B, record 3, Definition of W-axis:

Field	Columns	Format	Description
1	1- 8	8X	Spaces
2	9-16	A8	Caption: "W-axis ="
3	17-31	F15.5	X Coefficient in W-axis definition
4	32-46	F15.5	Y Coefficient (COSCUR(1-3,3))
5	47-61	F15.5	Z Coefficient in W-axis definition
6	62-76	F15.5	Coefficient of constant term in W-axis definition (RHOCUR(3))

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Cell Definition Entry: (continued)

This entry occurs only if the cutting plane is not parallel to one of the coordinate planes (Format B).

Format B, record 4, Layout of cells along U-axis:

Field	Columns	Format	Description
1	1- 7	7X	Spaces
2	8-16	I9	Number of cells along U-axis (NPTUXX)
3	17-31	F15.2	Step along U-axis (UUSTPX)
4	32-46	F15.2	Length of celled U-axis (UAXLNX)
5	47-61	F15.2	Direction factor for U-axis (UFACX)

Format B, record 5, Layout of cells along V-axis:

Field	Columns	Format	Description
1	1- 9	9X	Spaces
2	10-16	I7	Number of cells along V-axis (NPTVXX)
3	17-31	F15.2	Step along V-axis (VVSTPX)
4	32-46	F15.2	Length of celled V-axis (VAXLNX)
5	47-61	F15.2	Direction factor for V-axis (VFACX)

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Output Entry

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Format A, record 1:

Field	Columns	Format	Description
1	1-12	12X	Spaces
2	13-17	A5	Caption: "|Beg "
3	18-18	A1	V-axis designator (NAXIS(2,_))
4	19-20	A2	Caption: "-|"
5	21-44	24X	Spaces
6	45-45	A1	V-axis designator (NAXIS(2,_))
7	46-56	A11	Caption: "-box values"

Format B, record 1:

Field	Columns	Format	Description
1	1-12	12X	Spaces
2	13-20	A8	Caption: "|Beg V-|"
3	21-44	24X	Spaces
4	45-56	A12	Caption: "V-box values"

Formats A and B, record 2:

Field	Columns	Format	Description
1	1-12	12X	Spaces
2	13-20	A8	Caption: "|box No|"
3	21-80	60A1	Caption "_"

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Output Entry (continued)

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Format A and B, records 3-NVXCOL+2:

Field	Columns	Format	Description
1	1-12	12X	Spaces
2	13-13	A1	Caption: "¦"
3	14-19	I6	Beginning column number for this printed row (MKA)
4	20-20	A1	Caption: "¦"
5	21-26	I6	Cell MKA V-value (IVAXIS(MKA,_))
6	27-32	I6	Cell MKA+1 V-value (IVAXIS(MKA+1,_))
7	33-38	I6	Cell MKA+2 V-value (IVAXIS(MKA+2,_))
8	39-44	I6	Cell MKA+3 V-value (IVAXIS(MKA+3,_))
9	45-50	I6	Cell MKA+4 V-value (IVAXIS(MKA+4,_))
10	51-56	I6	Cell MKA+5 V-value (IVAXIS(MKA+5,_))
11	57-62	I6	Cell MKA+6 V-value (IVAXIS(MKA+6,_))
12	63-68	I6	Cell MKA+7 V-value (IVAXIS(MKA+7,_))
13	69-74	I6	Cell MKA+8 V-value (IVAXIS(MKA+8,_))
14	75-80	I6	Cell MKA+9 V-value (IVAXIS(MKA+9,_))

Notes:

1. NVXCOL = [(NPTVXX+9)/10] where [] designates "greatest integer less than or equal to."

2. MKA takes on the values 1, 11, 21, etc as needed for all such values no greater than NPTVXX (a total of NVXCOL values).

3. Each line will contain 10 V-values except possibly the last line, which will end with the NPTVXX-th value.

4. In Format A, the X-, Y-, or Z-value corresponding to the proper V-value is printed; in Format B, the V-value itself is printed. In each case it is the lower of the bounding V-values for the corresponding cell.

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Output Entry (continued)

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Format A and B, record NVXCOL+3: One-character blank record.

Format A, record NVXCOL+4:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 2	A1	U-axis designator (NAXIS(1,_))
3	3- 7	A5	Caption: "-box|"
4	8- 8	A1	U-axis designator (NAXIS(1,_))
5	9-17	A9	Caption: "-box|Beg "
6	18-18	A1	V-axis designator (NAXIS(2,_))
7	19-20	A2	Caption: "-|"
8	21-33	13X	Spaces
9	34-54	A21	Caption: "Maximum excursion in "
10	55-55	A1	W-axis direction designator (STRNOT(3,_))
11	56-56	A1	W-axis designator (NAXIS(3,_))
12	57-66	A10	Caption: " direction"

Format B, record NVXCOL+4:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2-20	A19	Caption: "U-box|U-box|Beg V-|"
3	21-33	13X	Spaces
4	34-66	A33	Caption: "Maximum excursion in W direction"

Format A and B, record NVXCOL+5:

Field	Columns	Format	Description
1	1- 2	2X	Spaces
2	3-20	A18	Caption: "No. |Value|box No|"
3	21-80	60A1	Caption: "_"

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Output Entry (continued)

One of two formats is used for this entry depending on whether the cutting plane is parallel to one of the coordinate planes (Format A) or not (Format B).

Maximum Excursion Cell Output Records NVXCOL+6 - NVXCOL+NPTUXX*NVXCOL+5

Formats A and B:

Field	Columns	Format	Description
1	1- 1	1X	Space
2	2- 6	I5	Cell U Row Number (L)
3	7- 7	A1	Caption: "|"
4	8-12	I5	Cell Row Beginning U-value (IUVALU)
5	13-13	A1	Caption: "|"
6	14-19	I6	Beginning Cell U Column No. (MKA)
7	20-20	A1	Caption: "|"
8	21-26	I6	Cell MKA V-value (NXHIST(1))
9	27-32	I6	Cell MKA+1 V-value (NXHIST(2))
10	33-38	I6	Cell MKA+2 V-value (NXHIST(3))
11	39-44	I6	Cell MKA+3 V-value (NXHIST(4))
12	45-50	I6	Cell MKA+4 V-value (NXHIST(5))
13	51-56	I6	Cell MKA+5 V-value (NXHIST(6))
14	57-62	I6	Cell MKA+6 V-value (NXHIST(7))
15	63-68	I6	Cell MKA+7 V-value (NXHIST(8))
16	69-74	I6	Cell MKA+8 V-value (NXHIST(9))
17	75-80	I6	Cell MKA+9 V-value (NXHIST(10))

Notes:

1. The histogram consists of NPTUXX rows and NPTVXX columns of cells containing the maximum W which has been encountered with a U and V within the cell. All cells in each row are printed together. For each row, the lower U-value bounding the cells in the row is properly converted and stored in IUVALU and the NVPTXX W-values for cells in the row are properly converted and stored in NXHIST(in groups of 10).

Table 6 Layout of Maximum Excursion Output File (continued)

Typical Histogram Output Entry (continued)

Maximum Excursion Cell Output Records NVXCOL+6 - NVXCOL+NPTUXX*NVXCOL+5

Notes: (continued)

2. NVXCOL = [(NPTVXX+9)/10] where [] designates "greatest integer less than or equal to."

3. MKA takes on the values 1, 11, 21, etc., as needed for all such values no greater than NPTVXX (a total of NVXCOL values).

4. Each line will contain 10 V-values except perhaps the last line, which will end with the NPTVXX-th value.

5. In Format A, the X-, Y-, or Z-value corresponding to the proper U-, V-, or W-value is printed; in Format B, the U-, V-, or W-value itself is printed. In each case it is the lower of the bounding U- or V-values for the corresponding cell that is used; for each cell, the W-value used is the maximum encountered within or on its boundaries.

6. All cells are initialized to -9999 so any cell where this value appears has had no points encountered.

3.0 Examples of WIREFRAM Input and Output

This section contains examples with commentary of the five input/output files/interaction described in Table 2 through Table 6 of the preceding section.

Figure 3 contains a listing of a Target Sample Data File described in Table 2. For brevity, this figure contains 1 of 45 repetitions (3 seat packages x 5 movements x 3 repetitions) for Subject 11007. This is the experimental data measured and recorded in the laboratory and later refined somewhat. The data defines the "wireframe envelope" which is analyzed by this program.

Figure 4 contains a listing of a normal interactive session. This session includes the problem specification described in Table 3 together with the normal interactive output while the program is running. This example shows a shortened run with 14 repetitions instead of the usual 45 repetitions. This example also illustrates that one of the repetitions is thrown out because of the presence of a "9999" in a data field of the Target Sample Data. The "9999" is used to indicate flawed data which cannot be processed by WIREFRAM. The normal interactive output is mostly a listing of all repetitions encountered together with appropriate warnings and/or error flags.

Figure 5 contains the first 3 repetitions of the output from the same run with the first hidden switch specified. The whole interactive output produced by the first hidden switch is about 25 times as voluminous as the normal output for this case. The additional interactive output is mostly a listing of each panel within each repetition together with the number of points computed to approximate the intersection curve for the panel.

No example is provided of the extensive output written into the created file, "WIREFRAM.AUX", which results from specifing the second hidden switch.

Figure 6 presents a listing of the Cutting Plane Family Description File for an artificial case which has four cutting plane families. The first family is two Z-slices and requests both Intersection Output and Repetition Maximum Excursion Output based on both the wireframe and the intersections. The second family is two X-slices and requests both Intersection Output and Repetition Maximum Excursion Output based on the intersections alone. The third family is a single skewed cutting plane and requests both Intersection Output and Repetition Maximum Excursion Output based on the wireframe alone. The fourth family is two Y-slices and requests both Intersection Output and Repetition Maximum Excursion based on both the wireframe and the intersections. Families 1, 2, and 4 will be reported using

Format A, and Family 3 will be reported using Format B. Families 1 through 3 use the three-point method of specifying the "parent" plane, and Family 4 uses the "equation" method of specifying the "parent" plane.

One additional special feature is illustrated in Figure 6; viz., the debugging controls are set to allow debugging printout only for Cutting Plane Family 2 and only for all targets of sample 1. Note that the second hidden switch still controls whether there is any debugging printout at all. Whatever level is requested on the second hidden switch will come out restricted as explained above.

Figures 7 and 8 present excerpts from the intersection and histogram output resulting when the Cutting Plane Family Description presented in Figure 6 is run on the Sample Target Data presented in Figure 3. The intersection data are presented for only the first three panels for each cutting plane. The histogram output is presented omitting blocks of "-9999"s. In each case an omission is signaled by the presence of an otherwise blank line with "* * *" somewhere in it.

Figures 9 through 12 present an example of the higher levels of Maximum Excursion Histogram Output. The Cutting Plane Family Description File is shown in Figure 9. All three levels (Repetition, Movement, and Seat) of Maximum Excursion Output are requested. Maximum Excursion is specified as the Negative X-direction. This Cutting Plane Description File was run on altered and shortened Target Sample Data for Subject 20103.

Figure 10 contains the first of the Repetition Maximum Excursion Histograms. Figure 11 contains the Movement Maximum Excursion Histogram, which contains the repetition in Figure 10. Figure 12 contains the Package Maximum Excursion Histogram, which contains the repetition in Figure 10 and the movement in Figure 11. Note that each higher level has some histogram cells where values were replaced by smaller ones occurring in other repetitions or movements.

The last set of examples illustrates the reason for caution in the use of this program. This contrasts two full runs: three seats with five movements, each with three repetitions, for a total of 45 repetitions. The first run (Figure 13) was set up for 132 cutting plane instances spaced at 4 mm with intersection curves evaluated every 2 mm and a maximum excursion done on 4-mm square cells evaluated every 2 mm. [Note: All final wireframe data analysis in the study was with a 6 mm spacing between cutting planes. See Figures 17 to 20.] The second run (Figure 14) was also set up for 132 cutting plane instances spaced at 10 mm with intersection curves evaluated every 5 mm. The value 132 should have been cut down to 53 for this run; this error resulted in about

2000 bytes of meaningless warning comments in each of the 108 resulting output files. The second run had maximum excursion done on 10-mm square cells evaluated every 5 mm. Figure 15 shows the normal interactive output for this run. The first run required 88:02.13 minutes on a 20 MHz 386, and the second run required 33:47.30 minutes. This is a ratio of about 2.6, a little more than the ratio of 10 mm to 4 mm. Figure 16 lists the 108 resulting files and gives their sizes in bytes.

The intersection output files total 29,474,591 bytes (28.1 MB) for the first run and 10,135,995 bytes (9.7 MB) for the second run, a ratio of 2.91. The histogram output files total 8,826,237 bytes (8.4 MB) and 2,070,747 bytes (2 MB) for the second run, a ratio of 4.26. Both these ratios have elements of both the ratio of 10 mm to 4 mm (2.5) and the square of that number (6.25). The data storage cost of intersection output is, however, approximately linearly related to the ratio (by a power of 1.17) while for histograms data there is an important contribution from the square of the ratio. (4.26 is 2.5 to the power 1.58.) It should be pointed out that the intersections have a critical dependence on the wire frame shape so that ratios can never provide better than ballpark estimates. The histogram should be more describable in terms of cell size, etc. These numbers are partially obscured by the error mentioned above. The reported ratios for the intersection and histogram files are probably each about 10% low.

Figures 17 through 20 are the WIREFRAM input data files used in the study. They are the same as the cutting plane description file examples in Figures 13 and 14 except that a) they are for four different histogram types, b) the spacing between cutting planes is 6 mm, and c) the boundaries of the leg-movement space are different. Figure 17, like Figures 13 and 14, is for a "ZMX" maximum excursion histogram, i.e., one for a maximum excursion coordinate of -X (==> MX) determined by cutting the wireframe with a family of Z = constant planes (horizontal). Figures 18, 19, and 20 are for "XPZ", "XPY", and "XMY" histograms, respectively. The maximum excursion coordinates are +Z, +Y, and -Y, respectively. All are for a family of X = constant cutting planes (vertical, transverse). While histogram cell sizes are 6 mm on a side, the maximum excursion values determined for these data sets are found by scanning the wireframe surface at a resolution at least as good as 2 mm in any part of the wireframe.

```
11007
 Econoline:  mvt=1, rep=1, npts=25
  1: (  274,  228,  550) (  150,  228,  551) (  120,  226,  533) (   90,  224,  502) (  -29,  215,  307) ( -129,  251,  181)
  2: (  274,  227,  550) (  150,  227,  551) (  119,  225,  532) (   89,  223,  498) (  -31,  214,  305) ( -131,  251,  180
  3: (  275,  227,  551) (  150,  227,  552) (  119,  225,  533) (   89,  222,  499) (  -31,  213,  306) ( -131,  250,  181
  4: (  280,  228,  558) (  157,  229,  568) (  123,  226,  545) (   90,  222,  501) (  -27,  213,  308) ( -134,  240,  165)
  5: (  294,  225,  574) (  171,  225,  592) (  132,  223,  567) (   96,  220,  517) (   -8,  217,  318) (  -89,  258,  189
  6: (  309,  220,  588) (  185,  219,  614) (  144,  217,  591) (  106,  216,  541) (   13,  225,  334) (  -60,  274,  205
  7: (  319,  217,  597) (  195,  216,  628) (  154,  214,  608) (  117,  214,  561) (   29,  236,  350) (  -38,  293,  220)
  8: (  323,  217,  600) (  197,  218,  632) (  158,  216,  615) (  122,  216,  574) (   36,  247,  361) (  -30,  309,  229)
  9: (  320,  223,  598) (  193,  228,  628) (  156,  224,  613) (  122,  222,  577) (   30,  257,  365) (  -70,  307,  202
 10: (  315,  234,  595) (  188,  241,  623) (  151,  236,  607) (  117,  233,  572) (   25,  266,  358) (  -52,  320,  203,
 11: (  313,  241,  594) (  186,  249,  620) (  149,  246,  604) (  115,  245,  567) (   23,  273,  354) (  -45,  332,  217)
 12: (  309,  245,  592) (  182,  255,  615) (  146,  253,  599) (  113,  253,  563) (   20,  277,  350) (  -49,  334,  213
 13: (  305,  249,  588) (  177,  259,  606) (  142,  258,  590) (  109,  258,  558) (   14,  279,  346) (  -60,  335,  210
 14: (  298,  252,  580) (  170,  262,  594) (  137,  261,  579) (  105,  261,  548) (    5,  279,  337) (  -72,  333,  201)
 15: (  293,  255,  574) (  166,  264,  584) (  133,  264,  568) (  101,  264,  536) (   -2,  279,  328) (  -82,  332,  193
 16: (  290,  255,  569) (  163,  264,  577) (  130,  264,  560) (   99,  265,  527) (   -7,  280,  321) (  -88,  333,  187
 17: (  289,  252,  566) (  163,  259,  573) (  129,  262,  555) (   97,  265,  521) (   -9,  282,  317) (  -91,  336,  185)
 18: (  289,  247,  564) (  163,  254,  570) (  130,  257,  551) (   98,  261,  517) (  -10,  281,  315) (  -92,  336,  185
 19: (  289,  243,  560) (  163,  250,  565) (  130,  253,  547) (   99,  257,  514) (  -11,  277,  313) ( -111,  326,  170
 20: (  288,  241,  556) (  162,  248,  560) (  131,  250,  542) (  100,  254,  509) (  -13,  275,  310) ( -100,  333,  183
 21: (  287,  241,  554) (  162,  248,  559) (  131,  250,  540) (  101,  253,  505) (  -15,  275,  308) ( -103,  333,  182)
 22: (  287,  241,  555) (  162,  248,  559) (  131,  250,  539) (  101,  253,  504) (  -15,  275,  308) ( -118,  325,  168
 23: (  288,  241,  554) (  163,  248,  559) (  132,  250,  540) (  101,  253,  505) (  -15,  275,  309) ( -118,  324,  169,
 24: (  289,  241,  554) (  164,  247,  558) (  133,  249,  539) (  102,  252,  504) (  -15,  275,  308) ( -103,  333,  184)
 25: (  289,  240,  554) (  164,  247,  557) (  133,  249,  538) (  103,  252,  504) (  -14,  274,  309) ( -104,  332,  184
```

Figure 3 Example of Sample Target Data for a Single Repetition of Subject 11007 Performing Movement 1 from the Econoline Seating Package

```
Please enter Time Point Increment
( 2 digits, default  1 ):? 1

Please enter Intersection Curve Step Limit
( 8 digits, default 1. ):?2.

Please enter File Name Stem
( 5 to 20 characters or <Return> to quit ):?20103fud

# Chars =    12, Stem =20103FUD              , File=20103FUD.LEG
Please enter file name containing cutting planes
( Up to 24 characters, <Return> for bounding planes ):?cutplane.zsl

Number of Cutting Plane Descriptions =  1
         1      Taurus       1      1       25
         2      Taurus       1      2       25
         3      Taurus       1      3       25
Case skipped due to "9999"
         4      Taurus       2      2       24
         5      Taurus       2      3       25
         6      Taurus       5      2       17
         7      Taurus       5      3       21
         8      Camaro       1      1       25
         9      Camaro       1      2       25
        10      Camaro       1      3       25
Case skipped due to "9999"
        11      Camaro       2      2       24
        12      Camaro       2      3       25
        13   Econoline       5      2       17
        14   Econoline       5      3       21
End of processing
```

Figure 4   Example of Normal Interactive Output

```
Please enter Time Point Increment
( 2 digits, default  1 ):? 1 1

Please enter Intersection Curve Step Limit
( 8 digits, default 1. ):?2.

Please enter File Name Stem
( 5 to 20 characters or <Return> to quit ):?20103fud

# Chars =    12, Stem =20103FUD            , File=20103FUD.LEG
Please enter file name containing cutting planes
( Up to 24 characters, <Return> for bounding planes ):?cutplane.zsl

Number of Cutting Plane Descriptions =  1
        1      Taurus      1      1      25
Panel Intersection Curve Points Recorded=   11     1     5     1     1
Panel Intersection Curve Points Recorded=   28     2     5     1     1
Panel Intersection Curve Points Recorded=   23     3     5     1     1
Panel Intersection Curve Points Recorded=    4     4     5     1     1
Panel Intersection Curve Points Recorded=    4     5     5     1     1
Panel Intersection Curve Points Recorded=    5     6     5     1     1
Panel Intersection Curve Points Recorded=    5     7     5     1     1
Panel Intersection Curve Points Recorded=    5     8     5     1     1
Panel Intersection Curve Points Recorded=    5     9     5     1     1
Panel Intersection Curve Points Recorded=    5    10     5     1     1
Panel Intersection Curve Points Recorded=    4    11     5     1     1
Panel Intersection Curve Points Recorded=    3    12     5     1     1
Panel Intersection Curve Points Recorded=    2    13     5     1     1
Panel Intersection Curve Points Recorded=    3    14     5     1     1
Panel Intersection Curve Points Recorded=    4    15     5     1     1
Panel Intersection Curve Points Recorded=    7    16     5     1     1
Panel Intersection Curve Points Recorded=    8    17     5     1     1
Panel Intersection Curve Points Recorded=    8    18     5     1     1
Panel Intersection Curve Points Recorded=    4    19     5     1     1
Panel Intersection Curve Points Recorded=    3    20     5     1     1
Panel Intersection Curve Points Recorded=   20    21     5     1     1
Panel Intersection Curve Points Recorded=   13    22     5     1     1
Panel Intersection Curve Points Recorded=   11    23     5     1     1
Panel Intersection Curve Points Recorded=    7    24     5     1     1
Panel Intersection Curve Points Recorded=    8     1     5     1     2
Panel Intersection Curve Points Recorded=   23     2     5     1     2
Panel Intersection Curve Points Recorded=   21     3     5     1     2
Panel Intersection Curve Points Recorded=    4     4     5     1     2
Panel Intersection Curve Points Recorded=    4     5     5     1     2
Panel Intersection Curve Points Recorded=    4     6     5     1     2
```

Figure 5 Example of Augmented Interactive Output
(Page 1 of 3)

```
Panel Intersection Curve Points Recorded=     5     7     5     1     2
Panel Intersection Curve Points Recorded=     5     8     5     1     2
Panel Intersection Curve Points Recorded=     4     9     5     1     2
Panel Intersection Curve Points Recorded=     4    10     5     1     2
Panel Intersection Curve Points Recorded=     3    11     5     1     2
Panel Intersection Curve Points Recorded=     3    12     5     1     2
Panel Intersection Curve Points Recorded=     2    13     5     1     2
Panel Intersection Curve Points Recorded=     3    14     5     1     2
Panel Intersection Curve Points Recorded=     4    15     5     1     2
Panel Intersection Curve Points Recorded=     6    16     5     1     2
Panel Intersection Curve Points Recorded=     7    17     5     1     2
Panel Intersection Curve Points Recorded=     7    18     5     1     2
Panel Intersection Curve Points Recorded=     4    19     5     1     2
Panel Intersection Curve Points Recorded=     3    20     5     1     2
Panel Intersection Curve Points Recorded=    17    21     5     1     2
Panel Intersection Curve Points Recorded=    11    22     5     1     2
Panel Intersection Curve Points Recorded=     6    23     5     1     2
Panel Intersection Curve Points Recorded=    11    24     5     1     2
End of Processing for Cutting Plane          0          0
        2      Taurus          1       2      25
Panel Intersection Curve Points Recorded=     4     1     5     1     1
Panel Intersection Curve Points Recorded=     2     2     5     1     1
Panel Intersection Curve Points Recorded=     3     3     5     1     1
Panel Intersection Curve Points Recorded=     5     4     5     1     1
Panel Intersection Curve Points Recorded=     6     5     5     1     1
Panel Intersection Curve Points Recorded=     9     6     5     1     1
Panel Intersection Curve Points Recorded=     6     7     5     1     1
Panel Intersection Curve Points Recorded=     6     8     5     1     1
Panel Intersection Curve Points Recorded=     3     9     5     1     1
Corner intersection is isolated, thrown out:    11     5     1     1
Panel Intersection Curve Points Recorded=     6    12     5     1     1
Panel Intersection Curve Points Recorded=    28    13     5     1     1
Panel Intersection Curve Points Recorded=    29    14     5     1     1
Panel Intersection Curve Points Recorded=    12    15     5     1     1
Panel Intersection Curve Points Recorded=    10    16     5     1     1
Panel Intersection Curve Points Recorded=    12    17     5     1     1
Panel Intersection Curve Points Recorded=    12    18     5     1     1
Panel Intersection Curve Points Recorded=    10    19     5     1     1
Panel Intersection Curve Points Recorded=    12    20     5     1     1
Panel Intersection Curve Points Recorded=    12    21     5     1     1
Panel Intersection Curve Points Recorded=     5    22     5     1     1
Panel Intersection Curve Points Recorded=     6    23     5     1     1
Panel Intersection Curve Points Recorded=     3    24     5     1     1
Panel Intersection Curve Points Recorded=     4     1     5     1     2
Panel Intersection Curve Points Recorded=     3     2     5     1     2
```

Figure 5 Example of Augmented Interactive Output
(continued) (Page 2 of 3)

```
Panel Intersection Curve Points Recorded=    3     3     5     1     2
Panel Intersection Curve Points Recorded=    5     4     5     1     2
Panel Intersection Curve Points Recorded=    6     5     5     1     2
Panel Intersection Curve Points Recorded=    8     6     5     1     2
Panel Intersection Curve Points Recorded=    6     7     5     1     2
Panel Intersection Curve Points Recorded=    5     8     5     1     2
Panel Intersection Curve Points Recorded=    4     9     5     1     2
Panel Intersection Curve Points Recorded=    4    10     5     1     2
Panel Intersection Curve Points Recorded=    5    11     5     1     2
Panel Intersection Curve Points Recorded=    5    12     5     1     2
Panel Intersection Curve Points Recorded=   23    13     5     1     2
Panel Intersection Curve Points Recorded=   25    14     5     1     2
Panel Intersection Curve Points Recorded=   11    15     5     1     2
Panel Intersection Curve Points Recorded=    9    16     5     1     2
Panel Intersection Curve Points Recorded=   11    17     5     1     2
Panel Intersection Curve Points Recorded=   12    18     5     1     2
Panel Intersection Curve Points Recorded=    9    19     5     1     2
Panel Intersection Curve Points Recorded=   18    20     5     1     2
Panel Intersection Curve Points Recorded=   10    21     5     1     2
Panel Intersection Curve Points Recorded=    4    22     5     1     2
Panel Intersection Curve Points Recorded=    5    23     5     1     2
Panel Intersection Curve Points Recorded=    4    24     5     1     2
End of Processing for Cutting Plane        0          0
        3      Taurus      1      3      25
Case skipped due to "9999"
End of Processing for Cutting Plane        0          0
```

Figure 5 Example of Augmented Interactive Output
(continued) (Page 3 of 3)

```
CUTTING    4
 1  2 3    -8.     Horizontal family    0 00.      2.       1 0 0
  0.       0.      -1.     -20.    0.      -1.     0.      -20.    -1.
  0.       +19.    +20.    +20.    2.      -20.    2.      2.      2.
 2  2 1    +7.     Vertical X-slice     2 00.      2.       1 0 0
1 0 0 0 0 0 0 0 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 1 1 1 1 1
  2.       0.      0.      2.      0.      14.     2.      17.     0.
  0.       +18.    +20.    -40.    2.      -40.    2.      2.      2.
 3  1 2    0.      Diagonal slice       0 00.      2.       1 0 0
  14.      0.      5.      -15.    0.      -10.    14.     20.     5.
  0.       10.     10.26784-40.    2.      -40.    2.      2.      2.
 4  2 3    +7.     Vertical Y-slice     0-2-3.     2.       1 0 0
  0.       0.      0.      0.      0.      0.      0.      0.      0.
  20.      18.     0.      -20.    2.      -40.    2.      2.      2.
```

Figure 6 Example of a Cutting Plane Family Description File with 4 Families and Repetition Maximum Excursion of Various Types

```
Wire Frame Intersection Curve File for Subject: TEST2
Seat=  Econoline, Movement=    1, Repetition=    1, No. Samples=    9
Cutting Plane Family No.  1 ("Horizontal family    "): plane no.  1, Z=     -1.0
    1    3    1    1            4    3    4
     1    -3    -4    -1             2    -2    -3    -1
     3    -2    -1    -1             4    -1     0    -1
    2    3    1    1            4    2    4
     1    -1    -8    -1             2    -2    -7    -1
     3    -2    -5    -1             4    -3    -4    -1
    3    2    1    1            8    3    2
     1     0   -10    -1             2     1   -10    -1
     3     3   -10    -1             4     4   -11    -1
     5     5   -11    -1             6     6   -11    -1
     7     7   -11    -1             8     8   -12    -1
     * * *
Cutting Plane Family No.  1 ("Horizontal family    "): plane no.  2, Z=     -9.0
    1    4    1    2            2    2    4
     1   -11    -4    -9             2    -9     0    -9
    2    4    1    2            2    2    4
     1    -9    -8    -9             2   -11    -4    -9
    3    4    1    2            4    2    4
     1    -9   -12    -9             2    -9   -11    -9
     3    -9    -9    -9             4    -9    -8    -9
     * * *
Cutting Plane Family No.  2 ("Vertical X-slice     "): plane no.  1, X=      2.0
    1    2    2    1            4    2    4
     1     2    -4     3             2     2    -3     2
     3     2    -1     1             4     2     0     0
    2    2    2    1            4    2    4
     1     2    -8     0             2     2    -7     1
     3     2    -5     2             4     2    -4     3
    3    2    2    1            4    2    4
     1     2   -12    -2             2     2   -11    -1
     3     2    -9    -1             4     2    -8     0
     * * *
Cutting Plane Family No.  2 ("Vertical X-slice     "): plane no.  2, X=     -5.0
    1    4    2    2            2    2    4
     1    -5    -4    -3             2    -5     0    -5
    2    4    2    2            2    2    4
     1    -5    -8    -5             2    -5    -4    -3
    3    4    2    2            4    2    4
     1    -5   -12    -6             2    -5   -11    -5
     3    -5    -9    -5             4    -5    -8    -5
     * * *
```

Figure 7 Excerpts from an Example of WIREFRAM Intersection Output for Same Case as Figure 6 (Page 1 of 2)

```
Instance:    3    1  Diagonal slice
    0.4594229           0.0000000           -0.8882176           -1.990833
   1    2    3    1              4     1     4
    1     8     -4     2             2     7     -3     1
    3     6     -1     1             4     4      0     0
   1    4    3    1              2     2     4
    1    -9     -4    -7             2    -5      0    -5
   2    2    3    1              4     1     2
    1     8     -4     2             2     7     -5     1
    3     6     -7     1             4     4     -8     0
     * * *
Cutting Plane Family No.  4 ("Vertical Y-slice     "): plane no.  1, Y=     -3.0
   1    1    4    1              7     1     3
    1    18     -3     0             2    16     -3     0
    3    15     -3     1             4    13     -3     1
    5    11     -3     1             6    10     -3     1
    7     8     -3     2
   1    2    4    1              6     1     3
    1     8     -3     2             2     6     -3     2
    3     5     -3     2             4     3     -3     2
    5     2     -3     2             6     0     -3     2
   1    3    4    1              4     1     3
    1     0     -3     2             2    -1     -3     1
    3    -2     -3     0             4    -3     -3    -2
     * * *
Cutting Plane Family No.  4 ("Vertical Y-slice     "): plane no.  2, Y=    -10.0
   3    1    4    2              7     1     3
    1    18    -10     1             2    16    -10     0
    3    15    -10     0             4    13    -10     0
    5    11    -10     0             6    10    -10     0
    7     8    -10    -1
   3    2    4    2              6     1     3
    1     8    -10    -1             2     6    -10    -1
    3     5    -10    -1             4     3    -10    -1
    5     2    -10    -1             6     0    -10    -1
   3    3    4    2              3     1     3
    1     0    -10    -1             2    -2    -10    -2
    3    -3    -10    -4
   * * *
```

Figure 7 (cont.) Excerpts from an Example of WIREFRAM Intersection Output for Same Case as Figure 6 (Page 2 of 2)

Wire Frame Maximum Excursion File for Subject: TEST2
Seat= Econoline, Movement= 1, Repetition= 1, No. Samples= 9
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 1, Z= -1.0
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 2, Z= -9.0

Beg Z-box No	Z-box values									
1	-20	-18	-16	-14	-12	-10	-8	-6	-4	-2

Y-box No.	Y-box Value	Beg Z-box No	Maximum excursion in -X direction									
1	0	1	-20	-19	-16	-15	-13	-11	-9	-6	-4	-3
2	-2	1	-20	-20	-18	-16	-13	-12	-10	-8	-6	-4
3	-4	1	-20	-20	-18	-16	-13	-12	-10	-8	-6	-4
4	-6	1	-20	-19	-16	-15	-13	-11	-9	-6	-4	-3
5	-8	1	-20	-18	-16	-14	-12	-10	-8	-6	-4	-2
6	-10	1	-19	-18	-16	-14	-13	-11	-8	-6	-3	-1
7	-12	1	-19	-18	-16	-14	-13	-11	-8	-5	-3	-3
8	-14	1	-17	-15	-14	-13	-20	-20	-19	-18	-17	-15
9	-16	1	-18	-17	-16	-20	-20	-20	-19	-18	-17	-15
10	-18	1	-20	-20	-20	-20	-19	-18	-16	-15	-13	-12

Figure 8 Example of Maximum Excursion Output for Same Case as Figures 6 and 7 (Page 1 of 4)

Cutting Plane Family No. 2 ("Vertical X-slice "): plane no. 1, X= 2.0

Beg X-box No	X-box values									
1	20	18	16	14	12	10	8	6	4	2
11	0	-2	-4	-6	-8	-10	-12	-14	-16	-18

Y-box No.	Y-box Value	Beg X-box No	Maximum excursion in Z direction									
1	0	1	0	0	0	1	1	1	1	1	1	1
		11	1	-2	-3	-5	-8	-10	-11	-13	-15	-18
2	-2	1	0	0	1	1	2	2	2	3	3	3
		11	3	0	-2	-4	-7	-9	-10	-12	-14	-17
3	-4	1	0	0	1	1	2	2	2	3	3	3
		11	3	0	-2	-4	-7	-9	-10	-12	-14	-17
4	-6	1	0	0	0	1	1	1	1	1	1	1
		11	1	-2	-3	-5	-8	-10	-11	-13	-15	-18
5	-8	1	1	1	0	0	0	0	0	0	0	0
		11	0	-2	-4	-6	-8	-10	-12	-14	-16	-18
6	-10	1	1	1	1	0	0	0	-1	-1	-1	-1
		11	-1	-3	-5	-7	-8	-10	-11	-14	-16	-18
7	-12	1	1	1	2	3	4	5	5	5	5	6
		11	6	0	-5	-7	-8	-10	-11	-14	-16	-19
8	-14	1	20	20	18	16	14	11	11	12	13	15
		11	15	3	2	3	4	5	5	1	-3	-6
9	-16	1	20	20	18	16	14	11	11	12	13	15
		11	15	3	2	3	4	5	5	1	-3	-6
10	-18	1	15	15	12	10	8	6	6	7	8	10
		11	10	2	0	0	-1	-1	-1	-5	-7	-10
11	-20	1	10	10	8	6	5	5	5	3	4	5
		11	5	2	-1	-3	-4	-6	-6	-9	-11	-13
12	-22	1	5	5	5	6	8	10	10	6	2	1
		11	0	-3	-5	-5	-5	-5	-5	-9	-12	-15
13	-24	1	0	1	4	6	8	10	10	6	2	-1
		11	-5	-8	-8	-7	-6	-5	-5	-9	-13	-16
14	-26	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		* * *										
20	-38	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 8 (cont.) Example of Maximum Excursion Output for Same Case as Figures 6 and 7 (Page 2 of 4)

```
Plane Instance:     3     1  Diagonal slice
     0.4594229           0.0000000           -0.8882176           -1.990833
Cells: U-axis =         0.00000         -1.00000         0.00000          0.00000
       V-axis =         0.45942          0.00000        -0.88822          8.00917
       W-axis =        -0.88822          0.00000        -0.45942         25.00000
            20             2.00            40.00           -1.00
            20             2.00            40.00           -1.00
```

Beg V-box No	V-box values									
1	0	2	4	6	8	10	12	14	16	18
11	20	22	24	26	28	30	32	34	36	38

U-box No.	U-box Value	Beg V-box No	Maximum excursion in W direction									
1	0	1	-9999	-9999	-9999	-9999	33	33	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	2	1	-9999	-9999	-9999	-9999	36	36	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	4	1	-9999	-9999	-9999	-9999	36	36	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	6	1	-9999	-9999	-9999	-9999	33	33	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	8	1	-9999	-9999	-9999	-9999	31	31	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	10	1	-9999	-9999	-9999	-9999	29	29	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	12	1	-9999	-9999	-9999	-9999	29	29	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
8	14	1	-9999	-9999	-9999	-9999	31	31	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
9	16	1	-9999	-9999	-9999	-9999	35	35	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
10	18	1	-9999	-9999	-9999	-9999	49	49	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
11	20	1	-9999	-9999	-9999	-9999	43	43	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
12	22	1	-9999	-9999	-9999	-9999	42	42	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
13	24	1	-9999	-9999	-9999	-9999	42	42	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		* * *										
20	38	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 8 (cont.) Example of Maximum Excursion Output for Same Case as Figures 6 and 7 (Page 3 of 4)

Cutting Plane Family No. 4 ("Vertical Y-slice "): plane no. 1, Y= -3.0
Cutting Plane Family No. 4 ("Vertical Y-slice "): plane no. 2, Y= -10.0

Beg Y-box No	Y-box values									
1	-21	-19	-17	-15	-13	-11	-9	-7	-5	-3
11	-1	1	3	5	7	9	11	13	15	17

X-box No.	X-box Value	Beg Y-box No	Maximum excursion in -Z direction									
1	20	1	8	3	0	0	1	0	0	0	0	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	18	1	7	3	0	0	0	0	0	0	0	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	16	1	6	4	2	1	0	0	0	0	0	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	14	1	4	5	3	1	0	0	0	0	1	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	12	1	2	4	5	1	-1	0	0	0	1	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	10	1	0	3	6	2	-1	-1	0	0	1	0
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	8	1	0	3	7	2	-1	-1	0	1	2	1
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
8	6	1	1	3	7	2	-2	-1	0	1	2	1
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
9	4	1	3	4	6	3	-2	-1	0	1	2	1
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
10	2	1	3	4	5	3	-2	-2	-1	1	2	1
		11	0	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 8 (cont.) Example of Maximum Excursion Output for Same Case as Figures 6 and 7 (Page 4 of 4)

```
CUTTING    1----This space can be used for data set description, notes, etc.----
  1  2  3   -20.   Horizontal family    -1   00.     4.          1  1  1
310.   200.   200.   -130.  200.    200.   310.   340.    200.
1.     55.    107.   +480.  24.     +480.  24.    8.      8.
```

Figure 9 Example of Cutting Plane Family Description with 3 Horizontal Cutting Planes and All Levels of Maximum Excursion Histograms

Wire Frame Maximum Excursion File for Subject: 20103
Seat= Taurus, Movement= 1, Repetition= 1, No. Samples= 25
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 1, Z= -200.0
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 2, Z= -220.0

Beg Z-box No	Z-box values									
1	145	169	193	217	241	265	289	313	337	361
11	385	409	433	457	481	505	529	553	577	601

Y-box No.	Y-box Value	Beg Z-box No	Maximum excursion in -X direction									
1	199	1	-162	-184	-177	-125	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	223	1	-141	-112	-144	-137	-96	-56	-19	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	247	1	-120	-98	-74	-55	-32	-12	-6	13	44	74
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	271	1	-115	-93	-72	-48	-26	-4	13	30	50	69
		11	88	112	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	295	1	-142	-152	-138	-106	-68	-36	-6	18	49	69
		11	90	113	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	319	1	-142	-152	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	343	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		* * *										
20	655	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 10 Example of Repetition Maximum Excursion Histogram Output Resulting from Case in Figure 9

Wire Frame Maximum Excursion File for Subject: 20103
Seat= Taurus, Movement= 1, Repetition= 0, No. Samples= 1
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 1, Z= -200.0
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 2, Z= -220.0

Beg Z-box No	Z-box values									
1	145	169	193	217	241	265	289	313	337	361
11	385	409	433	457	481	505	529	553	577	601

Y-box No.	Y-box Value	Beg Z-box No	Maximum excursion in -X direction									
1	199	1	-162	-184	-177	-125	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	223	1	-145	-172	-181	-153	-112	-64	-19	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	247	1	-134	-116	-100	-108	-95	-64	-25	6	38	74
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	271	1	-115	-93	-72	-49	-27	-7	13	30	40	68
		11	88	112	137	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	295	1	-142	-152	-138	-106	-75	-43	-12	17	40	62
		11	83	104	134	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	319	1	-142	-153	-145	-108	-54	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	343	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
			* * *									
20	655	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 11 Example of Movement Maximum Excursion Histogram Output Resulting from Case in Figure 9

Wire Frame Maximum Excursion File for Subject: 20103
Seat= Taurus, Movement= 0, Repetition= 0, No. Samples= 1
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 1, Z= -200.0
Cutting Plane Family No. 1 ("Horizontal family "): plane no. 2, Z= -220.0

Beg Z-box No	Z-box values									
1	145	169	193	217	241	265	289	313	337	361
11	385	409	433	457	481	505	529	553	577	601

Y-box No.	Y-box Value	Beg Z-box No	Maximum excursion in -X direction									
1	199	1	-162	-184	-177	-125	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	223	1	-145	-172	-181	-153	-112	-64	-19	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	247	1	-232	-158	-100	-108	-95	-64	-25	6	38	74
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	271	1	-183	-123	-84	-49	-27	-7	13	30	40	68
		11	88	112	137	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	295	1	-144	-152	-138	-106	-75	-43	-12	17	40	62
		11	83	104	134	-9999	-9999	-9999	-9999	-9999	-9999	-9999
6	319	1	-157	-153	-145	-108	-54	23	60	106	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
7	343	1	-167	-153	-104	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
8	367	1	-170	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		* * *										
13	487	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	41	46	113	182	-9999	-9999	-9999	-9999
14	511	1	-9999	-9999	-239	-252	-216	-173	-141	-111	-83	-58
		11	-36	-19	1	22	40	87	137	-9999	-9999	-9999
15	535	1	-9999	-114	-132	-168	-170	-163	-131	-105	-79	-60
		11	-43	-30	-13	0	17	36	59	-9999	-9999	-9999
16	559	1	-126	-133	-129	-109	-89	-88	-84	-70	-60	-50
		11	-43	-27	-14	0	14	26	51	90	-9999	-9999
17	583	1	-139	-137	-124	-103	-82	-65	-54	-44	-35	-24
		11	-14	-5	6	16	-9999	-9999	-9999	-9999	-9999	-9999
18	607	1	-145	-131	-111	-94	-74	-60	-50	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
19	631	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
20	655	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 12 Example of Vehicle Package Maximum Excursion Histogram Output Resulting from Case in Figure 9

```
CUTTING    1----This space can be used for data set description, notes, etc.----
   1 132  3    -4.    Horizontal family     -1   00.      2.          1  1  1
310.    200.    131.    -130.   200.    131.    310.    340.    131.
19.     13.     120.    +480.   4.      +520.   4.      2.      2.
```

Figure 13 Example of a Cutting Planes Description File (4 mm step, 132 planes in family)

```
CUTTING    1----This space can be used for data set description, notes, etc.----
   1 132  3    -10.   Horizontal family     -1   00.      5.          1  1  1
310.    200.    131.    -130.   200.    131.    310.    340.    131.
19.     13.     120.    +480.   10.     +520.   10.     5.      5.
```

Figure 14 Example of a Cutting Planes Description File (10 mm step, 132 planes in family)

```
Please enter Time Point Increment
( 2 digits, default  1 ):? 1

Please enter Intersection Curve Step Limit
( 8 digits, default 1. ):?2.

Please enter File Name Stem
( 5 to 20 characters or <Return> to quit ):?d:\wire\10803iid

# Chars =    24, Stem =D:\WIRE\10803IID, File=D:\WIRE\10803IID.LEG
Please enter file name containing cutting planes
( Up to 24 characters, <Return> for bounding planes ):?larrycut.ts2

Number of Cutting Plane Descriptions =  1
```

1	Taurus	1	1	25
2	Taurus	1	2	25
3	Taurus	1	3	24
4	Taurus	2	1	25
5	Taurus	2	2	23
6	Taurus	2	3	25
7	Taurus	3	1	17
8	Taurus	3	2	18
9	Taurus	3	3	17
10	Taurus	4	1	22
11	Taurus	4	2	20
12	Taurus	4	3	25
13	Taurus	5	1	21
14	Taurus	5	2	24
15	Taurus	5	3	21
16	Camaro	1	1	24
17	Camaro	1	2	23
18	Camaro	1	3	22
19	Camaro	2	1	25
20	Camaro	2	2	25
21	Camaro	2	3	25
22	Camaro	3	1	17
23	Camaro	3	2	16

Figure 15 Example of Interactive Output for WIREFRAM Run
(data from Figure 13 or Figure 14)
(Page 1 of 2)

24	Camaro	3	3	16
25	Camaro	4	1	20
26	Camaro	4	2	21
27	Camaro	4	3	17
28	Camaro	5	1	22
29	Camaro	5	2	21
30	Camaro	5	3	25
31	Econoline	1	1	22
32	Econoline	1	2	20
33	Econoline	1	3	21
34	Econoline	2	1	23
35	Econoline	2	2	24
36	Econoline	2	3	25
37	Econoline	3	1	16
38	Econoline	3	2	16
39	Econoline	3	3	15
40	Econoline	4	1	24
41	Econoline	4	2	23
42	Econoline	4	3	19
43	Econoline	5	1	20
44	Econoline	5	2	24
45	Econoline	5	3	22

End of processing

Figure 15 (cont.) Example of Interactive Output for WIREFRAM Run (data from Figure 13 or Figure 14)

(Page 2 of 2)

FILE NAME -Taurus-	4 mm step (Ex. 13) FILE SIZE (bytes)	10 mm step (Ex. 14) FILE SIZE (bytes)	FILE NAME -Econoline-	4 mm step (Ex. 13) FILE SIZE (bytes)	10 mm (Ex. 14) SIZE (bytes)
10803T11.WFA	440518	182403	10803E11.WFA	525673	215538
10803T00.WFB	140099	32869	10803E00.WFB	140099	32869
10803T10.WFB	140099	32869	10803E10.WFB	140099	32869
10803T11.WFB	140099	32869	10803E11.WFB	140099	32869
10803T12.WFA	466401	193466	10803E12.WFA	522864	216868
10803T12.WFB	140099	32869	10803E12.WFB	140099	32869
10803T13.WFA	584363	240675	10803E13.WFA	529403	218068
10803T13.WFB	140099	32869	10803E13.WFB	140099	32869
10803T21.WFA	339214	141688	10803E21.WFA	551849	229090
10803T20.WFB	140099	32869	10803E20.WFB	140099	32869
10803T21.WFB	140099	32869	10803E21.WFB	140099	32869
10803T22.WFA	407665	170965	10803E22.WFA	592657	238386
10803T22.WFB	140099	32869	10803E22.WFB	140099	32869
10803T23.WFA	477659	200861	10803E23.WFA	536754	219745
10803T23.WFB	140099	32869	10803E23.WFB	140099	32869
10803T31.WFA	542266	224632	10803E31.WFA	612367	248527
10803T30.WFB	140099	32869	10803E30.WFB	140099	32869
10803T31.WFB	140099	32869	10803E31.WFB	140099	32869
10803T32.WFA	551141	229182	10803E32.WFA	551079	226685
10803T32.WFB	140099	32869	10803E32.WFB	140099	32869
10803T33.WFA	622513	257570	10803E33.WFA	539000	223393
10803T33.WFB	140099	32869	10803E33.WFB	140099	32869
10803T41.WFA	561358	230060	10803E41.WFA	686538	283540
10803T40.WFB	140099	32869	10803E40.WFB	140099	32869
10803T41.WFB	140099	32869	10803E41.WFB	140099	32869
10803T42.WFA	563720	231824	10803E42.WFA	661696	272492
10803T42.WFB	140099	32869	10803E42.WFB	140099	32869
10803T43.WFA	588328	242233	10803E43.WFA	623939	254055
10803T43.WFB	140099	32869	10803E43.WFB	140099	32869
10803T51.WFA	514356	213603	10803E51.WFA	648096	268948
10803T50.WFB	140099	32869	10803E50.WFB	140099	32869
10803T51.WFB	140099	32869	10803E51.WFB	140099	32869
10803T52.WFA	656137	266005	10803E52.WFA	594740	241721
10803T52.WFB	140099	32869	10803E52.WFB	140099	32869
10803T53.WFA	610492	252709	10803E53.WFA	648388	267653
10803T53.WFB	140099	32869	10803E53.WFB	140099	32869

Figure 16 Directory of Files Produced by a WIREFRAM Run for Subject 10803 for the Cutting Plane Description Files in Figures 13 and 14.
(Page 1 of 2)

FILE NAME -Camaro-	4 mm step (Ex. 13) FILE SIZE (bytes)	10 mm step (Ex. 14) FILE SIZE (bytes)
10803C11.WFA	546119	226134
10803C00.WFB	140099	32869
10803C10.WFB	140099	32869
10803C11.WFB	140099	32869
10803C12.WFA	500799	209050
10803C12.WFB	140099	32869
10803C13.WFA	527911	215711
10803C13.WFB	140099	32869
10803C21.WFA	473984	199065
10803C20.WFB	140099	32869
10803C21.WFB	140099	32869
10803C22.WFA	445705	186966
10803C22.WFB	140099	32869
10803C23.WFA	444733	182852
10803C23.WFB	140099	32869
10803C31.WFA	515346	213448
10803C30.WFB	140099	32869
10803C31.WFB	140099	32869
10803C32.WFA	515074	215154
10803C32.WFB	140099	32869
10803C33.WFA	507207	211047
10803C33.WFB	140099	32869
10803C41.WFA	527819	214186
10803C40.WFB	140099	32869
10803C41.WFB	140099	32869
10803C42.WFA	549751	225201
10803C42.WFB	140099	32869
10803C43.WFA	474430	194536
10803C43.WFB	140099	32869
10803C51.WFA	591233	241962
10803C50.WFB	140099	32869
10803C51.WFB	140099	32869
10803C52.WFA	635093	258879
10803C52.WFB	140099	32869
10803C53.WFA	588213	239219
10803C53.WFB	140099	32869

Figure 16 (cont.) Directory of Files Produced by a WIREFRAM Run for Subject 10803 for the Cutting Plane Description Files in Figures 13 and 14.
(Page 2 of 2)

```
CUTTING    1        This file is for Z-cuts and maximum excursion in -X .
  1 -98    2    -6.     Z = const cuts        -1   00.      2.          1   1   1
516.    100.    90.     -288.   100.    90.     516.    754.    90.
0.      0.      0.      +654.   6.      +582.   6.      2.      2.
```

Figure 17 A Cutting Planes Description File for a ZMX Histogram (6 mm step, 98 planes in family)

```
CUTTING    1        This file is for X-cuts and maximum excursion in +Z .
  1-135    2    -6.     X = const cuts        -1   00.      2.          1   1   1
-288.   100.    90.     -288.   100.    672.    -288.   754.    90.
0.      0.      0.      +654.   6.      +804.   6.      2.      2.
```

Figure 18 A Cutting Planes Description File for an XPZ Histogram (6 mm step, 135 planes in family)

```
CUTTING    1        This file is for X-cuts and maximum excursion in +Y .
  1-135    2    -6.     X = const cuts        -1   00.      2.          1   1   1
516.    100.    90.     516.    754.    90.     516.    100.    672.
0.      0.      0.      +582.   6.      +804.   6.      2.      2.
```

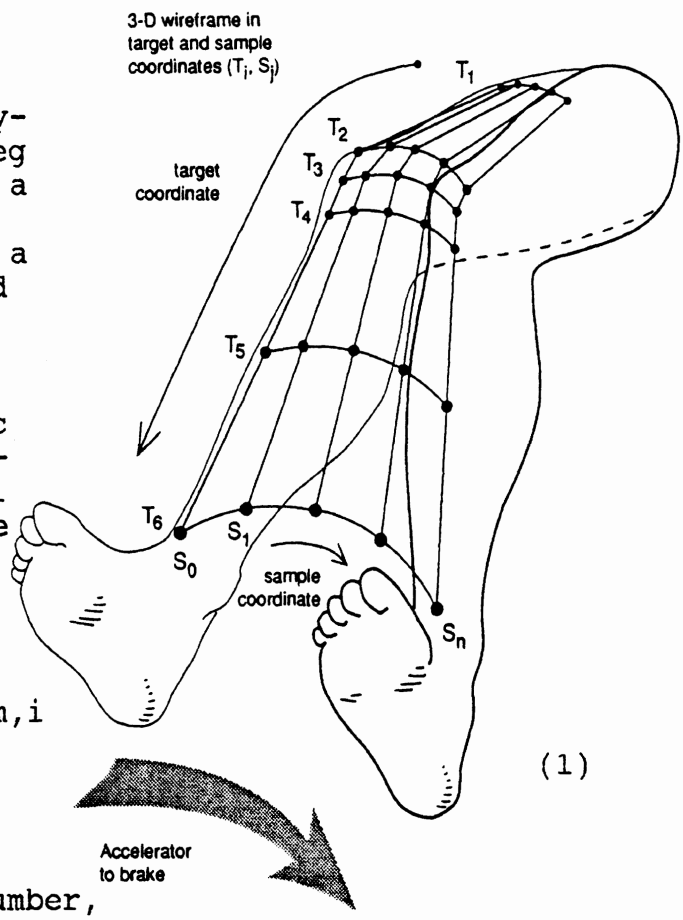
Figure 19 A Cutting Planes Description File for an XPY Histogram (6 mm step, 135 planes in family)

```
CUTTING    1        This file is for X-cuts and maximum excursion in -Y .
  1-135    2    -6.     X = const cuts        -1   00.      2.          1   1   1
-288.   754.    90.     -288.   100.    90.     -288.   754.    672.
0.      0.      0.      +582.   6.      +804.   6.      2.      2.
```

Figure 20 A Cutting Planes Description File for an XMY Histogram (6 mm step, 135 planes in family)

4.0 WIREFRAM Analysis

This section presents a summary of the wireframe analysis. The target data for a leg movement may be thought of as a series of sets of coordinate values. We let "P" represent a target point and "X", "Y", and "Z" represent the coordinate values. In equations, which apply to all coordinates separately, we will use a generic "x" to stand for the appropriate coordinate value. We will make the general symbols above specific by adding subscripts as shown below:



$$P_{n,m},\ X_{n,m},\ Y_{n,m},\ Z_{n,m},\ x_{n,m,i}$$

$$P_k,\ \hat{x}_k,\ \hat{y}_k,\ \hat{z}_k \qquad (1)$$

where n is the sample number,
m is the target number,
i is the coordinate number with 1=x, 2=y, 3=z, and
k is point number for plane definition (1, 2, or 3)

A panel is defined for each two consecutive targets for each two consecutive samples. Each panel is characterized by the "n" and "m" values for the lower left corner point. The coordinates of any point on the surface of the wireframe panel can be computed by the parametric equations:

$$x_i = \sigma_i\, S\, T + \beta_i\, S + \tau_i\, T + \delta_i \qquad (2a)$$

$$(0 \le S,\quad T \le 1)$$

for i = 1, 3, where

$$\tau_i = x_{n,m+1,i} - x_{n,m,i}$$

$$\sigma_i = x_{n+1,m+1,i} - x_{n+1,m,i} - \tau_i \qquad (2b)$$

$$\beta_i = x_{n+1,m,i} - x_{n,m,i}$$

$$\delta_i = x_{n,m,i}$$

The parameter "S" ranges in the sample direction and the parameter "T" ranges in the target direction. The panel and its boundaries are represented by the closed interval [0,1] in S and T.

Any cutting plane is represented in normal form by the equation:

$$\bar{\bar{\sigma}}_2\, x + \bar{\bar{\beta}}_2\, y + \bar{\bar{\tau}}_2\, z - \bar{\bar{\Theta}}_2 = 0$$

where (3a)

$$\bar{\bar{\sigma}}_2 = p \,/\, K, \quad \bar{\bar{\beta}}_2 = q \,/\, K, \quad \bar{\bar{\tau}}_2 = r \,/\, K$$

$$\bar{\bar{\Theta}}_2 = \bar{\bar{\sigma}}_2\, \hat{x}_1 + \bar{\bar{\beta}}_2\, \hat{y}_1 + \bar{\bar{\tau}}_2\, \hat{z}_1 \quad .$$

Here, p, q, r, and K are

$$p = \bar{\bar{\beta}}_3\, \tau_1' - \beta_1'\, \bar{\bar{\tau}}_3$$

$$q = \bar{\bar{\sigma}}_3\, \tau_1' - \sigma_1'\, \bar{\bar{\tau}}_3 \qquad (3b)$$

$$r = \bar{\bar{\sigma}}_3\, \beta_1' - \sigma_1'\, \bar{\bar{\beta}}_3 \, .$$

and

$$K = k \sqrt{p^2 + q^2 + r^2} \quad ,$$

where k is ± 1 and determined as described below. All factors in the expressions for p, q, and r are found from Equations (3c):

$$\bar{\bar{\sigma}}_3 = (\hat{x}_2 - \hat{x}_1)/\, d_{12}, \quad \bar{\bar{\beta}}_3 = (\hat{y}_2 - \hat{y}_1)/\, d_{12}, \quad \bar{\bar{\tau}}_3 = (\hat{z}_2 - \hat{z}_1)/\, d_{12}$$

$$\sigma_1' = (\hat{x}_3 - \hat{x}_1)/\, d_{13}, \quad \beta_1' = (\hat{y}_3 - \hat{y}_1)/\, d_{13}, \quad \tau_1' = (\hat{z}_3 - \hat{z}_1)/\, d_{13}$$

(3c)

where

$$d_{12} = \sqrt{(\hat{x}_2 - \hat{x}_1)^2 + (\hat{y}_2 - \hat{y}_1)^2 + (\hat{z}_2 - \hat{z}_1)^2}$$

$$d_{13} = \sqrt{(\hat{x}_3 - \hat{x}_1)^2 + (\hat{y}_3 - \hat{y}_1)^2 + (\hat{z}_3 - \hat{z}_1)^2} .$$

The quantity $k = \pm 1$ is chosen such that

$$\bar{\bar{\sigma}}_1 \hat{x}_3 + \bar{\bar{\beta}}_1 \hat{y}_3 + \bar{\bar{\tau}}_1 \hat{z}_3 - \bar{\bar{\Theta}}_3 > 0 ,$$

where

$$\bar{\bar{\sigma}}_1 = \bar{\bar{\beta}}_3 \bar{\bar{\tau}}_2 - \bar{\bar{\tau}}_3 \bar{\bar{\beta}}_2 \qquad (3d)$$

$$\bar{\bar{\beta}}_1 = \bar{\bar{\tau}}_3 \bar{\bar{\sigma}}_2 - \bar{\bar{\sigma}}_3 \bar{\bar{\tau}}_2$$

$$\bar{\bar{\tau}}_1 = \bar{\bar{\sigma}}_3 \bar{\bar{\beta}}_2 - \bar{\bar{\beta}}_3 \bar{\bar{\sigma}}_2 .$$

All factors in $\bar{\bar{\sigma}}_1$, $\bar{\bar{\beta}}_1$, and $\bar{\bar{\tau}}_1$ are normalized in Equations (3a), (3b), and (3c), so

$$\bar{\bar{\sigma}}_1^2 + \bar{\bar{\beta}}_1^2 + \bar{\bar{\tau}}_1^2 = 1$$

and

$$\bar{\bar{\Theta}}_1 = \bar{\bar{\sigma}}_1 \hat{x}_1 + \bar{\bar{\beta}}_1 \hat{y}_1 + \bar{\bar{\tau}}_1 \hat{z}_1 .$$

The intersection of any cutting plane with any panel is represented by all solutions (if any) of:

$$\bar{\sigma} S T + \bar{\beta} S + \bar{\tau} T + \bar{\delta} = 0 \qquad (4a)$$

$$(0 \le S, \quad T \le 1)$$

where

$$\bar{\sigma} = \bar{\bar{\sigma}}_2 \sigma_1 + \bar{\bar{\beta}}_2 \sigma_2 + \bar{\bar{\tau}}_2 \sigma_3$$

$$\bar{\beta} = \bar{\bar{\sigma}}_2 \beta_1 + \bar{\bar{\beta}}_2 \beta_2 + \bar{\bar{\tau}}_2 \beta_3$$

$$\bar{\tau} = \bar{\bar{\sigma}}_2 \tau_1 + \bar{\bar{\beta}}_2 \tau_2 + \bar{\bar{\tau}}_2 \tau_3 \qquad (4b)$$

$$\bar{\delta} = \bar{\bar{\sigma}}_2 X_{n,m} + \bar{\bar{\beta}}_2 Y_{n,m} + \bar{\bar{\tau}}_2 Z_{n,m} + \bar{\bar{\delta}}_2$$

Where the quantities S_o and S_1 are from Equations (7), the solutions of Equation (4) can be represented by the parametric equations:

$$x_i = (\bar{a}_i S^2 + \bar{b}_i S + \bar{c}_i) / (\bar{\sigma} S + \bar{\tau}) \qquad (5a)$$

$$(0 \leq S_o \leq S \leq S_1 \leq 1)$$

where

$$\bar{a}_i = \beta_i \bar{\sigma} - \sigma_i \bar{\beta}$$

$$\bar{b}_i = \beta_i \bar{\tau} + \bar{\sigma} x_{n,m,i} - \sigma_i \bar{\delta} - \tau_i \bar{\beta} \qquad (5b)$$

$$\bar{c}_i = \bar{\tau} x_{n,m,i} - \tau_i \bar{\delta}$$

If the solution found from Equations (5) is not meaningful, then the solution (intersections) is found instead from Equations (6), where T_o and T_1 are from Equation (7).

$$x_i = (\bar{A}_i T^2 + \bar{B}_i T + \bar{C}_i) / (\bar{\sigma} T + \bar{\beta}) \qquad (6a)$$

$$(0 \leq T_o \leq T \leq T_1 \leq 1)$$

where

$$\bar{A}_i = \tau_i \bar{\sigma} - \sigma_i \bar{\tau}$$

$$\bar{B}_i = \bar{\beta} \tau_i + \bar{\sigma} x_{n,m,i} - \sigma_i \bar{\delta} - \beta_i \bar{\tau} \qquad (6b)$$

$$\bar{C}_i = \bar{\beta} x_{n,m,i} - \beta_i \bar{\delta}$$

S_o, S_1, T_o, and T_1 are as follows:

$$S_o = - \bar{\delta} / \bar{\beta}$$

$$S_1 = - (\bar{\tau} + \bar{\delta}) / (\bar{\sigma} + \bar{\beta})$$

$$T_o = - \bar{\delta} / \bar{\tau} \qquad (7)$$

$$T_1 = - (\bar{\beta} + \bar{\delta}) / (\bar{\sigma} + \bar{\tau})$$

We can define a coordinate system with P_1 at its origin, with the W-axis along the directed line segment $\overline{P_1P_2}$ and the V-axis along the normal of the plane, and the U-axis normal to the other two. The origin can then be translated to a specified point and the directions of the axis reversed as desired.

The resulting system can be described as:

$$u = \bar{\bar{\sigma}}_1 x + \bar{\bar{\beta}}_1 y + \bar{\bar{\tau}}_1 z - \bar{\bar{\Theta}}_1$$

$$v = \bar{\bar{\sigma}}_2 x + \bar{\bar{\beta}}_2 y + \bar{\bar{\tau}}_2 z - \bar{\bar{\Theta}}_2 \qquad (8a)$$

$$w = \bar{\bar{\sigma}}_3 x + \bar{\bar{\beta}}_3 y + \bar{\bar{\tau}}_3 z - \bar{\bar{\Theta}}_3$$

where

$$\bar{\bar{\Theta}}_i = \bar{\bar{\sigma}}_i \hat{x}_1 + \bar{\bar{\beta}}_i \hat{y}_1 + \bar{\bar{\tau}}_i \hat{z}_1 , \quad i = 1, 3 \qquad (8b)$$

The inverse relationships are:

$$x = \bar{\bar{\sigma}}_1 u + \bar{\bar{\sigma}}_2 v + \bar{\bar{\sigma}}_3 w + \bar{\bar{\delta}}_1$$

$$y = \bar{\bar{\beta}}_1 u + \bar{\bar{\beta}}_2 v + \bar{\bar{\beta}}_3 w + \bar{\bar{\delta}}_2 \qquad (9a)$$

$$z = \bar{\bar{\tau}}_1 u + \bar{\bar{\tau}}_2 v + \bar{\bar{\tau}}_3 w + \bar{\bar{\delta}}_3$$

where

$$\bar{\bar{\delta}}_1 = -(\bar{\bar{\sigma}}_1 \bar{\bar{\Theta}}_1 + \bar{\bar{\sigma}}_2 \bar{\bar{\Theta}}_2 + \bar{\bar{\sigma}}_3 \bar{\bar{\Theta}}_3)$$

$$\bar{\bar{\delta}}_2 = -(\bar{\bar{\beta}}_1 \bar{\bar{\Theta}}_1 + \bar{\bar{\beta}}_2 \bar{\bar{\Theta}}_2 + \bar{\bar{\beta}}_3 \bar{\bar{\Theta}}_3) \qquad (9b)$$

$$\bar{\bar{\delta}}_3 = -(\bar{\bar{\tau}}_1 \bar{\bar{\Theta}}_1 + \bar{\bar{\tau}}_2 \bar{\bar{\Theta}}_2 + \bar{\bar{\tau}}_3 \bar{\bar{\Theta}}_3)$$

The (U,V,W) coordinates of any point on the panel can also be expressed as parametric equations in the parameters S and T as follows:

$$u = \hat{\sigma}_1 S T + \hat{\beta}_1 S + \hat{\tau}_1 T + \hat{\delta}_1$$

$$v = \hat{\sigma}_2 S T + \hat{\beta}_2 S + \hat{\tau}_2 T + \hat{\delta}_2 \qquad (10a)$$

$$w = \hat{\sigma}_3 S T + \hat{\beta}_3 S + \hat{\tau}_3 T + \hat{\delta}_3$$

$$(0 \leq S \; , \; T \leq 1)$$

where

$$\hat{\sigma}_i = \bar{\bar{\sigma}}_i \sigma_1 + \bar{\bar{\beta}}_i \sigma_2 + \bar{\bar{\tau}}_i \sigma_3$$

$$\hat{\beta}_i = \bar{\bar{\sigma}}_i \beta_1 + \bar{\bar{\beta}}_i b_2 + \bar{\bar{\tau}}_i b_3$$

$$\hat{\tau}_i = \bar{\bar{\sigma}}_i \tau_1 + \bar{\bar{\beta}}_i \tau_2 + \bar{\bar{\tau}}_i \tau_3 \qquad (10b)$$

$$\hat{\delta}_i = \bar{\bar{\sigma}}_i \delta_1 + \bar{\bar{\beta}}_i \delta_2 + \bar{\bar{\tau}}_i \delta_3 - \bar{\bar{\Theta}}_i$$

5.0 WIREFRAM Programmer's Guide

The source code of the WIREFRAM program is well documented with comment statements. All Fortran compilation parameters are described in Table 7. The definition for each parameter is given, as well as its maximum allowable value, i.e., the program limit.

Table 7 WIREFRAM Compilation Parameters

Compilation Parameter	Description	Current Value
LIMCHG	Maximum number of attempts to generate points of intersection curve within user specified distance of each other.	400 = 2 * MXPTOU
LIMCGP	LIMCHG + 1 computed for loop building.	401
MAXPLN	Maximum number of Cutting Plane Family Definitions that can be stored.	10
MAXSAM	Maximum number of samples that can be stored from the current repetition in the sample target data file.	30
MAXTRG	Maximum number of targets that can be stored from the current repetition in the sample target data file.	6
MAXUAX	Maximum number of histogram cells in the U-direction.	300
MAXVAX	Maximum number of histogram cells in the V-direction.	300
MINSAM	Minimum number of samples that must be present for a repetition to be used.	8
MSHSAM	Maximum number of panels in the wire frame mesh along the sample direction.	29 = MAXSAM-1
MSHTRG	Maximum number of panels in the wire frame mesh along the target direction.	5 = MAXTRG-1
MXPTOU	Maximum number of points reported for representing a single intersection curve for any panel.	200

APPENDIX A

Example Maximum Excursion Histogram Plots

Side, front, and top views of example XPZ maximum excursion histograms are shown in Figures A-1, A-2, A-3, and A-4. The contours in each plot are for an entire family of vertical, transverse cutting planes, i.e., parallel planes at X = constant for XPZ histograms. The cutting planes are 6 mm apart. The plots are for data that have been transformed to H-point coordinates. Except for having X-, Y-, and Z-values shifted to an H-point coordinate system, these plots illustrate maximum excursion histograms derived directly from WIREFRAM processing.

Figures A-5, A-6, A-7, and A-8 are from the same WIREFRAM histogram data except that the data have been processed by a program (SWEEP) that gives dimension and shape to each leg laterally from the sonic emitters, which (nominally) lie on a midplane for each leg.

These plots are for an 85th percentile maximum excursion histogram envelope for a "Group A / Group B" population defined only for the purpose of testing and illustration. The A/B population was defined by two groups as described below. The 85th percentile data were obtained by using the MXMXEX and PRCNTILE programs. (See the manual Determination of Nth Percentile Maximum Excursion Histograms.)

Population Group A:	the first six of the 201xx subjects, group weight = 0.50 (subjects 20101, 20102, 20103, 20104, 20105, 20106)
Population Group B:	the last four of the 201xx subjects, group weight = 0.50 (subjects 20107, 20108, 20109, 20111)

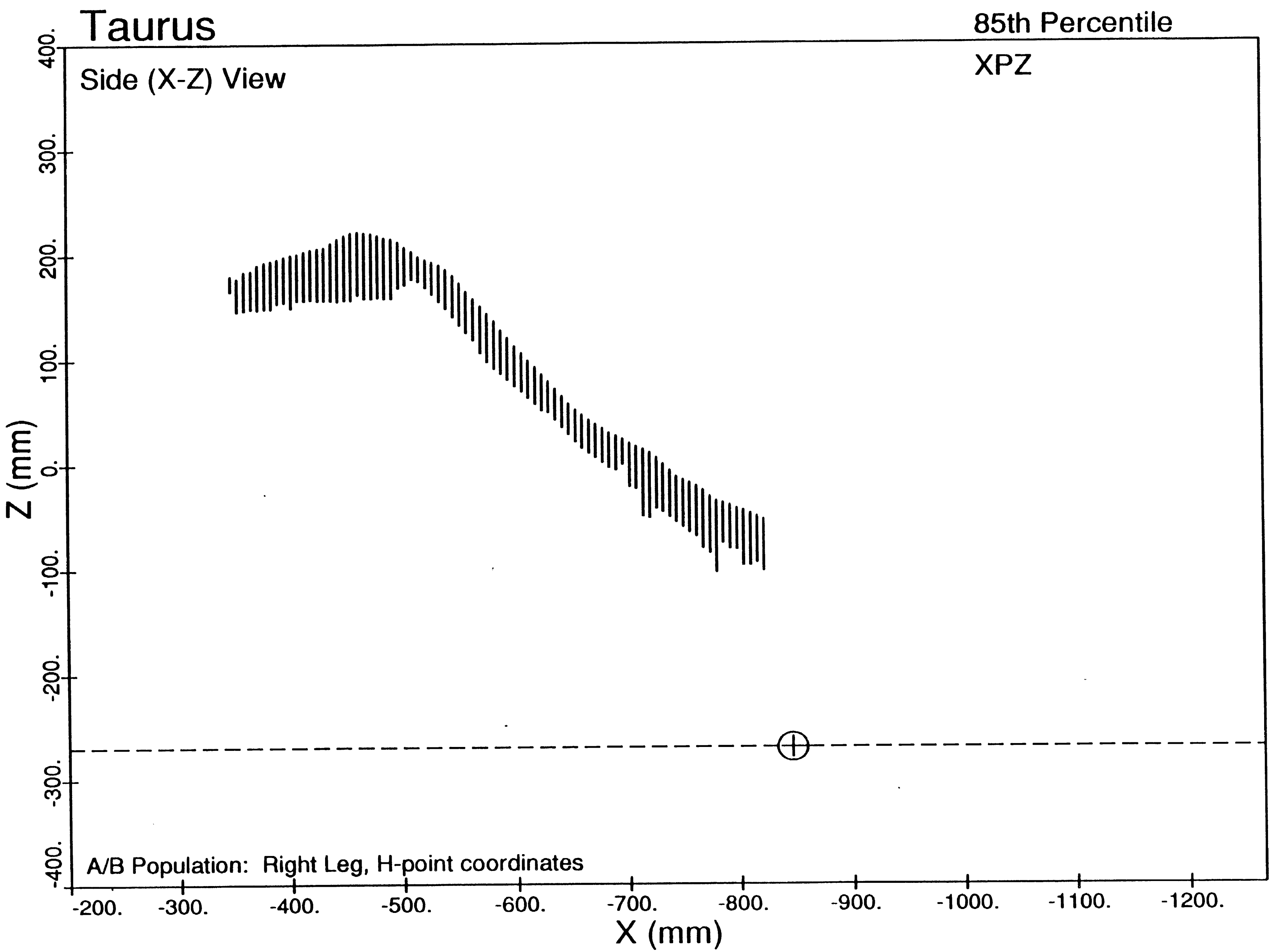


Figure A-1. Side View (Right Leg) of A/B XPZ Histogram

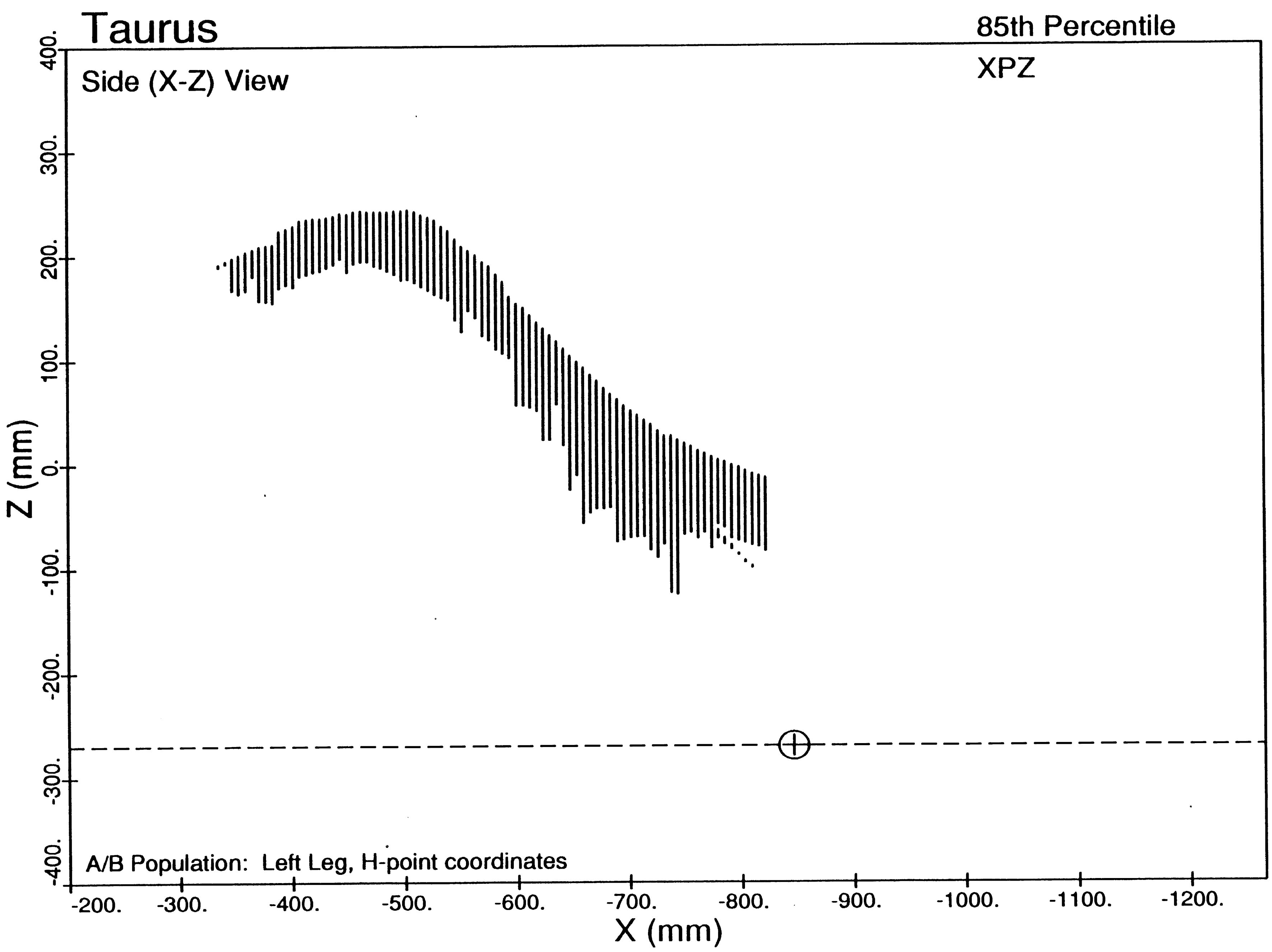


Figure A-2. Side View (Left Leg) of A/B XPZ Histogram

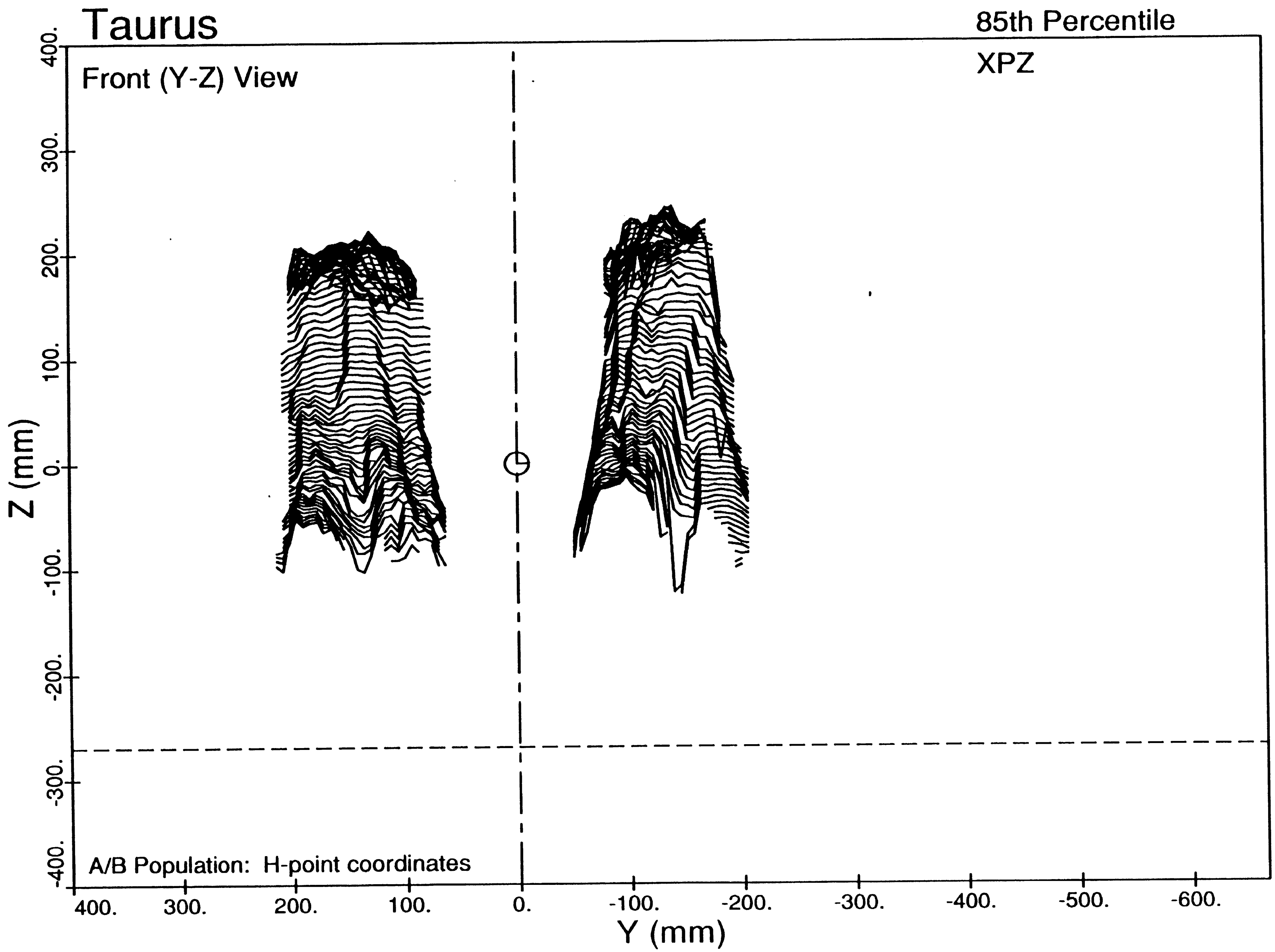


Figure A-3. Front View of A/B XPZ Histogram

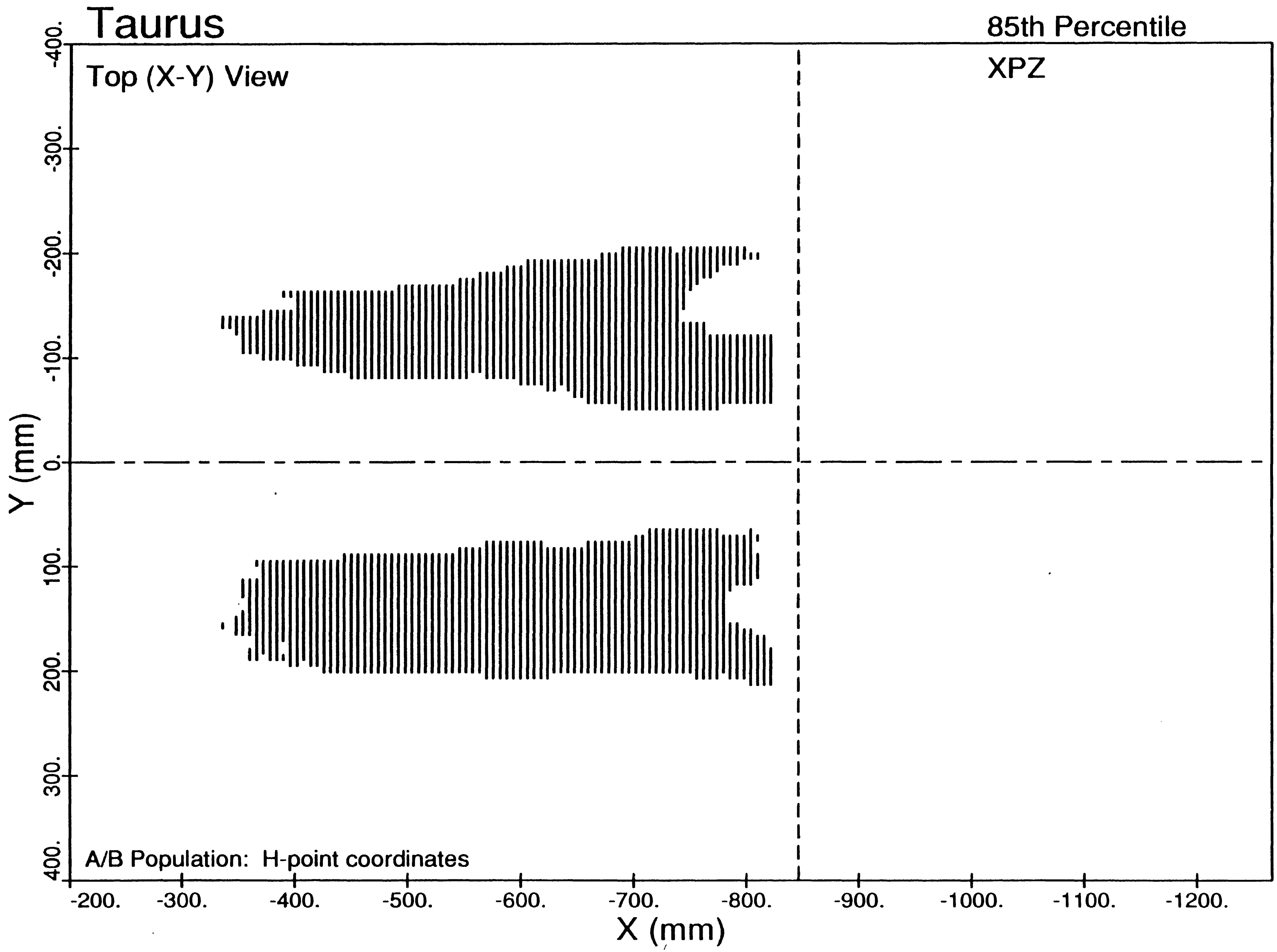


Figure A-4. Top View of A/B XPZ Histogram

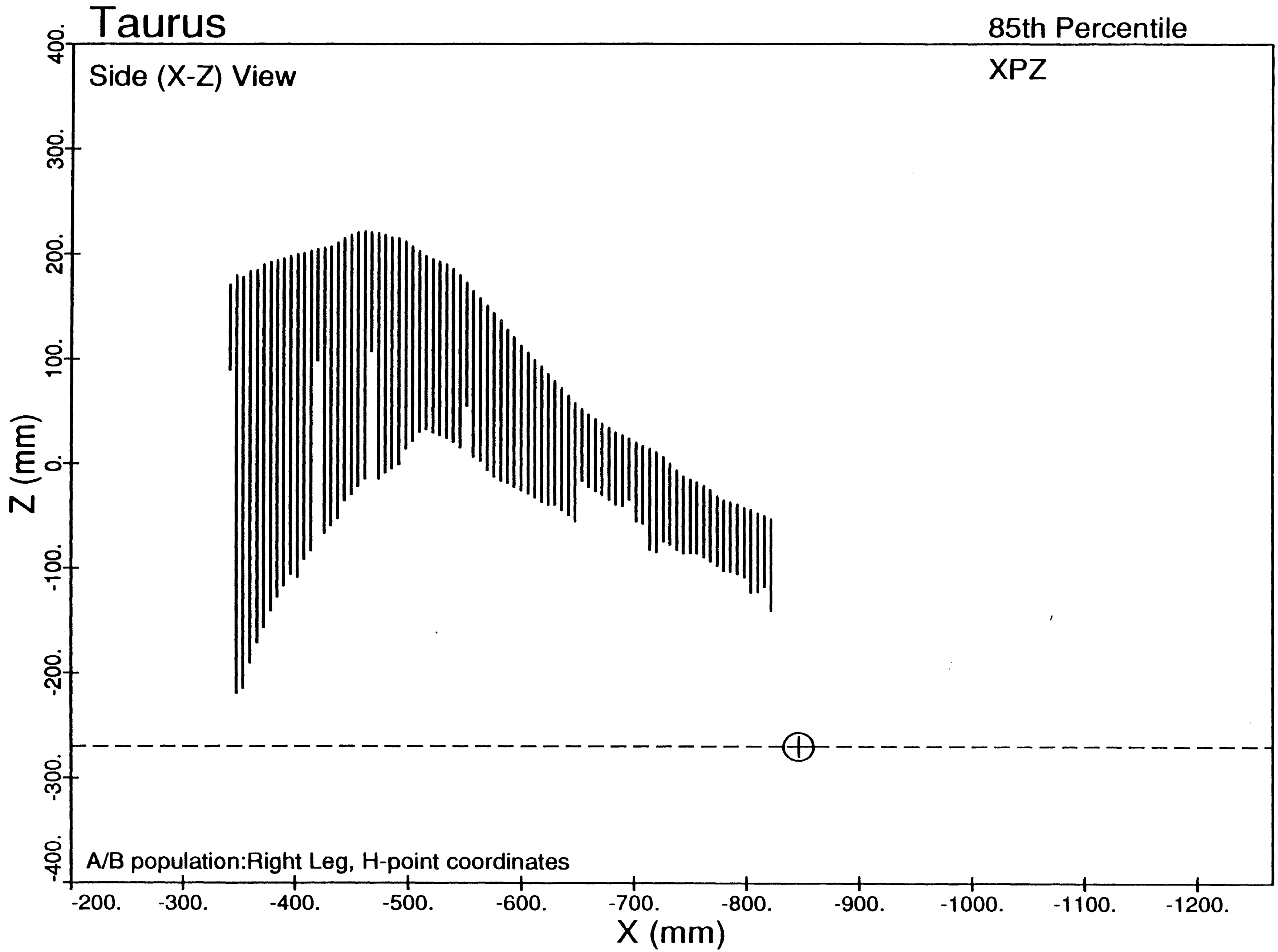


Figure A-5. Side View (Right Leg) of A/B XPZ Histogram (Swept)

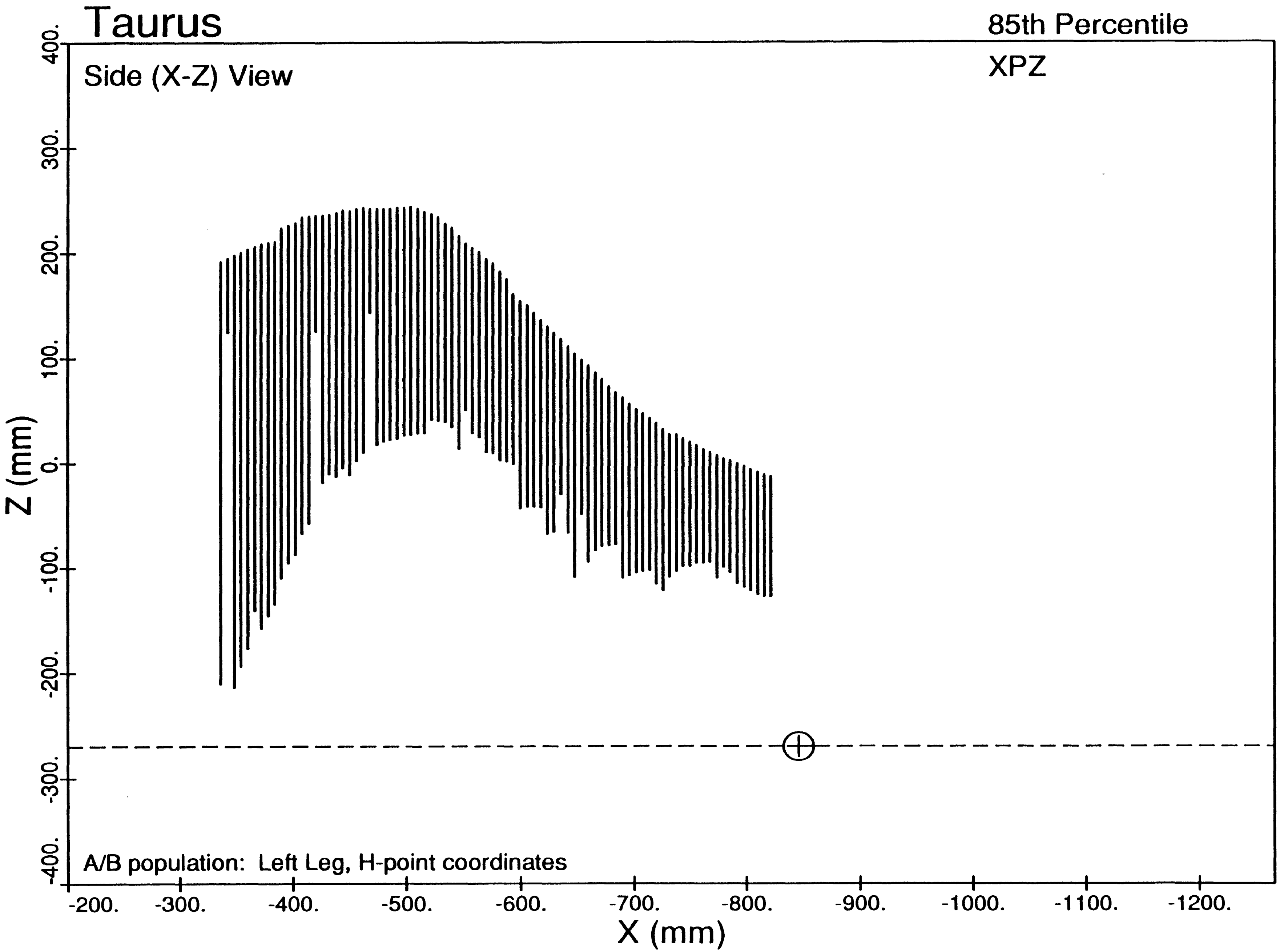


Figure A-6. Side View (Left Leg) of A/B XPZ Histogram (Swept)

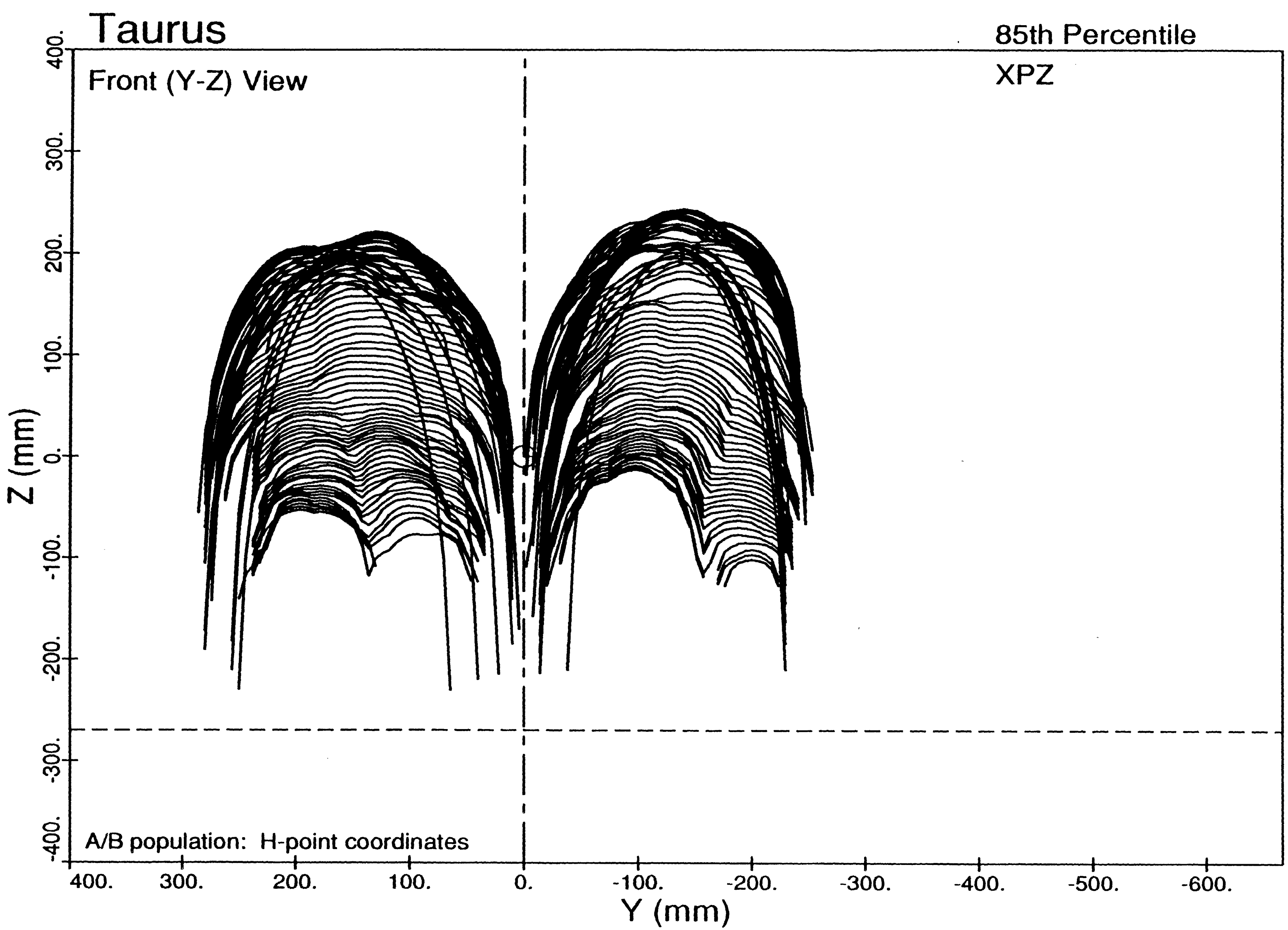


Figure A-7. Front View of A/B XPZ Histogram (Swept)

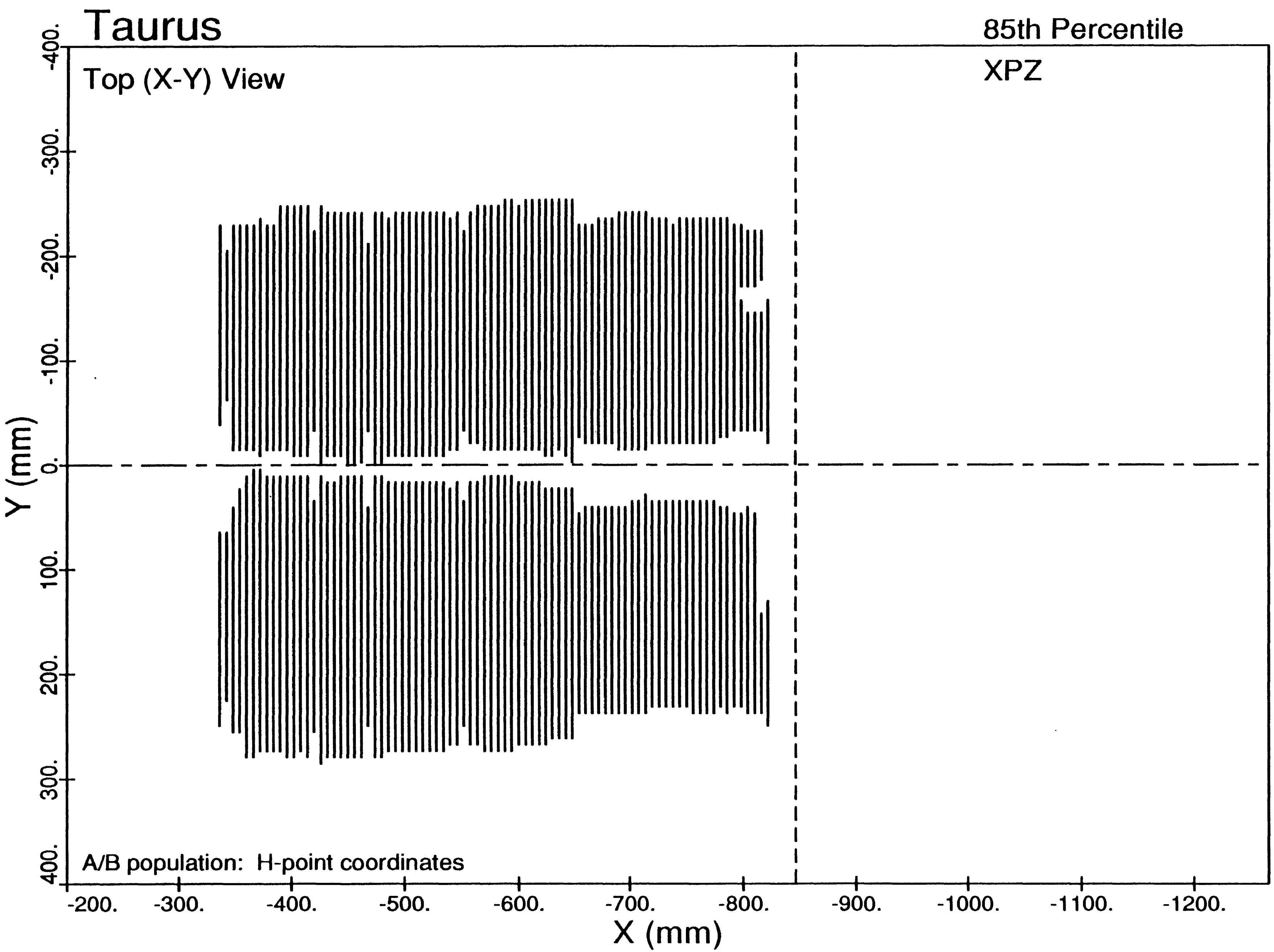


Figure A-8. Top View of A/B XPZ Histogram (Swept)