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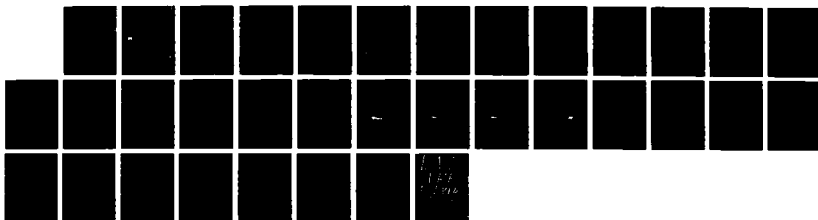
INTERACTIVE PLOTTING OF MASTRAN AERODYNAMIC MODELS
USING NPL0T AND DISSPLA(U) ANAMET LABS INC HAYWARD CA
S G HARRIS MAR 88 587-1A AFNL-TR-87-99 F33615-84-C-3216

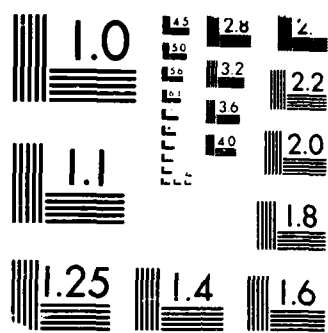
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INTERACTIVE PLOTTING OF NASTRAN AERODYNAMIC MODELS USING NPLOT AND DISSPLA

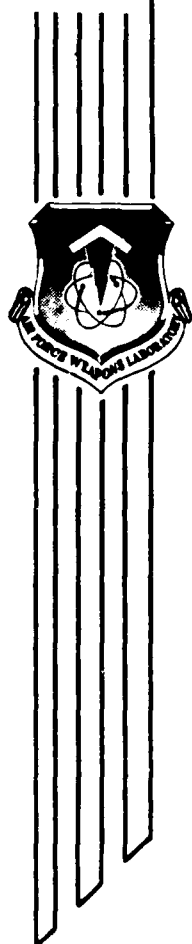
Steven G. Harris

Anamet Laboratories, Inc.
3400 Investment Boulevard
Hayward, California 94545-3811

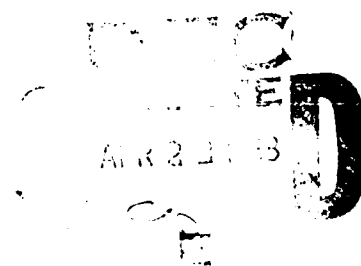
March 1988

Final Report

Approved for public release; distribution unlimited.



AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117-6008



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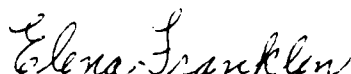
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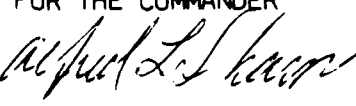
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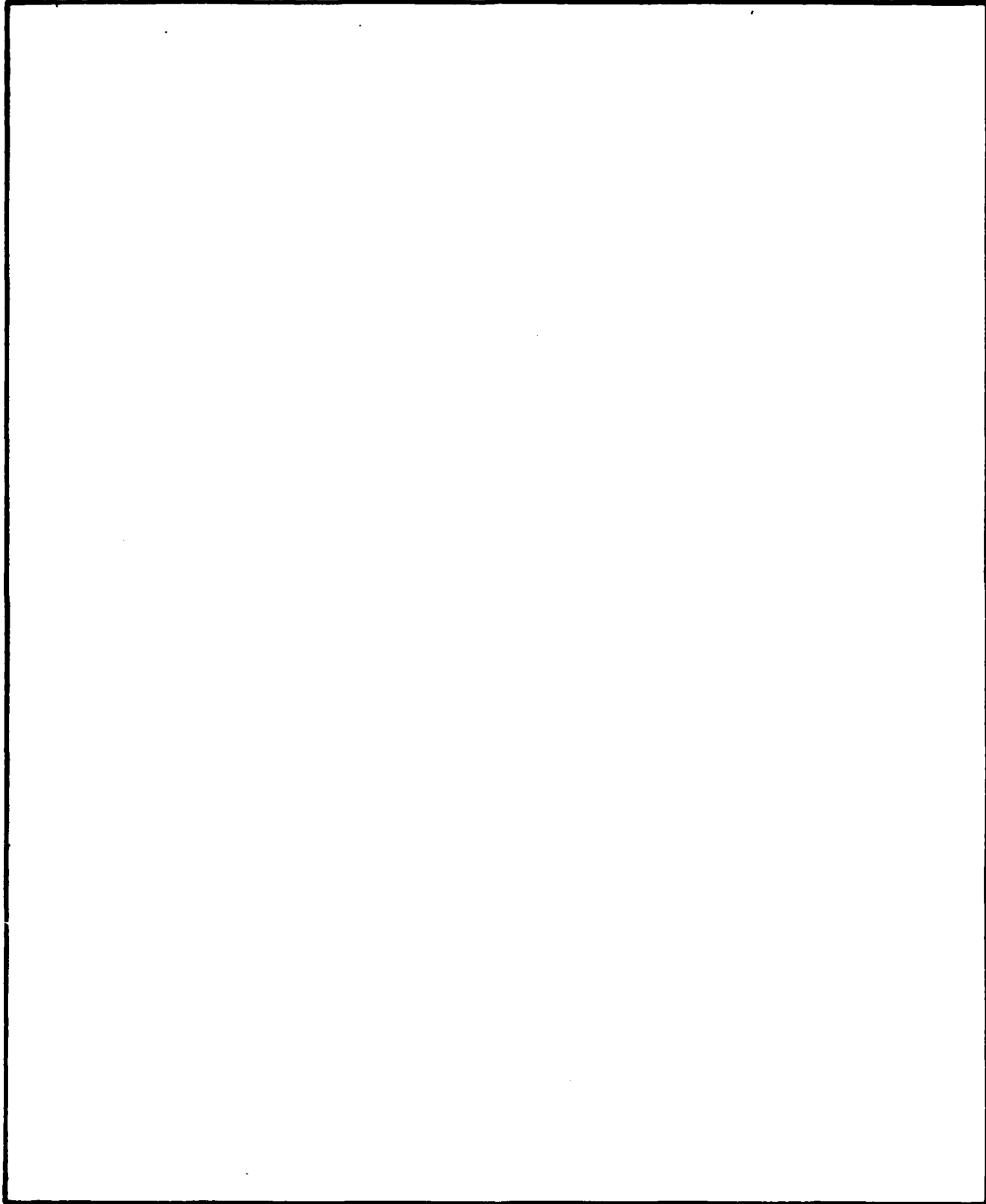
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PREFACE

This report describes extensions of the NPLOT program to permit plotting NAS-TRAN doublet lattice aerodynamic models. In addition, a translator is provided between Precision Visuals' DI-3000 plot package and ISSCO's DISSPLA plot package to permit NPLOT to be run at facilities that support only DISSPLA. The resulting package, while useful as a generic extension of the NPLOT code to support NASTRAN aerodynamics, can also be used for model checking when creating VIBRA-6 input using the methods established in previous ASIAC efforts.

For simplicity, the names of computer programs, plotting packages, subroutines, cards, and variables are defined after the references at the end of the report.

The author gratefully acknowledges the guidance and assistance of Mr. Gerald M. Campbell and Ms. Elena Franklin of AFWL/NTAT.

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1.0 BACKGROUND

The Aerospace Structures Information and Analysis Center (ASIAC) recently completed a task (Ref. 1) to provide a set of computer programs for generating NASTRAN (Ref. 2) and VIBRA-6 (Refs. 3 and 4) aircraft models. As part of this effort, a computer program for generating NASTRAN doublet lattice aerodynamic models was created, together with interface software to combine the NASTRAN model input and normal modes output to form a complete VIBRA-6 input deck. The resulting VIBRA-6 model can be used for evaluating aircraft vulnerability to nuclear blast.

While the model generation programs provided a link to NASTPLOT (Ref. 5) to plot the input data, it was found that NASTPLOT's plotting abilities were lacking in several areas. Most importantly, the aerodynamic model plotting was not sufficient. For aerodynamic bodies, only the body centerline was shown. In addition, the non-interactive nature of NASTPLOT makes it a slow debugging and model check-out tool, and it requires execution of NASTRAN to create its input files. For these reasons, ASIAC suggested using another program, NPLOT (Ref. 6), as the basis for an improved plotting capability for NASTRAN aerodynamic models.

NPLOT is a very capable interactive NASTRAN plotting package which was recently released by the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC). Aside from the standard perspective views of models, NPLOT has several features that make it attractive, including:

- Quick hidden and haloed line plotting capabilities
- Horizon and free edge plotting
- Plotting by element type, by property ID, or by user-defined model segments
- Undeformed and deformed model plots

The package is written to use DI-3000 (Ref. 7) for plotting, but NASA Goddard supplies a translator so that standard Tektronix PLOT10 (Ref. 8) utilities can be used as an alternative.

This report describes the extensions to NPLOT that were incorporated by ASIAC to plot NASTRAN doublet lattice aerodynamic models. The standard NPLOT package can be used to plot most NASTRAN structural elements, as well as rigid elements and elastic springs. The extended package includes NASTRAN aerodynamic panel and aerodynamic body elements. In addition, a DI-3000-to-DISSPLA translator is provided for DI-3000 calls needed in NPLOT so that NPLOT can be used with DISSPLA (Ref. 9) plot utilities. The translator is also documented in this report.

2.0 NPLOT EXTENSIONS FOR NASTRAN AERODYNAMICS

The structure of the NPLOT code allows a programmer to include a new NASTRAN element with minimal effort. However, aerodynamic elements are rather unusual in their definition, and the extension of NPLOT is consequently more complicated. The following sections will describe the basic flow of NPLOT, some details of NASTRAN aerodynamic element definition, and the extensions of NPLOT that are incorporated.

2.1 NPLOT FLOW

Figure 1 shows a simplified flow diagram for NPLOT as it processes the NASTRAN input deck in preparation for plotting.

The basic plot loop is preceded by a single scan of the input deck, with appropriate fixed-format card images placed into a single array in memory. This step eliminates the need for sequential file rewinds and scans in subsequent operations. During this initial scan of the input deck, grid point coordinates, coordinate system definitions, and eigenvalue extraction parameters are placed in separate arrays, and so do not require storage in the card image array.

A user selection of elements to be plotted causes the card image array to be searched for all appropriate element definitions. The user may select these elements by number, property, material or by user-defined model segments. As each element to be plotted is encountered, separate arrays defining vectors, surfaces and solids are augmented. Upon completion of the selection process, NPLOT simply works with these arrays of vectors, surfaces and solids to present a plot. Whether the vectors, surfaces and solids represent bars, quadrilaterals, tetrahedra, or, as in the present case, aerodynamic elements, makes no difference to NPLOT.

The next section describes the NASTRAN aerodynamic panel and body elements, and discusses how their definition prevents them from being incorporated into NPLOT in the same way as more standard NASTRAN elements.

2.2 NASTRAN AERODYNAMIC ELEMENT DEFINITION

Standard finite elements in any structural analysis code are defined by connecting predefined nodes in some order to describe a line, surface or solid. NPLOT takes advantage of this logic in its plotting approach. NASTRAN aerodynamic elements, however, are defined through a process which can include node and element definitions on one card, or on multiple, related cards. Conventional NASTRAN grids are not used to define aerodynamic elements in any case.

To illustrate the approach, consider the single aerodynamic panel shown in Figure 2. The location of the panel leading and trailing edges and the chord lengths are always defined on the CAERO1 card shown in Figure 3. The number of spanwise and chordwise

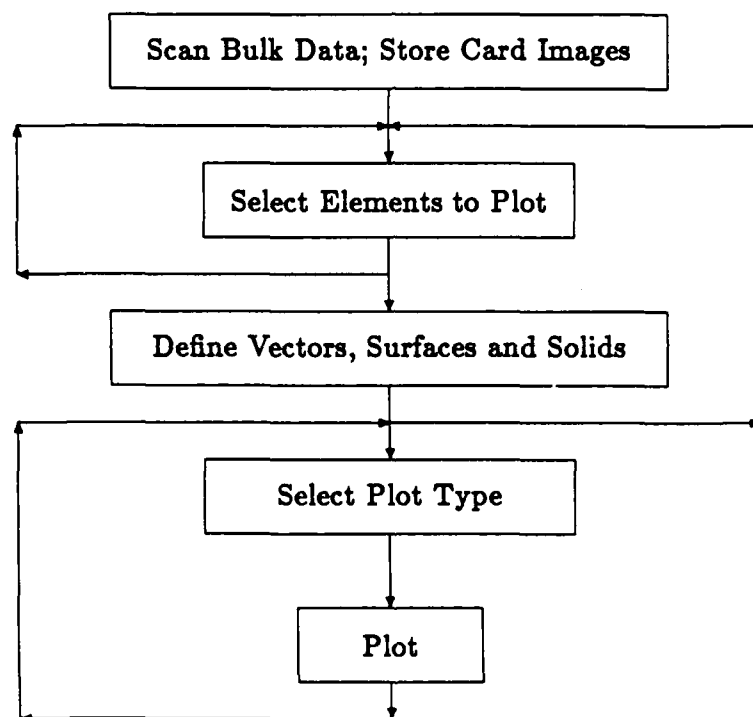
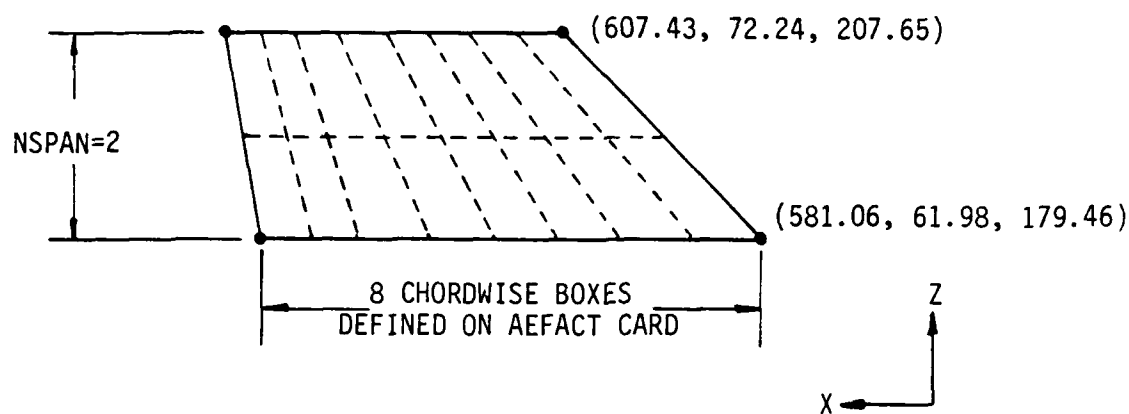


Figure 1. Basic NPLOt flow.



(a) Aerodynamic panel geometry.

CAERO1	306	69	2	0	0	48	1+CA	306
+CA	306	581.06	61.98	179.46	66.47	607.43	72.24	207.65
AEFACT	48	0.000	0.133	0.267	0.400	0.533	0.667	0.800
+AE	48A	0.900	1.000					
PAERO1	69							

(b) NASTRAN panel input data.

Figure 2. Aerodynamic panel definition.

Input Data Card CAERO1 Aerodynamic Panel Element Connection

Description: Defines an aerodynamic macro element (panel) in terms of two leading edge locations and side chords for Doublet-Lattice Theory.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CAERO1	EID	PID	CP	NSPAN	NCHORD	LSPAN	LCHORD	IGID	ABC
CAERO1	1000	1		3			2	1	ABC
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+BC	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

Field

Contents

EID	Element identification number (unique Integer > 0).
PID	Identification number of property card (Integer > 0) to specify associated bodies.
CP	Coordinate system for locating points 1 and 4 (Integer $\geq$ 0).
NSPAN	Number of spanwise boxes; if a positive value is given, equal divisions are assumed; if zero or blank, a list of division points follows (Integer $\geq$ 0).
NCHORD	Number of chordwise boxes (same rule as for NSPAN).
LSPAN	ID of an AEFAC data card containing a list of division points for spanwise boxes. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
LCHORD	ID of an AEFAC data card containing a list of division points for chordwise boxes. Used only if field 6 is zero or blank (Integer > 0 if NCHORD is zero or blank).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1;X4,Y4,Z4	Location of points 1 and 4, in coordinate system CP (Real).
X12; X43	Edge chord length (in aerodynamic coordinate system) (Real $\geq$ 0, and not both zero).

Figure 3. NASTRAN CAERO1 card definition.

Input Data Card AEFACT Aerodynamic Spanwise Divisions

Description: Used to specify box division points for flutter analysis .

Format and Example:

1	2	3	4	5	6	7	8	9	10
AEFACT	SID	D1	D2	D3	D4	D5	D6	D7	ABC
AEFACT	97	.3	.7	1.0					
+BC	D8	D9	--etc.--						

Field

Contents

SID Set identification number (Unique Integer > 0).
D1 Division point (Real).

- Remarks:
1. These factors must be selected by a CAERØi or PAERØi data card to be used by NASTRAN.
 2. Imbedded blank fields are forbidden.
 3. If used to specify box division points, note that there is one more division point than the number of boxes.

Figure 4. NASTRAN AEFACT card definition.

boxes can be defined on the CAERO1 card only if they are uniformly distributed across the panel span or chord; otherwise, the AEFACT card identifier is placed in the LSPAN or LCHORD field of the CAERO1 card. The AEFACT card, shown in Figure 4, is used to specify the spanwise and chordwise breakdown of the aerodynamic boxes across the panel. (It is also used for aerodynamic body elements, as discussed later.) Where were the grids defined? In fact, for the panel, a single aerodynamic grid is defined at each *box center*, so that there are NSPAN times NCHORD grids for each panel. NASTRAN requires the user to be aware of this hidden grid definition. In addition, NASTRAN creates a set of plot-only grids at the aerodynamic *box corners* that are then used by NASTPLOT for plotting.

The situation is further complicated in the case of aerodynamic body elements specified using the CAERO2 card shown in Figure 5. For bodies, not only must the lengthwise breakdown of elements be defined using the CAERO2 card, but the body radius and the circumferential shape must be defined on the PAERO2 card shown in Figure 6. When these quantities are uniform (e.g., ten elements of equal length along a body, or a body of constant radius), they can be specified directly. When they are nonuniform, NASTRAN employs the AEFACT card to specify the distribution.

To debug or check an aerodynamic model, the planform and box breakdown within the planform must be shown for each panel. For bodies, the body surface is of critical concern, since an improper intersection with a panel can cause numerical difficulties and misleading results in the aerodynamic analysis run. Because of these issues, grids must be created at box corners for panels and at the outer surface for bodies when plotting. Note that these plot grids do not correspond to the aerodynamic grids and degrees of freedom in NASTRAN, which are located at box centers and along body centerlines. Users are referred to the NASTRAN manual for additional details of aerodynamic modeling procedures.

2.3 NASTRAN AERODYNAMIC ELEMENT PLOTS USING NPLOT

It was desired that plotting of the aerodynamic model be incorporated as an integral part of NPLOT, so that the full capabilities of the standard package would be maintained. This was accomplished, and the only difference apparent to the end user is the addition of two new elements to the NPLOT element selection menu (CAERO1 and CAERO2), and the expanded plots when these elements are present in the model.

Figure 7 shows the modified flow of NPLOT used to incorporate aerodynamic model plotting. An additional pass through the input deck is made after the card images are stored in arrays in NPLOT subroutine RDBULK. The additional pass scans the array-resident bulk data for all CAERO1, CAERO2, PAERO2 and AEFACT cards. (PAERO1 is not used in plotting at this time). Data from these cards are placed in appropriate arrays as they are encountered. Following this additional scan, another subroutine is called to generate grids corresponding to each panel and body element and to place the necessary grid information in standard NPLOT arrays.

Vectors and surfaces for aerodynamic elements are loaded into the appropriate ar-

Input Data Card CAERO2 Aerodynamic Body Connection

Description: Defines an aerodynamic body for Doublet-Lattice aerodynamics

Format and Examples:

1	2	3	4	5	6	7	8	9	10
CAERO2	EID	PID	CP	NSB	NINT	LSB	LINT	IGID	
CAERO2	1500	2	100		4	99		1	ABC
	X1	Y1	Z1	X12					
+8C	-1.0	100.	-30.	175.					

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0).
PID	Property identification number (Integer > 0).
CP	Coordinate system for locating point 1 (Integer $\geq$ 0).
NSB	Number of slender body elements; if a positive number is given, NSB equal divisions are assumed; if zero or blank, see field 7 for a list of divisions (Integer $\geq$ 0).
NINT	Number of interference elements; if a positive number is given, NINT equal divisions are assumed; if zero or blank, see field 8 for a list of divisions (Integer $\geq$ 0).
LSB	ID of an AEFAC data card for slender body division points; used only if NSB, field 5 is zero or blank (Integer $\geq$ 0).
LINT	ID of an AEFAC data card containing a list of division points for interference elements; used only if NINT, field 6 is zero or blank (Integer > 0).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1	Location of point 1 in coordinate system CP (Real).
X12	Length of body in the x-direction of the aerodynamic coordinate system (Real > 0).

Figure 5. NASTRAN CAERO2 card definition.

Input Data Card PAERO2 Aerodynamic Body Properties

Description: Defines the cross-section properties of aerodynamic bodies

Format and Examples:

1	2	3	4	5	6	7	8	9	10
PAERO2	PID	ORIENT	WIDTH	AR	LRSB	LRIB	LTH1	LTH2	
PAERO2	2	Z	6.0	1.0	22	91	100		ABC
	THI1	THN1	THI2	THN2	THI3	THN3			
+BC	1	3							

Field

Contents

PID	Property identification number (Integer > 0).
ORIENT	Orientation flag "Z", "Y", or "ZY". Type of motion allowed for bodies (BCD). Refers to the aerodynamic coordinate system y direction of ACSID (see AERO data card).
WIDTH	Reference half-width of body (Real > 0.).
AR	Aspect ratio (height/width) (Real > 0.).
LRSB	ID of an AEFACT data card containing a list of slender body half-widths. If blank, the value of WIDTH will be used (Integer $\geq$ 0 or blank).
LRIB	ID of an AEFACT data card containing a list of interference body half-widths. If blank, the value of WIDTH will be used (Integer $\geq$ 0 or blank).
LTH1,LTH2	ID of AEFACT data cards for defining theta arrays for interference calculations (Integer $\geq$ 0).
THI1,THN1	The first and last interference element of a body to use the θ_1 array (Integer $\geq$ 0).

Figure 6. NASTRAN PAERO2 card definition.

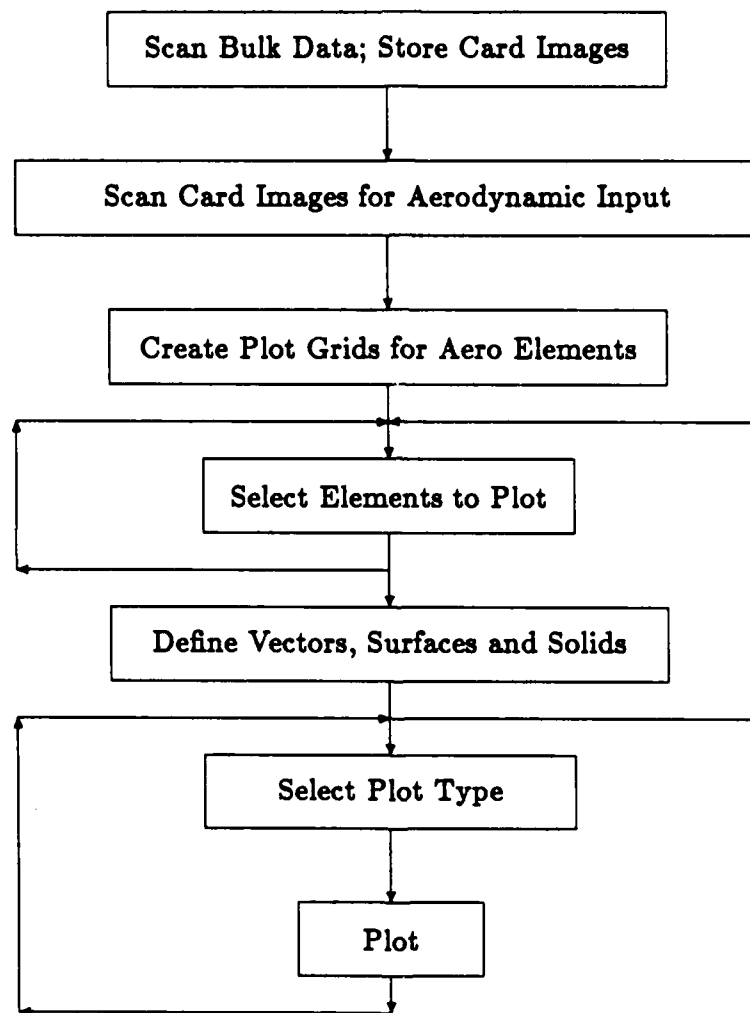


Figure 7. NPLLOT flow for aerodynamic model plotting.

rays in NPLOT subroutine ELTPRO, as an addition to the existing element support. Each panel element is represented by as many quadrilateral surfaces as there are boxes on that panel. Each body element is represented by a cylinder with a circumferential breakdown corresponding to the interference element theta points and radii as provided in the slender body definition. This approach is a compromise between separate plots for interference and slender body elements, and it was chosen to convey the most information in the least cluttered format.

Sample NPLOT plots of a model of the F/A-18 are shown in Figures 8 through 10. These plots show the effectiveness of the hidden and haloed line capability, and how the surface definition for the body elements can be used to check body-panel intersections. For comparison, a NASTPLOT plot of the same model is shown in Figure 11. Note that the bodies are plotted only as lines along their centerline.

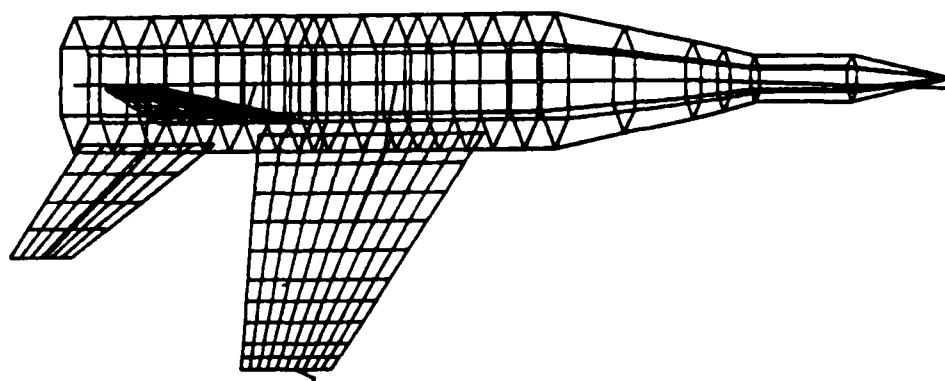
One comment should be made regarding NPLOT's handling of cases where elements intersect one another at locations other than edges. While such a situation would be indicative of an error in more standard structural modeling, it might not be for aerodynamic modeling. In aerodynamics, panels and bodies are splined to structural degrees of freedom; i.e., their displacements are defined in terms of displacements at structural grids. For this reason, it is common for a beam representation of a wing, for example, to lie within the aerodynamic panel planform, and therefore to intersect the aerodynamic box elements which have been defined for NPLOT plotting. An analogous situation occurs when the beam representing the fuselage intersects the surface of the aerodynamic body near the nose of the aircraft. When an intersection like this occurs, an error is seen in hidden line and horizon plots, in the form of elements or lines which are left out. This occurrence is a function of the hidden line algorithm used by NPLOT, and it should be anticipated by the user. It can be a useful tool in locating real modeling errors, but in the case of aerodynamics, it may indicate errors in an area which is modeled correctly.

Finally, it should be noted that the structure of the NPLOT program permitted incorporating the aerodynamic plotting capability by adding three subroutines and modifying four existing subroutines. The fact that such a major deviation from the normal anticipated use of NPLOT could be implemented with such localized changes to a program containing over fifty subroutines is indicative of a well-organized program.

Details of the modifications to the NPLOT computer program are described in Appendix A. Installation and execution instructions for the programs described in this report are provided in Appendix B. Documentation for NPLOT itself is available from GSFC (Ref. 6).

F/A-18 AIRCRAFT FOR DEC 19773

SYMMETRIC BOUNDARY CONDITIONS



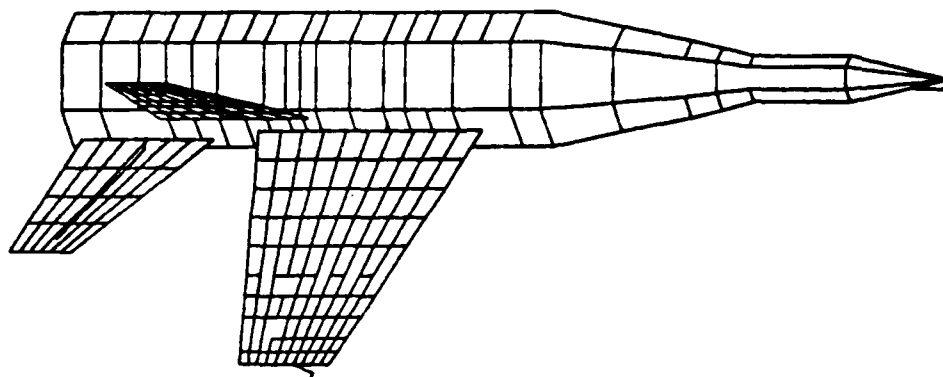
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21-111-07 084738

Figure 8. NPLLOT plot of F/A-18 — all elements.

F/A-18 REPORT FOR HCC 15773

SYMMETRIC BOUNDARY CONDITIONS



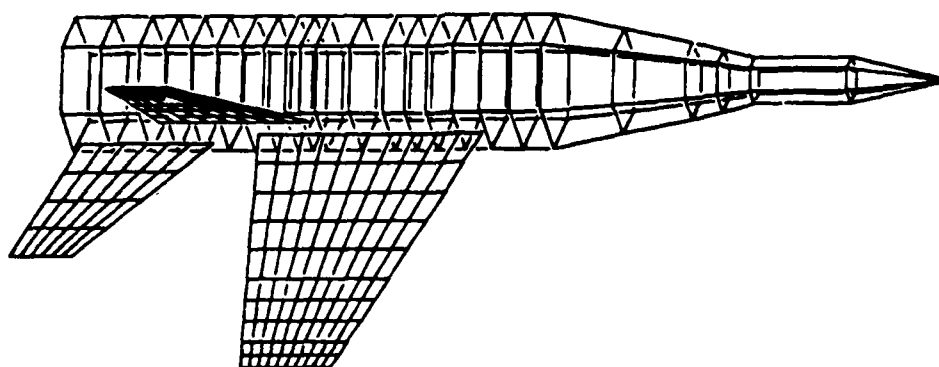
X-Y VIEW ELEMENTS ALL
ALPHA = 185. BETA = 34. GAMMA = 90. MU = 0. ZOUT = 0.

21-111-67 095042

Figure 9. NPROT plot of F/A-18 — all elements, hidden lines removed.

F/A-18 AIRCRAFT FOR MDG 15773

SYMMETRIC BOUNDARY CONDITIONS

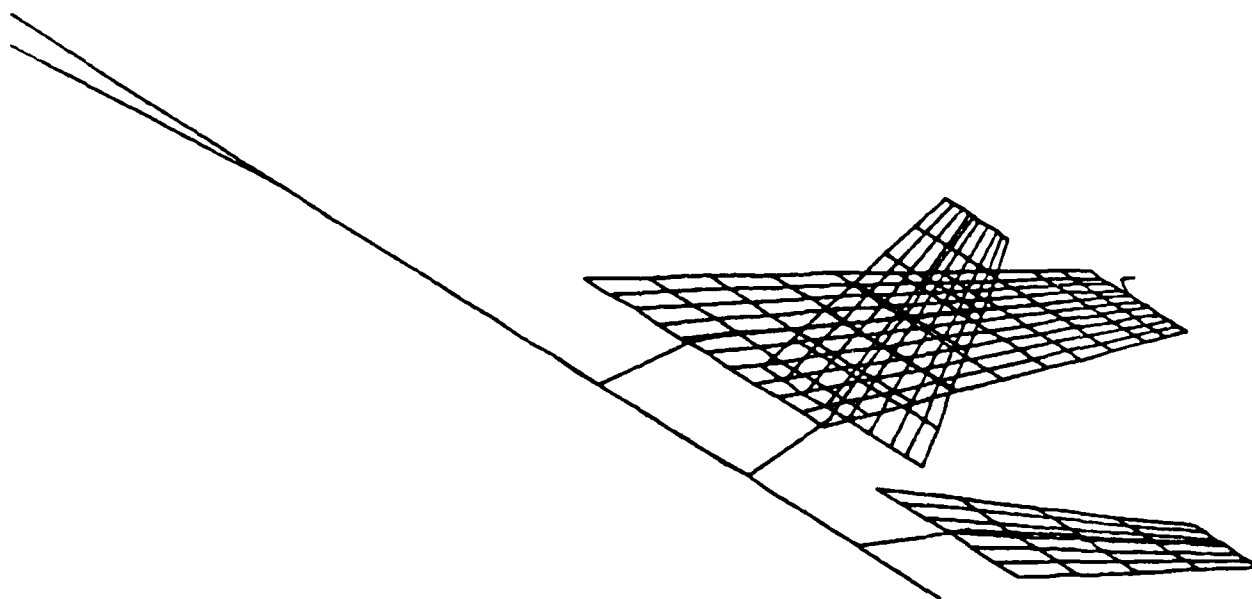


X-Y VIEW ELEMENTS: CROCI CROCI2
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NPLO DISTANCE = 3.000
 21-1111-87 083342

Figure 10. NPLOT plot of F/A-18 — aerodynamic elements only, haloed line plot.

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F/A-18 AIRCRAFT PER MOC 45773
PLOT RUN -- SYMMETRIC BOUNDARY CONDITIONS
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ISOMETRIC VIEW OF ALL ELEMENTS

Figure 11. NASTPLOT plot of F/A-18 — all elements.

3.0 DI-3000-TO-DISSPLA TRANSLATOR FOR NLOT

Since NLOT makes calls to DI-3000, and AFWL/NTAT (sponsoring this effort) did not have DI-3000 available to them, a translation package was prepared. The function of the translator is to permit NLOT to be used directly with DISSPLA, by providing a set of subroutines that emulate DI-3000 functions using DISSPLA utilities. Programming on the translator was started by AFWL personnel in 1985, but was not completed. Anamet's contribution to the translator consisted of debugging the existing code and adding some subroutines. NLOT was used as the testbed for the translator.

DI-3000 is heavily oriented toward interactive use; DISSPLA is generally not. DISSPLA's original emphasis was in device independent graphics, but mainly noninteractive off-line plotting. Both sets of software offer excellent meta plotting capabilities; i.e., creation of device independent plot files that can be postprocessed for use on virtually any plotting hardware. Both DI-3000 and DISSPLA are high-level graphics packages. While a translation of either package to a low-level plot package like PLOT10 is relatively straightforward, translation of one high-level package to another high-level package can be more difficult.

DISSPLA offers an optional feature called Dynamics which closely parallels the capabilities of DI-3000. Dynamics subroutines are oriented toward interactive plotting, so some of these subroutines are used in the translator. Table 1 summarizes the DI-3000 subroutines which are used by NLOT and which are supported by the translator. Also shown is a list of the DISSPLA subroutines used by the translator to implement the functionality of these DI-3000 subroutines.

The function of each of these subroutines is well-documented in the manuals for DI-3000 and DISSPLA, so no additional description will be provided here. At this release, only Tektronix terminals are supported; however, other terminal types can be added if the requisite DISSPLA interface drivers are available. The interface has also been successfully used on IBM-PC compatible computers using Tektronix PLOT10 emulation software (Ref. 10).

Limitations of the translator are summarized as follows:

- DI-3000 segmentation is not fully supported; however, segments can be opened and closed as required.
- Color is not supported.
- Only software-generated characters are supported.
- Only one logical display device is supported.
- Older releases of DISSPLA's Tektronix interface subroutines will not support return of a character string in the translator subroutine JLOCAT (using DISSPLA subroutine REQLOC). Installations with the older release will not be able

DI-3000 Subroutines Supported		DISSPLA Subroutines Used
JISTRG		ANGLE
JASPEK		AREA2D
JBACKG		BFLUSH *
JBEGIN		CONNPT
JCLOSE		CURPIC *
JCONVW		CURVE
JDEND		DONEPL
JDEVOF		GRAF
JDEVON		MIXALF
JDINIT		PAGE
JDRAW	DI-3000-to-DISSPLA Translator for NLOT	PTEKAL *
JEND		RESET
JFILES		REQLOC *
JFRAME		RLMESS
JIENAB		STRTP
JLOCAT		TKNOM *
JMARK		XGRAXS
JMOVE		XINVR
JOPEN		XMESS
JRMOVE		XPOS
JSETDB		YGRAXS
JVPORT		YINVR
JVSPAC		YPOS
JWCLIP		
JWINDO		

* These subroutines require the DISSPLA Dynamics option.

Table 1. DI-3000 and DISSPLA Subroutines Used by NLOT

to use NLOT's zoom capability because of this limitation. DISSPLA and the required interface software is available from Integrated Software Systems Corporation (ISSCO) in San Diego, California.

Some additional DI-3000 subroutine support is available in the translator beyond that for subroutines listed in Table 1. These subroutines have not been exercised, however, since they are not used by NLOT. They are included on the distribution tape described in Appendix B.

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7. "DI-3000 User's Guide," Precision Visuals, Inc., Boulder, CO, Release Number 4, March 1984.
8. PLOT10 Terminal Control System, Tektronix, Inc., Beaverton, OR., Release 3.3, 1976.
9. "DISSPLA User's Manual," Integrated Software Systems Corp., San Diego, CA, Version 10.0, 1985.
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DEFINITIONS OF NAMES COMPUTER PROGRAMS PLOTING PACKAGES, SUBROUTINES, CARDS, AND VARIABLES

NASTRAN	NASA Structural Analysis program
VIBRA-6	Vehicle Inelastic Bending Response Analysis program
DI-3000	Plotting package from Precision Visuals, Inc.
DISSPLA	Plotting package from Integrated Software Systems Corp.
NASTPLOT	Plotting package for NASTRAN
NPLOT	Plotting package for NASTRAN from Goddard Space Flight Center
PLOT10	Plotting package from Tektronix, Inc.
RDBULK	NPLOT program subroutine
ELTPRO	NPLOT program subroutine
REQLOC	DISSPLA program subroutine
JLOCAT	DI-3000 program subroutine
AEFACT	NASTRAN card, defines lists of real numbers for aerodynamics
CAERO1	NASTRAN card, defines aerodynamic panel connection
CAERO2	NASTRAN card, defines aerodynamic body connection
PAERO1	NASTRAN card, defines aerodynamic panel properties
PAERO2	NASTRAN card, defines aerodynamic body properties
LSPAN	NASTRAN variable identifying an AEFACT card with list of spanwise division points
LCHORD	NASTRAN variable identifying an AEFACT card with list of chordwise division points
NSPAN	NASTRAN variable for number of spanwise boxes
NCHORD	NASTRAN variable for number of chordwise boxes

APPENDIX A

SUMMARY OF CHANGES TO THE NPLOT PROGRAM

This appendix is provided to document the changes which were incorporated in the NPLOT program, including the addition of three new subroutines relating to plotting of NASTRAN doublet lattice aerodynamic models. The four existing NPLOT subroutines which required changing are:

RDBULK — The original NPLOT subroutine scans the NASTRAN bulk data deck, placing grid coordinates in a single array, and storing the remaining card images in another array for subsequent processing. Eigenvalue solution specification cards and coordinate system definitions are also placed in separate arrays for later use. The modifications required to this subroutine include calls to two new subroutines, AERO_READ and AERO_GRID, described later.

ELTPRO — The original NPLOT subroutine is used for element processing; i.e., the user chooses elements to be plotted, and the proper arrays are loaded specifying vectors, surfaces and solids. The first modification to this subroutine is the addition of appropriate menu picks for specifying aerodynamic element plotting. The vectors and surfaces corresponding to aerodynamic panels and bodies are then defined. This subroutine uses the grid definition supplied to it by the new subroutine AERO_GRID to define the vectors and surfaces for each aerodynamic element.

ELABELV — This subroutine provides the logic for numbering all supported element types plotted by NPLOT. It was extended to include NASTRAN CAERO1 and CAERO2 elements.

ELETITLE — This subroutine provides a cross-reference between the types of elements chosen by the user and the NASTRAN element name (e.g., CBAR, CQUAD, etc). It was extended to include NASTRAN CAERO1 and CAERO2 elements.

The three new subroutines added to NPLOT are AERO_READ, AERO_GRID and AERO_ERR. AERO_READ and AERO_GRID are called from the existing NPLOT subroutine RDBULK. AERO_ERR is called from AERO_GRID when an error is encountered in processing the aerodynamic elements.

The version of NPLOT which was used as the basis for this development work contained little, if any, error checking on the NASTRAN data. While fully debugged NASTRAN models can be easily plotted, errors encountered by NPLOT in processing the NASTRAN bulk data can result in a screen dump and traceback to the NPLOT subroutine causing the error. The new aerodynamic element routines provide some elementary NASTRAN data checks to prevent attempts to plot inconsistent models. For example, CAERO1 and CAERO2 elements which reference undefined AEFACT

cards are flagged as errors. The entire set of aerodynamic-related bulk data is scanned, and a summary of all errors is provided before NPLOT execution is halted.

The three new NPLOT subroutines for doublet lattice aerodynamic model plotting are:

AERO_READ — The card images stored in NPLOT array CARD are scanned for all CAERO1, CAERO2, AEFACT and PAERO2 cards. The appropriate information from the fields on these cards is stored in arrays which are passed through a new COMMON block, AERO.

AERO_GRID — For each CAERO1 element, the information passed through the AERO COMMON block is used to derive grid coordinates at the corners of each aerodynamic box. For each CAERO2 element, grids are defined at the outer surface of the aerodynamic body, at the angular locations specified for the interference body element and at the radii specified for the slender body element. Grids for aerodynamic element plotting begin at 100001, and are incremented as needed. The starting grid for each panel (CAERO1) and body (CAERO2) is stored so that the the vectors defining the panel or body can be derived in NPLOT subroutine ELTPRO.

AERO_ERR — This subroutine provides the error reporting when undefined AEFACT cards are referenced on CAERO and PAERO cards, and when undefined PAERO2 cards are referenced on CAERO2 cards.

Table A-1 summarizes the variables which are contained in COMMON block, AERO, used to store data relating to aerodynamic plotting. Note that arrays are fixed dimensioned, as opposed to being dynamically allocated within blank COMMON. This was done because the rest of NPLOT is fixed dimensioned, and the benefit of dynamic storage allocation was therefore not great. The following limitations are imposed on the aerodynamic model:

Maximum number of CAERO1 cards (panels)	20
Maximum number of CAERO2 cards (bodies)	20
Maximum number of PAERO2 cards	20
Maximum number of AEFACT cards	40
Maximum number of spanwise boxes per panel	25
Maximum number of chordwise boxes per panel	25
Maximum number of lengthwise elements per body	25
Maximum number of theta interference locations per body	25

In addition, all points on CAERO cards must be defined in terms of the global cartesian coordinate system, and (as in standard NPLOT) all continuation cards must follow their parents in sequence.

VARIABLE NAME	DESCRIPTION	NASTRAN NAME	TYPE
CAERO1 Related Variables			
CA1NBR(20)	CAERO1 numbers	EID	Integer
NSPAN(20)	Number of spanwise boxes	NSPAN	Integer
NCHORD(20)	Number of chordwise boxes	NCHORD	Integer
LSPAN(20)	ID of AEFACT card with spanwise box breakdown	LSPAN	Integer
LCHORD(20)	ID of AEFACT card with chordwise box breakdown	LCHORD	Integer
X1P(20)	X of panel inboard leading edge	X1	Real
Y1P(20)	Y of panel inboard leading edge	Y1	Real
Z1P(20)	Z of panel inboard leading edge	Z1	Real
X12P(20)	Chord length at panel inboard edge	X12	Real
X4P(20)	X of panel outboard leading edge	X4	Real
Y4P(20)	Y of panel outboard leading edge	Y4	Real
Z4P(20)	Z of panel outboard leading edge	Z4	Real
X43P(20)	Chord length at panel outboard edge	X43	Real
CAERO2 Related Variables			
CA2NBR(20)	CAERO2 numbers	EID	Integer
PID2(20)	CAERO2 property numbers	PID	Integer
NSB(20)	Number of slender body elements	NSB	Integer
NINT(20)	Number of interference body elements	NINT	Integer
LSB(20)	ID of AEFACT card with slender body element breakdown	LSB	Integer
LINT(20)	ID of AEFACT card with interference element breakdown	LINT	Integer
X1B(20)	X of body leading point	X1	Real
Y1B(20)	Y of body leading point	Y1	Real
Z1B(20)	Z of body leading point	Z1	Real
X12B(20)	Length of body	X12	Real

Table A-1. NPLOT aerodynamic variable definition.

VARIABLE NAME	DESCRIPTION	NASTRAN NAME	TYPE
PAERO2 Related Variables			
PA2NBR(20)	PAERO2 numbers	PID	Integer
WIDTH(20)	Reference half-width of body	WIDTH	Real
AR(20)	Aspect ratio (height/width)	AR	Real
LRSB(20)	ID of AEFACT card with slender body half-widths	LRSB	Integer
LRIB(20)	ID of AEFACT card with interference body half-widths	LRIB	Integer
LTH1(20)	ID of AEFACT card with theta array	LTH1	Integer
AEFACT Related Variables			
AEFNBR(40)	AEFACT numbers	SID	Integer
DIV(40,26)	Divisions from AEFACT card	D1-D26	Real
Miscellaneous Variables			
NDIV(40)	Number of divisions on AEFACT card		Integer
NAEF	Number of AEFACT cards		Integer
NCA1	Number of CAERO1 cards		Integer
NCA2	Number of CAERO2 cards		Integer
NPA2	Number of PAERO2 cards		Integer
PSTART(20)	Starting grid number for each CAERO1		Integer
BSTART(20)	Starting grid number for each CAERO2		Integer
NCIRC(20)	Number of points defined around a body		Integer

Table A-1. (Concluded.)

APPENDIX B

PROGRAM INSTALLATION AND EXECUTION

The aerodynamic plotting software was developed using NPLOT version 4.0, as delivered by GSFC to AFWL in July 1986. Although major additions to the existing code were confined to three new subroutines, the nature of the extension for aerodynamic model plotting required some changes to the original NPLOT source code, as described in Appendix A. For this reason, the source code for the three new subroutines and for the four modified NPLOT subroutines is delivered on the distribution tape. To facilitate incorporation of these extensions into future NPLOT releases, and to document fully the state of the NPLOT release that was used, the full NPLOT code is included separately.

The source code for the DI-3000-to-DISSPLA translator subroutines shown in the report body, Table 1 is also provided on the distribution tape. Note that the DISSPLA Dynamics option is required to use NPLOT with the translator. Other translator subroutines beyond those required only for NPLOT are also included. These subroutines have not been checked for correctness, but are supplied so that the translator can be used as the basis for a more comprehensive package.

The distribution tape is written using the BACKUP utility under VMS 4.5. To facilitate unloading of file that are logically separate, distinct sets of files are written to different save set names using BACKUP. For example, the original NPLOT version 4.0 source code is quite lengthy, and it may not be desirable to unload it; therefore, it is provided under a separate save set than the new and modified subroutines.

Note that a save set is provided with a new command file for execution of CREATR, NASTRAN, etc., as described in Reference 1 in the body of this report. The new command file provides access to NPLOT in addition to NASTPLOT when creating NASTRAN and VIBRA-6 aircraft models using CREATR and NAS2V6. The program provided under that ASIAC task to track execution history has also been extended to cover NPLOT. The save sets on the tape are:

Save Set Name	Description
INSTALL	Installation command file and instructions
COM	Miscellaneous DCL command files
NPLOTOLD	Full NPLOT version 4.0; source, etc.
NPLOTNEW	NPLOT modules NPLOTA and NPLOTB, with aerodynamic model plotting; source, etc.
AERO	Only the new and modified NPLOT subroutines; source, etc.
DITRANS	DI-3000-to-DISSPLA translator; source, etc.
SAMPLES	Sample NASTRAN data decks
VIBRACOM	New command files for CREATR/NASTRAN/VIBRA-6 execution, as described in Reference 1, but with NPLOT execution included

To install the programs, follow this procedure, where Mxxx: refers to the name of the tape drive on the system:

- Mount the tape on the drive, place it on-line and issue the command:
\$ MOUNT/FOREIGN Mxxx:
- Put the installation command file and instructions on the system
\$ BACKUP/REWIND/LOG Mxxx:INSTALL *
- Print or look at the installation instructions file, INSTRUCTIONS.TXT. Then, *edit INSTALL.COM and replace the destination directories for all save sets.*
- To install all the save sets at once, issue the command:
\$ @INSTALL
- To install a single save set, issue the command:
\$ @INSTALL savesetname
where savesetname is the one wanted.
- *Don't forget to edit all command files in save set COM to point to the proper directories.*
- As noted in Section 3, the DI-3000-to-DISSPLA translator requires the DISSPLA Dynamics option to link properly, and NPLOT's zoom capability may not work with older releases of DISSPLA's Tektronix interface subroutines.

A command file, LINKNPLOT.COM, is provided in save set COM to create the NPLOT executable by linking the various NPLOT object modules with the DI-3000-to-DISSPLA translator and the DISSPLA library. This command file was used on the NTAVAX at AFWL.

Note that a listing and description of the distribution tape contents is provided in save set INSTALL in the file INSTRUCTIONS.TXT. The distribution tape is available from ASIAC.

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