NASA Contractor Report 2850

A Program To Compute Three-Dimensional Subsonic Unsteady Aerodynamic Characteristics Using the Doublet Lattice Method, L216 (DUBFLX)

Volume II: Supplemental System Design and Maintenance Document

B. A. Harrison and M. Richard

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Volume II: Supplemental System Design and Maintenance Document

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1.0 SUMMARY

Program L216 (DUBFLX) is structured as nine overlays, one main and eight primary overlays. Input into the program is made via card and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing geometric and aerodynamic data.

Although L216 serves as a module of a DYLOFLEX system, it can be operated as a standalone program. Subroutines used by L216 include routines embedded in the program code and routines obtained from the standard FORTRAN and DYLOFLEX libraries.

2.0 INTRODUCTION

Program L216 (DUBFLX) can be used either as a standalone program or as a module of a program system called DYLOFLEX (see fig. 1), which was developed for NASA under contract NAS1-13918 (ref. 1). DUBFLX is used to compute subsonic unsteady aerodynamic forces which are required in aeroelastic analyses as developed under the criteria given in reference 2. The current version is a derivative of the original Air Force H7WC program (ref. 3). Structure of program H7WC was modified and streamlined for NASA. Program L216 contains enhancements to the streamlined version, as well as revisions to meet the DYLOFLEX specifications[1] in order to make it compatible with the other modules of the DYLOFLEX system.

This volume contains information for maintaining and/or revising the program L216. To meet this objective, the following items are described in some detail.

- Program design and structure
- Overlay purpose and description
- Input, output, and internal data base descriptions
- Test cases

[1]Clemmons, R. E.: *Programming Specifications for Modules of the Dynamic Loads System to Interface With FLEXSTAB*. NASA contract NAS1-13918, BCS-G0701, September 1975. (internal document)

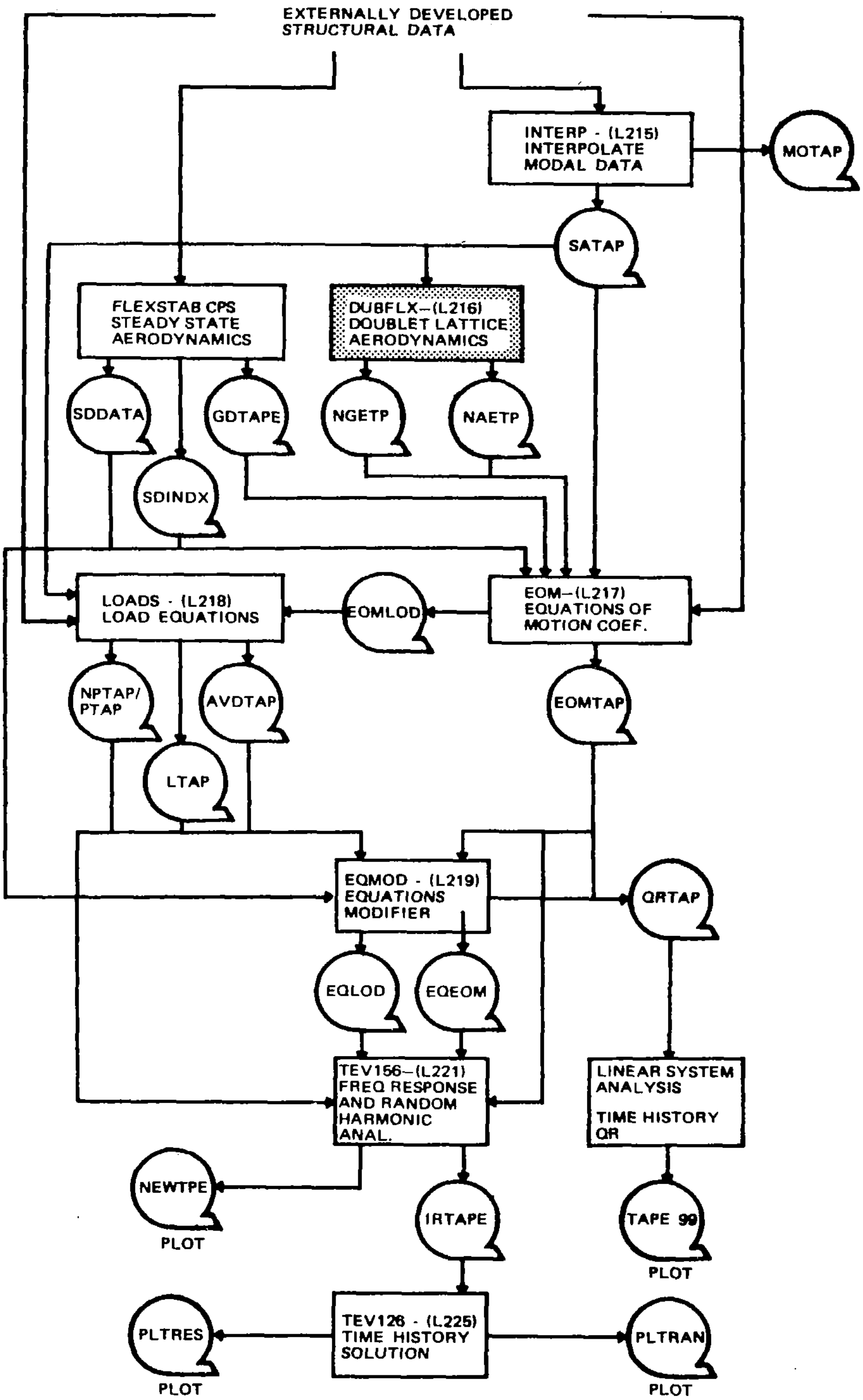


Figure 1. – DYLOFLEX Flow Chart

3.0 PROGRAM DESIGN AND STRUCTURE

Program L216 (DUBFLX) has the overlay structure shown in figure 2. The main overlay, (L216,0,0), calls into execution the primary overlays required to perform the analysis defined by card input data. To solve the non-AIC problem, the following primary overlays are called:

(L216,1,0)	INITIAL
(L216,2,0)	PRT2
(L216,4,0)	GEQ
(L216,5,0)	AMSOL
(L216,7,0)	GIN
(L216,8,0)	SAMODE

To solve the AIC problem, the primary overlays called are:

(L216,1,0)	INITIAL
(L216,2,0)	PRT2
(L216,3,0)	GEWSSL
(L216,5,0)	AMSOL
(L216,6,0)	AICSUB

Each of the overlays is described separately in the following sections. Included are the overlay's purpose, file communication, macro flow chart, and a list of subroutines called.

The external files read/written by L216 are displayed in figure 3.

Program L216 can serve as a module of the DYLOFLEX system or as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by L216. (See vol. I of this document for the required data and formats.)

This program requires subroutines that are not part of the L216 code. Some routines are automatically obtained from the standard FORTRAN library when the program is loaded. Others, however, are stored in the DYLOFLEX alternate subroutine library, which must be declared at the time of loading. Subsequent sections describe each overlay separately and contain tables displaying the routines called and the library in which they are located. All subroutines have only one entry point.

This volume describes the program in a macro sense. A more detailed discussion appears in the comments contained in the program source code. Each routine contains a preface describing the routine's purpose, author, analytical steps, modification history, input data, output data, glossary of variables, and list of other routines called. Embedded within the executable code are comments labelling each section and explaining logical branches.

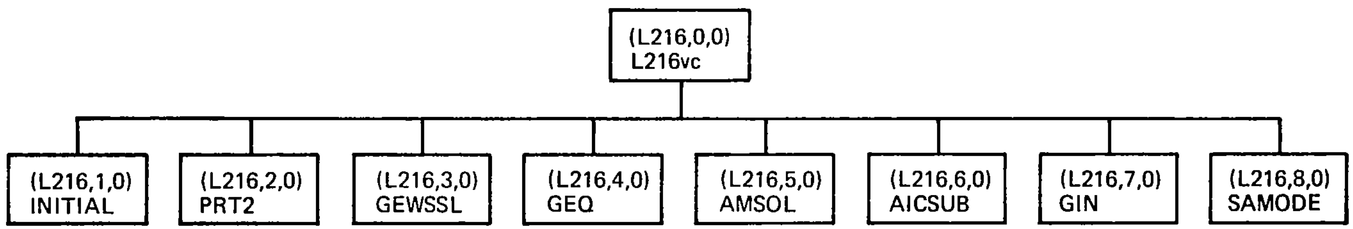


Figure 2. — Overlay Structure of L216 (DUBFLX)

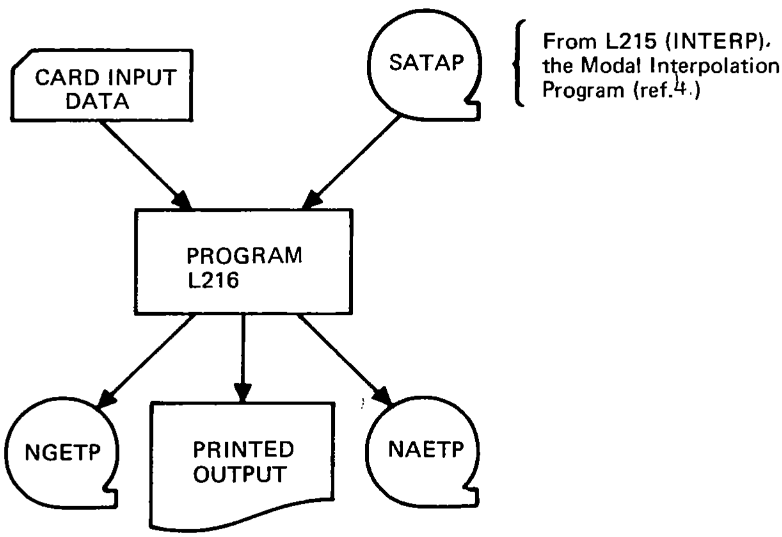


Figure 3. — External Data Files Communicating With L216 (DUBFLX)

3.1 OVERLAY (L216,0,0) - L216vc

The main overlay of L216 is named L216vc. The last two characters of the program name define the program version and the last correction set against that version, where v is a letter indicating the program version and c is an integer number indicating the last correction against version v.

Purpose of L216vc

L216vc performs certain bookkeeping tasks, directs the execution of the primary overlays, and aids the communication between primary overlays via labelled common blocks.

Analytical Steps of L216vc

L216vc performs its task in the following steps:

1. L216vc calls the subroutine PRGBEG to place the program header on the printed output.

2. The sequential and random access files used as scratch files are defined to the program.

3. The overlay INITIAL reads card input data for geometry and modal data.

4. For modal data saved on the file SATAP, the overlay SAMODE interpolates for mode shapes at all aerodynamic elements.

   L216vc repeats steps 5 through 8 for each reduced frequency:

5. L216vc computes the downwash factors matrix [D] in the overlay PRT2.

6. It computes the modified kinematic downwash, the $[W_{AIC}]$ matrix for AIC (in overlay GEWSSL), or the non-AIC [W] (in overlay GEQ) problems.

7. It solves the $[D^{-1}]\ [W] = [\Delta Cp]$ equation in overlay AMSOL to obtain the pressure coefficients.

8. It prints aerodynamic results for AIC problems by calling overlay AICSUB. For non-AIC problems, it calls overlay GIN to print the pressure and generalized air forces and sectional derivatives.

9. It looks for a CASE card to initiate the analysis of a new data set.

10. It calls the subroutine PRGEND to place the program termination header on the printed output.

The macro flow chart of this overlay appears in figure 4. The subroutines called are displayed in table 1.

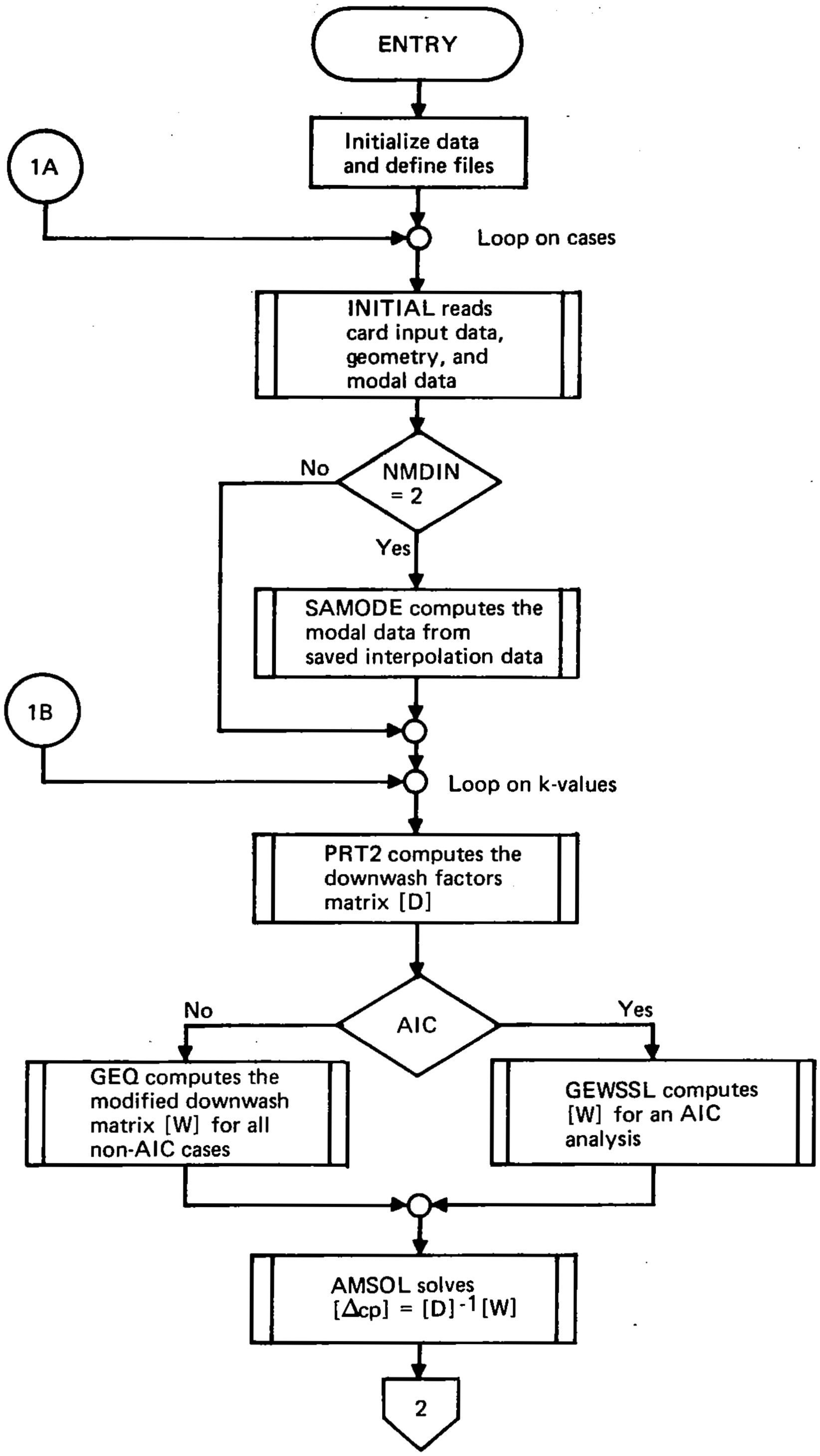


Figure 4. —Macro Flow Chart of Overlay (L216,0,0)—L216vc

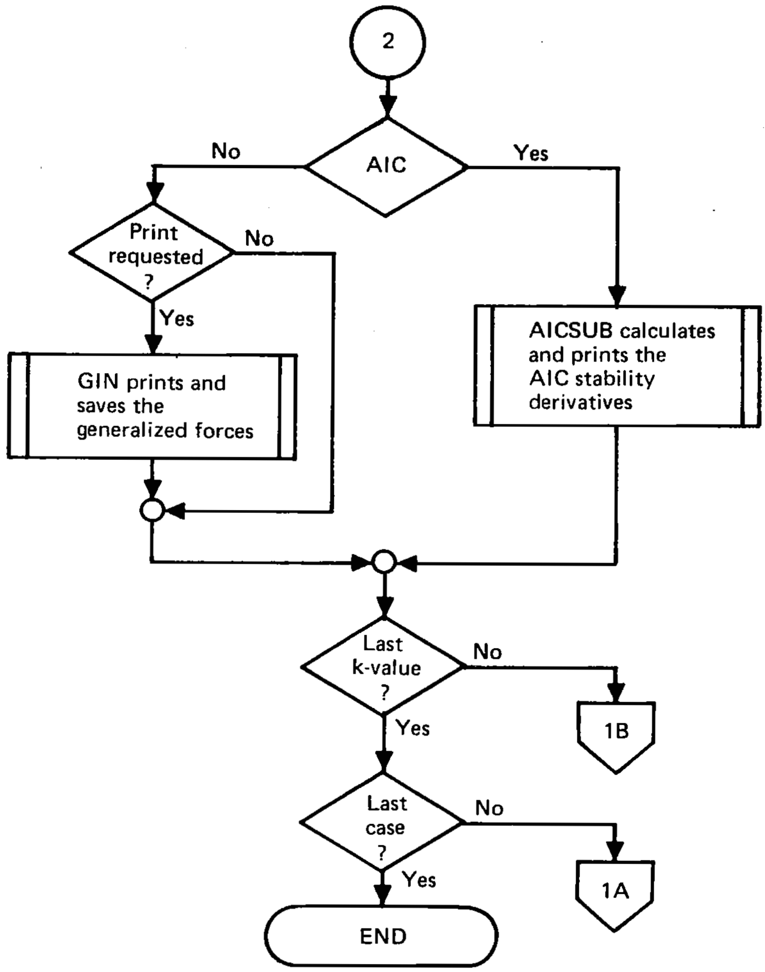


Figure 4.—(Concluded)

Table 1.—Routines Called by OVERLAY (L216,0,0,0)—L216vc

OVERLAY (L216, 0, 0)

PROGRAM L216vc

L216vc	BLKDAT	
	CLOSMS*	
	FETAD+	
	FETDEL+	
	FILLM	
	IRDCRD+	
	OPENMS*	
	PRGBEG+	
	PRGEND+	
	RETURNF+	
	SECOND*	
	WRTETP+	
	INITIAL	OVERLAY (L216,1,0)
	PRT2	OVERLAY (L216,2,0)
	GEWSSL	OVERLAY (L216,3,0)
	GEQ	OVERLAY (L216,4,0)
	AMSOL	OVERLAY (L216,5,0)
	AICSUB	OVERLAY (L216,6,0)
	GIN	OVERLAY (L216,7,0)
	SAMODE	OVERLAY (L216,8,0)

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

I/O Devices of L216vc

L216vc reads from the card input file card sets numbered 1.0 through 18.0. L216vc writes on the printed output file, messages indicating the program name and version, as it begins and ends execution. All other input/output to and from L216 takes place in lower level overlays.

3.2 OVERLAY(L216,1,0) – PROGRAM INITIAL

Purpose of INITIAL

INITIAL reads the card input data defining the problem geometry and modal data. It stores geometry in labelled common blocks for later use in L216 and writes geometry matrices onto the file NGETP for subsequent use in the DYLOFLEX equations of motion (L217 EOM) program described in reference 5.

Blocks of card input data are introduced by the keywords:

REDUCED FREQUENCIES	To introduce k-values
GEOMETRY	To introduce geometry data
PANEL	To define the lifting surface panel geometry and modal data
BODY	To define the slender body geometry and modal data
MODE	To specify the modal data set

Figure 5 is a macro flow chart of the program INITIAL. Table 2 displays the subroutines and functions called by the program INITIAL.

I/O Devices of INITIAL

INITIAL reads from:

INPUT (card reader)	Card sets 4 through 17.4

INITIAL writes on:

OUTPUT (printer)	The interpreted card input data and error diagnostics
NGETP (user-named file)	The geometry data in matrix form
NTP8 and NTP9 (random access scratch files)	The labelled common blocks of geometry and modal data are saved temporarily on these files to lower core storage requirements

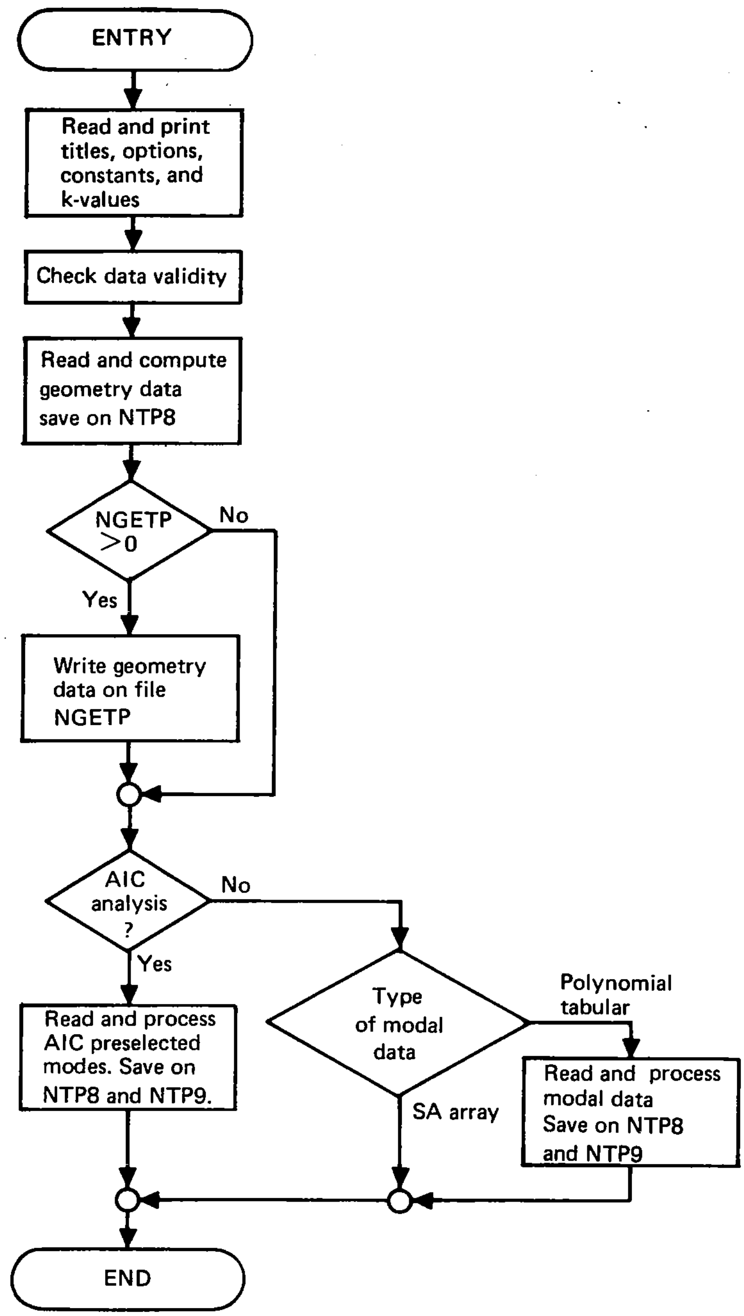


Figure 5. —Macro Flow Chart of Overlay (L216,1,0)—INITIAL

Table 2.—Routines Called by OVERLAY (L216,1,0)—INITIAL

OVERLAY (L216,1,0)

PROGRAM INITIAL

INITIAL	FETAC+	
	FETDEL+	
	GEB	WRITMS*
		STINDX*
	GESTORE	WRTETP+
	NAMFIL+	
	POLYB	STINDX*
		WRITMS*
		READMS*
	PRT1	FILLM
	PEDB	READMS*
		WRITMS*
		STINDX*
	WRITMS*	

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

3.3 OVERLAY(L216,2,0) - PRT2

Purpose of PRT2

PRT2 computes the steady and oscillatory components of the matrix of downwash factors [D] for all the lifting surface elements. It also modifies the downwash factors for the two planes of symmetry (Y = 0 and Z = 0). The matrix is written on scratch tape NTP1 for later use.

Analytical Steps of PRT2

PRT2 computes the downwash factors matrix from the expression

$$D = \int_{\substack{\text{sending}\\\text{element}}} K\,(x-\xi_{1/4},\ y-\eta,\ z-\zeta,\ \omega,\ M)\,d\sigma$$

where K is a nonplanar kernel function and σ is the tangential spanwise coordinate. The term ω is the frequency of oscillation and M is Mach number.

Figure 6 is the macro flow chart of PRT2. Table 3 displays the subroutines called by PRT2.

I/O Devices of PRT2

PRT2 reads from:

NTP8 (random access scratch file)	The labelled common block data

PRT2 writes on:

OUTPUT (printer)	Error diagnostics and intermediate debugging data if requested
NTP1 (sequential scratch file)	The [D] matrix

3.4 OVERLAY(L216,3,0) - GEWSSL

Purpose of GEWSSL

GEWSSL computes the downwash column vectors $\{W_{AIC}\}$ for each of the preselected AIC modes. Figure 7 is the macro flow chart of GEWSSL.

GEWSSL calls the subroutine READMS (in the FORTRAN library) and SSL.

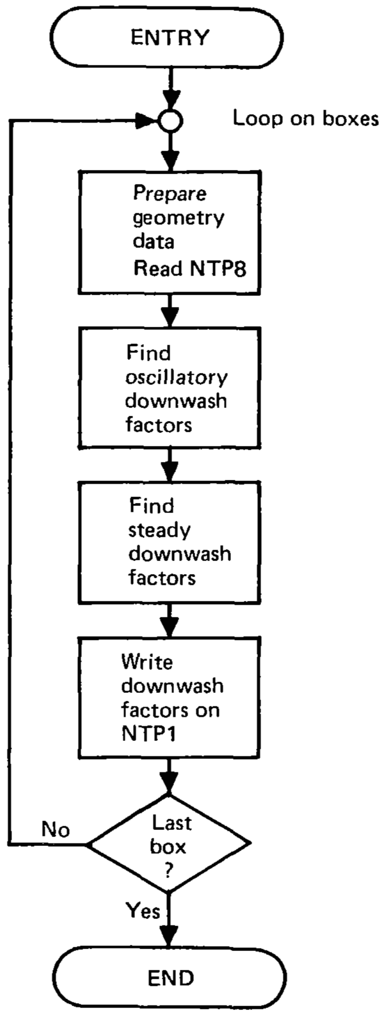


Figure 6. —Macro Flow Chart of Overlay (L216,2,0)—PRT2

Table 3.—Routines Called by OVERLAY (L216,2,0)—PRT2

- PRT2
  - INCRO
    - KERNEL
    - IDF1
    - IDF2
  - SNPDF
  - READMS*
  - REQFL+

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

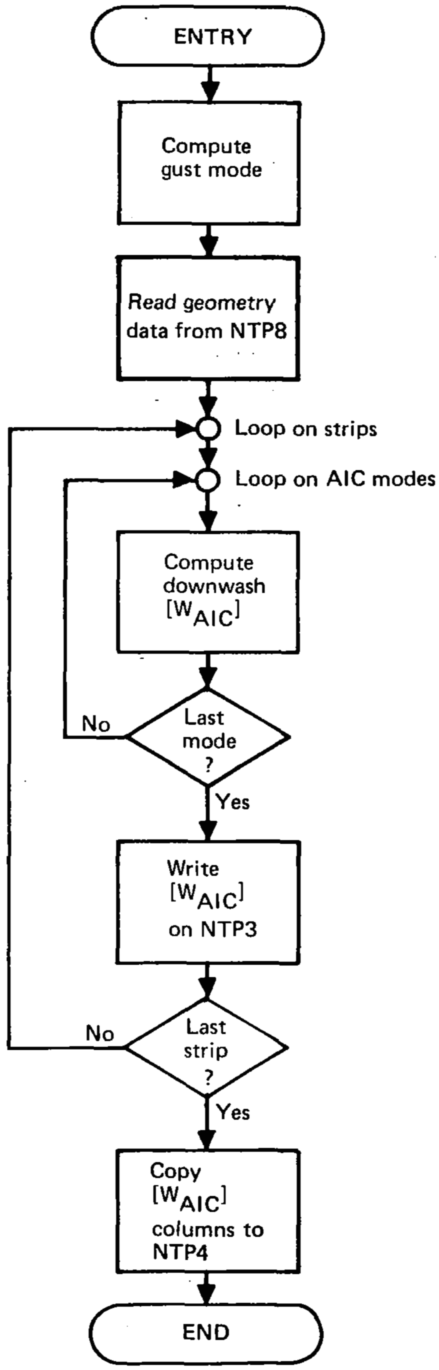


Figure 7. —Macro Flow Chart of Overlay (L216,3,0)—GEWSSL

I/O Devices of GEWSSL

GEWSSL reads from:

NTP8 (random access scratch file)	The geometry data GEWSSL writes on:

GEWSSL writes on:

OUTPUT (printer)	The modal data, the augmented downwash factors matrix, and error diagnostics
NTP3 (sequential scratch file)	The downwash matrix $[W_{AIC}]$ for all strips
NTP4 (sequential scratch file)	The downwash matrix $[W_{AIC}]$ by columns

3.5 OVERLAY(L216,4,0) - GEQ

Purpose of GEQ

GEQ computes the downwash matrix $[W]$ for all non-AIC analyses. For the structure with slender bodies, it also computes the pressure coefficients $[\Delta Cp]$ and the induced downwash $[W_B]$ on the lifting surfaces. The modified downwash matrix $[W\text{-}W_B]$ is then computed and stored.

Figure 8 is a macro flow chart of GEQ. Table 4 displays the routines called by GEQ.

I/O Devices of GEQ

GEQ reads from:

NTP3 (sequential scratch file)	The modified downwash matrix $[W\text{-}W_B]$
NTP8 (random access scratch file)	Labelled common block data

GEQ writes on:

OUTPUT	The calculated results and error diagnostics
NTP4 (sequential scratch file)	The modified downwash matrix $[W\text{-}W_B]$ by columns
NAETP (user named file)	The induced downwash matrix $[W_B]$

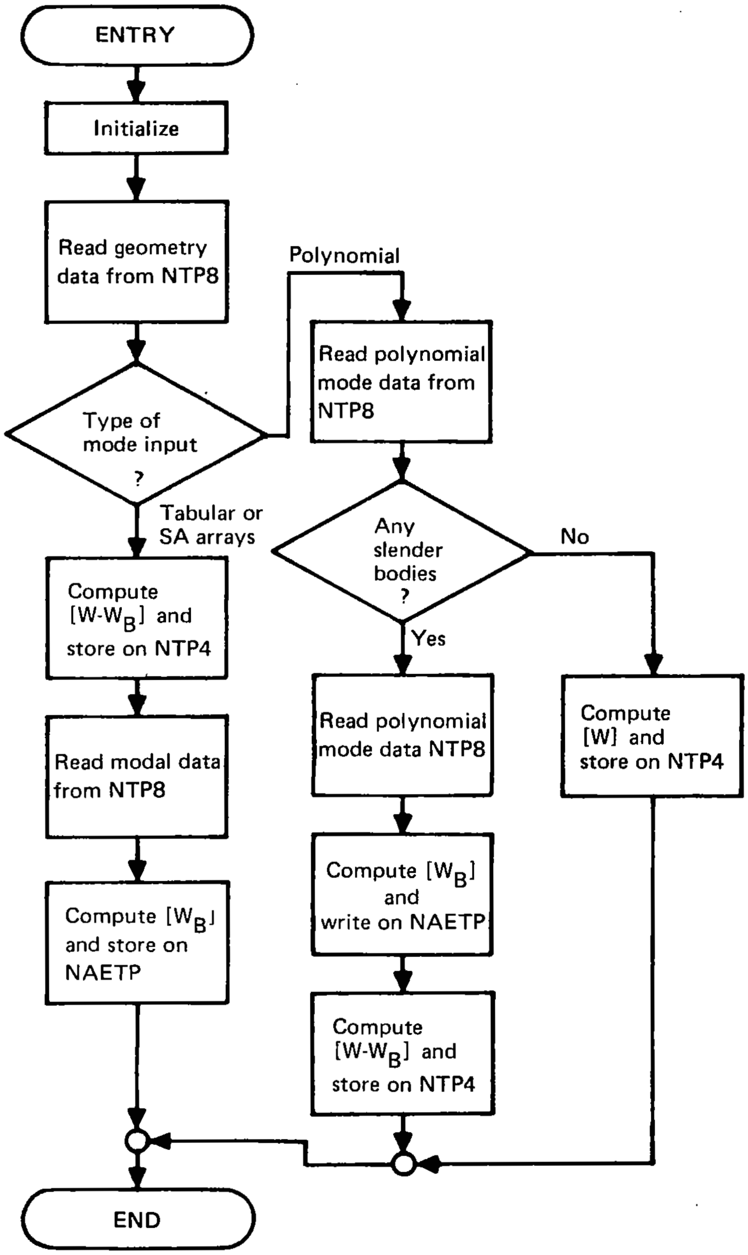


Figure 8. —Macro Flow Chart of Overlay (L216,4,0)—GEQ

Table 4.—Routines Called by OVERLAY (L216,4,0)—GEQ

- GEQ
  - DWGBD
    - BPRNT
    - COMBIN
    - READMS*
    - SUMER
      - TKER
      - WRTETP+
    - STINDX
  - PWGBD
    - AUGP
      - READMS*
      - SUMER
        - TKER
        - WRTETP+
      - BPRNT
    - COMBIN
    - READMS*
  - READMS*

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

3.6 OVERLAY(L216,5,0) - AMSOL

Purpose of AMSOL

AMSOL solves the simultaneous equations represented by the augmented downwash factors matrix,[D/W] It forms the $[D^{-1}W]$ matrix, which is used to obtain the lifting pressure coefficients $[\Delta Cp]$.

Analytical Steps of AMSOL

AMSOL checks the core storage available, initializes scratch files, and calls the subroutine QUAS for the matrix solution

$$[\Delta C_p] = [D]^{-1}[W]$$

where [D] is the downwash factors matrix and [W] is the modified downwash matrix. Figure 9 is the macro flow chart of AMSOL. Table 5 displays the subroutines called by AMSOL.

I/O Devices of AMSOL

AMSOL reads from:

NTP1 (sequential scratch file)	The matrix [D]
NTP4 (sequential scratch file	The matrix [W]

AMSOL writes on:

OUTPUT (printer)	The AIC solution (if requested) and error diagnostics
NTP3 (sequential scratch file)	The matrix $[D^{-1}W]$
NAETP (sequential output file)	The quasi inverse matrix $[D]^{-1}$

AMSOL writes/reads partitions of the [D/W] matrix on/from these sequential scratch files:

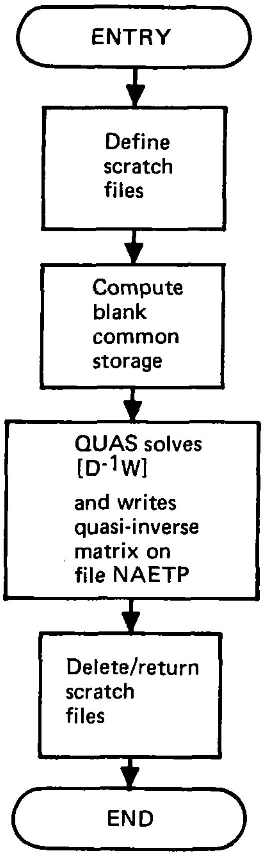


Figure 9. —Macro Flow Chart of Overlay (L216,5,0)—AMSOL

Table 5.—Routines Called by OVERLAY (L216,5,0)—AMSOL

AMSOL	FETAD+
	FETDEL+
	QUAS
	REQFL+
	RETURNF+

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

NTP2
NTP10
NTP11
LTAPE

3.7 OVERLAY(L216,6,0) - AICSUB

Purpose of AICSUB

AICSUB calculates and prints the AIC stability derivatives and pressure coefficients. When requested, it also computes and prints the harmonic gust coefficients.

Figure 10 is the macro flow chart of AICSUB. Table 6 displays the routines called by AICSUB.

I/O Devices of AICSUB.

AICSUB reads from:

NTP3 (sequential scratch file)	The solution matrix $[D^{-1}W]$ for analysis
NTP8	The geometry data and modal data (integration matrix B)
NTP9	The saved AIC dimensional matrix to form the AIC force coefficients

AICSUB writes on:

OUTPUT (printer)	The results and error diagnostics
NTP9	The AIC dimensional matrix (this data is subsequently read by subroutine FIN)

3.8 OVERLAY(L216,7,0) - GIN

Purpose of GIN

GIN computes and prints the pressure coefficients, sectional and total lift and moment coefficients, and generalized air forces. It also writes on the file NAETP the aerodynamic results required by the DYLOFLEX equations of motion (L217 EOM) program (ref. 6).

Figure 11 is the macro flow chart of GIN. Table 7 displays the subroutines called by GIN.

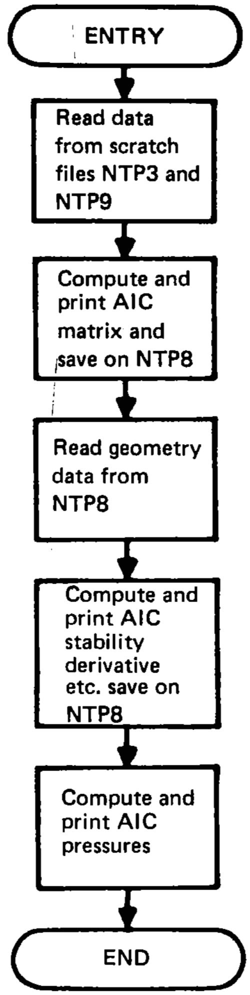


Figure 10. —Macro Flow Chart of Overlay (L216,6,0)—AICSUB

Table 6.–Subroutines Called by OVERLAY (L216,6,0)–AICSUB

- AICSUB
  - AER
    - STINDX*
    - READMS*
    - WRITMS*
  - AI
    - STINDX*
    - READMS*
    - WRITMS*
  - FIN
  - READMS*

* indicates a routine in the FORTRAN library

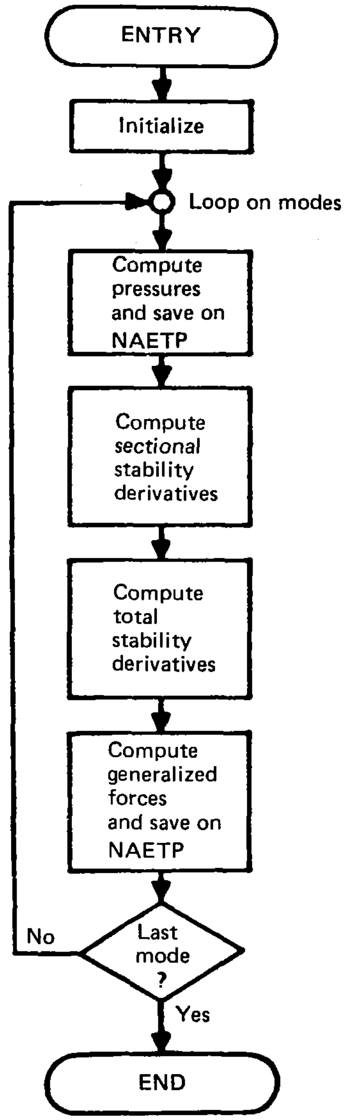


Figure 11. — Macro Flow Chart of Overlay (L216,7,0)—GIN

Table 7.—Routines Called by OVERLAY (L216,7,0)—GIN

GIN	READMS*
	STINDX*
	WRITMS*
	WRTETP+

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

I/O Devices of GIN

GIN reads from:

NTP3	The solution matrix $[D^{-1}W]$
NTP7	The slender body pressure coefficients
NTP8	The geometry data
NTP9	The modal data

GIN writes on:

OUTPUT (printer)	The calculated results and error diagnostics
NAETP (sequential output file)	The calculated aerodynamic data required by the equations of motion (L217 EOM) program (ref. 6)

3.9 OVERLAY(L216,8,0) - SAMODE

Purpose of SAMODE

SAMODE computes the modal input data from the SA arrays generated by the DYLOFLEX interpolation program (L215 INTERP) (ref. 4). For each lifting surface or slender body SAMODE reads the SA array from the file NTPSA and calculates the displacements, slopes, and the integration matrix [BQ].

Figure 12 is the macro flow chart of SAMODE. Table 8 displays the subroutines called by SAMODE.

I/O Devices of SAMODE

SAMODE reads from:

NTPSA	The modal interpolation array {SA} from L215 (INTERP) (ref. 5)
NTP1 (sequential scratch file)	The interpolated modal data

SAMODE writes on:

OUTPUT (printer)	The interpolated modal data and error diagnostics

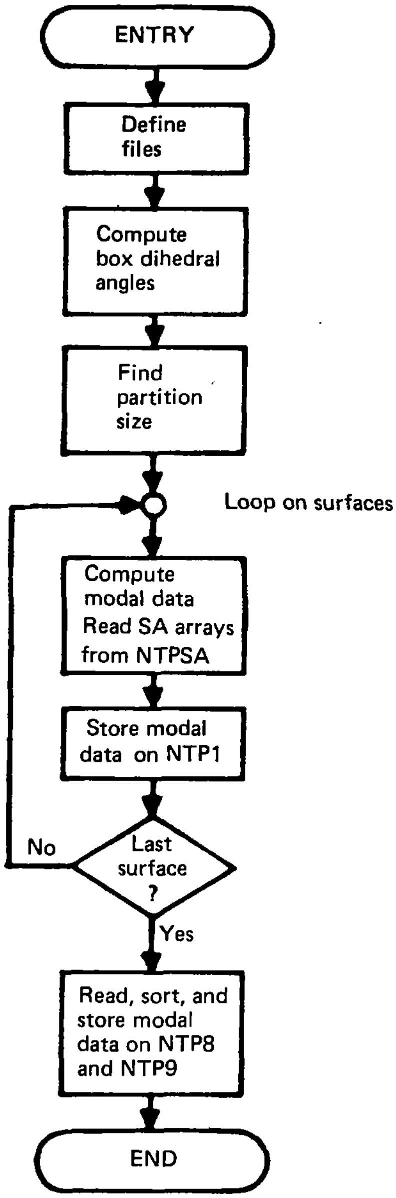


Figure 12. —Macro Flow Chart of Overlay (L216,8,0)—SAMODE

Table 8.—Routines Called by OVERLAY (L216,8,0)—SAMODE

SAMODE	EXPMD	
	FETAD+	
	FETDEL+	
	MDSA	AINTG+
		DERIVS
		READTP+
	READMS*	
	READTP+	
	RETURNF+	
	STINDX*	
	WRITMS*	

+ indicates a routine in the DYLOFLEX library

* indicates a routine in the FORTRAN library

NTP8 (random access file)	The modal displacements and slopes
NTP9 (random access file)	The integration matrix [BQ]

3.10 DATA BASES

L216 data bases include input and output files plus internal scratch files and common block storage.

3.10.1 INPUT DATA

The input data are from two sources: cards and magnetic files. The geometry data is always read from cards. The modal data may be input on cards or on the magnetic file generated by the DYLOFLEX modal interpolation (L215 INTERP) program (ref.[4]).

Card Input Data

The card input for L216 is described in detail in section 6.5.1 in volume I of this document.

Magnetic File Input Data

L216 reads only one file generated externally, the file NTPSA, containing modal interpolation data generated by the program L215 (INTERP). L215 and the file are described in detail in reference[4].

3.10.2 OUTPUT DATA

The results of an L216 execution will be printed and, optionally, written onto magnetic files.

Printed Output Data

A sample of the printed output of L216 is included with the sample problem in section 7.2 of volume I.

Magnetic File Output Data

Two magnetic files, NGETP and NAETP, are generated by the program. NGETP contains the saved geometry data, and NAETP contains the aerodynamic data. A detailed description of formats and contents of both appears in section 6.4 of volume I of this document.

3.10.3 INTERNAL DATA

Two methods are used to transfer data from one portion of the program to another: common blocks and scratch (temporary) storage files. In some parts of the program, even the common block data are stored temporarily on the scratch files to reduce the memory required to run the program.

Common Blocks

The common blocks used inside L216 may be grouped into four types:

1. Some labelled common blocks are defined in the (0,0) overlay and always reside in core. These labelled common blocks are named:

    /APPLE /

    /CHKPRT /

    /CNTRL /

    /INOUT /

    /MAE /

    /NTPS /

    /PROB /

    /PRTFLG /

    /PRTNQ /

    /RAF /

2. Several other labelled common blocks are defined in more than one overlay, but *not* in the (0,0) overlay. These common blocks are stored temporarily on the random access scratch file named NTP8 and read into core for the overlays in which they are required. They are named:

    /BODY/
    /GEBW/
    /PT1Q/
    /XXZ /
    /XYZ /
    /YZY /

3. A few labelled common blocks are defined in only one overlay, and are used to communicate with and between subroutines of that overlay. The locally defined common blocks are:

   /MGE /

   /P1GW /

   /RWBUFF/

   /STUFF /

4. Blank common is defined in several primary overlays. It is used to store large arrays. The array sizes are variable, dependent upon the problem sizes.

Table 9 shows which common blocks are used in each overlay. Table 10 contains detailed descriptions of the labelled common block elements. The following abbreviations are used in table 10 to describe the elements of each common block. The column labelled "T" in table 10 indicates variable type. The possible codes and their meaning in a FORTRAN sense are:

R Real

I Integer

C Complex

L Logical

H Hollerith

If the dimension column is left blank, "1" should be assumed.

Table 9.—Common Blocks Defined in Each Overlay

OVERLAY \ COMMON BLOCKS	/APPLE/	/BODY/	/CNTRL/	/CHKPRT/	/GEBW/	/MAE/	/MGE/	/NTPS/	/INOUT/	/PROB/	/PRTFLG/	/PRTNQ/	/PT1Q/	/P1GW/	/RAF/	/RWBUFF/	/STUFF/	/XXZ/	/XYZ/	/YXY/	Blank
(L216,0,0)-L216vc	X		X			X		X	X	X	X	X			X						
(L216,1,0)-INITIAL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
(L216,2,0)-PRT2	X		X	X	X			X	X	X	X	X	X				X				
(L216,3,0)-GEWSSL	X		X		X			X	X	X	X				X			X			X
(L216,4,0)-GEQ	X	X	X	X	X			X	X	X	X	X			X						X
(L216,5,0)-AMSOL								X	X	X	X										X
(L216,6,0)-AICSUB	X		X					X	X	X	X	X			X			X	X	X	X
(L216,7,0)-GIN	X	X	X	X	X			X	X	X	X	X			X			X			X
(L216,8,0)-SAMODE		X		X	X				X	X		X			X	X					X

Table 10.—Contents of Common Blocks

LABELED COMMON NAME: APPLE

DESCRIPTION: Constants commonly used.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	PI	R		π	Constant
2	TWOPI	R		2π	Constant
3	PI02	R		$\pi/2$	Constant
4	PISQ	R		π^2	Constant
5	RADEG	R			Conversion factor (radians to degrees)
6	SMALL	R		ϵ	Constant (10^{-4})

Table 10.—(Continued)

LABELED COMMON NAME: BODY

DESCRIPTION: Slender Body Segment Data

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	RO	R	80	R_{oj}	Body radius distribution.
	ROP	R	90	R'_{oj}	X-derivative of body radius distribution.
3	NBEA	R	20	nb_{e_i}	$nb_{e_i} = \sum_{j=1}^{i} (nfj-1)$ where nfj is the number of body segment endpoints for the jth body; i=1,NB.
4	BGMA	I	10	γ	Dihedral angle of body =0 for z bodies =$-\pi/2$ for y bodies
5	MRK	I	20,2		Column 1 - MRK(i,1)= First box number on the interference panels for the slender body i. Column 2 - MRK(i,2)= Last box number on the interference panels for the slender body i.

Table 10.—(Continued)

LABELED COMMON NAME: CHKPRT

DESCRIPTION: Debug Print Flag

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICKPRT	I	1		Debug Print Flag(=3)

Table 10.—(Continued)

LABELED COMMON NAME: CNTRL

DESCRIPTION: Problem control flags and counters

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NDELT	I		δ	Symmetry flag
2	IQ	I			Loop counter
3	IR	I			Loop counter
4	JSPECS	I			Symmetry Flag (Plane Z=0)
5	NGUST	I			Gust Flag
6	NYAW	I			Stability Derivative override flag.
7	NAIC	I			AIC Analysis Flag
8	NMDIN	I			Type of mode input
9	NPFM	I			Flag to print aero results
10	JRF	I			Reduced frequency index
11	IMX	I			Number of AIC modes

Table 10.—(Continued)

LABELED COMMON NAME: GEBW

DESCRIPTION: Geometry of receiving and sending points

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	GMA	R	50	γ	Dihedral angle array of panel strips.
2	EV	R	400	x	x-coordinates of sending points.
3	PV	R	400	y	y-coordinates of sending points.
4	ZV	R	400	z	z-coordinates of sending points.
5	SDELX	R	400		Average chord length of box
6	DELY	R	400		Box widths
7	X	R	400	$\bar{x}$	x-coordinates of receiving points.
8	Y	R	400	$\bar{y}$	y-coordinates of receiving points.
9	ZZ	R	400	$\bar{z}$	z-coordinates of receiving points.

Table 10.—(Continued)

LABELED COMMON NAME: INOUT

DESCRIPTION: Identifiers and Error Counter

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	INFIL	I			INPUT file (card reader) TAPE5
2	IUTFIL	I			OUTPUT file (line printer) TAPE6
3	IAERO	I			Flag to save aerodynamic results on the file NAETP. =0 do not save results =1 save generalized forces and unsteady pressures =2 save the matrices $[D]^{-1}$ and [F] =3 save all items listed under both 1 and 2 above.
4	KERROR	I			Fatal error counter
5	ICASE	I			Current case number
6	ICOND	I			Current condition number.

Table 10.—(Continued)

LABELED COMMON NAME: MAE

DESCRIPTION: Control matrix for saved Aerodynamic results

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MAC	I	85		See Section 3.6 of Volume I for details.
2	SHFTC	R	3,40		Shift for panel coordinates for modal interpolation.

Table 10.–(Continued)

LABELED COMMON NAME: MGE

DESCRIPTION: Geometry data to be saved on NGETP

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MGC	I	15		Control matrix (see Section 3.6 of Volume I for details).
2	MPSG	I	570		Geometric data for primary lifting surfaces.
3	MISG	I	570		Geometric data for interference lifting surfaces.
4	MSBG	I	400		Geometric data for slender bodies.
5	NLIFS	I			Number of primary lifting surfaces.
6	NINTS	I			Number of interference lifting surfaces.
7	NSBDS	I			Number of slender bodies.
8	MSBC	I	400		Box-surface correspondence array.

Table 10.—(Continued)

LABELED COMMON NAME: NTPS

DESCRIPTION: File names

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NTP1	I			File name SCTAP1
2	NTP2	I			File name SCTAP12
3	NTP3	I			File name SCTAP3
4	NTP4	I			File name SCTAP4
5	NTP5	I			File name SCTAP5
6	NTP6	I			File name SCTAP6
7	NTP7	I			File name SCTAP13
8	NTP8	I			File name SCTAP8
9	NTP9	I			File name SCTAP9
10	NTP10	I			File name SCTAP10
11	NAETP	I			User-supplied file name of saved aerodynamic results.
12	NGETP	I			User-supplied file name of saved geometry data.
13	NTPQ	I			Not used.
14	NTPSA	I			User-supplied file name of the modal SA arrays.

Table 10.–(Continued)

LABELED COMMON NAME: PROB

DESCRIPTION: General Data Array

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NBOX	I			Number of lifting surface boxes.
2	NB	I			Number of slender bodies.
3	NBE	I			Number of slender body elements.
4	NTOT	I			Total number of aerodynamic elements (NBOX+NBE).
5	NMD	I			Number of modes.
6	NRF	I			Number of reduced frequencies.
7	NSTRIP	I			Number of strips on lifting surfaces.
8	NSV	I			Number of strips on plane Y=0.
9	NBV	I			Number of boxes on vertical surfaces in plane Y=0.
10	NBF	I			First box number on vertical surfaces in plane Y=0.
11	NBL	I			Last box number on the vertical surfaces in plane Y=0.
12	NPC	I			Alternative mode selector of AIC analysis.
13	NMTP	I			Total number of modal polynomial coefficients defined on lifting surface panels.
14	NMTB	I			Total number of modal polynomial coefficients defined on slender bodies.
15	FMACH	R		M=v/c	Mach number.

Table 10.—(Continued)

LABELED COMMON NAME: PROB (Cont'd)

DESCRIPTION:

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
16	BETA	R		$\beta=\sqrt{1-M^2}$	Mach number function.
17	ACAP	R		A ref	Reference Area.
18	BR	R		b	Reference length used in computing reduced frequency.
19	AKDBR	R		k/b	"Normalized" reduced frequency.
20	RFREQ	R	70	$k=\omega b/V$	Reduced Frequency.
21	REFCHD	R		$\bar{c}$	Reference chord length.
22	REFSPN	R		s	Reference semispan
23	NCARAY	I	40		Number of chord-wise boundaries on a panel.
24	NSARAY	I	40		Number of span-wise boundaries on a panel.
25	NBARAY	I	40		Number of boxes on a panel.
26	WG	R			Gust velocity at XZRO.
27	VEL	R		V_∞	Aircraft speed.
28	GZRO	R		Γg	Dihedral angle of gust reference plane.
29	XZRO	R		Xo	Gust reference x location.
30	LIM	I	50,3		Summation limits of chord-wise integration on strips.
31	NSU	I			Number of lifting surfaces.
32	NSUBL	I	5,80		Lifting surface data.

Table 10.—(Continued)

LABELED COMMON NAME: PRTFLG

DESCRIPTION: Printing Options and Flags

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NDATA	I			Flag to print downwash factors matrix [D].
2	NSB	I			Flag to print slender body element downwash factor matrix [AZY].
3	NPR1	I			Flag to print AIC analysis matrix solution $[D^{-1}W]$.
4	NPR2	I			Flag to print AIC dimensional matrix [A].
5	NPR3	I			Flag to print stability derivatives for preselected modes of AIC analysis.

Table 10.—(Continued)

LABELED COMMON NAME: PRTNQ

DESCRIPTION: Panel Definition Array

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	COEFP	R	40		Coefficient modifier of panel modal data.
2	COEFB	R	20		Coefficient modifier of slender body modal data.
3	YIN	R	40		Inboard Y coordinate of edge of panel.
4	ZIN	R	40		Inboard Z coordinate of edge of panel.

Table 10.—(Continued)

LABELED COMMON NAME: PT1Q

DESCRIPTION: Geometry of sending points

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	Z1	R	400		Inboard X location of sending points.
2	P1	R	400		Inboard Y location of sending points.
3	ZZ1	R	400		Inboard Z location of sending points.
4	Z2	R	400		Outboard X location of sending points.
5	P2	R	400		Outboard Y location of sending points.
6	ZZ2	R	400		Outboard Z location of sending points.

Table 10.—(Continued)

LABELED COMMON NAME: P1GW

DESCRIPTION: AIC Panel Geometry

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	CT1	R	40		Chord length of inboard edge of panel.
2	CT2	R	40		Chord length of outboard edge of panel.
3	TS	R	70		Average fractional span-wise division of panel.

Table 10.–(Continued)

LABELED COMMON NAME: RAF

DESCRIPTION: Indices for Random Access Scratch Files

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IRAF8	I	71		Index for file NTP8.
2	IRAF9	I	71		Index for file NTP9.
3	FETGE	R	34		FET area for Saved Geometry file.
4	BUFGE	R	514		Buffer area for Saved Geometry file.

Table 10.—(Continued)

LABELED COMMON NAME: STUFF

DESCRIPTION: Interprogram data used in finding downwash factors

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	AX	R		$x - \xi$	X-EV } See common blocks /GEBW/ and /PT1Q/ for definition of these variables.
2	AY	R		$y - \eta$	Y-PV
3	AZ	R		$z - \zeta$	Z-ZV
4	AX1	R			X-Z1
5	AY1	R			Y-P1
6	AZ1	R			Z-ZZ1
7	AX2	R			X-Z2
8	AY2	R			Y-P2
9	AZ2	R			Z-ZZ2
10	GAMS	R		γ_r	Dihedral angle of the receiving point.
11	GAMSIG	R		γ_s	Dihedral angle of the sending point.
12	SGR	R		$\sin(\gamma r)$	Sine function of GAMS.
13	CGR	R		$\cos(\gamma r)$	Cosine function of GAMS.
14	SGS	R		$\sin(\gamma g)$	Sine of GAMSIG.
15	CGS	R		$\cos(\gamma g)$	Cosine of GAMSIG.
16	LHS	I			Left-hand side/right-hand side of wing flag.
17	IO	I			Index 1 to number of boxes on the strip.
18	NBXS	I			Sum of sending point box numbers on wing.

Table 10.—(Continued)

LABELED COMMON NAME: STUFF (Cont'd)

DESCRIPTION: ____________________

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
19	NCPNB	I			Sum of sending point boxes on the panel.
20	NDBLE	I			Symmetry flag for plane Z=0.
21	SL	R			Sine of sweep angle.
22	CL	R			Cosine of sweep angle.
23	TL	R			Tangent of sweep angle.
24	TWOE	R		2e	Width of sending box.
25	EE	R		e	Semi-width of sending box.
26	E2	R		e^2	Square of width of sending box.
27	XMULT	R			Multiplication factor (SDELX/BPI)
28	ETA	R		$\bar{y}$	Kernel interpolation variables
29	ZET	R		$\bar{z}$	Kernel interpolation variables
30	ETASQ	R		$\bar{y}^2$	Square of ETA.
31	ZETSQ	R		$\bar{z}^2$	Square of ZET.
32	PARN	R			Coefficients of the parabola for planar part of kernel integration.
33	ARE	R			Coefficients of the parabola for planar part of kernel integration.
34	AIM	R			Coefficients of the parabola for planar part of kernel integration.
35	BRE	R			Coefficients of the parabola for planar part of kernel integration.
36	BIM	R			Coefficients of the parabola for planar part of kernel integration.
37	CRE	R			Coefficients of the parabola for planar part of kernel integration.
38	CIM	R			Coefficients of the parabola for planar part of kernel integration.

Table 10.—(Continued)

LABELED COMMON NAME: XXZ

DESCRIPTION: Load Points and Strip Centerline

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	XOC	R	400		X location of load points.
2	XIJ	R	70		X location of leading edge at center of strip.

Table 10.—(Continued)

LABELED COMMON NAME: XYZ

DESCRIPTION: Strip Geometry Data

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	YS	R	70		Y location of strip centerline.
2	DELYS	R	70		Strip location in Y plane.
3	ZS	R	70		Z location of strip centerline.
4	DELZS	R	70		Strip width in Z plane.
5	FGAMMA	R	70		Strip dihedral angle.
6	CWIG	R	70		Average chord length of strip.

Table 10.—(Concluded)

LABELED COMMON NAME: YZY

DESCRIPTION: AIC Analysis Control Point Geometry

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	X1A	R	50		X location of 1st control point.
2	X3A	R	50		X location of 3rd control point.
3	X5A	R	50		X location of rotation axis for control surface.
4	X7A	R	50		X location of rotation axis for tab.
5	X2A	R	50		X location of 2nd control point.

Magnetic Files

L216 uses two random access files (NTP8 and NTP9) and eight sequential files (NTP1, NTP2, NTP3, NTP4, NTP7, NTP10, NTP11, and LTAPE) for temporary storage of data. The CDC random access routines READMS and WRITMS are used for NTP8 and NTP9. The sequential files are read/written with standard FORTRAN binary READ/WRITE statements.

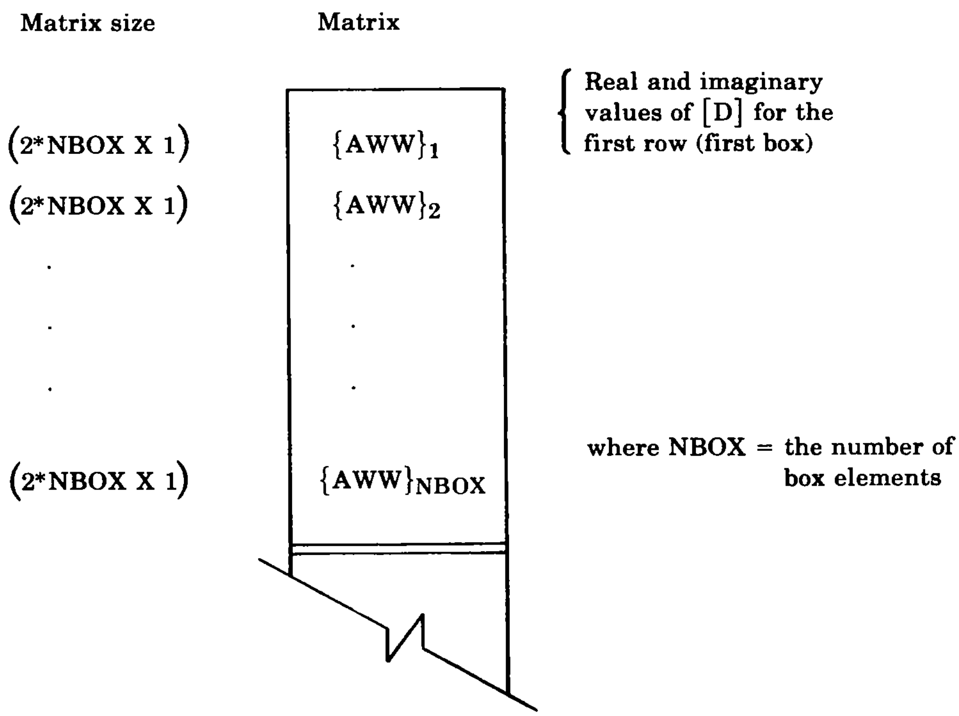
The files NTP2, NTP10, NTP11, and LTAPE are used for the out-of-core solution of the problem data in OVERLAY(L216,5,0) - AMSOL. The files are continually written, rewound, read, rewound, rewritten, etc., during the solution of the [D/W] matrix.

The file structure of the other scratch files is briefly described on the following pages.

NTP1 Scratch File

When the modal data are defined by the SA array, SAMODE temporarily stores the interpolated modal data arrays on NTP1. They are reread in the same program, SAMODE.

Usually, this file contains the downwash factors matrix [D] by rows. The matrix is formed in the program PRT2.



NTP3 Scratch File

The contents of this file are dependent upon the user options selected.

For AIC problems, NTP3 initially contains the gust modes and the downwash matrix $[W_{AIC}]$, created in GEWSSL and read by the subroutine SSL.

Matrix size	Matrix	
400 X 1	{GRHS}	Gust righthand sides
300 X 1	$\{W_{AIC}\}_2$	AIC downwash matrix (Mode 1)
300 X 1	$\{W_{AIC}\}_2$	(Mode 2)
.	.	.
.	.	.
.	.	.
300 X 1	$\{W_{AIC}\}_{NMD}$	(Mode NMD)

where NMD = no. of modes

After the AIC solution, NTP3 contains the AIC column of gammas formed by subroutine HSHDR.

Matrix size	Matrix	
(2*NBOX)X 1	$\{D^{-1}W_{AIC}\}_1$	Column 1 of gammas for AIC
	$\{D^{-1}W_{AIC}\}_2$	Column 2
.	.	.
.	.	.
.	.	.
(2*NBOX)X 1	$\{D^{-1}W_{AIC}\}_{NMD}$	

where NBOX = no. of box elements

NMD = no. of modes

For non-AIC problems, NTP3 initially contains the modified downwash column vectors created in subroutines AUGP or DWGBD and copied to NTP4 in the subroutine COMBIN.

Matrix size	Matrix	
(2*NBOX)X 1	$\{W-W_B\}_1$	Modified downwash matrix (Mode 1)
(2*NBOX)X 1	$\{W-W_B\}_2$	(Mode 2)
.	.	.
.	.	.
.	.	.
(2*NBOX)X 1	$\{W-W_B\}_{NMD}$	(Mode NMD)

where NBOX = no. of box elements

NMD = no. of modes

After the matrix solution, subroutine QUAS stores the pressure coefficients by columns for each mode.

Matrix size	Matrix	
(2*NBOX)X 1	$\{D^{-1}W\}_1$	Pressure coefficients (Mode 1)
(2*NBOX)X 1	$\{D^{-1}W\}_2$	(Mode 2)
.	.	.
.	.	.
.	.	.
(2*NBOX)X 1	$\{D^{-1}W\}_{NMD}$	(Mode NMD)

NBOX = no. of box elements

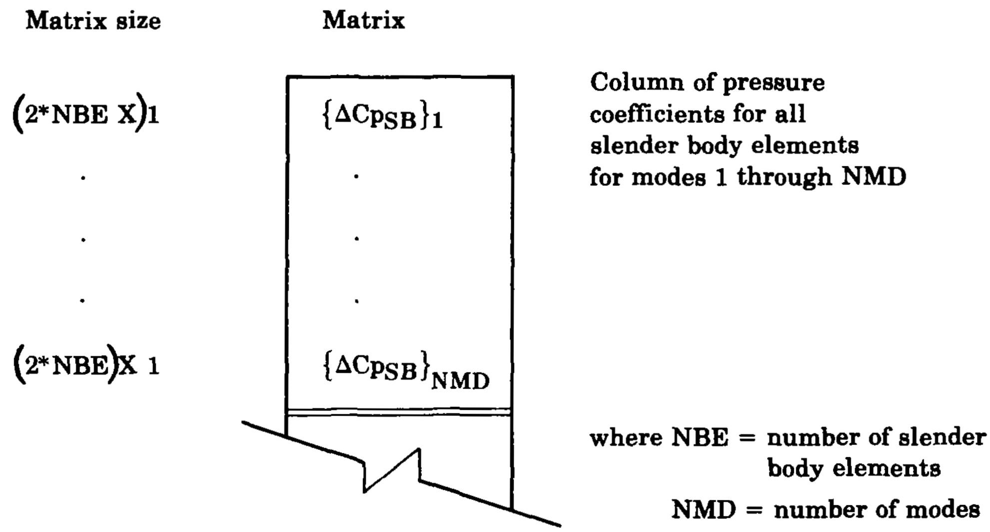
NMD = no. of modes

NTP4 Scratch File

NPT4 contains the modified downwash matrix $[W\text{-}W_B]$. The matrix is copied from NTP3 with no format changes by the subroutine COMBIN.

NTP7 Scratch File

This file contains the slender body pressure coefficients stored by the subroutine BPRNT. This file is read in the program GIN.



File Structure of NTP8

NTP8 is a random access file accessed through two index tables, IRAF8 and INDX8. The data written on this file is shown in table 11. The upper part of the figure displays the records defining polynomial modal data. The lower part displays records defining modal data input via SA arrays or tables. Table 12 displays the routines in which the data is read and written.

File Structure of NTP9

NTP9 is a random access file using two index tables, IRAF9 and INDX9. The contents of file NTP9 is shown in table 13. Table 14 displays the routines in which the data is read and written.

Table 11.— Contents of the File NTP8

Array Size	Indices in table IRAF8	Indices in table INDX8	ARRAY CONTENTS
1000	1		Polynomial Modal data for Panels
1000	2		Polynomial Modal data for Bodies
950	3		AIC Modal Data
420	11		Common Block /XYZ/
240	12		Common Block /BODY/
470	13		Common Block /XXZ/
3270	14		Common Block /GEBW/
2400	15		Common Block /PT1Q/
250	16		Common Block /YZY/
140	17		Common Block /PRTNQ/
1200		1	Displacements and Slopes for Mode 1
1200		2	Displacements and Slopes for Mode 2
		•	•
		•	•
		•	•
1200		NMD	Displacements and Slopes for Mode NMD
NMD+1	1		INDX8 table for Tabulated Mode Solution

Table 11.—(Concluded)

Array Size	Indices in table IRAF8	Indices in table INDX8	ARRAY CONTENTS
1600		1	AIC Super columns for Strip 1
1600		2	AIC Super columns for Strip 2
		•	•
		•	•
		•	•
1600		NSTRIP	AIC Super columns for strip NSTRIP
NSTRIP+1	5		Random Index Table INDX8
144	4		Static Stability Derivatives

Table 12.— Read/Write Activity on the File NTP8

Routine Performing Read/Write	Index Table	Record Number	R=Read W=Write
OVERLAY (L216,1,0)			
INITIAL	IRAF8	11	W
		12	W
		13	W
		14	W
		15	W
		16	W
GEB	IRAF8	3	W
POLYB	IRAF8	1	W
		2	W
REDB	IRAF8	1	W
	INDX8	1	W
		2	W
		⋮	⋮
		NMD	W
OVERLAY (L216,2,0)			
PRT2	IRAF8	14	R
		15	R

Table 12.—(Continued)

Routine Performing Read/Write	Index Table	Record Number	R=Read W=Write
OVERLAY (L216, 3, 0)			
GEWSSL	IRAF8	3	R
OVERLAY (L216, 4, 0)			
GEQ	IRAF8	12	R
		14	R
PWGBD	IRAF8	1	R
AUGP	IRAF8	2	R
DWGBD	IRAF8	1	R
	INDX8	1	R
		⋮	⋮
		NMD	R
OVERLAY (L216, 6, 0)			
AICSUB	IRAF8	11	R
		13	R
		16	R
AI	IRAF8	3	R
		5	W
	INDX8	1	W
		2	W
		⋮	⋮
		NSTRIP	W

Table 12.—(Concluded)

Routine Performing Read/Write	Index Table	Record Number	R=Read W=Write
AER	IRAF8	3	R
		4	W
		5	R
	INDX8	1	R
		2	R
		⋮	⋮
		NSTRIP	R
OVERLAY(L216,7,0)			
GIN	IRAF8	11	R
		12	R
		13	R
		14	R

where NMD = no. of nodes

NSTRIP = no. of strips

Table 13.—Contents of the File NTP9

Array Size	Indices in table IRAF9	Indices in table INDX9	Array Contents
			<u>AIC Solution</u>
NSTRIP+1	1		INDX9 Table
300		1	Integration Matrix Strip 1
300		2	Integration Matrix Strip 2
⋮		⋮	⋮
300		NSTRIP	Integration Matrix NSTRIP
			<u>Polynomial or Tabular Solution</u>
NMD+1	1		INDX9 Table
NTOT		1	Integration Matrix Model 1
NTOT		2	Integration Matrix Model 2
⋮		⋮	⋮
NTOT		NMD	Integration Matrix Model NMD

where NSTRIP = number of panel strips

NMD = number of modes

NTOT = number of boxes and body elements

Table 14.—Read/Write Activity on the File NTP9

Routine Performing Read/Write	Index Table	Record Number	R=Read W=Write
OVERLAY(L216, 1,0)			
GEB	INDX9	1	W
		2	W
		⋮	⋮
		NSTRIP	W
	IRAF9	1	W
POLYB	INDX9	1	R
		2	R
		⋮	⋮
		NMD	R
	IRAF9	1	W
REDB	INDX9	1	W
or		2	W
OVERLAY(L216,8,0)		⋮	⋮
SAMODE			
		NMD	W
	IRAF9	1	W

Table 14.—(Concluded)

Routine Performing Read/Write	Index Table	Record Number	R=Read W=Write
OVERLAY(L216,6,0)	IRAF9	1	R
AI	INDX9	1	R
		2	R
		⋮	⋮
		NSTRIP	R
OVERLAY(L216,7,0)			
GIN	IRAF9	1	R
	INDX9	1	R
		2	R
		⋮	⋮
		NMD	R

4.0 EXTENT OF CHECKOUT

Brief descriptions of the test cases and the program options tested are listed below. The modal data for all test cases, except case 7, consists of two rigid body modes, pitching and plunging.

Case 1: Original program H7WC sample problem consists of an aircraft fuselage as slender body, wing, and tail as lifting surfaces. Motion occurs in the Z direction only and is symmetric.

Case 2: Two wing panels with Y symmetry and Z antisymmetry. Two reduced frequencies of 0.0 and 3.0 and Mach number of 0.130 are specified.

Case 3: Two wing panels, a closed body with Z doublets. Two reduced frequencies of 0.0 and 0.150 and Mach number of 0.130 are specified.

Case 4: Fuselage, a nacelle, two wing panels, and a strut. Nacelle has Y and Z motions. Mach number is 0.85 and the reduced frequency is 0.50.

Case 5: Two panel wings with AIC's computed. Gust is also defined.

Case 6: Two panel wings with tabular modal data. Same as test case 2.

Case 7: Fuselage slender body with wing, horizontal tail, and vertical tail, as lifting surfaces. Motion occurs in the Y direction only, and is antisymmetric. The three modes are side translation, pitch, and yaw.

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May 1977

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Topical Report

16. Abstract

This document contains a description of the information necessary for execution of the digital computer program L216 on the CDC 6600. L216 characteristics based on the doublet lattice method.

Arbitrary aerodynamic configurations may be represented with combinations of nonplanar lifting surfaces composed of finite constant pressure panel elements, and axially symmetric slender bodies composed of constant pressure line elements.

Program input consists of configuration geometry, aerodynamic parameters, and modal data; output includes element geometry, pressure difference distributions, integrated aerodynamic coefficients, stability derivatives, generalized aerodynamic forces, and aerodynamic influence coefficient matrices. Optionally, modal data may be input on magnetic file (tape or disk), and certain geometric and aerodynamic output may be saved for subsequent use.

Documentation consists of two parts: *Volume I, Engineering and Usage; Volume II Supplemental System Design and Maintenance.*

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