N-TM-80040

NASA Technical Memorandum 80040

NASA-TM-80040 19810018577

A DIGITAL PROGRAM FOR CALCULATING THE INTERACTION BETWEEN FLEXIBLE STRUCTURES, UNSTEADY AERODYNAMICS AND ACTIVE CONTROLS

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January 1979

NASA
National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia 23665

1 Report No NASA TM-80040	2 Government Accession No	3 Recipient's Catalog No
4 Title and Subtitle A DIGITAL PROGRAM FOR CALCULATING THE INTERACTION BETWEEN FLEXIBLE STRUCTURES, UNSTEADY AERODYNAMICS AND ACTIVE CONTROLS		5 Report Date January 1979
		6 Performing Organization Code
7 Author(s) Ellwood L. Peele and William M. Adams, Jr.		8 Performing Organization Report No
		10 Work Unit No 505-07-33-04
9 Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665		11 Contract or Grant No
		13 Type of Report and Period Covered Technical Memorandum
12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		14 Sponsoring Agency Code

15 Supplementary Notes

16 Abstract

A computer program, ISAC, is described which calculates the stability and response of a flexible airplane equipped with active controls. The equations of motion relative to a fixed inertial coordinate system are formulated in terms of the airplane's rigid body motion and its unrestrained normal vibration modes. Unsteady aerodynamic forces are derived from a doublet lattice lifting surface theory. The theoretical basis for the program is briefly explained together with a description of input data and output results.

17 Key Words (Suggested by Author(s)) Active controls, aeroelasticity, and aerostructural feedback	18 Distribution Statement FEDD DISTRIBUTION

19 Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22 Price*
Unclassified	Unclassified	56	$4.50

Available. NASA's Industrial Applications Centers

N79-74037#

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INTRODUCTORY REMARKS

Active controls technology, (ACT), applied to airplanes involves the interaction between a flexible structure, the aerodynamic forces acting thereon, and automatically controlled aerodynamic surfaces. The aerodynamic surfaces are designed to alter the amplitude, phase and/or spatial distribution of these forces. The objectives are to achieve satisfactory rigid body and aeroelastic behavior using control surfaces in place of added structural material or less efficient planform geometry. There are five major applications of ACT ; augmented rigid body stability, augmented flexible body stability, reduction of rigid body gust response, reduction of structural loads due to gust, and the reduction of wing loads due to maneuvers. All of these tasks require the control of one or more aerodynamic surfaces responding to a combination of one or more rigid or flexible airframe responses or gust inputs.

To facilitate the design and analysis of the automatic control systems, it is necessary to have the capability to describe numerically the interaction between structural, aerodynamic, and control forces. This interaction is described in terms of response and stability characteristics. This capability, in the form of a computer program system, has been assembled and packaged and is identified by the acronym ISAC, i.e. Interaction of Structures, Aerodynamics and Controls. The system is in reality an assembly of several programs tied together through a common data base.

The following discussion is intended to explain the overall analysis capability of ISAC to a prospective user. The various mathematical, aerodynamic, structural, and control system theories underlying the program are given definitive treatment in the references. A brief statement of the related equations together with limitations on their applicability is given herein.

ACKNOWLEDGEMENTS

ISAC is a result of the joint efforts of the authors (Langley Research Center staff members assigned to the Active Control Project Office, ACPO) and Sherwood Tiffany and Jerry R. Newsom (employees of the Vought Corporation assigned to provide the ACPO with nonpersonal engineering services through contract NAS1-13500). The authors defined the overall objectives of ISAC and

developed certain engineering aspects while Jerry Newsom developed other engineering approaches and program capability. Sherwood Tiffany was primarily responsible for transforming the basic mathematical operations into a well structured, flexible, efficient digital program.

SYMBOLS

$A(s)$	coefficient of equations of motion which represent airframe motion
$A_o, A_1, \ldots A_n$	undetermined coefficients of polynomial, equation 15
$B(s)$	coefficient of excitation
b_i	coefficients of equation 15
$\bar{c}$	reference chord length
$[D]$	downwash, pressure differential influence matrix
D_{ij}	elements of D matrix
e	exponential number
$F^{-1}[f(\omega)]$	Fourier transform of $f(\omega)$
H_A	servo transfer function
$H_{\delta\delta}$	surface servo transfer function
$H_{\xi\delta}$	servo-main structure transfer function
$H(i\omega)$	frequency response function
h_a, h_s	deflection of aerodynamic and structural elements
i	$\sqrt{-1}$
K	Kernel function
k	reduced frequency, $\bar{c}\omega/2U$
M	Mach number
$M_{\xi\zeta}$, $M_{\xi\delta}$, etc.	generalized mass matrices

N_o	number of zero crossings
n_b	number of b coefficients
p	reduced Laplace variable $\bar{c}s/2U$
Q^M, Q^G	matrix of generalized aerodynamic forces due to airplane motion and gust input
q_∞	dynamic pressure, $1/2\ \rho U^2$
S_i	ith modal displacement stress coefficients
s	Laplace variable
T	geometric transformation matrix
$T_\xi(s)$	transfer function relating airplane motion to control surface actuator valve input
U	true airspeed
u	excitation matrix
w(x, y, z)	downwash due to airplane motion
W_G	downwash due to gust
X	generalized coordinate matrix
x_i	servo input command
x_c	command to actuator valve
x, y, z	Cartesian coordinates
η, ξ, δ	integration variable in equation 2
$\Delta P(x, y, z)$	pressure differential distribution
δ	control surface rotation generalized coordinate
γ	real part of Laplace variable
ω	circular frequency
ω_δ	natural frequency of surface

ω_ξ	natural frequency of structure
ξ	airplane motion generalized coordinate
σ	RMS value, defined by equation 11
$\phi(x, y)$	shape functions from vibration analysis
Φ_u	input power spectrum

THEORETICAL BASIS

In ISAC, the airplane is described in terms of a finite number of an infinite set of modes which represent the continuous structural/aerodynamic system. The equations of motion in terms of generalized coordinates, generalized masses, springs, dampers and aerodynamic forces are essentially the same as those developed and discussed in reference 1. The control systems are treated as additional degrees of freedom. Control surface deflections are related to sensor inputs through transfer functions.

Aerostructural Interface

An analysis proceeds from modal characteristics obtained separately by any suitable vibration analysis program such as that contained in Nastran, reference 2, to the aero/structure interface program DLIN. In essense DLIN finds a transformation, [T], utilizing the surface spline interpolation technique, reference 3, between deflections at structural nodes and deflections and slopes on aerodynamic boxes.

$$\begin{Bmatrix} h \\ \frac{dh}{dx} \end{Bmatrix}_a = [T] \begin{Bmatrix} h \end{Bmatrix}_s \qquad (1)$$

Once available, the aerodynamic deflections and slopes are used in the computation of aerodynamic pressures.

Generalized Aerodynamic Forces

An unsteady aerodynamic lifting surface theory known as the Doublet Lattice method, reference (4), is used to compute the generalized aerodynamic forces and is contained in program DLAT. The downwash (velocity of air particles normal to surface), at chosen reference points over the surface is equated to the surface integral of the differential pressure and an appropriate Kernel function is used to form the equation:

$$\left\{ w(x, y, z) \right\} = [D] \left\{ \Delta P(x, y, z) \right\} \tag{2}$$

where the elements of D are:

$$D_{ij} = \iint K(x-\xi, y-\eta, z-\delta, \omega, M) \, d\xi d\eta$$

and the downwash in terms of sinsuoidal surface deflections is:

$$\left\{ w \right\} = U \left\{ \frac{dh_a}{dx} \right\} + i\omega \left\{ h_a \right\}$$

The downwash arrays are computed internally in DLAT from the deflection h_a and slope $\frac{dh_a}{dx}$ arrays supplied by DLIN. Generalized aerodynamic forces matrices

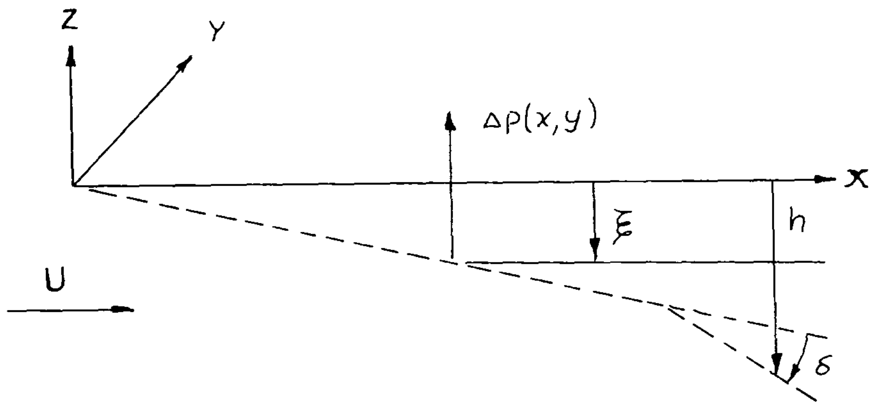
$$[Q(k, M)] = [\phi]^T [\Delta P(k, M)] \tag{3}$$

are generated by DLAT for use in the equations of motion described in the following section. The program DLAT contained herein is based on the program described in reference 4, except that programing modifications such as those described in reference 5 have been made. These modifications take full advantage of the particular NOS operating system currently in use at LaRC to increase program efficiency from the standpoint of core/time usage.

Equations of Motion

The equations of motion employed to describe the vehicle are, as previously stated, similiar to those developed for small perturbation aeroelastic analyses in reference 1. The reference axes shown in the sketch below

Reference Axes $h(x, y, t) = \sum \phi_\xi(x, y)\xi(t) + \sum \phi_\delta(x, y)\delta(t)$



are space fixed inertial and it is assumed that airplane motion relative to these axes is small so that the inertia tensor used to describe the system kinetic energy is unaltered. For clarity, the generalized coordinate matrix is partitioned into primary structure coordinates ξ, and control surface rotation coordinates δ; and, in like manner the equations are separated into generalized forces in the primary structure modes lift and moment etc. and generalized control surface hinge moments. If it is assumed that the Laplace transform of the generalized aerodynamic forces, Q, exists, the equations of motion, without an automatic control system, are:

$$\left[M_{\xi\xi}s^2 + (1 + iG)M_{\xi\xi}\omega_\xi^2 + q_\infty Q^M_{\xi\xi}\right]\xi + \left[M_{\xi\delta}s^2 + q_\infty Q^M_{\xi\delta}\right]\delta = q_\infty Q^G_\xi W_G + H_{\xi\delta}x_i \qquad (4)$$

$$\left[M_{\delta\xi}s^2 + q_\infty Q^M_{\delta\xi}\right]\xi + \left[M_{\delta\delta}s^2 + (1 + iG)M_{\delta\delta}\omega^2_\delta + q_\infty Q^M_{\delta\delta}\right]\delta = q_\infty Q^G_\delta W_G + H_{\delta\delta}x_i \qquad (5)$$

The aerodynamic terms, Q^G on the right side of equation (4) and (5) represent gust inputs. The control surface hinge moments included on the right side of equation (5) result from an input command, x_i, to a hydraulic servo and a flexible surface, represented by the generalized force $H_{\delta\delta}$. The generalized servo force acting on the structure is represented by the transfer function $H_{\xi\delta}$. If a signal proportional to the primary structural motion ξ_i and its derivatives is fed back to the servo as shown in the block diagram, figure 1, the servo input then consists of the sum of the feedback and a pilot command input

$$x_i = x_c - x_\xi \qquad (6)$$

where $\quad x_\xi = T_{AF} T_{FZ} \phi \xi = T_\xi \xi$

The matrices T_{AF}, T_{FZ} and ϕ represent sensor output to actuator input, sensor dynamics tranfer function and modal displacements and slopes respectively. When equation 6 is combined with equation 5 we get:

$$\left[M_{\delta\xi} s^2 + q_\infty Q^M_{\delta\xi} + H_{\delta\delta} T_\xi\right]\xi + \left[M_{\delta\delta} s^2 + (1 + iG) M_{\delta\delta}\omega_\delta{}^2 + q_\infty Q^M_{\delta\delta}\right]\delta$$

$$= q_\infty Q^G_\delta W_G + H_{\delta\delta} x_c \qquad (5a)$$

Equation (5a) can be simplified by assuming an infinitely rigid surface and an irreversible servo. The generalized hinge moment becomes H_A (surface rigid) and equation 5a becomes:

$$\left[H_A\right] T_\xi \xi + \left[\diagdown I \diagdown\right]\delta = \left[H_A\right] x_c \qquad (5b)$$

The substitution of equation (5b) into equation (4) yields:

$$\left\{M_{\xi\xi} s^2 + (1 + iG) M_{\xi\xi}\omega_\xi^2 + q_\infty Q^M_{\xi\xi} - \left(M_{\xi\delta} s^2 + q_\infty Q^M_{\xi\delta}\right)\left[H_{\xi\delta} H_A\right] T_\xi\right\}\xi$$

$$= q_\infty Q^G_\xi W_G - \left(M_{\xi\delta} s^2 + q_\infty Q^M_{\xi\delta}\right)\left[H_{\xi\delta} H_A\right] x_c \qquad (7)$$

Equation 4 with 5a or 7 is used to describe the motion of the aircraft and the control system and can be written more concisely as follows:

$$A(s)\,\overline{X} = B(s)\overline{u} \qquad (8)$$

where $A(s)$ is the left hand side of either equations 4 and 5a or 7, i.e. a matrix of the coefficients of ξ and δ which now are denoted $\overline{X}$, and $B(s)$ is the matrix of the coefficients of the right hand side of 4 and 5a or 7, and $\overline{u}$ contains W_G and x_c.

Equation 8 is essentially a set of simultaneous nonhomogeneous linear equations. The coefficients $A(s)$ and $B(s)$ consist of either rational polynomials of s of first or higher order or tabular functions of reduced frequency k and Mach number M. In either case, the primary tasks are to solve equation (8) for the generalized coordinates and to determine system stability. Whenever the closed form Laplace transform exists, standard procedures are available for solving for the transfer functions

$$\overline{X} = A(s)^{-1} B(s)\overline{u} \tag{9}$$

and then obtaining the inverse $X(t)$, and for determining the system stability from the roots of the characteristic equation $|A(s)|=0$. ISAC is designed to treat equation (8) both when the coefficients $A(s)$ and $B(s)$ are tabular functions of $s=i\omega$ or when they are functions of complex s.

In the former case, solutions are obtained for $\overline{X}$ after first obtaining the frequency response functions

$$H(i\omega) = \frac{X(i\omega)}{u_j(i\omega)} = A(i\omega)^{-1} B(i\omega) \tag{10}$$

Solutions found this way are valid only for stable systems (a result of the definition of the frequency response function), consequently it is essential to ascertain stability. Two methods of accomplishing this will be discussed later.

If the forcing function, $\overline{u}$, of equation (8) above is a nondeterministic, but Gaussian, random process, then two quantities, σ (the RMS value) and N_o (the average number of positive going zero crossings), suffice to describe the response of the generalized coordinates to this excitation. These quantities are found from the equations

$$\sigma_\xi = \left[\int_0^\infty |H(i\omega)|^2 \Phi_{u_j}(\omega)d\omega\right]^{\frac{1}{2}} \tag{11}$$

$$N_{o_\xi} = \frac{1}{2\pi\sigma_\xi}\left[\int_0^\infty \omega^2 |H(i\omega)|^2 \Phi_{u_j}(\omega)d\omega\right]^{\frac{1}{2}} \tag{12}$$

where $\Phi_u(\omega)$ is the power spectrum of the excitation u_j. It is further assumed that gust inputs (atmospheric turbulence) can be represented by a one dimensional point spectrum and that all u_j are uncorrelated. On the other hand if the forcing function is deterministic, for example, a discrete gust or a step control input, a time history solution for $\overline{X}$ is given by the inverse

Fourier transform,

$$X(t) = F^{-1}[H(i\omega)u(i\omega)] \tag{13}$$

This computation is done in ISAC using Fast Fourier Transform techniques. Solutions for response quantities which are composed of a combination of the generalized coordinates and their derivatives are similarly obtained. As an illustration, consider the structural stresses that are generated during the airplane response to gust or control surface excitation.

In ISAC, structural stresses are calculated by the modal displacement method

$$\sigma_p = \sum S_p^{(i)} X_i \tag{14}$$

where σ_p is the stress at some station p or the stress in some structural element and $S_p^{(i)}$ is the component of the stress σ_p contributed by a unit displacement in the ith generalized coordinate X_i. X_i can be taken either from equation 10 or 13 depending on whether the excitation is random or discrete. To repeat, it is necessary that the system be stable for the frequency response function to be valid. Methods employed herein for determining system stability are discussed in the next section.

As stated previously, active controls are employed for the alleviation of structural loads (stresses) which result both from atmospheric inputs (gust) and aircraft maneuvers. In ISAC, the equations of motion can describe only the small linear deviations from a rectilinear equilibrium flight path (gravity, thrust, drag forces are omitted) of an airplane compressed into essentially flat plate lifting surfaces. The stresses thus calculated are incremental loads which would have to be combined with the 1g loads for design purposes. Moreover, maneuver loads are calculated from time history response of the airplane to a pilot command. The load factor imposed is indicated by the output of a sensor located at the airplane center of gravity. The incremental structural load (for example, wing root bending moment for a given maneuver load factor) is the product of the load factor, the ratio of the structural load, and the center of gravity load factor for the given control surface input.

SYSTEM STABILITY

System characteristic roots are identified by an eigenvalue iteration scheme STABCAR, unpublished, and by a determinant search routine PROOT. PROOT, used herein for flutter analyses and root loci analyses is a digital program, presently unpublished, developed by the coauthor from the principles in reference 6. The many useful number sets obtained from the p-k solution are discussed in a later section. Both methods of finding the characteristic values yield equivalent results. Both are subject to a degree of unreliability in that convergence to desired roots is not assured. The p-k method, however, will almost always provide answers if sufficient care is taken in providing good initial guesses.

System stability can also be examined by determining the roots of the characteristic polynomial of equation (8), for which the aerodynamic forces are treated as functions of s. DLAT, the aerodynamic force generator within ISAC, provides aerodynamic forces only on the imaginary axis $s = i\omega$.

However, it is feasible using the concept of analytic continuation to provide an approximation to the aerodynamic forces for points near the imaginary axis. Theoretical descriptions of this approach are presented in reference 7. In ISAC the s-plane (actually p-plane where $p = \frac{\bar{c}s}{2U}$) approximation for the aerodynamic forces is of the form:

$$Q(p) = A_0 + A_1 p + A_2 p^2 + \sum^{n_b} \frac{A_{i+2}\, p}{(p + b_i)} \qquad (15)$$

where the real matrices $A_0, \ldots, A_{n_b+2}$ are determined by solving for the elements of these matrices that best fit, in a least squares sense, curves through

$$\left[Q(p = ik_1), Q(p = ik_2), \ldots, Q(p = ik_l)\right] \quad l \geq n_b + 2$$

The b_i are chosen to span the frequency range of interest. This form for the approximation is similar to that described in reference 7.

A capability for transforming the aerodynamics from functions of k to functions of p is included in the Dynares Program. The generalized aerodynamic forces, $Q(p)$, thus compiled are used in equation 8 in the same manner as the $Q(k)$. Specifically, values of $Q(p)$ for any arbitrary value of the argument s are found by evaluating equation 15.

PROGRAM STRUCTURE

ISAC relies heavily on the LaRC CDC computer and its particular operating system. Various programs are called and executed through NOS procedure files.

The basic structure of ISAC is shown in figure 2. The hub represents a data complex or specifically a random access file (TAPE9) from which and to which numerical data required by or generated by the various independent program modules is passed. The data complex can be accessed by the ISAC modules which read and/or store needed data. This capability allows convenient manipulation of and selection from a large amount of data. For example, the data base might contain several structural models and aerodynamic data at several Mach numbers for each of the structural models. The Dynares module can select from this data a particular structural model and a set of corresponding aerodynamics at a particular Mach number, thereby relieving the user of much of the effort of data storage and manipulation. Greater accuracy is achieved and fewer transcription errors are made in this way.

Since a portion of the Data Complex Manager (DCM) is included in each of the modules, it is possible to execute each either separately, or with appropriate job cards, in a single sequential run. Generally, seperate execution is preferred so that inspection of intermediate results can be made. Accuracy judgments should be made on the intermediate results because aeroelastic analyses still involve a certain degree of engineering judgment in choosing which structural modes to include, which interpolation method yields the best fit, and how to panel the lifting surfaces for the aerodynamic calculations.

NUMERICAL ANALYSIS

Numerical analyses are carried out in three steps, (1) description of airplane configuration, (2) instructions for solution types required and (3) specification of results to be output. The configuration description includes structural parameters, aerodynamic properties and control system definition.

The structural parameters; generalized masses, generalized stiffnesses, damping ratios and modal frequencies are obtained from independent vibration analyses. These data may be stored on (TAPE9) using the DCM or read into Dynares on (TAPE5). Dynares also has the option of computing generalized masses and stiffnesses from mode shapes and lumped mass data input through (TAPE5).

Generalized aerodynamic forces can be computed internally and stored on (TAPE9) or input directly to either (TAPE9) (DCM) or (TAPE5) (DYNARES). DLIN, executed first, is used to calculate mode shape data for the aerodynamic boxes from the flexible structural mode shapes input on (TAPE3). Wing geometry and paneling information is obtained from the same name list DLATINP (TAPE2) used by DLAT. The aerodynamic mode shapes are stored on (TAPE9) by selected DCM subroutines contained in DLIN. These data, identified as H14, H, and DH; are subsequently used in DLAT. Differential pressure distributions are calculated in DLAT for the flexible modal data either stored on (TAPE9) or read in on (TAPE5). Rigid body modes, control modes and sinusoidal gust mode shapes are generated internally. Generalized aerodynamic forces defined by equation

(3) are obtained from the pressure distributions generated for a variety of reduced frequencies and Mach numbers specified in DLATINP (TAPE2). The generalized aerodynamic forces are stored on (TAPE9) for use in Dynares whereas the pressure distribution, i.e. Aerodynamic influence coefficients, (very large arrays) may be saved on magnetic tape for other uses if desired.

After a description of the structural and aerodynamic properties are compiled, the control system elements are input to Dynares through the name lists, INPUT, CONSYM, ACTINP, FILTIN, and SENLOC. Transfer functions representing sensors and filters which possess specific frequency response characteristics may be computed internally. In addition, sensors may be moved from one location to another by setting ISENSE=1 and supplying the sensor location in SENLOC namelist.

To reiterate, the generalized aerodynamics forces are tabulated functions of Mach number and the reduced frequency k, and are based on a sinusoidal downwash. If, however, the downwash is nonsinusoidal, the aerodynamic forces are of questionable validity. To circumvent this difficulty, an approximation for $Q(s = \gamma + i\frac{2Uk}{\bar{c}})$ deemed valid for nonnegligible γ is achieved by transforming through a least squares fit the complex function $Q_{Real}(k) + iQ_{Imag}(k)$ of the real argument k to a real function of the complex argument $s = \gamma + \frac{2Uk}{\bar{c}}i$ and treating the result as if it were the Laplace transform of time dependent generalized aerodynamic forces. This transformation is accomplished in the program by setting ISPLANE=1 and supplying values for the parameters NCOEF, BN, NPOLYC, ICOF. Following transformation of the aerodynamics, all solutions follow as before except that the p-k analysis is now a p-p analysis, i.e. as far as the user is concerned, stability calculations are performed in the same manner in either case.

CONCLUDING REMARKS

The program described herein represents a research tool for the aeroelastician who must include automatic controls systems in an airplane analysis or the controls engineer who needs to include the effects of flexible structures and unsteady aerodynamics in the design of automatic control systems. The program is limited in some respects for both parties. Structural stresses are not detailed enough for structural sizing nor are the details of the control system hardware faithfully represented. Nevertheless, knowledge of the important interplay between the various parts of the total system can be provided through judicious parametric studies.

As mentioned earlier, this program is tailored to the LaRC computing system and hence may be unusable directly on other computing systems. Nevertheless, the possibility exists that someone with comparable computer facilities may find use for ISAC. Consequently, this program is documented to relieve them from duplicating the effort described herein.

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THE APPENDIX, ISAC INPUT DATA

Included in the following tables are instructions for compiling input data decks and definitions of the parameters involved. Each program is treated in the chronological order generally used. However, as previously stated, the stand alone programs can be executed consecutively in a single run. Intra program communication media are defined in Figure A1.

As presently constructed, the DLAT preprocessor, the DLIN, can accommodate noncoplanar horizontal lifting surfaces only. If vertical surfaces and bodies of revolution are to be included, the mode shape input to DLAT must be input through tapes and is not set up by DLIN.

If NB≠0, the body mode shapes must be input to DLAT directly. DLIN is not constructed to compute these data. The option for including additional modes will enable the user to input mode shape data for the body. This is accomplished in the following manner. NELAST, NR and NG are set equal to zero. Then NMD = NADD + NC and H14, H and DH are input for every box for all NADD modes. The NADD modes now will include all rigid body, elastic and gust modes. The control option, NC, will, however, still compute appropriate control surface mode shapes. The order of compiling card images input are given for each of the four ISAC programs in Table 1 through Table 4. Definitions of each of the input quantities are listed in tabular form following each deck listing.

Results of a flutter analysis using ISAC are included in the appendix, table 5 and figures A2 through A4. The sample problem is based on the jet transport characteristics given in reference 1. The analysis can be reproduced by requesting the data files from the authors.

Data Complex Manager

Table 1a

DCM - Order Of Input.-

File: INPUT

The input file consists of a string of operation codes each followed by card images consisting of data required by that operation code as follows:
Operation Codes: STORE, PRINT, WRITE, TOC, REWIND, END
If Op Code is:

a) TOC or REWIND,
   No further data required
   another OPERATION CODE.

b) STORE, then add the following:

   TYPE 1 data

   TYPE 2 data (if needed)

   TYPE 4 data

   another OPERATION CODE

c) PRINT or WRITE, then add the following:

   TYPE 1 data

   TYPE 2 data (if needed)

   TYPE 3 data (if needed)

   another OPERATION CODE

The input file is terminated when the operation code, END is encountered.

File: (TAPE5)

All formatted arrays to be stored on Data Complex in the order in which they are to be stored. This is determined by the user.

File: (TAPE7)

All binary arrays to be stored on Data Complex in the order in which they are to be stored. This also is determined by the user.

Definition Of Input.-

This program performs data management and manipulation of Data Complex for program ISAC, built-in capabilities are as follows:

1. STORE Store data into a dataset in Data Complex from another dataset or from (TAPE5), if formatted, or (TAPE7) if binary.

2. PRINT Print out a specified array from Data Complex to file OUTPUT.

3. WRITE Write out a specified array onto (TAPE6) if formatted, or (TAPE8) if binary.

4. TOC Print out Table of Contents of entire Data Complex. Or TOC N print out Table of Contents of dataset N.

5. REWIND N Rewind (TAPE N).

The array input and output can be either formatted or binary. If formatted, the format must also be specified on file INPUT.

STORE, PRINT, and WRITE, Operations require additional input - as follows

(TOC and REWIND do not):

Type 1: CODENAME, INPUT PARAM, OUTPUT PARAM, NWORDS, NRECORDS
.
.
.
END

Type 2: Format for reading from (TAPE5) if needed.
Type 3: Format for output-PRINT or WRITE - if needed.
Type 4. Header for storing - if needed.

Definitions:

CODENAME Code name of array to be processed as follows:

GMASS	(Generalized Masses)
FREQ	(Natural Frequencies)
AERO	(Red. Freq + Aero Table)
SPLANE	(S-Plane Coefficients)
LOADS	(Loads-Shear, Moment, Torque)
SENDEF	(Sensor Deflections)
DAMPINGS	(Structural Dampings)
DISP	(Modal Displacements)
MODES	(Selected Mode Shapes)
HHD	(H14, H34, DH1 Arrays)
SPLINE	(SPLINE COEEFICIENTS)
AIC	(AIC MATRIX)

INPUT PARAM A number indicating from where and how array is to be obtained.

=N>0 Read from data-set N.
=-1 Read from (TAPE5) in formatted form.
=-2 Read from (TAPE5) in binary form.

OUTPUT PARAM A number indicating where and how array is to be output.

=N>0 Store on data-set N.
=-1 Output (PRINT, WRITE, or PUNCH) in formatted form.

=-2 Output (PRINT, WRITE, or PUNCH) in binary form.

NWORDS Number of words in one record of array to be processed (input only if array is not already on Data Complex)

NRECORDS Number of records used to comprise entire array (input only if array is not already on Data Complex)

DCM-Sample Problem.-

Suppose it is desired to determine the contents of a dataset N of a data file XXX, then modify a portion of the set N update XXX and finally check the content. The following control deck and input file would be used.

```
JOB ...
USER ...
CHARGE ...
MAP, OFF.
GET,DCM/UN=887010C.
DCM.
EDIT,(TAPE6).
RENAME,(TAPE5)=(TAPE6).
DCM
REPLACE,(TAPE9)=XXX.
7/8/9
TOC
WRITE
GMASS    N   -1
END
(4E15.7)
END
7/8/9
...EDIT COMMANDS...
7/8/9
STORE
GMASS   -1    N
END
(4E15.7)
MODIFIED MASSES
TOC N
END
6/7/8/9
```

Aerostructural Interface

Table 2a

DLIN - Order Of Input.-

File: TAPE3

	Description	Format	Starting Column
Data 1	HEADER	8A10	Column 1
Data 2	NVIB	Free field	Column 1
Data 3	DLINPT Namelist	Name list	
Data 4	MODEPLT, Namelists (REPEAT FOR EACH SET OF MODE SHAPES)		
Data 5	DCM input-output parameters	Free field	Column 1
Data 6	I=1, NSECTNS		
(NSECTNS CARDS)	ISS(1,I),ISS(2,I),IPLATE(I), XO(I),YO(I),RO(I)	Free field	Column 1
Data 7	I=1, NSECTNA		
(NSECTNA CARDS)	IAS(1,I),IAS(2,I),NSS(I),ID(I)	Free field	Column 1
Data 8	I=1,NNODES		
(NNODES CARDS)	TAB(I,1),TAB(I,2),NØDE(I), IDF(1,I),IDF(2,I)	Free field	Column 1

File: TAPE1

Data 1

IM=1,NELAST
SKIP NSKIPL (Lines if formatted, records if binary)
I=1,NNODET
READ(DEFL(1,J),J=1,NDF) if formatted (18X,3E18.6/18X,3E18.6)

This is unnecessary if these deflections have previously been put into the Data-Complex (TAPE9) under the Codename - DISP.

File: TAPE5

All TAPE5 data for DLAT must also be input to DLIN. (See input for DLAT).

Table 2b

Definitions of DLIN input data

FILE: TAPE3.-

Data 1

HEADER - any user message

Data 2

NVIB - the NVIB parameter tells the program how the deflection data are coded on TAPE1.

If NVIB=NASTRAN, the program defaults NSKIPL=7 and reads in the deflection data according to the format (18x,3E18.6/18x,3E18.6)

If NVIB=SPAR, the program defaults NSKIPL=0 and reads in the deflection data as an unformatted binary form.

If NSKIPL is specified in DLINPT, that value will overide the above program defaults. Be careful to maintain consistency.

If NVIB is anything other than NASTRAN or SPAR, NSKIPL will be the value specified in DLINPT and the read format must be given. For example, two cards are required for NVIB:

ANYTHING	Card 1
(2E15.6)	Card 2

DATA 3, DEFINITIONS FOR NAMELIST /DLINPT/

```
  NAMELIST /DLINPT/ NSKIPL,NSECTINS,NSECTNA,NDF,NNODES,NNODET
 C          ,ISYM,MODE,NPMX,IPLTBOX,SCX,IPLTNOD,IPRINT,IPLIMS
 C          ,INTER,IDCM,ITOC,IBAUD
```

NSKIPL	NO. OF LINES (OR RECORDS) TO BE SKIPPED AT BEGINNING OF EACH MODAL SET OF INPUT DATA ON TAPE1. (DEFAULT FOR SPAR = 0, FOR NASTRAN = 7)
NSECTNS	NUMBER OF STRUCTURAL SECTIONS
NSECTNA	NUMBER OF AERODYNAMIC SECTIONS (OR PANELS)
NDF	NUMBER OF DEGREES OF FREEDOM OBTAINED FROM VIBRATION PROGRAM
NNODES	NUMBER OF NODES TO BE SELECTED FROM TOTAL OBTAINED FROM VIBRATION PROGRAM
NNODET	TOTAL NUMBER OF NODES OBTAINED IN VIBRATION PROGRAM
ISYM	MODE SHAPE SYMMETRY CODE FOR SPLINE COEFFICIENTS (IF 0, UNSYMMETRIC, IF 1, SYMMETRIC, IF -1, ASYMMETRIC)
MODE(I)=1	INDICATES THAT THAT MODE WILL BE SELECTED FROM IN DOING NODAL SELECTIONS IN OVERLAY(2,0)-NODESEL (DEFAULT = 1)
NPMX	MAXIMUM NUMBER OF NODES IN ANY ONE STRUCTURAL SECTION
IPLTBOX=1	PLOT AERODYNAMIC BOX LAYOUT
=0	DO NOT PLOT BOX LAYOUT
SCX	SCALE FACTOR FOR X-VALUES IN BOX LAYOUT =XMAX/FSX, WHERE XMAX IS AN APPROXIMATE MAXIMUM X VALUE AND FSX IS THE FRAME SIZE IN THE X DIRECTION.
SCY	SCALE FACTOR FOR Y-VALUES IN BOX LAYOUT =YMAX/FSY
NOTE:	IN ORDER TO HAVE NO DISTORTION DUE TO DIFFERENT SCALE FACTORS FOR X AND Y, SET SCX=SCY= MAX(XMAX/FSX,YMAX/FSY) (DEFAULT VALUES FOR SCX AND SCY=INT(MAX(X,Y)/10.)
IPLTNOD=1	PLOT STRUCTURAL NODE POINTS WILL BE PUT ON BOX LAYOUT IF IPLTBOX=1,OR PLOTTED ALONE IF IPLTBOX =0. SCX AND SCY WILL STILL USED.
IPRINT=0	PRINT ORIGINAL MODE SHAPES ON FILE OUTPUT (DEFAULT)
=1	PRINT ORIGINAL MODE SHAPES ON FILE TAPE6.
IPLTMS=0	MODAL DATA WILL BE COMPUTED FOR AERO. BOXES (DEFAULT)
=1	MODAL DATA FOR AERO. BOXES IS COMPUTED; AND MODAL DATA FOR PLOT POINTS IS COMPUTED AND PLOTTED.
=-1	COMPUTES AND PLOTS MODAL DATA FOR PLOT POINTS USING SELECTED DATA FROM TAPE9 (DATA COMPLEX) IF AVAILABLE FROM A PREVIOUS RUN.

```
INTER  =0     BATCH TYPE RUN. ADDITIONAL MODEPLT DATA
              READ IN FROM TAPE3.
              (DEFAULT)
       =1     INTERACTIVE TYPE RUN, ADDITIONAL MODEPLT DATA
              READ IN FROM FILE INPUT.
IDCM   =1     ALLOWS USER TO ACCESS DATA-COMPLEX
ITOC   =1     PRINT TABLE OF CONTENTS FOR DATA-COMPLEX
IBAUD         BAUD RATE (DIVIDED BY 10) TO TERMINAL WHEN TEKTRONIX
              PLOT ROUTINES ARE BEING USED
END  NAMELIST  DLINPT
```

DATA 4, DEFINITIONS OF VARIABLES IN NAMELIST/ MODEPLT/
(IF IPLTMS = +1 OR -1, MODEPLT NAMELISTS MUST BE SUPPLIED.
REPEAT FOR EACH SET OF MODESHAPE PLOTS.)

```
   NAMELIST /MODEPLT/ NSURF,XLE,YLE,NLEP,XTE,NTRP,NSPN
  C         ,NCHD,NSSP,SCXMS,SCYMS,SCZMS,SCZDEF,XV,YV,ZV
  C         ,ALPHA,BETA,XTRANS,NE,MODEMS,XOR,IPLAN,IBOTH
  C         ,INODELN,ISTOP
```

NSURF	NUMBER OF SURFACES TO BE PLOTTED
XLE(I,J)	X,Y - COORDS OF I"TH LEADING EDGE POINT ON J"TH SURFACE
YLE(I,J)	NEEDED TO DEFINE LEADING EDGE (OF SURFACE NUMBER J)
NLEP(J)	NUMBER OF LEADING EDGE POINTS NEEDED TO DEFINE J"TH SURFACE
XTE,YTE	DEFINED THE SAME AS ABOVE EXCEPT FOR TRAILING EDGE
NTRP(5)	NUMBER OF TRAILING EDGE POINTS NEEDED TO DEFINE J"TH SURFACE
NSPN(J)	NUMBER OF SPANWISE POINTS TO BE PLOTTED FOR J"TH SURFACE
NCHD(J)	NUMBER OF CHORDWISE PNTS TO BE PLOTTED FOR J"TH SURFACE
NSSP(J)	STRUCTURAL SECTION NUMBER WHICH CORRESPONDS TO J"TH SURFACE
SCXMS	SCALE FACTOR IN X-DIRECTION OF VIEWING IMAGE
SCYMS	SCALE FACTOR IN Y-DIRECTION OF VIEWING IMAGE
SCZMS	SCALE FACTOR IN Z-DIRECTION OF VIEWING IMAGE
SCZDEF	SCALE FACTOR FOR DEFLECTIONS, USED TO INCREASE OR DECREASE AMOUNT OF VIEWED DEFLECTION
XV,YV,ZV	COORDS OF VIEW POINT FOR PROJECTIVE PLOTS WITH RESPECT TO IMAGE SIZE.
ALPHA	ANGLE OF ROTATION ABOUT Z-AXIS OF VIEWING IMAGE
BETA	ANGLE OF ROTATION ABOUT Y-AXIS OF VIEWING IMAGE
XTRANS	AMOUNT OF X-TRANSLATION OF VIEWING IMAGE
NE	NUMBER OF TOTAL ELASTIC MODES TO BE PLOTTED

MODEMS(I)	=1	PLOT MODE SHAPE FOR ELASTIC MODE I
	=0	DO NOT PLOT MODE SHAPE FOR ELASTIC MODE I
XOR,YOR		LOCATION OF PLOT FRAME ORIGIN, USED TO SHIFT PLOTTED IMAGE IN PLOT FRAME
IPLAN	=1	PLOT UNDEFLECTED PLANFORM AND CONNECTING VECTORS TO DEFLECTED PLANFORM.
	=-1	PLOT UNDEFLECTED PLANFORM WITHOUT CONNECTING VECTORS
	=0	DO NOT PLOT PLANFORM. (DEFAULT=1)
IBOTH	=1	PLOT BOTH SIDES OF VIEWING IMAGE
	=0	DO NOT PLOT BOTH SIDES
INODELN	=1	PLOT NODE LINE ALONG WITH DEFECTED PLANFORM.
	=-1	PLOT NODE LINE ONLY.
	=0	DO NOT PLOT NODE LINE. (DEFAULT = 1)

```
ISTOP    =0   CONTINUE READING IN /MODEPLT/ NAMELISTS AND
              PLOTTING MODESHAPES
         =1   STOP READING IN /MODEPLT/ NAMELISTS.  THIS MUST
              BE SET  = 1 IN LAST /MODEPLT/ TO BE READ IN.
END NAMELIST MODEPLT
```

Data 5

DCM Input-Output Parameters are card images of the following type:

CODENAME, INP,OTP

where

CODENAME: DISP,MODES,HHD,SPLINE, or END

DISP — Modal displacements (deflections) from vibration program.

MODES — Selected MODE shapes (set up) by overlay NØDESEL.

HHD — Quarter chord deflections and slopes set up by overlay DEFLEC.

SPLINE — SPLINE COEFFICIENTS, used for interpolation, set up by overlay INTERP.

END — Ends DCM input.

INP — An INTEGER which indicates from where its corresponding array is to be obtained.

=-1 read from TAPE1 input file
= 0 not used as input to program

=n>0 read in from data-set n of Data Complex.

OTP — An INTEGER which indicates on which data-set of the Data Complex the array is to be stored.

=0 Not stored

=n>0 Stored on data-set n.

Note: For DISP, INP can be -1 or n>0
OTP can be 0 or >0

For MODES, INP = OTP = n>0

For HHD, INP = OTP = n>0

For SPLINE, if there are any PLATE type modes, then INP=OTP=n>0; otherwise INP=OTP=0.

DATA 6, STRUCTURAL MODEL DESCRIPTION

ISS(1,I)	BEGINNING NODE NUMBER OF STRUCTURAL SECTION I
ISS(2,I)	ENDING NODE NUMBER OF STRUCTURAL SECTION I
IPLATE(I)=1	INDICATES THAT STRUCTURAL SECTION I IS PLATE TYPE
IPLATE(I)=0	INDICATES THAT STRUCTURAL SECTION I IS BEAM TYPE
XO(I)	X COORD OF TRANSLATED AXIS OF SECTION I IF IPLATE(I)=1 - (XTE+XLE)/2 FOR THAT SECTION
YO(I)	Y COORD OF TRANSLATED AXIS OF SECTION I IF IPLATE(I)=1 - YROOT FOR THAT SECTION
RO(I)	ROTATION ANGLE OF ELASTIC AXIS OF SECTION I IF IPLATE(I)=1 - 1/B WHERE B=CROOT(I)/2

DATA 7, AERODYNAMIC MODEL DESCRIPTION

IAS(1,I)	BEGINNING BOX NUMBER OF I-TH SECTION
IAS(2,I)	ENDING BOX NUMBER OF I-TH SECTION
NSS(I)	STRUCTURAL SECTION NUMBER WHICH CORRESPONDS TO I-TH AERODYNAMIC SECTION
ID(I)	=XY, IF I-TH SECTION IS HORIZONTAL =XZ, IF I-TH SECTION IS VERTICAL

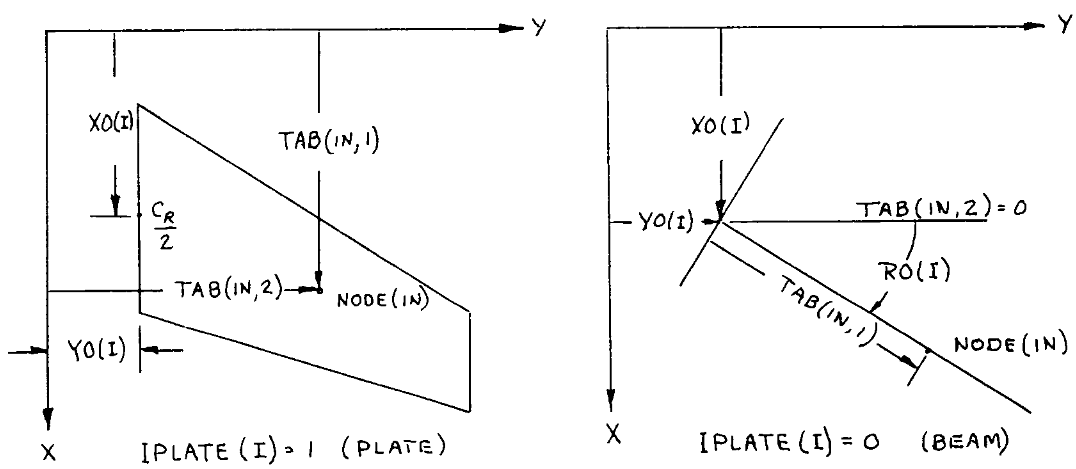
END TAPE3 DEFINITIONS

DATA 8-. Structural nodes (see Sketch A1)
TAB = COORDINATES OF NODES

NODE(IN) = NODE number to be selected

IDF(1,IN) = First Degree of Freedom to select (SEE NOTE)

IDF(2,IN)= (Optional) Second Degree of Freedom to select (SEE NOTE)



SKETCH A1 NOMENCLATURE STRUCTURAL SECTIONS

FILE: TAPE1.- Flexible mode shapes

DEFL(I,J) Is the J'th deflection for the I'th structural NODE

NOTE: THE SHAPE FUNCTIONS DEFL(I,J),OUTPUT FROM NASTRAN CONTAIN SIX DEGREES OF FREEDOM FOR EACH NODE. THE IDF PARAMETER SPECIFIES WHICH TWO OF SIX ARE TO BE USED.

DLIN - Sample Problem.- The following job illustrates how DLIN might be executed separately to store aerodynamic downwash data on TAPE9 and/or obtain a structural NODE plot.

```
DLINB, T200                              BINXX        XXXXX
USER,XXXXXXX,XXXXXXX.
CHARGE,XXXXXX,LRC.
MAP,OFF.
GET,TAPE9=BIS9.                           Omit if B1S9 has not been created
GET,TAPE1=NASBISC.
GET,TAPE3=DLIBC.
GET,TAPE5=DLABC.
ATTACH,FTNMLIB,LRCGOSF/UN=LIBRARY.
GET,ACPOLIB/UN=887010C.
GET,LGO=DLINBN/UN=887010C.
LDSET(LIB=ACPOLIB/FTNMLIB/LRCGOSF)
LGO.
PLOT.VARIAN(FSH=11.,FSV=8.5,AUTO(0))
REPLACE,TAPE9=BIS9.
DAYFILE,DLINDAY.
REPLACE,DLINDAY.
EXIT.
DAYFILE,DLINDAY.
REPLACE,DLINDAY.
END OF FILE
```

(The Data Files NASBISC, DLIBC and DLABC have been previously stored, DLIBC and DLABC could be card input, using COPYL, INPUT, XXX)

ACPOLIB is a library of data management routines and plot routines that may be required in various modules of ISAC.

Generalized Aerodynamic Forces

Table 3a

DLAT - Order Of Input.-

File: (User Supplied Name) will be accessed as TAPE5 by DLAT

	Description	Format	Starting Column
Data 1	HEADER	8A10	Column 2
Data 2	Namelist $DLATINP$	Namelist	Column 2
Data 3	DCM input-output parameters	Free field	Column 1
(Reads MODE shapes from TAPE9 if IDCM=1, or from TAPE9, Ser 1 if IDCM=0)			
Data 4	I=1, NP		
	(XCAP(J),J=1,4),(YCAP(J),J=1,2)	Free field	Column 1
	(ZCAP(J),J=1,2),NSPAN,NCHORD, COEF	Free field	Column 1
	(TH(I),I=1,NCHORD)	Free field	Column 1
	(TAU(I),I=1,NSPAN)	Free field	Column 1
Data 5 (if NB≠0)	I=1,NB		
	ZSC,YSC,NF,NZ,NY,COEFF, MRK(1),MRK(2)	Free field	Column 1
	(F(I),I=1,NF)	Free field	Column 1
	(RAD(I),I=1,NF)	Free field	Column 1
Data 6	(LIM(I,1),LIM(I,2),I=1,NSTRIP)	Free field	Column 1
(NADD additional MODE data can be read in here instead of or in addition to that on TAPE9 IF NADD = NMOORS - (NELAST + NR + NC)=0. NADD IS COMPUTED INTERNALLY.			
Data 7 (if NADD≠0)	I=1,NADD		
	(H14(J),J=1,NBOX)	(6F10.0)	Column 1
	(H(J),J=1,NBOX)	(6F10.0)	Column 1
	(DH1(J),J=1,NBOX)	(6F10.0)	Column 1
Data 8 (if NC≠0	I=1,NC		
	NBC,NCST,SWHL,ICTYPE	Free field	Column 1
	(ICBOX(IK),IK=1,NBC)	Free field	Column 1
Data 9 (if NBE≠0)	I=1, NMODES (include all MODES shapes)	REPEAT FOR EACH OF NBE BODIES	
	BQ(I),I=1,NBOXB		
	H(I),I=1,NBOXB		
	DH1(I),I=1,NBOXB		
	DH2(I),I=1,NBOXB		

Table 3b

Definitions For DLAT Input.-

Namelist - /DLATINP/FMACH,ACAP,REFCHD,NDELT,NP,NB,NRF,RFREQ,NSTRIP,NSV,NBV, NMODES,REFSPN,NBOX,NSNC,XZERO,XCG,IPRINT,NR,NELAST,NC,IDCM,ITOC, IRIG

FMACH	Mach number
ACAP	Reference area
REFCHD	Reference length K=(REFCHD*OMEGA)/(2.*U)
NDELT	Symmetry Flag (=1 Symmetric ,=-1 Antisym,=0 No-Sym)

NP	Total number of panels
NB	Total number of bodies, see text
NRF	Number of reduced frequencies
RFREQ	Array of reduced frequencies
NSTRIP	Total number of strips
NSV	Total number of strips on vertical panels on Y=0
NBV	Total number of boxes on vertical panels
NMODES	Total number of MODES (elastic+rigid+control+NADD)
NDATA	Print flag for slender body solution
REFSPN	=1.0
NBOX	Total number of boxes on lifting surface panel
NSNC	Max NSPAN*NCHORD value for any panel
XZERO	Gust reference station
XCG	Rotation point for rigid body pitch MODE
IPRINT	Print flag for BO,W and CP matrices
NR	Number of rigid body MODES
NELAST	Number of elastic MODES to be read from DATA-COMPLEX
NC	Number of control MODES shapes computed internally
IDCM	Allows user to access DATA-COMPLEX
ITOC	Print table of Contents for DATA-COMPLEX
IRIG	Array for rigid body Modes (IRIG(I),I=1,NR) (1) = Z-Displacement (PLUNGE) (2) = θ-Rotation (PITCH) (3) = Z-Velocity W (4) = Angular Velocity Q

DATA 3

DCM input-Output Parameters are card images of the following type:

CODENAME,INP,IØUT, (AICTAPE)

where

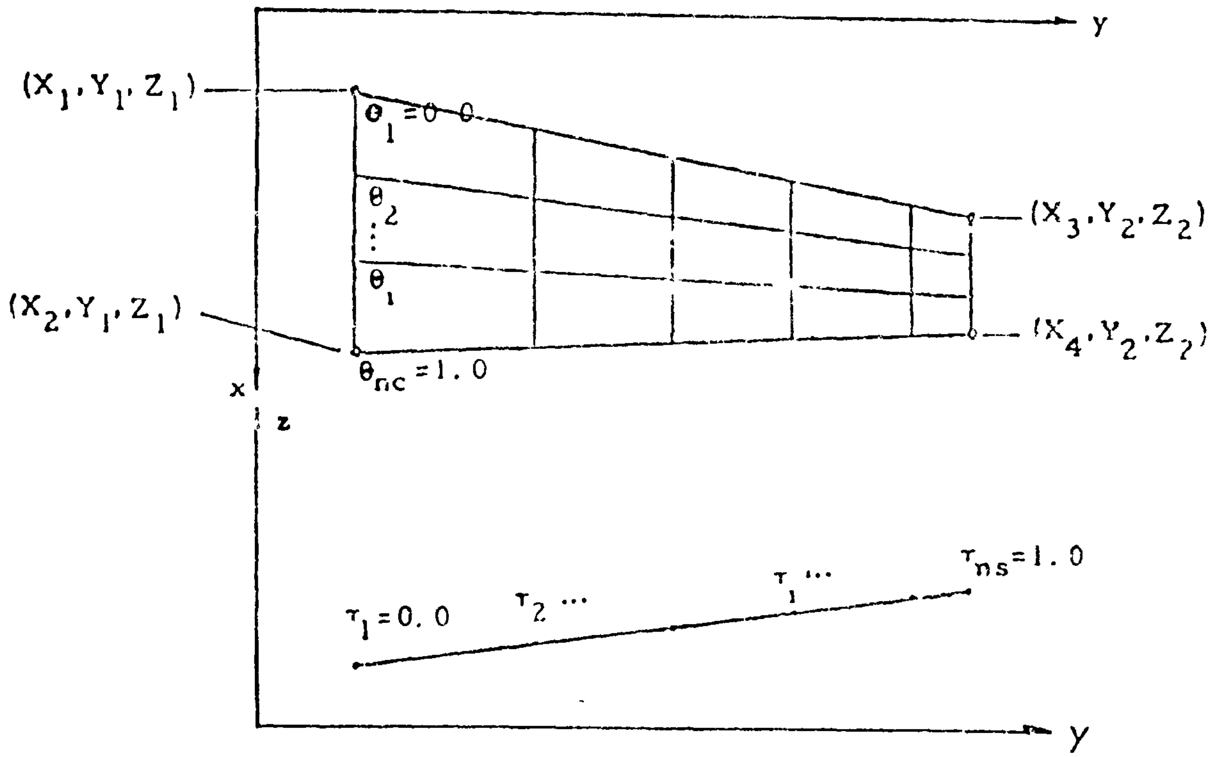
CODENAME	Is either HHD,AERØ,AIC, or END
INP=n>0	Is an integer which indicates from which data-set in Data-Complex array is to be read.
=0	Not read from Data-Complex
IOUT=n>0	Is an integer which indicates into which data-set array is to be stored.
=0	Not stored on Data-Complex.
AICTAPE	Filename of optional file to store AIC matrix on, other than TAPE 9.

NOTE: for HHD, INP=n≠0,IOUT=0
for AERO, IOUT=n≠0, INP=
for AIC, if AICTAPE is blank, and either INP or IOUT≠0, then TAPE 9 will be used for storage.

DATA 4

(XCAP(J),J=1,4)	The panel edge coordinates
(YCAP(J),J=1,2)	
(JCAP(J),J=1,2)	See Sketch 2.

XCAP(1),YCAP(1),ZCAP(1)	Inboard leading edge
XCAP(2),YCAP(1),ZCAP(1)	Inboard trailing edge
XCAP(3),YCAP(2),ZCAP(2)	Outboard leading edge



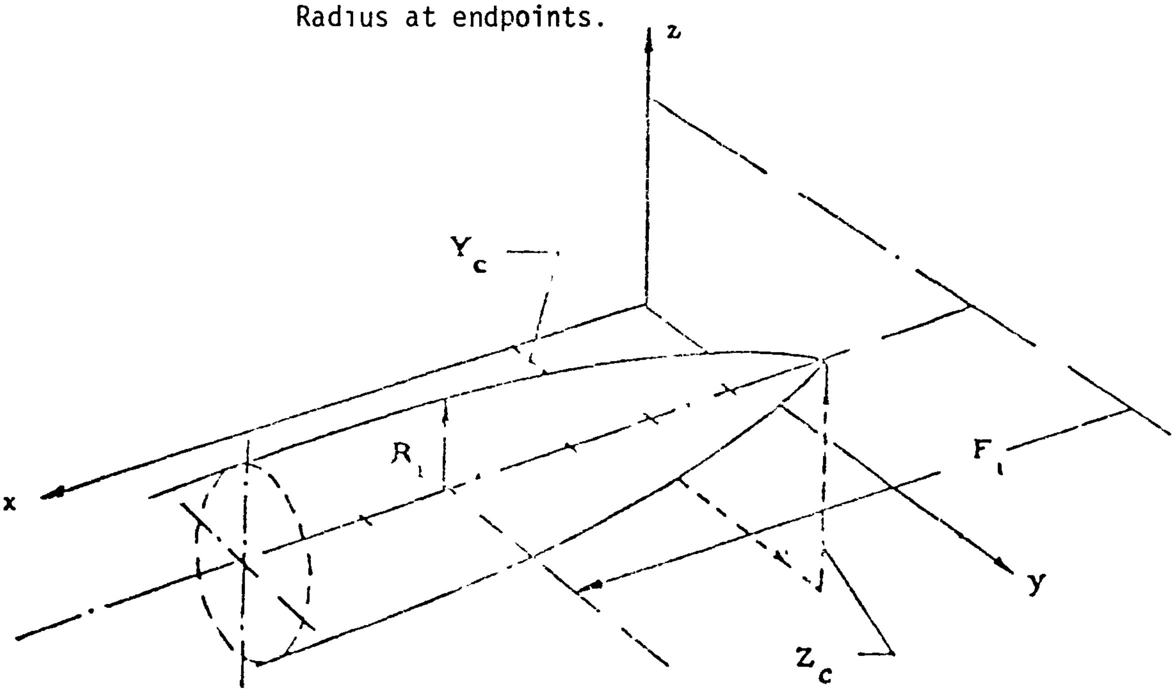
SKETCH A2. AERODYNAMIC PANEL GEOMETRY

θ	corresponds to TH input data, Chord Ratio
τ	corresponds to TAU input data, Span Ratio
(x,y,z)	corresponds to (XCAP,YCAP,ZCAP) input data.

NSPAN	Number of spanwise divisions for panel considered.
NCHORD	Number of chordwise divisions for panel considered.
COEF	Scale factor for panel deflection modes. If no scale factor is desired, must be set to 1.0.
THETA	Chordwise divisions in fraction of chord. Usually varies from 0.0 at leading edge to 1.0 at trailing edge.
TAU	Spanwise divisions in fraction of panel span. Usually 0.0 at inboard chord and 1.0 at outboard chord.

DATA 5

ZSC-Z_c	Z-coordinate of body-axis.
YSC-Y_c	Y-coordinate of body axis.
NF	Number of divisions on body.
NZ	If "1", the program will allow for doublets in the Z-direction and thus will be able to account for Z-or upwash. If not, set NZ = 0.
NY	If "1", program will allow for Y-doublets and thus Y-or sidewash.
COEF	Scale factor for body deflection mode.
MRK	Each body has associated with it interference lifting surfaces. MRK(1) represents the first box on these surfaces, and MRK(2) is the last box on the body interference lifting surface panels. Interference lifting surface panels are input after the regular lifting surfaces are input.
F	Endpoints of body divisions (starts at leading edge and ends at trailing edge). F=x coordinates of body element end points.
RAD	Radius at endpoints.



Sketch A3. Body Geometry

DATA 6

LIM	Summation limits for chordwise integration. Usually LIM 1 is the first box in a strip and LIM 2 is the last box where all boxes are numbered consecutively.

DATA 7

NADD	Number of additional modes, NADD = NMODES-(NELAST + NR + NC) NADD is computed by program, not input. The additional modes can be any arbitrary mode shapes. If all NELAST mode shape are to be input via TAPE 5 set NELAST =0.
H14,H	Deflections at 1/4 chord and 3/4 chord of box middle.
DH1,DHZ	1st and 2nd derivative with respect to streamwise direction. See Reference.

DATA 8

NBC	Number of boxes on control surface.
NBE	Number of slender bodies.
NBOXB	Number of boxes on each slender body.
NCST	Number of strips on each control surface.
SWHL	Sweep angle of hinge line or X-location of hinge, depending on the type of control surface.
ICTYPE = 0	For trailing edge control. (Default) (Input Sweep Angle).
= 1	For leading edge control. (input Sweep Angle).
= 2	For all movable surface control. (Input hinge location).
ICBOX	Box numbers of boxes on control surface, in ascending order.

DATA 9

BQ(I)	Integration matrix elements, i.e. area of ith box times deflection at quarter chord.
H(I)	Deflection at three-quarter chord of the ith box.
DH1(I),DH2(I)	First and second derivative of deflection shape at the three-quarter chord of the ith box.

DLAT - Sample Input.- The Doublet Lattice can also be executely independently provided downwash data has been previously stored or is input on TAPE 5.

Control Deck

```
DLATB,T500.                              BINXX     XXXXX
USER,XXXXXXX,XXXXXXX.
CHARGE,XXXXXX,LRC.
MAP,OFF.
GET,TAPE9=BIS9.
GET,TAPE5=DLABC.
GET,LGO=DLATBN/UN=887010C.
ATTACH,FTNMLIB/UN=LIBRARY.
GET,ACPOLIB/UN=887010C.
GET,DYLIB/UN=387010C.
LDSET(LIB=DYLIB/ACPOLIB/FTNMLIB.
LGO.
REPLACE,TAPE9=BIS9.
DAYFILE,DLATDAY.
REPLACE,DLATDAY.
EXIT.
DAYFILE,DLATDAY.
REPLACE,DLATDAY.
END OF FILE
```

STABILITY AND RESPONSE ANALYSES

The following table describes the procedure for executing the program DYNARES as a stand alone program. DYNARES will be utilized to a far greater extent that will either DLIN or DLAT since the latter programs generate configuration characteristics which may only be called upon once for the geometry and mode shape data and once each Mach number desired (DLAT only) whereas DYNARES will be used to perform stability and response analyses for a large number of variations of flight conditions and control system parameters.

Table 4a

Dynares, order of TAPE2 input data

	Description	Format
Data 1	NOCASES	Free field
Data 2	HEADER	8A10
Data 3	$ INPUT. . .$	Namelist
Data 4 (If IDCM=1)	DCM parameters	Free field
Data 5 (If ISENSE=1)	$ SENLOC. . .$	Namelist
Data 6 (If ICSPREAD≠0)	(CS(J,I),J=1,NM-Nc),I=NS)	Free field
Data 7 (If ICONSYS=1) and if KASE*>1, ICHANG1=1)	$ CONSYM. . .$	Namelist

Data 8 (If ICONSYS=1 and if KASE>1, ICHANG2=1)	I=1, NC J=1, NS $ FILTIN. . .$	Namelist
Data 9 (If ICONSYS=1 and if KASE>1, ICHANGE3=1)	$ ACTINP. . .$	Namelist
Data 10 (If ISELECT=1)	$ SELECT. . .$	Namelist
Data 11 (If any PLOT options are on)	$ PLTSEL. . .$	Namelist

If in Batch mode, repeat Data 2 - Data 10 for each case. In the Interactive mode, (NOCASES = -1), Data 3 through Data 11 are input via the terminal after the first case. Furthermore, the user will be asked at the beginning of each case whether he/she wishes to STOP. Answer 1, for yes, Depress Carriage Return) 0 (or CR) for no.

In both modes, after the first case, only changes to data need be input.

*KASE is a program computed index for tracking the case number.

Table 4b

Dynares - definition of TAPE2 data.

EXPLANATION OF NOCASES

NOCASES	NUMBER OF CASES TO BE RUN DURING EXECUTION OF JOB
	IF < 0, THE INTERACTIVE VERSION OF THE PROGRAM WILL BE IN EFFECT AND AFTER FIRST CASE IS RUN ALL ADDITIONAL INPUT WILL BE FROM TERMINAL

EXPLANATION OF PARAMETERS IN NAMELIST INPUT

NOTE - I PARAMETERS (LIKE IGUST,IFLUT,ETC) ARE ALL ON-OFF OPTIONS
1 - INDICATES ON
0 - INDICATES OFF (DEFAULT)
N PARAMETERS INDICATE "NUMBER OF"

IDCM=1	ALLOW USER TO MANAGE AND MANIPULATE DATA COMPLEX
=0	RETAIN AUTOMATIC PROGRAM MANAGEMENT OF DATA COMPLEX
ITOC=1	PRINT OUT TABLE OF CONTENTS OF DATA COMPLEX

DATA 3, DEFINITIONS OF VARIABLES IN NAMELIST/INPUT/

```
NAMELIST/INPUT/NM,NR,NC,NK,C,XCG,NPMX,NSECTNS,NNODES,
ISS,IPLATE,XO,YO,RO,IMAT,NMASS,KFIT,ISPLANE,NCOEF,BN,
NPOLYC,ICOF,ISENSE,NS,INTERP,ISYM,NGV,ELVN,IVANE,
ISCREAD,ISELECT,ICHANG1,ICHANG2,ICHANG3,ICSACT,IFORCE,
NFORCE,IFLUT,KVAR,NV,DV,VO,HO,RHOO,NIT,NCUT,NFINE,
EPSI,IOPT1,IOPT2,ITRACE,P1I,P2I,IPS,DEN,IOPT,XMACH,
CONFAC1,CONFAC2,CONFAC3,IGAIN,DELGAIN,ISTABCR,IZEROES,
SS,OMR,IGUST,NG,NGR,RHO,NINT,RFLOW,RFCUT,GL,UU,
NVEL,IVSLF,ISOUT,NLOAD,ITHRF,MINT,TMAX,IPR,KFVN,
NGTH,IFRQOUT,NCP,IPRINT,TFAC,IAPLT,ISPLT,IPKPLT,ITHPLT.
```

EXPLANATION OF PARAMETERS IN NAMELIST INPUT

Definition of Structural and Aerodynamic model

NM	NUMBER OF MODES(RIGID ,ELASTIC,AND CONTROL)
NR	NUMBER OF RIGID BODY MODES

NC	NUMBER OF CONTROL MODES
NK	NUMBER OF REDUCED FREQUENCIES
C	REFERENCE CHORD
XCG	X-COORD OF THE ROTATION POINT OF THE RIGID BODY PITCH MODE
NPMX	MAXIMUM NUMBER OF NODES IN ANY ONE STRUCTURAL SECTION
NSECTNS	NUMBER OF STRUCTURAL SECTIONS DATA THE NUMBER OF NODES AND BOXES ARE DIVIDED INTO
NNODES	TOTAL NUMBER OF NODES IN ALL STRUCTURAL SECTIONS
ISS(1,I)	BEGINNING NODE NUMBER OF STRUCTURAL SECTION I
ISS(2,I)	ENDING NODE NUMBER OF STRUCTURAL SECTION I
IPLATE(I) =1	INDICATES THAT STRUCTURAL SECTION I IS PLATE TYPE
IPLATE(I) =0	INDICATES THAT STRUCTURAL SECTION I IS BEAM TYPE
XO(I)	X COORD OF TRANSLATED AXIS OF SECTION I IF PLATE(I)=1,= (XTE+LE)/2 FOR THAT SECTION
YO(I)	Y COORD OF TRANSLATED AXIS OF SECTION I IF IPLATE(I)=1,= YROOT FOR THAT SECTION
RO(I)	ROTATION ANGLE OF ELASTIC AXIS OF SECTION I IF IPLATE(I)=1,= 1/B WHERE B=CROOT(I)/2
IMAT =1	INPUT LUMPED MASSES AND INERTIAS FROM WHICH GENERALIZED MASSES WILL BE COMPUTED
=0	INPUT GENERALIZED MASSES INSTEAD OF LUMPED MASSES
NMASS	NUMBER OF LUMPED MASSES
KFIT	TYPE OF FIT USED IN INTERPOLATING THE GENERALIZED AERODYNAMIC FORCE, Q(k) FOR THE INDEPENDENT VARIABLE K. KFIT =1 LINEAR KFIT =2 QUADRATIC KFIT =3 CUBIC SPLINE
ISPLANE=1	USE S-PLANE CURVE FIT TO AERODYNAMIC FORCES ASSUMING COEFFICIENTS HAVE BEEN PUT ON TAPE9 PREVIOUSLY
=2	COMPUTE COEFFICIENTS FOR FIT BY CALLING SPLANE FUNCTION USED FOR FIT IS SUM(I=1,NPOLYC) OF A(I)*S**(I-1) PLUS SUM(I=1,N) OF A(NPOLYC+N)*S/(BN(I)+S)
NCOEF	NUMBER OF COEFFS DESIRED IN S-PLANE FUNCTION = MAX(NPOLYC+N)
BN(I)	IS THE CONSTANT IN THE TERM S/(BN(I)+S)
NPOLYC(J)	IS THE DEGREE OF POLYNOMIAL IN S-PLANE FIT FOR J-TH(PRESSURE)MODE
ICOF(N,J)=1	(DEFAULT) ALLOWS N-TH COEF FOR J-TH MODE TO BE COMPUTED
=0	(INPUT) FORCES N-TH COEF OF J-TH MODE TO BE 0.0

Definition of Control System Model

ISENSE	COMPUTE SENSOR DEFLECTION USING OVERLAY(10.0)
NS	NUMBER OF SENSORS INCLUDING 2*NUMBER OF GUST VANES FOR ALL GUST VANES,THE FIRST NGV ARE LINEAR DISP. THE SECOND NGV ARE ANGULAR DISPLACEMENT

INTERP = 1	COMPUTE SPLINE COEFFS FOR OVERLAY(10.0)-SENSORS USING OVERLAY(7.0) - INTERP
ISYM =1	MODE SHAPE SYMMETRY CODE FOR SPLINE COEFFICIENTS (IF 0, UNSYMMETRIC, IF 1, SYMMETRIC, IF -1, ASYMMETRIC)
NGV	NUMBER OF GUST VANES
ELVN(I)	DISTANCE FROM GUST VANE TO GUST REFERENCE POINT FOR I-TH GUST INPUT
IVANE(I) =1	THERE IS A GUST VANE FOR I-TH GUST INPUT
=0	THERE IS NO CORRESPONDING GUST VANE
ICSREAD =1	READ IN ALTERNATE SENSOR DEFLECTION COEFFICIENTS TO REPLACE SOME OF THOSE COMPUTED BY SENSOR OVERLAY AND SAVED ON DATA COMPLEX

Options for modifying mathematical models

ISELECT =1	IF DIFFERENT MODAL COMBINATION IS TO BE SELECTED FOR ANALYSIS IN CURRENT CASE THAN IN PREVIOUS NOTE: IF=1, THEN ALL INPUT (INCLUDING CONTROL SYSTEM) IS BASED ON ORIGIANAL VALUES OF NM,NC, AND NR. IF=0 AND KASE .GT. 1,NEW NM,NC,AND NR VALUE MUST NOT BE INPUT IN NAMELIST /INPUT/AND ALL CONTROL SYSTEM CHANGES SHOULD BE WITH RESPECT TO NM,NC. AND NR OR PREVIOUS CASE
ICHANG1=1	IF ICONSYS=1 AND CHANGE IS TO BE MADE IN CONTROL NAMELIST/CONSYM/
ICHANG2=1	IF ICONSYS=1 AND CHANGE IS TO BE MADE IN CONTROL NAMELIST/FILTIN/
ICHANG3=1	IF ICONSYS=1 AND CHANGE IS TO BE MADE IN CONTROL NAMELIST/ACTINP/
ICSACT =1	IF ACTUATOR AND CONTROL SURFACE DYNAMIC CHARACTERISTICS ARE COMBINED AND HINGE MOMENTS AND INERTIAL MOMENTS OTHER THAN THE CONTROL SURFACE ARE NEGLECTED
=0	IF EFFECT OF INERTIAL AND AERO. HINGE MOMENTS UPON CONTROL SURFACE ARE CONSIDERED EXPLICITLY
IFORCE =1	REPLACE SOME COLUMN IN GUST INPUT ARRAY WITH A COLUMN FROM AERO ARRAY
NFORCE(I)	COLUMN NUMBER IN AERO ARRAY TO REPLACE I-TH COLUMN OF GUST INPUT ARRAY

Stability Analysis, PROOT

IFLUT =1	PERFORM FLUTTER ANALYSIS
KVAR	TELLS WHICH TYPE OF VARIATION IS TO BE USED
=1	VELOCITY VARIATION
=2	ALTITUDE VARIATION, DENSITY AND VELOCITY BASED ON STANDARD ATMOSPHERE TABLES
=3	DENSITY VARIATION
NV	NUMBER OF STEPWISE VARIATIONS

DV		AMOUNT OF STEPWISE CHANGE
VO		INITIAL VELOCITY, FOR DVAR=1 AND KVAR=3
HO		INITIAL ALTITUDE, FOR KVAR=2
RHOO		INITIAL DESNITY FOR KVAR=3
NIT		MAXIMUM NUMBER OF ITERATIONS FOR SOLVING DET=0
NCUT		NUMBER OF TIMES STEP SIZE IS HALVED IN TRYING TO CONVERGE ON ROOT
NFINE		NUMBER OF DIVISIONS OF DV FOR FINE SCAN
EPSI		CONVERGENCE CRITERION
IOPT1	=1	COMPUTES INITIAL GUESSES USING 2*PIE*C/VO*OMEGA FOR ELASTIC MODES ONLY FS AND GS ARE SCALING VALUES USED TO GET REAL AND IMAG PARTS OF P1 AND P2
IOPT2	=1	COMPUTES INITIAL INITIAL GUESSES USING STABCAR
ITRACE(I)	=1	(DEFAULT) TRACE I-THE MODE IN PKFLUT
	=0	DO NOT TRACE
P1I(J) P1I(J)		ARE TWO INITIAL GUESSES FOR ROOT FOR J-TH MODE
IPS		IS A PRAMETER WHICH INDICATES WHICH P1I AND P2I ARRAYS TO USE FOR INITIAL GUESSES FOR CURRENT RUN
	=0	P1SAVE(I)=P1I(I) AND P2SAVE(I)=P2I(I) ARE SAVED WHERE P1I AND P2I ARE THE FINAL VALUES OF P1 AND P2 IN PKFLUT FROM PRECEEDING RUN OR NEW VALUES BEING INPUT IN NAMELIST /INPUT/
	=1	P1I=P1SAVE AND P2I=P2SAVE,WHICH ARE THE INITIAL VALUES OF P1 AND P2 ARRAYS FROM PRECEEDING RUN
DEN		INPUT DENSITY FOR KVAR=1
IOPT	=1	MAKES DENSITY CORRESPOND TO REAL ATMOSPHERE ALSO INPUT XMACH,HO,CONFAC1,CONFAC2,CONFAC3
XMACH		MACH NUMBER,USED TO COMPUTE VELOCITY FOR KVAR=2
CONFAC1		CONVERSTION FACTOR TO CONVERT MAIN PROGRAM VEL TO FT/SEC
CONFAC2		CONVERSTION FACTOR TO CONVERT HO TO FT
CONFAC3		CONVERSTION FACTOR TO CONVERT DENSITY(IN SLUGS/(FT**3))TO UNITS DESIRED IN MAIN PROG.
IGAIN	=1	PERFORM A GAIN VARIATION MAKE DV=0 FOR FLUTTER OVERLAY
DELGAIN(I,J)		AMOUNT OF CONSTANT GAIN INCREASE FOR EACH ITERATION FOR I-TH CONTROL AND J-TH SENSOR COMBINATION

Stability Analysis STABCAR

ISTABCR	=1	COMPUTE STABILITY CHARACTERISTICS-POLES
	=2	COMPUTE BOTH STABILITY CHAR. AND GUST RESPONSE
IZEROES	=1	COMPUTE ZEROS ALSO
SS(I)		IS AN ARRAY OF COMPLEX GUESSES FOR THE POLES IN STABCAR IF THE ITERATION SCHEME DOESNT CONVERGE ON KNOWN ROOTS. IF SS(I) IS (0.,0.),THEN THE INITIAL GUESS WILL BE BASED ON NEXT HIGHEST EIGENVALUE FROM

	THE ONE JUST CONVERGED ON
OMR	IS AN INITIAL STARTING POINT FOR RK1 AND OMEGA. THIS MUST BE INPUT. RK1=OMR*C/(2.*U) OMEGA=CMPLX(-.5*OMR,OMR)

Response To Random Input (gust)

IGUST =1	PERFORM GUST RESPONSE ANALYSIS
NG	NUMBER OF GUST INPUTS USED
NGR	NUMBER OF GUST INPUTS READ IN FOR PSD OUTPUT
RHO	DENSITY FOR GUST NALYSIS
NINT	NUMBER OF INTERVALS/10 USED FOR INTEGRATION
RFLOW	LOWER LIMIT FOR INTEGRATION (REDUCED FREQ)
RFCUT	UPPER LIMIT FOR INTEGRATION(REDUCED FREQ)
GL	CHARACTERISTIC GUST LENGTH ERATION LOCATION
UU	VELOCITIES FOR GUST ANALYSIS
NVEL	NUMBER OF VELOCITIES
IUSLF =1	USE AN UNSTEADY LIFT FUNCTION APPROXIMATION= 1./(1.+2.*PIE*K)
ISOUT(I)=1	OBTAIN OUTPUT RESPONSE TO SENSOR I
NLOAD	NUMBER OF LOADS

Response To Discrete Input

ITHRF =1	PERFORM TIME HISTORY RESPONSE ANALYSIS
MINT	POWER OF 2 USED TO DETERMINE NUMBER OF POINTS IN FOURIER TRANSFORM, NPTS=2**MINT
TMAX	UPPER LIMIT ON TIME INTERVAL FOR TIME HISTORY
NOTE:	MINT AND TMAX SHOULD BE CHOSEN AS FOLLOWS 1. TMAX SUFFICIENTLY LONG TO PERMIT ALMOST STEADY STATE RESPONSE 2. NPTS CHOSEN SUCH THAT MAXIMUM OMEGA IS GREATER THAN THE HIGHEST SYSTEM FREQUENCY OF CONCERN 3. DELTA-T=TMAX/NPTS MUST BE ADEQUATELY SMALL TO DESCRIBE THE FORCING FUNCTION
IPR =1	INTERMEDIATE PRINTOUR IN TIME OVERLAY
KFUN(I)=	THE NUMBER CORRESPONDING TO THE BUILT-IN FORCING FUNCTION DESIRED, FOR I=1 TO NFOR INPUT A(I),B1(I),B2(I),B3(I),NGTH(I) - DEFINED AS FOLLOWS: (FOR FREQUENCY FUNCTIONS, THE TRANSFORM FOLLOWS: TYPE 1: F(T)=A*(1.-COS(B1*T)) ONE PERIOD TYPE 2: F(T)=A*SIN(B1*T) TYPE 3: STEP IN AT 0.,STEP OUT AT B1 F(T)=A ,0 < T < B1

=0 ,B1<T
TYPE 4: RAMP-IN , HOLD , RAMP-OUT
F(T)=A*T/B1, 0< T < B1
=A , B1 < T < B2
=A*(1.-(T-B2)/(B3-B2)),B2<T<B3
=0 , B3 < T

	=0	INDICATES TIME HISTORY ARRAY INPUT TO DESCRIBE FORCING FUNCTION
NGTH		NUMBER OF POINTS IN TIME AND TIME RESPONSE ARRAYS FOR FREQUENCY RESPONSE OUTPUT TO MULTIPLE INPUT
IFRQOUT	=1	DO ONLY FREQUENCY RESPONSE
	=2	DO BOTH FREQ. RESPONSE AND TIME HISTORY
	=0	DO NOT DO FREQUENCY RESPONSE (ONLY TIME HISTORY) (SEE ALSO KFUN)
NCP		NUMBER OF PILOT INPUTS

Instructions For Obtaining Printed Or Plotted Results

IPRINT	=1	INTERMEDIATE PRINTOUT IN GUST OVERLAY
TFAC		SCALE FACTOR FOR TEXTRONIX PLOT. DEFAULT= .014 INCREASE VALUE TO MAKE PLOT SMALLER
IAPLT	=1	PLOT AERODYNAMIC FORCES VS. REDUCED FREQUENCY
IFRFPLT	=1	PLOT FREQUENCY RESPONSE FROM GUST ANALYSIS
ISPLT	=1	PLOT POWER SPECTRA FROM GUST ANALYSIS
IPKPLT	=1	PLOT TWO*GAMMA AND FREQ FROM FLUTTER ANALYSIS VS. VELOCITY,DENSITY,OR ALTITUDE VARIATION (AND DYANMIC PRESSURE IF IMATCH = 1)
	=-1	PLOT ROOT-LOCUS WITH RESPECT TO VELOCITY,DENSITY OR ALTITUDE VARIATION
ITHPLT	=1	PLOT TIME HISTORY RESPONSE

TABLE 4c.

Supplementary Namelists

DATA 10 EXPLANATION OF PARAMETERS IN NAMELIST SELECT

IF ISELECT IS ON (ISELECT=1)

NMODES	Total number of modes to be selected from original data
NOC(I)	Mode number to be used in place of Mode I Example NOC(1)=3,NOC(2)=7,NOC(3)=9 and NMODES = 3 Means 3 MODES will selected and they will be MODES 3,7, and 9
NFNEW	New NF (Number of flutter modes looked at)
NCNEW	New NC (Number of control modes)
NRNEW	New NR (Number of rigid body modes)

NOT NECESSARY, BUT USE BOTH OR NEITHER

```
NKNEW                  New NK (Number of reduced frequencies)
NOK(I)                 Frequency number to be used in place of I-TH frequency
```

Sensor Location

DATA 5

IF ISENSE IS TURNED ON NAMELIST SENLOC MUST BE SUPPLIED

```
NAMELIST /SENLOC/ XS,YS,ITYPE
DIMENSION XS(10),YS(10),ITYPE(10)
```

EXPLANATION OF PARAMETERS IN NAMELIST /SENLOC/

```
XS,YS                  Array of sensor locations
                        for beam type, XS and YS should be unrotated
ITYPE                  Indicates whether linear or angular measurements
                        are to be taken
                        for I = 1, NS + NS
                        ITYPE(I)   =1     Linear measure
                        ITYPE(I)   =2     Angular measure
NSS(I)                 Structural section number which corresponds to I-TH
                        sensor
```

IF ICONSYS=1 SUPPLY NAMELISTS CONSYM, ACTINP, AND FILTIN FOR THE FIRST CASE, THEREAFTER, SUPPLY CHANGES ONLY IF ICHANG1, ICHANG3 OR ICHANG2 ARE TURNED ON.

DATA 7

```
NAMELIST /CONSYM/ ASD,XKS,IORD-ISDYN, GN
DIMENSION ASD(3,10),XKS(10),IORD(10),ISDYN(10),GN(10(10)
```

CONSYM is the block of parameters and coeffs used in subroutine SENDYN

EXPLANATION OF PARAMETERS IN NAMELIST CONSYM

```
ASD(I,J)               I-TH coeff. of denominator polynomial of sensor
                       transfer function which models sensor dynamics
                       for J-TH sensor.

                       (Default:  ASD(1,J)=1.,ASD(2,J)=ASD(3,J)=0.)

                       POLY = SUM(I=1,3) of ASD(I,J)*S**(I-1)

XKS(J)                 Numerator coefficient of J-TH sensor
                       (Default.  XKS=1.)

                       POLY = XKS(J)*S**(IORD(J))

IORD(J)                Is the J-TH sensor type

             =0        Displacement sensor

             =1        Rate sensor
```

	=2	Acceleration sensor
		(Default = 0)
ISDYN(J)		Indicates sensor dynamics
	=1	include sensor dynamics
	=0	perfect sensor (Default. = 0)
GN(I,J)		Gain for I-TH control and J-TH sensor
		(Default: = 0.)

Feedback Filter Description

DATA 8

```
NAMELIST /FILTIN/ TAU2,WN1,SN1,WN2,SN2,KIBDO,KIBD1,KIBD2,AN1,AD1,AL22,AL21,
                  IFILTER,AFN,AFD
DIMENSION IFILTER(12),TAU2(12),WN1(12),SNI(12),WN2(12),SN2(12)
C, KIBDO(12),KIBD1(12),KIBD2(12),AN1(12),AD1(12),AL22(12),AL21(12)
C, AFN(6,12),AFD(6,12)
REAL KIBDO,KIDB1,KIBD2
```

FILTIN is the block of coefficients used in subroutine FILDYN to model filter logic. there is a new set of coefficients for each sensor and control combination. Default values for all coeffs. except WN1,WN2, and AFD(1) are 0.. WN1 and WN2 are 1.0E+20 and AFD(1)=1.

EXPLANATION OF PARAMETERS IN NAMELIST /FILTIN/

(THESE COEFFICIENTS ARE ALL SUBSCRIPTED PER FILTER)

WN1,SN1	Natural frequency and damping ratio at first break point (beginning of notch)
TAU2	Time constant at second break point (low point of notch)
WN2,SN2	Natural frequency and damping ratio at third break point (end of notch)
KIBDO	Gains for integral
KIBD1	Proportional
KIBD2	Derivative outputs, respectively
AN1,AD1	Frequencies of zero and pole in lead-lag (lag-lead) compensator
AL22,AL21	Denominator coeffs, in second order lag filter 1./(1. + AL21*S + AL22*S**2)
AFN,AFD	Coeffs, of numerator and denominator polynomials for an overall transfer function representation of control logic between a given sensor - control pair.
IFILTER	An array indicating the types of filters to be combined

(in series) to make up a given filter

IFILTER(I) = 1 No further filtering
2 Notch filter
3 Integral
4 Proportional plus derivative
5 Lead-Lag or Lag-Lead
6 Second order lag
7 General rational function

Default Value is 1

EXAMPLE: IFILTER(1)=3,4,1 MEANS FILTER WILL BE MADE UP OF FILTERS OF TYPES 3 and 4

DATA 9

Actuator Description

NAMELIST /ACTINP/ AACTN,AACID,IACT
DIMENSION AACTN(4,10),AACTD(5,10),IACT(10)
This array of input is for the coeffs, in subroutine ACTDYN, there should be NC sets of coefficients

EXPLANATION OF PARAMETERS IN NAMELIST ACTINP

NACT(I,J) = 0, No
1, Yes — Ith pilot command is sent to ith actuator, default off

AACTN(I,J) — I-TH coefficients of numerator polynomial of actuator transfer function which modesl actuator for J-TH control.

(Default: AACTN(1,J)=1., All Others =0.)

POLY = S∑M(I=1,4) of AACTN(I,J)*S**(I-1)

AACTD — I-TH coefficients of denominator polynomial of transfer function which models actuator for J-TH control

(Default: AACTD(1,J)=1., All Others =0.)

POLY = S∑M(I=1,5) of AACTD(I,J)*S**(I-1)

IACT(J) — Indicates actuator dynamics
=1 Include actuator dyamics for J-TH control
=0 Perfect actuator

OUTPUT PLOTS

NAMELIST/PLTSEL/MODEA,MODES,MODEFR,MODEPK,MODETH
IF IAPLT = 1 INPUT;
MODEA(I,J)=1 (I,J) - TH mode curve of full aero Matrix including gust columns, as

NM+1,....,NM+NG. NOTE: I and J refer to original values of NM.

NOTE — The NM and NC values for the parameters that follow are those given by select option if used.

IF IFRFPLT=1 input;

MODEFR(I,J)=1 Plot (J-1)ST Derivative --J=1, Displacement J=2, Velocity, J=3, Acceleration--of the I"TH Mode Frequency Response.

IF ISPLT=1 input;

MODES(I) =1 Plot I-TH POWER SPECTRA.I computed as follows:

I=	1	- INPUT POWER SPECTRA
	2, NLOAD+1	- LOADS
	NLOAD+3, NSO+NLOAD+1	- SENSORS
	NSO+NLOAD+2,NSO+NLOAD+2NC+1	- CONTROLS

IF IPKLPLT=1 input;

MODEPK(I)=1 Plot I-TH Flutter Mode Output

IF ITHPLT=1 input;

MODETH(I)=1 Plot I-TH Time History. I computed as follows:

I=1,NM-NC	- QOFK(I)
I=NM-NC+1,NM	- CONTROL DISPLACEMENTS
I=NM+1,NM	- CONTROL RATES
I=NM+NC+1,NM+NC+NSO	- SENSORS
I=NM+NC+NSO+1,NM+NC+NSO+NLOAD	- LOADS

NOTE: NSO IS EQUAL TO THE SUM OF THE ONES IN THE NSOUT ARRAY

Table 4d.

Dynares - Order Of Input
File: Tape 5

	Description	Format
Data 1 (if DCM AERO-1)	(RFRQ(I),I=1,NK)	8F10.0
Data 2 (if DCM AERO-1)	For K = 1,NK	
	((AR(K,I,J),AI(K,I,J),I=1,NM),J=1,NM)	2E15.6
Data 3 (if DCM AERO-1)	For K = 1,NK	
	((AGR(K,I,J),AGI(K,I,J),I=1,NM),J=1,NGR)	2E15.6
Data 4 (if IMAT = 1)	(WMASS(I),I=1,NMAS	8F10.0
Data 5 (if IMAT = 1)	(INERTIA(I),I=1,NMASS)	5E15.7
Data 6 (if IMAT = 1)	For J = 1,NM	
	(MODE(I,J),I=1,NMASS)	8F10.0
	(SLOPE(I,J),I=1,NMASS)	8F10.0

Data 4 - Data 6 Replaced by the following if:
IMAT = 0 and DCM GMASS -1.

	For I = 1,NM	
	(GMASS(I,J),J=1,NM)	5E15.7
Data 7 (if DCM FREQ-1)	(FREQ(I),I=1,NM)	5E15.7
Data 8 (if DCM DAMPINGS-1)	(DAMPINGS(I),I=1,NM)	5E15.7
Data 9 (if NLOADS≠0 and DCM LOADS-1)	((CLOAD(J,I),J=1,NM),I=1,NLOAD)	FREE FIELD
Data 10 For each IG=1,NFOR such that KFUN(IG)=0		
	(GTH(I),TIME(I),I=1,NGTH(IG))	2E15.6
Data 11 (If DCM SENDEF-1)	(CS(J,I),J=1,NMNC),I=1,NS)	8F10.0

Table 4e.

DYNARES - TAPE 5 - DEFINITIONS

RFRQ	Reduced frequencies associated with Generalized Aerodynamic Forces.
AR(K,I,J) AI(K,I,J)	Real and Imaginary parts of Generalized Aerodynamic Forces For I-th MODE deflection and J-th mode downwash. The aerodynamic forces due to airplane motion are input columnwise.
AGR(K,I,J)	Real and Imaginary parts of external aerodynamic forces which may describe either gust force or any other external force such as a control surface force resulting from pilot commands which are not part of the automatic feedback system.
WMASS(I) INERTIA(I)	Lumped masses and inertia of I-th node.
MODE(I) SLOPE(I)	Deflection and slope at I-th node for the J-th assumed mode. The mode shape data can be taken from prior vibration analyses or represented by some suitable mathematical function.
GMASS(I,J)	Generalized mass.
FREQ(J)	Modal frequency from the vibration analysis or term used to describe the modal stiffness.
DAMPING(J)	Modal structural damping ratios.
CLOAD(I,J)	Stress coefficients at the I-th station for the J-th mode used in equation . The terms though meaningful only for slender beams, can be used to define any stress in any type of structure for which modal analysis is applicable.
GTH(I),TIME(I)	An array which describes an external forcing function. GTH(I) is the amplitude at some time TIME(I). Used in the time history overlay.

DYNARES - Sample Input

Control Deck

```
DYNAB,T530.                                  BINXX    XXXXX
USER,XXXXXXX,XXXXXXX.
CHARGE,XXXXXX,LRC.
MAP,OFF.
GET,INITIAL/UN=887010C.
CALL,INITIAL.
GET,DYNAV1B/UN=887010C.
GET,TAPE9=BIS92.
GET,TAPE2=BISC.
ATTACH,FTNMLIB,LRCGOSF/UN=LIBRARY.
GET,ACPOLIB/UN=887010C.
LDSET,LIB=ACPOLIB/FTNMLIB/LRCGOSF.
LOAD(DYNAV1B)
DYNARES.
PLOT.VARIAN(FSH=8.,FSV=11.,AUTO(0))

END OF FILE .
```

In the above run it is presupposed that all of configuration data has been stored on the file B1S92. If this is not the case, these data may be input through TAPE5 compiled as instructed in table 4c.

ISAC - Sample Problem for consecutive run

```
ISACB,T0550.
USER,
CHARGE,101390,LRC.
MAP,OFF.
GET,INITIAL/UN=887010C.
CALL,INITIAL.
GET,TAPE5=BIS5.
GET,DCM/UN=887010C.
DCM.
REPLACE,TAPE9=BIS92.
RETURN,TAPE5.
GET,TAPE1=NASBISC.
GET,TAPE3=DLIBC.
GET,TAPE5=DLABC.
GET,LGO=DLINBN/UN=887010C.
LDSET(LIB=ACPOLIB/FTNMLIB/LRCGOSF)
LGO.
REPLACE,TAPE9=BIS92.
DAYFILE,ISACDAY.
REPLACE,ISACDAY.
PLOT.VARIAN(FSH=11.,FSV=8.,AUTO(0))
REWIND,TAPE5.
RETURN,TAPE1.
GET,LGO=DLATBN/UN=887010C.
LDSET(LIB=ACPOLIB/FTNMLIB/LRCGOSF)
LGO.
REPLACE,TAPE9=BIS92.
DAYFILE,ISACDAY.
REPLACE,ISACDAY.
STATUS,F.
REWIND,OUTPUT.
COPYEI,OUTPUT=AA.
REPLACE,AA.
RETURN,TAPE1.
ATTACH,FTNMLIB,LRCGOSF/UN=LIBRARY.
GET,DYLIB,ACPOLIB/UN=887010C.
GET,TAPE9=BIS92.
GET,TAPE2=BISC.
GET,LGO=DYNAV1B/UN=887010C.
LDSET(LIB=ACPOLIB/FTNMLIB/LRCGOSF)
LGO.
PLOT.VARIAN(FSH=8.,FSV=11.,AUTO(0))
DAYFILE,ISACDAY.
REPLACE,ISACDAY.
EXIT.
DAYFILE,ISACDAY.
REPLACE,ISACDAY.
STORE
GMASS -1 1 4 1
FREQ -1 1 2 1
DAMPINGS -1 1 2 1
END
(2E15.7)
BISP C
SAME
BISP C
SAME
BISP C
TOC
END
```

NOTES

1. TAPE1 is a formatted tape generated by the vibration analysis program.

2. On an initial run.

3. Input data and results are shown in table 5 and figures A2 through A4.

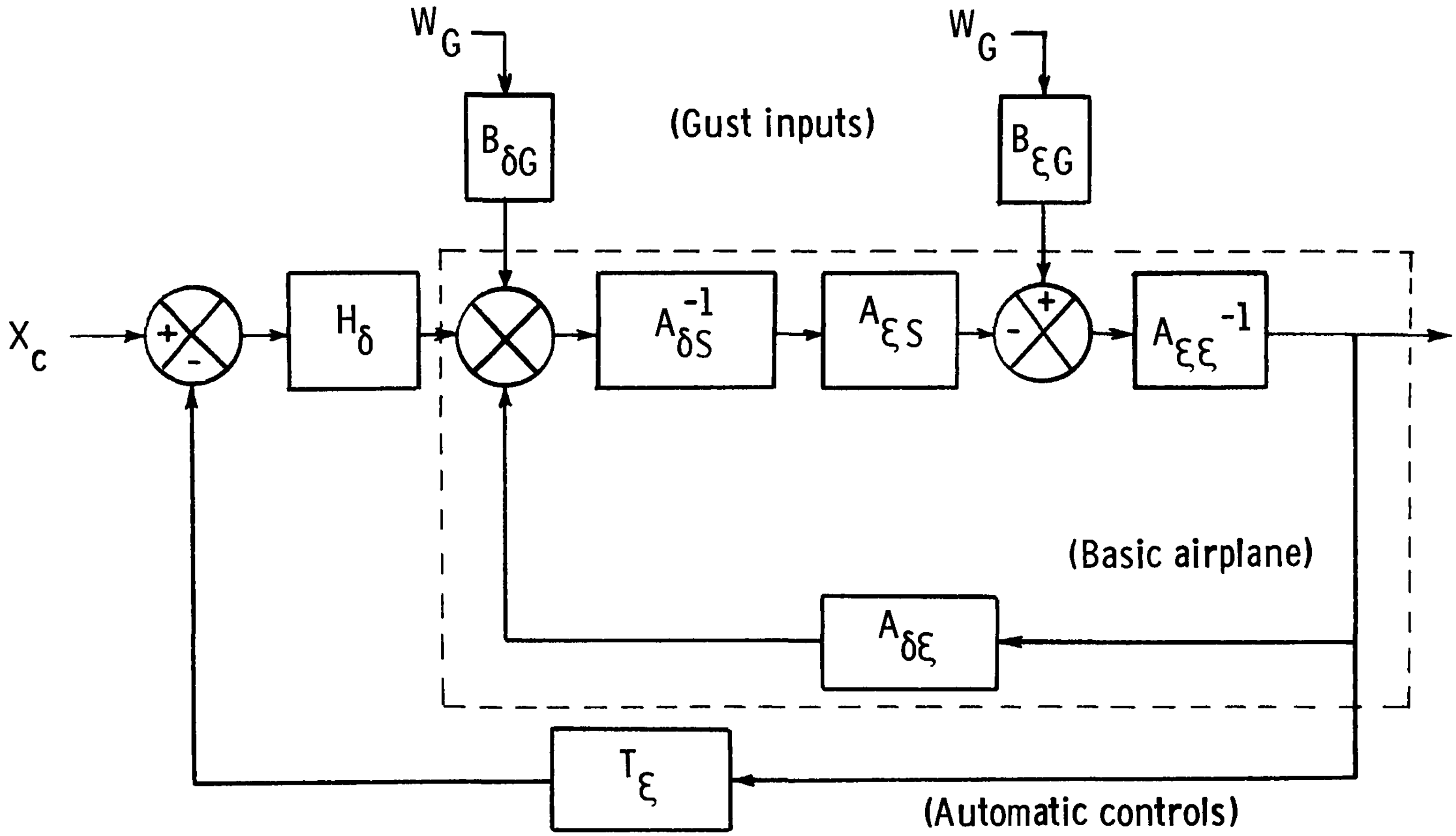


FIGURE 1. BLOCK DIAGRAM BASIC AIRPLANE, AUTOMATIC CONTROLS PILOT INPUTS AND GUST INPUTS

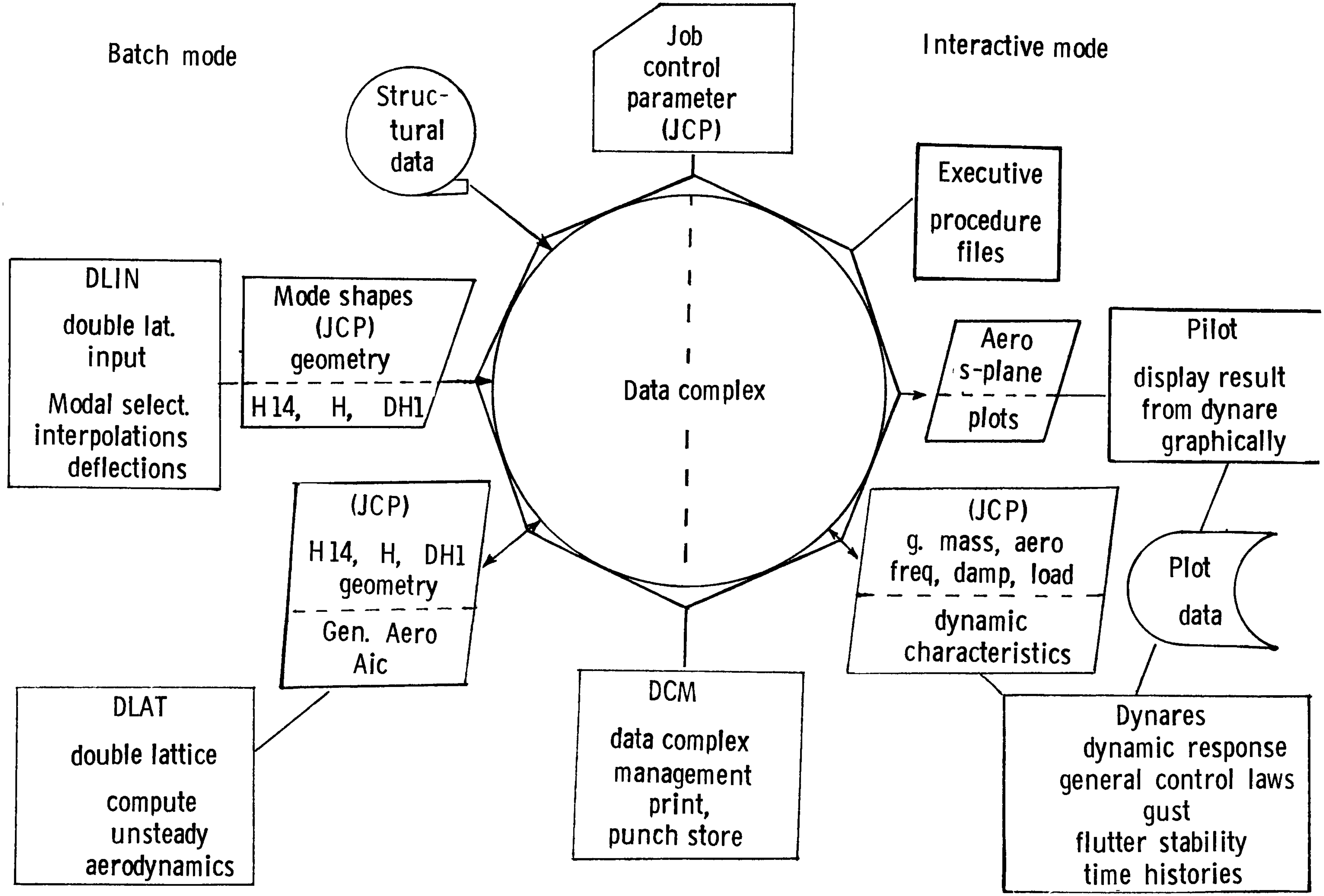


Figure 2. Program Structure

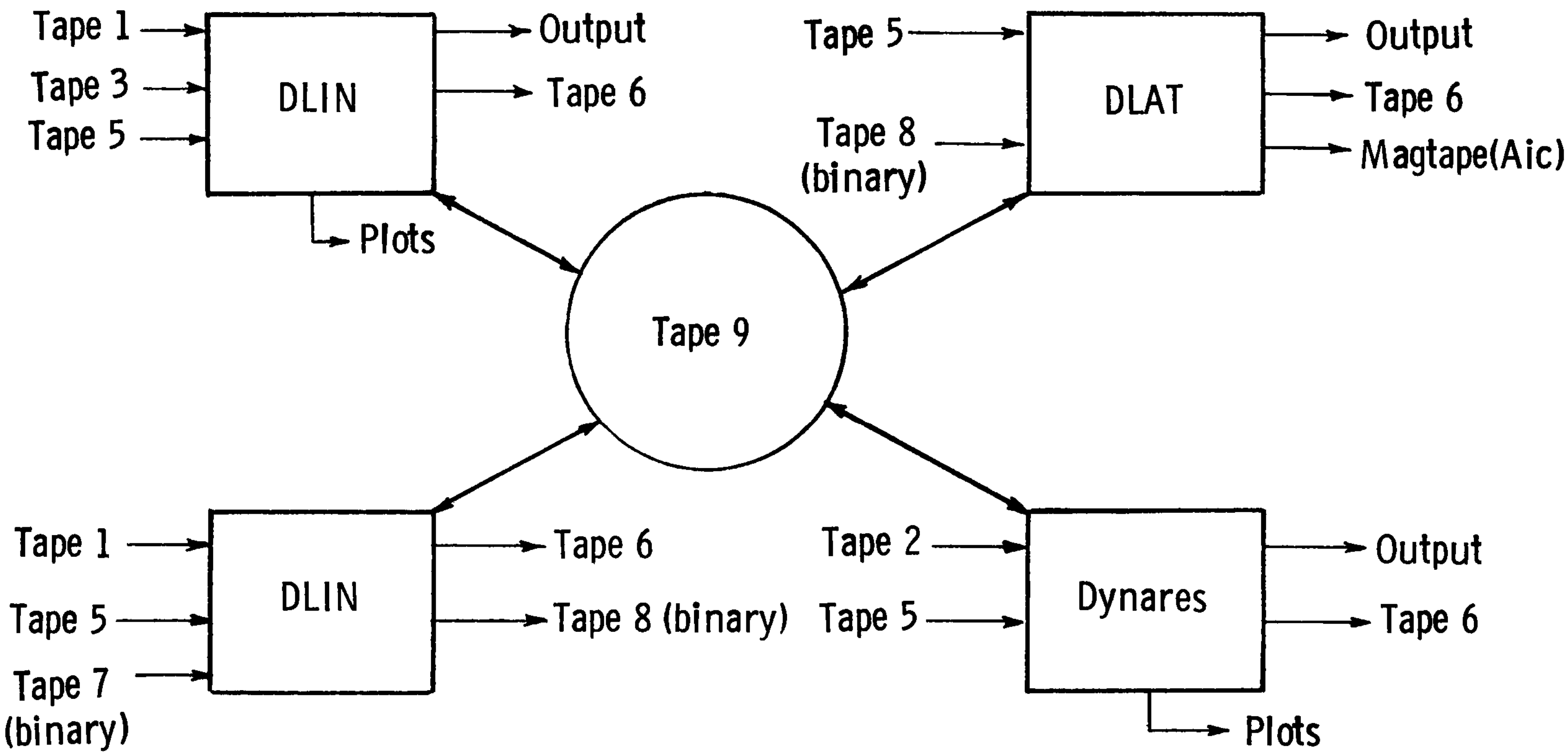
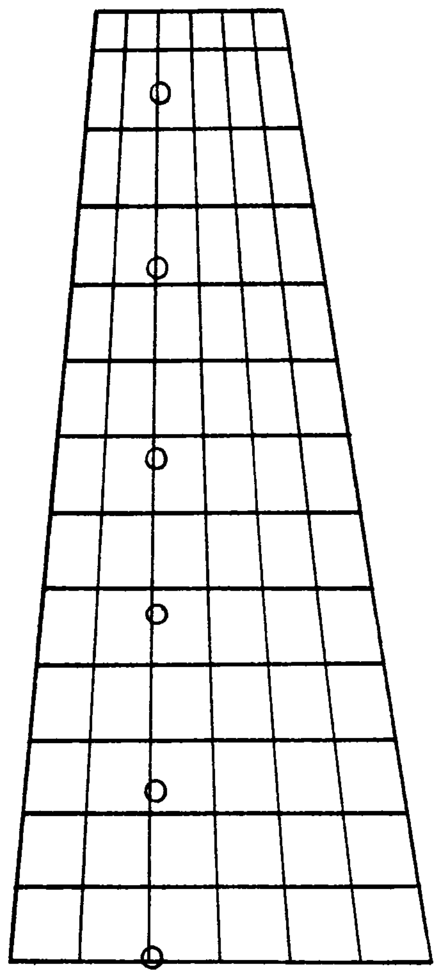
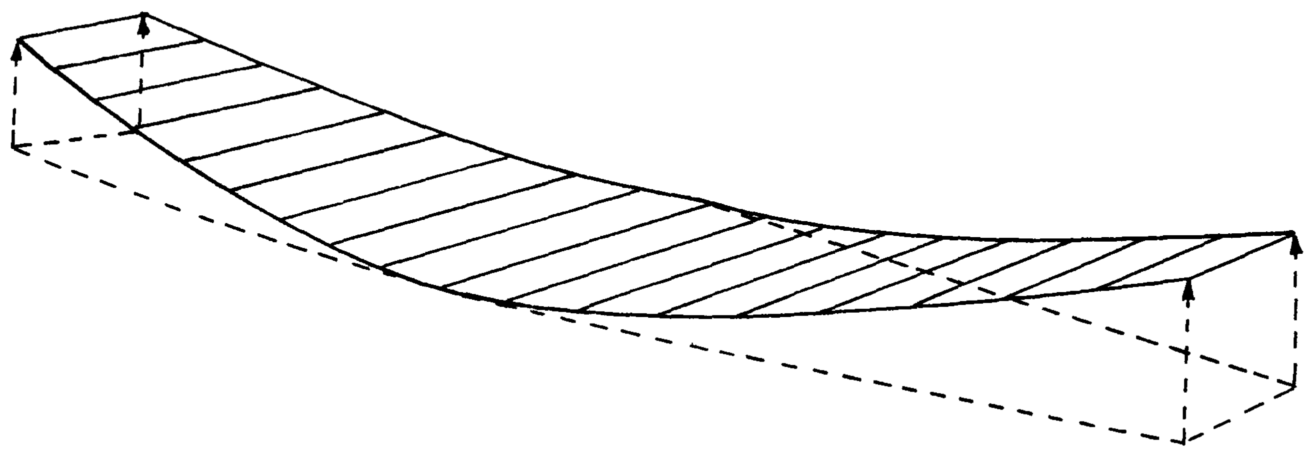


FIGURE A1. INTRA PROGRAM COMMUNICATION

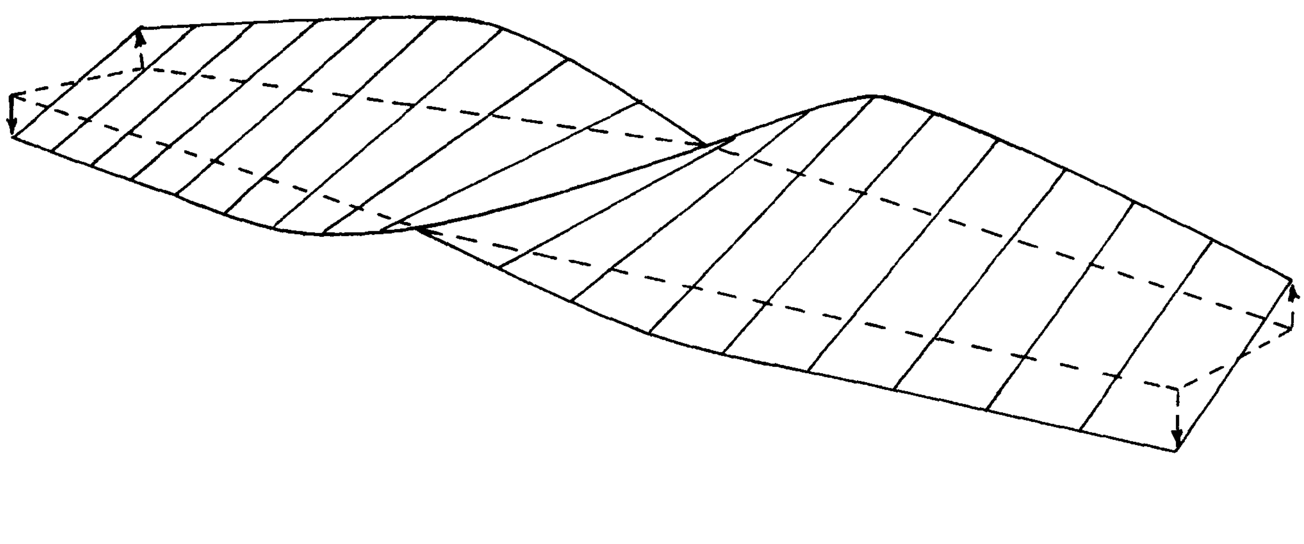


Bisplinghoff jet trans-cant

FIGURE A2. STRUCTURAL NODE AND AERODYNAMIC BOXES



Bisplinghoff jet trans-cant Mode = 1, Freq = 1. 83HZ, Gmass = 897E+01



Bisplinghoff jet trans-cant Mode = 2, Freq = 3. 65HZ, Gmass = . 995 +03

FIGURE A3. VIBRATION MODE SHAPES

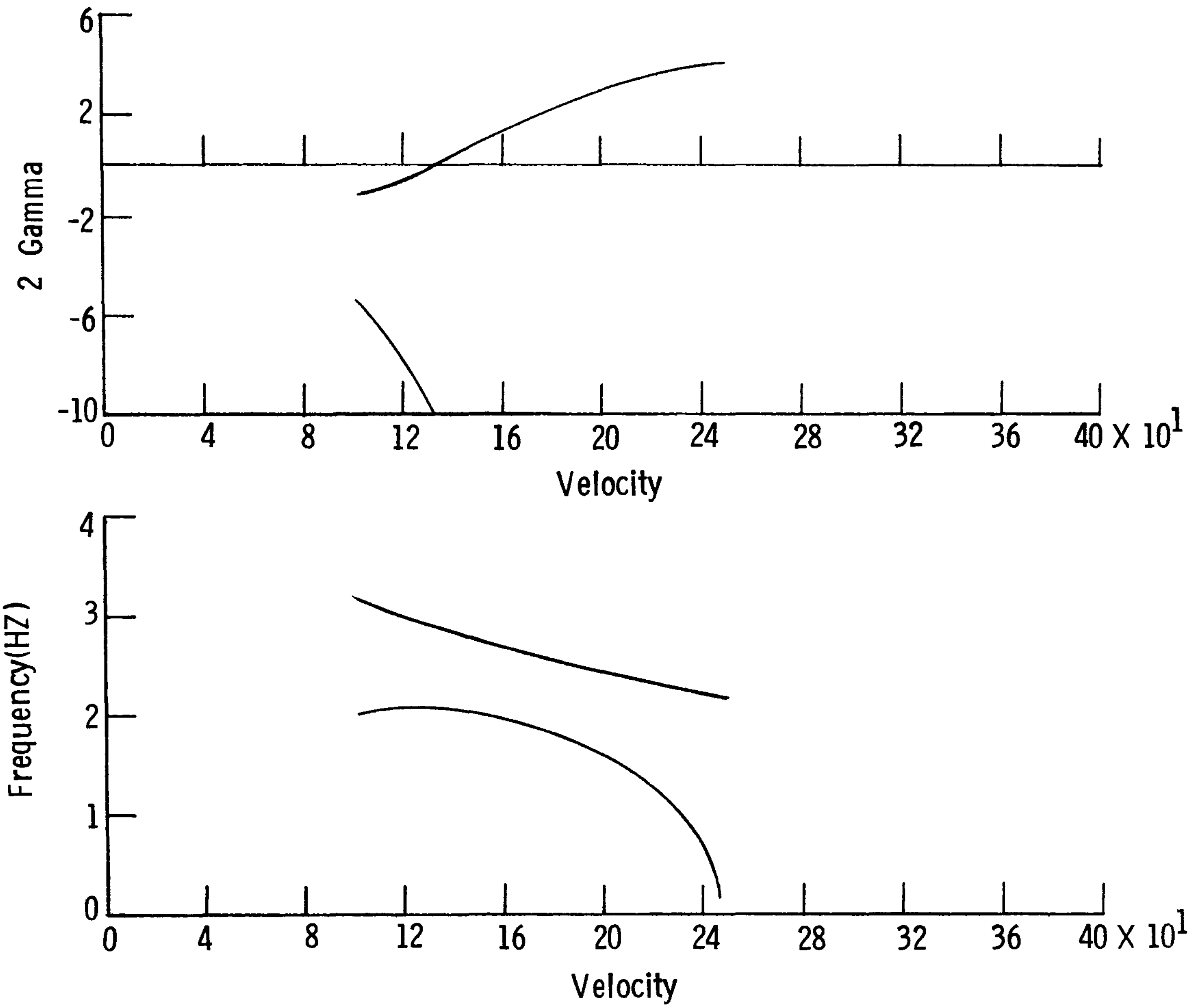


FIGURE A4. STABILITY CHARACTERISTICS V-G CURVE

```
$TITLE    = BISP-JET TRANSPORT                                                         1
$SUBTITLE= CANTILEVER                                                                   3
$LABEL    =                                                                             6
$EIGENVECTOR                                                                            7
$REAL OUTPUT                                                                            8
$SUBCASE ID =           1                                                               9
$EIGENVALUE = 00.1322011E+03  MODE =        1                                          10
       1        G       0.E+00           0.E+00            0.E+00                      11
-CONT-                  0.E+00           0.E+00            0.E+00                      12
       6        G       0.E+00           0.E+00            5.043396E-02                13
-CONT-                  9.422469E-04     3.041080E-05      0.E+00                      14
      12        G       0.E+00           0.E+00            1.995929E-01                15
-CONT-                  1.958649E-03     5.931993E-05      0.E+00                      16
      17        G       0.E+00           0.E+00            3.967001E-01                17
-CONT-                  2.678194E-03     4.825544E-05      0.E+00                      18
      22        G       0.E+00           0.E+00            7.004019E-01                19
-CONT-                  3.229044E-03     3.482329E-05      0.E+00                      20
      27        G       0.E+00           0.E+00            1.000000E+00                21
-CONT-                  3.377827E-03     2.624896E-05      0.E+00                      22
$TITLE    = BISP-JET TRANSPORT                                                         23
$SUBTITLE= CANTILEVER                                                                  25
$LABEL    =                                                                            28
$EIGENVECTOR                                                                           29
$REAL OUTPUT                                                                           30
$SUBCASE ID =           2                                                              31
$EIGENVALUE = 00.5272275E+03  MODE =        2                                          32
       1        G       0.E+00           0.E+00            0.E+00                      33
-CONT-                  0.E+00           0.E+00            0.E+00                      34
       6        G       0.E+00           0.E+00           -3.114013E-02                35
-CONT-                 -8.584063E-04    -3.017979E-02      0.E+00                      36
      12        G       0.E+00           0.E+00           -1.728147E-01                37
-CONT-                  4.510524E-04    -6.045485E-02      0.E+00                      38
      17        G       0.E+00           0.E+00           -9.132470E-03                39
-CONT-                  3.101806E-03    -6.254801E-02      0.E+00                      40
      22        G       0.E+00           0.E+00            4.510013E-01                41
-CONT-                  5.535883E-03    -6.445205E-02      0.E+00                      42
      27        G       0.E+00           0.E+00            1.000000E+00                43
-CONT-                  6.414236E-03    -6.543473E-02      0.E+00                      44
$TITLE    = BISP-JET TRANSPORT                                                         45
$SUBTITLE= CANTILEVER                                                                  47
$LABEL    =                                                                            50
$EIGENVECTOR                                                                           51
$REAL OUTPUT                                                                           52
$SUBCASE ID =           3                                                              53
?
```

TABLE 5A. SAMPLE PROBLEM INPUT DATA, NASBISC

```
 BISPLINGHOFF JET TRANS-CANT
NASTRAN
 $DLINPT NSECTNS=1,NSECTNA=1,NDF=6,
  NNODES=6,NNODET=6,NPMX=6,
  IPLTNOD=1,IPRINT=1,
   NSKIPL=7,SCX=100.,SCY=100.,
  IPLTMS=1,IBAUD=120,
  MODE=1,1,1,1,
  IDCM=1,IPLTBOX=1$
 $MODEPLT
  INODELN=1,
 NSURF    = 1,
 XLE      = .2E+03, .244E+03,
 YLE      = 0.0, .5E+03,
 NLEP     = 2,
 XTE      = .425E+03, .3438E+03,
 YTE      = 0.0, .5E+03,
 NTRP     = 2,
 NSPN     = 10,
 NCHD     = 3,
 NSSP     = 1,
 SCXMS    = .5E+02,
 SCYMS    = .75E+02,
 SCZMS    = .1E+01,
 SCZDEF   = .8E+00,
 XV       = .11E+04,
 YV       = .5E+02,
 ZV       = .5E+01,
 ALPHA    = .45E+02,
 BETA     = -.5E+01,
 XTRANS   = 0.0,
 NE       = 2,
 MODEMS   =1,0,0,0,0,
 XOR      = .2E+01,
 YOR      = .3E+01,
 IPLAN    = 1,
 IBOTH    = 1,
 ISTOP    =0,
 $END
 $MODEPLT ISTOP=1,MODEMS=0,1,SCZDEF=-
1.$
DISP  -1 1
MODES 1 1
HHD   0 1
SPLINE 1 1
END
1,6,0,278.75,0.,0.
1,78,1
0.,0.,1,3,+5
90.,0.,2,3,+5
186.,0.,3,3,+5
268.,0.,4,3,+5
368.,0.,5,3,+5
458.,0.,6,3,+5
?
```

TABLE 5b. SAMPLE PROBLEM INPUT DATA, DLIBC

```
 BISPLINGHOFF JET TRANSPORT CANTILEVER
 $DLATINP FMACH=.7,ACAP=81250.,NDELT=1,NP=1,NB=0,NRF=6,RFREQ=0.,.2,.4,
      .6,.8,1.,NSTRIP=13,NSV=0,NBV=0,NMODES=2,REFSPN=1.,NBOX=78,NSNC=98,
     REFCHD=162.5,IPRINT=1,XZERO=200.,XCG=280.4,NR=0,NC=0,NELAST=2,IDCM=1$

AERO 1 1
HHD 1 1
END
200. 425. 243.8 343.8 0. 500.
0.  0.  14  7  1.
0. .167  .333 .5  .667 .833  1.
0. .08  .16  .24  .32  .40  .48  .56  .64  .72  .80  .88  .96   1.
1 6  7 12 13 18 19 24 25 30 31 36 37 42 43 48 49 54 55 60 61 66  67 72
73 78
?
```

TABLE 5c. SAMPLE PROBLEM INPUT DATA, DLABC

d) INPUT DATA, BISC

```
  1
 BISPLINGHOFF JET TRAN FLUT CANTILEVER
 $INPUT NM=2,NR=0,NC=0,NK=6,NLOAD=0,C=162.5,KFIT=2,NS=0,XCG=280.4,
 NNODES=5,NSECTNS=1,NPMX=6,IPLATE=0,1,NINT=30,GL=30000.,
 XMACH=.7,H0=50000.,CONFAC1=.083333,CONFAC2=1.,CONFAC3=.000048225,
 DV=300.,NV=50,IOPT1=0,IGAIN=0,
  IFLUT=1,KVAR=1,IPKPLT=1,
  RHO0=1.15-7,IOPT2=1,
  DEN=1.146-7,V0=10000.,
 RFCUT=1.0,NCUT=4,NFINE=4,NIT=26,ISYM=1,ICSACT=1,EPSI=1.E-6,RFLOW=0.,
 ISENSE=0,IPRINT=10,NVEL=1,ICONSYS=0,KVAR=1,ISTABCR=0,IDCM=1,
  ISELECT=0,
   FS=.01,GS=1.,ND=1,
  R0=0.,1.,X0=278.8,0.,Y0=0.,0.,ISS=1,6,8,10$
ALL 1 0
END
 $PLTSEL MODEPK=1,1$
```

e) INPUT DATA, BIS5

```
          8.9735          0.0000
          0.0000        994.5340
          1.8300          3.6540
           .0300           .0300
?
```

TABLE 5. CONCLUDED

End of Document