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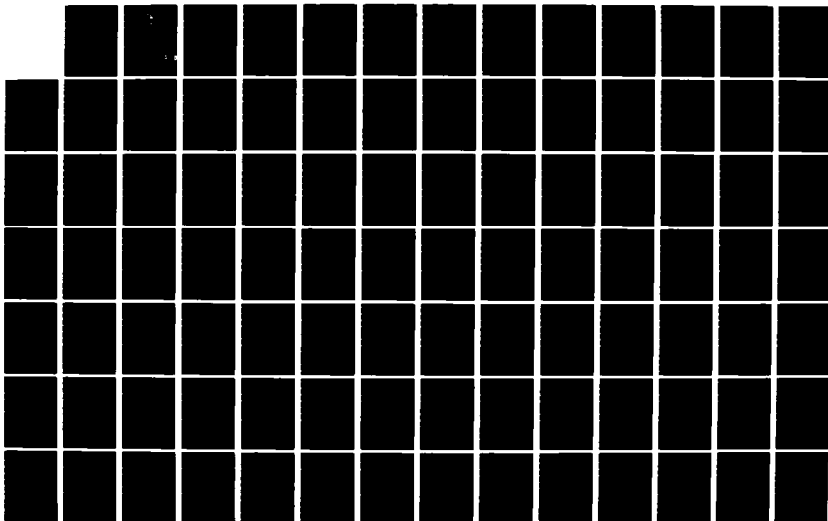
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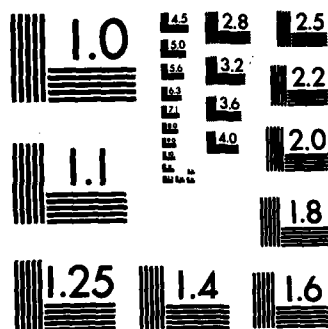
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STATIC AEROELASTIC ANALYSIS
OF
FLEXIBLE WINGS
VIA NASTRAN

THESIS

AFIT/GAE/AA/82D-16

Kim Jones
1Lt USAF

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STATIC AEROELASTIC ANALYSIS
OF
FLEXIBLE WINGS
VIA NASTRAN
PART I

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

By

Kim Jones, B.S.A.E.

1Lt USAF

Graduate Aerospace Engineering

December 1982

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Preface

This thesis is a continuation of the research done by Captain Lance P. Chrisinger in his M.S. Thesis at AFIT in 1980. The first part contains the theoretical development of the sequence along with the results of a survey of wing models. The survey determined the characteristics of average wing models that the procedure must be able to tolerate. The second part develops a procedure for designing and testing a NASTRAN module. Then the module used for the aeroelastic sequence, GIAS, is used as an example. The logical procedures in GIAS are then explained. Finally, a detailed description of the aeroelastic sequence is given along with a description of how to implement it.

I would like to extend my gratitude to Captain Hugh C. Briggs, who has understood and put up with me while guiding me through this thesis.

I would also like to thank Michael Bernier and Jim Trace for their help with the computer.

A very special thanks goes to my wife, Valerie, whose patience and understanding has helped greatly with my stay at AFIT.

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Abstract

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The purpose of this study was to expand the capabilities of the Static Flexible Wing Aeroelastic Sequence that Captain Lance P. Chrisinger developed for NASTRAN as his Master's Thesis at AFIT. Captain Chrisinger developed a basic procedure to enable NASTRAN to analyze flexible wing airloads and stresses. That capability is expanded to enable analysis of standard wing models.

A subroutine was incorporated into NASTRAN to eliminate extensive hand-calculation of transformation matrices.

The capability to tolerate control surfaces was discovered. Also, a survey of wing models in the Air Force inventory was taken to determine the characteristics of the average wing model. This was used to determine where the aeroelastic procedure was lacking in its ability to analyze wing models.

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STATIC
AEROELASTIC ANALYSIS
OF
FLEXIBLE WINGS
VIA NASTRAN
PART I

I. Introduction

An improved aeroelastic package has been developed to calculate stresses, displacements, and aerodynamic coefficients for flexible wings undergoing computer-generated airloads. The package is based on the readily available NASTRAN computer program and can tolerate moderately complex wing models with secondary structure. The need for such a package became evident as aircraft wings were designed with more structural flexibility. The changes in displacements caused by the airloads, and the changes in airloads caused by the displacements became significant enough to warrant attention. As a result, several aeroelastic analysis packages have been designed, such as FLEXLOADS and FLEXSTAB. However, all of the packages designed so far contain deficiencies that prevent them from efficiently solving complex wing structures. This package is an attempt to design an aeroelastic analysis program that does not have any serious drawbacks.

II. Background

The aeroelastic flexible wing problem is a study in fluid-structure interaction because the airloads on the structure are dependent on the displacements of the structure. Several packages have been designed to solve this interaction problem for aircraft wings.

Dual-Program Method

One type of solution technique uses an airloads generator computer program and a structural analysis package. The advantage of this method is that its parts are already in existence. However, there are some serious drawbacks to this solution technique. Much time is consumed in transforming the generated airloads into forces for the structural analysis package. Also, the displacements from the structural analysis package must be transformed into displacements for the airload generator. An additional problem with this method is the duplicate computer work required. As iterative passes are made through the airloads generator and structural analysis package the same equations are assembled and decomposed. This results in the same work being done with each pass through the system.

FLEXLOADS

Another solution technique aimed at solving the flexible wing problem involves a single program using an iterative solution. The program, FLEXLOADS, was developed by General Dynamics where it is currently being used to analyze several bombers and transports. They are also modifying FLEXLOADS to use with nonlinear aero theory in order to investigate the separation and stall flight regimes. Northrup is using FLEXLOADS in their analysis of several fighters. The advantages of FLEXLOADS are that it is a relatively small, easily manageable program and that it contains several different aero theories to choose from. A disadvantage is its size restriction of 165 degrees-of-freedom (DOF), which will limit the complexity of the models that can be analyzed. An attempt is being made at San Antonio Air Logistics Center (SAALC) to use Guyan Reduction to reduce the number of DOF of a T-37 wing model from 850 to 165 DOF and still keep its accuracy. They are currently having difficulty finding a representative set of nodes that leaves the natural frequencies and static displacements unaltered.

FLEXSTAB

Still another way to solve the flexible wing problem is to use FLEXSTAB, a computer program developed by Boeing. FLEXSTAB was originally designed as a stability analysis package but can also analyze structures. It is currently being used at Nasa-Dryden and Nasa-Wallops. The primary

disadvantage of FLEXSTAB is that it gives only approximations of the stresses and displacements because it uses equivalent beam elements rather than the detailed model.

Via NASTRAN

Captain Lance Chrisinger, in his Master's Thesis at AFIT, had previously done all the preliminary work of comparing these various solution techniques (Ref 3). The problems a solution technique must be able to tolerate in order to effectively solve a flexible wing are: a wide variety of element types, any odd characteristics of typical wing models such as node number resequencing (SEQGP) cards, and large numbers of elements. After looking at these requirements and the characteristics of all the available solution techniques it became apparent that there is a need for yet another solution technique. The solution technique must involve a complete, self-contained computer program. All of these qualities were found in the NASTRAN computer program. The one disadvantage that this program does have is that it is rather large and unwieldy. However, with the recent inclusion of an airload generator, NASTRAN has all the requirements to effectively solve a flexible wing. In addition, Captain Chrisinger built an instruction sequence for solving the flexible wing problem for a simple generic wing box (Ref 3).

III. Theory

There are two approaches to solving flexible wings. Both are based on the same assumptions but differ in methodology. In one scheme iterative passes are made through a sequence of steps while in the other the process is assembled into a single equation to be solved (Ref 2).

Iterative

The iterative solution consists of three parts: a pre-processor to set up the operations, an iterative loop that terminates when a specified tolerance is reached, and a post-processor to recover the output.

Definitions

- * - general matrix multiplier
- U_s - the change in structural deformation
(the first value is the initial structural displacements representing the initial angle-of-attack)
- U_{ST} - The cumulative structural deformation
- Q_s - The change in forces on the structural grid
- Q_{ST} - The cumulative forces on the structural grid
- Q_A - The changes in airloads on the aero grid
- Q_{AT} - The cumulative airloads on the aero grid

Procedure

set U_s = Angle of Attack initial angle of
set U_{st} = - Angle of Attack attack so the
initial angle of
attack will not be
included in summing
the deformations

set Q_{st} = 0

set Q_{AT} = 0

top of loop

$$U_A = G * U_s$$

G - transformation
matrix from struc-
tural displacements
to aero displace-
ments

$$Q_A = A_{AA}^{-1} * U_A$$

A_{AA} - matrix of aero
coefficients

$$Q_s = G' * Q_A$$

G' - transformation
matrix from airloads
on aero grid to
forces on structural
grid

$$U_s = K^{-1} * Q_s$$

K - stiffness matrix
cumulating structur-
al deformation
changes

$$U_{st} = U_{st} + U_s$$

$$Q_{ST} = Q_{ST} + Q_s$$

cumulating changes
in forces on struc-
tural grid

$$Q_{AT} = Q_{AT} + Q_A$$

cumulating changes
in airloads on aero
grid

go to top of loop unless the norm of the change
in structural displacements is less than
the tolerance

output

U_{ST}

Q_{ST}

Q_{AT}

aerodynamic coefficients

Noniterative

The noniterative scheme uses the same assumptions
but it is ordered differently (Ref 2):

Definitions

- * - general matrix multiplier
- K - the stiffness matrix
- U_s - structural deformations
- Q_s - structural forces
- G - the transformation from aero forces to
structural forces and also from structural
deformations to aero deformations
- AOA - initial angle of attack
- U_A - aero deformations

Q_A - aero forces
 CQ_A - coefficients of aero forces
 CP_A - coefficients of aero pressures
 $D1JK$ - matrix of aero coefficients, real
 part of complex aero wash
 $D2JK$ - matrix of aero coefficients, imaginary
 part of complex aero wash
 A_{JJ}^{-1} - matrix of aero influence coefficients
 SKJ - matrix of areas of the wing
 Q - dynamic pressure

Procedure

$$\begin{aligned}
 U_A &= G^T * U_s \\
 CP_A &= A_{JJ}^{-1} * [D1JK + i(D2JK)] * U_A \\
 CQ_A &= SKJ * CP_A \\
 Q_s &= Q * G * CQ_A
 \end{aligned}$$

therefore

$$Q_s = Q * G * SKJ * A_{JJ}^{-1} * [D1JK + i(D2JK)] * G^T * U_s$$

but

$$D2JK = 0 \quad \text{only concerned with static, zero frequency}$$

and

$$F = G * SKJ * A_{JJ}^{-1} * AOA \quad \text{rigid body } Q_s \text{ due to AOA}$$

and

$$FDEF = G * SKJ * A_{JJ}^{-1} * xD1JK * G^T \quad Q_s \text{ due to deformations}$$

therefore

$$Q_s = Q * [(F * AOA) + (FDEF * U_s)]$$

if

$$U_s = K^{-1} * Q_s$$

then

$$U_s = Q * K^{-1} * (AOA * F) + (FDEF * U_s)$$

$$[1 - (Q * K^{-1} * FDEF) * U_s = Q * K^{-1} * F * AOA$$

finally

$$U_s = [1 - (Q * K^{-1} * FDEF)]^{-1} * Q * K * F * AOA$$

The last equation is the one that is used for the noniterative scheme.

Comparison

There are two points to be considered when deciding which solution scheme to use for a particular problem. Both the accuracy and the expense (in terms of time to compute) is discussed. The accuracy of the iterative solution scheme can, at best, equal the accuracy of the noniterative solution. This is because they both make the same approximations but the iterative solution has an additional inherent error. The iterative solution takes a shorter time to assemble and decompose than the noniterative scheme but then also involves the time in going through the iteration loop. The noniterative scheme takes longer to assemble and decompose but once this is done, the equations are solved only once. Therefore, if the time to assemble and decompose the equations for a particular model in the iterative solution is significantly

shorter than that for the noniterative solution, then the iterative solution will take less time. In order for this to work, the assembly and decomposition time for the iterative solution has to be shorter than the noniterative solution by the amount of time it takes for the iterative solution to complete all the iterative passes. Recent experience indicates typically 3-6 passes are required for simple models. For the present work, the iterative scheme has been employed.

IV. Capabilities

The discussion of the capabilities of the current solution technique is broken into two parts. The first gives an outline of the applicable characteristics of NASTRAN. The second describes the capabilities of the instruction sequence.

As outlined in the background section, the primary disadvantage in using a program such as NASTRAN is its large size. Because of this the instruction sequence is more difficult to manipulate. Another disadvantage is that NASTRAN uses only one aero theory, a Doublet-Lattice Method. This theory does not generate any rotational forces; therefore, any bending elements in the model will not have forces along their rotational DOF due to the airloads. Despite these disadvantages, NASTRAN was chosen as a host program because of its several advantages. The most important of these is NASTRAN's ability to tolerate very large problems efficiently. Another major advantage is the wide variety of element types already available in NASTRAN. In addition, many options to the instruction sequence are easily implemented. These three advantages lend a great deal of flexibility to any instruction

sequence implemented with NASTRAN. This is essential when dealing with the wide range and variety of wing characteristics encountered.

This second section outlines the capabilities of the instruction sequence. The ultimate goal for the sequence is to be able to solve for the stresses, displacements, and aerodynamic coefficients of an entire flexible aircraft. Currently, a restricted type of flexible wing can be solved. Provisions have been made to calculate internally all of the transformation matrices and other derived input data. This enables the user to analyze a wing using an existing model with minimum additional input data. The instruction sequence is capable of solving deflected control surfaces as long as the deflections are small enough to stay within linear aero theory. Substructuring has not been attempted while using the instruction sequence. The only wing surface element type that can be used by the instruction sequence is the CQDMEM2 element. Provisions have yet to be made to tolerate grid point number resequencing (SEQGP) cards. Wing-fuselage aerodynamic interaction can be modeled by constructing an aero model of the fuselage near the wing root.

V. Procedure

This section is included in the event that someone with an understanding of the instruction sequence has a desire to use it. Within this section is an overview of additional input data that must be included with a standard model in NASTRAN format. The details of each additional piece of data are covered in Part II.

The instruction sequence requires that two subcases be run. The first subcase generates the initial angle of attack and the second subcase actually goes through the iterations. There are several PARAM cards that must be added. These are concerned with various dimensions of the wing model, the angle of attack, and the error deemed adequate for the iteration convergence. SPC cards are required for both subcases to help determine the AOA and to partition out the rotational DOF of the model. ASET cards are needed to narrow down the analysis set to just the Z DOF of every free node. A CAERO card and its support cards are needed to determine the flight regime. An EIGR card is needed to help set the initial angle of attack. SPLINE and SET cards are needed to build the transformation matrix from the displacements on the structural grid to the displacements and slopes on the aero grid. Finally, a table (TOSEL - Top Surface Element List) must be input in the Bulk Data Deck.

VI. Survey

In order for the instruction sequence to run efficiently with standard wing models their characteristics must be known. To this effect a survey of several wing models in the Air Force inventory was taken. The answers to a list of questions were compiled to determine the characteristics of the average wing model. Though several wings were surveyed, only four will be presented here. These depict typical wing models. The rest are not presented because of repetition.

Characteristics to be Determined

The characteristics investigated were:

1. The number of grid points and DOF. This is an estimate of the size of a typical wing model.
2. Whether the model has leading and/or trailing edge secondary structure. Since the aero and structural models should both have the same planforms structural models without the secondary structure will require modification.
3. If the model has been validated with only the 2-DOF in the analysis set. The model can be validated either by known static deformations or by known natural frequencies. This should have

been done because the current NASTRAN aero theories allow only the Z-DOF in the analysis set (Ref 1).

4. The existence of any stresses, displacements, basic aerodynamic coefficients, and distributions for flight test data and standard computer analysis. This provides a measurement standard for judging the accuracy of results. Computed versions of these items can be generated by the solution sequence to provide accuracy checks at various points in the sequence. The data from a standard computer analysis could be used to check the sequence before it enters the iterative loop. The flight test data provides a check for the final results from the solution sequence.
5. Types of area elements on the wing surface. Currently, only certain element types on the wing surface can be analyzed by the solution sequence.
6. If there are any bending elements in the model. This will affect the validation described in question 3 since the analysis set for the solution sequence is condensed to only translational DOF by Guyan reduction.
7. If there are any SEQGP cards. This would affect the internal equation numbering which in turn affects the calculation of some of the transformation matrices (Ref 1).

8. If the wing model includes wheel wells or other cutouts. This will become significant when aero theories are implemented that panel 3-D structures. The current theory uses 2-D lifting surfaces and is only affected by the curvature of mean camber surface (Ref 1).
9. Is it in NASTRAN format. Considerable time and money can be spent in reformatting data to NASTRAN format.

Characteristics of Wings in Survey

Several wing models were evaluated with respect to the criteria. These models are T-37, T-38, B-1, C-5, and KC-135. Also, a wing model termed the "Eglin Wing" was included in the survey. The four wings presented in detail are the T-37 wing, the T-38 wing, the "Eglin Wing," and the B-1 wing.

The T-37 is illustrated here because it is a typical early subsonic wing type (Fig 1). It only has two spars and a thin skin. Unlike modern fighters, the T-37 wing has a high aspect ratio and a complex wing carry-through connected to the fuselage. This carry-through will present some problems in determining the wing root boundary conditions for this type of wing. The T-37 wing model has 319 grid points with 850 DOF. The model has no leading or trailing edges and, therefore, no control surfaces. This particular wing model has been validated in the Z-DOF only. This is unusual, typically wing models contain rotational



Fig 1. Graphical Description of T-37 Wing Model

DOF. The T-37 wing model is validated under such conditions due to the Guyan Reduction efforts being done at SAALC on the T-37 wing model for the FLEXLOADS program. There is very little flight test data because the T-37 was built when extensive tests on new aircraft were not done. There is some aerodynamic computer analysis for the T-37 wing, primarily by the airloads program called USSAERO. Several types of area elements are used on the wing surface. There are very few bending elements encountered in the T-37 wing model, they are only in the wheel well. The T-37 wing model contains SEQGP cards because the grid numbers are encoded position coordinates. Finally, the T-37 wing model is already in NASTRAN format.

The T-38 wing is a typical modern fighter-type wing having several spars, thick skin, a low aspect ratio and 388 grid points with 1564 DOF (Fig 2). It does have a leading edge structure but no trailing edge because the control surfaces are typically analyzed separately from the wing. The model has not been validated using only the Z-DOF. There are large amounts of flight test data and computer analyses to provide check data for the solution sequence. There are four types of area elements on the wing surface, some of which are plates, and there are additional bending elements within the wing. There are SEQGP cards included in the model. Wheel wells are present in the model but the wheel covers have not been modeled.

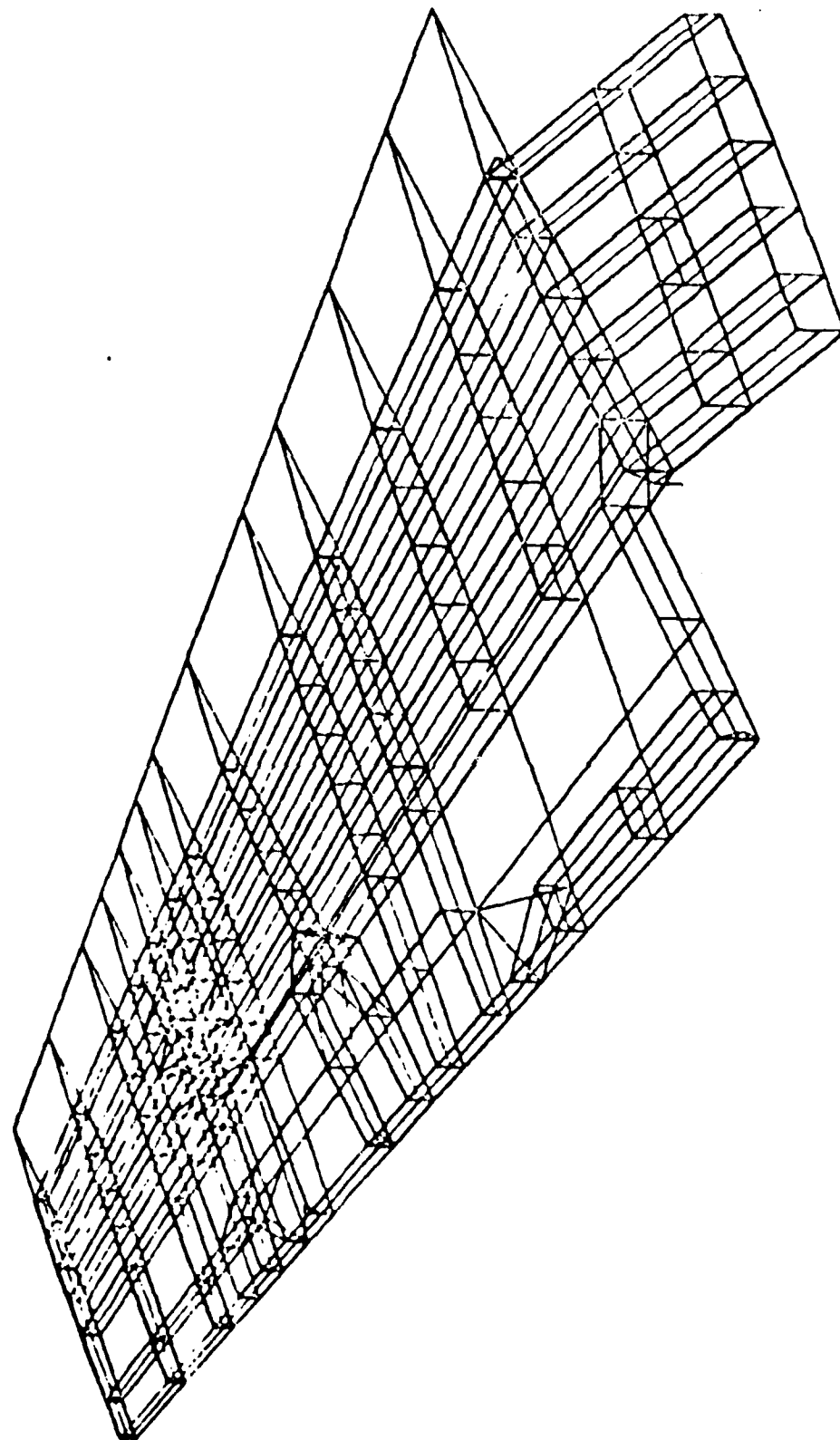


Fig 2. Graphical Description of T-38 Wing Model

Analyzing the wing is simplified by the fact that it is in NASTRAN format and has been analyzed in several static load conditions.

The Eglin Wing is presented because it is a typical damage tolerance wing model (Fig 3). These tend to be more complex because they have to closely trace the stresses throughout the wing. As a result, the Eglin Wing has 542 grid points with 2710 DOF. The model has both leading and trailing edges, the trailing edge consists partly of the control surfaces. It has not been validated with only the Z-DOF. The check data available is a minimum with only a small amount of computer analysis provided. There are several types of area elements on the wing surface in both triangular and quadrilateral shapes. The Eglin Wing does have bending elements. A large number of SEQGP cards are present which will affect the transformation matrices. The model also contains wheel well cutouts whose covers will have to be modeled if a 3-D aero theory is implemented. As with the T-38 wing model, the Eglin Wing is also in NASTRAN format and has been run in several static load cases.

Despite the effects of the wing pivot area, the B-1 wing model is taken as a typical "heavy-aircraft" type wing. These effects do not interfere with the present analysis so swing wing aircraft can also be analyzed. The outboard sections of the wing are fairly typical to other "heavy-aircraft" wings. Because the wing is large and complex, there are a great number of grid points and DOF, 5116 grid points with 24,361 DOF (Fig 4). Fortunately,

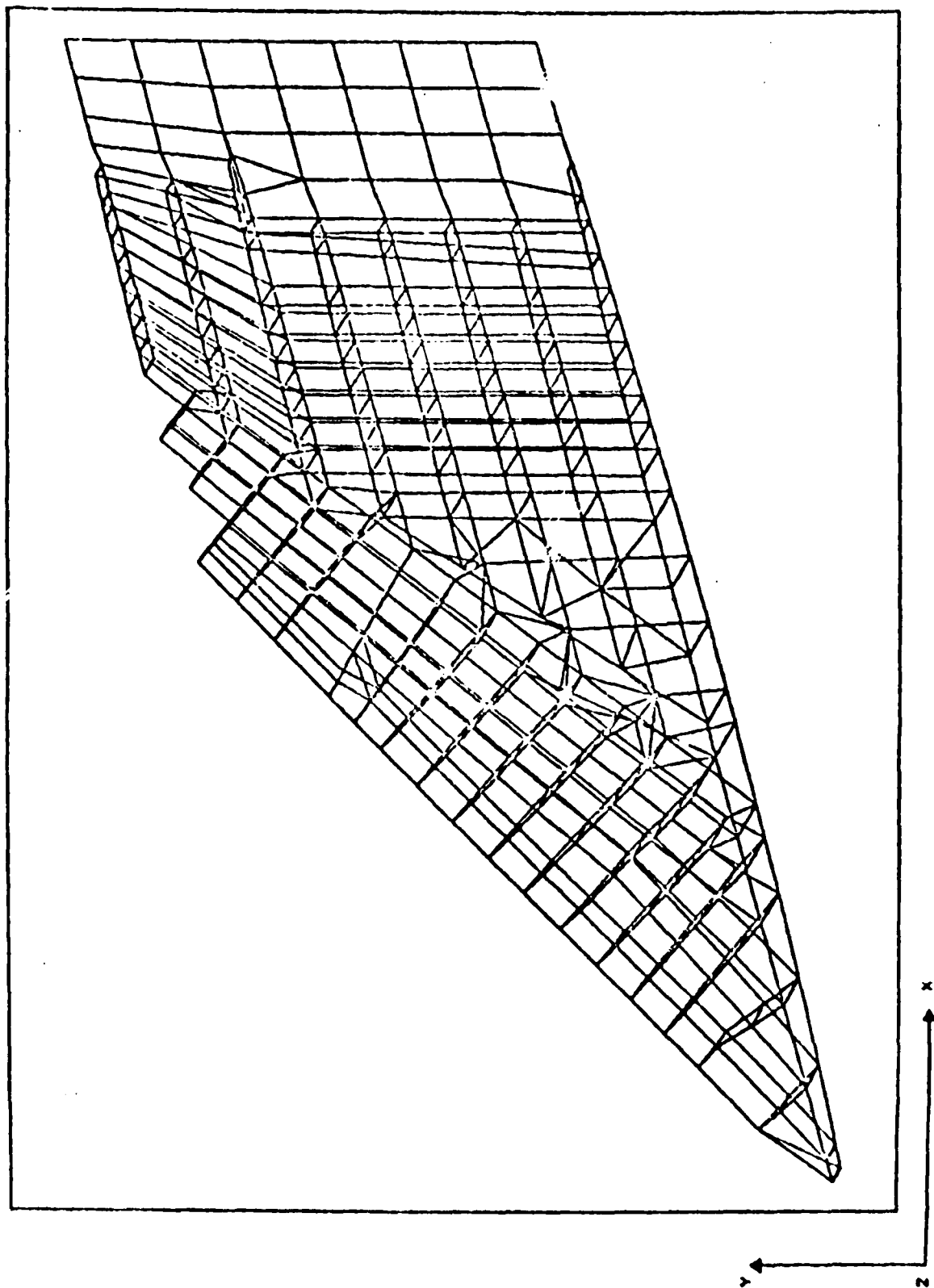


Fig 3a. Graphical Description of "Eglin Wing" Model

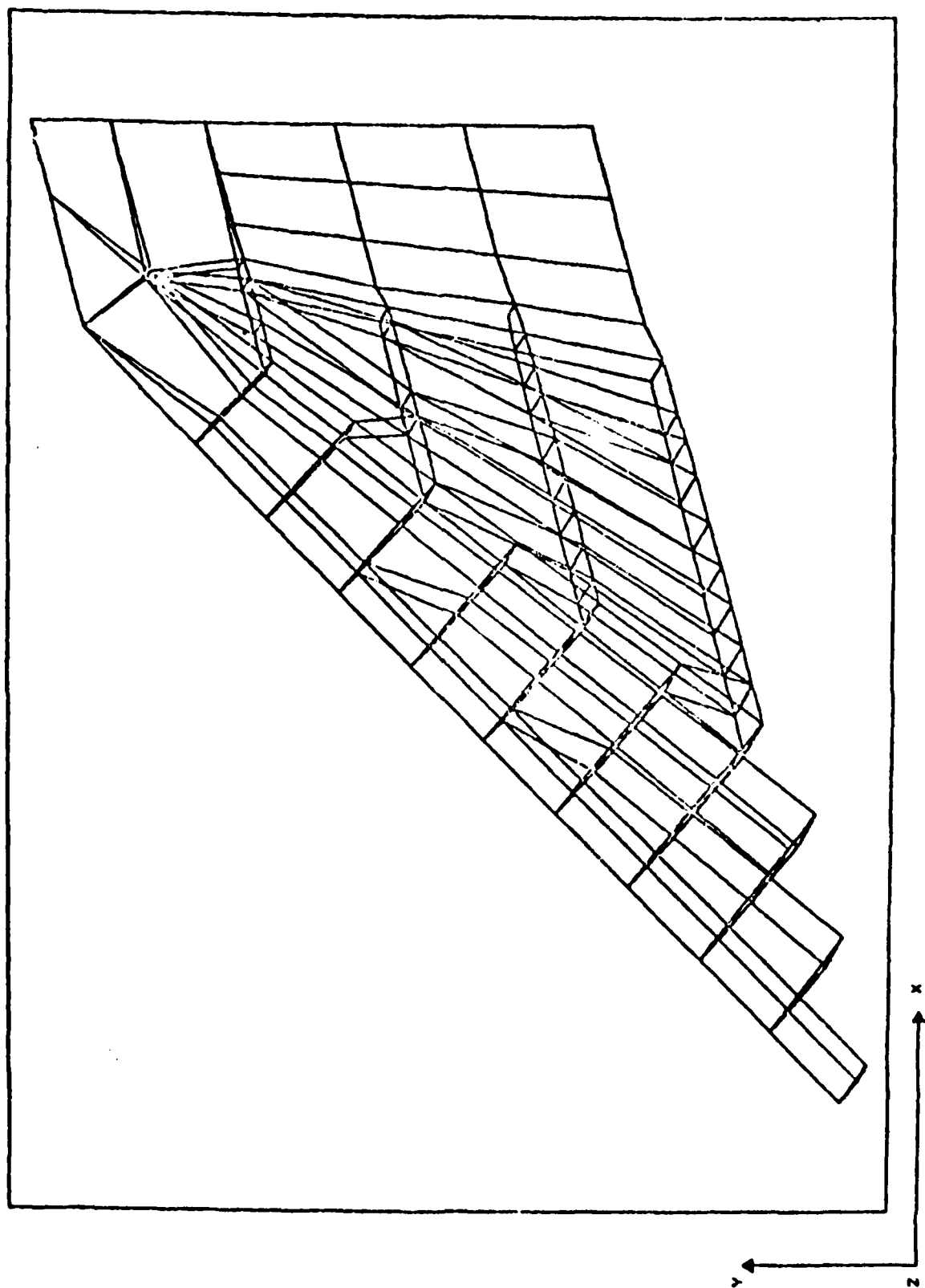


Fig 3b. Graphical Description of "Eglin Wing" Model (wing Tip)

INBOARD WING SUBSTRUCTURE

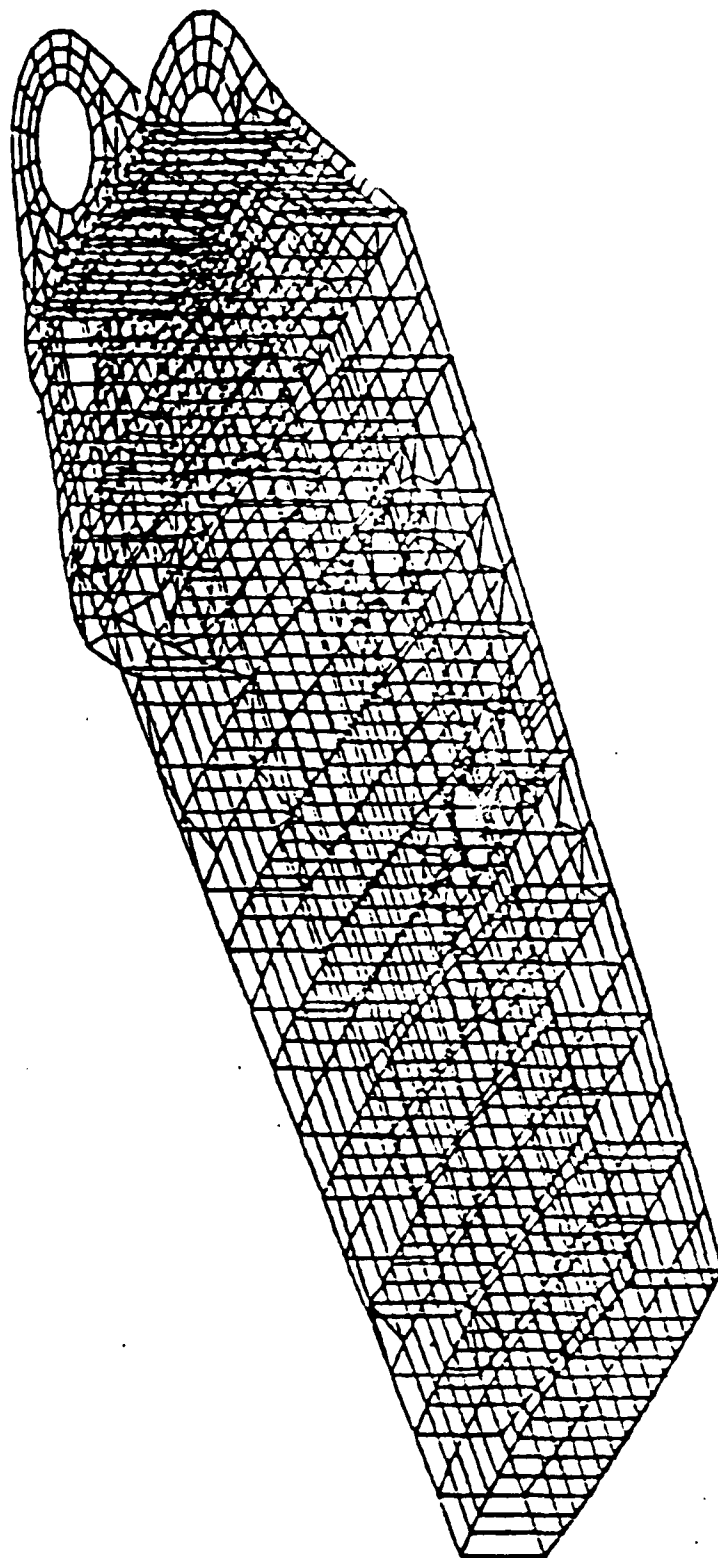


Fig 4a. Graphical Description of B-1 Wing Model (Inboard Substructure)

OUTBOARD WING SUBSTRUCTURE

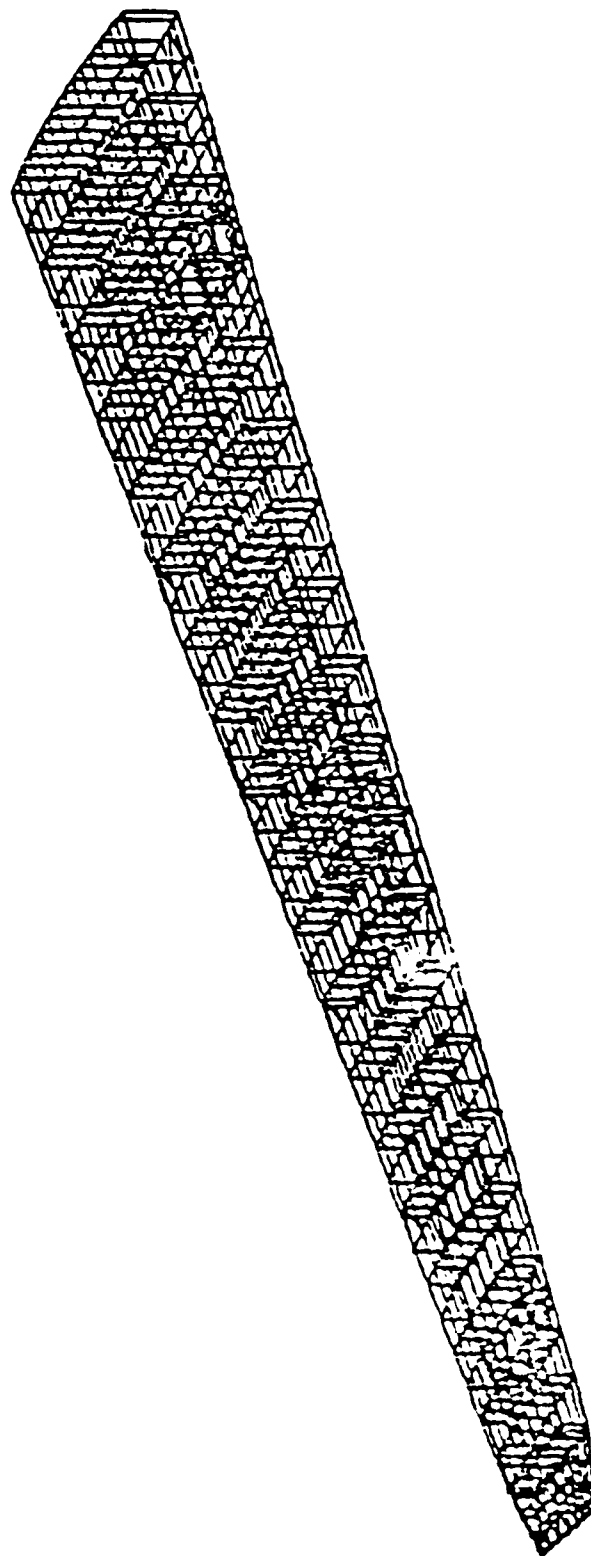


Fig 4b. Graphical Description of B-1 Wing Model (Outboard Substructure)

wings of this size can be analyzed using substructuring. The largest substructure in the B-1 wing model has 1605 grid points and 5479 DOF. This is still large but it is much more manageable than the entire wing. All parts of the wing are represented by the substructuring, including the leading and trailing edges, with the control surfaces. The B-1 wing model has not been validated using only the 2-DOF. There has been a lot of flight test data and computer analysis done on the B-1 wing. There are four types of area elements on the wing surface. The model includes bending elements, but no wheel wells or other cutouts. Since the B-1 model is not in NASTRAN format, SEQGP cards are not applicable.

Effects of Characteristics

Considering the wide range of characteristics of the wings in the survey, it is evident that compromises must be made. While the overriding concern in designing the solution sequence is to make it user-oriented, it is not possible to design the sequence for every characteristic. At times certain models will have to be altered to fit the sequence. The average size of wing models is fairly large and requires the sequence to use computer space efficiently. However, after the usage has been trimmed down as far as possible, there will still be some wing models that will be too large for the computer used. In these cases, either substructuring should be used or the complexity of the model lessened by Guyan Reduction

techniques.

If the structural wing model does not have leading and/or trailing edges, then two courses of action can be taken. One method is to alter the solution sequence to artificially transfer the loads from the leading and trailing edges to the structural wing box. However, this requires large amounts of the user's time. The second course of action would be to put leading edges on the wing model. This is the easier of the two in that, once done, it automates the load transfer from the edges to the wing box.

Since most wing models are not validated in the Z-DOF, there will be some error in using these models. The error can be measured by restricting the model to the Z-DOF, performing the validation procedures, and calculating how far off the model with only Z-DOF is from the actual structure. If the error determined is unacceptable, the model should be adjusted to give accurate values in the Z-DOF. Another course of action can be taken to reduce the error but it requires extensive rebuilding of the solution sequence. The only reason the models put through the solution sequence are reduced to Z-DOF is the aero analysis within the sequence cannot tolerate any displacements except out-of-plane translations. If desired, a different aero theory can be implemented into the solution sequence but it would require many months of effort to rebuild and debug the altered solution sequence.

Most wing models only use three or four area element

types on the wing surface. Given these element types, no problem is encountered with the solution sequence. However, if an element type different from those normally used is put on the wing surface then problems can arise. It is a simple matter to add that element type to the capabilities of the solution sequence, if sufficient knowledge of how the solution sequence works is available. Lacking that, it is advisable not to include the new element type in the wing surface.

Virtually every wing model contains bending elements. As with the validation of the models in the Z-DOF, the restriction of using bending elements in the solution sequence lies within the aero model. The bending elements will not be loaded by the aero forces in the rotational DOF. If the error incurred is unacceptable the recommended solutions are the same, either replace the bending elements or implement a different aero theory.

Most of the large wing models contain SEQGP cards in an effort to improve the bandwidth of the matrices involved. Currently there is no capability to tolerate SEQGP cards in the solution sequence so care should be taken in choosing the form of the input data for the wing model.

Most wing models contain wheel wells or other cutouts. This is not a problem with the present aero theory but it will need to be considered if a different aero theory is implemented. The most obvious solution is to include the wheel covers in the model. This will allow the wheel well

doors to be included as part of the lower wing surface.

A problem not previously mentioned is the aerodynamic interaction between the wing and other aircraft structures. If the wing is modeled alone then these effects are not taken into account. The aircraft structure that most commonly interacts with the wing is the fuselage. If the fuselage tends to be flat and vertical at the wing root, then the centerline symmetry condition of the wing alone will be a reasonable approximation. However, if the fuselage-wing root structure is rounded and smooth then there can be a great deal of crossflow. Other structures, such as engine inlets, engine exhaust, and wing mounted stores, can also affect the airflow across the wing. Wing-fuselage aerodynamic interaction can be modelled by constructing an aero model of the fuselage near the wing root.

The solution sequence can tolerate most of the characteristics of the average wing model. However, further revisions to the sequence would broaden its capabilities and applicability.

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STATIC AEROELASTIC ANALYSIS
OF
FLEXIBLE WINGS
VIA NASTRAN
PART II

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

By

Kim Jones, B.S.A.E.

1Lt

USAF

Graduate Aerospace Engineering

December 1982

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Abstract

This thesis is a continuation of the research done by Captain Lance P. Chrisinger in his M.S. Thesis at AFIT in 1980. Captain Chrisinger developed a basic procedure to enable NASTRAN to analyze flexible wing airloads and stresses. That capability is expanded in this report to enable analysis of standard wing models.

A subroutine was incorporated into NASTRAN to eliminate extensive hand-calculation of transformation matrices.

The capability to tolerate control surfaces was discovered. Also, a survey of wing models in the Air Force inventory was taken to determine the characteristics of the average wing model. This was used to determine where the aeroelastic procedure was lacking in its ability to analyze wing models.

STATIC
AEROELASTIC ANALYSIS
OF
FLEXIBLE WINGS
VIA NASTRAN
PART II

I. Introduction

This part presents a detailed account of the procedures associated with the NASTRAN instruction sequence for flexible wings. However, the presentation presumes a level of knowledge about NASTRAN and its organization. In order to fully understand the majority of this part, the reader must understand the organization of NASTRAN, to include datablocks, modules, links, and overlays. The reader should have taken, or have notes of, a course dealing with NASTRAN System Programming (Refs 3,4).

This part is organized into three sections. The first two describe a recommended procedure for designing and testing a module to be put inside NASTRAN. This will also include, as an example, the module designed to work within the NASTRAN instruction sequence to solve flexible wing problems. These two sections were included to illustrate a set of steps not given elsewhere on designing and testing a NASTRAN module. The third section in this part is a detailed account of how to run this instruction sequence, with an explanation of additions to the Bulk Data Deck.

II. Designing and Testing a NASTRAN Module

The following is a recommended procedure for designing and testing new NASTRAN modules. The procedure carries through from the initial conception of the need for a new module to the final testing of the module once it is inside NASTRAN. The procedure pulls together information from various NASTRAN publications to present a complete, logical sequence of steps to design and implement a module. These steps are designed to insure the most error free module in the least amount of time. These will minimize the debugging required while manipulating the entire NASTRAN package. To do this the module must be tested in an environment as close to NASTRAN as possible before the module is entered into NASTRAN. The recommended steps in designing and testing a NASTRAN module are:

1. Recognition of the Need. In designing a new DMAP sequence or running an extensive DMAP alter the user might recognize that none of the DMAP statements, nor any combination of them, provide him with a procedure he needs. The first thing he must do before considering adding a module is be sure that there is no other way to accomplish the procedure, even by a round-about method. The time and effort required to

design, test, and implement a new NASTRAN module is enough to make it a last resort. If it is at all reasonable to operate without the module then that course of action is recommended. In considering a DMAP to solve his problem the user might compare MSC NASTRAN to COSMIC NASTRAN. The MSC version contains many more modules and might have the proper DMAP modules where the COSMIC version did not.

2. Development of the logic process and recognition of required inputs. These two steps are lumped together because the logic processes inside the module must operate within the NASTRAN environment. Some of the inputs that would be ideal for the procedure might just not be there, or might exist but in a format that will increase the complexity of the module's logic. To determine exactly what is needed by the sequence from the module, and also to check the sequence, run the sequence with the module and its outputs replaced by hand-generated data.

3. Determine where to get the inputs.

There are several ways that inputs are available to a module. They can either be: an existing datablock, a datablock that can be built in the

DMAP before the module is executed using DMAP alters or the data that can be user supplied through PARAM, DTI, or DMI cards. Datablocks can be either matrices or tables. The way the data reaches the module will have an effect on its logic processes and on the amount of user input needed. It is desirable to require as little as possible from the user. This will reduce input errors.

4. Write the module with all of its NASTRAN-necessary parts. NASTRAN uses the Fortran IV computer language. Any limitations with this language must be taken into account when writing the module. The module will be operating in an environment with common statements, open core arrangements, and various other subroutines to which it has access. Depending on the design of the module, the use of these will have to be carefully planned out so as to minimize the module's use of computer time and space. This must be considered because the large variation of problem types encountered will cause the solution sequence to tax the capabilities of most any computer.
5. Build a file of the data the module will receive. This will be the input to a simulated environment built to debug the module as thoroughly as

possible before it is put inside NASTRAN. The content of the data should be from several sample cases to which the correct (or at least expected) answers are known. The form of the data can be up to the user but it should contain all the information that will reach the module, not just what the module will use. The procedures to develop this file are determined by how the module will get the data when it is incorporated into NASTRAN. To get the data that the user will supply to the module when it is incorporated into NASTRAN is relatively simple. Just put the data on the input file as it would appear in the Bulk Data Deck. The other data, those that are generated inside NASTRAN before the module, will require a different approach. A solution sequence nearly identical to the one that will use the module should be run. This solution sequence should not have the call to the module being developed. It is not necessary for the sequence to run until completion. All that is required is to derive the data that the module will use. This data should be punched out of a NASTRAN run onto a file. It is advisable to do this right after the last DMAP statement before the new module is called. It is easier to do this with a DMAP alter. The specific cards that

need to be inserted in the DMAP depends on the form of the data. If the data is in table format use the TABPCH module. If it is in matrix format use MATPUN.

6. Build environment around the module to simulate the NASTRAN environment. Ideally, this should be done with as few changes to the module as possible. The form of the module should be as close as possible to the form it will have when inside NASTRAN. The environment should consist of several subroutines, including the module, with a master sequence of commands whose job it will be to call an initialization subroutine and then the module. The module, in turn, will call utility subroutines. The environment should simulate all the common statements, open core, functions, and subroutines that the module will see while inside NASTRAN. The environment subroutines need not do exactly what the equivalent NASTRAN subroutines do, but they must return the same response to the module. Some of the subroutines the module calls may have to be copied from NASTRAN source code and put into the environment rather than just building similar ones. However, caution should be used in doing this because the subroutines pulled from NASTRAN will

have to have their NASTRAN environments simulated also. Their environments can be as simple as another utility subroutine or they can require an assortment of common statements, open core, functions, and subroutines of their own.

7. Run several test cases to debug the module in the environment. The test cases should use the input data described in Step 5. It is helpful here to put internal check statements within the environment. Perhaps printing out a simple statement telling which subroutine the program is in. The module must be debugged until the environment's output data is exactly what the user wants NASTRAN to see once it finishes executing the module.

8. Put the module inside NASTRAN.

The procedure to do this can be found in the NASTRAN Programmer's Manual, in most any other NASTRAN system programming text or from someone who has done it before and is knowledgeable about the NASTRAN system. The module must be put in a link that will allow it access to the subroutines and common areas the module needs.

9. Run additional tests on installed module until satisfied. These should begin with the same test cases run before, in Step 7. However, it might be a good idea to run additional cases. It could be helpful to have various matrices and tables

printed out at key locations within the DMAP. Of course, to run these cases, the trial DMAP should have been altered to include the call for the module.

III. Example of a New NASTRAN Module, GIAS

This section uses the NASTRAN module GIAS as an example of the procedure to design a module.

GIAS was designed to build various matrices used to solve the flexible wing problem. Beforehand, the matrices were manually calculated and entered into the program via DMI cards. The overriding concept in GIAS is to minimize the work the user must do. As many matrices as possible are built within GIAS. This leaves only one matrix, other than the normal model data, to be built by hand. As development on GIAS continues, this matrix will also be built inside NASTRAN.

The following is a reiteration of the steps necessary to design a module for NASTRAN, with specific application to GIAS.

1. Recognition of need. The solution sequence for solving flexible wings requires several transformation matrices and moment arm vectors. The procedure used to generate these matrices is much too detailed and complex for NASTRAN to accomplish it with DMAP. Therefore, in order to significantly reduce the amount of data to be entered by the user a new module is needed to calculate the extra data.

2&3. Development of logic process, recognition of required inputs and where to get them. Since the object of the module is to reduce the user's work most of the input data to the module already exists in NASTRAN while it is running. At this time there is only one additional table that needs to be input by hand. Those that already exist in NASTRAN are:

SIL - Scalar Index List

BGPA - Basic Grid Point definition table,
Aerodynamics

GPLA - Grid Point List, Aerodynamics

ACPT - Aerodynamic Connection and Property
Table

ECTA - Element Connection Table, Aerodynamics

Descriptions of the existing datablocks can be found in the NASTRAN programmer's manual.

The user-supplied table is:

TOSEL - Top Surface Element List

TOSEL contains a list of area element numbers on the top surface of the wing. The datablock is needed because the loads generated by the aerodynamic model in the solution sequence are only applied to the nodes of the elements listed in TOSEL. TOSEL contains one record for each type of area element on the upper surface.

The records are arranged so that the element type

code numbers are in increasing order. The first entry in each record is the BCD name of that element type. The entries following that, within each record, are the element numbers of that element type on the upper surface in increasing order. TOSEL cannot be derived inside NASTRAN; currently there is no method available to isolate the upper wing surface elements in a general wing model.

4. Write the module with all of its NASTRAN-necessary parts. The entire module is listed in the back of this volume (Appendix A). There are various items that need to be included in the module to allow it to operate within NASTRAN. For GIAS the NASTRAN-necessary parts are:

COMMON statements

COMMON//A - Obtains the variable "A" out of the blank common. "A" is the bottom of blank common.

COMMON/SYSTEM/IBUF - IBUF is the required length of GINO buffers

COMMON/PACKX/TYPIN, TYPOUT, IROW, NROW, INCR - Various parameters for the PACK subroutine

COMMON/ZOPEN/Z(1) - Designates a common area for working

DATA statements

DATA NAME/4HGIAS,4HREAD/ - Assigns a BCD value for NAME, a parameter for the MESSAGE subroutine, an error utility

DATA statements are also used to assign inputs the consecutive numbers 101-106. In addition, data statements are used to assign outputs the consecutive numbers 201-209.

Functions

CORSZ(Z,A) - Determines amount of open core available from the field length specified for the program run

Subroutines

GOPEN - Opens a datablock in order to read from it or write into it

CLOSE - Closes a datablock

READ - Reads from a datablock

PACK - Writes to a datablock

RDTRL - Reads the trailer of a datablock

WRTRL - Writes the trailer of a datablock

MESSAGE - Prints selected fatal errors as they occur

SSPLIN - Produces an interpolation matrix
A more detailed description of the
subroutines can be found in the NASTRAN
Programmer's Manual (Ref 2).

5. Build a computer file of the input data the module will receive. A listing of the input data to the simulated environment for a test case is included in this volume. TABPCH cards were inserted in the solution sequence near line 104; this is where GIAS was later put. Datablocks ACPT, TOSEL, ECTA, GPLA, BGPA, and SIL were output to logical file PUNCH. This file was then manipulated, along with the initialization subroutine (see subroutine INIT, Appendix A), to put these datablocks in a form where the rest of the simulated environment can use them.
6. Simulate the NASTRAN environment. All of the items discussed in Step 4 must be duplicated within the simulated environment. In the simulated environment they do not have to do exactly what the subroutines in NASTRAN do, but they must return the same response to the module being tested. The following are the simulated items in the environment for GIAS; they have the same names as the items in Step 4.

Function CORSZ(Z,A) - Returns a predetermined number to be the size of the Z array.

COMMON/SYSTEM/IBUF - Returns a predetermined arbitrary number to be the size of the buffers, the buffers used in the simulation.

Subroutines

INIT - The initialization subroutine, reads the input file into internal arrays for use by the subroutines READ and RDTRL.

GOPEN - Prints out the statement "Datablock ### opened" to announce the position of the program, but it really does nothing to the datablock.

CLOSE - Prints out the statement "Datablock ### closed" to announce the position of the program, but it really does nothing to the datablock.

READ - Fetches all or part of the datablock contained within a set of arrays prepared by subroutine INIT. It is more complex than an average read statement so it can handle any

errors it encounters, such as being asked to read past an End-of-File or an End-of-Record.

PACK - Prints out the name of the specified datablock along with its values, for inspection but does not create any files.

RDTRL - Reads the trailer of the datablock specified from the set of arrays prepared by INIT.

WRTRL - Prints out the trailer of the datablock specified.

MESSAGE - Prints out the specified error message.

SSPLIN - Produces an interpolation matrix. SSPLIN calls two other utility subroutines, INVERS and GMMATS. These must also be included in the environment. All three of these subroutines had to be copied directly from NASTRAN source code.

7. Run several test cases to debug the module. A simplified wing box was designed and run in NASTRAN using input entered by hand to replace

GIAS. Running several variations of this produced the required check data for the environment.

8. Put the module inside NASTRAN. Because SSPLIN is one of the utility subroutines used, GIAS was put into Link 11 of NASTRAN (Fig 2). The other subroutines needed are also available from this position.
9. Run additional test cases until satisfied. Both the simplified wing box mentioned in Step 7 and an intermediate complexity wing were run as final test cases.

IV. Logical Procedures Within GIAS

It was previously mentioned that GIAS created various transformation matrices and moment arms. This section will look at each of these datablocks and outline the logical procedures used to make them. Several of the procedures overlap within GIAS because several of the output datablocks use the same input.

Output Datablocks

The output datablocks are:

- SAS - A matrix containing ones where areas are in the SKJ matrix
- GTAK - Surface spline interpolation matrix for transformation of ΔP 's at the aero points to ΔP 's at the structural nodes
- TTTTT - Transformation matrix from ΔP 's at the structural points to loads at the structural nodes
- VGLS - A vector with ones in the proper positions so that when multiplied by the structural loads it sums them. VGLS also condenses PG down to nonzero terms.
- VTMA - Contains the moment arms for the aerodynamic pitching moment about the Y-axis.

- VTRA - Contains the moment arms for the aerodynamic rolling moment about the X-axis
- VTM - Contains the moment arms for the pitching moment about the Y-axis due to the transformed structural loads.
- VTR - Contains the moment arms for the rolling moment about the X-axis due to the transformed structural loads.
- AIDMT - Unit vector of length equal to the number of aerodynamic boxes.

Logical Procedures

The first datablocks built in GIAS are TTTT and VGLS. Even though they are built at the same time the logic to build each of them will be considered separately. TTTT transforms the Δp applied to the centroid of each area element on the upper surface of the wing model to loads on the upper surface structural nodes. The first step to do this is to multiply the Δp applied to the element by the area of the element. Using the geometry of the element the load over the element is then correctly partitioned out to each node of the element. The only information needed to calculate TTTT is the coordinates of the structural nodes on the upper surface and which elements they are associated with. Since VGLS is a list of ones in the Z DOF position for each node on the upper surface the only information needed is the upper surface node numbers.

The next datablocks built are VTM and VTR. The moment arms for the structural rolling and pitching moments are simply the coordinates of each upper surface node. This information was obtained when TTTT and VGLS were built.

VTMA and VTRA are built next. The only information needed for these two is the coordinates of the corners of the aero boxes. From these the coordinates of the 1/2-span 1/4-chord point of each aero box is found. This is the point of each box where the lift is assumed to act. The X and Y values of each of these are the entries in VTMA and VTRA, respectively.

All the information needed to calculate GTAK is now available. In order to calculate GTAK the subroutine SSPLIN needs to know the coordinates of the input and output points and how many of each there are. The input points are the points on the aero boxes where the pressure is assumed to act. The output points are the upper surface structural nodes. Because GTAK has to be built all at once, rather than a column at a time like other matrices, this is the procedure in GIAS that takes up the most computer memory. In fact, depending on the problem, this procedure could be the one that governs the amount of computer memory required for the entire analysis.

The last two datablocks built by GIAS are AIDMT and SAS. To build AIDMT only the number of aero boxes is

needed. SAS has ones down two of its diagonals and zeroes elsewhere. It has as many rows as two times the number of aero boxes and as many columns as the number of aero boxes.

V. Running the Flexible Wing Solution Sequence

In order to best use a solution sequence it is advisable to first understand how it works. Therefore, this section first presents a detailed outline of how the solution sequence for flexible wings operates. Afterward, an explanation of the Bulk Data Deck is presented. An example of the input deck is given in Appendix B.

Logical Procedures

The first part of the solution sequence (from now on, called DMAP) sets up the tables that describe the structural model. These include ECT (Element Connection Table) and GPL (Grid Point List). This set of matrices describes the unconstrained structural model. The constraints of the first subcase allow only rigid body pitch about the wing root trailing edge. This will be found in the eigenvalue analysis and used to set the initial angle of attack. The frequency limits of 0.0 to 1.0 on the EIGR card ensure that this is the only eigenvector used. The DOF are then further partitioned down by Guyan Reduction to only the remaining Z DOF since the aero model can only tolerate displacements in the Z-direction. A real eigenvalue analysis is then performed within a small frequency range around zero. The purpose of the analysis is to obtain the mode shape of the rigid body

pitch mode. The Z-displacement of the most in-board leading edge node, not including the wing root, is then normalized to one by selection of "point" on the EIGR card. All displacements are multiplied by a user calculated parameter, AOAP, in order to set the initial angle of attack (Fig 1). This procedure determines the zero-camber initial displacements of all the nodes. The indirect method of determining this is unavoidable because COSMIC NASTRAN has no module, or simple sequence of modules, that will do this. Camber is added to the wing, if desired, by using a parameter ICAMB and a matrix CAMBER. After this, various transformation matrices are built. The first one created is GTKA, which is built using the Bulk Data SPLINE cards. This will be used to transform the displacements of the structural model to values of slope on the aero model. These values will then be used by the aero analysis portion to specify the strengths of the downwash vector, DIJK or D2JK. This vector is then multiplied by the aero influence matrix for the Doublet-Lattice aero method, AJL^{-1} to determine the ΔC_p distribution on the aero model. Following the calculation of GTKA the module GIAS is called to determine other transformation matrices and moment arms. This ends the first subcase of the DMAP.

The second subcase is distinguished from the first by a change of SPC cards. The structural model is reconstrained to allow no rigid body motion. None of the nodes on the wing root have any active DOF; all the other

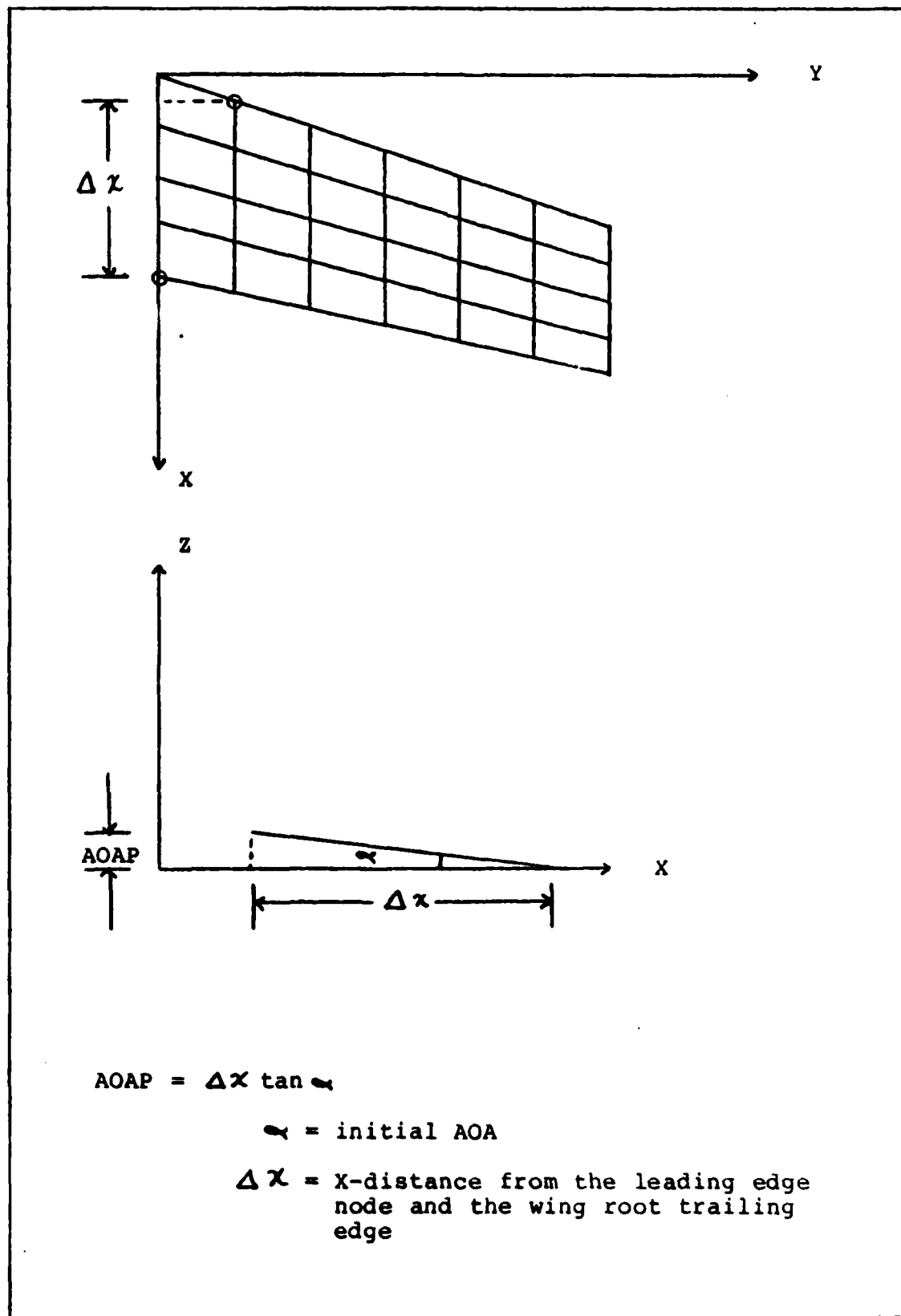


Fig 2. Determining AOAP

nodes are limited to only translational DOF. These nodes are then further reduced to only the Z DOF by ASET cards. This procedure locks the wing root at the initial AOA as determined by the eigenvalue analysis and AOAP. Then the matrices necessary for static deflection analysis are determined for this configuration. This analysis is then performed to determine the structural loads due to the initial AOA.

The next section is the most significant one of the DMAP. The iterative loop calculates the displacements, structural loads, and aero forces due to the structural deformations. Then the structural deformation due to the new airloads are calculated. The loop begins by finding the change in structural deformations due to the airload vector. On the first iteration the load vector is due to the initial AOA. On subsequent iterations it is due to the change in structural deformations. Then the incremental deformations are transformed to slopes on the aero model using the GTAK generated from the Bulk Data SPLINE cards. These slopes are used to determine incremental ΔC_p . The incremental ΔC_p are transformed to an incremental load vector which is used in the next iterative pass through the loop. This is accomplished by premultiplying the ΔC_p vector by GTAK and then by TTTTT. At the end of each increment the changes in deformations, structural loads, and aero forces are accumulated. The loop is finally left when the norm of incremental displacements (VNSR) is less

than the user supplied parameter ELOOP, or a total of ten incremental passes have been made. The loop gives the final values for the structural deformations, structural forces, and ΔC_p vector.

The DMAP then recovers the complete solution for both the analysis set and the omitted DOF. A complete stress recovery for all the structural elements can be done if requested by the user. The final section of the DMAP determines C_L , C_{np} , C_{nr} due to both the final aero forces and the final structural loads. Both sets are calculated to provide a means of checking the accuracy of the force transformations between the aero and structural models.

Implementation

In addition to the usual model used in structural analysis there are a few more cards, and one additional datablock, needed to run the DMAP. The extra datablock is TOSEL and is entered via DTI cards. TOSEL is the table of area element numbers on the upper wing surface. The records in TOSEL are organized according to element BCD names. A more detailed explanation of TOSEL is presented in Section III of this volume. The additional cards needed are (Ref 1):

- ASET1 - Defines the DOF in the analysis set. For the DMAP the analysis set should consist of only the Z-DOF for every non-wing-root node.
- CAERO1 - Divides the aero panels into equal boxes for the Doublet-Lattice aero theory. The param-

eters on this card are determined by the wing planform and the user's needs.

- AEFACT - Divides the aero panels into unequal boxes, used in conjunction with the CAERO1 card.
- PAERO1 - Defines associated bodies for the CAERO1 card.
- EIGR - Lists parameters for the real eigenvalue analysis. The frequency range of interest should be from 0.0 to 1.0 in order to include only the rigid body pitch mode. There is only one estimated and desired root in the frequency range. The eigenvector should be point normalized on the Z-displacement of the most in-board leading edge node, not including the wing root.
- AERO - Defines the basic aero parameters. The DMAP uses the parameter Q, the dynamic pressure, and the mach number from the MKAERO card instead of the parameters on the AERO card. Therefore the values on the aero card do not matter, but they have to be positive to allow the DMAP to complete the processing of the AERO card.
- MKAERO - Defines the mach number and reduced frequency for the desired flight condition. In the DMAP only one mach number and reduced frequency are allowed. The mach

number should be subsonic and representative of the desired flight condition. The reduced frequency should be a positive number very close to zero.

SPLINE1 - Defines the parameters for generation of a surface spline to interpolate the out-of-plane displacements on the structural model to out-of-plane displacements and slopes on the aero model. The **SPLINE1** card is used in exactly the same way as it is in the flutter analysis rigid format.

SET1 - List of structural grid points to be used with the **SPLINE1** card. Normally the list is only the nodes on the upper surface.

PARAM cards

AOAP - Used to set initial AOA. Real number. It multiplies the rigid body pitch mode eigenvector after the point normalization is done as specified on the **EIGR** card.

ELOOP - Tolerance of convergence for the iterative loop. It is compared to the norm of the change of deformations for each iteration. Real number.

LMODES - Number of modes to be used in the modal flutter formulation. Since

the only desired mode is the rigid body pitch mode LMODES is one.

LMODES is normally used when several eigenvectors are considered in a flutter analysis. In these cases the different eigenvectors are arranged as columns in a forcing vector for determination of modal pressures.

LMODES would then be the number of columns. LMODE is a real number.

- Q - Dynamic pressure. Must correspond to the desired flight condition.
Real number.
- RC - Root chord length. Used in formulating aerodynamic coefficients.
Real number.
- WAREA - Planform area of the model. Used in calculating aerodynamic coefficients. Real number.

As an option, camber can be added to the wing. If camber is required then an additional PARAM card should set ICAMB = 1. Also, the CAMBER vector must be input via DMI cards. CAMBER is as long as the number of corners on the aero boxes. If two or more aero panels are used then the common nodes on both panels are counted twice. The values

that are in CAMBER are the Z displacement of each aero box corner due to the camber of the airfoil. In addition, any control surface deflection can be treated as if it were a change in camber.

Finally, in order to run this DMAP for aeroelastic analysis of flexible wings, the case control and executive card decks must be formulated. The executive card deck must reflect the fact that a DMAP is being run rather than a rigid format. The case control deck notes the set identification number of the EIGR card in the Bulk Data Deck. The case control lists the two subcases and the SPC identification numbers for each. In addition, output requests as needed are specified in the case control. The values of the first subcase correspond to the initial pitch configuration; those of the second subcase are a final result of the iteration loop. All the available output requests for the static loads analysis rigid format are also available for the DMAP.

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Vita

Kim Jones was born on 28 February 1958 in Weisbaden, Germany. He graduated from high school in Clearwater, Florida in 1976 and was subsequently accepted into the Air Force Academy. A year after receiving a Bachelor of Science Degree in Aeronautical Engineering, he entered the School of Engineering, Air Force Institute of Technology, in June 1981.

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Appendix A

LOAD MAP - CIASCHV

PLA OF THE LOAD 111
LWA+1 OF THE LOAD 33330

TRANSFER ADDRESS -- CIASCHK 15310

PROGRAM ENTRY POINTS -- CIASCHK 15310

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCESSR VER LEVEL	HARDWARE	COMMENTS
/ZOPEN/	111	4704					
/ZSIZE/	5015	1					
CIASCHK	5016	10301	LGO	11/12/82 PTM	4.8 564	666X I	PROGRAM OPT-1
/SYSTEM/	15317	1					
/PACKX/	15320	5					
CIAS	15325	1725	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
/ZDATA/	17252	1024					
/DTRAIL/	20276	44					
INIT	20342	1522	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
MESSAGE	22064	50	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
SSPLIN	22134	704	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
CHMATS	23040	215	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
INVERS	23255	340	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
CORSZ	23615	11	LGO	11/12/82 PTM	4.8 564	666X I	FUNCTION OPT-1
COPIEN	23626	20	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
CLOSF	23646	20	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
PACK	23666	114	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
PDTRL	24002	73	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
K: -TFL	24075	41	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1
READ	24136	310	LGO	11/12/82 PTM	4.8 564	666X I	SUBROUTINEOPT-1

THE REST OF THE LOADER MAP IS NONAPPLICABLE

```

1      PROGRAM GIASCHE 74/74 OPT=1
      PROGRAM GIASCHE(INPUT,OUTPUT,TAPE5,TAPE6)
      COMMON/ZOPEN/7(2500)
      COMMON/FSIZE/SIZE
      SIZE=2500
      : CALL INIT
      : CALL GIAS
      STOP
      END
    
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
10272 GIASCHE

VARIABLES	SN	TYPE	RELOCATION	ZSIZE	O	Z	REAL	ARRAY	ZOPEN
FILE NAMES		MODE	2054	OUTPUT			4130	TAPE5	6204
EXTERNALS		TYPE	ARCS				INIT		
GIAS			0						

COMMON BLOCKS

ZOPEN	LENGTH
2500	1

STATISTICS

PROGRAM LENGTH	2648	180
BUFFER LENGTH	10015R	4109
CM LARFED COMMON LENGTH	4705R	2501

52000R CM USED

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SUBROUTINE CIAS
CIAS ACPT,TOSEL,ECTA,CPLA,BCPA,SIL/SAS,CTAK,TTTT,
VCLS,VTHA,VTRA,VTH,VTR,AIDMT/S
INTEGER SAS,CTAK,TTTT,VCLS,VTHA,VTH,VTRA,VTRA,AIDMT
INTEGER ACPT,TOSEL,ECTA,CPLA,BCPA,BUF1,BUF2,BUF3,CORSZ
INTEGER TRAIL,MCBA,MCBN,TYPIN,TYPOT,SIL,IZ
REAL Z
DIMENSION TRAIL(7),MCBA(7),MCBN(7),NAME(2),IZ(1)
EQUIVALENCE (IZ(1),Z(1))
COMMON //A
COMMON /SYSTEM/IRUP
COMMON /PACKX/TYPIN,TYPOT,IRON,NROW,INCR
COMMON /ZOPEN/Z(1)
STRING FOR MESSAGE UTILITY
DATA NAMEZ/ANGIAS,AREAD/
INPUT DATA BLOCKS LOCAL NAMES
DATA ACPT,TOSEL,ECTA,CPLA,BCPA,SIL/101,102,103,104,105,106/
OUTPUT DATA BLOCKS LOCAL NAMES
DATA SAS,CTAK,TTTT,VCLS,VTHA,VTRA,VTH,VTR,AIDMT/
*201,202,203,204,205,206,207,208,209/
INCR=1
GET END OF OPEN CORE
LCORE=CORSZ(Z,A)
SET UP A BUFFER FOR USE WITH COPEN AND READ
BUF1=LCORE-IRUP+1
IF (BUF1.LE.0) GO TO 500
AN "N" IS BEFORE THE DATA BLOCK NAME SPECIFIES THE FIRST
ADDRESS OF THE BLOCK IN OPEN CORE
AN "L" BEFORE THE DATA BLOCK NAME SPECIFIES A PARAMETER
WHICH IS THE LENGTH OF THE DATA BLOCK IN OPEN CORE
DATA BLOCK ACPT WILL BE FIRST IN OPEN CORE
MACPT=1
OPEN 'AERODYNAMIC CONNECTION AND PROPERTY TABLE'
CALL COPEN(ACPT,Z(BUF1),0)
GET 5+2*NP WORDS OF ACPT
WORD 1 IF: 1 - DLM (DOUBLET-LATTICE METHOD)
2 - STRIP THEORY
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FTN 4.F+544

74/74 CPT-1

SUBROUTINE CIAS

```

60      CALL READ(ACPT,Z(MACPT),3*2*NP,1,M)
      NI IS THE NUMBER OF AERO BOXES AND 1/4 CHORD, 1/2 SPAN AERO POINTS
      NI=12/(MACPT+1)
      CCC
      CLOSE ACCESS TO ACPT, BUT KEEP WHAT'S IN OPEN CORE ALREADY
      CALL CLOSE(ACPT,1)
      CCC
      FETCH TRAILER TO TOSEL (TOP SURFACE ELEMENT LIST) USER SUPPLIED
      ON DTI CARDS
      CCC
      TRAIL(1)=TOSEL
      CALL RDTRL(TRAIL)
      TRAILER OF TOSEL CONTAINS:
      CCC
      WORD 1 CINO DB NAME
      WORD 2 # OF ENTRIES IN TOSEL
      CCC
      WORD 3 0
      WORD 4 0
      WORD 5 0
      WORD 6 0
      CCC
      ND IS THE NUMBER OF STRUCTURAL ELEMENTS LOADED AND ALSO
      THE NUMBER OF DEPENDENT STRUCTURAL POINTS WHEN UNIFORM PRESSURE IS
      ASSUMED OVER STRUCTURAL BOXES
      CCC
      LATER ON (AFTER BUGS ARE ironed OUT) WILL READ TOSEL UNTIL #MEL
      THEN SAY ND=M
      CCC
      IT'S ALSO THE SIZE OF TOSEL
      ND=TRAIL(2)
      NTOSL=MACPT+3*2*NP
      READS IN ALL OF TOSEL
      REUSES 1ST BUFFER
      CCC
      CALL COPEN(TOSEL,Z(BUFI),0)
      CALL READ (TOSEL,Z(MTOSEL),ND,1,M)
      CALL CLOSE(TOSEL,1)
      GETS SIZE OF CPLA
      CCC
      CPLA (GRID POINT LIST-AERODYNAMIC)
      TRAIL(1)=CPLA
      CALL RDTRL(TRAIL)
      WORD 2 = # OF GRID POINTS + # OF SCALAR POINT (ASSUMED=0, + # OF
      EXTRA POINTS (ASSUMED=0) + # OF AERO POINTS
      CCC
      LCPLA=TRAIL(2)
      LSCPLA=4*LCPLA BECAUSE THERE ARE 4 WORDS PER POINT (WORD 1 = 1D#,
      WORDS 2,3,4 = X,Y,Z)
      CCC
      NGPA = BASIC GRID POINT DEFINITION TABLE - AERODYNAMIC
      INCPA=4*LCPLA
      READ IN ALL OF CPLA TO GET 1D#'S OF POINTS
      CALL COPEN(CPLA,Z(BUFI),0)
      NGPLA=NTOSL+ND
      CALL READ(CPLA,Z(NGCPLA),LCPLA,1,M)
      CALL CLOSE(CPLA,1)
      NGCPA=NGPLA+LCPLA
      NCORF=BUFI-1
      CHECK TO SEE IF ENOUGH OPEN CORE IS AVAILABLE
      IF(NCORE.LT.(NGCPA+LSCPLA)) GO TO 506
      READ IN ALL OF NGPA TO GET COORDINATES OF POINTS
      CALL COPEN(NGPA,Z(BUFI),0)
      CALL READ(NGPA,Z(NGNGPA),LSCPLA,1,M)
      CALL CLOSE(NGPA,1)
      ICQWEN=5304 IS THE INTERNAL IDENTIFIER OF CONWEN2 ELEMENTS
      CCC

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FTN 4.R+564

74/74 OPT-1

SUBROUTINE GIAS

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115 CCC THE FOLLOWING 6 STATEMENTS LOCATE THE RECORD FOR THESE
CCC ELEMENTS IN THE ECTA TABLE
CCC OPENS ECTA FOR READING
CCC ECTA = ELEMENTY CONNECTION TABLE - APRODYNAMIC
CCC CALL COPEN(ECTA,Z(BUFI),0)
120 CCC FROM HERE UNTIL STATEMENT LABEL 2 NON-CQDNEM2
CCC ELEMENTS ARE SCREENED OUT, THE RECORD CONTAINING ALL
CCC THE CQDNEM2 ELEMENTS IS LOCATED AND POSITIONED FOR READING
CCC ICQNM=5308
125 CCC ECTA=NBGPA+LNGPA
1 IF (12(NECTA).EQ.12(NECTA),3,0,M)
1 IF (12(NECTA).EQ.ICQNM) GO TO 2
CCC IF 4TH ARGUMENT OF READ EQUALS ONE THEN SKIP TO END OF RECORD
CCC WITHOUT TRANSFER OF DATA
CCC CALL READ(ECTA,12(NECTA),0,1,M)
130 CCC IF M NOT EQUAL TO ZERO THEN WE HAVE HIT THE END OF THE RECORD
CCC A FATAL ERROR
CCC IF (M.NE.0)GOTO 500
CCC GO TO NEXT RECORD LOOKING FOR CQDNEM2
CCC GO TO 1
135 CCC SET HERE WHEN CQDNEM2 RECORD IS FOUND
CCC SIL IS THE SCALAR INDEX LIST (SIMILAR TO AN ID ARRAY)
2 TRAIL(1)=SIL
CCC CALL NDTRL(TRAIL)
140 CCC SIZE OF SIL = NDOP+1
CCC NDOP=TRAIL(3)
CCC MCP=TRAIL(2)
145 CCC IF (MCP.NE.NDOP/6) GOTO 500
CCC OPEN 1 MORE GIMO BUFFER, TTTT MUST BE OPEN FOR
CCC WRITING WHILE ECTA IS OPEN FOR READING
RUF2=BUFI+1BUF
CCC MCORE=BUF2-1
CCC BECAUSE THERE ARE 7 WORDS PER CURRENT CQDNEM2 ELEMENT
CCC ONLY KEEP 7 WORDS OF CURRENT ECTA RECORD IN CORE AT A TIME
LECTA=7
CCC CHECK FOR ENOUGH SPACE IN GIMO TO PUT 2 BUFFERS
150 CCC IF (MCORE.LT.NECTA+LECTA) GOTO 500
CCC THE NEXT SEVERAL LINES DETERMINE THE POSITION AND
CCC SIZE OF VARIOUS ARRAYS TO BE PLACED IN OPEN CORE
CCC
155 CCC ND = # OF OUTPUT POINTS FOR SUBROUTINE SPLINE (IN THIS
CCC CASE IT ALSO HAPPENS TO BE THE # OF ELEMENTS ON THE UPPER SURFACE.)
CCC LND=2*ND
CCC NND=NECTA+LECTA
CCC NTEX=ND*LND
160 CCC TEX IS MCP-BY-1 CONTAINS X COORDS OF GRID POINTS
CCC TEY IS MCP-BY-1 CONTAINS Y COORDS OF GRID POINTS
CCC ONE WORD FOR ALL GRID POINTS IS ALLOCATED, WHEN GOING THROUGH
CCC TOSOL (LIST OF TOP SURFACE ELEMENTS) UPPER SURFACE NODE COORD
CCC WILL BE FILLED IN, LEAVING THE REST FILLED WITH THE FLAG VALUE.
CCC THEN, LATER ON, ONLY THE UPPER SURFACE NODES WILL BE PUT INTO
CCC TEAR AND TEYR
165 CCC LTEX=MCP
CCC NTEY=NTEX+LTEX
CCC LTFY=MCP
170 CCC NTTTT=NTEY+LTFY
CCC LTTTT=NDOP

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175  CCC      TTTT IS NDOF-NY-ND BUT ONLY ONE COLUMN IS BUILT AND PACKED
176  CCC      OUT AT A TIME. IN A COLUMN. PUT (1/4)AREA AT EACH UPPER SURFACE
177  CCC      ELEMENT'S TO ROW. THIS APPORTIONS 1/4 OF TOTAL ELEMENT
178  CCC      LOAD TO EACH CORNER NODE. NOTE! THIS ASSUMES APPROXIMATELY
179  CCC      SQUARE ELEMENTS.
180  CCC      NVCLS=NTTT+LTTTT
181  CCC      LVCLS=NDOF
182  CCC      ICOREM=NVCLS+LVCLS
183  CCC      CHECK FOR ENOUGH SPACE IN GINO TO PUT THE ABOVE ARRAYS
184  CCC      IF(INCORE.LT.ICOREN) GO TO 500
185  CCC      FLAG=-10000.0
186  CCC      FROM HERE TO STATEMENT LABEL 7 ARRAYS NTEX,NTEY
187  CCC      AND,NVCLS ARE INITIALIZED
188  CCC
189  CCC      VCLS IS NDOF-NY-ONE VECTOR TO PUT INTO PG TO GET TOTAL LEFT.
190  CCC      IT IS ALSO USED TO PARTITION PCT.
191  CCC      IT CONTAINS A 1.0 IN EACH UPPER SURFACE NODE TO DOF
192  CCC
193  CCC      NTEX AND NTEY ARE INITIALIZED TO FLAG IN ORDER TO LATER ON
194  CCC      SPOT ANY VALUES IN THEM THAT HAVE NOT BEEN USED
195  CCC      USED ITEMS HAD BETTER BE UPPER SURFACE NODES FROM CONNECTIVITIES
196  CCC      OF TOSEL CODMEM2'S
197  CCC      DO 9 J=1,NDOF
198  CCC      Z(NTEX+J-1)=FLAG
199  CCC      Z(NTEY+J-1)=FLAG
200  CCC      9 CONTINUE
201  CCC      DO 7 J=1,LVCLS
202  CCC      Z(NVCLS+J-1)=0.0
203  CCC      7 CONTINUE
204  CCC      CALL COPEN(TTTT,ZCNUF2),1)
205  CCC      SPECIFIES CHARACTERISTICS OF ARRAYS FOR PACK SUBROUTINE
206  CCC      REAL SINGLE PRECISION INPUT FROM Z ARRAY
207  CCC      TYPIM=1
208  CCC      REAL SINGLE PRECISION OUTPUT TO DATA BLOCK
209  CCC      TYPOT=1
210  CCC      INITIAL ROW POSITION
211  CCC      IRON=1
212  CCC      NROW WILL BE RESET PRIOR TO EACH CALL TO PACK SINCE MULTIPLE
213  CCC      MCR'S ARE MATRIX CONTROL BLOCKS FOR PACK ROUTINES
214  CCC      THEY WILL BE TRAILERS WHEN FINISHED, CONTENT IS THAT OF TRAILER
215  CCC      WORD 1 - GINO DR NAME
216  CCC      WORD 2 - # OF COLUMNS, ZERO INITIALLY, ACCUMULATED BY PACK
217  CCC      WORD 3 - # OF ROWS
218  CCC      WORD 4 - MATRIX SHAPE
219  CCC      WORD 5 - PRECISION 1 - REAL SINGLE PRECISION
220  CCC      WORD 6 - MAXIMUM DISTANCE BETWEEN NONZERO TERMS
221  CCC      WORD 7 - DENSITY
222  CCC      TRAILER FOR TTTT (TTTT SHOULD BE A NDOF*1 ARRAY)
223  CCC      MCR(1)=TTTT
224  CCC      MCR(2)=0
225  CCC      MCR(3)=LTTTT
226  CCC      MCR(4)=2
227  CCC      MCR(5)=1
228  CCC      MCR(6)=0
229  CCC      MCR(7)=0
230  CCC      LOOP 1 CALCULATES THE FOLLOWING DATA BLOCKS
231  CCC      TTTT,VCLS

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230 CCC DO OVER ALL ELEMENTS OF TOSL. DO LENGTH SHOULD BE SIZE OF
    CCC TOSL (NOT # OF SPLINE OUTPUT POINTS)
    DO 3 1-1,ND
    CCC READS IN ONE CQDHEM2 ELEMENT AT A TIME FROM ECTA
    CALL READ(ECTA,Z(NECTA),7,0,M)
    CCC MAKE SURE THE CQDHEM2 ELEMENTS PRESENTED BY TOSL
    ARE IN ASCENDING CONSECUTIVE ORDER OR THE FOLLOWING MESSES UP
    CCC
    CCC IF THIS CQDHEM2 IS NOT ON THE UPPER SURFACE TRY THE NEXT ONE
    CCC CONTEXT OF THE 7 WORDS PER CQDHEM2 ELEMENT IS
    WORD 1 - EID, ELEMENT NUMBER
    WORD 2 - PID, PROPERTY ID
    WORDS 3,4,5,6 - CORNER NODE #'S
    WORD 7 - TH, MATERIAL ORIENTATION ANGLE.
    FROM HERE TO LABEL 3 IS DONE ONCE FOR EACH CQDHEM2 ON THE UPPER
    CCC SURFACE
    IF(12(NECTA)-NE-12(NTOSL+1-1)) GO TO 4
    CCC CORNER NODE # FOR EACH CQDHEM2 ELEMENT
    IC1-12(NECTA+2)
    IC2-12(NECTA+3)
    IC3-12(NECTA+4)
    IC4-12(NECTA+5)
    240 CCC LATER ON (RIGHT AFTER LOOP 6) THE BCPA POINTERS (ICP#) ARE
    CCC CHECKED. IF THEY HAVEN'T CHANGED FROM ZERO THEN THE NODE
    CCC ISN'T IN BCPA, A BIG ERROR
    ICP1=0
    ICP2=0
    ICP3=0
    ICP4=0
    245 CCC LOCATES APPROPRIATE NODES IN GPLA
    CCC SEARCH GPLA - LIST OF ALL GRID POINT IDENTIFIERS FOR EACH
    CCC CORNER NODE. THE POSITION IN GPLA IS THE POINTER TO THE
    CCC ID, X, Y, Z OF THE NODE IN BCPA
    DO 6 J=1,LCPLA
    K=NCPLA+J-1
    IF(12(NECTA)-12(K)) IC1=NRGPA+(J-1)*4
    IF(12(NECTA)-12(K)) IC2=NRGPA+(J-1)*4
    IF(12(NECTA)-12(K)) IC3=NRGPA+(J-1)*4
    IF(12(NECTA)-12(K)) IC4=NRGPA+(J-1)*4
    250 CCC CONTINUE
    CCC IF NODE IN ECTA IS NOT IN GPLA, THE WORLD IS UPSIDE DOWN!
    IF(12(NECTA)-12(K)) GO TO 500
    IF(12(NECTA)-12(K)) GO TO 500
    IF(12(NECTA)-12(K)) GO TO 500
    IF(12(NECTA)-12(K)) GO TO 500
    255 CCC PUTS 1.0 INTO EACH UPPER SURFACE NODE Z DOF INTO VGLS
    Z(NVGLS+6*IC1-4)=1.0
    Z(NVGLS+6*IC2-4)=1.0
    Z(NVGLS+6*IC3-4)=1.0
    Z(NVGLS+6*IC4-4)=1.0
    260 CCC GET X,Y COORDS OF CORNER NODES FROM BCPA
    X1=Z(12(NECTA)+1)
    Y1=Z(12(NECTA)+2)
    X2=Z(12(NECTA)+3)
    Y2=Z(12(NECTA)+4)
    X3=Z(12(NECTA)+5)
    Y3=Z(12(NECTA)+6)
    265
    270
    275
    280
    285

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FTN 4.8+564

74/74 OPT-1

SUBROUTINE GIAS

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      X4=Z(IGP4+1)
      Y4=Z(IGP4+2)
      CCC  CENTROIDAL COORDINATES OF QUAD
      CCC  THE SPLINE OUTPUT POINTS
      Z(NNH+2*1-2)=(X1+X2+X3+X4)/4.
      Z(NHD+2*1-1)=(Y1+Y2+Y3+Y4)/4.
      CCC  AREA OF ELEMENT
      AREA=.5*(X3-X1)*(Y4-Y2)-(Y3-Y1)*(X4-X2))
      CCC  ZEROS OUT THE COLUMNS
      DO 11 J=1,LTITTT
      11 Z(NITTT+J-1)=0.0
      CCC  .25 LOAD ON MEMBRANES TO THEIR NODES IN Z DOF FOR EACH NODE.
      CCC  IN TITTT
      CCC  PRESUMES ALMOST SQUARE ELEMENTS
      Z(NITTT+6*IC1-4)=AREA*.25
      Z(NITTT+6*IC2-4)=AREA*.25
      Z(NITTT+6*IC3-4)=AREA*.25
      Z(NITTT+6*IC4-4)=AREA*.25
      CCC  LENGTH OF A COLUMN IN TITTT FOR PACK
      NROH=LTITTT
      CCC  PAGES TITTT ONE COLUMN AT A TIME
      CALL PACK(Z(NITTT),TITTT,MCBB)
      CCC  USED FOR VTH,VTR (THE MOMENT ARMS)
      CCC  THE MOMENT ARMS OF EACH NODE ARE THE COORDINATES OF THE NODE
      Z(MTEX-1+IC1)=X1
      Z(MTEX-1+IC2)=X2
      Z(MTEX-1+IC3)=X3
      Z(MTEX-1+IC4)=X4
      Z(MTEY-1+IC1)=Y1
      Z(MTEY-1+IC2)=Y2
      Z(MTEY-1+IC3)=Y3
      Z(MTEY-1+IC4)=Y4
      3 CONTINUE
      CALL CLOSE(ECTA,1)
      CALL CLOSE(TITTT,1)
      CALL WRITRL(MCRP)
      CCC  SET UP A MATRIX CONTROL BLOCK FOR PACKING VGLS
      CCC  TRAILER VGLS (SIZE = NDOF*1)
      MCRA(1)=VGLS
      MCRA(2)=0
      MCRA(3)=LVGLS
      MCRA(4)=2
      MCRA(5)=1
      MCRA(6)=0
      MCRA(7)=0
      CCC  SET COLUMN LENGTH FOR PACKING VGLS
      FROM=LVGLS
      CALL GOPEN(VGLS,Z(RUP1),1)
      CCC  PAGES THE ONE COLUMN OF VGLS
      CALL PACK(Z(NVGLS),VGLS,MCRA)
      CALL CLOSE(VGLS,1)
      CCC  CALL WRITRL(MCRA)
      CCC  NOW REDUCE TTX TO JUST UPPER SURFACE NODES AND PACK OUT
      CCC  AS VTH
      CCC  REUSE THE SPACE IN OPEN CORE USED BY TITTT, VGLS
      CALL GOPEN(VTH,Z(RUP1),1)
      CALL GOPEN(VTH,Z(RUP2),1)

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PTN 4.8-544

74/74 OPT=1

SUBROUTINE GIAS

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345 CCC OFFINES LENGTH AND POSITION OF TEXR AND TETR (MODIFIED
    CCC TRY AND TRY), TO BE PACKED AS VTM AND VTR
    CCC
    CCC ACTUAL # OF NODES ON UPPER SURFACE IS UNKNOWN, IT MUST
    CCC <= NCP. THE VARIABLE NC WILL COUNT THEM IN THE FOLLOWING LOOP.
    CCC FOR NOW JUST SET ASIDE NCP WORDS, THEN AFTER REDUCTION LOOP,
    CCC PACK OUT FIRST NC WORDS.
    NTEYR=NTTTT
    NTEYR=NTYR+NCP
    NC=0
    CCC LOOP 13 CALCULATES THE VTM AND VTR MATRICIES
    CCC FILTERS OUT THE UPPER SURFACE VALUES OF TEX AND TRY
    DO 13 J=1,NCP
    IF(Z(NTYR+J-1)-EQ-FLAG) GO TO 13
    Z(NTYR+NC)=Z(NTYR+J-1)
    Z(NTYR+NC)=Z(NTYR+J-1)
    NC=NC+1
    13 CONTINUE
    CCC IF NC=0 THEN FATAL ERROR, NO UPPER SURFACE NODES
    IF(NC.EQ.0) GOTO 500
    CCC TRAILER OF VTM (SIZE = NC)
    ROW=NC
    MCRA(1)=VTM
    MCRA(2)=0
    MCRA(3)=NC
    MCRA(4)=2
    MCRA(5)=1
    MCRA(6)=0
    MCRA(7)=0
    CCC TRAILER OF VTR (SIZE = NC)
    MCRR(1)=VTR
    MCRR(2)=0
    MCRR(3)=NC
    MCRR(4)=2
    MCRR(5)=1
    MCRR(6)=0
    MCRR(7)=0
    CCC PACKS NTEYR AND NTEYR AS VTM AND VTR
    CALL PACK(Z(NTYR),VTM,MCRA)
    CALL PACK(Z(NTYR),VTR,MCRR)
    CALL CLOSE(VTM,1)
    CALL CLOSE(VTR,1)
    CALL WRTTTL(MCRA)
    CALL WRTTTL(MCRR)
    CCC IDP'S OF AERO BOXES' CORNERS START AT MIL+1
    MIL=1000000
    1=1
    CCC MCB EQUALS THE NUMBER OF CHORDWISE BOXES
    CCC SETS POSITION AND SIZE IN OPEN CORE FOR AERO INPUT POINTS
    CCC FOR SUBROUTINE SPLINE
    LSTND=0
    NESTY=1
    CCC LOOP UNTIL STATEMENT LABEL 14 IS SIMILAR TO LOOP 3 BUT FOR
    CCC AERO POINTS
    CCC THE PLAN: BUILD COORDS OF SPLINE INPUT POINTS WHICH ARE THE
    CCC 1/2 STAY, 1/4 CHORD OF THE AERO BOXES (UNDER THE DELTA CP IS
    CCC PRELIMED TO LIVE). GET COORD OF THIS POINT FROM THE COORDS OF

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FTN 4.R4564

74/74 OPT-1

SUBROUTINE CIAS

400 CCC COPNER POINTS IN RCPA. THESE ARE ONLY USED BY THE SPLINE
 CCC SUBROUTINE

405 KNI-NTX
 DO 14 I=1,NP

MCR-12(NACPT+2+1)
 NBARAY-12(NACPT+2+NP+1)
 LP-NBARAY-NFSTBX+1
 DO 2R J=1,LP

ICORH=(J-1)/NCR+J+LSIND+MIL
 IA1-ICORH

IA2-ICORH+1

IA3-ICORH+NCR+1

IA4-ICORH+NCR+2

IAP1=0

IAP2=0

IAP3=0

IAP4=0

DO 15 KK=1,LCPLA

P=NCPLA+KK-1

IF(IA1-EQ-12(KK)) IAP1=NBGPA+(KK-1)*4

IF(IA2-EQ-12(KK)) IAP2=NBGPA+(KK-1)*4

IF(IA3-EQ-12(KK)) IAP3=NBGPA+(KK-1)*4

IF(IA4-EQ-12(KK)) IAP4=NBGPA+(KK-1)*4

15 CONTINUE

IF(IAP1-EQ-0) GO TO 500

IF(IAP2-EQ-0) GO TO 500

IF(IAP3-EQ-0) GO TO 500

IF(IAP4-EQ-0) GO TO 500

X1=2(IAP1+1)

X2=2(IAP2+1)

X3=2(IAP3+1)

X4=2(IAP4+1)

Y1=2(IAP1+2)

Y2=2(IAP2+2)

Y3=2(IAP3+2)

Y4=2(IAP4+2)

THESE ARE THE COORDINATES OF AERO POINTS AT THE

ONE QUARTER CHORD POINT OF THE BOX

L IS BOX #, WITH ONE INPUT POINT PER BOX IT IS ALSO THE

INDEPENDENT POINT #

Z(NNI+2*L-1)-(X1+X3+(X2+X4-X3-X1)/4.)/2.

Z(NNI+2*L-1)-(Y1+Y2+Y3+Y4)/4.

L=L+1

CCC NEXT BOX

2R CONTINUE

LSIND=1A4-MIL

NFSTBX=NBARAY+1

14 CONTINUE

CCC

ALL THE ABOVE ARRAYS EXCEPT THE ND AND NI ARRAYS ARE NO LONGER

NEEDED, THEREFORE, TO CONSERVE OPER CORP, THE ND AND NI ARRAYS

ARE MOVED DOWN TO THE BOTTOM AND THE SPACE REQUIRED BY SPLIN

IS PUT RIGHT ABOVE THEM. THIS WIPES OUT ALL THE PREVIOUS

APRAYS

CCC

DO 200 I=1,LND

200 7(I)=7(I+HND-1)

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460      NND=1
      LNI=2*NI
      DO 210 I=1,LNI
      210 Z(NND+LND+I-1)=Z(NNI+I-1)
      NNI=NND+LND
      CCC
      CCC
      CCC
465      TRAILER GTAK (SIZE = # OF AERO BOXES TIMES NUMBER OF
      STRUCTURAL BOXES)
      PRESUMES CONSTANT PRESSURE ASSUMPTION ON STRUCTURAL BOXES
      MCRA(1)=GTAK
      MCRA(2)=0
      MCRA(3)=ND
      MCRA(4)=2
      MCRA(5)=1
      MCRA(6)=0
      MCRA(7)=0
      NCTAK=NNI+NI*2
      FLAG FOR TRANSPOSITION: KT=0 DO NOT TRANSPOSE OUTPUT
      KT=0
      CCC
475      SYMMETRY FLAG FOR X-DIRECTION: KX=0 GENERAL
      KX=0
      CCC
      SYMMETRY FLAG FOR Y-DIRECTION: KY=0 GENERAL
      KY=0
      CCC
480      FLAG FOR SLOPES: KD=0 INTERPOLATION ONLY
      KD=0
      CCC
      ATTACHMENT FLEXIBILITY: REAL >= 0.0
      DE=0.0
      CCC
      RETURNS RUF2
      NCORE=RUF1-1
      CCC
485      SPECIFIES THE AMOUNT OF OPEN CORE REQUIRED TO RUN SSPLIM
      NSCF=(NI+3)*2+3*(NI+3)+NI*ND+NI*(NI+3)+2
      THIS CHECKS OPEN CORE TO SEE IF ENOUGH IS AVAILABLE
      IF(NCORE.LT.(NSCF+NCTAK)) GO TO 500
      CALL SSPLIM(NI,Z(NNI),ND,Z(NND),KX,KY,KD,DZ,Z(NCTAK),NSCF,
      *ISING)
      RESETS AMOUNT OF CORE LEFT ASIDE FOR BUFFERS (# OF BUFFERS
      REQUIRED CHARGES FROM 1 TO 2)
      CCC
495      NCORE=RUF2-1
      IF(NCORE.LT.(NCTAK+NI*ND)) GO TO 500
      CALL COPEN(GTAK,Z(RUF1),1)
      NROW=ND
      CCC
500      PACKS NI COLUMNS OF GTAK, EACH COLUMN IS ND LONG
      DO 16 J=1,NI
      CALL PACK(Z(NCTAK+(J-1)*ND),GTAK,MCRA)
      16 CONTINUE
      CALL CLOSE(GTAK,1)
      CALL UNTRL(MCRA)
      CALL COPEN(VTMA,Z(RUF1),1)
      CALL COPEN(VTRA,Z(RUF2),1)
      BEGIN A NEW TEX AND TXY (THIS TIME FOR AERO POINTS) AT
      CCC
505      POSITIONS NCTAK AND NCTAK+NI
      NTEX=NCTAK
      LTEX=NI
      LTFY=NI
      IF(NCORE.LT.(NTEX+LTFY)) GO TO 500
      CCC
510      LOOP 17 CALCULATES THE VTMA AND VTRA MATRICES

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535      DO 17 I=1,NI
      CCC      COORDINATES OF 1/4 POINTS OF AFRO BOXES
      7(NTEX+1-1)=2(NKI+2*1-1-1)
      Z(NTEX+1-1)=Z(NNI+2*1-1)
      17 CONTINUE
      NROW=NI
520      TRAILER VTMA (SIZE = NI*1)
      MCRA(1)=VTMA
      MCRA(2)=0
      MCRA(3)=NI
      MCRA(4)=2
      MCRA(5)=1
      MCRA(6)=0
      MCRA(7)=0
525      TRAILER VTVA (SIZE = NI*1)
      MCB(1)=VTVA
      MCB(2)=0
      MCB(3)=NI
      MCB(4)=2
      MCB(5)=1
      MCB(6)=0
      MCB(7)=0
530      PACRS BOTH VTMA AND VTVA AS NI BY 1 ARRAYS
      NOTICE BOTH PACRS USE SAME NROW VALUE
      CALL PACK(Z(NTEX),VTMA,MCRA)
      CALL PACK(Z(NTEY),VTVA,MCBB)
      CALL CLOSE(VTMA,1)
      CALL CLOSE(VTVA,1)
      CALL WRTTTL(MCRA)
      CALL WRTTTL(MCBB)
      NAIDMT=1
535      DO 18 I=1,NI
      Z(NAIDMT+1-1)=1.0
      18 CONTINUE
      CALL GOPEN(AIDMT,Z(BUF1),1)
      TRAILER AIDMT (VECTOR OF ONES NI LONG)
540      AIDMT IS USED IN CALCULATING THE CL OF THE AFRO MODEL
      MCRA(1)=AIDMT
      MCRA(2)=0
      MCRA(3)=NI
      MCRA(4)=2
      MCRA(5)=1
      MCRA(6)=0
      MCRA(7)=0
      NROW=NI
      CALL PACK(Z(NAIDMT),AIDMT,MCRA)
      CALL CLOSE (AIDMT,1)
      CALL WRTTTL(MCRA)
      CALL GOPEN(SAS,Z(BUF1),1)
      COMPLEX
      TYPLOT=1
      BEGIN AT BEGINNING OF OPEN CORE
545      NSEAS=1
      NROW=2*NI
      BELIEVES ONE (TYPE COMPLEX) CAN BE BUILT IN CORE AS TWO
      CONSECUTIVE VALUES
      NTL=NI*ERROR
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560
565
570

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CCC ENTIRE SAS IS BUILT IN CORE THEN PACKED, COULD BE BUILT
 CCC ONE COLUMN AT A TIME BUT BY NOW THERE IS LOTS OF ROOM
 CCC ZFPOS OUT SAS

575 DO 19 I=1,NL
 Z(NSAS+I-1)=0.0
 10 CONTINUE
 L=1

580 DO 20 I=1,NI
 REAL PART
 Z(NSAS+L+I-1+I-2)=1.0
 COMPLEX PART
 Z(NSAS+L+I-1+I-1)=1.0
 L=L+NROW

585 20 CONTINUE
 CCC TRAILER SAS
 MCRA(1)=SAS
 MCRA(2)=0
 MCRA(3)=NROW
 MCRA(4)=2
 MCRA(5)=3
 MCRA(6)=0
 MCRA(7)=0
 L=1

595 DO 21 I=1,NI
 CALL PACK(Z(NSAS+L-1),SAS,MCRA)
 L=L+NROW
 21 CONTINUE

600 CALL CLOSE(SAS,1)
 CALL UNTRL(MCRA)
 RETURN
 CCC GENERAL ERROR EXIT, NO CAUSES GIVEN
 500 N=-8

605 NSUB=16
 CALL MESSAGE(N,NSUB,NAMT)
 RETURN
 END

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
 1 GIAS

VARIABLES	SN	TYPE	RELOCATION		
1531 AJUNT		REAL	1513 ACPT		INTEGER
1517 RCPA		INTEGER	1632 AREA		REAL
1550 RUF2		INTEGER	1547 RUF1		INTEGER
1666 DZ		REAL	1551 RUF3		INTEGER
1606 FIAC		REAL	1515 ECTA		INTEGER
1522 CIAY		INTEGER	1516 GPLA		INTEGER
1653 IAP1		INTEGER	1610 I		INTEGER
1655 IAP3		INTEGER	1656 IAP2		INTEGER
1647 IAI		INTEGER	1656 IAP4		INTEGER
			1650 IAI2		INTEGER
					*UNDEF

125 2
0 3
0 6
0 11
0 15
0 16
0 19
0 28
0 210
1165 500

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES	EXT REFS	EXITS	NOT INNER
167	9	J	194 197	38	INSTACK			
177	7	J	198 200	28	INSTACK			
216	3	I	231 318	2028				
243	6	J	262 268	268	OPT			
353	11	J	295 296	28	INSTACK			
473	13	J	355 360	68	INSTACK			
5-2	14	I	403 447	1278				
553	28	J	407 444	1078				
576	15	KK	417 423	268	OPT			
675	200	I	455 456	38	INSTACK			
711	210	I	459 460	28	INSTACK			
760	16	J	499 501	118				
1017	17	I	514 518	38	INSTACK			
1062	18	I	545 547	28	INSTACK			
1122	19	I	574 576	28	INSTACK			
1130	20	I	578 584	78	INSTACK			
1150	21	I	594 597	108				

COMMON BLOCKS	LENGTH
/	1
SYSTEM	1
PACKX	5
ZOPEN	1

STATISTICS	PROGRAM LENGTH	17200	981
CM LAFLED COMMON LENGTH	78		7
CM BLANK COMMON LENGTH	18		1
520008 CM USED			

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1      CCC
   CCC
   CCC
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   CCC
   SUBROUTINE INIT
   CCC
   CCC
   CCC
   READS DATA BLOCKS FROM "PUNCH" TAPE INTO MEMORY
   COMMON/SYSTEM/IBUF
   COMMON/2DATA/ZACPT(49),ZRCFA(164),ZTOSL(4),ZCPLA(41),ZSIL(18)
   1,ZECTA(64,4)
   COMMON/OTRAIL/TACPT(4),TRCFA(6),TTOSL(6),TCPLA(6),TSIL(6),
   ITECTA(6)
   15  INTEGER TACPT,TTOSL,TECTA,TCPLA,TRCFA,TSIL,ZTOSL,
   ZCPLA,ZSIL,ZECTA,IZACPT(49)
   REAL ZACPT,ZRCFA
   EQUIVALENCE (IZACPT(49),ZACPT(49))
   INUF=8
   READ ACPT AND TRAILER
   CCC
   CCC
   CCC
   25  READ(5,930)(TACPT(I),I=1,6)
   FORMAT(24X,6I8)
   READ(5,500)
   300  FORMAT(18X)
   READ(5,931)(IZACPT(I),I=1,2)
   931  FORMAT(53X,13,13X,13)
   READ(5,932)IZACPT(3),IZACPT(4),ZACPT(5),IZACPT(6)
   932  FORMAT(23X,11,15X,11,E16.9,15X,11)
   IF(IZACPT(2)-EQ.3)GOTO 501
   IF(IZACPT(2)-EQ.3)GOTO 502
   READ(5,970)IZACPT(7),(ZACPT(I),I=8,10)
   970  FORMAT(23X,11,3E16.9)
   GOTO 510
   35  READ(5,503) IZACPT(1),I=7,10)
   503  FORMAT(8X,4(15X,11))
   GOTO 510
   40  READ(5,505)(IZACPT(1),I=7,9),ZACPT(10)
   505  FORMAT(23X,11,2(15X,11),E16.9)
   510  CONTINUE
   IF(IZACPT(2)-EQ.3)GOTO 511
   READ(5,971)(ZACPT(I),I=11,14)
   971  FORMAT(8X,4E16.9)
   GOTO 512
   45  READ(5,970)IZACPT(11),(ZACPT(I),I=12,14)
   511  CONTINUE
   512  IF(IZACPT(2)-EQ.3)GOTO 520
   IF(IZACPT(2)-EQ.3)GOTO 513
   READ(5,972)ZACPT(15),ZACPT(16),IZACPT(17),IZACPT(18)
   50  FORMAT(8X,2E16.9,2(15X,11))
   READ(5,970)IZACPT(19),(ZACPT(I),I=20,22)
   513  GOTO 530
   DO 514 J=1,2
   514  READ(5,971)(ZACPT(14+I+(J-1)*4),I=1,4)
   GOTO 530
   55  READ(5,971)(ZACPT(I),I=15,18)
   520

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60      530      READ(5,505)((IZACPT(1),I=19,21),ZACPT(22))
          CONTINUE
          NP=4
          IF(IZACPT(2)-EQ.2)NP=5
          IF(IZACPT(2)-EQ.3)GOTO 515
          DO 10 J=1,NP
            10      READ(5,971)((ZACPT(22+I+(J-1)*4),I=1,4)
                    IF(IZACPT(2)-EQ.2)GOTO 526
                    READ(5,973)((ZACPT(1),I=39,40)
                    FORMAT(8X,2E16.9)
                    GOTO 526
            515      READ(5,516)ZACPT(23), (IZACPT(1),I=24,26)
            516      FORMAT(8X,E16.9,3(15X,11))
            READ(5,970)IZACPT(27), (ZACPT(1),I=28,30)
            DO 517 J=1,4
            517      READ(5,971)((ZACPT(30+I+(J-1)*4),I=1,4)
                    READ(5,518)((ZACPT(1),I=47,49)
                    FORMAT(8X,2E16.9)
                    READ(5,500)
            70      READ TOSEL AND TRAILER
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            6075      3
            6080      3
            6085      3
            6090      3
            6095      3
            6100      3
            
```

```

115      DO 957 M=1,4
          READ(5,952)(ZEGTA(R*(M-1)+1+6,4),I=1,R)
          READ(5,955)ZEGTA(39,4)
116      CONTINUE
120      READ GPLA AND TRAILER
125      READ(5,930)(TGPLA(I),I=1,6)
          READ(5,500)
          READ(5,961)(ZGPLA(I),I=1,6)
          FORMAT(24X,610)
          NR=3
          IF(IZACPT(2).NE.1)NR=4
          DO 16 J=1,NR
            READ(5,952)(ZGPLA(R*(J-1)+6+1),I=1,R)
            IF(IZACPT(2).EQ.2)GOTO 540
            IF(IZACPT(2).EQ.3)GOTO 541
            READ(5,962)(ZGPLA(I),I=31,36)
            GOTO 550
          541 READ(5,542)(ZGPLA(I),I=39,41)
          542 FORMAT(8X,310)
          GOTO 550
          540 READ(5,543)ZGPLA(39)
          545 FORMAT(8X,18)
          550 CONTINUE
          962 FORMAT(8X,610)
          READ NGPA AND TRAILER
145      READ(5,930)(TBGPA(I),I=1,6)
          READ(5,500)
          READ(5,931)ZBGPA(1),ZBGPA(2)
          READ(5,963)(ZBGPA(I),I=3,6)
          FORMAT(21X,F3.1,E16.9,13X,F3.1,13X,F3.1)
          DO 17 J=1,5
            READ(5,964)(ZBGPA(J-1)+1+6),I=1,4)
            FORMAT(21X,F3.1,E16.9,13X,F3.1,E16.9)
            DO 18 J=1,11
              READ(5,965)(ZBGPA(J-1)+4+1+26),I=1,4)
              FORMAT(8X,2E16.9,13X,F3.1,E16.9)
              READ(5,966)(ZBGPA(I),I=71,74)
              FORMAT(8X,2E16.9,13X,F3.1,13X,F3.1)
              READ(5,964)(ZBGPA(I),I=75,78)
              READ(5,964)(ZBGPA(I),I=79,82)
              DO 19 J=1,3
                READ(5,965)(ZBGPA(J-1)+4+1+82),I=1,4)
                READ(5,964)(ZBGPA(I),I=95,98)
                NR=11
                IF(IZACPT(2).EQ.2)NR=14
                IF(IZACPT(2).EQ.3)NR=16
                DO 20 J=1,NR
                  READ(5,965)(ZBGPA(J-1)+4+1+98),I=1,4)
                  IF(IZACPT(2).EQ.2)GOTO 560
                  IF(IZACPT(2).EQ.3)GOTO 561
                  READ(5,967)ZBGPA(163),ZBGPA(164)
                  GOTO 570
                561 READ(5,967)ZBGPA(163),ZBGPA(164)

```

```

COTO 570
560 READ(5,967)ZRCPA(155),ZRCPA(156)
570 CONTINUE
967 FORMAT(8X,2E16.9)
    READ(5,500)
    READ(5,500)
    IF(IZACPT(2).EQ.1) READ(5,500)
    READ STL AND TRAILFR
    READ(5,930)(TSIL(I),I=1,6)
    READ(5,500)
    READ(5,961)(ZSIL(I),I=1,6)
    READ(5,969)(ZSIL(1+6),I=1,8)
    READ(5,968)(ZSIL(1+14),I=1,4)
    968 FORMAT(8X,418)
    969 FORMAT(8X,818)
    RETURN
    END
180 CCC
181 CCC
182 CCC
183
185
190

```

SYMBOLIC REFERENCE MAP (R-1)

ENTRY POINTS

1 INIT

VARIABLES	SN	TYPE	RELOCATION	0	IRUF	INTEGER	SYSTEM
1516 I	0	IZACPT	ARRAY ZDATA	1517 J	0	INTEGER	
1521 N	0	TACPT	ARRAY DTRAIL	1520 NR	6	INTEGER	ARRAY DTRAIL
36 TCCTA	0	TCCTA	ARRAY DTRAIL	22 TCPLA	22	INTEGER	ARRAY DTRAIL
30 TSIL	0	TSIL	ARRAY DTRAIL	14 TIOSEL	14	INTEGER	ARRAY DTRAIL
0 ZACPT	0	ZACPT	ARRAY ZDATA	61 ZRCPA	61	REAL	ARRAY ZDATA
424 ZECTA	0	ZECTA	ARRAY ZDATA	331 ZCPLA	331	INTEGER	ARRAY ZDATA
402 ZSIL	0	ZSIL	ARRAY ZDATA	325 ZTOSL	325	INTEGER	ARRAY ZDATA

FILE NAMES

TAPE 5

MODE

FMT

STATEMENT LABELS

1057 3	FMT	NO REFS
0 16	0	10
0 19	0	17
241 50	267 51	0 20
637 500	24 501	267 51
703 503	714 505	FMT
33 511	35 512	FMT
0 514	127 515	FMT
0 517	1051 518	FMT
156 526	73 530	FMT
404 541	1252 542	FMT
411 550	553 560	FMT

340 15	FMT
0 18	
0 43	
315 52	
21 502	
26 510	
45 513	
1024 516	
67 520	
407 540	
1261 545	
550 561	

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74/74 OPT-1

SUBROUTINE INIT
STATEMENT LABELS

555 570		631 930	FMT	646 931	FMT
661 932	PMT	1101 940	PMT	1121 950	PMT
0 951		1132 952	PMT	1141 953	PMT
0 954		1157 955	FMT	0 956	
0 957		1227 961	PMT	1263 962	PMT
1311 963	FMT	1325 964	FMT	1340 965	PMT
1351 966	FMT	1434 967	FMT	1512 968	PMT
1514 969	FMT	673 970	PMT	725 971	PMT
745 972	FMT	1014 973	PMT		

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
46	514	J	54 55	218	EXT REFS NOT INNER
51		I	55 55	128	EXT REFS
102	10	J	63 64	218	EXT REFS NOT INNER
105		I	64 64	128	EXT REFS
134	517	J	72 73	218	EXT REFS NOT INNER
137		I	73 73	128	EXT REFS
173	43	J	90 92	128	NOT INNER
200	43	I	91 92	28	
206	15	J	93 118	1358	EXT REFS NOT INNER
217	951	M	97 98	208	EXT REFS NOT INNER
222		I	98 98	118	EXT REFS
244	954	M	104 105	218	EXT REFS NOT INNER
247		I	105 105	128	EXT REFS
272	956	M	110 111	218	EXT REFS NOT INNER
275		I	111 111	128	EXT REFS
316	457	M	115 116	218	EXT REFS NOT INNER
321		I	116 116	128	EXT REFS
355	16	J	128 129	218	EXT REFS NOT INNER
360		I	129 129	128	EXT REFS
422	17	J	149 150	208	EXT REFS NOT INNER
425		I	150 150	118	EXT REFS
443	18	J	152 153	208	EXT REFS NOT INNER
446		I	153 153	118	EXT REFS
471	19	J	159 160	208	EXT REFS NOT INNER
474		I	160 160	118	EXT REFS
522	20	J	165 166	208	EXT REFS NOT INNER
525		I	166 166	118	EXT REFS
600		I	186 186	78	EXT REFS
613		I	187 187	78	EXT REFS

COMMON FLOCKS LENGTH
SYSTEM 1
ZDATA 532
DTRAIL 36

STATISTICS
PROGRAM LENGTH 15228 850
CM LABELED COMMON LENGTH 10718 560
520004 CM USED

EMERGENCY 136 MESSAGE 76/76 OPT-1

```

1      CCC
      CCC
      CCC
      CCC
      CCC
      5
      SURROUTINE MESAGE(MD,PARM,NAME)
      DIMENSION NAME(2)
      INTCGR PARM
      IF (PARM.EQ.21) GO TO 2
      IF (PARM.EQ.10) GO TO 4
      WRITE (6,400)
      400 FORMAT ("1",5X," FATAL ERROR SSPLIN")
      GO TO 3
      4 WRITE(6,402)
      402 FORMAT("1",5X,"FATAL ERROR CIAS")
      GOTO 3
      2 WRITE (6,401)
      401 FORMAT ("1",5X,"FATAL ERROR CHMATS")
      3 RETURN
      END
      20

```

SYMBOLIC REFERENCE MAP (R-1)

ENTRY POINTS	MESSAGE
--------------	---------

VARIABLES		SK	TYPE	RELOCATION		F.P.	
O	NAME		INTEGER	ARRAY		INTEGER	UNUSED
O	PARM		INTEGER				F.P.
FILE NAMES							
		MODE					
TAPE 6		FMT					
STATEMENT LABELS							
16	2		20	3			
24	401	FMT	43	401	FMT		
STATISTICS							
PROGRAM LENGTH		508	40				
520008 CH USED							

SUBROUTINE SSPLIN 74/74 OPT=1

```

115      GO TO 70
      C
      C
      C MATRIX COLUMN STORED
120      45 IC = NR*NI
      MP = IC+1
      DO 90 I = 1,NI
      DO 80 J = 1,N
      IC = IC+1
      G(IC) = 0.0
      IF(I.EQ.J) G(IC) = 1.0
80 CONTINUE
90 CONTINUE
      IF(IFT) GO TO 170
      NC = NI
      IA = IC
      GO TO 1
      C
      C
      C P MATRIX COLUMN STORED
135      95 IB = NR*NI
      MP = IB+1
      GO TO 110
100 IR = IA
110 NF = 2*ND
      K = IR+1
      DO 160 J = 1,NR,2
      DO 120 I = 1,NI,2
      IR = IR+1
      ALTI = 0.0
      ALTI2 = 0.0
      ALTI3 = 0.0
      ALTI4 = 0.0
      XM = XYD(J)-XYI(1)
      XP = XYI(1)+XYD(J)
      YM = XYD(J+1)-XYI(1+1)
      YP = XYI(1+1)+XYD(J+1)
      T1 = XM*YM + YM*YM
      T2 = XP*XP + YM*YM
      T3 = XM*XM + YP*YP
      T4 = XP*XP + YP*YP
      IF(T1.NE.0.0) ALTI = ALOC(T1)
      IF(T2.NE.0.0.AND.PX.NE.0) ALTI2 = ALOC(T2)
      IF(T3.NE.0.0.APD.KY.NE.0) ALTI3 = ALOC(T3)
      IF(T4.NE.0.0.AND.KX.NE.0) ALTI4 = ALOC(T4)
      C(IR) = T1*ALTI + T2*ALTI2*EX + T3*ALTI3*EY + T4*ALTI4*EX*EY
      IF(.NOT.IPD) GO TO 120
      IV = IR + N
      C(IV) = 2.0*(YM*(1.0+ALTI) + XP*(1.0+ALTI2)*EY +
      * XM*(1.0+ALTI3)*EY + XP*(1.0+ALTI4)*EX*EY)
120 CONTINUE
      NP = 0
      140 NOT-1000 GO TO 130
      141 = 140 + 1
      C(141) = 1.0
      IF(140) C(141+140*E) = 0.0
130 IF(.NOT.1X) GO TO 140

```

AD-A124 662

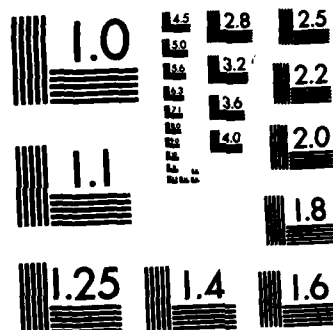
STATIC AEROELASTIC ANALYSIS OF FLEXIBLE WINGS VIA
NASTRAN PART I (U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING K JONES
DEC 82 AFIT/GAE/AA/82D-16-PT-1 F/G 1/3

2/2

UNCLASSIFIED

NL

							END						
							FILED						
							DTIC						



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

11/03/82 20.07.46

FTN 4.8+564

SUBROUTINE SSPLIN 74/74 OPT-1

```

      INP = INP + 1
      G(IIR+INR) = XYD(J)
      IF(IKD) G(IIR+INR+N) = 1.0
175  140 IF(.NOT.LV) GO TO 150
      INR = INP + 1
      G(IIR+INR) = XYD(J+1)
      IF(IKD) G(IIR+INR+N) = 0.0
180  150 IN = IR+INR + N*XD
      160 CONTINUE
      IF(.NOT.IKT) GO TO 180
      IA = IR
      NC = NR
      GO TO 1
      170 CONTINUE
      C
      CHMATS WANTS ROW STORED SO INVERT ROWS AND COLUMNS AND INVERT
      MULTIPLICATION ORDER
      C
      CALL CHMATS CT B
      CALL CHMATS(G(MP),NR,N,O,G(K),MI,M,1,G(IG))
      GO TO 1000
      180 CONTINUE
      C
      CALL CHMATS RT C
      CALL CHMATS(G(MP),NI,N,O,G(K),NB,N,1,G(IG))
      1000 RETURN
      END

```

SYMBOLIC REFERENCE MAP (P-1)

ENTRY POINTS

1 SSPLIN

VARIABLES	SN	TYPE	RELOCATION
630 ALT1	REAL		
632 ALT3	REAL		
570 BBT	REAL		
572 FX	REAL		
0 G	REAL	ARRAY	F.P.
602 IA	INTEGER		
625 IC	INTEGER		
603 II	INTEGER		
566 IKD	LOGICAL		
622 INR	INTEGER		
0 IINC	INTEGER		F.P.
606 JU	INTEGER		
0 KD	INTEGER		F.P.
0 KT	INTEGER		F.P.
0 LV	INTEGER		F.P.
603 LY	LOGICAL		
623 M	LOGICAL		
634 NANO	INTEGER	ARRAY	
634 NR	INTEGER		
634 NI	INTEGER		
634 NB	INTEGER		
634 MI	INTEGER		
634 M	INTEGER		
634 IG	INTEGER		
631 ALT2	REAL		
633 ALT4	REAL		
0 DZ	REAL		
573 EY	REAL		
605 I	INTEGER		
626 IR	INTEGER		
577 IC	INTEGER		
604 IK	INTEGER		
567 IKT	LOGICAL		
576 IS	INTEGER		
607 J	INTEGER		
601 K	INTEGER		
621 KK	INTEGER		
0 VX	INTEGER		F.P.
565 LORE	LOGICAL		
564 LY	LOGICAL		
571 N	INTEGER		
574 NR	INTEGER		
0 SCORE	INTEGER		F.P.
575 SCORING	INTEGER		

11/03/82 20.07.46

FTN 4.8+564

74/74 OPT-1
RELOCATION
P.P.

SUBROUTINE SSPLIN

VARIABLES SN TYPE
0 NI INTEGER
600 NI INTEGER
615 T1 REAL
617 T3 REAL
611 IM REAL
0 XVD REAL
613 YM REAL

627 NR
610 SUM
616 T2
620 T4
612 TP
0 XT1
614 TP

P.P.

ARRAY

REAL

CHMATS
MESSAGE

EXTERNALS TYPE
ALOC REAL
INVERS 8
ARCS 1 LIBRARY

INLINE FUNCTIONS TYPE
FLOAT REAL
ARCS 1 INTRIN

INTEGER 0 INTRIN

MAXO

STATEMENT LABELS

104 1
216 20
245 50
275 70
320 95
425 120
457 150
501 180
0 5
227 30
0 60
0 80
324 100
437 130
0 160
514 1000
212 10
236 40
271 65
0 90
326 110
447 140
471 170

PROPS LABEL INDEX FROM-TO LENGTH PROPERTIES

114 5 57 58 28 INSTACK
121 60 61 106 132B
125 20 J 64 90 74B
276 90 121 127 16B
303 80 J 122 126 5B
332 160 J 141 180 133B
333 120 142 165 75B
EXT REFS NOT INNER
EXT REFS
NOT INNER
INSTACK
EXT REFS NOT INNER
EXT REFS

STATISTICS
PROGRAM LENGTH
5200CF 4 USED
704N 452

```

1      CCC
2      CCC
3      CCC
4      CCC
5      CCC
6      SUBROUTINE CMHATS (A, IROWA, ICOLA, MTA, N, IROWB, ICOLB, NTB, C)
7      C*****
8      CMHATS - GENERAL MATRIX MULTIPLY
9      AND
10     TRANSPOSE
11     SINGLE PRECISION VERSION
12
13     PERFORMS
14     WHEN
15     A * B - C MTA=0 NTB=0
16     A * B TRANSPOSE - C MTA=0 NTB=1
17     A TRANSPOSE * B - C MTA=1 NTB=0
18     A TRANSPOSE * B TRANSPOSE - C MTA=1 NTB=1
19
20     C - IS A MATRIX (ROWA) ROWS BY (COLA) COLUMNS
21     B - IS A MATRIX (ROWB) ROWS BY (COLB) COLUMNS
22     A, B AND C ARE STORED BY ROWS (EXAMPLE)
23
24     MATRIX STORED
25     A= 1 2 3 4 5 6
26         1 2 3 4 5 6
27         1 2 3 4 5 6
28         1 2 3 4 5 6
29         1 2 3 4 5 6
30         1 2 3 4 5 6
31
32     C*****
33     C*****
34
35     IF MTA .LT. 0, C IS NOT ZEROED OUT. HENCE THE ROUTINE, IN THIS
36     CASE, COMPUTES A * B + D - C WHERE THE MATRIX D HAS BEEN
37     STORED ROW-WISE AT C BY THE CALLING PROGRAM. IF MTA = -1, A
38     IS TRANSPOSED. IF MTA = -2, A IS NOT TRANSPOSED. NTB IS
39     DEFINED AS ABOVE AND IS INDEPENDENT OF MTA.
40
41     INTEGER ROWA, COLA, ROWB, COLB
42
43     DIMENSION A(1), B(1), C(1), IPARM(2)
44
45     ROWA = IROWA
46     COLA = ICOLA
47     ROWB = IROWB
48     COLB = ICOLB
49     MTA = IARS(MTA)
50
51     IF (MTA .EQ. (-2)) NTB = 0
52     IF (NTA .EQ. 0) .AND. NTB .EQ. 0 IF (COLA = ROWB) RO,5,RO
53     IF (NTA .EQ. 1) .AND. NTB .EQ. 0 IF (ROWA = ROWB) RO,5,RO
54     IF (NTA .EQ. 0) .AND. NTB .EQ. 1 IF (COLA = COLB) RO,5,RO
55     IF (NTA .EQ. 1) .AND. NTB .EQ. 1 IF (ROWA = COLB) RO,5,RO

```

SUBROUTINE CHMATS 74/74 OPT=1

```

5 IF (NTA .EQ. 1) GO TO 10
  ILM= ROWA
  KLM= COLA
  INCI= COLA
  INCKA= 1
  GO TO 20
10 ILM= COLA
  KLM= ROWA
  INCI= 1
  INCKA= COLA
20 IF (NTB.EQ.1) GO TO 30
  JLM= COLB
  INCI= 1
  INCKB= COLB
  GO TO 40
30 JLM= ROWB
  INCI= COLB
  INCKB= 1
40 IF (MTA .LT. 0) GO TO 47
  LIM = ILM * JLM
  DO 45 I = 1,LIM
45 C(I) = 0.0
47 IJ = 0
  I = 0
50 I = 1 + 1
  IFIX=1*INCI-COLA
  J = 0
60 J = J + 1
  IJ=IJ+1
  IA=IFIX
  JB=J*INCJ-COLB
  K = 0
70 K = K + 1
  IA=IA+INCKA
  JB=JB+INCKB
  C(IJ)=C(IJ)+ A(IA) * B(JB)
  IF (K .LT. KLM) GO TO 70
  IF (J .LT. JLM) GO TO 60
  IF (I .LT. ILM) GO TO 50
  RETURN
80 IPARM(1) = NTA
  IPARM(2) = NTB
  CALL MESSAGE (-30,21,IPARM(1))
  RETURN
  END

```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 CHMATS

SUPROUTINE INVERS 74/74 OPT=1

```

50 A(ICOLUMN,L) = SWAP
   IF(M.LE.O) GO TO 70
   DO 60 L=1,M
     SWAP = B(IROW,L)
     B(IROW,L) = B(ICOLUMN,L)
     B(ICOLUMN,L) = SWAP
60 B(ICOLUMN,L) = SWAP
C
C   DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
70 PIVOT = A(ICOLUMN,ICOLUMN)
   DETERM = DETERM * PIVOT
   A(ICOLUMN,ICOLUMN) = 1.0E0
   DO 80 L=1,M
     A(ICOLUMN,L) = A(ICOLUMN,L) / PIVOT
   IF(M.LE.O) GO TO 100
   DO 90 L=1,M
     B(ICOLUMN,L) = B(ICOLUMN,L) / PIVOT
90 B(ICOLUMN,L) = B(ICOLUMN,L) / PIVOT
C
C   REDUCE NON PIVOT ROWS
C
100 DO 130 LI=1,M
   IF(LI.EQ.ICOLUMN) GO TO 130
   T = A(LI,ICOLUMN)
   A(LI,ICOLUMN) = 0.0E0
   DO 110 L=1,M
     A(LI,L) = A(LI,L) - A(ICOLUMN,L) * T
   IF(M.LE.O) GO TO 130
   DO 120 L=1,M
     B(LI,L) = B(LI,L) - B(ICOLUMN,L) * T
120 B(LI,L) = B(LI,L) - B(ICOLUMN,L) * T
130 CONTINUE
C
C   INTERCHANGE COLUMNS
C
DO 150 I=1,M
  L = N + 1 - I
  IF(INDEX(L,1).EQ.INDEX(L,2)) GO TO 150
  JROW = INDEX(L,1)
  JCOLUMN = INDEX(L,2)
  DO 140 K=1,M
    SWAP = A(K,JROW)
    A(K,JROW) = A(K,JCOLUMN)
    A(K,JCOLUMN) = SWAP
140 CONTINUE
150 CONTINUE
DO 170 K=1,M
  IF(INDEX(K,3).EQ.1) GO TO 160
  ISING = 2
  GO TO 180
160 CONTINUE
170 CONTINUE
  ISING = 1
180 RETURN
190 ISING = 2
  RETURN
END

```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 INVERS

VARIABLES	SN	TYPE	RELOCATION
0 A	REAL	ARRAY	F.P.
0 B	REAL	ARRAY	F.P.
260 I	INTEGER		
0 INDEX	INTEGER	ARRAY	F.P.
0 ISING	INTEGER		F.P.
266 JCOLUMN	INTEGER		
261 K	INTEGER		
264 L1	INTEGER		
0 M	INTEGER		F.P.
263 PIVOT	REAL		
267 T	REAL		

267	ANAX	REAL	F.P.
0	DETERM	REAL	
266	ICOLDM	INTEGER	
265	IROW	INTEGER	
257	J	INTEGER	
265	JROW	INTEGER	
262	L	INTEGER	
0	N	INTEGER	F.P.
0	NDIM	INTEGER	F.P.
267	SWAP	REAL	

INLINE FUNCTIONS TYPE ARCS
ABS REAL 1 INTRIN

STATEMENT LABELS

0	10	20	INACTIVE	46	30
31	40	0 50		0	60
115	70	0 80		0	90
146	100	0 110		0	120
205	130	0 140		234	150
245	160	0 170		251	180
252	190				

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES	EXITS	NOT INNER
21	10	J	30 31	2R	INSTACK	12	NOT INNER
25	130	I	32 R7	165B			
27	40	J	37				
32	70	F	39 45	16R	OPT		
73	50	L	55 58	4R	INSTACK		
110	60	L	60 63	4R	INSTACK		
130	80	L	70 71	3R	INSTACK		
142	90	L	73 74	3R	INSTACK		
147	130	L1	78 R7	41B			NOT INNER
163	110	L	82 R3	4R	INSTACK		
200	120	L	85 86	4R	INSTACK		
213	150	I	91 101	24B			NOT INNER
230	140	K	96 100	3B	INSTACK		
240	170	K	102 107	10B	OPT		EXITS

STATISTICS

PROGRAM	LENGTH	CM	USED
	340R		224


```

1      CCC
      CCC
      CCC
      CCC
      CCC
      SUBROUTINE COPEN(DB, BUFFER, NUM)
      INTEGER DB
      WRITE(6,910)DB
      FORMAT(IX,"OPENED DATABLOCK:",I5)
      RETURN
      END
10

```

SYMBOLIC REFERENCE MAP (R-1)

ENTRY POINTS
3 COPEN

VARIABLES	SN	TYPE	RELOCATION	INTEGER	F.P.
0 BUFFER		REAL	*UNUSED	0 DB	
0 NUM		INTEGER	*UNUSED		

FILE NAMES
TAPE6 FMT

STATEMENT LABELS
14 910 FMT

STATISTICS
PROGRAM LENGTH 208 16
52000 CH USED

```

1      CCC
      CCC
      CCC
      CCC
      CCC
      CCC
      SUBROUTINE CLOSE(DR,NUM)
      INTEGER DR
      WRITE(6,920)DR
920    FORMAT(IX,'CLOSED DATABLOCK: ',I5)
      RETURN
      END
10

```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 CLOSE

VARIABLES	SN	TYPE	RELOCATION	F.P.	0	NUM	INTEGER	*UNUSED	F.P.
DB	0	INTEGER							

FILE NAMES
TAPF6 PNT

STATEMENT LABELS
14 920 PNT

STATISTICS
PROGRAM LENGTH 208 16
52000 CH USED

```

1      CCC
      CCC
      CCC
      CCC
      CCC
5
10     SUBROUTINE PACK(ZN,DB,TRAILER)
      COMMON/PACKX/TYPIN,TYPOUT,IROW,NROW,INCR
      INTEGER TRAILER(7),DB
      DIMENSION ZN(1)
      WRITE(6,100) DB
      FORMAT(1X,"DATABLOCK=",15)
      NWDPLN=10
      J=0
      LIMIT=NROW/NWDPLN
      IF(LIMIT.LE.0)GOTO 200
      DO 300 I=1,LIMIT
        WRITE(6,110)(ZN(J+K),K=1,NWDPLN)
        J=J+NWDPLN
      CONTINUE
      300
      200 LIMIT=NROW-LIMIT+NWDPLN
      IF(LIMIT.LE.0)GOTO 400
      WRITE(6,110)(ZN(J+1),I=1,LIMIT)
      400 RETURN
      110 FORMAT(10(1X,E12.5))
      25  END
  
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 PACK

VARIABLES	SN	TYPE	RELOCATION	107	I	INTEGER	PACKX
0 DB	1	INTEGER	F.P.	107	1	INTEGER	PACKX
4 INCR	2	INTEGER	PACKX	2	IROW	INTEGER	PACKX
105 J	110	INTEGER		110	K	INTEGER	PACKX
106 LIMIT	3	INTEGER		3	NROW	INTEGER	PACKX
104 NWDPLN	0	INTEGER		0	TRAILER	INTEGER	PACKX
0 TYPIN	1	REAL		1	TYPOUT	REAL	PACKX
0 ZN		REAL	ARRAY				
			F.P.				

FILE NAMES
TAPES
FMT

STATEMENT LABELS
62 100 FMT
0 100

LOCUS	LABEL	INDEX	PROG-TC	LENGTH	PROPERTIES	EXT REFS	NOT INNER
14	100	1	16 19	20P	EXT REFS		
21		4	17 17	10R	EXT REFS		
22		1	27 22	10P	EXT REFS		

36 200

PAGE 2

11/03/82 20.07.46

FTN 4.84564

76/76 OPT-1

SUBROUTINE PACK
COMMON BLOCKS LENGTH
PAGE 5

STATISTICS
PROGRAM LENGTH 114R 76
CM LABELED COMMON LENGTH 5B 5
52000B CM USED

```

1      CCC
      CCC
      CCC
      CCC
      CCC
      CCC
      CCC

5      SUBROUTINE RDTBL(TRACE)
      COMMON/DTRACE/TACPT(6),TACPA(6),TTOSEL(6),TCPLA(6),TSIL(6),
      ITCTA(6)
      INTEGER TRACE(7),TACPT,TACPA,TTOSEL,TCPLA,TSIL,TECTA
      COTO(100,200,300,400,500,600),TRAIL(1)-100
      DO 10 I=1,6
      TRAIL(I+1)=TACPT(I)
      RETURN
      DO 20 I=1,6
      TRAIL(I+1)=TTOSEL(I)
      RETURN
      DO 30 I=1,6
      TRAIL(I+1)=TECTA(I)
      RETURN
      DO 40 I=1,6
      TRAIL(I+1)=TCPLA(I)
      RETURN
      DO 50 I=1,6
      TRAIL(I+1)=TACPA(I)
      RETURN
      DO 60 I=1,6
      TRAIL(I+1)=TSIL(I)
      RETURN
      END

```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 RDTBL

VARIABLES	SN	TYPE	RELOCATION	0	TACPT	INTEGER	ARRAY	DTRACE	DTRACE
72 I	1	INTEGER	ARRAY	0	TACPT	INTEGER	ARRAY	DTRACE	DTRACE
6 TACPA	1	INTEGER	ARRAY	36	TECTA	INTEGER	ARRAY	DTRACE	DTRACE
27 TCPLA	1	INTEGER	ARRAY	0	TRAIL	INTEGER	ARRAY	F.P.	F.P.
30 TSIL	1	INTEGER	ARRAY	14	TTOSEL	INTEGER	ARRAY	DTRACE	DTRACE

STATEMENT LABELS

0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950	960	970	980	990
0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950	960	970	980	990

LOOP LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
23 10	1	11 12	2R	INSTACK
32 20	1	14 15	2R	INSTACK
41 30	1	17 18	2R	INSTACK
50 40	1	20 21	2R	INSTACK
59 50	1	23 24	2R	INSTACK

STATISTICS

PROGRAM LENGTH	738	59
CM LABELED COMMON LENGTH	448	36
520008 CM USED		

```

SUBROUTINE WRTTL 74/74 OPT=1
1      CCC
      CCC
      CCC
      CCC
      CCC
5
      SUBROUTINE WRTTL(MC)
      INTEGER MC(7)
      WRITE(6,100)
      FORMAT(1X,'WRTTL SAID MCR--')
      DO 200 I=1,7
      100  WRITE(6,110)MC(I)
      110  FORMAT(3X,18)
      RETURN
      END

```

SYMBOLIC REFERENCE MAP (R-1)

ENTRY POINTS
3 WRTTL

VARIABLES	SM	TYPE	RELOCATION	0	MC	INTEGER	ARRAY	F.P.
36 I		INTEGER						

FILE NAMES MONF
TAPPA FMT

STATEMENT LABELS
24 100 FMT

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES	EXT	REFS
11	200	I	10 11	108			

STATISTICS
PROGRAM LENGTH 418 33
570008 CM USED

```

PTN 4-8+564

SURROUTINE READ 74/74 OPT-1

1 CCC
  CCC
  CCC
  CCC
  CCC

5
  SURROUTINE READ(DB,ZN,MW,FLAG,M)
  COMMON/ZDATA/ZACPT(49),ZBCPA(164),ZTOSEL(4),ZGPLA(41),ZSIL(18),
  ZECTA(64,4)
  INTEGER DB,FLAG,ZTOSEL,ZGPLA,ZSIL,ZECTA,ZNI(41)
  REAL ZACPT,ZBCPA,ZN(164),ZNR(41)
  EQUIVALENCE(ZNI(1),ZNR(1))
  DATA IACPT,ITOSEL,IECTA,JECTA,IGPLA,IBCPA,ISIL/1.1,1.1,1.1,1.1,1.1,1.1/
  READS DATA FROM VARIOUS ARRAYS INTO THE Z VECTOR
  COTO(10,20,30,40,50,60),DB-100
  READ FROM ACPT
  DO 200 I=1,MW
    IF(IACPT+1-1.GT.49)COTO 300
    ZN(I)=ZACPT(IACPT+1-1)
    IACPT=IACPT+MW
    M=MW
    IF(FLAG.NE.1)RETURN
    IACPT=50
    RETURN
  M=I-1
  IACPT=50
  RETURN

25
  READ FROM TOSEL

30
  DO 210 I=1,MW
    IF(ITOSEL+1-1.GT.4)COTO 320
    ZNI(I)=ZTOSEL(ITOSEL+1-1)
    ZN(I)=ZNR(I)
    ITOSEL=ITOSEL+MW
    M=MW
    IF(FLAG.NE.1)RETURN
    ITOSEL=5
    RETURN
  M=I-1
  ITOSEL=5
  RETURN

35
  READ FROM ECTA

40
  DO 220 I=1,MW
    IF(ZECTA(IECTA+1-1,JECTA).EQ.-1)COTO 340
    ZNI(I)=ZECTA(IECTA+1-1,JECTA)
    ZR(I)=ZNR(I)
    M=MW
    IECTA=IECTA+MW
    IF(FLAG.NE.1)RETURN
    IECTA=1
    IECTA=JUNCTA+1
    RETURN
  M=I-1
  IECTA=1
  JECTA=JECTA+1

45
  340

```

```

SUBROUTINE READ      74/74  OPT=1
IF(JECTA.LE.4)RETURN
JECTA=4
LECTA=64
RETURN
60      READ FROM CPLA
      DO 240 I=1,NW
      IF(1CPLA+I-1.GT.41)GOTO 360
      ZN(1)=2CPLA(1CPLA+I-1)
      ZN(1)=ZNR(1)
      1CPLA=1CPLA+NW
      M=NV
      IF(FLAG.NE.1)RETURN
      1CPLA=42
      RETURN
      360      M=1-1
      1CPLA=42
      RETURN
70      READ FROM BCPLA
      DO 250 I=1,NW
      IF(1BCPLA+I-1.GT.164)GOTO 380
      ZN(1)=2BCPLA(1BCPLA+I-1)
      1BCPLA=1BCPLA+NW
      M=NV
      IF(FLAG.NE.1)RETURN
      1BCPLA=165
      RETURN
80      READ FROM SIL
      DO 260 I=1,NW
      IF(1SIL+I-1.GT.19)GOTO 390
      ZN(1)=2SIL(1SIL+I-1)
      1SIL=1SIL+NW
      M=NV
      IF(FLAG.NE.1)RETURN
      1SIL=19
      RETURN
90      M=1-1
      1SIL=19
      RETURN
      END

```

SYMBOLIC REFERENCE MAP (R=1)

DTI	BCPA	0	41	23	0	0	0	0+RC	0
+RC	0ENDREC							+RC	1
DTI	BCPA			1				0+RC	2
+RC	2	0	-225000000E+01					0+RC	3
+RC	3	0	-225000000E+01					0+RC	4
+RC	4	0	-300000000E+01					0+RC	5
+RC	5	0	-300000000E+01					0+RC	6
+RC	6	0	-225000000E+01					0+RC	7
+RC	7	0	-225000000E+01					0+RC	8
+RC	8	0	-225000000E+01					0+RC	9
+RC	9	0	-225000000E+01					0+RC	10
+RC	10	0	-225000000E+01					0+RC	11
+RC	11	0	-225000000E+01					0+RC	12
+RC	12	0	-225000000E+01					0+RC	13
+RC	13	0	-225000000E+01					0+RC	14
+RC	14	0	-225000000E+01					0+RC	15
+RC	15	0	-225000000E+01					0+RC	16
+RC	16	0	-225000000E+01					0+RC	17
+RC	17	0	-225000000E+01					0+RC	18
+RC	18	0	-225000000E+01					0+RC	19
+RC	19	0	-225000000E+01					0+RC	20
+RC	20	0	-225000000E+01					0+RC	21
+RC	21	0	-225000000E+01					0+RC	22
+RC	22	0	-225000000E+01					0+RC	23
+RC	23	0	-225000000E+01					0+RC	24
+RC	24	0	-225000000E+01					0+RC	25
+RC	25	0	-225000000E+01					0+RC	26
+RC	26	0	-225000000E+01					0+RC	27
+RC	27	0	-225000000E+01					0+RC	28
+RC	28	0	-225000000E+01					0+RC	29
+RC	29	0	-225000000E+01					0+RC	30
+RC	30	0	-225000000E+01					0+RC	31
+RC	31	0	-225000000E+01					0+RC	32
+RC	32	0	-225000000E+01					0+RC	33
+RC	33	0	-225000000E+01					0+RC	34
+RC	34	0	-225000000E+01					0+RC	35
+RC	35	0	-225000000E+01					0+RC	36
+RC	36	0	-225000000E+01					0+RC	37
+RC	37	0	-225000000E+01					0+RC	38
+RC	38	0	-225000000E+01					0+RC	39
+RC	39	0	-225000000E+01					0+RC	40
+RC	40	0	-225000000E+01					0+RC	41
+RC	41	0	-225000000E+01					0+RC	42
+RC	42	0	-225000000E+01					0+RC	43

DTI	SIL	0	1A	10A	0	0	0	0+SI	0
+SI	0ENDREC							+SI	1
DTI	SIL			7	13			+SI	2
+SI	2	37	49	55	61			+SI	3
+SI	3	85	97	103	109			+SI	4

Appendix B

```

ID SAMPLE
APP DMAP
BEGIN $
$ SETS UP THE TABLES THAT DESCRIBE THE STRUCTURAL MODEL
$
GPI GEOM1,GEOM2,/GPL,EQEXIN,GPD1,CSTM,BGPD1,SIL/V,N,LUSET/ V,N,
MOCPT $
SAVE LUSET,MOCPT $
COND ERROR1,MOCPT $
CP2 GEOM2,EQEXIN/ECT $
PARAML PCDB,/C,N,PRES/C,N,/C,N,/C,N,/V,N,JHPPLOT $
CP3 GEOM3,EQEXIN,GEOM2,/CPT/V,N,MOCRAV $
TA1 ECT,EPT,BGPD1,SIL,GPT,CSTM/EST,CEI,GPECT,/V,N,LUSET/ V,N,
MOSIMP/C,N,1/V,N,MOCENL/V,N,GENEL $
SAVE MOCENL,MOSIMP,GENEL $
COND ERROR1,MOSIMP $
PARAM //C,N,ADD/V,N,MOCGX/C,N,1/C,N,0 $
EMC //C,N,ADD/V,N,MOCGX/C,N,1/C,N,0 $
EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MIDICT,,/V,N,MOCGX/ V,
N,MOCGX/C,N,/C,N,/C,N,/C,N,/C,Y,COUPHASS/C,Y,CPBAR/C,Y,CPROD/ C,Y,
CPQAD1/C,Y,CPQAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
CPQDPLT/C,Y,CPTMPLT/C,Y,CPTBSC $
SAVE MOCGX,MOCGX $
COND JHPCGX,MOCGX $
I-A GPECT,KDICT,MELM/KCGX,GPT $
LABEL JHPCGX $
COND ERROR1,MOCGX $
EMA GPECT,KDICT,MELM/MCG,/C,N,-1/C,Y,WTMASS=1.0 $
COND LGPWC,CRDPT $
CPWC BGPD1,CSTM,EQEXIN,MCG/OGPWG/V,Y,CRDPT=-1/C,Y,WTMASS $
OFF OGPGC,....//V,N,CARDNO $
LABEL LGPWC $
EQUIV KCGX,KCG/MOCENL $
COND LRL11,MOCENL $
SHA3 CEI,/KCGX/V,N,LUSET/V,N,MOCENL/C,N,-1 $
ADD KCGX,KCGY/KCG $
LABEL LRL11 $
PARAM //C,N,MPT/V,N,NSKIP/C,N,0/C,N,0 $
PARAM //C,N,SUB/V,N,DESINT/C,N,0/C,N,1 $
PURGE WRRR,DIJE,D2JE/DESINT $
PARAM //C,N,MPT/V,N,MOCAMBER/C,N,1/C,Y,ICAHB=-1 $
PURGE CAMBER/MOCAMBER $
$ THE CONSTRAINTS OF THE FIRST SURCASE ARE APPLIED
$
GPI4 CASECC,GEOMA,EQEXIN,GPD1,BGPD1,CSTM/RC, LUSET,ASET/V, N,LUSET/
V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OHIT/V,N,REACT/V,N,NSKIP/V,
K,REPEAT/V,N,MOCSET/V,N,MOL/V,N,MOA/C,Y,SUBID $
MPCF1,MPCF2,SINGLE,OHIT,REACT,NSKIP,REPEAT,MOCSET,MOL,MOA $
GPI5 GPL,GPT,LUSET,SIL/OGPST/V,N,MOCIST $
COND MOCIST $
I-A LRL4,MOCPT $
OFF OGPGC,....//V,N,CARDNO $
I-A I-A $
EQUIV KCGX,MPT/MPCF1/MCG,MAN/MPCF1 $
COND LRL2,MPCF1 $

```

```

MCE1      USET, RG/CH $
MCE2      USET, CH, ECC, MCC, /KHH, MHH, . $
LBLE2     LBL2 $
LBLE3     KHH, MFF/SINGLE/MHH, MFF/SINGLE $
LBLE4     LBL3, SINGLE $
LBLE5     USET, KHH, MHH, . /RFF, RFS, .MFF, . $
LBLE6     LBL3 $
LBLE7     RFF, KAA/ONIT/ MFF, NAA/ONIT $
LBLE8     CO/ONIT $
LBLE9     LBL5, ONIT $
LBLE10    /C, M, PREC/V, M, PREC $
LBLE11    USET/V, C, N, F/C, M, O/C, N, A $
LBLE12     RFF, V, /ROO, .KOA, KAA $
LBLE13     KOO/LOO, OOO/C, M, I/C, M, O/V, N, MIND/V, M, DET/V, M, NDET/V, M, SING $
LBLE14     MIND, DET, NDET, SING $
LBLE15     LOO, OOO, KOA/CO/C, M, I/C, M, -1/V, M, PREC/V, M, PREC $
LBLE16     KOA, CO, KAA/KA/C, M, I/C, M, I/C, M, I/V, M, PREC $
LBLE17     USET, CO, MFF/NA $
LBLE18     LBL5 $
LBLE19     LBL6, REACT $
LBLE20     USET, KAA, NAA/KLL, KLR, KRR, MLL, MLR, MRR $
LBLE21     KLL/LLL/ $
LBLE22     DH, MLL, MLR, MRR/HR $
LBLE23     LLL, KLR, KRR/DH $
LBLE24     LBL6 $
LBLE25     DYNAMICS, GPL, SIL, USET/GPLD, SILD, USETD, TFPPOOL, . . . . .EED, EODYN/V,
LBLE26     M, LUSET/V, N, LUSETD/V, N, NOTFL/V, M, MODTL/V, M, MODTL/V, M, HOPSDL/V, M, NOFRL/V,
LBLE27     M, NOFLTV/V, M, NOTRL/V, M, NOEED/C, M, I23/V, M, NOUE $
LBLE28     LUSETD, NOUE, NOEED $
LBLE29     ERROR2, NOEED $
LBLE30     CO, COD/NOUE/CH, CHD/NOUE $
LBLE31     $
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84

```
CASECC,UCV,KELM,KDICT,ECT,EQEXIN,CPECT,PGC,QC/QMRGYI,OCPPBI/
C.N.STATICS $
ONRGYI,OCPPBI,...// $
CASECC,CSHM,NPT,DIT,EQEXIM,SIL,GTTT,EDT,BGPD,T,QC,UCV,EST,
XYCDB,PGC/OPCI,OQC1,OUCVI,OES1,OEFL,PUCVI/C.M.STATICS/V,M,
NOSORT2--1 $
NOSORT2 $
LBL21,NOSORT2 $
OUCV1,OPC1,OQC1,OEFL,OES1,/OHCV2,OPG2,OQC2,OEFL,OES2, $
OUCV2,OPG2,OQC2,OEFL,OES2,//V,M,CARDNO $
CARDNO $
XYCDB,OPG2,OQC2,OUCV2,OES2,OEFL/XYPLTT/C,M,TRAN/C,M,PSET/V,M,N,
PFLE/V,M,CARDNO $
XYPLTT// $
DPLDT $
LBL21 $
OUCV1,OPC1,OQC1,OEFL,OES1,//V,M,CARDNO $
CARDNO $
P2,JUMPPLOT $
DPLDT $
PLTPAR,GPSETS,ELSETS,CASECC,BGPD,EOEXIN,SIL,PUCVI,CPECT,OESI/
PLOTXZ/V,M,NSIL/V,M,LUSET/V,M,JUMPPLOT/V,M,PLTLG/V,M,PFLE $
PFLE $
PLOTXZ// $
FINIS $
ERROR2 $
//C,M,-2/C,M,FLUTTER $
ERROR1 $
//C,M,-1/C,M,FLUTTER $
ERROR4 $
//C,M,-4/C,M,FLUTTER $
ERROR9 $
//C,M,-3/C,M,STATICS $
FINIS $
END $
TIME .0
DIAG 14
COND
$
$
$
TITLE-SAMPLE
METHOD-10
ECHO-POIN
DISPLACEMENT - ALL
SUBCASE TO SET INITIAL ANGLE OF ATTACK
SUBCASE 1
SPC = 1
$ SUBCASE TO CALCULATE DEFLECTIONS, ETC.
SUBCASE 2
SPC = 2
```

```

INPUT BULK DATA DECK ECHO
1 2 3 4 5 6 7 8 9 10
$ TOLERANCE OF ITERATION LOOP
PARAM ELOOP .01
$ ROOT CHORD
PARAM RC 40.0
$ WING PLANFORM AREA, AERO MODEL
PARAM WAREA 2100.0
$ DYNAMIC PRESSURE
PARAM Q 59.34009
$ ANGLE OF ATTACK PARAMETER
PARAM AOAP 1.134925 0.0
$ PARAMETER TO INCLUDE CAMBER MATRIX IN CALCULATIONS
PARAM ICAMB 1
$ PARAMETER TO PICK WHICH EIGENVECTOR TO USE
PARAM LHODES 1
$
$ CONSTRAINTS FOR BOTH SUBCASES
SPC1 1 2 1 THRU 6
SPC1 1 13 5
SPC1 1 456 1 THRU 18
SPC1 2 123 1 THRU 6
SPC1 2 456 1 THRU 18
$ DOF FOR ANALYSIS SET
ASET1 3 7 THRU 18
$
$
$ DMI CAMBER 0 2 1 1.3123 17 1
DMI CAMBER 1 15 1.3123 17 1.3123
$
$ AERODYNAMIC PARAMETERS
AERO 223.4 40.0 7.650-2 1
HKAERO1 .2
+FAERO1 1.0-15
$
$ DESCRIBES DIMENSIONS OF AERO MODEL
CAERO1 1000 1 2 610
+FAERO1 0.0 2.25 40. 11.25 45. 2.25 32.5 1
CAERO1 1050 1 1 1
+FAERO1 11.25 45. 2.25 16.25 15. 60. 2.25 15.
CAERO1 1075 1 1 1
+FAERO1 27.5 45. 2.25 16.25 30. 60. 2.25 15.
AERFACT 610 .0 .66666671.0
FAERO1 1
$
$
$ COORDINATE
COORD1 1 1 1 3 9 7
COORD2 2 2 3 5 11 9
COORD3 3 3 7 9 15 13

```

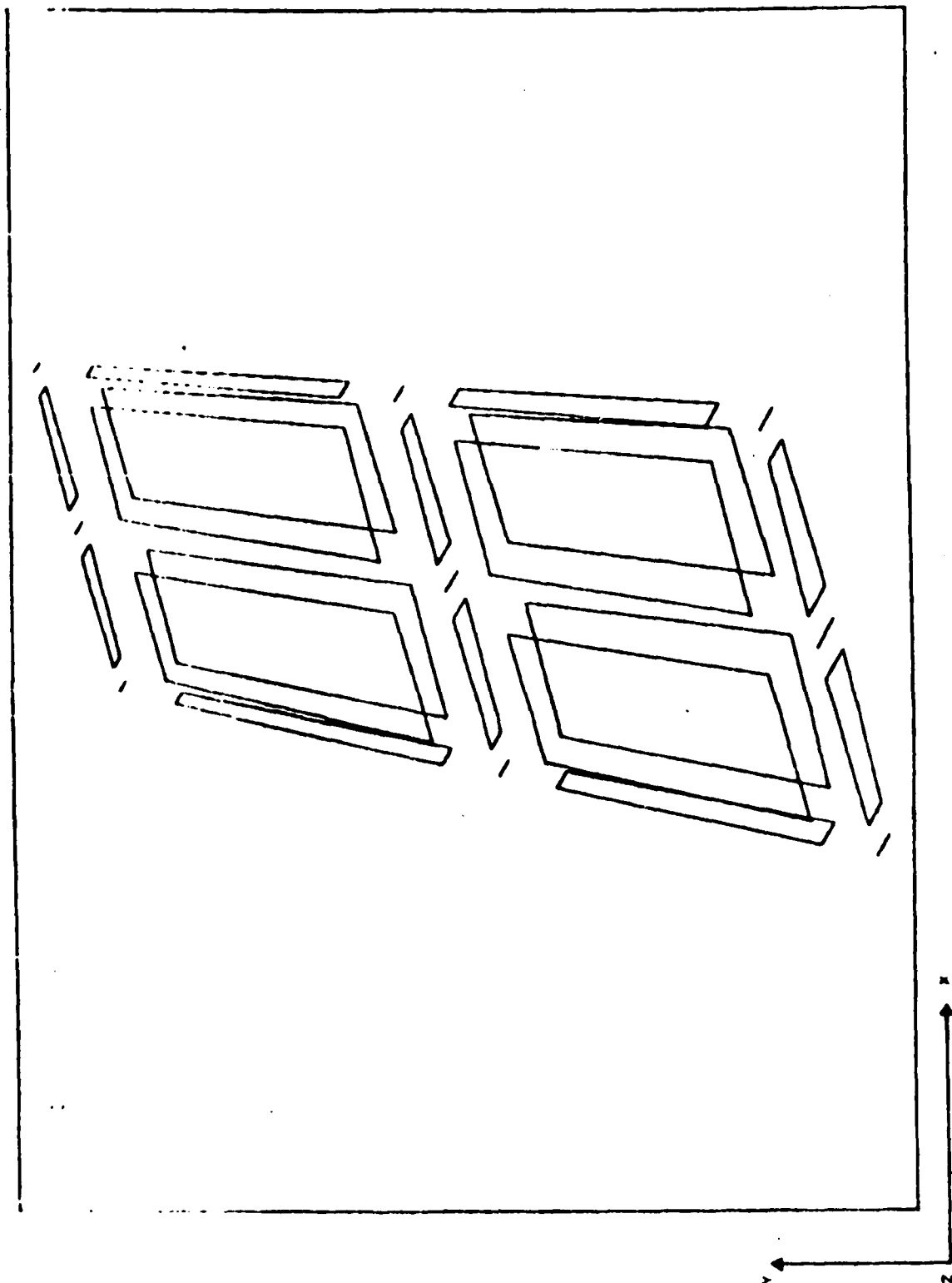


```

INPUT BULK DATA DECK ECHO
. 1 .. 2 .. 3 .. 4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
PQDNEM2 1 1.1
PQDNEM2 2 1.1
PQDNEM2 3 1.1
PQDNEM2 4 1.1
PQDNEM2 5 1.1
PQDNEM2 6 1.1
PQDNEM2 7 1.1
PQDNEM2 8 1.1
PROD 1 1.1
PROD 2 1.1
PROD 3 1.1
PROD 4 1.1
PROD 5 1.1
PROD 6 1.1
PROD 7 1.1
PROD 8 1.1
PROD 9 1.1
PSHEAR 1 1 .06
PSHEAR 2 1 .06
PSHEAR 5 1 .06
PSHEAR 6 1 .06
PSHEAR 7 1 .06
PSHEAR 8 1 .06
PSHEAR 9 1 .06
PSHEAR 10 1 .06
PSHEAR 11 1 .06
$
$
$ DEVINES THE TRANSFORMATION MATRIX FROM STRUCTURAL DEFORMATIONS
$ TO AERO DISPLACEMENTS
SET1 1 1 3 5 7 9 11 13
+S1 15 17
SPLINE1 2000 1000 1000 1003 1 0.0
SPLINE1 3000 1050 1050 1050 1 0.0
SPLINE1 4000 1075 1075 1075 1 0.0
D-1 TOSEL 0 4
+DT11 ENDREC
$
$
$ TOP SURFACE ELEMENT LIST
DT1 TOSEL 1 1 2 3 4 ENDRLC
ENDDATA
+S1
+DT11

```

2



REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFIT/GAE/AA/82D-16	2. GOVT ACCESSION NO. AD A724 662	3. RECIPIENT'S CATALOG NUMBER
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) NASTRAN Flexible-wings Aeroelastic Fluid-Structure Interfacing		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this study was to expand the capabilities of the Static Flexible Wing Aeroelastic Sequence that Captain Lance P. Chrisinger developed for NASTRAN as his Master's Thesis at AFIT. Captain Chrisinger developed a basic procedure to enable NASTRAN to analyze flexible wing airloads and stresses. That capability is expanded to enable analysis of standard wing models.		

END

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DTIC