USARTL-TR-77-54B

ROTORCRAFT FLIGHT SIMULATION, COMPUTER PROGRAM C81
Volume II - User's Manual

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Fort Eustis, Va. 23604

APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report documents an engineering analysis and resulting computer programs for the evaluation of rotary-wing aircraft performance, handling qualities, rotor blade loads, maneuvering characteristics, and rotor system aeroelastic stability through application of the modal technique to the rotor blade equations of motion and stepwise integration of the time domain equations for the rotor, hub, aircraft and control system. The primary computer programs associated with the current effort are the Mykestad Program, for computing rotor blade natural frequencies and mode shapes; and the Rotorcraft Flight Simulation, Computer Program C81, for computing the wide variety of flight characteristics listed above.

The version of C81 developed under this contract is designated version AGAJ77. The immediately preceding version in the public domain is designated version AGAJ76. AGAJ77 differs from AGAJ76 in the following respects: an improved autopilot; more comprehensive elastic rotor analysis; an improved engine/governor model; an improved wake analysis; and enhanced output capabilities. While most of these improvements were successfully installed in the computer software, extensive difficulties were experienced in the implementation of the elastic rotor refinements. While the other improvements may make the AGAJ77 version preferable for many types of studies, AGAJ76 is recommended for the examination of rotor dynamics and loads. In using either program, some evaluation of the program's applicability to the problem under investigation through correlation with existing data is a judicious first step.

The Project Engineer for this contract was Mr. Edward E. Austin, Aeromechanics Technical Area, Aeronautical Technology Division.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report consists of three volumes and documents the current version in the C81 family of rotorcraft flight simulation programs developed by Bell Helicopter Textron. This current version of the digital computer program is referred to as AGAJ77. The accompanying program for calculating fully coupled rotor blade mode shapes is called DNAM05, and the rotor wake program is called AR9102.

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The new or revised mathematical models or documentation incorporated into this report are listed below:

(1) The maneuver autopilot was modified to accept four more time history commands (pitch, roll, yaw, and climb rates) in addition to the normal load factor. A digital filter is used to process the airframe response signal in order to reduce the b-per-rev component and to smooth the autopilot-generated control commands.

(2) The effects of an offset pitch change axis have been incorporated in DNAM05 and C81.

(3) A first-order lag has been introduced into the engine power available calculations.

(4) The rotor-induced velocity distribution tables have been modified to be functions of advance ratio and wake-plane angle of attack. An average induced velocity table has been added to the analysis. In addition, the digital filter is used in the calculations to reduce the oscillation of the induced velocity experienced in previous versions of C81.

(5) A rotor contour plot option has been added.

(6) Time-history plots may now be made after time-variant trim.

(7) The rotorcraft flightpath stability analysis (STAB) has been modified to output the numerators of more transfer functions.

The first volume, the Engineer's Manual, presents an overview of the computer program capabilities plus discussions for the background and development of the principal mathematical models in the program. The models discussed include all those currently in the program.

Volume II, the User's Manual, contains the detailed information necessary for setting up an input data deck and interpreting the computed data. Volume III, the Programmer's Manual, includes a catalog of subroutines and a discussion of programming considerations. The source tapes and related software for the computer programs documented in this report are unpublished data on file at the Applied Technology Laboratory, U. S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia.

PREFACE

This report and its accompanying computer program were developed under Contract DAAJ02-77-C-0003 awarded in 1976 by the Eustis Directorate of the U. S. Army Air Mobiltiy Research and Development Laboratory (USAAMRDL)*. This report supersedes all previous versions of the program and documentation, including USAAMRDL-TR-76-41A, B, C.

Technical program direction was provided by Mr. E. E. Austin of USATL. The principal Bell Helicopter personnel associated with the current contract were Messrs. J. R. Van Gaasbeek, T. T. McLarty, P. Y. Hsieh, and Dr. S. G. Sadler.

*Redesignated Applied Technology Laboratory, U. S. Army Research and Technology Laboratories (AVRADCOM), effective 1 September 1977

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1.0 INTRODUCTION

The purposes of this volume of the report are to inform the reader of the capabilities of the current version of the Rotorcraft Flight Simulation Program C81 and to provide the information necessary for assembling an input data deck and for successfully executing the program. The previous version of the program (Reference 1) has been improved through modifications to the maneuver autopilot, the pitch-change axis geometry, the engine model and the Rotor Induced Velocity Distribution Tables. In addition, the user can now time-history and contour-plot rotor variables after time-variant trim.

This version of the program, designated AGAJ77, is capable of modeling the following components of a rotorcraft: a fuselage; two rotors, each with a modal pylon, aeroelastic blades, and a nacelle; a wing; four stabilizing surfaces, none of which must be purely vertical or horizontal; four external stores or aerodynamic brakes; a nonlinear, coupled control system including a collective bobweight, stability and control augmentation system, and maneuver autopilot simulator; two jets; a weapon; and an engine-governor system.

The six sections following this introduction present only the information required to set up and successfully execute a C81 simulation. The reader is referred to Volume I for documentation of the programmed mathematical models and to Volume III for information regarding the computer program hardware requirements and available software.

Section 2.0 of this report lists the input data for the program in a sequence that corresponds to the input and card sequence required for the data deck. The inputs are grouped according to either their function in the program or the rotorcraft component they simulate. For example, three of the input groups are the Program Logic Group, the Main Rotor Group, and the Wing Group. Each group is read into an array whose name is given in all uppercase letters at the left of the input sequence numbers in Section 2.0. Except for the first letter, the array names were chosen to be abbreviated acronyms for the title of the group or component. As an aid to the user and the programmer,

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[1]McLarty, T. T., et al., ROTORCRAFT FLIGHT SIMULATION WITH COUPLED ROTOR AEROELASTIC STABILITY ANALYSIS, Volumes I-III, Bell Helicopter Textron; USAAMRDL Technical Reports 76-41A, 76-41B, 76-41C, Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1977, AD A042464 (TR 76-41A only).

a special convention was established for the first letter of each array: arrays beginning with the letter I control program logic; arrays beginning with Y contain the inputs used in the equations that compute the aerodynamic forces on the rotor blades, wing, and stabilizing surface; arrays beginning with T contain times that are used during maneuvers; and arrays beginning with X contain, for the most part, inputs that are physically measurable quantities, e.g., locations, weights, angles, lengths, and control linkages.

Where possible, the definition of each input is a brief, one-line description, with the required units, if any, given in parentheses at the right end of the line. However, some inputs cannot be defined so concisely. In some of these cases, the FORTRAN symbol assigned to the input in the program is listed. The symbol is generally an acronym for the input, which will have meaning to the experienced user of the program.

In all cases where a FORTRAN array or variable name is used, the standard FORTRAN convention for the format of the input applies. That is, if the first letter of an array or symbol is I, J, K, L, M, or N, the corresponding input must be a fixed point number (integer), i.e., "I" format. All fixed-point inputs must end in the rightmost column of the field for the input and must not contain a decimal point. If the first letter is not one of the six listed above, the input must be a floating point (decimal) number, i.e., "F" format. In view of the floating point formats used in C81, all such inputs should include a decimal point. If the decimal point is omitted, it is placed at the far right end of the field. For example, if the number 1 is punched in the first column of a 10-column field and the decimal point is omitted, the number will be interpreted as 1000000000.0 rather than the 1.0 intended.

Section 2.0 is designed to be the only documentation that a very experienced user needs to set up an input deck. The less-experienced user should consult Section 3.0 for a more complete explanation of the inputs, setup of the deck, and program options. This section is arranged in the same order as Section 2.0 and includes many of the equations used in the various mathematical models.

Section 4.0 provides information on the output of the program. The first major subsection discusses the sign conventions, including definitions of the reference systems used, and can be useful in setting up the deck as well as in interpreting output. The remainder of Section 4.0 explains each group of output which the program can generate during a successful execution. The vast majority of the groups are output on the printer. This printed output falls into three general categories: input, trim, and maneuver data. In addition, some of the maneuver data can be output on a CALCOMP plotter. Examples of all possible groups of output data were taken from actual computer runs and are included in the section.

Section 5.0 lists and discusses the error messages that the program can generate. Some of the errors terminate program execution, while others are only warnings of conditions that may affect the data being computed. In each case, the source of the error is noted and, where necessary, a suggestion on how to correct the error is given. Section 6.0 identifies the variables that are saved for future analysis during the computations of trims and maneuvers.

Utilization instructions for three ancillary programs, DNAM05 AR9102 and AN9101, are presented in Section 7.0. These programs create Rotor Elastic Blade Data (DNAM05), Rotor-Induced Velocity Distribution Tables (AR9102), and C81 fuselage inputs from test data (AN9101).

In this document, the rotors are referred to as Main Rotor (or Rotor 1) and Tail Rotor (Rotor 2). In the output, additional names, which are appropriate to the rotorcraft configuration, are used. All rotor names fall into two groups:

(1) Rotor 1, First, Main, Right, Forward

(2) Rotor 2, Second, Tail, Left, Aft

The names within a group may be considered synonymous, with context determining the appropriate word. The groups also indicate the input groups that should be used for a specific rotor. For example, inputs for the forward rotor of a tandem-rotor configuration should be input to the Main Rotor Group and the aft rotor inputs to the Tail Rotor Group. However, this input sequence is not mandatory. (The program does not verify that Rotor 1 is actually forward or right of Rotor 2.) With careful attention to the rotor control linkages, the two rotor groups can be swapped to reverse the direction of rotation of each rotor. See Section 3.36 for additional details.

1.1 PRIMARY AND SECONDARY OPERATIONS OF THE PROGRAM

The general operations of which the program is capable are:

(1) Compute a trimmed flight condition

(2) Compute a maneuver

(3) Perform a rotorcraft stability analysis

(4) Perform parameter sweeps of trim conditions, with or without a rotorcraft stability analysis

(5) Retrieve maneuver time-history data stored on magnetic tape

(6) Plot maneuver time-history data

(7) Perform a rotor aeroelastic stability analysis

(8) Perform an harmonic analysis of maneuver time-history data

(9) Perform a vector analysis of maneuver time-history data

(10) Store maneuver time-history data on magnetic tape

The first five general operations are primary operations and are illustrated in the flow charts in Figures 1 through 8. These operations are shown alone, if possible, and in all permissible combinations with other operations. The last five operations are secondary operations and occur within the block labeled "Operations on Time-History Data" in Figures 1 through 5 and 7. The flow chart for the contents of this block is shown in Figure 9. The flow charts of the five secondary operations contained in the block are shown in Figures 10 through 15.

Each primary operation or combination of operations is controlled by input data. Thus, the flow charts for the primary operations all begin with a "Read Data Deck" block. Since the amount of data to be read depends on the operation or operations desired, a data deck in this context consists of a message card, an "NPART" card telling the program which primary operation or operations to perform, and the additional data necessary to perform the indicated operation(s). In some cases, the additional data are contained on 500 or more additional cards, e.g., trim, rotorcraft stability analysis, maneuver. In other cases, as little as one card of additional data is required, e.g., data retrieval followed by only one secondary operation.

As is implied by Figures 1 through 8, data decks of primary operations other than parameter sweeps cannot be stacked one after the other; each deck must be submitted as a separate computer job. This situation does not impose any significant hardship on the user, since

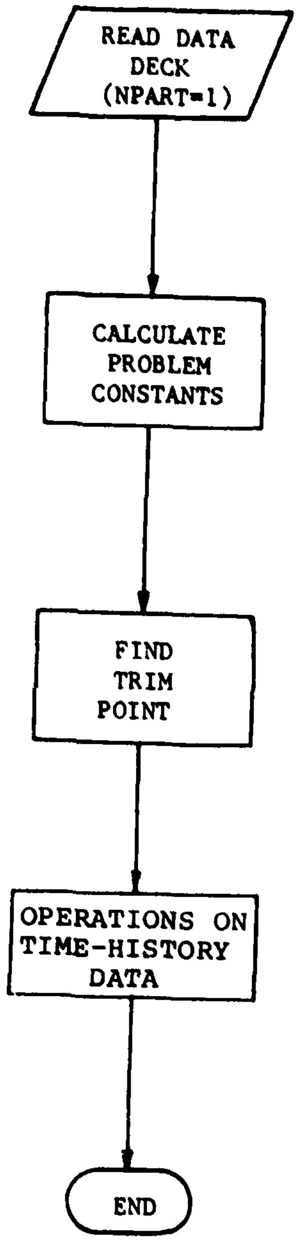

Figure 1. Trim-Only Operation.

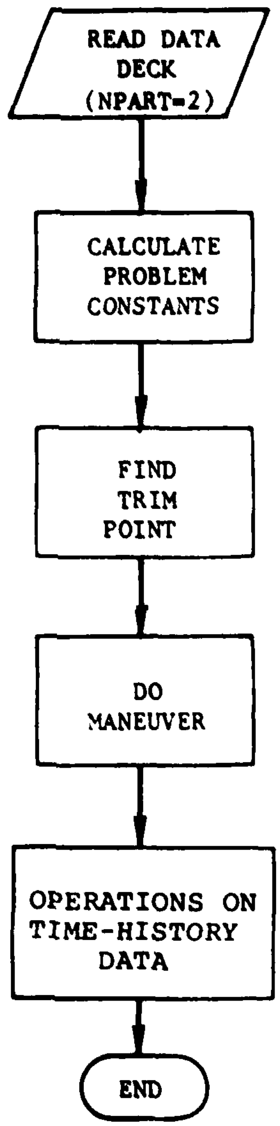

Figure 2. Trim Followed by Maneuver.

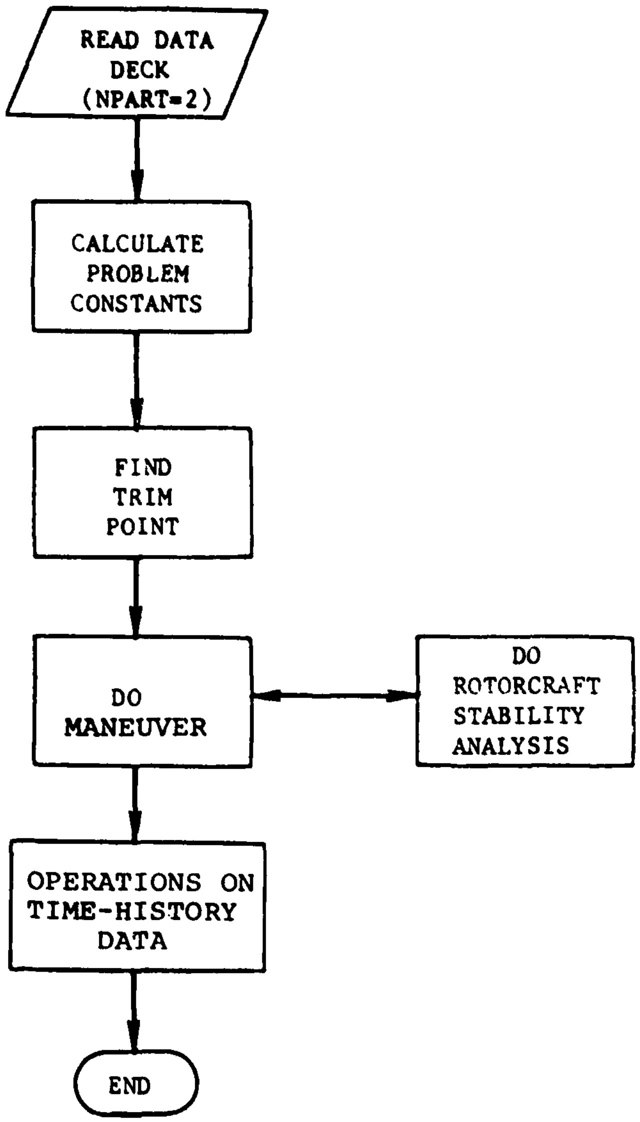

Figure 3. Trim Followed by Maneuver with Rotorcraft Stability Analysis.

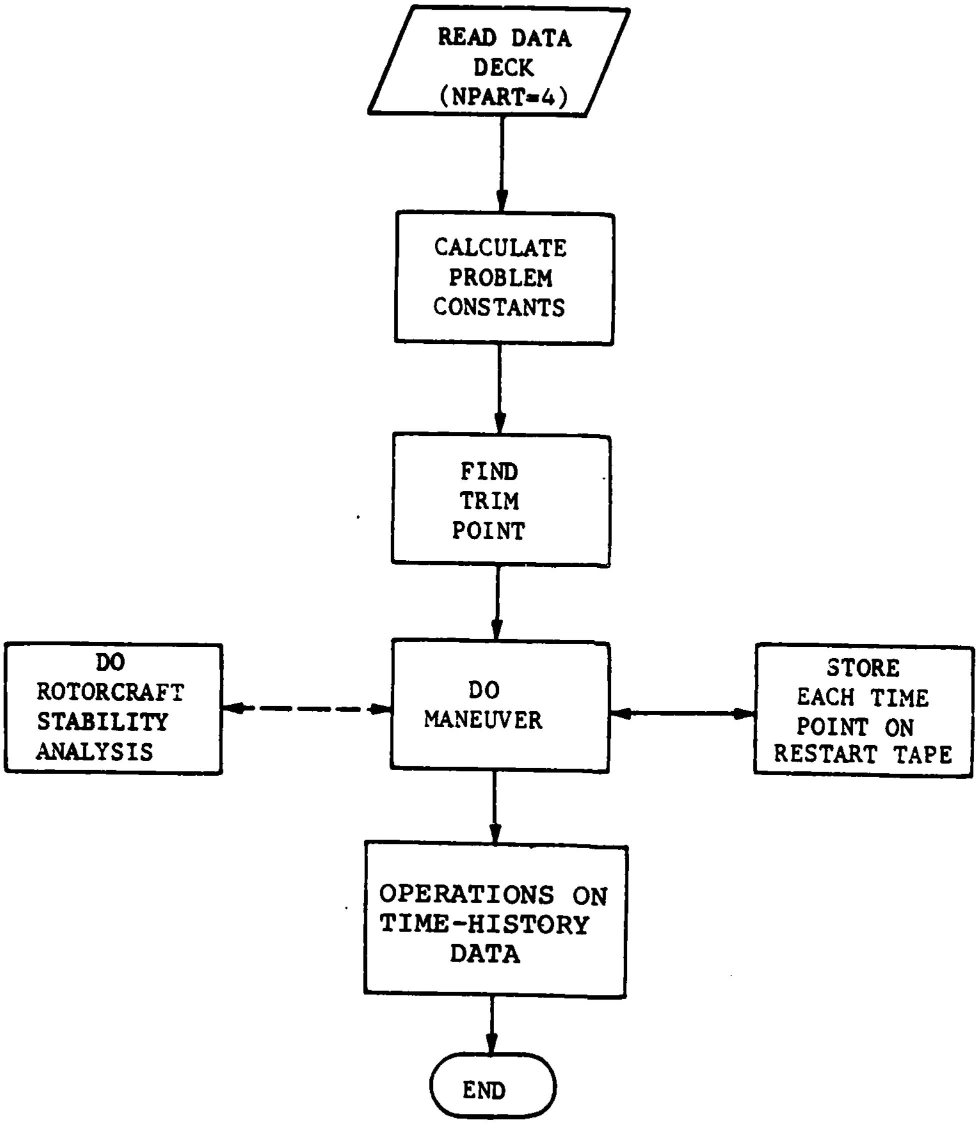

Figure 4. First Maneuver in Restart Procedure.

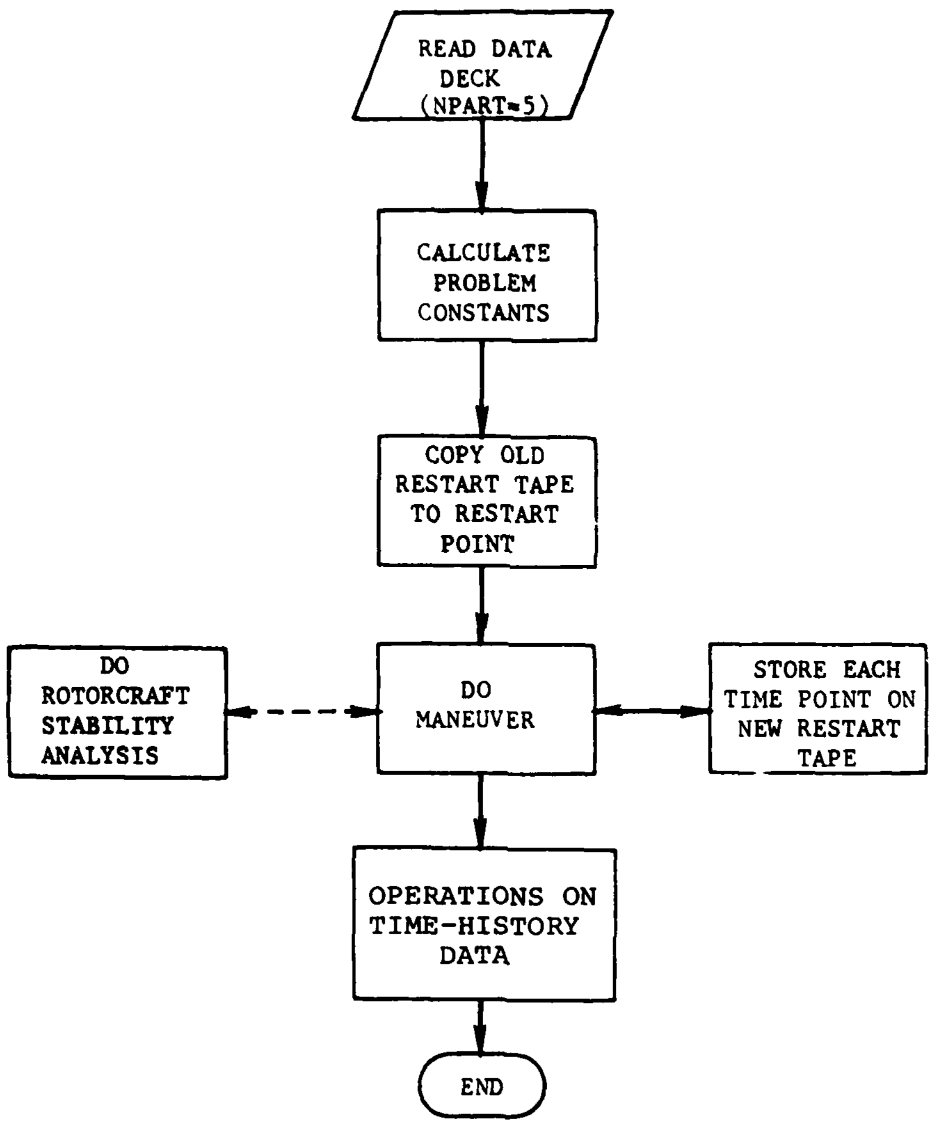

Figure 5. Second and Later Restart Maneuvers.

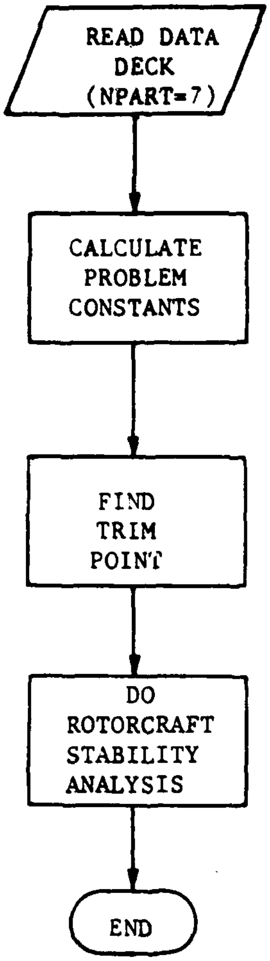

Figure 6. Trim and Rotorcraft Stability Analysis.

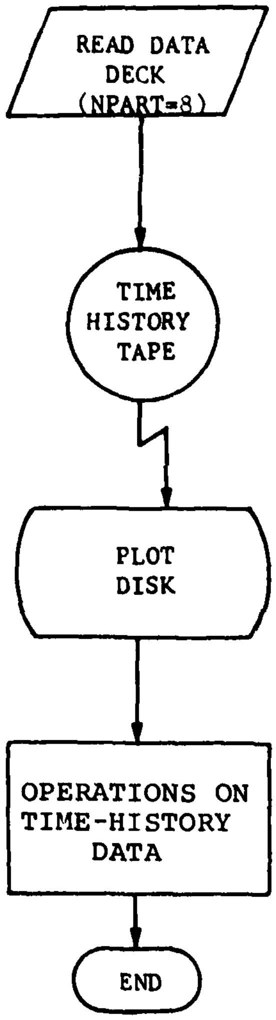

Figure 7. Retrieving Maneuver Data Stored Permanently.

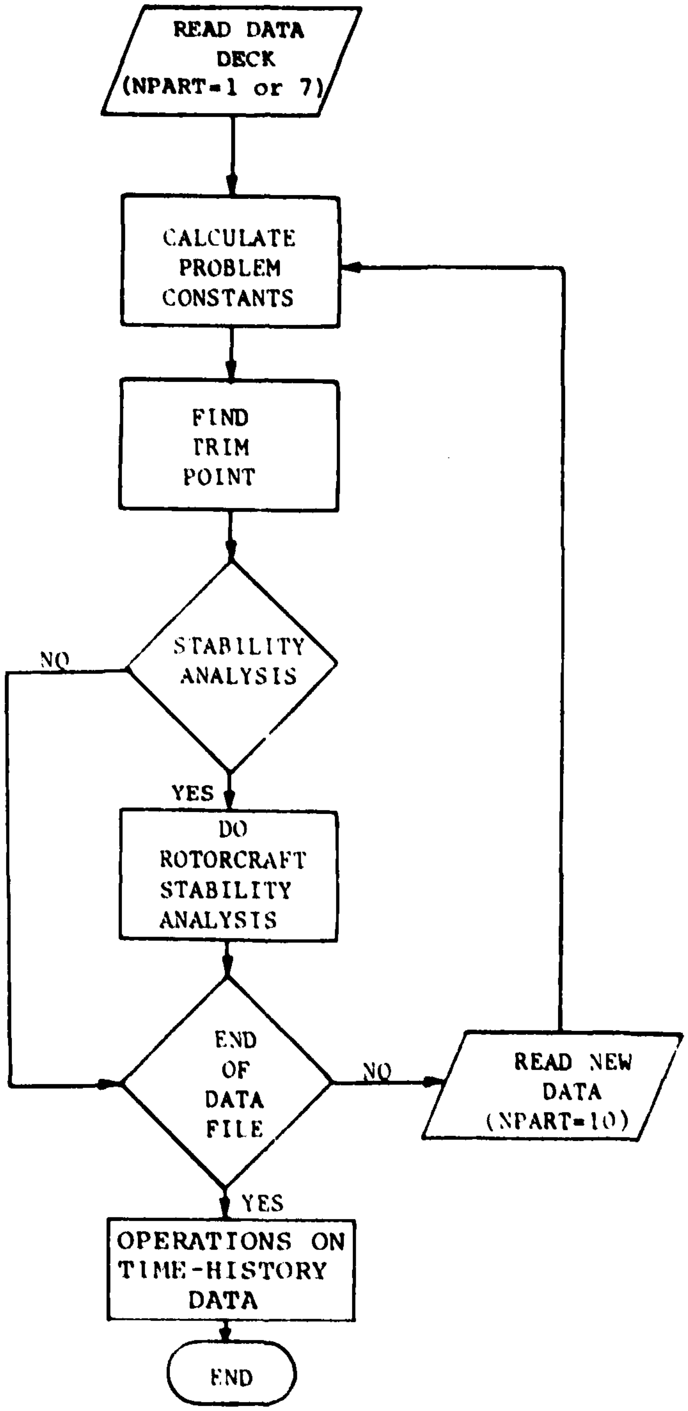

Figure 8. Trim or Trim and Rotorcraft Stability Analysis Followed by Parameter Sweep.

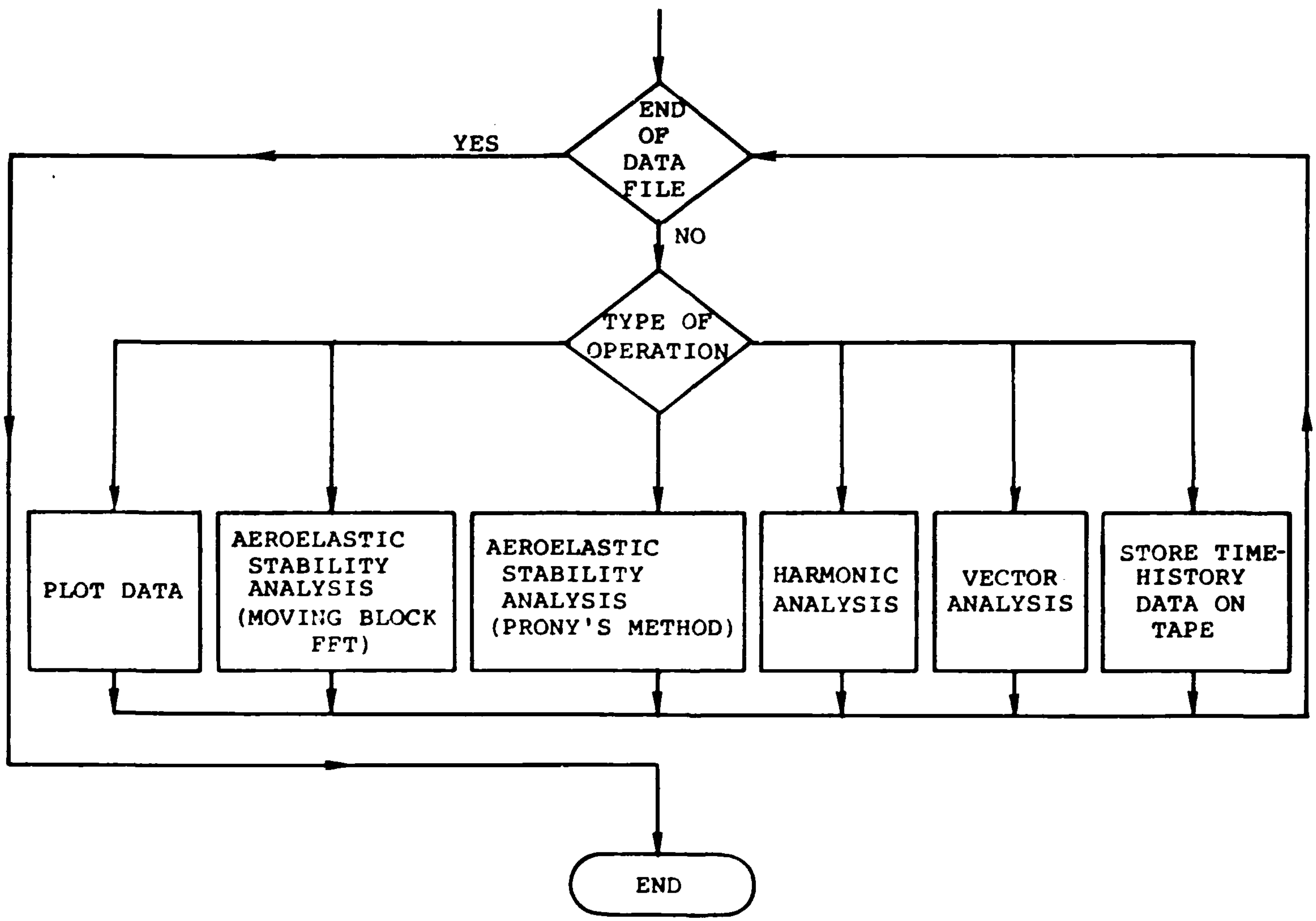

Figure 9. Block for Operations Performed on Time-History Data.

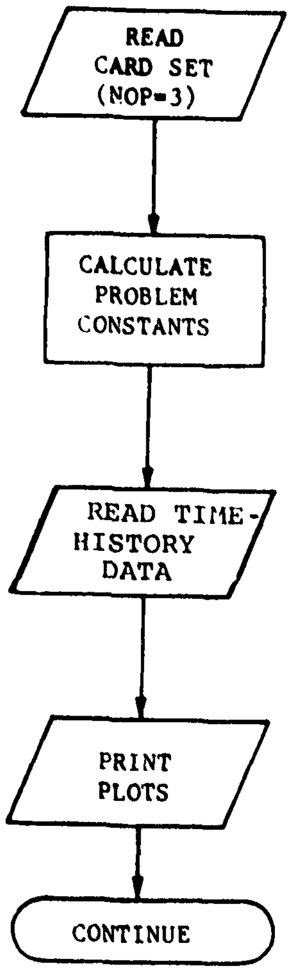

Figure 10. Plotting Operation.

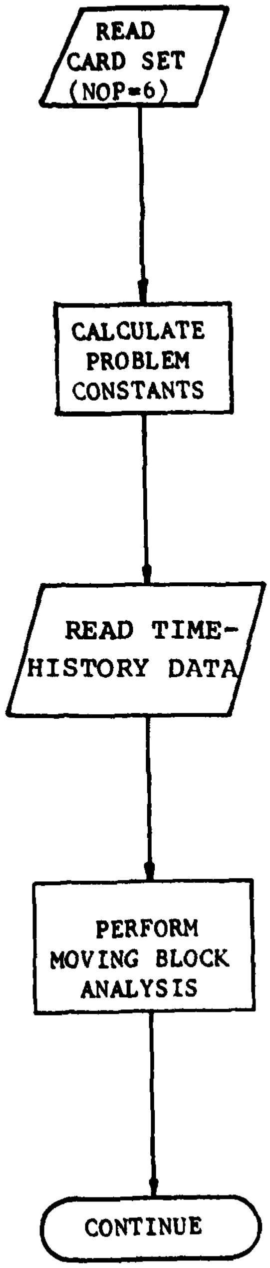

Figure 11. Moving Block Fast-Fourier-Transform Operation.

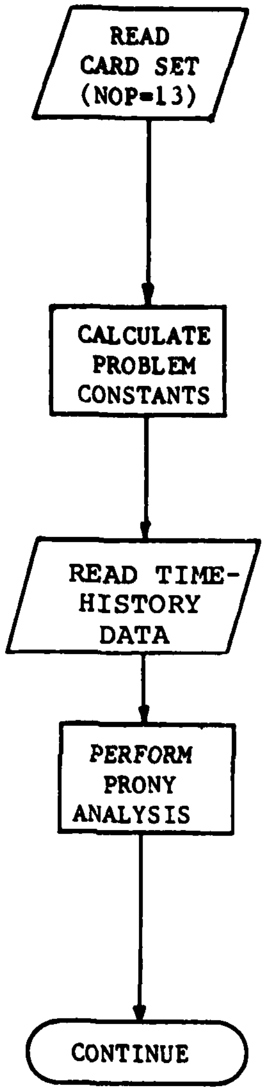

Figure 12. Prony Stability Analysis Operation.

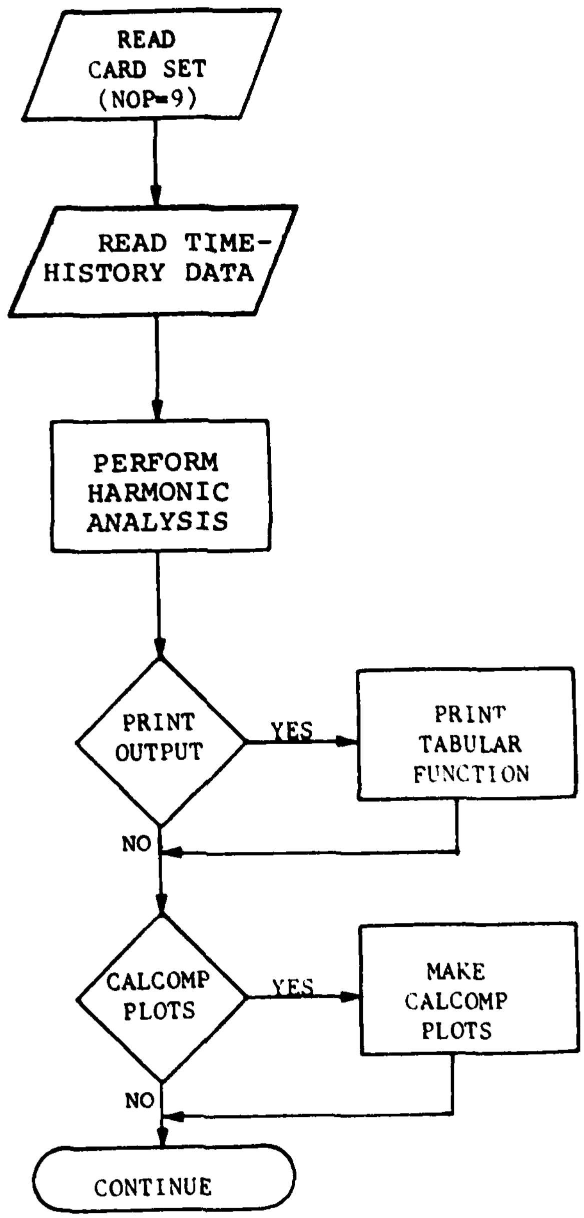

Figure 13. Harmonic Analysis Operation.

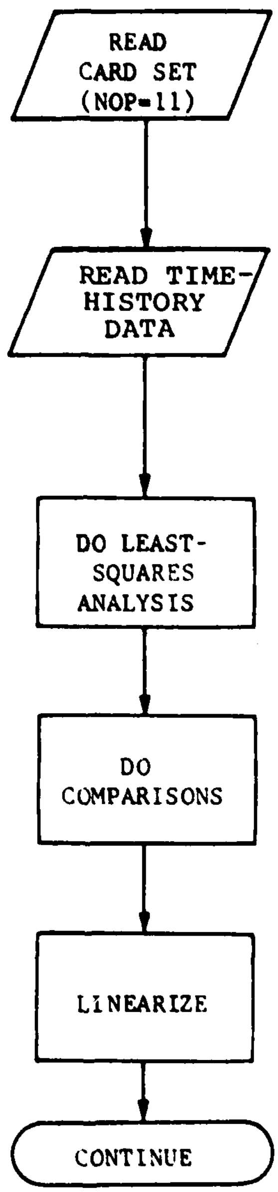

Figure 14. Vector Analysis and Data Reduction Operation.

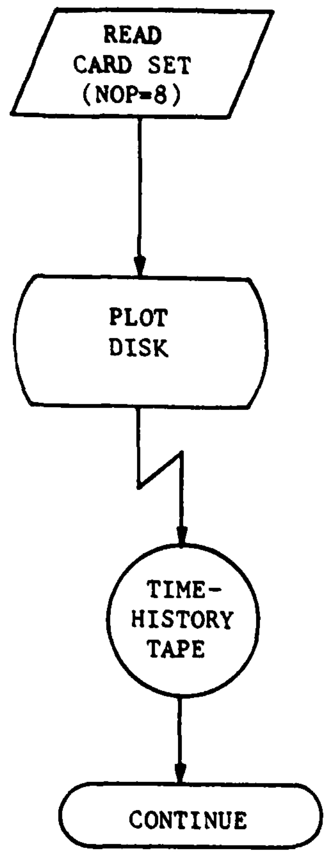

Figure 15. Operation for Storing Maneuver Time-History Data on Tape.

(1) the parameter sweep operation can be used to replace stacked trim-only (TRIM) and trim-and-stability-analysis (TRIM-STAB) decks, and

(2) in practice, the need to run more than one maneuver in a single job rarely, if ever, occurs.

The second step in several of the flow charts is "Calculate Problem Constants." In each operation containing this step, a number of quantities which remain constant throughout the performance of the operation(s) must be defined using the input data. For example, the body reference distances from the center of gravity to the location of specific rotorcraft components are computed. Performing such computations drastically reduces the number of program inputs and also provides program flexibility necessary for incorporating such operations as parameter sweeping.

1.2 DISCUSSION OF THE PROGRAM OPERATIONS

1.2.1 Primary Operations

In finding the trim point, the program iterates on the control positions, fuselage orientation, and/or rotor attitude to reach desired values of the rotor flapping moments and forces and moments on the fuselage center of gravity. When these desired values are all zero, the trim point is an unaccelerated flight condition. With controls locked and no external disturbances such as gusts, the rotorcraft would theoretically continue indefinitely along the straight flight path prescribed by the program inputs. The program also permits the calculation of two steady but accelerated flight conditions. In one, the rotorcraft is in a pushover or pullup condition at an input g-level. In the other, the rotorcraft is in a banked turn, either level or spiral, at an input g-level. In these cases the desired net forces and moments on the rotorcraft are not all zero, but depend on the input trim point. Either the unaccelerated or one of the steady accelerated flight conditions may be used as the starting point of the maneuver.

The rotorcraft stability analysis operation uses a trim point or a time point during a maneuver as its initial condition. The stability derivatives are computed by making small independent perturbations to each of the rotorcraft rigid-body degrees of freedom and primary flight controls, computing the forces and moments in the perturbed flight condition, subtracting the values of the forces and moments in the initial condition from those at the perturbed condition, and finally dividing the differences by the appropriate perturbations. Using these derivatives, the roots of the rotorcraft equations of motion, mode shapes associated with the roots, and transfer functions for the rotorcraft system are computed.

The parameter sweep operation may be used to simulate the stacking of TRIM and TRIM-STAB data decks for a given rotorcraft. Within a sweep deck, the user specifies by input data those cases in the sweep for which a rotorcraft stability analysis is and is not to be performed. The parameters most frequently swept include airspeed, gross weight, center-of-gravity station-line, incidence of an aerodynamic surface, atmospheric conditions, and g-level. Generally, within a single sweep deck, only one parameter is changed from case to case. However, any number and combination of inputs except some program logic switches and the values in some data tables may be swept. The assumption is made that each desired trim condition bears some relationship to the previous one, and that the previous trim point is a good starting condition for finding the next trim point. For example, in a speed sweep, a change of 20 or 30 knots is the most that should normally be used between 40 and 150 knots. Outside of this range, the maximum change should not exceed 10 knots.

All maneuvers require a trim point prior to computing the time history of a maneuver. The trim point is used to supply the initial conditions to a system of differential equations that describe the behavior of the rotorcraft in a maneuver. Various external inputs, or forcing functions, may be applied, such as control movements, gusts, store drops, and wing incidence change independent of control motion(s). At times specified by input data, the maneuver can be suspended while a rotorcraft or rotor aeroelastic stability analysis is performed. The maneuver is then resumed as if no interruption has occurred and continued until it reaches either the next time point to do a stability analysis or the end of the maneuver.

A maneuver restart operation is begun just like an ordinary maneuver using a trim condition as a starting point. The only difference is that the time-history variables and many intermediate variables are saved on the restart magnetic tape. Subsequent maneuver restarts use the condition at one of the saved time points and so do not require a trim condition or the complete data set defining the rotorcraft.

1.2.2 Secondary Operations

During the course of running a trim or maneuver, the values of a large number of time-history variables at each time point are saved on the plot disk. At the conclusion of the trim or maneuver, the secondary program operations specified in the input data are performed on these variables. For example, the user may select any of the saved variables to be plotted on the printer (or on CALCOMP if available). Plots made as part of a maneuver restart run will show the entire maneuver starting at time zero.

A complete harmonic analysis may also be made for any of the saved variables. A fast-Fourier-transform technique is used to examine a broad range of frequencies. This option is especially useful for studying rotor bending moments and related variables.

Frequently, maneuvers are run where one of the controls or the longitudinal mast tilt angle is varied sinusoidally. In this case, the vector analysis operation can be very useful. This analysis uses the least-squared-errors technique to fit the saved data to a curve of the form

$$F_i(t) = A_i \sin(\omega t + \phi_i) + B_i$$

Then, any amplitude ratios, A_i/A_j, and phase angle differences, $\phi_i - \phi_j$, may be computed. Lastly, linear combinations of the variables may be derived in the following form:

$$F_i(t) = C_i\ F_j(t) + D_i\ F_k(t) + E_i$$

If it is desired to perform additional plotting or analysis of the saved variables, they may be transferred from the plot disk to a magnetic time history tape. The data on the tape may then be reloaded to the plot disk for further use at a later time.

1.3 PROGRAMMING AND DOCUMENTATION CONSIDERATIONS

A great deal of effort has been expended to make the program as user-oriented as possible. Most of the switches controlling the different program options have been included in the Program Logic Group. The user can, therefore, determine the nature of the model, and the analysis to be used, by checking the inputs on the seven cards of this group.

Also, the documentation of the input format (Section 2.0) and the user's guide to the input format (Section 3.0) have been rewritten and expanded to make the definition of the inputs as clear and specific as possible. The definitions are not all easy to understand because of the nature of some of the variables, but it is thought that the definitions presented leave room for only one interpretation. A sample set of input data for a typical attack helicopter is included in Section 4.0 along with a detailed discussion of the program output so that the user can get an idea of the magnitude of most program inputs and outputs.

2.0 INPUT FORMAT

This section of the report presents the basic input format for an AGAJ76 card deck. The first subsection contains general information regarding the structure of and program features related to the card deck. The remaining subsections define the inputs to each of the basic input groups to the program. The groups are described in the same sequence in which they occur in the data deck.

For the very experienced user of C81, Section 2.0 is frequently the only documentation that is needed to set up, execute, and make changes to a data deck. When more explanation is required, the user should consult Section 3.0, which is arranged in the same order as Section 2.0 and includes detailed discussions of input definitions, program options, and many of the equations used in the program.

2.1 GENERAL

2.1.1 Composition of a Data Deck and Card Format

A complete input data deck for AGAJ77 can be divided into the 47 groups or sets of cards listed in Table 1. The first 39 groups form the basic card deck, which is used for trim-only and trim-and-rotorcraft-stability-analysis-only program operations. The remaining eight groups are only included in the deck when the maneuver program operation is to be performed.

The Program Logic Group is one of the most important groups in the deck. It controls which groups must be included in the deck and the program options that will be used in the computations. The input format for this group is 14 integer inputs per card with five column fields for each input (14I5 format). A primary reason for the integer format is to set the group apart from the remainder of the deck, in which the vast majority of the inputs are floating point numbers.

Except for the Program Logic Group, a standard format of seven floating point numbers in 10 column fields per card (7F10.0 format) is used wherever practical in the deck. Only the exceptions to this standard format are noted in the following sections. Where the format cannot be conveniently expressed by a FORTRAN statement like 7F10.0, the location of the input on the card is specified by the column or field of columns for the input. Unless otherwise noted, all formats start in Column 1, with Columns 71 through 80 reserved for the card sequence number.

TABLE 1. SEQUENTIAL SUMMARY OF INPUT GROUPS

Group Title	Sequence Number of ID Card *	Element Number in MODEL Data Set Array **	Section
Deck Identification & Program Flow Control Cards	None	N/A	2.2
Program Logic Group	10	1	2.3
Airfoil Data Table Group	None	N/A	2.4
Airfoil Data Table No. 1	21	2	2.4.1
Airfoil Data Table No. 2	22	3	2.4.1
Airfoil Data Table No. 3	23	4	2.4.1
Airfoil Data Table No. 4	24	5	2.4.1
Airfoil Data Table No. 5	25	6	2.4.1
Main Rotor Group	30	7	2.5
M/R Elastic Blade Data Group	40	8	2.6
Tail Rotor Group	50	9	2.7
T/R Elastic Blade Data Group	60	10	2.8
Rotor Aerodynamic Group	70	11	2.9
M/R Rotor - Induced Velocity Distribution (RIVD) Table	80	12	2.10.1
T/R RIVD Table	90	13	2.10.2
Rotor Wake Table Group	None	N/A	2.11
RWAS Table No. 1	***	14	2.11
RWAS Table No. 2	***	15	2.11
RWAS Table No. 3	***	16	2.11
RWAS Table No. 4	***	17	2.11
RWAS Table No. 5	***	18	2.11
RWAS Table No. 6	***	19	2.11
RWAS Table No. 7	***	20	2.11
RWAS Table No. 8	***	21	2.11
RWAS Table No. 9	***	22	2.11
RWAS Table No. 10	***	23	2.11
RWAS Table No. 11	***	24	2.11
RWAS Table No. 12	***	25	2.11

TABLE 1. (Concluded)

Group Title	Sequence Number of ID Card *	Element Number in MODEL Data Set Array **	Section
Fuselage Group	100	26	2.12
Landing Gear Group	110	27	2.13
Wing Group	120	28	2.14
Stabilizing Surface Groups	None	N/A	2.15
Stabilizing Surface No. 1	130	29	2.15.1
Stabilizing Surface No. 2	140	30	2.15.2
Stabilizing Surface No. 3	150	31	2.15.3
Stabilizing Surface No. 4	160	32	2.15.4
Jet Group	170	33	2.16
External Store/Aerodynamic Brake Group	180	34	2.17
Rotor Controls Group	190	35	2.18
Engine-Governor Group	200	36	2.19
Iteration Logic Group	210	37	2.20
Flight Constants Group	220	38	2.21
Bobweight Group	230	39	2.22
Weapons Group	240	40	2.23
SCAS Group	250	41	2.24
Stability Analysis Times Group	260	42	2.25
Blade Element Data Printout Times Group	270	43	2.26
Maneuver Time Card	None	N/A	2.27
Maneuver Specification Cards	None	N/A	2.28
Maneuver Analysis Cards	None	N/A	2.29-2.35

*"None" indicates that the group does not have an identification (ID) card.

**"N/A" indicates that the group is not included in the MODEL data set array.

***No specific sequence number on RWAS Table ID Cards.

2.1.2 Group Identification Cards and Data Library

The input groups which include a Group Identification (ID) Card are noted in Table 1 by the inclusion of a sequence number for the ID card.

The format for each of these ID cards is as follows:

Field	Description of the Input
Col 1→ 8	IDEN, data library name for the group
Col 11→70	Alphanumeric identifying comments (optional)
Col 71→80	Card sequence numbers (optional)

If the user's version of AGAJ76 does not include the Data Library Option, Columns 1 through 8 (IDEN) must be blank. If this option is included, IDEN may be used to call the required inputs for the corresponding group from the data library. If MODEL Option data sets are stored in the library, IDEN on CARD 10 (Program Logic Group ID Card) may be used to call a complete set of groups from the library.

Input data which are called from the library and whose array name is included in Table 2 can be updated with the &CHANGE program feature. When the MODEL Option is used, the &GROUPS program feature can be used to replace entire groups in the MODEL Option data set by reference to the element number given in Table 1. Figure 16 shows an example MODEL Option data deck with the &CHANGE and &GROUPS features employed. See Section 3.1.2 for a complete discussion of the Data Library and MODEL Options. See Section 3.1.3 for explanation of the &CHANGE and &GROUPS program features.

TABLE 2. INPUT DATA ARRAYS INCLUDED IN NAMELIST SPECIFICATION STATEMENT

Array Name and Range of Subscripts	Description of Array
IPL(1→98)	Program Logic Group
XMR(1→49)	Main Rotor Group
XMBS(1→20)	Main Rotor Blade Station Distribution
XMDP(1→9)	Main Rotor Elastomeric Damper
XMP(1→14)	Main Rotor Dynamic Pylon
XMACF(1→20)	Main Rotor Airfoil Aerodynamic Reference Center Distribution
XMC(1→20)	Main Rotor Chord Distribution
XMT(1→20)	Main Rotor Twist Distribution
XMDI(1→28)	Main Rotor Harmonic Blade Shaker and Harmonic Control Motion
IDTABM(1→20)	Main Rotor Airfoil Distribution
XMW(1→105)	Main Rotor Weight & Inertial Distribution
XGMS(1→18, 1→12)	Blade General Mode Shape Data
XTR(1→49)	Tail Rotor Group
XTBS(1→20)	Tail Rotor Blade Station Distribution
XTDP(1→9)	Tail Rotor Elastomeric Damper
XTP(1→14)	Tail Rotor Dynamic Pylon
XTACF(1→20)	Tail Rotor Airfoil Aerodynamic Reference Center Distribution
XTC(1→20)	Tail Rotor Chord Distribution
XTT(1→20)	Tail Rotor Twist Distribution
XTDI(1→28)	Tail Rotor Harmonic Blade Shaker and Harmonic Control Motion

TABLE 2. (Continued)

Array Name and Ranges of Subscripts	Description of Array
IDTABT(1→20)	Tail Rotor Airfoil Distribution
XTW(1→105)	Tail Rotor Weight & Inertial Distribution
YRR(1→35,1)	RAA Subgroup No. 1
YRR(1→35,2)	RAA Subgroup No. 2
YRR(1→35,3)	RAA Subgroup No. 3
YRR(1→35,4)	RAA Subgroup No. 4
YRR(1→35,5)	RAA Subgroup No. 5
XFS(1→98)	Fuselage Group
XLG1(1→14)	Landing Gear Subgroup No. 1
XLG2(1→14)	Landing Gear Subgroup No. 2
XLG3(1→14)	Landing Gear Subgroup No. 3
XLG4(1→14)	Landing Gear Subgroup No. 4
XLG5(1→14)	Landing Gear Subgroup No. 5
XWG(1→42)	Wing Group (Basic)
YWG(1→28)	Wing Aerodynamics
XCWG(1→14)	Wing Control Linkages
XSTB1(1→35)	Stabilizing Surface No. 1 Group (Basic)
YSTB1(1→28)	Surface No. 1 Aerodynamics
XCS1(1→14)	Surface No. 1 Control Linkages
XSTB2(1→35)	Stabilizing Surface No. 2 Group (Basic)
YSTB2(1→28)	Surface No. 2 Aerodynamics
XCS2(1→14)	Surface No. 2 Control Linkages
XSTB3(1→35)	Stabilizing Surface No. 3 Group (Basic)

TABLE 2. (Concluded)

Array Name and Range of Subscripts	Description of Array
YSTB3(1→28)	Surface No. 3 Aerodynamics
XCS3(1→14)	Surface No. 3 Control Linkages
XSTB4(1→35)	Stabilizing Surface No. 4 Group (Basic)
YSTB4(1→28)	Surface No. 4 Aerodynamics
XCS4(1→14)	Surface No. 4 Control Linkages
XJET(1→14)	Jet Group
XST1(1→21)	Store/Brake No. 1 } External Store/Aerodynamic Brake Group
XST2(1→21)	Store/Brake No. 2 } External Store/Aerodynamic Brake Group
XST3(1→21)	Store/Brake No. 3 } External Store/Aerodynamic Brake Group
XST4(1→21)	Store/Brake No. 4 } External Store/Aerodynamic Brake Group
XCON(1→28)	Rotor Controls Group (Basic)
XCRT(1→28)	Supplementary Rotor Controls
XNG(1→28)	Engine-Governor Group
XIT(1→21)	Iteration Logic Group
XFC(1→28)	Flight Constants Group
XBW(1→7)	Bobweight Group
XGN(1→7)	Weapons Group
XSCAS(1→28)	SCAS Group
TSTAB(1→14)	Stability Analysis Times Group
TAIR(1→14)	Blade Element Data Printout Times Group

The following sets of inputs are specifically excluded from the NAMELIST specification statement: All airfoil data tables, both mode shape arrays, both RIVD tables, and all RWAS tables.

```
1
  7081101 AH-1G SPEED SWEEP AT 4000', 95 DEGREES F
 EIGHT TOW MISSLES. ON OUTBOARD HARD POINTS. TRY 0012 AIRFOIL
 SAMPLE DECK TO DEMONSTRATE &GROUPS AND &CHANGE FEATURES
MODL2091
 &GROUPS MODEL(2)='CLCDVS12', MODEL(34)='XSTR2090',
         MODEL(38)='          ', &END
60.0                                100.0                  -3.0
35.0      45.0       50.0           50.0
-1.0      0.0        0.0            0.0      8500.0        200.0
                                             1.0           4000.0     95.0
 &CHANGE XFS(29)=5.5, XTR(42)=0.806     &END
10
 &CHANGE XFC(1)=80.0, IPL(71)=2,    &END
10
 &CHANGE XFC(1)=100.0    &END
10
 &CHANGE XFC(1)=120.0    &END
```

Figure 16. Example Data Deck for MODEL Option.

2.2 IDENTIFICATION AND PROGRAM FLOW CONTROL GROUP (See Section 3.2)

CARD 00 Message card. Columns 1-80, alphanumeric.

CARD 01 Col 1 - 2 NPART (permissible values are 1, 2, 4, 5, 6, 7, 8, and 10)
Col 4 - 6 NPRINT
Col 11 - 15 NVARA

CARD 02 Col 4 - 10 IPSN
Col 11 - 70 Identifying Comments

CARD 03 Col 1 - 68 Identifying Comments

CARD 04 Col 1 - 68 Identifying Comments

2.3 PROGRAM LOGIC GROUP (See Section 3.3)

CARD 10 Program Logic Group Identification Card

Col 11 - 70 Identifying Comments

CARD 11 Input Group Control Logic (14I5 format)

IPL
(1) Switch for reading reduced data deck (0 = off)
(2) Number of Airfoil Data Tables (= 0, 1, 2, 3, 4, or 5)
(3) Switch for deleting rotor groups (0 = include both rotor groups)
(4) Number of main rotor blade segments ($\geq$0, uniform; 0 reset to 20)
(5) Number of tail rotor blade segments ($\geq$0, uniform; 0 reset to 3)
(6) Number of main rotor mode shapes $\leq$11 } Total
(7) Number of tail rotor mode shapes $\leq$11 } $\leq$12
(8) Currently unused
(9) Number of main rotor pylon modes ($\leq$4; >0, full rotor mass included; <0, no rotor mass included)
(10) Number of tail rotor pylon modes
(11) Number of Rotor Airfoil Aerodynamic Subgroups (= 1, 2, 3, 4 or 5)
(12) Switch for reading Rotor-Induced Velocity Distribution Tables (0 = off)
(13) Switch for reading Rotor Wake Tables (0 = off)
(14) Switch for harmonic blade shaker and harmonic control motion (0 = off)

CARD 12 Input Group Control Logic (14I5 format)

IPL (15) Switch for reading Wing Group (0 = off)
(16) Switch for reading Stabilizing Surface #1 Group
(17) Switch for reading Stabilizing Surface #2 Group
(18) Switch for reading Stabilizing Surface #3 Group
(19) Switch for reading Stabilizing Surface #4 Group
(20) Switch for reading Jet Group (0 = off)
(21) Number of Store/Brake subgroups (= 0, 1, 2, 3, or 4)
(22) Switch for reading Supplemental Rotor Controls subgroup (0 = off)
(23) Switch for reading maneuver input groups (0 = off)
(24) Number of Landing Gear Subgroups (= 0, 1, 2, 3, 4 or 5)
(25) }
(26) } Currently unused
(27) Rotor fold indicator (0 = unfolded)
(28) Switch for shifting cg with rotor folding (0 = no shift)

CARD 13

IPL (29)
↓ } Currently unused
(42)

CARD 14 Analysis Logic (14I5 format)

IPL (43) Flight condition indicator (0 = turn or unaccelerated flight)
(44) Euler angle iteration selector for TRIM (0 = holds yaw angle constant)
(45) Switch for computing partial derivative matrix (0 = every fifth iteration)
(46) Control variable for main rotor steady state aerodynamics
(47) Control variable for tail rotor steady state aerodynamics
(48) Switch for activating unsteady rotor aerodynamic options (0 = off)
(49) Switch for specifying which rotor can use the time-variant (TV) analysis (0 = none; both rotors use quasi-static (QS) analysis)
(50) Switch for activating TV analysis in TRIM and MANU when IPL(49) $\neq$ 0 (0 = QS trim followed by TV trim and maneuver)

(51) Control variable for rebalancing main rotor in TRIM (0 = off; >0 locks flapping; <0 locks cyclic)
(52) Control variable for rebalancing tail rotor in TRIM (0 = off; >0 locks flapping; <0 locks cyclic)
(53) Switch for calculation of blade element accelerations
(54) Currently unused
(55) Switch for Wagner function (0 = off)
(56) Switch for locking fuselage degrees of freedom in maneuver (0 = unlocked)

CARD 15 Currently unused

IPL (57) ↓ (70) } Currently unused

CARD 16 Output Control Logic (14I5 format)

IPL
(71) Print control for input data (0 = print all input data)
(72) Print control for trim iteration data (0 = minimum output)
(73) Print control for optional trim page (0 = page omitted)
(74) Currently unused
(75) Print control for main rotor blade element aerodynamic data
(76) Print control for tail rotor blade element aerodynamic data
(77) Station number for main rotor bending moment data
(78) Station number for tail rotor bending moment data
(79) Switch for storing contour plot data (0 = off)
(80) (81) (82) (83) } Currently unused
(84) Print control for Time-Variant Trim data ($\neq$ 0 suppresses printout)

CARD 17 Rotorcraft Stability Analysis and Miscellaneous Logic (14I5 format)

IPL
(84) Switch for fuselage coupling in STAB (0 = uncoupled)
(86) Switch for pylon degrees of freedom in STAB (0 = off)

(87) Switch for rotor degrees of freedom in STAB (0 = off)

(88) Switch for rebalancing rotors in STAB when IPL(87) = 0 (0 = rebalance)

(89) Output control for STAB matrices (0 = print only)

(90) Output selector for STAB diagnostics (0 = off)

(91) Currently unused

(92) Switch for Thrust-Induced Velocity History in STAB

(93) STAB numerators logic switch

(94) Switch to suppress force and moment summary output from perturbations ($\neq$ 0 suppresses)

(95)
(96)
(97)
(98) } Currently unused

2.4 AIRFOIL DATA TABLE GROUP (See Section 3.4)

This group does not have an all-inclusive group identification card (which would logically be CARD 20); each set of tables has its own.

2.4.1 Airfoil Data Table Set No. 1 (include only if IPL(2)≥1)

CARD 21 Table Identification Card

CARD 21/A Title and Control Card (7A4, A2, 6I2 format)

Col 1-30 Alphanumeric Title for the sets of tables
31-32 NXL, number of Mach number entries in C_L table
33-34 NZL, number of angle of attack entries in C_L table
35-36 NXD, number of Mach number entries in C_D table
37-38 NZD, number of angle of attack entries in C_D table
39-40 NXM, number of Mach number entries in C_M table
41-42 NZM, number of angle of attack entries in C_M table

2.4.1.1 Lift Coefficient Table

CARD 21/B1 Mach number entries for C_L table (7X, 9F7.0 format)

Col 8-14 M_1, lowest Mach number
15-21 M_2, next highest Mach number
22-28 M_3, next highest Mach number
29-35 M_4, next highest Mach number
36-42 M_5, next highest Mach number
43-49 M_6, next highest Mach number
50-56 M_7, next highest Mach number
57-63 M_8, next highest Mach number
64-70 M_9, next highest Mach number

CARDS 21/B2 Additional Mach Numbers (include only if NXL ≥10)

Same format as CARD 21/B1; include additional cards as required with the same format to input NXL values of Mach numbers

Card Sets for Angle of Attack/Lift Coefficient Data

NZL card sets follow the Mach number entries. Each set has the following format:

First Card:

Col	1-7	Angle of attack, degrees
	8-14	Coefficient at $M = M_1$
	15-21	Coefficient at $M = M_2$
	22-28	Coefficient at $M = M_3$
	29-35	Coefficient at $M = M_4$
	36-42	Coefficient at $M = M_5$
	43-49	Coefficient at $M = M_6$
	50-56	Coefficient at $M = M_7$
	57-63	Coefficient at $M = M_8$
	64-70	Coefficient at $M = M_9$

Second Card: (include only if NZL $\geq$10)

Col	1-7	(Not used)
	8-14	Coefficient at $M = M_{10}$
	15-21	Coefficient at $M = M_{11}$
	22-28	Coefficient at $M = M_{12}$
	29-35	Coefficient at $M = M_{13}$
	36-42	Coefficient at $M = M_{14}$
	43-49	Coefficient at $M = M_{15}$
	50-56	Coefficient at $M = M_{16}$
	57-63	Coefficient at $M = M_{17}$
	64-70	Coefficient at $M = M_{18}$

Third Card: (include only if NZL $\geq$19)

Same format as Second Card; include additional cards as required to input NXL values of C_L.

2.4.1.2 Drag Coefficient Table

CARDS 21/C1, 21/C2, etc. Mach number entries

Same format as CARDS 21/B1, 21/B2, etc; NXD entries required.

Card Sets for Angle of Attack/Drag Coefficient Data

NZD card sets required; same format as for lift coefficient card sets; NXD values of C_D required for each card set.

2.4.1.3 Pitching Moment Coefficient Table

CARDS 21/D1, 21/D2, etc.

Same format as lift and drag coefficient tables; NXM Mach number entries required; NZM card sets required with NXM values of C_M for each card set.

2.4.2 Airfoil Data Table Set No. 2 (include only if IPL(2) $\geq$2)

CARD 22 Table Identification Card

CARD 22/A Title and Control Card

CARDS 22/B1 Lift Coefficient Table

CARDS 22/C1 Drag Coefficient Table

CARDS 22/D1 Pitching Moment Coefficient Table

2.4.3 Airfoil Data Table Set No. 3 (include only if IPL(2) $\geq$3)

CARD 23 Table Identification Card

CARD 23/A Title and Control Card

CARDS 23/B1 Lift Coefficient Table

CARDS 23/C1 Drag Coefficient Table

CARDS 23/D1 Pitching Moment Coefficient Table

2.4.4 Airfoil Data Table Set No. 4 (include only if IPL(2) $\geq$4)

CARD 24 Table Identification Card

CARD 24/A Title and Control Card

CARDS 24/B1 Lift Coefficient Table

CARDS 24/C1 Drag Coefficient Table

CARDS 24/D1 Pitching Moment Coefficient Table

2.4.5 Airfoil Data Table Set No. 5 (include only if IPL(2) = 5)

CARD 25	Table Identification Card
CARD 25/A	Title and Control Card
CARDS 25/B1	Lift Coefficient Table
CARDS 25/C1	Drag Coefficient Table
CARDS 25/D1	Pitching Moment Coefficient Table

NOTE: A set of tables for an NACA 0012 airfoil is compiled within the program and stored in the region allocated for Data Table Set No. 5. If IPL(2) = 5, the fifth set of tables input overlays this set of internal 0012 tables. For the 380K version of C81, the 0012 tables are internally stored in the region allocated for Data Table Set No. 2, and if IPL(2) = 2, the second table input overlays the 0012 tables.

2.5 MAIN ROTOR GROUP (See Section 3.5)

(Omit if IPL(3) = 1 or 3)

CARD 30 Main Rotor Group Identification Card

Col 11 - 70 Identifying Comments

CARD 31

XMR	(1)	Number of blades	
	(2)	Undersling	(in.)
	(3)	Aerodynamic reference center offset, + fwd (ONLY if constant)	(in.)
	(4)	Radius	(ft)
	(5)	Chord (ONLY if constant)	(in.)
	(6)	Total twist (ONLY if linear)	(deg)
	(7)	Flapping stop location	(deg)

CARD 32

XMR	(8)	Stationline	Location of mast pivot point for mast tilt and conversion maneuvers	(in.)
	(9)	Buttline		(in.)
	(10)	Waterline		(in.)
	(11)	Blade weight (ignored if IPL(6) $\neq$ 0)		(lb)
	(12)	Blade inertia (ignored if IPL(6) $\neq$ 0)		($slug/ft^2$)
	(13)	Rotor to engine gear ratio		(Rotor RPM/Engine RPM)
	(14)	Pitch-lag coupling		(deg/deg)

CARD 33

XMR	(15)	Rotor-to-swashplate angle ratio	(deg/deg)
	(16)	Hub-type indicator (0.0 = gimballed)	
	(17)	Flapping stop spring rate	(ft-lb/deg)
	(18)	Flapping spring rate	(ft-lb/deg)
	(19)	Reduced rotor frequency for UNSAN option	(cycles/rev)
	(20)	Lead-lag damper	(ft-lb/deg/sec)
	(21)	Hub extent	(ft)

CARD 34

XMR	(22)	Precone	(deg)
	(23)	Pitch-change axis location (0.0 = 25% chord)	(chords)
	(24)	Pitch-flap coupling angle, δ_3	(deg)
	(25)	Drag coefficient for hub	

	(26)	Lead-lag spring rate	(ft-lb/deg)
	(27)	Coefficient for tip-vortex effect (0.0 = off)	
	(28)	Currently inactive	

CARD 35

XMR	(29)	Tip sweep angle (+ aft)	(deg)
	(30)	Tip loss factor (= 0, uses equation)	
	(31)	Moment arm of pitch-link attach point (+ fwd)	(in.)
	(32)	Distance from hub to pitch-horn attach point	(in.)
	(33)	Coefficient of rotor downwash at fuselage center of pressure	
	(34)	Currently unused	
	(35)	Pitch-cone coupling ratio (if IPL(6) = 0)	(deg/deg)

CARD 36

XMR	(36)	Rotor nacelle weight	(lb)
	(37)	Stationline } Location of rotor nacelle	(in.)
	(38)	Buttline } center of gravity	(in.)
	(39)	Waterline	(in.)
	(40)	Rotor nacelle differential flat plate drag area	(ft^2)
	(41)	Distance from mast pivot point to rotor nacelle aerodynamic center	(ft)
	(42)	1st mass moment of inertia for blade (ignored if IPL(6) $\neq$ 0)	(slug-ft)

CARD 37

XMR	(43)	Control phasing	(deg)
	(44)	Longitudinal mast tilt (+ fwd)	(deg)
	(45)	Lateral mast tilt (+ right)	(deg)
	(46)	Mast length	(ft)
	(47)	Flapping angle at which nonlinear flapping spring is engaged	(deg)
	(48)	Nonlinear flapping spring rate	(ft-lb/deg^r)
	(49)	r - order of the nonlinearity	

CARD 38

XMR	(50)	Main rotor filter frequency (default is main rotor 1/rev)	(Hz)
	(51)	Prelag angle	(deg)
	(52)	Radius at which prelag starts	(ft)
	(53)	Radius at which precone starts	(ft)

	(54)	Inplane PCA offset at XMR(52)	(ft)
	(55)	Feathering bearing torsional spring rate	(in.-lb/deg)
	(56)	Neutral angle for feathering bearing spring	(deg)

CARD 39 Blade Radial Station Data (Include only if IPL(4)<0)

XMBS	(1)	Radius to outboard end of Segment No. 1	(in.)
	(2)	Radius to outboard end of Segment No. 2	(in.)
	(3)	Radius to outboard end of Segment No. 3	(in.)
	(4)	Radius to outboard end of Segment No. 4	(in.)
	(5)	Radius to outboard end of Segment No. 5	(in.)
	(6)	Radius to outboard end of Segment No. 6	(in.)
	(7)	Radius to outboard end of Segment No. 7	(in.)

CARD 3A

XMBS	(8)	Radius to outboard end of Segment No. 8	(in.)
	(9)	Radius to outboard end of Segment No. 9	(in.)
	(10)	Radius to outboard end of Segment No. 10	(in.)
	(11)	Radius to outboard end of Segment No. 11	(in.)
	(12)	Radius to outboard end of Segment No. 12	(in.)
	(13)	Radius to outboard end of Segment No. 13	(in.)
	(14)	Radius to outboard end of Segment No. 14	(in.)

CARD 3B

XMBS	(15)	Radius to outboard end of Segment No. 15	(in.)
	(16)	Radius to outboard end of Segment No. 16	(in.)
	(17)	Radius to outboard end of Segment No. 17	(in.)
	(18)	Radius to outboard end of Segment No. 18	(in.)
	(19)	Radius to outboard end of Segment No. 19	(in.)
	(20)	Radius to outboard end of Segment No. 20	(in.)
	(21)	Currently inactive	

CARD 3C First Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 1$)

XMP	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Collective coupling	(rad)
	(5)	Longitudinal cyclic coupling	(rad)
	(6)	Lateral cyclic coupling	(rad)
	(7)	Currently unused	

CARD 3D First Pylon Mode Shape, Card 2 (include with CARD 3C)

XMP	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARD 3E Second Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 2$)

XMP	(15)	Generalized inertia	(in.-lb-sec^2)
	(16)	Natural frequency	(Hz)
	(17)	Damping ratio	
	(18)	Collective coupling	(rad)
	(19)	Longitudinal cyclic coupling	(rad)
	(20)	Lateral cyclic coupling	(rad)
	(21)	Currently unused	

CARD 3F Second Pylon Mode Shape, Card 2 (include with CARD 3E)

XMP	(22)	X displacement at top of mast	(in.)
	(23)	Y displacement at top of mast	(in.)
	(24)	Z displacement at top of mast	(in.)
	(25)	θ_x (roll) angle at top of mast	(rad)
	(26)	θ_y (pitch) angle at top of mast	(rad)
	(27)	θ_z (windup) angle at top of mast	(rad)
	(28)	Currently unused	

CARD 3G Third Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 3$)

XMP	(29)	Generalized inertia	(in.-lb-sec^2)
	(30)	Natural frequency	(Hz)
	(31)	Damping ratio	
	(32)	Collective coupling	(rad)
	(33)	Longitudinal cyclic coupling	(rad)
	(34)	Lateral cyclic coupling	(rad)
	(35)	Currently unused	

CARD 3H Third Pylon Mode Shape, Card 2 (include with CARD 3G)

XMP	(36)	X displacement at top of mast	(in.)
	(37)	Y displacement at top of mast	(in.)
	(38)	Z displacement at top of mast	(in.)
	(39)	θ_x (roll) angle at top of mast	(rad)

(40) θ_y (pitch) angle at top of mast (rad)

(41) θ_z (windup) angle at top of mast (rad)

(42) Currently unused

CARD 3I Fourth Pylon Mode Shape, Card 1 (include only if $|IPL(9)|=4$)

XMP
(43) Generalized inertia (in.-lb-sec^2)
(44) Natural frequency (Hz)
(45) Damping ratio
(46) Collective coupling (rad)
(47) Longitudinal cyclic coupling (rad)
(48) Lateral cyclic coupling (rad)
(49) Currently unused

CARD 3J Fourth Pylon Mode Shape, Card 2 (include with CARD 3I)

XMP
(50) X displacement at top of mast (in.)
(51) Y displacement at top of mast (in.)
(52) Z displacement at top of mast (in.)
(53) θ_x (roll) angle at top of mast (rad)
(54) θ_y (pitch) angle at top of mast (rad)
(55) θ_z (windup) angle at top of mast (rad)
(56) Currently unused

CARDS 3K, 3L, 3M - (include only if XMR(3)≥100.)

XMACF(1)→XMACF(20) { Airfoil aerodynamic reference center offset distribution; positive forward; Blade Stations 1 to 20 (root to tip) (in.)

CARDS 3N, 3O, 3P - (Include only if XMR(5) = 0.0)

XMC(1)→XMC(20) { Blade chord distribution; Blade Stations No. 1 to 20 (root to tip) (in.)

CARDS 3Q, 3R, 3S - (Include only if XMR(6)≥100.0)

XMT(1)→XMT(20) { Blade twist distribution; Blade Stations No. 1 to 20 (root to tip) (deg)

CARD 3T Harmonic Blade Shaker (Include only if IPL(14) = 1 or 3)

XMDI
(1) Amplitude of shaker force (lb)
(2) Shaker frequency (/rev)

(3) Phase angle of shaker force, Blade 1 (deg)
(4) Blade station number at which force is applied
(5) Angle of force relative to beamwise upward (90° is chordwise aft) (deg)
(6) Indicator for type of mode forced
(7) Number of blades shaken (default = all)

CARD 3U First Harmonic Control Shaker (Include only if IPL(14) = 1 or 3)

XMDI	(8)	Amplitude of harmonic control motion	(deg)
	(9)	Frequency of harmonic control motion	(/rev)
	(10)	Phase of control motion	(deg)
	(11)	Swashplate rocking axis orientation	(deg)
	(12)	Indicator for type of control motion	
	(13)	Number of blades with harmonic control motion	
	(14)	Currently unused	

CARD 3V Second Harmonic Control Shaker (Include only if IPL(14) = 1 or 3)

XMDI	(15)	Amplitude of harmonic control motion	(deg)
	(16)	Frequency of harmonic control motion	(/rev)
	(17)	Phase of control motion	(deg)
	(18)	Swashplate rocking axis orientation	(deg)
	(19)	Indicator for type of control motion	
	(20)	Number of blades with harmonic control motion	
	(21)	Currently unused	

CARD 3W Third Harmonic Control Shaker (Include only if IPL(14) = 1 or 3)

XMDI	(22)	Amplitude of harmonic control motion	(deg)
	(23)	Frequency of harmonic control motion	(/rev)
	(24)	Phase of control motion	(deg)
	(25)	Swashplate rocking axis orientation	(deg)
	(26)	Indicator for type of control motion	
	(27)	Number of blades with harmonic control motion	
	(28)	Currently unused	

CARD 3X - (Include only if IPL(46)<0) (20I1 format)

IDTABM(1)→IDTABM(20) { Blade airfoil distribution; Blade Stations No. 1 to 20 (root to tip)

2.6 MAIN ROTOR ELASTIC BLADE DATA GROUP (See Section 3.6)

(Omit if IPL(6) = 0)

CARD 40 Main Rotor Elastic Blade Data Group Identification Card

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2.6.1 Average Running Weight of Blade Segment

CARD 41/A1

XMW	(1)	Blade Segment No. 1 (root)	(lb/in.)
	(2)	Blade Segment No. 2	(lb/in.)
	(3)	Blade Segment No. 3	(lb/in.)
	(4)	Blade Segment No. 4	(lb/in.)
	(5)	Blade Segment No. 5	(lb/in.)
	(6)	Blade Segment No. 6	(lb/in.)
	(7)	Blade Segment No. 7	(lb/in.)

CARD 41/A2

XMW	(8)	Blade Segment No. 8	(lb/in.)
	(9)	Blade Segment No. 9	(lb/in.)
	(10)	Blade Segment No. 10	(lb/in.)
	(11)	Blade Segment No. 11	(lb/in.)
	(12)	Blade Segment No. 12	(lb/in.)
	(13)	Blade Segment No. 13	(lb/in.)
	(14)	Blade Segment No. 14	(lb/in.)

CARD 41/A3

XMW	(15)	Blade Segment No. 15	(lb/in.)
	(16)	Blade Segment No. 16	(lb/in.)
	(17)	Blade Segment No. 17	(lb/in.)
	(18)	Blade Segment No. 18	(lb/in.)
	(19)	Blade Segment No. 19	(lb/in.)
	(20)	Blade Segment No. 20	(lb/in.)
	(21)	Tip Weight	(lb)

2.6.2 Average Running Beamwise Mass Moment of Inertia of Blade Segment

CARD 41/B1

XMW	(22)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
	(23)	Blade Segment No. 2	(in.-lb-sec^2/in.)
	(24)	Blade Segment No. 3	(in.-lb-sec^2/in.)
	(25)	Blade Segment No. 4	(in.-lb-sec^2/in.)
	(26)	Blade Segment No. 5	(in.-lb-sec^2/in.)

(27) Blade Segment No. 6 (in.-lb-sec^2/in.)
(28) Blade Segment No. 7 (in.-lb-sec^2/in.)

CARD 41/B2

XMW (29) Blade Segment No. 8 (in.-lb-sec^2/in.)
(30) Blade Segment No. 9 (in.-lb-sec^2/in.)
(31) Blade Segment No. 10 (in.-lb-sec^2/in.)
(32) Blade Segment No. 11 (in.-lb-sec^2/in.)
(33) Blade Segment No. 12 (in.-lb-sec^2/in.)
(34) Blade Segment No. 13 (in.-lb-sec^2/in.)
(35) Blade Segment No. 14 (in.-lb-sec^2/in.)

CARD 41/B3

XMW (36) Blade Segment No. 15 (in.-lb-sec^2/in.)
(37) Blade Segment No. 16 (in.-lb-sec^2/in.)
(38) Blade Segment No. 17 (in.-lb-sec^2/in.)
(39) Blade Segment No. 18 (in.-lb-sec^2/in.)
(40) Blade Segment No. 19 (in.-lb-sec^2/in.)
(41) Blade Segment No. 20 (in.-lb-sec^2/in.)
(42) Currently unused

2.6.3 <u>Average Running Chordwise Mass Moment of Inertia of Blade Segment</u>

CARD 41/C1

XMW (43) Blade Segment No. 1 (root) (in.-lb-sec^2/in.)
(44) Blade Segment No. 2 (in.-lb-sec^2/in.)
(45) Blade Segment No. 3 (in.-lb-sec^2/in.)
(46) Blade Segment No. 4 (in.-lb-sec^2/in.)
(47) Blade Segment No. 5 (in.-lb-sec^2/in.)
(48) Blade Segment No. 6 (in.-lb-sec^2/in.)
(49) Blade Segment No. 7 (in.-lb-sec^2/in.)

CARD 41/C2

XMW (50) Blade Segment No. 8 (in.-lb-sec^2/in.)
(51) Blade Segment No. 9 (in.-lb-sec^2/in.)
(52) Blade Segment No. 10 (in.-lb-sec^2/in.)
(53) Blade Segment No. 11 (in.-lb-sec^2/in.)
(54) Blade Segment No. 12 (in.-lb-sec^2/in.)
(55) Blade Segment No. 13 (in.-lb-sec^2/in.)
(56) Blade Segment No. 14 (in.-lb-sec^2/in.)

CARD 41/C3

XMW (57) Blade Segment No. 15 (in.-lb-sec^2/in.)
(58) Blade Segment No. 16 (in.-lb-sec^2/in.)

	(59)	Blade Segment No. 17	(in.-lb-sec^2/in.)
	(60)	Blade Segment No. 18	(in.-lb-sec^2/in.)
	(61)	Blade Segment No. 19	(in.-lb-sec^2/in.)
	(62)	Blade Segment No. 20	(in.-lb-sec^2/in.)
	(63)	Currently unused	

2.6.4 Average Beamwise Center of Gravity Offset of Blade Segment

CARD 41/D1

XMW	(64)	Blade Segment No. 1 (root)	(in.)
	(65)	Blade Segment No. 2	(in.)
	(66)	Blade Segment No. 3	(in.)
	(67)	Blade Segment No. 4	(in.)
	(68)	Blade Segment No. 5	(in.)
	(69)	Blade Segment No. 6	(in.)
	(70)	Blade Segment No. 7	(in.)

CARD 41/D2

XMW	(71)	Blade Segment No. 8	(in.)
	(72)	Blade Segment No. 9	(in.)
	(73)	Blade Segment No. 10	(in.)
	(74)	Blade Segment No. 11	(in.)
	(75)	Blade Segment No. 12	(in.)
	(76)	Blade Segment No. 13	(in.)
	(77)	Blade Segment No. 14	(in.)

CARD 41/D3

XMW	(78)	Blade Segment No. 15	(in.)
	(79)	Blade Segment No. 16	(in.)
	(80)	Blade Segment No. 17	(in.)
	(81)	Blade Segment No. 18	(in.)
	(82)	Blade Segment No. 19	(in.)
	(83)	Blade Segment No. 20	(in.)
	(84)	cg offset of tipweight	(in.)

2.6.5 Average Chordwise Center of Gravity Offset of Blade Segment

CARD 41/E1

XMW	(85)	Blade Segment No. 1 (root)	(in.)
	(86)	Blade Segment No. 2	(in.)
	(87)	Blade Segment No. 3	(in.)
	(88)	Blade Segment No. 4	(in.)
	(89)	Blade Segment No. 5	(in.)
	(90)	Blade Segment No. 6	(in.)
	(91)	Blade Segment No. 7	(in.)

CARD 41/E2

XMW	(92)	Blade Segment No. 8	(in.)
	(93)	Blade Segment No. 9	(in.)
	(94)	Blade Segment No. 10	(in.)
	(95)	Blade Segment No. 11	(in.)
	(96)	Blade Segment No. 12	(in.)
	(97)	Blade Segment No. 13	(in.)
	(98)	Blade Segment No. 14	(in.)

CARD 41/E3

XMW	(99)	Blade Segment No. 15	(in.)
	(100)	Blade Segment No. 16	(in.)
	(101)	Blade Segment No. 17	(in.)
	(102)	Blade Segment No. 18	(in.)
	(103)	Blade Segment No. 19	(in.)
	(104)	Blade Segment No. 20	(in.)
	(105)	cg offset of tipweight	(in.)

2.6.6 Blade Mode Shape Data

The IPL(6) main rotor mode shapes are input here. Each mode shape is input on (|IPL(4)|+5) cards. The format for all the cards in a mode shape is 6F10.0. In the following discussion, MN is the mode shape number (≤IPL(6)).

2.6.6.1 First Mode (MN = 1)

CARD 42/A1 Blade General Mode Shape Data

XGMS	(1,MN)	Mode type indicator	
	(2,MN)	Natural frequency	(/rev)
	(3,MN)	Generalized inertia	(slug-ft^2)
	(4,MN)	Modal damping ratio	
	(5,MN)	Inplane hub shear coefficient	(lb)
	(6,MN)	Out-of-plane hub shear coefficient	(lb)

CARD 42/A2

XGMS	(7,MN)	Pitch-link load coefficient	(lb)
	(8,MN)	Lag angle	(deg)
	(9,MN)	Reference RPM	(rpm)
	(10,MN)	Reference collective	(deg)
	(11,MN)	Pitch bearing out-of-plane slope	(deg)
	(12,MN)	Pitch bearing inplane slope	(deg)

CARD 42/A3

XGMS	(13,MN)	Integral of (OP component) x (r)dm	(slug-ft^2)

(14,MN)	Integral of (OP component)dm	(slug-ft)
(15,MN)	Integral of (IP component) x (r)dm	(slug-ft^2)
(16,MN)	Integral of (IP component)dm	(slug-ft)
(17,MN)	Pitch bearing out-of-plane displacement	(ft)
(18,MN)	Pitch bearing inplane displacement	(ft)

CARD 42/B1 Blade Mode Shape

Mode Shape Data at Station No. 0 (Center of Rotation)

(1)	Out-of-plane displacement	(ft)
(2)	Inplane displacement	(ft)
(3)	Torsional displacement	(deg)
(4)	Out-of-plane bending moment coefficient	(ft-lb)
(5)	Inplane bending moment coefficient	(ft-lb)
(6)	Torsional moment coefficient	(ft-lb)

CARD 42/B2 Blade Mode Shape Data at Station No. 1 (XMBS(1))

(7)	Out-of-plane displacement	(ft)
(8)	Inplane displacement	(ft)
(9)	Torsional displacement	(deg)
(10)	Out-of-plane bending moment coefficient	(ft-lb)
(11)	Inplane bending moment coefficient	(ft-lb)
(12)	Torsional moment coefficient	(ft-lb)

CARD 42/B3
CARD 42/B4
etc.
.
.
.

Format repeated until there are ($|IPL(4)|$+1) cards, one for each station

CARD 42/C1 Cyclic Detuning Data

(1)	Natural frequency at low rpm and low pitch angle	(cpm)
(2)	Natural frequency at low rpm and high pitch angle	(cpm)
(3)	Natural frequency at high rpm and low pitch angle	(cpm)
(4)	Natural frequency at high rpm and high pitch angle	(cpm)
(5)	Difference between reference pitch angle and high or low value	(deg)
(6)	Difference between reference rpm and either high or low value	(rpm)

2.6.6.2 Second and Subsequent Blade Modes

CARDS 43/A1 through 43/C1 (Include only if IPL(6)$\geq$2) (MN = 2)

Input sequence and format similar to that of blade mode 1.

CARDS 44/A1 through 44/C1 (Include only if IPL(6)$\geq$3) (MN = 3)

Input sequence and format similar to that of blade mode 1.

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.

CARDS 4C/A1 through 4C/C1 (Include only if IPL(6)=11) (MN = 11)

Input sequence and format similar to that of blade mode 1.

2.7 <u>TAIL ROTOR GROUP</u> (See Section 3.7)

(Omit if IPL(3) = 2 or 3)

CARD 50 Tail Rotor Group Identification Card

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CARD 51

XTR	(1)	Number of blades	
	(2)	Undersling	(in.)
	(3)	Aerodynamic reference center offset, + fwd (ONLY if constant)	(in.)
	(4)	Radius	(ft)
	(5)	Chord (ONLY if constant)	(in.)
	(6)	Total twist (ONLY if linear)	(deg)
	(7)	Flapping stop location	(deg)

CARD 52

XTR	(8)	Stationline } Location of mast pivot point for mast tilt and conversion maneuvers	(in.)
	(9)	Buttline } Location of mast pivot point for mast tilt and conversion maneuvers	(in.)
	(10)	Waterline } Location of mast pivot point for mast tilt and conversion maneuvers	(in.)
	(11)	Blade weight (ignored if IPL(7) ≠ 0)	(lb)
	(12)	Blade inertia (ignored if IPL(7) ≠ 0)	($slug\text{-}ft^2$)
	(13)	Rotor-to-engine gear ratio(Rotor RPM/Engine RPM)	
	(14)	Pitch-lag coupling	(deg/deg)

CARD 53

XTR	(15)	Rotor-to-swashplate angle ratio	(deg/deg)
	(16)	Hub-type indicator (0.0 = gimballed)	
	(17)	Flapping stop spring rate	(ft-lb/deg)
	(18)	Flapping spring rate	(ft-lb/deg)
	(19)	Reduced rotor frequency for UNSAN option	(cycles/rev)
	(20)	Lead-lag damper	(ft-lb/deg/sec)
	(21)	Hub extent	(ft)

CARD 54

XTR	(22)	Precone	(deg)
	(23)	Pitch-change axis location (0.0 = 25% chord)	(chords)
	(24)	Pitch-flap coupling angle, δ_3	(deg)
	(25)	Drag coefficient for hub	

	(26)	Lead-lag spring rate	(ft-lb/deg)
	(27)	Coefficient for tip vortex effect (0.0 = off)	
	(28)	Sidewash coefficient	

CARD 55

XTR	(29)	Tip sweep angle (+ aft)	(deg)
	(30)	Tip loss factor (= 0, uses equations)	
	(31)	Moment arm of pitch-link attach point (+ fwd)	(in.)
	(32)	Distance from hub to pitch-horn attach point	
	(33)	Coefficient of rotor downwash at fuselage center of pressure	
	(34)	Currently unused	
	(35)	Pitch-cone coupling ratio (if IPL(7) = 0)	(deg/deg)

CARD 56

XTR	(36)	Rotor nacelle weight	(lb)
	(37)	Stationline } Location of rotor nacelle center of gravity	(in.)
	(38)	Buttline } Location of rotor nacelle center of gravity	(in.)
	(39)	Waterline } Location of rotor nacelle center of gravity	(in.)
	(40)	Rotor nacelle differential flat plate drag area	(ft^2)
	(41)	Distance from mast pivot point to rotor nacelle aerodynamic center	(ft)
	(42)	1st mass moment of inertia for blade (ignored if IPL(7) $\neq$ 0)	(slug-ft)

CARD 57

XTR	(43)	Control phasing	(deg)
	(44)	Longitudinal mast tilt (+ fwd)	(deg)
	(45)	Lateral mast tilt (= ±90 for tail rotor)	(deg)
	(46)	Mast length	(ft)
	(47)	Flapping angle at which nonlinear flapping spring is engaged	(deg)
	(48)	Nonlinear flapping spring rate	(ft-lbf/deg^r)
	(49)	r - order of the nonlinearity	

CARD 58

XTR	(50)	Tail rotor filter frequency (default is tail rotor 1/rev)	(Hz)
	(51)	Prelag angle	(deg)
	(52)	Radius at which prelag starts	(ft)
	(53)	Radius at which precone starts	(ft)

	(54)	Inplane PCA offset at XTR(52)	(ft)
	(55)	Feathering bearing torsional spring rate	(in.-lb/deg)
	(56)	Neutral angle for feathering bearing spring	(deg)

CARD 59 Blade Radial Station Data (Include only if IPL(5)<0)

XTBS	(1)	Radius to outboard end of Segment No. 1	(in.)
	(2)	Radius to outboard end of Segment No. 2	(in.)
	(3)	Radius to outboard end of Segment No. 3	(in.)
	(4)	Radius to outboard end of Segment No. 4	(in.)
	(5)	Radius to outboard end of Segment No. 5	(in.)
	(6)	Radius to outboard end of Segment No. 6	(in.)
	(7)	Radius to outboard end of Segment No. 7	(in.)

CARD 5A

XTBS	(8)	Radius to outboard end of Segment No. 8	(in.)
	(9)	Radius to outboard end of Segment No. 9	(in.)
	(10)	Radius to outboard end of Segment No. 10	(in.)
	(11)	Radius to outboard end of Segment No. 11	(in.)
	(12)	Radius to outboard end of Segment No. 12	(in.)
	(13)	Radius to outboard end of Segment No. 13	(in.)
	(14)	Radius to outboard end of Segment No. 14	(in.)

CARD 5B

XTBS	(15)	Radius to outobard end of Segment No. 15	(in.)
	(16)	Radius to outboard end of Segment No. 16	(in.)
	(17)	Radius to outboard end of Segment No. 17	(in.)
	(18)	Radius to outboard end of Segment No. 18	(in.)
	(19)	Radius to outboard end of Segment No. 19	(in.)
	(20)	Radius to outboard end of Segment No. 20	(in.)
	(21)	Radius to outboard end of Segment No. 21	(in.)

CARD 5C First Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 1$)

XTP1	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Longitudinal cyclic coupling	(rad)
	(5)	Lateral cyclic coupling	(rad)
	(6)	Collective coupling	(rad)
	(7)	Currently unused	

CARD 5D First Pylon Mode Shape, Card 2 (include with CARD 5C)

XTP1	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARD 5E Second Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 2$)

XTP2	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Longitudinal cyclic coupling	(rad)
	(5)	Lateral cyclic coupling	(rad)
	(6)	Collective coupling	(rad)
	(7)	Currently unused	

CARD 5F Second Pylon Mode Shape, Card 2 (include with CARD 5E)

XTP2	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARD 5G Third Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 3$)

XTP3	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Longitudinal cyclic coupling	(rad)
	(5)	Lateral cyclic coupling	(rad)
	(6)	Collective coupling	(rad)
	(7)	Currently unused	

CARD 5H Third Pylon Mode Shape, Card 2 (include with CARD 5G)

XTP3	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)

(13) θ_z (windup) angle at top of mast (rad)

(14) Currently unused

CARD 5I Fourth Pylon Mode Shape, Card 1 (include only if |IPL(10)| =4)

XTP4	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Longitudinal cyclic coupling	(rad)
	(5)	Lateral cyclic coupling	(rad)
	(6)	Collective coupling	(rad)
	(7)	Currently unused	

CARD 5J Fourth Pylon Mode Shape, Card 2 (include with CARD 5I)

XTP4	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARDS 5K, 5L, 5M - (Include only if XTR(3)$\geq$100.)

XTACF(1)→XTACF(20) { Airfoil aerodynamic reference center offset distribution, + fwd (root to tip) (in.)

CARDS 5N, 5O, 5P - (Include only if XTR(5) = 0.0)

XTC(1)→XTC(20) Blade chord distribution (root to tip)(in.)

CARDS 5Q, 5R, 5S - (Include only if XTR(6)$\geq$100.0)

XTT(1)→XTT(20) Blade twist distribution (root to tip)(deg)

CARD 5T Harmonic Blade Shaker (Include only if IPL(14) = 2 or 3)

XTDI	(1)	Amplitude of shaker force	(lb)
	(2)	Shaker frequency	(/rev)
	(3)	Phase angle of shaker force, blade 1	(deg)
	(4)	Blade station number at which force is applied	
	(5)	Angle of force relative to beamwise upward (90° is chordwise aft)	(deg)

(6) Indicator for type of mode forced
(7) Number of blades shaken (default = all)

CARD 5U First Harmonic Control Shaker (Include only if IPL(14) = 2 or 3)

XTDI	(8)	Amplitude of harmonic control motion	(deg)
	(9)	Frequency of harmonic control motion	(/rev)
	(10)	Phase of control motion	(deg)
	(11)	Swashplate rocking axis orientation	(deg)
	(12)	Indicator for type of control motion	
	(13)	Number of blades with harmonic control motion	
	(14)	Currently unused	

CARD 5V Second Harmonic Control Shaker (Include only if IPL(14) = 2 or 3)

	(15)	Amplitude of harmonic control motion	(deg)
	(16)	Frequency of harmonic control motion	(/rev)
	(17)	Phase of control motion	(deg)
	(18)	Swashplate rocking axis orientation	(deg)
	(19)	Indicator for type of control motion	
	(20)	Number of blades with harmonic control motion	
	(21)	Currently unused	

CARD 5W Third Harmonic Control Shaker (Include only if IPL(14) = 2 or 3)

XTDI	(22)	Amplitude of harmonic control motion	(deg)
	(23)	Frequency of harmonic control motion	(/rev)
	(24)	Phase of control motion	(deg)
	(25)	Swashplate rocking axis orientation	(deg)
	(26)	Indicator for type of control motion	
	(27)	Number of blades with harmonic control motion	
	(28)	Currently unused	

CARD 5X - (Include only if IPL(47)<0 (20I1 format)

IDTABT(1)→IDTABT(20) { Blade airfoil distribution; blade Stations 1 to 20 (root to tip)

2.8 TAIL ROTOR ELASTIC BLADE DATA GROUP (See Section 3.8)

(Omit if IPL(7) = 0)

CARD 60 Tail Rotor Elastic Blade Data Group Identification Card

Col 11 - 70 Identifying Comments

2.8.1 Average Running Weight of Blade Segment

CARD 61/A1

XTW (1)	Blade Segment No. 1 (root)	(lb/in.)
(2)	Blade Segment No. 2	(lb/in.)
(3)	Blade Segment No. 3	(lb/in.)
(4)	Blade Segment No. 4	(lb/in.)
(5)	Blade Segment No. 5	(lb/in.)
(6)	Blade Segment No. 6	(lb/in.)
(7)	Blade Segment No. 7	(lb/in.)

CARD 61/A2

XTW (8)	Blade Segment No. 8	(lb/in.)
(9)	Blade Segment No. 9	(lb/in.)
(10)	Blade Segment No. 10	(lb/in.)
(11)	Blade Segment No. 11	(lb/in.)
(12)	Blade Segment No. 12	(lb/in.)
(13)	Blade Segment No. 13	(lb/in.)
(14)	Blade Segment No. 14	(lb/in.)

CARD 61/A3

XTW(15)	Blade Segment No. 15	(lb/in.)
(16)	Blade Segment No. 16	(lb/in.)
(17)	Blade Segment No. 17	(lb/in.)
(18)	Blade Segment No. 18	(lb/in.)
(19)	Blade Segment No. 19	(lb/in.)
(20)	Blade Segment No. 20	(lb/in.)
(21)	Tip Weight	(lb)

2.8.2 Average Running Beamwise Mass Moment of Inertia of Blade Segment

CARD 61/B1

XTW(22)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
(23)	Blade Segment No. 2	(in.-lb-sec^2/in.)
(24)	Blade Segment No. 3	(in.-lb-sec^2/in.)
(25)	Blade Segment No. 4	(in.-lb-sec^2/in.)

(26)	Blade Segment No. 5	(in.-lb-sec^2/in.)
(27)	Blade Segment No. 6	(in.-lb-sec^2/in.)
(28)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 61/B2

XTW(29)	Blade Segment No. 8	(in.-lb-sec^2/in.)
(30)	Blade Segment No. 9	(in.-lb-sec^2/in.)
(31)	Blade Segment No. 10	(in.-lb-sec^2/in.)
(32)	Blade Segment No. 11	(in.-lb-sec^2/in.)
(33)	Blade Segment No. 12	(in.-lb-sec^2/in.)
(34)	Blade Segment No. 13	(in.-lb-sec^2/in.)
(35)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 61/B3

XTW(36)	Blade Segment No. 15	(in.-lb-sec^2/in.)
(37)	Blade Segment No. 16	(in.-lb-sec^2/in.)
(38)	Blade Segment No. 17	(in.-lb-sec^2/in.)
(39)	Blade Segment No. 18	(in.-lb-sec^2/in.)
(40)	Blade Segment No. 19	(in.-lb-sec^2/in.)
(41)	Blade Segment No. 20	(in.-lb-sec^2/in.)
(42)	Currently unused	

2.8.3 Average Running Chordwise Mass Moment of Inertia of Blade Segment

CARD 61/C1

XTW(43)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
(44)	Blade Segment No. 2	(in.-lb-sec^2/in.)
(45)	Blade Segment No. 3	(in.-lb-sec^2/in.)
(46)	Blade Segment No. 4	(in.-lb-sec^2/in.)
(47)	Blade Segment No. 5	(in.-lb-sec^2/in.)
(48)	Blade Segment No. 6	(in.-lb-sec^2/in.)
(49)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 61/C2

XTW(50)	Blade Segment No. 8	(in.-lb-sec^2/in.)
(51)	Blade Segment No. 9	(in.-lb-sec^2/in.)
(52)	Blade Segment No. 10	(in.-lb-sec^2/in.)
(53)	Blade Segment No. 11	(in.-lb-sec^2/in.)
(54)	Blade Segment No. 12	(in.-lb-sec^2/in.)
(55)	Blade Segment No. 13	(in.-lb-sec^2/in.)
(56)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 61/C3

XTW(57)	Blade Segment No. 15	(in.-lb-sec^2/in.)
(58)	Blade Segment No. 16	(in.-lb-sec^2/in.)
(59)	Blade Segment No. 17	(in.-lb-sec^2/in.)
(60)	Blade Segment No. 18	(in.-lb-sec^2/in.)
(61)	Blade Segment No. 19	(in.-lb-sec^2/in.)
(62)	Blade Segment No. 20	(in.-lb-sec^2/in.)
(63)	Currently unused	

2.8.4 Average Beamwise Center of Gravity Offset of Blade Segment

CARD 61/D1

XTW(64)	Blade Segment No. 1 (root)	(in.)
(65)	Blade Segment No. 2	(in.)
(66)	Blade Segment No. 3	(in.)
(67)	Blade Segment No. 4	(in.)
(68)	Blade Segment No. 5	(in.)
(69)	Blade Segment No. 6	(in.)
(70)	Blade Segment No. 7	(in.)

CARD 61/D2

XTW(71)	Blade Segment No. 8	(in.)
(72)	Blade Segment No. 9	(in.)
(73)	Blade Segment No. 10	(in.)
(74)	Blade Segment No. 11	(in.)
(75)	Blade Segment No. 12	(in.)
(76)	Blade Segment No. 13	(in.)
(77)	Blade Segment No. 14	(in.)

CARD 61/D3

XTW(78)	Blade Segment No. 15	(in.)
(79)	Blade Segment No. 16	(in.)
(80)	Blade Segment Nc. 17	(in.)
(81)	Blade Segment No. 18	(in.)
(82)	Blade Segment No. 19	(in.)
(83)	Blade Segment No. 20	(in.)
(84)	cg offset of tipweight	(in.)

2.8.5 Average Chordwise Center of Gravity Offset of Blade Segment

CARD 61/E1

XTW(85)	Blade Segment No. 1 (root)	(in.)
(86)	Blade Segment No. 2	(in.)

(87)	Blade Segment No. 3	(in.)
(88)	Blade Segment No. 4	(in.)
(89)	Blade Segment No. 5	(in.)
(90)	Blade Segment No. 6	(in.)
(91)	Blade Segment No. 7	(in.)

CARD 61/E2

XTW(92)	Blade Segment No. 8	(in.)
(93)	Blade Segment No. 9	(in.)
(94)	Blade Segment No. 10	(in.)
(95)	Blade Segment No. 11	(in.)
(96)	Blade Segment No. 12	(in.)
(97)	Blade Segment No. 13	(in.)
(98)	Blade Segment No. 14	(in.)

CARD 61/E3

XTW(99)	Blade Segment No. 15	(in.)
(100)	Blade Segment No. 16	(in.)
(101)	Blade Segment No. 17	(in.)
(102)	Blade Segment No. 18	(in.)
(103)	Blade Segment No. 19	(in.)
(104)	Blade Segment No. 20	(in.)
(105)	cg offset of tipweight	(in.)

2.8.6 Blade Mode Shape Data

The IPL(7) tail rotor mode shapes are input here. Each mode shape is input on (|IPL(5)| +5) cards. The format for all the cards in a mode shape is 6F10.0. In the following discussion, MN is the mode shape number ($\leq$IPL(7)).

2.8.6.1 First Mode (MN = 1)

CARD 62/A1 Blade General Mode Shape Data

XGMS	(1,MN+IPL(6))*	Mode type indicator	
	(2,MN+IPL(6))	Natural frequency	(/rev)
	(3,MN+IPL(6))	Generalized inertia	(slug-ft^2)
	(4,MN+IPL(6))	Modal damping ratio	
	(5,MN+IPL(6))	Inplane hub shear coefficient	(lb)
	(6,MN+IPL(6))	Out-of-plane hub shear coefficient	(lb)

*The second subscript is MN+IPL(6) because the tail rotor general mode shape data is stored in the XGMS array after the main rotor general mode shape data.

CARD 62/A2

XGMS	(7,MN+IPL(6))	Pitch-Link Load Coefficient	(lb)
	(8,MN+IPL(6))	Lag Angle	(deg)
	(9,MN+IPL(6))	Reference RPM	(rpm)
	(10,MN+IPL(6))	Reference Collective	(deg)
	(11,MN+IPL(6))	Pitch bearing out-of-plane slope	(deg)
	(12,MN+IPL(6))	Pitch bearing inplane slope	(deg)

CARD 62/A3

XGMS	(13,MN+IPL(6))	Integral of (OP component) x (r)dm	($slug\text{-}ft^2$)
	(14,MN+IPL(6))	Integral of (OP component)dm	(slug-ft)
	(15,MN+IPL(6))	Integral of (IP component) x (r)dm	($slug\text{-}ft^2$)
	(16,MN+IPL(6))	Integral of (IP component)dm	(slug-ft)
	(17,MN+IPL(6))	Pitch bearing out-of-plane displacement	(ft)
	(18,MN+IPL(6))	Pitch bearing inplane displacement	(ft)

CARD 62/B1 Blade Mode Shape

Mode Shape Data at Station No. 0 (Center of Rotation)

(1)	Out-of-plane displacement	(ft)
(2)	Inplane displacement	(ft)
(3)	Torsional displacement	(deg)
(4)	Out-of-plane bending moment coefficient	(ft-lb)
(5)	Inplane bending moment coefficient	(ft-lb)
(6)	Torsional moment coefficient	(ft-lb)

CARD 62/B2 Blade Mode Shape Data at Station No. 1 (XTBS(1))

(7)	Out-of-plane displacement	(ft)
(8)	Inplane displacement	(ft)
(9)	Torsional displacement	(deg)
(10)	Out-of-plane bending moment coefficient	(ft-lb)
(11)	Inplane bending moment coefficient	(ft-lb)
(12)	Torsional moment coefficient	(ft-lb)

CARD 62/B3 Format repeated until there are (|IPL(5)|+1)
CARD 62/B4 cards, one for each station
etc.

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CARD 62/C1 Cyclic Detuning Data

(1)	Natural frequency at low rpm and low pitch angle	(cpm)
(2)	Natural frequency at low rpm and high pitch angle	(cpm)
(3)	Natural frequency at high rpm and low pitch angle	(cpm)
(4)	Natural frequency at high rpm and high pitch angle	(cpm)
(5)	Difference between reference pitch angle and high or low value	(deg)
(6)	Difference between reference rpm and either high or low value	(rpm)

2.8.6.2 Second and Subsequent Blade Modes

CARDS 63/A1 through 63/C1 (Include only if IPL(7)≥2) (MN = 2)

Input sequence and format similar to that of blade Mode 1.

CARDS 64/A1 through 64/C1 (Include only if IPL(7)≥3) (MN = 3)

Input sequence and format similar to that of blade Mode 1.

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CARDS 6C/A1 through 6C/C1 (Include only if IPL(7)=11) (MN = 11)

Input sequence and format similar to that of Mode 1.

2.9 ROTOR AERODYNAMIC GROUP (omit only if IPL(3) = 3 and IPL(11) = 0)

CARD 70 Rotor Aerodynamic Group Identification Card

2.9.1 Rotor Airfoil Aerodynamic (RAA) Subgroup No. 1

CARD 71A

YRR	(1,1)	Drag divergence Mach number for $\alpha = 0$	
	(2,1)	Mach number for lower boundary of supersonic region	
	(3,1)	Maximum C_L, normal flow, M = 0	
	(4,1) (5,1) (6,1)	Coefficients of Mach number in maximum C_L equation, normal flow	
	(7,1)	Maximum C_L, reversed flow, M = 0	

CARD 71B

YRR	(8,1)	Slope of lift curve for M = 0	(/deg)
	(9,1) (10,1) (11,1)	Coefficients of M for lift-curve slope in subsonic region	(/deg) (/deg) (/deg)
	(12,1)	C_D for $\alpha = 0$, M = 0	
	(13,1) (14,1)	Coefficients of α in nondivergent drag equation	(/deg) (/deg^2)

CARD 71C

YRR	(15,1)	Coefficient in supersonic drag equation	
	(16,1)	Maximum nondivergent C_D	
	(17,1)	Thickness/chord ratio	
	(18,1)	Control variable for using data table (=0.0, uses equations: >0, uses YRR(18,1)th table - internal 0012 table is Table 5)	
	(19,1)	Drag rise coefficient	(/deg)
	(20,1)	Coefficient of yaw angle in Mach number equation	
	(21,1)	Exponent in Mach number equation for yawed flow	

CARD 71D

YRR	(22,1) (23,1) (24,1)	Coefficients of α for Mach critical in steady C_M equation	(/deg^2) (/deg)
	(25,1)	C_M for $\alpha = 0$, M = 0	
	(26,1)		

	(27,1)	Switch for UNSAN yawed flow effects (0 = off)	
	(28,1)	Maximum value of yawed flow angle	(deg)

CARD 71E

YRR	(29,1)	Zero lift line orientation at M = 0, normal flow	(deg)
	(30,1)	Coefficients for zero lift line	(deg)
	(31,1)	orientation as a function of Mach	(deg)
		number	
	(32,1)		
	(33,1)	Increment to steady state lift coefficient	
	(34,1)	Increment to steady state drag coefficient	
	(35,1)	Increment to steady state pitching moment coefficient	

2.9.2 <u>RAA Subgroup No. 2</u> (Include only if IPL(11)≥2)

CARD 72A
CARD 72B
CARD 72C } YRR(1,2)→YRR(35,2)
CARD 72D
CARD 72E

2.9.3 <u>RAA Subgroup No. 3</u> (Include only if IPL(11)≥3)

CARD 73A
CARD 73B
CARD 73C } YRR(1,3)→YRR(35,3)
CARD 73D
CARD 73E

2.9.4 <u>RAA Subgroup No. 4</u> (Include only if IPL(11)≥4)

CARD 74A
CARD 74B
CARD 74C } YRR(1,4)→YRR(35,4)
CARD 74D
CARD 74E

2.9.5 <u>RAA Subgroup No. 5</u> (Include only if IPL(11) = 5)

CARD 75A
CARD 75B
CARD 75C } YRR(1,5)→YRR(35,5)
CARD 75D
CARD 75E

2.10 ROTOR INDUCED VELOCITY DISTRIBUTION TABLES GROUP (omit if IPL(12) = 0)

A rotor induced velocity distribution (RIVD) table may be input for each rotor. If a table is not input for a particular rotor, the distribution is computed from the equation in Section 3.10.3.

2.10.1 Main Rotor Table (include only if IPL(12) = 1 or 3)

CARD 80 Main Rotor RIVD Table Identification Card

CARD 80/A Title and Control Card (8A4, 8X, 4I3, 8X, F10.0 format)

Col	1-32	Alphanumeric title for table	
	36-38	NMU, Number of advance ratios ($1 \le NMU \le 10$)	
	39-41	NAA, Number of angle-of-attacks ($1 \le NAA \le 5$)	
	42-44	NHH, Order of highest harmonic ($0 \le NHH \le 9$)	
	45-47	NRS, Number of radial stations (if input as 0, defaults to radial stations given in main rotor group)	
	51-60	Reference resultant force magnitude	(lbf)

2.10.1.1 Advance Ratio Inputs

CARD 80/B1 (include only if $NMU \ge 2$; 7F10.0 format)

WKMU	(1)	Smallest advance ratio
	(2)	Next larger advance ratio
	(3)	Next larger advance ratio
	(4)	Next larger advance ratio
	(5)	Next larger advance ratio
	(6)	Next larger advance ratio
	(7)	Next larger advance ratio

CARD 80/B2 (include only if $NMU \ge 8$; 3F10.0 format)

WKMU	(8)	Next larger advance ratio
	(9)	Next larger advance ratio
	(10)	Next larger advance ratio

2.10.1.2 Wake Plane Angle-of-Attack Inputs

CARD 80/C (include only if $NAA \ge 2$; 5F10.0 format)

WKAA	(1)	Smallest wake plane angle-of-attack (positive nose up)	(deg)
	(2)	Next larger angle-of-attack	(deg)

(3) Next larger angle-of-attack (deg)
(4) Next larger angle-of-attack (deg)
(5) Next larger angle-of-attack (deg)

NOTE: WKAA(1) < WKAA(2) < WKAA(3) < WKAA(4) < WKAA(5)

2.10.1.3 Radial Station Inputs

CARD 80/D (Include only if NRS ≠ 0, 7F10.0 format)

WKRS (1) Radius to RIVD Table Station 1 (Fraction of rotor radius)
(2) Radius to RIVD Table Station 2
(3) Radius to RIVD Table Station 3
(4) Radius to RIVD Table Station 4
(5) Radius to RIVD Table Station 5
(6) Radius to RIVD Table Station 6
(7) Radius to RIVD Table Station 7

CARD 80/E (Include only if NRS ≠ 0, 7F10.0 format)

WKRS (8) Radius to RIVD Table Station 8
(9) Radius to RIVD Table Station 9
(10) Radius to RIVD Table Station 10
(11) Radius to RIVD Table Station 11
(12) Radius to RIVD Table Station 12
(13) Radius to RIVD Table Station 13
(14) Radius to RIVD Table Station 14

CARD 80/F (Include only if NRS ≠ 0, 7F10.0 format)

WKRS(15) Radius to RIVD Table Station 15
(16) Radius to RIVD Table Station 16
(17) Radius to RIVD Table Station 17
(18) Radius to RIVD Table Station 18
(19) Radius to RIVD Table Station 19
(20) Radius to RIVD Table Station 20
(21) Currently unused

NOTE: All three cards (CARD 80/D, CARD 80/E and CARD 80/F) must be included if NRS ≠ 0.0. Station 1 must not be at the center of rotation, but should be the inner-most RIVD station. These cards must not be included if NRS = 0.

2.10.1.4 Sets of Coefficients (NMU*NAA*NRS sets required)

Each set of coefficients corresponds to a specific combination of advance ratio, angle-of-attack, and radial station (WKMU(I), WKAA(J), and WKRS(K) respectively). See Figure 17 for input sequence of the sets. Each set of coefficients starts on a new card and consists of one to six cards in the following format:

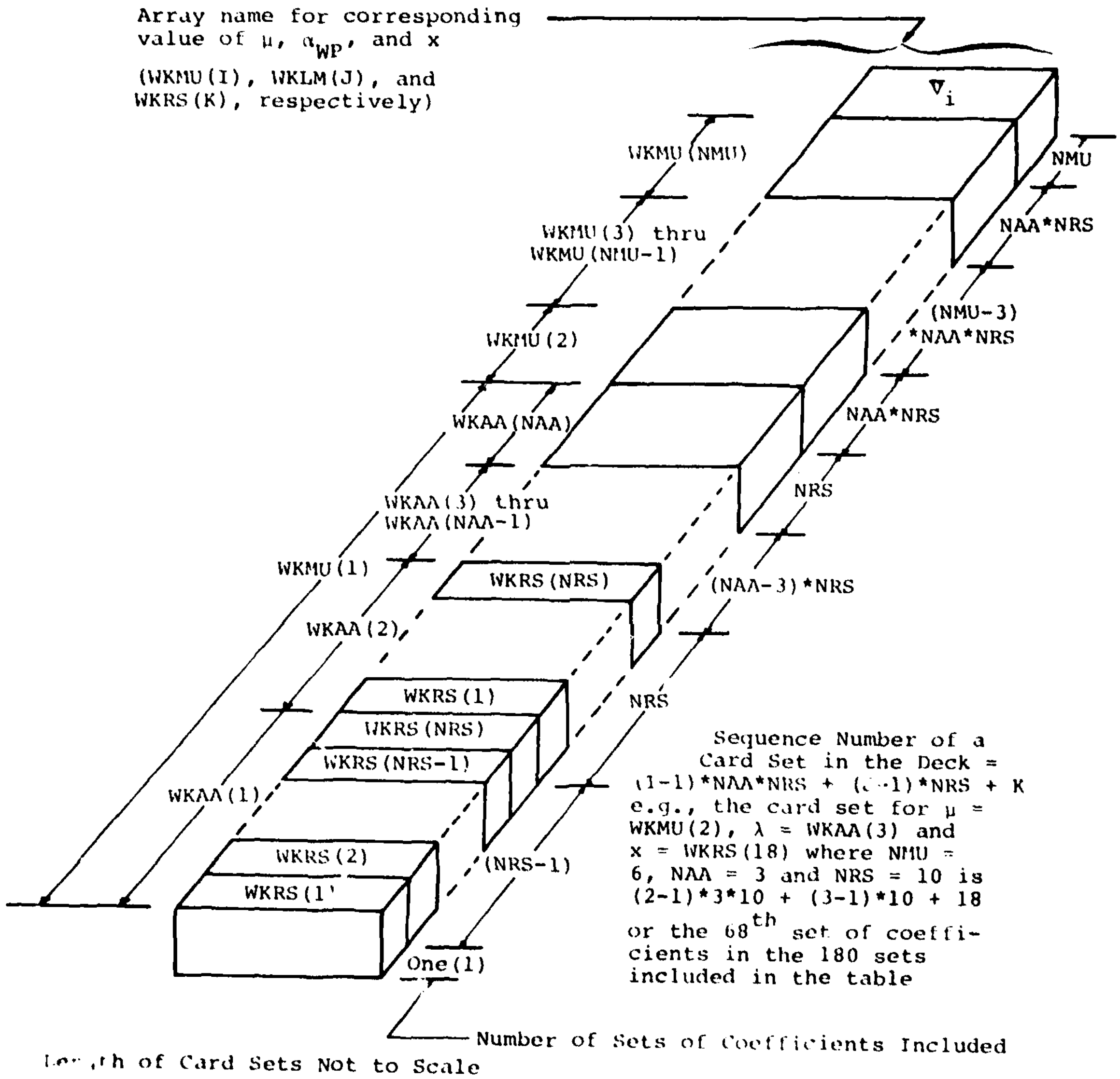

Figure 17. Schematic Diagram of Card Deck for RIVD Table.

First Card (7F10.0 format)

Col	1-10	Constant (zeroth harmonic)
	11-20	Sine component of first harmonic
	21-30	Cosine component of first harmonic
	31-40	Sine component of second harmonic
	41-50	Cosine component of second harmonic
	51-60	Sine component of third harmonic
	61-70	Cosine component of third harmonic

Second Card (include only if NHH $\geq$ 4; 10X, 6F10.0 format)

Col	1-10	(Not used)
	11-20	Sine component of fourth harmonic
	21-30	Cosine component of fourth harmonic
	31-40	Sine component of fifth harmonic
	41-50	Cosine component of fifth harmonic
	51-60	Sine component of sixth harmonic
	61-70	Cosine component of sixth harmonic

Third Card (include only if NHH $\geq$ 7)

Sine and cosine components for seventh, eighth and ninth harmonics; same format as second card.

2.10.1.5 Average Induced Velocity Table (NMU cards)

The average induced velocities computed by the wake program for each combination of advance ratio and angle-of-attack are input in this table.

First Card (5F10.0 format)

Col	1-10	Value for first advance ratio, first angle-of attack	(ft/sec)
	11-20	Value for first advance ratio, second angle-of-attack	(ft/sec)
	21-30	Value for first advance ratio, third angle-of-attack	(ft/sec)
	31-40	Value for first advance ratio, fourth angle-of-attack	(ft/sec)
	41-50	Value for first advance ratio, fifth angle-of-attack	(ft/sec)
	51-60	Currently unused	
	61-70	Currently unused	

Second Card (Include only if NMU $\geq$ 2; 5F10.0 format)

This card contains the values of the average induced velocity for the second advance ratio for each of the angles-of-attack.

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Tenth Card (Include only if NMU = 10; 5F10.0 format)

This card contains the values of the average induced velocity for each of the angles-of-attack for the tenth advance ratio.

2.10.2 Tail Rotor Table (include only if IPL(12) = 2 or 3)

Format for this table is the same as for the Main Rotor Table.

CARD 90	Tail Rotor RIVD Table Identification Card
CARD 90/A	Title and Control Card
CARD 90/B1 CARD 90/B2	Advance ratio inputs
CARD 90/C	Wake-plane angle-of-attack inputs

Sets of Coefficients

Tail rotor RIVD coefficients are input in the same format as those for the main rotor (Section 2.10.1). There will be NMU*NAA*NRS sets of up to six cards each, plus NMU cards containing the average induced velocities.

2.11 ROTOR WAKE AT AERODYNAMIC SURFACES TABLES GROUP (Omit if IPL(13) = 0)

If IPL(13) ≠ 0, exactly IPL(13) tables must be input. The format for each table is identical to each other and similar to the RIVD tables discussed in Section 2.10. The format for an example table follows:

First Card: Table Identification Card

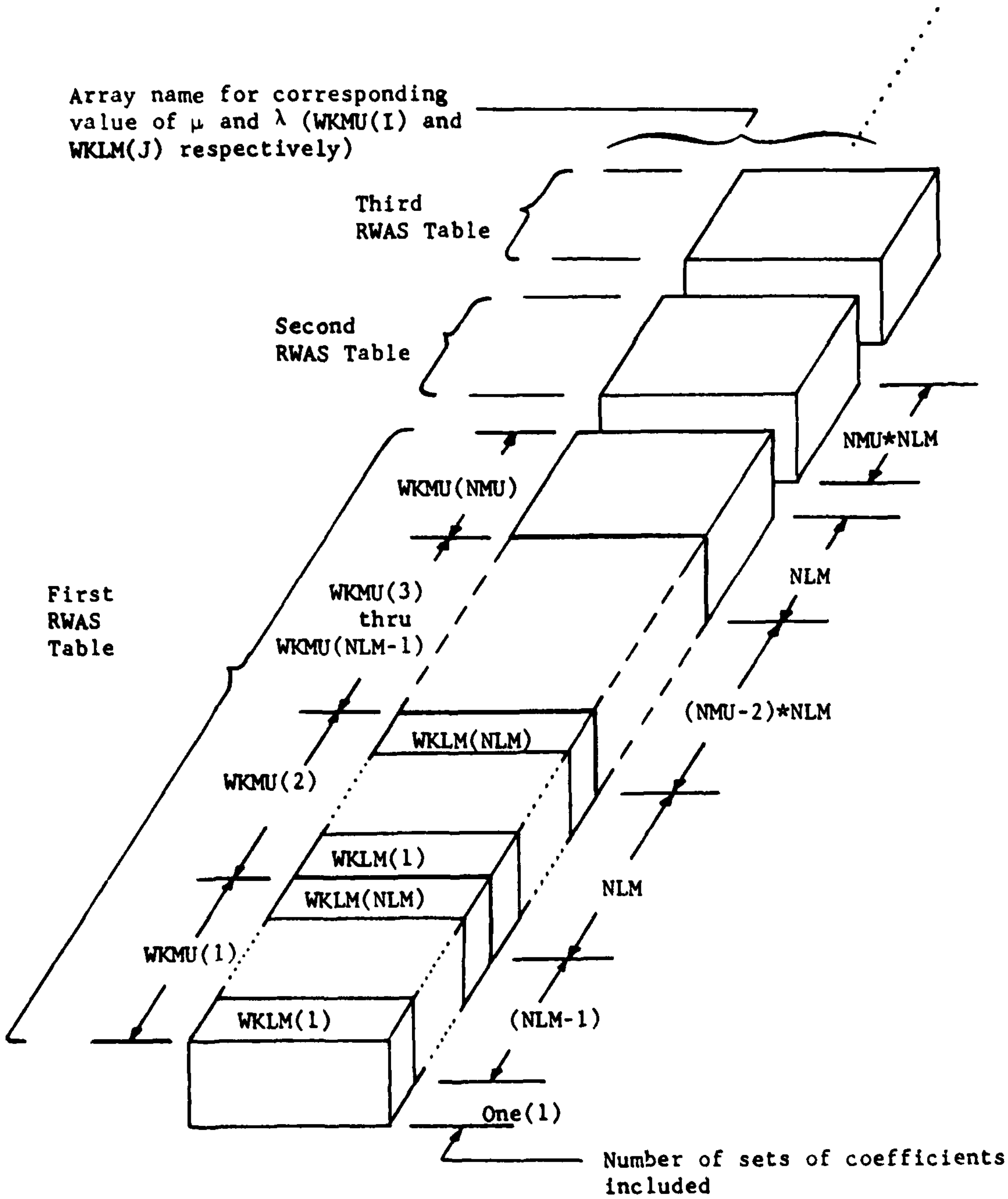
Second Card: Title and Control Card (8A4, 8X, 3I3 format)

Col	1-32	Alphanumeric title for table
	41-43	NMU, Number of advance ratios ($1 \le NMU \le 3$)
	44-46	NLM, Number of inflow ratios ($1 \le NLM \le 2$)
	47-49	NHH, Order of highest harmonic ($0 \le NHH \le 7$)

Next Card: Advance ratio inputs; 3F10.0 format; include if and only if NMU ≥ 2

Next Card: Inflow ratio inputs; 2F10.0 format; include if and only if NLM = 2

Next Cards: Set of coefficients; NMU*NLM sets required; one to three cards for each set; same format as for sets of coefficients in RIVD Tables (see Section 2.10.1.3); see Figure 18 for input sequence of the sets.



Length of Card Sets Not to Scale

Figure 18. Schematic Diagram of Card Deck for a Set of RWAS Tables.

2.12 FUSELAGE GROUP (include only if IPL(1) = 0)

CARD 100 Fuselage Group Identification Card

2.12.1 Basic Inputs

CARD 101

XFS	(1)	Gross weight		(lb)
	(2)	Stationline	Location of fuselage data reference point	(in.)
	(3)	Buttline		(in.)
	(4)	Waterline		(in.)
	(5)	Stationline	Location of center of gravity	(in.)
	(6)	Buttline		(in.)
	(7)	Waterline		(in.)

CARD 102

XFS	(8)	Aircraft rolling inertia, I_{xx}	(slug-ft^2)
	(9)	Aircraft pitching inertia, I_{yy}	(slug-ft^2)
	(10)	Aircraft yawing inertia, I_{zz}	(slug-ft^2)
	(11)	Aircraft product of inertia, I_{xz}	(slug-ft^2)
	(12)	Force and moment equation use indicator, LGF	
	(13)	Phasing Angle (Nominal/Phasing)	(deg)
	(14)	Phasing Angle (High/Phasing)	(deg)

2.12.2 Aerodynamic Inputs (Wind Axis)

Cards 103 through 10E contain the coefficients for the High Angle and Nominal Angle Equations. The asterisk (*) indicates that the input is considered necessary; see Section 3.12.

2.12.2.1 Coefficients for Lift Equations

CARD 103

XFS	(15)	L/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^2)
	(16)	L/q at $\psi_w = 180°$, $\theta_w = 0°$ (Rwd Flt)	(ft^2)
	(17)	Approx. peak L/q for $0° \leq \theta_w \leq 90°$, $\psi_w = 0°$	(ft^2)
	(18)	Value of θ_w for XFS(17)	(deg)
	(19)	L/q at $\psi_w = 0°$, $\theta_w = 90°$ (Vert Flt.)	(ft^2)
	(20)	L/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^2)
	(21)	$\partial(L/q)/\partial\psi_w$	(ft^2/deg)

CARD 104

XFS	(22)	$\partial(L/q)/\partial(\psi_W^2)$	(ft^2/deg^2)
	*(23)	$\partial(L/q)/\partial\theta_W$; lift-curve slope at $\psi_W = 0°$	(ft^2/deg)
	(24)	$\partial(\partial(L/q)/\partial\psi_W)/\partial\theta_W$	(ft^2/deg^2)
	(25)	$\partial(\partial(L/q)/\partial(\psi_W^2))/\partial\theta_W$	(ft^2/deg^3)
	(26)	$\partial(L/q)/\partial(\theta_W^2)$	(ft^2/deg^2)
	(27)	$\partial(\partial(L/q)/\partial\psi_W)/\partial(\theta_W^2)$	(ft^2/deg^3)
	(28)	$\partial(L/q)/\partial(\theta_W^3)$	(ft^2/deg^3)

2.12.2.2 Coefficients for Drag Equations

CARD 105

XFS	*(29)	D/q at $\psi_W = \theta_W = 0°$ (Fwd Flt)	(ft^2)
	(30)	D/q at $\psi_W = 180°$, $\theta_W = 0°$ (Rwd Flt)	(ft^2)
	(31)	D/q at $\psi_W = 90°$, $\theta_W = 0°$(Sideward Flt)	(ft^2)
	(32)	D/q at $\theta_W = -90°$ (Ascending Vertical) Flt.)	(ft^2)
	(33)	D/q at $\theta_W = +90°$ (Descending Vertical Flt.)	(ft^2)
	(34)	Currently unused	
	(35)	$\partial(D/q)/\partial\psi_W$	(ft^2/deg)

CARD 106

XFS	*(36)	$\partial(D/q)/\partial(\psi_W^2)$; variation of drag with ψ_W^2 at $\theta_W = 0°$	(ft^2/deg^2)
	*(37)	$\partial(D/q)/\partial\theta_W$; variation of drag with θ_W at $\psi_W = 0°$	(ft^2/deg)
	(38)	$\partial(\partial(D/q)/\partial\psi_W)/\partial\theta_W$	(ft^2/deg^2)
	(39)	$\partial(\partial(D/q)/\partial(\psi_W^2))/\partial\theta_W$	(ft^2/deg^3)
	*(40)	$\partial(D/q)/\partial(\theta_W^2)$; variation of drag with θ_W^2 at $\psi_W = 0°$	(ft^2/deg^2)
	(41)	$\partial(\partial(D/q)/\partial\psi_W)/\partial(\theta_W^2)$	(ft^2/deg^3)
	(42)	$\partial(D/q)/\partial(\theta_W^3)$	(ft^2/deg^3)

2.12.2.3 Coefficients for Pitching Moment Equations

CARD 107

XFS	*(43)	M/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^3)
	(44)	M/q at $\psi_w = 180°$, $\theta_w = 0°$ (Rwd Flt)	(ft^3)
	(45)	Approx. peak M/q for $0° \leq \theta_w \leq 90°$, $\psi_w = 0°$	(ft^3)
	(46)	Value of θ_w for XFS(45)	(deg)
	(47)	M/q at $\psi_w = 0°$, $\theta_w = 90°$ (Vertical Flt)	(ft^3)
	(48)	M/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^3)
	(49)	$\partial(M/q)/\partial\psi_w$	(ft^3/deg)

CARD 108

XFS	(50)	$\partial(M/q)/\partial(\psi_w^2)$	(ft^3/deg^2)
	*(51)	$\partial(M/q)/\partial\theta_w$; static longitudinal stability	(ft^3/deg)
	(52)	$\partial(\partial(M/q)/\partial\Psi_w)/\partial\theta_w$	(ft^3/deg^2)
	(53)	$\partial(\partial(M/q)/\partial(\psi_w^2))/\partial\theta_w$	(ft^3/deg^3)
	(54)	$\partial(M/q)/\partial(\theta_w^2)$	(ft^3/deg^2)
	(55)	$\partial(\partial(M/q)/\partial\psi_w)/\partial(\theta_w^2)$	(ft^3/deg^3)
	(56)	$\partial(M/q)/\partial(\theta_w^3)$	(ft^3/deg^3)

2.12.2.4 Coefficients for Side Force Equations

CARD 109

XFS	(57)	Y/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^2)
	(58)	Approx. peak Y/q for $0 \leq \psi_w \leq 90°$, $\theta_w = 0°$	(ft^2)
	(59)	Value of ψ_w for XFS(58)	(deg)
	(60)	Y/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^2)
	(61)	$\partial(Y/q)/\partial\theta_w$	(ft^2/deg)
	(62)	$\partial(Y/q)/\partial(\theta_w^2)$	(ft^2/deg^2)
	(63)	$\partial(Y/q)/\partial(\theta_w^3)$	(ft^2/deg^3)

CARD 10A

XFS	*(64)	$\partial(Y/q)/\partial\psi_w$; slope of Y versus ψ_w at $\theta_w = 0°$	(ft^2/deg)
	(65)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial\psi_w$	(ft^2/deg^2)
	(66)	$\partial(\partial(Y/q)/\partial(\theta_w^2))/\partial\psi_w$	(ft^2/deg^3)
	(67)	$\partial(Y/q)/\partial(\psi_w^2)$	(ft^2/deg^2)
	(68)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial(\psi_w^2)$	(ft^2/deg^3)
	(69)	$\partial(Y/q)/\partial(\psi_w^3)$	(ft^2/deg^3)
	(70)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial(\psi_w^3)$	(ft^2/deg^4)

2.12.2.5 Coefficients for Rolling Moment Equations

CARD 10B

XFS	(71)	1/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^3)
	(72)	Approx. peak 1/q for $0 \le \psi_w \le 90°$, $\theta_w = 0°$	(ft^3)
	(73)	Value of ψ_w for XFS(72)	(deg)
	(74)	1/q at $\psi_w = \theta_w = 0°$ (Fwd. Flt.)	(ft^3)
	(75)	$\partial(1/q)/\partial\theta_w$	(ft^3/deg)
	(76)	$\partial(1/q)/\partial(\theta_w^2)$	(ft^3/deg^2)
	(77)	$\partial(1/q)/\partial(\theta_w^3)$	(ft^3/deg^3)

CARD 10C

XFS	*(78)	$\partial(1/q)/\partial\psi_w$; slope of RM curve for ψ_w at $\theta_w = 0°$	(ft^3/deg)
	(79)	$\partial(\partial(1/q)/\partial\theta_w)/\partial\psi_w$	(ft^3/deg^2)
	(80)	$\partial(\partial(1/q)/\partial(\theta_w^2)/\partial\psi_w$	(ft^3/deg^3)
	(81)	$\partial(1/q)/\partial(\psi_w^2)$	(ft^3/deg^2)
	(82)	$\partial(\partial(1/q)/\partial\theta_w)/\partial(\psi_w^2)$	(ft^3/deg^3)
	(83)	$\partial(1/q)/\partial(\psi_w^3)$	(ft^3/deg^3)
	(84)	$\partial(\partial(1/q)/\partial\theta_w)/\partial(\psi_w^3)$	(ft^3/deg^4)

2.12.2.6 Coefficients for Yawing Moment Equations

CARD 10D

XFS	(85)	N/q at $\psi_W = 90°$, $\theta_W = 0°$ (Sideward Flt)	(ft^3)
	(86)	Approx. peak N/q for $0 \le \psi_W \le 90°$, $\theta_W = 0°$	(ft^3)
	(87)	Value of ψ_W for XFS(86)	(deg)
	(88)	N/q at $\psi_W = \theta_W = 0°$ (Fwd. Flt.)	(ft^3)
	(89)	$\partial(N/q)/\partial\theta_W$	(ft^3/deg)
	(90)	$\partial(N/q)/\partial(\theta_W^2)$	(ft^3/deg^2)
	(91)	$\partial(N/q)/\partial(\theta_W^3)$	(ft^3/deg^3)

CARD 10E

XFS	*(92)	$\partial(N/q)/\partial\psi_W$; slope of YM curve for ψ_W at $\theta_W = 0°$	(ft^3/deg)
	(93)	$\partial(\partial(N/q)/\partial\theta_W)/\partial\psi_W$	(ft^3/deg^2)
	(94)	$\partial(\partial(N/q)/\partial(\theta_W^2))/\partial\psi_W$	(ft^3/deg^3)
	(95)	$\partial(N/q)/\partial(\psi_W^2)$	(ft^3/deg^2)
	(96)	$\partial(\partial(N/q)/\partial\theta_W)/\partial(\psi_W^2)$	(ft^3/deg^3)
	(97)	$\partial(N/q)/\partial(\psi_W^3)$	(ft^3/deg^3)
	(98)	$\partial(\partial(N/q)/\partial\theta_W)/\partial(\psi_W^3)$	(ft^3/deg^4)

CARDS 10F through 10J must be input if IPL(9) $\neq$ 0. These cards contain the data for calculation of linear accelerations at a specified point in the fixed system. All 5 cards must be input.

CARD 10 F

XFSMS	(1,1)	Stationline	Location of specified point at which accelerations are desired	(in.)
	(2,1)	Buttline		(in.)
	(3,1)	Waterline		(in.)
	(4,1)	Currently unused		
	(5,1)			
	(6,1)			
	(7,1)			

CARD 10G

XFSMS	(8,1)	X_1	Mode shape components of	(ft)
	(9,1)	Y_1	pylon mode 1 at the	(ft)
	(10,1)	Z_1	specified point	(ft)
	(11,1) (12,1) (13,1) (14,1)		Currently unused	

CARD 10H

XFSMS	(15,1)	X_2	Mode shape components of	(ft)
	(16,1)	Y_2	pylon mode 2 at the	(ft)
	(17,1)	Z_2	specified point	(ft)
	(18,1) (19,1) (20,1) (21,1)		Currently unused	

CARD 10I

XFSMS	(22,1)	X_3	Mode shape components of	(ft)
	(23,1)	Y_3	pylon mode 3 at the	(ft)
	(24,1)	Z_3	specified point	(ft)
	(25,1) (26,1) (27,1) (28,1)		Currently unused	

CARD 10J

XFSMS	(29,1)	X_4	Mode shape components of	(ft)
	(30,1)	Y_4	pylon mode 4 at the	(ft)
	(31,1)	Z_4	specified point	(ft)
	(32,1) (33,1) (34,1) (35,1)		Currently unused	

2.13 LANDING GEAR GROUP (Omit if IPL(24) = 0 or IPL(1) ≠ 0)

CARD 110 Landing Gear Group Identification Card

2.13.1 Landing Gear Group No. 1 (Include only if IPL(24)≥1)

CARD 111

XLG1	(1)	Stationline	Location of Gear Point (GP)	(in.)
	(2)	Buttline		(in.)
	(3)	Waterline		(in.)
	(4)	Spring constant		(lb/(ft)*)
	(5)	Exponent of GP displacement		
	(6)	Damper constant		(lb/(ft/sec)**)
	(7)	Exponent of GP velocity		

CARD 112

XLG1	(8)	Drag area of gear	(ft^2)
	(9)	Currently unused	
	(10)	Coefficient of friction	
	(11)	Pitch angle to line of action	(deg)
	(12)	Roll angle to line of action	(deg)
	(13)	Main rotor downwash factor	
	(14)	Tail rotor downwash factor	

2.13.2 Landing Gear Group No. 2 (Include only if IPL(24)≥2)

CARD 113, CARD 114 — XLG2(1)→XLG2(14); same input sequence and format as XLG1(1)→XLG1(14).

2.13.3 Landing Gear Group No. 3 (Include only if IPL(24)≥3)

CARD 115, CARD 116 — XLG3(1)→XLG3(14); same input sequence and format as XLG1(1)→XLG1(14).

2.13.4 Landing Gear Group No. 4 (Include only if IPL(24)≥4)

CARD 117, CARD 118 — XLG4(1)→XLG4(14); same input sequence and format as XLG1(1)→XLG1(14).

2.13.5 Landing Gear Group No. 5 (Include only if IPL(24)=5)

CARD 119, CARD 11A — XLG5(1)→XLG5(14); same input sequence and format as XLG1(1)→XLG1(14).

NOTE: The landing gear model has not yet been implemented in C81. The user may read in this group, but it will not affect the analysis.

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*Exponent of denominator equals XLG1(5)
**Exponent of denominator equals XLG1(7)

2.14 <u>WING GROUP</u> (omit if IPL(15) = 0 or IPL(1) ≠ 0)

CARD 120 Wing Group Identification Card

2.14.1 <u>Basic Inputs</u>

CARD 121

XWG	(1)	Wing area (including carry-through)	(ft^2)
	(2)	Stationline } Location of center of	(in.)
	(3)	Buttline } pressure for right	(in.)
	(4)	Waterline } wing panel	(in.)
	(5)	Incidence angle (+ nose up)	(deg)
	(6)	Effective dihedral angle (+ up)	(deg)
	(7)	Sweep angle of quarter chord line (+ aft)	(deg)

CARD 122

XWG	(8)	Geometric aspect ratio	
	(9)	Spanwise efficiency factor	
	(10)	Taper ratio of wing (tip chord/root chord)	
	(11)	Coefficient in equation for dynamic pressure reduction at stabilizers due to wing	
	(12)	Dynamic pressure reduction at wing due to fuselage	
	(13)	Coefficient in equation for wing wake centerline deflection	(deg)
	(14)	Control surface (flap) deflection	(deg)

CARD 123

XWG	(15)	} Coefficients for change in lift coefficient as a function of control	(deg)
	(16)	} surface deflection	(/deg^2)
	(17)	} Coefficients for change in maximum lift coefficient as a function of	(/deg)
	(18)	} control surface deflection	(/deg^2)
	(19)	} Coefficients for change in profile drag coefficient as a function of	(/deg)
	(20)	} control surface deflection	(/deg^2)
	(21)	Currently unused	

CARD 124

XWG	(22)	Coefficients for change in wing pitching moment as a function of control surface deflection	(/deg)
	(23)		($/deg^2$)
	(24)	Coefficients for downwash at the right wing panel due to the fuselage	(/deg)
	(25)		(deg/deg)
	(26)		(deg/deg^2)
	(27)	Coefficients for sidewash at the right wing panel due to fuselage	(deg/deg)
	(28)		(deg/deg^3)

CARD 125

XWG	(29)	Effect of Rotor 1 wake on R/H wing panel
	(30)	Effect of Rotor 1 wake on L/H wing panel
	(31)	Effect of Rotor 2 wake on L/H wing panel
	(32)	Effect of Rotor 2 wake on R/H wing panel
	(33)	Coefficient of sideslip in roll moment equation
	(34)	Coefficient of sideslip and C_L in roll moment equation
	(35)	Coefficient of yaw rate and C_L in roll moment equation

CARD 126

XWG	(36)	Coefficient of roll rate in roll moment equation
	(37)	Coefficient of sideslip in yaw moment equation
	(38)	Coefficient of sideslip and C_L^2 in yaw moment equation
	(39)	Coefficient of yaw rate and C_L^2 in yaw moment equation
	(40)	Coefficient of yaw rate and C_{D_o} in yaw moment equation
	(41)	Coefficient of roll rate and C_L in yaw moment equation
	(42)	Coefficient of roll rate and $dC_D/d\alpha$ in yaw moment equation

2.14.2 Aerodynamic Inputs

CARD 127

YWG	(1)	Drag divergence Mach number for $\alpha = 0$	
	(2)	Mach number for lower boundary of supersonic region	
	(3)	Maximum C_L normal flow, M (Mach number) = 0	
	(4) (5) (6)	Coefficient of Mach number in maximum C_L equation, normal flow	
	(7)	Maximum C_L, reversed flow, M = 0	

CARD 128

YWG	(8)	Slope of lift curve for M = 0	(/deg)
	(9) (10) (11)	Coefficients of M for lift curve slope in subsonic region	(/deg) (/deg) (/deg)
	(12)	C_D for $\alpha = 0$, M = 0	
	(13)	Coefficients of α in a non-	(/deg)
	(14)	divergent drag equation	($/deg^2$)

CARD 129

YWG	(15)	Coefficient in supersonic drag equation	
	(16)	Maximum nondivergent C_D	
	(17)	Thickness/chord ratio	
	(18)	Control variable for use of data table	
	(19)	Drag rise coefficient	(/deg)
	(20) (21)	Currently unused	

CARD 12A

YWG	(22) (23) (24)	Coefficients for α for Mach Critical in steady C_M equation	($/deg^2$) (deg)
	(25)	C_M for $\alpha = 0$, M = 0	
	(26) (27) (28)	Currently unused	

NOTE: The descriptions for the aerodynamic inputs for the stabilizing surfaces (YSTB1, YSTB2, YSTB3, and YSTB4 arrays) are identical to that for the YWG array.

2.14.3 <u>Control Linkage Inputs</u> (Include only if IPL(15)>0)

CARD 12B

XCWG	(1)	Coefficients for rigging wing angle to collective stick position	(deg/in.)
	(2)		(deg/in.^{2})
	(3)	Breakpoint for collective rigging	(%)
	(4)	Coefficients for rigging wing to longitudinal cyclic stick position	(deg/in.)
	(5)		(deg/in.^{2})
	(6)	Breakpoint for longitudinal cyclic rigging	(%)
	(7)	Linkage switch (0.0 for incidence)	

CARD 12C

XCWG	(8)	Coefficients for rigging right wing panel to lateral cyclic stick position	(deg/in.)
	(9)		(deg/in.^{2})
	(10)	Breakpoint for lateral stick rigging	(%)
	(11)	Coefficients for rigging right wing panel to pedal position	(deg/in.)
	(12)		(deg/in.^{2})
	(13)	Breakpoint for pedal rigging	(%)
	(14)	Coefficient for rigging wing angle to longitudinal mast tilt	(deg/deg)

2.15 <u>STABILIZING SURFACE GROUPS</u> (Omit all four groups if IPL(16) = IPL(17) = IPL(18) = IPL(19) = 0 or IPL(1) ≠ 0)

2.15.1 <u>Stabilizing Surface Group No. 1</u> (Include only if IPL(16) ≠ 0)

CARD 130 Stabilizing Surface Group No. 1 Identification Card

2.15.1.1 <u>Basic Inputs</u>

CARD 131

XSTB1	(1)	Stabilizing surface area	(ft^2)
	(2)	Stationline } Location of center of pressure for the stabilizing surface	(in.)
	(3)	Buttline } Location of center of pressure for the stabilizing surface	(in.)
	(4)	Waterline } Location of center of pressure for the stabilizing surface	(in.)
	(5)	Incidence angle	(deg)
	(6)	Effective dihedral angle (+ up)	(deg)
	(7)	Sweep angle of quarter-chord line (+ aft)	(deg)

CARD 132

XSTB1	(8)	Geometric aspect ratio of surface	
	(9)	Spanwise efficiency factor	
	(10)	Taper ratio	
	(11)	Tailboom bending coefficient	(rad/lb)
	(12)	Dynamic pressure reduction at surface due to fuselage	
	(13)	Downwash at surface due to wing	(deg)
	(14)	Control surface deflection	(deg)

CARD 133

XSTB1	(15)	} Coefficients for change in lift coefficient as a function of control surface deflection	(/deg)
	(16)	} Coefficients for change in lift coefficient as a function of control surface deflection	($/deg^2$)
	(17)	} Coefficients for change in maximum lift coefficient as a function of control surface deflection	(/deg)
	(18)	} Coefficients for change in maximum lift coefficient as a function of control surface deflection	($/deg^2$)
	(19)	} Coefficients for change in profile drag as a function of control surface deflection	(/deg)
	(20)	} Coefficients for change in profile drag as a function of control surface deflection	($/deg^2$)
	(21)	Currently unused	

CARD 134

XSTB1	(22)	Coefficients for change in surface pitching moment coefficient as a function of control surface deflection	(/deg)
	(23)		(/deg^2)
	(24)	Coefficients for downwash at surface due to the fuselage	(deg)
	(25)		(deg/deg)
	(26)		(deg/deg^2)
	(27)	Coefficients for sidewash at the surface due to the fuselage	(deg/deg)
	(28)		(deg/deg^3)

CARD 135

XSTB1	(29)	Effect of Rotor 1 wake on the surface	
	(30)	Velocity at which surface starts to enter Rotor 1 wake	(kn)
	(31)	Velocity at which surface is completely in the Rotor 1 Wake	(kn)
	(32)	Effect of Rotor 2 wake on the surface	
	(33)	Velocity at which surface starts to enter Rotor 2 wake	(kn)
	(34)	Velocity at which surface is completely in the Rotor 2 wake	(kn)
	(35)	Currently unused	

2.15.1.2 Aerodynamic Inputs

CARD 136
CARD 137
CARD 138
CARD 139

YSTB1(1)→YSTB1(28) (See Section 2.14.2)

2.15.1.3 Control Linkage Inputs (Include only if IPL(16)>0)

CARD 13A

XCS1	(1)	Coefficients for rigging stabilizer angle to collective position	(deg/in.)
	(2)		(deg/in.^{2})
	(3)	Breakpoint for collective rigging	(%)
	(4)	Coefficients for rigging stabilizer angle to longitudinal cyclic stick position	(deg/in.)
	(5)		(deg/in.^{2})
	(6)	Breakpoint for longitudinal cyclic rigging	(%)
	(7)	Linkage switch (0.0 for incidence)	

CARD 13B

XCS1	(8)	Coefficients for rigging stabilizer angle to lateral cyclic position	(deg/in.)
	(9)		(deg/in.^{2})
	(10)	Breakpoint for lateral cyclic rigging	(%)
	(11)	Coefficients for rigging stabilizer angle to pedal position	(deg/in.)
	(12)		(deg/in.^{2})
	(13)	Breakpoint for pedal rigging	(%)
	(14)	Coefficient for rigging stabilizer to longitudinal mast tilt	(deg/deg)

2.15.2 Stabilizing Surface No. 2 (Include only if IPL(17) ≠ 0)

CARD 140 Stabilizing Surface No. 2 Identification Card

2.15.2.1 Basic Inputs

CARD 141
CARD 142
CARD 143 } XSTB2(1)→XSTB2(35)
CARD 144
CARD 145

2.15.2.2 Aerodynamic Inputs

CARD 146
CARD 147
CARD 148 } YSTB2(1)→YSTB2(28)
CARD 149

2.15.2.3 Control Linkage Inputs (Include only if IPL(17)>0)

CARD 14A
CARD 14B } XCS2(1)→XCS2(14)

2.15.3 Stabilizing Surface No. 3 (Include only if IPL(18) ≠ 0)

CARD 150 Stabilizing Surface No. 3 Identification Card

2.15.3.1 Basic Inputs

CARD 151
CARD 152
CARD 153 } XSTB3(1)→XSTB3(35)
CARD 154
CARD 155

2.15.3.2 Aerodynamic Inputs

CARD 156
CARD 157
CARD 158
CARD 159 } YSTB3(1)→YSTB3(28)

2.15.3.3 Control Linkage Inputs (Include only if IPL(18)>0)

CARD 15A
CARD 15B } XCS3(1)→XCS3(14)

2.15.4 Stabilizing Surface No. 4 (Include only if IPL(19) ≠ 0)

CARD 160 Stabilizing Surface No. 4 Identification Card

2.15.4.1 Basic Inputs

CARD 161
CARD 162
CARD 163
CARD 164
CARD 165 } XSTB4(1)→XSTB4(35)

2.15.4.2 Aerodynamic Inputs

CARD 166
CARD 167
CARD 168
CARD 169 } YSTB4(1)→YSTB4(28)

2.15.4.3 Control Linkage Inputs (Include only if IPL(19)>0)

CARD 16A
CARD 16B } XSC4(1)→XSC4(14)

2.16 JET GROUP (Omit if IPL(20) = 0 or IPL(1) ≠ 0)

CARD 170 Jet Group Identification Card

CARD 171

XJET	(1)	Number of controllable jets		
	(2)	Thrust of right, or first, jet		(lb)
	(3)	Thrust of left, or second, jet		(lb)
	(4)	Stationline	Location of right (first) jet thrust	(in.)
	(5)	Buttline		(in.)
	(6)	Waterline		(in.)
	(7)	Currently unused		

CARD 172

XJET	(8)	Yaw angle, body to right (first) jet	(deg)
	(9)	Pitch angle, body to right (first) jet	(deg)
	(10)–(14)	Currently unused	

2.17 <u>EXTERNAL STORE/AERODYNAMIC BRAKE GROUP</u> (Omit entire group if IPL(21) = 0 or IPL(1) ≠ 0)

CARD 180 Store/Brake Group Identification Card

2.17.1 <u>Store/Brake No. 1</u> (Include only if IPL(21)≥1)

CARD 181A

XST1	(1)	Weight of store (<0 for aerodynamic brake)	(lb)
	(2)	Stationline } Location of store/	(in.)
	(3)	Buttline } brake center of	(in.)
	(4)	Waterline } gravity	(in.)
	(5)	Distance from cg to center of pressure at α_{sc} = 0 (+ aft)	(in.)
	(6)	Distance from cp at α_{sc} = 0 to cp at α_{sc} = ±90° (+ aft)	(in.)
	(7)	Dynamic pressure loss at store	

CARD 181B

XST1	(8)	Store rolling inertia	(slug-ft^2)
	(9)	Store pitching inertia	(slug-ft^2)
	(10)	Store yawing inertia	(slug-ft^2)
	(11)	Store product of inertia	(slug-ft^2)
	(12)	Induced velocity factor from main rotor	
	(13)	Induced velocity factor from tail rotor	
	(14)	Aerodynamic break deployment	(%)

CARD 181C

XST1	(15)	L_0/q	Coefficients for store/ brake lift, drag, and side force equations	(ft^2)
	(16)	L_1/q		(ft^2)
	(17)	D_0/q		(ft^2)
	(18)	D_{SIDE}/q		(ft^2)
	(19)	D_{TOP}/q		(ft^2)
	(20)	Y_0/q		(ft^2)
	(21)	Y_1/q		(ft^2)

2.17.2 Store/Brake No. 2 (Include only if IPL(21)≥2)

CARD 182A }
CARD 182B } XST2(1)→XST2(21); same input sequence and format as XST1(1)→XST1(21)
CARD 182C }

2.17.3 Store/Brake No. 3 (Include only if IPL(21)≥3)

CARD 183A }
CARD 183B } XST3(1)→XST3(21); same input sequence and format AS XST1(1)→XST1(21)
CARD 183C }

2.17.4 Store/Brake No. 4 (Include only if IPL(21) = 4)

CARD 184A }
CARD 184B } XST4(1)→XST4(21); same input sequence and format as XST1(1)→XST1(21)
CARD 184C }

2.18 ROTOR CONTROLS GROUP

CARD 190 Controls Group Identification Card

2.18.1 Basic Controls Subgroup

CARD 191

XCON	(1)	Range of collective stick	(in.)
	(2)	Collective pitch for Rotor 1 with stick full down ($\beta_M = 0$)	(deg)
	(3)	Range of collective pitch for Rotor 1 ($\beta_M = 0$)	(deg)
	(4)	Rotor 1 collective pitch lock indicator ($\neq 0$ for locked)	
	(5)	Rotor 1 root collective pitch if XCON(4) $\neq 0$	(deg)
	(6)	Change in jet thrust with collective stick position	(lb/in.)
	(7)	Currently unused	

CARD 192

XCON	(8)	Range of longitudinal cyclic stick	(in.)
	(9)	Rotor 1 cyclic swashplate angle with stick full aft	(deg)
	(10)	Range of cyclic swashplate angle for rotor 1 due to longitudinal cyclic	(deg)
	(11)	Rotor 1 cyclic swashplate angle lock indicator ($\neq 0$ for locked)	
	(12)	Rotor 1 cyclic swashplate angle at XCON (14) azimuth if XCON(11) $\neq 0$	(deg)
	(13)	Change in jet thrust with longitudinal cyclic stick position	(lb/in.)
	(14)	Azimuth angle of maximum swashplate displacement with longitudinal cyclic stick for Rotor 1 (Default value is 0.0)	(deg)

CARD 193

XCON	(15)	Range of lateral cyclic stick	(in.)
	(16)	Rotor 1 cyclic swashplate angle with stick full left	(deg)
	(17)	Range of cyclic swashplate angle for Rotor 1 due to lateral cyclic	(deg)
	(18)	Rotor 1 cyclic swashplate angle lock indicator ($\neq 0$ for locked)	

	(19)	Rotor 1 cyclic swashplate angle at XCON(21) azimuth if XCON(18) ≠ 0	(deg)
	(20)	Change in jet thrust with lateral cyclic stick position	(lb/in.)
	(21)	Azimuth angle of maximum swashplate motion with lateral cyclic stick for rotor 1 (Default value is 270.0)	(deg)

CARD 194

XCON	(22)	Range of pedals	(in.)
	(23)	Rotor 2 collective pitch with pedals full right	(deg)
	(24)	Range of collective pitch for Rotor 2	(deg)
	(25)	Rotor 2 collective pitch lock indicator (≠ 0 for locked)	
	(26)	Rotor 2 collective pitch if XCON(25) ≠ 0	(deg)
	(27)	Change in jet thrust with pedal position	(lb/in.)
	(28)	Currently unused	

2.18.2 <u>Supplementary Controls Subgroup</u> (Include only if IPL(22) ≠ 0)

CARDS 195 through 198 give the control system coupling ratios for both rotors. In the following discussion,

X_1 = Fixed-system collective intermediate control angle

X_2 = Fixed-system longitudinal cyclic intermediate control angle

X_3 = Fixed-system lateral cyclic intermediate control angle

X_4 = Fixed-system tail rotor collective intermediate control angle

For i = 1 or 2:

$(\theta_o)'_i$ = Collective intermediate control angle, i^{th} rotor

$(B_1)'_i$ = Longitudinal cyclic intermediate control angle, i^{th} rotor

$(A_1)'_i$ = Lateral cyclic intermediate control angle, i^{th} rotor

CARD 195 Collective Control Coupling

XCRT	(1)	$\partial(\theta_o)'_1/\partial X_1$	(default = 1.0)	(deg/deg)
	(2)	$\partial(\theta_o)'_2/\partial X_1$		(deg/deg)
	(3)	$\partial(B_1)'_1/\partial X_1$		(deg/deg)
	(4)	$\partial(B_1)'_2/\partial X_1$		(deg/deg)
	(5)	$\partial(A_1)'_1/\partial X_1$		(deg/deg)
	(6)	$\partial(A_1)'_2/\partial X_1$		(deg/deg)
	(7)	Currently unused		

CARD 196 Longitudinal Cyclic Control Coupling

XCRT	(8)	$\partial(\theta_o)'_1/\partial X_2$		(deg/deg)
	(9)	$\partial(\theta_o)'_2/\partial X_2$		(deg/deg)
	(10)	$\partial(B_1)'_1/\partial X_2$	(default = 1.0)	(deg/deg)
	(11)	$\partial(B_1)'_2/\partial X_2$		(deg/deg)

(12) $\partial(A_1)'_1/\partial X_2$ (deg/deg)

(13) $\partial(A_1)'_2/\partial X_2$ (deg/deg)

(14) Currently unused

CARD 197 Lateral Cyclic Control Coupling

XCRT (15) $\partial(\theta_o)'_1/\partial X_3$ (deg/deg)

(16) $\partial(\theta_o)'_2/\partial X_3$ (deg/deg)

(17) $\partial(B_1)'_1/\partial X_3$ (deg/deg)

(18) $\partial(B_1)'_2/\partial X_3$ (deg/deg)

(19) $\partial(A_1)'_1/\partial X_3$ (default = 1.0) (deg/deg)

(20) $\partial(A_1)'_2/\partial X_3$ (deg/deg)

(21) Currently unused

CARD 198 Pedal Control Coupling

XCRT (22) $\partial(\theta_o)'_1/\partial X_4$ (deg/deg)

(23) $\partial(\theta_o)'_2/\partial X_4$ (default = 1.0) (deg/deg)

(24) $\partial(B_1)'_1/\partial X_4$ (deg/deg)

(25) $\partial(B_1)'_2/\partial X_4$ (deg/deg)

(26) $\partial(A_1)'_1/\partial X_4$ (deg/deg)

(27) $\partial(A_1)'_2/\partial X_4$ (deg/deg)

(28) Currently unused

CARD 199 Control Linkage to Longitudinal Mast Tilt Angle

XCRT (29) Switch to change rotor control linkages with longitudinal mast tilt (0.0 = no change)

(30), (31) Coefficients for changing XCON(2) as a function of longitudinal mast tilt (30: deg/deg; 31: deg/deg^2)

(32) Range of collective pitch for Rotor 1 at longitudinal mast tilt = 90° (default = 100.0) (deg)

(33) Coefficient for modifying XCRT(5) and XCRT(6) as a function of longitudinal mast tilt (deg/deg)

	(34) }	Coefficients for modifying	(deg/deg)
	(35) }	XCRT(10) as a function of longitudinal mast tilt	(deg)

CARD 19A Nonlinear Rigging

XCRT	(36)	Coefficient for nonlinear rigging of collective	(deg/in.^{2})
	(37) }	Coefficients for nonlinear	(deg/in.^{2})
	(38) }	rigging of longitudinal cyclic	(deg/in.^{3})
	(39) }	Coefficients for nonlinear	(deg/in.^{2})
	(40) }	rigging of lateral cyclic	(deg/in.^{3})
	(41) }	Coefficients for nonlinear	(deg/in.^{2})
	(42) }	rigging of pedals	(deg/in.^{3})

CARD 19B Cyclic Actuator Phasing

XCRT	(43)	Azimuth for maximum swashplate motion with longitudinal cyclic stick for Rotor 2 (default = 0.0)	(deg)
	(44)	Azimuth for maximum swashplate motion with lateral cyclic stick for Rotor 2 (default = 270.0)	(deg)
	(45) }		
	(46) }		
	(47) }	Currently unused	
	(48) }		
	(49) }		

2.19 ENGINE-GOVERNOR GROUP

CARD 200 Engine-Governor Group Identification Card

CARD 201 Maximum Continuous Horsepower Available Card

XNG	(1)	Continuous transmission horsepower limit	(HP)
	(2)	Lowest temperature for continuous horsepower available curve	(°C)
	(3)	Continuous horsepower available at lowest temperature	(HP)
	(4)	Medium temperature for continuous horsepower available curve	(°C)
	(5)	Continuous horsepower available at medium temperature	(HP)
	(6)	Highest temperature for continuous horsepower available curve	(°C)
	(7)	Continuous horsepower available at highest temperature	(HP)

CARD 202 Maximum Takeoff Horsepower Available Card

XNG	(8)	Takeoff transmission horsepower limit	(HP)
	(9)	Lowest temperature for takeoff horsepower available curve	(°C)
	(10)	Takeoff horsepower available at lowest temperature	(HP)
	(11)	Medium temperature for takeoff horsepower available curve	(°C)
	(12)	Takeoff horsepower available at medium temperature	(HP)
	(13)	Highest temperature for takeoff horsepower available curve	(°C)
	(14)	Takeoff horsepower available at highest temperature	(HP)

CARD 203 Engine-Governor Constants Card

XNG	(15)	Drive system rotational speed	(RPM)
	(16)	Governor power gain (default = 1.0)	(HP/RPM)
	(17)	Time constant for engine power increase (default = ∞)	(sec)
	(18)	Time constant for engine power decrease (default = ∞)	(sec)
	(19)	Rotor 1 rotational inertia (default = $bI_{b_{MR}}$)	(slug-ft^2)
	(20)	Rotor 2 rotational inertia (default = $bI_{b_{TR}}$)	(slug-ft^2)
	(21)	Drive system rotational inertia	(slug-ft^2)

CARD 204

XNG	(22)	Rotor 1 transmission efficiency ratio (default = 1.0)	
	(23)	Rotor 2 transmission efficiency ratio (default = 1.0)	
	(24)	Overall transmission efficiency ratio (default = 1.0)	
	(25)	Accessory horsepower	(HP)
	(26)	Currently unused	
	(27)	Currently unused	
	(28)	Currently unused	

2.20 ITERATION LOGIC GROUP

CARD 210 Iteration Logic Group Identification Card

CARD 211

XIT	(1)	Iteration limit for TRIM	
	(2)	$\Delta\Psi$ of rotor(s) for time-variant trim	(deg)
	(3)	Limiter for change in average rotor-induced velocity	(ft/sec)
	(4)	Partial derivative increment for STAB	
	(5)	Number of rotor revolutions to be plotted after time-variant trim (default = none)	
	(6)	Number of rotor revolutions in TVT and FTVT (0 reset to 3.0 in FTVT, to 5.0 in TVT)	
	(7)	Damper to suppress blade torsional "bounce" (0 reset to 1.)	

CARD 212

XIT	(8)	Minimum value for main rotor flapping angle correction limit	(deg)
	(9)	Minimum value for tail rotor flapping angle correction limit	(deg)
	(10)	Maximum value for use of variable damper for main rotor	(ft-lb)
	(11)	Maximum value for use of variable damper for tail rotor	(ft-lb)
	(12)	Starting value for TRIM correction limit	(deg)
	(13)	Minimum value for TRIM correction limit	(deg)
	(14)	Maximum value for use of variable damper in TRIM	(lb or ft-lb)

CARD 213

XIT	(15)	Allowable error in longitudinal force balance	(lb)
	(16)	Allowable error in lateral force balance	(lb)
	(17)	Allowable error in vertical force balance	(lb)
	(18)	Allowable error in pitching and yawing moment balance	(ft-lb)
	(19)	Allowable error in rolling moment balance	(ft-lb)
	(20)	Allowable error in main rotor flapping moment balance	(ft-lb)
	(21)	Allowable error in tail rotor flapping moment balance	(ft-lb)

2.21 FLIGHT CONSTANTS GROUP

CARD 220 Flight Constants Group Identification Card

CARD 221

XFC	(1)	Forward velocity (ground reference)	(kn)
	(2)	Lateral velocity (ground reference)	(kn)
	(3)	Rate of climb (ground reference)	(ft/sec)
	(4)	Geometric altitude (controls ground effect)	(ft)
	(5)	Euler angle yaw (heading angle)	(deg)
	(6)	Euler angle pitch	(deg)
	(7)	Euler angle roll	(deg)

CARD 222

XFC	(8)	Collective stick position	(%)
	(9)	Longitudinal cyclic stick position	(%)
	(10)	Lateral cyclic stick position	(%)
	(11)	Pedal position	(%)
	(12)	g level	
	(13), (14)	Currently unused	

CARD 223

XFC	(15)	Main rotor longitudinal flapping angle	(deg)
	(16)	Main rotor lateral flapping angle	(deg)
	(17)	Tail rotor longitudinal flapping angle	(deg)
	(18)	Tail rotor lateral flapping angle	(deg)
	(19)	Main rotor thrust	(lb)
	(20)	Tail rotor thrust	(lb)
	(21)	Currently unused	

CARD 224

XFC	(22), (23), (24), (25)	Currently unused	
	(26)	Atmospheric logic switch (0.0 = Std Day; >0, XFC(28) is F°; <0, XFC(28) is C°; >100.0, XFC(27) is the density of ratio and XFC(28) is the speed of sound)	
	(27)	Pressure altitude or density ratio	(ft)
	(28)	Ambient temperature or speed of sound	(°C, °F, or ft/sec)

NOTE: END OF TRIM OR TRIM-STAB DECK; NPART = 1 AND NPART = 7 DECKS MAY ONLY BE FOLLOWED BY PARAMETER-SWEEP CARDS (NPART = 10), CONTOUR PLOT CARDS (NOP = 12) OR TIME-HISTORY PLOT CARDS (NOP = 3 AND 14), IN APPROPRIATE COMBINATIONS.

2.22 BOBWEIGHT GROUP (Include only if NPART = 2 or 4 and IPL(23) ≠ 0)

CARD 230 Bobweight Group Identification Card

CARD 231

XBW	(1)	Effectivity coefficient	(deg/in.)
	(2)	Spring constant	(lb/in.)
	(3)	Damping coefficient	(lb-sec/in.)
	(4)	Weight of bobweight	(lb)
	(5)	Currently unused	
	(6)		
	(7)	Preload	(g)

2.23 WEAPONS GROUP (Include only if NPART = 2 or 4 and IPL(23) ≠ 0)

CARD 240 Weapons Group Identification Card

CARD 241

XGN	(1)	Stationline	Location of weapon	(in.)
	(2)	Buttline		(in.)
	(3)	Waterline		(in.)
	(4)	Azimuth (+ right)		(deg)
	(5)	Elevation (+ up)		(deg)
	(6)	Currently unused		
	(7)			

Note: Use the weapons group in conjunction with a J = 16 card, Section 3.27.2.10.

2.24 <u>SCAS GROUP</u> (Include only if NPART = 2 or 4 and IPL(23) ≠ 0)

CARD 250 SCAS Group Identification Card

CARD 251

XSCAS	(1)	K_H, Roll response feedback gain		(in. of stick)/(deg/sec)
	(2)	τ_1	Roll channel time constants	(sec)
	(3)	τ_2		(sec)
	(4)	τ_3		(sec)
	(5)	τ_4		(sec)
	(6)	τ_5		(sec)
	(7)	K_G, Roll pilot feed-forward gain		(in. of stick)/(in. of stick/sec)

CARD 252

XSCAS	(8)	K_H, Pitch response feedback gain		(in. of stick)/(deg/sec)
	(9)	τ_1	Pitch channel time constants	(sec)
	(10)	τ_2		(sec)
	(11)	τ_3		(sec)
	(12)	τ_4		(sec)
	(13)	τ_5		(sec)
	(14)	K_G, Pitch pilot feed-forward gain		(in. of stick)/(in. of stick/sec)

CARD 253

XSCAS	(15)	K_H, Yaw response feedback gain		(in. of pedal)/(deg/sec)
	(16)	τ_1	Yaw channel time constants	(sec)
	(17)	τ_2		(sec)
	(18)	τ_3		(sec)
	(19)	τ_4		(sec)
	(20)	τ_5		(sec)
	(21)	K_G, Yaw pilot feed-forward gain		(in. of pedal)/(in. of pedal/sec)

CARD 254

XSCAS	(22)	Maximum authority in Roll	(%)
	(23)	Maximum authority in Pitch	(%)
	(24)	Maximum authority in Yaw	(%)
	(25)	Dead band for d/dt (Roll Moment)	(ft-lb/sec)
	(26)	Dead band for d/dt (Pitch Moment)	(ft-lb/sec)
	(27)	Dead band for d/dt (Yaw Moment)	(ft-lb/sec)
	(28)	Currently unused	

2.25 <u>STABILITY ANALYSIS TIMES GROUP</u> (Include only if **NPART** = 2, 4, or 5 and IPL(23) ≠ 0)

CARD 260 Stability Analysis Times Group Identification Card

CARD 261

TSTAB	(1)	Time or azimuth angle for first analysis	(sec or deg)
	(2)	Time or azimuth angle for second analysis	(sec or deg)
	(3)	Time or azimuth angle for third analysis	(sec or deg)
	(4)	Time or azimuth angle for fourth analysis	(sec or deg)
	(5)	Time or azimuth angle for fifth analysis	(sec or deg)
	(6)	Time or azimuth angle for sixth analysis	(sec or deg)
	(7)	Time or azimuth angle for seventh analysis	(sec or deg)

CARD 262

TSTAB	(8)	Time or azimuth angle for eighth analysis	(sec or deg)
	(9)	Time or azimuth angle for ninth analysis	(sec or deg)
	(10)	Time or azimuth angle for tenth analysis	(sec or deg)
	(11)	Time or azimuth angle for eleventh analysis	(sec or deg)
	(12)	Time or azimuth angle for twelfth analysis	(sec or deg)
	(13)	Time or azimuth angle for thirteenth analysis	(sec or deg)
	(14)	Time or azimuth angle for fourteenth analysis	(sec or deg)

NOTE: If no rotorcraft stability analyses are to be performed, TSTAB(1) must refer to a time or rotor azimuth angle after the end of the maneuver. A value of 9999. (seconds) is suggested as the input for such a case.

2.26 BLADE ELEMENT DATA PRINTOUT GROUP (Include only if NPART = 2, 4, or 5 and IPL(23) $\neq$ 0)

CARD 270 Blade Element Data Printout Group Identification Card

CARD 271

TAIR	(1)	Time or azimuth angle for first printout	(sec or deg)
	(2)	Time or azimuth angle for second printout	(sec or deg)
	(3)	Time or azimuth angle for third printout	(sec or deg)
	(4)	Time or azimuth angle for fourth printout	(sec or deg)
	(5)	Time or azimuth angle for fifth printout	(sec or deg)
	(6)	Time or azimuth angle for sixth printout	(sec or deg)
	(7)	Time or azimuth angle for seventh printout	(sec or deg)

CARD 272

TAIR	(8)	Time or azimuth angle for eighth printout	(sec or deg)
	(9)	Time or azimuth angle for ninth printout	(sec or deg)
	(10)	Time or azimuth angle for tenth printout	(sec or deg)
	(11)	Time or azimuth angle for eleventh printout	(sec or deg)
	(12)	Time or azimuth angle for twelfth printout	(sec or deg)
	(13)	Time or azimuth angle for thirteenth printout	(sec or deg)
	(14)	Time or azimuth angle for fourteenth printout	(sec or deg)

NOTE: If no printouts are to be made, TAIR(1) must refer to a time or rotor azimuth angle after the end of the maneuver. A value of 9999. (seconds) is suggested as the input for such a case.

2.27 <u>MANEUVER TIME CARD</u> (Include only if NPART = 2, 4, or 5)

CARD 301

TCI	(1)	Start time of maneuver	(sec)
	(2)	First time or azimuth increment	(sec or deg)
	(3)	Time to stop using first increment	(sec)
	(4)	Second time or azimuth increment	(sec or deg)
	(5)	Time to stop using second increment and return to first increment	(sec)
	(6)	Time to stop the maneuver	(sec)
	(7)	Currently unused	

2.28 <u>MANEUVER SPECIFICATION CARDS</u> (These cards may be included only if NPART = 2, 4, or 5)

CARD 311

Col	1	NEXTJ (= 0 for last card in group)
Col	2 - 5	J, variation selector
Col	11 - 20	Inputs which define the variations for each value of J in 6F10.0 format
Col	21 - 30	
Col	31 - 40	
Col	41 - 50	
Col	51 - 60	
Col	61 - 70	

CARD 312 Same format as CARD 311

CARD 313 Same format as CARD 311

CARD 314 Same format as CARD 311

etc.

2.29 PLOTTING OF TIME-VARIANT TRIM OR MANEUVER TIME-HISTORY DATA (This group may be included only if NPART = 1, 2, 4, 5, or 7; otherwise it must be excluded)

CARD 401

Col	2	NOP (Must equal 3 for plotting)
Col	4 - 6	NPRINT Print Control

CARDS 402A, 402B, ... (One for each set of plots desired - 10 maximum)

Col	3 - 5	KV1, Code of variable 1
Col	8 - 10	KV2, Code of variable 2
Col	13 - 15	KV3, Code of variable 3
Col	20	KEY (1 = plot on Printer only)
Col	25	KEYS (0 = last 402-type card)
Col	31 - 40	SC1, Minimum scale for KV1
Col	41 - 50	SC2, Minimum scale for KV2
Col	51 - 60	SC3, Minimum scale for KV3

See Section 6 for the code numbers to be used for KV1, KV2, and KV3.

2.30 STABILITY ANALYSIS USING MOVING BLOCK FAST FOURIER TRANSFORM (These cards may be included only if NPART = 2, 4, 5 or 8)

CARD 501

Col.	2	NOP (must equal 6 for moving block FFT method)

CARD 502A, 502B, ...

Col.	1	NEXT V ($\neq$ 0, another CARD 502 follows; =0 last card in group)	
	6 - 10	Code number of variable to be analyzed (see Section 6; data must be available from maneuver)	
	11 - 15	N, number of cycles of data, at frequency f, to be analyzed	
	21 - 30	t_o, start time	(sec)
	31 - 40	f, central frequency for moving block FFT	(Hz)
	41 - 50	Δf, half-bandwidth for analysis	(Hz)

NOTE: The last CARD 502 must have a zero in Column 1, and all other CARD 502's must have a digit other than zero in Column 1. Also, the variable to be analyzed has to have been computed during the maneuver; i.e., if the user wishes to analyze the stability of Rotor 1 bending moment data, Rotor 1 must have been elastic and time-variant during the maneuver.

2.31 STORING MANEUVER TIME-HISTORY DATA ON TAPE (This card may be included only if NPART = 2, 4, or 5)

CARD 601

Col.	2	NOP (must be equal 8 for tape file operations)
	11 - 15	NOP1 (must be blank or all zeros to store data)

NOTE: Maneuver time-history data which has been stored on tape can be retrieved with NPART = 8 (see CARD 01).

2.32 HARMONIC ANALYSIS OF TIME-VARIANT TRIM OR MANEUVER TIME-HISTORY DATA (These cards may be included only if NPART = 1, 2, 4, 5, or 8)

CARD 701

Col.	2	NOP (must equal 9 for harmonic analysis)	
	11 - 15	NVARA, number of variables to be frequency analyzed	
	21 - 25	AL(1), start time for interval to be analyzed	(sec)
	26 - 30	AH(1), stop time for interval to be analyzed	(sec)
	31 - 35	NVARB, print control for amplitude function (0 = print only)	
	41 - 45	AL(2), base frequency for analysis (0.0 = M/R 1/rev)	(cps)

CARDS 702A, 702B, etc.

Code numbers of variables to be analyzed (see Section 6 for code numbers). Format is up to 14 code numbers per card in 5-column fields, right justified (14I5 format).

2.33 VECTOR ANALYSIS OF MANEUVER TIME-HISTORY DATA (These cards may be included only if NPART = 2, 4, 5, or 8)

CARD 801

Col	1 - 2	NOP (must equal 11 for curve fitting)	
	11 - 15	NVARA, total number of curves to be fit in Step 1	
	21 - 25	AL(1), baseline frequency for Step 1	(cps)
	31 - 35	NVARB, total number of reference curves for Step 2	
	41 - 45	AL(2), total number of curve fits in Step 3	
	51 - 55	NVARC, number of time points to be skipped before step 1 curve fit begins	

CARD 802A, 802B, etc.

Code number of curves to be fit in Step 1 (NVARA inputs, 14I5 format)

CARD 803A, 803B, etc. (NVARB sets of these cards, 14I5 for each card)

Col	1 - 5	NX, quantity of variables to be compared to reference variables
	6 - 10	Code number of reference variable
	11 - 15 16 - 20 21 - 25 . . .	NX code numbers of variables to be compared to reference variable

CARDS 804A, 804B, etc. (AL(2) cards of this type)

Col	1 - 5	Code number for variable C
	6 - 10	Code number for variable D
	11 - 15	Code number for variable E

See Section 6 for the code numbers of the variables.

2.34 STABILITY ANALYSIS USING PRONY'S METHOD (These cards may included only if NPART = 2, 4, 5, or 8)

CARD 901

Col	1 - 2	NOP (must equal 13 for Prony's method)

CARD 902A, 902B, ...

Col	1	NEXT V = 0, last card in group, output based on rotor 1 rpm = 1, output based on rotor 1 rpm = 2, output based on rotor 2 rpm
	6 - 10	Code number of variable to be analyzed (see Section 6; data must be available from maneuver)
	14 - 15	Number of terms to be used in curve fit (maximum of 40)
	21 - 30	Start time
	31 - 40	Stop time

NOTE: The last CARD 902 must have a zero in Column 1, and all other CARD 902's must have a digit other than zero in Column 1. Also, the variable to be analyzed has to have been computed during the maneuver; i.e., if the user wishes to examine the stability of Rotor 1 bending moment data, Rotor 1 must have been elastic and time-variant during the maneuver.

2.35 TABULATIONS AND CONTOUR PLOTS OF SELECTED VARIABLES (Include only if IPL(79) $\neq$ 0 in one or more cases in a run)

CARD 1001

Col 1-2	NOP (must equal 12 for tabulation and contour plot operation)
11-15	NVARA, switch for tabulations (0 = off, 1 = on)
31-35	NVARB, switch for contour plots (0 = off, 1 = on)
51-55	NVARC, quantity of variables selected ($1 \leq$ NVARC ≤ 20)

CARDS 1002, 1002A

Code numbers of variables to be presented (see Section 3.35 for code numbers of variables). Format is up to 14 code numbers per card in 5-column fields (14I5 format). Omit CARD 1002A if NVARC $\leq$ 14.

3.0 USER'S GUIDE TO INPUT FORMAT

This section of the report presents a discussion of the inputs defined in Section 2.0. It is primarily intended for the inexperienced user of the program and for reference purposes. To simplify cross-reference between the two sections, the numbers of the subsections of this section correspond to those in Section 2.0; e.g., the inputs for the Main Rotor given in Section 2.5 are discussed in Section 3.5.

The units for each dimensional input are given at the right side of the page throughout Section 2.0. Whenever possible, inputs that are normally classified as nondimensional are given units to help explain them.

Most inputs are read into arrays. The first character in each array name and in most individual variables is a code for the general classification of the array or variable, as follows:

- X In general, inputs which can be physically measured, analytically determined, or defined, and which relate directly to the rotorcraft configuration.
- Y Inputs related to aerodynamic characteristics of the airfoil sections or surfaces.
- I Integer inputs which control program logic.
- T Inputs related to time points in a maneuver.

3.1 GENERAL

3.1.1 Composition of a Data Deck and Card Format

An input data deck must be set up to perform one and only one of the following primary program operations:

(1) Determination of trimmed flight condition only.
(2) Trim followed by maneuver without rotorcraft stability analysis.
(3) Trim followed by maneuver with rotorcraft stability analysis during maneuver.
(4) Trim followed by maneuver where maneuver time point data are stored for a subsequent restart of the maneuver.

(5) Manuever restart.
(6) Trim followed by rotorcraft stability analysis; no maneuver.
(7) Retrieval of maneuver data stored on tape.
(8) Sweeps of trim conditions with or without rotorcraft stability analysis.

These eight operations are shown in Figures 1 through 8 respectively. The implication of the statement "one and only one" above is that data decks that perform different primary operations must not be stacked; they must be submitted as separate runs. For example, suppose the user wants data on a particular configuration for: (1) a trim and a rotorcraft stability analysis at 100 knots, and (2) a maneuver which starts from a 120-knot trim condition. The two cases must be submitted separately. However, in the first case the user may set it up as a parameter sweep so that the 100-knot trim with rotorcraft stability analysis is followed by a trim at 120 knots. The data from the 120-knot trim can then be used as inputs to the second case to shorten the time required for the 120-knot trim prior to the maneuver. It is not possible to follow a parameter sweep case with a maneuver.

The AGAJ77 input deck is subdivided into input groups where each group contains a set of related data (e.g., rotor, fuselage, and wing parameters; program logic specification; and data tables). The complete list of all possible input groups in the order in which they must be input is presented in Table 1.

In most cases, the user will not need to use every group to define the configuration that is to be simulated. Hence, as a user convenience, the first two data cards of the first group of input data (the Program Logic Group) contain over 20 switches that specify the groups and/or arrays that must or must not be included in the data deck. This feature eliminates the necessity of including sets of blank cards or dummy inputs for groups which are not needed. During the reading of the data deck and initialization of input data, many checks are performed to assure that the specifications of the Program Logic Group and the groups that follow are compatible and complete. Obviously, the checking procedure cannot correct or diagnose every possible input error, and the user must exercise the normal amount of care in following the instructions of this input guide.

In Section 2.0, each card of input data is identified by a sequence number. Within an individual group the numbers are consecutive. However, the capability of adding and deleting entire groups from the deck precludes consecutive numbering between groups. Considering the large number of cards which can be included in a deck, it is strongly recommended that all cards be numbered according to the sequence numbers given in Section 2.0 and used in this section. Doing so will greatly simplify locating specific inputs and reconstructing a dropped or shuffled deck.

3.1.2 Group Identification Cards and Data Library

All of the AGAJ77 input groups are headed by a Group Identification (ID) Card. The use of this card is discussed in this section and is not repeated for each group with an ID card.

The primary purpose of the ID cards is to provide a means for using the Data Library Option discussed below. Hence, groups which cannot be called from the data library (i.e., deck identification cards and the maneuver time specification and data analysis cards) do not have ID cards. A secondary purpose of the ID cards is to provide a convenient means of identifying the start of a new group and including comments pertaining to individual groups in the deck.

The Data Library Option (and its MODEL Option subset) is included in the master version of AGAJ77. The local programmer should be consulted to see if the option is available with the installed version of the program; if it is not (or the option is not to be used), the first eight columns of each ID card must be blank, and the following discussion may be bypassed.

The data stored on the data library consist of two types:

(1) The input data for a specific input group of a particular rotorcraft (Group Data Sets)
(2) The set of input groups which constitute all the groups needed for a particular rotorcraft (Model Data Sets)

The number of cards in a Group Data Set is equal to the maximum number of cards which may be required for the appropriate input group. The number of cards in a Model Data Set is 43 where each card corresponds to a particular input group and one element of the MODEL array in the program. Setup and maintenance of the data library are generally assigned to a programmer. Consequently, the technical details relating the establishment of a data library are not presented in this volume.

Each Group and Model Data Set on the library is assigned a unique eight-character alphanumeric name. These names are then used to identify the data sets and as the data on the cards in a Model Data Set. The characters used in the name of a Group Data Set are arbitrary, but the first four characters in the name of any Model Data Set must be MODL.

Once data are stored on the library, IDEN on the ID cards may be used to call a data set from the library. When the first eight columns of an ID card are blank, it is assumed that the library is not to be used, and all cards for the appropriate input groups must follow the ID card. If these columns are not blank, they are assumed to contain the name of a data set which is on the library, and the program searches the library for the data set with the corresponding name. If the name is not found, a message to that effect is printed and execution of the program is terminated.

When the name is a group name (i.e., does not start with the four characters MODL) and is found, the corresponding data set is used as the input data for that group. In this case, all remaining cards for that group must be omitted from the card deck. The reading of each group ID card is completely independent of the reading of each other ID card. Hence, a card deck may contain any combination of groups called from library and groups input on cards which suits the user's purpose.

When a Model Data Set is to be used, the library name must be input on CARD 10 (the Program Logic Group ID Card). If the first four columns on CARD 10 contain the characters MODL, the program will search the data library for the Model Data Set with the corresponding eight-character name. If the name is not found, execution terminates. When the data set is found, the program then uses the library groups whose names are in the Model Data Set as the source of input data for all input groups. In this case, the cards for all groups included in the data set must be omitted from the card deck.

3.1.3 Procedures for Changing Input Data

Frequently, it is desirable or necessary to change the values of a few individual inputs in groups called from the library and/or to replace certain groups in a Model Data Set with other groups. Also, it is necessary to have a means of changing inputs when performing parameter sweeps. The &CHANGE and &GROUPS program features are provided to accomplish these tasks.

The cards that are used to exercise these features must conform to a special format:

(1) Column 1 of all cards must be blank.

(2) Columns 2 through 8 of the first card must contain the seven characters &CHANGE or &GROUPS, as appropriate.

(3) Column 9 of the first card must be blank.

(4) Change items (defined below) can start in or after Column 10 of the first card and in or after Column 2 of any subsequent card(s); items must be separated by commas, and not extend past Column 70.

(5) After the last character of the last change item there must be a comma or a blank column followed by the four characters &END.

3.1.3.1 Change Items for &CHANGE Cards

The change items for &CHANGE cards must be in one of two forms:

Symbolic Name = Constant

or

Array Name = Set of Constants (separated by commas)

The set of characters to be used for Symbolic Name is the array name and element number of the variable to be changed. Only those arrays and elements listed in Table 2 can be changed. Constant is the new value of the variable indicated. The set of characters for Array Name must be one of the array names included in Table 2. The Set of Constants is then the new values for the array. The number of constants in the set must be less than or equal to the dimension of the array as given in Table 2. In the Set of Constants the successive occurrences of the same constant can be represented by the form

k*constant

where k is a nonzero integer specifying the number of times the constant is to occur.

Blank columns are permitted before and after the equal sign in a change item and after the comma which separates change items. However, blank columns are not permitted within a name or a constant, and trailing blanks after an integer or exponent are treated as zeros.

Although a set of change items can be continued onto as many cards as needed, a single change item must not be split between cards and only the data on the first card of a continued set will be printed in the output data.

An example of the data for the &CHANGE operation is as follows:

```
                  Column 1
                      ↓
First Card:           b&CHANGEbXFS(1)=9500.0, XMR(44)=5.0,

Second Card:          bIPL(48)=0, TAIR=7*9999., &END
```

where b indicates a mandatory blank column; other blank columns shown are optional. This example will change gross weight to 9500 pounds, the main rotor longitudinal mast tilt angle to 5 degrees, the rotor aerodynamic option to steady state only, and the first seven times for blade element data printout to 9999.0 seconds.

It is not necessary that change items be in any specified order. For example, the first change item can be for XFS(10), the second for XFS(8), and the third for XFS(1), the fourth for IPL(45), etc.

As noted above, only the first card of a set of &CHANGE cards like the example is printed in the output data. To get data from both cards included in the printout, use the following form:

```
                  Column 1
                      ↓
First Card:           b&CHANGEbXFS(1)=9500., XMR(44)=5.0, &END
                      ↓
Second Card:          b&CHANGEbIPL(48)=0, TAIR=7*9999., &END
```

Like the continued card set, this form can also consist of as many cards as needed; each will be included in the printout. (NOTE: only one &CHANGE card can follow an NPART=10 card.)

3.1.3.2 Change Items for &GROUPS Cards

The change items for &GROUPS cards must be in the following form:

MODEL(xx) = 'yyyyyyyy'

The blanks on either side of the equal sign are optional. MODEL is an array in the program (dimensioned to 43); the data for the elements of this array are the Model Data Sets stored on library. The symbol xx must be the one- or two-digit element number of the group to be replaced (element numbers are defined in Table 1). The symbol yyyyyyyy is the eight-character name for the data library group which is to replace the xx element. The apostrophes at either end of the library name are mandatory.

An example of the data for the &GROUPS operation is as follows:

```
Column 1
   ↓
   b&GROUPSbMODEL(3)='CLCD0015', &END
```

This example will cause the second airfoil data table (MODEL array element number 3) to be replaced by the CLCD0015 data table.

To replace the entire xx element of a Model Data Set with a group which is not on library, leave the eight columns for the MODEL element name (yyyyyyyy) completely blank. The required location in the deck for the externally supplied group(s) is discussed in the next subsection. The rules for the form of the &GROUPS change items are the same as for the &CHANGE change items.

3.1.3.3 Location of &CHANGE and &GROUPS Cards

When &CHANGE cards are used to update individual data library groups, the set of cards is to be placed immediately after the Group ID card of the group being changed. When used to make changes for parameter sweeps, the cards are placed immediately after the sweep card (the second CARD 01, or NPART card, with NPART=10) which follows the last card of the Flight Constants Group (CARD 224).

The location of the &GROUPS and &CHANGE cards in a deck which uses the MODEL Option is shown in the sample deck listed in Figure 16. In the example, the first airfoil data table (element 2) is to be replaced by the CLCD0090 table from the library while the Iteration Logic Group (element 37) and the Blade Element Data Printout Times Group (element 43) are to be replaced with data included in the deck. The &CHANGE card shown updates the gross weight and the Stability Analysis Times Group.

The general rules for including the cards for groups with blank names in the &GROUPS card are:

(1) the order of input of the change items on the &GROUPS card is optional, but the added groups must be included in the deck in the same sequence as their MODEL array element number, and

(2) the ID card of the included group must not be included in the deck.

Although it is possible in some cases to change the values on the first two cards of the Program Logic Group (IPL(1-28), which specify the groups that must be in the deck), the procedure is complex, not recommended, and not discussed in this report. If a Model Data Set needs to be changed that drastically, the user should be entering data by individual groups, not MODEL Option.

3.2 IDENTIFICATION AND PROGRAM FLOW CONTROL GROUP

CARD 00 Message Card

The alphanumeric inputs on this card are printed six times on the first page of printed output. The comments are intended to describe the disposition of the input card deck and printed output.

CARD 01 NPART Card

This card includes the primary program control variable, NPART, and is referred to as the NPART card. Permissible values of NPART on this card are 1, 2, 4, 5, 7, and 8. The value of NPART specifies the type of operation to be performed.

- 1 = Trim only
- 2 = Trim followed by maneuver (maneuver not to be restarted)
- 4 = Trim followed by maneuver (maneuver to be re-started)
- 5 = Maneuver restart
- 7 = Trim followed by rotorcraft stability analysis
- 8 = Retrieve maneuver data from tape for analysis

Within a single computer run, only one of the above operations may be specified. That is, data decks must not be stacked together into a single run. A more complete explanation of each NPART value is given below.

NPART = 1 Compute a trimmed flight condition only. See Figure 1. The NPRINT and NVARA inputs are not used. Subject to the IPL values, a data set of CARDS 02 through and including 224 must follow. The only cards which may follow CARD 214 are NPART = 10 cards (and their associated &CHANGE cards), contour plot cards and time-history plot cards.

NPART = 2 Compute a trimmed flight condition followed by a maneuver. See Figures 2 and 3. Subject to the IPL values, a data set of CARDS 02 through 301 (the time card) plus at least one 311-type card (J-card) must follow. The maneuver start time on CARD 301 is set to zero regardless of the input value.

Cards which follow the last J-card specify the operation(s) to be performed on the maneuver data computed. The options are plotting, harmonic analysis, vector analysis, and storing the maneuver data on tape; they are activated by sets of 400-, 500-, 600-, and 700- series cards respectively. Since each operation is an option, the appropriate card set must be input to perform the desired operation; if a card set is omitted, the corresponding operation is omitted. The card sets may be input in any sequence desired. If none of these card sets is included, the last J-card is the final card of the deck.

NPRINT Specifies the frequency of printout of maneuver data. The program prints data showing initial conditions for the maneuver (maneuver time t = 0) and for every NPRINTth time point thereafter. A blank or zero input is reset to unity.

The NVARA input is not used.

NPART = 4 Same as NPART = 2, except that the maneuver data will be stored so that it can be recalled at a later date for a maneuver restart (NPART = 5). See Figure 4. The use of this option will require the assistance of the local programmer to set up the restart tape.

NPART = 5 This is a maneuver restart case following the initial NPART = 4 case. See Figure 5. The local programmer should be consulted for at least the first case of this type. The complete data set for a maneuver restart is given in Table 3.

All program and iteration logic specified in the initial NPART = 4 run remains unchanged except that the TSTAB and TAIR groups or at least their identification cards must be included, regardless of the value of IPL(23) on the initial run. No &CHANGE cards are permitted.

NPART = 7 Compute a trimmed flight condition followed by a stability analysis. See Figure 6. The cards required are the same as for NPART = 1. An NPART = 10 card may follow CARD 214. Note that if the time-variant rotor analysis is activated for either rotor, a rotorcraft stability analysis cannot be performed. A stability analysis should not be performed for hover. That flight condition should be simulated with some small, nonzero, airspeed (typically, 0.001 knot).

TABLE 3. MANEUVER RESTART CASE

CARD 00	Message Card
CARD 01	NPART Card: enter 5 in Column 2.
CARD 02, 03, 04	IPSN and Comments
CARD 250	Stability Times Group: if the TSTAB group is not called from the data library, CARDS 251 and 252 must also be included.
CARD 260	BEA Data Printout Times Group: if the TAIR group is not called from the data library, CARDS 261 and 262 must also be included.
CARD 301	Time Card: the start time is the time at which the maneuver is to be restarted; it must be greater than zero and less than the last time point of the maneuver being restarted. The time for restart need not be identically equal to a previous time point.
CARD 311, etc.	At least one maneuver command (J-card) is required. It may be followed by plot cards, etc., as with any maneuver.

NPART = 8 This value of NPART causes data stored on tape to be loaded on the plot disk. See Figure 7. The local programmer should be consulted prior to its use. The value of NVARA on this card must not be equal to zero. Once the data has been placed on the plot disk, 400-, 500-, and 600-series cards may be used for plotting, harmonic analysis, or vector analysis of the data. CARD 701 is used to store on tape the data which the NPART = 8 card retrieves.

Following a data set for trim only or trim-and-rotorcraft-stability analysis (NPART = 1 or 7), the parameter sweep option may be exercised by including an NPART = 10 card after CARD 224.

NPART = 10 This value of NPART permits the changing of user-selected inputs and retrimming the configuration. See Figure 8.

NVARA If NVARA = 0, the program will attempt only to iterate to a new trim condition (equivalent to NPART = 1); if NVARA ≠ 0, the program will attempt to trim and, if successful, will also perform a rotorcraft stability analysis (equivalent to NPART = 7).

The data set for NPART = 10 consists of the following cards:

First Card:	CARD 01	NPART card with NPART = 10
Subsequent card(s):	&CHANGE	Changes to input data using NAMELIST input as described below.

An NPART = 10 data set may be followed only by another NPART = 10 data set, contour plot cards or time-history plot cards.

The &CHANGE cards can be used to change the value of any input or inputs on CARDS 11 through 224 except for some of the program logic inputs, the rotor mode shapes, and the inputs to the airfoil data and rotor-induced velocity distribution tables.

Program logic inputs IPL(1-7) and IPL(9-24) must not be changed. These inputs control the initial reading of data groups or blocks, and NAMELIST input is not capable of reading additional groups or blocks.

If the switch for reading the rotor-induced velocity distribution table(s), IPL(12), is zero, it must not be changed. If it is not zero, it may be changed to any permissible value, i.e., 0, 1, 2, or 3. All other IPL values may be changed as desired.

When using NPART = 10 the changes made should be reasonable (e.g., less than 20 to 30 knots in airspeed, 10 to 20 feet per second in rate of climb, less than 3 to 5 degrees in aerodynamic surface incidence). The larger the number of simultaneous changes made, the smaller the individual changes should be. The program assumes the last trim point is a good starting point for the next trim case. If the changes are too large and XFC(5-12) and XFC(15-20) are not updated by the user, the chances of achieving a new trim are slim.

CARD 02 (Comment Card No. 1)

IPSN is a numeric title for the data set for identification purposes. It is printed in the output heading. The remainder of the card contains alphanumeric identifying comments which are printed in output headings as data set identification. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

CARD 03 (Comment Card No. 2)

This card also contains alphanumeric comments which are included in the output headings. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

CARD 04 (Comment Card No. 3)

The card also contains alphanumeric comments. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

3.3 PROGRAM LOGIC GROUP

CARD 10 is the identification (ID) card for the Program Logic Group. If the Data Library Option is available, the ID card may call one of several standard sets of program logic from the library, and CARDS 11-17 must then be omitted.

CARDS 11-17 contain the bulk of the program logic. All the IPL inputs are integers (14I5 format). The logic inputs control the data groups which must be included in the input data, the program options to be used (such as unsteady aerodynamics, time-variant rotor analysis, etc.), and the data to be output. The logic has been chosen so that for the simplest cases most inputs are zero. In general, nonzero inputs activate the options and/or necessitate inputs of additional data.

For the options related to the rotors, a 0-1-2-3 type logic switch is used wherever possible. This type of switch operates in the following manner:

0 turns the option off for both rotors;

1 turns the option on for the main rotor only;

2 turns the option on for the tail rotor only;

3 turns the option on for both rotors.

CARD 11 Input Group Control Logic

IPL(1) can be used to reduce the number of input data groups to only those normally required for a wind tunnel simulation. If IPL(1) = 0, the required number of groups is not affected by IPL(1). If IPL(1) $\neq$ 0, the data deck may include only the following groups:

- CARDS 00 through 17 (Identification and Program Logic)
- Data tables specified by IPL(2)
- Main Rotor Group
- Main Rotor Elastic Blade Data Group (if IPL(6)>0)
- Rotor Aerodynamic Group
- Main Rotor Induced Velocity Distribution Table (if IPL(11)>0)
- Rotor Controls Group
- Engine Group
- Iteration Logic Group
- Flight Constants Group
- Five Maneuver-Only Groups (i.e., Bobweight, Weapons, SCAS, STAB Times, and Blade Element Data Times Groups)

If NPART = 1 or 7, the five maneuver-only groups must be omitted; if NPART = 2 or 4, IPL(23) controls the reading of these five groups. IPL(1) $\neq$ 0 overrides the inputs for IPL(3) and (15-21).

IPL(2) specifies the total number of airfoil data tables included in the input deck. Permissible inputs are 0, 1, 2, 3, 4, or 5. Note that if a rotor aerodynamic subgroup specifies that it uses an airfoil data table, the corresponding table must be input and that reading a table does not necessarily mean that it will be used (see the Airfoil Data Table Group, Section 3.4, and the Rotor Aerodynamic Group, Section 3.9).

IPL(3) deletes the reading of specified rotor groups. It is a 0-1-2-3 type switch, e.g., 0 requires input of both rotor groups (none deleted) and 3 requires deletion of both groups. When a group is deleted, its ID card must also be deleted.

IPL(4) specifies the number of main rotor blade segments. If the value of IPL(4)>0, then the segments are of uniform length. No more than 20 blade segments can be used for the main rotor. If the analysis includes an elastic main rotor (IPL(6)>0), IPL(4) must be equal to the number of blade segments for which modal displacements are given. The default value for IPL(4) is 20 segments.

IPL(5) specifies the number of tail rotor blade segments. If the value of IPL(5)>0, then the segments are of uniform length. No more than 20 segments can be used for the tail rotor. If the analysis includes an elastic tail rotor (IPL(7)>0), IPL(5) must be equal to the number of blade segments for which modal displacements are given. The default value for IPL(5) is 3 segments in order to reduce computer run time.

For both IPL(4) and IPL(5) the minimum number of segments for a rotor without elastic inputs is 3. If at least one rotor mode shape is input, a one-segment blade may be represented. It is recommended, though that at least 5 segments be used. If fewer segments are to be used, set the hub extent to zero and the tip loss factor to 1.0 for that rotor.

IPL(6) and (7) control the reading of the elastic blade data sets for the main rotor and tail rotor respectively. If IPL(6) = 0, all main rotor elastic blade data (weight, inertia, and mode shape distributions on CARDS 40, 41, etc.) must be omitted from the input deck and the blade weight, inertia and first mass moment must be input. Similarly, if IPL(7) = 0, all tail rotor elastic blade data (CARDS 60, 61, etc.) must be omitted. For positive, nonzero inputs, the values of IPL(6) and IPL(7) specify the number of mode shapes which must be included in the Main and Tail Rotor Elastic Blade Data Groups, respectively.

Up to 11 blade modes may be input for each rotor with a total of 12 blade modes. Note that inputting blade mode shapes does not necessarily imply coupling between the blade dynamics and aerodynamics. The rotor may be elastic without being aeroelastic. See the description of IPL(49) and IPL(50). If elastic blade data are included, the blade weight and inertia inputs (XMR(11), XMR(12), and XMR(42)) in the corresponding rotor group(s) are ignored.

IPL(8) is currently unused.

IPL(9) controls the reading of the main rotor pylon mode shape cards (CARDS 3E through 3L). The absolute value of IPL(9) is the number of mode shapes, while its algebraic sign denotes whether or not the mode shapes were generated with the rotor mass on the mast (IPL(9)>0) or not (IPL(9)<0). If IPL(9) = 0, no main rotor pylon mode shape cards are read.

IPL(10) controls the reading of the tail rotor pylon mode shape cards in a manner identical to that of IPL(9).

IPL(11) specifies the total number of rotor airfoil aerodynamic subgroups included in the Rotor Aerodynamic Group. Permissible inputs are 0 to 5 inclusive. As long as the input data includes at least one rotor group, an input of 0 is reset to 1 and one subgroup must be input. If both rotors are deleted (IPL(3) = 3), IPL(11) may be input as zero to delete the reading of the Rotor Airfoil Aerodynamic Group in its entirety.

IPL(12) controls the reading and use of the Rotor-Induced Velocity Distribution (RIVD) tables that are described in Section 3.10. It is a 0-1-2-3 type switch. That is, if IPL(12) = 0, both the main rotor and tail rotor RIVD tables must be omitted; if IPL(12) = 1, the main rotor table must be input and tail rotor table omitted; if IPL(12) = 2, the tail rotor table must be input and the main rotor table omitted; if IPL(12) = 3, both tables must be input. If a table is not input for a particular rotor, an empirically derived equation is used to compute the distribution for that rotor. This default equation is given in Section 3.34.2.

IPL(13) specifies the number of RWAS (Rotor Wake at Aerodynamic Surfaces) tables which must be included in the deck. The permissible number of tables is 0 to 12 inclusive. Note that the tables are numbered sequentially on input, that these sequence numbers are later used to call specific tables, and that reading in a table does not necessarily mean it is used. The format for each table is given in Section 3.11, and their use is discussed in Section 3.14.1 for the wing and Section 3.15.2 for the stabilizing surfaces.

IPL(14) is a 0-1-2-3 switch that controls the reading of the blade harmonic shaker and harmonic control motion cards.

CARD 12

IPL(15) controls the reading of the basic and aerodynamic inputs to the Wing Group (CARDS 120-12A) and the Wing Control Linkages Subgroup (CARDS 12B and 12C). If IPL(15) = 0, both the Group and Linkages Subgroup must be omitted; if IPL(15)>0, both must be included. If IPL(15)<0, then CARDS 120-12A must be included and CARDS 12B and 12C must be omitted (i.e., the wing incidence and control surface deflection are independent of the flight controls).

IPL(16) controls the reading of the basic and aerodynamic inputs to the Stabilizing Surface Number 1 Group (CARDS 130→139) and the Stabilizing Surface Number 1 Control Linkage Subgroup (CARDS 13A and 13B). If IPL(16) = 0, the entire Stabilizing Surface Number 1 Group, including ID card and Linkage Subgroup, must be omitted. If IPL(16)>0, the Stabilizing Surface Number 1 Group and its Linkage Subgroup must be included. If IPL(16) <0, the Stabilizing Surface Number 1 Group is included, but the linkage subgroup must not be included (i.e., both the incidence angle and control surface deflection of Stabilizing Surface Number 1 are independent of the flight controls).

IPL(17), IPL(18), and IPL(19) control the reading of Stabilizing Surface Number 2, Stabilizing Surface Number 3, and Stabilizing Surface Number 4 Groups and their respective Linkage Subgroups as described for IPL(16).

IPL(20) controls the reading of the Jet Group. If IPL(20) = 0, the entire Jet Group including ID card must be omitted; otherwise it must be included.

IPL(21) controls the reading of the External Store/Aerodynamic Brake Group (CARDS 180-18C) and is equivalent to the number of store/brake subgroups which are to be included. If IPL(21) = 0, the entire group, including the identification card, must be omitted. If IPL(21)>0, the group must include the identification card and the specified number of subgroups; e.g., if IPL(21) = 3, the group must consist of 10 cards (one identification card plus three subgroups of three cards each).

IPL(22) controls reading of the Supplemental Rotor Control Subgroup (CARDS 195-198). If IPL(22) = 0, the subgroup must be omitted, otherwise it must be included.

IPL(23) controls the reading of the Bobweight, Weapons, SCAS, Stability Times, and Blade Element Printout Groups when NPART = 2 or 4. If IPL(23) = 0, all five groups must be omitted; if IPL(23) ≠ 0, all five must be included. If NPART does not equal 2 or 4, all the groups must be omitted. This input affects the reading of the last two groups when NPART = 5.

IPL(24) controls the reading of the Landing Gear Subgroups (Cards 110-11A). If IPL(24) = 0, then the entire Landing Gear Group, including ID card, must be omitted. If IPL(24)>0, then the Landing Gear ID card and exactly IPL(24) Landing Gear Subgroups must be included in the deck.

IPL(25) and IPL(26) are currently inactive.

IPL(27) controls the position of the rotor blades for side-by-side folding rotor configurations. It should be input as zero for all other rotor configurations. If IPL(27) = 0, both rotors are defined to be unfolded and turning at the rpm determined by XMR(13) and XFC(25) for Rotor 1 and XTR(13) and XFC(25) for Rotor 2. If IPL(27) ≠ 0, the rotors are defined to be stopped and folded; in this case, the data should be set up as if the rotors were unfolded and at normal RPM except that:

(1) IPL(27) ≠ 0.0

(2) Controls are locked by setting XCON(4), XCON(11), XCON(18), and XCON(25) ≠ 0.0

(3) Maneuver input cards for J = 18 and J = 27 have a time of 0.0, i.e., for J = 18, $\Omega_B > 0$

IPL(28) controls the cg shift with rotor folding. If IPL(28) = 0, no shift is computed; ≠ 0, cg shift is computed. This single switch applies to both rotors.

CARD 13

IPL(29)-IPL(42) are currently inactive.

CARD 14

IPL(43) defines the flight condition to be trimmed in conjunction with the specified g-level, XFC(12), and the input Euler roll angle, XFC(7), as described below.

IPL(43)	XFC(12)	Flight Condition
= 0	= 0.0	Unaccelerated flight
	≥ 1.0	Coordinated turn at g-level of XFC(12)
≠ 0	> 1.0	Zero-turn-rate pullup at g-level of XFC(12)
	< 1.0	Zero-turn-rate pushover at g-level of XFC(12)

In addition, the following applies to coordinated turns:

(1) Regardless of the TRIM procedure specified by IPL(44), the program will iterate on pitch and yaw.

(2) The "fixed" roll angle for each iteration is determined from the previous iteration by solving the following relationship for roll angle:

$$n*\cos\Phi = \cos\theta*\cos^2\Phi + (\cos\theta*\sin^2\Phi + \tan\beta*\sin\Phi*\sin\theta)/K$$

where

$K = 1 + (\tan\theta\tan\alpha)/\cos\Phi$

θ = Euler pitch angle

Φ = Euler roll angle

n = g level, XFC(12)

α = angle of attack

β = angle of sideslip

(3) The turn direction is selected by use of the sign on the input roll angle, XFC(7). A positive or zero value gives a right turn, a negative value a left turn.

IPL(44) controls the Euler angle held constant during the TRIM procedure. If IPL(44) = 0, the TRIM procedure holds the yaw angle constant. It is necessary to hold yaw constant for low speed or hover cases, since the force and moment derivatives with yaw angle all go to zero in hover. If IPL(44) $\neq$ 0, the TRIM procedure holds the Euler roll angle constant and iterates on pitch and yaw. This tends to give the most realistic TRIM conditions at high speeds, since a pilot has a more sensitive feeling for a roll angle than a yaw angle. Generally, the program trims more readily to a given yaw angle. If IPL(43), the TRIM type indicator, specifies a coordinated turn, the TRIM procedure iterates on pitch and yaw regardless of the value of IPL(44).

IPL(45) controls the computation of the partial derivative matrix during trim. Permissible values are 0, 1, 2, 3, 4, and 5. If IPL(45) = 0, the matrix is computed every fifth iteration, i.e., iterations 1, 6, 11, ... etc., and uses the most recently computed matrix for iterations in which the matrix is not computed. If IPL(45) $\neq$ 0, the matrix is computed every

IPL(45)th iteration. Computing the matrix for every iteration rather than for every fifth iteration will increase the run time for trim by a factor of approximately three. Computation at every iteration is normally necessary only when there is difficulty getting a case to trim with IPL(45) = 0. In all cases, odd number inputs for IPL(45) work better than even numbers.

IPL(46) controls the steady state aerodynamics used for the main rotor. If IPL(46) = 1, 2, 3, 4, or 5, the IPL(46)th Rotor Airfoil Aerodynamic (RAA) Subgroup is used to compute the main rotor aerodynamic coefficients at all blade stations (i.e., the blade has a constant airfoil section root to tip). If IPL(46) = 0, it is reset to 1. If IPL(46)<0, the main rotor blade airfoil distribution card, CARD 3V, is read and used to assign the RAA subgroups to Blade Stations Number 1 through IPL(4). CARD 3V must be omitted if IPL(46)≥0 and must be included if IPL(46)<0.

IPL(47) controls the steady state aerodynamics used for the tail rotor in the same manner as IPL(46) controls the main rotor aerodynamics. However, the sign of IPL(47) controls the reading of only the tail rotor airfoil distribution, CARD 5V, and has no effect on CARD 3V, just as IPL(46) has no effect on reading CARD 5V. Note that both IPL(46) and (47) must be less than or equal to IPL(10), the number of RAA subgroups.

IPL(48) controls which option is to be used for rotor unsteady aerodynamics. It is a 0-1-2-3 type switch with the added feature that positive values activate the UNSAN unsteady aerodynamic model for the specified rotor(s) while negative values activate the BUNS unsteady aerodynamic model. See Volume I for discussion of these two models. If IPL(48) = 0, unsteady aerodynamics are ignored in the rotor computations. If an option is activated, it is activated for all blade segments not included in the rotor hub. Even if activated, neither option will affect computation unless the time-variant rotor analysis discussed below is used.

The program includes the option for two basic types of rotor analyses where each type has two possible blade configurations:

Type I:	Quasi-static with (A) rigid blades or (B) aeroelastic blades
Type II:	Time-variant with (A) rigid blades or (B) aeroelastic blades

First harmonic participation factors are computed for each mode during quasi-static trim, but they are not printed out.

IPL(49) specifies the rotor(s) for which the time-variant rotor analysis can be used and operates as a 0-1-2-3 type switch. If IPL(49) = 0 the time-variant analysis (Types IIA and IIB) cannot be used in any part of the program and the value of IPL(50) will be ignored. In this case, both rotors will use the quasi-static analysis (Type IA or IB) for both trim and maneuver. Type IA will be used when no elastic blade data are input (IPL(6) or (7) = 0) and Type IB will be used for a rotor if the blade data are input. If IPL(49) = 1 or 2, the Type II analysis will be used for the specified rotor and Type I will be used for the other rotor. If IPL(49) = 3, the Type II analysis will be used for both rotors. As with IPL(49) = 0, the choice between Type IA and IB and between Type IIA and IIB depends on the availability of elastic blade data. Note that if IPL(49) $\neq$ 0, the rotorcraft stability analysis cannot be performed. That is, NPART must not equal 7, and either the TSTAB group must be omitted or the TSTAB(1) input must be greater than the duration of the maneuver. The TSTAB group is discussed in Section 3.24; also see IPL(23).

If IPL(49) $\neq$ 0, then IPL(50) controls the portion of the program in which the time-variant analysis is to be used for the rotor(s) specified by IPL(49). Table 4 shows the type of rotor analysis used for each rotor as a function of the values of IPL(49) and (50). The azimuth increment to be used in the time-variant portion of a trim is input on CARD 201, XIT(2). See Section 3.19. The azimuth increment for the quasi-static portion of a trim is fixed at 30 degrees. The azimuth (or time) increment used in maneuver is input on CARD 301, TCI(2). See Section 3.26.

The time-variant portion of a quasi-static trim followed by a time-variant trim (a QS-TV trim; IPL(50) = 0) is in essence a time history of XIT(6) rotor revolutions with the fuselage and control positions locked. For each rotor which is time-variant, the additional run time for the time-variant trim after the quasi-static trim will be about the same as the time for a maneuver of XIT(6) rotor revolutions.

For a fully time-variant trim (IPL(50) = 2), each trim iteration will require about 3 to 6 times the run time of an equivalent quasi-static iteration depending on azimuth increment and whether one or both rotors are time-variant. Additional run time must be allocated accordingly for a fully time-variant trim. However, it cannot be predetermined whether a fully time-variant trim will require more or fewer iterations than a corresponding quasi-static trim.

TABLE 4. ROTOR ANALYSIS USED DURING TRIM AND MANEUVER

Inputs		Rotor	Analysis Used	
IPL(49)	IPL(50)		In Trim	In Maneuver
0	(Ignored)	1 (Main)	QS	QS
		2 (Tail)	QS	QS
1	0	1	QS-TV	TV
		2	QS	QS
	1	1	QS	TV
		2	QS	QS
	2	1	TV	TV
		2	QS	QS
2	0	1	QS	QS
		2	QS-TV	TV
	1	1	QS	QS
		2	QS	QS
	2	1	QS	QS
		2	TV	TV
3	0	1	QS-TV	TV
		2	QS-TV	TV
	1	1	QS	TV
		2	QS	TV
	2	1	TV	TV
		2	TV	TV

QS = Quasi-static rotor analysis

TV = Time-variant rotor analysis

QS-TV = Quasi-static trim followed by a time-variant trim. During the time-variant portion of this type trim, only the flapping, pylon, and mast windup angles of the time-variant rotor are allowed to vary; the fuselage and control positions are held fixed at the values determined by the quasi-static trim. If both rotors are time-variant, they are trimmed independently of each other.

IPL(51) and IPL(52) control the moment balancing procedures used for the main and tail rotor respectively during each individual trim iteration. Although virtually identical in operation, the two inputs are completely independent of each other. If IPL(51) and IPL(52) = 0, the fully coupled 10 x 10 system of trim equations is used for each trim iteration. For the quasi-static rotor analysis (IPL(49) = 0) this means that the longitudinal and lateral flapping moments of each rotor are computed only once during a single trim iteration using the current values of cyclic pitch and flapping angles. That is, the rotor moments as calculated are used, and no attempt is made to reduce any moment imbalance during a trim iteration. For the time-variant rotor analysis, IPL(51) and IPL(52) must both be zero. IPL(51) = IPL(52) = 0 is considered to be the standard procedure for iterating to a trimmed flight condition regardless of the rotor analysis being used.

If the quasi-static rotor analysis is being used, nonzero values of IPL(51) and IPL(52) can be used to decouple sets of rotor flapping moment equations from the standard 10 x 10 system and to activate one of two alternate procedures for reducing the flapping moment imbalances in the uncoupled set(s) of rotor equations. The systems of equations to be used in each trim iteration are given in Table 5.

TABLE 5. SYSTEMS OF EQUATIONS USED IN TRIM

IPL(51)	IPL(52)	Systems of Equations
= 0	= 0	One 10 x 10 system (both rotors and airframe)
≠ 0	= 0	One 2 x 2 system (main rotor) One 8 x 8 system (tail rotor and airframe)
= 0	≠ 0	One 2 x 2 system (tail rotor) One 8 x 8 system (main rotor and airframe)
≠ 0	≠ 0	Two 2 x 2 systems (one for each rotor) One 6 x 6 system (airframe)

NOTE: The user cannot decouple the rotor analysis if the fully time-variant trim (IPL(49) = 1, IPL(50) = 2, for example) is being used.

When IPL(51) or IPL(52) is not equal to zero, the sign of the input determines which of the moment balancing procedures is to be used. If the input is greater than zero, flapping angles are locked and cyclic pitch angles are changed to trim the appropriate set(s) of decoupled rotor equations. If the input is less than zero, the cyclic pitch angles are locked and the flapping angles are changed to trim the appropriate set(s) of decoupled rotor equations. The magnitude of the input specifies the maximum number of subiterations (rotor iterations within the trim iteration) that are permitted to trim the appropriate rotor. A system of decoupled rotor equations is defined to be trimmed when the magnitude of the moment imbalance is less than the allowable error (XIT(20) for the main rotor, XIT(21) for the tail rotor). Note that IPL(51) and (52) control only rotor moment balancing procedures. The allowable errors for the force and moment summary, XIT(15) through XIT(19), do not affect rotor moment balancing during a single trim iteration.

IPL(53) is a 0-1-2-3 switch which activates the calculation of blade element accelerations for the designated rotor or rotors.

IPL(54) is currently inactive.

IPL(55) controls the use of the Wagner function for the time delay of lift buildup on the wing (See Section 5-7 of Reference 2).

= 0 function is inactive

= 1 function active only for the first value of the time increment on CARD 301

= 2 function active only for the second value of the time increment on CARD 301

IPL(56) controls the fuselage degrees of freedom in maneuvers. If IPL(56) = 0, the fuselage has the conventional six degrees of freedom. If IPL(56) ≠ 0, all fuselage degrees of freedom are suppressed (locked out) during maneuvers. Although this input is independent of all other logic inputs, it is normally used only for wind tunnel simulations, e.g., IPL(1), IPL(51), or IPL(52) ≠ 0.

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[2] Bisplinghoff, Raymond L., Ashley, Holt, and Halfman, Robert L., AEROELASTICITY, Addison-Wesley Publishing Company, Reading Massachusetts, 1955, pp. 281-293.

CARD 15

IPL(57) through IPL(70) are currently inactive.

CARD 16

IPL(71) controls the formal printout of input data which normally precedes the start of the first TRIM iteration. Increased values of IPL(71) progressively suppress more and more data as indicated below:

Value of IPL(71)	Printout Suppressed
= 0	None
≥ 1	All data tables (airfoil, elastic blade, RIVD, and RWAS tables)
≥ 2	All group ID cards (except Program Logic Group) and all input groups (printout of &CHANGE Cards is not suppressed)
≥ 3	Problem heading and identifying comments (from CARDS 02, 03, and 04) when NPART = 10; &CHANGE Card(s) and input data for maneuvers in all cases

Printout of the problem heading, identifying comments, and Program Logic Group ID cannot be suppressed on the first cases in a run because these data are printed before the IPL group is read in. The data deck listing printout at the start of each run is never suppressed. Note that in the second and subsequent cases in a parameter sweep (i.e., when NPART = 10), printout of all data tables is automatically suppressed. To print out the tables in these cases, IPL(71) must be reset to zero in the &CHANGE card of each case for which the print is desired.

IPL(72) controls the printout of the trim iteration data as follows:

IPL(72) = 0	Rotor data and force and moment summary from last iteration only. Last partial derivative matrix computed.
≥ 1	Iteration heading (with QS or TV notation); Time-variant heading and dependent participation factor for time variant iteration; force and moment summary for each iteration and partial derivative matrix when calculated.

If

IPL(72) $\geq$ 2 — Rotor data, Force and Moment Summaries, and Dependent Participation Factors (if applicable) during Partial Derivative Matrix calculations during TRIM. Rotor data and Force and Moment Summaries during the calculation of the Control Power Partial Derivative Matrices during STAB. Rotor and pylon moments and angles and rotor balance parameters (if applicable) during TRIM, STAB and MANEUVER.

In addition, if

IPL(72) $\geq$ 3 — Harmonic response for modes 2 through 11 are printed out.

IPL(73) controls the printout of the optional trim page. It is a 0-1-2-3 type switch; e.g., 0 omits the optional page for both rotors and 3 prints one of the optional trim pages for each rotor.

IPL(74) is currently inactive.

IPL(75) controls printout of blade element aerodynamic (BEA) data for the main rotor as follows:

IPL(75) = 0 or 1 — No BEA data are printed

$\geq$ 2 — BEA data are printed along with bending moment data at the maneuver time points specified in the Blade Element Data Printout Group. (See Section 3.25). If no maneuver is computed, IPL(75) $\leq$ 2 has no effect.

$\geq$ 3 — BEA data are printed after a QS trim and along with bending moment data at the maneuver time points specified in the Blade Element Data Printout Group.

<u>WARNING</u>: IPL(75) should <u>never</u> be set larger than 3 for a normal run. IPL(75) inputs of 4, 5 and 6 are intended only for very detailed diagnostic checks by the programmer; these values will generate <u>huge</u> stacks of output containing data which is not needed for normal runs. For reference only, the effects of values of 4, 5, and 6 are as follows:

IPL(75) $\geq$ 4	BEA data are printed after QS trim and at <u>every</u> time point in a maneuver <u>regardless</u> of the value of NPRINT on CARD 01 and the values in the Blade Element Data Printout Group.
$\geq$ 5	The virtual work and its components for each mode shape of each blade of each rotor are printed at each iteration in trim and at every time point in maneuver.
$\geq$ 6	BEA data are also printed for each rotor revolution in trim. The output generated by this value of IPL(75) is extremely voluminous.

<u>NOTE</u>: Blade-element aerodynamics data will not be printed if the main rotor is time-variant (IPL(50) = 1 or 3). The contour plot option should be used to print out aerodynamic quantities for a time-variant main rotor.

IPL(76) controls printout of blade element aerodynamic (BEA) data for the tail rotor as described for the main rotor in the description of IPL(75). These diagnostics will not be printed for the tail rotor if it is time-variant (IPL(50) = 2 or 3). Use the contour plot option to print out tail rotor aerodynamics in this case.

IPL(77) and IPL(78) are used to select the blade station at which the beamwise, chordwise, and torsional moments are calculated at each time point in a time-variant maneuver, for the main and tail rotors, respectively. There are up to 20 blade stations numbered sequentially from 0 at the hub (zero radius) to 19 at the next-to-last station. (The moment at 100-percent radius is always zero.)

IPL(79) controls the storing of certain rotor variables for tabulation and contour plots. See Section 3.35 (1000-series cards) for a listing of the data stored and instructions for printing the data. Data are stored for each rotor during trim and maneuver according to the following table (no data are stored during stability analysis):

IPL(79)	TRIM	MANEUVER
0	None	None
1	Main rotor only	Main rotor only
2	Tail rotor only	None
3	Both rotors	Main rotor only

In trim the source of the stored data is a function of the type of trim procedure (rotor analysis) that is active for the appropriate rotor:

TRIM TYPE	DATA SOURCE
QS	Extra QS rotor revolution computed after normal QS trim
QS-TV	Extra QS rotor revolution computed after QS trim and last revolution of TV trim
FTV	Last (third) revolution of the baseline calculation of each trim iteration

QS = Quasi-static; TV = Time-variant; QS-TV = QS followed by TV; FTV = Fully TV

In maneuver the source of the stored data is also a function of the type of rotor analysis:

ROTOR ANALYSIS	DATA SOURCE
QS	Rotor revolution computed at each value of TAIR
TV	Rotor revolution that starts at each value of TAIR

For QS rotor analysis, the data stored are for the single, representative blade used in that analysis. For TV analysis, the data stored are for Blade 1 of the rotor. IPL(79) may be used to store data for any case where NPART = 1, 2, 4, 5, 7, or 10. Note that in parameter sweeps, the value of IPL(79) can be changed at the start of each case in the sweep, and that the 1000-series cards must follow the last case in the sweep. If data are to be stored during maneuver, remember to set IPL(23) $\neq$ 0 and to include the five maneuver input groups so that the TAIR inputs can be made. When data are to be stored during maneuver and the TV rotor analysis is active, consecutive values of TAIR should be more than one rotor revolution apart. If a TAIR input specifies that data are to be stored, but one revolution has not been completed, the input will be ignored.

IPL(81) through IPL(83) are currently inactive.

IPL(84) controls the printout of the modal participation factors during Time-variant Trim. If IPL(84) = 0, the participation factors are printed out regardless of the value of IPL(72). If IPL(84) ≠ 0, the participation factors are not printed.

CARD 17

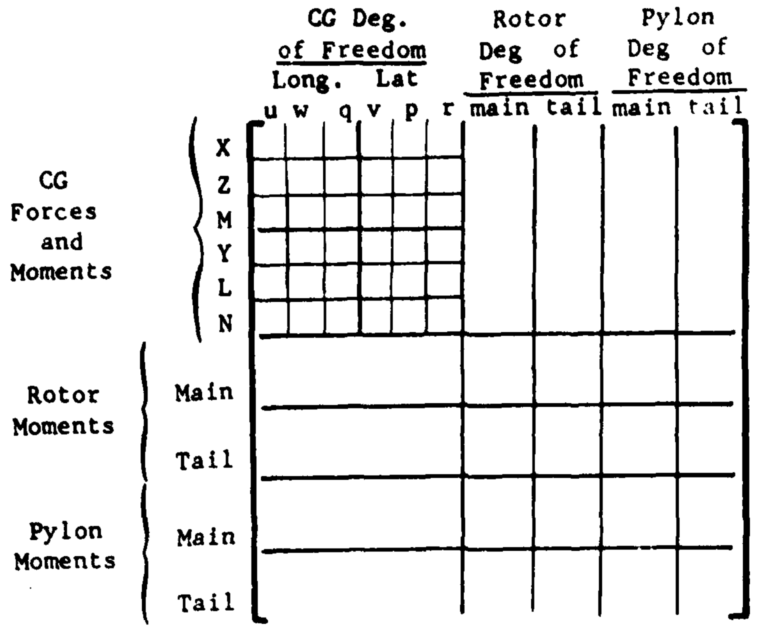
IPL(85), (86), (87), and (88) provide the user with control over the coupling in the rotorcraft stability analysis subroutine, STAB. Some graphical examples of the effect of IPL(85), (86), and (87) on the matrix used in STAB are shown in Figure 19. These three switches are completely independent of each other. IPL(85) controls the coupling between the three longitudinal fuselage equations and the three lateral fuselage equations. If IPL(85) = 0, the fuselage is represented by two 3 x 3 matrices. If IPL(85) ≠ 0, the fuselage is represented by a 6 x 6 matrix.

IPL(86) controls the rotor dynamic pylon degrees of freedom in STAB. It is a 0-1-2-3 type switch. If IPL(86) = 3, the pylon degrees of freedom for both rotors are included explicitly. If IPL(86) is zero, the pylon degrees of freedom do not appear in the rotorcraft stability analysis. IPL(86) must be compatible with the pylon data read in by IPL(9) and IPL(10). As a safeguard, the program resets IPL(86) to zero if IPL(9), IPL(10), and IPL(86) are incompatible.

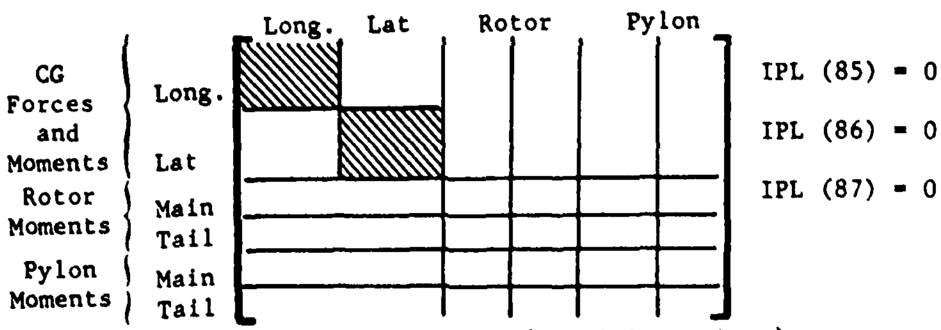
IPL(87) controls the rotor flapping degrees of freedom in STAB. It is a 0-1-2-3 type switch. If IPL(87) = 3, the rotor flapping equations appear explicitly in the rotorcraft stability analysis. In this case all partial derivatives are made without changing the flapping angles. If IPL(87) = 0, the rotor effects enter the rotorcraft stability analysis by adjusting the flapping angles to a new stabilized position for each partial derivative. See Figure 20 for logic flow on the STAB partial derivatives.

If the flapping degrees of freedom are excluded by IPL(87), these degrees of freedom can be included in the stability derivatives by changing the flapping angles to rebalance the rotors. If IPL(88) = 0, the rotor(s) will be rebalanced; if IPL(88) ≠ 0, no rebalancing takes place. This option is intended to be used for diagnostic purposes, not to represent a real rotorcraft.

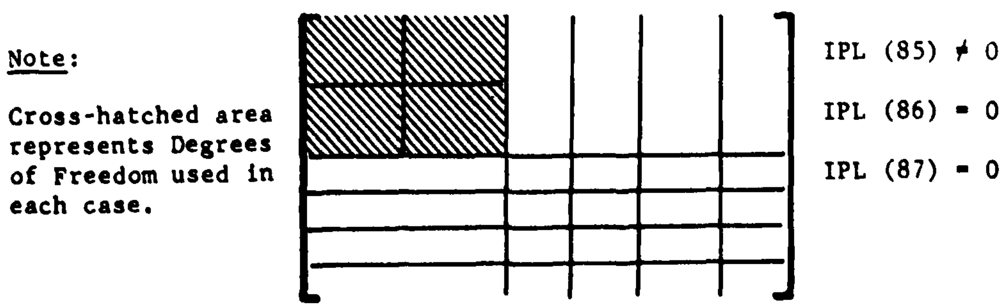
IPL(89) controls the option to print or punch on cards the mass, damping, and stiffness matrices used in the rotorcraft stability analysis. The punch option is useful when the user plans to input these matrices to another computer program.



(a) Basic Stability Analysis Matrix

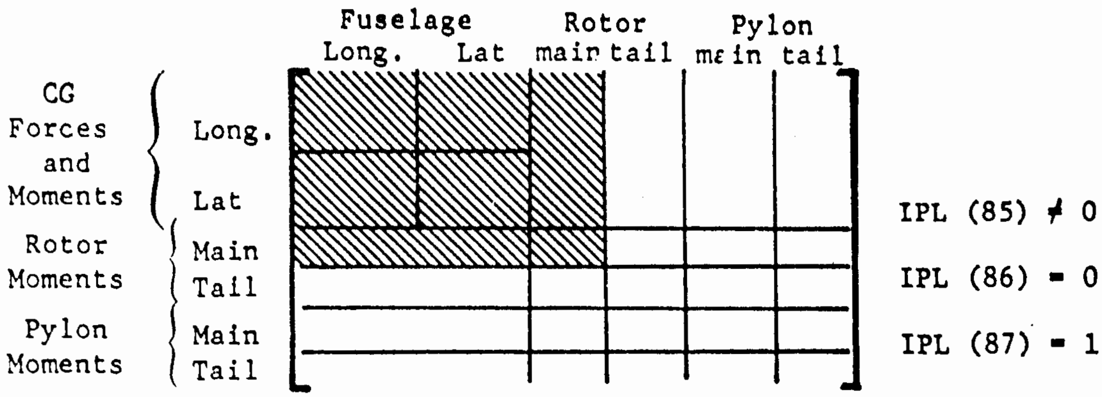


(b) Uncoupled Fuselage (Two 3x3 Matrices)

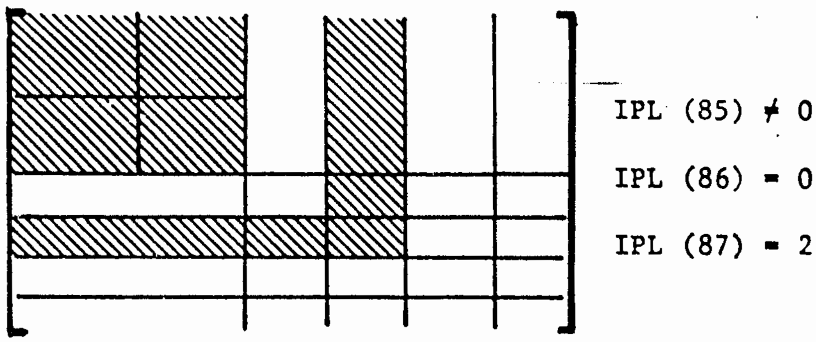


(c) Coupled Fuselage (One 6x6 Matrix)

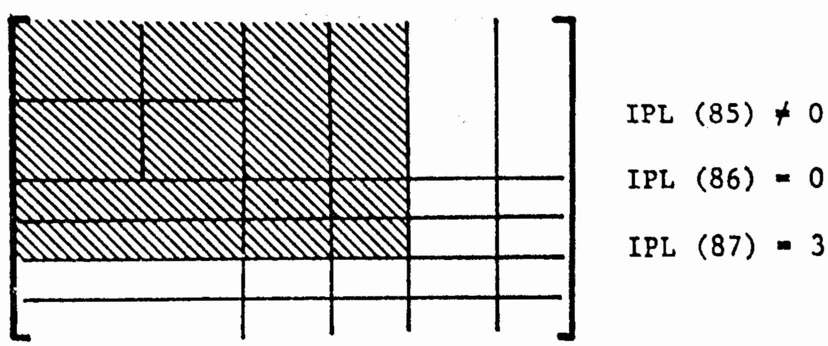
Figure 19. Schematic of Matrices Used in the Rotorcraft Stability Analysis.



(d) Coupled Fuselage - Main Rotor

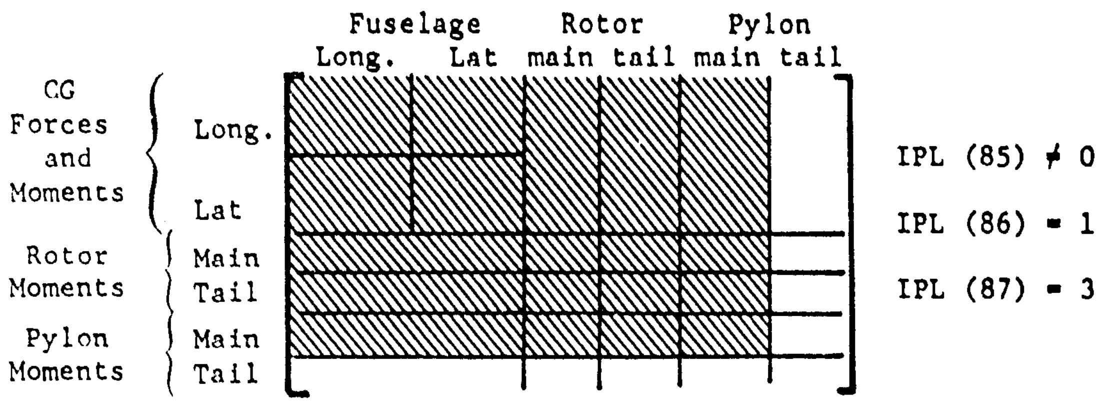


(e) Coupled Fuselage - Tail Rotor

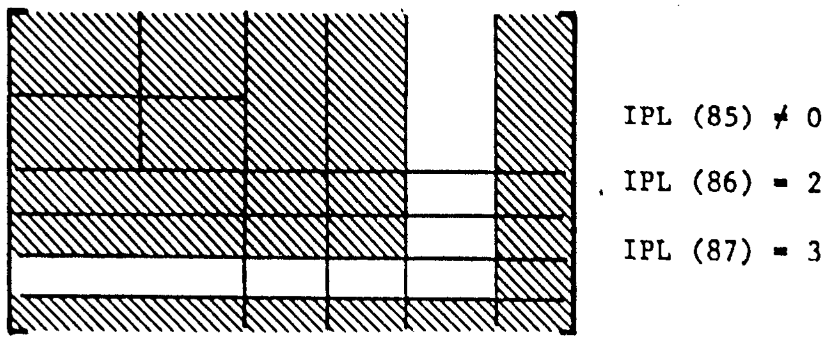


(f) Coupled Fuselage - Both Rotors

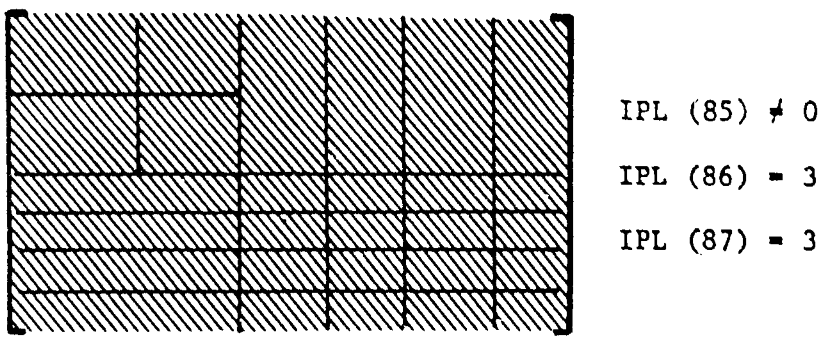
Figure 19. Continued.



(g) Coupled Fuselage - Both Rotors - Main Pylon



(h) Coupled Fuselage - Both Rotors - Tail Pylon



(i) Coupled Fuselage - Both Rotors - Both Pylons

Figure 19. Concluded.

IPL(89) = 0 to print only
1 to punch only
2 to print and punch
3 to suppress print and punch

The form of the punched output is explained in Section 4.11.4.

IPL(90) should always be zero. It is intended for diagnostic use by the programmer only and is discussed in detail in Volume III.

IPL(92) controls the printout of the Thrust-Induced Velocity History in STAB when the rotor or pylon degrees of freedom are activated. See Figure 20. IPL(92) = 0 suppresses the printout.

Table 6 gives the value of IPL(93) required to print the numerators of the transfer functions computed by STAB.

TABLE 6. VALUES OF IPL(93) TO PRINT THE NUMERATORS OF THE TRANSFER FUNCTIONS.

Denominator of Transfer Function	Numerator of Transfer Function							
	u	w	θ	v	Φ	ψ	M/R Flapping Long.	M/R Flapping Lat
Collective	2	1	1	3	3	3	4,-1	4,-1
Long. Cyc	2	1	0,-1	3	3	3	4,-1	4,-1
Lat Cyc	3	3	3	2	0,-1	1	4,-1	4,-1
Pedal	3	3	3	2	1	0,-1	4,-1	4,-1

The printing of the force and moment summary during the perturbation calculations in STAB can be suppressed by setting IPL(94) to a nonzero value.

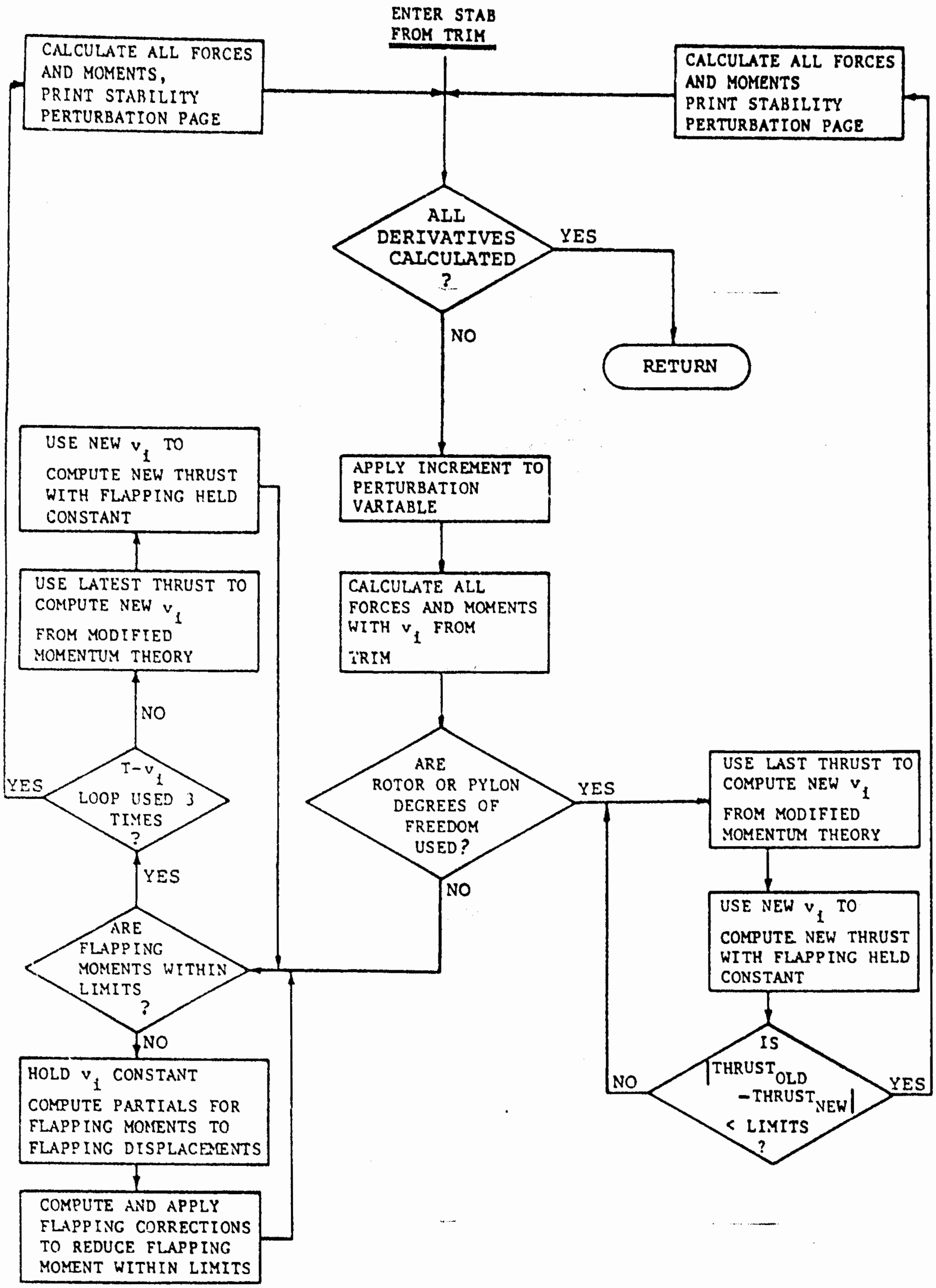


Figure 20. Logic Flow for STAB Partial Derivatives.

3.4 AIRFOIL DATA TABLE GROUP

The Airfoil Data Table Group does not have a group identification card of its own; i.e., no CARD 20. Rather, each data table included in the group has its own identification card.

3.4.1 Airfoil Data Table Sets

The number of airfoil data table sets to be included is specified by IPL(2). IPL(2) may equal 0, 1, 2, 3, 4, or 5. A set of tables for an NACA 0012 airfoil section is compiled within the program and stored in the space allocated for the fifth table. If IPL(2) specifies that five tables are to be read in, the fifth external table will overlay the internal 0012 data.

This internal 0012 table may be used any time four or less airfoil data tables are read in, i.e., IPL(2) = 0, 1, 2, 3, or 4. The 0012 table (if not overlaid) or any table that is input can be assigned to any one of the five rotor airfoil aerodynamic subgroups or to the five aerodynamic surfaces by use of the 18th aerodynamic input, e.g., YRR(18,J), J = 1, 2, 3, 4, or 5, YWG(18), YSTB1(18). Note, however, that data tables for the rotor must be airfoil section (two-dimensional) data, while tables for the aerodynamic surfaces must be surface (three-dimensional) data. See Sections 3.9.2 and 3.14.2 for further details on assigning data tables to the rotor and aerodynamic surfaces respectively.

The contents of each data table set are the same:

(1) Identification Card
(2) Title and Control Card
(3) Lift Coefficient Table (at least 3 cards)
(4) Drag Coefficient Table (at least 3 cards)
(5) Pitching Moment Coefficient Table (at least 3 cards)

The specific format for the first two cards of each set is identical, while the general format for each of the three tables in any set is the same. Note that angle of attack is the only parameter which ever appears in the first seven-column field on any card in any table.

The Mach number entries in each table must start at zero and be in increasing order of magnitude. Note that if the computed Mach number exceeds the highest Mach number in the table, the table lookup routine extrapolates the data to the computed Mach number.

The card set for the first angle of attack in each table must be for -180 degrees and the last for +180 degrees. Each card set for an angle of attack starts on a new card. In between the card sets for these two angles, the card sets for other angles must be in increasing value of angle of attack. It is not necessary to have uniform increments between values of angle of attack or Mach number in a table or to have the same angles or Mach numbers in each table. It is assumed that the angle of attack entries in all airfoil data tables are the angles of attack of the chordline of the airfoil section or surface. This assumption should be remembered when developing the inputs for the control system rigging of cambered surfaces.

The minimum value for each of the six integer inputs on the control card (NXL through NZM) is 2. The maximum values of these inputs are defined by the maximum permissible number of entries in a table, i.e.,

Lift Table:	NXL*NZL + NXL + NZL $\leq$ 500
Drag Table:	NXD*NZD + NXD + NZD $\leq$ 1100
Pitching Moment Table:	NXM*NZM + NXM + NZM $\leq$ 575

For example, if the lift table is to have 10 Mach number entries (NZL = 10), then the number of angles of attack must be less than or equal to 44 (44 * 10 + 44 + 10 = 494). The minimum size table (2 by 2) is frequently used to enter a dummy pitching moment coefficient table (C_M = 0 at all Mach numbers). Such a table would require NXM = 2 and NZM = 2 on the Title and Control Card plus the following three cards for the table:

First Card:

Col	8-14	0.0 (lowest Mach number)
	15-21	1.5 (or any Mach number greater than the expected maximum)

Second Card:

Col	1-7	-180 (minimum angle of attack)
	8-14	0.0 (C_M at α = -180°, M = 0)
	15-21	0.0 (C_M at α = -180°, M = 1.5)

Third Card:

Col	1-7	180.0 (maximum angle of attack)
	8-14	0.0 (C_M at α = 180°, M = 0)
	15-21	0.0 (C_M at α = 180°, M = 1.5)

3.5 MAIN ROTOR GROUP

This entire group must be omitted if IPL(3) = 1 or 3. This rotor always rotates counterclockwise when viewed from above, i.e., the standard direction of rotation for main rotors of American-made helicopters.

CARD 31

The number of blades, XMR(1), must be in the range from 2 to 7 inclusive. The geometric and physical properties of each blade and its attachment to the rotor hub are assumed to be identical to those of all other blades.

The rotor undersling, XMR(2), may be a nonzero quantity only for a teetering or gimbaled rotor. It is the vertical distance between the flapping axis and the pitch-change axis at a radius of XMR(53) feet. It is positive if the pitch-change axis is below the flapping axis. See Section 3.5.1 for additional details.

If the offset of the airfoil aerodynamic reference center from the pitch-change axis is constant, this single value may be input as XMR(3). In this case, the reference offset distribution on CARDS 3K, 3L, and 3M must be omitted. If XMR(3) >100., the distribution must be input. The offset distance is positive for the reference center in front of the blade reference line.

The rotor radius, XMR(4), is measured from the centerline of rotor rotation to the blade tip.

If the chord is constant over the blade radius, this single value may be entered as XMR(5), and the chord distribution on CARDS 3N, 3O, and 3P must be omitted. If XMR(5) = 0, the chord distribution must be input.

If the blade twist is linear and less than 100 degrees from root to tip, the total twist may be input as XMR(6), and the program will compute the distribution. In this case, CARDS 3Q, 3R, and 3S must be omitted. If XMR(6)>100, these twist distribution cards must be included. Positive twist is in the direction of positive blade pitch. The normal rotor blade with washout will have negative twist.

The flapping stop location, XMR(7), is the maximum amount the hub can flap without hitting the flapping stop spring. The normal input is positive. See also XMR(17), CARD 33.

CARD 32

The location of the shaft pivot point as specified by XMR(8), (9), and (10) is primarily intended for use with tilt-rotor configurations. These inputs, in conjunction with the mast tilt angles and length (XMR(44), (45), and (46) on CARD 37) are used to determine the stationline, buttline, and waterline of the rotor hub, the point at which the summation of the rotor forces acts. For other than tilt-rotor aircraft, the shaft pivot point is normally located at the rotor hub, and the mast length, XMR(46), is set to 0.0.

Blade weight and inertia (XMR(11) and XMR(12), respectively) are only mandatory inputs when IPL(6) = 0 (i.e., when the main rotor elastic blade data set is not input). As used here the word blade includes the appropriate portion of the rotor hub as well as the blade itself for a teetering or gimbaled rotor. Blade weight is then the weight of a single blade/hub combination in pounds for a teetering or gimballed rotor. Blade inertia is the inertia of a single blade/hub combination about the line which passes through the blade feathering axis and the shaft. For an articulated rotor, XMR(11) and XMR(12) represent the mass and inertia of that portion of the rotor outboard of the flapping hinge, with the inertia calculated about the flapping axis. If the main rotor elastic blade data set is input (IPL(6) $\neq$ 0), the blade weight and inertia are internally computed from the blade weight distribution in the elastic blade data set, XMW(1) through XMW(21), and the values of XMR(11) and XMR(12) are ignored. All XMR(1) blades are assumed to be identical.

XMR(14), the pitch-lag coupling ratio, is positive for a nose-up angle with aft (positive) blade motion. (This input is used in conjunction with the lag angle input for each rotor mode shape.) The lag angle for the Ith mode is the product of XGMS(8,I) times the modal participation factor for that mode. The sum is taken for all the modes and multiplied by XMR(14) to get the change in blade pitch. Note that this input is not effective unless the rotor elastic data are input.

CARD 33

XMR(16), the hub-type indicator, is zero for a gimbaled or teetering rotor and nonzero for a hingeless or articulated rotor. The distinguishing characteristic of a gimbaled or teetering rotor is that the response of any blade depends on the loading on all of the blades because of the moments transmitted across the rotor hub. On a rigid or articulated rotor, each blade acts independently with the difference between these two being in the mode shape characteristics.

The flapping stop spring rate, XMR(17), is used in the dynamic model of the flapping stops. When flapping exceeds XMR(7), a restoring moment proportional to the displacement relative to the stop is applied.

The flapping spring rate per blade, XMR(18), generates a restoring moment whenever there is any flapping. See the description of the nonlinear flapping spring, on CARD 37, for further explanation.

In the explanation of XMR(17) and XMR(18), flapping is defined as the slope of the blade at the hub including displacements from all modes, but not including precone.

The reduced rotor frequency, XMR(19), is used only when the UNSAN unsteady aerodynamic option is activated for the rotor. Otherwise, the input is ignored. If the input is less than or equal to zero, it is reset to unity (1-per-rev). See the discussion of UNSAN in Volume I to aid in determining this input.

The lead-lag damper, XMR(20), is used in conjunction with the lag angle input with the rotor mode shapes. The operation is similar to XMR(14) above except that the damper uses the modal velocities rather than the displacements.

If a blade segment is completely inboard of the hub extent, XMR(21), the segment produces no lift or pitching moment and has a drag coefficient of XMR(25) based on the planform area of the segment. If a blade segment is partially or completely outboard of the hub extent, the airfoil aerodynamics specified by IPL(46) on CARD 14 are used for the segment. If $|IPL(4)|$ is less than 5, set XMR(21) = 0.0.

CARD 34

The location of the pitch-change axis, XMR(23), is the distance from the quarter (25 percent) chord of the blade to the blade feathering axis in units of chord lengths. Positive XMR(23) is toward the trailing edge of the blade. For example, if the pitch-change axis is 30-percent chord aft of the leading edge, XMR(23) should equal 0.05 (5 percent aft of the 25-percent chord line). Similarly, if the axis is at 17-percent chord, XMR(23) should equal -0.08 (8 percent forward of 25-percent chord line). A value of 0.0 (equivalent to 25-percent chord) is the normal input. This input is only used when one of the unsteady aerodynamic options is activated (i.e., IPL(48) $\neq$ 0). Also, see Section 3.5.1.

The positive pitch-flap coupling angle, XMR(24), acts to reduce blade pitch with positive flapping. The tangent of the angle should be considered as having units of degrees of blade pitch change per degree of blade flapping. Also, see Section 3.5.1.

The drag coefficient for the hub, XMR(25), is discussed with hub extent on CARD 33.

The lead-lag spring rate, XMR(26), operates in conjunction with the lag angle input with the rotor mode shapes. It causes an inplane restoring moment in a manner exactly analogous to the operation of XMR(14) above.

If a Rotor-Induced Velocity Distribution Table is not input, the coefficient for tip vortex effect, XMR(27), can be used to modify the induced velocity distribution on the outboard 30 percent of the rotor blade to simulate the effect of shed tip vortices. The simulation gives improved airload calculations in the low-speed range by modeling the rotor as a wing with tip vortices and modifying the radial induced velocity distribution in the vicinity of the advancing and retreating blade tips (see Section 3.10.3). However, power and other performance values are not affected significantly. Rotor bending moments computed by another version of this program showed improved correlation with test data when a value of 10 was used for this coefficient. If the input is zero, the effect is removed.

CARD 35

The tip sweep angle, XMR(29), is the sweepback angle of the leading edge of the most outboard segment of the blade; it is also discussed in Section 3.9.2 as X(29).

The value of XMR(30) gives the tip-loss factor. If XMR(30) = 0, the tip-loss factor is computed internally (see Section 3.4 in Volume I). If IPL(4) is less than 5, set XMR(30) = 1.0.

If XMR(30) ≠ 0, then the lift is zero over that portion of the blade outboard of XMR(30)*XMR(4).

See Section 3.5.1 for a discussion of XMR(31) and XMR(32).

The shaft axis component of the rotor average induced velocity is multiplied by XMR(33) and applied at the fuselage center of pressure, in the direction parallel to the rotor shaft, and is used in the calculation of the fuselage angle of attack.

XMR(35) is the main rotor pitch-cone coupling ratio and is equal to the degrees of collective pitch for 1 degree of coning. The input is ignored if any main rotor mode shapes are input (i.e., IPL(6) $\neq$ 0).

CARD 36

The intended use of the rotor nacelle inputs on this card is to simulate changes in aerodynamic forces and in the cg location of a tilt-rotor aircraft during conversion. Each rotor has its own nacelle, although for a tilt-rotor aircraft all nacelle inputs are normally identical except that the buttline of the aerodynamics centers, XMR(38) and XTR(38), are opposite in sign. For configurations other than tilt-rotor aircraft, the nacelle weight should be set to zero. However, even with zero nacelle weight, the nacelle drag inputs can still be used to simulate such effects as drag of a fairing around the mast, additional hub drag, etc.

Rotor nacelle weight, XMR(36), is the total weight of the nacelle, dynamic pylon, rotor hub, blades, etc., which contribute to a shift of the aircraft cg with longitudinal mast tilt angle. If the longitudinal mast tilt angle is to remain constant at the input value of XMR(44) during the run, and the aircraft cg input on CARD 101 is the aircraft cg for the input mast tilt angles of both rotors, then nacelle weight should be input as zero. Otherwise, a shift from the cg input on CARD 101 will be calculated as explained below.

Nacelle cg inputs, XMR(37-39), are intended to locate the cg of the moveable weight (pylon, rotor, etc.) for zero degrees longitudinal mast tilt and XMR(45) degrees lateral mast tilt. Since only the longitudinal tilt angle is variable during a maneuver and longitudinal tilt is in the body X-Z plane, only shifts in cg stationline and waterline are calculated. The shifts of cg station, ΔSTA, and waterline, ΔWL, due to longitudinal mast tilt angle, β_m, are given by the following equations:

$$\Delta STA = Z\sin\beta_m + X(1 - \cos\beta_m)$$

$$\Delta WL = Z(1 - \cos\beta_m) - X\sin\beta_m$$

where

X = [XMR(36)/XFS(1)]*[XMR(8) - XMR(37)]

Z = [XMR(36)/XFS(1)]*[XMR(10) - XMR(39)]

The rotor nacelle differential flat plate drag area, XMR(40), is defined as the increase in the total flat plate drag of the aircraft (without rotors and at zero angles of attack and sideslip) as the longitudinal mast tilt angle is changed from 90 degrees (horizontal) to 0 degrees (vertical). Note that the main rotor and tail rotor nacelle are modeled separately; hence, this differential flat plate drag area is for one nacelle only. From XMR(40), the nacelle drag area, D_N, is computed by the following equation:

$$D_N = XMR(40)*\cos^3(\alpha_N)$$

where α_N is the angle between the free-stream velocity vector and its projection on the plane perpendicular to the rotor mast. This drag is then applied at the nacelle aerodynamic center which is assumed to be on the centerline of the mast at a distance XMR(41) feet from the mast pivot point. The direction for positive XMR(41) is defined as up the mast when the mast is vertical.

XMR(42) is the first mass-moment of the rotor about the flapping axis. If XMR(42) is input as zero for a quasi-static rotor, then the first mass moment is computed from the equation

$$\text{First Mass Moment} = \sqrt{XMR(11) * XMR(12)/32.19}$$

CARD 37

The control phasing, XMR(43), is defined in Figure 22, in Section 3.5.1.

The longitudinal and lateral mast tilt angles, XMR(44) and XMR(45) respectively, are both zero for a mast which is vertical, i.e., parallel to the body Z-axis. For nonzero mast angles, the angles are treated as ordered rotations where the longitudinal mast tilt angle is the first rotation (positive forward) and the lateral tilt mast angle is the second rotation (positive right). The mast length XMR(46) is the distance from the mast pivot point (XMR(8), (9), and (10) on CARD 32) to the rotor hub. The direction for positive XMR(46) is defined as up the mast when the mast is vertical. The mast length may be zero if the location of the hub is given by XMR(8), (9), and (10).

The nonlinear flapping spring is engaged whenever the absolute value of the hub flapping angle, β_H, is greater than XMR(47). The order of the nonlinearity, r, is XMR(49) and need not be integer. The nonlinear spring rate, XMR(48), is based on this nonlinear order.

The equation for the flapping spring moment, M_B, is

$$M_B = XMR(18) * \beta_H, \qquad |\beta_H| \leq XMR(47)$$

$$M_B = M_o + \beta_H\left(XMR(18) + XMR(48) * \beta_H^{\;XMR(49)-1}\right), \qquad |\beta_H| > XMR(47)$$

where

$$M_o = -XMR(48) * XMR(47) ** XMR(49)$$

CARD 38

XMR(50) is the break frequency of the filter used for the maneuver autopilot and for induced velocity calculations. The magnitude and time-lag functions for the filter are

$$|H(if)| = \frac{1}{\sqrt{1 + \left(\frac{f}{f_u}\right)^6}}$$

$$T_d(f) = \frac{\sum_{m=0}^{2} \dfrac{\left(\frac{f}{f_u}\right)^{2m}}{\sin\{(2m+1)\frac{\pi}{6}\}}}{f_u \; 2\pi\left(1 + \left(\frac{f}{f_u}\right)^6\right)}$$

where

f = signal frequency, Hz

f_u = upper break frequency of filter, XMR(50)

It is suggested that the user try XMR(50) equal to main rotor 1-per-rev, in Hertz. In that case, the magnitude and time lags are

Steady State: $|H(0)| = 1.0$

$$T_d(0) = \frac{0.31831}{f_u} \text{ seconds}$$

1-per-rev: $|H(if_u)| = 0.7071$

$$T_d(f_u) = \frac{0.3979}{f_u} \text{ seconds}$$

2-per-rev: $|H(2if_u)| = 0.12403$

$$T_d(2f_u) = \frac{0.0930}{f_u}$$

If the user wishes to chose a value of XMR(50) other than 1-per-rev, higher harmonic attenuation must be traded for steady state time lag.

XMR(51), XMR(52), XMR(53), and XMR(54) are used in conjunction with XMR(2) and XMR(22) to define the pitch-change axis geometry, as shown in Figure 21. All quantities shown on the figure are positive.

XMR (55) and (56) are used to compute the increment to the pitch link load due to a feathering bearing with a non-zero torsional spring rate (such as an elastomeric bearing). The incremental pitch link load is

$$\Delta PLL = -(\theta_{grip} - XMR(56))* \frac{XMR(55)}{XMR(31)}$$

The geometric pitch angle, θ_{grip}, is the angle at the radius specified by XMR(32), so XMR(56), the pitch angle at which there is no pitching moment due to the feathering bearing, should be referenced to that radius also.

CARDS 39, 3A, and 3B (include these cards only if IPL(4) < 0)

The radii to the outboard end of the blade segments are input on these cards if the segments are of unequal lengths. All three cards must be input regardless of the number of segments.

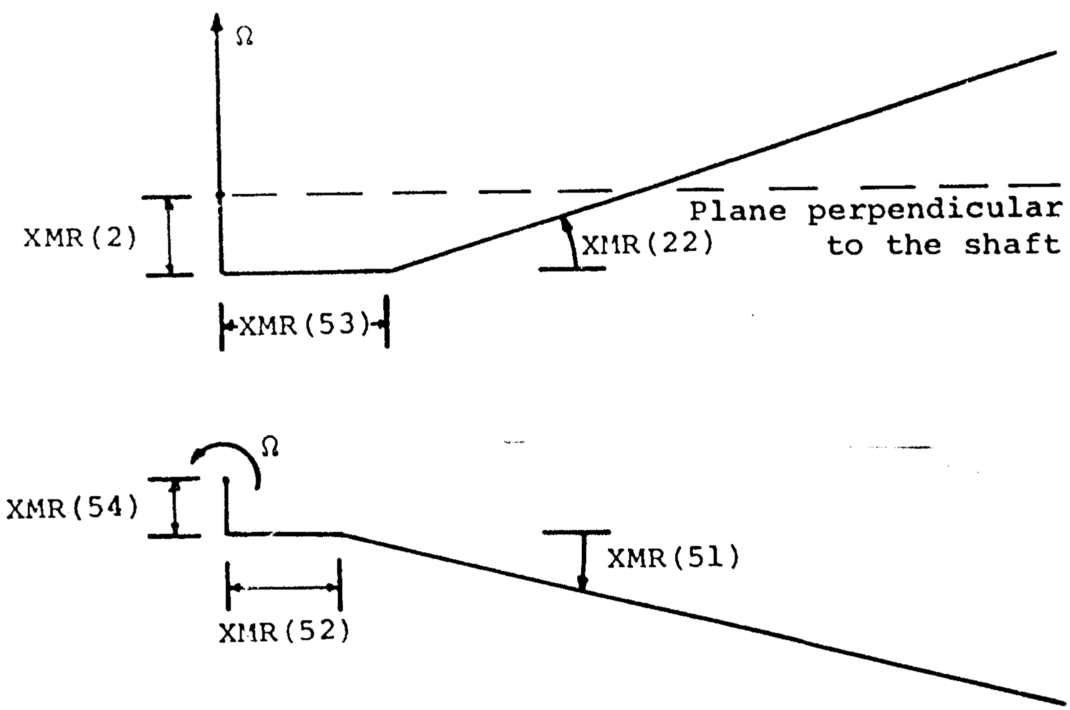


Figure 21. Definition of Pitch-Change-Axis Offset Inputs.

CARD 3C (Include this card only if IPL(9) ≠ 0)

The modal pylon inputs used in C81 can be generated by NASTRAN, or by some similar program, with or without the rotor mass included in the airframe eigenvalue solution. If the rotor mass was included in the NASTRAN model, it must have been represented as a point mass. All of the |IPL(9)| main rotor pylon modes must have been generated in the same manner, i.e., they all must have the effects of rotor mass, or none of them should. C81 properly accounts for the inclusion of the rotor mass (see Section 3.3 of Volume I).

The generalized inertia, XMP(1), natural frequency, XMP(2), and modal damping ratio, XMP(3), are all readily found as results of the airframe frequency analysis.

The swashplate coupling angle inputs, XMP(4), XMP(5), and XMP(6), are all multiplied by the pylon modal participation factor to give the swashplate coupling; i.e., when the participation factor is 1.0, the longitudinal cyclic coupling angle is XMP(4) radians.

CARD 3D (Include this card only if IPL(9) ≠ 0.0)

The pylon mode shape displacement components are to be input in <u>body reference coordinates</u>, not <u>shaft reference coordinates</u>. This is only important if the rotor mast is tilted with respect to the body reference system.

XMP(8) and XMP(9) are the longitudinal and lateral linear displacements at the top of the mast. XMP(10) is the airframe vertical linear displacement at the top of the mast.

XMP(11) and XMP(12) are the body-reference pitch and roll angles of the top of the mast, i.e., they are the body-reference-system longitudinal and lateral angular displacements of the top of the mast. XMP(13) is the body-reference Z-axis torsional windup of the mast and pylon. Due to the generality of the mode shape inputs, one of the modes can represent the mast windup response, but the θ_x and θ_y components, XMP(11) and XMP(12), will be nonzero for this mode if there is any mast tilt.

CARDS 3E, 3F

Include these cards only if |IPL(9)| ≥2. The description for this pylon mode is identical to that of the first pylon mode, CARDS 3D and 3E, with XMP(15) through XMP(28) replacing XMP(1) through XMP(14).

CARDS 3G, 3H

Include these cards only if $|IPL(9)| \geq 3$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 3D and 3E, with XMP(29) through XMP(42) replacing XMP(1) through XMP(14).

CARDS 3I, 3J

Include these cards only if $|IPL(9)| = 4$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 3D and 3E, with XMP(43) through XMP(52) replacing XMP(1) through XMP(14).

CARDS 3K, 3L, 3M

These three cards may be used to input a nonuniform chordwise offset of the airfoil aerodynamic reference centers from the pitch-change axis. The airfoil aerodynamic reference center is the point about which the aerodynamic forces and moments are resolved for the equations or for the table being used for that segment. These cards must be omitted if $XMR(3) < 100$ and must be included if $XMR(3) \geq 100$. The subscript of each entry in the XMACF array corresponds to the blade station number of the entry (e.g., XMACF(15) is at Blade Station No. 15).

CARDS 3N, 3O, 3P

These three cards may be used to input a nonuniform chord distribution for the blade. The cards must be omitted if $XMR(5) \neq 0$ and must be included if $XMR(5) = 0$. The subscript of each entry in the XMC array corresponds to the blade station number of the entry; e.g., XMC(6) is the chord at Blade Station No. 6. The chord at Blade Station No. 0 is not input; it is assumed to be equal to the chord at Blade Station No. 1. The distribution must be root to tip.

CARDS 3Q, 3R, 3S

These three cards may be used to input a nonuniform twist distribution for the blade. The cards must be omitted if XMR(6) < 100. The subscript of each entry in the XMT array corresponds to the blade station number of the entry; e.g., XMT(11) is the twist at Blade Station No. 11. The twist angle at Blade Station No. 0 is not input; it is defined to be zero and the twist distribution is then the set of angles of the chord line at the appropriate blade station with respect to the root collective pitch angle. Positive twist, like positive collective pitch, is defined as leading edge up. The distribution must be root to tip.

CARD 3T

This card must be read if IPL(14) = 1 or 3. The inputs on this card control an harmonic blade shaker located at blade station XMDI(4). The shaker applies a force to the blade along a line of action passing through the axis of computation and tilted XMDI(5) degrees back from the beamwise direction, positive up (for XMDI(5) = 0) if XMDI(1) is positive. The equation for the force depends on the value of XMDI(6);

XMDI(6) = 1.0, collective mode excitation

$$F = XMDI(1) * \cos(XMDI(2)*\Omega*t + XMDI(3))$$

where Ω is the main rotor rotational speed.

XMDI(6) = -1.0, cyclic mode excitation

$$F = XMDI(1) * \cos(XMDI(2)*\Omega*t + XMDI(3) + \Delta\Psi_i)$$

where $\Delta\psi_i = \psi_i - \psi_1$ (azimuth of i^{th} blade - azimuth of blade 1).

XMDI(6) = 0.0, scissor mode excitation

$$F = XMDI(1) * \cos(XMDI(2)*\Omega*t + XMDI(3) + \frac{XMR(1)}{1} \Delta\Psi)$$

The force is applied to XMR(1) - XMDI(7) blades.

CARD 3U

This card must be read if IPL(14) = 1 or 3. The inputs on this card control an harmonic control shaker which applies additional harmonics to the swashplate. For XMDI(12) = 1.0, a collective control motion results,

$$\Delta\theta = XMDI(8) * \cos(XMDI(9)*\Omega*t + XMDI(10))$$

This control motion is applied to XMR(1) - XMDI(13) blades.

For XMDI(12) = 0.0, the harmonic excitation will have the same effect as moving the cyclic stick in a circular motion, giving a change in root geometric pitch for the i^{th} blade, $\Delta\theta_i$, of

$$\Delta\theta_i = XMDI(8) * \cos(XMDI(9)*\Omega*t + XMDI(10) - \Psi_i)$$

For XMDI(12) = -1.0, the harmonic excitation will be equivalent to rocking the swashplate about a nonrotating axis which is XMDI(11) degrees from due aft, measured in the direction in which the rotor is turning. In this case, the change in geometric pitch for the i^{th} blade is

$$\Delta\theta_i = XMDI(8) * \cos(XMDI(9)*\Omega*t + XMDI(10)) * F$$

where

$$F = \sin(XMDI(11))*\cos(\psi_i) + \cos(XMDI(11))*\sin(\psi_i).$$

CARD 3V

The inputs on this card, XMDI(15) through XMDI(21), may be used in the same manner as the inputs on CARD 3U, XMDI(8) through XMDI(14). If the second control shaker is not needed in the analysis, set XMDI(15) = 0.0.

CARD 3W

The inputs on this card, XMDI(22) through XMDI(28), may be used in the same manner as the inputs on CARD 3U, XMDI(8) through XMDI(14). If the third control shaker is not needed in the analysis, set XMDI(22) = 0.0.

CARD 3X

This card may be used to input a nonuniform airfoil section distribution for the blade. The card must be omitted if IPL(46) $\geq$ 0 and must be included if IPL(46) < 0. The format for the IDTABM array is 20I1 starting in column 1. These integer inputs correspond to the sequence number of the Rotor Airfoil Aerodynamic (RAA) Subgroup which is to be used at the specified blade station. The subscript of each entry in the IDTABM array specifies the blade station number of the entry. For example, if IDTABM(13) = 4, RAA Subgroup No. 4 is used at Blade Station No. 13. Each value of IDTABM must be less than or equal to IPL(46), the total number of RAA subgroups input. The airfoil section at Blade Station No. 0, the blade theoretical root, is not input; it is assumed to be part of the hub and capable of producing only drag based on the hub drag coefficient, XMR(25).

3.5.1 Rotor Hub and Control System Geometry

A top and side view of the geometry of the main rotor hub and control system, including the sign conventions for the XMR inputs that define this geometry, are given in Figure 22. The sketch may also be used for the second (or tail) rotor by interpreting it as a view from the bottom of the rotor disk rather than the top. Note that the sketch depicts a leading-edge pitch horn. However, the sign conventions are not a function of the type of pitch horn; hence, to define a trailing-edge pitch horn, simply input a negative length for l_p. See Section 8.1 in Volume I for additional details.

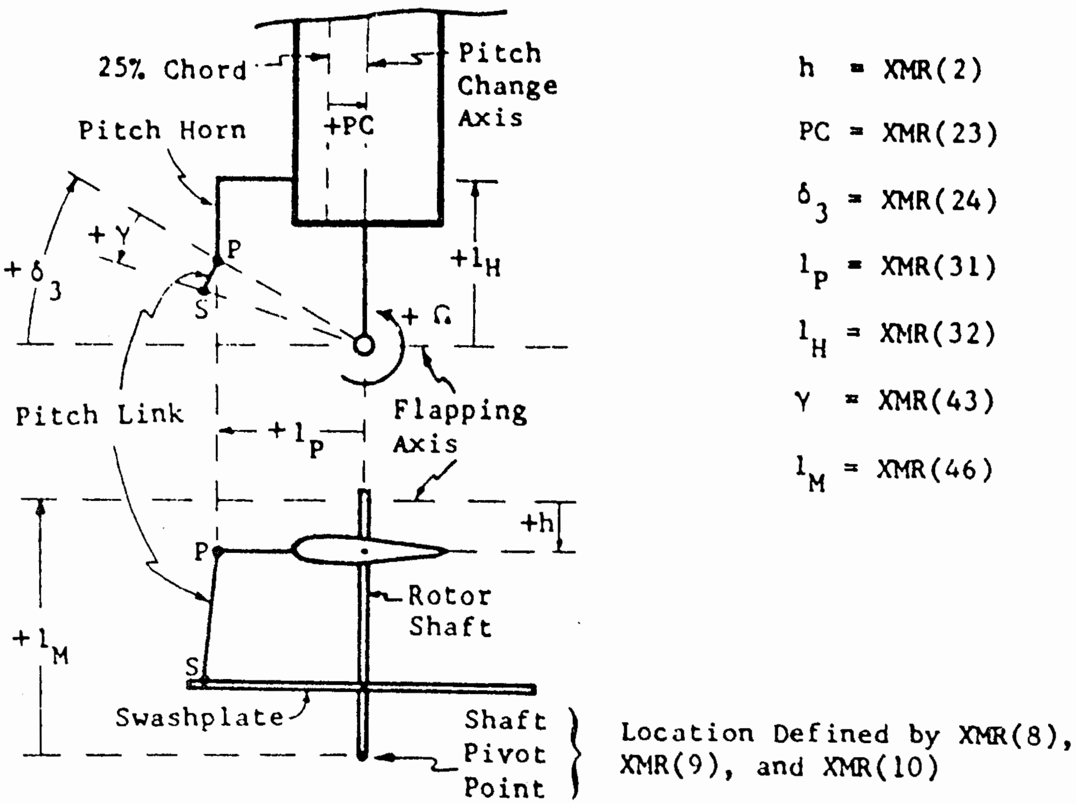


Figure 22. Definition of Pitch-Horn, Hub and Swashplate Geometry Inputs.

Point P is the pitch-link attachment point on the pitch horn. Point S is the pitch-link attachment point on the swashplate. The distance from Point P to Point S is the length of the pitch link.

The lengths l_p and l_H are used to compute pitch-link loads in the following manner. The torsional moment at l_H inches from the hub is divided by l_p, the moment arm of the pitch-link attachment point. (The torsional moment inboard of l_H is set to zero.) The resulting force, or pitch-link load (in pounds), is printed in the 0-percent radius (root) location on the torsional loads page.

3.6 MAIN ROTOR ELASTIC BLADE DATA GROUP

If IPL(6) = 0, this entire group must be omitted. The group consists of six distributions of rotor blade parameters; weight, beamwise mass moment of inertia, chordwise mass moment of inertia, beamwise center of gravity offset, chordwise center of gravity offset and the mode shapes. The first five distributions are input in three card sets, and all three cards are input for each of these sets regardless of the number of main rotor blade segments, |IPL(4)|. All six distributions are given from root to tip, and the segments in these distributions correspond to the segments used in the Main Rotor Group. Therefore, if unequal segment length was used, the segments in the Main Rotor Elastic Blade Data Group must have the same lengths as those described in the XMBS array. All blades of the rotor are assumed to have identical properties.

CARD 40

The first card of the data set is the identification card. If the data library option is available, the ID card can call a data set from the library and the remaining cards must be omitted. If the data library is not used, the ID card must be followed by the six distributions.

CARDS 41/A1, 41/A2, 41/A3

The blade weight distribution inputs, XMW(1) - XMW(20), are defined to be the average values in pounds per inch across each of the blade segments. If less than 20 segments are used, then XMW(|IPL(4)| +1) through XMW(20) should be input as 0.0. The tip weight, XMW(21), is concentrated at the tip of the blade (r/R = 1.0).

CARDS 41/B1, 41/B2, 41/B3, 41/C1, 41/C2, 41/C3

The beamwise mass moments of inertia, XMW(22) - XMW(41), are about the chordline of the airfoil section, while the chordwise mass moments of inertia, XMW(43) - XMW(62), are about a line perpendicular to the chordline and located at the quarter chord of the segment. Normally, the chordwise inertias are much larger than the corresponding beamwise inertias. The units for both are in.-lb-sec^2/in. If less than 20 segments are used, then XMW(|IPL(4)| +22) through XMW(41) and XMW(|IPL(4)| +43) through XMW(62) should be input as 0.0. XMW(42) and XMW(63) are the mass moments of inertia of the tip weight about the cg of the tip weight.

CARDS 41/D1, 41/D2, 41/D3, 41/E1, 41/E2, 41/E3

The average beamwise center-of-gravity offset, XMW(64) - XMW(84), and the average chordwise center-of-gravity offset, XMW(85) - XMW(105), are measured from the pitch change axis in the local beam-chord reference system. If less than 20 segments are used, then XMW(|IPL(4)| +64) through XMW(84) and XMW(|IPL(4)| +85) through XMW(104) should be input as 0.0. XMW(84) and XMW(105) are the center-of-gravity offsets of the tip weight, XMW(21).

CARD SETS 42/A1, 43/A1, ..., 4C/A1

These cards contain the coupled blade mode shapes. Exactly IPL(6) sets of mode shape data must be input, and IPL(6) + IPL(7) must be less than or equal to 12. Each mode shape (card set) consists of |IPL(4)| +5 cards. The first three cards contain 14 constants for that mode shape, six fields per card. The next |IPL(4)| +1 cards contain the modal displacement and bending moment coefficients at the blade stations. (Station 0 is the blade root while Station |IPL(4)| is the tip.) The last card contains information describing the change in the natural frequency of the mode with changes in RPM or root collective. If this last card is blank, the natural frequency remains constant at the value input on the first card of the set. As used here, pitch angle refers to the pitch angle at zero radius (this is the reference point for all blade pitch angles in C81). The set of data for Mode 1 (CARDS 42/A1 through 42/C1) is detailed in Section 2.6.6.1. The sets of data for additional modes use the same input sequence and format as Mode 1, so only the inputs for Mode 1 will be described here.

If the mode shapes were generated by Program DNAM05 (see Section 7.0), all the inputs to AGAJ77 were punched in the proper format.

CARD 42/A1

The mode type indicator, XGMS(1,1), is used for gimbaled or teetering rotors to characterize the moment transfer across the rotor hub. See Volume I for a discussion of the four mode types.

Input Value	Mode Type
-2	Independent
-1	Cyclic
[illegible]	Scissor
[illegible]	Collective

An independent mode responds to all forcing frequencies. The independent mode type is intended to be used for torsional modes primarily. For an articulated or rigid rotor, XMR(16)≠0, the mode type indicator is not used, and any value may be input without effect.

The natural frequency, XGMS(2,1), is input as the ratio of the modal natural frequency to the rotor rotational frequency, i.e., XGMS(2,1) equals the natural frequency in cycles per minute divided by the RPM, XGMS(9,1).

The generalized inertia, XGMS(3,1), is the inertia for the modal equation for this mode, and is computed as part of the mode shape calculations.

The modal damping ratio, XGMS(4,1), is the ratio of the damping to the critical damping. Good data for this input are difficult to find, but the range is generally accepted to be around 0.005 to 0.02, except for modes which have a large amount of torsional response. In this case, the control system damping, which is also difficult to determine, should be included in XGMS(4,1). The control system damping is already included in the value punched by DNAM05. A value between 0.05 and 0.10 has been found to give good results.

The inplane and out-of-plane hub shear coefficients, XGMS (5,1) and XGMS(6,1), when multiplied by the modal participation factor, give the shears at the center of rotation in the shaft reference coordinate system.

CARD 42/A2

The pitch-link load coefficient, XGMS(7,1) gives the pitch-link load when multiplied by the modal participation factor.

The lag angle, XGMS(8,1), is the angle about the actual inplane hinge when the modal participation factor is 1.0. This input is valid only for an articulated rotor.

The reference RPM and reference root collective, XGMS(9,1) and XGMS(10,1), are the values at which the mode shape was generated. XGMS(10,1) is measured at the center of rotation.

The out-of-plane and inplane slopes of the pitch-change axis, relative to the undeformed position, due to the first mode, are equal to XGMS(11,1) and XGMS(12,1) multiplied by the modal participation factor.

CARD 42/A3

For the discussion of the inputs on this card, let

OP(r) = the blade out-of-plane displacement component, as a function of r

IP(r) = the blade inplane displacement com ponent, as a function of r

dm = the blade section infinitesimal mass

$$XGMS(13,1) = \int_0^R OP(r) \cdot r \cdot dm$$

$$XGMS(14,1) = \int_0^R OP(r) \cdot dm$$

$$XGMS(15,1) = \int_0^R IP(r) \cdot r \cdot dm$$

$$XGMS(16,1) = \int_0^R IP(r) \cdot dm$$

The out-of-plane and inplane displacement of the pitch bearings, relative to its undeformed position, for this mode is computed by multiplying XGMS(17,1) and XGMS(18,1) by the modal participation factor.

CARD 42/B2

The modal displacements and bending moment coefficients at the blade stations are given on this card and on the subsequent |IPL(4)| cards. Each card has the same format, and the displacements and bending moment coefficients are measured in the rotor shaft coordinate system. The blade displacements and bending moments due to this mode are equal to these inputs when the modal participation factor equals 1.0. Note that these variables cannot be changed by NAMELIST.

CARD 42/C1

The input data on the last card of each mode, which changes the natural frequency as a function of blade pitch angle and rpm, is based on plus and minus increments of each variable about the reference values given on CARD 42/A2, XGMS(9,1) and XGMS(10,1). The high and low values of pitch <u>must</u> be equidistant from the reference value. The same is true of the rpm.

CARDS 43/A1 through the last card in the set.

The inputs for each of the remaining IPL(6)-1 modes are made in the same way as those of the first mode.

<u>NOTE</u>: It is imperative that the first mode entered be the primary out-of-plane mode characterized by a natural frequency close to 1-per-rev. This is necessary for the rotor elastic trim to work properly. Other than the first mode, the order in which the modes are entered is entirely a user option.

3.7 TAIL ROTOR GROUP

The Main Rotor and Tail Rotor models are identical except that the Tail Rotor always rotates clockwise with respect to its mast as viewed from the top. Note that for zero mast tilt angles the tail rotor mast is vertical. The inputs required and the input sequence are identical for the two groups with the following exceptions:

(1) XTR(28), the sidewash coefficient, does not have a counterpart XMR(28) in the Main Rotor Group.
(2) The effect of program logic inputs: IPL(1),(7),(10), and (47) affect the tail rotor but not the main rotor; different values of IPL(3) are used for the tail rotor; IPL(6),(9), and IPL(46) do not affect the tail rotor.

Hence, see the Main Rotor Group for all except:

CARD 50

If IPL(1) $\neq$ 0 or if IPL(3) = 2 or 3, omit the entire tail rotor group.

CARD 52

The blade weight and second mass moment of inertia inputs, XTR(11) and (12), are ignored if IPL(7) $\neq$ 0; i.e., when one or more tail rotor mode shapes are input.

CARD 53

If $|$IPL(5)$|$ is less than 5, set XTR(21) = 0.0.

CARD 54

Tail rotor sidewash coefficient, XTR(28), is used to simulate the effect of the fuselage on the wind vector at the tail rotor as follows:

$$V_T = V_F \text{ (1. - XTR(28))}$$

where V_F and V_T are the lateral components of the wind vector, in body reference, felt by the fuselage and the tail rotor, respectively.

CARD 55

If $|$IPL(5)$|$ is less than 5, set XTR(30) = 1.0.

CARD 56

XTR(42), the first mass moment of inertia of the tail rotor, is ignored if IPL(7) $\neq$ 0.

CARD 57

For the tail rotor to act as an antitorque rotor, the mast must be tilted from the vertical to its proper orientation, e.g., XTR(44) = 0.0 and XTR(45) = ±90. If XTR(45) = +90 (tilted to the right), the advancing blade is at the top of the rotor disc (clockwise rotation when viewed from the right side of the aircraft). If XTR(45) = -90 (tilted to the left), the advancing blade is at the bottom of the rotor disc (counter-clockwise rotation when viewed from the right side of the aircraft).

It should be noted that with XTR(45) = +90, the tail rotor thrust vector is positive to starboard, so that an increase in tail rotor collective will increase the nose-to-port yawing moment (i.e., a negative yawing moment). Likewise, for XTR(45) = -90, an increase in tail rotor collective will cause an increase in nose-to-starboard (positive) yawing moment. For cambered airfoils, it may be necessary to input an inverted CLCD table for the tail rotor.

The tail rotor nonlinear flapping spring model is identical to that of the main rotor.

CARD 58

The tail rotor filter frequency should be chosen with the same considerations as the main rotor filter frequency. A value equal to tail rotor 1-per-rev is recommended. The tail rotor pitch-change axis geometry is defined using the same model as the main rotor.

CARDS 59, 5A, and 5B (Include only if IPL(5)<0)

The radius to the outboard end of the blade segments are input on these cards if the segments are unequal in length. All three cards must be input regardless of the number of segments.

CARDS 5C and 5D (Include only if IPL(10) $\neq$ 0)

The tail rotor elastic pylon inputs are similar to those for the main rotor, as described in Section 3.5. Since the mode shape components are in the body reference system, the Y component of the mode shape, XTPi(9), will be in a direction generally parallel to the shaft of an anti-torque rotor, and will be exactly aligned with it if the lateral tail rotor mast tilt is ±90° and there is no longitudinal tail rotor mast tilt.

CARDS 5E and 5F (Include only if $|IPL(10)| \geq 2$)

The second tail rotor pylon mode shape is input in the same format as the first mode shape.

CARDS 5G and 5H (Include only if $|IPL(10)| \geq 3$)

The third tail rotor pylon mode shape is input in the same format as the first mode shape.

CARDS 5I and 5J (Include only if $|IPL(10)| = 4$)

The fourth tail rotor pylon mode shape is input in the same format as the first mode shape.

CARDS 5K, 5L, and 5M

The nonuniform chordwise airfoil aerodynamic reference center distribution for the tail rotor is input on these cards. Include all three cards if $XTR(3) \geq 100.0$ and omit the cards if $XTR(3) < 100.0$.

CARDS 5N, 5O, 5P

The nonuniform chord distribution for the tail rotor is input on these cards. All three cards must be included if XTR(5) = 0.0, and they must be omitted if $XTR(5) \neq 0.0$.

CARDS 5Q, 5R, 5S

The nonuniform twist distribution for the tail rotor is input on these cards. All three cards must be included if $XTR(6) \geq 100.0$, and they must be omitted if $XTR(6) < 100.0$.

CARDS 5T, 5U, 5V, 5W

These cards are to be read only if IPL(14) = 2 or 3. The tail rotor harmonic blade shaker and harmonic control motion models are identical to those of the main rotor.

CARD 5X

The nonuniform airfoil section distribution is input on this card, which is included if $IPL(47) < 0$. The card must be omitted if $IPL(47) \geq 0$.

3.8 <u>TAIL ROTOR ELASTIC BLADE DATA GROUP</u>

This group is included only if IPL(7) $\neq$ 0. The tail rotor elastic blade data is input in the same sequence and format as that of the main rotor (see Section 3.6), except for the Blade General Mode Shape Data, CARDS 62/A1, 62/A2, 62/A3, 63/A1, 63/A2, 63/A3, etc. The second subscript for the XGMS array is of a different form than for the main rotor, because the tail rotor general mode shape data is stored immediately following the main rotor XGMS data. This difference is only important in a NAMELIST procedure. Remember that IPL(6) + IPL(7) must be less than or equal to 12.

The same caveat about the first mode shape in the group, namely that it must be that out-of-plane mode whose frequency is nearest 1-per-rev, pertains to the tail rotor also.

3.9 ROTOR AERODYNAMIC GROUP

This group is composed of not more than five Rotor Airfoil Aerodynamic (RAA) subgroups, which are numbered sequentially on input. IPL(10) in the Program Logic Group specifies the number of subgroups to be input. If both rotor groups are deleted (IPL(3) = 3), it is not necessary to read any RAA subgroups (IPL(11) = 0); however, if IPL(3) ≠ 3, at least one subgroup is required and a zero input for IPL(11) will be reset to one.

Each subgroup consists of five cards that contain the YRR inputs. In the YRR(I,J) array, I is the sequence number of the inputs for one subgroup (I = 1 through 35) and J is the sequence number of the subgroup (J = 1 through 5). The data sequence for Subgroup No. 1 is given in Section 2.9. Inputs for other subgroups are in the identical sequence and format as for Subgroup No. 1. Each subgroup represents one airfoil section and is independent of all other RAA subgroups.

Normally, only one or two subgroups are needed: one for the main rotor and possibly a different one for the tail rotor. The additional subgroups are included so that blades which have a variable airfoil section along their span can be modeled. IPL(46) and (47) in the Program Logic Group control the option for variable airfoil sections along the blades for the main rotor and tail rotor respectively. If the option is activated, an airfoil section distribution for the appropriate rotor is read. This distribution specifies which RAA subgroup is to be used at Blade Stations No. 1 through No. 20. See the discussion of IPL(46) and (47) on CARD 14 and IDTABM(1-20) on CARD 30 for additional details.

In the following discussion, Y(I) refers to the Ith input of a subgroup, e.g., Y(18) is YRR(18,K), where K indicates the sequence number of the subgroup. In addition, X(J) refers to the Jth input of the Main or Tail Rotor Group, e.g., X(29) is XMR(29) or XTR(29), depending on which rotor contains the blade segment of interest.

3.9.1 Aerodynamic Options

The inputs to the RAA subgroups are used by the CDCL subroutine to compute the steady state coefficients of airfoil section lift, drag, and pitching moment at Blade Stations No. 1 through No. 20 as functions of the local angle of attack, α, and Mach number, M. The program also includes two independent models for computing the effects of yawed flow. Each model is associated with one of the two models for unsteady aerodynamics; BUNS and UNSAN. The BUNS yawed flow model is controlled by Y(28) and the UNSAN by Y(27).

Y(28) is the maximum value for the yawed flow angle in the BUNS model. The angle is in degrees, and an input of zero effectively deactivates the model. The value of this input does not affect Y(27).

Y(27) acts as a switch for the UNSAN model only and is interpreted as follows:

0 = off

1 = active for drag only

2 = active for lift only

3 = active for both

The program includes logic which prevents both yawed flow models being activated simultaneously when the unsteady aerodynamic options are off (IPL(48) = 0). When one of the unsteady options is on, the logic also assumes that only the yawed flow associated with the unsteady model activated by IPL(20) can be used. See Table 7.

TABLE 7. RELATIONSHIP OF UNSTEADY AND YAWED FLOW MODELS

Unsteady Model	Value of IPL(48)		Description of the Effect
BUNS	< 0	Y(27) reset to zero	UNSAN model turned off; BUNS model may be on or off
None	= 0	Y(28) reset to zero if Y(27)>0	Either model may be used; BUNS model turned off if UNSAN model turned on
UNSAN	> 0	Y(28) reset to zero	BUNS model turned off; UNSAN model may be on or off

The BUNS and UNSAN unsteady aerodynamic models and the UNSAN yawed flow model are discussed in Section 3.4 of Volume I. In essence, both unsteady models are very similar in that each computes increments to the aerodynamic coefficients which are added to the steady state values. The following section describes how the CDCL subroutine computes the steady state coefficients using the BUNS yawed flow model.

3.9.2 Steady State Aerodynamic Coefficients

The steady state aerodynamic coefficients may be computed from equations which use the YRR inputs or interpolated from data tables. The control variable Y(18) specifies which method is to be used. The basic independent variables used by both the equations and the table lookup procedure are angle of attack and Mach number. A complete discussion of Y(18) is found at the end of this section. It is mentioned here primarily to caution the user that even though a table lookup procedure is used, many of the data for the equations must be entered as realistic values if either unsteady aerodynamic option is used. The variables that fall into this category are Y(1) through Y(11), Y(17), Y(20), Y(21), and Y(29) through Y(32).

The calculation of the steady state aerodynamic coefficients is the same at all blade stations with two exceptions. Near the blade root the computations are modified for hub extent as discussed in the Main Rotor Group. At the blade tip, sweep is accounted for in the following manner:

The tip sweep angle input, X(29), is used to modify the radial and tangential velocity components impinging on the most outboard segment of the rotor blade. The sweep angle is the amount the leading edge is swept back with respect to the blade pitch-change axis. A more complete explanation of the tip sweep equations is given in Section 3.4 of Volume I of this report.

The equations and logic checks used for all other blade segments are given below. The initial step is to determine the effective Mach number and angle of attack.

Let the local velocity components U_T, U_P and U_R be the tangential, perpendicular, and radial velocities, respectively. Then the yawed flow angle is

$$\Lambda = [\mathrm{Min}\ \{Y(28),\ \tan^{-1}(U_R/U_T)\ \}] * \mathrm{sign}[\tan^{-1}(U_R/U_T)]$$

and an effective Mach number is defined as

$$M = V/V_{sound} \quad [\cos Y(20)\ \Lambda]^{Y(21)}$$

where

$$V = [U_R^{\ 2} + U_T^{\ 2} + U_P^{\ 2}]^{1/2}$$

and

V_{sound} = Speed of sound based on the values of XFC(26), (27), and (28).

This form of the Mach number expression is developed in Volume I of this report. Suggested values for Y(20) and Y(21) are 0.2 and 1.0 (or 1.0 and 0.5) respectively, as discussed in Section 3.4 of Volume I.

The angle of attack of the blade segment, α, is defined by

$$\alpha = \theta + \alpha_o + \phi$$

and it is assumed that

$$-180° < \alpha \leq 180°$$

In the equation for α, θ is the local pitch, or feathering, of the chordline at the appropriate blade station. It is determined from control system geometry, blade geometry, and elastic blade deflections, from the equation given in the discussion of CARD 37.

The term α_o is the angle between the chordline and the zero lift line of the segment. When equations are used to compute the aerodynamic coefficients,

$$\alpha_o = Y(29) + Y(30)*M + Y(31)*M^2 + Y(32)*M^3$$

When data tables are used, α_o is defined as zero since the data tables are assumed to be a function of chordline angle of attack. However, if the UNSAN unsteady aerodynamic option is activated (IPL(48)>0) and data tables are used, the values of Y(29) through Y(32) must be realistic inputs since they are used in the UNSAN analysis and are not computed from the tables.

The term ϕ is the local inflow angle, and is normally negative.

$$\phi = \tan^{-1}(U_P/U_T)$$

Hence, when equations are used, α is the angle of attack of the zero lift line and when data tables are used, it is the angle of attack of the airfoil section chordline.

For rotors with cambered airfoils where the chordline and zero lift line are not coincident, it is advisable to use data tables rather than equations to compute the aerodynamic coefficients. The mathematical model described by the equations was originally developed for symmetric airfoils exclusively. In most cases it is only marginally adequate for modeling the asymmetric stall characteristics about the zero lift line, the shift in zero lift line orientation in reversed flow, and the variations of coefficients with Mach number associated with cambered rotor airfoil sections. Hence, if the user wishes to model cambered airfoil sections with equations, the flight conditions should be restricted to those where rotor stall is not significant and the reversed flow region is small; e.g., low blade loading coefficient (c_t/σ) and low advance ratio (μ).

A modified angle of attack is then computed from

$$\alpha_1 = \begin{cases} \alpha \cos \Lambda & \text{if} |\alpha| < 90° \\ \alpha & \text{if} |\alpha| > 90° \end{cases}$$

If Y(18) indicates that the table lookup procedure is to be used, the procedure is entered at this point with the above values of α_1 and M, and returns the interpolated values of the aerodynamic coefficients. The lift coefficient is then divided by cos Λ and all three coefficients are returned to the subroutine that called CDCL.

If Y(18) indicates that equations are to be used, the next step is to determine the lift curve slope of the airfoil at the current Mach number.

The input value of the Mach number at the lower boundary of the supersonic region, Y(2), is checked against a calculated value, M_{sc}, to determine the value of the lower boundary to be used, M_s.

$$M_s = \text{Max}\ \{Y(2),\ M_{sc}\}$$

The expression for M_{sc} is obtained by assuming that the slope of the lift curve at the critical Mach number, Y(1), is equal to the slope of the lift curve at M_{sc}.

The equation for the slope of the lift curve takes one of three forms, depending on whether the Mach number is subsonic, transonic, or supersonic.

$$a_1 = Y(8) + Y(9)M + Y(10)M^2 + Y(11)M^3 \qquad \text{(subsonic)}$$

$$a_2 = B_0 + B_1 M + B_2 M^2 \qquad \text{(transonic)}$$

$$a_3 = 4/\left(57.3\sqrt{M^2 - 1}\right) \qquad \text{(supersonic)}$$

Since the critical Mach number is subsonic, the slope of the lift curve at M = Y(1) is

$$(a_1)_{CR} = Y(8) + Y(9)*Y(1) + Y(10)*Y(1)^2 + Y(11)*Y(1)^3$$

If $M = M_{sc}$ in the equation for the supersonic lift curve slope, a_3, and $a_3 = (a_1)_{CR}$, then

$$M_{sc} = 1 + (0.0698/(a_1)_{CR})^2$$

Then the final selection for the slope of the lift curve, a, is made:

$$a = \begin{cases} a_1 \text{ if } M < Y(1) \\ a_2 \text{ if } Y(1) \le M < M_s \\ a_3 \text{ if } M_s \le M \end{cases}$$

The coefficients B_0, B_1, and B_2 in the equation for a_2 are computed internally by matching end points with a_1 and a_3 and the slope of a_3.

$$a_2 = a_1 \qquad \text{at } M = Y(1)$$

$$\left.\begin{aligned} a_2 &= a_3 \\ \frac{da_2}{dM} &= \frac{da_3}{dM} \end{aligned}\right\} \qquad \text{at } M = M_s$$

Next a test is made on α to see if the airfoil is in normal or reversed flow. Several intermediate variables in the calculation of lift coefficient are set according to the results. The angle of attack, α, is further resolved to be between plus and minus 90 degrees in either case.

If $|\alpha_1| \leq 90°$,

$$\alpha = |\alpha_1|$$

$$C_{L_O} = Y(3)$$

$$K_L = Y(4)M + Y(5)M^2 + Y(6)M^3$$

$$\alpha_B = [(C_{L_O} + K_L)/a] + 5°$$

If $|\alpha_1| > 90°$,

$$\alpha = 180° - |\alpha_1|$$

$$C_{L_O} = Y(7)$$

$$K_L = 0$$

$$\alpha_B = [C_{L_O}/a] + 5°$$

The C_L versus α curve has the form shown in Figure 23. At the point P_1 in Figure 23,

$$C_L = C_{L_O} + K_L$$

$$\alpha = C_L/a = \alpha_s$$

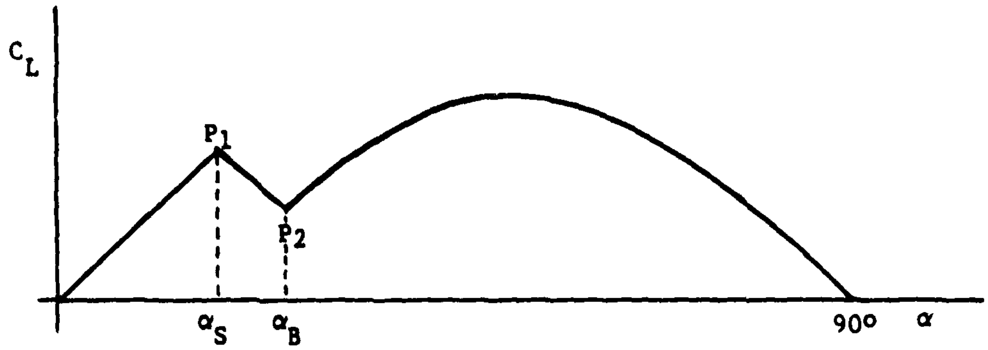


Figure 23. General Lift Coefficient Versus Angle of Attack Curve.

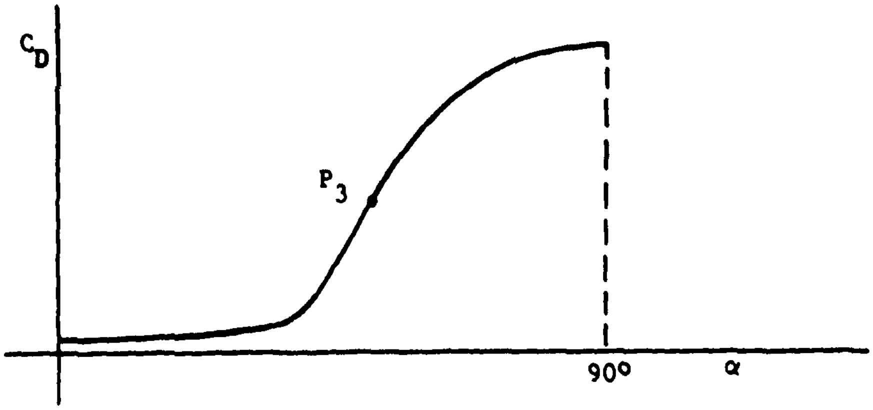


Figure 24. General Drag Coefficient Versus Angle of Attack Curve.

At P_2 in Figure 23,

$$\alpha = \alpha_B$$

Linear interpolation is used to evaluate C_L for points between P_1 and P_2.

For $\alpha_B \leq \alpha \leq 90°$,

$$C_L = [\{1.876 \sin \alpha - (.581)\} K + 0.81] \cos \alpha$$

where

$$K = \begin{cases} 1 + 0.25M^4 & \text{if } M \leq 1 \\ 0.85 + 0.82/[M\ 0.8] & \text{if } M > 1 \end{cases}$$

The form of the C_D versus α curve is shown in Figure 24. At the point P_3 in Figure 24, $\alpha = \alpha_x$ and $C_D = C_{D_X}$, where either $\alpha_X = \alpha_s$ and $C_{D_X} < Y(16)$, or $\alpha_X < \alpha_s$ and $C_{D_X} = Y(16)$.

For M<Y(2), i.e., below the supersonic region, the drag coefficient expression used depends on the value of α.

For $0 \leq \alpha \leq \alpha_X$,

$$C_D = \text{Min} \left\{ \begin{array}{l} Y(16),\ (Y(12) + Y(13)\alpha + Y(14)\alpha^2 \\ \\ + \text{Max}\ \{0,\ Y(19)\alpha - Y(1) + \text{Max}[M,\ 0.35]\}) \end{array} \right\}$$

NOTE: In this drag equation, α is the angle of attack with respect to the airfoil section zero lift line. Hence, for cambered airfoil sections where chordline and zero lift line are not coincident, care should be taken that the coefficients Y(12), (13), and (14) are referenced to the zero lift line rather than to the chordline.

If the drag rise coefficient, Y(19), is input as zero, it is reset to 0.0332 per degree.

For $\alpha_X \leq \alpha \leq 90°$ or $C_D \leq C_{D_X}$,

$$C_D = K_4 \sin^2 \alpha + (C_{D_X} - K_4 \sin^2 \alpha_X) \cos \alpha / \cos \alpha_X$$

where $K_4 = 2.1\ K$.

In the supersonic region, $M \geq M_s$

$$C_D = \text{Min}\left(Y(16),\ \left\{ Y(12) + 4[(\alpha/57.3)^2 + Y(15)]/\sqrt{M^2 - 1} \right\} \right)$$

The calculation of steady state pitching moment coefficients is best understood by following the logic flow chart in Figure 25, which is repeated from Volume I. The procedure was developed in order to curve fit C_M versus α curves at various Mach numbers such as those sketched in Figure 26. The symbols used in the flow chart are defined in terms of the inputs below. Reasonable values of the inputs for an NACA 0012 airfoil section are listed in brackets.

$A_1 = Y(22)$	[-.002488]
$A_2 = Y(23)$	[-.009456]
$A_3 = Y(24)$	[.82]
$A_4 = Y(25)$	[0.0]

The inputs Y(22), Y(23), and Y(24) are coefficients for a quadratic function of α determining the corresponding value of Mach number at which the C_M curve breaks sharply away from the input constant value, Y(25).

For $\alpha < 90°$, the first series of calculations and tests is to determine the relative sizes of α, the angle of attack, α_B, corresponding to $M_{eff} = M$ on the "break" curve mentioned previously, and of A_5, the critical value of α defined by the "break" curve for M = 0. The evaluation of C_M is different for $o \leq \alpha \leq \alpha_B$, $\alpha_B < \alpha \leq A_5$, and for $A_5 < \alpha < 90°$.

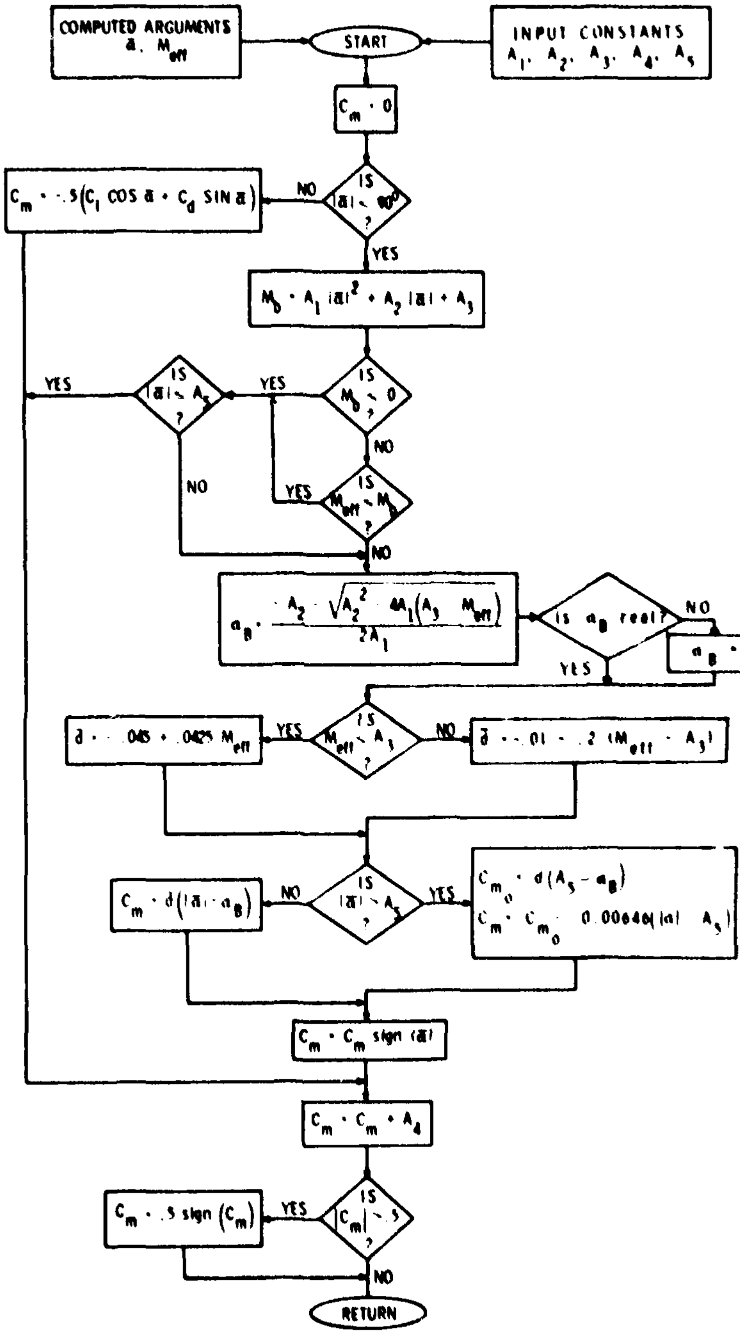


Figure 25. Flow Chart for Steady-State Pitching Moment Calculation.

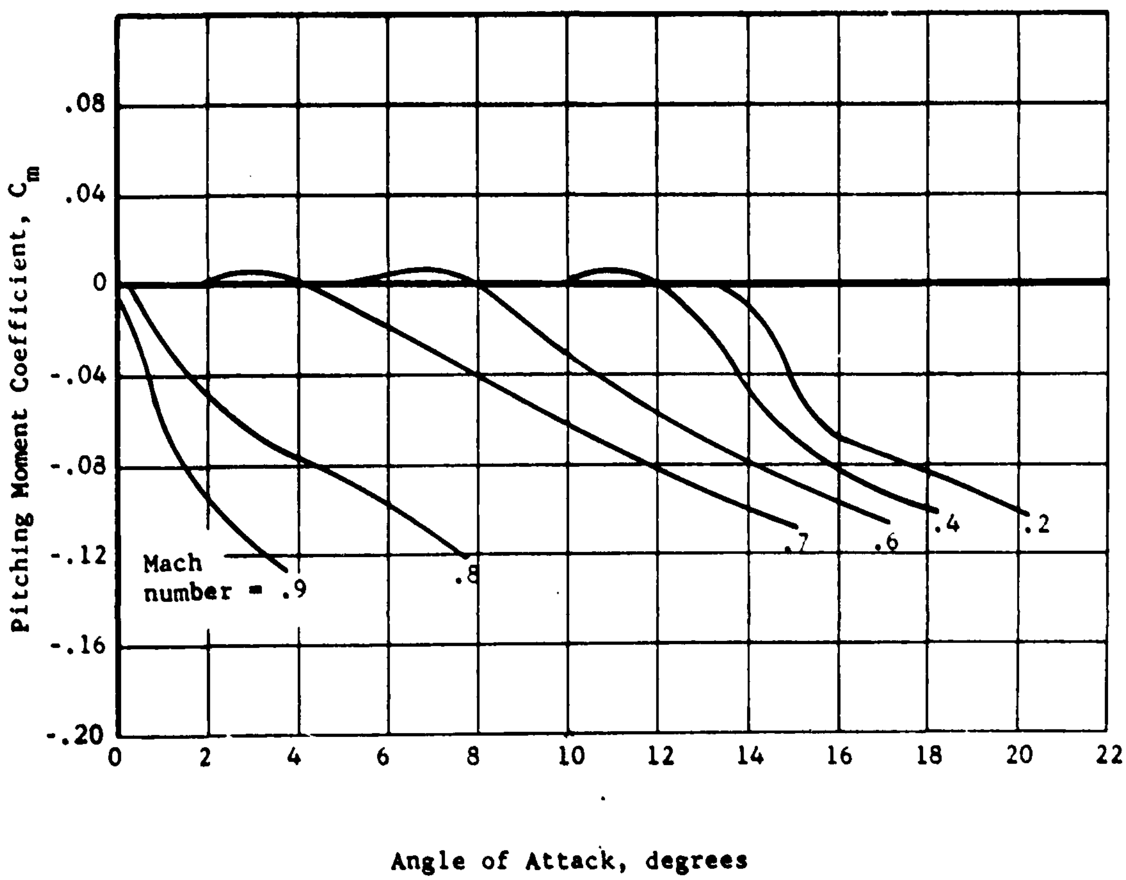


Figure 26. Typical Curves of Pitching Moment Coefficient Versus Angle of Attack at Various Mach Numbers.

For α less than α_B,

$$C_M = Y(25)$$

For α between α_B and A_5, a slope, $\bar{d}$, is computed for the C_M line between α_B and A_5. This slope depends on M_{eff} and an input critical value, Y(24), which is the point on the "break" curve for $\alpha = 0$. The pitching moment coefficient is calculated from

$$C_M = (|\alpha| - \alpha_B)\bar{d} \text{ sign}(\alpha) + Y(25)$$

If α is greater than A_5, a second slope included in the program is used.

$$C_M = (A_5 - \alpha_B)\bar{d} - 0.00646 (|\alpha| - A_5) \text{ sign } (\alpha) + Y(25)$$

For $\alpha \geq 90°$, the aerodynamic center is assumed to be located at the 0.75 chord rather than at the 0.25 chord. The pitching moment about the blade neutral axis (assumed to be at the 0.25 chord) is in this case mainly due to lift and drag forces. Hence,

$$C_M = -0.5(C_L \cos \alpha + C_D \sin \alpha) + Y(25)$$

As shown in the flow diagram (Figure 25), the absolute value of C_M is limited not to exceed 0.5 in all cases.

Y(33), Y(34), and Y(35) are increments which are added to the steady state value of the lift, drag, and pitching moment coefficients, respectively. Each increment is added to its corresponding coefficient, whether the coefficient is computed from equations or obtained from a data table. However, the most common use of these increments is with data tables. For example, if all drag coefficients in a table appear uniformly too high or too low, Y(34) can be used to change the drag at all combinations of angle of attack and Mach number without having to repunch the entire drag table. Similarly, Y(33) can be used to cause an effective shift in the zero lift line orientation.

NOTE: The control variable for the use of C_L, C_D, and C_M tables, Y(18), operates as follows:

(1) If Y(18) = 0, the aerodynamic coefficients are computed from the above equations using the YRR inputs.

(2) If Y(18) > 0, the Y(18)th Airfoil Data Table included in the Data Table Group will be used to compute the steady state aerodynamic coefficients. Note that a set of data tables for the NACA 0012 airfoil is stored permanently in Airfoil Data Table No. 5. This table is stored internally as Airfoil Data Table No. 2 in the 300K version of the program. These tables are shown in Figure 27. See Data Table Group for additional details.

VERT-SIK 0012 + CM   CLCD DATA TABLES USED

CL

ALPHA/MACH	0.0	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000	1.00000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-172.00000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000
-161.00000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000
-147.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-129.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-49.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-39.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-21.00000	-0.80000	-0.80000	-0.81000	-0.83000	-0.85000	-0.85000	-0.85000	-0.71000	-0.68000	-0.64000	-0.64000
-16.50000	-1.00700	-1.00700	-0.94400	-0.96000	-0.96500	-0.96500	-0.96500	-0.79500	-0.76000	-0.70000	-0.70000
-15.00000	-1.19000	-1.19000	-1.09000	-1.05500	-0.99000	-0.98000	-0.98000	-0.83000	-0.79000	-0.72000	-0.72000
-14.00000	-1.33300	-1.33300	-1.22000	-1.09600	-1.00000	-0.97000	-0.97000	-0.84000	-0.80500	-0.73000	-0.73000
-13.00000	-1.33400	-1.33400	-1.28000	-1.12000	-1.00000	-0.96000	-0.96000	-0.85000	-0.81500	-0.73500	-0.73500
-12.00000	-1.25500	-1.25500	-1.26000	-1.13000	-1.00000	-0.94700	-0.94000	-0.85000	-0.82000	-0.74000	-0.74000
-11.00000	-1.16100	-1.16100	-1.19000	-1.12000	-0.99400	-0.93000	-0.92300	-0.85000	-0.81000	-0.74000	-0.74000
-10.00000	-1.05500	-1.05500	-1.10000	-1.08200	-0.98500	-0.91000	-0.90000	-0.84500	-0.80500	-0.73000	-0.73000
-8.00000	-0.84400	-0.84400	-0.88000	-0.90700	-0.92200	-0.87000	-0.84000	-0.82000	-0.77000	-0.69500	-0.69500
-6.00000	-0.63300	-0.63300	-0.66000	-0.68400	-0.74100	-0.77000	-0.75000	-0.77000	-0.72000	-0.59300	-0.59300
-4.00000	-0.42200	-0.42200	-0.44000	-0.45600	-0.49400	-0.54400	-0.57800	-0.62700	-0.60300	-0.39600	-0.39600
-2.00000	-0.21100	-0.21100	-0.22000	-0.22800	-0.24700	-0.27200	-0.31300	-0.35000	-0.39500	-0.20000	-0.20000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00000	0.21100	0.21100	0.22000	0.22800	0.24700	0.27200	0.31300	0.35000	0.39500	0.20000	0.20000
4.00000	0.42200	0.42200	0.44000	0.45600	0.49400	0.54400	0.57800	0.62700	0.60300	0.39600	0.39600
6.00000	0.63300	0.63300	0.66000	0.68400	0.74100	0.77000	0.75000	0.77000	0.72000	0.59300	0.59300
8.00000	0.84400	0.84400	0.88000	0.90700	0.92200	0.87000	0.84000	0.82000	0.77000	0.69500	0.69500
10.00000	1.05500	1.05500	1.10000	1.08200	0.98500	0.91000	0.90000	0.84500	0.80500	0.73000	0.73000
11.00000	1.16100	1.16100	1.19000	1.12000	0.99400	0.93000	0.92300	0.85000	0.81000	0.74000	0.74000
12.00000	1.25500	1.25500	1.26000	1.13000	1.00000	0.94700	0.94000	0.85000	0.82000	0.74000	0.74000
13.00000	1.33400	1.33400	1.28000	1.12000	1.00000	0.96000	0.96000	0.85000	0.81500	0.73500	0.73500
14.00000	1.33300	1.33300	1.22000	1.09600	1.00000	0.97000	0.97000	0.84000	0.80500	0.73000	0.73000
15.00000	1.19000	1.19000	1.09000	1.05500	0.99000	0.98000	0.98000	0.83000	0.79000	0.72000	0.72000
16.50000	1.00700	1.00700	0.94400	0.96000	0.96500	0.96500	0.96500	0.79500	0.76000	0.70000	0.70000
21.00000	0.80000	0.80000	0.81000	0.83000	0.85000	0.85000	0.85000	0.71000	0.68000	0.64000	0.64000
39.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
49.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
129.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
147.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
161.00000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000
172.50000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 27. Set of Data Tables for the NACA 0012 Airfoil Section.

VERT-SIK 0012 + CM CLCD DATA TABLES USED

CD

ALPHA/MACH	0.0	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000	1.00000
-180.00000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200
-175.00000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
-170.00000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
-165.00000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
-160.00000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
-140.00000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
-120.00000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
-110.00000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
-100.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
-90.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
-80.00000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
-70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
-60.00000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
-50.00000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
-30.00000	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200
-21.00000	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200
-16.00000	0.15500	0.15500	0.18100	0.20700	0.23500	0.25700	0.27400	0.29200	0.30500	0.34200	0.34200
-15.00000	0.10200	0.10200	0.14800	0.18100	0.20900	0.23300	0.25200	0.27100	0.28200	0.29800	0.29800
-14.00000	0.03800	0.03800	0.09900	0.14600	0.18000	0.21200	0.23300	0.24900	0.26000	0.29300	0.29300
-13.00000	0.02640	0.02640	0.04550	0.09400	0.14800	0.19100	0.21600	0.23100	0.23900	0.27200	0.29200
-12.00000	0.02200	0.02200	0.03000	0.06000	0.11100	0.16400	0.19800	0.21100	0.22000	0.25200	0.29100
-11.00000	0.01960	0.01960	0.02320	0.03800	0.07800	0.13500	0.17000	0.19200	0.20200	0.23200	0.27500
-10.00000	0.01740	0.01740	0.01890	0.02590	0.05300	0.10500	0.14500	0.17600	0.18600	0.21300	0.25400
-9.00000	0.01540	0.01540	0.01590	0.01870	0.03510	0.07700	0.12200	0.15900	0.17200	0.19900	0.23200
-8.00000	0.01380	0.01380	0.01380	0.01470	0.02200	0.05300	0.10100	0.14000	0.15500	0.18300	0.21400
-7.00000	0.01220	0.01220	0.01220	0.01230	0.01410	0.03500	0.08200	0.11100	0.13900	0.16900	0.19200
-6.00000	0.01100	0.01100	0.01100	0.01100	0.01100	0.02120	0.06150	0.08200	0.12000	0.14000	0.17000
-5.00000	0.01000	0.01000	0.01000	0.01000	0.01000	0.01320	0.03800	0.05400	0.08800	0.11100	0.14000
-4.00000	0.00930	0.00930	0.00930	0.00930	0.00930	0.01000	0.01670	0.03000	0.05750	0.09500	0.11200
-3.00000	0.00880	0.00880	0.00880	0.00880	0.00880	0.00900	0.01020	0.01750	0.03550	0.08600	0.10200
-2.00000	0.00850	0.00850	0.00850	0.00850	0.00850	0.00850	0.00860	0.01170	0.02400	0.08100	0.09800
-1.00000	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00910	0.01750	0.07800	0.09600
0.0	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.01370	0.07800	0.09500
1.00000	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00910	0.01750	0.07800	0.09600
2.00000	0.00850	0.00850	0.00850	0.00850	0.00850	0.00850	0.00860	0.01170	0.02400	0.08100	0.09800
3.00000	0.00880	0.00880	0.00880	0.00880	0.00880	0.00900	0.01020	0.01750	0.03550	0.08600	0.10200
4.00000	0.00930	0.00930	0.00930	0.00930	0.00930	0.01000	0.01670	0.03000	0.05750	0.09500	0.11200
5.00000	0.01000	0.01000	0.01000	0.01000	0.01000	0.01320	0.03800	0.05400	0.08800	0.11100	0.14000
6.00000	0.01100	0.01100	0.01100	0.01100	0.01100	0.02120	0.06150	0.08200	0.12000	0.14000	0.17000
7.00000	0.01220	0.01220	0.01220	0.01230	0.01410	0.03500	0.08200	0.11100	0.13900	0.16900	0.19200
8.00000	0.01380	0.01380	0.01380	0.01470	0.02200	0.05300	0.10100	0.14000	0.15500	0.18300	0.21400
9.00000	0.01540	0.01540	0.01590	0.01870	0.03510	0.07700	0.12200	0.15900	0.17200	0.19900	0.23200
10.00000	0.01740	0.01740	0.01890	0.02590	0.05300	0.10500	0.14500	0.17600	0.18600	0.21300	0.25400
11.00000	0.01960	0.01960	0.02320	0.03800	0.07800	0.13500	0.17000	0.19200	0.20200	0.23200	0.27500
12.00000	0.02200	0.02200	0.03000	0.06000	0.11100	0.16400	0.19800	0.21100	0.22000	0.25200	0.29100
13.00000	0.02640	0.02640	0.04550	0.09400	0.14800	0.19100	0.21600	0.23100	0.23900	0.27200	0.29200
14.00000	0.03800	0.03800	0.09900	0.14600	0.18000	0.21200	0.23300	0.24900	0.26000	0.29300	0.29300
15.00000	0.10200	0.10200	0.14800	0.18100	0.20900	0.23300	0.25200	0.27100	0.28200	0.29800	0.29800
16.00000	0.15500	0.15500	0.18100	0.20700	0.23500	0.25700	0.27400	0.29200	0.30500	0.34200	0.34200
21.00000	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200
30.00000	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200
50.00000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
60.00000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
80.00000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
90.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
100.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
110.00000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
120.00000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
140.00000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
160.00000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
165.00000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
170.00000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
175.00000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
180.00000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200

Figure 27. Continued.

VERT-SIK 0012 + CM   CLCD DATA TABLES USED

CM

ALPHA/MACH	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-170.00000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000
-165.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-160.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-135.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-90.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-30.00000	0.17400	0.18400	0.19600	0.21400	0.23500	0.25000	0.26400	0.27700	0.29800
-23.00000	0.11200	0.11800	0.12800	0.14400	0.15700	0.17100	0.18300	0.20600	0.23200
-16.00000	0.07300	0.07800	0.08600	0.09700	0.10800	0.11700	0.13700	0.17600	0.20000
-15.00000	0.05400	0.06500	0.07300	0.08400	0.09700	0.11100	0.13300	0.17300	0.19500
-14.00000	0.0	0.02700	0.05400	0.06800	0.08600	0.10300	0.12700	0.16700	0.18900
-13.00000	0.0	-0.00150	0.02500	0.05000	0.07400	0.09300	0.12200	0.16300	0.18400
-12.00000	0.0	0.0	0.00200	0.03000	0.06000	0.08300	0.11600	0.15700	0.17600
-11.00000	0.0	0.0	-0.00300	0.01400	0.04600	0.07400	0.10800	0.14900	0.17000
-10.00000	0.0	0.0	-0.00150	0.00200	0.03200	0.06500	0.10000	0.14200	0.16300
-9.00000	0.0	0.0	0.0	-0.00300	0.01600	0.05400	0.08900	0.13200	0.15400
-8.00000	0.0	0.0	0.0	-0.00400	0.00500	0.04100	0.08200	0.12300	0.14500
-7.00000	0.0	0.0	0.0	0.0	-0.00400	0.02750	0.07200	0.11250	0.13600
-6.00000	0.0	0.0	0.0	0.0	-0.00300	0.01600	0.06250	0.10000	0.12500
-4.00000	0.0	0.0	0.0	0.0	0.0	0.00500	0.04000	0.07600	0.10200
-3.00000	0.0	0.0	0.0	0.0	0.0	-0.00250	0.02600	0.06650	0.08700
-2.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.01300	0.05300	0.07000
-1.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.00350	0.03300	0.04500
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.00350	-0.03300	-0.04500
2.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.01300	-0.05300	-0.07000
3.00000	0.0	0.0	0.0	0.0	0.0	0.00250	-0.02600	-0.06650	-0.08700
4.00000	0.0	0.0	0.0	0.0	0.0	-0.00500	-0.04000	-0.07600	-0.10200
6.00000	0.0	0.0	0.0	0.0	0.00300	-0.01600	-0.06250	-0.10000	-0.12500
7.00000	0.0	0.0	0.0	0.0	0.00400	-0.02750	-0.07200	-0.11250	-0.13600
8.00000	0.0	0.0	0.0	0.00400	-0.00500	-0.04100	-0.08200	-0.12300	-0.14500
9.00000	0.0	0.0	0.0	0.00300	-0.01600	-0.05400	-0.08900	-0.13200	-0.15400
10.00000	0.0	0.0	0.00150	-0.00200	-0.03200	-0.06500	-0.10000	-0.14200	-0.16300
11.00000	0.0	0.0	0.00300	-0.01400	-0.04600	-0.07400	-0.10800	-0.14900	-0.17000
12.00000	0.0	0.0	-0.00200	-0.03000	-0.06000	-0.08300	-0.11600	-0.15700	-0.17600
13.00000	0.0	0.00150	-0.02500	-0.05000	-0.07400	-0.09300	-0.12200	-0.16300	-0.18400
14.00000	0.0	-0.02700	-0.05400	-0.06800	-0.08600	-0.10300	-0.12700	-0.16700	-0.18900
15.00000	-0.05400	-0.06500	-0.07300	-0.08400	-0.09700	-0.11100	-0.13300	-0.17300	-0.19500
16.00000	-0.07300	-0.07800	-0.08600	-0.09700	-0.10800	-0.11700	-0.13700	-0.17600	-0.20000
23.00000	-0.11200	-0.11800	-0.12800	-0.14400	-0.15700	-0.17100	-0.18300	-0.20600	-0.23200
30.00000	-0.17400	-0.18400	-0.19600	-0.21400	-0.23500	-0.25000	-0.26400	-0.27700	-0.29800
90.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
135.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
160.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
165.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
170.00000	-0.40000	-0.40000	-0.40000	-C.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 27. Concluded.

3.10 ROTOR-INDUCED VELOCITY DISTRIBUTION TABLE GROUP

The induced velocity distribution over each rotor can be computed from either the equation given in Section 3.10.3 or a Rotor-Induced Velocity Distribution (RIVD) table. IPL(12) controls the read-in of RIVD tables and the option of using a table or the equation.

Value of IPL(12)	RIVD Table(s) Required	Effect
0	None	Both rotors use equation
1	Main rotor table only	Main rotor uses table; tail rotor uses equation
2	Tail rotor table only	Main rotor uses equation; tail rotor uses table
3	Both main rotor and tail rotor table	Each rotor uses its respective table

When a table is used, the local induced velocity is computed from the following summation:

$$v_i(\mu, \alpha_{WP}, r/R, \Psi) = \bar{V}_i \left[a(1) + \sum_{n=1}^{NHH} \{ a(2n)*\sin(n\Psi) + a(2n+1)*\cos(n\Psi) \} \right]$$

where

v_i = local induced velocity, ft/sec

$\bar{V}_i$ = average induced velocity over the rotor disc, ft/sec

μ = advance ratio (velocity in plane perpendicular to rotor shaft/tip speed)

α_{WP} = wake-plane angle of attack

r/R = radial blade station (nondimensional)

Ψ = blade azimuth angle

a(i) = coefficients of the harmonics (nondimensional)

NHH = order of the highest harmonic

n = summation variable

The coefficients a(i) are computed from the table as functions of μ, α_{WP}, and r/R for the appropriate rotor. $\bar{V}_i$ is interpolated from a separate table for the given μ and α_{WP}. Note that the a(i) are velocities which have been normalized by $\bar{V}_i$.

An RIVD table itself consists of sets of Fourier coefficients that are derived from a curve fit of the above equation to data generated by a rotor wake analysis of the user's choosing. The $\bar{V}_i$ table is generated by the same program, and the a(i) must be normalized by the $\bar{V}_i$ for that μ and α_{WP}. Section 7.2 describes a program for generating the RIVD tables.

Each set of coefficients in the table corresponds to data at specific values of μ, α_R, and r/R. The number of sets of coefficients in a table and the number of coefficients in a set are defined by the inputs on the Title and Control Card (CARD 80A or 90A). The permissible values of the integer inputs on these cards are:

Number of advance ratios:	$1 \leq NMU \leq 10$
Number of inflow ratios:	$1 \leq NAA \leq 5$
Number of harmonics:	$0 \leq NHH \leq 9$
Number of radial stations (NRS):	$0 \leq NRS \leq \|IPL(4)\| +1$ (Main Rotor)
	$0 \leq NRS \leq \|IPL(5)\| +1$ (Tail Rotor)

If either NMU or NLM is input as zero, it is reset to unity.

The radii for the blade stations used for the RIVD table must be input whenever NRS $\neq$ 0. The radial stations must coincide with radial stations used in the Main Rotor Group (and the Main Rotor Elastic Blade Data Group, if input) but the RIVD tables may contain data for fewer radial stations than the other two groups. If fewer RIVD table stations are used, AGAJ77 interpolates the values at the intermediate stations.

The number of coefficients in a set (NCA) is then

$$NCA = 2*NHH + 1$$

Which implies

$$1 \leq NCA \leq 19$$

Hence, one RIVD table may then consist of from 3 to 400 sets of 1 to 19 coefficients each (3 to 7600 total entries).

The RIVD table can be considered to be |IPL(4)| +1 (or |IPL(5)| +1) independent tables, with each one being a bivariant table in μ and α_{WP} at a given radial station.

During the rotor computations, a table lookup procedure is then used to obtain the set of coefficients a(i) from the appropriate radial station table. This table lookup procedure performs bivariant interpolation using the computed values of μ and α_R whenever both values are within the range of their respective inputs. If a computed value is outside the range of its input, the procedure uses the input value that is closest to the computed value (i.e., the nearest boundary of the table); it does not extrapolate to a computed value. Note that the boundaries of a table can be pictured in a μ-α_{WP} plane as a rectangle (when both NMU and NAA are greater than unity), a line (when either NMU or NAA is unity, but the other is not), or a point (when both NMU and NAA are unity). Hence, in the trivial case (NMU = NAA = 1), the coefficients are dependent on radial station but independent of μ and α_{WP}. If only one of these control variables is unity, the coefficient will be independent of the associated ratio, but dependent on the other ratio as well as the radial station.

With regard to the input format of the sets of coefficients, it should be emphasized that only the constant coefficient is ever input in the first 10-column field on a card; each set must start on a new card. Inputs following the constant are in pairs (the sine and cosine components of the appropriate harmonic). When used, the fourth and seventh pairs of harmonic components start on a new card in the <u>second</u> 10-column field (columns 11 through 20 for the sine component). Only the cards necessary to input NHH harmonics are to be included in the sets of cards. For example, if NHH = 4, the third card described in Section 2.10.1.4 must be omitted.

The average induced velocities input on the table must correspond to the combinations of μ and α_{WP} used for the table. There will be NMU cards in the average induced velocity table.

3.10.3 Induced Velocity Distribution

If the Rotor-Induced Velocity Distribution Table is not read in or not used for a particular rotor, the distribution of the average induced velocity over the rotor disk is made by an equation internal to the program. The equation is

$$v_i = \bar{V}_i \quad \frac{4}{3}\, x\, [1 + f_1(\mu)*\cos \Psi] + f_2(x, \Psi)*f_1(\mu)*K_{27}\sqrt{-0.5*V_N^2 + \sqrt{0.25*V_N^4 + (\bar{V}_i)_N^2}}$$

where v_i is the local induced velocity

$\bar{V}_i$ is the average induced velocity across the rotor disc

x is the nondimensional blade station (0 = root, 1 = tip)

Ψ is the blade azimuth angle

K_{27} is XMR(27) or XTR(27), as appropriate

V_N is the flight path airspeed in ft/sec divided by 1.0 ft/sec

$(\bar{V}_i)_N$ is $\bar{V}_i$ in ft/sec divided by 1.0 ft/sec

The two functions, f_1 and f_2, are defined as follows:

$$f_1(\mu) = \begin{cases} 0.5 & \text{if } \Omega < 1 \text{ rad/sec} \\ 11.25\,\mu & \text{if } \Omega \geq 1 \text{ and } \mu < 0.1067 \\ 1.36 - 1.5\,\mu & \text{if } \Omega \geq 1 \text{ and } 0.1067 \leq \mu < 0.573 \\ 0.5 & \text{if } \Omega \geq 1 \text{ and } \mu \geq 0.573 \end{cases}$$

$$f_2(x,\Psi) = \begin{cases} 0.0 & \text{if } x \geq 0.7 \text{ or } (105° < \Psi < 255°) \\ & \text{or } (315° \leq \Psi < 360°) \text{ or } (0° \leq \Psi \leq 45°) \\ \sin 6(|\psi - 45|) & \text{if } x \geq 0.7 \text{ and if } (45° \leq \Psi < 105°) \\ & \text{or } (255° \leq \Psi \leq 315°) \end{cases}$$

The f_2 function is intended to account for the tip vortex effect as discussed in Section 3.5. The calculation of $\bar{V}_i$ is described in Section 3.4 of Volume I of this report.

3.11 ROTOR WAKE AT AERODYNAMIC SURFACES TABLES GROUP

The wake from each rotor that acts at each aerodynamic surface can be computed from either individual inputs or Rotor Wake at Aerodynamic Surface (RWAS) Tables. Exactly IPL(13) RWAS tables must be input where $0 \leq$ IPL(13) ≤ 12. However, RWAS tables are used only when inputs in the wing and/or stabilizing surface groups specify their use. For the wing, these controlling inputs are XWG(29) through XWG(32); for the i^{th} stabilizing surface group the controlling inputs are XSTBi(29) and XSTBi(32). See Sections 3.14 and 3.15 for details.

When a table is used, the velocity superimposed on the flow field at an aerodynamic surface due to rotor-induced velocity is computed from the following summation:

$$(v_i)_{jk} = (\bar{V}_i)_k \left\{ a(1) + \sum_{n=1}^{NHH} \left[a(2n)*\sin(n\Psi_k) + a(2n+1)*\cos(n\Psi_k) \right] \right\}$$

where $(v_i)_{jk}$ = superimposed velocity on the j^{th} surface due to the k^{th} rotor, ft/sec

$(\bar{V}_i)_k$ = average induced velocity across the disk of the k^{th} rotor, ft/sec

$a(i)$ = coefficients of the harmonics (functions of μ and λ of the k^{th} rotor)

Ψ_k = azimuth angle of Blade 1 of the k^{th} rotor

NHH = order of the highest harmonic

n = summation variable

Note that if the k^{th} rotor uses the quasi-static rotor analysis, only the constant term, a(1), is included in the equation (i.e., the value of the summation of the harmonics during a complete rotor revolution is assumed to be zero). The above statement applies to each rotor, independent of the analysis being used on the other rotor.

As implied by the j and k subscripts above, each table is assumed to correspond to the effect a particular rotor has on a particular surface, e.g., the effect of the main rotor on the left wing panel, the tail rotor on Stabilizing Surface No. 3. The 12 possible tables allow input of a separate table for each combination of the two rotors and the six surfaces (two wing panels and four stabilizing surfaces).

It is emphasized that in preparing an RWAS table the input coefficients must be normalized by the value of $\bar{V}_i$ which is computed in this program for the appropriate rotor. Since inputs to the aerodynamic surface groups noted above can assign any one of the RWAS tables to simulate the defined effect of that input, care must be exercised to assure that the table used is based on the correct rotor-induced velocity and surface location. For example, XSTB2(32) can be used to specify the table which gives the effect of the tail-rotor-induced velocity on Stabilizing Surface No. 3; the referenced table must then have been normalized by the $\bar{V}_i$ of the tail rotor, and the μ and λ inputs must be for the tail rotor.

The composition of an RWAS table is essentially the same as an RIVD table except that the velocity computed from an RWAS table is not dependent on blade radial station and λ is used as an independent variable instead of α_R. Hence, each set of coefficients in an RWAS table corresponds to the wake velocity at specified values of μ and λ and at a specific location with respect to the appropriate rotor. The number of sets of coefficients in a table and the number of coefficients in a set are defined by the inputs on the Title and Control Card. The permissible values of the integer inputs on this card are:

Number of advance ratios:	$1 \leq NMU \leq 10$
Number of inflow ratios:	$1 \leq NLM \leq 5$
Number of harmonics:	$0 \leq NHH \leq 7$

If NMU or NLM is input as zero, it is reset to unity. Hence, each RWAS table may consist of 1 to 6 sets of 1 to 3 coefficients (1 to 18 entries).

3.12 FUSELAGE GROUP (Include this group only if IPL(1) = 0)

3.12.1 Basic Inputs

CARD 101

Gross weight, XFS(1), is the total weight of the baseline configuration being simulated; i.e., it includes the fuselage, pylons, landing gear, empennage, rotors, fuel, crew, etc. However, this number must not include the weight of external stores included in the Store/Brake Group. Store weight is added to XFS(1) prior to commencing the TRIM procedure.

The Fuselage Data Reference Point defines the point of application of body lift, drag, and side force. When the inputs on CARDS 103 through 10E are based on wind tunnel data, the data reference point is the point on the wind tunnel model (in terms of full-scale inches) about which the force and moment data were resolved in data reduction.

CG location is for the total weight of the baseline configuration to be simulated, i.e., XFS(1), with 0 degrees mast tilt, stores off, and rotors unfolded. The cg location is internally recalculated prior to commencing the TRIM procedure for nonzero mast tilt with nonzero pylon weight, store weights greater than zero, and rotor folding. Note that the longitudinal centerline of the airframe must be buttline zero to be compatible with the aerodynamic surface and jet thrust models. Hence, lateral cg location must be with respect to this line.

CARD 102

Inertias are for the gross weight and cg location input on CARD 101, i.e., the total aircraft less stores. They are internally recalculated when external stores are added by the input data and when they are dropped during a maneuver.

The program contains two models for the fuselage aerodynamic forces and moments:

(1) the Nominal Angle Equation (NAE) model and
(2) the High Angle Equation (HAE) model

The NAE model provides very precise simulation of wind tunnel data over a limited range of aerodynamic angles while the HAE model is less precise, but provides simulation at all possible aerodynamic angles.

With the equation use indicator, XFS(12), and low and high phasing angles, XFS(13) and XFS(14) respectively, the user can specify the flight regime on which the inputs to the NAE model are based and the aerodynamic angles where the program changes from the NAE model to the phasing region to the HAE model. This option allows the user to obtain the more precise simulation provided by the NAE model in the flight regime for which the most accurate data is available.

The program calculates a complex angle of attack, α_c, which includes both angle of attack and sideslip. In forward flight it is defined as

$$\alpha_c = \cos^{-1} (u_{fus}/V)$$

where

u_{fus} = the body axis x velocity, including the components of rotor downwash in the body x direction

$V = \sqrt{u_{fus}^2 + w_{fus}^2}$

w_{fus} = the body axis z velocity, including the components of rotor downwash in the body z direction.

This angle determines which model is to be used.

For the normal situation when flight test or analytical data are input to the NAE model, the simplest procedure is to set XFS(12), (13), and (14) all to zero. For these inputs, the NAE model will be used only when α_c is less than 15 degrees; the HAE model will be used only when α_c is greater than 35 degrees; and the two models will be phased together when α_c is between 15 and 35 degrees.

When both XFS(13) and (14) are input as zero, the program resets them to 15 and 35 degrees respectively as indicated above. For the case of forward-flight inputs to the NAE model, it is only necessary that XFS(12) = 0.0 and XFS(13) be less than XFS(14), not that all three be zero. If the test data input to the NAE model indicates that 15 and 35 are not the best phasing angles, the user should input better ones.

If test or analytical data is available for rearward or sideward flight, it is possible to specify that the NAE model inputs are from one of these flight regimes and that the model should be used in that flight regime.

To specify that the NAE model inputs are in a particular flight regime and are to be used there, use the following guidelines:

Forward Flight:	XFS(12) = 0.0,	$\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$
Rearward Flight:	XFS(12) = 0.0,	$\lvert XFS(13)\rvert \geq \lvert XFS(14)\rvert$
Left Sideward Flight:	XFS(12) $\neq$ 0.0,	$\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$
Right Sideward Flight:	XFS(12) $\neq$ 0.0,	$\lvert XFS(13)\rvert \geq \lvert XFS(14)\rvert$

When XFS(12) = 0.0, the definition of α_c is as above:

$$\alpha_c = \cos^{-1}(u/V)$$

However, when XFS(12) $\neq$ 0.0, the definition is

$$\alpha_c = \cos^{-1}(-v/V)$$

where v is the body axis Y velocity.

In other words, for XFS(12) = 0.0 (forward or rearward flight), α_c is with respect to the positive body X axis while for XFS(12) $\neq$ 0.0 (sideward flight), α_c is with respect to the negative body Y axis.

The regions where the NAE and HAE models are active and the region where they are phased together are then a function only of the relative magnitudes of XFS(13) and XFS(14).

If $\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$, then only the NAE model is active when

$$0 \leq \lvert\alpha_c\rvert \leq \lvert XFS(13)\rvert$$

while only the HAE model is active when

$$\lvert XFS(14)\rvert \leq \lvert\alpha_c\rvert \leq 180$$

and the models are phased together when

$$\lvert XFS(13)\rvert < \lvert\alpha_c\rvert < \lvert XFS(14)\rvert$$

If XFS(13) $\geq$ XFS(14), then only the NAE model is active when

$$180 \geq \lvert\alpha_c\rvert \geq \lvert XFS(13)\rvert$$

while only the HAE model is active when

$$|XFS(14)| \geq |\alpha_c| \geq 0$$

and the models are phased together when

$$|XFS(13)| > |\alpha_c| > |XFS(14)|$$

The Nominal Angle Equation (NAE) and High Angle Equation (HAE) for a specific force or moment are phased together in the appropriate region by the following relationship:

$$(\text{Force or moment}) = (\text{NAE})*\cos^2(\alpha_{ph}) + (\text{HAE})*\sin^2(\alpha_{ph})$$

where $\alpha_{ph} = 0.5\ [\alpha_c - XFS(13)]/[XFS(14) - XFS(13)]$

3.12.2 Aerodynamic Forces and Moments (Wind Axis Inputs)

CARDS 103 through 10E contain the coefficients of the High Angle and Nominal Angle Equations. As shown in the input guide (Section 2.12.2), the coefficients for each force and moment are grouped together on sets of two cards each. Most inputs are described as partial derivatives of the force or moment divided by dynamic pressure with respect to θ_w and/or ψ_w. The remaining inputs are angles and semidimensional forces and moments. Since rotorcraft do not have a generally accepted reference area and volume for completely nondimensionalizing fuselage force and moment data, the coefficients are left in units of square feet of force and cubic feet of moment per degree to a specified power. The per-degree units are used only to give as much physical meaning to the inputs as possible. All inputs with per-degree units are actually coefficients of a sinusoid and are converted to per-radian units by the program. The angles θ_w and ψ_w are the fuselage aerodynamic pitch and yaw angles respectively and are defined as

$$\theta_w = \tan^{-1}(w/u)$$

$$\psi_w = -\sin^{-1}(v/V)$$

where u, v, and w are respectively the x, y, and z body axis components of the free-stream (flightpath) velocity V. These are the angles normally recorded from a pyramidal balance during a wind tunnel test. Note that ψ_w is not sideslip angle.

The parameter q in the coefficient descriptions is dynamic pressure

$$q = 0.5 \rho V^2$$

where ρ is the air density.

Tables 8 through 13 contain the equations for the HAE and NAE models. Each table contains the equations for one of the forces or moments.

These equations were developed to provide very accurate simulation of wind tunnel data. The user is not expected to be able to define all 83 inputs without such test data. In particular, a complete set of inputs for the Nominal Angle Equations requires test data. If wind tunnel data are available, the digital computer program AN9101 described in Section 7.3 can be used to reduce the test data to coefficients which can be input directly to the program. If such data are not available, the 11 inputs with an asterisk beside them in Section 2.12.2 are considered to be the minimum necessary inputs. These inputs are XFS(15), (23), (29), (36), (37), (40), (43), (51), (64), (78), and (92). Each is a coefficient in one of the Nominal Angle Equations. By using only these 11 inputs, the user has, in effect, assumed that all aerodynamic angles in the simulation will be small, i.e., less than 10 to 15 degrees, and that aerodyanmic cross-coupling is negligible. Each Nominal Angle Equation which results from using only these eleven inputs is included in the appropriate table with the complete HAE and NAE models (Tables 8 through 13). The resulting equation is labeled as the Small Angle/Uncoupled Equation. These six equations are basically the same equations used in the AGAJ71 and earlier versions of C81.

When using the Small Angle/Uncoupled Equation all other inputs to the Nominal Angle Equations may be zero, and XFS(13) should be about 10 to 15 degrees, i.e., the accuracy limit of the input data. If the user is quite certain that α_c will not exceed XFS(13) during any simulation, the inputs to the HAE model may also be zero.

When the HAE model is needed, the inputs should be based on wind axis test data where the model was yawed to $\psi_w = \pm 180$ degrees at $\theta_w = 0$ and pitched to $\theta_w = \pm 90$ degrees at $\psi_w = 0$. If such data are not available, most of the inputs can be determined by estimating the fuselage drag and aerodynamic center location for sideward and vertical flight. The drag times the moment arms of the aerodynamic center about the data reference point will provide values for most of the moment inputs to the HAE model. Extrapolation of any available test data for a similar configuration could also be used.

TABLE 8. FUSELAGE LIFT EQUATIONS

High Angle Equation

$$L = q(L_1*\cos^2\psi_w + L_2*\sin^2\psi_w)$$

where $L_1 = \begin{cases} XFS(15) + L_3*\sin^2\theta_w + L_4*\sin(2\theta_w) & \text{if } |\psi_w| \le 90 \\ XFS(19) - L_5*\cos^2\theta_w - L_4*\sin(2\theta_w) & \text{if } |\psi_w| > 90 \end{cases}$

$L_2 =$ $XFS(20)*\cos\theta_w + XFS(57)*\sin\theta_w$

$L_3 =$ $XFS(19) - XFS(15)$

$L_4 =$ $\dfrac{[XFS(17) - XFS(15) - L_3*\sin^2(XFS(18)/RTD]}{\sin(2*XFS(18)/RTD)}$

$L_5 =$ $XFS(19) - XFS(16)$

Nominal Angle Equation

$$\begin{aligned} L = q\{&[L_0/q + XFS(21)*RTD*\sin\psi_w + XFS(22)*RTD^2*\sin^2\psi_w] \\ &+ 0.5*[XFS(23)*RTD + XFS(24)*RTD^2*\sin\psi_w \\ &\quad + XFS(25)*RTD^3*\sin^2\psi_w]\sin(2\theta_w) \\ &+ 0.25*[XFS(26)*RTD^2 + XFS(27)*RTD^3*\sin\psi_w]*\sin^2(2\theta_w) \\ &+ 0.125*XFS(28)*RTD^3*\sin^3(2\theta_w)\} \end{aligned}$$

where L_0/q =
- $XFS(15)$ if $XFS(12) = 0.0$ and $XFS(13) < XFS(14)$
- $XFS(16)$ if $XFS(12) = 0.0$ and $XFS(13) \geq XFS(14)$
- $XFS(20)$ if $XFS(12) \neq 0$

Small Angle/Uncoupled Equation

$$L = q(L_0/q + XFS(23)*\theta_w)$$

where L_0/q is defined above

θ_w is in degrees

L = Lift in pounds (wind axis system)

XFS(15) through XFS(28) are the inputs on CARDS 103 and 104

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 9. FUSELAGE DRAG EQUATIONS

<u>High Angle Equation</u>

$$D = q[D_1*\cos^2\psi_w + XFS(31)*\sin^2\psi_w]$$

where $D_1 = D_2*\cos^2\theta_w + D_v*\sin^2\theta_w$

$$D_2 = \begin{cases} XFS(29) \text{ if } |\psi_w| \le 90 \\ XFS(30) \text{ if } |\psi_w| > 90 \end{cases}$$

$$D_v = \begin{cases} XFS(32) \text{ if } \theta_w \le 0 \\ XFS(33) \text{ if } \theta_w > 0 \end{cases}$$

<u>Nominal Angle Equation</u>

$$D = q\{[D_0/q + XFS(35)*RTD*\sin\psi_w + XFS(36)*RTD^2*\sin^2\psi_w]$$
$$+ [XFS(37)*RTD + XFS(38)*RTD^2*\sin\psi_w + XFS(39)*RTD^3*\sin^2\psi_w]*\sin\theta_w$$
$$+ [XFS(40)*RTD^2 + XFS(41)*RTD^3*\sin\psi_w]*\sin^2\theta_w$$
$$+ XFS(42)*RTD^3*\sin^3\theta_w\}$$

where
$$D_0/q = \begin{cases} XFS(29) \text{ if } XFS(12) = 0 \text{ and } XFS(13) < XFS(14) \\ XFS(30) \text{ if } XFS(12) = 0 \text{ and } XFS(13) \ge XFS(14) \\ XFS(31) \text{ if } XFS(12) \ne 0 \end{cases}$$

<u>Small Angle/Uncoupled Equation</u>

$$D = q[D_0/q + XFS(37)*\theta_w + XFS(40)*\theta_w^2 + XFS(36)*\psi_w^2]$$

where D_0/q is defined above

θ_w and ψ_w are in degrees

D = Drag in pounds (wind axis system)

XFS(29) through XFS(42) are the inputs on CARDS 105 and 106

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 10. FUSELAGE PITCHING MOMENT EQUATIONS

High Angle Equations

$$M = q[M_1*\cos^2\psi + M_2*\sin^2\psi]$$

where $M_1 = \begin{cases} XFS(43) + M_3*\sin^2\theta_w + M_4*\sin(2\theta_w) & \text{if } |\psi_w| \le 90 \\ XFS(47) - M_5*\cos^2\theta_w - M_4*\sin(2\theta_w) & \text{if } |\psi_w| > 90 \end{cases}$

$M_2 = XFS(85)*\sin\theta_w + XFS(48)*\cos^2\theta_w$

$M_3 = XFS(47) - XFS(43)$

$$M_4 = \frac{[XFS(45) - XFS(43) - M_3*\sin^2(XFS(46)/RTD)]}{\sin(2*XFS(46)/RTD)}$$

$M_5 = XFS(47) - XFS(44)$

Nominal Angle Equation

$$M = q\{[M_0/q + XFS(49)*RTD*\sin\psi_w + XFS(50)*RTD^2*\sin^2\psi_w]$$
$$+ 0.5*[XFS(51)*RTD + XFS(52)*RTD^2*\sin\psi_w + XFS(53)*RTD^3*\sin^2\psi_w]*\sin(2\theta_w)$$
$$+ 0.25*[XFS(54)*RTD^2 + XFS(55)*RTD^3*\sin\psi_w]*\sin^2(2\theta_w)$$
$$+ 0.125*XFS(56)*RTD^3*\sin^3(2\theta_w)\}$$

where $M_0/q = \begin{cases} XFS(43) & \text{if } XFS(12) = 0 \text{ and } XFS(13) < XFS(14) \\ XFS(44) & \text{if } XFS(12) = 0 \text{ and } XFS(13) \ge XFS(14) \\ XFS(48) & \text{if } XFS(12) \ne 0 \end{cases}$

Small Angle/Uncoupled Equation

$$M = q(M_0/q + XFS(51)*\theta_w)$$

where θ_w is in degrees and M_0/q is defined above

M = Pitching Moment in foot-pounds (wind axis system)

XFS(43) through XFS(56) are the inputs on CARDS 107 and 108

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 11. FUSELAGE SIDE FORCE EQUATIONS

High Angle Equation

$$Y = q[Y_1*\cos^2\theta_w - XFS(20)*\sin^2\theta_w*\sin\psi_w]$$

where $$Y_1 = XFS(57)*\sin\psi_w + Y_2*\sin(2\psi_w)$$

$$Y_2 = \frac{[XFS(58) - XFS(57)*\sin(XFS(59)/RTD)]}{\sin(2*XFS(59)/RTD)}$$

Nominal Angle Equation

$$\begin{aligned} Y = q\{&[XFS(60) + XFS(61)*RTD*\sin\theta_w + XFS(62)*RTD^2*\sin^2\theta_w \\ &+ XFS(63)*RTD^3*\sin^3\theta_w] \\ &+ 0.50*[XFS(64)*RTD + XFS(65)*RTD^2*\sin\theta_w + XFS(66)*RTD^3*\sin^2\theta_w]*\sin(2\psi_w) \\ &+ 0.25*[XFS(67)*RTD^2 + XFS(68)*RTD^3*\sin\theta_w]*\sin^2(2\psi_w) \\ &+ 0.125*[XFS(69)*RTD^3 + XFS(70)*RTD^4*\sin\theta_w]*\sin^3(2\psi_w)\} \end{aligned}$$

Small Angle/Uncoupled Equation

$$Y = q(XFS(60) + XFS(64) * \psi_w)$$

where ψ_w is in degrees

Y = Side Force in pounds (wind axis system)

XFS(57) through XFS(70) are the inputs on CARDS 109 and 10A

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 12. FUSELAGE ROLLING MOMENT EQUATIONS

High Angle Equation

$$\ell = q[\ell_1 * \cos^2\theta_w + XFS(71) * \sin^2\theta_w * \sin\psi_w]$$

where $\ell_1 = XFS(71) * \sin\psi_w + \ell_2 * \sin(2\psi_w)$

$$\ell_2 = \frac{[XFS(72) - XFS(71) * \sin(XFS(73)/RTD)]}{\sin(2 * XFS(73)/RTD)}$$

Nominal Angle Equation

$$\ell = q\{[XFS(74) + XFS(75) * RTD * \sin\theta_w + XFS(76) * RTD^2 * \sin^2\theta_w + XFS(77) * RTD^3 \sin^3\theta_w]$$
$$+ 0.5 * [XFS(78) * RTD + XFS(79) * RTD^2 * \sin\theta_w + XFS(80) * RTD^3 * \sin^2\theta_w] * \sin(2\psi_w)$$
$$+ 0.25 * [XFS(81) * RTD^2 + XFS(82) * RTD^3 * \sin\theta_w] * \sin^2(2\psi_w)$$
$$+ 0.125 * [XFS(83) * RTD^3 + XFS(84) * RTD^4 * \sin\theta_w] * \sin^3(2\psi_w)\}$$

Small Angle/Uncoupled Equation

$$\ell = q(XFS(74) + XFS(78) * \psi_w)$$

where ψ_w is in degrees

ℓ = Rolling Moment in foot-pounds (wind axis system)

XFS(71) through XFS(84) are the inputs on CARDS 10B and 10C

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 13. FUSELAGE YAWING MOMENT EQUATIONS

High Angle Equation

$$N = q[N_1*\cos^2\theta_w - XFS(48)*\sin^2\theta_w*\sin\psi_w]$$

where
$$N_1 = XFS(85)*\sin\psi_w + N_2*\sin(2\psi_w)$$

$$N_2 = \frac{[XFS(86) - XFS(85)*\sin(XFS(87)/RTD)]}{\sin(2*XFS(87)/RTD)}$$

Nominal Angle Equation

$$N = q\{[XFS(88) + XFS(89)*RTD*\sin\theta_w + XFS(90)*RTD^2*\sin^2\theta_w + XFS(91)*RTD^3*\sin^3\theta_w]$$
$$+ 0.5*[XFS(92)*RTD + XFS(93)*RTD^2*\sin\theta_w + XFS(94)*RTD^3*\sin^2\theta_w]\sin(2\psi_w)$$
$$+ 0.25*[XFS(95)*RTD^2 + XFS(96)*RTD^3*\sin\theta_w]\sin^2(2\psi_w)$$
$$+ 0.125*[XFS(97)*RTD^3 + XFS(98)*RTD^4*\sin\theta_w]\sin^3(2\psi_w)\}$$

Small Angle/Uncoupled Equation

$$N = q(XFS(88) + XFS(92) * \psi_w)$$

where ψ_w is in degrees

N = Yawing Moment in foot-pounds (wind axis system)

XFS(85) through XFS(98) are the inputs on CARDS 10D and 10E

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

3.12.3 Accelerations at a Specified Point on the Airframe

CARDS 10D through 10J must be input whenever IPL(9) $\neq$ 0. The data on these cards are used to compute the accelerations at a given airframe location for each of the pylon modes. The data on CARD 10F define the location of the point and the data on CARDS 10G through 10J give the linear components of each pylon mode at that point.

The moment arms from the airframe center of mass to the specified point are defined as

$$X_p = (X_{cg} - XFSMS(1,1)) \quad \text{(positive forward)}$$

$$Y_p = -(Y_{cg} - XFSMS(2,1)) \quad \text{(positive to the right)}$$

$$Z_p = (Z_{cg} - XFSMS(3,1)) \quad \text{(positive down)}$$

Given the linear and angular accelerations of the center of mass, ($\ddot{X}_{cg}$, $\ddot{Y}_{cg}$, $\ddot{Z}_{cg}$, $\ddot{\theta}_x$, $\ddot{\theta}_y$, $\ddot{\theta}_z$), the linear accelerations at the specified point are

$$\ddot{X}_p = (\ddot{X}_{cg} + \sum_n \ddot{q}_n \, \delta_{x_n} + Z_p\ddot{\theta}_y - Y_p\ddot{\theta}_z)$$

$$\ddot{Y}_p = (\ddot{Y}_{cg} + \sum_n \ddot{q}_n \, \delta_{y_n} + X_p\ddot{\theta}_z - Z_p\ddot{\theta}_x)$$

$$\ddot{Z}_p = (\ddot{Z}_{cg} + \sum_n \ddot{q}_n \, \delta_{z_n} - X_p\ddot{\theta}_y + Y_p\ddot{\theta}_x)$$

where

$\ddot{q}_n$ is the second derivative of the modal participation factor of the n^{th} pylon mode

δ_{x_n} is the x-component of the n^{th} pylon mode at the specified point

δ_{y_n} is the y-component

δ_{z_n} is the z-component

The accelerations are output in g's. $\ddot{X}_p$ is positive forward, $\ddot{Y}_p$ is positive to the right and $\ddot{Z}_p$ is positive down.

3.13 LANDING GEAR GROUP

The landing gear analysis has not yet been inserted in C81. The user may input the landing gear data described in Section 2.13, but it will not have any effect on the analysis.

3.14 <u>WING GROUP</u> (Omit entire group if IPL(1) = 0 or IPL(15) = 0)

3.14.1 Basic Model

CARD 121

Wing area should include carry-through area if any. The program divides the area equally between the left and right wing panels.

The center of pressure and dihedral angle inputs (XWG(2), (3), (4), and (6)) are for the right wing panel. The left panel is assumed to be symmetrical to the right panel about the zero buttline plane. XWG(5) is the incidence angle of each panel when all primary flight controls are at 50 percent and the control surface deflection is zero. It is positive for leading edge up. Positive dihedral angle, XWG(6), means the outboard tip of each panel is up. See Figure 28.

The sweepback angle, XWG(7), is positive aft.

CARD 122

The geometric aspect ratio, XWG(8), is to be defined by the planform area in the plane of the sweepback angle and the span in the body Y-Z plane.

The spanwise efficiency factor, XWG(9), relates the geometric aspect ratio to the effective aspect ratio. See Section 3.14.2 for further details. A value of 0.66 to 0.70 has generally been used with success.

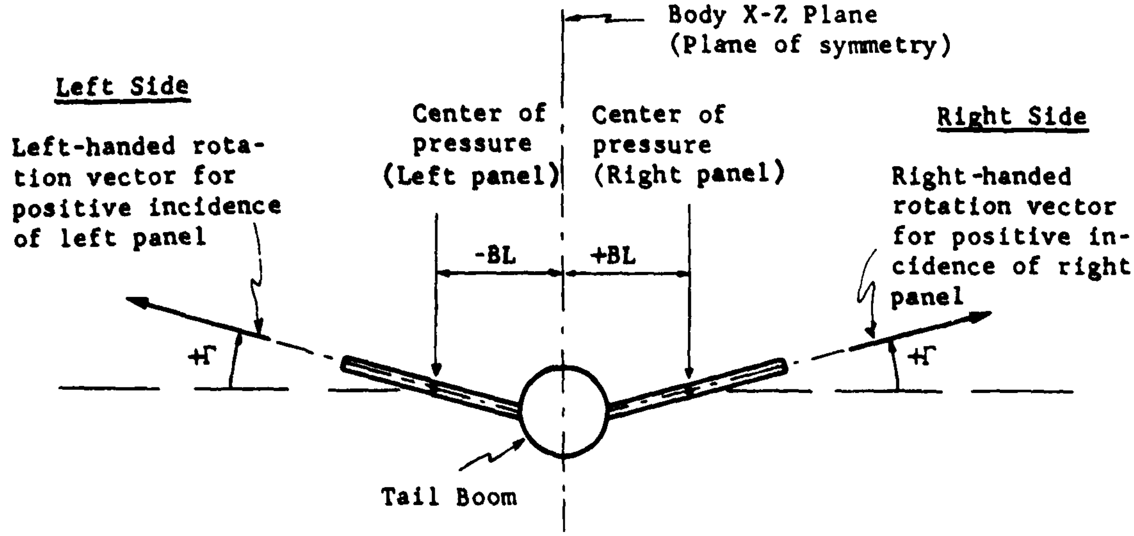
The taper ratio of the surface, XWG(10), is equal to the surface tip chord divided by the root chord; e.g., 1.0 is a parallelogram, 0.0 is a triangle.

XWG(11) and XWG(13) are used in calculating dynamic pressure loss at the stabilizing surfaces due to the wing, as discussed at the end of this section. The Wing Group does not have a counterpart to XSTB(11), the tailboom bending coefficient. Although similar in use, XWG(13) and XSTB1(13) are not necessarily equal. NACA reports have recommended a value of 2.42 for XWG(11).

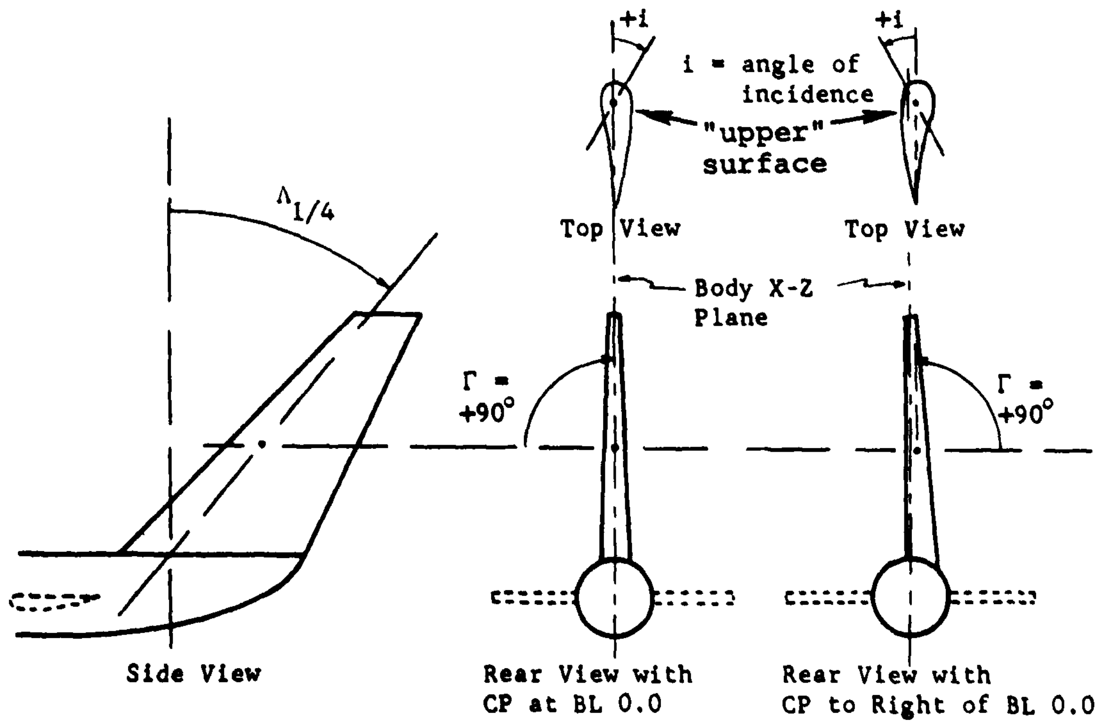
XWG(12) is the dynamic pressure loss at the wing due to the fuselage.

$$q_{wing} = q_{freestream} (1.0 - XWG(12))$$

Control surface deflection, XWG(14), is positive for trailing edge down.



(a) Rear View of Wing or Symmetrical Horizontal Stabilizer With Positive Dihedral.



(b) Three-View of Swept Vertical Stabilizer With Center of Pressure on and to the Right of the Fuselage Plane of Symmetry.

Figure 28. Aerodynamic Surface Dihedral and Incidence Angles.

CARD 123

The model for changing surface lift coefficient, maximum lift coefficient, drag coefficient, and pitching moment coefficient with control surface, or flap, deflection is based on analysis and data from Reference 3 and Chapter 6 of Reference 4. The change in lift coefficient due to flap deflection, δ_f, is

$$(\Delta C_L)_f = XWG(15)*\delta_f + XWG(16)*\delta_f*|\delta_f|$$

and the change in maximum lift coefficient is

$$(\Delta C_L)_{max} = XWG(17)*\delta_f + XWG(18)*\delta_f^2 + (\Delta C_L)_f$$

The inputs XWG(17) and XWG(18) account for the situation where the maximum lift coefficient is increased more or less than the change in lift coefficient.

The change in profile drag coefficient due to flap deflection is

$$(\Delta C_D)_f = XWG(19)*\delta_f + XWG(20)*\delta_f^2$$

CARD 124

The change in pitching moment coefficient due to flap deflection is

$$(\Delta C_M)_f = XWG(22)*\delta_f + XWG(23)*\delta_f*|\delta_f|$$

CARD 125

XWG(29) through (32) control the effect of the wake from each rotor on the flow field at each wing panel. These effects are represented by superimposing two velocity vectors (one from each rotor) on the flow field at each panel. Each velocity vector is a function of the induced velocity at the specified rotor disc. The function may be either a constant or a value obtained from a Rotor Wake at Aerodynamic Surface (RWAS) Table. It is necessary that the four functions all be constants or all be from RWAS tables; combinations of constants and tables are not permitted.

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[3]Young, A. D., THE AERODYNAMIC CHARACTERISTICS OF FLAPS, British Aeronautical Research Council RM No. 2622, February 1947 (also printed as R.A.E. Report Aero. 2185, August 1947).

[4]McCormick, B. W., Jr., AERODYNAMICS OF V/STOL FLIGHT, Academic Press, New York, 1967, pp. 167-193.

The magnitude of these wake effect inputs controls which function will be used. If the inputs are less than or equal to 100, four velocity vectors will be computed using the input values as constant factors:

$$(\Delta\vec{V})_{1R} = XWG(29)*(\bar{V}_i)_1$$

$$(\Delta\vec{V})_{1L} = XWG(30)*(\bar{V}_i)_1$$

$$(\Delta\vec{V})_{2L} = XWG(31)*(\bar{V}_i)_2$$

$$(\Delta\vec{V})_{2R} = XWG(32)*(\bar{V}_i)_2$$

where $\Delta\vec{V}$ is the velocity to be superimposed, and $\bar{V}_i$ is the average induced velocity at the rotor disc.

The numerical subscripts refer to the rotor (1 = main, 2 = tail), and the alphabetical subscripts to the wing panel (R = right, L = left). The velocities are defined to be parallel to their associated rotor shaft.

If the four inputs are greater than 100, 100 is subtracted from each input, and the RWAS table with the corresponding input sequence number is then used to supply a number that replaces the appropriate XWG input in the above equations. For example, if XWG(30) = 104.0, the fourth RWAS table will be used to compute the velocity vector at the left wing panel due to the main rotor wake.

It is emphasized that if one effect is to be represented by a constant, all four effects must be represented by a constant; similarly, if one effect is to be represented by a table, all must be represented by a table. When using tables, care should be exercised to assure that the proper table is used. See Section 3.11 for a discussion of the RWAS tables. However, these restrictions on tables or constants apply only to a single aerodynamic surface; i.e., the type of representation used by the wing or any one of the four stabilizing surfaces does not affect the representation used by any other aerodynamic surface.

CARDS 126 and 127

Inputs XWG(33) through XWG(42) are based on data from Reference 5 (pp. 486-495). They are used to calculate the wing contribution to static and dynamic stability. The static derivatives (those which are coefficients of β) may be included in the fuselage group aerodynamics or simulated with appropriate values of wing sweep and/or dihedral. If this is done, XWG(33), (34), (37), and (38) should be set to zero. It is not possible to simulate the dynamic derivatives (those which are coefficients of p and r) with any other section of the program. In the Force and Moment Summary of the program output, one-half of the increments to the rolling and yawing moments calculated from the equations below is added to each wing panel.

$$\Delta L_W = F\Big[\beta*[XWG(33) + XWG(34)*C_L] + ts*[XWG(35)*r*C_L + XWG(36)*p]\Big]$$

and

$$\Delta N_W = F\Big[\beta*[XWG(37) + XWG(38)*C_L{}^2] + ts*[r*\{XWG(39)*C_L{}^2 + XWG(40)*C_{D_O}*\cos\beta\} + p*\{XWG(41)*C_L + XWG(42)*(dC_D/d\alpha)*\cos\beta\}]\Big]$$

where

F = $0.5\rho SV^2B$

ts = 0.5 B/V

V = airspeed

B = wing span

S = wing area

β = sideslip angle

α = wing angle of attack

p = roll rate of fuselage in the stability axis system

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[5] Etkin, Bernard, DYNAMICS OF FLIGHT, New York, John Wiley and Sons, Inc., 1959, pp. 486-495.

r = yaw rate of fuselage in the stability axis system

L = roll moment of wings due to rates and sideslip

N = yaw moment of wings due to rates and sideslip

ΔL_W and ΔN_W are computed in the stability axis system and are resolved into the body axis system.

3.14.2 Aerodynamic Inputs for Stabilizing Surfaces and Wing

The last four cards of each aerodynamic surface input group are termed the aerodynamic inputs: YWG(1-28), YSTB1(1-28), YSTB2(1-28), YSTB3(1-28), and YSTB4(1-28). These inputs are used in conjunction with inputs from the corresponding XWG or XSTBi (i=1 to 4) arrays to compute the lift, drag, and pitching moment coefficients of each surface. The user has the option of specifying that the coefficients be computed from equations or obtained from data tables. In the following discussion, Y(I) refers to the I^{th} aerodynamics input, YWG(I) or YSTBi(I), for the appropriate aerodynamic surface and X(J) refers to the J^{th} input in the corresponding XWG or XSTBi array.

If the control variable Y(18) = 0, subroutine CLCD computes the aerodynamic coefficients from equations as functions of the angle of attack, α; angle of sideslip, β; Mach number, M; surface planform geometry; and the spanwise efficiency factor, e. If Y(18)>0, the data tables are used to compute the coefficients as described at the end of this section and in the discussion of the Data Table Group.

When Y(18) = 0, the aerodynamic inputs are coefficients of equations that describe the infinite aspect ratio, or two-dimensional, aerodynamic coefficients of the airfoil section of the surface. It is assumed that the section is constant along the span and parallel to the longitudinal centerline of the aircraft. Subroutine CLCD then corrects the input data for finite aspect ratio, A; sweepback of the quarter chord line, $\Lambda_{1/4}$; sideslip angle between the airfoil section and local flow, β; change in maximum lift coefficient due to control surface deflection; and change in lift, drag, and pitching moment coefficients due to control surface deflection. Note that all angles of attack used in this model are zero lift line angles of attack. The model was developed to simulate the characteristics of symmetrical airfoils. If cambered airfoils are to be modeled and the angle between the chordline and zero lift line of the section is more than a few degrees, it is suggested that data tables rather than equations be used.

The geometry and effectiveness of the surface are defined from the following inputs.

$\bar{y}$ = buttline of surface center of pressure = X(3)

$\Lambda_{1/4}$ = sweepback of quarter chord = X(7)

A = geometric aspect ratio = X(8)

e = spanwise efficiency factor = X(9)

λ = taper ratio of surface = X(10)

The spanwise efficiency factor, e, should be unity for the ideal case where the surface has an elliptical lift distribution and uniform downwash. However, the ideal case is the exception, not the rule, and the value of e is rarely unity. Factors which affect the value of e are the geometry of the surface (including aspect ratio, taper, and sweep) and the degree of end plating caused by adjacent structure.

Analytical prediction of e is difficult at best. A surface which has a large end plate (e.g., a T-tail) may have a value of e as high as 1.5 or more. A straight untapered, unswept surface may have a value of e as low as 0.6 or less. A typical value of e for unend-plated aerodynamic surfaces on helicopters is about 0.7. The user should consult such reference books as Etkin, DATCOM, Perkins and Hage, or Dommasch (References 5, 6, 7, and 8) to obtain a more intuitive feel for the value which should be chosen for this spanwise efficiency factor.

Using the above parameters, the sweepback of the half chord, $\Lambda_{1/2}$, is

$$\Lambda_{1/2} = \tan^{-1} \left[\tan \Lambda_{1/4} - (1 - \lambda)/(A(1 + \lambda))\right]$$

and the effective sweepback angle, Λ^*, and effective aspect

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[6]USAF STABILITY AND CONTROL DATCOM, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, February 1972.

[7]Perkins, C. D., and Hage, R. E., AIRPLANE PERFORMANCE STABILITY AND CONTROL, John Wiley and Sons, Inc., New York 1967, page 93.

[8]Dommasch, D. O., Sherby, S. S., and Conolly, T. F., AIRPLANE AERODYNAMICS, Pitman Publishing Corporation, New York 1967, page 158.

ratio, A^*, are

$$\Lambda^* = \Lambda_{1/2} - (\text{sign } \bar{y})\beta$$

$$A^* = eA \cos^2 (\Lambda^*)/ \cos^2 (\Lambda_{1/2})$$

Let α_1 be the angle of attack input to CLCD and assume that

$$-180° < \alpha_1 \leq 180°$$

Then for unstalled flow, the two-dimensional subsonic lift curve slope, a_o, is defined as

$$a_o = Y(8) + Y(9)*M + Y(10)*M^2 + Y(11)*M^3$$

the three-dimensional subsonic lift curve slope, a_1, as

$$a_1 = (2\ A^*/57.3)\Big/\left[2 + \sqrt{(2\ A^*/a_o)^2\ [1 + \{\tan^2\Lambda^*/(1-M^2)\}] + 4}\right]$$

the transonic lift curve slope, a_2, as

$$a_2 = B_o + B_1\ M + B_2\ M^2$$

and the supersonic lift curve slope, a_3, as

$$a_3 = (4/57.3)/\sqrt{M^2 - 1}$$

The input value for the lower boundary of the supersonic region, Y(2), is checked against a calculated value M_{sc}:

$$M_s = \text{Max}\ \{Y(2),\ M_{sc}\}$$

where

$$M_{sc} = \sqrt{1 + [(4/57.3)/(a_1)_{CR}]^2}$$

and $(a_1)_{CR}$ is a_1 evaluated at the drag divergence Mach number, Y(1). The coefficients B_0, B_1, and B_2 are computed internally by equating a_2 to a_1 and a_3, and the slope of a_2 to that of a_3 as follows:

$$a_2 = a_1 \qquad \text{at } M = Y(1),\ \beta = 0$$

$$a_2 = a_3 \qquad \text{at } M = M_s$$

$$\frac{da_2}{dM} = \frac{da_3}{dM} \qquad \text{at } M = M_s$$

Then the lift curve slope of the surface for unstalled flow, a, is defined as

$$a = \begin{cases} a_1 \text{ if } M < Y(1) \\ a_2 \text{ if } Y(1) \leq M < M_s \\ a_3 \text{ if } M_s \leq M \end{cases}$$

Having determined the unstalled lift curve slope, subroutine CLCD establishes the curve of C_L versus α for all the angles of attack.

If $\left|\alpha_1\right| \leq 90°$, i.e., forward flight,

$$\alpha = \left|\alpha_1\right|$$

$$SG = \alpha_1/\left|\alpha_1\right|$$

$$C_{L_0} = Y(3) + SG(\Delta C_L)_{max}$$

$$K_L = Y(4)*M + Y(5)*M^2 + Y(6)*M^3$$

$$\alpha_S = (C_{L_0} + K_L)/a$$

$$\alpha_B = \alpha_S + 5°$$

where $(\Delta C_L)_{max}$ is the increment to the maximum lift coefficient due to control surface deflection, as calculated in the aerodynamic surface section.

If $\alpha_1 > 90°$, i.e., rearward flight or reversed flow,

$$\alpha = 180° - |\alpha_1|$$

$$SG = -\alpha_1/|\alpha_1|$$

$$C_{L_0} = Y(7) + SG(\Delta C_L)_{max}$$

$$K_L = 0$$

$$\alpha_S = C_{L_0}/a$$

$$\alpha_B = \alpha_S + 5°$$

For $0 \leq \alpha \leq \alpha_B$

$$C_L' = a\alpha$$

If $C_L' \leq C_{L_0}$, then

$$C_L = C_L' + SG(\Delta C_L)_f$$

where $(\Delta C_L)_f$ is the increment to C_L due to flap deflection as calculated in the aerodynamic surface section.

If $C_L' > C_{L_0}$, then C_L is determined by linear interpolation in the following manner.

$$C_{L_{max}} = C_{L_0} + K_L + SG(\Delta C_L)_f$$

$C_{L_B} = C_L$ at $\alpha = \alpha_B$ as discussed below.

Then

$$C_L = C_{L_{max}} + (C_{L_{max}} - C_{L_B})(\alpha - \alpha_S)/5°$$

In either case, the induced angle of attack, α_i, is

$$\alpha_i = C_L/\ A^*$$

For $\alpha_B \le \alpha \le 90°$, the lift coefficient is calculated from the following empirical expression for C_L as a function of the equivalent two-dimensional angle of attack, α_2,

$$C_L = \left[\{2\ C_{L_0} \sin \alpha_2 - .81\}K_3 + 0.81\right] \cos \alpha_2 + SG^*(\Delta C_L)_f$$

$$K_3 = \begin{cases} 1 + 0.25\ M^4 \text{ if } M \le 1 \\ 0.84 + 0.082/(M-0.8) \text{ if } M > 1 \end{cases}$$

The value of C_{L_0} is based on the magnitude of α_1 as described above, and ΔC_L is the increment due to control surface deflection.

The angle α_2 is related to the angle α by the induced angle of attack, α_i.

$$\alpha_2 = \alpha - \alpha_i$$

where, as above, $\alpha_i = C_L/\ \pi A^*$

The angle α_2 represents the angle of attack needed on an infinite aspect ratio surface to provide the same lift as the aerodynamic surface in question.

Hence, C_L and α_i are functions of each other. Consequently, a small angle assumption is used for α_i and the above expressions for C_L, α_2, and α_i are rearranged to define α_i as a function of C_{L_0}, αk, and K_3.

Then

$$C_L = (A^*)\alpha_i$$

The form of the C_L versus α curve is shown in Figure 23 for zero control surface deflection. At point P_1 in the figure,

$$C_L = C_{L_0} + K_L$$

$$\alpha = \alpha_S = C_L/a$$

At point P_2 in Figure 23,

$$\alpha = \alpha_B$$

and C_L is defined by the procedure discussed for $\alpha_B \leq \alpha \leq 90°$. Control surface deflection shifts the curve vertically and may change the difference between C_L at $\alpha = 0$ and C_L at $\alpha = \alpha_S$.

The form of the C_D versus α curve is shown in Figure 24. At point P_3 in Figure 24, $\alpha = \alpha_x$ and $C_D = C_{D_x}$. The values of α_x are C_{D_x} are defined from the maximum value for nondivergent drag, Y(16); the stall angle, α_S; and the equation for non-divergent drag, $(C_D)_{ND}$.

$$(C_D)_{ND} = Y(12) + Y(13)*\alpha_2 + Y(14)*\alpha_2^2 + (\Delta C_D)_f$$

$$+ \text{Max}\ \{0,\ Y(19)*\alpha_2 - Y(1) + \text{Max}[M,\ 0.35]\}$$

where $\alpha_2 = \alpha - \alpha_1$, as in the model for lift coefficient,

$(\Delta C_D)_f$ = increment to profile drag due to control surface (flap) deflection and

C_{D_S} = $(C_D)_{ND}$ evaluated at $\alpha_2 = \alpha_S - (\alpha_i)_S$

If $C_{D_S} \leq Y(16)$

$$\alpha_X = \alpha_S - (\alpha_i)_S$$

$$C_{D_X} = C_{D_S}$$

If $C_{D_S} > Y(16)$

$$C_{D_X} = Y(16)$$

$$\alpha_X = \alpha_2 \text{ for } (C_D)_{ND} = Y(16)$$

Then, for $0 \leq \alpha \leq \alpha_X$

$$C_D = (C_D)_{ND}$$

and for $\alpha_X < \alpha \leq 90°$

$$\left[C_D = 2. + (\alpha_2 - 90°)^2(C_{D_X} - 2.)/(\alpha_X - 90°)^2\right]$$

In the supersonic region, $M > M_S$

$$C_D = \text{Min}\left[Y(16), \quad Y(12) + 4[(\alpha_2/57.3)^2 + Y(15)]/\sqrt{M^2 - 1}\right]$$

The value usually used for Y(15) is 0.04. The supersonic lift and drag for the wing and stabilizing surfaces is de-emphasized because this computer program was never intended to simulate such high-speed flight. The supersonic functions are included primarily because the C_L and C_D calculations were originally developed for the rotors and later were applied to the other aerodynamic surfaces. A secondary reason for this inclusion is to maintain the similarity between the input and mathematical models used for the aerodynamic surfaces (CLCD subroutine) and the rotors (CDCL subroutine).

Once determined, the C_L and C_D coefficients are assumed to act in an axis system which is pitched up α_i degrees with respect to the wind vector. Consequently, before returning the value of C_L and C_D to the aerodynamic surface section of the program, they are resolved back to wind axis,

$$C_{L_{wind}} = C_L \cos \alpha_i - C_D \sin \alpha_i * SG$$

$$C_{D_{wind}} = C_D \cos \alpha_i + C_L \sin \alpha_i * SG$$

The calculation of the aerodynamic pitching moment is performed in the same manner as for the rotor except that the section pitching moment coefficient, Y(25), is modified for sweep and aspect ratio effects. That is, substitute the following expression for Y(25) in the rotor discussion:

$$Y(25) = A^* \cos^2(\Lambda_{1/r})/(A^* + 2 \cos(\Lambda_{1/4})) + (\Delta C_M)_f$$

where $(\Delta C_M)_f$ is the increment to pitching moment due to control surface (flap) deflection.

It is possible to use sets of data tables for determining the aerodynamic coefficients as a function of α and M. The tables available for use are those input to the Data Table Group.

If Y(18) > 0, the Y(18)th airfoil data table is used to determine the coefficients as functions of α_1 and M.

<u>CAUTION</u>:

Coefficients obtained from tables are <u>not</u> corrected for aspect ratio or sweep effects. Hence, the data in tables to be used by aerodynamic surfaces must be for the specific surface which is being simulated, i.e., three-dimensional test data at zero sideslip. Data from tables are corrected for yawed flow and control surface deflection as follows:

$$C_L = [(C_L)_{Table} + (\Delta C_L)_f] \cos^2 (\Lambda^*)/\cos (\Lambda_{1/2})$$

$$C_D = [(C_D)_{Table} + (\Delta C_D)_f]$$

$$C_M = [(C_M)_{Table} + (\Delta C_M)_f] \cos^2 (\Lambda^*)/\cos (\Lambda_{1/2})$$

<u>NOTE</u>: If tables are used by the wing, the wing aerodynamic inputs should still be input to provide a realistic value for the stall angle, α_S. This angle is used in computing the effect of the wing on the flow field at the stabilizing surfaces.

3.14.3 Flow Field at Stabilizing Surfaces due to Wing

As mentioned in the discussion of Stabilizing Surface No. 1, the wing can affect the flow field at the stabilizing surfaces. It does so in the following manner.

A dynamic pressure reduction at each surface due to the wing is calculated using XWG(11) and (13). The equations used were taken from NACA Report Number 648, Reference 9. The general situation is shown in Figure 29.

The deflection of the centerline of the wing wake from the free-stream direction, ε_{wake}, is calculated from XWG(13).

$$\varepsilon_{wake} = XWG(13)*C_{L_{wing}}$$

The dynamic pressure loss, η_q, is represented as a functional part of the free-stream value such that

$$q_{reduced} = q_{free\ stream}(1-\eta_q)$$

The maximum value of η_q occurs at the center of the wing wake and at the trailing edge of the wing. The input XWG(11) is used to determine this maximum reduction, $\eta_{q_{max}}$.

$$\eta_{q_{max}} = XWG(11)* \quad C_{D_{wing}}{}^{1/2}$$

Then the dynamic pressure loss may be calculat~d at any point inside the wing wake.

$$\eta_q = \frac{\eta_{q_{max}} \cos^2 (\pi D/2h)}{(\xi + 0.3)}$$

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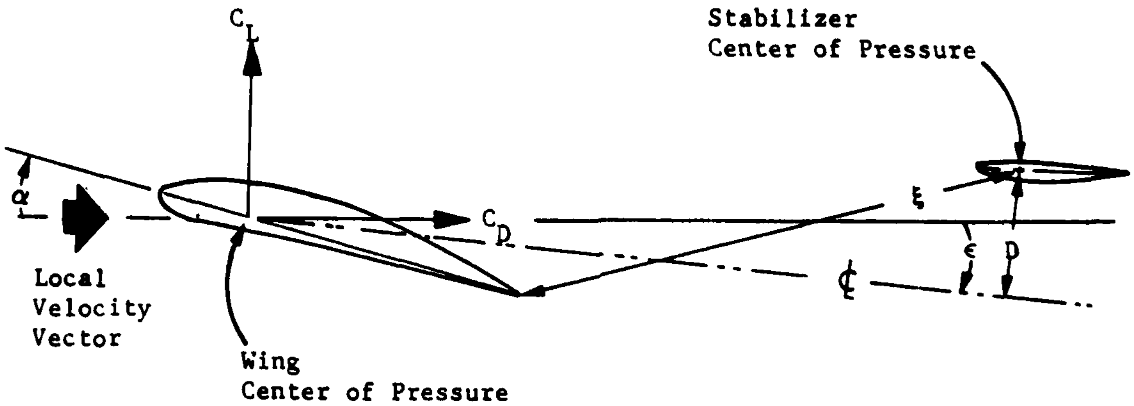
[9]Silverstein, A., and Katzoff, S., DESIGN CHARTS FOR PREDICTING DOWNWASH ANGLE AND WAKE CHARACTERISTICS BEHIND PLAIN AND FLAPPED WINGS, NACA Report No. 648, 1939.



℄ is the centerline of the wing wake.

The figure is in the body X-Z plane.

Figure 29. Wing Wake Model.

where

D is the vertical distance from the centerline of the wake to the elevator (as shown in Figure 29),

h is the half width of the wing wake at the elevator station, and

ξ is the distance of the elevator behind the wing trailing edge normalized by the wing mean aerodynamic chord (as shown in Figure 29).

D, h, and ξ are internally calculated based on wing/stabilizing surface geometry and aerodynamics.

In addition, a downwash angle at each surface due to the wing is computed using the 13th input of the appropriate stabilizing surface, e.g., XSTB1(13) for Surface No. 1. The angle for Surface No. 1 is then

$$\varepsilon_{wash} = XSTB1(13)*C_{L_{wing}}$$

Note that although XWG(13) and XSTB1(13) are used in similar-looking equations, they are different inputs and in most cases have different values.

Using ε_{wash} and η_q, the flow field is then modified at the stabilizing surface in the same manner as was done for the downwash and dynamic pressure reduction at the surface due to the fuselage.

See Section 3.14.2 for the discussion of the wing aerodynamic computations.

3.14.4 Control Linkage Inputs

Because of the similarity of the control linkage models for the wing and the stabilizing surfaces, the control linkage inputs for both are discussed in this section. The wing controls subgroup is XCWG, while the corresponding subgroups for the stabilizing surfaces are XCS1, XCS2, XCS3, and XCS4 for the first, second, third, and fourth surfaces, respectively. In the following discussion, the term XCSj(I) refers to the I^{th} input of the j^{th} stabilizing surface linkage subgroup. The wing linkage subgroup can be considered equivalent to the zeroth surface subgroup, i.e., XCS0(I) is synonymous with XCSW(I). Similarly, XSTBj(k) refers to the K^{th} input of the j^{th} basic surface group with XSTB0(K) and XWG(K) being equivalent.

The inputs to each subgroup define the control linkages from the primary flight controls and the longitudinal mast tilt angle of Rotor 1 to the incidence or control surface deflection angles of the corresponding aerodynamic surface. The linkages can be either linear or parabolic.

The reading of XCWG is controlled by IPL(15). If IPL(15) > 0, the XCWG inputs (CARDS 12B and 12C) must be included; if IPL(15) ≤ 0, the two cards must be omitted.

The read-in of the linkage subgroup for the stabilizing surface is controlled by IPL(16) through IPL(19). If one of these values is positive, then that Stabilizing Surface Group must include a Linkage Subgroup. If the value is negative, the Linkage Subgroup must be omitted.

Each subgroup uses the identical input format and the same mathematical model for calculating the increments to be added to the incidence or control surface deflection angle of the surface. However, the wing is divided into left and right panels, with the inputs controlling the right panel. For collective or longitudinal cyclic stick linkages, the increments are added to each wing panel symmetrically; for lateral cyclic stick or pedal position linkages, the increments for the left panel are the negative of those on the right (i.e., asymmetric deflection).

The primary flight controls cannot be linked to incidence and control surface deflection simultaneously. If XCSj(7) = 0, control linkages will change only the incidence angle, XSTBj(5), of the surface. If XCSj(7) ≠ 0, the linkage will change only the control surface deflection, XSTBj(14). During maneuvers, incidence and/or control surface deflection may be changed independently of the control linkages described in this section (see Section 3.28.2.27). Either or both angles can be changed in maneuver regardless of the value of XSCj(7).

XCSj(3), (6), (10), and (13) define breakpoints in the curves of the control linkages. These breakpoints permit control linkages that provide a zero increment to the appropriate angle of the surface if the control is to one side of the breakpoint and a nonzero value when the control is to the opposite side.

If XCSj(3) = 0.0, the increment for the j^{th} surface due to collective stick displacement is

$$(\Delta i_1)_j = XCSj(1) * K_1 + XCSj(2) * K_1^2$$

If XCSj(6) = 0.0, the increment for the j^{th} surface due to longitudinal cyclic stick displacement is

$$(\Delta i_2)_j = XCSj(4) * K_2 + XCSj(5) * K_2^2$$

If XCSj(10) = 0.0, the increment for the j^{th} surface due to lateral cyclic stick displacement is

$$(\Delta i_3)_j = XCSj(8) * K_3 + XCSj(9) * K_3^2$$

If XCSj(13) = 0.0, the increment for the j^{th} surface due to pedal displacement is

$$(\Delta i_4)_j = XCSj(11) * K_4 + XCSj(12) * K_4^2$$

where K_1, K_2, K_3, and K_4 are the control deflections in inches from the 50-percent control position. The total increment to the appropriate angle of the jth surface due to the primary flight controls is then

$$\Delta i_j = (\Delta i_1)_j + (\Delta i_2)_j + (\Delta i_3)_j + (\Delta i_4)_j$$

The effect of a nonzero breakpoint for the collective stick linkage, XCSj(3) $\neq$ 0, is discussed below. The effect of nonzero XCSj(6), (10), and (13) is identical.

If XCSj(3) > 0, then the control linkage is active only when the magnitude of the stick position is greater than the breakpoint, i.e.,

$$(\Delta i_1)_j = 0, \text{ if } \delta_{COLL} \leq XCSj(3)$$

$$= XCSj(1) * k_1 + XCSj(2) * k_1^2, \text{ if } \delta_{COLL} > XCSj(3)$$

and if XCSj(3) < 0, then the control linkage is active only when the magnitude of the stick position is less than the magnitude of the breakpoint, i.e.,

$$(\Delta i_1)_j = 0, \text{ if } \delta_{COLL} \geq XCSj(3)$$

$$= XCSj(1) * k_1 + XCSj(2) * k_1^2, \text{ if } \delta_{COLL} < |XCSj(3)|$$

where $k_1 = (\delta_{COLL} - XCSj(3)) * XCON(1)/100$.

For constant values of XCSj(1) and (2), the effect of the breakpoint on the increment is shown in Figure 30.

Similarly, the increment due to longitudinal cyclic with XCSj(6) ≠ 0 is as follows:

if XCSj(6) > 0,

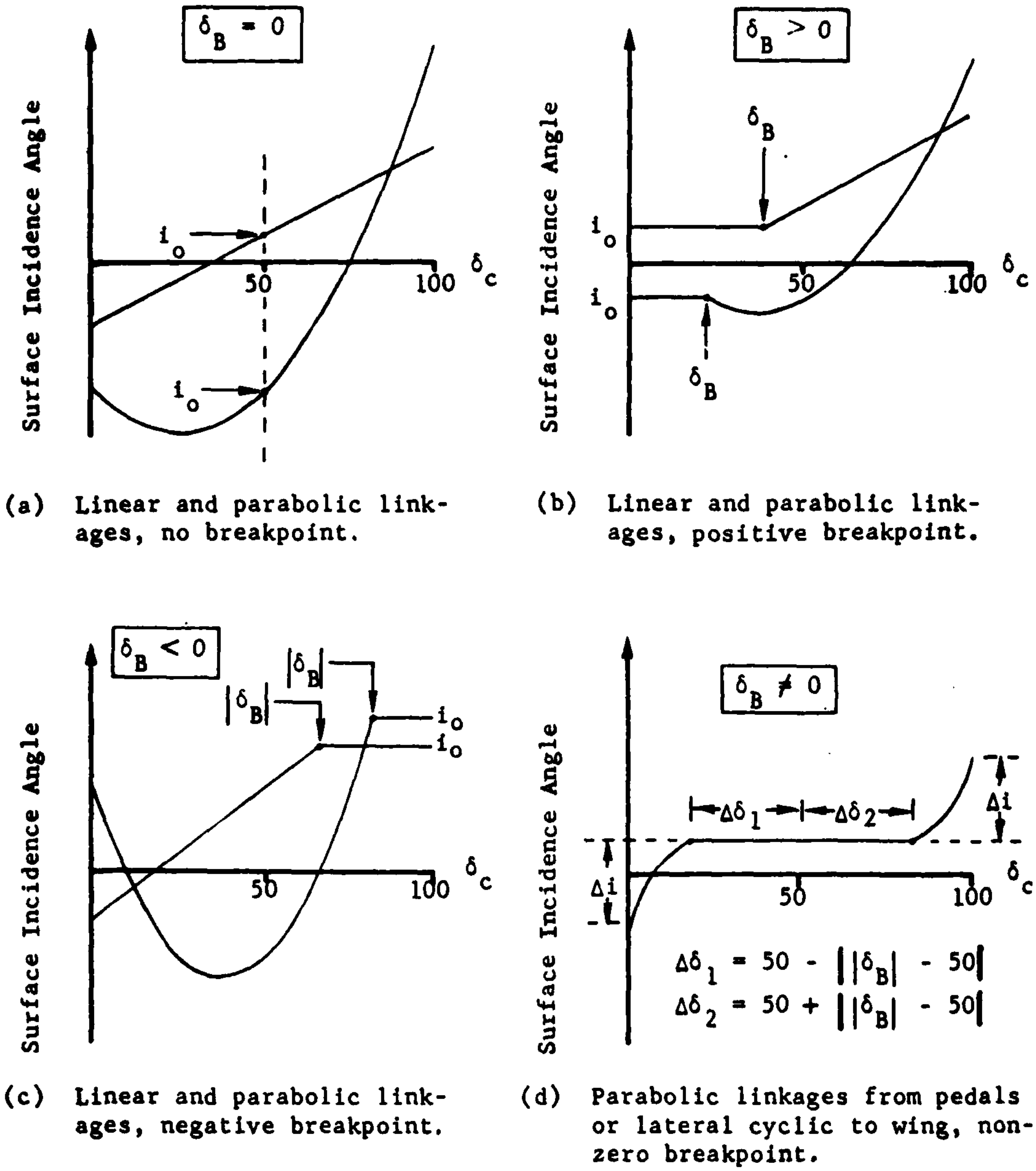
$$(\Delta i_2)_j = 0 \text{ if } \delta_{LONG} \leq XCSj(6)$$

$$= XCSj(4) * k_2 + XCSj(5) * k_2^2 \text{ if } \delta_{LONG} > XCSj(6)$$

and if XCSj(6) < 0,

$$(\Delta i_2)_j = 0 \text{ if } \delta_{LONG} \geq XCSj(6)$$

$$= XCSj(4) * k_2 + XCSj(5) * k_2^2 \text{ if } \delta_{LONG} < |XCSj(6)|$$



(a) Linear and parabolic linkages, no breakpoint.

(b) Linear and parabolic linkages, positive breakpoint.

(c) Linear and parabolic linkages, negative breakpoint.

(d) Parabolic linkages from pedals or lateral cyclic to wing, nonzero breakpoint.

δ_c = Control position, percent of full throw

δ_B = Control position for breakpoint, percent

i_o = Basic (input) incidence angle for surface, degrees

Figure 30. Aerodynamic Surface Control Linkages.

where $k_2 = (\delta_{LONG} - XCSj(6)) * XCON(7)/100$

For the stabilizing surfaces, the increments due to lateral cyclic, $(\Delta i_3)_j$, are computed similarly by replacing XCSj(4), (5), and (6) with XCSj(8), (9), and (10) plus replacing δ_{LONG} and XCON(7) with δ_{LAT} and XCON(15). For the increment due to pedal, $(\Delta i_4)_j$, XCSj(11), (12), (13), δ_{PED}, and XCON(22) are substituted.

For the lateral cyclic and pedal linkages to the wing angles, nonzero breakpoints, XCWG(10) or (13), operate in a slightly different manner from that discussed above. As shown in Figure 30 the linkage is asymmetrical about the 50-percent control position. In equation form, the increment added to the right panel is

$$(\Delta i_3)_0 = XCWG(8) * k_3 + XCWG(9) * k_3^2$$

where

$$k_3 = \begin{cases} (\delta_{LAT} - \delta_2) * XCON(17)/100, & \text{if } \delta_{LAT} > \delta_2 \\ (\delta_{LAT} - \delta_1) * XCON(17)/100, & \text{if } \delta_{LAT} < \delta_1 \\ 0, & \text{if } \delta_1 \le \delta_{LAT} \le \delta_2 \end{cases}$$

and $$\left.\begin{aligned} \delta_1 &= 50 - XCWG(10) \\ \delta_2 &= 50 + XCWG(10) \end{aligned}\right\} \quad XCWG(10) > 0$$

The increment added to the left wing panel is the negative of the increment added to the right panel. The increment to each panel due to pedal position is handled in the identical manner.

An increment, Δi_m, can be added to the appropriate surface angle as a function of the longitudinal mast tilt of Rotor 1.

$$(\Delta i_m)_j = XCSj(14) * (\text{longitudinal mast tilt angle})$$

The total increment to the appropriate angle of the j^th surface is then

$$\Delta i_j = (\Delta i_1)_j + (\Delta i_2)_j + (\Delta i_3)_j + (\Delta i_4)_j + (\Delta i_m)_j$$

If XCSj(7) = 0, the geometric angle of incidence for the j^th surface is then

$$i_j = \Delta i_j + \text{XSTBj}(5)$$

and the control surface angle is

$$\delta_j = \text{XSTBj}(14)$$

If XCSj(7) ≠ 0,

$$i_j = \text{XSTBj}(5)$$

and

$$\delta_j = \Delta i_j + \text{XSTBj}(14)$$

Increments due to J cards (J = 36) are then added to the above values.

3.15 STABILIZING SURFACE GROUPS

3.15.1 Surface No. 1 (Include only if IPL(1) = 0 and IPL(16) ≠ 0)

CARD 131

Stabilizing surface area should include carry-through area if any.

Location of the center of pressure is the point of application of lift and drag forces used to determine moments about the aircraft center of gravity due to these forces.

XSTB1(5) is the incidence angle of the surface when all primary flight controls are at 50 percent and the control surface deflection is zero. If equations are being used, this angle should be the zero lift line angle; if tables are used, it should be chordline incidence. Positive incidence is a right-handed rotation about the positive axis of incidence change; e.g., for a horizontal surface, positive incidence is leading edge up.

The axis of incidence change is assumed to lie in the body Y-Z plane that contains the center of pressure of the surface, i.e., the plane at stationline XSTB1(2). The dihedral angle, XSTB1(6), is the angle in this Y-Z plane between the Y-axis (horizontal) and the axis of incidence change. At XSTB1(6) = 0, the positive axis of incidence change is parallel to the positive body Y-axis. If the surface is on the right side of the aircraft, the dihedral angle is positive for the right-hand, or outboard, tip up (i.e., if the cp buttline, XSTB1(3), is greater than zero, positive dihedral, XSTB1(6), is a left-handed rotation about an axis parallel to the positive body X-axis). If the surface is on the centerline or left side of the aircraft, the dihedral angle is positive for the left-hand, or outboard, tip up (i.e., if the cp buttline is equal to or less than zero, positive dihedral is a right-hand rotation about an axis parallel to the positive body X-axis). See Figure 28.

The sweepback angle of the quarter chord, XSTB1(7), is positive aft and lies in the plane formed by the axis of incidence change and the zero lift line.

CARD 132

Aspect ratio, spanwise efficiency factor, and taper ratio (XSTB1(8), (9), and (10), respectively) are identical to the corresponding wing inputs (XWG(8), (9), and (10), respectively.)

The tailboom bending coefficient, XSTB1(11), reduces the lift coefficient on the surface by the formula

$$C_L' = C_L/[1 + XSTB1(11)*q_s*S_s*C_L/\alpha]$$

where C_L = lift coefficient from subroutine CLCD

q_s = dynamic pressure at the surface

S_s = area of the surface

α = angle of attack of the surface (in radians)

C_L' = lift coefficient used for the surface

XSTB1(12) and XSTB1(13) are discussed in Section 3.15.2.

Positive control surface deflection, XSTB1(14), is defined in the same direction as positive zero lift line incidence, i.e., a right-handed rotation about the positive axis of incidence change. For a horizontal surface this corresponds to trailing edge down.

CARDS 133 and 134

The inputs for changing the lift, drag, and pitching moment of a stabilizing surface with control deflection are identical to those for the wing. See CARD 12B and 12C in Section 3.14.4, and substitute XSTB1 for XWG. See the following section for a discussion of XSTB1(24) through (28), which is on CARD 134.

3.15.2 Flow Field at the Stabilizers

Inputs XSTB1(12), (13), and (24) through (34) define the flow field at the surface in the following manner.

The free-stream velocity components at the stabilizing surface are the velocity components at the fuselage center of pressure in a reference system yawed through an angle σ_f and pitched through the angle ε_f, with respect to the body axes. These resulting velocity components are resolved into the body axis system and are multiplied by the dynamic pressure ratio factor $\sqrt{1\text{-XSTB1}(12)}$.

The wash angles at the surface due to the fuselage (σ_f and ε_f) are defined according to the type of fuselage equation which is being used, i.e., Nominal Angle, High Angle, or Phased.

If the Nominal Angle fuselage equations are being used,

$$\varepsilon_f = \varepsilon_L = [XSTB1(24)*DTR + 0.5*XSTB1(25)*\sin(2\theta_w) + 0.25*RTD*XSTB1(26)*\sin^2(2\theta_w)]$$

$$\sigma_f = \sigma_L = [XSTB1(27) + 0.25*RTD^2*XSTB1(28)*\sin^2(2\theta_w)]*0.5*\sin(2\psi_w)$$

where θ_w and ψ_w are the fuselage aerodynamic pitch and yaw angles respectively, and ε_f and σ_f are in radians.

Note that the above equation can be approximated for small angles as

$$\varepsilon_L' = (XSTB1(24) + XSTB1(25)*\theta_w + XSTB1(26)*\theta_w^2)$$

$$\sigma_L' = (XSTB1(27) + XSTB1(28)*\theta_w^2)*\psi_w$$

where θ_w, ψ_w, ε_L', and σ_L' are all in degrees.

In the phasing region

$$\varepsilon_f = \varepsilon_L*\cos^2(\alpha_{ph})$$

$$\sigma_f = \sigma_L*\cos^2(\alpha_{ph})$$

where α_{ph} is the phasing angle defined in the fuselage discussion (Section 3.12.1).

If the High Angle fuselage equations are being used,

$$\varepsilon_f = \sigma_f = 0$$

If the wing group is included, downwash and dynamic pressure loss at the surface due to the wing will be computed as discussed in the Wing Group section. If the wing is excluded these calculations will be bypassed, and the value of XSTB1(13) will be ignored.

Inputs XSTB1(29) through (34) control the effect of the rotor wake on the flow field at the surface. If XSTB1(29) and (32) are greater than 100, RWAS tables will be used to compute the effect in the same manner as is done for the wing (see CARD 125 in Section 3.14.1). In this case, XSTB1(30), (31), (33), and (34) are ignored. If both inputs are less than or equal to 100, the effect will be computed in a manner similar to that for the wing. The difference is that the two inputs following XSTB1(29) and (32) define the body axis X velocities at which the surface starts to enter the wake and is completely within the wake. See Figure 31. As with the wing, both effects must be represented by constants or both by tables.

3.15.3 Aerodynamic Inputs

See Section 3.14.2 for discussion of the aerodynamic computations.

3.15.4 Control Linkage Inputs (Include only if IPL(16) > 0)

The stabilizing surfaces use the identical mathematical model and input format as the wing for linking the surface incidence or control surface deflection to the primary flight controls. See Section 3.14.4 and replace XCWG with XCS1 in the discussion.

3.15.5 Surface No. 2 (Include only if IPL(1) = 0 and IPL(17) ≠ 0)

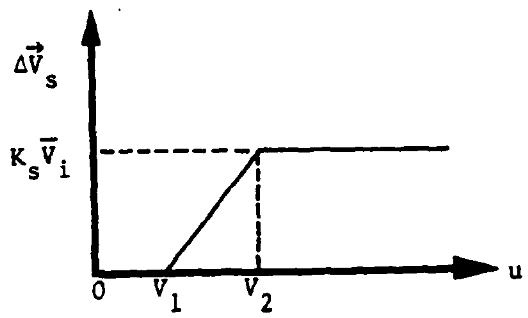
The mathematical model for Stabilizing Surface No. 2 is identical to that for Stabilizing Surface No. 1. Refer to Section 3.15.1 and substitute XSTB2 for XSTB1 in the discussion. Include the control linkage inputs (XCS2) only if IPL(17) > 0.

3.15.6 Surface No. 3 (Include only if IPL(1) = 0 and IPL(18) ≠ 0)

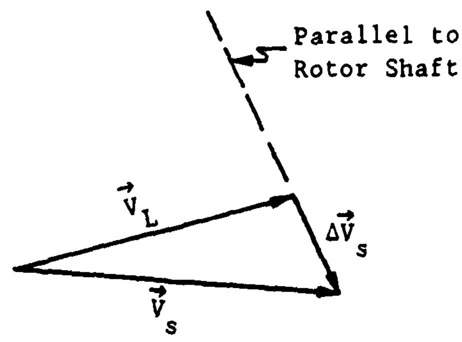
The mathematical model for Stabilizing Surface No. 3 is identical to that for Stabilizing Surface No. 1. Refer to Section 3.15.1 and substitute XSTB3 for XSTB1 in the discussion. Include the control linkage inputs (XCS3) only if IPL(18) > 0.

3.15.7 Surface No. 4 (Include only if IPL(1) = 0 and IPL(19) ≠ 0)

The mathematical model for Stabilizing Surface No. 4 is identical to that for Stabilizing Surface No. 1. Refer to Section 3.15.1 and substitute XSTB4 for XSTB1 in the discussion. Include the control linkage inputs (XCS4) only if IPL(19) > 0.



(a) Computation of $\Delta\vec{V}_s$



(b) Local Flow with Downwash

$\vec{V}_L$ = local velocity vector at stabilizer excluding rotor downwash

$\Delta\vec{V}_s$ = change in $\vec{V}_L$ due to rotor wake

$\vec{V}_s$ = $\vec{V}_L + \Delta\vec{V}_s$

$\bar{V}_i$ = average induced velocity across the rotor disc, parallel to the rotor shaft

u = body X axis component of flight path velocity V

K_s = XSTB1(29), main rotor induced velocity factor

V_1 = XSTB1(30), the u velocity at which the stabilizer enters the rotor downwash

V_2 = XSTB1(31), the u velocity at which the stabilizer is completely immersed in rotor downwash

NOTE: V_1 must not be greater than V_2. Although it is permissible for V_1 to equal V_2, this is actually a contradiction: the surface cannot start to enter and be completely immersed in the downwash at the same velocity. Hence, if $V_1 = V_2$, the following definition applies:

$$\left|\Delta\vec{V}_s\right| = \begin{cases} 0.0 \text{ if } u \leq V_2 \\ K_s\,\bar{V}_i \text{ if } u > V_2 \end{cases}$$

Figure 31. Effect of Rotor Downwash on the Flow Field at the Stabilizing Surfaces.

3.16 JET GROUP (Omit entire group if IPL(1) ≠ 0 or IPL(20) = 0)

CARD 171

The number of controllable jets, XJET(1), defines which of the two jet thrusts can be linked to the flight controls. If XJET(1) = 0.0, neither jet can be controlled. In this case all four jet control linkages in the Controls Group (i.e., XCON(6), XCON(13), XCON(20), and XCON(27) described in Section 3.18) must be zero. If they are not, program execution will terminate during initialization.

If XJET(1) = 1.0, only the right (first) jet thrust, XJET(2), can be changed by control motion. If XJET(1) = 2.0, both jet thrusts can be changed by control motion. During maneuvers either jet thrust may be changed independently of the value of XJET(1) and the control linkages, as discussed in Section 3.18. The location of the right jet is the point of application of its thrust. The left (second) jet is located at the same stationline and waterline as the right jet, but at Buttline -XJET(5). It is not necessary that the right (first) jet be located on the right side of the rotorcraft. However, it will be labeled in the output as the right jet regardless of its location. Similarly, the left (second) jet buttline location is always -XJET(5) and will always be labeled as the left jet.

CARD 172

The jet thrust vectors are oriented with respect to the body reference system by a set of ordered rotations: yaw, then pitch. For the right jet, the rotations are right-handed, while for the left jet they are left-handed. Hence both the location and orientation of the two thrust vectors are symmetrical about the body X-Z plane.

For XJET(2) and XJET(3) positive and XJET(8) = XJET(9) = 0.0, both vectors are parallel to the body X-axis and cause positive (forward) forces in the body reference system. A positive yaw angle will then cause a right (positive) body Y-force from the right jet and a left (negative) body Y-force from the left jet. Positive pitch angle will cause an upward (negative) body Z-force from both jets.

3.17 EXTERNAL STORE/AERODYNAMIC BRAKE GROUP (Omit entire group if IPL(1) ≠ 0 or IPL(21) = 0)

This group consists of exactly IPL(21) Store/Brake subgroups. The sequence number of the subgroup is the same as the input sequence. Each subgroup uses the same input format and mathematical model. A single subgroup is intended to represent a single store/brake, and all subgroups are mutually independent.

3.17.1 Store/Brake No. 1 (Include only if IPL(21) ≥ 1)

CARD 181A

The weight input, XST1(1), defines how the subgroup is to be used. This weight must not be included in the aircraft gross weight, XFS(1). If XST1(1) = 0, all calculations for this subgroup are bypassed.

If XST1(1) > 0, the subgroup is defined to be an external store, and the following applies: prior to starting the TRIM procedure, the store weight and inertias (XST1(1) and XST1(8) through XST1(11)) are added to the weight and appropriate inertial inputs in the Fuselage Group, XFS(1) and XFS(8) through XFS(11). The aircraft cg and inertias are then recalculated for each external store subgroup. When a store is dropped in the maneuver section, the aircraft weight, cg, and inertias are recalculated to reflect the jettison. Note that when using the sweep option (NPART = 10), the baseline values of aircraft weight, cg, and inertias, XFS(1) and XFS(5) through XFS(11), change only when changed by NAMELIST inputs. The recalculated values are never carried forward to subsequent cases. Consequently, the recalculation procedure is performed at the start of each and every case in the sweep using the current values of baseline and store weight, cg, and inertias, i.e., XFS(1), XFS(5) through XFS(11), XST1(1) through XST1(4), and XST1(8) through XST1(11).

If, on the other hand, XST1(1) < 0, the subgroup is defined to be an aerodynamic brake. A brake is assumed to be an integral part of the airframe with its weight and inertias included in the inputs to the Fuselage Group. Aircraft weight, cg, and inertias are not recalculated.

In the maneuver section, only store subgroups can be dropped (J = 35), and only brake subgroups can be deployed (J = 34). J-Card inputs which command otherwise (i.e., drop a brake or deploy a store) will terminate execution.

The aerodynamic forces of both stores and brakes act at the center of pressure. The cp is assumed to be at the same buttline and waterline as the store/brake cg. The cp stationline is calculated by

$$(SL)_{cp} = XST1(2) + XST1(5) + XST1(6)*\sin^2\alpha_{sc}$$

The dynamic pressure loss ratio, XST1(7), is the ratio of local dynamic pressure loss at the store/brake to free-stream dynamic pressure, neglecting rotor downwash. An input of zero indicates that the total free stream dynamic pressure acts at the store/brake.

CARD 181B

The store inertias are those of the store about its own cg, in the fuselage body axis coordinate system, and are not to be included in the inertias in the Fuselage Group. If the store inertias are given in the store axis system, they must be resolved into the fuselage body axis system before input to C81.

The induced velocity factor is the fraction of the induced velocity at the rotor disc which acts at the store/brake cp. With no interference and a fully developed downwash, this factor would theoretically be 2.0. In practice, it would be less than 2.0 due to interference effects, nonuniform downwash, and the rotor wake not being fully contracted.

The lift, drag, and side forces calculated are each multiplied by XST1(14)/100 to simulate aerodynamic brake deployment. If XST1(1) indicates that a store is to be simulated, XST1(14) is reset to 100 percent.

CARD 181C

The wind axis aerodynamic forces on the store/brake are calculated from the following equations. These forces are separate aerodynamic forces and are not included in the forces generated by any other group (component of the aircraft).

$$\text{Lift} = q_s\ [XST1(15)*\cos\psi_s + XST1(16)*\sin(2\theta_s)*\cos\psi_s]$$

$$\text{Drag} = q_s\ [XST1(17)*(\cos^2\psi_s)*(\cos^2\theta_s) + XST1(18)*\sin^2\psi_s + XST1(19)*(\cos^2\psi_s)*(\sin^2\theta_s)]$$

$$\text{Side Force} = q_s\ [XST1(20)*\cos^2\theta_s + XST1(21)*\sin(2\psi_s)*\cos^2\theta_s]$$

where V_s = 1-XST1(7) * $V_{free\ stream}$ + XST1(12)*$(\bar{V}_i)_{M/R}$

+ XST1(13)*$(\bar{V}_i)_{T/R}$

$q_s = 0.5\rho * V_s^2 *$XST1(14)/100

$\theta_s = \tan^{-1}(w_s/u_s)$

$\psi_s = -\sin^{-1}(v_s/V_s)$

$\alpha_{sc} = \cos^{-1}(u_s/V_s)$

u_s = body axis x component of V_s at store/brake

v_s = body axis y component of V_s at store/brake

w_s = body axis z component of V_s at store/brake

$\bar{V}_i$ = average induced velocity at disc of specified rotor

3.17.2 Store/Brake No. 2 (Include only if IPL(21) $\geq$ 2)

CARDS 182A, 182B, and 182C contain the inputs for Store/Brake No. 2. Refer to the section on Store/Brake No. 1, and substitute XST2(I) for XST1(I).

3.17.3 Store/Brake No. 3 (Include only if IPL(21) $\geq$ 3)

CARDS 183A, 183B, and 183C contain the inputs for Store/Brake No. 3. Refer to the section on Store Brake No. 1, and substitute XST3(I) for XST1(I).

3.17.4 Store/Brake No. 4 (Include only if IPL(21) = 4)

CARDS 184A, 184B, and 184C contain the inputs for Store/Brake No. 4. Refer to the section on Store/Brake No. 1, and substitute XST4(I) for XST1(I).

3.18 ROTOR CONTROLS GROUP

The Controls Group is divided into two subgroups: Basic and Supplemental. The Basic Rotor Controls subgroup is a required input. The reading of the Supplemental Rotor Controls subgroup is controlled by IPL(22). This optional subgroup is only a necessary input for tandem and side-by-side rotor configurations although it can also be used to simulate very complex control systems for single main rotor helicopters. Figure 32 is a schematic diagram of the complete AGAJ77 rotor control system. The Controls Group defines the linkages between the pilot controls and rotors for a rigid pylon, no collective bobweight, and SCAS off, i.e., the blocks labeled "BASIC RIGGING", "NONLINEAR RIGGING," and "CONTROL COUPLING/MIXING BOX" in Figure 32. The outputs of the rotor controls mathematical model are the root collective blade angle and swashplate angles of each rotor.

The models for the rotor controls, pylon coupling, bobweight, and SCAS are mutually independent. That is, the value of any output of any one model does not affect the value of the outputs of any other model. The outputs of the last three models are treated as increments which are added to the appropriate output of the rotor controls model.

3.18.1 Basic Rotor Controls Subgroup

The inputs on CARDS 191 through 194 are termed the Basic Rotor Control, or XCON, inputs. These inputs define the basic linkages between each of the four primary flight controls (collective, longitudinal cyclic and lateral cyclic, and pedal) and the rotor control angles. All linkages are linear and uncoupled and are normally the only Rotor Controls Group inputs needed for a single-main-rotor helicopter. With these linkages, the collective stick controls the root collective pitch (as measured at the center of rotation) of Rotor 1, and the pedals control only the root collective pitch of Rotor 2.

If XCON(14) = 0.0 and XCON(21) = 270.0 (the default values), then longitudinal cyclic stick motion will yield longitudinal swashplate rotation, and lateral cyclic stick motion will give a lateral swashplate rotation. Fixed system control phasing will occur if XCON(14) ≠ 0.0 and XCON(21) ≠ 270.0, and the swashplate longitudinal and lateral rotational axes will not be perpendicular if XCON(14) and XCON(21) are not 90 degrees apart.

The cyclic pitch for Rotor 2 is defined to be zero when using just the Basic Rotor Controls (IPL(22) = 0).

The equations for the control angles computed from the XCON inputs are given in Table 14. Note that the fourth input on each of the four cards can be used to lock the appropriate control angle at the value of the fifth input on the same card.

The sixth input on each of the four basic control cards is the linkage between the specified control and jet thrust. The equations for the individual increments to the jet thrust and the total jet thrust are also given in Table 14. The jet to which the controls are linked is a function of XJET(1) in the Jet Group. Also, the increment to jet thrust is proportional to the difference between the control position input to the Flight Constants Group and the current control position during the trim iterations or maneuver time history. That is, the change in jet thrust is proportional to a change in control position, not to the absolute value of that control position.

3.18.2 <u>Supplemental Rotor Controls Subgroup</u> (XCRT(1-49), omit if IPL(22) = 0)

The inputs to this subgroup are primarily intended to provide control linkages used in configurations other than single main rotor helicopters, e.g., tandem or side-by-side rotor helicopters and tilt rotor or composite aircraft. If the program decides that the configuration is not a single-main-rotor helicopter (KONFIG $\neq$ 1, see Section 3.34.1), an error message will be generated if XCRT inputs are not included.

The linkages defined in the Basic Controls subgroup are a subset of the complete rotor control system model shown in Figure 32. To use the complete model, both the Basic and Supplemental Rotor Controls subgroups must be input.

In the Basic Controls Subgroup discussed in the previous section, each primary flight control is linked linearly to a single blade or swashplate angle. In the completed model described below, each control is linked to the fixed-system intermediate control angles. The linkage may be linear, parabolic, or cubic, and in the case of the collective stick the linkage can be a function of the longitudinal mast tilt angle of Rotor 1. Then each fixed-system intermediate control angle is in turn linked to between 2 and 6 specific blade or swashplate angles. These linkages are linear but can be functions of the longitudinal mast tilt angle of Rotor 1.

TABLE 14. BASIC ROTOR CONTROL RIGGING

Rotor 1

$$(\theta_o)_1 = \begin{cases} XCON(2) + XCON(3)*\delta_{COLL}/100 & \text{if } XCON(4) = 0 \\ XCON(5) & \text{if } XCON(4) \neq 0 \end{cases}$$

$$(B_1)_1 = (A_1)_1'*\cos(XCON(21)) + (B_1)_1'*\cos(XCON(14))$$

$$(A_1)_1 = -(A_1)_1'*\sin(XCON(21)) - (B_1)_1'*\sin(XCON(14))$$

where

$$(B_1)_1' = \begin{cases} XCON(9) + XCON(10)*\delta_{LONG}/100 & \text{if } XCON(11) = 0 \\ XCON(12) & \text{if } XCON(11) \neq 0 \end{cases}$$

$$(A_1)_1' = \begin{cases} XCON(16) + XCON(17)*\delta_{LAT}/100 & \text{if } XCON(18) = 0 \\ XCON(19) & \text{if } XCON(18) \neq 0 \end{cases}$$

Rotor 2

$$(\theta_o)_2 = \begin{cases} XCON(23) + XCON(24)*\delta_{PED}/100 & \text{if } XCON(25) = 0 \\ XCON(26) & \text{if } XCON(25) \neq 0 \end{cases}$$

Jets

$$(\Delta T_{JET})_1 = XCON(6)*XCON(1)*[\delta_{COLL} - XVC(8)]/100$$

$$(\Delta T_{JET})_2 = XCON(13)*XCON(8)*[\delta_{LONG} - XVC(9)]/100$$

$$(\Delta T_{JET})_3 = XCON(20)*XCON(15)\ [\delta_{LAT} - XVC(10)]/100$$

$$(\Delta T_{JET})_4 = XCON(27)*XCON(22)\ [\delta_{PED} - XVC(11)]/100$$

$$T_{JET} = (T_{JET})_{INPUT} + \sum_{i=1}^{4} (\Delta T_{JET})_i$$

δ_{COLL} = Collective stick position, in percent, from full down

δ_{LONG} = Longitudinal cyclic stick position, in percent, from full aft

δ_{LAT} = Lateral cyclic stick position, in percent, from full left

δ_{PED} = Pedal position, in percent, from full right

XVC(8) = Input value of δ_{COLL} (%) XVC(10) = Input value of δ_{LAT} (%)

XVC(9) = Input value of δ_{LONG} (%) XVC(11) = Input value of δ_{PED} (%)

$(T_{JET})_{INPUT}$ = Thrust of controllable jet(s), XJET(2) and/or XJET(3)

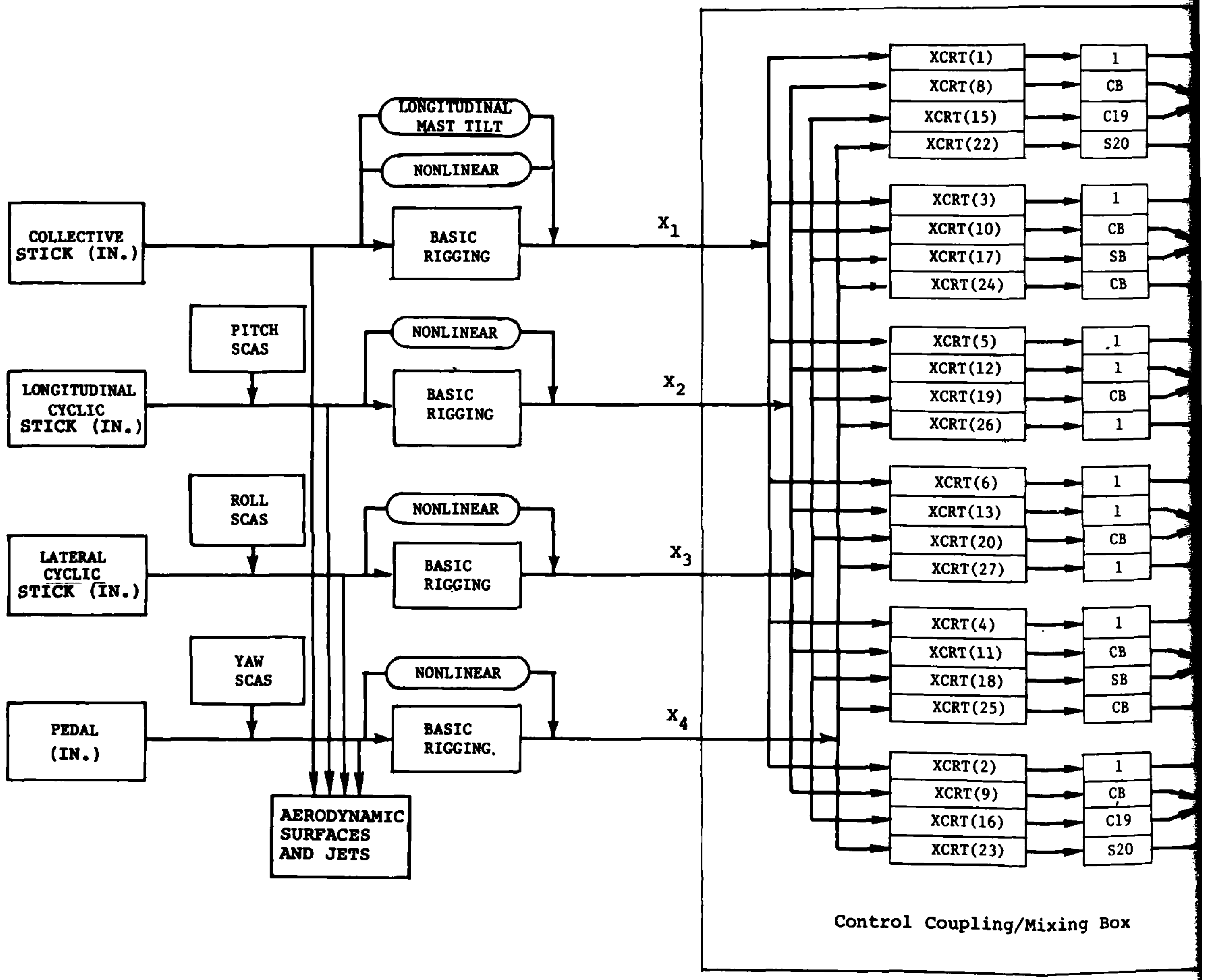
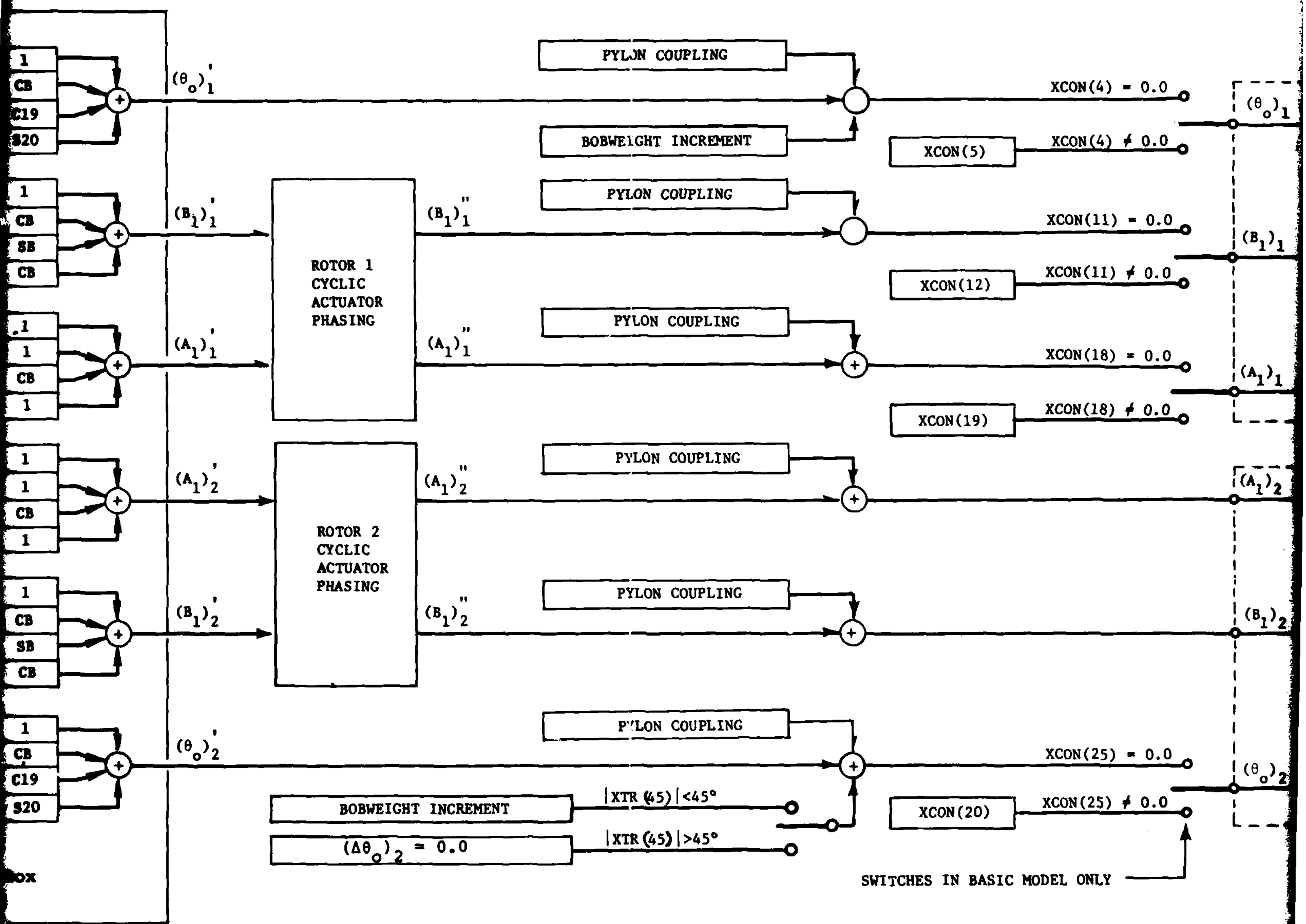
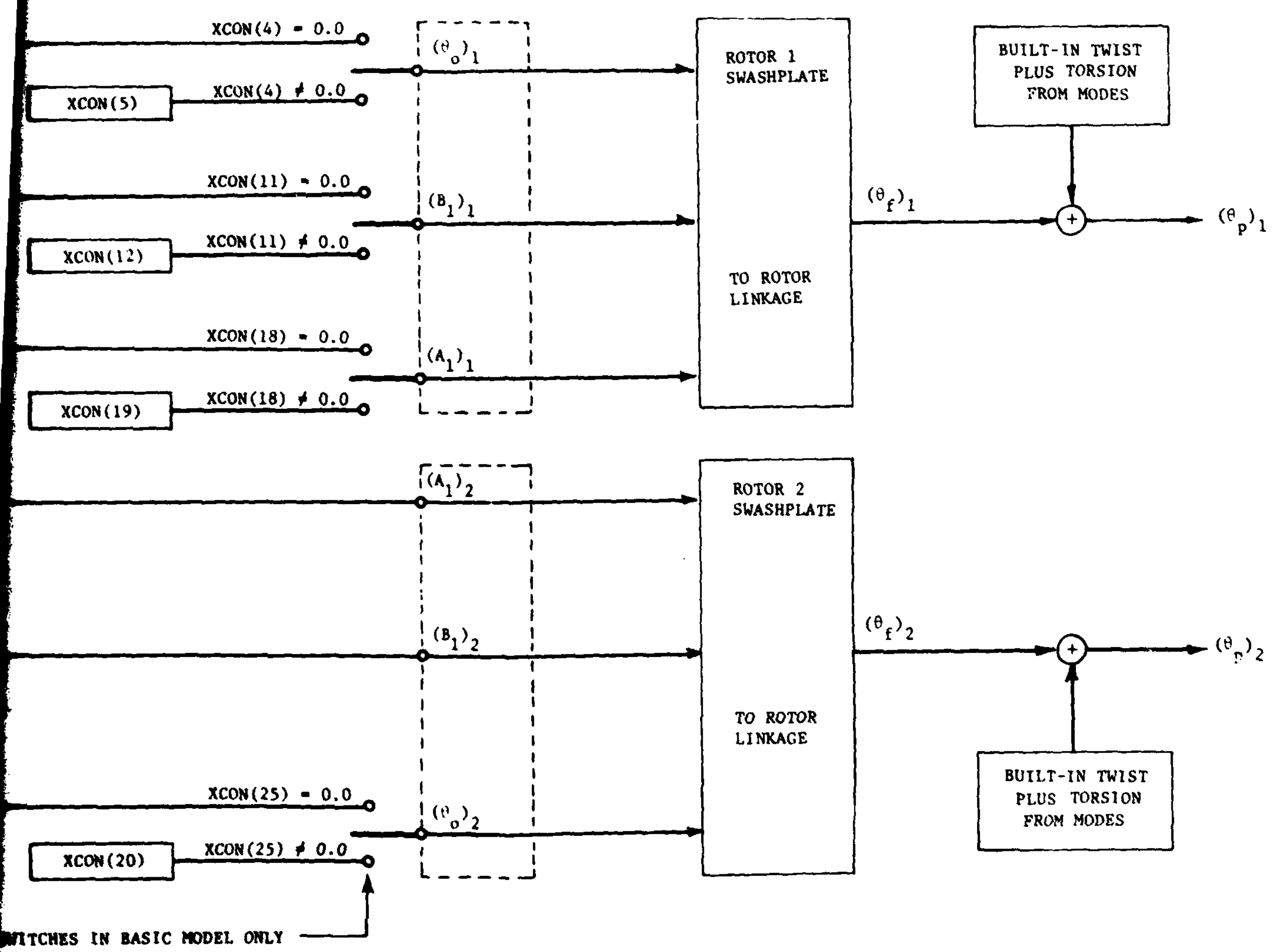


Figure 32. Schematic Diagram of Rotor Control System.



1
CB
C19
S20
CB
SB
ROTOR 1 CYCLIC ACTUATOR PHASING
ROTOR 2 CYCLIC ACTUATOR PHASING
PYLON COUPLING
BOBWEIGHT INCREMENT
XCON(4) = 0.0
XCON(4) ≠ 0.0
XCON(5)
XCON(11) = 0.0
XCON(11) ≠ 0.0
XCON(12)
XCON(18) = 0.0
XCON(18) ≠ 0.0
XCON(19)
XCON(25) = 0.0
XCON(25) ≠ 0.0
XCON(20)
|XTR (45)|<45°
|XTR (45)|>45°
(Δθo)2 = 0.0
SWITCHES IN BASIC MODEL ONLY
OX

2



XCON(4) = 0.0
XCON(5)
XCON(4) ≠ 0.0
(θo)1
ROTOR 1
SWASHPLATE
TO ROTOR
LINKAGE
BUILT-IN TWIST
PLUS TORSION
FROM MODES
XCON(11) = 0.0
XCON(12)
XCON(11) ≠ 0.0
(B1)1
(θf)1
(θp)1
XCON(18) = 0.0
XCON(19)
XCON(18) ≠ 0.0
(A1)1
(A1)2
ROTOR 2
SWASHPLATE
(B1)2
(θf)2
(θp)2
TO ROTOR
LINKAGE
BUILT-IN TWIST
PLUS TORSION
FROM MODES
XCON(25) = 0.0
XCON(20)
XCON(25) ≠ 0.0
(θo)2
WITCHES IN BASIC MODEL ONLY

The fixed-system intermediate control angles, X1 through X4, are defined in Table 15. The effects of longitudinal mast tilt on X1, the fixed-system collective intermediate control angle, are controlled by XCRT(29) through XCRT(32) on CARD 199. DTMIN is the change in minimum value of fixed-system collective angle due to mast tilt, while CTRNG is the change in the range of the input.

The control coupling ratios, input on CARDS 195 through 198, give the user the capability to control the cyclic swashplate angles of Rotor 2. In addition, fixed-system control phasing can be introduced through control coupling. If the Rotor 1 phasing is done in this manner, then XCON(14) and XCON(21) should be input as 0.0 and 270.0. Likewise, if the phasing for Rotor 2 is done by control coupling, then XCRT(43) and XCRT(44) (which are the analogues to XCON(14) and XCON(21) for Rotor 2) should be input as 0.0 and 270.0. All control coupling operations are performed in the Control Coupling/Mixing Box (Figure 32). The effects of Rotor 1 longitudinal mast tilt are also accounted for in this box.

The outputs from the Control Coupling/Mixing Box are the collective intermediate control angle and the cyclic intermediate control angles for both rotors, $(\theta_o)'_i$, $(B_1)'_i$, and $(A_1)'_i$, $i = 1$ or 2. The cyclic intermediate control angles are phased according to the cyclic actuator phasing angles, XCON(14), XCON(21), XCRT(43), and XCRT(44), and the increments to all six intermediate control angles due to pylon coupling are added to give the six fixed swashplate control angles, $(\theta_o)_i$, $(A_1)_i$, and $(B_1)_i$, $i=1$ or 2. The two collective angles are passed through to the rotating system, while the cyclic swashplate angles are commutated to get the cyclic control angles in the rotating system.

The blade root pitch angle for each rotor, measured at the center of rotation, is computed from the rotating swashplate components, γ and δ_3 for that rotor.

TABLE 15. FIXED-SYSTEM INTERMEDIATE CONTROL ANGLES

Collective

$$X_1 = [XCON(2) + DTMIN] + [XCON(3) + DTRNG]*\delta_{COLL}/100 + XCRT(36)*K_1^2$$

Longitudinal Cyclic

$$X_2 = XCON(9) + XCON(10)*\delta_{LONG}/100 + (\Delta X_2)_{SCAS} + XCRT(37)*K_2^2 + XCRT(38)*K_2^3$$

Lateral Cyclic

$$X_3 = XCON(16) + XCON(17)*\delta_{LAT}/100 + (\Delta X_3)_{SCAS} + XCRT(39)*K_3^2 + XCRT(40)*K_3^3$$

Pedal

$$X_4 = XCON(23) + XCON(24)*\delta_{PED}/100 + (\Delta X_4)_{SCAS} + XCRT(41)*K_4^2 + XCRT(42)*K_4^3$$

$$\left.\begin{aligned} K_1 &= (\delta_{COLL} - 50)*XCON(1)/100 \\ K_2 &= (\delta_{LONG} - 50)*XCON(8)/100 \\ K_3 &= (\delta_{LAT} - 50)*XCON(15)/100 \\ K_4 &= (\delta_{PED} - 50)*XCON(22)/100 \end{aligned}\right\} \quad \text{Control deflections in inches from the 50\% position}$$

$$DTMIN = \begin{cases} XCRT(30)*\beta_m + XCRT(31)*\beta_m^2 & XCRT(29) \neq 0.0 \\ 0.0 & XCRT(29) = 0.0 \end{cases}$$

$$DTRNG = \begin{cases} [XCRT(32) - XCON(3)]*\beta_m/(\ /2) & XCRT(29) \neq 0.0 \\ 0.0 & XCRT(29) = 0.0 \end{cases}$$

β_m = Longitudinal mast tilt angle of Rotor 1, degrees

$(\Delta X_2)_{SCAS}$ = Change in longitudinal cyclic input due to SCAS

$(\Delta X_3)_{SCAS}$ = Change in lateral cyclic input due to SCAS

$(\Delta X_4)_{SCAS}$ = Change in pedal input due to SCAS

3.19 ENGINE-GOVERNOR GROUP

CARD 201

The maximum sea-level, installed, continuous horsepower available is computed from the tabular data input on this card.

The program uses the outside air temperature printed on the trim page to determine the maximum continuous engine horsepower available. XNG(2) through XNG(7), shown in Figure 33, must be sea-level quantities. XNG(1) is not a function of the atmospheric conditions. If the OAT is less than T1, then the power is taken as P1, and if the OAT is greater than T3, the power is taken as P3. If T3 and P3 are input as zero, and the OAT is greater than T2, then the power is taken as P2. The horsepower computed from the table is multiplied by the atmospheric pressure ratio to yield the maximum installed continuous horsepower for the temperature and pressure defining the flight condition. If this horsepower is greater than the transmission limit horsepower, XNG(1), it is reset to that value.

If XNG(2) through XNG(7) are input as zero, then XNG(1) is the maximum continuous horsepower available.

CARD 202

The maximum sea-level, installed takeoff horsepower available is computed from the tabular data on this card in the same manner as the maximum continuous horsepower is computed from the data on CARD 201. Using Figure 33, with

T_1 = XNG(9) P_1 = XNG(10)

T_2 = XNG(11) P_2 = XNG(12)

T_3 = XNG(13) P_3 = XNG(14)

XNG(9) through XNG(14) must be sea-level quantities. XNG(8) is not a function of the atmospheric conditions.

The value computed from the table is multiplied by the pressure ratio and is compared with the takeoff transmission horsepower limit, with the smaller value being used. If XNG(9) through XNG(14) are input as zero, then XNG(8) is the maximum takeoff horsepower available.

Takeoff horsepower available is used for maneuver-in-trim cases and in maneuvers.

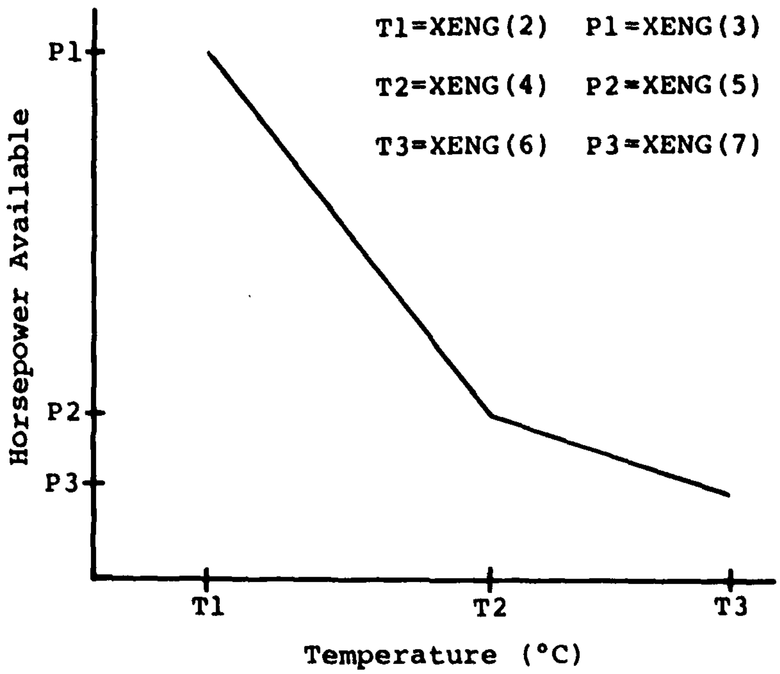


Figure 33. Typical Engine Horsepower Available Curve.

CARD 203

The drive system rotational speed, XNG(15), is multiplied by the rotor-to-engine gear ratios (XMR(13) and XTR(13)) to give the rotor rotational speeds.

The governor power gain, XNG(16), is used in the dynamic engine model in maneuvers (NPART = 2, 4, 5, 7 or 8) and represents the commanded change in horsepower due to a change in Rotor 1 rpm.

The discrepancy between the instantaneous horsepower required and the instantaneous horsepower available is divided by the appropriate time constant, XNG(17) or XNG(18), to yield the horsepower-available time derivative.

CARD 204

The total power required is

$$P_R = \frac{\dfrac{P_{R_I}}{XNG(22)} + \dfrac{P_{R_{II}}}{XNG(23)} + P_{ACC}}{XNG(24)}$$

where

P_{R_I} = Rotor 1 power required

$P_{R_{II}}$ = Rotor 2 power required

P_{ACC} = accessory power required, XNG(25)

3.20 ITERATION LOGIC GROUP

CARD 211

The program is permitted up to XIT(1) iterations to converge to a trimmed flight condition. If the force and moment summations are not less than the allowable errors, XIT(15) through XIT(21), execution terminates.

If the time-variant trim option is activated (IPL(49)≠0), the increment between the rotor azimuth angles used in the analysis may be input in XIT(2). If the input is 0.0, XIT(2) is reset to 15.0 degrees. If the input is not zero, the program examines the natural frequencies of the modes of both rotors. It then checks that the current value of XIT(2) will provide at least 10 points for each cycle of the highest frequency present and, if necessary, resets XIT(2) to satisfy this condition. The value of XIT(2) is then checked to see if it is less than 2.0 degrees or greater than 30.0 degrees. If it is, XIT(2) is then reset to the nearer value. If either of the unsteady aerodynamic options is activated (IPL(48) ≠ 0), XIT(2) should be less than 10 degrees for the numerical differentiation to work properly. See Section 3.26 for additional discussion of azimuth increments.

XIT(3) is the induced velocity change limiter. It is equal to half the maximum amount the induced velocity is allowed to change within iterations in TRIM and between time points in maneuver. Three thrust-induced velocity iterations are made within each trim iteration in the TRIM portion of the program. The sign of XIT(3) controls the application of the limit in these thrust-induced velocity iterations. If XIT(3) > 0, the limit is applied to the first and third passes through this loop. If XIT(3) < 0, the limit is applied to all three passes. If XIT(3) = 0, it is reset to 0.5 ft/sec. Note that the input sign of XIT(3) controls only the manner in which the limit is applied. The sign of the increment applied within the program is determined by the program. This option allows the user to better regulate the numerical bounce problem sometimes encountered when performing a TRIM.

XIT(4) is a nondimensional factor used to compute the increments to the linear and angular velocities to be used in the STAB subroutine. The angular rate increments are 0.10 radian per second times the input, and the linear rate increments are 10 feet per second times the input.

Time-history plots of variables listed in Section 6 may be made after trim if either rotor is time-variant and 0 < XIT(5) ≤ XIT(6). In this case, data for the last XIT(5) revolutions will be plotted.

XIT(6) is used to control the number of rotor revolutions computed in the time-variant rotor analysis, both as the normal TVT following a QS trim and in the rotor analysis in the fully-time-variant trim. If XIT(6) is input as 0.0, the defaults are 5.0 revolutions in TVT and 3.0 in FTVT. For soft-inplane rotors it has been found that the default value of 5 revolutions in TVT is usually not enough to achieve a periodic solution; 10 to 15 revolutions may be required, depending on the damping present.

XIT(7) controls a numerical damping procedure to assist in finding QS trim conditions for elastic rotors with torsion in the mode shapes. The input should always be between 0.0 and 1.0. An input of 1.0 would provide no damping (0.0 defaults to 1.0). An input of 0.5 gives a simple averaging procedure, and 0.3 seems to be the best choice in most cases. Smaller inputs have been used, but they may slow the trim convergence.

CARD 212

XIT(8) through (11) are the inputs for the numerical damping procedure used for rotor rebalancing. In trim, rotor rebalancing can only occur when a rotor is decoupled from the standard "10 by 10" trim procedure (i.e., IPL(51) or (52) do not equal zero). In a rotorcraft stability analysis, rebalancing of a rotor can only occur if its flapping degrees-of-freedom are locked out by IPL(87), and IPL(88) specifies that rebalancing is to be performed. The rebalancing procedure is never used in maneuvers. If no rebalancing takes place, XIT(8) through (11) can be ignored. However, if the main rotor is to be rebalanced, the starting value for the correction limit is eight times the minimum value, XIT(8). If at any time the magnitude of any moment imbalance is less than the damper limiter, XIT(10), the correction limit is halved with the restriction that it is never less than XIT(8). For the tail rotor, XIT(9) is used in place of XIT(8) and XIT(11) in place of XIT(10).

XIT(12), (13), and (14) are the inputs for the numerical damping procedure used in trimming the force and moment imbalance about the cg. If, after the baseline calculation of a trim iteration, all imbalances are not less than the allowable errors, the imbalances and the latest partial derivative matrix are used to compute a correction to each trim variable. The corrections are then compared to a correction limit. If the magnitude of any correction exceeds the limit, all corrections are multiplied by the same ratio such that the magnitude of the largest correction is equal to the limit. XIT(12) is the starting value of this limit. If the absolute value of all force and moment imbalances for the baseline calculations of an iteration are less than XIT(14), then the limit is halved with the restriction that the limit is never less than XIT(13). If a partial derivative matrix is to be computed for an iteration, the value of the partial derivative increment is set equal to 0.5 times the correction limit.

CARD 213

XIT(15) through XIT(21), the allowable errors, are the maximum magnitudes of the force and moment imbalances permitted for a trimmed flight condition. That is, the trim iteration procedure continues until XIT(1) iterations are exceeded, or the absolute values of force and moment imbalances are less than the corresponding allowable errors. Normally, the smaller the allowable errors, the larger the number of iterations required for trim.

A good method for determining the values to be input to XIT(15) through XIT(21) is as follows. Define the maximum levels of

(1) the three linear accelerations at the cg (a_x, a_y, a_z),

(2) the three angular accelerations about the cg ($\dot{p}$, $\dot{q}$, $\dot{r}$), and

(3) the flapping acceleration of each rotor ($\ddot{\beta}_{M/R}$, $\ddot{\beta}_{T/R}$)

at which the particular flight condition can be considered to be trimmed.

With these maximum desirable accelerations in units of ft/sec^2 and deg/sec^2, reasonable values for the allowable errors are then

XIT(15) $\leq$ (a_x)*XFS(1)/32.17

XIT(16) $\leq$ (a_y)*XFS(1)/32.17

XIT(17) $\leq$ (a_z)*XFS(1)/32.17

XIT(18) $\leq$ ($\dot{q}$)*XFS(9)/57.3 and ($\dot{r}$)*XFS(10)/57.3

XIT(19) $\leq$ ($\dot{p}$)*XFS(8)/57.3

XIT(20) $\leq$ ($\ddot{\beta}_{M/R}$)*(total M/R flapping inertia)/57.3

XIT(21) $\leq$ ($\ddot{\beta}_{T/R}$)*(total T/R flapping inertia)/57.3

For wind tunnel simulations (IPL(1), IPL(51), or IPL(52) $\neq$ 0), the first five allowable error inputs should be very large (e.g., 100,000 or more), while the last two should be realistic error limits. This action prevents the program from continuing to iterate to forces and moments about the cg that are less than the allowable errors when the only requirement is that the rotor flapping moment imbalance be within the specified error limits.

3.21 FLIGHT CONSTANTS GROUP

CARD 221

The input velocities are with respect to the ground. The forward velocity is not necessarily the total velocity.

The altitude input is the height above the ground. It is used in the calculations for ground effect and the landing gear forces, and locates the helicopter with respect to a trailing vortex pair, if used (see J=37, Section 3.27.2.28). If the input altitude is negative, the program stops. This input has no relationship to the pressure altitude, XFC(27), on CARD 214.

The Euler angles are the angles from the ground reference system to the body reference system. Yaw is positive nose right; pitch is positive nose up; roll is positive down right.

CARD 222

The collective and cyclic stick and pedal positions are the initial settings with which the program begins its TRIM iterations.

The g level, XFC(12), is the acceleration in g's along the body Z axis (see TRIM type indicator, IPL(43) on CARD 14).

CARD 223

The flapping angle and rotor thrust inputs are used as initial values in the TRIM iteration procedure.

CARD 224

XFC(26), the atmospheric logic switch, is used in conjunction with the pressure altitude, XFC(27), and ambient temperature, XFC(28), to compute the density ratio, σ'; density altitude, h_D; and speed of sound, V_s. If XFC(26) = 0, standard-day conditions are assumed, XFC(28) is ignored, and the parameters are calculated from the following equations:

$$\theta_S = 1 - (0.687535 \times 10^{-5})*XFC(27)$$

$$T_A = 288.16\ \theta_S - 273.16$$

$$\sigma' = (\theta_S)^{4.2561}$$

$$V_s = 65.811366 \sqrt{T_A + 273.16}$$

$$h_D = XFC(27)$$

If XFC(26) ≠ 0, nonstandard-day conditions are assumed. If XFC(26) > 0, the ambient temperature is defined to be in degrees Fahrenheit and

$$T_A = 5[XFC(28) - 32]/9$$

If XFC(26) < 0, then XFC(28) is defined to be in degrees centigrade and

$$T_A = XFC(28)$$

Then

$$\delta = (\theta_S)^{5.2561}$$

$$\theta = (T_A + 273.16)/288.16$$

$$\sigma' = \delta/\theta$$

$$V_s = 65.811366 \quad T_A + 273.16$$

$$h_D = (1 - (\sigma')^{0.23496})/(0.687535 \times 10^{-5})$$

If XFC(26) $\geq$ 100.0, then XFC(27) and (28) are defined to be the density ratio and speed of sound, respectively:

σ' = XFC(27)   (dimensionless)

V_s = XFC(28)   (ft/sec)

and the pressure and density altitudes and ambient temperatures are computed within the program based on the preceding equations.

NOTE: For TRIM or TRIM-STAB input decks (NPART = 1 or 7), the only cards which may follow CARD 214 are those of a parameter sweep (NPART = 10), contour plot control cards (NOP=12), or time-history plot cards (NOP=3 and 14).

3.22 BOBWEIGHT GROUP (Include only if NPART = 2 or 4 and IPL(23) ≠ 0)

CARD 231

For no bobweight, set XBW(1) = 0.

If XBW(1) ≠ 0, the following bobweight model is used.

The bobweight system acts to reduce collective pitch with increasing load factor during maneuvers. The system is assumed to be mounted so that the weight is free to translate only parallel to the body vertical, or Z, axis. The equation of motion for the weight in the system is

$$\frac{1}{12} m\ddot{\delta} + C\dot{\delta} + K\delta = F_{BW}$$

where

δ = the linear displacement of the bobweight from its position at 1.0 g, positive down (in.)

$\dot{\delta}$ = linear velocity (in./sec)

$\ddot{\delta}$ = linear acceleration (in./sec^2)

F_{BW} = bobweight forcing function described below (lb)

K = XBW(2), the spring constant (lb/in.)

C = XBW(3), the damping coefficient (lb-sec/in.)

W = XBW(4), the weight of the bobweight (lb)

m = W/32.17, the mass of the bobweight (slugs)

Other symbols used are

n_p = XBW(7), the system preload (g)

n = load factor (g)

$\Delta\theta_o$ = increment to collective pitch due to bobweight displacement (deg)

η = XBW(1), linkage of δ to $\Delta\theta_o$ (deg/in.)

The forcing function is defined as a function of W, n, and n_p at each time point during the maneuver. At time t = 0,

$$\ddot{\delta} = \dot{\delta} = \delta = 0.0$$

and

$$F_{BW} = \text{Max }[0,\ W(n-n_p)]$$

NOTE: The bobweight is not active during the trim procedure. Hence, if a maneuver is started from a trim where n is greater than n_p, collective stick position (and possibly other control positions if control coupling is present) will not be correct. Since maneuvers are normally started from 1.0 g flight and the preload is greater than 1.0, this should not create a problem.

At the first time point where n exceeds n_p, whether at or following the start of the maneuver, the forcing function is defined there and at subsequent time points as

$$F_{BW} = W(n-n_p)$$

That is, once n exceeds n_p, the forcing function can be negative if n later drops below n_p. This definition of F_{BW} applies as long as

$$\delta > 0.0 \text{ or } \ddot{\delta} \geq 0.0$$

at each subsequent time point.

If at any time point the computations yield $\delta \leq 0.0$ and $\ddot{\delta} < 0.0$, the bobweight parameters for the next time point are reinitialized to

$$\ddot{\delta} = \dot{\delta} = \delta = 0$$

and

$$F_{BW} = \text{Max }[0,\ W(n-n_p)]$$

i.e., the same values as at t = 0. Subsequent computations proceed as from t = 0.

The increment added to collective pitch is then

$$\Delta\theta_o = -\eta\delta$$

i.e., positive bobweight displacement and positive linkage reduces collective pitch. This increment is always added to the main rotor collective. If the tail rotor (Rotor 2) lateral mast tilt angle, XTR(45), is less than 45 degrees, the increment is also added to the Rotor 2 collective pitch.

3.23 <u>WEAPONS GROUP (Include only if NPART = 2 or 4 and IPL(23) ≠ 0)</u>

CARD 241

Stationline, buttline, and waterline are used to locate the point of application of the recoil force of the weapon.

Azimuth and elevation define the orientation of the weapon with respect to the fuselage. Positive azimuth is to the right; positive elevation is up. With both angles zero, the weapon is aligned parallel to the body X axis and is defined to be firing in the positive X-direction (forward).

The recoil force is prescribed on a 311-type card. See Section 3.27.2.10, J = 16. For a weapon firing in the direction prescribed by the orientation angles, the sign of the recoil force should normally be negative (i.e., opposite to the direction of firing).

3.24 SCAS GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

The Stability and Control Augmentation System (SCAS) is programmed to simulate an actual hardware system which provides improved stability and response to pilot inputs. The system block diagram is shown in Figure 34.

The quantities in Figure 34 are

B = control input (equal to appropriate stick input; see Figure 32)

B_G = SCAS feedforward added to stick input to offset feedback

B_H = SCAS feedback dependent on ship response

$S_M = B + B_G - B_H$ = total control input

G_P = feedforward transfer function

H = feedback transfer function

η = ship response variable (roll, pitch, or yaw); dots indicate time derivatives

The feedback transfer function has the following form:

$$H = \frac{B_H}{\eta} = \frac{K_H\, s(\tau_1 s + 1)(\tau_2 s + 1)}{(\tau_3 s + 1)(\tau_4 s + 1)(\tau_5 s + 1)}$$

where

s = Laplace Transform Operator $\frac{d}{dt}$ and the other variables are defined in terms of the inputs in Section 2.24.

The feedforward transfer function has the following form:

$$G_P = \frac{B_G}{B} = \frac{K_G s}{(\tau_3 s + 1)(\tau_4 s + 1)(\tau_5 s + 1)}$$

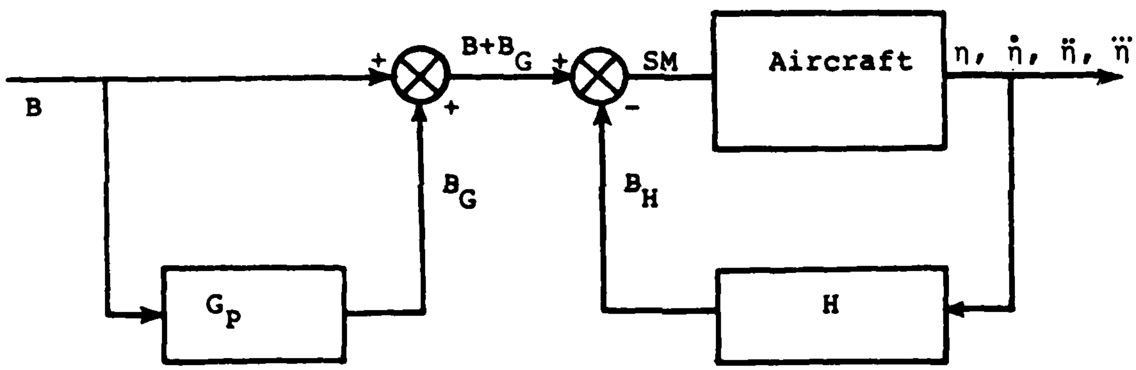


Figure 34. Block Diagram for SCAS Model.

In the program, these equations are written and solved in the form of differential equations:

$$C_1 B_H + C_2 \ddot{B}_H + C_3 \dot{B}_H + B_H = C_4 \eta + C_5 \ddot{\eta} + K_H \dot{\eta}$$

$$C_1 B_G + C_2 \ddot{B}_G + C_3 \dot{B}_G + B_G = K_G \dot{B}$$

where

$$C_1 = \tau_3 \tau_4 \tau_5$$

$$C_2 = \tau_3 \tau_4 + \tau_4 \tau_5 + \tau_3 \tau_5$$

$$C_3 = \tau_3 + \tau_4 + \tau_5$$

$$C_4 = \tau_1 \tau_2 K_H$$

$$C_5 = (\tau_1 + \tau_2)\ K_H$$

The variables used in the general equations above are defined in terms of the input variables for the three SCAS channels in the table below.

General Equation	Roll Channel	Pitch Channel	Yaw Channel
K_H	XSCAS(1)	XSCAS(8)	XSCAS(15)
K_G	XSCAS(7)	XSCAS(14)	XSCAS(21)
τ_1	XSCAS(2)	XSCAS(9)	XSCAS(16)
τ_2	XSCAS(3)	XSCAS(10)	XSCAS(17)
τ_3	XSCAS(4)	XSCAS(11)	XSCAS(18)
τ_4	XSCAS(5)	XSCAS(12)	XSCAS(19)
τ_5	XSCAS(6)	XSCAS(13)	XSCAS(20)
η	roll angle	pitch angle	yaw angle

CARD 254

The SCAS has one independent channel for roll, pitch, and yaw. See Section 3.27.2.17, J=24, 25, and 26 for procedure to activate the system.

The maximum change that the roll channel of the SCAS may make is ± XSCAS (22) percent of the full range of the lateral cyclic. The maximum authorities in pitch and yaw are similarly defined.

The dead bands on the moment derivatives are used to negate the numerical noise that may be generated in the numerical differentiation process necessary to obtain these quantities. A value of 100 has been satisfactory for those cases run to date.

3.25 STABILITY ANALYSIS TIMES GROUP (Include only if NPART=2 or 4 and IPL(23) ≠ 0, or if NPART = 5)

The inputs to this group (the TSTAB array) specify the points during a maneuver where a rotorcraft stability analysis is to be performed. This rotorcraft stability analysis is the same as that performed after TRIM when NPART = 7 or when NPART = 10 and NVARC = 1.

The sign of each TSTAB input determines the units assigned to it. If the input is positive, its value is assumed to be time in seconds. If the input is negative, its absolute value is assumed to be the total azimuth angle of Blade 1 of the main rotor in degrees. This total azimuth angle is defined as zero degrees (blade parallel to the tail boom, pointing aft) at maneuver time zero, and increases by 360 degrees for each complete rotor revolution. It is not necessary that the inputs be all positive (seconds) or all negative (degrees). However, it is mandatory that each TSTAB input specify a point in the maneuver that occurs after the point specified by the preceding TSTAB input. Hence, to avoid input errors, it is suggested that all inputs be in consistent units, particularly if the maneuver involves a change in rotor rpm.

It is emphasized that total azimuth angles are referenced to time zero. Hence, angles in the second rotor revolution are between 360 and 720 (inputs of -360.0 to -720.0); an input of -90.0 will only generate a rotorcraft stability analysis during the first rotor revolution.

NOTE: If the time-variant rotor analysis is activated (IPL(49) ≠ 0), rotorcraft stability analyses cannot be performed, and TSTAB(1) must consequently specify a time or azimuth angle which occurs after the end of the maneuver. Otherwise, execution will terminate at the time point corresponding to TSTAB(1). A value of 9999. (seconds) for TSTAB(1) is suggested in this case.

3.26 BLADE ELEMENT DATA PRINTOUT GROUP (Include only if NPART = 2 or 4 and IPL(23) ≠ 0 or if NPART = 5)

CARDS 271 and 272

The inputs to this group (the TAIR array) specify the points during the maneuver where blade element data are to be printed. TAIR inputs are interpreted in the same manner as TSTAB inputs (i.e., positive inputs are taken as seconds from the start of the maneuver and negative inputs as degrees of total azimuth angle for Blade 1 of the main rotor). See Section 3.24 for a more complete discussion. The output obtained at the specified points may be dynamic loads only, aerodynamic loads only, or both, as discussed below.

If IPL(75) = 0 or 1, the beamwise bending moment, chordwise bending moment, and torsional moment are printed for each radial station on each blade of Rotor 1. These moments have been resolved through the blade pitch angle so they really are beamwise and chordwise.

If IPL(75) = 2, detailed aerodynamic data are printed for each radial station on each blade of Rotor 1 in addition to the bending moments.

IPL(76) controls the printout of the bending moment and aerodynamic data for Rotor 2.

Note that bending moment data will be printed only when the specified rotor uses the time-variant analysis. If printout of moment data is specified for a rotor that uses the quasi-static analysis, the program ignores the inputs and does not print the data. However, blade element aerodynamic data will be printed at the specified times regardless of the type of rotor analysis which is active.

The TAIR inputs are also used to specify the points during a maneuver where data are to be stored for contour plotting (IPL(79) ≠ 0). Note that only main rotor data are stored during a maneuver. If the quasi-static rotor analysis is used, the inputs specify the point in the maneuver where data are to be stored. If the time-variant rotor analysis is used, the inputs specify the point at which storing of data is to begin; data storing continues at each subsequent time point until one rotor revolution is completed. Once storage has begun for a revolution, any TAIR input that occurs prior to the end of that revolution will be ignored as far as storing contour plot data; however, other blade element data will be printed as specified by IPL(75), IPL(76), and the value of TAIR.

3.27 <u>MANEUVER TIME CARD</u> (Include only if NPART = 2, 4, or 5)

CARD 301

This card and subsequent cards are to be included in the data deck only when running a maneuver; i.e., NPART = 2, 4, or 5 on CARD 01.

For NPART = 2 or 4, the start time, TCI(1), is assumed to be zero, and any other input is ignored. For NPART = 5, the start time is the time at which the maneuver is to be restarted; it must be greater than zero and less than the last time point of the maneuver being restarted. See discussion of CARD 01 for further details.

TCI(2) is used to specify the first base value of the time increment (Δt) between the calculation of maneuver time points. The Δt computed from TCI(2) will be used during the interval of TCI(1) to TCI(3) seconds of maneuver time. If TCI(2) < 1.0, the input is taken to be Δt in seconds. If TCI(2) $\geq$ 1.0, the input is taken to be the increment in Rotor 1 azimuth location in degrees between time points; in this case, the time increment to be used is defined as

$$\Delta t = TCI(2)/(6\Omega_1)$$

where Ω_1 is the rotational speed of Rotor 1 in units of rpm and Δt is in seconds.

To insure stability of the numerical integration technique during a time-variant maneuver (IPL(49) $\neq$ 0), the azimuth increment should always be less than or equal to 15 degrees. If aeroelastic blades are included in the simulation, an additional constraint is that at least 10 time points should be computed for each cycle of the highest natural frequency in the rotor mode shape data. For example, if the highest natural frequency is 3.0/rev, one cycle occurs every 120 degrees and the azimuth increment should then be less than or equal to 12 degrees. These requirements for the azimuth increment apply to time-variant trims as well as to time-variant maneuvers. If either unsteady aerodynamic option is activated (IPL(48) $\neq$ 0), the azimuth increment for maneuver should not be greater than about 15 degrees; 10 degrees or less is preferable.

It may be desirable to change the value of Δt because of a change in rotor speed. For this case, TCI(4) can be used to specify the value of Δt to be used between TCI(3) and TCI(5) seconds of maneuver time. Like TCI(2), TCI(4) may be either a time or azimuth increment. It is not necessary that TCI(2) and TCI(4) be the same type of increment; e.g., one may be time and the other azimuth. Do not change the time increment in the period in which the rotor aeroelastic stability is being analyzed.

If TCI(6), the time to stop the maneuver, is greater than TCI(5), the program then uses the Δt based on TCI(2) between TCI(5) and TCI(6) seconds of maneuver time. If TCI(5) is the time to stop the maneuver, as well as the time to stop using the Δt based on TCI(4), the TCI(6) input may be zero or blank. If a second time increment is not desired, then TCI(4) and TCI(5) should be input as 0.0. In this case, TCI(6) will be ignored and TCI(3) is taken as the time to stop the maneuver.

When the time increment is changed during a maneuver, it may be desirable to change the frequency of printout of the time points; i.e., to change the value of NPRINT input on CARD 01. This may be done with a J = 31 card (see Section 3.27.2.22).

3.28 <u>MANEUVER SPECIFICATION CARDS</u> (May be included only if NPART = 2, 4, or 5)

CARD 311

NEXTJ = 0 This is the last card of the 311 type.

NEXTJ ≠ 0 Another card of the 311 type follows.

J Type of variation, explained in list below.

If NPART = 2, 4, or 5, one card of the 311 type must be included and up to 20 may be included. All have the same format (I1, I4, 5X, 6F10.0). It is not necessary to have the J values in numerical order, and there may be several cards with the same value of J. It is necessary that NEXTJ ≠ 0 on all of these cards except the last one, which must have NEXTJ = 0.

3.28.1 <u>Summary of Permissible J Values</u>

Permissible values of J are from 1 to 37. The type of variation that occurs for each value of J is given in the following list.

J = 1	movement of collective stick
J = 2	movement of longitudinal cyclic stick
J = 3	movement of lateral cyclic stick
J = 4	movement of pedal
J = 5	inactive
J = 6	folding rotors aft after tilting forward and stopping
J = 7, J = 8	inactive
J = 9	a vertical ramp gust; ramp length may be zero
J = 10	a vertical sine-squared gust
J = 11	a horizontal ramp gust; ramp length may be zero
J = 12	a horizontal sine-squared gust
J = 13	a change in engine torque supplied
J = 14	a change in auxiliary thrust supplied
J = 15	inactive
J = 16	weapon fire
J = 17	change of longitudinal mast tilt angle and of rpm on both rotors
J = 18	rotor brake
J = 19	inactive
J = 20	sinusoidal movement of controls or mast
J = 21, J = 22	inactive
J = 23	rpm-dependent hub springs
J = 24	SCAS roll channel

J = 25 SCAS pitch channel
J = 26 SCAS yaw channel
J = 27 folding rotors horizontally after stop
J = 28 rpm dependent flapping stops
J = 29 connecting and disconnecting helicopter controls
J = 30 rotor moment balancing mechanism
J = 31 changing NPRINT
J = 32 simplified automatic pilot simulation
J = 33 inactive
J = 34 deployment of an aerodynamic brake
J = 35 dropping an external store
J = 36 changing incidence or control surface deflection angles of aerodynamic surfaces
J = 37 a trailing vortex system
J = 38 }
J = 39 } inactive
J = 40 }
J = 41 roll rate input to autopilot (P-tracker)
J = 42 pitch rate input to autopilot (Q-tracker)
J = 43 yaw rate input to autopilot (R-tracker)
J = 44 normal load factor input to autopilot (G-tracker)
J = 45 rate-of-climb input to autopilot (RC-tracker)

3.28.2 Inputs for J-Cards

The input format for each of the currently available J-cards is given below. Start and stop times refer to the time from the start of maneuver unless otherwise noted.

3.28.2.1 J = 1, 2, 3, 4 (Control Movements)

Col	11-20	Start time for input rate 1	(sec)
	21-30	Input rate 1	(in./sec)
	31-40	Stop time for input rate 1	(sec)
	41-50	Start time for input rate 2	(sec)
	51-60	Input rate 2	(in./sec)
	61-70	Stop time for input rate 2	(sec)

For normal control rigging, positive control rates correspond to up collective, forward longitudinal cyclic, right lateral cyclic and up tail rotor collective.

If the computed control position is greater than 100 percent or less than 0 percent, it is reset to 100 or 0 percent respectively. Hence, if a control is put on a stop by rate and time inputs that would normally put the control past its stop, subsequent rate and time inputs should be with respect to the stop, not to the imaginary position beyond the stop.

3.28.2.2 J = 5

J = 5 is currently inactive

3.28.2.3 J = 6 (Folding Rotors Aft)

Col	11-20	Start time (after Ω=0)	(sec)
	21-30	Rate (positive to fold aft)	(deg/sec)
	31-40	Stop time (after Ω=0)	(sec)
	41-50	Start time (after Ω=0)	(sec)
	51-60	Rate (positive to fold aft)	(deg/sec)
	61-70	Stop time (after Ω=0)	(sec)

3.28.2.4 J = 7, J = 8

J = 7 and 8 are currently inactive

3.28.2.5 J = 9 and 11 (Vertical and Horizontal Ramp Gust, Respectively) (see Figure 35)

Col	11-20	(1) Starting distance (in ground X-Y plane)	(ft)
	21-30	(2) 1st max velocity (positive down or north)	(ft/sec)
	31-40	(3) 1st ramp length	(ft)
	41-50	(4) Distance gust is steady	(ft)
	51-60	(5) 2nd ramp length	(ft)
	61-70	(6) 2nd max velocity (measured from first max velocity)	(ft/sec)

NOTE: J = 9 or 11 may only be used once per maneuver run.

3.28.2.6 J = 10 and J = 12 (Vertical and Horizontal Sine-Squared Gust, Respectively) (see Figure 36)

Col	11-20	(1) Starting distance	(ft)
	21-30	(2) 1st max value (positive down or north)	(ft/sec)
	31-40	(3) 1st gust length	(ft)
	41-50	(4) Distance between gusts	(ft)
	51-60	(5) 2nd gust length	(ft)
	61-70	(6) 2nd max value	(ft/sec)

NOTE: J = 10 or 12 may only be used once per maneuver run.

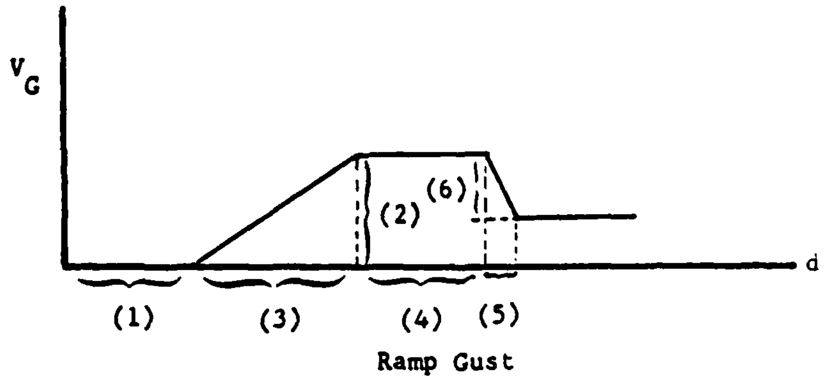


Figure 35. Definition of Terms Describing Gust Velocity Versus Distance for a Ramp Gust.

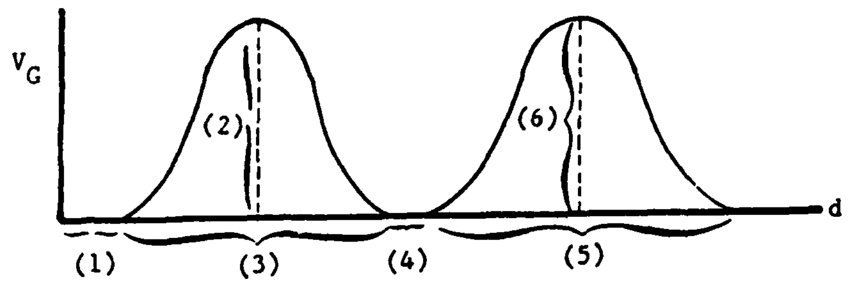


Figure 36. Definition of Terms Describing Gust Velocity Versus Distance for Sine-Squared Gusts.

3.28.2.7 J = 13

J = 13 is currently inactive.

3.28.2.8 J = 14 (Auxiliary Jet Thrust)

Col	11-20	Start time for jet thrust variation	(sec)
	21-30	Type of variation indicator, TVI	
	31-40	Rate of change of jet thrust, RJT	(lb/sec)
	41-50	Stop time for variation	(sec)
	51-60	Final value of jet thrust	(lb)
	61-70	Affected jet; = 1.0 for left jet, = 2.0 for right jet	

Three types of jet thrust variation are possible based on the value of TVI.

If TVI = 0.0, the rate RJT acts for the specified time, i.e., the stop time minus start time. The input for the final value of jet thrust is ignored in this case.

If TVI = 1.0, the rate RJT acts until the final value of jet thrust specified in columns 51 to 60 is attained. The input for the stop time is ignored in this case.

Following one or more J = 14 cards where TVI = 0.0 or 1.0, it may be desirable to change the jet thrust back to its value at the start of the maneuver, the trim value. To do this, set TVI = 2.0, which will cause the final value of thrust (columns 51 to 60) to be reset to the trim value and TVI to be reset to 1.0. The specified rate will then act until the jet thrust returns to the trim value. The input stop time is ignored in this case. TVI should not equal 2.0 unless a previous J = 14 card has changed the jet thrust from the trim value.

3.28.2.9 J = 15

J = 15 is currently inactive

3.28.2.10 J = 16 (Machine Gun Fire, Ramp Only) (see Figure 37)

Col	11-20	(1) Start time	(sec)
	21-30	(2) Stop time	(sec)
	31-40	(3) Max force (normally negative)	(lb)
	41-50	(4) Ramp length	(sec)
	51-60 61-70	Inactive	

For the normal case of a weapon firing forward, the reaction force should be negative. See the Weapons Group (Section 3.22) for additional details.

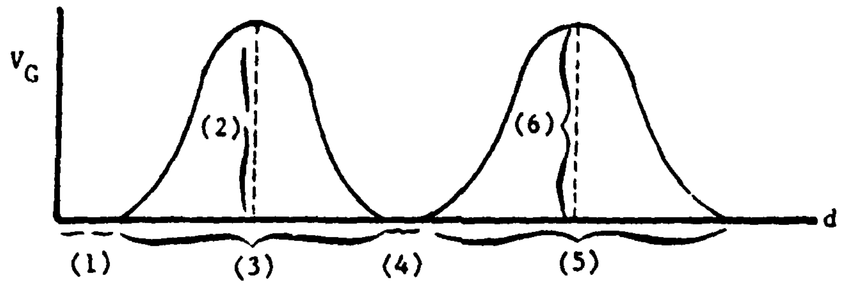


Figure 36. Definition of Terms Describing Gust Velocity Versus Distance for Sine-Squared Gusts.

3.28.2.7 J = 13

J = 13 is currently inactive.

3.28.2.8 J = 14 (Auxiliary Jet Thrust)

Col	11-20	Start time for jet thrust variation	(sec)
	21-30	Type of variation indicator, TVI	
	31-40	Rate of change of jet thrust, RJT	(lb/sec)
	41-50	Stop time for variation	(sec)
	51-60	Final value of jet thrust	(lb)
	61-70	Affected jet; = 1.0 for left jet, = 2.0 for right jet	

Three types of jet thrust variation are possible based on the value of TVI.

If TVI = 0.0, the rate RJT acts for the specified time, i.e., the stop time minus start time. The input for the final value of jet thrust is ignored in this case.

If TVI = 1.0, the rate RJT acts until the final value of jet thrust specified in columns 51 to 60 is attained. The input for the stop time is ignored in this case.

Following one or more J = 14 cards where TVI = 0.0 or 1.0, it may be desirable to change the jet thrust back to its value at the start of the maneuver, the trim value. To do this, set TVI = 2.0, which will cause the final value of thrust (columns 51 to 60) to be reset to the trim value and TVI to be reset to 1.0. The specified rate will then act until the jet thrust returns to the trim value. The input stop time is ignored in this case. TVI should not equal 2.0 unless a previous J = 14 card has changed the jet thrust from the trim value.

3.28.2.9 J = 15

J = 15 is currently inactive

3.28.2.10 J = 16 (Machine Gun Fire, Ramp Only) (see Figure 37)

Col	11-20	(1) Start time	(sec)
	21-30	(2) Stop time	(sec)
	31-40	(3) Max force (normally negative)	(lb)
	41-50	(4) Ramp length	(sec)
	51-60	Inactive	
	61-70	Inactive	

For the normal case of a weapon firing forward, the reaction force should be negative. See the Weapons Group (Section 3.22) for additional details.

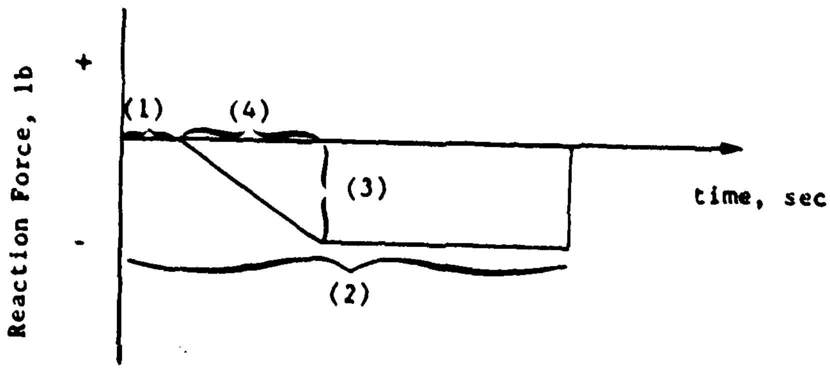


Figure 37. Definition of Terms Describing the Weapon Recoil Force Versus Time.

3.28.2.11 J = 17 (Longitudinal Mast Tilt on Both Rotors)
(see Figure 38)

Col 11-20	Start time for mast tilt	(sec)
21-30	Rate of mast tilt	(deg/sec)
31-40	Stop time for mast tilt	(sec)
41-50	(Inactive)	
51-60	α, mast tilt angle at which rpm change is activated	(deg)
61-70	$\Omega_H - \Omega_A$, change in rpm in converting from airplane mode to helicopter mode	(rpm)

$$\Omega = \begin{cases} \Omega_A + (\Omega_H - \Omega_A)*\cos[90(\beta_m-\alpha)/(90-\alpha)] & \text{if } \beta_m>\alpha \\ \Omega_H & \text{if } \beta_m \le \alpha \end{cases}$$

where

β_m = longitudinal mast tilt angle

Ω = current rotor rpm

Ω_H = rotor rpm in helicopter mode ($\beta_m = 0°$)

Ω_A = rotor rpm in airplane mode ($\beta_m = 90°$)

3.28.2.12 J = 18 (Rotor Brake)

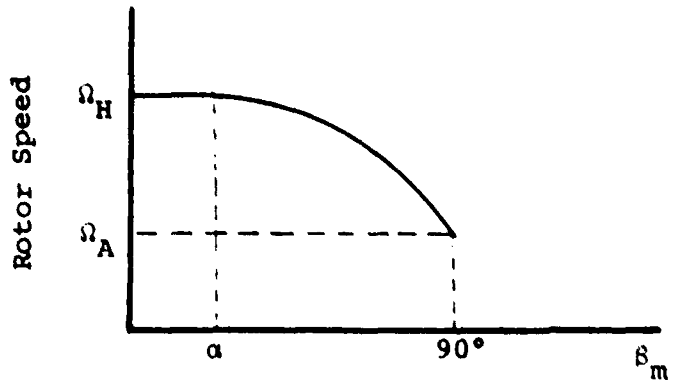
Col 11-20	Maximum brake torque	(ft-lb)
21-30	RPM at which brake engages, Ω_b	(rpm)
31-40	Target azimuth position for stop	(deg)
41-50	Time to stop applying brake	(sec)
51-60	Inactive	
61-70	Inactive	

3.28.2.13 J = 19

J = 19 is currently inactive

3.28.2.14 J = 20 (Sinusoidal Movement of Controls or Mast)

Col 11-20	Start time	(sec)
21-30	Frequency	(Hz)
31-40	Amplitude	(in./deg)
41-50	Stop time	(sec)
51-60	Control to be moved	
61-70	Inactive	



$$\Omega = \begin{cases} \Omega_A + (\Omega_H-\Omega_A)*\cos\left[90(\beta_m-\alpha)/(90-\alpha)\right] & \text{if } \beta_m>\alpha \\ \Omega_H & \text{if } \beta_m\leq\alpha \end{cases}$$

Figure 38. Definition of Terms Describing the Variation of Rotor Speed with Mast Angle.

Amplitude is in inches for controls or in degrees for mast tilt. The code for the control to be moved is

1.0 = Collective stick
2.0 = Longitudinal cyclic stick
3.0 = Lateral cyclic stick
4.0 = Pedal
5.0 = Longitudinal mast tilt

Note that if the control code is 5.0, the longitudinal mast tilt angle of <u>both</u> rotors is varied.

3.28.2.15 <u>J = 21 and 22</u>

J = 21 and 22 are currently inactive

3.28.2.16 <u>J = 23 (RPM-Dependent Hub Springs)</u>

Col	11-20	Rotor number (1.0 or 2.0)	(ft-lb/deg)
	21-30	K_B hub spring value in lower rpm range	(rpm)
	31-40	Ω_1 top of lower rpm range	(rpm)
	41-50	Ω_2 bottom of upper rpm range	(rpm)
	51-60	Inactive	
	61-70	Inactive	

Let Ω be the rpm of Rotor 1, K_I be XMR(18) or XTR(18), as appropriate, and K_h be the rpm-dependent value of the appropriate hub spring. Then

$$K_h = \begin{cases} K_I & \text{if } \Omega \geq \Omega_2 \\ \dfrac{K_B - K_I}{\Omega_I - \Omega_2} \quad \Omega - \Omega_2 \quad + K_I & \text{if } \Omega_1 < \Omega < \Omega_2 \\ K_B & \text{if } \Omega \leq \Omega_1 \end{cases}$$

In other words, the extreme values for the hub springs are K_B, and the input in the appropriate rotor group is K_I. Linear interpolation is used in the transition region.

3.28.2.17 J = 24, 25, 26 (SCAS Channels)

Col 11-20	Time to activate SCAS channel
21-30	Time to turn off SCAS channel
31-40	Inactive
41-50	Inactive
51-60	Inactive
61-70	Inactive

3.28.2.18 J = 27 (Horizontal Fold, for Main Rotor Only)

Col 11-20	Start time	(sec after Ω=0)
21-30	Rate	(deg/sec)
31-40	Stop time	(sec after Ω=0)
41-50	Blade number (each blade moves independently)	
51-60	Inactive	
61-70	Inactive	

3.28.2.19 J = 28 (RPM Dependent Flapping Stops)

Same as for J = 23 except that mechanism affected is flapping stops and K_B is in degrees.

3.28.2.20 J = 29 (Control Changer - to Lock or Unlock Swashplate)

Col 11-20	Start time	(sec)
21-30	Stop time	(sec)
31-40	Indicator; = 0.0 if start time is in maneuver seconds, ≠ 0.0 if start is in seconds after Ω=0.0	
41-50	Indicator; = 0.0 if stop time is in maneuver seconds, ≠0.0 if stop time is in seconds after Ω=0.0	
51-60	Indicates which controls to lock or unlock; 1.0 is for Rotor 1 collective; 2.0 is for Rotor 1 longitudinal cyclic; 4.0 is for Rotor 1 lateral cyclic; 8.0 is for Rotor 2 collective. For any combination, add the indicators. 0.0 is equivalent to 15.0, which affects all controls.	
61-70	Inactive	

If this mechanism is switched off during a maneuver, swashplate settings will immediately assume the value dictated by the control positions. Care should be taken to set the controls so that there are no discontinuities.

3.28.2.21 J = 30 (Mechanism for Balancing Main Rotor Force and Moments During Horizontal Fold)

Col 11-20	Start time	(sec after Ω=0)
21-30	Stop time	(sec after Ω=0)
31-40	∂(Z-force)/∂(collective)	(lb/deg)
41-50	∂(longitudinal flapping moment)/ ∂ (longitudinal cyclic)	(ft-lb/deg)
51-60	∂ (lateral flapping moment)/ ∂ (lateral cyclic)	(ft-lb/deg)
61-70	Maximum rate of change of controls (collective and cyclic)	(deg/sec)

3.28.2.22 J = 31 (Changing Printout Frequency)

Col 11-20	Time to change NPRINT	(sec)
21-30	New NPRINT	
31-40	Time to change NPRINT	(sec)
41-50	New NPRINT	
51-60	Time to change NPRINT	(sec)
61-70	New NPRINT	

NPRINT must be input as a floating number; therefore, punch a decimal point on the data card. The use of NPRINT is as described for CARD 01, NPART = 2.

As an example of the use of this value of J, as well as an example of the use of the provision for different time increments on CARD 301, consider the following hypothetical situation.

A maneuver was run in which a pitch divergence occurred. Analysis of the output indicated that the divergence started between 3.5 and 3.75 seconds. The time increment used was .05 and NPRINT was 5 throughout the run, which lasted 7.5 seconds.

A new maneuver was then set up, identical to the first except that the time card, CARD 301, now contained 0.0, 0.05, 3.5, 0.005, 3.75, 3.75 as the consecutive inputs instead of 0.0, 0.05, 7.5, blank, blank, blank which were used on the previous run. NPRINT on CARD 01 was changed from 5 to 70. An additional CARD 311 was input which had a J of 31. The number 3.5 was in Columns 11-20, the number 1.0 in Columns 21-30, and the rest of the card was blank.

In the output (see Section 4 for a complete explanation of all outputs), the trim page was followed by the maneuver page for maneuver time of 0.0 second. The next time point for which output was given was 3.5 seconds and output was given at every 0.005 second until 3.75 seconds. The result was no output for time points of no interest, but complete coverage of the time interval of interest.

3.28.2.23 J = 32 (Automatic Pilot)

Col	11-20	Time to activate autopilot	(sec)
	21-30	Maximum rate for cyclic stick motion	(%/sec)
	31-40	Maximum rate for collective stick motion	(%/sec)
	41-50	Maximum rate for pedal motion	(%/sec)
	51-60	Time interval to zero rates	(sec)
	61-70	Time interval to zero displacements	(sec)

CAUTION: At least one partial derivative matrix must be computed prior to activating the Automatic Pilot. Without such a matrix, execution will terminate when the Automatic Pilot is activated.

The Automatic Pilot control corrections are determined from the simultaneous solution of the three moment equations and the Z-force equation with the moment and force imbalances as the coefficient terms. The dependent variables are the control corrections. If there is a prescribed input from any of the controls (J=1, 2, 3, or 4), the Automatic Pilot will not move that control.

3.28.2.24 J = 33

J = 33 is currently inactive

3.28.2.25 J = 34 (Aerodynamic Brake Deployment)

Col	11-20	Time to start change in deployment	(sec)
	21-30	Rate of deployment change	(%/sec)
	31-40	Time to stop change in deployment	(sec)
	41-50	Brake number	
	51-60	Inactive	
	61-70	Inactive	

The Brake Number (Col 41-50) must be 1, 2, 3, or 4, which corresponds to the first, second, third, or fourth subgroup of the External Stores/Aerodynamic Brake Group (CARDS 181A-184C). If the Brake Number specified corresponds to a subgroup that is supposed to be an external store; i.e., having a weight greater than zero, execution is terminated. Deployment is stopped at 0 or 100-percent deployment regardless of the rate and time inputs.

3.28.2.26 J = 35 (External Store Drop)

Col	11-20	Time to drop store (t_D)	(sec)
	21-30	Sequence number of store to be dropped	
	31-40	Duration of jettison reaction forces (Δt_{JF})	(sec)
	41-50	X-Reaction force (+ forward)	(lb)
	51-60	Y-Reaction force (+ right)	(lb)
	61-70	Z-Reaction force (+ down)	(lb)

The sequence number of the store to be dropped must be 1.0, 2.0, 3.0, or 4.0, i.e., the first, second, third, or fourth Store/Brake subgroup. If the sequence number corresponds to a subgroup that is not used or is an aerodynamic brake rather than a store (weight $<$ 0 instead of $>$ 0), execution will terminate. The jettison reaction forces start acting at the drop time (t_D) and stop at $t_D + \Delta t_{JF}$ seconds of maneuver time. The reaction forces are defined in body axis. For example, if a store is jettisoned straight down, the reaction force will be up and the Z-direction reaction force (Col 61-70) should be negative.

3.28.2.27 J = 36 (Change of Incidence or Control Surface Angles)

Col	11-20	Start time	(sec)
	21-30	Rate of angle change	(deg/sec)
	31-40	Stop time	(sec)
	41-50	Surface indicator, SI	
	51-60	Type of change indicator, CI	
	61-70	(Inactive)	

The surface indicator, SI, specifies which surface is involved.

$$SI = \begin{cases} 0 \text{ or } 5 \text{ for wing} \\ 1, 2, 3, \text{ or } 4 \text{ for Stabilizing Surface No. 1, No. 2,} \\ \quad \text{No. 3, or No. 4 respectively} \end{cases}$$

The type of change indicator, CI, specifies the angle to be changed.

$$CI \begin{cases} = 0.0 \text{ for change of incidence angle} \\ \neq 0.0 \text{ for change of control surface, or flap, angle} \end{cases}$$

For the wing, the angle change is symmetrical. For all surfaces, positive incidence change is leading edge up; positive control surface deflection is trailing edge down.

3.28.2.28 J = 37 (Trailing Vortex System)

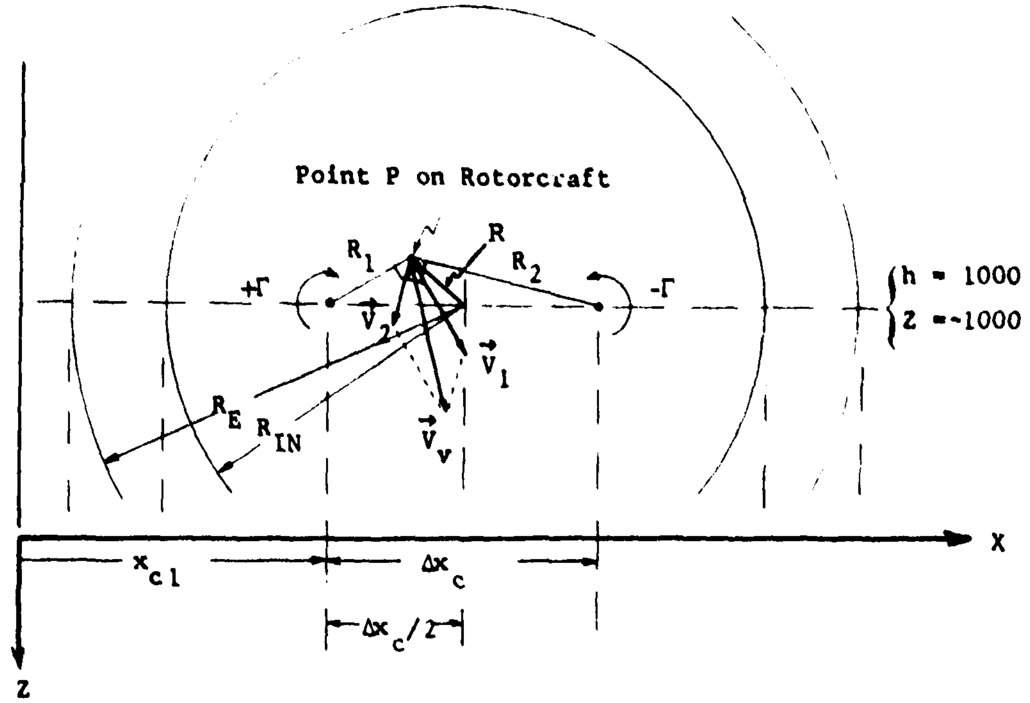
Col 11-20	X-distance to center of first core (x_{c1})	(ft)
21-30	X-distance between core centers (Δx_c)	(ft)
31-40	Circulation strength of first vortex (Γ)	(ft^2/sec)
41-50	Core size factor (K_c)	(ft^2)
51-60	Distance in the X-Z plane from center of vortex system to start of vortex velocity field (R_E)	(ft)
61-70	Distance in the X-Z plane from center of vortex system to where the rotorcraft is completely within the vortex velocity field (R_{IN})	(ft)

The trailing vortex system consists of two equal-strengthed, counterrotating vortices. The system is defined in the X-Z plane of the ground reference system as shown in Figure 39. Note that the vortex pair is located at a geometric altitude of 1000 feet, so that the vertical distance between the vortex pair system and the helicopter is 1000 - XFC(4) .

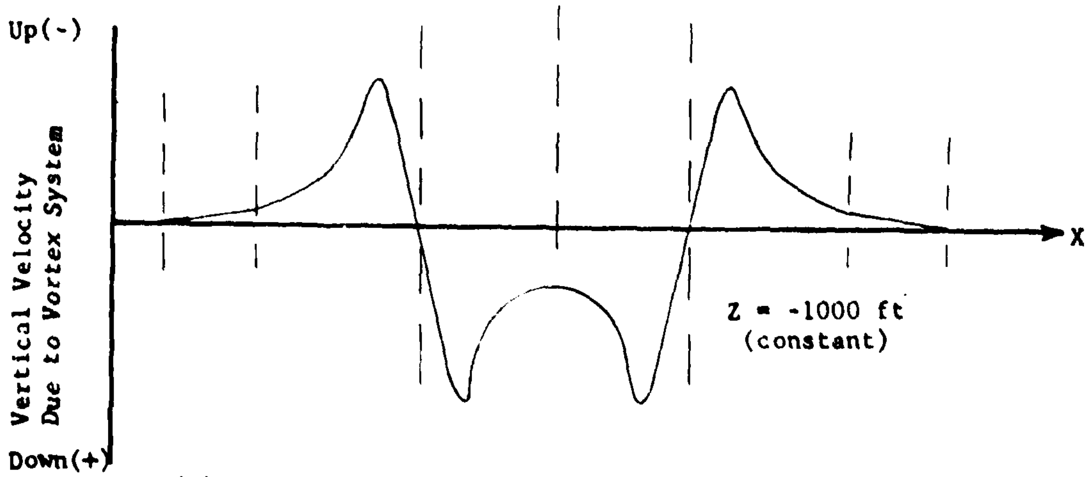
The velocity at a point P on the rotorcraft due to the vortex system is

$$\vec{V}_V = \begin{cases} 0 \text{ if } R \geq R_E \\ (\vec{V}_1 + \vec{V}_2) \cos^2 (RF) \text{ if } R_E > R > R_{IN} \\ \vec{V}_1 + \vec{V}_2 \quad \text{if } R \leq R_{IN} \end{cases}$$

where R is the distance from the center of the vortex system to the point; $\vec{V}_1$ and $\vec{V}_2$ are the vortex velocity vectors at the point due to the first and second vortex, respectively; RF is a phasing factor; and R_E and R_{IN} are inputs.



(a) Geometry of Vortex System in Ground Reference.



(b) Vertical Velocity due to Vortex System at Constant Altitude in Ground Reference.

Figure 39. Trailing Vortex System Model.

$$\vec{V}_1 = \frac{\Gamma}{2\pi R_1} (1-e^{-R_1^2/K_c})$$

$$\vec{V}_2 = \frac{\Gamma}{2\pi R_2} (1-e^{-R_2^2/K_c})$$

$$RF = \frac{\pi}{2} \frac{R-R_{IN}}{R_E-R_{IN}}$$

where R_1 and R_2 are the distances from the centers of the first and second vortex, respectively, to the point on the rotorcraft and K_c is an input.

Note that the velocity field is independent of ground reference Y-location (i.e., the velocity along any line parallel to the ground Y-axis is constant). Hence, by inputting appropriate values of forward and lateral velocities, rate of climb, and heading angle (XFC(1), (2), (3), and (5) respectively), the vortex velocity field can be approached from any desired angle. The body axis components of the velocity at the rotorcraft cg due to the vortex system are printed under the headings of gust velocities on the maneuver-time-point page of the printout. Velocities at other points on the rotorcraft are not printed out.

CAUTION: As with horizontal and vertical gusts (J = 9, 10, 11, or 12), be sure that the inputs do not put the rotor into the velocity field too early. As a rule of thumb, $(x_{c1} + \Delta x_c/2 - R_E)$ should be greater than the rotor radius.

3.28.2.29 J = 38, 39, and 40

J = 38, 39, and 40 are currently inactive.

3.28.2.30 J = 41 (Roll Rate Input to Autopilot (P-Tracker))

Col 11-20	Time to start variation of desired roll rate	(sec)
21-30	First rate of change of desired roll rate	(deg/sec/sec)
31-40	Time to stop first rate	(sec)
41-50	Time to start second variation	(sec)
51-60	Second rate of change of desired roll rate	(deg/sec/sec)
61-70	Time to stop second rate	(sec)

This input is used to track an input roll-rate time history. Do not input a J = 3 card (normal control rigging). The user must input a J = 32 card.

3.28.2.31 J = 42 (Pitch Rate Input to Autopilot (Q-Tracker))

Col	11-20	Time to start variation of desired pitch rate	(sec)
	21-30	First rate of change of desired pitch rate	(deg/sec/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired pitch rate	(deg/sec/sec)
	61-70	Time to stop second rate	(sec)

This input is used to track an input pitch-rate time history. Do not input a J = 2 card (normal control rigging). The user must input a J = 32 card.

3.28.2.32 J = 43 (Yaw Rate Input to Autopilot (R-Tracker))

Col	11-20	Time to start variation of desired yaw rate	(sec)
	21-30	First rate of change of desired yaw rate	(deg/sec/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired yaw rate	(deg/sec/sec)
	61-70	Time to stop second rate	(sec)

This input is used to track an input yaw-rate time history. With normal control rigging for a single-main-rotor helicopter, the user should not input a J = 4 card. A J = 32 card must be input.

3.28.2.33 J = 44 (Normal Load Factor Input to Autopilot (G-Tracker))

Col	11-20	Time to start variation of desired normal load factor	(sec)
	21-30	First rate of change of desired normal load factor	(g/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired normal load factor	(g/sec)
	61-70	Time to stop second rate	(sec)

The normal load factor input is used to simulate a cyclic-only, symmetric pullup or pushover with a specified normal load factor time history. A J = 32 card must be input and, with normal control rigging, the user should not input a J = 1 or J = 2 card.

3.28.2.34 J = 45 (Rate-of-Climb Input to Autopilot (RC-Tracker))

Col	11-20	Time to start variation of desired rate of climb	(sec)
	21-30	First rate of change of desired rate of climb	(ft/sec/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired rate of climb	(ft/sec/sec)
	61-70	Time to stop second rate	(sec)

This input is used to track an input rate-of-climb time history. A J = 32 card must be input.

3.29 <u>PLOTTING OF TIME-HISTORY DATA</u>

Whenever time-history data are available the 400 series of cards may be used to plot the data. This procedure is an option. If it is not to be used, simply omit the 400-series cards. The data may be plotted on the computer printer or put on tape for plotting by the CALCOMP plotter. Consult your local programmer for the proper setup for jobs that write a tape for CALCOMP plotting.

Time-history data is stored after any trim case for which $0 < XIT(5) \leq XIT(6)$ and may be plotted by inserting 400-type cards in the data deck. If only one trim is being performed, a 401-type card and up to 10 402-type cards are placed immediately after the Flight Constants Group.

If a parameter sweep is being run, all the time-history plot cards must be placed after all the NPART = 10 card sets. The first set of 400-type cards will refer to the first trim case for which time-history plot data was stored. The user can sequence the program to the next set of stored time-history data with an NPART = 14 card. If the user wishes to plot this data, 400-type cards should be inserted after the NPART = 14 card. If the user wishes to skip this particular set of time-history plot data, no 400-type cards should be inserted after the NPART = 14 card. To skip the first set of time-history plot data, the user should insert an NPART = 14 card immediately after the NPART = 10 cards and then another NPART = 14 card to sequence to the next set of plot data. The NPART = 14 card is used to index to the next set of data.

For a trim-and-maneuver case, with $0 < XIT(5) \leq XIT(6)$, the 400-type cards for plotting the trim data are placed immediately after the J-cards. These plot cards are followed by an NPART = 14 card and the 400-type cards for plotting the maneuver time histories. If the user has set $0 < XIT(5) \leq XIT(6)$ but does not wish to plot the trim data, then the first set of 400-type cards should be deleted from the deck. The NPART = 14 card is still required, though, to index the plotting routine to the second set of time-history data stored on disk.

CARD 401

Column 2 must contain the integer 3 to call the plotting routine. NPRINT specifies that the first and every NPRINTth data point following are to be plotted. If NPRINT = 0, it is reset to unity.

CARDS 402A, 402B, etc.

One 402-type card is required for each plot. A maximum of 30 of these cards is permitted after each CARD 401. Each plot may contain one to three variables. The first three inputs on a 402-type card are the code numbers for the variable(s) to be plotted. The code numbers must be integers. If only one variable is to be plotted, the code numbers must be in Columns 3-5; if only two are to be plotted, only Columns 3-5 and 8-10 are to be used. The code numbers are given in Section 6.

KEY (column 20) controls where the plotting is done.

= 0 for CALCOMP only
= 1 for printer only
= 2 for both

KEYS (column 25) controls the reading of additional 402-type cards

= 1 when another 402-type card follows
= 0 for last 402-type card

The program internally computes its own scales for plotting each variable based on the maximum and minimum values of the variables during the time history and internally specified minimum scales. The internal minimum scale may be overriden for each variable with the last three inputs on the 402-type card. The minimum scale inputs are in units of the appropriate variable per inch for printer plots and units per centimeter for CALCOMP plots.

3.30 STABILITY ANALYSIS USING MOVING BLOCK FAST FOURIER TRANSFORM

The stability of any of the 2400 variables listed in Section 6 can be examined by a moving block fast Fourier transform analysis after a maneuver (NPART = 2, 4, 5, or 8). Rotor stability can only be investigated if the rotor was elastic and time-variant during the maneuver. The use of the analysis is controlled by the 500-series cards, which must be omitted if this option is not to be invoked.

CARD 501

Column 2 must contain the integer 6 to call the moving block FFT analysis.

CARD 502A, B, ...

All except the last of these cards must have a digit other than zero in the first column. The last CARD 502 must have a zero in the first column to signify the end of the group.

The variable numbers are given in Section 6. The code number must be right-justified in the field.

The analysis uses the maneuver-generated values of the selected variable in the time period between t_o and $t_o + \Delta t$, where

t_o = input start time

$\Delta t = 1.5(N/f)$

N = Number of cycles, at frequency f, to be analyzed

f = Central frequency for analysis

Δf = Half bandwidth for analysis

Therefore, t_o must be chosen so that there are at least 1.5*N cycles, at the frequency f, before the end of the maneuver.

The analysis then divides the data up into several overlapping blocks of data, each of which is N/f seconds long, and searches for the best-fit response frequency in the bandwidth $f-\Delta f$ to $f+\Delta f$. This best-fit frequency and the damping ratio for the variable are printed out. See Section 13 of Volume 1 for more details of the analysis.

3.31 STORING MANEUVER TIME-HISTORY DATA ON TAPE

CARD 601

Following a maneuver (NPART = 2, 4, or 5), it may be desirable to store the time history of the maneuver on tape so that the data can be recalled later for additional analysis or plotting. Inputs of 8 and 0 in Columns 2 and 15 respectively will store the data. However, consult your local programmer for the proper setup of the job before attempting to use this option. See NPART = 8 on CARD 01 for instructions on retrieving the data that a CARD 601 stores.

3.32 HARMONIC ANALYSIS OF TIME-HISTORY DATA

When time history data are available, the 700-series cards may be used to perform harmonic analysis of specified variables. This procedure is an option. If it is not to be used, simply omit the 700-series cards. Consult your local programmer for proper setup of jobs which write a tape for CALCOMP plotting. Refer to Section 6 for the code numbers discussed below.

The 700-series cards are inserted in the deck in the same manner as the 400 series cards using NPART = 14 cards (as described in Section 3.29) if necessary.

CARD 701

NOP in Column 2 must contain the integer 9 to call the harmonic analysis routine.

AL(1) is the start time and AH(1) is the stop time for the analysis. Both times are measured in seconds from the start time of the maneuver. The difference between the two times is referred to as Δt_A, the time interval for analysis:

$$\Delta t_A = AH(1) - AL(1)$$

NVARA is the total number of variables that are to be analyzed. NVARA must be less than or equal to 30 and an integer input.

AL(2) specifies the baseline frequency (ω) for the analysis. If AL(2) > 0.0, the input is taken to be ω in hertz. If AL(2) = 0.0, ω is set equal to the main rotor 1-per-rev frequency.

$$\omega = \Omega_1/60$$

where Ω_1 is the rotation speed of Rotor 1 in rpm. If AL(2) $\leq$ 0.0.

$$\omega = \Omega_2/60$$

where Ω_2 is the Rotor 2 rpm. If AL(2) $\leq$ 0.0 and the rotor rpm changes during Δt_A, the appropriate 1-per-rev frequency at AL(1) seconds maneuver time will be used for the analysis.

If AL(2) $\leq$ 0.0, it is necessary that

$$\Delta t_A \geq 1/\omega$$

If AL(2) > 0.0, this condition should also be met; otherwise, the data generated will be meaningless. That is, the time interval for analysis must be greater than or equal to the time for one complete revolution of the appropriate rotor. However, it is not necessary that Δt_A be an integer multiple of $1/\omega$.

The analysis computes a function of amplitude versus frequency, $A(k\omega)$, for each of the NVARA variables whose code number is input on the 502-type cards discussed below. In the analysis, each variable is assumed to be a function of time, f(t).

$$f(t) = a_o + \sum_{k=1}^{N} [a_k \cos(2\pi k\omega t) + b_k \sin(2\pi k\omega t)]$$

The summation variable N is defined as

$$N = [(n-1)/2] + 1$$

where n equals the number of time points in the Δt_A interval or 500, whichever is smaller. The brackets ([ ]) in the equation for N indicate that the enclosed term is truncated to be an integer. The amplitude function is then

$$A(k\omega) = \sqrt{a_k^2 + b_k^2}$$

NVARB controls the output of $A(k\omega)$. If NVARB = 0, the data are tabulated on the printer only; if NVARB = 1, the data are stored on magnetic tape for CALCOMP plotting (use type 10357, centimeter paper); if NVARB = 2, the data are both tabulated on the printer and stored on tape.

CARDS 702A, 702B, etc.

These cards contain the code numbers of the variables to be analyzed. A total of NVARA code numbers must be included in 14I5 format using as many cards as required. No completely blank cards are permitted.

3.33 VECTOR ANALYSIS OF MANEUVER TIME-HISTORY DATA

When maneuver data are available, the 800-series cards may be used to perform a vector analysis of selected variables. This procedure is an option that uses the technique of least-squared-errors curve fitting. If it is not to be used, simply omit the 800-series cards. Consult your local programmer for proper setup of jobs that write a tape for CALCOMP plotting. Refer to Section 6 for the code numbers discussed below.

CARD 801

Columns 1 and 2 must contain the integer 11 to call the curve-fitting routine. This procedure has three possible steps to it. The first step must be performed if either the second or third step is to be performed. The second and third steps are independent of each other, and each is optional.

Step 1:

Initially, the time histories, f(t), of the NVARA curves whose code numbers are given on the 802-type card(2) are curve fit to the equation

$$f(t) = A + B \sin(\omega t + \phi)$$

where ω is the baseline frequency, AL(1), and A, B, and ϕ are the constant, amplitude, and phase angle to be computed. This step will yield NVARA sets of A, B, and ϕ values. Permissible values of NVARA are 1 to 100.

Step 2:

Next, the amplitudes and phase angles computed in Step 1 may be compared to each other. The values computed are

$$R_B = B_i/B_x = \text{amplitude ratio}$$

$$R_\phi = \phi_i - \phi_x = \text{phase-angle difference}$$

where the subscript x indicates one of the NVARB reference variables and the subscript i indicates one of the NX variables that is to be compared to that reference value. The code numbers are input on 803-type cards. Note that only those code numbers used in Step 1 can be used in Step 2 and that the code number of a reference variable must not be included in the corresponding NX code numbers. Step 2 may be bypassed by setting NVARB = 0 and omitting all 803-type cards. Permissible values of NVARB and NX are 0 to 100.

Step 3:

The curve fits from Step 1 can themselves be fitted to an equation of the following form:

C = KD*D + DE*E + F

where C, D, and E are the f(t) corresponding to the three code numbers input on 804-type cards. Substituting each f(t) into the above equation, expanding the $\sin(\omega t + \phi)$ term to $(\sin\omega t \cos\phi + \cos\omega t \sin\phi)$, and equating the coefficients of like harmonics yields three equations in the three unknowns of KD, KE, and F. The equations are solved, and the three computed constants are output.

Since AL(2) of the 804-type cards must be included, AL(2) curve fits of the coefficients from Step 1 will be made. Note that, as in Step 2, only code numbers (variables) used in Step 1 can be used in Step 3. This step may be bypassed by setting AL(2) = 0.0 and omitting all 804-type cards. Permissible values of AL(2) = 0.0 to 100.

CARDS 802A, 802B, etc.

The 802-type cards contain the NVARA code numbers for the variables to be curve fit by Step 1. Up to 14 code numbers may be input on each card in integer fields of 5 (14I5 format). Blank cards are not permitted.

CARDS 803A, 803B, etc.

NVARB sets of the 803-type card must be included. Each set contains a code number for a reference variable plus the quantity (NX) and code numbers of the other variables to be used in Step 2. Each card is in 14I5 format. No blank cards are permitted.

CARDS 804A, 804B, etc.

AL(2) cards of the 804-type must be included. These cards contain the code numbers of the variables to be used in Step 3.

3.34 STABILITY ANALYSIS USING PRONY'S METHOD

The stability of any of the 2400 variables listed in Section 6 can be examined by Prony's method after a maneuver (NPART = 2, 4, 5, or 8). Rotor stability can only be investigated if the rotor was elastic and time-variant during the maneuver. The use of this analysis is controlled by the 900-series cards, which must be omitted if this option is not to be invoked.

CARD 901

Columns 1 and 2 must contain the number 13 to use this stability analysis.

CARDS 902A, 902B, ...

All except the last of these cards must have a 1 or a 2 punched in the first column. The last CARD 902 must have a zero in Column 1.

If the digit in Column 1 is zero or 1, the output frequency is normalized on the RPM of Rotor 1, while the output is normalized on the Rotor 2 RPM if Column 1 contains a 2.

The variable numbers are given in Section 6. The code number must be right-justified in the field.

Up to 40 terms can be used in the curve fit of the values of the variable between the start and stop time.

See Section 13 of Volume 1 for a detailed description of this stability analysis.

3.35 TABULATION AND CONTOUR PLOTS OF SELECTED ROTOR VARIABLES

When IPL(79) ≠ 0 the values of 39 rotor variables are stored as functions of blade radius and azimuth location for the last revolution of the specified rotor(s) in trim and for specified rotor revolutions during a maneuver, if any. The 1000-series cards are then used to select which of these 39 variables are to be presented as tabulations and contour plots in the printed output. The print output is shown and discussed in Section 4.15. Note that if data are stored for several trim points in a parameter sweep run, the 1000-series cards must follow the *last NPART = 10 data set in the deck. Do not include any 1000-*series cards if IPL(79) = 0 for all cases in a run.

CARD 1001

Columns 1 and 2 must contain the integer 12 to call the tabulation and contour plot routine. NVARA and NVARB are switches for printing the tabulations and contour plots, respectively. If one of the switches is set to zero, the corresponding option is printed. NVARC is the quantity of variables that are to be tabulated and/or plotted.

CARDS 1002, 1002A, 1002B

These three cards contain the code numbers for the variables that are to be tabulated and/or plotted. The code numbers are defined in Table 16 and are integer (right-justified) inputs. Enter the first 14 code numbers in consecutive 5-column fields on CARD 1002 (14I5 format). If NVARC ≥ 15, enter additional code numbers on CARD 1002A. If NVARC ≥ 29, enter the remaining code numbers on CARD 1002B. Only read the number of cards necessary for the number of code numbers.

CAUTION: This option can generate large amounts of output. Each contour plot requires one printed page and each tabulation requires one or two printed pages. Hence, if data for 10 revolutions are stored and all 30 variables are both printed and plotted, the output for this option alone will be 600 to 900 pages. In a case like this, the deck should be set up to print the output offline. Consult your local programmer for the setup for offline print.

TABLE 16. CODE NUMBERS FOR ROTOR CONTOUR PLOTS

Code Number	Variable	Units
1	Mach number	-
2	Angle of attack	deg
3	Steady lift coefficient	-
4	Unsteady lift coefficient increment*	-
5	Total lift coefficient	-
6	Steady drag coefficient	-
7	Steady pitching moment coefficient	-
8	Unsteady pitching moment coefficient increment*	-
9	Total pitching moment coefficient	-
10	Lift distribution ($q\ C_l\ c$)	lb_f/ft
11	Normal force distribution ($q\ C_N\ c$)	lb_f/ft
12	Drag distribution ($q\ C_D\ c$)	lb_f/ft
13	Inplane force distribution ($q\ C_x\ c$)	lb_f/ft
14	Pitching moment distribution ($q\ C_M\ c^2$)	ft-lb_f/ft
15	Torque distribution	ft-lb_f/ft
16	Inflow angle	deg
17	Geometric pitch angle	deg
18	Induced velocity	ft/sec
19	Inflow velocity	ft/sec
20	Tangential velocity	ft/sec
21	Radial velocity	ft/sec
22	Yawed flow angle	deg

TABLE 16. Concluded

Code Number	Variable	Units
23	Out-of-plane displacement	ft
24	Inplane displacement	ft
25	Torsional displacement	deg
26	Beamwise acceleration	ft/sec^2
27	Inplane acceleration	ft/sec^2
28	Torsional acceleration	ft/sec^2
29	Stall angle of attack**	deg
30	Stall indicator***	-
31	Normal force coefficient (C_N)	
32	Chord force coefficient (C_C)	
33	Inducted power	HP/ft
34	Profile power	HP/ft
35	Angle of attack rate	deg/sec
36	Analytic geometric pitch rate	deg/sec
37	Analytic geometric pitch acceleration	deg/sec^2
38	Numerical geometric pitch rate	deg/sec
39	Numerical geometric pitch acceleration	deg/sec^2
40	Currently unused	
41	Currently unused	
42	Currently unused	

*In trim, only available when both time-variant rotor analysis and unsteady aerodynamics are active. In maneuver, only available when unsteady aerodynamics are active.

**The stall angle of attack is computed from values input in the YRR array. These numbers should be accurately input even if a table is being used.

***The stall indicator is 1 if the angle of attack is positive and greater than the stall angle. If the angle of attack is negative and if the absolute value of the angle of attack is greater than the stall angle, the stall indicator is -1. Otherwise, the stall indicator is zero.

3.36 CONFIGURATION DETERMINATION

The program examines several inputs to determine the configuration of the rotorcraft which is being simulated. The inputs are

XTR(45),	the Tail Rotor lateral mast tilt
XFS(5),	the stationline of the rotorcraft cg
XMR(8),	the stationline of the Main Rotor shaft pivot point
XTR(8),	the stationline of the Tail Rotor shaft pivot point

Using the following definitions

$$(l_x)_{R1} = (XMR(8) - XFS(5))/12$$

$$(l_x)_{R2} = (XTR(8) - XFS(5))/12$$

and the following logic

TRIND = 0
TRIND1 = 0
IF $|XTR(45)| < 45°$, TRIND = 1
IF TRIND $\neq$ 0 and $|(l_x)_{R1} - (l_x)_{R2}| \leq 5$ feet, TRIND1 = 1

The value of the configuration variable KONFIG is then defined as

KONFIG = 1. + TRIND + TRIND1

Based on the value of KONFIG, the program assigns names to the input rotor groups and assumes a type of configuration as shown in Table 17.

TABLE 17. ROTOR NAMING CONVENTION

Value of KONFIG	Defined Configuration	Names Assigned by Program: Main Rotor Group (Rotor 1)	Tail Rotor Group (Rotor 2)
1	Single-main-rotor helicopter	MAIN	TAIL
2	Tandem-rotor helicopter	FORWARD	AFT
3	Side-by-Side*	RIGHT	LEFT

* Same as tilt-rotor, composite, or coaxial.

The value of KONFIG is then used as follows:

(1) To determine if the Supplemental Rotor Controls Subgroup should be input, i.e., if KONFIG $\neq$ 1, an error message is generated, since the other two configurations cannot be controlled without the XCRT array.

(2) To eliminate numeric "noise" in the partial derivatives for a particular configuration, e.g., if the Supplemental Rotor Controls Subgroup is not input for KONFIG = 1, the Rotor 1 flapping moments due to pedal displacement and the Rotor 2 flapping moments due to displacement of collective and cyclic sticks are set to zero.

(3) To define the names to be printed in the output heading for each rotor.

(4) To modify control linkages or angles to be compatible with the configuration.

Note that in naming the rotors, the value of KONFIG may not assign the name expected to a particular rotor. For example, consider a tandem-rotor helicopter. In naming the rotors, the program assumes that the front rotor rotates counterclockwise and was input to the Main Rotor Group and that the aft rotor rotates clockwise and was input to the Tail Rotor Group. However, the user may want to reverse the rotation of each rotor, in which case the aft rotor would be input to the Main Rotor Group and the forward rotor to the Tail Rotor Group.

The program does not check to see if the rotor it is calling FORWARD is actually forward of the other rotor. Hence, if the user does swap rotor groups to reverse their rotation, the program will be ignorant of it and will still call the rotor input to the Main Rotor Group the FORWARD rotor. This rotor will be in front of the REAR rotor for positive values of the airspeed, XFC(1). The same situation applies to the RIGHT and LEFT rotors of side-by-side configurations, so that the RIGHT rotor will be to the right of the LEFT rotor for positive values of the airspeed, XFC(1). A coaxial configuration is treated like a side-by-side; its rotors are named RIGHT and LEFT rather than indicating which rotor is on the top or bottom.

Note, however, when swapping rotor groups that the sign conventions for positive lateral swashplate angle are not the same for both rotors. Hence, the user should check all control linkages prior to running a deck with swapped rotors.

4.0 OUTPUT GUIDE

The output available to be printed is divided into the several groups listed in Table 18, with a statement as to when each group will, will not, or may be printed. The sequence of the groups in the table corresponds to the sequence in which they are printed in the output and are discussed in this section. As the table indicates, not all groups will necessarily be printed during a particular run. The printout of most groups depends on the type of run (value of NPART), the type of data included in the input deck (elastic blade data, airfoil data tables, etc.), and the program options activated by the input data (time-variant trim, blade element data, etc.,). The printout for each of the groups in Table 18 is discussed following a description of the reference systems and sign conventions used for the input and output data.

4.1 REFERENCE SYSTEMS

All of the basic analyses in C81 were developed and programmed in Cartesian coordinate systems. The coordinate systems that are of most importance to the user include the ground, fuselage, body, aerodynamic surface, rotorshaft, rotor analysis, and wind reference (or axis) systems. Each reference system is oriented with respect to one or more of the other systems by a set of ordered angular rotations.

C81 uses Euler angles to orient the body reference system with respect to the ground reference (see Figure 40). Both reference systems are right-handed coordinate systems with positive rotations defined by the right-hand rule. Hence, the three rotations in order are:

(1) Psi (ψ): a positive rotation about the ground reference Z axis - a yaw rotation.

(2) Theta (θ): a positive rotation about the Y axis, which has been previously oriented through the ψ rotation - a pitch rotation.

(3) Phi (Φ): a positive rotation about the X axis, which has been oriented by the ψ and θ rotations - a roll rotation.

Although all reference systems in C81 are oriented by ordered rotations, not all the ordered angles and their sign conventions are truly Euler angles. This point will be made clear in the following discussion of the seven reference systems mentioned above.

TABLE 18. OUTPUT GROUPS

Output Groups	Value of NPART 1	2	4	5	7	8	10
Input Data							
Data Deck Listing	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Problem Identification	Norm	Norm	Norm	Norm	Norm	Norm	Norm
Basic Data Groups	Norm	Norm	Norm	No	Norm	No	Norm
Elastic Blade Data	(A)	(A)	(A)	No	(A)	No	No
Check of Aerodynamic Inputs	(B)	(B)	(B)	No	(B)	No	(B)
Accelerated Flight Conditions	Yes	Yes	Yes	No	Yes	No	Yes
Maneuver Specification	No	Norm	Norm	Norm	No	No	No
Airfoil, RIVD, RWAS Data Tables	(A)	(A)	(A)	No	(A)	No	No
Trim Iteration Page(s)	Norm	Norm	Norm	No	Norm	No	Yes
Standard Trim Page	Yes	Yes	Yes	No	Yes	No	Yes
Optional Trim Page	(C)	(C)	(C)	No	(C)	No	(C)
Time-Variant Trim Data	(C)	(C)	(C)	No	No	No	(C)
Maneuver-Time-Point Printout							
External Store Drop	No	(C)	(C)	(C)	No	No	No
Time-Point Page(s)	No	Norm	Norm	Norm	No	No	No
Rotor Elastic Response	No	(D)	(D)	(D)	No	No	No
Time History Plots	(C)	(C)	(C)	(C)	(C)	(C)	(C)
Output of Vector and Harmonic Analysis	No	(C)	(C)	(C)	No	(C)	No
Output of Stability Analysis	No	(C)	(C)	(C)	Yes	No	(C)
Blade Aerodynamic Data	(C)	(C)	(C)	(C)	(C)	No	(C)
Blade Bending Moment Data	No	(C)	(C)	(C)	No	No	No

Yes: The group is always printed for specified value of NPART.
No : The group is never printed for specified value of NPART.
Norm: The group is normally printed, but can be suppressed by appropriate input values.
(A) : The group is printed only if the corresponding data block(s) or table(s) is input; printout can be suppressed.
(B) : The group is printed only if errors are detected in the aerodynamic inputs.
(C) : The group is printed only if the corresponding operation or option is called for by input data.
(D) : The group is printed only if elastic blade data are available.

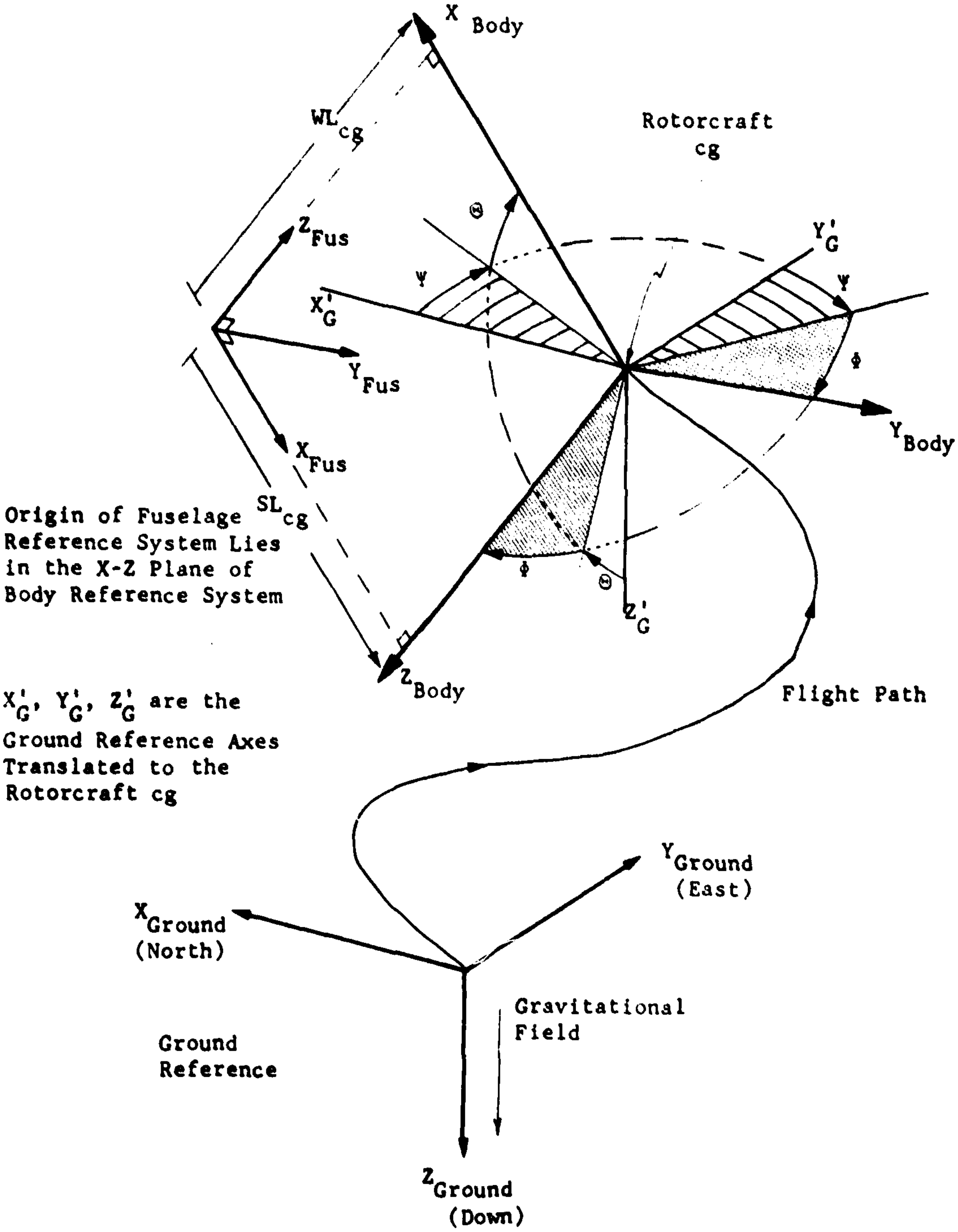


Figure 40. Relationship of Ground, Body, and Fuselage Reference Systems.

4.1.1 Ground Reference System

The C81 Ground Reference System, a right-handed coordinate system, is fixed to the surface of a flat earth with its Z axis pointing down through the center of the gravitational field, its X axis pointing due north, and its Y axis pointing due east. In C81 the gravitational constant is defined to be 32.17 feet per second squared. During trim and at time zero of all maneuvers, the ground reference X and Y coordinates of the rotorcraft center of gravity are zero, and the Z coordinate is the negative of the geometric altitude.

4.1.2 Fuselage Reference System

The C81 input format uses the Fuselage Reference System, a right-handed coordinate system, to define the locations of components or properties on the rotorcraft, e.g., the shaft pivot point, the center of gravity, and centers of pressure for the aerodynamic surfaces. As its name implies, this system is fixed with respect to the structure of the rotorcraft. The system is equivalent to the conventional stationline-buttline-waterline (SBW) coordinate system used in the design of most aircraft. The location of its origin is arbitrary. However, for AGAJ77, it must lie in the vertical plane of symmetry of the fuselage if certain program features such as locating the jets and orienting aerodynamic surfaces are to work properly.

In the Fuselage (SBW) Reference System, the X (stationline) axis is positive aft, the Y (buttline) axis is positive to starboard and the Z axis is positive toward the top of the airframe. X, Y, and Z coordinates (stationlines, buttlines, and waterlines) are defined to be in inches from the origin. This reference system is used only for input data.

4.1.3 Body Reference System

The Body Reference System, a right-handed coordinate system, is the primary reference system in C81. It is the reference system in which total rotorcraft forces and moments are summed during both trim and maneuver and is the system in which the rotorcraft stability analysis equations were derived. The origin of the system is defined to be at the rotorcraft cg, which is located by X, Y, and Z coordinates in the Ground Reference System. The axes of the system are oriented with respect to the Ground Reference System by Euler rotations of ψ, θ, and Φ as discussed previously.

If the Fuselage Reference System is rotated 180 degrees about its Y axis, and its origin moved to the rotorcraft cg, the rotated and translated system is defined to be coincident with the Body Reference System. Hence, the Y axes of both the Fuselage and Body Reference Systems are positive to starboard, while the Body Reference X axis is positive forward and the Z axis is positive toward the bottom of the rotorcraft.

As with the Fuselage Reference System, the Body Reference System is fixed with respect to the structure of the rigid body rotorcraft. During trim, the system may rotate with respect to the Ground Reference System and during maneuvers it may translate as well. The relationships between the Ground, Fuselage, and Body Reference Systems are shown in Figure 40. If the cg location is recomputed prior to trim or during maneuver bacause of store input or drop(s), the origin of the Body Reference System moves to the new cg location. Moment arms from the cg to the rotor hubs, wing, etc., are recomputed each time the cg moves.

4.1.4 Aerodynamic Surface Reference System

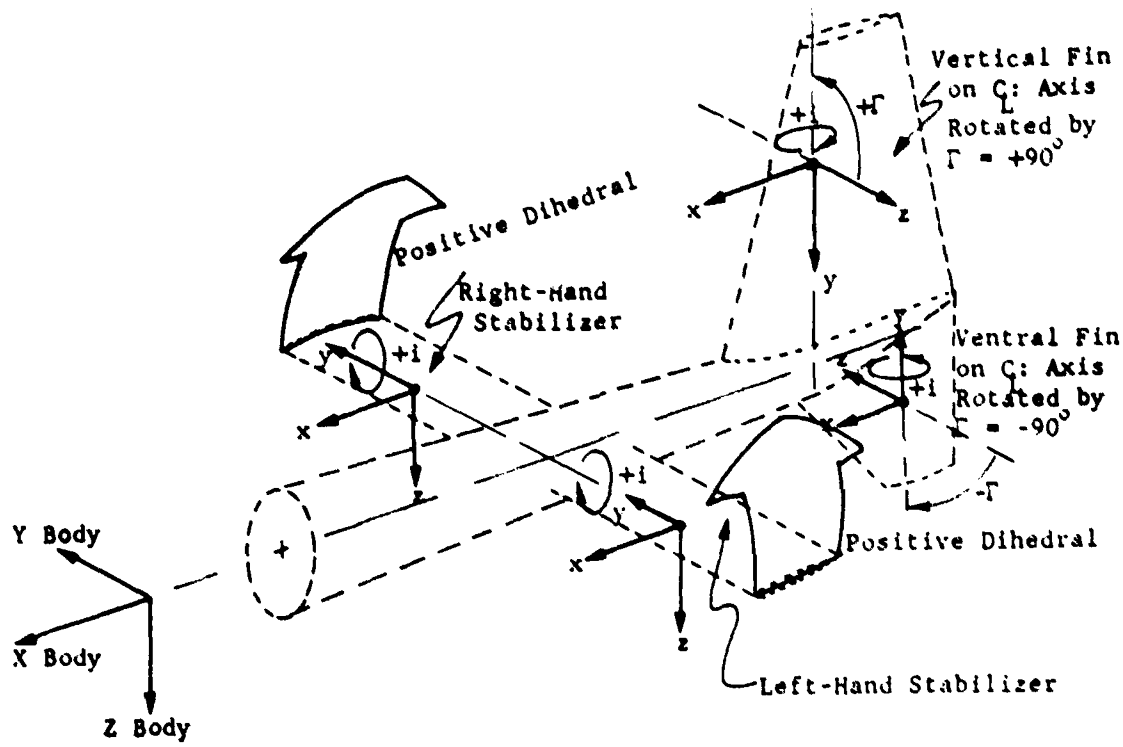
Each wing panel and each of the four stabilizing surfaces uses a separate Aerodynamic Surface Reference System to define the orientation of that surface's axis of incidence change and the incidence angle. Each system is a right-handed coordinate system with its origin at the center of pressure of the appropriate surface. The orientation of each system is defined with respect to the body axis by two ordered rotations:

(1) Γ: dihedral angle rotation and

(2) i: a positive rotation about the Y axis, which has been previously rotated through Γ - an incidence rotation.

Dihedral angle, Γ, is always defined to be positive in the direction that displaces the outboard tip of a surface upward with respect to a Fuselage Reference System X - Y plane. That is, for a surface whose center of pressure is on or to the left of the fuselage plane of symmetry (buttline ≤ 0), positive dihedral is a right-handed rotation about the body X axis. If the center of pressure is to the right (buttline > 0), positive dihedral angle is a left-handed rotation. The implications of these definitions are that horizontal stabilizing surfaces with dihedral or anhedral should be modeled as two separate surfaces. A vertical fin with its center of pressure at or to the left of buttline 0.0 should be considered to have a +90-degree dihedral angle.

Positive incidence is always defined as a right-handed rotation about the Y axis of the aerodynamic reference system. Hence, the Y axis and the axis of incidence change are coincident. The relationship of the Body and Aerodynamic Surface Reference Systems is shown in Figure 41.



SURFACE	WING AND HORIZONTAL STABILIZERS		VERTICAL AND VENTRAL FINS	
CP Location	Dihedral: Γ	Incidence	Dihedral: Γ	Incidence
Buttline > 0 (Rt of ℄)	< + 90 > - 90	+ L.E. UP + L.E. UP	+90 -90	+ L.E. Left + L.E. Right
Buttline ≤ 0 (ON or LT of ℄)	< + 90 > - 90	+ L.E. UP + L.E. UP	+90 -90	+ L.E. Right + L.E. Left

Figure 41. Relationship of Body and Aerodynamic Surface Reference Systems.

The orientation of the Y axis and the origin of each system are fixed with respect to the Body Reference System during all trims and maneuvers, but the control linkages can rotate each system about its Y axis.

4.1.5 Rotor Shaft Reference System

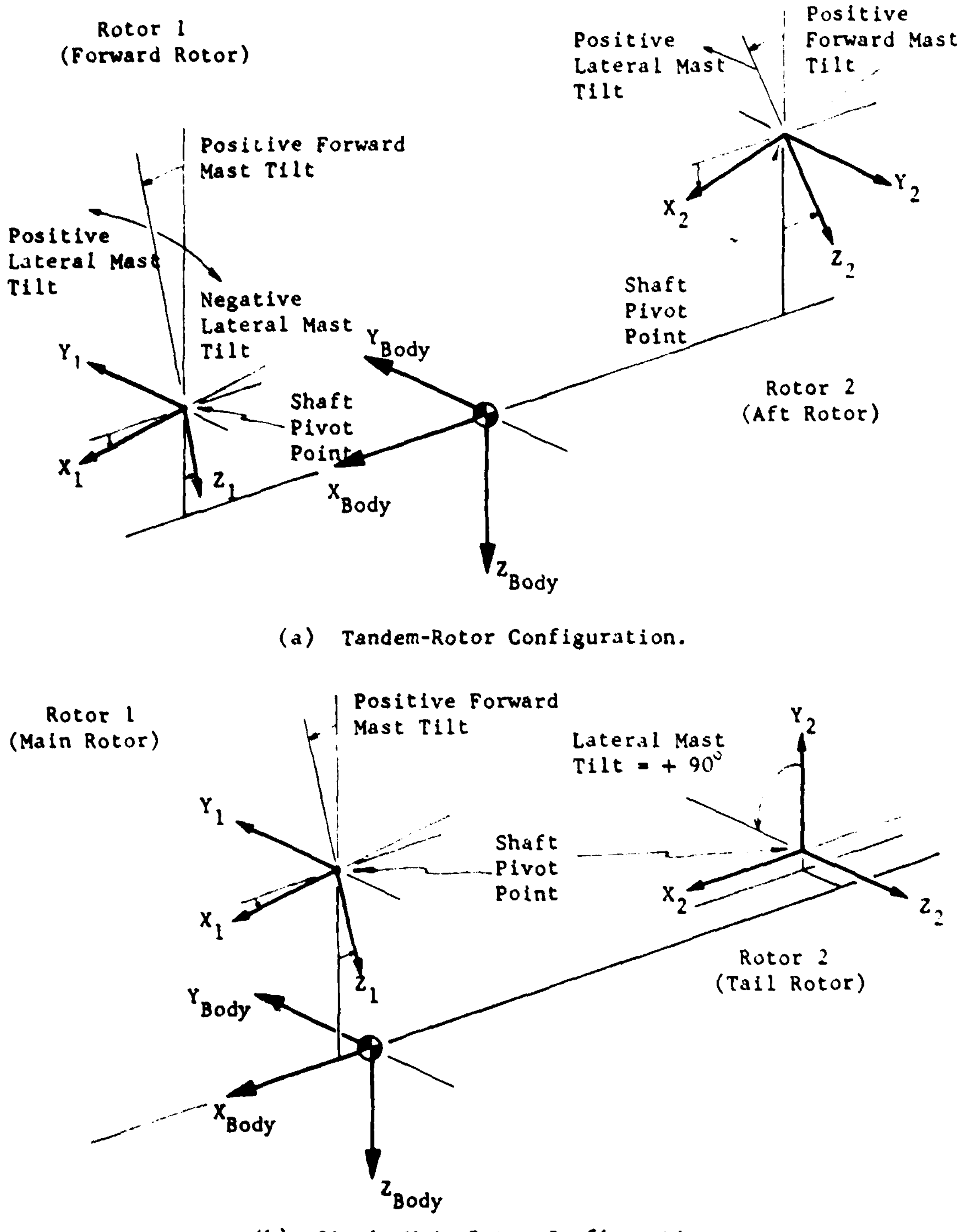
The program uses two independent Rotor Shaft Reference Systems, one for each rotor. The origin of each system is at the shaft pivot point of its respective rotor, and, as noted earlier, the Rotor 1 Shaft Reference System is a right-handed coordinate system, while the Rotor 2 system is left-handed. Each system is oriented with respect to the Body Reference System by ordered rotations through the longitudinal mast tilt angle and lateral mast tilt angle.

The most convenient means of describing the positive directions of the rotations is to say that positive mast tilt angles will tilt the rotor shaft forward and then to the right for both rotors. Hence, if all four mast angles are zero, the X and Z axes of both Rotor Shaft Reference Systems and the Body Reference System are parallel and point in the same direction. However, the Y axis of the Rotor 2 Shaft Reference System points in the opposite direction of the other two Y axes. The origins of both Rotor Shaft Reference Systems are fixed with respect to the Body Reference System during both trim and maneuver. The orientation is fixed during trim, but the longitudinal mast tilt angle can be changed during a maneuver, which does reorient the system.

Note that if the longitudinal mast tilt angle changes in maneuver, and the lateral mast tilt is nonzero, the longitudinal rotation will be about the body reference Y axis, not the shaft reference Y axis. That is, at each time point the orientation is determined by the two ordered rotations from the Body Reference System, not by one rotation from the initial Shaft Reference orientation. Figure 42 shows the relationship of the two Rotor Shaft Reference Systems to the Body Reference System.

4.1.6 Rotor Analysis Reference Systems

The program uses two independent Rotor Analysis Reference Systems: the system for Rotor 1 is oriented with respect to the Rotor 1 Shaft Reference System and the system for Rotor 2 with respect to the Rotor 2 Shaft Reference System. The origin of each system is located at the hub of its respective rotor; i.e., the Rotor Shaft Reference System X and Y coordinates of the origin of the Rotor Analysis Reference System are zero and the Z coordinate is the negative of the mast length. The Rotor Analysis Reference Systems are oriented with respect to



(a) Tandem-Rotor Configuration.

(b) Single-Main-Rotor Configuration.

Figure 42. Relationship of Body and Shaft Reference Systems.

the Rotor Shaft Reference System by a single rotation about the shaft reference Z axis. This angle is the rigid body azimuth angle of the blade being analyzed. Hence, the Rotor Analysis Reference Systems are rotating reference systems with respect to the Rotor Shaft and Body Reference Systems. For Rotor 1 the right-handed rotation vector points up (negative Z direction) and for Rotor 2 the left-handed rotation vector points up (negative Z direction). Figure 43 shows the relationship of the Rotor Analysis Reference Systems to the Rotor Shaft Reference Systems.

4.1.7 Wind Reference Systems

All aerodynamic loads are computed in the Wind Reference System. By definition, a Wind Reference System only has a velocity component along its X axis; the Y and Z velocities are identically zero. Since the local flow at each rotorcraft component on which aerodynamic forces and moment act is normally not parallel to the flight path velocity vector, separate reference systems are defined for each component. The origin of each of the Local Wind Reference Systems is at the center of pressure or aerodynamic data reference point of each component. Each system is oriented with respect to the corresponding component system (e.g., Body, Aerodynamic Surface, and Rotor Shaft Reference Systems) by one of two possible sets of two ordered rotations. The first set of possible angles corresponds to angles commonly measured in flight test:

(1) Negative Beta ($-\beta$): a rotation (equal to the negative of the sideslip angle β) about the component Z axis, and

(2) Negative Alpha ($-\alpha$): a rotation (equal to the negative of the angle of attack α) about the component Y axis, which has been rotated through $-\beta$ previously, where $\alpha = \alpha_{wind}$.

The second set corresponds to angles commonly measured in wind tunnel tests and are a set of inverse Euler angles with roll deleted:

(1) Negative Aerodynamic Pitch Angle ($-\theta_W$): a rotation (equal to the negative of θ_W) about the component Y axis, and

(2) Negative Aerodynamic Yaw Angle ($-\psi_W$): a rotation (equal to the negative of ψ_W) about the Z axis, which has been rotated through $-\theta_W$ previously.

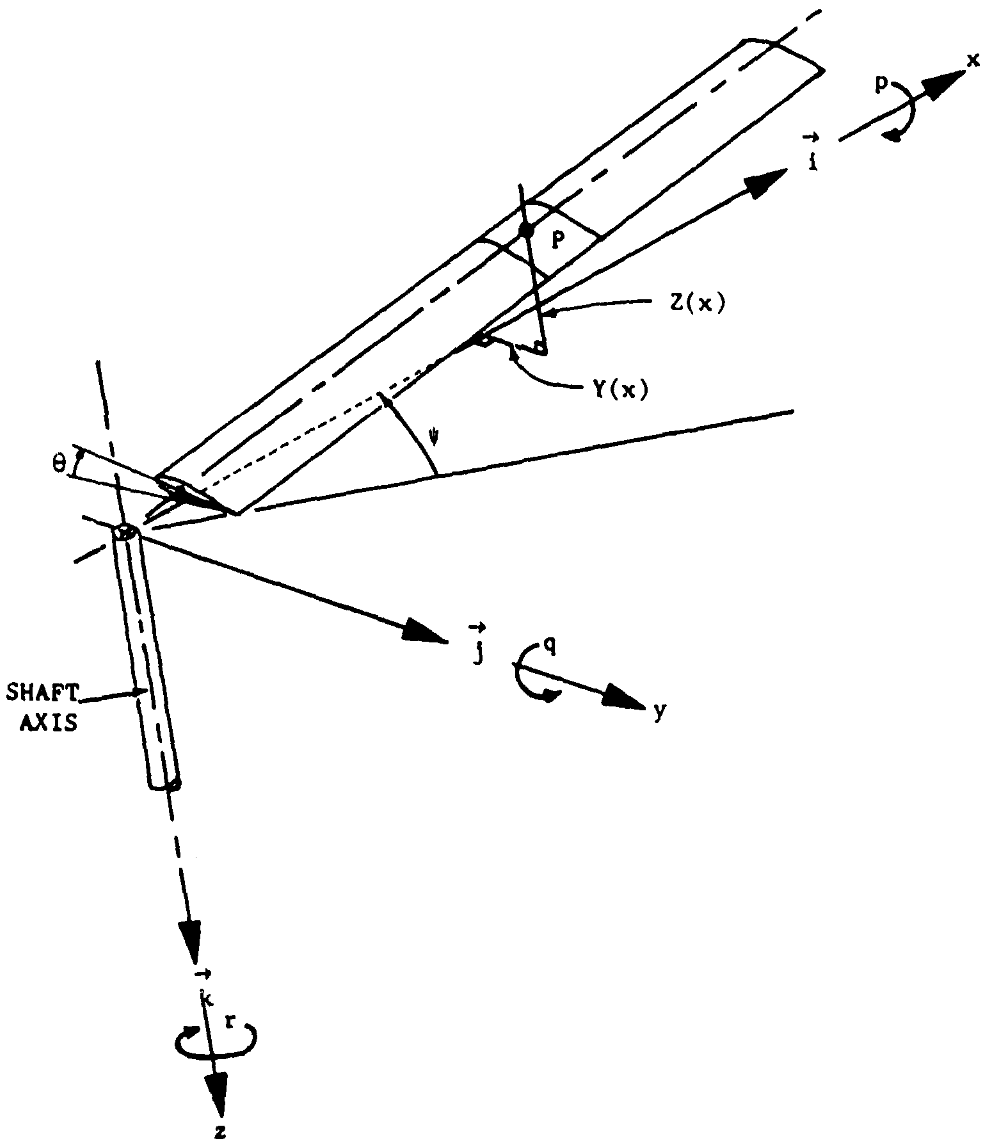


Figure 43. Reference System for Rotor Analysis.

Each of these four angles is defined by trigonometric functions of X, Y, and Z velocities in the component reference system. The definitions of α_{wind} and θ_w are identical, and the two angles can be used interchangeably. However, β and ψ_w are not identical. See Figure 44 and Section 4.2.3.2 for the definitions of these angles.

Orientation of a Wind Reference System with respect to ground reference only is meaningless and cannot be defined. The orientation of the wind vector, and hence the X axis of a Wind Reference System, can be defined by two Euler-type angles; i.e., azimuth (yaw) and elevation (pitch). However, the orientation of the Y and Z axes about the X axis cannot be defined without referring to one of the rotorcraft component reference systems. This situation does not limit any analysis or computation since the point of interest is the action of the air mass on a component, not the ground.

4.2 SIGN CONVENTIONS

The sign conventions of the most commonly used rotor-related parameters are summarized in Table 19. The conventions listed are for the condition where both rotor shafts are vertical (i.e., a tandem or side-by-side rotor helicopter) and are stated in terms of pilot reference. For nonvertical shaft(s), the rotor-related sign conventions remain unchanged with respect to the Rotor Shaft Reference System. Table 20 gives the rotor designation and sign conventions for four standard rotorcraft configurations.

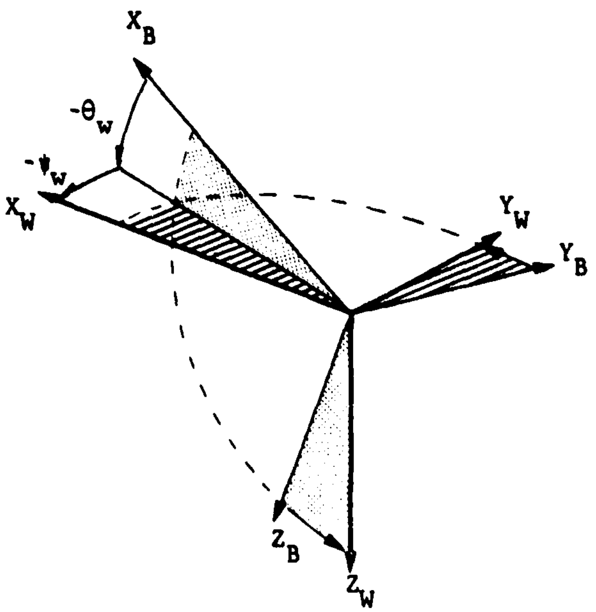
Additional discussion of some of these rotor-related parameters and parameters mentioned in Section 4.1 is included below.

4.2.1 Rotor Flapping and Elastic Displacements

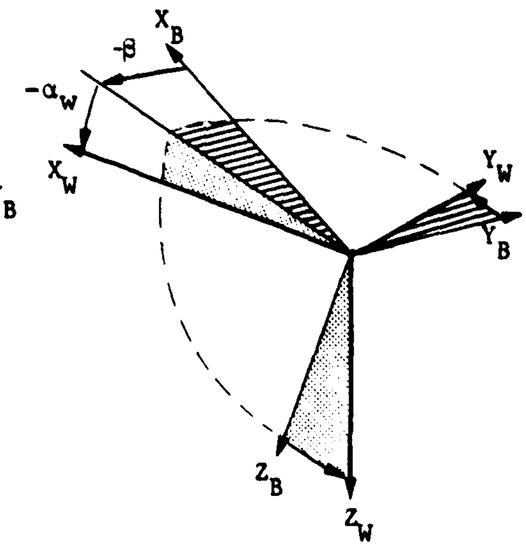
Rotor flapping can be defined with respect to either the Rotor Analysis or Rotor Shaft Reference System of the appropriate rotor. Shaft reference flapping is divided into a longitudinal and a lateral component. Rotor Analysis Reference System flapping (instantaneous value of flapping) is based on the out-of-plane displacement of the blade tip for the first mode (rigid body mode) of the rotor at a particular azimuth angle. If coning is neglected,

$$\beta(\psi) = -a_1 \cos \psi - b_1 \sin \psi$$

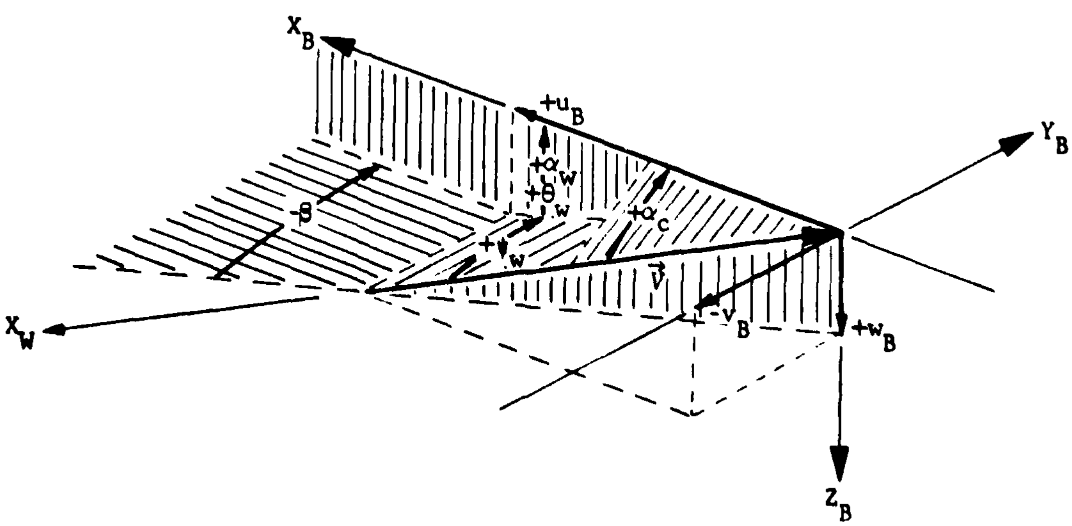
B = Body
W = Wind



(a) Rotations With Wind Tunnel Angles.



(b) Rotations With Flight Test Angles.



(c) Planes in Which Angles Are Measured.

Figure 44. Relationship of Wind and Body (Component) Reference Systems.

TABLE 19. SIGN CONVENTIONS FOR ROTOR RELATED PARAMETERS

Parameter	Positive Direction of Parameter Rotor 1	 Rotor 2
Shaft Reference System (origin at shaft pivot point)		
X-Axis	Forward	Forward
Y-Axis	Right	Left
Z-Axis	Down	Down
Mast Tilt Angle		
Longitudinal $(\beta_m)_F$	Forward	Forward
Lateral $(\beta_m)_L$	Right	Right
Swashplate Angles		
Longitudinal (B_1)	Forward	Forward
Lateral (A_1)	Down Right	Down Right
Control Phasing Angle (γ) (measured from the projection on the swashplate of the pitch-link attach point to the pitch horn	In same direction as blade rotation	In same direction as blade rotation
Pylon Motions		
Longitudinal (a_F)	Forward	Forward
Lateral (a_L)	Right	Left
Direction of Rotor Rotation (as viewed from above)	Counterclockwise (right-handed rotation vector up)	Clockwise (left-handed rotation vector up)
Pitch-Flap Coupling Angle (δ_3) (measured from 90 ahead of blade feathering axis)	Opposite to direction of blade rotation	Opposite to direction of blade rotation
Shaft Axis Flapping		
Longitudinal (a_1)	Aft	Aft
Lateral (b_1)	Down Right	Down Left
Blade Rigid-Body Displacements		
Flapping (β)	Up	Up
Twist, Collective Pitch, and Feathering $(\theta_o$, θ_1, and $\theta_f)$	Blade leading edge up	Blade Leading edge up

TABLE 19. (Concluded)

Blade Elastic Displacements		
Out-of-Plane	Up	Up
Inplane	Opposite to direction of blade rotation	Opposite to direction of blade rotation
Torsion	Blade leading edge up	Blade leading edge up
Rotor Forces		
H-Force (H)	Aft	Aft
Y-Force (Y)	Right	Left
Thrust (T)	Up	Up

Assumptions used in making the above definitions:

(1) Both rotor shafts are vertical with respect to the Fuselage Reference System.

(2) Rotor hub is at or above shaft pivot point and pylon focal points.

(3) The directions are with respect to a forward-facing pilot.

TABLE 20. CONVENTIONS FOR SPECIFIC CONFIGURATIONS

	Single-Rotor Helicopter (KONFIG=1)	Tandem-Rotor Helicopter (KONFIG=2)	Prop-Rotor Aircraft (Helicopter Mode) (KONFIG = 3)	Prop-Rotor Aircraft (Airplane Mode) (KONFIG = 3)
Rotor 1				
Designation	MAIN	FORWARD	RIGHT	RIGHT
Thrust	Up	Up	Up	Forward
H-Force	Aft	Aft	Aft	Up
Y-Force	Right	Right	Right	Right
Rotor 2				
Designation	TAIL	AFT	LEFT	LEFT
Thrust	Right	Up	Up	Forward
H-Force	Aft	Aft	Aft	Up
Y-Force	*	Left	Left	Left

Directions noted are with respect to a forward-facing pilot

* Tail rotor Y-Force: + Up for + 90 lateral mast tilt
+ Down for -90 lateral mast tilt

For tail rotor lateral mast tilt of:

+ 90 : the blade above the rotor hub rotates toward the front of the helicopter
- 90 : the blade above the rotor hub rotates toward the rear of the helicopter

where

a_1 = longitudinal flapping angle (shaft reference)

b_1 = lateral flapping angle (shaft reference)

ψ = blade azimuth location

β = instantaneous value of flapping

The shaft reference flapping angles define the orientation of the rigid body tip path plane. However, they are not ordered rotations. The angles a_1 and b_1 are independent positive rotations about the shaft reference Y and X axes respectively as shown in Figure 45. Note that for Rotor 1 this means right-handed rotations about the right-handed coordinate system, while for Rotor 2 it means left-handed rotations about a left-handed system. Based on these definitions for a_1 and b_1, positive β (equivalent to positive out-of-plane displacement) is up the shaft (the negative Z direction).

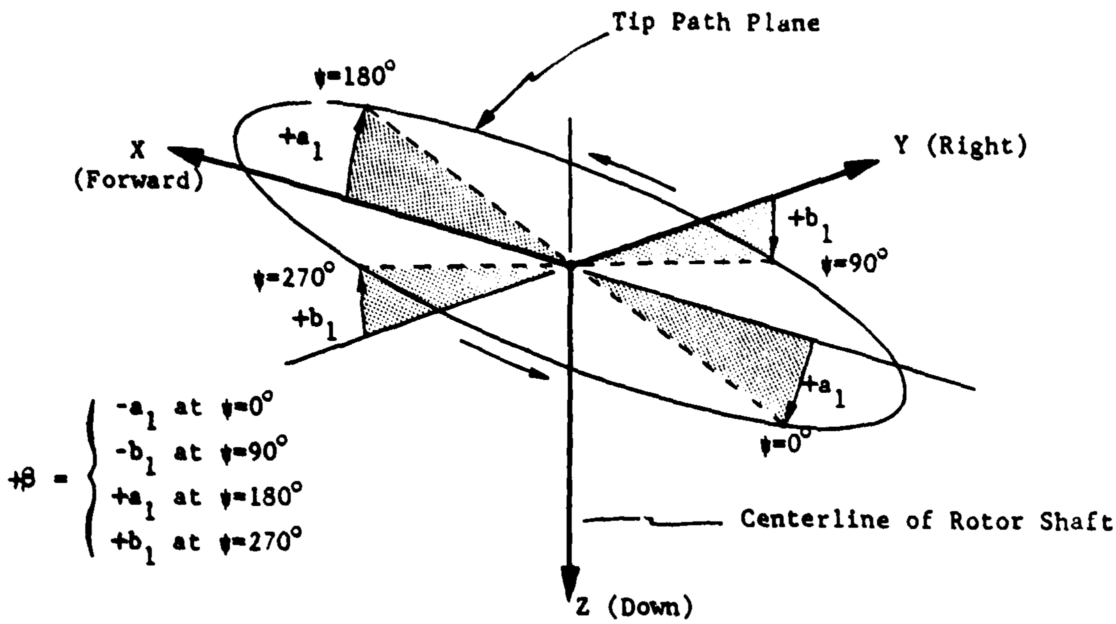
When using the quasi-static rotor analysis, the rotor equations are solved in terms of a_1 and b_1. From these values, β can be calculated for any azimuth. However, when the time-variant rotor analysis is used, the value of β, not a_1 and b_1, is solved for at each azimuth location. Hence, with only a single azimuth location, a_1 and b_1 cannot be defined. In this case, the values of β at the current and previous four azimuth positions are used to solve the following equation in five unknowns:

$$\beta(\psi) = a_o - a_1 \cos\psi - b_1 \sin\psi - a_2 \cos\psi - b_2 \sin\psi$$

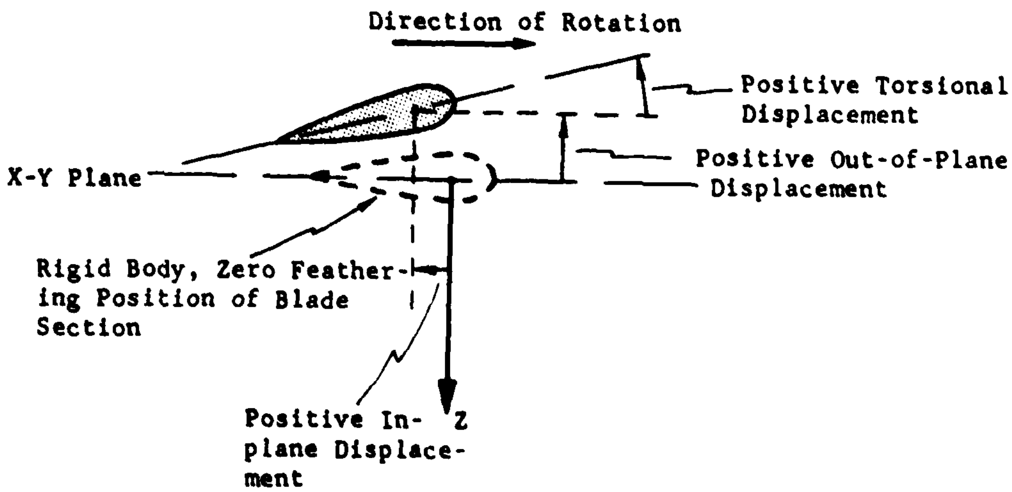
This method eliminates the steady and 2-per-rev components from the a_1 and b_1 time histories.

Positive inplane displacements of a point on a blade indicate that the blade is lagging behind the rigid body feathering axis. That is, the usual positive drag force produces a positive inplane displacement.

A positive torsional displacement twists the blade leading edge up with respect to the plane of rotation. This is the same direction as positive geometric twist, collective pitch, and cyclic feathering.



(a) Shaft Axis Flapping for Rotor 1



(b) Elastic Displacements

Figure 45. Blade Flapping and Elastic Displacement.

4.2.2 Control Positions

4.2.2.1 Position in Percent or Inches

4.2.2.1.1 Collective Stick

Zero percent collective stick is full down. Positive stick motion in percent or inches is upward.

4.2.2.1.2 Longitudinal Cyclic Stick

Zero percent longitudinal cyclic stick is full aft. Positive stick motion in percent or inches is forward.

4.2.2.1.3 Lateral Cyclic Stick

Zero percent lateral cyclic stick is full left. Positive stick motion in percent or inches is to the right.

4.2.2.1.4 Pedals

Zero percent pedal is full right. Positive pedal motion in percent or inches is to the left. That is, positive pedal tends to make the rotorcraft yaw nose left.

4.2.2.2 Positions in Radians or Degrees

When control positions are expressed in radians or degrees, these values correspond to the control angles computed from the basic rigging equations (see Table 15 in Section 3.18). Hence, they are the control angles without nonlinearities and control mixing. These units appear most frequently in the partial derivative matrix printed during trim iterations.

4.2.3 Miscellaneous Quantities

4.2.3.1 Climb and Heading Angles

The climb angle is the angle of the flightpath relative to the X-Y plane in ground reference. It is positive if the rotorcraft is climbing. The heading angle is the direction of the flightpath on the compass. Zero heading is due north, along the ground reference X axis. A heading of 90 degrees is due east.

4.2.3.2 Aerodynamic Angles

The Local Wind Reference Systems are oriented with respect to the Body, Rotor Shaft, or Aerodynamic Surface Reference Systems by what are referred to as aerodynamic angles (see Section 4.1.7). These angles are based on the components of velocity including gusts along the X, Y, and Z axes of the appropriate reference system.

Pitch Angle of Attack, $\theta_w = \theta_{wind} = \tan^{-1} \frac{\text{Z velocity}}{\text{X velocity}}$

$$= \tan^{-1} \frac{w}{u}$$

if $u = w = 0$, $\theta_w = 0$ by definition

Yaw Angle of Attack (or Aerodynamic Yaw Angle) = ψ_w

$$= \sin^{-1} \frac{\text{-Y velocity}}{\text{Total velocity}} = \sin^{-1} \frac{-v}{V}$$

if $V = 0$, $\psi_w = 0$ by definition

Angle of Sideslip = $\beta = \tan^{-1} \frac{\text{Y velocity}}{\text{X velocity}} = \tan^{-1} \frac{v}{u}$

4.2.3.3 Gust Velocities

All gusts are defined with respect to the Body Reference System as follows:

(1) The forward component of gust velocity is positive if the gust is moving in the positive X direction.

(2) The lateral component of gust velocity is positive if the gust is moving in the positive Y direction.

(3) The vertical component of gust velocity is positive if the gust is moving in the positive Z direction.

4.2.3.4 Acceleration Levels in G

The acceleration levels in units of g are defined with respect to the Body Reference System as follows:

(1) Forward acceleration is positive, in the positive X direction.

(2) Positive lateral g level is to port, in the negative Y direction.

(3) Positive vertical g level is upward, in the negative Z direction. For straight and level flight, the vertical g level is 1.00.

4.3 OUTPUT GROUPS FOR INPUT DATA

4.3.1 Data Deck Listing (Figures 46 and 47)

Following the printout of the computer operating system information (JCL cards, run time, etc.), the message on the first card of the data deck, CARD 00, is printed six times on one page. This message is intended to instruct the computing control section as to the disposition of the printed output and card deck. After printing CARD 00, the program lists the entire card deck which was submitted. This is strictly a listing of the cards; it is without regard to any illegal characters, input format errors, or program logic. This listing can be useful in locating input data errors that may be found in the following output groups.

4.3.2 Input Data Printout

4.3.2.1 Problem Identification (Figure 48)

The value of the primary control variable, NPART, the problem identification number, IPSN, and the three cards of comments (CARDS 02, 03, and 04) appear at the beginning of each problem.

4.3.2.2 Basic Input Data Groups

All basic groups of input data except the elastic blade data blocks, airfoil data tables and the rotor-induced velocity distribution table are printed in the same sequence in which they are input. The data for each of these basic groups are printed whether the group is input on cards or called from the data library. If a group is called from library and altered by an &CHANGE card, the &CHANGE card is listed and the group is updated with the specified changes. However, during parameter

PLEASE RETURN TO J.R. VAN GAASBEEK. ROTOR DYNAMICS. EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK. ROTOR DYNAMICS. EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS. EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS. EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS. EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK. ROTOR DYNAMICS. EXT. 2886

Figure 46. Message Card.

```
2  12                                                                                          00000020
   9041802 AH-1G + OLS ROTOR SIMULATION                                                        00000030
SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4.                                 00000040
VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558                                  00000050
          OLS PROGRAM LOGIC GROUP                                                              00000060
    0     2     0   -20     5     9     0     0     0     0     2     0     0     0            00000070
   -1    -1     1     1     0     0     0     0     0     0     0     0     0     0            00000080
    0     0     0     0     0     0     0     0     0     0     0     0     0     0            00000090
    0     1     5     1     2     0     1     0     0     0     0     0     0     0            00000100
    0     0     0     0     0     0     0     0     0     0     0     0     0     0            00000110
    0     1     1     0     0     0     0     0     0     0     0     0     0     0            00000120
    1     0     3     0     0     0     0     0     0     0     0     0     0     0            00000130
CLCD5474                                                                                       00000140
CLCD0015                                                                                       00000150
MNRTOLSN                                                                                       00000160
          540279   26 SEG OLS MR   PRECONE AND UNDERSLING HSOFT =  -17.2                       00000170
    5.3702      5.7138      6.1672      4.8217      0.9520      0.7750      0.8580             00000180
    0.8360      0.8690      0.7620      0.7260      0.8750      1.0980      1.0620             00000190
    1.0390      1.2600      1.1860      1.2660      1.1890      1.1600      0.0                00000200
0.00010000.05902813 0.08980000.01307974 0.00240000.00170000.00170000                           00000210
0.00170000.00180000.00140000.00130000.00140000.00240000.00240000                               00000220
0.00140000.00120000.00130000.00150000.00180000.00270000.0                                      00000230
0.06900000.11485489 0.11896987 0.22638170 0.11830000.11890000.14690000                         00000240
0.14530000.15530000.13570000.13050000.12800000.14600000.12900000                               00000250
0.11590000.12550000.10450000.12260000.11610000.13990000.0                                      00000260
    0.0         0.0         0.0         0.0         0.0         0.0         0.0                00000270
    0.0         0.0         0.0         0.0         0.0         0.0         0.0                00000280
    0.0         0.0         0.0         0.0         0.0         0.0         0.0                00000290
    0.0         0.0533      3.6100      1.5292      0.9000      1.3900      1.7700             00000300
    1.7100      2.3850      1.4500      1.3400      0.8500      0.5708     -0.5500             00000310
    0.0100     -1.0170     -1.8700     -1.1290     -1.9700     -0.4300      0.0                00000320
       -1.    1.000027    3.102101       0.000       -4.78     5783.71              1 -10000330
     22.34    0.0           324.00       15.00    2.612248   -0.000515              1 -10000340
   68.2346      5.0431     -0.0661     -0.0025    0.053497    0.000179              1 -10000350
 -0.000001    0.000181    -0.11166      0.0000    -84.5548     16.4948   1 -1          00000360
  0.022734    0.000181    -0.09915     10.7704    -81.9709    -18.4911   1 -1          00000370
  0.078096    0.000172    -0.04525     10.6955    -75.9978   -120.2014   1 -1          00000380
  0.142384    0.000141    -0.10118     18.6203    -69.9713    -78.4327   1 -1          00000390
  0.200446    0.000082    -0.13366     35.0195    -63.7284    -35.0390   1 -1          00000400
  0.250541    0.000029    -0.16444     48.6442    -57.0024    -14.3409   1 -1          00000410
  0.309331   -0.000041    -0.20535     62.6420    -50.3783     -7.8001   1 -1          00000420
  0.350624   -0.000099    -0.23791     70.8787    -45.5232      8.2013   1 -1          00000430
  0.390743   -0.000160    -0.27199     76.1566    -41.3468     27.2729   1 -1          00000440
  0.450479   -0.000257    -0.32259     78.4713    -35.9540     63.0444   1 -1          00000450
  0.500340   -0.000344    -0.36633     77.6669    -31.8884    104.7575   1 -1          00000460
  0.550166   -0.000436    -0.41214     72.2795    -28.4886    137.3630   1 -1          00000470
  0.590156   -0.000515    -0.44544     66.2597    -26.1889    165.3552   1 -1          00000480
  0.649793   -0.000631    -0.48431     57.4585    -23.1217    199.1138   1 -1          00000490
  0.699654   -0.000727    -0.51026     51.2416    -20.0790    216.7308   1 -1          00000500
  0.749566   -0.000819    -0.52917     46.9985    -17.0037    223.8854   1 -1          00000510
  0.803685   -0.000917    -0.54184     43.3100    -13.5433    218.5189   1 -1          00000520
  0.849522   -0.000996    -0.54781     33.4991     -9.9614    174.3218   1 -1          00000530
  0.901486   -0.001080    -0.55048     23.9515     -6.3769    123.1197   1 -1          00000540
  0.949750   -0.001149    -0.55078     12.4606     -3.0319     60.3629   1 -1          00000550
  1.000000   -0.001212    -0.55071      2.3620     -0.5999      9.7422   1 -1          00000560
                                                                        15  324.  1-00000570
       -1.    1.599443    2.510698       0.020     5251.70    -1296.81              2 -10000580
  -1342.10    0.0           324.00       15.00   -2.723861    0.235062              2 -10000590
    0.0825     -0.8280     48.7245      1.3001   -0.044664   -0.196211              2 -10000600
  0.000000   -0.198724     0.00091          0.     118480.          3.   2 -1          00000610
 -0.015490   -0.198288    -0.00595       -1331.    115642.         26.   2 -1          00000620
 -0.068209   -0.192127     2.75899       -4255.    107964.       1127.   2 -1          00000630
 -0.113171   -0.165107     3.04416       -7167.     97854.        721.   2 -1          00000640
 -0.146630   -0.119578     3.17903       -9922.     88256.        534.   2 -1          00000650
 -0.164771   -0.073806     3.26606      -11555.     79730.        455.   2 -1          00000660
 -0.168256   -0.011751     3.35636      -11833.     70298.        428.   2 -1          00000670
 -0.161672    0.036395     3.41793      -11297.     63969.        390.   2 -1          00000680
 -0.150265    0.086024     3.46774      -10433.     58003.        358.   2 -1          00000690
 -0.127438    0.164085     3.51943       -6883.     49397.        319.   2 -1          00000700
 -0.104608    0.232488     3.54963       -7506.     42478.        288.   2 -1          00000710
 -0.079476    0.303352     3.56914       -6116.     35829.        273.   2 -1          00000720
 -0.057949    0.361824     3.57654       -5038.     30703.        263.   2 -1          00000730
 -0.024688    0.451099     3.58243       -3628.     23497.        258.   2 -1          00000740
  0.003881    0.527312     3.58168       -2643.     17972.        24[illegible].   2 -1          00000750
  0.032833    0.604731     3.57976       -1835.     12967.        238.   2 -1          00000760
  0.064471    0.689616     3.58036       -1160.      8270.        220.   2 -1          00000770
  0.091373    0.761986     3.58214        -698.      5019.        179.   2 -1          00000780
  0.121690    0.844[illegible]    [illegible]        -[illegible].      2239.        131.   2 -1          00000790
  0.149339    [illegible]                            [illegible]     70.5592   2 -1          00000800
  0.1[illegible]                                                [illegible]   2 -1          00000810
                                                                        [illegible]-00000820
```

Figure 47. Partial Printout of Data Deck Listing.

BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ77I4   COMPUTED 05/21/79

AH-1G + OLS ROTOR SIMULATION
SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4,
VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558

INPUT DATA

OLS PROGRAM LOGIC GROUP

PROGRAM LOGIC GROUP

0	2	0	-20	5	9	0	0	0	0	2	0	0	0
-1	-1	1	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	5	1	2	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0	0	0	0	0	0
1	0	3	0	0	0	0	0	0	0	0	0	0	0

CLC05474   J.R.VAN GAASBEEK (10-25-77)
MODEL 209 M/R AIRFOIL DATA TABLE   AG

CLC00015   PAI (03-19-77)
NACA 0015 AS PROVIDED BY PAI (03-19-77)

MNRTOLSN   VAN GAASBEEK   (05-02-79)
AH-1G MAIN ROTOR GROUP 209 ROTOR WITH OLS INSTR., NO PYLON

MAIN ROTOR GROUP

2.000000	4.500000	101.0000	22.00000	.0	-10.00000	12.00000
200.0000	.0	152.7600	475.6001	1385.080	.4910000E-01	.0
1.000000	.0	18099.00	.0	1.000000	.0	3.400000
2.750000	.0	.0	.1300000	.0	.0	.0
.0	.0	-9.067000	14.10000	.0	.0	-.0820000
.0	.0	.0	.0	2.000000	-.7590000	100.5500
.0	.0	.0	.0	.0	.0	.0
5.400000	.0	.0	.0	.0	.0	.0
6.000000	20.57500	37.50000	52.80000	66.00000	81.50000	92.39999
103.0000	118.8000	132.0000	146.2000	156.8000	171.6000	184.8000
198.0000	212.3000	224.4000	238.1000	250.8000	264.0000	.0
.0	.0	.0	.0	.0	.0	-.2812500
-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500
-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	.0
14.00000	19.60001	8.200000	27.00000	27.00000	27.00000	28.62500
28.62500	28.62500	28.62500	28.62500	28.62500	28.62500	28.62500
28.62500	28.62500	28.62500	28.62500	28.62500	28.62500	.0

540279   26 SEG OLS MR PRECONE AND UNDERSLING MSOFT = -17.2

TLRTOLS1   VAN GAASBEEK   (05-03-79)
AH-1G TAIL ROTOR GROUP   (OLS CORRELATION)

TAIL ROTOR GROUP

2.000000	.4100000	.0	4.250000	8.400000	.0	11.00000
520.0699	14.10000	118.2700	15.08100	1.532000	.2510000	.0
.0	.0	10000.00	.0	.0	.0	.5410000
1.500000	.0	45.00000	.1200000	.0	.0	.2000000
.0	.0	2.030000	2.760000	.0	.0	.0
.0	.0	.0	.0	.2500000	.0	.5600000
.0	.0	-90.00000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0

Figure 48. Problem Identification and Basic Input Data Group.

AEROOLS1 VAN GAASBEEK (05-03-79)
AH-1G M/R IN GROUP ONE. T/R IN GROUP TWO (OLS CORRELATION)

RTR AERODYNAMIC GROUP

.7800000	1.110000	1.232300	.2964000	-2.307400	1.540000	.8000000
.1084000	-.1029000	.3846000	-.2449000	.0	.0	.0
.0	.0	.9710002E-01	1.000000	.0	.2000000	1.000000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.3000000E-02	.0
.7500000	1.292000	1.491600	.1263000	-1.728600	.4167000	.8000000
.1080000	-.1907000	.8779000	-.8683000	.0	.0	.0
.0	.0	.1500000	2.000000	.0	.2000000	1.000000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0

FLGEOLSN VAN GAASBEEK (05-08-79)
AH-1G FUSELAGE GRP BASE W/INSTRUMENTATION (OLS CORRELATION)

&CHANGE XFS(1)=8289.0,XFS(5)=196.7,XFS(7)=74.88,XFS(8)=2650.8,

FUSELAGE GROUP

8289.000	200.0000	.0	71.20000	196.7000	.0	74.88000
2650.800	12977.40	10613.80	464.2000	.0	30.00000	45.00000
.0	.0	.0	.0	.0	.0	-.1649200E-01
-.1794500E-01	.3200000	-.1903000E-02	-.1300000E-02	.2500000E-02	-.1530000E-03	-.3050000E-03
5.500000	.0	.0	.0	59.00000	59.00000	.2415900E-01
.3000000E-01	.3200000E-01	.0	.5000001E-03	.1000000E-01	.0	-.3000000E-03
-27.00000	.0	.0	.0	.0	.0	-.1883000E-02
.3054500	4.000000	.0	.3000000E-01	-.1000000E-01	.0	-.2500000E-02
.0	.0	.0	1.600000	.0	-.1500000E-01	.0
2.400000	.5000000E-01	.3000000E-02	-.2866700E-01	.0	-.1083200E-01	.0
.0	.0	.0	-4.705800	-.6500000	.4500000E-01	.9999999E-03
-.4000000	-.1800000	.0	.0	.0	.0	.0
.0	.0	.0	-3.500000	-.8500000	-.6000000E-01	.1100000E-01
17.57001	.0	.0	.1453300E-01	.0	-.1529300E-01	.0

WINGOLS1 VAN GAASBEEK (05-08-79)
AH-1G WING GROUP

WING GROUP

28.14999	189.7300	28.53000	68.28000	14.00000	3.240000	11.43000
3.860000	.9800000	.5880000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.8400000	1.250000	1.200000	.0	.0	.0	1.100000
.1070000	.0	.5350000E-01	.0	.1000000E-01	.0	.3330000E-03
.0	.2000000	.2700000	.0	.0	.0	.0
-.2000000E-02	-.9000000E-02	.8200000	.0	.0	.0	.0

AH-1G VERTICAL STABILIZER GROUP (OLS CORRELATION)

STABILIZER NO. 1 GROUP

18.87000	501.1001	.0	97.17999	4.500000	90.00000	47.59000
1.620000	.9900000	.4800000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.8400000	1.250000	1.200000	.0	.0	.0	1.200000
.1000000	.0	.5000000E-01	.0	.8000001E-02	.0	.1370000E-03
.4000000E-01	.2000000	.1500000	.0	.3320000E-01	.0	.0
-.2000000E-02	-.9000000E-02	.8200000	-.4999999E-02	.0	.0	.0

Figure 48. Continued.

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                              AH-1G R/H HORIZONTAL STABILIZER GROUP   (OLS CORRELATION)
                                                     STABILIZER NO.  2 GROUP
7.570000        397.5000        18.62000        55.66000        .6970000        .0              16.28000
1.490000        .9800000        .6600000        .0              .0              1.000000        .0
.0              .0              .0              .0              .0              .0              .0
.0              .0              .0              .0              .0              .0              .0
.0              -1.000000       -1.390000       .0              .0              .0              .0
.8400000        1.250000        1.200000        .0              .0              .0              1.200000
.8700001E-01    .0              .4350000E-01    .0              .8000001E-02    .0              .3283999E-03
.4000000E-01    .2000000        .1500000        .0              .3320000E-01    .0              .0
-.2000000E-02   -.9000000E-02   .8200000        .6999999E-01    .0              .0              .0

.0              .0              .0              .4328580        .2205690        .0              .0
.0              .0              .0              .0              .0              .0              .0

                              AH-1G L/H HORIZONTAL STABILIZER GROUP   (OLS CORRELATION)
                                                     STABILIZER NO.  3 GROUP
7.570000        397.5000        -18.62000       55.66000        .6970000        .0              16.28000
1.490000        .9800000        .6600000        .0              .0              1.000000        .0
.0              .0              .0              .0              .0              .0              .0
.0              .0              .0              .0              .0              .0              .0
.0              -1.000000       -1.000000       .0              .0              .0              .0
.8400000        1.250000        1.200000        .0              .0              .0              1.200000
.8700001E-01    .0              .4350000E-01    .0              .8000001E-02    .0              .3283999E-03
.4000000E-01    .2000000        .1500000        .0              .3320000E-01    .0              .0
-.2000000E-02   -.9000000E-02   .8200000        .6999999E-01    .0              .0              .0

.0              .0              .0              .4328580        .2205690        .0              .0
.0              .0              .0              .0              .0              .0              .0

                              AH-1G CONTROLS GROUP  S/N 20391  (OLS CORRELATION)
                                                        CONTROLS GROUP
10.00000        7.800000        19.80000        .0              .0              .0              .0
12.00000        -15.60000       30.60001        .0              .0              .0              .0
12.00000        -11.00000       16.87000        .0              .0              .0              .0
6.500000        10.00000        -28.37000       .0              .0              .0              .0

                              ENGAH1G1  VAN GAASBEEK        (05-03-79)
                                        AH-1G ENGINE-GOVERNOR GROUP
                                                       ENGINE GOVERNOR GROUP
1134.000        -50.00000       1760.000        -21.50000       1610.000        35.00000        920.0000
1134.000        -50.00000       1865.000        -21.50000       1760.000        35.00000        1060.000
6600.000        1.000000        1.500000        .7000000        .0              .0              .0
1.000000        1.000000        .9700000        12.00000        .0              .0              .0

                               ITERATION LIMITS GROUP
                                                        ITERATION GROUP
41.00000        10.00000        .5000000        .5000000        3.000000        5.000000        .3000000
.2000000        .2000000        1500.000        500.0000        1.000000        .1000000        2000.000
25.00000        25.00000        25.00000        25.00000        25.00000        25.00000        5.000000

                              OLS FLIGHT CONSTANTS GROUP
                                                       FLIGHT CONSTANTS GROUP
133.5000        .0              .0              1000.000        .0              -4.000000       .0
30.00000        65.00000        60.00000        50.00000        .0              .0              .0
.5000000        .4000000        -2.000000       1.300000        7700.000        -350.0000       .0
.0              .0              .0              .0              .0              5000.000        .0
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Figure 48. Continued.

SUPER 540 EXT'DSUPER 540 EXT'D CLCD DATA TABLES USED
CL

ALPHA/MACH	0.0	0.30000	0.50000	0.60000	0.65000	0.70000	0.75000	0.80000	0.85000	0.90000	1.00000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-172.00000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000
-161.00000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000
-147.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-129.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-49.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-39.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-21.00000	-0.80000	-0.81000	-0.85000	-0.85000	-0.85000	-0.85000	-0.71500	-0.68000	-0.66400	-0.64000	-0.64100
-18.00000	-0.85800	-0.85800	-0.88200	-0.87000	-0.87000	-0.86400	-0.75400	-0.72200	-0.69800	-0.67000	-0.66800
-14.00000	-1.17000	-1.17000	-0.92800	-0.87100	-0.87200	-0.85300	-0.84100	-0.80100	-0.76700	-0.72800	-0.72800
-12.00000	-1.22000	-1.22000	-0.93500	-0.86700	-0.86700	-0.83900	-0.84000	-0.81800	-0.77800	-0.74000	-0.73700
-11.00000	-1.18000	-1.18000	-0.93400	-0.86200	-0.86000	-0.82900	-0.83200	-0.81200	-0.77700	-0.74000	-0.72600
-10.00000	-1.07000	-1.07000	-0.93000	-0.85300	-0.85400	-0.81500	-0.82000	-0.80300	-0.77000	-0.73400	-0.70500
-9.00000	-0.96800	-0.96800	-0.92000	-0.83800	-0.84000	-0.80500	-0.80100	-0.78100	-0.75200	-0.71800	-0.67200
-8.00000	-0.86000	-0.86000	-0.89000	-0.81300	-0.81900	-0.77800	-0.78000	-0.75300	-0.73000	-0.69000	-0.63200
-7.00000	-0.75300	-0.75300	-0.83000	-0.78400	-0.78500	-0.75400	-0.74200	-0.72000	-0.70400	-0.65200	-0.58100
-6.00000	-0.64500	-0.64500	-0.71000	-0.74500	-0.72200	-0.72100	-0.67900	-0.67200	-0.66800	-0.60100	-0.52000
-4.00000	-0.43000	-0.43000	-0.47400	-0.52400	-0.55600	-0.58900	-0.56500	-0.56000	-0.52000	-0.45000	-0.36000
-2.00000	-0.21500	-0.21500	-0.23700	-0.26200	-0.27800	-0.29800	-0.31200	-0.31200	-0.26000	-0.22500	-0.18000
0.0	0.0	0.0	0.0	0.0	0.0	C.0	0.0	0.0	0.0	0.0	0.0
2.00000	0.21500	0.21500	0.23700	0.26200	0.27800	0.29800	0.31200	0.31200	0.26000	0.22500	0.18000
4.00000	0.43000	0.43000	0.47400	0.52400	0.55600	0.58900	0.56500	0.56000	0.52000	0.45000	0.36000
6.00000	0.64500	0.64500	0.71000	0.74500	0.72200	0.72100	0.67900	0.67200	0.66800	0.60100	0.52000
7.00000	0.75300	0.75300	0.83000	0.78400	0.78500	0.75400	0.74200	0.72000	0.70400	0.65200	0.58100
8.00000	0.86000	0.86000	0.89000	0.81300	0.81900	0.77800	0.78000	0.75300	0.73000	0.69000	0.63200
9.00000	0.96800	0.96800	0.92000	0.83800	0.84000	0.80500	0.80100	0.78100	0.75200	0.71800	0.67200
10.00000	1.07500	1.07500	0.93000	0.85300	0.85400	0.81500	0.82000	0.80300	0.77000	0.73400	0.70500
11.00000	1.18400	1.18400	0.93400	0.86200	0.86000	0.82900	0.83200	0.81200	0.77700	0.74000	0.72600
12.00000	1.22000	1.22000	0.93500	0.86700	0.86700	0.83900	0.84000	0.81800	0.77800	0.74000	0.73700
14.00000	1.17200	1.17200	0.92800	0.87100	0.87200	0.85300	0.84100	0.80100	0.76700	0.72800	0.72800
18.00000	0.85800	0.85800	0.88200	0.87000	0.87000	0.86400	0.75400	0.72200	0.69800	0.67000	0.66800
21.00000	0.80000	0.81000	0.85000	0.85000	0.85000	0.85000	0.71500	0.68000	0.66400	0.64000	0.64100
39.00000	1.18000	1.18000	1.18000	1.18000	1.16000	1.16000	1.16000	1.16000	1.18000	1.18000	1.16000
49.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
129.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
147.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
161.00000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000
172.50000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 48. Continued.

SUPER 540 EXT'D SFR 540 EXT'D CLCD DATA TABLES USED

CD

ALPHA/MACH	0.0	0.30000	0.50000	0.60000	0.65000	0.70000	0.75000	0.80000	0.85000	0.90000	1.00000
-180.0000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200
-175.0000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
-170.0000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
-165.0000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
-160.0000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
-140.0000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
-120.0000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
-110.0000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
-100.0000	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
-90.0000	2.02200	2.02200	2.02200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
-80.0000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
-70.0000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
-60.0000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
-50.0000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
-30.0000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000
-28.0000	0.54000	0.54000	0.56300	0.57800	0.57800	0.58100	0.58100	0.58100	0.58100	0.58100	0.58100
-26.0000	0.48000	0.48000	0.52200	0.54500	0.54500	0.54700	0.55800	0.55800	0.55800	0.55800	0.55800
-24.0000	0.42000	0.42000	0.46900	0.50000	0.50200	0.51200	0.52600	0.52600	0.52600	0.52600	0.52600
-22.0000	0.35800	0.35800	0.40900	0.44800	0.46100	0.47200	0.48900	0.49100	0.49100	0.49100	0.49100
-20.0000	0.29900	0.29900	0.35100	0.39600	0.41400	0.43100	0.45100	0.45300	0.45300	0.45300	0.45300
-18.0000	0.24000	0.24000	0.30000	0.34500	0.37000	0.38600	0.40700	0.41400	0.41900	0.41900	0.41900
-16.0000	0.19100	0.19100	0.25300	0.30000	0.32600	0.34100	0.35800	0.36700	0.38100	0.38900	0.38900
-15.0000	0.16700	0.16700	0.23200	0.27500	0.30300	0.31800	0.33300	0.34200	0.36500	0.37200	0.37200
-13.5000	0.13500	0.13500	0.20200	0.24400	0.27100	0.28300	0.29900	0.30900	0.33900	0.35000	0.35100
-12.5000	0.10050	0.10050	0.17500	0.22000	0.24900	0.26100	0.27400	0.28500	0.32100	0.33500	0.33600
-11.5000	0.04600	0.04600	0.14200	0.18800	0.22600	0.23800	0.25100	0.26100	0.30200	0.31900	0.32100
-10.5000	0.02600	0.02600	0.11000	0.15800	0.19500	0.21200	0.22900	0.24000	0.28700	0.30200	0.30500
-9.5000	0.01750	0.01750	0.07800	0.12700	0.16400	0.18800	0.20400	0.21800	0.26900	0.28700	0.29100
-8.5000	0.01250	0.01250	0.04900	0.09600	0.13300	0.16200	0.18000	0.19500	0.25000	0.26900	0.27300
-7.5000	0.01020	0.01020	0.02740	0.06600	0.10200	0.13200	0.15500	0.17100	0.23000	0.25000	0.25700
-6.5000	0.00920	0.00920	0.01240	0.03900	0.07100	0.10200	0.12700	0.14600	0.21000	0.23000	0.23900
-5.5000	0.00850	0.00850	0.01000	0.02230	0.04150	0.07150	0.09850	0.12000	0.18700	0.21100	0.22000
-4.5000	0.00800	0.00800	0.00920	0.01340	0.02000	0.04300	0.07000	0.10000	0.16600	0.19000	0.19800
-3.5000	0.00790	0.00790	0.00860	0.00890	0.01260	0.02600	0.04500	0.07000	0.14100	0.16600	0.17600
-2.5000	0.00740	0.00740	0.00780	0.00780	0.00930	0.01650	0.02700	0.04200	0.11000	0.14000	0.15000
-1.5000	0.00710	0.00710	0.00710	0.00700	0.00730	0.00980	0.01650	0.02650	0.07000	0.10500	0.12000
-0.5000	0.00680	0.00680	0.00680	0.00670	0.00650	0.00720	0.00890	0.01680	0.05000	0.07200	0.09500
0.0	0.00680	0.00680	0.00670	0.00660	0.00650	0.00680	0.00740	0.01500	0.04500	0.06900	0.09300
0.5000	0.00680	0.00680	0.00680	0.00670	0.00650	0.00720	0.00890	0.01680	0.05000	0.07200	0.09500
1.5000	0.00710	0.00710	0.00710	0.00700	0.00730	0.00980	0.01650	0.02650	0.07000	0.10500	0.12000
2.5000	0.00740	0.00740	0.00780	0.00780	0.00930	0.01650	0.02700	0.04200	0.11000	0.14000	0.15000
3.5000	0.00790	0.00790	0.00860	0.00890	0.01280	0.02600	0.04500	0.07000	0.14100	0.16600	0.17600
4.5000	0.00800	0.00800	0.00920	0.01340	0.02000	0.04300	0.07000	0.10000	0.16600	0.19000	0.19800
5.5000	0.00850	0.00850	0.01000	0.02230	0.04150	0.07150	0.09850	0.12000	0.18700	0.21100	0.22000
6.5000	0.00920	0.00920	0.01240	0.03900	0.07100	0.10200	0.12700	0.14600	0.21000	0.23000	0.23900
7.5000	0.01020	0.01020	0.02740	0.06600	0.10200	0.13200	0.15500	0.17100	0.23000	0.25000	0.25700
8.5000	0.01250	0.01250	0.04900	0.09600	0.13300	0.16200	0.18000	0.19500	0.25000	0.26900	0.27300
9.5000	0.01750	0.01750	0.07800	0.12700	0.16400	0.18800	0.20400	0.21800	0.26900	0.28700	0.29100
10.5000	0.02600	0.02600	0.11000	0.15800	0.19500	0.21200	0.22900	0.24000	0.28700	0.30200	0.30500
11.5000	0.04600	0.04600	0.14200	0.18800	0.22600	0.23800	0.25100	0.26100	0.30200	0.31900	0.32100
12.5000	0.10050	0.10050	0.17500	0.22000	0.24900	0.26100	0.27400	0.28500	0.32100	0.33500	0.33600
13.5000	0.13500	0.13500	0.20200	0.24400	0.27100	0.28300	0.29900	0.30900	0.33900	0.35000	0.35100
15.0000	0.16700	0.16700	0.23200	0.27500	0.30300	0.31800	0.33300	0.34200	0.36500	0.37200	0.37200
16.0000	0.19100	0.19100	0.25300	0.30000	0.32600	0.34100	0.35800	0.36700	0.38100	0.38900	0.38900
18.0000	0.24000	0.24000	0.30000	0.34500	0.37000	0.38600	0.40700	0.41400	0.41900	0.41900	0.41900
20.0000	0.29900	0.29900	0.35100	0.39600	0.41400	0.43100	0.45100	0.45300	0.45300	0.45300	0.45300
22.0000	0.35800	0.35800	0.40900	0.44800	0.46100	0.47200	0.48900	0.49100	0.49100	0.49100	0.49100
24.0000	0.42000	0.42000	0.46900	0.50000	0.50200	0.51200	0.52600	0.52600	0.52600	0.52600	0.52600
26.0000	0.48000	0.48000	0.52200	0.54500	0.54500	0.54700	0.55800	0.55800	0.55800	0.55800	0.55800
28.0000	0.54000	0.54000	0.56300	0.57800	0.57800	0.58100	0.58100	0.58100	0.58100	0.58100	0.58100
30.0000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000
50.0000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
60.0000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
70.0000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
80.0000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
90.0000	2.02200	2.02200	2.02200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
100.0000	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
110.0000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
120.0000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
140.0000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
160.0000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
165.0000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
170.0000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
175.0000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
180.0000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200

Figure 48. Continued.

SUPER 540 EXT'DSUPER 540 EXT'D CLCD DATA TABLES USED
CM

ALPHA/MACH	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-170.00000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000
-165.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-160.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-135.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-90.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-30.00000	0.17400	0.18400	0.19600	0.21400	0.23500	0.25000	0.26400	0.27700	0.29800
-23.00000	0.11200	0.11800	0.12800	0.14400	0.15700	0.17100	0.18300	0.20600	0.23200
-16.00000	0.07300	0.07800	0.08600	0.09700	0.10800	0.11700	0.13700	0.17600	0.20000
-15.00000	0.05400	0.06500	0.07300	0.08400	0.09700	0.11100	0.13300	0.17300	0.19500
-14.00000	0.0	0.02700	0.05400	0.06800	0.08600	0.10300	0.12700	0.16700	0.18900
-13.00000	0.0	0.00150	0.02500	0.05000	0.07400	0.09300	0.12200	0.16300	0.18400
-12.00000	0.0	0.0	0.00200	0.03000	0.06000	0.08300	0.11600	0.15700	0.17600
-11.00000	0.0	0.0	-0.00300	0.01400	0.04600	0.07400	0.10800	0.14900	0.17000
-10.00000	0.0	0.0	-0.00200	0.00200	0.03200	0.06500	0.10000	0.14200	0.16300
-9.00000	0.0	0.0	0.0	-0.00300	0.01600	0.05400	0.06900	0.13200	0.15400
-8.00000	0.0	0.0	0.0	-0.00400	0.00500	0.04100	0.08200	0.12300	0.14500
-7.00000	0.0	0.0	0.0	0.0	-0.00400	0.02750	0.07200	0.11250	0.13600
-6.00000	0.0	0.0	0.0	0.0	-0.00300	0.01600	0.06200	0.10000	0.12500
-4.00000	0.0	0.0	0.0	0.0	0.0	0.00500	0.04000	0.07600	0.10200
-3.00000	0.0	0.0	0.0	0.0	0.0	-0.00300	0.02600	0.06650	0.08700
-2.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.01300	0.05300	0.07000
-1.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.00350	0.03300	0.04500
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.00400	-0.03300	-0.04500
2.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.01300	-0.05300	-0.07000
3.00000	0.0	0.0	0.0	0.0	0.0	0.00250	-0.02600	-0.06700	-0.08700
4.00000	0.0	0.0	0.0	0.0	0.0	-0.00500	-0.04000	-0.07600	-0.10200
6.00000	0.0	0.0	0.0	0.0	0.00300	-0.01600	-0.06300	-0.10000	-0.12500
7.00000	0.0	0.0	0.0	0.0	0.00400	-0.02800	-0.07200	-0.11300	-0.13600
8.00000	0.0	0.0	0.0	0.00400	-0.00500	-0.04100	-0.08200	-0.12300	-0.14500
9.00000	0.0	0.0	0.0	0.00300	-0.01600	-0.05400	-0.08900	-0.13200	-0.15400
10.00000	0.0	0.0	0.00150	-0.00200	-0.03200	-0.06500	-0.10000	-0.14200	-0.16300
11.00000	0.0	0.0	0.00300	-0.01400	-0.04600	-0.07400	-0.10800	-0.14900	-0.17000
12.00000	0.0	0.0	-0.00200	-0.03000	-0.06000	-0.08300	-0.11600	-0.15700	-0.17600
13.00000	0.0	-0.00200	-0.02500	-0.05000	-0.07400	-0.09300	-0.12200	-0.16300	-0.18400
14.00000	0.0	-0.02700	-0.05400	-0.06800	-0.08600	-0.10300	-0.12700	-0.16700	-0.18900
15.00000	-0.05400	-0.06500	-0.07300	-0.08400	-0.09700	-0.11100	-0.13300	-0.17300	-0.19500
16.00000	-0.07300	-0.07800	-0.08600	-0.09700	-0.10800	-0.11700	-0.13700	-0.17600	-0.20000
23.00000	-0.11200	-0.11800	-0.12800	-0.14400	-0.15700	-0.17100	-0.18300	-0.20600	-0.23200
30.00000	-0.17400	-0.18400	-0.19600	-0.21400	-0.23500	-0.25000	-0.26400	-0.27700	-0.29800
90.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
135.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
160.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
165.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
170.00000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Listing of other airfoil table deleted.

Figure 48. Concluded.

sweeps (NPART = 10), the inputs in the groups are changed, and the &CHANGE card is not printed out. The user should refer to the Data Deck Listing to verify which inputs were changed in such sweeps.

4.3.3 Elastic Blade Data (Figure 49)

If elastic blade data blocks are input, the sets of data within each block are printed in the order of input with the main rotor block followed by the tail rotor block. The printout of the weight, beamwise and chordwise inertias, and center of gravity offsets is followed by the total weight, tip weight, and flapping inertia of each blade.

The modal displacements and bending moment coefficients for each mode are printed as input, from root to tip, in the Rotor Shaft Reference System for that rotor (see section 4.1.5).

The remaining constants input for each mode (mode type, generalized inertia, damping ratio, etc.) are printed immediately following the mode shapes.

4.3.4 Check of Aerodynamic Inputs

Several of the inputs to the Rotor Airfoil Aerodynamic Subgroups and the Wing and Stabilizing Surface Aerodynamic Groups are changed if their input values do not satisfy certain criteria or are obviously unreasonable. An error message is printed, after the printout of any aeroelastic blade data, explaining the action taken. The changing of any of these values will not in itself terminate execution.

4.3.5 Trim Condition in Accelerated Flight

If the rotorcraft is to be trimmed in accelerated flight, i.e., a coordinated turn, a pullup, or pushover, information is printed concerning these conditions following any correction to aerodynamic inputs. No message is printed for an unaccelerated flight condition.

MAIN ROTOR AEROELASTIC BLADE DISTRIBUTIONS AND DATA

BLADE NUMBER	STATION RADIUS(IN)	WEIGHT (LB/IN)	BEAMWISE INERTIA (IN-LB-SEC**2/IN)	CHORDWISE INERTIA (IN-LB-SEC**2/IN)	BEAMWISE CG OFFSET (IN)	CHORDWISE CG OFFSET (IN)
1	6.00	5.3702	0.0001	0.0690	0.0	0.0
2	20.57	5.7138	0.0590	0.1149	0.0	0.053
3	37.50	6.1672	0.0898	0.1190	0.0	3.610
4	52.80	4.8217	0.0131	0.2264	0.0	1.529
5	66.00	0.9520	0.0024	0.1183	0.0	0.900
6	81.50	0.7750	0.0017	0.1189	0.0	1.390
7	92.40	0.8580	0.0017	0.1469	0.0	1.770
8	103.00	0.8360	0.0017	0.1453	0.0	1.710
9	118.80	0.8690	0.0018	0.1553	0.0	2.385
10	132.00	0.7620	0.0014	0.1357	0.0	1.450
11	145.20	0.7260	0.0013	0.1305	0.0	1.340
12	155.80	0.8750	0.0014	0.1280	0.0	0.850
13	171.60	1.0980	0.0024	0.1460	0.0	0.571
14	184.80	1.0620	0.0024	0.1290	0.0	-0.550
15	198.00	1.0390	0.0014	0.1159	0.0	0.010
16	212.30	1.2600	0.0012	0.1255	0.0	-1.017
17	224.40	1.1860	0.0013	0.1045	0.0	-1.870
18	238.10	1.2660	0.0015	0.1226	0.0	-1.129
19	250.80	1.1890	0.0018	0.1161	0.0	-1.970
20	264.00	1.1600	0.0027	0.1399	0.0	-0.430

TOTAL BLADE WEIGHT = 486.19 LB   BLADE TIP WEIGHT = 0.0 LB   FLAPPING INERTIA/BLADE = 1503.4 SLUG-FT**2

Figure 49. Elastic Blade Data and Rotor-Induced Velocity Distribution Table.

MAIN ROTOR

MODE 1

BLADE STATION NUMBER	BLADE STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	-0.0000	0.0002	-0.1117	0.0	-84.6	15.5
1	6.00	0.0227	0.0002	-0.0992	10.8	-82.0	-18.5
2	20.57	0.0781	0.0002	-0.0452	10.7	-76.0	-120.2
3	37.50	0.1424	0.0001	-0.1012	18.6	-70.0	-78.4
4	52.80	0.2004	0.0001	-0.1336	35.0	-63.7	-35.0
5	66.00	0.2505	0.0000	-0.1644	48.6	-57.0	-14.3
6	81.50	0.3093	-0.0000	-0.2053	62.6	-50.4	-7.8
7	92.40	0.3506	-0.0001	-0.2379	70.9	-45.5	8.2
8	103.00	0.3907	-0.0002	-0.2720	76.2	-41.3	27.3
9	118.80	0.4505	-0.0003	-0.3226	78.5	-36.0	63.0
10	132.00	0.5003	-0.0003	-0.3683	77.7	-31.9	104.3
11	145.20	0.5502	-0.0004	-0.4121	72.3	-28.5	137.4
12	155.80	0.5902	-0.0005	-0.4454	66.3	-26.2	165.4
13	171.60	0.6498	-0.0006	-0.4843	57.5	-23.1	199.1
14	184.80	0.6997	-0.0007	-0.5103	51.2	-20.1	216.7
15	198.00	0.7496	-0.0008	-0.5292	47.0	-17.0	223.9
16	212.30	0.8037	-0.0009	-0.5418	43.3	-13.5	218.5
17	224.40	0.8495	-0.0010	-0.5478	33.5	-10.0	174.3
18	238.10	0.9015	-0.0011	-0.5505	24.0	-6.4	123.1
19	250.80	0.9498	-0.0011	-0.5508	12.5	-3.0	60.4
20	264.00	1.0000	-0.0012	-0.5507	2.4	-0.6	9.7

MODE 2

BLADE STATION NUMBER	BLADE STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	-0.1987	0.0009	0.0	118480.0	3.0
1	6.00	-0.0155	-0.1983	-0.0060	-1331.0	115642.0	26.0
2	20.57	-0.0682	-0.1921	2.7590	-4255.0	107964.0	1127.0
3	37.50	-0.1132	-0.1651	3.0442	-7167.0	97864.0	721.0
4	52.80	-0.1466	-0.1196	3.1790	-9922.0	88256.0	534.0
5	66.00	-0.1648	-0.0738	3.2661	-11555.0	79730.0	455.0
6	81.50	-0.1683	-0.0118	3.3564	-11833.0	70298.0	428.0
7	92.40	-0.1617	0.0364	3.4179	-11297.0	63969.0	390.0
8	103.00	-0.1503	0.0860	3.4677	-10433.0	58003.0	358.0
9	118.80	-0.1274	0.1641	3.5194	-8883.0	49397.0	319.0
10	132.00	-0.1046	0.2325	3.5496	-7506.0	42478.0	288.0
11	145.20	-0.0795	0.3034	3.5691	-6116.0	35829.0	273.0
12	155.80	-0.0579	0.3618	3.5785	-5038.0	30703.0	263.0
13	171.60	-0.0247	0.4511	3.5824	-3628.0	23497.0	256.0
14	184.80	0.0039	0.5273	3.5817	-2643.0	17972.0	248.0
15	198.00	0.0328	0.6047	3.5798	-1835.0	12967.0	238.0
16	212.30	0.0645	0.6896	3.5804	-1160.0	8270.0	220.0
17	224.40	0.0914	0.7620	3.5821	-698.0	5019.0	179.0
18	238.10	0.1217	0.8443	3.5844	-343.0	2239.0	131.0
19	250.80	0.149[illegible]	0.9206	3.5821	-125.1	630.3	70.6
20	264.00	0.1776	1.0000	3.5812	-15.8	14.3	16.4

MODE 3

BLADE STATION NUMBER	BLADE STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.2116	0.0044	0.0	-175567.0	207.0
1	6.00	-0.0011	0.2109	0.0270	-8809.0	-172326.0	207.0
2	20.57	-0.1268	0.2020	70.5222	30877.0	-162611.0	34301.0
3	37.50	-0.3065	0.1669	79.7210	35776.0	-149901.0	29179.0
4	52.80	-0.4537	0.1075	83.2022	29450.0	-138456.0	26511.0
5	66.00	-0.5672	0.0527	86.1894	22025.0	-127607.0	24384.0
6	81.50	-0.6718	-0.0127	89.8236	14900.0	-114613.0	23390.0
7	92.40	-0.7172	-0.0571	92.4823	10669.0	-105400.0	21940.0
8	103.00	-0.7340	-0.0977	95.1171	7740.0	-96290.0	20560.0
9	118.80	-0.7168	-0.1552	98.8238	4367.0	-82737.0	18686.0
10	132.00	-0.6632	-0.2001	102.0923	2131.0	-71591.0	16677.0
11	145.20	-0.5752	-0.2425	105.2356	1250.0	-60564.0	15111.0
12	155.80	-0.4788	-0.2745	107.6866	1150.0	-51512.0	13748.0
13	171.60	-0.3082	-0.3211	110.8172	644.0	-39763.0	12171.0
14	184.80	-0.1465	-0.3597	113.1275	-248.0	-30483.0	10436.0
15	198.00	0.0261	-0.3986	115.1347	-1582.0	-22145.0	9079.0
16	212.30	0.2226	-0.4411	116.9251	-3376.0	-14390.0	7621.0
17	224.40	0.3921	-0.4775	118.1693	-3335.0	-8856.0	6109.0
18	238.10	0.5784	-0.5198	119.2222	-3269.0	-4136.0	4650.0
19	250.80	0.7342	-0.5610	119.7944	-2071.0	-1284.0	2769.0
20	264.00	0.8800	-0.6055	120.0000	-444.6	-73.9	922.1

Figure 49. Continued.

MODE 4

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0419	-0.0115	0.0	-57826.0	-113.0
1	6.00	-0.0616	0.0417	-0.0531	4550.0	-57153.0	-18.0
2	20.57	-0.1504	0.0389	-14.0466	9059.0	-55043.0	-5566.0
3	37.50	-0.2414	0.0273	-15.5866	16924.0	-51193.0	-5580.0
4	52.80	-0.3215	0.0067	-16.2922	18850.0	-47080.0	-5667.0
5	66.00	-0.3841	-0.0117	-16.9015	17879.0	-43320.0	-5411.0
6	81.50	-0.4419	-0.0325	-17.6594	16792.0	-38797.0	-5236.0
7	92.40	-0.4721	-0.0463	-18.2368	16134.0	-35554.0	-5027.0
8	103.00	-0.4930	-0.0590	-18.8368	15389.0	-32395.0	-4844.0
9	118.80	-0.5060	-0.0762	-19.7575	14210.0	-27680.0	-4646.0
10	132.00	-0.4982	-0.0885	-20.6523	13261.0	-23770.0	-4398.0
11	145.20	-0.4698	-0.0984	-21.5933	12495.0	-19916.0	-4108.0
12	155.80	-0.4301	-0.1042	-22.3851	12081.0	-16877.0	-3806.0
13	171.60	-0.3373	-0.1088	-23.4731	11387.0	-12587.0	-3368.0
14	184.80	-0.2268	-0.1086	-24.3278	10587.0	-9330.0	-2762.0
15	198.00	-0.0843	-0.1046	-25.1013	9685.0	-6417.0	-2213.0
16	212.30	0.1050	-0.0962	-25.8065	8324.0	-3780.0	-1623.0
17	224.40	0.2902	-0.0864	-26.2839	6402.0	-2104.0	-1123.0
18	238.10	0.5217	-0.0730	-26.6846	3896.0	-804.0	-742.0
19	250.80	0.7522	-0.0590	-26.9601	1568.0	-167.0	-482.0
20	264.00	1.0000	-0.0437	-27.0797	105.4	6.5	-229.8

MODE 5

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	-0.0236	-0.0008	0.0	89348.0	175.0
1	6.00	0.1158	-0.0233	0.0733	-8930.0	88887.0	-4.0
2	20.57	0.2755	-0.0195	-1.9248	-49701.0	87177.0	-4538.0
3	37.50	0.3985	-0.0102	-2.2671	-74151.0	83913.0	2364.0
4	52.80	0.4756	0.0095	-1.6942	-66384.0	81304.0	5667.0
5	66.00	0.4899	0.0188	-0.9647	-50901.0	78374.0	6954.0
6	81.50	0.4109	0.0134	0.1293	-36891.0	73469.0	7317.0
7	92.40	0.3041	0.0016	1.0642	-29167.0	69289.0	7714.0
8	103.00	0.1703	-0.0141	2.1428	-22539.0	64859.0	7933.0
9	118.80	-0.0623	-0.0405	3.9515	-13304.0	57874.0	7987.0
10	132.00	-0.2652	-0.0613	5.7191	-6210.0	51810.0	7553.0
11	145.20	-0.4529	-0.0771	7.5055	840.0	45758.0	6943.0
12	155.80	-0.5761	-0.0834	8.8911	6571.0	40957.0	6235.0
13	171.60	-0.6896	-0.0794	10.6038	14180.0	33773.0	5346.0
14	184.80	-0.6983	-0.0611	11.7716	18470.0	27684.0	4593.0
15	198.00	-0.6126	-0.0281	12.6917	20770.0	21642.0	4151.0
16	212.30	-0.4059	0.0241	13.4269	19836.0	15191.0	3844.0
17	224.40	-0.1471	0.0794	13.9573	16276.0	10065.0	3732.0
18	238.10	0.2160	0.1506	14.4030	9609.0	4986.0	3258.0
19	250.80	0.5927	0.2211	14.4710	3388.0	1590.0	2142.0
20	264.00	1.0000	0.2960	14.4252	-46.5	58.8	644.6

MODE 6

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	-0.0327	6702.0	0.0	-23.0
1	6.00	0.0018	-0.0005	-0.0344	4030.0	-55.0	-26.0
2	20.57	0.0461	-0.0016	-1.7771	2564.0	-181.0	-100.0
3	37.50	0.1060	-0.0024	-1.8273	1925.0	-239.0	-70.0
4	52.80	0.1613	-0.0029	-1.8537	1418.0	-279.0	-34.0
5	66.00	0.2101	-0.0032	-1.8818	1059.4	-297.1	-14.3
6	81.50	0.2692	-0.0031	-1.9202	803.0	-286.0	-7.7
7	92.40	0.3115	-0.0028	-1.9510	699.6	-263.2	8.4
8	103.00	0.3529	-0.0026	-1.9839	620.3	-238.4	27.8
9	118.80	0.4149	-0.0021	-2.0330	526.4	-199.3	64.3
10	132.00	0.4668	-0.0018	-2.0786	463.9	-166.6	107.4
11	145.20	0.5189	-0.0014	-2.1228	398.7	-136.9	141.5
12	155.80	0.5607	-0.0010	-2.1571	348.5	-115.0	171.1
13	171.60	0.6234	-0.0005	-2.1982	285.8	-85.0	207.2
14	184.80	0.6762	-0.0000	-2.2263	245.4	-62.2	226.8
15	198.00	0.7293	0.0005	-2.2474	217.0	-41.6	235.3
16	212.30	0.7872	0.0011	-2.2619	193.0	-22.9	230.6
17	224.40	0.8366	0.0017	-2.2691	146.9	-12.4	184.5
18	238.10	0.8926	0.0023	-2.2726	101.6	-4.2	130.6
19	250.80	0.9451	0.0030	-2.2732	51.0	-0.5	64.0
20	264.0C	1.0000	0.0037	-2.2731	8.8	0.1	10.1

Figure 49. Continued.

MODE 7

BLADE STATION NUMBER	RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	-0.0000	-0.0000	-0.1374	-8787.0	0.0	240.0
1	6.00	-0.0047	-0.0168	-0.1163	-13704.0	1913.0	248.0
2	20.57	-0.1817	-0.0573	61.6346	17066.0	6310.0	28746.0
3	37.50	-0.4024	-0.0994	69.2832	18879.0	8575.0	23847.0
4	52.80	-0.5810	-0.1321	72.1635	10624.0	7423.0	21324.0
5	66.00	-0.7092	-0.1543	74.5974	2413.0	5912.0	19488.0
6	81.50	-0.8108	-0.1696	77.5302	-3799.0	4790.0	18657.0
7	92.40	-0.8458	-0.1726	79.6600	-6554.0	4278.0	17445.0
8	103.00	-0.8494	-0.1692	81.7494	-7805.0	4007.0	16298.0
9	118.80	-0.8100	-0.1555	84.6567	-8489.0	3700.0	14744.0
10	132.00	-0.7376	-0.1366	87.1726	-8445.0	3454.0	1[illegible]106.0
11	145.20	-0.6319	-0.1116	89.5764	-7236.0	3329.0	11860.0
12	155.80	-0.5226	-0.0874	91.4372	-5790.0	3251.0	10792.0
13	171.60	-0.3332	-0.0468	93.7982	-4189.0	2926.0	9576.0
14	184.80	-0.1557	-0.0098	95.5322	-3508.0	2474.0	8268.0
15	198.00	0.0337	0.0291	97.0350	-3435.0	1888.0	7224.0
16	212.30	0.2495	0.0729	98.3768	-3947.0	1150.0	6112.0
17	224.40	0.4367	0.1106	99.3129	-3331.0	687.0	4919.0
18	238.10	0.6455	0.1531	100.1060	-2898.0	209.0	3669.0
19	250.80	0.8258	0.1911	100.5290	-1754.0	-16.0	2218.0
20	264.00	1.0000	0.2295	100.6786	-376.4	-31.1	722.9

MODE 8

BLADE STATION NUMBER	RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	0.0000	-21027.0	0.0	9.0
1	6.00	-0.0046	-0.0062	-0.0030	-8200.0	760.0	17.0
2	20.57	-0.0800	-0.0212	-14.6321	-5885.0	2422.0	-8807.0
3	37.50	-0.1764	-0.0392	-17.0180	2139.0	4000.0	-8273.0
4	52.80	-0.2653	-0.0551	-18.0434	5893.0	4657.0	-8137.0
5	66.00	-0.3373	-0.0675	-18.9279	6777.0	4679.0	-7732.0
6	81.50	-0.4091	-0.0792	-20.0258	7663.0	4686.0	-7487.0
7	92.40	-0.4509	-0.0853	-20.8593	8272.0	4693.0	-7181.0
8	103.00	-0.4840	-0.0897	-21.7195	8659.0	4657.0	-6909.0
9	118.80	-0.5159	-0.0925	-23.0248	9034.0	4561.0	-6598.0
10	132.00	-0.5238	-0.0913	-24.2749	9273.0	4426.0	-6225.0
11	145.20	-0.5099	-0.0860	-25.5760	9598.0	4288.0	-5820.0
12	155.80	-0.4806	-0.0786	-26.6613	10006.0	4175.0	-5407.0
13	171.60	-0.3993	-0.0615	-28.1413	10396.0	3897.0	-4822.0
14	184.80	-0.2938	-0.0414	-29.2985	10326.0	3529.0	-4016.0
15	198.00	-0.1513	-0.0160	-30.3440	10009.0	3069.0	-3287.0
16	212.30	0.0439	0.0170	-31.2984	9054.0	2440.0	-2493.0
17	224.40	0.2386	0.0486	-31.9470	7172.0	1766.0	-1782.0
18	238.10	0.4851	0.0874	-32.4932	4487.0	987.0	-1209.0
19	250.80	0.7327	0.1254	-32.8631	1845.0	365.0	-766.0
20	264.00	1.0000	0.1659	-33.0216	126.5	25.5	-334.6

MODE 9

BLADE STATION NUMBER	RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	0.0000	42432.0	0.0	-113.0
1	6.00	0.0096	0.0262	-0.0015	18085.0	-10114.0	-129.0
2	20.57	0.1806	0.0889	-5.6868	-20265.0	-33017.0	-101.0
3	37.50	0.3602	0.1495	-4.7047	-47203.0	-51037.0	7382.0
4	52.80	0.4925	0.1895	-3.4335	-41747.0	-54657.0	11288.0
5	66.00	0.5477	0.2085	-2.0164	-27565.0	-53023.0	13007.0
6	81.50	0.5019	0.2040	0.0115	-15615.0	-51151.0	13519.0
7	92.40	0.4080	0.1859	1.7154	-9552.0	-49749.0	14098.0
8	103.00	0.2789	0.1594	3.6402	-4573.0	-47962.0	14443.0
9	118.80	0.0401	0.1083	6.8243	2344.0	-44289.0	14612.0
10	132.00	-0.1773	0.0600	9.9592	7583.0	-40388.0	14112.0
11	145.20	-0.3856	0.0113	13.1873	12857.0	-35808.0	13274.0
12	155.80	-0.5275	-0.0249	15.7657	17228.0	-31660.0	12241.0
13	171.60	-0.6693	-0.0701	19.0832	23023.0	-24838.0	10852.0
14	184.80	-0.6981	-0.0961	21.4807	25813.0	-19007.0	9417.0
15	198.00	-0.6268	-0.1095	23.4896	26575.0	-13417.0	8369.0
16	212.30	-0.4268	-0.1091	25.2059	23828.0	-8139.0	7395.0
17	224.40	-0.1671	-0.0983	26.4211	18881.0	-4594.0	6644.0
18	238.10	0.2020	-0.0780	27.4493	10738.0	-1865.0	5491.0
19	250.80	0.5855	-0.0549	27.8414	3624.0	-479.0	3558.0
20	264.00	1.0000	-0.0294	27.9108	-88.0	-29.0	1142.0

Figure 49. Continued.

MODE NUMBER	1	2	3	4	5	6
MODE TYPE	RIGID BODY	CYCLIC	CYCLIC	CYCLIC	CYCLIC	COLLECTIVE
NATURAL FREQUENCY,/REV	0.10000E+01	0.15994E+01	0.23579E+01	0.28561E+01	0.45021E+01	0.10434E+01
GENERALIZED INERTIA	0.31021E+01	0.25107E+01	0.13776E+02	0.22168E+01	0.26917E+01	0.28919E+01
DAMPING RATIO	0.0	0.20000E-01	0.40000E-01	0.23000E-01	0.21000E-01	0.20000E-01
COEF OF INPLANE SHEAR AT HUB,LB	-0.47800E+01	0.52517E+04	-0.55916E+04	-0.11085E+04	0.62458E+03	-0.16160E+02
COEF OF OUT-OF-PLANE SHEAR AT HUB,LB	0.57837E+04	-0.12968E+04	0.17334E+05	-0.24900E+05	0.47759E+05	0.58069E+04
COEF FOR PITCH LINK LOAD,LB	0.22340E+02	-0.13421E+04	-0.44840E+05	0.76262E+04	0.56574E+04	0.12100E+02
LEAD-LAG HINGE DISPLACEMENT,DEG	0.0	0.0	0.0	0.0	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * R * DM	0.68235E+02	0.82500E-01	-0.12861E+01	0.48180E+00	-0.12342E+01	0.65721E+02
INTEGRAL OF OUT-OF-PLANE * DM	0.50431E+01	-0.82800E+00	-0.25932E+01	-0.21624E+01	0.21936E+01	0.46028E+01
INTEGRAL OF INPLANE * R * DM	-0.66100E-01	0.48725E+02	-0.30656E+02	-0.68485E+01	0.37770E+01	0.20000E-03
INTEGRAL OF INPLANE * DM	-0.25000E-02	0.13001E+01	-0.27900E+00	-0.19470E+00	0.95000E-02	-0.17600E-01
OUT-OF-PLANE SLOPE AT PCA, DEG	0.26122E+01	-0.27239E+01	-0.71023E+01	-0.35797E+01	0.64927E+01	0.23191E+01
INPLANE SLOPE AT PCA, DEG	-0.51500E-03	0.23506E+00	-0.37012E+00	-0.10723E+00	0.16453E+00	-0.55155E-01
OUT-OF-PLANE DISPLACEMENT AT PCA, FT	0.53497E-01	-0.44664E-01	-0.58877E-01	-0.11609E+00	0.21622E+00	0.23977E-01
INPLANE DISPLACEMENT AT PCA, FT	0.17900E-03	-0.19621E+00	0.20783E+00	0.40737E-01	-0.21749E-01	-0.11650E-02

MODE NUMBER	7	8	9	10	11
MODE TYPE	COLLECTIVE	COLLECTIVE	COLLECTIVE	NOT USED	NOT USED
NATURAL FREQUENCY,/REV	0.22701E+01	0.30110E+01	0.46846E+01	0.0	0.0
GENERALIZED INERTIA	0.10994E+02	0.22098E+01	0.28077E+01	0.0	0.0
DAMPING RATIO	0.38000E-01	0.27000E-01	0.20000E-01	0.0	0.0
COEF OF INPLANE SHEAR AT HUB,LB	-0.81107E+04	-0.30912E+04	0.26935E+05	0.0	0.0
COEF OF OUT-OF-PLANE SHEAR AT HUB,LB	0.86322E+04	-0.26826E+05	0.51157E+05	0.0	0.0
COEF FOR PITCH LINK LOAD,LB	-0.37321E+05	0.11888E+05	-0.71120E+02	0.0	0.0
LEAD-LAG HINGE DISPLACEMENT,DEG	0.0	0.0	0.0	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * R * DM	-0.26732E+01	-0.14912E+01	-0.64790E+00	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * DM	-0.33422E+01	-0.17705E+01	0.18164E+01	0.0	0.0
INTEGRAL OF INPLANE * R * DM	0.77050E+00	-0.14600E+00	-0.28150E+00	0.0	0.0
INTEGRAL OF INPLANE * DM	-0.74260E+00	-0.36280E+00	0.98360E+00	0.0	0.0
OUT-OF-PLANE SLOPE AT PCA, DEG	-0.98475E+01	-0.36961E+01	0.86894E+01	0.0	0.0
INPLANE SLOPE AT PCA, DEG	-0.19368E+01	-0.70075E+00	0.29818E+01	0.0	0.0
OUT-OF-PLANE DISPLACEMENT AT PCA, FT	-0.90404E-01	-0.44422E-01	0.10030E+00	0.0	0.0
INPLANE DISPLACEMENT AT PCA, FT	-0.39431E-01	-0.14444E-01	0.61502E-01	0.0	0.0

Figure 49. Continued.

TABLES USED IN ROTOR WAKE ANALYSIS

MAIN ROTOR TABLE

OL535A.610-615.324.1,0.8636 NMU = 3 NAA = 3 NHH = 6 NRS = 20 REF FORCE = 7525. LB

X/R MU = 0.14929 #KAA = -4.50000 AVG IND VEL = 13.63908 FT/SEC

0.02	0.9565000	0.0233800	0.1373600	-0.2695300	0.[illegible]250700	-0.0059600	0.0889800	0.0413100	0.0539500
		-0.0206900	-0.0581500	-0.0269800	0.0489800				
0.08	0.8971900	0.0325300	0.2373300	-0.1500100	0.0443200	0.0059700	0.0669400	-0.0165100	0.0251400
		-0.0012600	-0.0015400	-0.0353900	0.0145900				
0.14	0.8811800	0.0552900	0.2970500	-0.0381400	0.0059800	0.0367200	0.0898300	0.0103500	0.0108400
		0.0434300	0.0132200	-0.0166200	-0.0236600				
0.20	0.8675100	0.0348600	0.2825700	0.0487300	-0.0524300	-0.0225500	0.1063700	0.0738000	0.0072300
		0.0090100	-0.0100200	0.0119100	-0.0105700				
0.25	0.8997300	0.0216400	0.2045900	0.0850400	-0.0531300	-0.0456800	0.0663700	0.0738300	0.0154600
		0.0144300	-0.0246800	0.0000800	-0.0150900				
0.31	0.9837000	0.0001800	0.1383100	0.1676900	-0.0079000	-0.0488900	0.0335100	0.0696300	-0.0075900
		0.0106600	-0.0638300	-0.0415800	-0.0412100				
0.35	1.0007095	-0.1221000	0.1107600	0.2322100	0.0757700	-0.0705700	-0.0223100	0.0256100	0.0100200
		0.0092400	-0.0633600	-0.0361800	-0.0185000				
0.39	0.9717900	-0.1640400	0.2329800	0.2001800	0.0580900	-0.0120200	-0.0472000	-0.0968200	0.0696700
		0.0418600	-0.1164300	-0.0009500	0.0433600				
0.45	0.9848100	-0.1216600	0.3705200	0.0724300	0.0455900	0.0022500	-0.0141000	-0.0968200	0.0400500
		-0.0236700	-0.0240500	0.0268300	-0.0409500				
0.50	1.0275002	-0.1502300	0.4538400	0.0706500	0.0244900	-0.0340400	-0.0017200	-0.0862100	0.0747500
		-0.0359400	-0.0483100	0.0137500	-0.0212200				
0.55	0.9323200	-0.0757700	0.7774700	-0.0752500	-0.2225000	0.0678700	0.1610700	-0.0996900	0.0046300
		-0.0917700	0.0146100	0.1076900	-0.1216500				
0.59	0.8713700	-0.1074800	0.9384100	-0.1464100	-0.2711400	0.1856100	0.1334100	-0.1295100	0.0925300
		-0.1149600	-0.0711400	0.1595400	-0.1394700				
0.65	0.8217800	-0.1478000	0.9821300	-0.1319500	-0.0542100	0.1718900	-0.0237100	-0.0609000	0.0067200
		-0.1193300	-0.0005600	0.1182600	-0.0224600				
0.70	0.8427000	-0.1411300	1.0196104	-0.1653600	-0.0452900	0.1626400	-0.0485700	-0.0248600	0.0019400
		-0.0523300	0.0067300	0.0234300	0.0009200				
0.75	0.8021700	-0.2370200	1.1223698	-0.1140300	0.0675900	0.1167800	-0.2243500	0.0800700	0.0463600
		-0.0988700	0.0775800	-0.0053700	-0.1011500				
0.80	0.8919600	-0.4018800	1.1511698	0.0128700	0.1175800	0.0852700	-0.3335100	0.0449600	0.1034000
		-0.0176100	0.0860800	-0.0780300	-0.1234600				
0.85	1.0202599	-0.3532900	1.0542097	-0.0119000	0.2527400	0.0170600	-0.2163000	0.0339600	-0.0112700
		0.0289800	0.0146800	-0.0130200	-0.0635500				
0.90	1.2978601	-0.3475600	1.0359001	-0.0382200	0.4068200	-0.0525100	-0.2313800	0.0702600	-0.1513200
		0.0682300	0.0595900	-0.0463300	0.0239700				
0.95	1.1667004	-0.5569100	2.1171703	-0.2967700	0.6183400	0.1579300	-0.5086200	0.1950800	-0.3379500
		-0.0691100	0.168430C	-0.1424200	0.1380900				
1.00	1.5590601	-0.5924200	3.1306295	-0.7320900	1.9494696	-0.5792100	0.5106900	-0.2485400	-0.1631600
		0.1096800	-0.1995300	0.3464500	-0.1406300				

X/R MU = 0.14929 #KAA = -2.25000 AVG IND VEL = 13.50807 FT/SEC

0.02	0.8835200	0.0484100	0.2155200	-0.2888100	0.1538300	0.0455600	-0.0982600	-0.0789900	0.0436200
		0.0072800	-0.1081300	-0.0446900	0.0047700				
0.08	0.8396600	0.0791700	0.3425000	-0.1986300	0.0629700	0.0545200	0.0621500	-0.0613300	0.0118700
		0.0168300	0.0024100	-0.0546100	-0.0012100				
0.14	0.8058500	0.0915800	0.3333400	-0.0635700	-0.0243400	0.0317400	0.1250400	-0.0208200	-0.0124900
		0.0129100	0.0320900	-0.0536100	[illegible]				
0.20	0.8191300	0.0893200	0.2055900	[illegible]			[illegible]	0.0104900	0.0012500
		0.0142000	-0.0003700						
0.25	0.8474200	0.0823700	[illegible]						0.0156200
		0.0151500							
0.31	0.9544200	[illegible]							
0.35	[illegible]								

Listing of remainder of RIVD table deleted.

Figure 49. Concluded.

4.3.6 Maneuver Specification (Figure 50)

The program prints the contents of the time card (CARD 301) and all maneuver control cards (all 311-type cards, the J-cards) before starting the trim procedure. A program-supplied title for the action caused by each J-card is included to the left of the numerical inputs of the J-cards. This serves as a record of the type of maneuver specified as well as a quick way to check the input data.

4.3.7 Airfoil Data Table Printout

The sets of Airfoil Data Tables input in the Data Table Group are printed in their order of input. If the internal NACA 0012 table is used, it is printed last. Each set consists of three independent tables in the following order: lift, drag, and pitching moment coefficients. The Mach number values are listed across the page, and angle of attack values are listed down the page. The inputs on the title card of each set of tables precede the printout of each set. Each table in each set is identified. See Figure 27 for the printout of the 0012 airfoil table.

4.3.8 Rotor-Induced Velocity Distribution (RIVD) Table Printout

The RIVD table is printed only when it is included in the input data. The printout heading is "TABLES USED IN ROTOR WAKE ANALYSIS" and is followed by the table title, and a statement of the number of advance ratios (NMU), angles of attack (NAA), harmonics (NHH), and radial stations (NRS). The reference thrust level at which the table was computed is printed at the end of this line. The sets of coefficients are then printed in essentially the same format used for input, i.e., the table for the first set of advance and inflow ratios, followed by the table for the second set, etc. The heading for each table includes the advance ratio, wake plane angle of attack, and average induced velocity for the table. For each table the NRS values of radial station are listed in the leftmost column. The first number to the right of the X/R value is the constant coefficient; the next two are the sine and cosine coefficients, respectively, for the first harmonic; the next two are for the second harmonic, etc. If more than four harmonics are included, the fifth harmonic pair is printed immediately below the first harmonic pair. The printouts of four pairs of coefficients per line continues until all coefficients are printed for the first value of X/R. The succeeding sets of coefficients for each value of X/R are printed in the same format.

INPUT DATA FOR MANEUVER

START (SEC)	DELT1 (SEC)	MAX1 (SEC)	DELT2 (SEC)	MAX2 (SEC)	MAX3 (SEC)
0.0	7.500000	1.000000	7.500000	0.0	0.0

	J	XCIT(J,1)	(J,2)	(J,3)	(J,4)	(J,5)	(J,6)
COLLECTIVE STICK	1	0.0	0.0	5.000	5.000	0.0	5.000
G-TRACKER AUTO PILOT	44	0.0	0.0	0.200	0.200	0.270	0.750
G-TRACKER AUTO PILOT	44	0.750	0.067	1.500	1.500	0.343	3.250
G-TRACKER AUTO PILOT	44	3.250	-0.100	5.250	5.250	-0.333	6.000
G-TRACKER AUTO PILOT	44	6.000	-0.087	7.150	7.150	-0.176	8.000
SIMULATE AUTO PILOT	32	0.0	40.000	40.000	40.000	0.300	0.300

Figure 50. Maneuver Specification.

4.4 TRIM ITERATION PAGE (Figure 51)

If IPL(72) = 1, a trim iteration page is printed for each trim iteration computed.

4.4.1 Parameters in Iterations

The VAR(I) array printed across the top of the page gives the current values of the 10 variables which are changed during the trim procedure.

VAR(1)	=	Collective Stick Position, in percent
VAR(2)	=	Longitudinal Cyclic Stick Position, in percent
VAR(3)	=	Lateral Cyclic Stick Position, in percent
VAR(4)	=	Pedal Position, in percent
VAR(5)	=	Fuselage Pitch Angle, in degrees
VAR(6)	=	Fuselage Roll or Yaw Angle, in degrees (choice of roll or yaw is made by user, IPL(44))
VAR(7)	=	Main, Forward, or Right Rotor Longitudinal Flapping Angle, in degrees (a_{1s})
VAR(8)	=	Main, Forward, or Right Rotor Lateral Flapping Angle, in degrees (b_{1s})
VAR(9)	=	Tail, Aft, or Left Rotor Longitudinal Flapping Angle, in degrees (a_{1s})
VAR(10)	=	Tail, Aft, or Left Rotor Lateral Flapping Angle, in degrees (b_{1s})

If a fully time-variant trim is used for a rotor, the rotor flapping angles are not independent variables and are not included in the VAR(I) array. For example, if IPL(49) = 1 and IPL(50) = 2, the main rotor is fully time-variant, and the VAR array printed out only has eight components, with the last two being the tail rotor flapping angles.

4.4.2 Rotor Performance

The two rows below the VAR(I) array give the following quantities for the two rotors:

- Thrust in shaft reference (lb)
- H-Force in shaft reference (lb)
- Y-Force in shaft reference (lb)

***** START OF QS ITERATION 6 *****

VAR(I) 33.44273 67.20140 54.46669 52.91405 -6.11640 -2.31644 0.65107 -0.37691 -1.74680 1.24218

	THRUST	H-FORCE	Y-FORCE	TORQUE	IND. V.	JET THRUST	
MAIN ROTOR	7892.	309.	-187.	13406.	6.329	RIGHT/CENTER	0.
TAIL ROTOR	-338.	29.	-5.	140.	-7.293	LEFT	0.

FORCE AND MOMENT SUMMARY

	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-397.4	-229.2	137.4	-137.1	-2005.6	-2160.7
MAIN ROTOR	-309.3	-186.6	-7892.1	-1210.8	-163.1	51.3
TAIL ROTOR	-28.7	337.6	-5.2	1214.8	-35.3	-9081.4
RIGHT WING	-72.0	-25.5	-381.0	-891.9	181.7	156.3
LEFT WING	-70.0	17.8	-363.1	853.5	172.4	-156.0
STABILIZER #1	-12.7	84.5	1.3	156.4	57.5	-2149.9
STABILIZER #2	0.9	-0.4	55.6	85.3	972.2	5.3
STABILIZER #3	0.8	-0.4	54.4	-85.4	951.7	7.7
GROSS WEIGHT	883.2	0.0	8241.8			
M.R. TORQUE				0.0	-0.0	13405.9
T.R. TORQUE				0.0	-139.6	-0.0
TOTAL	-5.3	-2.1	-150.9	-15.2	-8.0	78.5

PARTIAL DERIVATIVE MATRIX

	X-FORCE	Y-FORCE	Z-FORCE	YAW MOM	PITCH MOM	ROLL MOM	MR F/A MOM	MR LAT MOM	TR F/A MOM	TR LAT MOM
COLLECTIVE	-4363.	-4499.	-151642.	201309.	-13387.	-29200.	40011.	1040566.	0.	0.
F/A CYCLIC	4262.	3300.	68120.	-21415.	-22838.	21344.	-5826.	-1311065.	0.	0.
LAT CYCLIC	-1544.	6880.	3615.	-35189.	11015.	39461.	-1158497.	-4603.	0.	0.
PEDAL	415.	-6594.	58.	177540.	1766.	-23777.	0.	0.	-1123.	6554.
PITCH	-9660.	-1388.	-66071.	18718.	-21661.	-11236.	10266.	263650.	-524.	-89.
YAW	-561.	12441.	1663.	-75032.	989.	21932.	-93086.	-26327.	156.	-1270.
MR F/A FLAP	-3735.	559.	11679	-4243.	27451.	3631.	219127.	-1085136.	0.	0.
MR LAT FLAP	361.	1422.	-12131.	48462.	-5676.	9226.	1182640.	228084.	0.	0.
TR F/A FLAP	210.	93.	253.	-2753.	5151.	632.	0.	0.	8918.	-6610.
TR LAT FLAP	399.	-2602.	-179.	69767.	-4941.	-9618.	0.	0.	10474.	9532.
-ERROR	5.	2.	151.	-78.	8.	15.	181.	-2055.	1.	0.

Figure 51. Trim Iteration Page.

- Torque (Z component) in shaft reference (ft-lb)
- Average induced velocity (ft/sec)

The values of the left and right jet thrusts are also included in this block of data.

4.4.3 Force and Moment Summary

This block of output shows the contribution to the total forces and moments of each component of the rotorcraft that is included in the input data. The X-force, Y-force, Z-force, roll moment, pitch moment, and yaw moment are in body reference, with the forces in pounds and the moments in foot-pounds.

Each force and moment forms one column of the summary, where each row corresponds to a component of the rotorcraft. Except for the JETS AND GUNS row, only the components for which an input group was included are printed. If, for example, only two stabilizing surfaces were input, the rows for Stabilizing Surfaces No. 3 and No. 4 will not be printed. The complete list of possible rows in order is as follows:

FUSELAGE
MAIN ROTOR
TAIL ROTOR
RIGHT WING
LEFT WING
STABILIZER #1
STABILIZER #2
STABILIZER #3
STABILIZER #4
JETS AND GUNS
STORE/BRAKE #1
STORE/BRAKE #2
STORE/BRAKE #3
STORE/BRAKE #4
GROSS WEIGHT
M.R. TORQUE
T.R. TORQUE
TOTAL

Note that the rows labeled M.R. TORQUE and T.R. TORQUE include the moment due to flapping restraint as well as the body axis components of the appropriate shaft axis rotor torques. The rows labeled MAIN ROTOR and TAIL ROTOR include only the effects of the rotor forces acting at each hub when resolved to the cg. The drag of the rotor pylons, computed from XMR(40) and XTR(40), in wind reference, is resolved into body reference and included in the FUSELAGE forces and moments.

4.4.4 Partial Derivative Matrix

This matrix gives the partial derivative of each force and moment with respect to each of the iteration variables. The units are pounds per radian on the force derivatives and foot-pounds per radian on the moment derivatives. For the controls, the angles are rotor blade angles. The line labeled -ERROR gives the negative of the force and the moment imbalances at this iteration. If IPL(45) = 0 or 5, this matrix is computed and printed at every fifth iteration; otherwise, it is computed and printed every IPL(45)th iteration.

4.4.5 Correction Array

The line labeled CORRECTIONS gives the computed changes in the iteration variables array VAR(I), in radians. They are in the same order as the VAR(I) and the partial derivative rows. It is printed only when one or more of the computed corrections is greater than the maximum allowed by variable damper procedures. If such a case occurs, the computed corrections are multiplied by a ratio that will make all corrections within the allowable range, and this ratio is printed along with the sequence number of the iteration variable that determined it. The ratioed correctons are then added to the iteration variables to determine the values for the next iteration. It should be noted again that the CORRECTIONS are in radians and not in the same units as the VAR(I). The printing of this array generally indicates that the inputs for the maximum allowable corrections were too small or that the values of VAR(I) may not be converging to a trim solution. The array is most useful when a case does not trim, since it indicates which VAR(I) is preventing trim.

4.5 TRIMMED FLIGHT CONDITIONS PAGES

Two types of printouts are possible for the data computed in the last trim iteration, the standard trim page and the optional trim page. The standard trim page is always printed. If the optional trim page is to be printed, it follows the standard trim page if only a quasi-static trim is computed.

When performing a quasi-static trim followed by a time-variant trim, the standard trim page will be printed twice with data regarding the time-variant trim printed in between the two. The second trim page will be an update of the first page, reflecting the effects of the time-variant trim. If the switch to print the optional trim page is turned on, the optional page will be printed after the blade bending moment data are printed out. The data printed out during a time-variant trim is discussed in Section 4.6.

4.5.1 Standard Trim Page (Figure 52)

This page follows the final trim iteration. The final iteration occurs either when all forces and moment imbalances are within their respective allowable errors (XIT(15) through XIT(21)), or after XIT(1) iterations have been performed. If the page is printed because XIT(1) iterations were executed without trimming, the trim page is printed even though the rotorcraft is not actually trimmed. However, program execution terminates immediately after the printout. When the page is printed because the imbalances are within the prescribed limits, the program continues on to subsequent operations or cases.

The data are printed in blocks as discussed below.

4.5.1.1 Problem Identification

The problem identification consists of a line containing the name of the program and the date the job was computed followed by the alphanumeric comments input on CARDS 02, 03, and 04.

4.5.1.2 Trim Condition Specification

A one-line message is printed, stating whether or not the rotorcraft is in a trimmed flight condition, the number of trim iterations used, the computer CPU time used, and the value of NPART. As implied above, the rotorcraft is termed trimmed when the imbalances are less than the allowable errors, and not trimmed when XIT(1) iterations are performed without the imbalances being less than the allowable errors.

4.5.1.3 Atmospheric Parameters

This block of data describes the atmospheric conditions in which the rotorcraft was trimmed. These quantities are all consistent and conform with the standard atmosphere prescribed by the International Civil Aviation Organization (ICAO). This defined atmosphere is the same as the 1962 United States standard.

```
BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ7714   COMPUTED 05/21/79

                AH-1G + OLS ROTOR SIMULATION
                SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4.            NPART = 2
                VOLUME II OF THE PROGRAM DOCUMENTATION.  BASED ON COUNTER 568
   ROTORCRAFT IS TRIMMED AFTER 24 ITERATIONS.    0.766 MINUTES ELAPSED COMPUTING TIME.

                              ATMOSPHERIC CONDITIONS (ICAO)
                      DENSITY ALTITUDE   (FT)    5000.        ALTITUDE ABOVE GROUND  (FT)      1000.00
                      DENSITY RATIO              0.8617       SPEED OF SOUND      (FT/SEC)     1097.80
PRESSURE ALTITUDE  (FT)    5000.                              TEMPERATURE RATIO                0.966
PRESSURE RATIO             0.832
TEMPERATURE     (DEG C)    5.09
                                                                   ------BLADE------          -JET THRUST-
                                  ----POWER/TORQUE----          TIP   ADV BLD   INERTIA           LBS
                                   SHAFT      TORQUE   SPEED    SPEED MACH NO  SLUG-FT-SQ   RT     0.0
---WEIGHTS---  CENTER OF GRAVITY (IN)  HORSEPOWER  FT-LB  RPM    747.  0.884   1503.388     LT     0.0
   POUNDS       S.L.    B.L.   W.L.                             737.  0.877      1.532
BASIC A/C 8289. 196.70  0.0   74.88   MAIN. REQD  818.23   13261.3   324.1
STURES       0.                       TAIL. REQD   43.82     138.9  1656.6
TOTAL     8289. 196.70  0.0   74.88   ACCS. REQD   12.00
                                      TOTAL REQD  901.09     686.0  6600.0
                                      ENG AVAIL  1134.00
                                     BODY REFERENCE
                                 V        W        P        Q        R
          VELOCITY   223.839   9.074  -24.152     0.0      0.0      0.0

                                        ----AERODYNAMIC SURFACES----                  AERODYNAMIC ANGLE
                                                 ---BODY AXIS FORCES---               ATTACK  SIDESLIP
                           ANGLE OF   FLAP                                            2.18    -6.15
----FLIGHT PATH CONDITION---   SURFACE INCIDENCE ANGLE  X +FWD  Y +RIGHT  Z +DOWN     -4.03     2.31
TRUE AIRSPEED   (KNOTS)  133.50  NO. 1   4.50     0.0    -12.8     84.9      1.3
GROUND SPEED    (KNOTS)  133.50  NO. 2   2.65     0.0      0.9     -0.4     54.6      -4.03     2.31
RATE OF CLIMB  (FT/SEC)    0.0                                                          0.0      0.0
CLIMB ANGLE     (DEG)      0.0                             0.8     -0.4     53.4
HEADING ANGLE   (DEG)      0.0   NO. 3   2.65     0.0      0.0      0.0      0.0      7.98     2.65
ANGLE OF ATTACK (DEG)     -6.16  NO. 4   0.0      0.0                                 7.72     1.96
ANGLE OF SIDESLIP (DEG)    2.32                            -71.8    -25.4   -379.0
ANGLE OF AERO YAW (DEG)   -2.31  RT WING 14.00    0.0     -69.8     17.7   -361.2
ACCELERATIONS  VERT (G)    0.99  LT WING 14.00    0.0
               FWD  (G)    0.11
               LAT  (G)    0.00
                                     GROUND REFERENCE
                                                     DISPLACEMENTS
                 EULER ANGLES TO BODY REFERENCE      X          Y        Z
                     PSI       THETA      PHI     225.321      0.0      0.0
     VELOCITY        0.0        0.0       0.0
     LOCATION      -2.308     -6.158      0.0                   ---HUB-MAST-PYLON---------(MAIN)---(TAIL)-
                                                                DELTA 3          (DEG)      0.0     45.0
                        ----SWASH PLATE ANGLE (DEGREES)---------  PHASING        (DEG)      0.0      0.0
CONTROL DISPLACEMENTS   ------MAIN ROTOR------  ------TAIL ROTOR-----  HUB SPRING MOMENT F/A   -0.      0.
    ---PERCENT---        COLL    F/A     LAT     COLL    F/A     LAT       (FT-LB)   LAT     0.       0.
                         14.28   0.0     0.0     0.0     0.0     0.0   PYLON ANGLES  F/A     0.0      0.0
COLL     (UP)   32.74    0.0     5.18    0.0     0.0     0.0     0.0      (DEG)      LAT     0.0      0.0
F/A CYC  (FWD)  67.91    0.0     0.0    -1.84    0.0     0.0     0.0   MAST ANGLE (DEG) F/A  0.0    -90.00
LAT CYC  (RT)   54.28    0.0     0.0     0.0    -4.87    0.0     0.0                  LAT
PEDAL    (LT)   52.78    0.0     0.0     0.0     0.0     0.0     0.0
SUM OF PYLON AND SCAS    0.0     0.0     0.0    -4.87    0.0     0.0
TOTAL SWASH PLATE ANG   14.28    5.18   -1.84

                                              --ROTORS--                     ADVANCE    CP       CT      INDUCED
                                              FORCES (SHAFT AXIS) POUNDS      RATIO   X10**5   X10**4   VELOCITY
     BLADE FEATHERING - DEG    FLAPPING - DEG  THRUST   H-FORCE   Y-FORCE     0.300    34.711   44.601     0.23
     MEAN    PSI=0   PSI=90     F/A     LAT    7745.34   310.62   -182.99     0.305    51.721  -52.982    -7.22
MAIN 14.28    1.84   -5.18     0.725  -0.403   -334.87    28.48     -5.01
TAIL -4.87   -1.73    1.24    -1.728   1.237                                  HUB MOTION (FT)         MAST
                                                                                                      WIND-UP
                                  SHAFT AXIS DATA AT ROTOR HUB                 X       Y       Z      (DEG)
                    BETA                              SHEAR FORCES (POUNDS)   0.0     0.0     0.0      0.0
            HUB     LIMIT    VELOCITIES (FT/SEC)      X        Y        Z     0.0     0.0     0.0      0.0
  PSI (DEG) (DEG)   (DEG)     U        V        W    448.3     26.2   -8898.8
MAIN  0.0    0.0    12.00   223.84    9.07   -24.15  -28.5     -5.0    334.9
TAIL  0.0    0.0    11.00   223.84  -24.15     7.26
                                                                             INDUCED    PROFILE
                              ---WAKE PLANE DATA---  WAKE PLANE FLAPPING ANGLES  POWER   POWER
                              COMPLEX ANGLE   PHASE       F/A       LAT
     FILTERED       TOTAL       OF ATTACK     ANGLE      (DEG)     (DEG)     385.22    433.01
  RESULTANT FORCE  VELOCITY      (DEG)        (DEG)       2.30     -1.35       5.34     38.48
     (POUNDS)      (FT/SEC)     -3.8029      -2.404     175.14    179.14
MAIN  7753.72      225.32        3.0777       6.118
TAIL   336.12      225.28
```

Figure 52. Trimmed Flight Condition Page.

4.5.1.4 Physical and Power Parameters

Data on the rotorcraft weight and center-of-gravity location are presented immediately below the left end of the atmospheric data. The data include the weight and cg location without external stores, the total weight of all external stores, and the gross weight and cg location with stores. The stores-on data are those that are used during the trim procedure. The other data are for reference only.

To the right of the weight and cg data and in the center of the page are the power and torque required for each rotor and the accessories. The total required horsepower includes the effects of the efficiency ratios.

To the right of the power and torque data are rotor blade parameters. Tip speed is in feet per second, and advancing blade Mach number is computed at the blade tip. Blade flapping inertia is for a single blade.

To the right of the blade data are the thrusts of the right and left jets in pounds.

4.5.1.5 Body Reference Parameters

The linear and angular velocities of the rotorcraft in the Body Reference System are printed immediately below the physical and power parameter printout. The sequence of outputs is X, Y, and Z linear velocities in feet per second followed by the roll, pitch, and yaw angular velocities in degrees per second.

4.5.1.6 Flight Path and Aerodynamic Surface Parameters

Below the body reference data are the parameters which define and orient the rotorcraft with respect to the flightpath. True airspeed is the airspeed along the flightpath and is equal to the groundspeed only when the rate of climb is zero. (The program assumes that with no gusts the air mass is stationary with respect to the ground.) The climb and heading angles are defined in Section 4.2.3.1. The three aerodynamic angles and accelerations are defined in Sections 4.2.3.2 and 4.2.3.4 respectively. Note that the three accelerations are in the Body Reference System.

The aerodynamic surface parameters are to the right of the flightpath conditions. These parameters consist of the angle of incidence; flap or control surface angle; body axis X, Y, and Z forces; and aerodynamic angles for the right and left panels of the wing and for each of the four stabilizing surfaces. The aerodynamic angles are defined like the fuselage angles in Section 4.2.3.2 except that the velocities used in the definition are in the Aerodynamic Surface Reference System rather than in the Body Reference System.

4.5.1.7 Ground Reference Parameters

Below the flightpath and aerodynamic surface data are the ground reference parameters. The location and rates of change of the three ground-to-body Euler angles are printed in degrees and degrees per second, respectively.

4.5.1.8 Flight and Rotor Control Parameters

Below and to the left of the ground reference parameters are the positions of the four primary flight controls in percent. To the right of the control positions is a matrix of the contributions of each of these controls plus the pylon and SCAS to each of the swashplate angles of each rotor. The entries in the bottom row of the matrix are simply the summation of the column above them. All entries are in degrees and these swashplate angles are applied to the rotor (collectively and cyclicly) at the center of rotation. The collective pitch of the swashplate would be more properly expressed as a vertical displacement of the swashplate or collective pitch sleeve. However, the control system model is not currently capable of providing this data.

To the right of the control contribution matrix are data for the hub, mast, and pylon plus the values of the pitch-flap-coupling and control-phasing angles. The mast angle and pylon deflections are defined in Table 19. The hub-spring moments are in the Rotor Shaft Reference System.

4.5.1.9 Rotor Parameters

Below the controls data are the rotor parameters. This output group consists of the blade feathering, flapping, rotor forces, advance ratio, power and thrust coefficients, and induced velocity for each rotor. All parameters are in the Rotor Shaft Reference System. The blade feathering angles are measured at the theoretical blade root (Station No. 0). The mean blade feathering angle is identical to the collective pitch printed in the controls matrix. The longitudinal feathering angle (PSI = 0) and lateral angle (PSI = 90) will differ from the F/A and LAT swashplate angles when the value of the pitch-flap-coupling angle minus the control-phasing angle ($\delta_3 - \gamma$) is nonzero. Sign conventions for the flapping angles are defined in Section 4.2.1. Thrust is positive up the rotor shaft. H-force and Y-force are positive in the direction of the positive shaft reference X and Y axes, respectively.

$$\text{ADVANCE RATIO} = \mu = \frac{\text{velocity in the shaft X-Y plane}}{\text{rotor tip speed}}$$

and is dimensionless.

The power coefficient is defined as

$$CP = \text{power}/(\rho\ \pi\ R^2(\Omega R)^3)$$

and the thrust coefficient as

$$CT = \text{thrust}\ /(\rho\ \pi\ R^2(\Omega R)^2)$$

where ρ = air density (slug/ft^3),

R = rotor radius (ft)

ΩR = rotor tip speed (ft/sec)

Both coefficients are dimensionless. The nondimensionalization factors used here are not the same as those used in the optional trim page.

The induced velocity is the average value over the rotor disc in feet per second.

The next two lines on the trim page give the hub flapping angles for both rotors (which are equal to zero for a quasi-static rotor), the hub velocities in shaft reference, the steady component of the hub shears and displacements, and the mean mast windup angle, in degrees.

This shaft-axis data is followed by the wake-plane data for each rotor. The resultant force is the square root of the sum of the squares of the thrust, H-force and Y-force. The angle of attack and flapping angles have the same sign convention as the other rotor angles, and the phase angle is positive in the same direction as rotor azimuth.

The induced and profile power for each rotor are printed to the right of the wake-plane data.

4.5.2 Optional Trim Page (Figure 53)

Printout of this page is controlled by IPL(73). The optional trim page is most useful for presenting data from a wind tunnel simulation.

BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ7714   COMPUTED 05/21/79

AH-1G + OLS ROTOR SIMULATION
SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4,
VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558

ROTOR CONTROLS		ROTOR PARAMETERS		TUNNEL PARAMETERS		PROGRAM OPTIONS	
COLLECTIVE PITCH	14.282 DEG	ROTOR SPEED	324.06 RPM	FORWARD SPEED	133.50 KTS	NO INPUT MODES	9
F/A CYCLIC PITCH	5.181 DEG	SOLIDITY	0.0631	ADVANCE RATIO	0.3018	MX YAW FLOW, TIP	0.0 DEG
LAT CYCLIC PITCH	-1.842 DEG	BLADE RADIUS	22.00 FT	ADV TIP MACH NO	0.885	AERODYNAMICS, TIP	TABLE
TOT CYC FEATHER	5.499 DEG	CHORD, AVG	26.18 IN	SIGMA PRIME	0.862	TORSION	ON
DELTA 3	0.0 DEG	PRECONE	2.75 DEG	MAST TILT ANGLE	0.0 DEG	NON STEADY AERO	OFF
F/A FLAP ANGLE	0.798 DEG	CONING	-0.767 DEG	TPP ANG OF ATTACK	-5.36 DEG	FLAP ITERATION	OFF
LAT FLAP ANGLE	-0.706 DEG	TWIST	-10.00 DEG	CNT PL ANG OF ATTACK	-11.34 DEG	FREQUENCY CHANGE	OFF
TOTAL FLAP ANGLE	1.665 DEG	TIP SWEEP	0.0 DEG	ROTOR TIP SPEED	746.6 FT/SEC	ELASTIC PYLON	OFF

* * * * * *   FORCES AND MOMENTS   * * * * * *

WIND AXIS SYSTEM	DIMENSIONLESS HELICOPTER	DIMENSIONLESS FIXED-WING	DIMENSIONAL	SHAFT AXIS SYSTEM	DIMENSIONLESS HELICOPTER	DIMENSIONLESS FIXED-WING	DIMENSIONAL
LIFT FORCE	0.0696835	1.2017040	7638.93 LBS	THRUST	0.0696835	1.2017040	7638.93 LBS
DRAG FORCE	0.0028276	0.0487619	309.97 LBS	H FORCE	0.0028276	0.0487619	309.97 LBS
LAT FORCE	-0.0019409	-0.0334704	-212.76 LBS	Y FORCE	-0.0019409	-0.0334704	-212.76 LBS
ROLL MOMENT	0.0000000	0.0000000	0.00 FT-LBS	ROLL MOMENT	0.0000000	0.0000000	0.00 FT-LBS
PITCH MOMENT	0.0	0.0	0.0 FT-LBS	PITCH MOMENT	0.0	0.0	0.0 FT-LBS
YAW MOMENT	0.0053793	0.0463836	12973.33 FT-LBS	YAW MOMENT	0.0053793	0.0463836	12973.33 FT-LBS
				POWER	0.0053793	0.3073747	800.46 HP

* * * * * *   ROTOR LOADS   * * * * * *

	BEAM LOADS (IN-LBS)				CHORD LOADS (IN-LBS)					TORSION LOADS (IN-LBS)			
R/R	MEAN	OSC	MAX AZ	MIN AZ	MEAN	OSC	MAX AZ	MIN AZ	R/R	MEAN	OSC	MAX AZ	MIN AZ
0.0	-20346.40	11530.83	270.	200.	-1180.87	51275.16	310.	30.	0.0	514.20	1171.72	130.	200.
0.02	-11708.61	7732.00	280.	30.	161.03	49183.78	310.	30.	0.02	411.85	834.98	310.	190.
0.08	-6002.45	7085.04	280.	180.	2734.99	44652.28	310.	30.	0.08	865.18	5669.18	110.	330.
0.14	-5279.28	9834.57	280.	90.	4981.72	39567.34	210.	30.	0.14	876.32	5497.89	100.	330.
0.20	-4376.20	10304.05	10.	100.	5974.68	35734.72	210.	30.	0.20	887.72	5635.00	100.	330.
0.25	-3274.14	8800.97	10.	100.	6062.37	32276.20	210.	30.	0.25	754.26	5417.73	100.	320.
0.31	-3085.56	7561.09	10.	100.	6030.11	28480.17	210.	30.	0.31	636.22	5268.63	100.	320.
0.35	-3415.93	7001.45	10.	100.	5909.23	25943.75	210.	30.	0.35	539.08	5121.85	100.	320.
0.39	-3817.85	6525.02	10.	100.	5701.84	23542.48	210.	30.	0.39	447.33	5013.73	100.	320.
0.45	-4653.12	5829.73	10.	100.	5233.56	20118.64	210.	30.	0.45	330.71	4961.85	100.	320.
0.50	-5186.55	5535.25	270.	100.	4691.91	17381.36	210.	30.	0.50	223.13	4883.31	100.	320.
0.55	-5281.58	6118.54	270.	110.	4050.90	14767.63	210.	30.	0.55	77.80	4740.25	100.	320.
0.59	-5510.54	6828.30	270.	110.	3337.89	12854.05	210.	130.	0.59	-55.05	4565.44	100.	320.
0.65	-5830.92	7803.54	260.	120.	1999.92	10392.44	210.	130.	0.65	-258.43	4295.63	100.	320.
0.70	-5901.91	8227.76	260.	120.	1077.05	8516.67	310.	130.	0.70	-474.45	3789.75	100.	320.
0.75	-5783.51	8225.07	260.	120.	341.04	6791.52	310.	130.	0.75	-663.99	3296.83	100.	320.
0.80	-5227.42	7430.79	260.	120.	-183.04	4969.06	310.	130.	0.80	-821.61	2708.29	100.	320.
0.85	-4129.50	5899.59	260.	120.	-386.96	3431.89	310.	130.	0.85	-790.32	2015.17	100.	320.
0.90	-2546.06	3534.24	260.	120.	-326.74	1837.60	320.	130.	0.90	-658.93	1409.80	100.	0.
0.95	-998.07	1356.06	320.	120.	-140.21	659.15	320.	130.	0.95	-341.05	820.80	100.	0.

Figure 53. Optional Tr im Page.

4.5.2.1 Problem Identification

The standard trim page heading with comment cards is repeated at the top of the optional trim page(s).

4.5.2.2 Parameter Listing

Four blocks of data are printed across the page below the problem identification: rotor controls, rotor parameters, (wind) tunnel parameters, and program options. The items printed are generally either self-explanatory or have been explained previously. The dimensions, if any, for all parameters are included in the printout.

If the blade chord is not constant, the average value of chord is printed.

If the blade geometric twist is not linear, the printed twist value is the total twist angle between the root and the tip.

The solidity parameter, σ, is defined as

$$\sigma = b\bar{c}/\pi R$$

where b = number of blades

$\bar{c}$ = average chord

R = rotor radius

4.5.2.3 Forces and Moments

The rotor forces and moments printed below the parameter are listed in both the wind reference and shaft reference systems. Rotor power is printed in the shaft axis columns only. Each set of data consists of two nondimensional coefficients and the dimensional values for each force and moment. The factors that the dimensional forces, moments, and power are divided by to give their nondimensional forms are given below:

	Forces	Moments	Power
Helicopter	$\rho bcR(\Omega R)^2$	$\rho bcR(\Omega R)^2 R$	$\rho bcR(\Omega R)^3$
Fixed Wing	$qD^2\sigma$	$qD^3\sigma$	$qD^2\sigma V$

where

ρ = air density (slugs/ft^3)

b = number of blades

c = chord (ft)

R = rotor radius (ft)

Ω = rotor speed (rad/sec)

V = wind velocity (ft/sec)

$q = 1/2\ \rho\ V^2$ (lbf/ft^2)

D = diameter of rotor disk = 2R (ft)

σ = rotor solidity = $bcR/\pi R^2$

4.5.2.4 Rotor Loads

If rotor blade elastic mode shapes have been included in the analysis, a summary of the beam, chord, and torsional rotor loads is printed below the forces and moments. Data are presented for all blade stations. The higher the station number or percent radius, the more outboard the station is. The data for each of the three loads consists of the mean and oscillatory values plus blade azimuth location for the maximum and minimum loads. The loads are in inch-pounds; the azimuth angles are in degrees.

4.6 TIME-VARIANT TRIM DATA

Using appropriate input values, it is possible to compute the trimmed flight condition using only a quasi-static rotor analysis, or to compute first a trim with the quasi-static analysis and follow it with a time-variant trim (TVT) of the rotor. The output of the TVT following a quasi-static trim is discussed below.

4.6.1 The Time History (Figure 54)

Following the quasi-static trim, the program computes a time history of XIT(6) revolutions for each rotor for which the time-variant analysis is to be used. During the computations, the fuselage and flight control degrees of freedom are locked out and the orientation and control positions are held fixed at the values in the quasi-static trim condition. However, all rotor and pylon modes which are input are free. The output of a TVT includes the complete time history for each time-variant rotor and elastic pylon (if activiated).

The time history is printed in columnar form with the variables identified only at the beginning. The azimuth location in degrees of Blade No. 1 is the column headed REF BLADE PSI. If the rotor(s) use the elastic blade representation, up to 11 modal participation factors are listed under DEPENDENT PARTICIPATION FACTORS, depending on the number of mode shapes input for that rotor. If a rigid blade is used, only the first factor is nonzero. Four more participation factors are printed out for the main rotor pylon modes. If two elastic rotors are

***** START OF TV ITERATION 1 *****

REF BLADE PSI	1	2	3	4	5	6	7	8	9	10	11	P1	P2	P3	P4	PDDX/G	PDDY/G	PDDZ/G
				DEPENDENT PARTICIPATION FACTORS														
.0	-.27839	.38583E-02	-.17969E-02	.14551E-01	.16996E-03	-.25971	-.37030E-02	-.19276E-01	-.75670E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
7.6596	-.25529	-.36140E-02	-.17399E-02	.52026E-02	-.39548E-03	-.25798	-.35911E-02	-.18737E-01	-.79846E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
15.319	-.22753	-.12904E-01	-.16199E-02	-.44112E-02	-.92550E-03	-.25156	-.32266E-02	-.16772E-01	-.93845E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
22.979	-.19536	-.20741E-01	-.15455E-02	-.14079E-01	-.14821E-02	-.24158	-.27764E-02	-.13854E-01	-.11093E-01	.0	.0	.0	.0	.0	.0	.0	.0	.0
30.638	-.15939	-.28031E-01	-.16040E-02	-.23564E-01	-.20860E-02	-.22960	-.24223E-02	-.10724E-01	-.12264E-01	.0	.0	.0	.0	.0	.0	.0	.0	.0
38.298	-.12056	-.34830E-01	-.18007E-02	-.32666E-01	-.26903E-02	-.21741	-.22751E-02	-.82805E-02	-.12187E-01	.0	.0	.0	.0	.0	.0	.0	.0	.0
45.957	-.79983E-01	-.41258E-01	-.20463E-02	-.41213E-01	-.31939E-02	-.20673	-.23393E-02	-.73593E-02	-.10555E-01	.0	.0	.0	.0	.0	.0	.0	.0	.0
53.617	-.38834E-01	-.47385E-01	-.21923E-02	-.49040E-01	-.34901E-02	-.19903	-.25288E-02	-.85137E-02	-.76213E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
61.277	.19486E-02	-.53156E-01	-.21154E-02	-.55880E-01	-.35644E-02	-.19527	-.27478E-02	-.11791E-01	-.41996E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
68.936	.41819E-01	-.58362E-01	-.17849E-02	-.61370E-01	-.35485E-02	-.19576	-.29645E-02	-.16694E-01	-.14208E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
76.596	.80533E-01	-.62679E-01	-.12700E-02	-.65159E-01	-.36437E-02	-.20030	-.32281E-02	-.22341E-01	-.28421E-03	.0	.0	.0	.0	.0	.0	.0	.0	.0
84.255	.11789	-.65779E-01	-.68731E-03	-.67061E-01	-.39726E-02	-.20853	-.36278E-02	-.27748E-01	-.11943E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
91.915	.15350	-.67418E-01	-.13372E-03	-.67165E-01	-.44752E-02	-.22017	-.42252E-02	-.32108E-01	-.37336E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
99.574	.18670	-.67488E-01	.35319E-03	-.65863E-01	-.49360E-02	-.23505	-.50035E-02	-.34940E-01	-.68235E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
107.23	.21668	-.65994E-01	.77248E-03	-.63713E-01	-.51287E-02	-.25296	-.58833E-02	-.36093E-01	-.92286E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
114.89	.24272	-.63000E-01	.11112E-02	-.61229E-01	-.49626E-02	-.27343	-.67685E-02	-.35578E-01	-.10122E-01	.0	.0	.0	.0	.0	.0	.0	.0	.0
122.55	.26432	-.58574E-01	.13234E-02	-.58706E-01	-.45147E-02	-.29559	-.75807E-02	-.33523E-01	-.94209E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
130.21	.28120	-.52777E-01	.13489E-02	-.56161E-01	-.39402E-02	-.31827	-.82610E-02	-.30112E-01	-.77466E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
137.87	.29327	-.45711E-01	.11445E-02	-.53362E-01	-.33742E-02	-.34021	-.87634E-02	-.25605E-01	-.60792E-02	.0	.0	.0	.0	.0	.0	.0	.0	.0
145.53	.30040	-.37545E-01	.71317E-03	[illegible]	[illegible]E-02	-.36023	-.90389E-02	-.20380E-01	-.52962E-02	.0	.0	.0				.0	.0	.0
153.19	.30242	-.28534E-0[illegible]					-.90361E-02	-.14947E-01	-.58353E-02	.0	.0						.0	.0
160.85	.29908						[illegible]87E-02	-.98913E-02	-.75576E-02	.0								.0
168.51								-.57889E-02	-.98441E-02									

Figure 54. Partial Printout of Time-Variant Trim Data.

being used, the time history for the second rotor follows immediately after the first. A new set of headings is not printed, so it is necessary to count the rotor revolutions to find the dividing point.

A time history of rotor blade displacement or bending moment at the j^{th} station ($D_j(t)$ or $BM_j(t)$) can be computed from the participation factors for the last rotor revolution. Multiply the participation factor for the i^{th} mode, $\delta_i(t)$, by either the displacement or bending moment coefficient of the i^{th} mode at the j^{th} station (MS_{ij} or BMC_{ij}) and sum over all modes to get the value at that time-point, i.e.,

$$D_j(t) = \sum_{i=1}^{NMODES} \delta_i(t) MS_j$$

$$BM_j(t) = \sum_{i=1}^{NMODES} \delta_i(t) BMC_j$$

Note that the bending moment coefficients are in the inplane-out-of-plane coordinate system, not beam-chord.

4.6.2 Revised Trim Data

At the end of the time-history printout(s), the VAR(I) values, rotor performance data, and force and moment summary (see Sections 4.4.1, 4.4.2, and 4.4.3 respectively) are printed again for comparison to the quasi-static trim values. Note that the rotor flapping angles are not printed with VAR(I) since they are not controlled variables. In addition to the normal force and moment summary, the rotor flapping moment about the hub is printed at the end of the summary. The standard trim page is then printed again, this time with the rotor parameters reset to the values at the end of the time-variant trim.

The resultant force vector on the time-variant trim page is based on the filtered thrust, filtered H-force and filtered Y-force at $\psi = 0$. It may not agree with the value based on the average quantities printed a few lines above, as the filtered quantities are equal to the average plus a small contribution due to the attenuated, lagged higher harmonic components.

4.6.3 Rotor Dynamic Analysis

A harmonic analysis of the time history is performed, and a rotor bending moment summary is printed after the Revised Trim Page.

4.6.3.1 Harmonic Analysis of Elastic Rotor Parameters (Figure 55)

The results of a harmonic analysis of the time histories, shown in Figure 55, are printed in tabular form. From left to right, the nine columns of data are the coefficients for the zero (constant) through eighth rotor harmonic. The printout of all cosine components precedes that of the sine components. The rows labeled 1 through IPL(6) (or IPL(7) for the tail rotor) are the harmonics of the rotor modal participation factors, while the last four rows are for the pylon modes.

The harmonic content of the blade displacements can be determined from the harmonic content of the participation factors by using the following equation:

$$D_{\cos_{n,j}} = \sum_{i=i}^{NMODES} \delta_{\cos_{n,i}} MS_{ij}$$

$$D_{\sin_{n,j}} = \sum_{i=i}^{NMODES} \delta_{\sin_{n,i}} MS_{ij}$$

where $D_{\cos_{n,j}}$ = n^{th} harmonic cosine component of displacement at the j^{th} station

$D_{\sin_{n,j}}$ = n^{th} harmonic sine component of displacement at the j^{th} station

$\delta_{\cos_{n,i}}$ = n^{th} harmonic cosine component of the participation factor of the i^{th} mode

$\delta_{\sin_{n,i}}$ = n^{th} harmonic sine component of the participation factor of the i^{th} mode

$MS_{i,j}$ = modal displacement of the i^{th} mode at the j^{th} station

NMODES = number of modes

Note that the modal displacements are in the inplane-out-of-plane coordinate system, not beam-chord.

HARMONIC ANALYSIS OF ROTOR 1

COSINE COMPONENTS

1	-.662621E-03	-.320338	.444364E-03	-.579733E-02	.696030E-04	.177558E-02	.947790E-04	-.443357E-04	.943935E-04
2	.185703E-03	-.149114E-02	-.130245E-02	-.290520E-02	-.273135E-03	.145414E-03	-.205286E-03	-.228634E-03	-.181793E-03
3	-.284035E-04	-.251487E-03	.862313E-04	.198073E-02	.252998E-04	-.436201E-03	.788476E-05	.722359E-04	.496435E-05
4	-.198039E-04	.138126E-01	.514117E-04	-.145934E-02	-.290557E-05	.696857E-03	-.345326E-05	-.675612E-04	-.104181E-05
5	.961791E-05	.174434E-03	.169834E-04	-.728437E-03	-.353363E-04	-.228880E-02	-.603850E-05	.125405E-03	-.348126E-05
6	-.271495	.445650E-03	-.659444E-01	-.188166E-03	.326621E-03	-.117693E-03	.317376E-03	-.840020E-04	-.106215E-03
7	-.439357E-02	.347473E-04	-.405931E-02	.257046E-04	-.698763E-03	.601848E-05	-.374386E-04	-.330362E-05	.136127E-04
8	-.195329E-01	-.751670E-04	.113782E-01	.123550E-03	-.974346E-03	-.193794E-05	.176398E-03	.258757E-05	-.107109E-04
9	-.755602E-02	.111277E-04	-.357193E-02	.920860E-06	.238099E-02	-.101320E-04	-.605941E-03	-.740936E-05	.370874E-04
10	.0	.0	.0	.0	.0	.0	.0	.0	.0
11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12	.0	.0	.0	.0	.0	.0	.0	.0	.0
13	.0	.0	.0	.0	.0	.0	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.0	.0	.0	.0	.0

SINE COMPONENTS

1	.0	.272205	.107407E-02	-.920384E-02	.362634E-03	-.279942E-03	.193359E-03	.294131E-03	.139210E-03
2	.0	-.635598E-01	-.303104E-02	-.354984E-02	-.658571E-03	-.643783E-03	-.396660E-03	-.300040E-03	-.274502E-03
3	.0	-.398584E-03	.285021E-04	.389217E-02	.217072E-06	-.122601E-03	.619500E-05	-.440686E-04	.307324E-05
4	.0	-.684697E-01	-.569286E-04	.295639E-02	.240540E-05	-.328213E-03	-.870065E-05	.795539E-04	-.382713E-05
5	.0	-.469214E-02	.195391E-04	-.220622E-02	.148904E-04	.626253E-03	.525674E-05	-.123227E-03	.864127E-06
6	.0	.750783E-03	-.201909E-01	-.126341E-03	-.422136E-02	-.190531E-03	.497845E-03	-.141895E-03	-.170786E-03
7	.0	-.114386E-04	.657846E-02	-.129688E-03	.739360E-03	-.199570E-04	-.187027E-03	-.134547E-04	.567581E-05
8	.0	-.152079E-04	.730565E-02	-.827017E-04	-.129001E-02	-.657059E-06	.432688E-03	-.713802E-05	-.369813E-04
9	.0	.103470E-04	-.977174E-03	.428147E-04	-.240131E-02	-.439669E-04	-.637210E-03	-.511266E-05	.269491E-04
10	.0	.0	.0	.0	.0	.0	.0	.0	.0
11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12	.0	.0	.0	.0	.0	.0	.0	.0	.0
13	.0	.0	.0	.0	.0	.0	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.0	.0	.0	.0	.0

SHEARS AND MOMENTS AT TOP OF MAST IN SHAFT REFERENCE FOR ROTOR 1

X SHEAR		Y SHEAR		Z SHEAR		PITCH MOMENT		ROLL MOMENT	
COS	SIN	COS	SIN	COS	SIN	COS	SIN	COS	SIN
566.560	0.0	-5.298	0.0	-8760.785	0.0	-0.000	0.0	0.000	0.0
24.111	-26.299	-28.231	-66.897	-11.663	-10.428	-0.000	-0.001	0.002	0.000
120.346	375.170	-81.420	1270.126	1806.896	606.363	-0.000	-0.000	0.000	0.000
17.730	-13.211	36.388	65.345	8.199	-5.119	0.000	-0.000	0.000	0.000
-4.546	-96.242	190.628	120.872	-286.484	213.107	0.000	-0.000	-0.000	0.000
1.012	-3.899	4.470	8.233	2.182	6.994	0.000	0.000	-0.000	0.000
-4.089	10.794	-22.465	31.167	68.342	85.379	0.000	0.000	-0.000	-0.000
-0.034	-3.010	3.567	4.526	1.941	1.996	-0.000	0.000	-0.000	0.000
-3.732	-7.595	7.133	-4.814	-3.337	-2.818	-0.000	0.000	0.000	-0.000

Figure 55. Harmonic Analysis Following Time-Variant Trim.

The tabulation of the participation factor harmonics is followed by a tabulation of the nonrotating hub shears, giving the steady through 8-per-rev sin ωt and cos ωt components.

If elastic pylon modes were included, a similar tabulation of fixed system hub vibrations follows. AMP is the square root of the sum of the squares of the sine and cosine components. The vibrations are in g's.

If the main rotor pylon was represented by elastic modes, a tabulation of accelerations at a specified point is printed after the hub vibrations.

4.6.3.2 Rotor Bending Moment Summary for Elastic Rotor (Figure 56)

A seven-page listing of rotor bending moments in blade reference is printed for each time-variant rotor following the harmonic analysis. Tables of the beam, chord, and torsional moments for the first eight rotor harmonics and at all radial stations are shown on the first six pages. A summary of the minimum, maximum, and oscillatory moments, with azimuth locations for the extreme values, is printed on the seventh page. The oscillatory moment is defined as one-half the difference of maximum and minimum, regardless of frequency considerations. All moments are in inch-pounds.

4.7 TIME-HISTORY PLOTS (Figure 57)

Time-history plots may be generated after time-variant trims, if $0 < XIT(5) \leq XIT(6)$, and after maneuvers, or both. The format of the two plots is almost identical.

4.7.1 Problem Identification

The same problem identification used for the trim pages (CARDS 02, 03, and 04) is used as the heading for the time-history plots. The words TRIM NO. and a number are printed below and to the left of these titles for plots after a TVT, and the word MANEUVER appears for time-history plots from the maneuver portion of the program.

4.7.2 Variables Plotted and Their Scales

The plot symbols used are the numbers 1, 2, and 4. The variables corresponding to each symbol and its units are printed as part of the plot heading. If two or all three of the curves intersect at a single point, the symbol printed is the sum of the individual symbols. For example, the symbol 7(= 1 + 2 + 4) means that all three curves pass through the point where the 7 is printed.

ROTOR NUMBER 1 BEAM BENDING MOMENTS INCH-POUNDS

SINE COMPONENTS

STAT	R/R	R(IN)	STEADY	1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
19	0.950	250.80	0.0	-1257.01	-27.32	-99.66	-149.47	20.75	-13.91	-1.68	0.74
18	0.902	238.10	0.0	-3173.30	25.46	-175.47	-408.99	56.15	-52.07	-6.75	3.12
17	0.850	224.40	0.0	-5127.14	133.33	-173.38	-696.81	92.20	-100.38	-12.00	6.92
16	0.804	212.30	0.0	-6371.42	200.33	-105.71	-884.61	110.27	-128.67	-12.57	10.49
15	0.750	198.00	0.0	-6853.39	317.28	125.81	-988.24	110.53	-148.41	-9.39	15.23
14	0.700	184.80	0.0	-6716.11	380.62	395.69	-984.57	93.10	-142.73	-1.14	19.29
13	0.650	171.60	0.0	-6255.49	404.59	695.53	-921.95	64.96	-120.44	10.91	23.22
12	0.590	155.80	0.0	-5177.73	367.59	1089.16	-772.62	18.38	-73.96	30.07	27.93
11	0.550	145.20	0.0	-4352.54	309.44	1321.95	-651.86	-14.15	-36.90	43.41	30.48
10	0.500	132.00	0.0	-3453.20	299.31	1677.59	-505.62	-66.80	7.98	60.45	34.33
9	0.450	118.80	0.0	-2784.61	386.29	2070.88	-346.76	-102.03	51.57	75.97	37.50
8	0.390	103.00	0.0	-2075.83	539.38	2582.09	-130.91	-163.33	106.93	94.73	40.68
7	0.350	92.40	0.0	-1817.10	680.63	2890.73	37.87	-208.36	144.64	105.04	40.70
6	0.309	81.50	0.0	-1644.16	916.70	3293.46	246.40	-260.17	184.46	115.54	40.12
5	0.250	66.00	0.0	-2131.07	1406.08	3969.10	640.80	-380.63	256.75	130.95	35.16
4	0.200	52.80	0.0	-3630.45	1994.20	4560.15	1105.66	-515.84	336.31	141.18	23.28
3	0.142	37.50	0.0	-4047.30	2157.93	4750.82	1346.40	-593.38	331.46	133.33	11.91
2	0.078	20.57	0.0	-1526.07	727.96	3328.78	624.71	-402.79	82.70	75.94	10.94
1	0.023	6.00	0.0	-2590.00	-2843.75	-21.04	-811.38	-53.69	-155.70	16.78	4.92
0	0.0	0.0	0.0	61.73	-4676.76	40.90	-1318.85	-36.29	-373.80	-11.14	0.42

COSINE COMPONENTS

STAT	R/R	R(IN)	STEADY	1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
19	0.950	250.80	-825.07	226.22	139.27	-89.07	100.39	-60.91	-21.36	2.20	1.15
18	0.902	238.10	-2192.57	596.89	209.99	-178.63	293.09	-190.80	-66.49	8.77	4.21
17	0.850	224.40	-3703.49	1017.97	211.37	-230.95	518.10	-332.78	-119.22	17.11	8.42
16	0.804	212.30	-4747.64	1342.51	245.94	-242.15	666.62	-397.86	-150.27	21.74	11.66
15	0.750	198.00	-5390.32	1605.91	210.68	-159.11	764.11	-403.04	-167.28	25.24	15.17
14	0.700	184.80	-5552.27	1784.26	265.71	-52.46	772.17	-326.09	-159.08	24.52	17.33
13	0.650	171.60	-5479.11	1934.98	397.65	67.02	729.82	-194.82	-135.34	21.30	18.88
12	0.590	155.80	-5060.12	2063.72	629.42	228.71	620.36	29.56	-88.25	14.56	20.11
11	0.550	145.20	-4686.42	2120.96	809.20	325.12	528.31	191.92	-51.79	9.58	20.46
10	0.500	132.00	-4324.12	2249.27	1020.58	469.99	416.54	394.64	-7.33	4.24	21.51
9	0.450	118.80	-4020.34	2403.03	1197.77	630.94	288.70	589.38	37.32	-0.05	22.43
8	0.390	103.00	-3671.57	2594.79	1377.64	839.40	111.26	839.35	95.24	-5.88	23.18
7	0.350	92.40	-3440.30	2686.85	1452.09	964.27	-34.80	1006.44	136.38	-10.44	22.45
6	0.309	81.50	-3227.74	2776.89	1443.39	1130.71	-215.94	1200.35	183.42	-16.38	21.28
5	0.250	66.00	-3102.59	2918.35	1355.97	1388.96	-583.82	1569.05	271.20	-31.50	16.59
4	0.200	52.80	-3186.15	2973.11	1168.84	1588.35	-1048.17	1948.41	371.00	-53.11	7.27
3	0.142	37.50	-3876.42	2559.96	79.20	1702.28	-1233.90	2111.15	399.04	-65.04	-0.46
2	0.078	20.57	-6395.08	1201.72	-2609.96	1334.17	-374.94	1393.13	183.97	-34.84	2.68
1	0.023	6.00	-12448.93	484.86	-4309.04	-100.53	966.02	419.74	-97.77	-15.46	1.55
0	0.0	0.0	-20284.59	55.20	-9577.46	-51.76	1561.97	-15.57	-323.89	-11.13	11.37

a) Typical Bending Moment Printout.

Figure 56. Bending Moment Output Following Time-Variant Trim.

STAT	R/R	R(IN)		ROTOR NUMBER 1 1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
19	0.950	250.80	AMPLTD	1277.21	141.92	133.66	180.06	64.35	25.49	2.77	1.37
			PHASE	-79.80	-5.56	-43.93	-14.03	32.24	-24.49	-5.34	4.12
18	0.902	238.10	AMPLTD	3228.95	211.53	250.40	503.16	198.89	84.45	11.07	5.24
			PHASE	-79.36	3.46	-45.17	-13.59	32.72	-23.66	-5.37	4.57
17	0.850	224.40	AMPLTD	5227.22	249.91	288.78	868.31	345.31	155.85	20.90	10.90
			PHASE	-78.77	16.12	-47.70	-13.34	32.90	-23.32	-5.01	4.92
16	0.804	212.30	AMPLTD	6511.32	317.20	264.22	1107.67	412.86	197.83	25.11	15.69
			PHASE	-78.10	19.58	-52.14	-13.25	32.90	-23.24	-4.29	5.24
15	0.750	198.00	AMPLTD	7039.03	380.85	202.84	1249.19	417.92	223.62	26.93	21.49
			PHASE	-76.81	28.21	47.22	-13.07	32.93	-23.07	-2.91	5.64
14	0.700	184.80	AMPLTD	6949.08	464.19	399.15	1251.25	339.12	213.73	24.54	25.93
			PHASE	-75.12	27.54	32.52	-12.97	32.81	-23.02	-0.38	6.01
13	0.650	171.60	AMPLTD	6547.92	567.29	698.76	1175.85	205.36	181.17	23.93	29.93
			PHASE	-72.81	22.75	28.17	-12.91	32.31	-23.06	3.87	6.36
12	0.590	155.80	AMPLTD	5573.85	728.89	1112.91	990.85	34.81	115.15	33.41	34.42
			PHASE	-68.27	15.14	26.05	-12.81	6.37	-23.34	9.17	6.78
11	0.550	145.20	AMPLTD	4841.80	866.35	1361.34	839.06	192.44	63.59	44.45	36.71
			PHASE	-64.02	10.46	25.39	-12.74	-0.84	-24.09	11.08	7.02
10	0.500	132.00	AMPLTD	4121.14	1063.56	1742.18	655.10	398.70	10.84	60.59	40.51
			PHASE	-56.92	8.17	24.78	-12.63	-1.64	22.10	12.28	7.24
9	0.450	118.80	AMPLTD	3678.13	1258.52	2164.86	451.22	598.14	63.66	75.97	43.70
			PHASE	-49.21	8.94	24.35	-12.56	-1.96	9.02	12.86	7.39
8	0.390	103.00	AMPLTD	3322.95	1479.47	2715.10	171.80	855.10	143.20	94.92	46.82
			PHASE	-38.66	10.69	24.00	-12.41	-2.20	8.05	13.36	7.54
7	0.350	92.40	AMPLTD	3243.61	1603.69	3047.32	51.43	1027.78	198.80	105.56	46.48
			PHASE	-34.07	12.56	23.85	33.15	-2.34	7.78	13.67	7.64
6	0.309	81.50	AMPLTD	3227.13	1709.89	3482.15	327.63	1229.51	260.13	116.70	45.41
			PHASE	-30.63	16.21	23.68	32.81	-2.50	7.53	14.01	7.76
5	0.250	66.00	AMPLTD	3613.62	1953.38	4205.11	866.87	1604.84	373.46	134.68	38.88
			PHASE	-36.14	23.02	23.57	33.08	-2.74	7.24	14.79	8.09
4	0.200	52.80	AMPLTD	4692.50	2311.49	4828.85	1523.53	2015.54	500.74	150.84	24.39
			PHASE	-50.68	29.81	23.60	33.37	-2.97	7.03	15.80	9.08
3	0.142	37.50	AMPLTD	4788.95	2159.39	5046.59	1826.28	2192.95	518.75	148.34	11.92
			PHASE	-57.69	43.95	23.43	33.13	-3.14	6.62	16.57	11.53
2	0.078	20.57	AMPLTD	1942.43	2709.58	3586.20	728.59	1450.19	201.70	83.56	11.26
			PHASE	-51.78	82.21	22.72	30.24	-3.23	4.03	16.38	9.53
1	0.023	6.00	AMPLTD	2635.00	5162.82	102.71	1261.56	423.16	183.85	22.81	5.16
			PHASE	-79.40	-73.29	-56.06	-10.01	-1.46	-20.35	18.95	9.06
0	0.0	0.0	AMPLTD	82.81	10658.33	65.97	2036.66	39.49	494.61	15.75	14.15
			PHASE	48.19	-76.99	47.23	-10.09	-22.64	-21.82	-19.28	4.57

a) Concluded.

Figure 56. Continued.

ROTOR NUMBER 1SUMMARY INCH POUNDS

STATION	BEAM BENDING MOMENT OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ	CHORD BENDING MOMENT OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ
19	1356.06	357.99	320.	-2354.12	120.	659.15	518.94	320.	-799.36	130.
18	3534.24	988.19	260.	-6080.30	120.	1837.60	1510.86	320.	-2164.34	130.
17	5899.59	1770.09	260.	-10029.10	120.	3431.89	3044.93	310.	-3818.85	130.
16	7430.79	2203.36	260.	-12658.21	120.	4969.06	4786.02	310.	-5152.11	130.
15	8225.07	2441.56	260.	-14008.58	120.	6791.52	7132.56	310.	-6450.48	130.
14	8227.76	2325.85	260.	-14129.68	120.	8516.67	9593.72	310.	-7439.62	130.
13	7803.54	1972.62	260.	-13634.46	120.	10392.44	12392.36	210.	-8392.52	130.
12	6828.30	1317.78	270.	-12338.84	110.	12854.05	16191.94	210.	-9516.16	130.
11	6118.54	836.96	270.	-11400.12	110.	14767.63	18818.54	210.	-10716.73	30.
10	5536.25	348.71	270.	-10721.80	100.	17381.36	22073.27	210.	-12689.44	30.
9	5829.73	1176.62	10.	-10482.85	100.	20118.64	25352.20	210.	-14885.08	30.
8	6525.02	2707.17	10.	-10342.87	100.	23542.48	29244.32	210.	-17840.64	30.
7	7001.45	3585.52	10.	-10417.38	100.	25943.75	31852.98	210.	-20034.52	30.
6	7561.09	4475.53	10.	-10646.65	100.	28480.17	34510.29	210.	-22450.05	30.
5	8800.97	5526.83	10.	-12075.11	100.	32276.20	38338.57	210.	-26213.82	30.
4	10304.05	5927.86	10.	-14680.26	100.	35734.72	41709.41	210.	-29760.05	30.
3	9834.57	4555.29	280.	-15113.85	90.	39567.34	44549.08	210.	-34585.64	30.
2	7085.04	1082.59	280.	-13087.50	180.	44652.28	47387.29	310.	-41917.31	30.
1	7732.00	-3976.61	280.	-19440.61	30.	49183.78	49344.83	310.	-49022.77	30.
0	11530.83	-8615.57	270.	-31877.24	200.	51275.16	50094.29	310.	-52456.04	30.

TORSIONAL BENDING MOMENT

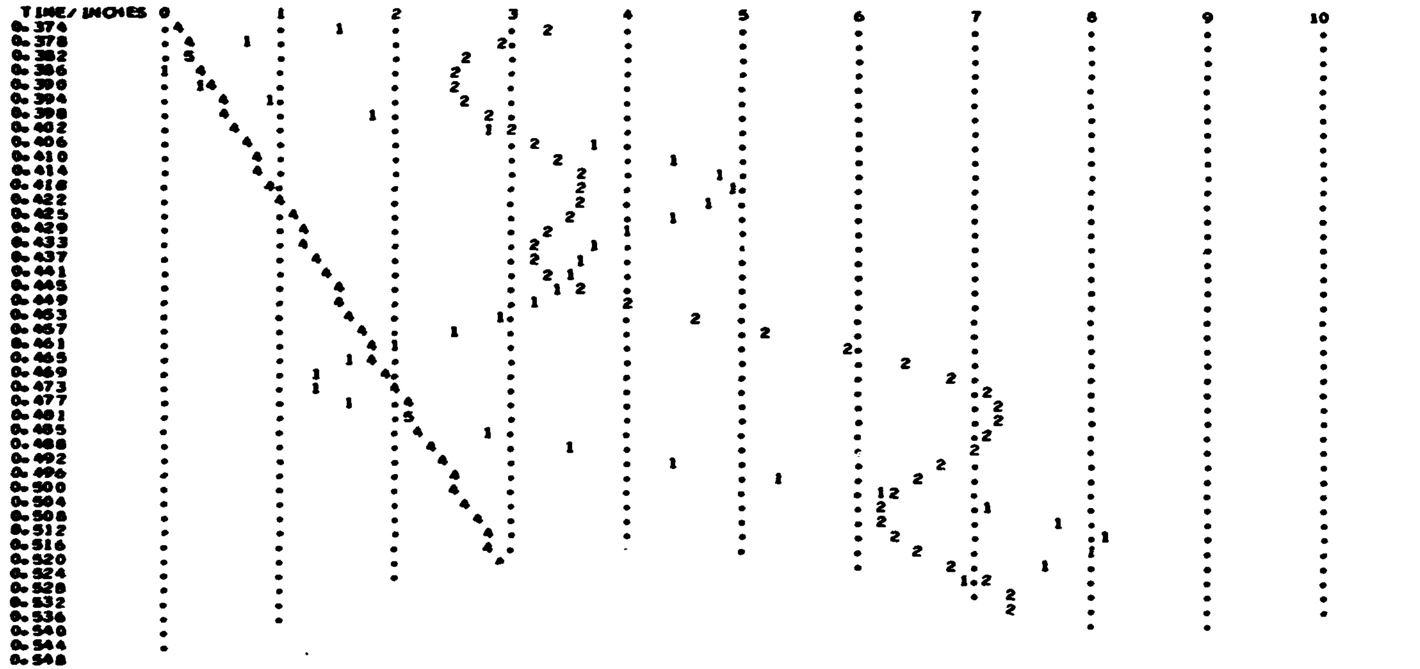
STATION	OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ
19	820.80	479.75	100.	-1161.85	0.
18	1409.80	750.87	100.	-2068.74	0.
17	2015.17	1224.85	100.	-2805.50	320.
16	2708.29	1886.68	100.	-3529.89	320.
15	3296.83	2632.84	100.	-3960.81	320.
14	3789.75	3315.30	100.	-4264.20	320.
13	4295.63	4037.20	100.	-4554.07	320.
12	4565.44	4510.39	100.	-4620.49	320.
11	4740.25	4818.05	100.	-4662.45	320.
10	4883.31	5096.44	100.	-4670.18	320.
9	4961.85	5292.56	100.	-4631.14	320.
8	5013.73	5461.06	100.	-4566.40	320.
7	5121.85	5660.93	100.	-4582.77	320.
6	5268.63	5904.86	100.	-4632.41	320.
5	5417.73	6172.00	100.	-4663.47	320.
4	5635.00	6522.72	100.	-4747.29	330.
3	5497.89	6374.21	100.	-4621.57	330.
2	5669.18	6534.36	110.	-4804.01	330.
1	834.98	1246.82	310.	-423.13	190.
0	1171.72	1685.92	130.	-657.51	200.
PLL	699.85	694.05	330.	-708.66	110.

b) Bending Moment Summary Page.

Figure 56. Concluded.

```
                         BELL HELICOPTER TEXTRON
              ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ7714
                           COMPUTED  05/21/79

        3      9041802      AH-1G + OLS ROTOR SIMULATION
                     SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4.
TRIM NO.  1          VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558
                                                           SYMBOL 1 = RTR 1.BLD 1.STA   1. BEAM BEND MOM. IN-LB
                                                           SYMBOL 2 = RTR 1.BLD 1.STA   1. CHRD BEND MOM. IN-LB
                                                           SYMBOL 4 = ROTOR 1. AZIMUTH LOCATION. BLADE 1. DEG
   SCALE  1   FROM -20000.000  TO        0.0 ,  1 INCH =  2000.000      3 FOR 1 + 2        ON SAME PRINT POS.
   SCALE  2   FROM-100000.000  TO 100000.000,  1 INCH = 20000.000      5 FOR 1 + 4        ON SAME PRINT POS.
   SCALE  4   FROM       0.0   TO   1000.000,  1 INCH =    100.000      6 FOR 2 + 4        ON SAME PRINT POS.
                                                                         7 FOR 1 + 2 + 4 ON SAME PRINT POS.
```



a) After Time-Variant Trim.

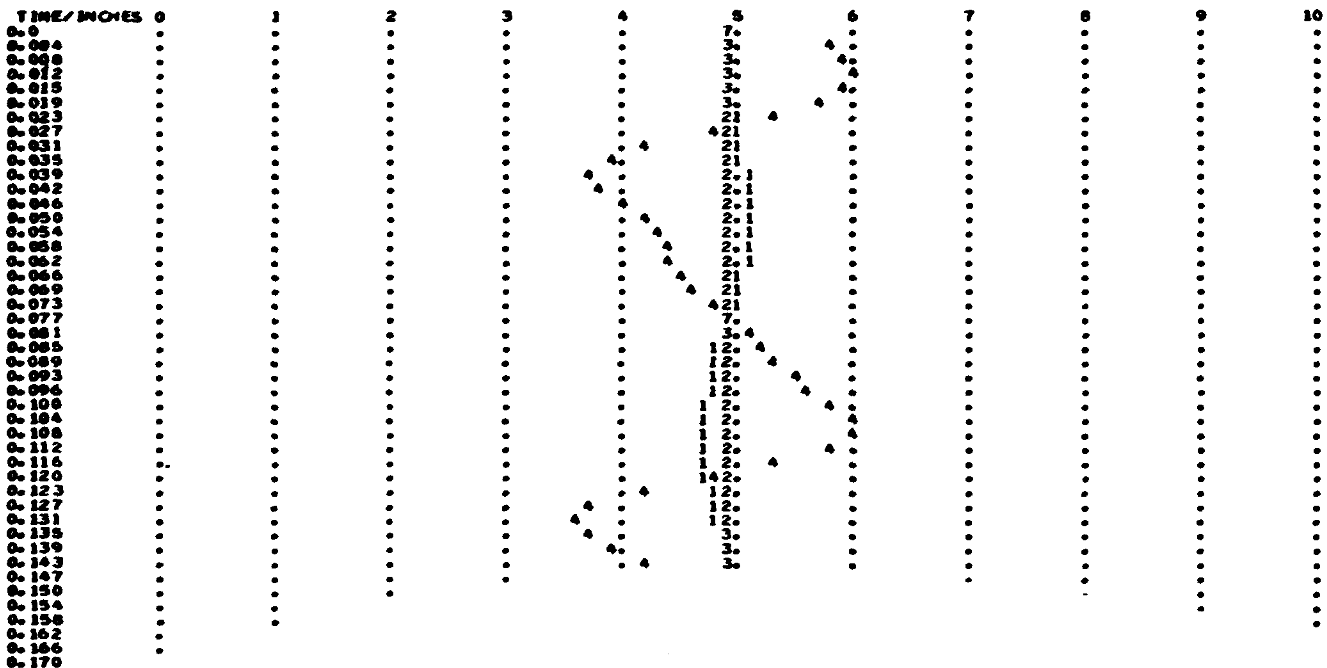
Figure 57. Sample Time-History Plot.

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ7714
COMPUTED 05/21/79

3 9041802 AH-1G + OLS ROTOR SIMULATION
SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4.
MANEUVER VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558

SYMBOL 1 = FILTERED NORMAL LOAD FACTOR, G
SYMBOL 2 = DESIRED NORMAL LOAD, G
SYMBOL 4 = VERTICAL ACC, G

SCALE	1	FROM	0.0	TO	2.000,	1 INCH =	0.200	3 FOR 1 + 2	ON SAME PRINT POS.
SCALE	2	FROM	0.0	TO	2.000,	1 INCH =	0.200	5 FOR 1 + 4	ON SAME PRINT POS.
SCALE	4	FROM	0.0	TO	2.000,	1 INCH =	0.200	6 FOR 2 + 4	ON SAME PRINT POS.
								7 FOR 1 + 2 + 4	ON SAME PRINT POS.



b) After Maneuver.

Figure 57. Concluded.

The lower and upper limits on the plot scale are given for each variable plotted. The scale in units per inch is also given.

4.7.3 General Comments

The user is cautioned that the automatic plot scaling procedure may expand small variations completely out of proportion to their true importance. Be certain to check the scales on all plots.

Time is the independent variable, and is printed along the left edge of the plot, defining the time axis. For plots after TVT, time will not start at 0.0 if XIT(5) < XIT(6). Maneuver plots will always start at t = 0.0. If the time increment is changed at some point during a maneuver, there will be a change in the time scale at this point. The resulting compression or expansion of the time scale may cause apparent discontinuities that are not actually in the data. The user should check the time scale carefully.

Each plot card, Card 402, is independent of all other plot cards. Thus, if desired, one variable may be plotted on more than one plot. One example that has proved useful is rotor azimuth position. This variable will help in pointing out any change in time scale, as well as giving phase information.

The dots printed down the page are spaced at 1-inch intervals to make it easier to read the plot values by eye. They also provide reference lines to help see slower variations on long time histories.

It is recommended that the user avoid plotting periodic variables of approximately the same magnitude, with near-zero phase shifts, on the same plot, as it will be difficult to differentiate between the traces.

The plot routine can store the values of all plot variables for a maximum of 2500 time points. Should the user specify NPRINT = 1 on Card 401 for a particularly long maneuver, the program will keep internally doubling NPRINT until the total number of points to be plotted is less than or equal to 2500. In like manner, no more than 2500 points may be plotted from a TVT.

4.7.4 CALCOMP Plots

The names of the variables plotted appear at the top of each CALCOMP page along with their respective plot symbols. The vertical scales and the plots themselves are identified by the plot symbols.

The recommendation with respect to plotting similar periodic variables on the same plot also applies to CALCOMP plots. A maximum of 2500 time points may be plotted.

4.8 MANEUVER-TIME-POINT PRINTOUT (Figure 58)

It is possible to print out data computed during a maneuver at specified time points. The value of NPRINT on CARD 01 specifies that data is to be printed each NPRINTth time point.

4.8.1 External Store Drop Printout

A message is printed stating which store was dropped whenever an external store is jettisoned during the maneuver. Also, the values for the gross weight, cg location, and inertias of the rotorcraft following the drop are printed. If two or more stores are dropped simultaneously, indepedent messages are printed for each drop. The printout precedes the printout of the first time point without the store(s).

4.8.2 Time-Point Page

The format of and data on the maneuver-time-point page are identical to those of the standard trim page with the following exceptions. The problem identification data, trim condition specification, and atmospheric parameters are omitted; some data in the aerodynamic surfaces printout are changed; and some data are added at the top of the page, to the body and ground reference parameters, and to the rotor parameter printouts. The added data are discussed below.

4.8.2.1 Identification

The first line of the maneuver-time-point page contains the current time in the maneuver and the total elapsed computer CPU time.

4.8.2.2 Body Reference Data

In the body reference data printout, the three body linear accelerations in feet per second squared and the body angular accelerations in degrees per second squared are added to the printout. Also, the velocity and acceleration of the collective bobweight are included. Since the bobweight equation is written in terms of collective pitch angles, the parameters are angular velocity and acceleration in degrees per second and degrees per second squared, respectively.

4.8.2.3 Flightpath and Aerodynamic Surface Parameters

The printout of the flightpath and aerodynamic surface parameters is the same as on the standard trim page except that

```
        0.185   SECONDS MANEUVER TIME              1.985   MINUTES ELAPSED COMPUTING TIME

---WEIGHTS---    CENTER OF GRAVITY (IN)      ---------POWER/TORQUE---------   ---------BLADE---------    -JET THRUST-
     POUNDS      S.L.     B.L.    W.L.                 SHAFT   TORQUE   SPEED     TIP   ADV BLD   INERTIA         LBS
BASIC A/C 8289.  196.70   0.0     74.88              HORSEPOWER  FT-LB    RPM    SPEED  MACH NO  SLUG-FT-SQ
STORES       0.                          MAIN. REQD    679.82  11055.9  323.0    744.   0.882    1503.388    RT     0.0
TOTAL     8289.  196.70   0.0     74.88  TAIL. REQD     38.80    123.4 1650.9    735.   0.874       1.532    LT     0.0
                                         ACCS. REQD     12.00
                                         TOTAL REQD    753.22    573.8 6577.4
                                          ENG AVAIL    767.74

                                            BODY REFERENCE                                    GUSTS AT CG (FT/SEC)
                      U          V          W          P          Q          R        BOBWT        FWD    0.0
        VELOCITY   223.844     9.428    -23.932     -0.764     -0.000     -0.547      0.0         LAT    0.0
        ACCEL.       0.735     1.565     -2.866    -22.564     -6.614     -0.034      0.0         VERT   0.0

----FLIGHT PATH CONDITION------          --------------------------AERODYNAMIC SURFACES---------------------------------
TRUE AIRSPEED       (KNOTS)    133.50              ANGLE OF    FLAP     -------WIND AXIS COEF-------      AERODYNAMIC ANGLE
GROUND SPEED        (KNOTS)    133.50     SURFACE  INCIDENCE   ANGLE       CL        CD         CM        ATTACK   SIDESLIP
RATE OF CLIMB      (FT/SEC)     -0.17     NO. 1       4.50      0.0      0.0810    0.0093    -0.0019      2.03     -6.10
CLIMB ANGLE           (DEG)     -0.04     NO. 2       2.65      0.0     -0.1362    0.0137     0.0456     -3.98      2.44
HEADING ANGLE         (DEG)     -0.01
ANGLE OF ATTACK       (DEG)     -6.10     NO. 3       2.65      0.0     -0.1328    0.0136     0.0453     -3.97      2.44
ANGLE OF SIDESLIP     (DEG)      2.41     NO. 4       0.0       0.0      0.0       0.0        0.0         0.0       0.0
ANGLE OF AERO YAW     (DEG)     -2.40
ACCELERATIONS  VERT     (G)      1.09     RT WING    14.00      0.0      0.5303    0.0436     0.0         8.04      2.74
               FWD      (G)      0.08     LT WING    14.00      0.0      0.5045    0.0411     0.0         7.77      2.05
               LAT      (G)      0.03

                                                  GROUND REFERENCE
                          EULER ANGLES TO BODY REFERENCE         DISPLACEMENTS
                            PSI       THETA      PHI        X          Y          Z
              VELOCITY    -0.550     -0.001    -0.705    225.316    -0.047      0.172     DISTANCE      41.7
              LOCATION    -2.395     -6.152    -0.137     41.717    -0.005   -999.986     ALTITUDE    1000.0

CONTROL DISPLACEMENTS    ------------SWASH PLATE ANGLE (DEGREES)------------       --HUB-MAST-PYLON-------(MAIN)---(TAIL)-
    ---PERCENT---        -------MAIN ROTOR-------   -------TAIL ROTOR-------        DELTA 3       (DEG)        0.0     45.0
                           COLL     F/A     LAT      COLL     F/A     LAT           PHASING       (DEG)        0.0      0.0
COLL      (UP)    32.74   14.28     0.0     0.0       0.0     0.0     0.0           HUB SPRING MOMENT  F/A     0.       0.
F/A CYC  (FWD)    68.84    0.0      5.46    0.0       0.0     0.0     0.0                 (FT-LB)     LAT      0.       0.
LAT CYC   (RT)    55.05    0.0      0.0    -1.71      0.0     0.0     0.0           PYLON ANGLES       F/A     0.0      0.0
PEDAL     (LT)    49.45    0.0      0.0     0.0      -3.93    0.0     0.0                   (DEG)     LAT      0.0      0.0
SUM OF PYLON AND SCAS      0.0      0.0     0.0       0.0     0.0     0.0           MAST ANGLE (DEG)   F/A     0.0      0.0
TOTAL SWASH PLATE ANG     14.28     5.46   -1.71     -3.93    0.0     0.0                              LAT     0.0    -90.00

-------------------------------------------------------ROTORS---------------------------------------------------------------
       BLADE FEATHERING - DEG        FLAPPING - DEG         FORCES (SHAFT AXIS) POUNDS      ADVANCE     CP        CT      INDUCED
       MEAN     PSI=0   PSI=90       F/A        LAT         THRUST   H-FORCE   Y-FORCE      RATIO    X10**5    X10**4    VELOCITY
MAIN   14.28    1.71    -5.46    -4490.594    912.979      8509.18   101.80   -298.40       0.301    29.137    49.336       6.42
TAIL   -3.93   -1.38     0.85       -1.378      0.848      -257.48    23.88     -2.09       0.306    46.262   -41.017      -5.65
                    BETA                          SHAFT AXIS DATA AT ROTOR HUB                      HUB MOTION (FT)          MAST
     PSI (DEG)    HUB     LIMIT      VELOCITIES (FT/SEC)          SHEAR FORCES (POUNDS)                                    WIND-UP
                 (DEG)    (DEG)       U        V        W          X        Y         Z            X       Y       Z       (DEG)
MAIN  359.27    -0.96    12.00     223.84    9.34   -23.93      509.5   -26.0    -7099.3        0.0     0.0     0.0       0.0
TAIL   36.62    -0.32    11.00     223.85  -23.95     7.75      -25.3    -3.0      254.8        0.0     0.0     0.0       0.0

------------------------------------WAKE PLANE DATA--------------------------------------
        FILTERED              TOTAL      COMPLEX ANGLE     PHASE     WAKE PLANE FLAPPING ANGLES      INDUCED       PROFILE
     RESULTANT FORCE        VELOCITY       OF ATTACK       ANGLE          F/A          LAT            POWER         POWER
        (POUNDS)            (FT/SEC)         (DEG)         (DEG)         (DEG)        (DEG)
MAIN    7356.93              225.31        -3.6600        -2.465          2.38        -1.30           410.04        269.78
TAIL     258.60              225.27         3.3464         6.086        174.70       179.54             4.37         34.42
```

Figure 58. Maneuver-Time-Point Printout Page.

the body axis X, Y, and Z aerodynamic forces acting on the aerodynamic surface are changed to nondimensional lift, drag, and pitching moment coefficients in the wind axis reference system. The body axis X, Y, and Z forces are available from the force and moment summary which immediately follows the time-point page.

4.8.2.4 Ground Reference Parameters

The ground reference parameter printout is the same as on the standard trim page with the following data added: the X, Y, and Z displacement of the rotorcraft center of gravity from the origin of the ground reference system, the distance of the cg from the origin of the ground reference system as measured in the ground X-Y plane, and the geometric altitude of the cg (the negative of the ground reference Z-location). These additional data are in feet. Note that in the ground reference system, all maneuvers start with X = Y = 0 and Z = -(geometric altitude).

4.8.2.5 Flight and Rotor Control Parameters

The rotor parameters printout on the time-point page includes all data shown on the standard trim page plus additional rotor and mast data and the values of the gusts at the rotorcraft cg.

PSI (DEG) is the azimuth location of Blade No. 1 of each rotor. BETA refers to blade flapping at the hub with respect to the shaft reference X-Y plane. HUB is the flapping angle at the hub for Blade No. 1 at its present azimuth.

The forward, lateral, and vertical components of the gust velocities at the center of gravity are in body reference and have the units of feet per second.

4.8.3 Force and Moment Summary (Figure 59)

The maneuver-time-point page is followed by a force and moment summary for that time point. The format of the summary is identical to the summary printed during trim iterations.

4.8.4 Rotor Elastic Response (Figure 59)

The azimuth location of each blade is given for reference. The instantaneous values of the generalized coordinates for each blade and each mode are avilable for detailed study. The three components of blade tip deflection provide the user with a clear indication of the overall rotor behavior. The out-of-plane and inplane deflections are in feet, and the elastic twist deflection is in degrees.

FORCE AND MOMENT SUMMARY

	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-397.1	-238.6	137.2	-142.1	-2000.3	-2229.4
MAIN ROTOR	-101.8	-298.4	-8509.2	-1936.6	-1679.4	82.1
TAIL ROTOR	-23.9	257.5	-2.1	928.6	30.0	-6923.3
RIGHT WING	-72.1	-25.7	-382.0	-894.0	182.2	156.4
LEFT WING	-78.0	17.7	-363.4	854.3	172.6	-156.1
STABILIZER #1	-12.5	79.1	1.3	146.3	56.8	-2012.3
STABILIZER #2	0.8	-0.4	53.9	82.6	944.1	5.4
STABILIZER #3	0.7	-0.4	52.6	-82.6	920.7	7.7
GROSS WEIGHT	888.3	-19.7	8241.2			
M.R. TORQUE				0.0	0.0	11245.9
T.R. TORQUE				0.0	-124.4	-0.0
TOTAL	212.4	-229.1	-770.5	-1043.6	-1499.1	176.4
FLAPPING MOMENT AT M.R. HUB				-6204.6	78.5	

**** MAIN ROTOR ****

VARIABLE	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
AZIMUTH	359.273	179.273	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 1	-0.306	0.306	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 2	0.003	-0.003	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 3	0.001	-0.001	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 4	0.012	-0.012	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 5	-0.003	0.003	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 6	-0.332	-0.332	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 7	-0.010	-0.010	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 8	-0.008	-0.008	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 9	-0.009	-0.009	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIP DEFL.OUT-OF-PLANE	-0.632	-0.062	0.0	0.0	0.0	0.0	0.0
TIP DEFL.INPLANE	0.167	0.010	0.0	0.0	0.0	0.0	0.0
TIP TWIST DEFL.	-0.342	-0.089	0.0	0.0	0.0	0.0	0.0
VERTICAL SHEAR AT HUB	1341.911	5769.371	0.0	0.0	0.0	0.0	0.0
INPLANE SHEAR AT HUB	-139.121	-137.054	0.0	0.0	0.0	0.0	0.0
LOADS AT R = 0.0 IN							
BEAM BENDING MOMENT	-28389.500	-28385.371	0.0	0.0	0.0	0.0	0.0
CHORD BENDING MOMENT	-8291.859	8308.543	0.0	0.0	0.0	0.0	0.0
TORSIONAL MOMENT	-188.732	22.168	0.0	0.0	0.0	0.0	0.0
PITCH LINK TENSION	303.258	226.321	0.0	0.0	0.0	0.0	0.0
	MODE 1	MODE 2	MODE 3	MODE 4	X-ACC	Y-ACC	Z-ACC
PYLON GEN.COORD / ACC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACCELERATIONS AT THE SPECIFIED POINT(S)		0.023	0.049	-0.089			

Figure 59. Maneuver-Time-Point Force and Moment Summary and Rotor Elastic Response Printout.

4.8.4.1 Blade Shear Forces

The out-of-plane components of shear are given for each blade in pounds. This shows how the blades share the total shear forces given above in the rotor variables.

4.8.4.2 Bending Moments at User-Selected Location

At one radial station selected by the user, IPL(77) or IPL(78), the computer program calculates and prints the beamwise bending moment, the chordwise bending moment, and the torsional moment for each blade in inch-pounds. The beam and chord moments have been resolved through the geometric pitch angle from the out-of-plane and inplane directions so that the values printed will be in the same coordinate system as test data.

4.9 OUTPUT OF HARMONIC ANALYSIS ROUTINE (Figure 60)

This program option gives a harmonic analysis (frequency versus amplitude function) for selected variables from a set of maneuver data.

4.9.1 Printed Output

4.9.1.1 Variable Identification

An identifying phrase and units for the variable analyzed are printed at the head of each page of harmonic analysis data.

4.9.1.2 Frequency-Amplitude Table

The frequency and amplitude data are presented in three pairs of columns. The frequency is given in cycles per second, and the amplitude is in the units given in the heading.

4.9.2 CALCOMP Output

An amplitude-versus-frequency plot generated by the harmonic analysis routine consists of the tabulated points connected by straight-line segments. The zero value or steady component is always plotted as zero. The actual value is then given at the bottom of the page unless it is too big for the CALCOMP to handle. The variable identification with units is also given at the bottom of the page.

4.10 VECTOR ANALYSIS DATA (Figure 61)

This program option gives a vector analysis (least-squared-errors curve fit) of selected variables from a set of maneuver data.

TIP DEFL.OUT-OF-PLANE.ROTOR 1.BLADE 1.FT

FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE
0.0	-0.2982140E+00	0.4320854E+02	0.3241731E-03	0.8641710E+02	0.1872705E-03
0.5401069E+01	0.3256608E+00	0.4860960E+02	0.3290193E-03	0.9181816E+02	0.1803994E-03
0.1080214E+02	0.5573843E-01	0.5401068E+02	0.2872818E-03	0.9721922E+02	0.1755383E-03
0.1620320E+02	0.8813135E-02	0.5941174E+02	0.2574248E-03	0.1026203E+03	0.1706738E-03
0.2160426E+02	0.5900230E-02	0.6481282E+02	0.2376609E-03	0.1080214E+03	0.1670421E-03
0.2700534E+02	0.2012561E-03	0.7021388E+02	0.2140822E-03	0.1134224E+03	0.1642455E-03
0.3240640E+02	0.7476972E-03	0.7561496E+02	0.2042394E-03	0.1188235E+03	0.1621863E-03
0.3780748E+02	0.4642115E-03	0.8101602E+02	0.1960053E-03	0.1242246E+03	0.1618797E-03

TIP DEFL. INPLANE.ROTOR 1.BLADE 1.FT

FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE
0.0	0.7448947E-01	0.4320854E+02	0.4541436E-03	0.8641710E+02	0.2619540E-03
0.5401069E+01	0.1263581E+00	0.4860960E+02	0.4093612E-03	0.9181816E+02	0.2529623E-03
0.1080214E+02	0.1778458E-01	0.5401068E+02	0.3769158E-03	0.9721922E+02	0.2460759E-03
0.1620320E+02	0.5578477E-02	0.5941174E+02	0.3487652E-03	0.1026203E+03	0.2403385E-03
0.2160426E+02	0.9390234E-03	0.6481282E+02	0.3223279E-03	0.1080214E+03	0.2357296E-03
0.2700534E+02	0.5144130E-03	0.7021388E+02	0.3017264E-03	0.1134224E+03	0.2323958E-03
0.3240640E+02	0.6661157E-03	0.7561496E+02	0.2858490E-03	0.1188235E+03	0.2302318E-03
0.3780748E+02	0.5177287E-03	0.8101602E+02	0.2728614E-03	0.1242246E+03	0.2291122E-03

TIP TWIST DEFL..ROTOR 1.BLADE 1.DEG

FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE
0.0	0.6023836E+00	0.4320854E+02	0.5617794E-02	0.8641710E+02	0.4159354E-03
0.5401069E+01	0.1400865E+01	0.4860960E+02	0.4830810E-03	0.9181816E+02	0.3906100E-03
0.1080214E+02	0.8107513E+00	0.5401068E+02	0.8863646E-03	0.9721922E+02	0.3984214E-03
0.1620320E+02	0.4300417E+00	0.5941174E+02	0.7725088E-03	0.1026203E+03	0.3683241E-03
0.2160426E+02	0.6590557E-01	0.6481282E+02	0.7213312E-03	0.1080214E+03	0.3248544E-03
0.2700534E+02	0.9074575E-01	0.7021388E+02	0.5102695E-03	0.1134224E+03	0.3076312E-03
0.3240640E+02	0.5318958E-01	0.7561496E+02	0.3902775E-03	0.1188235E+03	0.2905834E-03
0.3780748E+02	0.1506592E-01	0.8101602E+02	0.3542334E-03	0.1242246E+03	0.2858839E-03

Figure 60. Output of Harmonic Analysis Routine.

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAJ7714
COMPUTED 05/21/79

11 9041802 AH-1G + OLS ROTOR SIMULATION
SAMPLE MANEUVER CASE TO GET OUTPUT FOR INCLUSION IN SECTION 4.
VOLUME II OF THE PROGRAM DOCUMENTATION _ BASED ON COUNTER 558

LEAST SQUARES CURVE FIT STARTING AFTER 0.390 SECONDS MANEUVER TIME

F(T) = AMPLITUDE*SIN(OMEGA*T + PHASE ANGLE) + CONSTANT WITH OMEGA =10.800 CPS

VARIABLE	AMPLITUDE	PHASE ANGLE (DEGREES)	CONSTANT	COEF OF CORR
ROTOR 1. THRUST. LB	1504.5	74.977	7622.5	.91846
ROTOR 1. H-FORCE. LB	211.48	-65.830	397.86	.98494
ROTOR 1. Y-FORCE. LB	245.79	-142.35	-209.94	.98883

AMPLITUDE AND PHASE ANGLE COMPARISONS

VARIABLES		AMPLITUDE RATIO	PHASE ANGLE DIFFERENCE
ROTOR 1. H-FORCE. LB	/ROTOR 1. THRUST. LB	.14057	-140.81
ROTOR 1. Y-FORCE. LB	/ROTOR 1. THRUST. LB	.16337	-217.33

VARIABLE 'A' AS A LINEAR COMBINATION OF VARIABLES 'B' AND 'C'.

A = KB*B + KC*C + KD

VARIABLE	NAME	COEFFICIENT
A	ROTOR 1. THRUST. LB	
B	ROTOR 1. H-FORCE. LB	-4.4360
C	ROTOR 1. Y-FORCE. LB	-3.9777
	CONSTANT	8153.0

Figure 61. Vector Analysis Data.

4.10.1 Curve-Fit Analysis

4.10.1.1 Problem Identification

This output is the same as the headings printed for the trim page(s) and for time-history plots.

4.10.1.2 Curve-Fit Heading

The maneuver time at which the curve fit starts is given. All time points prior to this time are disregarded by the curve-fit procedure. The frequency used in the curve fit, OMEGA, is given in cycles per second. The curve-fit function, F(T), is expressed in general form:

F(T) = AMPLITUDE * SIN(OMEGA * T + PHASE ANGLE) + CONSTANT

(where T is time as measured during maneuver).

4.10.1.3 Variable, Amplitude, Phase Angle, and Constant

Below the general equation are five columns as follows:

(1) VARIABLE: In this column the variable being curve fit is identified, and its units are given.

(2) AMPLITUDE: This number may be substituted into the general equation for AMPLITUDE. The units are those given under VARIABLE.

(3) PHASE ANGLE: This number may be substituted into the general equation for PHASE ANGLE. The units are degrees, as labeled.

(4) CONSTANT: This quantity may also be substituted directly into the general equation. The units are those given under VARIABLE.

(5) COEF OF CORR: This denotes the coefficient of correlation and is a measure of how well the variable under consideration is fit by a sinusoidal variation at the frequency selected. A number greater than 0.95 in this column indicates a reasonably good fit. A smaller value is generally caused by other frequency content or a transient condition.

4.10.2 Amplitude and Phase Angle Comparisons

The problem identification is repeated at the top of the following page.

The magnitude and phase angles between variable vectors are compared for selected pairs of variables. The variables compared are labeled as VARIABLE A/VARIABLE B. The variable identifications used are the same as those used on the previous page and for the plot headings. The amplitude ratio printed is AMPLITUDE A divided by AMPLITUDE B. The phase angle difference is PHASE ANGLE A minus PHASE ANGLE B.

4.10.3 Variable "A" as a Linear Combination of Variables "B" and "C"

Following the amplitude and phase angle comparisons, the program skips to the top of the next page and again prints the problem identification heading.

If all the selected variables are viewed as vectors rotating at the same rotational speed, OMEGA, any one variable may be expressed as a linear combination of two other variables and as a constant as long as the phase angle between the two variables is not 0 or 180 degrees. This relationship is given generally in the heading as A = KB * B + KC * C + KD.

Here A, B, and C are the variables concerned. The variable identification phrase is printed for each in the output. KB, KC, and KD are constants determined by the program and printed in the column labeled COEFFICIENT. In this row for variable B, the coefficient is KB; in the row for variable C, the coefficient is KC; and in the unlabeled variable row, which has the word CONSTANT to the right of the row, the coefficient is KD.

4.10.4 Time Used

The time used in the vector analysis process is printed along with the total elapsed computing time at the completion of the vector analysis routine.

4.11 OUTPUT OF ROTORCRAFT STABILITY ANALYSIS ROUTINE (STAB)

The operation of the rotorcraft stability analysis routine (STAB) depends on the numerical evaluation of a number of partial derivatives that appear in the equations of motion for the rotorcraft. A frequency analysis is made on the equations of motion with controls fixed and following step inputs to the controls. As used here, "s" is the Laplace operator.

4.11.1 Control Partial Derivative Matrices (Figure 62)

4.11.1.1 Force and Moment Derivatives

The first version of the control partial derivative matrix is printed with units of pounds per inch or foot-pounds per

CONTROL PARTIAL DERIVATIVE MATRICES

POUNDS/INCH OR FOOT-POUNDS/INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	21.52	125.1	-41.90	-31.31
Y-FORCE	-134.0	129.4	143.9	517.7
Z-FORCE	-4443.	2661.	33.11	82.11
YAW MOM	4207.	1193.	-690.5	-.1376E+05
PITCH MOM	70.12	-2053.	294.3	-99.94
ROLL MOM	-946.6	912.8	1016.	2169.
M.R. F/A FLAP MOM	-3991.	3461.	-.2842E+05	-458.5
M.R. LAT FLAP MOM	.3967E+05	-.5975E+05	-105.9	159.3
T.R. F/A FLAP MOM	.0	.0	.0	76.99
T.R. LAT FLAP MOM	.0	.0	.0	-558.8

FT/SEC**2 OR RAD/SEC**2 PER INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.8323E-01	.4838	-.1620	-.1211
Y-FORCE	-.5183	.5005	.5563	2.002
Z-FORCE	-17.18	10.29	.1281	.3175
YAW MOM	.4111	.1166	-.6747E-01	-1.345
PITCH MOM	.5901E-02	-.1728	.2477E-01	-.8410E-02
ROLL MOM	-.3260	.3143	.3499	.7469
M.R. F/A FLAP MOM	-2.655	2.302	-18.91	-.3050
M.R. LAT FLAP MOM	26.38	-39.74	-.7046E-01	.1060
T.R. F/A FLAP MOM	.0	.0	.0	50.25
T.R. LAT FLAP MOM	.0	.0	.0	-364.8

CONVENTIONAL FIXED WING NON-DIMENSIONAL DERIVATIVES

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.1296E-01	.7535E-01	-.2524E-01	-.1886E-01
Y-FORCE	-.8072E-01	.7794E-01	.8664E-01	.3118
Z-FORCE	-2.676	1.603	.1994E-01	.4946E-01
YAW MOM	.2431	.6893E-01	-.3990E-01	-.7950
PITCH MOM	.1564E-01	-.4579	.6564E-01	-.2229E-01
ROLL MOM	-.5469E-01	.5274E-01	.5871E-01	.1253
M.R. F/A FLAP MOM	-.8902	.7720	-6.339	-.1023
M.R. LAT FLAP MOM	2.292	-3.452	-.6120E-02	.9205E-02
T.R. F/A FLAP MOM	.0	.0	.0	.1717E-01
T.R. LAT FLAP MOM	.0	.0	.0	-.3229E-01

Figure 62. Control Partial Derivative Matrix from STAB.

inch. The response to each of the 14 degrees of freedom available in STAB is evaluated and ratioed to be the response to a 1-inch step input from each of the four controls. The rotor flapping angles are changed to reduce the rotor flapping moments to less than the allowable error if the rotor degrees of freedom are not turned on.

4.11.1.2 Control Derivatives in Terms of Accelerations

The second version of the control partial derivative matrix contains the same information as the first. In this matrix, the force and moment derivatives have been divided by the appropriate masses or inertias to give the units of linear or angular acceleration per inch of control. These numbers may be thought of as the accelerations at the instant immediately after a step input from the controls. The same labels are used for the rows of the second matrix as for the first.

4.11.1.3 Conventional Fixed-Wing Nondimensional Derivatives

If the rotorcraft does not have a wing or if the airspeed is less than 1.0 knots, this matrix is not printed. The reader is referred to Etkin, Reference 5, for the nondimensionalizing factors and for interpretation of the first six rows of the third matrix. No attempt will be made to interpret or explain the last eight rows of this matrix because conventional fixed-wing concepts do not apply to helicopter rotors and pylons.

4.11.2 Partial Derivatives for Rotorcraft Stability Analysis Degrees of Freedom

The next pages of output contain detailed information used for the calculation of the partial derivatives for each degree of freedom that is activated in STAB. The partial derivatives are evaluated in the same order in which the variables are listed below. See Figure 63.

4.11.2.1 Rotorcraft Stability Analysis Degrees of Freedom

At the top of each partial derivative page is a list of the current value of each of the possible degrees of freedom. All FUS (fuselage) parameters are in the body reference system and all M.R. and T.R. (rotor) parameters are in the appropriate shaft reference system. By a comparison of two successive pages, it is possible to tell which variable is being perturbed and by how much.

```
  FUS. U = 243.67046  FUS. W =  -20.36525   FUS. Q =    0.0      FUS. V =    7.88955   FUS. P =    0.0      FUS. R =    0.0
M.R. F/A  FLAP  RATE =    0.0   M.R. LAT  FLAP  RATE =    0.0    T.H. F/A  FLAP  RATE =    0.0    T.R. LAT  FLAP  RATE =    0.0
M.R. F/A  FLAP  DISP =  -0.9304 M.R. LAT  FLAP  DISP =  -0.6403  T.R. F/A  FLAP  DISP =  -1.6845  T.R. LAT  FLAP  DISP =  1.3849
```

	THRUST	H-FORCE	Y-FORCE	TORQUE	IND. V.	JET THRUST	
MAIN ROTOR	7456.	59.	-191.	13530.	7.967	RIGHT/CENTER	0.
TAIL ROTOR	-322.	26.	-6.	119.	-6.492	LEFT	0.

FORCE AND MOMENT SUMMARY

	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-469.6	-193.1	128.8	-255.4	-1848.5	-2079.2
MAIN ROTOR	-59.4	-191.3	-7455.6	-1351.4	792.2	-9.6
TAIL ROTOR	-26.0	322.1	-5.6	1342.8	-39.4	-8560.4
RIGHT WING	-91.0	-34.7	-525.1	-1249.2	477.8	184.6
LEFT WING	-69.3	25.2	-507.2	1206.5	461.5	-189.5
STABILIZER #1	-15.6	118.6	1.4	287.8	74.1	-2977.7
STABILIZER #2	-3.1	-0.1	6.6	8.9	153.3	7.0
STABILIZER #3	-3.1	-0.1	6.5	-11.5	151.3	-2.7
GROSS WEIGHT	708.8	-46.4	8288.6			
M.R. TORQUE				0.0	-0.0	13530.3
T.R. TORQUE				0.0	-119.3	-0.0
TOTAL	-48.3	0.2	-61.4	-21.5	102.8	-97.1

DELTA

FORCE AND MOMENT SUMMARY

	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-19.0	-1.8	2.7	-6.6	-52.7	-41.6
MAIN ROTOR	-19.1	-4.4	-7.4	-31.4	135.3	-0.2
TAIL ROTOR	-1.0	0.7	0.1	2.9	7.0	-16.3
RIGHT WING	-4.1	-1.7	-26.7	-63.5	24.3	8.1
LEFT WING	-4.0	1.3	-26.2	62.4	23.9	-8.4
STABILIZER #1	-0.7	6.2	0.0	15.2	2.8	-156.8
STABILIZER #2	-0.3	-0.0	-1.2	-1.8	-17.2	0.4
STABILIZER #3	-0.3	-0.0	-1.1	1.7	-16.9	-0.4
GROSS WEIGHT	0.0	0.0	0.0			
M.R. TORQUE				0.0	0.0	117.7
T.R. TORQUE				0.0	-3.8	-0.0
TOTAL	-48.3	0.3	-59.7	-21.1	102.6	-97.4

Figure 63. Example of Partial Derivatives for STAB Degrees of Freedom.

The 30 variables which may be perturbed are perturbed in the following order:

FUS. U = velocity in the X direction (ft/sec)

FUS. W = velocity in the Z direction (ft/sec)

FUS. Q = pitch rate (deg/sec)

FUS. V = velocity in the Y direction (ft/sec)

FUS. P = roll rate (deg/sec)

FUS. R = yaw rate (deg/sec)

M.R. PYLON MODE 1 RATE = (deg/sec)

M.R. PYLON MODE 2 RATE = (deg/sec)

M.R. PYLON MODE 3 RATE = (deg/sec)

M.R. PYLON MODE 4 RATE = (deg/sec)

T.R. PYLON MODE 1 RATE = (deg/sec)

T.R. PYLON MODE 2 RATE = (deg/sec)

T.R. PYLON MODE 3 RATE = (deg/sec)

T.R. PYLON MODE 4 RATE = (deg/sec)

M.R. F/A FLAP. RATE = (deg/sec)

M.R. LAT FLAP. RATE = (deg/sec)

T.R. F/A FLAP. RATE = (deg/sec)

T.R. LAT FLAP. RATE = (deg/sec)

M.R. PYLON MODE 1 DISP = (deg)

M.R. PYLON MODE 2 DISP = (deg)

M.R. PYLON MODE 3 DISP = (deg)

M.R. PYLON MODE 4 DISP = (deg)

T.R. PYLON MODE 1 DISP = (deg)

T.R. PYLON MODE 2 DISP = (deg)

T.R. PYLON MODE 3 DISP = (deg)

T.R. PYLON MODE 4 DISP = (deg)

M.R. F/A FLAP. DISP = (deg)

M.R. LAT FLAP. DISP = (deg)

T.R. F/A FLAP. DISP = (deg)

T.R. LAT FLAP. DISP = (deg)

4.11.2.2 Rotor Performance

These two rows are identical to those described in the discussion of the trim iteration page, Section 4.4.2.

4.11.2.3 Force and Moment Summary

This block of output is the same as described in Section 4.4.3. The forces and moments printed here are computed after the small increment in the pertinent variable has been made. All data are in the body reference system.

4.11.2.4 Delta Force and Moment Summary

This block of output presents the changes in the force and moment contributions in exactly the same format as the full force and moment summary. Each number in this block is obtained by taking the corresponding value from the force and moment summary immediately above, less the corresponding value at the trim condition or at the current maneuver time point.

4.11.3 Rotorcraft Stability Partial Derivative Matrices

4.11.3.1 Total Partial Derivative Matrix (Figure 64)

A summary of the partial derivatives computed from the data on the previous pages is printed on this page. Each row gives the partial derivatives of some force or moment, as labeled, with respect to the perturbation variables used.

4.11.3.2 Rotor Partial Derivative Matrix (Figure 64)

A summary of the rotor partial derivatives computed from the data on the previous pages is printed at the top of this page. Each row gives the partial derivatives of some force, moment, or flapping angle, as labeled, with respect to the linear and angular velocities U, W, Q, V, P, and R. The units are feet, pounds, radians, and seconds.

STABILITY PARTIAL DERIVATIVES (TOTAL AIRCRAFT)

	U	W	Q	V	P	R
X-FORCE	-9.6658	2.1495	1085.5	2.6231	-891.09	-15.146
Z-FORCE	-11.941	-257.16	1072.3	-6.9906	-22052.	652.27
PITCH MOMENT	20.525	-52.065	-9895.5	.59174	7421.2	23.039
Y-FORCE	.54785E-01	-6.5838	-924.58	-57.640	-1453.7	614.13
ROLL MOMENT	-4.2179	-52.321	-6481.6	-126.17	-10108.	2156.7
YAW MOMENT	-19.472	30.291	14531.	302.86	-13017.	-17379.
M.R. F/A FLAP MOM	-21.898	-170.84	.67364E+06	466.61	.12976E+06	-360.58
M.R. LAT FLAP MOM	299.75	1222.8	-.15037E+06	118.22	.72933E+06	1266.2
T.R. F/A FLAP MOM	-.70166	-2.2478	-75.515	-.61713	-62.073	-211.08
T.R. LAT FLAP MOM	-1.8498	-.16959	20.144	6.2942	-178.84	-133.88

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	53.599	-9.5166	.37109	.38574	-3557.5	59.487	166.12	201.22
Z-FORCE	-45.936	-997.03	-.46875	-.46875	16001.	-6173.0	281.48	-109.30
PITCH MOMENT	-376.27	127.11	-9.1397	-5.0262	24326.	-111.50	6170.2	-3107.2
Y-FORCE	-35.161	-62.949	.66895	-7.7930	287.87	695.67	73.564	-2945.8
ROLL MOMENT	-248.31	-444.87	2.4072	-33.061	2033.3	4913.8	635.60	-12472.
YAW MOMENT	804.22	-861.02	-18.966	206.72	60835.	23420.	-2147.7	78345.
M.R. F/A FLAP MOM	32998.	-1128.2	5.2913	5.2913	.16006E+06	.11184E+07	-93.331	-93.331
M.R. LAT FLAP MOM	-322.07	33980.	4.3875	4.3875	-.98783E+06	.20769E+06	-82.430	-82.430
T.R. F/A FLAP MOM	.66263E-02	.66263E-02	58.241	-.63833	.66263E-02	.66263E-02	9493.0	11426.
T.R. LAT FLAP MOM	.17670E-01	.17670E-01	-.62950	53.289	.17670E-01	.17670E-01	-8659.9	9631.7

ROTOR PARTIAL DERIVATIVE MATRICES

MAIN ROTOR

	U	W	Q	V	P	R
THRUST	1.4766	219.06	-1195.8	7.5070	22053.	-650.86
H-FORCE	3.6210	-5.8145	-1096.2	-1.0007	892.69	-9.4254
F/A FLAPPING	.0	.0	.0	.0	.0	.0
Y-FORCE	-.88927	-7.0620	-917.63	-3.3803	-1408.2	13.457
TORQUE	23.542	19.037	14418.	11.499	-14121.	-1807.7
LAT FLAPPING	.0	.0	.0	.0	.0	.0

	F/A FLAP RATE	LAT FLAP RATE	F/A FLAP DISP	LAT FLAP DISP
THRUST	45.936	997.0	-16001.	6173.0
H-FORCE	-53.603	9.5142	3557.5	-59.492
F/A FLAPPING	.0	.0	.0	.0
Y-FORCE	-35.145	-62.974	287.88	695.69
TORQUE	805.47	-868.36	60820.	23384.
LAT FLAPPING	.0	.0	.0	.0

TAIL ROTOR

	U	W	Q	V	P	R
THRUST	-.13037	-.32358	-12.041	10.281	20.317	-340.04
H-FORCE	.19331	.37762E-01	.96069	-.47751	-.83374	17.521
F/A FLAPPING	.0	.0	.0	.0	.0	.0
Y-FORCE	.22283E-01	-.90695E-01	-2.6095	.92117E-01	1.8852	-1.6926
TORQUE	.76967	.47791E-01	1.9958	-.19168	23.072	1.2503
LAT FLAPPING	.0	.0	.0	.0	.0	.0

	F/A FLAP RATE	LAT FLAP RATE	F/A FLAP DISP	LAT FLAP DISP
THRUST	.14648E-01	.14648E-01	.14648E-01	.14648E-01
H-FORCE	-.91553E-03	-.91553E-03	-.91553E-03	-.91553E-03
F/A FLAPPING	.0	.0	.0	.0
Y-FORCE	.95367E-04	.95367E-04	.95367E-04	.95367E-04
TORQUE	-.39673E-02	-.39673E-02	-.39673E-02	-.39673E-02
LAT FLAPPING	.0	.0	.0	.0

Figure 64. Rotor and Total Partial Derivative Matrices.

4.11.4 Mass, Damping, and Stiffness Matrices (Figure 65)

The mass, damping, and stiffness matrices which are used to calculate the rotorcraft stability characteristics are printed next. The reader is referred to Volume I for the analytical background of these three matrices.

If IPL(89) = 1 or 2, these three matrices will be punched on cards. The punched output is headed by an identification card that consists of the IPSN input from CARD 01, the date, rotorcraft gross weight, cg stationline, groundspeed, and ambient temperature. Since the matrices are sparse, only the nonzero elements are punched. The format of the matrix element card is:

Column	
1	Matrix Indicator (I1)
6-8	Row Number of element (I2)
9-10	Column Number of element (I2)
11-25	Value of the element specified above (E15.8)
26-28	Row
29-30	Column
31-45	Value
46-48	Row
49-50	Column
51-65	Value
66-80	Date and Groundspeed

Values of the matrix indicator are

= 0 for stiffness matrix

= 1 for damping matrix

= 2 for mass matrix

The matrix indicator and each row and column number are integer inputs (I-format). The values of the elements are in scientific notation (E-format). Each matrix begins on a new card. An end-of-data card (I punched 20 times) follows the last card of the last matrix.

MASS MATRIX

	U DOT	W DOT	Q DOT	V DOT	P DOT	R DOT
X-FORCE	258.57	.0	.0	.0	.0	.0
Z-FORCE	.0	258.61	.0	.0	.0	.0
PITCH MOMENT	.0	.56110	11083.	.0	.0	.0
Y-FORCE	.0	.0	.0	258.57	.0	.0
ROLL MOMENT	.0	.47302E-03	.0	.0	2904.0	-585.00
YAW MOMENT	.0	.0	.0	.0	-585.00	10234.
M.R. F/A FLAP MOM	.0	.0	-1503.4	.0	.0	.0
M.R. LAT FLAP MOM	.0	.0	.0	.0	-1503.4	.0
T.R. F/A FLAP MOM	.0	.0	-.48102E-06	.0	.0	1.5320
T.R. LAT FLAP MOM	.0	.0	.0	.0	1.5320	.0

	M.R. F/A FLAP ACC.	M.R. LAT FLAP ACC.	T.R. F/A FLAP ACC.	T.R. LAT FLAP ACC.
X-FORCE	.0	.0	.0	.0
Z-FORCE	.0	.0	.0	.0
PITCH MOMENT	.0	.0	.0	.0
Y-FORCE	.0	.0	.0	.0
ROLL MOMENT	.0	.0	.0	.0
YAW MOMENT	.0	.0	.0	.0
M.R. F/A FLAP MOM	-1503.4	.0	.0	.0
M.R. LAT FLAP MOM	.0	-1503.4	.0	.0
T.R. F/A FLAP MOM	.0	.0	-1.5320	.0
T.R. LAT FLAP MOM	.0	.0	.0	-1.5320

DAMPING MATRIX

	U	W	Q	V	P	R
X-FORCE	9.6658	-2.1495	-6351.5	-2.6231	891.09	-2024.9
Z-FORCE	11.941	257.16	-63044.	6.9906	24092.	-652.27
PITCH MOMENT	-20.525	52.065	9885.5	-.59174	-7421.2	-23.039
Y-FORCE	-.54785E-01	6.5838	924.68	57.680	6719.7	61358.
ROLL MOMENT	4.2179	52.321	6481.8	126.17	10108.	-2156.7
YAW MOMENT	19.472	-30.291	-14531.	-302.86	13017.	17379.
M.R. F/A FLAP MOM	21.898	170.84	-.67364E+06	-466.81	-.12976E+06	360.58
M.R. LAT FLAP MOM	-299.75	-1222.8	.15037E+06	-118.22	-.72933E+06	-1266.2
T.R. F/A FLAP MOM	.70166	2.2478	75.515	.61713	82.073	211.08
T.R. LAT FLAP MOM	1.8498	.16959	-20.144	-6.2542	178.84	133.88

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE
X-FORCE	-53.599	9.5166	-.37109	-.38574
Z-FORCE	45.938	997.03	.46875	.46875
PITCH MOMENT	376.27	-117.11	9.1397	5.0262
Y-FORCE	35.161	62.988	-.66895	7.7930
ROLL MOMENT	248.31	444.87	-2.4072	33.061
YAW MOMENT	-804.22	861.02	18.906	-206.72
M.R. F/A FLAP MOM	-32998.	-.10091E+06	.0	.0
M.R. LAT FLAP MOM	.10236E+06	-33980.	.0	.0
T.R. F/A FLAP MOM	.0	.0	-58.241	-530.90
T.R. LAT FLAP MOM	.0	.0	532.17	-53.289

Figure 65. Stability Matrices and Stick-Fixed Stability Results.

STIFFNESS MATRIX

	X	Z	THETA	Y	PHI	PSI
X-FORCE	.0	.0	8288.6	.0	.0	46.437
Z-FORCE	.0	.0	-708.79	.0	-46.437	.0
PITCH MOMENT	.0	.0	.0	.0	.0	.0
Y-FORCE	.0	.0	.0	.0	-8288.6	708.79
ROLL MOMENT	.0	.0	.0	.0	.0	.0
YAW MOMENT	.0	.0	.0	.0	.0	.0
M.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
M.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0

	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	3557.5	-59.487	-166.12	-201.22
Z-FORCE	-16001.	6173.0	-281.48	109.30
PITCH MOMENT	-24328.	111.50	-6170.2	3107.2
Y-FORCE	-287.87	-695.67	-73.564	2945.8
ROLL MOMENT	-2033.3	-4913.8	-635.60	12472.
YAW MOMENT	-60835.	-23420.	2147.7	-78345.
M.R. F/A FLAP MOM	-.18006E+06	-.11184E+07	.0	.0
M.R. LAT FLAP MOM	.98783E+06	-.20769E+06	.0	.0
T.R. F/A FLAP MOM	.0	.0	-9493.0	-11426.
T.R. LAT FLAP MOM	.0	.0	8659.9	-9631.7

CONTROLS-FIXED ROOTS AND TRANSFER FUNCTION DENOMINATOR

	ROOTS REAL	ROOTS IMAG	DENOMINATORS TAU	DENOMINATORS DAMP	PERIOD	TIME TO HALF-DBL	CYCLES TO HALF-DBL	UNDAMPED NAT FREQ RAD/SEC	UNDAMPED NAT FREQ CPS	DAMPING RATIO
# 1	.38685D-01	.84874D-01	114.94	-8.8930	74.030	17.918	0.242	.933E-01	.148E-01	-0.41474
# 2	-.16979	.0	.0	5.8898	0.0	4.082	0.0	.170	.270E-01	1.00000
# 3	-.78505	.0	.0	1.2738	0.0	0.883	0.0	.785	.125	1.00000
# 4	-.11752	2.0465	.23797	.55932E-01	3.070	5.898	1.921	2.05	.326	0.05733
# 5	-2.0913	3.3443	.64276E-01	.26884	1.879	0.331	0.176	3.94	.628	0.53020
# 6	-11.868	2.1828	.68573E-02	.16300	2.879	0.058	0.020	12.1	1.92	0.98350
# 7	-18.854	16.063	.16300E-02	.61464E-01	0.391	0.037	0.094	24.8	3.94	0.76121
# 8	-11.405	67.011	.21642E-03	.49368E-02	0.094	0.061	0.648	68.0	10.8	0.16779
# 9	-17.579	363.23	.75618E-05	.26586E-03	0.017	0.039	2.279	364.	57.9	0.04834

Figure 65. Concluded.

.1 › Stick-Fixed Rotorcraft Stability Results (Figure 65)

The rotorcraft characteristic equation, with controls fixed, is solved for its complex roots and associated response modes. These results are presented in several ways as discussed below

4.11.5.1 Roots

The real and imaginary parts of the roots of the rotorcraft characteristic equation are printed under the headings REAL and IMAG. The units are radians per second. If z is the response of some mode, the response expression may be written directly in terms of the real and imaginary parts.

$$z = Ae^{(REAL*t)} \cos(IMAG*t) = A(REAL + IMAG*j)$$

where t = time

A = constant (dependent on initial condition)

In terms of the damping ratio, ζ damped natural frequency, ω_d, and undamped natural frequency, ω_n, the printed roots are

$$REAL = \zeta\omega_n$$

$$IMAG = \omega_d = \omega_n\sqrt{1 - \zeta^2}$$

The roots may also be used to form the denominator, d(s), of the frequency response polynomial.

$$d(s) = \prod_{i=1}^{n} (s - REAL_i + IMAG_i*j)(s - REAL_i - IMAG_i*j)$$

where s = Laplace operator

Π = continued product notation

$j = \sqrt{-1}$

n = number of roots printed

i = sequence number of root in printout

Note that in the case of complex conjugate parts of roots, only the root with the positive imaginary part is printed.

4.11.5.2 Terms in Denominator of Laplace Transfer Function

Each root or pair of roots generates the terms in one factor of the denominator of the Laplace transfer function, D(s).

$$D(s) = \prod_{i=1}^{n} (TAU_i * s^2 + DAMP_i * s + 1)$$

where

$$TAU_i = 1/(REAL_i^2 + IMAG_i^2) = 1/\omega_n^2$$

$$DAMP_i = -2*REAL_i/(REAL_i^2 + IMAG_i^2) = -2\zeta/\omega_n$$

and Π, n and i are as defined in the previous section.

4.11.5.3 Period

For the oscillatory roots of the rotorcraft characteristic equation, the period of the damped oscillation is given in seconds.

PERIOD = 2 /IMAG

For the roots with a zero imaginary part, the period is a meaningless concept, so a zero appears in the output.

4.11.5.4 Rate of Convergence or Divergence

The column headed TIME TO HALF-DBL depends only on the value of the real part of the root. If the real part is negative, the time to half amplitude, in seconds, is printed. If the real part is positive, the time to double amplitude in seconds is printed.

TIME TO HALF-DBL = ln(.5)/REAL

The column headed CYCLES TO HALF-DBL contains the number of cycles to half or double amplitude based on the damped natural frequency (IMAG) for the oscillatory roots.

CYCLES TO HALF-DBL = (TIME TO HALF-DBL)/PERIOD

For aperiodic roots, a zero is printed.

4.11.5.5 Undamped Natural Frequency and Damping Ratio

The undamped natural frequency, ω_n, is based on the absolute value of the complex root.

$$\omega_n = REAL^2 + IMAG^2$$

Thus, ω_n is defined even for an aperiodic root. The calculated value of ω_n is given both in radians per second and cycles per second. The damping ratio, ζ, in combination with the undamped natural frequency, completely describes the root.

$$\zeta = REAL/\omega_n$$

For a stable aperiodic root, the damping ratio is 1. For an unstable aperiodic root, the damping ratio is -1.

4.11.5.6 Stability Mode Shapes (Figure 66)

In the stability mode shape printout, each column represents one mode. The first column on the left is associated with the first root printed, the second with the second root, and so forth. Each component of a mode shape has a relative magnitude (MAGN) and a phase angle (PHASE). As implied by the column heading, magnitude is the top number of the pairs printed out and phase angle is the bottom. The normal printout provides for eight columns (mode shapes of roots). If more than eight roots are computed, the additional roots are printed in the same format below the first set. Columns after the last root are set to zero.

The mode shapes associated with the rotorcraft characteristic roots are first printed as normalized with respect to THETA, then as normalized with respect to PHI, and lastly as normalized with respect to the largest participation factor (variable). In all three sets of normalized mode shapes, the normalizing variable always has a magnitude of 1.000 (nondimensional) and a phase angle of 0.0 degrees. The fuselage degrees of freedom used for the mode shapes are not the same as those used in the rest of the rotorcraft stability analysis. The following variables are used.

U/VELOCITY = u/V = perturbation velocity in X-direction divided by total velocity (nondimensional)

C O N T R O L S - F I X E D   M O D E   S H A P E S

-------------- NORMALIZED WRT THETA --------------

ROOT	# 1 MAGN PHASE	# 2 MAGN PHASE	# 3 MAGN PHASE	# 4 MAGN PHASE	# 5 MAGN PHASE	# 6 MAGN PHASE	# 7 MAGN PHASE	# 8 MAGN PHASE
FUSELAGE								
U/VELOCITY	1.217 130.8	.5033 .0	.2932E-01 .0	.7819E-01 29.68	.2366 -11.77	.4982 -13.22	.3134 162.2	1.770 -80.66
ALPHA	.7245E-01 68.20	.1478 180.0	4.686 180.0	.6898 13.13	1.364 7.864	1.491 107.5	1.895 109.6	16.00 -31.11
THETA	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
BETA	.1094 -136.8	.2219 .0	2.573 .0	.0485 -59.08	2.109 -174.6	2.677 138.2	9.040 -57.79	2.058 6.199
PHI	3.174 -98.58	2.239 .0	1.462 .0	1.131 62.74	1.317 12.47	2.259 -57.59	4.725 -51.80	3.531 -99.24
PSI	3.978 -160.8	2.143 180.0	2.489 180.0	.7445 120.0	2.173 -.1793	2.324 -38.71	10.85 116.0	.4292 162.0
M.R. F/A FLAP	.1216 -21.97	.1975 180.0	2.117 180.0	1.134 159.3	4.707 -122.3	59.55 -26.51	47.03 -31.64	1294. -128.9
M.R. LAT FLAP	.6558E-01 -171.3	.1563 .0	.5064 .0	1.344 -79.09	2.196 -47.37	46.56 -135.2	20.27 -142.5	1298. 141.6
T.R. F/A FLAP	.2213E-01 -74.41	.4263E-02 .0	.1408 .0	.9845E-01 -43.35	.1958 158.3	.6868 128.4	908.0 -68.14	1.129 124.5
T.R. LAT FLAP	.3060E-01 118.4	.6590E-02 .0	.2919 180.0	.7950E-01 125.2	.1101 32.39	.5938 135.6	893.6 31.49	.8953 -93.11

ROOT	# 9 MAGN PHASE	#10 MAGN PHASE	#11 MAGN PHASE	#12 MAGN PHASE	#13 MAGN PHASE	#14 MAGN PHASE	#15 MAGN PHASE	#16 MAGN PHASE
FUSELAGE								
U/VELOCITY	4.142 71.93	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
ALPHA	4.927 -8.174	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
THETA	1.000 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
BETA	57.58 -154.7	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PHI	9.879 135.6	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PSI	27.42 -44.72	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. F/A FLAP	.9848 -70.74	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. LAT FLAP	16.42 -96.07	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. F/A FLAP	.3447E+06 -171.4	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. LAT FLAP	.3453E+06 98.70	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0

Figure 66. Examples of Mode Shapes of Stability Results.

------------- NORMALIZED WRT PHI -------------

ROOT FUSELAGE	# 1 MAGN PHASE	# 2 MAGN PHASE	# 3 MAGN PHASE	# 4 MAGN PHASE	# 5 MAGN PHASE	# 6 MAGN PHASE	# 7 MAGN PHASE	# 8 MAGN PH
U/VELOCITY	.3835 -130.6	.4035 .0	.2006E-01 .0	.6914E-01 -33.06	.1796 -134.5	.2205 44.37	.6633E-01 154.0	.5014 16.59
ALPHA	.2912E-01 166.8	.6601E-01 180.0	3.206 180.0	.7869 -49.61	1.035 -114.9	.6600 166.0	.4012 161.4	4.533 68.13
THETA	.3150 98.58	.4467 .0	.6842 .0	.8843 -62.74	.7591 -122.7	.4426 57.59	.2116 51.80	.2832 99.24
BETA	.3447E-01 -38.25	.9911E-01 .0	1.760 .0	.7503 -121.8	1.601 62.61	1.185 -164.2	1.913 -5.909	.5829 105.4
PHI	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
PSI	1.253 -62.21	.9573 180.0	1.703 180.0	.6583 57.83	1.650 -122.9	1.029 18.89	2.296 167.8	.1216 -98.74
M.R. F/A FLAP	.3830E-01 76.61	.8824E-01 180.0	1.448 180.0	1.003 96.52	3.573 114.9	26.36 31.08	9.956 19.95	366.4 -29.67
M.R. LAT FLAP	.2066E-01 -72.72	.6981E-01 .0	.3465 .0	1.189 -141.8	1.667 -170.1	20.61 -77.61	4.291 -90.67	367.7 -119.1
T.R. F/A FLAP	.6970E-02 24.17	.1904E-02 .0	.9636E-01 .0	.8706E-01 -106.1	.1487 35.52	.3040 -174.0	192.2 -16.34	.5199 -136.2
T.R. LAT FLAP	.9640E-02 -143.1	.3837E-02 .0	.1997 180.0	.7030E-01 62.46	.8359E-01 -90.36	.2628 173.1	189.1 83.29	.2536 6.122

ROOT FUSELAGE	# 9 MAGN PHASE	#10 MAGN PHASE	#11 MAGN PHASE	#12 MAGN PHASE	#13 MAGN PHASE	#14 MAGN PHASE	#15 MAGN PHASE	#16 MAGN PHASE
U/VELOCITY	.4193 -63.71	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
ALPHA	.4987 -143.8	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
THETA	.1012 -135.6	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
BETA	5.790 69.67	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PHI	1.000 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PSI	2.776 179.6	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. F/A FLAP	.9968E-01 153.6	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. LAT FLAP	1.662 128.3	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. F/A FLAP	.3489E+05 52.91	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. LAT FLAP	.3495E+05 -36.94	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0

Figure 66. Continued.

NORMALIZED WRT LARGEST

ROOT	# 1 MAGN PHASE	# 2 MAGN PHASE	# 3 MAGN PHASE	# 4 MAGN PHASE	# 5 MAGN PHASE	# 6 MAGN PHASE	# 7 MAGN PHASE	# 8 MAGN PHASE
FUSELAGE								
U/VELOCITY	.3060 -96.98	.4035 .0	.6257E-02 180.0	.5817E-01 -44.98	.5026E-01 70.29	.8366E-02 44.45	.3451E-03 26.33	.1363E-02 -57.83
ALPHA	.2324E-01 -159.6	.6601E-01 180.0	1.000 .0	.6620 -61.53	.2898 89.93	.2504E-01 166.1	.2087E-02 33.68	.1233E-01 -8.288
THETA	.2514 132.2	.4467 .0	.2134 180.0	.7440 -74.66	.2125 82.06	.1679E-01 57.67	.1101E-02 -75.89	.7782E-03 22.82
BETA	.2751E-01 -4.633	.9911E-01 .0	.5490 180.0	.6313 -133.7	.4482 -92.58	.4496E-01 -164.1	.9956E-02 -133.7	.1586E-02 29.02
PHI	.7979 33.62	1.000 .0	.3119 180.0	.8414 -11.92	.2799 -156.2	.3794E-01 .7561E-01	.5204E-02 -127.7	.2719E-02 -76.42
PSI	1.000 -28.59	.9573 180.0	.5311 .0	.5539 45.91	.4618 81.98	.3903E-01 18.96	.1196E-01 40.15	.3306E-03 -175.2
M.R. F/A FLAP	.3056E-01 110.2	.8824E-01 180.0	.4518 .0	.8438 84.60	1.000 -40.26	1.000 31.16	.5180E-01 -107.7	.9964 -106.1
M.R. LAT FLAP	.1648E-01 -39.10	.6981E-01 .0	.1081 180.0	1.000 -153.8	.4666 34.69	.7819 -77.54	.2233E-01 141.6	1.000 164.5
T.R. F/A FLAP	.5562E-02 57.79	.1904E-02 .0	.3006E-01 180.0	.7325E-01 -118.0	.4161E-01 -119.7	.1153E-01 -174.0	1.000 -144.0	.8699E-03 147.3
T.R. LAT FLAP	.7692E-02 -109.4	.3837E-02 .0	.6228E-01 .0	.5915E-01 50.54	.2340E-01 114.5	.9972E-02 173.2	.9842 -44.39	.6896E-03 -70.29

ROOT	# 9 MAGN PHASE	#10 MAGN PHASE	#11 MAGN PHASE	#12 MAGN PHASE	#13 MAGN PHASE	#14 MAGN PHASE	#15 MAGN PHASE	#16 MAGN PHASE
FUSELAGE								
U/VELOCITY	.1200E-04 171.8	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
ALPHA	.1427E-04 91.66	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
THETA	.2896E-05 99.84	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
BETA	.1943E-03 -54.85	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PHI	.2861E-04 -124.5	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
PSI	.7941E-04 55.11	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. F/A FLAP	.2852E-05 29.10	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
M.R. LAT FLAP	.4756E-04 3.768	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. F/A FLAP	.9982 -71.61	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0
T.R. LAT FLAP	1.000 -161.5	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0	.0 .0

Figure 66. Concluded.

ALPHA = w/V = perturbation velocity in Z-direction divided by total velocity (nondimensional); approximately the same as angle of attack (radians)

THETA = ∫ q dt = the integral of the pitch rate (radians); approximately the same as pitch angle

BETA = Δv/V = perturbation velocity in Y-direction divided by total velocity (radians); approximately the same as sideslip angle

PHI = ∫ p dt = integral of roll rate (radians); approximately the same as roll angle

PSI = ∫ r dt = integral of yaw rate (radians); approximately the same as yaw angle

If activated, the pylon and flapping variables are all given as angular displacements in radians.

4.11.6 <u>Transfer Function Numerator</u> (Figure 67)

Following the mode shapes, the numerators of the transfer functions for aircraft response and/or flapping angles as specified by IPL(93) are printed. For each of the numerators printed, the value labeled GAIN is the constant term in the frequency response polynomial; STATIC GAIN is the gain term to be used in the Laplace transfer function.

The complex roots of the frequency response polynomial are printed in pairs of columns labeled REAL and IMAG. Below the real and imaginary roots are the corresponding values in the numerator of the Laplace transfer function, TAU and DAMP. The numerator of the Laplace transfer function N(s), may be written as follows:

$$N(s) = \text{STATIC GAIN} * \prod_{k=1}^{M} (\text{TAU}_k * s^2 + \text{DAMP}_k * s + 1)$$

and the frequency response polynomial as

$$n(s) = (\text{GAIN}) * \prod_{k=1}^{M} [\,(s-\text{Real}_k + \text{IMAG}_k * j)$$

$$(s-\text{REAL}_k - \text{IMAG}_k * j)]$$

TRANSFER FUNCTION DATA

THETA / LONG CYC		PHI / LAT CYC		PSI / PEDAL	
NUMERATORS					
GAIN =	.17327	GAIN =	-.34022	GAIN =	1.3170
REAL	IMAG	REAL	IMAG	REAL	IMAG
.28210E-02	.0	-.11116E-01	.0	.61091E-01	.18982
-.40374E-01	.0	.73525E-02	.23396	-.15294	.27619
-.95466E-02	.43608	-.96371	.64064	-1.4757	.0
-.94468	.0	-.91022	2.4311	-.65397	2.6483
-1.4838	2.2910	-9.3235	.0	-12.449	2.0824
-10.461	.0	-15.196	.0	-18.990	13.097
-21.300	.0	-18.870	16.063	-11.428	66.997
-18.868	16.076	-7.8602	63.859	-14.614	360.72
-5.7916	64.775	-17.577	363.23	.0	.0
-17.579	363.23	.0	.0	.0	.0

STATIC GAIN =	-.48896E-03	STATIC GAIN =	-.21521E-01	STATIC GAIN =	.70683
TAU	DAMP	TAU	DAMP	TAU	DAMP
.0	-354.48	.0	89.960	25.149	-3.0727
.0	24.769	18.251	-.26838	10.033	3.0689
5.2561	.10035	.74675	1.4393	.0	.67767
.0	1.0586	.14840	.27015	.13439	.17577
.13422	.39831	.0	.10726	.62771E-02	.15629
.0	.95590E-01	.0	.65806E-01	.18792E-02	.71372E-01
.0	.46948E-01	.16284E-02	.61455E-01	.21649E-03	.49481E-02
.16275E-02	.61415E-01	.24156E-03	.37974E-02	.76728E-05	.22426E-03
.23645E-03	.27388E-02	.75619E-05	.26583E-03	.0	.0
.75618E-05	.26585E-03	.0	.0	.0	.0

Figure 67. Numerator of Transfer Functions.

where k = sequence number of root

M = total number of roots printed

The complete transfer function, G(s), can then be formed as either

$$G(s) = N(s)/D(s)$$

or

$$G(s) = n(s)/d(s)$$

where D(s) and d(s) are the denominator of the transfer function and the frequency response polynominal discussed in section 4.11.5.2.

Zero roots are not printed for either the stick fixed or control input solutions, so the final order of the transfer function generated as described above may be incorrect. In this case usually one more "s" in the denominator will correct the situation. The need for this correction may be found by inspecting the numerator and denominator polynomials. The transfer function is correct when the highest power of "s" for the denominator is 2 larger than that for the numerator.

4.11.7 Frequency Response (Figure 68)

The frequency response of the transfer functions is tabulated following the transfer function numerator printout. The data listed are the frequency in hertz and radians per second, the gain in the decibel equivalent of a magnitude in degrees per inch of control, and the phase in degrees. The range of frequencies is 0.01 to 100 radians per second. Construction of a Bode plot for each transfer function is greatly simplified with these data.

4.12 BLADE ELEMENT AERODYNAMIC DATA

Blade element aerodynamic data are printed for the rotor(s) specified by IPL(75) and IPL(76) in conjunction with the times in the Blade Element Printout Times Group. A set of aerodynamic data is composed of blocks of data where each block presents data at all blade radial stations for one blade of one rotor at a single blade azimuth location. The printout of the set of data blocks precedes the maneuver-time-point page with which it is associated. When data for both rotors are to be printed, the data for the main rotor (Rotor 1) precedes that for the tail rotor (Rotor 2).

------------ F R E Q U E N C Y   R E S P O N S E ------------

FREQ(RAD/SEC)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	FREQ(HZ)
0.0100	20.577	31.398	44.429	-46.341	72.176	-88.660	0.0016
0.0125	20.625	32.122	43.485	-39.506	70.254	-88.292	0.0020
0.0160	20.823	34.516	42.699	-31.970	68.137	-87.738	0.0025
0.0200	21.161	38.150	42.206	-25.395	66.238	-87.034	0.0032
0.0250	21.688	43.207	41.895	-19.095	64.360	-86.016	0.0040
0.0300	22.292	48.429	41.760	-14.042	62.848	-84.803	0.0048
0.0350	22.947	53.669	41.720	-9.6627	61.590	-83.346	0.0056
0.0400	23.633	58.919	41.737	-5.5921	60.517	-81.590	0.0064
0.0500	25.029	69.684	41.851	2.5615	58.750	-76.935	0.0080
0.0600	26.352	81.392	41.954	11.784	57.266	-70.342	0.0095
0.0700	27.442	94.631	41.876	22.829	55.815	-61.478	0.0111
0.0800	28.096	109.36	41.412	35.654	54.134	-50.627	0.0127
0.1000	27.610	138.35	38.782	61.548	49.436	-28.662	0.0159
0.1250	24.843	162.27	33.383	82.417	42.018	-13.868	0.0199
0.1600	20.516	176.95	25.011	93.171	32.240	-16.816	0.0255
0.2000	16.106	-176.88	13.743	91.310	24.571	-39.067	0.0318
0.2500	11.064	-174.09	3.2315	-50.274	20.856	-58.320	0.0398
0.3000	5.9761	-172.69	10.999	-68.252	19.617	-58.261	0.0477
0.3500	.55978E-01	-170.65	12.707	-70.895	19.309	-51.754	0.0557
0.4000	-8.9349	-162.61	13.095	-71.788	19.474	-45.380	0.0637
0.5000	-6.8863	-6.8137	12.705	-71.702	20.136	-37.614	0.0796
0.6000	-.90268	-2.2997	11.913	-70.234	20.668	-34.326	0.0955
0.7000	1.5481	-1.4205	11.125	-67.902	21.023	-33.026	0.1114
0.8000	3.0008	-1.0169	10.465	-65.023	21.279	-32.582	0.1273
1.0000	4.9443	-.38829	9.6649	-58.545	21.727	-32.650	0.1592
1.2500	7.0941	.25672	9.7067	-50.696	22.540	-33.414	0.1989
1.6000	11.367	-1.2958	12.053	-43.335	25.064	-36.725	0.2546
2.0000	22.128	-48.271	21.177	-79.849	33.478	-82.755	0.3183
2.5000	10.753	-137.23	8.7446	-152.15	19.066	-157.14	0.3979
3.0000	5.1293	-140.21	3.6244	-140.83	13.305	-135.11	0.4775
3.5000	2.2247	-143.05	1.7142	-136.69	12.153	-126.07	0.5570
4.0000	.92147E-01	-146.05	.36901	-138.91	11.393	-128.06	0.6366
5.0000	-3.6908	-159.07	-2.4867	-148.15	9.0546	-139.02	0.7958
6.0000	-7.1284	-167.35	-5.4156	-155.68	6.2990	-147.92	0.9549
7.0000	-10.153	-173.00	-8.0956	-160.75	3.6852	-153.78	1.1141
8.0000	-12.800	-177.00	-10.472	-164.24	1.3403	-157.66	1.2732
10.0000	-17.234	177.70	-14.471	-168.74	-2.6046	-162.23	1.5915
12.5000	-21.673	173.70	-18.471	-172.14	-6.4957	-165.21	1.9894
16.0000	-26.597	170.52	-22.905	-175.06	-10.697	-167.57	2.5465
20.0000	-31.048	168.64	-26.929	-177.13	-14.423	-169.57	3.1831
25.0000	-35.481	167.49	-30.978	-178.79	-18.158	-171.83	3.9789
30.0000	-39.094	166.82	-34.321	-179.93	-21.269	-173.74	4.7746
35.0000	-42.167	166.23	-37.200	179.20	-23.949	-175.22	5.5704
40.0000	-44.894	165.51	-39.773	178.52	-26.299	-176.29	6.3662
50.0000	-49.959	163.60	-44.507	178.38	-30.252	-177.62	7.9577
60.0000	-56.053	168.77	-49.186	-172.25	-33.478	-178.34	9.5493
70.0000	-57.364	-155.42	-49.627	-154.61	-36.194	-178.86	11.1408
80.0000	-56.656	-161.93	-50.160	-162.79	-38.556	-179.21	12.7324
100.0000	-59.870	-172.08	-53.850	-171.59	-42.489	-179.58	15.9155

Figure 68. Frequency Response of Transfer Functions.

The number of data blocks included in the printout for one rotor depends on which rotor analysis (time-variant or quasi-static) is active for the rotor in question at the time of printout. When the time-variant rotor analysis is active, the number of blocks also depends on the number of blades on the rotor while the format of each block depends on which, if either, of the unsteady aerodynamic options is active.

If the quasi-static rotor analysis is active for a rotor when aerodynamic data are to be printed, the set of data printed for that rotor consists of a data block for each of 12 azimuth locations (30-degree increments) of a representative blade. If the time-variant rotor analysis is active, the set of data for the rotor consists of one data block for each blade at the azimuth angle corresponding to the maneuver time point, i.e., two to seven data blocks.

The data blocks consist of six parameters that are independent of blade radial station and nine or fourteen parameters that can vary with radial station. The printout includes nine parameters when the unsteady aerodynamic options are turned off; when either unsteady option is active, five additional parameters are included. Of these five additional parameters, three are the same regardless of which option is active, while the remaining two are a function of the active option. All parameters are defined in Table 21.

Figure 69 contains examples of blade element aerodynamic data printout. The data are for a two-bladed time-variant rotor with the unsteady aerodynamic option off, the BUNS option on, and the UNSAN option on.

4.13 BLADE ELEMENT BENDING MOMENT DATA

When the time-variant rotor analysis is active, a tabulation of the instantaneous values of beam, chord, and torsional moments at each radial station on each blade is printed at the times specified in the Blade Element Printout Times Group. The values of IPL(75) and IPL(76) specify the rotor(s) to be included in the printout. Data are printed at all radial stations, with Station |IPL(4)| -1 (|IPL(5)| -1 for the tail rotor) printed first and Station 0 (the root) last. The tip station is omitted from the printout since all moments are defined to be zero at this point. The units for all three moments are inch-pounds. Figure 70 is an example of the printout for one rotor. The printout of this data follows the rotor elastic response (Figure 58) of the time point with which it is associated. If data for both rotors are to be printed, the main rotor (Rotor 1) is printed first.

TABLE 21. DEFINITIONS OF BLADE ELEMENT AERODYNAMIC PARAMETERS

Parameters That are Independent of Radial Station
(All six parameters included in each printout)

Name	Description	Units
PSI	Azimuth location of blade	deg
U-HUB	Shaft reference X-component of velocity at rotor hub	ft/sec
V-HUB	Shaft reference Y-component of velocity at rotor hub	ft/sec
W-HUB	Shaft reference Z-component of velocity at rotor hub	ft/sec
GEO PITCH	Geometric blade pitch angle at Station 0 (root) for azimuth location PSI	deg
BETA (HUB)	Flapping angle at the hub (i.e., the angle between the shaft reference X-Y plane and the blade pitch-change axis at Station 0) for azimuth location PSI	deg

Parameters Which are Dependent on Radial Station

Name	Printout Code *	Description	Units
STA	A	Blade station number starting at the tip and continuing to Station 1	-
UT	A	Tangential component of the total local velocity, i.e., component that is perpendicular to the local pitch-change axis and parallel to the local chord line	ft/sec
UP	A	Perpendicular component of the total velocity, i.e., component that is perpendicular to both the local pitch-change axis and the local chordline	ft/sec
UR	A	Radial component of the total local velocity, i.e., component that is parallel to the local pitch-change axis	ft/sec
MACH	A	Local Mach number	-
ALPHA	A	Local angle of attack	deg

TABLE 21. (Concluded)

Name	Printout Code *	Description	Units
CL	A	Total local lift coefficient including unsteady aerodynamics effects if any	-
DCL	B	Increment to local steady state lift coefficient from the BUNS option; included in the value of CL	-
CDR	U	Radial component of drag coefficient from the UNSAN option	-
CM	A	Total local pitching moment coefficient including unsteady aerodynamics effects if any	-
DCM	B	Increment to local steady state pitching moment coefficient from the BUNS unsteady aerodynamic option; included in the value of CM	-
HVDD	U	Second time derivative of the oscillatory part of the local blade position (h_v); equivalent to the first time derivative of the oscillatory part of the local heaving velocity	ft/sec^2
ALPHAD	B&U	Alpha dot, the first time derivative of ALPHA	deg/sec
THETAD	B&U	Theta dot, the first time derivative of theta (the local blade pitch angle)	deg/sec
THETADD	B&U	Theta double dot, the second time derivative of theta (derivative of THETAD)	deg/sec^2

*Printout code definition:

A = variable always included in printout

B = variable included in printout only when BUNS unsteady aerodynamic option is active

U = variable included in printout only when UNSAN unsteady aerodynamics option is active

B&U = variable included in the printout only when one of the unsteady aerodynamics options is active

PSI = 359. U-HUB = 223.84 V-HUB = 9.34 W-HUB = -23.93 GEO. PITCH = 16.06 BETA(HUB) = 1.79

STA	UT	UP	UR	MACH	ALPHA	CL	CD	CM
20	751.25	-46.02	-229.69	0.717	2.216	0.0	0.02077	-0.00497
19	713.78	-45.72	-229.36	0.684	2.559	0.3718	0.01767	-0.00248
18	677.75	-45.46	-229.00	0.653	2.875	0.4011	0.01417	-0.00278
17	638.90	-45.17	-228.57	0.619	3.204	0.4297	0.01282	-0.00403
16	604.61	-44.91	-228.16	0.590	3.475	0.4510	0.01184	-0.00443
15	564.10	-44.47	-227.70	0.556	3.780	0.4742	0.01254	-0.00466
14	526.73	-43.92	-227.29	0.524	4.044	0.4912	0.01251	-0.00481
13	489.37	-43.23	-226.91	0.493	4.288	0.5064	0.01203	-0.00497
12	444.68	-42.13	-226.52	0.456	4.556	0.5286	0.01198	-0.00519
11	414.71	-41.32	-226.27	0.432	4.703	0.5394	0.01193	-0.00529
10	377.39	-40.20	-225.98	0.402	4.842	0.5475	0.01184	-0.00537
9	340.07	-39.01	-225.72	0.373	4.908	0.5472	0.01169	-0.00537
8	295.41	-37.53	-225.42	0.340	4.839	0.5308	0.01143	-0.00521
7	265.45	-36.53	-225.22	0.319	4.663	0.5061	0.01120	-0.00497
6	234.63	-35.51	-225.03	0.298	4.324	0.4648	0.01098	0.0
5	190.81	-34.12	-224.74	0.270	3.403	0.3658	0.01085	0.0
4	153.48	-32.99	-224.48	0.250	1.928	0.2072	0.01023	0.0
3	110.22	-31.78	-224.18	0.229	0.0	0.0	0.13000	0.0
2	62.46	-30.75	-223.79	0.213	0.0	0.0	0.13000	0.0
1	21.86	-31.56	-223.18	0.206	0.0	0.0	0.13000	0.0

PSI = 179. U-HUB = 223.84 V-HUB = 9.34 W-HUB = -23.93 GEO. PITCH = 12.50 BETA(HUB) = 3.58

STA	UT	UP	UR	MACH	ALPHA	CL	CD	CM
20	734.55	-11.50	223.44	0.699	1.515	0.0	0.01288	-0.00000
19	697.62	-11.26	223.53	0.667	1.987	0.2830	0.01294	-0.00278
18	662.07	-10.98	223.66	0.637	2.444	0.3345	0.01181	-0.00288
17	623.69	-10.64	223.81	0.604	2.943	0.3872	0.01148	-0.00372
16	589.78	-10.26	223.99	0.575	3.390	0.4333	0.01171	-0.00426
15	549.70	-9.83	224.17	0.541	3.913	0.4837	0.01263	-0.00475
14	512.70	-9.46	224.33	0.510	4.393	0.5250	0.01251	-0.00509
13	475.69	-9.13	224.47	0.479	4.866	0.5707	0.01236	-0.00560
12	431.42	-8.91	224.58	0.443	5.404	0.6230	0.01251	-0.00611
11	401.71	-8.77	224.65	0.419	5.757	0.6562	0.01284	-0.00643
10	364.72	-8.71	224.71	0.390	6.166	0.6932	0.01315	-0.00679
9	327.72	-8.73	224.76	0.362	6.535	0.7250	0.01338	-0.00709
8	283.43	-8.90	224.79	0.330	6.894	0.7528	0.01389	-0.00736
7	253.70	-9.05	224.82	0.309	7.072	0.7640	0.01327	-0.00747
6	223.12	-9.23	224.84	0.289	7.180	0.7722	0.01288	0.0
5	179.61	-9.63	224.86	0.262	7.095	0.7632	0.01280	0.0
4	142.53	-10.11	224.87	0.243	6.628	0.7129	0.01233	0.0
3	99.49	-10.77	224.89	0.224	0.0	0.0	0.13000	0.0
2	51.77	-11.18	224.93	0.210	0.0	0.0	0.13000	0.0
1	10.08	-9.57	225.04	0.205	0.0	0.0	0.13000	0.0

a) Printout with unsteady aerodynamic options off.

Figure 69. Blade Element Aerodynamic Data.

PSI = 360. U-HUB = 223.88 V-HUB = 9.15 W-HUB = -23.76 GEO. PITCH = 15.17 BETA(HUB) = 2.76

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	752.08	-51.65	-226.16	0.717	1.702	0.0	-0.01440	0.01669	-0.00117	0.00233	-57.58	-55.49	13359.45
19	714.82	-51.26	-225.97	0.684	2.034	0.28193	-0.01470	0.01482	-0.00027	0.00243	-53.27	-55.79	13356.34
18	678.98	-50.80	-225.75	0.653	2.335	0.31098	-0.01508	0.01241	-0.00006	0.00256	-49.40	-56.37	13317.91
17	640.33	-50.31	-225.50	0.620	2.645	0.33947	-0.01548	0.01170	-0.00032	0.00269	-44.78	-56.95	13251.57
16	606.21	-49.86	-225.25	0.591	2.899	0.36050	-0.01594	0.01123	-0.00073	0.00281	-40.98	-57.62	13176.23
15	565.90	-49.17	-224.96	0.557	3.182	0.38300	-0.01653	0.01146	-0.00083	0.00293	-35.99	-58.62	13061.36
14	528.72	-48.39	-224.72	0.525	3.425	0.39947	-0.01711	0.01161	-0.00077	0.00315	-30.71	-59.59	12919.66
13	491.54	-47.45	-224.56	0.494	3.646	0.41328	-0.01759	0.01166	-0.00066	0.00340	-24.18	-60.52	12767.81
12	447.07	-46.07	-224.29	0.458	3.883	0.43324	-0.01780	0.01164	-0.00051	0.00375	-13.10	-61.57	12589.16
11	417.24	-45.08	-224.16	0.433	4.009	0.44272	-0.01761	0.01159	-0.00033	0.00401	-3.43	-62.28	12382.88
10	380.09	-43.74	-224.03	0.404	4.118	0.44957	-0.01665	0.01149	-0.00002	0.00439	12.54	-63.11	12173.67
9	342.94	-42.35	-223.91	0.375	4.151	0.44900	-0.01434	0.01135	0.00043	0.00484	34.58	-64.03	11949.28
8	298.47	-40.67	-223.78	0.342	4.037	0.43497	-0.00828	0.01116	0.00121	0.00548	72.56	-65.26	11703.45
7	268.62	-39.57	-223.69	0.320	3.823	0.41500	-0.00032	0.01102	0.00193	0.00600	109.80	-66.36	11544.93
6	237.91	-38.49	-223.60	0.299	3.430	0.38183	0.01305	0.01087	0.00640	0.00640	163.97	-67.66	11380.40
5	194.21	-37.07	-223.48	0.272	2.403	0.31086	0.05249	0.01037	0.00766	0.00766	280.77	-69.68	11165.15
4	156.97	-35.98	-223.37	0.251	0.803	0.20790	0.12161	0.00989	0.00866	0.00866	427.52	-71.57	10994.91
3	113.78	-34.82	-223.24	0.230	0.0	0.0	0.12161	0.13000	0.0	0.00866	0.0	-71.57	10994.91
2	66.33	-33.95	-223.02	0.214	0.0	0.0	0.12161	0.13000	0.0	0.00866	0.0	-71.57	10994.91
1	25.42	-35.15	-222.56	0.206	0.0	0.0	0.12161	0.13000	0.0	0.00866	0.0	-71.57	10994.91

PSI = 180. U-HUB = 223.88 V-HUB = 9.15 W-HUB = -23.76 GEO. PITCH = 13.40 BETA(UB) = 2.64

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	739.28	-10.68	220.20	0.703	1.331	0.0	0.03050	0.01268	-0.00654	-0.00616	128.16	117.24	-7786.71
19	702.92	-10.35	220.43	0.670	1.816	0.29159	0.03183	0.01255	-0.00936	-0.00649	125.88	117.68	-7793.78
18	666.15	-9.99	220.69	0.639	2.291	0.34794	0.03335	0.01162	-0.01001	-0.00687	123.57	118.68	-7777.41
17	627.43	-9.53	221.02	0.606	2.818	0.40709	0.03524	0.01142	-0.01123	-0.00736	120.98	120.07	-7748.72
16	593.20	-9.07	221.36	0.577	3.292	0.45891	0.03720	0.01162	-0.01225	-0.00774	118.45	121.68	-7719.57
15	552.74	-8.62	221.74	0.543	3.844	0.51601	0.03999	0.01251	-0.01431	-0.00924	115.74	124.02	-7650.28
14	515.39	-8.32	222.07	0.511	4.345	0.56313	0.04309	0.01251	-0.01634	-0.01087	113.24	126.50	-7585.65
13	478.02	-8.12	222.38	0.480	4.832	0.61376	0.04675	0.01234	-0.01887	-0.01285	110.46	129.16	-7504.05
12	433.30	-8.20	222.67	0.444	5.371	0.67144	0.05206	0.01249	-0.02207	-0.01549	107.16	132.43	-7378.99
11	403.29	-8.29	222.85	0.420	5.719	0.70821	0.05626	0.01278	-0.02385	-0.01692	103.91	134.71	-7270.71
10	365.92	-8.58	223.09	0.396	6.105	0.74834	0.06201	0.01307	-0.02571	-0.01839	98.39	137.38	-7133.26
9	328.55	-8.99	223.28	0.362	6.434	0.78210	0.06946	0.01311	-0.02740	-0.01975	89.82	139.67	-7003.35
8	283.92	-9.67	223.49	0.329	6.709	0.80897	0.07670	0.01330	-0.02913	-0.02122	73.22	141.97	-6875.40
7	253.81	-10.16	223.63	0.308	6.811	0.81768	0.08200	0.01282	-0.03043	-0.02244	55.29	143.39	-6794.40
6	222.04	-10.69	223.76	0.288	6.813	0.81406	0.08131	0.01251	-0.02298	-0.02298	27.19	144.72	-6726.02
5	179.55	-11.56	223.95	0.261	6.507	0.77760	0.07793	0.01221	-0.02530	-0.02530	-42.99	146.44	-6650.86
4	141.67	-12.37	224.10	0.242	5.757	0.66469	0.04577	0.01168	-0.02883	-0.02883	-163.36	147.82	-6597.70
3	99.33	-13.33	224.27	0.223	0.0	0.0	0.04577	0.13000	0.0	-0.02883	0.0	147.82	-6597.70
2	56.37	-14.13	224.48	0.210	0.0	0.0	0.04577	0.13000	0.0	-0.02883	0.0	147.82	-6597.70
1	9.63	-13.12	224.76	0.205	0.0	0.0	0.04577	0.13000	0.0	-0.02883	0.0	147.82	-6597.70

b) Printout with BUNS unsteady aerodynamics option active.

Figure 69. Continued.

PSI = 360. U-HUB = 223.91 V-HUB = 8.31 W-HUB = -23.80 GEO. PITCH = 14.01 BETA(HUB) = 3.65

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	753.05	-81.38	-220.92	0.719	0.417	0.0	0.07021	0.01070	0.00425	0.00488	-66.22	66.15	-5061.14
19	715.87	-78.81	-220.92	0.686	0.797	0.22854	0.05649	0.01063	0.00266	0.00491	-61.43	59.86	-5046.29
18	680.12	-76.42	-220.86	0.655	1.139	0.27392	0.04859	0.01020	0.00221	0.00491	-56.83	59.04	-5039.92
17	641.55	-73.84	-220.81	0.622	1.491	0.31848	0.04253	0.01013	0.00178	0.00491	-51.53	57.58	-5041.61
16	607.48	-71.63	-220.74	0.592	1.773	0.34869	0.03571	0.01026	0.00136	0.00479	-46.46	56.94	-5043.71
15	567.22	-69.61	-220.69	0.558	2.079	0.38054	0.03046	0.01058	0.00099	0.00473	-40.18	53.71	-5054.12
14	530.05	-66.60	-220.66	0.527	2.329	0.40463	0.02923	0.01082	0.00077	0.00474	-33.98	51.36	-5062.56
13	492.97	-64.16	-220.74	0.495	2.545	0.42501	0.03341	0.01103	0.00068	0.00486	-26.85	48.78	-5079.99
12	448.36	-61.11	-220.87	0.459	2.762	0.45275	0.05004	0.01111	0.00101	0.00546	-16.91	45.35	-5111.72
11	418.48	-59.05	-221.00	0.434	2.867	0.46715	0.07886	0.01107	0.00140	0.00599	-7.88	42.72	-5134.20
10	381.26	-56.47	-221.19	0.405	2.946	0.48011	0.26454	0.01061	0.00217	0.00689	6.40	39.32	-5159.13
9	344.03	-53.90	-221.38	0.376	2.926	0.48192	0.44018	0.01017	0.00323	0.00797	26.62	35.72	-5165.22
8	299.44	-52.91	-221.56	0.342	2.739	0.46753	0.67315	0.00979	0.00510	0.00969	62.47	31.41	-5152.56
7	259.51	-48.93	-221.76	0.321	2.468	0.44439	0.87756	0.01000	0.00687	0.01124	99.17	28.19	-5114.24
6	238.76	-47.02	-221.91	0.300	1.996	0.39929	1.11962	0.01068	0.01236	0.01236	153.88	24.82	-5082.74
5	194.87	-44.51	-222.08	0.272	0.814	0.25736	1.46771	0.01312	0.01275	0.01275	274.58	19.99	-4959.73
4	157.51	-42.48	-222.21	0.251	-0.951	0.06357	0.91926	0.12378	-0.00135	-0.00326	424.43	15.86	-4864.46
3	114.03	-40.22	-222.43	0.231	0.0	0.0	0.91926	0.13000	0.0	-0.00326	0.0	15.86	-4864.46
2	66.10	-38.40	-222.40	0.214	0.0	0.0	0.91926	0.13000	0.0	-0.00326	0.0	15.86	-4864.46
1	25.64	-39.28	-221.84	0.207	0.0	0.0	0.91926	0.13000	0.0	-0.00326	0.0	15.86	-4864.46

PSI = 180. U-HUB = 223.91 V-HUB = 8.31 W-HUB = -23.80 GEO. PITCH = 14.55 BETA(HUB) = 1.61

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	741.30	14.16	212.96	0.763	2.534	0.0	0.13693	0.02040	-0.00722	-0.00741	256.05	153.57	17142.71
19	704.10	12.85	213.45	0.670	2.991	0.37089	0.20396	0.01814	-0.00958	-0.00768	256.70	153.91	17103.92
18	668.29	11.67	214.64	0.639	3.448	0.42563	0.26826	0.01481	-0.01253	-0.00801	257.50	154.69	16982.84
17	629.63	10.52	214.76	0.606	3.967	0.48114	0.33338	0.01455	-0.01342	-0.00841	258.36	155.72	16746.84
16	595.45	9.65	215.48	0.577	4.444	0.52696	0.38774	0.01370	-0.01399	-0.00884	258.78	156.85	16472.54
15	555.05	8.57	216.31	0.543	5.007	0.57756	0.45257	0.01302	-0.01505	-0.00944	258.85	158.36	16073.56
14	517.73	7.50	217.06	0.511	5.524	0.61999	0.51209	0.01225	-0.01609	-0.01003	258.00	159.82	15621.11
13	456.40	6.38	217.80	0.481	6.035	0.66577	0.57760	0.01185	-0.01737	-0.01085	255.88	161.24	15115.66
12	435.73	4.75	218.58	0.444	6.605	0.71890	0.66316	0.01162	-0.01901	-0.01198	251.64	162.77	14422.09
11	405.74	3.67	219.12	0.420	6.983	0.75299	0.72064	0.01147	-0.02023	-0.01287	246.78	163.66	13886.54
10	368.39	2.11	219.72	0.391	7.398	0.78659	0.79035	0.01128	-0.02167	-0.01399	237.89	164.47	13218.16
9	331.04	0.41	220.31	0.362	7.749	0.80911	0.85267	0.01108	-0.02303	-0.01513	224.53	164.96	12537.34
8	296.33	-1.87	220.93	0.329	8.022	0.82345	0.91703	0.01076	-0.02477	-0.01675	200.29	165.14	11791.58
7	256.32	-3.45	221.35	0.309	8.108	0.82563	0.93949	0.01059	-0.02612	-0.01807	175.29	165.07	11298.00
6	225.44	-5.20	221.77	0.288	8.053	0.81309	0.88452	0.01060	-0.01828	-0.01828	137.03	164.90	10810.38
5	181.53	-7.91	222.32	0.262	7.579	0.76603	0.58341	0.01095	-0.02079	-0.02079	46.49	164.62	10161.24
4	144.10	-10.31	222.78	0.242	6.572	0.67196	-0.53657	0.02260	-0.02360	-0.02360	-101.45	164.37	9639.24
3	100.52	-13.11	223.37	0.223	0.0	0.0	-0.53657	0.13000	0.0	-0.02360	0.0	164.37	9639.24
2	52.37	-16.08	223.96	0.210	0.0	0.0	-0.53657	0.13000	0.0	-0.02360	0.0	164.37	9639.24
1	10.48	-16.57	224.46	0.205	0.0	0.0	-0.53657	0.13000	0.0	-0.02360	0.0	164.37	9639.24

c) Printout with UNSAN unsteady aerodynamic option active.

Figure 69. Concluded.

MAIN ROTOR

BEAM BENDING MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	-28389.500	-28385.371	0.0	0.0	0.0	0.0	0.0
1	-14850.254	-16498.773	0.0	0.0	0.0	0.0	0.0
2	-6159.855	-12718.449	0.0	0.0	0.0	0.0	0.0
3	351.821	-10285.309	0.0	0.0	0.0	0.0	0.0
4	2162.837	-8160.781	0.0	0.0	0.0	0.0	0.0
5	2023.220	-6657.666	0.0	0.0	0.0	0.0	0.0
6	1565.936	-5577.008	0.0	0.0	0.0	0.0	0.0
7	1142.942	-5195.121	0.0	0.0	0.0	0.0	0.0
8	650.328	-5027.738	0.0	0.0	0.0	0.0	0.0
9	-191.043	-4880.512	0.0	0.0	0.0	0.0	0.0
10	-912.947	-4636.076	0.0	0.0	0.0	0.0	0.0
11	-1709.355	-4984.699	0.0	0.0	0.0	0.0	0.0
12	-2399.405	-5225.301	0.0	0.0	0.0	0.0	0.0
13	-3292.395	-5410.027	0.0	0.0	0.0	0.0	0.0
14	-3716.699	-5297.973	0.0	0.0	0.0	0.0	0.0
15	-3833.076	-4956.324	0.0	0.0	0.0	0.0	0.0
16	-3424.390	-4160.636	0.0	0.0	0.0	0.0	0.0
17	-2699.595	-3164.024	0.0	0.0	0.0	0.0	0.0
18	-1525.183	-1771.312	0.0	0.0	0.0	0.0	0.0
19	-511.096	-607.914	0.0	0.0	0.0	0.0	0.0

CHORD BENDING MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	-8291.659	6306.543	0.0	0.0	0.0	0.0	0.0
1	-7242.504	9398.570	0.0	0.0	0.0	0.0	0.0
2	-4814.445	11405.000	0.0	0.0	0.0	0.0	0.0
3	-2556.314	12735.363	0.0	0.0	0.0	0.0	0.0
4	-1462.119	12931.559	0.0	0.0	0.0	0.0	0.0
5	-983.283	12579.172	0.0	0.0	0.0	0.0	0.0
6	-546.610	11904.437	0.0	0.0	0.0	0.0	0.0
7	-305.067	11258.156	0.0	0.0	0.0	0.0	0.0
8	-130.273	10305.361	0.0	0.0	0.0	0.0	0.0
9	7.965	9258.078	0.0	0.0	0.0	0.0	0.0
10	34.542	6699.916	0.0	0.0	0.0	0.0	0.0
11	-28.533	6857.035	0.0	0.0	0.0	0.0	0.0
12	-153.031	5770.727	0.0	0.0	0.0	0.0	0.0
13	-373.607	4205.254	0.0	0.0	0.0	0.0	0.0
14	-545.601	2974.153	0.0	0.0	0.0	0.0	0.0
15	-667.650	1667.756	0.0	0.0	0.0	0.0	0.0
16	-656.965	921.221	0.0	0.0	0.0	0.0	0.0
17	-563.566	376.133	0.0	0.0	0.0	0.0	0.0
18	-319.866	59.755	0.0	0.0	0.0	0.0	0.0
19	-95.735	-16.410	0.0	0.0	0.0	0.0	0.0

TORSION MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	-168.732	22.166	0.0	0.0	0.0	0.0	0.0
1	-55.747	-130.545	0.0	0.0	0.0	0.0	0.0
2	-2146.367	-2350.222	0.0	0.0	0.0	0.0	0.0
3	-2948.143	-2325.192	0.0	0.0	0.0	0.0	0.0
4	-3530.506	-2294.194	0.0	0.0	0.0	0.0	0.0
5	-3720.148	-2269.266	0.0	0.0	0.0	0.0	0.0
6	-3745.520	-2242.800	0.0	0.0	0.0	0.0	0.0
7	-3815.139	-2191.585	0.0	0.0	0.0	0.0	0.0
8	-3885.639	-2122.721	0.0	0.0	0.0	0.0	0.0
9	-4020.678	-1995.917	0.0	0.0	0.0	0.0	0.0
10	-4102.512	-1823.215	0.0	0.0	0.0	0.0	0.0
11	-4111.871	-1676.553	0.0	0.0	0.0	0.0	0.0
12	-4079.384	-1538.096	0.0	0.0	0.0	0.0	0.0
13	-4031.220	-1386.587	0.0	0.0	0.0	0.0	0.0
14	-3841.640	-1257.917	0.0	0.0	0.0	0.0	0.0
15	-3650.467	-1174.858	0.0	0.0	0.0	0.0	0.0
16	-3361.249	-1094.187	0.0	0.0	0.0	0.0	0.0
17	-2789.500	-979.188	0.0	0.0	0.0	0.0	0.0
18	-2096.117	-791.500	0.0	0.0	0.0	0.0	0.0
19	-1185.789	-480.538	0.0	0.0	0.0	0.0	0.0

Figure 70. Blade Element Bending Moment Data.

It is emphasized that this bending moment data is only printed for a rotor that uses the time-variant analysis; if IPL(75) or IPL(76) specify that data be printed for a rotor which uses the quasi-static analysis, the program ignores the input and does not print any moment data.

4.14 STABILITY ANALYSIS DATA

The results of the Moving Block Fast Fourier Transform stability analysis (NOP = 6, 500-series cards) or the stability analysis using Prony's method (NOP = 13, 900-series cards) are printed out after the maneuver is completed. The output for each starts at the top of a new page with a heading giving the program title and run date, the value of NOP, and the contents of cards 03, 04 and 05. The format of the remaining output is different for each type of analysis.

4.14.1 Moving Block Fast Fourier Transform (Figure 71)

A block of output is printed for each variable analyzed, with the first line of the block giving the variable name and its code number. The next three lines give the start and stop time for the analysis, the frequency range, and the number of cycles analyzed. (This is merely a recapitulation of the data input on the 502 card.) The next two lines give the predominant frequency in the range of interest and the damping values for that response frequency.

4.14.2 Stability Analysis Using Prony's Method (Figure 72)

The results of the analysis of each variable are printed in a separate block with the variable name and code number printed in the first line. The second and third lines contain the start and stop time and the number of terms used in the curve fit of the variable in this time period, as requested on the 902 card. The curve fit is of the form

$$v(t) = \sum_{j=1}^{jmax} \left(B_j e^{(\text{Real part})t} \; e^{i(\text{Imaginary Part})t} \right)$$

The coefficients in this summation are tabulated versus j in the output. The "real part" is the damping term, and the percentage damping and phase angle for this value are computed and printed at the right-hand side of the tabulation. A negative damping percentage indicates an unstable term. The imaginary part is the frequency of oscillation of the term, and it is printed out in radians/second, hertz, and per-rev for the user's convenience.

```
DAMPING DETERMINED BY MOVING BLOCK FFT FOR   GEN.COORD.. PYLON 1. MODE 1                         VARIABLE CODE = 1466
   TIME INTERVAL ANALYZED:       START:  0.0   SECONDS         STOP:  0.856 SECONDS
   FREQUENCY BAND ANALYZED:        2.500 HERTZ  TO     3.500 HERTZ
   NUMBER OF CYCLES ANALYZED IS   2
   ACTUAL FREQUENCY IS   3.503 HERTZ
   DAMPING EXPONENT IS   -0.24768 /SECOND  (NEGATIVE STABLE)     AND THE DAMPING IS  1.12517 % CRITICAL  (POSITIVE STABLE).


DAMPING DETERMINED BY MOVING BLOCK FFT FOR   GEN.COORD.. PYLON 1. MODE 2                         VARIABLE CODE = 1467
   TIME INTERVAL ANALYZED:       START:  0.0   SECONDS         STOP:  0.833 SECONDS
   FREQUENCY BAND ANALYZED:        2.860 HERTZ  TO     3.800 HERTZ
   NUMBER OF CYCLES ANALYZED IS   2
   ACTUAL FREQUENCY IS   3.601 HERTZ
   DAMPING EXPONENT IS   -0.73437 /SECOND  (NEGATIVE STABLE)     AND THE DAMPING IS  3.24601 % CRITICAL  (POSITIVE STABLE).
```

Figure 71. Output from Stability Analysis Using Moving Block Fast Fourier Transform.

STABILITY ANALYSIS BY PRONY CURVE FIT METHOD FOR: GEN.COORD., PYLON 1, MODE 1 VARIABLE CODE = 1466

TIME INTERVAL ANALYZED: START: 0.0 SECONDS STOP: 0.987 SECONDS

30 TERMS USED FOR THE CURVE FIT

ROOT NUMBER J	ABSOLUTE AMPLITUDE B(J)	REAL PART (/SEC)	IMAGINARY PART (RAD/SEC)	IMAGINARY PART (HZ)	IMAGINARY PART (PER REV)	PERCENT DAMPING	PHASE ANGLE (DEG)
1	0.04155	-0.33	0.0	0.0	0.0	100.00	180.00
2	0.09247	-63.14	0.0	0.0	0.0	100.00	0.0
3	1.04294	-0.55	26.81	4.27	0.79	2.04	70.83
4	0.09558	-1.07	40.99	6.52	1.21	2.62	-86.18
5	0.10502	-0.12	67.65	10.77	1.99	0.17	-113.65
6	0.03580	-1.26	95.14	15.14	2.80	1.33	-97.01
7	0.01612	-8.43	113.61	18.08	3.35	7.40	-1.88
8	0.00796	-0.12	135.46	21.56	3.99	0.09	67.26
11	0.01511	-102.61	206.95	32.94	6.10	44.42	13.63

STABILITY ANALYSIS BY PRONY CURVE FIT METHOD FOR: GEN.COORD., PYLON 1, MODE 2 VARIABLE CODE = 1467

TIME INTERVAL ANALYZED: START: 0.0 SECONDS STOP: 0.987 SECONDS

36 TERMS USED FOR THE CURVE FIT

ROOT NUMBER J	ABSOLUTE AMPLITUDE B(J)	REAL PART (/SEC)	IMAGINARY PART (RAD/SEC)	IMAGINARY PART (HZ)	IMAGINARY PART (PER REV)	PERCENT DAMPING	PHASE ANGLE (DEG)
1	0.03306	-3.27	0.0	0.0	0.0	100.00	180.00
2	0.12294	-234.12	0.0	0.0	0.0	100.00	180.00
3	0.11349	-43.92	0.0	0.0	0.0	100.00	0.0
4	0.53859	-0.65	22.92	3.65	0.68	2.82	76.84
5	0.00671	-4.34	36.51	5.81	1.08	11.80	-134.01
6	0.03197	-0.09	67.57	10.75	1.99	0.14	-19.95
7	0.00710	-1.72	94.37	15.02	2.78	1.82	20.90
8	0.01245	-11.12	121.21	19.29	3.57	9.13	149.69
9	0.00282	-0.13	135.25	21.53	3.99	0.10	176.01
16	0.11741	-55.72	393.45	62.62	11.59	14.02	17.35

Figure 72. Output from Stability Analysis Using Prony's Method.

4.15 CONTOUR PLOTS

The C81 contour plot option provides tabulations and digital contour plots of selected variables when IPL(79) ≠ 0. The selection of the variables and the type of output is made using the 1000-series cards, NOP=12 (see Sections 2.35 and 3.35).

The value of the variable is tabulated by radial station, radius, and azimuth if NVARA ≠ 0. The radial station and radius are printed at the left end of the rows of data and the azimuth, in degrees, is printed at the top of the columns. See Figure 73.

The digital contour plot of a variable is printed if NVARB ≠ 0 (see Figure 74). The edge of the rotor disk is delineated by asterisks and blazes of asterisks divide the disk into 30-degree segments. The range of the value of the variable at a point on the disk is denoted by the symbol printed at that point, with the symbol key printed to the right of the plot. The plotting routine ignores a few of the largest and smallest values of the variable over the rotor disk and then divides the remaining range into 10 equal sub-ranges and assigns a symbol to each.

Note that a tabulation or contour plot of a variable on a time-variant rotor during a maneuver will, in general, show a discontinuity at the azimuth location at which the tabulation or plot begins. The azimuth just preceding that starting azimuth on the tabulation or on the plot corresponds to a time equal to one rotor revolution later.

If both NVARA and NVARB are other than zero, the tabulation for a particular variable precedes the contour plot.

ROTOR 1 QUASI-STATIC TRIM POINT 1

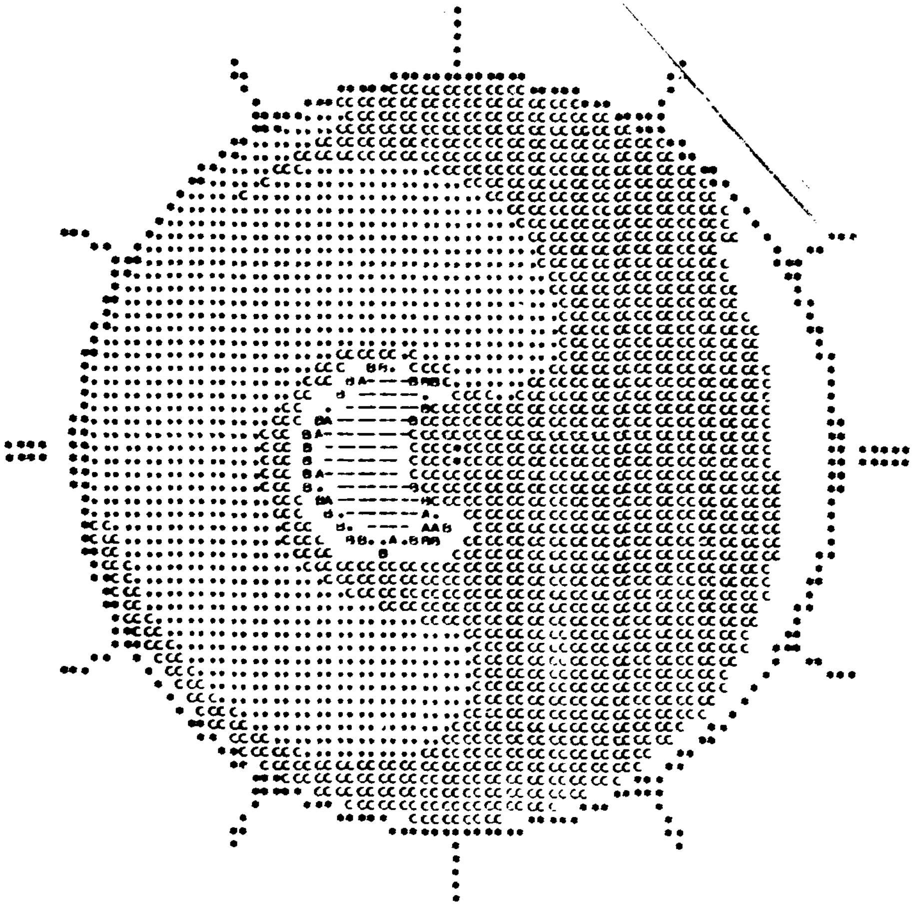
ANGLE OF ATTACK (DEG) CODE = 2

STA/RADIUS	LB/PSI	0.0	30.00	60.00	90.00	120.00	150.00	180.00	210.00	240.00	270.00	300.00	330.00
20	264.00	-0.423	-1.161	-1.005	-0.716	-1.105	0.910	2.889	6.024	7.200	8.071	-0.473	-0.965
19	250.00	2.662	1.086	-0.483	-0.713	-0.379	1.086	3.710	5.965	8.213	5.573	3.937	3.786
18	238.10	3.797	1.702	0.285	-0.290	-0.357	0.970	2.812	4.463	5.424	5.807	6.119	5.125
17	224.40	4.325	2.297	0.673	0.011	0.280	1.627	3.691	5.502	6.505	6.899	6.849	5.920
16	212.30	4.654	2.623	1.030	0.410	0.766	2.163	4.323	6.199	7.158	7.209	7.182	6.357
15	198.00	4.928	2.943	1.404	0.865	1.300	2.726	4.949	6.820	7.636	7.577	7.364	6.668
14	184.80	5.099	3.197	1.710	1.276	1.700	3.215	5.481	7.300	7.926	7.626	7.392	6.810
13	171.60	5.175	3.404	1.832	1.447	2.320	3.642	6.007	7.665	8.074	7.422	7.146	6.440
12	155.80	5.298	3.616	2.295	1.459	2.687	4.215	6.511	8.011	7.991	6.665	6.616	6.542
11	145.20	5.276	3.727	2.527	1.707	3.041	4.562	6.834	8.161	7.684	5.738	5.902	6.323
10	132.00	5.151	3.904	2.840	1.973	3.483	4.980	7.194	8.229	6.865	3.740	4.423	5.781
9	118.80	4.877	4.071	3.146	2.211	3.934	5.393	7.503	8.112	5.191	-0.116	1.040	4.085
8	103.00	4.338	4.152	3.579	1.954	3.975	5.975	7.747	7.628	0.552	-11.809	-4.431	2.981
7	92.40	3.644	4.230	3.736	2.179	3.690	6.386	7.797	7.012	-7.487	-34.219	-13.782	1.069
6	81.50	2.724	4.212	3.688	2.361	3.075	6.833	7.825	5.568	-30.849	-87.606	-34.598	-2.191
5	66.00	0.703	4.188	3.922	2.638	2.663	6.471	7.960	0.219	-116.766	-132.043	-95.853	-11.284
4	52.80	-1.782	4.100	3.886	2.511	2.683	6.540	7.759	-17.621	-140.744	-142.410	-126.648	-30.384
3	37.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	26.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 73. Data Tabulation from Contour Plot Option.

ROTOR 1 QUASI-STATIC TRIM POINT 1

ANGLE OF ATTACK (DEG) CODE = 2



PSI=0

SYMBOL	RANGE
-	< -25.000
	-25.000 . . . < -20.000
A	-20.000 . . . < -15.000
.	-15.000 . . . < -10.000
B	-10.000 . . . < -5.000
	-5.000 . . . < 0.0
C	0.0 . . . < 5.000
.	5.000 . . . < 10.000
D	10.000 . . . < 15.000
	15.000 . . . < 20.000
E	20.000 . . . < 25.000
*	≥ 25.000

Figure 74. Rotor Contour Plot.

5.0 DIAGNOSTIC AND ERROR MESSAGES

5.1 GENERAL

All of the messages generated by the computer program itself rather than by the computer operating system are listed below. The messages are in strict alphabetical order.

Two or more words or phrases enclosed in brackets, one above the other, indicates that it is possible to have either word or phrase, but only one, in the message when it is printed out. An underline in the message indicates a place for a numerical value in the message.

Each message is followed by the name of the subroutine that printed it out. The next statement describes the condition that caused the message to be printed. Next is an indication of the consequences of the condition followed by instructions to the user.

5.2 MESSAGES

5.2.1 ABNORMALLY RETURNED FROM SUBROUTINE TVT SEE YOUR PROGRAMMER(S)

From TVT

An error was encountered in TVT. See your programmer(s).

EXECUTION TERMINATES.

5.2.2 ALLEVIATION DEVICE FOR WINGS BYPASSED BECAUSE WING CHORD IS TOO SMALL FOR THIS TIME INCREMENT AND VELOCITY

From WAG

The analysis contained in WAG assumes that a minimum number of data points will be sampled in a distance traveled, which is calculated from the wing chord. This message indicates that the ratio, $V(\Delta t)$ (wing chord), is too large for the numerical procedure (message activated only during maneuver).

WAG is bypassed for wing. Execution continues.

To eliminate the message, make Δt (or $\Delta\Psi$) on data card 301 smaller.

5.2.3 AN ATTEMPT WAS MADE TO MANIPULATE A VARIABLE WHICH HAD NOT BEEN INCLUDED IN THE GROUP TO BE FITTED. PROCESSING TERMINATED

From CURVET

During the amplitude and phase angle comparison of the linearization portion of the curve-fit section of the program, a request was made to use a variable for which no prior request to fit that variable had been made. Thus, the necessary information had not been computed and so the comparison or linearization could not be made.

Comparison and linearization terminates.

Check input data to curve-fit routine for error indicated.

5.2.4 BANKED TURN WITH G LEVEL = ______

From TURN

Based on inputs for IPL(43) and XFC(12), a trim in a steady turn has been specified. This message is for information only.

$$\text{5.2.5 CHANGE IN JET THRUST WITH} \left\{ \begin{array}{c} \text{COLLECTIVE} \\ \text{F/A CYCLIC} \\ \text{LAT CYCLIC} \\ \text{PEDAL} \end{array} \right\} \text{STICK POSITION}$$

INPUT IS IN ERROR

From JFBGIN

The number of controlled jets, XJET(1), was input as zero, but the change in jet thrust with the specified control was not zero.

Problem step terminates.

Check the values of XJET(1), XCON(1), XCON(6), XCON(13), XCON(20), and XCON(27) for errors.

5.2.6 CHECK INPUT FUSELAGE INERTIAS. THE NUMBERS INPUT ARE PHYSICALLY IMPOSSIBLE AND CANNOT BE HANDLED BY THIS PROGRAM.

From MNEM or EXTORS

This message indicates that $I_X I_Z - I_{XZ}^2 = 0$, which is physically impossible.

Problem step terminates.

Change the input data for I_X, I_Z, or I_{XZ} for fuselage and stores.

5.2.7 CHECK PART 2 DATA CARD____________J CODE IS___________

From SIVAR or TIVAR

A value for J on 311-type card has been input for which an operation is not defined.

Problem step terminates.

Change the card indicated by the message.

5.2.8 COLLECTIVE STICK / F/A CYCLIC STICK / LAT. CYCLIC STICK / PEDAL } POSITION EXCEEDS STOPS

(—— PERCENT FULL THROW COMPUTED)

From TRIM

The computed control position is beyond the input limits. Check these inputs and check to see that a realistic flight condition is being simulated.

5.2.9 COMPUTED CORRECTIONS EXCEEDED HALF PI

From ITRIM

A correction computed in the trim iteration procedure exceeds an angle of one-half radian. Check which correction is the largest and examine the most recently computed partial derivatives matrix to determine the cause.

Problem step terminates.

5.2.10 DATA ERROR . . . NPART = __________

From MAIN

The control program, MAIN, read an incorrect value of NPART on CARD 01, or an incorrect value of NOP on CARD 401, 501, 601, 701, 801, or 901. This error most commonly occurs after another error has interrupted the normal sequence of events by terminating the problem step.

Problem step terminates.

5.2.11 DRAG DIVERGENCE MACH NUMBER INPUT FOR xxxx IS IN ERROR IT HAS BEEN RESET TO __________

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4

From YSINIT or YRINIT

Y(1) for rotor or surface aerodynamic data was input greater than or equal to 1. This is a warning message.

5.2.12 ERROR IN READING OR WRITING DATA FOR CONTOUR PLOTS.

From CONTOUR

This message indicates a JCL error or a hardware problem. Check with your local programmer. Contour plot task is terminated, execution of following tasks continues.

5.2.13 EXCESSIVE ANGLE OF ATTACK FOR N = $\begin{Bmatrix}1\\2\end{Bmatrix}$

From CDCL

The angle of attack of a blade segment on the $\begin{Bmatrix}\text{main}\\\text{tail}\end{Bmatrix}$ rotor exceeded 20 radians.

Problem step terminates.

5.2.14 EXCESSIVE ANGLE OF ATTACK ON = $\left\{\begin{array}{l}\text{STB1}\\ \text{STB2}\\ \text{STB3}\\ \text{STB4}\\ \text{RWG}\\ \text{LWG}\end{array}\right\}$

From CLCD

Subrouting CLCD was entered with the angle of attack of the

$\left\{\begin{array}{l}\text{Stabilizer No. 1}\\ \text{Stabilizer No. 2}\\ \text{Stabilizer No. 3}\\ \text{Stabilizer No. 4}\\ \text{Right Wing Panel}\\ \text{Left Wing Panel}\end{array}\right\}$ greater than 20 radians

Problem step terminates.

5.2.15 EXECUTION TERMINATED IN SUBROUTINE VIND. CONVERGENCE FAILURE FOR INDUCED VELOCITY. RESIDUE GREATER THAN .100 FT/SEC

From VIND

The thrust-induced velocity loop did not converge. Check to see that a realistic flight condition is being simulated.

5.2.16 F/A CYCLIC STICK POSITION EXCEEDS STOPS. (____PERCENT FULL THROW COMPUTED)

From TRIM

See Section 5.2.7.

5.2.17 FUSELAGE PITCH ANGLE IS 90 DEGREES

From FUSACC

The fuselage has reached a pitch angle that is singular for the Euler angle rotations. Check to see that a realistic flight condition is being simulated.

Program step terminates.

5.2.18 HUB TYPE AND MODE TYPES ARE INCONSISTENT IN THE INPUT TO {MAIN / TAIL} ROTOR

From INRO

The user is inputting independent modes for a teetering (gimbaled) rotor, or cyclic and collective modes for an articulated (or rigid) rotor. Check inputs.

Program step terminates.

5.2.19 INPUT FOR NO. OF ADVANCE RATIOS, __________, IS IN ERROR.

From REDRWK, REDSWK (preceded by STABILIZING SURFACE #______)

The input for the number of advance ratio entries in the rotor-induced velocity distribution table, or for a rotor-wake-at-surface table, is greater than 10, the maximum allowable.

Problem step terminates.

Check for mispunched input or reduce the input to 10 or less.

5.2.20 INPUT TO IPL(________) IS IN ERROR

From ERRCHK

IPL input indicated has an illegal value. Problem step terminates.

Check for mispunched input or refer to Section 3 to find the reason the input was interpreted as an error.

5.2.21 INPUT TO {MAIN / TAIL} BLADE WEIGHT, INERTIA OR FIRST MASS MOMENT IS IN ERROR.

From INBLDM

One of these inputs is inconsistent. Check inputs.

Program step terminates.

5.2.22 INPUT TO {MAIN / TAIL} ROTOR BLADE RADIAL STATION ______ IS IN ERROR.

From INBLD

The radial stations input for the rotor give a segment length less than or equal to zero. Check inputs.

Problem step terminates.

5.2.23 INPUT FOR NO. OF INFLOW RATIOS, _______, IS IN ERROR.

From REDSWK (Preceded by STABILIZING SURFACE #______)

The input for the number of inflow ratio entries in the rotor-wake-at-surface table is greater than 5, the maximum allowable.

Problem step terminates.

Check for mispunched input or reduce the input to 5 or less.

5.2.24 INPUT FOR NO. OF WAKE PLANE ANGLES-OF-ATTACK_____________ IS IN ERROR

From REDRWR

The input for the number of wake plane angles-of-attack entries in the rotor-induced velocity distribution table is greater than 5, the maximum allowable.

Problem step terminates.

Check for mispunched input or reduce the input to 5 or less.

5.2.25 INPUT FOR NO. OF RADIAL STATIONS IS ________ IN ERROR.

From REDRWK

The input for the number of radial station entries in the rotor-induced velocity distribution table is not equal to one of the values specified.

Problem step terminates.

Check for mispunched input or change the input to one of the prescribed values.

5.2.26 INPUT FOR THE HIGHEST HARMONIC __________ IS IN ERROR.

From REDRWK, REDSWK

The input for the number of the highest harmonic in the rotor-induced velocity distribution table is greater than 9.

Problem step terminates.

Check for mispunched input or reduce the input to 9 or less.

5.2.27 INPUTS TO CONTROL VARIABLES FOR USE OF AIRFOIL AERODYNAMIC TABLES OR EQUATIONS ARE IN ERROR.

From START

The value of Y(18) in the Rotor, Wing or Stabilizing Surface Aerodynamics groups was less than 0 or greater than 5. The value must be between 0 and 5.

Check inputs.

Program step terminates.

5.2.28 INPUT TO NUMBER OF TRANSFER FUNCTIONS REQUESTED HAS BEEN RESET TO 0. EXECUTION CONTINUES.

From LGCINT

Input for IPL(93) was outside the range -1 to 4. Recheck input for IPL(93). Execution continues with three standard transfer functions calculated for Stability Analysis.

5.2.29 INPUT TO RIVD TABLE IS IN ERROR. BLADE RADIAL STATION ________ IS AT ________.

From REDRWK

The radial stations input with the RIVD table do not agree with those input in the rotor group. Check inputs.

Problem step terminates.

Check inputs.

Program step terminates.

5.2.30 INPUT TO SWITCH FOR READING ROTOR CONTROL INPUTS IS IN ERROR

From XCONIN

The value of IPL(22) indicates that the rotor supplementary controls group is not to be read. However, other data indicates that the configuration being simulated is not a single-main-rotor helicopter. These situations are not compatible.

Problem step terminates.

Add the specified controls subgroup, using blank cards if the inputs are not to be used. Check location and orientation of rotors.

5.2.31 THE INPUT TO THE BREAK POINT FOR NONLINEAR HUB SPRING IS IN ERROR. IT HAS BEEN RESET TO ZERO.

From INRO

The breakpoint for the nonlinear hub spring was input less than zero. The nonlinear hub spring rate is set to zero and execution continues.

5.2.32 INPUT TO TRANSMISSION HORSEPOWER LIMIT, _____________ IS IN ERROR.

From MAXHP

A negative value was input for transmission power limit. Problem is terminated.

5.2.33 INPUT TO WEIGHT OR TIME TO DROP EXTERNAL STORE NO. ____ IS IN ERROR.

From SIVAR

The time to drop the referenced store on a 311-type card is less than zero or the weight input, XSTi(1), for the referenced store (i) is less than or equal to zero. The weight input of a store/brake group must be greater than zero for a store which is to be dropped.

Problem step terminates.

Check inputs for time to drop store (J = 35) and weight of store to be dropped for input errors.

5.2.34 IPSN INDICATED NOT ON LIBRARY.

From C81L

In an operation with NPART = 8, NVARA ≠ 0 on Card 01, the IPSN input on card 02 does not match any IPSN on the file tape.

Problem step terminates.

Check input IPSN and list of IPSN's on the file tape.

5.2.35 LAT CYCLIC STICK POSITION EXCEEDS STOPS (______PERCENT FULL THROW COMPUTED)

From TRIM

See Section 5.2.7.

5.2.36 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR FLAPPING CORRECTION IS INFINITE.

From ITROT

The iteration loop in the rotor analysis that balances the rotor flapping moments was activated and could not compute a correction to the flapping angles.

Problem step terminates.

Check configuration, flight regime, and spatial orientation for compatibility.

5.2.37 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR FLAPPING MOMENT IS NOT IN BALANCE AFTER _______________ITERATIONS.

From ITROT

The iteration loop in the rotor analysis that balances the rotor flapping moments was activated but could not balance the rotor in the number of iterations allowed.

Problem step terminates.

Check configuration, flight regime, and spatial orientation for compatibility.

5.2.38 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR HAS ZERO DETERMINANT IN THE COMPUTATION OF EQUIVALENT MASS DISTRIBUTION.

From INBMSS

When the rotor is not represented by normal modes, the mass distribution is determined from the blade weight, first mass moment, and second mass moment of inertia. This error message indicates that the three values input for the indicated rotor are incompatible.

Check inputs.

Problem step terminates.

5.2.39 {MAIN / TAIL} ROTOR INERTIA = __________ SLUG - FT ** 2

From INRO

When a rotor is represented by a set of mode shapes, this message is printed to give the computed inertia. It is not an error message unless the computed inertia is less than zero. In that case, check the input mass distribution.

When the rotor is not represented by a set of mode shapes, then the rotor inertia is input by XMR(12) or XTR(12). This message is printed if either of these is less than zero. Check your inputs.

Problem step terminates if the inertia is less than zero.

5.2.40 {MAIN / TAIL} ROTOR RADIUS HAS BEEN RESET TO THE LAST VALUE OF THE BLADE RADIAL STATION DISTRIBUTION.

From INBLD

Warning message. The input for rotor radius based on the segment lengths is not the same as the value of XMR(4) or XTR(4). XMR(4) or XTR(4) is changed to agree with the segment data in the blade aeroelastic data group.

5.2.41 MEMBER __________ NOT IN C81LIB

From REDID

An attempt was made to read a data group from the data library, and the group was not on the library. Problem step terminates.

Check data for a misspelled group name, or if the member printed on the message appears to be data, check for extra or missing data cards.

5.2.42 NO TVT PLOTS. INPUT TO NO. OF REVS TO BE PLOTTED DURING TVT WAS___________

From TRIM

XIT(5) was either less than or equal to zero or greater than XIT(6), so no time-history plots can be produced following the TVT. Execution continues.

5.2.43 THE PARTIAL DERIVATIVE MATRIX IS SINGULAR. THIS IS PROBABLY CAUSED BY ONE OF THE CONTROLS BEING UNCONNECTED.

From ITRIM

During the TRIM procedure, a singular partial derivative matrix occurred. The usual cause is an error in the input data for one of the controls. Previous matrices, if any, should be examined for a near-zero row or column to help locate the cause.

Problem step terminates.

5.2.44 PEAK FORCE/MOMENT OR ITS CORRESPONDING ANGLE INPUT FOR FUSELAGE

$$\left\{ \begin{array}{l} \text{LIFT} \\ \text{PITCH} \\ \text{SIDE FRC} \\ \text{ROLL} \\ \text{YAW} \end{array} \right\} \quad \text{EQUATION IS IN ERROR}$$

IT HAS BEEN RESET TO 0.

From FUSINT

According to the inputs to the fuselage High Angle Equations a nonzero peak force or moment occurs at a zero aerodynamic angle or a zero peak force or moment occurs at a nonzero aerodynamic angle. The peak force or moment and the angle have been reset to zero. Based on the equation indicated, check the following fuselage inputs.

LIFT:	XFS(17) and XFS(18)
PITCH:	XFS(45) and XFS(46)
SIDE FORCE:	XFS(58) and XFS(59)
ROLL:	XFS(72) and XFS(73)
YAW:	XFS(86) and XFS(87)

Warning message only. Execution continues.

5.2.45 THE PHASE ANGLE DIFFERENCE BETWEEN _______ AND _______ IS A MULTIPLE OF 180 DEGREES. THEREFORE, NO VARIABLE CAN BE EXPRESSED AS A LINEAR FUNCTION OF THEM.

From CURVET

The vector analysis section of the program where the coefficients in the expression A = KB * B + KC * C + D are derived has failed because of the linear dependency of B and C.

Program goes to next set of variables.

5.2.46 PEDAL POSITION EXCEEDS STOPS (_________ PERCENT FULL THROW COMPUTED)

From TRIM

See Section 5.2.7.

5.2.47 PULL-UP WITH G-LEVEL = ______

From TURN

Inputs for IPL(43) and XFC(12) have indicated a trim in a symmetric pullup with the g-level specified. This message is for information only.

5.2.48 PUSH-OVER WITH G-LEVEL = _______

From TURN

Inputs for IPL(43) and XFC(12) have indicated a trim in a symmetric pushover with the g-level specified. This message is for information only.

5.2.49 RATIO APPLIED TO CORRECTION VECTOR IS _____________ FROM COMPONENT ______.

From NCDAMP

During the trim iteration procedure, the calculated corrections exceeded the limits. All of the corrections have been multiplied by the printed ratio that was determined by setting the largest correction equal to its limit. The component is the column number of the largest correction.

5.2.50 ROTOR ________ INDUCED VELOCITY NOT CONVERGED TO .0001 FT/SEC; DELTA IS __________; VALUE USED IS ___________

From VIND

The induced velocity calculated for the indicated rotor has not converged in the thrust-induced velocity calculations. The value subsequently used is given.

This is a warning message only. Execution continues.

5.2.51 ... SHIP CONTACTS GROUND

From VIND

Altitude, XFS(4), has become negative.

Problem step terminates.

Find out why ship lost altitude and correct.

5.2.52 SINGULAR MATRIX ENCOUNTERED IN STABILITY ANALYSIS AT M = ___________

From INTFRQ

Problem terminates. Check with the local programmer.

5.2.53 SINGULAR MATRIX ENCOUNTERED IN SUBR. SOLVE

From SOLVE

Problem terminates. Check with the local programmer.

5.2.54 { STB1 / STB2 / STB3 / STB4 / RWG / LWG } { ENTERING / LEAVING } STALL

From CLCD

The angle of attack of one of the fixed aerodynamic surfaces has just crossed the stall point in the direction indicated. For information only.

5.2.55 THE START TIME __________ SECONDS IS GREATER THAN THE LAST TIME POINT ON THE TAPE _____ SECONDS.

From MOVBLK

The start time input on the NOP = 6 card is after the final time point of the time-history record. This is a probable input error. This NOP = 6 card is skipped. Execution continues.

5.2.56 STORE NO._____HAS BEEN DROPPED.

Followed by new values of weight, stationline, buttline, and waterline of the cg, and aircraft inertias.

From EXTORS. For information only.

5.2.57 SUPERSONIC MACH NUMBER FOR xxxx IS IN ERROR. IT HAS BEEN RESET TO ___________.

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4.

From YRNIT or YSINIT.

Y(2) was input less than or equal to 1.

This is a warning message. Execution continues.

5.2.58 TAIL ROTOR FLAPPING CORRECTION IS INFINITE

From ITROT

See Section 5.2.33.

5.2.59 TAIL ROTOR FLAPPING MOMENT IS NOT IN BALANCE AFTER ______________ ITERATIONS.

From ITROT

See Section 5.2.34.

5.2.60 TAIL ROTOR HAS ZERO DETERMINANT IN THE COMPUTATION OF EQUIVALENT MASS DISTRIBUTION.

From INBLDM

See Section 5.2.35.

5.2.61 TAIL ROTOR INERTIA = __________ SLUG-FT ** 2

From INRO

See Section 5.2.36

5.2.62 THERE ARE NOT ENOUGH POINTS AVAILABLE FOR HARMONIC ANALYSIS.

From FSFT

Either the maneuver record is too short or the time increments are too large to generate the data needed for the harmonic analysis (NOP = 9). The harmonic analysis is skipped. Any following tasks are executed as usual.

5.2.63 THE TIME HISTORY DOES NOT CONTAIN ___ CYCLES FOR VARIABLE ___ TO DO MOVING BLOCK ANALYSIS. THE MAX NO. OF CYCLES HAS BEEN CHANGED TO ___.

From MOVBLK

The time-history record is too short to have the number of cycles requested at the frequency requested for the moving block stability analysis (NOP=6). The program calculates the maximum number of cycles available and uses that value as printed. If the maximum number f cycles is two or less, the moving block analysis for this variable ends; execution for other variables or tasks continues.

5.2.64 TIME VARIANT ROTORS CANNOT BE USED IN A STABILITY ANALYSIS.

From INSTAB

An attempt was made to enter the rotorcraft stability analysis routines with a time-variant rotor. The rotorcraft stability analysis is predicated upon using the quasi-static rotor analysis.

Program execution is terminated.

Either use the quasi-static rotor analysis or eliminate the request for a rotorcraft stability analysis.

5.2.65 THE TIME-VARIANT TRIM HAS BEEN TURNED OFF IN THE STABILITY ANALYSIS.

From ERRCHK

Warning message that for a stability analysis case (NPART = 7), IPL(49) was input as nonzero requesting a time-variant trim. IPL(49) is reset to zero and the stability analysis is run as requested.

5.2.66 ** TOTAL POWER REQUIRED EXCEEDS TOTAL AVAILABLE. TRIM CONTINUES.

From WRTMNV

Power required for trim condition exceeds the input power available. Execution continues.

5.2.67 TYPE OF MANEUVERS ARE MIXED UP. EXECUTION TERMINATED.

From MANTYP

On CARDS 301 the J values include 101, 102, and/or 103 along with the standard values. It is not permitted to run maneuver perturbations and other maneuver inputs at the same time.

5.2.68 WARNING, THE PARTIAL DERIVATIVE MATRIX MAY BE IN ERROR.

From ITROT

In the rotor analysis, the iteration loop that balances the rotor flapping moments and the thrust-induced velocity iteration loop are both activated. While each is able to converge separately, they have not been able to converge together.

Warning message only. Execution continues.

Exercise care in use of the partial derivative matrix immediately following this message.

5.2.69 WEIGHT INPUT FOR DRAG BRAKE NO. _______ IS IN ERROR.

From SIVAR

This message indicates that a nonzero brake deployment (XSTi(14) > 0) has been input for a store/brake group that has a positive weight (XSTi(1) > 0), which is the correct input for a store. Check the inputs for the indicated store/brake group and make these two inputs consistent.

Problem step terminates.

5.2.70

$$\begin{Bmatrix} Y(22) \\ Y(23) \\ Y(24) \end{Bmatrix} \text{ FOR xxxx HAS BEEN RESET TO } \begin{Bmatrix} -1. \\ 0. \\ 0. \end{Bmatrix}$$

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4.

From YRINIT or YSINIT

The data input for the pitching moment coefficient was inconsistent and the adjustment indicated was made to make the data consistent.

Warning message only. Execution continues.

5.2.71 ZERO DEMONINATOR ENCOUNTERED WHEN ATTEMPTED TO CALCULATE $\left\{\begin{matrix}\text{MAIN}\\ \text{TAIL}\end{matrix}\right\}$ BLADE FLAPPING OR CYCLIC INCREMENTS.

From MBAL

Cramer's rule is used to solve for the flapping or cyclic increments in the rotor balancing iterations during trim. This error occurs when the denominator, which is the determinant of the coefficient matrix for the two flapping equations, is zero (i.e., the two equations are not independent). Check the rotor and controls inputs for consistency.

Problem step terminates.

6.0 VARIABLES SAVED DURING TIME-VARIANT TRIMS AND MANEUVERS

The values of over 2300 variables are saved at each time point during a maneuver simulation, and may be saved for XIT(5) rotor revolutions during a time-variant trim. The program can perform one or more of the following operations on these data during, or at the end of, the maneuver.

(1) Plotting (see Section 3.29)
(2) Harmonic Analysis (see Section 3.32)
(3) Vector Analysis (see Section 3.25)
(4) Stability Analysis (see Sections 3.30 and 3.34)

Time-variant trim data may be plotted.

As noted in the referenced sections, code numbers are used to identify the variable(s) to be plotted or analyzed. The code number for each variable saved is given in Table 22.

The variables saved can be grouped into the six general classifications given below:

Range of Code Numbers	Source or Type of Data
1 - 132	Force and moment summary
133 - 345	Maneuver time point page
346 - 485	Elastic response of Rotor 1
486 - 625	Elastic response of Rotor 2
626 - 1045	Blade element moment data for Rotor 1
1046 - 1465	Blade element moment data for Rotor 2
1466 - 1485	Elastic pylon data
1486 - 1504	Rotor pitch link loads
1510 - 1515	Pylon accelerations
1516 - 1520	Autopilot inputs
1521 - 1533	Filter outputs
1534 - 1953	Blade element acceleration data for Rotor 1
1954 - 2373	Blade element acceleration data for Rotor 2
2374 - 2376	Accelerations at specified airframe location

The code numbers marked "Not used" are reserved for future additions to the list of variables saved and do not contain any meaningful data.

The code numbers for the bending moments and accelerations at each blade station of blade 1 of rotor 1 are given in Table 23.

TABLE 22. CODE NUMBERS FOR VARIABLES SAVED DURING TIME-VARIANT TRIM AND MANEUVER.

Number	Description
1	TOTAL X-FORCE ON C.G., LB
2	X-FORCE FROM RIGHT WING, LB
3	X-FORCE FROM LEFT WING, LB
4	NOT USED
5	NOT USED
6	X-FORCE FROM FUSELAGE, LB
7	X-FORCE FROM JETS/GUN FIRE,LB
8	X-FORCE FROM ROTOR1, LB
9	X-FORCE FROM ROTOR2, LB
10	X-FORCE FROM WEIGHT, LB
11	TOTAL Y-FORCE ON C.G., LB
12	NOT USED
13	Y-FORCE FROM FUSELAGE, LB
14	Y-FORCE FROM JETS/GUN FIRE,LB
15	Y-FORCE FROM ROTOR1, LB
16	Y-FORCE FROM ROTOR2, LB
17	Y-FORCE FROM WEIGHT, LB
18	TOTAL Z-FORCE ON C.G., LB
19	Z-FORCE FROM RIGHT WING, LB
20	Z-FORCE FROM LEFT WING, LB
21	NOT USED
22	Z-FORCE FROM FUSELAGE, LB
23	Z-FORCE FROM JETS/GUN FIRE,LB
24	Z-FORCE FROM ROTOR1, LB
25	Z-FORCE FROM ROTOR2, LB
26	Z-FORCE FROM WEIGHT, LB
27	TOTAL ROLL MOM ON C.G., FT-LB
28	ROLL MOM FROM RIGHT WING, LB
29	ROLL MOM FROM LEFT WING, FT-LB
30	NOT USED
31	NOT USED
32	ROLL MOM FROM FUSELAGE, FT-LB
33	ROLL MOM FROM JETS/GUN FIRE,FT-LB
34	ROLL MOM FROM ROTOR1 FORCES, FT-LB
35	ROLL MOM FROM ROTOR2 FORCES, FT-LB
36	ROLL MOM FROM ROTOR1 TORQUE, FT-LB
37	ROLL MOM FROM ROTOR2 TORQUE, FT-LB
38	TOTAL PITCH MOM ON C.G., FT-LB
39	PITCH MOM FROM RIGHT WING, FT-LB
40	PITCH MOM FROM LEFT WING, FT-LB
41	NOT USED
42	NOT USED
43	PITCH MOM FROM FUSELAGE, FT-LB
44	PITCH MOM FROM JETS/GUN FIRE,FT-LB
45	PITCH MOM FROM ROTOR1 FORCES, FT-LB
46	PITCH MOM FROM ROTOR2 FORCES, FT-LB
47	PITCH MOM FROM ROTOR1 TORQUE, FT-LB
48	PITCH MOM FROM ROTOR2 TORQUE, FT-LB
49	TOTAL YAW MOM ON C.G., FT-LB
50	YAW MOM FROM RIGHT WING, FT-LB
51	YAW MOM FROM LEFT WING, FT-LB
52	NOT USED
53	NOT USED
54	YAW MOM FROM FUSELAGE, FT-LB
55	YAW MOM FROM JETS/GUN FIRE,FT-LB
56	YAW MOM FROM ROTOR1 FORCES, FT-LB
57	YAW MOM FROM ROTOR2 FORCES, FT-LB
58	YAW MOM FROM ROTOR1 TORQUE, FT-LB
59	YAW MOM FROM ROTOR2 TORQUE, FT-LB
60	X-FORCE FROM STABILIZER 1, LB

TABLE 22. Continued.

Number	Description
61	X-FORCE FROM STABILIZER 2, LB
62	X-FORCE FROM STABILIZER 3, LB
63	X-FORCE FROM STABILIZER 4, LB
64	Y-FORCE FROM STABILIZER 1, LB
65	Y-FORCE FROM STABILIZER 2, LB
66	Y-FORCE FROM STABILIZER 3, LB
67	Y-FORCE FROM STABILIZER 4, LB
68	Z-FORCE FROM STABILIZER 1, LB
69	Z-FORCE FROM STABILIZER 2, LB
70	Z-FORCE FROM STABILIZER 3, LB
71	Z-FORCE FROM STABILIZER 4, LB
72	NOT USED
73	NOT USED
74	NOT USED
75	ROLL MOM FROM STAB NO. 1, FT-LB
76	ROLL MOM FROM STAB NO. 2, FT-LB
77	ROLL MOM FROM STAB NO. 3, FT-LB
78	ROLL MOM FROM STAB NO. 4, FT-LB
79	PITCH MOM FROM STAB NO. 1, FT-LB
80	PITCH MOM FROM STAB NO. 2, FT-LB
81	PITCH MOM FROM STAB NO. 3, FT-LB
82	PITCH MOM FROM STAB NO. 4, FT-LB
83	YAW MOM FROM STAB NO. 1, FT-LB
84	YAW MOM FROM STAB NO. 2, FT-LB
85	YAW MOM FROM STAB NO. 3, FT-LB
86	YAW MOM FROM STAB NO. 4, FT-LB
87	NOT USED
88	NOT USED
89	NOT USED
90	Y-FORCE FROM RIGHT WING, LB
91	Y-FORCE FROM LEFT WING, LB
92	NOT USED
93	NOT USED
94	NOT USED
95	NOT USED
96	NOT USED
97	NOT USED
98	NOT USED
99	NOT USED
100	NOT USED
101	NOT USED
102	NOT USED
103	NOT USED
104	X-FORCE FROM STORE NO. 1, LB
105	X-FORCE FROM STORE NO. 2, LB
106	X-FORCE FROM STORE NO. 3, LB
107	X-FORCE FROM STORE NO. 4, LB
108	Y-FORCE FROM STORE NO. 1, LB
109	Y-FORCE FROM STORE NO. 2, LB
110	Y-FORCE FROM STORE NO. 3, LB
111	Y-FORCE FROM STORE NO. 4, LB
112	Z-FORCE FROM STORE NO. 1, LB
113	Z-FORCE FROM STORE NO. 2, LB
114	Z-FORCE FROM STORE NO. 3, LB
115	Z-FORCE FROM STORE NO. 4, LB
116	ROLL MOM FROM STORE NO. 1, FT-LB
117	ROLL MOM FROM STORE NO. 2, FT-LB
118	ROLL MOM FROM STORE NO. 3, FT-LB
119	ROLL MOM FROM STORE NO. 4, FT-LB
120	PITCH MOM FROM STORE NO. 1, FT-LB

TABLE 22. Continued.

Number	Description
121	PITCH MOM FROM STORE NO. 2, FT-LB
122	PITCH MOM FROM STORE NO. 3, FT-LB
123	PITCH MOM FROM STORE NO. 4, FT-LB
124	YAW MOM FROM STORE NO. 1, FT-LB
125	YAW MOM FROM STORE NO. 2, FT-LB
126	YAW MOM FROM STORE NO. 3, FT-LB
127	YAW MOM FROM STORE NO. 4, FT-LB
128	NOT USED
129	NOT USED
130	NOT USED
131	NOT USED
132	NOT USED
133	ROTOR 1, HORSEPOWER
134	ROTOR 1, TORQUE, FT-LB
135	ROTOR 1, RPM
136	ROTOR 1, TIP SPEED, FT/SEC
137	ROTOR 1, ADV BLADE MACH NUMBER
138	NOT USED
139	RIGHT JET, LB
140	NOT USED
141	C.G. STATION LINE LOCATION, IN.
142	C.G. BUTT LINE LOCATION, IN.
143	C.G. WATER LINE LOCATION, IN.
144	ROTOR 2, HORSEPOWER
145	ROTOR 2, TORQUE, FT-LB
146	ROTOR 2, RPM
147	ROTOR 2, TIP SPEED, FT/SEC
148	ROTOR 2, ADV BLADE MACH NUMBER
149	NOT USED
150	LEFT JET THRUST, LB
151	ACCESSORY HORSEPOWER
152	TOTAL SHAFT HORSEPOWER REQUIRED
153	ENGINE TORQUE REQUIRED, FT-LB
154	ENGINE RPM
155	ENGINE SHAFT HORSEPOWER AVAILABLE
156	X-COMP GUST VEL., BODY AXES, FT/SEC
157	U VELOCITY, BODY AXES, FT/SEC
158	V VELOCITY, BODY AXES, FT/SEC
159	W VELOCITY, BODY AXES, FT/SEC
160	P VELOCITY, BODY AXES, DEG/SEC
161	Q VELOCITY, BODY AXES, DEG/SEC
162	R VELOCITY, BODY AXES, DEG/SEC
163	COLLEC. BOBWT. VELOCITY, DEG/SEC
164	Y-COMP GUST VEL., BODY AXES, FT/SEC
165	U-DOT ACCEL., BODY AXES, FT/SEC/SEC
166	V-DOT ACCEL., BODY AXES, FT/SEC/SEC
167	W-DOT ACCEL., BODY AXES, FT/SEC/SEC
168	P-DOT ACCEL, BODY AXES, DEG/SEC/SEC
169	Q-DOT ACCEL, BODY AXES, DEG/SEC/SEC
170	R-DOT ACCEL, BODY AXES, DEG/SEC/SEC
171	COLLEC. BOBWT. ACCEL., DEG/SEC/SEC
172	Z-COMP GUST VEL., BODY AXES, FT/SEC
173	TRUE AIR SPEED, KTS
174	GROUND SPEED, KTS
175	RATE OF CLIMB, FT/SEC
176	STAB NO. 1 ANGLE OF INCIDENCE, DEG
177	STAB NO. 1 FLAP ANGLE, DEG
178	STAB NO. 1 LIFT COEFFICIENT
179	STAB NO. 1 DRAG COEFFICIENT
180	STAB NO. 1 PITCHING MOMENT COEF

TABLE 22. Continued.

Number	Description
181	STAB NO. 1 ANGLE OF ATTACK, DEG
182	STAB NO. 1 SIDESLIP ANGLE, DEG
183	CLIMB ANGLE, DEG
184	STAB NO. 2 ANGLE OF INCIDENCE, DEG
185	STAB NO. 2 FLAP ANGLE, DEG
186	STAB NO. 2 LIFT COEFFICIENT
187	STAB NO. 2 DRAG COEFFICIENT
188	STAB NO. 2 PITCHING MOMENT COEF
189	STAB NO. 2 ANGLE OF ATTACK, DEG
190	STAB NO. 2 SIDESLIP ANGLE, DEG
191	HEADING ANGLE, DEG
192	ANGLE OF ATTACK, DEG
193	STAB NO. 3 ANGLE OF INCIDENCE, DEG
194	STAB NO. 3 FLAP ANGLE, DEG
195	STAB NO. 3 LIFT COEFFICIENT
196	STAB NO. 3 DRAG COEFFICIENT
197	STAB NO. 3 PITCHING MOMENT COEF
198	STAB NO. 3 ANGLE OF ATTACK, DEG
199	STAB NO. 3 SIDESLIP ANGLE, DEG
200	ANGLE OF SIDESLIP, DEG
201	STAB NO. 4 ANGLE OF INCIDENCE, DEG
202	STAB NO. 4 FLAP ANGLE, DEG
203	STAB NO. 4 LIFT COEFFICIENT
204	STAB NO. 4 DRAG COEFFICIENT
205	STAB NO. 4 PITCHING MOMENT COEF
206	STAB NO. 4 ANGLE OF ATTACK, DEG
207	STAB NO. 4 SIDESLIP ANGLE, DEG
208	ANGLE OF AERO YAW, DEG
209	VERTICAL ACC, G
210	RIGHT WING ANGLE OF INCIDENCE, DEG
211	RIGHT WING FLAP ANGLE, DEG
212	RIGHT WING LIFT COEFFICIENT
213	RIGHT WING DRAG COEFFICIENT
214	RIGHT WING PITCHING MOMENT COEF
215	RIGHT WING ANGLE OF ATTACK, DEG
216	RIGHT WING SIDESLIP ANGLE, DEG
217	FORWARD ACC, G
218	LEFT WING ANGLE OF INCIDENCE, DEG
219	LEFT WING FLAP ANGLE, DEG
220	LEFT WING LIFT COEFFICIENT
221	LEFT WING DRAG COEFFICIENT
222	LEFT WING PITCHING MOMENT COEF
223	LEFT WING ANGLE OF ATTACK, DEG
224	LEFT WING SIDESLIP ANGLE, DEG
225	LATERAL ACC, G
226	YAW VELOCITY, FIXED/BODY, DEG/SEC
227	PITCH VELOCITY, FIXED/BODY, DEG/SEC
228	ROLL VELOCITY, FIXED/BODY, DEG/SEC
229	X-COMP VELOCITY, FIXED AXES, FT/SEC
230	Y-COMP VELOCITY, FIXED AXE , FT/SEC
231	Z-COMP VELOCITY, FIXED AXES, FT/SEC
232	TOTAL DISTANCE FLOWN, FT
233	YAW ANGLE, FIXED/BODY, DEG
234	PITCH ANGLE, FIXED/BODY, DEG
235	ROLL ANGLE, FIXED/BODY, DEG
236	X-COMP DISP., FIXED AXES, FT
237	Y-COMP DISP., FIXED AXES, FT
238	Z-COMP DISP., FIXED AXES, FT
239	ALTITUDE, FT
240	NOT USED

TABLE 22. Continued.

Number	Description
241	NOT USED
242	NOT USED
243	NOT USED
244	COLLECTIVE STICK POSITION, PCT
245	ROTOR 1, COLL FROM COLL STICK, DEG
246	ROTOR 1, F/A FROM COLL STICK, DEG
247	ROTOR 1, LAT FROM COLL STICK, DEG
248	ROTOR 2, COLL FROM COLL STICK, DEG
249	ROTOR 2, F/A FROM COLL STICK, DEG
250	ROTOR 2, LAT FROM COLL STICK, DEG
251	ROTOR 1, HUB SPRING F/A MOMENT, FT-LB
252	ROTOR 2, HUB SPRING F/A MOMENT, FT-LB
253	F/A CYCLIC STICK POSITION, PCT
254	ROTOR 1, COLL FROM F/A STICK, DEG
255	ROTOR 1, F/A FROM F/A STICK, DEG
256	ROTOR 1, LAT FROM F/A STICK, DEG
257	ROTOR 2, COLL FROM F/A STICK, DEG
258	ROTOR 2, F/A FROM F/A STICK, DEG
259	ROTOR 2, LAT FROM F/A STICK, DEG
260	ROTOR 1, HUB SPRING LAT MOMENT, FT-LB
261	ROTOR 2, HUB SPRING LAT MOMENT, FT-LB
262	LATERAL CYCLIC STICK POSITION, PCT
263	ROTOR 1, COLL FROM LAT STICK, DEG
264	ROTOR 1, F/A FROM LAT STICK, DEG
265	ROTOR 1, LAT FROM LAT STICK, DEG
266	ROTOR 2, COLL FROM LAT STICK, DEG
267	ROTOR 2, F/A FROM LAT STICK, DEG
268	ROTOR 2, LAT FROM LAT STICK, DEG
269	ROTOR 1, F/A PYLON DISPLACEMENT, DEG
270	ROTOR 2, F/A PYLON DISPLACEMENT, DEG
271	PEDAL POSITION, PCT
272	ROTOR 1, COLL FROM PEDAL
273	ROTOR 1, F/A FROM PEDAL
274	ROTOR 1, LAT FROM PEDAL
275	ROTOR 2, COLL FROM PEDAL
276	ROTOR 2, F/A FROM PEDAL
277	ROTOR 2, LAT FROM PEDAL
278	ROTOR 1, LATERAL PYLON DISPLACEMENT, DEG
279	ROTOR 2, LATERAL PYLON DISPLACEMENT, DEG
280	ROTOR 1, COLL FROM SCAS + PYLON, DEG
281	ROTOR 1, F/A FROM SCAS + PYLON, DEG
282	ROTOR 1, LAT FROM SCAS + PYLON, DEG
283	ROTOR 2, COLL FROM SCAS + PYLON, DEG
284	ROTOR 2, F/A FROM SCAS + PYLON, DEG
285	ROTOR 2, LAT FROM SCAS + PYLON, DEG
286	ROTOR 1, F/A MAST ANGLE, DEG
287	ROTOR 2, F/A MAST ANGLE, DEG
288	ROTOR 1, TOTAL COLLECTIVE, DEG
289	ROTOR 1, TOTAL F/A CYCLIC, DEG
290	ROTOR 1, TOTAL LATERAL CYCLIC, DEG
291	ROTOR 2, TOTAL COLLECTIVE, DEG
292	ROTOR 2, TOTAL F/A CYCLIC, DEG
293	ROTOR 2, TOTAL LATERAL CYCLIC, DEG
294	ROTOR 1, LAT MAST ANGLE, DEG
295	ROTOR 2, LAT MAST ANGLE, DEG
296	ROTOR 1, BLADE MEAN FEATHERING, DEG
297	ROTOR 1, BLADE FEATHER AT PSI=0, DEG
298	ROTOR 1, BLADE FEATHER AT PSI=90, DEG
299	ROTOR 1, F/A FLAPPING, MAST/TPP, DEG
300	ROTOR 1, LATERAL FLAPPING, MAST/TPP, DEG

TABLE 22. Continued.

Number	Description
301	ROTOR 1, THRUST, LB
302	ROTOR 1, H-FORCE, LB
303	ROTOR 1, Y-FORCE, LB
304	ROTOR 1, ADVANCE RATIO
305	ROTOR 1, POWER COEFFICIENT
306	ROTOR 1, THRUST COEFFICIENT
307	ROTOR 1, INDUCED VELOCITY, FT/SEC
308	ROTOR 2, BLADE MEAN FEATHERING, DEG
309	ROTOR 2, BLADE FEATHER AT PSI=0, DEG
310	ROTOR 2, BLADE FEATHER AT PSI=90, DEG
311	ROTOR 2, F/A FLAPPING, MAST/TPP, DEG
312	ROTOR 2, LATERAL FLAPPING, MAST/TPP, DEG
313	ROTOR 2, THRUST, LB
314	ROTOR 2, H-FORCE, LB
315	ROTOR 2, Y-FORCE, LB
316	ROTOR 2, ADVANCE RATIO
317	ROTOR 2, POWER COEFFICIENT
318	ROTOR 2, THRUST COEFFICIENT
319	ROTOR 2, INDUCED VELOCITY, FT/SEC
320	ROTOR 1, AZIMUTH LOCATION, BLADE 1, DEG
321	ROTOR 1, FLAPPING,HUB/MAST,BLADE 1,DEG
322	ROTOR 1, FLAPPING LIMIT, DEG
323	ROTOR 1, U VELOCITY, MAST AXES, FT/SEC
324	ROTOR 1, V VELOCITY, MAST AXES, FT/SEC
325	ROTOR 1, W VELOCITY, MAST AXES, FT/SEC
326	ROTOR 1, X SHEAR FORCE, LB
327	ROTOR 1, Y SHEAR FORCE, LB
328	ROTOR 1, Z SHEAR FORCE, LB
329	NOT USED
330	NOT USED
331	NOT USED
332	NOT USED
333	ROTOR 2, AZIMUTH LOCATION, BLADE 1, DEG
334	ROTOR 2, FLAPPING,HUB/MAST,BLADE 1,DEG
335	ROTOR 2, FLAPPING LIMIT, DEG
336	ROTOR 2, U VELOCITY, MAST AXES, FT/SEC
337	ROTOR 2, V VELOCITY, MAST AXES, FT/SEC
338	ROTOR 2, W VELOCITY, MAST AXES, FT/SEC
339	ROTOR 2, X SHEAR FORCE, LB
340	ROTOR 2, Y SHEAR FORCE, LB
341	ROTOR 2, Z SHEAR FORCE, LB
342	NOT USED
343	NOT USED
344	NOT USED
345	NOT USED
346	AZIMUTH, ROTOR 1, BLADE 1, DEG
347	AZIMUTH, ROTOR 1, BLADE 2, DEG
348	AZIMUTH, ROTOR 1, BLADE 3, DEG
349	AZIMUTH, ROTOR 1, BLADE 4, DEG
350	AZIMUTH, ROTOR 1, BLADE 5, DEG
351	AZIMUTH, ROTOR 1, BLADE 6, DEG
352	AZIMUTH, ROTOR 1, BLADE 7, DEG
353	GEN.COORD.,ROTOR 1,MODE 1,BLADE 1
354	GEN.COORD.,ROTOR 1,MODE 1,BLADE 2
355	GEN.COORD.,ROTOR 1,MODE 1,BLADE 3
356	GEN.COORD.,ROTOR 1,MODE 1,BLADE 4
357	GEN.COORD.,ROTOR 1,MODE 1,BLADE 5
358	GEN.COORD.,ROTOR 1,MODE 1,BLADE 6
359	GEN.COORD.,ROTOR 1,MODE 1,BLADE 7
360	GEN.COORD.,ROTOR 1,MODE 2,BLADE 1

TABLE 22. Continued.

Number	Description
361	GEN.COORD.,ROTOR 1,MODE 2,BLADE 2
362	GEN.COORD.,ROTOR 1,MODE 2,BLADE 3
363	GEN.COORD.,ROTOR 1,MODE 2,BLADE 4
364	GEN.COORD.,ROTOR 1,MODE 2,BLADE 5
365	GEN.COORD.,ROTOR 1,MODE 2,BLADE 6
366	GEN.COORD.,ROTOR 1,MODE 2,BLADE 7
367	GEN.COORD.,ROTOR 1,MODE 3,BLADE 1
368	GEN.COORD.,ROTOR 1,MODE 3,BLADE 2
369	GEN.COORD.,ROTOR 1,MODE 3,BLADE 3
370	GEN.COORD.,ROTOR 1,MODE 3,BLADE 4
371	GEN.COORD.,ROTOR 1,MODE 3,BLADE 5
372	GEN.COORD.,ROTOR 1,MODE 3,BLADE 6
373	GEN.COORD.,ROTOR 1,MODE 3,BLADE 7
374	GEN.COORD.,ROTOR 1,MODE 4,BLADE 1
375	GEN.COORD.,ROTOR 1,MODE 4,BLADE 2
376	GEN.COORD.,ROTOR 1,MODE 4,BLADE 3
377	GEN.COORD.,ROTOR 1,MODE 4,BLADE 4
378	GEN.COORD.,ROTOR 1,MODE 4,BLADE 5
379	GEN.COORD.,ROTOR 1,MODE 4,BLADE 6
380	GEN.COORD.,ROTOR 1,MODE 4,BLADE 7
381	GEN.COORD.,ROTOR 1,MODE 5,BLADE 1
382	GEN.COORD.,ROTOR 1,MODE 5,BLADE 2
383	GEN.COORD.,ROTOR 1,MODE 5,BLADE 3
384	GEN.COORD.,ROTOR 1,MODE 5,BLADE 4
385	GEN.COORD.,ROTOR 1,MODE 5,BLADE 5
386	GEN.COORD.,ROTOR 1,MODE 5,BLADE 6
387	GEN.COORD.,ROTOR 1,MODE 5,BLADE 7
388	GEN.COORD.,ROTOR 1,MODE 6,BLADE 1
389	GEN.COORD.,ROTOR 1,MODE 6,BLADE 2
390	GEN.COORD.,ROTOR 1,MODE 6,BLADE 3
391	GEN.COORD.,ROTOR 1,MODE 6,BLADE 4
392	GEN.COORD.,ROTOR 1,MODE 6,BLADE 5
393	GEN.COORD.,ROTOR 1,MODE 6,BLADE 6
394	GEN.COORD.,ROTOR 1,MODE 6,BLADE 7
395	GEN.COORD.,ROTOR 1,MODE 7,BLADE 1
396	GEN.COORD.,ROTOR 1,MODE 7,BLADE 2
397	GEN.COORD.,ROTOR 1,MODE 7,BLADE 3
398	GEN.COORD.,ROTOR 1,MODE 7,BLADE 4
399	GEN.COORD.,ROTOR 1,MODE 7,BLADE 5
400	GEN.COORD.,ROTOR 1,MODE 7,BLADE 6
401	GEN.COORD.,ROTOR 1,MODE 7,BLADE 7
402	GEN.COORD.,ROTOR 1,MODE 8,BLADE 1
403	GEN.COORD.,ROTOR 1,MODE 8,BLADE 2
404	GEN.COORD.,ROTOR 1,MODE 8,BLADE 3
405	GEN.COORD.,ROTOR 1,MODE 8,BLADE 4
406	GEN.COORD.,ROTOR 1,MODE 8,BLADE 5
407	GEN.COORD.,ROTOR 1,MODE 8,BLADE 6
408	GEN.COORD.,ROTOR 1,MODE 8,BLADE 7
409	GEN.COORD.,ROTOR 1,MODE 9,BLADE 1
410	GEN.COORD.,ROTOR 1,MODE 9,BLADE 2
411	GEN.COORD.,ROTOR 1,MODE 9,BLADE 3
412	GEN.COORD.,ROTOR 1,MODE 9,BLADE 4
413	GEN.COORD.,ROTOR 1,MODE 9,BLADE 5
414	GEN.COORD.,ROTOR 1,MODE 9,BLADE 6
415	GEN.COORD.,ROTOR 1,MODE 9,BLADE 7
416	GEN.COORD.,ROTOR 1,MODE 10BLADE 1
417	GEN.COORD.,ROTOR 1,MODE 10BLADE 2
418	GEN.COORD.,ROTOR 1,MODE 10BLADE 3
419	GEN.COORD.,ROTOR 1,MODE 10BLADE 4
420	GEN.COORD.,ROTOR 1,MODE 10BLADE 5

TABLE 22. Continued.

Number	Description
421	GEN.COORD.,ROTOR 1,MODE 10BLADE 6
422	GEN.COORD.,ROTOR 1,MODE 10BLADE 7
423	GEN.COORD.,ROTOR 1,MODE 11BLADE 1
424	GEN.COORD.,ROTOR 1,MODE 11BLADE 2
425	GEN.COORD.,ROTOR 1,MODE 11BLADE 3
426	GEN.COORD.,ROTOR 1,MODE 11BLADE 4
427	GEN.COORD.,ROTOR 1,MODE 11BLADE 5
428	GEN.COORD.,ROTOR 1,MODE 11BLADE 6
429	GEN.COORD.,ROTOR 1,MODE 11BLADE 7
430	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 1,FT
431	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 2,FT
432	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 3,FT
433	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 4,FT
434	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 5,FT
435	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 6,FT
436	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 7,FT
437	TIP DEFL. INPLANE,ROTOR 1,BLADE 1,FT
438	TIP DEFL. INPLANE,ROTOR 1,BLADE 2,FT
439	TIP DEFL. INPLANE,ROTOR 1,BLADE 3,FT
440	TIP DEFL. INPLANE,ROTOR 1,BLADE 4,FT
441	TIP DEFL. INPLANE,ROTOR 1,BLADE 5,FT
442	TIP DEFL. INPLANE,ROTOR 1,BLADE 6,FT
443	TIP DEFL. INPLANE,ROTOR 1,BLADE 7,FT
444	TIP TWIST DEFL.,ROTOR 1,BLADE 1,DEG
445	TIP TWIST DEFL.,ROTOR 1,BLADE 2,DEG
446	TIP TWIST DEFL.,ROTOR 1,BLADE 3,DEG
447	TIP TWIST DEFL.,ROTOR 1,BLADE 4,DEG
448	TIP TWIST DEFL.,ROTOR 1,BLADE 5,DEG
449	TIP TWIST DEFL.,ROTOR 1,BLADE 6,DEG
450	TIP TWIST DEFL.,ROTOR 1,BLADE 7,DEG
451	VERTICAL HUB SHEAR,ROTOR 1,BLADE 1,LB
452	VERTICAL HUB SHEAR,ROTOR 1,BLADE 2,LB
453	VERTICAL HUB SHEAR,ROTOR 1,BLADE 3,LB
454	VERTICAL HUB SHEAR,ROTOR 1,BLADE 4,LB
455	VERTICAL HUB SHEAR,ROTOR 1,BLADE 5,LB
456	VERTICAL HUB SHEAR,ROTOR 1,BLADE 6,LB
457	VERTICAL HUB SHEAR,ROTOR 1,BLADE 7,LB
458	INPLANE HUB SHEAR,ROTOR 1,BLADE 1,LB
459	INPLANE HUB SHEAR,ROTOR 1,BLADE 2,LB
460	INPLANE HUB SHEAR,ROTOR 1,BLADE 3,LB
461	INPLANE HUB SHEAR,ROTOR 1,BLADE 4,LB
462	INPLANE HUB SHEAR,ROTOR 1,BLADE 5,LB
463	INPLANE HUB SHEAR,ROTOR 1,BLADE 6,LB
464	INPLANE HUB SHEAR,ROTOR 1,BLADE 7,LB
465	BEAM BEND.MOMENT,ROTOR 1,BLADE 1,IN-LB
466	BEAM BEND.MOMENT,ROTOR 1,BLADE 2,IN-LB
467	BEAM BEND.MOMENT,ROTOR 1,BLADE 3,IN-LB
468	BEAM BEND.MOMENT,ROTOR 1,BLADE 4,IN-LB
469	BEAM BEND.MOMENT,ROTOR 1,BLADE 5,IN-LB
470	BEAM BEND.MOMENT,ROTOR 1,BLADE 6,IN-LB
471	BEAM BEND.MOMENT,ROTOR 1,BLADE 7,IN-LB
472	CHORD BEND.MOMENT,ROTOR 1,BLADE 1,IN-LB
473	CHORD BEND.MOMENT,ROTOR 1,BLADE 2,IN-LB
474	CHORD BEND.MOMENT,ROTOR 1,BLADE 3,IN-LB
475	CHORD BEND.MOMENT,ROTOR 1,BLADE 4,IN-LB
476	CHORD BEND.MOMENT,ROTOR 1,BLADE 5,IN-LB
477	CHORD BEND.MOMENT,ROTOR 1,BLADE 6,IN-LB
478	CHORD BEND.MOMENT,ROTOR 1,BLADE 7,IN-LB
479	TORSIONAL MOMENT,ROTOR 1,BLADE 1,IN-LB
480	TORSIONAL MOMENT,ROTOR 1,BLADE 2,IN-LB

TABLE 22. Continued.

Number	Description
481	TORSIONAL MOMENT,ROTOR 1,BLADE 3,IN-LB
482	TORSIONAL MOMENT,ROTOR 1,BLADE 4,IN-LB
483	TORSIONAL MOMENT,ROTOR 1,BLADE 5,IN-LB
484	TORSIONAL MOMENT,ROTOR 1,BLADE 6,IN-LB
485	TORSIONAL MOMENT,ROTOR 1,BLADE 7,IN-LB
486	AZIMUTH, ROTOR 2, BLADE 1, DEG
487	AZIMUTH, ROTOR 2, BLADE 2, DEG
488	AZIMUTH, ROTOR 2, BLADE 3, DEG
489	AZIMUTH, ROTOR 2, BLADE 4, DEG
490	AZIMUTH, ROTOR 2, BLADE 5, DEG
491	AZIMUTH, ROTOR 2, BLADE 6, DEG
492	AZIMUTH, ROTOR 2, BLADE 7, DEG
493	GEN.COORD.,ROTOR 2,MODE 1,BLADE 1
494	GEN.COORD.,ROTOR 2,MODE 1,BLADE 2
495	GEN.COORD.,ROTOR 2,MODE 1,BLADE 3
496	GEN.COORD.,ROTOR 2,MODE 1,BLADE 4
497	GEN.COORD.,ROTOR 2,MODE 1,BLADE 5
498	GEN.COORD.,ROTOR 2,MODE 1,BLADE 6
499	GEN.COORD.,ROTOR 2,MODE 1,BLADE 7
500	GEN.COORD.,ROTOR 2,MODE 2,BLADE 1
501	GEN.COORD.,ROTOR 2,MODE 2,BLADE 2
502	GEN.COORD.,ROTOR 2,MODE 2,BLADE 3
503	GEN.COORD.,ROTOR 2,MODE 2,BLADE 4
504	GEN.COORD.,ROTOR 2,MODE 2,BLADE 5
505	GEN.COORD.,ROTOR 2,MODE 2,BLADE 6
506	GEN.COORD.,ROTOR 2,MODE 2,BLADE 7
507	GEN.COORD.,ROTOR 2,MODE 3,BLADE 1
508	GEN.COORD.,ROTOR 2,MODE 3,BLADE 2
509	GEN.COORD.,ROTOR 2,MODE 3,BLADE 3
510	GEN.COORD.,ROTOR 2,MODE 3,BLADE 4
511	GEN.COORD.,ROTOR 2,MODE 3,BLADE 5
512	GEN.COORD.,ROTOR 2,MODE 3,BLADE 6
513	GEN.COORD.,ROTOR 2,MODE 3,BLADE 7
514	GEN.COORD.,ROTOR 2,MODE 4,BLADE 1
515	GEN.COORD.,ROTOR 2,MODE 4,BLADE 2
516	GEN.COORD.,ROTOR 2,MODE 4,BLADE 3
517	GEN.COORD.,ROTOR 2,MODE 4,BLADE 4
518	GEN.COORD.,ROTOR 2,MODE 4,BLADE 5
519	GEN.COORD.,ROTOR 2,MODE 4,BLADE 6
520	GEN.COORD.,ROTOR 2,MODE 4,BLADE 7
521	GEN.COORD.,ROTOR 2,MODE 5,BLADE 1
522	GEN.COORD.,ROTOR 2,MODE 5,BLADE 2
523	GEN.COORD.,ROTOR 2,MODE 5,BLADE 3
524	GEN.COORD.,ROTOR 2,MODE 5,BLADE 4
525	GEN.COORD.,ROTOR 2,MODE 5,BLADE 5
526	GEN.COORD.,ROTOR 2,MODE 5,BLADE 6
527	GEN.COORD.,ROTOR 2,MODE 5,BLADE 7
528	GEN.COORD.,ROTOR 2,MODE 6,BLADE 1
529	GEN.COORD.,ROTOR 2,MODE 6,BLADE 2
530	GEN.COORD.,ROTOR 2,MODE 6,BLADE 3
531	GEN.COORD.,ROTOR 2,MODE 6,BLADE 4
532	GEN.COORD.,ROTOR 2,MODE 6,BLADE 5
533	GEN.COORD.,ROTOR 2,MODE 6,BLADE 6
534	GEN.COORD.,ROTOR 2,MODE 6,BLADE 7
535	GEN.COORD.,ROTOR 2,MODE 7,BLADE 1
536	GEN.COORD.,ROTOR 2,MODE 7,BLADE 2
537	GEN.COORD.,ROTOR 2,MODE 7,BLADE 3
538	GEN.COORD.,ROTOR 2,MODE 7,BLADE 4
539	GEN.COORD.,ROTOR 2,MODE 7,BLADE 5
540	GEN.COORD.,ROTOR 2,MODE 7,BLADE 6

TABLE 22. Continued.

Number	Description
541	GEN.COORD.,ROTOR 2,MODE 7,BLADE 7
542	GEN.COORD.,ROTOR 2,MODE 8,BLADE 1
543	GEN.COORD.,ROTOR 2,MODE 8,BLADE 2
544	GEN.COORD.,ROTOR 2,MODE 8,BLADE 3
545	GEN.COORD.,ROTOR 2,MODE 8,BLADE 4
546	GEN.COORD.,ROTOR 2,MODE 8,BLADE 5
547	GEN.COORD.,ROTOR 2,MODE 8,BLADE 6
548	GEN.COORD.,ROTOR 2,MODE 8,BLADE 7
549	GEN.COORD.,ROTOR 2,MODE 9,BLADE 1
550	GEN.COORD.,ROTOR 2,MODE 9,BLADE 2
551	GEN.COORD.,ROTOR 2,MODE 9,BLADE 3
552	GEN.COORD.,ROTOR 2,MODE 9,BLADE 4
553	GEN.COORD.,ROTOR 2,MODE 9,BLADE 5
554	GEN.COORD.,ROTOR 2,MODE 9,BLADE 6
555	GEN.COORD.,ROTOR 2,MODE 9,BLADE 7
556	GEN.COORD.,ROTOR 2,MODE 10BLADE 1
557	GEN.COORD.,ROTOR 2,MODE 10BLADE 2
558	GEN.COORD.,ROTOR 2,MODE 10BLADE 3
559	GEN.COORD.,ROTOR 2,MODE 10BLADE 4
560	GEN.COORD.,ROTOR 2,MODE 10BLADE 5
561	GEN.COORD.,ROTOR 2,MODE 10BLADE 6
562	GEN.COORD.,ROTOR 2,MODE 10BLADE 7
563	GEN.COORD.,ROTOR 2,MODE 11BLADE 1
564	GEN.COORD.,ROTOR 2,MODE 11BLADE 2
565	GEN.COORD.,ROTOR 2,MODE 11BLADE 3
566	GEN.COORD.,ROTOR 2,MODE 11BLADE 4
567	GEN.COORD.,ROTOR 2,MODE 11BLADE 5
568	GEN.COORD.,ROTOR 2,MODE 11BLADE 6
569	GEN.COORD.,ROTOR 2,MODE 11BLADE 7
570	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 1,FT
571	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 2,FT
572	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 3,FT
573	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 4,FT
574	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 5,FT
575	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 6,FT
576	TIP DEFL.OUT-OF-PLANE,ROTOR 2,BLADE 7,FT
577	TIP DEFL. INPLANE,ROTOR 2,BLADE 1,FT
578	TIP DEFL. INPLANE,ROTOR 2,BLADE 2,FT
579	TIP DEFL. INPLANE,ROTOR 2,BLADE 3,FT
580	TIP DEFL. INPLANE,ROTOR 2,BLADE 4,FT
581	TIP DEFL. INPLANE,ROTOR 2,BLADE 5,FT
582	TIP DEFL. INPLANE,ROTOR 2,BLADE 6,FT
583	TIP DEFL. INPLANE,ROTOR 2,BLADE 7,FT
584	TIP TWIST DEFL.,ROTOR 2,BLADE 1,DEG
585	TIP TWIST DEFL.,ROTOR 2,BLADE 2,DEG
586	TIP TWIST DEFL.,ROTOR 2,BLADE 3,DEG
587	TIP TWIST DEFL.,ROTOR 2,BLADE 4,DEG
588	TIP TWIST DEFL.,ROTOR 2,BLADE 5,DEG
589	TIP TWIST DEFL.,ROTOR 2,BLADE 6,DEG
590	TIP TWIST DEFL.,ROTOR 2,BLADE 7,DEG
591	VERTICAL HUB SHEAR,ROTOR 2,BLADE 1,LB
592	VERTICAL HUB SHEAR,ROTOR 2,BLADE 2,LB
593	VERTICAL HUB SHEAR,ROTOR 2,BLADE 3,LB
594	VERTICAL HUB SHEAR,ROTOR 2,BLADE 4,LB
595	VERTICAL HUB SHEAR,ROTOR 2,BLADE 5,LB
596	VERTICAL HUB SHEAR,ROTOR 2,BLADE 6,LB
597	VERTICAL HUB SHEAR,ROTOR 2,BLADE 7,LB
598	INPLANE HUB SHEAR,ROTOR 2,BLADE 1,LB
599	INPLANE HUB SHEAR,ROTOR 2,BLADE 2,LB
600	INPLANE HUB SHEAR,ROTOR 2,BLADE 3,LB

TABLE 22. Continued.

Number	Description
601	INPLANE HUB SHEAR,ROTOR 2,BLADE 4,LB
602	INPLANE HUB SHEAR,ROTOR 2,BLADE 5,LB
603	INPLANE HUB SHEAR,ROTOR 2,BLADE 6,LB
604	INPLANE HUB SHEAR,ROTOR 2,BLADE 7,LB
605	BEAM BEND.MOMENT,ROTOR 2,BLADE 1,IN-LB
606	BEAM BEND.MOMENT,ROTOR 2,BLADE 2,IN-LB
607	BEAM BEND.MOMENT,ROTOR 2,BLADE 3,IN-LB
608	BEAM BEND.MOMENT,ROTOR 2,BLADE 4,IN-LB
609	BEAM BEND.MOMENT,ROTOR 2,BLADE 5,IN-LB
610	BEAM BEND.MOMENT,ROTOR 2,BLADE 6,IN-LB
611	BEAM BEND.MOMENT,ROTOR 2,BLADE 7,IN-LB
612	CHORD BEND.MOMENT,ROTOR 2,BLADE 1,IN-LB
613	CHORD BEND.MOMENT,ROTOR 2,BLADE 2,IN-LB
614	CHORD BEND.MOMENT,ROTOR 2,BLADE 3,IN-LB
615	CHORD BEND.MOMENT,ROTOR 2,BLADE 4,IN-LB
616	CHORD BEND.MOMENT,ROTOR 2,BLADE 5,IN-LB
617	CHORD BEND.MOMENT,ROTOR 2,BLADE 6,IN-LB
618	CHORD BEND.MOMENT,ROTOR 2,BLADE 7,IN-LB
619	TORSIONAL MOMENT,ROTOR 2,BLADE 1,IN-LB
620	TORSIONAL MOMENT,ROTOR 2,BLADE 2,IN-LB
621	TORSIONAL MOMENT,ROTOR 2,BLADE 3,IN-LB
622	TORSIONAL MOMENT,ROTOR 2,BLADE 4,IN-LB
623	TORSIONAL MOMENT,ROTOR 2,BLADE 5,IN-LB
624	TORSIONAL MOMENT,ROTOR 2,BLADE 6,IN-LB
625	TORSIONAL MOMENT,ROTOR 2,BLADE 7,IN-LB
626	RTR 1,BLD 1,STA 19, BEAM BEND MOM, IN-LB
627	RTR 1,BLD 2,STA 19, BEAM BEND MOM, IN-LB
628	RTR 1,BLD 3,STA 19, BEAM BEND MOM, IN-LB
629	RTR 1,BLD 4,STA 19, BEAM BEND MOM, IN-LB
630	RTR 1,BLD 5,STA 19, BEAM BEND MOM, IN-LB
631	RTR 1,BLD 6,STA 19, BEAM BEND MOM, IN-LB
632	RTR 1,BLD 7,STA 19, BEAM BEND MOM, IN-LB
633	RTR 1,BLD 1,STA 18, BEAM BEND MOM, IN-LB
634	RTR 1,BLD 2,STA 18, BEAM BEND MOM, IN-LB
635	RTR 1,BLD 3,STA 18, BEAM BEND MOM, IN-LB
636	RTR 1,BLD 4,STA 18, BEAM BEND MOM, IN-LB
637	RTR 1,BLD 5,STA 18, BEAM BEND MOM, IN-LB
638	RTR 1,BLD 6,STA 18, BEAM BEND MOM, IN-LB
639	RTR 1,BLD 7,STA 18, BEAM BEND MOM, IN-LB
640	RTR 1,BLD 1,STA 17, BEAM BEND MOM, IN-LB
641	RTR 1,BLD 2,STA 17, BEAM BEND MOM, IN-LB
642	RTR 1,BLD 3,STA 17, BEAM BEND MOM, IN-LB
643	RTR 1,BLD 4,STA 17, BEAM BEND MOM, IN-LB
644	RTR 1,BLD 5,STA 17, BEAM BEND MOM, IN-LB
645	RTR 1,BLD 6,STA 17, BEAM BEND MOM, IN-LB
646	RTR 1,BLD 7,STA 17, BEAM BEND MOM, IN-LB
647	RTR 1,BLD 1,STA 16, BEAM BEND MOM, IN-LB
648	RTR 1,BLD 2,STA 16, BEAM BEND MOM, IN-LB
649	RTR 1,BLD 3,STA 16, BEAM BEND MOM, IN-LB
650	RTR 1,BLD 4,STA 16, BEAM BEND MOM, IN-LB
651	RTR 1,BLD 5,STA 16, BEAM BEND MOM, IN-LB
652	RTR 1,BLD 6,STA 16, BEAM BEND MOM, IN-LB
653	RTR 1,BLD 7,STA 16, BEAM BEND MOM, IN-LB
654	RTR 1,BLD 1,STA 15, BEAM BEND MOM, IN-LB
655	RTR 1,BLD 2,STA 15, BEAM BEND MOM, IN-LB
656	RTR 1,BLD 3,STA 15, BEAM BEND MOM, IN-LB
657	RTR 1,BLD 4,STA 15, BEAM BEND MOM, IN-LB
658	RTR 1,BLD 5,STA 15, BEAM BEND MOM, IN-LB
659	RTR 1,BLD 6,STA 15, BEAM BEND MOM, IN-LB
660	RTR 1,BLD 7,STA 15, BEAM BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
661	RTR 1,BLD 1,STA 14, BEAM BEND MOM, IN-LB
662	RTR 1,BLD 2,STA 14, BEAM BEND MOM, IN-LB
663	RTR 1,BLD 3,STA 14, BEAM BEND MOM, IN-LB
664	RTR 1,BLD 4,STA 14, BEAM BEND MOM, IN-LB
665	RTR 1,BLD 5,STA 14, BEAM BEND MOM, IN-LB
666	RTR 1,BLD 6,STA 14, BEAM BEND MOM, IN-LB
667	RTR 1,BLD 7,STA 14, BEAM BEND MOM, IN-LB
668	RTR 1,BLD 1,STA 13, BEAM BEND MOM, IN-LB
669	RTR 1,BLD 2,STA 13, BEAM BEND MOM, IN-LB
670	RTR 1,BLD 3,STA 13, BEAM BEND MOM, IN-LB
671	RTR 1,BLD 4,STA 13, BEAM BEND MOM, IN-LB
672	RTR 1,BLD 5,STA 13, BEAM BEND MOM, IN-LB
673	RTR 1,BLD 6,STA 13, BEAM BEND MOM, IN-LB
674	RTR 1,BLD 7,STA 13, BEAM BEND MOM, IN-LB
675	RTR 1,BLD 1,STA 12, BEAM BEND MOM, IN-LB
676	RTR 1,BLD 2,STA 12, BEAM BEND MOM, IN-LB
677	RTR 1,BLD 3,STA 12, BEAM BEND MOM, IN-LB
678	RTR 1,BLD 4,STA 12, BEAM BEND MOM, IN-LB
679	RTR 1,BLD 5,STA 12, BEAM BEND MOM, IN-LB
680	RTR 1,BLD 6,STA 12, BEAM BEND MOM, IN-LB
681	RTR 1,BLD 7,STA 12, BEAM BEND MOM, IN-LB
682	RTR 1,BLD 1,STA 11, BEAM BEND MOM, IN-LB
683	RTR 1,BLD 2,STA 11, BEAM BEND MOM, IN-LB
684	RTR 1,BLD 3,STA 11, BEAM BEND MOM, IN-LB
685	RTR 1,BLD 4,STA 11, BEAM BEND MOM, IN-LB
686	RTR 1,BLD 5,STA 11, BEAM BEND MOM, IN-LB
687	RTR 1,BLD 6,STA 11, BEAM BEND MOM, IN-LB
688	RTR 1,BLD 7,STA 11, BEAM BEND MOM, IN-LB
689	RTR 1,BLD 1,STA 10, BEAM BEND MOM, IN-LB
690	RTR 1,BLD 2,STA 10, BEAM BEND MOM, IN-LB
691	RTR 1,BLD 3,STA 10, BEAM BEND MOM, IN-LB
692	RTR 1,BLD 4,STA 10, BEAM BEND MOM, IN-LB
693	RTR 1,BLD 5,STA 10, BEAM BEND MOM, IN-LB
694	RTR 1,BLD 6,STA 10, BEAM BEND MOM, IN-LB
695	RTR 1,BLD 7,STA 10, BEAM BEND MOM, IN-LB
696	RTR 1,BLD 1,STA 9, BEAM BEND MOM, IN-LB
697	RTR 1,BLD 2,STA 9, BEAM BEND MOM, IN-LB
698	RTR 1,BLD 3,STA 9, BEAM BEND MOM, IN-LB
699	RTR 1,BLD 4,STA 9, BEAM BEND MOM, IN-LB
700	RTR 1,BLD 5,STA 9, BEAM BEND MOM, IN-LB
701	RTR 1,BLD 6,STA 9, BEAM BEND MOM, IN-LB
702	RTR 1,BLD 7,STA 9, BEAM BEND MOM, IN-LB
703	RTR 1,BLD 1,STA 8, BEAM BEND MOM, IN-LB
704	RTR 1,BLD 2,STA 8, BEAM BEND MOM, IN-LB
705	RTR 1,BLD 3,STA 8, BEAM BEND MOM, IN-LB
706	RTR 1,BLD 4,STA 8, BEAM BEND MOM, IN-LB
707	RTR 1,BLD 5,STA 8, BEAM BEND MOM, IN-LB
708	RTR 1,BLD 6,STA 8, BEAM BEND MOM, IN-LB
709	RTR 1,BLD 7,STA 8, BEAM BEND MOM, IN-LB
710	RTR 1,BLD 1,STA 7, BEAM BEND MOM, IN-LB
711	RTR 1,BLD 2,STA 7, BEAM BEND MOM, IN-LB
712	RTR 1,BLD 3,STA 7, BEAM BEND MOM, IN-LB
713	RTR 1,BLD 4,STA 7, BEAM BEND MOM, IN-LB
714	RTR 1,BLD 5,STA 7, BEAM BEND MOM, IN-LB
715	RTR 1,BLD 6,STA 7, BEAM BEND MOM, IN-LB
716	RTR 1,BLD 7,STA 7, BEAM BEND MOM, IN-LB
717	RTR 1,BLD 1,STA 6, BEAM BEND MOM, IN-LB
718	RTR 1,BLD 2,STA 6, BEAM BEND MOM, IN-LB
719	RTR 1,BLD 3,STA 6, BEAM BEND MOM, IN-LB
720	RTR 1,BLD 4,STA 6, BEAM BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
721	RTR 1,BLD 5,STA 6, BEAM BEND MOM, IN-LB
722	RTR 1,BLD 6,STA 6, BEAM BEND MOM, IN-LB
723	RTR 1,BLD 7,STA 6, BEAM BEND MOM, IN-LB
724	RTR 1,BLD 1,STA 5, BEAM BEND MOM, IN-LB
725	RTR 1,BLD 2,STA 5, BEAM BEND MOM, IN-LB
726	RTR 1,BLD 3,STA 5, BEAM BEND MOM, IN-LB
727	RTR 1,BLD 4,STA 5, BEAM BEND MOM, IN-LB
728	RTR 1,BLD 5,STA 5, BEAM BEND MOM, IN-LB
729	RTR 1,BLD 6,STA 5, BEAM BEND MOM, IN-LB
730	RTR 1,BLD 7,STA 5, BEAM BEND MOM, IN-LB
731	RTR 1,BLD 1,STA 4, BEAM BEND MOM, IN-LB
732	RTR 1,BLD 2,STA 4, BEAM BEND MOM, IN-LB
733	RTR 1,BLD 3,STA 4, BEAM BEND MOM, IN-LB
734	RTR 1,BLD 4,STA 4, BEAM BEND MOM, IN-LB
735	RTR 1,BLD 5,STA 4, BEAM BEND MOM, IN-LB
736	RTR 1,BLD 6,STA 4, BEAM BEND MOM, IN-LB
737	RTR 1,BLD 7,STA 4, BEAM BEND MOM, IN-LB
738	RTR 1,BLD 1,STA 3, BEAM BEND MOM, IN-LB
739	RTR 1,BLD 2,STA 3, BEAM BEND MOM, IN-LB
740	RTR 1,BLD 3,STA 3, BEAM BEND MOM, IN-LB
741	RTR 1,BLD 4,STA 3, BEAM BEND MOM, IN-LB
742	RTR 1,BLD 5,STA 3, BEAM BEND MOM, IN-LB
743	RTR 1,BLD 6,STA 3, BEAM BEND MOM, IN-LB
744	RTR 1,BLD 7,STA 3, BEAM BEND MOM, IN-LB
745	RTR 1,BLD 1,STA 2, BEAM BEND MOM, IN-LB
746	RTR 1,BLD 2,STA 2, BEAM BEND MOM, IN-LB
747	RTR 1,BLD 3,STA 2, BEAM BEND MOM, IN-LB
748	RTR 1,BLD 4,STA 2, BEAM BEND MOM, IN-LB
749	RTR 1,BLD 5,STA 2, BEAM BEND MOM, IN-LB
750	RTR 1,BLD 6,STA 2, BEAM BEND MOM, IN-LB
751	RTR 1,BLD 7,STA 2, BEAM BEND MOM, IN-LB
752	RTR 1,BLD 1,STA 1, BEAM BEND MOM, IN-LB
753	RTR 1,BLD 2,STA 1, BEAM BEND MOM, IN-LB
754	RTR 1,BLD 3,STA 1, BEAM BEND MOM, IN-LB
755	RTR 1,BLD 4,STA 1, BEAM BEND MOM, IN-LB
756	RTR 1,BLD 5,STA 1, BEAM BEND MOM, IN-LB
757	RTR 1,BLD 6,STA 1, BEAM BEND MOM, IN-LB
758	RTR 1,BLD 7,STA 1, BEAM BEND MOM, IN-LB
759	RTR 1,BLD 1,STA 0, BEAM BEND MOM, IN-LB
760	RTR 1,BLD 2,STA 0, BEAM BEND MOM, IN-LB
761	RTR 1,BLD 3,STA 0, BEAM BEND MOM, IN-LB
762	RTR 1,BLD 4,STA 0, BEAM BEND MOM, IN-LB
763	RTR 1,BLD 5,STA 0, BEAM BEND MOM, IN-LB
764	RTR 1,BLD 6,STA 0, BEAM BEND MOM, IN-LB
765	RTR 1,BLD 7,STA 0, BEAM BEND MOM, IN-LB
766	RTR 1,BLD 1,STA 19, CHRD BEND MOM, IN-LB
767	RTR 1,BLD 2,STA 19, CHRD BEND MOM, IN-LB
768	RTR 1,BLD 3,STA 19, CHRD BEND MOM, IN-LB
769	RTR 1,BLD 4,STA 19, CHRD BEND MOM, IN-LB
770	RTR 1,BLD 5,STA 19, CHRD BEND MOM, IN-LB
771	RTR 1,BLD 6,STA 19, CHRD BEND MOM, IN-LB
772	RTR 1,BLD 7,STA 19, CHRD BEND MOM, IN-LB
773	RTR 1,BLD 1,STA 18, CHRD BEND MOM, IN-LB
774	RTR 1,BLD 2,STA 18, CHRD BEND MOM, IN-LB
775	RTR 1,BLD 3,STA 18, CHRD BEND MOM, IN-LB
776	RTR 1,BLD 4,STA 18, CHRD BEND MOM, IN-LB
777	RTR 1,BLD 5,STA 18, CHRD BEND MOM, IN-LB
778	RTR 1,BLD 6,STA 18, CHRD BEND MOM, IN-LB
779	RTR 1,BLD 7,STA 18, CHRD BEND MOM, IN-LB
780	RTR 1,BLD 1,STA 17, CHRD BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
781	RTR 1,BLD 2,STA 17, CHRD BEND MOM, IN-LB
782	RTR 1,BLD 3,STA 17, CHRD BEND MOM, IN-LB
783	RTR 1,BLD 4,STA 17, CHRD BEND MOM, IN-LB
784	RTR 1,BLD 5,STA 17, CHRD BEND MOM, IN-LB
785	RTR 1,BLD 6,STA 17, CHRD BEND MOM, IN-LB
786	RTR 1,BLD 7,STA 17, CHRD BEND MOM, IN-LB
787	RTR 1,BLD 1,STA 16, CHRD BEND MOM, IN-LB
788	RTR 1,BLD 2,STA 16, CHRD BEND MOM, IN-LB
789	RTR 1,BLD 3,STA 16, CHRD BEND MOM, IN-LB
790	RTR 1,BLD 4,STA 16, CHRD BEND MOM, IN-LB
791	RTR 1,BLD 5,STA 16, CHRD BEND MOM, IN-LB
792	RTR 1,BLD 6,STA 16, CHRD BEND MOM, IN-LB
793	RTR 1,BLD 7,STA 16, CHRD BEND MOM, IN-LB
794	RTR 1,BLD 1,STA 15, CHRD BEND MOM, IN-LB
795	RTR 1,BLD 2,STA 15, CHRD BEND MOM, IN-LB
796	RTR 1,BLD 3,STA 15, CHRD BEND MOM, IN-LB
797	RTR 1,BLD 4,STA 15, CHRD BEND MOM, IN-LB
798	RTR 1,BLD 5,STA 15, CHRD BEND MOM, IN-LB
799	RTR 1,BLD 6,STA 15, CHRD BEND MOM, IN-LB
800	RTR 1,BLD 7,STA 15, CHRD BEND MOM, IN-LB
801	RTR 1,BLD 1,STA 14, CHRD BEND MOM, IN-LB
802	RTR 1,BLD 2,STA 14, CHRD BEND MOM, IN-LB
803	RTR 1,BLD 3,STA 14, CHRD BEND MOM, IN-LB
804	RTR 1,BLD 4,STA 14, CHRD BEND MOM, IN-LB
805	RTR 1,BLD 5,STA 14, CHRD BEND MOM, IN-LB
806	RTR 1,BLD 6,STA 14, CHRD BEND MOM, IN-LB
807	RTR 1,BLD 7,STA 14, CHRD BEND MOM, IN-LB
808	RTR 1,BLD 1,STA 13, CHRD BEND MOM, IN-LB
809	RTR 1,BLD 2,STA 13, CHRD BEND MOM, IN-LB
810	RTR 1,BLD 3,STA 13, CHRD BEND MOM, IN-LB
811	RTR 1,BLD 4,STA 13, CHRD BEND MOM, IN-LB
812	RTR 1,BLD 5,STA 13, CHRD BEND MOM, IN-LB
813	RTR 1,BLD 6,STA 13, CHRD BEND MOM, IN-LB
814	RTR 1,BLD 7,STA 13, CHRD BEND MOM, IN-LB
815	RTR 1,BLD 1,STA 12, CHRD BEND MOM, IN-LB
816	RTR 1,BLD 2,STA 12, CHRD BEND MOM, IN-LB
817	RTR 1,BLD 3,STA 12, CHRD BEND MOM, IN-LB
818	RTR 1,BLD 4,STA 12, CHRD BEND MOM, IN-LB
819	RTR 1,BLD 5,STA 12, CHRD BEND MOM, IN-LB
820	RTR 1,BLD 6,STA 12, CHRD BEND MOM, IN-LB
821	RTR 1,BLD 7,STA 12, CHRD BEND MOM, IN-LB
822	RTR 1,BLD 1,STA 11, CHRD BEND MOM, IN-LB
823	RTR 1,BLD 2,STA 11, CHRD BEND MOM, IN-LB
824	RTR 1,BLD 3,STA 11, CHRD BEND MOM, IN-LB
825	RTR 1,BLD 4,STA 11, CHRD BEND MOM, IN-LB
826	RTR 1,BLD 5,STA 11, CHRD BEND MOM, IN-LB
827	RTR 1,BLD 6,STA 11, CHRD BEND MOM, IN-LB
828	RTR 1,BLD 7,STA 11, CHRD BEND MOM, IN-LB
829	RTR 1,BLD 1,STA 10, CHRD BEND MOM, IN-LB
830	RTR 1,BLD 2,STA 10, CHRD BEND MOM, IN-LB
831	RTR 1,BLD 3,STA 10, CHRD BEND MOM, IN-LB
832	RTR 1,BLD 4,STA 10, CHRD BEND MOM, IN-LB
833	RTR 1,BLD 5,STA 10, CHRD BEND MOM, IN-LB
834	RTR 1,BLD 6,STA 10, CHRD BEND MOM, IN-LB
835	RTR 1,BLD 7,STA 10, CHRD BEND MOM, IN-LB
836	RTR 1,BLD 1,STA 9, CHRD BEND MOM, IN-LB
837	RTR 1,BLD 2,STA 9, CHRD BEND MOM, IN-LB
838	RTR 1,BLD 3,STA 9, CHRD BEND MOM, IN-LB
839	RTR 1,BLD 4,STA 9, CHRD BEND MOM, IN-LB
840	RTR 1,BLD 5,STA 9, CHRD BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
841	RTR 1,BLD 6,STA 9, CHRD BEND MOM, IN-LB
842	RTR 1,BLD 7,STA 9, CHRD BEND MOM, IN-LB
843	RTR 1,BLD 1,STA 8, CHRD BEND MOM, IN-LB
844	RTR 1,BLD 2,STA 8, CHRD BEND MOM, IN-LB
845	RTR 1,BLD 3,STA 8, CHRD BEND MOM, IN-LB
846	RTR 1,BLD 4,STA 8, CHRD BEND MOM, IN-LB
847	RTR 1,BLD 5,STA 8, CHRD BEND MOM, IN-LB
848	RTR 1,BLD 6,STA 8, CHRD BEND MOM, IN-LB
849	RTR 1,BLD 7,STA 8, CHRD BEND MOM, IN-LB
850	RTR 1,BLD 1,STA 7, CHRD BEND MOM, IN-LB
851	RTR 1,BLD 2,STA 7, CHRD BEND MOM, IN-LB
852	RTR 1,BLD 3,STA 7, CHRD BEND MOM, IN-LB
853	RTR 1,BLD 4,STA 7, CHRD BEND MOM, IN-LB
854	RTR 1,BLD 5,STA 7, CHRD BEND MOM, IN-LB
855	RTR 1,BLD 6,STA 7, CHRD BEND MOM, IN-LB
856	RTR 1,BLD 7,STA 7, CHRD BEND MOM, IN-LB
857	RTR 1,BLD 1,STA 6, CHRD BEND MOM, IN-LB
858	RTR 1,BLD 2,STA 6, CHRD BEND MOM, IN-LB
859	RTR 1,BLD 3,STA 6, CHRD BEND MOM, IN-LB
860	RTR 1,BLD 4,STA 6, CHRD BEND MOM, IN-LB
861	RTR 1,BLD 5,STA 6, CHRD BEND MOM, IN-LB
862	RTR 1,BLD 6,STA 6, CHRD BEND MOM, IN-LB
863	RTR 1,BLD 7,STA 6, CHRD BEND MOM, IN-LB
864	RTR 1,BLD 1,STA 5, CHRD BEND MOM, IN-LB
865	RTR 1,BLD 2,STA 5, CHRD BEND MOM, IN-LB
866	RTR 1,BLD 3,STA 5, CHRD BEND MOM, IN-LB
867	RTR 1,BLD 4,STA 5, CHRD BEND MOM, IN-LB
868	RTR 1,BLD 5,STA 5, CHRD BEND MOM, IN-LB
869	RTR 1,BLD 6,STA 5, CHRD BEND MOM, IN-LB
870	RTR 1,BLD 7,STA 5, CHRD BEND MOM, IN-LB
871	RTR 1,BLD 1,STA 4, CHRD BEND MOM, IN-LB
872	RTR 1,BLD 2,STA 4, CHRD BEND MOM, IN-LB
873	RTR 1,BLD 3,STA 4, CHRD BEND MOM, IN-LB
874	RTR 1,BLD 4,STA 4, CHRD BEND MOM, IN-LB
875	RTR 1,BLD 5,STA 4, CHRD BEND MOM, IN-LB
876	RTR 1,BLD 6,STA 4, CHRD BEND MOM, IN-LB
877	RTR 1,BLD 7,STA 4, CHRD BEND MOM, IN-LB
878	RTR 1,BLD 1,STA 3, CHRD BEND MOM, IN-LB
879	RTR 1,BLD 2,STA 3, CHRD BEND MOM, IN-LB
880	RTR 1,BLD 3,STA 3, CHRD BEND MOM, IN-LB
881	RTR 1,BLD 4,STA 3, CHRD BEND MOM, IN-LB
882	RTR 1,BLD 5,STA 3, CHRD BEND MOM, IN-LB
883	RTR 1,BLD 6,STA 3, CHRD BEND MOM, IN-LB
884	RTR 1,BLD 7,STA 3, CHRD BEND MOM, IN-LB
885	RTR 1,BLD 1,STA 2, CHRD BEND MOM, IN-LB
886	RTR 1,BLD 2,STA 2, CHRD BEND MOM, IN-LB
887	RTR 1,BLD 3,STA 2, CHRD BEND MOM, IN-LB
888	RTR 1,BLD 4,STA 2, CHRD BEND MOM, IN-LB
889	RTR 1,BLD 5,STA 2, CHRD BEND MOM, IN-LB
890	RTR 1,BLD 6,STA 2, CHRD BEND MOM, IN-LB
891	RTR 1,BLD 7,STA 2, CHRD BEND MOM, IN-LB
892	RTR 1,BLD 1,STA 1, CHRD BEND MOM, IN-LB
893	RTR 1,BLD 2,STA 1, CHRD BEND MOM, IN-LB
894	RTR 1,BLD 3,STA 1, CHRD BEND MOM, IN-LB
895	RTR 1,BLD 4,STA 1, CHRD BEND MOM, IN-LB
896	RTR 1,BLD 5,STA 1, CHRD BEND MOM, IN-LB
897	RTR 1,BLD 6,STA 1, CHRD BEND MOM, IN-LB
898	RTR 1,BLD 7,STA 1, CHRD BEND MOM, IN-LB
899	RTR 1,BLD 1,STA 0, CHRD BEND MOM, IN-LB
900	RTR 1,BLD 2,STA 0, CHRD BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
901	RTR 1,BLD 3,STA 0, CHRD BEND MOM, IN-LB
902	RTR 1,BLD 4,STA 0, CHRD BEND MOM, IN-LB
903	RTR 1,BLD 5,STA 0, CHRD BEND MOM, IN-LB
904	RTR 1,BLD 6,STA 0, CHRD BEND MOM, IN-LB
905	RTR 1,BLD 7,STA 0, CHRD BEND MOM, IN-LB
906	RTR 1,BLD 1,STA 19, TORS MOM, IN-LB
907	RTR 1,BLD 2,STA 19, TORS MOM, IN-LB
908	RTR 1,BLD 3,STA 19, TORS MOM, IN-LB
909	RTR 1,BLD 4,STA 19, TORS MOM, IN-LB
910	RTR 1,BLD 5,STA 19, TORS MOM, IN-LB
911	RTR 1,BLD 6,STA 19, TORS MOM, IN-LB
912	RTR 1,BLD 7,STA 19, TORS MOM, IN-LB
913	RTR 1,BLD 1,STA 18, TORS MOM, IN-LB
914	RTR 1,BLD 2,STA 18, TORS MOM, IN-LB
915	RTR 1,BLD 3,STA 18, TORS MOM, IN-LB
916	RTR 1,BLD 4,STA 18, TORS MOM, IN-LB
917	RTR 1,BLD 5,STA 18, TORS MOM, IN-LB
918	RTR 1,BLD 6,STA 18, TORS MOM, IN-LB
919	RTR 1,BLD 7,STA 18, TORS MOM, IN-LB
920	RTR 1,BLD 1,STA 17, TORS MOM, IN-LB
921	RTR 1,BLD 2,STA 17, TORS MOM, IN-LB
922	RTR 1,BLD 3,STA 17, TORS MOM, IN-LB
923	RTR 1,BLD 4,STA 17, TORS MOM, IN-LB
924	RTR 1,BLD 5,STA 17, TORS MOM, IN-LB
925	RTR 1,BLD 6,STA 17, TORS MOM, IN-LB
926	RTR 1,BLD 7,STA 17, TORS MOM, IN-LB
927	RTR 1,BLD 1,STA 16, TORS MOM, IN-LB
928	RTR 1,BLD 2,STA 16, TORS MOM, IN-LB
929	RTR 1,BLD 3,STA 16, TORS MOM, IN-LB
930	RTR 1,BLD 4,STA 16, TORS MOM, IN-LB
931	RTR 1,BLD 5,STA 16, TORS MOM, IN-LB
932	RTR 1,BLD 6,STA 16, TORS MOM, IN-LB
933	RTR 1,BLD 7,STA 16, TORS MOM, IN-LB
934	RTR 1,BLD 1,STA 15, TORS MOM, IN-LB
935	RTR 1,BLD 2,STA 15, TORS MOM, IN-LB
936	RTR 1,BLD 3,STA 15, TORS MOM, IN-LB
937	RTR 1,BLD 4,STA 15, TORS MOM, IN-LB
938	RTR 1,BLD 5,STA 15, TORS MOM, IN-LB
939	RTR 1,BLD 6,STA 15, TORS MOM, IN-LB
940	RTR 1,BLD 7,STA 15, TORS MOM, IN-LB
941	RTR 1,BLD 1,STA 14, TORS MOM, IN-LB
942	RTR 1,BLD 2,STA 14, TORS MOM, IN-LB
943	RTR 1,BLD 3,STA 14, TORS MOM, IN-LB
944	RTR 1,BLD 4,STA 14, TORS MOM, IN-LB
945	RTR 1,BLD 5,STA 14, TORS MOM, IN-LB
946	RTR 1,BLD 6,STA 14, TORS MOM, IN-LB
947	RTR 1,BLD 7,STA 14, TORS MOM, IN-LB
948	RTR 1,BLD 1,STA 13, TORS MOM, IN-LB
949	RTR 1,BLD 2,STA 13, TORS MOM, IN-LB
950	RTR 1,BLD 3,STA 13, TORS MOM, IN-LB
951	RTR 1,BLD 4,STA 13, TORS MOM, IN-LB
952	RTR 1,BLD 5,STA 13, TORS MOM, IN-LB
953	RTR 1,BLD 6,STA 13, TORS MOM, IN-LB
954	RTR 1,BLD 7,STA 13, TORS MOM, IN-LB
955	RTR 1,BLD 1,STA 12, TORS MOM, IN-LB
956	RTR 1,BLD 2,STA 12, TORS MOM, IN-LB
957	RTR 1,BLD 3,STA 12, TORS MOM, IN-LB
958	RTR 1,BLD 4,STA 12, TORS MOM, IN-LB
959	RTR 1,BLD 5,STA 12, TORS MOM, IN-LB
960	RTR 1,BLD 6,STA 12, TORS MOM, IN-LB

TABLE 22. Continued.

Number	Description
961	RTR 1.BLD 7.STA 12. TORS MOM, IN-LB
962	RTR 1.BLD 1.STA 11. TORS MOM, IN-LB
963	RTR 1.BLD 2.STA 11. TORS MOM, IN-LB
964	RTR 1.BLD 3.STA 11. TORS MOM, IN-LB
965	RTR 1.BLD 4.STA 11. TORS MOM, IN-LB
966	RTR 1.BLD 5.STA 11. TORS MOM, IN-LB
967	RTR 1.BLD 6.STA 11. TORS MOM, IN-LB
968	RTR 1.BLD 7.STA 11. TORS MOM, IN-LB
969	RTR 1.BLD 1.STA 10. TORS MOM, IN-LB
970	RTR 1.BLD 2.STA 10. TORS MOM, IN-LB
971	RTR 1.BLD 3.STA 10. TORS MOM, IN-LB
972	RTR 1.BLD 4.STA 10. TORS MOM, IN-LB
973	RTR 1.BLD 5.STA 10. TORS MOM, IN-LB
974	RTR 1.BLD 6.STA 10. TORS MOM, IN-LB
975	RTR 1.BLD 7.STA 10. TORS MOM, IN-LB
976	RTR 1.BLD 1.STA 9. TORS MOM, IN-LB
977	RTR 1.BLD 2.STA 9. TORS MOM, IN-LB
978	RTR 1.BLD 3.STA 9. TORS MOM, IN-LB
979	RTR 1.BLD 4.STA 9. TORS MOM, IN-LB
980	RTR 1.BLD 5.STA 9. TORS MOM, IN-LB
981	RTR 1.BLD 6.STA 9. TORS MOM, IN-LB
982	RTR 1.BLD 7.STA 9. TORS MOM, IN-LB
983	RTR 1.BLD 1.STA 8. TORS MOM, IN-LB
984	RTR 1.BLD 2.STA 8. TORS MOM, IN-LB
985	RTR 1.BLD 3.STA 8. TORS MOM, IN-LB
986	RTR 1.BLD 4.STA 8. TORS MOM, IN-LB
987	RTR 1.BLD 5.STA 8. TORS MOM, IN-LB
988	RTR 1.BLD 6.STA 8. TORS MOM, IN-LB
989	RTR 1.BLD 7.STA 8. TORS MOM, IN-LB
990	RTR 1.BLD 1.STA 7. TORS MOM, IN-LB
991	RTR 1.BLD 2.STA 7. TORS MOM, IN-LB
992	RTR 1.BLD 3.STA 7. TORS MOM, IN-LB
993	RTR 1.BLD 4.STA 7. TORS MOM, IN-LB
994	RTR 1.BLD 5.STA 7. TORS MOM, IN-LB
995	RTR 1.BLD 6.STA 7. TORS MOM, IN-LB
996	RTR 1.BLD 7.STA 7. TORS MOM, IN-LB
997	RTR 1.BLD 1.STA 6. TORS MOM, IN-LB
998	RTR 1.BLD 2.STA 6. TORS MOM, IN-LB
999	RTR 1.BLD 3.STA 6. TORS MOM, IN-LB
1000	RTR 1.BLD 4.STA 6. TORS MOM, IN-LB
1001	RTR 1.BLD 5.STA 6. TORS MOM, IN-LB
1002	RTR 1.BLD 6.STA 6. TORS MOM, IN-LB
1003	RTR 1.BLD 7.STA 6. TORS MOM, IN-LB
1004	RTR 1.BLD 1.STA 5. TORS MOM, IN-LB
1005	RTR 1.BLD 2.STA 5. TORS MOM, IN-LB
1006	RTR 1.BLD 3.STA 5. TORS MOM, IN-LB
1007	RTR 1.BLD 4.STA 5. TORS MOM, IN-LB
1008	RTR 1.BLD 5.STA 5. TORS MOM, IN-LB
1009	RTR 1.BLD 6.STA 5. TORS MOM, IN-LB
1010	RTR 1.BLD 7.STA 5. TORS MOM, IN-LB
1011	RTR 1.BLD 1.STA 4. TORS MOM, IN-LB
1012	RTR 1.BLD 2.STA 4. TORS MOM, IN-LB
1013	RTR 1.BLD 3.STA 4. TORS MOM, IN-LB
1014	RTR 1.BLD 4.STA 4. TORS MOM, IN-LB
1015	RTR 1.BLD 5.STA 4. TORS MOM, IN-LB
1016	RTR 1.BLD 6.STA 4. TORS MOM, IN-LB
1017	RTR 1.BLD 7.STA 4. TORS MOM, IN-LB
1018	RTR 1.BLD 1.STA 3. TORS MOM, IN-LB
1019	RTR 1.BLD 2.STA 3. TORS MOM, IN-LB
1020	RTR 1.BLD 3.STA 3. TORS MOM, IN-LB

TABLE 22. Continued.

Number	Description
1021	RTR 1,BLD 4,STA 3, TORS MOM, IN-LB
1022	RTR 1,BLD 5,STA 3, TORS MOM, IN-LB
1023	RTR 1,BLD 6,STA 3, TORS MOM, IN-LB
1024	RTR 1,BLD 7,STA 3, TORS MOM, IN-LB
1025	RTR 1,BLD 1,STA 2, TORS MOM, IN-LB
1026	RTR 1,BLD 2,STA 2, TORS MOM, IN-LB
1027	RTR 1,BLD 3,STA 2, TORS MOM, IN-LB
1028	RTR 1,BLD 4,STA 2, TORS MOM, IN-LB
1029	RTR 1,BLD 5,STA 2, TORS MOM, IN-LB
1030	RTR 1,BLD 6,STA 2, TORS MOM, IN-LB
1031	RTR 1,BLD 7,STA 2, TORS MOM, IN-LB
1032	RTR 1,BLD 1,STA 1, TORS MOM, IN-LB
1033	RTR 1,BLD 2,STA 1, TORS MOM, IN-LB
1034	RTR 1,BLD 3,STA 1, TORS MOM, IN-LB
1035	RTR 1,BLD 4,STA 1, TORS MOM, IN-LB
1036	RTR 1,BLD 5,STA 1, TORS MOM, IN-LB
1037	RTR 1,BLD 6,STA 1, TORS MOM, IN-LB
1038	RTR 1,BLD 7,STA 1, TORS MOM, IN-LB
1039	RTR 1,BLD 1,STA 0, TORS MOM, IN-LB
1040	RTR 1,BLD 2,STA 0, TORS MOM, IN-LB
1041	RTR 1,BLD 3,STA 0, TORS MOM, IN-LB
1042	RTR 1,BLD 4,STA 0, TORS MOM, IN-LB
1043	RTR 1,BLD 5,STA 0, TORS MOM, IN-LB
1044	RTR 1,BLD 6,STA 0, TORS MOM, IN-LB
1045	RTR 1,BLD 7,STA 0, TORS MOM, IN-LB
1046	RTR 2,BLD 1,STA 19, BEAM BEND MOM, IN-LB
1047	RTR 2,BLD 2,STA 19, BEAM BEND MOM, IN-LB
1048	RTR 2,BLD 3,STA 19, BEAM BEND MOM, IN-LB
1049	RTR 2,BLD 4,STA 19, BEAM BEND MOM, IN-LB
1050	RTR 2,BLD 5,STA 19, BEAM BEND MOM, IN-LB
1051	RTR 2,BLD 6,STA 19, BEAM BEND MOM, IN-LB
1052	RTR 2,BLD 7,STA 19, BEAM BEND MOM, IN-LB
1053	RTR 2,BLD 1,STA 18, BEAM BEND MOM, IN-LB
1054	RTR 2,BLD 2,STA 18, BEAM BEND MOM, IN-LB
1055	RTR 2,BLD 3,STA 18, BEAM BEND MOM, IN-LB
1056	RTR 2,BLD 4,STA 18, BEAM BEND MOM, IN-LB
1057	RTR 2,BLD 5,STA 18, BEAM BEND MOM, IN-LB
1058	RTR 2,BLD 6,STA 18, BEAM BEND MOM, IN-LB
1059	RTR 2,BLD 7,STA 18, BEAM BEND MOM, IN-LB
1060	RTR 2,BLD 1,STA 17, BEAM BEND MOM, IN-LB
1061	RTR 2,BLD 2,STA 17, BEAM BEND MOM, IN-LB
1062	RTR 2,BLD 3,STA 17, BEAM BEND MOM, IN-LB
1063	RTR 2,BLD 4,STA 17, BEAM BEND MOM, IN-LB
1064	RTR 2,BLD 5,STA 17, BEAM BEND MOM, IN-LB
1065	RTR 2,BLD 6,STA 17, BEAM BEND MOM, IN-LB
1066	RTR 2,BLD 7,STA 17, BEAM BEND MOM, IN-LB
1067	RTR 2,BLD 1,STA 16, BEAM BEND MOM, IN-LB
1068	RTR 2,BLD 2,STA 16, BEAM BEND MOM, IN-LB
1069	RTR 2,BLD 3,STA 16, BEAM BEND MOM, IN-LB
1070	RTR 2,BLD 4,STA 16, BEAM BEND MOM, IN-LB
1071	RTR 2,BLD 5,STA 16, BEAM BEND MOM, IN-LB
1072	RTR 2,BLD 6,STA 16, BEAM BEND MOM, IN-LB
1073	RTR 2,BLD 7,STA 16, BEAM BEND MOM, IN-LB
1074	RTR 2,BLD 1,STA 15, BEAM BEND MOM, IN-LB
1075	RTR 2,BLD 2,STA 15, BEAM BEND MOM, IN-LB
1076	RTR 2,BLD 3,STA 15, BEAM BEND MOM, IN-LB
1077	RTR 2,BLD 4,STA 15, BEAM BEND MOM, IN-LB
1078	RTR 2,BLD 5,STA 15, BEAM BEND MOM, IN-LB
1079	RTR 2,BLD 6,STA 15, BEAM BEND MOM, IN-LB
1080	RTR 2,BLD 7,STA 15, BEAM BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
1081	RTR 2,BLD 1,STA 14, BEAM BEND MOM, IN-LB
1082	RTR 2,BLD 2,STA 14, BEAM BEND MOM, IN-LB
1083	RTR 2,BLD 3,STA 14, BEAM BEND MOM, IN-LB
1084	RTR 2,BLD 4,STA 14, BEAM BEND MOM, IN-LB
1085	RTR 2,BLD 5,STA 14, BEAM BEND MOM, IN-LB
1086	RTR 2,BLD 6,STA 14, BEAM BEND MOM, IN-LB
1087	RTR 2,BLD 7,STA 14, BEAM BEND MOM, IN-LB
1088	RTR 2,BLD 1,STA 13, BEAM BEND MOM, IN-LB
1089	RTR 2,BLD 2,STA 13, BEAM BEND MOM, IN-LB
1090	RTR 2,BLD 3,STA 13, BEAM BEND MOM, IN-LB
1091	RTR 2,BLD 4,STA 13, BEAM BEND MOM, IN-LB
1092	RTR 2,BLD 5,STA 13, BEAM BEND MOM, IN-LB
1093	RTR 2,BLD 6,STA 13, BEAM BEND MOM, IN-LB
1094	RTR 2,BLD 7,STA 13, BEAM BEND MOM, IN-LB
1095	RTR 2,BLD 1,STA 12, BEAM BEND MOM, IN-LB
1096	RTR 2,BLD 2,STA 12, BEAM BEND MOM, IN-LB
1097	RTR 2,BLD 3,STA 12, BEAM BEND MOM, IN-LB
1098	RTR 2,BLD 4,STA 12, BEAM BEND MOM, IN-LB
1099	RTR 2,BLD 5,STA 12, BEAM BEND MOM, IN-LB
1100	RTR 2,BLD 6,STA 12, BEAM BEND MOM, IN-LB
1101	RTR 2,BLD 7,STA 12, BEAM BEND MOM, IN-LB
1102	RTR 2,BLD 1,STA 11, BEAM BEND MOM, IN-LB
1103	RTR 2,BLD 2,STA 11, BEAM BEND MOM, IN-LB
1104	RTR 2,BLD 3,STA 11, BEAM BEND MOM, IN-LB
1105	RTR 2,BLD 4,STA 11, BEAM BEND MOM, IN-LB
1106	RTR 2,BLD 5,STA 11, BEAM BEND MOM, IN-LB
1107	RTR 2,BLD 6,STA 11, BEAM BEND MOM, IN-LB
1108	RTR 2,BLD 7,STA 11, BEAM BEND MOM, IN-LB
1109	RTR 2,BLD 1,STA 10, BEAM BEND MOM, IN-LB
1110	RTR 2,BLD 2,STA 10, BEAM BEND MOM, IN-LB
1111	RTR 2,BLD 3,STA 10, BEAM BEND MOM, IN-LB
1112	RTR 2,BLD 4,STA 10, BEAM BEND MOM, IN-LB
1113	RTR 2,BLD 5,STA 10, BEAM BEND MOM, IN-LB
1114	RTR 2,BLD 6,STA 10, BEAM BEND MOM, IN-LB
1115	RTR 2,BLD 7,STA 10, BEAM BEND MOM, IN-LB
1116	RTR 2,BLD 1,STA 9, BEAM BEND MOM, IN-LB
1117	RTR 2,BLD 2,STA 9, BEAM BEND MOM, IN-LB
1118	RTR 2,BLD 3,STA 9, BEAM BEND MOM, IN-LB
1119	RTR 2,BLD 4,STA 9, BEAM BEND MOM, IN-LB
1120	RTR 2,BLD 5,STA 9, BEAM BEND MOM, IN-LB
1121	RTR 2,BLD 6,STA 9, BEAM BEND MOM, IN-LB
1122	RTR 2,BLD 7,STA 9, BEAM BEND MOM, IN-LB
1123	RTR 2,BLD 1,STA 8, BEAM BEND MOM, IN-LB
1124	RTR 2,BLD 2,STA 8, BEAM BEND MOM, IN-LB
1125	RTR 2,BLD 3,STA 8, BEAM BEND MOM, IN-LB
1126	RTR 2,BLD 4,STA 8, BEAM BEND MOM, IN-LB
1127	RTR 2,BLD 5,STA 8, BEAM BEND MOM, IN-LB
1128	RTR 2,BLD 6,STA 8, BEAM BEND MOM, IN-LB
1129	RTR 2,BLD 7,STA 8, BEAM BEND MOM, IN-LB
1130	RTR 2,BLD 1,STA 7, BEAM BEND MOM, IN-LB
1131	RTR 2,BLD 2,STA 7, BEAM BEND MOM, IN-LB
1132	RTR 2,BLD 3,STA 7, BEAM BEND MOM, IN-LB
1133	RTR 2,BLD 4,STA 7, BEAM BEND MOM, IN-LB
1134	RTR 2,BLD 5,STA 7, BEAM BEND MOM, IN-LB
1135	RTR 2,BLD 6,STA 7, BEAM BEND MOM, IN-LB
1136	RTR 2,BLD 7,STA 7, BEAM BEND MOM, IN-LB
1137	RTR 2,BLD 1,STA 6, BEAM BEND MOM, IN-LB
1138	RTR 2,BLD 2,STA 6, BEAM BEND MOM, IN-LB
1139	RTR 2,BLD 3,STA 6, BEAM BEND MOM, IN-LB
1140	RTR 2,BLD 4,STA 6, BEAM BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
1141	RTR 2,BLD 5,STA 6, BEAM BEND MOM, IN-LB
1142	RTR 2,BLD 6,STA 6, BEAM BEND MOM, IN-LB
1143	RTR 2,BLD 7,STA 6, BEAM BEND MOM, IN-LB
1144	RTR 2,BLD 1,STA 5, BEAM BEND MOM, IN-LB
1145	RTR 2,BLD 2,STA 5, BEAM BEND MOM, IN-LB
1146	RTR 2,BLD 3,STA 5, BEAM BEND MOM, IN-LB
1147	RTR 2,BLD 4,STA 5, BEAM BEND MOM, IN-LB
1148	RTR 2,BLD 5,STA 5, BEAM BEND MOM, IN-LB
1149	RTR 2,BLD 6,STA 5, BEAM BEND MOM, IN-LB
1150	RTR 2,BLD 7,STA 5, BEAM BEND MOM, IN-LB
1151	RTR 2,BLD 1,STA 4, BEAM BEND MOM, IN-LB
1152	RTR 2,BLD 2,STA 4, BEAM BEND MOM, IN-LB
1153	RTR 2,BLD 3,STA 4, BEAM BEND MOM, IN-LB
1154	RTR 2,BLD 4,STA 4, BEAM BEND MOM, IN-LB
1155	RTR 2,BLD 5,STA 4, BEAM BEND MOM, IN-LB
1156	RTR 2,BLD 6,STA 4, BEAM BEND MOM, IN-LB
1157	RTR 2,BLD 7,STA 4, BEAM BEND MOM, IN-LB
1158	RTR 2,BLD 1,STA 3, BEAM BEND MOM, IN-LB
1159	RTR 2,BLD 2,STA 3, BEAM BEND MOM, IN-LB
1160	RTR 2,BLD 3,STA 3, BEAM BEND MOM, IN-LB
1161	RTR 2,BLD 4,STA 3, BEAM BEND MOM, IN-LB
1162	RTR 2,BLD 5,STA 3, BEAM BEND MOM, IN-LB
1163	RTR 2,BLD 6,STA 3, BEAM BEND MOM, IN-LB
1164	RTR 2,BLD 7,STA 3, BEAM BEND MOM, IN-LB
1165	RTR 2,BLD 1,STA 2, BEAM BEND MOM, IN-LB
1166	RTR 2,BLD 2,STA 2, BEAM BEND MOM, IN-LB
1167	RTR 2,BLD 3,STA 2, BEAM BEND MOM, IN-LB
1168	RTR 2,BLD 4,STA 2, BEAM BEND MOM, IN-LB
1169	RTR 2,BLD 5,STA 2, BEAM BEND MOM, IN-LB
1170	RTR 2,BLD 6,STA 2, BEAM BEND MOM, IN-LB
1171	RTR 2,BLD 7,STA 2, BEAM BEND MOM, IN-LB
1172	RTR 2,BLD 1,STA 1, BEAM BEND MOM, IN-LB
1173	RTR 2,BLD 2,STA 1, BEAM BEND MOM, IN-LB
1174	RTR 2,BLD 3,STA 1, BEAM BEND MOM, IN-LB
1175	RTR 2,BLD 4,STA 1, BEAM BEND MOM, IN-LB
1176	RTR 2,BLD 5,STA 1, BEAM BEND MOM, IN-LB
1177	RTR 2,BLD 6,STA 1, BEAM BEND MOM, IN-LB
1178	RTR 2,BLD 7,STA 1, BEAM BEND MOM, IN-LB
1179	RTR 2,BLD 1,STA 0, BEAM BEND MOM, IN-LB
1180	RTR 2,BLD 2,STA 0, BEAM BEND MOM, IN-LB
1181	RTR 2,BLD 3,STA 0, BEAM BEND MOM, IN-LB
1182	RTR 2,BLD 4,STA 0, BEAM BEND MOM, IN-LB
1183	RTR 2,BLD 5,STA 0, BEAM BEND MOM, IN-LB
1184	RTR 2,BLD 6,STA 0, BEAM BEND MOM, IN-LB
1185	RTR 2,BLD 7,STA 0, BEAM BEND MOM, IN-LB
1186	RTR 2,BLD 1,STA 19, CHRD BEND MOM, IN-LB
1187	RTR 2,BLD 2,STA 19, CHRD BEND MOM, IN-LB
1188	RTR 2,BLD 3,STA 19, CHRD BEND MOM, IN-LB
1189	RTR 2,BLD 4,STA 19, CHRD BEND MOM, IN-LB
1190	RTR 2,BLD 5,STA 19, CHRD BEND MOM, IN-LB
1191	RTR 2,BLD 6,STA 19, CHRD BEND MOM, IN-LB
1192	RTR 2,BLD 7,STA 19, CHRD BEND MOM, IN-LB
1193	RTR 2,BLD 1,STA 18, CHRD BEND MOM, IN-LB
1194	RTR 2,BLD 2,STA 18, CHRD BEND MOM, IN-LB
1195	RTR 2,BLD 3,STA 18, CHRD BEND MOM, IN-LB
1196	RTR 2,BLD 4,STA 18, CHRD BEND MOM, IN-LB
1197	RTR 2,BLD 5,STA 18, CHRD BEND MOM, IN-LB
1198	RTR 2,BLD 6,STA 18, CHRD BEND MOM, IN-LB
1199	RTR 2,BLD 7,STA 18, CHRD BEND MOM, IN-LB
1200	RTR 2,BLD 1,STA 17, CHRD BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
1201	RTR 2,BLD 2,STA 17, CHRD BEND MOM, IN-LB
1202	RTR 2,BLD 3,STA 17, CHRD BEND MOM, IN-LB
1203	RTR 2,BLD 4,STA 17, CHRD BEND MOM, IN-LB
1204	RTR 2,BLD 5,STA 17, CHRD BEND MOM, IN-LB
1205	RTR 2,BLD 6,STA 17, CHRD BEND MOM, IN-LB
1206	RTR 2,BLD 7,STA 17, CHRD BEND MOM, IN-LB
1207	RTR 2,BLD 1,STA 16, CHRD BEND MOM, IN-LB
1208	RTR 2,BLD 2,STA 16, CHRD BEND MOM, IN-LB
1209	RTR 2,BLD 3,STA 16, CHRD BEND MOM, IN-LB
1210	RTR 2,BLD 4,STA 16, CHRD BEND MOM, IN-LB
1211	RTR 2,BLD 5,STA 16, CHRD BEND MOM, IN-LB
1212	RTR 2,BLD 6,STA 16, CHRD BEND MOM, IN-LB
1213	RTR 2,BLD 7,STA 16, CHRD BEND MOM, IN-LB
1214	RTR 2,BLD 1,STA 15, CHRD BEND MOM, IN-LB
1215	RTR 2,BLD 2,STA 15, CHRD BEND MOM, IN-LB
1216	RTR 2,BLD 3,STA 15, CHRD BEND MOM, IN-LB
1217	RTR 2,BLD 4,STA 15, CHRD BEND MOM, IN-LB
1218	RTR 2,BLD 5,STA 15, CHRD BEND MOM, IN-LB
1219	RTR 2,BLD 6,STA 15, CHRD BEND MOM, IN-LB
1220	RTR 2,BLD 7,STA 15, CHRD BEND MOM, IN-LB
1221	RTR 2,BLD 1,STA 14, CHRD BEND MOM, IN-LB
1222	RTR 2,BLD 2,STA 14, CHRD BEND MOM, IN-LB
1223	RTR 2,BLD 3,STA 14, CHRD BEND MOM, IN-LB
1224	RTR 2,BLD 4,STA 14, CHRD BEND MOM, IN-LB
1225	RTR 2,BLD 5,STA 14, CHRD BEND MOM, IN-LB
1226	RTR 2,BLD 6,STA 14, CHRD BEND MOM, IN-LB
1227	RTR 2,BLD 7,STA 14, CHRD BEND MOM, IN-LB
1228	RTR 2,BLD 1,STA 13, CHRD BEND MOM, IN-LB
1229	RTR 2,BLD 2,STA 13, CHRD BEND MOM, IN-LB
1230	RTR 2,BLD 3,STA 13, CHRD BEND MOM, IN-LB
1231	RTR 2,BLD 4,STA 13, CHRD BEND MOM, IN-LB
1232	RTR 2,BLD 5,STA 13, CHRD BEND MOM, IN-LB
1233	RTR 2,BLD 6,STA 13, CHRD BEND MOM, IN-LB
1234	RTR 2,BLD 7,STA 13, CHRD BEND MOM, IN-LB
1235	RTR 2,BLD 1,STA 12, CHRD BEND MOM, IN-LB
1236	RTR 2,BLD 2,STA 12, CHRD BEND MOM, IN-LB
1237	RTR 2,BLD 3,STA 12, CHRD BEND MOM, IN-LB
1238	RTR 2,BLD 4,STA 12, CHRD BEND MOM, IN-LB
1239	RTR 2,BLD 5,STA 12, CHRD BEND MOM, IN-LB
1240	RTR 2,BLD 6,STA 12, CHRD BEND MOM, IN-LB
1241	RTR 2,BLD 7,STA 12, CHRD BEND MOM, IN-LB
1242	RTR 2,BLD 1,STA 11, CHRD BEND MOM, IN-LB
1243	RTR 2,BLD 2,STA 11, CHRD BEND MOM, IN-LB
1244	RTR 2,BLD 3,STA 11, CHRD BEND MOM, IN-LB
1245	RTR 2,BLD 4,STA 11, CHRD BEND MOM, IN-LB
1246	RTR 2,BLD 5,STA 11, CHRD BEND MOM, IN-LB
1247	RTR 2,BLD 6,STA 11, CHRD BEND MOM, IN-LB
1248	RTR 2,BLD 7,STA 11, CHRD BEND MOM, IN-LB
1249	RTR 2,BLD 1,STA 10, CHRD BEND MOM, IN-LB
1250	RTR 2,BLD 2,STA 10, CHRD BEND MOM, IN-LB
1251	RTR 2,BLD 3,STA 10, CHRD BEND MOM, IN-LB
1252	RTR 2,BLD 4,STA 10, CHRD BEND MOM, IN-LB
1253	RTR 2,BLD 5,STA 10, CHRD BEND MOM, IN-LB
1254	RTR 2,BLD 6,STA 10, CHRD BEND MOM, IN-LB
1255	RTR 2,BLD 7,STA 10, CHRD BEND MOM, IN-LB
1256	RTR 2,BLD 1,STA 9, CHRD BEND MOM, IN-LB
1257	RTR 2,BLD 2,STA 9, CHRD BEND MOM, IN-LB
1258	RTR 2,BLD 3,STA 9, CHRD BEND MOM, IN-LB
1259	RTR 2,BLD 4,STA 9, CHRD BEND MOM, IN-LB
1260	RTR 2,BLD 5,STA 9, CHRD BEND MOM, IN-LB

TABLE 22. Continued.

Number	Description
1261	RTR 2.BLD 6.STA 9. CHRD BEND MOM. IN-LB
1262	RTR 2.BLD 7.STA 9. CHRD BEND MOM. IN-LB
1263	RTR 2.BLD 1.STA 8. CHRD BEND MOM. IN-LB
1264	RTR 2.BLD 2.STA 8. CHRD BEND MOM. IN-LB
1265	RTR 2.BLD 3.STA 8. CHRD BEND MOM. IN-LB
1266	RTR 2.BLD 4.STA 8. CHRD BEND MOM. IN-LB
1267	RTR 2.BLD 5.STA 8. CHRD BEND MOM. IN-LB
1268	RTR 2.BLD 6.STA 8. CHRD BEND MOM. IN-LB
1269	RTR 2.BLD 7.STA 8. CHRD BEND MOM. IN-LB
1270	RTR 2.BLD 1.STA 7. CHRD BEND MOM. IN-LB
1271	RTR 2.BLD 2.STA 7. CHRD BEND MOM. IN-LB
1272	RTR 2.BLD 3.STA 7. CHRD BEND MOM. IN-LB
1273	RTR 2.BLD 4.STA 7. CHRD BEND MOM. IN-LB
1274	RTR 2.BLD 5.STA 7. CHRD BEND MOM. IN-LB
1275	RTR 2.BLD 6.STA 7. CHRD BEND MOM. IN-LB
1276	RTR 2.BLD 7.STA 7. CHRD BEND MOM. IN-LB
1277	RTR 2.BLD 1.STA 6. CHRD BEND MOM. IN-LB
1278	RTR 2.BLD 2.STA 6. CHRD BEND MOM. IN-LB
1279	RTR 2.BLD 3.STA 6. CHRD BEND MOM. IN-LB
1280	RTR 2.BLD 4.STA 6. CHRD BEND MOM. IN-LB
1281	RTR 2.BLD 5.STA 6. CHRD BEND MOM. IN-LB
1282	RTR 2.BLD 6.STA 6. CHRD BEND MOM. IN-LB
1283	RTR 2.BLD 7.STA 6. CHRD BEND MOM. IN-LB
1284	RTR 2.BLD 1.STA 5. CHRD BEND MOM. IN-LB
1285	RTR 2.BLD 2.STA 5. CHRD BEND MOM. IN-LB
1286	RTR 2.BLD 3.STA 5. CHRD BEND MOM. IN-LB
1287	RTR 2.BLD 4.STA 5. CHRD BEND MOM. IN-LB
1288	RTR 2.BLD 5.STA 5. CHRD BEND MOM. IN-LB
1289	RTR 2.BLD 6.STA 5. CHRD BEND MOM. IN-LB
1290	RTR 2.BLD 7.STA 5. CHRD BEND MOM. IN-LB
1291	RTR 2.BLD 1.STA 4. CHRD BEND MOM. IN-LB
1292	RTR 2.BLD 2.STA 4. CHRD BEND MOM. IN-LB
1293	RTR 2.BLD 3.STA 4. CHRD BEND MOM. IN-LB
1294	RTR 2.BLD 4.STA 4. CHRD BEND MOM. IN-LB
1295	RTR 2.BLD 5.STA 4. CHRD BEND MOM. IN-LB
1296	RTR 2.BLD 6.STA 4. CHRD BEND MOM. IN-LB
1297	RTR 2.BLD 7.STA 4. CHRD BEND MOM. IN-LB
1298	RTR 2.BLD 1.STA 3. CHRD BEND MOM. IN-LB
1299	RTR 2.BLD 2.STA 3. CHRD BEND MOM. IN-LB
1300	RTR 2.BLD 3.STA 3. CHRD BEND MOM. IN-LB
1301	RTR 2.BLD 4.STA 3. CHRD BEND MOM. IN-LB
1302	RTR 2.BLD 5.STA 3. CHRD BEND MOM. IN-LB
1303	RTR 2.BLD 6.STA 3. CHRD BEND MOM. IN-LB
1304	RTR 2.BLD 7.STA 3. CHRD BEND MOM. IN-LB
1305	RTR 2.BLD 1.STA 2. CHRD BEND MOM. IN-LB
1306	RTR 2.BLD 2.STA 2. CHRD BEND MOM. IN-LB
1307	RTR 2.BLD 3.STA 2. CHRD BEND MOM. IN-LB
1308	RTR 2.BLD 4.STA 2. CHRD BEND MOM. IN-LB
1309	RTR 2.BLD 5.STA 2. CHRD BEND MOM. IN-LB
1310	RTR 2.BLD 6.STA 2. CHRD BEND MOM. IN-LB
1311	RTR 2.BLD 7.STA 2. CHRD BEND MOM. IN-LB
1312	RTR 2.BLD 1.STA 1. CHRD BEND MOM. IN-LB
1313	RTR 2.BLD 2.STA 1. CHRD BEND MOM. IN-LB
1314	RTR 2.BLD 3.STA 1. CHRD BEND MOM. IN-LB
1315	RTR 2.BLD 4.STA 1. CHRD BEND MOM. IN-LB
1316	RTR 2.BLD 5.STA 1. CHRD BEND MOM. IN-LB
1317	RTR 2.BLD 6.STA 1. CHRD BEND MOM. IN-LB
1318	RTR 2.BLD 7.STA 1. CHRD BEND MOM. IN-LB
1319	RTR 2.BLD 1.STA 0. CHRD BEND MOM. IN-LB
1320	RTR 2.BLD 2.STA 0. CHRD BEND MOM. IN-LB

TABLE 22. Continued.

Number	Description
1321	RTR 2,BLD 3,STA 0, CHRD BEND MOM, IN-LB
1322	RTR 2,BLD 4,STA 0, CHRD BEND MOM, IN-LB
1323	RTR 2,BLD 5,STA 0, CHRD BEND MOM, IN-LB
1324	RTR 2,BLD 6,STA 0, CHRD BEND MOM, IN-LB
1325	RTR 2,BLD 7,STA 0, CHRD BEND MOM, IN-LB
1326	RTR 2,BLD 1,STA 19, TORS MOM, IN-LB
1327	RTR 2,BLD 2,STA 19, TORS MOM, IN-LB
1328	RTR 2,BLD 3,STA 19, TORS MOM, IN-LB
1329	RTR 2,BLD 4,STA 19, TORS MOM, IN-LB
1330	RTR 2,BLD 5,STA 19, TORS MOM, IN-LB
1331	RTR 2,BLD 6,STA 19, TORS MOM, IN-LB
1332	RTR 2,BLD 7,STA 19, TORS MOM, IN-LB
1333	RTR 2,BLD 1,STA 18, TORS MOM, IN-LB
1334	RTR 2,BLD 2,STA 18, TORS MOM, IN-LB
1335	RTR 2,BLD 3,STA 18, TORS MOM, IN-LB
1336	RTR 2,BLD 4,STA 18, TORS MOM, IN-LB
1337	RTR 2,BLD 5,STA 18, TORS MOM, IN-LB
1338	RTR 2,BLD 6,STA 18, TORS MOM, IN-LB
1339	RTR 2,BLD 7,STA 18, TORS MOM, IN-LB
1340	RTR 2,BLD 1,STA 17, TORS MOM, IN-LB
1341	RTR 2,BLD 2,STA 17, TORS MOM, IN-LB
1342	RTR 2,BLD 3,STA 17, TORS MOM, IN-LB
1343	RTR 2,BLD 4,STA 17, TORS MOM, IN-LB
1344	RTR 2,BLD 5,STA 17, TORS MOM, IN-LB
1345	RTR 2,BLD 6,STA 17, TORS MOM, IN-LB
1346	RTR 2,BLD 7,STA 17, TORS MOM, IN-LB
1347	RTR 2,BLD 1,STA 16, TORS MOM, IN-LB
1348	RTR 2,BLD 2,STA 16, TORS MOM, IN-LB
1349	RTR 2,BLD 3,STA 16, TORS MOM, IN-LB
1350	RTR 2,BLD 4,STA 16, TORS MOM, IN-LB
1351	RTR 2,BLD 5,STA 16, TORS MOM, IN-LB
1352	RTR 2,BLD 6,STA 16, TORS MOM, IN-LB
1353	RTR 2,BLD 7,STA 16, TORS MOM, IN-LB
1354	RTR 2,BLD 1,STA 15, TORS MOM, IN-LB
1355	RTR 2,BLD 2,STA 15, TORS MOM, IN-LB
1356	RTR 2,BLD 3,STA 15, TORS MOM, IN-LB
1357	RTR 2,BLD 4,STA 15, TORS MOM, IN-LB
1358	RTR 2,BLD 5,STA 15, TORS MOM, IN-LB
1359	RTR 2,BLD 6,STA 15, TORS MOM, IN-LB
1360	RTR 2,BLD 7,STA 15, TORS MOM, IN-LB
1361	RTR 2,BLD 1,STA 14, TORS MOM, IN-LB
1362	RTR 2,BLD 2,STA 14, TORS MOM, IN-LB
1363	RTR 2,BLD 3,STA 14, TORS MOM, IN-LB
1364	RTR 2,BLD 4,STA 14, TORS MOM, IN-LB
1365	RTR 2,BLD 5,STA 14, TORS MOM, IN-LB
1366	RTR 2,BLD 6,STA 14, TORS MOM, IN-LB
1367	RTR 2,BLD 7,STA 14, TORS MOM, IN-LB
1368	RTR 2,BLD 1,STA 13, TORS MOM, IN-LB
1369	RTR 2,BLD 2,STA 13, TORS MOM, IN-LB
1370	RTR 2,BLD 3,STA 13, TORS MOM, IN-LB
1371	RTR 2,BLD 4,STA 13, TORS MOM, IN-LB
1372	RTR 2,BLD 5,STA 13, TORS MOM, IN-LB
1373	RTR 2,BLD 6,STA 13, TORS MOM, IN-LB
1374	RTR 2,BLD 7,STA 13, TORS MOM, IN-LB
1375	RTR 2,BLD 1,STA 12, TORS MOM, IN-LB
1376	RTR 2,BLD 2,STA 12, TORS MOM, IN-LB
1377	RTR 2,BLD 3,STA 12, TORS MOM, IN-LB
1378	RTR 2,BLD 4,STA 12, TORS MOM, IN-LB
1379	RTR 2,BLD 5,STA 12, TORS MOM, IN-LB
1380	RTR 2,BLD 6,STA 12, TORS MOM, IN-LB

TABLE 22. Continued.

Number	Description
1381	RTR 2,BLD 7,STA 12, TORS MOM, IN-LB
1382	RTR 2,BLD 1,STA 11, TORS MOM, IN-LB
1383	RTR 2,BLD 2,STA 11, TORS MOM, IN-LB
1384	RTR 2,BLD 3,STA 11, TORS MOM, IN-LB
1385	RTR 2,BLD 4,STA 11, TORS MOM, IN-LB
1386	RTR 2,BLD 5,STA 11, TORS MOM, IN-LB
1387	RTR 2,BLD 6,STA 11, TORS MOM, IN-LB
1388	RTR 2,BLD 7,STA 11, TORS MOM, IN-LB
1389	RTR 2,BLD 1,STA 10, TORS MOM, IN-LB
1390	RTR 2,BLD 2,STA 10, TORS MOM, IN-LB
1391	RTR 2,BLD 3,STA 10, TORS MOM, IN-LB
1392	RTR 2,BLD 4,STA 10, TORS MOM, IN-LB
1393	RTR 2,BLD 5,STA 10, TORS MOM, IN-LB
1394	RTR 2,BLD 6,STA 10, TORS MOM, IN-LB
1395	RTR 2,BLD 7,STA 10, TORS MOM, IN-LB
1396	RTR 2,BLD 1,STA 9, TORS MOM, IN-LB
1397	RTR 2,BLD 2,STA 9, TORS MOM, IN-LB
1398	RTR 2,BLD 3,STA 9, TORS MOM, IN-LB
1399	RTR 2,BLD 4,STA 9, TORS MOM, IN-LB
1400	RTR 2,BLD 5,STA 9, TORS MOM, IN-LB
1401	RTR 2,BLD 6,STA 9, TORS MOM, IN-LB
1402	RTR 2,BLD 7,STA 9, TORS MOM, IN-LB
1403	RTR 2,BLD 1,STA 8, TORS MOM, IN-LB
1404	RTR 2,BLD 2,STA 8, TORS MOM, IN-LB
1405	RTR 2,BLD 3,STA 8, TORS MOM, IN-LB
1406	RTR 2,BLD 4,STA 8, TORS MOM, IN-LB
1407	RTR 2,BLD 5,STA 8, TORS MOM, IN-LB
1408	RTR 2,BLD 6,STA 8, TORS MOM, IN-LB
1409	RTR 2,BLD 7,STA 8, TORS MOM, IN-LB
1410	RTR 2,BLD 1,STA 7, TORS MOM, IN-LB
1411	RTR 2,BLD 2,STA 7, TORS MOM, IN-LB
1412	RTR 2,BLD 3,STA 7, TORS MOM, IN-LB
1413	RTR 2,BLD 4,STA 7, TORS MOM, IN-LB
1414	RTR 2,BLD 5,STA 7, TORS MOM, IN-LB
1415	RTR 2,BLD 6,STA 7, TORS MOM, IN-LB
1416	RTR 2,BLD 7,STA 7, TORS MOM, IN-LB
1417	RTR 2,BLD 1,STA 6, TORS MOM, IN-LB
1418	RTR 2,BLD 2,STA 6, TORS MOM, IN-LB
1419	RTR 2,BLD 3,STA 6, TORS MOM, IN-LB
1420	RTR 2,BLD 4,STA 6, TORS MOM, IN-LB
1421	RTR 2,BLD 5,STA 6, TORS MOM, IN-LB
1422	RTR 2,BLD 6,STA 6, TORS MOM, IN-LB
1423	RTR 2,BLD 7,STA 6, TORS MOM, IN-LB
1424	RTR 2,BLD 1,STA 5, TORS MOM, IN-LB
1425	RTR 2,BLD 2,STA 5, TORS MOM, IN-LB
1426	RTR 2,BLD 3,STA 5, TORS MOM, IN-LB
1427	RTR 2,BLD 4,STA 5, TORS MOM, IN-LB
1428	RTR 2,BLD 5,STA 5, TORS MOM, IN-LB
1429	RTR 2,BLD 6,STA 5, TORS MOM, IN-LB
1430	RTR 2,BLD 7,STA 5, TORS MOM, IN-LB
1431	RTR 2,BLD 1,STA 4, TORS MOM, IN-LB
1432	RTR 2,BLD 2,STA 4, TORS MOM, IN-LB
1433	RTR 2,BLD 3,STA 4, TORS MOM, IN-LB
1434	RTR 2,BLD 4,STA 4, TORS MOM, IN-LB
1435	RTR 2,BLD 5,STA 4, TORS MOM, IN-LB
1436	RTR 2,BLD 6,STA 4, TORS MOM, IN-LB
1437	RTR 2,BLD 7,STA 4, TORS MOM, IN-LB
1438	RTR 2,BLD 1,STA 3, TORS MOM, IN-LB
1439	RTR 2,BLD 2,STA 3, TORS MOM, IN-LB
1440	RTR 2,BLD 3,STA 3, TORS MOM, IN-LB

TABLE 22. Continued.

Number	Description
1441	RTR 2,BLD 4,STA 3, TORS MOM, IN-LB
1442	RTR 2,BLD 5,STA 3, TORS MOM, IN-LB
1443	RTR 2,BLD 6,STA 3, TORS MOM, IN-LB
1444	RTR 2,BLD 7,STA 3, TORS MOM, IN-LB
1445	RTR 2,BLD 1,STA 2, TORS MOM, IN-LB
1446	RTR 2,BLD 2,STA 2, TORS MOM, IN-LB
1447	RTR 2,BLD 3,STA 2, TORS MOM, IN-LB
1448	RTR 2,BLD 4,STA 2, TORS MOM, IN-LB
1449	RTR 2,BLD 5,STA 2, TORS MOM, IN-LB
1450	RTR 2,BLD 6,STA 2, TORS MOM, IN-LB
1451	RTR 2,BLD 7,STA 2, TORS MOM, IN-LB
1452	RTR 2,BLD 1,STA 1, TORS MOM, IN-LB
1453	RTR 2,BLD 2,STA 1, TORS MOM, IN-LB
1454	RTR 2,BLD 3,STA 1, TORS MOM, IN-LB
1455	RTR 2,BLD 4,STA 1, TORS MOM, IN-LB
1456	RTR 2,BLD 5,STA 1, TORS MOM, IN-LB
1457	RTR 2,BLD 6,STA 1, TORS MOM, IN-LB
1458	RTR 2,BLD 7,STA 1, TORS MOM, IN-LB
1459	RTR 2,BLD 1,STA 0, TORS MOM, IN-LB
1460	RTR 2,BLD 2,STA 0, TORS MOM, IN-LB
1461	RTR 2,BLD 3,STA 0, TORS MOM, IN-LB
1462	RTR 2,BLD 4,STA 0, TORS MOM, IN-LB
1463	RTR 2,BLD 5,STA 0, TORS MOM, IN-LB
1464	RTR 2,BLD 6,STA 0, TORS MOM, IN-LB
1465	RTR 2,BLD 7,STA 0, TORS MOM, IN-LB
1466	GEN.COORD., PYLON 1, MODE 1
1467	GEN.COORD., PYLON 1, MODE 2
1468	GEN.COORD., PYLON 1, MODE 3
1469	GEN.COORD., PYLON 1, MODE 4
1470	GEN.COORD., PYLON 2, MODE 1
1471	GEN.COORD., PYLON 2, MODE 2
1472	GEN.COORD., PYLON 2, MODE 3
1473	GEN.COORD., PYLON 2, MODE 4
1474	PYLON 1, X-DISP., SHAFT AXES, FT
1475	PYLON 1, Y-DISP., SHAFT AXES, FT
1476	PYLON 1, Z-DISP., SHAFT AXES, FT
1477	PYLON 1, X-ANGLE, SHAFT AXES, DEG
1478	PYLON 1, Y-ANGLE, SHAFT AXES, DEG
1479	PYLON 1, Z-ANGLE, SHAFT AXES, DEG
1480	PYLON 2, X-DISP., SHAFT AXES, FT
1481	PYLON 2, Y-DISP., SHAFT AXES, FT
1482	PYLON 2, Z-DISP., SHAFT AXES, FT
1483	PYLON 2, X-ANGLE, SHAFT AXES, DEG
1484	PYLON 2, Y-ANGLE, SHAFT AXES, DEG
1485	PYLON 2, Z-ANGLE, SHAFT AXES, DEG
1486	RTR 1, BLD 1, PITCH LINK TENSION, LB
1487	RTR 1, BLD 2, PITCH LINK TENSION, LB
1488	RTR 1, BLD 3, PITCH LINK TENSION, LB
1489	RTR 1, BLD 4, PITCH LINK TENSION, LB
1490	RTR 1, BLD 5, PITCH LINK TENSION, LB
1491	RTR 1, BLD 6, PITCH LINK TENSION, LB
1492	RTR 1, BLD 7, PITCH LINK TENSION, LB
1493	NOT USED
1494	NOT USED
1495	NOT USED
1496	NOT USED
1497	NOT USED
1498	RTR 2, BLD 1, PITCH LINK TENSION, LB
1499	RTR 2, BLD 2, PITCH LINK TENSION, LB
1500	RTR 2, BLD 3, PITCH LINK TENSION, LB

TABLE 22. Continued.

Number	Description
1501	RTR 2, BLD 4, PITCH LINK TENSION, LB
1502	RTR 2, BLD 5, PITCH LINK TENSION, LB
1503	RTR 2, BLD 6, PITCH LINK TENSION, LB
1504	RTR 2, BLD 7, PITCH LINK TENSION, LB
1505	NOT USED
1506	NOT USED
1507	NOT USED
1508	NOT USED
1509	NOT USED
1510	PYLON 1, X-ACCELERATION, BODY AXIS, G
1511	PYLON 1, Y-ACCELERATION, BODY AXIS, G
1512	PYLON 1, Z-ACCELERATION, BODY AXIS, G
1513	PYLON 2, X-ACCELERATION, BODY AXIS, G
1514	PYLON 2, Y-ACCELERATION, BODY AXIS, G
1515	PYLON 2, Z-ACCELERATION, BODY AXIS, G
1516	DESIRED ROLL RATE, DEG/SEC
1517	DESIRED PITCH RATE, DEG/SEC
1518	DESIRED YAW RATE, DEG/SEC
1519	DESIRED NORMAL LOAD, G
1520	DESIRED RATE-OF-CLIMB, FT/SEC
1521	ROTOR 1, FILTERED THRUST, LB
1522	ROTOR 2, FILTERED THRUST, LB
1523	ROTOR 1, FILTERED H-FORCE, LB
1524	ROTOR 2, FILTERED H-FORCE, LB
1525	ROTOR 1, FILTERED Y-FORCE, LB
1526	ROTOR 2, FILTERED Y-FORCE, LB
1527	FILTERED NORMAL LOAD FACTOR, G
1529	FILTERED CG BODY X-FORCE, LB
1529	FILTERED CG BODY Y-FORCE, LB
1530	FILTERED CG BODY Z-FORCE, LB
1531	FILTERED CG BODY ROLL MOM, FT-LB
1532	FILTERED CG BODY PITCH MOM, FT-LB
1533	FILTERED CG BODY YAW MOM, FT-LB
1534	RTR 1,BLD 1,STA 20, BEAM ACC, FT/SEC**2
1535	RTR 1,BLD 2,STA 20, BEAM ACC, FT/SEC**2
1536	RTR 1,BLD 3,STA 20, BEAM ACC, FT/SEC**2
1537	RTR 1,BLD 4,STA 20, BEAM ACC, FT/SEC**2
1538	RTR 1,BLD 5,STA 20, BEAM ACC, FT/SEC**2
1539	RTR 1,BLD 6,STA 20, BEAM ACC, FT/SEC**2
1540	RTR 1,BLD 7,STA 20, BEAM ACC, FT/SEC**2
1541	RTR 1,BLD 1,STA 19, BEAM ACC, FT/SEC**2
1542	RTR 1,BLD 2,STA 19, BEAM ACC, FT/SEC**2
1543	RTR 1,BLD 3,STA 19, BEAM ACC, FT/SEC**2
1544	RTR 1,BLD 4,STA 19, BEAM ACC, FT/SEC**2
1545	RTR 1,BLD 5,STA 19, BEAM ACC, FT/SEC**2
1546	RTR 1,BLD 6,STA 19, BEAM ACC, FT/SEC**2
1547	RTR 1,BLD 7,STA 19, BEAM ACC, FT/SEC**2
1548	RTR 1,BLD 1,STA 18, BEAM ACC, FT/SEC**2
1549	RTR 1,BLD 2,STA 18, BEAM ACC, FT/SEC**2
1550	RTR 1,BLD 3,STA 18, BEAM ACC, FT/SEC**2
1551	RTR 1,BLD 4,STA 18, BEAM ACC, FT/SEC**2
1552	RTR 1,BLD 5,STA 18, BEAM ACC, FT/SEC**2
1553	RTR 1,BLD 6,STA 18, BEAM ACC, FT/SEC**2
1554	RTR 1,BLD 7,STA 18, BEAM ACC, FT/SEC**2
1555	RTR 1,BLD 1,STA 17, BEAM ACC, FT/SEC**2
1556	RTR 1,BLD 2,STA 17, BEAM ACC, FT/SEC**2
1557	RTR 1,BLD 3,STA 17, BEAM ACC, FT/SEC**2
1558	RTR 1,BLD 4,STA 17, BEAM ACC, FT/SEC**2
1559	RTR 1,BLD 5,STA 17, BEAM ACC, FT/SEC**2
1560	RTR 1,BLD 6,STA 17, BEAM ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
1561	RTR 1.BLD 7.STA 17. BEAM ACC. FT/SEC**2
1562	RTR 1.BLD 1.STA 16. BEAM ACC. FT/SEC**2
1563	RTR 1.BLD 2.STA 16. BEAM ACC. FT/SEC**2
1564	RTR 1.BLD 3.STA 16. BEAM ACC. FT/SEC**2
1565	RTR 1.BLD 4.STA 16. BEAM ACC. FT/SEC**2
1566	RTR 1.BLD 5.STA 16. BEAM ACC. FT/SEC**2
1567	RTR 1.BLD 6.STA 16. BEAM ACC. FT/SEC**2
1568	RTR 1.BLD 7.STA 16. BEAM ACC. FT/SEC**2
1569	RTR 1.BLD 1.STA 15. BEAM ACC. FT/SEC**2
1570	RTR 1.BLD 2.STA 15. BEAM ACC. FT/SEC**2
1571	RTR 1.BLD 3.STA 15. BEAM ACC. FT/SEC**2
1572	RTR 1.BLD 4.STA 15. BEAM ACC. FT/SEC**2
1573	RTR 1.BLD 5.STA 15. BEAM ACC. FT/SEC**2
1574	RTR 1.BLD 6.STA 15. BEAM ACC. FT/SEC**2
1575	RTR 1.BLD 7.STA 15. BEAM ACC. FT/SEC**2
1576	RTR 1.BLD 1.STA 14. BEAM ACC. FT/SEC**2
1577	RTR 1.BLD 2.STA 14. BEAM ACC. FT/SEC**2
1578	RTR 1.BLD 3.STA 14. BEAM ACC. FT/SEC**2
1579	RTR 1.BLD 4.STA 14. BEAM ACC. FT/SEC**2
1580	RTR 1.BLD 5.STA 14. BEAM ACC. FT/SEC**2
1581	RTR 1.BLD 6.STA 14. BEAM ACC. FT/SEC**2
1582	RTR 1.BLD 7.STA 14. BEAM ACC. FT/SEC**2
1583	RTR 1.BLD 1.STA 13. BEAM ACC. FT/SEC**2
1584	RTR 1.BLD 2.STA 13. BEAM ACC. FT/SEC**2
1585	RTR 1.BLD 3.STA 13. BEAM ACC. FT/SEC**2
1586	RTR 1.BLD 4.STA 13. BEAM ACC. FT/SEC**2
1587	RTR 1.BLD 5.STA 13. BEAM ACC. FT/SEC**2
1588	RTR 1.BLD 6.STA 13. BEAM ACC. FT/SEC**2
1589	RTR 1.BLD 7.STA 13. BEAM ACC. FT/SEC**2
1590	RTR 1.BLD 1.STA 12. BEAM ACC. FT/SEC**2
1591	RTR 1.BLD 2.STA 12. BEAM ACC. FT/SEC**2
1592	RTR 1.BLD 3.STA 12. BEAM ACC. FT/SEC**2
1593	RTR 1.BLD 4.STA 12. BEAM ACC. FT/SEC**2
1594	RTR 1.BLD 5.STA 12. BEAM ACC. FT/SEC**2
1595	RTR 1.BLD 6.STA 12. BEAM ACC. FT/SEC**2
1596	RTR 1.BLD 7.STA 12. BEAM ACC. FT/SEC**2
1597	RTR 1.BLD 1.STA 11. BEAM ACC. FT/SEC**2
1598	RTR 1.BLD 2.STA 11. BEAM ACC. FT/SEC**2
1599	RTR 1.BLD 3.STA 11. BEAM ACC. FT/SEC**2
1600	RTR 1.BLD 4.STA 11. BEAM ACC. FT/SEC**2
1601	RTR 1.BLD 5.STA 11. BEAM ACC. FT/SEC**2
1602	RTR 1.BLD 6.STA 11. BEAM ACC. FT/SEC**2
1603	RTR 1.BLD 7.STA 11. BEAM ACC. FT/SEC**2
1604	RTR 1.BLD 1.STA 10. BEAM ACC. FT/SEC**2
1605	RTR 1.BLD 2.STA 10. BEAM ACC. FT/SEC**2
1606	RTR 1.BLD 3.STA 10. BEAM ACC. FT/SEC**2
1607	RTR 1.BLD 4.STA 10. BEAM ACC. FT/SEC**2
1608	RTR 1.BLD 5.STA 10. BEAM ACC. FT/SEC**2
1609	RTR 1.BLD 6.STA 10. BEAM ACC. FT/SEC**2
1610	RTR 1.BLD 7.STA 10. BEAM ACC. FT/SEC**2
1611	RTR 1.BLD 1.STA 9. BEAM ACC. FT/SEC**2
1612	RTR 1.BLD 2.STA 9. BEAM ACC. FT/SEC**2
1613	RTR 1.BLD 3.STA 9. BEAM ACC. FT/SEC**2
1614	RTR 1.BLD 4.STA 9. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 5.STA 9. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 6.STA 9. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 7.STA 9. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 1.STA 8. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 2.STA 8. BEAM ACC. FT/SEC**2
[illegible]	RTR 1.BLD 3.STA 8. BEAM ACC. FT/SEC**2

TABLE 22. Continued.

Number	Description
1621	RTR 1,BLD 4,STA 8, BEAM ACC, FT/SEC**2
1622	RTR 1,BLD 5,STA 8, BEAM ACC, FT/SEC**2
1623	RTR 1,BLD 6,STA 8, BEAM ACC, FT/SEC**2
1624	RTR 1,BLD 7,STA 8, BEAM ACC, FT/SEC**2
1625	RTR 1,BLD 1,STA 7, BEAM ACC, FT/SEC**2
1626	RTR 1,BLD 2,STA 7, BEAM ACC, FT/SEC**2
1627	RTR 1,BLD 3,STA 7, BEAM ACC, FT/SEC**2
1628	RTR 1,BLD 4,STA 7, BEAM ACC, FT/SEC**2
1629	RTR 1,BLD 5,STA 7, BEAM ACC, FT/SEC**2
1630	RTR 1,BLD 6,STA 7, BEAM ACC, FT/SEC**2
1631	RTR 1,BLD 7,STA 7, BEAM ACC, FT/SEC**2
1632	RTR 1,BLD 1,STA 6, BEAM ACC, FT/SEC**2
1633	RTR 1,BLD 2,STA 6, BEAM ACC, FT/SEC**2
1634	RTR 1,BLD 3,STA 6, BEAM ACC, FT/SEC**2
1635	RTR 1,BLD 4,STA 6, BEAM ACC, FT/SEC**2
1636	RTR 1,BLD 5,STA 6, BEAM ACC, FT/SEC**2
1637	RTR 1,BLD 6,STA 6, BEAM ACC, FT/SEC**2
1638	RTR 1,BLD 7,STA 6, BEAM ACC, FT/SEC**2
1639	RTR 1,BLD 1,STA 5, BEAM ACC, FT/SEC**2
1640	RTR 1,BLD 2,STA 5, BEAM ACC, FT/SEC**2
1641	RTR 1,BLD 3,STA 5, BEAM ACC, FT/SEC**2
1642	RTR 1,BLD 4,STA 5, BEAM ACC, FT/SEC**2
1643	RTR 1,BLD 5,STA 5, BEAM ACC, FT/SEC**2
1644	RTR 1,BLD 6,STA 5, BEAM ACC, FT/SEC**2
1645	RTR 1,BLD 7,STA 5, BEAM ACC, FT/SEC**2
1646	RTR 1,BLD 1,STA 4, BEAM ACC, FT/SEC**2
1647	RTR 1,BLD 2,STA 4, BEAM ACC, FT/SEC**2
1648	RTR 1,BLD 3,STA 4, BEAM ACC, FT/SEC**2
1649	RTR 1,BLD 4,STA 4, BEAM ACC, FT/SEC**2
1650	RTR 1,BLD 5,STA 4, BEAM ACC, FT/SEC**2
1651	RTR 1,BLD 6,STA 4, BEAM ACC, FT/SEC**2
1652	RTR 1,BLD 7,STA 4, BEAM ACC, FT/SEC**2
1653	RTR 1,BLD 1,STA 3, BEAM ACC, FT/SEC**2
1654	RTR 1,BLD 2,STA 3, BEAM ACC, FT/SEC**2
1655	RTR 1,BLD 3,STA 3, BEAM ACC, FT/SEC**2
1656	RTR 1,BLD 4,STA 3, BEAM ACC, FT/SEC**2
1657	RTR 1,BLD 5,STA 3, BEAM ACC, FT/SEC**2
1658	RTR 1,BLD 6,STA 3, BEAM ACC, FT/SEC**2
1659	RTR 1,BLD 7,STA 3, BEAM ACC, FT/SEC**2
1660	RTR 1,BLD 1,STA 2, BEAM ACC, FT/SEC**2
1661	RTR 1,BLD 2,STA 2, BEAM ACC, FT/SEC**2
1662	RTR 1,BLD 3,STA 2, BEAM ACC, FT/SEC**2
1663	RTR 1,BLD 4,STA 2, BEAM ACC, FT/SEC**2
1664	RTR 1,BLD 5,STA 2, BEAM ACC, FT/SEC**2
1665	RTR 1,BLD 6,STA 2, BEAM ACC, FT/SEC**2
1666	RTR 1,BLD 7,STA 2, BEAM ACC, FT/SEC**2
1667	RTR 1,BLD 1,STA 1, BEAM ACC, FT/SEC**2
1668	RTR 1,BLD 2,STA 1, BEAM ACC, FT/SEC**2
1669	RTR 1,BLD 3,STA 1, BEAM ACC, FT/SEC**2
1670	RTR 1,BLD 4,STA 1, BEAM ACC, FT/SEC**2
1671	RTR 1,BLD 5,STA 1, BEAM ACC, FT/SEC**2
1672	RTR 1,BLD 6,STA 1, BEAM ACC, FT/SEC**2
1673	RTR 1,BLD 7,STA 1, BEAM ACC, FT/SEC**2
1674	RTR 1,BLD 1,STA 20, CHORD ACC, FT/SEC**2
1675	RTR 1,BLD 2,STA 20, CHORD ACC, FT/SEC**2
1676	RTR 1,BLD 3,STA 20, CHORD ACC, FT/SEC**2
1677	RTR 1,BLD 4,STA 20, CHORD ACC, FT/SEC**2
1678	RTR 1,BLD 5,STA 20, CHORD ACC, FT/SEC**2
1679	RTR 1,BLD 6,STA 20, CHORD ACC, FT/SEC**2
1680	RTR 1,BLD 7,STA 20, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
1681	RTR 1,BLD 1,STA 19, CHORD ACC, FT/SEC**2
1682	RTR 1,BLD 2,STA 19, CHORD ACC, FT/SEC**2
1683	RTR 1,BLD 3,STA 19, CHORD ACC, FT/SEC**2
1684	RTR 1,BLD 4,STA 19, CHORD ACC, FT/SEC**2
1685	RTR 1,BLD 5,STA 19, CHORD ACC, FT/SEC**2
1686	RTR 1,BLD 6,STA 19, CHORD ACC, FT/SEC**2
1687	RTR 1,BLD 7,STA 19, CHORD ACC, FT/SEC**2
1688	RTR 1,BLD 1,STA 18, CHORD ACC, FT/SEC**2
1689	RTR 1,BLD 2,STA 18, CHORD ACC, FT/SEC**2
1690	RTR 1,BLD 3,STA 18, CHORD ACC, FT/SEC**2
1691	RTR 1,BLD 4,STA 18, CHORD ACC, FT/SEC**2
1692	RTR 1,BLD 5,STA 18, CHORD ACC, FT/SEC**2
1693	RTR 1,BLD 6,STA 18, CHORD ACC, FT/SEC**2
1694	RTR 1,BLD 7,STA 18, CHORD ACC, FT/SEC**2
1695	RTR 1,BLD 1,STA 17, CHORD ACC, FT/SEC**2
1696	RTR 1,BLD 2,STA 17, CHORD ACC, FT/SEC**2
1697	RTR 1,BLD 3,STA 17, CHORD ACC, FT/SEC**2
1698	RTR 1,BLD 4,STA 17, CHORD ACC, FT/SEC**2
1699	RTR 1,BLD 5,STA 17, CHORD ACC, FT/SEC**2
1700	RTR 1,BLD 6,STA 17, CHORD ACC, FT/SEC**2
1701	RTR 1,BLD 7,STA 17, CHORD ACC, FT/SEC**2
1702	RTR 1,BLD 1,STA 16, CHORD ACC, FT/SEC**2
1703	RTR 1,BLD 2,STA 16, CHORD ACC, FT/SEC**2
1704	RTR 1,BLD 3,STA 16, CHORD ACC, FT/SEC**2
1705	RTR 1,BLD 4,STA 16, CHORD ACC, FT/SEC**2
1706	RTR 1,BLD 5,STA 16, CHORD ACC, FT/SEC**2
1707	RTR 1,BLD 6,STA 16, CHORD ACC, FT/SEC**2
1708	RTR 1,BLD 7,STA 16, CHORD ACC, FT/SEC**2
1709	RTR 1,BLD 1,STA 15, CHORD ACC, FT/SEC**2
1710	RTR 1,BLD 2,STA 15, CHORD ACC, FT/SEC**2
1711	RTR 1,BLD 3,STA 15, CHORD ACC, FT/SEC**2
1712	RTR 1,BLD 4,STA 15, CHORD ACC, FT/SEC**2
1713	RTR 1,BLD 5,STA 15, CHORD ACC, FT/SEC**2
1714	RTR 1,BLD 6,STA 15, CHORD ACC, FT/SEC**2
1715	RTR 1,BLD 7,STA 15, CHORD ACC, FT/SEC**2
1716	RTR 1,BLD 1,STA 14, CHORD ACC, FT/SEC**2
1717	RTR 1,BLD 2,STA 14, CHORD ACC, FT/SEC**2
1718	RTR 1,BLD 3,STA 14, CHORD ACC, FT/SEC**2
1719	RTR 1,BLD 4,STA 14, CHORD ACC, FT/SEC**2
1720	RTR 1,BLD 5,STA 14, CHORD ACC, FT/SEC**2
1721	RTR 1,BLD 6,STA 14, CHORD ACC, FT/SEC**2
1722	RTR 1,BLD 7,STA 14, CHORD ACC, FT/SEC**2
1723	RTR 1,BLD 1,STA 13, CHORD ACC, FT/SEC**2
1724	RTR 1,BLD 2,STA 13, CHORD ACC, FT/SEC**2
1725	RTR 1,BLD 3,STA 13, CHORD ACC, FT/SEC**2
1726	RTR 1,BLD 4,STA 13, CHORD ACC, FT/SEC**2
1727	RTR 1,BLD 5,STA 13, CHORD ACC, FT/SEC**2
1728	RTR 1,BLD 6,STA 13, CHORD ACC, FT/SEC**2
1729	RTR 1,BLD 7,STA 13, CHORD ACC, FT/SEC**2
1730	RTR 1,BLD 1,STA 12, CHORD ACC, FT/SEC**2
1731	RTR 1,BLD 2,STA 12, CHORD ACC, FT/SEC**2
1732	RTR 1,BLD 3,STA 12, CHORD ACC, FT/SEC**2
1733	RTR 1,BLD 4,STA 12, CHORD ACC, FT/SEC**2
1734	RTR 1,BLD 5,STA 12, CHORD ACC, FT/SEC**2
1735	RTR 1,BLD 6,STA 12, CHORD ACC, FT/SEC**2
1736	RTR 1,BLD 7,STA 12, CHORD ACC, FT/SEC**2
1737	RTR 1,BLD 1,STA 11, CHORD ACC, FT/SEC**2
1738	RTR 1,BLD 2,STA 11, CHORD ACC, FT/SEC**2
1739	RTR 1,BLD 3,STA 11, CHORD ACC, FT/SEC**2
1740	RTR 1,BLD 4,STA 11, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
1741	RTR 1,BLD 5,STA 11, CHORD ACC, FT/SEC**2
1742	RTR 1,BLD 6,STA 11, CHORD ACC, FT/SEC**2
1743	RTR 1,BLD 7,STA 11, CHORD ACC, FT/SEC**2
1744	RTR 1,BLD 1,STA 10, CHORD ACC, FT/SEC**2
1745	RTR 1,BLD 2,STA 10, CHORD ACC, FT/SEC**2
1746	RTR 1,BLD 3,STA 10, CHORD ACC, FT/SEC**2
1747	RTR 1,BLD 4,STA 10, CHORD ACC, FT/SEC**2
1748	RTR 1,BLD 5,STA 10, CHORD ACC, FT/SEC**2
1749	RTR 1,BLD 6,STA 10, CHORD ACC, FT/SEC**2
1750	RTR 1,BLD 7,STA 10, CHORD ACC, FT/SEC**2
1751	RTR 1,BLD 1,STA 9, CHORD ACC, FT/SEC**2
1752	RTR 1,BLD 2,STA 9, CHORD ACC, FT/SEC**2
1753	RTR 1,BLD 3,STA 9, CHORD ACC, FT/SEC**2
1754	RTR 1,BLD 4,STA 9, CHORD ACC, FT/SEC**2
1755	RTR 1,BLD 5,STA 9, CHORD ACC, FT/SEC**2
1756	RTR 1,BLD 6,STA 9, CHORD ACC, FT/SEC**2
1757	RTR 1,BLD 7,STA 9, CHORD ACC, FT/SEC**2
1758	RTR 1,BLD 1,STA 8, CHORD ACC, FT/SEC**2
1759	RTR 1,BLD 2,STA 8, CHORD ACC, FT/SEC**2
1760	RTR 1,BLD 3,STA 8, CHORD ACC, FT/SEC**2
1761	RTR 1,BLD 4,STA 8, CHORD ACC, FT/SEC**2
1762	RTR 1,BLD 5,STA 8, CHORD ACC, FT/SEC**2
1763	RTR 1,BLD 6,STA 8, CHORD ACC, FT/SEC**2
1764	RTR 1,BLD 7,STA 8, CHORD ACC, FT/SEC**2
1765	RTR 1,BLD 1,STA 7, CHORD ACC, FT/SEC**2
1766	RTR 1,BLD 2,STA 7, CHORD ACC, FT/SEC**2
1767	RTR 1,BLD 3,STA 7, CHORD ACC, FT/SEC**2
1768	RTR 1,BLD 4,STA 7, CHORD ACC, FT/SEC**2
1769	RTR 1,BLD 5,STA 7, CHORD ACC, FT/SEC**2
1770	RTR 1,BLD 6,STA 7, CHORD ACC, FT/SEC**2
1771	RTR 1,BLD 7,STA 7, CHORD ACC, FT/SEC**2
1772	RTR 1,BLD 1,STA 6, CHORD ACC, FT/SEC**2
1773	RTR 1,BLD 2,STA 6, CHORD ACC, FT/SEC**2
1774	RTR 1,BLD 3,STA 6, CHORD ACC, FT/SEC**2
1775	RTR 1,BLD 4,STA 6, CHORD ACC, FT/SEC**2
1776	RTR 1,BLD 5,STA 6, CHORD ACC, FT/SEC**2
1777	RTR 1,BLD 6,STA 6, CHORD ACC, FT/SEC**2
1778	RTR 1,BLD 7,STA 6, CHORD ACC, FT/SEC**2
1779	RTR 1,BLD 1,STA 5, CHORD ACC, FT/SEC**2
1780	RTR 1,BLD 2,STA 5, CHORD ACC, FT/SEC**2
1781	RTR 1,BLD 3,STA 5, CHORD ACC, FT/SEC**2
1782	RTR 1,BLD 4,STA 5, CHORD ACC, FT/SEC**2
1783	RTR 1,BLD 5,STA 5, CHORD ACC, FT/SEC**2
1784	RTR 1,BLD 6,STA 5, CHORD ACC, FT/SEC**2
1785	RTR 1,BLD 7,STA 5, CHORD ACC, FT/SEC**2
1786	RTR 1,BLD 1,STA 4, CHORD ACC, FT/SEC**2
1787	RTR 1,BLD 2,STA 4, CHORD ACC, FT/SEC**2
1788	RTR 1,BLD 3,STA 4, CHORD ACC, FT/SEC**2
1789	RTR 1,BLD 4,STA 4, CHORD ACC, FT/SEC**2
1790	RTR 1,BLD 5,STA 4, CHORD ACC, FT/SEC**2
1791	RTR 1,BLD 6,STA 4, CHORD ACC, FT/SEC**2
1792	RTR 1,BLD 7,STA 4, CHORD ACC, FT/SEC**2
1793	RTR 1,BLD 1,STA 3, CHORD ACC, FT/SEC**2
1794	RTR 1,BLD 2,STA 3, CHORD ACC, FT/SEC**2
1795	RTR 1,BLD 3,STA 3, CHORD ACC, FT/SEC**2
1796	RTR 1,BLD 4,STA 3, CHORD ACC, FT/SEC**2
1797	RTR 1,BLD 5,STA 3, CHORD ACC, FT/SEC**2
1798	RTR 1,BLD 6,STA 3, CHORD ACC, FT/SEC**2
1799	RTR 1,BLD 7,STA 3, CHORD ACC, FT/SEC**2
1800	RTR 1,BLD 1,STA 2, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
1801	RTR 1,BLD 2,STA 2, CHORD ACC, FT/SEC**2
1802	RTR 1,BLD 3,STA 2, CHORD ACC, FT/SEC**2
1803	RTR 1,BLD 4,STA 2, CHORD ACC, FT/SEC**2
1804	RTR 1,BLD 5,STA 2, CHORD ACC, FT/SEC**2
1805	RTR 1,BLD 6,STA 2, CHORD ACC, FT/SEC**2
1806	RTR 1,BLD 7,STA 2, CHORD ACC, FT/SEC**2
1807	RTR 1,BLD 1,STA 1, CHORD ACC, FT/SEC**2
1808	RTR 1,BLD 2,STA 1, CHORD ACC, FT/SEC**2
1809	RTR 1,BLD 3,STA 1, CHORD ACC, FT/SEC**2
1810	RTR 1,BLD 4,STA 1, CHORD ACC, FT/SEC**2
1811	RTR 1,BLD 5,STA 1, CHORD ACC, FT/SEC**2
1812	RTR 1,BLD 6,STA 1, CHORD ACC, FT/SEC**2
1813	RTR 1,BLD 7,STA 1, CHORD ACC, FT/SEC**2
1814	RTR 1,BLD 1,STA 20, TORS ACC, DEG/SEC**2
1815	RTR 1,BLD 2,STA 20, TORS ACC, DEG/SEC**2
1816	RTR 1,BLD 3,STA 20, TORS ACC, DEG/SEC**2
1817	RTR 1,BLD 4,STA 20, TORS ACC, DEG/SEC**2
1818	RTR 1,BLD 5,STA 20, TORS ACC, DEG/SEC**2
1819	RTR 1,BLD 6,STA 20, TORS ACC, DEG/SEC**2
1820	RTR 1,BLD 7,STA 20, TORS ACC, DEG/SEC**2
1821	RTR 1,BLD 1,STA 19, TORS ACC, DEG/SEC**2
1822	RTR 1,BLD 2,STA 19, TORS ACC, DEG/SEC**2
1823	RTR 1,BLD 3,STA 19, TORS ACC, DEG/SEC**2
1824	RTR 1,BLD 4,STA 19, TORS ACC, DEG/SEC**2
1825	RTR 1,BLD 5,STA 19, TORS ACC, DEG/SEC**2
1826	RTR 1,BLD 6,STA 19, TORS ACC, DEG/SEC**2
1827	RTR 1,BLD 7,STA 19, TORS ACC, DEG/SEC**2
1828	RTR 1,BLD 1,STA 18, TORS ACC, DEG/SEC**2
1829	RTR 1,BLD 2,STA 18, TORS ACC, DEG/SEC**2
1830	RTR 1,BLD 3,STA 18, TORS ACC, DEG/SEC**2
1831	RTR 1,BLD 4,STA 18, TORS ACC, DEG/SEC**2
1832	RTR 1,BLD 5,STA 18, TORS ACC, DEG/SEC**2
1833	RTR 1,BLD 6,STA 18, TORS ACC, DEG/SEC**2
1834	RTR 1,BLD 7,STA 18, TORS ACC, DEG/SEC**2
1835	RTR 1,BLD 1,STA 17, TORS ACC, DEG/SEC**2
1836	RTR 1,BLD 2,STA 17, TORS ACC, DEG/SEC**2
1837	RTR 1,BLD 3,STA 17, TORS ACC, DEG/SEC**2
1838	RTR 1,BLD 4,STA 17, TORS ACC, DEG/SEC**2
1839	RTR 1,BLD 5,STA 17, TORS ACC, DEG/SEC**2
1840	RTR 1,BLD 6,STA 17, TORS ACC, DEG/SEC**2
1841	RTR 1,BLD 7,STA 17, TORS ACC, DEG/SEC**2
1842	RTR 1,BLD 1,STA 16, TORS ACC, DEG/SEC**2
1843	RTR 1,BLD 2,STA 16, TORS ACC, DEG/SEC**2
1844	RTR 1,BLD 3,STA 16, TORS ACC, DEG/SEC**2
1845	RTR 1,BLD 4,STA 16, TORS ACC, DEG/SEC**2
1846	RTR 1,BLD 5,STA 16, TORS ACC, DEG/SEC**2
1847	RTR 1,BLD 6,STA 16, TORS ACC, DEG/SEC**2
1848	RTR 1,BLD 7,STA 16, TORS ACC, DEG/SEC**2
1849	RTR 1,BLD 1,STA 15, TORS ACC, DEG/SEC**2
1850	RTR 1,BLD 2,STA 15, TORS ACC, DEG/SEC**2
1851	RTR 1,BLD 3,STA 15, TORS ACC, DEG/SEC**2
1852	RTR 1,BLD 4,STA 15, TORS ACC, DEG/SEC**2
1853	RTR 1,BLD 5,STA 15, TORS ACC, DEG/SEC**2
1854	RTR 1,BLD 6,STA 15, TORS ACC, DEG/SEC**2
1855	RTR 1,BLD 7,STA 15, TORS ACC, DEG/SEC**2
1856	RTR 1,BLD 1,STA 14, TORS ACC, DEG/SEC**2
1857	RTR 1,BLD 2,STA 14, TORS ACC, DEG/SEC**2
1858	RTR 1,BLD 3,STA 14, TORS ACC, DEG/SEC**2
1859	RTR 1,BLD 4,STA 14, TORS ACC, DEG/SEC**2
1860	RTR 1,BLD 5,STA 14, TORS ACC, DEG/SEC**2

TABLE 22. Continued.

Number	Description
1861	RTR 1,BLD 6,STA 14, TORS ACC, DEG/SEC**2
1862	RTR 1,BLD 7,STA 14, TORS ACC, DEG/SEC**2
1863	RTR 1,BLD 1,STA 13, TORS ACC, DEG/SEC**2
1864	RTR 1,BLD 2,STA 13, TORS ACC, DEG/SEC**2
1865	RTR 1,BLD 3,STA 13, TORS ACC, DEG/SEC**2
1866	RTR 1,BLD 4,STA 13, TORS ACC, DEG/SEC**2
1867	RTR 1,BLD 5,STA 13, TORS ACC, DEG/SEC**2
1868	RTR 1,BLD 6,STA 13, TORS ACC, DEG/SEC**2
1869	RTR 1,BLD 7,STA 13, TORS ACC, DEG/SEC**2
1870	RTR 1,BLD 1,STA 12, TORS ACC, DEG/SEC**2
1871	RTR 1,BLD 2,STA 12, TORS ACC, DEG/SEC**2
1872	RTR 1,BLD 3,STA 12, TORS ACC, DEG/SEC**2
1873	RTR 1,BLD 4,STA 12, TORS ACC, DEG/SEC**2
1874	RTR 1,BLD 5,STA 12, TORS ACC, DEG/SEC**2
1875	RTR 1,BLD 6,STA 12, TORS ACC, DEG/SEC**2
1876	RTR 1,BLD 7,STA 12, TORS ACC, DEG/SEC**2
1877	RTR 1,BLD 1,STA 11, TORS ACC, DEG/SEC**2
1878	RTR 1,BLD 2,STA 11, TORS ACC, DEG/SEC**2
1879	RTR 1,BLD 3,STA 11, TORS ACC, DEG/SEC**2
1880	RTR 1,BLD 4,STA 11, TORS ACC, DEG/SEC**2
1881	RTR 1,BLD 5,STA 11, TORS ACC, DEG/SEC**2
1882	RTR 1,BLD 6,STA 11, TORS ACC, DEG/SEC**2
1883	RTR 1,BLD 7,STA 11, TORS ACC, DEG/SEC**2
1884	RTR 1,BLD 1,STA 10, TORS ACC, DEG/SEC**2
1885	RTR 1,BLD 2,STA 10, TORS ACC, DEG/SEC**2
1886	RTR 1,BLD 3,STA 10, TORS ACC, DEG/SEC**2
1887	RTR 1,BLD 4,STA 10, TORS ACC, DEG/SEC**2
1888	RTR 1,BLD 5,STA 10, TORS ACC, DEG/SEC**2
1889	RTR 1,BLD 6,STA 10, TORS ACC, DEG/SEC**2
1890	RTR 1,BLD 7,STA 10, TORS ACC, DEG/SEC**2
1891	RTR 1,BLD 1,STA 9, TORS ACC, DEG/SEC**2
1892	RTR 1,BLD 2,STA 9, TORS ACC, DEG/SEC**2
1893	RTR 1,BLD 3,STA 9, TORS ACC, DEG/SEC**2
1894	RTR 1,BLD 4,STA 9, TORS ACC, DEG/SEC**2
1895	RTR 1,BLD 5,STA 9, TORS ACC, DEG/SEC**2
1896	RTR 1,BLD 6,STA 9, TORS ACC, DEG/SEC**2
1897	RTR 1,BLD 7,STA 9, TORS ACC, DEG/SEC**2
1898	RTR 1,BLD 1,STA 8, TORS ACC, DEG/SEC**2
1899	RTR 1,BLD 2,STA 8, TORS ACC, DEG/SEC**2
1900	RTR 1,BLD 3,STA 8, TORS ACC, DEG/SEC**2
1901	RTR 1,BLD 4,STA 8, TORS ACC, DEG/SEC**2
1902	RTR 1,BLD 5,STA 8, TORS ACC, DEG/SEC**2
1903	RTR 1,BLD 6,STA 8, TORS ACC, DEG/SEC**2
1904	RTR 1,BLD 7,STA 8, TORS ACC, DEG/SEC**2
1905	RTR 1,BLD 1,STA 7, TORS ACC, DEG/SEC**2
1906	RTR 1,BLD 2,STA 7, TORS ACC, DEG/SEC**2
1907	RTR 1,BLD 3,STA 7, TORS ACC, DEG/SEC**2
1908	RTR 1,BLD 4,STA 7, TORS ACC, DEG/SEC**2
1909	RTR 1,BLD 5,STA 7, TORS ACC, DEG/SEC**2
1910	RTR 1,BLD 6,STA 7, TORS ACC, DEG/SEC**2
1911	RTR 1,BLD 7,STA 7, TORS ACC, DEG/SEC**2
1912	RTR 1,BLD 1,STA 6, TORS ACC, DEG/SEC**2
1913	RTR 1,BLD 2,STA 6, TORS ACC, DEG/SEC**2
1914	RTR 1,BLD 3,STA 6, TORS ACC, DEG/SEC**2
1915	RTR 1,BLD 4,STA 6, TORS ACC, DEG/SEC**2
1916	RTR 1,BLD 5,STA 6, TORS ACC, DEG/SEC**2
1917	RTR 1,BLD 6,STA 6, TORS ACC, DEG/SEC**2
1918	RTR 1,BLD 7,STA 6, TORS ACC, DEG/SEC**2
1919	RTR 1,BLD 1,STA 5, TORS ACC, DEG/SEC**2
1920	RTR 1,BLD 2,STA 5, TORS ACC, DEG/SEC**2

TABLE 22. Continued.

Number	Description
1921	RTR 1,BLD 3,STA 5, TORS ACC, DEG/SEC**2
1922	RTR 1,BLD 4,STA 5, TORS ACC, DEG/SEC**2
1923	RTR 1,BLD 5,STA 5, TORS ACC, DEG/SEC**2
1924	RTR 1,BLD 6,STA 5, TORS ACC, DEG/SEC**2
1925	RTR 1,BLD 7,STA 5, TORS ACC, DEG/SEC**2
1926	RTR 1,BLD 1,STA 4, TORS ACC, DEG/SEC**2
1927	RTR 1,BLD 2,STA 4, TORS ACC, DEG/SEC**2
1928	RTR 1,BLD 3,STA 4, TORS ACC, DEG/SEC**2
1929	RTR 1,BLD 4,STA 4, TORS ACC, DEG/SEC**2
1930	RTR 1,BLD 5,STA 4, TORS ACC, DEG/SEC**2
1931	RTR 1,BLD 6,STA 4, TORS ACC, DEG/SEC**2
1932	RTR 1,BLD 7,STA 4, TORS ACC, DEG/SEC**2
1933	RTR 1,BLD 1,STA 3, TORS ACC, DEG/SEC**2
1934	RTR 1,BLD 2,STA 3, TORS ACC, DEG/SEC**2
1935	RTR 1,BLD 3,STA 3, TORS ACC, DEG/SEC**2
1936	RTR 1,BLD 4,STA 3, TORS ACC, DEG/SEC**2
1937	RTR 1,BLD 5,STA 3, TORS ACC, DEG/SEC**2
1938	RTR 1,BLD 6,STA 3, TORS ACC, DEG/SEC**2
1939	RTR 1,BLD 7,STA 3, TORS ACC, DEG/SEC**2
1940	RTR 1,BLD 1,STA 2, TORS ACC, DEG/SEC**2
1941	RTR 1,BLD 2,STA 2, TORS ACC, DEG/SEC**2
1942	RTR 1,BLD 3,STA 2, TORS ACC, DEG/SEC**2
1943	RTR 1,BLD 4,STA 2, TORS ACC, DEG/SEC**2
1944	RTR 1,BLD 5,STA 2, TORS ACC, DEG/SEC**2
1945	RTR 1,BLD 6,STA 2, TORS ACC, DEG/SEC**2
1946	RTR 1,BLD 7,STA 2, TORS ACC, DEG/SEC**2
1947	RTR 1,BLD 1,STA 1, TORS ACC, DEG/SEC**2
1948	RTR 1,BLD 2,STA 1, TORS ACC, DEG/SEC**2
1949	RTR 1,BLD 3,STA 1, TORS ACC, DEG/SEC**2
1950	RTR 1,BLD 4,STA 1, TORS ACC, DEG/SEC**2
1951	RTR 1,BLD 5,STA 1, TORS ACC, DEG/SEC**2
1952	RTR 1,BLD 6,STA 1, TORS ACC, DEG/SEC**2
1953	RTR 1,BLD 7,STA 1, TORS ACC, DEG/SEC**2
1954	RTR 2,BLD 1,STA 20, BEAM ACC, FT/SEC**2
1955	RTR 2,BLD 2,STA 20, BEAM ACC, FT/SEC**2
1956	RTR 2,BLD 3,STA 20, BEAM ACC, FT/SEC**2
1957	RTR 2,BLD 4,STA 20, BEAM ACC, FT/SEC**2
1958	RTR 2,BLD 5,STA 20, BEAM ACC, FT/SEC**2
1959	RTR 2,BLD 6,STA 20, BEAM ACC, FT/SEC**2
1960	RTR 2,BLD 7,STA 20, BEAM ACC, FT/SEC**2
1961	RTR 2,BLD 1,STA 19, BEAM ACC, FT/SEC**2
1962	RTR 2,BLD 2,STA 19, BEAM ACC, FT/SEC**2
1963	RTR 2,BLD 3,STA 19, BEAM ACC, FT/SEC**2
1964	RTR 2,BLD 4,STA 19, BEAM ACC, FT/SEC**2
1965	RTR 2,BLD 5,STA 19, BEAM ACC, FT/SEC**2
1966	RTR 2,BLD 6,STA 19, BEAM ACC, FT/SEC**2
1967	RTR 2,BLD 7,STA 19, BEAM ACC, FT/SEC**2
1968	RTR 2,BLD 1,STA 18, BEAM ACC, FT/SEC**2
1969	RTR 2,BLD 2,STA 18, BEAM ACC, FT/SEC**2
1970	RTR 2,BLD 3,STA 18, BEAM ACC, FT/SEC**2
1971	RTR 2,BLD 4,STA 18, BEAM ACC, FT/SEC**2
1972	RTR 2,BLD 5,STA 18, BEAM ACC, FT/SEC**2
1973	RTR 2,BLD 6,STA 18, BEAM ACC, FT/SEC**2
1974	RTR 2,BLD 7,STA 18, BEAM ACC, FT/SEC**2
1975	RTR 2,BLD 1,STA 17, BEAM ACC, FT/SEC**2
1976	RTR 2,BLD 2,STA 17, BEAM ACC, FT/SEC**2
1977	RTR 2,BLD 3,STA 17, BEAM ACC, FT/SEC**2
1978	RTR 2,BLD 4,STA 17, BEAM ACC, FT/SEC**2
1979	RTR 2,BLD 5,STA 17, BEAM ACC, FT/SEC**2
1980	RTR 2,BLD 6,STA 17, BEAM ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
1981	RTR 2,BLD 7,STA 17, BEAM ACC, FT/SEC**2
1982	RTR 2,BLD 1,STA 16, BEAM ACC, FT/SEC**2
1983	RTR 2,BLD 2,STA 16, BEAM ACC, FT/SEC**2
1984	RTR 2,BLD 3,STA 16, BEAM ACC, FT/SEC**2
1985	RTR 2,BLD 4,STA 16, BEAM ACC, FT/SEC**2
1986	RTR 2,BLD 5,STA 16, BEAM ACC, FT/SEC**2
1987	RTR 2,BLD 6,STA 16, BEAM ACC, FT/SEC**2
1988	RTR 2,BLD 7,STA 16, BEAM ACC, FT/SEC**2
1989	RTR 2,BLD 1,STA 15, BEAM ACC, FT/SEC**2
1990	RTR 2,BLD 2,STA 15, BEAM ACC, FT/SEC**2
1991	RTR 2,BLD 3,STA 15, BEAM ACC, FT/SEC**2
1992	RTR 2,BLD 4,STA 15, BEAM ACC, FT/SEC**2
1993	RTR 2,BLD 5,STA 15, BEAM ACC, FT/SEC**2
1994	RTR 2,BLD 6,STA 15, BEAM ACC, FT/SEC**2
1995	RTR 2,BLD 7,STA 15, BEAM ACC, FT/SEC**2
1996	RTR 2,BLD 1,STA 14, BEAM ACC, FT/SEC**2
1997	RTR 2,BLD 2,STA 14, BEAM ACC, FT/SEC**2
1998	RTR 2,BLD 3,STA 14, BEAM ACC, FT/SEC**2
1999	RTR 2,BLD 4,STA 14, BEAM ACC, FT/SEC**2
2000	RTR 2,BLD 5,STA 14, BEAM ACC, FT/SEC**2
2001	RTR 2,BLD 6,STA 14, BEAM ACC, FT/SEC**2
2002	RTR 2,BLD 7,STA 14, BEAM ACC, FT/SEC**2
2003	RTR 2,BLD 1,STA 13, BEAM ACC, FT/SEC**2
2004	RTR 2,BLD 2,STA 13, BEAM ACC, FT/SEC**2
2005	RTR 2,BLD 3,STA 13, BEAM ACC, FT/SEC**2
2006	RTR 2,BLD 4,STA 13, BEAM ACC, FT/SEC**2
2007	RTR 2,BLD 5,STA 13, BEAM ACC, FT/SEC**2
2008	RTR 2,BLD 6,STA 13, BEAM ACC, FT/SEC**2
2009	RTR 2,BLD 7,STA 13, BEAM ACC, FT/SEC**2
2010	RTR 2,BLD 1,STA 12, BEAM ACC, FT/SEC**2
2011	RTR 2,BLD 2,STA 12, BEAM ACC, FT/SEC**2
2012	RTR 2,BLD 3,STA 12, BEAM ACC, FT/SEC**2
2013	RTR 2,BLD 4,STA 12, BEAM ACC, FT/SEC**2
2014	RTR 2,BLD 5,STA 12, BEAM ACC, FT/SEC**2
2015	RTR 2,BLD 6,STA 12, BEAM ACC, FT/SEC**2
2016	RTR 2,BLD 7,STA 12, BEAM ACC, FT/SEC**2
2017	RTR 2,BLD 1,STA 11, BEAM ACC, FT/SEC**2
2018	RTR 2,BLD 2,STA 11, BEAM ACC, FT/SEC**2
2019	RTR 2,BLD 3,STA 11, BEAM ACC, FT/SEC**2
2020	RTR 2,BLD 4,STA 11, BEAM ACC, FT/SEC**2
2021	RTR 2,BLD 5,STA 11, BEAM ACC, FT/SEC**2
2022	RTR 2,BLD 6,STA 11, BEAM ACC, FT/SEC**2
2023	RTR 2,BLD 7,STA 11, BEAM ACC, FT/SEC**2
2024	RTR 2,BLD 1,STA 10, BEAM ACC, FT/SEC**2
2025	RTR 2,BLD 2,STA 10, BEAM ACC, FT/SEC**2
2026	RTR 2,BLD 3,STA 10, BEAM ACC, FT/SEC**2
2027	RTR 2,BLD 4,STA 10, BEAM ACC, FT/SEC**2
2028	RTR 2,BLD 5,STA 10, BEAM ACC, FT/SEC**2
2029	RTR 2,BLD 6,STA 10, BEAM ACC, FT/SEC**2
2030	RTR 2,BLD 7,STA 10, BEAM ACC, FT/SEC**2
2031	RTR 2,BLD 1,STA 9, BEAM ACC, FT/SEC**2
2032	RTR 2,BLD 2,STA 9, BEAM ACC, FT/SEC**2
2033	RTR 2,BLD 3,STA 9, BEAM ACC, FT/SEC**2
2034	RTR 2,BLD 4,STA 9, BEAM ACC, FT/SEC**2
2035	RTR 2,BLD 5,STA 9, BEAM ACC, FT/SEC**2
2036	RTR 2,BLD 6,STA 9, BEAM ACC, FT/SEC**2
2037	RTR 2,BLD 7,STA 9, BEAM ACC, FT/SEC**2
2038	RTR 2,BLD 1,STA 8, BEAM ACC, FT/SEC**2
2039	RTR 2,BLD 2,STA 8, BEAM ACC, FT/SEC**2
2040	RTR 2,BLD 3,STA 8, BEAM ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
2041	RTR 2,BLD 4,STA 8, BEAM ACC, FT/SEC**2
2042	RTR 2,BLD 5,STA 8, BEAM ACC, FT/SEC**2
2043	RTR 2,BLD 6,STA 8, BEAM ACC, FT/SEC**2
2044	RTR 2,BLD 7,STA 8, BEAM ACC, FT/SEC**2
2045	RTR 2,BLD 1,STA 7, BEAM ACC, FT/SEC**2
2046	RTR 2,BLD 2,STA 7, BEAM ACC, FT/SEC**2
2047	RTR 2,BLD 3,STA 7, BEAM ACC, FT/SEC**2
2048	RTR 2,BLD 4,STA 7, BEAM ACC, FT/SEC**2
2049	RTR 2,BLD 5,STA 7, BEAM ACC, FT/SEC**2
2050	RTR 2,BLD 6,STA 7, BEAM ACC, FT/SEC**2
2051	RTR 2,BLD 7,STA 7, BEAM ACC, FT/SEC**2
2052	RTR 2,BLD 1,STA 6, BEAM ACC, FT/SEC**2
2053	RTR 2,BLD 2,STA 6, BEAM ACC, FT/SEC**2
2054	RTR 2,BLD 3,STA 6, BEAM ACC, FT/SEC**2
2055	RTR 2,BLD 4,STA 6, BEAM ACC, FT/SEC**2
2056	RTR 2,BLD 5,STA 6, BEAM ACC, FT/SEC**2
2057	RTR 2,BLD 6,STA 6, BEAM ACC, FT/SEC**2
2058	RTR 2,BLD 7,STA 6, BEAM ACC, FT/SEC**2
2059	RTR 2,BLD 1,STA 5, BEAM ACC, FT/SEC**2
2060	RTR 2,BLD 2,STA 5, BEAM ACC, FT/SEC**2
2061	RTR 2,BLD 3,STA 5, BEAM ACC, FT/SEC**2
2062	RTR 2,BLD 4,STA 5, BEAM ACC, FT/SEC**2
2063	RTR 2,BLD 5,STA 5, BEAM ACC, FT/SEC**2
2064	RTR 2,BLD 6,STA 5, BEAM ACC, FT/SEC**2
2065	RTR 2,BLD 7,STA 5, BEAM ACC, FT/SEC**2
2066	RTR 2,BLD 1,STA 4, BEAM ACC, FT/SEC**2
2067	RTR 2,BLD 2,STA 4, BEAM ACC, FT/SEC**2
2068	RTR 2,BLD 3,STA 4, BEAM ACC, FT/SEC**2
2069	RTR 2,BLD 4,STA 4, BEAM ACC, FT/SEC**2
2070	RTR 2,BLD 5,STA 4, BEAM ACC, FT/SEC**2
2071	RTR 2,BLD 6,STA 4, BEAM ACC, FT/SEC**2
2072	RTR 2,BLD 7,STA 4, BEAM ACC, FT/SEC**2
2073	RTR 2,BLD 1,STA 3, BEAM ACC, FT/SEC**2
2074	RTR 2,BLD 2,STA 3, BEAM ACC, FT/SEC**2
2075	RTR 2,BLD 3,STA 3, BEAM ACC, FT/SEC**2
2076	RTR 2,BLD 4,STA 3, BEAM ACC, FT/SEC**2
2077	RTR 2,BLD 5,STA 3, BEAM ACC, FT/SEC**2
2078	RTR 2,BLD 6,STA 3, BEAM ACC, FT/SEC**2
2079	RTR 2,BLD 7,STA 3, BEAM ACC, FT/SEC**2
2080	RTR 2,BLD 1,STA 2, BEAM ACC, FT/SEC**2
2081	RTR 2,BLD 2,STA 2, BEAM ACC, FT/SEC**2
2082	RTR 2,BLD 3,STA 2, BEAM ACC, FT/SEC**2
2083	RTR 2,BLD 4,STA 2, BEAM ACC, FT/SEC**2
2084	RTR 2,BLD 5,STA 2, BEAM ACC, FT/SEC**2
2085	RTR 2,BLD 6,STA 2, BEAM ACC, FT/SEC**2
2086	RTR 2,BLD 7,STA 2, BEAM ACC, FT/SEC**2
2087	RTR 2,BLD 1,STA 1, BEAM ACC, FT/SEC**2
2088	RTR 2,BLD 2,STA 1, BEAM ACC, FT/SEC**2
2089	RTR 2,BLD 3,STA 1, BEAM ACC, FT/SEC**2
2090	RTR 2,BLD 4,STA 1, BEAM ACC, FT/SEC**2
2091	RTR 2,BLD 5,STA 1, BEAM ACC, FT/SEC**2
2092	RTR 2,BLD 6,STA 1, BEAM ACC, FT/SEC**2
2093	RTR 2,BLD 7,STA 1, BEAM ACC, FT/SEC**2
2094	RTR 2,BLD 1,STA 20, CHORD ACC, FT/SEC**2
2095	RTR 2,BLD 2,STA 20, CHORD ACC, FT/SEC**2
2096	RTR 2,BLD 3,STA 20, CHORD ACC, FT/SEC**2
2097	RTR 2,BLD 4,STA 20, CHORD ACC, FT/SEC**2
2098	RTR 2,BLD 5,STA 20, CHORD ACC, FT/SEC**2
2099	RTR 2,BLD 6,STA 20, CHORD ACC, FT/SEC**2
2100	RTR 2,BLD 7,STA 20, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
2101	RTR 2,BLD 1,STA 19, CHORD ACC, FT/SEC**2
2102	RTR 2,BLD 2,STA 19, CHORD ACC, FT/SEC**2
2103	RTR 2,BLD 3,STA 19, CHORD ACC, FT/SEC**2
2104	RTR 2,BLD 4,STA 19, CHORD ACC, FT/SEC**2
2105	RTR 2,BLD 5,STA 19, CHORD ACC, FT/SEC**2
2106	RTR 2,BLD 6,STA 19, CHORD ACC, FT/SEC**2
2107	RTR 2,BLD 7,STA 19, CHORD ACC, FT/SEC**2
2108	RTR 2,BLD 1,STA 18, CHORD ACC, FT/SEC**2
2109	RTR 2,BLD 2,STA 18, CHORD ACC, FT/SEC**2
2110	RTR 2,BLD 3,STA 18, CHORD ACC, FT/SEC**2
2111	RTR 2,BLD 4,STA 18, CHORD ACC, FT/SEC**2
2112	RTR 2,BLD 5,STA 18, CHORD ACC, FT/SEC**2
2113	RTR 2,BLD 6,STA 18, CHORD ACC, FT/SEC**2
2114	RTR 2,BLD 7,STA 18, CHORD ACC, FT/SEC**2
2115	RTR 2,BLD 1,STA 17, CHORD ACC, FT/SEC**2
2116	RTR 2,BLD 2,STA 17, CHORD ACC, FT/SEC**2
2117	RTR 2,BLD 3,STA 17, CHORD ACC, FT/SEC**2
2118	RTR 2,BLD 4,STA 17, CHORD ACC, FT/SEC**2
2119	RTR 2,BLD 5,STA 17, CHORD ACC, FT/SEC**2
2120	RTR 2,BLD 6,STA 17, CHORD ACC, FT/SEC**2
2121	RTR 2,BLD 7,STA 17, CHORD ACC, FT/SEC**2
2122	RTR 2,BLD 1,STA 16, CHORD ACC, FT/SEC**2
2123	RTR 2,BLD 2,STA 16, CHORD ACC, FT/SEC**2
2124	RTR 2,BLD 3,STA 16, CHORD ACC, FT/SEC**2
2125	RTR 2,BLD 4,STA 16, CHORD ACC, FT/SEC**2
2126	RTR 2,BLD 5,STA 16, CHORD ACC, FT/SEC**2
2127	RTR 2,BLD 6,STA 16, CHORD ACC, FT/SEC**2
2128	RTR 2,BLD 7,STA 16, CHORD ACC, FT/SEC**2
2129	RTR 2,BLD 1,STA 15, CHORD ACC, FT/SEC**2
2130	RTR 2,BLD 2,STA 15, CHORD ACC, FT/SEC**2
2131	RTR 2,BLD 3,STA 15, CHORD ACC, FT/SEC**2
2132	RTR 2,BLD 4,STA 15, CHORD ACC, FT/SEC**2
2133	RTR 2,BLD 5,STA 15, CHORD ACC, FT/SEC**2
2134	RTR 2,BLD 6,STA 15, CHORD ACC, FT/SEC**2
2135	RTR 2,BLD 7,STA 15, CHORD ACC, FT/SEC**2
2136	RTR 2,BLD 1,STA 14, CHORD ACC, FT/SEC**2
2137	RTR 2,BLD 2,STA 14, CHORD ACC, FT/SEC**2
2138	RTR 2,BLD 3,STA 14, CHORD ACC, FT/SEC**2
2139	RTR 2,BLD 4,STA 14, CHORD ACC, FT/SEC**2
2140	RTR 2,BLD 5,STA 14, CHORD ACC, FT/SEC**2
2141	RTR 2,BLD 6,STA 14, CHORD ACC, FT/SEC**2
2142	RTR 2,BLD 7,STA 14, CHORD ACC, FT/SEC**2
2143	RTR 2,BLD 1,STA 13, CHORD ACC, FT/SEC**2
2144	RTR 2,BLD 2,STA 13, CHORD ACC, FT/SEC**2
2145	RTR 2,BLD 3,STA 13, CHORD ACC, FT/SEC**2
2146	RTR 2,BLD 4,STA 13, CHORD ACC, FT/SEC**2
2147	RTR 2,BLD 5,STA 13, CHORD ACC, FT/SEC**2
2148	RTR 2,BLD 6,STA 13, CHORD ACC, FT/SEC**2
2149	RTR 2,BLD 7,STA 13, CHORD ACC, FT/SEC**2
2150	RTR 2,BLD 1,STA 12, CHORD ACC, FT/SEC**2
2151	RTR 2,BLD 2,STA 12, CHORD ACC, FT/SEC**2
2152	RTR 2,BLD 3,STA 12, CHORD ACC, FT/SEC**2
2153	RTR 2,BLD 4,STA 12, CHORD ACC, FT/SEC**2
2154	RTR 2,BLD 5,STA 12, CHORD ACC, FT/SEC**2
2155	RTR 2,BLD 6,STA 12, CHORD ACC, FT/SEC**2
2156	RTR 2,BLD 7,STA 12, CHORD ACC, FT/SEC**2
2157	RTR 2,BLD 1,STA 11, CHORD ACC, FT/SEC**2
2158	RTR 2,BLD 2,STA 11, CHORD ACC, FT/SEC**2
2159	RTR 2,BLD 3,STA 11, CHORD ACC, FT/SEC**2
2160	RTR 2,BLD 4,STA 11, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
2161	RTR 2,BLD 5,STA 11, CHORD ACC, FT/SEC**2
2162	RTR 2,BLD 6,STA 11, CHORD ACC, FT/SEC**2
2163	RTR 2,BLD 7,STA 11, CHORD ACC, FT/SEC**2
2164	RTR 2,BLD 1,STA 10, CHORD ACC, FT/SEC**2
2165	RTR 2,BLD 2,STA 10, CHORD ACC, FT/SEC**2
2166	RTR 2,BLD 3,STA 10, CHORD ACC, FT/SEC**2
2167	RTR 2,BLD 4,STA 10, CHORD ACC, FT/SEC**2
2168	RTR 2,BLD 5,STA 10, CHORD ACC, FT/SEC**2
2169	RTR 2,BLD 6,STA 10, CHORD ACC, FT/SEC**2
2170	RTR 2,BLD 7,STA 10, CHORD ACC, FT/SEC**2
2171	RTR 2,BLD 1,STA 9, CHORD ACC, FT/SEC**2
2172	RTR 2,BLD 2,STA 9, CHORD ACC, FT/SEC**2
2173	RTR 2,BLD 3,STA 9, CHORD ACC, FT/SEC**2
2174	RTR 2,BLD 4,STA 9, CHORD ACC, FT/SEC**2
2175	RTR 2,BLD 5,STA 9, CHORD ACC, FT/SEC**2
2176	RTR 2,BLD 6,STA 9, CHORD ACC, FT/SEC**2
2177	RTR 2,BLD 7,STA 9, CHORD ACC, FT/SEC**2
2178	RTR 2,BLD 1,STA 8, CHORD ACC, FT/SEC**2
2179	RTR 2,BLD 2,STA 8, CHORD ACC, FT/SEC**2
2180	RTR 2,BLD 3,STA 8, CHORD ACC, FT/SEC**2
2181	RTR 2,BLD 4,STA 8, CHORD ACC, FT/SEC**2
2182	RTR 2,BLD 5,STA 8, CHORD ACC, FT/SEC**2
2183	RTR 2,BLD 6,STA 8, CHORD ACC, FT/SEC**2
2184	RTR 2,BLD 7,STA 8, CHORD ACC, FT/SEC**2
2185	RTR 2,BLD 1,STA 7, CHORD ACC, FT/SEC**2
2186	RTR 2,BLD 2,STA 7, CHORD ACC, FT/SEC**2
2187	RTR 2,BLD 3,STA 7, CHORD ACC, FT/SEC**2
2188	RTR 2,BLD 4,STA 7, CHORD ACC, FT/SEC**2
2189	RTR 2,BLD 5,STA 7, CHORD ACC, FT/SEC**2
2190	RTR 2,BLD 6,STA 7, CHORD ACC, FT/SEC**2
2191	RTR 2,BLD 7,STA 7, CHORD ACC, FT/SEC**2
2192	RTR 2,BLD 1,STA 6, CHORD ACC, FT/SEC**2
2193	RTR 2,BLD 2,STA 6, CHORD ACC, FT/SEC**2
2194	RTR 2,BLD 3,STA 6, CHORD ACC, FT/SEC**2
2195	RTR 2,BLD 4,STA 6, CHORD ACC, FT/SEC**2
2196	RTR 2,BLD 5,STA 6, CHORD ACC, FT/SEC**2
2197	RTR 2,BLD 6,STA 6, CHORD ACC, FT/SEC**2
2198	RTR 2,BLD 7,STA 6, CHORD ACC, FT/SEC**2
2199	RTR 2,BLD 1,STA 5, CHORD ACC, FT/SEC**2
2200	RTR 2,BLD 2,STA 5, CHORD ACC, FT/SEC**2
2201	RTR 2,BLD 3,STA 5, CHORD ACC, FT/SEC**2
2202	RTR 2,BLD 4,STA 5, CHORD ACC, FT/SEC**2
2203	RTR 2,BLD 5,STA 5, CHORD ACC, FT/SEC**2
2204	RTR 2,BLD 6,STA 5, CHORD ACC, FT/SEC**2
2205	RTR 2,BLD 7,STA 5, CHORD ACC, FT/SEC**2
2206	RTR 2,BLD 1,STA 4, CHORD ACC, FT/SEC**2
2207	RTR 2,BLD 2,STA 4, CHORD ACC, FT/SEC**2
2208	RTR 2,BLD 3,STA 4, CHORD ACC, FT/SEC**2
2209	RTR 2,BLD 4,STA 4, CHORD ACC, FT/SEC**2
2210	RTR 2,BLD 5,STA 4, CHORD ACC, FT/SEC**2
2211	RTR 2,BLD 6,STA 4, CHORD ACC, FT/SEC**2
2212	RTR 2,BLD 7,STA 4, CHORD ACC, FT/SEC**2
2213	RTR 2,BLD 1,STA 3, CHORD ACC, FT/SEC**2
2214	RTR 2,BLD 2,STA 3, CHORD ACC, FT/SEC**2
2215	RTR 2,BLD 3,STA 3, CHORD ACC, FT/SEC**2
2216	RTR 2,BLD 4,STA 3, CHORD ACC, FT/SEC**2
2217	RTR 2,BLD 5,STA 3, CHORD ACC, FT/SEC**2
2218	RTR 2,BLD 6,STA 3, CHORD ACC, FT/SEC**2
2219	RTR 2,BLD 7,STA 3, CHORD ACC, FT/SEC**2
2220	RTR 2,BLD 1,STA 2, CHORD ACC, FT/SEC**2

TABLE 22. Continued.

Number	Description
2221	RTR 2,BLD 2,STA 2, CHORD ACC, FT/SEC**2
2222	RTR 2,BLD 3,STA 2, CHORD ACC, FT/SEC**2
2223	RTR 2,BLD 4,STA 2, CHORD ACC, FT/SEC**2
2224	RTR 2,BLD 5,STA 2, CHORD ACC, FT/SEC**2
2225	RTR 2,BLD 6,STA 2, CHORD ACC, FT/SEC**2
2226	RTR 2,BLD 7,STA 2, CHORD ACC, FT/SEC**2
2227	RTR 2,BLD 1,STA 1, CHORD ACC, FT/SEC**2
2228	RTR 2,BLD 2,STA 1, CHORD ACC, FT/SEC**2
2229	RTR 2,BLD 3,STA 1, CHORD ACC, FT/SEC**2
2230	RTR 2,BLD 4,STA 1, CHORD ACC, FT/SEC**2
2231	RTR 2,BLD 5,STA 1, CHORD ACC, FT/SEC**2
2232	RTR 2,BLD 6,STA 1, CHORD ACC, FT/SEC**2
2233	RTR 2,BLD 7,STA 1, CHORD ACC, FT/SEC**2
2234	RTR 2,BLD 1,STA 20, TORS ACC, DEG/SEC**2
2235	RTR 2,BLD 2,STA 20, TORS ACC, DEG/SEC**2
2236	RTR 2,BLD 3,STA 20, TORS ACC, DEG/SEC**2
2237	RTR 2,BLD 4,STA 20, TORS ACC, DEG/SEC**2
2238	RTR 2,BLD 5,STA 20, TORS ACC, DEG/SEC**2
2239	RTR 2,BLD 6,STA 20, TORS ACC, DEG/SEC**2
2240	RTR 2,BLD 7,STA 20, TORS ACC, DEG/SEC**2
2241	RTR 2,BLD 1,STA 19, TORS ACC, DEG/SEC**2
2242	RTR 2,BLD 2,STA 19, TORS ACC, DEG/SEC**2
2243	RTR 2,BLD 3,STA 19, TORS ACC, DEG/SEC**2
2244	RTR 2,BLD 4,STA 19, TORS ACC, DEG/SEC**2
2245	RTR 2,BLD 5,STA 19, TORS ACC, DEG/SEC**2
2246	RTR 2,BLD 6,STA 19, TORS ACC, DEG/SEC**2
2247	RTR 2,BLD 7,STA 19, TORS ACC, DEG/SEC**2
2248	RTR 2,BLD 1,STA 18, TORS ACC, DEG/SEC**2
2249	RTR 2,BLD 2,STA 18, TORS ACC, DEG/SEC**2
2250	RTR 2,BLD 3,STA 18, TORS ACC, DEG/SEC**2
2251	RTR 2,BLD 4,STA 18, TORS ACC, DEG/SEC**2
2252	RTR 2,BLD 5,STA 18, TORS ACC, DEG/SEC**2
2253	RTR 2,BLD 6,STA 18, TORS ACC, DEG/SEC**2
2254	RTR 2,BLD 7,STA 18, TORS ACC, DEG/SEC**2
2255	RTR 2,BLD 1,STA 17, TORS ACC, DEG/SEC**2
2256	RTR 2,BLD 2,STA 17, TORS ACC, DEG/SEC**2
2257	RTR 2,BLD 3,STA 17, TORS ACC, DEG/SEC**2
2258	RTR 2,BLD 4,STA 17, TORS ACC, DEG/SEC**2
2259	RTR 2,BLD 5,STA 17, TORS ACC, DEG/SEC**2
2260	RTR 2,BLD 6,STA 17, TORS ACC, DEG/SEC**2
2261	RTR 2,BLD 7,STA 17, TORS ACC, DEG/SEC**2
2262	RTR 2,BLD 1,STA 16, TORS ACC, DEG/SEC**2
2263	RTR 2,BLD 2,STA 16, TORS ACC, DEG/SEC**2
2264	RTR 2,BLD 3,STA 16, TORS ACC, DEG/SEC**2
2265	RTR 2,BLD 4,STA 16, TORS ACC, DEG/SEC**2
2266	RTR 2,BLD 5,STA 16, TORS ACC, DEG/SEC**2
2267	RTR 2,BLD 6,STA 16, TORS ACC, DEG/SEC**2
2268	RTR 2,BLD 7,STA 16, TORS ACC, DEG/SEC**2
2269	RTR 2,BLD 1,STA 15, TORS ACC, DEG/SEC**2
2270	RTR 2,BLD 2,STA 15, TORS ACC, DEG/SEC**2
2271	RTR 2,BLD 3,STA 15, TORS ACC, DEG/SEC**2
2272	RTR 2,BLD 4,STA 15, TORS ACC, DEG/SEC**2
2273	RTR 2,BLD 5,STA 15, TORS ACC, DEG/SEC**2
2274	RTR 2,BLD 6,STA 15, TORS ACC, DEG/SEC**2
2275	RTR 2,BLD 7,STA 15, TORS ACC, DEG/SEC**2
2276	RTR 2,BLD 1,STA 14, TORS ACC, DEG/SEC**2
2277	RTR 2,BLD 2,STA 14, TORS ACC, DEG/SEC**2
2278	RTR 2,BLD 3,STA 14, TORS ACC, DEG/SEC**2
2279	RTR 2,BLD 4,STA 14, TORS ACC, DEG/SEC**2
2280	RTR 2,BLD 5,STA 14, TORS ACC, DEG/SEC**2

TABLE 22. Continued.

Number	Description
2281	RTR 2, BLD 6, STA 14, TORS ACC, DEG/SEC**2
2282	RTR 2, BLD 7, STA 14, TORS ACC, DEG/SEC**2
2283	RTR 2, BLD 1, STA 13, TORS ACC, DEG/SEC**2
2284	RTR 2, BLD 2, STA 13, TORS ACC, DEG/SEC**2
2285	RTR 2, BLD 3, STA 13, TORS ACC, DEG/SEC**2
2286	RTR 2, BLD 4, STA 13, TORS ACC, DEG/SEC**2
2287	RTR 2, BLD 5, STA 13, TORS ACC, DEG/SEC**2
2288	RTR 2, BLD 6, STA 13, TORS ACC, DEG/SEC**2
2289	RTR 2, BLD 7, STA 13, TORS ACC, DEG/SEC**2
2290	RTR 2, BLD 1, STA 12, TORS ACC, DEG/SEC**2
2291	RTR 2, BLD 2, STA 12, TORS ACC, DEG/SEC**2
2292	RTR 2, BLD 3, STA 12, TORS ACC, DEG/SEC**2
2293	RTR 2, BLD 4, STA 12, TORS ACC, DEG/SEC**2
2294	RTR 2, BLD 5, STA 12, TORS ACC, DEG/SEC**2
2295	RTR 2, BLD 6, STA 12, TORS ACC, DEG/SEC**2
2296	RTR 2, BLD 7, STA 12, TORS ACC, DEG/SEC**2
2297	RTR 2, BLD 1, STA 11, TORS ACC, DEG/SEC**2
2298	RTR 2, BLD 2, STA 11, TORS ACC, DEG/SEC**2
2299	RTR 2, BLD 3, STA 11, TORS ACC, DEG/SEC**2
2300	RTR 2, BLD 4, STA 11, TORS ACC, DEG/SEC**2
2301	RTR 2, BLD 5, STA 11, TORS ACC, DEG/SEC**2
2302	RTR 2, BLD 6, STA 11, TORS ACC, DEG/SEC**2
2303	RTR 2, BLD 7, STA 11, TORS ACC, DEG/SEC**2
2304	RTR 2, BLD 1, STA 10, TORS ACC, DEG/SEC**2
2305	RTR 2, BLD 2, STA 10, TORS ACC, DEG/SEC**2
2306	RTR 2, BLD 3, STA 10, TORS ACC, DEG/SEC**2
2307	RTR 2, BLD 4, STA 10, TORS ACC, DEG/SEC**2
2308	RTR 2, BLD 5, STA 10, TORS ACC, DEG/SEC**2
2309	RTR 2, BLD 6, STA 10, TORS ACC, DEG/SEC**2
2310	RTR 2, BLD 7, STA 10, TORS ACC, DEG/SEC**2
2311	RTR 2, BLD 1, STA 9, TORS ACC, DEG/SEC**2
2312	RTR 2, BLD 2, STA 9, TORS ACC, DEG/SEC**2
2313	RTR 2, BLD 3, STA 9, TORS ACC, DEG/SEC**2
2314	RTR 2, BLD 4, STA 9, TORS ACC, DEG/SEC**2
2315	RTR 2, BLD 5, STA 9, TORS ACC, DEG/SEC**2
2316	RTR 2, BLD 6, STA 9, TORS ACC, DEG/SEC**2
2317	RTR 2, BLD 7, STA 9, TORS ACC, DEG/SEC**2
2318	RTR 2, BLD 1, STA 8, TORS ACC, DEG/SEC**2
2319	RTR 2, BLD 2, STA 8, TORS ACC, DEG/SEC**2
2320	RTR 2, BLD 3, STA 8, TORS ACC, DEG/SEC**2
2321	RTR 2, BLD 4, STA 8, TORS ACC, DEG/SEC**2
2322	RTR 2, BLD 5, STA 8, TORS ACC, DEG/SEC**2
2323	RTR 2, BLD 6, STA 8, TORS ACC, DEG/SEC**2
2324	RTR 2, BLD 7, STA 8, TORS ACC, DEG/SEC**2
2325	RTR 2, BLD 1, STA 7, TORS ACC, DEG/SEC**2
2326	RTR 2, BLD 2, STA 7, TORS ACC, DEG/SEC**2
2327	RTR 2, BLD 3, STA 7, TORS ACC, DEG/SEC**2
2328	RTR 2, BLD 4, STA 7, TORS ACC, DEG/SEC**2
2329	RTR 2, BLD 5, STA 7, TORS ACC, DEG/SEC**2
2330	RTR 2, BLD 6, STA 7, TORS ACC, DEG/SEC**2
2331	RTR 2, BLD 7, STA 7, TORS ACC, DEG/SEC**2
2332	RTR 2, BLD 1, STA 6, TORS ACC, DEG/SEC**2
2333	RTR 2, BLD 2, STA 6, TORS ACC, DEG/SEC**2
2334	RTR 2, BLD 3, STA 6, TORS ACC, DEG/SEC**2
2335	RTR 2, BLD 4, STA 6, TORS ACC, DEG/SEC**2
2336	RTR 2, BLD 5, STA 6, TORS ACC, DEG/SEC**2
2337	RTR 2, BLD 6, STA 6, TORS ACC, DEG/SEC**2
2338	RTR 2, BLD 7, STA 6, TORS ACC, DEG/SEC**2
2339	RTR 2, BLD 1, STA 5, TORS ACC, DEG/SEC**2
2340	RTR 2, BLD 2, STA 5, TORS ACC, DEG/SEC**2

TABLE 22. Concluded.

Number	Description
2341	RTR 2,BLD 3,STA 5, TORS ACC, DEG/SEC**2
2342	RTR 2,BLD 4,STA 5, TORS ACC, DEG/SEC**2
2343	RTR 2,BLD 5,STA 5, TORS ACC, DEG/SEC**2
2344	RTR 2,BLD 6,STA 5, TORS ACC, DEG/SEC**2
2345	RTR 2,BLD 7,STA 5, TORS ACC, DEG/SEC**2
2346	RTR 2,BLD 1,STA 4, TORS ACC, DEG/SEC**2
2347	RTR 2,BLD 2,STA 4, TORS ACC, DEG/SEC**2
2348	RTR 2,BLD 3,STA 4, TORS ACC, DEG/SEC**2
2349	RTR 2,BLD 4,STA 4, TORS ACC, DEG/SEC**2
2350	RTR 2,BLD 5,STA 4, TORS ACC, DEG/SEC**2
2351	RTR 2,BLD 6,STA 4, TORS ACC, DEG/SEC**2
2352	RTR 2,BLD 7,STA 4, TORS ACC, DEG/SEC**2
2353	RTR 2,BLD 1,STA 3, TORS ACC, DEG/SEC**2
2354	RTR 2,BLD 2,STA 3, TORS ACC, DEG/SEC**2
2355	RTR 2,BLD 3,STA 3, TORS ACC, DEG/SEC**2
2356	RTR 2,BLD 4,STA 3, TORS ACC, DEG/SEC**2
2357	RTR 2,BLD 5,STA 3, TORS ACC, DEG/SEC**2
2358	RTR 2,BLD 6,STA 3, TORS ACC, DEG/SEC**2
2359	RTR 2,BLD 7,STA 3, TORS ACC, DEG/SEC**2
2360	RTR 2,BLD 1,STA 2, TORS ACC, DEG/SEC**2
2361	RTR 2,BLD 2,STA 2, TORS ACC, DEG/SEC**2
2362	RTR 2,BLD 3,STA 2, TORS ACC, DEG/SEC**2
2363	RTR 2,BLD 4,STA 2, TORS ACC, DEG/SEC**2
2364	RTR 2,BLD 5,STA 2, TORS ACC, DEG/SEC**2
2365	RTR 2,BLD 6,STA 2, TORS ACC, DEG/SEC**2
2366	RTR 2,BLD 7,STA 2, TORS ACC, DEG/SEC**2
2367	RTR 2,BLD 1,STA 1, TORS ACC, DEG/SEC**2
2368	RTR 2,BLD 2,STA 1, TORS ACC, DEG/SEC**2
2369	RTR 2,BLD 3,STA 1, TORS ACC, DEG/SEC**2
2370	RTR 2,BLD 4,STA 1, TORS ACC, DEG/SEC**2
2371	RTR 2,BLD 5,STA 1, TORS ACC, DEG/SEC**2
2372	RTR 2,BLD 6,STA 1, TORS ACC, DEG/SEC**2
2373	RTR 2,BLD 7,STA 1, TORS ACC, DEG/SEC**2
2374	X-ACC AT A SPECIFIED POINT, BODY AXIS, G
2375	Y-ACC AT A SPECIFIED POINT, BODY AXIS, G
2376	Z-ACC AT A SPECIFIED POINT, BODY AXIS, G
2377	NOT USED
2378	NOT USED
2379	NOT USED
2380	NOT USED
2381	NOT USED
2382	NOT USED
2383	NOT USED
2384	NOT USED
2385	NOT USED
2386	NOT USED
2387	NOT USED
2388	NOT USED
2389	NOT USED
2390	NOT USED
2391	NOT USED
2392	NOT USED
2393	NOT USED
2394	NOT USED
2395	NOT USED
2396	NOT USED
2397	NOT USED
2398	NOT USED
2399	NOT USED
2400	NOT USED

TABLE 23. PLOT CODES FOR BENDING MOMENTS AND ACCELERATIONS AT EACH STATION ON BLADE 1 OF ROTOR 1

STATION	BEAM		CHORD		TORSION	
(Root to Tip)	Moment	Accel	Moment	Accel	Moment	Accel
0 (0% R)	759	*	899	*	1039	*
1	752	1667	892	1807	1032	1947
2	745	1660	885	1800	1025	1940
3	739	1653	878	1793	1018	1933
4	731	1646	871	1786	1011	1926
5	724	1639	864	1779	1004	1919
6	717	1632	857	1772	997	1912
7	710	1625	850	1765	990	1905
8	703	1618	843	1758	983	1898
9	696	1611	836	1751	976	1891
10	689	1604	829	1744	969	1884
11	682	1597	822	1737	962	1877
12	675	1590	815	1730	955	1870
13	668	1583	808	1723	948	1863
14	661	1576	801	1716	941	1856
15	654	1569	794	1709	934	1849
16	647	1562	787	1702	927	1842
17	640	1555	780	1695	920	1835
18	633	1548	773	1688	913	1828
19	626	1541	766	1681	906	1821
20	*	1534	*	1674	*	1814

*Not available for this station.

7.0 AUXILIARY PROGRAMS

Three digital computer programs, DNAM05, AR9101, and AN9101 are used to prepare C81 input data. Program DNAM05 is used to compute coupled rotor natural frequencies and mode shapes from a set of blade structural parameters, AR9102 computes the rotor-induced velocity distribution, and AN9101 converts airframe wind tunnel test data to the AGAJ77 input format. All three programs can punch their output for direct inclusion in an AGAJ77 deck. DNAM05 and AR9102 are coded in FORTRAN IV while AN9101 is a PL/1 program.

7.1 ROTOR NATURAL FREQUENCY PROGRAM DNAM05

7.1.1 Analytical Model

The analysis incorporated in this program is described in Section 3.2 of Volume I.

DNAM05 computes the natural frequencies and mode shapes of the rotor described by the user's input. The program assumes a natural frequency ω, solves a matrix equation with five known boundary conditions, and then finds the value of ω for which the resulting polynomial is zero. Three types of mode shapes are computed and printed, depending upon rotor type, as follows: (1) hingeless or articulated-collective and scissors, (2) teetering or gimbaled (2, 3 or 5 blades)-collective and cyclic, (3) teetering or gimabled (4 or 6 blades)-collective, cyclic and scissors. Note that if SLAMUR is specified, all mode types will be computed and printed.

A maximum of 40 blade segments allows the user to make a detailed dynamic definition in the areas of interest. Blade segment data must be input in order out the blade to prevent negative segment lengths from being generated. Numerical problems may result if segment lengths less than 1% of the radius are used.

In the hub region, the beamwise and chordwise offsets of the cg, neutral axis, and shear center are defined relative to a radial axis through the center of rotation. The hub segments are all segments which lie entirely inboard of the radius where the blade reference system starts, RBCS. (See Figures 75 and 76.) For linear twist distributions, the blade twist is given as:

$$\theta_i = 0 \text{ for } i < \text{LPHOFF}$$

$$\theta_i = (\text{Twist}/R_{Tip})R_i + \text{THINC for } i > \text{LPHOFF}.$$

All offsets measured relative to Hub Reference Axis inboard of RBCS, as at 1.

All offsets measured relative to Blade System Reference Axis outboard of RBCS, as at 2.

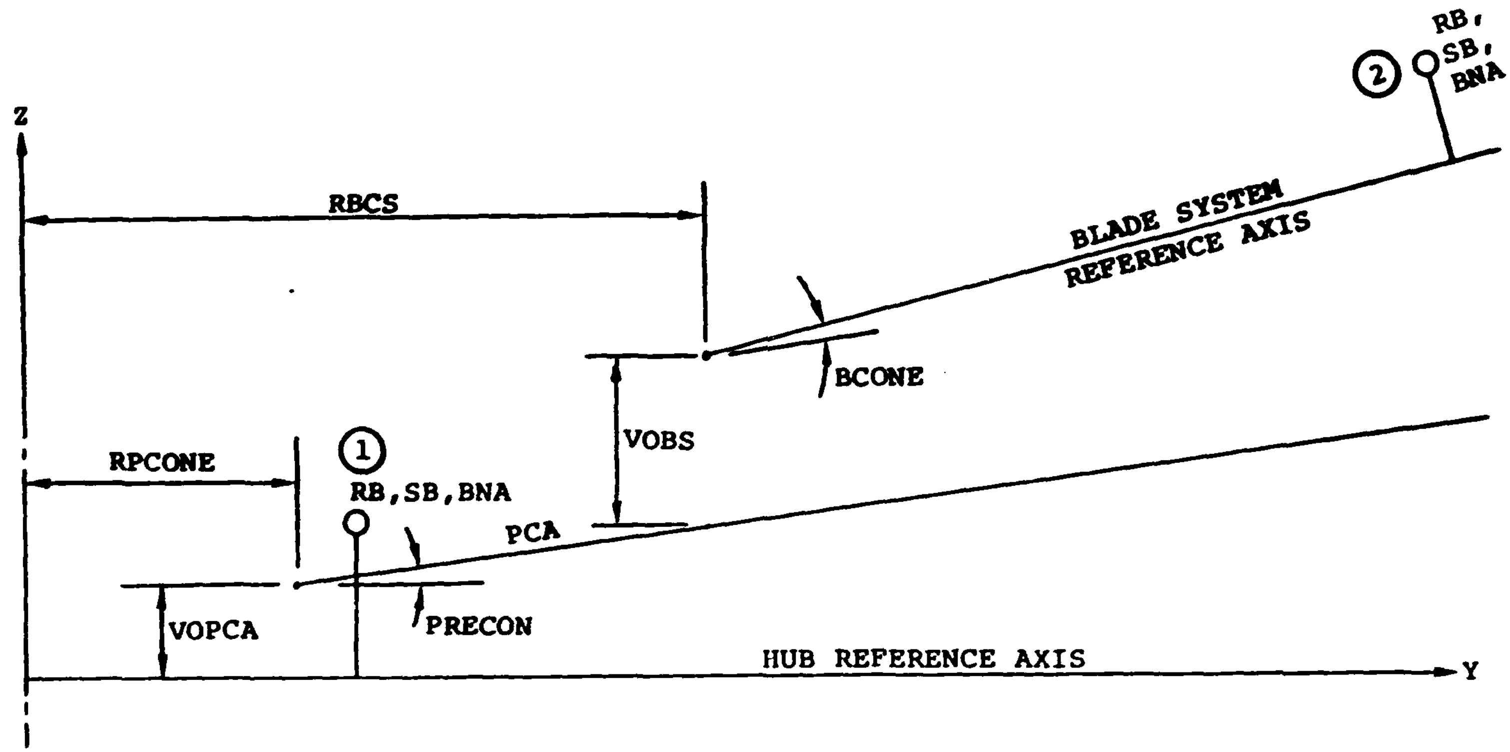
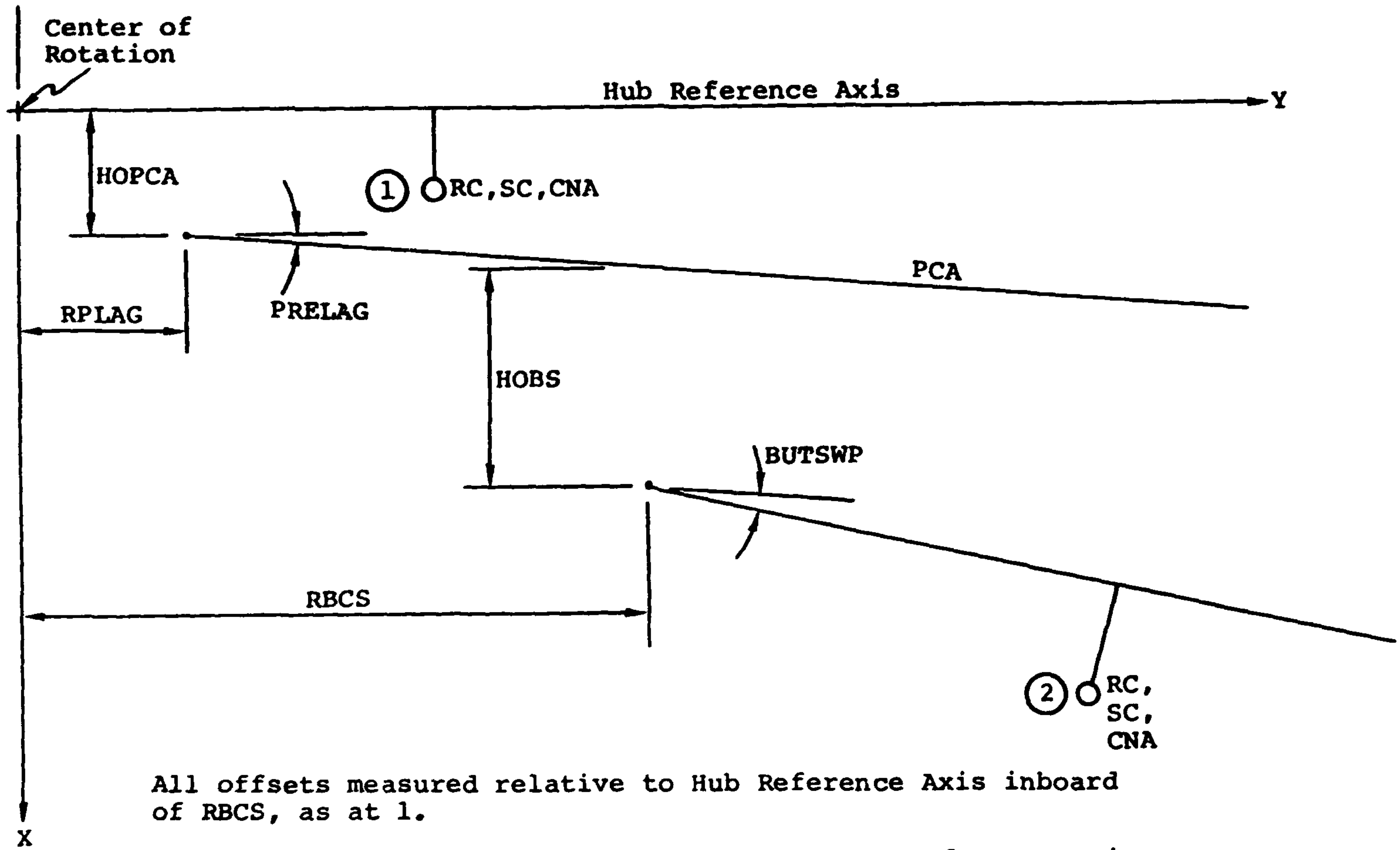


Figure 75. Out-of-Plane Offsets and Slopes for PCA and Blade System Axes.



All offsets measured relative to Hub Reference Axis inboard of RBCS, as at 1.

All offsets measured relative to Blade System Reference Axis outboard of RBCS, as at 2.

Figure 76. Inplane Offsets and Slopes for PCA and Blade System Axes.

The input linear twist should be based on the full radius even though the twist is zero inside of JHUB.

Outboard of RBCS, the cg, neutral axis, and shear center offsets are defined relative to an arbitrary blade reference system. It has been assumed that the blade built-in twist is a rotation about the blade reference axis, although this should only be significant for highly twisted rotors. The PCA (Pitch Change Axis) is used as the reference calculations for all internal calculations. The necessary transformations are made for each value of collective pitch.

In order to model articulation hinges, DNAM05 will accept a zero EI input for a segment in either beamwise or chordwise direction, or the inputs for hinge offsets. If a zero EI is input, it is best to use the zero EI for a short segment with the unequal segment option because that segment is modeled as a rigid element with a pin joint at the outboard end. The inputs for flapping spring and lag spring may be used for restraint about the hinges if desired.

There are four inputs which describe the geometry of the hub for torsional behavior. The input for the number of nonfeathering hub segments (JHUB) is used in all cases, but serves an additional purpose when torsion is used. The feathering bearings are assumed to be just outboard of segment number JHUB or the distance PHOFF (the radial location of the pitch horn attachment), whichever is less. The feathering bearings are modeled as one segment with a very small torsional stiffness. This value is set internally to 10^{-4} times GI for the tip segment or 10^{-4}*CK/ZBAR(N), whichever is larger. If the rotor being modeled does not have feathering bearings, the user should input JHUB as zero. This will activate the bearingless rotor model, which does not modify the GI values input. The pitch horn geometry is sketched in Figure 77.

The inputs PHOFF, PARM, PHMASS, PHMR, PHMC, PHMB, EIPH and PLSTA, along with the control system spring rate, determine the torsional moment, vertical shear and out-of-plane bending moment put into the blade from the pitch horn and control system. The pitch horn model described by these inputs will give rise to pitch-flap and pitch-cone coupling independent of the hinge skew angle inputs. It is necessary for rotors with a feathering bearing (JHUB>0) to have PHOFF≥Z(2) or no feathering bearing is modeled.

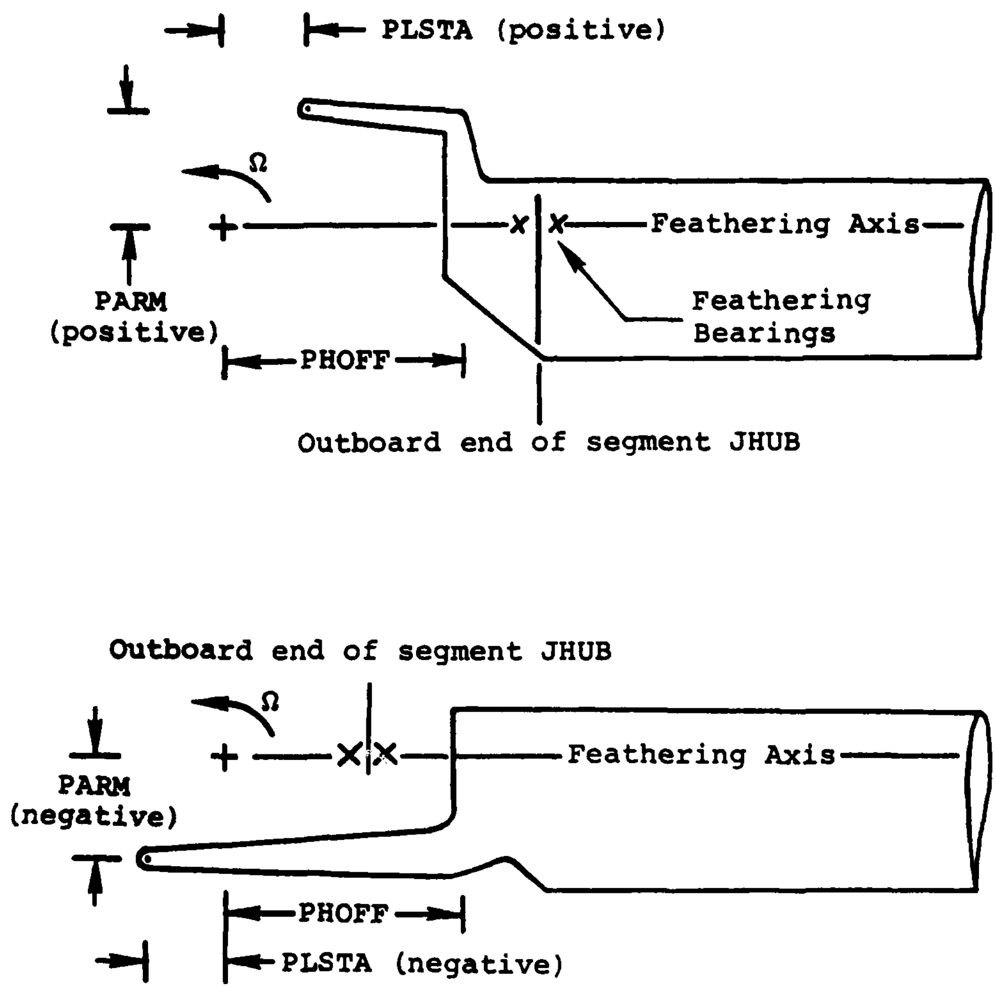


Figure 77. Definition of Pitch Horn Geometry.

7.1.2 Restrictions

The maximum number of segments is 40. The maximum number of segments to be punched is 20. If NEWPUNCH or SLAMUR is specified, the user may request a maximum of 14 punched modes. XNIN and XNOUT may not be changed under the NAMELIST option. If the number of hub segments is to be changed, the variable JHUB must be input in integer form. Blade segment data must be input in order out the blade. Segment length should be greater than 1% of the radius. The control word DECK or READONLY must appear on the second card of each DNAM05 deck. If NEWPUNCH or SLAMUR are to be used for any subsequent cases, it must appear on the first CARD 2 of the deck. PHOFF$\geq$Z(2) is required to permit a feathering bearing model.

Some input is required only if certain options are specified on CARD 2.

7.2 INPUT GUIDE FOR DNAM05

This section contains all the information necessary to set up a DNAM05 deck. Since the input format varies from card to card, the format will be given for each card. The NAMELIST name of those variables which can be changed on an &INPUT card will also be given.

7.2.1 Input Format for DNAM05

CARD 1 (20A4)

80 columns of alphanumeric data giving the user's name, group, telephone extension and any special run dispositon instructions.

CARD 2 Control Card (7(A4,6X))

This card contains the program control instructions. The words do not need to be in a particular order, but they must be left-justfied in each 10-column field, i.e., the words must start in columns 1, 11, 21, etc. The control word DECK must appear on the second card of each DNAM05 deck.

Control Words	
DECK	Read full data deck
READONLY	Read full data deck, skip execution and go to first NAMELIST
NAMELIST	Read changes to previous case (see 7.2.2)

PUNCH	Punch elastic data for input to C81 (pre-1976 format)
NEWPUNCH	Punch elastic data for input to C81 in new format (must be on first CARD 2 if it will be used for any subsequent case)
SLAMUR	Punch elastic data for input to the SLAMUR version of C81 (must be on first CARD 2 if used anywhere in deck)
MODES	Print mode shapes at one combination of rpm and collective pitch
ALLMODES	Print all calculated mode shapes
PLOT	Make fan plots on CALCOMP (Type 401-A paper)
TORSION	Read and/or use torsion data
TWIST	Read and/or use nonlinear twist distribution
NOT20	The number of segments used will not be 20. Input number of segments to be input on CARD 6.
UNEQUAL	The unequal segment length option will be used
END	End problem

CARD 3 (A4, A3, IX, 18A4)

NAME	7-column alphanumeric problem identificaton name
ITLE	72-column alphanumeric problem description. The first 40 characters are printed on one line and the last 32 characters are printed below them.

CARD 4 (7F10.0)

Column			
1-10	JHUB	Number of nonfeathering hub segments	
11-20	TORSO	Effective torsional spring rate of drive system per blade/10^6	$\left(\frac{\text{in.-lb}}{\text{rad}}\right)$
21-30	VMASS	Effective vertical hub mass per blade	(lb_m)

31-40	HMASS	Effective inplane hub mass per blade	(lb_m)
41-50	VSOFT	Effective vertical restraint/10^6	$\left(\frac{1}{lb}\right)$
51-60	HSOFT	Effective inplane restraint/10^6	$\left(\frac{1}{lb}\right)$
61-70	RSOFT	Flapping spring rate for flapping restraint at center of rotation (gimbaled rotors only), per blade	$\left(\frac{ft-lb}{deg}\right)$
CARD 5	(7F10.0)		
1-10	AZBAR	Segment length for equal segments	(in.)
11-20	RPMA	Initial rpm	(rpm)
21-30	RPMB	Intermediate rpm	(rpm)
31-40	RPMC	Final rpm	(rpm)
41-50	COLLA	Initial root collective - measured at center of rotation	(deg)
51-60	COLLB	Intermediate root collective	(deg)
61-70	COLLC	Final root collective	(deg)
CARD 6	(7F10.0)		
1-10	TWIST	Rotor linear twist, washout negative	(deg)
11-20	BLADES	Number of blades	
21-30	CHORD	Chord	(in.)
31-40	PSQR	Initial frequency in sweep (Default value = .1*RPMA)	(/rev)
41-50	DP	Delta frequency in sweep (Default value = 0.25*max (RPMA, RPMB, RPMC))	(/rev)
51-60	PLAST	Final frequency in sweep (Default value = 10*max (RPMA, RPMB, RPMC))	(/rev)
61-70	HUBTYP	Hub type indicator; 0 for teetering or gimbaled; 1 for articulated or hingless	

CARD 7 (7F10.0)

1-10	XNIN	Number of segments to be input (40 maximum)	
11-20	XNOUT	Number of segments to be punched for C81 (20 maximum)	
21-30	CK	Control system spring rate	$\left(\frac{\text{in.-lb}}{\text{rad}}\right)$
31-40	CDAMP	Control system damping (based on that for a nonrotating, rigid blade)	(%)
41-50	PHOFF	Pitch-horn radial attachment point	(in.)
51-60	PARM	Pitch-horn moment arm about pitch-change axis (positive for leading edge pitch horn)	(in.)
61-70	PLSTA	Radial station where pitch horn is attached to the pitch link	(in.)

CARD 8 (7F10.0)

1-10	FHOFF	Flapping hinge radial station	(in.)
11-20	FLPSPR	Rate of flapping spring at offset flapping hinge	$\left(\frac{\text{ft-lb}}{\text{deg}}\right)$
21-30	FHANGL	Skew angle of flapping hinge that yields pitch-flap coupling (positive for pitch down with up flapping)	(deg)
31-40	CHOFF	Lag hinge radial station	(in.)
41-50	SPRLG	Spring rate for lag spring	$\left(\frac{\text{ft-lb}}{\text{deg}}\right)$
51-60	ALPHAI	Skew angle of lag hinge which yields flap-lag coupling (positive for flap up, lag aft)	(deg)
61-70	ALPHA3	Skew angle of lag hinge which yields pitch-lag coupling (positive pitch up for lag aft)	(deg)

CARD 9 (6F10.0)

1-10	RPCONE	Radius where rotor precone begins (the out-of-plane geometry is shown in Figure 75)	(in.)

11-20	PRECON	Precone angle (out-of-plane) of the pitch-change axis (PCA)	(deg)
21-30	VOPCA	Vertical offset of the PCA at radius = RPCONE	(in.)
31-40	RPLAG	Radius where rotor prelag begins (the inplane geometry is shown in Figure 76)	(in.)
41-50	PRELAG	Prelag angle (inplane) of the PCA	(deg)
51-60	HOPCA	Horizontal offset of the PCA at radius = RPLAG	(in.)

CARD 10 (6F10.0)

1-10	RBCS	Radius where the blade coordinate system starts	(in.)
11-20	BCONE	Out-of-plane angle of the blade coordinate system relative to the PCA at 0° collective pitch	(deg)
21-30	VOBS	Vertical offset of the blade coordinate system from the PCA at 0° collective and radius = RBCS	(in.)
31-40	BUTSWP	Inplane angle of the blade coordinate system relative to the PCA at 0° collective	(deg)
41-50	HOBS	Horizontal offset of the blade coordinate system from the PCA at 0° collective and radius = RBCS	(in.)
51-60	THINC	Twist increment at PHOFF for linear twist	(deg)

CARD 11 (5F10.0)

Card 11 currently has no active inputs.

The rotor blade structural properties are input on the next XNIN cards (or 2*XNIN cards if TORSION was listed on CARD 2), from zero radius to the tip.

CARD 12 (7F10.0)

Blade Parameters for Segment

1-10	Z(2)	Distance from center of rotation to outboard end of segment. (May be zero for equal segments)	(in.)
11-20	WTPL(1)	Average weight per inch for segment	(lb-in.^{2})
21-30	EIB(1)	Effective beamwise stiffness/ 10^6 for segment	(lb-in.^{2})
31-40	EIC(1)	Effective chordwise stiffness/ 10^6 for segment	(lb-in.^{2})
41-50	THD(2)	Twist angle at outboard end of segment. (May be input as zero for linear twist)	(deg)
51-60	RB(1)	Beamwise offset of cg for segment (+ up)	(in.)
61-70	RC(1)	Chordwise offset of cg for segment (+ aft)	(in.)

CARD 12A (7F10.0)

OPTIONAL: Include only if TORSION was listed on CARD 2.

1-10	EYEB(1)	Average beamwise mass moment of inertia for segment	(in.-lb-sec^2)
11-20	EYEC(1)	Average chordwise mass moment of inertia for segment	(in.-lb-sec^2)
	NOTE:	EYEC >> EYEB	
21-30	GI(1)	Effective torsional stiffness/ 10^6 for segment	(lb-in.^{2})
31-40	SB(1)	Beamwise shear center offset for segment (+ up)	(in.)
41-50	SC(1)	Chordwise shear center offset for segment (+ aft)	(in.)
51-60	BNA(1)	Beamwise neutral axis offset for segment (+ up)	(in.)

61-70	CNA(1)	Chordwise neutral axis offset for segment (+ aft)	(in.)

CARD 13 (CARD 13A), CARD 14 (CARD 14A), through CARD XNIN+11 (CARD XNIN+11)A) contain the structural properties for the remaining segments of the blade, in the same format as CARD 12 and CARD 12A.

CARD XNIN+12 (4F10.0)

1-10	TIPWT	Additional balance weight (at 99% radius)	(lb)
11-20	RB(N+1)	Beamwise cg offset for tip weight	(in.)
21-30	RC(N+1)	Chordwise cg offset for tip weight	(in.)
31-40	FUNC	Low rpm to be used for uncoupled modes if PLOT was specified on CARD 2. (Default value is 1/3 RPMA)	(rpm)

CARDS XNIN+13, XNIN+14 (14I5)

OPTIONAL: If NEWPUNCH was specified on *CARD 2 and XNOUT on CARD 7 is less than XNIN*

ICUT — This card lists the station numbers for the stations to be eliminated in the punched output, in ascending order (XNIN-XNOUT values). ICUT is in 5 column fields without decimal (I5 format), 14 per card. The second card is omitted if less than 15 inputs are needed. Station 0 is at radius 0.0, and cannot be eliminated. Station 1 is at radius Z(2), Station 2 is at radius Z(3), etc. Station XNIN may not be eliminated.

CARD XNIN+15 (14I5)

NOTE: This card must be input if NEWPUNCH has been specified. If XNIN=XNOUT, it replaces CARDS XNIN+8 and XNIN+9. The card contains a series of right-justified integers specifying which mode shapes are to be punched.

Cyclic modes are denoted by negative integers, collective modes by positive integers and scissors modes by integers in excess of 100. The value of the integer (or the value minus 100 for scissors modes) indicate which modes of that type are to be punched. The first cyclic mode found by the program would be specified by -1, the third collective mode found would be specified by 3, and the second scissors mode found would be selected by 102.

The appropriate subscripted namelist variable is MODEP.

7.2.2 Parameter Sweeps Using NAMELIST

A range of values may be swept for a variable by running additional cases using the NAMELIST option. Three additional cards are required for each extra case:

a. Another CARD 2. Include NAMELIST and all options desired for this case.

b. Another CARD 3. The user changes ID number and description for each case.

c. Parameter changes for this case from the preceding case are made in the following form:

   &INPUT $\text{variable}_1 = \text{number}_1$, $\text{variable}_2 = \text{number}_2$,
   &END

Note that the &INPUT must be preceded and followed by one blank space. The variable names are given in the right-hand column of the input format. The variable list may be carried over onto another card, but all data on subsequent cards must precede &END.

The values for XNIN and XNOUT may be not be changed by namelist. These variables are not included in the list.

If the number of hub segments is to be changed by namelist, the variable JHUB must be put in integer form, i.e., it must be followed immediately by a comma. This is mentioned because JHUB is a decimal input in the basic deck.

7.2.3 Mass Addition Under NAMELIST

Three additional variables are available under the NAMELIST option to allow the user to simulate the addition of a concentrated mass at a specified spanwise and chordwise location.

The three subscripted variables are ISEG, ADMASS, DAHPCA.

ISEG(I) = number of the segment at which the mass is added.

ADMASS(I) = the amount of mass added (lbm)

DAHPCA(I) = distance of the added mass ahead of the pitch change axis (inch).

The subscript within the brackets is the serial number for the mass addition. For example:

```
&INPUT   ISEG(1) = 18, ADMASS(1) = 3.0, DAHPCA(1) = -0.9,
         ISEG(2) = 22, ADMASS(2) =-5.0, DAHPCA(2) =  0.5,
&END
```

means the user wants to add 3 pounds in segment 18, 0.9 inch behind the PCA, and remove 5 pounds from segment 22 at a point 0.5 inch ahead of the PCA. 99 modifications are possible, hence the maximum subscript is 99 (i.e., ISEG(99)).

It should be noted that this change takes place in the NAMELIST option only and leaves the basic deck permanently changed, i.e., these three new NAMELIST variables make cumulative changes to the deck, and the user should keep track of the changes. In the above example, if the next NAMELIST change reads

```
&INPUT   ISEG(1) = 18, ADMASS(1) = -3.0, DAHPCA(1) = -0.9,
         & END
```

then the 3-pound mass, added in Segment 18 previously, is now removed. In the same NAMELIST case, many serialized changes can pertain to a single segment itself. Even if only one of the three variables (ISEG, ADMASS, or DAHPCA) is changed, all three should be redefined in a serialized fashion.

The program redefines the values of WTPL (weight per unit length), RC (distance of the segment cg behind the PCA), and EYEC (the chordwise mass moment of inertia about the cg, per unit span) for the segment defined by ISEG. Becasue RC and EYEC are also modified instead of just WTPL, the effects of mass addition on the blade torsional mode shape are expected to be well represented.

7.3 DNAMO5 OUTPUT

DNAMO5 output consists of printed listings, punched cards and CALCOMP plots, as requested by the user (on CARD 2).

The user should request program DNAM05 on the Service Request Card, unless plots were specified, in which case DNAM06P must be requested. A salmon-colored Off-Line Processing Request card must also be submitted with the deck, specifying CALCOMP plots on 401-A paper.

The frequency plots show natural frequency versus RPM. Uncoupled frequencies are plotted as solid lines, with the Southwell coefficients printed to the right of the lines. The coupled frequencies are plotted as open symbols.

The printout consists of

(1) a page with the contents of CARD 1 printed repeatedly

(2) a listing of the remainder of the input deck

(3) Four pages showing the input and default values used

(4) pages tabulating and plotting the coupled mode shapes found by the analysis

(5) a summary of the coupled mode shape frequencies

If CALCOMP plots were requested, a summary of the uncoupled frequencies is printed.

7.4 ROTOR-INDUCED VELOCITY DISTRIBUTION TABLE GENERATOR, PROGRAM AR9102

Computer program AR9102 has been developed to generate non-uniform rotor-induced velocity distribution (RIVD) tables for C81. The program utilizes the simplified free-trailing wake analysis of Crimi (Reference 10).

The basic assumptions inherent in the analysis are:

1. The rotor blades are replaced by single lifting line vortices with strengths varying harmonically with azimuth position.

2. The wake is represented by individual free vortices trailing from the tip of each blade bound vortex.

3. Trailing root vortices and shed vortices are omitted.

4. The effects of viscosity and compressibility are neglected.

The total fluid velocity at an arbitrary point is expressed by the Biot-Savart law given in vector form as

[10]Crimi, Peter, THEORETICAL PREDICTION OF THE FLOW IN THE WAKE OF A HELICOPTER ROTOR, Cornell Aeronautical Laboratory Report No. BB-1994-5-1 and -2, New York, September 1965.

$$\vec{V}(\vec{r}_p) = -\frac{1}{4}\pi \int \frac{\Gamma(\vec{r})\,\vec{r}_1 \times d\vec{r}}{r_1^3} + \vec{V} \tag{1}$$

where the integral extends over all vortex elements in the flow. Equation (1) is employed to calculate the velocity at each element of the trailing vortex so that the wake distribution may be determined.

The analysis begins by calculating a helical wake shape (assuming uniform inflow) and strength from given vehicle parameters and flight conditions. The bound vortex strength is approximated assuming the circulation is equal to the maximum value of an elliptical spanwise distribution and that blade lift is constant about the azimuth,

$$\frac{\Gamma_m}{\Omega R^2} = \frac{8L(1 - 2\mu \sin\psi)}{\rho\pi b\Omega^2 R^4} \tag{2}$$

Once the blade vertex strength is known, the trailing wake strength at any point is simply given by the circulation about the blade when it generates that point in the wake.

Observe that Equation (1) is indeterminate when the distance between adjacent points on the vortex (r_1) approaches zero. Therefore, to obtain self-induced wake distortions, the vortex representation includes a finite core of rotational fluid. Since the velocity induced by the core at a point depends on the curvature of the core through that point, a circular arc is fitted through the point in question and two adjacent points.

The trailing vortex geometry is shown in Figure 78. If it is assumed that vorticity varies linearly and the core radii are small with respect to vortex radius of curvature, the self-induced velocity is given by

$$V_{s_i} = \frac{1}{8\pi R}\left\{\Gamma_{i-1}\left[\ln\frac{8\mathcal{R}}{a_{i-1}}\tan\frac{\phi_{i-1}}{4} + \frac{1}{4}\right.\right. \tag{3}$$

$$\left.\left. + \Gamma_i \ln\frac{8\mathcal{R}}{a_i}\tan\frac{\phi_i}{4} + \frac{1}{4}\right]\right\}$$

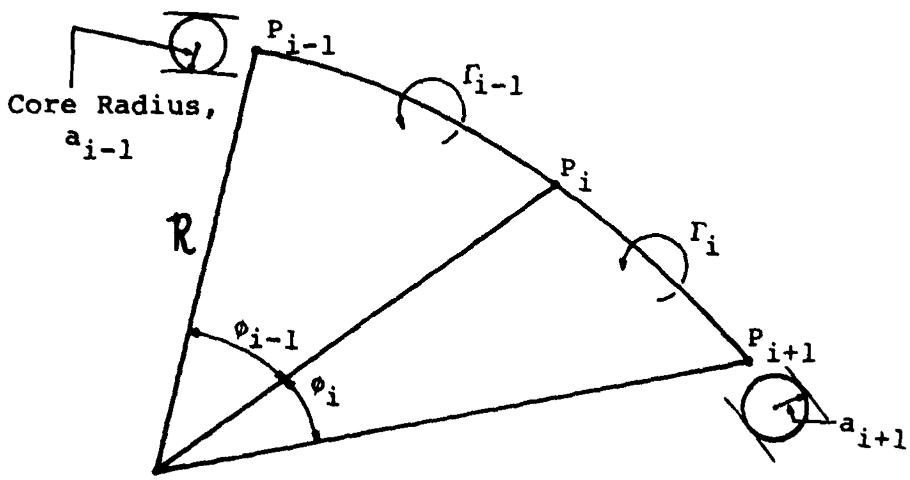


Figure 78. Trailing Vortex Geometry in AR9101.

The core radius, a (immediately after rollup), is determined from energy considerations and has been found to be relatively insensitive to azimuth position for various flight conditions. Thus, a constant value based on percent rotor radius (default equals 5 percent) is assigned to the first element trailing the blade. Further downstream, however, vortex stretching and vortex enlargement or "bursting" due to blade-vortex interaction significantly affect the core size. Hence, the volume of core fluid is assumed constant, yielding a relation fixing the radii in terms of vortex length.

Each point on the trailing wake is convected by the surrounding fluid at the local velocity determined by Equations (1) and (3). Thus, given its initial position, the location of a point at any instant is specified by the displacement relationship

$$\vec{r}(t) = \vec{r}(t_o) + \int_{t_o}^{t} \vec{V}[r(\tau)]\, d\tau \qquad (4)$$

The free wake geometry is obtained by applying Equation (4) to all points in the flow. Once the wake shape has been determined, the velocity field about the rotor at all nonwake points is calculated using Equation (1).

The wake analysis requires solution of Equation (4) where the integrand is defined by Equation (2), resulting in a nonlinear integral equation. The solution is obtained by a digital computer program that requires stepwise and interpolative approximations of the continuous functions. For example, the line integral along each tip vortex assumes that the vortex contains small rectilinear segments of constant circulation strength having initial lengths equal to the arc length of the blade tip swept through finite azimuth increments. Also, the time integration defining segment endpoint displacement is performed assuming the velocity remains constant over a time interval corresponding to the azimuth increment size.

7.4.1 Rotor-Induced Velocity Distribution (RIVD) Tables

Inputs to the computer program fall into three general categories: (1) inputs describing rotor and flight conditions, (2) inputs controlling degree of accuracy, and (3) inputs controlling various options and program logic. Using these inputs, the tip vortex locations and the velocity field about the rotor are determined by the wake model. The velocity components are normalized by either the computed value or an input value of the average induced velocity over the entire rotor disk. The normalized z-component of velocity can then be harmonically analyzed to yield rotor-induced velocity distribution tables compatible with C81.

7.5 INPUT FORMAT FOR AR9102

CARDS 1-3 (20A4)

Alphanumeric title cards

CARD 4 (8A4)

Alphanumeric title card - punched out with table

CARD 5 (7F10.0)

BATA
(1) Number of blades (ft)
(2) Radius, R (in.)
(3) Chord
(4) Currently used
(5) rpm
(6) Density ratio
(7) Currently unused

CARD 6 (7F10.0)

(8) Number of radial segments (default = 20)
(9) Azimuth increment, (default = 10) (deg)
(10) Vortex core radius, a_V (default = 0.05) (%R)
(11) Vortex bursting factor, K_B, used as $K_B a_V$. Default value is a function of airspeed, as shown in Figure 79. Input K_B = 1.0 for no bursting

(12) Assymmetric blade loading, percent circulation of Blade 1 (default = 1.0)
(13) Currently unused
(14) Set equal to 1.0 to read optional CARD B, otherwise to 0.0 - use only if the harmonic coefficients are to be nondimensionalized on an input average induced velocity instead of the one internally computed

CARD 7 (7F10.0)

(15) Number of advance ratios
(16) Number of inflow ratios or wake plane angles of attack
(17) Program control variable, JGO

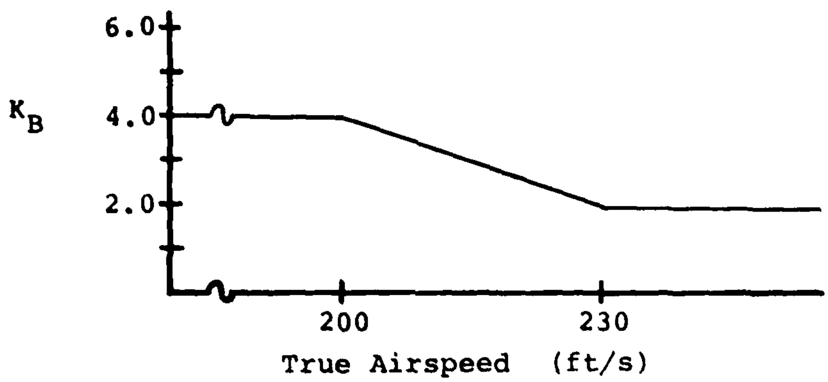


Figure 79. Default Vortex Bursting Factor in AR9101.

JGO = 0.0 generate RIVD table at constant inflow ratio (λ) dependent on first set of λ's calculated

= 1.0 same as JGO = 0 except λ's are input on additional CARDs C

= 2.0 input wake plane angles of attack, α_{WP}, for each λ and μ combination, on optional CARD D

= 3.0 RIVD tables at constant α_{WP}'s based on $\alpha_{WP_{min}}$ and $\alpha_{WP_{max}}$

= 4.0 RIVD tables at constant α_{WP}'s; input up to 10 α_{WP}'s to be used on optional CARD E

(18) Number of radial segments for output - read optional CARDs A if greater than 0.

(19)
(20) } Currently unused
(21)

CARD 8 (7F10.0)

(22) Printed output control

= 0.0	prints induced velocities (+ down) and harmonics as used in RIVD tables
= 1.0	same as 0.0, plus vortex locations
= 2.0	same as 1.0, plus all velocities
= 3.0	same as 0.0, plus all velocities

(23) NPUNC Punch control

<10	no punched output
>10	punches out RIVD tables, NPUNC/10 times

(24) Maximum harmonic to be punched must be ≤ 9 (default = 6)

(25)
(26)
(27) } Currently unused
(28)

CARD 9 (7F10.0)

(29)	Minimum resultant force	(lb)
(30)	Maximum resultant force	(lb)
(31)	Minimum airspeed	(KTAS)
(32)	Wake plane angle of attack at minimum airspeed-positive if resultant force inclined aft from perpendicular to wind	(deg)
(33)	Maximum airspeed	(KTAS)
(34)	Wake plane angle of attack at maximum airspeed	(deg)
(35)	Currently unused	

CARD 10 Currently unused

OPTIONAL CARDS - must be read in this order.

CARDs A Read only if BATA(18) > 0 (7F10.0)

Read the desired output radius distribution. Distribution must be root-to-tip. Three cards must be read even if BATA(18) < 14.

CARDs B Read only if BATA (14) = 1.0 (7F10.0)

Read in up to 14 average induced velocities (computed by C81, for example) for each μ - positive down. Must read two cards for each μ. (ft/sec)

CARDs C Read only if BATA(17) = 1.0 (7F10.0)

Read desired λ's
Must read two cards

CARDs D Read only if BATA(17) = 2.0 (10F7.0)

Read α_{WP}'s for each λ (deg)
Must read one card for each μ.

CARDs E Read only if BATA(17) = 4.0

Read α_{WP}'s - same α_{WP}'s used for all μ's (deg)
Must read two cards

7.6 AR9102 USER NOTES

This program is normally used by setting BATA(17) = JGO = 3.0, setting the minimum and maximum resultant forces equal, and sweeping on μ and α_{WP}. There will be BATA(15) advance ratios, evenly distributed between the airspeeds of BATA(31) and BATA(33), and BATA(16) wake plane angles of attack for each advance ratio, evenly distributed between BATA(32) and BATA (34).

The average induced velocity computed by this program, VITV, differs from that computed by C81 subroutine VIND, which is also calculated by AR9102 and printed out as VINC81. This latter quantity is based on zero hub extent and no tip loss. Since VIND uses an empirical expression for the average induced velocity, the difference between its v_i and that computed by AR9102 is not surprising.

If BATA(18) $\neq$ 0, the program expects a desired radius distribution to be input, on OPTIONAL CARDs A. All three cards must be input, and the radius distribution may be input in any units, as it is internally non-dimensionalized by the BATA(18)th radius input. The RIVD table punched under this option will have values of the induced velocity harmonics at the radii specified on CARDs A.

The punched output begins with a card-image of CARD 4 and each set of coefficients begins with a header card giving the advance ratio, inflow ratio, and wake plane angle of attack for that set. These header cards must be sorted out and an average induced velocity table created before the RIVD table is input to C81.

7.7 DATA FOR FUSELAGE AERODYNAMIC INPUTS

When wind tunnel data are available, the digital computer program AN9101 can be used to reduce the data to the AGAJ77 input format. The program was written in the PL/1 computer language. The input formats were chosen so that either fixed or floating point numbers may be input for any numeric data. It is not necessary to right-justify fixed point inputs.

The input data to the program consists of two cards of identifying comments and program logic variables and up to 300 data points of force and moment wind tunnel data. Each data point is input on one card and includes data point identification and the values of the pitch and yaw angles and the six force and moment values at those angles.

AN9101 is not an integral part of AGAJ77. AN9101 only prepares data for input to AGAJ77.

7.8 INPUT FORMAT FOR AN9101

Card 1

Col 1 - 70	Alphanumeric identifying comments	
Col 71 - 80	SC, Scale Correction factor	

Card 2

Col 1 - 70	Alphanumeric identifying comments	
Col 71 - 75	NPTs, Number of cards (data points) in the following data set	
Col 76 - 80	IO, Output selector switch ($\neq$ 1 print only, = 1 print and punch)	

Card 3 through (NPTS + 2)

Col 1 - 5	The test (or run) number, or other numeric identification	
Col 6 - 11	Pitch angle	(deg)
Col 12 - 17	Yaw angle	(deg)
Col 18 - 25	Lift/(Dynamic Pressure)	(ft^2)
Col 26 - 33	Drag/(Dynamic Pressure)	(ft^2)
Col 34 - 41	Pitching Moment/(Dynamic Pressure)	(ft^3)
Col 42 - 49	Side Force/(Dynamic Pressure)	(ft^2)
Col 50 - 57	Rolling Moment/(Dynamic Pressure)	(ft^3)
Col 58 - 65	Yawing Moment/(Dynamic Pressure)	(ft^3)
Col 76 - 77	Sequence number of test point in data run, or other numeric identification	

Card NPTS + 3

Col 1 - 10	CODE

7.9 USER'S GUIDE TO AN9101 INPUT FORMAT

This program performs least-squared-error curve fits of wind tunnel force and moment data in order to determine the inputs to the Nominal Angle Fuselage Force and Moment Equations of the Rotorcraft Flight Simulation Computer Program AGAJ77.

Card 1

The alphanumeric identifying comments are the first line of the printed output and, if punched ouput is selected, the first card of the punched output.

SC is the ratio of the desired scale of the output data to the scale of the input data; e.g., if full-scale data (scale = 1) are desired and the input data are from a 1/8 scale model where the data are still in model scale, then SC = 1(1/8) = 8. If the input data have already been converted to full scale, then SC = 1. If SC is deleted, or zero, the program sets SC = 1.

Card 2

The alphanumeric identifying comments are the second line of the printed output and, if punched output is selected, the second card of the punched output.

NPTS is the number of data points. It is equal to the number of cards in the data set which follow Card 2. The value of NPTS must be less than or equal to 300.

The value of IO determines the type of output from the program

IO ≠ Only printed (on-line) output is to be provided.

IO = 1 In addition to the printed output, the coefficients calculated are punched on cards in the format required for Cards 103 through 10E of AGAJ76, the Rotorcraft Flight Simulation Program.

Card 3 through (NPTS + 2)

The input CODE specified the type of data which follows:

CODE = 0 All new data follows; a new Card 1 follows this card.

CODE = 1 Data points are to be added to the data previously computed; a new Card 2 follows (Card 1 is deleted); NPTS on the new Card 2 is only the number of data points (cards) added to the data set, not the new total number of points in the set.

If CODE ≠ 0 or ≠ 1, the program assumes all data has been processed and the run is terminated.

7.10 OUTPUT GUIDE FOR AN9101

The user may select printed output only or printed and punched output. The printed output includes the coefficients of the fitted equations and comparison of the calculated and input data points. If punched output is selected in addition to the printed output, fourteen cards are punched. The first two cards contain the identifying comments from AN9101 Cards 1 and 2. The remaining twelve cards contain all the coefficients of the Nominal Angle Equations in the sequence and format required for AGAJ77, i.e., Cards 103 through 10E of the Fuselage Group. The data are fitted to the following equations:

Lift (L) and Pitching Moment (M)

$$
\begin{aligned}
L \text{ or } M = {} & C_{00} + C_{10} \sin \Psi_w + C_{20} \sin^2 \Psi_w \\
& + [C_{01} + C_{11} \sin \Psi_w + C_{21} \sin^2 \Psi_w] \sin (2\theta_w) \\
& + [C_{02} + C_{12} \sin \Psi_w] \sin^2 (2\theta_w) \\
& + C_{03} \sin^3 (2\theta_w)
\end{aligned}
$$

Drag (D)

$$
\begin{aligned}
D = {} & C_{00} + C_{10} \sin \Psi_w + C_{20} \sin^2 \Psi_w \\
& + [C_{01} + C_{11} \sin \Psi_w + C_{21} \sin^2 \Psi_w] \sin \theta_w \\
& + [C_{02} + C_{12} \sin \Psi_w] \sin^2 \theta_w + C_{03} \sin^3 \theta_w
\end{aligned}
$$

Side Force (Y), Rolling Moment (l), and Yawing Moment (N)

$$
\begin{aligned}
Y, l, \text{ or } N = {} & C_{00} + C_{10} \sin \theta_w + C_{20} \sin^2 \theta_w + C_{30} \sin^3 \theta_w \\
& + [C_{01} + C_{11} \sin \theta_w + C_{12} \sin^2 \theta_w] \sin(2\Psi_w) \\
& + [C_{02} + C_{12} \sin \theta_w] \sin^2 (2\Psi_w) \\
& + [C_{03} + C_{13} \sin\theta_w] \sin^3 (2\Psi_w)
\end{aligned}
$$

where θ_w = wind tunnel pitch angle

Ψ_w = wind tunnel yaw angle

C_{ij} = coefficients of equations

In the output data the coefficients, C_{ij}, are identified by the subscript, ij. The coefficients are printed out in "non-dimensional" and "dimensional" form. "Nondimensional" indicates that the coefficients are in units of ft^2 or ft^3, which are the units of C_{ij} in the above equations. "Dimensional" indicates that the coefficients are in units of ft^2 or ft^3 per degree to the appropriate power. The "dimensional" coefficients are those that would be used if the above equations were redefined for small angles; e.g., $\sin \Psi_w \sim \Psi_w$, $\sin^2(2\theta_w) \sim 4(\theta_w)^2$, and θ_w and Ψ_w were defined to be in degrees. The "dimensional" coefficients are the inputs to AGAJ77. Initialization routines in AGAJ77 convert the coefficients to their "nondimensional" values prior to using them in calculations. The sequence number of the coefficient in the AGAJ77 XFS array is given at the far right, e.g., for lift data, C_{00} is input to XFS(15).

Following the coefficient data is a tabulation of the input and calculated data. The first five columns are the wind tunnel input data:

RUN	=	Wind tunnel run number
PT	=	Number of data point in the run
PITCH	=	Pitch angle, deg
YAW	=	Yaw angle, deg
INPUT	=	Force or moment (corrected to full scale), ft^2 or ft^3

The next three columns are calculated data:

CALCULATION	=	Value of force or moment calculated using the appropriate equation and coefficients
DELTA	=	Input value minus calculated value (INPUT-CALCULATION)
REL-DEL	=	Delta divided by input value (DELTA/INPUT)

At the end of these data are two parameters useful in judging the quality of the curve fit:

SUM OF ABS (ERRORS)/POINTS = $(\Sigma\ \text{DELTA})/\text{NPTS}$

RMS ERROR/POINTS = $(\Sigma(\text{DELTA})^2)/\text{NPTS}$

A printout of the inputs to AGAJ77 in the format of AGAJ77 follows the parameters.

See Figure 80 for a sample printout from AN9101.

PROGRAM AS312A
CURVE FIT ANALYSIS OF WIND TUNNEL DATA
USING METHOD OF LEAST-SQUARED ERRORS

MODEL 206   TEST 294   FUSELAGE W/SKID GEAR   RUNS 210 THRU 214
FINAL CHECK CASES

DRAG DATA

COEFFICIENTS OF EQUATION

SUB-SCRIPT	NON-DIMENSIONAL	DIMENSIONAL	AGAJ73 INPUT
00	2.10 FT**2	2.099379 FT**2/DEG**0	XFS(29)
10	-0.66 FT**2	-0.011553 FT**2/DEG**1	XFS(35)
20	67.67 FT**2	0.020613 FT**2/DEG**2	XFS(36)
01	-2.92 FT**2	-0.050906 FT**2/DEG**1	XFS(37)
11	2.02 FT**2	0.000615 FT**2/DEG**2	XFS(38)
21	0.84 FT**2	0.000004 FT**2/DEG**3	XFS(39)
02	29.90 FT**2	0.009108 FT**2/DEG**2	XFS(40)
12	-1.95 FT**2	-0.000010 FT**2/DEG**3	XFS(41)
03	-10.99 FT**2	-0.000058 FT**2/DEG**3	XFS(42)

INPUT DATA AND CALCULATIONS

RUN/PT		PITCH	YAW	INPUT	CALCULATION	DELTA	REL-DEL
210	1	-11.76	0.00	3.8100	4.0289	-0.219	-0.05746
210	2	-10.46	-16.01	9.3000	9.1174	0.183	0.01964
210	3	-10.53	-12.01	6.6600	6.8494	-0.189	-0.02844
210	4	-10.45	-8.01	4.9300	5.1408	-0.211	-0.04276
210	5	-10.69	-6.01	4.5200	4.5950	-0.075	-0.01660
210	6	-10.76	-4.00	4.2800	4.1633	0.117	0.02726
210	7	[illegible]	[illegible]	4.0600	4.1110	-0.051	-0.01256
[illegible]				[illegible]	4.0404	-0.230	-0.06048

Figure 80. Sample Output from Program AN9101.

(Data for Runs 211 through 213 omitted).

[illegible]	[illegible]	18.08	-14.01				
214	6	18.33	-11.99	6.6800			
214	7	18.49	-10.00	5.9600	5.9174	[illegible]	[illegible]
214	8	18.60	-8.01	5.2300	5.2036	0.026	0.00505
214	9	18.69	-6.01	4.6800	4.6407	0.039	0.00840
214	10	18.73	-4.01	4.3200	4.2292	0.091	0.02103
214	11	18.75	-2.01	4.1100	3.9773	0.133	0.03230
214	12	18.76	0.00	4.0600	3.8883	0.172	0.04229
214	13	18.76	1.99	4.1500	3.9628	0.187	0.04512
214	14	18.75	4.01	4.3000	4.2034	0.097	0.02247
214	15	18.75	5.99	4.5300	4.6036	-0.074	-0.01625
214	16	18.75	8.01	5.0700	5.1754	-0.105	-0.02079
214	17	18.67	10.01	5.7500	5.8842	-0.134	-0.02335
214	18	18.49	12.01	6.5300	6.7271	-0.197	-0.03019
214	19	18.35	13.99	7.6000	7.7187	-0.119	-0.01562
214	20	18.19	15.99	8.7100	8.8619	-0.152	-0.01744
214	21	18.05	17.99	9.9700	10.1497	-0.180	-0.01803
214	22	18.06	20.02	11.6700	11.6261	0.044	0.00376
214	23	18.78	-0.01	4.0600	3.8926	0.167	0.04123

SUM OF ABS(ERRORS)/POINTS= 0.2304
RMS ERROR/POINTS= 0.0267

INPUTS FOR AGAJ73
2.0994 -0.011553AGAJ73 25
0.020613 -0.050906 0.000615 0.000004 0.009108 -0.000016 -0.000058AGAJ73 26

Figure 80. Concluded.

8.0 REFERENCES

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