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Flexible Vehicle	Modeling	Precompiler
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KONPACT is a system of digital computer programs that will design optimal or sub-optimal control systems especially for aircraft with lightly damped modes. This program represents advanced computational techniques to perform modern control synthesis, analysis, and design of automatic control systems. KONPACT augments aircraft mathematical models produced from such advanced programs as the FLEXSTAB Level 2.01.00 with control system dynamics and then designs and analyzes quadratic optimal or suboptimal control systems.		

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The KONPACT User's Manual is the third volume of a report prepared under contract F33615-75-C-3046. This manual is arranged to aid the user in preparing input data decks, and executing the programs. This volume also contains two C-5A demonstration examples and results. The user background is assumed in the area of the dynamics of aircraft and control system design.

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## FOREWORD

The research described in this report was prepared by Honeywell Inc., Minneapolis, Minnesota 55413, under Air Force Contract F33615-75-C-3046. It was initiated under the AFFDL task number 82190221, "Optimal Control of Flexible Aircraft," project number 8219, "Stability and Control of Aerospace Vehicles." This work was directed by the Control Criteria Branch (FGC), Flight Control Division of the Air Force Flight Dynamics Laboratory, and was administered by Mr. Charles R. Stockdale of the Control Criteria Branch. Special thanks to Mr. Robert C. Schwanz of FGC and Mr. Gary Grimes of ASD/ADDP for their continued support toward this contract.

The technical work reported in this volume was conducted by the Research Department at the Systems and Research Center of Honeywell Inc. Dr. A. F. Konar was the Honeywell Program Manager and the principal investigator on this contract. He was assisted by Mr. C. R. Stone, Dr. J. K. Mahesh, and Miss M. Hank. This report covers work from April 1975 to April 1976.

The work under this contract was reported in three volumes entitled, "Active Control Synthesis for Flexible Vehicles."

- Volume I. KONPACT Theoretical Description
- Volume II. KONPACT Program Listing
- Volume III. KONPACT User's Manual

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## SECTION I

### INTRODUCTION

The general objective of this study is to develop techniques and tools necessary for rapid design of an active control system for aircraft with lightly damped structural modes. The synthesis techniques provided here are aimed at reducing the engineering man-hours presently required for flight control system design, thus effecting a cost reduction. Improvements in the fatigue life, ride qualities and/or handling qualities of military aircraft are sought by controlling the lightly damped modes and thus improving their mission performance.

The present scope of this study is to develop programs to interface the level 2.01.00 FLEXSTAB computer program system with existing Air Force-owned optimal control computer programs. These programs represent advanced computational techniques required to perform quantitative analysis of multisurface control systems. The resulting interface program system is called "KONPACT - Computer Programs for Active Control Technology." Working together with FLEXSTAB, KONPACT provides the capability to model, synthesize, analyze, and design automatic control systems. It can also be used as a stand-alone program.

The work performed under this contract is reported in three volumes:

- Volume I. KONPACT Theoretical Description and Demonstration
- Volume II. KONPACT Program Listing
- Volume III. KONPACT User's Manual

This document reports the user's information needed to execute KONPACT. It also contains two C-5A demonstration examples and results.

The purposes of including these demonstration examples are first to document the input data and resulting output that are required to design the C-5A handling quality controller and the C-5A Active Load Distribution Control System using the FLEXSTAB C-5A model. This model is documented in References 8, 9 and 11; the designed controllers are discussed in Reference 4.

The second purpose is to provide concrete examples of the inputs that are required to execute KONPACT. A majority of the input options available to the user to execute KONPACT are contained in these examples. In addition, the resulting outputs from the KONPACT input deck setups are displayed to familiarize the user with the output formats. It must be noted that in this report the terms "vehicle model" and "vehicle" are used interchangeably; both terms refer to the mathematical models generated from the level 2.01.00 FLEXSTAB linear systems analysis program (Reference 1).

Section II presents briefly the description of KONPACT programs. A short description of the design process is presented first for completeness. Subsequently, a general description of input cards to execute KONPACT is given.

In Section III the program execution procedure for the modeling program (KONPACT-1) is described. The formats of the input data deck and printed outputs are also described in detail.

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In Section IV the program execution procedure for the design program (KONPACT-2) is described. The formats of the input data deck and printed outputs are also described.

Section V contains the demonstration example for the handling quality design for the C-5A FLEXSTAB vehicle model. The deck set-up and the printed results are displayed, and the results are discussed.

Section VI contains the demonstration example for the ALDCS controller design for the C-5A FLEXSTAB vehicle model. The deck set-up is displayed, and the final results are discussed.

The analytical techniques and algorithms used in KONPACT are described in Volume I. Volume I also demonstrates how these techniques are applied to flexible aircraft control system designs.

Documentation of KONPACT was beyond the scope of this contract. To aid the user, the listings of source programs which implement the mathematical analysis and models presented in Volume I are given in Volume II.

## SECTION II

### DESCRIPTION OF KONPACT PROGRAM

#### INTRODUCTION

KONPACT is a system of computer programs developed by Honeywell under Air Force Contract No. F33615-75-C-3046. KONPACT uses the state space approach for modeling flight control systems, and it designs the controllers using optimal control methodology. KONPACT interfaces with the linear systems analysis (LSA) program of the Level 2 FLEXSTAB Program system developed by Boeing under Air Force Contract No. F33615-72-C-1172 (Reference 1). KONPACT can also be used as a stand-alone program.

KONPACT operates on CDC 6000 and CDC 7000 series computers and can be easily modified to operate on other computers. KONPACT has been written in Extended Fortran IV language.

In this section, the design process is reviewed and motivation is given for developing KONPACT program. A general description of KONPACT program is presented in terms of overlay organization and information flow. The input cards for KONPACT are also described.

## REVIEW OF DESIGN PROCESS

Basically, optimal control design of flight control systems involves two major steps. The first step is to obtain the state space description of the flight control system. The second step is to obtain optimal feedback gains via the optimal control methods.

The flight control system consists of the basic vehicle, sensor equations, load equations, actuator dynamics, controller specifications, Wagner-Kussner dynamics, etc. Level 2 FLEXSTAB calculates the basic vehicle model, sensor equations, and load equations. The remaining dynamics of the flight control system are input by the user, and the KONPACT program combines and calculates the flight control system model.

The optimal state feedback gains are computed using the DIAK program, and the feedback gains are reduced to gains only on specified measurements using the FFOC program.

## OVERLAY ORGANIZATION

KONPACT consists of two programs: a modeling program (KONPACT-1) and a design program (KONPACT-2). KONPACT-1 interfaces with FLEXSTAB through the LSA program to obtain the vehicle model and augments the specified dynamics to obtain the state space description (quadruple data) of the flight control system. These data are utilized by KONPACT-2 (which contains the subprograms DIAK and FFOC that are described in Reference 2) in the design of the optimal feedback gains. Also KONPACT-2 interfaces with FLEXSTAB through the LSA program to evaluate the performance of the above-designed optimal flight control system.

Table 1 provides a brief description of programs KONPACT-1 and KONPACT-2 and their subprograms. The interface between KONPACT and the LSA program is illustrated in Figure 1.\* The overlay structure of the KONPACT-1 program is illustrated in Figure 2. It consists of a main overlay and five primary overlays (Reference 3). The overlay structure of the KONPACT-2 program is illustrated in Figure 3. It consists of a main overlay and three primary overlays.

Table 1. KONPACT Program Descriptions

PROGRAM	SUBPROGRAM	DESCRIPTION
KONPACT-1	STAMK1	State space modeling program Obtains state space model from LSA simulator deck data
	STAMK2	Obtains state space model from transfer function data
	STAMK3	Obtains state space model from quadruple data and interconnection data
	STAMK4	Obtains state space model from simulation equations (user written)
	CONDK	Modifies the state space model by scaling, shuffling, truncating, and residualizing the system variables
KONPACT-2		Optimal design program
	DATAK	Prepares data for DIAK, FFOC and LSA programs
	DIAK	Designs full state feedback optimal controllers
	FFOC	Designs reduced state (practical) feedback optimal controllers

\* Illustrations start at page No. 75



## INFORMATION FLOW

The normal sequence for obtaining an overall state space model of a flight control system using the modeling program (KONPACT-1) is as follows:

- The vehicle model is obtained by using either the STAMK1 (for LSA data) or STAMK4 (for other types of vehicle data) subprograms.
- The actuator, sensor, controller, implicit and explicit models are obtained by using either the STAMK2 (with transfer function input data) or STAMK3 (with quadruple input data) subprograms.
- The subsystems defined above are combined to get an overall system by using the STAMK3 (interconnection data) subprogram.
- The overall system model is conditioned (modified) by scaling and/or shuffling and/or truncating and/or residualizing the variables using the CONDK subprogram. This subprogram also develops the rate of change of response variables when required.

The normal sequence for designing optimal feedback controllers and evaluating the performance of the resulting system using the design program KONPACT-2 is as follows:

- Full state feedback control gains are obtained by varying the quadratic weights and using the DIAK subprogram.
- The resulting full state feedback control gains are reduced to gains only on specified measurements by using the FFOC subprogram.

- The performance of the resulting closed loop system is evaluated using the LSA program.
- The above steps are repeated until a satisfactory design is obtained.

Table 2 describes the data tapes used in KONPACT-1 and KONPACT-2 programs. The state space model data (quadruple data) and the name list data are written on tapes QDATA and NDATA, respectively. The vehicle data (simulator deck data) is written on tape VDATA. The feedback gain data from DIAK and FFOC are written on tapes DDATA and FDATA, respectively. The overall system data in frequency representation form is written on tape SDSTP for use by the LSA program. The DATAK subprogram is used in preparing data tapes for DIAK, FFOC, and LSA.

Table 2. KONPACT Data Tapes

Tape Name	Contents	Generating Program	Benefiting Program(s)
VDATA	Simulator Interface data in the form of card images	LSA	KONPACT-1
QDATA	Quadruple (A, B, C, D) or state variable representation data	KONPACT-1	KONPACT-1 KONPACT-2
NDATA	Name list data of the state variable representation	KONPACT-1	KONPACT-1
DDATA	Full state feedback gain data in the form of card images	KONPACT-2	KONPACT-2
FDATA	Reduced feedback gain data in the form of card images	KONPACT-2	KONPACT-2
SDSTP	Frequency domain representation of quadruple data	KONPACT-2	LSA



## VARIABLE DIMENSIONING

Variable dimensioning (Dynamic Data Storage) technique (Reference 7) is used for efficient data storage. This technique also facilitates changing the amount of allocated (required) storage space by a data card input. In KONPACT-1, the subprogram arrays (whose sizes depend on the maximum system dimension inputs) are stored in scratch storage blocks using variable entry points. In the subprograms the arrays are dimensioned with integer variables. These "variable DIMENSION statements" remain unchanged although the amount of required data storage is altered. The maximum size of the scratch storage blocks is specified in a "fixed DIMENSION statement" in the main program.

The size of storage actually needed by the arrays varies, depending on the maximum system dimension inputs. Thus, if the maximum size a user allows for his problem changes, only the "fixed DIMENSION statements" in the main program need to be changed. The change of the main program of KONPACT-1 is done by a precompiler, as discussed in Section III. The user provides the new maximum system dimensions by data cards. Updating and running with updated main program are done with control cards in a single run. For more details on variable dimensioning, the user is referred to Volume II (Reference 5).

Modularization and variable dimensioning of DIAK and FFOC subprograms in KONPACT-2 were beyond the scope of this contract.

## INPUT CARDS

The first logical record of the input file (deck) contains the job control cards, and the subsequent logical records are the data deck cards. Figure 4 illustrates a typical input deck structure. It consists of job control cards and one logical record of data deck cards.

### Job Control Cards

Job control cards are statements instructing the computer how to process a job. Job control cards are always the first group of cards in a deck set-up.

### Data Deck Cards

The data deck input to the KONPACT programs consists mainly of conventional data cards containing information arranged according to standard Fortran formats. In addition, the data decks may contain three special card types: Program Control Cards, Data Control Cards, and Data Comment Cards. (For detailed format descriptions of data deck cards, see Sections III and IV.)

Conventional Data Cards--These cards contain the data input by the user to: 1) describe the model, 2) describe the interconnections, 3) select variables, and 4) describe the variables.

Numerical data are generally read under the 5(2I2, E12.6) Fortran format, and the alphanumeric data under the 20A4 format. Some data cards contain mixed alphanumeric and numeric data. The actual format used by each

data card or set of data cards is specified in the text and on figures illustrating data card arrangements. All alphanumeric data must be left-justified and all numeric data must be right-justified.

Program Control Cards--These cards contain a dollar sign (\$) in Column 1 followed by descriptive words which identify the program that will be used to process the data. There are nine program control cards and they are listed in Table 3. Only Columns 1 through 4 are interpreted.

Table 3. List of Program Control Cards

Program Control Card	Subprogram	Program
\$LSA DATA	STAMK1	KONPACT-1
\$TRANSFER FN DATA	STAMK2	
\$QUADRUPLE DATA	STAMK3	
\$INTERCONNECTION DATA	STAMK3	
\$SIMULATION DATA	STAMK4	
\$CONDITIONING DATA	CONDK	
\$DIAK DATA	DIAK	KONPACT-2
\$FFOC DATA	FFOC	
\$LSA DATA	LSA (only prepares data for LSA)	

Data Comment Cards--These cards contain any appropriate comments the user wishes to make. Column 1 should contain a C and Column 2 should be left blank. The comment starts from Column 3 and can go up to Column 80. Any number of comment cards, inserted anywhere in the data deck, can be utilized to aid the KONPACT user in identifying important data items.

Data and Flow Control Cards--These are descriptive words, starting from Column 1, which identify key blocks of data. The data and flow control cards are listed in Table 4.

### Imbedded Blanks

The user input cards to KONPACT (Table 4) contain descriptive words with imbedded blanks, e.g., PRINT<sub>Δ</sub> INPUT<sub>Δ</sub> DATA. These imbedded blanks are necessary for the execution of KONPACT program.

Table 4. Data and Flow Control Cards

Data and Flow Control Card	Description	Program
<p>PRINT NOTHING                      PRINT INPUT DATA                      PRINT OUTPUT DATA                      PRINT FINAL OUTPUT DATA                      PRINT EVERYTHING</p>	<p>Print specification cards</p>	<p>KONPACT-1                      KONPACT-2</p>
<p>CONTINUATION RUN</p>	<p>Indicates that the present run is a continuation of the previous run</p>	<p>KONPACT-1</p>
<p>REFERENCE</p>	<p>Indicates the beginning of system reference specification group</p>	<p>KONPACT-1</p>
<p>SYSTEM No n</p>	<p>System specification card                      n-system number (1 through 9)                      xxxx--Description of the system (e.g., vehicle, actuator)                      yyyy--Comments about the system</p>	
<p>STATE</p>	<p>This system description card is also used as a label to write quadruple data and name list data on files QDATA and NDATA</p> <p>Indicates that name list data for states follows</p>	<p>KONPACT-1</p>

Table 4. Data and Flow Control Cards (Continued)

Data and Flow Control Card	Description	Program
OUTPUT	Indicates that name list data for outputs follows	
INPUT	Indicates that name list data for inputs follows	
BLOCK m	Indicates that transfer function data for block m follows	KONPACT-1 (STAMK2)
BLOCK m DELAY	Indicates that specification for delay block m follows	
UI/U	Indicates that connection data for internal inputs to blocks from external inputs follows	
UI/RI	Indicates that connection data for internal input to blocks from internal outputs of blocks follows	
R/U	Indicates that connection data for external outputs from external inputs follows	

Table 4. Data and Flow Control Cards (Continued)

Data and Flow Control Card	Description	Program
R/RI	Indicates that connection data for external outputs from internal outputs of blocks follows	KONPACT-1 (STAMK3)
UI <sub>m</sub> /U	Indicates that interconnection data for inputs to system m from external inputs follows	KONPACT-1 (STAMK3)
UI <sub>m</sub> /RI <sub>n</sub>	Indicates that interconnection data for system m from outputs of system n follows	KONPACT-1 (STAMK3)
R/RI <sub>n</sub>	Indicates that interconnection data for external outputs from outputs of system n follows	KONPACT-1 (STAMK3)
R/U	Indicates that interconnection data for external outputs from external inputs follows	KONPACT-1 (CONDK)
SELECT CONTROL INPUTS	Indicates that inputs to be selected as control inputs follows	KONPACT-1 (CONDK)
SELECT DISTURBANCE INPUTS	Indicates that inputs to be selected as disturbance inputs follows	KONPACT-1 (CONDK)

Table 4. Data and Flow Control Cards (Continued)

Data and Flow Control Card	Description	Program
CONSTRUCT DESIGN RESPONSES	Indicates that specification for constructing design responses follows	
RESIDUALIZE STATES IN OUTPUTS	Indicates that outputs (which must have the states in their equations residualized) follows	
TRUNCATE STATES IN OUTPUTS	Indicates that outputs (which must have the states in their equations truncated) follows	KONPACT-1 (CONDK)
END	Indicates the end of a group of data	KONPACT-1 KONPACT-2
STOP	Indicates the end of the data for one run	
C   xxxx	Comment Card, xxxx indicates comment	



## SECTION III

### STATE MODELING PROGRAM (KONPACT-1)

#### INTRODUCTION

KONPACT-1 program interfaces with Level 2 FLEXSTAB through the linear system analysis (LSA) program to obtain the vehicle model in state space form (quadruple data). KONPACT-1 also augments or combines the vehicle model with the dynamics of actuator model, controller model, etc., as specified by the user, to obtain the state space model of the overall flight control system. The user-specified dynamics can be either in the form of transfer functions or simulation equations. KONPACT-1 program can also be used independent of FLEXSTAB as a stand-alone program, to obtain state space models of flight control systems and other control systems.

This section describes the execution procedure for the KONPACT-1 program. The description of input data and output data is given here. The program timing and central memory requirement estimates are also discussed.

#### PROGRAM EXECUTION PROCEDURE

Figure 5 shows the block diagram of data flow in KONPACT-1. The MAIN program reads card input data, reorganizes it, and writes it on BINPUT file. The BINPUT file is used as card input data by the subprograms.

The job control cards, used for executing KONPACT-1 programs, are those commonly used by the SCOPE 3.4.1 operating system for CDC 6000 and CDC 7000 series computers. For a detailed description of job control cards, the user is referred to the SCOPE Manual (Reference 3). In the following discussion, job control card illustrations are based on using permanent disc files; here the disc files are used to store output data required for succeeding runs. The user is referred to the ASD Computer Center's User's Guide (Reference 6) if magnetic tapes are used.

When executed, the FLEXSTAB/LSA program produces the simulator deck data for the vehicle (Reference 1). Figure 6 illustrates the job control cards for storing the aforementioned vehicle data on VDATA file. More than one set of vehicle data can be stored on VDATA file. Each set is identified by the first card in the set which contains the description (i.e., label) of the particular vehicle model.

Since it contains card images, the data on file VDATA are formatted. KONPACT-1 program does not accept unformatted data on VDATA file.

Job control cards to create QDATA and NDATA files are illustrated in Figure 7. There are two logical records of data following the job control cards. The first logical record contains the specification of KONPACT-1 subprograms used and the maximum system dimensions needed for the job. This record is data for the precompiler program PRECOM. The second logical record is the modeling data. The state space model (quadruple data) for each system specified by the user is written on QDATA file and the name list data for each system is written on NDATA file. The data on QDATA and NDATA files are unformatted. Figure 8 illustrates

the job control cards for adding new system data on QDATA and NDATA files using KONPACT-1 program.

## INPUT DATA

The input data for the KONPACT-1 program consists of three groups. The first group is the simulator deck data. These data are on file VDATA in the form of card images. The second group is the data for the precompiler program PRECOM in the form of cards. The third group of data is the additional modeling data also in the form of cards.

### Simulator Deck Data

The simulator deck data are produced by FLEXSTAB/LSA in the form of a punched card deck. This is subsequently input on file VDATA by the user for KONPACT-1 program. The FLEXSTAB/LSA equations, which represent the simulator deck data, are shown in Figure 9. The simulator deck data structure with the formats is shown in Figure 10. The first card describes the simulator deck data and serves as a header card. If more than one set of simulator deck data is written on file VDATA, then a particular simulator deck data can be retrieved by specifying the corresponding header card. Following the header card is the matrix name card which contains one of the standard matrix names (defined in Figure 9), along with the row and column size of the matrix. The matrix name card is followed by a deck of cards which contain the elements of the matrix. The formats for the matrix data are given in Table 5. The last card of the simulator deck data is a matrix name card with the name \*FINISHED\* and size 0 x 0.

Table 5. Formats for the Matrices in the Simulator Deck Data

CARD 1 (A10, 215)		
Column	Contents	Explanation
1-10	NAME	Name of the matrix
11-15	NROWS	Number of rows in the matrix
16-20	NCOLS	Number of columns in the matrix
CARD SET 2 (6E10.0)		
1-10	$A_{ij}$	Elements of the matrix
11-20	$A_{i, j+1}$	Stored by rows, six elements per card
21-30	$A_{i, j+2}$	
31-40	⋮	
41-50	$A_{i+1, 1}$	
51-60	$A_{i+1, 2}$	

Precompiler Data

The user defines the KONPACT-1 subprograms and the values of the maximum system dimensions needed for executing his job. The KONPACT-1 basic subprograms are STAMK1, STAMK2, STAMK3, STAMK4, and CONDK. If the user does not specify any subprograms to be used, the precompiler assumes that all subprograms will be used in the execution of the job.

The names of the maximum system dimensions (Table 6) are NXM, NRM, NUM, NYM, MSB, AND MTB where:

NXM = Maximum number of states

NRM = Maximum number of outputs

NUM = Maximum number of inputs

NYM = Maximum number of summing point equations = (no. of all internal inputs + no. of all internal outputs) - (Reference 4).

MSB = Maximum number of systems to be combined (interconnected) at one time  $\leq 9$

MTB = Maximum number of transfer function blocks in a system.

Only nonzero system dimensions need be specified. The formats for precompiler data are shown in Table 6.

## Modeling Data

Each system (i. e., vehicle, actuator, controller) in KONPACT-1 is assigned a system number by the user. System number 9 is reserved for the Implicit model. An interconnection of one or more systems is defined as a new system. KONPACT-1 program obtains the state space model (quadruple data) for each system along with a name list data for the system variables. The system variables are the states, inputs, and outputs of the system. When the state space model of a system is conditioned (i. e., scaled, shuffled) by KONPACT-1, its system number

Table 6. Formats for Precompiler Data

CARD SET 1 (A6)		
Column	Contents	Explanation
1-6	NAME	Name of the subprogram
CARD SET 2 (A4, I3)		
1-4	NAME	Name of the Maximum System Dimension
5-7	MSD	Value of the Maximum System Dimension

is retained. The state space models (quadruple data) for all systems are written on file QDATA along with the label cards to locate data. The name list data for all systems are written on file NDATA using the same labels. There may be more than one system with the same system number. A reference table associating the most recent system description with a system number is written on file NDATA. System numbers along with the reference table are used for fetching quadruple data and name list data of systems from QDATA and NDATA files.

Modeling data consist of several groups of data. They are the print specification group, the system reference specification group, and the system description group. A general picture of modeling data is given in Figure 11.

The print specification group specifies the printed output the user desires. The various print specification cards and their descriptions are given in Table 7. Any number of print specification cards can be used. If no print specification cards are used, a default specification consisting of PRINT INPUT DATA and PRINT FINAL OUTPUT DATA will be assumed by the program.

Table 7. Print Specification Cards

Print Specification Card	Result
PRINT NOTHING	Nothing is printed on the line printer
PRINT INPUT DATA	Input data cards will be printed
PRINT OUTPUT DATA	Output data for each system modelled will be printed in detail
PRINT FINAL OUTPUT DATA	Only the state space model data for each system will be printed
PRINT EVERYTHING	Debugging Information will be printed in addition to the above



The system reference specification group specifies the system description that should be used in the reference table. Figure 12 illustrates the system reference data. An example of reference specification is given in Section VI.

There are as many groups of system description cards in the model input data as there are systems whose state space model is being computed by the program. Figure 13 illustrates the system description data for a system described by FLEXSTAB/LSA equations. The FLEXSTAB/LSA simulator deck data is on file VDATA and only the header card is needed to retrieve this data. The name list data arrays for the system variables is shown in Table 8. If the name list data is not used by the user, a default name list is produced by the program and is useful in keeping track of the system variables.

Figure 14 illustrates the system description input data for transfer functions. This form of system description is most often used for actuators, sensors, and controllers. First the transfer function data in the form of either rational transfer function coefficients or transport (time) delay parameters are specified. The connection data for the transfer function blocks are specified next. This is followed by name list data in the end. The format for the transport time delay parameters are given in Table 9. An example of transfer function data and connection data specification are given in Section V.

Figure 15 illustrates the system description input data when data are in state space form (quadruple data). First the quadruple data are specified and are followed by the name list data.



Table 8. Formats for Name List Data

CARD SET 1 (I2, 6X, 2A4, 4X, 10A4, 4X, 4A4)		
Column	Contents	Explanation
1-2	NNS	Number of the state variable
9-16	VNS	Name of the state variable
21-60	DESS	Description of the state variable
65-80	UNITS	Units of the state variable
CARD SET 2 (I2, 6X, 2A4, 4X, 10A4, 4X, 4A4)		
1-2	NNO	Number of the output variable
9-16	VNO	Name of the output variable
21-60	DESO	Description of the output variable
65-80	UNITO	Units of the output variable
CARD SET 3 (I2, 6X, 2A4, 4X, 10A4, 4X, 4A4)		
1-2	NNI	Number of the Input variable
9-16	VNI	Name of the Input variable
21-60	DESI	Description of the Input variable
65-80	UNITI	Units of the Input variable

Table 9. Formats for Transfer Function Data

CARD SET 1 (6E12.6, 2I2)		
Column	Contents	Explanation
1-12	TD	Transport (or Time) delay in seconds
13-24	XX	X-coordinate value, at which wind gust is acting, in feet
25-36	XR	Reference X-coordinate value in feet
37-48	UU	Velocity of wind in feet/sec
49-60	OMEGM	Maximum frequency in radians/sec
61-72	DELPHM	Maximum phase error in radians
73-74	ND	Number of Denominator terms in Pade approximation.
75-76	NN	Number of Numerator terms in Pade approximation.

Note: The rational transfer function data and connection data are specified as matrix data and are always read using the format (5(2I2, E12.6)). Only the nonzero elements need be specified.

Figure 16 illustrates the system description input data for a system described as an interconnection of several systems. The maximum number of systems that can be combined into one system is nine. The interconnection data, which specifies the system numbers of the systems being interconnected, are specified as a matrix data. Only the nonzero elements need be specified. The interconnection data are followed by the name list data. An example of interconnection of several systems is given in Section V.

Figure 17 illustrates the system description input data for a system described as the conditioning or modification of a system whose state space model has already been obtained by the program. The conditioning data consists of scaling data, response specification data, and reduction and shuffling data. The formats for scaling data are given in Table 10. The conditioned or modified system gets the same system number as the original system and will be the current system in the system reference table. An example of conditioning a system is given in Section VI.

Table 10. Formats for Scaling Data

CARD SET 1 (A6, 4X, E14.6, 6X, 4A4, 4X, 4A4)		
Column	Contents	Explanation
1-6	VN	Name of the scaled variable
11-24	SC	Scale factor
31-46	UN	Old units
51-66	UNN	New units

Note: Name of the scaled variable such as those listed in Table 8 should be of the following form: X(4), R(8), U(7) etc.

## OUTPUT DATA

### File Output Data

KONPACT-1 program writes the state space model (quadruple data) for each system on QDATA file. It uses the system description card as the label to store data for several systems on the same file. This label card is

used for retrieving the quadruple data. Similarly, the name list data for each system are written on NDATA file using the system description card as the label. In addition, the system reference table is written on NDATA file for continuation runs (see Figure 8). Figure 18 shows the way in which data is stored on files QDATA and NDATA.

## Print Output Data

The print output depends on the print specification of the user. The following summarizes the sequence of print output:

- Input data cards are printed (if PRINT INPUT DATA is specified).
- For each subsystem defined, the input data to the system is printed after the system heading (if PRINT OUTPUT DATA is specified).
- For each subsystem defined, the state space data (quadruple data) and the name list data are printed after the system heading (if either PRINT OUTPUT DATA or PRINT FINAL OUTPUT DATA is specified).

## PROGRAM TIMING AND CENTRAL MEMORY REQUIREMENT ESTIMATES

### Program Timing Estimate

An approximate formula for the central processor time ( $T_{cp}$ ) in decimal seconds is:

$$T_{cp} = T_{Load\ cp} + \frac{(NX + NR + NU)}{10} * NS$$

where:

$T_{\text{Load cp}}$  = Program Loading Time (typically 4 seconds)

NX = number of states of the system

NR = number of outputs of the system

NU = number of inputs of the system

NS = number of systems modeled.

An approximate formula for Input/Output Time ( $T_{\text{I/O}}$ ) in decimal seconds is:

$$T_{\text{I/O}} = T_{\text{Load I/O}} + (NX + NR + NU) * NS$$

where:

$T_{\text{Load I/O}}$  = Program Loading Time (typically 20 seconds).

## Central Memory Requirement Estimate

The precompiler program can be used to obtain the central memory required for executing the job. The precompiler data was discussed earlier. An example job set-up is shown in Figure 19. When this job is executed, the central memory required to execute KONPACT-1 program is printed out.

## SECTION IV

## DESIGN PROGRAM (KONPACT-2)

## INTRODUCTION

KONPACT-2 program interfaces with the modeling program KONPACT-1 via the data file QDATA for the design model. KONPACT-2 program also interfaces with the linear system analysis (LSA) program of FLEXSTAB via the data file SDSTP for performance evaluation of the open or closed loop system. KONPACT-2 program consists of three subprograms namely DIAK, FFOC, and DATAK. The DIAK subprogram developed by Honeywell (Reference 2) computes the optimal state feedback gains. The FFOC subprogram also developed by Honeywell (Reference 2) computes the optimal feedback gains on specified measurements (i. e., Simplified Controller Design). The DATAK subprogram developed under the present contract reads data from data files and data cards and prepares the input data to execute DIAK and FFOC programs.

The DATAK subprogram also computes the frequency domain representation of the open loop or closed loop system for use by the LSA program. The KONPACT-2 program can also be used, independent of KONPACT-1 and LSA programs, as a stand-alone program for computing optimal feedback gains.

This section describes the execution procedure for the KONPACT-2 program. The description of input data and output data are given here.

## PROGRAM EXECUTION PROCEDURE

Figure 20 shows a block diagram of the data flow in KONPACT-2. The DATAK subprogram reads data for DIAK and open loop quadruple data from file QDATA (obtained by executing KONPACT-1 program) and prepares the data for DIAK subprogram on a scratch file. The DIAK subprogram reads the data on the scratch file and computes optimal state feedback gains and writes them on file DDATA. The DATAK program then reads FFOC data, open loop quadruple data on file QDATA, and gains on file DDATA and prepares the data for FFOC subprogram on the scratch file. The FFOC subprogram reads the data on the scratch file and computes sub-optimal feedback gains on specified measurement and writes them on file FDATA. Finally the DATAK subprogram reads LSA data, open loop quadruple data on file QDATA, and gains on file FDATA (it can also read gains on file DDATA or gains on cards); it computes the frequency domain representation of the open or closed loop system for LSA program and writes it on file SDSTP. The data on files DDATA and FDATA are formatted whereas the data on file SDSTP are not formatted. The job control cards, used for executing KONPACT-2 programs, are those commonly used by the SCOPE 3.4.1 operating system for CDC 6000 and CDC 7000 series computers. For detailed description of job control cards, the user is referred to the SCOPE manual (Reference 3). The data files of KONPACT-2, namely DDATA, FDATA and SDSTP, are written on permanent disc files which are cataloged at the end of the job. To use magnetic tapes instead of permanent disc files, the user is referred to the ASD Computer Center User's Guide (Reference 6).



Job control cards to execute KONPACT-2 program is illustrated in Figure 21. The input data cards follow the job control cards. In Figure 21 it is assumed that the input data consists of data for DIAK subprogram, data for FFOC subprogram, and data for obtaining frequency domain representation of the closed loop system for LSA program. In practice, however, several iterations are made with DIAK data alone and subsequently with FFOC data alone to obtain final feedback gains. DIAK programs can also be used for covariance analysis alone or time response alone for the final closed loop system. The user must attach and catalog the required data files.

## INPUT DATA

Figure 22 illustrates the card input data for KONPACT-2 program. It consists of four different groups of data. They are the print specification data, the DIAK input data, the FFOC input data, and the LSA input data.

The print specification data is described in Section III. In this program, the print specifications control only the printed output from DATAK subprogram and have no control over the printed output from the DIAK and the FFOC subprograms. Modifications in DIAK and FFOC were beyond the scope of the contract.

The DIAK input data and the FFOC input data are shown in Figure 23 and Figure 24, respectively. The sequence and meaning of data cards for DIAK and FFOC programs as documented in Reference 2 are retained fully. Under KONPACT-2 program, comment cards can be inserted anywhere in the data;



options are provided to read certain matrix data from QDATA, DDATA and FDATA files in addition to reading them from card input data. The options for various matrix data in the KONPACT-2 program are shown in Table 11. These options are selected by the use of data control cards.

The list of data control cards is given in Table 12. The user should consult Reference 2 for the details of the input data for the DIAK and the FFOC subprograms. Several examples are given in Section VI.

The LSA input data (to compute frequency domain data for LSA program) are shown in Figure 25. The open loop quadruple data are input from QDATA file. Option is provided to read the feedback gains from DDATA or FDATA file or from card input data. If feedback gains are provided, the KONPACT-2 program computes the frequency domain representation for the closed loop system. If no feedback gains are provided, the KONPACT-2 program computes the frequency domain representation for the open loop system.

## OUTPUT DATA

### File Output Data

Optimal state feedback gain matrix data are written on file DDATA when DIAK subprogram is executed. Optimal reduced feedback gain matrix data are written on file FDATA when FFOC subprogram is executed. Frequency domain data are written on file SDSTP when DATAK subprogram is executed.

The data on files DDATA and FDATA are formatted, and the data on file SDSTP are not formatted.

Table 11. Options for Obtaining Matrix Data for the KONPACT-2 Program

Matrix Name	Explanation	Options			
		Card Input	QDATA File	DDATA File	FDATA File
F	State Transition Matrix	X	X		
G1	Control Input Matrix	X	X		
G2	Disturbance Input Matrix	X	X		
XI	Initial Condition Matrix	X			
XLDXL	State Limit Rate Limit Matrix	X			
CL	Command Level Matrix	X			
H	State Response Matrix	X	X		
D	Control Response Matrix	X	X		
AM	Measurement Matrix	X	X		
BK	Initial Feedback gain Matrix	X		X	
Q	Quadratic Weights Matrix	X			
AKG	Optimal State Feedback Gains	X		X	
AK(K1(1))	Fixed gains for $\lambda = 1$	X			
BK(K2)	Gains to be reduced	X			
AK(K1( $\lambda$ ))	Fixed gains for $\lambda$	X			X
DELK( $\Delta$ K1( $\lambda$ ))	Predictor gains for $\lambda$	X			X

Table 12. List of Data Control Cards for the KONPACT-2 Program

Data Control Card	Explanation
DATA ON CARDS AND TAPE	Indicates that Matrix data is both on cards and tape (file). This card should be followed by the system label card to retrieve quadruple data from file QDATA
DATA ON CARDS ONLY	Indicates that Matrix data is on cards only
READ CARD FOR MATRIX xxxxx	xxxx - Matrix Name. This card should be followed by the Matrix data on cards
READ TAPE FOR MATRIX xxxxx	xxxx - Matrix Name. The corresponding Matrix data is obtained from QDATA file
READ TAPE FOR MATRIX BK (BK is the starting gain read by DIAK)	This card should be followed by the label card under which the optimal state feedback gain Matrix is written on file DDATA
GAINS MATRIX FOR CASE I (I is the Quadratic Weight iteration number in the DIAK run)	Label card under which the optimal state feedback gain Matrix is written on file DDATA

Table 12. List of Data Control Cards for the KONPACT-2 Program (Continued)

Data Control Card	Explanation
<p>READ TAPE FOR MATRIX AKG (AKG is the optimal gain read by FFOC)</p>	<p>This card should be followed by the label card under which the optimal state feedback gain matrix is written on file DDATA</p>
<p>READ TAPE FOR MATRIX AK(KI(<math>\lambda</math>))</p>	<p>This card should be followed by the label card under which the reduced feedback gain matrix is written on file FDATA</p>
<p>GAIN MATRIX</p>	<p>Label card under which the reduced feedback gain matrix is written on file FDATA</p>
<p>READ TAPE FOR MATRIX DELK(<math>\Delta</math>KI(<math>\lambda</math>))</p> <p>PREDICTOR GAINS</p>	<p>This card should be followed by the label card under which the predictor gain matrix is written on file FDATA</p> <p>Label card under which the predictor gain matrix is written on file FDATA</p>

## Print Output Data

The following items summarize the print output.

- Card input data are printed (if PRINT INPUT DATA is specified).
- Output data from the DIAK subprogram are printed.
- Output data from the FFOC subprogram are printed.
- Frequency domain data are printed.

## PROGRAM TIMING AND CENTRAL MEMORY REQUIREMENT ESTIMATES

It is very difficult to estimate the time required to execute KONPACT-2 program because of the several options provided in the DIAK and FFOC subprograms.

A central memory of 165000 octal is required to execute KONPACT-2 program. This value is based on the maximum system dimensions presently used in program KONPACT-2. The values of the maximum system dimensions and the main programs in which they are defined are shown in Table 13. For changing the maximum system dimensions, the user should consult Reference 2.

Table 13. Maximum System Dimensions Used in KONPACT-2

Maximum System Dimension	Defined in Program DIAK	Defined in Program FFOC	Defined in Programs MAIN and DATAK
Maximum Number of States (NXM, MX)	40	40	50
Maximum Number of Outputs (NRM)	-	-	70
Maximum Number of Inputs (NUM)	-	-	20
Maximum Number of Design Responses (MR)	40	40	-
Maximum Number of Measurements (MM)	-	40	-
Maximum Number of Control Inputs (MU)	6	6	-
Maximum Number of Disturbance Inputs (MN)	2	2	-
Maximum Number of Plotting Variables (MXR)	80	-	-
Maximum Number of Feed Forward Gains (MFF)	-	9	-
Maximum Number of Feedback Gains (MFB)	-	40	-
Maximum Number of Fixed Gains (MF)	-	50	-

## SECTION V

## DEMONSTRATION EXAMPLE 1

## INTRODUCTION

The example chosen in this section for demonstration is the design of a handling qualities controller for the C-5A basic vehicle (cruise flight condition). This model was generated from the Air Force Level 2.01.00 FLEXSTAB Computer Programming System (Reference 1).

In the following subsection, the problem statement and the method of solution are discussed first. Then the deck set-up for solving the problem using KONPACT is explained. Finally, the computer printout and the final design results are discussed.

It is assumed that the user is now familiar with the optimal control programs (DIAK and FFOC) and the design procedures listed in Reference 2.

## PROBLEM STATEMENT

The problem is to design a controller for the C-5A basic vehicle (cruise flight condition) so that the controlled vehicle will have the desired handling quality (Reference 10). The handling quality criterion in this example is prescribed in terms of the short period poles. The desired short period poles are given as:  $\omega_n = 3$  rad/sec and  $\zeta = 0.7$ .



## METHOD OF SOLUTION

The C-5A handling quality controller, designed via the optimal control synthesis technique, is carried out in three parts: a) design model generation, b) controller design, and c) performance evaluation.

Design model generation consists of three steps. The first step is to obtain the required dynamics (i.e., vehicle, actuator, pilot model, implicit model) needed for the C-5A handling quality design process. The second step is to augment the C-5A vehicle model with appropriate pilot model, actuator, and implicit model (see Figure 26). The third step is to select the design responses and obtain a design model.

Controller design consists of two steps. The first step is to obtain optimal state feedback controller gains by varying the quadratic weights on selected design responses so that the handling quality criterion is met. The second step is to obtain reduced feedback gains so that only a specified set of sensors is used, and the handling quality criterion is not compromised.

Performance evaluation of the closed loop system is obtained to check the design.

### Design Model Generation

Figure 26 shows a schematic diagram of the design model. In the following paragraphs, the steps for obtaining the design model are described.



C-5A Basic Vehicle for Cruise Flight Condition (Static Elastic Symmetric Dynamic Math Model)--The C-5A basic vehicle for cruise flight condition (static elastic symmetric model) is provided by the FLEXSTAB LSA program in the form of a simulator deck data.

This model is given system number 1 (S-1, Figure 26) and STAMK1 subprogram in KONPACT-1 is used to obtain the state space model from the simulator deck data. The system variables are the following:

States:  $u, w, q, \theta$

Outputs:  $q_s, n_{a_1}, n_{a_2}, n_{a_3}$

Inputs:  $\delta_a, \delta_e, \dot{\delta}_a, \dot{\delta}_e, w_{g1}, w_{g2}, w_{g3}, \dot{w}_{g1}, \dot{w}_{g2}, \dot{w}_{g3},$   
 $w_{gs1}, w_{gs2}, w_{gs3}, \dot{w}_{gs1}, \dot{w}_{gs2}, \dot{w}_{gs3}$

Table 14 gives their description and also forms the basis for the name list data input.

C-5A Reduced Vehicle for Cruise Flight Condition (Reduced Static Elastic Symmetric Dynamic Math Model)--The handling quality controller design requires only the short period dynamics (i. e.,  $w$  and  $q$ ),  $\delta_e$  input, and  $q_s$  and  $n_{a_1}$  outputs. The reduced model is obtained by truncating the states  $u$  and  $\theta$  and omitting the inputs and outputs not needed. Also, the states  $w$  and  $q$  are defined as outputs. This reduced model is obtained by using the CONDK subprogram in KONPACT-1. The system number 1 is retained for the reduced system (S-1, Figure 26). The system variables in this case are:

Table 14. Description of the System Variables for the C-5A Static Elastic Vehicle  
(Cruise Flight Condition)

Variable		Description	Unit
u	U	Velocity Along X Axis	Inch/Sec
w	W	Velocity Along Z Axis	Inch/Sec
q	Q	Pitch Rate	Radian/Sec
$\theta$	THETA	Pitch Attitude	Radian
$q_s$	SASGY	Pitch Rate Gyro	Radian/Sec
$n_{a1}$	AZAP	Normal Accelerometer Fuselage	Inch/Sec <sup>2</sup>
$n_{a2}$	AZFB	Normal Accelerometer Frontspar	Inch/Sec <sup>2</sup>
$n_{a3}$	AZRB	Normal Accelerometer Backspar	Inch/Sec <sup>2</sup>
$\delta a$	BDAIL	Aileron Deflection	Radian
$\delta e$	BDELV	Elevator Deflection	Radian
$\dot{\delta a}$	BDAILDOT	Aileron Deflection Rate	Radian/Sec
$\dot{\delta e}$	BDELVDOT	Elevator Deflection Rate	Radian/Sec
wg1	WG1	Gust Input at -1020 in from CG	Inch/Sec
wg2	WG2	Gust Input at 0 in from CG	Inch/Sec
wg3	WG3	Gust Input at 1020 in from CG	Inch/Sec
$\dot{w}g1$	WG1DOT	Gust Input Rate of WG1	Inch/Sec <sup>2</sup>
$\dot{w}g2$	WG2DOT	Gust Input Rate of WG2	Inch/Sec <sup>2</sup>
$\dot{w}g3$	WG3DOT	Gust Input Rate of WG3	Inch/Sec <sup>2</sup>
wgs1	WGS1	Steady Gust Input	Inch/Sec
wgs2	WGS2	Steady Gust Input	Inch/Sec
wgs3	WGS3	Steady Gust Input	Inch/Sec
$\dot{w}gs1$	WGS1DOT	Steady Gust Input Rate	Inch/Sec <sup>2</sup>
$\dot{w}gs2$	WGS2DOT	Steady Gust Input Rate	Inch/Sec <sup>2</sup>
$\dot{w}gs3$	WGS3DOT	Steady Gust Input Rate	Inch/Sec <sup>2</sup>

States:     w, q  
Outputs:     $q_s, n_{a1}, w, q$   
Inputs:      $\delta_e$

Actuator Model--The actuator is given by the transfer function:

$$H_a(s) = \frac{b_a}{s + a_a} ; \quad a_a = b_a = 7.5. \quad (3)$$

The actuator is given a system number 2 (S-2, Figure 26) and is modeled using the STAMK2 subprogram in KONPACT-1.

Pilot Model--The pilot model is a first order lag filter given by the transfer function:

$$H_p(s) = \frac{b_p}{s + a_p} ; \quad a_p = 0.1, \quad b_p = 0.223 \times 10^{-3}. \quad (4)$$

The pilot input time constant is chosen as 10 seconds since this gave good GLA (Gust Load Alleviation) performance when used with rate model following (Reference 10). The gain  $b_p$  is chosen to be  $0.223 \times 10^{-3}$  in order to obtain an rms pilot input of  $0.5 \times 10^{-3}$  radian (0.0287 degree). This is an important factor in reduced (not full) control since optimal gains depend on covariance analysis.

The pilot model is given a system number 3 and is also modeled using the STAMK2 subprogram in KONPACT-1.

Interconnection of Reduced Vehicle, Actuator, and Pilot Model into a System Called Plant--The interconnections for the plant are shown in Figure 26. The interconnections are described by the following equations:

$$\begin{pmatrix} U_{i1} \\ U_{i2} \\ U_{i3} \end{pmatrix} = \begin{pmatrix} UI1/RI1 & UI1/RI2 & UI1/RI3 \\ \text{---} & \text{---} & \text{---} \\ UI2/RI1 & UI2/RI2 & UI2/RI3 \\ \text{---} & \text{---} & \text{---} \\ UI3/RI1 & UI3/RI2 & UI3/RI3 \end{pmatrix} \begin{pmatrix} r_{i1} \\ r_{i2} \\ r_{i3} \end{pmatrix} + \begin{pmatrix} UI1/U \\ \text{---} \\ UI2/U \\ \text{---} \\ UI3/U \end{pmatrix} (U) \quad (5)$$

$$(r) = (R/RI1 \quad R/RI2 \quad R/RI3) \begin{pmatrix} r_{i1} \\ r_{i2} \\ r_{i3} \end{pmatrix} + (R/U) (U) \quad (6)$$

where  $U_{i1}$ ,  $U_{i2}$ , and  $U_{i3}$  are the inputs to systems 1, 2, and 3, respectively, and  $r_{i1}$ ,  $r_{i2}$ , and  $r_{i3}$  are the outputs from systems 1, 2, and 3, respectively.  $U$  is the input to the plant, and  $r$  is the output from the plant. Definitions of the inputs and outputs in terms of the system physical variables are given in Table 15.

Table 15. Input/Output Definitions for Obtaining Static Elastic Plant Model

System No.	Name	Input Definition	Output Definition
1	Reduced Vehicle	$U_{i1} = \delta_e$	$r_{i1} = \text{Col } \{q_s, n_{a1}, w, q\}$
2	Actuator	$U_{i2} = \delta_{ec}$	$r_{i2} = \delta_e$
3	Pilot Model	$U_{i3} = \eta_p$	$r_{i3} = r_p$
4	Plant	$U = \text{Col } \{\eta_p, u_c\}$	$r = \text{Col } \{q_s, n_{a1}, w, q, r_p\}$

Thus the non-null interconnection matrices are given in the following:

$$U_{I1}/R_{I2} = (1)$$

$$U_{I2}/U = (0 \quad 1)$$

$$U_{I3}/U = (1 \quad 0)$$

$$R/R_{I1} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad (7)$$

$$R/R_{I3} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$$

The interconnection data are used by subprogram STAMK3 of KONPACT-2 to model the plant. The plant is given a system number 4 (S-4, Figure 26).

Implicit Model--The implicit model is used to generate model following error rate responses (Reference 10). These model following error rate responses are weighted during the design step to achieve handling quality criteria.

The implicit model construction is described in the following.

The reduced C-5A vehicle is described by the equations:

$$\begin{aligned}\dot{w} &= A_{11}w + A_{12}q + B_{11} \delta_e \\ \dot{q} &= A_{21}w + A_{22}q + B_{21} \delta_e\end{aligned}\tag{8}$$

where the values of the coefficients for cruise flight condition are given by:

$$A = \begin{pmatrix} -0.67868 & 8741.2 \\ -0.0001874 & -1.1011 \end{pmatrix} \quad B = \begin{pmatrix} 0.33079 \\ -1.6064 \end{pmatrix}\tag{9}$$

The implicit vehicle is described by the equations:

$$\begin{aligned}\dot{w}_M &= A_{11} w_M + A_{12} q_M + B_{11} u_M \\ \dot{q}_M &= \hat{A}_{21} w_M + \hat{A}_{22} q_M + B_{12} u_M\end{aligned}\tag{10}$$

where  $w_M$  and  $q_M$  are state variables of the implicit model, and  $u_M$  is the input to the implicit model.

As can be seen, the coefficients of the first row of the implicit model transition matrix are the same as the corresponding elements of the vehicle equation. The second row coefficients are obtained from the handling quality criteria, the prescribed short period poles. These are given as:

$$\omega_n = 3 \text{ rad/sec and } \zeta = 0.7.$$

The corresponding characteristic equation is:

$$\Delta(s) = s^2 + 2 \zeta \omega_n s + \omega_n^2 \quad (11)$$

since:

$$\begin{aligned} \text{tr}(A) &= -2 \zeta \omega_n = -4.2 \\ \det(A) &= \omega_n^2 = 9 \end{aligned} \quad (12)$$

and:

$$\begin{aligned} A_{11} + \hat{A}_{22} &= -4.2 \\ A_{11} \hat{A}_{22} - A_{12} \hat{A}_{21} &= 9 \end{aligned} \quad (13)$$

and the results are:

$$\begin{aligned} \hat{A}_{21} &= -.0007562 \text{ and} \\ \hat{A}_{22} &= -3.5213. \end{aligned} \quad (14)$$

The implicit model is always given the system number 9 (S-9, Figure 26).

Interconnection of the Plant and the Implicit Model (Overall System)--

The interconnections for the overall system are shown in Figure 26.

Table 16 gives input/output definitions for this case. The non-null interconnection matrices are given by:

$$\begin{aligned} \text{UI9/RI4} &= (0 \quad 0 \quad 0 \quad 0 \quad 1) \\ \text{UI4/U} &= \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \\ \text{R/RI4} &= \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1/U_0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix} & (15) \\ \text{R/RI9} &= \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ -1 & 0 \\ 0 & -1 \end{pmatrix} \end{aligned}$$

The interconnection data are used by subprogram STAMK3 of KONPACT-1 to model the overall system. The overall system is given a system number 5 (S-5, Figure 26).



Table 16. Input/Output Definitions for Obtaining Overall Static Elastic System Model

System No.	Name	Input Definition	Output Definition
4	Plant	$u_{i4} = \text{Col} \{ \eta_p, u_c \}$	$r_{i4} = \text{Col} \{ q_s, n_{a1}, w, q, r_p \}$
9	Implicit Model	$u_{i9} = u_M$	$r_{i9} = \text{Col} \{ w_M, q_M \}$
5	Overall System	$u = \text{Col} \{ \eta_p, u_c \}$	$r = \text{Col} \{ q_s, n_{a1}, \alpha, r_p, e_{wi}, e_{qi} \}$

Overall System (Design Model)-- The design response specifications, sensor specifications, control input specifications, and disturbance input specifications are used by the CONDK subprogram of KONPACT-1 to obtain the design model. System number 5 is retained for the design model (S-5, Figure 26).

The specified design responses for this example are:

$$(q, \alpha, \delta_e, \dot{\delta}_e, \dot{e}_{wi}, \dot{e}_{qi}).$$

The specified sensor responses are:

$$(q_s, n_{a1}, \delta_e, r_p).$$

The specified control inputs are:

$$(u_c).$$

The specified disturbance inputs are:

$$(\eta_p).$$

The implicit model is automatically truncated by the CONDK subprogram after model following error rate equations are obtained internally. (For an explicit model, a system number other than 9 should be assigned.)

The dynamics needed by the subprograms DIAK, FFOC, and DATAK in KONPACT-2 are given by the following equations (see Reference 2):

$$\begin{aligned}\dot{x} &= (F)x + (G_1)u + (G_2)\eta \\ r &= (H)x + (\tilde{D})u \\ m &= (AM)x\end{aligned}\tag{16}$$

where:

x is the state variables

u is the control variables

$\eta$  is the disturbance variables

r is the design responses

m is the measurements.

The quadruple data (A, B, C, D) representing the design model contain the previously mentioned matrices as shown below:

$$\begin{aligned}A &= (F) & B &= (G_1 \mid G_2) \\ C &= \left( \begin{array}{c} H \\ AM \end{array} \right) & D &= \left( \begin{array}{c|c} \tilde{D} & O \\ \hline O & O \end{array} \right)\end{aligned}\tag{17}$$

## Controller Design

Figure 27 represents a block diagram of the design process. The starting design response weights are shown in Figure 28. In the following paragraphs, the steps for obtaining the handling quality controller design are described.

### Optimal State Feedback Gains for Handling Quality Controller Design--

Using the overall system design model described earlier, the optimal state feedback gains are computed by the DIAK subprogram of KONPACT-2 for the specified quadratic weights. The quadratic weights are varied and the optimal state feedback gains are computed until the handling quality criterion is met. The variation of quadratic weights and the resulting system gains are shown in Figure 29.

Reduced Optimal Feedback Gains--The optimal full state feedback control law is given by:

$$\delta_{ec} = (K_{q_s}) q_s = (K_{n_{al}}) n_{al} + (K_{\delta_e}) \delta_e + (K_{r_p}) r_p. \quad (18)$$

Reduced optimal feedback gains are obtained for two cases by the FFOC subprogram (see Figure 30). In the first case, the gain on measurement  $\delta_e$  alone is reduced to zero. In the second case, the gains on measurements  $\delta_e$  and  $n_{al}$  are reduced to zero. The effect of these reductions is presented in Figure 31. The first reduction maintains the desired C-5A handling qualities.

## Performance Evaluation

In Figures 32 through 34 the time responses of the open and closed loop system are obtained to demonstrate the desired handling quality. These time responses are due to the elevator input contained in each figure. The short period pole locations are also checked out which is demonstrated in Figure 30.

## DECK SET-UP

Figure 35 shows the static elastic simulator deck data which are calculated by the FLEXSTAB/LSA program. The precompiler data needed for KONPACT-1 are shown in Figure 36. It consists of the subprograms that will be needed to execute the KONPACT-1 input data. The input data to produce the design model of the overall system are shown in Figure 37. The KONPACT-2 input data required to obtain optimal state feedback gains (using the DIAK subprogram) are shown in Figure 38. The KONPACT-2 input data required to compute the feedback gains only on specified measurements (using the FFOC subprogram) are shown in Figure 39. The KONPACT-2 input data required to obtain time response (using the DIAK subprogram) are shown in Figure 40.

## OUTPUT DESCRIPTION

KONPACT-1 output data are shown in Figures 41 through 53. The corresponding input data are shown in Figure 37. The C-5A vehicle simulator deck data, for cruise flight condition in matrix form, are given in Figure 41, and the corresponding vehicle quadruple data, along with the name list data, are given in Figure 42. The reduced vehicle name list data and quadruple data are given in Figure 43. The actuator transfer function data are given in Figure 44, and the corresponding actuator quadruple data along with the name list data are given in Figure 45. The pilot model transfer function data are given in Figure 46 and the corresponding pilot model quadruple data, along with the name list data, are given in Figure 47. The interconnection data for the plant are given in Figure 48, and the corresponding plant quadruple data, along with the name list data, are given in Figure 49. The

implicit model name list data and the quadruple data are given in Figure 50. The interconnection data for the overall system are given in Figure 51, and the corresponding overall system quadruple data, along with the name list data, are given in Figure 52. The overall system design model name list data and quadruple data are given in Figure 53.

KONPACT-2 output data, obtaining optimal state feedback gains using DIAK subprogram, are shown in Figure 54. Even though the corresponding input data given in Figure 38 contain five different quadratic weighting matrices, the output data shown here contain the iterations for the fourth quadratic weighting matrix. The results for the other quadratic weighting matrices are summarized in the next subsection.

KONPACT-2 output data, for obtaining feedback gains on specified measurements using the FFOC subprogram, are shown in Figure 55.

KONPACT-2 output data, for obtaining time response of closed loop system using the DIAK subprogram, are shown in Figure 56.

## DISCUSSION OF RESULTS

In the first step of the design optimal gains,  $K_{qs}$ ,  $K_{na1}$ ,  $K_{\delta e}$ , and  $K_{rp}$  are determined by varying the quadratic weights and using the DIAK subprogram until the handling quality criterion is met. Figure 29 shows the variation in gains and the closed loop eigenvalues when the weight  $Q_6$  is varying from .001 to 10.0. The movement of the closed loop eigenvalues is also shown in Figure 31.

In the second step of the design, the number of feedback gains is reduced by using the FFOC subprogram. When both  $K_{\delta_e}$  and  $K_{n_{a1}}$  are reduced, the resulting closed loop eigenvalues do not meet the handling quality criterion. When only  $K_{\delta_e}$  is reduced, the handling quality criterion is met. The variation in gains and the closed loop eigenvalues when the reduction of gains takes place are shown in Figure 30. The movement of the closed loop eigenvalues is also shown in Figure 31.

The step response for  $q$ ,  $\alpha$ , and  $\delta_e$  for the open loop system is shown in Figure 32. The step response for  $q$ ,  $\alpha$ , and  $\delta_e$  for the full state optimal closed loop system is shown in Figure 33. The step response for  $q$ ,  $\alpha$ , and  $\delta_e$  for the reduced (only  $K_{\delta_e}$  is reduced) optimal closed loop system is shown in Figure 34. As can be seen, the reduced feedback optimal system develops responses similar to the full state optimal system.

## SECTION VI

### DEMONSTRATION EXAMPLE 2

#### INTRODUCTION

The example chosen in this section for demonstration is the repeat design of the Active Lift Distribution Control System (ALDCS) for the C-5A vehicle (cruise flight condition) per Reference 10. The vehicle model was generated from the Air Force Level 2.01.00 FLEXSTAB Computer Programming System (Reference 1).

The problem statement and the method of solution are discussed first. Next, the deck set-up for solving the problem using KONPACT is explained. Finally, the computer printout and the final design results are discussed.

#### PROBLEM STATEMENT

ALDCS design goals are shown in Table 17. The problem is to design a controller for the C-5A vehicle (cruise flight condition) to meet these goals.

#### METHOD OF SOLUTION

The C-5A ALDCS controller design via the optimal control synthesis technique is carried out in three parts: a) design model generation, b) controller design, and c) performance evaluation.

Table 17. C-5A ALDCS Design Goals

Design Goal	Criterion Specification
<p>Handling Qualities</p>	<ul style="list-style-type: none"> <li>• Same stick displacement/g (steady state) as A/C with SAS*</li> <li>• <math>\alpha, \dot{\theta}</math> command response close to that for A/C with SAS</li> </ul>
<p>Gust Load Alleviation</p>	<ul style="list-style-type: none"> <li>• RMS value of B120.4 wing root bending moment due to wind less than 0.70 of that for the free A/C</li> <li>• RMS value of T120.4 wing root torsional moment due to wind not more than 1.05 of that for the free A/C</li> </ul>
<p>Maneuver Load Control</p>	<ul style="list-style-type: none"> <li>• Steady state B120.4/g due to commands should be less than 0.70 of that for the free A/C</li> <li>• The B120.4 response to step commands should not markedly reverse directions</li> </ul>

\* SAS may be taken as  $u_{\delta_{ei}} = 0.5 q_s$



## Design Model Generation

Figures 57a and 57b show schematic diagrams of the design model. In the following paragraphs, the steps for obtaining the design model are described.

C-5A Vehicle for Cruise Flight Condition--The C-5A vehicle for cruise flight condition (Residual Elastic Symmetric Model) is provided by the FLEXSTAB (LSA program) in the form of a simulator deck data written on file VDATA. A full description of the model is presented in References 8 and 9 and therefore will not be repeated in this report. This model is given system number 1 (S-1, Figure 57a), and the STAMK1 subprogram in KONPACT-1 is used to obtain the state space model from the simulator deck data. For a definition of the load reference axis systems used to define (Bi, Ti i = 1, ...15), see Figure 4 of Reference 4. The system variables are the following:

States:  $u, w, q, \theta, \eta_1, \eta_2, \dots, \eta_{15}, \dot{\eta}_1, \dot{\eta}_2, \dots, \dot{\eta}_{15}$

Outputs:  $q_s, n_{a1}, n_{a2}, n_{a3}, S1, B1, T1, S2, B2, T2, \dots,$   
 $S5, B5, T5$

Inputs:  $\delta_a, \delta_{ei}, \delta_{eo}, \dot{\delta}_a, \dot{\delta}_{ei}, \dot{\delta}_{eo}, w_{g1}, w_{g2}, w_{g3}, \dot{w}_{g1}, \dot{w}_{g2}, \dot{w}_{g3}$

Table 18 describes these symbols and forms the basis for the namelist data. Note that a redefinition of generalized coordinates has been made from "U<sub>1i</sub>" to " $\eta_i$ " to facilitate later discussion.

Table 18. Description of the System Variables for C-5A Residual Elastic Vehicle (Cruise Flight Condition)

Variable	Description	Unit
u	Velocity Along X Axis	Inch/Sec
w	Velocity Along Z Axis	Inch/Sec
q	Pitch Rate	Radian/Sec
$\theta$	Pitch Attitude	Radian
$\eta_1$	Bending Mode Displacement	Inch
$\eta_2$	Bending Mode Displacement	Inch
$\eta_3$	Bending Mode Displacement	Inch
$\eta_4$	Bending Mode Displacement	Inch
$\eta_5$	Bending Mode Displacement	Inch
$\eta_6$	Bending Mode Displacement	Inch
$\eta_7$	Bending Mode Displacement	Inch
$\eta_8$	Bending Mode Displacement	Inch
$\eta_9$	Bending Mode Displacement	Inch
$\eta_{10}$	Bending Mode Displacement	Inch
$\eta_{11}$	Bending Mode Displacement	Inch
$\eta_{12}$	Bending Mode Displacement	Inch
$\eta_{13}$	Bending Mode Displacement	Inch
$\eta_{14}$	Bending Mode Displacement	Inch
$\eta_{15}$	Bending Mode Displacement	Inch

Table 18. Description of the System Variables for C-5A Residual Elastic Vehicle (Cruise Flight Condition) (Continued)

Variable	Description	Unit
$\dot{\eta}_1$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_2$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_3$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_4$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_5$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_6$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_7$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_8$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_9$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{10}$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{11}$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{12}$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{13}$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{14}$	Bending Mode Rate	Inch/Sec
$\dot{\eta}_{15}$	Bending Mode Rate	Inch/Sec
$q_s$	Pitch Rate Gyro	Radian/Sec
$n_{a1}$	Normal Accelerometer Fuselage	Inch/Sec <sup>2</sup>
$n_{a2}$	Normal Accelerometer Frontspar	Inch/Sec <sup>2</sup>
$n_{a3}$	Normal Accelerometer Backspar	Inch/Sec <sup>2</sup>

Table 18. Description of the System Variables for C-5A Residual Elastic Vehicle (Cruise Flight Condition) (Continued)

Variable	Description	Unit
S1	Shear Force (120.0)	Lb
B1	Bending Moment (120.0)	Inch-Lb
T1	Torsion Moment (120.0)	Inch-Lb
S2	Shear Force (328.2)	Lb
B2	Bending Moment (328.2)	Inch-Lb
T2	Torsion Moment (328.2)	Inch-Lb
S3	Shear Force (575.1)	Lb
B3	Bending Moment (575.1)	Inch-Lb
T3	Torsion Moment (575.1)	Inch-Lb
S4	Shear Force (746.0)	Lb
B4	Bending Moment (746.0)	Inch-Lb
T4	Torsion Moment (746.0)	Inch-Lb
S5	Shear Force (920.0)	Lb
B5	Bending Moment (920.0)	Inch-Lb
T5	Torsion Moment (920.0)	Inch-Lb
$\delta_a$	Aileron Deflection	Radian
$\delta_{ei}$	Inboard Elevator Deflection	Radian
$\delta_{eo}$	Outboard Elevator Deflection	Radian

Table 18. Description of the System Variables for C-5A Residual Elastic Vehicle (Cruise Flight Condition) (Concluded)

Variable	Description	Unit
$\dot{\delta}_a$	Aileron Deflection Rate	Radian/Sec
$\dot{\delta}_{ei}$	Inboard Elevator Deflection Rate	Radian/Sec
$\dot{\delta}_{eo}$	Outboard Elevator Deflection Rate	Radian/Sec
$w_{g1}$	Gust Input at -1020 in from CG	Inch/Sec
$w_{g2}$	Gust Input at 0 in from CG	Inch/Sec
$w_{g3}$	Gust Input at 1020 in from CG	Inch/Sec
$\dot{w}_{g1}$	Gust Input Rate	Inch/Sec <sup>2</sup>
$\dot{w}_{g2}$	Gust Input Rate	Inch/Sec <sup>2</sup>
$\dot{w}_{g3}$	Gust Input Rate	Inch/Sec <sup>2</sup>
DELADOT		
DELEIDOT		
DELEODOT		
WG1		
WG2		
WG3		
WG1DOT		
WG2DOT		
WG3DOT		

C-5A Converted Vehicle for Cruise Flight Condition--It is assumed that the ALDCS controller design requires only the short period dynamics (i. e.,  $w$  and  $q$ ) and the flexure mode states ( $\eta_1, \dots, \eta_{15}, \dot{\eta}_1, \dots, \dot{\eta}_{15}$ ). In this case the assumption is valid, as the unaugmented C-5A has substantial separation between its short period and plugoid modes. For other aircraft of reduced static stability that do not possess this eigenvalue separation, the assumption is then, of course, not valid. Also, the design requires that units of some of the variables need to be changed (see Table 19). The C-5A converted vehicle is obtained by truncating the states  $u$  and  $\theta$  and

Table 19. Change of Units for Some of the System Variables of C-5A Residual Elastic Vehicle (Cruise Flight Condition)

Variable	Old Unit	New Unit	Scale Factor
$q$	Radian/Sec	Inch/Sec	0.164789E 04
$w_{g1}$	Inch/Sec	Feet/Sec	0.833333E-01
$w_{g2}$	Inch/Sec	Feet/Sec	0.833333E-01
$w_{g3}$	Inch/Sec	Feet/Sec	0.833333E-01
$\dot{w}_{g1}$	Inch/Sec	Feet/Sec	0.833333E-01
$\dot{w}_{g2}$	Inch/Sec	Feet/Sec	0.833333E-01
$\dot{w}_{g3}$	Inch/Sec	Feet/Sec	0.833333E-01
$n_{a1}$	Inch/Sec <sup>2</sup>	1G	0.258800E-02
$n_{a2}$	Inch/Sec <sup>2</sup>	1G	0.258800E-02
$n_{a3}$	Inch/Sec <sup>2</sup>	1G	0.258800E-02

changing the units of the variables specified. System number 1 is retained for the converted vehicle (S-1, Figure 57a) and is obtained using the CONDK subprogram.

Actuator Model--The actuator block diagram is shown in Figure 58. The actuator is given a system number 2 (S-2, Figure 57a) and is modeled using the STAMK2 subprogram in KONPACT-1.

Gust Model--The gust model block diagram is shown in Figure 59, and the gust model (Reference 10) coefficients are shown in Table 20. The gust model is given a system number 3 (S-3, Figure 57a) and is modeled using the STAMK3 subprogram in KONPACT-1.

Table 20. Gust Model Coefficients

Coefficient	Description	Value
$\tilde{a}_1$	Wind filter coefficient	0.42
$\tilde{a}_0$	Wind filter coefficient	0.0441
$\tilde{b}_1$	Wind filter coefficient	0.7937
$\tilde{b}_0$	Wind filter coefficient	-0.2371
$v_{NT}$	Kussner coefficient for nose and tail	9.0284
$v_w$	Kussner coefficient for wing	4.4596
$T_w$	First order time delay filter coefficient	0.0744
$\hat{a}_1$	Second order time delay filter coefficient	16.0044
$\hat{a}_0$	Second order time delay filter coefficient	96.0523
$\hat{b}_1$	Second order time delay filter coefficient	-8.0022
$\hat{b}_0$	Second order time delay filter coefficient	224.1219



Interconnection of Converted Vehicle, Actuator and Gust Model (Plant)--

The interconnections for the plant are shown in Figure 57a. The non-null interconnection matrices for these interconnections are obtained as in Section V. The interconnection data are used by subprogram STAMK3 of KONPACT-1 to model the plant. Two additional responses  $\alpha$  and  $q_{cg}$  are defined here for the plant. The plant is given a system number 4 (S-4, Figure 57a).

Plant Design Model--The load rate responses ( $\dot{B}_1, \dot{T}_1, \dot{B}_2, \dot{T}_2, \dots, \dot{B}_5, \dot{T}_5$ ) are obtained here by using the CONDK subprogram of KONPACT-1. The system number 4 is retained for the plant design model (S-4, Figure 57a).

Reduced Order Plant Models--The plant obtained in the preceding step contains 15 flexure modes. This is reduced to the six lowest frequency flexure modes by residualization and truncation procedures (Reference 4). Three different models are obtained. The procedure for obtaining the three models is shown in Table 21. The system reference specification is used to obtain

Table 21. Reduced Order Plant Model (Six Modes) Obtained from Residual Elastic Plant Design Model (15 Modes)

Name	Procedure
F24RR	Obtained by residualizing states, design responses, and sensor measurements.
F24RT	Obtained by residualizing states and design responses and truncating sensor measurements.
F24TT	Obtained by truncating states, design responses and sensor measurements.

the three models from the plant design model (see Figure 79). The F24RR model is used for the ALDCS controller design.

ALDCS Controller Model--The block diagram of the ALDCS controller is shown in Figure 60. This model is given system number 5 (S-5, Figure 57b). The STAMK4 subprogram in KONPACT-1 models the controller dynamics using the user written subroutine SIMK2. The program listing for SIMK2 for the ALDCS controller is given in Figure 61. The system variables for the ALDCS controller are the following:

States: (A21RL, GLAF, MLC1, HP, F3E, MLC2, P)

Outputs: ( $u_{\delta a}$ ,  $u_{\delta ei}$ ,  $u_{\delta eo}$ )

Inputs: ( $u_{c1}$ ,  $u_{c2}$ ,  $\eta_p$ ,  $\delta_a$ ,  $\delta_{ei}$ , A21R, AFUS, TFUS, ACG).

The gains KAF and KM1 for the ALDCS controller are obtained by conducting three steady state tests (Reference 4) on the corresponding plant model (F24RR). The steady state tests made are given in Table 22. These tests are described more fully in Reference 4.

Reduced ALDCS Controller--The general ALDCS controller modeled in the previous step is reduced by truncating the states (HP, F3E, MLC2). The block diagram of the reduced controller is shown in Figure 62. The system number 5 is retained for the reduced ALDCS controller (S-5, Figure 57) and is obtained using the CONDK subprogram.

Interconnection of the Reduced Plant and the Reduced Controller (Overall System)--The interconnections for the overall system are shown in Figure 57b. The non-null interconnection matrices for these interconnections are obtained as in Section V. The interconnection data are used by subprogram STAMK3 of KONPACT-1 to model the overall system. The model following

Table 22. Steady State Responses

Case	SS Connection	Prescribed Output	Required Input	Additional Computed Outputs
Free A/C		$\bar{q} = 0.04377$ (rad/sec)	$\bar{p} = -0.0737$ $S_{ei} = S_{eo} = p$	$\bar{BI} = 0.6479 \times 10^8$ (in-lbs)
A/C + SAS		$\bar{q} = 0.04377$ (rad/sec)	$\bar{p} = -0.0896$ $\frac{\delta_{eo}}{\delta_{ei}} = \bar{p}$ $\frac{\delta_{ei}}{\delta_{ei}} = \bar{p} + 0.5\bar{q}$	$\bar{\delta}_{ei} = -0.0677$
A/C + ALDCS		$\bar{q} = 0.94377$ $.7\bar{BI} = 0.4531 \times 10^8$ $\frac{\delta_{eo}}{\delta_{ei}} = -0.0896$	$\bar{\delta}_a = -0.2752$ $\frac{\delta_{ei}}{\delta_{ei}} = -0.0226$	

error rates for handling quality are defined as additional responses. The overall system is given a system number 6 (S-6, Figure 57b).

Overall System (Design Model)--The design response specifications, sensor specifications, control input specifications, and disturbance input specifications are used by the CONDK subprogram of KONPACT-1 to obtain the design model. System number 6 is retained for the design model (S-6, Figure 57b). The specifications for this model are listed in Table 23.

## Controller Design

Figure 63 represents a block diagram of the design process. The design response weights are shown in Figure 64. In the following paragraphs, the steps for obtaining the ALDCS controller design are described.

Optimal State Feedback Gains for ALDCS Controller Design--Using the overall system design model described earlier, the optimal state feedback gains are computed by the DIAK subprogram of KONPACT-2 for the specified quadratic weights. The quadratic weights are varied, and the corresponding optimal state feedback gains are computed until the ALDCS design goals are met.

Reduced Optimal Feedback Gains--Starting from the optimal state feedback control law, reduced optimal feedback gains are obtained by the FFOC subprogram. The reduced control law is given by the following equations:

$$u_{\delta a} = (K1_{DELA}) \delta_a + (K1_{A21RL}) A21RL + (K1_{GLAF}) GLAF \quad (19)$$

$$u_{\delta ei} = (K2_{A21R}) A21R + (K2_{AFUS}) + (K2_{TFUS}) TFUS + (K2_P) p. \quad (20)$$

Table 23. Response Specifications for the Overall System Residual Elastic Design Model

Specification	Variable		Description	Units
Design Output	MLC1	MLC1	Full State MLC for Aileron	
	B1	B1	Bending Moment (120.0)	Inch-Lb
	T1	T1	Torsion Moment (120.0)	Inch-Lb
	$q_s$	SASGY	Pitch Rate Gyro	Radian/Sec
	B2	B2	Bending Moment (328.2)	Inch-Lb
	T2	T2	Torsion Moment (328.2)	Inch-Lb
	$\dot{\delta}_a$	D/DT of	( XA Actuator State )	Radian /Sec
	B3	B3	Bending Moment (575.1)	Inch-Lb
	T3	T3	Torsion Moment (575.1)	Inch-Lb
	$\dot{\delta}_{ei}$	D/DT of	( XEI Actuator State )	Radian /Sec
	B4	B4	Bending Moment (746.0)	Inch-Lb
	T4	T4	Torsion Moment (746.0)	Inch-Lb
	$\delta_a$	XA	Actuator State	Radian
	B5	B5	Bending Moment (920.0)	Inch-Lb
	T5	T5	Torsion Moment (920.0)	Inch-Lb
	$\delta_{ei}$	XEI	Actuator State	Radian
	$\dot{B}_1$	D/DT of	( B1 Bending Moment )	Inch-Lb /Sec
$\dot{T}_1$	D/DT of	( T1 Torsion Moment )	Inch-Lb /Sec	
$\dot{\eta}_1$	UE1DOT	Bending Mode Rate	Inch/Sec	

Table 23. Response Specifications for the Overall System Residual Elastic Design Model (Continued)

Specification	Variable	Description	Units
Design Output (continued)	$\dot{B}_2$	( B2 Bending Moment )	Inch-Lb /Sec
	$\dot{T}_2$	( T2 Torsion Moment )	Inch-Lb /Sec
	$\dot{\eta}_2$	Bending Mode Rate	Inch/Sec
	$\dot{B}_3$	( B3 Bending Moment )	Inch-Lb /Sec
	$\dot{T}_3$	( T3 Torsion Moment )	Inch-Lb /Sec
	$\dot{\eta}_3$	Bending Mode Rate	Inch/Sec
	$\dot{B}_4$	( B4 Bending Moment )	Inch-Lb /Sec
	$\dot{T}_4$	( T4 Torsion Moment )	Inch-Lb /Sec
	$\dot{\eta}_4$	Bending Mode Rate	Inch/Sec
	$\dot{B}_5$	( B5 Bending Moment )	Inch-Lb /Sec
	$\dot{T}_5$	( T5 Torsion Moment )	Inch-Lb /Sec
	$\dot{\eta}_5$	Bending Mode Rate	Inch/Sec
	$\dot{\eta}_6$	Bending Mode Rate	Inch/Sec
	$\dot{e}_w$	Imp Model Error Rate for w	
	$\dot{e}_q$	Imp Model Error Rate for q	
	$\alpha$	Angle of Attack	Radian
	$u_{c1}$	Aileron Optimal Control Input	
$u_{c2}$	Inboard Elev Optimal Control Inp		

Table 23. Response Specifications for the Overall System Residual Elastic Design Model (Continued)

Specification	Variable		Description	Units
Sensor Output	p	P	Pilot Filter	
	P <sub>1</sub>	P1	Kussner State ( NT )	Feet/Sec
	P <sub>2</sub>	P2	Transport Delay State ( W )	Feet/Sec
	P <sub>3</sub>	P3	Transport Delay State ( T )	Feet/Sec
	P <sub>4</sub>	P4	Transport Delay State ( T )	
	P <sub>5</sub>	P5	Kussner State ( W )	
	P <sub>6</sub>	P6	Wind Filter State	
	w <sub>g</sub>	WG	Wind Gust State	
	w	W	Velocity Along Z Axis	Inch/Sec
	$\eta_1$	UE1	Bending Mode Displacement	Inch
	$\delta_a$	XA	Aileron Deflection	Radian
	$\delta_{ei}$	XEI	Inboard Elevator Deflection	Radian
	$\delta_{eo}$	XEO	Outboard Elevator Deflection	Radian
	$\dot{\eta}_1$	UE1DOT	Bending Mode Rate	Inch/Sec
	$\dot{\eta}_2$	UE2DOT	Bending Mode Rate	Inch/Sec
	$\dot{\eta}_3$	UE3DOT	Bending Mode Rate	Inch/Sec
	n <sub>a3</sub>	AZRB	Normal Accelerometer Backspar	1G
$\dot{\eta}_4$	UE4DOT	Bending Mode Rate	Inch/Sec	
$\dot{\eta}_5$	UE5DOT	Bending Mode Rate	Inch/Sec	



Table 23. Response Specifications for the Overall System Residual Elastic Design Model (Concluded)

Specification	Variable	Description	Units
Sensor Output (continued)	$\dot{\eta}_6$	Bending Mode Rate	Inch/Sec
	$n_{a1}$	Normal Accelerometer	1G
	$q_s$	Pitch Rate Gyro	Radian/Sec
	$\eta_2$	Bending Mode Displacement	Inch
	$\eta_4$	Bending Mode Displacement	Inch
	$\eta_6$	Bending Mode Displacement	Inch
	A21RL	Lagged Normal Acceleration	1G
	MLC1	Full State MLC for Aileron	
	GLAF	Gust Load Alleviation Filter	
	Control Input	$u_{c1}$	Aileron Optimal Control Input
$u_{c2}$		Inboard Elev Optimal Control Inp	
Gust Input	$\eta_g$	White Noise Input to Gust Model	Feet/Sec
	$\eta_p$	White Noise Input to Pilot Flite	



The gain variations required to produce the reduced optimal feedback gains are shown in Figure 43 and 44 of Reference 4.

## The Tuning of Reduced Optimal Feedback Gains for Steady State Requirements--

The gain  $K_2^p$  is adjusted to meet the steady state requirements in the elevator loop (Reference 4).

## Performance Evaluation

The time response and covariance response of the final closed loop system are obtained using the DIAK subprogram. Figures 66 through 74 demonstrate that the ALDCS load relief and the handling quality design goals are satisfied. The resulting eigenvalues for the free, SAS and ALDCS aircrafts are shown in Figure 66. Figures 67 through 69 present the angle of attack ( $\alpha$ ) time responses due to a pilot elevator command. For the free, SAS and ALDCS aircrafts, Figures 70 through 72 present the pitch rate ( $q$ ) time response. Figures 73 and 74 present a tabular listing of the steady state values of response variables due to a 1-g incremental maneuver and of the covariance results due to  $\eta_g$  and  $\eta_p$ .

## DECK SET-UP

Figure 75 shows the simulator deck data which are calculated by the FLEXSTAB/LSA program. Using this data, the plant design model is obtained. The precompiler data needed for this step are shown in Figure 76, and the corresponding KOMPACT-1 input data are shown in Figure 77. In the second step, the reduced order plants (F24RR, F24RT and F24TT) are obtained. The precompiler data for this step are shown in Figure 78, and the corresponding KOMPACT-1 input data are shown in Figure 79. In the third step, the

reduced order plant is combined with the reduced ALDCS controller to obtain the overall system. The precompiler data and KONPACT-1 input data for this step are shown in Figures 80 and 81. In the fourth step, the overall system design model is obtained. The precompiler data and KONPACT-1 input data for this step are shown in Figures 82 and 83. The KONPACT-2 input data required to obtain optimal state feedback gains (using the DIAK subprogram) are shown in Figure 84.

The KONPACT-2 input data required to compute the feedback gains only on specified measurements (using the FFOC subprogram) are shown in Figure 85. The KONPACT-2 input data required to obtain time response (using the DIAK subprogram) of the closed loop system are shown in Figure 86. The KONPACT-2 input data required to obtain covariance response (using the DIAK subprogram) of the closed loop system are shown in Figure 87. The KONPACT-2 input data to prepare frequency domain data for the LSA program are shown in Figure 88, and the corresponding data for the LSA program to evaluate power spectral density are shown in Figure 89.

## OUTPUT DESCRIPTION

KONPACT-1 output data are shown in Figures 90 and 91. The C-5A vehicle quadruple data along with the name list data are given in Figure 90. This system 1 quadruple data is the state space representation of the unaugmented FLEXSTAB, residual elastic math model of Figure 75 and represents the output resulting from the KONPACT-1 input data deck shown in Figure 77. The system ALDCS overall design model is shown in Figure 91 and represents the output from the KONPACT-1 input data deck of Figure 83;

the model contains the F24RR model, control surface actuator dynamics, the gust model dynamics, and the ALDCS controller. This model is used in DIAK and FFOC to produce the reduced controller gains. The KONPACT-2 output data are summarized more fully in the next section.

## DISCUSSION OF RESULTS

The optimal reduced feedback gains for the ALDCS design are shown in Figure 65.

The eigenvalue comparison for open loop vehicle, SAS vehicle, and closed loop (reduced feedback only) vehicle are shown in Figure 66. The time response of the open loop vehicle, SAS vehicle, and closed loop (using the reduced controller of Figure 62) vehicle are shown in Figures 67, 68 and 69 for response  $\alpha$  and in Figures 70, 71 and 72 for response  $q$ . It can be seen that the handling quality requirements are met.

The covariance response due to gust load for open loop vehicle and closed loop (reduced feedback only) vehicle are shown in Figure 73. It is seen that the gust load alleviation requirements are met.

The steady state responses for 1 g maneuver for open loop vehicle and closed loop (reduced feedback only) vehicle are shown in Figure 74. It is seen that maneuver load control requirements are met.

The torsional moment (T1) design requirement for this controller is not satisfied. T1 is increased 80 percent due to this reduced controller of Figure 62. This controller was designed by a single run through the FFOC program as described in Reference 4. Due to the time and funding constraints of this study, the controller was not refined to meet this design requirement.

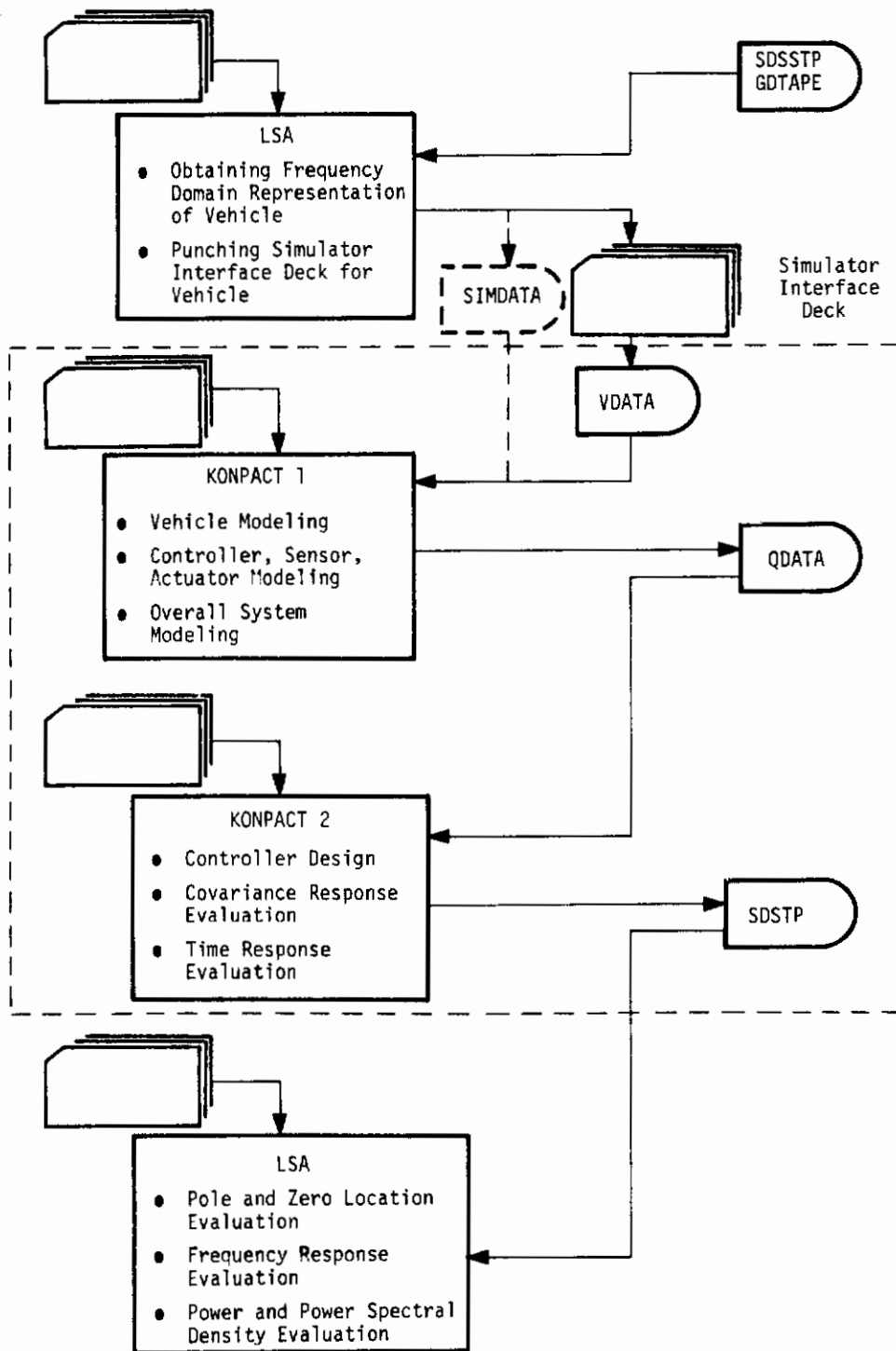


Figure 1. Interface Between LSA and KONPACT Programs

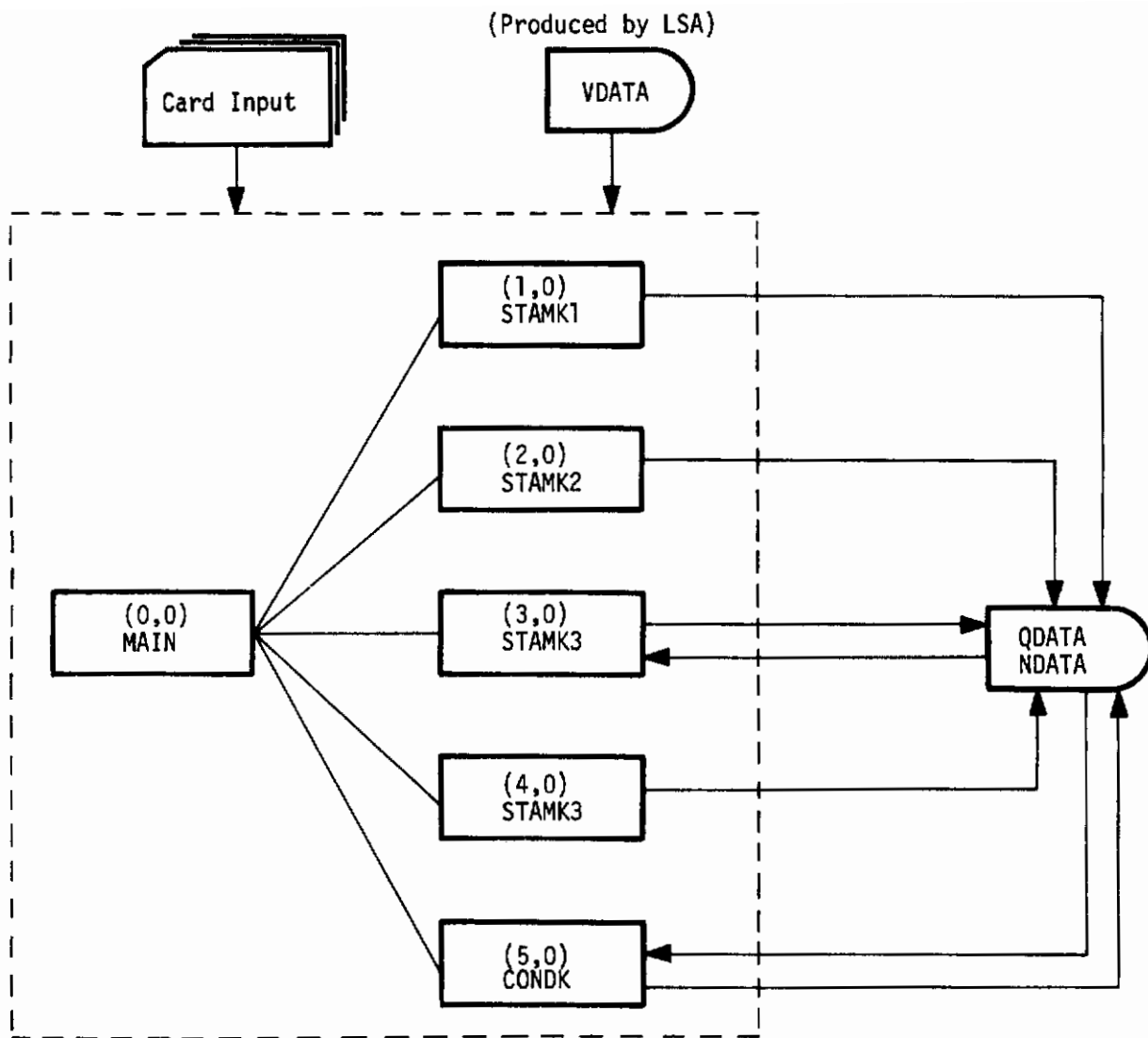


Figure 2. Overlay Structure of KONPACT-1

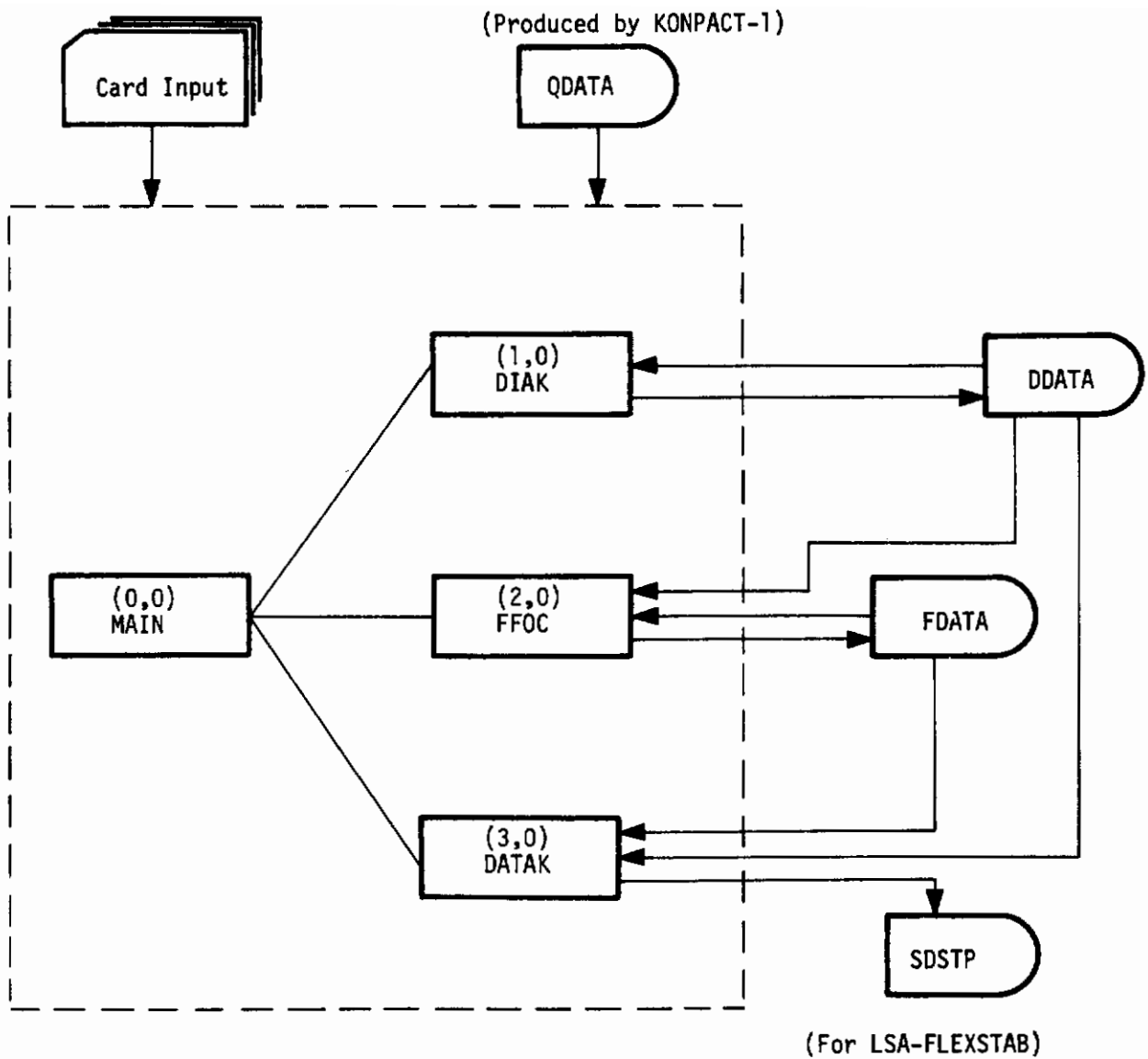


Figure 3. Overlay Structure of KONPACT-2

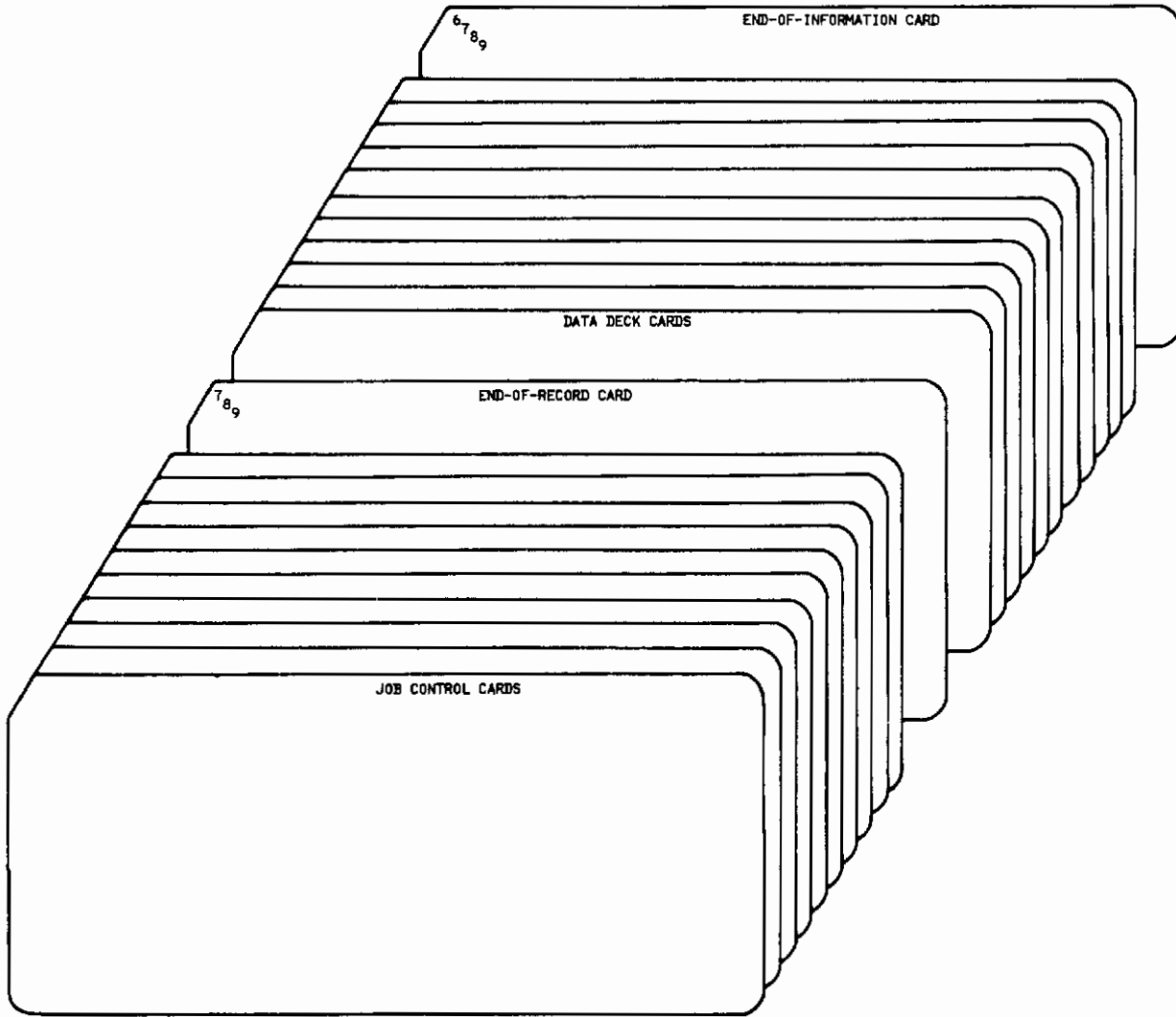


Figure 4. Typical Input Deck Structure

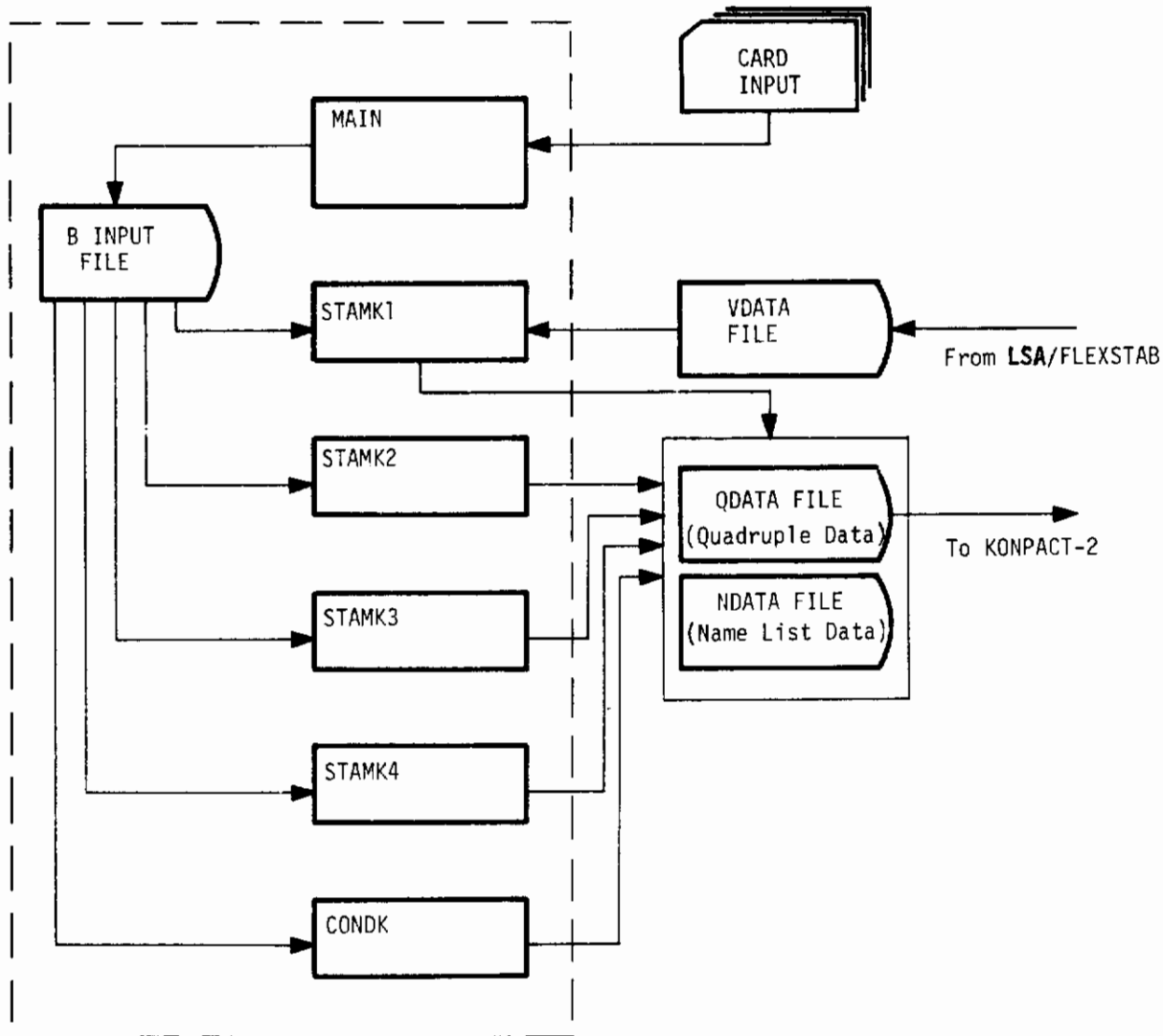


Figure 5. Data Flow in KONPACT-1



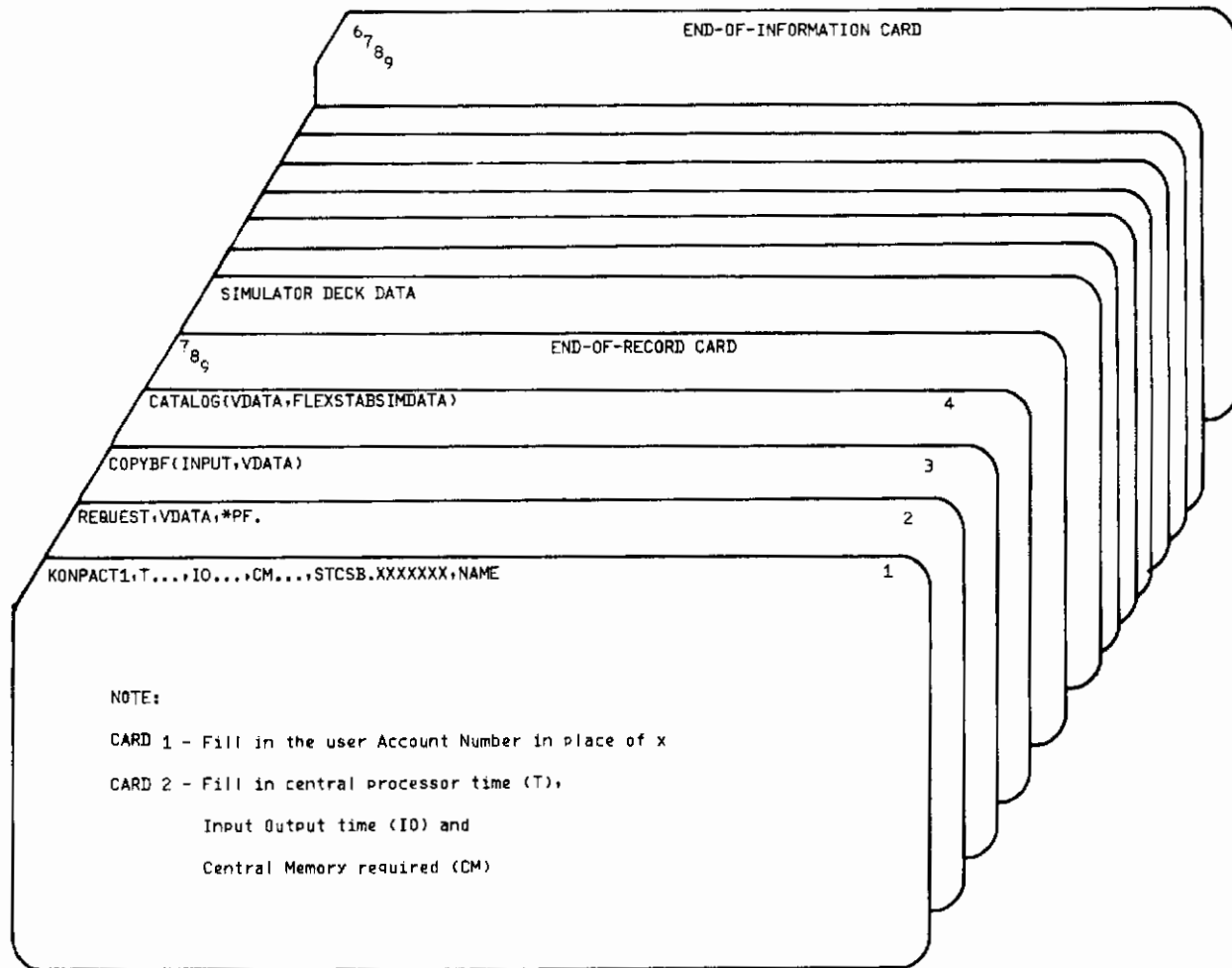


Figure 6. Control Card Arrangement to Create VDATA File

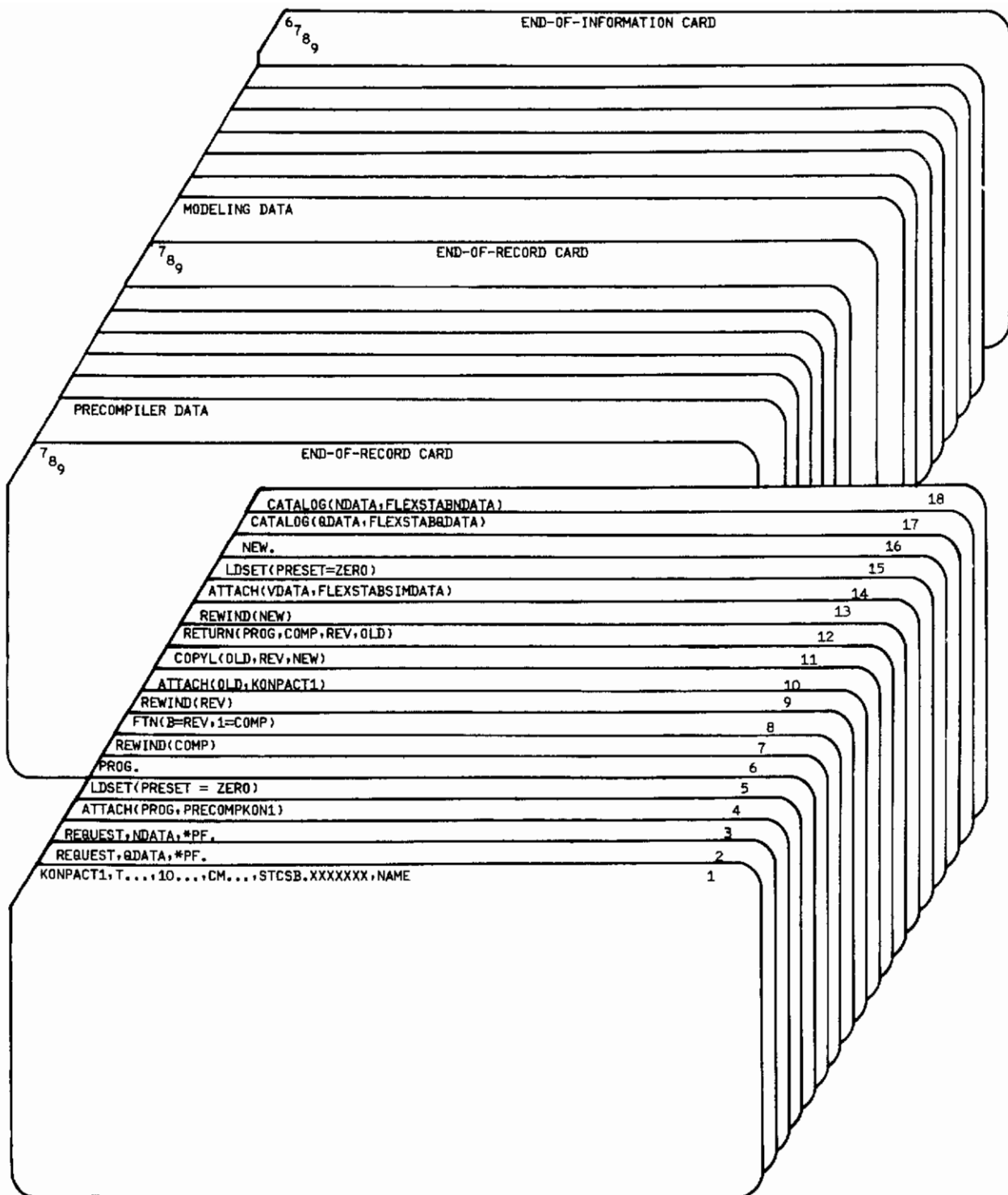


Figure 7. Control Card Arrangement to Execute KONPACT-1 and Create QDATA and NDATA Files

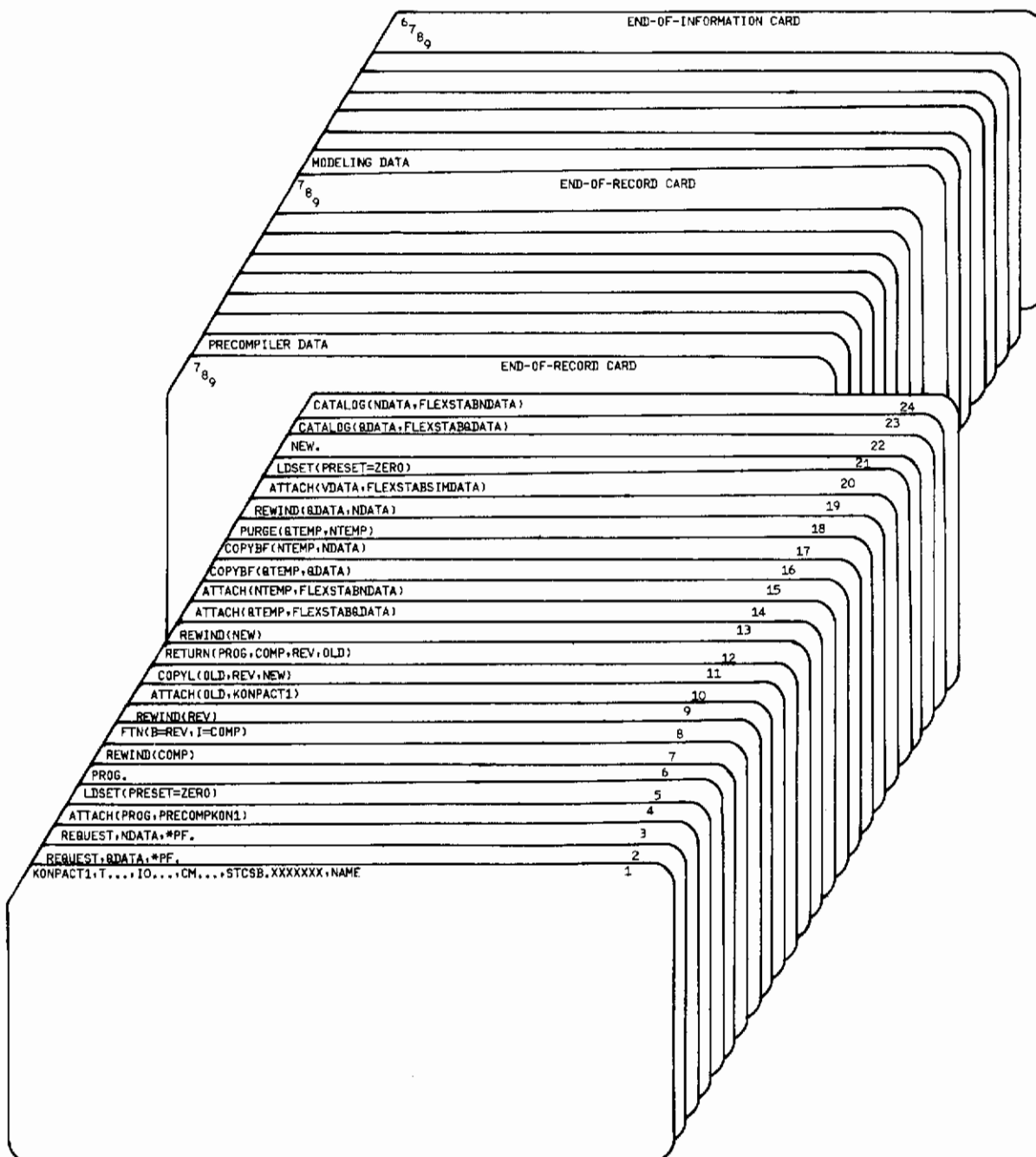


Figure 8. Control Card Arrangement to Execute KOMPACT-1 and Add New System Data on QDATA and NDATA Files

$$\{V_p\} = [u, w, q, v, p, r]^T$$

$$\{u_i\} = [u_{i1}, u_{i2}, \dots, u_{in}]^T$$

$u_{i1}$  is the  $i^{\text{th}}$  generalized elastic coordinate

$$\{r'_{op}\} = [\theta_p, \phi_p, \psi_p]^T$$

$$\{T\} = [y_1, y_2, \dots, y_{m_1}]^T$$

$\{T\}$  is the column vector of  $m_1$  sensors

$$\{L\} = [L_1, L_2, \dots, L_{m_2}]^T$$

$\{L\}$  is the column vector of  $m_2$  loads where  $\{L_i\} = [S_i, B_i, T_i]^T$  and where  $\{L_i\}$  is the column vector of shear, bending and torsion at the  $i^{\text{th}}$  station

$\{\delta_s\}$  is the column vector of control surface inputs

$\{u'_g\}, \{v'_g\}$  and  $\{w'_g\}$  column vectors of banded gust inputs

$\{u'_{gs}\}, \{v'_{gs}\}$  and  $\{w'_{gs}\}$  column vectors of the steady distribution of banded gust inputs

Figure 9. FLEXSTAB/LSA Equations for Simulator Deck Data

$$\begin{aligned}
 \{\dot{v}_p\} &= [\text{VP/VPO}] \{v_p\} + [\text{VP/VPI}]^* \{\dot{v}_p\} + [\text{VP/UEO}] \{u_1\} + [\text{VP/UE1}] \{\dot{u}_1\} + [\text{VP/UE2}] \{\ddot{u}_1\} \\
 &+ [\text{VP/UGO}] \{u'_g\} + [\text{VP/UGI}]^* \{\dot{u}'_g\} + [\text{VP/UGSO}] \{u'_{gs}\} + [\text{VP/UGSI}]^* \{\dot{u}'_{gs}\} \\
 &+ [\text{VP/VGO}] \{v'_g\} + [\text{VP/VGI}]^* \{\dot{v}'_g\} + [\text{VP/VGSO}] \{v'_{gs}\} + [\text{VP/VGSI}]^* \{\dot{v}'_{gs}\} \\
 &+ [\text{VP/WGO}] \{w'_g\} + [\text{VP/WGI}] \{\dot{w}'_g\} + [\text{VP/WGSO}] \{w'_{gs}\} + [\text{VP/WGSI}] \{\dot{w}'_{gs}\} \\
 &+ [\text{VP/DELISO}] \{\delta_s\} + [\text{VP/DELSI}] \{\dot{\delta}_s\} + [\text{VP/DELS2}]^* \{\ddot{\delta}_s\} + [\text{VP/RO}] \{r'_{op}\} + [\text{VP/RI}] \{r'_{op}\} \\
 \{\ddot{u}_1\} &= [\text{UE/VPO}] \{v_p\} + [\text{UE/VPI}] \{\dot{v}_p\} + [\text{UE/UEO}] \{u_1\} + [\text{UE/UE1}] \{\dot{u}_1\} + [\text{UE/UE2}]^* \{\ddot{u}_1\} \\
 &+ [\text{UE/UGO}] \{u'_g\} + [\text{UE/UGI}] \{\dot{u}'_g\} + [\text{UE/UGSO}] \{u'_{gs}\} + [\text{UE/UGSI}]^* \{\dot{u}'_{gs}\} \\
 &+ [\text{UE/VGO}] \{v'_g\} + [\text{UE/VGI}] \{\dot{v}'_g\} + [\text{UE/VGSO}] \{v'_{gs}\} + [\text{UE/VGSI}]^* \{\dot{v}'_{gs}\} \\
 &+ [\text{UE/WGO}] \{w'_g\} + [\text{UE/WGI}] \{\dot{w}'_g\} + [\text{UE/WGSO}] \{w'_{gs}\} + [\text{UE/WGSI}]^* \{\dot{w}'_{gs}\} \\
 &+ [\text{UE/DELISO}] \{\delta_s\} + [\text{UE/DELSI}] \{\dot{\delta}_s\} + [\text{UE/DELS2}]^* \{\ddot{\delta}_s\} \\
 \{r'_{op}\} &= [\text{R/VPO}] \{v_p\} + [\text{R/VPI}]^* \{\dot{v}_p\} + [\text{R/RO}] \{r'_{op}\} + [\text{R/RI}]^* \{\dot{r}'_{op}\}
 \end{aligned}$$

Figure 9. FLEXSTAB/LSA Equations for Simulator Deck Data (Continued)

$$\begin{aligned}
 \{T\} &= [T/VPO] \{V_p\} + [T/VP1] \{\dot{V}_p\} + [T/UEO] \{u_1\} + [T/UE1] \{\dot{u}_1\} + [T/UE2] \{\ddot{u}_1\} \\
 &+ [T/UGO] \{u'_g\} + [T/UG1] \{\dot{u}'_g\} + [T/UGSO] \{u'_{gs}\} + [T/UGS1] \{\dot{u}'_{gs}\} \\
 &+ [T/VGO] \{v'_g\} + [T/VG1] \{\dot{v}'_g\} + [T/VGSO] \{v'_{gs}\} + [T/VGS1] \{\dot{v}'_{gs}\} \\
 &+ [T/WGO] \{w'_g\} + [T/WG1] \{\dot{w}'_g\} + [T/WGSO] \{w'_{gs}\} + [T/WGS1] \{\dot{w}'_{gs}\} \\
 &+ [T/DEL SO] \{\delta_s\} + [T/DELS1] \{\dot{\delta}_s\} + [T/DELS2] \{\ddot{\delta}_s\} \\
 &+ [T/RO] \{r'_{op}\} + [T/R1] \{\dot{r}'_{op}\}
 \end{aligned}$$

$$\begin{aligned}
 \{L\} &= [L/VPO] \{V_p\} + [L/VP1] \{\dot{V}_p\} + [L/UEO] \{u_1\} + [L/UE1] \{\dot{u}_1\} + [L/UE2] \{\ddot{u}_1\} \\
 &+ [L/UGO] \{u'_g\} + [L/UG1] \{\dot{u}'_g\} + [L/UGSO] \{u'_{gs}\} + [L/UGS1] \{\dot{u}'_{gs}\} \\
 &+ [L/VGO] \{v'_g\} + [L/VG1] \{\dot{v}'_g\} + [L/VGSO] \{v'_{gs}\} + [L/VGS1] \{\dot{v}'_{gs}\} \\
 &+ [L/WGO] \{w'_g\} + [L/WG1] \{\dot{w}'_g\} + [L/WGSO] \{w'_{gs}\} + [L/WGS1] \{\dot{w}'_{gs}\} \\
 &+ [L/DEL SO] \{\delta_s\} + [L/DELS1] \{\dot{\delta}_s\} + [L/DELS2] \{\ddot{\delta}_s\} \\
 &+ [L/RO] \{r'_{op}\} + [L/R1] \{\dot{r}'_{op}\}
 \end{aligned}$$

**NOTE:**

- The capital letter O should be the number zero 0.
- The coefficients with \* are not output by FLEXSTAB but are accepted by KONPACT
- The coefficients with \*\* are not accepted by KONPACT nor output from FLEXSTAB but are included in the equations for completeness
- The coefficients with ° are output by FLEXSTAB but are not accepted by KONPACT

Figure 9. FLEXSTAB/LSA Equations for Simulator Deck Data (Concluded)

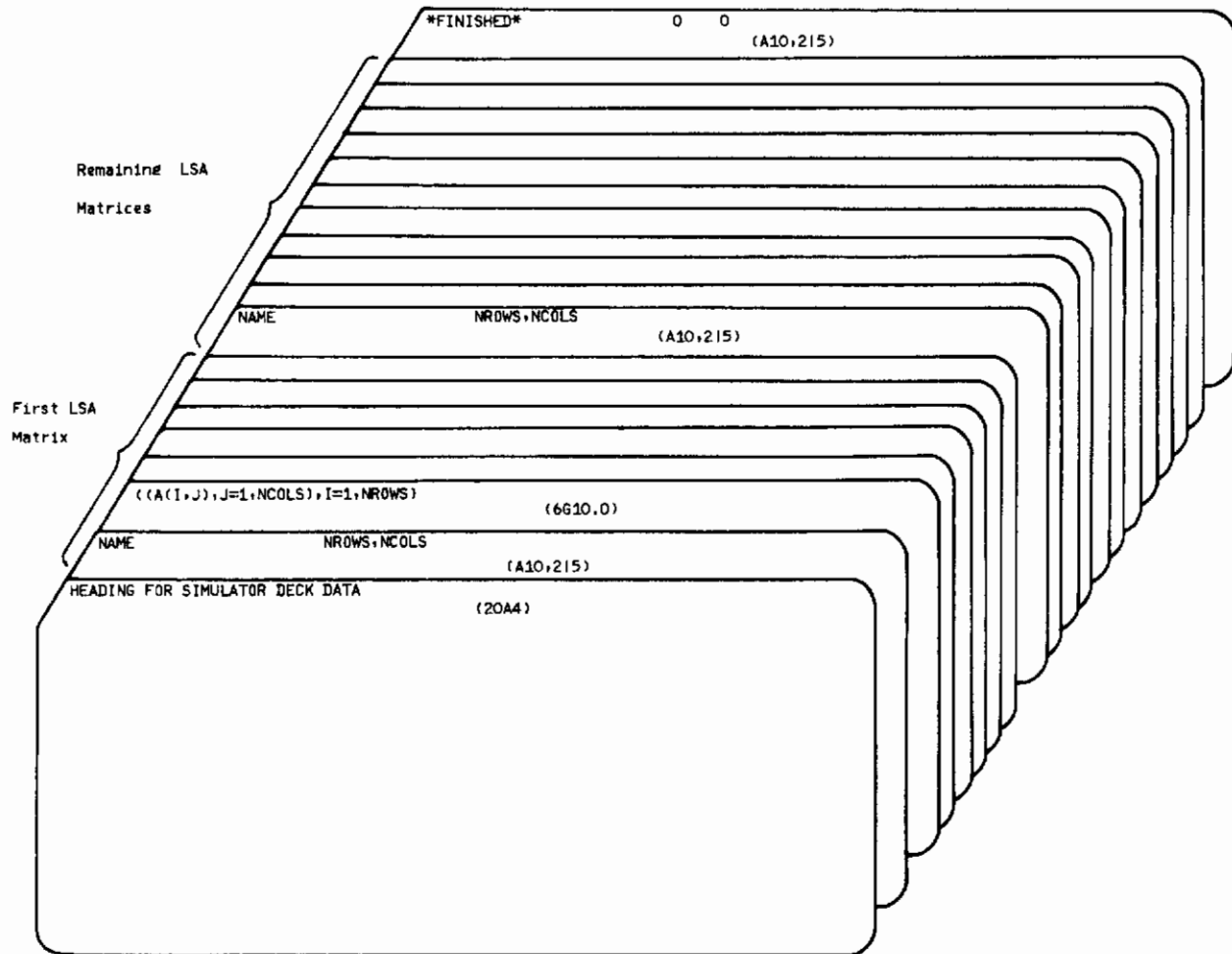


Figure 10. FLEXSTAB/LSA Simulator Deck Data Card Arrangement

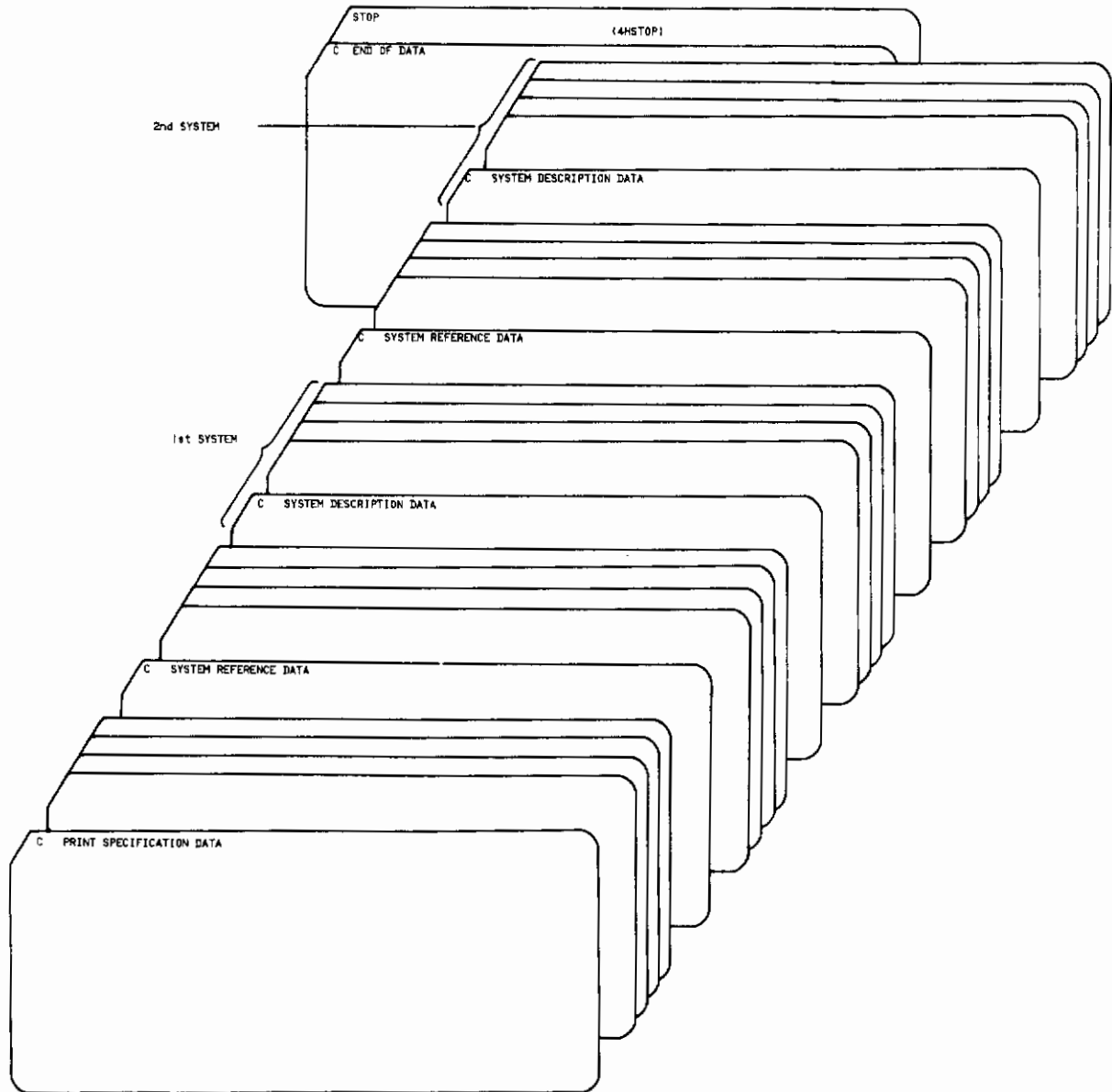


Figure 11. KONPACT-1 Modeling Data System Arrangement



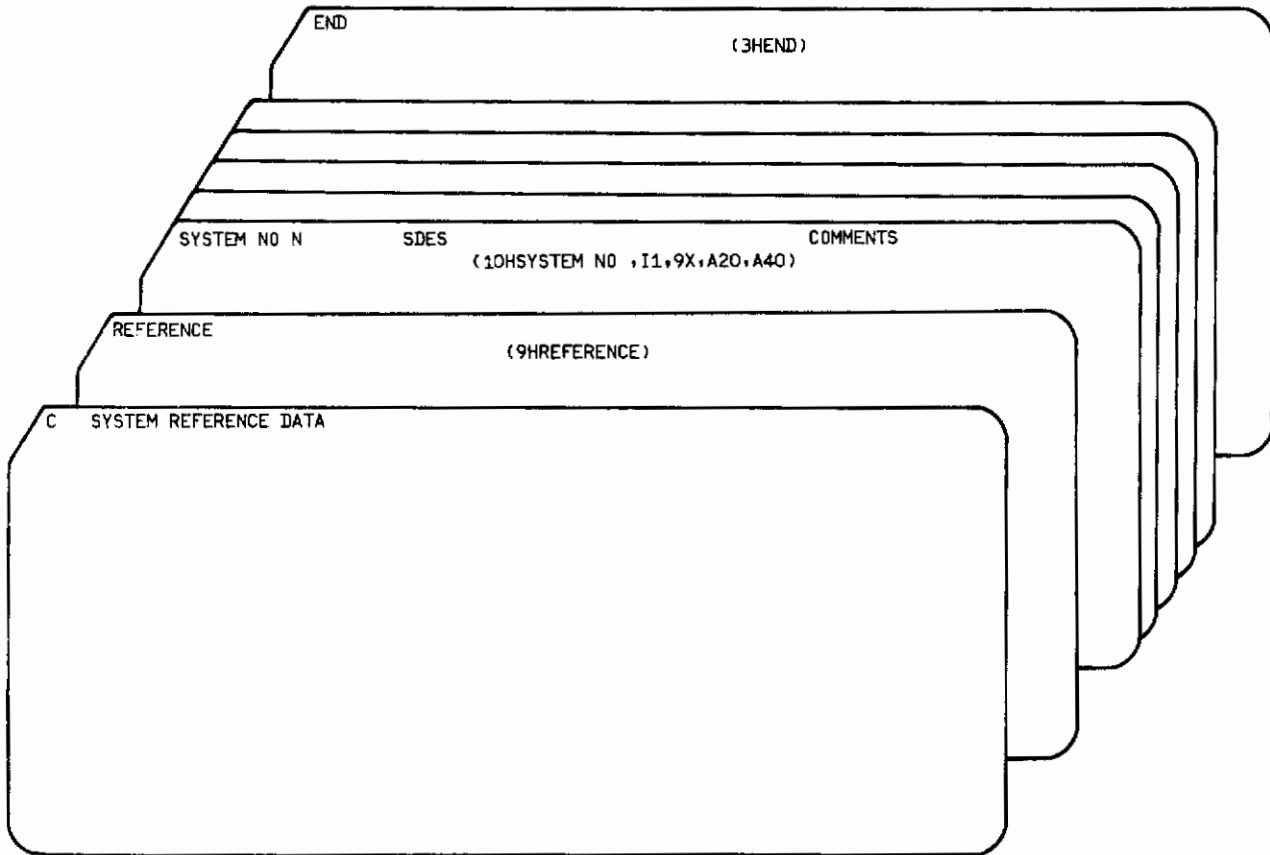


Figure 12. KONPACT-1 System Reference Control Card Arrangement

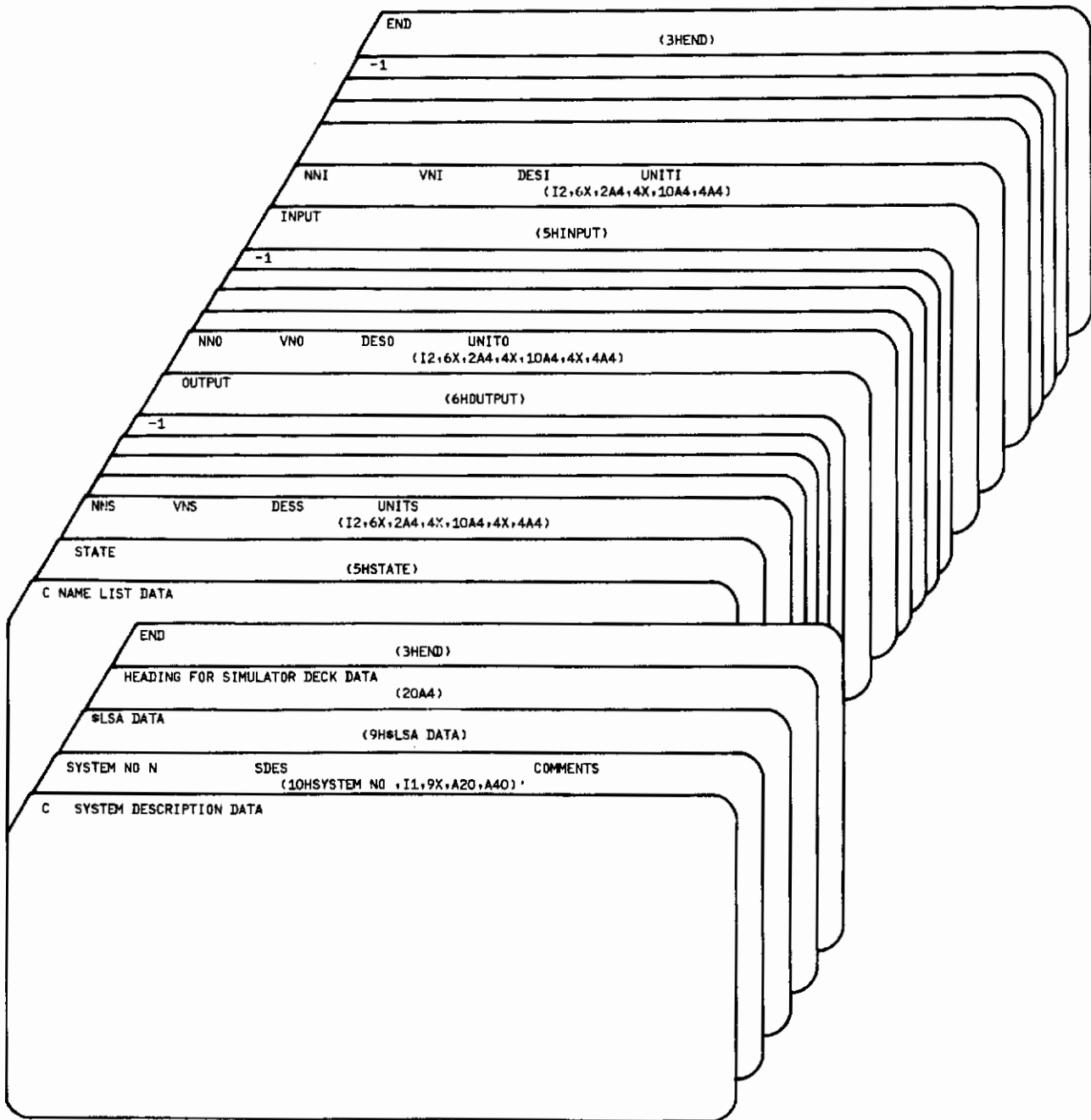


Figure 13. System Description Data (for using STAMK1) Card Arrangement

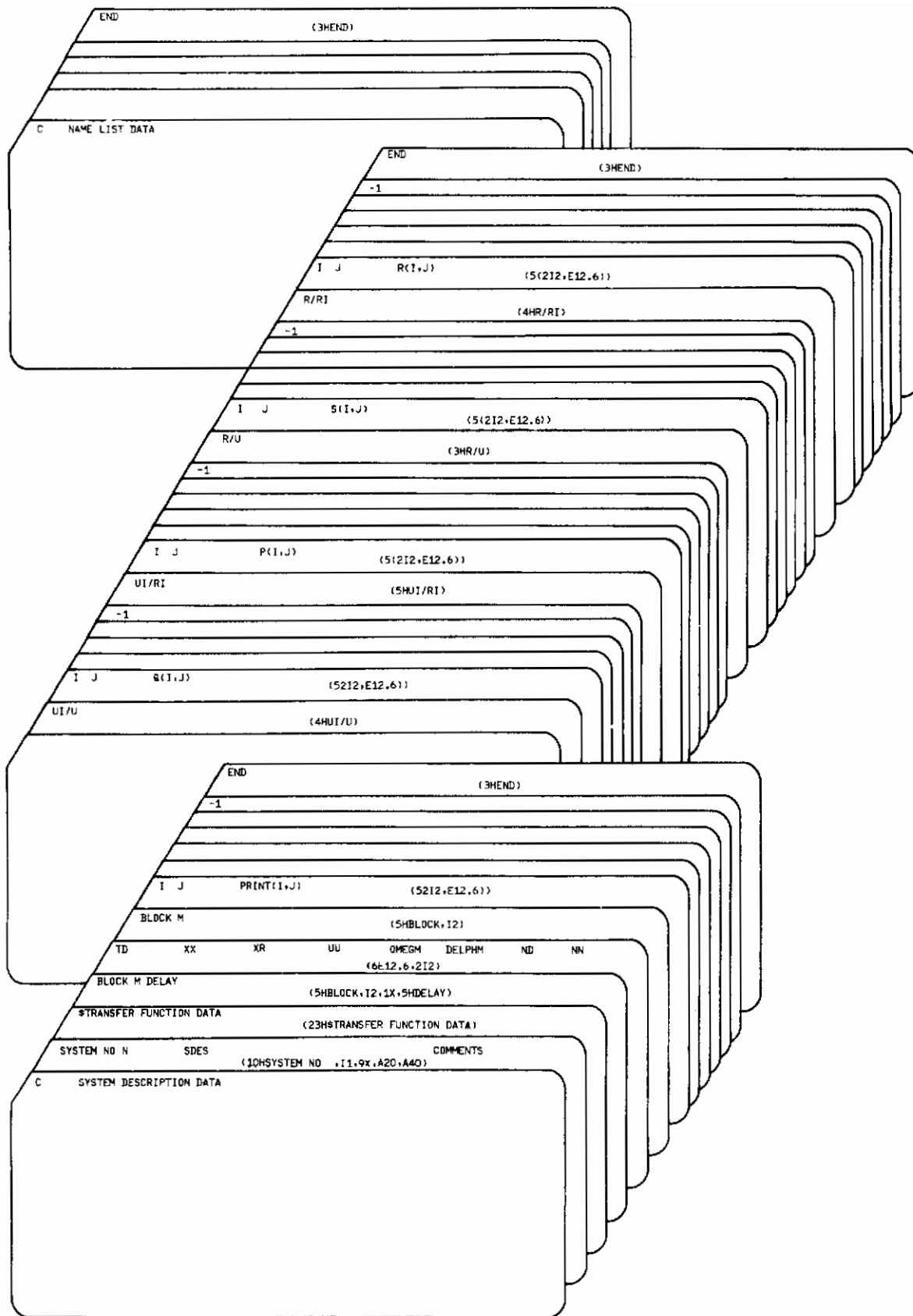


Figure 14. System Description Data (for Using STAMK2) Card Arrangement

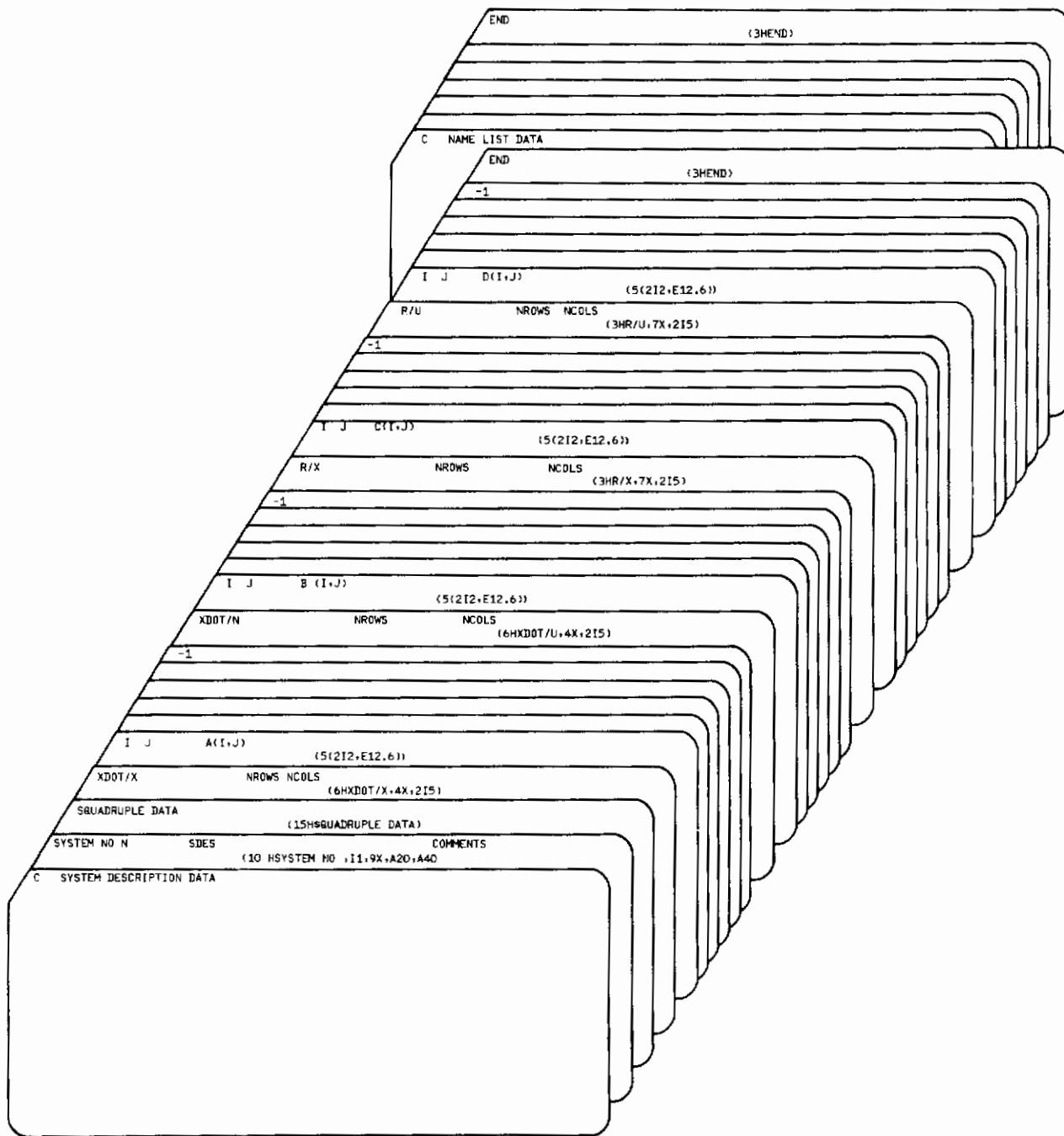


Figure 15. System Description Data (for using STAMK3 - Quadruple Data) Card Arrangement

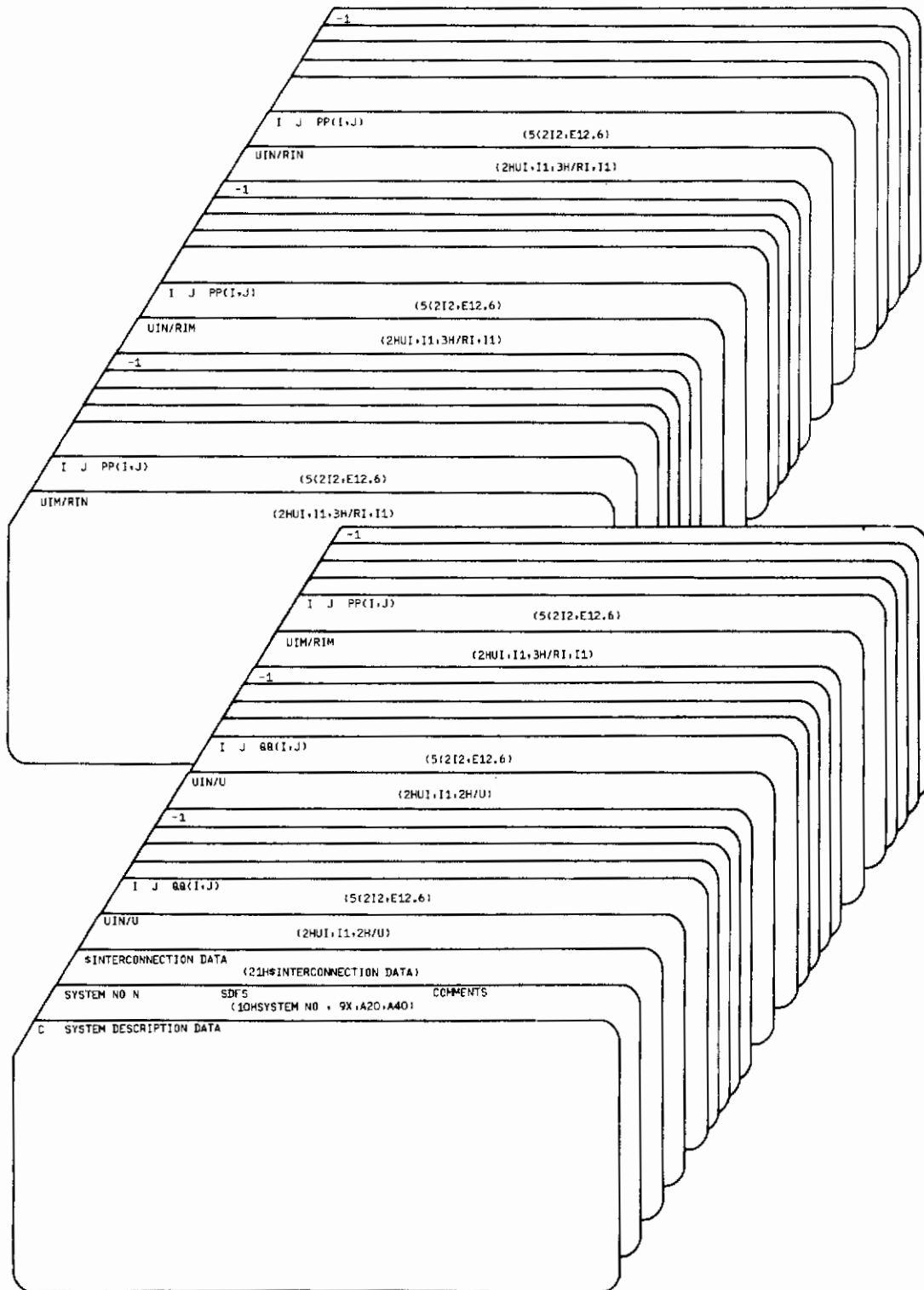


Figure 16. System Description Data (for using STAMK3 - Interconnection Data) Card Arrangement

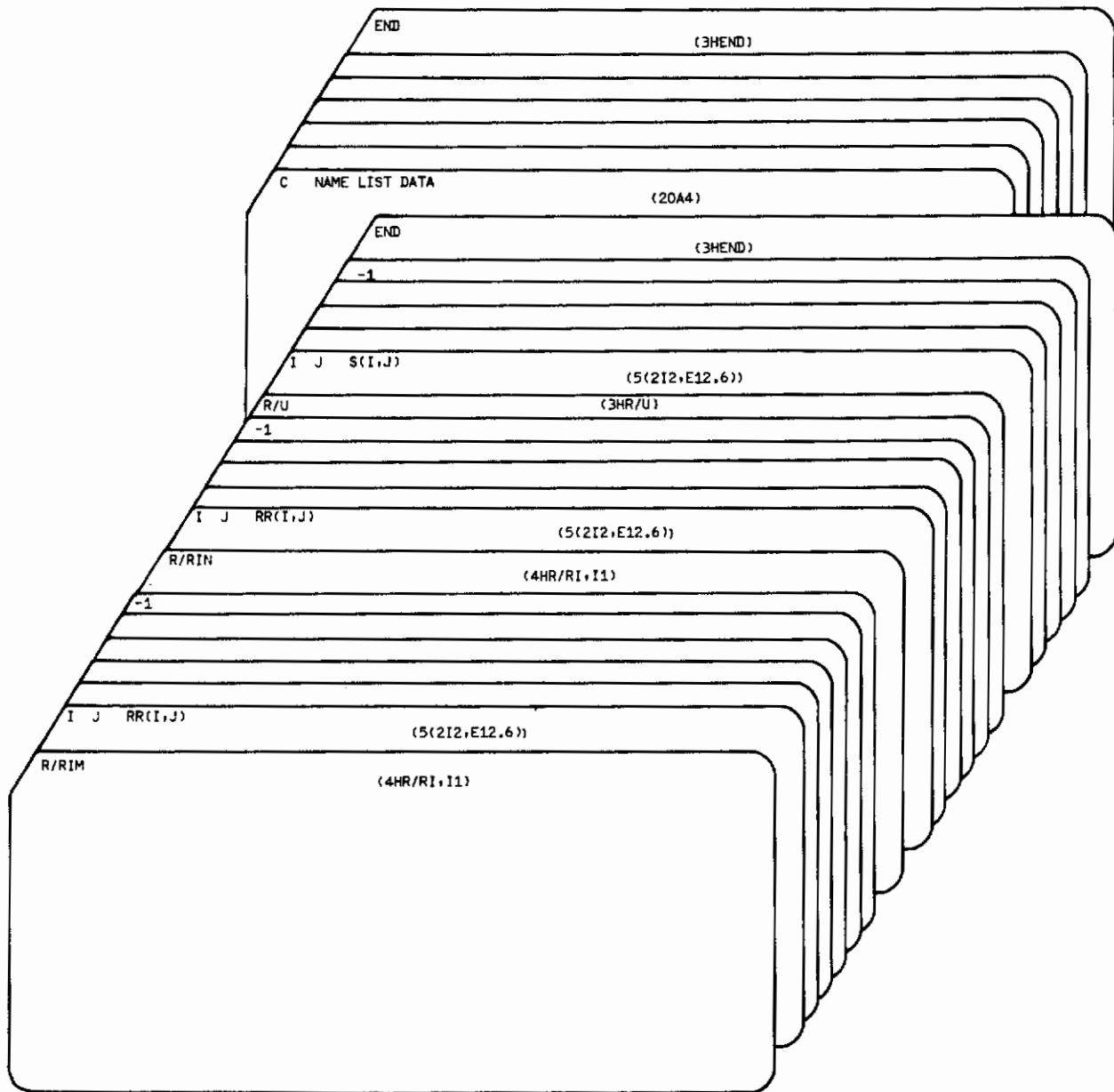


Figure 16. System Description Data (for using STAMK3 - Interconnection Data) Card Arrangement (Concluded)

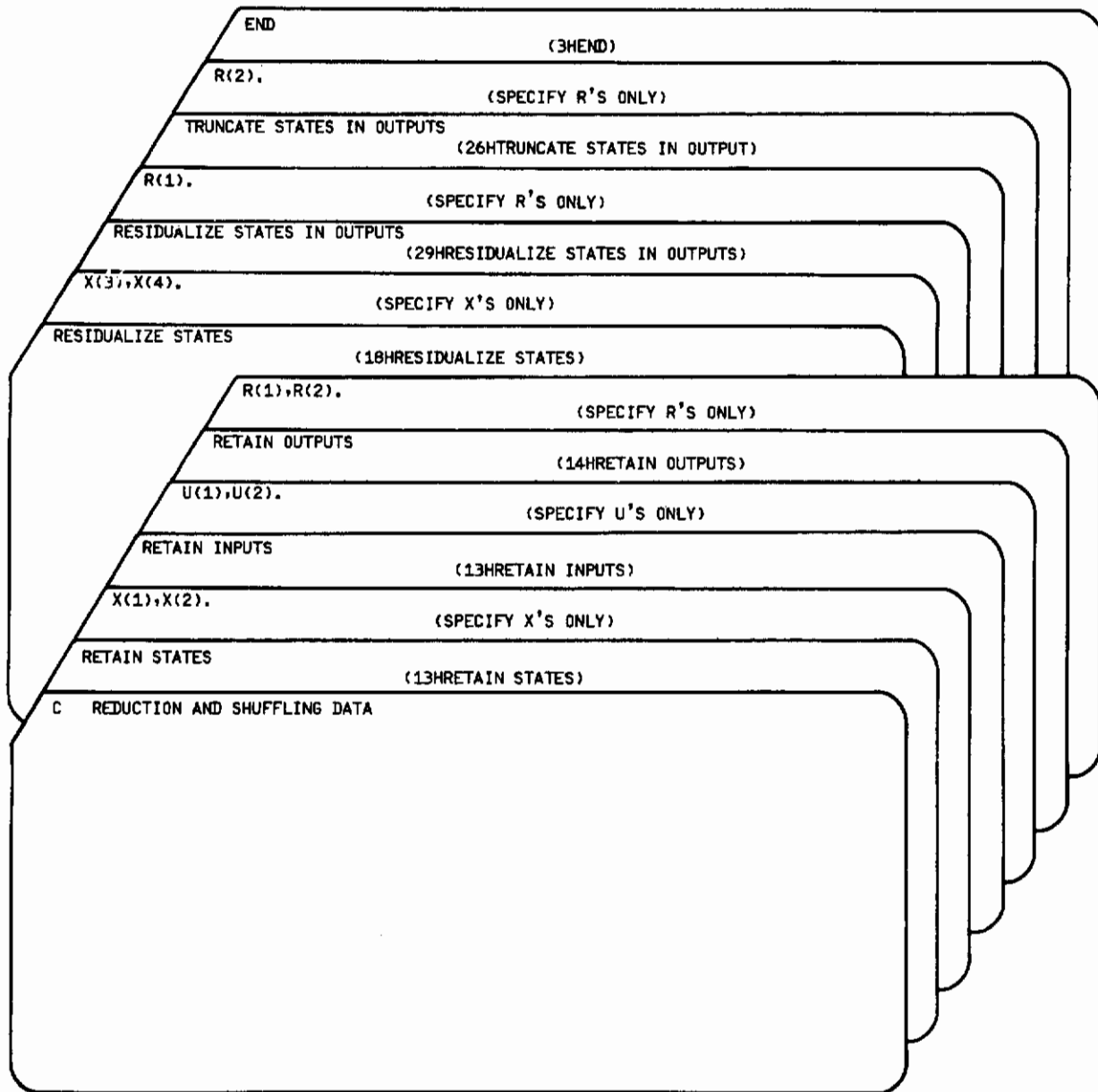


Figure 17. System Description Data (for using CONDK)  
Card Arrangement

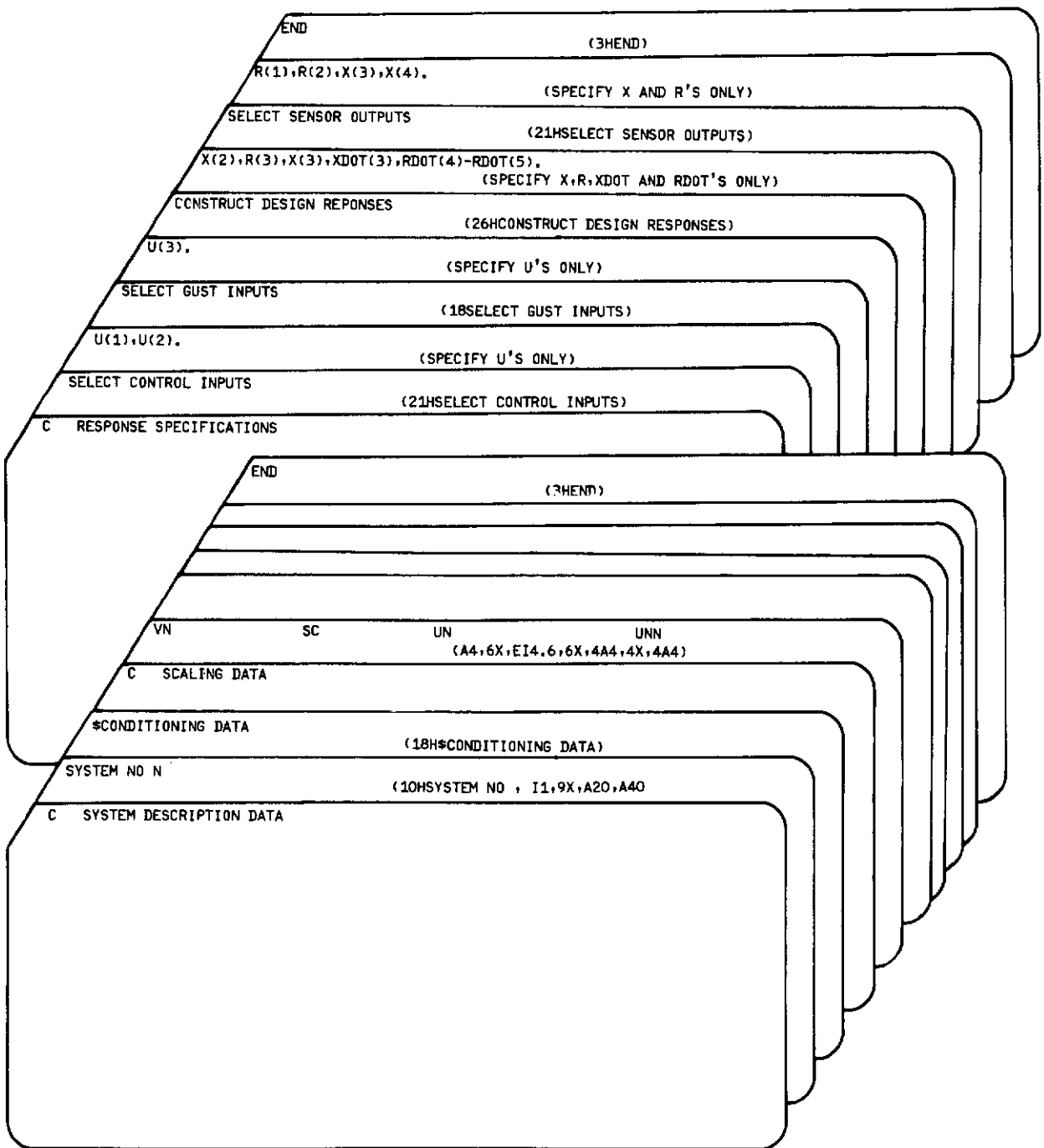


Figure 17. System Description Data (for using CONDK) Card Arrangement (Concluded)



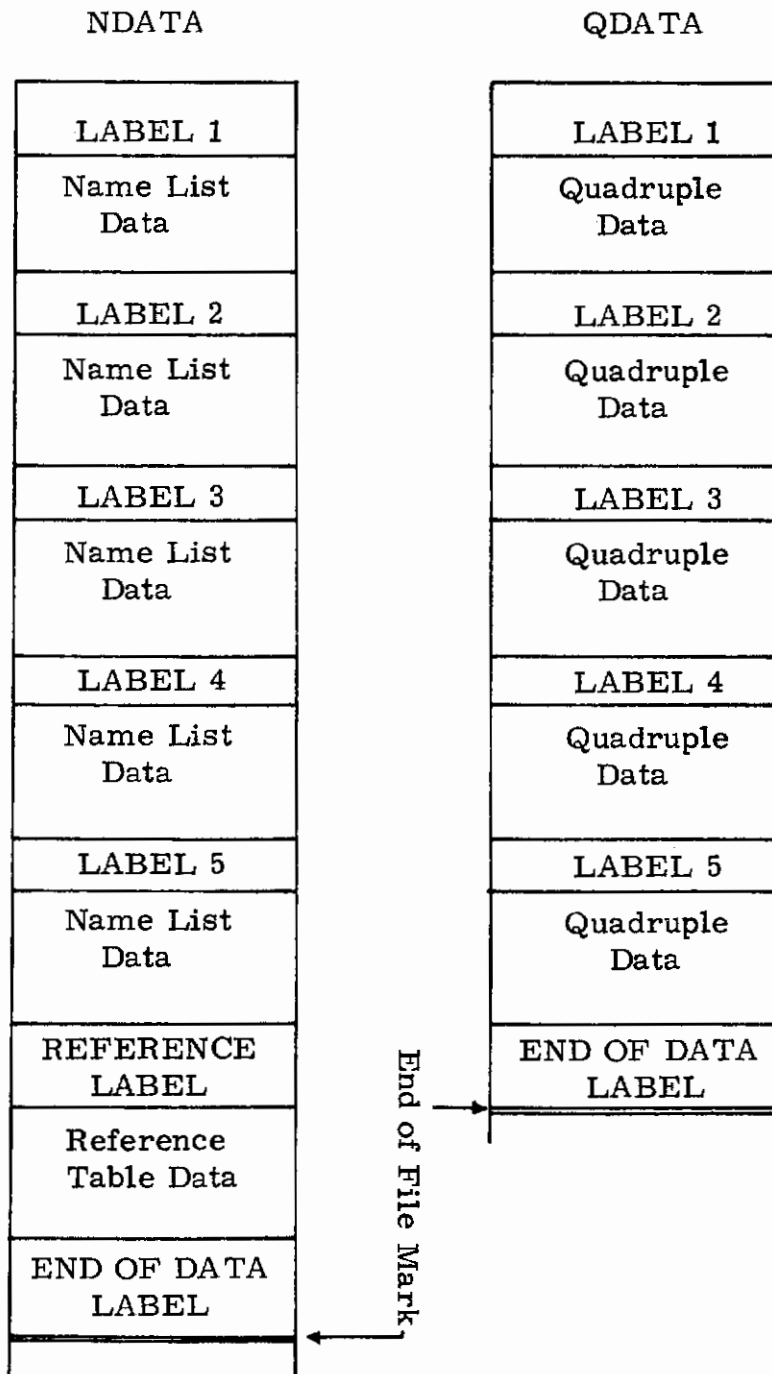


Figure 18. Data Written on Files QDATA and NDATA

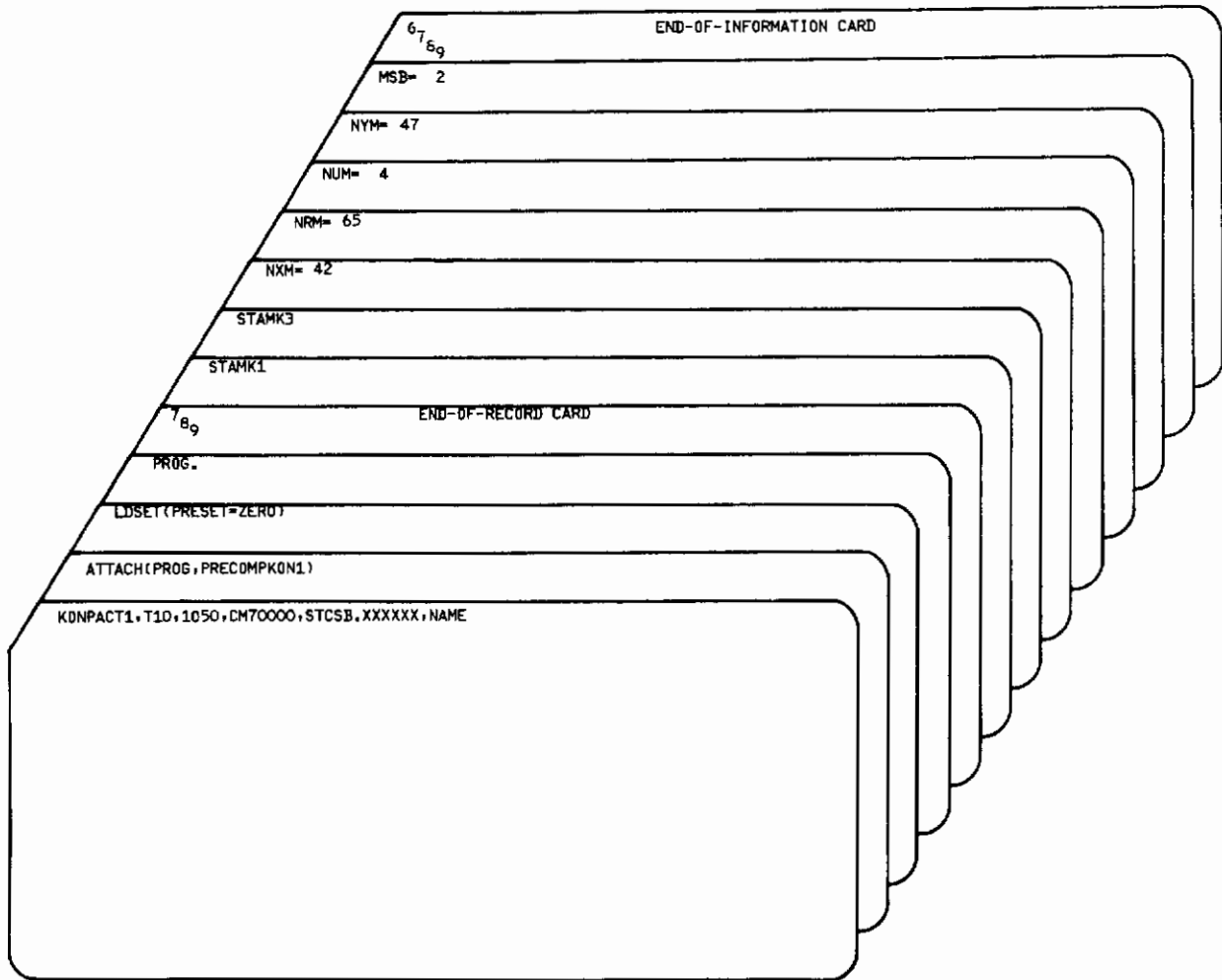


Figure 19. Precompiler Job Set-Up for Computing KOMPACT-1 Central Memory Required

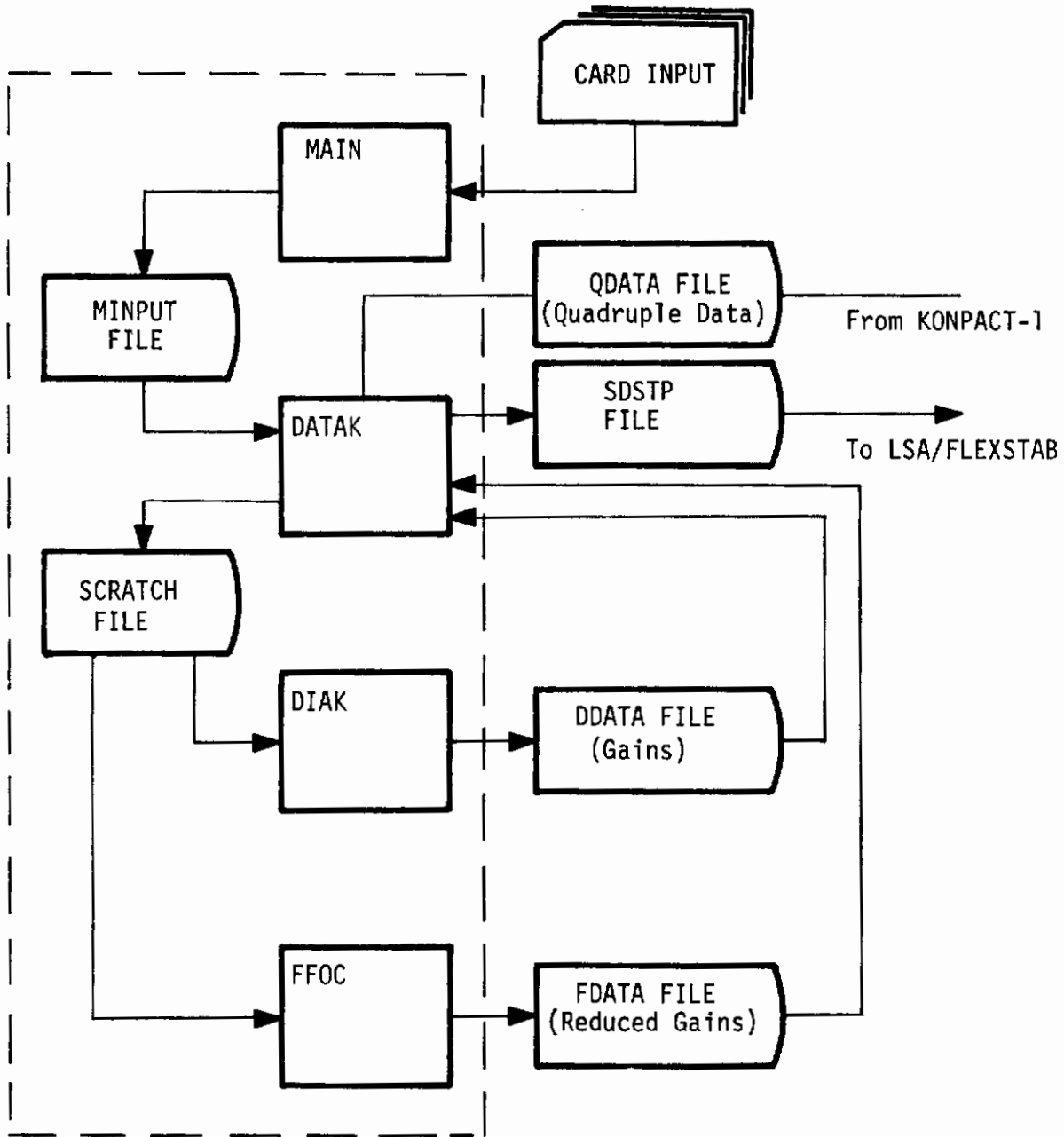


Figure 20. Data Flow in KONPACT-2

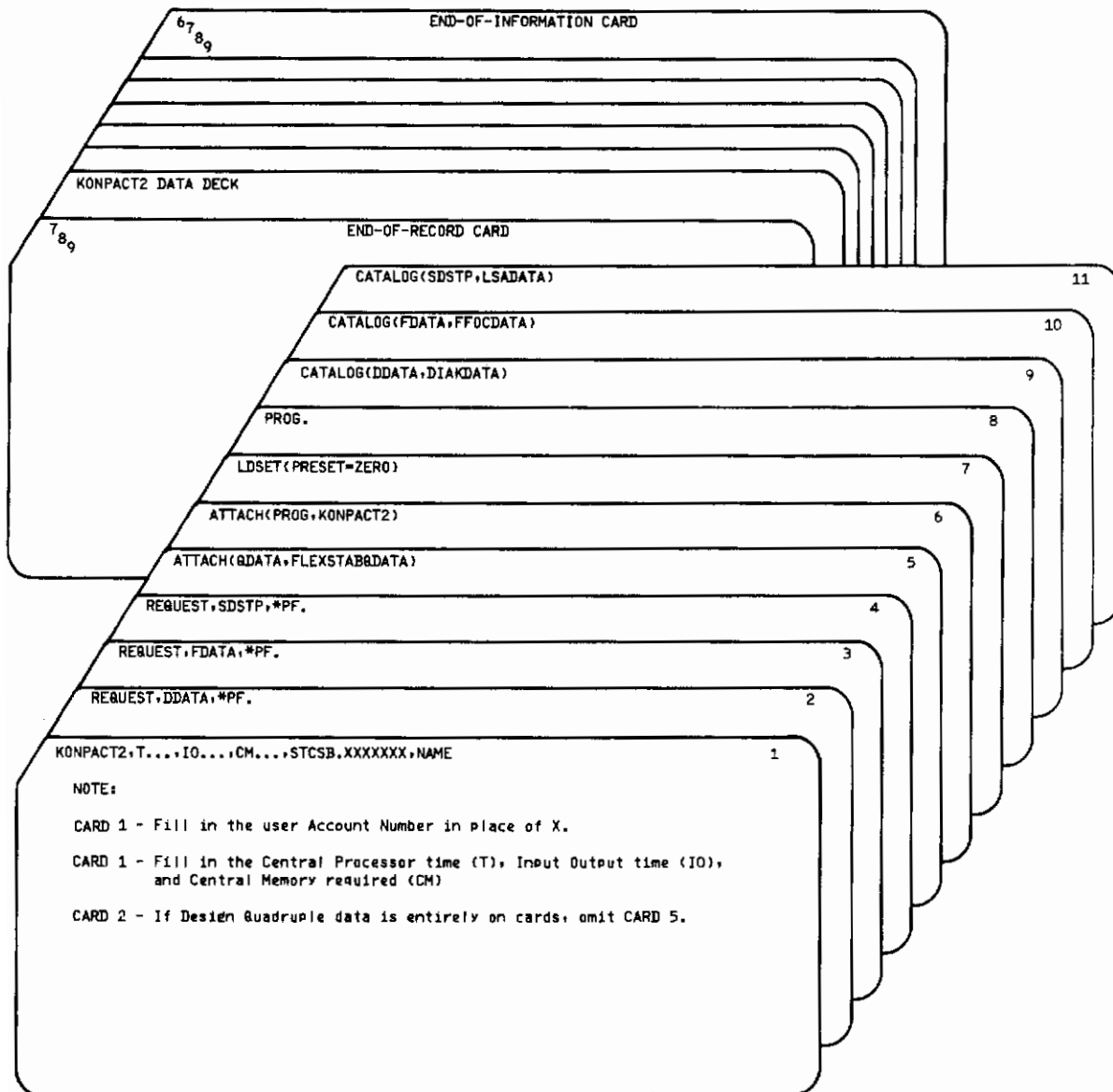


Figure 21. Control Card Arrangement to Execute KONPACT-2 Program and Create Files DDATA, FDATA and SDSTP

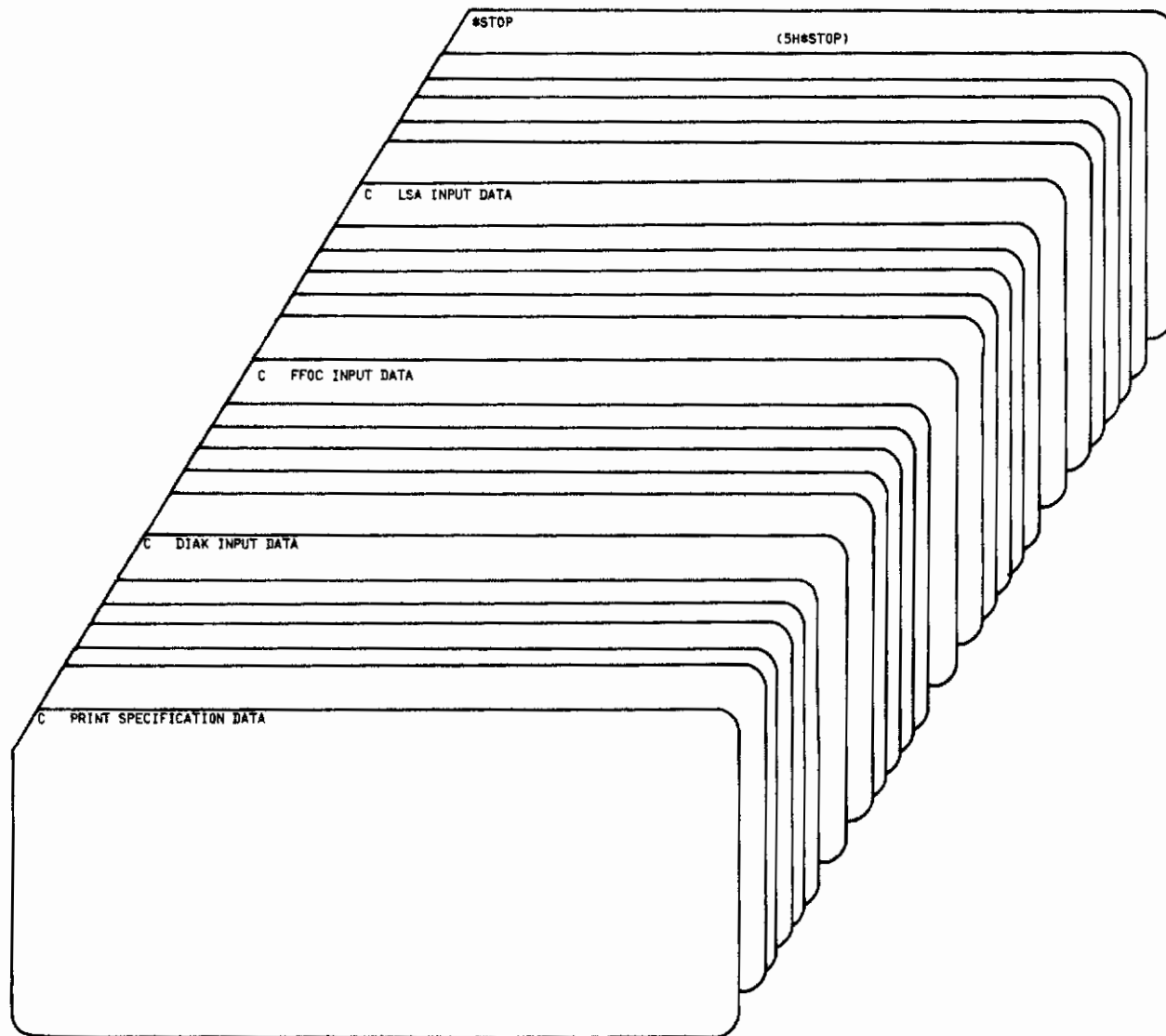


Figure 22. Typical KONPACT-2 Input Data Subprogram Execution Arrangement

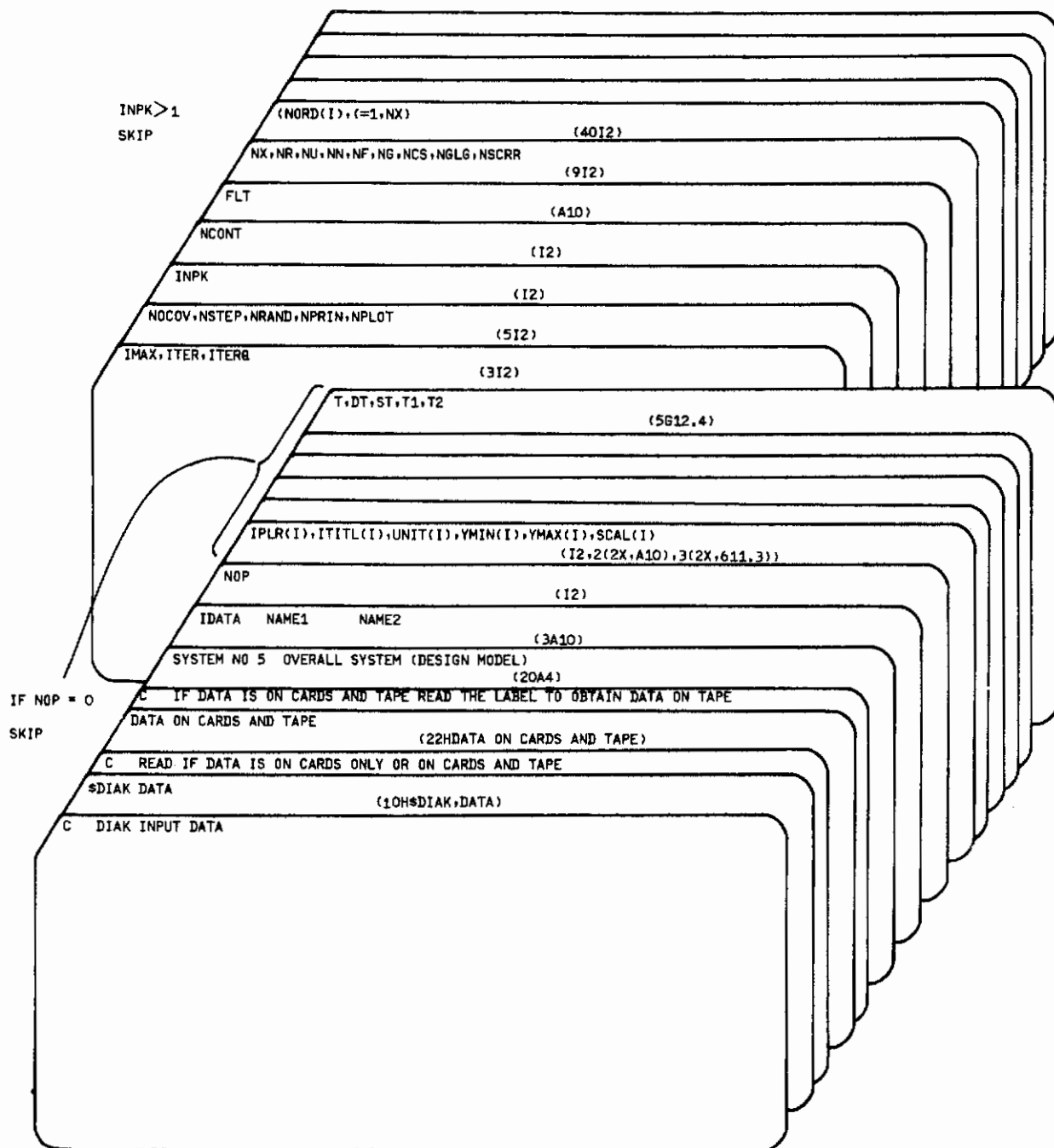


Figure 23. KONPACT-2 Input Data (for using DIAK) Card Arrangement (See Reference 2 for Variable Definitions)

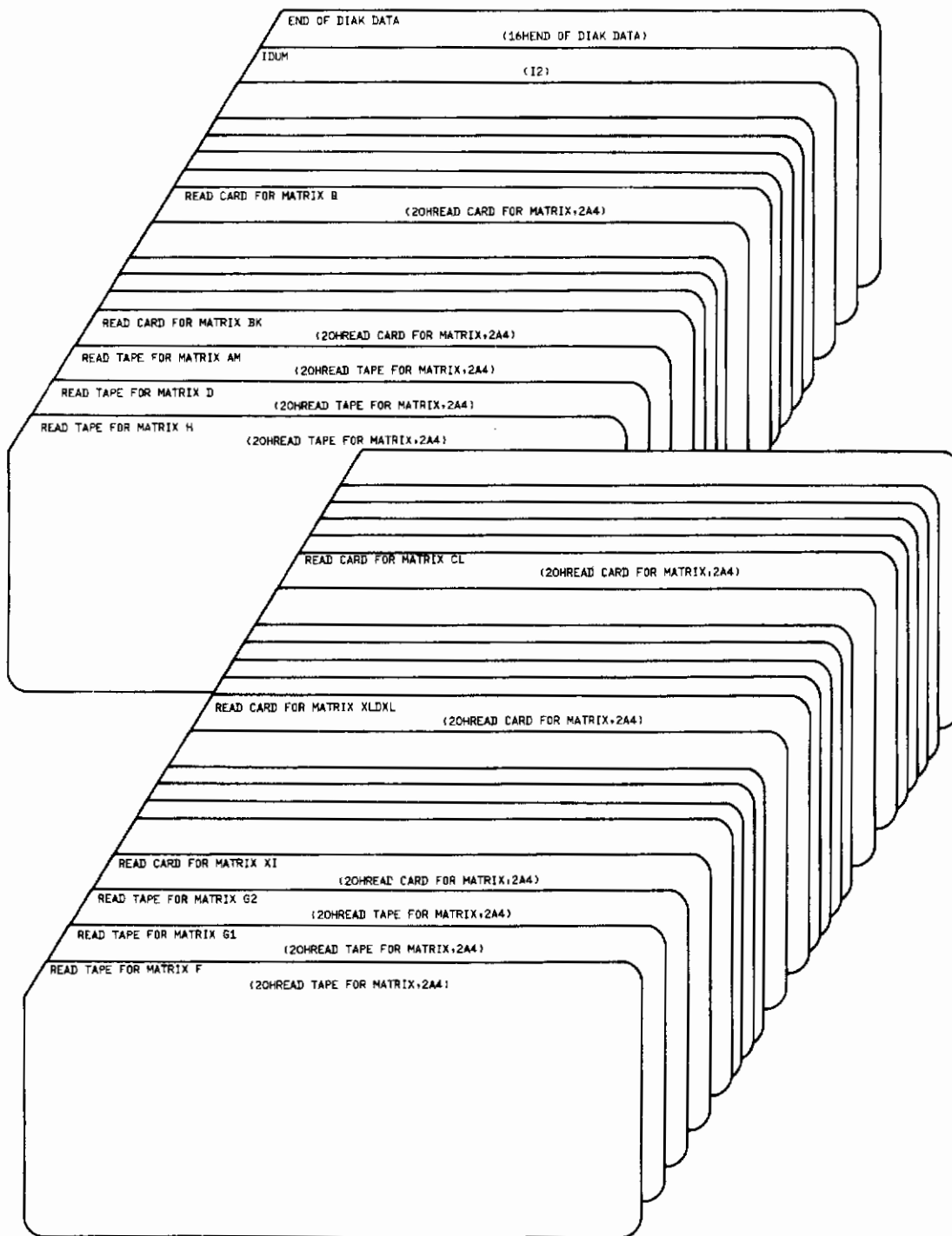


Figure 23. KONPACT-2 Input Data (for using DIAK) Card Arrangement (See Reference 2 for Variable Definitions) (Concluded)

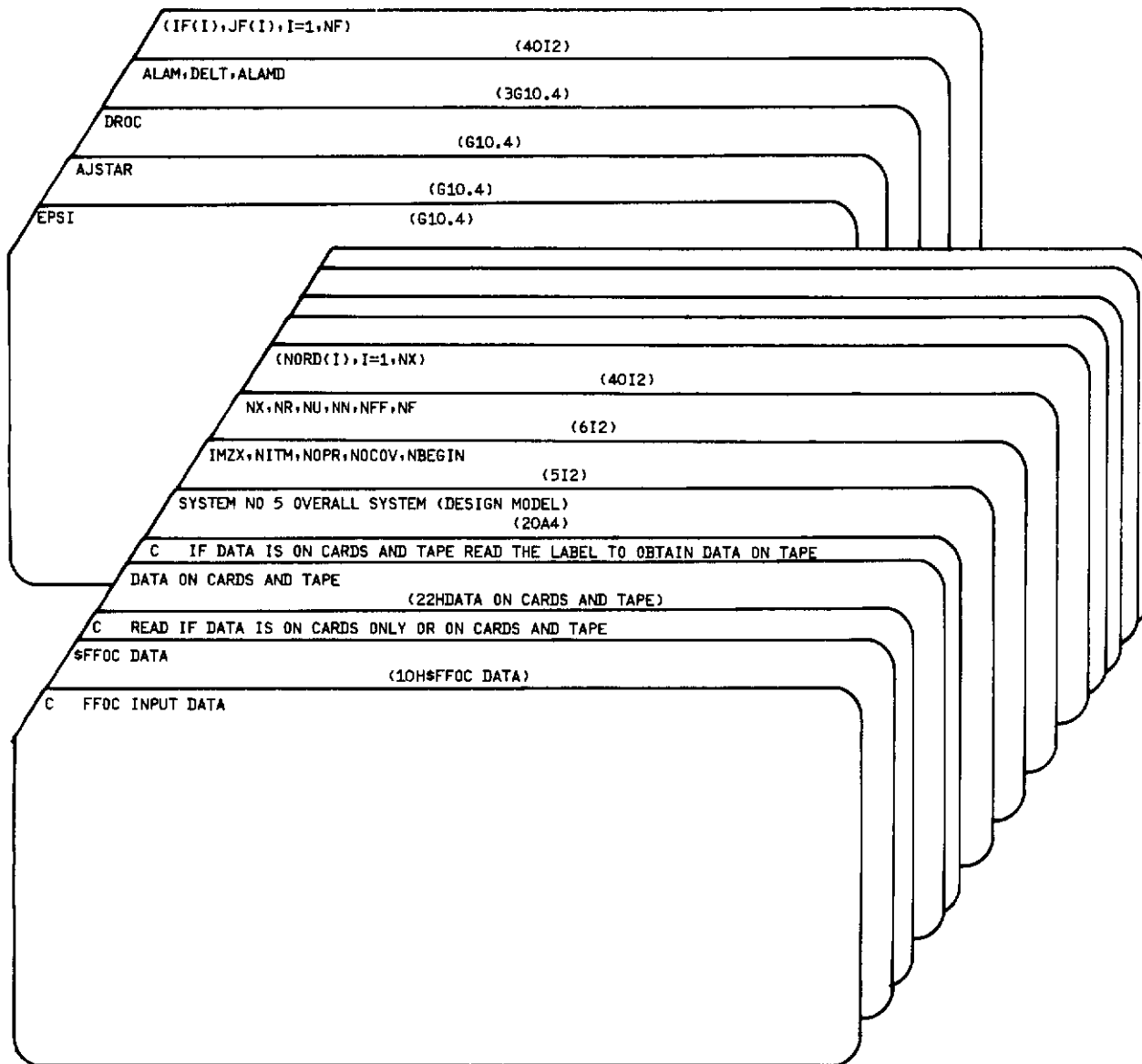


Figure 24. KONPACT-2 Input Data (for using FFOC) Card Arrangement (See Reference 2 for Variable Definition)



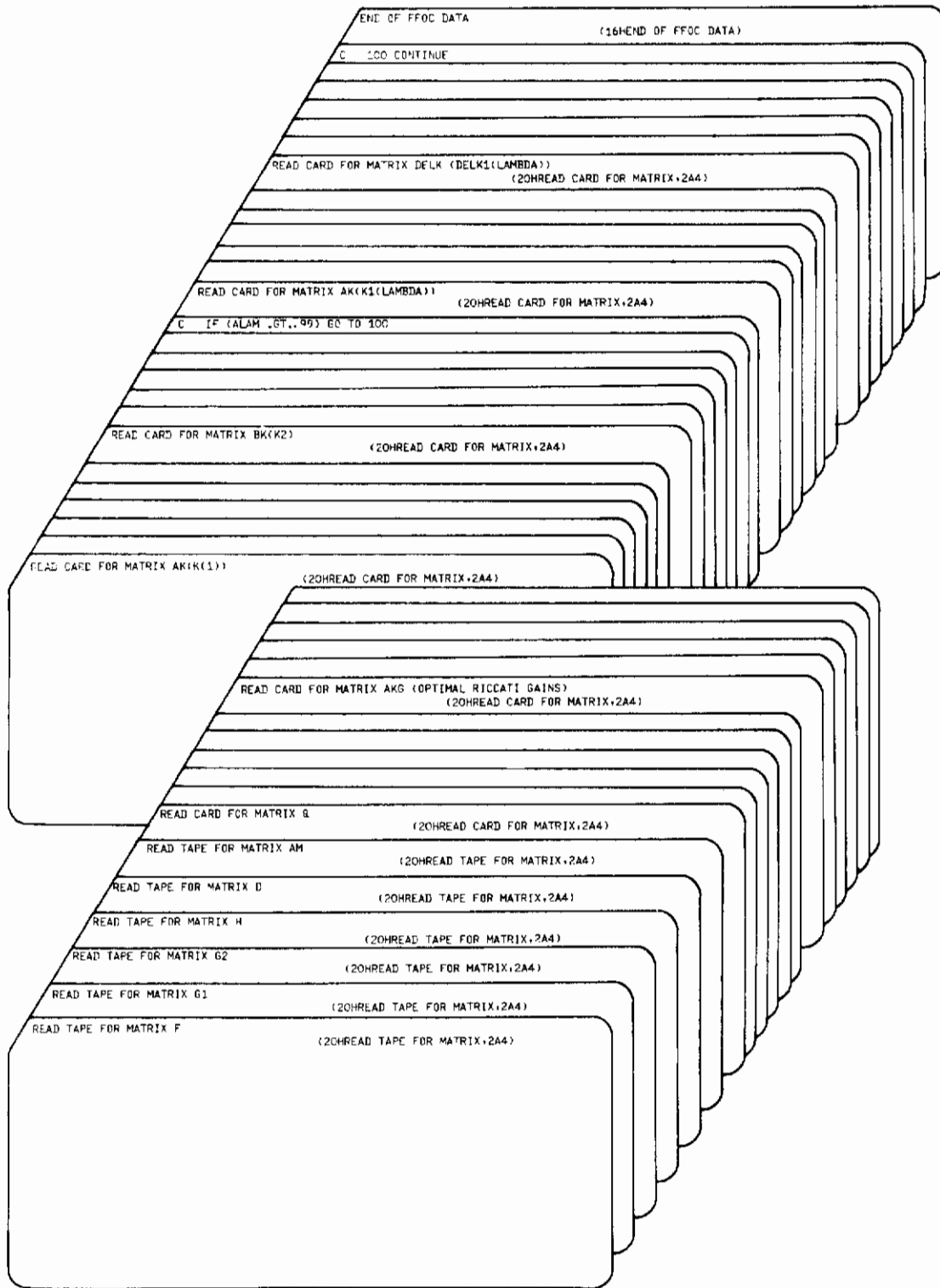


Figure 24. KONPACT-2 Input Data (for Using FFOC) Card Arrangement (See Reference 2 for Variable Definition) (Concluded)

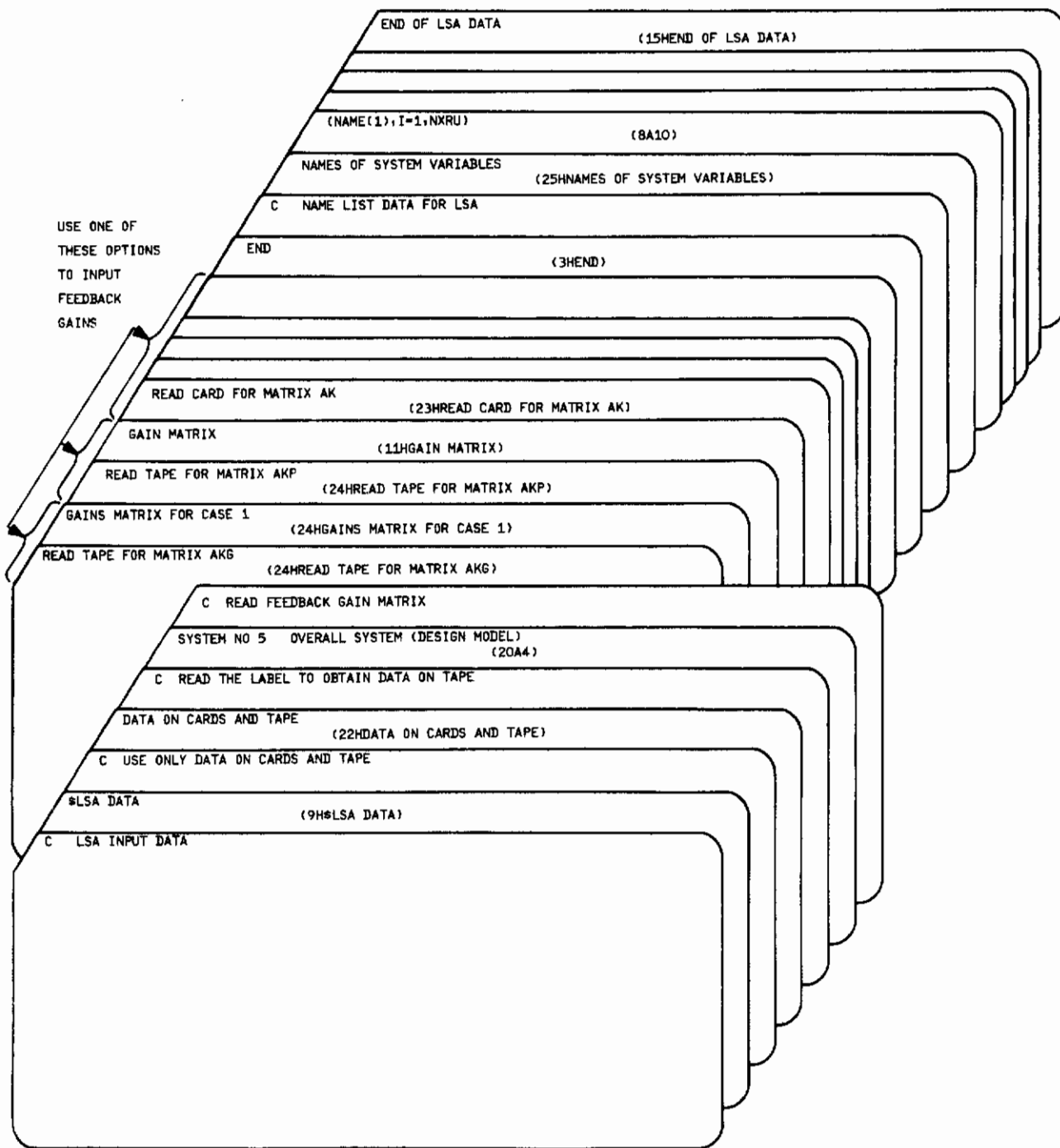


Figure 25. KOMPACT-2 Input Data (To Compute Frequency Domain Data for LSA Program) Card Arrangement

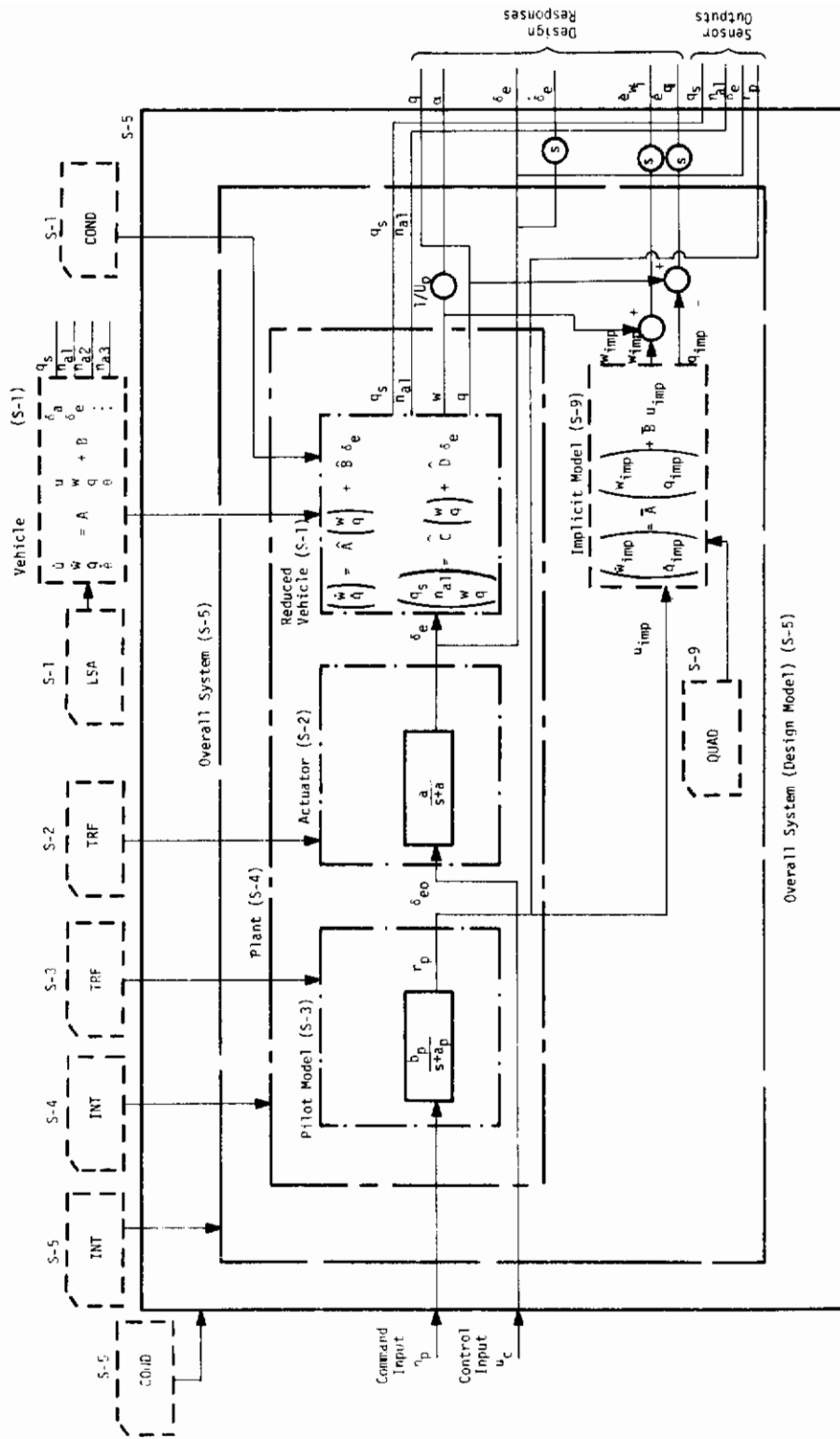


Figure 26. Model Generation for Design of Handling Quality Controller (C-5A Cruise Flight Condition)

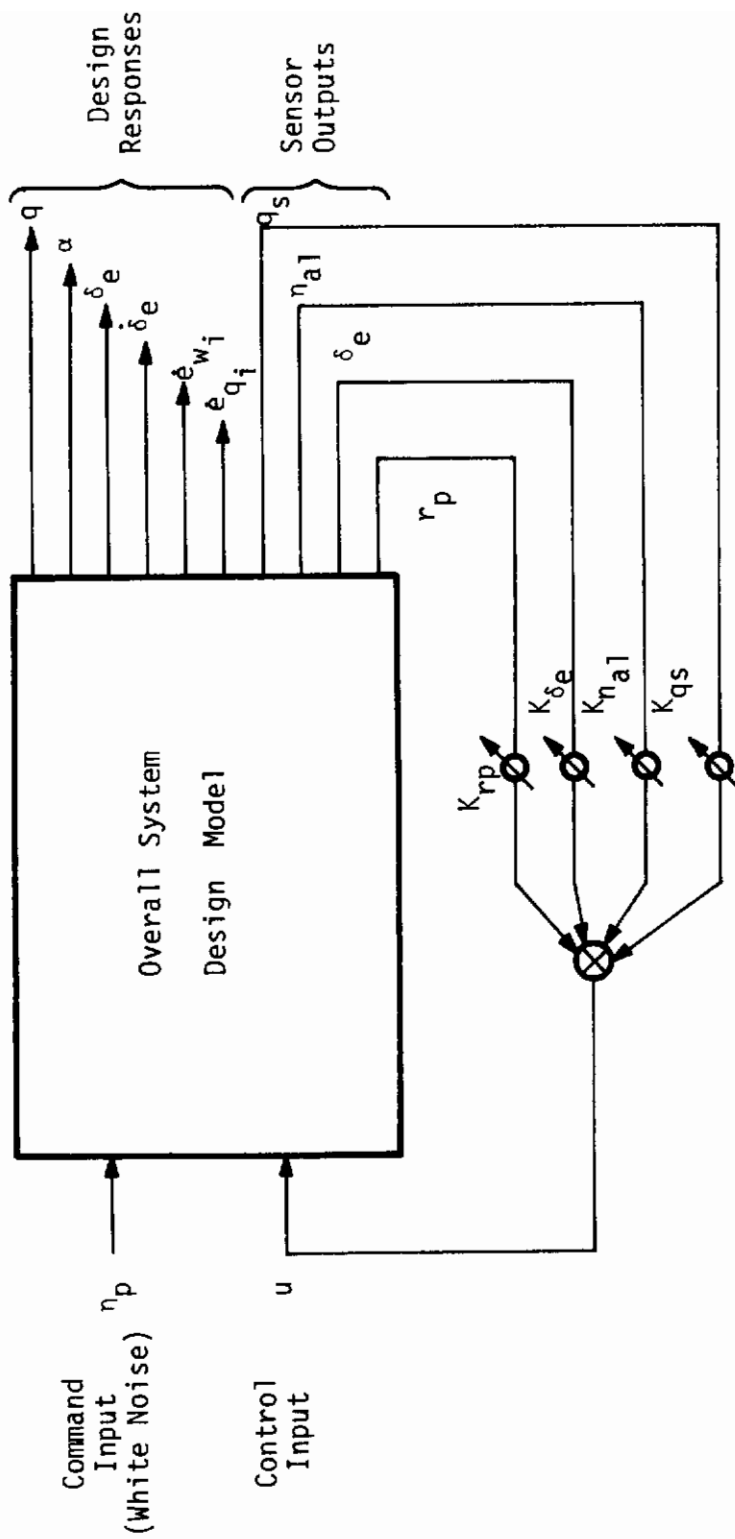


Figure 27. Design Process for Handling Quality Controller Design (C-5A Cruise Flight Condition)

Response	Weight	Starting Value
$q$	$Q_1$	0.0
$\alpha$	$Q_2$	0.0
$\delta_e$	$Q_3$	1.0
$\dot{\delta}_e$	$Q_4$	1.0
$\dot{e}_{w_i}$	$Q_5$	0.0
$\dot{e}_{q_i}$	$Q_6$	1.0

Figure 28. Design Response Weights for Handling Quality Controller Design (C-5A Cruise Flight Condition)

C-5A Optimal Handling Quality Controller Gains

Quadratic Weight	Measurement Feedback Gains					Closed Loop Eigenvalues			
	$K_{Q_3}$	$K_{n_{a1}}$	$K_{\delta_e}$	$K_{r_p}$	Eigenvalues Real	Imaginary	Damping Ratio	Frequency	
$Q_3 = 1.0$	0.25915E+00	-0.43376E-04	0.49053E+01	0.14992E+00	-0.10000000				
$Q_4 = 1.0$					-2.22291093				
$Q_6 = 0.01$					-1.21796628	1.87880916	-0.54396452	2.23905464	
$Q_3 = 1.0$	0.96923E+00	-0.24015E-03	0.30298E+01	0.49663E+00	-0.10000000				
$Q_4 = 1.0$					-1.82555509	2.23250534	-0.63302171	2.88387439	
$Q_6 = 0.1$					-4.14911024				
$Q_3 = 1.0$	0.31169E+01	-0.95075E-03	-0.90191E+00	0.15939E+01	-0.10000000				
$Q_4 = 1.0$					-2.12981340	2.12634262	-0.70766317	3.00855779	
$Q_6 = 1.0$					-12.02171321				
$Q_3 = 1.0$	0.97681E+01	-0.32524E-02	-0.12297E+02	0.50667E+01	-0.10000000				
$Q_4 = 1.0$					-38.08451043				
$Q_6 = 10.0$					-2.15590788	2.09553392	-0.71707598	3.00652644	
$Q_3 = 1.0$	0.30722E+02	-0.10552E-01	-0.48020E+02	0.16050E+02	-0.10000000				
$Q_4 = 1.0$					-2.15829309	2.09228636	-0.71800679	3.00597593	
$Q_6 = 100.0$					-120.47517594				

Figure 29. Variation of Design Performance with Change in Quadratic Weight

C-5A Reduced Handling Quality Controller Gains

Method	Quadratic Cost	Measurement Feedback Gains				Closed Loop Eigenvalues			
		$K_{\phi_s}$	$K_{n_{a1}}$	$K_{\phi_e}$	$K_{T_p}$	Eigenvalues Real	Imaginary	Damping Ratio	Frequency
Full State Feedback	0.89930792E+08	0.31169E+01	-0.95073E-03	-0.90191E+00	0.15939E+01	-0.10000000 -2.12981340 -12.02171321	2.12634262	-0.70769317	3.00955779
Only $K_{\phi_e}$ is Reduced	0.10012954E-07	0.30264E+01	-0.90347E-03	0.0	0.15102E+01	-0.10000000 -10.62888367 -2.24188055	2.16354058	-0.71956724	3.11558565
Both $K_{\phi_e}$ and $K_{n1}$ are Reduced	0.33886061E-07	0.13608E+01	0.0	0.0	0.42425E+00	-0.10000000 -4.04893107 -1.25505802	2.50123388	-0.85075915	4.74919760

Figure 30. Variation of Design Performance When the Feedback Gains Are Reduced

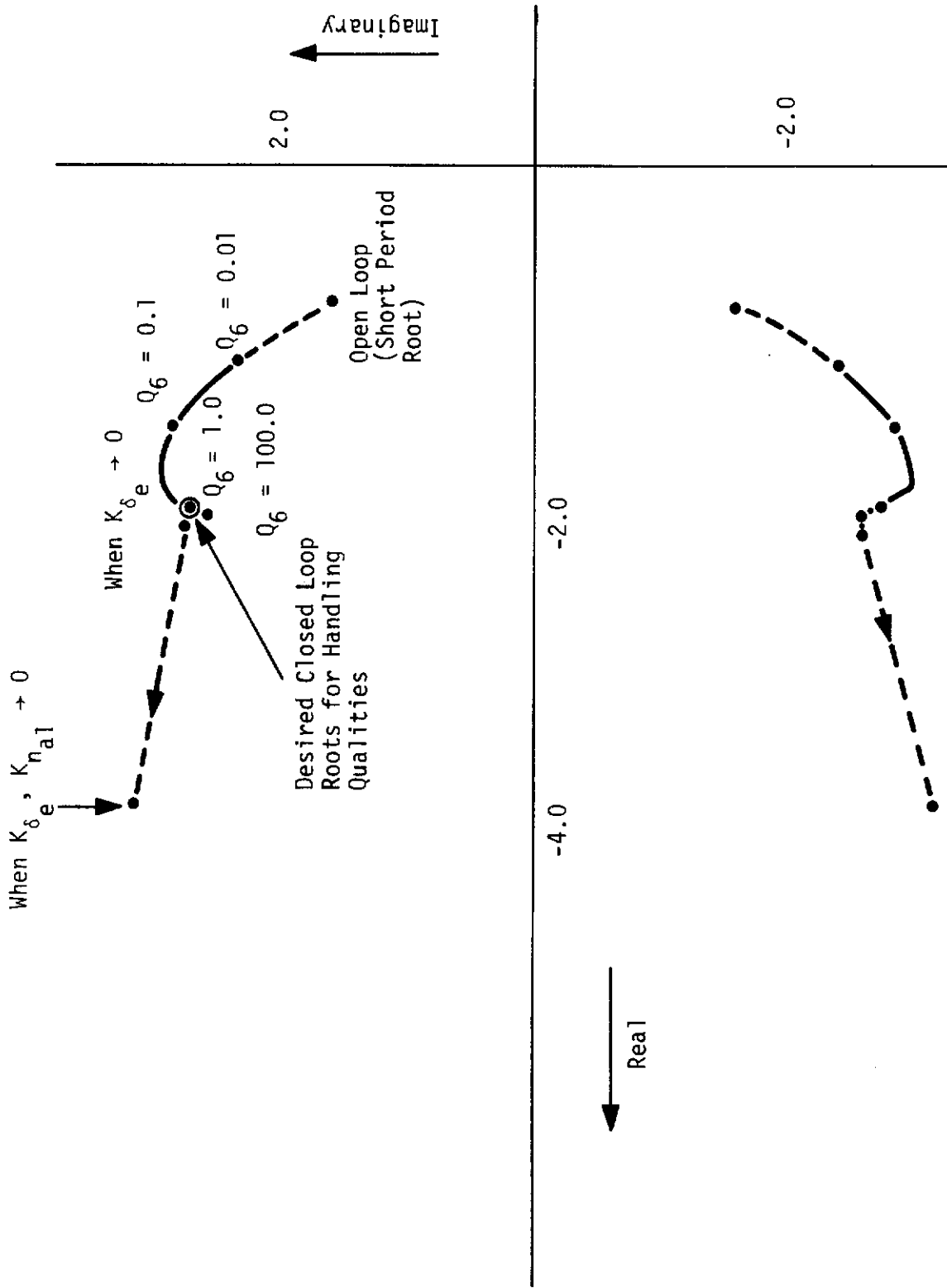


Figure 31. Movement of Eigenvalues During Handling Quality Controller Design (C-5A Cruise Flight Condition)



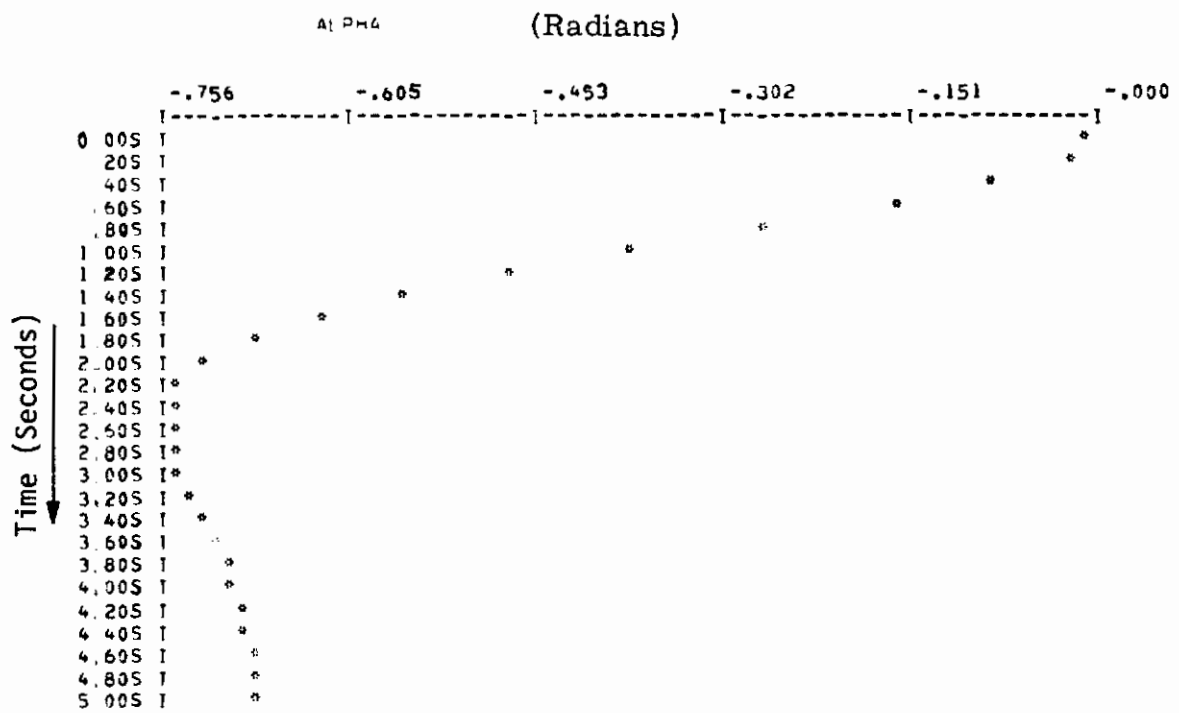
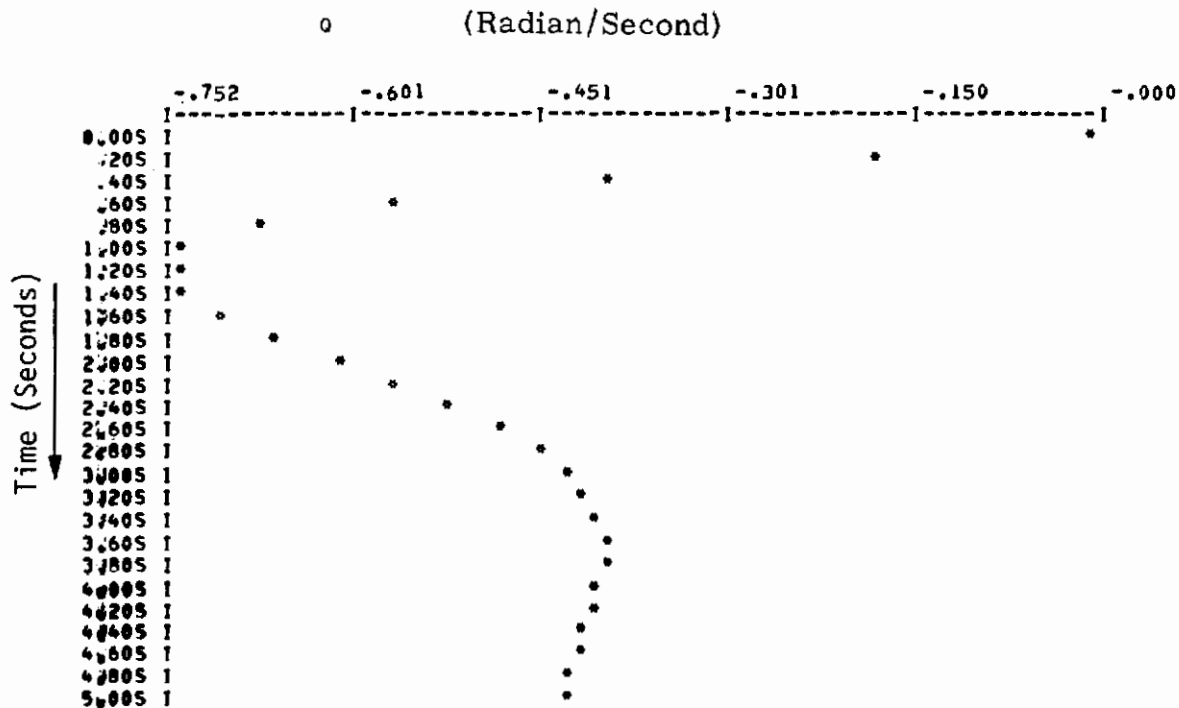


Figure 32. Response of C-5A Open Loop Static Elastic System to Elevator Command



Figure 32. Response of C-5A Open Loop Static Elastic System to Elevator Command (Concluded)

# Contrails

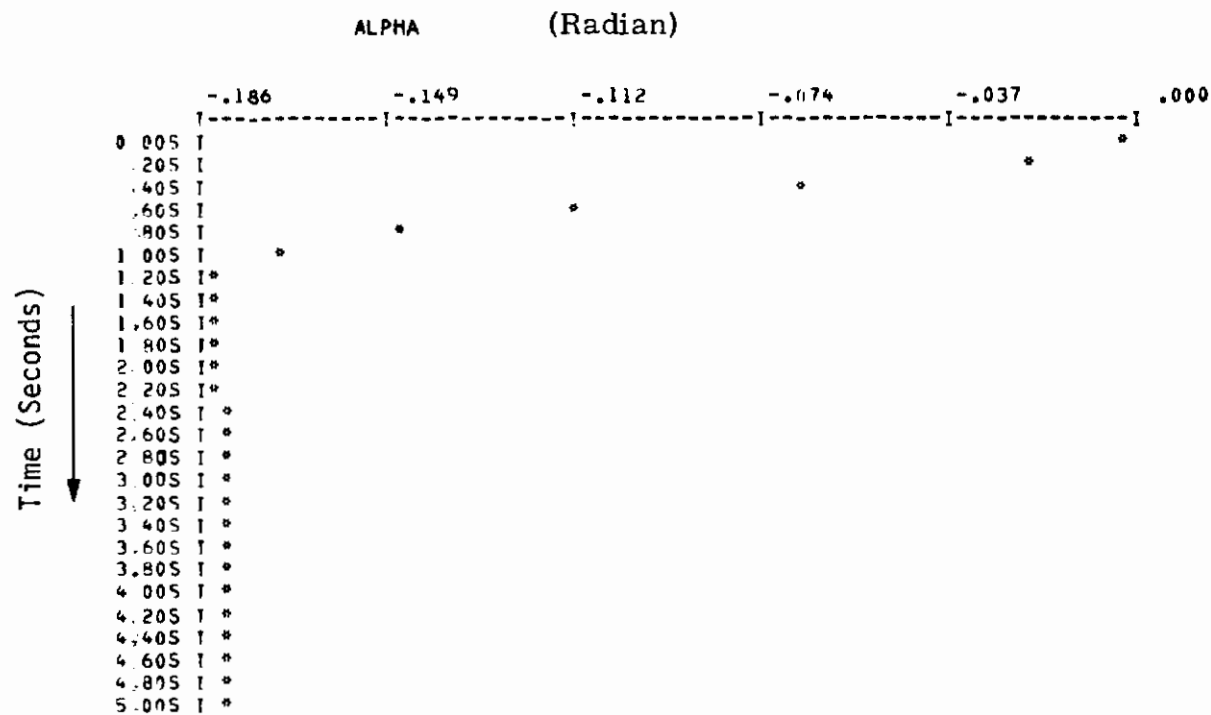
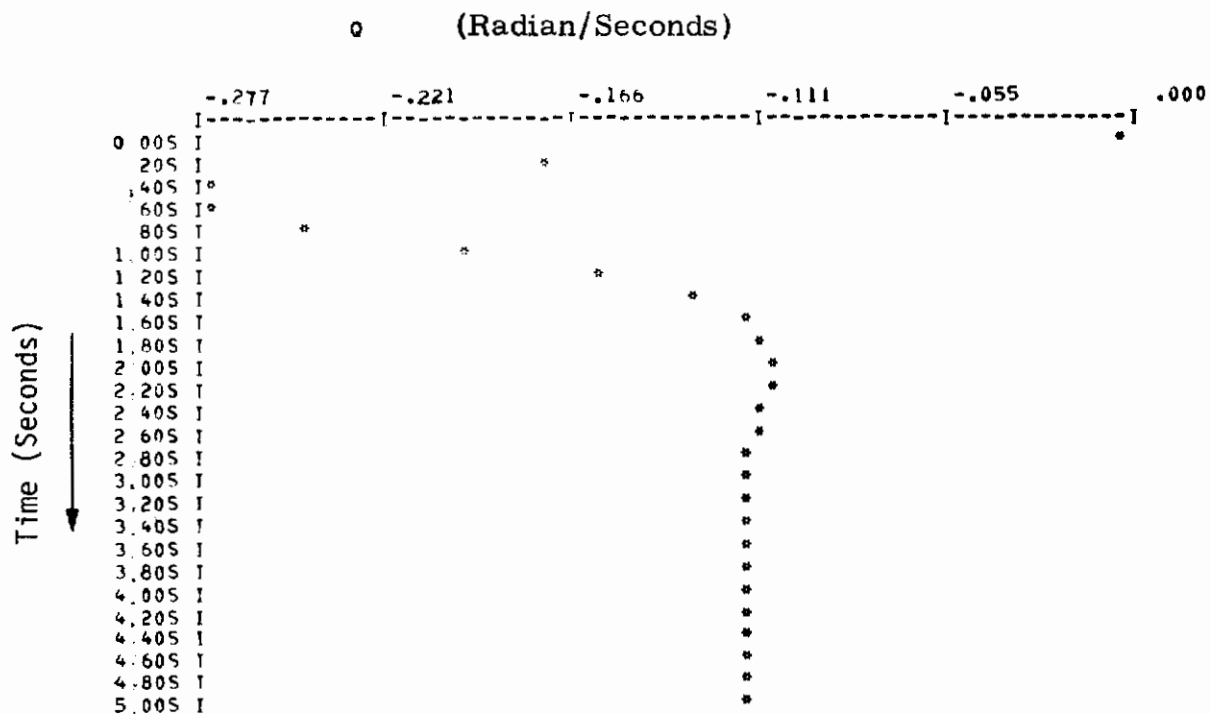


Figure 33. Response of C-5A Full State Feedback Static Elastic System to Elevator Command

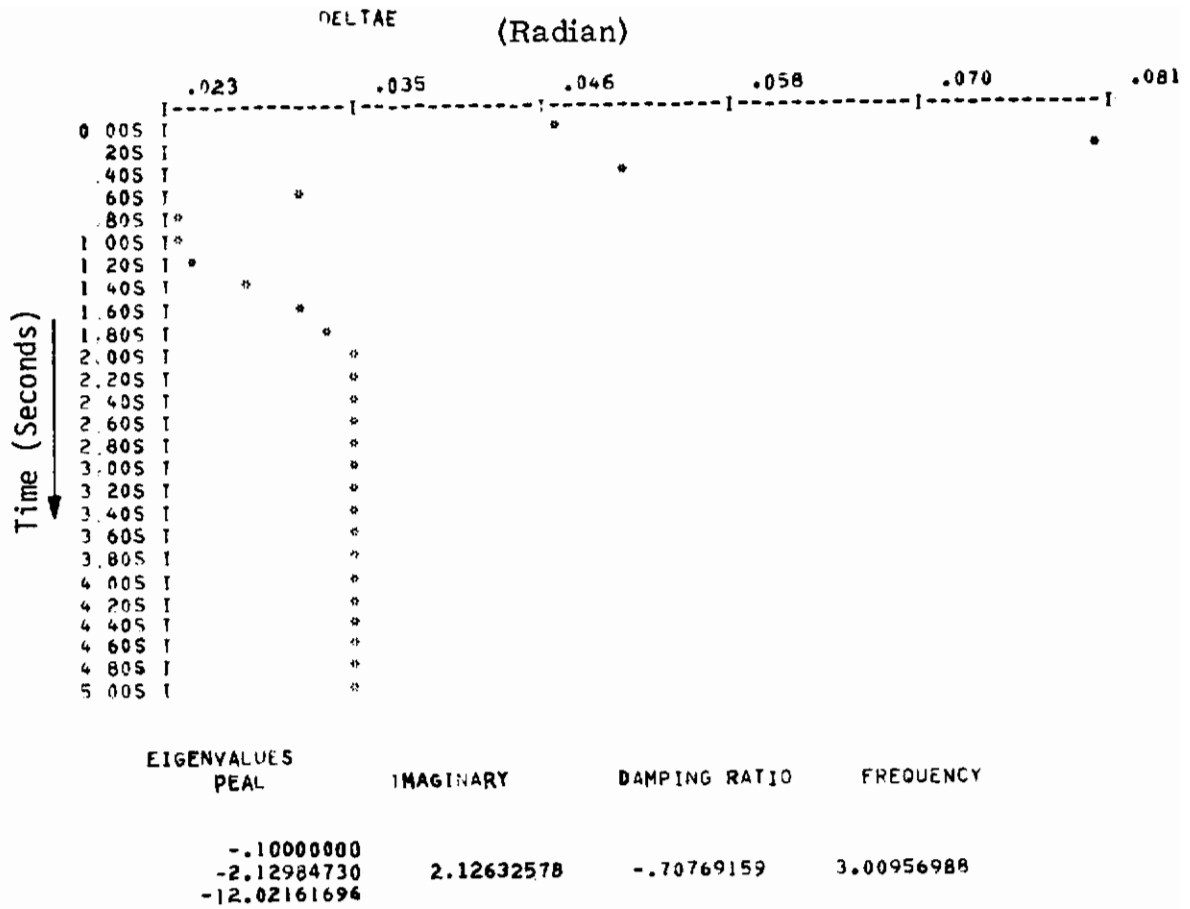


Figure 33. Response of C-5A Full State Feedback Static Elastic System to Elevator Command (Concluded)

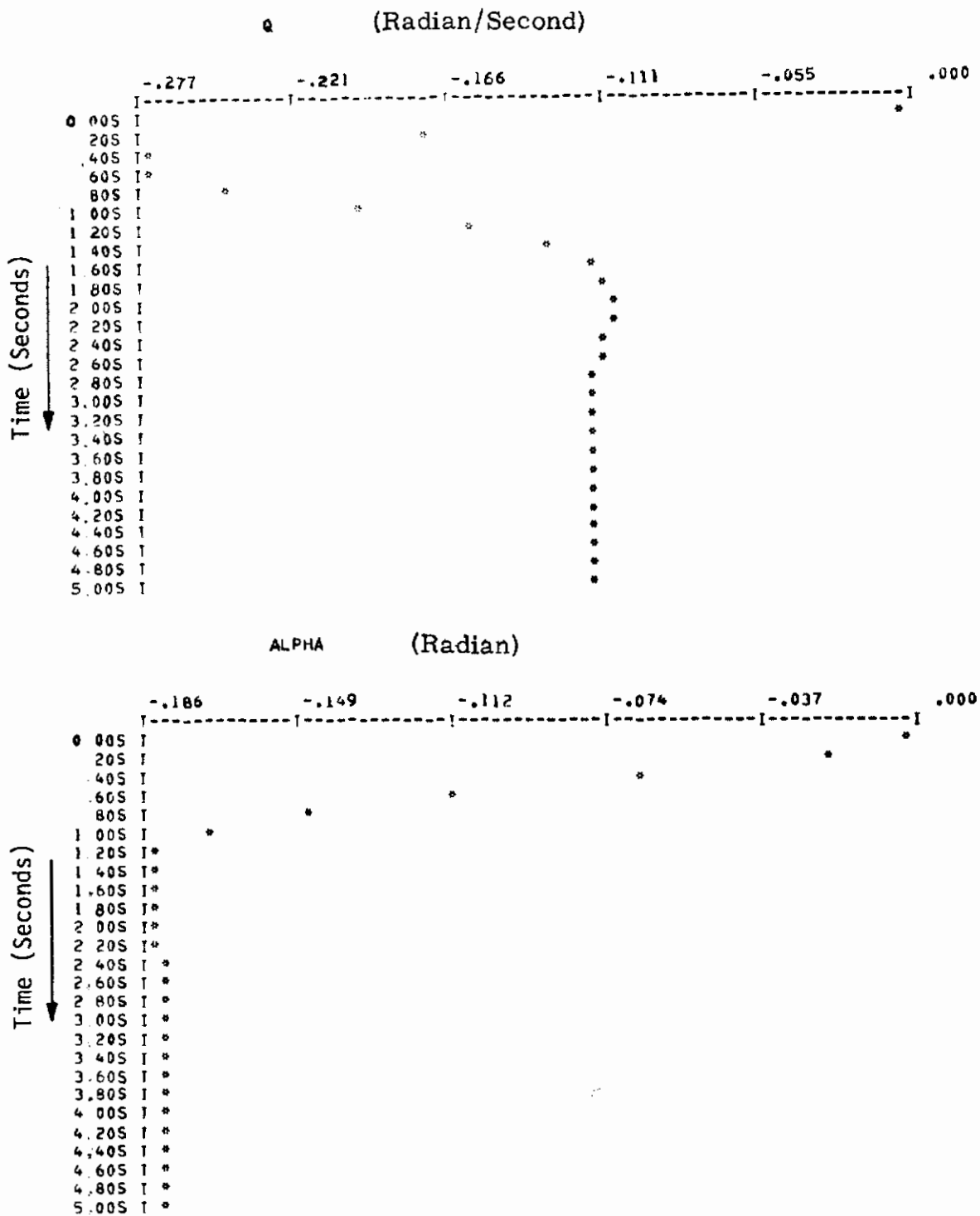


Figure 34. Response of C-5A Reduced Feedback Static Elastic System ( $K_{\delta e} = 0$ ) to Elevator Command

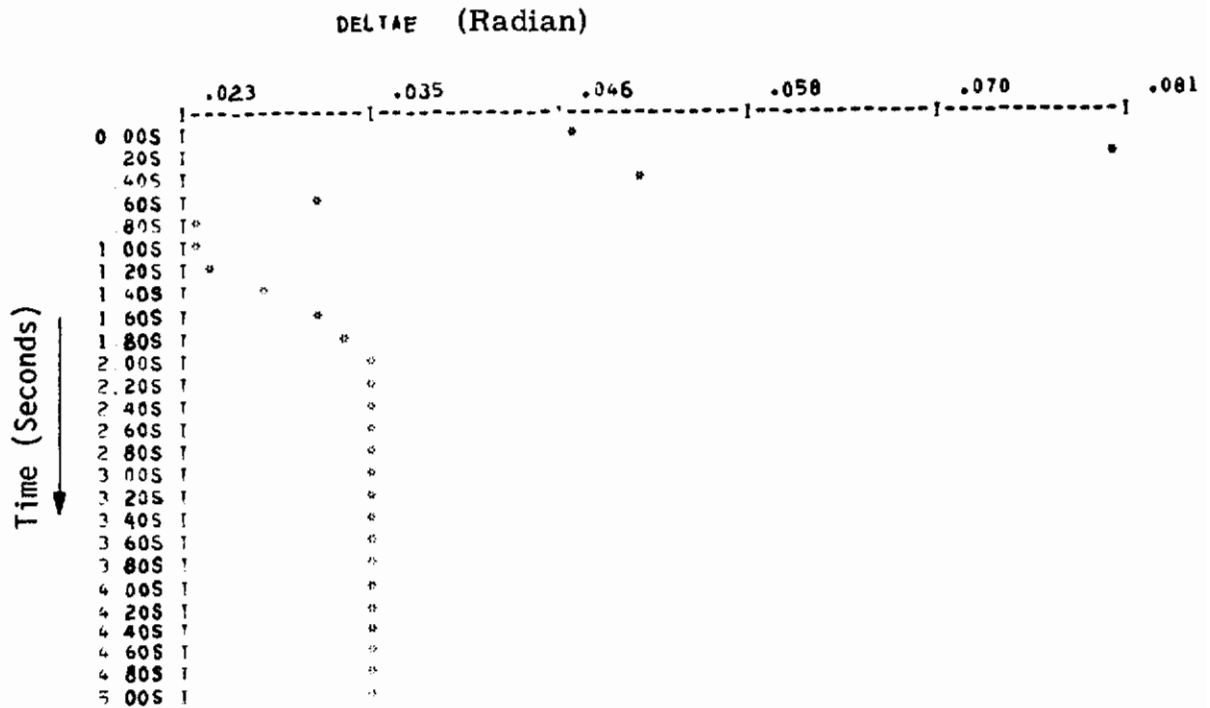


Figure 34. Response of C-5A Reduced Feedback Static Elastic System ( $K_e^{\delta} = 0$ ) to Elevator Command (Concluded)

```

STATIC-ELASTIC      SYMMETRIC
VP/VP0              3      3
-.00397921-.02045144-331.21146-.11892511-.67867980 8741.2021
.192E-05-.00018740-1.1011024
VP/R0               3      1
-385.82558-14.851845 .00049192
VP/DELS0            3      2
-1.1624795-3.4864771-154.42869-330.79430-.29081411-1.6063686
(BANDING)           1      3
-1017.9353 0.      1017.9353
VP/WG0              3      3
.00113479 .01926954 .471E-04 .10077881 .57802128-.00012030
.00042632-.00019920 -.397E-04
VP/WG1              3      3
-.640E-04-.00077100 .661E-05-.00174649-.01756977 .00124663
-.200E-05 .397E-04 -.403E-05
VP/WG50             3      3
.00113479 .01926954 .471E-04 .10077881 .57802128-.00012030
.00042632-.00019920 -.397E-04
VP/WG51             3      3
-.640E-04-.00077100 .661E-05-.00174649-.01756977 .00124663
-.200E-05 .397E-04 -.403E-05
R/VP0               1      3
-0.      -0.      1.0000000
R/R0                1      1
-0.
T/VP0               4      3
0.      0.      1.0000000 0.      0.      -8839.9124
0.      0.      -8839.9124 0.      0.      -8839.9124
T/VP1               4      3
.367E-06 .432E-05 .00344891 0.      1.0000000-724.21672
0.      1.0000000 246.83328 0.      1.0000000 349.82328
T/R0                4      1
0.      14.588241 14.588241 14.588241
T/R1                4      1
0.      0.      0.
T/DELS0             4      2
0.      0.      0.      0.      0.      0.
0.      0.
T/DELS1             4      2
.00770793 0.      0.      0.      0.      0.
0.      0.
T/WG0               4      3
0.      0.      0.      0.      0.      0.
0.      0.      0.      0.      0.      0.
T/WG50              4      3
0.      0.      0.      0.      0.      0.
0.      0.      0.      0.      0.      0.
*FINISHED*         0      0
    
```

Figure 35. FLEXSTAB/LSA Static Elastic Simulator Deck Data

```

STAMK1
STAMK2
STAMK3
CONDK
NXM= 6
NUM= 16
NRM= 10
NYM= 10
MSR= 3
MTR= 1
    
```

Figure 36. Figure 37 Precompiler Data (KONPACT-1)

```

C INPUT DATA FOR DEMONSTRATION EXAMPLE
C SPECIFY PRINTING
PRINT OUTPUT DATA
PRINT INPUT DATA
C DEFINE VEHICLE
SYSTEM NO 1          VEHICLE ( STATIC ELASTIC SYMMETRIC )
SLSA DATA
STATIC-ELASTIC      SYMMETRIC
END
C NAME LIST DATA
STATE
1      X( 1)        U      VELOCITY ALONG X AXIS
2      X( 2)        W      VELOCITY ALONG Z AXIS          INCH/SEC
3      X( 3)        Q      PITCH RATE                    RADIAN/SEC
4      X( 4)        THETA  PITCH ATTITUDE                RADIAN
-1
OUTPUT
1      R( 1)        SASGY  PITCH RATE GYRO                    RADIAN/SEC
2      R( 2)        AZAP   NORMAL ACCELEROMETER            INCH/SEC2
3      R( 3)        AZFB   NORMAL ACCELEROMETER FRONTPAR   INCH/SEC2
4      R( 4)        AZRB   NORMAL ACCELEROMETER BACKSPAR   INCH/SEC2
-1
INPUT
1      U( 1)        BDAIL  AILERON DEFLECTION                RADIAN
2      U( 2)        BDELV  ELEVATOR DEFLECTION                RADIAN
3      U( 3)        BDAILDOT AILERON DEFLECTION RATE          RADIAN/SEC
4      U( 4)        BDELVDOT ELEVATOR DEFLECTION RATE          RADIAN/SEC
5      U( 5)        WG1    GUST INPUT AT -1020 IN FROM CG     INCH/SEC
6      U( 6)        WG2    GUST INPUT AT 0 IN FROM CG         INCH/SEC
7      U( 7)        WG3    GUST INPUT AT 1020 IN FROM CG      INCH/SEC
8      U( 8)        WG1DOT  GUST INPUT RATE                    INCH/SEC2
9      U( 9)        WG2DOT  GUST INPUT RATE                    INCH/SEC2
10     U(10)        WG3DOT  GUST INPUT RATE                    INCH/SEC2
11     U(11)        WGS1   STEADY GUST INPJT                  INCH/SEC
12     U(12)        WGS2   STEADY GUST INPJT                  INCH/SEC
13     U(13)        WGS3   STEADY GUST INPJT                  INCH/SEC
14     U(14)        WGS1DOT STEADY GUST INPJT RATE            INCH/SEC2
15     U(15)        WGS2DOT STEADY GUST INPJT RATE            INCH/SEC2
16     U(16)        WGS3DOT STEADY GUST INPJT RATE            INCH/SEC2
-1
END
    
```

Figure 37. KONPACT-1 Input Data for Static Elastic Model (Resulting KONPACT-1 Output Shown in Figures 41 through 53)



```
C DEFINE REDUCED VEHICLE
SYSTEM NO 1      VEHICLE ( STATIC ELASTIC SYMMETRIC - REDUCED )
$CONDITIONING DATA
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT OUTPUTS
R(1),R(2),X(2),X(3).
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(2),X(3).
RETAIN INPUTS
U(2).
END
C DEFINE ACTUATOR
SYSTEM NO 2      ACTUATOR
$TRANSFER FUNCTION DATA
BLOCK 1
  1 2 .750000E 01 2 1 .100000E 01 2 2 .750000E 01
-1
END
UI/U
  1 1 .100000E 01
-1
R/R1
  1 1 .100000E 01
-1
END
C NAME LIST DATA
STATE
  1      X( 1)      DELE   ELEVATOR DEFLECTION      RADIAN
-1
OUTPUT
  1      R( 1)      DELE   ELEVATOR DEFLECTION      RADIAN
-1
INPUT
  1      U( 1)      DELEC  ELEVATOR COMMAND      RADIAN
-1
END
```

Figure 37. KONPACT-1 Input Data for Static Elastic Model (Continued)

```
C DEFINE PILOT MODEL
SYSTEM NO 3          PILOT MODEL
$TRANSFER FUNCTION DATA
BLOCK 1
  1 2 .223610E-03 2 1 .100000E 01 2 2 .100000E 00
-1
END
UI/U
  1 1 .100000E 01
-1
R/R1
  1 1 .100000E 01
-1
END
C NAME LIST DATA
STATE
  1      X( 1)      XP      PILOT MODEL STATE      RADIAN
-1
OUTPUT
  1      R( 1)      FP      PILOT COMMAND      RADIAN
-1
INPUT
  1      U( 1)      ETAP    PILOT MODEL INPUT      RADIAN
-1
END
C DEFINE PLANT
SYSTEM NO 4          PLANT ( PILOT MODEL + ACTUATOR + VEHICLE )
$INTERCONNECTION DATA
UI1/U
-1
UI2/U
  1 2 .100000E 01
-1
UI3/U
  1 1 .100000E 01
-1
UI1/R12
  1 1 .100000E 01
-1
R/R11
  1 1 .100000E 01 2 2 .100000E 01 3 3 .100000E 01 4 4 .100000E 01
-1
R/R13
  5 1 .100000E 01
-1
END
C NO NAME LIST DATA IS NEEDED
END
C DEFINE IMPLICIT MODEL
SYSTEM NO 9          IMPLICIT MODEL
$QUADRUPLE DATA
XDOT/X      2      2
  1 1-.678680E 00 1 2 .874120E 04 2 1-.756200E-03 2 2-.352130E 01
-1
XDOT/U      2      1
  1 1-.330794E 03 2 1-.160637E 01
-1
R/X      2      2
  1 1 .100000E 01 2 2 .100000E 01
-1
END
```

Figure 37. KONPACT-1 Input Data for Static Elastic Model (Continued)

```

C NAME LIST DATA
STATE
  1      X( 1)      WI      IMP MODEL VELOCITY      FEET/SEC
  2      X( 2)      OI      IMP MODEL PITCH RATE    RADIANS/SEC
-1
OUTPUT
  1      R( 1)      WI      IMP MODEL VELOCITY      FEET/SEC
  2      R( 2)      OI      IMP MODEL PITCH RATE    RADIANS/SEC
-1
INPUT
  1      U( 1)      DELEI   IMP MODEL INPUT      RADIANS
-1
END
C DEFINE OVERALL SYSTEM
SYSTEM NO 5      OVERALL SYSTEM ( PLANT + IMPLICIT MODEL )
$INTERCONNECTION DATA
UI4/U
  1 1 .100000E 01 2 2 .100000E 01
-1
UI9/U
-1
UI9/RI4
  1 5 .100000E 01
-1
R/R14
  1 1 .100000E-01 2 2 .100000E 01 3 3 .113100E-03 5 3 .100000E 01 6 4 .100000E 01
  4 5 .100000E 01
-1
R/R19
  5 1-.100000E 01 6 2-.100000E 01
-1
END
C NAME LIST DATA
OUTPUT
  3      R( 3)      ALPHA   ANGLE OF ATTACK      RADIAN
-1
END
C DEFINE OVERALL SYSTEM WITH DESIGN RESPONSE SPECIFICATIONS
SYSTEM NO 5      OVERALL SYSTEM ( DESIGN MODEL )
$CONDITIONING DATA
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT CONTROL INPUTS
U(2).
SELECT COMMAND INPUTS
U(1).
CONSTRUCT DESIGN RESPONSES
X(2),R(3),X(3),XDOT(3),RDOT(5)-RDOT(6).
SELECT SENSOR OUTPUTS
R(1),R(2),X(3),R(4).
END
C NO REDUCTION AND SHUFFLING DATA
END
STOP

```

Figure 37. KONPACT-1 Input Data for Static Elastic Model  
(Concluded)

```
C DESIGN USING DIAK FOR THE DEMONSTRATION EXAMPLE
C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
$DIAK DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 5          OVERALL SYSTEM ( DESIGN MODEL )
C READ DATE AND USER ID
AUG 17. 75   J K MAMESH
C NOP - NO OF VARIABLES BEING PLOTTED
C READ NOP
0
C GO TO 100 IF NOP.EQ.0
C READ (PLR(I),ITITL(I),UNIT(I),YMIN(I),YMAX(I),SCAL(I),I=1,NOP)
C READ T,DT,ST,T1,T2
C 100 CONTINUE
C READ IMAX,ITER,ITERQ
4030 4
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 SKIP CORRELATION ANALYSIS
C NSTEP=0 NO STEP INPUTS
C NSTEP=1 STEP COMMANDS
C NSTEP=2 STEP GUSTS
C NSTEP=3 BOTH (1 AND 2)
C NSTEP=4 NO STEP INPUTS - TRANSIENTS ONLY
C NRAND=0 NO RANDOM INPUTS
C NRAND=1 GUSTS
C NPRIN=0 DO NOT PRINT RESPONSES
C NPRIN=1 PRINT RESPONSES
C NPLOT=0 NO PLOTS
C NPLOT=1 CALCOMP PLOTS
C NPLOT=2 LINE PRINTER PLOTS
C NPLOT=3 BOTH (1 AND 2)
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
3 0 0 0 0
C INPK=1 NEW INPUT GAINS
C INPK=2 NEW STARTING ROUTINE GAINS
C INPK=3 USE GAINS IN STORAGE
C INPK=4 USE INPUT GAINS IN STORAGE
C READ INPK
1
C NCONT=0 DONOT COMPUTE OPTIMAL GAINS - USE INPUT GAINS AND DATA IN
C          COVARIANCE AND TIME RESPONSE ANALYSIS ONLY
C NCONT=1 COMPUTE OPTIMAL GAINS
C NCONT=2 COMPUTE OPTIMAL GAINS WITH AUTOMATIC Q SELECTION ON CONTROL RATES
C READ NCONT
1
C READ FLIGHT CONDITION NUMBER
45
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NN - NO OF DISTURBANCE INPUTS
C NF - NO OF FEEDBACK STATES
C NG - NO OF GUST INPUTS
C NCS - NO OF COMMAND INPUTS = NO OF COMMAND STATES
C NGLG - NO OF GUST LIFT GROWTH STATES
C NSCRR - START OF CONTROL RATE RESPONSE IN THE RESPONSE VECTOR
C READ NX,NR,NU,NN,NF,NG,NCS,NGLG,NSCRR
4 6 1 1 4 0 0 0 7
```

Figure 38. KONPACT-2 Input Data for Static Elastic Model (Employing DIAK to Compute Optimal State Feedback Gains) (Resulting KONPACT-2 Output Shown in Figure 54)

```
C GO TO 200 IF INPK.GT.1
C READ (NORD(I),I=1,NX)
  1 2 3 4
C 200 CONTINUE
C F IS STATE TRANSITION MATRIX
READ TAPE FOR MATRIX F
C G1 IS CONTROL INPUT MATRIX
READ TAPE FOR MATRIX G1
C G2 IS DISTURBANCE INPUT MATRIX
READ TAPE FOR MATRIX G2
C XI IS INITIAL CONDITION MATRIX
READ CARD FOR MATRIX XI

C XLDXL IS STATE LIMIT - RATE LIMIT MATRIX
READ CARD FOR MATRIX XLDXL
  1 1 .100000E 20 2 1 .100000E 20 3 1 .100000E 20 4 1 .100000E 20
  1 2 .100000E 20 2 2 .100000E 20 3 2 .100000E 20 4 2 .100000E 20

C CL IS COMMAND LEVEL MATRIX
READ CARD FOR MATRIX CL

C H IS STATE RESPONSE MATRIX
READ TAPE FOR MATRIX H
C D IS CONTROL RESPONSE MATRIX
READ TAPE FOR MATRIX D
C AM IS MEASUREMENT MATRIX
READ TAPE FOR MATRIX AM
C RK IS INITIAL FEEDBACK GAIN MATRIX
READ CARD FOR MATRIX RK

C Q IS QUADRATIC WEIGHTS MATRIX
READ CARD FOR MATRIX Q
  3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E-01

C IDUM=0 ANOTHER RUN
C IDUM=1 NO MORE RUNS
C READ IDUM
  0
C INPD=1 COMPLETELY NEW DATA
C INPD=2 CHANGE SELECTED QUADRATIC WEIGHTS ONLY - USE SOME GAINS IN STORAGE
C INPD=3 CHANGE SELECTED QUADRATIC WEIGHTS ONLY WITH OPTION FOR NEW GAINS
C INPD=4 CHANGE SELECTED DATA
C INPD=5 CHANGE SELECTED DATA IN MEASUREMENT MATRIX AND QUADRATIC WEIGHTS
C WITH OPTION FOR NEW GAINS
C READ INPD,INPK
  2 3
C READ NCONT
  1
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
  3 0 0 0 0
READ CARD FOR MATRIX Q
  3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E-00

C READ IDUM
  0
C READ INPD,INPK
  2 3
C READ NCONT
  1
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
  3 0 0 0 0
READ CARD FOR MATRIX Q
  3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E 01
```

Figure 38. KONPACT-2 Input Data for Static Elastic Model (Employing DIAK to Compute Optimal State Feedback Gains) (Continued)

```
C READ IDUM
0
C READ INPD,INPK
2 3
C READ NCONT
1
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
3 0 0 0 0
READ CARD FOR MATRIX Q
3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E 02

C READ IDUM
0
C READ INPD,INPK
2 3
C READ NCONT
1
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
3 0 0 0 0
READ CARD FOR MATRIX Q
3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E 03

C READ IDUM
1
END OF DIAK DATA
STOP
```

Figure 38. KONPACT-2 Input Data For Static Elastic Model (Employing DIAK to Compute Optimal State Feedback Gains) (Concluded)

# Contrails

```
C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
$FFOC DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 5          OVERALL SYSTEM ( DESIGN MODEL )
C IMAX - MAXIMUM NO OF LYRUBOV SOLUTION ITERATIONS
C NITM - MAXIMUM NO OF COST CALCULATIONS
C NOPR=0 USE PROJECTED GRADIENT
C NOPR=1 DONOT USE PROJECTED GRADIENT
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 SKIP CORRELATION ANALYSIS
C NBEGIN,GT,0 TEST FOR LARGE D-COST ON FIRST INCREMENT OF LAMDA
C NBEGIN=0 NO TEST
C READ IMAX,NITM,NOPR,NOCOV,NBEGIN
30 4 1 3 1
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NV - NO OF DISTURRANCE INPUTS
C NFF - NO FEED FORWARD STATES
C NF - NO OF FIXED GAINS
C READ NX,NU,NU,NN,NFF,NF
4 6 1 1 1 1
C READ (NOR(I),I=1,NX)
1 2 3 4
C EPSI - INITIAL STEP SIZE
C READ EPSI
.1000E 00
C AJSTAR - LOWEST COST EXPECTED
C READ AJSTAR
.9993E-08
C DROC - DEIRED RATIO OF COSTS
C READ DROC
.1190E 01
C ALAM - INTEGRATION PARAMETER - LAMDA
C DELT - INTEGRATION STEP SIZE
C ALAMD - LOWER BOUND ON LAMDA FOR THE PRESENT RUN
C READ ALAM,DELT,ALAMD
.1000E 01 .2000E 00 .0000E 00
C IF - FIXED GAIN ROW INDEX
C JF - FIXED GAIN COLUMN INDEX
C READ (IF(I),JF(I),I=1,NF)
1 1 1 2 1 4
READ TAPE FOR MATRIX F
READ TAPE FOR MATRIX G1
READ TAPE FOR MATRIX G2
READ TAPE FOR MATRIX H
READ TAPE FOR MATRIX D
READ TAPE FOR MATRIX AM
READ CARD FOR MATRIX Q
3 3 .100000E 01 4 4 .100000E 01 6 6 .100000E 01
READ CARD FOR MATRIX AKG(OPTIMAL RICCATI GAINS)
1 1 .505050E-03 1 2 .255790E 01 1 3-.700160E 01 1 4 .356410E-03
READ CARD FOR MATRIX AK(K1(I))
READ CARD FOR MATRIX BK(K2)
C IF (ALAM,GT,.99) GO TO 100
READ CARD FOR MATRIX AK(K1(LAMBDA))
READ CARD FOR MATRIX DELK(DELK1(LAMBDA))
C 100 CONTINUE
END
```

Figure 39. KONPACT-2 Input Data for Static Elastic Model (Employing FFOC to Compute Reduced Feedback Gains) (Resulting KONPACT-2 Output Shown in Figure 55)

```

C DESIGN USING DIAK FOR THE IDENTIFICATION EXAMPLE
C READ FOR WHAT PROGRAM (DIAG,FEED,LSA) THE DATA IS
$DIAK DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 5 OVERALL SYSTEM DESIGN MODEL 1
C READ DATE AND USER ID
AUG 17, 75 J K AGHESH
C NOP - NO OF VARIABLES BEING PLOTTED
C READ NOP
3
C GO TO 100 IF NOP.EQ.0
C READ (PLR(I),ITITLE(I),UNIT(I),YMIN(I),YMAX(I),SCAL(I),(I=1,NOP)
1 0
2 ALPHA
3 DELTAE
C READ T,DT,ST,TL,TP
5.0 2.12 0.2 0.0 0.0
C 100 CONTINUE
C READ IMAX,ITER,ITEMO
4030 4
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 S-TP CORRELATION ANALYSIS
C NSTEP=0 NO STEP INPUTS
C NSTEP=1 STEP COMMANDS
C NSTEP=2 STEP GUSTS
C NSTEP=3 BOTH (1 AND 2)
C NSTEP=4 NO STEP INPUTS - TRANSIENTS ONLY
C NRAND=0 NO RANDOM INPUTS
C NRAND=1 GUSTS
C NPRIN=0 DO NOT PRINT RESPONSES
C NPRIN=1 PRINT RESPONSES
C NPLOT=0 NO PLOTS
C NPLOT=1 CALCOMP PLOTS
C NPLOT=2 LINE PRINTER PLOTS
C NPLOT=3 BOTH (1 AND 2)
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
1 1 0 1 2
C INPK=1 NEW INPUT GAINS
C INPK=2 NEW STARTING ROUTINE GAINS
C INPK=3 USE GAINS IN STORAGE
C INPK=4 USE INPUT GAINS IN STORAGE
C READ INPK
1
C NCONT=0 DONOT COMPUTE OPTIMAL GAINS - USE INPUT GAINS AND DATA IN
C COVARIANCE AND TIME RESPONSE ANALYSIS ONLY
C NCONT=1 COMPUTE OPTIMAL GAINS
C NCONT=2 COMPUTE OPTIMAL GAINS WITH AUTOMATIC 0 SELECTION ON CONTROL RATES
C READ NCONT
0
C READ FLIGHT CONDITION NUMBER
45
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NV - NO OF DISTURBANCE INPUTS
C NF - NO OF FEEDBACK STATES
C NG - NO OF GUST INPUTS
C NCS - NO OF COMMAND INPUTS (AS IN COMMAND STATES)
C NGLS - NO OF GUST STATE LENGTH STATES
C NSCRP - START OF CONTROL RATE RESPONSE IN THE RESPONSE VECTOR
C READ NX,NR,NU,NV,NF,NG,NCS,NGLS,NSCRP
4 6 1 1 3 0 1 7
C GO TO 200 IF NCONT.EQ.0
C READ (MDM(I),I=1,NX)
1 2 3 4
C 200 CONTINUE

```

**Figure 40. KONPACT-2 Input Data for Static Elastic Model (Employing DIAK to Evaluate Time Responses) (Resulting KONPACT-2 Output Shown in Figure 56)**



# Contrails

```
C F IS STATE VECTOR MATRIX
READ TAPE FOR MATRIX F
C G1 IS CONTROL POINT MATRIX
READ TAPE FOR MATRIX G1
C G2 IS INITIAL CONTROL POINT MATRIX
READ TAPE FOR MATRIX G2
C XI IS INITIAL CONTROL POINT MATRIX
READ CARD FOR MATRIX XI

C XLOXL IS STATE VECTOR - STATE LEVEL MATRIX
READ CARD FOR MATRIX XLOXL
  1 1 .100000E 20 1 1 .100000E 20 1 1 .100000E 20 4 1 .100000E 20
  1 2 .100000E 20 2 1 .100000E 20 2 1 .100000E 20 4 2 .100000E 20

C CL IS COMMAND LEVEL MATRIX
READ CARD FOR MATRIX CL
  1 1 .467157E -1

C H IS STATE RESPONSE MATRIX
READ TAPE FOR MATRIX H
C R IS CONTROL RESPONSE MATRIX
READ TAPE FOR MATRIX R
C AM IS RESPONSE MATRIX
READ TAPE FOR MATRIX AM
C BK IS INITIAL FEEDBACK GAIN MATRIX
READ CARD FOR MATRIX BK
  1 1 .31169E 01 1 25.55 2001.43 1 35.961910E 00 1 4 .159390E 01

C Q IS QUANTILE WEIGHTS MATRIX
READ CARD FOR MATRIX Q

C IDUM=0 ANOTHER RUN
C IDUM=1 NO MORE RUNS
C READ IDUM
1
END OF DATA
STOP
```

Figure 40. KONPACT-2 Input Data for Static Elastic Model (Employing DIAK to Evaluate Time Responses) (Concluded)

```
*****  
* SYSTEM NO 1 VEHICLE ( STATIC ELASTIC SYMMETRIC ) *  
* *****
```

\*\*\* LSA - FLEXSTAB DATA \*\*\*

STATIC-ELASTIC SYMMETRIC

VP/VP0 MATRIX \* SIZE = 3 X 3

	1-COLUMN	2-COLUMN	3-COLUMN
1-ROW	-.3979210E-02	-.2045144E-01	-.3312115E+03
2-ROW	-.1189251E+00	-.6786798E+00	.8741202E+04
3-ROW	.1920000E-05	-.1874000E-03	-.1101102E+01

VP/R0 MATRIX \* SIZE = 3 X 1

	1-COLUMN
1-ROW	-.3858256E+03
2-ROW	-.1485185E+02
3-ROW	.4919200E-03

VP/DELS0 MATRIX \* SIZE = 3 X 2

	1-COLUMN	2-COLUMN
1-ROW	-.1162480E+01	-.3486477E+01
2-ROW	-.1544287E+03	-.3307943E+03
3-ROW	-.2908141E+00	-.1606360E+01

(BANDING) MATRIX \* SIZE = 1 X 3

	1-COLUMN	2-COLUMN	3-COLUMN
1-ROW	-.1017935E+04	0.	.1017935E+04

Figure 41. KONPACT-1 Output for C-5A Static Elastic Model  
(Cruise Flight Condition) (See Figure 37 for KONPACT-1  
Input)

# Contrails

```
VP/WG0  MATRIX , SIZE = 3 X 3

      1-COLUMN      2-COLUMN      3-COLUMN
1-ROW  .1134790E-02  .1926954E-01  .4710000E-04
2-ROW  .1007788E+00  .5780213E+00  -.1203000E-03
3-ROW  .4263200E-03  -.1992000E-03  -.3970000E-04

VP/WG1  MATRIX , SIZE = 3 X 3

      1-COLUMN      2-COLUMN      3-COLUMN
1-ROW  -.6400000E-04  -.7710000E-03  .6610000E-05
2-ROW  -.1746490E-02  -.1756977E-01  .1246630E-02
3-ROW  -.2000000E-05  .3970000E-04  -.4030000E-05

VP/WG50  MATRIX , SIZE = 3 X 3

      1-COLUMN      2-COLUMN      3-COLUMN
1-ROW  .1134790E-02  .1926954E-01  .4710000E-04
2-ROW  .1007788E+00  .5780213E+00  -.1203000E-03
3-ROW  .4263200E-03  -.1992000E-03  -.3970000E-04

VP/WG51  MATRIX , SIZE = 3 X 3

      1-COLUMN      2-COLUMN      3-COLUMN
1-ROW  -.6400000E-04  -.7710000E-03  .6610000E-05
2-ROW  -.1746490E-02  -.1756977E-01  .1246630E-02
3-ROW  -.2000000E-05  .3970000E-04  -.4030000E-05

R/VP0  MATRIX , SIZE = 1 X 3

      1-COLUMN      2-COLUMN      3-COLUMN
1-ROW  -.0          -.0          .1000000E+01
```

Figure 41. KONPACT-1 Output for C-5A Static Elastic Model  
(Cruise Flight Condition) (See Figure 37 for KONPACT-1  
Input) (Continued)

# Contrails

```
R/R0      MATRIX * SIZE = 1 X 1

      1-COLUMN

1-ROW    -.0

T/VP0     MATRIX * SIZE = 4 X 3

      1-COLUMN      2-COLUMN      3-COLUMN

1-ROW    0.          0.          .1000000E+01
2-ROW    0.          0.          -.8839912E+04
3-ROW    0.          0.          -.8839912E+04
4-ROW    0.          0.          -.8839912E+04

T/VP1     MATRIX * SIZE = 4 X 3

      1-COLUMN      2-COLUMN      3-COLUMN

1-ROW    .3670000E-06 .4320000E-05 .3448910E-02
2-ROW    0.          .1000000E+01 -.7242167E+03
3-ROW    0.          .1000000E+01 .2468333E+03
4-ROW    0.          .1000000E+01 .3498233E+03

T/P0      MATRIX * SIZE = 4 X 1

      1-COLUMN

1-ROW    0.
2-ROW    .1458824E+02
3-ROW    .1458824E+02
4-ROW    .1458824E+02

T/R1      MATRIX * SIZE = 4 X 1

      1-COLUMN

1-ROW    0.
2-ROW    0.
3-ROW    0.
4-ROW    0.
```

Figure 41. KONPACT-1 Output for C-5A Static Elastic Model (Cruise Flight Condition) (See Figure 37 for KONPACT-1 Input) (Continued)

# Contrails

T/DELS0 MATRIX \* SIZE = 4 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	0.	0.

T/DELS1 MATRIX \* SIZE = 4 X 2

	1-COLUMN	2-COLUMN
1-ROW	.7707930E-02	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	0.	0.

T/WG0 MATRIX \* SIZE = 4 X 3

	1-COLUMN	2-COLUMN	3-COLUMN
1-ROW	0.	0.	0.
2-ROW	0.	0.	0.
3-ROW	0.	0.	0.
4-ROW	0.	0.	0.

T/WGS0 MATRIX \* SIZE = 4 X 3

	1-COLUMN	2-COLUMN	3-COLUMN
1-ROW	0.	0.	0.
2-ROW	0.	0.	0.
3-ROW	0.	0.	0.
4-ROW	0.	0.	0.

\*FINISHED\*

Figure 41. KONPACT-1 Output for C-5A Static Elastic Model  
(Cruise Flight Condition) (See Figure 37 for KONPACT-1  
Input) (Concluded)

```

*****
* SYSTEM NO 1          VEHICLE ( STATIC ELASTIC SYMMETRIC )
*
*****

```

```

NUMBER OF STATES = 4
NUMBER OF OUTPUTS = 4
NUMBER OF INPUTS = 16

```

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
<b>STATE</b>		
1 X( 1)	U VELOCITY ALONG X AXIS	INCH/SEC
2 X( 2)	W VELOCITY ALONG Z AXIS	INCH/SEC
3 X( 3)	Q PITCH RATE	RADIAN/SEC
4 X( 4)	THETA PITCH ATTITUDE	RADIAN
<b>OUTPUT</b>		
1 R( 1)	SASGY PITCH RATE GYRO	RADIAN/SEC
2 R( 2)	AZAP NORMAL ACCELEROMETER	INCH/SEC2
3 R( 3)	AZFB NORMAL ACCELEROMETER FRONTSPAR	INCH/SEC2
4 R( 4)	AZRB NORMAL ACCELEROMETER BACKSPAR	INCH/SEC2
<b>INPUT</b>		
1 U( 1)	RDAIL AILERON DEFLECTION	RADIAN
2 U( 2)	RDELV ELEVATOR DEFLECTION	RADIAN
3 U( 3)	RDAILDOT AILERON DEFLECTION RATE	RADIAN/SEC
4 U( 4)	RDELVDOT ELEVATOR DEFLECTION RATE	RADIAN/SEC
5 U( 5)	WG1 GUST INPUT AT -1020 IN FROM CG	INCH/SEC
6 U( 6)	WG2 GUST INPUT AT 0 IN FROM CG	INCH/SEC
7 U( 7)	WG3 GUST INPUT AT 1020 IN FROM CG	INCH/SEC
8 U( 8)	WG1DOT GUST INPUT RATE	INCH/SEC2
9 U( 9)	WG2DOT GUST INPUT RATE	INCH/SEC2
10 U(10)	WG3DOT GUST INPUT RATE	INCH/SEC2
11 U(11)	WGS1 STEADY GUST INPUT	INCH/SEC
12 U(12)	WGS2 STEADY GUST INPUT	INCH/SEC
13 U(13)	WGS3 STEADY GUST INPUT	INCH/SEC
14 U(14)	WGS1DOT STEADY GUST INPUT RATE	INCH/SEC2
15 U(15)	WGS2DOT STEADY GUST INPUT RATE	INCH/SEC2
16 U(16)	WGS3DOT STEADY GUST INPUT RATE	INCH/SEC2

\*\*\* QUADRUPLE DATA \*\*\*

Figure 42. KONPACT-1 Output--C-5A Static Elastic Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (See Figure 37 for KONPACT-1 Input)

```

MATRIX A                SIZE = 4 X 4

      1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN

1-ROW  -.3979210E-02  -.2045144E-01  -.3312115E+03  -.3858256E+03
2-ROW  -.1189251E+00  -.6786798E+00  .8741202E+04  -.1485185E+02
3-ROW  .1920000E-05  -.1874000E-03  -.1101102E+01  .4919200E-03
4-ROW  0.             0.             .1000000E+01  0.

MATRIX B                SIZE = 4 X 16

      1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN      5-COLUMN      6-COLUMN      7-COLUMN

1-ROW  -.1162480E+01  -.3486477E+01  0.             0.             .1134790E-02  .1926954E-01  .4710000E-04
2-ROW  -.1544287E+03  -.3307943E+03  0.             0.             .1007788E+00  .5780213E+00  -.1203000E-03
3-ROW  -.2908141E+00  -.1606369E+01  0.             0.             .4263200E-03  -.1992000E-03  -.3970000E-04
4-ROW  0.             0.             0.             0.             0.             0.             0.

      8-COLUMN      9-COLUMN      10-COLUMN      11-COLUMN      12-COLUMN      13-COLUMN      14-COLUMN

1-ROW  -.6400000E-04  -.7710000E-03  .6610000E-05  .1134790E-02  .1926954E-01  .4710000E-04  -.6400000E-04
2-ROW  -.1746490E-02  -.1756977E-01  .1246630E-02  .1007788E+00  .5780213E+00  -.1203000E-03  -.1746490E-02
3-ROW  -.2000000E-05  .3970000E-04  -.4030000E-05  .4263200E-03  -.1992000E-03  -.3970000E-04  -.2000000E-05
4-ROW  0.             0.             0.             0.             0.             0.             0.

      15-COLUMN      16-COLUMN

1-ROW  -.7710000E-03  .6610000E-05
2-ROW  -.1756977E-01  .1246630E-02
3-ROW  .3970000E-04  -.4030000E-05
4-ROW  0.             0.

MATRIX C                SIZE = 4 X 4

      1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN

1-ROW  -.5085949E-06  -.3585728E-05  .1033843E+01  -.2040614E-03
2-ROW  -.1203156E+00  -.5429616E+00  .6987265E+03  -.6198607E+00
3-ROW  -.1184512E+00  -.7249364E+00  -.3704990E+03  -.1421819E+00
4-ROW  -.1182534E+00  -.7442367E+00  -.4839016E+03  -.9151893E-01

```

Figure 42. KONPACT-1 Output--C-5A Static Elastic Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (See Figure 37 for KONPACT-1 Input) (Continued)

MATRIX D                                  SIZE = 4 X 16

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN
1-ROW	-.1670550E-02	-.6970532E-02	.7707930E-02	0.	.1906120E-05	.1817101E-05	-.1374241E-06
2-ROW	.5618375E+02	.8325647E+03	0.	0.	-.2079693E+00	.7222853E+00	.2863110E-01
3-ROW	-.2262113E+03	-.7727995E+03	0.	0.	.2060088E+00	.5288521E+00	-.9919581E-02
4-ROW	-.2561622E+03	-.8927194E+03	0.	0.	.2499155E+00	.5083365E+00	-.1400828E-01
	8-COLUMN	9-COLUMN	10-COLUMN	11-COLUMN	12-COLUMN	13-COLUMN	14-COLUMN
1-ROW	-.1446614E-07	.6073734E-07	-.8511240E-08	.1906120E-05	.1817101E-05	-.1374241E-06	-.1446614E-07
2-ROW	-.2980566E-03	-.4632117E-01	.4165223E-02	-.2079693E+00	.7222853E+00	.2863110E-01	-.2980566E-03
3-ROW	-.2240157E-02	-.7770489E-02	.2518919E-03	.2060088E+00	.5288521E+00	-.9919581E-02	-.2240157E-02
4-ROW	-.2446137E-02	-.3681784E-02	-.1631578E-03	.2499155E+00	.5083365E+00	-.1400828E-01	-.2446137E-02
	15-COLUMN	16-COLUMN					
1-ROW	-.6073736E-07	-.8511244E-08					
2-ROW	-.4632117E-01	.4165223E-02					
3-ROW	-.7770489E-02	.2518919E-03					
4-ROW	-.3681786E-02	-.1631578E-03					

Figure 42. KONPACT-1 Output--C-5A Static Elastic Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (See Figure 37 for KONPACT-1 Input) (Concluded)



```

*****
* SYSTEM NO 1          VEHICLE ( STATIC ELASTIC SYMMETRIC - REDUCED )
*
*****

```

```

NUMBER OF STATES = 2
NUMBER OF OUTPUTS = 4
NUMBER OF INPUTS = 1

```

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
STATE		
1    X( 1)	W    VELOCITY ALONG Z AXIS	INCH/SEC
2    X( 2)	Q    PITCH RATE	RADIAN/SEC
OUTPUT		
1    R( 1)	SASGY PITCH RATE GYRO	RADIAN/SEC
2    R( 2)	AZAP  NORMAL ACCELEROMETER	INCH/SEC <sup>2</sup>
3    R( 3)	W    VELOCITY ALONG Z AXIS	INCH/SEC
4    R( 4)	Q    PITCH RATE	RADIAN/SEC
INPUT		
1    U( 1)	BDELV ELEVATOR DEFLECTION	RADIAN

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A                    SIZE = 2 X 2

	1-COLUMN	2-COLUMN
1-ROW	-.6786798E+00	.8741202E+04
2-ROW	-.1874000E-03	-.1101102E+01

MATRIX B                    SIZE = 2 X 1

	1-COLUMN
1-ROW	-.3307943E+03
2-ROW	-.1606369E+01

Figure 43. KONPACT-1 Output--Reduced C-5A Static Elastic Vehicle Name List Table and Quadruple Data (Cruise Flight Condition)  
(See Figure 37 for KONPACT-1 Input)

```
MATRIX C                SIZE = 4 X 2

      1-COLUMN          2-COLUMN

1-ROW  -.3585728E-05    .1033843E+01
2-ROW  -.5429616E+00    .6987265E+03
3-ROW  .1000000E+01     0.
4-ROW  0.                .1000000E+01
```

```
MATRIX D                SIZE = 4 X 1

      1-COLUMN

1-ROW  -.6979532E-02
2-ROW  .8325647E+03
3-ROW  0.
4-ROW  0.
```

Figure 43. KONPACT-1 Output--Reduced C-5A Static Elastic Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (See Figure 37 for KONPACT-1 Input) (Concluded)

```
.....  
* SYSTEM NO 2      ACTUATOR  
*  
.....
```

\*\*\* TRANSFER FUNCTION DATA FOR BLOCKS \*\*\*

BLOCK 1

	S**1 TERM	S**0 TERM
NUMERATOR	0.	7.50000
DENOMINATOR	1.00000	7.50000

\*\*\* CONNECTION DATA FOR BLOCKS \*\*\*

MATRIX P                    SIZE = 1 X 1

1-COLUMN

1-ROW 0.

MATRIX Q                    SIZE = 1 X 1

1-COLUMN

1-ROW .1000000E+01

MATRIX R                    SIZE = 1 X 1

1-COLUMN

1-ROW .1000000E+01

Figure 44. Actuator Transfer Function Data  
(See Figure 37 for KONPACT-1 Input)

```
MATRIX S          SIZE = 1 X 1
                1-COLUMN
            1-ROW  0.
```

Figure 44. Actuator Transfer Function Data (Concluded)

```
*****  
* SYSTEM NO 2          ACTUATOR  
*  
*****
```

```
NUMBER OF STATES = 1  
NUMBER OF OUTPUTS = 1  
NUMBER OF INPUTS = 1
```

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
STATE		
1 X ( 1)	DELE ELEVATOR DEFLECTION	RADIAN
OUTPUT		
1 R ( 1)	DELE ELEVATOR DEFLECTION	RADIAN
INPUT		
1 U ( 1)	DELEC ELEVATOR COMMAND	RADIAN

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A                    SIZE = 1 X 1

1-COLUMN

1-ROW    -.7500000E+01

MATRIX B                    SIZE = 1 X 1

1-COLUMN

1-ROW    .1000000E+01

Figure 45. Actuator Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input)

# Contrails

MATRIX C                    SIZE = 1 X 1

1-COLUMN

1-ROW    .7500000E+01

MATRIX D                    SIZE = 1 X 1

1-COLUMN

1-ROW    0.

Figure 45. Actuator Name List Table and Quadruple Data (Concluded)

```
.....*
* SYSTEM NO 3      PILOT MODEL
* .....*

*** TRANSFER FUNCTION DATA FOR BLOCKS ***

BLOCK 1

          ***I TERM   S**0 TERM
NUMERATOR  0.          .223610E-03
DENOMINATOR 1.00000   .100000

          *** CONNECTION DATA FOR BLOCKS ***

MATRIX P          SIZE = 1 X 1
          1-COLUMN
1-ROW  0.

MATRIX Q          SIZE = 1 X 1
          1-COLUMN
1-ROW  .1000000E+01

MATRIX R          SIZE = 1 X 1
          1-COLUMN
1-ROW  .1000000E+01

MATRIX S          SIZE = 1 X 1
          1-COLUMN
1-ROW  0.
```

Figure 46. Pilot Model Transfer Function Data  
(See Figure 37 for KONPACT-1 Input)

```
*****  
* SYSTEM NO 3          PILOT MODEL                               *  
*                                                                 *  
*****
```

```
NUMBER OF STATES = 1  
NUMBER OF OUTPUTS = 1  
NUMBER OF INPUTS = 1
```

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
STATE		
1 X( 1)	XP PILOT MODEL STATE	RADIAN
OUTPUT		
1 R( 1)	FP PILOT COMMAND	RADIAN
INPUT		
1 U( 1)	ETAP PILOT MODEL INPUT	RADIAN

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A SIZE = 1 X 1

1-COLUMN

1-ROW -.1000000E+00

MATRIX B SIZE = 1 X 1

1-COLUMN

1-ROW .1000000E+01

Figure 47. Pilot Model Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input)



# Contrails

```
          1-COLUMN
1-ROW    .2236100E-03

MATRIX D          SIZE = 1 X 1
          1-COLUMN
1-ROW    0.

MATRIX C          SIZE = 1 X 1
```

Figure 47. Pilot Model Name List Table and Quadruple Data (Concluded)

# Contrails

```

*****
*
* SYSTEM NO 4          PLANT ( PILOT MODEL + ACTUATOR + VEHICLE )
*
*****

```

\*\*\* INTERCONNECTION DATA \*\*\*

MATRIX P                    SIZE = 3 X 6

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN
1-ROW	0.	0.	0.	0.	.1000000E+01	0.
2-ROW	0.	0.	0.	0.	0.	0.
3-ROW	0.	0.	0.	0.	0.	0.

MATRIX Q                    SIZE = 3 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	.1000000E+01
3-ROW	.1000000E+01	0.

MATRIX R                    SIZE = 5 X 6

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN
1-ROW	.1000000E+01	0.	0.	0.	0.	0.
2-ROW	0.	.1000000E+01	0.	0.	0.	0.
3-ROW	0.	0.	.1000000E+01	0.	0.	0.
4-ROW	0.	0.	0.	.1000000E+01	0.	0.
5-ROW	0.	0.	0.	0.	0.	.1000000E+01

MATRIX S                    SIZE = 5 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	0.	0.

Figure 48. Plant (Pilot Model and Actuator and Static Elastic Vehicle) Interconnection Data (See Figure 37 for KONPACT-1 Input)

# Contracts

```
*****  
* SYSTEM NO 4          PLANT ( PILOT MODEL + ACTUATOR + VEHICLE ) *  
*  
*****
```

```
NUMBER OF STATES = 4  
NUMBER OF OUTPUTS = 5  
NUMBER OF INPUTS = 2
```

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
STATE		
1 X( 1)	W VELOCITY ALONG Z AXIS	INCH/SEC
2 X( 2)	Q. PITCH RATE	RADIAN/SEC
3 X( 3)	DELE ELEVATOR DEFLECTION	RADIAN
4 X( 4)	XP PILOT MODEL STATE	RADIAN
OUTPUT		
1 R( 1)	SASGY PITCH RATE GYRO	RADIAN/SEC
2 R( 2)	AZAP NORMAL ACCELEROMETER	INCH/SEC2
3 R( 3)	W VELOCITY ALONG Z AXIS	INCH/SEC
4 R( 4)	Q PITCH RATE	RADIAN/SEC
5 R( 5)	FP PILOT COMMAND	RADIAN
INPUT		
1 U( 1)	ETAP PILOT MODEL INPJT	RADIAN
2 U( 2)	DELEC ELEVATOR COMMAND	RADIAN

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A                    SIZE = 4 X 4

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN
1-ROW	-.6786798E+00	.8741202E+04	-.2480957E+04	0.
2-ROW	-.1874000E-03	-.1101102E+01	-.1204776E+02	0.
3-ROW	0.	0.	-.7500000E+01	0.
4-ROW	0.	0.	0.	-.1000000E+00

Figure 49. Plant Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input)

# Contrails

MATRIX B SIZE = 4 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	.1000000E+01
4-ROW	.1000000E+01	0.

MATRIX C SIZE = 5 X 4

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN
1-ROW	-.3585728E-05	.1033843E+01	-.5227899E-01	0.
2-ROW	-.5429616E+00	.6987265E+03	.6244235E+04	0.
3-ROW	.1000000E+01	0.	0.	0.
4-ROW	0.	.1000000E+01	0.	0.
5-ROW	0.	0.	0.	.2236100E-03

MATRIX D SIZE = 5 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	0.	0.
5-ROW	0.	0.

Figure 49. Plant Name List Table and Quadruple Data (See Figure 37 for KONPACT-1 Input) (Concluded)

```
*****  
* SYSTEM NO 9          IMPLICIT MODEL  
*  
*****
```

NUMBER OF STATES = 2  
NUMBER OF OUTPUTS = 2  
NUMBER OF INPUTS = 1

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME		DESCRIPTION	UNIT
STATE			
1	X( 1)	WI IMP MODEL VELOCITY	FEET/SEC
2	X( 2)	QI IMP MODEL PITCH RATE	RADIANS/SEC
OUTPUT			
1	R( 1)	WI IMP MODEL VELOCITY	FEET/SEC
2	R( 2)	QI IMP MODEL PITCH RATE	RADIANS/SEC
INPUT			
1	U( 1)	DELEI IMP MODEL INPUT	RADIANS

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A                    SIZE = 2 X 2

	1-COLUMN	2-COLUMN
1-ROW	-.6786800E+00	.8741200E+04
2-ROW	-.7562000E-03	-.3521300E+01

MATRIX B                    SIZE = 2 X 1

	1-COLUMN
1-ROW	-.3307940E+03
2-ROW	-.1606370E+01

Figure 50. Implicit Model Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input)

```
MATRIX C                SIZE = 2 X 2
                        1-COLUMN    2-COLUMN
1-ROW  .1000000E+01  0.
2-ROW  0.            .1000000E+01

MATRIX D                SIZE = 2 X 1
                        1-COLUMN
1-ROW  0.
2-ROW  0.
```

Figure 50. Implicit Model Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input) (Concluded)

# Contrails

```

*****
* SYSTEM NO 5          OVERALL SYSTEM ( PLANT + IMPLICIT MODEL )
*
*****

*** INTERCONNECTION DATA ***

MATRIX P          SIZE = 3 X 7

      1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN      5-COLUMN      6-COLUMN      7-COLUMN

1-ROW  0.           0.           0.           0.           0.           0.           0.
2-ROW  0.           0.           0.           0.           0.           0.           0.
3-ROW  0.           0.           0.           0.           .1000000E+01  0.           0.

MATRIX Q          SIZE = 3 X 2

      1-COLUMN      2-COLUMN

1-ROW  .1000000E+01  0.
2-ROW  0.           .1000000E+01
3-ROW  0.           0.

MATRIX R          SIZE = 6 X 7

      1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN      5-COLUMN      6-COLUMN      7-COLUMN

1-ROW  .1000000E+01  0.           0.           0.           0.           0.           0.
2-ROW  0.           .1000000E+01  0.           0.           0.           0.           0.
3-ROW  0.           0.           .1131000E-01  0.           0.           0.           0.
4-ROW  0.           0.           0.           0.           .1000000E+01  0.           0.
5-ROW  0.           0.           .1000000E+01  0.           0.           -.1000000E+01  0.
6-ROW  0.           0.           0.           .1000000E+01  0.           0.           -.1000000E+01

MATRIX S          SIZE = 6 X 2

      1-COLUMN      2-COLUMN

1-ROW  0.           0.
2-ROW  0.           0.
3-ROW  0.           0.

4-ROW  0.           0.
5-ROW  0.           0.
6-ROW  0.           0.

```

Figure 51. Overall System (Plant and Implicit Model)  
Interconnection Data (See Figure 37 for KONPACT-1  
Input)

# Contrails

```

*****
*
* SYSTEM NO 5          OVERALL SYSTEM ( PLANT + IMPLICIT MODEL )
*
*****

```

NUMBER OF STATES = 6  
 NUMBER OF OUTPUTS = 6  
 NUMBER OF INPUTS = 2

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME		DESCRIPTION	UNIT
STATE			
1	X( 1)	W VELOCITY ALONG Z AXIS	INCH/SEC
2	X( 2)	Q PITCH RATE	RADIAN/SEC
3	X( 3)	DELE ELEVATOR DEFLECTION	RADIAN
4	X( 4)	XP PILOT MODEL STATE	RADIAN
5	X( 5)	WI IMP MODEL VELOCITY	FEET/SEC
6	X( 6)	QI IMP MODEL PITCH RATE	RADIANS/SEC
OUTPUT			
1	R( 1)	SASGY PITCH RATE GYRO	RADIAN/SEC
2	R( 2)	AZAP NORMAL ACCELEROMETER	INCH/SEC <sup>2</sup>
3	R( 3)	ALPHA ANGLE OF ATTACK	RADIAN
4	R( 4)	FP PILOT COMMAND	RADIAN
5	R( 5)	EWI MODEL FOLL ERROR	FEET/SEC
6	R( 6)	EQI MODEL FOLL ERROR	RADIANS/SEC
INPUT			
1	U( 1)	ETAP PILOT MODEL INPJT	RADIAN
2	U( 2)	DELEC ELEVATOR COMMAND	RADIAN

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A                                  SIZE = 6 X 6

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN
1-ROW	-.6786798E+00	.8741202E+04	-.2480957E+04	0.	0.	0.
2-ROW	-.1874000E-03	-.1101102E+01	-.1204776E+02	0.	0.	0.
3-ROW	0.	0.	-.7500000E+01	0.	0.	0.
4-ROW	0.	0.	0.	-.1000000E+00	0.	0.
5-ROW	0.	0.	0.	-.7396885E-01	-.6786800E+00	.8741200E+04
6-ROW	0.	0.	0.	-.3592004E-03	-.7562000E-03	-.3521300E+01

Figure 52. Overall System Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input)



MATRIX B SIZE = 6 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	.1000000E+01
4-ROW	.1000000E+01	0.
5-ROW	0.	0.
6-ROW	0.	0.

MATRIX C SIZE = 6 X 6

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN
1-ROW	-.3585728E-05	.1033843E+01	-.5227899E-01	0.	0.	0.
2-ROW	-.5429616E+00	.6987265E+03	.6244235E+04	0.	0.	0.
3-ROW	.1131000E-03	0.	0.	0.	0.	0.
4-ROW	0.	0.	0.	.2236100E-03	0.	0.
5-ROW	.1000000E+01	0.	0.	0.	-.1000000E+01	0.
6-ROW	0.	.1000000E+01	0.	0.	0.	-.1000000E+01

MATRIX D SIZE = 6 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	0.	0.
5-ROW	0.	0.
6-ROW	0.	0.

Figure 52. Overall System Name List Table and Quadruple Data  
(See Figure 37 for KONPACT-1 Input) (Concluded)

```

*****
* SYSTEM NO 5          OVERALL SYSTEM ( DESIGN MODEL )          *
*****

NUMBER OF STATES = 4
NUMBER OF OUTPUTS=10
NUMBER OF INPUTS = 2

*** NAME LIST TABLE ***

VARIABLE NAME      DESCRIPTION                                UNIT

STATE
1      X( 1)        W      VELOCITY ALONG Z AXIS                INCH/SEC
2      X( 2)        Q      PITCH RATE                          RADIAN/SEC
3      X( 3)        DELE  ELEVATOR DEFLECTION                 RADIAN
4      X( 4)        XP     PILOT MODEL STATE                   RADIAN

DESIGN OUTPUT
1      R( 1)        Q      PITCH RATE                          RADIAN/SEC
2      R( 2)        ALPHA ANGLE OF ATTACK                 RADIAN
3      R( 3)        DELE  ELEVATOR DEFLECTION                 RADIAN
4      R( 4)        D/DT OF ( DELE  ELEVATOR DEFLECT )  RADIAN /SEC
5      R( 5)        D/DT OF ( EWI   MODEL FOLL ERROR )  FEET/SEC /SEC
6      R( 6)        D/DT OF ( EOI   MODEL FOLL ERROR )  RADIAN/SEC /SEC

SENSOR OUTPUT
7      R( 7)        SASGY PITCH RATE GYRO                 RADIAN/SEC
8      R( 8)        AZAP  NORMAL ACCELEROMETER             INCH/SEC2
9      R( 9)        DELE  ELEVATOR DEFLECTION                 RADIAN
10     R(10)        FP     PILOT COMMAND                       RADIAN

CONTROL INPUT
1      U( 1)        DELEC ELEVATOR COMMAND                 RADIAN

COMMAND INPUT
2      U( 2)        ETAP  PILOT MODEL INPUT                 RADIAN

*** QUADRUPLE DATA ***

MATRIX A                                SIZE = 4 X 4

          1-COLUMN      2-COLUMN      3-COLUMN      4-COLUMN

```

Figure 53. Overall System (Design Model) Name List Table and Quadruple Data (See Figure 37 for KONPACT-1 Input)

1-ROW	-.6786798E+00	.8741207E+04	-.2480957E+04	0.
2-ROW	-.1874000E-03	-.1101107E+01	-.1204776E+02	0.
3-ROW	0.	0.	-.7500000E+01	0.
4-ROW	0.	0.	0.	-.1000000E+00

MATRIX B                      SIZE = 4 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	.1000000E+01	0.
4-ROW	0.	.1000000E+01

MATRIX C                      SIZE = 10 X 4

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN
1-ROW	0.	.1000000E+01	0.	0.
2-ROW	.1131000E-03	0.	0.	0.
3-ROW	0.	0.	.1000000E+01	0.
4-ROW	0.	0.	-.7500000E+01	0.
5-ROW	.2000000E-06	.2100000E-02	-.2480957E+04	.7396885E-01
6-ROW	.5688000E-03	.2420198E+01	-.1204776E+02	.3592004E-03
7-ROW	-.3585728E-05	.1033843E+01	-.5227899E-01	0.
8-ROW	-.5429616E+00	.6987265E+03	.6244235E+04	0.
9-ROW	0.	0.	.1000000E+01	0.
10-ROW	0.	0.	0.	.2236100E-03

MATRIX D                      SIZE = 10 X 2

	1-COLUMN	2-COLUMN
1-ROW	0.	0.
2-ROW	0.	0.
3-ROW	0.	0.
4-ROW	.1000000E+01	0.
5-ROW	0.	0.
6-ROW	0.	0.
7-ROW	0.	0.
8-ROW	0.	0.
9-ROW	0.	0.
10-ROW	0.	0.

Figure 53. Overall System (Design Model) Name List Table and Quadruple Data (See Figure 37 for KONPACT-1 Input) (Concluded)

# Contrails

TODAY'S DATE AUG 17, 75      IDENTIFICATION      J K MAHESH

MAX NUMBER OF INNER-LOOP ITERATIONS 40    MAX NUMBER OF OUTER-LOOP ITERATIONS 30  
MAX NUMBER OF ITERATIONS ON ELIMINATING CONTROL SURFACE FEEDBACKS 4

NEW PROFILE WITH IPO = 1    IPRK = 1    NCONT = 0  
NCOOV = 1  
NSTEP = 1    NPAID = 0  
NPRIN = 1    NPLOT = 0

FLIGHT CONDITION 45                      RUN 1

ORDER OF SYSTEM = 4  
NUMBER OF RESPONSES = 6  
NUMBER OF CONTROLS = 1  
NUMBER OF DISTURBANCE INPUTS = 1  
NUMBER OF FEEDBACK STATES = 3  
NUMBER OF GUST INPUTS = 0  
NUMBER OF COMMAND STATES = 1  
NUMBER OF GUST LIFT GROWTH STATES = 0  
CONTROL RATE RESPONSES START WITH RESPONSE 7

STATES ARE ORDERED AS

1   2   3   4

F MATRIX

ROW 1				
	-.67858E+10	.87412E+04	-.24819E+04	0.
ROW 2				
	-.18740E-03	-.11011E+01	-.12048E+02	0.
ROW 3				
	0.	0.	-.75000E+01	0.
ROW 4				
	0.	0.	0.	-.10000E+00

Figure 54. KOMPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KOMPACT-2 Input)

```
      G1 MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
.10000E+01
ROW  4
  0.

      G2 MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
  0.
ROW  4
.10000E+01

      INITIAL CONDITION MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
  0.
ROW  4
  0.

      STATE LIMIT - RATE LIMIT MATRIX

ROW  1
.10000E+20 .10000E+20
ROW  2
.10000E+20 .10000E+20
ROW  3
.10000E+20 .10000E+20
ROW  4
.10000E+20 .10000E+20

      COMMAND LEVEL MATRIX

ROW  1
  0.
```

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Continued)

```
      H MATRIX

ROW  1
0.      .10000E+01 0.      0.
ROW  2
.11310E-03 0.      0.      0.
ROW  3
0.      0.      .10000E+01 0.
ROW  4
0.      0.      -.75000E+01 0.
ROW  5
.20000E-06 .21000E-02 -.24810E+04 .73969E-01
ROW  6
.56880E-03 .24202E+01 -.12048E+02 .35920E-03

      D MATRIX

ROW  1
0.
ROW  2
0.
ROW  3
0.
ROW  4
.10000E+01
ROW  5
0.
ROW  6
0.

      M MATRIX

ROW  1
-.35857E-05 .10338E+01 -.52279E-01 0.
ROW  2
-.54296E+00 .69873E+03 .62442E+04 0.
ROW  3
0.      0.      .10000E+01 0.
ROW  4
0.      0.      0.      .22361E-03

      INPUT GAINS MATRIX

ROW  1
0.      0.      0.      0.
```

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Continued)

QUADRATIC WEIGHTING MATRIX

ROW	1					
0.		0.	0.	0.	0.	0.
ROW	2					
0.		0.	0.	0.	0.	0.
ROW	3					
0.		0.	.10000E+01	0.	0.	0.
ROW	4					
0.		0.	0.	.10000E+01	0.	0.
ROW	5					
0.		0.	0.	0.	0.	0.
ROW	6					
0.		0.	0.	0.	0.	.10000E+01

STARTING MATRICES FOR PA+A\*P+Q-PEP=0

A MATRIX

ROW	1			
0.		-.67868E+00	.87412E+04	-.24810E+04
ROW	2			
0.		-.18740E-03	-.11011E+01	-.12048E+02
ROW	3			
0.		0.	0.	0.
ROW	4			
0.		0.	0.	-.10000E+00

E MATRIX

ROW	1			
0.		0.	0.	0.
ROW	2			
0.		0.	0.	0.
ROW	3			
0.		0.	.10000E+01	0.
ROW	4			
0.		0.	0.	0.

Q MATRIX

ROW	1			
0.		.32353E-06	.13766E-02	-.68529E-02
ROW	2			
0.		.13766E-02	.58574E+01	-.29159E+02
ROW	3			
0.		-.68529E-02	-.29159E+02	.14615E+03
ROW	4			
0.		.20431E-06	.86934E-03	-.43276E-02

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Continued)

## RICCATI MATRIX

ROW 1	.22055E-07	.10279E-03	-.50505E-03	.14428E-07
ROW 2	.10279E-03	.50478E+00	-.25579E+01	.69776E-04
ROW 3	-.50505E-03	-.25579E+01	.14502E+02	-.35641E-03
ROW 4	.14428E-07	.69776E-04	-.35641E-03	.99931E-08

## GAINS MATRIX

ROW 1	.50505E-03	.25579E+01	-.70016E+01	.35641E-03
-------	------------	------------	-------------	------------

## KSTAD MATRIX

ROW 1	.31169E+01	-.95075E-03	-.90191E+00	.15939E+01
-------	------------	-------------	-------------	------------

## COVARIANCE ANALYSIS FOR DISTURBANCE 1

ITER= 6

## COVARIANCE MATRIX

ROW 1	.60988E+00	.43836E-04	-.12389E-04	-.16770E+01
ROW 2	.43836E-04	.46111E-08	-.11033E-08	-.13808E-03
ROW 3	-.12389E-04	-.11033E-08	.35333E-09	.39850E-04
ROW 4	-.16770E+01	-.13808E-03	.39850E-04	.50000E+01

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Continued)



RESPONSE COVARIANCE MATRIX

ROW 1	.46111E-08	.49578E-08	-.11033E-08	.72035E-09	-.74764E-05	-.21240E-09
ROW 2	.49578E-08	.78014E-08	-.14012E-08	.23888E-09	-.10553E-04	-.13834E-10
ROW 3	-.11033E-08	-.14012E-08	.35333E-09	.34384E-18	.20711E-05	.34025E-09
ROW 4	.72035E-09	.23888E-09	.34384E-18	.43296E-08	.29477E-06	.43762E-08
ROW 5	-.74764E-05	-.10553E-04	.20711E-05	.29477E-06	.14905E-01	.12137E-05
ROW 6	-.21240E-09	-.13834E-10	.34025E-09	.43762E-08	.12137E-05	.53102E-08

MEASUREMENT COVARIANCE MATRIX

ROW 1	.47265E-08	-.27468E-04	-.11146E-08	-.31041E-07
ROW 2	-.27468E-04	.23694E+00	.81622E-05	.23768E-03
ROW 3	-.11146E-08	.81622E-05	.35333E-09	.89110E-08
ROW 4	-.31041E-07	.23768E-03	.89110E-08	.25001E-06

CONTROL COVARIANCE MATRIX

ROW 1	.24204E-07
-------	------------

R.M.S. CONTROLS

1	.15557738E-03
---	---------------

R.M.S. MEASUREMENTS

1	.68749906E-04
2	.48676891E+00
3	.18797035E-04
4	.50000716E-03

R.M.S. RESPONSES

1	.67905385E-04
2	.88325398E-04
3	.18797035E-04
4	.65799636E-04
5	.12208759E+00
6	.72870834E-04

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Continued)

TOTAL RESPONSE COVARIANCE MATRIX

ROW 1	.46111E-08	.49578E-08	-.11033E-08	.72035E-09	-.74764E-05	-.21240E-09
ROW 2	.49578E-08	.78014E-08	-.14012E-08	.23888E-09	-.10553E-04	-.13834E-10
ROW 3	-.11033E-08	-.14012E-08	.35333E-09	.34384E-18	.20711E-05	.34025E-09
ROW 4	.72035E-09	.23888E-09	.34384E-18	.43296E-08	.29477E-06	.43762E-08
ROW 5	-.74764E-05	-.10553E-04	.20711E-05	.29477E-06	.14905E-01	.12137E-05
ROW 6	-.21240E-09	-.13834E-10	.34025E-09	.43762E-08	.12137E-05	.53102E-08

TOTAL RESPONSE CROSS-CORRELATION MATRIX

ROW 1	.10000E+01	.82661E+00	-.86434E+00	.16122E+00	-.90181E+00	-.42924E-01
ROW 2	.82661E+00	.10000E+01	-.84398E+00	.41103E-01	-.97865E+00	-.21494E-02
ROW 3	-.86434E+00	-.84398E+00	.10000E+01	.27800E-09	.90248E+00	.24840E+00
ROW 4	.16122E+00	.41103E-01	.27800E-09	.10000E+01	.36694E-01	.91268E+00
ROW 5	-.90181E+00	-.97865E+00	.90248E+00	.36694E-01	.10000E+01	.13642E+00
ROW 6	-.42924E-01	-.21494E-02	.24840E+00	.91268E+00	.13642E+00	.10000E+01

TOTAL R.M.S. RESPONSES

1	.67905385E-04
2	.88325398E-04
3	.18797035E-04
4	.65799636E-04
5	.12208759E+00
6	.72870834E-04

QUADRATIC COST = .99930792E-08

EIGENVALUES	REAL	IMAGINARY	DAMPING RATIO	FREQUENCY
	-.10000000			
	-2.12981340	2.12634262	-.70768317	3.00955779
	-12.02171321			

Figure 54. KONPACT-2 Output (Employing DIAK to Compute Optimal State Feedback Gains) for Static Elastic Design Model (See Figure 38 for KONPACT-2 Input) (Concluded)

MAXIMUM NO. OF INNER LOOP ITERATIONS = 30

MAXIMUM NO. OF OUTER LOOP ITERATIONS = 4

NOCOV = 3      NBEGIN = 1      NOPR = 1

NO. OF STATES = 4      NO. OF RESPONSES = 6

NO. OF CONTROLS = 1      NO. OF DISTURBANCES = 1

NO. OF FEEDFORWARD STATES = 1

NO. OF FIXED-FORM GAINS = 3

LOWEST COST EXPECTED(AJSTAR)

.9993E-08

STATES ARE ORDERED AS SUCH

1 2 3 4

FIXED GAINS      ROW      COLUMN

1	1
1	2
1	4

F MATRIX

ROW 1				
	-.67868E+00	.87412E+04	-.24810E+04	0.
ROW 2				
	-.18740E-03	-.11011E+01	-.12048E+02	0.
ROW 3				
	0.	0.	-.75000E+01	0.
ROW 4				
	0.	0.	0.	-.10000E+00

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input)

```
          G1 MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
.10000E+01
ROW  4
  0.

          G2 MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
  0.
ROW  4
.10000E+01

          H MATRIX

ROW  1
  0.          .10000E+01  0.          0.
ROW  2
.11310E-03  0.          0.          0.
ROW  3
  0.          0.          .10000E+01  0.
ROW  4
  0.          0.          -.75000E+01  0.
ROW  5
.20000E-06  .21000E-02  -.24810E+04  .73969E-01
ROW  6
.56880E-03  .24202E+01  -.12048E+02  .35920E-03

          D MATRIX

ROW  1
  0.
ROW  2
  0.
ROW  3
  0.
ROW  4
.10000E+01
ROW  5
  0.
ROW  6
  0.
```

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

```
PRESENT PREDICTOR -- DELK1(LAMBDA)

ROW 1
0. 0. 0. 0.

LAMBDA = .800

ITERATION 0

STEP SIZE = .10000000E+00

GAINS MATRIX

ROW 1
.311169E+01 -.95076E-03 0. .15939E+01

EIGENVALUES
REAL IMAGINARY DAMPING RATIO FREQUENCY

-.10000000
-2.15059734 2.13688926 -.70936394 3.03172634
-11.79980541

COST = .10004701E-07

GRADIENT TRANSFORMATION MATRIX

EIGENVALUES
REAL IMAGINARY DAMPING RATIO FREQUENCY

4.18723627
*06942.92723083
*13005.09111023

GRADIENT NORM = .49622850E-01

NORMALIZED GRADIENT
```

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

# Contrails

```
M MATRIX
ROW 1
-.35857E-05 .10338E+01 -.52279E-01 0.
ROW 2
-.54296E+00 .69873E+03 .62442E+04 0.
ROW 3
0. 0. .10000E+01 0.
ROW 4
0. 0. 0. .22351E-03

Q MATRIX
ROW 1
0. 0. 0. 0. 0. 0.
ROW 2
0. 0. 0. 0. 0. 0.
ROW 3
0. 0. .10000E+01 0. 0. 0.
ROW 4
0. 0. 0. .10000E+01 0. 0.
ROW 5
0. 0. 0. 0. 0. 0.
ROW 6
0. 0. 0. 0. 0. .10000E+01

MEASUREMENT MATRIX FOR FIXED FORM GAINS
ROW 1
-.35857E-05 .10338E+01 -.52279E-01 0.
ROW 2
-.54296E+00 .69873E+03 .62442E+04 0.
ROW 3
0. 0. 0. .22351E-03

OPTIMAL RICCATI GAINS
ROW 1
.50505E-03 .25579E+01 -.70016E+01 .35641E-03

INITIAL GAINS -- K1(1)
ROW 1
.31169E+01 -.95076E-03 0. .15939E+01

K2 MATRIX
ROW 1
0. 0. -.90190E+00 0.
```

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

ROW 1  
.73172E+00 -.34457E-03 0. .68160E+00

ITERATION 1

STEP SIZE = .10000000E+00

GAINS MATRIX

ROW 1  
.30437E+01 -.91631E-03 0. .15257E+01

COST = .10103211E-07

ITERATION 2

STEP SIZE = .10000000E+00

GAINS MATRIX

ROW 1  
.30803E+01 -.93353E-03 0. .15598E+01

COST = .10006006E-07

ITERATION 3

STEP SIZE = .24319639E-01

GAINS MATRIX

ROW 1  
.30991E+01 -.94238E-03 0. .15773E+01

COST = .99938133E-08

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

```
GRADIENT TRANSFORMATION MATRIX

EIGENVALUES
  REAL          IMAGINARY      DAMPING RATIO    FREQUENCY

      4.22334554
+85915.44786072
+38993.33885193

GRADIENT NORM = .56747673E-03

NORMALIZED GRADIENT

ROW 1
.88761E+00 -.23964E-03 0.          .46060E+00

ITERATION 4

STEP SIZE = .24319639E-01

GAINS MATRIX

ROW 1
.30775E+01 -.93655E-03 0.          .15661E+01

COST = .99963171E-08

ITERATION 5

STEP SIZE = .24319639E-01

GAINS MATRIX

ROW 1
.30883E+01 -.93947E-03 0.          .15717E+01

COST = .99944217E-08
```

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)



# Contrails

```
ITERATION 6

STEP SIZE = .33174557E-03

GAIN MATRIX

ROW 1
.30988E+01 -.94230E-03 0. .15772E+01

COST = .99978129E-08

GRADIENT TRANSFORMATION MATRIX

EIGENVALUES          IMAGINARY          DAMPING RATIO          FREQUENCY
  REAL
    4.22055896
*62154.56547546
*38047.32069397

RATIO OF COSTS = .9989

GRADIENT NORM = .10439977E-03

NORMALIZED GRADIENT

ROW 1
-.88391E+00 .24050E-03 0. -.46755E+00

K*(LAMBDA) FOR RESPONSE CALCULATIONS

ROW 1
.30988E+01 -.94230E-03 -.72152E+00 .15772E+01
```

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

# Contrails

## COVARIANCE ANALYSIS FOR DISTURBANCE 1

### COVARIANCE MATRIX

```
ROW 1
.60985E+00 .43834E-04 -.12387E-04 -.16770E+01
ROW 2
.43834E-04 .46124E-09 -.11033E-08 -.13809E-03
ROW 3
-.12387E-04 -.11033E-08 .35365E-09 .39850E-04
ROW 4
-.16770E+01 -.13809E-03 .39850E-04 .50000E+01
```

### R.M.S. RESPONSES

```
1 .67914617E-04
2 .88322819E-04
3 .18805485E-04
4 .65632853E-04
5 .12209592E+00
6 .73023937E-04
```

### TOTAL R.M.S. RESPONSES

```
1 .67914617E-04
2 .88322819E-04
3 .18805485E-04
4 .65632853E-04
5 .12209592E+00
6 .73023937E-04
```

### EIGENVALUES

REAL	IMAGINARY	DAMPING RATIO	FREQUENCY
-1.19000000			
-2.14993682	2.13286748	-.70991605	3.02843810
-11.74735972			

### NEW PREDICTOR

```
POK 1
-.18090E-01 .84593E-05 0. -.16729E-01
```

LAMBDA = .600

ITERATION 7

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Continued)

# Contrails

## K\*(LAMBDA) FOR RESPONSE CALCULATIONS

ROW 1  
.30264E+01 -.90847E-03 .88115E-14 .15102E+01

## COVARIANCE ANALYSIS FOR DISTURBANCE 1

### COVARIANCE MATRIX

ROW 1  
.60969E+00 .43823E-04 -.12379E-04 -.16769E+01  
ROW 2  
.43823E-04 .46179E-08 -.11037E-08 -.13807E-03  
ROW 3  
-.12379E-04 -.11037E-08 .35502E-09 .39849E-04  
ROW 4  
-.16769E+01 -.13807E-03 .39849E-04 .50000E+01

### R.M.S. RESPONSES

1 .67955011E-04  
2 .88311304E-04  
3 .18842019E-04  
4 .64980631E-04  
5 .12213247E+00  
6 .73725507E-04

### TOTAL R.M.S. RESPONSES

1 .67955011E-04  
2 .88311304E-04  
3 .18842019E-04  
4 .64980631E-04  
5 .12213247E+00  
6 .73725507E-04

### EIGENVALUES

REAL	IMAGINARY	DAMPING RATIO	FREQUENCY
-.10000000			
-10.62688367			
-2.24188055	2.16354058	-.71956724	3.11559565

### NEW PREDICTOR

ROW 1  
-.18090E-01 .84593E-05 0. -.16729E-01

Figure 55. KONPACT-2 Output (Employing FFOC to Compute Reduced Feedback Gains) for Static Elastic Design Model (See Figure 39 for KONPACT-2 Input) (Concluded)

# Contrails

TODAY'S DATE AUG 17, 75      IDENTIFICATION      J K MAHESH

TIME RESPONSES PLOTTING TIME = 5.000  
SAMPLE INTERVAL = .2000E-01  
PLOTTING SAMPLE INTERVAL = .2000  
FIRST DELAY TIME = 0.  
SECOND DELAY TIME = 0.

## PLOTTING VARIABLES

RESPONSE NUMBER	RESPONSE VARIABLE	RESPONSE UNITS	MIN SCALE	MAX SCALE	SCALE FACTOR
1	Q		-0	-0	1.00
2	ALPHA		-0	-0	1.00
3	DELTA E		-0	-0	1.00

MAX NUMBER OF INNER-LOOP ITERATIONS 40    MAX NUMBER OF OUTER-LOOP ITERATIONS 30  
MAX NUMBER OF ITERATIONS ON ELIMINATING CONTROL SURFACE FEEDBACKS 4

NEW PROBLEM WITH INPD = 1    INPK = 1    NCONT = 1  
NOCOV = 3  
NSTEP = 0    NRAND = 0  
NPRIN = 0    NPLOT = 0

FLIGHT CONDITION 45                      RUN 1

ORDER OF SYSTEM = 4  
NUMBER OF RESPONSES = 6  
NUMBER OF CONTROLS = 1  
NUMBER OF DISTURBANCE INPUTS = 1  
NUMBER OF FEEDBACK STATES = 4  
NUMBER OF GUST INPUTS = 0  
NUMBER OF COMMAND STATES = 0  
NUMBER OF GUST LIFT GROWTH STATES = 0  
CONTROL RATE RESPONSES START WITH RESPONSE 7

STATES ARE ORDERED AS

1   2   3   4

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input)

```
F MATRIX  
  
ROW 1  
-.67868E+00 .87412E+04 -.24810E+04 0.  
ROW 2  
-.18740E-03 -.11011E+01 -.12048E+02 0.  
ROW 3  
0. 0. -.75000E+01 0.  
ROW 4  
0. 0. 0. -.10000E+00
```

```
G1 MATRIX  
  
ROW 1  
0.  
ROW 2  
0.  
ROW 3  
.10000E+01  
ROW 4  
0.
```

```
G2 MATRIX  
  
ROW 1  
0.  
ROW 2  
0.  
ROW 3  
0.  
ROW 4  
.10000E+01
```

```
INITIAL CONDITION MATRIX  
  
ROW 1  
0.  
ROW 2  
0.  
ROW 3  
0.  
ROW 4  
0.
```

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input) (Continued)

## STATE LIMIT - RATE LIMIT MATRIX

```
ROW 1
.10000E+20 .10000E+20
ROW 2
.10000E+20 .10000E+20
ROW 3
.10000E+20 .10000E+20
ROW 4
.10000E+20 .10000E+20
```

## COMMAND LEVEL MATRIX

```
ROW 1
.44716E+ 4
```

## H MATRIX

```
ROW 1
0. .10000E+01 0. 0.
ROW 2
.11310E-03 0. 0. 0.
ROW 3
0. 0. .10000E+01 0.
ROW 4
0. 0. -.75000E+01 0.
ROW 5
.20000E-06 .21000E-02 -.24810E+04 .73969E-01
ROW 6
.56880E-03 .24202E+01 -.12048E+02 .35920E-03
```

## D MATRIX

```
ROW 1
0.
ROW 2
0.
ROW 3
0.
ROW 4
.10000E+01
ROW 5
0.
ROW 6
0.
```

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input) (Continued)

M MATRIX

ROW	1				
		-.35857E-5	.10338E+01	-.52279E-01	0.
ROW	2				
		-.54296E+00	.69873E+03	.62442E+04	0.
ROW	3				
		0.		.10000E+01	0.
ROW	4				
		0.	0.		.22361E-03

INPUT GAINS MATRIX

ROW	1				
		.31169E+1	-.95075E-03	-.90191E+00	.15939E+01

QUADRATIC WEIGHTING MATRIX

ROW	1					
		0.	0.	0.	0.	0.
ROW	2					
		0.	0.	0.	0.	0.
ROW	3					
		0.	0.	0.	0.	0.
ROW	4					
		0.	0.	0.	0.	0.
ROW	5					
		0.	0.	0.	0.	0.
ROW	6					
		0.	0.	0.	0.	0.

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input) (Continued)

# Contrails

## AIRCRAFT RESPONSES WITH PRESCRIBED GAINS

### TIME RESPONSES

AUG 17, 75

J K MAHESH

FLIGHT CONDITION 45

RUN 1

THERE ARE 3 RESPONSES TO COMPUTE

### TIME RESPONSES FOR DISTURBANCE 1

TIME =	0.000				
Q	= 0.	ALPHA	= 0.	DELTA E	= .48E-01
TIME =	.200				
Q	= -.17	ALPHA	= -.21E-01	DELTA E	= .81E-01
TIME =	.400				
Q	= -.27	ALPHA	= -.64E-01	DELTA E	= .52E-01
TIME =	.600				
Q	= -.28	ALPHA	= -.11	DELTA E	= .32E-01
TIME =	.800				
Q	= -.24	ALPHA	= -.15	DELTA E	= .24E-01
TIME =	1.000				
Q	= -.20	ALPHA	= -.17	DELTA E	= .23E-01
TIME =	1.200				
Q	= -.16	ALPHA	= -.18	DELTA E	= .25E-01
TIME =	1.400				
Q	= -.13	ALPHA	= -.19	DELTA E	= .29E-01
TIME =	1.600				
Q	= -.11	ALPHA	= -.19	DELTA E	= .32E-01
TIME =	1.800				
Q	= -.11	ALPHA	= -.18	DELTA E	= .34E-01
TIME =	2.000				
Q	= -.11	ALPHA	= -.18	DELTA E	= .35E-01
TIME =	2.200				
Q	= -.11	ALPHA	= -.18	DELTA E	= .35E-01
TIME =	2.400				
Q	= -.11	ALPHA	= -.18	DELTA E	= .35E-01

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input) (Continued) (See Figure 33 for On-Line Time History Plots)



# Contrails

TIME =	2.600	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	2.800	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	3.000	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	3.200	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	3.400	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	3.600	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	3.800	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	4.000	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	4.200	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	4.400	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	4.600	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	4.800	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				
TIME =	5.000	ALPHA	= -.18	DELTA E	= .35E-01
Q	= -.11				

Figure 56. KONPACT-2 Output (Employing DIAK to Evaluate Time Responses to Elevator Command) for Static Elastic Design Model (See Figure 40 for KONPACT-2 Input) (Continued) (See Figure 33 for On-Line Time History Plots)

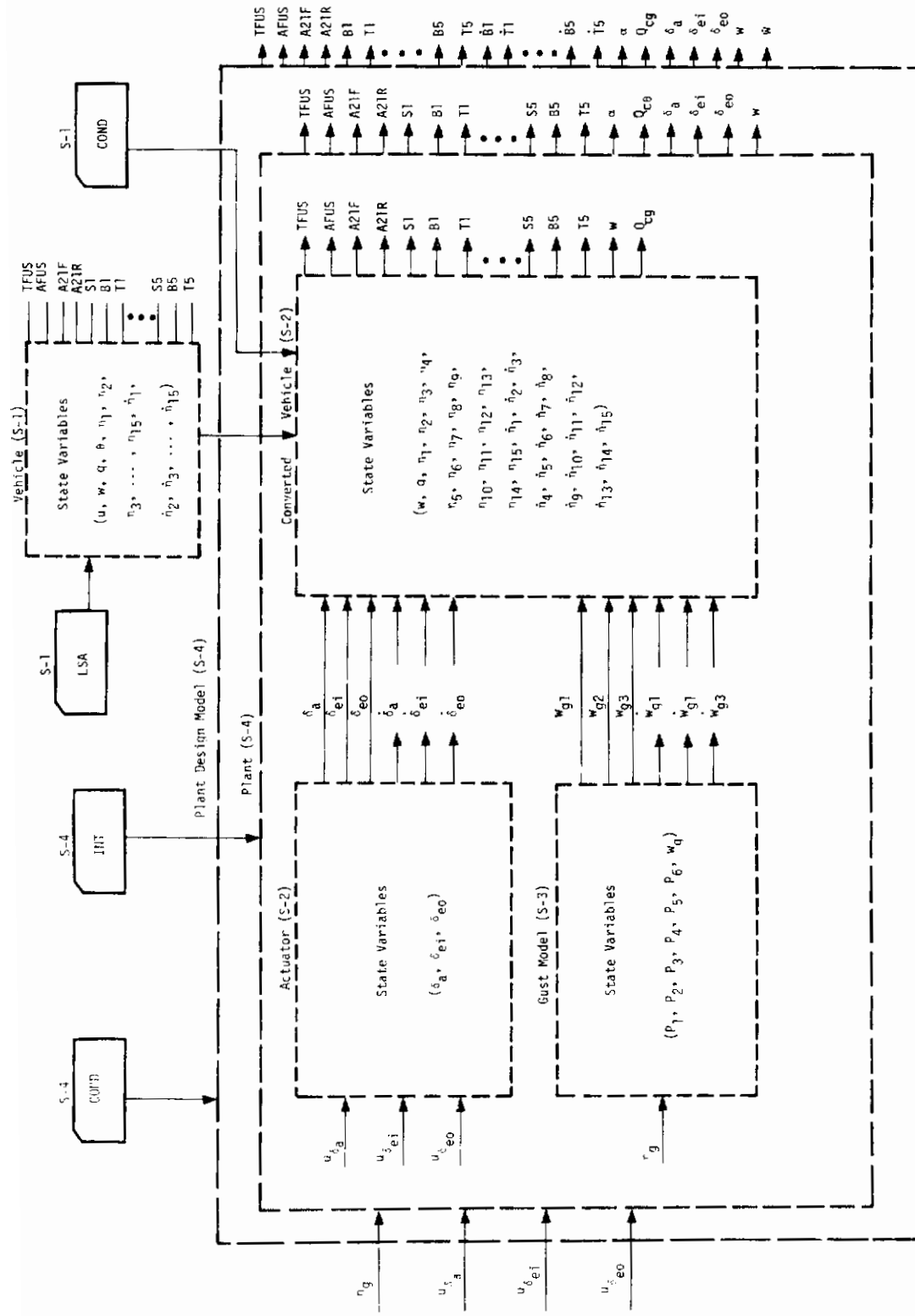


Figure 57a. Design Model Generation for ALDCS Controller Design (C-5A Cruise Flight Condition)

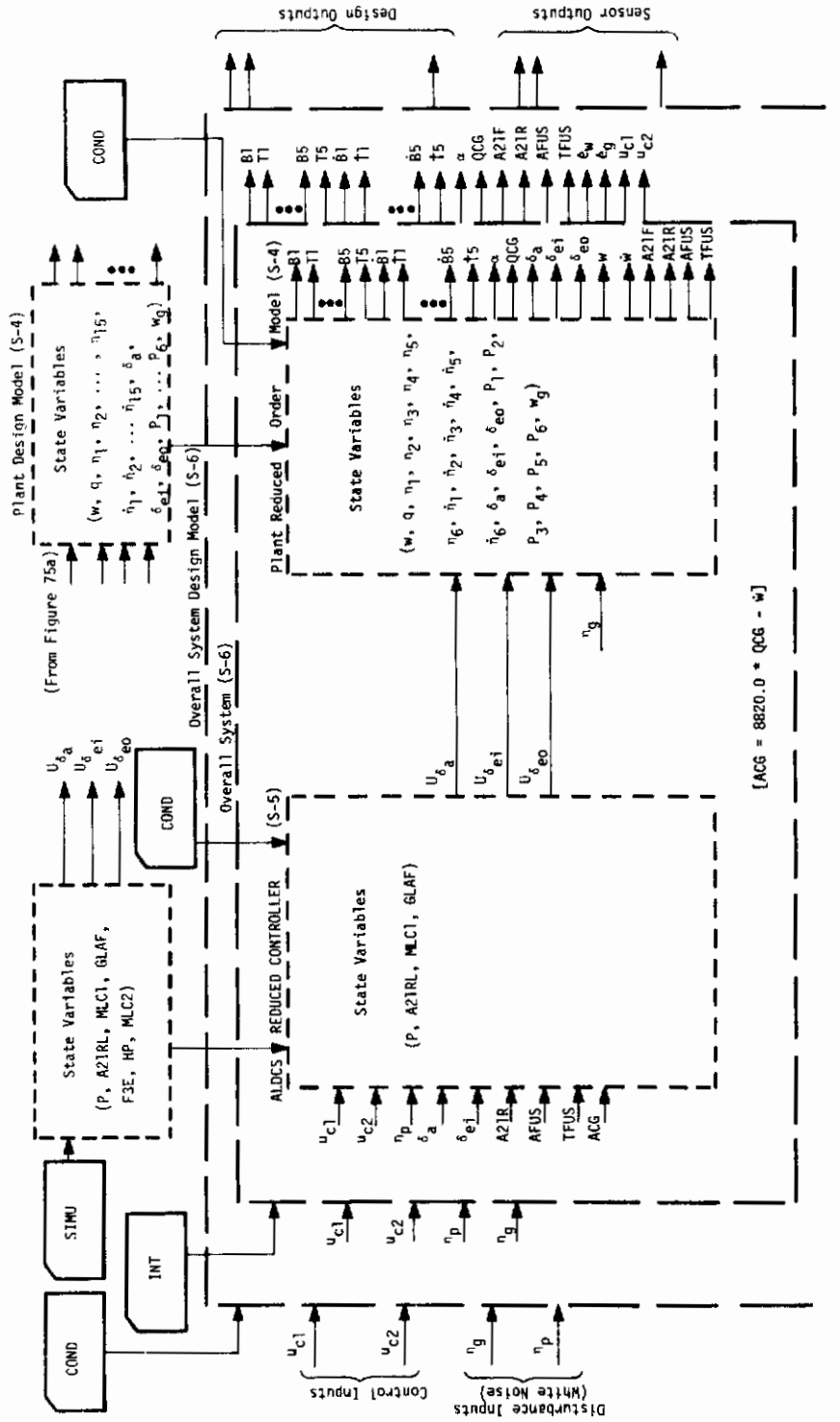


Figure 57b. Design Model Generation for ALDCS Controller Design (C-5A Cruise Flight Condition)

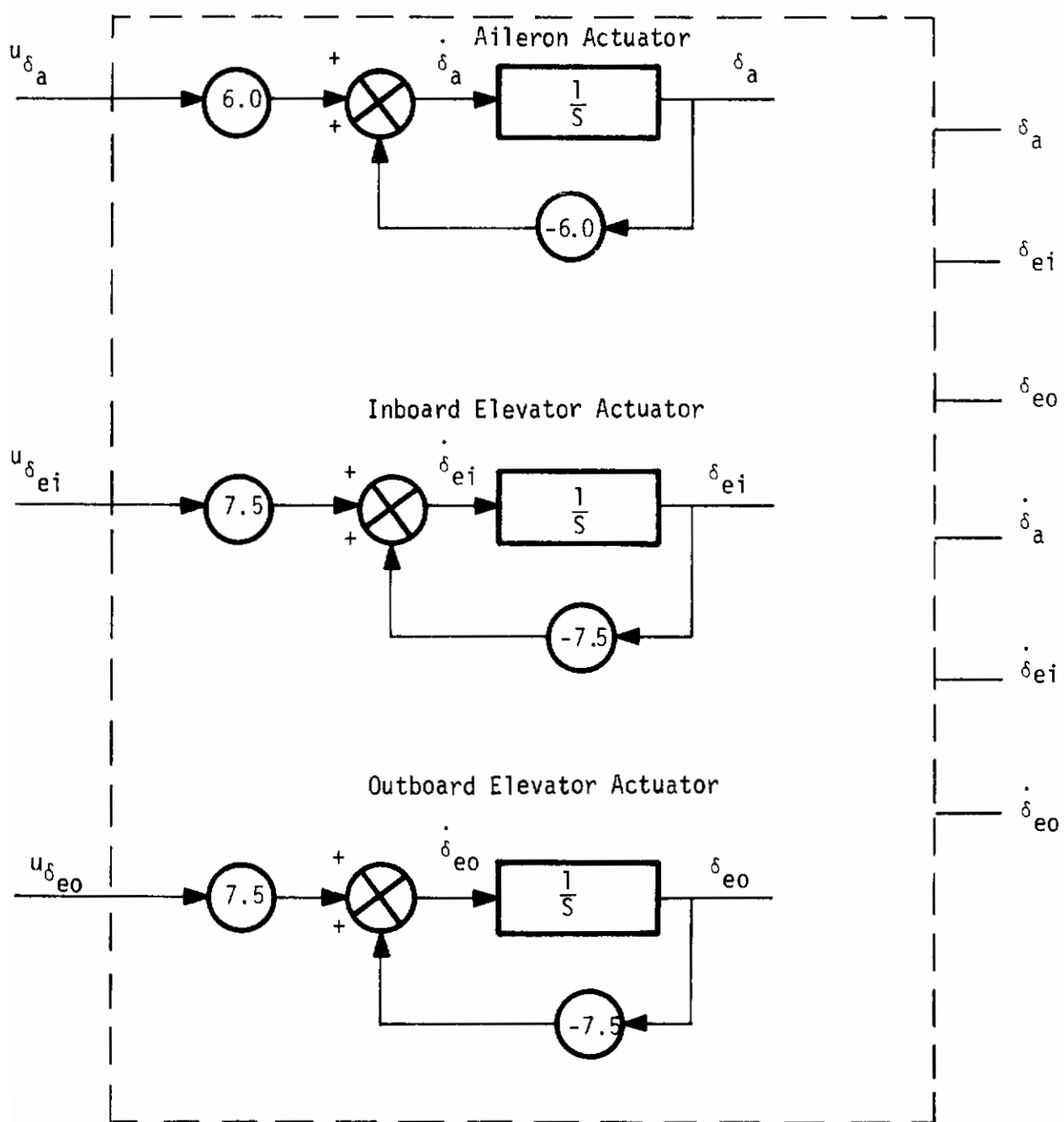


Figure 58. Actuator Block Diagram

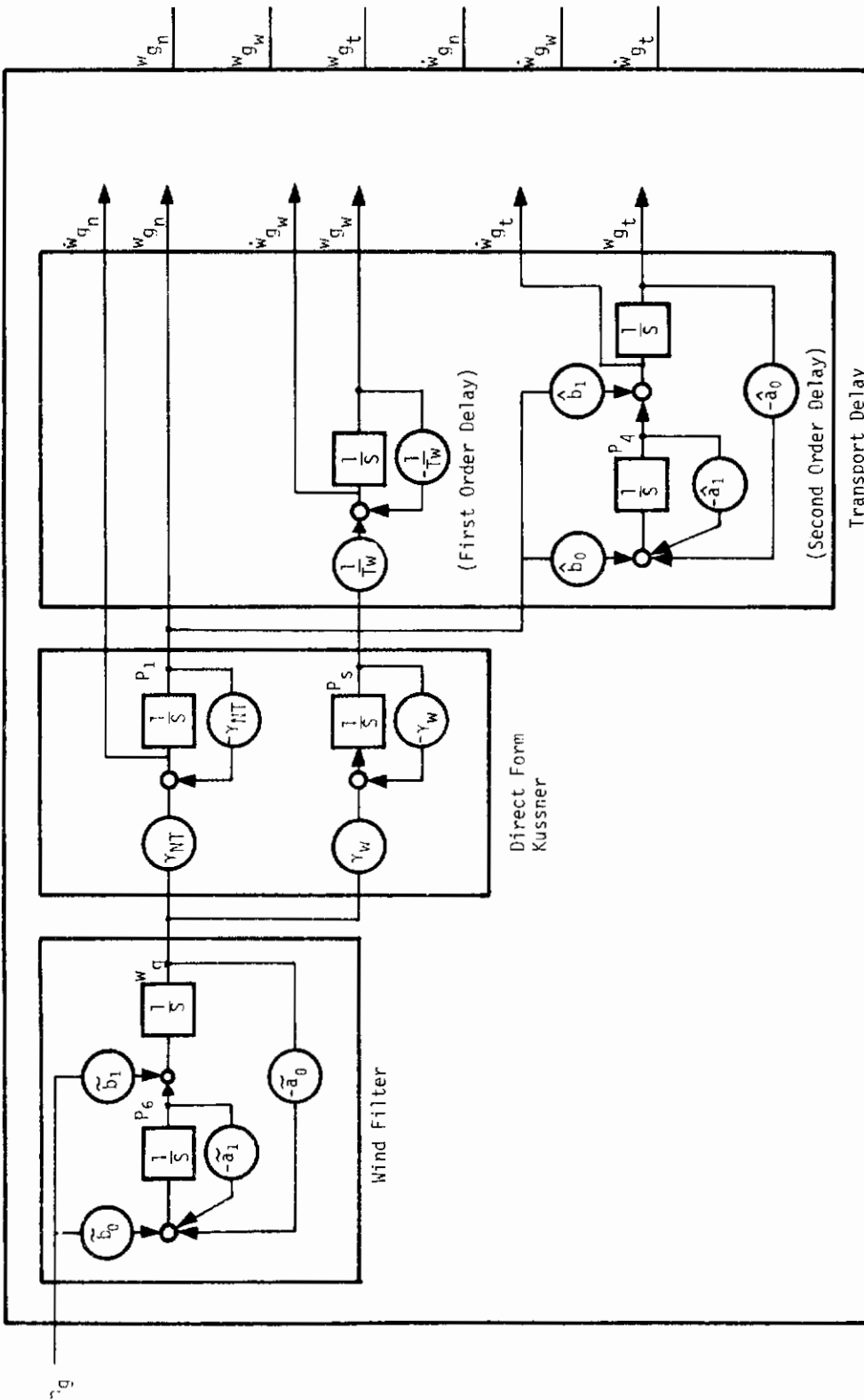


Figure 59. Gust Model Block Diagram

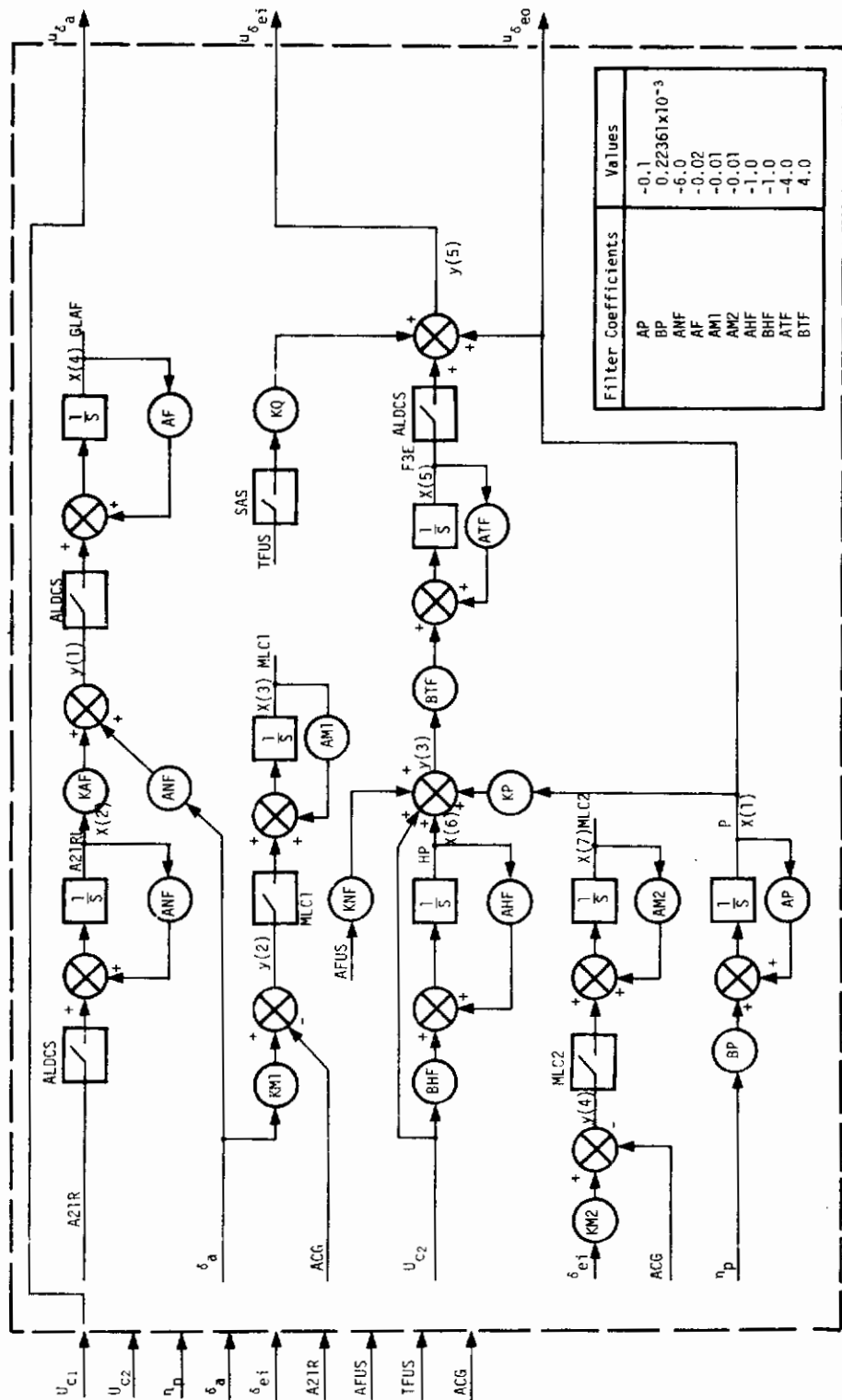


Figure 60. ALDCS Controller Block Diagram

# Contrails

```

SUBROUTINE SIMK2(XDOT,Y,X,U,XDOTL,YL,RL,NX,NY,NR,NU,INIT,T)      SIMK2  2
C                                                                    SIMK2  3
C PURPOSE - TO IMPLEMENT SIMULATION EQUATIONS FOR CSA CONTROLLER  SIMK2  4
C ANALYSIS - A F KONAR / J K MAMESH - THE HONEYWELL INC          SIMK2  5
C DATE WRITTEN - 1975                                           SIMK2  6
C                                                                    SIMK2  7
C ARGUMENTS LIST                                                SIMK2  8
C   XDOT      ARRAY FOR STATE DERIVATIVES                       SIMK2  9
C   Y         ARRAY FOR Y EQUATIONS                             SIMK2 10
C   X         ARRAY FOR STATES                                 SIMK2 11
C   U         ARRAY FOR EXTERNAL INPUTS                       SIMK2 12
C   XDOTL     OUTPUT     ARRAY FOR DERIVATIVE OF STATE        SIMK2 13
C   YL        OUTPUT     ARRAY FOR Y EQUATION VARIABLES        SIMK2 14
C   RL        OUTPUT     ARRAY FOR EXTERNAL RESPONSE VARIABLES SIMK2 15
C   NX        OUTPUT     NUMBER OF STATES                     SIMK2 16
C   NY        OUTPUT     NUMBER OF Y EQUATIONS                 SIMK2 17
C   NR        OUTPUT     NUMBER OF OUTPJTS                     SIMK2 18
C   NU        OUTPUT     NUMBER OF INPUTS                      SIMK2 19
C   INIT      INPUT      INITIAL MODE FLAG                     SIMK2 20
C   T         OUTPUT     SAMPLE TIME                           SIMK2 21
C                                                                    SIMK2 22
C   DIMENSION XDOT(NX),Y(NY),X(NX),U(NU),XDOTL(NX),YL(NY),RL(NR) SIMK2 23
C   COMMON /INOUT/ IR,IW,IPRINT,INSERT,LOCATE,NULL,MARK(20),JN,JQ,JS SIMK2 24
C   DIMENSION CARD(20)                                          SIMK2 25
C   REAL KM1,KM2,KAF,KQ,KP,KNF,MLC1,MLC2                       SIMK2 26
C   DATA HENDB,HWITC,MAINB/4HEND ,4HWITC,4HAIN /              SIMK2 27
C   DATA HMLC1,HMLC2,HSASB,HALDC/4HMLC1,4HMLC2,4HSAS ,4HALDC/ SIMK2 28
C   DATA HKM1B,HKM2B,HKAFB,HKQBR/4HKM1 ,4HKM2 ,4HKAF ,4HKQ /  SIMK2 29
C   DATA HKPBB,HKNFB/4HKP ,4HKNF /                             SIMK2 30
C                                                                    SIMK2 31
C   CHECK IF INITIALIZATION MODE                                SIMK2 32
C                                                                    SIMK2 33
C   IF(INIT.NE.0) GO TO 100                                     SIMK2 34
C                                                                    SIMK2 35
C   SET FILTER GAINS                                           SIMK2 36
C                                                                    SIMK2 37
C   AP=-.1 $ BP=.22361E-03                                     SIMK2 38
C   ANF=-6.0                                                  SIMK2 39
C   AF=-.02                                                  SIMK2 40
C   AM1=-.01                                                 SIMK2 41
C   AM2=-.01                                                 SIMK2 42
C   AHF=-1. $ BHF=-1.                                        SIMK2 43
C   ATF=-4.0 $ BTF=4.0                                       SIMK2 44
C                                                                    SIMK2 45
C   SET CONTROLLER SWITCHES                                    SIMK2 46
C                                                                    SIMK2 47
C   SAS=0.0 $ ALDCS=0.0 $ MLC1=0.0 $ MLC2=0.0               SIMK2 48
C                                                                    SIMK2 49
C   SET CONTROLLER GAINS                                       SIMK2 50
C                                                                    SIMK2 51
C   KM1=1.0/0.26                                             SIMK2 52
C   KM2=1.0/0.05591                                         SIMK2 53
C   KAF=36.0*0.26                                           SIMK2 54
C   KQ=0.5                                                  SIMK2 55
C   KP=0.7068                                               SIMK2 56
C   KNF=-0.09                                              SIMK2 57
C                                                                    SIMK2 58
C   READ CONTROLLER SWITCHES ON AND CONTROLLER GAIN VALUES  SIMK2 59
C                                                                    SIMK2 60
C   10 CONTINUE                                              SIMK2 61
C   READ(IR,20)CARD                                          SIMK2 62
C   20 FORMAT(20A4)                                          SIMK2 63
C   IF(CARD(1).EQ.HENDR)GO TO 80                             SIMK2 64

```

Figure 61. Subroutine SIMK2 Program Listing

# Contrails

```

      IF(CARD(4).NE.HWITC)GO TO 40
C
C      READ CONTROLLER SWITCHES ON
C
30  CONTINUE
      READ(IR,20)CARD
      IF(CARD(1).EQ.HENDR)GO TO 10
      IF(CARD(1).EQ.HMLC1)MLC1=1.0
      IF(CARD(1).EQ.HMLC1)GO TO 30
      IF(CARD(1).EQ.HMLC2)MLC2=1.0
      IF(CARD(1).EQ.HMLC2)GO TO 30
      IF(CARD(1).EQ.HSASR)SAS=1.0
      IF(CARD(1).EQ.HSASR)GO TO 30
      IF(CARD(1).EQ.HALDC1)ALDCS=1.0
      IF(CARD(1).EQ.HALDC1)GO TO 30
      IF(CARD(1).EQ.HALDC2)GO TO 30
      STOP 111
C
C      READ CONTROLLER GAIN VALUES
C
C
40  CONTINUE
      IF(CARD(4).NE.HAINR)STOP 111
50  CONTINUE
      READ(IR,20)CARD
      IF(CARD(1).EQ.HENDR)GO TO 10
      IF(CARD(1).EQ.HKM1R)READ(IR,60)KM1
60  FORMAT(E12.6)
      IF(CARD(1).EQ.HKM1R)GO TO 50
      IF(CARD(1).EQ.HKM2R)READ(IR,60)KM2
      IF(CARD(1).EQ.HKM2R)GO TO 50
      IF(CARD(1).EQ.HKAFR)READ(IR,60)KAF
      IF(CARD(1).EQ.HKAFR)GO TO 50
      IF(CARD(1).EQ.HKQBR)READ(IR,60)KQ
      IF(CARD(1).EQ.HKQBR)GO TO 50
      IF(CARD(1).EQ.HKPBR)READ(IR,60)KP
      IF(CARD(1).EQ.HKPBR)GO TO 50
      IF(CARD(1).EQ.HKNFR)READ(IR,60)KNF
      IF(CARD(1).EQ.HKNFR)GO TO 50
      STOP 111
80  CONTINUE
C
C      SET DIMENSIONS OF SYSTEM
C
C      NX=7 $ NR=3 $ NU=9 $ NY=5
C
C      RETURN
C
C      RETURN
C
C      SIMULATION EQUATIONS
C
100 CONTINUE
C
C      DIFFERENTIAL EQUATIONS
C
      XDOTL(1)=AP*X(1)+BP*U(3)
      XDOTL(2)=ANF*X(2)+ALDCS*U(6)
      XDOTL(3)=AM1*X(3)+MLC1*Y(2)
      XDOTL(4)=AF*X(4)+ALDCS*Y(1)
      XDOTL(5)=ATF*X(5)+RTF*Y(3)
      XDOTL(6)=AMF*X(6)+RMF*U(2)
      XDOTL(7)=AM2*X(7)+MLC2*Y(4)
C
C      SUMMING POINT EQUATIONS
C
      YL(1)=KAF*X(2)+ANF*U(4)
      YL(2)=KM1*U(4)-U(9)

```

```

SIMK2 65
SIMK2 66
SIMK2 67
SIMK2 68
SIMK2 69
SIMK2 70
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SIMK2 72
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SIMK2118
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SIMK2120
SIMK2121
SIMK2122
SIMK2123
SIMK2124
SIMK2125
SIMK2126
SIMK2127
SIMK2128
SIMK2129
SIMK2130

```

Figure 61. Subroutine SIMK2 Program Listing (Continued)



```
YL(3)=KP*X(1)+X(6)+U(2)+KNF*U(7)      SIMK2131
YL(4)=KM2*U(5)-U(9)                    SIMK2132
YL(5)=ALDCS*X(5)+X(1)+SAS*KQ*U(8)      SIMK2133
C                                         SIMK2134
C RESPONSE EQUATIONS                     SIMK2135
C                                         SIMK2136
RL(1)=U(1)                              SIMK2137
RL(2)=Y(5)                              SIMK2138
RL(3)=X(1)                              SIMK2139
C                                         SIMK2140
C RETURN                                 SIMK2141
C                                         SIMK2142
RETURN                                    SIMK2143
END                                        SIMK2144
```

Figure 61. Subroutine SIMK2 Program Listing (Concluded)

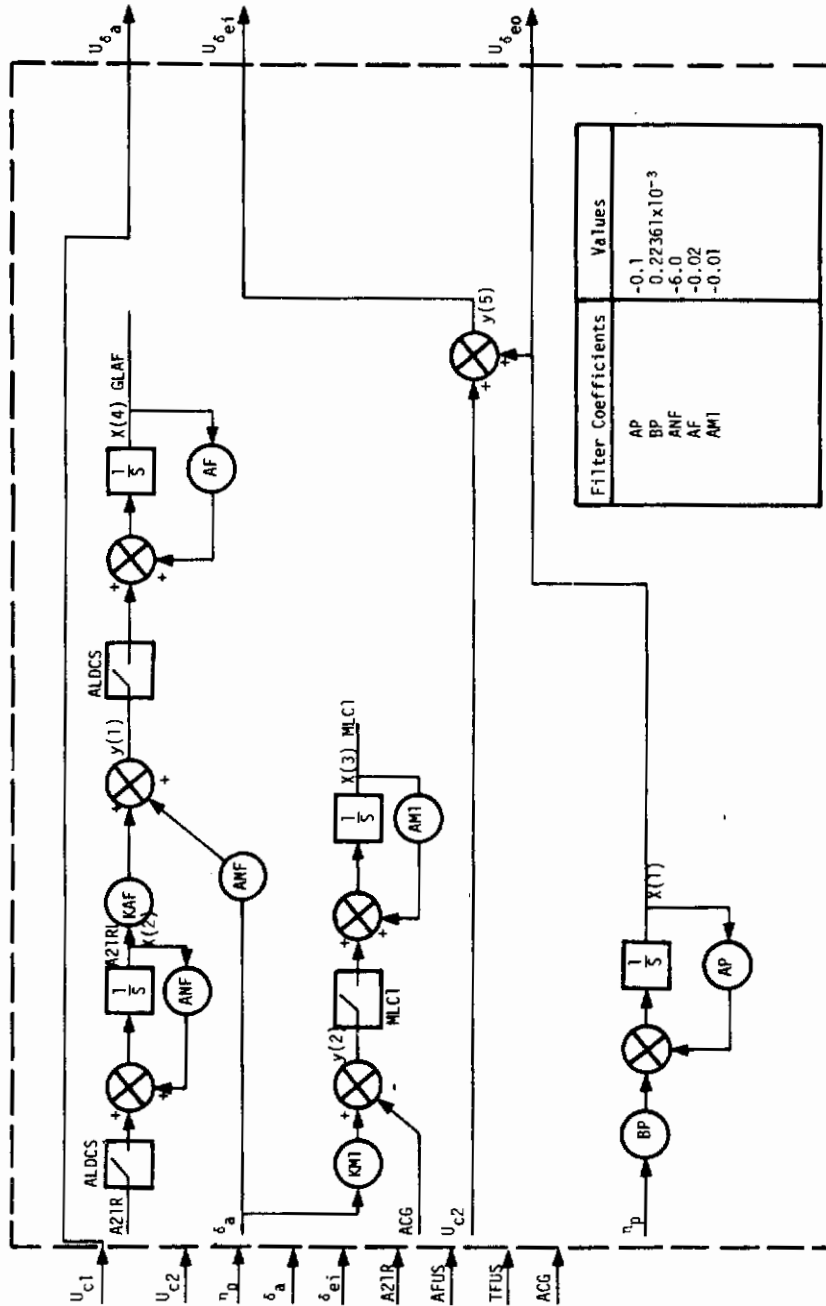


Figure 62. Reduced ALDCS Controller Block Diagram

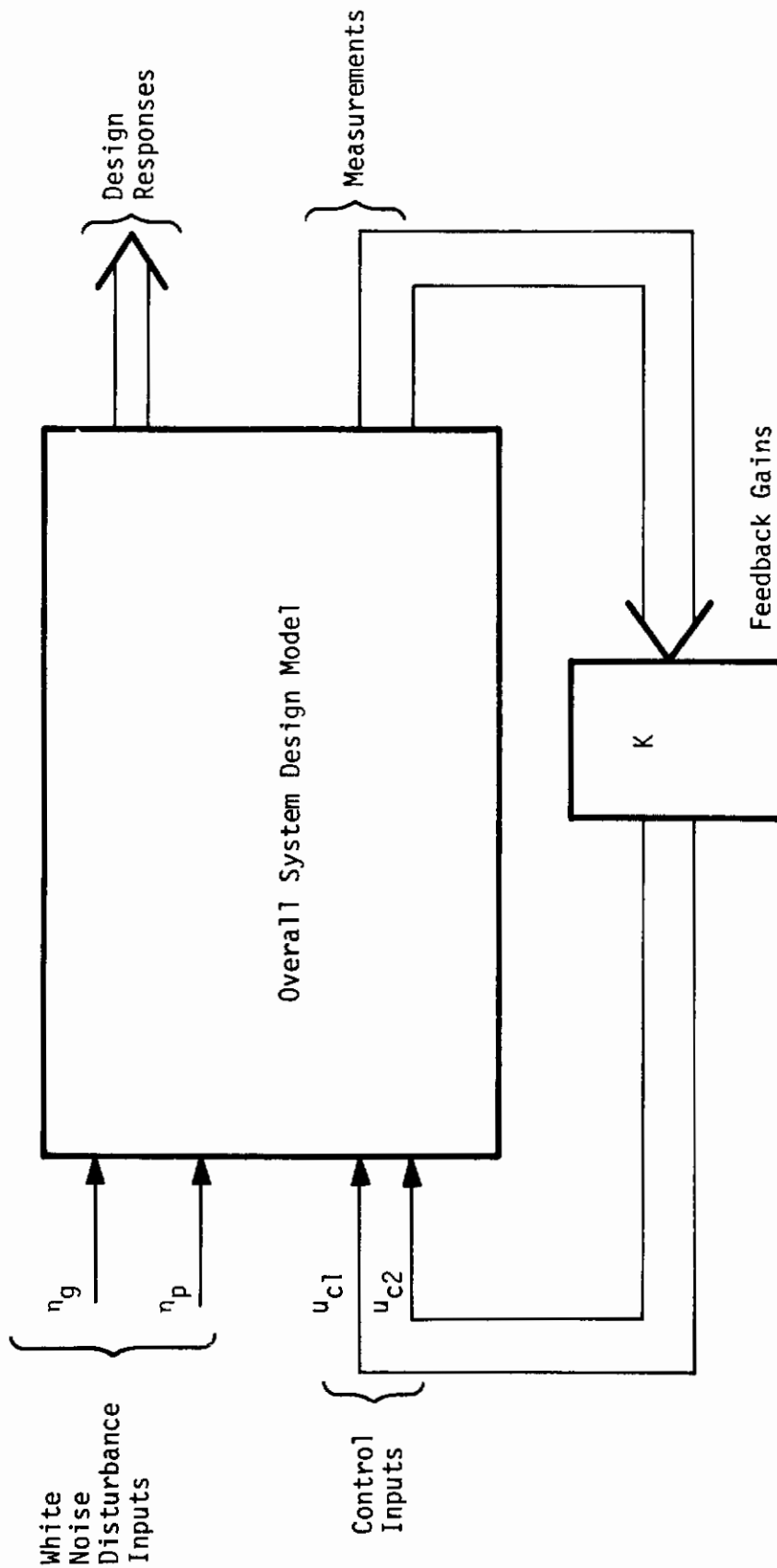


Figure 63. Procedure for ALDCS Controller Design

Response	Weight	Value
MLC1	$Q_1$	0.800E+01
B1	$Q_2$	0.100E-01
T1	$Q_3$	0.100E-08
$q_s$	$Q_4$	0
$B_2$	$Q_5$	0
$T_2$	$Q_6$	0
$\dot{\delta}_a$	$Q_7$	0.500E+04
$B_3$	$Q_8$	0
$T_3$	$Q_9$	0
$\dot{\delta}_{ei}$	$Q_{10}$	0.600E+06
$B_4$	$Q_{11}$	0
$T_4$	$Q_{12}$	0
$\delta_a$	$Q_{13}$	0
$B_5$	$Q_{14}$	0
$T_5$	$Q_{15}$	0
$\delta_{ei}$	$Q_{16}$	0
$\dot{B}_1$	$Q_{17}$	0.750E-13
$\dot{T}_1$	$Q_{18}$	0.100E-10
$\dot{\eta}_1$	$Q_{19}$	0

Figure 64. Design Response Weights for ALDCS Controller Design (C-5A Cruise Flight Condition)

Response	Weight	Value
$\dot{B}_2$	$Q_{20}$	0.100E-13
$\dot{T}_2$	$Q_{21}$	0.100E-11
$\dot{\eta}_2$	$Q_{22}$	0
$\dot{B}_3$	$Q_{23}$	0.200E-13
$\dot{T}_3$	$Q_{24}$	0.200E-11
$\dot{\eta}_3$	$Q_{25}$	0
$\dot{B}_4$	$Q_{26}$	0.800E-13
$\dot{T}_4$	$Q_{27}$	0.100E-10
$\dot{\eta}_4$	$Q_{28}$	0
$\dot{B}_5$	$Q_{29}$	0.200E-12
$\dot{T}_5$	$Q_{30}$	0.200E-10
$\dot{\eta}_5$	$Q_{31}$	0
$\dot{\eta}_6$	$Q_{32}$	0
$\dot{e}_w$	$Q_{33}$	0.100E+01
$\dot{e}_q$	$Q_{34}$	0.100E+01
$\alpha$	$Q_{35}$	0
$u_{c1}$	$Q_{36}$	0
$u_{c2}$	$Q_{37}$	0

Figure 64. Design Response Weights for ALDCS Controller Design (C-5A Cruise Flight Condition) (Concluded)

Gains	Values
$K1_{DELA}$	-7.812
$K1_{A21RL}$	11.94
$K1_{GLAF}$	1.969
$K2_{A21R}$	0.002565
$K2_{AFUS}$	-0.06401
$K2_{TFUS}$	0.4904
$K2_P^*$	0.178

\*  $K_{2P}$  GAIN obtained by FFOC is subsequently adjusted to satisfy the steady state ALDCS requirements for  $\delta_{ei}$ .

Figure 65. Reduced Feedback Gains for ALDCS Controller Design (C-5A Cruise Flight Condition)

Association	Free		SAS		ALDCS	
	Real $\omega_n$	$\zeta$	Real $\omega_n$	$\zeta$	Real $\omega_n$	$\zeta$
$\delta, \alpha$	1.5501	0.5785	1.8495	0.7945	1.7393	0.7354
$\eta_1, \dot{\eta}_1$	5.5283	0.0892	5.5268	0.0900	3.7410	0.2501
$\eta_2, \dot{\eta}_2$	15.5911	0.0699	15.5825	0.0689	14.2402	0.1852
$\eta_3, \dot{\eta}_3$	17.2662	0.0491	17.0292	0.0450	17.2567	0.0169
$\eta_4, \dot{\eta}_4$	18.3701	0.0245	18.3543	0.0233	18.3744	0.0216
$\eta_5, \dot{\eta}_5$	19.3531	0.0315	19.3488	0.0312	19.1853	0.0324
$\eta_6, \dot{\eta}_6$	22.1171	0.0487	22.1011	0.0484	21.9848	0.0569
$\delta_a$	-6.0		-6.0		-1.2552	
$\delta_{ei}$	-7.5		-6.6171		-8.0200	
$\delta_{eo}$	-7.5		-7.5		-7.5	
A21RL	-6.0		-6.0		30.5312	0.8669
GLAF	-0.02		-0.02		30.5312	0.8669
MLCI	-0.01		-0.01		-0.01	
Pilot Filter	-0.1		-0.1		-0.1	
Gust Filter	-0.21		-0.21		-0.21	
Gust Filter	-0.21		-0.21		-0.21	
Wing Kussner	-9.156		-9.156		-9.156	
1st Order Delay	-13.427		-13.427		-13.427	
2nd Order Delay	9.802	0.8165	9.802	0.8165	9.802	0.8165
Tail Kussner	-18.493		-18.493		-18.493	

Figure 66. Eigenvalue Comparison of Open Loop, SAS, and ALDCS (Reduced Feedback) Residual Elastic Vehicle (C-5A Cruise Flight Condition)

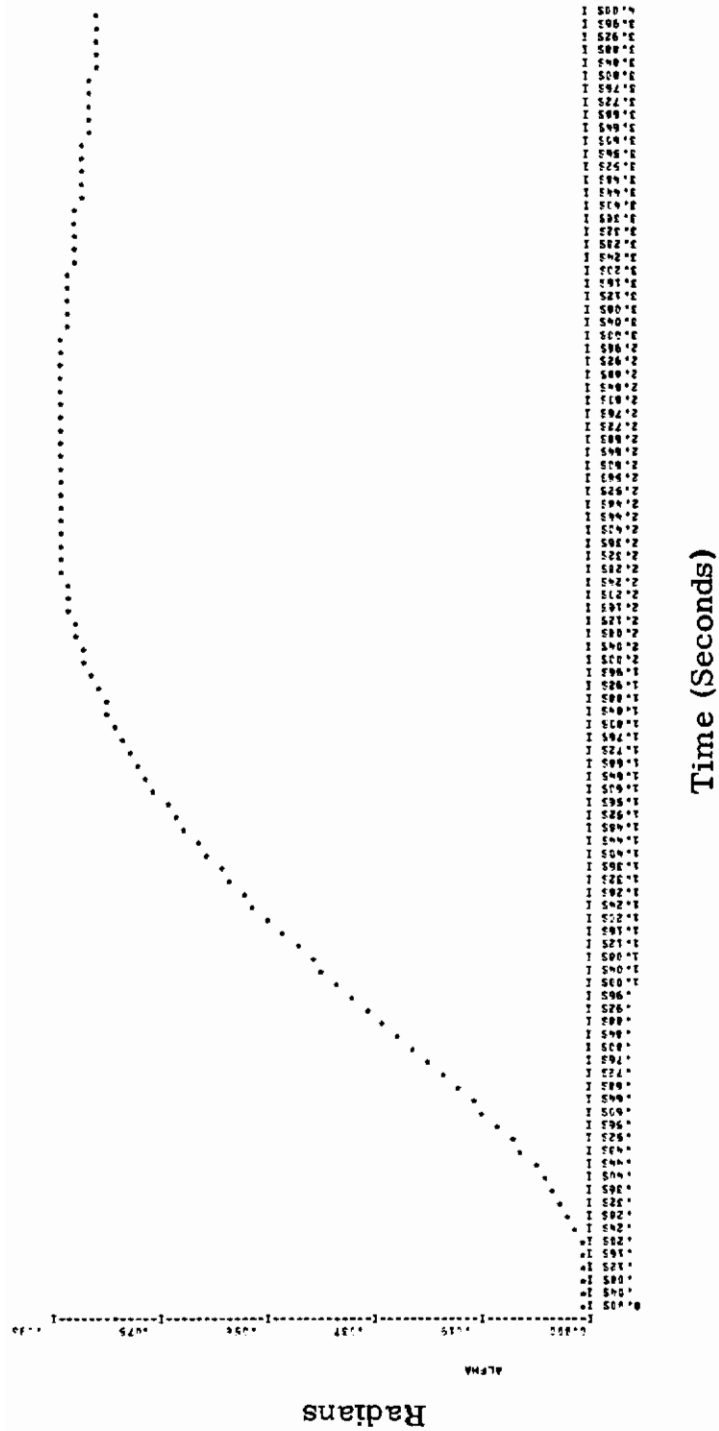
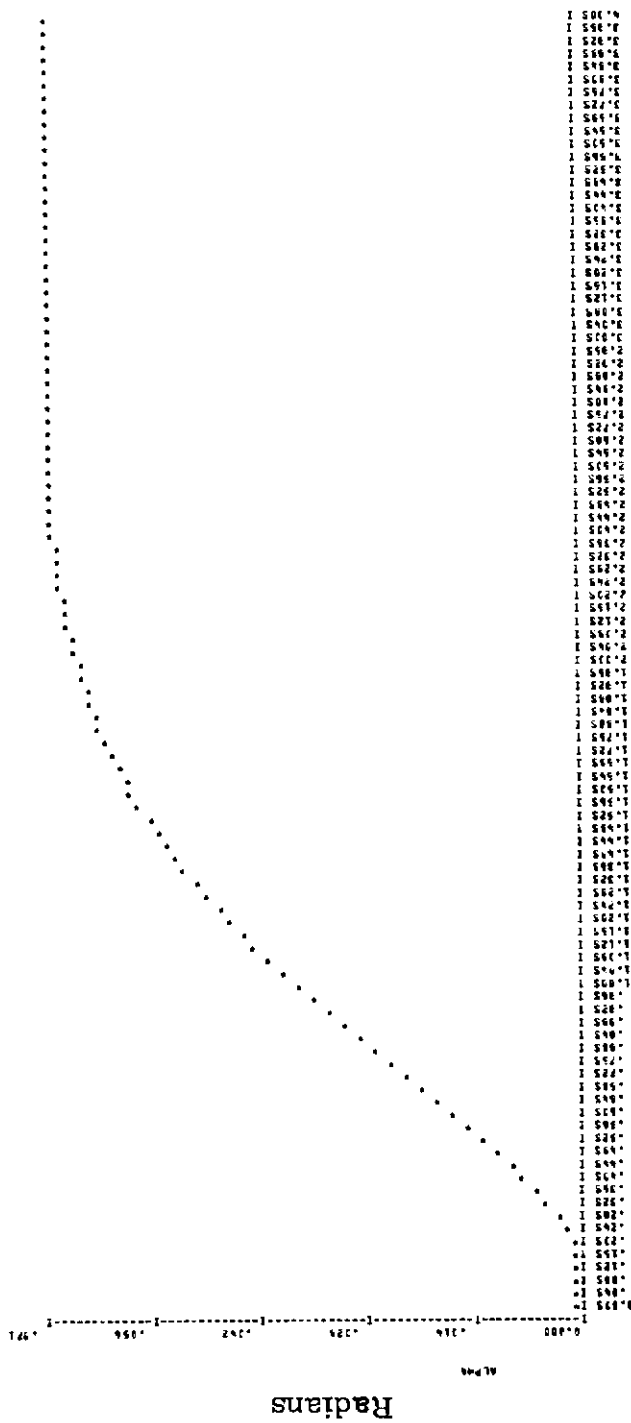


Figure 67. Alpha Response of C-5A Open Loop F24RR Model to Elevator Command





Time (Seconds)  
Figure 68. Alpha Response of C-5A SAS F24RR Model to Elevator Command

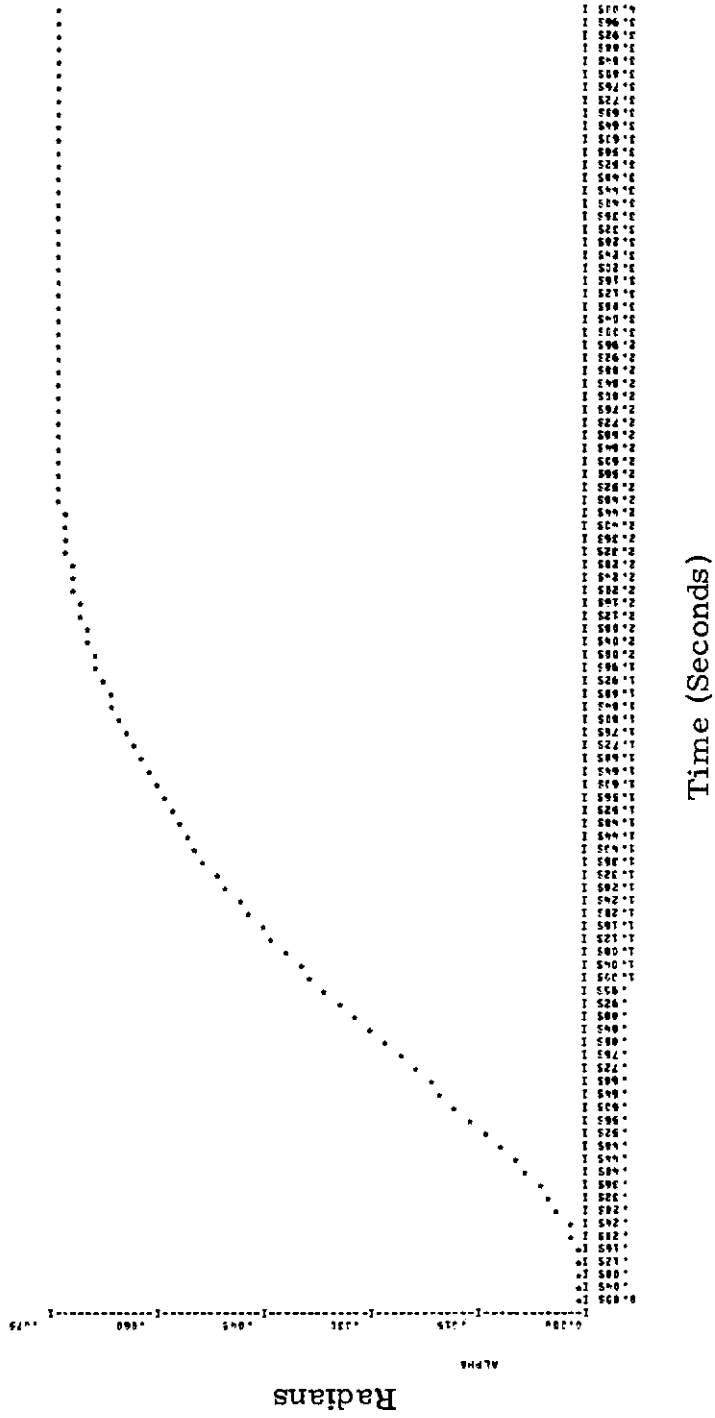


Figure 69. Alpha Response of C-5A ALDCS F24RR Model to Elevator Command

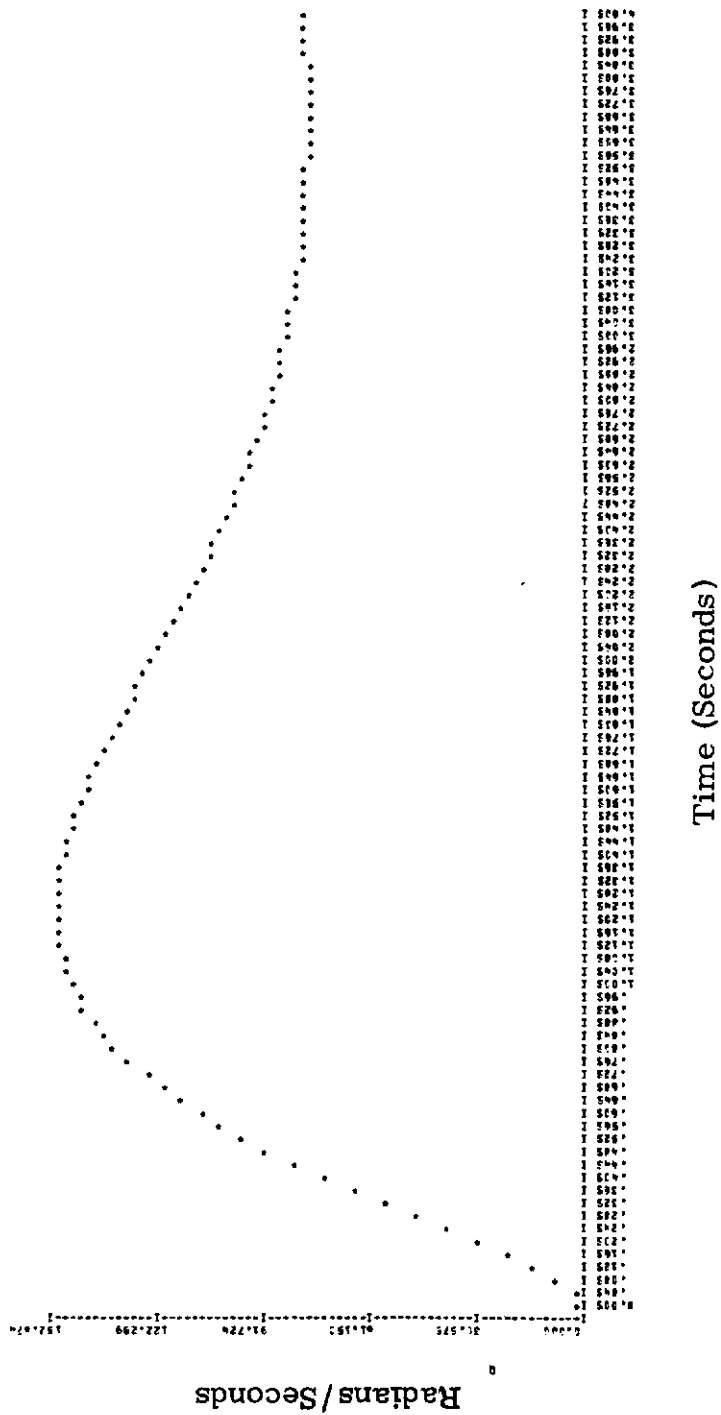


Figure 70. Pitch Rate Response of C-5A Open Loop F24RR Model to Elevator Command

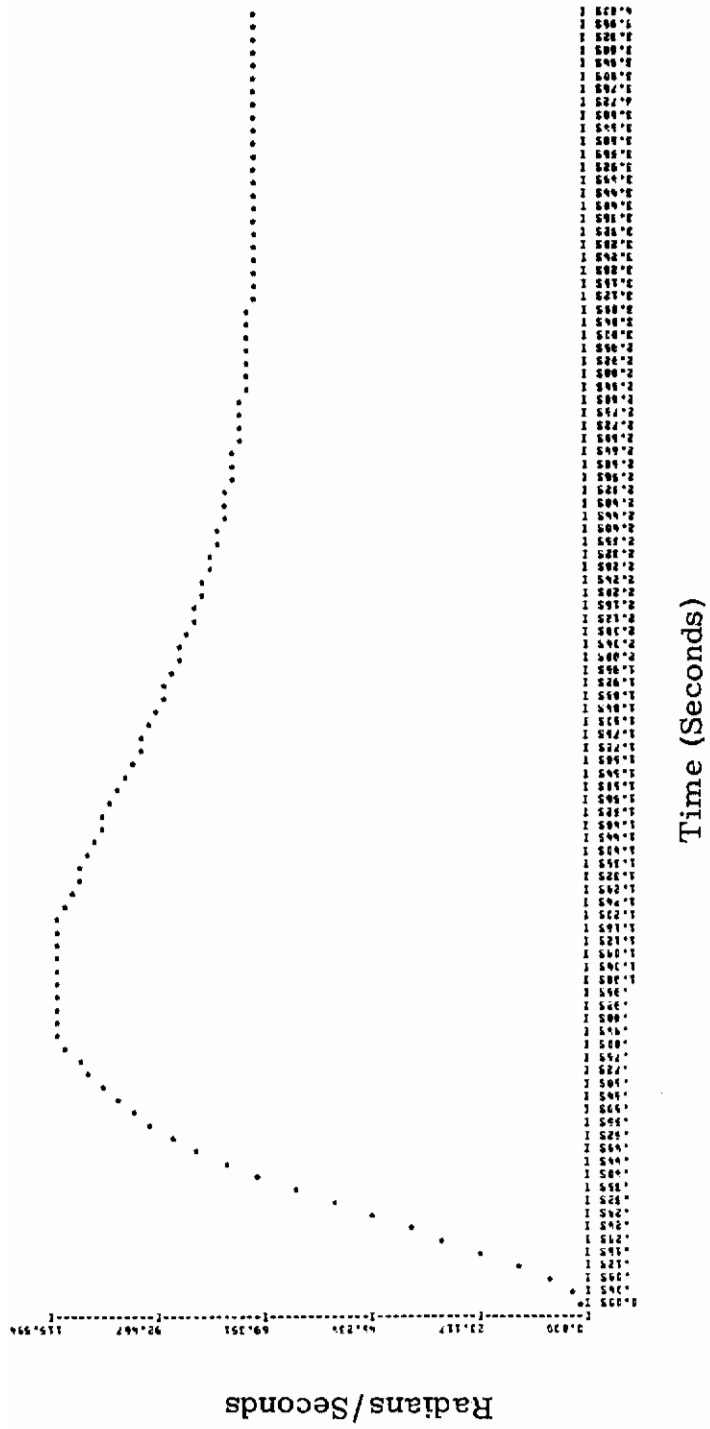


Figure 71. Pitch Rate Response of C-5A SAS F24RR Model to Elevator Command

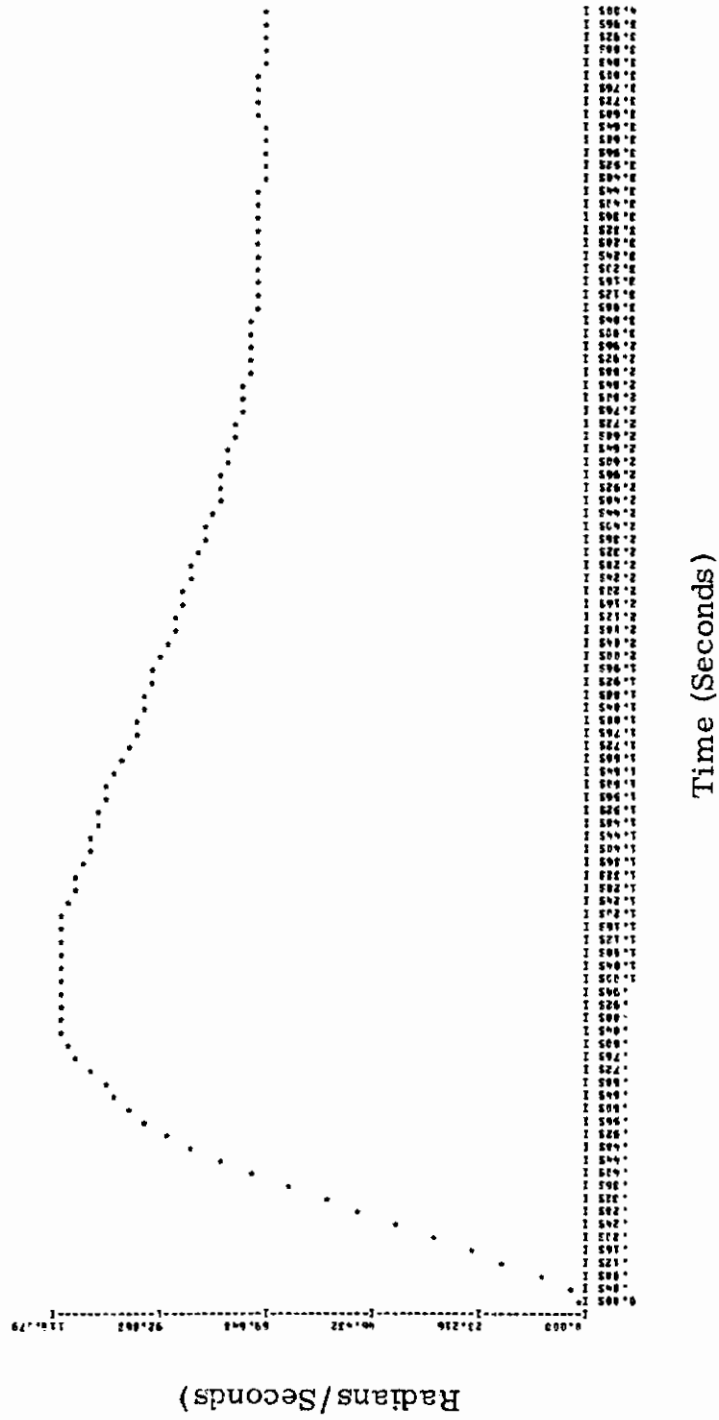


Figure 72. Pitch Rate Response of C-5A ALDCS F24RR Model to Elevator Command

VARIABLE	DESCRIPTION	UNIT	ETAG(FREE)	ETAG(ALDCS)	ETAP(FREE)	ETAP(ALDCS)
R(1)	MLC1 FULL STATE MLC FOR AILERON					
R(2)	B1 BENDING MOMENT (120.4)	INCH-LB	20356177E+02	13475114E+01	7854210E+02	7854210E+02
R(3)	T1 TORSION MOMENT (120.4)	INCH-LB	83965416E+06	5774117E+05	3461516E+09	3461516E+09
R(4)	TFUS PITCH RATE GYRO OUTPUT	NADIAN/SEC	23319730E+06	13531164E+05	1071935E+06	1071935E+06
R(5)	B2 BENDING MOMENT (329.3)	INCH-LB	76644287E+03	5633751E+03	3366796E+03	3366796E+03
R(6)	T2 TORSION MOMENT (329.3)	INCH-LB	53341243E+06	33341243E+06	2725131E+06	2725131E+06
R(7)	O/DI OF DELTA AILERON POSITION	INCH-LB / SEC	2635161E+05	55231037E+05	1192116E+05	1192116E+05
R(8)	B3 BENDING MOMENT (577.3)	INCH-LB	27366141E+14	1946111E+12	1147582E+14	1147582E+14
R(9)	T3 TORSION MOMENT (577.3)	INCH-LB	2642657E+06	1781227E+05	1327688E+06	1327688E+06
R(10)	O/DI OF DELTA INBOARD EL-AIQR	INCH-LB / SEC	2565893E+05	15734094E+05	1172009E+05	1172009E+05
R(11)	B4 BENDING MOMENT (740.3)	INCH-LB	1426210E+09	1493882E+02	4313606E+03	4313606E+03
R(12)	T4 TORSION MOMENT (740.3)	INCH-LB	3119323E+05	1533336E+06	7105913E+03	7105913E+03
R(13)	DELA AILERON POSITION	NADIAN	4561390E+15	3916726E+02	1912637E+15	1912637E+15
R(14)	B5 BENDING MOMENT (923.3)	INCH-LB	6334112E+05	39421591E+05	2915921E+05	2915921E+05
R(15)	T5 TORSION MOMENT (923.3)	INCH-LB	1145963E+05	13763592E+05	6114826E+04	6114826E+04
R(16)	DELE1 INBOARD ELEVATOR POSITION	NADIAN	2681774E+14	5932337E+03	4567678E+03	4567678E+03
R(17)	O/DI OF B1 BENDING MOMENT	INCH-LB / SEC	2914412E+07	52413061E+07	1446190E+06	1446190E+06
R(18)	O/DI OF T1 TORSION MOMENT	INCH-LB / SEC	5112844E+06	3732314E+05	3266124E+05	3266124E+05
R(19)	ETABO1 STRAIGHT BENDING MODE VELOCITY	INCH/SEC	1342287E+01	9929597E+01	5612988E+00	5612988E+00
R(20)	O/DI OF B2 BENDING MOMENT	INCH-LB / SEC	1338490E+07	1333159E+07	1171751E+05	1171751E+05
R(21)	O/DI OF T2 TORSION MOMENT	INCH-LB / SEC	1147317E+05	1337523E+05	1135283E+05	1135283E+05
R(22)	ETA2001 BENDING MODE VELOCITY	INCH/SEC	1113432E+05	1712391E+05	9813497E+01	9813497E+01
R(23)	O/DI OF B3 BENDING MOMENT	INCH-LB / SEC	6781460E+05	7533302E+06	9426978E+05	9426978E+05
R(24)	O/DI OF T3 TORSION MOMENT	INCH-LB / SEC	1312277E+05	9351154E+05	1130939E+02	1130939E+02
R(25)	ETABO2 BENDING MODE VELOCITY	INCH/SEC	1413272E+06	1813564E+06	1027344E+01	1027344E+01
R(26)	O/DI OF B4 BENDING MOMENT	INCH-LB / SEC	1062282E+09	1312535E+05	2383261E+09	2383261E+09
R(27)	O/DI OF T4 TORSION MOMENT	INCH-LB / SEC	6771219E+09	1257284E+05	6061801E+04	6061801E+04
R(28)	ETA4001 BENDING MODE VELOCITY	INCH/SEC	6714415E+01	1336452E+01	3352377E+01	3352377E+01
R(29)	O/DI OF B5 BENDING MOMENT	INCH-LB / SEC	1473192E+06	6531227E+06	1115978E+02	1115978E+02
R(30)	O/DI OF T5 TORSION MOMENT	INCH-LB / SEC	3565522E+05	1333332E+05	4174567E+04	4174567E+04
R(31)	ETA5001 BENDING MODE VELOCITY	INCH/SEC	2256705E+01	1110955E+01	2231997E+01	2231997E+01
R(32)	ETA6001 BENDING MODE VELOCITY	INCH/SEC	7247407E+01	1236073E+01	6261293E+01	6261293E+01
R(33)	EGOT IMP MODEL ERROR RATE FOR W		7867593E+01	5314393E+00	4251364E+01	4251364E+01
R(34)	EGOT IMP MODEL ERROR RATE FOR G		8965438E+01	1232377E+01	5129591E+01	5129591E+01
R(35)	ALPHA ANGLE OF ATTACK	RADIAN	1443734E+02	1643734E+02	1443734E+01	1443734E+01
R(36)	U1 AILERON OPTIMAL CONTROL INPUT		L	L	L	L
R(37)	U2 INBOARD ELEV OPTIMAL CONTROL INPUT		E	E	E	E

Figure 73. Covariance (RMS) Comparison of Open Loop and Closed Loop ALDCS (Reduced Feedback) Residual Elastic Vehicle (C-5A Cruise Flight Condition)

VARIABLE	DESCRIPTION	UNIT	F24RR (FREE)	F24RR (ALDCS)
X(1)	W HEAVE VELOCITY	INCH/SEC	-.6130E+03	-.5534E+03
X(2)	Q PITCH RATE	INCH/SEC	-.7212E+02	-.7212E+02
X(3)	ETA2001 BENDING MODE VELOCITY	INCH/SEC	-.1135E-10	-.9747E-11
X(4)	ETA2002 BENDING MODE VELOCITY	INCH/SEC	-.8497E-11	-.1443E-10
X(5)	ETA3001 BENDING MODE VELOCITY	INCH/SEC	-.2116E-10	-.1503E-10
X(6)	ETA3002 BENDING MODE VELOCITY	INCH/SEC	0.	0.
X(7)	ETA5001 BENDING MODE VELOCITY	INCH/SEC	0.	0.
X(8)	ETA5002 BENDING MODE VELOCITY	INCH/SEC	-.7336E-11	-.1233E-10
X(9)	ETA1 BENDING MODE DEFLECTION	INCH	-.7437E+03	-.1033E+03
X(10)	ETA2 BENDING MODE DEFLECTION	INCH	-.1416E+02	-.2253E+02
X(11)	ETA3 BENDING MODE DEFLECTION	INCH	-.7476E+01	-.1773E+02
X(12)	ETA4 BENDING MODE DEFLECTION	INCH	-.4614E+01	-.5915E+01
X(13)	ETA5 BENDING MODE DEFLECTION	INCH	-.4737E+01	-.9333E+01
X(14)	ETA6 BENDING MODE DEFLECTION	INCH	-.7449E+01	-.5415E+01
X(15)	DELTA AIRSPOON POSITION	RADIAN	-.1673E-14	-.2752E+00
X(16)	DELTA AIRSPOON FLAP POSITION	RADIAN	-.7377E-01	-.7272E-01
X(17)	AZ1RL LASTED NORMAL ACCELERATION	LS	-.1649E+00	-.1658E+01
X(18)	MLG1 FULL STATE W/C FOR AIRLION	LS	-.1485E+75	-.6527E+02
X(19)	SLAP 5JST LOAD ALLEVATION FILTER	LS	-.4824E+02	-.2232E+00
X(20)	DELTA OJ133430 ELEVATOR POSITION	RADIAN	-.7377E-01	-.8957E-01
X(21)	P PILOT FILTERS	FEET/SEC	0.	0.
X(22)	P1 KJSSWER STATE ( M )	FEET/SEC	0.	0.
X(23)	P2 TRANSPORT DELAY STATE ( M )	FEET/SEC	0.	0.
X(24)	P3 TRANSPORT DELAY STATE ( T )	FEET/SEC	0.	0.
X(25)	P4 TRANSPORT DELAY STATE ( T )	FEET/SEC	0.	0.
X(26)	P5 KJSSWER STATE ( M )	FEET/SEC	0.	0.
X(27)	WIND FILTER STATE	FEET/SEC	0.	0.
X(28)	WIND GUST STATE	FEET/SEC	0.	0.

Figure 74. Steady State Response Comparison of Open Loop and Closed Loop ALDCS (Reduced Feedback) Residual Elastic Vehicle (C-5A Cruise Flight Condition)

VARIABLE	DESCRIPTION	UNIT	F24RR (FRFE)	F24RR (ALDCS)
R(1)	MLD1 FJL STATE HLC FOR AILERON			
R(2)	R1 BENDING MOMENT (120.4)	IN24-LR	-1.3859E+05	.6520E+02
R(3)	R1 TORSION MOMENT (120.4)	IN24-LR		.4531E+09
R(4)	R1 PITCH RATE (323.8) DEJPT	RAD14/SEC	-1.1666E+08	-1.4774E+07
R(5)	R2 BENDING MOMENT (323.8)	IN24-LR	-4.377E+01	.4377E+01
R(6)	R2 TORSION MOMENT (323.8)	IN24-LR	-4.373E+08	-2.120E+05
R(7)	D/DT OF ( DELTA AILERON POSITION )	RAD14N	-1.596E+07	.5375E+07
R(8)	R3 BENDING MOMENT (577.3)	IN24-LR	-1.162E+13	-1.3327E+13
R(9)	R3 TORSION MOMENT (577.3)	IN24-LR	-1.942E+08	.3241E+07
R(10)	D/DT OF ( DELTA INBOARD ELEVATOR )	RAD14N	-1.1734E+07	.4433E+07
R(11)	R4 BENDING MOMENT (748.3)	IN24-LR	-1.446E+13	-1.553E+13
R(12)	R4 TORSION MOMENT (748.3)	IN24-LR	.1169E+08	-7.34E+05
R(13)	DELTA AILERON POSITION	RAD14N	.2289E+07	.5357E+07
R(14)	R5 BENDING MOMENT (323.8)	IN24-LR	.167E+14	-2.752E+07
R(15)	R5 TORSION MOMENT (323.8)	IN24-LR	-4.614E+07	-2.133E+07
R(16)	DELTA INBOARD ELEVATOR POSITION	RAD14N	.1195E+17	.3523E+17
R(17)	D/DT OF ( R1 BENDING MOMENT )	RAD14N	-1.737E+01	-2.657E+11
R(18)	D/DT OF ( R1 TORSION MOMENT )	IN24-LR	.9168E+05	.2571E+15
R(19)	STABDT BENDING MODE VELOCITY	IN24/SEC	-1.048E+05	-1.174E+04
R(20)	D/DT OF ( R2 BENDING MOMENT )	IN24-LR	.1135E+10	.9747E+11
R(21)	D/DT OF ( R2 TORSION MOMENT )	IN24-LR	-1.415E+04	-1.132E+04
R(22)	D/DT OF ( R3 BENDING MOMENT )	IN24-LR	.5941E+05	-8.520E+05
R(23)	D/DT OF ( R3 TORSION MOMENT )	IN24/SEC	-1.849E+11	-1.900E+10
R(24)	STABDT BENDING MODE VELOCITY	IN24/SEC	-1.1301E+04	-1.355E+04
R(25)	D/DT OF ( R4 BENDING MOMENT )	IN24-LR	-1.794E+05	-1.520E+05
R(26)	D/DT OF ( R4 TORSION MOMENT )	IN24/SEC	.2115E+18	.1590E+18
R(27)	ETABDT BENDING MODE VELOCITY	IN24/SEC	-1.462E+06	-1.732E+05
R(28)	D/DT OF ( R5 BENDING MOMENT )	IN24-LR	.6548E+05	.1359E+04
R(29)	D/DT OF ( R5 TORSION MOMENT )	IN24/SEC	0.	0.
R(30)	ETABDT BENDING MODE VELOCITY	IN24/SEC	.615E+05	.3203E+05
R(31)	D/DT OF ( R6 BENDING MOMENT )	IN24-LR	.1747E+05	-1.595E+04
R(32)	D/DT OF ( R6 TORSION MOMENT )	IN24/SEC	0.	0.
R(33)	ETABDT BENDING MODE VELOCITY	IN24/SEC	-1.7306E+11	-1.203E+10

Figure 74. Steady State Response Comparison of Open Loop and Closed Loop ALDCS (Reduced Feedback) Residual Elastic Vehicle (C-5A Cruise Flight Condition) (Continued)



VARIABLE	DESCRIPTION	UNIT	F24R(FRFE)	F24R(IALDCS)
R1331	E400T IMP MODEL EROR RATE FOR 4			
R1341	E300T IMP MODEL EROR RATE FOR 3			
R1351	ALPHA ANGLE OF ATTACK			
R1451	UI AILERON OPTIMAL CONTROL INPUT	RADIAN	-.5025E+01	-.6455E+02
R1471	U2 INWARD ELEV OPTIMAL CONTROL IMP		-.5812E+02	-.4501E+02
R1481	P PILOT FILTER		-.6951E+01	-.7401E+01
R1491	KJSSNER STATE ( M )		0.	-.7522E+01
R1501	TRANSPORT DELAY STATE ( M )		0.	-.5761E+01
R1511	TRANSPORT DELAY STATE ( Y )		0.	-.8957E+01
R1521	KJSSNER STATE ( M )		0.	0.
R1531	TRANSPORT DELAY STATE ( Y )		0.	0.
R1541	KJSSNER STATE ( M )		0.	0.
R1551	TRANSPORT DELAY STATE ( Y )		0.	0.
R1561	W WING VELOCITY	INCH/SEC	-.6131E+03	-.5374E+03
R1571	ETA1 RENDING MODE DEFLECTION	INCH	-.2437E+03	-.1935E+03
R1581	DELA AILERON POSITION	RADIAN	-.1671E+14	-.2852E+03
R1591	DELEX INWARD ELEVATOR POSITION	RADIAN	-.1717E+01	-.2557E+01
R1601	DELEO OUTBOARD ELEVATOR POSITION	RADIAN	-.7377E+01	-.5957E+01
R1611	ETA100T RENDING MODE VELOCITY	INCH/SEC	-.1130E+11	-.9747E+11
R1621	ETA200T RENDING MODE VELOCITY	INCH/SEC	-.1090E+11	-.1850E+10
R1631	ETA300T RENDING MODE VELOCITY	INCH/SEC	-.2016E+10	-.1590E+10
R1641	AZ1R ACCELEROMETER OUTPUT (21)	LS	-.1131E+01	-.1041E+01
R1651	ETA400T RENDING MODE VELOCITY	INCH/SEC	0.	0.
R1661	ETA500T RENDING MODE VELOCITY	INCH/SEC	0.	0.
R1671	ETA600T RENDING MODE VELOCITY	INCH/SEC	-.7374E+11	-.1231E+10
R1681	EFUS FUSELAGE ACCELERMETER OUTPUT	LS	-.1131E+01	-.1811E+01
R1691	IFUS PITCH RATE GYRO OUTPUT	RADIAN/SEC	-.4377E+01	-.4375E+01
R1701	ETA2 RENDING MODE DEFLECTION	INCH	-.1456E+02	-.2559E+02
R1711	ETA3 RENDING MODE DEFLECTION	INCH	-.4618E+01	-.5851E+01
R1721	ETA4 RENDING MODE DEFLECTION	INCH	-.3000E+01	-.5401E+01
R1731	AZ1RL LAGS-U NORMAL ACCELERATION	LS	-.1090E+10	-.1868E+03
R1641	WLC1 FULL STATE MLC FOR AILERON		-.1899E+05	-.5200E+02
R1651	GL1F GUST LOAD ALLOCATION FILTER		-.8201E+02	-.2252E+05
J1 1)	UI AILERON OPTIMAL CONTROL INPUT		0.	0.
J1 2)	U2 INWARD ELEV OPTIMAL CONTROL IMP		0.	0.
J1 3)	ETAG WHITE NOISE INPUT TO EUST MODEL		0.	0.
J1 4)	ETAP WHITE NOISE INPUT TO PILOT FILTE		-.1296E+02	-.4035E+02

Figure 74. Steady State Response Comparison of Open Loop and Closed Loop ALDCS (Reduced Feedback) Residual Elastic Vehicle (C-5A Cruise Flight Condition) (Concluded)

# Contrails

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RESIDUAL ELASTIC SYMM MODEL FOR C-5A - CRUISE FC - SIMULATOR+LOADS
VP/VP0      3      3
-.00429945-.02221338-331.1139A-.12829425-.74720972 8702.1163
.166E-04-.00022A32-1.4500579
VP/R0      3      1
-385.82631-14.861017 .00065497
VP/UE0      3      15
-.00443178 .01762208 .04196189-.03456080 .02761235 .06659994
.00475302-.01217318 .03A23A7A-.054A032A-.00359150 .19A03665
.04947272 .18119655 .00330519-.14143904 .99812274 1.2456986
-.09319856 1.0038251 2.3611481 .07548381 .31443768 .17771544
-2.20A0705-1.6378190 5.2770A17 1.4249977 1.78A6709 .49467956
.609E-04 .0021706A-.001A5419 .04059401-.00032719 .009373A1
-.00014460 .00269390-.00404407-.03439606-.01110904-.00A45762
-.001705A8-.02500596 .00429A0A
VP/UE1      3      15
.467E-04-.00133964-.00126279 .00026379-.00118676-.00122343
.00012860-.00014741 .00057407-.00028292 .00045350-.00083405
.00019711 .00126419-.00013A1A-.00206095-.02767947-.03935766
.00931621-.03369196-.029A8175 .00401039-.00616641 .02052229
-.01317274 .00439134-.01328124 .006A1500 .037A5743-.00943701
.856E-05 .8A9E-04 -.6A4E-05 .962E-05 .198E-04 .841E-04
.889E-05 -.395E-04 .706E-04 -.417E-04 -.579E-04 .00011511
-.162E-05 .923E-04 -.609E-05
VP/DELS0   3      3
-5.4925994-1.7050581-.9156896A-333.59862-325.63081-155.29877
-.34600370-2.0417125-.94981711
VP/DELS1   3      3
.73869070 .22813551 .37041322 26.06368A 15.479868 4.80A7476
.00697673 .06093970 .01A26A2
UE/VP0     15      3
-1.9373934-10.506462 9006.4A11-1.74A1294-4.1234743 16998.436
-.41173411-A.6140424-11557.520 .44347947 3.6415277 3261.3287
-.5247A066-4.219947A-1634.63A6 .573A2195 3.6667163 6722.0876
.22030336 1.5022779 482.37075 .95356065 6.3398A70 1799.4256
-.24962945-1.731853A-921.14A77-.A7807407-10.251416-1A155.76A
.87420022-.4.3364167-279A3.549 1.3415404 8.4247239 2795.0052
1.7616946 4.5227348-1330.8576 .36656721 .82392412 2133.2591
-.91785696-1.2079489-2270.1196
UE/UE0     15      15
-30.4A5354 19.391921 56.028124-10.171551 41.469784 61.549574
-2.8972A36 14.594618-14.94079A 20.03464A 4A.956748 16A.85402
40.9A4925 132.33A04-36.A11711-3.4056642-262.92228 40.221394
-8.08822010 16.1419A1 25.1A6088 3.5246996-41.785290 6A.197409
25.502171 132.17233 133.7459A 43.394513 364.29533-44.658765
1.1245210 20.855570-286.48930 8.244928A-6.7644543 8.4192823
-.99343001 21.172117-32.597677-66.813027-121.78329-40.825165
-5.8012207-188.36643 33.349414 .65926107-7.6661135 3.0846219
-337.45262-.41543544-A.2215A14 5.4794623-11.129285 2.1055190
22.312917 15.441793 5.24A95A8-2.6203773 43.151566-10.806641
-1.0349996 A.8437192 3.0212702 1.1561867-376.29368 13.702993
7.5486499 4.2705A81-2.3614941-19.1A1170-26.920371 12.518081
9.1448948-27.647957 3.9510A44-1.3425209-2.1438495 11.099543
-4.5205537 4.6817007-488.69704-5.2191898 13.924185-21.936990
39.361146 15.414560 44.A93964-2.0052886 15.412A95-10.532289
.24630208-2.9584517-2.3566723 3.1407013 2.9339487-4.8561996
-869.49371 .58030260-2.2A44959 6.9215477 5.9154A99-2.7377137
-3.892A225-5.8838357 .25100059 .26713914-7.9070113-4.6748512
-4.3072159-1.185129A-16.317A4A-1.3521224-111A.1167 1.5255700
24.271477 32.942982-53.161164-10.24127A 19.652385-8.A010299
1.3992338-2.4720133-9.4009799 .45640672-5.6792558-.24200461
1.5360745-.51382135-1187.2777-17.713024-22.307592 24.080724
1.6353963-5.5809213 8.2057A07 1.6130163 29.525296-19.884540
6.8324223-1.9267A07 14.061403-.95457012 25.712072-35.089181
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Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data

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-1535,1712-159,72371-39,514274-5,7273029-233,55383 47,145909
4,3435877 13,558536-55,574412 15,411081-21,746374-17,338490
-1,0857242 48,626008-71,973264-107,22585-1852,2635-157,20590
-39,176218-458,61955 51,138113 3,6278063-17,791667-25,774769
3,2398873-22,089729-35,512174 ,87703400-10,097129 14,128689
3,3859473 10,567335-2326,4111-11,972974 121,34604 2,7945327
2,3273001-10,413884-20,439598 2,2500783-14,465021-29,752436
-1,3979228-2,6852283-3,3600094 25,898154 4,9722292-87,309668
-2624,0574-51,864589 1,4908106-,87618583 3,9837447 5,2997431
-2,3309268 4,2674225 6,3382397-2,2140693 13,580033-15,208968
1,4730177 1,7604798 11,995887 15,600568-5678,4885-3,5452522
-,18419708 4,9016592 ,34461214 ,71837606 ,95950297 8,8661369
,49521765 1,9888717 1,2738738-20,922688-26,630565 28,591270
3,9150706-2,7594187-6402,5948
UE/UE1 15 15
-,98083365-,55539586-,38458898 ,07795086-,48349057-1,1010514
-,13504753 ,62632416-,95130499 ,74639514 ,39775718-,76904809
,22298967-1,3318416-,03796466-,11013300-2,3581959-,54790010
,07242212-,88161625-1,1792227 ,02150448-,18137382 ,21050968
,49868364 1,2234733-1,9459970 ,39512703 ,10761534 ,94022333
,30216167 ,49114299-1,6052819 ,24504391-,43950536-,00202989
,13778918-,48426736 ,85422109-1,0570486-,90779317 ,05475970
-,07266241 1,1455057-,19737437-,07988990-,03677338 ,29930062
-,82969228 ,16018989-,05576332-,01775403 ,19218552-,43406743
,40943196 ,22744527 ,04138057-,01464876-,40266651 ,08913015
,01516289-,24683434-,60756145 ,13945914-1,2513436-,33026297
,12612712-,28890036 ,56726743-,39346984-,15618498-,17718551
,03993655 ,58007515-,03758451-,35397329-,08706477-,15652641
-,04058211-,20134080-,2,2682529-,17557617 ,74496007-1,1567504
,97280745 ,14962680-,05448577-,32147517-1,3335487 ,08959601
-,02835641 ,10173740 ,12773200-,07469697 ,05537069 ,00538426
-1,2948958 ,18332419-,28490244 ,2,277281 ,02266303 ,18873552
-,03228024-,33502452 ,02231553-,04474452-,04246022 ,75142324
-,00330689 ,11933492 ,36787809 ,06841820-1,8994782 ,58919991
-,06226135 ,53377103-,61511295 ,11213028 ,65802309-,10634622
,14488235 ,22792012-,07061462 ,01024996 ,02808196-,10749705
-,11874432 ,71561117-,2,4915549 ,37120082-,56429434 ,4408441
-,23512556-1,0761403 ,11681415 ,32973114 ,58430129-,56971972
-,02277135-,21742534 ,47680756 ,22675617-,69711295 ,13912636
-3,7991667-2,3954900 ,85399022-,02808763 2,1715534 ,32315129
,53334631 1,9045113-,42501534 ,22476514 ,35487186 1,5842104
,19570234-,42229117 ,94571824-,2,7895982-5,7603214 1,8308552
-,19948539 1,4439955 ,09919316 ,43544676-,14268667-,28035531
-,03835875-,07391334 ,90881823 ,04089674-,37192805 ,28707358
-,16543267-,05276579-4,3639672-,09732987 1,4865712-,02273456
,10243970 ,32907346 ,46157527-,11182374 ,41239704 ,44287671
-,02062026-,03334162-,20212127 ,15054990-,27719285 ,05695818
-2,4204879-,04568709 ,27539981-,22673493 ,36600176 ,08270275
,02007305 ,23946631-,04419329-,14752247 ,77539909-1,1250664
,66422634-,20199578-,12163724 ,53946302-,6,9446169 ,02365915
,09131541-,14193432-,27183266 ,04238321-,19570289-,17495197
,05775477-,03286472 ,17345622-,12633512 ,50450074-,09781566
-,09053573 ,42033553-3,3746445
UE/DELS0 15 3
-19605,297 0883,6586 4429,7033 8216,8778 22493,528 11537,304
5783,7670-23039,891-11761,724-1032,9789 6652,3252 3528,3241
4978,7363-5109,7866-2783,8694-28,8,6868 7392,3594 4164,2126
-1679,6640 1084,3789 753,56749 8723,9963 4747,5345 3970,2872
-9313,0495-1147,7915-2888,1071 3219,9179-17085,596-18640,417
-988,21959-23167,839-28664,719 13639,546 684,32089 641,16248
1408,0041 1128,7460 411,25281-4475,3364 335,17789 68,884850
-307,72743-4597,1692-783,08529
UE/DELS1 15 3
592,00399-194,66586-59,280556 244,77227-623,44535-102,00169
198,14693 697,6983A 215,3925A-100,40142-214,15746-64,185287
266,82834 172,27157 53,700694 54,028624-231,18283-71,346802

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Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data (Continued)

# Contrails

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-58.908966-43.009656-13.190119-131.13007-210.06681-67.590538
-100.89926 131.32670 39.080432 295.79147 802.69450 272.61043
-53.667857 1234.9627 348.14657-304.46230-97.453345-30.186817
-349.59765-126.10895-38.747396 4.2341307-9.9961419-3.0689516
123.09109 206.28345 65.791572
(RANDING) 1 3
-1017.9353 . 1017.9353
VP/MG0 3 3
.00068762 .02038288 .617E-04 .09875633 .61164902 .00069319
.00052956-.04026129 -.377E-04
UE/MG0 15 3
.16053825 .49877805-.00467151 .08765934 .51768377 .00031766
.07686027-.12689837-.00651579-.03914621 .00910250 .02266228
.05890345 .06571938-.00308661-.00503706 .15353125 .0212626
-.01836896-.02034209 .00096430-.08509149-.11372971 .0423883
.03248499 .04398091-.02161165 .09366904-.22760063-.00879506
-.00873206-.57225011-.00612468-.06010001-.05343044 .00330862
-.09899411-.19623512 .00418338 .01202568 .11890706 .00060426
.04035424 .02689123-.00232471
VP/MG1 3 3
-.638E-04-.00081640 .644E-05-.00195900-.01825717 .00127011
-.348E-05 .484E-04 -.344E-05
UE/MG1 15 3
-.00220147-.02920713 .00057390-.00108861-.01515461 .00105080
-.00032847 .01170023-.00082544 .00027671-.00314859 .00225277
-.00057503 .00146783-.00014237-.00026657-.00070001 .00049098
.00017903-.00046391 .444E-04 .00086800-.00134345 .00014902
-.00033249 .00048963 -.552E-04-.00025545 .01605667-.00122561
.00120123 .02302176-.00167122 .00055970-.00206008 .00018617
.00113664 .00107798 -.189E-04-.00032669-.00405859 .00028832
-.00035799 .00175444-.00015204
R/VP0 1 3
0. 1.0000000
R/R0 1 1
0.
T/VP0 4 3
0. 1.0000000 0. 0. -R039.9124
0. -R039.9124 0. 0. -R039.9124
T/VP1 4 3
.302E-07 .257E-06 .572E-04 0. 1.0000000-724.21672
0. 1.0000000 246.83328 0. 1.0000000 349.82328
T/R0 4 1
0. 0.
T/R1 4 1
0. 0.
T/DELS0 4 3
0. 0. 0. 0. 0.
0. 0. 0. 0. 0.
T/DELS1 4 3
.769E-04 0. 0. 0. 0.
0. 0. 0. 0. 0.
T/UE0 4 15
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. 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.
T/UE1 4 15
-.117E-04 .823E-04 -.584E-04 .181E-04 -.475E-05 .299E-04
-.254E-05 -.601E-04 .587E-04 .00013085 -.552E-04 .405E-04
.692E-04 .756E-04 .00023863 0. 0. 0.

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Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data (Continued)

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0.      .      .      .      .      .
0.      .      .      .      .      .
0.      .      .      .      .      .
0.      .      .      .      .      .
0.      .      .      .      .      .
0.      .      .      .      .      .
T/UEZ      4      15
-.377E-08 -.294E-08 .121E-07 -.331E-08 .599E-08 .379E-08
-.4101E-08 .158E-08 -.310E-08 -.581E-08 -.575E-08 -.178E-08
-.976E-09 -.705E-09 .134E-07 .008E-016-.03790546 .01718768
-.00313161-.00317229-.00520680 .00116754 .01270543-.01111168
-.01720711 .00824522-.00328841-.00168990 .00130294 .00461607
.11651679-.04371319 .00400672 .00674489 .00770139 .11844071
.00859085-.02555050-.00418567 .01802077-.01073599-.05829632
-.03147002-.03822730 .00855784 .13074090-.09453520-.05262336
.01780807-.04396924 .07456597 .02465811-.09847138 .10864986
-.04414072 .00893867-.17422969-.01433580 .04376353-.00530119
T/W60      4      3
0.      .      .      .      .      .
0.      .      .      .      .      .
L/VPO      15      3
.5099E+02 .2551E+03 .4444E+03 .1944E+05 .1060E+06-.7944E+07
-.4650E+04-.2540E+05 .1175E+07 .3174E+02 .1755E+03-.5422E+04
.1172E+05 .4652E+05-.7427E+07 .5845E+03 .3267E+04-.4715E+05
.1772E+02 .9904E+02-.1043E+05 .5172E+04 .3223E+05-.4557E+07
.5247E+03 .3353E+04 .3749E+06 .1219E+07 .7186E+02-.1096E+05
.2776E+04 .1743E+05-.3228E+07 .6414E+03 .4341E+04 .1323E+07
.4197E+01 .2617E+02-.1346E+05 .1087E+04 .7279E+04-.1210E+07
.3359E+03 .2323E+04 .8673E+06
L/VPI      15      3
0.      -.1566E+02-.3744E+040.      -.8663E+04-.1596E+07
0.      .1710E+04 .2948E+060.      -.1263E+02-.2567E+04
0.      -.5949E+04-.9955E+060.      -.5354E+03-.1154E+06
0.      -.8714E+01-.1458E+040.      -.3240E+04-.4913E+06
0.      .4603E+03-.9442E+050.      -.6986E+01-.1116E+04
0.      -.1852E+04-.2713E+060.      -.2784E+03-.8898E+05
0.      -.7807E+01-.4143E+030.      -.7910E+03-.1134E+06
0.      -.1440E+03-.4823E+05
L/UE0      15      15
.7444E+02-.2689E+03-.6121E+03 .1093E+03-.4022E+03-.5834E+03
.1364E+02 .9695E+02-.1158E+03-.1557E+03-.3268E+03-.4977E+03
-.7250E+02-.4956E+02 .5629E+02 .5644E+05-.1908E+06-.4049E+06
.7788E+05-.3083E+06-.3720E+06 .3453E+05-.9253E+05 .1789E+06
-.2662E+06-.1965E+06-.3982E+06-.6446E+05 .3748E+06 .5779E+05
-.2030E+05 .6347E+05 .1345E+06-.2731E+05 .1094E+06 .1219E+06
-.1338E+05 .4294E+05-.7909E+05 .1136E+06 .7985E+05 .1312E+06
.3273E+05-.1892E+06-.3115E+05 .7230E+02-.2158E+03-.5429E+03
.9488E+02-.3874E+03-.5114E+03 .1890E+02 .1561E+02 .1903E+02
-.2130E+07-.2954E+03-.5147E+03-.1892E+03 .1967E+03 .0532E+02
.4400E+05-.1444E+06-.3057E+06 .6101E+05-.2418E+06-.2759E+06
.3357E+05-.1107E+06 .2007E+06-.2454E+06-.1439E+06-.2952E+06
-.5045E+05 .3886E+06 .4353E+05-.1169E+04 .2232E+04 .4490E+04
-.2308E+04 .6592E+04 .7574E+03-.2364E+04 .9609E+04-.1569E+05
.2104E+05 .1234E+05 .6036E+04 .9461E+04-.5019E+05-.2977E+04
.6349E+02-.2043E+03-.4408E+03 .8464E+02-.3435E+03-.4031E+03
.4067E+02-.1083E+03 .2047E+03-.2949E+03-.2290E+03-.3140E+03
-.1348E+03 .4094E+03 .6744E+02 .2404E+05-.8948E+05-.1778E+06
.3697E+05-.1438E+06-.1546E+06 .2814E+05-.9777E+05 .1692E+06
-.1797E+06-.7581E+05-.1922E+06-.1507E+05 .3026E+06 .2077E+05
.1305E+04-.4628E+04-.8357E+04 .9702E+03-.7062E+04-.1170E+05
.2504E+03-.2490E+04 .4935E+04 .1734E+04 .4881E+04-.2786E+04
.3577E+04-.1246E+05 .2147E+03 .5394E+02-.1799E+03-.7644E+03
.8693E+02-.2982E+03-.3346E+03 .5152E+02-.1565E+03 .2809E+03
-.3239E+03-.1540E+03-.2812E+03-.5778E+02 .4081E+03 .4809E+02
.1531E+05-.5385E+05-.1044E+06 .2294E+05-.8516E+05-.0025E+05

```

Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data (Continued)



```
.1946E+05-.7210E+05 .1234E+06-.1204E+06-.3901E+05-.1400E+06
.3222E+04 .2268E+06 .9717E+04 .1453E+04-.8601E+04-.1042E+05
.2135E+04-.9521E+04-.1475E+05 .7441E+03-.4323E+04 .5640E+04
.2416E+04 .5688E+04-.1536E+04-.1307E+04-.1076E+05-.1162E+04
.3155E+02-.1325E+03-.2168E+03 .4856E+02-.1752E+03-.1757E+03
.4419E+02-.1589E+03 .2836E+03-.3333E+03-.1038E+03-.2663E+03
.3473E+02 .4113E+03 .3267E+02 .6757E+04-.2492E+05-.4423E+05
.9937E+04-.3802E+05-.3855E+05 .9977E+04-.3956E+05 .8626E+05
-.5957E+05-.135CE+05-.8678E+05 .3865E+04 .1492E+06 .2125E+04
.1117E+04-.6373E+04-.7081E+04 .1356E+04-.6375E+04-.9693E+04
.9534E+03-.5096E+04 .8840E+04-.1976E+04 .4851E+04-.7516E+03
.2932E+04-.9610E+04-.6512E+03
L/UE1 15 15
.3794E+01 .1891E+02 .1549E+02-.2989E+01 .1544E+02 .2097E+02
-.2984E+00-.2904E+01 .1819E+01-.3763E+01-.7698E+01 .2033E+02
-.3024E+01-.5433E+00 .6728E+00 .5728E+04 .6868E+04 .6273E+04
-.1289E+04 .6376E+04 .1097E+05 .7328E+03-.4088E+04 .5973E+04
-.5357E+04-.3210E+04 .1135E+05-.2320E+04 .1001E+05 .6676E+03
-.2473E+04-.1045E+04 .7514E+03-.2480E+02-.3506E+03-.7230E+03
-.2481E+03 .7455E+03-.1175E+04 .1350E+04 .1260E+04-.1272E+03
.7149E+03-.2341E+04 .2678E+03 .5448E+01 .1297E+02 .1051E+02
-.2298E+01 .1192E+02 .1474E+02 .1387E+00-.2474E+01 .2472E+01
-.3944E+01-.5855E+01 .1619E+02-.3881E+01 .6447E+01 .1924E+01
.5077E+04 .3665E+04 .3302E+04-.7424E+03 .3568E+04 .7344E+04
.7625E+03-.3685E+04 .5763E+04-.4778E+04-.2040E+04 .7484E+04
-.1698E+04 .9748E+04 .3445E+03-.3854E+03 .8787E+03 .1092E+04
-.3028E+03 .1250E+04 .1799E+04-.3997E+02-.1171E+03 .1093E+03
-.1317E+03 .2150E+03 .1890E+04 .1050E+03-.2700E+03 .2914E+02
.6803E+01 .6370E+01 .5166E+01-.1776E+01 .5733E+01 .9173E+01
.6480E+00-.3145E+01 .5263E+01-.5034E+01-.3608E+01 .1394E+02
-.4524E+01 .1360E+02 .6741E+00 .3799E+04 .1197E+04 .1328E+04
-.2401E+03 .1399E+04 .4480E+04 .6862E+03-.3095E+04 .4976E+04
-.3683E+04-.8290E+03 .3781E+04-.6158E+03 .7165E+04 .7349E+01
.2262E+02 .6989E+03 .1295E+04-.2044E+03 .9775E+03 .1435E+04
-.5317E+02 .1699E+03-.1962E+03-.6325E+02 .5435E+02 .9745E+03
.3256E+03-.4287E+03-.1147E+01 .6438E+01 .4022E+01 .4112E+01
-.9576E+00 .4138E+01 .9029E+01 .9299E+00-.4476E+01 .7689E+01
-.6361E+01-.2605E+01 .1195E+02-.1524E+01 .1186E+02 .1317E+00
.2161E+04 .3183E+03 .6125E+03-.3599E+02 .5819E+03 .2907E+04
.5388E+03-.2423E+04 .3804E+04-.2679E+04-.2880E+03 .1417E+04
.3833E+02 .4690E+04-.5507E+02 .6793E+02 .5662E+03 .9580E+03
-.1865E+03 .7861E+03 .1044E+04-.9749E+02 .3509E+03-.6265E+03
.2521E+03-.7543E+02 .6345E+03 .6814E+02-.5280E+03 .5031E+02
.4827E+01 .1156E+00 .3283E+00 .1887E+00 .4422E+00 .5741E+01
.1313E+01-.5662E+01 .9230E+01-.6412E+01-.5242E+00 .4237E+01
.7014E+00 .8497E+01-.2292E+00 .1044E+04-.8229E+02 .1657E+03
.3959E+02 .1273E+03 .1469E+04 .3256E+03-.1466E+04 .2204E+04
-.1465E+04-.3168E+02-.2446E+03 .1470E+03 .2781E+04-.5658E+02
.8200E+02 .2983E+03 .5654E+03-.9738E+02 .4652E+03 .6969E+03
-.6697E+02 .2903E+03-.5409E+03 .2404E+03-.8589E+02 .4239E+03
-.7447E+02-.4974E+03 .3425E+02
L/UE2 15 15
.8248E+01 .4944E+01 .1632E+01-.1775E+01 .3095E+01-.2584E+01
-.7568E+00-.2807E+01 .1777E+01 .4365E+00-.5621E+00 .2227E+00
-.2927E+01-.1993E+01 .6489E+00 .7950E+04 .1373E+04 .7815E+03
-.8576E+03 .1883E+04-.5712E+03-.3507E+03-.7086E+03 .2040E+03
-.3905E+03 .1748E+03 .4155E+03-.3198E+03 .1480E+03-.1404E+03
-.3104E+04 .2200E+03 .5832E+03 .1120E+03 .1226E+03 .9889E+03
.1404E+03-.1582E+03 .4548E+03-.1918E+03 .5867E+02 .4213E+03
-.5607E+02 .2549E+03 .1490E+03 .9800E+01 .4405E+01 .2051E+01
-.1922E+01 .3162E+01-.2818E+01-.7799E+00-.2046E+01 .1100E+01
-.7986E+00 .1456E+00 .2169E+01-.2755E+01-.1163E+01-.7837E+00
.6652E+04 .2339E+03 .2223E+03-.4158E+03 .9904E+03-.2416E+03
-.1847E+03-.8263E+02-.2210E+03-.2671E+03 .1893E+03 .2823E+03
.3372E+03 .4582E+03-.1591E+03-.4780E+03 .6375E+03 .7683E+03
-.1536E+03 .6579E+03 .7047E+03 .2684E+02-.3029E+03 .3986E+03
```

Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data (Continued)

```
-.2735E+03 .1022E+07 .3907E+03-.1273E+03 .1239E+03-.1046E+02
.9326E+01 .1851E+01 .1293E+01-.1167E+01 .2000E+01-.1810E+01
-.6514E+00 .5658E+00-.1074E+01-.9794E+00 .6440E+00-.1280E+00
.1920E+01 .1942E+01-.3523E-01 .4324E+04-.5327E+03-.1260E+03
-.7462E+02 .1377E+03 .3458E+03-.5519E+02 .6872E+02-.1009E+03
-.6495E+02 .8680E+02 .3921E+03 .2788E+03 .3606E+03-.9994E+02
-.3214E+02 .4083E+03 .5749E+03-.9234E+02 .4533E+03 .6023E+03
-.3934E+02 .6656E+02-.6940E+02-.8333E+02 .6127E+02-.8940E+02
.3939E+03-.1150E+03 .7368E+02 .8451E+01-.8643E+00-.4036E+00
-.2602E+00 .2319E+00-.4103E+00-.2624E+00 .7214E+00-.1105E+01
.1970E+00 .1005E+00 .1736E+01 .1384E+00 .1770E+01-.9590E-01
.2651E+04-.7065E+03-.2566E+03 .5724E+02-.9495E+02 .6207E+03
.4654E+02-.1462E+03 .4942E+02-.8992E+01 .2376E+02 .3055E+03
.7726E+02-.5078E+02-.5344E+02-.1154E+03 .1341E+03 .2698E+03
-.2125E+02 .2140E+03 .4440E+03-.1742E+02 .1107E+03-.2683E+03
.1748E+03-.6814E+02-.2990E+02-.9203E+02-.3264E+02 .2894E+02
.7222E+01-.7803E+01-.7026E+00 .1573E+00-.2846E+00 .1621E+01
.9546E-01-.1829E+00-.4156E-01 .3709E-01 .8394E-01 .1920E+01
.4331E+00-.1126E+01-.2574E-01 .1186E+04-.4173E+03-.1395E+03
.5120E+02-.7731E+02 .4616E+03 .5576E+02-.1847E+03 .1383E+03
-.3404E+02 .1612E+02-.6746E+02 .4235E+01-.6765E+02-.1564E+02
-.5208E+02 .1263E+03 .2300E+03-.2581E+02 .1937E+03 .3927E+03
-.2376E+02 .1284E+03-.3017E+03 .1987E+03-.7999E+02-.4218E+02
-.1583E+03 .2634E+02 .4525E+01
L/DELS0 15 3
.1228E+06-.1627E+06-.4347E+05 .1319E+09-.7733E+08-.7287E+08
-.6024E+08 .3188E+08 .1358E+08 .1781E+06-.9908E+05-.4205E+05
.1169E+09-.6118E+08-.2604E+08-.1558E+08 .5253E+07 .2260E+07
.1369E+06-.8811E+05-.3750E+05 .8329E+08-.3700E+08-.1576E+08
-.7846E+07 .1469E+07 .6343E+06 .1404E+06-.7405E+05-.3156E+05
.5797E+08-.2145E+08-.9142E+07-.7460E+07 .1861E+07 .7954E+06
.1315E+06-.5688E+05-.2425E+05 .3132E+08-.9108E+07-.3882E+07
-.7095E+07 .1148E+07 .4916E+06
L/DELS1 15 3
-.9780E+04 .1027E+04 .3017E+03-.5495E+07 .1340E+07 .4078E+06
.1516E+07-.4836E+06-.2098E+06-.7823E+04 .1457E+04 .4399E+03
-.3896E+07 .1174E+07 .3591E+06-.1523E+06-.1633E+06-.5074E+05
-.5686E+04 .1682E+04 .5143E+03-.2157E+07 .7597E+06 .2330E+06
-.2719E+06-.6187E+05-.1937E+05-.4666E+04 .1488E+04 .4562E+03
-.1227E+07 .4434E+06 .1360E+06-.2980E+06-.7956E+05-.2489E+05
-.2340E+04 .1336E+04 .4118E+03-.5640E+06 .1850E+06 .5671E+05
-.2192E+06-.4533E+05-.1417E+05
L/WG0 15 3
.2892E+02-.2823E+03-.1700E+01 .2216E+05-.1270E+06-.1119E+04
-.9044E+04 .3408E+05 .3648E+03 .2824E+02-.2023E+03-.1447E+01
.1755E+05-.8320E+05-.8710E+03-.1431E+04-.1902E+04 .6633E+02
.2527E+02-.1231E+03-.1259E+01 .1664E+05-.4234E+05-.5329E+03
-.3963E+03-.2981E+04 .2398E+02 .2124E+02-.9200E+02-.1104E+01
.6162E+04-.2327E+05-.3134E+03-.5504E+03-.3911E+04 .1997E+02
.1646E+02-.4184E+02-.7974E+00 .2615E+04-.9762E+04-.1322E+03
-.3334E+03-.2006E+04 .1625E+02
L/WG1 15 3
.6915E+00 .1480E+02 .1758E+00 .2602E+03 .8325E+04 .7788E+02
-.4870E+02-.1648E+04-.1325E+02 .4578E+00 .1203E+02 .1409E+00
.1509E+03 .5757E+04 .4175E+02 .1747E+02 .5056E+03 .1255E+02
.2246E+00 .8424E+01 .6540E-01 .6472E+02 .3178E+04 .1529E+02
.1178E+02 .3826E+03 .5941E+01 .1469E+00 .6813E+01 .2654E-01
.3529E+02 .1811E+04 .5348E+01 .1260E+02 .2647E+03 .1096E+01
.3666E-01 .3755E+01 .1494E-01 .1539E+02 .7739E+03 .1713E+01
.6461E+01 .1361E+03 .1381E+01
*FINISHED* 0 0
```

Figure 75. FLEXSTAB/LSA Residual Elastic Simulator Deck Data (Concluded)

```

STAMK1
STAMK2
STAMK3
CONDK
NXM= 42
NRM= 31
NUM= 12
NYM= 49
MSB= 3
MTB= 3

```

Figure 76. Figure 77 Precompiler Data (KONPACT-1)

\*\*\* INPUT DATA CARDS \*\*\*

```

C SPECIFY PRINTING
PRINT OUTPUT DATA
PRINT INPUT DATA
C DEFINE VEHICLE
SYSTEM NO 1 FLEXSTAB C5A A/C F34 ( RESIDUAL ELASTIC SYMMETRIC - RES )
$LSA DATA
RESIDUAL ELASTIC SYMM MODEL FOR C-5A - CRUISE FC - SIMULATOR-LOADS
END
C NAME LIST DATA
STATE
1      X( 1)      U      VELOCITY ALONG X AXIS      INCH/SEC
2      X( 2)      W      VELOCITY ALONG Z AXIS      INCH/SEC
3      X( 3)      Q      PITCH RATE      RADIAN/SEC
4      X( 4)      THETA  PITCH ATTITUDE      RADIAN
5      X( 5)      UE1    BENDING MODE DISPLACEMENT      INCH
6      X( 6)      UE2    BENDING MODE DISPLACEMENT      INCH
7      X( 7)      UE3    BENDING MODE DISPLACEMENT      INCH
8      X( 8)      UE4    BENDING MODE DISPLACEMENT      INCH
9      X( 9)      UE5    BENDING MODE DISPLACEMENT      INCH
10     X(10)      UE6    BENDING MODE DISPLACEMENT      INCH
11     X(11)      UE7    BENDING MODE DISPLACEMENT      INCH
12     X(12)      UE8    BENDING MODE DISPLACEMENT      INCH
13     X(13)      UE9    BENDING MODE DISPLACEMENT      INCH
14     X(14)      UE10   BENDING MODE DISPLACEMENT      INCH
15     X(15)      UE11   BENDING MODE DISPLACEMENT      INCH
16     X(16)      UE12   BENDING MODE DISPLACEMENT      INCH
17     X(17)      UE13   BENDING MODE DISPLACEMENT      INCH
18     X(18)      UE14   BENDING MODE DISPLACEMENT      INCH
19     X(19)      UE15   BENDING MODE DISPLACEMENT      INCH
20     X(20)      UE1DOT  BENDING MODE RATE      INCH/SEC
21     X(21)      UE2DOT  BENDING MODE RATE      INCH/SEC
22     X(22)      UE3DOT  BENDING MODE RATE      INCH/SEC
23     X(23)      UE4DOT  BENDING MODE RATE      INCH/SEC
24     X(24)      UE5DOT  BENDING MODE RATE      INCH/SEC
25     X(25)      UE6DOT  BENDING MODE RATE      INCH/SEC
26     X(26)      UE7DOT  BENDING MODE RATE      INCH/SEC
27     X(27)      UE8DOT  BENDING MODE RATE      INCH/SEC
28     X(28)      UE9DOT  BENDING MODE RATE      INCH/SEC
29     X(29)      UE10DOT BENDING MODE RATE      INCH/SEC
30     X(30)      UE11DOT BENDING MODE RATE      INCH/SEC
31     X(31)      UE12DOT BENDING MODE RATE      INCH/SEC
32     X(32)      UE13DOT BENDING MODE RATE      INCH/SEC
33     X(33)      UE14DOT BENDING MODE RATE      INCH/SEC
34     X(34)      UE15DOT BENDING MODE RATE      INCH/SEC
-1
OUTPUT
1      R( 1)      SASGY  PITCH RATE GYRO      RADIAN/SEC
2      R( 2)      AZAP   NORMAL ACCELEROMETER      INCH/SEC2
3      R( 3)      AZFR   NORMAL ACCELEROMETER FRONTPAR      INCH/SEC2
4      R( 4)      AZRR   NORMAL ACCELEROMETER BACKSPAR      INCH/SEC2
5      R( 5)      S1     SHEAR FORCE (120.0)      LB
6      R( 6)      R1     BENDING MOMENT (120.0)      INCH-LB
7      R( 7)      T1     TORSION MOMENT (120.0)      INCH-LB
8      R( 8)      S2     SHEAR FORCE (328.2)      LB
9      R( 9)      R2     BENDING MOMENT (328.2)      INCH-LB
10     R(10)      T2     TORSION MOMENT (328.2)      INCH-LB
11     R(11)      S3     SHEAR FORCE (575.1)      LB
12     R(12)      R3     BENDING MOMENT (575.1)      INCH-LB
13     R(13)      T3     TORSION MOMENT (575.1)      INCH-LB

```

Figure 77. KONPACT-1 Input Data to Produce F42D Model



```

14      R(14)      S4      SHEAR FORCE      (746.0)      LB
15      R(15)      R4      BENDING MOMENT (746.0)      INCH-LB
16      R(16)      T4      TORSION MOMENT (746.0)      INCH-LB
17      R(17)      S5      SHEAR FORCE      (920.0)      LB
18      R(18)      R5      BENDING MOMENT (920.0)      INCH-LB
19      R(19)      T5      TORSION MOMENT (920.0)      INCH-LB
-1
INPUT
1      U( 1)      RDAIL  AILERON DEFLECTION      RADIAN
2      U( 2)      RDEI   INBOARD ELEVATOR DEFLECTION      RADIAN
3      U( 3)      RDEO   OUTBOARD ELEVATOR DEFLECTION      RADIAN
4      U( 4)      RDAILDOT AILERON DEFLECTION RATE      RADIAN/SEC
5      U( 5)      RDEINDOT INBOARD ELEVATOR DEFLECTION RATE      RADIAN/SEC
6      U( 6)      RDEODOT OUTBOARD ELEVATOR DEFLECTION RATE      RADIAN/SEC
7      U( 7)      WG1    GUST INPUT AT -1020 IN FROM CG      INCH/SEC
8      U( 8)      WG2    GUST INPUT AT 0 IN FROM CG      INCH/SEC
9      U( 9)      WG3    GUST INPUT AT 1020 IN FROM CG      INCH/SEC
10     U(10)      WG1DOT GUST INPUT RATE      INCH/SEC2
11     U(11)      WG2DOT GUST INPUT RATE      INCH/SEC2
12     U(12)      WG3DOT GUST INPUT RATE      INCH/SEC2
-1
END
C DEFINE CONVERTED VEHICLE
SYSTEM NO 1 CONVERTED FLEXSTAB CSA A/C F32 ( FLEXSTAR-RES TO HI/GELAC )
$CONDITIONING DATA
C SCALING DATA
SCALE THE VARIABLES
X(3)      .164789E 04      RADIAN/SEC      INCH/SEC
U(7)      .833333E-01      INCH/SEC      FEET/SEC
U(8)      .833333E-01      INCH/SEC      FEET/SEC
U(9)      .833333E-01      INCH/SEC      FEET/SEC
U(10)     .833333E-01      INCH/SEC      FEET/SEC
U(11)     .833333E-01      INCH/SEC      FEET/SEC
U(12)     .833333E-01      INCH/SEC      FEET/SEC
R(2)      .258800E-02      INCH/SEC2      1G
R(3)      .258800E-02      INCH/SEC2      1G
R(4)      .258800E-02      INCH/SEC2      1G
END
C RESPONSE SPECIFICATIONS
SELECT OUTPUTS
R(1)-R(19),X(2),X(3).
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(2),X(3),X(20)-X(34),X(5)-X(19).
END
C DEFINE ACTUATOR
SYSTEM NO 2      ACTUATOR      ( FIRST ORDER )
$TRANSFER FUNCTION DATA
BLOCK 1
1 2 .100000E 01 2 1 .164667E 00 > > .100000E 01
-1
BLOCK 2
1 2 .100000E 01 2 1 .133333E 00 > > .100000E 01
-1
BLOCK 3
1 2 .100000E 01 2 1 .133333E 00 > > .100000E 01
-1
END
C CONNECTION DATA
U1/U
1 1 .100000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
U1/R1
-1
R/R1

```

Figure 77. KONPACT-1 Input Data to Produce F42D Model  
(Continued)

# Contrails

```

1 1 .100000E 01 2 2 .100000E 01 3 3 .100000E 01
4 1-.600000E 01 5 2-.750000E 01 6 3-.750000E 01
-1
R/U
4 1 .600000E 01 5 2 .750000E 01 6 3 .750000E 01
-1
END
C NAME LIST DATA
STATE
1 X( 1)      XA      ACTUATOR STATE          RADIAN
2 X( 2)      XEI      ACTUATOR STATE          RADIAN
3 X( 3)      XEO      ACTUATOR STATE          RADIAN
-1
OUTPUT
1 R( 1)      DELEI  AILERON POSITION          RADIAN
2 R( 2)      DELEI  INBOARD ELEVATOR POSITION RADIAN
3 R( 3)      DELEO  OUTBOARD ELEVATOR POSITION RADIAN
4 R( 4)      DELENDOT AILERON VELOCITY       RADIAN/SEC
5 R( 5)      DELEIDOT INBOARD ELEVATOR VELOCITY RADIAN/SEC
6 R( 6)      DELEODOT OUTBOARD ELEVATOR VELOCITY RADIAN/SEC
-1
INPUT
1 U( 1)      UDELEI AILERON CONTROL INPUT  RADIAN
2 U( 2)      UDELEI INBOARD ELEVATOR CONTROL INPUT  RADIAN
3 U( 3)      UDELEO OUTBOARD ELEVATOR CONTROL INPUT  RADIAN
-1
END
C DEFINE GUST MODEL
SYSTEM NO 3          GUST MODEL          ( WITH FIRST ORDER KUSSNER )
SQUADRUPL DATA
XDOT/X              7      7
1 1-.184930E 02 1 7 .184930E 02 2 2-.134270E 02 2 5 .134270E 02 3 1-.800330E 01
3 4 .100000E 01 4 1 .224180E 03 4 3-.960780E 02 4 4-.160070E 02 5 5-.915550E 01
5 7 .915550E 01 6 6-.420000E 00 6 7-.441000E-01 7 6 .100000E 01
-1
XDOT/U              7      1
6 1-.237100E 00 7 1 .793700E 00
-1
R/X
1 1 .100000E 01 2 2 .100000E 01 3 3 .100000E 01 4 1-.184930E 02 4 7 .184930E 02
5 2-.134270E 02 5 5 .134270E 02 6 3-.800330E 01 6 4 .100000E 01
-1
R/U
6      1
-1
END
C NAME LIST DATA
STATE
1 X( 1)      P1      KUSSNER STATE ( NT )    FEET/SEC
2 X( 2)      P2      TRANSPORT DELAY STATE ( W ) FEET/SEC
3 X( 3)      P3      TRANSPORT DELAY STATE ( T ) FEET/SEC
4 X( 4)      P4      TRANSPORT DELAY STATE ( T )
5 X( 5)      P5      KUSSNER STATE ( W )
6 X( 6)      P6      WIND FILTER STATE
7 X( 7)      WG      WIND GUST STATE
-1
OUTPUT
1 R( 1)      WGN     WIND GUST TO NOSE      FEET/SEC
2 R( 2)      WGW     WIND GUST TO WING      FEET/SEC
3 R( 3)      WGT     WIND GUST TO TAIL      FEET/SEC
4 R( 4)      WGNDOT WIND GUST RATE TO NOSE FEET/SEC2
5 R( 5)      WGWDOT WIND GUST RATE TO WING FEET/SEC2
6 R( 6)      WGTDOT WIND GUST RATE TO TAIL FEET/SEC2
-1
INPUT
1 U( 1)      ETAG    WHITE NOISE INPUT TO GUST MODEL FEET/SEC
-1

```

Figure 77. KONPACT-1 Input Data to Produce F42D Model (Continued)

```

END
C DEFINE PLANT
SYSTEM NO 4 PLANT=F42 (CONVERTED FLEXSTAR CSA A/C (REF) + ACTUATOR + GUST MODEL)
$INTERCONNECTION DATA
UI1/U
-1
UI1/R12
1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
UI1/R13
7 3 .10000E 01 8 2 .100000E 01 9 1 .100000E 01
-1
UI2/U
1 2 .10000E 01 2 3 .100000E 01 3 4 .100000E 01
-1
UI3/U
1 1 .10000E 01
-1
R/R11
1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01 4 4 .100000E 01 5 5 .100000E 01
6 6 .10000E 01 7 7 .100000E 01 8 8 .100000E 01 9 9 .100000E 011010 .100000E 01
1111 .10000E 011212 .100000E 011313 .100000E 011414 .100000E 011515 .100000E 01
1616 .100000E 011717 .100000E 011818 .100000E 011919 .100000E 012020 .113378E-03
2121 .60660E-032520 .100000E 01
-1
R/R12
22 1 .10000E 0123 2 .100000E 0124 3 .100000E 01
-1
R/R13
20 2 .113378E-03
-1
END
C NAME LIST DATA
OUTPUT
20 R(20) ALPHA ANGLE OF ATTACK RADIAN
21 R(21) QCG PITCH RATE AT CG RADIAN/SEC
-1
END
C DEFINE PLANT DESIGN MODEL
SYSTEM NO 4 PLANT=F42D ( CONVERTED FLEXSTAR CSA A/C + ACTUATOR + GUST MODEL )
$CONDITIONING DATA
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT CONTROL INPUTS
U(2)-U(4).
SELECT GUST INPUTS
U(1).
CONSTRUCT DESIGN RESPONSES
R(6),R(7),R(9),R(10),R(12),R(13),R(15),R(16),R(18),R(19),
RDOT(6),RDOT(7),RDOT(9),RDOT(10),RDOT(12),RDOT(13),RDOT(15),RDOT(16),
RDOT(18),RDOT(19),R(26)-R(25),RDOT(25).
SELECT SENSOR OUTPUTS
R(3),R(4),R(2),R(1).
END
C NO REDUCTION AND SHUFFLING DATA
END
STOP

```

**Figure 77. KONPACT-1 Input Data to Produce F42D Model (Concluded)**

```
CONDK
NXM= 42
NRM= 31
NUM= 12
```

Figure 78. Figure 79 Precompiler Data (KONPACT-1)

```
*** INPUT DATA CARDS ***
```

```
PRINT INPUT DATA
PRINT OUTPUT DATA
CONTINUATION RUN
C DEFINE F24 PLANT MODEL = RESIDUALIZING STATES + RESPONSE AND MEASUREMENTS
SYSTEM NO 4 PLANT= F24RR (FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL)
%CONDITIONING DATA
C NO SCALING DATA
END
C NO RESPONSE SPECIFICATION DATA
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(8),X(18)-X(23),X(33)-X(42),
RESIDUALIZE STATES
X(9)-X(17),X(24)-X(32),
RESIDUALIZE STATES IN OUTPUTS
R(1)-R(31),
END
REFERENCE
SYSTEM NO 4 PLANT=F42D ( CONVERTED FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL )
END
C DEFINE F24 PLANT MODEL = RESIDUALIZING STATES AND RESPONSES
C AND TRUNCATING MEASUREMENTS
SYSTEM NO 4 PLANT= F24RT (FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL)
%CONDITIONING DATA
C NO SCALING DATA
END
C NO RESPONSE SPECIFICATION DATA
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(8),X(18)-X(23),X(33)-X(42),
RESIDUALIZE STATES
X(9)-X(17),X(24)-X(32),
RESIDUALIZE STATES IN OUTPUTS
R(1)-R(27),
TRUNCATE STATES IN OUTPUTS
R(28)-R(31),
END
REFERENCE
SYSTEM NO 4 PLANT=F42D ( CONVERTED FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL )
END
C DEFINE F24 PLANT MODEL = TRUNCATING STATES + RESPONSE AND MEASUREMENTS
SYSTEM NO 4 PLANT= F24TT (FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL)
%CONDITIONING DATA
C NO SCALING DATA
END
C NO RESPONSE SPECIFICATION DATA
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(8),X(18)-X(23),X(33)-X(42),
END
STOP
```

Figure 79. KONPACT-1 Input Data to Produce F24RR, F24RT, and F24TT Models

```

STANK3
STANK4
NXM= 28
NRM= 31
NUM= 9
NYN= 47
MSB= 2
  
```

Figure 80. Figure 81 Precompiler Data (KONPACT-1)

```

*** INPUT DATA CARDS ***

PRINT INPUT DATA
PRINT OUTPUT DATA
CONTINUATION RUN
C DEFINE CONTROLLER FOR CSA ALDCS DESIGN
SYSTEM NO 5 CONTROLLER FOR CSA ALDCS DESIGN
$SIMULATION DATA
C SET WHICH CONTROLLER SWITCHES SHOULD BE ON
CONTROLLER SWITCHES ON
ALDCS
SAS
MLC1
MLC2
END
C READ ANY CHANGE IN CONTROLLER GAINS
CONTROLLER GAIN VALUES
KAF
  9 9
KM1
-1403.78
KD
  0.0
KNF
  0.0
KP
  0.0
END
END
C NAME LIST DATA
STATE
  1 X( 1) P PILOT FILTER
  2 X( 2) A2INL LAGGED NORMAL ACCELERATION 1G
  3 X( 3) MLC1 FULL STATE MLC FOR AILERON
  4 X( 4) GLAF GUST LOAD ALLEVIATION FILTER
  5 X( 5) F3E 3RD BENDING MODE FILTER ON ELEVATOR
  6 X( 6) HP HIGH PASS FILTER ON ELEVATOR
  7 X( 7) MLC2 FULL STATE MLC FOR ELEVATOR
-1
OUTPUT
  1 R( 1) HDELA AILERON COMMAND OUTPUT RADIAN
  2 R( 2) HDELEI INBOARD ELEVATOR COMMAND OUTPUT RADIAN
  3 R( 3) HDELEO OUTBOARD ELEVATOR COMMAND OUTPUT RADIAN
-1
INPUT
  1 U( 1) U1 AILERON OPTIMAL CONTROL INPUT
  2 U( 2) U2 INBOARD ELEV OPTIMAL CONTROL INPUT
  3 U( 3) ETAP WHITE NOISE INPUT TO PILOT FILTER
  4 U( 4) DELA AILERON POSITION RADIAN
  5 U( 5) DELET INBOARD ELEVATOR POSITION RADIAN
  6 U( 6) A2IR ACCELEROMETER OUTPUT (P1) 1G
  7 U( 7) AFUS FINSELAGE ACCELEROMETER OUTPUT 1G
  8 U( 8) TFUS PITCH RATE GYRO OUTPUT RADIAN/SEC
  9 U( 9) ACG ACCELERATION AT CG INCH/SEC2
-1
END
C DEFINE REDUCED CONTROLLER FOR CSA ALDCS DESIGN REPFAT
SYSTEM NO 5 CONTROLLER FOR CSA ALDCS DESIGN (REDUCED)
$CONDITIONING DATA
C NO SCALING DATA
END
  
```

Figure 81. KONPACT-1 Input Data to Produce F24TT Plus Controller Model

# Contrails

```
C NO RESPONSE SPECIFICATION
END
C REDUCTION DATA
RETAIN STATES
X(1)-X(4).
RESIDUALIZE STATES
X(5).
RESIDUALIZE STATES IN OUTPUTS
R(1)-R(3).
END
REFERENCE
SYSTEM NO 4 PLANT- F24PR (FLEXSTAR CSA A/C + ACTUATOR + GUST MODEL)
END
C DEFINE OVERALL SYSTEM
SYSTEM NO 6 OVERALL SYSTEM (F24PR + REDUCED CONTROLLER)
$INTERCONNECTION DATA
UI4/U
  4 4 .10000E 01
-1
UI5/U
  1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
UI4/RIS
  1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
UI5/R14
  423 .10000E 01 524 .100000E 01 629 .100000E 01 730 .100000E 01 831 .100000E 01
  927-.10000E 01 922 .8A2000E 04
-1
R/R14
  1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01 4 4 .100000E 01 5 5 .100000E 01
  6 6 .10000E 01 7 7 .100000E 01 8 8 .100000E 01 9 9 .100000E 011010 .100000E 01
 1111 .10000E 011212 .100000E 011313 .100000E 011414 .100000E 011515 .100000E 01
 1616 .10000E 011717 .100000E 011818 .100000E 011919 .100000E 012020 .100000E 01
 2121 .10000E 012222 .100000E 012323 .100000E 012424 .100000E 012530 .100000E 01
 2631 .10000E 01
 2722 .114854E 032723-.284800E 032724-.224700E 032725-.471200E 02
 2822 .132854E 042823-.653000E 032824-.265760E 042825-.613000E 03
-1
R/R15
 27 3 .27482E 0328 3 .324900E 04
-1
R/U
 29 1 .10000E 0130 2 .100000E 01
-1
END
C NAME LIST DATA
OUTPUT
 27 R(27) FWDOT IMP MODEL ERROR RATE FOR W
 28 R(24) FODOT IMP MODEL ERROR RATE FOR Q
 29 R(29) 01 AILERON OPTIMAL CONTROL INPUT
 30 R(30) 02 INBOARD ELEVEN OPTIMAL CONTROL INPUT
-1
END
REFERENCE
SYSTEM NO 4 PLANT- F24PT (FLEXSTAR CSA A/C + ACTUATOR + GUST MODEL)
END
C DEFINE OVERALL SYSTEM
SYSTEM NO 6 OVERALL SYSTEM (F24PT + REDUCED CONTROLLER)
$INTERCONNECTION DATA
UI4/U
  4 4 .10000E 01
-1
UI5/U
  1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
```

Figure 81. KONPACT-1 Input Data to Produce F24TT Plus Controller Model (Continued)

# Contrails

```
U14/R15
 1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
U15/R14
423 .10000E 01 524 .100000E 01 629 .100000E 01 730 .100000E 01 831 .100000E 01
927-.10000E 01 922 .882000E 04
-1
R/R14
 1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01 4 4 .100000E 01 5 5 .100000E 01
 6 6 .10000E 01 7 7 .100000E 01 8 8 .100000E 01 9 9 .100000E 011010 .100000E 01
1111 .10000E 011212 .100000E 011313 .100000E 011414 .100000E 011515 .100000E 01
1616 .10000E 011717 .100000E 011818 .100000E 011919 .100000E 012020 .100000E 01
2121 .10000E 012222 .100000E 012323 .100000E 012429 .100000E 012530 .100000E 01
2631 .10000E 01
2722 .114853E 032723-.284800E 032724-.229700E 032725-.471200E 02
2822 .132855E 042823-.607000E 032824-.265700E 042825-.612000E 03
-1
R/R15
27 3 .27682E 0328 3 .326900E 04
-1
R/U
29 1 .10000E 0130 2 .100000E 01
-1
END
C NAME LIST DATA
OUTPUT
27 R(27) FADOT IMP MODEL ERROR RATE FOR W
28 R(28) FADOT IMP MODEL ERROR RATE FOR D
29 R(29) 01 AILERON OPTIMAL CONTROL INPUT
30 R(30) 02 INBOARD ELEV OPTIMAL CONTROL INPUT
-1
END
REFERENCE
SYSTEM NO 4 PLANT- F24TT (FLEXSTAR CSA A/C + ACTUATOR + GUST MODEL)
END
C DEFINE OVERALL SYSTEM
SYSTEM NO 5 OVERALL SYSTEM (F24TT + REDUCED CONTROLLER)
%INTERCONNECTION DATA
U14/U
 4 4 .10000E 01
-1
U15/U
 1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
U14/R15
 1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01
-1
U15/R14
423 .10000E 01 524 .100000E 01 629 .100000E 01 730 .100000E 01 831 .100000E 01
927-.10000E 01 922 .882000E 04
-1
R/R14
 1 1 .10000E 01 2 2 .100000E 01 3 3 .100000E 01 4 4 .100000E 01 5 5 .100000E 01
 6 6 .10000E 01 7 7 .100000E 01 8 8 .100000E 01 9 9 .100000E 011010 .100000E 01
1111 .10000E 011212 .100000E 011313 .100000E 011414 .100000E 011515 .100000E 01
1616 .10000E 011717 .100000E 011818 .100000E 011919 .100000E 012020 .100000E 01
2121 .10000E 012222 .100000E 012323 .100000E 012429 .100000E 012530 .100000E 01
2631 .10000E 01
2722 .114853E 032723-.284800E 032724-.229700E 032725-.471200E 02
2822 .132855E 042823-.607000E 032824-.265700E 042825-.612000E 03
-1
R/R15
27 3 .27682E 0328 3 .326900E 04
-1
R/U
29 1 .10000E 0130 2 .100000E 01
```

Figure 81. KONPACT-1 Input Data to Produce F24TT Plus Controller Model (Continued)

# Contrails

```
-1  
END  
C NAME LIST DATA  
OUTPUT  
27      R(27)      EWDOT  IMP MODEL ERROR RATE FOR W  
28      R(28)      EQDOT  IMP MODEL ERROR RATE FOR Q  
29      R(29)      U1     AILERON OPTIMAL CONTROL INPUT  
30      R(30)      U2     INBOARD ELEV OPTIMAL CONTROL INPUT  
-1  
END  
STOP
```

Figure 81. KONPACT-1 Input Data to Produce F24TT Plus Controller Model (Concluded)



CONDK  
NXM= 31  
NRM= 70  
NUM= 4

Figure 82. Figure 83 Precompiler Data (KONPACT-1)

(KONPACT-1 Output is Shown in Figure 90)

\*\*\* INPUT DATA CARDS \*\*\*

```
PRINT INPUT DATA
PRINT OUTPUT DATA
CONTINUATION RUN
REFERENCE
SYSTEM NO 6 OVERALL SYSTEM (( F24RR + REDUCED CONTROLLER)
END
C DEFINE OVERALL SYSTEM DESIGN MODEL
SYSTEM NO 6 OVERALL SYSTEM (( F24RR + REDUCED CONTROLLER) DESIGN MODEL
$CONDITIONING DATA
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT CONTROL INPUTS
U(1),U(2),
SELECT GUST INPUTS
U(4),U(3),
CONSTRUCT DESIGN RESPONSES
X(27),R(1),R(2),R(26),R(3),R(4),XDOT(15),R(5),R(6),XDOT(16),R(7),R(8),X(15),
R(9),R(10),X(16),R(11),R(12),X(3),R(13),R(14),X(4),R(15),R(16),X(5),R(17),R(18),
X(6),R(19),R(20),X(7),X(8),R(27),R(28),R(21),R(29),R(30),
SELECT SENSOR OUTPUTS
X(25),X(18)-X(24),X(11),X(9),X(15)-X(17),X(3)-X(5),R(24),X(6)-X(8),R(25),
R(26),X(10),X(12),X(14),X(26)-X(28),
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(16),X(26)-X(28),X(17),X(25),X(18)-X(24),
END
REFERENCE
SYSTEM NO 6 OVERALL SYSTEM (( F24RT + REDUCED CONTROLLER)
END
C DEFINE OVERALL SYSTEM DESIGN MODEL
SYSTEM NO 6 OVERALL SYSTEM (( F24RT + REDUCED CONTROLLER) DESIGN MODEL
$CONDITIONING DATA
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT CONTROL INPUTS
U(1),U(2),
SELECT GUST INPUTS
U(4),U(3),
CONSTRUCT DESIGN RESPONSES
X(27),R(1),R(2),R(26),R(3),R(4),XDOT(15),R(5),R(6),XDOT(16),R(7),R(8),X(15),
R(9),R(10),X(16),R(11),R(12),X(3),R(13),R(14),X(4),R(15),R(16),X(5),R(17),R(18),
X(6),R(19),R(20),X(7),X(8),R(27),R(28),R(21),R(29),R(30),
SELECT SENSOR OUTPUTS
X(25),X(18)-X(24),X(11),X(9),X(15)-X(17),X(3)-X(5),R(24),X(6)-X(8),R(25),
R(26),X(10),X(12),X(14),X(26)-X(28),
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(16),X(26)-X(28),X(17),X(25),X(18)-X(24),
END
REFERENCE
SYSTEM NO 6 OVERALL SYSTEM (( F24TT + REDUCED CONTROLLER)
END
C DEFINE OVERALL SYSTEM DESIGN MODEL
SYSTEM NO 6 OVERALL SYSTEM (( F24TT + REDUCED CONTROLLER) DESIGN MODEL
$CONDITIONING DATA
```

Figure 83. KONPACT-1 Input Data to Produce F24RR Plus Reduced Controller Model

```
C NO SCALING DATA
END
C RESPONSE SPECIFICATIONS
SELECT CONTROL INPUTS
U(1),U(2),
SELECT GUST INPUTS
U(4),U(3),
CONSTRUCT DESIGN RESPONSES
X(27)*R(1),R(2),R(26),R(3),R(4),XDOT(15),R(5),R(6),XDOT(16),R(7),R(8),X(15),
R(9),R(10),X(16),R(11),R(12),X(3),R(13),R(14),X(4),R(15),R(16),X(5),R(17),R(18),
X(6),R(19),R(20),X(7),X(8),R(27),R(28),R(21),R(29),R(30),
SELECT SENSOR OUTPUTS
X(25)*X(18)-X(24),X(1),X(9),X(15)-X(17),X(3)-X(5),R(24)*X(6)-X(8),R(25),
R(26)*X(10),X(12),X(14),X(26)-X(28),
END
C REDUCTION AND SHUFFLING DATA
RETAIN STATES
X(1)-X(16),X(26)-X(28),X(17),X(25),X(18)-X(24),
END
STOP
```

Figure 83. KONPACT-1 Input Data to Produce F24RR Plus Reduced Controller Model (Concluded)

```
C DESIGN USING DIAK FOR THE DEMONSTRATION EXAMPLE
C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
%0IAK DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 6 OVERALL SYSTEM ( F24PR + REDUCED CONTROLLER) DESIGN MODEL
C READ DATE AND USER ID
JAN 10. 75   J K MAHESH
C NOP - NO OF VARIABLES BEING PLOTTED
C READ NOP
      0
C GO TO 100 IF NOP.EQ.0
C READ (PLR(I),ITITL(I),UNIT(I),YMIN(I),YMAX(I),SCAL(I),I=1,NOP)
C READ T,DT,ST,T1,T2
C 100 CONTINUE
C READ IMAX,ITER,ITERO
2015 0
C NCOV=1 NO COVARIANCE ANALYSIS
C NCOV=2 COVARIANCE ANALYSIS
C NCOV=3 SKIP CORRELATION ANALYSIS
C NSTEP=0 NO STEP INPUTS
C NSTEP=1 STEP COMMANDS
C NSTEP=2 STEP GUSTS
C NSTEP=3 BOTH (1 AND 2)
C NSTEP=4 NO STEP INPUTS - TRANSIENTS ONLY
C NRAND=0 NO RANDOM INPUTS
C NRAND=1 GUSTS
C NPRIN=0 DO NOT PRINT RESPONSES
C NPRIN=1 PRINT RESPONSES
C NPLOT=0 NO PLOTS
C NPLOT=1 CALCOMP PLOTS
C NPLOT=2 LINE PRINTER PLOTS
C NPLOT=3 BOTH (1 AND 2)
C READ NCOV,NSTEP,NRAND,NPRIN,NPLOT
3 0 0 0 0
C INPK=1 NEW INPUT GAINS
C INPK=2 NEW STARTING ROUTINE GAINS
C INPK=3 USE GAINS IN STORAGE
C INPK=4 USE INPUT GAINS IN STORAGE
C READ INPK
      1
C NCONT=0 DONOT COMPUTE OPTIMAL GAINS - USE INPUT GAINS AND DATA IN
C   COVARIANCE AND TIME RESPONSE ANALYSIS ONLY
C NCONT=1 COMPUTE OPTIMAL GAINS
C NCONT=2 COMPUTE OPTIMAL GAINS WITH AUTOMATIC Q SELECTION ON CONTROL RAT
C READ NCONT
      1
C READ FLIGHT CONDITION NUMBER
412301
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NM - NO OF DISTURRANCE INPUTS
C NF - NO OF FEEDBACK STATES
C NG - NO OF GUST INPUTS
C NCS - NO OF COMMAND INPUTS = NO OF COMMAND STATES
C NGLG - NO OF GUST LIFT GROWTH STATES
C NSCR - START OF CONTROL RATE RESPONSE IN THE RESPONSE VECTOR
C READ NX,NR,NU,NN,NF,NG,NCS,NGLG,NSCR
2037 2 228 0 0 013
C GO TO 200 IF INPK.GT.1
```

Figure 84. KONPACT-2 Input Data (Employing DIAK to Compute Optimal State Feedback Gains)

```
C READ (NORD(I),I=1,NX)
1 2 3 4 5 6 7 8 910111213141516171819202122232425262728
C 200 CONTINUE
C F IS STATE TRANSITION MATRIX
READ TAPE FOR MATRIX F
C G1 IS CONTROL INPUT MATRIX
READ TAPE FOR MATRIX G1
C G2 IS DISTURBANCE INPUT MATRIX
READ TAPE FOR MATRIX G2
C X1 IS INITIAL CONDITION MATRIX
READ CARD FOR MATRIX XE

C XLDXL IS STATE LIMIT - RATE LIMIT MATRIX
READ CARD FOR MATRIX XLDXL

C CL IS COMMAND LEVEL MATRIX
READ CARD FOR MATRIX CL

C H IS STATE RESPONSE MATRIX
READ TAPE FOR MATRIX H
C D IS CONTROL RESPONSE MATRIX
READ TAPE FOR MATRIX D
C AM IS MEASUREMENT MATRIX
READ TAPE FOR MATRIX AM
C RK IS INITIAL FEEDBACK GAIN MATRIX
READ CARD FOR MATRIX RK
111 .24410E 00 126 .14630E 01 128 .13560E 01
2 1 .50240E 00 217 .009674E 00 221-.94230E-01 222 .11980E 01

C Q IS QUADRATIC WEIGHTS MATRIX
READ CARD FOR MATRIX Q
1 1 .90000E 01 2 2 .10000E-10 3 3 .10000E-08 7 7 .50000E 041010 .60000E 06
1717 .75000E-131818 .10000E-102020 .10000E-132121 .10000E-112323 .20000E-13
2424 .20000E-112626 .80000E-132727 .10000E-102929 .20000E-123030 .20000E-10
3333 .10000E 013434 .10000E 01

C IDUM=0 ANOTHER RUN
C IDUM=1 NO MORE RUNS
C READ IDUM
1
END OF DIAK DATA
$STOP
```

Figure 84. KONPACT-2 Input Data (Employing DIAK to Compute Optimal State Feedback Gains) (Concluded)

```

C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
$FFOC DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 6 OVERALL SYSTEM (I F24R - REDUCED CONTROLLER) DESIGN MODEL
C IMAX - MAXIMUM NO OF LYBUNDY SOLUTION ITERATIONS
C NITN - MAXIMUM NO OF COST CALCULATIONS
C NOPR=0 USE PROJECTED GRADIENT
C NOPR=1 DO NOT USE PROJECTED GRADIENT
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 SKIP CORRELATION ANALYSIS
C NREGIN,GT,0 TEST FOR LARGE D-COST ON FIRST INCREMENT OF LAMDA
C NBEGIN=0 NO TEST
C READ IMAX,NITN,NOPR,NOCOV,NBEGIN
2.8 0 3 1
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NN - NO OF DISTURBANCE INPUTS
C NFF - NO FEED FORWARD STATES
C NF - NO OF FIXED GAINS
C READ NX,NU,NN,NFF,NF
2.837 2 2 9 7
C READ (NDRD(I),I=1,NX)
  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
C EPSI - INITIAL STEP SIZE
C READ EPSI
.5000E 00
C AJSTAR - LOWEST COST EXPECTED
C READ AJSTAR
.8584E 02
C DROC - DESIRED RATIO OF COSTS
C READ DROC
.1100E 01
C ALAM - INTEGRATION PARAMETER - LAMDA
C DELT - INTEGRATION STEP SIZE
C ALAMD - LOWER BOUND ON LAMDA FOR THE PRESENT RUN
C READ ALAM,DELT,ALAMD
.1000E 01 .2900E 00 .0000E 00
C IF - FIXED GAIN ROW INDEX
C JF - FIXED GAIN COLUMN INDEX
C READ (IF(I),JF(I),I=1,NF)
  111 126 124 2 1 217 221 222
READ TAPE FOR MATRIX F
READ TAPE FOR MATRIX G1
READ TAPE FOR MATRIX G2
READ TAPE FOR MATRIX H
READ TAPE FOR MATRIX D
READ TAPE FOR MATRIX AM
READ CARD FOR MATRIX Q
  1 1 .800000E 01 2 2 .100000E-10 3 3 .100000E-08 7 7 .500000E 04 10 10 .600000E 06
1717 .750000E-13 1818 .100000E-10 1920 .100000E-13 21 21 .100000E-11 23 23 .200000E-13
2424 .200000E-11 26 26 .800000E-13 27 27 .100000E-10 29 29 .200000E-13 30 30 .200000E-10
3333 .100000E 01 34 34 .100000E 01
READ TAPE FOR MATRIX AK(OPTIMAL RICCATI GAINS)
GAINS MATRIX FOR CASE 1
READ CARD FOR MATRIX AK(K1(I))
READ CARD FOR MATRIX BK(K2)
C IF (ALAM,GT,.99) GO TO 100
C 100 CONTINUE
END OF FFOC DATA
$STOP

```

Figure 85. KONPACT-2 Input Data (Employing FFOC to Compute Reduced Feedback Gains)

```
C DESIGN USING DIAK FOR THE DEMONSTRATION EXAMPLE
C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
$DIAK DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE-
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 6 OVERALL SYSTEM (( F24RK + REDUCED CONTROLLER) DESIGN MODEL
C READ DATE AND USER ID
JAN 13, 75 J K MAHESH
C NOP - NO OF VARIABLES BEING PLOTTED
C READ NOP
12
C GO TO 100 IF NOP.EQ.0
C READ (PLP(I),ITITL(I),UNIT(I),YMIN(I),YMAX(I),SCAL(I),I=1,NOP)
2 B1
3 T1
7 DELADOT
10 DELEIDOT
13 DELA
16 DELEI
35 ALPHA
39 Q
46 ETA1
47 ETA3
50 ETA6
57 DELEO
C READ T,DT,ST,T1,TP
4.0 0.01 0.04 0.0 0.0
C 100 CONTINUE
C READ IMAX,ITER,ITEPO
0 0 0
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 SKIP CORRELATION ANALYSIS
C NSTEP=0 NO STEP INPUTS
C NSTEP=1 STEP COMMANDS
C NSTEP=2 STEP GUSTS
C NSTEP=3 BOTH (1 AND 2)
C NSTEP=4 NO STEP INPUTS - TRANSIENTS ONLY
C NRAND=0 NO RANDOM INPUTS
C NRAND=1 GUSTS
C NPRIN=0 DO NOT PRINT RESPONSES
C NPRIN=1 PRINT RESPONSES
C NPLDT=0 NO PLOTS
C NPLDT=1 CALCOMP PLOTS
C NPLDT=2 LINE PRINTER PLOTS
C NPLDT=3 BOTH (1 AND 2)
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLDT
1 1 0 1 2
C INPK=1 NEW INPUT GAINS
C INPK=2 NEW STARTING POINTING GAINS
C INPK=3 USE GAINS IN STORAGE
C INPK=4 USE INPUT GAINS IN STORAGE
C READ INPK
1
C NCONT=0 DONOT COMPUTE OPTIMAL GAINS - USE INPUT GAINS AND DATA IN
COVARIANCE AND TIME RESPONSE ANALYSIS ONLY
C NCONT=1 COMPUTE OPTIMAL GAINS
C NCONT=2 COMPUTE OPTIMAL GAINS WITH AUTOMATIC 2 SELECTION ON CONTROL RATES
C READ NCONT
4
C READ FLIGHT CONDITION NUMBER
```

Figure 86. KONPACT-2 Input Data (Employing DIAK to Evaluate Time Responses)

```
412301
C NX = NO OF STATES
C NR = NO OF RESPONSES
C NU = NO OF CONTROL INPUTS
C NY = NO OF DISTURBANCE INPUTS
C NF = NO OF FEEDBACK STATES
C NG = NO OF GUST INPUTS
C NCS = NO OF COMMAND INPUTS = NO OF COMMAND STATES
C NGLG = NO OF GUST LIFT GROWTH STATES
C NSCR = START OF CONTROL RATE RESPONSE IN THE RESPONSE VECTOR
C READ NX,NP,NU,NN,NF,NG,NCS,NGLG,NSCR
2837 2 227 1 0 7
C GO TO 200 IF INPK.GT.1
C READ (NOR(I),I=1,NX)
  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 22 23 24 25 26 27 28 21
C 200 CONTINUE
C F IS STATE TRANSITION MATRIX
READ TAPE FOR MATRIX F
C G1 IS CONTROL INPUT MATRIX
READ TAPE FOR MATRIX G1
C G2 IS DISTURBANCE INPUT MATRIX
READ TAPE FOR MATRIX G2
C XI IS INITIAL CONDITION MATRIX
READ CARD FOR MATRIX XI

C XLDXL IS STATE LIMIT = RATE LIMIT MATRIX
READ CARD FOR MATRIX XLDXL

C CL IS COMMAND LEVEL MATRIX
READ CARD FOR MATRIX CL
  1 1-.08957 E 01
C H IS STATE RESPONSE MATRIX
READ TAPE FOR MATRIX H
C D IS CONTROL RESPONSE MATRIX
READ TAPE FOR MATRIX D
C AM IS MEASUREMENT MATRIX
READ TAPE FOR MATRIX AM
C RK IS INITIAL FEEDBACK GAIN MATRIX
READ CARD FOR MATRIX RK
  111-.78123 E 01 126 .110400E 02 127 .196900E 01
  2 1 .01780 E 01 217 .002565E 03 221-.640100E-01 222 .049040E 01
C Q IS QUADRATIC WEIGHTS MATRIX
READ CARD FOR MATRIX Q

C IDUM=0 ANOTHER RUN
C IDUM=1 NO MORE RUNS
C READ IDUM
  1
END OF DIAK DATA
$STOP
```

Figure 86. KONPACT-2 Input Data (Employing DIAK to Evaluate Time Responses) (Concluded)

```

C DESIGN USING DIAK FOR THE DEMONSTRATION EXAMPLE
C READ FOR WHAT PROGRAM ( DIAK,FFOC,LSA ) THE DATA IS
$DIAK DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 6 OVERALL SYSTEM (( F24PR * REDUCED CONTROLLER) DESIGN MODEL
C READ DATE AND USER ID
JAN 10 75 J K MAHESH
C NOP - NO OF VARIABLES BEING PLOTTED
C READ NOP
0
C GO TO 100 IF NOP.FO.0
C READ (PLR(I),ITITL(I),UNIT(I),YMIN(I),YMAX(I),SCAL(I),I=1,NOP)
C READ T,DT,ST,T1,T2
C 100 CONTINUE
C READ IMAX,ITER,ITERD
2015 0
C NOCOV=1 NO COVARIANCE ANALYSIS
C NOCOV=2 COVARIANCE ANALYSIS
C NOCOV=3 SKIP CORRELATION ANALYSIS
C NSTEP=0 NO STEP INPUTS
C NSTEP=1 STEP COMMANDS
C NSTEP=2 STEP GUSTS
C NSTEP=3 BOTH (1 AND 2)
C NSTEP=4 NO STEP INPUTS - TRANSIENTS ONLY
C NRAND=0 NO RANDOM INPUTS
C NRAND=1 GUSTS
C NPRIN=0 DO NOT PRINT RESPONSES
C NPRIN=1 PRINT RESPONSES
C NPLOT=0 NO PLOTS
C NPLOT=1 CALCOMP PLOTS
C NPLOT=2 LINE PRINTER PLOTS
C NPLOT=3 BOTH (1) AND (2)
C READ NOCOV,NSTEP,NRAND,NPRIN,NPLOT
3 0 0 0 0
C INPK=1 NEW INPUT GAINS
C INPK=2 NEW STARTING POINT GAINS
C INPK=3 USE GAINS IN STORAGE
C INPK=4 USE INPUT GAINS IN STORAGE
C READ INPK
1
C NCONT=0 DONOT COMPUTE OPTIMAL GAINS - USE INPUT GAINS AND DATA IN
C COVARIANCE AND TIME RESPONSE ANALYSIS ONLY
C NCONT=1 COMPUTE OPTIMAL GAINS
C NCONT=2 COMPUTE OPTIMAL GAINS WITH AUTOMATIC 2 SELECTION ON CONTROL RAT
C READ NCONT
1
C READ FLIGHT CONDITION NUMBER
412301
C NX - NO OF STATES
C NR - NO OF RESPONSES
C NU - NO OF CONTROL INPUTS
C NN - NO OF DISTURRANCE INPUTS
C NF - NO OF FEEDBACK STATES
C NG - NO OF GUST INPUTS
C NCS - NO OF COMMAND INPUTS = NO OF COMMAND STATES
C NGLG - NO OF GUST LIFT GROWTH STATES
C NSCRR - START OF CONTROL RATE RESPONSE IN THE RESPONSE VECTOR
C READ NX,NR,NU,NN,NF,NG,NCS,NGLG,NSCRR
2837 2 228 4 6 013
C GO TO 200 IF INPK.GT.1

```

**Figure 87. KONPACT-2 Input Data (Employing DIAK to Evaluate Covariance Responses)**



```
C READ (NOR(I),J)=1,NX)
  1 2 3 4 5 6 7 8 910111213141516171819202122232425262728
C 200 CONTINUE
C F IS STATE TRANSITION MATRIX
READ TAPE FOR MATRIX F
C G1 IS CONTROL INPUT MATRIX
READ TAPE FOR MATRIX G1
C G2 IS DISTURBANCE INPUT MATRIX
READ TAPE FOR MATRIX G2
C X1 IS INITIAL CONDITION MATRIX
READ CARD FOR MATRIX X1

C XLDXL IS STATE LIMIT - RATE LIMIT MATRIX
READ CARD FOR MATRIX XLDXL

C CL IS COMMAND LEVEL MATRIX
READ CARD FOR MATRIX CL

C H IS STATE RESPONSE MATRIX
READ TAPE FOR MATRIX H
C D IS CONTROL RESPONSE MATRIX
READ TAPE FOR MATRIX D
C AM IS MEASUREMENT MATRIX
READ TAPE FOR MATRIX AM
C BK IS INITIAL FEEDBACK GAIN MATRIX
READ CARD FOR MATRIX BK

C Q IS QUADRATIC WEIGHTS MATRIX
READ CARD FOR MATRIX Q
  1 1 .00000E 01 2 2 .100000E-10 3 3 .100000E-08 7 7 .500000E 041010 .600000E 06
1717 .750000E-131818 .100000E-102020 .100000E-122121 .100000E-112323 .200000E-13
2424 .200000E-112626 .800000E-132727 .100000E-102929 .200000E-123030 .200000E-10
3333 .100000E 013434 .100000E 01

C IDUM=0 ANOTHER RUN
C IDUM=1 NO MORE RUNS
C READ IDUM
  1
END OF DIAK DATA
SSTOP
```

Figure 87. KONPACT-2 Input Data (Employing DIAK to Evaluate Covariance Responses (Concluded))

# Contrails

```
C LSA INPUT DATA
SLSA DATA
C READ IF DATA IS ON CARDS ONLY OR ON CARDS AND TAPE
DATA ON CARDS AND TAPE
C IF DATA IS ON CARDS AND TAPE READ THE LABEL TO OBTAIN DATA ON TAPE
SYSTEM NO 4 PLANT-F42D ( CONVERTED FLEXSTAB CSA A/C + ACTUATOR + GUST MODEL )
C INSERT DATA ON CARDS IF ANY
END
C NAME LIST DATA FOR LSA
NAME
W          Q          UE100T  UE300T  UE400T  UE500T  UE600T  UE700T
UE800T  UE900T  UE1000T UE1100T UE1200T UE1300T UE1400T UE1500T
UE1600T UE1          UE3          UE4          UE5          UE6          UE7          UE8
UE9          UE10         UE11         UE12         UE13         UE14         UE15         UE16
XA          XE1          KF0          P1          P2          P3          P4          P5
P6          W0          B1          T1          B2          T2          B3          T3
B4          T4          B5          T5          B100T       T100T       B200T       T200T
B300T       T300T       R400T       T400T       B500T       T500T       ALPHA       QCG
DELA        DELE1       DELE2       WR          W00T        A21F        A21R        AFUS
TFUS        UDELA      UDFLE1     UDELE0     ETAG
END OF LSA DATA
$STOP
```

Figure 88. KONPACT-2 Input Data (to Prepare Frequency Domain Data for LSA Program)

```
DATA FOR LSA(SCRATCH=20000)
IDENTIFICATION(PCSA MODEL.MANFISH)
READ A(S)
PRINT SYSTEM MATRIX
COMPUTE PULES
COMPUTE ZEROS(P1/ETAG)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+6.0E 12)
COMPUTE ZEROS(T1/ETAG)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+7.0E 10)
COMPUTE ZEROS(Q1/UDELA)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+4.0E 17)
COMPUTE ZEROS(T1/UDELA)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+4.0E 16)
COMPUTE ZEROS(Q1/UDELEI)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+5.0E 17)
COMPUTE ZEROS(T1/UDELEI)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+3.0E 16)
COMPUTE ZEROS(Q1/ETAG)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+7.0)
COMPUTE ZEROS(Q1/UDELA)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+1.0E 05)
COMPUTE ZEROS(Q1/UDELEI)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+4.0E 06)
COMPUTE ZEROS(U1E3/ETAG)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+2.0E-01)
COMPUTE ZEROS(U1E3/UDELA)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+1.0E 04)
COMPUTE ZEROS(U1E3/UDELEI)
COMPUTE PSD
PLOT PSD(LINEAR+0.1+10.0+0.1+2.0E 04)
END
```

Figure 89. LSA Input Data (to Evaluate Power Spectral Density)

.....  
 \* SYSTEM NO 1 FLESTAR CSA A/C F34 ( RESIDUAL ELASTIC SYMMETRIC - RES )  
 \* .....

NUMBER OF STATES =34  
 NUMBER OF OUTPUTS=19  
 NUMBER OF INPUTS =12

\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
STATE		
1 X(1)	VELOCITY ALONG X AXIS	INCH/SEC
2 X(2)	VELOCITY ALONG Z AXIS	INCH/SEC
3 X(3)	PITCH RATE	RADIAN/SEC
4 X(4)	THETA	INCH
5 X(5)	UE1 BENDING MODE DISPLACEMENT	INCH
6 X(6)	UE2 BENDING MODE DISPLACEMENT	INCH
7 X(7)	UE3 BENDING MODE DISPLACEMENT	INCH
8 X(8)	UE4 BENDING MODE DISPLACEMENT	INCH
9 X(9)	UE5 BENDING MODE DISPLACEMENT	INCH
10 X(10)	UE6 BENDING MODE DISPLACEMENT	INCH
11 X(11)	UE7 BENDING MODE DISPLACEMENT	INCH
12 X(12)	UE8 BENDING MODE DISPLACEMENT	INCH
13 X(13)	UE9 BENDING MODE DISPLACEMENT	INCH
14 X(14)	UE10 BENDING MODE DISPLACEMENT	INCH
15 X(15)	UE11 BENDING MODE DISPLACEMENT	INCH
16 X(16)	UE12 BENDING MODE DISPLACEMENT	INCH
17 X(17)	UE13 BENDING MODE DISPLACEMENT	INCH
18 X(18)	UE14 BENDING MODE DISPLACEMENT	INCH
19 X(19)	UE15 BENDING MODE DISPLACEMENT	INCH
20 X(20)	UE100T BENDING MODE RATE	INCH/SEC
21 X(21)	UE200T BENDING MODE RATE	INCH/SEC
22 X(22)	UE300T BENDING MODE RATE	INCH/SEC
23 X(23)	UE400T BENDING MODE RATE	INCH/SEC
24 X(24)	UE500T BENDING MODE RATE	INCH/SEC
25 X(25)	UE600T BENDING MODE RATE	INCH/SEC
26 X(26)	UE700T BENDING MODE RATE	INCH/SEC
27 X(27)	UE800T BENDING MODE RATE	INCH/SEC
28 X(28)	UE900T BENDING MODE RATE	INCH/SEC
29 X(29)	UE1000T BENDING MODE RATE	INCH/SEC
30 X(30)	UE1100T BENDING MODE RATE	INCH/SEC
31 X(31)	UE1200T BENDING MODE RATE	INCH/SEC
32 X(32)	UE1300T BENDING MODE RATE	INCH/SEC
33 X(33)	UE1400T BENDING MODE RATE	INCH/SEC
34 X(34)	UE1500T BENDING MODE RATE	INCH/SEC
OUTPUT		
1 R(1)	SASGY PITCH RATE GYRO	RADIAN/SEC

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition)

2 R(1,2) AZAP NORMAL ACCELEROMETER INCH/SEC2  
 3 R(1,3) AZE# NORMAL ACCELEROMETER FRONTSPAR INCH/SEC2  
 4 R(1,4) AZM# NORMAL ACCELEROMETER BACKSPAR INCH/SEC2  
 5 R(1,5) S1 SHEAR FORCE (120,0) LB INCH-LB  
 6 R(1,6) P1 BENDING MOMENT (120,0) LB INCH-LB  
 7 R(1,7) T1 TORSION MOMENT (120,0) LB INCH-LB  
 8 R(1,8) S2 SHEAR FORCE (328,2) LB INCH-LB  
 9 R(1,9) P2 BENDING MOMENT (328,2) LB INCH-LB  
 10 R(1,10) T2 TORSION MOMENT (328,2) LB INCH-LB  
 11 R(1,11) S3 SHEAR FORCE (575,1) LB INCH-LB  
 12 R(1,12) T3 TORSION MOMENT (575,1) LB INCH-LB  
 13 R(1,13) S4 SHEAR FORCE (746,0) LB INCH-LB  
 14 R(1,14) P4 BENDING MOMENT (746,0) LB INCH-LB  
 15 R(1,15) T4 TORSION MOMENT (746,0) LB INCH-LB  
 16 R(1,16) S5 SHEAR FORCE (920,0) LB INCH-LB  
 17 R(1,17) P5 BENDING MOMENT (920,0) LB INCH-LB  
 18 R(1,18) T5 TORSION MOMENT (920,0) LB INCH-LB  
 19 R(1,19)

INPUT

1 U(1,1) RDAIL AILERON DEFLECTION RADIAN  
 2 U(1,2) RDEI INBOARD ELEVATOR DEFLECTION RADIAN  
 3 U(1,3) RDEO OUTBOARD ELEVATOR DEFLECTION RADIAN  
 4 U(1,4) RDAILOUT AILERON DEFLECTION RATE RADIAN/SEC  
 5 U(1,5) RDEIOUT INBOARD ELEVATOR DEFLECTION RATE RADIAN/SEC  
 6 U(1,6) RDEOOUT OUTBOARD ELEVATOR DEFLECTION RATE RADIAN/SEC  
 7 U(1,7) W61 GUST INPUT AT -1020 IN FROM CG INCH/SEC  
 8 U(1,8) W62 GUST INPUT AT 0 IN FROM CG INCH/SEC  
 9 U(1,9) W63 GUST INPUT AT 1020 IN FROM CG INCH/SEC  
 10 U(1,10) W64 GUST INPUT RATE INCH/SEC2  
 11 U(1,11) W65 GUST INPUT RATE INCH/SEC2  
 12 U(1,12) W66 GUST INPUT RATE INCH/SEC2

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A

SIZE = 34 X 34

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN
1-ROW	-.4209E-02	-.0721E-01	-.3311E+03	-.3058E+03	-.4432E-02	.1762E-01	.4196E-01	-.4561E-02	.2761E-01	.6660E-01
2-ROW	-.1283E+00	-.7472E+00	-.0702E+04	-.1486E+02	-.1614E+00	.9881E+00	.1247E+01	-.0320E-01	.1004E+01	.2361E+01
3-ROW	.1660E-04	-.2283E-03	-.1450E+01	-.6549E-03	-.6090E-04	.2171E-02	-.1854E-02	.5940E-03	-.3272E-03	.3734E-03
4-ROW	0.	0.	-.1000E+01	0.	0.	0.	0.	0.	0.	0.
5-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-ROW	-.1937E-01	-.1051E+02	.0006E+04	0.	-.3049E+02	.1939E+02	.5603E+02	-.1017E+02	-.4147E+02	.6155E+02
21-ROW	-.1748E+01	-.4123E+01	.1700E+05	0.	-.3406E+01	-.2629E+03	.4022E+02	-.8082E+01	-.1614E+02	.2519E+02

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)

MATRIX A

SIZE = 34 X 34

	11-COLUMN	12-COLUMN	13-COLUMN	14-COLUMN	15-COLUMN	16-COLUMN	17-COLUMN	18-COLUMN	19-COLUMN	20-COLUMN
22-ROW	-.6117E+00	-.6614E+01	-.1156E+05	0.	-.1125E+01	-.2086E+02	-.2867E+03	-.8245E+01	-.6764E+01	-.8419E+01
23-ROW	-.4435E+00	-.3642E+01	-.3261E+04	0.	-.5924E-01	-.7466E+01	-.3085E+01	-.3375E+03	-.4154E+00	-.A225E+01
24-ROW	-.5248E+00	-.4220E+01	-.1635E+04	0.	-.1035E+01	-.8844E+01	-.3021E+01	-.1150E+01	-.3763E+03	-.1378E+02
25-ROW	-.5730E+00	-.3667E+01	-.6322E+04	0.	-.1343E+01	-.2144E+01	-.1110E+02	-.4521E+01	-.6082E+01	-.4887E+03
26-ROW	-.2083E+00	-.1502E+01	-.4824E+03	0.	-.2643E+00	-.2958E+01	-.2357E+01	-.3167E+01	-.2934E+01	-.4856E+01
27-ROW	-.5086E+00	-.6366E+01	-.1799E+04	0.	-.5671E+00	-.7897E+01	-.6675E+01	-.4307E+01	-.1185E+01	-.1632E+02
28-ROW	-.2498E+00	-.1732E+01	-.9211E+03	0.	-.1398E+01	-.6723E+01	-.9401E+01	-.4564E+00	-.5479E+01	-.2428E+00
29-ROW	-.8798E+00	-.1025E+02	-.1816E+05	0.	-.1813E+01	-.4953E+02	-.1988E+02	-.6832E+01	-.1927E+01	-.1408E+02
30-ROW	-.8742E+01	-.4336E+01	-.2796E+05	0.	-.4344E+01	-.3358E+02	-.5557E+02	-.1541E+02	-.2175E+02	-.1234E+02
31-ROW	-.1342E+01	-.4425E+01	-.2795E+04	0.	-.3628E+01	-.1779E+02	-.2577E+02	-.3240E+01	-.2209E+02	-.3551E+02
32-ROW	-.1762E+01	-.9523E+01	-.1340E+04	0.	-.2327E+01	-.1841E+02	-.2644E+02	-.2050E+01	-.1447E+02	-.2975E+02
33-ROW	-.3666E+00	-.8739E+00	-.2133E+04	0.	-.3984E+01	-.3984E+01	-.5300E+01	-.2331E+01	-.6267E+01	-.6338E+01
34-ROW	-.9179E+00	-.3208E+01	-.12270E+04	0.	-.1842E+00	-.4902E+01	-.3446E+00	-.7184E+00	-.9595E+00	-.8866E+01

MATRIX A

SIZE = 34 X 34

	21-COLUMN	22-COLUMN	23-COLUMN	24-COLUMN	25-COLUMN	26-COLUMN	27-COLUMN	28-COLUMN	29-COLUMN	30-COLUMN
1-ROW	-.4753E-02	-.1217E-01	-.3824E-01	-.5460E-01	-.3593E-02	-.1909E+00	-.4947E-01	-.1812E+00	-.3305E-02	-.4670E-04
2-ROW	-.9548E-01	-.3144E+00	-.1777E+00	-.2208E+01	-.1638E+01	-.5277E+01	-.1430E+01	-.1789E+01	-.4947E+00	-.2067E-02
3-ROW	-.1444E-03	-.7693E-02	-.4944E-02	-.4396E-02	-.1111E-01	-.6457E-02	-.1706E-02	-.2501E-01	-.4298E-02	-.8560E-05
4-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-ROW	-.2897E+01	-.1459E+02	-.1494E+02	-.2003E+02	-.4894E+02	-.1609E+03	-.4098E+02	-.1323E+03	-.3681E+02	-.9808E+00
21-ROW	-.3525E+01	-.4170E+02	-.6820E+02	-.2550E+02	-.1322E+03	-.4339E+02	-.4339E+02	-.3643E+03	-.4466E+02	-.1101E+00
22-ROW	-.9934E+01	-.2117E+02	-.3260E+02	-.6683E+02	-.1218E+03	-.4083E+02	-.5801E+01	-.1884E+03	-.3335E+02	-.3022E+00
23-ROW	-.5479E+01	-.1113E+02	-.2104E+01	-.2231E+02	-.3544E+02	-.5249E+01	-.2620E+01	-.4315E+02	-.1001E+02	-.7989E-01
24-ROW	-.2549E+01	-.8271E+01	-.2361E+01	-.1918E+02	-.2692E+02	-.1252E+02	-.9145E+01	-.2765E+02	-.3951E+01	-.1514E-01
25-ROW	-.5219E+01	-.1392E+02	-.2194E+02	-.3936E+02	-.5541E+02	-.6489E+02	-.2005E+01	-.1541E+02	-.1053E+02	-.3539E+00
26-ROW	-.8695E+03	-.4903E+00	-.2254E+01	-.6922E+01	-.5815E+01	-.2738E+01	-.3897E+01	-.5884E+01	-.2510E+00	-.2834E-01
27-ROW	-.1352E+01	-.1118E+04	-.1524E+01	-.2827E+02	-.3794E+02	-.5318E+02	-.1042E+02	-.1965E+02	-.8801E+01	-.4433E-01
28-ROW	-.1530E+01	-.5134E+00	-.1187E+04	-.1771E+02	-.2231E+02	-.4408E+02	-.1635E+01	-.4581E+01	-.8206E+01	-.1449E+00
29-ROW	-.9546E+00	-.2571E+02	-.3509E+02	-.1535E+04	-.1597E+03	-.3951E+02	-.5327E+01	-.2336E+03	-.4315E+02	-.3292E+00
30-ROW	-.1086E+01	-.4863E+02	-.7157E+02	-.1078E+03	-.1852E+04	-.1572E+03	-.3918E+02	-.4586E+03	-.5134E+02	-.5336E+00
31-ROW	-.8776E+00	-.1010E+02	-.1413E+02	-.3386E+01	-.1057E+02	-.2326E+04	-.1197E+02	-.1213E+03	-.2795E+01	-.4354E+00
32-ROW	-.1398E+01	-.2685E+01	-.3380E+01	-.2590E+02	-.4977E+01	-.8031E+02	-.2624E+04	-.5186E+02	-.1491E+01	-.1024E+00
33-ROW	-.2214E+01	-.1358E+02	-.1521E+02	-.1473E+01	-.3760E+01	-.1200E+02	-.1500E+02	-.5678E+04	-.3545E+01	-.2267E+00
34-ROW	-.4952E+00	-.1989E+01	-.1274E+01	-.2099E+02	-.2663E+02	-.2059E+02	-.3915E+01	-.2759E+01	-.6403E+04	-.9139E-01

MATRIX A

SIZE = 34 X 34

	21-COLUMN	22-COLUMN	23-COLUMN	24-COLUMN	25-COLUMN	26-COLUMN	27-COLUMN	28-COLUMN	29-COLUMN	30-COLUMN
1-ROW	-.1340E-02	-.1263E-02	-.2634E-03	-.11147E-02	-.1223E-02	-.1286E-03	-.1474E-03	-.5740E-03	-.2829E-03	-.4535E-03
2-ROW	-.2768E-01	-.7936E-01	-.9316E-02	-.3369E-01	-.2988E-01	-.4010E-02	-.5166E-02	-.2052E-01	-.1317E-01	-.4391E-02
3-ROW	-.8890E-04	-.6840E-05	-.9620E-05	-.1940E-04	-.8410E-04	-.8890E-05	-.3950E-04	-.7060E-04	-.6130E-04	-.6790E-04

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)

	31-COLUMN	32-COLUMN	33-COLUMN	34-COLUMN
4-ROW	0.	0.	0.	0.
5-ROW	0.	0.	0.	0.
6-ROW	0.	0.	0.	0.
7-ROW	0.	0.	0.	0.
8-ROW	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.
10-ROW	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.
17-ROW	0.	0.	0.	0.
18-ROW	0.	0.	0.	0.
19-ROW	0.	0.	0.	0.
20-ROW	0.	0.	0.	0.
21-ROW	0.	0.	0.	0.
22-ROW	0.	0.	0.	0.
23-ROW	0.	0.	0.	0.
24-ROW	0.	0.	0.	0.
25-ROW	0.	0.	0.	0.
26-ROW	0.	0.	0.	0.
27-ROW	0.	0.	0.	0.
28-ROW	0.	0.	0.	0.
29-ROW	0.	0.	0.	0.
30-ROW	0.	0.	0.	0.
31-ROW	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.
33-ROW	0.	0.	0.	0.
34-ROW	0.	0.	0.	0.

MATRIX A SIZE = 34 X 34

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)



MATRIX B												
SIZE = 34 X 12												
	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN	11-COLUMN	12-COLUMN
28-ROW	.6408E+00	-.2351E+00	-.1074E+01	.1168E+00								
29-ROW	.8548E+00	-.2608E-01	.2172E+01	.3232E+00								
30-ROW	.1831E+01	-.1995E+00	.1444E+01	.9193E-02								
31-ROW	-.4364E+01	-.9733E-01	.1887E+01	-.2273E-01								
32-ROW	.5696E-01	-.2420E+01	-.5687E-02	.2754E+00								
33-ROW	-.1214E+00	-.5395E+00	-.6945E-01	.2366E-01								
34-ROW	-.3782E-01	-.9854E-01	.4293E+00	-.3375E+01								
1-ROW	-.5493E+01	-.1705E+01	-.9157E+00	.7387E+00	.2281E+00	.7641E-01	.6874E-03	.2938E-01	.6678E-04	-.6380E-04		
2-ROW	-.3336E+03	-.3256E+03	-.1553E+03	.2686E+02	.1540E+02	.4889E+01	.9874E-01	.6114E+00	.6932E-03	-.1959E-02		
3-ROW	-.3468E+00	-.2842E+01	-.9488E+00	.6977E-02	.6894E-01	.1883E-01	-.5296E-03	-.2613E-03	-.3778E-04	-.3480E-05		
4-ROW	0	0	0	0	0	0	0	0	0	0		
5-ROW	0	0	0	0	0	0	0	0	0	0		
6-ROW	0	0	0	0	0	0	0	0	0	0		
7-ROW	0	0	0	0	0	0	0	0	0	0		
8-ROW	0	0	0	0	0	0	0	0	0	0		
9-ROW	0	0	0	0	0	0	0	0	0	0		
10-ROW	0	0	0	0	0	0	0	0	0	0		
11-ROW	0	0	0	0	0	0	0	0	0	0		
12-ROW	0	0	0	0	0	0	0	0	0	0		
13-ROW	0	0	0	0	0	0	0	0	0	0		
14-ROW	0	0	0	0	0	0	0	0	0	0		
15-ROW	0	0	0	0	0	0	0	0	0	0		
16-ROW	0	0	0	0	0	0	0	0	0	0		
17-ROW	0	0	0	0	0	0	0	0	0	0		
18-ROW	0	0	0	0	0	0	0	0	0	0		
19-ROW	0	0	0	0	0	0	0	0	0	0		
20-ROW	-.1961E+05	.9884E+04	.4430E+04	-.5920E+03	-.1947E+03	-.5920E+02	.1685E+00	.4988E+00	-.4672E-02	-.2281E-02		
21-ROW	.8212E+04	.2299E+05	.1154E+05	-.2488E+03	-.6234E+03	-.1920E+03	.8766E-01	.5175E+00	.3177E-03	-.1688E-02		
22-ROW	.5784E+04	-.2381E+05	-.1176E+05	.1981E+03	.6877E+03	.2154E+03	.7666E-01	-.1269E+00	-.6516E-02	-.3285E-03		
23-ROW	-.1033E+04	.6667E+04	.3528E+04	-.1094E+03	-.2142E+03	.6619E+02	-.3905E-01	.9103E-02	.2662E-02	.2767E-03		
24-ROW	.4879E+04	-.1110E+04	-.2784E+04	.2888E+03	.1723E+03	.5330E+02	.5898E-01	.6571E-01	-.3087E-02	-.5750E-03		
25-ROW	-.2809E+04	.7392E+04	.4164E+04	-.5891E+02	-.2312E+03	.7135E+02	-.5837E-02	.1535E+00	.2126E-02	-.2666E-03		
26-ROW	-.1888E+04	.1888E+04	.7536E+03	.5891E+02	-.4381E+02	-.1328E+02	.1837E-01	-.2034E+00	.9643E-03	.1790E-03		
27-ROW	.8724E+04	.4748E+04	.3078E+04	-.1311E+03	-.2181E+03	-.6359E+02	-.8509E-01	-.1137E+00	.4239E-02	.8480E-03		
28-ROW	-.9133E+04	-.3148E+04	-.2888E+04	-.1089E+03	.1313E+03	.3984E+02	.3246E+03	.4396E-01	-.1612E-02	-.3325E-03		
29-ROW	.9882E+03	-.1709E+05	-.1864E+05	.2958E+03	.8827E+03	.2326E+03	.8767E-01	-.2277E+00	-.6765E-02	-.2355E-03		
30-ROW	.1364E+05	.6853E+03	.6412E+03	-.5387E+02	.1235E+04	.3481E+03	-.8732E-02	-.5723E+00	-.6156E-02	.1281E-02		
31-ROW	-.1488E+04	.1129E+04	.4113E+03	-.9745E+02	.9745E+02	.3818E+02	-.6818E-01	-.5343E-01	.3389E-02	.5597E-03		
32-ROW	-.4475E+04	.3357E+03	.6888E+02	.4234E+03	-.1281E+03	-.3835E+02	-.9899E-01	-.1962E+00	.4183E-02	.1137E-02		
33-ROW	-.3677E+03	-.6597E+04	-.7031E+03	-.1239E+03	.2803E+03	.6579E+02	.1280E-01	.2689E-01	-.2327E-02	-.3580E-03		
34-ROW	0	0	0	0	0	0	0	0	0	0		

MATRIX B												
SIZE = 34 X 12												
	11-COLUMN	12-COLUMN										
1-ROW	-.8164E-03	.6440E-05										
2-ROW	-.1826E-01	-.1270E-02										
3-ROW	.4844E-04	-.3840E-05										
4-ROW	0	0										
5-ROW	0	0										
6-ROW	0	0										
7-ROW	0	0										
8-ROW	0	0										
9-ROW	0	0										

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)



	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN
10-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SIZE = 19 X 34

MATRIX C

	11-COLUMN	12-COLUMN	13-COLUMN	14-COLUMN	15-COLUMN	16-COLUMN	17-COLUMN	18-COLUMN	19-COLUMN	20-COLUMN
1-ROW	0.0029E+06	-0.1514E-05	0.3547E-05	0.7648E-05	0.9994E-05	0.5286E-05	0.2866E-05	0.3249E-05	-0.6616E-04	-0.1170E-04
2-ROW	-0.0824E+00	-0.1406E+02	0.1337E+02	0.2436E+02	-0.1334E+02	0.8831E+01	0.4682E+01	-0.5604E+01	-0.3005E+02	0.6689E-02
3-ROW	-0.8332E+01	0.3493E+02	-0.3398E+01	-0.2563E+02	0.1452E+02	0.1617E+03	0.8693E+02	0.2079E+03	-0.5121E+01	-0.1696E+00
4-ROW	-0.2258E+02	0.1182E+03	-0.1401E+03	0.6601E+02	-0.1744E+02	0.4407E+03	0.4313E+02	-0.2741E+03	0.3211E+02	-0.2407E+00
5-ROW	0.7055E+03	0.3140E+04	-0.1940E+04	-0.9289E+03	0.1160E+04	0.1050E+04	0.8198E+04	0.1399E+05	-0.4503E+04	-0.2688E+01
6-ROW	0.1343E+06	0.7814E+06	-0.9730E+05	0.3780E+06	-0.7463E+05	0.7976E+05	0.1167E+07	0.9314E+06	0.6398E+06	-0.1544E+04

SIZE = 19 X 34

MATRIX C

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)

	21-COLUMN	22-COLUMN	23-COLUMN	24-COLUMN	25-COLUMN	26-COLUMN	27-COLUMN	28-COLUMN	29-COLUMN	30-COLUMN
7-ROW	-1288E+06	-1901E+06	-5960E+05	-3268E+06	-1755E+05	-1261E+07	5947E+05	-2000E+07	-8702E+06	-5324E+03
8-ROW	6795E+03	2264E+04	1067E+04	8384E+03	2737E+02	1582E+04	7699E+04	9222E+04	2136E+04	-1801E+01
9-ROW	1799E+06	633E+05	3692E+05	2622E+06	1804E+06	807E+05	5518E+06	-1332E+07	9168E+06	-1238E+04
10-ROW	-1597E+05	-647E+06	-4755E+05	3839E+06	-1738E+06	-8244E+06	3525E+06	-6717E+06	7238E+05	-1201E+03
11-ROW	5938E+03	-607E+03	1417E+04	1195E+04	807E+03	1333E+04	-4697E+04	-9238E+04	-8675E+02	-1815E+01
12-ROW	3665E+05	-435E+05	1808E+06	2593E+05	-3915E+05	5893E+06	-5983E+06	-6329E+06	-4745E+06	-8161E+03
13-ROW	2489E+03	-4120E+03	8073E+05	1189E+06	3681E+06	-1017E+07	-1017E+07	-8638E+04	-4745E+06	-1181E+02
14-ROW	-3422E+05	-1569E+06	-2476E+05	-4196E+03	1871E+05	-4918E+06	-1193E+03	-1286E+06	-6959E+06	-1409E+01
15-ROW	1492E+05	-1194E+06	3148E+05	-2259E+06	1831E+06	7882E+06	2410E+06	1553E+06	-2715E+06	-4931E+03
16-ROW	-7253E+02	-2052E+03	1124E+03	-1321E+03	5863E+01	-9416E+03	7366E+04	-6080E+01	-6080E+01	-1645E+01
17-ROW	-4549E+05	-2027E+06	-1491E+05	3368E+05	6689E+04	-2394E+04	-2286E+05	5679E+06	6784E+05	-2796E+03
18-ROW	2863E+05	-1140E+06	3579E+06	-2795E+06	1255E+06	1119E+06	4225E+06	-1651E+06	-2866E+05	-1136E+02

MATRIX C SIZE = 19 X 34

	31-COLUMN	32-COLUMN	33-COLUMN	34-COLUMN	35-COLUMN	36-COLUMN	37-COLUMN	38-COLUMN	39-COLUMN	40-COLUMN
1-ROW	4229E-04	-5843E-04	1811E-04	-4771E-05	2988E-04	-2536E-05	-6011E-04	5872E-04	1309E-03	-6516E-04
2-ROW	1282E-01	-7432E-01	4085E-02	-7345E-02	-1444E-01	-8527E-03	-9395E-02	-7075E-02	2850E-01	-3349E-02
3-ROW	2828E-02	-1294E+00	-1111E-01	-1099E+00	-3875E+00	-3824E-01	1821E+00	-1658E+00	9369E-01	-2128E-01
4-ROW	1964E+00	4029E+01	3288E-01	9119E+00	-2517E+00	-1201E+00	5719E+00	-7544E+00	4242E+00	-7098E-01
5-ROW	7634E+00	-1185E+01	5393E+00	8471E+00	7928E+01	1292E+00	2511E+01	-1864E+01	-1449E+01	-2488E+00
6-ROW	7821E+03	-1708E+01	6596E+03	-1177E+04	1128E+04	4235E+03	6432E+03	-1191E+02	3614E+03	-1884E+03
7-ROW	3697E+03	-2725E+03	-1989E+03	3852E+03	-6896E+02	-1734E+03	-1632E+02	-3445E+03	1754E+03	-2912E+03
8-ROW	3144E+01	-1382E+01	1439E+01	-2731E+01	2826E+01	9348E+00	-2389E+01	-6331E+00	5864E+00	-1679E+00
9-ROW	2234E+03	5830E+02	3044E+03	-6893E+03	4954E+03	1782E+03	1782E+03	-2535E+03	3718E+03	-2136E+03
10-ROW	1055E+03	-1744E+03	8510E+02	-3897E+03	-4726E+03	2554E+02	-4136E+03	-5874E+03	3481E+03	-2311E+03
11-ROW	-2123E+01	-6415E+00	8351E+00	-1411E+01	2603E+01	7339E+00	-2994E+00	8004E+00	1844E+01	-1141E+01
12-ROW	3834E+02	1624E+03	5356E+02	-6831E+02	-1726E+03	6927E+02	-6326E+02	1126E+03	9863E+02	-8743E+02
13-ROW	1744E+01	-2089E+01	2751E+02	1161E+03	2658E+03	5507E+02	-1685E+03	2187E+03	-1528E+02	-1044E+03
14-ROW	4364E+03	2249E+03	-4614E+02	1832E+03	-5921E+03	2255E+00	-8279E+00	1351E+01	-7716E+00	-3049E-01
15-ROW	1988E+03	1392E+03	-6671E+02	1108E+03	-1533E+03	-6811E+02	-8559E+02	-1922E+02	3217E+02	-9577E+01
16-ROW	1872E+00	-6113E+00	1794E+00	-1427E+01	3895E+01	6838E+01	-6017E+00	2768E+03	2885E+03	-6479E+02
17-ROW	2877E+03	3753E+02	-2482E+02	1733E+02	4324E+01	-8273E+02	2549E+03	-1908E+03	7485E+02	-1007E+02
18-ROW	-1094E+03	-1806E+03	3215E+02	-1876E+03	-3738E+03	3854E+02	-1673E+03	4414E+03	-2967E+03	1302E+03

MATRIX C SIZE = 19 X 34

	31-COLUMN	32-COLUMN	33-COLUMN	34-COLUMN	35-COLUMN	36-COLUMN	37-COLUMN	38-COLUMN	39-COLUMN	40-COLUMN
1-ROW	4888E-04	6928E-04	7582E-04	-2384E-03	-2384E-03	-2384E-03	-2384E-03	-2384E-03	-2384E-03	-2384E-03
2-ROW	1458E-01	-1458E-02	-1458E-01	-3429E-01	-3429E-01	-3429E-01	-3429E-01	-3429E-01	-3429E-01	-3429E-01
3-ROW	2845E+00	3752E-01	5152E-01	-2152E-02	-2152E-02	-2152E-02	-2152E-02	-2152E-02	-2152E-02	-2152E-02
4-ROW	1896E+01	1387E-01	1217E+01	2847E-01	2847E-01	2847E-01	2847E-01	2847E-01	2847E-01	2847E-01
5-ROW	6238E+01	6851E+01	7888E+01	-2822E+01	-2822E+01	-2822E+01	-2822E+01	-2822E+01	-2822E+01	-2822E+01
6-ROW	6749E+03	8396E+03	7248E+03	5864E+03	5864E+03	5864E+03	5864E+03	5864E+03	5864E+03	5864E+03
7-ROW	2587E+03	1562E+03	-6139E+03	-1539E+03	-1539E+03	-1539E+03	-1539E+03	-1539E+03	-1539E+03	-1539E+03
8-ROW	9001E+00	6294E+01	7897E+01	1528E+01	1528E+01	1528E+01	1528E+01	1528E+01	1528E+01	1528E+01
9-ROW	2512E+03	-6174E+03	-8561E+03	5895E+03	5895E+03	5895E+03	5895E+03	5895E+03	5895E+03	5895E+03
10-ROW	5889E+03	-2837E+03	-5156E+03	-6413E+02	-6413E+02	-6413E+02	-6413E+02	-6413E+02	-6413E+02	-6413E+02
11-ROW	2174E+01	-4541E+01	-6719E+01	9419E+01	9419E+01	9419E+01	9419E+01	9419E+01	9419E+01	9419E+01
12-ROW	3452E+03	-6964E+03	-6470E+03	2487E+03	2487E+03	2487E+03	2487E+03	2487E+03	2487E+03	2487E+03
13-ROW	3942E+01	-3752E+03	4836E+03	-2466E+03	-2466E+03	-2466E+03	-2466E+03	-2466E+03	-2466E+03	-2466E+03
14-ROW	1824E+01	9294E+00	6245E+01	7705E+01	7705E+01	7705E+01	7705E+01	7705E+01	7705E+01	7705E+01
15-ROW	1145E+03	-1145E+03	5452E+03	-1145E+03	-1145E+03	-1145E+03	-1145E+03	-1145E+03	-1145E+03	-1145E+03
16-ROW	2784E+03	2174E+03	2486E+03	-8738E+02	-8738E+02	-8738E+02	-8738E+02	-8738E+02	-8738E+02	-8738E+02
17-ROW	5359E+01	-8945E+00	-8806E+01	-7191E+01	-7191E+01	-7191E+01	-7191E+01	-7191E+01	-7191E+01	-7191E+01
18-ROW	1564E+03	-4876E+01	2602E+03	4467E+02	4467E+02	4467E+02	4467E+02	4467E+02	4467E+02	4467E+02

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Continued)

MATRIX D      SIZE = 15 X 12

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN
19-ROW	.4997E+02	.3255E+03	-.8922E+02	-.1999E+02						
1-ROW	.3796E-04	-.4680E-03	-.7908E-05	.8626E-04	.6106E-05	.2847E-05	.5614E-07	.1442E-06	-.1989E-08	-.7105E-09
2-ROW	-.2585E+02	-.7757E+02	-.1384E+02	.5338E-01	.3651E-01	.1152E-01	-.2909E+00	.7717E+00	.2805E-01	.6645E-03
3-ROW	-.6140E-04	-.1706E+03	-.1052E+03	.1329E+03	.2703E-02	.8489E-01	.2544E+00	.6101E+00	-.9493E-02	-.3129E-02
4-ROW	-.9194E+04	-.1431E+03	-.1143E+03	.1111E+03	.3209E+02	.1009E+02	.3086E+00	.5895E+00	-.1329E-01	-.3499E-02
5-ROW	.9233E+04	-.1244E+04	.7348E+03	-.1684E+04	-.4716E+03	-.1466E-03	.2815E+02	-.2837E+03	-.1666E+01	.8490E-02
6-ROW	.1129E+07	.4921E+06	.4223E+05	-.1452E+04	-.4704E+04	-.1490E+05	.2210E+05	-.1271E+04	-.1117E+04	.7157E+00
7-ROW	.6549E+06	-.1602E+07	-.6044E+05	-.2165E+06	.7683E+03	-.5061E-03	-.9158E+04	.3377E+05	.3686E+03	.1473E+01
8-ROW	-.2344E-03	-.1123E+04	-.8922E+03	.2125E+03	.6779E+02	.2109E+02	.2829E+02	-.2023E+03	-.1450E+01	-.3434E-03
9-ROW	.1146E+06	.1104E+07	.2569E+05	-.4653E+05	-.3637E+05	-.1124E+05	.1754E+05	-.8322E+04	-.8708E+03	.9348E-01
10-ROW	.5987E+06	-.8200E+06	-.4905E+05	-.7275E+05	.2236E+05	.6297E+04	-.1454E+04	-.1952E+04	.6723E+02	.2707E+00
11-ROW	-.1270E+04	.4358E+03	-.5871E+02	-.1135E+03	-.2804E+02	.9012E-01	.2525E+02	-.1231E+03	-.1258E+01	.2576E-03
12-ROW	-.1696E+06	.8552E+06	.1944E+05	-.2851E+05	-.2633E+05	-.8191E+04	.1064E+05	.4233E+05	-.5327E-03	-.1580E-01
13-ROW	.6820E-04	-.5184E+06	-.2332E+05	-.7689E+05	.1636E+04	.2656E+03	-.4309E+03	-.3067E+04	.2524E+02	.4315E+00
14-ROW	.4303E+04	.8822E+03	.1775E+03	-.5901E+03	-.1128E+01	-.1128E+01	.2106E+02	-.9235E+02	-.1096E+01	.2063E-02
15-ROW	-.1186E+04	.4322E+06	.1664E+05	-.4186E+05	-.2034E+05	-.6391E+04	.6152E+04	-.2329E+05	.3129E+03	.1073E+00
16-ROW	.8553E+06	-.1760E+06	-.5551E+05	-.9953E+05	-.1335E+05	-.4314E+04	-.5893E+03	-.3901E+04	.2146E+02	.4716E+00
17-ROW	-.4561E+04	-.4201E+03	-.3042E+03	.5025E+03	.7331E+02	.2330E+02	.1660E+02	-.4153E+02	-.8032E-00	-.1690E-02
18-ROW	-.1288E+37	.2427E+05	-.2717E+05	.6068E+05	.9847E+04	.3050E+04	.2629E+04	-.4743E+04	-.1328E+03	-.1659E+00
19-ROW	-.1633E+06	-.1104E+06	-.5604E+05	.3507E+05	.9355E+04	.2908E+04	-.3246E+03	-.1989E+04	.1588E+02	-.1100E+00

MATRIX D      SIZE = 12 X 12

	11-COLUMN	12-COLUMN
1-ROW	-.1974E-08	.1085E-09
2-ROW	-.5253E-01	.3998E-02
3-ROW	-.7156E-02	.4690E-03
4-ROW	-.2433E-02	.6948E-05
5-ROW	.1478E-02	.3423E-03
6-ROW	.1486E+01	-.7793E-01
7-ROW	.4704E+01	-.2732E+00
8-ROW	.3433E-02	-.2862E-03
9-ROW	.2635E+00	-.1792E-01
10-ROW	.4584E+00	-.2014E-01
11-ROW	.4572E-03	-.2491E-04
12-ROW	-.5342E+00	.7888E-01
13-ROW	.1089E+01	-.5876E-01
14-ROW	.1719E-02	-.2004E-04
15-ROW	-.6374E-01	.8830E-02
16-ROW	.9466E+00	-.4582E-01
17-ROW	-.2427E-02	.4800E-04
18-ROW	-.1544E+00	.2174E-02
19-ROW	-.8777E-01	.9557E-03

Figure 90. C-5A Vehicle Name List Table and Quadruple Data (Cruise Flight Condition) (Concluded)

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*
* SYSTEM NO 6 OVERALL SYSTEM ( ( F2ARR + REDUCED CONTROLLER) DESIGN MODEL
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NUMBER OF STATES = 28
NUMBER OF OUTPUTS = 65
NUMBER OF INPUTS = 4

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\*\*\* NAME LIST TABLE \*\*\*

VARIABLE NAME	DESCRIPTION	UNIT
<b>STATE</b>		
1 X(1)	W VELOCITY ALONG Z AXIS	INCH/SEC
2 X(2)	0 PITCH RATE	INCH/SEC
3 X(3)	UE1DOT HENDING MOUF RATE	INCH/SEC
4 X(4)	UE2DOT HENDING MOUF RATE	INCH/SEC
5 X(5)	UE3DOT HENDING MOUF RATE	INCH/SEC
6 X(6)	UE4DOT HENDING MOUF RATE	INCH/SEC
7 X(7)	UE5DOT HENDING MOUF RATE	INCH/SEC
8 X(8)	UE6DOT HENDING MOUF RATE	INCH/SEC
9 X(9)	UE1 HENDING MOUF DISPLACEMENT	INCH
10 X(10)	UE2 HENDING MOUF DISPLACEMENT	INCH
11 X(11)	UE3 HENDING MOUF DISPLACEMENT	INCH
12 X(12)	UE4 HENDING MOUF DISPLACEMENT	INCH
13 X(13)	UE5 HENDING MOUF DISPLACEMENT	INCH
14 X(14)	UE6 HENDING MOUF DISPLACEMENT	INCH
15 X(15)	XA ACTUATOR STATE	RADIAN
16 X(16)	XE1 ACTUATOR STATE	IG
17 X(17)	AZ1RL LAGGED NORMAL ACCELERATION	RADIAN
18 X(18)	MLC1 FULL STATE MLC FOR AILERON	IG
19 X(19)	GLAF GUST LOAD ALLEVIATION FILTER	RADIAN
20 X(20)	KEO ACTUATOR STATE	IG
21 X(21)	P PILOT FILTER	RADIAN
22 X(22)	P1 KUSSNER STATE ( NT )	FEET/SEC
23 X(23)	P2 TRANSPORT DELAY STATE ( Y )	FEET/SEC
24 X(24)	P3 TRANSPORT DELAY STATE ( T )	FEET/SEC
25 X(25)	P4 TRANSPORT DELAY STATE ( T )	FEET/SEC
26 X(26)	P5 KUSSNER STATE ( W )	FEET/SEC
27 X(27)	P6 WIND FILTER STATE	FEET/SEC
28 X(28)	WG WIND GUST STATE	FEET/SEC
<b>DESIGN OUTPUT</b>		
1 R(1)	MLC1 FULL STATE MLC FOR AILERON	INCH-LB
2 R(2)	B1 BENDING MOMENT (120.0)	INCH-LB
3 R(3)	T1 TORSION MOMENT (120.0)	RADIAN/SEC
4 R(4)	SAGY SAGGY	INCH-LB
5 R(5)	B2 BENDING MOMENT (328.2)	INCH-LB
6 R(6)	T2 TORSION MOMENT (328.2)	INCH-LB
7 R(7)	D/DT OF ( XA ACTUATOR STATE )	RADIAN /SEC

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input)

H	U	DESCRIPTION	UNITS
8	U(8)	BENDING MOMENT (575.11)	INCH-LB
9	U(9)	TORSION MOMENT (575.11)	INCH-LB
10	U(10)	ACTUATOR STATE (X F1)	RADIAN
11	R(11)	HENDING MOMENT (746.0)	INCH-LB
12	R(12)	TORSION MOMENT (746.0)	INCH-LB
13	R(13)	ACTUATOR STATE	RADIAN
14	R(14)	BENDING MOMENT (926.0)	INCH-LB
15	R(15)	TORSION MOMENT (926.0)	INCH-LB
16	R(16)	ACTUATOR STATE	RADIAN
17	R(17)	HENDING MOMENT	INCH-LB
18	R(18)	TORSION MOMENT	INCH-LB
19	R(19)	BENDING MODE RATE	INCH/SEC
20	R(20)	TORSION MODE RATE	INCH/SEC
21	R(21)	HENDING MOMENT	INCH-LB
22	R(22)	TORSION MOMENT	INCH-LB
23	R(23)	BENDING MODE RATE	INCH/SEC
24	R(24)	TORSION MODE RATE	INCH/SEC
25	R(25)	HENDING MOMENT	INCH-LB
26	R(26)	TORSION MOMENT	INCH-LB
27	R(27)	BENDING MODE RATE	INCH/SEC
28	R(28)	TORSION MODE RATE	INCH/SEC
29	R(29)	HENDING MOMENT	INCH-LB
30	R(30)	TORSION MOMENT	INCH-LB
31	R(31)	BENDING MODE RATE	INCH/SEC
32	R(32)	TORSION MODE RATE	INCH/SEC
33	R(33)	IMP MODEL ERROR RATE FOR 4	RADIAN
34	R(34)	IMP MODEL ERROR RATE FOR 0	RADIAN
35	R(35)	ANGLE OF ATTACK	RADIAN
36	R(36)	AILERON OPTIMAL CONTROL INPUT	RADIAN
37	R(37)	INBOARD ELEV OPTIMAL CONTROL INPUT	RADIAN
SENSOR OUTPUT			
38	R(38)	PILOT FILTER	FEET/SEC
39	R(39)	KUSSNER STATE (HT)	FEET/SEC
40	R(40)	TRANSPORT DELAY STATE (X)	FEET/SEC
41	R(41)	TRANSPORT DELAY STATE (Y)	FEET/SEC
42	R(42)	TRANSPORT DELAY STATE (Z)	FEET/SEC
43	R(43)	KUSSNER STATE (W)	FEET/SEC
44	R(44)	WIND FILTER STATE	INCH/SEC
45	R(45)	WIND GUST STATE	INCH
46	R(46)	VELOCITY ALONG Z AXIS	RADIAN
47	R(47)	BENDING MODE DISPLACEMENT	INCH/SEC
48	R(48)	ACTUATOR STATE	INCH/SEC
49	R(49)	ACTUATOR STATE	INCH/SEC
50	R(50)	ACTUATOR STATE	INCH/SEC
51	R(51)	HENDING MODE RATE	INCH/SEC
52	R(52)	TORSION MODE RATE	INCH/SEC
53	R(53)	BENDING MODE RATE	INCH/SEC
54	R(54)	TORSION MODE RATE	INCH/SEC
55	R(55)	NORMAL ACCELEROMETER RACK SPAN	INCH/SEC
56	R(56)	HENDING MODE RATE	INCH/SEC
57	R(57)	HENDING MODE RATE	INCH/SEC
58	R(58)	HENDING MODE RATE	INCH/SEC
59	R(59)	PITCH RATE GYRO	INCH/SEC
60	R(60)	HENDING MODE DISPLACEMENT	INCH
61	R(61)	HENDING MODE DISPLACEMENT	INCH
62	R(62)	HENDING MODE DISPLACEMENT	INCH
63	R(63)	LAGGED NORMAL ACCELERATION	INCH
64	R(64)	FULL STATE PLC FOR AILERON	INCH
65	R(65)	GUST LOAD ALLEVIATION FILTER	INCH
CONTROL INPUT			
1	U(1)	AILERON OPTIMAL CONTROL INPUT	
2	U(2)	INBOARD ELEV OPTIMAL CONTROL INPUT	

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)



GUST INPUT  
 3 U ( 3 ) ZTAG WHITE NOISE INPUT TO GUST MODEL FEET/SEC  
 4 U ( 4 ) ETAP WHITE NOISE INPUT TO PILOT FILTE

\*\*\* QUADRUPLE DATA \*\*\*

MATRIX A SIZE = 24 X 24

	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN
1-RW	-.7039E+00	-.5313E+01	-.1928E-02	-.2983E-01	-.3857E-01	-.8984E-02	-.3345E-01	-.3145E-01	-.1564E+00	-.8750E+00
2-RW	-.3154E+00	-.1255E+01	-.6592E-02	-.1226E-01	-.3577E-02	-.1274E-01	-.2823E-01	-.1231E+00	-.3793E-01	-.3187E+01
3-RW	-.9086E+01	-.5844E+01	-.9485E+00	-.4988E+00	-.4855E+00	-.8735E-01	-.4694E+00	-.1840E+01	-.3812E+02	-.1929E+02
4-RW	-.8178E+01	-.7187E+01	-.4822E+01	-.2185E+01	-.6882E+00	-.9188E-01	-.8491E+00	-.1876E+01	-.2884E+01	-.2610E+03
5-RW	-.5975E+01	-.5758E+01	-.2574E+00	-.2855E+00	-.1558E+01	-.2224E+00	-.1640E+00	-.1111E+00	-.7593E+00	-.1773E+02
6-RW	-.3888E+01	-.1534E+01	-.6681E-01	-.7738E-02	-.2718E+00	-.8223E+00	-.1640E+00	-.2495E-01	-.1462E+00	-.6417E+01
7-RW	-.3988E+01	-.4273E+00	-.7476E-02	-.2794E+00	-.5924E+00	-.1333E+00	-.1252E+00	-.3526E+00	-.1066E+01	-.7827E+01
8-RW	-.3586E+01	-.3727E+01	-.3324E+00	-.4724E-01	-.3777E+00	-.3067E-01	-.2025E+00	-.2222E+01	-.1208E+01	-.1158E+01
9-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-RW	-.2287E-02	-.1915E-03	-.4891E-03	-.3464E-03	-.1265E-03	-.5225E-04	-.1499E-03	-.4759E-03	-.1806E-01	-.7056E-01
18-RW	-.7639E+00	-.3768E-01	-.1924E-02	-.2983E-01	-.3857E-01	-.8984E-02	-.3345E-01	-.3145E-01	-.1564E+00	-.8750E+00
19-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

MATRIX A SIZE = 24 X 24

	11-COLUMN	12-COLUMN	13-COLUMN	14-COLUMN	15-COLUMN	16-COLUMN	17-COLUMN	18-COLUMN	19-COLUMN	20-COLUMN
1-RW	-.1243E+01	-.1066E+00	-.9652E+00	-.2252E+01	-.3078E+03	-.2024E+03	0.	0.	0.	-.1064E+03
2-RW	-.2331E+01	-.7885E+00	-.2309E+00	-.7611E+00	-.5253E+03	-.3858E+04	0.	0.	0.	-.1181E+04
3-RW	-.5250E+02	-.4957E+01	-.3938E+02	-.5848E+02	-.1851E+05	-.9281E+04	0.	0.	0.	-.3588E+04
4-RW	-.3439E+02	-.4685E+01	-.1331E+02	-.2595E+02	-.7882E+04	-.2088E+05	0.	0.	0.	-.8997E+04
5-RW	-.2821E+03	-.6464E+01	-.5884E+01	-.8788E+01	-.5997E+04	-.2082E+05	0.	0.	0.	-.9149E+04
6-RW	-.1888E+01	-.3770E+03	-.7743E+00	-.8122E+01	-.1109E+04	-.5997E+04	0.	0.	0.	-.2741E+04
7-RW	-.6896E+01	-.9810E+00	-.3762E+03	-.1322E+02	-.4288E+04	-.4559E+04	0.	0.	0.	-.2215E+04
8-RW	-.9353E+01	-.4117E+01	-.5172E+01	-.4893E+03	-.2288E+04	-.6782E+04	0.	0.	0.	-.3317E+04
9-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)



	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN	5-COLUMN	6-COLUMN	7-COLUMN	8-COLUMN	9-COLUMN	10-COLUMN
8-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37-ROW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SIZE = 65 X 28

MATRIX C

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)



MATRIX C

SIZE = 65 X 20

	11-COLUMN	12-COLUMN	13-COLUMN	14-COLUMN	15-COLUMN	16-COLUMN	17-COLUMN	18-COLUMN	19-COLUMN	20-COLUMN
1-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2-R0M	-.1569E+05	-.2483E+06	-.6438E+05	-.4232E+05	0.	0.	0.	0.	0.	0.
3-R0M	-.1745E+06	-.7569E+05	-.5429E+05	-.5300E+05	-.6311E+07	0.	0.	0.	0.	0.
4-R0M	-.3421E+05	-.1245E+05	-.2230E+05	-.1323E+05	-.4221E+04	-.3593E+06	0.	0.	0.	0.
5-R0M	-.7137E+04	-.1442E+05	-.3527E+05	-.2466E+05	-.6697E+04	-.1192E+07	0.	0.	0.	0.
6-R0M	-.2228E+04	-.2243E+05	-.2297E+04	-.3389E+04	-.3734E+07	-.3754E+06	0.	0.	0.	0.
7-R0M	0.	0.	0.	0.	-.6000E+01	0.	0.	0.	0.	0.
8-R0M	-.7221E+05	-.2307E+05	-.3251E+05	-.4823E+05	-.4453E+07	-.4448E+06	0.	0.	0.	0.
9-R0M	-.1516E+06	-.1166E+05	-.1735E+05	-.2881E+04	-.1708E+04	-.6167E+06	0.	0.	0.	0.
10-R0M	0.	0.	0.	0.	0.	-.7500E+01	0.	0.	0.	0.
11-R0M	-.3985E+05	-.2070E+05	-.4990E+05	-.2612E+04	-.2143E+07	-.7000E+01	0.	0.	0.	0.
12-R0M	-.313E+05	-.6650E+04	-.9184E+05	-.27505E+04	-.2745E+07	-.2489E+06	0.	0.	0.	0.
13-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14-R0M	-.6616E+05	-.1912E+05	-.3555E+05	-.2077E+04	-.1900E+01	0.	0.	0.	0.	0.
15-R0M	-.6631E+05	-.6627E+04	-.7870E+05	-.1976E+04	-.3831E+07	-.1781E+06	0.	0.	0.	0.
16-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17-R0M	-.8968E+05	-.1762E+06	-.1825E+05	-.6498E+04	-.7476E+07	-.7039E+06	0.	0.	0.	0.
18-R0M	-.1764E+05	-.5922E+05	-.1124E+04	-.9457E+05	-.7589E+07	-.1479E+08	0.	0.	0.	0.
19-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20-R0M	-.8513E+05	-.4117E+05	-.2694E+05	-.2765E+06	-.1651E+08	-.1424E+04	0.	0.	0.	0.
21-R0M	-.124E+04	-.1001E+05	-.1420E+05	-.2278E+06	-.9974E+07	-.1083E+08	0.	0.	0.	0.
22-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23-R0M	-.8191E+05	-.1002E+05	-.2904E+04	-.4300E+05	-.1891E+08	-.1326E+08	0.	0.	0.	0.
24-R0M	-.7486E+05	-.0929E+04	-.5640E+05	-.1309E+06	-.5127E+07	-.6776E+07	0.	0.	0.	0.
25-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26-R0M	-.7764E+05	-.2102E+05	-.5520E+05	-.2329E+06	-.1568E+08	-.7931E+07	0.	0.	0.	0.
27-R0M	-.2644E+05	-.2164E+05	-.3040E+05	-.9990E+05	-.3208E+07	-.2562E+07	0.	0.	0.	0.
28-R0M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29-R0M	-.2954E+05	-.1204E+05	-.1817E+05	-.1981E+06	-.1630E+08	-.2534E+07	0.	0.	0.	0.
30-R0M	-.4352E+05	-.3934E+04	-.6661E+05	-.1732E+06	-.5824E+06	-.9684E+06	0.	0.	0.	0.

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)

	21-COLUMN	22-COLUMN	23-COLUMN	24-COLUMN	25-COLUMN	26-COLUMN	27-COLUMN	28-COLUMN
31-ROW	0.	0.	0.	0.	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.	0.	0.	0.	0.
33-ROW	.9962E-16	.6224E-17	.9962E-15	.1992E-15	-.2868E+03	-.2297E+03	0.	0.
34-ROW	.1152E-14	.7202E-16	.1152E-14	-.2305E-14	-.6030E+03	-.2657E+04	0.	-.4712E+02
35-ROW	0.	0.	0.	0.	0.	0.	0.	-.6120E+03
36-ROW	0.	0.	0.	0.	0.	0.	0.	0.
37-ROW	0.	0.	0.	0.	0.	0.	0.	0.
38-ROW	0.	0.	0.	0.	0.	0.	0.	0.
39-ROW	0.	0.	0.	0.	0.	0.	0.	0.
40-ROW	0.	0.	0.	0.	0.	0.	0.	0.
41-ROW	0.	0.	0.	0.	0.	0.	0.	0.
42-ROW	0.	0.	0.	0.	0.	0.	0.	0.
43-ROW	0.	0.	0.	0.	0.	0.	0.	0.
44-ROW	0.	0.	0.	0.	0.	0.	0.	0.
45-ROW	0.	0.	0.	0.	0.	0.	0.	0.
46-ROW	0.	0.	0.	0.	0.	0.	0.	0.
47-ROW	0.	0.	0.	0.	0.	0.	0.	0.
48-ROW	0.	0.	0.	0.	0.	0.	0.	0.
49-ROW	0.	0.	0.	0.	0.	0.	0.	0.
50-ROW	0.	0.	0.	0.	0.	0.	0.	0.
51-ROW	0.	0.	0.	0.	0.	0.	0.	0.
52-ROW	0.	0.	0.	0.	0.	0.	0.	0.
53-ROW	.5112E-01	.1492E-01	.5689E-01	.7715E-01	-.1103E+02	.5095E+00	0.	0.
54-ROW	0.	0.	0.	0.	0.	0.	0.	0.
55-ROW	0.	0.	0.	0.	0.	0.	0.	0.
56-ROW	0.	0.	0.	0.	0.	0.	0.	0.
57-ROW	0.	0.	0.	0.	0.	0.	0.	0.
58-ROW	-.1149E-01	.2786E-02	.3377E-02	.8341E-02	-.2862E+00	-.5471E+00	0.	0.
59-ROW	-.3421E-05	.1245E-05	-.2239E-05	-.1323E-05	-.4721E-04	-.5491E-03	0.	-.3614E+00
60-ROW	0.	0.	0.	0.	0.	0.	0.	-.2287E-03
61-ROW	0.	0.	0.	0.	0.	0.	0.	0.
62-ROW	0.	0.	0.	0.	0.	0.	0.	0.
63-ROW	0.	0.	0.	0.	0.	0.	0.	0.
64-ROW	0.	0.	0.	0.	0.	0.	0.	0.
65-ROW	0.	0.	0.	0.	0.	0.	0.	0.

	21-COLUMN	22-COLUMN	23-COLUMN	24-COLUMN	25-COLUMN	26-COLUMN	27-COLUMN	28-COLUMN
1-ROW	0.	0.	0.	0.	0.	0.	0.	0.
2-ROW	0.	0.	0.	0.	0.	0.	0.	0.
3-ROW	0.	0.	0.	0.	0.	0.	0.	0.
4-ROW	0.	0.	0.	0.	0.	0.	0.	0.
5-ROW	0.	0.	0.	0.	0.	0.	0.	0.
6-ROW	0.	0.	0.	0.	0.	0.	0.	0.
7-ROW	0.	0.	0.	0.	0.	0.	0.	0.
8-ROW	0.	0.	0.	0.	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.	0.	0.	0.	0.
10-ROW	.7500E+01	0.	0.	0.	0.	0.	0.	0.
11-ROW	0.	0.	0.	0.	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.	0.	0.	0.	0.
17-ROW	.4007E+07	.1873E+07	.2051E+04	.1118E+05	.2652E+06	-.2648E+08	0.	-.2478E+06
18-ROW	-.1655E+08	.5035E+06	-.5302E+07	-.2843E+05	-.1099E+06	-.5441E+07	0.	.6181E+05
19-ROW	0.	0.	0.	0.	0.	0.	0.	0.
20-ROW	.1245E+04	-.1492E+07	.1340E+04	-.1640E+04	.2105E+04	-.1341E+08	0.	-.1932E+06
21-ROW	-.9829E+07	.1251E+06	.3772E+05	-.3820E+04	-.1744E+05	-.3145E+06	0.	-.1492E+05
22-ROW	0.	0.	0.	0.	0.	0.	0.	0.
23-ROW	.7402E+07	-.6030E+04	.6814E+07	.2295E+04	-.1277E+04	-.6820E+07	0.	-.1182E+06

MATRIX C SIZE = 65 X 28

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)

Row	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN
24-ROW	-.5645E+07	.3644E+05	.5140E+04	-.6740E+04
25-ROW	0.	0.	0.	0.
26-ROW	4.042E+07	-.6214E+04	-.3754E+07	-.7342E+05
27-ROW	-.1736E+07	-.5235E+05	-.6525E+05	-.7071E+04
28-ROW	0.	0.	0.	0.
29-ROW	-.5172E+05	-.2231E+04	.1557E+07	-.3155E+05
30-ROW	-.1720E+07	-.2764E+05	-.3134E+04	-.3843E+04
31-ROW	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.
33-ROW	.2760E+07	.7781E-14	.3985E-15	.0062E-16
34-ROW	.3664E+04	.0003E-17	.4009E-14	.1152E-14
35-ROW	0.	0.	0.	0.
36-ROW	0.	0.	0.	0.
37-ROW	0.	0.	0.	0.
38-ROW	0.	0.	0.	0.
39-ROW	-.1000E+01	.1000E+01	.1000E+01	.1000E+01
40-ROW	0.	0.	0.	0.
41-ROW	0.	0.	0.	0.
42-ROW	0.	0.	0.	0.
43-ROW	0.	0.	0.	0.
44-ROW	0.	0.	0.	0.
45-ROW	0.	0.	0.	0.
46-ROW	0.	0.	0.	0.
47-ROW	0.	0.	0.	0.
48-ROW	0.	0.	0.	0.
49-ROW	0.	0.	0.	0.
50-ROW	0.	0.	0.	0.
51-ROW	0.	0.	0.	0.
52-ROW	0.	0.	0.	0.
53-ROW	0.	0.	0.	0.
54-ROW	0.	0.	0.	0.
55-ROW	0.	-.3855E+03	.1707E-01	.0944E-02
56-ROW	0.	0.	0.	0.
57-ROW	0.	0.	0.	0.
58-ROW	0.	.0671E-03	.2404E-01	-.0955E-02
59-ROW	0.	-.2443E-07	.1679E-05	.6729E-05
60-ROW	0.	0.	0.	0.
61-ROW	0.	0.	0.	0.
62-ROW	0.	0.	0.	0.
63-ROW	0.	0.	0.	0.
64-ROW	0.	0.	0.	0.
65-ROW	0.	0.	0.	0.

MATRIX D SIZE = 65 X 4

Row	1-COLUMN	2-COLUMN	3-COLUMN	4-COLUMN
1-ROW	0.	0.	0.	0.
2-ROW	0.	0.	0.	0.
3-ROW	0.	0.	0.	0.
4-ROW	0.	0.	0.	0.
5-ROW	0.	0.	0.	0.
6-ROW	0.	0.	0.	0.
7-ROW	.6880E+01	0.	0.	0.
8-ROW	0.	0.	0.	0.
9-ROW	0.	0.	0.	0.
10-ROW	0.	.7500E+01	0.	0.
11-ROW	0.	0.	0.	0.
12-ROW	0.	0.	0.	0.
13-ROW	0.	0.	0.	0.
14-ROW	0.	0.	0.	0.
15-ROW	0.	0.	0.	0.
16-ROW	0.	0.	0.	0.

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Continued)

17-ROW	.6775E+07	.2691E+17	0.	0.
18-ROW	.1942E+07	-1.202E+05	0.	0.
19-ROW	0.	0.	0.	0.
20-ROW	.6874E+06	.8709E+07	0.	0.
21-ROW	.3652E+07	-6.156E+07	0.	0.
22-ROW	0.	0.	0.	0.
23-ROW	-1.118E+07	.4414E+07	0.	0.
24-ROW	.3617E+07	-4.894E+07	0.	0.
25-ROW	0.	0.	0.	0.
26-ROW	-7.115E+06	.3241E+07	0.	0.
27-ROW	.5132E+07	-1.122E+07	0.	0.
28-ROW	0.	0.	0.	0.
29-ROW	.1726E+07	.1521E+05	0.	0.
30-ROW	-.9777E+06	-7.875E+05	0.	0.
31-ROW	0.	0.	0.	0.
32-ROW	0.	0.	0.	0.
33-ROW	0.	0.	0.	0.
34-ROW	0.	0.	0.	0.
35-ROW	0.	0.	0.	0.
36-ROW	.1908E+01	0.	0.	0.
37-ROW	0.	.1008E+01	0.	0.
38-ROW	0.	0.	0.	0.
39-ROW	0.	0.	0.	0.
40-ROW	0.	0.	0.	0.
41-ROW	0.	0.	0.	0.
42-ROW	0.	0.	0.	0.
43-ROW	0.	0.	0.	0.
44-ROW	0.	0.	0.	0.
45-ROW	0.	0.	0.	0.
46-ROW	0.	0.	0.	0.
47-ROW	0.	0.	0.	0.
48-ROW	0.	0.	0.	0.
49-ROW	0.	0.	0.	0.
50-ROW	0.	0.	0.	0.
51-ROW	0.	0.	0.	0.
52-ROW	0.	0.	0.	0.
53-ROW	0.	0.	0.	0.
54-ROW	0.	0.	0.	0.
55-ROW	0.	0.	0.	0.
56-ROW	0.	0.	0.	0.
57-ROW	0.	0.	0.	0.
58-ROW	0.	0.	0.	0.
59-ROW	0.	0.	0.	0.
60-ROW	0.	0.	0.	0.
61-ROW	0.	0.	0.	0.
62-ROW	0.	0.	0.	0.
63-ROW	0.	0.	0.	0.
64-ROW	0.	0.	0.	0.
65-ROW	0.	0.	0.	0.

Figure 91. Overall System Design Model Name List Table and Quadruple Data (See Figure 83 for KONPACT-1 Input) (Concluded)

SECTION VII

CONCLUSIONS AND RECOMMENDATIONS

This volume provides two demonstration examples to aid the user of KONPACT in preparing input decks and executing the programs.

The preliminary emphasis in this study has been interface software development and the demonstration of its use. These have been achieved. For future work it is recommended that the ALDCS design using the FLEXSTAB/LSA data be reinvestigated and refined to meet the torsional moment constraint and phase/gain margin requirements.

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