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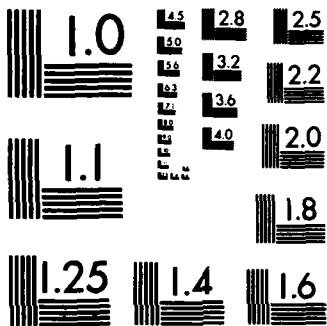
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THESIS

DEVELOPMENT OF A FLIGHT SIMULATION
CONCEPT AND AERODYNAMIC BUILDUP
FOR INVESTIGATION OF DEPARTURE
PREVENTION SYSTEMS IN TACTICAL AIRCRAFT

by

Albert Lawrence Raithel, III

September 1983

Thesis Advisor:

Marle D. Hewett

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incorporation in the simulation, including the aerodynamic equations of the model base aircraft, sample program statements and output.

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by

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Lieutenant, United States Navy
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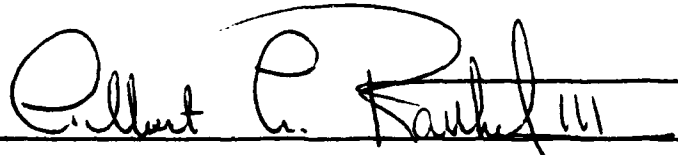
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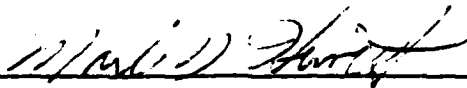
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Dean of Science and Engineering

ABSTRACT

The conceptual development of a computer flight simulation for design, testing and analysis of departure prevention systems, simulation capability and programming are discussed, along with required research material and data. A description is given of the aerodynamic buildup program written for incorporation in the simulation, including the aerodynamic equations of the model base aircraft, sample program statements and output.

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I. INTRODUCTION

Throughout the history of aviation, departure from controlled flight has been a persistent problem. Departure has occurred during various periods of aviation history for different reasons. In the early years, it was an inadequate knowledge of aerodynamic effects leading to poor or inadequate designs. In more recent years, modern design techniques and an improved understanding of aerodynamics, and stability and control have led to the design of high performance aircraft which constantly fly at the limits of their operating envelopes and that in less than a seconds time can be outside of that envelope departing controlled flight. In past times, recovery from departure was often a relatively easy procedure. It still is with simple, basic, fundamental, stable aircraft designs. Recent state-of-the-art tactical aircraft, however, realize their capabilities by displaying neutral or unstable static stability compensated for by digital fly-by-wire control systems. These aircraft with their instabilities and non-conventional aerodynamic design features are not so easily recovered.

As aircraft control systems have been developed over the years, many and varied departure control, departure prevention and departure recovery systems have been developed and flown. The majority of these systems have been limiting type systems, which in some way limit the operation of the aircraft; an angle-of-attack limiter being a common example.

During the performance of an aircraft mission, an actual departure, whether controlled or uncontrolled, recoverable or unrecoverable, will

result in at least the loss of mission effectiveness and probably the loss of man or aircraft or both. By the same means, restructuring aircraft operation to levels below the maximum designed capability in order to avoid potential departure situations may result in the same losses of mission, man and/or aircraft. For these reasons it is desirable to develop a departure prevention system for tactical aircraft that is as "non-limiting" as possible.

This thesis is the first report on the development of a computer flight simulation for the design, testing and analysis of modern optimal, adaptive departure systems. It contains the results of project definition and planning, and the details of the aerodynamic buildup developed for incorporation in the flight simulation program package.

II. SIMULATION CONCEPT DESCRIPTION

A. SIMULATION CAPABILITY

The development of a flight simulation is very dependent on the purpose for which it will be utilized. A full flight simulation is required for full motion base simulator, whereas a much reduced version may be used for investigation of carrier landing characteristics. The following are some of the key points considered and decisions made in determining the type and extent of the simulation needed for this project.

1. Although data indicates that departure is still a problem in older tactical aircraft, the application of modern active control techniques to departure systems is most applicable to fly-by-wire or control-by-wire systems.
2. Availability of data led to utilization of the McDonnell Douglas F/A-18A as the simulation data base.
3. The desire to avoid the additional knowns and unknowns of supersonic flight performance reduced the simulation speed envelope to the subsonic regime.
4. For the most applicable case, the simulation will involve up-and-away flight conditions only.
5. The outer loop closures of the aircraft automatic flight control system will not be simulated but in its place an outer-loop maneuvering autopilot will be modeled. The aircraft control augmentation system will be simulated.

6. Given the above conditions and the potential to depart flight throughout the entire flight envelope the full aircraft system in terms of operating limits, control laws and systems will be modeled as closely as possible to the model base aircraft.

The resulting flight simulation will be comparable with other digital fly-by-wire aircraft. Controlled maneuvers will be precisely performed and repeatable via the maneuvering autopilot and the performance and flying qualities should match closely with that of the F/A-18.

B. SIMULATION PROGRAMMING

The programming of a flight simulation generally consists of three major components, a flight control laws model, an aerodynamic buildup, and flight dynamics calculations. Each of these components is quite complex in itself with the entire simulation requiring several programmers. This results in a modular type programming with each of the three components comprising a module. This is an optimum situation in that each module, control laws, aerodynamic buildup, and flight dynamic performs different calculations for which programming can be specifically tailored. Once programmed, each module can be tested by test stubs to verify results prior to inclusion in the full flight simulation program. The use of modular programming reduces the complexity of the simulation and allows identification of real and potential problems in the simulation by testing each module through the full range of flight conditions. The tailoring of the programming for the various modules led to the utilization of both CSMP and FORTRAN computer languages, in the simulation. The appropriate language is utilized in the simulation where the following characteristics are advantageous;

CSMP:

- The capability to handle nonlinear and time-invariant problems.
- The provisions to allow the modeling/simulation of a physical system utilizing block diagrams.

FORTTRAN:

- The capability to handle a large quantity of data.
- The capability for formatted output.
- The capability for logic, branching and subroutines.

CSMP is generally used for the dynamic flight control laws model, the flight dynamics calculations, the program controls and unformatted output. FORTRAN language is used for the aerodynamic buildup, gain functions, other minor functions where necessary and the simulation formatted output.

The use of each language where appropriate results in a faster, more accurate, more efficient flight simulation.

C. SIMULATION FORMAT AND OPERATION

The flight simulation program format consists of the three major modules; flight control laws model, aerodynamic buildup and flight dynamics calculations along with a program explanations section, a program control and output section and minor subroutines and functions. The following is a brief description of the operation of the flight simulations program (see Figure 1). Command inputs are made to the dynamic flight control laws model (CSMP), the output of which are control surface deflections, of leading edge and trailing edge flaps, ailerons, horizontal stabilizer, rudder and speedbrake. These surface deflections are input to the aerodynamic buildup (FORTRAN) the output of which

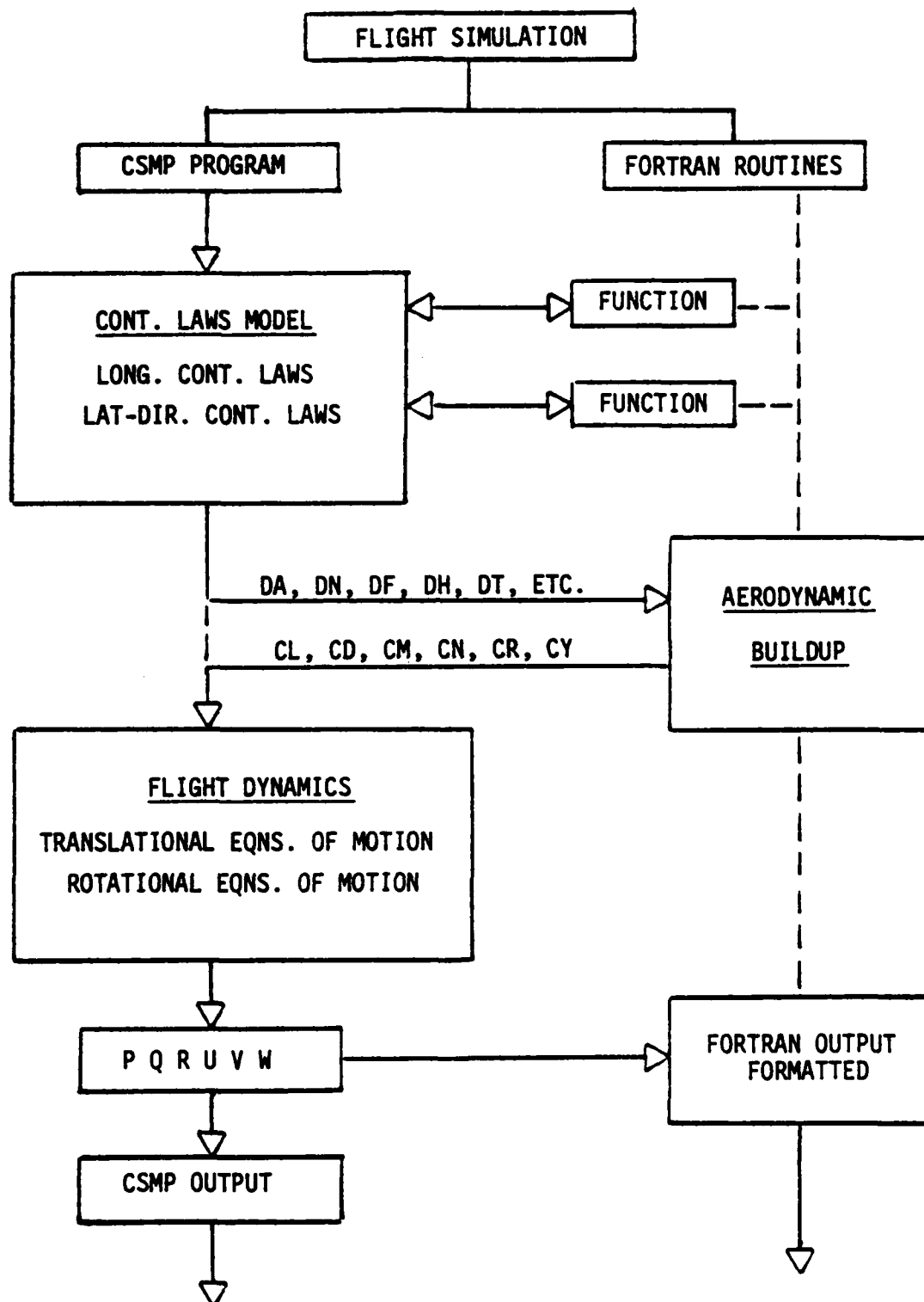


Figure 1

are the aircraft total coefficients for lift, drag, pitching moment, rolling moment, yawing moment and side force. These coefficients are inputs to the flight dynamics module where aircraft rotational and translational motions of pitch rate, roll rate, yaw rate and U, V, W velocities are computed from the equations of motion. The aircraft motions are fed back to the command input side of the flight control laws module for comparison to commanded inputs and subsequent command modification. The program run time, integration time and other control functions are input from the CSMP program. Output is generated from both CSMP statements and FORTRAN subroutines for formatting.

III. DATA AND RESOURCES

In developing a flight simulation, two types of information are needed: (1) required information - flight systems description, etc., and (2) reference information - programming options, etc. Reviewing wide range of tasks required for a simulation of this magnitude the need to have a source library is obvious. The project has four distinct tasks to be performed, (1) project definition and planning, (2) mathematical modeling, (3) programming and (4) testing and analysis. Research material and required data was collected in each of these areas for use in completing the tasks. The collected material can be divided into six areas, (1) General Departure Information, (2) Aerodynamic Data, (3) Flight Control Laws, (4) Maneuvering Autopilots, (5) Programming Techniques, and (6) Flying Qualities. The following is a list of the major resources obtained for the flight simulation project, and a brief description of each.

A. GENERAL DEPARTURE INFORMATION

Reference 1 contains all mishap reports from mishaps classified by type as uncontrolled flight. It is subdivided into jet, prop and helicopter mishaps and provides information on mishap causes, phase of mission and a narrative of the mishap.

B. FLIGHT CONTROL LAWS

Reference 2 is a description of the inner and outer loop control laws. It is presented in three sections as follows:

1. Flight Control System Characteristics: Inner Loop Theory of Operation. This section contained information on the longitudinal, lateral and directional control laws, quad sensor signals, actuator systems, angle-of attack system and air data system.

2. Automatic Flight Control System: Theory of Operation.

3. Autothrottle: Theory of Operation.

Reference 3 contains system descriptions and diagrams of the following systems pertinent to a flight simulation: longitudinal and lateral-directional control systems, flap commands, mechanical primary controls, flight control electronic set, actuation devices, and throttle control.

Reference 4 is the F/A-18 version 8.2.1 flight control system description and theory of operation. It contains a description of the flight control hardware and interfaces and the system theory of operation including software architecture and mathematical characteristics of inner and outer loop control laws.

C. STABILITY AND CONTROL

Reference 5 contains the stability and control characteristics of the production F/A-18 high speed maneuvering and high lift configurations, derived from wind tunnel test and revised where appropriate to reflect the results of developmental flight tests. The report presents data in a graphical form for status longitudinal and lateral-directional stability and control, and the longitudinal, and lateral-directional dynamic derivatives.

D. FLYING/HANDLING QUALITIES

Reference 6 presents the flying and handling qualities of the F/A-18 fighter escort configuration. Longitudinal and lateral-directional modes

and responses, unaugmented characteristics, and spin departure characteristics are included. Information is in both graphical and tabular form.

E. MANEUVERING AUTOPILOT

Reference 7 is a discussion of developing a maneuvering autopilot. It includes maneuvering requirements, linear analysis and design, control law development, command generation and flight experience.

F. PROGRAMMING TECHNIQUES

Information on programming techniques for manipulating large quantities of data with emphasis on flight simulations and aerodynamic buildups was obtained from both Northrop Aircraft Corp. and the Naval Air Development Center.

This is by no means a complete list of the information obtained. It is, however, the primary material used during the project. It is discussed to indicate the type of materials required to develop a flight simulation. The general departure material was used to determine what flight conditions should be investigated. The flight control laws material is being utilized to develop the dynamic flight control law model. The stability and control data is used in the aerodynamic buildup. The maneuvering autopilot data is used for modeling the outer loop maneuvering autopilot. The programming techniques material is used for programming methodology and the flying qualities data is used for verification of simulation model response.

IV. AERODYNAMIC BUILDUP

A. CONSIDERATIONS

As discussed earlier, the major parts to a flight simulation program are a flight control laws model, an aerodynamic buildup and flight dynamics calculations. The following is a description of the aerodynamic buildup developed for incorporation into the flight simulation program. In developing the buildup, the following goals were set.

1. Simplicity and intelligibility.
2. Ability to operate as a separate program or be incorporated as a subprogram in a larger simulation.
3. Provide proper results throughout the entire range of flight conditions for the simulation.
4. Flexibility, versatility and alterability.

The aerodynamic buildup constitutes a large portion of the entire simulation. It also involves the manipulation of very large quantities of data. Its programming must consider, integration with other program modules, data handling times and storage space. These considerations impact on decisions about programming language, programming methodology, and data storage and retrieval techniques.

B. AERODYNAMIC EQUATIONS

The operation of the flight simulation program, discussed in Chapter Two, indicated the inputs to the aerodynamic buildup are the aircraft control surface deflections and the outputs are the aircraft aerodynamic coefficients. The first task was the determination of what control

surface deflections and flight conditions affected each coefficients and to what extent. For example, lift coefficient is changed by deflecting the horizontal stabilizer. How much it is changed is determined by the amount of deflection, the airspeed, and the angle-of-attack. This information was determined from the model base aerodynamic equations [Ref. 4]. Below is a list of the control surfaces and flight conditions affecting each coefficient. The complete aerodynamic equations with definitions and explanations are provided in the appendix.

1. Lift Coefficient is a function of: Mach No., altitude, angle-of-attack, leading-edge flap (LEF) deflection, trailing-edge flap (TEF) deflection, horizontal tail deflection, speedbrake deflection, aileron deflection, pitch rate and angle-of-attack rate.

2. Drag Coefficient is a function of: Mach No., angle-of-attack, LEF deflection, TEF deflection, horizontal tail deflection, aileron deflection and speedbrake deflection.

3. Pitching Moment Coefficient is a function of: same as lift coefficient with the addition of rudder deflection.

4. Yawing Moment Coefficient is a function of: Mach No., altitude, angle-of-attack, sideslip angle, LEF deflection, TEF deflection, differential tail deflection, speedbrake deflection, rudder deflection, aileron deflection, roll rate and yaw rate.

5. Rolling Moment is a function of: same as yawing moment with the addition of flaperon or differential TEF deflection.

6. Side Force Coefficient is a function of: same as yawing moment.

C. AERODYNAMIC DATA

Once the aerodynamic equations were obtained the next task was to obtain the value of each term in each equations for given flight conditions or, the aerodynamic data. This data, presented graphically [Ref. 4] was derived from wind tunnel testing but updated where possible by developmental flight test results. The data was given for low angle-of-attack and high angle-of-attack, considered to be forty degrees or higher. The distinction exists for the following reason: Above forty degrees angle-of-attack the leading-edge flaps are fixed to 34 degrees and the trailing-edge flaps are undeflected. This is the configuration used in measuring the basic coefficients and no increments are added for leading or trailing-edge flaps. Below 40° angle-of-attack the basic coefficients are measured at the zero flap deflections configuration and increments are added for leading and trailing edge flap deflections as necessary.

Data was available for most of the flight envelope. In instances where no data was available, such as high angle-of-attack speedbrake data, the increments were set to zero. If for some increment data was not available throughout the desired ranges, judgment was made to determine the increment in one of three ways. 1) If the data reports noted that linear interpolation was possible, then the value was so obtained, 2) If it appeared that the increment was approaching to be zero, realistically it was made to go to zero or, 3) If no other indications existed, the increment was left constant through the range. As an example, consider yawing moment increment due to speedbrake deflection. The data was presented for sideslip angles of positive two and ten degrees. The incremental changes were required over a sideslip angle range from negative twenty to positive twenty degrees.

The discrepancy was solved as follows. The increments were linearly interpolated between zero and ten degrees and then held constant from ten to twenty degrees. The negative sideslip angle values were determined by using the negative of the positive sideslip angle values. These adjustments to the actual aerodynamic data comprise a very small percentage of the data. They do not occur in any critical values of flight conditions and are determined realistically enough to have no adverse effect on the validity of the simulation. In contrast by covering the complete range of flight conditions, the aerodynamic buildup provides for a more realistic simulation. Once the aerodynamic data were obtained and evaluated, they had to be extracted from the graphical form to tabular form for computer entry. The values of flight conditions and surface deflections for which data are tabulated is presented in the appendix.

D. PROGRAMMING

As originally envisioned, the aerodynamic buildup would be an integral part of the main simulation CSMP program. This approach quickly ran into problems with handling functions of three and four variables, large quantities of numbers and sorting techniques. It was decided to program the aerodynamic buildup as a FORTRAN routine used as a subprogram in the flight simulation. The additional requirement of providing aircraft coefficients continuously throughout the flight envelope from aerodynamic data tabulated at specific intervals led to the use of a table look-up routine with interpolation functions, for intermediate flight conditions. The program procedure is exactly the same for each coefficient as follows:

1. A data file exists holding all the values of all the terms in the aerodynamic equation for given flight conditions.

2. The program reads the data file and loads the data into program matrices. There then exists a separate data matrix for each term in the respective coefficients aerodynamic equation.

3. These matrices are then printed out to display the data being used in the buildup.

4. The program then makes calls to interpolation subroutines to determine the actual value of each term in the aerodynamic equation for the existing flight conditions.

5. The terms are then added appropriately to form the total coefficient.

An example of the program for lift coefficient is provided in the appendix. Each coefficient varies only in the terms of the aerodynamic equation.

The aerodynamic buildup program is segmented into six major sections.

Section One: Variable definition, explanations, declarations and program parameters. This section contains FORTRAN declaration and dimension statements, program operation notes and control cards. The control cards provide the options for obtaining or deleting hardcopy output of the aerodynamic data, and the computed derivatives and coefficients. Additionally, the user can select to use test input flight conditions or inputs from another source, such as the main simulation program.

Section Two: Aerodynamic data and constants. This section contains the read and write statements for each of the six coefficients to load the program data matrices and provide hardcopy output of the tabulated data, if desired.

Section Three: Test flight condition inputs. This section provides the operator the input of test flight conditions and control surface conditions. Standard day atmospheric tables incorporated in the program can also be selected if desired. This section can be totally deleted when the program is used as a subprogram to a larger simulation.

Section Four: Aerodynamic buildup. This section contains for each coefficient the interpolation subroutine call statements to the data matrices to determine the value of the terms in the aerodynamic equations. The total coefficients are actually determined in this section by summing the terms in the respective equations.

Section Five: Output. This section contains the format statements for the formatted output of hardcopy data and results.

Section Six: Subroutines. This section contains the interpolation subroutines used by the program. There are four subroutines, one each for functions of one, two, three or four variables.

V. SUMMARY

There are no conclusions to draw for this report. A few comments can be made on the work that was done. The flight simulation project, initial project definition and planning was completed and the project is well underway. The initial concepts and requirements are still effective, changed only for further clarification as work progresses. Ideas on programming are continually changing as problems are continually encountered and methods found to solve them. The final developed simulation will be completed in agreement with the ideas of this report. The aerodynamic buildup is complete. The program and data are on file at the Naval Postgraduate School, Monterey, CA. Point-of-contact is Dr. Marle D. Hewett, Department of Aeronautics (Code 67). The results of the aerodynamic buildup are verified as in agreement with tabulated and hand-calculated values. The programming though not extremely efficient, is simple, intelligible and flexible for use by various project members or even various projects.

APPENDIX A AERODYNAMIC EQUATIONS

THE FOLLOWING ARE THE AERODYNAMIC EQUATIONS USED TO COMPUTE THE AERODYNAMIC COEFFICIENTS OF THE F/A-18 AIRCRAFT. EACH EQUATION IS GIVEN IN TERMS OF THE STATIC AND DYNAMIC COEFFICIENTS, FOLLOWED BY DEFINITIONS OF EACH TERM IN THE EQUATION. A LIST OF DERIVATIVES AND THE RESPECTIVE INDEPENDENT VARIABLES IS ALSO SHOWN FOR EACH COEFFICIENT.

THE FOLLOWING TERMS ARE USED MULTIPLE TIMES IN THE EQUATIONS

ALFA	-	ANGLE OF ATTACK
ALFACT	-	RATE OF CHANGE OF ANGLE OF ATTACK
ALTD	-	AIRCRAFT ALTITUDE
B	-	WING SPAN (AIRCRAFT REFERENCE)
BETA	-	SIDESLIP ANGLE
BETACT	-	RATE OF CHANGE OF SIDESLIP ANGLE
C	-	WING CHORD (AIRCRAFT REFERENCE)
CA	-	AVERAGE AILERON DEFLECTION (LEFT OR RIGHT)
DAL/R	-	AVERAGE AILERON DEFLECTION (LEFT OR RIGHT)
DDA	-	DIFFERENTIAL AILERON DEFLECTION (DAL - DAR)
DDF	-	DIFFERENTIAL TRAILING EDGE FLAP DEFLECTION (DFL - DFR)
DDN	-	DIFFERENTIAL LEADING EDGE FLAP DEFLECTION (DNL - DNR)
CT	-	DIFFERENTIAL HORIZONTAL TAIL DEFLECTION (DHL - DHR)
DF	-	AVERAGE TRAILING EDGE FLAP DEFLECTION (DFL + DFR) / 2
DFL/R	-	TRAILING EDGE FLAP DEFLECTION
DH	-	AVERAGE HORIZONTAL TAIL DEFLECTION (DHL + DHR) / 2
DHL/R	-	STABILIZER/HORIZONTAL TAIL DEFLECTION (LEFT OR RIGHT)
DN	-	AVERAGE LEADING EDGE FLAP DEFLECTION
DNL/R	-	LEADING EDGE FLAP DEFLECTION (DNL + DNR) / 2
DR	-	AVERAGE RUDDER DEFLECTION (LEFT OR RIGHT)
DRL/R	-	RUDDER DEFLECTION (LEFT OR RIGHT)
DSB	-	SPEED BRAKE DEFLECTION
LEF	-	LEADING EDGE FLAP
MACH	-	AIRCRAFT MACH NUMBER (FREE STREAM)
P	-	ROLL RATE
Q	-	PITCH RATE
QC	-	DYNAMIC PRESSURE
R	-	YAW RATE
TEF	-	TRAILING EDGE FLAP
VT	-	TOTAL AIRCRAFT VELOCITY

LONGITUDINAL AERODYNAMIC EQUATIONS

LIFT COEFFICIENT

STATIC LIFT COEFFICIENT

$$CLST = CLBAS + (DCLDN * DN) + (DCLDF * DF) + (DCLDHL + DCLDHR) * FRCLDH / 2 + DCLDSB + (DCLDAL + DCLCAR) * FRCLDA$$

DYNAMIC LIFT COEFFICIENT

$$CLDYN = CLQ * (Q * C) / (2 * VT) + CLA * (ALFADT * C) / (2 * VT)$$

TOTAL LIFT COEFFICIENT

$$CL = CLST + CLDYN$$

WHERE:

CL	-	TOTAL LIFT COEFFICIENT
CLBAS	-	LIFT DUE TO ANGLE-OF-ATTACK RATE (PER RAD.)
CLDYN	-	BASIC CONFIGURATION LIFT COEFFICIENT
CLQ	-	DYNAMIC LIFT COEFFICIENT
CLST	-	LIFT DUE TO PITCH RATE (PER RAD.)
DCLDAL/R	-	STATIC LIFT COEFFICIENT AILERON DEFLECTION
DCLDF	-	(LIFT INCREMENT DUE TO AILERON)
DCLDHL/R	-	(LIFT INCREMENT DUE TO STABILATOR DEFLECTION)
DCLDHR/R	-	(LIFT INCREMENT DUE TO STABILATOR DEFLECTION)
DCLCN	-	(LIFT INCREMENT DUE TO DEFLECTION (PER DEG.)
DCLDSB	-	LIFT INCREMENT DUE TO SPEED BRAKE DEFLECTION
FRCLDA	-	FLEX/RIGIDITY RATIO FOR LIFT DUE TO AILERON
FRCLDH	-	FLEX/RIGIDITY RATIO FOR LIFT DUE TO STABILATOR

```

AND:
CLBAS      MACH:  ALTD:  ALFA )
DCLCN      MACH:  ALTD:  ALFA )
DCLCF      MACH:  ALTD:  ALFA )
DCLOH      ( MACH:  DH:  ALFA )
FRCLCF      ALTD:  MACH )
DCLOSE      MACH:  DSB:  ALFA )
DCLLA      MACH:  DA:  ALFA )
FRCLLA      ALTD:  MACH )
CLQ         MACH:  ALTD:  ALFA )
CLA         MACH:  ALTD:  ALFA )

```

CRAG COEFFICIENT

STATIC DRAG COEFFICIENT

$$CDST = CIBAS + (DCDDHL + DCDDHR) / 2 + DCDDSB + (DCDDAL + DCDDAR) + DCDDMF$$

#

TOTAL CRAG COEFFICIENT

$$CD = CDST$$

WHERE:

CD	-	TOTAL DRAG COEFFICIENT
CD BAS	-	BASIC CONFIGURATION DRAG COEFFICIENT
CD ST	-	STATIC DRAG COEFFICIENT
DCDDAL/R	-	DRAG INCREMENT DUE TO AILERON DEFLECTION (LEFT OR RIGHT AILERON)
DCDDPL/R	-	DRAG INCREMENT DUE TO STABILATOR DEFLECTION (LEFT OR RIGHT STABILATOR)
DCDMF	-	DRAG INCREMENT DUE TO MANUEVERING FLAP DEFLECTION
DCDCSE	-	DRAG INCREMENT DUE TO SPEED BRAKE DEFLECTION

AND:

CD BAS	=	F(MACH, ALFA)
DCDDH	=	F(MACH, DH, ALFA)
DCDDA	=	F(MACH, DA, ALFA)
DCDCSE	=	F(MACH, DSB, ALFA)
DCDMF	=	F(MACH, DN, ALFA)

PITCHING MOMENT COEFFICIENT

STATIC PITCHING MOMENT COEFFICIENT

$$CMST = CMBAS + (DCMDN * DN) + (DCMDF * DF) + (CCMDHL + DCMDHR) * FRCMDH / 2 + DCMDSB + DCMDR + (DCMDAL + LCMDAR) * FRCMDA$$

DYNAMIC PITCHING MOMENT COEFFICIENT

$$CMDYN = CMQ * (Q * C) / (2 * VT) + CMA * (ALFADT * C) / (2 * VT)$$

TOTAL PITCHING MOMENT COEFFICIENT

$$CM = CMST + CMDYN$$

WHERE:

CM	-	TOTAL PITCHING MOMENT COEFFICIENT
CMA	-	PITCHING MOMENT DUE TO ANGLE-OF-ATTACK RATE (PER RAD.) COEFFICIENT
CMBAS	-	BASIC CONFIGURATION PITCHING MOMENT COEFFICIENT
CMQ	-	DYNAMIC PITCHING MOMENT COEFFICIENT
CMST	-	PITCHING MOMENT DUE TO PITCH RATE (PER RAD.) COEFFICIENT
DCMDAL/R	-	STATIC PITCHING MOMENT COEFFICIENT DUE TO AILERON DEFLECTION (LEFT OR RIGHT AILERON) (PER DEG.)
DCMDF	-	PITCHING MOMENT INCREMENT DUE TO DEFLECTION (PER DEG.)
DCMDFL/R	-	PITCHING MOMENT INCREMENT DUE TO STABILATOR DEFLECTION (LEFT OR RIGHT STABILATOR) (PER DEG.)
DCMDN	-	PITCHING MOMENT INCREMENT DUE TO DEFLECTION (PER DEG.)
DCMDR	-	PITCHING MOMENT INCREMENT DUE TO RUDDER DEFLECTION (PER DEG.)
DCMDSB	-	PITCHING MOMENT INCREMENT DUE TO SPEED BRAKE DEFLECTION
FRCMDA	-	FLEX/RIGIDITY RATIO FOR PITCHING MOMENT DUE TO AILERON DEFLECTION
FRCMDH	-	FLEX/RIGIDITY RATIO FOR PITCHING MOMENT DUE TO STABILATOR DEFLECTION

```

AND:
CMBAS S      MACH;  ALTD;  ALFA ;
DCMCHN F(    MACH;  ALTD;  ALFA ;
DCMCHCF F(    MACH;  ALTD;  ALFA ;
DCMCHCH F(    MACH;  ALTD;  ALFA ;
DCMCHSB F(    MACH;  ALTD;  ALFA ;
DCMDR F(    MACH;  ALTD;  ALFA ;
DCMCA F(    MACH;  ALTD;  ALFA ;
DCMCA F(    MACH;  ALTD;  ALFA ;
CMQ F(    MACH;  ALTD;  ALFA ;
CMA F(    MACH;  ALTD;  ALFA ;

```

LATERAL-DIRECTIONAL AERODYNAMIC EQUATIONS

YAWING MOMENT COEFFICIENT

STATIC YAWING MOMENT COEFFICIENT

$$\begin{aligned} \text{CNST} = & \text{CNBAS} + (\text{DCNBFX} * \text{BETA}) + \text{CCNDN} + \text{DCNDF} \\ & + (\text{DCNDAL} + \text{DCNDAR}) * \text{FRCNDA} \\ & + (\text{KRDR} * \text{DCNDR} * \text{FRCNDR}) \\ & + (\text{DCNDT} * \text{FRCNDT} * \text{DT}) + (\text{CCNDSB} * \text{BETA}) \end{aligned}$$

DYNAMIC YAWING MOMENT COEFFICIENT

$$\text{CNDYN} = (\text{CNR} + \text{DCNRFX}) * (\text{R} * \text{B}) / (2 * \text{VT}) \\ + (\text{CNP} * \text{FRGNP}) * (\text{P} * \text{B}) / (2 * \text{VT})$$

TOTAL YAWING MOMENT COEFFICIENT

$$\text{CN} = \text{CNST} + \text{CNDYN}$$

WHERE:

CN	-	TOTAL YAWING MOMENT COEFFICIENT
CNBAS	-	BASIC CONFIGURATION YAWING MOMENT COEFFICIENT
CNDYN	-	DYNAMIC YAWING MOMENT COEFFICIENT
CNP	-	YAWING MOMENT DUE TO ROLL RATE
CNR	-	YAWING MOMENT DUE TO YAW RATE
CNST	-	STATIC YAWING MOMENT COEFFICIENT
DCNBFX	-	YAWING MOMENT FLEXIBILITY DERIVATIVE DUE TO SIDESLIP
DCNDAL/R	-	YAWING MOMENT INCREMENT DUE TO AILERON DEFLECTION (LEFT OR RIGHT AILERON)
DCNDF	-	YAWING MOMENT INCREMENT DUE TO TEF DEFLECTION (PER DEG.)
DCNCA	-	YAWING MOMENT INCREMENT DUE TO LEF DEFLECTION (PER DEG.)
DCNDR	-	YAWING MOMENT INCREMENT DUE TO RUDDER DEFLECTION (PER DEG.)
DCNCSB	-	YAWING MOMENT INCREMENT DUE TO SPEED BRAKE DEFLECTION
DCNDT	-	YAWING MOMENT INCREMENT DUE TO DIFFERENTIAL TAIL DEFLECTION
DCNRFX	-	YAWING MOMENT INCREMENT DUE TO FLEXIBILITY DUE TO

FRCNCA	-	SIDESLIP	
FRCNCR	-	FLEX/RIGIDITY RATIO FOR YAWING MOMENT	DUE TO
FRCNCT	-	AILERON DEFLECTION	
FRCNF	-	FLEX/RIGIDITY RATIO FOR YAWING MOMENT	DUE TO
KRDR	-	RUDDER DEFLECTION	
	-	FLEX/RIGIDITY RATIO FOR YAWING MOMENT	DUE TO
	-	DIFFERENTIAL HORIZONTAL TAIL	
	-	FLEX/RIGIDITY RATIO FOR YAWING MOMENT	DUE TO
	-	ROLL RATE	
	-	RUDDER POWER FACTOR	DUE TO STABILATOR POSITION

AND:

CNBS	F(	MACH,	ALFA,	BETA,
DCNBN	= F(	MACH,	DN,	ALFA,
DCNDF	= F(	MACH,	DF,	ALFA,
DCNCT	= F(	MACH,	DH,	ALFA,
FRCNCT	= F(	MACH,	ALTD,	ALFA,
DCNCSB	= F(	MACH,	DSB,	BETA,
DCNCF	= F(	MACH,	DR,	BETA,
FRCNDR	= F(	ALTD,	MACH,	ALFA,
DCNDA	= F(	MACH,	DA,	ALFA,
FRCNCA	= F(	ALTD,	MACH,	ALFA,
CNP	= F(	MACH,	ALFA,	ALFA,
DCNRF	= F(	ALTD,	MACH,	ALFA,
FRCNF	= F(	MACH,	ALFA,	ALFA,
DCNBF	= F(	MACH,	QC,	ALFA,
KRDR	= F(	CH,	ALFA,	ALFA,

FRCRCR - FLEX/RIGIDITY RATIO FOR ROLLING MOMENT LWE TO
 RUDDER DEFLECTION
 FRCRCT - FLEX/RIGIDITY RATIO FOR ROLLING MOMENT DUE TO
 DIFFERENTIAL HORIZONTAL TAIL DEFLECTION

AND:
 CRBAS F(MACH; ALFA; BETA)
 DCRCA F(MACH; DN; ALFA; BETA)
 DCRDF F(MACH; DF; ALFA; BETA)
 DCRDCT F(MACH; DM; ALFA)
 FRCRCT F(MACH; MACH;)
 DCRDCE F(MACH; DSB; BETA; ALFA)
 DCRCCR F(MACH; DR; BETA; ALFA)
 FRCRCR F(MACH; MACH;)
 CCRCA F(MACH; DA; ALFA)
 FRCRCA F(MACH; MACH;)
 CRR F(MACH; ALID; ALFA)
 CRP F(MACH; MACH;)
 DCRREFX F(ALFA; QC; ALFA)
 DCRASY F(MACH; QC)
 DCRBFX F(MACH;)
 CRDDN F(MACH; ALTD; ALFA)
 CRDDF F(MACH; ALTD; ALFA)

SIDE FORCE COEFFICIENT

STATIC SIDE FORCE COEFFICIENT

$$CYST = CYBAS + (DCYBFX * BETA) + DCYDN + DCYDF \\ + (DCYDAL + DCYDAR) * FRCYDA + (DCYDR * FRCYDR) \\ + (DCYDT * FRCYDT * DT) + (DCYDSB * BETA)$$

DYNAMIC SIDE FORCE COEFFICIENT

$$CYDYN = (CYR + DCYRFX) * (R * B) / (2 * VT) \\ + (CYP * FRCYP) * (P * B) / (2 * VT)$$

TOTAL SIDE FORCE COEFFICIENT

$$CY = CYST + CYDYN$$

WHERE:

CY	-	TOTAL SIDE FORCE COEFFICIENT
CYBAS	-	BASIC CONFIGURATION SIDE FORCE COEFFICIENT
CYDYN	-	DYNAMIC SIDE FORCE COEFFICIENT
CYP	-	SIDE FORCE DUE TO ROLL RATE
CYR	-	SIDE FORCE DUE TO YAW RATE
CYST	-	STATIC SIDE FORCE COEFFICIENT
DCYBFX	-	SIDE FORCE FLEXIBILITY DERIVATIVE DUE TO SLIP
DCYDAL/R	-	SIDE FORCE INCREMENT DUE TO AILERON DEFLECTION (LEFT OR RIGHT AILERON)
DCYDA	-	SIDE FORCE INCREMENT DUE TO LEF DEFLECTION
DCYDF	-	SIDE FORCE INCREMENT DUE TO REF DEFLECTION
DCYDR	-	SIDE FORCE INCREMENT DUE TO RUDDER DEFLECTION
DCYDSB	-	SIDE FORCE INCREMENT DUE TO SPEEDBRAKE DEFLECTION
DCYDT	-	DEFLECTION INCREMENT DUE TO DIFFERENTIAL TAIL
DCYRFX	-	SIDE FORCE INCREMENT DUE TO FLEXIBILITY DUE TO SLIP
FRCYDA	-	FLEX/RIGIDITY RATIO FOR SIDE FORCE DUE TO AILERON DEFLECTION
FRCYDR	-	FLEX/RIGIDITY RATIO FOR SIDE FORCE DUE TO RUDDER DEFLECTION
FRCYDT	-	FLEX/RIGIDITY RATIO FOR SIDE FORCE DUE TO DIFFERENTIAL TAIL DEFLECTION
FRCYP	-	FLEX/RIGIDITY RATIO FOR SIDE FORCE DUE TO ROLL RATE

```

AND:
CYBAS  = F( MACH, ALFA, BETA,
DCYCA  = F( MACH, DN, ALFA, BETA )
DCYCF  = F( MACH, DF, ALFA, BETA )
DCYDT  = F( MACH, DH, ALFA,
FRCYCT  = F( ALTD, MACH,
DCYCSB  = F( MACH, DSB, BETA, ALFA )
DCYDR  = F( MACH, DR, BETA, ALFA )
FRCYCR  = F( ALTD, MACH,
DCYCA  = F( MACH, DA, ALFA )
FRCYCA  = F( ALTD, MACH,
CYR  = F( ALTD, MACH, ALFA )
CYP  = F( MACH, ALFA )
DCYRFX  = F( MACH, ALFA )
FRCYF  = F( ALTD, MACH )
CYBFLX  = F( ALTD, MACH )

```

APPENDIX B

REFERENCE FLIGHT CONDITIONS

INDEPENDENT VARIABLE TABULATED VALUES

REFERENCE ANGLE OF ATTACK VALUES - LONGITUDINAL DATA					
-4.0	0.0	4.0	8.0	12.0	16.0
28.0	32.0	36.0	40.0	45.0	50.0
65.0	70.0	75.0	80.0	85.0	90.0
					24.0
					60.0

REFERENCE ANGLE OF ATTACK VALUES - LATERAL-DIRECTIONAL DATA

0.0	10.0	15.0	20.0	25.0	30.0
45.0	50.0	55.0	60.0	65.0	70.0
85.0	90.0				
					35.0
					75.0
					40.0
					80.0

REFERENCE ALTITUDE VALUES

0.0	20000.0	40000.0	60000.0
-----	---------	---------	---------

REFERENCE SIDESLIP ANGLE VALUES

-20.0	-10.0	-12.0	-8.0	-4.0	0.0	4.0	8.0
12.0	10.0	20.0					

REFERENCE AILERON DEFLECTION VALUES

-25.0	-12.5	0.0	12.5	25.0
-------	-------	-----	------	------

REFERENCE T.E. FLAP DEFLECTION VALUES

0.0 20.0

REFERENCE HORIZ. TAIL DEFLECTION VALUES

-24.0 -12.0 -6.0 0.0 6.0 10.5

REFERENCE L.E. FLAP DEFLECTION VALUES

0.0 25.0

REFERENCE MANEUVERING FLAP < LEF > VALUES

0.0 6.0 15.0 34.0

REFERENCE RUDDER DEFLECTION VALUES

-30.0 0.0 30.0

REFERENCE SPEED BRAKE DEFLECTION VALUES

0.0 60.0

REFERENCE DYNAMIC PRESSURE VALUES

0.0 2000.0

REFERENCE MACH NUMBER VALUES

0.2 0.6 0.8 0.9

ATMOSPHERIC TABLE ALTITUDE VALUES

0.0	1000.0	2000.0	3000.0	4000.0	5000.0	6000.0	7000.0
8000.0	5000.0	10000.0	11000.0	12000.0	13000.0	14000.0	15000.0
16000.0	17000.0	18000.0	19000.0	20000.0	21000.0	22000.0	23000.0
24000.0	25000.0	26000.0	27000.0	28000.0	29000.0	30000.0	31000.0
32000.0	33000.0	34000.0	35000.0	36000.0	40000.0	45000.0	50000.0
55000.0	60000.0	65000.0					

APPENDIX C

SAMPLE PROGRAM STATEMENTS

EXAMPLE: THIS IS A LISTING OF THE AERODYNAMIC BUILDUP FOR LIFT COEFFICIENT ONLY. THE FULL AERODYNAMIC BUILDUP FOLLOWS THE SAME FORMAT EXPANDED IN SECTIONS ONE, TWO, FOUR AND FIVE FOR THE REMAINING COEFFICIENTS. SECTION THREE IS THE SAME AS THE FULL BUILDUP. THE SUBROUTINES HAVE BEEN LISTED IN ANOTHER APPENDIX.

THIS PROGRAM PERFORMS THE AERODYNAMIC BUILD-UP FOR THE F/A-18A FIGHTER ATTACK AIRCRAFT. TABULATED AERODYNAMIC DATA EXTRAPOLATED FROM GRAPHICAL PRESENTATIONS IS REFERENCED USING INTERPOLATION ROUTINES FOR INTERMEDIATE AND TABULATED FLIGHT CONDITIONS. THE AIRCRAFT TOTAL COEFFICIENTS FOR LIFT, DRAG, PITCHING MOMENT, ROLLING MOMENT, YAWING MOMENT, AND SIDEWAVE FORCE ARE DETERMINED USING THE REQUIRED AERODYNAMIC CONTROL DATA ALONG WITH ADDITIONAL REQUIREMENTS. THE AERODYNAMIC COEFFICIENTS CAN BE DETERMINED THROUGH THE FOLLOWING RANGE OF FLIGHT CONDITIONS:

MACH NUMBER:	2 - 9	SEA LEVEL - 60,000 FT
ALTITUDE:	-14 - 90 DEG	
ANGLE-OF-ATTACK:	-120 - 20 DEG	
SIDESLIP ANGLE:	4.2 - 1200.8	
DYNAMIC PRESSURE:		

THE PROGRAM PROVIDES RESULTS OF THE COEFFICIENT BUILDUP FOR INDEPENDENT STUDY OR FOR INTEGRATION INTO FLIGHT SIMULATION PROGRAMS.

THE PROGRAM IS SEGMENTED INTO SIX MAJOR SECTIONS AS FOLLOWS:

SECTION ONE:	VARIABLE DEFINITION, EXPLANATIONS, DECLARATIONS, AND PROGRAM PARAMETERS
SECTION TWO:	AERODYNAMIC DATA AND CONSTANTS
SECTION THREE:	TEST FLIGHT CONDITION INPUTS
SECTION FOUR:	AERODYNAMIC BUILD-UP
SECTION FIVE:	OUTPUT AND CONTROL
SECTION SIX:	SUBROUTINES

EACH SECTION IS FURTHER DIVIDED INTO MULTIPLE SUBSECTIONS AS REQUIRED AND INDICATED IN THE PROGRAM COMMENTS.

PROGRAMMER IS: LT. A.L. RAITHEL, H-232, EXT. 2866

SECTION 1: DEFINITIONS, EXPLANATIONS, DECLARATIONS AND PROGRAM PARAMETERS

()	ALFA	ANGLE OF ATTACK OF	ANGLE OF ATTACK
()	ALTC	RATE OF CHANGE OF	ANGLE OF ATTACK
()	ATMOS1	AIRCRAFT ALTITUDE	TABLE
()	ATMOS2	STANDARD DAY DENSITY	TABLE
()	B	STANDARD DAY SONIC	VELOCITY TABLE
()	BETA	WING SPAN (AIRCRAFT	REFERENCE)
()	BETACT	SIDESLIP ANGLE	OF SIDESLIP ANGLE
()	C	RATE OF CHANGE OF	AIRCRAFT REFERENCE
()	CL	WING CHORD (AIRCRAFT	REFERENCE)
()	CLA	TOTAL LIFT COEFFICIENT	
()	CLBAS	LIFT DUE TO ANGLE-OF-ATTACK	RATE (PER RAD.)
()	CLDYN	BASIC CONFIGURATION	LIFT COEFFICIENT
()	CLOUD	DYNAMIC LIFT COEFFICIENT	
()		CONTROL VARIABLE FOR	OUTPUT OF LIFT COEFFICIENT
()	CLQ	DERIVATIVES	
()	CLST	LIFT DUE TO PITCH	RATE (PER RAD.)
()	CL1	STATIC LIFT COEFFICIENT	
()	CL2	CLBAS DATA TABLE	
()	CL3	CLDYN DATA TABLE	
()	CL4	CLDHF DATA TABLE	
()	CL5	CLDHH DATA TABLE	
()	CL6	CLCSB DATA TABLE	
()	CL7	CLCDA DATA TABLE	
()	CL8	CLCDA DATA TABLE	
()	CL9	CLCDA DATA TABLE	
()	CL10	CLCDA DATA TABLE	
()	DAL/R	AILERON DEFLECTION	(LEFT OR RIGHT)
()	DCLDAL/R	AILERON DEFLECTION	DUE TO AILERON DEFLECTION
()	DCLDF	LIFT INCREMENT DUE	TO AILERON DEFLECTION (PER DEG.)
()	DCLDFL/R	LIFT INCREMENT DUE	TO STABILATOR DEFLECTION
()		LIFT INCREMENT DUE	TO STABILATOR
()	DCLDN	LIFT INCREMENT DUE	TO SPEED BRAKE DEFLECTION
()	DCLDSB	LIFT INCREMENT DUE	TO SPEED BRAKE DEFLECTION
()	DDA	DIFFERENTIAL AILERON	DEFLECTION (DAL - DAR)
()	DDF	DIFFERENTIAL TRAILING	EDGE FLAP DEFLECTION (DFL - DFR)
()	DDN	DIFFERENTIAL LEADING	EDGE FLAP DEFLECTION (DNL - DNR)
()	DT	DIFFERENTIAL HORIZONTAL	TAIL DEFLECTION (DHL - DHR)
()	DF	AVERAGE TRAILING	EDGE FLAP DEFLECTION

()	DFL/R	-	TRAILING EDGE FLAP DEFLECTION	(DFL + DFR) / 2
()	DH	-	AVERAGE HORIZONTAL TAIL DEFLECTION	(DHL + DHR) / 2
()	DHL/R	-	STABILATOR/HORIZONTAL TAIL DEFLECTION (LEFT	
()	DN	-	OR RIGHT)	
()	DN	-	AVERAGE LEADING EDGE FLAP DEFLECTION	
()	DNL/R	-	LEADING EDGE FLAP DEFLECTION (LEFT OR RIGHT)	(DNL + DNR) / 2
()	DR	-	AVERAGE RUDDER DEFLECTION	
()	DRL/R	-	RUDDER DEFLECTION (LEFT OR RIGHT)	(DRL + DRR) / 2
()	DSB	-	SPEED BRAKE DEFLECTION	
()	FORVAR	-	FOUR VARIABLE INTERPOLATION SUBROUTINE	
()	FRCLCA	-	FLEX/RIGIDITY RATIO FOR LIFT DUE TOAILERON	
()	FRCLCH	-	DEFLECTION	
()	HCAD	-	DEFLEX/RIGIDITY RATIO FOR LIFT DUE TO STABILATOR	
()	HCCD	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	HCCCL	-	ATMOSPHERIC DATA	
()	HCCM	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	HCCN	-	DRAG COEFFICIENT DERIVATIVE DATA	
()	HCCR	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	HCCY	-	LIFT COEFFICIENT DERIVATIVE DATA	
()	HCFC	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	HCI	-	PITCHING MOMENT COEFFICIENT DERIVATIVE DATA	
()	I	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	IVALF1()	-	ROLLING MOMENT COEFFICIENT DERIVATIVE DATA	
()	IVALF2()	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	IVALTC()	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	IVBETA()	-	SIDE FORCE COEFFICIENT DERIVATIVE DATA	
()	IVDA()	-	CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
()	IVDF()	-	FLIGHT CONDITION INPUTS	
			CONTROL VARIABLE FOR HARDCOPY OUTPUT OF TABULATED	
			FLIGHT CONDITION FOR HARDCOPY OUTPUT OF TABULATED	
			INTEGRAL VALUE FOR SUBSCRIPTING	
			INDEPENDENT VARIABLE ALFA VALUES FOR WHICH	
			LONGITUDINAL DATA IS TABULATED	
			INDEPENDENT VARIABLE ALFA VALUES FOR WHICH	
			LATERAL-DIRECTIONAL DATA IS TABULATED	
			INDEPENDENT VARIABLE ALTITUDE VALUES FOR WHICH	
			DATA IS TABULATED	
			INDEPENDENT VARIABLE BETA VALUES FOR WHICH DATA	
			IS TABULATED	
			INDEPENDENT VARIABLEAILERON DEFLECTION VALUES	
			FOR WHICH DATA IS TABULATED	
			INDEPENDENT VARIABLETEF DEFLECTION VALUES FOR	
			WHICH DATA IS TABULATED	

()	IVDH()	-	INDEPENDENT VARIABLE HCRIZ. TAIL DEFLECTION
()	IVDN()	-	VALUES FOR WHICH DATA IS TABULATED
()	IVDR()	-	INDEPENDENT VARIABLE LEF DEFLECTION VALUES FOR WHICH DATA IS TABULATED
()	IVDSE()	-	INDEPENDENT VARIABLE RUDDER DEFLECTION VALUES FOR WHICH DATA IS TABULATED
()	IVQC()	-	INDEPENDENT VARIABLE SPEED BRAKE DEFLECTION VALUES FOR WHICH DATA IS TABULATED
()	IVMACH()	-	INDEPENDENT VARIABLE DYNAMIC PRESSURE VALUES FOR WHICH DATA IS TABULATED
()	IVMF()	-	INDEPENDENT VARIABLE MACH VALUES FOR WHICH DATA IS TABULATED
()	J	-	INDEPENDENT VARIABLE MANEUVERING FLAP LEF DEFLECTIONS VALUES FOR WHICH DATA IS TABULATED
()	K	-	INTEGER VALUE FOR SUBSCRIPTING
()	KRDR	-	INTEGER VALUE FOR SUBSCRIPTING
()	L	-	RUDDER POWER FACTOR DUE TO STABILATOR POSITION
()	LE.E.C.	-	INTEGRAL VALUE FOR SUBSCRIPTING
()	LEF	-	LEADING EDGE DOWN
()	LE.E.L.	-	LEADING EDGE FLAP
()	MACH	-	LEADING EDGE LEFT
()	ONEVAR	-	AIRCRAFT MACH NUMBER (FREE STREAM)
()	P	-	ONE VARIABLE INTERPOLATION SUBROUTINE
()	Q	-	ROLL RATE
()	QC	-	PITCH RATE
()	R	-	DYNAMIC PRESSURE
()	RHO	-	ATMOSPHERIC DENSITY
()	STDALT()	-	ATMOSPHERIC TABLE FOR STANDARD DAY ATMOSPHERIC DATA
()	SVEL	-	ALTITUDE
()	TAC	-	SONIC VELOCITY
()	TCSD	-	CONTROL VARIABLE FOR INPUT CF TEST ATMOSPHERIC DATA
()	TFC	-	CONTRGL VARIABLE FOR INPUT CF TEST CONTROL SURFACE DEFLECTIONS
()	T.E.C.	-	CONTROL VARIABLE FOR INPUT OF TEST FLIGHT CONDITION PARAMETERS
()	THRVAR	-	TRAILING EDGE DOWN
()	TUVAR	-	TRAILING EDGE FLAP
()	VT	-	THREE VARIABLE INTERPOLATION SUBROUTINE
()	WSMX	-	TWO VARIABLE INTERPOLATION SUBROUTINE
()	WSMXY	-	TOTAL AIRCRAFT VELOCITY
()	WSMXYZ	-	WORKING SPACE MATRIX FOR SUBROUTINES (ONE DIMENSIONAL)
()		-	WORKING SPACE MATRIX FOR SUBROUTINES (TWO DIMENSIONAL)
()		-	WORKING SPACE MATRIX FOR SUBROUTINES (THREE DIMENSIONAL)

PROGRAM OPERATION NOTES:

- (1) THE FOLLOWING FILE DEFINITIONS APPLY TO THIS PROGRAM FOR TRANSFER OF DATA BETWEEN THE PROGRAM DATA TABLES AND THE DATA FILES

FILEDEF 01 DISK	F18IV DATA	A	-	IV DATA
FILEDEF 02 DISK	F18CL DATA	A	-	CL DATA
FILEDEF 03 DISK	F18CD DATA	A	-	CD DATA
FILEDEF 04 DISK	F18CM DATA	A	-	CM DATA
FILEDEF 07 DISK	F18CN DATA	A	-	CN DATA
FILEDEF 08 DISK	F18CR DATA	A	-	CR DATA
FILEDEF 09 DISK	F18CY DATA	A	-	CY DATA
FILEDEF 10 DISK	ATMOS DATA	A	-	ATMOSPHERIC DATA

- (2) THE PROGRAM AERODYNAMIC DATA TABLES ARE AUTOMATICALLY LOADED FROM THE DATA FILES FOR THE AERODYNAMIC BUILDUP CALCULATIONS. IF A HARDCOPY OF A DATA TABLE IS DESIRED SET THE APPROPRIATE PARAMETER EQUAL TO ONE. IF NO HARDCOPY IS DESIRED SET THE PARAMETER EQUAL TO ZERO. I.E. IF A HARDCOPY OF THE TABULATED CL DATA IS DESIRED SET HCCL/1/. IF NO HARDCOPY OF THE CY DATA IS DESIRED SET HCCY/0/. SET THE PARAMETERS IN SECTION ONE PROGRAM CONTROL DATA CARDS.

- (3) IF A HARDCOPY OF THE OUTPUT AERODYNAMIC COEFFICIENT DERIVATIVES IS DESIRED, SET THE APPROPRIATE PARAMETER EQUAL TO ONE. IF NO HARDCOPY IS DESIRED, SET THE PARAMETER EQUAL TO ZERO. I.E. IF A HARDCOPY OF THE OUTPUT CL DERIVATIVES IS DESIRED SET CLOUD/1/. IF NO HARDCOPY OF CN DERIVATIVES IS DESIRED, SET CNDOUT/0/. SET THE PARAMETERS IN SECTION ONE PROGRAM CONTROL DATA CARDS.

- (4) IF A PROGRAM RUN REQUIRES TEST FLIGHT CONDITION INPUTS SET THE APPROPRIATE PARAMETER EQUAL TO ONE. IF THE INPUTS ARE BEING PROVIDED BY A FLIGHT SIMULATION SET THE PARAMETER EQUAL TO ZERO. I.E. IF THE VALUES FOR FLIGHT CONDITIONS ALFA, MACH, Q, ETC. IF ARE GENERATED IN A MAIN PROGRAM, SET IFC/0/. IF THE VALUES OF DYNAMIC PRESSURE, VELOCITY, ETC. ARE NOT PROVIDED, SET IAC/1/. TO UTILIZE THE INCORPORATED ATMOSPHERIC DATA TABLES.

- (5) THIS AERODYNAMIC BUILDUP USES THE FOLLOWING SIGN CONVENTIONS FOR CONTROL SURFACE DEFLECTIONS

DHL/R - POSITIVE I.E.D.

DNL/R - POSITIVE L.E.D.
 DFL/R - POSITIVE T.E.D.
 DAL/R - POSITIVE T.E.D.
 DRL/R - POSITIVE T.E.L.

(6) DATA IN THIS PROGRAM IS READ AND WRITTEN BY ROWS, WITH
 THE RIGHT MOST ARGUMENT INCREMENTING MOST OFTEN. I.E.
 CLEAR = F (MACH, ALTD, ALFA) = CL1(4, 4, 22) IS READ AND
 WRITTEN,
 (1,1,1), (1,1,2), (1,1,8),
 (1,1,9), (1,2,2), (1,2,4), (1,2,21), (1,4,1),
 (1,2,22), (1,3,1), ... (1,3,22), ...
 (2,1,1), (2,1,22), etc.

ALL NUMBERS IN THE PROGRAM NOT DECLARED ARE REAL NUMBERS

DIMENSION/DECLARATION STATEMENT

```

REAL B, C, ALFA, BETA, ALTD, MACH, QC, Q, ALFADI, VT, P, R, DSB,
# GAL, DAR, GDA, DFL, DFR, CF, DNL, ENR, DN, ORL, DRR, DR,
# DHL, DFR, CH, DT, KRDR, SIGALT(43), ATPOS1(43), ATMOS2(43),
# IVALF1(22), IVALF2(18), IVALTD(4), IVBETA(11), IVDA(5),
# IVEF(2), IVDH(6), IVDN(2), IVDR(3), IVDSB(2), IVQC(2),
# IVMF(4), IVMACH(4), WSNXYZ(5,16,22), WSMXY(5,16), WSMX(22)

DIMENSION CD1(4,22), CD2(4,6,22), CD3(4,5,22), CD4(4,2,22),
# CD5(4,4,22),
# CL1(4,4,22), CL2(4,4,22), CL3(4,4,22), CL4(4,6,22),
# CL5(4,4), CL6(4,2,22), CL7(4,5,22), CL8(4,4), CL9(4,4,22),
# CL10(4,4,22), CM1(4,4,22), CM2(4,4,22), CM3(4,4,22),
# CM4(4,6,22), CM5(4,4), CM6(4,2,22), CM7(4,3,22), CM8(4,5,22),
# CM9(4,4), CM10(4,4,22), CM11(4,4,22),
# CN1(4,18,11), CN2(4,2,18,11), CN3(4,2,18,11), CN4(4,6,18),
# CN5(4,4,18), CN6(4,2,11,18), CN7(4,3,11,18), CN8(4,4),
# CN9(4,5,18), CN10(4,4), CN11(4,18), CN12(4,18), CN13(4,4),
# CN14(4,18), CN15(4,2,18), CN16(6,18),
# CR1(4,18,11), CR2(4,2,18,11), CR3(4,2,18,11), CR4(4,6,18),
# CR5(4,4), CR6(4,2,11,18), CR7(4,3,11,18), CR8(4,4),
# CR9(4,5,18), CR10(4,4), CR11(4,18), CR12(4,4,18), CR13(4,4),
# CR14(18), CR15(4,2,18), CR16(4,2), CR17(4,4,18),

```

```

#      CY1(4,18,11), CY2(4,2,18,11), CY3(4,2,18,11), CY4(4,6,18),
#      CY5(4,4), CY6(4,2,11,18), CY7(4,3,11,18), CY8(4,4),
#      CY9(4,5,18), CY10(4,4), CY11(4,18), CY12(4,18), CY13(4,4),
#      CY14(4,4), CY15(4,4)

```

```

INTEGER I, J, K, L,

```

```

#      PCAL, HCCD, HCCL, HCCM, HCCN, HCCR, HCCY, HCFC, HCIV,
#      CDOUT, CLOUT, CMOUT, CNOUT, CROUT, CYOUT,
#      TAC, TCSD, TFC

```

PROGRAM CONTROL DATA

```

DATA  PCAD/O/, HCCD/O/, HCCL/1/, HCCM/O/, HCCN/O/, HCCR/O/,
#      FCCY/O/, HCFC/1/, HCIV/O/
DATA  CECUT/O/, CLOUT/1/, CMOUT/O/, CNOUT/C/,
#      CROUT/O/, CYOUT/O/
DATA  TAC/1/, TCSD/1/, TFC/1/

```

SECTION 2: AERODYNAMIC DATA AND CONSTANTS

THIS SECTION READS/LOADS THE AERODYNAMIC DATA FROM THE DATA FILES INTO THE APPROPRIATE PROGRAM DATA TABLE AND IF DESIRED PROVIDES A HARDCOPY OF DATA TABLES. REFER TO THE NOTES IN SECTION ONE FOR VERIFICATION OF HARDCOPY OUTPUT.

AIRCRAFT ASSOCIATED CONSTANTS

DATA 8/37.42/, C/11.52/

AERODYNAMIC DATA

INDEPENDENT VARIABLE DATA

ANGLE OF ATTACK - IVALF1

ANGLE CF ATTACK - IVALF2

ALTITUDE - IVALTD

SIDESLIP ANGLE - IVBETA

AILERON DEFLECTION - IVDA

TRAILING EDGE FLAP DEFLECTION - IVDF

HORIZONTAL TAIL DEFLECTION - IVDH

LEADING EDGE FLAP DEFLECTION - IVDN

RUDDER DEFLECTION - IVDR

SPEED BRAKE DEFLECTION - IVDSB

DYNAMIC PRESSURE - IVQC

MACH NUMBER - IVMACH

STANDARD ALTITUDE - STDALT

MANEUVERING FLAP DEFLECTION (LEF) - IVMF

```

READ(1,100) ( IVALF1(I), I = 1,22 )
READ(1,100) ( IVALF2(I), I = 1,18 )
READ(1,100) ( IVALTD(I), I = 1,4 )
READ(1,100) ( IVBETA(I), I = 1,11 )
READ(1,100) ( IVDA(I), I = 1,5 )
READ(1,100) ( IVDF(I), I = 1,2 )
READ(1,100) ( IVDH(I), I = 1,6 )
READ(1,100) ( IVON(I), I = 1,2 )
READ(1,100) ( IVOR(I), I = 1,3 )
READ(1,100) ( IVDSB(I), I = 1,2 )
READ(1,100) ( IVQC(I), I = 1,2 )
READ(1,100) ( IVMACH(I), I = 1,4 )
READ(1,100) ( STDALT(I), I = 1,43 )
READ(1,100) ( IVMF(I), I = 1,4 )

IF ( MCIV .EQ. 0 ) GO TO 101
WRITE(6,105)
WRITE(6,110)
WRITE(6,120) ( IVALF1(I), I = 1,22 )
WRITE(6,112)
WRITE(6,120) ( IVALF2(I), I = 1,18 )
WRITE(6,130)
WRITE(6,120) ( IVALTD(I), I = 1,4 )
WRITE(6,140)
WRITE(6,120) ( IVBETA(I), I = 1,11 )
WRITE(6,150)

```

```

WRITE(6,120) ( IVDA(I), I = 1,5 )
WRITE(6,160)
WRITE(6,120) ( IVDF(I), I = 1,2 )
WRITE(6,170)
WRITE(6,120) ( IVDH(I), I = 1,6 )
WRITE(6,180)
WRITE(6,120) ( IVDN(I), I = 1,2 )
WRITE(6,185)
WRITE(6,120) ( IVMF(I), I = 1,4 )
WRITE(6,190)
WRITE(6,120) ( IVDR(I), I = 1,3 )
WRITE(6,200)
WRITE(6,120) ( IVDSB(I), I = 1,2 )
WRITE(6,210)
WRITE(6,120) ( IVQC(I), I = 1,2 )
WRITE(6,215)
WRITE(6,120) ( IVMACH(I), I = 1,4 )
WRITE(6,219)
WRITE(6,120) ( STDALT(I), I = 1,43 )

```

101 CONTINUE

ATMOSPHERIC DATA

```

RHO ( ATMOS1 ) = F( ALTD )
SVEL ( ATMOS2 ) = F( ALTD )
REAC(10,100) ( ATMOS1(I), I = 1,43 )
REAC(10,100) ( ATMOS2(I), I = 1,43 )
IF ( FCAL .EQ. 0 ) GC TC 103
WRITE(6,221)

```

```
WRITE(6,222) ( ATMOS1(I), I = 1,43 )  
WRITE(6,223) ( ATMOS2(I), I = 1,43 )
```

CONTINUE

103

LONGITUDINAL DERIVATIVE DATA

LIFT COEFFICIENT

```

CLBAS ( CL1 ) = F( MACH, ALTD, ALFA )
DCLEN ( CL2 ) = F( MACH, ALTD, ALFA )
DCLOF ( CL3 ) = F( MACH, ALTD, ALFA )
DCLDH ( CL4 ) = F( MACH, DH, ALFA )
FRCLCH ( CL5 ) = F( ALTD, MACH )
DCLESE ( CL6 ) = F( MACH, DSB, ALFA )
DCLOA ( CL7 ) = F( MACH, DA, ALFA )
FRCLCA ( CL8 ) = F( ALTD, MACH )
CLQ ( CL9 ) = F( MACH, ALTD, ALFA )
CLA ( CL10 ) = F( MACH, ALTD, ALFA )

READ(2,10) (( CL1(I,J,K), K = 1,22 ), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL2(I,J,K), K = 1,22 ), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL3(I,J,K), K = 1,22 ), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL4(I,J,K), K = 1,22 ), J = 1,6 ), I = 1,4 )
READ(2,10) (( CL5(I,J), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL6(I,J,K), K = 1,22 ), J = 1,2 ), I = 1,4 )
READ(2,10) (( CL7(I,J,K), K = 1,22 ), J = 1,5 ), I = 1,4 )
READ(2,10) (( CL8(I,J), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL9(I,J,K), K = 1,22 ), J = 1,4 ), I = 1,4 )
READ(2,10) (( CL10(I,J,K), K = 1,22 ), J = 1,4 ), I = 1,4 )

```

```

IF ( HCCL .EC. 0 ) GO TO 201
WRITE(6,225)

WRITE(6,230)
DO 232 I = 1,4
DO 232 J = 1,4
WRITE(6,236) IVMACH(I), IVALTD(J),
WRITE(6,240) ( CL1(I,J,K), K = 1,22 )
CONTINUE
232

WRITE(6,250)
DO 252 I = 1,4
DO 252 J = 1,4
WRITE(6,256) IVMACH(I), IVALTD(J),
WRITE(6,260) ( CL2(I,J,K), K = 1,22 )
CONTINUE
252

WRITE(6,270)
DO 272 I = 1,4
DO 272 J = 1,4
WRITE(6,276) IVMACH(I), IVALTD(J),
WRITE(6,280) ( CL3(I,J,K), K = 1,22 )
CONTINUE
272

WRITE(6,280)
DO 282 I = 1,4
DO 282 J = 1,6
WRITE(6,286) IVMACH(I), IVDN(J),
WRITE(6,290) ( CL4(I,J,K), K = 1,22 )
CONTINUE
282

WRITE(6,300)
DO 302 I = 1,4
WRITE(6,306) IVALTD(I),
WRITE(6,310) (CL5(I,J), J = 1,4 )
CONTINUE
302

WRITE(6,310)
DO 312 I = 1,4
DO 312 J = 1,2
WRITE(6,316) IVMACH(I), IVD5B(J),
WRITE(6,290) ( CL6(I,J,K), K = 1,22 )
CONTINUE
312

WRITE(6,320)
DO 322 I = 1,4

```

```

DO 322 J = 1,5
  WRITE(6,324) IVMACH(I), IVDA(J)
  WRITE(6,290) ( CL7(I,J,K), K = 1,22 )
CONTINUE
322

  WRITE(6,330)
  DO 332 I = 1,4
    WRITE(6,334) IVALTD(I)
    WRITE(6,240) (CL8(I,J), J = 1,4 )
CONTINUE
332

  WRITE(6,340)
  DO 342 I = 1,4
    DO 344 J = 1,4
      WRITE(6,344) IVMACH(I), IVALTD(J)
      WRITE(6,120) ( CL9(I,J,K), K = 1,22 )
CONTINUE
342

  WRITE(6,350)
  DO 352 I = 1,4
    DO 354 J = 1,4
      WRITE(6,354) IVMACH(I), IVALTD(J)
      WRITE(6,120) ( CL10(I,J,K), K = 1,22 )
CONTINUE
352
CONTINUE
201

```

DRAG COEFFICIENT DATA

PITCHING MOMENT COEFFICIENT DATA

LATERAL-DIRECTIONAL DERIVATIVES

YAWING MOMENT COEFFICIENT DATA

ROLLING MOMENT COEFFICIENT DATA

SIDE FORCE COEFFICIENT DATA

SECTION THREE: TEST FLIGHT CONDITICN INPUTS

THIS SECTION INPUTS THE VALUES CF INCEPENDENT VARIABLES DESCRIBING THE AIRCRAFT FLIGHT CONDITION. A HARDCOPY OF THE INPUTS IS GENERATED AUTOMATICALLY WITH EACH PROGRAM RUN.

```

1619 IF ( TFC .EQ. 0 ) GO TO 1619
      DATA MACH/.6/, ALTD/40000./, ALFA/20./, BETA/-6./
      DATA Q/.2/, ALFADT/.4/, P/.5/, R/.5/
      CONTINUE

```

```

1621 IF ( TAC .EQ. 0 ) GO TO 1621
      CALL GNEVAR( STDALT, 43, ATMOS1, ALTC, 3, RHO )
      CALL CNEVAR( STDALT, 43, ATMOS2, ALTC, 3, SVEL )
      VT = PACF * SVEL
      QC = .5 * RHG * VT**2
      CONTINUE

```

```

      IF ( TCSC .EQ. 0 ) GO TO 1623
      DATA DAL/12.5/, DAR/-12.5/, DNL/25./, CNR/25./,
            DFL/20./, DFR/20./, DHL/-6./, DHR/-6./,
            DFL/-20./, DRR/-30./, DSB/60./

```

```

      DDA = ( CAL - DAR )
      DF = ( DFL + DFR ) / 2
      DDF = ( DFL - DFR )

```

```

DH = ( DFL + DHR ) / 2
DN = ( DAL + DNR ) / 2
DDN = ( [NR - DNL ]
DR = ( DFL + DRR ) / 2
DT = ( DFL - DHR )

```

1623

CONTINUE

```

IF ( PCFC .EG. 0 ) GO TO 1625

```

```

WRITE(6,2000)

```

```

WRITE(6,2010) ALFA, BETA, ALTD, MACH, QC, Q, ALFADT

```

```

WRITE(6,2015)

```

```

WRITE(6,120) VT, P, R

```

```

WRITE(6,2020)

```

```

WRITE(6,120) DAL, DAR, DDA, DFL, DFR, DF, DDF

```

```

WRITE(6,2022)

```

```

WRITE(6,120) DNL, DNR, DN, DDN, DHL, DHR, DH, DT

```

```

WRITE(6,2024)

```

```

WRITE(6,120) DRL, DRR, DR, DSB

```

CONTINUE

1625

SECTION 4: AERODYNAMIC BUILD-UP

THIS SECTION MAKES CALLS TO INTERPOLATION SUBROUTINES WHICH INTERPOLATE THE TABULATED DATA FOR THE PROPER VALUES OF THE AERODYNAMIC DERIVATIVES FOR THE GIVEN FLIGHT CONDITION. THE DERIVATIVES ARE THEN SUMMED TO CALCULATE THE STATIC AND DYNAMIC COEFFICIENTS FROM WHICH THE TOTAL COEFFICIENT IS FORMED. REFER TO THE NOTES IN SECTION ONE FOR VERIFICATION OF HARDCOPY OUTPUT.

LIFT COEFFICIENT

CLBAS

CALL THRVAR(IVMACH, IVALTD, IVALF1, 4, 4, 22, CL1, WSMXY,
WSMX, MACH, ALTD, ALFA, 3, 3, 3, CLBAS,)

#

DCLDN

CALL THRVAR(IVMACH, IVALTD, IVALF1, 4, 4, 22, CL2, WSMXY,
WSMX, MACH, ALTD, ALFA, 3, 3, 3, DCLDN,)

#

DCLOF

CALL THRVAR(IVMACH, IVALTD, IVALF1, 4, 4, 22, CL3, WSMXY,
WSMX, MACH, ALTD, ALFA, 3, 3, 3, DCLOF,)

#

DCLDHL

CALL THRVAR(IVMACH, IVDH, IVALF1, 4, 6, 22, CL4, WSMXY,
WSMX, MACH, DHL, ALFA, 3, 3, 3, DCLDHL,)

#

DCLDHR

CALL THRVAR(IVMACH, IVDH, IVALF1, 4, 6, 22, CL4, WSMXY,
WSMX, MACH, DHR, ALFA, 3, 3, 3, DCLDHR,)

#

FRCLDH

CALL TUVAR(IVALTD, IVMACH, 4, 4, CL5, WSMX, ALTD, MACH,
3, 3, FRCLDH,)

#

DCLOSE

```

# CALL THRVAR( IVMACH, IVDSB, IVALF1, 4, 2, 22, CL6, WSMXY,
# WSMX, MACH, DSB, ALFA, 3, 1, 3, DCCLDSB )
# DCLEAL
# CALL THRVAR( IVMACH, IVDA, IVALF1, 4, 5, 22, CL7, WSMXY,
# WSMX, MACH, DAL, ALFA, 3, 3, 3, DCCLDAL )
# DCLEAR
# CALL THRVAR( IVMACH, IVDA, IVALF1, 4, 5, 22, CL7, WSMXY,
# WSMX, MACH, DAR, ALFA, 3, 3, 3, DCCLDAR )
# FRCLCA
# CALL TUVAR( IVALD, IVMACH, 4, 4, CL8, WSMX, ALTD, MACH,
# 3, 3, FRCLDA )
# CLQ
# CALL THRVAR( IVMACH, IVALTD, IVALF1, 4, 4, 22, CL9, WSMXY,
# WSMX, MACH, ALTD, ALFA, 3, 3, 3, CLQ )
# CLA
# CALL THRVAR( IVMACH, IVALTD, IVALF1, 4, 4, 22, CL10, WSMXY,
# WSMX, MACH, ALTD, ALFA, 3, 3, 3, CLA )
# STATIC LIFT COEFFICIENT
# CLST = CLBAS + ( DCCLDN * DN ) + ( DCCLDF * DF )
# + ( DCCLDHL + DCCLDHR ) * FRCLDF / 2
# + DCCLDSB + ( DCCLDAL + DCCLDAR ) * FRCLDA
# DYNAMIC LIFT COEFFICIENT
# CLDYN = CLQ * ( C * C ) / ( 2 * VT )
# + CLA * ( ALFADT * C ) / ( 2 * VT )
# TOTAL LIFT CCEFFICIENT
# CL = CLST + CLDYN

```

```

IF ( CLCUT .EQ. 0 ) GO TO 1050
WRITE(6,100C)

```

```
WRITE(6,101C) CLBAS, DCLDN, DCLDF, DCLDHL, DCLDHR, FRCLDH  
WRITE(6,260) DCLDSB, DCLDAL, DCLDAR, FRCLDA, CLQ, CLA  
WRITE(6,102C)  
WRITE(6,290) CLST, CLDYN, CL  
WRITE(6,103C)  
WRITE(6,260) CLST, CLDYN, CL
```

1050 CONTINUE

DRAG COEFFICIENT

PITCHING MOMENT COEFFICIENT

LATERAL-DIRECTIONAL DERIVATIVES

YAWING MOMENT COEFFICIENT

ROLLING MOMENT COEFFICIENT

SIDE FORCE COEFFICIENT

WRITE(6,5000)
WRITE(6,240) CD, CL, CM, CN, CR, CY

SECTION 5: OUTPUT AND CONTROL

```

100  FORMAT(8F10.4)
105  FORMAT('1',//,23X,'INDEPENDENT VARIABLE TABULATED VALUES')
110  FORMAT(///,18X,'REFERENCE ANGLE OF ATTACK VALUES',
#      '- LONGITUDINAL DATA',/)
112  FORMAT(///,14X,'REFERENCE ANGLE OF ATTACK VALUES',
#      '- LATERAL-DIRECTIONAL DATA',/)
120  FORMAT(/,8F10.1)
130  FORMAT(///,20X,'REFERENCE ALTITUDE VALUES',/)
140  FORMAT(///,20X,'REFERENCE SIDESLIP ANGLE VALUES',/)
150  FORMAT(///,20X,'REFERENCE AILERON DEFLECTION VALUES',/)
160  FORMAT(///,20X,'REFERENCE T.E. FLAP DEFLECTION VALUES',/)
170  FORMAT(///,20X,'REFERENCE HORIZ. TAIL DEFLECTION VALUES',/)
180  FORMAT(///,20X,'REFERENCE L.E. FLAP DEFLECTION VALUES',/)
185  FORMAT(///,20X,'REFERENCE MANEUVERING FLAP < LEF > VALUES',/)
190  FORMAT(///,20X,'REFERENCE RUDDER DEFLECTION VALUES',/)
200  FORMAT(///,20X,'REFERENCE SPEED BRAKE DEFLECTION VALUES',/)
210  FORMAT(///,20X,'REFERENCE DYNAMIC PRESSURE VALUES',/)
215  FORMAT(///,20X,'REFERENCE MACH NUMBER VALUES',/)
219  FORMAT(///,20X,'ATMOSPHERIC TABLE ALTITUDE VALUES',/)
220  FORMAT(/,8F10.5)
221  FORMAT('1',//,20X,'STANDARD DAY ATMOSPHERIC TABLES',/)
222  FORMAT(///,20X,'STANDARD DAY ATMOSPHERIC DENS-ITY')
223  FORMAT(/,8F10.7)

```

```

224  FORMAT(///,20X,'STANDARD DAY SONIC VELOCITY')
225  FORMAT('1',///,26X,'LIFT COEFFICIENT DERIVATIVE DATA')
230  #  FORMAT(///,18X,'LIFT COEFFICIENT - BASIC CONFIGURATION ',
      < CLBAS >,//)
236  #  FORMAT(///,1CX,'MACH NO. = ',F6.2,5X,'ALTD. = ',F8.2,5X,'ALFA = ',
240  #  FORMAT(//,8F10.2)
250  #  FORMAT(///,18X,'LIFT INCREMENT DUE TO LEF DEFLECTION ',
      < DCLDN >,//)
256  #  FORMAT(///,5X,'MACH NO. = ',F5.1,5X,'ALTD. = ',F7.1,5X,'ALFA = ALL')
260  #  FORMAT(//,8F10.4)
270  #  FORMAT(///,18X,'LIFT INCREMENT DUE TO TEF DEFLECTION ',
      < DCLEF >,//)
276  #  FORMAT(///,5X,'MACH NO. = ',F5.1,5X,'ALTD. = ',F7.1,5X,'ALFA = ALL')
280  #  FORMAT(///,13X,'LIFT INCREMENT DUE TO HORIZONTAL TAIL',
      DEFLECTION < DCLDH >,//)
286  #  FORMAT(///,5X,'MACH NO. = ',F5.1,5X,'CN = ',F5.1,5X,'ALFA = ALL')
290  #  FORMAT(//,8F10.3)
300  #  FORMAT(///,5X,'FLEX/RIGIDITY FACTOR FOR LIFT DUE TO',
      HORIZONTAL TAIL DEFLECTION < FRCLDH >,//)
306  #  FORMAT(///,5X,'ALTD. = ',F7.1,5X,'MACH NO. = ALL')
310  #  FORMAT(///,13X,'LIFT INCREMENT DUE TO SPEED BRAKE',
      DEFLECTION < DCLEDB >,//)
316  #  FORMAT(///,5X,'MACH NO. = ',F5.1,5X,'OSB. = ',F5.1,5X,'ALFA = ALL')
320  #  FORMAT(///,17X,'LIFT INCREMENT DUE TO AILERON',
      DEFLECTION < DCLEDA >,//)
324  #  FORMAT(///,5X,'MACH NO. = ',F5.1,5X,'CA = ',F5.1,5X,'ALFA = ALL')
330  #  FORMAT(///,9X,'FLEX/RIGIDITY FACTOR FOR LIFT DUE TO',
      AILERON DEFLECTION < FRCLDA >,//)

```

```

334  FORMAT(//,5X,'ALTD. =',F7.1,5X,'MACF NC. = ALL.')
```

```

340  FORMAT(////,27X,'LIFT DUE TO PITCH RATE  < CLQ >',//)
```

```

344  FORMAT(//,5X,'MACH NO. =',F5.1,5X,'ALTD. =',F7.1,5X,'ALFA = ALL.')
```

```

350  #  FORMAT(////,23X,'LIFT DUE TO ANGLE CF ATTACK RATE',
      #  < CLQ >',//)
```

```

1000 #  FORMAT(////,10X,'OUTPUT VALUES CF LIFT COEFFICIENT',
      #  ' DERIVATIVES',//)
```

```

1010 #  FORMAT(4X,'CLBAS',5X,'DCLDN',5X,'DCLODF',5X,'DCLDHL',4X,'DCLDHR',
      #  4X,'FRCLOH')
```

```

1020 #  FORMAT(//,4X,'DCLDSB',4X,'DCLDAL',4X,'DCLDAR',4X,'FRC LDA',
      #  6X,'CLQ',6X,'CLA')
```

```

1030 #  FORMAT(//,5X,'CLST',6X,'CLDYN',3X,'CL TOTAL')
```

```

2000 #  FORMAT(01,////,23X,'FLIGHT CONDITION PARAMETERS',//)
```

```

2010 #  FORMAT(6X,'ALFA',6X,'BETA',4X,'ALTD',8X,'MACH',3X,'DYNPRESS',7X,
      #  6X,'EX',6X,'ALFADT')
```

```

2015 #  FORMAT(//,7X,'VT',9X,'P',9X,'R')
```

```

2020 #  FORMAT(//,7X,'DAL',7X,'DAR',7X,'DDA',8X,'DFL',6X,'DFR',8X,'DF',
      #  8X,'CDF')
```

```

2022 #  FORMAT(//,7X,'DNL',7X,'DNR',7X,'DN',8X,'DDN',8X,'DHL',8X,'DHR',
      #  7X,'CH',8X,'DT')
```

```

2024 #  FORMAT(//,7X,'DRL',7X,'DRR',7X,'DR',8X,'DSB')
```

```

5000 #  FORMAT(01,////,10X,'TOTAL AERODYNAMIC COEFFICIENTS',//,10X,
      #  'CD',10X,'CL',10X,'CN',10X,'CR',10X,'CY',//)
```

SECTION SIX: SUBROUTINES

STOP
END

THE FOLLOWING SUBROUTINES ARE INCORPORATED IN THE AERODYNAMIC BUILDUP IN SECTION SIX. THEY ARE BASIC INTERPOLATION ROUTINES FOR DETERMINING THE VALUES OF FLIGHT DERIVATIVES AT FLIGHT CONDITIONS OTHER THAN THOSE FOR WHICH DATA IS TABULATED. A BRIEF EXPLANATION IS PROVIDED AT THE BEGINNING OF EACH.

APPENDIX D SUBROUTINES

	A	10
SUBROUTINE CNEVAR (Z,NZ,FZ,ZIN,NDEGZ,ANS)		
	A	20
	A	30
	A	40
	A	50
	A	60
	A	70
	A	80
	A	90
	A	100
	A	110
	A	120
	A	130
	A	140
	A	150
	A	160
	A	170
	A	180
	A	190
	A	200
	A	210
	A	220
	A	230
	A	240
	A	250
	A	260
	A	270
	A	280
	A	290
	A	300
	A	310
	A	320
	A	330
	A	340
	A	350

SUBROUTINE CNEVAR (Z,NZ,FZ,ZIN,NDEGZ,ANS)

SUBROUTINE CNEVAR INTERPOLATES A FUNCTION OF ONE VARIABLE USING LAGRANGIAN POLYNOMIALS OF DEGREE SPECIFIED.
SPACING OF DATA POINTS NEED NOT BE UNIFORM.
FUNCTION SHOULD BE SMOOTH IN ALL DIMENSIONS.
INDEPENDENT VARIABLE MUST BE GIVEN IN INCREASING ORDER.

VARIABLES: GF VALUES OF THE INDEPENDENT VARIABLE
Z: ARRAY OF THE ARRAY OF INDEPENDENT VARIABLE
NZ: DIMENSION OF VALUES OF THE FUNCTION EVALUATED AT THE POINTS
FZ: ARRAY SPECIFIED IN Z. THE DIMENSION OF FZ IS NZ.
ZIN: INPUT VALUES OF THE INDEPENDENT VARIABLE
(THE POINT AT WHICH THE FUNCTION IS EVALUATED)
NDEGZ: THE DEGREE OF THE POLYNOMIAL FITTED TO THE FUNCTION.
ANS: THE INTERPOLATED VALUE OF THE FUNCTION

DIMENSION FZ(NZ),Z(NZ)

IF ((NDEGZ+1).GT.NZ) NDEGZ=NZ-1

DO 10 I=1,NZ

THI=Z(I)-ZIN

IF (THI.GE.0.) GO TO 20

CONTINUE

I=NZ

NZLO=I-(INT(FLOAT(NDEGZ)/2.))+1

NZHI=NZLC+NDEGZ

IF (NZLC.GE.1) GO TO 40

NZLC=NZLC+1

NZHI=NZHI+1

GO TO 30

IF (NZHI.LE.NZ) GO TO 50

NZLO=NZLC-1

NZHI=NZHI-1

GO TO 40

CONTINUE

10

20

30

40

50

```

360
A 370
A 380
A 390
A 400
A 410
A 420
A 430
A 440
A 450
A 460
A 470
A 480
A 490
A 500-
A 510-

```

INITIALIZATION

```

ANS=0.0

```

COMPUTE INTERPCLATED VALUES

```

DO 70 L=NZLC,NZHI
TERM=FZ(L)
DO 60 M=NZLC,NZHI
IF (L.EC.M) GO TO 60
TERM=TERM*(ZIN-Z(M))/(Z(L)-Z(M))
CONTINUE
ANS=ANS+TERM
CONTINUE
RETURN
END

```

```

60
70

```

```

SUBROUTINE TUVAR (Y,Z,NY,NZ,FYZ,FY,YIN,ZIN,NDEGY,NDEGZ,ANS)
A 10

SUBROUTINE TUVAR INTERPOLATES A FUNCTION OF TWO VARIABLES USING
LAGRANGIAN POLYNOMIALS OF DEGREE SPECIFIED BY THE USER.
SPACING OF DATA POINTS NEED NOT BE UNIFORM. FUNCTION SHOULD
BE SMOOTH IN ALL DIMENSIONS. INDEPENDENT VARIABLES SHOULD BE
GIVEN IN INCREASING ORDERS.
A 20
A 30
A 40
A 50
A 60

VARIABLES:
Y,Z: ARRAYS OF VALUES OF THE TWO INDEPENDENT VARIABLES
NY,NZ: DIMENSIONS OF THE ARRAYS OF INDEPENDENT VARIABLES
FYZ: ARRAY OF VALUES OF THE FUNCTION EVALUATED AT THE POINTS
SPECIFIED IN Y & Z. THE DIMENSION OF FYZ = (NY,NZ)
FY: SUBROUTINE WORKSPACE OF THE DIMENSION (NY)
YIN,ZIN: INPUT VALUES OF THE TWO INDEPENDENT VARIABLES
NDEGY,NDEGZ: THE DESIRED DEGREE OF THE INTERPOLATING POLYNOMIAL IN
THE Y & Z DIMENSIONS RESPECTIVELY.
NDEGY SHOULD BE LESS THAN OR EQUAL TO NY-1,
AND NDEGZ LESS THAN OR EQUAL TO NZ-1.
A 70
A 80
A 90
A 100
A 110
A 120
A 130
A 140
A 150
A 160
A 170
A 180
A 190
A 200
A 210
A 220
A 230
A 240
A 250
A 260
A 270
A 280
A 290
A 300
A 310
A 320
A 330
A 340
A 350
A 360
A 370
A 380
A 390
A 400
A 410
A 420
A 430
A 440
A 450

ANS: THE INTERPOLATED VALUE OF THE FUNCTION

METHOD: FIRST, THE PROGRAM INTERPOLATES FOR THE GIVEN VALUE OF ZIN
FOR ALL COMBINATIONS OF Y. THESE ARE STORED IN ARRAY FY.
THESE VALUES ARE THEN INTERPOLATED FOR THE GIVEN VALUE OF YIN
WHICH YIELDS ANS.

DIMENSION FYZ(NY,NZ),Y(NY),Z(NZ),FY(NY)

FIRST SECTION SELECTS POINTS FOR INTERPOLATION

IF ((NDEGZ+1).GT.NZ) NDEGZ=NZ-1
DO 10 I=1,NZ
THIS=Z(I)-ZIN
IF (THIS.GE.0.) GO TO 20
CONTINUE
I=NZ
NZLQ=1-(INT(FLOAT(NDEGZ)/2.))+1)
NZHI=NZLQ+NDEGZ
IF (NZLQ.GE.1) GO TO 40
NZLQ=NZLQ+1
NZHI=NZHI+1
GO TO 30
IF (NZHI.LE.NZ) GO TO 50
NZLQ=NZLQ-1
NZHI=NZHI-1
GO TO 40

```

```

50  CONTINUE
    IF ((NDEGY+1).GT.NY) NDEGY=NY-1
    DO 60 I=1,NY
    THIS=Y(I)-VIN
    IF (THIS.GE.0.) GO TO 70
    CONTINUE
    I=NY
    NYLO=1-(INT(FLOAT(NDEGY)/2.))+1
    NYHI=NYLO+NDEGY
    IF (NYLLC.GE.1) GO TC 90
    NYLO=NYLC+1
    NYHI=NYFI+1
    GO TO 80
    IF (NYHI.LE.NY) GO TO 100
    NYLO=NYLO-1
    NYHI=NYHI-1
    GO TO 90
    CONTINUE
100  CONTINUE

INITIALIZATION

ANS=0.0
DO 110 J=NYLO,NYHI
    FY(J)=C.C
    CONTINUE
110  COMPUTE INTERPLATED VALUES
    DO 140 J=NYLO,NYHI
    DO 130 L=NZLO,NZHI
    TERM=FYZ(J,L)
    DO 120 M=NZLO,NZHI
    IF (L.EC.M) GO TO 120
    TERM=TERM*(ZIN-Z(M))/(Z(L)-Z(M))
    CONTINUE
    FY(J)=FY(J)+TERM
130  CONTINUE
140  CONTINUE
    DO 160 L=NYLO,NYHI
    TERM=FY(L)
    DO 150 M=NYLO,NYHI
    IF (L.EC.M) GO TO 150
    TERM=TERM*(YIN-Y(M))/(Y(L)-Y(M))
    CONTINUE
    ANS=ANS+TERM
150  CONTINUE
160  CONTINUE
    RETURN
    END

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A 460
A 470
A 480
A 490
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A 520
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A 540
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A 600
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A 620
A 630
A 640
A 650
A 660
A 670
A 680
A 690
A 700
A 710
A 720
A 730
A 740
A 750
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A 770
A 780
A 790
A 800
A 810
A 820
A 830
A 840
A 850
A 860
A 870
A 880
A 890
A 900
A 910
A 920
A 930
A 940
A 950
A 960
A 970
A 980
A 990
A 1000

```

1 SUBROUTINE THRVAR (X,Y,Z,NX,NY,NZ,FXYZ,FX,XIN,YIN,ZIN,NDEGX,
  NDEGY,NDEGZ,ANS)
  A 10
  A 20

SUBROUTINE THRVAR INTERPOLATES A FUNCTION OF THREE VARIABLES USING
LAGRANGIAN POLYNOMIALS OF DEGREE SPECIFIED BY THE USER.
SPACING OF DATA POINTS NEED NOT BE UNIFORM. FUNCTION SHOULD
BE SMOOTH IN ALL DIMENSIONS. INDEPENDENT VARIABLES MUST BE GIVEN
IN INCREASING ORDERS.
  A 30
  A 40
  A 60
  A 70

VARIABLES:
X,Y,Z: ARRAYS OF VALUES OF THE THREE INDEPENDENT VARIABLES
NX,NY,NZ: DIMENSIONS OF THE ARRAYS OF INDEPENDENT VARIABLES
FXYZ: ARRAY OF VALUES OF THE FUNCTION EVALUATED AT THE POINTS
SPECIFIED IN X,Y & Z. THE DIMENSION OF FXYZ = (NX,NY,NZ)
FX,FX: SUBROUTINE WORKSPACES OF THE APPROPRIATE DIMENSIONS
I,E, FXY(NX,NY),FX(NX)
XIN,YIN,ZIN: INPUT VALUES OF THE THREE INDEPENDENT VARIABLES
NDEGX,NDEGY,NDEGZ: THE DESIRED DEGREE OF THE FUNCTION IS EVALUATED)
POLYNOMIAL IN THE X,Y & Z DIMENSIONS RESPECTIVELY.
NDEGX SHOULD BE LESS THAN OR EQUAL TO NX-1.
NDEGY SHOULD BE LESS THAN OR EQUAL TO NY-1.
AND NDEGZ LESS THAN OR EQUAL TO NZ-1.
ANS: THE INTERPOLATED VALUE OF THE FUNCTION
METHOD. FIRST, THE PROGRAM INTERPOLATES FOR THE GIVEN VALUE OF ZIN
FOR ALL COMBINATIONS OF X & Y. THESE ARE STORED IN ARRAY FXY. OF
SUBSEQUENTLY THE VALUE OF YIN IS INTERPOLATED FOR ALL VALUES OF
X IN FXY, YIELDING FX. THEN XIN IS INTERPOLATED YIELDING ANS.

DIMENSION FXYZ(NX,NY,NZ),X(NX),Y(NY),Z(NZ),FGY(NX,NY),FX(NX)

FIRST SECTION SELECTS POINTS FOR INTERPOLATION

IF ((NDEGX+1).GT.NX) NDEGX=NX-1
DO 10 I=1,NX
THIS=X(I)-XIN
IF (THIS.GE.0.) GO TO 20
CONTINUE
I=NX
NXLO=1-(INT(FLOAT(NDEGX)/2.))+1
NXHI=NXLC+NDEGX
IF (NXLC.GE.1) GO TO 40
NXLO=NXLC+1
NXHI=NXHI+1
GO TO 30
IF (NXHI.LE.NX) GO TO 50
NXLC=NXLC-1

```



```

180 DO 210 I=NXLO,NXHI
190 DO 200 J=NYLO,NYHI
200 DO 190 L=NZLO,NZHI
210 TERM=FX(Y(I,J,L))
DO 180 M=NZLO,NZHI
IF (L.EC.M) GO TO 180
TERM=TERM*(ZIN-Z(M))/(Z(L)-Z(M))
CONTINUE
FX(Y(I,J))=FX(Y(I,J))+TERM
CONTINUE
CONTINUE
CONTINUE
DO 240 I=NXLO,NXHI
DO 230 L=NYLO,NYHI
TERM=FX(Y(I,L))
DO 220 M=NYLO,NYHI
IF (L.EC.M) GO TO 220
TERM=TERM*(YIN-Y(M))/(Y(L)-Y(M))
CONTINUE
FX(I)=FX(I)+TERM
CONTINUE
CONTINUE
DO 260 L=NXLO,NXHI
TERM=FX(L)
DO 250 M=NXLO,NXHI
IF (L.EC.M) GO TO 250
TERM=TERM*(XIN-X(M))/(X(L)-X(M))
CONTINUE
ANS=ANS+TERM
CONTINUE
RETURN
END

```

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A 550
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A 980
A 990

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40      NWHI=NWHI+1
      GO TO 30
      IF (NWHI.LE.NW) GO TO 50
      NWLO=NWLC-1
      NWHI=NWHI-1
      GO TO 40
50      CONTINUE
      IF ((NCEGX+1).GT.NX) NDEGX=NX-1
      DO 60 I=1,NX
      THIS=X(I)-XIN
      IF (THIS.GE.O.) GO TO 70
      CONTINUE
60      I=NX
      NXLO=1-(INT(FLOAT(NCEGX)/2.))+1)
      NWHI=NWLC+NCEGX
      IF (NXLC.GE.1) GO TO 90
      NXLO=NWLC+1
      NWHI=NWHI+1
      GO TO 80
90      IF (NWHI.LE.NX) GO TO 100
      NXLO=NWLC-1
      NWHI=NWHI-1
      GO TO 90
100     CONTINUE
      IF ((NDEGY+1).GT.NY) NDEGY=NY-1
      DO 110 I=1,NY
      THIS=Y(I)-YIN
      IF (THIS.GE.O.) GO TO 120
      CONTINUE
110     I=NY
      NYLO=1-(INT(FLOAT(NDEGY)/2.))+1)
      NWHI=NWLC+NCEGY
      IF (NYLC.GE.1) GO TO 140
      NYLO=NWLC+1
      NWHI=NWHI+1
      GO TO 130
140     IF (NWHI.LE.NY) GO TO 150
      NYLO=NWLC-1
      NWHI=NWHI-1
      GO TO 140
150     CONTINUE
      IF ((NCEGZ+1).GT.NZ) NDEGZ=NZ-1
      DO 160 I=1,NZ
      THIS=Z(I)-ZIN
      IF (THIS.GE.O.) GO TO 170
      CONTINUE
160     I=NZ
      NZLO=1-(INT(FLOAT(NCEGZ)/2.))+1)
170

```

```

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770
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790
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830
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850
860
870
880
890
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910
920
930

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A \$40
 A \$50
 A \$60
 A \$70
 A \$80
 A \$90
 A1000
 A1010
 A1020
 A1030
 A1040
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 A1080
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 A1100
 A1110
 A1120
 A1130
 A1140
 A1150
 A1160
 A1170
 A1180
 A1190
 A1200
 A1210
 A1220
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 A1280
 A1290
 A1300
 A1310
 A1320
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 A1340
 A1350
 A1360
 A1370
 A1380
 A1390
 A1400
 A1410

```

180  NZHI=NZLC+NCEGZ
      IF (NZLC-GE.1) GO TO 190
      NZLO=NZLC+1
      NZHI=NZHI+1
      GO TO 180
190  IF (NZHI-LE.NZ) GO TO 200
      NZLO=NZLC-I
      NZHI=NZHI-1
      GO TO 190
200  CONTINUE

      INITIALIZATION
      ANS=0.C
      DO 230 I=NWLO,NWHI
      DO 220 J=NXLO,NXHI
      DO 210 K=NYLO,NYHI
      FWXY(I,J,K)=0.C
210  CONTINUE
220  FWX(I,J)=0.C
      CONTINUE
230  COMPUTE INTERPLATED VALUES
      DO 280 I=NWLO,NWHI
      DO 270 J=NXLO,NXHI
      DO 260 K=NYLO,NYHI
      DO 250 L=NZLO,NZHI
      TERM=FWXYZ(I,J,K,L)
      DO 240 M=NZLO,NZHI
      IF (L-EG.M) GO TO 240
      TERM=TERM*(ZIN-Z(M))/(Z(L)-Z(M))
      CONTINUE
      FWX(I,J,K)=FWXY(I,J,K)+TERM
240  CONTINUE
250  CONTINUE
260  CONTINUE
270  CONTINUE
280  CONTINUE
      DO 320 I=NWLO,NWHI
      DO 310 J=NXLO,NXHI
      DO 300 L=NYLO,NYHI
      TERM=FWXYZ(I,J,L)
      DO 290 M=NYLO,NYHI
      IF (L-EG.M) GO TO 290
      TERM=TERM*(YIN-Y(M))/(Y(L)-Y(M))
      CONTINUE
      FWX(I,J)=FWX(I,J)+TERM
290  CONTINUE
300  CONTINUE
  
```

A1420
 A1430
 A1440
 A1450
 A1460
 A1470
 A1480
 A1490
 A1500
 A1510
 A1520
 A1530
 A1540
 A1550
 A1560
 A1570
 A1580
 A1590
 A1600
 A1610
 A1620
 A1630-

```

310 CONTINUE
320 DO 350 I=NWLO,NWHI
    L=NXLO,NXHI
    TERM=FW(X(I,L))
    DO 330 M=NXLO,NXHI
      IF (L*EC.M) GO TO 330
      TERM=TERM*(XIN-X(M))/X(L)-X(M))
    CONTINUE
    FW(I)=FW(I)+TERM
  CONTINUE
330 DO 370 L=NWLO,NWHI
    TERM=FW(L)
    DO 360 P=NWLO,NWHI
      IF (L*EC.M) GO TO 360
      TERM=TERM*(WIN-W(M))/W(L)-W(M))
    CONTINUE
    ANS=ANS+TERM
  CONTINUE
  RETURN
  END
340
350
360
370
  
```

LIFT COEFFICIENT DERIVATIVE DATA

LIFT COEFFICIENT - BASIC CONFIGURATION < CLBAS >

MACH NO. =	0.20	ALTD. =	0.0	ALFA =	ALL	
-0.35	-0.04	0.26	0.56	0.86	1.10	1.33 1.50
1.60	1.68	1.70	1.90	1.76	1.60	1.46 1.27
1.10	0.90	0.70	0.46	0.28	0.10	

MACH NO. =	0.20	ALTD. =	20000.0	ALFA =	ALL	
-0.35	-0.04	0.26	0.56	0.86	1.10	1.33 1.50
1.60	1.68	1.70	1.90	1.76	1.60	1.46 1.27
1.10	0.90	0.70	0.46	0.28	0.10	

MACH NO. =	0.20	ALTD. =	40000.0	ALFA =	ALL	
-0.35	-0.04	0.26	0.56	0.86	1.10	1.33 1.50
1.60	1.68	1.70	1.90	1.76	1.60	1.46 1.27
1.10	0.90	0.70	0.46	0.28	0.10	

MACH NO. =	0.20	ALTD. =	60000.0	ALFA =	ALL	
-0.35	-0.04	0.26	0.56	0.86	1.10	1.33 1.50
1.60	1.68	1.70	1.90	1.76	1.60	1.46 1.27
1.10	0.90	0.70	0.46	0.28	0.10	

APPENDIX E
SAMPLE OUTPUT

MACF NO. =	0.60	ALTD. =	0.0	ALFA =	ALL	
-0.42	0.30	0.65	0.94	1.14	1.33	1.48
1.62	1.67	1.90	1.76	1.60	1.46	1.27
1.10	0.70	0.46	0.28	0.10		
MACF NO. =	0.60	ALTD. = 20000.0		ALFA =	ALL	
-0.42	0.30	0.65	0.94	1.14	1.35	1.50
1.63	1.68	1.90	1.76	1.60	1.46	1.27
1.10	0.70	0.46	0.28	0.10		
MACF NO. =	0.60	ALTD. = 40000.0		ALFA =	ALL	
-0.42	0.30	0.65	0.94	1.14	1.36	1.51
1.65	1.70	1.90	1.76	1.60	1.46	1.27
1.10	0.70	0.46	0.28	0.10		
MACF NO. =	0.60	ALTD. = 60000.0		ALFA =	ALL	
-0.42	0.30	0.65	0.94	1.14	1.36	1.51
1.65	1.70	1.90	1.76	1.60	1.46	1.27
1.10	0.70	0.46	0.28	0.10		
MACF NO. =	0.80	ALTD. =	0.0	ALFA =	ALL	
-0.47	0.35	0.72	0.95	1.10	1.27	1.40
1.52	1.65	1.88	1.75	1.60	1.46	1.27
1.10	0.70	0.46	0.28	0.10		
MACF NO. =	0.80	ALTD. = 20000.0		ALFA =	ALL	
-0.47	0.35	0.72	0.97	1.13	1.30	1.44

1.56	1.65	1.70	1.88	1.75	1.60	1.46	1.27
1.10	0.90	0.70	0.46	0.28	0.10		
MACH NO. = 0.80 ALTD. = 40000.0 ALFA = ALL							
-0.47	-0.06	0.35	0.72	0.97	1.13	1.32	1.47
1.58	1.67	1.72	1.88	1.75	1.60	1.46	1.27
1.10	0.90	0.70	0.46	0.28	0.10		
MACH NO. = 0.80 ALTD. = 60000.0 ALFA = ALL							
-0.47	-0.06	0.35	0.72	0.97	1.13	1.32	1.47
1.58	1.67	1.72	1.88	1.75	1.60	1.46	1.27
1.10	0.90	0.70	0.46	0.28	0.10		
MACH NO. = 0.90 ALTD. = 0.0 ALFA = ALL							
-0.54	-0.10	0.40	0.80	1.02	1.20	1.35	1.40
1.56	1.66	1.69	1.88	1.75	1.60	1.46	1.27
1.10	0.90	0.70	0.46	0.28	0.10		
MACH NO. = 0.90 ALTD. = 20000.0 ALFA = ALL							
-0.54	-0.10	0.40	0.80	1.04	1.23	1.39	1.45
1.62	1.71	1.75	1.88	1.75	1.60	1.46	1.27
1.10	0.90	0.70	0.46	0.28	0.10		
MACH NO. = 0.90 ALTD. = 40000.0 ALFA = ALL							
-0.54	-0.10	0.40	0.80	1.05	1.25	1.42	1.48
1.64	1.74	1.76	1.88	1.75	1.60	1.46	1.27

1.10	0.90	0.70	0.46	0.28	0.10	
MACH NO. = 0.90 ALTD. = 60000.0 ALFA = ALL						
-0.54	-0.10	0.40	0.80	1.05	1.25	1.42
1.64	1.75	1.78	1.88	1.75	1.60	1.46
1.10	0.90	0.70	0.46	0.28	0.10	
						1.48
						1.27

LIFT INCREMENT DUE TO LEF DEFLECTION < DCLDN >

MACH NO. = C.2	ALTD. = 0.0	ALFA = ALL	
-0.0017	-0.0017	-0.0016	-0.0013
0.0024	0.0044	0.0062	0.0
0.0	C.0	0.0	0.0
			0.0010
			0.0
			0.0009
			0.0

MACH NO. = C.2	ALTD. = 20000.0	ALFA = ALL	
-0.0017	-0.0017	-0.0016	-0.0013
C.0024	0.0044	0.0062	0.0
0.0	C.0	0.0	0.0
			0.0010
			0.0
			0.0009
			0.0

MACH NO. = C.2	ALTD. = 40000.0	ALFA = ALL	
-0.0017	-0.0017	-0.0016	-0.0013
C.0024	0.0044	0.0062	0.0
0.0	C.0	0.0	0.0
			0.0010
			0.0
			0.0009
			0.0

MACH NO. = C.2	ALTD. = 60000.0	ALFA = ALL
----------------	-----------------	------------

-0.0017	-0.0017	-0.0016	-0.0016	-0.0015	0.0010	0.0009
0.0024	0.0044	0.0062	0.0	0.0	0.0	0.0
C.0	0.0	0.0	0.0	0.0		
MACH NO. = C.6 ALTD. = 0.0 ALFA = ALL						
-0.0030	-0.0028	-0.0023	-0.0012	0.0007	0.0025	0.0027
0.0028	C.0047	0.0062	0.0	0.0	0.0	0.0
C.0	0.0	0.0	0.0	0.0		
MACH NO. = C.6 ALTD. = 20000.0 ALFA = ALL						
-0.0030	-0.0028	-0.0023	-0.0012	0.0007	0.0025	0.0027
0.0028	0.0047	0.0062	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0		
MACH NO. = C.6 ALTD. = 40000.0 ALFA = ALL						
-0.0030	-0.0028	-0.0023	-0.0012	0.0007	0.0025	0.0027
C.0028	0.0047	0.0062	0.0	0.0	0.0	0.0
C.0	C.0	0.0	0.0	0.0		
MACH NO. = C.6 ALTD. = 60000.0 ALFA = ALL						
-0.0030	-0.0028	-0.0023	-0.0012	0.0007	0.0025	0.0027
0.0028	0.0047	0.0062	0.0	0.0	0.0	0.0
C.0	C.0	0.0	0.0	0.0		
MACH NO. = C.8 ALTD. = 0.0 ALFA = ALL						
-0.0032	-0.0025	-0.0022	-0.0022	-0.0012	0.0011	0.0010
0.0004	C.0004	0.0017	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
MACH NO. = C.8 ALTD. = 20000.0 ALFA = ALL									
-C.0031	-0.0024	-0.0021	-0.0020	-0.0005	0.0010	0.0023	0.0025	0.0	0.0
0.0022	C.0022	0.0035	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
MACH NO. = C.8 ALTD. = 40000.0 ALFA = ALL									
-0.0030	-0.0023	-0.0020	-0.0019	-0.0008	0.0014	0.0029	0.0032	0.0	0.0
C.0031	0.0032	0.0045	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MACH NO. = C.8 ALTD. = 60000.0 ALFA = ALL									
-0.0030	-0.0023	-0.0020	-0.0019	-0.0008	0.0015	0.0032	0.0036	0.0	0.0
0.0034	0.0036	0.0048	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C.0	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MACH NO. = C.9 ALTD. = 0.0 ALFA = ALL									
0.0025	-C.0004	-0.0051	-0.0067	-0.0048	-0.0015	-0.0002	0.0007	0.0	0.0
0.0002	-C.0005	-0.0011	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MACH NO. = C.9 ALTD. = 20000.0 ALFA = ALL									
0.0027	C.0	-0.0050	-0.0064	-0.0042	-0.0003	0.0015	0.0029	0.0	0.0
C.0028	C.0020	0.0014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MACH NO. = C.9		ALTD. = 40000.0		ALFA = ALL	
0.0028	0.0	-0.0050	-0.0062	-0.0035	0.0002
0.0040	0.0033	0.0027	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
MACH NO. = C.9		ALTD. = 60000.0		ALFA = ALL	
0.0029	0.0	-0.0050	-0.0062	-0.0035	0.0003
0.0045	0.0038	0.0032	0.0	0.0	0.0
C.0	C.0	0.0	0.0	0.0	0.0

FLEX/RIGIDITY FACTOR FOR LIFT DUE TO HORIZONTAL TAIL DEFLECTION < FRCLDH >

ALTD. = C.0		MACH NO. = ALL	
C.990	C.520	C.860	0.775
ALTD. = 20000.0		MACH NO. = ALL	
C.990	C.560	0.928	0.880
ALTD. = 40000.0		MACH NO. = ALL	
0.995	0.586	0.965	0.945
ALTD. = 60000.0		MACH NO. = ALL	
1.100	0.595	0.985	0.975

FLIGHT CONDITION PARAMETERS

ALFA	BETA	ALTD	MACH	DYNPRESS	Q	ALFADT
20.0	-6.0	40000.0	0.6	98.8	0.2	0.4
VT	P	R				
581.1	0.5	0.5				
DAL	LAR	DDA	DFL	DFR	DF	DDF
12.5	-12.5	25.0	20.0	20.0	20.0	0.0
DNL	ENR	DN	DDN	DHL	DHR	DH
25.0	25.0	25.0	0.0	-6.0	-6.0	-6.0
DRL	LRR	DR	DSB			
-30.0	-30.0	-30.0	60.0			
						DT
						0.0

OUTPUT VALUES OF LIFT COEFFICIENT DERIVATIVES

CLBAS	CCLCN	DCLOF	DCLOHL	CCLDHR	FRCLDH
1.3600	0.0025	0.0110	-0.0850	-0.0850	0.9860
DCLOSB	CCLCAL	DCLOAR	FRCLDA	CLQ	CLA
-0.032	0.026	-0.014	1.180	3.300	2.400
CLST	CCLYN	CL TOTAL			
1.5408	0.0161	1.5569			

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