A REAL-TIME DIGITAL PROGRAM
FOR ESTIMATING AIRCRAFT STABILITY
AND CONTROL PARAMETERS FROM
FLIGHT TEST DATA BY USING
THE MAXIMUM LIKELIHOOD METHOD

by Randall D. Grove and Stanley C. Mayhew

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A computer program (Langley program C1123) has been developed for estimating aircraft stability and control parameters from flight test data. These parameters are estimated by the maximum likelihood estimation procedure implemented on a real-time digital simulation system, which uses the Control Data 6600 computer. This system allows the investigator to interact with the program in order to obtain satisfactory results. Part of this system, the control and display capabilities, is described for this program. This report also describes the computer program by presenting the program variables, subroutines, flow charts, listings, and operational features. Program usage is demonstrated with a test case using pseudo or simulated flight data.
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SUMMARY

A computer program (Langley program C1123) has been developed for estimating aircraft stability and control parameters from flight test data. These parameters are estimated by the maximum likelihood estimation procedure implemented on a real-time digital simulation system, which uses the Control Data 6600 computer. This system allows the investigator to interact with the program in order to obtain satisfactory results. Part of this system, the control and display capabilities, is described for this program. This report also describes the computer program by presenting the program variables, subroutines, flow charts, listings, and operational features. Program usage is demonstrated with a test case using pseudo or simulated flight data.

INTRODUCTION

A computer program has been developed at the Langley Research Center to improve the capabilities for estimating aircraft stability and control parameters. Improved capabilities result from the combined utilization of the inherent features of the Langley real-time simulation (RTS) system and the maximum likelihood method. The program has been designed to take advantage of the integrated software and hardware features comprising the RTS system. This system allows the analyst to be an integral part in controlling the direction of the parameter identification study, that is, the analyst communicates or interacts with the program. The analyst interacts with the program by selecting the mathematical model to be used, the variables to be matched with the flight test data, and the parameters to be estimated. The RTS display features aid the analyst in determining whether any further interaction is necessary and when to stop the computer run. The analyst uses the results of the computer run as an aid to solve the problems of correlation, uniqueness, and identifiability of the parameters. Parameter estimation is not a straightforward procedure; thus, having the capability of the analyst interacting with the program is highly desirable.

*Electronic Associates, Inc.
The objective of this report is to present the computer program which was written especially for the RTS system at Langley. A description of the system software is beyond the scope of this report; however, the RTS subroutines used are briefly described in order to aid in understanding the flow of the program. The program flow differs from batch programs in that operator action is required. In presenting the program, it becomes necessary to describe the program control station (appendix A) from which the analyst interacts with the program. The maximum likelihood estimation procedure for extracting the stability and control parameters was developed in reference 1.

The program has been dynamically checked by comparing its output with the output of an independently written batch program. Test cases were made by use of simulated flight data with different measurement noise levels to check the estimation procedure. (See ref. 1.) Application of this program is not restricted to the aircraft example being used in this report. The program may be applied to other aircraft as well as other dynamic vehicles satisfying the assumptions of the maximum likelihood estimator. (See ref. 1.) The program developed has been successfully applied to the analysis of flight test data for generically different aircraft. (See refs. 2 to 5.) These reports on the analysis of flight test data also reflect the desirability of analyst program interaction.

SYMBOLS

Symbols on CalComp plots (figs. 2 and 4) are not standard because of the limitations of the computer.

$A$ sensitivity coefficient matrix

$\vec{a}_I$ accelerometer vector at instrument location

$a_X, a_Y, a_Z, \vec{a}_I$ longitudinal, lateral, and normal (positive down) components of $\vec{a}_I$

b wing span

$C_l, C_m, C_n$ rolling-, pitching-, and yawing-moment coefficients

$(C_l)_{\beta, \delta_a, \delta_r}$ rolling-moment coefficient at $\beta = \beta_t, \delta_a = \delta_a, \delta_r = \delta_r, t$

$(C_m)_{\alpha_a, \delta_e}$ pitching-moment coefficient at $\alpha_a = \alpha_a, \delta_e = \delta_e, t$
\((C_n)_{\beta_t, \delta_a, t, \delta_r, t}\) yawing-moment coefficient at \(\beta = \beta_t, \ \delta_a = \delta_a, t, \ \delta_r = \delta_r, t\)

\(C_T, C_{T, 0}, C_{T_B}\) main-engine thrust coefficients

\(C_{T_T}, C_{T_T^t}, C_{T_T}^t\) tail-rotor thrust coefficients

\(C_X, C_Y, C_Z\) longitudinal-, lateral-, and normal-force coefficients

\(C_{X, 0}, C_{Z, 0}\) longitudinal-force and normal-force coefficients at \(\alpha_a = \delta_e = 0\)

\((C_X)_{\alpha_a, t, \delta_e, t}\) longitudinal-force coefficient at \(\alpha_a = \alpha_a, t, \ \delta_e = \delta_e, t\)

\(C_Y, 0\) lateral-force coefficient at \(\beta = \delta_a = \delta_r = 0\)

\((C_Y)_{\beta_t, \delta_a, t, \delta_r, t}\) lateral-force coefficient at \(\beta = \beta_t, \ \delta_a = \delta_a, t, \ \delta_r = \delta_r, t\)

\((C_Z)_{\alpha_a, t, \delta_e, t}\) normal-force coefficient at \(\alpha_a = \alpha_a, t, \ \delta_e = \delta_e, t\)

\(\bar{c}\) mean aerodynamic chord

\(D_E, D_T\) blade diameters of main engine and tail rotor

\(\bar{F}\) vector function defined in equations of motion

\(F_j\) components of \(\bar{F}\), where \(j = 1, 2, \ldots, 8\)

\(G\) sensitivity equation matrix

\(g\) acceleration due to gravity

\(I_X, I_Y, I_Z\) moment of inertia about X-, Y-, and Z-axis, respectively

\(I_{XZ}\) product of inertia

\(i, j, k\) integers

\(i_w\) wing tilt angle
\[ J_N \] performance index function

\[ \tilde{\ell}, \tilde{r_b}, \tilde{T_P} \] coefficients in moment equations

\[ M_X, M_Y, M_Z \] rolling, pitching, and yawing moments

\[ m \] mass

\[ N \] number of data points

\[ P_E, P_T \] normalized throttle settings of main engine and tail rotor

\[ p, q, r \] roll, pitch, and yaw angular velocities

\[ p' \] number of parameters

\[ R \] measurement noise covariance matrix

\[ S \] wing area

\[ T \] flight-test time period

\[ T_X, T_Y, T_Z \] thrust along X-, Y-, and Z-axis, respectively

\[ t \] time

\[ t_i \] data point time, where \( i = 1, 2, \ldots, N \)

\[ u, v, w \] longitudinal, lateral, and vertical velocity components

\[ V \] true airspeed

\[ V_{SS} \] slipstream airspeed

\[ X, Y, Z \] coordinate axes

\[ \bar{x} \] state vector

\[ x_k \] components of \( \bar{x} \), where \( k = 1, 2, \ldots, 8 \)

\[ 4 \]
\( x_X, y_X, z_X \)  
center-of-gravity offsets of X-axis accelerometer

\( x_Y, y_Y, z_Y \)  
center-of-gravity offsets of Y-axis accelerometer

\( x_Z, y_Z, z_Z \)  
center-of-gravity offsets of Z-axis accelerometer

\( \bar{y} \)  
variables in performance index function

\( \bar{\alpha} \)  
parameter vector

\( \Delta \bar{\alpha} \)  
parameter change vector

\( \alpha_a, \beta \)  
angles of attack and sideslip

\( \alpha_i \)  
components of \( \bar{\alpha} \), where \( i = 1, 2, \ldots, 40 \)

\( \beta_T \)  
tail-rotor blade angle

\( \bar{\delta} \)  
control deflection vector

\( \delta_a, \delta_e, \delta_r \)  
aileron, elevator, and rudder control deflections

\( \bar{\delta}_B, \Delta \bar{B} \)  
relationships of blade angles for main engines

\( \delta_{ik} \)  
Kronecker delta

\( \bar{\eta} \)  
measurement noise vector

\( \eta_E, \eta_T \)  
main-engine and tail-rotor speeds

\( \eta_i \)  
components of \( \bar{\eta} \), where \( i = 1, 2, \ldots, 11 \)

\( \rho \)  
average density

\( \rho_{\alpha_i, \alpha_j} \)  
correlation coefficient of \( \alpha_i \) and \( \alpha_j \)

\( \sigma_{\alpha_i}^2, \sigma_{\alpha_i} \)  
variance and standard deviation of \( \alpha_i \)
\( \sigma_{\eta_i \eta_j} \)  
\( \phi, \theta, \psi \)  
\( \frac{\partial C_X}{\partial \alpha_a} \)  
\( \frac{\partial C_X}{\partial \beta} \)  
\( \frac{\partial C_X}{\partial \delta_e} \)  
\( \frac{\partial C_Y}{\partial \alpha_a} \)  
\( \frac{\partial C_Y}{\partial \beta} \)  
\( \frac{\partial C_Y}{\partial \delta_e} \)  
\( \frac{\partial C_Z}{\partial \alpha_a} \)  
\( \frac{\partial C_Z}{\partial \beta} \)  
\( \frac{\partial C_Z}{\partial \delta_e} \)  

Stability and control derivatives:

\[
C_{Xq} = \frac{\partial C_X}{\partial q_c} \frac{2V}{\partial \alpha_a} \\
C_{Y_p} = \frac{\partial C_Y}{\partial p_b} \frac{2V}{\partial \beta} \\
C_{Zq} = \frac{\partial C_Z}{\partial q_c} \frac{2V}{\partial \delta_e}
\]

\[
C_{Xa} = \frac{\partial C_X}{\partial \alpha_a} \\
C_{Yr} = \frac{\partial C_Y}{\partial \beta} \\
C_{Za} = \frac{\partial C_Z}{\partial \delta_e}
\]

\[
C_{lp} = \frac{\partial C_l}{\partial p_b} \frac{2V}{\partial \alpha_a} \\
C_{Yp} = \frac{\partial C_Y}{\partial \beta} \\
C_{Zp} = \frac{\partial C_Z}{\partial \delta_e}
\]

\[
C_{lr} = \frac{\partial C_l}{\partial r_b} \frac{2V}{\partial \alpha_a} \\
C_{Yr} = \frac{\partial C_Y}{\partial \beta} \\
C_{Zr} = \frac{\partial C_Z}{\partial \delta_e}
\]

\[
C_{l\beta} = \frac{\partial C_l}{\partial \beta} \\
C_{Y\delta_r} = \frac{\partial C_Y}{\partial \delta_r} \\
C_{n_r} = \frac{\partial C_n}{\partial \delta_r}
\]

\[
C_{l\beta} = \frac{\partial C_l}{\partial \beta} \frac{2V}{\partial \alpha_a} \\
C_{m_q} = \frac{\partial C_m}{\partial \alpha_a} \\
C_{n\beta} = \frac{\partial C_n}{\partial \beta}
\]

\[
C_{l\delta_a} = \frac{\partial C_l}{\partial \delta_a} \\
C_{m\alpha_a} = \frac{\partial C_m}{\partial \alpha_a} \\
C_{n\delta_a} = \frac{\partial C_n}{\partial \delta_a}
\]

\[
C_{l\delta_r} = \frac{\partial C_l}{\partial \delta_r} \\
C_{m\alpha_a} = \frac{\partial C_m}{\partial \alpha_a} \\
C_{n\delta_r} = \frac{\partial C_n}{\partial \delta_r}
\]

\[
C_{m\delta_e} = \frac{\partial C_m}{\partial \delta_e} \\
C_{n\delta_e} = \frac{\partial C_n}{\partial \delta_e}
\]
PROBLEM DESCRIPTION

The stability and control parameters are the unknown coefficients in the differential equations of motion of the aircraft. The maximum likelihood estimation procedure, using the method of quasilinearization, estimates the stability and control parameters by minimizing the difference between the flight test measurements and the calculated solution of the differential equations of motion of the aircraft.

The measured control deflections of the aircraft are used as inputs to the equations of motion, and the flight test measurements are assumed to be the true solution with measurement noise (Gaussian with zero mean). The initial conditions of the state are included as unknown parameters and the accelerometer equations supplement the equations of motion in the estimation procedure.

Aircraft Mathematical Model

The detailed nonlinear aircraft mathematical model is described in appendix B, where the equations of motion are represented in vector notation by

\[
\dot{\mathbf{x}} = \mathbf{F}(\mathbf{x}, \ddot{\mathbf{\alpha}}, \ddot{\mathbf{\delta}}, V, \mathbf{\alpha}_a, \dot{\mathbf{\alpha}}_a, \beta, \dot{\beta})
\]  

(1)
For simplicity in describing the estimation procedure, let the equations of motion be written as

\[ \ddot{x} = \ddot{F}(\ddot{x}, \ddot{\alpha}, \ddot{\delta}) \]  

(1a)

where the terms omitted in equation (1a) are auxiliary relationships. The equation variables (states) are

\[ \ddot{x}(\ddot{\alpha}, t) = [u, v, w, p, q, r, \theta, \phi]^T \]

(2)

The parameter vector is

\[ \ddot{\alpha} = [\alpha_1, \alpha_2, \ldots, \alpha_p]^T \]

(3)

The control inputs are

\[ \ddot{\delta} = [\ddot{\delta}_a, \ddot{\delta}_e, \ddot{\delta}_r]^T = \ddot{\delta}M \]

(4)

Integration of the equations of motion yields the nominal solution \( \ddot{x}(\ddot{\alpha}, t) \), where \( \ddot{\alpha} \) is the nominal or current value of the parameter vector. These parameters are the aerodynamic coefficients (stability and control parameters) and the initial conditions of the states. The initial values of the coefficients are determined from a prior estimate (wind-tunnel data or analysis) and the initial states are determined from the flight test data.

The accelerometer equations

\[ \ddot{a}_I = (a_{X,I}, a_{Y,I}, a_{Z,I})^T \]

(5)

are algebraic functions of the states and their derivatives. These equations need only to be evaluated and not integrated.

**Sensitivity Equations**

The sensitivity equations are derived by formally differentiating the equations of motion with respect to each parameter. (See ref. 1.) The sensitivity equations are (by using eq. (1a))

\[ \frac{d}{dt} \left( \frac{\partial \ddot{x}}{\partial \alpha_i} \right) = \sum_{k=1}^{8} \frac{\partial \ddot{F}}{\partial x_k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial \ddot{F}}{\partial \alpha_i} = G(t) \left( \frac{\partial \ddot{x}}{\partial \alpha_i} \right) + \frac{\partial \ddot{F}}{\partial \alpha_i} \quad (i = 1, 2, \ldots, p') \]

(6)
This system of equations represents \( p' \) sets of eight simultaneous differential equations. Integration yields the sensitivity coefficients \( \frac{\partial x_k}{\partial \alpha_i} \). All the initial conditions are zero except for

\[
\left. \frac{\partial x_k}{\partial \alpha_i} \right|_{t=0} = \left. \frac{\partial x_k}{\partial x_i(0)} \right|_{t=0} = \delta_{ik}
\]

The accelerometer sensitivity coefficients \( \frac{\partial a_I}{\partial \alpha_i} \) are functions of the sensitivity equations and coefficients previously defined. The sensitivity equations and accelerometer sensitivity coefficients are presented in detail in appendix C.

### Maximum Likelihood Estimation Equations

The maximum likelihood estimation equations (using quasilinearization) are derived from the likelihood function in reference 1. The maximum likelihood parameter estimation procedure (the accelerometer equations being neglected) is diagramed in figure 1. The estimation procedure is initially formulated by using the complete mathematical model; then, by using variable dimensioning (appendix D), it is reduced to the specific flight test case being analyzed.

The parameter-change equations are

\[
\Delta \overline{\alpha} = \left[ \sum_{i=1}^{N} A^T(t_i) R^{-1} A(t_i) \right]^{-1} \left[ \sum_{i=1}^{N} A^T(t_i) R^{-1} \overline{\eta}(t_i) \right]
\]

(7)

where

\[
A(t_i) = \left( \frac{\partial \overline{y}^O}{\partial \alpha_1}, \frac{\partial \overline{y}^O}{\partial \alpha_2}, \ldots, \frac{\partial \overline{y}^O}{\partial \alpha_p} \right)
\]

\[
\overline{\eta}(t_i) = \overline{y}^M(t_i) - \overline{y}^O(t_i)
\]

\[
\overline{y}^M(t_i) = \begin{bmatrix} \overline{x}^M(t_i) \\ \overline{a}_I^M(t_i) \end{bmatrix} \quad \overline{y}^O(t_i) = \begin{bmatrix} \overline{x}^O(t_i) \\ \overline{a}_I^O(t_i) \end{bmatrix}
\]

Here \( \overline{y}^O \) denotes the variables in the performance index function.
The covariance matrix for the parameters is

\[
\left[ \sum_{i=1}^{N} A^T(t_i) R^{-1} A(t_i) \right]^{-1}
\]

The covariance matrix for the measurement noise is

\[
R^0(N) \triangleq \text{Estimate of } R = \frac{1}{N} \sum_{i=1}^{N} \vec{\eta}(t_i) \vec{\eta}^T(t_i)
\]

and the performance index function to be minimized is

\[
J_N(\vec{\alpha}^0) = |R^0(N)|
\] (9)

The flight test data are composed of the onboard instrument measurements of the aircraft behavior and are assumed to be the output of the aircraft mathematical model superimposed with instrument noise. These data contain many individual aircraft maneuvers stored on one magnetic tape, each maneuver being easily accessible to the central memory of the computer. These data are used for comparison with the mathematical model output and for initialization of and control input to the equations of motion. The measurements \( \vec{y}^M(t_i) \) and \( \vec{\delta}^M(t_i) \) for \( i = 1, 2, \ldots, N \) are known for all performance index variables and control deflections corresponding to the aircraft mathematical model.

The steps in the maximum likelihood estimation procedure, corresponding to figure 1, are as follows:

(1) Initialize the system parameters where \( \vec{\alpha}^0 \) denotes the nominal or current values of the parameters.

(2) Integrate the equations of motion and the sensitivity equations to obtain the nominal solution and the sensitivity coefficient matrix, respectively.

(3) Calculate the comparisons of the flight test data and nominal solution for each data point time at \( t_i \) where \( i = 1, 2, \ldots, N \) and \( t_1 = 0 \) and \( t_N = T \).

(4) Calculate the maximum likelihood estimation equations from the comparisons in step (3) and the sensitivity coefficient matrix in step (2). (Dashed lines in fig. 1 indicate accumulation of information over the flight test time period \( T \).)

(5) Calculate the performance index \( J_N(\vec{\alpha}^0) \).

(6) Calculate the parameter changes \( \Delta \vec{\alpha} \) and the statistical information matrix \( R^0(N) \).
(7) Update the nominal parameter values in step (1) to start the next iteration procedure and repeat steps until convergence. Convergence of the estimation procedure is assumed when the change in the performance index is small enough to satisfy the criterion of the analyst.

PROGRAM DESCRIPTION

Labeled COMMON

The following list contains the FORTRAN variables appearing in labeled COMMON and descriptions of each variable:

<table>
<thead>
<tr>
<th>COMMON label</th>
<th>FORTRAN variable(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTCOMM/T</td>
<td>t</td>
<td>t, updated in subroutine IGRATE1</td>
</tr>
<tr>
<td>H</td>
<td>Integration step size used in subroutine IGRATE1 (H = DT)</td>
<td></td>
</tr>
<tr>
<td>INT</td>
<td>Flow control parameter used in subroutine IGRATE1</td>
<td></td>
</tr>
<tr>
<td>NEQ</td>
<td>Number of integrations performed in subroutine IGRATE1, NEQ ≤ 249</td>
<td></td>
</tr>
<tr>
<td>ISHEME</td>
<td>Selects integration scheme in subroutine IGRATE1</td>
<td></td>
</tr>
<tr>
<td>DERINT(2,249)</td>
<td>Array of integrals and derivatives in subroutine IGRATE1</td>
<td></td>
</tr>
<tr>
<td>INTRN(5,249)</td>
<td>Temporary storage array for subroutine IGRATE1</td>
<td></td>
</tr>
<tr>
<td>REALTIM/ADC(32)</td>
<td>Analog-to-digital converter input array</td>
<td></td>
</tr>
<tr>
<td>DAC(64)</td>
<td>Digital-to-analog converter output array</td>
<td></td>
</tr>
<tr>
<td>LDISI(108)</td>
<td>Logical discrete input array</td>
<td></td>
</tr>
<tr>
<td>COMMON label</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>/REALTIM/</td>
<td>LDISO(196)</td>
<td>Logical discrete output array</td>
</tr>
<tr>
<td></td>
<td>NOPER</td>
<td>Return addresses from subroutine RTMODE</td>
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<td></td>
<td>NHOLD</td>
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<tr>
<td></td>
<td>NRESET</td>
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<tr>
<td></td>
<td>NTERM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPRINT</td>
<td>Not used with subroutine PCCEXEC</td>
</tr>
<tr>
<td></td>
<td>NREAD</td>
<td></td>
</tr>
<tr>
<td>/ALGOR/</td>
<td>NPAR</td>
<td>Total number of parameters</td>
</tr>
<tr>
<td></td>
<td>IPAR</td>
<td>Maximum number of active parameters</td>
</tr>
<tr>
<td></td>
<td>INTP(30)</td>
<td>Array denoting active parameters</td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>Number of active parameters</td>
</tr>
<tr>
<td></td>
<td>INTV(8)</td>
<td>Array denoting active equation variables</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Number of active equation variables</td>
</tr>
<tr>
<td></td>
<td>INTA(11)</td>
<td>Array denoting active performance index variables</td>
</tr>
<tr>
<td></td>
<td>IA</td>
<td>Number of active performance index variables</td>
</tr>
<tr>
<td></td>
<td>IA1</td>
<td>Number of active equation variables which are active performance index variables</td>
</tr>
<tr>
<td></td>
<td>IA2</td>
<td>IA-IA1</td>
</tr>
<tr>
<td>COMMON label</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
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<td>/ALGOR/</td>
<td>PARAM(40)</td>
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<td>DPARAM(30)</td>
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<td></td>
<td>ALV(11)</td>
<td>Arrays of labels for printout</td>
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<td></td>
<td>DVAR(8)</td>
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</tr>
<tr>
<td></td>
<td>DALG(11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALG(40)</td>
<td>Auxiliary storage array for AL</td>
</tr>
<tr>
<td></td>
<td>IAC(40)</td>
<td>Auxiliary storage array for INTEG(I) (I = 1, 2, ..., 40)</td>
</tr>
<tr>
<td></td>
<td>IEVEN</td>
<td>Used with LOGIC(11)</td>
</tr>
<tr>
<td></td>
<td>WT(11,11)</td>
<td>$R_j^{N-1}$</td>
</tr>
<tr>
<td></td>
<td>COM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L1</td>
<td>Labels for printout</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>/COMM1/</td>
<td>IRR</td>
<td>Error condition set by subroutine NAMECRT</td>
</tr>
<tr>
<td></td>
<td>IPL</td>
<td>Overlay level numbers used by subroutine PCCEXEC</td>
</tr>
<tr>
<td></td>
<td>ISL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TABLE(199)</td>
<td>Array of floating-point numbers to be displayed and/or changed</td>
</tr>
<tr>
<td></td>
<td>INTEG(99)</td>
<td>Array of integer numbers to be displayed and/or changed</td>
</tr>
<tr>
<td>COMMON label</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>/COMM1/</td>
<td>LOGIC(20)</td>
<td>Logical array for selecting program options</td>
</tr>
<tr>
<td></td>
<td>NTAB</td>
<td>Dimensions used by subroutines DATABLX and INOUT</td>
</tr>
<tr>
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<td>FDR(201)</td>
<td>( \delta^M_r(t_i) )</td>
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</table>

Arrays of matrix operation and dimension information used by subroutine MASCNT
COMMON label FORTRAN variable(s) Description

/FLIGHT/ FBT(201) $\beta_T(t_i)$
FDB(201) $\delta B(t_i)$
FDELB(201) $\Delta B(t_i)$
FPPER(201) $P_E(t_i)$
FTP(201) $P_T(t_i)$
BETAT $\beta_T$
ETA $\eta_E$
ETAT $\eta_T$
FCT(12) Array containing function for $C_T \beta_T \beta_T$
CTT $C_{TT}$
CT $C_T$

Display Arrays

The real-time simulation program uses specified arrays (subroutine DSPLAY arrays) for displaying and/or changing the value of desired program variables. (See appendix A.) The desired program variables as defined in these specified arrays are assigned display addresses as shown in the following table:

<table>
<thead>
<tr>
<th>Subroutine DSPLAY arrays</th>
<th>Display address</th>
<th>Maximum number of elements</th>
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<tbody>
<tr>
<td>TABLE(I)</td>
<td>I</td>
<td>199</td>
</tr>
<tr>
<td>INTEG(I)</td>
<td>I + 200</td>
<td>99</td>
</tr>
<tr>
<td>LOGIC(I)</td>
<td>I + 300</td>
<td>99</td>
</tr>
<tr>
<td>ADC(I) (not used)</td>
<td>I + 400</td>
<td>99</td>
</tr>
<tr>
<td>DAC(I)</td>
<td>I + 500</td>
<td>99</td>
</tr>
<tr>
<td>LDISI(I)</td>
<td>I + 600</td>
<td>99</td>
</tr>
<tr>
<td>LDISO(I)</td>
<td>I + 700</td>
<td>199</td>
</tr>
</tbody>
</table>
This type of addressing is called "IN TABLES" addressing. For program variables not in subroutine DSPLAY arrays, a type of addressing called "NO TABLES" addressing is used.

Subroutine DSPLAY arrays are listed below with their associated FORTRAN variables and descriptions (elements not mentioned are not used). The array elements are equivalenced to the FORTRAN variables, except where equality signs indicate. TABLE is a floating-point number array, and equivalence between FORTRAN variables is indicated by a semicolon.

<table>
<thead>
<tr>
<th>TABLE element(s)</th>
<th>FORTRAN variable(s)</th>
<th>Description</th>
</tr>
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<td>1</td>
<td>AL(1);UO</td>
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<td>2</td>
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<td>( \langle C_x \rangle_{\alpha_a,t,\delta_e,t} )</td>
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<tr>
<td>3</td>
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</tr>
<tr>
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<td>AL(4);CXQ</td>
<td>C_xq</td>
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<td>AL(6);PHIO</td>
<td>( \phi(0) )</td>
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<td>AL(11);CZDE</td>
<td>C_{Z\delta_e}</td>
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<td>GRAV</td>
<td>g</td>
</tr>
<tr>
<td>123</td>
<td>RHO</td>
<td>( \rho )</td>
</tr>
<tr>
<td>124</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>125</td>
<td>B</td>
<td>b</td>
</tr>
<tr>
<td>126</td>
<td>CBAR</td>
<td>( \bar{c} )</td>
</tr>
<tr>
<td>127</td>
<td>DEAMPL</td>
<td>Amplitude of ( \delta_e ) for test case</td>
</tr>
<tr>
<td>128</td>
<td>DEFREQ</td>
<td>Frequency of ( \delta_e ) for test case</td>
</tr>
<tr>
<td>129</td>
<td>ALPHAT</td>
<td>( \alpha_{a,t} )</td>
</tr>
<tr>
<td>130</td>
<td>DT</td>
<td>Integration step size (H = DT)</td>
</tr>
<tr>
<td>131</td>
<td>TT</td>
<td>Time interval for flight test data tape</td>
</tr>
<tr>
<td>132</td>
<td>TS</td>
<td>Tape starting time for putting in flight data</td>
</tr>
<tr>
<td>133</td>
<td>TIMF</td>
<td>Final time for CRT display</td>
</tr>
<tr>
<td>134</td>
<td>=T</td>
<td>t</td>
</tr>
<tr>
<td>135</td>
<td>=U</td>
<td>u</td>
</tr>
<tr>
<td>TABLE element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>136</td>
<td>=V</td>
<td>v</td>
</tr>
<tr>
<td>137</td>
<td>=W</td>
<td>w</td>
</tr>
<tr>
<td>138</td>
<td>=P</td>
<td>p</td>
</tr>
<tr>
<td>139</td>
<td>=Q</td>
<td>q</td>
</tr>
<tr>
<td>140</td>
<td>=R</td>
<td>r</td>
</tr>
<tr>
<td>141</td>
<td>=THE</td>
<td>θ</td>
</tr>
<tr>
<td>142</td>
<td>=PHI</td>
<td>φ</td>
</tr>
<tr>
<td>143</td>
<td>=PSI</td>
<td>ψ</td>
</tr>
<tr>
<td>144</td>
<td>=UDOT</td>
<td>Ĩ</td>
</tr>
<tr>
<td>145</td>
<td>=VDOT</td>
<td>ṽ</td>
</tr>
<tr>
<td>146</td>
<td>=WDOT</td>
<td>Ṡ</td>
</tr>
<tr>
<td>147</td>
<td>=PDOT</td>
<td>ķ</td>
</tr>
<tr>
<td>148</td>
<td>=QDOT</td>
<td>ģ</td>
</tr>
<tr>
<td>149</td>
<td>=RDOT</td>
<td>ĵ</td>
</tr>
<tr>
<td>150</td>
<td>=THEDOT</td>
<td>ħ</td>
</tr>
<tr>
<td>151</td>
<td>=PHIDOT</td>
<td>Ī</td>
</tr>
<tr>
<td>152</td>
<td>=PSIDOT</td>
<td>Ī</td>
</tr>
<tr>
<td>154</td>
<td>XX</td>
<td>xX</td>
</tr>
<tr>
<td>TABLE element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
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</tr>
<tr>
<td>155</td>
<td>YX</td>
<td>yX</td>
</tr>
<tr>
<td>156</td>
<td>ZX</td>
<td>zX</td>
</tr>
<tr>
<td>157</td>
<td>XY</td>
<td>xY</td>
</tr>
<tr>
<td>158</td>
<td>YY</td>
<td>yY</td>
</tr>
<tr>
<td>159</td>
<td>ZY</td>
<td>zY</td>
</tr>
<tr>
<td>160</td>
<td>XZ</td>
<td>xZ</td>
</tr>
<tr>
<td>161</td>
<td>YZ</td>
<td>yZ</td>
</tr>
<tr>
<td>162</td>
<td>ZZ</td>
<td>zZ</td>
</tr>
<tr>
<td>169</td>
<td>CMCON</td>
<td>Constant used with LOGIC(6)</td>
</tr>
<tr>
<td>170</td>
<td>DALMLT</td>
<td>Parameter step size multiplier</td>
</tr>
<tr>
<td>171</td>
<td>UCRTBI</td>
<td>u bias for CalComp, CRT, and DAC presentations</td>
</tr>
<tr>
<td>172</td>
<td>AIW</td>
<td>i_w</td>
</tr>
<tr>
<td>173</td>
<td>CTO</td>
<td>C_{T,0}</td>
</tr>
<tr>
<td>174</td>
<td>CTTO</td>
<td>C_{T_{00}}</td>
</tr>
<tr>
<td>175</td>
<td>CTB</td>
<td>C_{T_B}</td>
</tr>
<tr>
<td>176</td>
<td>CTBT</td>
<td>C_{T_B T}</td>
</tr>
<tr>
<td>177</td>
<td>D</td>
<td>D_E</td>
</tr>
<tr>
<td>178</td>
<td>CAPDT</td>
<td>D_T</td>
</tr>
<tr>
<td>TABLE element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>179</td>
<td>ELBAR</td>
<td>$l$</td>
</tr>
<tr>
<td>180</td>
<td>ELTP</td>
<td>$l_{TP}$</td>
</tr>
<tr>
<td>181</td>
<td>RB</td>
<td>$r_b$</td>
</tr>
<tr>
<td>182</td>
<td>PPER</td>
<td>$P_E$</td>
</tr>
<tr>
<td>183</td>
<td>TPER</td>
<td>$P_T$</td>
</tr>
<tr>
<td>184</td>
<td>BTBIAS</td>
<td>Flight test data biases</td>
</tr>
<tr>
<td>185</td>
<td>PPERBI</td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>TPERBI</td>
<td></td>
</tr>
<tr>
<td>187</td>
<td>DET1</td>
<td>Inverse determinant of parameter covariance matrix</td>
</tr>
<tr>
<td>188</td>
<td>DET2</td>
<td>$</td>
</tr>
<tr>
<td>191-194</td>
<td>DRSD(4)</td>
<td>Array of desired standard deviations of random numbers</td>
</tr>
</tbody>
</table>

INTEG is an integer number array.

<table>
<thead>
<tr>
<th>INTEG element(s)</th>
<th>FORTRAN variable(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-40</td>
<td></td>
<td>Array denoting activeness of parameters</td>
</tr>
<tr>
<td>51-61</td>
<td>INTY(11)</td>
<td>Array denoting activeness of performance index variables</td>
</tr>
<tr>
<td>62</td>
<td>NOPTS</td>
<td>N</td>
</tr>
<tr>
<td>63</td>
<td>INC</td>
<td>Sample rate for flight data tape</td>
</tr>
<tr>
<td>INTEG element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>64</td>
<td>IPRINT</td>
<td>Selects options in overlay level (2,0)</td>
</tr>
<tr>
<td>65</td>
<td>NPLOT</td>
<td>Density of plotting symbols for CalComp plots</td>
</tr>
<tr>
<td>66</td>
<td>IREAD</td>
<td>Selects options in overlay level (3,0)</td>
</tr>
<tr>
<td>67</td>
<td>KSCAN</td>
<td>Scan rate, used by subroutine SCANNER</td>
</tr>
<tr>
<td>81-88</td>
<td>INTX(8)</td>
<td>Array denoting activeness of equation variables</td>
</tr>
</tbody>
</table>

LOGIC is a logical array and the descriptions are for a true (.T.) value.

<table>
<thead>
<tr>
<th>LOGIC element(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calculate $R_j^{-1}(N)$</td>
</tr>
<tr>
<td>2</td>
<td>Diagonalize $R_j(N)$</td>
</tr>
<tr>
<td>3</td>
<td>Set $P_F = FPPER(1)$</td>
</tr>
<tr>
<td>4</td>
<td>Set $P_T = FTPER(1)$</td>
</tr>
<tr>
<td>5</td>
<td>Calculate $C_T \beta_T$ from FCT(12) and $\beta_T$</td>
</tr>
<tr>
<td>6</td>
<td>Set $C_{Z_{\delta_e}} = CMCON \cdot C_{m\delta_e}$</td>
</tr>
<tr>
<td>7</td>
<td>Set longitudinal states equal to flight test data</td>
</tr>
<tr>
<td>8</td>
<td>Set $\alpha_{a,t} = \tan^{-1} \frac{w(0)}{u(0)}$</td>
</tr>
<tr>
<td>9</td>
<td>Calculate parameters to trim $\dot{x}$ to zero</td>
</tr>
<tr>
<td>10</td>
<td>Automate LOGIC(9)</td>
</tr>
<tr>
<td>11</td>
<td>Automate two-pass updating</td>
</tr>
</tbody>
</table>
DAC is an output array for the time history recorder.

<table>
<thead>
<tr>
<th>DAC element(s)</th>
<th>FORTRAN variable(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>((U-\text{UCRTBI})/\text{UMAX})</td>
<td>Normalized time history recordings</td>
</tr>
<tr>
<td>2</td>
<td>(V/\text{VMAX})</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>(W/\text{WMAX})</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>(P/\text{PMAX})</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>(Q/\text{QMAX})</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>(R/\text{RMAX})</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>(\text{THE}/\text{THMAX})</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>(\text{PHI}/\text{PHMAX})</td>
<td></td>
</tr>
</tbody>
</table>

LDISI is a logical discrete input array where the descriptions are for true (.T.) values of the switches.

<table>
<thead>
<tr>
<th>LDISI element(s)</th>
<th>FORTRAN variable(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-16</td>
<td></td>
<td>Data entry keyboard</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>OPERATE (OPER) mode switch</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>HOLD mode switch</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>RESET mode switch</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>TERMINATE (TERM) mode switch</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>CHANGE mode switch</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>SCAN mode switch</td>
</tr>
<tr>
<td>LDISI element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>RELEASE mode switch, releases CHANGE or SCAN mode switch</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>ERASE mode switch</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>IDLE mode switch</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>PRINT mode switch</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>READ mode switch</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>RELEASE mode switch, releases ERASE, IDLE, PRINT, or READ mode switch</td>
</tr>
<tr>
<td>33</td>
<td>FSS(1)</td>
<td>Accelerometer variables for CRT display and CalComp plot</td>
</tr>
<tr>
<td>34</td>
<td>FSS(2)</td>
<td>CalComp plot of flight data only</td>
</tr>
<tr>
<td>35</td>
<td>FSS(3)</td>
<td>Fill flight data arrays with pseudo data</td>
</tr>
<tr>
<td>36</td>
<td>FSS(4)</td>
<td>Initialize variable dimensioning</td>
</tr>
<tr>
<td>37</td>
<td>FSS(5)</td>
<td>Iteration printout on MF file</td>
</tr>
<tr>
<td>39</td>
<td>FSS(7)</td>
<td>Lateral variables for CRT display and CalComp plot</td>
</tr>
<tr>
<td>40</td>
<td>FSS(8)</td>
<td>Control variables for CRT display and CalComp plot</td>
</tr>
<tr>
<td>41</td>
<td>FSS(9)</td>
<td>Pseudo flight controls</td>
</tr>
<tr>
<td>42</td>
<td>FSS(10)</td>
<td>Skip update of $\dot{\alpha}$</td>
</tr>
<tr>
<td>43</td>
<td>FSS(11)</td>
<td>Activates typewriter for subroutine DSPLAY</td>
</tr>
<tr>
<td>LDISO element(s)</td>
<td>FORTRAN variable(s)</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>44</td>
<td>FSS(12)</td>
<td>Retain $\bar{x}(0)$ in ALG array</td>
</tr>
<tr>
<td>45</td>
<td>FSS(13)</td>
<td>Exit CRT or CalComp loop</td>
</tr>
<tr>
<td>46</td>
<td>FSS(14)</td>
<td>Replot the CRT or CalComp plot</td>
</tr>
<tr>
<td>47</td>
<td>FSS(15)</td>
<td>Enter CRT loop</td>
</tr>
<tr>
<td>48</td>
<td>FSS(16)</td>
<td>&quot;IN TABLES&quot; addressing (false (.F.) for &quot;NO TABLES&quot; addressing)</td>
</tr>
</tbody>
</table>

LDISO is a logical discrete output array used to turn the white indicator lights (WL) on (.T.) and off (.F.). The diagnostics are given for .T. value.

<table>
<thead>
<tr>
<th>LDISO element</th>
<th>FORTRAN variable(s)</th>
<th>Diagnostic</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>WL(1)</td>
<td>Default value used for IPRINT</td>
</tr>
<tr>
<td>62</td>
<td>WL(2)</td>
<td>CalComp plot completed</td>
</tr>
<tr>
<td>63</td>
<td>WL(3)</td>
<td>Error in CalComp plot loop</td>
</tr>
<tr>
<td>66</td>
<td>WL(6)</td>
<td>Default value used for IREAD</td>
</tr>
<tr>
<td>67</td>
<td>WL(7)</td>
<td>Attempted to read flight data beyond end of file</td>
</tr>
<tr>
<td>70</td>
<td>WL(10)</td>
<td>$N &gt; NPTS$</td>
</tr>
<tr>
<td>71</td>
<td>WL(11)</td>
<td>$IP &gt; IPAR$</td>
</tr>
<tr>
<td>72</td>
<td>WL(12)</td>
<td>Inactive equation variable in performance index</td>
</tr>
<tr>
<td>73</td>
<td>WL(13)</td>
<td>$</td>
</tr>
</tbody>
</table>
LDISO element(s) | FORTRAN variable(s) | Diagnostic
--- | --- | ---
74 | WL(14) | $u < 5$
75 | WL(15) | $|v| > u$
76 | WL(16) | $|\alpha_a| > 1.5$
77 | WL(17) | Invalid flight data location used
78 | WL(18) | DET1 = 0
79 | WL(19) | DET2 = 0
80 | WL(20) | In CRT loop

Subroutine Descriptions

The following are the subroutines used and brief statements describing their functions.

<table>
<thead>
<tr>
<th>Subroutine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCALE</td>
<td>Determines origin and scale factor of time axis for CalComp plots</td>
</tr>
<tr>
<td>ATERM</td>
<td>Does final processing and halts execution</td>
</tr>
<tr>
<td>AXES</td>
<td>Draws and annotates axes for CalComp plots</td>
</tr>
<tr>
<td>CALPLT</td>
<td>Moves plotter pen to new location or signals end of CalComp job</td>
</tr>
<tr>
<td>CLRPLLOT</td>
<td>Clears the CRT plot of the calculated variables</td>
</tr>
<tr>
<td>CLRTABL</td>
<td>Clears existing plot parameter tables for CRT variables</td>
</tr>
<tr>
<td>CREATEF</td>
<td>Creates disk file for flight data tape</td>
</tr>
<tr>
<td>CRTPLOT</td>
<td>Establishes plot parameters for CRT variables and/or generates annotated plotting grids</td>
</tr>
<tr>
<td>Subroutine</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CYCLE</td>
<td>Sets up return address for subroutine RECYCLE</td>
</tr>
<tr>
<td>DATABLX</td>
<td>Specifies the variable arrays for subroutine DSPLAY</td>
</tr>
<tr>
<td>DAYTIM</td>
<td>Provides date and time of day</td>
</tr>
<tr>
<td>DSPLAY</td>
<td>Activates data entry keyboard and digital decimal display unit</td>
</tr>
<tr>
<td>ENDPLOT</td>
<td>Marks an end to the CRT plot</td>
</tr>
<tr>
<td>ERASE</td>
<td>Erases data on real-time disk file</td>
</tr>
<tr>
<td>GETRAN</td>
<td>Generates Gaussian random numbers</td>
</tr>
<tr>
<td>GRID</td>
<td>Draws grid for CalComp plots</td>
</tr>
<tr>
<td>HALT</td>
<td>Signals completion of real-time portion of program</td>
</tr>
<tr>
<td>IGRATE1</td>
<td>Integrates variables in DERINT(2,J) and stores results in DERINT(1,J) (J = 1, 2, ..., NEQ)</td>
</tr>
<tr>
<td>INOUT</td>
<td>Sets up arrays for input/output conversion</td>
</tr>
<tr>
<td>LDRSEC</td>
<td>Provides for PRINT and READ mode entries into subroutine RTMODE</td>
</tr>
<tr>
<td>LEROY</td>
<td>Controls CalComp plotting with liquid ink pen</td>
</tr>
<tr>
<td>LINE</td>
<td>CalComp routine to draw a continuous line and/or a symbol</td>
</tr>
<tr>
<td>MASCNT</td>
<td>Performs matrix algebra operations</td>
</tr>
<tr>
<td>NAMECRT</td>
<td>Identifies and initializes usage of the CRT console</td>
</tr>
<tr>
<td>NM218</td>
<td>Initializes usage of typewriter</td>
</tr>
<tr>
<td>NOTATE</td>
<td>Draws alphanumeric characters for CalComp plots</td>
</tr>
<tr>
<td>Subroutine</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>NUMBER</td>
<td>Draws floating-point numbers for CalComp plots</td>
</tr>
<tr>
<td>OPERATE</td>
<td>Causes readout of DAC and LDISO arrays and readin of LDISI array</td>
</tr>
<tr>
<td>PCCEXEC</td>
<td>Controls overlay loading for RTS jobs</td>
</tr>
<tr>
<td>PLAYBAK</td>
<td>Plays back data recorded on real-time disk file, one frame at a time</td>
</tr>
<tr>
<td>PRINTER</td>
<td>Causes routing of MF disk file to printer</td>
</tr>
<tr>
<td>PSEUDO</td>
<td>Saves plotting information in order to use CalComp postprocessor</td>
</tr>
<tr>
<td>READOUT</td>
<td>Specifies quantities to be recorded and frequency of recording for the real-time disk file</td>
</tr>
<tr>
<td>READY</td>
<td>Signals that the program is ready for real-time operation</td>
</tr>
<tr>
<td>RECIN</td>
<td>Inputs flight test data</td>
</tr>
<tr>
<td>RECORD</td>
<td>Records quantities as specified in subroutine READOUT</td>
</tr>
<tr>
<td>RECYCLE</td>
<td>Signals end of a cycle when in the OPERATE mode and returns to address specified by subroutine CYCLE</td>
</tr>
<tr>
<td>RITECRT</td>
<td>Issues plotting requests to CRT system</td>
</tr>
<tr>
<td>RTMODE</td>
<td>Entry into the mode control routine</td>
</tr>
<tr>
<td>SCANNER</td>
<td>Increments display address</td>
</tr>
<tr>
<td>TYPEVAR</td>
<td>Types out data displayed on DDDU</td>
</tr>
<tr>
<td>UNLODE</td>
<td>Erases data stored on CRT file</td>
</tr>
<tr>
<td>XDSPLAY</td>
<td>Initializes data entry keyboard and DDDU, and routes program listing</td>
</tr>
</tbody>
</table>
OVERLAY Program Descriptions, Flow Charts, and Listings

The program uses RTS central memory overlay capabilities controlled by subroutine PCCEXEC where level (4,0) is the real-time operational level. A brief description, flow chart, and FORTRAN source listing are presented for each overlay level (excluding subroutines previously described).

**OVERLAY(XC142FL,0,0)** - The main overlay, level (0,0), is always resident in central memory. It includes the labeled COMMON, the initial call to subroutine PCCEXEC, and other system initialization calls.

```
OVERLAY (XC142FL,0,0)
```

```
PROGRAM XC142A (INPUT, OUTPUT)
```

```
Memory allocation
```

```
Call PSEUDO
```

```
Call NAMECRT
```

```
Initialize overlay file name XC142FL
```

```
Call PCCEXEC
```

```
OVERLAY (XC142FL,1,0)
```

```
Call DISPLAY
```

```
Call CLRTABL
```

```
END
```

(Not executed but causes loading in this overlay)
OVERLAY (XC142FL,1,0). - The initialization overlay, level (1,0), is automatically loaded by the initial call to subroutine PCCEXEC. Upon completion of level (1,0), overlay (4,0) is automatically loaded.
10 TABLE(1)=0.
   DO 20 I=65,78
20   TABLE(I)=1.
   NINT=99
   DO 30 I=1,NINT
30   INTEG(I)=0
   NLOG=20
   DO 40 I=1,NLOG
40   LOGIC(I)=.F.
   LOGIC(1)=.T.
   LOGIC(2)=.T.
   NADC=0
   NDAC=8
   NLDI=48
   DO 50 I=1,NLDI
50   LDISI(I)=.F.
   NLDO=180
   DO 60 I=1,NLDO
60   LDISO(I)=.FALSE.
   CALL DATABLX (TABLE,NTAB,INTEG,NINT,LOGIC,NLOG,NADC,NDAC,NLDI,NDAC,NLDI,NDISI,NLDI,NLDO)
   CALL INOUT (ADC,NDAC,DA,NDAC,LDISI,NLDI,LDISO,NLDO)
   CALL NM218 (5LOSCAR)
   NT=1
   CALL READOUT (6,NT,U,V,W,P,Q,R)
   CALL READOUT (6,NT,T,THE,PHI,AXI,AYI,AZI)
   DRAD=57.2958
   RADD=1./DRAD
   PI=3.14159
   IR(1)=13
   IR(2)=2357
   NRN=4
   NPTS=201
   ISKIP=JSKIP=KSKIP=0
   TY=0.
   MAXPAGE=10
   LABT=10HTIME (SEC)
   LABU=10HU (FT/SEC)
   LABV=10HV (FT/SEC)
   LABW=10HW (FT/SEC)
   LABP=10HP(RAD/SEC)
   LABQ=10HQ(RAD/SEC)
   LABR=10HR(RAD/SEC)
   LABTH=10HTHETA(RAD)
   LABPH=10HPHI (RAD)
   LABAX=10HAXI (G)
   LABAY=10HAYI (G)
   LABAZ=10HAZI (G)
   LABDA=10HDA (RAD)
   LABDE=10HDE (RAD)
   LABDR=10HDR (RAD)
   NAM25=6LTAPE25
   DO 70 I=1,7
70   ITRNMLT(I)=0
   IMULTA(I)=0
   IMULTB(I)=0
   INVSEN(I)=0
   39
70 INVWT(1) = 0
ITRNMLT(1) = 23
ITRNMLT(5) = IMULTA(6) = INVWT(5) = 1
ITRNMLT(7) = IMULTA(5) = IMULTA(7) = INVSEN(5) = IMULTB(5) = IMULTB(6) = IPAR
IMULTB(7) = IPAR
IMULTA(1) = IMULTB(1) = 20
IMULTA(4) = IMULTB(4) = 1
INVSEN(1) = INVWT(1) = 10
INVSEN(4) = INVWT(4) = 2
UMAX = 20
VMAX = 40
WMAX = 10
PMAX = QMAX = RMAX = 2
THMAX = PHMAX = AXMAX = AYMAX = 4
AZMAX = 2
DAMAX = DEMAX = DRMAX = 1
PASS = -1
AIX = 150000
AIY = 128000
AIZ = 270000
WEIGHT = 36050
GRAV = 32.17
RHO = .002242
S = 534
B = 67.5
CBAR = 6.07
DEFRE = 1
DT = .03125
TT = .03125
TIME = 10
XX = 10
YY = 2
ZX = 5
XY = 7
YY = 9
ZY = 4
XZ = 2
YZ = 5
ZZ = 7
DALMNT = 1
UCRTBI = 200
CTO = .03
D = 15.5
DO 80 I = 1, 8
INTX(I) = 1
80  INTY(1) = 1
  NOPTS = 81
  INC = 4
  IPRINT = 1
  NPRINT = 2
  IREAD = 1
  KSCAN = 2
  ETA = 1232.75 / 60.
  U0 = 120.1 * 689
  TMP = 5 * U0 ** 2
  CX0 = -8. * ETA ** 2 * D ** 4 * CTO / TMP
  CXAL = -0.29
  W0 = 5.
  CZ0 = -2. * WEIGHT / (RHO * TMP)
  CZAL = -4.30
  Q0 = -0.15
  CM0 = -1.49
  CM0 = -31.14
  VO = 10.
  CYB = -1.70
  CYP = 0.50
  CYR = 0.40
  RO = -0.15
  CLB = -0.18
  CLP = -0.72
  CLR = 0.20
  RO = 0.15
  CNE = 0.06
  CNP = 0.05
  CNR = 0.70
  INTEG(2) = INTEG(8) = INTEG(9) = INTEG(14) = INTEG(16) = INTEG(20) = 1
  INTEG(22) = INTEG(23) = INTEG(27) = INTEG(29) = INTEG(30) = INTEG(35) = 1
  INTEG(37) = INTEG(38) = 1
  DO 90 1 = 1 + NPAR
     ALG(1) = AL(1)
               B 0197
  90  IAC(1) = INTEG(1)
     ALG(2) = -1
     ALG(8) = -1
     ALG(9) = -3
     ALG(14) = -1
     ALG(16) = -22
     ALG(20) = 0
     ALG(22) = 3
     ALG(23) = 2
     ALG(27) = -13
     ALG(29) = -4
     ALG(30) = 15
     ALG(35) = 0.3
     ALG(37) = 0.2
     ALG(38) = -4
     RETURN
     END

41
OVERLAY (XC142FL,2,0). - The print overlay, level (2,0), is loaded when the PRINT mode is selected on the program control console. The integer IPRINT, preset in level (4,0), selects one of the five options in the PRINT overlay. The CalComp plot option is presented in appendix E. The primary overlay, level (4,0), is automatically loaded upon completion of level (2,0).
OVERLAY(XC142FL.2.0)

PROGRAM XPRINT

LOGICAL FSS(16),LDISI,LDISO,LOGIC,VARCHNG,WL(39)

DIMENSION X(203), Yl(203), Y2(203), Y3(203), Y4(203), Z1(203), Z2(203),

1203), Z3(203), Z4(203), DATE(2), DRM(4), DRSD(4), RAN(4,201), RN(4)

2), RSD(4)

COMMON /INTCOMM/ T,H,INTQ,EISCHEM,DERINT(2,249)

COMMON /INTINTR/ INTERN(5,249)

COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD

1,NRESET,INTERM,NPRINT,NREAD

COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA,IA

12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE

COMMON /XINTCOMM/ T,H,INTQ,EISCHEM,DERINT(2,249)

COMMON /XINTINTR/ INTERN(5,249)

COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD

1,NRESET,INTERM,NPRINT,NREAD

COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA,IA

12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE

COMMON /XINTCOMM/ T,H,INTQ,EISCHEM,DERINT(2,249)

COMMON /XINTINTR/ INTERN(5,249)

COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD

1,NRESET,INTERM,NPRINT,NREAD
REWIND MF
RETURN
CALL GETRAN (IR+1,2*DMY,Y1+Y2)
DO 50 I=1,NRN
DO 50 J=1,NPTS
CALL GETRAN (IR+2,2*RAN(I,J),Y1+Y2)
CONTINUE
DO 60 I=1,NRN
RN(I)=0.
RSD(I)=0.
DO 60 J=1,NPTS
RN(I)=RN(I)+RAN(I,J)
RSD(I)=RSD(I)+RAN(I,J)**2
DO 70 I=1,NRN
RN(I)=RN(I)*PTSINV
RSD(I)=SQRT(RSD(I)*PTSINV-RN(I)**2)
RSD(I)=DRSD(I)/RSD(I)
DO 80 I=1,NRN
DO 80 J=1,NPTS
RAN(I,J)=RAN(I,J)*RSD(I)+RN(I)
CONTINUE
DO 90 I=1,NRN
RN(I)=0.
RSD(I)=0.
DO 90 J=1,NPTS
RN(I)=RN(I)+RAN(I,J)
RSD(I)=RSD(I)+RAN(I,J)**2
DO 100 I=1,NRN
RN(I)=RN(I)*PTSINV
RSD(I)=SQRT(RSD(I)*PTSINV-RN(I)**2)
CONTINUE
DO 110 I=1,NOPTS
UM(I)=UM(I)+RAN(1,I)
WM(I)=WM(I)+RAN(2,I)
QM(I)=QM(I)+RAN(3,I)
THM(I)=THM(I)+RAN(4,I)
WRITE (MF,450) RN,NOPTS,(DRM(I),RN(I),DRSD(I),RSD(I)),I=1,NRN
RETURN
IF (JSKIP.GT.0) GO TO 130
CALL CALPLOT (0,0,3)
CALL LEROY
K=-1 FOR SYMBOL EVERY DATA POINT
K=-2 FOR SYMBOL EVERY OTHER DATA POINT, ETC.
JSKIP=JSKIP+1
BI=SF4=0.
IF (.NOT.FSS(I)) GO TO 140
SF1=AZMAX
SF2=AYMAX
SF3=AXMAX
GO TO 170
IF (.NOT.FSS(7)) GO TO 150
SF1=PHMAX
SF2=VMAX
SF3=RMAX
SF4=PMAX
GO TO 170
IF (.NOT.FSS(8)) GO TO 160
SF1=DRMAX
SF2=DEMAX
SF3=DMAX
GO TO 170
160 SF1=TMXMAX
SF2=QMAX
SF3=WMAX
SF4=UMAX
BI=UCRTBI
170 ZT=BI+SF4
ZB=BI-SF4
IF (FSS(2).OR.FSS(8)) GO TO 220
1=0
J=J+1
180 CALL PLAYBAK(215S)
J=J+1
IF (MOD(J*NOITSPS)*GT*0) GO TO 180
I=I+1
IF (I.GT.NOPTS) GO TO 180
IF (I.EQ.FSSU) GO TO 190
Y1(I)=AZ1
Y2(I)=AY1
Y3(I)=AX1
Y4(I)=0
GO TO 210
190 IF (.NOT.FSSU) GO TO 200
Y1(I)=PHI
Y2(I)=V
Y3(I)=R
Y4(I)=P
GO TO 210
200 Y1(I)=THE
Y2(I)=Q
Y3(I)=W
Y4(I)=U
210 IF (Y1(I)*GT*SF1) Y1(I)=SF1
IF (Y2(I)*GT*SF2) Y2(I)=SF2
IF (Y3(I)*GT*SF3) Y3(I)=SF3
IF (Y4(I)*GT*ZT) Y4(I)=ZT
IF (Y1(I)*LT*-SF1) Y1(I)=-SF1
IF (Y2(I)*LT*-SF2) Y2(I)=-SF2
IF (Y3(I)*LT*-SF3) Y3(I)=-SF3
IF (Y4(I)*LT*ZB) Y4(I)=ZB
GO TO 180
215 IF (I.EQ.NOITPS) GO TO 220
WL(3)=T
RETURN
220 DO 270 I=1.NOITPS
X(I)=DELX*(I-1)
IF (.NOT.FSS(1)) GO TO 230
Z1(I)=AZM(I)
Z2(I)=AYM(I)
Z3(I)=AXM(I)
Z4(I)=0
GO TO 260
230 IF (.NOT.FSS(7)) GO TO 240
Z1(I)=PHM(I)
Z2(I)=VM(I)
Z3(I)=RM(I)
Z4(I)=PM(I)
GO TO 260
240 IF (.NOT.FSS(8)) GO TO 250
Z1(I)=FDR(I)
Z2(I)=FDE(I)
Z3(I)=FDA(I)
Z4(I)=0
GO TO 260
250  Z1(I)=THM(I)                C 0192
    Z2(I)=QM(I)                  C 0193
    Z3(I)=WM(I)                  C 0194
    Z4(I)=UM(I)                  C 0195
260  IF (Z1(I)>SF1) Z1(I)=SF1      C 0196
    IF (Z2(I)>SF2) Z2(I)=SF2      C 0197
    IF (Z3(I)>SF3) Z3(I)=SF3      C 0198
    IF (Z4(I)>ZT) Z4(I)=ZT        C 0199
    IF (Z1(I)<-SF1) Z1(I)=-SF1    C 0200
    IF (Z2(I)<-SF2) Z2(I)=-SF2    C 0201
    IF (Z3(I)<-SF3) Z3(I)=-SF3    C 0202
    IF (Z4(I)<ZB) Z4(I)=ZB        C 0203
270  CONTINUE                      C 0204
    CALL DAYTIM (DATE)           C 0205
    CALL NOTATE (-1.5*0.0*0.7*DATE(1)+90*10) C 0206
    CALL NOTATE (-1.5*2.4*0.7*DATE(2)+90*10) C 0207
    CALL NOTATE (-1.5*4.8*0.7*HRUN NO*90*7) C 0208
    CALL NUMBER (-1.5*6.5*0.7*RUN+90*11) C 0209
    CALL NOTATE (-1.5*7.5*0.7*HITER=90*5) C 0210
    CALL NUMBER (-1.5*8.7*0.7*PASS+90*11) C 0211
    CALL ASCALE (X*5.+NOPTS+1,10) C 0212
    LPT=NOPTS+1                   C 0213
    JPT=NOPTS+2                   C 0214
    XM=X(LPT)                     C 0215
    XS=X(JPT)                     C 0216
    CALL GRID (0..0..5..5..10..4) C 0217
    CALL AXES (0..0..0..5..XM*XS+1*10..LABT..14..-10) C 0218
    YM=-SF1                       C 0219
    YS=-SF2                       C 0220
    Y1(LPT)=Z1(LPT)=YM            C 0221
    Y1(JPT)=Z1(JPT)=YS            C 0222
    IF (.NOT.FSS(1)) GO TO 280    C 0223
    CALL AXES (0..0..90..2..YM*YS+5*10..12HAZI (G UNITS) ..14+12) C 0224
    CALL LINE (XY*Z1*NOPTS+1*K=3*07) C 0225
    IF (.NOT.FSS(2)) CALL LINE (XY*Y1*NOPTS+1*0*0*0*07) C 0226
    CALL CALPLT (0..2.75..-3)    C 0227
    CALL GRID (0..0..5..5..10..4) C 0228
    CALL AXES (0..0..0..5..XM*XS+1*10..LABT..14..-10) C 0229
    YM=-SF2                       C 0230
    YS=SF2                        C 0231
    Y2(LPT)=Z2(LPT)=YM            C 0232
    Y2(JPT)=Z2(JPT)=YS            C 0233
    CALL AXES (0..0..90..2..YM*YS+5*10..12HAZI (G UNITS) ..14+12) C 0234
    CALL LINE (XY*Z2*NOPTS+1*K=3*07) C 0235
    IF (.NOT.FSS(2)) CALL LINE (XY*Y2*NOPTS+1*0*0*0*07) C 0236
    CALL CALPLT (0..2.75..-3)    C 0237
    CALL GRID (0..0..5..5..10..4) C 0238
    CALL AXES (0..0..0..5..XM*XS+1*10..LABT..14..-10) C 0239
    YM=-SF3                       C 0240
    YS=SF3                        C 0241
    Y3(LPT)=Z3(LPT)=YM            C 0242
    Y3(JPT)=Z3(JPT)=YS            C 0243
    CALL AXES (0..0..90..2..YM*YS+5*10..12HAZI (G UNITS) ..14+12) C 0244
    CALL LINE (XY*Z3*NOPTS+1*K=3*07) C 0245
    IF (.NOT.FSS(2)) CALL LINE (XY*Y3*NOPTS+1*0*0*0*07) C 0246
    CALL CALPLT (12..-5..5..-3)  C 0247
    GO TO 310                    C 0248
IF (*NOT FSS(7)) GO TO 290
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABPH 14+10)
CALL LINE (X ZI NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y1 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
YM=SF2
YS=SF2
Y2(LPT)=Z2(LPT)=YM
Y2(JPT)=Z2(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABV 14+10)
VMIN=YMP 3048
VMX=YS 3048
CALL AXES (X Z2 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y2 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
YM=SF2
YS=SF2
Y2(LPT)=Z2(LPT)=YM
Y2(JPT)=Z2(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABV 14+10)
VMIN=YMP 3048
VMX=YS 3048
CALL AXES (X Z2 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y2 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
Y4(LPT)=Z4(LPT)=YM
Y4(JPT)=Z4(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z4 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y4 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
GO TO 310
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
GO TO 300
IF (*NOT FSS(8)) GO TO 300
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z1 NOPTS 1 K 3 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
GO TO 310
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0.0 0.90 2. YM+YS 5+10 LABR 14+10)
CALL LINE (X Z3 NOPTS 1 K 3 07)
IF (*NOT FSS(2)) CALL LINE (X Y3 NOPTS 1 0.0 07)
CALL CALPLT (0.2 75 3)
CALL GRID (0.0 5 5 10 4)
CALL AXES (0.0 0.5 XM XS 110 LABT 14 10)
GO TO 310
CONTINUE
CALL AXES (0,0,90,0,2,YM,YS,5,10,LABTH,14,10)
CALL LINE (X+Z1,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y1,NOPTS,1,0,0,07)
CALL CALPLT (10,0,2,75,-3)
CALL GRID (0,0,5,0,5,10,4)
CALL AXES (0,0,0,0,5,0,0,0,0,LABT,14,-10)
YM=-SF2
YS=SF2
Y2(LPT)=Z2(LPT)=YM
Y2(JPT)=Z2(JPT)=YS
CALL AXES (0,0,0,0,90,0,2,YM,YS,5,10,LABQ,14,10)
CALL LINE (X+Z2,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y2,NOPTS,1,0,0,07)
CALL CALPLT (0,0,2,75,-3)
CALL GRID (0,0,5,0,5,10,4)
CALL AXES (0,0,0,0,0,0,0,0,LABT,14,-10)
YM=-SF3
YS=SF3
Y3(LPT)=Z3(LPT)=YM
Y3(JPT)=Z3(JPT)=YS
CALL AXES (0,0,0,0,90,0,2,YM,YS,5,10,LABW,14,10)
CALL LINE (X+Z3,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y3,NOPTS,1,0,0,07)
CALL CALPLT (0,0,2,75,-3)
CALL GRID (0,0,5,0,5,10,4)
CALL AXES (0,0,0,0,0,0,0,0,LABS,14,-10)
YM=Z3
YS=SF4
Y4(LPT)=Z4(LPT)=YM
Y4(JPT)=Z4(JPT)=YS
CALL AXES (0,0,0,0,90,0,2,YM,YS,5,10,LABU,14,10)
CALL LINE (X+Z4,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y4,NOPTS,1,0,0,07)
CALL CALPLT (12,0,2,75,-3)
WMIN=YM*3048
WMX=YM*3048
CALL AXES (5,0,0,90,0,2,WMIN,WMX,5,10,9M (M/SEC),14,-9)
CALL LINE (X+Z3,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y3,NOPTS,1,0,0,07)
CALL CALPLT (0,0,2,75,-3)
CALL GRID (0,0,5,0,5,10,4)
CALL AXES (0,0,0,0,0,5,0,0,0,0,LABM,14,-10)
YM=Z2
YS=SF4
Y4=LPT)=Z4(LPT)=YM
Y4(JPT)=Z4(JPT)=YS
CALL AXES (0,0,0,0,90,0,2,YM,YS,5,10,LABD,14,10)
CALL LINE (X+Z4,NOPTS,1,K,3,07)
IF (.NOT.FSSC(2)) CALL LINE (X+Y4,NOPTS,1,0,0,07)
CALL CALPLT (12,0,2,75,-3)

WL(2)=.T.
CALL DISPLAY
CALL OPERATE
IF (.NOT.FSSU(4)) GO TO 330
WL(2)=.F.
CALL OPERATE
GO TO 130

IF (.NOT.FSSU(3)) GO TO 320

WL(2)=.F.
RETURN

FORMAT (/V/6H RUN=\"F4,0\"//16(AB*2;A2,L1))
FORMAT (/H//10H ACTIVE EQUATION VARIABLES ARE \"A3*7(A1;A3))
FORMAT (/H//10H ACTIVE ALGORITHM VARIABLES ARE \"A3*10(A1;A3))
FORMAT (/H//10H PARAM VALUE ACT)/*(5(2XAlan*1E13,6,1X3))
FORMAT (/9H UMULT =E13,6,9H VMULT =E13,6,9H WMULT =E13,6,9H
1 PMULT =E13,6,9H QMULT =E13,6,9H RMULT =E13,6,9H THMULT =E13)
2*6,0H PMULT =E13,6,9H QMULT =E13,6,9H RMULT =E13,6,9H THMULT =E13
3T=E13,6,9H DAMULT =E13,6,9H DEMULT =E13,6,9H DRMULT =E13,6,9H
4 UBIAS =E13,6,9H VBIAS =E13,6,9H WBIAS =E13,6,9H PBIAS =E13
5*6,0H QBIAS =E13,6,9H RBIAS =E13,6,9H THBIAS =E13,6,9H PHBIA =E13
6S=E13,6,9H AXBIAS =E13,6,9H AYBIAS =E13,6,9H AZBIAS =E13,6,9H
7 DABIAS =E13,6,9H DEBIAS =E13,6,9H DRBIAS =E13,6)
OVERLAY (XC142FL, 3.0).- The read overlay, level (3,0), is loaded when the READ mode is selected on the program control console. The primary overlay, level (4,0), is automatically loaded upon completion of level (3,0). The integer IREAD preset in level (4,0) selects one of the six options in the READ overlay, one option being to input flight test data.

The flight test data input option uses a tape that was made by altering the original time records of all runs so that monotonically increasing time serves as the tape index key. Another aspect of the tape is that the time interval between consecutive points is constant for a given run, but does vary from run to run. The analyst can readily determine TS, TT, and NOPTS (tape starting time, tape time interval, and number of points, respectively) from the tape printout, but must consider frequencies involved to determine INC (sample rate of flight data tape). A major factor in determining INC is that DELX (program time interval of flight data, where DELX = TT . INC) must be an integral multiple of DT (program integration step size).

This option also provides the analyst with the opportunity to use biases and multipliers to eliminate certain apparent anomalies in the flight test data. An example of this usage is the putting in of control input trim conditions as biases.

To input flight test data, the determined values for TS, TT, NOPTS, INC, and any multipliers and/or biases must be entered into the computer. Then IREAD is changed to 6 and the READ switch is depressed. Input of flight test data is completed when the READ mode light comes on; if WL(7) is also on, an error in entering these values is apparent. The bottom RELEASE switch is depressed to complete the return to level (4,0).

The flow chart of the flight test data input option follows the flow chart of overlay level (3,0).
PROGRAM XCREAD

Memory allocation

IREAD

<1 or >6

WL(6) = .T.

= 1

(D0055)
Reset parameter value and activeness

= 2

(D0059)
Store parameter value and activeness

= 3

(D0072)
Nominal run conditions

= 4

(D0088)
Longitudinal run conditions

= 5

(D0106)
Lateral run conditions

= 6

(D0126)
Flight test data input option

IREAD = 2

RETURN

OVERLAY (XC142FL,4,0)

END
FLIGHT TEST DATA INPUT OPTION

Entry when IREAD = 6

WL(7) = .F.

KSkip > 0

Yes

Rewind LUN25
UM(I) = 1000000
I = 1, 2, . . ., NPTS

Call CREATEF (LUN25)

I = 0
J = -1

Yes

I = I + 1

J = J + 1

Call RECIN

END FILE LUN25

Yes

WL(7) = .T.

No

Starting time reached

Yes

MOD(J, INC) = 0

UM(I) = UMULT · (UM(I) - UBIAS)

(see lines D0145 - D0162)

Yes

I < NOPTS

No

\( \bar{x}(0) = \bar{x}^M(t_1) \)

IREAD = 2

RETURN

OVERLAY (XC142FL,4,0)
OVERLAY (XC142FL.3.0)

PROGRAM XREAD

LOGICAL LDISO, LDISO, LOGIC, VARCHNG, WL(39), FSS(16)

DIMENSION FW(25)(1025), AL(40), INTX(8), INTY(11)

COMMON /INTCOMM/ THINT, NEQ, ISCHM, DERRINT(2,249)

COMMON /INTINTR/ INTERN(5.249)

COMMON /REALTIM/ ADC(32), DAC(64), LDISO(108), LDISO(196), NOPER, NHOLD

1*NRESET, NTERM, NPRINT, NREAD

COMMON /ALGOR/ NPAR, IPAR, INTP(30), IP, INTV(8), INT(11), IA, IA1, IA

12, PARAM(40), DPARAM(30), ALV(11), DVAR(8), DALG(11), ALG(40), IAC(40), IE

DO 20 1 = 1, NPAR

20 AL(I) = ALG(I)

RETURN

DO 20 1 = 1, NPAR

ALG(I) = TABLE(I)

RETURN

10 DO READ = 1 TO STORE ALG IN AL. ETC.

11 READ = 6

12 READ = 1

13 READ = 4

14 READ = 2

15 READ = 3

IF (L.GE.1. AND. L.LE.6) GO TO 10

RETURN

DO 30 1 = 1, NPAR

AL(1) = ALG(1)

30 INTG(1) = IAC(1)

RETURN

40 DO 50 1 = 1, NPAR

ALG(1) = TABLE(1)

50 RETURN

52
50  IAC(1)=INTEG(1) D 0062
    IF (FSS(12)) RETURN D 0063
    ALG(1)=UM(1) D 0064
    ALG(18)=VM(1) D 0065
    ALG(7)=WM(1) D 0066
    ALG(25)=PM(1) D 0067
    ALG(12)=QM(1) D 0068
    ALG(33)=RM(1) D 0069
    ALG(5)=THM(1) D 0070
    ALG(6)=PHM(1) D 0071
    RETURN D 0072
60  AIXZ=.8000
    RHO=.002186 D 0073
    S=.53*4 D 0074
    DT=.05 D 0075
    TT=.05 D 0076
    TIMF=8* D 0077
    CTB=.8423 D 0078
    CTT=.573 D 0079
    CAPDT=8* D 0080
    ELBAR=20.54 D 0081
    ELTP=32.09 D 0082
    RB=1.6 D 0083
    INC=9 D 0084
    DO 70 I=154,162 D 0085
    RETURN D 0086
70  TABLE(I)=0. D 0087
    RETURN D 0088
80  DO 90 I=1,11 D 0089
    IF (I.LT.9) INTX(I)=0 D 0090
90  INTY(I)=1 D 0091
    INTX(1)=INTX(3)=INTX(5)=INTX(7)=1 D 0092
    INTY(2)=INTY(4)=INTY(6)=INTY(8)=INTY(10)=0 D 0093
    DI=U0 D 0094
    D2=W0 D 0095
    D3=Q0 D 0096
    D4=THEO D 0097
    DO 100 I=1,NPAR D 0098
    AL(I)=0. D 0099
    INTEG(I)=0 D 0100
    IF (I.LE.17) INTEG(I)=1 D 0101
100  CONTINUE D 0102
    INTEG(6)=0 D 0103
    U0=D1 D 0104
    W0=D2 D 0105
    Q0=D3 D 0106
    THEO=D4 D 0107
    RETURN D 0108
110  DO 120 I=1,11 D 0109
    IF (I.LT.9) INTX(I)=0 D 0110
120  INTY(I)=0 D 0111
    INTX(2)=INTX(4)=INTX(6)=INTX(8)=1 D 0112
    INTY(2)=INTY(4)=INTY(6)=INTY(8)=INTY(10)=1 D 0113
    DI=U0 D 0114
    D2=V0 D 0115
    D3=P0 D 0116
    D4=R0 D 0117
    D5=PH10 D 0118
    DO 130 I=1,NPAR D 0119
    AL(I)=0. D 0120
    INTEG(I)=1 D 0121
    IF (I.LE.17) INTEG(I)=0 D 0122

53
CONTINUE
INTEGR(6)=1
UO=D1
VO=D2
PO=D3
RO=D4
PHIO=D5
RETURN
140 IF (K.SKIP*GT.0) GO TO 150
K.SKIP=1
CALL CREATEF (LUN25,FWA25,1025,FET25,NAM25)
150 DO 160 I=1,NPTS
160 UM(I)=I*I*E6
I=0
J=-1
170 I=I+1
180 J=J+1
190 CALL RECIN (LUN25,1*ICOUNT,X,UM(I),VM(I),WM(I),PM(I),QM(I),RM(I),THM(I),PHI(M(I),AXM(I),AYM(I),AZM(I),FDB(I),FDE(I),FDR(I),FBT(I),FDB(I),21,FDELB(I),FPPER(I),FTPER(I))
IF (ENDIFILE LUN25) 200,210
200 RETURN
210 IF (X*LT*(TS-.001)) GO TO 190
IF (MOD(J,INC)*NE*0) GO TO 180
UM(I)=UMULT*(UM(I)-UBIAS)
VM(I)=VMULT*(VM(I)-VBIAS)
WM(I)=WMULT*(WM(I)-WBIAS)
PM(I)=PMULT*(PM(I)-PBIAS)
QM(I)=QMULT*(QM(I)-QBIAS)
RM(I)=RMULT*(RM(I)-RBIAS)
THM(I)=THMULT*(THM(I)-THBIAS)
PHI(M(I)=PHMULT*(PHM(I)-PHBIAS)
AXM(I)=AXMULT*(AXM(I)-AXBIAS)
AYM(I)=AYMULT*(AYM(I)-AYBIAS)
AZM(I)=AZMULT*(AZM(I)-AZBIAS)
FDB(I)=DAMULT*(FDB(I)-DABIAS)
FDE(I)=DEMULT*(FDE(I)-DEBIAS)
FDR(I)=DMULT*(FDR(I)-DRBIAS)
FBT(I)=BT(I)-BTBIAS
IF (FDELB(I)*LT*0.0) FDELB(I)=0.
FPPER(I)=FPPER(I)-PPERBI
FTPER(I)=FTPER(I)-TPERBI
IF (I*LT*NOPTS) GO TO 170
I=UM(I)
UCRT=I
UO=UM(I)
VO=VM(I)
WO=WM(I)
PO=PM(I)
QO=QM(I)
RO=RM(I)
THEO=THM(I)
PHIO=PHI(M(I)
RETURN
END
OVERLAY (XC142FL,4,0).- Overlay level (4,0) nominally operates in real time and is automatically loaded upon exiting levels (1,0), (2,0), and (3,0). Level (4,0) can cause the loading of levels (2,0) or (3,0) by selecting PRINT or READ mode, respectively, on the program control console. Level (4,0) contains the maximum likelihood estimation procedure (fig. 1) and CRT display loop.

The CRT display loop has been developed to present time history comparisons between flight data and calculated results. The performance index variables and control deflections are divided into four separate displays (each selectable from the program control console). The displays consist of multiple grids and annotated axes with

(1) A (.) symbol to represent flight data points
(2) Continuous vectors between calculated data points.

Displays available are selected as shown in the following table:

<table>
<thead>
<tr>
<th>Display</th>
<th>FSS(1)</th>
<th>FSS(7)</th>
<th>FSS(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal ((u, w, q, \theta))</td>
<td>.F.</td>
<td>.F.</td>
<td>.F.</td>
</tr>
<tr>
<td>Lateral ((p, r, v, \phi))</td>
<td>.F.</td>
<td>.T.</td>
<td>.F.</td>
</tr>
<tr>
<td>Accelerometer ((a_{X,L}, a_{Y,L}, a_{Z,L}))</td>
<td>.T.</td>
<td>.F.</td>
<td>.F.</td>
</tr>
<tr>
<td>Controls ((\delta_a, \delta_e, \delta_T) (flight data only))</td>
<td>.F.</td>
<td>.F.</td>
<td>.T.</td>
</tr>
</tbody>
</table>

The CRT display loop is entered by any of the following methods:

(1) Depressing FSS(15) and then releasing when in the RESET mode
(2) Depressing FSS(15) and then releasing when an operational error occurs
(3) Automatically upon completion of any iteration
(4) Automatically upon completion of pseudo data fill.

All four methods result in the program awaiting operator action, but method (4) first clears the existing display and plots the selected display. The operator action awaited is that of either requesting another display or exiting the CRT display loop. Requesting another display is accomplished by setting the appropriate FSS and depressing FSS(14) and then releasing. Exiting the CRT display loop is accomplished by depressing FSS(13).

The flow chart for the CRT display loop follows the flow chart for overlay level (4,0).
CRT DISPLAY LOOP

(E0932) WL(20) = .T.

Call ENDPLOT

FSS(3) = .T.

No

Yes

(E0936) Call UNLODE

Call CLRTABL

NPASS = 1

(details for plots of flight data)

(E0945) Call CRTPLOT

(for accelerometer, control, lateral or longitudinal plots)

NPASS = 0

(details for plots of calculated data)

(E0982) Call RITECRT

(for flight data plots of selected option)

Call ENDPLOT

FSS(8) = .T.

Yes

No

(E1011) Call CLRTABL

NPASS = 0

No

Yes

(E1020) Call ENDPLOT

(E1021) Call DISPLAY

Call OPERATE

FSS(14) = .T.

Yes

No

(E1024) FSS(13) = .T.

No

Yes

(E1025) Call CLRPLOT

(E1026) Call ERASE

No

IPRINT = 4

Yes

(E1027) W(L30) = .F.

(E0165)
OVERLAY(XC142FL.4.0)  E 0001
PROGRAM XCMAIN  E 0002
REAL LIX,MIY,NIZ  E 0003
LOGICAL FSS(16)»LDISI,LDISO,LOGIC>VARCHNG,VL(39) E 0004
DIMENSION AL(40). DDELA(30). DDX(11) . DPXTWDX(30). DX(11), INTX(8) E 0005
3A(40)  E 0008
COMMON /INTCOMM/ T,H,INT.NEQ.ISCHEME.DERINT(2,249) E 0009
COMMON /INTINTR/ INTERN(5,249) E 0010
COMMON /REALTIM/ ADC (32)«DAC (64) »LDISI(d08).LDISO(d96).NOPER.NHOLD E 0011
1>NRESET.NPRINT.NREAD E 0012
COMMON /ALGOR/ NPAR.I PAR.INTP(30).1P.INTV(8).I V.INTA(11).IA.1Al .IA E 0013
12«PARAM(40) »DPARAM(30) .ALV( 1 1) .DVAR(8) . DALG ( 1 1).ALG(40) » IAC (40) » IE E 0014
2VEN,WT(11,11).COM»LI.L2 E 0015
COMMON /COMM/ IRR. I PL.ISL•TABLE(199).1NTEG(99).LOGIC(20) .NTAB.NIN E 0016
1T.NLOG.NADC.NDAC.NLDI.NLDO.NTER.NPR1NT.NREAD E 0017
COMMON /ALGOR/ NPAR.I PAR.INTP(30).1P.INTV(8).I V.INTA(11).IA.1Al .IA E 0018
12«PARAM(40) »DPARAM(30) .ALV( 1 1) .DVAR(8) . DALG ( 1 1).ALG(40) » IAC (40) » IE E 0019
2VEN,WT(11,11).COM»LI.L2 E 0020
COMMON /COMM/ IRR. I PL.ISL•TABLE(199).1NTEG(99).LOGIC(20) .NTAB.NIN E 0021
1T.NLOG.NADC.NDAC.NLDI.NLDO.NTER.NPR1NT.NREAD E 0022
1PER(201).FPTR(201).BETAT.ETA,E E 0025
TAT.FCT(12)»CTT.CT E 0026
EQUIVALENCE (PF(1,3)«F13>. (PF(1,4»F14). ' (PF(1.5)«F15). (PF(1.6)«F16) . (PF(1.7)«F17). (PF(1.8)«F18) E 0027
6). (G(22,6).G26) E 0033
8ISO(61).WL(1)). (FSS(1).LDISI(33)). (DERINT(1,1)).U). (DERINT(2,1)).E E 0035
9UDOT). (DERINT(1,2).V). (DERINT(2,2).VDOT). (DERINT(1,3).W) (DERI E 0036
$1T(1,4).WOT). (DERINT(2,4).WDOT). (DERINT(1,5).Q) (DERI E 0037
$). (DERINT(2,5).QDOT). (DERINT(1,6).R). (DERI E 0038
5T(1,7).THE) (DERINT(2,7).THEDOT). (DERINT(1,8).PHI). (DERINT(2,8). E 0039
$PHIDOT). (DERINT(1,9).PS1). (DERINT(2,9).PSIDOT) E 0040
$s). (TABLE(67).WMULT). (TABLE(68).WMULT) E 0055
$s). (TABLE(75).DMULT). (TABLE(76).DMULT) E 0058
$s). (TABLE(77).JUBIAS) E 0058
EQUIVALENCE (TABLE(80),VBIAS), (TABLE(81),WBIAS), (TABLE(82),PBIAS). E 0059
1), (TABLE(83),QBIAS), (TABLE(84),RBIAS), (TABLE(85),TBIAS). E 0060
2E(86),PBIAS), (TABLE(87),AxBIAS), (TABLE(88),AYBIAS), (TABLE(89). E 0061
3A2BIAS), (TABLE(90),DABIAS), (TABLE(91),DEBIAS), (TABLE(92),DRBIAS E 0062
4), (TABLE(98),RUN), (TABLE(99),PASS), (TABLE(100),APJ), (TABLE(101 E 0063
5),DRM(1)), (TABLE(117),AIX), (TABLE(118),AIY), (TABLE(119),AIZ). (E 0064
6TABLE(120),AIXZ), (TABLE(121),WEIGHT), (TABLE(122),GRAV), (TABLE(E 0065
723),RHO), (TABLE(124),S), (TABLE(125),B), (TABLE(126),CBAR), (TABLE(E 0066
8E(127),DEAML), (TABLE(128),DEFREG), (TABLE(129),ALPHAT), (TABLE(E 0067
930),DT), (TABLE(131),TT), (TABLE(132),TS), (TABLE(133),TIMF), (TABLE(E 0068
$LE(154),XX), (TABLE(155),XY), (TABLE(156),ZX), (TABLE(157),XY). (TE 0069
$ABLE(158),YY), (TABLE(159),ZY), (TABLE(160),XZ), (TABLE(161),YZ). E 0070
$TABLE(162),ZZ), (TABLE(169),CMCON), (TABLE(170),DALMLT), (TABLE(E 0071
$71),UCRTBI), (TABLE(172),AIW), (TABLE(173),CT0), (TABLE(174),CTTO) E 0072
$1, (TABLE(175),CTB), (TABLE(176),CTBT), (TABLE(177),D), (TABLE(178) E 0073
$LTAB(182),PPER), (TABLE(183),TPER), (TABLE(184),BTBIAS), (TABLE(E 0075
$85),PPERBI), (TABLE(186),TPERBI), (TABLE(187),DET1), (TABLE(188),D E 0076
$ET2) E 0077
EQUIVALENCE (TABLE(191),DRSD(1)), (INTEG(51),INTY(1)), (INTEG(E 0078
1NOPTS), (INTEG(53),INC), (INTEG(64),IPRINT), (INTEG(65),NPLOT), (I E 0079
3NTEG(66),IREAD), (INTEG(67),KSCAN), (INTEG(81),INTX(1)) E 0080
C ARRAYS DIRECTLY INVOLVED IN ALGORITHM E 0081
C AL(I) CONTAINS VALUES FOR PARAMETERS (ALPHAS) E 0082
C INTEG(I) = 1 FOR ACTIVE PARAMETER, 0 FOR INACTIVE PARAMETER E 0083
C INTX(I) = 1 FOR ACTIVE STATE, 0 FOR INACTIVE STATES E 0084
C INTY(I) = 1 FOR ACTIVE, 0 FOR INACTIVE ALG. VARIABLE E 0085
C INTP(I) ACTIVE PARAMETERS E 0086
C INTA(I) ACTIVE STATE VARIABLES E 0087
C INTA(I) ACTIVE ALG. VARIABLES E 0088
C P(y) SENSITIVITY EQUATION MATRIX E 0089
C PF(I,J) EXPLICIT PARTIALS IN SENSITIVITY EQUATIONS E 0090
C PX(I,J) SENSITIVITY COEFFICIENTS E 0091
C PXD(I,J) DERIVATIVES OF PX E 0092
C DX(I) DIFFERENCE OF MEASURED AND CALCULATED STATE VARIABLES E 0093
C DDX(I) PACKED DX ARRAY E 0094
C XBAR(I) MEAN OF MEASUREMENT NOISE E 0095
C SD(I,J) STANDARD DEVIATION MATRIX E 0096
C WT(I,J) WEIGHT MATRIX E 0097
C PXWX(I,J) INTERMEDIATE CALCULATION E 0098
C PXdux(I,J) ACCUMULATED DPXDXDX FROM TIME=0 TO END OF ITERATION E 0099
C ICXPX(I,J) COVARIANCE MATRIX OF PARAMETERS E 0100
C DPXDXDX(I) RIGHT HAND SIDE OF PARAMETER CHANGE EQUATION E 0101
C DDEL/I) PACKED DELA ARRAY E 0102
C DELA(I) DELTA ALPHAS FOR PARAMETERS (UPDATES) E 0103
C WL(10) INDICATES NOPTS. GT. NPTS E 0104
C WL(11) INDICATES IP. GT. IPAR E 0105
C WL(12) INDICATES ERROR IN INITIALIZATION OF STATES E 0106
C WL(13) INDICATES ABS(THE) GT. 1.5 RADIAN S E 0107
C WL(14) INDICATES U. LT. 5. FPS E 0108
C WL(15) INDICATES ABS(V) GT. U E 0109
C WL(16) INDICATES ABS(ALF) GT. 1.5 RADIAN S E 0110
C WL(17) INDICATES ATTEMPTING TO USE UNFILLED FLIGHT DATA E 0111
C WL(18) INDICATES COVARIANCE MATRIX SINGULAR (DET1=0) E 0112
C WL(19) INDICATES WEIGHT MATRIX SINGULAR (DET2=0) E 0113
C WL(20) INDICATES IN CRT LOOP E 0114
C FSS(I)='T' FOR ACCELERATIONS ON CRT E 0115
C FSS(3)='T' FOR CALCOMP OF FLIGHT DATA ONLY E 0116
C FSS(4)='T' FOR PSEUDO-DATA-FILL E 0117
C FSS(5)='T' TEMPORARILY FOR VARIABLE DIMENSIONS E 0118
C FSS(5)='T' FOR OUTPUT LISTING E 0119
FSS(7)=.T. FOR LATERAL STATES ON CRT
FSS(8)=.T. FOR CONTROLS ON CRT
FSS(9)=.T. FOR PSEUDO FLIGHT FUNCTIONS
FSS(10)=.T. TO SKIP UPDATE OF ALPHAS
FSS(11)=.T. TO ENABLE TYPEWRITER
FSS(12)=.T. TO RETAIN STATE i.e. s DURING STORING OF AL IN ALG
FSS(13)=.T. TO EXIT CRT LOOP
FSS(14)=.T. TEMP. FOR REPLOT
FSS(15)=.T. TO ENTER CRT LOOP
FSS(16)=.T. FOR TABLES ADDRESSING
FSS(7)=.F. FOR LONGITUDINAL STATES ON CRT
LOGIC(1)=.T. TO CALCULATE WEIGHT UPDATES
LOGIC(2)=.T. FOR DIAGONALIZED WEIGHT MATRIX
LOGIC(3)=.T. FOR MAIN PROP=FTP(1)
LOGIC(4)=.T. FOR TAIL = FTP(1)
LOGIC(5)=.T. FOR CTT=F(BETAT)
LOGIC(6)=.T. FOR CZDE=CMDE*CMCON
LOGIC(7)=.T. FOR LONGITUDINAL STATES=FLIGHT DATA
LOGIC(8)=.T. FOR ALFT = ATAN(WO/UO)
LOGIC(9)=.T. FOR TRIM CONDITIONS
LOGIC(10)=.T. FOR AUTOMATIC TRIM
LOGIC(11)=.T. FOR AUTOMATIC 2 PASS SYSTEM

IPRINT=1 TO PRINT ICS SET VALUE BEFORE PRINT
IPRINT=2 TO REWIND MF FILE SET VALUE BEFORE PRINT
IPRINT=3 TO OBTAIN RANDOM NUMBERS SET VALUE BEFORE PRINT
IPRINT=4 FOR CALCOMP PLOT (SET VALUE BEFORE EXITING CRT LOOP AND ENTERING PRINT - USES FSS(1,2,7,8,13,14))
IPRINT=5 TO RETURN (ROUTES OUTPUT)
IPRINT=6 TO FILL FLIGHT DATA ARRAYS SET VALUE BEFORE READ
CALL LDRSEC
IF (.ISKIP.GT.0) GO TO 10
ISKIP=1
CALL CYCLE (90006S)
ASSIGN 90001 TO NOPER
ASSIGN 90002 TO NMHOLD
ASSIGN 90003 TO NRESET
ASSIGN 90004 TO NTERM
ASSIGN 90014 TO NPRINT
ASSIGN 90015 TO NREAD
CALL XDSPLAY (LDISI,LDISO,VARCHNG,ITYPE,IVARBUF,FSS(16))
10 CALL READY
90003 CONTINUE
IF (.NOT.*FSS(4)) GO TO 110
40 INT(1)=10H
DO 40 I=1,IPAR
INTP(IP)=0
DO 50 I=1,IPAR
IF (INTP(IP).EQ.0) GO TO 50
IP=IP+1
INTP(IP)=1
DPARAM(IP)=PARAM(IP)
90003 CONTINUE
CONTINUE
IF (IP.LE.IPARI) GO TO 60
WL(11)=T
GO TO 740
DO 70 I=1,8
IF (INTY(I).EQ.0) GO TO 70
IF (INTX(I).EQ.1) GO TO 70
WL(12)=T
GO TO 740
70 CONTINUE
IA1=0
IV=0
DO 80 I=1,8
DVAR(I)=0H
INTV(I)=0
IF (INTY(I).EQ.1) IA1=IA1+1
IF (INTX(I).EQ.0) GO TO 80
IV=IV+1
DVAR(IV)=ALV(I)
INTV(IV)=1
80 CONTINUE
IA=0
DO 90 I=1,11
DALG(I)=10H
INTA(I)=0
IF (INTY(I).EQ.0) GO TO 90
IA=IA+1
DALG(IA)=ALV(I)
INTA(IA)=1
CONTINUE
IA2=IA-IA1
ITRNMUT(2)=ITRNMUT(4)=IMULTA(3)=INVWT(2)=INVWT(3)=IA
ITRNMUT(3)=IMULTA(2)=INVSEN(2)=INVSEN(3)=IMULTB(2)=IMULTB(3)=IP
IF (.NOT.LOGIC(1)) GO TO 110
DO 100 I=1,IA
DO 100 J=1,IA
WT(I,J)=0.
CONTINUE
NEO=9+IP*IV
IF (FSS<3> NEO<9
DO 120 I=1,IA
XBAR(I)=0.
DO 120 J=1,IP
SD(I,J)=0.
DO 130 I=1,IP
PXTDX(I)=0.
DO 130 J=1,IP
PXTPX(I,J)=0.
K=9
DO 230 I=1,IV
II=INTV(I)
DO 230 J=1,IP
JJ=INTP(J)
K=K+1
DERINT(I,J,K)=0.
GO TO (140,150,160,170,180,190,200,210), 11
140 IF (JJ*EQ.1) 220,230
150 IF (JJ*EQ.18) 220,230
160 IF (JJ*EQ.7) 220,230
170 IF (JJ*EQ.25) 220,230
180 IF (JJ*EQ.12) 220,230
190 IF (JJ*EQ.33) 220,230
DO 240 J=1,NPAR
DELA(J)=0.
DO 240 I=1,B
IF (I.LT.7) PXD(I,J)=0.
IF (J.LT.9) G(I,J)=0.
PF(I,J)=0.
G(8,4)=1.
INT=0
H=DT
VARCHNG=.FALSE.
T=0.
U=U0
V=V0
W=W0
P=P0
O=CO
R=RO
THE=THEO
PHI=PHIO
PSI=0.
CYCL=2.*PI/DEFREQ
ALFT=ALPHAT*RADD
IF (LOGIC(B)) ALFT=ATAN2(WO,U0)
AJ=0.
ITS=-1
NOEL=0
DELX=TT*INC
NOITSPS=DELX/DT
TMAXX=DELX*(NOPTS-1)
PTSNV=1./NOPTS
GINV=1./GRAV
AMASINV=GRAV/WEIGHT
AIYINV=1./AIY
BTWO=5*B
CBAR2=5*CBAR
RHOS2=RHO*S+.5
A1=RHOS2*AMASINV
A2=A1*CBAR2
A3=A1*BTWO
A4=RHOS2*B
A5=A4*BTWO
CONIN=1./(A1*X-A1Z-AIXZ**2)
A6=A1Z*CONIN
A7=(A1Z-A1X)*AIYINV
A8=RHOS2*CBAR2*AIYINV
A9=A8*CBAR2
VDTCON=1./(1.-A3*CYBD)
PF21=A3*VDTCON
A9CMALD=A9*CMALD
B1=A1XZ*CONIN
B2=AIY-A1Z
B3=A1X-AIY
B4=A1XZ*AIYINV
B5=A1X*CONIN
PF41=A5*(A6*CLBD+B1*CNBD)
PF61=A5*(B1*CLBD+B5*CNBD)
B42=2.*B4
CIW=COS(AIW)
$SI = \sin(\alpha W)$

$CLDAP = CLDA*C + CNDAP = CLDA*SIW + CNDAP = CLDA*SIW*CNDA*CIW$

$CON = 2 \cdot \rho \cdot \delta^4$

$CON1 = 2 \cdot \rho \cdot \delta$

$CON2 = ELBAR*CTB*CON$

$CON3 = CIW*CON1$

$CON4 = SIW*CON1$

$CON5 = SIW*CON2$

$CON6 = CIW*CON2$

$CON7 = RB*CON1$

$CON8 = \rho \cdot \text{CAPDT}^4$

$CON9 = \text{ELTP} \cdot CON8$

$DCON = B \cdot \rho \cdot D^4 / \pi$

$90006 \text{ CONTINUE}$

$ITs = ITs + 1$

$90002 \text{ CONTINUE}$

$90008 \text{ CONTINUE}$

$K = 9$

$DO 260 J = 1, 1, P$

$260 PX(1, J) = \text{DERINT}(1, K)$

IF (.NOT. \text{FSS}(9)) GO TO 270

$\text{BETAT} = DA = DB = DE = \text{DELAB} = DR = \text{PPER} = \text{TPER} = 0.$

IF (T \leq \text{CYCL}) DE = DAMPL * SIN(DEFREQ * T)

GO TO 280

$270 \text{ FT} = T$

$\text{IS} = \text{FT} / \text{DELX}$

$\text{SS} = \text{FT} / \text{DELX} - \text{IS}$

$\text{IS} = \text{IS} + 1$

$\text{IS} = \text{IS} + 1$

$\text{IS} = \text{IS} + 1$

IF (IS2 \geq \text{NOPTS}) IS2 = NOPTS

$\text{SS} = \text{IS} - \text{SS}$

$\text{DA} = \text{SS} \cdot \text{FDA}(\text{IS}1) + \text{SS} \cdot \text{FDA}(\text{IS}2)$

$\text{DE} = \text{SS} \cdot \text{FDE}(\text{IS}1) + \text{SS} \cdot \text{FDE}(\text{IS}2)$

$\text{DR} = \text{SS} \cdot \text{FDR}(\text{IS}1) + \text{SS} \cdot \text{FDR}(\text{IS}2)$

$\text{BETAT} = \text{SS} \cdot \text{FBT}(\text{IS}1) + \text{SS} \cdot \text{FBT}(\text{IS}2)$

$\text{DB} = \text{SS} \cdot \text{FDB}(\text{IS}1) + \text{SS} \cdot \text{FDB}(\text{IS}2)$

$\text{DELB} = \text{SS} \cdot \text{FDELB}(\text{IS}1) + \text{SS} \cdot \text{FDELB}(\text{IS}2)$

$\text{PPER} = \text{PPER}(1)$

IF (.NOT. \text{LOGIC}(3)) PPER = SS1 * FPPER(IS1) + SS * FPPER(IS2)

$\text{TPER} = \text{TPER}(1)$

IF (.NOT. \text{LOGIC}(4)) TPER = SS1 * FTPER(IS1) + SS * TPER(IS2)

IF (.NOT. \text{LOGIC}(7)) GO TO 280

$U = \text{SS} \cdot \text{UM}(\text{IS}1) + \text{SS} \cdot \text{UM}(\text{IS}2)$

$W = \text{SS} \cdot \text{WM}(\text{IS}1) + \text{SS} \cdot \text{WM}(\text{IS}2)$

$O = \text{SS} \cdot \text{OM}(\text{IS}1) + \text{SS} \cdot \text{OM}(\text{IS}2)$

$\text{THE} = \text{SS} \cdot \text{THM}(\text{IS}1) + \text{SS} \cdot \text{THM}(\text{IS}2)$

$280 \text{ CONTINUE}$

IF (ABS(THE) \leq 1.5) GO TO 290

$\text{WL}(17) = +T$

GO TO 740

$290 \text{ CONTINUE}$

IF (U \geq 5) GO TO 300

$\text{WL}(14) = +T$

GO TO 740

$300 \text{ CONTINUE}$

IF (ABS(V) \leq U) GO TO 310

$\text{WL}(1) = +T$

GO TO 740
310 UINV=1/U
ALF=ATAN2(W+U)-ALFT
IF (ABS(ALF)*LT.1.5) GO TO 320
WL(16)=T.
GO TO 740
320 U2=U*U
V2=V*V
W2=W*W
VR=SQRT(V2)
VRINV=1/VR
BET=ASIN(V*VRINV)
ETA=1232.*PPER/60.*
ETAT=40.*TPER
CT=CTO+CTB*DELB
IF (.NOT.LOGIC(5)) GO TO 330
FBET=ABS(BETAT*DRAO)
IF (FBET.GT.22.) FBET=22.
IS=FBET*5
SS=FBET*5-IS
TDUM=(1-SS)*FCT(IS+1)+SS*FCT(IS+2)
IF (BETAT.LT.0.) TDUM=-TDUM
CTT=TDUM+CTT
GO TO 340
CONTINUE
CTT=CTBT+BETAT+CTT
CONTINUE
TEMP=ETA**2
TEMP1=CT*TEMP
TEMP2=DB*TEMP
TEMP3=ETAT**2*CTT
TX=CON3*TEMP1
TZ=CON4*TEMP1-CON8*TEMP3
AMX=CON5*TEMP2
AMY=CON7*TEMP1-CON9*TEMP3
AMZ=CON6*TEMP2
VSS2=DCON*TEMP1
VSS=SQRT(VSS2)
VSR=VSS+VR
VSRV=VSR*VRINV
VSR2=VSR**2
STHE=SIN(THE)
CTHE=COS(THE)
SPHI=SIN(PHI)
CPHI=COS(PHI)
GCTHE=GRAV*CTHE
GSTHE=GRAV*STHE
TTHE=TAN(THE)
TXM=AMASINV*TX
TYM=AMASINV*TY
TZM=AMASINV*TZ
AMY=AIYINV*AMY
AIU=AI*U
AIV=AI*V
AIW=AI*W
A4U=A4*U
A4V=A4*V
A4W=A4*W
A8U=A8*U
A8V=A8*V
A8W=A8*W
A1VR=A1*VR
A2VR=A2*VR
A3VR=A3*VR
A4VR=A4*VR
A5VR=A5*VR
A9VR=A9*VR
A1VR2=A1*VR2
A4VR2=A4*VR2
A4VS2=A4*VS2
A8VR2=A8*VR2
B2VR=BTW2*VR1V
P22=PF21*VR
P42=A6*A5VR
P43=A4VS2*DA
P44=B1*A5VR
P62=BU*A5VR
CBAR2VR=CBAR2*VR1V
P2=P*P
Q2=Q*Q
R2=R*R
PQ=P*Q
PR=P*R
QR=Q*R
Q1=Q*A1*Z
CXI=CXI+ALF*CXAL
CX2=CXO+Q*CBAR2VR
CYI=CYO+BET*CYB+DR*CYDR
CY2=B2VR*(P*CYP+R*CYR)
CZI=CZO+ALF*CZAL+DE*CZDE
CZ2=CZO+Q*CBAR2VR
FXM=A1VR2*(CX1+CX2)
FYM=A1VR2*(CY1+CY2)
FZM=A1VR2*(CZ1+CZ2)
UDP=R*V*O*GSTHE
VDP=R*U*O+GCTHE*SPHI
WDP=O*U*O+GCTHE*CPHI
UDOT=UDP+FXM+TXM
VDOT=VDTPC*(VDP+FYM+TYM)
WDOT=WDP+FZM+TZM
IF (INTX(1)*EQ.0) UDOT=0.
IF (INTX(2)*EQ.0) VDOT=0.
IF (INTX(3)*EQ.0) WDOT=0.
IF (.NOT.LOGIC(9)) GO TO 350
CALL HALT
CXI=CXI-CXO
CYI=CYI-CYO
CZI=CZI-CZO
TMP1=A1VR2
CXO=CXO-UDOT*TMP1
CYO=CYO-VDOT*TMP1/VDTPC
CZ0=CZ0-WDOT*TMP1
UDOT=0.
VDOT=0.
WDOT=0.
CXI=CXI+CXO
CYI=CYI+CYO
CZI=CZI+CZO
CONTINUE

ALFD=VDOT*U1NV

BETD=VDOT*V1NV

BDB2VR=BDT*B2VR

CL1=CLO+BET*CLB+DR*CLDR

CL2=(BETD*CLBD+P*CLP+R*CLR)*B2VR

CL3=DA*CL3AP

CM1=CMO+ALF*CMAL+DE*CMDE

CM2=(ALFD*CMALD+Q*CMQ)*CBAR2VR

CNI=CN0+BET*CNB+DR*CNDR

CN2=(BETD*CNBD+P*CNP+R*CNR)*B2VR

CN3=DA*CN3AP

LIX=A4VR2*(CL1+CL2)+A4VSR2*CL3

MIY=A8VR2*(CM1+CM2)

NZ=A4VR2*(CN1+CN2)-A4VSR2*CN3

FAP=O*(B2*R+P*A1XZ)+L1X+AMX

FP=O*(B3*R+P*AIXZ)+NIZ+AMZ

PDOT=A6*FAP+B1*F6P

QDOT=AT*PR+B4*(R2-P2)+MIY+AMY

RDOT=B1*F4P+B5*F6P

IF (INTX(4) .EQ.O) PDOT=0.

IF (INTX(5) .EQ.O) QDOT=0.

IF (INTX(6) .EQ.O) RDOT=0.

IF (.NOT.FS) GO TO 360

LOGIC(9)=.F.

CL1=CL1-CLO

CM1=CM1-CMO

CN1=CN1-CN0

TMP4=1/A4VR2

CLO=CLO-FAP+TMP4

CMO=CMO-QDOT/A8VR2

CNO=CNO-F6P*TMP4

PDOT=0.

QDOT=0.

RDOT=0.

CL1=CL1+CLO

CM1=CM1+CMO

CN1=CN1+CNO

CALL READY

CONTINUE

AXCG=GINV*(UDOT-UDP)

AYCG=GINV*(VDOT-VDP)

AZCG=GINV*(WDOT-WDP)

AXI=AXCG+GINV*(-(R2+G2)*XX+(PG-RDOT)*YY+(PR+QDOT)*ZX)

AYI=AYCG+GINV*(-(PQ+RDOT)*XY-(P2+R2)*YY+(QR-PDOT)*ZY)

AZI=AZCG+GINV*(-(PQ+RDOT)*XY+(PR+QDOT)*YZ-(P2+Q2)*ZZ)

THEDOT=Q*CPHI-R*SPHI

PSIDOT=(Q*SPHI+R*CPHI)/CTHE

PHIDOT=P*PSIDOT*STHE

IF (INTX(7) .EQ.O) THEDOT=0.

IF (INTX(8) .EQ.O) PHIDOT=0.

IF (.NOT.FS) GO TO 370

IF (MOD(ITS.NOITSPS).NE.O) GO TO 530

IF (.NOT.LDISI(18)) NOEL=NOEL+1

UM(NOEL)=U

VM(NOEL)=V

WM(NOEL)=W

PM(NOEL)=P

GM(NOEL)=Q

RM(NOEL)=R

THM(NOEL)=THE

PMH(NOEL)=PHI
AXM(NOEL) = AXI
AYM(NOEL) = AI
AZM(NOEL) = AZI
FDA(NOEL) = DA
FDE(NOEL) = DE
FDR(NOEL) = DR
FBT(NOEL) = BETAT
FDB(NOEL) = DB
FDELA(NOEL) = DB
FPPER(NOEL) = PPER
FTPER(NOEL) = TPER
GO TO 530
CONTINUE
PF(1,2) = A1VR2
PF(1,3) = A1VR2*ALF
PF(1,4) = A2VR*O
PF(2,19) = VDOTCON*A1VR2
PF(2,20) = F219*BET
PF(2,21) = PF21*VDOT
PF(2,22) = PF22*BET
PF(2,23) = PF22*P
PF(2,24) = F219*O
PF(3,8) = A1VR2
PF(3,9) = F13
PF(3,10) = F14
PF(3,11) = A1VR2*DE
PF(4,19) = F219*PF41
PF(4,20) = F220*PF41
PF(4,21) = F221*PF41
PF(4,22) = F222*PF41
PF(4,23) = F223*PF41
PF(4,24) = F224*PF41
PF(4,26) = A6*A4VR2
PF(4,27) = F426*BET
PF(4,28) = PF42* BETD
PF(4,29) = PF42*P
PF(4,30) = PF42*R
PF(4,31) = F426*DR
PF(4,32) = PF43*(A6*CIW-B1*SIW)
PF(4,34) = B1*A4VR2
PF(4,35) = F434*BET
PF(4,36) = PF44* BETD
PF(4,37) = PF44*P
PF(4,38) = PF44*R
PF(4,39) = F434*DR
PF(4,40) = -PF43*(B1*CIW+A6*SIW)
PF(5,8) = A1VR2*9CMALD
PF(5,9) = F39*A9CMALD
PF(5,10) = F310*A9CMALD
PF(5,11) = F311*A9CMALD
PF(5,13) = A8VR2
PF(5,14) = A8VR2*ALF
PF(5,15) = A9VR*ALFD
PF(5,16) = A9VR*O
PF(5,17) = A8VR2*DE
PF(6,19) = F219*PF61
PF(6,20) = F220*PF61
PF(6,21) = F221*PF61
PF(6,22) = F222*PF61
PF(6,23) = F223*PF61
PF(6,24) = F224*PF61
PF(6,26) = F434
PF(6,27) = F435
PF(6,28) = F436
PF(6,29) = F437
PF(6,30) = F438
PF(6,31) = F439
PF(6,32) = PF43*(B1*CIW-B5*SIW)
PF(6,34) = B5*A4VR2
PF(6,35) = F634*BET
PF(6,36) = PF62*BETD
PF(6,37) = PF62*P
PF(6,38) = PF62*R
PF(6,39) = F634*DR
PF(6,40) = PF63*(B5*CIW+B1*SIW)
G1P = 2*CX1+CX2
G2P = 2*CY1+CY2*CYB
G3P = 2*CM1+CM2
G4P = 2*(CL1+CL3*VSRVR)+CL2-BET*CLB-BDB2VR*CLB
G5P = 2*CM1+CM2
G6P = 2*(CN1-CN3*VSRVR)+CN2-BET*CNB-BDB2VR*CNB
G(1,1) = A1U*G1P-A1W*CXAL
G(1,2) = A1V*G1P+R
G(1,3) = A1W*G1P+A1U*CXAL-Q
G(1,4) = A2VR*CXO-W
G(1,6) = V
G(1,7) = -GCTHE
G(2,1) = VDTCON*(A1U*G2P-R)
G(2,2) = VDTCON*(A1V*G2P+A1VR*CYB)
G(2,3) = VDTCON*(A1W*G2P+P)
G(2,4) = VDTCON*(A3VR*CYP+W)
G(2,5) = VDTCON*(A3VR*CYR-U)
G(2,7) = -GSTHE*SPHI*VDTCON
G(2,8) = GCTHE*PHI*VDTCON
G(3,1) = A1U*G3P-A1W*CXAL+Q
G(3,2) = A1V*G3P-P
G(3,3) = A1W*G3P+A1U*CXAL
G(3,4) = V
G(3,5) = A2VR*CXO+U
G(3,7) = -GSTHE*PHI
G(3,8) = -GCTHE*PHI
G41 = A4U*G4P
G42 = A4V*G4P+A4VR*CLB
G43 = A4W*G4P
G44 = G4+G4P*CLP
G45 = R*B2+P*A1XZ
G46 = Q*B2+A5VR*CLR
G61 = A4U*G6P
G62 = A4V*G6P+A4VR*CNB
G63 = A4W*G6P
G64 = Q*B3+A5VR*CNB
G65 = P*B3-R*A1XZ
G66 = A5VR*CNB-01
G(4,1) = A6*G41+B1*G61+PF41*G21
G(4,2) = A6*G42+B1*G62+PF41*G22
G(4,3) = A6*G43+B1*G63+PF41*G23
G(4,4) = A6*G44+B1*G64+PF41*G24
G(4,5) = A6*G45+B1*G65
G(4,6) = A6*G46+B1*G66+PF41*G26
G(4,7) = PF41*G27
G(4,8) = PF41*G28
G(5,1) = ABU*G5P-ABW*CMAL+9CMALD*(G31-ALFD)
G(5,2) = ABV*G5P+A9CMALD*G32
G(5,3) = ABW*G5P+A9CMALD*G33+ABU*CMAL
G(5,4) = R*A7-B42*P+A9CMALD*G34
G(5,5) = A9VR*CMQ+G35
G(5,6) = P*A7+B42*R
G(5,7) = A9CMALD*G37
G(5,8) = A9CMALD*G38
G(6,1) = B1*G41+B5*G61+PF61*G21
G(6,2) = B1*G42+B5*G62+PF61*G22
G(6,3) = B1*G43+B5*G63+PF61*G23
G(6,4) = B1*G44+B5*G64+PF61*G24
G(6,5) = B1*G45+B5*G65
G(6,6) = B1*G46+B5*G66+PF61*G26
G(6,7) = PF61*G27
G(6,8) = PF61*G28
G(7,5) = CPHI
G(7,6) = -SPHI
G(7,8) = -PS1DOT*CTHE
G(8,5) = SPHI*THE
G(8,6) = CPHI*THE
G(8,7) = PS1DOT/CTHE
G(8,8) = SPHETHEL THE
L = 9
DO 390 I = 1, IV
II = INTV(I)
DO 390 J = 1, IP
L = L + 1
JJ = INTP(J)
GPX = 0
DO 380 K = 1, IV
KK = INTV(K)
GPX = GPX + G(I1, KK)*PX(K, J)
DERINT(2, L) = GPX + PF(I1, JJ)
1F (I1 LT 7) PXD(I1, JJ) = DERINT(2, L)
CONTINUE
1F (IA1 EQ IA) GO TO 450
G(1,1) = 0
G(1,2) = -R
G(1,3) = Q
G(1,4) = XY*Q+ZX*R
G(1,5) = -2*XQ+YX*P+W
G(1,6) = -2*XQ+ZX*P-V
G(1,7) = GCTHE
G(2,1) = R
G(2,2) = 0
G(2,3) = -P
G(2,4) = -W+XY*Q-2*YX*P
G(2,5) = XY*P+ZY*R
G(2,6) = U-2*YY*R+ZY*Q
G(2,7) = GSTHE+SPHI
G(2,8) = GSTHE*CPHI
G(3,1) = 0
G(3,2) = P
G(3,3) = 0
G(3,4) = V+XX*R-2*ZZ*P
G(3,5) = -U+YZ*R-2*ZZ*Q
G(3,6) = XZ*P+YZ*Q
G(3,7) = GSTHE*CPHI
G(3,8) = GSTHE*SPHI
L=IV
M=IA1
DO 440 I=I+IA2
L=L+1
M=M+1
II=INTA(M)-8
DO 440 J=1+IP
JJ=INTP(J)
GPX=0
DO 400 K=1+IV
KK=INTV(K)
GPX=GPX+G([II, KK]*PX(K, J))
GO TO (410, 420, 430, 440, 450, 460, 470, 480, 490)

410 PX(L, J)=GPX+PXD(1, JJ)+ZXPXD(5, JJ)-YXPXD(6, JJ))*GINV
GO TO 440

420 PX(L, J)=GPX+PXD(2, JJ)-ZYPXD(4, JJ)+XY*PXD(6, JJ))*GINV
GO TO 440

430 PX(L, J)=[GPX+PXD(3, JJ)+YZ*PXD(4, JJ)-XZ*PXD(5, JJ)]*GINV

440 CONTINUE
G(1, 4)=G(2, 5)=G(3, 6)=0.
CONTINUE
IF (IA1.EQ. IV) GO TO 480
J=0
L=0
DO 470 I=1, 11
IF (I.LE.8) J=J+INTX(I)
IF (INTY(I).EQ. 0) GO TO 470
L=L+1
IF (I.GT.8) J=J+1
DO 460 K=1+IP
PX(L, K)=PX(J, K)
CONTINUE
CONTINUE
IF (MOD(ITS, NOITSPS).NE. 0) GO TO 530
IF (.NOT.*LDISI(I8)) NOEL=NOEL+1
IF (UM(NOEL).Lt.1.5) GO TO 490
WL(17)=-I
GO TO 740

490 CONTINUE
DX(1)=UM(NOEL)-U
DX(2)=VM(NOEL)-V
DX(3)=WM(NOEL)-W
DX(4)=PM(NOEL)-P
DX(5)=QM(NOEL)-Q
DX(6)=RM(NOEL)-R
DX(7)=THM(NOEL)-THE
DX(8)=PHM(NOEL)-PHI
DX(9)=AXM(NOEL)-AXI
DX(10)=AYM(NOEL)-AYI
DX(11)=AZM(NOEL)-AZI
DO 500 I=1, IA
II=INTA(I)
DDX(I)=DX(I)
AJ=AJ+DDX(I)**2
CONTINUE
DO 510 J=1, IA
SD(I, J)=SD(I, J)+DDX(I)*DDX(J)*PTINV
C PXTWT=(PX)*T(WT)
CALL MASCNT (ITRNMNT, PX, WT, PXTWT)
C DPXTDX= (PXTWT)(DDX)
CALL MASCNT (IMULTA*PXTWT*DDX*DPXTWDX)
DO 520 I=1,IP
PXTDX(I)=PXTDX(I)+DPXTWDX(I)
DO 520 J=1,IP
DO 520 K=1,1A
520 PXTPX(I,J)=PXTPX(I,J)+PXTWT(I,K)*PX(K,J)
530 CONTINUE

C OACS FOR TIME HISTORY RECORDERS
      TABLE*134)=T
      TABLE(135)=U
      TABLE(136)=V
      TABLE(137)=W
      TABLE(138)=P
      TABLE(139)=Q
      TABLE(140)=R
      TABLE(141)=THE
      TABLE(142)=PHI
      TABLE(143)=PSI
      TABLE(144)=UDOT
      TABLE(145)=VDOT
      TABLE(146)=WDOT
      TABLE(147)=PDOT
      TABLE(148)=QDOT
      TABLE(149)=RDOT
      TABLE(150)=THEDOT
      TABLE(151)=PHIDOT
      TABLE(152)=PSIDOT

C DACS FOR TIME HISTORY RECORDERS
      DAC(1)=(U-UCRTBI)/UMAX
      DAC(2)=V/VMAX
      DAC(3)=W/WMAX
      DAC(4)=P/PMAX
      DAC(5)=Q/QMAX
      DAC(6)=R/RMAX
      DAC(7)=THE/THMAX
      DAC(8)=PHI/PHMAX

C RITECRT PLOTS IN REAL TIME IF T .LE. TMAXX
      IF (.NOT.FSS*3).AND.(T.LE.TMAXX) CALL RITECRT
1AGE
      IF (LDISI(22)) CALL SCANNER (KSCAN)
      CALL DISPLAY
      IF (LDISI(17)) GO TO 90050
      IF (VARCHNG.AND.FSS(11)) CALL TYPEVAR
      IF (FSS(11).AND.LDISI(14)) CALL TYPEVAR
      IF (FSS(15)) GO TO 770
560 IF (FSS(3)) GO TO 770
      CALL HALT
      IF (.NOT.FSSUOM) GO TO 690
      IF (.NOT.LOGIC*11)) GO TO 370
      IEVEN=IEVEN+1
      IF (MOD(IEVEN+2),EQ,0) GO TO 690
570 CONTINUE
PASS=PASS+1
DO 580 J=1,IP
DO 580 I=J,IP
580 PXTPX(I,J)=PXTPX(J,I)
C PXTPX=(PXTPX)INV
CALL MASCN (INVSEN,PXTPX,DET1,AA1)
IF (DET1*NE.0.) GO TO 590
WL(18)=T
GO TO 750
C AJP=AJ
590 DDELA=(PXTPX)(PXTDX)
CALL MASCN (IMULTB,PXTPX,PXTDX,DDELA)
DO 600 I=1,IP
   I=INTP(I)
600 DDELA(I)=DDELA(I)*DALMLT
C FSS(5) ON TO WRITE AL AND DELA ON TAPE 50
IF (.NOT.FSS(5)) GO TO 670
WRITE (MF,960) RUN,PASS,DET1,DET2,AJP
WRITE (MF,970) DALG(I),((COM,DALG(I)),I=2,IA)
WRITE (MF,980) ICUMUL,IXBAR(I),I=1,IA
WRITE (MF,1000) WT(I,J),J=1,IA
610 CONTINUE
WRITE (MF,1010)
DO 620 I=1,IA
WRITE (MF,990) (XBAR(I),J=1,IA)
620 CONTINUE
WRITE (MF,1020) ((PARAM(I),AL(I),DELA(I)),I=1,NPAR)
IERR=0
DO 640 I=1,IP
IF (PXTPX(I,I)*GT.*E-20) GO TO 630
IERR=1
WRITE (MF,1030) RUN,PASS,PXTPX(I,I)
630 CONTINUE
DDELAL(I)=SORT(PXTPX(I,I))
IF (IERR.EQ.1) CALL PRINTER
DO 650 J=1,IP
650 PXTPX(I,J)=PXTPX(I,J)/(DDELA(I)*DDELA(J))
IF (I*EQ.J) PXTPX(I,I)=DDELA(I)
CONTINUE
WRITE (MF,1040)
DO 660 K=1,IP,B
660 CONTINUE
WRITE (MF,1050) (PARAM(I),K=1,KK)
IF (K*K*GT.*IP) KK=IP
WRITE (MF,1060) (PARAM(I), (PXTPX(I,J),J=K,KK))
CONTINUE
WRITE (MF,1070)
CONTINUE
DO 680 I=1,NPAR
AL(I)=AL(I)+DELA(I)
IF (LOGIC(6)) CZDE=CMDE*CMCON
CONTINUE
IF (.NOT. LOGIC(1)) GO TO 730
DO 700 I=1,IA
DO 700 J=I,IA
WT(I,J)=SD(I,J)
IF (.NOT. LOGIC(2)) GO TO 720
DO 710 I=1,IA
DO 710 J=I,IA
IF (I .NE. J) WT(I,J)=0.
CONTINUE
WT= (WT)**-1
CALL MASCNT (INVWT,WT,DET2,AA2)
IF (DET2 .NE. 0.) GO TO 730
*L(IQ)=.T.
GO TO 750
CONTINUE
IF (LOGIC(IO)) LOGIC(9)=.T.
GO TO 780
CALL HALT
CALL DSPLAY
CALL OPERATE
IF (.NOT.FSS(15)) GO TO 750
DO 760 I=10,19
WL(.F.)=0.
GO TO 780
CALL HALT
CONTINUE
WL(20)=.T.
CALL ENDPLOT
IF (.NOT.FSS(3)) GO TO 920
CALL UNLODE
CALL CRTPLOT (1,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AXI,AXMAX,0.1,LABAX)
CALL CRTPLOT (2,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AYI,AYMAX,0.1,LABAY)
CALL CRTPLOT (3,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AZI,AZMAX,0.1,LABAZ)
GO TO 840
IF (.NOT.FSS(7)) GO TO 820
CALL CRTPLOT (1,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,P,PMAX,0.1,LABP)
CALL CRTPLOT (2,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,R,RMAX,0.1,LABR)
CALL CRTPLOT (3,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,V,VMAX,0.1,LABV)
CALL CRTPLOT (4,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,PHI,PHMAX,0.1,LABPH)
GO TO 840
IF (.NOT.FSS(S)) GO TO 830
CALL CRTPLOT (1,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,DA,DMAX,0)
CALL CRTPLOT (2,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,DE,DEMAX,0)
CALL CRTPLOT (3,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,DR,DRMAX,0)
GO TO 840
830 CONTINUE
CALL CRTPLOT (1,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,UMAX,UOFF)
CALL CRTPLOT (2,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,WMAX,0)
CALL CRTPLOT (3,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,QMAX,0)
CALL CRTPLOT (4,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,THE,THMAX,0)
CONTINUE
IF (NPASS.EQ.0) GO TO 900
T=DELX
IF (LDISI(19)) NOEL=NOPTS
DO 890 I=1,NOEL
T=T+DELX
IF (.NOT.FSS(I)) GO TO 850
AXI=AXM(I)
AYI=AYM(I)
AZI=AZM(I)
GO TO 880
850 CONTINUE
IF (.NOT.FSS(I)) GO TO 860
P=PM(I)
R=RM(I)
V=VM(I)
PHI=PHM(I)
GO TO 880
860 IF (.NOT.FSS(I)) GO TO 870
DA=FDA(I)
DE=FDE(I)
DR=FDRI(I)
GO TO 880
870 U=UM(I)
W=WM(I)
Q=QM(I)
THE=THM(I)
880 CALL RITECRT (.T,.F.,MAXPAGE)
890 CONTINUE
CALL ENDPLOT
IF (FSS(S)) GO TO 910
CALL CLRNTAXL
NPASS=0
NFREQ=NOITSPS
NRITE=1
NTYPE=1
GO TO 800
900 CALL PLAYBAK(910S)
CALL RITECRT (.T,.F.,MAXPAGE)
GO TO 900
910 CALL ENDPLOT
program usage

The use of the program is demonstrated by showing the setup of the longitudinal equations of motion, run procedure, and output listings for the test case. The test case consists of pseudo flight data, which are generated by integrating the longitudinal equations of motion for fixed parameter values (called the true values) and then adding random number sequences (measurement noise) to the variables. The parameter values are then offset to become the starting point of the estimation program. The integration scheme (from subroutine IGRATE1) used is second-order Adams-Bashforth, a 1-pass integration scheme. (See ref. 1.)

Test Case Setup

The longitudinal equations of motion are

\[ \ddot{u} = -q w - g \sin \theta + \frac{1}{2} \frac{\rho}{m} V^2 S (C_X, \theta) \]  
\[ \ddot{w} = q u + g \cos \theta + \frac{1}{2} \frac{\rho}{m} V^2 S (C_Z, \alpha + C_Z \alpha_a \alpha_a + C_Z \delta_e \delta_e) \]

\(10\)
\(11\)
\[ q = \frac{1}{2} \frac{P}{I_Y} v^2 S c \left( C_{m,0} + C_m \alpha_a \alpha_a + \frac{q \delta_e}{2V} + C_m \delta_e \delta_e \right) \]  \hspace{1cm} (12)

\[ \dot{\theta} = q \]  \hspace{1cm} (13)

where

\[ \delta_e = \begin{cases} 
0.1 \sin 2.5t & (0 \leq t \leq \pi/1.25) \\
0 & (t > \pi/1.25) 
\end{cases} \]

\[ V = \sqrt{u^2 + w^2} \]

\[ \alpha_a = \tan^{-1} \frac{w}{u} \]

The longitudinal equations are generated from the equations of motion in appendix B by the variable-dimensioning arrays described in appendix D.

For the active equation variables \( u, w, q, \) and \( \theta, \) the input array \( \text{INTX} \) is

\[ \text{INTX} = (1, 0, 1, 0, 1, 0, 1, 0) \]

and hence

\[ \text{INTV} = (1, 3, 5, 7, 0, \ldots, 0) \quad (IV = 4) \]

For the active performance index variables \( u, w, q, \) and \( \theta, \) the input array \( \text{INTY} \) is

\[ \text{INTY} = (1, 0, 1, 0, 1, 0, 0, 0, 0, 0) \]

and hence

\[ \text{INTA} = (1, 3, 5, 7, 0, \ldots, 0) \quad (IA = IA1 = 4) \]
For the active parameters (see TABLE array in section "Display Arrays"), all the 
INTEG\(_{40}(I)\) values are 0 except for \( I = 2, 8, 9, 11, 13, 14, 16, 17 \), and hence

\[
\text{INTP} = (2, 8, 9, 11, 13, 14, 16, 17, 0, \ldots, 0) \quad (\text{IP} = 8)
\]

By putting in these arrays and the FORTRAN variables listed in the subroutine 
DSPLAY arrays, the test case is set up.

Test Case Run Procedure

The program deck or the data cell control cards are read into the computer after 
selecting RESET mode and both RELEASE switches, and FSS 3, 4, 9, and 16 true. The 
dynamic check case is then run before the test case or normal use of the parameter esti-
mation program.

The step-by-step procedure for running the test case from the control console is 
described as follows:

<table>
<thead>
<tr>
<th>Steps</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Change constants, ( \bar{\alpha} ) and activeness by ( \text{means of DDDU}. ) Depress FSS(3), FSS(4), FSS(5), and FSS(9), and then release FSS(4).</td>
<td>Program initialization.</td>
</tr>
<tr>
<td>(2) Depress PRINT switch.</td>
<td>I.C. printout of true parameters.</td>
</tr>
<tr>
<td>(3) When RESET light comes on, depress lower RELEASE switch.</td>
<td>Return to level (4,0).</td>
</tr>
<tr>
<td>(4) Depress OPER switch.</td>
<td>OPERATE to fill flight-data arrays with pseudo data.</td>
</tr>
<tr>
<td>(5) When WL(20) comes on: release FSS(3) and FSS(9); depress RESET switch and depress FSS(13), then release FSS(13).</td>
<td>End of pseudo data fill and return to RESET mode.</td>
</tr>
<tr>
<td>(6) Change to desired standard deviations and change IPRINT to 3 by means of the the DDDU, then depress PRINT switch.</td>
<td>Adds random numbers to pseudo data and prints characteristics.</td>
</tr>
<tr>
<td>(7) When RESET light comes on, depress lower RELEASE switch.</td>
<td>Return to level (4,0).</td>
</tr>
</tbody>
</table>
Steps

(8) Change $\tilde{\alpha}$ to offset values and change IPRINT to 1, then depress PRINT switch.

(9) When RESET light comes on, depress lower RELEASE switch.

(10) Depress FSS(10) and OPER switch.

(11) When WL(20) comes on, release FSS(10) and depress FSS(13).

(12) Release FSS(13) at convergence.

(13) When WL(20) comes on: depress RESET switch; and depress FSS(13), then release.

(14) Depress PRINT switch.

(15) When RESET light comes on, depress lower RELEASE switch.

Task

Inputs $\tilde{\alpha}$ offsets and gets I.C. printout.

Return to level (4,0).

OPERATE to obtain initial weighting.

OPERATE automatically updating $\tilde{\alpha}$.

Stops run.

Return to RESET mode.

Routes maximum likelihood printout.

Return to level (4,0).

Output Listings

Four output listings are presented to illustrate the computer printouts. (Note that variables in $\tilde{y}_J$ are referred to as algorithm variables in the output listings.)

(1) Random number characteristics where RN and RSD denote the means and standard deviations, respectively, used in the program

(2) Initial condition printout
   (a) Showing the true parameter values used to generate the pseudo test case
   (b) Showing the offset parameter values used as the starting point for the estimation procedure
(3) Maximum likelihood printout for each iteration (a total of 11) where the modified covariance matrix for the parameters is

\[
\begin{pmatrix}
\sigma_{\alpha_1} & \rho_{\alpha_1 \alpha_2} & \cdots & \rho_{\alpha_1 \alpha_{iP}} \\
\rho_{\alpha_2 \alpha_1} & \sigma_{\alpha_2} & \cdots & \rho_{\alpha_2 \alpha_{iP}} \\
& \cdots & \cdots & \\
\rho_{\alpha_{iP} \alpha_1} & \rho_{\alpha_{iP} \alpha_2} & \cdots & \sigma_{\alpha_{iP}}
\end{pmatrix}
\]

Tabulated results of the test cases are presented in reference 1. Figure 2 shows the CalComp plot representation of the CRT display of the converged solution and the pseudo data, and the control inputs.

**RANDOM NUMBER CHARACTERISTICS**

**RUN**= 1  **NOPTS**= 201

<table>
<thead>
<tr>
<th>DRM(1)</th>
<th>RN(1)</th>
<th>DRSD(1)</th>
<th>RSD(1)</th>
</tr>
</thead>
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<td>-7.944999E-15</td>
<td>5.000000E-01</td>
<td>5.000000E-01</td>
</tr>
<tr>
<td>0.</td>
<td>3.6641090E-15</td>
<td>3.000000E-00</td>
<td>3.000000E-00</td>
</tr>
<tr>
<td>0.</td>
<td>-3.866448E-17</td>
<td>2.000000E-02</td>
<td>2.000000E-02</td>
</tr>
<tr>
<td>0.</td>
<td>-5.153423E-16</td>
<td>2.000000E-02</td>
<td>2.000000E-02</td>
</tr>
</tbody>
</table>
**INITIAL CONDITION PRINTOUT (TRUE PARAMETER VALUES)**

RUN = 1

LOGIC (1) = T LOGIC (2) = T LOGIC (3) = F LOGIC (4) = F LOGIC (5) = F

LOGIC (6) = F LOGIC (7) = F LOGIC (8) = F LOGIC (9) = F LOGIC (10) = F LOGIC (11) = F

ACTIVE EQUATION VARIABLES ARE . . U, W, Q, THE

ACTIVE ALGORITHM VARIABLES ARE . . U, W, Q, THE

<table>
<thead>
<tr>
<th>PARAM</th>
<th>VALUE</th>
<th>ACT</th>
<th>PARAM</th>
<th>VALUE</th>
<th>ACT</th>
<th>PARAM</th>
<th>VALUE</th>
<th>ACT</th>
<th>PARAM</th>
<th>VALUE</th>
<th>ACT</th>
<th>PARAM</th>
<th>VALUE</th>
<th>ACT</th>
</tr>
</thead>
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<tr>
<td>UO</td>
<td>2.99999E+02</td>
<td>F</td>
<td>CXO</td>
<td>1.120000E-01</td>
<td>T</td>
<td>CXAL</td>
<td>0</td>
<td>F</td>
<td>CXQ</td>
<td>0</td>
<td>F</td>
<td>THEO</td>
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<td>F</td>
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<td>F</td>
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<td>CZAL</td>
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<td>F</td>
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<table>
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<th>WMULT</th>
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<th>1.000000E+00</th>
<th>RMULT</th>
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<td>AMULT</td>
<td>1.000000E+00</td>
<td>DMULT</td>
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<table>
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<th>WEIGHT</th>
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<td>ZZ</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CMCON | 0     | DALMUL | 1.000000E+00 | UCRTRB1| 2.100000E+02 | AIW   | 0     | CTO    | 0     | CT0    | 0     |
| CTRB | 0     | CTR    | 0     | D      | 0     | CAPDT  | 0     | ELBAR  | 0     | ELPB   | 0     |
| RB    | 0     | PPER   | 0     | TPER   | 0     | BTIAS  | 0     | PPERBI | 0     | TPERBI | 0     |
| TX    | 0     | TY     | 0     | TZ     | 0     | AMX    | 0     | AMY    | 0     | AMZ    | 0     |

NQPTS = 201 INC = 1
INITIAL CONDITION PRINTOUT (OFFSET PARAMETER VALUES)

RUN= 1
LOGIC (1)=T LOGIC (2)=T LOGIC (3)=F LOGIC (4)=F LOGIC (5)=F LOGIC (6)=F
LOGIC (7)=F LOGIC (8)=F LOGIC (9)=F LOGIC (10)=F LOGIC (11)=F

ACTIVE EQUATION VARIABLES ARE ... U  W  Q  THE

ACTIVE ALGORITHM VARIABLES ARE ... U  W  Q  THE

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# ALGORITHM PRINTOUT

**RUN**: 1  **PASS**: 0  **DET1**: 2.184853E+17  **DET2**: 2.911344E+00  **AP**: 1.322543E+05  

**ACTIVE ALGORITHM VARIABLES ARE**: U, W, Q, THE

**PACKED MEAN ALGORITHM**

-1.7961E+01  -5.1772E+00  2.6770E-02  1.4646E-01

**PACKED NOISE COVARIANCE MATRIX**

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<th>-4.0594E+00</th>
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**PACKED WEIGHT MATRIX**

|          | 1.6781E-03 | 0.0. | 1.6122E-02 | 0.0. | 0.0. | 3.9311E+02 | 0.0. | 3.2298E+01 |

**PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE**

| UO | 2.699900E+02 | 0.0. | CXO | 1.000000E+01 | 5.441510E-03 | CXAL | 0.0. |
| CNO | 0.0. | 0.0. | THEO | 8.000000E+02 | 0.0. | PHIO | 0.0. |
| WO | 5.000000E+00 | 0.0. | CZO | -8.300000E+01 | -4.528541E-01 | CZAL | -3.500000E+00 | -7.836530E+01 |
| CNO | 0.0. | 0.0. | CZO | -4.000000E+00 | -1.10759E+00 | CZAL | 0.0. | 0.0. |
| CMQ | 1.000000E+00 | 5.925843E-03 | CMAL | -5.300000E-01 | -2.62519E-01 | CMALD | 0.0. | 0.0. |
| CMQ | 2.500000E-01 | -1.671633E+01 | CMDE | -2.000000E+00 | -1.079041E+00 | VO | 0.0. | 0.0. |
| CYO | 0.0. | 0.0. | CYB | 0.0. | 0.0. | CYD | 0.0. | 0.0. |
| CYP | 0.0. | 0.0. | CYR | 0.0. | 0.0. | CLR | 0.0. | 0.0. |
| CNO | 0.0. | 0.0. | CLO | 0.0. | 0.0. | CLP | 0.0. | 0.0. |
| CNO | 0.0. | 0.0. | CLD | 0.0. | 0.0. | RO | 0.0. | 0.0. |
| CNO | 0.0. | 0.0. | CNO | 0.0. | 0.0. | CNB | 0.0. | 0.0. |
| CNO | 0.0. | 0.0. | CNO | 0.0. | 0.0. | CNB | 0.0. | 0.0. |
| CMQ | 0.0. | 0.0. | CMQ | 0.0. | 0.0. | CNO | 0.0. | 0.0. |

**MODIFIED PARAMETER COVARIANCE MATRIX**

| CNO | 1.32971E-02 | -5.09530E+02 | -9.66967E-05 | -1.822915E-01 | 1.331663E-01 | 2.07192E-01 | 2.917058E-02 | 1.719726E-01 |
| CNO | 5.69730E+02 | 4.170712E-02 | 8.307203E-01 | 2.979134E-01 | 3.498151E-02 | 3.127489E-01 | 4.412566E-01 | -8.200848E-02 |
| CZDE | 1.822915E-01 | -2.979134E-01 | 4.127494E-01 | 1.351781E+00 | 1.637372E-01 | -5.025312E-01 | -4.601351E-01 | -4.06792E-01 |
| CMQ | 1.331663E-01 | 2.979134E-01 | 4.127494E-01 | 1.351781E+00 | 1.637372E-01 | -5.025312E-01 | -4.601351E-01 | -4.06792E-01 |
| CMQ | 2.07192E-01 | 3.498151E-02 | 8.307203E-01 | 2.979134E-01 | 3.498151E-02 | 3.127489E-01 | 4.412566E-01 | -8.200848E-02 |
| CMQ | 2.917058E-02 | 3.127489E-01 | -3.314947E-01 | -5.025312E-01 | -6.30407E-01 | 4.07069E-02 | 1.265490E-01 | 3.70+23E+00 |

---

**TABLE:**

- **UO, CXO, THEO, CYO, CNO, CNO, CMQ, CNO, CNO, CNO:** These are parameters and their values in the algorithm run.
- **PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE:** These indicate changes in the parameters and their values.
- **MODIFIED PARAMETER COVARIANCE MATRIX:** This shows the covariance matrix for the modified parameters.
ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 1 DET1= 4.566813E+15 DET2= 2.911344E+00 AJP= 3.417685E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U . .W .Q . THE

PACKED MEAN ARRAY
-1.9312E+00 -2.7791E-02 2.6002E-03 1.5732E-02

PACKED NOISE COVARIANCE MATRIX
6.6354E+00 -3.3881E-01 1.8591E-04 -4.4760E-02
-3.8881E-01 1.0367E+01 3.3539E-03 1.0495E-02
1.8591E-04 3.3539E-03 5.6745E-04 3.5200E-05
-4.4760E-02 1.0495E-02 3.5200E-05 7.9216E-04

PACKED WEIGHT MATRIX
1.6781E-03 0. 0. 0.
0. 1.6122E-02 0. 0.
0. 0. 3.9311E+02 0.
0. 0. 0. 3.2298E+01

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
UD 2.099000E+02 0. CXO 1.054415E-01 1.527980E-03 CAZL 0. 0.
CZO 0. 0. THEO 8.000000E-02 0.
W0 5.000000E+00 0. CZO -1.252856E+00 -3.605968E-02 CZA0 4.283653E+00 -2.625515E-01
CZO 0. 0. CZE 5.110759E+00 5.156919E-01 QD 0. 0.
CMO 1.592584E-02 3.606238E-03 CMAL -7.605739E-01 -4.926042E-02 CMALD 0. 0.
CMQ -4.171633E+01 9.767419E-00 CMDE -3.079041E+00 -2.713502E-02 VO 0. 0.
CYO 0. 0. CY0 0. 0. CYBD 0. 0.
CYP 0. 0. CYR 0. 0. CYDR 0. 0.
PO 0. 0. CLO 0. 0. CLB 0. 0.
CLBD 0. 0. CLP 0. 0. CLR 0. 0.
CLDR 0. 0. CLDA 0. 0. RO 0. 0.
CND 0. 0. CNE 0. 0. CNBD 0. 0.
CNP 0. 0. CNR 0. 0. CNDR 0. 0.
CNOA 0. 0.

MODIFIED PARAMETER COVARIANCE MATRIX

CXO 1.388403E-02 2.483655E-02 6.178364E-02 -1.564695E-01 3.617779E-01 9.985538E-02 1.099767E-01 1.802458E-01
CZO 2.483655E-02 3.007918E-02 -6.082048E-01 -1.132642E-01 5.954329E-02 2.025015E-01 1.840243E-01 9.665531E-02
CZDE -1.564695E-01 -1.132642E-01 3.301225E-01 1.431255E+00 3.045813E-01 -4.785760E-01 -3.105557E-01 -3.501976E-01
CMO 3.617779E-01 5.954329E-02 6.339838E-02 3.045813E-01 2.397161E-03 -5.553772E-01 2.170690E-01 1.604847E-01
CMAL 9.985538E-02 1.840243E-01 -4.118849E-01 -3.105557E-01 1.756323E-01 -1.083625E-01 4.967757E+00 7.737113E-01
CMQ 1.099767E-01 1.802458E-01 -9.665531E-02 1.112003E-02 -3.501976E-01 1.604847E-01 -1.083625E-01 2.138615E-01
CMDE
ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 2 DET1= 4.174016E+24 DET2= 3.092048E+05 AJP= 1.902637E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

PACKED MEAN ARRAY
3.7179E-01 -1.3210E-01 3.4749E-04 1.4559E-03

PACKED NOISE COVARIANCE MATRIX
4.8250E-01 2.1328E-02 -3.8777E-04 -7.9297E-04
2.1328E-02 8.9826E+00 -2.3407E-03 -1.4428E-03
-3.8777E-04 -2.3407E-03 3.9899E-04 6.5345E-06
-7.9297E-04 -1.4428E-03 6.5345E-06 4.0680E-04

PACKED WEIGHT MATRIX
1.5071E-01 0. 0.
0. 9.6663E-02 0.
0. 0. 1.7623E+03 0.
0. 0. 0. 1.2624E+03

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
U0 2.099000E+02 0. CXD 1.069695E-01 2.453560E-03 CXAL 0. 0.
CXD 0. 0. THEO 8.000000E+02 0. PHIO 0.
WO 5.000000E+00 0. CJOE -4.959667E+00 -5.297208E-02 QO 0.
CJO 0. 0. CMAL -8.098934E-01 -9.923283E-03 CMALD 0.
CMO -3.194681E+01 -1.180978E+00 CMDE -3.106176E+00 1.608270E-02 VD 0.
CMO 0. 0. CYB 0.
CYP 0. 0. CYR 0.
PO 0. 0. CLK 0.
CLBD 0. 0. CLP 0.
CLDR 0. 0. CLDA 0.
CND 0. 0. CNB 0.
CND 0. 0. CNR 0.
CND 0. 0.

MODIFIED PARAMETER COVARIANCE MATRIX

CZD 9.497733E-02 9.533276E-03 -7.001E-01 -1.0815E-01 5.6427E-01 1.35372E-02 3.671161E-01 2.489799E-01
CZL -2.1361E-01 -7.001E-01 2.6695E-01 3.6350E-01 -1.0015E-01 -7.1510E-03 -5.9316E-01 -1.4319E-01
CZD -5.1394E-01 -1.0815E-01 3.6350E-01 5.5311E-01 5.3537E-01 -5.4132E-01 -3.2187E-01 -3.2969E-01
CMO 1.8748E-04 1.0015E-01 -1.0015E-01 -5.4132E-01 9.9190E-04 -5.0783E-03 1.3103E-01 -2.7090E-02
CMAL 1.017347E-01 3.5337E-01 -7.1510E-03 -5.4132E-01 -5.0783E-03 2.0633E-02 -2.7946E-02 -1.9646E-02
CMQ 3.995688E-01 3.5337E-01 -5.9316E-01 -3.2187E-01 -1.9646E-02 7.5317E-02 7.5317E-02 7.5317E-02
CMDE 3.349321E-01 2.489799E-01 -1.4319E-01 -3.2969E-01 7.5317E-02 7.5317E-02 7.5317E-02 7.5317E-02
ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 3 DET1= 2.173468E+27 DET2= 7.034618E-07 AJP= 1.830437E+03

ACTIVE ALGORITHM VARIABLES ARE U, W, Q, THE

PACKED MEAN ARRAY
-1.3953E-02 -1.8858E-02 2.1345E-04 9.9433E-04

PACKED NOISE COVARIANCE MATRIX
2.5447E-01 4.8338E-02 -4.5240E-04 -1.0977E-03 1.5680E-03
4.8338E-02 8.8514E+00 -2.5297E-03 -1.3953E+00 -2.5447E+00
-4.5240E-04 -2.5297E-03 3.9852E-04 5.0384E-06 3.9540E-04
-1.0977E-03 -1.3953E+00 6.0384E-06 3.9540E-04

PACKED WEIGHT MATRIX
2.0726E+00 0. 0. 0.
C. 1.1133E-01 0. 0. 0.
C. 0. 2.5063E+03 0. 0.
C. 0. 0. 2.4582E+03

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
UD 2.0999900E+02 0. CXL 1.094231E-01 6.475541E-04 CAL 0. 0.
CXX 0. 0. 0. THEO 8.030900E-02 0. 0. 0.
WO 5.003000E+00 0. 0. CZO -1.291446E+00 1.668864E-03 CZL -4.428492E+00 6.331718E-03
CZ0 0. 0. 0. CDE -4.668639E-00 -2.386667E-01 QQ 0. 0.
CMO -3.312989E+01 1.507396E-04 0. 0. CMG -3.000945E+00 1.0985320E-02 WD 0. 0.
CMQ 0. 0. 0. CYO 0. 0. 0. CYB 0. 0.
CYP 0. 0. 0. CYR 0. 0. 0. CYDR 0. 0.
PO 0. 0. 0. CLO 0. 0. 0. CLR 0. 0.
CLOD 0. 0. 0. CLDA 0. 0. 0. RO 0. 0.
CNO 0. 0. 0. CNB 0. 0. 0. CNBD 0. 0.
CNP 0. 0. 0. CNR 0. 0. 0. CNDR 0. 0.
CNO 0. 0.

MODIFIED PARAMETER COVARIANCE MATRIX

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MODIFIED PARAMETER COVARIANCE MATRIX

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ALGORITHM PRINTOUT – Continued

RUN = 1  PASS = 4  DFT1 = 1.14056E+28  DFT2 = 3.585114E-07  AJP = 1.838583E+03

ACTIVE ALGORITHM VARIABLES ARE U, W, Q, THE

PACKED MEAN ARRAY
-9.0181E-03 -5.4658E-02 2.9479E-04 1.1456E-03

PACKED NOISE COVARIANCE MATRIX
2.4623E-01 4.2017E-02 -4.2549E-04 -1.3149E-03
4.2017E-02 8.9202E+00 -2.8076E-03 -1.3149E-03
-4.2549E-04 -2.8076E-03 3.9913E-04 5.0420E-06
-1.3149E-03 -1.3149E-03 5.0420E-06 3.9828E-04

PACKED WEIGHT MATRIX
3.9298E+00 0.0 0.0 0.0
1.1298E-01 0.0 0.0 0.0
0.0 3.5093E+03 0.0 0.0
0.0 0.0 2.5037E+03 0.0

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
UG 2.09930E+02 0.0 CIO 1.10071E-01 1.60421E-05 CXL 0.0 0.0
CIO 0.0 0.0 THEO 8.00000E-02 0.0 PHIO 0.0 0.0
WG 5.00000E+00 0.0 CZO -1.28977E+00 5.805288E-04 CZL -4.434823E+00 -7.395059E-04
CZO 0.0 0.0 CZDE -4.86699E+00 -3.65240E-02 QD 0.0 0.0
CMO 1.95634E+02 3.363449E-05 CAML -8.218868E-01 2.290303E-04 CMAL 0.0 0.0
CMO -3.267326E+01 -1.190056E-01 CMOE -3.074323E+00 -1.139747E-02 VQ 0.0 0.0
CYO 0.0 0.0 CYB 0.0 0.0 CYBD 0.0 0.0
CYP 0.0 0.0 CYR 0.0 0.0 CYDR 0.0 0.0
PO 0.0 0.0 CLO 0.0 0.0 CLB 0.0 0.0
CLRO 0.0 0.0 CLP 0.0 0.0 CLR 0.0 0.0
CNO 0.0 0.0 CLDA 0.0 0.0 RO 0.0 0.0
CNP 0.0 0.0 CNB 0.0 0.0 CNBD 0.0 0.0
CDN 0.0 0.0 CNR 0.0 0.0 CNDR 0.0 0.0

MODIFIED PARAMETER COVARIANCE MATRIX

CZO -3.133256E-01 -7.045692E-01 2.235314E-01 3.650897E-01 -1.507491E-01 2.977621E-02 -6.420382E-01 -1.491636E-01
CMO -2.555880E-01 1.992884E-02 2.977621E-02 -6.420382E-01 -3.964290E-01 1.658863E-02 1.821608E-01 3.393999E-02
CMO 3.250012E-01 -6.420382E-01 -2.405253E-01 7.523306E-02 6.420382E-01 1.234104E+00 1.821608E-01 1.821608E-01
ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 5 DET1= 1.225144E+28 DET2= 3.483735E-07 AJP= 1.840700E+03

ACTIVE ALGORITHM VARIABLES ARE • • U • • , THE

Packed Mean Array
-5.6360E-03 -6.9424E-02 3.2014E-04 1.2667E-03

Packed Noise Covariance Matrix
2.4535E-01 4.0423E-02 -4.3564E-04 -1.0238E-03
4.0423E-02 8.9116E-00 -2.8455E-03 1.2668E-03
-4.3564E-04 -2.8455E-03 3.9910E-04 5.3289E-06
-1.0238E-03 -1.2668E-03 5.3289E-06 3.5881E-04

Packed Weight Matrix
4.0613E+00 0.
0. 1.1236E-01 0.
0. 0. 2.5054E+00 0.
0. 3. 0.

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE  
UD 2.099000E+02 0. CXD 1.100850E-01 1.711584E-05 CSD 0. 0.  
CQ 0. 0. TPED 8.000000E-02 0. 0. PHIO 0. 0.  
WQ 5.000000E+00 0. CQD -1.289196E+00 2.408599E-05 CSD -4.435563E+00 2.265796E-04  
CQ 0. 0. CZDE -4.925352E+00 3.311569E-03 QD 0. 0.  
CA 1.959712E-02 2.683831E-06 CMAL -8.216578E-01 4.584780E-05 CMALD 0. 0.  
CMQ -5.279227E+01 -6.166114E-03 CMQD -3.085628E+00 7.093316E-04 VG 0. 0.  
CYO 0. 0. CYB 0. 0. CYBD 0. 0.  
CYP 0. 0. CYR 0. 0. CYRD 0. 0.  
PO 0. 0. CLO 0. 0. CLB 0. 0.  
CLBD 0. 0. CLP 0. 0. CLR 0. 0.  
BD 0. 0. CLDA 0. 0. RO 0. 0.  
CND 0. 0. CNB 0. 0. CNBD 0. 0.  
CNP 0. 0. CNR 0. 0. CNDR 0. 0.  
CNDA 0. 0.  

Modified Parameter Covariance Matrix

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ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 6 DET1= 1.231132E+28 DET2= 3.480124E-07 AJP= 1.840942E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U . . . U THE

PACKED MEAN ARRAY
-5.5126E-03 -7.0467E-02 3.2046E-04 1.2668E-03

PACKED NOISE COVARIANCE MATRIX
2.4531E-01 4.0320E-02 -4.3616E-04 -1.0230E-03
4.0320E-02 3.9128E+00 -2.8430E-03 -1.2619E-03
-4.3616E-04 -2.8430E-03 3.9910E-04 5.3430E-06
-1.0230E-03 -1.2619E-03 5.3430E-06 3.5883E-04

PACKED WEIGHT MATRIX
4.0758E+00 0. 0. 0.
0. 1.1221E-01 0. 0.
0. 0. 2.5056E+03 0.
0. 0. 0. 2.5075E+03

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
UD 2.099000E+02 0. 0. CXO 1.100968E-01 1.163282E-07 CXAL 0. 0.
CQ 0. 0. 0. THEO 8.000000E-02 0. 0. PHID 0. 0.
WO 5.000000E+00 0. 0. CZD 1.289172E+00 7.819492E-06 CZAL -4.435336E+00 -8.690501E-05
CQ 0. 0. 0. CIDE -4.928663E+00 -3.145478E-04 Q3 0. 0.
CMO 1.959980E-02 2.142493E-07 CMAL -8.216119E-01 1.022085E-05 CMALD 0. 0.
CMQ -3.279843E+01 -1.103374E-03 CMDE -3.086337E+00 -1.348413E-04 VO 0. 0.
CYD 0. 0. CYB 0. 0. CYBD 0. 0.
CP 0. 0. CPY 0. 0. CYDR 0. 0.
FO 0. 0. 0. CLO 0. 0. CLA 0. 0.
CLBD 0. 0. CLP 0. 0. CLR 0. 0.
CLUD 0. 0. CLDA 0. 0. RO 0. 0.
CND 0. 0. CNB 0. 0. CNBD 0. 0.
CNP 0. 0. CNR 0. 0. CNDR 0. 0.
CND 0. 0. 0.

MODIFIED PARAMETER COVARIANCE MATRIX

CDO 9.378918E-02 7.820373E-03 -7.042382E-01 2.230846E-01 3.639507E-01 -1.513518E-01 2.859480E-02 -6.429889E-01 -1.485731E-02
CZAL -3.195967E-01 -7.042382E-01 2.230846E-01 3.639507E-01 -1.513518E-01 2.859480E-02 -6.429889E-01 -1.485731E-02
**ALGORITHM PRINTOUT - Continued**

RUN = 1 PASS = 7 DET1 = 1.231219E+28 DET2 = 3.480109E-07 AJP = 1.840966E+03

**ACTIVE ALGORITHM VARIABLES ARE** U, W, THE

**PACKED MEAN ARRAY**
-5.49283E-03 -7.3646E+02 3.2065E-04 1.26841E-03

**PACKED NOISE COVARIANCE MATRIX**
2.4530E-01 +0.0312E-02 -4.3630E-04 -1.0229E-03
4.0312E-02 8.9129E+00 -2.8431E-03 -1.2617E-03
-4.3630E-04 -2.8431E-03 3.9910E-04 5.3471E-05
-1.0229E-03 -1.2617E-03 5.3471E-05 3.9883E-04

**PACKED WEIGHT MATRIX**
4.0765E+00 0. 0. 0.
0. 1.1220E-01 0. 0.
0. 0. 2.5056E+03 0.
0. 0. 0. 2.5074E+03

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**MODIFIED PARAMETER COVARIANCE MATRIX**

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ALGORITHM PRINTOUT – Continued

RUN=1  PASS=8  DET1=1.231248E+28  DET2=3.430108E+07  AJP=1.840969E+03

ACTIVE ALGORITHM VARIABLES ARE...U...W....Q....THE

PACKED MEAN ARRAY
-5.4913E-03 -7.3656E-02 3.2065E-04 1.2681E-03

PACKED NOISE COVARIANCE MATRIX
2.4530E-01 4.0311E-02 -4.3630E-04 -1.0229E-03
4.0311E-02 8.9130E+00 -2.8431E-03 -1.2617E-03
-4.3630E-04 -2.8431E-03 5.3472E-06 3.9883E-04
-1.0229E-03 -1.2617E-03 5.3472E-06 3.9883E-04

PACKED WEIGHT MATRIX
4.0766E+00 0.0 0.0
1.1220E-01 0.0 0.0
2.5056E+03 0.0 0.0
2.5073E+03

PARAM VALUE CHANGE PARAM VALUE CHANGE PARAM VALUE CHANGE
UO 2.099300E+02 0.0 CXO 1.163700E-01 -7.717599E-09 CXAL 0.0 0.0
CXQ 0.0 0.0 THE 8.000000E-02 0.0 PHIO 0.0 0.0
WO 5.000000E+00 0.0 CZO -1.289164E+00 1.338340E+07 CZAL -4.343240E+00 -1.972368E-06
CZO 0.0 0.0 CDE -4.929016E+00 -2.661941E+06 QD 0.0 0.0
CNO 1.963000E+02 1.522098E-09 CFAL -8.216099E+01 1.095997E-07 CHALD 0.0 0.0
CMQ -3.279954E+01 -6.122211E-06 CMOE -3.038647E+00 -1.257595E-06 VO 0.0 0.0
CYO 0.0 0.0 CYB 0.0 0.0
CYP 0.0 0.0 CYR 0.0 0.0
PD 0.0 0.0 CLD 0.0 0.0
CLBO 0.0 0.0 CLR 0.0 0.0
CLDR 0.0 0.0 CLDA 0.0 0.0
CNO 0.0 0.0 CNB 0.0 0.0
CNP 0.0 0.0 CNR 0.0 0.0
CND 0.0 0.0

MODIFIED PARAMETER COVARIANCE MATRIX

CZAL -3.190537E-01 -7.042247E-01 2.230633E-01 1.363922E-01 -1.257170E-01 1.513710E-01 2.861534E-02 -6.420838E-01 -1.485638E-01
CMQ -3.190537E-01 -3.702024E-01 -2.983939E-01 2.396340E-01 2.861534E-02 -8.420838E-01 1.513710E-01 2.861534E-02 -1.485638E-01
CMQ -3.702024E-01 -2.983939E-01 2.396340E-01 2.861534E-02 -8.420838E-01 1.513710E-01 2.861534E-02 -1.485638E-01 5.584104E-01
### ALGORITHM PRINTOUT – Continued

RUN= 1 PASS= 9 DET1= 1.231246E+28 DET2= 3.480108E-07 AJP= 1.840969E+03

**ACTIVE ALGORITHM VARIABLES ARE . . . U . . . W . . . C . . . THE**

PACKED MEAN ARRAY
-5.4911E-03 -7.0658E-02 3.2065E-04 1.2682E-03

PACKED NOISE COVARIANCE MATRIX
2.4530E-01 4.0311E-02 -4.3630E-04 -1.0229E-03
4.0311E-02 8.9130E+00 -2.8431E-03 -1.2617E-03
-4.3630E-04 -2.8431E-03 3.9910E-04 5.3472E-06
-1.0229E-03 -1.2617E-03 5.3472E-06 3.5883E-04

PACKED WEIGHT MATRIX
4.0766E+00 0.
0.1.1220E-01 0.
0.0.
2.5056E+03 0.
2.5073E+03

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MODIFIED PARAMETER COVARIANCE MATRIX

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## ALGORITHM PRINTOUT – Concluded

RUN= 1 PASS= 10 DET1= 1.231249E+28 DET2= 3.480108E-07 AJP= 1.840969E+03

### ACTIVE ALGORITHM VARIABLES ARE... U, W, Q, THE

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### PACKED NOISE COVARIANCE MATRIX
-2.57359E-01 -4.43630E-04 -1.0229E-03 -5.3742E-06

### PACKED WEIGHT MATRIX
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0.0 1.120E+01 0.0 0.0
0.0 0.0 2.5056E+03 0.0
0.0 0.0 0.0 2.5073E+03

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### MODIFIED PARAMETER COVARIANCE MATRIX

| CJO    | 9.378269E-02 | 7.820814E-03 | -7.64224E-01 | -2.573919E-02 | 6.761419E-01 | 2.257754E-02 | 3.070243E-01 | 5.369313E-02 |
| CJO    | -3.19637E-01 | 7.04224E-01  | 2.235863E-01 | 3.639320E-01  | -1.513713E-01 | 2.861588E-02 | -6.429488E-01 | -1.445637E-01 |
| CJO    | 9.378269E-02 | 7.820814E-03 | -7.64224E-01 | -2.573919E-02 | 6.761419E-01 | 2.257754E-02 | 3.070243E-01 | 5.369313E-02 |
| CMQ    | 7.915706E-02 | 2.613461E-01 | 4.432570E-01 | 3.236841E-01 | 7.327144E-01 | 5.584705E-02 |
| CMQ    | 3.236841E-02 | -5.369313E-02 | 1.485637E-01 | -1.977856E-01 | 4.942664E-02 | -3.254150E-02 | 7.327144E-01 | 5.584705E-02 |
CONCLUDING REMARKS

A computer program has been developed for estimating aircraft stability and control parameters from flight test data. The maximum likelihood estimation program has been implemented on the Langley real-time simulation system. The control and display capabilities of the system allow the analyst to interact with the program. The interactive capability is highly desirable, as evident in the reports on the analysis of flight test data. Variable dimensioning allows the analyst to activate any part of the nonlinear six-degree-of-freedom aircraft mathematical model, select the variables in the performance index function, and choose which parameters are to be estimated. Although this report uses a particular aircraft example, it is applicable to any dynamic system fitting into the framework of the program.

Langley Research Center,
National Aeronautics and Space Administration,
APPENDIX A

PROGRAM CONTROL AND DISPLAY CAPABILITIES

The computer program has been written in FORTRAN IV (75,000 octal locations) and run on the RTS system of the Control Data series 6000 digital computer complex. The computer program was mechanized into an iterative estimation procedure with manual interactive control and graphic display capabilities through the utilization of the RTS system. Figure 3(a) shows a photograph of the program control station and figure 3(b) shows a closeup of the control panel. The components are listed below as they appear (left to right) in figure 3:

Program control station:
- Graphic display unit
  - Cathode ray tube (CRT)
  - Interactive keyboard
- Time history recorder
- x-y plotter (not used)
- Control console
  - White indicator lights (WL)
  - Red indicator lights, bottom row (not used)
  - Function sense switches (FSS)
  - Mode control switches
  - Data entry keyboard
  - Digital decimal display unit (DDDU)
  - Potentiometers (not used)
  - Output device (typewriter)

The CRT displays the flight test maneuver at the start of each iteration. The response of the equations of motion as it is computed in the digital program is plotted with the flight test maneuver for direct comparison. This display permits quick analysis of each flight test case on an iteration to iteration basis. Figure 4 shows CalComp plots representing three CRT displays; they are part of the dynamic check.

The analyst investigating the stability and control derivatives of the aircraft has direct control of the computer program through the control console. The white indicator lights (WL(1) - WL(39)) are used to indicate program status or diagnostics. The diagnostics are described in the LDISO array of the Display Arrays section. The function sense switches (FSS(1) to FSS(16)) are used to select program options (switch depressed results in logical true value). The options are described in the LDISI array of the Display Arrays section.
APPENDIX A – Continued

The mode control keyboard (shown below) is used to control the running of the RTS computer program.

<table>
<thead>
<tr>
<th>OPER</th>
<th>HOLD</th>
<th>RESET</th>
<th>TERM</th>
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<tbody>
<tr>
<td>CHANGE</td>
<td>SCAN</td>
<td>RELEASE</td>
<td></td>
</tr>
<tr>
<td>IDLE</td>
<td>READ</td>
<td>PRINT</td>
<td>RELEASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ERASE</td>
<td></td>
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</tbody>
</table>

Each switch (mode) is briefly described as to its use (mode nominally active when switch depressed):

**OPER (OPERATE)** – allows normal running of parameter estimation procedure (integration of equations of motion and sensitivity equations)

**HOLD** – holds estimation procedure at last time point (stops integration)

**RESET** – initializes estimation procedure at \( t = 0 \)

**TERM (TERMINATE)** – terminates program at control console and transfers control to graphic display unit

Activation of one mode automatically deactivates the previous one. The following modes are temporarily activated by the analyst during the parameter estimation study (normally when in **RESET** or **HOLD** modes):

**CHANGE** – changes program variable to the new value entered on the data entry keyboard and displayed on the DDDU

**SCAN** – scans through the display addresses in conjunction with subroutine SCANNER

**RELEASE** – releases **CHANGE** and **SCAN** modes

**ERASE** – erases real-time disk file
APPENDIX A – Continued

IDLE – idles the computer (no computations)
READ – loads read overlay
PRINT – loads print overlay
RELEASE – releases the four preceding modes

The data entry keyboard (shown below) is used to input new values for program variables.

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<thead>
<tr>
<th></th>
<th>0</th>
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<tr>
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<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>DECIMAL POINT</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>TAB</td>
<td>CR</td>
<td>ERASE</td>
<td>CR</td>
<td></td>
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</tbody>
</table>

The keyboard is used in conjunction with the DDDU (shown below).

<table>
<thead>
<tr>
<th>(Address field)</th>
<th>(Magnitude field)</th>
<th>(Exponent field)</th>
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<tr>
<td>A₁ A₂ A₃</td>
<td>± M₁ M₂ M₃ M₄ M₅</td>
<td>± E₁ E₂</td>
</tr>
</tbody>
</table>

The procedure for changing a floating-point number is as follows:

1. Enter address field – A₁ A₂ A₃
2. Depress TAB
3. Enter magnitude field – ± M₁ M₂ M₃ M₄ M₅
4. Depress TAB
5. Enter exponent field – ± E₁ E₂
6. Depress TAB
APPENDIX A – Concluded

(7) Depress \text{CR}

(8) Depress \text{CHANGE}

(9) Depress \text{RELEASE}

As the numbers and signs (plus sign assumed) are entered on the keyboard, they are displayed on the DDDU. The DDDU shows the final form of the number entered by the keyboard. Integers and logical variables are entered in a similar manner but with a different format. The switches \text{ERASE} and \text{CR} are used to erase the data field and character just entered, respectively.

The typewriter is used to type out the new and old values of the program variables. The time history recorder plots the variables defined in the DAC array (Display Arrays section). The interactive keyboard is used to restart and exit the program from the RTS system. A card reader and high-speed printer are located near the program control station and are easily accessible to the program operator.
APPENDIX B

EQUATIONS OF MOTION AND ACCELEROMETER EQUATIONS

The mathematical model is that of a nonlinear six-degree-of-freedom rigid-body aircraft, in particular, a V/STOL tilt-wing aircraft. The equations of motion are

\[ \dot{x} = F(x,\alpha,\delta,V,\alpha_a,\dot{\alpha}_a,\beta,\dot{\beta}) \]

\[ = [F_1, F_2, \ldots, F_8]^T \]  \hspace{1cm} (B1)

The state vector is

\[ \bar{x} = [x_1, x_2, \ldots, x_8]^T \]

\[ = [u,v,w,p,q,r,\theta,\phi]^T \]  \hspace{1cm} (B2)

The parameter vector is

\[ \bar{\alpha} = [\alpha_1, \alpha_2, \ldots, \alpha_{40}]^T \]

\[ = [u(0), (C_X)_{\alpha,t,\delta_e,t}, \ldots, C_n\delta_a]^T \]  \hspace{1cm} (B3)

The control deflection vector is

\[ \bar{\delta} = [\delta_a, \delta_e, \delta_r]^T \]  \hspace{1cm} (B4)

The equations of motion in detail are

\[ \dot{u} = F_1(x,\alpha,\delta,V,\alpha_a) \]

\[ = -qw + rv - g \sin \theta + a_1V^2(C_{X1} + C_{X2}) + \frac{T_X}{m} \]  \hspace{1cm} (B5)
$\dot{v} = F_2(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta)\]

$$\frac{-ru + pw + g \cos \theta \sin \phi + a_1 V^2 \left( C_{Y1} + C_{Y2} \right) + \frac{T_Y}{m}}{1 - a_3 C_Y \beta}$$

(B6)

$\dot{w} = F_3(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \alpha_a)\]

$$-pv + qu + g \cos \theta \cos \phi + a_1 V^2 \left( C_{Z1} + C_{Z2} \right) + \frac{T_Z}{m}$$

(B7)

$\dot{p} = F_4(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta})\]

$$a_6 F'_4(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta}) + b_1 F'_6(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta})$$

$$= a_6 \left[ b_2 qr + I_{XZ} pq + a_4 V^2 \left( C_{l1} + C_{l2} \right) + a_4 V S^2 \left( C_{l3} \right) + M_X \right]$$

$$+ b_1 \left[ b_3 pq - I_{XZ} qr + a_4 V^2 \left( C_{n1} + C_{n2} \right) - a_4 V S^2 \left( C_{n3} \right) + M_Z \right]$$

(B8)

$\dot{q} = F_5(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \alpha_a, \dot{\alpha}_a)\]

$$= a_7 pq + b_4 \left( r^2 - p^2 \right) + a_8 V^2 \left( C_{m1} + C_{m2} \right) + \frac{M_Y}{I_Y}$$

(B9)

$\dot{r} = F_6(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta})\]

$$= b_1 F'_4(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta}) + b_5 F'_6(\overline{x}, \overline{\alpha}, \overline{\delta}, V, \beta, \dot{\beta})$$

(B10)

$\dot{\theta} = F_7(\overline{t})\]

$$= q \cos \phi - r \sin \phi$$

(B11)
\[ \phi = F_{\theta}(\vec{x}) \]

\[ = p + (q \sin \phi + r \cos \phi) \tan \theta \quad \text{(B12)} \]

where

\[ a_1 = \frac{1}{2} \rho S \]
\[ a_2 = a_1 \left( \frac{c}{2} \right) \]
\[ a_3 = a_1 \left( \frac{b}{2} \right) \]
\[ a_4 = \frac{1}{2} \rho S b \]
\[ a_5 = a_4 \left( \frac{b}{2} \right) \]
\[ a_6 = \frac{I_z}{I_{x_l z} - I_{xz}^2} \]
\[ a_7 = \frac{I_z - I_x}{I_y} \]
\[ a_8 = \frac{1}{2} \frac{\rho}{I_y} \cdot \text{Sec}^2 \theta \]
\[ a_9 = a_8 \left( \frac{c}{2} \right) \]

\[ b_1 = \frac{I_{xz}}{I_{x_l z} - I_{xz}^2} \]
\[ b_2 = I_Y - I_Z \]
\[ b_3 = I_X - I_Y \]

\[ b_4 = \frac{I_{xz}}{I_y} \]
\[ b_5 = \frac{I_X}{I_{x_l z} - I_{xz}^2} \]

and

\[ V_S = V_{SS} + V \]

\[ C_{x_1} = \left( C_{x} \right)_{\alpha_{a,t}, \delta_{e,t}} + C_{x \alpha_a} \left( \alpha_a - \alpha_{a,t} \right) \]
\[ C_{x_2} = C_{x q} \frac{q e}{2 V} \]

\[ C_{y_1} = \left( C_{y} \right)_{\beta_{l}, \delta_{e,t}} + C_{y \beta} \left( \beta - \beta_l \right) + C_{y \delta_r} \left( \delta_r - \delta_{r,t} \right) \]
\[ C_{y_2} = \frac{b}{2 V} \left( C_{y p} + C_{y r} \right) \]

\[ C_{z_1} = \left( C_{z} \right)_{\alpha_{a,t}, \delta_{e,t}} + C_{z \alpha_a} \left( \alpha_a - \alpha_{a,t} \right) + C_{z \delta_e} \left( \delta_e - \delta_{e,t} \right) \]
\[ C_{z_2} = C_{z q} \frac{q e}{2 V} \]

\[ C_{l_1} = \left( C_{l} \right)_{\beta_{l}, \delta_{e,t}} + C_{l \beta} \left( \beta - \beta_l \right) + C_{l \delta_r} \left( \delta_r - \delta_{r,t} \right) \]
\[ C_{l_2} = \frac{b}{2 V} \left( C_{l p} + C_{l r} \right) \]

\[ C_{l_3} = C_{l_{\beta a}} \left( \beta_a - \beta_{a,t} \right) \]

\[ C_{m_1} = \left( C_{m} \right)_{\alpha_{a,t}, \delta_{e,t}} + C_{m \alpha_a} \left( \alpha_a - \alpha_{a,t} \right) + C_{m \delta_e} \left( \delta_e - \delta_{e,t} \right) \]
\[ C_{m_2} = \frac{c}{2 V} \left( C_{m \alpha_a} + C_{m q} \right) \]

\[ C_{m_3} = C_{m_{\beta a}} \left( \beta_a - \beta_{a,t} \right) \]

\[ C_{n_1} = \left( C_{n} \right)_{\beta_{l}, \delta_{e,t}} + C_{n \beta} \left( \beta - \beta_l \right) + C_{n \delta_r} \left( \delta_r - \delta_{r,t} \right) \]
\[ C_{n_2} = \frac{b}{2 V} \left( C_{n p} + C_{n r} \right) \]

\[ C_{n_3} = C_{n_{\beta a}} \left( \beta_a - \beta_{a,t} \right) \]

\[ C_{n_{\delta a}} = C_{n \delta a} \sin \delta_{a,w} + C_{n \delta a} \cos \delta_{a,w} \]

\[ C_{n_{\delta a}} = C_{n \delta a} \sin \delta_{a,w} + C_{n \delta a} \cos \delta_{a,w} \]
APPENDIX B – Continued

The auxiliary equations are

\[ \dot{\psi} = \frac{q \sin \phi + r \cos \phi}{\cos \theta} \]

\[ V = \sqrt{u^2 + v^2 + w^2} \]

\[ \alpha_a = \tan^{-1} \frac{w}{u} \]

\[ \dot{\alpha}_a \approx \frac{\dot{w}}{u} \]

\[ \beta = \sin^{-1} \frac{v}{V} \]

\[ \dot{\beta} \approx \frac{\dot{v}}{V} \]

\[ V_{SS} = \frac{8}{\pi} \eta E^2 D E^2 C_T \]

The trim conditions are

\[ \alpha_{a,t} = \begin{cases} \text{ALPHAT or} \\
\tan^{-1} \frac{w(0)}{u(0)} \end{cases} \]

\[ \beta_t = 0 \]

\[ \delta_{a,t} = \text{DABIAS} \]

\[ \delta_{e,t} = \text{DEBIAS} \]

\[ \delta_{r,t} = \text{DRBIAS} \]
The thrust and moment equations are known inputs (flight test data and constants) to the equations of motion.

\[
\begin{align*}
T_x &= 4\rho \eta_E^2 D_E^4 C_T \cos i_w \\
T_y &= 0 \\
T_z &= -4\rho \eta_E^2 D_E^4 C_T \sin i_w - \rho \eta_T^2 D_T^4 C_{TT} \\
M_x &= 2\rho \eta_E^2 D_E^4 \bar{l} C_{TB} \bar{B} \sin i_w \\
M_y &= -4\rho \eta_E^2 D_E^4 r_b C_T - \rho \eta_T^2 D_T^4 \bar{l}_{TP} C_{TT} \\
M_z &= 2\rho \eta_E^2 D_E^4 \bar{l} C_{TB} \bar{B} \cos i_w
\end{align*}
\] (B14)

where

\[
\begin{align*}
C_T &= C_{T0} + C_{TB} \bar{B} \\
C_{TT} &= C_{TT0} + C_T \beta_T \bar{B} \\
\eta_E &= \frac{1232}{60} P_E \\
\eta_T &= \frac{2400}{60} P_T
\end{align*}
\]

The accelerometer measurements and equations were included in the parameter estimation algorithm to improve the extraction process. They are used with or can replace the linear velocities \( u, v, \) and \( w \). The accelerometer equations were transformed to the instrument location from the center of gravity (ref. 6).
APPENDIX B – Concluded

\[ \bar{\mathbf{a}}_I = \begin{bmatrix}
  a_{X,I} \\
  a_{Y,I} \\
  a_{Z,I}
\end{bmatrix} \]

\[
\begin{bmatrix}
  \dot{u} + qw - rv + g \sin \theta \\
  \dot{v} + ru - pw - g \cos \theta \sin \phi \\
  \dot{w} + pv - qu - g \cos \theta \cos \phi
\end{bmatrix} = \frac{1}{g} \begin{bmatrix}
  -(q^2 + r^2)x_X + (pq - \dot{r})y_X + (pr + \dot{q})z_X \\
  (pq + r)x_Y - (p^2 + r^2)y_Y + (qr - \dot{p})z_Y \\
  (pr - \dot{q})x_Z + (qr + \dot{p})y_Z - (p^2 + q^2)z_Z
\end{bmatrix}
\]

(B15)

The accelerometer equations need only to be evaluated and not integrated.
APPENDIX C

SENSITIVITY EQUATIONS AND ACCELEROMETER SENSITIVITY COEFFICIENTS

The sensitivity equations for the method of quasilinearization are presented in detail for the equations of motion presented in appendix B.

The sensitivity equations are

\[
\frac{d}{dt}\left(\frac{\partial \mathbf{x}}{\partial \alpha_i}\right) = \left(\frac{\partial \mathbf{x}}{\partial \alpha_i}\right)
\]

\[
= \left\{ \sum_{k=1}^{8} \frac{\partial F}{\partial x_k} \frac{\partial x_k}{\partial \alpha_i} \right\} + \frac{\partial F}{\partial V} \sum_{k=1}^{3} \frac{\partial V}{\partial x_k} \frac{\partial x_k}{\partial \alpha_i} + \frac{\partial F}{\partial \alpha_a} \sum_{k=1}^{3} \frac{\partial \alpha_a}{\partial x_k} \frac{\partial x_k}{\partial \alpha_i} \\
+ \frac{\partial F}{\partial \alpha_a} \frac{\partial \alpha_a}{\partial x_1} \frac{\partial x_1}{\partial \alpha_i} + \frac{\partial F}{\partial \beta} \frac{\partial \beta}{\partial x_2} \frac{\partial x_2}{\partial \alpha_i} \sum_{k=1}^{3} \frac{\partial V}{\partial x_k} \frac{\partial x_k}{\partial \alpha_i}
\]

\[
= G'(t) \left(\frac{\partial x}{\partial \alpha_i}\right) + \left[ \frac{\partial F}{\partial \alpha_a} \frac{\partial \alpha_a}{\partial x_3} \frac{\partial x_3}{\partial \alpha_i} + \frac{\partial F}{\partial \beta} \frac{\partial \beta}{\partial x_2} \frac{\partial x_2}{\partial \alpha_i} \right] + \frac{\partial F}{\partial \alpha_i}
\]

where

\[G'(t) = \left[ g'_{j\alpha}(t) \right] \quad (j, k = 1, 2, \ldots, 8)\]

The functions \(F_2\) and \(F_3\) do not contain \(\alpha_a\) or \(\beta\). Thus,

\[
\frac{d}{dt}\left(\frac{\partial x}{\partial \alpha_1}\right) = G(t) \left(\frac{\partial x}{\partial \alpha_1}\right) + F(\alpha_i) \quad (i = 1, 2, \ldots, 40)
\]
APPENDIX C – Continued

where

\[
\frac{\delta x}{\delta \alpha_i} = \left[ \frac{\delta u}{\delta \alpha_i}, \frac{\delta v}{\delta \alpha_i}, \frac{\delta w}{\delta \alpha_i}, \frac{\delta p}{\delta \alpha_i}, \frac{\delta q}{\delta \alpha_i}, \frac{\delta r}{\delta \alpha_i}, \frac{\delta \theta}{\delta \alpha_i}, \frac{\delta \phi}{\delta \alpha_i} \right]^T
\]

\[
G(t) = \left[ g_{jk}(t) \right] \quad (j,k = 1, 2, \ldots, 8)
\]

\[
\tilde{F}(\alpha_i) = \left[ \tilde{F}_1(\alpha_i), \tilde{F}_2(\alpha_i), \ldots, \tilde{F}_8(\alpha_i) \right]^T
\]

(1) Sensitivity equations derived from \( \dot{u} \) equation:

\[
\frac{d}{dt} \left( \frac{\delta u}{\delta \alpha_i} \right) = \sum_{k=1}^{8} g_{1k} \left( \frac{\delta x_k}{\delta \alpha_i} \right) + \frac{\delta F_1}{\delta \alpha_i}
\]  \hspace{1cm} (C3)

where

\[
g_{11} = a_1 u \left( 2C_{X1} + C_{X2} \right) - a_1 C_{Xa} w
\]

\[
g_{12} = r + a_1 v \left( 2C_{X1} + C_{X2} \right)
\]

\[
g_{13} = -q + a_1 w \left( 2C_{X1} + C_{X2} \right) + a_1 C_{Xa} u
\]

\[
g_{14} = 0
\]

\[
g_{15} = -w + a_2 V C_{Xq}
\]

\[
g_{16} = v
\]

\[
g_{17} = -g \cos \theta
\]

\[
g_{18} = 0
\]
and

\[ \frac{\delta F_1}{\delta \alpha_2} = a_1 V^2 \]

\[ \frac{\delta F_1}{\delta \alpha_3} = a_1 V^2 (\alpha_a - \alpha_a, t) \]

\[ \frac{\delta F_1}{\delta \alpha_4} = a_2 Vq \]

(2) Sensitivity equations derived from \( \dot{v} \) equation:

\[ \frac{d}{dt} \left( \frac{\delta v}{\delta \alpha_i} \right) = \sum_{k=1}^g \xi_{2k} \left( \frac{\partial \alpha_k}{\partial \alpha_i} \right) + \frac{\delta F_2}{\delta \alpha_i} \]  

where

\[ \xi_{21} \approx \frac{-r + a_1 u (2C_{Y1} + C_{Y2} - C_{Y, \beta})}{1 - a_3 C_{Y, \beta}} \]

\[ \xi_{22} \approx \frac{a_1 V (2C_{Y1} + C_{Y2} - C_{Y, \beta}) + a_1 V C_{Y, \beta}}{1 - a_3 C_{Y, \beta}} \]

\[ \xi_{23} \approx \frac{p + a_1 w (2C_{Y1} + C_{Y2} - C_{Y, \beta})}{1 - a_3 C_{Y, \beta}} \]

\[ \xi_{24} = \frac{w + a_3 V C_{Y, p}}{1 - a_3 C_{Y, \beta}} \]

\[ \xi_{25} = 0 \]

\[ \xi_{26} = \frac{-u + a_3 V C_{Y, r}}{1 - a_3 C_{Y, \beta}} \]
\[
g_{27} = -g \sin \theta \sin \phi \frac{1}{1 - a_3 C Y_\beta}
\]

\[
g_{28} = g \cos \theta \cos \phi \frac{1}{1 - a_3 C Y_\beta}
\]

and

\[
\frac{\partial F_2}{\partial \alpha_{19}} = \frac{a_1 V^2}{1 - a_3 C Y_\beta}
\]

\[
\frac{\partial F_2}{\partial \alpha_{20}} = \frac{a_1 V^2 (\beta - \beta_t)}{1 - a_3 C Y_\beta}
\]

\[
\frac{\partial F_2}{\partial \alpha_{21}} = \frac{a_3 \dot{V}}{1 - a_3 C Y_\beta}
\]

\[
\frac{\partial F_2}{\partial \alpha_{22}} = \frac{a_3 V_p}{1 - a_3 C Y_\beta}
\]

\[
\frac{\partial F_2}{\partial \alpha_{23}} = \frac{a_3 V_r}{1 - a_3 C Y_\beta}
\]

\[
\frac{\partial F_2}{\partial \alpha_{24}} = \frac{a_1 V^2 (\delta_r - \delta_{r,t})}{1 - a_3 C Y_\beta}
\]

(3) Sensitivity equations derived from \( \dot{w} \) equation:

\[
\frac{d}{dt} \left( \frac{\partial w}{\partial \alpha_i} \right) = \sum_{k=1}^{8} g_{3k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial F_3}{\partial \alpha_i} \tag{C5}
\]

where

\[
g_{31} = q + a_1 u \left( 2C Z_1 + C Z_2 \right) - a_1 C Z_\alpha w
\]

\[
g_{32} = -p + a_1 v \left( 2C Z_1 + C Z_2 \right)
\]
\( g_{33} = a_1 v (2CZ_1 + CZ_2) + a_1 CZ_\alpha a \ u \)

\( g_{34} = -v \)

\( g_{35} = u + a_2 VCZ_q \)

\( g_{36} = 0 \)

\( g_{37} = -g \sin \theta \cos \phi \)

\( g_{38} = -g \cos \theta \sin \phi \)

and

\[ \frac{\partial F_3}{\partial \alpha_8} = a_1 v^2 \]

\[ \frac{\partial F_3}{\partial \alpha_9} = a_1 v^2 (\alpha_a - \alpha_{a,t}) \]

\[ \frac{\partial F_3}{\partial \alpha_{10}} = a_2 Vq \]

\[ \frac{\partial F_3}{\partial \alpha_{11}} = a_1 v^2 (\delta_e - \delta_{e,t}) \]

(4) Sensitivity equations derived from \( \dot{p} \) equation:

\[ \frac{d}{dt} \left( \frac{\partial p}{\partial \alpha_i} \right) = \sum_{k=1}^{8} \left( \frac{\partial^2 \Phi_4}{\partial \alpha_i \partial \alpha_k} \left( \frac{\partial \Phi_4}{\partial \alpha_k} \right) + \frac{\partial^2 \Phi_2}{\partial \alpha_i \partial \alpha_k} \left( \frac{\partial \Phi_2}{\partial \alpha_k} \right) \right) + \sum_{k=1}^{8} \left( \frac{\partial \Phi_6}{\partial \alpha_i} \frac{\partial \Phi_6}{\partial \alpha_k} \left( \frac{\partial \Phi_6}{\partial \alpha_k} \right) \right) \]

\[ = \sum_{k=1}^{8} \left( \frac{\partial \Phi_4}{\partial \alpha_i} \right) \left( \frac{\partial \Phi_4}{\partial \alpha_k} \right) + \sum_{k=1}^{8} \left( \frac{\partial \Phi_6}{\partial \alpha_i} \right) \left( \frac{\partial \Phi_6}{\partial \alpha_k} \right) \]

\[ (C6) \]
where

\[ g''_{41} \approx a_4 u \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} - C_{l\beta} \frac{\dot{\beta}_b}{2V} \right) \]

\[ g''_{42} \approx a_4 v \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} - C_{l\beta} \frac{\dot{\beta}_b}{2V} \right) + a_4 V C_{l\beta} \]

\[ g''_{43} \approx a_4 w \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} - C_{l\beta} \frac{\dot{\beta}_b}{2V} \right) \]

\[ g_{44}''' = I_{XZ} q + a_5 V C_{l_p} \]

\[ g_{45}''' = b_2 r + I_{XZ} p \]

\[ g_{46}''' = b_2 q + a_5 V C_{l_r} \]

\[ g_{47}''' = g_{48}''' = 0 \]

and

\[ g_{61}''' \approx a_4 u \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} - C_{n\beta} \frac{\dot{\beta}_b}{2V} \right) \]

\[ g_{62}''' \approx a_4 v \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} - C_{n\beta} \frac{\dot{\beta}_b}{2V} \right) + a_4 V C_{n\beta} \]

\[ g_{63}''' \approx a_4 w \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} - C_{n\beta} \frac{\dot{\beta}_b}{2V} \right) \]

\[ g_{64}''' = b_3 q + a_5 V C_{n_p} \]

\[ g_{65}''' = b_3 p - I_{XZ} r \]
\[ e_{66}'' = -I_{XZ}q + a_5 V_C n_r \]

\[ e_{67}'' = e_{68}'' = 0 \]

and

\[ \frac{\partial F_4'}{\partial \alpha_{26}} = \frac{\partial F_6'}{\partial \alpha_{34}} = a_4 V^2 \]

\[ \frac{\partial F_4'}{\partial \alpha_{27}} = \frac{\partial F_6'}{\partial \alpha_{35}} = a_4 V^2 \beta - \beta_t \]

\[ \frac{\partial F_4'}{\partial \alpha_{28}} = \frac{\partial F_6'}{\partial \alpha_{36}} = a_5 V \beta \]

\[ \frac{\partial F_4'}{\partial \alpha_{29}} = \frac{\partial F_6'}{\partial \alpha_{37}} = a_5 V_p \]

\[ \frac{\partial F_4'}{\partial \alpha_{30}} = \frac{\partial F_6'}{\partial \alpha_{38}} = a_5 V_r \]

\[ \frac{\partial F_4'}{\partial \alpha_{31}} = \frac{\partial F_6'}{\partial \alpha_{39}} = a_4 V^2 (\delta_r - \delta_r, t) \]

\[ \frac{\partial F_4'}{\partial \alpha_{32}} = \frac{\partial F_6'}{\partial \alpha_{40}} = a_4 V_S^2 \cos \omega (\delta_a - \delta_a, t) \]

\[ \frac{\partial F_4'}{\partial \alpha_{40}} = \frac{\partial F_6'}{\partial \alpha_{32}} = -a_4 V_S^2 \sin \omega (\delta_a - \delta_a, t) \]

\[ \frac{\partial F_4'}{\partial \dot{\beta}} = \frac{\partial \dot{\beta}}{\partial \dot{v}} = a_4 C_l \beta \]

\[ \frac{\partial F_6'}{\partial \dot{\beta}} = \frac{\partial \dot{\beta}}{\partial \dot{v}} = a_4 C_n \beta \]
(5) Sensitivity equations derived from \( \dot{q} \) equation:

\[
\frac{d}{dt} \left( \frac{\partial q}{\partial \alpha_i} \right) = \sum_{k=1}^{8} \left( g_{5k}' \frac{\partial F_5}{\partial \dot{\alpha}} + g_{3k}' \left( \frac{\partial x_k}{\partial \alpha_i} \right) \right) + \left( \frac{\partial F_5}{\partial \alpha_i} + \frac{\partial F_5}{\partial \dot{\alpha}} \frac{\partial \dot{\alpha}}{\partial \alpha_i} + \frac{\partial F_5}{\partial w} \frac{\partial w}{\partial \alpha_i} \right)
\]

\[
= \sum_{k=1}^{8} g_{5k}' \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \tilde{F}_5(\alpha_i) \quad \text{(C7)}
\]

where

\[ g_{51}' = a_8 u (2C_{m1} + C_{m2}) - a_8 C_m \dot{\alpha} w - a_9 C_m \dot{\alpha} \dot{\alpha} \]

\[ g_{52}' = a_8 v (2C_{m1} + C_{m2}) \]

\[ g_{53}' = a_8 w (2C_{m1} + C_{m2}) + a_9 C_m \alpha_\dot{u} \]

\[ g_{54}' = a_7 r - 2b_4 p \]

\[ g_{55}' = a_9 V C m q \]

\[ g_{56}' = a_7 p + 2b_4 r \]

\[ g_{57}' = g_{58}' = 0 \]

and

\[ \frac{\partial F_5}{\partial \alpha_{13}} = a_8 V^2 \]

\[ \frac{\partial F_5}{\partial \alpha_{14}} = a_8 V^2 (\alpha_a - \alpha_{a,t}) \]
APPENDIX C – Continued

\[ \frac{\partial F_5}{\partial \alpha_{15}} = a_9 V \dot{\alpha}_a \]

\[ \frac{\partial F_5}{\partial \alpha_{16}} = a_9 V q \]

\[ \frac{\partial F_5}{\partial \alpha_{17}} = a_9 V^2 (q_e - q_{e,t}) \]

\[ \frac{\partial F_5}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{\omega}} = a_9 C_m \dot{\alpha}_a \]

(6) Sensitivity equations derived from \( \dot{r} \) equation:

\[ \frac{d}{dt} \left( \frac{\partial r}{\partial \alpha_1} \right) = b_1 \left[ \sum_{k=1}^{8} \left( g_{4k}'' + \frac{\partial F_4'}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_1} \right) + \left( \frac{\partial F_4'}{\partial \alpha_1} + \frac{\partial F_4'}{\partial \beta} \frac{\partial F_2}{\partial \alpha_1} \right) \right] \]

\[ + b_5 \left[ \sum_{k=1}^{8} \left( g_{6k}'' + \frac{\partial F_6'}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_1} \right) + \left( \frac{\partial F_6'}{\partial \alpha_1} + \frac{\partial F_6'}{\partial \beta} \frac{\partial F_2}{\partial \alpha_1} \right) \right] \]

\[ = \sum_{k=1}^{8} \left( g_{6k}' + b_1 \frac{\partial F_4'}{\partial \alpha_1} \frac{\partial \beta}{\partial v} g_{2k} + b_5 \frac{\partial F_6'}{\partial \alpha_1} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_1} \right) + b_1 \tilde{F}_4' (\alpha_1) + b_5 \tilde{F}_6' (\alpha_1) \]

\[ = \sum_{k=1}^{8} g_{6k} \left( \frac{\partial x_k}{\partial \alpha_1} \right) + \tilde{F}_6 (\alpha_1) \quad (C8) \]

where all the terms have been defined in the derivation of the sensitivity equations for \( \dot{p} \) equation.
(7) Sensitivity equations derived from $\dot{\theta}$ equation:

\[
\frac{d}{dt}\left(\frac{\partial \theta}{\partial \alpha_i}\right) = \sum_{k=1}^{8} g_{7k}\left(\frac{\partial x_k}{\partial \alpha_i}\right)
\]

(C9)

where

$g_{71} = g_{72} = g_{73} = g_{74} = 0$

$g_{75} = \cos \phi$

$g_{76} = -\sin \phi$

$g_{77} = 0$

$g_{78} = -\psi \cos \theta$

(8) Sensitivity equations derived from $\dot{\phi}$ equation:

\[
\frac{d}{dt}\left(\frac{\partial \phi}{\partial \alpha_i}\right) = \sum_{k=1}^{8} g_{8k}\left(\frac{\partial x_k}{\partial \alpha_i}\right)
\]

(C10)

where

$g_{81} = g_{82} = g_{83} = 0$

$g_{84} = 1$

$g_{85} = \sin \phi \tan \theta$

$g_{86} = \cos \phi \tan \theta$
The accelerometer sensitivity coefficients were derived in terms of the sensitivity equations and coefficients for the equations of motion, and need only to be evaluated and not integrated.

(1) Sensitivity equations derived from $a_{X,I}$ equation:

$$
\frac{\delta a_{X,I}}{\delta \sigma_i} = \frac{1}{g} \left[ \frac{\partial \nu}{\partial \sigma_i} + \frac{\partial w}{\partial \sigma_i} + \left( yX + zX \right) \frac{\partial p}{\partial \sigma_i} + \left( -2xX + yX + w \right) \frac{\partial q}{\partial \sigma_i} \right] \\
+ \left( -2xX + zX - y \right) \frac{\partial r}{\partial \sigma_i} + g \cos \theta \left( \frac{\partial \theta}{\partial \sigma_i} + \frac{\partial \phi}{\partial \sigma_i} + \frac{\partial \psi}{\partial \sigma_i} \right) - yX \frac{\partial \psi}{\partial \sigma_i} \right] \tag{C11}
$$

(2) Sensitivity equations derived from $a_{Y,I}$ equation:

$$
\frac{\delta a_{Y,I}}{\delta \sigma_i} = \frac{1}{g} \left[ \frac{\partial u}{\partial \sigma_i} - p \left( \frac{\partial \theta}{\partial \sigma_i} \right) + \left( -w + xY - 2yY \right) \frac{\partial p}{\partial \sigma_i} + \left( xY + zY \right) \frac{\partial q}{\partial \sigma_i} + \left( u - 2yY + zY \right) \frac{\partial r}{\partial \sigma_i} \right] \\
+ \sin \theta \sin \phi \frac{\partial \phi}{\partial \sigma_i} - g \sin \theta \cos \phi \frac{\partial \theta}{\partial \sigma_i} + \frac{\partial \psi}{\partial \sigma_i} + \frac{\partial \phi}{\partial \sigma_i} - yY \frac{\partial \psi}{\partial \sigma_i} \right] \tag{C12}
$$

(3) Sensitivity equations derived from $a_{Z,I}$ equation:

$$
\frac{\delta a_{Z,I}}{\delta \sigma_i} = \frac{1}{g} \left[ q \frac{\partial u}{\partial \sigma_i} + p \left( \frac{\partial \theta}{\partial \sigma_i} \right) + \left( v + xZ - 2zZ \right) \frac{\partial p}{\partial \sigma_i} + \left( -u + yZ - 2zZ \right) \frac{\partial q}{\partial \sigma_i} + \left( xZ + yZ \right) \frac{\partial r}{\partial \sigma_i} \right] \\
+ \sin \theta \cos \phi \frac{\partial \phi}{\partial \sigma_i} + g \sin \theta \sin \phi \frac{\partial \psi}{\partial \sigma_i} + \frac{\partial \psi}{\partial \sigma_i} + \frac{\partial \phi}{\partial \sigma_i} - xZ \frac{\partial \psi}{\partial \sigma_i} \right] \tag{C13}
$$
APPENDIX D

VARIABLE DIMENSIONING

The flight test runs do not necessitate the use of all the equation variables \( \{x\} \), variables in the performance index function \( \{y\} \), and parameters \( \{a\} \) for specific cases. These cases involve only a specific part of the program, as with an excitation of only the longitudinal motion of the aircraft. Variable dimensioning of the estimation procedure furnishes the analyst with the means of altering the program to meet the specific needs of each flight test run; that is, the mathematical model of the aircraft dynamic response, the variables to be compared with flight test data, and the parameters to be estimated.

Variable dimensioning of the estimation procedure is accomplished by using the three input arrays \( \text{INTX}(8), \text{INTY}(11), \text{INTEG}_{40}(\text{INTEG}(I), \ I = 1, 2, \ldots, 40) \); the use of these arrays dimension \( \{x\} \), \( \{y\} \), and \( \{a\} \), respectively, in the program. The elements of each array are entered as integers 1 or 0 to indicate whether the variables or parameters are active or inactive, respectively.

The input array \( \text{INTX} \) specifies the activeness for each equation variable in the equations of motion and the sensitivity equations; inactive variables are treated as constants. From the input array \( \text{INTX} \)

\[
\text{INTX} = (1, 0, 1, \ldots, 1, 0)
\]

\( k_1 \ k_2, \ldots, k_{IV} \)

\[
\text{IV} = \sum_{K=1}^{8} \text{INTX}(K)
\]

where \( k_1, k_2, \ldots, k_{IV} \) are element locations, \( \text{INTV} \) is generated,

\[
\text{INTV} = (k_1, k_2, \ldots, k_{IV}, 0, \ldots, 0)
\]

which is a sequence of integers denoting the active equation variables in \( \{x\} \).

The input array \( \text{INTY} \) specifies the activeness for each variable in \( \{y\} \); inactive variables are ignored. From the input array \( \text{INTY} \)

\[
\text{INTY} = (1, 0, 1, \ldots, 1, 0)
\]

\( k_1 \ k_2, \ldots, k_{IV} \)

\[
\text{IVY} = \sum_{K=1}^{11} \text{INTY}(K)
\]

where \( k_1, k_2, \ldots, k_{IV} \) are element locations, \( \text{INTVY} \) is generated,

\[
\text{INTVY} = (k_1, k_2, \ldots, k_{IV}, 0, \ldots, 0)
\]

which is a sequence of integers denoting the active variables in \( \{y\} \).

The input array \( \text{INTEG} \) specifies the activeness for each parameter in \( \{a\} \); inactive parameters are ignored. From the input array \( \text{INTEG} \)

\[
\text{INTEG} = (1, 0, 1, \ldots, 1, 0)
\]

\( k_1 \ k_2, \ldots, k_{IV} \)

\[
\text{INTEG}(I) = \sum_{I=1}^{40} \text{INTEG}(I)
\]

where \( k_1, k_2, \ldots, k_{IV} \) are element locations, \( \text{INTPEG} \) is generated,

\[
\text{INTPEG} = (k_1, k_2, \ldots, k_{IV}, 0, \ldots, 0)
\]
APPENDIX D – Continued

\( \text{ITY} = (1, 0, 1, \ldots, 1, 0) \)

\( j_1 \quad j_2, \ldots, j_{IA} \)

\[ \text{IA} = \sum_{J=1}^{11} \text{ITY}(J) \]

\( \text{INTA} \) is generated,

\[ \text{INTA} = (j_1, j_2, \ldots, j_{IA}, 0, \ldots, 0) \]

which is a sequence of integers denoting the active variables in \( \hat{y} \). The integer \( IA_1 \),

\[ IA_1 = \sum_{J=1}^{8} \text{ITY}(J) \]

denotes the number of active variables in \( \hat{x} \) that are active variables in \( \hat{y} \).

The input array \( \text{INTEG}_{40} \) specifies the activeness of each parameter in the estimation procedure; inactive parameters are treated as constants. From the input array \( \text{INTEG}_{40} \)

\[ \text{INTEG}_{40} = (0, \ldots, 0, 1, 0, 1, \ldots, 1, 0, \ldots, 0) \]

\( i_1 \quad i_2, \ldots, i_{IP} \)

\[ IP = \sum_{I=1}^{40} \text{INTEG}(I) \]

\( \text{INTP} \) is generated,

\[ \text{INTP} = (i_1, i_2, \ldots, i_{IP}, 0, \ldots, 0) \]

which is a sequence of integers denoting the active parameters in \( \hat{\alpha} \). The program is dimensioned for \( IP \leq 30 \).

The resulting arrays (\( \text{INTV}, \text{INTA}, \text{INTP} \)) and numbers (\( IV, IA, IA_1, IP \)) are used in

\text{FORTRAN DO LOOP} and matrix operations.

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APPENDIX D – Continued

The equations of motion are reduced to the form

\[ \dot{x}_{eq} = \ddot{F}_{eq}(\bar{x}, \bar{\alpha}, \bar{\delta}) = \left( \dot{x}_{k_1}, \dot{x}_{k_2}, \ldots, \dot{x}_{k_{IV}} \right)^T \]  

(D1)

by multiplying each of the original equations of motion (eq. (1a)) by their respective element of \( INTX \); that is, inactive equation variables have their derivatives set to zero.

The original sensitivity equations (eq. (6)) are reduced by using the arrays \( INTP \) and \( INTV \) as indices in the FORTRAN DO LOOP to the form

\[
\frac{d}{dt} \left( \frac{\partial \bar{x}_{\text{INTV}(K')}}{\partial \alpha_{\text{INTP}(I)}} \right) = \sum_{K=1}^{IV} \frac{\partial \bar{F}_{\text{INTV}(K')}}{\partial \bar{x}_{\text{INTV}(K)}} \left( \frac{\partial \bar{x}_{\text{INTV}(K)}}{\partial \alpha_{\text{INTP}(I)}} \right) + \frac{\partial \bar{F}_{\text{INTV}(K')}}{\partial \alpha_{\text{INTP}(I)}} \\
(K' = 1, 2, \ldots, IV; \ I = 1, 2, \ldots, IP) \quad (D2)
\]

The accelerometer equations and sensitivity coefficients are handled in a similar manner to generate \( \bar{\alpha}_J \) and \( \frac{\partial \bar{\alpha}_J}{\partial \alpha_{\text{INTP}(I)}} \), respectively.

The original parameter change equations (eq. (7)) reduce to

\[
\Delta \bar{\alpha}_J = \left[ \sum_{i=1}^{N} A_J^T(t_i) R_J^{-1} A_J(t_i) \right]^{-1} \left[ \sum_{i=1}^{N} A_J^T(t_i) R_J^{-1} \bar{\eta}_J(t_i) \right] \quad (D3)
\]

where

\[
A_J(t_i) = \begin{pmatrix}
\frac{\partial \bar{y}_J^O}{\partial \alpha_{i_1}}, \frac{\partial \bar{y}_J^O}{\partial \alpha_{i_2}}, \ldots, \frac{\partial \bar{y}_J^O}{\partial \alpha_{i_{IP}}}
\end{pmatrix}
\]

\[
\bar{\eta}_J(t_i) = \bar{y}_J^M(t_i) - \bar{y}_J^O(t_i)
\]

\[
\bar{y}_J^M(t_i) = \begin{bmatrix}
\bar{x}_J^M(t_i) \\
\bar{a}_J^M(t_i)
\end{bmatrix} \quad \bar{y}_J^O = \begin{bmatrix}
\bar{x}_J^O(t_i) \\
\bar{a}_J^O(t_i)
\end{bmatrix}
\]
APPENDIX D – Concluded

The vector \( \frac{\delta \tilde{x}_{eq}}{\delta \alpha_{\text{INTP}(I)}} \) is searched at each \( t_i \) for the sensitivity coefficients associated with the active algorithm variables by using the array INTA. The selected sensitivity coefficients are then packed into the vector \( \frac{\delta \tilde{x}_J}{\delta \alpha_{\text{INTP}(I)}} \) in order to form \( A_J(t) \). If \( IA1 = IV \), no search is made, since this condition implies that \( \tilde{x}_{eq} = \tilde{x}_J \). The INTA array also selects \( \eta_J(t_1) \) from the original vector \( \eta(t_i) \).

The covariance matrix for the parameters becomes

\[
\left[ \sum_{i=1}^{N} A_J^T(t_i) R_J^{-1} A_J(t_i) \right]^{-1} = \begin{pmatrix}
\sigma_{\alpha_1}^2 & \rho_{\alpha_1 \alpha_2} \sigma_{\alpha_1} \sigma_{\alpha_2} & \cdots & \rho_{\alpha_1 \alpha_{IP}} \sigma_{\alpha_1} \sigma_{\alpha_{IP}} \\
\rho_{\alpha_1 \alpha_2} \sigma_{\alpha_1} \sigma_{\alpha_2} & \rho_{\alpha_2}^2 & \cdots & \rho_{\alpha_2 \alpha_{IP}} \sigma_{\alpha_2} \sigma_{\alpha_{IP}} \\
\vdots & \vdots & \ddots & \vdots \\
\rho_{\alpha_{IP} \alpha_1} \sigma_{\alpha_{IP}} \sigma_{\alpha_1} & \rho_{\alpha_{IP} \alpha_2} \sigma_{\alpha_{IP}} \sigma_{\alpha_2} & \cdots & \sigma_{\alpha_{IP}}^2
\end{pmatrix} \tag{D4}
\]

The covariance matrix for the measurement noise becomes

\[
R^0_J(N) \triangleq \text{Estimate of } R_J = \frac{1}{N} \sum_{i=1}^{N} \eta_J(t_i) \eta_J^T(t_i) = \begin{pmatrix}
\sigma_{\eta_1}^2 & \sigma_{\eta_1 \eta_2} & \cdots & \sigma_{\eta_1 \eta_{IA}} \\
\sigma_{\eta_1 \eta_2} & \sigma_{\eta_2}^2 & \cdots & \sigma_{\eta_2 \eta_{IA}} \\
\vdots & \vdots & \ddots & \vdots \\
\sigma_{\eta_{IA} \eta_1} & \sigma_{\eta_{IA} \eta_2} & \cdots & \sigma_{\eta_{IA}}^2
\end{pmatrix} \tag{D5}
\]

and the performance index to be minimized becomes

\[
J_N(\alpha^0_J) = |R^0_J(N)| \tag{D6}
\]
APPENDIX E

CALCOMP PLOT OPTION

CalComp plots similar to the CRT displays can be obtained in overlay level (2,0). The main difference being that the (+) symbol is used to represent flight data points. Other differences are options to plot flight data only (FSS(2) true), and a variable (NPLOT) to alter the density of flight data points to be plotted. Examples of CalComp plots are shown in figures 2 and 4.

The CalComp plot option is entered by setting IPRINT to 4 by means of the DDDU before exiting the CRT display loop. (Replotting of the CRT display just before entering the CalComp plot option causes erasure of the real-time disk file, and thereby prevents CalComp plots of calculated data.) After exiting the CRT loop, set FSS as shown in the CRT discussion of overlay level (4,0), and depress PRINT switch. When processing of the selected plot is completed, WL(2) will come on to signal the need for operator action. Additional plots can be obtained by setting the appropriate FSS before depressing FSS(14) and then releasing. Exiting the CalComp loop is accomplished by depressing FSS(13).

The flow chart of the CalComp plot option follows.
CALCOMP PLOT OPTION

APPENDIX E – Concluded

Entry when IPRINT = 6

(C0104) WL(3) = .F.

JSKIP > 0

Yes

No

(C0106) Call CALPLT

Call LEROY

(C0110) JSKIP = JSKIP + 1

Calculate scale factors and biases

Yes

No

(C0117) Call PLAYBAK

Fill and limit

Y1(I), Y2(I), Y3(I), and Y4(I),

I = 1, 2, ..., NOPTS

with calculated data

(C0169) I = NOPTS

No

Yes

Fill and limit

Z1(I), Z2(I), Z3(I), and Z4(I)

I = 1, 2, ..., NOPTS

with flight data

Call DAYTIM; NOTATE; NUMBER;

ASCALE; GRID; AXES; LINE

(to plot y and/or z against t)

WL(2) = .T.

(C0153) Call DISPLAY

Call OPERATE

Call OPERATE

WL(2) = .F.

Yes

No

(C0359) FSS(13) = .T.

(C0356) FSS(14) = .T.

No

No

(WL(2) = .F.)

IPRINT = 5

RETURN

OVERLAY (XC142FL, 5, 0)
REFERENCES


Figure 1.- Maximum likelihood parameter estimation procedure.
Figure 2. - CalComp plot of pseudo flight and calculated (converged solution) longitudinal motion, and control inputs.
(b) Control inputs.

Figure 2.- Concluded.
Figure 3.- Operational control features.

(a) Typical program control station.
(b) Closeup of control panel on the program control console.

Figure 3.- Concluded.
(a) Longitudinal motion.

Figure 4. - CalComp plot of pseudo and calculated (nonconverged solution) motion.
(b) Lateral motion.

Figure 4. - Continued.
(c) Accelerometer.

Figure 4.- Concluded.
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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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