NASA CONTRACTOR REPORT NASA CR-132676

FLIGHT INSTRUMENTATION SPECIFICATION FOR PARAMETER IDENTIFICATION PROGRAM USER'S GUIDE

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D.C. • JUNE 1975

FOREWORD

The development of the SCIP2 computer program described in this report was supported under NASA Contract No. NAS 1-10791, by Langley Research Center, Hampton, Virginia. Project monitors were W. H. Bryant and W. F. Hodge.

The SCIP2 Program documentation is divided into two sections: the User's Guide and the Program Description. Section 1 through 4 detail the operation of the SCIP2 program with a brief general description and purpose of the program. Section 5 and 6 describe the program structure in detail. A summary of the equations coded in the program is found in the Appendix.

An accompanying document, NASA CR-132675, contains use of these techniques. This report is a revision of a previously published user's guide for the SCIP2 programs (NASA CR-112122). The latest version has the capability to allow investigation of both airplanes and helicopters.

CONVERSION TABLE

Conversions From English Units to the International System of Units

TO CONVERT FROM	TO	MULTIPLY BY
foot	meter	3.048×10^{-1}*
foot^{-1}	meter^{-1}	3.2808399
inch	meter	2.54×10^{-2}*
inch^{-1}	meter^{-1}	3.9370079×10^{-1}
knot	meter second^{-1}	5.1444444×10^{-1}
degree (angle)	radian	1.7453293×10^{-2}
degree^{-1} (angle)	radian^{-1}	5.7295780×10^{1}
inch foot^{-1}	meter meter^{-1}	8.3333333×10^{-2}
foot inch^{-1}	meter meter^{-1}	1.2×10^{1}*
foot degree^{-1}	meter radian^{-1}	1.7463754×10^{1}
slug foot^{2}	$\text{kilogram meter}^{2}$	1.3558179
g (gravity)	meter second^{-2}	9.80665*
g^{-1}	$\text{second}^{2}\ \text{meter}^{-1}$	1.0197162×10^{-1}
$\text{degree second}^{-1}\ g^{-1}$	$\text{radian second meter}^{-1}$	1.7797405×10^{-3}
$\text{degree hour}^{-1}\ g^{-1}$	$\text{radian second meter}^{-1}$	6.4070659
$\text{degree hour}^{-1}\ g^{-2}$	$\text{radian second}^{3}\ \text{meter}^{-2}$	6.5333890×10^{-1}

*denotes an exact number

The computer programs described in this report use the English system of units. The table above is provided to those readers who wish to convert the program output to the International System of Units.

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

SCIP2 PROGRAM USERS' GUIDE

1.0 INTRODUCTION

SCIP2 is a set of four digital computer programs which can be used to investigate the effects of instrumentation errors on the accuracy of aircraft and helicopter stability-and-control derivatives identified from flight test data. The programs assume that the differential equations of motion are linear and consist of small perturbations about a quasi-steady flight condition. It is also assumed that a Newton-Raphson optimization technique is used for identifying the estimates of the parameters.

The uses which can be made of SCIP2 include:

1. The effect of instrumentation errors on the statistical accuracy of the stability-and-control derivatives and other parameters identified from flight-test data can be determined. This includes the mean error and standard deviation of each of the identified parameters. The contribution of each error source to each parameter is determined.

2. The effects of such variables as aircraft type and flight condition, control-input sequence, and data-sampling rate on the accuracy of the identified parameters can be determined.

3. Trade-off studies can be made between instrument quality and identification accuracy.

4. Different combinations of instruments can be studied for use in collecting the flight data.

5. Trade-off studies between fewer instruments with greater quality and more instruments can be made.

6. The necessary instrument accuracy required in a flight-test program to allow identifying aircraft parameters to a desired level of certainty can be specified.

2.0 PROGRAM EXECUTION INFORMATION

2.1 Programs

SCIP2 consists of four separate computer programs - two aircraft programs (ENSMBLX program and SDMDE2 program) and two helicopter programs (VTLENS program and VTLMD2 program). The user must select the appropriate program according to his need.

2.2 Program Requirements

The programs were first written on the UNIVAC-1108 computer and then converted to the CDC-6600 computer. Thus, the programs may be executed on either machine with very few changes. The remainder of the User's Guide focuses on the CDC-6600 application.

2.2.1 Storage Requirements

The following table shows the storage requirements for each of the four programs:

PROGRAM	STORAGE (Loading)	STORAGE (Execution)
ENSMBLX (AIRCRAFT ENSEMBLE)	$(57,600)_8$	$(46,200)_8$
SDMDE2 (AIRCRAFT SIMULATED DATA)	$(55,600)_8$	$(44,300)_8$
VTLENS (HELICOPTER ENSEMBLE)	$(60,400)_8$	$(47,000)_8$
VTLMD2 (HELICOPTER SIMULATED DATA)	$(56,000)_8$	$(45,000)_8$

Table 2.1 Storage Requirements

The program sizes were obtained by compiling the programs under FORTRAN 2.3 RUN COMPILER and by loading the programs using the SCOPE 3.4.1 LOADER. The storage requirements may vary slightly depending on the SCOPE releases.

2.2.2 File Requirements

The programs use standard input and output files as well as mass storage files for auxiliary storage areas. Table 2.2 illustrates the file requirements.

FILE NAME	ENSEMBLE PROGRAMS (ENSMBLX and VTLENS)	SIMULATED DATA PROGRAMS (SDMDEZ and VTLMDZ)
INPUT (TAPE 5)	yes	yes
OUTPUT (TAPE 6)	yes	yes
TAPE 11	yes	no
PUNCH	no	yes

Table 2.2 File Requirements

The mass-storage files are accessed by the standard FORTRAN unformatted input-output method.

2.3 Execution Time

The execution time for the program depends on the version of the program selected. The shortest case will be the ESTIM=1 Short Period Ensemble Analysis without lag for the aircraft equations (roughly 20 seconds), and the longest will be the ESTIM=3 Lateral Simulated Data Analysis with lags for the helicopter equations (possibly as much as 3 minutes per Monte arlo sample for a case with 300 data points). Furthermore, the execution time is proportional to the number of parameters to be estimated, the size of integration step and the number of sample points.

2.4 Multiple Case

The programs allow execution of more than one case per job. This is accomplished by sequential sets of input data. Each case requires complete respecification of all input data. Note that no mixing of the Ensemble Analysis and the Simulated Data Analysis is allowed, nor mixing of the aircraft and the helicopter is allowed since each is a separate program. However, the user may execute the longitudinal equations and the lateral equations one after the other.

3.0 INPUT ELEMENT DESCRIPTIONS

This section is divided into two parts - one for the airplane programs and another for the VTOL programs

3.1 Aircraft Program

There are two types of input data for this program - fixed-field data and namelist data.

3.1.1 Fixed Field Data

Three fixed-field data cards are required for each case - an options card, an equation card and an instrument card.

Card 1 : Options (A6, 4X, 30L1)

30 logical option fields on this card specify various input and output options. If the option field contains "T", then that option is exercised.

Table 3.1 shows the correspondence between the input option field and the group of input data controlled by it. The printout which results from setting the output options to "T" is discussed in Section 4.

Card 2 : Equation (A6)

This card specifies the equations to be analyzed. A lower case b indicates a blank space.

"FULLbb" - if the full longitudinal equations are to be used;
"SPLbbb" - if short-period longitudinal equations are to be used;
"LATbbb" - if the lateral equations are to be used.

Card 3 : Instruments (7A6)

This card specifies the instruments to be used in the analysis. A user may use all instruments or any subset. A lower case b indicates a blank space.

The longitudinal instruments are:

INPUT	MEANING
"PAGbbb"	pitch attitude gyro
"PRGbbb"	pitch rate gyro
"AØAVbb"	angle-of-attack vane
"AVPTbb"	air velocity from pitot tube
"AXACCb"	axial (longitudinal) accelerometer
"NØRACb"	normal accelerometer
"PAACCb"	pitch angular accelerometer

The lateral instruments are:

INPUT	MEANING
"AØSVbb"	angle-of-sideslip vane
"RRGbbb"	roll rate gyro
"YRGbbb"	yaw rate gyro
"RAGbbb"	roll attitude gyro
"LATACb"	lateral accelerometer
"RAACCb"	roll angular accelerometer
"YAACCb"	yaw angular accelerometer

3.1.2 Namelist Data

Table 3.1 lists the input variables by namelist groups and corresponding input options. Input variable description, variable type and units are also given in the table. The table includes both longitudinal and lateral variables.

Table 3.1 Input Data for the Airplane Programs

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
1-3	(not used)				
4	RFTRAJ				Reference trajectory data:
		THETAO	deg	F	Nominal pitch angle, θ_o.
		ALPHAO	deg	F	Nominal angle-of-attack, α_o.
		VEL	ft/sec	F	Nominal airspeed, V_T.
5	OPTONS				Estimation option:
		ESTIM	-	I	Estimate option, =1 if only parameters are to be estimated; =2 if initial conditions as well as parameters are to be estimated; =3 if bias error, parameters, and those initial condition errors which do not correlate with bias errors are to be estimated; =4 if initial condition errors, parameters, and those bias errors which do not correlate with initial condition errors are to be estimated.
6	MISC				Miscellaneous data:
		DT	sec	F	Integration step size.
		DTS	sec	F	Time interval between two successive data samplings.
		TAU	sec	F	Time to the first sample point of the lagged control ($0 \le TAU \le DTS$).
		NØP	-	I	Number of sample points on the trajectory.
		MXITR**	-	I	Maximum number of Newton-Raphson iterations allowed.

* (F = Floating point)
(I = Integer)

** Only applicable for the Simulated Data program. The default values are MXITR=10, EPI=1.0E-6, EP2=1.0E-6, and NMC=10, respectively.

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
		EP1**	-	F	Convergence criteria, for Newton-Raphson iteration (used to test ratios).
		EP2**	-	F	Convergence criteria (absolute change).
		NMC**	-	I	Number of Monte Carlo samples.
7	LONGDR				Longitudinal parameters and options:
		MQ	1/sec	F	M_q
		MW	1/ft-sec	F	M_w
		ZW	1/sec	F	Z_w
		MU	1/ft-sec	F	M_u
		ZU	1/sec	F	Z_u
		XU	1/sec	F	X_u
		XW	1/sec	F	X_w
		MDE	1/deg-sec^2	F	$M_{\delta e}$
		ZDE	ft/deg-sec^2	F	$Z_{\delta e}$
		IFXMQ	-	I	Option to fix any parameters to an arbitrary value. If any of these variables is non-zero, then the corresponding parameter (whose name appears as the fourth through last characters) is not estimated (e.g., IFXMQ = 1, then MQ is not estimated). Nominally all the values are zero (i.e. all parameters are estimated).
		IFXMW	-	I	
		IFXZW	-	I	
		IFXMU	-	I	
		IFXZU	-	I	
		IFXXU	-	I	
		IFXXW	-	I	
		IFXMDE	-	I	
		IFXZDE	-	I	

* (F = Floating point)
(I = Integer)

** Only applicable for the Simulated Data program. The default values are MXITR=10, EPI=1.0E-6, EP2=1.0E-6, and NMC=10, respectively.

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
		IFLPRM	-	I	Alternately, IFLPRM(I) may be used to set the option. The index I refers to the parameters in the same order as shown in the list.
7	LATDR				Lateral parameters, moment and product of inertia, and options:
		YBETA	1/sec	F	Y_β
		LBETA	$1/sec^2$	F	L_β
		NBETA	$1/sec^2$	F	N_β
		LP	1/sec	F	L_p
		NP	1/sec	F	N_β
		LR	1/sec	F	L_r
		NR	1/sec	F	N_r
		YDELA	1/sec	F	$Y_{\delta a}$
		LDELA	$1/sec^2$	F	$L_{\delta a}$
		NDELA	$1/sec^2$	F	$N_{\delta a}$
		YDELR	1/sec	F	$Y_{\delta r}$
		LDELR	$1/sec^2$	F	$L_{\delta r}$
		NDELR	$1/sec^2$	F	$N_{\delta r}$
		XXI	$slug\text{-}ft^2$	F	I_{XX}
		XZI	$slug\text{-}ft^2$	F	I_{XZ} Moments and product of inertia
		ZZI	$slug\text{-}ft^2$	F	I_{ZZ}

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
		IFXYBT	-	I	
		IFXLBT	-	I	
		IFXNBT	-	I	
		IFXLP	-	I	
		IFXNP	-	I	Option to fix a parameter to an arbitrary value. If any of these variables is now zero, then the corresponding parameters (whose name appears as the fourth through last characters) is not estimated. (For example, if IFXLP = 1 then L_p is not estimated; if = 0, then it is estimated.)
		IFXLR	-	I	
		IFXNR	-	I	
		IFXYDA	-	I	
		IFXLDA	-	I	
		IFXNDA	-	I	
		IFXYDR	-	I	
		IFXLDR	-	I	
		IFXNDR	-	I	
		IFLPRM(I)	-	I	Alternatively, IFLPRM(I) may be used to set the option. The index I refers to the parameters in the same order as shown above.
8	CONSEQ				Input control sequence:
		NDP	-	I	Number of discrete input control values $(1<\mathrm{NDP}\leq 100)$.
		DLTA	sec	F	An array of NDP time points at which input control values are given.
		DLU1	deg	F	An array of NDP control values, δe if in longitudinal mode or δa if in lateral mode.
		DLU2	deg	F	An array of NDP control values, δr for lateral mode.

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
9	FICERR				Longitudinal initial condition errors:
		EDELT	deg	F	$\Delta\theta$.
		EDELQ	deg/sec	F	Δq.
		EDELW	ft/sec	F	Δw.
		EDELU	ft/sec	F	Δu.
	LICERR				Lateral initial condition errors:
		EDELB	deg	F	$\Delta\beta$.
		EDELP	deg/sec	F	Δp.
		EDELR	deg/sec	F	Δr.
		EDELF	deg	F	$\Delta\phi$.
10	PITATT				Pitch attitude errors (longitudinal):
		WTHETA	deg	F	W_θ - noise
		BTHETA	deg	F	b_θ - bias
		ETHETA	-	F	e_θ - scaling
	AOSVAN				Angle-of-attack sideslip vane errors (lateral):
		WBETA	deg	F	W_β - noise
		BBETA	deg	F	b_β - bias
		EBETA	-	F	e_β - scaling
11	PITRAT				Pitch rate errors (longitudinal):
		WQ	deg/sec	F	W_q - noise
		BQ	deg/sec	F	b_q - bias
		EQ	-	F	e_q - scaling

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
	ROLRAT				Roll rate errors (lateral):
		WP	deg/sec	F	w_p - noise
		BP	deg/sec	F	b_p - bias
		EP	-	F	e_p - scaling
		GP	deg	F	γ_p - misalignment
12	AOAVAN				Angle-of-attack vane errors (longitudinal):
		WALPHA	deg	F	w_α - noise
		BALPHA	deg	F	b_α - bias
		EALPHA	-	F	e_α - scaling
	YAWRAT				Yaw rate errors (lateral):
		WR	deg/sec	F	w_r - noise
		BR	deg/sec	F	b_r - bias
		ER	-	F	e_r - scaling
		GR	deg	F	γ_r - misalignment
13	AVPTUB				Axial velocity pilot tube errors (longitudinal):
		WU	ft/sec	F	w_u - noise
		BU	ft/sec	F	b_u - bias
		EU	-	F	e_u - scaling
	ROLATT				Roll attitude errors (lateral):
		WPHI	deg	F	w_ϕ - noise
		BPHI	deg	F	b_ϕ - bias
		EPHI	-	F	e_ϕ - scaling

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
14	AXIACC				Axial accelerometer errors (longitudinal):
		WNX	g's	F	w_{nx} - noise
		BNX	g's	F	b_{nx} - bias
		ENX	-	F	e_{nx} - scaling
		GNX	deg	F	γ_{nx} - misalignment
	LATACC				Lateral accelerometer errors (lateral):
		WNY	g's	F	w_{ny} - noise
		BNY	g's	F	b_{ny} - bias
		ENY	-	F	e_{ny} - scaling
15	NORMAC				Normal accelerometer errors (longitudinal):
		WNZ	g's	F	w_{nz} - noise
		BNZ	g's	F	b_{nz} - bias
		ENZ	-	F	e_{nz} - scaling
		GNZ	deg	F	γ_{nz} - misalignment
	RANACC				Roll angular accelerometer errors (lateral):
		WPDØT	deg/sec^2	F	$w_{\dot{p}}$ - noise
		BPDØT	deg/sec^2	F	$b_{\dot{p}}$ - bias
		EPDØT	-	F	$e_{\dot{p}}$ - scaling
		GPDØT	deg	F	$\gamma_{\dot{p}}$ - misalignment

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
16	PANACC				Pitch angular accelerometer errors (longitudinal):
		WQDØT	deg/sec^2	F	$w_{\dot{q}}$ - noise
		BQDØT	deg/sec^2	F	$b_{\dot{q}}$ - bias
		EQDØT	-	F	$e_{\dot{q}}$ - scaling
	YANACC				Yaw angular accelerometer errors (lateral):
		WRDØT	deg/sec^2	F	$w_{\dot{r}}$ - noise
		BRDØT	deg/sec^2	F	$b_{\dot{r}}$ - bias
		ERDØT	-	F	$e_{\dot{r}}$ - scaling
		GRDØT	deg	F	$\gamma_{\dot{r}}$ - misalignment
17	LAGS1				Output lags (inverse of time constants) for longitudinal instruments:
		FTHETA	1/sec	F	f
		FQ	1/sec	F	f_q
		FALPHA	1/sec	F	f_α
		FU	1/sec	F	f_u
		FNX	1/sec	F	f_{nx}
		FNZ	1/sec	F	f_{nz}
		FQDØT	1/sec	F	$f_{\dot{q}}$
	LAGS2				Output lags (inverse of time constants) for lateral instruments:
		FBETA	1/sec	F	f_β
		FP	1/sec	F	f_p

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
		FR	1/sec	F	f_r
		FPHI	1/sec	F	f_ϕ
		FNY	1/sec	F	f_{ny}
		FPDOT	1/sec	F	$f_{\dot{p}}$
		FRDOT	1/sec	F	$f_{\dot{r}}$
18	CGUNCR				C.G. uncertainties applicable for both longitudinal and lateral equations:
		EXCG	ft	F	e_{cgx} - uncertainty in x direction.
		EYCG	ft	F	e_{cgy} - uncertainty in y direction.
		EZCG	ft	F	e_{cgz} - uncertainty in z direction.
19	CPTERR				Control surface position transmitter errors:
		WDE	deg	F	$w_{\delta e}$
		WDA	deg	F	$w_{\delta a}$ } noise errors
		WDR	deg	F	$w_{\delta r}$
		BDE	deg	F	$b_{\delta e}$
		BDA	deg	F	$b_{\delta a}$ } bias errors
		BDR	deg	F	$b_{\delta r}$
		EDE	-	F	$e_{\delta e}$
		EDA	-	F	$e_{\delta a}$ } scale errors
		EDR	-	F	$e_{\delta r}$
		FDE	1/sec	F	$f_{\delta e}$
		FDA	1/sec	F	$f_{\delta a}$ } lags (inverse time constants)
		FDR	1/sec	F	$f_{\delta r}$

* (F = Floating point)
(I = Integer)

Table 3.1 Input Data for the Airplane Programs (cont.)

INPUTS	IDENTIFIER	VARIABLES	UNIT	TYPE*	DESCRIPTION
20	CGAPL				C.G. accelerometer location errors:
		EAX	ft	F	e_{ax}
		EAY	ft	F	e_{ay}
		EAZ	ft	F	e_{az}
21	ABVANE				Vane location errors:
		EVX	ft	F	e_{vx}
22	ERRMAT				General error matrix:
		T	-	F	7 x 7 matrix of general errors.

* (F = Floating point)
(I = Integer)

3.2 Helicopter Programs

There are two types of input data for this program, similar to the case of the aircraft programs.

3.2.1 Fixed Field Data

Four fixed field data cards are required for each case - an option card, a title card, an equation card and an instrument card.

Card 1 : Option (A6, 4X, 30L1)

30 logic option fields on this card may be used to specify various output options. Unlike the aircraft programs, the namelist data are not controlled by these options. However, the output options are the same as in the aircraft programs (see Section 4).

Card 2: Title (12A6)

A run title of not more than 72 characters to be printed at the beginning of the output.

Card 3 : Equations (A6)

This card specifies the equations to be analyzed. Only full longitudinal equations, if "FULLbb" or "LØNGbb", and lateral equations, if "LATbbb", are allowed on this card.

Card 4 : Instruments (7A6)

This card specifies the instruments to be used. The instruments are identical to the aircraft instruments (see Section 3.1.1).

3.2.2 Namelist Data

There are only two namelist groups in the helicopter programs - one for the longitudinal equations and another for the lateral equations. Table 3.2 lists the input variables, units, types and the descriptions of the longitudinal variables under the namelist group "LONGDT" and Table 3.3 lists the same for the lateral equations under the namelist group "LATDAT".

Table 3.2 LONGDT - Namelist Input Data for VTOL (Longitudinal)

VARIABLE	UNIT	TYPE*	DESCRIPTION
THETAO	deg	F	Nominal pitch angle, θ_o.
ALPHAO	deg	F	Nominal angle-of-attack, α_o.
VEL	ft/sec	F	Nominal airspeed, V_T.
ESTIM	-	I	Estimate option (same as airplane; see p. 7)
DT	sec	F	Integration step size.
DTS	sec	F	Time interval between samples.
TAU	sec	F	Time to the first sample point of the lagged control ($0<TAU\leq DTS$).
NMC**	-	I	Number of Monte Carlo samples.
NØP	-	I	Number of sample points on the trajectory.
MXITR**	-	I	Maximum number of Newton-Raphson iterations allowed within a Monte Carlo sample
EP1**	-	F	Convergence criteria for Newton-Raphson optimization scheme (i.e. $\max \left\lvert \frac{\Delta P_i}{P_i} \right\rvert \leq$ EP1).
EP2**	-	F	Convergence criteria for Newton-Raphson iteration (i.e. if $\lvert P_i \rvert <$ EP2, $\lvert \Delta P_i \rvert <$ EP2 is used instead of the above ratio.
NDP	-	I	Number of input control data points ($2\leq NDP\leq 301$).
DLTA	sec	F	An array of NDP time points at which input control data are given.
DLUE	in	F	An array of NDP values of the control δ_e corresponding to DLTA times.
DLUC	in	F	An array of NDP values of the control δ_e corresponding to DLTA times.
MQ	1/sec	F	M_q
ZQ	ft/sec	F	Z_q
XQ	ft/sec	F	X_q longitudinal parameters
MW	1/ft-sec	F	M_w
ZW	1/sec	F	Z_w
XW	1/sec	F	X_w

* (F = Floating point)
(I = Integer)

** Variables used only if the Simulated Data program is exercised. Default values are NMC=10, MXITR=10, EP1=1.0E-6, and EP2=1.0E-6.

Table 3.2 LONGDT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
MU	1/ft-sec	F	M_u
ZU	1/sec	F	Z_u
XU	1/sec	F	X_u
MDE	$1/\text{in-sec}^2$	F	$M_{\delta e}$
ZDE	ft/in-sec^2	F	$Z_{\delta e}$ longitudinal parameters
XDE	$\text{ft/sec}^2\text{-in}$	F	$X_{\delta e}$
MDC	$1/\text{in-sec}^2$	F	$M_{\delta e}$
ZDC	ft/in-sec^2	F	$Z_{\delta e}$
XDC	ft/in-sec^2	F	$X_{\delta e}$
IFXMQ	-	I	
IFXZQ	-	I	
IFXXQ	-	I	
IFXMW	-	I	
IFXZW	-	I	
IFXXW	-	I	Option to fix any parameter to its input value. If any of these variables are non-zero, then the corresponding parameter is not estimated. These options may also be set using the IFLPRM array; for example, IFLPRM(4) is equivalent to IFXMW.
IFXMU	-	I	
IFXZU	-	I	
IFXXU	-	I	
IFXMDE	-	I	
IFXZDE	-	I	
IFXXDE	-	I	
IFXMDC	-	I	
IFXZDC	-	I	
IFXXDC	-	I	
EDELT	deg	F	Initial condition error, $\Delta\theta$.
EDELQ	deg/sec	F	Initial condition error, Δq.
EDELW	ft/sec	F	Initial condition error, Δw.
EDELU	ft/sec	F	Initial condition error, Δu.
WTHETA	deg	F	Pitch attitude error - noise, n_θ.
BTHETA	deg	F	Pitch attitude error - bias, b_θ.
ETHETA	-	F	Pitch attitude error - scaling, e_θ.

* (F = Floating point)
(I = Integer)

Table 3.2 LONGDT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
WQ	deg/sec	F	Pitch rate error - noise, n_q.
BQ	deg	F	Pitch rate error - bias, b_q.
EQ	-	F	Pitch rate error - scaling, e_q.
WALPHA	deg	F	Angle-of-attack vane error - noise, n_α.
BALPHA	deg	F	Angle-of-attack vane error - bias, b_α.
EALPHA	-	F	Angle-of-attack vane error - scaling, e_α.
WU	ft/sec	F	Axial velocity pitot tube error - noise, n_u.
BU	ft/sec	F	Axial velocity pitot tube error - bias, b_u.
EU	-	F	Axial velocity pitot tube error - scaling, e_u.
WNX	g's	F	Axial accelerometer error - noise, n_{ax}.
BNX	g's	F	Axial accelerometer error - bias, b_{ax}.
ENX	-	F	Axial accelerometer error - scaling, e_{ax}.
GNX	deg	F	Axial accelerometer error - misalignment, γ_{ax}.
WNZ	g's	F	Normal accelerometer error - noise, n_{az}.
BNZ	g's	F	Normal accelerometer error - bias, b_{az}.
ENZ	-	F	Normal accelerometer error - scaling, e_{az}.
GNZ	deg	F	Normal accelerometer error - misalignment, γ_{az}.
WQDOT	deg/sec^2	F	Pitch angular accelerometer error - noise, n_q.
BQDOT	deg/sec^2	F	Pitch angular accelerometer error - bias, b_q.
EQDOT	-	F	Pitch angular accelerometer error - scaling, e_q.
FTHETA	1/sec	F	f_θ
FQ	1/sec	F	f_q
FALPHA	1/sec	F	f_α — Diagonal elements of a matrix representing inverse of output time constants.
FU	1/sec	F	f_u
FNX	1/sec	F	f_{nx}
FNZ	1/sec	F	f_{nz}
FQDOT	1/sec	F	$f_{\dot{q}}$
EXCG	ft	F	C.G. uncertainty in x direction, e_{cgx}.
EYCG	ft	F	C.G. uncertainty in y direction, e_{cgy}.
EZCG	ft	F	C.G. undertainty in z direction, e_{cgz}.

* (F = Floating point)
(I = Integer)

Table 3.2 LONGDT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
WDE	in	F	Differential collective (or longitudinal cyclic) pitch error - noise, $n_{\delta e}$.
BDE	in	F	Differential collective (or longitudinal cyclic) pitch error - bias, $b_{\delta e}$.
EDE	-	F	Differential collective (or longitudinal cyclic) pitch error - scaling, $e_{\delta e}$.
FDE	1/sec	F	Inverse of control measurement time constant, $f_{\delta e}$.
WDC	in	F	Collective pitch error - noise, $n_{\delta e}$.
BDC	in	F	Collective pitch error - bias, $b_{\delta e}$.
EDC	-	F	Collective pitch error - scaling, $e_{\delta e}$.
FDC	1/sec	F	Inverse of control measurement time constant, $f_{\delta e}$.
EAX	ft	F	C.G. accelerometer location error in x direction, $e_{a\ell x}$.
EAY	ft	F	C.G. accelerometer location error in y direction, $e_{a\ell y}$.
EAZ	ft	F	C.G. accelerometer location error in z direction, $e_{a\ell z}$.
T	-	F	7x7 general error matrix.
CMAT		F	2x4 matrix of state-variable-feedback gains, where CMAT is the matrix C in the expression $u_{fdbk} = -Cx$.
CMAT (1,1)	in/rad	F	$\Delta\theta$ feedback gain for δ_e.
CMAT (2,1)	in/rad	F	$\Delta\theta$ feedback gain for δ_c.
CMAT (1,2)	in-sec/rad	F	Δq feedback gain for δ_e.
CMAT (2,2)	in-sec/rad	F	Δq feedback gain for δ_c.
CMAT (1,3)	in-sec/ft	F	Δw feedback gain for δ_e.
CMAT (2,3)	in-sec/ft	F	Δw feedback gain for δ_c.
CMAT (1,4)	in-sec/ft	F	Δu feedback gain for δ_e.
CMAT (2,4)	in-sec/ft	F	Δu feedback gain for δ_c.
CARD	-	F	>0 will cause the F, G, and C matrices to be punched out, =0 means no punched cards output.
STVOUT	sec^{-1}	F	Standard deviations of the measurement (output) lags; STVOUT is an array with dimension 7.
STVCNT	sec^{-1}	F	Standard deviation of the control lags; STVCNT is an array with dimension 2.

* (F = Floating point)
(I = Integer)
(L = Logical)

Table 3.2 LONGDT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
BFLAG		L	Set = T will cause measurement and control lags to have a beta density function, Set = F causes a normal density function.
BDIST		F	Parameters specifying the beta density function. (Ignored if BFLAG = F.) See BDIST has dimension 3. BDIST(1) = n BDIST(2) = r BDIST(3) = 1.0 where n and r are parameters of the normalized beta density function (see Appendix A).

NOTE: The input value for each error source is one standard deviation. The mean value is assumed to be zero in every case unless noted otherwise.

* (F = Floating point)
(I = Integer)
(L = Logical)

Table 3.3 LATDAT - Namelist Input Data for VTOL (Lateral)

VARIABLE	UNIT	TYPE*	DESCRIPTION
THETAO	deg	F	Nominal pitch angle, θ_o.
ALPHAO	deg	F	Nominal angle-of-attack, α_o.
VEL	ft/sec	F	Nominal airspeed, V_T.
ESTIM	-	I	Estimate option (same as airplane case, p.7)
DT	sec	F	Integration step size.
DTS	sec	F	Time interval between sampling points.
TAU	sec	F	Time to the first sample point of the lagged control (0<TAU≤DTS).
NMC**	-	I	Number of Monte Carlo samples.
NØP	-	I	Number of sample points on the trajectory.
MXITR**	-	I	Maximum number of Newton-Raphson iterations allowed within a Monte Carlo sample.
EP1**	-	F	Convergence criteria for Newton-Raphson method. (see p. 18)
EP2**	-	F	Convergence criteria for Newton-Raphson method in case the magnitude of parameter is small. (see p. 18)
NDP	-	I	Number of input control data points (2≤NDP≤301).
DLTA	sec	F	An array of NDP time points at which input control data are given.
DLUA	in	F	An array of NDP values of the control δ_a corresponding to DLTA times.
DLUR	in	F	An array of NDP values of the control δ_r corresponding to DLTA times.
YV	1/sec	F	Y_v
LV	1/ft-sec	F	L_v
NV	1/ft-sec	F	N_v
YP	ft/sec	F	Y_p
LP	1/sec	F	L_p
NP	1/sec	F	N_p
YR	ft/sec	F	Y_r lateral parameters
LR	1/sec	F	L_r
NR	1/sec	F	N_r
YDA	ft/in-sec^2	F	$Y_{\delta a}$
LDA	1/in-sec^2	F	$L_{\delta a}$
NDA	1/in-sec^2	F	$N_{\delta a}$

* (F = Floating point)
(I = Integer)

** Variables used only if the Simulated Data Mode 2 program is exercised. Default values are NMC=10, MXITR=10, EP1=1.0E-6, EP2=1.0E-6.

Table 3.3 LATDAT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
YDR	$ft/in\text{-}sec^2$	F	Y_{δ_r}
LDR	$1/in\text{-}sec^2$	F	L_{δ_r} lateral parameters
NDR	$1/in\text{-}sec^2$	F	N_{δ_r}
XXI	$slug\text{-}ft^2$	F	I_{XX}
XZI	$slug\text{-}ft^2$	F	I_{XZ} moments and product of inertia
ZZI	$slug\text{-}ft^2$	F	I_{ZZ}
IFXYV	-	I	
IFXLV	-	I	
IFXNV	-	I	
IFXYP	-	I	
IFXLP	-	I	
IFXNP	-	I	
IFXYR	-	I	Option to fix any parameter to its input value. If any of these variables are non-zero, then the corresponding parameter is not estimated. These options may also be set using the IFLPRM array; for example, IFLPRM(4) is equivalent to IFXYP.
IFXLR	-	I	
IFXNR	-	I	
IFXYDA	-	I	
IFXLDA	-	I	
IFXNDA	-	I	
IFXYDR	-	I	
IFXLDR	-	I	
IFXNDR	-	I	
EDELV	ft/sec	F	Initial condition error, Δv.
EDELP	deg/sec	F	Initial condition error, Δp.
EDELR	deg/sec	F	Initial condition error, Δr.
EDELF	deg	F	Initial condition error, $\Delta\phi$.
WBETA	ft/sec	F	Angle-of-sideslip error - noise, n_β.
BBETA	ft/sec	F	Angle-of-sideslip error - bias, b_β.
EBETA	-	F	Angle-of-sideslip error - scaling, e_β.
WP	deg/sec	F	Roll rate error - noise, n_p.
BP	deg/sec	F	Roll rate error - bias, b_p.
EP	-	F	Roll rate error - scaling, e_p.
GP	deg	F	Roll rate error - misalignment, γ_p.

* (F = Floating point)
(I = Integer)

Table 3.3 LATDAT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
WR	deg/sec	F	Yaw rate error - noise, n_r.
BR	deg/sec	F	Yaw rate error - bias, b_r.
ER	-	F	Yaw rate error - scaling, e_r.
GR	deg	F	Yaw rate error - misalignment, γ_r.
WPHI	deg	F	Roll attitude error - noise, n_ϕ.
BPHI	deg	F	Roll attitude error - bias, b_ϕ.
EPHI	-	F	Roll attitude error - scaling, e_ϕ.
WNY	g's	F	Lateral accelerometer error - noise, n_{ay}.
BNY	g's	F	Lateral accelerometer error - bias, b_{ay}.
ENY	-	F	Lateral accelerometer error - scaling, e_{ay}.
WPDOT	deg/sec^2	F	Roll angular accelerometer error - noise, $n_{\dot{p}}$.
BPDOT	deg/sec^2	F	Roll angular accelerometer error - bias, $b_{\dot{p}}$.
EPDOT	-	F	Roll angular accelerometer error - scaling, $e_{\dot{p}}$.
GPDOT	deg	F	Roll angular accelerometer error - misalignment, $\gamma_{\dot{p}}$.
WRDOT	deg/sec^2	F	Yaw angular accelerometer error - noise, $n_{\dot{r}}$.
BRDOT	deg/sec^2	F	Yaw angular accelerometer error - bias, $b_{\dot{r}}$.
ERDOT	-	F	Yaw angular accelerometer error - scaling, $e_{\dot{r}}$.
GRDOT	deg	F	Yaw angular accelerometer error - misalignment, $\gamma_{\dot{r}}$.
FBETA	1/sec	F	f_β
FP	1/sec	F	f_p
FR	1/sec	F	f_r
FPHI	1/sec	F	f_ϕ — Diagonal elements of a matrix representing inverse of output time constants
FNY	1/sec	F	f_{ny}
FPDOT	1/sec	F	$f_{\dot{p}}$
FRDOT	1/sec	F	$f_{\dot{r}}$
EXCG	ft	F	C.G. uncertainty in x direction, e_{cgx}.
EYCG	ft	F	C.G. uncertainty in y direction, e_{cgy}.
EZCG	ft	F	C.G. uncertainty in z direction, e_{cgz}.

* (F = Floating point)
(I = Integer)

Table 3.3 LATDAT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
WDA	in	F	Roll cyclic error - noise, $n_{\delta a}$.
BDA	in	F	Roll cyclic error - bias, $b_{\delta a}$.
EDA	-	F	Roll cyclic error - scaling, $e_{\delta a}$.
FDA	1/sec	F	Inverse of control measurement time constant, $f_{\delta a}$.
WDR	in	F	Yaw cyclic error - noise, $n\delta_r$.
BDR	in	F	Yaw cyclic error - bias, $b\delta_r$.
EDR	-	F	Yaw cyclic error - scaling, $e\delta_r$.
FDR	1/sec	F	Inverse of control measurement time constant, $f_{\delta r}$.
EAX	ft	F	C.G. accelerometer location error in x direction, $e_{a\ell x}$.
EAY	ft	F	C.G. accelerometer location error in y direction, $e_{a\ell y}$.
EAZ	ft	F	C.G. accelerometer location error in z direction, $e_{a\ell z}$.
EVX	ft	F	Vane location error, e_{vx}.
T	-	F	7x7 general error matrix.
CMAT		F	2x4 matrix of state-variable-feedback gains, where CMAT is the matrix C in the expression $u_{fdbk} = -Cx$.
CMAT(1,1)	in-sec/ft	F	Δv feedback gain for δ_a.
CMAT(2,1)	in-sec/ft	F	Δv feedback gain for δ_r.
CMAT(1,2)	in-sec/rad	F	$\Delta \dot{p}$ feedback gain for δ_a.
CMAT(2,2)	in-sec/rad	F	$\Delta \dot{p}$ feedback gain for δ_r.
CMAT(1,3)	in-sec/rad	F	$\Delta \dot{r}$ feedback gain for δ_a.
CMAT(2,3)	in-sec/rad	F	$\Delta \dot{r}$ feedback gain for δ_r.
CMAT(1,4)	in/rad	F	$\Delta\phi$ feedback gain for δ_a.
CMAT(2,4)	in/rad	F	$\Delta\phi$ feedback gain for δ_r.
CARD	-	F	>0 will cause the F, G, and C matrices to be punched out, =0 means no punched cards output.
STVOUT	sec^{-1}	F	Standard deviation of the measurement (output) lags; STVOUT is an array with dimension 7.
STVCNT	sec^{-1}	F	Standard deviation of the control lags; STVCNT is an array with dimension 2.

* (F = Floating point)
(I = Integer)

Table 3.3 LATDAT - Namelist Input Data for VTOL (cont.)

VARIABLE	UNIT	TYPE*	DESCRIPTION
BFLAG		L	Set = T will cause measurement and control lags to have a beta density function, Set = F causes a normal density function.
BDIST		F	Parameters specifying the beta density function. (Ignored if BFLAG = F.) BDIST has dimension 3. BDIST(1) = n BDIST(2) = r BDIST(3) = 1.0 where n and r are parameters of the normalized beta density function (see Appendix A).

NOTE: The input value for each error source is one standard deviation. The mean value is assumed to be zero in every case unless noted otherwise.

* (F = Floating point)
(I = Integer)
(L = Logical)

3.3 Sample Cases

3.3.1 Example 1

Figure 3.1 shows the input for running the Airplane Ensemble Program with the lateral equations of motion. Parameters of the F and G matrices as well as initial condition errors for the F-4C aircraft are estimated. Seven instruments are used to measure the output.

3.3.2 Example 2

Figure 3.2 shows the input for running the Airplane Simulated Data Program with the full longitudinal equations of motion. Only parameters of the F and G matrices for the F-4C aircraft are estimated. All seven instruments are used to measure the output. Three Monte Carlo samples were taken in this execution.

3.3.3 Example 3

Figure 3.3 shows the input for running the VTOL Ensemble Program with longitudinal equations of motion. The nominal parameters specify an unstable F matrix, which is stabilized by the feedback-gains matrix, C. Parameters of the F and G matrices for the CH-46 helicopter are estimated. All seven instruments are used to measure the output. Measurement lags and control errors and lags were included.

3.3.4 Example 4

Figure 3.4 shows the input used to run the VTOL Simulated Data Program with lateral equations of motion. Parameters of the F and G matrices are estimated. Three Monte Carlo samples are taken.

```
ENSMBL     TT TTTTTTTTTTTTTTTTT   TTTTTT
LAT
AOSV  RRG   YRG   RAG   LATAC RAACC YAACC
 $RFTRAJ  THETA0=2.6, ALPHA0=2.6,  VEL=827.25, $
 $OPTONS  ESTIM=2,  $
 $MISC  DT=0.01, DTS=0.0501,  NOP=100,
   TAU=0.0501,
 $END
 $LATDR
  YBETA=-.156883, YDELA=-.00338, YDELR=.0246, LBETA=-15.977874,
    LP   =-1.608354, LR   =.384035, LDELA=10.920,LDELR=2.540,
  NBETA=6.563033,  NP   =-.099733,NR   =-.343175, NDELA=.707,
  NDELR=-3.902,  XZI=0.0,  XXI=1.0,  ZZI=1.0,
 $END
 $CONSEQ
  NDP=26,
  DLTA=-0.1,0.40001,0.40002,0.80001,0.80002,1.10001,1.10002,1.20001,
      1.20002,1.60001,1.60002,2.00001,2.00002,2.30001,2.30002,2.40001,
      2.40002,2.70001,2.70002,3.20001,3.20002,3.60001,3.60002,10.00001,
      10.0002,100.,
  DLU1=1.0,1.0,3.0,3.0,1.0,1.0,1.0,1.0,-1.0,-1.0,-3.0,-3.0,-1.0,-1.0,
      -1.0,-1.0,8*-0.1,0.0,0.0,
  DLU2=-0.5,-0.5,-0.5,-0.5,-0.5,-0.5,0.5,0.5,
      0.5,0.5,0.5,0.5,0.5,0.5,0.0,0.0,0.0,0.0,2.5,2.5,-1.5,-1.5,-0.3,
      -0.3,-0.3,-0.3,
 $END
 $LICERR
 $END
 $AOSVAN  WBETA =0.05, BBETA=0.05, EBETA=0.005,  $
 $ROLRAT  WP    =.10,  BP   =.10,  EP    =.005,  GP=.6, $
 $YAWRAT  WR    =.10,  BR   =.10,  ER    =.005,  GR=.6, $
 $ROLATT  WPHI  =.50,  BPHI =.50,  EPHI  =.005,  $
 $LATACC  WNY   =5.E-4,BNY  =5.E-4,ENY   =.005,  $
 $RANACC  WPDOT =.10,  BPDOT=.10,  EPDOT=.005,  BPDOT=.6,  $
 $YANACC  WRDOT =.10,  BRDOT=.10,  ERDOT=.005,  GRDOT=.6,  $
 $LAGS2
  FBETA=62.,  FP=62., FR=62.,  FPHI=62.,
   FNY=62.,  FPDOT=62.,  FRDOT=62.,
 $END
 $CGUNCR  EXCG  =.50,  EZCG =.50,  $
 $CPTERR
   WDA=0.1,  BDA=0.1,  EDA=0.01,  FDA=62.,
   WDR=0.1,  BDR=0.1,  EDR=0.01,  FDR=62.,
 $END
 $CGAPL   EAX   =5.0,  EAZ  =2.0,  $
 $ABVANE  EVX   =20.0,  $
 ••
```

Figure 3.1 Example Input for Airplane Ensemble Program

```
SIMDAT    TT TTTTT TTTTTTTTTTT   TTTTTT
FULL
PAG   PRG   AOAV  AVPT  AXACC NORAC PAACC
 $RFTRAJ  ALPHA0=2.6, THETA0=2.6, VEL=827.25, $
 $OPTONS ESTIM=1, $
 $MISC
   DT=0.025, DTS=0.05, NOP=100,
   NOP=300,
   MXITR=1,    DT=0.01,  DTS=0.0501,
   EP2=1.0E-5,
   MXITR=10,  EP1=0.01,  EP2=0.001,
   MODE=2,  NMC=1,
   MXITR=10,
   TAU=0.01,
  TAU=0.0501,
  NMC=1,
   NMC=3,
 $END
 $LONGDR
  MQ=-.719212, MW=-.010309, MU=-.000465, MDE=-16.21,
  ZW=-.762451, ZU=-.061697, ZDE=-1.245520, XW=.027260,
  XU=-.007009,  $
 $CONSEQ
   DLTA=-0.1,0.30001,0.30002,0.60001,0.60002,10.0001,10.0002,30.0001,
   DLU1= 2.5,2.5,-2.5,-2.5,-0.5,-0.5,0.5,0.5,
   NDP=8,
 $END
 $PITATT  WTHETA=.15,  BTHETA=.15,  ETHETA=.005, $
 $PITRAT  WQ    =.10,  BQ     =.10,  EQ     =.005, $
 $AOAVAN  WALPHA=.10,  BALPHA=.10,  EALPHA=.005, $
 $AVPTUB
   WU=1.0, BU=1.0, EU=0.005,
 $END
 $AXIACC  WNX   =.005, BNX   =.005, ENX   =.005,  GNX=.6 , $
 $NORMAC  WNZ   =.005, BNZ   =.005, ENZ   =.005,  GNZ=.6 , $
 $PANACC  WQDOT =.10,  BQDOT =.10,  EQDOT =.005, $
 $LAGS1
   FTHETA=62.,     FQ=62.,     FALPHA=62.,    FU=62.,
   FU=62.,     FNX=62.,     FNZ=62.,     FQDOT=62.,
 $END
 $CGUNCR  EXCG  =.50,  EZCG  =.50, $
 $CPTERR
  BDE=0.1,  EDE=0.01, WDE=0.1,
   FDE=62.,
   FDE=62.5,
   WDE=0.0,
 $END
 $CGAPL   EAX   =5.0,  EAZ   =2.0, $
 $ABVANE  EVX   =20.0, $
**
```

Figure 3.2 Example Input for Airplane Simulated Data Program

```
@ELT,IL CHKOUT
PROCESSED BY UNIVAC 1100 SERIES ELT PROCESSOR LEVEL W7 AT 11:31:26 AM ON MONDAY, SEPTEMBER 9, 1974  (CREATING CYCLE 0)

        ENSMBL     T                             TTTTTT
        FULL
        PAG   PRG   AQAV  AVPT  AXACC NORAC PAACC
         $LONGDT  DT=0.01, DTS=0.011, TAU=0.011, NMC=1, NOP=100, ESTIM=1,
          THETAO=6.719, ALPHA0=13.759, VEL=68.02,
          MXITR=1, EP1=.01, EP2=.00001,
          EVX=20., EAX=5., EAZ=2., EXCG=0.5, EZCG=0.5,
          MQ=-1.344, MW=+0.020, ZW=-0.606, MU=-0.003, ZU=-0.119, XU=-0.017,
          XW=+0.082, XQ=+1.070, ZQ=-1.873, MDE=0.405, ZDE=0.605, XDE=0.117,
          MDC=0.604, XDC=0.866, ZDC=-7.359,
          IFLPRM=15*0.,
          CMAT=.0372158,0.,.0510459,0.,.0449635,0.,-.0459085, 0.,
          WTHETA=0.15, BTHETA=0.15, ETHETA=.005,
          WQ=0.1,         BQ=0.1,          EQ=.005,
          WALPHA=0.1,  BALPHA=0.1,   EALPHA=.005,
          WU=1.,          BU=1.,           EU=1.,
          WNX=.005,       BNX=.005,        ENX=.005,      GNX=0.6,
          WNZ=.005,       BNZ=.005,        ENZ=.005,      GNZ=0.6,
          WQDOT=0.1,      BQDOT=0.1,       EQDOT=.005,    GQDOT=0.,
          NDP=17,
          DLTA=0.0000,0.3927,0.7854,1.1781,1.5707,1.9634,2.3561,2.4788,3.1416,
                3.5343,3.9270,4.3197,4.7123,5.1050,5.4977,5.8904,6.2832,284*0.,
          DLUE=0.4904,0.4619,0.4157,0.3536,0.2778,0.1913,0.0976,0.0000,-.0976,
                -.1913,-.2778,-.3536,-.4157,-.4619,-.4904,-.5000,-.5000,284*0.,
          DLUC=0.0000,0.0976,0.1913,0.2778,0.3536,0.4157,0.4619,0.5000,0.4904,
                0.4619,0.4157,0.3536,0.2778,0.1913,0.0975,0.0000,285*0.,
          FTHETA=62.,FQ=62.,FALPHA=62.,FU=62.,FNX=62.,FNZ=62.,FQDOT=62.,
          BDE=0.1,BDC=0.1,EDE=.01,EDC=.01,FDE=62.,FDC=62.,
         $END

END ELT.  TIME: 0.0672 SECONDS.
```

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Figure 3.3 Example Input for VTOL Ensemble Program

```
SIMDAT     TT TTTTT TTTTTTTTTTT    TTTTTT
LAT
AOSV  RRG    YRG    RAG    LATAC RAACC YAACC
 SLATDAT
  YV=-.082, LV=-.010, NV=-.002, YP=-1.333, LP=-.703, NP=-.025,
  YR=-.223, LR=-.070, NR=-.042, YDA=.954,  LDA=.454, NDA=.027,
  YDR=.104, LDR=-.136, NDR=.170, THETA0=6.719, ALPHA0=13.75, VEL=68.02,
  ESTIM=1, DT=0.1, DTS=0.11, TAU=0.1, NOP=99,
   MXITR=20,  NMC=1,  EP1=0.01, EP2=1.0E-5,
   NMC=3,
  WBETA=0.05,  BBETA=0.05,  EBETA=0.005,
  WP   =0.1,   BP   =0.1,   EP   =0.005,   GP=0.6,
  WR   =0.1,   BR   =0.1,   ER   =0.005,   GR=0.6,
  WPHI =0.5,   BPHI =0.5,   EPHI =0.005,
  WNY  =0.0005,BNY  =0.0005,ENY  =0.005,
  WPDOT=0.1,   BPDOT=0.6,   EPDOT=0.005,
  WRDOT=0.1,   BRDOT=0.1,   ERDOT=0.005,   GRDOT=0.6,
  EXCG =0.5,   EZCG =0.5,   EAX  =5.0,  EAZ=2.0,  EVX=20.,
   NDP=100,
   DLTA=0.,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,
        1.,1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,
        2.,2.1,2.2,2.3,2.4,2.5,2.6,2.7,2.8,2.9,
        3.,3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,
        4.,4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,
        5.,5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,
        6.,6.1,6.2,6.3,6.4,6.5,6.6,6.7,6.8,6.9,
        7.,7.1,7.2,7.3,7.4,7.5,7.6,7.7,7.8,7.9,
        8.,8.1,8.2,8.3,8.4,8.5,8.6,8.7,8.8,8.9,
        9.,9.1,9.2,9.3,9.4,9.5,9.6,9.7,9.8,9.9,
   DLUA=.27436462,.30697129,.31817003,.30858923,.27960615,.23329410,.17234128,
       .099944715,.019683387,-.064623996,-.14907054,-.22981638,
       -.30324040,-.36608278,-.41557249,-.44953408,-.46646997,-.46561464,
       -.44695839,-.41124025,-.35991004,-.29506130,-.21933809,-.13581966,
       -.047887504,.040919272,.12705423,.20711353,.27797895,.33694809,
        .38184684,.41111857,.42388719,.41999098,.39998629,.36512064,.31727654,
        .25888867,.19283762,.12232484,.050734556,-.018512606,-.082106804,
       -.13699187,-.18049663,-.21045097,-.22527950,-.22407060,-.20661731,
       -.17342797,-.12570683,-.065304766,.53572403E-2,.83389245E-1,
        .16555354,.24840096,.32841619,.40216707,.46645024,.51842798,.55574977,
        .57665464,.58004845,.56555344,.53352883,.48505988,.42191685,.34648550,
        .26167136,.17078244,.77394353E-1,-1.4795740E-1,-.10212090,-.18109514,
       -.24855744,-.30180290,-.33869484,-.35775423,-.35822212,-.34009247,
      -.30411446    ,-.25176330    ,-.18518152    ,-.10709272    ,
      -.20691283E-1, .70487035E-1, .16270835    , .25219328    ,
       .33526948    , .40852108    , .46892770    , .51398519    ,
       .54180791    , .55120285    , .54171659    , .51365157    ,
       .46805055    , .40665135    , .33181285    , .24641500    ,
  DLUR= .35045058    , .29690383    , .24831535    , .20581121    , .17020075    ,
       .14195191    , .12118265    , .10766857    , .10086613    , .99950444E-1,
       .10386536    , .11138381    , .12117541    , .13187785    , .14216914    ,
       .15083699    , .15684225    , .15937335    , .15788901    , .15214761    ,
       .14222134    , .12849468    , .11164699    , .92620157E-1, .72572494E-1,
       .52820982E-1, .34774627E-1, .19861648E-1, .94541330E-2, .47934353E-2,
       .69199651E-1, .34327138E-1, .60177214E-1, .93891717E-1, .13481833    ,
       .18193246    , .23386573    , .28895082    , .34528133    , .40078368    ,
       .45329938    , .50067315    , .54084388    , .57193405    , .59233463    ,
       .60078044    , .59641379    , .57883254    , .54812077    , .50486013    ,
       .45012109    , .38543392    , .31274046    , .23432801    , .15274782    ,
       .70721465    ,-.89616270    ,-.83551504    ,-.15044492    ,-.20728873    ,
      -.25207560    ,-.28322654    ,-.29965861    ,-.30083321    ,-.26678403    ,
```

Figure 3.4 Example Input for VTOL Simulated Data Program (page 1 of 2)

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```
   -.25812216   ,-.21601896   ,-.16216619   ,-.98715277E-1,-.28197577E-1,
    .46571217E-1, .12259861   , .19683142   , .26627460   , .32810994   ,
    .37980755   , .41922805   , .44470931   , .45513532   , .44998405   ,
    .42935211   , .39395465   , .34510186   , .28465018   , .21493335   ,
    .13867274   , .58872171E-1,-.21298651E-1,-.98628347E-1,-.16999082   ,
   -.23246810   ,-.28346775   ,-.32082612   ,-.34289612   ,-.34861492   ,
   -.33754862   ,-.30991248   ,-.26656554   ,-.20897976   ,
 FBETA=62.,  FP=62.,  FR=62.,  FPHI=62.,  FNY=62.,
  FPDOT=62.,  FRDOT=62.,  FDA=62.,  FDR=62.,
  DT=0.01,
 $END
**
```

Figure 3.4 (page 2 of 2)

4.0 OUTPUT DESCRIPTION

The output from the SCIP2 programs will be discussed in two parts--the Ensemble Analysis and the Simulated Data Analysis. The output format will be the same for the aircraft and the helicopter programs except for the parameter identifiers.

4.1 Ensemble Analysis

4.1.1 Input Summary

A summary of the input is printed first. The namelist input data are printed in their entirety, and then selected program variables are tabulated.

4.1.2 Estimated State Vector and Input Control

If INPUTS(25) is "TRUE", then the estimated state vector $\hat{y}$ and the control vector u_m are printed at each sample point (every DTS-seconds).

4.1.3 Covariance Matrix

If INPUTS(26) is "TRUE", then two covariance matrices, $\left[\frac{\partial^2 J}{\partial p^2}\right]^{-1}$ and $\left[\frac{\partial 2 J}{\partial p^2}\right]^{-1} + \left[\frac{\partial}{\partial e}(\delta p)\ E(ee^T)\ \frac{\partial}{\partial e}(\delta p)^T\right]$ are printed. $\left[\frac{\partial 2 J}{\partial p^2}\right]^{-1}$ is the covariance due to noise and $\left[\frac{\partial}{\partial e}(\delta p)\ E(ee^T)\ \frac{\partial}{\partial e}(\delta p)^T\right]$ is the covariance due to the random error sources.

4.1.4 Normalized Covariance Matrix

If INPUTS(27) is "TRUE", then the normalized covariance matrices are printed. The relationship between the normalized and unnormalized covariance matrices is given by the following equations:

diagonal elements $\quad c_{ii} = \sqrt{c'_{ii}}$

off-diagonal elements $\quad c_{ij} = \dfrac{c'_{ij}}{c_{ii}c_{ij}}$

where the primed variables are the unnormalized covariance matrix elements and the unprimed variables are normalized.

4.1.5 Sensitivity Derivatives

If INPUTS(28) is "TRUE", the sensitivity derivatives, $\frac{\partial}{\partial e}(\delta p)$ with respect to every non-zero error source as well as the magnitude of the error are printed in a matrix format.

4.1.6 Mean Expected Error Vector

If INPUTS(29) is "TRUE", then the mean expected error vector, $\frac{\partial}{\partial e}(\delta p)\, E(e)$, is printed for each element of the parameter vector.

4.2 Simulated Data Analysis

4.2.1 Monte Carlo Sample Output

The standard output quantities for each Monte Carlo sample consist of:

(a) Error vector, $\Delta p = p - \hat{p}_k$, where p is the true parameter vector and $\hat{p}_k$ is the estimated parameter vector resulting from the k^{th} Newton-Raphson Step.

(b) Normalized Error Vector, $(\Delta p(i)/p(i))$.

(c) Mean Error Vector, $\overline{\Delta p_m}$, where the subscript m refers to the m number of Monte Carlo samples, and

$$\overline{\Delta p_m} = \frac{1}{m} \sum_{i=1}^{m} \Delta p_i .$$

(d) Covariance Matrix, C_m, where

$$C_m(i,j) = \frac{1}{m-1}\sum_{i=1}^{m}(\Delta P_i - \overline{\Delta P}_m)(\Delta P_i - \overline{\Delta P}_m)^T$$

4.2.2 Newton-Raphson Step Output

If INPUTS(25) is "TRUE", then several quantities from each Newton-Raphson step are printed. These quantities include:

(a) Gradient Vector, $-\left(\frac{\partial J}{\partial p}\right) = \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T R^{-1} (y_i - \hat{y}_i)$.

(b) Error Vector, $\Delta p_k = -\left[\frac{\partial^2 J}{\partial p^2}\right]^{-1}\left(\frac{\partial J}{\partial p}\right)^T$, from each Newton-Raphson step.

(c) Updated Parameter Estimate Vector, $\hat{p}_{k+1} = \hat{p}_k + \Delta p_k$.

(d) Convergence criteria,

$$\text{COST1} = \max\left\{\left|\frac{\Delta p_i}{p_i}\right|, \ i = 1,\ldots,n \ (\text{number of parameters})\right\}$$

$$\text{COST2} = \sum_{i=1}^{n}\left|\frac{\Delta p_i}{p_i}\right|$$

When COST1 < EP1 and $|\Delta p_i|$<EP2 when $|p_i|$<EP2, then convergence is assumed.

4.2.3 Monte Carlo Summary

After the specified number of Monte Carlo samples are taken, a summary of the error statistics is displayed. The summary includes:

(a) Mean Error Vector, $\overline{\Delta p}_m = \frac{1}{m}\sum_{i=1}^{m} \Delta p_i$;

(b) Covariance Matrix, $C_m(i,j)$;

(c) Normalized Covariance Matrix, C'. The relationship between the normalized covariance matrix elements is the same as in Section 4.1.4.

4.3 Sample Output

4.3.1 Example 1

Figure 4.1 shows the output corresponding to the input Example 1, given for the Aircraft Ensemble Program. The namelist printout is deleted from this section.

4.3.2 Example 2

Figure 4.2 shows the output corresponding to the input Example 2, given for the Aircraft Simulated Data Program. Again, the namelist printout is deleted from this section.

4.3.3 Example 3

Figure 4.3 shows the output corresponding to the input Example 3, given for the VTOL Ensemble Program. This example includes a feedback-gain matrix, C. The namelist printout is included in this section.

4.3.4 Example 4

Figure 4.4 shows the output corresponding to the input Example 4, given for the VTOL Simulated Data Program. This example produces a detailed Newton-Raphson step output as well as Monte Carlo sample outputs. After three samples, the summary of error statistical output is produced.

ENSEMBLE ** LATERAL ANALYSIS
PARAMETERS AND INITIAL CONDITIONS ESTIMATE

INPUT SUMMARY

ENSMBL T T F T T T T T T T T T T T T T T T T T T F F F T T T T T T

ESTIM= 2 MODE= 0 SAMPLE POINTS= 100 SAMPLE RATE= .050 MONTE CARLO 0 RUNS

YBETA =-1.568830E-01	LBETA =-1.597787E+01	NBETA = 6.563033E+00	LP =-1.608354E+00	NP =-9.973300E-02
LR = 3.840350E-01	NR =-3.431750E-01	YDELA =-3.380000E-03	LDELA = 1.092000E+01	NDELA = 7.070000E-01
YDELR = 2.460000E-02	LDELR = 2.540000E+00	NDELR =-3.902000E+00		

ALPHA= 2.6000 THETA= 2.6000 VELOCITY= 827.2500

ERROR VECTORS

	BIASES	SCALE	MISALIGN	LAG	NOISE
BETA	5.0000000E-02	5.0000000E-03	0.	6.2000000E+01	5.0000000E-02
P	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01
R	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01
PHI	5.0000000E-01	5.0000000E-03	0.	6.2000000E+01	5.0000000E-01
NY	5.0000000E-04	5.0000000E-03	0.	6.2000000E+01	5.0000000E-04
P-DOT	6.0000000E-01	5.0000000E-03	0.	6.2000000E+01	1.0000000E-01
R-DOT	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01

	I. C.		ACCEL		C. G.		VANE
BETA	0.	AX	5.0000000E+00	CG X	5.0000000E-01	VX	2.0000000E+01
P	0.	AY	0.	CG Y	0.		
R	0.	AZ	2.0000000E+00	CG Z	5.0000000E-01		
PHI	0.						

CONTROL ERRORS

BDA	1.0000000E-01	EDA	1.0000000E-02	FDA	6.2000000E+01
BDR	1.0000000E-01	EDR	1.0000000E-02	FDR	6.2000000E+01

Figure 4.1 Example Output for Aircraft Ensemble Program (page 1 of 10)

SCIP2 STATE MEASUREMENT AND CONTROL SEQUENCE

TIME (SEC)	BETA (DEG)	P (DEG/SEC)	R (DEG/SEC)	PHI (DEG)	NY (G'S)	P-DOT (DEG/SEC**2)	R-DOT (DEG/SEC**2)	DEL A (DEG)	DEL R (DEG)
.0500	-.00	.47	.13	.01	-.01	9.01	2.54	1.00	-.50
.1000	-.01	.90	.25	.05	-.01	8.49	2.40	1.00	-.50
.1500	-.03	1.32	.37	.10	-.01	8.09	2.23	1.00	-.50
.2000	-.04	1.71	.48	.18	-.00	7.78	2.04	1.00	-.50
.2500	-.07	2.10	.57	.28	-.00	7.55	1.82	1.00	-.50
.3000	-.09	2.47	.66	.39	-.00	7.38	1.59	1.00	-.50
.3500	-.12	2.84	.73	.53	.00	7.27	1.35	1.00	-.50
.4000	-.15	3.20	.79	.68	.00	7.19	1.09	1.00	-.50
.4500	-.18	3.55	.84	.85	.00	28.97	2.25	3.00	-.50
.5000	-.21	4.96	.94	1.06	.00	27.27	1.86	3.00	-.50
.5500	-.25	6.28	1.03	1.35	.01	25.71	1.48	3.00	-.50
.6000	-.28	7.53	1.09	1.70	.01	24.26	1.11	3.00	-.50
.6500	-.31	8.71	1.14	2.10	.01	22.90	.77	3.00	-.50
.7000	-.34	9.82	1.17	2.57	.01	21.61	.44	3.00	-.50
.7500	-.37	10.87	1.18	3.09	.02	20.38	.15	3.00	-.50
.8000	-.40	11.86	1.18	3.66	.02	19.19	-.11	3.00	-.50
.8500	-.42	12.79	1.17	4.28	.02	-3.81	-1.76	1.00	-.50
.9000	-.43	12.61	1.08	4.92	.02	-3.31	-1.81	1.00	-.50
.9500	-.44	12.46	.99	5.55	.02	-2.92	-1.83	1.00	-.50
1.0000	-.45	12.32	.90	6.17	.02	-2.65	-1.82	1.00	-.50
1.0500	-.45	12.19	.81	6.79	.02	-2.49	-1.78	1.00	-.50
1.1000	-.44	12.07	.72	7.39	.02	-2.42	-1.70	1.00	-.50
1.1500	-.43	11.95	.64	8.00	.03	.11	-5.49	1.00	.50
1.2000	-.41	11.94	.37	8.59	.03	-.33	-5.25	1.00	.50
1.2500	-.37	11.91	.12	9.19	.03	-22.79	-6.34	-1.00	.50
1.3000	-.32	10.80	-.19	9.76	.03	-21.90	-5.80	-1.00	.50
1.3500	-.26	9.72	-.46	10.27	.03	-21.27	-5.19	-1.00	.50
1.4000	-.19	8.67	-.70	10.73	.02	-20.84	-4.52	-1.00	.50
1.4500	-.11	7.63	-.91	11.13	.01	-20.57	-3.81	-1.00	.50
1.5000	-.02	6.61	-1.08	11.49	.01	-20.41	-3.06	-1.00	.50
1.5500	.08	5.59	-1.22	11.79	.00	-20.34	-2.29	-1.00	.50
1.6000	.18	4.57	-1.31	12.04	-.01	-20.31	-1.51	-1.00	.50
1.6500	.27	3.56	-1.37	12.24	-.01	-42.12	-2.16	-3.00	.50
1.7000	.37	1.50	-1.46	12.36	-.02	-40.42	-1.27	-3.00	.50
1.7500	.47	-.48	-1.50	12.39	-.02	-38.80	-.42	-3.00	.50
1.8000	.56	-2.38	-1.50	12.31	-.03	-37.22	.37	-3.00	.50
1.8500	.65	-4.21	-1.46	12.14	-.04	-35.67	1.11	-3.00	.50
1.9000	.73	-5.95	-1.39	11.88	-.04	-34.09	1.78	-3.00	.50
1.9500	.80	-7.62	-1.29	11.54	-.05	-32.48	2.37	-3.00	.50
2.0000	.86	-9.20	-1.15	11.12	-.05	-30.82	2.86	-3.00	.50
2.0500	.90	-10.70	-1.00	10.62	-.06	-7.26	4.68	-1.00	.50
2.1000	.94	-11.06	-.76	10.07	-.06	-7.12	4.85	-1.00	.50
2.1500	.96	-11.41	-.52	9.51	-.06	-6.77	4.93	-1.00	.50
2.2000	.96	-11.73	-.27	8.93	-.06	-6.22	4.90	-1.00	.50
2.2500	.95	-12.02	-.03	8.34	-.06	-5.50	4.79	-1.00	.50
2.3000	.93	-12.28	.21	7.73	-.06	-4.64	4.58	-1.00	.50
2.3500	.89	-12.49	.43	7.11	-.06	-4.91	6.24	-1.00	.50
2.4000	.84	-12.70	.73	6.48	-.06	-3.64	5.82	-1.00	0.00
2.4500	.77	-12.85	1.01	5.84	-.05	7.60	5.94	-.10	0.00
2.5000	.69	-12.45	1.29	5.21	-.05	8.37	5.27	-.10	0.00
2.5500	.60	-12.01	1.54	4.61	-.04	9.25	4.53	-.10	0.00

Figure 4.1 (page 2 of 10)

SCIP2 STATE MEASUREMENT AND CONTROL SEQUENCE

TIME (SEC)	BETA (DEG)	P (DEG/SEC)	R (DEG/SEC)	PHI (DEG)	NY (G'S)	P-DOT (DEG/SEC**2)	R-DOT (DEG/SEC**2)	DEL A (DEG)	DEL R (DEG)
2.6000	.49	-11.52	1.74	4.02	-.03	10.22	3.72	-.10	0.00
2.6500	.38	-10.99	1.91	3.46	-.03	11.23	2.87	-.10	0.00
2.7000	.26	-10.40	2.03	2.93	-.02	12.23	1.99	-.10	0.00
2.7500	.14	-9.76	2.11	2.43	.02	19.55	-8.66	-.10	2.50
2.8000	.03	-8.79	1.66	1.97	.03	19.53	-9.32	-.10	2.50
2.8500	-.05	-7.82	1.18	1.56	.03	19.12	-9.79	-.10	2.50
2.9000	-.11	-6.88	.68	1.20	.04	18.32	-10.09	-.10	2.50
2.9500	-.14	-5.99	.17	.88	.04	17.17	-10.20	-.10	2.50
3.0000	-.14	-5.17	-.34	.60	.04	15.70	-10.12	-.10	2.50
3.0500	-.12	-4.43	-.84	.36	.04	13.94	-9.87	-.10	2.50
3.1000	-.07	-3.78	-1.32	.15	.03	11.93	-9.45	-.10	2.50
3.1500	.00	-3.24	-1.78	-.03	.03	9.71	-8.86	-.10	2.50
3.2000	.10	-2.81	-2.21	-.19	.02	7.34	-8.13	-.10	2.50
3.2500	.22	-2.50	-2.59	-.32	-.03	-5.31	8.33	-.10	-1.50
3.3000	.32	-2.80	-2.16	-.46	-.04	-6.39	8.92	-.10	-1.50
3.3500	.41	-3.14	-1.70	-.61	-.05	-7.02	9.35	-.10	-1.50
3.4000	.47	-3.49	-1.23	-.78	-.05	-7.20	9.61	-.10	-1.50
3.4500	.50	-3.85	-.74	-.97	-.05	-6.98	9.70	-.10	-1.50
3.5000	.51	-4.19	-.26	-1.17	-.05	-6.39	9.62	-.10	-1.50
3.5500	.49	-4.48	.22	-1.39	-.05	-5.45	9.38	-.10	-1.50
3.6000	.45	-4.73	.68	-1.62	-.05	-4.23	8.97	-.10	-1.50
3.6500	.39	-4.90	1.11	-1.86	-.03	.30	3.74	-.10	-.30
3.7000	.31	-4.86	1.28	-2.10	-.02	1.53	3.16	-.10	-.30
3.7500	.22	-4.75	1.43	-2.33	-.02	2.78	2.54	-.10	-.30
3.8000	.13	-4.58	1.54	-2.56	-.01	4.01	1.89	-.10	-.30
3.8500	.04	-4.35	1.61	-2.78	-.01	5.19	1.21	-.10	-.30
3.9000	-.06	-4.06	1.66	-2.99	.00	6.30	.53	-.10	-.30
3.9500	-.16	-3.72	1.67	-3.18	.01	7.31	-.15	-.10	-.30
4.0000	-.26	-3.33	1.64	-3.35	.01	8.21	-.81	-.10	-.30
4.0500	-.35	-2.90	1.59	-3.51	.02	8.97	-1.44	-.10	-.30
4.1000	-.44	-2.44	1.50	-3.64	.03	9.59	-2.03	-.10	-.30
4.1500	-.52	-1.94	1.39	-3.74	.03	10.05	-2.57	-.10	-.30
4.2000	-.59	-1.43	1.24	-3.82	.04	10.34	-3.05	-.10	-.30
4.2500	-.65	-.91	1.08	-3.88	.04	10.46	-3.47	-.10	-.30
4.3000	-.71	-.39	.90	-3.91	.05	10.41	-3.81	-.10	-.30
4.3500	-.75	.13	.70	-3.92	.05	10.18	-4.07	-.10	-.30
4.4000	-.78	.63	.49	-3.90	.05	9.80	-4.25	-.10	-.30
4.4500	-.80	1.10	.28	-3.85	.05	9.25	-4.35	-.10	-.30
4.5000	-.81	1.55	.06	-3.78	.05	8.56	-4.37	-.10	-.30
4.5500	-.80	1.96	-.16	-3.70	.05	7.74	-4.30	-.10	-.30
4.6000	-.78	2.32	-.37	-3.59	.05	6.80	-4.15	-.10	-.30
4.6500	-.76	2.63	-.57	-3.47	.05	5.77	-3.93	-.10	-.30
4.7000	-.72	2.90	-.76	-3.33	.05	4.67	-3.64	-.10	-.30
4.7500	-.67	3.10	-.93	-3.18	.04	3.51	-3.29	-.10	-.30
4.8000	-.61	3.25	-1.09	-3.03	.04	2.31	-2.88	-.10	-.30
4.8500	-.55	3.33	-1.22	-2.86	.04	1.10	-2.42	-.10	-.30
4.9000	-.48	3.36	-1.33	-2.70	.03	-.09	-1.93	-.10	-.30
4.9500	-.41	3.32	-1.41	-2.54	.03	-1.25	-1.41	-.10	-.30
5.0000	-.33	3.23	-1.47	-2.37	.02	-2.37	-.87	-.10	-.30

Figure 4.1 (page 3 of 10)

D2JDP2 MATRIX INVERSE

	YB	LB	NB	LP	NP	LR	NR	YDA	LDA	NDA
YB	2.068E-07	1.278E-05	-2.685E-06	-5.090E-08	-1.042E-07	3.578E-07	4.036E-08	2.105E-08	4.862E-07	-3.321E-07
LB	1.278E-05	3.190E-03	-1.558E-04	1.154E-04	-1.062E-05	2.289E-04	6.615E-06	1.122E-06	1.135E-04	-1.342E-05
NB	-2.685E-06	-1.558E-04	2.741E-04	4.850E-07	1.117E-05	-2.803E-05	3.289E-05	-1.462E-07	2.427E-05	1.300E-05
LP	-5.090E-08	1.154E-04	4.850E-07	1.165E-05	-2.774E-07	1.999E-05	-5.478E-07	3.056E-08	-6.719E-06	1.636E-07
NP	-1.042E-07	-1.062E-05	1.117E-05	-2.774E-07	7.739E-07	-7.082E-07	2.841E-06	-1.445E-08	4.989E-07	-6.549E-07
LR	3.578E-07	2.289E-04	-2.803E-05	1.999E-05	-7.082E-07	1.759E-04	2.762E-05	1.379E-07	-6.673E-05	-1.328E-05
NR	4.036E-08	6.615E-06	3.289E-05	-5.478E-07	2.841E-06	2.762E-05	3.203E-05	1.875E-07	7.097E-06	-1.196E-05
YDA	2.105E-08	1.122E-06	-1.462E-07	3.056E-08	-1.445E-08	1.379E-07	1.875E-07	2.034E-08	8.761E-07	-1.138E-07
LDA	4.862E-07	1.135E-04	2.427E-05	-6.719E-06	4.989E-07	-6.673E-05	7.097E-06	8.761E-07	2.054E-04	2.604E-06
NDA	-3.321E-07	-1.342E-05	1.300E-05	1.636E-07	-6.549E-07	-1.328E-05	-1.196E-05	-1.138E-07	2.604E-06	1.175E-05
YDR	1.950E-08	1.334E-06	-8.967E-07	-2.703E-08	-1.848E-08	4.811E-09	-1.015E-08	5.421E-09	1.618E-07	-7.751E-08
LDR	1.528E-06	3.217E-04	-6.886E-05	1.201E-05	-1.832E-06	2.207E-05	-7.938E-06	1.995E-07	3.763E-05	-9.243E-07
NDR	-2.726E-06	-2.618E-04	4.508E-05	-9.810E-07	3.405E-06	3.156E-06	1.232E-05	-4.533E-08	1.643E-06	-3.249E-06
BETA	1.225E-07	-7.689E-06	-7.679E-06	-1.656E-06	-7.125E-08	-2.703E-06	-9.120E-07	2.073E-08	1.375E-06	-3.458E-06
P	-2.948E-08	8.108E-05	2.662E-05	6.626E-06	2.442E-06	1.480E-05	8.839E-06	-1.393E-07	4.617E-06	1.346E-06
R	3.300E-07	-3.739E-05	-1.826E-05	-5.965E-06	1.507E-06	-8.562E-06	-2.702E-06	-5.006E-07	-4.523E-05	-4.699E-06
PHI	1.920E-07	-3.414E-04	-8.344E-05	-2.447E-05	-6.319E-06	-6.177E-05	-2.561E-05	2.533E-07	-2.598E-06	2.402E-06

	YDR	LDR	NDR	BETA	P	R	PHI
YB	1.950E-08	1.528E-06	-2.726E-06	1.225E-07	-2.948E-08	3.300E-07	1.920E-07
LB	1.334E-06	3.217E-04	-2.618E-04	-7.689E-06	8.108E-05	-3.739E-05	-3.414E-04
NB	-8.967E-07	-6.886E-05	4.508E-05	-7.679E-06	2.662E-05	-1.826E-05	-8.344E-05
LP	-2.703E-08	1.201E-05	-9.810E-07	-1.656E-06	6.626E-06	-5.965E-06	-2.447E-05
NP	-1.848E-08	-1.832E-06	3.405E-06	-7.125E-08	2.442E-06	1.507E-06	-6.319E-06
LR	4.811E-09	2.207E-05	3.156E-06	-2.703E-06	1.480E-05	-8.562E-06	-6.177E-05
NR	-1.015E-08	-7.938E-06	1.232E-05	-9.120E-07	8.839E-06	-2.702E-06	-2.561E-05
YDA	5.421E-09	1.995E-07	-4.533E-08	2.073E-08	-1.393E-07	-5.006E-07	2.533E-07
LDA	1.618E-07	3.763E-05	1.643E-06	1.375E-06	4.617E-06	-4.523E-05	-2.598E-06
NDA	-7.751E-08	-9.243E-07	-3.249E-06	-3.458E-06	1.346E-06	-4.699E-06	2.402E-06
YDR	2.054E-08	4.990E-07	-2.109E-07	1.310E-08	8.227E-09	1.157E-07	1.134E-07
LDR	4.990E-07	1.829E-04	-1.508E-05	-1.079E-06	7.381E-06	1.833E-06	-4.337E-05
NDR	-2.109E-07	-1.508E-05	6.696E-05	3.919E-08	2.936E-06	-2.075E-06	-1.426E-05
BETA	1.310E-08	-1.079E-06	3.919E-08	3.816E-06	-1.308E-06	3.404E-06	9.596E-06
P	8.227E-09	7.381E-06	2.936E-06	-1.308E-06	5.015E-04	2.978E-05	-3.219E-04
R	1.157E-07	1.833E-06	-2.075E-06	3.404E-06	2.978E-05	4.882E-05	6.461E-05
PHI	1.134E-07	-4.337E-05	-1.426E-05	9.596E-06	-3.219E-04	6.461E-05	2.739E-03

Figure 4.1 (page 4 of 10)

NORMALIZED D2JDP2 INVERSE

	YB	LB	NB	LP	NP	LR	NR	YDA	LDA	NDA
YB	4.547E-04	4.976E-01	-3.567E-01	-3.280E-02	-2.605E-01	5.933E-02	1.568E-02	3.245E-01	7.460E-02	-2.130E-01
LB	4.976E-01	5.648E-02	-1.666E-01	5.987E-01	-2.137E-01	3.056E-01	2.070E-02	1.393E-01	1.402E-01	-6.932E-02
NB	-3.567E-01	-1.666E-01	1.655E-02	8.584E-03	7.666E-01	-1.277E-01	3.511E-01	-6.190E-02	1.023E-01	2.290E-01
LP	-3.280E-02	5.987E-01	8.584E-03	3.413E-03	-9.239E-02	4.417E-01	-2.836E-02	6.278E-02	-1.374E-01	1.398E-02
NP	-2.605E-01	-2.137E-01	7.666E-01	-9.239E-02	8.797E-04	-6.070E-02	5.706E-01	-1.151E-01	3.956E-02	-2.172E-01
LR	5.933E-02	3.056E-01	-1.277E-01	4.417E-01	-6.070E-02	1.326E-02	3.680E-01	7.293E-02	-3.511E-01	-2.921E-01
NR	1.568E-02	2.070E-02	3.511E-01	-2.836E-02	5.706E-01	3.680E-01	5.659E-03	2.323E-01	8.750E-02	-6.166E-01
YDA	3.245E-01	1.393E-01	-6.190E-02	6.278E-02	-1.151E-01	7.293E-02	2.323E-01	1.426E-04	4.286E-01	-2.328E-01
LDA	7.460E-02	1.402E-01	1.023E-01	-1.374E-01	3.956E-02	-3.511E-01	8.750E-02	4.286E-01	1.433E-02	5.300E-02
NDA	-2.130E-01	-6.932E-02	2.290E-01	1.398E-02	-2.172E-01	-2.921E-01	-6.166E-01	-2.328E-01	5.300E-02	3.428E-03
YDR	2.992E-01	1.649E-01	-3.780E-01	-5.526E-02	-1.466E-01	2.531E-03	-1.251E-02	2.652E-01	7.879E-02	-1.578E-01
LDR	2.484E-01	4.211E-01	-3.076E-01	2.602E-01	-1.539E-01	1.231E-01	-1.037E-01	1.034E-01	1.941E-01	-1.994E-02
NDR	-7.326E-01	-5.665E-01	3.328E-01	-3.513E-02	4.730E-01	2.909E-02	2.659E-01	-3.884E-02	1.401E-02	-1.158E-01
BETA	1.380E-01	-6.969E-02	-2.375E-01	-2.485E-01	-4.146E-02	-1.043E-01	-8.250E-02	7.440E-02	4.912E-02	-5.165E-01
P	-2.895E-03	6.411E-02	7.181E-02	8.670E-02	1.239E-01	4.982E-02	6.974E-02	-4.362E-02	1.439E-02	1.753E-02
R	1.039E-01	-9.474E-02	-1.578E-01	-2.502E-01	2.451E-01	-9.240E-02	-6.833E-02	-5.023E-01	-4.516E-01	-1.962E-01
PHI	8.069E-03	-1.155E-01	-9.631E-02	-1.370E-01	-1.372E-01	-8.900E-02	-8.646E-02	3.394E-02	-3.464E-03	1.339E-02

	YDR	LDR	NDR	BETA	P	R	PHI
YB	2.992E-01	2.484E-01	-7.326E-01	1.380E-01	-2.895E-03	1.039E-01	8.069E-03
LB	1.649E-01	4.211E-01	-5.665E-01	-6.969E-02	6.411E-02	-9.474E-02	-1.155E-01
NB	-3.780E-01	-3.076E-01	3.328E-01	-2.375E-01	7.181E-02	-1.578E-01	-9.631E-02
LP	-5.526E-02	2.602E-01	-3.513E-02	-2.485E-01	8.670E-02	-2.502E-01	-1.370E-01
NP	-1.466E-01	-1.539E-01	4.730E-01	-4.146E-02	1.239E-01	2.451E-01	-1.372E-01
LR	2.531E-03	1.231E-01	2.909E-02	-1.043E-01	4.982E-02	-9.240E-02	-8.900E-02
NR	-1.251E-02	-1.037E-01	2.659E-01	-8.250E-02	6.974E-02	-6.833E-02	-8.646E-02
YDA	2.652E-01	1.034E-01	-3.884E-02	7.440E-02	-4.362E-02	-5.023E-01	3.394E-02
LDA	7.879E-02	1.941E-01	1.401E-02	4.912E-02	1.439E-02	-4.516E-01	-3.464E-03
NDA	-1.578E-01	-1.994E-02	-1.158E-01	-5.165E-01	1.753E-02	-1.962E-01	1.339E-02
YDR	1.433E-04	2.575E-01	-1.799E-01	4.678E-02	2.564E-03	1.156E-01	1.513E-02
LDR	2.575E-01	1.352E-02	-1.362E-01	-4.084E-02	2.437E-02	1.940E-02	-6.127E-02
NDR	-1.799E-01	-1.362E-01	8.183E-03	2.452E-03	1.602E-02	-3.629E-02	-3.329E-02
BETA	4.678E-02	-4.084E-02	2.452E-03	1.953E-03	-2.991E-02	2.494E-01	9.387E-02
P	2.564E-03	2.437E-02	1.602E-02	-2.991E-02	2.239E-02	1.903E-01	-2.747E-01
R	1.156E-01	1.940E-02	-3.629E-02	2.494E-01	1.903E-01	6.987E-03	1.767E-01
PHI	1.513E-02	-6.127E-02	-3.329E-02	9.387E-02	-2.747E-01	1.767E-01	5.233E-02

Figure 4.1 (page 5 of 10)

ENSEMBLE COVARIANCE

	YB	LB	NB	LP	NP	LR	NR	YDA	LDA	NDA
YB	3.350E-05	-1.173E-03	7.951E-05	-2.012E-04	5.040E-05	5.256E-05	2.776E-04	-1.478E-05	-3.153E-04	-1.979E-04
LB	-1.173E-03	5.793E-01	1.144E-01	4.353E-02	3.753E-03	1.078E-01	1.900E-02	1.765E-03	-9.904E-03	1.188E-02
NB	7.951E-05	1.144E-01	8.177E-02	-8.041E-04	7.114E-03	3.312E-02	3.207E-02	-1.082E-03	-4.238E-03	-6.887E-03
LP	-2.012E-04	4.353E-02	-8.041E-04	5.209E-03	-8.836E-04	5.470E-03	-4.122E-03	3.879E-04	2.101E-03	3.155E-03
NP	5.040E-05	3.753E-03	7.114E-03	-8.836E-04	8.007E-04	2.854E-03	3.998E-03	-1.438E-04	-1.494E-03	-1.438E-03
LR	5.256E-05	1.078E-01	3.312E-02	5.470E-03	2.854E-03	3.798E-02	1.972E-02	1.785E-04	-1.264E-02	-5.406E-03
NR	2.776E-04	1.900E-02	3.207E-02	-4.122E-03	3.998E-03	1.972E-02	2.301E-02	-5.648E-04	-1.140E-02	-9.178E-03
YDA	-1.478E-05	1.765E-03	-1.082E-03	3.879E-04	-1.438E-04	1.785E-04	-5.648E-04	4.467E-05	9.697E-05	2.448E-04
LDA	-3.153E-04	-9.904E-03	-4.238E-03	2.101E-03	-1.494E-03	-1.264E-02	-1.140E-02	9.697E-05	3.022E-02	7.555E-03
NDA	-1.979E-04	1.188E-02	-6.887E-03	3.155E-03	-1.438E-03	-5.406E-03	-9.178E-03	2.448E-04	7.555E-03	4.865E-03
YDR	-1.367E-05	5.049E-04	-3.112E-04	1.044E-04	-3.489E-05	9.688E-05	-8.941E-05	1.346E-05	-7.170E-05	2.900E-05
LDR	-9.360E-05	6.122E-02	1.923E-02	3.675E-03	1.183E-03	1.508E-02	6.128E-03	5.317E-05	-6.826E-04	-5.234E-05
NDR	5.519E-06	1.574E-02	1.799E-02	-7.846E-04	1.743E-03	8.684E-03	9.245E-03	-2.359E-04	-2.435E-04	-2.586E-03
BETA	1.281E-04	-6.179E-03	4.536E-03	-2.027E-03	1.003E-03	3.157E-03	6.407E-03	-1.597E-04	-5.155E-03	-3.475E-03
P	-1.381E-03	2.645E-01	8.018E-02	2.167E-02	7.079E-04	-6.828E-03	-2.075E-02	-1.160E-04	5.279E-02	2.620E-02
R	4.119E-04	2.851E-02	3.682E-02	-4.910E-03	4.625E-03	2.203E-02	2.510E-02	-7.207E-04	-1.762E-02	-1.034E-02
PHI	1.799E-03	1.343E-01	7.880E-02	-8.440E-03	1.348E-02	1.684E-01	1.087E-01	-1.747E-04	-1.127E-01	-5.037E-02

	YDR	LDR	NDR	BETA	P	R	PHI
YB	-1.367E-05	-9.360E-05	5.519E-06	1.281E-04	-1.381E-03	4.119E-04	1.799E-03
LB	5.049E-04	6.122E-02	1.574E-02	-6.179E-03	2.645E-01	2.851E-02	1.343E-01
NB	-3.112E-04	1.923E-02	1.799E-02	4.536E-03	8.018E-02	3.682E-02	7.880E-02
LP	1.044E-04	3.675E-03	-7.846E-04	-2.027E-03	2.167E-02	-4.910E-03	-8.440E-03
NP	-3.489E-05	1.183E-03	1.743E-03	1.003E-03	7.079E-04	4.625E-03	1.348E-02
LR	9.688E-05	1.508E-02	8.684E-03	3.157E-03	-6.828E-03	2.203E-02	1.684E-01
NR	-8.941E-05	6.128E-03	9.245E-03	6.407E-03	-2.075E-02	2.510E-02	1.087E-01
YDA	1.346E-05	5.317E-05	-2.359E-04	-1.597E-04	-1.180E-04	-7.207E-04	-1.747E-04
LDA	-7.170E-05	-6.826E-04	-2.435E-04	-5.155E-03	5.279E-02	-1.762E-02	-1.127E-01
NDA	2.900E-05	-5.234E-05	-2.586E-03	-3.475E-03	2.620E-02	-1.034E-02	-5.037E-02
YDR	1.054E-05	1.839E-05	-7.244E-05	-9.723E-07	-3.527E-04	-1.218E-04	4.184E-04
LDR	1.839E-05	6.953E-03	3.243E-03	-2.489E-04	2.405E-02	7.086E-03	4.185E-02
NDR	-7.244E-05	3.243E-03	7.298E-03	1.450E-03	8.630E-03	8.176E-03	3.096E-02
BETA	-9.723E-07	-2.489E-04	1.450E-03	3.355E-03	-1.205E-02	7.119E-03	1.418E-02
P	-3.527E-04	2.405E-02	8.630E-03	-1.205E-02	4.459E-01	-2.818E-02	-6.017E-01
R	-1.218E-04	7.086E-03	8.176E-03	7.119E-03	-2.818E-02	3.293E-02	1.515E-01
PHI	4.184E-04	4.185E-02	3.096E-02	1.418E-02	-6.017E-01	1.515E-01	1.960E+00

Figure 4.1 (page 6 of 10)

NORMALIZED COVARIANCE

	YB	LB	NB	LP	NP	LR	NR	YDA	LDA	NDA
YB	5.788E-03	-2.663E-01	4.803E-02	-4.817E-01	3.077E-01	4.659E-02	3.162E-01	-3.821E-01	-3.134E-01	-4.901E-01
LB	-2.663E-01	7.611E-01	5.255E-01	7.924E-01	1.742E-01	7.264E-01	1.645E-01	3.469E-01	-7.485E-02	2.237E-01
NB	4.803E-02	5.255E-01	2.860E-01	-3.896E-02	8.791E-01	5.943E-01	7.394E-01	-5.660E-01	-8.527E-02	-3.453E-01
LP	-4.817E-01	7.924E-01	-3.896E-02	7.217E-02	-4.327E-01	3.889E-01	-3.765E-01	8.041E-01	1.674E-01	6.268E-01
NP	3.077E-01	1.742E-01	8.791E-01	-4.327E-01	2.830E-02	5.176E-01	9.315E-01	-7.603E-01	-3.037E-01	-7.285E-01
LR	4.659E-02	7.264E-01	5.943E-01	3.889E-01	5.176E-01	1.949E-01	6.669E-01	1.371E-01	-3.732E-01	-3.977E-01
NR	3.162E-01	1.645E-01	7.394E-01	-3.765E-01	9.315E-01	6.669E-01	1.517E-01	-5.570E-01	-4.325E-01	-8.675E-01
YDA	-3.821E-01	3.469E-01	-5.660E-01	8.041E-01	-7.603E-01	1.371E-01	-5.570E-01	6.684E-03	8.347E-02	5.250E-01
LDA	-3.134E-01	-7.485E-02	-8.527E-02	1.674E-01	-3.037E-01	-3.732E-01	-4.325E-01	8.347E-02	1.738E-01	6.232E-01
NDA	-4.901E-01	2.237E-01	-3.453E-01	6.268E-01	-7.285E-01	-3.977E-01	-8.675E-01	5.250E-01	6.232E-01	6.975E-02
YDR	-7.272E-01	2.043E-01	-3.352E-01	4.455E-01	-3.798E-01	1.531E-01	-1.816E-01	6.203E-01	-1.270E-01	1.280E-01
LDR	-1.709E-01	8.501E-01	7.108E-01	5.382E-01	4.418E-01	8.177E-01	4.270E-01	8.407E-02	-4.150E-02	-7.931E-03
NDR	1.116E-02	2.421E-01	7.363E-01	-1.273E-01	7.210E-01	5.216E-01	7.134E-01	-4.132E-01	-1.640E-02	-4.341E-01
BETA	3.820E-01	-1.402E-01	2.739E-01	-4.848E-01	6.121E-01	2.797E-01	7.292E-01	-4.125E-01	-5.120E-01	-8.602E-01
P	-3.572E-01	5.204E-01	4.199E-01	4.495E-01	3.747E-02	-5.247E-02	-2.048E-01	-2.645E-02	4.548E-01	5.624E-01
R	3.921E-01	2.064E-01	7.096E-01	-3.749E-01	9.008E-01	6.230E-01	9.117E-01	-5.942E-01	-5.585E-01	-8.166E-01
PHI	2.220E-01	1.260E-01	1.969E-01	-8.354E-02	3.402E-01	6.173E-01	5.118E-01	-1.867E-02	-4.633E-01	-5.159E-01

	YDR	LDR	NDR	BETA	P	R	PHI
YB	-7.272E-01	-1.709E-01	1.116E-02	3.820E-01	-3.572E-01	3.921E-01	2.220E-01
LB	2.043E-01	8.501E-01	2.421E-01	-1.402E-01	5.204E-01	2.064E-01	1.260E-01
NB	-3.352E-01	7.108E-01	7.363E-01	2.739E-01	4.199E-01	7.096E-01	1.969E-01
LP	4.455E-01	5.382E-01	-1.273E-01	-4.848E-01	4.495E-01	-3.749E-01	-8.354E-02
NP	-3.798E-01	4.418E-01	7.210E-01	6.121E-01	3.747E-02	9.008E-01	3.402E-01
LR	1.531E-01	8.177E-01	5.216E-01	2.797E-01	-5.247E-02	6.230E-01	6.173E-01
NR	-1.816E-01	4.270E-01	7.134E-01	7.292E-01	-2.048E-01	9.117E-01	5.118E-01
YDA	6.203E-01	8.407E-02	-4.132E-01	-4.125E-01	-2.645E-02	-5.942E-01	-1.867E-02
LDA	-1.270E-01	-4.150E-02	-1.640E-02	-5.120E-01	4.548E-01	-5.585E-01	-4.633E-01
NDA	1.280E-01	-7.931E-03	-4.341E-01	-8.602E-01	5.624E-01	-8.166E-01	-5.159E-01
YDR	3.247E-03	5.986E-02	-2.612E-01	-5.171E-03	-1.627E-01	-2.068E-01	9.206E-02
LDR	5.986E-02	9.462E-02	4.012E-01	-4.542E-02	3.807E-01	4.126E-01	3.160E-01
NDR	-2.612E-01	4.012E-01	8.543E-02	2.931E-01	1.513E-01	5.274E-01	2.589E-01
BETA	-5.171E-03	-4.542E-02	2.931E-01	5.792E-02	-3.114E-01	6.773E-01	1.749E-01
P	-1.627E-01	3.807E-01	1.513E-01	-3.114E-01	6.678E-01	-2.326E-01	-6.436E-01
R	-2.068E-01	4.126E-01	5.274E-01	6.773E-01	-2.326E-01	1.815E-01	5.962E-01
PHI	9.206E-02	3.160E-01	2.589E-01	1.749E-01	-6.436E-01	5.962E-01	1.400E+00

Figure 4.1 (page 7 of 10)

SENSITIVITY DERIVATIVES

PARAMETER	ERROR SOURCE BIASES BETA	P	R	PHI	NY	P-DOT	R-DOT	SCALE BETA	P	R
INPUT	5.000E-02	1.000E-01	1.000E-01	5.000E-01	5.000E-04	6.000E-01	1.000E-01	5.000E-03	5.000E-03	5.000E-03
YB	-9.659F-04	8.883E-04	1.493E-03	-4.383E-06	3.290E-01	3.139E-03	-2.744E-03	8.326E-03	3.634E-03	7.694E-03
LB	-8.823E-03	3.963E-01	1.307E-01	-2.441E-03	-1.249E+01	-9.473E-01	-1.651E-01	7.245E-01	-2.312E+00	7.096E-01
NB	-1.138E-02	1.598E-01	-7.068E-02	5.158E-03	4.908E+00	-3.169E-01	-2.347E-02	-1.706E-01	-3.267E-01	5.750E-02
LP	5.866E-03	7.738E-03	-9.130E-04	-4.731E-04	-4.597E+00	-6.301E-02	9.007E-03	-5.788E-03	1.889E-01	-7.974E-03
NP	-3.835F-03	1.723E-02	-1.392E-03	6.021E-04	2.823E+00	-1.292E-02	-5.948E-03	-6.044E-03	2.699E-02	-8.497E-04
LR	-1.303E-02	2.107E-01	2.278E-02	2.118E-03	7.325E+00	-9.837E-02	3.221E-03	8.043E-03	7.463E-02	-1.823E-02
NR	-3.424E-02	1.187E-01	6.707E-03	3.820E-03	2.217E+01	-1.901E-02	-2.851E-02	-1.330E-02	-9.053E-02	9.956E-03
YDA	2.773E-05	-6.142E-04	5.559E-05	-3.196E-05	-1.904E-01	5.004E-04	4.661E-04	-2.315E-04	-5.744E-03	2.401E-04
LDA	1.821E-02	-9.183E-02	-8.947E-03	-3.161E-03	-2.018E+01	-8.747E-02	4.704E-02	-3.677E-02	1.011E+00	2.346E-02
NDA	2.043E-02	-4.039E-02	-1.805E-02	-1.458E-03	-1.353E+01	-4.361E-02	2.082E-02	-1.085E-02	1.790E-01	-8.370E-04
YDR	-1.534E-04	1.375E-04	2.767E-04	2.043E-05	2.306E-01	6.997E-04	-2.818E-04	1.041E-03	2.442E-03	6.167E-05
LDR	7.509E-03	6.954E-02	2.190E-02	-7.157E-04	-4.717E+00	-1.058E-01	-6.227E-03	8.627E-02	-5.566E-01	-1.489E-03
NDR	-1.533E-04	4.356E-02	-1.705E-02	1.517E-03	3.026E+00	-5.158E-02	3.765E-02	-1.706E-01	-2.129E-01	-1.799E-01
BETA	-1.478E-03	-3.202E-03	1.103E-02	1.496E-03	7.704E-01	1.861E-02	-4.298E-03	6.128E-03	-1.247E-01	7.103E-03
P	6.995E-04	6.300E-01	1.825E-02	-3.690E-03	9.400E-01	-1.025E+00	-6.846E-02	8.957E-03	3.568E+00	7.477E-03
R	-2.205E-02	1.043E-01	5.588E-02	4.054E-02	2.078E+01	-1.446E-02	-7.357E-02	6.139E-02	4.345E-01	1.023E-02
PHI	1.997E-01	-7.701E-01	9.097E-01	9.575E-01	-1.420E+02	8.268E-01	8.428E-02	-5.245E-03	-2.536E+00	9.756E-02

PARAMETER	ERROR SOURCE PHI	NY	P-DOT	R-DOT	MISALN P	R	R-DOT	C. G. CG X	CG Z	ACCEL AX
INPUT	5.000E-03	5.000E-03	5.000E-03	5.000E-03	6.000E-01	6.000E-01	6.000E-01	5.000E-01	5.000E-01	5.000E+00
YB	5.146E-05	-1.577E-01	6.691E-03	1.261E-01	-3.816E-06	-2.146E-04	-1.851E-03	-4.630E-03	-8.973E-03	-4.630E-03
LB	-1.479E-01	-1.114E-01	-1.274E+01	1.328E+01	-9.953E-03	-3.267E-02	-1.726E-01	6.634E-01	-6.227E-02	6.635E-01
NB	-3.145E-02	-9.065E-02	-4.088E-01	9.263E-01	1.631E-04	4.333E-03	2.055E-02	-2.820E-01	2.441E-02	-2.820E-01
LP	1.044E-03	1.025E-02	-2.185E-01	4.692E-02	1.587E-04	-1.058E-03	-8.030E-04	1.201E-01	-6.213E-03	1.201E-01
NP	-1.161E-03	-1.635E-02	5.438E-02	-6.920E-02	6.494E-06	3.244E-04	1.183E-03	-3.880E-02	1.780E-03	-3.880E-02
LR	-3.617E-02	-2.168E-01	7.023E-01	-2.269E-01	-1.575E-03	4.204E-05	3.137E-02	8.628E-02	-3.570E-02	8.840E-02
NR	-1.480E-02	1.057E-02	5.486E-02	-1.150E-01	-2.226E-05	4.410E-03	3.931E-02	-1.457E-01	7.868E-03	-1.456E-01
YDA	-6.256E-05	-3.790E-03	1.627E-03	4.033E-03	1.034E-05	1.470E-04	1.101E-03	1.318E-02	-7.346E-04	1.318E-02
LDA	2.572E-02	1.995E-02	8.827E+00	3.649E-01	-1.177E-03	1.505E-02	1.026E-01	-7.199E-04	3.361E-03	-5.492E-04
NDA	7.725E-03	6.635E-02	2.667E-01	2.584E-01	-3.759E-04	-1.796E-03	-6.172E-03	6.496E-02	5.027E-04	6.491E-02
YDR	1.461E-04	2.337E-02	-2.242F-03	-1.476E-03	-5.700E-06	-5.913E-07	9.682E-05	4.417E-03	4.462E-03	4.417E-03
LDR	-3.645E-02	-2.271E-03	2.838E+00	-9.309E-02	1.309E-03	-1.945E-03	7.968E-03	2.978E-02	-4.338E-03	2.978E-02
NDR	-1.216E-02	-3.052E-02	7.078E-02	-3.320E+00	1.420E-04	7.686E-03	6.312E-02	-6.739E-02	4.842E-03	-6.732E-02
BETA	-1.252E-04	-4.265E-03	1.453F-01	-4.203E-02	1.906E-04	4.911E-04	-5.960E-03	-3.798E-02	2.459E-03	-3.798E-02
P	-5.164E-04	-1.605E-02	-3.707F+00	-6.460E-02	-5.751E-03	-1.283E-03	-1.504E-02	-2.084E-02	-5.329E-04	-2.086E-02
R	8.593E-02	-3.544E-02	-2.702F-01	-3.385E-01	-7.576E-04	-7.813E-03	-6.886E-02	-1.763E-01	8.358E-03	-1.764E-01
PHI	2.254E+00	6.546E-02	7.046E-02	5.426E-02	4.979F-03	-3.515E-03	2.195F-02	5.769E-02	-5.591E-04	5.774E-02

Figure 4.1 (page 8 of 10)

PARAMETER	ERROR SOURCE									
		VANE	LAG							CBIASE
	AZ	VX	BETA	P	R	PHI	NY	P-DOT	R-DOT	BDA
INPUT	2.000E+00	2.000E+01	6.200E+01	6.200E+01	6.200E+01	6.200E+01	6.200E+01	6.200E+01	6.200E+01	1.000E-01
YB	-8.973E-03	6.217E-08	-7.400E-07	1.457E-06	-1.558E-07	6.782E-08	3.708E-06	5.039E-05	3.441E-05	-5.354E-03
LB	-6.227E-02	-7.331E-05	-4.796E-05	-2.459E-03	-3.736E-05	-9.532E-05	-1.900E-04	6.122E-03	3.296E-03	-3.168E+00
NB	2.441E-02	-2.532E-05	-3.655E-06	-5.400E-04	-1.261E-05	-2.457E-05	-5.819E-04	-1.042E-03	-1.487E-03	-1.320E+00
LP	-6.213E-03	-8.562E-06	2.634E-06	-3.490E-04	-2.006E-06	-8.264E-06	1.596E-04	-1.307E-03	2.757E-05	-9.021E-02
NP	1.780E-03	-1.139E-06	-1.132E-06	-3.604E-05	-2.191E-06	-1.886E-06	-8.610E-05	-3.550E-05	-1.434E-04	-1.208E-01
LR	-3.570E-02	-1.195E-04	-2.134E-05	-4.557E-05	-1.081E-04	-1.474E-05	-1.099E-03	1.227E-03	-1.801E-03	-1.453E+00
NR	7.868E-03	-1.195E-04	-2.985E-05	-8.354E-05	-9.382E-05	-7.617E-06	-1.271E-03	3.212E-04	-1.950E-03	-7.638E-01
YDA	-7.346E-04	-2.413E-06	-4.593E-07	-2.236E-06	-1.111E-06	2.398E-08	2.090E-05	2.997E-05	-1.545E-05	2.983E-03
LDA	3.361E-03	-1.708E-04	-3.422E-05	1.666E-04	-6.045E-05	4.681E-06	2.924E-04	8.267E-03	-8.142E-04	5.576E-01
NDA	5.627E-04	4.950E-05	1.395E-05	9.029E-05	3.108E-05	3.108E-06	4.883E-04	4.472E-05	6.878E-04	2.180E-01
YDR	4.462E-03	1.572E-07	-7.181E-08	1.002E-06	-8.265E-08	2.662E-08	1.618E-05	1.914E-05	1.945E-06	1.152E-04
LDR	-4.338E-03	4.305E-06	-4.798E-06	-3.838E-04	2.370E-06	-1.226E-05	3.150E-04	1.879E-03	3.304E-04	-5.792E-01
NDR	4.842E-03	-6.128E-05	-2.397E-06	-9.348E-05	-3.580E-05	-4.999E-06	-2.610E-04	-2.581E-04	-1.656E-03	-3.398E-01
BETA	2.459E-03	6.264E-07	-1.942E-06	-3.104E-05	7.576E-06	9.503E-08	-1.913E-05	4.357E-05	8.635E-05	4.130E-02
P	-5.329E-04	2.114E-05	2.976E-06	8.617E-04	-1.288E-06	-2.650E-05	-1.964E-04	1.499E-03	-2.628E-04	2.198E+00
R	8.358E-03	1.282E-04	1.513E-05	1.792E-04	5.176E-05	-8.767E-06	-2.375E-04	-7.528E-04	-5.922E-04	-1.035E+00
PHI	-5.591E-04	-4.786E-05	-2.010E-06	2.175E-04	-5.357E-05	-7.479E-05	5.542E-04	-5.482E-04	1.024E-03	-1.181E+01

PARAMETER	ERROR SOURCE				
		CSCALE		C LAG	
	BDR	EDA	EDR	FDA	FDR
INPUT	1.000E-01	1.000E-02	1.000E-02	6.200E+01	6.200E+01
YB	1.250E-02	1.290E-03	3.759E-03	-3.028E-05	-5.895E-05
LB	1.410E+00	1.198E-01	4.701E-01	9.955E-04	-7.586E-03
NB	8.594E-01	2.403E-02	2.325E-02	-8.346E-05	3.781E-03
LP	-7.893E-02	-2.613E-02	1.272E-02	1.656E-03	-1.796E-04
NP	1.451E-01	3.774E-03	8.620E-03	9.135E-06	2.969E-04
LR	1.005E+00	-9.244E-02	-1.899E-01	5.021E-03	-3.162E-03
NR	1.041E+00	1.273E-02	1.468E-01	-6.272E-05	3.176E-03
YDA	-6.835E-03	4.309E-03	-4.157E-04	-2.333E-05	-8.228E-06
LDA	-8.658E-01	-1.029E+01	4.216E-02	-8.543E-03	7.294E-04
NDA	-5.001E-01	-6.790E-01	-8.818E-02	-1.567E-05	-1.340E-03
YDR	6.318E-03	2.809E-04	-2.366E-02	-1.281E-05	-2.532E-05
LDR	1.864E-01	3.954E-02	-2.279E+00	-2.761E-04	-1.852E-03
NDR	2.679E-01	2.673E-03	3.856E+00	2.442E-04	2.067E-03
BETA	5.321E-01	8.791E-03	3.334E-03	-5.461E-05	-1.965E-05
P	-1.179E+00	6.244E-02	-1.666E-02	5.380E-04	1.666E-04
R	1.089E+00	-3.721E-02	4.676E-02	5.706E-04	2.859E-04
PHI	2.564E+00	2.215E-03	-1.918E-03	-9.488E-04	-2.106E-04

DETERMINANT OF D2JDP2 = 1.23543053E+21

ERROR SUMMARY

ERROR	TIMES
10049	10003

Figure 4.1 (page 9 of 10)

```
 06/12/74 SCP 3.4.1 6600 SN58  PSR370    04/25/74
09.38.16.NNT002W  FROM F4
09.38.16.IP  00000512 WORDS - FILE INPUT  , DC 00
09.38.16.NNT,T100.         024H,9468,91186,TANIGU
09.38.16..
09.38.29.ATTACH,OPL,ENSMBS1,ID=SCIWEPCO.
09.38.29.PF CYCLE NO. = 001
09.38.29.UPDATE,P=OPL,C=CMP.
09.38.51. UPDATE COMPLETE.
09.38.51.REWIND,CMP.
09.38.51.RUN(S,,,CMP.
09.39.02.REWIND,LGO.
09.39.05.ATTACH,OLD,ENSMBR1,ID=SCIWEPCO.
09.39.07.PF CYCLE NO. = 001
09.39.07.COPYL(OLD,LGO,NEW)
09.39.25. DRVXXX   UPDATED
09.39.28. ENSMB    UPDATED
09.39.39. PRTLS2   UPDATED
09.39.43.COPYL DONE
09.39.46.NEW.
09.40.13.    25.877 RT SECONDS LOAD TIME
09.41.58.STOP
09.41.59.OP  00012096 WORDS - FILE OUTPUT , DC 40
09.41.59.CPA      31.621 SEC.       31.621 ADJ.
09.41.59.IO        3.151 SEC.        3.151 ADJ.
09.41.59.CM      662.247 KWS.       40.419 ADJ.
09.41.59.SS                         75.193
09.41.59.PP       58.818 SEC.     DATE 06/12/74
09.41.59.EJ  END OF JOB, F4
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ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4.1 (page 10 of 10)

SIMULATED DATA ** FULL LONGITUDINAL ANALYSIS
PARAMETERS ESTIMATE ONLY

INPUT SUMMARY

SIMDAT T T F T T T T T F T T T T T T T T T T T F F F T T T T T T

ESTIM= 1 MODE= 2 SAMPLE POINTS= 300 SAMPLE RATE= .050 MONTE CARLO 3 RUNS

MQ	=-7.192120E-01	MW	=-5.906622E-01	ZW	=-7.624510E-01	MU	=-2.664254E-02	ZU	=-6.169700E-02
XU	=-7.009000E-03	XW	= 2.726000E-02	MDE	=-1.621000E+01	ZDE	=-1.245520E+00		

ALPHA= 2.6000 THETA= 2.6000 VELOCITY= 827.2500

ERROR VECTORS

	BIASES	SCALE	MISALIGN	LAG	NOISE
THETA	1.5000000E-01	5.0000000E-03	0.	6.2000000E+01	1.5000000E-01
Q	1.0000000E-01	5.0000000E-03	0.	6.2000000E+01	1.0000000E-01
ALPHA	1.0000000E-01	5.0000000E-03	0.	6.2000000E+01	1.0000000E-01
U	1.0000000E+00	5.0000000E-03	0.	6.2000000E+01	1.0000000E+00
NX	5.0000000E-03	5.0000000E-03	6.0000000E-01	6.2000000E+01	5.0000000E-03
NZ	5.0000000E-03	5.0000000E-03	6.0000000E-01	6.2000000E+01	5.0000000E-03
Q-DOT	1.0000000E-01	5.0000000E-03	0.	6.2000000E+01	1.0000000E-01

I. C.		ACCEL		C. G.		VANE	
THETA	0.	AX	5.0000000E+00	CG X	5.0000000E-01	VX	2.0000000E+01
Q	0.	AY	0.	CG Y	0.		
W	0.	AZ	2.0000000E+00	CG Z	5.0000000E-01		
U	0.						

CONTROL ERRORS

BDE 1.0000000E-01 EDE 1.0000000E-02 FDE 6.2500000E+01

Figure 4.2 Example Output for Aircraft Simulated Data Program (page 1 of 11)

```
*****     SIMULATED DATA MODE 2     *****

***** MONTE CARLO SAMPLE NO.          1  *****

NEWTON-RAPHSON ITERATION NO.     1     COST1=   1.08958E+01     COST2=   1.89214E+01     J =   1.53516E+05

NEWTON-RAPHSON GRADIENT VECTOR
MQ    -1.20151E+05    MW    -2.26319E+05    ZW    -1.00067E+05    MU    -2.83944E+05    ZU     1.99577E+05
XU     3.45779E+04    XW    -8.33319E+04    MDE    8.56642E+03    ZDE    8.78518E+03

NEWTON-RAPHSON STEP ERROR VECTOR
MQ    -1.22592E-01    MW    -4.21695E-02    ZW    -4.88896E-02    MU    -2.90293E-01    ZU    -2.06820E-01
XU     1.08701E-02    XW    -1.63080E-02    MDE    3.13008E-01    ZDE    2.73884E+00

PARAMETER ESTIMATE VECTOR (K+1)

MQ    -8.41804E-01    MW    -6.32832E-01    ZW    -8.11341E-01    MU    -3.16935E-01    ZU    -2.68517E-01
XU     3.86113E-03    XW     1.09520E-02    MDE   -1.58970E+01    ZDE    1.49332E+00


NEWTON-RAPHSON ITERATION NO.     2     COST1=   2.96625E+00     COST2=   3.82846E+00     J =   6.33400E+04

NEWTON-RAPHSON GRADIENT VECTOR
MQ    -9.60323E+03    MW    -1.52189E+05    ZW     6.82009E+04    MU     2.29385E+05    ZU    -1.60774E+05
XU    -1.77330E+05    XW     1.64889E+05    MDE   -6.91150E+02    ZDE    2.10790E+01

NEWTON-RAPHSON STEP ERROR VECTOR
MQ    -1.54592E-02    MW    -2.22709E-03    ZW    -6.23493E-03    MU     6.43999E-02    ZU     4.30738E-02
XU    -1.14531E-02    XW    -4.98720E-03    MDE   -3.03758E-02    ZDE    1.75476E-02

PARAMETER ESTIMATE VECTOR (K+1)

MQ    -8.57263E-01    MW    -6.35059E-01    ZW    -8.17575E-01    MU    -2.52535E-01    ZU    -2.25443E-01
XU    -7.59195E-03    XW     5.96481E-03    MDE   -1.59274E+01    ZDE    1.51087E+00
```

Figure 4.2 (page 2 of 11)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 3.78843E-02 COST2= 7.51116E-02 J = 5.42781E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-5.58343E+02	MW	1.00332E+03	ZW	-4.52292E+02	MU	8.18644E+03	ZU	-5.95527E+03
XU	-4.31321E+03	XW	4.05687E+03	MDE	-1.17682E+02	ZDE	8.37499E+01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-2.57199E-03	MW	4.48368E-04	ZW	-6.85343E-04	MU	2.41989E-03	ZU	9.85944E-04
XU	-1.21765E-04	XW	2.25972E-04	MDE	-7.36369E-03	ZDE	3.36330E-03		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.59835E-01	MW	-6.34610E-01	ZW	-8.18261E-01	MU	-2.50115E-01	ZU	-2.24457E-01
XU	-7.71372E-03	XW	6.19078E-03	MDE	-1.59347E+01	ZDE	1.51423E+00		

NEWTON-RAPHSON ITERATION NO. 4 COST1= 5.19860E-03 COST2= 8.45238E-03 J = 5.42593E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-6.49965E+01	MW	-2.39897E+02	ZW	-7.73356E+01	MU	-2.41530E+01	ZU	1.97870E+01
XU	4.17295E+01	XW	3.35807E+01	MDE	-3.93834E-02	ZDE	-3.42496E-01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-1.05739E-04	MW	-3.53680E-05	ZW	-7.67796E-05	MU	-7.95009E-05	ZU	-9.83324E-05
XU	1.61245E-05	XW	3.21834E-05	MDE	-4.69958E-05	ZDE	1.99849E-04		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.59941E-01	MW	-6.34646E-01	ZW	-8.18338E-01	MU	-2.50195E-01	ZU	-2.24555E-01
XU	-7.69759E-03	XW	6.22296E-03	MDE	-1.59348E+01	ZDE	1.51443E+00		

Figure 4.2 (page 3 of 11)

ERROR VECTOR

MQ	1.40729E-01	MW	4.39836E-02	ZW	5.58866E-02	MU	2.23552E-01	ZU	1.62858E-01
XU	6.88592E-04	XW	2.10370E-02	MDE	-2.75222E-01	ZDE	-2.75995E+00		

NORMALIZED PARAMETER ERROR VECTOR

MQ	-1.95671E-01	MW	-7.44649E-02	ZW	-7.32986E-02	MU	-8.39081E+00	ZU	-2.63965E+00
XU	-9.82440E-02	XW	7.71718E-01	MDE	1.69785E-02	ZDE	2.21590E+00		

AVERAGE ERROR VECTOR

MQ	1.40729E-01	MW	4.39836E-02	ZW	5.58866E-02	MU	2.23552E-01	ZU	1.62858E-01
XU	6.88592E-04	XW	2.10370E-02	MDE	-2.75222E-01	ZDE	-2.75995E+00		

COVARIANCE MATRIX

	MQ	MW	ZW	MU	ZU	XU	XW	MDE	ZDE
MQ	0.	0.	0.	0.	0.	0.	0.	0.	0.
MW	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZW	0.	0.	0.	0.	0.	0.	0.	0.	0.
MU	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZU	0.	0.	0.	0.	0.	0.	0.	0.	0.
XU	0.	0.	0.	0.	0.	0.	0.	0.	0.
XW	0.	0.	0.	0.	0.	0.	0.	0.	0.
MDE	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZDE	0.	0.	0.	0.	0.	0.	0.	0.	0.

Figure 4.2 (page 4 of 11)

```
***** MONTE CARLO SAMPLE NO.          2  *****

NEWTON-RAPHSON ITERATION NO.      1      COST1=   1.01938E+01     COST2=   1.75166E+01      J =   1.66061E+05

   NEWTON-RAPHSON GRADIENT VECTOR
   MQ       -1,55348E+05     MW      -2.38384E+05     ZW       -6.07174E+04     MU       -3,06320E+05     ZU        2,13914E+05
   XU        2,79455E+04     XW      -2.67785E+04     MDE       2.07563E+04     ZDE       8,34058E+03

   NEWTON-RAPHSON STEP ERROR VECTOR
   MQ       -1.17078E-01     MW      -4.05215E-02     ZW       -4.81515E-02     MU       -2,71588E-01     ZU       -1,93897E-01
   XU        1.08635E-02     XW       5.34097E-04     MDE       9.01638E-01     ZDE       2.81540E+00

   PARAMETER ESTIMATE VECTOR (K+1)

   MQ       -8,36290E-01     MW      -6.31184E-01     ZW       -8.10603E-01     MU       -2,98231E-01     ZU       -2,55594E-01
   XU        3,85446E-03     XW       2.77941E-02     MDE      -1.53084E+01     ZDE       1,56988E+00

NEWTON-RAPHSON ITERATION NO.      2      COST1=   1.27060E+00     COST2=   1.74479E+00      J =   5.43781E+04

   NEWTON-RAPHSON GRADIENT VECTOR
   MQ       -1,31126E+04     MW      -9,23122E+04     ZW        1.96914E+04     MU        1.16064E+05     ZU       -8,23999E+04
   XU       -6,83873E+04     XW       6.16764E+04     MDE      -6.97817E+02     ZDE       2,44264E+02

   NEWTON-RAPHSON STEP ERROR VECTOR
   MQ       -2,39776E-02     MW      -3.57741E-03     ZW       -1.03419E-02     MU        4,47368E-02     ZU        2,83515E-02
   XU       -4,89749E-03     XW      -3,73999E-03     MDE      -3,43117E-02     ZDE       4,60863E-02

   PARAMETER ESTIMATE VECTOR (K+1)

   MQ       -8,60268E-01     MW      -6.34761E-01     ZW       -8.20944E-01     MU       -2,53494E-01     ZU       -2,27242E-01
   XU       -1,04303E-03     XW       2,40541E-02     MDE      -1,53427E+01     ZDE       1,61597E+00
```

Figure 4.2 (page 5 of 11)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 5.06536E-01 COST2= 5.42067E-01 J = 5.09514E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-9.32235E+02	MW	1.94955E+03	ZW	-1.93215E+03	MU	-8.53820E+02	ZU	5.72758E+02
XU	1.53163E+03	XW	1.02403E+02	MDE	-4.21039E+01	ZDE	1.52367E+01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-3.08642E-03	MW	2.40472E-04	ZW	-6.35043E-04	MU	-3.74898E-04	ZU	-4.77839E-04
XU	5.28333E-04	XW	6.02255E-04	MDE	-7.44925E-03	ZDE	-2.72471E-03		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.63354E-01	MW	-6.34521E-01	ZW	-8.21580E-01	MU	-2.53869E-01	ZU	-2.27720E-01
XU	-5.14699E-04	XW	2.46564E-02	MDE	-1.53501E+01	ZDE	1.61324E+00		

NEWTON-RAPHSON ITERATION NO. 4 COST1= 4.52063E-04 COST2= 1.57046E-03 J = 5.09454E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-7.80640E+01	MW	-2.07807E+02	ZW	-7.65775E+01	MU	5.77609E+01	ZU	-3.17880E+01
XU	4.77071E+00	XW	-4.41087E+01	MDE	-5.04601E-02	ZDE	-4.15596E-01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-1.50884E-04	MW	-1.91683E-05	ZW	-6.66151E-05	MU	9.80390E-05	ZU	9.86975E-05
XU	1.58319E-06	XW	-1.11462E-05	MDE	-1.29543E-04	ZDE	-6.94920E-06		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.63505E-01	MW	-6.34540E-01	ZW	-8.21646E-01	MU	-2.53771E-01	ZU	-2.27621E-01
XU	-5.13116E-04	XW	2.46452E-02	MDE	-1.53503E+01	ZDE	1.61323E+00		

Figure 4.2 (page 6 of 11)

ERROR VECTOR

MQ	1.44293E-01	MW	4.38776E-02	ZW	5.91951E-02	MU	2.27128E-01	ZU	1.65924E-01
XU	-6.49588E-03	XW	2.61479E-03	MDE	-8.59747E-01	ZDE	-2.85875E+00		

NORMALIZED PARAMETER ERROR VECTOR

MQ	-2.00627E-01	MW	-7.42854E-02	ZW	-7.76379E-02	MU	-8.52502E+00	ZU	-2.68934E+00
XU	9.26792E-01	XW	9.59203E-02	MDE	5.30381E-02	ZDE	2.29523E+00		

AVERAGE ERROR VECTOR

MQ	1.42511E-01	MW	4.39306E-02	ZW	5.75409E-02	MU	2.25340E-01	ZU	1.64391E-01
XU	-2.90365E-03	XW	1.18259E-02	MDE	-5.67485E-01	ZDE	-2.80935E+00		

COVARIANCE MATRIX

	MQ	MW	ZW	MU	ZU	XU	XW	MDE	ZDE
MQ	3.176E-06	-9.446E-08	2.948E-06	3.186E-06	2.732E-06	-6.402E-06	-1.642E-05	-5.209E-04	-8.805E-05
MW	-9.446E-08	2.809E-09	-8.768E-08	-9.476E-08	-8.125E-08	1.904E-07	4.882E-07	1.549E-05	2.618E-06
ZW	2.948E-06	-8.768E-08	2.737E-06	2.958E-06	2.536E-06	-5.942E-06	-1.524E-05	-4.835E-04	-8.172E-05
MU	3.186E-06	-9.476E-08	2.958E-06	3.196E-06	2.741E-06	-6.422E-06	-1.647E-05	-5.225E-04	-8.833E-05
ZU	2.732E-06	-8.125E-08	2.536E-06	2.741E-06	2.350E-06	-5.507E-06	-1.412E-05	-4.480E-04	-7.573E-05
XU	-6.402E-06	1.904E-07	-5.942E-06	-6.422E-06	-5.507E-06	1.290E-05	3.309E-05	1.050E-03	1.775E-04
XW	-1.642E-05	4.882E-07	-1.524E-05	-1.647E-05	-1.412E-05	3.309E-05	8.484E-05	2.692E-03	4.551E-04
MDE	-5.209E-04	1.549E-05	-4.835E-04	-5.225E-04	-4.480E-04	1.050E-03	2.692E-03	8.542E-02	1.444E-02
ZDE	-8.805E-05	2.618E-06	-8.172E-05	-8.833E-05	-7.573E-05	1.775E-04	4.551E-04	1.444E-02	2.441E-03

Figure 4.2 (page 7 of 11)

***** MONTE CARLO SAMPLE NO. 3 *****

NEWTON-RAPHSON ITERATION NO. 1 COST1= 1.02992E+01 COST2= 1.79439E+01 J = 1.64284E+05

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-1.45339E+05	MW	-2.11466E+05	ZW	-7.08343E+04	MU	-2.97495E+05	ZU	2.06960E+05
XU	3.01376E+04	XW	-5.63807E+04	MDE	1.78686E+04	ZDE	9.17354E+03		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-1.19631E-01	MW	-3.99133E-02	ZW	-4.45547E-02	MU	-2.74398E-01	ZU	-1.94828E-01
XU	1.04321E-02	XW	-7.73073E-03	MDE	7.77240E-01	ZDE	2.95762E+00		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.38843E-01	MW	-6.30576E-01	ZW	-8.07006E-01	MU	-3.01040E-01	ZU	-2.56525E-01
XU	3.42307E-03	XW	1.95293E-02	MDE	-1.54328E+01	ZDE	1.71210E+00		

NEWTON-RAPHSON ITERATION NO. 2 COST1= 2.25889E+00 COST2= 2.84122E+00 J = 5.67572E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-1.23379E+04	MW	-1.11820E+05	ZW	3.61842E+04	MU	1.52644E+05	ZU	-1.07980E+05
XU	-1.04547E+05	XW	9.36609E+04	MDE	-5.95053E+02	ZDE	1.19403E+02		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-2.24708E-02	MW	-3.04432E-03	ZW	-8.18206E-03	MU	5.17441E-02	ZU	3.44149E-02
XU	-7.73234E-03	XW	-4.14168E-03	MDE	-3.34453E-02	ZDE	3.47311E-02		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.61314E-01	MW	-6.33620E-01	ZW	-8.15188E-01	MU	-2.49296E-01	ZU	-2.22110E-01
XU	-4.30927E-03	XW	1.53876E-02	MDE	-1.54662E+01	ZDE	1.74683E+00		

Figure 4.2 (page 8 of 11)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 6.24232E-02 COST2= 9.63590E-02 J = 5.18305E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-8.25886E+02	MW	1.37990E+03	ZW	-1.34425E+03	MU	2.25909E+03	ZU	-1.69590E+03
XU	-3.65187E+02	XW	1.20160E+03	MDE	-6.57979E+01	ZDE	3.66456E+01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-2.91233E-03	MW	3.00040E-04	ZW	-6.07068E-04	MU	7.85631E-04	ZU	2.06857E-04
XU	2.68999E-04	XW	3.73035E-04	MDE	-7.37154E-03	ZDE	-9.33429E-04		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.64226E-01	MW	-6.33320E-01	ZW	-8.15795E-01	MU	-2.48510E-01	ZU	-2.21903E-01
XU	-4.04027E-03	XW	1.57606E-02	MDE	-1.54736E+01	ZDE	1.74590E+00		

NEWTON-RAPHSON ITERATION NO. 4 COST1= 2.18688E-03 COST2= 3.17466E-03 J = 5.18244E+04

NEWTON-RAPHSON GRADIENT VECTOR

MQ	-7.29522E+01	MW	-2.13417E+02	ZW	-7.83413E+01	MU	1.30272E+01	ZU	-3.02044E+00
XU	2.22593E+01	XW	-1.10198E+01	MDE	1.53429E-02	ZDE	-4.23365E-01		

NEWTON-RAPHSON STEP ERROR VECTOR

MQ	-1.36999E-04	MW	-2.57952E-05	ZW	-7.04609E-05	MU	1.26537E-05	ZU	5.91116E-06
XU	8.83559E-06	XW	9.03117E-06	MDE	-1.05828E-04	ZDE	7.81083E-05		

PARAMETER ESTIMATE VECTOR (K+1)

MQ	-8.64363E-01	MW	-6.33346E-01	ZW	-8.15865E-01	MU	-2.48498E-01	ZU	-2.21897E-01
XU	-4.03144E-03	XW	1.57696E-02	MDE	-1.54737E+01	ZDE	1.74597E+00		

Figure 4.2 (page 9 of 11)

ERROR VECTOR

MQ	1.45151E-01	MW	4.26834E-02	ZW	5.34143E-02	MU	2.21855E-01	ZU	1.60200E-01
XU	-2.97756E-03	XW	1.14904E-02	MDE	-7.36317E-01	ZDE	-2.99149E+00		

NORMALIZED PARAMETER ERROR VECTOR

MQ	-2.01819E-01	MW	-7.22637E-02	ZW	-7.00561E-02	MU	-8.32710E+00	ZU	-2.59656E+00
XU	4.24820E-01	XW	4.21510E-01	MDE	4.54236E-02	ZDE	2.40180E+00		

AVERAGE ERROR VECTOR

MQ	1.43391E-01	MW	4.35149E-02	ZW	5.61654E-02	MU	2.24179E-01	ZU	1.62994E-01
XU	-2.92828E-03	XW	1.17141E-02	MDE	-6.23762E-01	ZDE	-2.87007E+00		

COVARIANCE MATRIX

	MQ	MW	ZW	MU	ZU	XU	XW	MDE	ZDE
MQ	3.667E-06	-7.947E-07	-4.554E-07	7.968E-08	-6.377E-07	-4.312E-06	-1.114E-05	-4.463E-04	-1.656E-04
MW	-7.947E-07	3.475E-07	1.085E-06	9.027E-07	1.107E-06	1.474E-07	4.185E-07	5.712E-05	5.223E-05
ZW	-4.554E-07	1.085E-06	5.608E-06	5.168E-06	5.534E-06	-3.894E-06	-9.851E-06	-1.675E-04	1.125E-04
MU	7.968E-08	9.027E-07	5.168E-06	4.830E-06	5.073E-06	-4.224E-06	-1.072E-05	-2.176E-04	8.218E-05
ZU	-6.377E-07	1.107E-06	5.534E-06	5.073E-06	5.471E-06	-3.602E-06	-9.101E-06	-1.414E-04	1.192E-04
XU	-4.312E-06	1.474E-07	-3.894E-06	-4.224E-06	-3.602E-06	8.604E-06	2.206E-05	7.027E-04	1.213E-04
XW	-1.114E-05	4.185E-07	-9.851E-06	-1.072E-05	-9.101E-06	2.206E-05	5.659E-05	1.807E-03	3.170E-04
MDE	-4.463E-04	5.712E-05	-1.675E-04	-2.176E-04	-1.414E-04	7.027E-04	1.807E-03	6.328E-02	1.646E-02
ZDE	-1.656E-04	5.223E-05	1.125E-04	8.218E-05	1.192E-04	1.213E-04	3.170E-04	1.646E-02	9.000E-03

Figure 4.2 (page 10 of 11)

****

SUMMARY OF ERROR STATISTICS AFTER 3 SAMPLES

AVERAGE ERROR VECTOR

MQ	1.43391E-01	MW	4.35149E-02	ZW	5.61654E-02	MU	2.24179E-01	ZU	1.62994E-01
XU	-2.92828E-03	XW	1.17141E-02	MDE	-6.23762E-01	ZDE	-2.87007E+00		

COVARIANCE MATRIX

	MQ	MW	ZW	MU	ZU	XU	XW	MDE	ZDE
MQ	3.667E-06	-7.947E-07	-4.554E-07	7.968E-08	-6.377E-07	-4.312E-06	-1.114E-05	-4.463E-04	-1.656E-04
MW	-7.947E-07	3.475E-07	1.085E-06	9.027E-07	1.107E-06	1.474E-07	4.185E-07	5.712E-05	5.223E-05
ZW	-4.554E-07	1.085E-06	5.608E-06	5.168E-06	5.534E-06	-3.894E-06	-9.851E-06	-1.675E-04	1.125E-04
MU	7.968E-08	9.027E-07	5.168E-06	4.830E-06	5.073E-06	-4.224E-06	-1.072E-05	-2.176E-04	8.218E-05
ZU	-6.377E-07	1.107E-06	5.534E-06	5.073E-06	5.471E-06	-3.602E-06	-9.101E-06	-1.414E-04	1.192E-04
XU	-4.312E-06	1.474E-07	-3.894E-06	-4.224E-06	-3.602E-06	8.604E-06	2.206E-05	7.027E-04	1.213E-04
XW	-1.114E-05	4.185E-07	-9.851E-06	-1.072E-05	-9.101E-06	2.206E-05	5.659E-05	1.807E-03	3.170E-04
MDE	-4.463E-04	5.712E-05	-1.675E-04	-2.176E-04	-1.414E-04	7.027E-04	1.807E-03	6.328E-02	1.646E-02
ZDE	-1.656E-04	5.223E-05	1.125E-04	8.218E-05	1.192E-04	1.213E-04	3.170E-04	1.646E-02	9.000E-03

NORMALIZED COVARIANCE MATRIX

	MQ	MW	ZW	MU	ZU	XU	XW	MDE	ZDE
MQ	1.915E-03	-7.040E-01	-1.004E-01	1.893E-02	-1.424E-01	-7.676E-01	-7.735E-01	-9.266E-01	-9.114E-01
MW	-7.040E-01	5.895E-04	7.773E-01	6.968E-01	8.032E-01	8.525E-02	9.436E-02	3.852E-01	9.339E-01
ZW	-1.004E-01	7.773E-01	2.368E-03	9.929E-01	9.991E-01	-5.605E-01	-5.529E-01	-2.812E-01	5.009E-01
MU	1.893E-02	6.968E-01	9.929E-01	2.198E-03	9.869E-01	-6.553E-01	-6.484E-01	-3.936E-01	3.942E-01
ZU	-1.424E-01	8.032E-01	9.991E-01	9.869E-01	2.339E-03	-5.250E-01	-5.172E-01	-2.404E-01	5.371E-01
XU	-7.676E-01	8.525E-02	-5.605E-01	-6.553E-01	-5.250E-01	2.933E-03	1.000E+00	9.523E-01	4.359E-01
XW	-7.735E-01	9.436E-02	-5.529E-01	-6.484E-01	-5.172E-01	1.000E+00	7.523E-03	9.551E-01	4.441E-01
MDE	-9.266E-01	3.852E-01	-2.812E-01	-3.936E-01	-2.404E-01	9.523E-01	9.551E-01	2.516E-01	6.897E-01
ZDE	-9.114E-01	9.339E-01	5.009E-01	3.942E-01	5.371E-01	4.359E-01	4.441E-01	6.897E-01	9.487E-02

ERROR SUMMARY

ERROR	TIMES
10049	10002

Figure 4.2 (page 11 of 11)

```
@ASG,T 11.,F4


@XQT SCIP2
 $LONGDT
 NDP     =              +17
 DLTA    =      .00000000E+00,   .39270000E+00,   .78540000E+00,   .11781000E+01,
                .15707000E+01,   .19634000E+01,   .23561000E+01,   .27488000E+01,
                .31416000E+01,   .35343000E+01,   .39270000E+01,   .43197000E+01,
                .47123000E+01,   .51050000E+01,   .54977000E+01,   .58904000E+01,
                .62832000E-01,   .00000000E+00,   .00000000E+00,   .00000000E+00,
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Figure 4.3 Example Output for VTOL Ensemble Program (page 1 of 15)

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           .00000000E+00
DLUE    =  .49040000E+00,  .46190000E+00,  .41570000E+00,  .35360000E+00,
           .27780000E+00,  .19130000E+00,  .97600000E-01,  .00000000E+00,
          -.97600000E-01, -.19130000E+00, -.27780000E+00, -.35360000E+00,
          -.41570000E+00, -.46190000E+00, -.49040000E+00, -.50000000E+00,
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Figure 4.3 (page 2 of 15)

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          .00000000E+00,  .00000000E+00,  .00000000E+00,  .00000000E+00,
          .00000000E+00
DLUC    = .00000000E+00,  .97600000E-01,  .19130000E+00,  .27780000E+00,
          .35360000E+00,  .41570000E+00,  .46190000E+00,  .50000000E+00,
          .49040000E+00,  .46190000E+00,  .41570000E+00,  .35360000E+00,
          .27780000E+00,  .19130000E+00,  .97600000E-01,  .00000000E+00,
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Figure 4.3 (page 3 of 15)

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.00000000E+00,	.00000000E+00,	.00000000E+00,	.00000000E+00,
.00000000E+00,	.00000000E+00,	.00000000E+00,	.00000000E+00,
.00000000E+00,	.00000000E+00,	.00000000E+00,	.00000000E+00,

Figure 4.3 (page 4 of 15)

```
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00
THETAO    =    .67190000E+01
ALPHAO    =    .13759000E+02
VEL       =    .68020000E+02
EXCG      =    .50000000E+00
EYCG      =    .00000000E+00
EZCG      =    .50000000E+00
T         =    .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00,   .00000000E+00,   .00000000E+00,   .00000000E+00,
               .00000000E+00
ESTIM     =               +1
DT        =    .10000000E-01
NMC       =               +1
DTS       =    .11000000E-01
TAU       =    .11000000E-01
NOP       =             +100
MXITR     =               +1
EP1       =    .10000000E-01
EP2       =    .10000000E-04
EVX       =    .20000000E+02
EAX       =    .50000000E+01
EAY       =    .00000000E+00
EAZ       =    .20000000E+01
MQ        =   -.13440000E+01
ZQ        =   -.18730000E+01
XQ        =    .10700000E+01
MW        =    .20000000E-01
ZW        =   -.60800000E+00
XW        =    .82000000E-01
MU        =   -.80000000E-02
ZU        =   -.11900000E+00
XU        =   -.17000000E-01
MDE       =    .40600000E+00
ZDE       =    .60500000E+00
XDE       =    .11700000E+00
MDC       =    .64000000E-01
ZDC       =   -.73590000E+01
XDC       =    .66600000E+00
IFXMQ     =               +0
IFXZQ     =               +0
IFXXQ     =               +0
```

ORIGINAL PAGE IS OF POOR QUALITY

Figure 4.3 (page 5 of 15)

```
IFXMW    =            +0
IFXZW    =            +0
IFXXW    =            +0
IFXMU    =            +0
IFXZU    =            +0
IFXXU    =            +0
IFXMDE   =            +0
IFXZDE   =            +0
IFXXDE   =            +0
IFXMDC   =            +0
IFXZDC   =            +0
IFXXDC   =            +0
WTHETA   =   .15000000E+00
BTHETA   =   .15000000E+00
ETHETA   =   .50000000E-02
WQ       =   .10000000E+00
BQ       =   .10000000E+00
EQ       =   .50000000E-02
WALPHA   =   .10000000E+00
BALPHA   =   .10000000E+00
EALPHA   =   .50000000E-02
WU       =   .10000000E+01
BU       =   .10000000E+01
EU       =   .10000000E+01
WNX      =   .50000000E-02
BNX      =   .50000000E-02
ENX      =   .50000000E-02
GNX      =   .60000000E+00
WNZ      =   .50000000E-02
BNZ      =   .50000000E-02
ENZ      =   .50000000E-02
GNZ      =   .60000000E+00
WQDOT    =   .10000000E+00
BQDOT    =   .10000000E+00
EQDOT    =   .50000000E-02
GQDOT    =   .00000000E+00
EDELT    =   .00000000E+00
EDELQ    =   .00000000E+00
EDELW    =   .00000000E+00
EDELU    =   .00000000E+00
FTHETA   =   .62000000E+02
FQ       =   .62000000E+02
FALPHA   =   .62000000E+02
FU       =   .62000000E+02
FNX      =   .62000000E+02
FNZ      =   .62000000E+02
FQDOT    =   .62000000E+02
WDE      =   .00000000E+00
WDC      =   .00000000E+00
BDE      =   .10000000E+00
BDC      =   .10000000E+00
EDE      =   .10000000E-01
EDC      =   .10000000E-01
FDE      =   .62000000E+02
FDC      =   .62000000E+02
CMAT     =   .37215800E-01,  .00000000E+00,  .51045900E-01,  .00000000E+00,
             .44963500E-01,  .00000000E+00, -.45908500E-01,  .00000000E+00
```

Figure 4.3 (page 6 of 15)

```
09/09/74  11:31:16 MOHR    000373D70    000373         2      199                              DATE 090974        PAGE    18
STVOUT   =      .00000000E+00
STVCNT   =      .00000000E+00
CARD     =      .00000000E+00
IFLPRM   =               +0,            +0,            +0,            +0,
                         +0,            +0,            +0,            +0,
                         +0,            +0,            +0,            +0,
                         +0,            +0,            +0
$END
```

65

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4.3 (page 7 of 15)

ENSEMBLE ** FULL LONGITUDINAL ANALYSIS
PARAMETERS ESTIMATE ONLY

INPUT SUMMARY

ENSMBL T F F F F F F F F F F F F F F F F F F F F F T T T T T T

ESTIM= 1 MODE= 0 SAMPLE POINTS= 100 SAMPLE RATE= .010 MONTE CARLO 0 RUNS

MQ	= -.134400+01	MW	= .114592+01	ZW	= -.603000+00	MU	= -.458366+00	ZU	= -.119000+00
XU	= -.170000-01	XW	= .820000-01	MDE	= .232621+02	ZDE	= .605000+00		
ZQ	= -.326900-01	XQ	= .186750-01	MDC	= .365691+01	ZDC	= -.735900+01	XDC	= .866000+00
XDE	= .117000+00								

ALPHA= 13.7590 THETA= 6.7190 VELOCITY= 66.0200

ERROR VECTORS

	BIASES	SCALE	MISALIGN	LAG	NOISE
THETA	.1500000+00	.5000000-02	.0000000	.6200000+02	.1500000+00
Q	.1000000+00	.5000000-02	.0000000	.6200000+02	.1000000+00
ALPHA	.1000000+00	.5000000-02	.0000000	.6200000+02	.1000000+00
U	.1000000+01	.1000000+01	.0000000	.6200000+02	.1000000+01
NX	.5000000-02	.5000000-02	.6000000+00	.6200000+02	.5000000-02
NZ	.5000000-02	.5000000-02	.6000000+00	.6200000+02	.5000000-02
Q-DOT	.1000000+00	.5000000-02	.0000000	.6200000+02	.1000000+00

	I. C.		ACCEL		C. G.		VANE
THETA	.0000000	AX	.5000000+01	CG X	.5000000+00	VX	.2000000+02
Q	.0000000	AY	.0000000	CG Y	.0000000		
W	.0000000	AZ	.2000000+01	CG Z	.5000000+00		
U	.0000000						

CONTROL ERRORS

BDE	.1000000+00	EDE	.1000000-01	FDE	.6200000+02
BDC	.1000000+00	EDC	.1000000-01	FDC	.6200000+02

Figure 4.3 (page 8 of 15)

SCIP2 STATE MEASUREMENT AND CONTROL SEQUENCE

TIME (SEC)	THETA (DEG)	Q (DEG/SEC)	ALPHA (DEG)	U (FT/SEC)	NX (G'S)	NZ (G'S)	Q-DOT (DEG/SEC**2)	DEL-E (IN)	DEL-C (IN)
.0100	.00	.11	.00	.00	.00	.01	11.11	.49	.00
.0200	.00	.22	.01	.00	.00	.01	10.83	.49	.00
.0300	.01	.33	.01	.00	.00	.01	10.55	.49	.01
.0400	.01	.43	.02	.00	.00	.01	10.27	.49	.01
.0500	.01	.53	.02	-.00	.00	.00	10.01	.49	.01
.0600	.02	.63	.03	-.00	.00	.00	9.74	.49	.01
.0700	.03	.73	.04	-.00	.00	.00	9.49	.49	.02
.0800	.03	.82	.05	-.00	.00	.00	9.23	.48	.02
.0900	.04	.91	.05	-.01	.00	.00	8.99	.48	.02
.1000	.05	1.00	.06	-.01	.00	-.00	8.75	.48	.02
.1100	.06	1.09	.07	-.01	.00	-.00	8.51	.48	.03
.1200	.07	1.17	.09	-.01	.00	-.00	8.28	.48	.03
.1300	.09	1.26	.10	-.02	.00	-.00	8.06	.48	.03
.1400	.10	1.33	.11	-.02	.00	-.00	7.84	.48	.03
.1500	.11	1.41	.12	-.02	.00	-.01	7.62	.48	.04
.1600	.13	1.49	.13	-.03	.00	-.01	7.41	.48	.04
.1700	.14	1.56	.15	-.03	.00	-.01	7.20	.48	.04
.1800	.16	1.63	.16	-.03	.00	-.01	7.00	.48	.04
.1900	.18	1.70	.18	-.04	.00	-.01	6.80	.48	.05
.2000	.19	1.77	.19	-.04	.00	-.01	6.61	.48	.05
.2100	.21	1.83	.20	-.05	.00	-.01	6.42	.48	.05
.2200	.23	1.90	.22	-.05	.00	-.01	6.23	.47	.05
.2300	.25	1.96	.24	-.06	.00	-.01	6.05	.47	.06
.2400	.27	2.02	.25	-.06	.00	-.01	5.87	.47	.06
.2500	.29	2.08	.27	-.07	.00	-.02	5.70	.47	.06
.2600	.31	2.13	.29	-.08	.01	-.02	5.53	.47	.06
.2700	.33	2.19	.30	-.08	.01	-.02	5.36	.47	.07
.2800	.35	2.24	.32	-.09	.01	-.02	5.20	.47	.07
.2900	.38	2.29	.34	-.09	.01	-.02	5.04	.47	.07
.3000	.40	2.34	.35	-.10	.01	-.02	4.89	.47	.07
.3100	.42	2.39	.37	-.11	.01	-.02	4.73	.47	.08
.3200	.45	2.43	.39	-.12	.01	-.02	4.58	.47	.08
.3300	.47	2.48	.41	-.12	.01	-.02	4.44	.47	.08
.3400	.50	2.52	.43	-.13	.01	-.03	4.30	.47	.08
.3500	.52	2.57	.45	-.14	.01	-.03	4.16	.46	.09
.3600	.55	2.61	.47	-.15	.01	-.03	4.02	.46	.09
.3700	.57	2.65	.48	-.16	.01	-.03	3.89	.46	.09
.3800	.60	2.68	.50	-.17	.01	-.03	3.75	.46	.09
.3900	.63	2.72	.52	-.17	.01	-.03	3.63	.46	.10
.4000	.66	2.76	.54	-.18	.01	-.03	3.49	.46	.10
.4100	.68	2.79	.56	-.19	.01	-.03	3.36	.46	.10
.4200	.71	2.82	.58	-.20	.01	-.03	3.23	.46	.10
.4300	.74	2.86	.60	-.21	.01	-.03	3.10	.46	.11
.4400	.77	2.89	.62	-.22	.01	-.04	2.98	.46	.11
.4500	.80	2.92	.64	-.23	.01	-.04	2.86	.46	.11
.4600	.83	2.94	.66	-.24	.01	-.04	2.74	.45	.11
.4700	.86	2.97	.68	-.25	.01	-.04	2.62	.45	.12
.4800	.89	3.00	.70	-.26	.01	-.04	2.51	.45	.12
.4900	.92	3.02	.72	-.27	.01	-.04	2.39	.45	.12
.5000	.95	3.04	.74	-.29	.01	-.04	2.29	.45	.12
.5100	.98	3.07	.76	-.30	.01	-.04	2.18	.45	.13

Figure 4.3 (page 9 of 15)

SCIP2 STATE MEASUREMENT AND CONTROL SEQUENCE

TIME (SEC)	THETA (DEG)	Q (DEG/SEC)	ALPHA (DEG)	U (FT/SEC)	NX (G'S)	NZ (G'S)	Q-DOT (DEG/SEC**2)	DEL-E (IN)	DEL-C (IN)
.5200	1.01	3.09	.78	-.31	.01	-.04	2.07	.45	.13
.5300	1.04	3.11	.79	-.32	.01	-.04	1.97	.45	.13
.5400	1.07	3.13	.81	-.33	.01	-.05	1.87	.44	.13
.5500	1.10	3.15	.83	-.34	.01	-.05	1.78	.44	.14
.5600	1.13	3.16	.85	-.36	.01	-.05	1.68	.44	.14
.5700	1.16	3.18	.87	-.37	.01	-.05	1.59	.44	.14
.5800	1.20	3.20	.89	-.38	.01	-.05	1.50	.44	.14
.5900	1.23	3.21	.91	-.40	.01	-.05	1.41	.44	.14
.6000	1.26	3.22	.93	-.41	.01	-.05	1.32	.44	.15
.6100	1.29	3.24	.95	-.42	.01	-.05	1.23	.44	.15
.6200	1.33	3.25	.97	-.43	.01	-.05	1.15	.44	.15
.6300	1.36	3.26	.98	-.45	.01	-.05	1.07	.43	.15
.6400	1.39	3.27	1.00	-.46	.01	-.06	.99	.43	.16
.6500	1.42	3.28	1.02	-.48	.01	-.06	.91	.43	.16
.6600	1.46	3.29	1.04	-.49	.01	-.06	.84	.43	.16
.6700	1.49	3.30	1.06	-.50	.01	-.06	.76	.43	.16
.6800	1.52	3.30	1.07	-.52	.01	-.06	.69	.43	.17
.6900	1.56	3.31	1.09	-.53	.01	-.06	.62	.43	.17
.7000	1.59	3.32	1.11	-.55	.01	-.06	.55	.43	.17
.7100	1.62	3.32	1.13	-.56	.01	-.06	.48	.42	.17
.7200	1.65	3.33	1.14	-.58	.01	-.06	.41	.42	.18
.7300	1.69	3.33	1.16	-.59	.01	-.06	.35	.42	.18
.7400	1.72	3.33	1.18	-.61	.01	-.06	.28	.42	.18
.7500	1.75	3.34	1.19	-.63	.01	-.07	.22	.42	.18
.7600	1.79	3.34	1.21	-.64	.01	-.07	.16	.42	.19
.7700	1.82	3.34	1.23	-.66	.01	-.07	.10	.42	.19
.7800	1.85	3.34	1.24	-.67	.01	-.07	.04	.42	.19
.7900	1.89	3.34	1.26	-.69	.01	-.07	-.02	.41	.19
.8000	1.92	3.34	1.27	-.71	.01	-.07	-.08	.41	.19
.8100	1.96	3.34	1.29	-.72	.01	-.07	-.15	.41	.20
.8200	1.99	3.34	1.30	-.74	.01	-.07	-.21	.41	.20
.8300	2.02	3.34	1.32	-.76	.01	-.07	-.27	.41	.20
.8400	2.06	3.33	1.33	-.77	.01	-.07	-.33	.41	.20
.8500	2.09	3.33	1.35	-.79	.01	-.07	-.39	.41	.21
.8600	2.12	3.33	1.36	-.81	.01	-.07	-.44	.40	.21
.8700	2.16	3.32	1.38	-.83	.01	-.08	-.50	.40	.21
.8800	2.19	3.32	1.39	-.84	.01	-.08	-.55	.40	.21
.8900	2.22	3.31	1.40	-.86	.01	-.08	-.60	.40	.21
.9000	2.25	3.30	1.42	-.88	.01	-.08	-.66	.40	.22
.9100	2.29	3.30	1.43	-.90	.01	-.08	-.71	.40	.22
.9200	2.32	3.29	1.44	-.91	.01	-.08	-.76	.39	.22
.9300	2.35	3.28	1.46	-.93	.01	-.08	-.80	.39	.22
.9400	2.39	3.27	1.47	-.95	.01	-.08	-.85	.39	.23
.9500	2.42	3.27	1.48	-.97	.01	-.08	-.90	.39	.23
.9600	2.45	3.26	1.49	-.99	.01	-.08	-.94	.39	.23
.9700	2.48	3.25	1.50	-1.01	.01	-.08	-.98	.39	.23
.9800	2.52	3.24	1.51	-1.03	.01	-.08	-1.03	.38	.23
.9900	2.55	3.23	1.53	-1.05	.01	-.08	-1.07	.38	.24
1.0000	2.58	3.22	1.54	-1.07	.01	-.08	-1.11	.38	.24

Figure 4.3 (page 10 of 15)

D2JDP2 MATRIX INVERSE

	MQ	ZQ	XQ	MW	ZW	XW	MU	ZU	XU	MDE
MQ	.244-02	-.176-04	.150-05	-.873-02	.132-03	.341-03	-.115-01	.172-03	.641-03	-.344-02
ZQ	-.176-04	.529-02	.166-04	.261-05	-.224-01	-.167-03	-.652-04	-.247-01	-.236-03	.694-04
XQ	.150-05	.166-04	.533-02	-.368-03	.317-04	-.226-01	-.637-03	.124-03	-.249-01	.270-03
MW	-.873-02	.261-05	-.368-03	.505-01	-.477-03	.432-04	.478-01	-.871-03	-.160-02	.143-01
ZW	.132-03	-.224-01	.317-04	-.477-03	.122+00	.435-03	-.280-04	.122+00	.890-03	-.431-03
XW	.341-03	-.167-03	-.226-01	.432-04	.435-03	.123+00	.170-02	-.565-04	.123+00	-.144-02
MU	-.115-01	-.652-04	-.637-03	.478-01	-.280-04	.170-02	.701-01	-.421-03	-.350-04	.119-01
ZU	.172-03	-.247-01	.124-03	-.871-03	.122+00	-.585-04	-.421-03	.152+00	.434-03	-.469-03
XU	.641-03	-.236-03	-.249-01	-.160-02	.890-03	.123+00	-.350-04	.434-03	.153+00	-.154-02
MDE	-.344-02	.694-04	.270-03	.143-01	-.431-03	-.144-02	.119-01	-.469-03	-.154-02	.965-02
ZDE	-.598-04	-.864-02	-.950-04	.200-03	.357-01	.513-03	.394-03	.303-01	.480-03	-.323-03
XDE	-.285-03	.650-04	-.869-02	.134-02	-.267-03	.360-01	.160-02	-.419-03	.304-01	-.334-03
MDC	-.215-01	.353-05	.375-04	-.314-01	.325-03	-.282-03	.113+00	.607-03	-.335-03	.114-02
ZDC	.422-04	-.214-01	-.813-05	.680-04	-.313-01	-.102-03	-.176-03	.112+00	-.132-03	.336-03
XDC	.430-04	-.224-04	-.214-01	.156-03	-.178-03	-.318-01	-.228-03	-.766-04	.111+00	-.655-04

	ZDE	XDE	MDC	ZDC	XDC
MQ	-.598-04	-.285-03	-.215-01	.422-04	.430-04
ZQ	-.864-02	.650-04	.353-05	-.214-01	-.224-04
XQ	-.950-04	-.869-02	.375-04	-.813-05	-.214-01
MW	.200-03	.134-02	-.314-01	.680-04	.156-03
ZW	.357-01	-.267-03	.325-03	-.313-01	-.178-03
XW	.513-03	.360-01	-.282-03	-.102-03	-.318-01
MU	.394-03	.160-02	.113+00	-.176-03	-.228-03
ZU	.303-01	-.419-03	.607-03	.112+00	-.766-04
XU	.480-03	.304-01	-.335-03	-.132-03	.111+00
MDE	-.323-03	-.334-03	.114-02	.336-03	-.655-04
ZDE	.220-01	.391-03	.339-03	.126-02	-.326-03
XDE	.391-03	.226-01	-.141-03	-.316-03	.492-04
MDC	.339-03	-.141-03	.996+00	-.581-03	.151-03
ZDC	.126-02	-.316-03	-.581-03	.998+00	.446-03
XDC	-.326-03	.492-04	.151-03	.446-03	.100+01

NORMALIZED D2JDP2 INVERSE

	MQ	ZQ	XQ	MW	ZW	XW	MU	ZU	XU	MDE
MQ	.494-01	-.491-02	.417-03	-.786+00	.763-02	.197-01	-.879+00	.893-02	.332-01	-.707+00
ZQ	-.491-02	.727-01	.312-02	.160-03	-.884+00	-.654-02	-.336-02	-.873+00	-.829-02	.970-02
XQ	.417-03	.312-02	.730-01	-.224-01	.124-02	-.884+00	-.329-01	.435-02	-.871+00	.376-01
MW	-.786+00	.160-03	-.224-01	.225+00	-.607-02	.548-03	.803+00	-.995-02	-.182-01	.646+00
ZW	.763-02	-.884+00	.124-02	-.607-02	.349+00	.355-02	-.303-03	.898+00	.652-02	-.125-01
XW	.197-01	-.654-02	-.884+00	.548-03	.355-02	.351+00	.183-01	-.428-03	.900+00	-.418-01
MU	-.879+00	-.336-02	-.329-01	.803+00	-.303-03	.183-01	.265+00	-.408-02	-.338-03	.455+00
ZU	.893-02	-.873+00	.435-02	-.995-02	.898+00	-.428-03	-.406-02	.389+00	.285-02	-.172-01
XU	.332-01	-.829-02	-.871+00	-.182-01	.652-02	.900+00	-.338-03	.285-02	.391+00	-.401-01
MDE	-.707+00	.970-02	.376-01	.646+00	-.125-01	-.418-01	.455+00	-.122-01	-.401-01	.984-01
ZDE	-.817-02	-.802+00	-.878-02	.601-02	.691+00	.986-02	.101-01	.525+00	.828-02	-.222-01
XDE	-.384-01	.595-02	-.792+00	.396-01	-.508-02	.683+00	.403-01	-.717-02	.518+00	-.220-01
MDC	-.437+00	.487-04	.515-03	-.140+00	.934-03	-.804-03	.427+00	.156-02	-.658-03	.116-01
ZDC	.854-03	-.295+00	-.111-03	.303-03	-.898-01	-.292-03	-.666-03	.287+00	-.337-03	.341-02
XDC	.871-03	-.308-03	-.294+00	.696-03	-.509-03	-.906-01	-.862-03	-.197-03	.284+00	-.666-03

	ZDE	XDE	MDC	ZDC	XDC
MQ	-.817-02	-.384-01	-.437+00	.854-03	.871-03
ZQ	-.802+00	.595-02	.487-04	-.295+00	-.308-03
XQ	-.878-02	-.792+00	.515-03	-.111-03	-.294+00
MW	.601-02	.396-01	-.140+00	.303-03	.696-03

Figure 4.3 (page 11 of 15)

ZW	.691+00	-.508-02	.434-03	-.898-01	-.509-03
XW	.986-02	.683+00	-.804-03	-.292-03	-.906-01
MU	.101-01	.403-01	.427+00	-.666-03	-.862-03
ZU	.525+00	-.717-02	.156-02	.287+00	-.197-03
XU	.828-02	.518+00	-.858-03	-.337-03	.284+00
MDE	-.222-01	-.226-01	.116-01	.341-02	-.666-03
ZDE	.148+00	.176-01	.230-02	.852-02	-.220-02
XDE	.176-01	.150+00	-.940-03	-.211-02	.328-03
MDC	.230-02	-.940-03	.998+00	-.583-03	.152-03
ZDC	.852-02	-.211-02	-.583-03	.999+00	.447-03
XDC	-.220-02	.328-03	.152-03	.447-03	.100-01

ENSEMBLE COVARIANCE

	MQ	ZQ	XQ	MW	ZW	XW	MU	ZU	XU	MDE
MQ	.899-01	-.681-01	-.270+00	.702-01	.308+00	.144+01	-.291+00	.544+00	.799+00	.127+01
ZQ	-.681-01	.377+01	.231+02	-.266+01	-.169+02	-.122+03	-.388+01	-.276+02	-.100+03	.275+00
XQ	-.270+00	.231+02	.146+03	-.173+02	-.103+03	-.771+03	-.254+02	-.171+03	-.634+03	.146+01
MW	.702-01	-.266+01	-.173+02	.233+01	.119+02	.916+02	.300+01	.196+02	.764+02	.139+01
ZW	.308+00	-.169+02	-.103+03	.119+02	.756+02	.546+03	.173+02	.125+03	.447+03	-.105+01
XW	.144+01	-.122+03	-.771+03	.916+02	.546+03	.408+04	.134+03	.905+03	.336+04	-.769+01
MU	-.291+00	-.388+01	-.254+02	.300+01	.173+02	.134+03	.580+01	.285+02	.113+03	-.450+01
ZU	.544+00	-.276+02	-.171+03	.196+02	.125+03	.905+03	.285+02	.206+03	.739+03	-.191+01
XU	.799+00	-.100+03	-.634+03	.764+02	.447+03	.336+04	.113+03	.739+03	.277+04	-.631+01
MDE	.127+01	.275+00	.146+01	.139+01	-.105+01	-.769+01	-.450+01	-.191+01	-.631+01	.226+02
ZDE	.639-01	-.256+01	-.155+02	.186+01	.115+02	.818+02	.257+01	.187+02	.675+02	.417+00
XDE	.602+00	-.427+02	-.268+03	.316+02	.191+03	.142+04	.461+02	.316+03	.117+04	-.258+01
MDC	-.230+00	.146+01	.708+01	-.382+00	-.644+01	-.375+02	-.755-01	-.113+02	-.257+02	.792-01
ZDC	.101+01	-.456+02	-.282+03	.322+02	.204+03	.149+04	.464+02	.339+03	.122+04	-.291+01
XDC	-.256+01	.101+03	.625+03	-.705+02	-.451+03	-.331+04	-.101+03	-.753+03	-.268+04	.643+01

	ZDE	XDE	MDC	ZDC	XDC
MQ	.639-01	.602+00	-.230+00	.101+01	-.256+01
ZQ	-.256+01	-.427+02	.146+01	-.456+02	.101+03
XQ	-.155+02	-.268+03	.708+01	-.282+03	.625+03
MW	.186+01	.316+02	-.382+00	.322+02	-.705+02
ZW	.115+02	.191+03	-.644+01	.204+03	-.451+03
XW	.818+02	.142+04	-.375+02	.149+04	-.331+04
MU	.257+01	.461+02	-.755-01	.464+02	-.101+03
ZU	.187+02	.316+03	-.113+02	.339+03	-.753+03
XU	.675+02	.117+04	-.257+02	.122+04	-.268+04
MDE	.417+00	-.258+01	.792-01	-.291+01	.643+01
ZDE	.201+01	.284+02	-.771+00	.300+02	-.656+02
XDE	.284+02	.495+03	-.144+02	.523+03	-.116+04
MDC	-.771+00	-.144+02	.426+01	-.202+02	.494+02
ZDC	.300+02	.523+03	-.202+02	.564+03	-.126+04
XDC	-.656+02	-.116+04	.494+02	-.126+04	.282+04

NORMALIZED COVARIANCE

	MQ	ZQ	XQ	MW	ZW	XW	MU	ZU	XU	MDE
MQ	.300+00	-.117+00	-.745-01	.153+00	.118+00	.750-01	-.403+00	.126+00	.506-01	.888+00
ZQ	-.117+00	.194+01	.985+00	-.898+00	-.100+01	-.985+00	-.829+00	-.999+00	-.978+00	.298-01
XQ	-.745-01	.985+00	.121+02	-.940+00	-.983+00	-.100+01	-.873+00	-.987+00	-.998+00	.255-01
MW	.153+00	-.898+00	-.940+00	.153+01	.899+00	.940+00	.818+00	.897+00	.951+00	.191+00
ZW	.118+00	-.100+01	-.983+00	.899+00	.870+01	.984+00	.828+00	.998+00	.977+00	-.255-01
XW	.750-01	-.985+00	-.100+01	.940+00	.984+00	.639+02	.873+00	.987+00	.998+00	-.253-01
MU	-.403+00	-.829+00	-.873+00	.818+00	.828+00	.873+00	.241+01	.825+00	.888+00	-.393+00

Figure 4.3 (page 12 of 15)

ZU	.126+00	-.999+00	-.987+00	.897+00	.998+00	.987+00	.825+00	.144+02	.976+00	-.279-01
XU	.506-01	-.978+00	-.998+00	.951+00	.977+00	.998+00	.888+00	.978+00	.527+02	-.252-01
MDE	.888+00	.298-01	.255-01	.191+00	-.255-01	-.253-01	-.393+00	-.279-01	-.252-01	.476+01
ZDE	.150+00	-.930+00	-.903+00	.858+00	.935+00	.904+00	.754+00	.918+00	.904+00	.618-01
XDE	.902-01	-.987+00	-.999+00	.931+00	.986+00	.999+00	.861+00	.991+00	.995+00	-.244-01
MDC	-.372+00	.364+00	.284+00	-.121+00	-.359+00	-.285+00	-.152-01	-.383+00	-.236+00	.807-02
ZDC	.141+00	-.989+00	-.985+00	.889+00	.986+00	.985+00	.812+00	.994+00	.973+00	-.258-01
XDC	-.161+00	.979+00	.974+00	-.869+00	-.976+00	-.975+00	-.788+00	-.988+00	-.959+00	.254-01
	ZDE	XDE	MDC	ZDC	XDC					
MQ	.150+00	.902-01	-.372+00	.141+00	-.161+00					
ZQ	-.930+00	-.987+00	.364+00	-.989+00	.979+00					
XQ	-.903+00	-.999+00	.284+00	-.985+00	.974+00					
MW	.858+00	.931+00	-.121+00	.889+00	-.869+00					
ZW	.935+00	.986+00	-.359+00	.986+00	-.976+00					
XW	.904+00	.999+00	-.285+00	.985+00	-.975+00					
MU	.754+00	.861+00	-.152-01	.812+00	-.788+00					
ZU	.918+00	.991+00	-.383+00	.994+00	-.988+00					
XU	.904+00	.995+00	-.236+00	.973+00	-.959+00					
MDE	.616-01	-.244-01	.807-02	-.258-01	.254-01					
ZDE	.142+01	.901+00	-.264+00	.891+00	-.872+00					
XDE	.901+00	.222+02	-.314+00	.990+00	-.982+00					
MDC	-.264+00	-.314+00	.206+01	-.412+00	.451+00					
ZDC	.891+00	.990+00	-.412+00	.237+02	-.997+00					
XDC	-.872+00	-.982+00	.451+00	-.997+00	.531+02					

EXPECTED MEAN ERROR

MQ	-.31542+00	ZQ	-.28632+00	XQ	.77269-01	MW	.14505+01	ZW	.75370+00
XW	-.18502-01	MU	.16805+01	ZU	.12870+01	XU	-.43636-01	MDE	-.36977+00
ZDE	-.38275+01	XDE	-.34208+00	MDC	-.91658+00	ZDC	.18243+01	XDC	-.61027+00

Figure 4.3 (page 13 of 15)

SENSITIVITY DERIVATIVES

PARAMETER	ERROR SOURCE BIASES THETA	Q	ALPHA	U	NX	NZ	Q-DOT	SCALE THETA	Q	ALPHA
INPUT	.150+00	.100+00	.100+00	.100+01	.500-02	.500-02	.100+00	.500-02	.500-02	.500-02
MQ	.236-01	.172+00	.260-01	-.142-02	-.149+01	-.120+01	.201+00	.593-01	.697+00	.566-01
ZQ	-.689-03	-.396-02	-.203-01	.516-03	.674+00	.378+01	.405-02	-.129-02	-.132-01	.109+00
XQ	.152-02	.509-02	.141-01	-.324-03	.362+01	.990-01	-.287-02	.265-02	.134-01	-.214-01
MW	.377-01	.693+00	.675-01	-.245-02	-.162+01	-.131+01	-.342+00	.454-01	.182+01	.504-01
ZW	-.222-01	-.150+00	.731+00	.171-02	.418+01	-.955+01	-.304+00	-.381-01	-.449+00	.999+00
XW	-.142-02	.143-01	-.171+00	.121-01	.333+01	.343+01	.793-01	-.279-02	.521-01	-.227+00
MU	-.152+00	-.371+00	-.179+00	.131-02	.933+01	.534+01	-.218+01	-.237+00	-.104+01	-.215+00
ZU	-.402-01	-.277+00	.863-01	.888-03	.133+01	-.347+02	-.538+00	-.700-01	-.842+00	.840+00
XU	.635-03	.310-01	-.274-01	.445-02	-.134+02	.431+01	.112+00	.893-03	.105+00	-.211+00
MDE	.394+00	.163+01	.508+00	-.324-02	.225+01	-.881+01	.106+01	.554+00	.386+01	.496+00
ZDE	-.441-01	-.235+00	.305+01	.524-02	.848+01	.307+02	-.285+00	-.711-01	-.670+00	.182+01
XDE	.896-02	.524-01	-.740+00	.574-01	.628+02	.850+01	.742-01	.142-01	.151+00	-.441+00
MDC	-.581+00	-.408+01	-.688+00	.362-02	-.390+01	.155+02	.321+01	-.102+01	-.125+02	-.910+00
ZDC	.687-01	.380+00	-.272+01	-.673-02	-.118+02	.489+02	.471+00	.112+00	.110+01	-.278+01
XDC	-.166-01	-.908-01	.657+00	-.593-01	.415+01	-.118+02	-.122+00	-.270-01	-.261+00	.673+00

PARAMETER	ERROR SOURCE U	NX	NZ	Q-DOT	MISALN NX	NZ	C. G. CG X	CG Z	ACCEL AX	AZ
INPUT	.100+01	.500-02	.500-02	.500-02	.600+00	.600+00	.500+00	.500+00	.500+01	.200+01
MQ	.484-03	-.134-02	.283-01	.504+00	.407-03	-.122-03	.184-02	-.105-01	.366-02	.105-01
ZQ	-.199-03	.180-02	-.151+00	-.593-01	-.319-04	.563-03	.975-02	.330-02	.168-01	-.330-02
XQ	-.468-03	.345-01	-.425-03	-.102-01	.295-02	.745-05	.146-02	-.218-01	.548-04	.218-01
MW	.210-02	.439-02	.278-01	-.472+00	.171-02	-.133-03	.181-03	.377-03	.185-02	-.377-03
ZW	-.120-02	.354-01	.376-01	-.867+00	.327-02	-.613-03	-.171-01	.381-02	-.291-02	-.381-02
XW	-.112-01	.103+00	-.206+00	.380+00	.141-01	.606-03	-.331-03	.174-01	-.316-02	-.174-01
MU	-.692-03	.129+00	-.235+00	-.152+01	.151-01	.766-03	-.301-03	-.194-02	-.990-02	.194-02
ZU	-.763-03	.107-01	.235+01	-.167+01	.903-03	-.657-02	.213-01	-.211-03	.206-01	.211-03
XU	-.113-01	-.123+00	-.305+00	.495+00	-.131-01	.859-03	-.127-03	-.205-01	-.374-04	.205-01
MDE	.194-02	.133-01	.232+00	.165+02	.952-03	-.951-03	.751-03	.592-02	.232-01	-.592-02
ZDE	-.254-02	.469-01	.142+01	-.206+01	.311-02	-.154-02	-.415+00	.261-01	-.312+00	-.261-01
XDE	-.205-01	.865-01	-.178+00	.551+00	-.132-01	.819-03	-.129-02	.411+00	-.262-01	-.411+00
MDC	-.269-02	-.267-01	-.492+00	.159+02	-.217-02	.185-02	-.956-03	-.878-02	-.350-01	.678-02
ZDC	.344-02	-.742-01	-.132+01	.325+01	-.559-02	.536-02	-.401-02	-.305-01	-.126+00	.305-01
XDC	.314-01	.262-01	.320+00	-.835+00	.198-02	-.130-02	.972-03	.108-01	.305-01	-.108-01

PARAMETER	ERROR SOURCE VANE VX	LAG THETA	Q	ALPHA	U	NX	NZ	Q-DOT	CHIASE BDE	BDC
INPUT	.200+02	.620+02	.620+02	.620+02	.620+02	.620+02	.620+02	.620+02	.100+00	.100+00
MQ	-.182-02	.248-04	-.669-05	.123-04	.375-06	-.234-05	-.720-04	-.282-02	-.268+01	-.453+00
ZQ	-.705-02	-.619-06	-.255-04	.807-04	-.151-06	.186-05	-.106-02	.623-04	-.694-01	.190+02
XQ	.140-02	.120-05	.883-05	-.161-04	-.646-06	.535-04	.120-03	.140-03	-.121-01	.118+03
MW	-.167-02	.159-04	.702-04	.114-04	.127-05	-.213-04	-.391-04	.985-02	-.322+01	-.133+02
ZW	-.142-01	-.182-04	-.375-04	-.739-04	-.725-06	.141-04	.178-02	.696-03	-.776-01	-.548+02
XW	.263-02	-.900-06	-.920-05	.235-04	-.415-05	-.134-03	-.242-03	-.101-02	-.249-01	-.622+03
MU	.960-02	-.133-03	-.606-03	-.909-04	-.329-06	.533-05	.623-03	.116-01	.893+01	-.190+02
ZU	.685-03	-.331-04	-.230-04	-.269-03	-.444-06	.707-05	.326-02	.146-02	.243+00	-.142+03

Figure 4.3 (page 14 of 15)

XU	-.809-04	.839-06	-.171-04	.665-04	-.368-05	-.102-03	-.606-03	-.117-02	.347-01	-.505+03
MDE	-.225-01	.304-03	.163-02	.215-03	.120-05	.783-05	-.150-02	-.463-02	-.475+02	.121+01
ZDE	-.103+00	-.358-04	-.476-03	.112-02	-.172-05	.242-04	-.880-02	.131-02	-.123+01	-.123+02
XDE	.249-01	.735-05	.112-03	-.273-03	-.150-04	.852-04	.198-02	-.549-03	-.242+00	-.216+03
MDC	.340-01	-.482-03	-.141-02	-.274-03	-.155-05	-.111-04	.181-02	-.125-01	-.266-01	.932+01
ZDC	.122+00	.560-04	.557-03	-.114-02	.230-05	-.345-04	.791-02	-.219-02	-.945-02	-.237+03
XDC	-.295-01	-.135-04	-.135-03	.275-03	.207-04	.129-04	-.191-02	.574-03	.344-02	.531+03

PARAMETER	ERROR SOURCE			
	CSCALE		C LAG	
	EDE	EDC	FDE	FDC
INPUT	.100-01	.100-01	.620+02	.620+02
MQ	.108+02	.320+01	-.161-02	-.660-03
ZQ	.284+02	-.271+02	-.284-02	.195-03
XQ	.273+03	.119+02	.209-04	-.240-03
MW	-.628+02	-.126+02	.816-02	.574-02
ZW	-.135+03	.132+03	.167-01	-.198-02
XW	-.144+04	-.596+02	.117-03	.868-03
MU	-.112+03	-.185+02	.901-02	.429-02
ZU	-.168+03	.149+03	.162-01	-.174-02
XU	-.150+04	-.636+02	-.250-03	.751-03
MDE	.141+01	-.354+01	.231-02	.127-02
ZDE	-.365+02	.391+02	.452-02	-.274-03
XDE	-.417+03	-.183+02	.657-04	.416-03
MDC	-.141+03	-.321+02	.270-02	-.131-01
ZDC	-.148+03	.720+02	-.101-01	.421-02
XDC	.114+02	-.148+02	-.201-02	.749-03

DETERMINANT OF D2JDP2 = .27550126+08

@FIN

Figure 4.3 (page 15 of 15)

SIMULATED DATA ** LATERAL ANALYSIS
PARAMETERS ESTIMATE ONLY

INPUT SUMMARY

SIMDAT

ESTIM= 1 MODE= 2 SAMPLE POINTS= 99 SAMPLE RATE= .100 MONTE CARLO 3 RUNS

EP1= .0100 EP2= .0000 MAX ITERATION= 20 INTEGRATION STEP SIZE= .0100

YV	=-8.200000E-02	LV	=-5.729578E-01	NV	=-1.145916E-01	YP	=-2.326524E-02	LP	=-7.030000E-01
NP	=-2.500000E-02	YR	=-3.892084E-03	LR	=-7.000000E-02	NR	=-4.200000E-02	YDA	= 9.540000E-01
LDA	= 2.601228E+01	NDA	= 1.546986E+00	YDR	= 1.040000E-01	LDR	=-7.792226E+00	NDR	= 0.

ALPHA= 13.7500 THETA= 6.7190 VELOCITY= 68.0200

ERROR VECTORS

	BIASES	SCALE	MISALIGN	LAG	NOISE
BETA	5.0000000E-02	5.0000000E-03	0.	6.2000000E+01	5.0000000E-02
P	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01
R	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01
PHI	5.0000000E-01	5.0000000E-03	0.	6.2000000E+01	5.0000000E-01
NY	5.0000000E-04	5.0000000E-03	0.	6.2000000E+01	5.0000000E-04
P-DOT	6.0000000E-01	5.0000000E-03	0.	6.2000000E+01	1.0000000E-01
R-DOT	1.0000000E-01	5.0000000E-03	6.0000000E-01	6.2000000E+01	1.0000000E-01

I. C.		ACCEL		C. G.		VANE	
V	0.	AX	5.0000000E+00	CG X	5.0000000E-01	VX	2.0000000E+01
P	0.	AY	0.	CG Y	0.		
R	0.	AZ	2.0000000E+00	CG Z	5.0000000E-01		
PHI	0.						

CONTROL ERRORS

BDA	0.	EDA	0.	FDA	6.2000000E+01
BDR	0.	EDR	0.	FDR	6.2000000E+01

Figure 4.4 Example Output for VTOL Simulated Data Program (page 1 of 13)

***** MONTE CARLO SAMPLE NO. 1 *****

NEWTON-RAPHSON ITERATION NO. 1 COST1= 1.78170E+01 COST2= 3.48386E+01 J = 3.25644E+05

NEWTON-RAPHSON GRADIENT VECTOR

YV	-5.02134E+05	LV	-8.47323E+04	NV	1.03194E+05	YP	-7.43078E+04	LP	4.69969E+04
NP	-1.11073E+05	YR	-7.82819E+04	LR	1.42921E+04	NR	-1.84499E+04	YDA	9.14928E+04
LDA	1.32600E+03	NDA	-4.79066E+03	YDR	-6.31258E+04	LDR	-4.12940E+02	NDR	6.40043E+03

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-5.89221E-02	LV	-3.15409E-02	NV	-1.44287E-02	YP	-5.71686E-02	LP	3.90880E-02
NP	-3.47579E-03	YR	-6.93452E-02	LR	-2.25435E-01	NR	-3.41610E-02	YDA	2.36989E+00
LDA	-9.53529E-01	NDA	-2.93540E-01	YDR	-6.92191E-01	LDR	-5.46465E-01	NDR	1.54009E-01

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.40922E-01	LV	-6.04499E-01	NV	-1.29020E-01	YP	-8.04338E-02	LP	-6.63912E-01
NP	-2.84758E-02	YR	-7.32373E-02	LR	-2.95435E-01	NR	-7.61610E-02	YDA	3.32389E+00
LDA	2.50588E+01	NDA	1.25345E+00	YDR	-5.88191E-01	LDR	-8.33869E+00	NDR	1.54009E-01

NEWTON-RAPHSON ITERATION NO. 2 COST1= 2.33122E-01 COST2= 8.66595E-01 J = 2.50405E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	-6.97065E+04	LV	-4.76995E+04	NV	5.92860E+04	YP	2.41819E+04	LP	3.67379E+04
NP	-6.13110E+04	YR	-2.40561E+04	LR	1.67706E+04	NR	-2.23942E+04	YDA	-9.97685E+02
LDA	9.25231E+02	NDA	-1.41100E+03	YDR	-1.50149E+03	LDR	6.08039E+02	NDR	2.51545E+02

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-3.85446E-03	LV	-2.66560E-03	NV	5.11515E-04	YP	4.47525E-03	LP	-2.64097E-03
NP	2.27056E-03	YR	-1.69618E-02	LR	3.04472E-02	NR	-5.50451E-03	YDA	1.64474E-03
LDA	5.80037E-02	NDA	3.87903E-02	YDR	-7.97202E-03	LDR	3.46071E-02	NDR	3.59029E-02

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.44777E-01	LV	-6.07164E-01	NV	-1.28509E-01	YP	-7.59585E-02	LP	-6.66553E-01
NP	-2.62052E-02	YR	-9.01991E-02	LR	-2.64988E-01	NR	-8.16655E-02	YDA	3.32554E+00
LDA	2.51168E+01	NDA	1.29224E+00	YDR	-5.96163E-01	LDR	-8.30408E+00	NDR	1.89912E-01

Figure 4.4 (page 2 of 13)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 8.20051E-02 COST2= 1.82000E-01 J = 2.36643E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	-7.09880E+02	LV	1.41240E+02	NV	-3.08847E+02	YP	4.06546E+02	LP	1.88009E+02
NP	-3.31589E+02	YR	1.26734E+02	LR	1.50527E+01	NR	2.81574E+00	YDA	-2.38158E+01
LDA	3.79457E+00	NDA	-9.18056E+00	YDR	2.24983E+01	LDR	-8.26845E+00	NDR	2.06196E+00

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-1.94529E-04	LV	-5.73820E-04	NV	-7.34497E-04	YP	-3.26689E-05	LP	1.76995E-05
NP	-1.03463E-03	YR	-3.53924E-04	LR	-2.38829E-03	NR	2.20120E-03	YDA	-1.33646E-03
LDA	1.17951E-03	NDA	-1.27596E-02	YDR	-9.47658E-04	LDR	2.06734E-03	NDR	-1.55737E-02

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.44971E-01	LV	-6.07738E-01	NV	-1.29243E-01	YP	-7.59912E-02	LP	-6.66535E-01
NP	-2.72399E-02	YR	-9.05530E-02	LR	-2.67376E-01	NR	-7.94643E-02	YDA	3.32420E+00
LDA	2.51179E+01	NDA	1.27948E+00	YDR	-5.97110E-01	LDR	-8.30202E+00	NDR	1.74338E-01

NEWTON-RAPHSON ITERATION NO. 4 COST1= 6.43854E-03 COST2= 1.99285E-02 J = 2.36638E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	7.69964E+00	LV	-3.12922E+01	NV	1.84151E+01	YP	5.19482E-01	LP	1.73010E+01
NP	-2.35508E+01	YR	-1.45962E+01	LR	1.30910E+01	NR	-6.95799E+00	YDA	-2.61174E-01
LDA	1.45255E-01	NDA	2.49470E-01	YDR	-2.51445E-01	LDR	-2.90135E-01	NDR	2.25494E+00

NEWTON-RAPHSON STEP ERROR VECTOR

YV	4.10863E-05	LV	1.07051E-04	NV	9.84492E-05	YP	-6.45450E-06	LP	-1.30873E-04
NP	7.22784E-05	YR	2.39635E-04	LR	1.25350E-03	NR	6.93802E-05	YDA	2.54025E-04
LDA	2.71347E-04	NDA	9.30627E-04	YDR	1.68924E-04	LDR	-2.39763E-04	NDR	1.12248E-03

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.44930E-01	LV	-6.07631E-01	NV	-1.29145E-01	YP	-7.59977E-02	LP	-6.66666E-01
NP	-2.71676E-02	YR	-9.03134E-02	LR	-2.66123E-01	NR	-7.93949E-02	YDA	3.32445E+00
LDA	2.51182E+01	NDA	1.28041E+00	YDR	-5.96942E-01	LDR	-8.30226E+00	NDR	1.75461E-01

Figure 4.4 (page 3 of 13)

ERROR VECTOR

YV	6.29300E-02	LV	3.46733E-02	NV	1.45532E-02	YP	5.27324E-02	LP	-3.63338E-02
NP	2.16758E-03	YR	8.64213E-02	LR	1.96123E-01	NR	3.73949E-02	YDA	-2.37045E+00
LDA	8.94075E-01	NDA	2.66579E-01	YDR	7.00942E-01	LDR	5.10031E-01	NDR	-1.75461E-01

NORMALIZED PARAMETER ERROR VECTOR

YV	-7.67439E-01	LV	-6.05163E-02	NV	-1.27001E-01	YP	-2.26658E+00	LP	5.16640E-02
NP	-8.67030E-02	YR	-2.22044E+01	LR	-2.80175E+00	NR	-8.90355E-01	YDA	-2.48475E+00
LDA	3.43713E-02	NDA	1.72321E-01	YDR	6.73982E+00	LDR	-6.54538E-02	NDR	RRRRR

AVERAGE ERROR VErTOR

YV	6.29300E-02	LV	3.46733E-02	NV	1.45532E-02	YP	5.27324E-02	LP	-3.63338E-02
NP	2.16758E-03	YR	8.64213E-02	LR	1.96123E-01	NR	3.73949E-02	YDA	-2.37045E+00
LDA	8.94075E-01	NDA	2.66579E-01	YDR	7.00942E-01	LDR	5.10031E-01	NDR	-1.75461E-01

COVARIANCE MATRIX

	YV	LV	NV	YP	LP	NP	YR	LR	NR	YDA
YV	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LV	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NV	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
YP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
YR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
YDA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LDA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NDA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
YDR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LDR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NDR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	LDA	NDA	YDR	LDR	NDR
YV	0.	0.	0.	0.	0.
LV	0.	0.	0.	0.	0.
NV	0.	0.	0.	0.	0.
YP	0.	0.	0.	0.	0.
LP	0.	0.	0.	0.	0.
NP	0.	0.	0.	0.	0.
YR	0.	0.	0.	0.	0.
LR	0.	0.	0.	0.	0.
NR	0.	0.	0.	0.	0.
YDA	0.	0.	0.	0.	0.
LDA	0.	0.	0.	0.	0.
NDA	0.	0.	0.	0.	0.
YDR	0.	0.	0.	0.	0.
LDR	0.	0.	0.	0.	0.
NDR	0.	0.	0.	0.	0.

Figure 4.4 (page 4 of 13)

***** MONTE CARLO SAMPLE NO. 2 *****

NEWTON-RAPHSON ITERATION NO. 1 COST1= 1.37142E+01 COST2= 2.89676E+01 J = 2.81617E+05

NEWTON-RAPHSON GRADIENT VECTOR

YV	-4.47094E+05	LV	-1.20820E+05	NV	1.81158E+05	YP	-8.34164E+04	LP	4.56295E+04
NP	-1.46129E+05	YR	-8.16504E+04	LR	1.77822E+04	NR	-4.27469E+04	YDA	8.51421E+04
LDA	1.34015E+03	NDA	-5.10750E+03	YDR	-6.07844E+04	LDR	1.38692E+03	NDR	1.18393E+03

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-5.53358E-02	LV	-6.14765E-02	NV	-2.90217E-02	YP	-5.47808E-02	LP	1.11656E-02
NP	-2.54959E-02	YR	-5.33766E-02	LR	-9.08178E-02	NR	1.95596E-02	YDA	2.22862E+00
LDA	-8.81377E-01	NDA	2.67717E-01	YDR	-6.71261E-01	LDR	-5.23539E-01	NDR	-4.33751E-01

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.37336E-01	LV	-6.34434E-01	NV	-1.43613E-01	YP	-7.80460E-02	LP	-6.91834E-01
NP	-5.04959E-02	YR	-5.72687E-02	LR	-1.60818E-01	NR	-2.24404E-02	YDA	3.18262E+00
LDA	2.51309E+01	NDA	1.81470E+00	YDR	-5.67261E-01	LDR	-8.31576E+00	NDR	-4.33751E-01

NEWTON-RAPHSON ITERATION NO. 2 COST1= 3.00096E-01 COST2= 7.90063E-01 J = 1.82812E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	-8.99274E+04	LV	-2.06183E+04	NV	1.66397E+04	YP	5.79159E+04	LP	3.29493E+04
NP	-4.86984E+04	YR	-3.81955E+03	LR	1.06637E+04	NR	-1.28665E+04	YDA	2.59386E+02
LDA	6.90382E+02	NDA	-9.52549E+02	YDR	-9.68322E+02	LDR	-2.81602E+02	NDR	1.46494E+03

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-3.97558E-03	LV	5.56921E-04	NV	-6.38201E-06	YP	4.37539E-03	LP	1.46725E-04
NP	1.90917E-03	YR	-3.72434E-03	LR	4.82608E-02	NR	4.91160E-03	YDA	1.68087E-02
LDA	9.02552E-02	NDA	1.99876E-02	YDR	-1.07329E-02	LDR	7.48926E-02	NDR	1.48755E-02

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.41311E-01	LV	-6.33877E-01	NV	-1.43620E-01	YP	-7.36706E-02	LP	-6.91688E-01
NP	-4.85867E-02	YR	-6.09931E-02	LR	-1.12557E-01	NR	-1.75288E-02	YDA	3.19943E+00
LDA	2.52212E+01	NDA	1.83469E+00	YDR	-5.77994E-01	LDR	-8.24087E+00	NDR	-4.18875E-01

Figure 4.4 (page 5 of 13)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 9.92291E-02 COST2= 1.73620E-01 J = 1.72469E+04

NEWTON-RAPHSON GRAD[illegible] VECTOR

YV	8.155[illegible]E+02	LV	3.63533E+02	NV	-1.63421E+02	YP	3.53018E+02	LP	-5.33151E+02
NP	4.9[illegible]25E+02	YR	3.94075E+02	LR	-2.03090E+02	NR	1.36360E+02	YDA	2.77019E+01
LDA	-9.98951E+00	NDA	3.84527E+00	YDR	1.56144E+01	LDR	-2.00827E-02	NDR	-3.78783E+01

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-6.50392E-05	LV	-5.22308E-04	NV	-5.01779E-04	YP	-3.00118E-05	LP	5.65505E-06
NP	-7.87020E-04	YR	-1.17188E-04	LR	-2.61130E-03	NR	1.73936E-03	YDA	-5.28442E-04
LDA	-2.05946E-03	NDA	-7.25385E-03	YDR	-5.56572E-04	LDR	-2.12733E-03	NDR	-9.40650E-03

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.41376E-01	LV	-6.34400E-01	NV	-1.44121E-01	YP	-7.37006E-0[illegible]	LP	-6.91682E-01
NP	-4.93737E-02	YR	-6.11102E-02	LR	-1.15168E-01	NR	-1.57894E-02	YDA	3.19890E+00
LDA	2.52191E+01	NDA	1.82744E+00	YDR	-5.78551E-01	LDR	-8.24300E+00	NDR	-4.28282E-01

NEWTON-RAPHSON ITERATION NO. 4 COST1= 1.33081E-02 COST2= 3.29004E-02 J = 1.72465E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	5.52027E-01	LV	-1.33440E+01	NV	-1.57209E-01	YP	7.24720E-01	LP	9.92677E+00
NP	-1.11115E+01	YR	-1.63967E+00	LR	7.03876E+00	NR	-1.13349E+00	YDA	-1.25907E-01
LDA	1.02476E-01	NDA	2.07553E-01	YDR	-5.77334E-02	LDR	-2.16149E-01	NDR	1.80236E+00

NEWTON-RAPHSON STEP ERROR VECTOR

YV	2.84450E-05	LV	7.07901E-05	NV	7.48446E-05	YP	-2.00522E-05	LP	-1.73841E-04
NP	2.75710E-05	YR	2.60585E-04	LR	1.33001E-03	NR	2.10128E-04	YDA	2.20385E-04
LDA	8.21152E-04	NDA	3.96145E-04	YDR	1.28682E-04	LDR	4.91573E-04	NDR	5.41990E-04

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.41348E-01	LV	-6.34329E-01	NV	-1.44047E-01	YP	-7.37207E-02	LP	-6.91856E-01
NP	-4.93461E-02	YR	-6.08497E-02	LR	-1.13838E-01	NR	-1.55793E-02	YDA	3.19912E+00
LDA	2.52199E+01	NDA	1.82783E+00	YDR	-5.78422E-01	LDR	-8.24251E+00	NDR	-4.27740E-01

Figure 4.4 (page 6 of 13)

NEWTON-RAPHSON ITERATION NO. 5 COST1= 2.81299E-03 COST2= 5.13427E-03 J = 1.72465E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	-1.33803E+00	LV	8.14166E-01	NV	-9.42578E-01	YP	-7.52739E-02	LP	-1.53556E-01
NP	-1.02996E-01	YR	-7.49706E-02	LR	-3.30841E-01	NR	4.56155E-01	YDA	1.54447E-03
LDA	1.66247E-02	NDA	-1.55126E-01	YDR	1.29780E-02	LDR	2.48056E-02	NDR	-3.91121E-01

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-3.99677E-06	LV	-1.60433E-05	NV	-1.56440E-05	YP	4.79901E-07	LP	4.78451E-06
NP	-1.88704E-05	YR	-1.64110E-05	LR	-7.92368E-05	NR	4.38243E-05	YDA	-2.14310E-05
LDA	-7.20460E-05	NDA	-2.27999E-04	YDR	-1.89401E-05	LDR	-3.21496E-05	NDR	-2.68019E-04

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.41352E-01	LV	-6.34345E-01		-1.44062E-01	YP	-7.37202E-02	LP	-6.91851E-01
NP	-4.93650E-02	YR	-6.08661E-02		-1.13918E-01	NR	-1.55355E-02	YDA	3.19910E+00
LDA	2.52199E+01	NDA	1.82761E+00		-5.78441E-01	LDR	-8.24254E+00	NDR	-4.28008E-01

ERROR VECTOR

YV	5.93519E-02	LV	6.13871E-02	NV	2.94706E-02	YP	5.04550E-02	LP	-1.11489E-02
NP	2.43650E-02	YR	5.69740E-02	LR	4.39175E-02	NR	-2.64645E-02	YDA	-2.24510E+00
LDA	7.92432E-01	NDA	-2.80619E-01	YDR	6.82441E-01	LDR	4.50314E-01	NDR	4.28008E-01

NORMALIZED PARAMETER ERROR VECTOR

YV	-7.23804E-01	LV	-1.07141E-01	NV	-2.57180E-01	YP	-2.16869E+00	LP	1.58590E-02
NP	-9.74600E-01	YR	-1.46384E+01	LR	-6.27393E-01	NR	6.30108E-01	YDA	-2.35335E+00
LDA	3.04638E-02	NDA	-1.81398E-01	YDR	6.56193E+00	LDR	-5.77901E-02	NDR	RRRRR

AVERAGE ERROR VECTOR

YV	6.11410E-02	LV	4.80302E-02	NV	2.20119E-02	YP	5.15937E-02	LP	-2.37414E-02
NP	1.32663E-02	YR	7.16976E-02	LR	1.20020E-01	NR	5.46518E-03	YDA	-2.30778E+00
LDA	8.43253E-01	NDA	-7.02026E-03	YDR	6.91691E-01	LDR	4.80172E-01	NDR	1.26274E-01

Figure 4.4 (page 7 of 13)

COVARIANCE MATRIX

	YV	LV	NV	YP	LP	NP	YR	LR	NR	YDA
YV	3.201E-06	-2.390E-05	-1.334E-05	2.037E-06	-2.253E-05	-1.986E-05	2.634E-05	1.362E-04	5.712E-05	-1.121E-04
LV	-2.390E-05	1.784E-04	9.963E-05	-1.521E-05	1.682E-04	1.482E-04	-1.967E-04	-1.016E-03	-4.265E-04	8.372E-04
NV	-1.334E-05	9.963E-05	5.563E-05	-8.493E-06	9.392E-05	8.278E-05	-1.098E-04	-5.676E-04	-2.382E-04	4.675E-04
YP	2.037E-06	-1.521E-05	-8.493E-06	1.297E-06	-1.434E-05	-1.264E-05	1.677E-05	8.666E-05	3.636E-05	-7.137E-05
LP	-2.253E-05	1.682E-04	9.392E-05	-1.434E-05	1.586E-04	1.398E-04	-1.854E-04	-9.583E-04	-4.021E-04	7.893E-04
NP	-1.986E-05	1.482E-04	8.278E-05	-1.264E-05	1.398E-04	1.232E-04	-1.634E-04	-8.446E-04	-3.544E-04	6.956E-04
YR	2.634E-05	-1.967E-04	-1.098E-04	1.677E-05	-1.854E-04	-1.634E-04	2.168E-04	1.121E-03	4.701E-04	-9.228E-04
LR	1.362E-04	-1.016E-03	-5.676E-04	8.666E-05	-9.583E-04	-8.446E-04	1.121E-03	5.792E-03	2.430E-03	-4.770E-03
NR	5.712E-05	-4.265E-04	-2.382E-04	3.636E-05	-4.021E-04	-3.544E-04	4.701E-04	2.430E-03	1.020E-03	-2.001E-03
YDA	-1.121E-04	8.372E-04	4.675E-04	-7.137E-05	7.893E-04	6.956E-04	-9.228E-04	-4.770E-03	-2.001E-03	3.928E-03
LDA	9.092E-05	-6.788E-04	-3.791E-04	5.787E-05	-6.400E-04	-5.641E-04	7.483E-04	3.868E-03	1.623E-03	-3.185E-03
NDA	4.895E-04	-3.654E-03	-2.041E-03	3.116E-04	-3.445E-03	-3.037E-03	4.028E-03	2.082E-02	8.736E-03	-1.715E-02
YDR	1.655E-05	-1.236E-04	-6.899E-05	1.053E-05	-1.165E-04	-1.027E-04	1.362E-04	7.040E-04	2.954E-04	-5.798E-04
LDR	5.342E-05	-3.988E-04	-2.227E-04	3.400E-05	-3.760E-04	-3.314E-04	4.396E-04	2.272E-03	9.534E-04	-1.871E-03
NDR	-5.398E-04	4.030E-03	2.251E-03	-3.436E-04	3.800E-03	3.349E-03	-4.443E-03	-2.296E-02	-9.634E-03	1.891E-02

	LDA	NDA	YDR	LDR	NDR
YV	9.092E-05	4.895E-04	1.655E-05	5.342E-05	-5.398E-04
LV	-6.788E-04	-3.654E-03	-1.236E-04	-3.988E-04	4.030E-03
NV	-3.791E-04	-2.041E-03	-6.899E-05	-2.227E-04	2.251E-03
YP	5.787E-05	3.116E-04	1.053E-05	3.400E-05	-3.436E-04
LP	-6.400E-04	-3.445E-03	-1.165E-04	-3.760E-04	3.800E-03
NP	-5.641E-04	-3.037E-03	-1.027E-04	-3.314E-04	3.349E-03
YR	7.483E-04	4.028E-03	1.362E-04	4.396E-04	-4.443E-03
LR	3.868E-03	2.082E-02	7.040E-04	2.272E-03	-2.296E-02
NR	1.623E-03	8.736E-03	2.954E-04	9.534E-04	-9.634E-03
YDA	-3.185E-03	-1.715E-02	-5.798E-04	-1.871E-03	1.891E-02
LDA	2.583E-03	1.390E-02	4.701E-04	1.517E-03	-1.533E-02
NDA	1.390E-02	7.486E-02	2.531E-03	8.169E-03	-8.255E-02
YDR	4.701E-04	2.531E-03	8.557E-05	2.762E-04	-2.791E-03
LDR	1.517E-03	8.169E-03	2.762E-04	8.915E-04	-9.009E-03
NDR	-1.533E-02	-8.255E-02	-2.791E-03	-9.009E-03	9.104E-02

Figure 4.4 (page 8 of 13)

***** MONTE CARLO SAMPLE NO. 3 *****

NEWTON-RAPHSON ITERATION NO. 1 COST1= 1.26915E+01 COST2= 2.56244E+01 J = 2.45438E+05

NEWTON-RAPHSON GRADIENT VECTOR

YV	-4.06745E+05	LV	-8.85427E+04	NV	1.15696E+05	YP	-8.60011E+04	LP	4.07610E+04
NP	-1.13497E+05	YR	-7.52139E+04	LR	1.49366E+04	NR	-2.66426E+04	YDA	7.87072E+04
LDA	1.10732E+03	NDA	-5.02912E+03	YDR	-5.57700E+04	LDR	4.03757E+02	NDR	4.38099E+03

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-4.78276E-02	LV	-2.38020E-02	NV	-1.20571E-02	YP	-5.00109E-02	LP	1.40369E-02
NP	2.03853E-03	YR	-4.93964E-02	LR	-5.93732E-02	NR	-2.52379E-02	YDA	2.04351E+00
LDA	-8.72461E-01	NDA	-5.19121E-01	YDR	-6.17309E-01	LDR	-4.35034E-01	NDR	1.39370E-01

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.29828E-01	LV	-5.96760E-01	NV	-1.26649E-01	YP	-7.32761E-02	LP	-6.88963E-01
NP	-2.29615E-02	YR	-5.32884E-02	LR	-1.29373E-01	NR	-6.72379E-02	YDA	2.99751E+00
LDA	2.51398E+01	NDA	1.02787E+00	YDR	-5.13309E-01	LDR	-8.22726E+00	NDR	1.39370E-01

NEWTON-RAPHSON ITERATION NO. 2 COST1= 1.44565E-01 COST2= 3.77678E-01 J = 1.99611E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	-4.28656E+04	LV	-7.69242E+03	NV	5.94041E+03	YP	2.61582E+04	LP	1.11979E+04
NP	-1.74155E+04	YR	-2.65396E+03	LR	4.03725E+03	NR	-4.16549E+03	YDA	9.05269E+01
LDA	2.36903E+02	NDA	-3.34129E+02	YDR	-4.09578E+02	LDR	-5.64957E+01	NDR	5.44993E+02

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-2.05348E-03	LV	-2.54066E-04	NV	-3.10619E-04	YP	2.08223E-03	LP	-9.98570E-04
NP	7.48212E-04	YR	-3.20046E-03	LR	1.87028E-02	NR	2.75222E-03	YDA	3.54062E-03
LDA	1.86017E-02	NDA	-1.70920E-03	YDR	-6.63713E-03	LDR	1.56415E-02	NDR	-4.53782E-03

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.31881E-01	LV	-5.97014E-01	NV	-1.26959E-01	YP	-7.11939E-02	LP	-6.89962E-01
NP	-2.22133E-02	YR	-5.64889E-02	LR	-1.10670E-01	NR	-6.44857E-02	YDA	3.00105E+00
LDA	2.51584E+01	NDA	1.02616E+00	YDR	-5.19946E-01	LDR	-8.21162E+00	NDR	1.34832E-01

Figure 4.4 (page 9 of 13)

NEWTON-RAPHSON ITERATION NO. 3 COST1= 2.56479E-02 COST2= 6.11035E-02 J = 1.97656E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	6.69923E+01	LV	5.98375E+01	NV	-3.90656E+01	YP	1.33478E+02	LP	-7.11529E+01
NP	2.61778E+01	YR	8.12133E+01	LR	-3.33507E+01	NR	2.93196E+01	YDA	2.32335E+00
LDA	-1.39697E+00	NDA	-2.29370E-01	YDR	2.95397E+00	LDR	-8.67057E-01	NDR	-3.46530E+00

NEWTON-RAPHSON STEP ERROR VECTOR

YV	-2.43569E-05	LV	-1.39284E-04	NV	-1.26517E-04	YP	-8.44393E-06	LP	-3.80834E-05
NP	-2.92804E-04	YR	-4.35191E-05	LR	-6.14691E-04	NR	7.19177E-04	YDA	-2.82283E-04
LDA	-5.65286E-04	NDA	-2.66489E-03	YDR	-2.49956E-04	LDR	-1.18339E-04	NDR	-3.45817E-03

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.31905E-01	LV	-5.97153E-01	NV	-1.27086E-01	YP	-7.12024E-02	LP	-6.90000E-01
NP	-2.25061E-02	YR	-5.65324E-02	LR	-1.11285E-01	NR	-6.37665E-02	YDA	3.00077E+00
LDA	2.51579E+01	NDA	1.02349E+00	YDR	-5.20196E-01	LDR	-8.21174E+00	NDR	1.31374E-01

NEWTON-RAPHSON ITERATION NO. 4 COST1= 2.66261E-03 COST2= 6.06836E-03 J = 1.97656E+04

NEWTON-RAPHSON GRADIENT VECTOR

YV	1.90435E+00	LV	-5.26357E+00	NV	3.20290E+00	YP	2.07966E-01	LP	2.37062E+00
NP	-3.34113E+00	YR	-1.92718E+00	LR	2.15882E+00	NR	-6.27481E-01	YDA	-1.85033E-02
LDA	7.98809E-03	NDA	4.27332E-02	YDR	-2.64142E-02	LDR	-5.56152E-03	NDR	2.87656E-01

NEWTON-RAPHSON STEP ERROR VECTOR

YV	7.53461E-06	LV	1.95475E-05	NV	1.83970E-05	YP	-1.77659E-06	LP	-3.05031E-05
NP	8.52420E-06	YR	5.37153E-05	LR	2.96309E-04	NR	4.16611E-05	YDA	5.75146E-05
LDA	1.39420E-04	NDA	1.18419E-04	YDR	3.28609E-05	LDR	3.19535E-05	NDR	1.19845E-04

PARAMETER ESTIMATE VECTOR (K+1)

YV	-1.31898E-01	LV	-5.97134E-01	NV	-1.27067E-01	YP	-7.12041E-02	LP	-6.90030E-01
NP	-2.24975E-02	YR	-5.64787E-02	LR	-1.10989E-01	NR	-6.37248E-02	YDA	3.00082E+00
LDA	2.51580E+01	NDA	1.02361E+00	YDR	-5.20163E-01	LDR	-8.21170E+00	NDR	[illegible].31494E-01

Figure 4.4 (page 10 of 13)

ERROR VECTOR

YV	4.98979E-02	LV	2.41758E-02	NV	1.24759E-02	YP	4.79389E-02	LP	-1.29697E-02
NP	-2.50246E-03	YR	5.25866E-02	LR	4.09687E-02	NR	2.17248E-02	YDA	-2.04682E+00
LDA	8.54285E-01	NDA	5.23377E-01	YDR	6.24163E-01	LDR	4.19479E-01	NDR	-1.31494E-01

NORMALIZED PARAMETER ERROR VECTOR

YV	-6.08511E-01	LV	-4.21947E-02	NV	-1.08872E-01	YP	-2.06054E+00	LP	1.84491E-02
NP	1.00099E-01	YR	-1.35112E+01	LR	-5.85554E-01	NR	-5.17258E-01	YDA	-2.14552E+00
LDA	3.28416E-02	NDA	3.38320E-01	YDR	6.00157E+00	LDR	-5.38330E-02	NDR	RRRRR

AVERAGE ERROR VECTOR

YV	5.73933E-02	LV	4.00787E-02	NV	1.88332E-02	YP	5.03754E-02	LP	-2.01508E-02
NP	8.01004E-03	YR	6.53273E-02	LR	9.36764E-02	NR	1.08851E-02	YDA	-2.22079E+00
LDA	8.46931E-01	NDA	1.69779E-01	YDR	6.69182E-01	LDR	4.59941E-01	NDR	4.03512E-02

COVARIANCE MATRIX

	YV	LV	NV	YP	LP	NP	YR	LR	NR	YDA
YV	3.022E-05	4.367E-05	1.493E-05	1.049E-05	-4.193E-05	2.616E-05	6.531E-05	2.882E-04	-2.542E-06	-7.267E-04
LV	4.367E-05	2.454E-04	1.170E-04	9.234E-06	5.503E-05	1.824E-04	-2.980E-05	-2.587E-04	-3.705E-04	-8.252E-04
NV	1.493E-05	1.170E-04	5.730E-05	2.083E-06	3.979E-05	8.860E-05	-3.271E-05	-2.109E-04	-1.932E-04	-2.413E-04
YP	1.049E-05	9.234E-06	2.083E-06	3.833E-06	-1.831E-05	4.381E-06	2.670E-05	1.220E-04	1.103E-05	-2.595E-04
LP	-4.193E-05	5.503E-05	3.979E-05	-1.831E-05	1.315E-04	5.543E-05	-1.694E-04	-8.281E-04	-2.291E-04	1.151E-03
NP	2.616E-05	1.824E-04	8.860E-05	4.381E-06	5.543E-05	1.374E-04	-4.197E-05	-2.862E-04	-2.932E-04	-4.507E-04
YR	6.531E-05	-2.980E-05	-3.271E-05	2.670E-05	-1.694E-04	-4.197E-05	2.257E-04	1.083E-03	2.444E-04	-1.723E-03
LR	2.882E-04	-2.587E-04	-2.109E-04	1.220E-04	-8.281E-04	-2.862E-04	1.083E-03	5.249E-03	1.334E-03	-7.763E-03
NR	-2.542E-06	-3.705E-04	-1.932E-04	1.103E-05	-2.291E-04	-2.932E-04	2.444E-04	1.334E-03	7.384E-04	-3.913E-04
YDA	-7.267E-04	-8.252E-04	-2.413E-04	-2.595E-04	1.151E-03	-4.507E-04	-1.723E-03	-7.763E-03	-3.913E-04	1.775E-02
LDA	3.305E-05	-5.110E-04	-2.761E-04	2.962E-05	-4.002E-04	-4.147E-04	4.520E-04	2.385E-03	1.122E-03	-1.484E-03
NDA	-9.989E-04	-5.248E-03	-2.484E-03	-2.231E-04	-1.027E-03	-3.883E-03	4.330E-04	4.566E-03	7.740E-03	1.933E-02
YDR	1.797E-04	2.756E-04	9.710E-05	6.187E-05	-2.393E-04	1.682E-04	3.776E-04	1.655E-03	-4.709E-05	-4.302E-03
LDR	1.873E-04	5.586E-05	-1.985E-05	7.196E-05	-3.959E-04	-8.246E-06	5.508E-04	2.581E-03	4.163E-04	-4.767E-03
NDR	2.841E-04	4.053E-03	2.047E-03	-1.971E-05	1.916E-03	3.136E-03	-1.867E-03	-1.078E-02	-7.354E-03	-2.340E-03

	LDA	NDA	YDR	LDR	NDR
YV	3.305E-05	-9.989E-04	1.797E-04	1.873E-04	2.841E-04
LV	-5.110E-04	-5.248E-03	2.756E-04	5.586E-05	4.053E-03
NV	-2.761E-04	-2.484E-03	9.710E-05	-1.985E-05	2.047E-03
YP	2.962E-05	-2.231E-04	6.187E-05	7.196E-05	-1.971E-05
LP	-4.002E-04	-1.027E-03	-2.393E-04	-3.959E-04	1.916E-03
NP	-4.147E-04	-3.883E-03	1.682E-04	-8.246E-06	3.136E-03
YR	4.520E-04	4.330E-04	3.776E-04	5.508E-04	-1.867E-03
LR	2.385E-03	4.566E-03	1.655E-03	2.581E-03	-1.078E-02
NR	1.122E-03	7.740E-03	-4.709E-05	4.163E-04	-7.354E-03
YDA	-1.484E-03	1.933E-02	-4.302E-03	-4.767E-03	-2.340E-03
LDA	1.749E-03	1.057E-02	1.479E-04	8.628E-04	-1.085E-02
NDA	1.057E-02	1.124E-01	-6.272E-03	-1.708E-03	-8.542E-02
YDR	1.479E-04	-6.272E-03	1.070E-03	1.095E-03	2.007E-03
LDR	8.628E-04	-1.708E-03	1.095E-03	1.413E-03	-2.530E-03
NDR	-1.085E-02	-8.542E-02	2.007E-03	-2.530E-03	7.546E-02

Figure 4.4 (page 11 of 13)

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SUMMARY OF ERROR STATISTICS AFTER 3 SAMPLES

AVERAGE ERROR VECTOR

YV	5.73933E-02	LV	4.00787E-02	NV	1.88332E-02	YP	5.03754E-02	LP	-2.01508E-02
NP	8.01004E-03	YR	6.53273E-02	LR	9.36764E-02	NR	1.08851E-02	YDA	-2.22079E+00
LDA	8.46931E-01	NDA	1.69779E-01	YDR	6.69182E-01	LDR	4.59941E-01	NDR	4.03512E-02

COVARIANCE MATRIX

	YV	LV	NV	YP	LP	NP	YR	LR	NR	YDA
YV	3.022E-05	4.367E-05	1.493E-05	1.049E-05	-4.193E-05	2.616E-05	6.531E-05	2.882E-04	-2.542E-06	-7.267E-04
LV	4.367E-05	2.454E-04	1.170E-04	9.234E-06	5.503E-05	1.824E-04	-2.980E-05	-2.587E-04	-3.705E-04	-8.252E-04
NV	1.493E-05	1.170E-04	5.730E-05	2.083E-06	3.979E-05	8.860E-05	-3.271E-05	-2.109E-04	-1.932E-04	-2.413E-04
YP	1.049E-05	9.234E-06	2.083E-06	3.833E-06	-1.831E-05	4.381E-06	2.670E-05	1.220E-04	1.103E-05	-2.595E-04
LP	-4.193E-05	5.503E-05	3.979E-05	-1.831E-05	1.315E-04	5.543E-05	-1.694E-04	-8.281E-04	-2.291E-04	1.151E-03
NP	2.616E-05	1.824E-04	8.860E-05	4.381E-06	5.543E-05	1.374E-04	-4.197E-05	-2.862E-04	-2.932E-04	-4.507E-04
YR	6.531E-05	-2.980E-05	-3.271E-05	2.670E-05	-1.694E-04	-4.197E-05	2.257E-04	1.083E-03	2.444E-04	-1.723E-03
LR	2.882E-04	-2.587E-04	-2.109E-04	1.220E-04	-8.281E-04	-2.862E-04	1.083E-03	5.249E-03	1.334E-03	-7.763E-03
NR	-2.542E-06	-3.705E-04	-1.932E-04	1.103E-05	-2.291E-04	-2.932E-04	2.444E-04	1.334E-03	7.384E-04	-3.913E-04
YDA	-7.267E-04	-8.252E-04	-2.413E-04	-2.595E-04	1.151E-03	-4.507E-04	-1.723E-03	-7.763E-03	-3.913E-04	1.775E-02
LDA	3.305E-05	-5.110E-04	-2.761E-04	2.962E-05	-4.002E-04	-4.147E-04	4.520E-04	2.385E-03	1.122E-03	-1.484E-03
NDA	-9.989E-04	-5.248E-03	-2.484E-03	-2.231E-04	-1.027E-03	-3.883E-03	4.330E-04	4.566E-03	7.740E-03	1.933E-02
YDR	1.797E-04	2.756E-04	9.710E-05	6.187E-05	-2.393E-04	1.682E-04	3.776E-04	1.655E-03	-4.709E-05	-4.302E-03
LDR	1.873E-04	5.586E-05	-1.985E-05	7.196E-05	-3.959E-04	-8.246E-06	5.508E-04	2.581E-03	4.163E-04	-4.767E-03
NDR	2.841E-04	4.053E-03	2.047E-03	-1.971E-05	1.916E-03	3.136E-03	-1.867E-03	-1.078E-02	-7.354E-03	-2.340E-03

	LDA	NDA	YDR	LDR	NDR
YV	3.305E-05	-9.989E-04	1.797E-04	1.873E-04	2.841E-04
LV	-5.110E-04	-5.248E-03	2.756E-04	5.586E-05	4.053E-03
NV	-2.761E-04	-2.484E-03	9.710E-05	-1.985E-05	2.047E-03
YP	2.962E-05	-2.231E-04	6.187E-05	7.196E-05	-1.971E-05
LP	-4.002E-04	-1.027E-03	-2.393E-04	-3.959E-04	1.916E-03
NP	-4.147E-04	-3.883E-03	1.682E-04	-8.246E-06	3.136E-03
YR	4.520E-04	4.330E-04	3.776E-04	5.508E-04	-1.867E-03
LR	2.385E-03	4.566E-03	1.655E-03	2.581E-03	-1.078E-02
NR	1.122E-03	7.740E-03	-4.709E-05	4.163E-04	-7.354E-03
YDA	-1.484E-03	1.933E-02	-4.302E-03	-4.767E-03	-2.340E-03
LDA	1.749E-03	1.057E-02	1.479E-04	8.628E-04	-1.085E-02
NDA	1.057E-02	1.124E-01	-6.272E-03	-1.708E-03	-8.542E-02
YDR	1.479E-04	-6.272E-03	1.070E-03	1.095E-03	2.007E-03
LDR	8.628E-04	-1.708E-03	1.095E-03	1.413E-03	-2.530E-03
NDR	-1.085E-02	-8.542E-02	2.007E-03	-2.530E-03	7.546E-02

Figure 4.4 (page 12 of 13)

NORMALIZED COVARIANCE MATRIX

	YV	LV	NV	YP	LP	NP	YR	LR	NR	YDA
YV	5.495E-03	5.071E-01	3.588E-01	9.746E-01	-6.651E-01	4.060E-01	7.908E-01	7.236E-01	-1.701E-02	-9.922E-01
LV	5.071E-01	1.566E-02	9.864E-01	3.011E-01	3.064E-01	9.935E-01	-1.266E-01	-2.280E-01	-8.704E-01	-3.954E-01
NV	3.588E-01	9.864E-01	7.569E-03	1.405E-01	4.584E-01	9.987E-01	-2.877E-01	-3.846E-01	-9.394E-01	-2.393E-01
YP	9.746E-01	3.011E-01	1.405E-01	1.958E-03	-8.155E-01	1.909E-01	9.078E-01	8.598E-01	2.074E-01	-9.949E-01
LP	-6.651E-01	3.064E-01	4.584E-01	-8.155E-01	1.147E-02	4.124E-01	-9.830E-01	-9.967E-01	-7.353E-01	7.532E-01
NP	4.060E-01	9.935E-01	9.987E-01	1.909E-01	4.124E-01	1.172E-02	-2.384E-01	-3.370E-01	-9.207E-01	-2.886E-01
YR	7.908E-01	-1.266E-01	-2.877E-01	9.078E-01	-9.830E-01	-2.384E-01	1.502E-02	9.947E-01	5.986E-01	-8.611E-01
LR	7.236E-01	-2.280E-01	-3.846E-01	8.598E-01	-9.967E-01	-3.370E-01	9.947E-01	7.245E-02	6.778E-01	-8.042E-01
NR	-1.701E-02	-8.704E-01	-9.394E-01	2.074E-01	-7.353E-01	-9.207E-01	5.986E-01	6.778E-01	2.717E-02	-1.081E-01
YDA	-9.922E-01	-3.954E-01	-2.393E-01	-9.949E-01	7.532E-01	-2.886E-01	-8.611E-01	-8.042E-01	-1.081E-01	1.332E-01
LDA	1.438E-01	-7.801E-01	-8.722E-01	3.618E-01	-8.346E-01	-8.460E-01	7.194E-01	7.871E-01	9.870E-01	-2.663E-01
NDA	-5.419E-01	-9.992E-01	-9.789E-01	-3.398E-01	-2.672E-01	-9.881E-01	8.597E-02	1.880E-01	8.496E-01	4.326E-01
YDR	9.994E-01	5.377E-01	3.921E-01	9.659E-01	-6.378E-01	4.386E-01	7.682E-01	6.983E-01	-5.297E-02	-9.870E-01
LDR	9.061E-01	9.486E-02	-6.977E-02	9.779E-01	-9.186E-01	-1.872E-02	9.755E-01	9.477E-01	4.075E-01	-9.519E-01
NDR	1.881E-01	9.419E-01	9.843E-01	-3.665E-02	6.083E-01	9.739E-01	-4.524E-01	-5.417E-01	-9.852E-01	-6.393E-02

	LDA	NDA	YDR	LDR	NDR
YV	1.438E-01	-5.419E-01	9.994E-01	9.061E-01	1.881E-01
LV	-7.801E-01	-9.992E-01	5.377E-01	9.486E-02	9.419E-01
NV	-8.722E-01	-9.789E-01	3.921E-01	-6.977E-02	9.843E-01
YP	3.618E-01	-3.398E-01	9.659E-01	9.779E-01	-3.665E-02
LP	-8.346E-01	-2.672E-01	-6.378E-01	-9.186E-01	6.083E-01
NP	-8.460E-01	-9.881E-01	4.386E-01	-1.872E-02	9.739E-01
YR	7.194E-01	8.597E-02	7.682E-01	9.755E-01	-4.524E-01
LR	7.871E-01	1.880E-01	6.983E-01	9.477E-01	-5.417E-01
NR	9.870E-01	8.496E-01	-5.297E-02	4.075E-01	-9.852E-01
YDA	-2.663E-01	4.326E-01	-9.870E-01	-9.519E-01	-6.393E-02
LDA	4.182E-02	7.538E-01	1.081E-01	5.489E-01	-9.449E-01
NDA	7.538E-01	3.353E-01	-5.718E-01	-1.355E-01	-9.274E-01
YDR	1.081E-01	-5.718E-01	3.272E-02	8.903E-01	2.234E-01
LDR	5.489E-01	-1.355E-01	8.903E-01	3.759E-02	-2.450E-01
NDR	-9.449E-01	-9.274E-01	2.234E-01	-2.450E-01	2.747E-01

ERROR SUMMARY

ERROR	TIMES
10049	10001

Figure 4.4 (page 13 of 13)

5.0 PROGRAM FUNCTIONAL ORGANIZATION

Flow charts of the Ensemble Error Analysis and Simulated Data Analysis Programs are shown in Figures 5.1 and 5.2, respectively. The subroutine calling structures are shown in Figures 5.3 and 5.4.

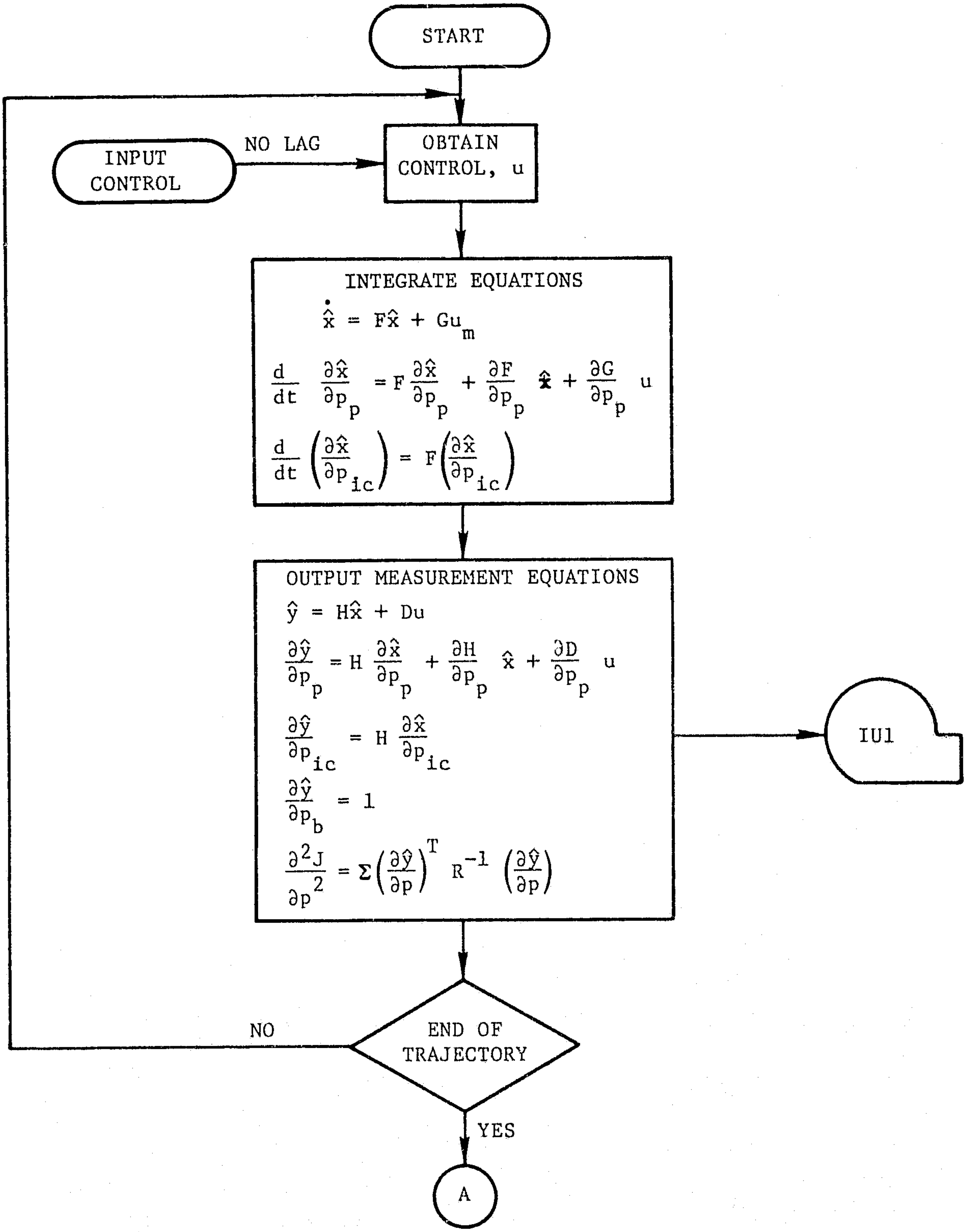

Figure 5.1 Flow Chart of Ensemble Error Analysis Programs (page 1 of 3)

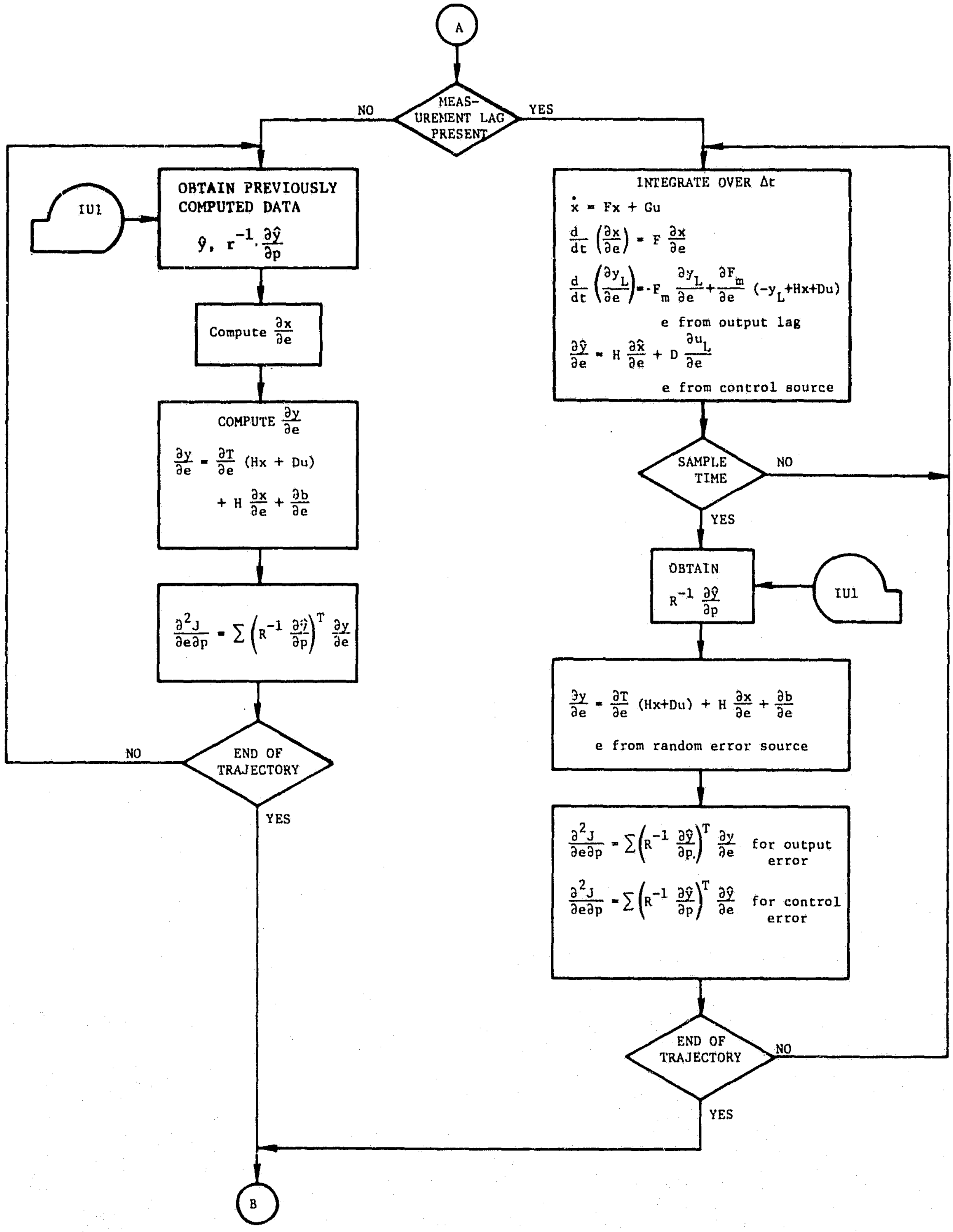

Figure 5.1 (page 2 of 3)

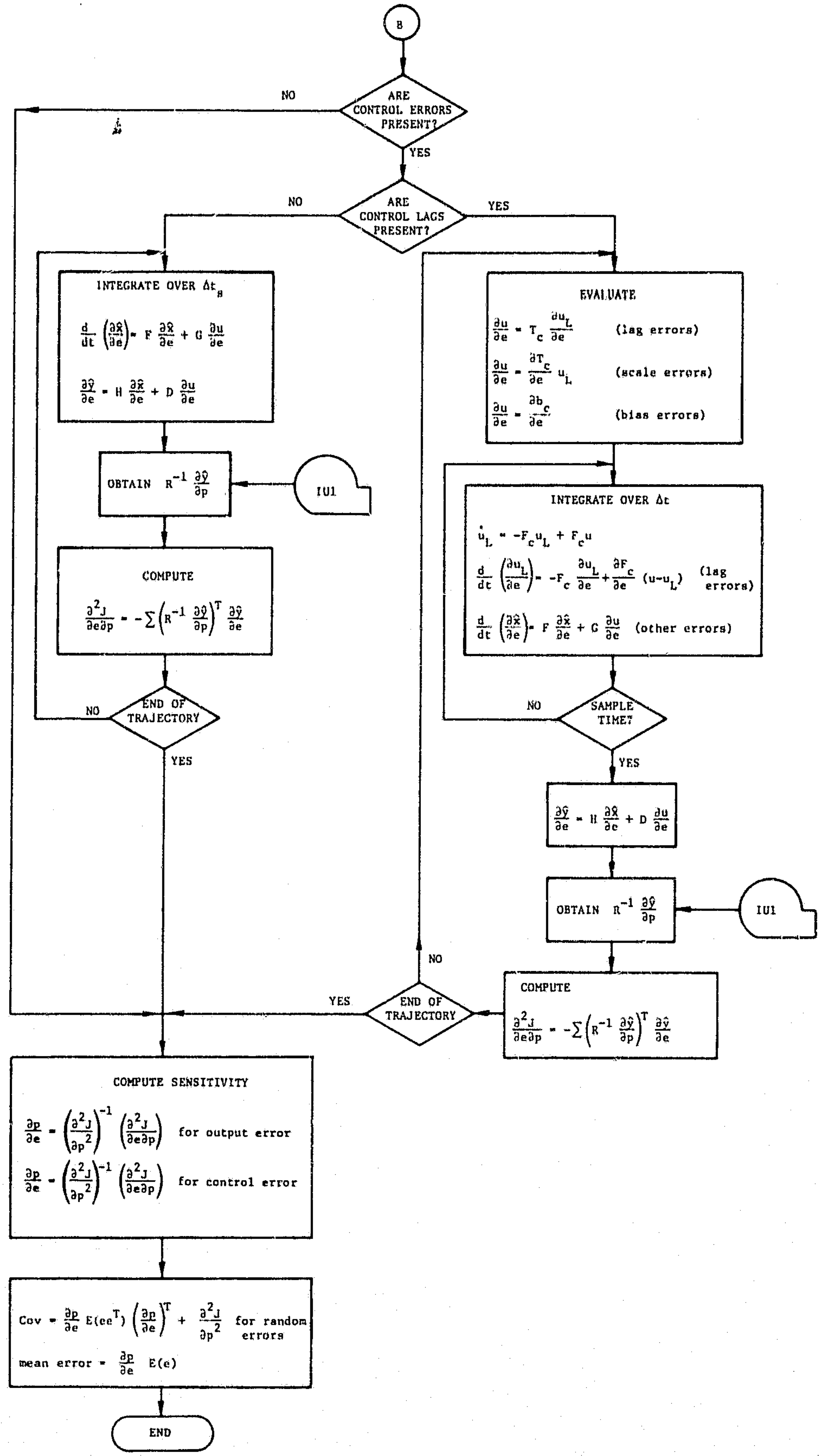

Figure 5.1 (page 3 of 3)

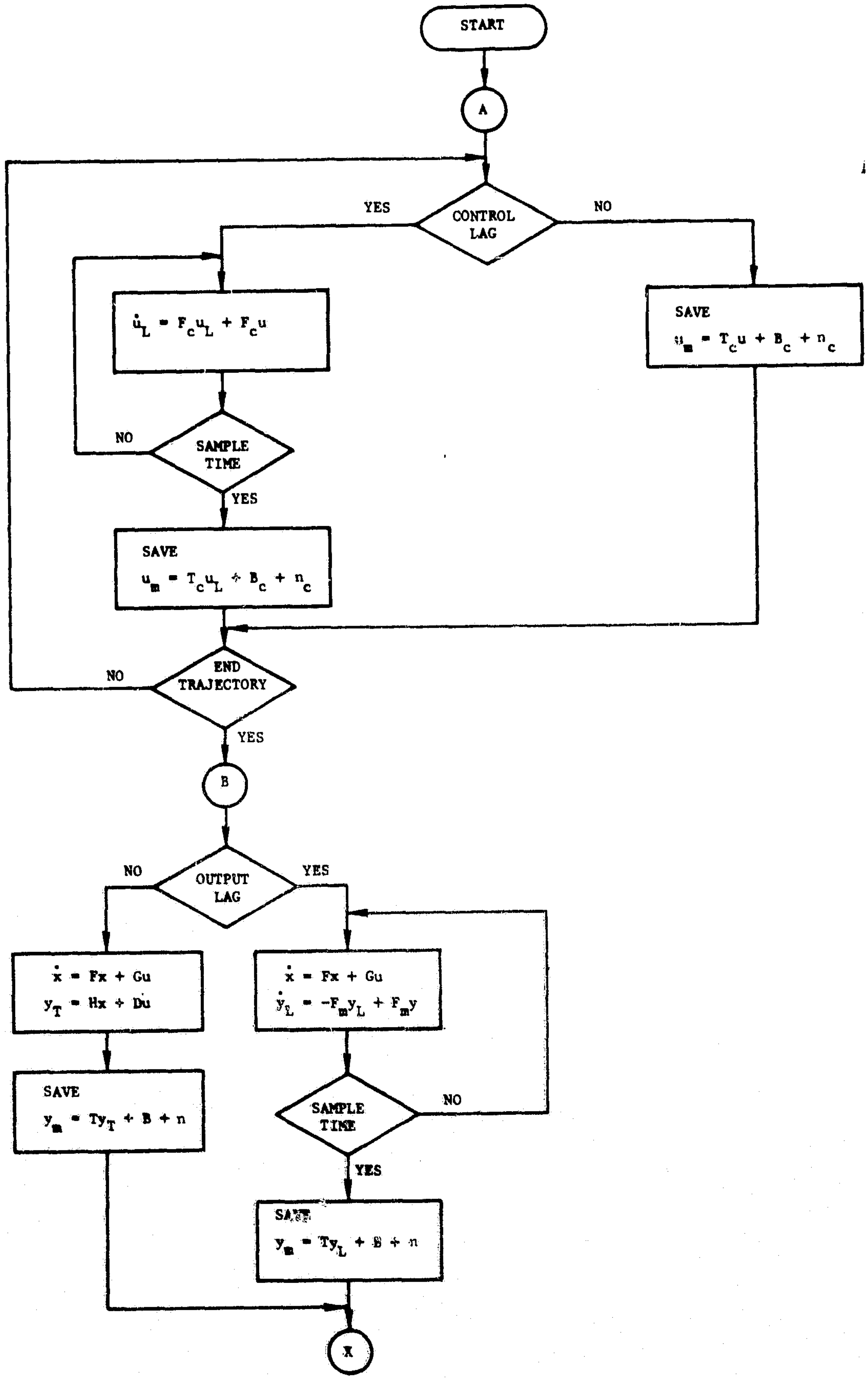

Figure 5.2 Flow Chart of Simulated Data Analysis Programs (page 1 of 3)

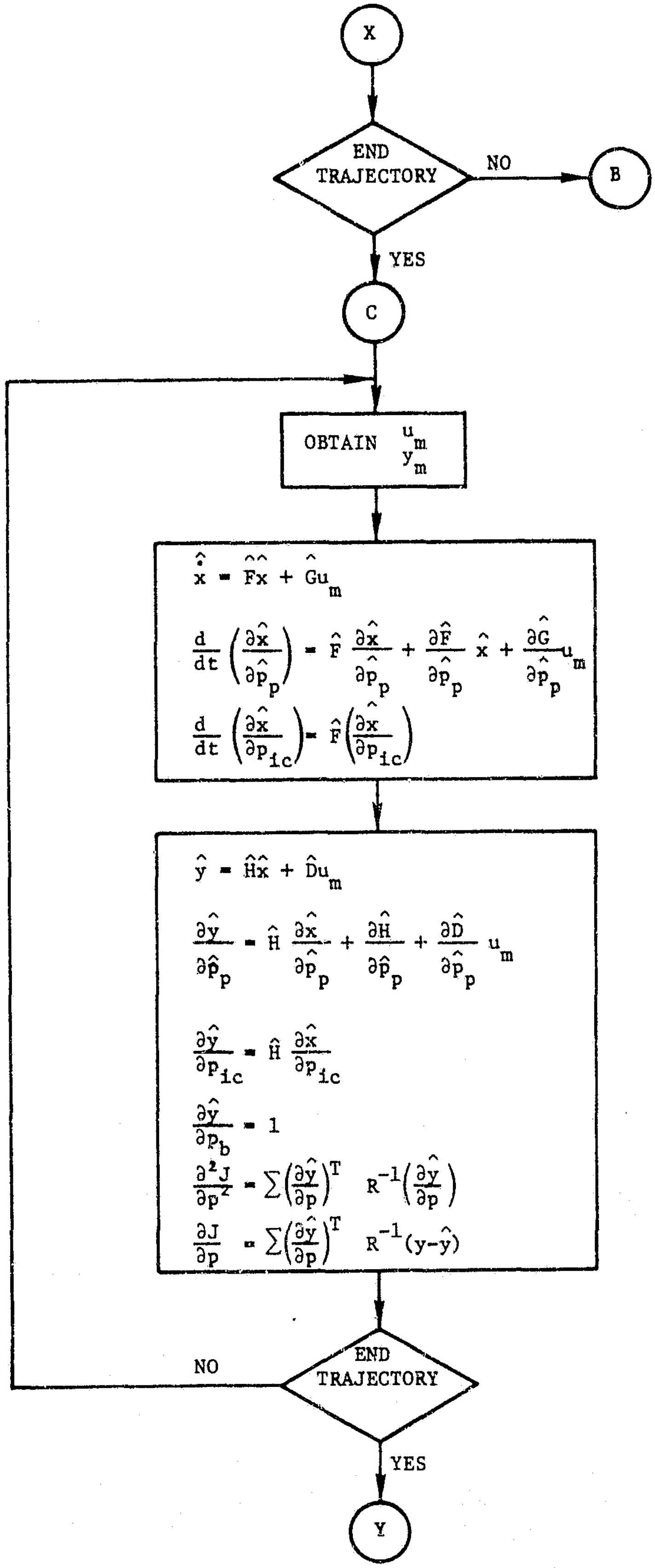

Figure 5.2 (page 2 of 3)

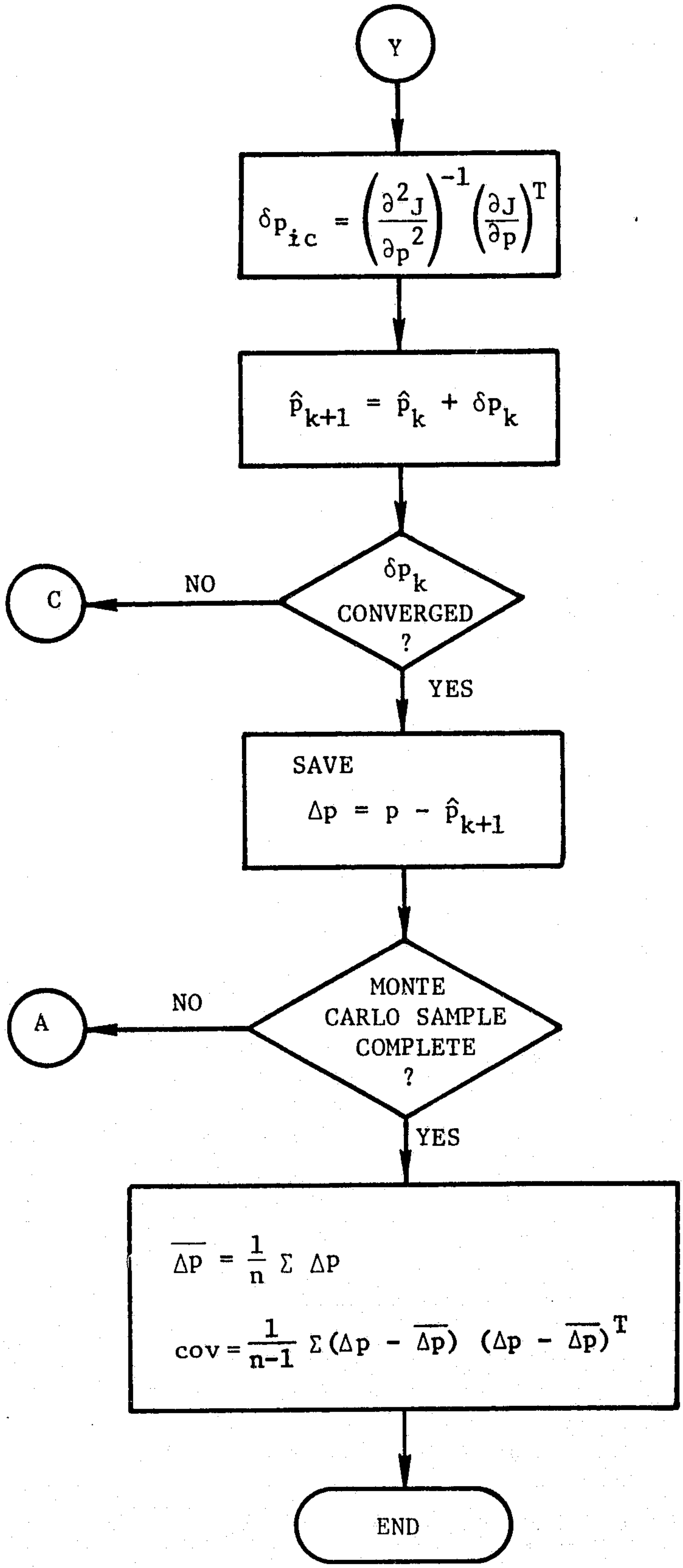

Figure 5.2 (page 3 of 3)

C-2

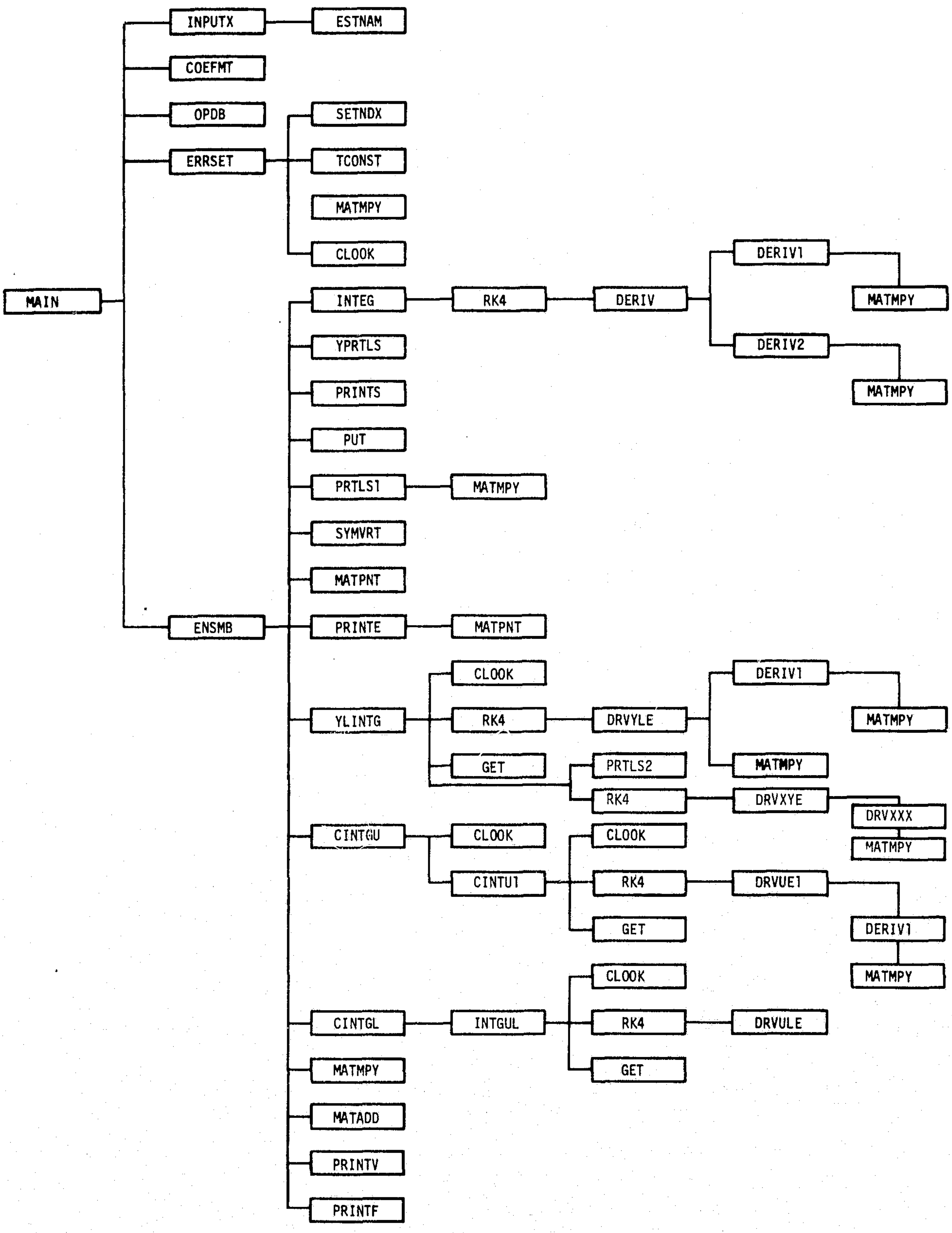

Figure 5.3 Subroutine Calling Structure of Ensemble Error Analysis Programs

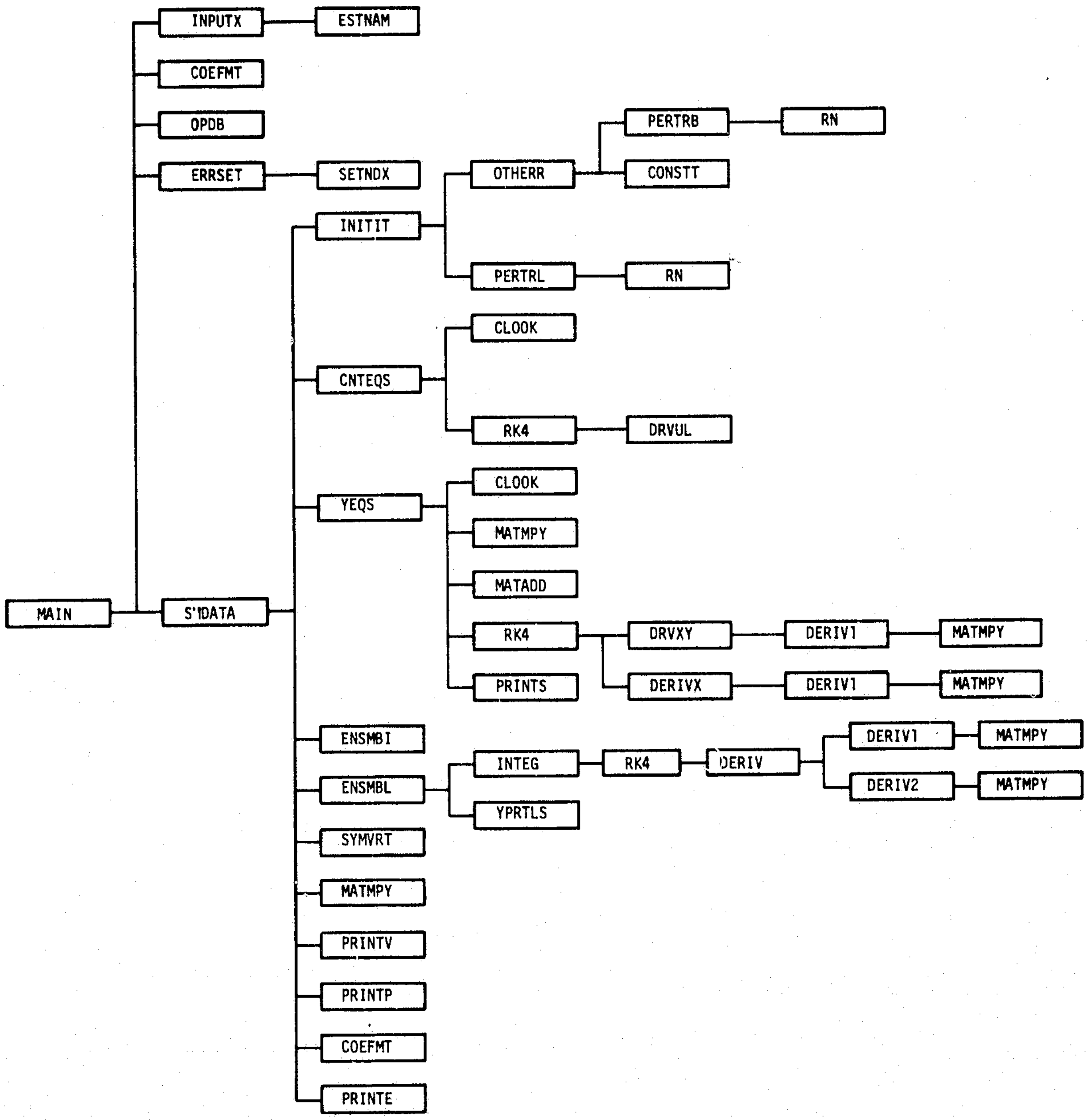

Figure 5.4 Subroutine Calling Structure of Simulated Data Analysis Programs

6.0 SUBPROGRAMS DESCRIPTIONS

The subroutines in the SCIP2 Programs are described in this section. First to be discussed are subroutines shared by the Ensemble Error Analysis and Simulated Data Analysis Programs, and then follow sections discussing subroutines unique to each of these programs.

6.1 Subroutines Common to Ensemble and Simulated Data Programs

BLØCK DATA

The BLØCK DATA subroutine is used to initialize variables in labeled commons at load time (see Table 3.2). This subroutine also includes all the labeled commons for the entire program for the storage allocation purpose (CDC-6600).

SUBRØUTINE CLØØK

This subroutine performs a table look-up in the arrays DLTA, DLU1, and DLU2 to find the "pilot's" control input at a specified time in the trajectory.

Calling sequence - CALL CLØØK (TM,IP)

where TM is the specified time,

IP is the index value in array DLTA which was found in the last previous call to CLØØK. (In the VTØL Ensemble Program, IP does not appear in the calling list.)

SUBRØUTINE CØEFMT

This subroutine evaluates the F, G, H, and D matrices from the parameter values passed to it through CØMMØN/PARAM/. On its initial call it performs unit conversions. In the VTØL programs where the feedback gains matrix C is present, the computed matrices are (F-GC), (H-DC), G, and D.

Calling sequence - CALL CØEFMT (FF,GG,H,D,IFL)

where FF is the computed F or F-GC matrix,

GG is the computed G matrix,

H is the computed H or H-DC matrix,

D is the computed D matrix,

IFL is a flag which, if set to zero, causes initializing and unit-conversion calculations to be performed. (IFL does not appear in the Ensemble Programs.)

DERIV

This subroutine computes the time derivatives of the state vector and the partial derivatives of the state vector with respect to parameters. It computes:

$$\frac{d}{dt}(x) = Fx + Du$$

by calling DERIV1, and

$$\frac{d}{dt}\left(\frac{\partial x}{\partial p}\right) = F\frac{\partial x}{\partial p} + \frac{\partial F}{\partial p}x + \frac{\partial G}{\partial p}u ,$$

by calling DERIV2.

Calling sequence - CALL DERIV (XMAT,T,DX,K,L,M)

where XMAT is the M x L matrix of the function

T is the integration variable, time

DX is the derivative being computed

K is not used

L is the number of columns in XMAT and DX

M is the number of rows in XMAT and DX

DERIV1

This subroutine computes the time derivative of the state vector, $\hat{x}$:

$$\frac{d}{dt}(\hat{x}) = F\hat{x} + Gu_m .$$

Calling Sequence - CALL DERIV1(F,X,G,U,L,M,N,DXDT)

where F is the matrix F

X is the state vector $\hat{x}$

G is the matrix G

U is the control vector u_m

L, M, and N are used to specify sub-matrix of F and G which are used; i.e., L x M sub-matrix of F and L x N sub-matrix of G.

DXDT is the time derivative of state vector $\hat{x}$, $\frac{d}{dt}(\hat{x})$.

DERIV2

This subroutine computes the time derivatives of the partial derivatives of the state vector with respect to the parameters

$$\frac{d}{dt}\left(\frac{\partial \hat{x}}{\partial p}\right) = F\left(\frac{\partial \hat{x}}{\partial p}\right) + \frac{\partial F}{\partial p}\hat{x} + \frac{\partial G}{\partial p}u_m .$$

Calling Sequence - CALL DERIV2 (FMAT,PDXDP,X,U,ROW1,COL1,ROW2,COL2,M,N,
L,DXDPDT,NEQ)

where FMAT is the matrix F

PDXDP is the matrix of the partial derivatives, $\frac{\partial \hat{x}}{\partial p}$.

X is the state vector, $\hat{x}$

U is the control vector, u_m

SUBRØUTINE ERRSET

This subroutine sets up a vector of flags ERRNDX corresponding to every error source.

ERRNDX(i) = n = 0: means the i^{th} error source is absent
$\neq$ 0: means the i^{th} error source occupies the n^{th} position in ERRVEC vector.

This subroutine also sets up a vector ERRVEC and NAMERR where non-zero error value and the names of non-zero error sources are stored. ERRVEC and NAMERR are packed arrays. If ERRNDX(i) = n $\neq$ 0, then the i^{th} error value is stored in ERRVEC(n) and hollerith name is stored in NAMERR(n,1) and NAMERR(n,2).

Calling Sequence - CALL ERRSET (BIAS,EP,GM,EIC,FF,NAMPAR,NAMICC)

where BIAS is a vector of bias errors (b's)
EP is a vector of scaling errors (e's)
GM is a vector of misalignment (γ's)
EIC is a vector of initial condition errors (x(0))
FF is a vector of lag errors (f's)
NAMPAR is a vector of hollerith names for parameters
NAMICC is a vector of hollerith names of initial conditions

SUBRØUTINE ESTNAM

This subroutine sets up a vector of hollerith names for all parameters to be estimated.

Calling Sequence - CALL ESTNAM

SUBROUTINE INPUTX

This subroutine reads all the namelist input and deletes instruments as specified by the input.

Calling Sequence - CALL INPUTX

SUBRØUTINE INTEG

This subroutine controls the integration of aircraft dynamic equations. It integrates one time step, Δt_s, for each call to INTEG.

Calling Sequence - CALL INTEG (KKQS,STATES,I)

where KKQS is the number of vector equations to be integrated

STATES is an array containing the state vector

I is the sample point number

SUBRØUTINE MATADD

This subroutine performs matrix addition or matrix subtraction.

Calling Sequence - CALL MATADD (A,B,C,N,M,NA,NB,NC,L)

where A is a NA by M matrix

B is a NB by M matrix

C is a NC by M matrix

N and M specify the submatrix for which addition or subtraction is to be performed

NA, NB, and NC specify the row number of matrices A, B, and C, respectively.

L is a flag to specify addition or subtraction

= 0: addition

≠ 0: subtraction

SUBRØUTINE MATMPY

This subroutine multiplies two matrices, $C = A \cdot B$

Calling Sequence - CALL MATMPY (A,B,C,L,M,N,N1,N2,N3)

where A is a N1 by M matrix

B is a N2 by N matrix

C is a N3 by N product matrix

L is the number of rows in A for which multiplication is performed

M is the number of columns in A and the number of rows in B for which multiplication is performed

N is the number of columns in B and C for which multiplication is performed

N1, N2, N3 are the row dimensions of A, B, and C matrices, respectively.

SUBRØUTINE MATPNT

This subroutine prints out covariance matrices with the parameter names top to bottom and across the page. It prints 10 columns at a time.

Calling Sequence - CALL MATPNT (MATRIX,N1,N2,NX,HEAD)

where MATRIX is the covariance matrix

N1 and N2 specify the dimensions of submatrix to be printed

NX is the row dimension of MATRIX

HEAD is the header vector. It may contain up to 40 characters.

SUBRØUTINE ØPDB

This subroutine controls the print out of input summary for the SCIP2 programs.

Calling Sequence - CALL OPDB (NAMPAR)

where NAMPAR is the array containing the hollerith names of the output measurement states

SUBRØUTINE PRINTE

This subroutine controls the print out of normalized covariance matrix.

Calling Sequence - CALL PRINTE (COV,HEAD)

where COV is the covariance matrix

HEAD is the header vector

SUBRØUTINE PRINTS

This subroutine prints measurement vector and control vector at each sample time point.

Calling Sequence - CALL PRINTS (NN,YY)

where NN is the sample point number

YY is the measurement vector

SUBRØUTINE PRINTV

This subroutine prints the expected values of δp vector.

Calling Sequence - CALL PRINTV (HEAD,EVDP)

where HEAD is the header vector

EVDP is the expected value vector

SUBRØUTINE RK4

This subroutine integrates a matrix of differential equations one step using a 4th order Runge-Kutta method.

Calling Sequence - CALL RK4 (X,T,DT,K,L,M,DERIV)

where X is the matrix of the initial values and temporary storage area. Upon completion of this subroutine, the integrated matrix is stored in place of the initial values.

T is the integration variable

DT is the integration step-size

K is the number of rows of X-matrix to be integrated

L is 4 times the column dimension of X

M is the maximum row dimension of X

DERIV is the name of the subroutine which computes the time derivative of the dependent variables

SUBRØUTINE SETNDX

This subroutine sets up the error index for each error source and the error name for the output header.

Calling Sequence - CALL SETNDX (A,M,NE,NAME)

where
- A is the array containing the error source
- M is the dimension of A
- NE is the number of non-zero elements in A
- NAME is the array containing the hollerith names of the error source in A

SUBRØUTINE SYMVRT

This subroutine inverts a variably dimensioned symmetric matrix. The calculation is done in double precision.

Calling Sequence - CALL SYMVRT (A,N,M,DET)

where
- A is the matrix to be inverted. Upon exit from this subroutine, A contains the inverse.
- N is the dimension of submatrix of A to be inverted
- M is the maximum row dimension of A
- DET is the absolute value of the determinant A

SUBRØUTINE YPRTLS

This subroutine computes the estimated measurement vector, $\hat{y}$, its partial derivatives, with respect to the parameters, $\frac{\partial \hat{y}}{\partial p}$, and $R^{-1} \frac{\partial \hat{y}}{\partial p}$ to form the $\frac{\partial^2 J}{\partial p^2}$ matrix.

Calling Sequence - CALL YPRTLS

6.2 Additional Subroutines in the Ensemble Error Analysis Programs

SUBRØUTINE CINTGL

This subroutine defines the initial $\frac{\partial u}{\partial e}$ vector and calls INTGUL to integrate the control lag equations.

Calling Sequence - CALL CINTGL

SUBRØUTINE CINTGU

This subroutine defines the initial $\hat{x}$ vector and $\partial\hat{x}/\partial e$ and $\partial\hat{y}/\partial e$ matrices and calls CINTU1 to compute their time histories.

Calling Sequence - CALL CINTGU

SUBRØUTINE CINTU1

This subroutine computes the control error sensitivities of the estimated state and measurements according to the equations

$$\frac{d}{dt}\left(\frac{\partial \hat{x}}{\partial e}\right) = F\,\frac{\partial \hat{x}}{\partial e} + G\,\frac{\partial u_m}{\partial e}$$

(by calling RK4 with DRVUE1 as the routine defining the derivatives)

$$\frac{\partial \hat{y}}{\partial e} = H\,\frac{\partial \hat{x}}{\partial e} + D\,\frac{\partial u_m}{\partial e}$$

and then computes the contribution of the control errors to the $\partial p/\partial e$ matrix as

$$\left(\frac{\partial p}{\partial e}\right)_{\substack{\text{control}\\ \text{errors}}} = -\sum_{i=1}^{N}\left(\frac{\partial \hat{y}}{\partial p}\right)^{T} R^{-1}\left(\frac{\partial \hat{y}}{\partial e}\right)$$

Calling Sequence - CALL CINTU1 (XX,PDUDEB,PDUDES,PDPDEC,PDYDEC,NEQX),

where XX is a matrix containing $\partial\hat{x}/\partial e$,

PDUDEB is a matrix containing $\partial u_m/\partial e$, where e is a control bias,

PDUDES is a matrix containing $\partial u_m/\partial e$, where e is a control scale factor error,

PDPDEC is a matrix containing $\partial p/\partial e$, where e is a control bias or scale factor error,

PDYDEC is a matrix containing $\partial y/\partial e$, where e is a control bias or scale factor error,

NEQX is 4 times the number of control biases and scale factor errors and is needed in the call to SUBRØUTINE RK4.

SUBRØUTINE DRVUE1

This subroutine is called by RK4, the Runge-Kutta integration subroutine, and calculates $\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial e}\right)$ where e is a random control error (scale factor or bias).

Calling Sequence - CALL DRVUE1 (XX,TM,DX,K,L,M)

where XX is an array storing $\partial\hat{x}/\partial e$,

TM is the independent variable, time,

DX is the derivative to be computed, $\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial e}\right)$,

K,L,M are dummies.

SUBRØUTINE DRVULE

This subroutine is called by RK4, the Runge-Kutta integration subroutine, and calculates

$$\dot{u}_L = -F_c\, u_L + F_c u$$

$$\frac{d}{dt}\left(\frac{\partial u_L}{\partial e_{F_c}}\right) = -F_c \frac{\partial u_L}{\partial e_{F_c}} - u_L + u_{input}$$

$$\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial e_{B_c}}\right) = F \frac{\partial\hat{x}}{\partial e_{B_c}} + G \frac{\partial u_m}{\partial e_{B_c}}$$

$$\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial e_{T_c}}\right) = F\,\frac{\partial\hat{x}}{\partial e_{T_c}} + G\,\frac{\partial u_m}{\partial e_{T_c}}$$

$$\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial e_{F_c}}\right) = F\,\frac{\partial\hat{x}}{\partial e_{F_c}} + G\,\frac{\partial u_m}{\partial e_{F_c}}$$

where e_{F_c} are control lags, e_{B_c} are control biases, and e_{T_c} are control scale factor errors (refer to Section A.3.3).

Calling Sequence - CALL DRVULE (XX,TIME,DXX,KK,LL,MM)

where XX is an array which contains u_L, $\partial u_L/\partial e_{F_c}$, $\partial\hat{x}/\partial e_{B_c}$, $\partial\hat{x}/\partial e_{T_c}$, and $\partial\hat{x}/\partial e_{F_c}$,

TIME is the independent variable, time,

DXX is the computed derivative of the variables in the array XX,

KK,LL,MM are dummies.

SUBRØUTINE DRVXXX

This subroutine computes the derivative $\frac{d}{dt}\left(\frac{\partial y_L}{\partial e_{IC}}\right)$ so that it may be integrated by RK4, the Runge-Kutta integration routine (refer to Section A.3.2).

Calling Sequence - CALL DRVXXX (DXDE,DYDE,DDXDE,DDYDE)

where DXDE contains $\partial x/\partial e_{IC}$

DYDE contains $\partial y_T/\partial e_{IC}$

DDXDE contains the computed $\frac{d}{dt}\left(\frac{\partial x}{\partial e_{IC}}\right)$

DDYDE contains the computed $\frac{d}{dt}\left(\frac{\partial y_L}{\partial e_{IC}}\right)$

SUBRØUTINE DRVXYE

This subroutine is called by RK4, the Runge-Kutta integration routine, and sets up the call to DRVXXX, which actually computes the derivatives required.

Calling Sequence - CALL DRVXYE (XX,TM,DX,MM,LL,KK)

where XX contains $\partial x/\partial e_{IC}$ and $\partial y_L/\partial e_{IC}$

TM is the independent variable, time

DX contains the time derivatives of XX,

MM,LL,KK are dummies.

SUBRØUTINE DRVYLE

This subroutine is called by RK4, the Runge-Kutta integration subroutine, and calculates

$$\dot{x} = Fx + Gu$$

$$y = Hx + Du$$

$$\dot{y}_L = -F_m y_L + F_m y$$

$$\frac{d}{dt}\left(\frac{\partial y_L}{\partial e_{F_m}}\right) = -F_m \frac{\partial y_L}{\partial e_{F_m}} - y_L + y$$

where e_{F_m} is a measurement lag (refer to Section A.3.2).

Calling Sequence - CALL DRVYLE (XM,TM,DXM,K,L,M)

where XM is an array containing x, y_L, and $\partial y_L/\partial e_{F_m}$,

TM is the independent variable, time,

DXM is an array containing the derivatives of the variables in XM,

K,L,M are dummies.

SUBROUTINE ENSMB

This subroutine is the main working routine for the Ensemble Error Analysis. By calling the appropriate subroutines, it computes and prints out

x, y, $\frac{\partial y}{\partial p}$, $\frac{\partial^2 J}{\partial p^2}$, $\frac{\partial y}{\partial e}$, the parameter error covariance $E(\delta p \delta p^T)$, the sensitivity of the parameter estimates $\frac{\partial}{\partial e}(\delta p)$, and the mean error of the parameter estimates $E(\partial p)$. Refer to Section A.3.

Calling Sequence - CALL ENSMB.

SUBRØUTINE GET

This subroutine retrieves from storage on logical unit IU1 the time histories of the variables $\hat{x}$, $\partial\hat{x}/\partial p$, $\hat{y}$, and $R^{-1}(\partial\hat{y}/\partial p)$, which were stored there by SUBRØUTINE PUT.

Calling Sequence - CALL GET (ITM)

where ITM is the number of the sample time point.

SUBRØUTINE INTGUL

This subroutine calls RK4, the Runge-Kutta integration routine, which calls DRVULE, to compute u_L, $\partial u_L/\partial e_{F_c}$, $\partial\hat{x}/\partial e_c$, where e_{F_c} is a control lag and e_c is any control error. Then the sensitivity matrices of the measurement estimates with respect to the control errors, $\partial\hat{y}/\partial e_c$, and of the parameter estimates with respect to the control errors, $\partial p/\partial e_c$, are computed. (Refer to Section A.3.3.)

Calling Sequence - CALL INTGUL (UU,DUDE,DXDE,PDYDEF,PDPDEF,NEQX)

where
- UU is a vector containing u_L,
- DUDE is a vector containing the non-zero, elements of $\partial u_L/\partial e_{F_c}$,
- DXDE is a matrix containing $\partial\hat{x}/\partial e_c$,
- PDYDEF is a matrix containing $\partial\hat{y}/\partial e_c$,
- PDPDEF is a matrix containing $\partial p/\partial e_c$,
- NEQX is 4 times the number of equations integrated by the call to RK4.

SUBRØUTINE PRINTF

This subroutine prints the matrix $\partial p/\partial e$.

Calling Sequence - CALL PRINTF (HEAD,MATRIX)

where HEAD is a label printed above the matrix,

MATRIX is an array containing $\partial p/\partial e$.

SUBRØUTINE PRTLS1

This subroutine computes the partial derivatives matrix of the measurements with respect to the measurement errors $\partial y/\partial e_m$, when no measurement lags are present. (Refer to Section A.3.2.)

Calling Sequence - CALL PRTLS1 (INDX)

where INDX is the sample point number.

SUBRØUTINE PRTLS2

This subroutine computes the partial derivatives matrix of the measurements with respect to the measurement errors, $\partial y/\partial e_m$, when measurement lags are present. (Refer to Section A.3.2.)

Calling Sequence - CALL PRTLS2 (YL,PDYL,DYLDE)

where YL is a vector containing y_L,

PDYL is a vector containing the diagonal elements of $\partial y_L/\partial e_{F_c}$ (all off-diagonal elements are zero).

DYLDE is a matrix containing the partial derivatives of y_L with respect to initial condition errors, $\partial y_L/\partial e_{IC}$.

SUBRØUTINE PUT

This subroutine places in storage on logical unit IU1 the time histories of the variables $\hat{x}$, $\partial\hat{x}/\partial p$, $\hat{y}$, and $R^{-1}(\partial\hat{y}/\partial p)$, which are later retrieved by SUBRØUTINE GET.

Calling Sequence - CALL PUT (ITM)

where ITM is the number of the sample time point.

SUBRØUTINE TCØNST

This subroutine constructs the T matrix using only the mean errors. The T matrix is the scaling matrix for the output measurements.

Calling Sequence - CALL TCØNST.

SUBRØUTINE YLINTG

This subroutine is only called when measurement lags are present. YLINTG performs several functions: (1) it calls RK4, the Runge-Kutta integration routine, which calls DRVYLE, to compute x, y, y_L, and $\partial y_L/\partial e_{F_C}$, (2) it calls RK4, which calls DRVXYE, to compute the partial derivatives of the state with respect to the initial conditions, $\partial x/\partial e_{IC}$, (3) it calls PRTLS2 to compute $\partial y/\partial e$ for output measurement errors, and (4) it computes $\partial p/\partial e$ for output measurement errors.

Calling Sequence - CALL YLINTG (XX,YL,PDY,DXDE,DYLDE,NEQ1,NEQ2)

where XX contains the state vector, x,

YL contains the lagged measurements, y_L,

PDY contains the diagonal elements of the partial derivatives of y_L with respect to the lags,

DXDE contains $\partial x/\partial e_{IC}$,

DYLDE contains $\partial y_L/\partial e$ for output measurement errors,

NEQ1 and NEQ2 are 4 times the number of equations integrated in the first and second calls to RK4, respectively.

6.3 Additional Subroutines in the Simulated Data Analysis Programs

SUBRØUTINE CNTEQS

This subroutine computes u_m, the measured control inputs (exclusive of feedback control, if any), according to the equations in Section A.2.1 and stores them in an array called STØR1. This is done for any possible combination of control errors - lags, biases, or scaling errors.

Calling Sequence - CALL CNTEQS.

SUBRØUTINE CØNSTT

This subroutine sets up the scaling matrix, T, for the output measurements. It includes all applicable mean and random errors.

Calling Sequence - CALL CØNSTT.

SUBRØUTINE DERIVX

This subroutine is called by RK4 and sets up the call to DERIV1 so that the aircraft state equations may be integrated. This subroutine is called only in the case when no output lags are present.

Calling Sequence - CALL DERIVX (XMAT,T,DX,K,L,M)

where XMAT contains the aircraft state, x,

T is the independent variable, time,

DX is the time derivative of XMAT,

K is not used,

L is the column dimension of XMAT and DX,

M is the row dimension of XMAT and DX.

SUBRØUTINE DRVUL

This subroutine is called by RK4 to integrate the control lag equation

$$\dot{u}_L = F_c(u-u_L)$$

Calling Sequence - CALL DRVUL (UMAT,TM,DUMAT,KK,LL,MM)

where UMAT contains the lagged control input, u_L,

TM is the independent variable, time

DUMAT is the time derivative of UMAT,

KK,LL,MM are dummies.

SUBRØUTINE DRVXY

This subroutine is called by RK4 to integrate the state and the output measurement lag equations. It computes (refer to Section A.2.1)

$$\dot{x} = Fx + Gu \text{ (by calling DERIV1)}$$

$$y_T = Hx + Du$$

$$\dot{y}_L = F_m y_T - F_m y_L$$

Calling Sequence - CALL DRVXY (XMAT,TM,DX,KK,LL,MM)

where XMAT contains x and y_L,

TM is the independent variable, time,

DX contains the time derivatives of XMAT,

KK,LL,MM are dummies.

SUBRØUTINE EMSMBI

This subroutine initializes certain arrays in preparation to the first call to SUBRØUTINE ENSMBL.

Calling Sequence - CALL ENSMBI.

SUBRØUTINE ENSMBL

This subroutine calls INTEG to integrate the state equations to obtain $\hat{x}$, calls YPRTLS to compute $\hat{y}$ and $\partial\hat{y}/\partial p$, and then computes the information matrix, $\partial^2 J/\partial p^2$. It is called once per integration step and performs its calculations over that one step.

Calling Sequence - CALL ENSMBL (ITM)

where ITM is the sample time point number.

SUBRØUTINE INITIT

This subroutine prepares for the generation of the simulated aircraft data at the beginning of each Monte Carlo sample by calling SUBRØUTINES ØTHERR and PERTRL to obtain new values for the errors.

Calling Sequence - CALL INITIT (IFN)

where IFN is a flag which is set to unity if the last Monte Carlo sample has been reached and is zero otherwise.

SUBRØUTINE ØTHERR

This subroutine calls PERTRB to compute new values for the output and input measurement errors and the state initial condition errors, if any, and calls CØNSTT to set up the new output measurement scaling matrix, T, at the beginning of a new Monte Carlo sample.

Calling Sequence - CALL ØTHERR (IERTN)

where IERTN is no longer used.

SUBRØUTINE PERTRB

This subroutine calls the pseudo-random number generating function, RN, which returns a normally distributed random number whose standard deviation is unity and mean is zero, and multiplies this number by the input value of the standard deviation of an error source. This procedure creates a new sample value for the error.

Calling Sequence - CALL PERTRB (ERR,INDX,NERS)

where ERR is an array containing the standard deviations of the error sources,

INDX is an array containing the index number of the error sources,

NERS is the number of error values to be computed.

SUBRØUTINE PERTRL

This subroutine computes new sample values for the lags. This is done by calling the pseudo-random number generating function, RN, which returns a normally distributed random number whose mean is zero and standard deviation is unity, then multiplying this number by the input value of the lag's standard deviation and adding the input value of its mean. Random numbers exceeding 3 standard deviations are not allowed.

Calling Sequence - CALL PERTRL (F,INDEX,STV,NER)

where F is an array containing the computed values for the lags,

INDEX is the index values of the errors (lags),

STV is an array containing the standard deviations of the lags,

NER is the number of lag values to be computed.

SUBRØUTINE RN

This function computes a normally distributed random number with zero mean and unit variance.

Calling Sequence - RAND=RN (I)

where RAND is the random number returned by the function,

I is a dummy variable (CDC-6600).

SUBRØUTINE SMDATA

This subroutine is the major working routine for the Simulated Data Analysis Program. By calling appropriate subroutines, it computes all the Monte Carlo samples - generates the simulated aircraft data and performs the Newton-Raphson algorithm to compute the identified parameters. Then it computes and prints out a summary of the parameter error statistics - the estimated mean errors and estimated covariance of the errors.

Calling Sequence - CALL SMDATA.

SUBRØUTINE YEQS

This subroutine, which is called by SUBRØUTINE SMDATA, computes the simulated aircraft output measurement sequence (refer to Section A.2.1). It calls the Runge-Kutta integration routine, RK4, which in turn calls either DERIVX to integrate the $\dot{x}$ equation when measurement lags are not present or DRVXY to integrate the $\dot{x}$ and $\dot{y}_L$ equations when lags are present. Then the subroutine computes the output measurements and stores them in the array STØR2.

Calling Sequence - CALL YEQS.

APPENDIX A

SUMMARY OF EQUATIONS CODED IN ANALYSIS PROGRAMS

A.1 INTRODUCTION AND GENERAL COMMENTS

The instrumentation error analyses of Chapter III of Reference 1 were implemented in four computer programs, collectively named SCIP2. These four programs are the CTOL and VTOL aircraft versions of the ensemble error analysis and simulated data analysis. Each of these programs contains longitudinal and lateral equations of motion.

The VTOL aircraft programs have the option of specifying state-variable feedback in the control; the CTOL aircraft programs do not. The equations in this appendix describe the VTOL aircraft programs. By setting the feedback gains matrix C to zero, the equations reduce to those of the CTOL aircraft programs.

Differential equations are integrated by a classical, fourth-order Runge-Kutta routine. This routine has the well known advantages of good accuracy and fixed step-size. The input control as used by the programs is piecewise constant over each integration step. To have made it continuous would have significantly increased the computational complexity and execution time of the programs without benefit of an equivalently significant increase in accuracy.

The three time increments used in the programs are:

Δt - This is the time step of the Runge-Kutta integration package when control or measurement lags are present. It is set small enough so the effect of the highest frequency dynamics is correctly simulated. This term is usually governed by the control or output measurement lag with the smallest time constant.

Δt_s - This is the sample time increment used by the identification process. When measurement lags are not present, it is used as the integration step.

τ - This is the time delay which governs when sampling of the control input begins after time zero. Normally, $0 \leq \tau \leq \Delta t_s$. Use of τ enables sampling the control input at different time points than the output measurements.

The equations presented below parallel those of Chapter III of Reference 1. The equations of the Simulated Data (Monte Carlo) Analysis Program will be presented first and then the equations of the Ensemble Error Analysis Program.

A.2 SIMULATED DATA ANALYSIS PROGRAM

Each Monte Carlo sample begins with the generation of simulated test data. These data are then used by the modified Newton-Raphson parameter identification process, which begins its iterative search with the true values of the parameters.

The random errors contained in B, part of T, B_c, T_c, F_m, F_c, and x_o are generated at the beginning of each Monte Carlo run using the input standard deviations and the random number generator. They are held constant during each single Monte Carlo run. The random noise n_i and n_{ci} are regenerated at each sample point during each run. Each of the mean errors in T are set equal to the values input and not changed during any of the runs.

A.2.1 Simulated Test Data Equations

$$\dot{x} = (F-GC)x + Gu_{input}; \qquad x(o) = x_o \tag{A.1}$$

$$y_T = (H-DC)x + Du_{input} \tag{A.2}$$

which are the true measurements,

$$\dot{y}_L = -F_m y_L + F_m y_T; \qquad y_L(0) = (H-DC)x_o \tag{A.3}$$

which causes a first-order lag (note that the lagged measurements are initially set to the true measurements), and

$$y_i = Ty_{L_i} + B + n_i \tag{A.4}$$

are the measurements recorded at the i^{th} sample point. Sampling occurs every Δt_s seconds starting at time $t=\Delta t_s$. If measurement lags are not present, then y_{T_i} is substituted for y_{Li} in Eq. (A.4), and Eq. (A.3) is not integrated.

The equations which produce the recorded control input are:

$$u = u_{input} \tag{A.5}$$

which is the true control (exclusive of feedback) which is input to the program,

$$\dot{u}_L = -F_c u_L + F_c u; \qquad u_L(0) = 0 \tag{A.6}$$

which causes a first-order lag (note that the lagged controls are initially in trim), and

$$u_{m_i} = T_c u_{Li} + B_c + n_{ci} \tag{A.7}$$

is the recorded control input taken at the i^{th} sample point. If lags are present, this samples u_L every Δt_s seconds beginning at time $t = \tau$. If control lags are not present, then u_i is substituted for u_{Li} in Eq. (A.7), and Eq. (A.6) is not integrated.

A.2.2 Parameter Identification Algorithm

The estimated state and measurement vectors result from these equations:

$$\dot{\hat{x}} = \left[F(p) - G(p)C\right]\hat{x} + G(p)u_m; \qquad \hat{x}(o) = x_o \tag{A.8}$$

$$\hat{y} = \left[H(p) - D(p)C\right]\hat{x} + D(p)u_m \tag{A.9}$$

The partial derivative matrix $\partial\hat{y}/\partial p$ evaluated at $\hat{p}$ results from the following equations, which appear in Chapter III of Reference 1 as Eqs. (63)-(68). The equation

$$\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial p_p}\right) = (\hat{F}-\hat{G}C)\left(\frac{\partial\hat{x}}{\partial p_p}\right) + \left(\frac{\partial\hat{F}}{\partial p_p} - \frac{\partial\hat{G}}{\partial p_p}C\right)\hat{x} + \frac{\partial\hat{G}}{\partial p_p}u_m; \qquad \left.\frac{\partial\hat{x}}{\partial p_p}\right|_{t=0} = 0 \tag{A.10}$$

is integrated, where p_p is the parameter vector containing the elements presented in Eqs. (37), (38), or (43) of Chapter III, Reference 1. If state initial conditions are also estimated, the identification process integrates

$$\frac{d}{dt}\left(\frac{\partial\hat{x}}{\partial p_{IC}}\right) = (\hat{F}-\hat{G}C)\left(\frac{\partial\hat{x}}{\partial p_{IC}}\right); \qquad \left.\frac{\partial\hat{x}}{\partial p_{IC}}\right|_{t=0} = I \tag{A.11}$$

Then, from Eq. (A.9), the output sensitivity matrix for the parameters p_p is

$$\frac{\partial\hat{y}}{\partial p_p} = (\hat{H}-\hat{D}C)\frac{\partial\hat{x}}{\partial p_p} + \left(\frac{\partial\hat{H}}{\partial p_p} - \frac{\partial\hat{D}}{\partial p_p}C\right)\hat{x} + \frac{\partial\hat{D}}{\partial p_p}u \tag{A.12}$$

For the initial conditions, this becomes

$$\frac{\partial\hat{y}}{\partial p_{IC}} = (\hat{H}-\hat{D}C)\frac{\partial\hat{x}}{\partial p_{IC}} \tag{A.13}$$

If output measurement biases are also estimated, the sensitivities

$$\frac{\partial \hat{y}}{\partial p_b} = I \tag{A.14}$$

must be included. The total sensitivity matrix is then

$$\frac{\partial \hat{y}_i}{\partial p} \triangleq \left[\frac{\partial \hat{y}_i}{\partial p_p} \quad \frac{\partial \hat{y}_i}{\partial p_{IC}} \quad \frac{\partial \hat{y}_i}{\partial p_b} \right] \tag{A.15}$$

The parameter step for the k^{th} iteration of the modified Newton-Raphson algorithm is

$$\partial p_k = p_{k+1} - p_k = -\left[\frac{\partial^2 J}{\partial p^2}\right]_{p_k} \left(\frac{\partial J}{\partial p}\right)^T_{p_k} \tag{A.16}$$

which is computed as

$$\partial p_k = \left[\sum_{i=1}^{N} \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T_{p_k} R^{-1} \left(\frac{\partial \hat{y}_i}{\partial p}\right)_{p_k}\right]^{-1} \sum_{i=1}^{N} \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T_{p_k} R^{-1} \left[y_i - (\hat{y}_i)_{p_k}\right] \tag{A.17}$$

This is Eq. (61) of Chapter III, Reference 1 evaluated with each parameter set to its value on the k^{th} iteration.

A.2.3 Sample Statistics

Let Δp_j be the difference between the values of p to which the algorithm converges on the j^{th} Monte Carlo run and the true values of p. Then, for m Monte Carlo runs, the mean error in p is

$$\overline{\Delta p} \triangleq E\{\Delta p\} = \frac{1}{m} \sum_{j=1}^{m} \Delta p_j \tag{A.18}$$

and the sample covariance about this mean is

$$E\,\{\delta p \delta p^T\} = \frac{1}{m-1} \sum_{j=1}^{m} (\Delta p_j - \overline{\Delta p})\,(\Delta p_j - \overline{\Delta p})^T \tag{A.19}$$

A.2.4 Representation of Lag Time Constants

The diagonal matrices F_m and F_c contain as elements the inverse time constants of the output measurement lags and the control input lags, respectively. In an actual instrumentation system, these inverse time constants are random variables whose true probability density functions are unknown. The Simulated Data Analysis Programs permit the user the option of modeling the density function as a truncated normal distribution or as a beta distribution. The normal distribution is truncated at $\pm\, 3\sigma$. Hence, by choosing the mean to be at least three times the standard deviation, the user is guaranteed that a lag time constant will always be positive.

The beta distribution [2] allows wide latitude in shaping the density function. This density function is defined as

$$f_\beta(p|r,n) \triangleq \frac{(n-1)!}{(r-1)!\,(n-r-1)!}\; p^{r-1}\; (1-p)^{n-r-1} \tag{A.20}$$

where p   is the normalized random variable, $0 \leq p \leq 1$,

n,r   are parameters which determine the shape of the density function, $n > r > 0$.

Examples of f_β for various values of n and r are shown in Figure A.1. The mean and variance of this normalized distribution are

$$\mu_p = \frac{r}{n} \tag{A.21}$$

$$\sigma_p^2 = \frac{r(n-r)}{n^2(n+1)} \tag{A.22}$$

If f is an inverse time constant and μ_f and σ_f^2 are its desired mean and variance, which are inputs to the program, then

$$f = a + bp \tag{A.23}$$

where

$$a = \mu_f - b\mu_p \tag{A.24}$$

$$b = \frac{\sigma_f}{\sigma_p} \tag{A.25}$$

are coefficients which transform the normalized, β-distributed, random variable p to the desired β-distributed, random variable f.

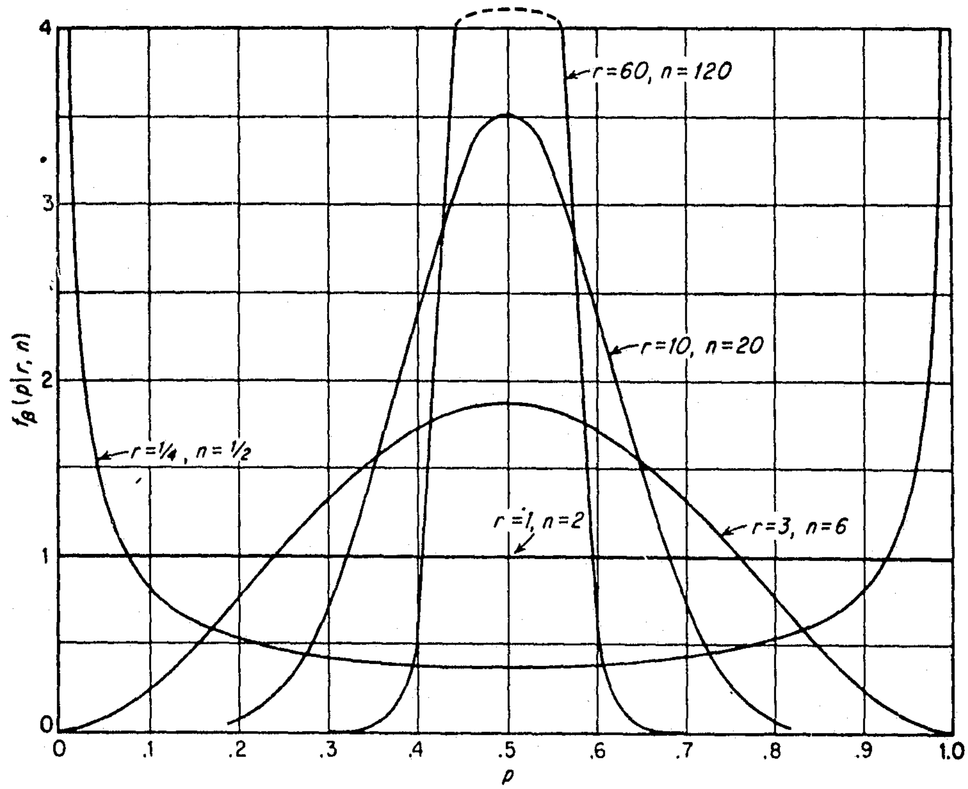

Figure A.1(a) Beta Density Function
μ_p=0.5

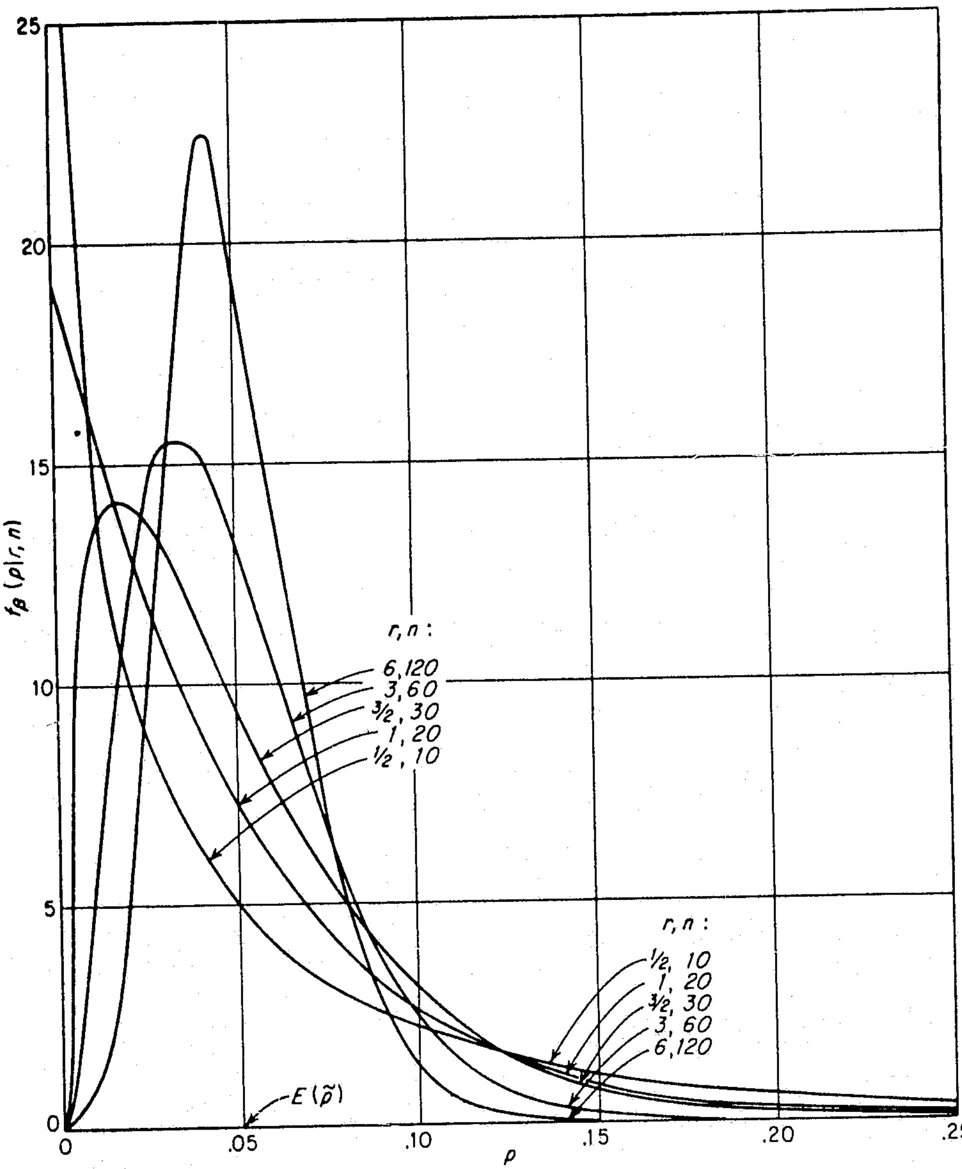

Figure A.1(b) Beta Density Function
$\mu_p = 0.05$

A.3 ENSEMBLE ERROR ANALYSIS PROGRAM

A.3.1 Major Results

The major results of the Ensemble Error Analysis Program are:

(1) The sensitivity matrix of the parameter estimates to errors e in the measurements

$$\frac{\partial}{\partial e}(\delta p) = \left[\frac{\partial^2 J}{\partial p^2}\right]^{-1} \sum_{i=1}^{N} \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T R^{-1} \left(\frac{\partial y_i}{\partial e}\right), \tag{A.20}$$

(2) The sensitivity matrix of the parameter estimates to errors e in the control inputs

$$\frac{\partial}{\partial e}(\delta p) = -\left[\frac{\partial^2 J}{\partial p^2}\right]^{-1} \sum_{i=1}^{N} \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T R^{-1} \left(\frac{\partial \hat{y}_i}{\partial e}\right), \tag{A.21}$$

(3) The total covariance of the parameter estimates

$$E(\delta p \delta p^T) = \left[\frac{\partial^2 J}{\partial p^2}\right]^{-1} + \left(\frac{\partial}{\partial e}(\delta p)\right) E(ee^T) \left(\frac{\partial}{\partial e}(\delta p)\right)^T \tag{A.22}$$

where here e refers to random errors (whether measurement or control errors), and

(4) The mean error of the parameter estimates

$$E(\delta p) = \frac{\partial}{\partial e}(\delta p)\, E(e) \tag{A.23}$$

where here e refers to mean errors. The information matrix is computed as

$$\frac{\partial^2 J}{\partial p^2} = \sum_{i=1}^{N} \left(\frac{\partial \hat{y}_i}{\partial p}\right)^T R^{-1} \left(\frac{\partial \hat{y}_i}{\partial p}\right) \tag{A.24}$$

Each of Eqs. (A.20) through (A.24) is evaluated with the parameters set to their true values.

In order to calculate Eqs. (A.20) through (A.24), the program must compute the matrices $\partial\hat{y}_i/\partial p$, $\partial y_i/\partial e$ (for measurement errors), and $\partial\hat{y}_i/\partial e$ (for control errors). The first of these is computed according to Eqs. (A.10) through (A.15) with the parameters set to their true values (i.e., "hats" do not appear on the F, G, H, and D matrices). The matrices $\partial y_i/\partial e$ and $\partial\hat{y}_i/\partial e$ are the subjects of the next two sections.

A.3.2 Output Errors

The sensitivity of y_i to each output error e must be computed. For biases,

$$\frac{\partial y_i}{\partial e_B} = I \tag{A.25}$$

For errors which appear in the matrix T,

$$\frac{\partial y_i}{\partial e_T} = \frac{\partial T}{\partial e_T} y_{L_i} \tag{A.26}$$

(Substitute y_T for y_L if there are no lags.)

For errors in the initial conditions,

$$\frac{\partial y_i}{\partial e_{IC}} = T \frac{\partial y_{L_i}}{\partial e_{IC}} \tag{A.27}$$

where

$$\frac{d}{dt}\left(\frac{\partial y_L}{\partial e_{IC}}\right) = -F_m \frac{\partial y_L}{\partial e_{IC}} + F_m \frac{\partial y_T}{\partial e_{IC}} \; ; \qquad \left.\frac{\partial y_L}{\partial e_{IC}}\right|_{t=0} = 0 \tag{A.28}$$

must be integrated,

$$\frac{\partial y_T}{\partial e_{IC}} = (H-DC)\,\frac{\partial x}{\partial e_{IC}} \tag{A.29}$$

and

$$\frac{d}{dt}\left(\frac{\partial x}{\partial e_{IC}}\right) = (F-GC)\,\frac{\partial x}{\partial e_{IC}}\ ; \qquad \left.\frac{\partial x}{\partial e_{IC}}\right|_{t=0} = I \tag{A.30}$$

must be integrated. If there are no measurement lags, then Eq. (A.28) is omitted, and $\partial y_T/\partial e_{IC}$ is substituted for $\partial y_L/\partial e_{IC}$ in Eq. (A.27).

For measurement lags e_{F_m},

$$\frac{\partial y_i}{\partial e_{F_m}} = T\,\frac{\partial y_{L_i}}{\partial e_{F_m}} \tag{A.31}$$

where

$$\frac{d}{dt}\left(\frac{\partial y_L}{\partial e_{F_m}}\right) = -F_m\left(\frac{\partial y_L}{\partial e_{F_m}}\right) - (y_L - y_T)\,; \qquad \left.\frac{\partial y_L}{\partial e_{F_m}}\right|_{t=0} = 0 \tag{A.32}$$

must be integrated.

The results of Eqs. (A.25) through (A.32) are combined to form

$$\frac{\partial y_i}{\partial e} \triangleq \left[\frac{\partial y_i}{\partial e_B}\,,\ \frac{\partial y_i}{\partial e_T}\,,\ \frac{\partial y_i}{\partial e_{IC}}\,,\ \frac{\partial y_i}{\partial e_{F_m}}\right] \tag{A.33}$$

Note that these equations require y_L and y_T, which are computed by means of Eqs. (A.1) through (A.3).

A.3.3 Control Input Errors

The sensitivity of y_i to each input error e must be computed.

$$\frac{\partial \hat{y}_i}{\partial e} = (H-DC)\frac{\partial \hat{x}_i}{\partial e} + D\frac{\partial u_{m_i}}{\partial e} \tag{A.34}$$

$$\frac{d}{dt}\left(\frac{\partial \hat{x}}{\partial e}\right) = (F-GC)\frac{\partial \hat{x}}{\partial e} + G\frac{\partial u_m}{\partial e} \ ; \qquad \left.\frac{\partial \hat{x}}{\partial e}\right|_{t=0} = 0 \tag{A.35}$$

where $\partial u/\partial e$ depends upon the error.

For biased errors,

$$\frac{\partial u_m}{\partial e_{B_C}} = I \tag{A.36}$$

For errors which appear in T_c,

$$\frac{\partial u_m}{\partial e_{T_C}} = \frac{\partial T_c}{\partial e_{T_C}} u_L \tag{A.37}$$

If there are no control lags, u is substituted for u_L.

For control lags e_{F_C},

$$\frac{\partial u_m}{\partial e_{F_C}} = T_c \frac{\partial u_L}{\partial e_{F_C}} \tag{A.38}$$

where

$$\frac{d}{dt}\left(\frac{\partial u_L}{\partial e_{F_C}}\right) = -F_c \frac{\partial u_L}{\partial e_{F_C}} - u_L + u \ ; \qquad \left.\frac{\partial u_L}{\partial e_{F_C}}\right|_{t=0} = 0 \tag{A.39}$$

Note that u and u_L are required. These are obtained by computing Eqs. (A.5) and (A.6).

REFERENCES

1. Sorensen, J.A., Mohr, R.L., and Cline, T.B., "Instrumentation Requirements for Aircraft Parameter Identification with Application to the Helicopter," NASA CR-   , prepared under Contract No. NAS1-12876 by Systems Control, Inc. (Vt).

2. Raiffa, H., and Schlaifer, R., "Applied Statistical Decision Theory," MIT Press, Cambridge, Mass., 1961.