ANL-82-57

ANL--82-57

DE84 011861

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.

EN ONLY

**STATISTICAL IDENTIFICATION OF
EFFECTIVE INPUT VARIABLES**

by

J. K. Vaurio

Reactor Analysis and Safety Division

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

September 1982

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	1
I. INTRODUCTION.....	2
II. SCREENING METHODS.....	4
A. The Procedure.....	4
B. Selection of Cases.....	4
C. Stagewise Correlation Analysis.....	6
D. Successive Regression Analysis.....	9
E. Comparison with a Matrix Method.....	9
F. Threshold Effect Analysis.....	12
III. CODE VALIDATION.....	15
IV. APPLICATIONS.....	22
V. USER'S MANUAL FOR SCREEN.....	36
A. Program Summary.....	36
B. Program Abstract.....	37
C. Program Use.....	41
1. Task Descriptions.....	41
2. Input Instructions.....	47
3. Flow Diagrams.....	54
4. Subroutine Functions.....	54
VI. SUMMARY.....	58
APPENDICES.....	61
A. Program Listing.....	61
B. Sample Input/Output.....	147
ACKNOWLEDGEMENTS.....	193
REFERENCES.....	193

LIST OF FIGURES

<u>No.</u>	<u>Title</u>	<u>Page</u>
1.	Use of SCREEN to Identify Effective Input Parameters.....	5
2.	Ranking by Correlation Coefficients.....	17
3.	Ranking by Stagewise-Correlation Method.....	18
4.	Ranking by Matrix Method.....	19
5.	Best Regression Function of the Work Potential W_c	27
6.	Individual Sensitivities of the Work Potential W_c	28
7.	Probability Densities of the Work Potential W_c with Uniform Sampling Densities for the Input Parameters.....	30
8.	Probability Densities of W_c with Input-parameters Distributions.....	31
9.	Sensitivities of the Mass of Fuel Vaporized, M_v	32
10.	Sensitivities of the Energy in Molten Fuel, E_m	33
11.	Sensitivities of the Total Energy, E_t	34
12.	Sequence of Subprograms in SCREEN.....	55

LIST OF TABLES

<u>No.</u>	<u>Title</u>	<u>Page</u>
I.	Probability Distributions Available in the SCREEN Code.....	7
II.	The Sample Size vs β for $\alpha = 0.01$	8
III.	Orders of Importance Obtained with Different Methods for Output Variable y_2	15
IV.	Results for y_3 with Successive Regression.....	16
V.	Orders of Importance Obtained with Student's Statistics.....	20
VI.	Input Parameters Varied in Venus-II Sensitivity Study.....	22
VII.	Output-variable Statistics from 40 Random Cases.....	24
VIII.	Orders of Importance Obtained with Different Methods for Output Variable w_c	26

STATISTICAL IDENTIFICATION OF EFFECTIVE INPUT VARIABLES

by

J. K. Vaurio

ABSTRACT

A statistical sensitivity analysis procedure has been developed for ranking the input data of large computer codes in the order of sensitivity-importance. The method is economical for large codes with many input variables, since it uses a relatively small number of computer runs. No prior judgemental elimination of input variables is needed. The screening method is based on stagewise correlation and extensive regression analysis of output values calculated with selected input value combinations. The regression process deals with multivariate nonlinear functions, and statistical tests are also available for identifying input variables that contribute to threshold effects, i.e., discontinuities in the output variables.

A computer code SCREEN has been developed for implementing the screening techniques. The efficiency has been demonstrated by several examples and applied to a fast reactor safety analysis code (Venus-II). However, the methods and the coding are general and not limited to such applications.

I. INTRODUCTION

The purpose of sensitivity screening techniques is to identify a group of most important input parameters of a computer code when the total number of input variables is large or comparable to the number of computer runs that can be carried out within the limits of time and economy. Important input parameters are those that contribute most to the total uncertainty of an output variable. Thus, the output variable is sensitive to these input variables, and significant uncertainties are associated with these input variables so that the combination of the two characteristics contribute to the output uncertainty.

A statistical screening procedure has been developed at Argonne National Laboratory and applied for ranking input parameters of a large computer code. The method is especially aimed for complex codes with a large number of input variables. The conventional sensitivity method of varying the input parameters one-by-one to obtain the partial derivatives of the output variables can be an expensive process and it often relies on linearity. If nonlinear terms are included it is often necessary to make somewhat arbitrary assumptions about higher order derivatives to cut down the number of computer runs.¹ Even many advanced statistical methods reported earlier²⁻⁴ need engineering judgement for initial screening of input parameters so that the final number submitted for the method is smaller than the number of data points (computer runs). The matrix method of Ref. 5 is relevant to the problem of many input parameters, but it also relies on linearity. Some earlier statistical works are described in Ref. 6.

This report presents a screening method that does not use subjective judgement to eliminate variables but deals with nonlinearities and many input parameters. Typical output variables of an accident-analysis code depend on many material properties and other input parameters. The uncertainty or variation of an output variable is determined by the uncertainties or variations of the input variables. The purpose of the sensitivity analysis method presented here is not to determine all sensitivity coefficients, i.e., first or higher order partial derivatives of an output variable with respect to all

input variables. The purpose is, rather, to determine a group of input variables that are most "effective" in the sense that their variation (uncertainty) causes most of the variation (uncertainty) of the output variable. Such information can be used to direct experimental work or physical modeling to important parameters or phenomena. Since the screening method uses a limited number of computer runs, the results obtained are true only to certain degree of probability, which increases as the number of runs increases.

One can also say that the purpose of the screening techniques is to identify a group of input parameters such that a relatively simple analytic function in terms of these parameters approximates the output variables well enough in the region of variation. Such approximating function is usually very economical to use in probabilistic Monte-Carlo studies.

The screening methodology is presented in Chapter II, including a comparison to the matrix method⁵ as well as a description of statistical tests that have to be done to assess the significance of the results at different stages of the analysis. Thus, standard statistical tables are needed in conjunction with this code. Verification of the method is illustrated in Chapters III and IV with several examples including a comprehensive sensitivity study on Venus-II accident analysis code. The user's manual for the computer code (SCREEN) developed to implement these techniques is presented in Chapter V. Program listing and input/output examples are given in the appendixes. A summary and possible future developments are described in Chapter VI.

II. SCREENING METHODS

A. The Procedure

The first task in the screening procedure is to determine the cases to be run with a deterministic accident-analysis code. This can be done by assigning probability distribution for all input variables to let the SCREEN code sample a certain number of cases, i.e., input value combinations. These combinations of parameter values are input to a deterministic accident-analysis code. The results of these deterministic consequence calculations are input to the second part of the SCREEN code that carries out the correlation and regression analysis to be described later in this report. Figure 1 illustrates the flow of information between the SCREEN code and a deterministic accident-analysis code.

B. Selection of Cases

Since the goal is to identify a group of most influential input variables using a relatively small number of computer runs, it is very important to select the input values for these cases so that the information content is maximized. This can not be achieved, for example, by varying input parameters one at a time, since every run would only contain information about one sensitivity coefficient, and the total number of cases needed would exceed the total number of input variables. Most of the standard "designs", (as the input value selection schemes are called in the response surface literature⁷) have the drawback that they require more cases than is the number of input variables. This makes most standard designs impracticable⁸ when one has tens or hundreds of input variables but wants to limit the number of runs to less than 100. It is evident that many or all of the input variables have to be varied from case to case to make sure that each case increases information about many input variables. One solution is to use random sampling. That is, for each case to be run, sample values for all input variables from certain probability (uncertainty) distributions.

Fig. 1. Use of SCREEN to Identify Effective Input Parameters.

Eight different distributions are available for this purpose in the SCREEN code. These are listed in Table I. Thus, continuous distributions are used rather than discrete levels. There is some justification to use uniform distributions in a sensitivity study, since that provides information evenly for the whole range of interest and also because the exact form of the distribution is usually not known. However, it is important to select the widths or standard deviations of the distributions as realistically as possible. For example, using 99% confidence intervals consistently for all variables ensures that the sensitivity/importance measures obtained by the screening procedure for different variables are meaningful for relative comparisons.

It may be worth mentioning here that systematic or stratified sampling⁹ is not considered necessary in this application, since it is very unlikely that too many variables would happen to have similar values in two different cases sampled. In any case, since the rest of the screening method and code (Part II) are independent of how the input values are selected (Part I), the user can select his own design without using the sampling options available in SCREEN. For example, Latin hypercube or fractional factorial designs⁷ may be used.

C. Stagewise Correlation Analysis

The screening is based on statistical methods available for selecting "best" regression equations. A brief description of the methods is given since they are slightly modified from standard techniques^{10,11}. The screening starts with a stagewise correlation analysis. The correlation coefficient between an input variable and an output variable is proportional to both the sensitivity coefficient and the uncertainty of the input variable, which product correctly reflects the importance. The impact of the input parameter most correlated with the output variable is subtracted from the data, and a new correlation analysis is performed for the residuals. The impact of the input parameter most correlated with the residual data is then subtracted, and a new correlation analysis is performed for the new residuals, and so on. This correlation procedure identifies parameters with strong linear or monotonic effect on the output.

TABLE I. Probability Distributions Available in the SCREEN Code

Name of Distribution	Functional Form	Parameters to be Specified
Uniform	$\frac{1}{b-a} ; a \leq z \leq b$	$a, b ; b > a$
Normal	$\frac{1}{\sigma \sqrt{2\pi}} e^{-(z-\mu)^2/2\sigma^2}$	$\mu, \sigma ; \sigma > 0$
Exponential I	$\frac{1}{\beta} e^{-(z-\alpha)/\beta} ; z \geq \alpha$	$\alpha, \beta ; \beta > 0$
Exponential II	$\frac{1}{\beta} e^{+(z-\alpha)/\beta} ; z \leq \alpha$	$\alpha, \beta ; \beta > 0$
Truncated Normal I	$\frac{K_a}{\sigma \sqrt{2\pi}} e^{-(z-\mu)^2/2\sigma^2} ; z \geq a, K_a = \frac{1}{1-F(a)}^*$	$a, \mu, \sigma ; \sigma > 0$
Truncated Normal II	$\frac{K_b}{\sigma \sqrt{2\pi}} e^{-(z-\mu)^2/2\sigma^2} ; z \leq b, K_b = \frac{1}{F(b)}^*$	$b, \mu, \sigma ; \sigma > 0$
Beta	$\frac{1}{b-a} \frac{\Gamma(\lambda+\eta)}{\Gamma(\lambda)\Gamma(\eta)} \left(\frac{z-a}{b-a}\right)^{\lambda-1} \left[1 - \frac{z-a}{b-a}\right]^{\eta-1} ; a \leq z \leq b$	$a, b, \lambda, \eta ; \lambda, \eta > 0, b > a$
Log-normal	$\frac{1}{\sigma z \sqrt{2\pi}} e^{-(\ln z - \mu)^2/2\sigma^2} ; z > 0$	$\mu, \sigma ; \sigma > 0$

* $F(x) = .5 + .5 \operatorname{erf} \left(\frac{x-\mu}{\sigma \sqrt{2}} \right)$

Assume that we want to identify input variables that explain more than a certain fraction β of the total variance of the output. For any sample size N (N = no. of output values = no. of computer runs) there is a probability α that an input variable which really is not important, appears as if it explains a fraction β or more of the total variation. Table II has been constructed from an F-distribution to give N for a selected β when $\alpha = 0.01$. The table also gives $F_{0.01}(1, N-2) = (N-2)\beta/(1-\beta)$. Similar tables can be constructed for other values of α by using the relation

$$\left(\frac{\alpha_1}{\alpha_2}\right)^2 \approx \frac{F_2}{F_1} \left[\frac{1 + F_2/(N-2)}{1 + F_1/(N-2)} \right]^{N-3}, \quad (1)$$

where F_1 and F_2 are the F-values corresponding to the tail probabilities α_1 and α_2 , respectively.

TABLE II. The Sample Size vs β for $\alpha = 0.01$

Sample N	Fraction β	$F_{0.01}(1, N-2)$
5	0.919	34.12
10	0.585	11.26
15	0.411	9.07
20	0.315	8.28
30	0.214	7.64
40	0.162	7.35
60	0.109	7.10
80	0.082	6.97
100	0.066	6.91

D. Successive Regression Analysis

The screening continues with a stepwise regression analysis, which is essentially a series of least-squares fittings of multivariate second-degree functions. This process is expected to identify parameters that may be mis-ranked in the correlation procedure. The regression is performed first with

quadratic functions of two parameters, going through all possible parameter pairs and identifying pairs that give a good fit to the data. The results obtained are used to select a seedgroup of parameters for the next phase. The regression analysis is then performed successively with overlapping groups of parameters, retaining parameters that have been found to be important (yielding small residual errors for the fitted function) and replacing the rest, going several times through all input variables. At each step the residual variance of the regression model of the parameter group is used as a criterion in selecting parameters for the next step. A measure of "spuriousness" has been developed that is the product of the residual variance and the total sensitivity of a model. It will be explained in the following section and it is also used as a selection criterion.

For a general nonlinear regression analysis the significance of adding an input variable to the model is tested by comparing the relative improvement in the residual sum of squares to an $F(N-K, N-M)$ -variable, when K is the number of coefficients in the seed model and M the number of coefficients in the tested (larger) model. The SCREEN-code prints out information facilitating such statistical testing.

E. Comparison with a Matrix Method

A linear-sensitivity matrix method is included in SCREEN and its efficiency has been compared with other methods. The modification made to the original method of T. Krieger et al.^{5,12} are: (1) the values of the input parameters are sampled from a continuous interval rather than from two discrete levels, and (2) the reference point is dealt with in the same way as any other data point.

The matrix method assumes a linear relationship between the input and output variables:

$$\bar{X}\bar{a} = \bar{y}, \quad (2)$$

where the components of $\bar{y}$ are the n output values (of a safety-analysis code), the components of $\bar{a}$ are the m ($m > n$) unknown sensitivity coefficients, and X is a rectangular matrix of dimension $n \times m$ with elements X_{ij} determined by the values of the input parameters in all n cases. An estimate for $\bar{a}$ is the special solution

$$\bar{a}_p = X^T (XX^T)^{-1} \bar{y}, \quad (3)$$

where X^T is the transpose of X . Equation 3 yields estimates for all m components of $\bar{a}$ even if the number of data in Eq. 2 is $n < m$. The estimate $\bar{a}_p$ minimizes the sum

$$\sum_{j=1}^m a_{pj}^2. \quad (4)$$

In regression analysis, the starting equation is

$$\bar{y} = X\bar{a} + \bar{\epsilon}, \quad (5)$$

where $m < n$ and the components ϵ_i of $\bar{\epsilon}$ are the residual errors of the regression model. The least-squares solution

$$\bar{a}_{ls} = (X^T X)^{-1} X^T \bar{y} \quad (6)$$

now yields the minimum of

$$\sum_{i=1}^n \epsilon_i^2. \quad (7)$$

The "spuriousness" referred to in Chapter II.D is defined in SCREEN as

$$\sqrt{\frac{1}{n-m} \sum_{i=1}^n \epsilon_i^2 \cdot \text{SENS}^2} \cdot \sigma_0^2, \quad (8)$$

where σ_0^2 is the variance of the original raw data, $(\bar{y})$ and SENS^2 is a sensitivity measure of the regression model, closely related to

$$\sum_{i=1}^m a_{lsi}^2 \quad (9)$$

The standard stepwise regression analysis using minimum residual error criterion only, Eq. (7), sometimes fails to identify an important input variable.^{10,13} The spuriousness criterion, Eq. (8), is provided in SCREEN as an alternative criterion for selecting seed groups of variables in each step of the regression procedure, to minimize the likelihood of missing important variables.

It may be worth mentioning that in our case the data $\bar{y}$ is free from random errors in the usual sense since it is obtained with a deterministic computer code that always produces the same $\bar{y}$ from the same input X . The error $\bar{\epsilon}$ in this case, Eq. (5), is due to the fact that our model $X\bar{a}$ is incomplete in general, due to both a limited number of parameters used, and the assumed form of dependency. The randomness of $\bar{\epsilon}$ is due to the fact that the input X is randomly sampled. Nevertheless, the standard equations and arguments of correlation and regression analysis can be followed, and the input parameters that yield a good fit are natural candidates for significant parameters. Some extra test runs may be needed at the end to demonstrate the significance.

F. Threshold Effect Analysis

The SCREEN code also includes techniques to identify input variables that contribute to threshold effects (discontinuities) of an output variable. Examples to these discontinuities in fast reactor safety analysis are the super-prompt criticality and the molten fuel-coolant interaction in hypothetical accidents: these thresholds may not be exceeded in the "base case" analysis, but variations in input parameter values can lead to the undesirable side of a threshold. It is important to determine which input variables most likely bring the accident scenario across the boundary. Many consequences are discontinuous across such boundaries, since quite different physical

phenomena may dominate on different sides of the threshold. Therefore, the correlation and regression methods developed earlier can be misleading or ineffective.

The techniques developed here are based on statistical testing of the differences of the conditional distributions of the input variables on both sides of a threshold. The method is again aimed for codes that have a large number of input variables so that studying the sensitivities one by one would be prohibitively expensive. The procedure uses the same data as the correlation and regression analysis, i.e., a reasonably small number $n < 100$ output values, calculated with randomly sampled input value combinations. The input variables X_i ($i = 1, 2, \dots, m$) are sampled from probability density functions $p_i(X_i)$, defined in Table I. The criterion function $y(\bar{X})$ for a threshold, such as the maximum reactivity or the interface temperature, has a conditional probability distribution $P_i(y > \alpha | X_i) = \text{probability that } y \text{ is greater than a given critical value, } \alpha, \text{ given that input variable no. } i \text{ has a value } X_i$. Based on the theory of conditional probabilities, the conditional density of X_i is

$$q_i(X_i | y > \alpha) = P_i(y > \alpha | X_i) p_i(X_i) / P(y > \alpha) , \quad (10)$$

where $P(y > \alpha)$ is the unconditional distribution of y ,

$$P(y > \alpha) = \int_{-\infty}^{\infty} P_i(y > \alpha | X_i) p_i(X_i) dX_i . \quad (11)$$

Now, if y does not depend on X_i , $P_i(y > \alpha | X_i) = P(y > \alpha)$, and Eq. (10) yields $q_i = p_i$, i.e., the density of X_i does not depend on whether $y > \alpha$ or $y < \alpha$. On the other hand, the more y depends on X_i , the more we expect q_i to deviate from p_i . The basis of the technique is to compare the characteristics of q_i and p_i ($i = 1, 2, \dots, m$) and determine for which i they are significantly different, thereby revealing parameters that contribute most to the threshold effect.

The condition $y > \alpha$ divides the sample of n accident analysis cases into subsets C_1 with n_1 cases ($y < \alpha$) and C_2 with $n_2 = n - n_1$ cases ($y > \alpha$). For example, a sample may include n_1 super-prompt-critical versus n_2 non-prompt-critical cases. The n values of a particular input parameter X_i are originally sampled from p_i for all n cases, but the sample mean value of the values in the subset C_1 is different from the mean value in the subset C_2 . Differencies in the standard deviations and extreme values can also be tested with the SCREEN code. Significant differencies imply the importance of X_i to the particular threshold effect. For example, the following characteristic is calculated in SCREEN for all $i = 1, 2, \dots, m$ and tested for significance¹⁴:

$$t_1 = (m_1 - m_2) \left[n_1 n_2 (n - 2) \right]^{1/2} / \left[n(n_1 s_1^2 + n_2 s_2^2) \right]^{1/2}, \quad (12)$$

where m_1 and m_2 are the sample mean values of X_i in the subsets C_1 and C_2 , respectively, and s_1 and s_2 are the sample estimates for the standard deviations in the subsets. The parameters t_1 is tested against a Student's t distribution with $n-2$ degrees of freedom. Other tests are also available for comparing m_1 with the total sample mean, and for comparing s_1^2 or s_2^2 with the original sampling variance. The parameters t_2 to be tested against a $t(n_1 - 1)$ distribution is

$$t_2 = \frac{m_1 - m}{s_1} \sqrt{\frac{(n_1 - 1)(n_1 + n_2)}{n_2}},$$

where m is the sample mean value $= (n_1 m_1 + n_2 m_2)/n$. The parameter t_1 is used when the criterion separating the two subsets is very clear and there is no uncertainty as to what subset each case belongs to. The parameter t_2 is used if only one subset (C_1) is "pure", while the complement subset C_2 may include cases that actually belong to the first subset.

An extreme value test is available for the smallest (or largest) value of X_i in subset C_1 , compared to that in the total sample. The test statistic is

$$z_{\text{extr}} = \frac{\text{Max} \left\{ \left| \frac{\text{Min}(z_j)}{c_1} - z_{j_2} \right|, \left| \frac{\text{Max}(z_j)}{c_1} - z_{j_1} \right| \right\}}{\sigma_j},$$

where z_{j_1} and z_{j_2} are the largest and smallest values of z_j in the total sample of n cases, and σ_j is the standard deviation of z_j . Extreme-value distributions are used in SCREEN for testing z_{extr} . The code calculates t_1 , t_2 , and z_{extr} for all input variables and lists 20 largest values of each.

III. CODE VALIDATION

To demonstrate the efficiencies of the screening methods, a problem with a known correct solution was analyzed. An example with 500 input variables was analyzed from 40 runs. The input variables x_i ($i = 1, \dots, 500$) were normalized and uniformly distributed between 0 and 1. The four output variables used in this study were

$$y_j = f_{j1} + 2f_{j2} + 3f_{j3} + 4f_{j4} + 5f_{j5} + \epsilon(\bar{x}); j = 1, 2, 3, 4, \quad (13)$$

where

$$f_{1i} = x_i, f_{2i} = x_i^2, f_{3i} = (x_i - 1/2)^2, \text{ and } f_{ji} = x_i x_{i-1}. \quad (14)$$

The term $\epsilon(\bar{x})$ is a "background" that depends on the input variables $x_6, \dots, x_{500}$ and contributes about 25% of the total variation of y_j . Evidently, the correct order of importance of the input variables is No. 5, 4, 3, 2, 1, with the rest of the variables less important than x_1 . The orders of importance obtained with different screening methods are listed in Table III for output variable y_2 . Even in this case with a nonlinear (but monotonic) y_2 , the correlation methods, as well as the matrix method of T. Krieger et al., work relatively well, about as well as for the linear output y_1 .

TABLE III. Orders of Importance Obtained with Different Methods for Output Variable y_2

Correlation Coefficients	Matrix Method ^a	Stagewise Correlation	Successive Regression Analyses/Criteria
5	5	5	4-5/ME ^b , MS ^c
2	2	4	3-4-5/ME
3	4	3	2-4-5/MS
4	297	280	3-4-5-254/ME
455	194	195	2-3-4-5/MS
297	426	2	2-3-4-5-300/ME
239	456	202	2-3-4-5-429/MS
340	3	306	
123	123	51	
51	84	349	

^aT. Krieger et al., Trans. Am. Nucl. Soc. 28, 515 (1978).

^bME: This group yields minimum residual error.

^cMS: This group yields minimum spuriousness.

The regression analysis with an increasing number of parameters clearly confirms the first three parameters and indicates that x_2 is also an important candidate. The statistics of 40 cases is not enough to identify x_1 as an important contributor. The standard stepwise regression analysis using minimum residual error criteria only (ME in Table III) missed input variable x_2 as an important one. The spuriousness referred to by MS in Table III is defined in Eq. (8).

For the nonlinear, nonmonotonic output variables y_3 and y_4 , neither the matrix method nor the correlation methods yield any significant results; the regression analyses are essential. The results obtained for y_3 are given in Table IV. For y_4 , the regression analysis was equally effective. These analyses were also performed for an increased number of runs and demonstrated that the efficiency of all methods improves with increasing sample size.

TABLE IV. Results for y_3 by Successive Regression

4-5/ME	2-3-4-5/ME,MS
5-280/MS	2-3-4-5-380/ME
3-4-5/ME	2-3-4-5-429/MS
2-4-5/MS	

The relative rankings of the input variables 1-5 with these three methods are presented in Figs. 2, 3, 4 for the nonlinear but monotonic output variable y_2 . Short horizontal lines in these figures indicate variables 6 to 500, which are known not to be really important ones. The correct ranking 5-4-3-2-1 is almost obtained by the stagewise correlation method with a sample size of 80, as indicated in Fig. 3.

Fig. 2. Ranking by Correlation Coefficients.

Fig. 3. Ranking by Stagewise-correlation Method.

Fig. 4. Ranking by Matrix Method.

In Figs. 2 and 4, variable 1 is not identified. The following conclusions can be drawn from these results:

1. There is a critical sample size (30-40 in this case) at which the correlation method can identify an effective input variable.
2. Even below the critical sample size, the *matrix method* ranks important variables toward the top of the list.
3. Above the critical sample size, the stagewise correlation method seems to be most effective. The matrix method and the correlation coefficients yield about identical results.
4. The successive regression analyses are essential for identifying input variables with nonlinear or nonmonotonic impact on the output (Table IV).

The threshold effect analysis, described in Chapter II.F, have also been demonstrated by using the same example of 500 input parameters and the functions y_1 and y_2 defined in Eq. (13). Notice that the criterion function y can be continuous across the threshold, but does not have to be. The order of importance obtained for the input variables with test thresholds $y_1 > 3.0$, 2.0, 1.0 and 0.0 are given in Table V. The sample sizes are $n_2 = 11, 22, 34,$

TABLE V. Orders of Importance Obtained with Student's Statistics

$y_1 > 3.0$	$y_1 > 2.0$	$y_1 > 1.0$	$y_1 > 0.0$
$n_2 = 11$	$n_2 = 22$	$n_2 = 34$	$n_2 = 42$
3	4	3	5
301	5	4	4
4	2	490	3
383	490	5	135
123	331	2	490
2	3	171	2

and 42 in these cases ($n = 80$). The tests seem to be effective even with a relatively small subset, compared to the number of input variables ($m = 500$). Similar results were obtained with y_2 . A few additional runs varying just the parameters at the top of the list would confirm which ones are really important (i.e., revealing parameters 5, 4, 3, 2). The number of computer runs needed in this technique is small compared to one-at-a-time studies. It should be mentioned also that the subset sample sizes (n_2) were too small for the correlation methods to identify important variables in these cases. Thus, testing subset statistics seems to be an effective way to identify input variables causing threshold effects. In an actual application, this technique has revealed that a high fuel swelling rate and initial porosity caused excessive steady-state temperatures in a fast reactor analysis with the SAS3D code.

With a nonmonotonic criterion function y_3 the mean value test is not effective, whereas tests based on comparison of standard deviations of the subsets are more effective.

IV. APPLICATIONS

The SCREEN code has been applied to Venus-II, a fast reactor disassembly-analysis code.¹⁵ The system analyzed was a demonstration-size LMFBR with a nominal power of 975 MWt. The postulated disassembly analysis was started from an elevated power and temperature level, assuming a voided core due to sodium boiling prior to the disassembly. Thirteen input parameters were varied in this study within the regions of variation given in Table VI. Experimental and theoretical evidence was used to determine the uncertainties for the material-property characteristics (A, B, F, H, I, J, K, L). The values in Table VI are assumed to represent approximately 99% confidence limits. For the initial-conditions variables (C, D, E, G, M), somewhat arbitrary uncertainty intervals were selected. For example, the reactivity ramp rates 50-90 \$/s are higher than what is usually considered a best estimate value for a CRBR-type reactor. Higher values were selected in this study mainly to cut down computer time.

TABLE VI. Input Parameters Varied in VENUS-II Sensitivity Study

Symbol	Definition	Nominal Value	Variation/ Uncertainty
A	Fuel vapor pressure factor	ANL-EOS ^a	Factor 1/2 to 4
B	Heat capacity of fuel	0.437 kJ/kg·K	± 12%
C	Radial restraint pressure	10 ⁴ pascals	± 50%
D	Initial reactivity	1.0 dollar	Factor 1 to 1.01
E	Reactivity insertion rate	70 dollar/s	± 20 dollars/s
F	Neutron generation time	0.5 μ s	± 20%
G	Initial power	50 P ₀ ^b	± 50%
H	Heat of fusion of fuel	280 kJ/kg	± 5%
I	Doppler coefficient	-0.00435	± 20%
J	Density of fuel	9152 kg/m ³	± 2%
K	Density of sodium	843 kg/m ³	± 1%
L	Density of steel	7787 kg/m ³	± 1%
M	Initial fuel temperature (ave.) ^c	2900 K	± 200%

^aStandard ANL equation-of-state in Venus-II.

^bP₀ = 975 MW, nominal steady-state power of the reactor.

^cThe melting point is 3040 K.

The screening was performed with respect to five different output variables considered to be meaningful indicators of potential core and vessel damage. These output variables were:

- (1) Total Energy at the end of excursion above operating temperature (E_t).
- (2) Energy in molten fuel at or above melting point (E_m).
- (3) Work potential from isentropic fuel-vapor expansion to 1 atm (W_1).
- (4) Mass of fuel vaporized in expansion to 1 atm (M_v).
- (5) Work potential from isentropic fuel-vapor expansion to the cover gas volume 20 m^3 (W_c).

The first two can be calculated directly with VENUS-II. To perform the isentropic expansion work and vapor calculation, a subroutine developed earlier¹⁶ was added to the VENUS-II code. The same equation of state (and input variables A and B) was used in the isentropic expansion calculation as was used in the VENUS-II disassembly phase.

Detailed damage-potential studies have shown the W_c , expansion work to cover-gas volume, is quantitatively the best measure of the damage potential. If the transient leads to the failure of the primary vessel, the fuel vapor is released to the containment building. In that case, M_v is a measure of the total source of radioactivity. For this reason, W_c and M_v are considered as the most relevant consequence variables.

Since we have 13 input variables, 14 runs with VENUS-II would be needed to solve all linear sensitivities. A complete second-degree model would have 105 coefficients to be solved. In this work, we decided to study how much information the screening procedure is able to extract from $N = 40$ cases, with randomly selected input values within the uncertainty intervals indicated in Table VI. To cover the region of interest, the values were sampled from

uniform sampling distributions for all input variables B through M and for a logarithmic variable $a = \ln(A)/69.979$ within the interval 0.99-1.02, which corresponds to a factor 1/2 to 4 for A.

Table VII summarizes the output-variable statistics. The ratios E_t/E_m , E_m/M_v , and W_1/W_c have small variations around the mean values, as compared with the large variations of the individual consequences. This indicates strong correlation between the consequence variables. The correlation between M_v and W_c can be presented as

$$M_v = 780 \text{ kg} + 5.5 W_c \frac{\text{kg}}{\text{MJ}} + \epsilon. \quad (14)$$

where the "scatter" ϵ has a standard deviation of 150 kg.

Table VII. Output-variable Statistics from 40 Random Cases

Symbol	Definition	Mean Value	Standard Deviation	Largest Value	Smallest Value
E_t	Total energy generated (MJ)	9579.	1472.	12710.	6635.
E_m	Energy in molten fuel (MJ)	8070.	1340.	11400.	5450.
W_1	Expansion work to 1 bar (MJ)	990.	343.	1859.	417.
M_v	Mass of vaporized fuel (kg)	2000.	463.	3046.	1117.
W_c	Expansion work to 20m ³ (MJ)	220.	89.	485.	82.
	E_t/E_m	1.19	0.06	1.40	1.09
	E_m/M_v	4.11	0.38	5.30	3.48
	W_1/W_c	4.61	0.60	5.90	3.80

The results of the screening process are presented in Table VIII for the work potential W_C . Listed are the input variables for which the F test indicated higher than 99% confidence. Variables identified at the 95% level are given in parentheses. The last column gives the residual errors of successive quadratic regression models and may be compared to the standard deviation of 89 MJ of the original raw data.

The results indicate that the uncertainties of the reactivity ramp rate (E) and Doppler coefficient (I) are most important to the uncertainty of the damage potential, but the heat capacity of the fuel (B) and the initial power level (G) are also effective. The group of six input variables, E, I, B, F, G and A, accounts for 99% of the total variance of W_C . The relative importance values of these variables in the order given are 1.00, 0.78, 0.53, 0.40, 0.35, and 0.28. These relative values include contributions from all terms in which the input variable appears, i.e., linear, quadratic, and product terms. The second-degree regression function (reponse surface) of these six variables is graphically presented in Fig. 5. The heat capacity B seems to become more important if the nominal value is increased. Increasing the initial power (G) or the Doppler coefficient (I), or decreasing the fuel-vapor pressure (A), would increase the sensitivities to these variables.

To verify the screening results, a conventional sensitivity analyses was carried out by varying input parameters one at a time. The most important sensitivities of W_C are presented in Fig. 6. The variations of the input parameters in these calculations were 40-80 \$/s for the ramp rate (E), 2740-3140 K for the average fuel temperature (M), factor 1-8 for the fuel-vapor pressure ($\alpha = 1.00$ to 1.03), and the intervals of Table VIII for the rest of the input variables.

The results in Fig. 6 confirm the screening results of Fig. 5, but also reveal some features due to a different reference point. For example, increasing the initial fuel temperature (M) above the reference (melting) point increases the computation time considerably, due to short time steps requested by early vaporization and displacement-reactivity feedback. If larger variations above the melting point are realistic, then M belongs to the

group of important input variables. (W_c is a nonmonotonic function of both A and M).

The work potential W_c as a function of the heat capacity (B) is almost constant below the reference point, but increases rapidly above the reference value. Transformations can be used to linearize such behavior and further improve the accuracy of the response surface.

TABLE VIII. Orders of Importance Obtained with Different Methods for Output Variables W_c

Correlation Coefficient	Stagewise Correlation	Successive Regression Analyses/Criteria	Residual Mean Square Error (MJ)
E	E	E-I/ME, MS ^a	44.
(I)	I	E-I-B/ME	37.
(B)	A	E-I-A/MS	41.
	F	E-I-B-A/ME	28.
	G	E-I-B-F/MS	28.
	(B)	E-I-B-A-F/ME, MS	16.
	(K)	E-I-B-F-G-A/ME, MS	7.

^aME = This group yields minimum residual error.

MS = This group yields minimum spuriousness.

Fig. 5 Best Regression Function of the Work Potential W_c .

Fig. 6. Individual Sensitivities of the Work Potential W_C .

The same data of 40 random cases used with SCREEN was also used with PROSA-2. It determined the response surface of W_C in terms of the six input variables identified by SCREEN and confirmed the regression coefficients. Then PROSA-2 was used to generate the probability distribution of W_C from 40 000 samples calculated from the response surface. The result is presented in Fig. 7. The horizontal error bar in Fig. 7 indicates that accuracy of the response surface. Since the sample of 40 000 is large, virtually no vertical error is present. The distribution of the 40 original random cases calculated with Venus-II (+ expansion subroutine) is also presented in Fig. 7. For this, the vertical error bars are large due to the small sample. Included in Fig. 7 is also a log-normal distribution fitted to the original 40 cases. However, no theoretical basis is known for the log-normal distribution in this case. The response surface simulation is preferable due to its superior overall accuracy.

The results of Fig. 7 were obtained using the original uniform distributions for the input variables. PROSA-2 can also use sampling distributions that are different from those used to select the original data points. In curves 1 and 2 of Fig. 8, the input variables have the same standard deviations but different distributions, uniform in curve 1 and normal in curve 2. Curve 3 was obtained with normal input distributions but standard deviations reduced so that the original 99% uncertainty intervals of the input variables correspond to ± 2.58 standard deviations. Curve 3 in Fig. 8 represents a realistic distribution of the work potential in this example.

Similar sensitivity studies were performed for other output variables of Table VII. For M_V , the screening gave the order of importance E, I, B, A, F, G, with relative importance values 1.00, 0.78, 0.77, 0.47, 0.41, and 0.25, respectively. The main reason for the "scatter" ϵ in Eq. 14 is that the fuel-vapor pressure uncertainty (A) and the specific heat (B) contribute more to M_V than to W_C , i.e., $\epsilon \approx \epsilon(A, B)$. A one-at-a-time sensitivity study confirmed these screening results. Figure 9 indicates that M_V in terms of A and B has a different behavior from that of W_C in Fig. 6.

Fig. 7. Probability Densities of the Work Potential W_c with Uniform Sampling Densities for the Input Parameters.

Fig. 8. Probability Densities of W_c with several Input Parameter Distributions.

Fig. 9. Sensitivities of the Mass of Fuel Vaporized, M_v .

Fig. 10. Sensitivities of the Energy in Molten Fuel, E_m .

Fig. 11. Sensitivities of the Total Energy, E_t .

For the other consequences W_1 , E_m , and E_t , the equation-of-state variables A and B turn out to be as important as E and I, respectively. The most important sensitivities of E_m are presented in Fig. 10 and those of E_t in Fig. 11. The total energy E_t is very sensitive to the initial temperature M, whereas E_m is not. The total energy E_t is proportional to the specific heat (B), a behavior very different from that of W_c in Fig. 6.

In summary, this study shows that the screening process reliably identifies important input variables for a safety-analysis code such as VENUS-II. This work also revealed some nonlinearities and sensitivities that were not evident from earlier sensitivity studies made on VENUS-II.¹⁶ Concerning material properties in particular, there seems to be some justification for attempts to determine the fuel specific-heat parameter (B) and the vapor pressure (A) more accurately than they are currently known. However, the uncertainty of A may be somewhat overestimated in Table VI. Use of a smaller uncertainty would reduce the sensitivity importance of A. The Doppler coefficient (I) and the reactivity ramp rate (E) currently cause most of the uncertainties in the disassembly damage potential. Thus, the greatest emphasis in the modeling should be directed toward determining correct conditions at the beginning of the disassembly calculation.

V. USER'S MANUAL FOR SCREEN

A. Program Summary

The program performs the following main functions:

1. The program selects values for the input parameters of a deterministic computer code from input-specified regions of interest. The regions are defined by probability distributions and confidence intervals. The program arranges the input values into combinations called "knot-points".
2. With output values ("consequences") from the deterministic code for each input-parameter combination provided above, the program identifies most important input parameters by using (1) stagewise correlation analysis, (2) successive regression analyses and (3) statistical testing of subset characteristics. The regression models used and evaluated are multi-variable second-degrees polynomials.
3. Produces input cards in correct format to a response surface analysis and simulation code PROSA-2, that calculates probability distributions of the output variables ("consequences").

The first step can be omitted if the user wants to use his own design of knot-points. The second and third steps would still be usable for screening and response surface calculations. Step three can be omitted if PROSA-2 will not be used.

The SCREEN code has been used mainly in conjunction with accident-analysis codes, but the methods and the programming are completely general and not limited to such applications.

B. Program Abstract

This program abstract is provided in the form recommended by the National Energy Software Center.

1. Name of Program: SCREEN
2. Computer for Which Program is Designed: IBM 370/195
3. Description of Problem: The problem is to determine a group of most important input parameters of a computer code when the total number of input variables is large, so large that standard sensitivity evaluations varying each input variable (one or two at a time) would be prohibitively expensive.
4. Method of Solution: As input data, the program needs the probability distributions and/or a specified interval for the input parameters of the deterministic computer code being evaluated. The first part of the program calculates input value combinations (knot-point coordinates) that serve as input for the deterministic code that calculates the values of interesting output variables (consequences) in the specified knot-points.

The output/consequence values in the knot-points are used in the second part of SCREEN to determine (1) which input variables are most correlated with the output/consequence values, using stagewise correlation techniques, (2) which input variables most likely contribute to discontinuities or threshold effects in the output variables, using statistical tests for subset characteristics, and (3) which group of input parameters yields the best significant regression model, using quadratic models and successive regression analyses with increasing number of parameters. The regression part evaluates all regressions of two variables and uses the principle of stepwise regression analysis for larger number of variables. A special feature is that both residual errors and special sensitivity/spuriousness indices can be used when selecting seed input variables for each step of the regression analysis. The significance of each added parameter of a model can be assessed by

F-statistics for regression models. The Students t-statistics and extreme value statistics are used for threshold effects testing.

5. Restrictions on the Complexity of the Problem: The maximum number of variable input parameters and consequence (output) variables that can be analyzed simultaneously are 1000 and 6, respectively. The restriction of six output variables is not serious since separate screening runs can be done for any additional consequence variables of interest.

When selecting the cases to be run (knot-points, in the first part of SCREEN) eight optional distributions are available for the input parameters, including uniform, exponential, normal, truncated normal, log-normal and beta distributions. Values for the input parameters are sampled from these distributions so that mutual independence of the parameters is preserved. This is important for the success of the correlation and regression procedures. (Correct correlations between input parameters, if any, can be applied when calculating probability distributions with the PROSA-2 code after the screening procedure).

6. Typical Running Time: The running time depends strongly on the size of the problem, i.e., number of input parameters (NTOT), knot-points (NRANKP) and the number of regression steps needed to complete the screening. For small problems (NTOT, NRANKP < 50) the total running time is typically a few seconds whereas large problems (NTOT $\approx$ 500, NRANKP $\approx$ 50) take several minutes per consequence (IBM 370/195).

7. Unusual Features of the Program: Compared to other screening techniques available the SCREEN program has several features that are somewhat unique.

- (1) The values of the input parameters (knot-point coordinates) are selected from a continuous distribution rather than from discrete levels. This provides information more evenly from the whole region of interest, and it also facilitates the use of nonlinear models. However, the user may also select his own design.

- (2) Quadratic regression models are used, rather than linear models.
- (3) The total number of input variables (NTOT) may be much larger than the number of cases (NRANKP), and no prior elimination of variables by judgement is needed.
- (4) The regression analysis in SCREEN is more extensive than the standard stepwise regression analysis procedure. All regressions are calculated with one-and two-parametric models, whereas stepwise procedure is used for multiparametric models. At each step the residual error criterion as well as a special sensitivity/spuriousness criterion (developed in this work) can be used for selecting seed parameters for the next step. This provides redundancy and confidence that significant models, parameter combinations, are not missed (as it is known to happen sometimes when the standard stepwise process is applied routinely).
- (5) Extreme value and t-tests are used to identify parameters important to threshold (discontinuity) effects.

8. Related and Auxiliary Programs: The SCREEN code can be used in conjunction with any separate deterministic code (typically an accident-analysis code) that provides data for screening.

The SCREEN code can also be used to generate input data for a response-surface analysis code PROSA-2 in correct format. However, SCREEN is a stand-alone code and does not need PROSA-2 for screening.

9. Status: SCREEN is operational at ANL and will be released to the National Energy Software Center.

10. References: References 8, 13, 20.

11. Machine Requirements: IBM 370/195, Card Read/Punch; Line Printer.

12. Programming Language Used: FORTRAN IV.

13. Operating System: IBM System 370/Model 195, Fortran IV (G) or (H) compiler with optimizer.

14. Other Programming or Operating Information or Restrictions:

- a. The program contains some FORMAT statements in the T Format code as well as ERR= and END= operatives in a READ statement. These are IBM extensions to ANS FORTRAN.
- b. The program calls uniform random numbers U (between 0 and 1) by the statement.

U = FLTRNF (0).

The FLTRNF function subprogram is a private library routine at ANL and should be provided separately in installations outside of ANL. Other random variates are calculated from U in the SCREEN code.

- c. Fixed dimensions cannot be used for the arrays (vectors and matrices) used in the regression analysis, because their size is determined by the number of parameters, knot-points and consequence variables in each job. Therefore, space for these arrays in the computer is organized using dynamic allocation.²¹ The main program SCREEN calls ANL library subroutines ALLOC2 and FREE2 that allocate and release correct space for the arrays that may vary from job to job.

15. Name and Establishment of the Author: J. K. Vaurio, FRSTMC, Argonne National Laboratory, Bldg. 207, 9700 South Cass Avenue, Argonne, Illinois 60439.

16. Material Available: Source decks, sample problem, job control cards and documentation.

17. Category: P, General Mathematical and Computing System Routines.

18. Keywords: Accident analysis, correlation, disassembly, discontinuity, probabilistic, random, regression, response-surface, risk, safety, sampling, screening, sensitivity, spuriousness, statistical, stepwise, threshold, VENUS.

C. Program Use

SCREEN can be directed to perform different tasks. The task to be executed is specified by the input variable JOBS. The tasks are described in Section IV.C.1. The input for each task is specified in Section IV.C.2. The flow diagram of the program is presented in Section IV.C.3, and the function of each subroutine is briefly described in Section IV.C.4.

1. Task Descriptions

Each execution of the program performs one of the following tasks, specified by the input variable JOBS. After each task, the program control returns to the beginning and a new job starts (if not stopped by an END-OF-FILE).

Task 1 (JOBS = 1): Knot-point Coordinates

- (1) Reads in distributions of all NTOT input parameters.
- (2) Calculates variation intervals for all input parameters based on the probability range variable PROB and the distributions of the parameters.
- (3) Randomly samples NRANKP sets of values for the NTOT input parameters (from the distributions within the intervals determined above). These sets, i.e., input value combinations, are called knot-points.

- (4) Prints and punches the knot-points, in a generic format as well as in the format determined in Subroutine SASIN.
- (5) If TEST = 0, returns control to the beginning and starts a new job (if not stopped by an EOF).
- (6) If TESTS = 1, calculates "consequences" in the knot-points using test subroutine TEXASS, and prints and punches these consequences. (This output can serve as input in later Tasks).

Task 2 (JOBS = 2): Stagewise correlation and subset properties

- (1) Reads in consequences as well as coordinates (values of input parameters) for the NRankP knot-points.
- (2) Calculates mean values and standard deviations of the consequences and input variables (from the sample of NEWKN or NRankP cases), as well as the largest and smallest value of each consequence in the subset of NEWKN cases. The histograms of the consequences are also calculated from the sample, and edited.
- (3) Calculates and edits 20 largest correlation coefficients between a consequence variable and the input parameters.
- (4) Subtracts the impact of the most correlating parameter from the original consequence data, and calculates the largest correlation coefficients between the residual consequence variable and the input parameters. Edits 20 largest coefficients for the residual consequence.
- (5) Repeats the subtraction and correlation analysis (stagewise correlation analysis) down to fourth residuals, for each consequence variable. Standard deviations of the residual consequences are also printed out, as well as F - statistics variables for significance testing.

- (6) Calculates and edits 30 largest correlation coefficient between input parameters from the sample. (Since in the sampling in Task 1, input variables are mutually independent, the correlations between them as calculated from the sample of size NRANKP are due to statistical variations rather than real. A large coefficient between input variables that both appear high in the stagewise correlation lists is a warning that both may not really be important).
- (7) Calculates characteristics of the input parameters in the subset of NEWNKN cases, compared to all NRANKP cases, to determine which input parameters may be important for causing a case to belong (or not belong) to the subset. These characteristics include 1) the deviation of the subset average from the true average, scaled by the standard deviation, 2) two Student's t-variables for testing the difference of two sample mean values, 3) deviations of the largest and smallest values in the subset from those in the total sample, 4) order statistics probabilities for these deviations. Based on these characteristics for all NTOT input parameters, 20 candidate parameters are listed that most likely cause or contribute to the subset categorization.
- (8) Returns control to the beginning and starts a new job (if not stopped by an EOF).

Task 3 (JOBS = 3): Regression analyses with two variables

Task 3 performs a series of successive regression analyses.

- (1) In subroutine GROUP1, performs least squares fitting of quadratic single-variable functions of the consequence variables. NTOT fittings are performed for each of the NCONS consequence variables, since the free (independent) variable goes one by one through all input

variables. The residual errors of each fit are calculated and 20 best fitting input parameters are listed. The total sensitivities of all fits are also calculated, and the spuriousness indeces are edited.

- (2) If JOBS3G > 2, subroutine GROUP2 performs least squares fitting of quadratic two-variable functions to the consequence variables. One of the two variables is the one that gave the best fit in GROUP1, the other one varies going through all other input parameters. The best fits by residual errors, spuriousness indeces and error statistics are edited. Then the permanent member of the variable pair is changed to the one that gave the smallest residual error, and the process is repeated.
- (3) If JOBS3G > 3, subroutine GROUP3 performs a procedure similar to GROUP2, except that minimum spuriousness is the criterion in selecting new seed variables (permanent members of the variable pairs).
- (4) If JOBS3G > 4, subroutine GROUP4 fits quadratic functions of two variables to the consequence variables, going through all parameters pairs, and calculates residual errors, lists 20 best fits and edit also spuriousness indeces. The total number of fits is $NTOT \times (NTOT - 1)/2$. GROUP4 is more complete and time consuming, than subroutines GROUP1, 2, or 3.
- (5) Calculates linear sensitivity estimates using essentially the matrix methods approach of Refs. 5 and 12. (This option is provided for making comparisons and testing the efficiency of various procedures). One hundred input parameters with highest sensitivity estimates are listed (all if $NTOT < 100$).

Task 4 (JOBS = 4): Successive regression analyses

Task 4 performs a series of least-squares fittings of multivariate second-degree functions. Since it would be too expensive in many cases to

perform all possible regressions with more than two variables, the results of Task 3 are first used to select candidate seed input parameter pairs for Task 4. For each seed pair (input parameters no. 15 and 162, for example), Task 4 fits all quadratic functions of three parameters, keeping two of the parameters the same (no. 15 and 162 in the example) and varying the third through all the rest of the input parameters. Task 4 also calculates the residual errors and spuriousness indices of the fitted models, and lists 10 best fitting triplets of the input parameters, together with information suitable for testing statistical significance of the added (third) input parameter. The sensitivity-importance of each input parameters in the model is also calculated.

The next step in screening is to select seed triplets, and let Task 4 to find best combinations of four input variables, and so on. Several seed groups can be input at the same time to be used in a single run.

Task 5 (JOBS = 5): Specific regression models

Task 5 fits multivariate second-degree functions (of user-specified input parameters) to the output (consequence) data and calculates residual errors and spuriousness indices for the fitted models. The sensitivity-importance of each input parameter in the model is also calculated. An arbitrary number of models can be fitted for each output variable in a single computer run.

No screening is performed automatically per se in task 5, i.e., only input-specified combinations of input parameters are used.

Task 6 (JOBS = 6): Knot-points for PROSA-2

Task 6 is normally used after the screening (Task 2, 3 or 4) has been completed, to generate input cards in correct format for the PROSA-2

code.^{8,19} Since PROSA-2 is used with a limited number of input variables (the number given by input variable NGPMAx) compared to the total number (NTOT), task 6 is used to pick up the values of the NGPMAx input parameters in the knot-points, and to punch those values in suitable format on cards. As input, task 6 needs the numbers of the SCREEN input parameters that are defined as the input parameters for PROSA-2, as well as all NRANKP knot-point cards used for SCREEN in task 2, 3 and 4.

2. Input Instructions

<u>Card 1</u>			
<u>Variable</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
NTOT	1-4	I4	Total number of input parameters (NTOT < 1000).
JOBS	5-6	I2	Task indicator (see Sec. IV.C.1).
PROB	7-16	F10.8	Probability range to select the sampling intervals for knot-point coordinates. Select PROB < 0.1.
NCONS	17-19	I3	Number of consequence (output) variables (< 6).
LINIT	21-25	I5	Consequence no. to be started from, in Task 3. (Default = 1).
JOBS3G	26-30	I5	Indicates what subroutines GROUP1 to GROUP4 are used in Task 3. (Default = 4).
TEST	34-36	I3	Control variable for testing, using subroutine TEXASS (TEST = 0, 1, 2, 3, 4, 5).
WORK	37-42	I6	Work number.
NCORR	43-47	I5	Not in use; set blank or zero.
NRANKP	53-57	I5	Number of cases, i.e., number of knot-points available (JOBS > 1) or to be selected (JOBS = 1).
NTRAPA	66-70	I5	Not in use; set blank or zero.
NTRACO	71-75	I5	Not in use; set blank or zero.
NGPMAX	76-78	I3	Maximum number of parameters to be included in the regression model (in Task 6 only).

Note 1: NCONS, LINIT, JOBS3G and NGPMAX are not used in Task 1 (JOBS = 1).

Note 2: Task 6 (JOBS = 6) only uses variables NTOT, JOBS, WORK, NRANKP and NGPMAX.

Additional Input

Additional input depends on the Task indicated by input variable JOBS.

Task 1 (JOBS = 1):Next NTOT Cards

<u>Variable</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
K	1- 3	I3	Parameter number (1 to NTOT)
NAME	4- 9	A6	Parameter name
JDIS	10-11	I2	Parameter-distribution indicator (1 < JDIS < 8).
UADIS	12-22	E11.5	First distribution parameter
UBDIS	23-33	E11.5	Second distribution parameter
UCDIS	34-44	E11.5	Third distribution parameter
UDDIS	45-55	E11.5	Fourth distribution parameter
JJK(12)	57-79	I2I2	Not in use.

Note: The distributions and distribution parameters in use are as follows:

JDIS	ADIS	BDIS	CDIS	DDIS
1 - Uniform	Upper limit	Lower limit	-	-
2 - Normal	Mean value	Standard deviation	-	-
3 - Exponential I	Lower limit	Scale constant	-	-
4 - Exponential II	Upper limit	Scale constant	-	-
5 - Truncated normal I	Mean value	Standard deviation	Lower limit	-
6 - Truncated normal II	Mean value	Standard deviation	Upper limit	-
7 - Beta	Mean limit	Upper limit	Mean value	Standard deviation
8 - Log-normal	Mean value	Standard deviation	-	-

Tasks 2, 3, 4, 5 (JOBS = 2, 3, 4 or 5):Card 2

The integer variable NEWNKN, format I5, in columns 1 to 5 indicates how many of the total NRANKP cases (knot-points) are used in the screening process. Thus, this provides the possibility to use a subset of all available cases (NEWNKN < NRANKP). If all cases are used, NEWNKN can be set to zero (or = NRANKP).

Next cards (if NEWNKN > 0)

Next card(s) indicate(s) the NEWNKN knot-point numbers (i.e., case numbers) that are included, each occupying 5 columns in format 16I5. One card is needed if $0 < \text{NEWNKN} < 17$, two cards if $16 < \text{NEWNKN} < 33$, etc.

Next NRANKP cards (Consequence cards)

These cards contain values for the NCONS consequence variables in all NRANKP knot-points.

<u>Variable</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
INDEX	1-2	I2	Not in use; set to 50.
KNOT	3-6	I4	Knot-point number (KNOT=1, 2, . . . , NRANKP).
CONS(1)	9-20	E12.6	The value of the first consequence variable at the knot-point KNOT.
CONS(2)	21-32	E12.6	The second consequence variable.
.	.		.
.	.		.
.	.		.
CONS(NCONS)		E12.6	The last consequence variable (maximum NCONS = 6).

Knot-point coordinates

NRANKP sets of knot-point coordinates are input here.

The first card of each set contains:

- (1) INDEX in columns 1-2, format I2, that should be set to 50;
- (2) KNOT in columns 3-6, format I4, indicating the knot-point number (KNOT = 1, 2, . . ., NRANKP);
- (3) The values of the first six input parameters in the knot-point KNOT, each occupying 12 columns in format G12.5.

The rest of the cards for each set (if NTOT > 6) contain values of the other input parameters in order, format 6G12.5, i.e., six parameters on each card, until all NTOT parameter values are given.

Thus, the total number of cards in this group is approximately NRANKP x NTOT/6.

Additional input for Task 4 only (JOBS = 4):

1. The first card in this group indicates how many seed groups will be used for each consequence in this run. These numbers ISINGL (L) are given in format 6I5, one number for each consequence (L = 1, 2, . . ., NCONS < 6).
2. One additional card is needed for each seed group to identify its members (i.e., the input parameters by their numbers). Each of these cards contains the following information:

<u>Variable</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
NSINGL	1-5	I5	Seed group identification number, specified by the user (not used by the program).
NGP	6-10	I5	Number of parameters in each regression group; recommended value NP + 1.
NP	11-15	I5	Number of parameters in the seed group ^a .
KORG(1)	16-20	I5	Number of the first parameter in the seed group.
KORG(2)	21-25	I5	Number of the second parameter in the seed group.
.			
.			
.			
KORG(NP)		I5	Number of the last parameter in the seed group.

^aNote: (NGP-NP) parameters are replaced at each step of the screening.

Additional input for Task 5 only (JOBS = 5)

Input for Task 5 is similar to that of Task 4, with the exception that NGP = NP. The parameter groups specified are not seed groups but specific groups of input parameters for which the regression analyses are performed.

Input for Task 6 only (JOBS = 6)

1. First input Card 1 that defines NTOT, JOBS (= 6), WORK, NRANKP and NGPMAX as described before.
2. Next NGPMAX cards define which NGPMAX input parameters (out of the total NTOT) will be used in a simulation with the PROSA-2 computer code.¹⁹ Each of these NPMAX cards contains two numbers:

<u>Variable</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
INDP(J)	1- 5	I5	The number of the input variable INDS(J) in the PROSA-2 calculations.
INDS(J)	6-10	I5	The number of the input variable in the SCREEN calculations.

Note: Normally INDP(J) = J (J = 1, 2, . . ., NGPMAX), and the numbers INDS(J) indicates the input parameters that have been found to be most important in the SCREEN calculations (Tasks 2, 3 or 4).

3. Next NRANKP sets of cards contain the values of the input parameters in all NRANKP cases (knot-points).

The first card of each set contains:

- (1) INDEX in columns 1-2, format I2. This number should be set to value 50;
- (2) KNOT in columns 3-6, format I4, indicating the knot-point number (KNOT = 1,2, . . ., NRANKP);
- (3) The values of the first six input parameters in the knot-point KNOT, each occupying 12 columns in format G12.5.

The rest of the cards for each set (if $NTOT > 6$) contain values of the other input parameters in order, format 6G12.5, i.e., six parameters on each card until all $NTOT$ parameter values are given.

Thus, the total number of cards in this group is approximately $NRANKP \times NTOT/6$.

3. Flow Diagram

The flow diagram of the program is presented in Fig. 12. The main control routine (MAIN) consists of four major parts as indicated in Fig. 12. These parts can be associated with Tasks 1 through 4 ($JOB = 1, 2, 3$ and 4) described in Section V. C. 1. These parts are not completely isolated from each other since certain portions of Part 1 are common to all tasks and special features cause interconnections between various parts of the MAIN program.

4. Subroutine Functions

Figure 12 shows the calling sequence and conditions for the subroutines. The function of each subroutine is described briefly below.

ABEND	Terminates execution due to allocation error in ALLOC2.
ALLOC2	Function subprogram in MAIN; dynamically allocates space for arrays used. Applied Mathematics Division library subprogram.
COMS	Comdeck COMS is a group of COMMON statements called by subroutines.
FITIN	Calculates correlations between input parameters and residual consequences variables, after seed-regression functions have been subtracted from the original consequence data (in Task 15).
FREE2	Releases space allocated by ALLOC2.

Fig. 12. Sequence of Subprograms in SCREEN.

GROUP1	<p>Fits second-degree functions of one input parameters to the consequence data and calculates residual errors.</p> <p>Finds a group of best fits, i.e., most influential input parameters.</p>
GROUP2	<p>Fits quadratic surfaces of two input parameters to the consequence data and calculates residual errors. Finds a group of best fits, i.e., most influential pairs of input parameters.</p>
GROUP3	<p>Similar to GROUP2, but the selection criterion is the product of the residual error and the sensitivity of the model.</p>
GROUP4	<p>Fits quadratic surfaces of two input parameters to the consequence data going through all possible pairs of input parameters.</p> <p>Calculates residual errors and finds a group of best fits, i.e., most influential pairs of input parameters.</p>
HIST0	<p>Calculates histograms of the consequence variables.</p>
INIT	<p>Sets initial value zeros.</p>
JOB51	<p>Calculates knot-point coordinates and variation intervals for input parameters.</p>
KNOTSS	<p>Calculates intervals for input parameters, using probability range input variable PROB.</p>
LISENS	<p>Calculates linear sensitivities with a matrix method.</p>
MAIN	<p>Overall control routine.</p>
MATINV	<p>Matrix inversion subroutine.</p>
MXMULT	<p>Matrix multiplication subroutine.</p>

PACORR	Calculates correlations between input parameters (from the sample used as knot-points).
PLOTFP	Plots the histograms (distributions) of the consequence variables.
PRINTH	Edits probability distributions and joint distributions.
PROSIN	Prepares input cards for PROSA-2 from those input to SCREEN.
PUNCH	User specified: Punches input cards for an external code that calculates consequences.
READIN	Reads in consequences and co-ordinates (values of the input parameters) of the knot-points. Calculates statistics of the raw input data and performs stagewise correlation analysis.
SAMPLE	Samples values for the input parameters from their distributions.
SASIN	User specified; Prepares input cards for an external code that calculates consequences. (Current format in the program package is consistent with SAS3D accident analysis code).
SCRAM	Fits multivariate quadratic functions to the consequence data, calculates residual error statistics and sensitivities of the models finds most influential input parameters and prints the response surface coefficients.
SSHIFT	Calculates subset statistics to detect deviations from the total sample, to discover threshold effects.
TEXASS	User specified; Calculates consequence values from analytical equations.

VI. SUMMARY

In summary, statistical sensitivity analysis techniques and a related computer code SCREEN have been developed for identifying and ranking most important input parameters of large computer codes. These screening techniques are especially aimed for complex codes with a large number of input variables such that standard non-statistical sensitivity studies searching for all first- and second-order derivatives would be too expensive. The current techniques determine a group of most important input parameters rather than sensitivities with respect to all input variables. The result of the procedure is correct only within a certain degree of confidence (probability) and can be verified with a few extra test cases.

The methods used are (1) stagewise correlation analysis to determine input variables most correlated with the output variables, (2) extended stepwise regression analysis to determine most significant input variables with quadratic regression models, and (3) statistical testing of subset characteristics to determine input variables causing or contributing to discontinuities of the output variables.

The values of the input parameters for the cases that are used in the screening process are selected randomly from a continuous interval rather than from discrete levels, to ensure uniform coverage. Since the number of cases is normally large enough (20 or more), no special effort is needed to spread the cases satisfactory over the region. The regression analysis procedure is extended from the standard stepwise procedure by calculating all regressions with one- and two-parametric models, and using both residual errors and a special sensitivity/spuriousness criterion in the stepwise process with multi-parameter models. This provides redundancy and adds confidence to the results.

The methods and the code have been applied extensively to test problems and to a fast reactor accident analysis code VENUS-II. These studies demonstrate the consistency of the screening techniques and provide detailed sensitivity information about VENUS-II.

Future efforts may be directed towards increasing the efficiency and automation of the statistical tests, graphical displays of the results, further optimization of the selection of cases (designs) and models, including functional transformations similar to those used in PROSA-2.¹⁹

Other avenues for sensitivity analysis development include development of perturbation methods using adjoint equations which is currently underway.²² This approach is complementary to the statistical screening techniques. It requires development of an adjoint code, the cost of which can in many cases exceed the cost of running the forward cases needed in statistical methods. On the other hand, statistical methods may not be the best solution to all problems.

APPENDIX A

Program Listing


```

MEMBER NAME MAIN
C MAIN SCREEN
  INTEGER ALLOC2
  COMMON /TERRA/ST(1)
  COMMON /LARGE/ T(1)
  COMMON /NFRIT/JOKE,JTWO,JTHREE
  COMMON /JOB/JOBSV
*CALL COMS
  COMMON /ZETAP/ZETA(100,6)
  COMMON /HISPL0/NHLS(6,12),NJOINT(6,6,12,12)
  COMMON /TRANSF/NTBAPA,NTRACO,JTEA(7),JTYPE(7),ITRA(7),LTYPE(7),APA(
17),BPA(7),ACO(7),BCO(7)
  COMMON /SAVE/SAVE(1000),ZSS(1000)
  DIMENSION ISINGL(6)
C
C MAIN PROGRAM
C MAIN PROGRAM USES ALLOC2 (DOCUMENTATION... ANDLIB VOL. VIII
C Z071S & ALLOC) TO DYNAMICALLY ALLOCATE SPACE FOR ARRAYS USED IN
C CURVE FITTING ROUTINES. SPACE NEEDED DEPENDS ON THE NUMBER OF
C PARAMETERS AND THE NUMBER OF CONSEQUENCES.
C   NWD5 ... IS THE TOTAL NUMBER OF WORDS IN THESE ARRAYS.
C   IPATFI ... DETERMINES THE PRECISION OF THE ARRAYS.
C             (1=SINGLE, 2=DOUBLE, 4=QUADRUPL)
C   T ... ALLOCATED ARRAY WHERE THE OTHER ARRAYS (ZF,ETC.) ARE STORED
C IN THE CALL DRIVER STATEMENT, THE ADDRESS OF THE FIRST LOCATION OF
C EACH ARRAY IS PASSED, AND DRIVER USES THE ARRAYS AS DIMENSIONED IN
C DRIVER (TWO DIMENSION, DOUBLE PRECISION). ALLOC2 RETURNS IERR AS
C AS NEGATIVE IF THE ALLOCATION IS UNSUCCESSFUL. ABEND IS AN ABNORMAL
C TERMINATION DUMP.
C
  DATA IREAD,IWRITE,IPUNCH/5,6,7/
C
  3 CONTINUE
C READ JOB INFO
  READ(IREAD,1001,END=989) NTOT,JOBS,PROB,NCONS,LIMIT,JOBS3G,TEST,WO
1BK,NCORR,NRANKP,NTRAPA,NTRACO,NGPMAX
1001 FORMAT(I4,I2,F10.8,I3,I5,I5,3X,I3,I6,I5,5X,I5,8X,215,I3)
C ECHO OUTPUT
  WRITE(IWRITE,1002) WORK,JOBS,NTOT,PROB,NCONS,TEST,NCORR,NRANKP,NTR
1APA,NTRACO,NGPMAX
C NGPMAX IS USED IN JOBS=6 ONLY, MAXIMUM NUMBER OF MODEL PARAMETERS
C WITH NRANKP KNOT-POINTS
C
1002 FORMAT(1H1,15X,28HPARAMETER SCREENING WORK NO.,I7,7H, JOBS=,I3,///
11H+,5X,26HTOTAL NUMBER OF PARAMETERS,6H NTOT=,I5/1H ,5X,23HPROBABI
2LITY RANGE PROB=,F10.8/1H ,5X,29HNUMBER OF CONSEQUENCES NCONS=,I4,
3/1H ,5X,18HTEST OPTION TEST=,I3/1H ,5X,26HNO. OF CORRELATIONS NCO
4RP=,I3,/1H ,5X,33HNO. OF RANDOM KNOT-POINTS NRANKP=,I4/1H ,5X,40HN
5O. OF PARAMETER TRANSFORMATIONS NTRAPA=,I3/1H ,5X,42HNO. OF CONSEQ
6UENCE TRANSFORMATIONS NTRACO=,I3/1H ,5X,45HMAXIMUM NO. OF PARAMETE
7RS IN A GROUP, NGPMAX=,I3//)
C
C LIMIT INDICATES THE CONSEQUENCE NUMBER TO BE STARTED FROM IN JOBS=3
C JOBS3G INDICATES WHAT SUBROUTINES GROUP1 TO GROUP4 ARE CALLED JOBS=3
  IF(LIMIT.LE.0) LIMIT = 1
  IF(JOBS3G.LE.0) JOBS3G = 4
  IF(JOBS.EQ.3) WRITE(IWRITE,1003) LIMIT,JOBS3G
1003 FORMAT(1H ,5X,42HTHE ANALYSIS STARTS FROM CONSEQUENCE NO. LIMIT =,
115/1H ,5X,32HSUBROUTINES GROUP1 THROUGH GROUP,11,10H ARE USED //)

```

MEMBER NAME MAIN

```

      JOBSV = JOBS
      NKNOT = NANKP
      NKCTSV = NANKP
C NKNOT=NANKP,BUT NANKP ONLY IN THE COMMON BLOCK, NKNOT IS PASSED
C DEFAULT FOR NGPMAX
      PKNOT = 2.* FLOAT(NKNOT) +0.2500
      PKNOT = SQRT(PKNOT)
      NSUP = INT(PKNOT - 1.50)
      IF(NGPMAX.LE.0.OR.NGPMAX.GT.NSUP) WRITE(IWRITE,1501) NGPMAX,NSUP
1501 FORMAT(1H,6X,13HINPUT NGPMAX=,I3,2X,11HREPLACED BY,I3//)
      IF(NGPMAX.LE.0.OR.NGPMAX.GT.NSUP) NGPMAX = NSUP
      NFAPA = NTOT
C NFAPA IS IN COMMON BLOCK CONS , NTOT IS NOT
      IF(JOBS.EQ.6) CALL PROSIN(NGPMAX)
      IF(JOBS.EQ.6) GO TO 3
C
C DYNAMIC ALLOCATION FOR JOBS1 AND PERMANENT FOR JOBS.GT.1
C
C DIMENSION ST
      IBATPI = 2
      NWDSP = 11 * NTOT + IBATPI* NANKP* (NTOT + NCONS) + 20
      KLOCP = ALLOC2(IERR,NWDSP)
      IF(IERR.GT.0) GO TO 129
      WRITE(IWRITE,1050) NWDSP
1050 FORMAT(1H,10X,36HERROR--UNABLE TO ALLACATE SPACE FOR ,I6,23H SING
1LE PRECISION WORDS,/11X,24HEXECUTION WILL FERMINATE)
      CALL ABEND
129 CONTINUE
      JLOC = LOC(ST)
      IOFFST = (KLOCP - JLOC)/4
      IPA = 1 + IOFFST
      IDI = IPA + NTOT
      IAD = IDI + NTOT
      IBD = IAD + NTOT
      ICD = IBD + NTOT
      IDD = ICD + NTOT
      ISZ = IDD + NTOT
      IER = ISZ + NTOT
      IZ0 = IER + NTOT
      IZ1 = IZ0 + NTOT
      IZ2 = IZ1 + NTOT
      IZP = IZ2 + NTOT
      ICF = IZP + NTOT * NANKP * IBATPI
      WRITE(IWRITE,1039) NWDSP,IOFFST,KLOCP,JLOC
1039 FORMAT(8H0 NWDSP=,I10,10H IOFFST= ,I10,2X,6HKLOCP=,I9,7H JLOC=,I
110//)
      CALL JOBS1(ST(IPA),ST(IDI),ST(IAD),ST(IBD),ST(ICD),S
1T(IDD),ST(IZ0),ST(IZ1),ST(IZ2),ST(IZP),NTOT,NKNOT)
C CALCULATE AND PRINT 22,20,21
      CALL KNOTSS(ST(IPA),ST(IDI),ST(IAD),ST(IBD),ST(ICD),ST(IDD),ST(IZ0
1),ST(IZ1),ST(IZ2),NTGT)
      IF(TEST.NE.1) GO TO 93
C PUNCH TEST CONSEQUENCES
      DO 92 I=1,NANKP
      WRITE(IPUNCH,1622) INDEX,I,(ZETA(I,L),L=1,NCONS)
      WRITE(IWRITE,1621) INDEX,I,(ZETA(I,L),L=1,NCONS)
      92 CONTINUE
1621 FORMAT(1H,6X,215,(6E16.6))

```

```

MEMBER NAME MAIN
1622 POPMAT(17,14,2X,(6F12.6))
93 CONTINUE
IF (JOBS.EQ.1) GO TO 3
C END OF JOBS1
CALL READIN(ST(IZE),ST(ICP),NTCT,NKNOT)
C
C NKNOT AND NPANKP MAY HAVE CHANGED IN READIN,
C KNOTSV SAVES THE ORIGINAL VALUE
C
C
CALL PACORR(ST(IZR),ST(IZO),NTCT,NKNOT,KNOTSV)
C
CALL SSHIFT(ST(IPA),ST(IDI),ST(IAD),ST(IRD),ST(ICD),ST(IDD),ST(IZ3
1),ST(IZ1),ST(IZ2),ST(IZR),NTOT,NKNOT,KNOTSV)
IF (JOBS.EQ.2) GO TO 3
C END OF JOBS2
C ALL DATA IS IN, SCREENING STARTS
MLOC = LOCF(T)
NCONSV = NCONS
NCONS = 1
IF (JOBS.GE.4) GO TO 301
DO 300 L=LIMIT,NCONSV
WRITE(IWRITE,1043) L
1043 FORMAT(1F1, //35H FITTING REGRESSIONS TO CONSEQUENCE,I3/)
DO 200 NPARA = 1,2
N = NPAPA
NCOEF2 = 1 + 2*N + ((N*(N-1)) + 1)/2
NWDS = IRATPI * NCOEF2 * (2*NKNOT + NCONS + NCOEF2) + 10
KLOC = ALLOC2(IERR,NWDS)
IF (IERR.GT.0) GO TO 130
WRITE(IWRITE,1050) NWDS
CALL ARFND
130 CONTINUE
IOFPT = (KLOC - MLOC)/4
IZP = 1 + IOFPT
C RE1EMBER NCONS = 1 HERE
IBF = IZP + NKNOT * NCOEF2 * IRATPI
IZPP = IPP + NCOEF2 * NCONS * IRATPI
IAMAT = IZPP + NKNOT * NCOEF2 * IRATPI
IEND = IAMAT + NCOEF2 * NCOEF2 * IRATPI - IOFPT
WRITE(IWRITE,1040) NWDS,IPND,IOFPT,KLOC,MLOC
1040 FORMAT(9H0 NWDS = ,I10,9H IEND = ,I10,2X,7HIOFPT = ,I10,2X,6HKLOC
1= ,I10,2X,6HMLOC = ,I10/)
IF (NPARA.EQ.1) CALL GROUP1(T(IZP),T(IBF),T(IZPP),T(IAMAT),ST(IZR),
1ST(ICP),NTOT,NKNOT,NCOEF2,ST(IZO),ST(IZ1),ST(IZ2),KNOTSV)
IF (NPARA.EQ.2.AND.JOBS3G.GE.2)
1 CALL GROUP2(T(IZP),T(IBF),T(IZPP),T(IAMAT),ST(IZR),
1ST(ICP),NTOT,NKNOT,NCOEF2,ST(IZO),ST(IZ1),ST(IZ2),KNOTSV)
IF (NPARA.EQ.2.AND.JOBS3G.GE.3)
1 CALL GROUP3(T(IZP),T(IBF),T(IZPP),T(IAMAT),ST(IZR),
1ST(ICP),NTOT,NKNOT,NCOEF2,ST(IZO),ST(IZ1),ST(IZ2),KNOTSV)
IF (NPARA.EQ.2.AND.JOBS3G.GE.4)
1 CALL GROUP4(T(IZP),T(IBF),T(IZPP),T(IAMAT),ST(IZR),
1ST(ICP),NTOT,NKNOT,NCOEF2,ST(IZO),ST(IZ1),ST(IZ2),KNOTSV)
CALL PFEF2(KLOC,NWDS)
200 CONTINUE
201 CONTINUE
N = NPARA

```

```

MEMBER NAME MAIN
C PREPARE AND ALLOCATE FOR MAXIMUM GROUP SIZE
C IT FITS A SECOND DEGREE SURFACE OF THE PARAMETERS OF THE GROUP TO
C THE CONSEQUENCE DATA AND EVALUATES THE RESIDUAL ERRORS, THEN GOES
C TO THE NEXT GROUP. IT EDITS TEN BEST GROUPS (SMALLEST RESIDUAL MEAN
C SQUARE ERRORS) AND THE SENSITIVITIES OF THE PARAMETERS IN EACH GROUP
C THE BASE GROUP IS INPUT SPECIFIED BY THE PARAMETER NUMBERS
C KORG(I), I.E. 10, ACTUALLY I=1,...,NP.
C SEVERAL BASE GROUPS CAN BE USED IN THE SAME JOBS (WORK) FOR EACH
C CONSEQUENCE. ISINGL(I) IS THE NUMBER OF BASE GROUPS FOR CONSEQ. I.
C
C NGP HAS TO BE GT. NP IN JOBS 4, BECAUSE NP IS THE NUMBER OF PERMANENT
C MEMBERS OF THE GROUP, AND NGP IS THE TOTAL NUMBER IN THE GROUP.
C (NGP - NP) IS THE NUMBER OF PARAMETERS CHANGED
C
C JOBS 5 FITS INDIVIDUAL SECOND DEGREE SURFACES OF INPUT SPECIFIED
C PARAMETERS (IT DOES NOT AUTOMATICALLY GO THROUGH ALL PARAMETERS)
C FOR JOBS 5 ISINGL(I) INDICATES THE NUMBER OF INDIV. GROUPS FOR CONS.
C I. NGP=NP IN JOBS 5 FOR EACH GROUP (EACH GROUP IS BASE GROUP)
307 CONTINUE
C LINEAR SENSITIVITIES WITH MATRIX METHOD, BLOCK 600 INSTRUCTIONS
DO 600 L=LIMIT,NCONSV
WRITE(IWRITE,1063) L
1063 FORMAT(1H1, //53H LINEAR SENSITIVITIES BY MATRIX METHOD, CONSEQUENCE, I3/)
NCOEF1 = NTOT + 1
NWDS = IRATPI*(NCOEF1*(2*NKNOT + NCONS) + NKNCT*NKNOT)
KLOC = ALOC2(IERR,NWDS)
IF(IERR.GT.0) GO TO 630
WRITE(IWRITE,1050) NWDS
CALL ABEND
630 CONTINUE
IOFFT = (KLOC - MLOC) / 4
IZF = 1 + IOFFT
C STILL NCONS=1, NCONSV SAVES ORIGINAL NCONS
IBF = IZF + NKNCT*NCOEF1*IRATPI
IZFP = IBF + NCOEF1*NCONS*IRATPI
IAMAT = IZFP + NKNCT*NCOEF1*IRATPI
IEND = IAMAT + NKNCT*NKNCT*IRATPI - IOFFT
WRITE(IWRITE,1040) NWDS, IEND, IOFFT, KLOC, MLOC
CALL LISFNS(T(IZF), T(IBF), T(IZFP), T(IAMAT), ST(IZE), ST(ICF), ST(IZO),
1, ST(IZ1), ST(IZ2), NTOT, NKNCT, NCOEF1, KNOTSV)
CALL FREF2(KLOC, NWDS)
600 CONTINUE
C END OF LINEAR SENSITIVITY MATRIX METHOD BLOCK
IF(JOBS.FQ.3) GO TO 3
301 CONTINUE
C JOBS4 STARTS
C JOBS 4 KEEPS A SUBGROUP OF PARAMETERS WITHIN THE GROUP AND CHANGES THE REST
IF(JOBS.GE.4) READ(IREAD,5001) (ISINGL(I), I=1,6)
C JOBS5 IS FOR SINGLE GROUPS, NO SCREENING
C ISINGL(I) INDICATES HOW MANY SINGLE GROUPS FOR CONSEQUENCE I
IF(JOBS.FQ.5) WRITE(IWRITE,5002) (ISINGL(I), I=1, NCONSV)
5001 FORMAT(6I5)
5002 FORMAT(1H1, 8X, 36HJOBS = 5, SINGLE GROUPS TO BE FITTED/1H0, 8X, 42HNO
14REPS OF GROUPS FOR THE CONSEQUENCES ARE, 6I6/)
IF(JOBS.FQ.4) WRITE(IWRITE,5003) (ISINGL(I), I=1, NCONSV)
5003 FORMAT(1H1, 8X, 60HJOBS = 4, NUMREPS OF INITIAL GROUPS FOR THE CONSE
1QUENCES ARE/1H0, 8X, 6I6//)

```

```

MEMBER NAME MAIN
      DC 400 L=1,NCONSV
      ISIMAX = ISINGL(I)
      IF (ISIMAX.LE.3) GO TO 400
      WRITE(IWRITE,2000) L
      DO 400 ISI=1,ISIMAX
2000  FORMAT(1P,10X,25HSCREENING FOR CONSEQUENCE,I3//)
      READ(IREAD,2001) NSINGL,NGP,NP,(KORG(I),I=1,10)
      C
      C
2001  FORMAT(3I5,10I5)
      410 CONTINUE
      WRITE(IWRITE,2002) NSINGL,NGP,NP,(KORG(I),I=1,10)
      C NSINGL IS NOT USED BY THE PROGRAM, IT IS FOR USERS IDENTIFICATION ONLY
      C
      C
2002  FORMAT(1H,8X,16HINPUT GROUP //1H,28HNSINGL NGP NP PARAME
1TERS/1H,3I5,10I5//1H,8X,54HNSINGL= IDENTIFICATION NUMBER FOR THE
2INITIAL GROUP /1H,8X,42HNGP = NUMBER OF PARAMETERS IN EACH G
3ROUP/1H,8X,57HNP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EAC
4H STEP//)
      C
      C
      C NGP - NP = NUMBER OF PARAMETERS REPLACED AT EACH STEP
      C
      IF(NGP.LE.0.OR.NGP.GT.NSUP) WRITE(IWRITE,2003) NSUP
      IF(NGP.LE.0.OR.NGP.GT.NSUP) NGP = NSUP
2003  FORMAT(1H,8X,15HNGP IS RESET TO,I3//)
      C
      C
      IF(JOBS.EQ.5.AND.NP.NE.NGP) WRITE(IWRITE,2004) NP
      IF(JOBS.EQ.5.AND.NP.NE.NGP) NGP = NP
      IF(JOBS.EQ.15.AND.NGP.NE.NP) NGP = NP
2004  FORMAT(1H,8X,14HNGP RESET TO,I3,25H=NP BECAUSE JOBS = 5 //)
      C
      C
      C
      IF(JOBS.NE.5.AND.JOBS.NE.15.AND.NP.GE.NGP) WRITE(IWRITE,2005)
2005  FORMAT(1P,8X,39HINCONSISTENT NSINGL, NGP AND NP, I PASS//)
      IF(JOBS.NE.5.AND.JOBS.NE.15.AND.NP.GE.NGP) GO TO 400
      C
      C
      N=NGP
      NCOEF2 = 1 + 2*N + ((N*(N-1)) + 1) / 2
      NWDS = IPATFI * NCOEF2 * (2*NKNCT + NCONS + NCOEF2)
      C
      C
      KLOC = ALLOC2(IPPR,NWDS)
      IF(IERP.GT.0) GO TO 430
      WRITE(IWRITE,1050) NWDS
      CALL ABFND
2006  CONTINUE
      IOFFT = (KLOC - NLOC) / 4
      C
      C
      IZF = 1 + IOFFT
      IFF = IZF + NKNCT * NCOEF2 * IPATFI
      IZFP = IFF + NCOEF2 * NCONS * IPATFI
      C

```

```

MEMBER NAME MAIN
C NCONS = 1
C
  IAHAT = IZFP + NKNOT * NCOEF2 * IRATFI
  IEND = IAHAT + NCOEF2 * NCOEF2 * IRATFI - IOFFT
C
C
  WRITE(IWFITE,1040) NWDS,IPND,IOFFT,KLOC,MLJC
  CALL SCRAM(T(IZF),T(IBF),T(IZFP),T(IAHAT),ST(IZF),ST(ICF),STOT,NKN
  OT,NCOEF2,ST(IZG),ST(IZ1),ST(IZ2),KNOTSV)
C
C
  CALL FREE2(KLOC,NWDS)
  IF(JOBS.GT.4) GO TO 399
  WRITE(IWFITE,3001) L,NSINGL
3001 FORMAT(1H1,9X,65HTHE REFERENCE GROUP FITTING IS NOW PERFORMED FOR
  THIS CONSEQUENCE,I4,3X,16H, GROUP NSINGL =,I6//)
  IE = (NGP+1) * (NGP+2) / 2
  NE = NFRANKP - NE
  KE = NP - (NP+1) * (NP+2) / 2
  WRITE(IWFITE,3002) NP,NGP,IE,KE,NE
3002 FORMAT(1H,5X,52HFOR TESTING THE SIGNIFICANCE OF THE ADDED PARAMET
  1ERS//1H,5X,51H( USS(NP) - USS(IG) ) * (NFRANKP - N)/( K * USS(IG))
  2//1H,5X,53HMAY BE COMPARED TO AN F(K,NFRANKP-N) VARIABLE /
  31HC,6X,76HUSS(NP) = RESIDUAL SUM OF SQUARES FOR THE BASE GROUP OF
  4NP PARAMETERS , NP =,I4//1H,8X,85HUSS(IG) = SAME FOR A LARGER GRO
  5UP IG WITH NGP PARAMETERS, INCL. THE BASE GROUP, NGP =,I4/6H)
  6,8X,22HIE = (NGP+1)*(NGP+2)/2 =,I4//1H,13X,25HE = N - (NP+1)*(NP+2
  7)/2 =,I4//1H,13X,12HNFRANKP - N =,I5/1H1)
  NGP = NP
  JOBS = 5
  GO TO 41G
399 JOBS = JOBSV
400 CONTINUE
  GO TO 3
985 STOP 1
END

```

BPM NAME CONS

*CONDECK CONS

```

      INTEGER WORK, TEST
      REAL NAMEA, NAMEB
      COMMON/INTGR1/      JORS, L
      COMMON/KNOT/        TEST, INDEX, J, K, NPARA
      COMMON/KNOTC/        PROB
      COMMON/KNOT1/ZMJ, ZIJ, ZIJJ, ZMK, ZIK, ZIJK, ZCJ, ZCK, ZETH, ZETI, ZETIX
1, ZETC, ZETCJ, ZETCK, DJ, CJ, DJK, SJ
      COMMON/TEX/ CONS(6)
      COMMON/GROUP/MSINGL, MGP, MP, KORG(12)
      COMMON/HISTOC/ APZETA(6), AVZET(6), SDZET(6), SCALE, MCGNS
      COMMON/RIGCON/
2          SEMAX(6), JMAX(6), SECMAX(6), KMAX(6), SIMSD(6),
3      CPLOT(9), ZPLOT(9)
      COMMON/PPH1/ AJCINT(12), ERR(12), MC, MD
      COMMON/CONDIT/ MCF(4), LCR(4), PCR(4)
      COMMON/FLAG/ IFLAG
      COMMON/CORREL/ITYPE(12), ILEAD(12), IDEP(12), PLEAD(12), FORP(12),
INCORR
      COMMON/ALPHA/ ALFA(12, 12)
      COMMON/HOMP/CM1(12), CM2(12), CM3(12), CM4(12), CM11(12, 12), COR(12, 12)
      COMMON/COMCO/ CORREL(6, 6), SINCOR(6, 6)
      COMMON/CFROUT/A(6), MSA, WORK
      COMMON/NEAN/NPANKP

```

*DECK

```

12ENSEN NAME FITIN
      SUBROUTINE FITIN(ZR,CFNEW,NTOT,NKNOT)
C
C  USED IF AND ONLY IF INPUT JOBS=15, FITIN CALCULATES CORRELATIONS
C  (AS IN JOBS 2) FOR RESIDUALS AFTER THE SEED REGRESSION RESULT (AS OF
C  JOBS 5) IS SUBTRACTED FROM THE ORIGINAL DATA CONSEQUENCES
C
C  CALLED BY SCRAM
C
C
      REAL*8 Z,ZP,CFNEW
*CALL CONS
      COMMON/ZETAR/ZETA(100,6)
      DIMENSION CFNEW(100,1)
      DIMENSION Z(1000)
      DIMENSION ZR(NKNOT,NTOT)
      DIMENSION SPCOR(20), JORG(20), SPVAR(20), SPMEAN(20)
C
      DATA IREAD,IWRITE,IMINA/5,6,5/
      COMMON/TRANSF/NIRAPA,NTPACO,JTRA(7),JTYPE(7),LTRA(7),LTYPE(7),APA(
17),BPA(7),ACO(7),BCO(7)
C
C  INITIAL ZERCS
C
      RKMEAN = 0.
      RKCH2 = 0.
      RKMAX = -1.0E+49
      RKMIN = +1.0E+49
C
      WRITE(IWRITE,2000)1.
2000 FORMAT(1H1,10X,21HRESIDUAL CONSEQUENCES,13/1H ,7X,5HINDEX,10X,4HKN
10T,/)
      DO 11 K = 1,NRANKP
      RKCONS= CFNEW(K,1)
      INDEX = 50
      KNOT = K
      WRITE(IWRITE,2002) INDEX,KNOT,RKCONS
C
C
C
C
      RKMEAN = RKMEAN + RKCONS
      RKCH2 = RKCH2 + RKCONS * RKCONS
      IF(RKCONS.GT.RKMAX) RKMAX = RKCONS
      IF(RKCONS.LT.RKMIN) RKMIN = RKCONS
11 CONTINUE
C
C  CFNEW IS A WORKING PLACE,ZETA PERMANENT STORAGE
C
2002 FORMAT(1H ,6X,15,8X,14,(6E16.6))
C
C
C
C
      WRITE(IWRITE,3000)
      RKAVE = RKMEAN / NRANKP

```



```

MEMBER NAME FITIN
      RKMEAN = RKAVE
C
C
      RKVAR = RKC12 / NRANKP - RKAVE * RKAVE
      DMRAN = NRANKP - 1
      DM = NRANKP
      RKVAR = RKVAR * DM / DMRAN
      RKC12 = RKVAR
      RKS1 = 0.
      IF (RKVAR.GT.0.) RKS0 = SQRT (RKVAR)
      WRITE (IWRITE,3001) L, RKAVE, BRSD, RKMAX , RKMIN
C
C
3001 FORMAT ('0 CHARACTERISTICS OF RANDOM KNOT POINT SAMPLE CONSEQUENCES
C
C
C
      1/'0 CONSEQUENCE      MEAN VALUE STD DEVIATION MAXIMUM VALUE MI
      1MINUM VALUE'/)
3001 FORMAT (1H0,6X,I4,4X,G14.5,1X,G14.5,1X,G14.5,1X,G14.5)
C READIN 2
C
C
C
C
C THIS PART OF READIN CALCULATES AND EDITS NMAXP LARGEST CORRELATION
C COEFFICIENTS BETWEEN A CONSEQUENCE AND THE PARAMETERS
      NMAXP = MIN0 (20, NTOT)
      DO 110 I=1, NMAXP
        SP1EAN(I)=0.
        SPCOP(I)=0.
        SPVAR(I)=0.
        JORG(I)=0
110 CONTINUE
      WRITE (IWRITE,4000) L
4000 FORMAT ('H0,8X,40H CORRELATION COEFFICIENTS FOR CONSEQUENCE,I4,12H.
1PARAMETERS//3H ,5HPARAMETER,2X,25H CORR.COEFF. SQUARE P/)
      DO 112 J=1, NPARA
        SZMEAN=0.
        SZVAR=0.
        SCOR=0.
        DO 113 KN=1, NRANKP
          ZPR=ZR(KN,J)
          SZMEAN=SZMEAN + ZPR
          SZVAR=SZVAR + ZPR*ZPR
          SCOR= SCOR + ZPR*(CFNFD(KN,1) - PKMEAN)
113 CONTINUE
        SZMEAN=SZMEAN/NRANKP
C FROM NOW ON Z(J) IS USED
C SAVE SZMEAN'S IN THIS SUBROUTINE
        Z(J)=SZMEAN
        SZVAR=SZVAR/NRANKP - SZMEAN * SZMEAN
        SCOR= SCOR/NRANKP
        SCCR= SCOR/SQRT (SZVAR*RKC12 *DMRAN/DM)
        ABSCCR= ABS(SCOR)
        DO 114 J=1, NMAXP
          ABSP= ABS(SPCOP(I))
          IF (ABSP.GT. ABSCCR) GO TO 114

```

MEMBER NAME FITIM

```

      INDMAX=NMAXP - 1
      DO 115 IND=1,INDMAX
        JK=NMAXP +1 - IND
        IKP=JK - 1
        SPMEAN(IK)=SPMEAN(IKP)
        SPCOR(IK)=SPCOR(IKP)
        SPVAR(IK)=SPVAR(IKP)
        JOEG(IK)=JOEG(IKP)
115    CONTINUE
        SPMPAN(I)=SZMEAN
        SPCOR(I)=SCOR
        SPVAR(I)=SZVAR
        JOEG(I)=J
        SCOR=0.
        ABSCOR=0.
114    CONTINUE
112    CONTINUE
        NDF=NRANKP - 2
        DO 120 I=1,NMAXP
          JB=JOEG(I)
          SC=SPCOR(I)
          RSQ= SC * SC
          FVAR= NDF * RSQ
          WRITE(IWRITE,4001) JB,SC,RSQ,FVAR
4001    FORMAT(1H,5X,I4,F10.5,F10.5,F10.5/)
120    CONTINUE
          WRITE(IWRITE,4002) NDF
4002    FORMAT(1H,5X,30HCOMPARE LAST COLUMN TO AN F(1,,13,9H) VARIABLE//)
          JB1 = JOEG(1)
          SZSD1= SQRT(SPVAR(1))
          B1 = SPCOR(1) * SQRT(RKCM2 ) / SZSD1
          WRITE(IWRITE,4003) JB1, SZSD1, B1
4003    FORMAT(1H0,5X,30HTHE MOST CORRELATING PARAMETER,13,/1H,5X,29HHAS
          1SAMPLE STANDARD DEVIATION,612.5/1H,5X,24HREGRESSION COEFFICIENT 8
          2,5X,612.5//)
C   RESIDUAL CONSEQUENCES
      DO 200 K=1,NRANKP
        CFNEW(K,1)=CFNEW(K,1)-FKMEAN-B1*(ZB(K,JB1) - Z(JB1))
200    CONTINUE
C   CORRELATIONS WITH THE RESIDUAL CONSEQUENCE
      DO 210 J=1,NMAXP
        SPCOR(I)=0.
        SPVAR(I)=0.
        JOEG(I) = 0
210    CONTINUE
        DO 212 J=1,NPAKA
          SVAR=0.
          SCOF=0.
          SZVAR=0.
          DO 213 KN=1,NRANKP
            ZRF=ZB(KN,J) - Z(J)
            SEUR=CFNEW(KN,1)
            SCOF=SCOF + ZRF*SEUR
            SVAP=SVAP + SEUR*SEUR
            SZVAR=SZVAR + ZRF*ZRF
213    CONTINUE
          DNP= NRANKP -1
          SVAP = SVAP/ NRANKP

```

YESR22 NAME PITIN

```

      SZVAR = SZVAR / NFRANKP
      SCOR = SCOR / NFRANKP
      SCOP = SCOR / SQRT(SVAR*SZVAR)
      ABSCOR=ABS(SCOR)
      DO 214 I=1,NMAXP
      ABSP=ABS(SPCOR(I))
      IF(ABSCOR.LT.ABSP) GO TO 214
      INDMAX = NMAXP - I
      DO 215 IND=1,INDMAX
      IK=NMAXP + * - IND
      IKP = IK - 1
      JORG(IK) = JORG(IKP)
      SPCOR(IK) = SPCOR(IKP)
      SPVAR(IK) = SPVAR(IKP)
215  CONTINUE
      JORG(I) = J
      SPCOR(I) = SCOR
      SPVAR(I) = SZVAR
      SCOR = 0.
      ABSCOR = 0.
214  CONTINUE
212  CONTINUE
      SDEV = SQRT(SVAR)
      WRITE(IWRITE,4099) L,SDEV
4099  FORMAT(1E,3X,11HCONSEQUENCE,I3,2X,28HRESIDUAL STANDARD DEVIATION=
1,G12.5//)
      WRITE(IWRITE,4100) L
4100  FORMAT(1H0,6X,36HCORRELATIONS OF RESIDUAL CONSEQUENCE,I4,16H WIT
1H PARAMETERS//37F PARAMETER CORR.COEF. SQUARE F/)
      DO 220 I=1,NMAXP
      JB=JORG(I)
      SC= SPCOR(I)
      RSQ = SC * SC
      FVAR = NDF * RSQ
      WRITE(IWRITE,4001) JB,SC,RSQ,FVAR
220  CONTINUE
      WRITE(IWRITE,4002) NDF
C
C
      JB2 = JORG(1)
      SZSD2 = SQRT(SPVAR(1))
      B2 = SPCOR(1) * SQRT(SVAR) / SZSD2
      WRITE(IWRITE,4103) JB2, SZSD2, B2
4103  FORMAT(1H0,5X,32HTHE SECOND CORRELATING PARAMETER,I4,/3H ,28HHAS
1SAMPLE STANDARD DEVIATION,G12.5/1H ,5X,24HREGRESSION COEFFICIENT B
2,5X,G12.5/)
C
C SECOND RESIDUALS OF THE CONSEQUENCES
      DO 300 K=1,NFRANKP
      CFNEW(F,1)=CFNEW(K,1) - B2*(2E(K,JB2) - Z(JB2))
300  CONTINUE
C CORRELATIONS WITH SECOND RESIDUALS
C
C
C
      DO 310 I=1,NMAXF
      SPCOR(I) = 0.
      SPVAR(I) = 0.

```

MEMBER NAME FITTIN

```

      JORG(I) = 0.
310  CONTINUE
      DO 312 J=1,NPARA
      SVAR = 0.
      SCOP = 0.
      SZVAR = 0.
      DO 313 KH = 1, NBRANKP
      ZRR = ZR(KH,J) - Z(J)
      SEUF = CFMEU(KH,1)
      SCOR = SCOP + ZRR * SEUR
      SVAR = SVAR + SEUR * SEUR
      SZVAR = SZVAR + ZRR * ZRR
313  CONTINUE
      DNP = NBRANKP - 1
      SVAR = SVAR / NBRANKP
      SZVAR = SZVAR / NBRANKP
      SCOR = SCOR / NBRANKP
      SCCB = SCOP / SQRT(SVAR * SZVAR)
      ABSOR=ABS(SCOR)
      DO 314 I=1,NMAXP
      APSP = ABS(SPCOR(I))
      IF(ABSOR.LT.ABSP) GO TO 314
      INDMAX = NMAXP - I
      DO 315 IND=1,INDMAX
      IK = NMAXP + 1 - IND
      IKP = IK - 1
      JOEG(IK) = JOEG(IKP)
      SPCOR(IK) = SPCOR(IKP)
      SPVAR(IK) = SPVAR(IKP)
315  CONTINUE
      JORG(I) = J
      SPCOP(I) = SCOR
      SPVAR(I) = SZVAR
      SCOR = 0.
      ABSOR = 0.
314  CONTINUE
312  CONTINUE
      SDEV = SQRT(SVAR)
      WRITE(IWRITE,4099) L,SDEV
      WRITE(IWRITE,4109) L
4109  FORMAT(1H0,6X,39H CORRELATIONS OF RESIDUAL CONSEQUENCE,14,16H WITH
      1H PARAMETERS//37H PARAMETER CORR.COEF. SQUARE F/)
      DO 320 I=1,NMAXP
      JR = JORG(I)
      SC = SPCOR(I)
      RSQ = SC * SC
      FVAR = NDF * RSQ
      WRITE(IWRITE,4001) JB,SC,RSQ,FVAR
320  CONTINUE
      WRITE(IWRITE,4002) NDF
C
C
      JB2 = JORG(1)
      SZSD2 = SQRT(SPVAR(1))
      B2 = SPCOR(1) * SQRT(SVAR) / SZSD2
      WRITE(IWRITE,4104) JB2,SZSD2,B2
4104  FORMAT(1H0,5X,31H THE THIRD CORRELATING PARAMETER,13/1H ,5X,29H HAS
      1SAMPLE STANDARD DEVIATION,312.5/1H ,5X,26H REGRESSION COEFFICIENT

```

```

NUMBER NAME PITIN
      2 B,5X,G12.5/)
C  THIRD RESIDUAL STANDARD DEVIATION
      DO 400 K=1,NBANKP
        CPNEW(K,1) = CPNEW(K,1) -B2*(ZP(K,J82) - Z(J82));
      400 CONTINUE
C  STANDARD DEVIATION OF THE THIRD RESIDUALS
      SVAE = 0.
      DO 413 KK=1,NBANKP
        SEUR = CPNEW(KK,1)
        SVAE = SVAE + SEUR*SEUR
      413 CONTINUE
      SVAE = SVAE/ NBANKP
      SDEV= SQRT(SVAE)
      WRITE(IWRITE,4099) L,SDEV
111  CONTINUE
      RETURN
      END

```

```

12ND28 NAME GROUP1
      SUBROUTINE GROUP1(ZP,BF,ZPF,AMAT,ZR,CF,NTOT,NKNOT,NCOEF2,ZO,Z1,Z2,
      1KNOTSV)
      C
      C FITS QUADPATIC SURFACES TO THE CONSEQUENCE DATA, NPARA=1, NCONS=1
      C
      C OUTPUT OPTIONS
      C
      C IOUT = 0 , MINIMUM OUTPUT
      C IOUT = 1 , ERROR STATISTICS OUTPUT FOR ALL PARAMETERS
      C IOUT = 2 , ERRORS OUTPUT IN ALL KNOTS FOR ALL PARAMETERS
      C
      *CALL CONS
      REAL *R ZP,BF,ZPF,AMAT,ZR,CF,CFA,I,DZJ,DZX
      COMMON/TRANSP/ETRAPA,ETRACO,JTPA(7),LTBA(7),LTYPE(7),JTYPE(7),APA(
      17),BPA(7),ACO(7),BCO(7)
      COMMON/HEBIT/JONF,JTWO,JTHREE
      C
      C
      DIMENSION ZP(NKNOT,NCOEF2),BF(NCOEF2,1),ZPF(NCOEF2,NKNOT)
      DIMENSION AMAT(NCOEF2,NCOEF2),ZR(KNOTSV,NTOT),CF(KNOTSV,1),ZO(NTOT
      1)
      DIMENSION Z1(NTOT),Z2(NTOT)
      COMMON/ZETAP/ZETA(100,6)
      DIMENSION SENST(20),ERMS(20),JORG(20)
      DIMENSION ERS(20)
      DATA IWRITE/6/
      DATA IOUT/0/
      DATA WBIG,WSMA,WMS/0.0,0.0,1.0/
      C
      C
      C THE VALUE OF I (CONSEQUENCE INDEX) IS DETERMINED IN MAIN THRU CONS
      C PARAMETER CYCLING INSIDE GROUP1 WITH VARIABLE JP
      C
      C NPARA = 1 IN THIS SUBROUTINE, NTOT = TOTAL NO. OF PARAMETERS
      C NCONS=1 IN THIS SUBROUTINE, NCONSV=NO. OF CONSEQUENCES, KNOWN TO MAIN ONLY
      C
      JTWO = 0
      PFOMIN = 1.0E+48
      WRITE(IWRITE,167C)
      167C FORMAT('F1,3X,20H**SUBROUTINE GROUP 1//')
      C
      DO 5 J = 1,NCOEF2
      DO 1 M = 1,NCOEF2
      1 AMAT(M,J) = 0.0D0
      DO 5 K = 1,NRANKF
      ZF(K,J) = 0.0D0
      5 ZPF(J,K) = 0.0D0
      DO 7 M = 1,NCOEF2
      7 BF(M,1) = 0.0D0
      DO 9 J=1,NRANKF
      9 CF(J,1)=ZETA(J,1)
      C
      C
      NMAXP=JINO(20,NTOT)
      DO 110 I=1,NMAXP
      JORG(I)=0
      110 ERMS(I) = 1.0E+49
      SENST(I)=0.

```

MEMBER NAME GROUP1

```

C
C   DEFINE MATRIX ZF AND ZFP
C
      DO 500 JF=1,NTOT
      IF(IOUT.GT.0)
1680 1WRITE(IWRITE,1680) JP
      FORMAT(1H0,3X,2GHEXPLAINING PARAMETER,I4/)
      DO 2 KNCT=1,NPANKP
C
      ZP(KNCT,1)=1.000
      ZFP(1,KNCT)=1.000
      DO 3 J=1,NPABA
      J1=J+1
      J2=J1+NPABA
      J3= NPABA+1 + J*NPABA - J*J1/2
      DZJ=ZP(KNCT,JP)-ZP(JP)
      ZP(KNCT,J1)=DZJ
      ZP(KNCT,J2)=DZJ*DZJ
      ZFP(J1,KNCT)=DZJ
      ZFP(J2,KNCT)=DZJ*DZJ
      IF(J.GE.NPABA) GO TO 3
C
C
C   DO LOOP 4 IS BYPASSED IN GROUP 1
C
      DO 4 K=J1,NPABA
      K1=J3+K
      DZK=ZP(KNCT,K)-ZP(K)
      ZP(KNCT,K1)=DZJ*DZK
4      ZFP(K1,KNCT)=DZJ*DZK
3      CONTINUE
2      CONTINUE
C   THE NEXT THREE STATEMENTS SOLVE LEAST SQUARES FITTING EQUATION
C   (ZP'ZF)FP = ZP'CF FOR BP
C
      CALL MMULT(ZFP,CF,BF,NCOEF2,NPANKP,NCONS,KNOTSV)
      CALL MMULT(ZFP,ZP,AMAT,NCOEF2,NPANKP,NCOEF2,NPANKP)
      CALL MATINV(AMAT,NCOEF2,BP,NCONS,DET2,ICOR)
      ICOR = ICOR * 30
      IF(IOUT.GE.1)
1690 1WRITE(IWRITE,2300) DET2,ICOR
      FORMAT('DETERMINANT OF ZFP*ZF = ',G15.6,' TIMES 1.0D',I4)
C
C   CALCULATE AND OUTPUT FITTED SURFACE ERRORZ: MAXIMUM AND MINIMUM,
C   MEAN SQUARE ERROR, REFERENCE VALUE AND FRACTIONAL ERROR.
1690 1FORMAT(1H0,10X,23H*FITTED SURFACE ERRORS*/1H0,5X,4HKNCT,6X,13HAPPR
10XIMATION,8X,5HEXACT,10X,10HDIFFERENCE,5X,15HFOR CONSEQUENCE,I4/)
      DN = NPANKP - NCOEF2
      IF(DN.LE.0) DN = 1.0E-10
      SUMSQ = 0.0
      BIG = -1.0E+49
      IBIG = 1
      SMALL = 1.0E+49
      ISMALL = 1
      IF(IOUT.EQ.2) WRITE(IWRITE,1690) L
      DO 21 JP=1,NPANKP
      CFA = 0.1
      DO 22 IC=1,NCOEF2

```

```

124828 NAME GROUP1
      CPA=CPA + 7P(IP,IC) * BP(IC,1)
22 CONTINUE
      X=CPA - CF(IR,1)
      IF(X.GT.BIG) IBIG =IR
      IF(X.GT.BIG) BIG = X
      IF(X.LT.SMALL) ISMALL =IR
      IF(X.LT.SMALL) SMALL = X
      IF(IOUT.EQ.2) WRITE(IWRITE,1700) IR,CPA,CF(IR,1),X
C
C
      SUMSQ = SUMSQ + X*X
21 CONTINUE
      IF(IOUT.GT.0)
        WRITE(IWRITE,1701) L,IBIG,BIG,ISMALL,SMALL
      IF(NTRACO.LE.0) GO TO 99
C MAX ERROR CONSEQUENCES TO BE INVERSE TRANSFORMED
      LTP = 0
      DO 701 I=1,NTRACO
        LL = LTRA(I)
C
C
        IF(LL.NE.I) GO TO 701
        LTP = LTYPE(I)
        AC = ACO(I)
        BC = BCO(I)
        CPBIG = CF(IBIG,L)
        CPABIG = CPBIG + BIG
C
C
        CFSMA = CF(ISMALL,L)
        CPASMA = CFSMA + SMALL
        GO TO (101,200,300,400,500,600,700),LTP
101 BCC = 1./BC
C
C
        CPBIG = CPBIG**BCC + AC
        CPABIG = CPABIG**BCC + AC
        CFSMA = CFSMA**BCC + AC
        CPASMA = CPASMA**BCC + AC
C
C
        GO TO 701
200 CPBIG = EXP(CPBIG) + AC
        CPABIG = EXP(CPABIG) + AC
        CFSMA = EXP(CFSMA) + AC
        CPASMA = EXP(CPASMA) + AC
        GO TO 701
300 CPBIG = BC*ALOG(CPBIG) + AC
        CPABIG = BC*ALOG(CPABIG) + AC
        CFSMA = BC*ALOG(CFSMA) + AC
        CPASMA = BC*ALOG(CPASMA) + AC
C
C
        GO TO 701
400 CPBIG = BC*TAN(CPBIG) + AC
        CPABIG = BC*TAN(CPABIG) + AC
        CFSMA = BC*TAN(CFSMA) + AC
        CPASMA = BC*TAN(CPASMA) + AC

```


1E1B23 NAME GROUP1

```

C
C
500 CONTINUE
600 CONTINUE
700 CONTINUE
701 CONTINUE
    IF (LTYPE.EQ.3) GO TO 99
    BIG = CPABIG - CFBIG
    SMALL = CPASMA - CFSMA
    PRABIG = BIG/CFBIG
    FPASMA = SMALL/CFSMA
    WRITE (IWRITE,7001) CPABIG,CFBIG,BIG,PRABIG
    WRITE (IWRITE,7002) CPASMA,CFSMA,SMALL,PRASMA
7001 FORMAT(1H+,4X,20HINVERSE TR MAX,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HEXACT=,F12.5,2X,9HFRACTION=,F10.6/)
C
C
7002 FORMAT(1H+,4X,20HINVERSE TR MIN,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HEXACT=,F12.5,2X,9HFRACTION=,F10.6/)
99 CONTINUE
C
C ERRORS INVERSE TRANSFORMED
C
    FMSE = SQRT(SUMSQ/DN)
    IF (BF(1,1).EQ.0.) FRAERR = 0.0
    IF (BF(1,1).NE.0.0) FRAERR = FMSE / DABS(BF(1,1))
    IF (IOUT.GE.1)
        IWRITE(IWRITE,1702) FMSE,BF(1,1),FRAERR
1702 FORMAT(1H+,4X,14,3X,E16.6,2X,E15.6,4X,E15.6)
1701 FORMAT(1H+,12H*CONSEQUENCE,14,3X,15HMAX ERROR KNOT=,I4,7H VALUE=,E
116.6,3X,15HMIN ERROR KNOT=,I4,7H VALUE=,E15.6/)
1702 FORMAT(1H+,20H MEAN SQUARE ERROR=,E15.6,11H REF VALUE=,E15.6,3X,1
10HFRACTION =,F9.5/)
    IF (IOUT.GE.1)
        IWRITE(IWRITE,1703) NKNOT,MCOEF2,SUMSQ
1703 FORMAT(1H+,9X,8HMFANKP =,I4,9X,8HMCOP2 =,I4,9X,25HSUM OF RESIDUAL
1 SQUARES =,G13.5//)
    AA = BF(1,1)
    BB = BF(2,1)
    CC = BF(3,1)
C
C
    DZ1 = Z1(JP) - ZC(JP)
    DZJ2 = Z2(JP) - ZC(JP)
    SENSIT = ABS((BB + CC*DZ1) * DZ1) + ABS((B9 + CC* DZJ2) * DZJ2)
C
    FMTE = WBIG*BIG+ WMS*FMSE - WSM*SMALL
    SIN = SDZET(L)
    SO2 = SIN * SIN
    FMTE2 = FMTE*FMTE
    IF (FMTE2.GF.SO2) GO TO 30
    FACTOP = FMTE2/(SO2-FMTE2)
    PRCD = SENSIT * FACTOP
    IF (PRCD.IT.PROMIN) JTWO = JP
    IF (PRCD.IT.PROMIN) PROMIN = PRCD
C
    DO 114 I=1,NMAXP
    VFET=FRMS(I)

```

```

MEMBER NAME GROUP1
      IF (FMTE.GT.VERT) GO TO 114
      INDMAX = NMAXP - 1
C
C
      DO 115 IFD=1,INDMAX
      IK=NMAXP + 1 - IND
      IKF= IK - 1
      EPS(IK)=EPS(IKF)
      JOFG(IK)=JORG(IKF)
C
      ERS(IK) = EPS(IKF)
C
115  SENST(IK)=SENST(IKF)
      JORG(I)=JP
      ERMS(I) = FMTE
      SENST(I)=SENSIT
      ERS(I) = FACTOR * SENSIT
      FMTE = *.1E+49
      SENSIT=0.
114  CONTINUE
C
C
C
C
      30 CONTINUE
800  CONTINUE
C
C  AVERAGE ERROR IS NOT EQUAL TO THE MEAN SQUARE ERROR EXACTLY
      WRITE(IWRITE,4000)
4000 FORMAT(1H0,6X,51HPARAMETERS IN THE ORDER OF INCREASING AVERAGE ERR
10P/1H0,53H PARAM AV. ERROR SENSITIVITY SPURIOUSNESS //)
      WRITE(IWRITE,4001) (JORG(I),ERMS(I),SENST(I),ERS(I),J=1,NMAXP)
4001 FORMAT(1H,5X,(16,3G12.5))
      WRITE(IWRITE,4002) PRONIN,JTWO
4002 FORMAT(1H,5X,19HSMALLEST SPURIOUSNESS IS,6I2.5,14H FOR PARAMETER,14/)
      JONE = JORG(1)
      RETURN
      END

```

```

1234567 NAME2 GROUP2
      SUBROUTINE GROUP2(ZF,BF,ZFP,AMAT,ZR,CF,NTOT,NKNOT,NCOEF2,ZJ,Z1,Z2,
      1KNOTSV)
      C
      C
      C
      C FITS QUADRATIC SURFACES TO THE CONSEQUENCE DATA, SPARA=2, NCONS=1
      C TWO PARAMETER SURFACES, ALL PAIRS WITH LEADING PARAMETER JONE PERMANENT
      C JONE SET BY SUBR. GROUP1 FIRST
      C IN GROUP2 JONE CHANGED TO THE PARTNER THAT DECREASES M.S. ERROR MOST
      C IN GROUP3 JONE SELECTED TO MINIMIZE THE PRODUCT OF SS ERROR AND THE
      C SENSITIVITY OF THE MODEL.
      C
      C
      C
      *CALL CONS
      C      REAL NAMEA,NAMEB
      C      REAL *8 ZF,BF,ZFP,AMAT,ZR,CF,CFA,X,DZJ,DZK
      C      COMMON/MPBIT/JONE,JTWO,JTHREE
      C      COMMON/TRANSP/MPAPA,MPRACO,JTFA(7),LTFA(7),LTYPE(7),JTYPE(7),APA(
      17),BPA(7),ACO(7),BCO(7)
      C
      C
      C
      C      DIMENSION ZF(NKNOT,NCOEF2),BF(NCOEF2,1),ZFP(NCOEF2,NKNOT)
      C      DIMENSION AMAT(NCOEF2,NCOEF2),ZR(KNOTSV,NTOT),CF(KNOTSV,1),ZJ(NTOT
      1)
      C      DIMENSION Z1(NTOT),Z2(NTOT)
      C      COMMON/ZETA1/ZETA(100,6)
      C      DATA IWRITE/6/
      C      DATA IOUT/0/
      C      DIMENSION SENST(20),ERMS(20),JORG(20)
      C      DIMENSION ZPS(20)
      C
      C
      C THE VALUE OF I (CONSEQUENCE INDEX) IS DETERMINED IN MAIN THRU CONS
      C PARAMETER CYCLING INSIDE GROUP2 WITH VARIABLE JP
      C
      C NCONS=1 IN THIS SUBROUTINE, NCONSV=NO. OF CONSEQUENCES, KNOWN TO MAIN ONLY
      C      WRITE(IWRITE,1670)
      1670 FORMAT(1H1,3X,18H SUBROUTINE GFCOP 2//)
      C
      C
      C      JONESV = JONE
      C      ERMAJ = 1.0E+49
      3 CONTINUE
      C      DO 5 J = 1,NCOEF2
      C      DO 1 M = 1,NCOEF2
      1 AMAT(M,J) = 0.000
      C      DO 5 K = 1,NRANKP
      C      ZP(K,J) = 0.000
      5 ZFP(J,K) = 0.000
      C      DO 7 M = 1,NCOEF2
      C      BF(M,1) = 0.000
      7 DO 9 J=1,NRANKP
      C      CF(J,1)=ZETA(J,L)
      9
      C
      C
      C      NMAXP=JTWO(20,NTOT)
      C      DO 110 I=1,NMAXP

```

```

MEMBER NAME GROUP2
      JOEG(I)=0
      ERMS(I)= 1.0E+49
      ERS(I) = 0.
110  SENST(I)=0.
C
C  DEFINE MATRIX ZF AND ZFP
C
      DO 800 JP=1,NTOT
      IF(JP.EQ.JONE) GO TO 800
      IF(IOUT.GT.0)
        1WRITE(IWRITE,1680) JONE,JP
1680  FORMAT('H0,3X,10HPARAMETERS,I4,1H,14//')
      DO 2  KNOT=1,NRANKP
C
C  PARAMETER JONE IS PERMANENTLY THE FIRST(J=1),DETERMINED FIRST IN GROUP1
C
      ZF(KNOT,1)=1.0D0
      ZFP(1,KNOT) =1.0D0
      J= 1
      J1=J+1
      J2=J1+NPARA
      J3= NPARA+1 + J*NPARA - J*J1/2
      DZJ= ZR(KNOT,JONE) - Z0(JONE)
      ZF(KNOT,J1) =DZJ
      ZF(KNOT,J2) =DZJ*DZJ
      ZFP(J1,KNOT)=DZJ
      ZFP(J2,KNOT) = DZJ*DZJ
C
C
C
      K=J1
      K1 = J3 + K
      DZK = ZR(KNOT,JP) - Z0(JP)
      ZF(KNOT,3)= DZK
      ZF(KNOT,5)= DZK * DZK
      ZFP(3,KNOT)= DZK
      ZFP(5,KNOT)= DZK * DZK
      ZF(KNOT,K1) = DZJ*DZK
      ZFP(K1,KNOT) = DZJ * DZK
2    CONTINUE
C
C  THE NEXT THREE STATEMENTS SOLVE LEAST SQUARES FITTING EQUATION
C  (ZF'ZF)BF = ZF'CF FOR BF
C
C
      CALL MXMULT(ZFP,CF,BF,NCOEF2,NRANKP,NCONS,KNOTSV)
      CALL MXMULT(ZFP,ZF,AMAT,NCOEF2,NRANKP,NCOEF2,NFANKP)
      CALL MATINV(AMAT,NCOEF2,BF,NCONS,DET2,ICOR)
      IF(DET2.EQ.0.) WRITE(IWRITE,1680) JONE,JP
      ICOF = ICOF * 30
      IF(IOUT.GE.1)
        1WRITE(IWRITE,2300) DET2,ICOR
2300  FORMAT('0DETERMINANT OF ZFP*ZF = ',G15.6,' TIMES 1.0D',I4)
C
C  CALCULATE AND OUTPUT FITTED SURFACE ERRORZ: MAXIMUM AND MINIMUM,
C  MEAN SQUARE ERROR, REFERENCE VALUE AND FRACTIONAL ERROR.
1690  FORMAT('H0,10X,23H*FITTED SURFACE ERRORS*/H0,5X,4HKNOT,6X,13HAPPR
      1OXIMATION,8X,5HEXACT,10X,10HDIFFERENCE,5X,15HFOR CONSEQUENCE,I4//')

```

NAME GROUP2

C
C
C

```

      DN = NFRANKP - NCOEF2
      IF (DN.LE.0.) DN = 1.0E-10
      SUMSQ = 0.0
      BIG = -1.0E+49
      IBIG = 1
      SMALL = 1.0E+49
      ISMALL = 1
      IF (IOUT.EQ.2) WRITE(IWRITE,1650) L
      DO 21 IR=1,NBANKP
      CFA = 0.0
      DO 22 IC=1,NCOEF2
      CFA = CFA + ZF(IR,IC) * BF(IC,1)
22 CONTINUE
      X = CFA - CF(IR,1)
      IF (X.GT.BIG) IBIG = X
      IF (X.GT.BIG) BIG = X
      IF (X.LT.SMALL) ISMALL = X
      IF (X.LT.SMALL) SMALL = X
      IF (IOUT.EQ.2) WRITE(IWRITE,1700) IR,CFA,CF(IR,1),X

```

C
C

```

      SUMSQ = SUMSQ + X*X
21 CONTINUE
      IF (IOUT.GE.1)
      WRITE(IWRITE,1701) L,IBIG,BIG,ISMALL,SMALL
      IF (NTRACO.LE.0) GO TO 99

```

C
C
C
C

NAME ERROR CONSEQUENCES TO BE INVERSE TRANSFORMED

C

```

      LTYP = 0
      DO 701 I=1,NTRACO
      LI = LTPA(I)

```

C
C

```

      IF (LI.NE.L) GO TO 701
      LTYP = LTYPE(I)
      AC = BCO(I)
      EC = BCO(I)
      CPBIG = CF(IBIG,I)
      CFABIG = CPBIG + BIG

```

C
C

```

      CFSMA = CF(ISMALL,L)
      CPASMA = CFSMA + SMALL
      GO TO (101,200,300,400,500,600,700),LTYP
101 BCC = 1./BC

```

C

```

      CPBIG = CPBIG**BCC + AC
      CFABIG = CFABIG**BCC + AC
      CFSMA = CFSMA**BCC + AC
      CPASMA = CPASMA**BCC + AC

```

C
C

```

      GO TO 701

```

TEMPERATURE GROUP2

```

200 CFBIG = EXP(CFBIG) + AC
   CFABIG= EXP(CFABIG) + AC
   CFSMA = EXP(CFSMA) + AC
   CFASMA= EXP(CFASMA) + AC
   GO TO 701
300 CFBIG = BC*ALOG(CFBIG) + AC
   CFABIG= BC*ALOG(CFABIG) + AC
   CFSMA = BC*ALOG(CFSMA) + AC
   CFASMA= BC*ALOG(CFASMA) + AC
C
C
   GO TO 701
400 CFBIG = EC*TAN(CFBIG) + AC
   CFABIG= EC*TAN(CFABIG) + AC
   CFSMA = EC*TAN(CFSMA) + AC
   CFASMA= EC*TAN(CFASMA) + AC
C
C
500 CONTINUE
600 CONTINUE
700 CONTINUE
701 CONTINUE
   IF (LTYP.EQ.0) GO TO 99
   BIG = CFABIG - CFBIG
   SMALL = CFASMA - CFSMA
   PRABIG = BIG/CFBIG
   PRASMA = SMALL/CFSMA
   WRITE (IWRITE,7001) CFABIG,CFBIG,BIG,PRABIG
   WRITE (IWRITE,7002) CFASMA,CFSMA,SMALL,PRASMA
7001 FORMAT (1H+,4X,20HINVERSE TR MAX,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HEBROB=,F12.5,2X,9HPFRACTION=,F10.6/)
C
C
7002 FORMAT (1H+,4X,20HINVERSE TR MIN,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HEBROB=,E12.5,2X,9HPFRACTION=,F10.6/)
99 CONTINUE
C
C ERRORS INVPRES TRANSFORMED
C
   FMSE= SOFT(SUMSQ/DN)
   IF (BF(1,1).EQ.0.) FRAERR = 0.0
   IF (BF(1,1).NE.0.0, FRAERR = FMSE / DABS(BF(1,1))
   IF (IOUT.GT.0)
   IWRITE (IWRITE,1702) FMSE,BF(1,1),FRAERR,SUMSQ
1700 FORMAT (1H ,4X,I4,3X,E16.6,2X,E15.6,4X,E15.6)
1701 FORMAT (1H0,12H*CONSEQUENCE,I4,3X,15HMAX ERROR KNOT=,I4,7H VALUE=,E
116.6,3X,15HMIN ERROR KNOT=,I4,7H VALUE=,E16.6/)
1702 FORMAT (1H ,20H MEAN SQUARE ERROR=,E15.6,11H REF VALUE=,F15.6,3X,1
10HPFRACTION =,F9.5,3X,15HSUM OF SQUARES=,G13.5/)
   CROSSW= 1.
   AA= BF(1,1)
   B1= BF(2,1)
   C1= BF(4,1)
   B2= BF(3,1)
   C2= BF(5,1)
   DD= BF(6,1)
   DZ1= 2*(JONE) - 20(JONE)
   DZ2= 22(JONE) - 20(JONE)

```

MEMBER NAME GROUP2

```

C
C
    DK1= Z1(JP) - ZC(JP)
    DK2= Z2(JP) - ZC(JP)
    SENS12= CD * DZ1 * DK1 * CROSSM
    SENS12 = ABS(SENS12)
    SENS1= ABS((B1 + C1*DZ1) * DZ1) + ABS((B1 + C1*DZ2)*DZ2)
    SENS2= ABS((B2 + C2*DK1)*DK1) + ABS((B2 + C2*DK2) * DK2)
    SENSIT= SENS1 + SENS2 + SENS12
    VEFT= ERMS(1)

C
    SIM = SDZET(L)
    SO2 = SIP * SIM
    FMSE2 = FMSE * FMSE
    IF(FMSE2.GE.SO2) GO TO 30
    FACTOR = FMSE2/(SO2 - FMSE2)
    FES = FACTOR * SENSIT

C
    DO 114 I=1,NMAXP
    VEET=ERMS(I)
    IF(FMSE.GT.VEET) GO TO 114
    INDMAX = NMAXP - I

C
C
    DO 115 IND=1,INDMAX
    IK=NMAXP + 1 - IND
    IKP= IK - 1
    ERMS(IK)=ERMS(IKP)
    ERS(IK) = FES(IFP)
    JORG(IK)=JORG(IKF)

C
C
115  SENSIT(IK)=SENSIT(IKP)
    JORG(I)=JP
    ERMS(I)=FMSE
    SENSIT(I)=SENSIT
    ERS(I) = FES
    FMSE = 1.1E+49
    SENSIT=0.
114  CONTINUE

C
C
    30 CONTINUE
800  CONTINUE
    WRITE(IWRITE,4000) L
    4000 FORMAT(12H CONSEQUENCE,I4,374
    1/1H ,65HPARAMETER PAIRS, M.S.ERRORS AND TOTAL SPNSITIVITIES, SPORI
    2OUSNESS/)
    WRITE(IWRITE,4001)JONE, (JORG(I),ERMS(I),SENSIT(I),ERS(I),I=1,NMAXP)
    4001 FORMAT(1H ,15HJONE PARAMETER=,I4,(I6,3G12.5))
    VEFT = ERMS(1)
    IF(VEFT.LT.FEMAJ) JONE = JORG(1)
    IF(VEFT.LT.ERNAJ) ERNAJ = VEFT
    JREF = JORG(1)
    IF(JONE.EQ.JREF) GO TO 3
    RETURN
END

```

```

MEMBER NAME GROUP3
      SUBROUTINE GROUP3(ZP,BF,ZFP,ANAT,ZK,CF,NTOT,NKNOT,NCOEF2,ZO,Z1,Z2,
      1KNOTSV)
C
C
C FITS QUADRATIC SURFACES TO THE CONSEQUENCE DATA, NPAPA=2, NCONS=1
C TWO PARAMETER SURFACES, ALL PAIRS WITH LEADING PARAMETER JONE PERMANENT
C JONE SET BY SUBP. GROUP1 FIRST
C IN GROUP2 JONE CHANGED TO THE PARTNER THAT DECREASES M.S. ERROR MOST
C IN GROUP3 JONE SELECTED TO MINIMIZE THE PRODUCT OF MS ERROR AND THE
C SENSITIVITY OF THE MODEL
C
*CALL CONS
C
      REAL NPAPA,NAMES
      REAL *8 ZP,BF,ZFP,ANAT,ZK,CF,CFA,X,DZJ,DZK
      COMMON/HERIT/JONE,JTWO,JTHREE
      COMMON/TRANSF/NTFAPA,NTFACO,JTRA(7),LTRA(7),LTYPE(7),JTYPE(7),APA(
      17),BPA(7),ACO(7),BCO(7)
C
C
C
      DIMENSION ZP(NKNOT,NCOEF2),BF(NCOEF2,1),ZFP(NCOEF2,NKNOT)
      DIMENSION ANAT(NCOEF2,NCOEF2),ZP(KNOTSV,NTOT),CF(KNOTSV,1),ZO(NTOT
      1)
      DIMENSION Z1(NTOT),Z2(NTOT)
      COMMON/ZETAB/ZETA(100,6)
      DATA IWRITE/6/
      DATA IOUT/0/
      DATA CROSSW/1.0/
      DIMENSION SENST(20),PRMS(20),JORG(20)
      DIMENSION ERS(20)
C
C
C THE VALUE OF L (CONSEQUENCE INDEX) IS DETERMINED IN MAIN THRU CONS
C PARAMETER CYCLING INSIDE GROUP2 WITH VARIABLE JP
C
C NCONS=1 IN THIS SUBROUTINE, NCONSV=NO. OF CONSEQUENCES, KNOWN TO MAIN ONLY
      WRITE(IWRITE,1670)
1670 FORMAT(1H1,3X,18HSUBROUTINE GROUP 3//)
C
C
      ERSMAJ = 1.0E+49
      JONESV = JONE
3 CONTINUE
      DO 5 J = 1,NCOEF2
      DO 1 M = 1,NCOEF2
1 ANAT(M,J) = 0.0D0
      DO 5 K = 1,NRANKP
      ZP(K,J) = 0.0D0
5 ZFP(J,K) = 0.0D0
      DO 7 M = 1,NCOEF2
7 BF(M,1) = 0.0D0
      DO 9 J=1,NRANKP
9 CF(J,1)=ZETA(J,L)
C
C
      NMAXP=NTOT(20,NTOT)
      DO 110 I=1,NMAXP
      JORG(I)=C

```



```

MEMBER NAME GROUP3
      ERMS(J) = 1.0E+24
      SEMST(I) = 1.0E+24
      ERS(I) = 1.0E+48
110 CONTINUE
C
C   DEFINE MATRIX ZF AND ZFP
C
      DO 800 JP=1,KTOT
      IF(JP.EQ.JONE) GO TO 800
      IF(IOUT.GT.0)
1690 1WRITE(IWRITE,168C) JONE,JP
      FORMAT(1H0,3X,10HPARAMETERS,I4,1H,I4//)
      DO 2 KNCT=1,NRANKP
C
C   PARAMETER JONE IS PERMANENTLY THE FIRST(J=1), DETERMINED FIRST IN GROUP1
C
      ZF(KNOT,1)=1.0DC
      ZFP(1,KNCT) =1.0D0
      J= 1
      J1=J+1
      J2=J1+NPARA
      J3= NPARA+1 + J*NPARA - J*J1/2
      DZJ= ZR(KNOT,JONE) - Z0(JONE)
      ZF(KNOT,J1) =DZJ
      ZF(KNOT,J2) =DZJ+DZJ
      ZFP(J1,KNCT)=DZJ
      ZFP(J2,KNCT) = DZJ+DZJ
C
C
C
      K=J1
      K1 = J3 + K
      DZK = ZR(KNOT,JP) - Z0(JP)
      ZF(KNOT,3) = DZK
      ZF(KNOT,5) = DZK * DZK
      ZFP(3,KNCT) = DZK
      ZFP(5,KNCT) = DZK * DZK
      ZF(KNOT,K1) = DZJ*DZK
      ZFP(K1,KNCT) = DZJ * DZK
2
      CONTINUE
C
C   THE NEXT THREE STATEMENTS SOLVE LEAST SQUARES FITTING EQUATION
C   (ZF'ZF)BF = ZF'CF FOR BF
C
C
      CALL MMULT(ZFP,CF,BF,NCOE2,NRANKP,NCONS,KNOTSV)
      CALL MMULT(ZFP,ZF,AMAT,NCOE2,NRANKP,NCOE2,NRANKP)
      CALL MATINV(AMAT,NCOE2,BF,NCONS,DFT2,ICOR)
      ICOP = ICOR * 30
      IF(IOUT.GE.1)
1690 1WRITE(IWRITE,2300) DET2,ICOP
      IF(DET2.EQ.0.) WRITE(IWRITE,168C) JONE,JP
2300 FORMAT('DETERMINANT OF ZFP*ZF = ',G15.6,' TIMES 1.0D',I4)
C
C   CALCULATE AND OUTPUT FITTED SURFACE ERROR: MAXIMUM AND MINIMUM,
C   MEAN SQUARE ERROR, REFERENCE VALUE AND FRACTIONAL ERROR.
1690 1FORMAT(1H0,10X,23H*FITTED SURFACE ERRORS*/1H0,5X,4HKNOT,6X,13HAPPR
      10XIMATION,8X,5H1XACT,10X,10HDIFFERENCE,5X,15HPCF CONSEQUENCE,I4//)

```

MEMBER NAME GROUP3

```

C
C
C
      DN = NFRANKP - NCOEF2
      IF(DN.LE.0.) DN = 1.E-10
      SUMSQ = 0.0
      BIG = -1.E+49
      IBIG = 1
      SMALL = 1.E+49
      ISMALL = 1
      IF(IOUT.EQ.2) WRITE(IWRITE,1690) L
      DO 21 IR=1,NFRANKP
      CFA = 0.0
      DO 22 IC=1,NCOEF2
      CFA=CFA + ZP(IR,IC) * BP(IC,1)
22 CONTINUE
      X=CFA - CP(IR,1)
      IF(X.GT.BIG) IBIG = X
      IF(X.GT.BIG) BIG = X
      IF(X.LT.SMALL) ISMALL = IR
      IF(X.LT.SMALL) SMALL = X
      IF(IOUT.EQ.2) WRITE(IWRITE,1700) IR,CFA,CP(IR,1),X
C
C
      SUMSQ = SUMSQ + X*X
21 CONTINUE
      IF(IOUT.GE.1)
      IWRITE(IWRITE,1701) L,IBIG,BIG,ISMALL,SMALL
      IF(NTRACC.LE.0) GO TO 99
C
C
C 1AX ERROR CONSEQUENCES TO BE INVERSE TRANSFORMED
C
      LTP = 0
      DO 701 I=1,NTRACC
      LL = LTRA(I)
C
C
      IF(LL.NP.L) GO TO 701
      LTP = LTYPE(I)
      AC = ACC(I)
      BC = BCC(I)
      CFBIG = CP(IRIG,L)
      CFABIG = CFBIG + BIG
C
C
      CFSMA = CP(ISMALL,I)
      CPASMA = CFSMA + SMALL
      GO TO (101,200,300,400,500,600,700),LTP
101 BCC = 1./BC
C
      CFBIG = CFBIG**BCC + AC
      CFABIG = CFABIG **BCC +AC
      CFSMA = CFSMA **BCC +AC
      CPASMA = CPASMA**BCC +AC
C
C
      GO TO 701

```

MEMBER NAME GROUP3

```

200 CFBIG = FXP(CFBIG) + AC
   CFABIG= EXP(CFABIG) + AC
   CFSMA = FXP(CFSMA) + AC
   CPASMA= FXP(CPASMA) + AC
   GO TO 701
300 CFBIG = BC*ALOG(CFBIG) + AC
   CFABIG= BC*ALOG(CFABIG) + AC
   CFSMA = BC*ALOG(CFSMA) + AC
   CPASMA= BC*ALOG(CPASMA) + AC
C
C
   GO TO 701
400 CFEIG = PC*TAN(CFBIG) + AC
   CFABIG= BC*TAN(CFABIG) + AC
   CFSMA = BC*TAN(CFSMA) + AC
   CPASMA= PC*TAN(CPASMA) + AC
C
C
500 CONTINUE
600 CONTINUE
700 CONTINUE
701 CONTINUE
   IF(LTYP.EQ.0) GO TO 99
   BIG = CFABIG - CFBIG
   SMALL = CPASMA - CFSMA
   PRABIG = BIG/CFBIG
   PRASMA = SMALL/CFSMA
   WRITE(IWRITE,7001) CFABIG,CFSIG,BIG,PRABIG
   WRITE(IWRITE,7002) CPASMA,CFSMA,SMALL,PRASMA
7001 FORMAT(1H+,4X,20HINVERSE TR MAX,APPR=,E12.5,2X,6HREACT=,E12.5,2X,6
1HEEROR=,F12.5,2X,9HFFACTION=,F10.6/)
C
C
7002 FORMAT(1H+,4X,20HINVERSE TR MIN,APPR=,E12.5,2X,6HREACT=,E12.5,2X,6
1HEEROR=,E12.5,2X,9HFFACTION=,F10.6/)
99 CONTINUE
C
C ERRORS INVERSE TRANSFORMED
C
   FMSE= SQRT(SUMSQ/DN)
   IF(BF(1,1).EQ.0.) FRAERR = 0.0
   IF(BF(1,1).NE.0.0) FRAERR = FMSE / DABS(BF(1,1))
   IF(ROUT.GT.0)
   1WRITE(IWRITE,1702) FMSE,BF(1,1),FRAERR,SUMSQ
1700 FORMAT(1H+,4X,14,3X,E16.6,2X,E15.6,4X,E15.6)
1701 FORMAT(1H0,12H+CONSEQUENCE,14,3X,15HMAX ERROR KNOT=,14,7H VALUE=,E
116.6,3X,15HMIN ERROR KNOT=,14,7H VALUE=,E16.6/)
1702 FORMAT(1H+,20H MEAN SQUARE ERROR=,E15.6,11H REF VALUE=,E15.6,3X,1
1GHFFACTION =,F9.5,3X,15HSUM OF SQUARES=,G13.5//)
   AA= BF(1,1)
   B1= BF(2,1)
   C1= BF(3,1)
   B2= BF(3,1)
   C2= BF(5,1)
   DD= BF(6,1)
   DZ1= Z1(JONE) - Z0(JONE)
   DZ2= Z2(JONE) - Z0(JONE)
C

```

DESPER NAME GROUP?

```

C
  DK1= Z1(JP) - Z0(JP)
  DK2= Z2(JP) - Z0(JP)
  SENS12= DD * DZ1 * DK1 * CROSSW
  SENS12 = ABS(SENS12)
  SENS1= ABS((B1 + C1*DZ1) * DK1) + ABS((B1 + C1*DZ2)*DK2)
  SENS2= ABS((B2 + C2*DK1)*DK1) + ABS((B2 + C2*DK2) * DK2)
  SENSIT= SENS1 + SENS2 + SENS12
  VERT= PRMS(1)

C
  SIN = SDZET(L)
  SO2 = SIN*SIN
  FMSE2 = FMSE*FMSE
  IF(FMSE2.GE.SO2) GO TO 30
  FACTOR = FMSE2 / (SO2 - FMSE2)
  PES = FACTOR * SENSIT

C
  DO 114 I=1,NMAXP
  VERT = ERS(I)
  IF(PES.GT.VERT) GO TO 114
  INDMAX = NMAXP - I

C
C
C
  DO 115 IND=1,INDMAX
  IX=NMAXP + 1 - IND
  IKP= IX - 1
  ERMS(IK)=ERMS(IKP)
  JORG(IK)=JORG(IKP)

C
  ERS(IK) = ERS(IKP)

C
115  SENST(IK)=SENST(IKP)
  JORG(I)=JP
  ERMS(I)=FMSE
  ERS(I) = PES
  SENST(I)=SENSIT
  PES = 1.1E+48
  FMSE = 1.1E+24
  SENSIT=0.

114  CONTINUE

C
C
30  CONTINUE
600  CONTINUE
  WRITE(17FITE,4000) L
  4000  FORMAT(12H CONSEQUENCE,I4,37H
1/1H ,65HPARAMETER PAIRS, 1.S.ERRORS AND TOTAL SENSITIVITIES, SPORI
2OUSNESS/)
  WRITE(17FITE,4001)JONE, (JORG(I),ERMS(I),SENST(I),ERS(I),I=1,NMAXP)
  4001  FORMAT(1H ,15HJONE PARAMETER=,I4,(I6,3G12.5))
  VERT = ERS(1)
  IF(VERT.IT.PRSMAJ) JONE = JORG(1)
  IF(VERT.IT.PRSMAJ) ERSMAJ = VERT
  JREF = JORG(1)
  IF(JONE.EQ.JREF) GO TO 1
  RETURN
END

```

```

1E1BER NAME GROUP4
      SUBROUTINE GROUP4(ZP,BP,ZPP,AMAT,ZR,CP,NTOT,NKNOT,NCOEF2,Z1,Z2,
      1KNOTSV)
      C
      C
      C FITS QUADRATIC SURFACES TO THE CONSEQUENCE DATA, NPARA=2, NCONS=1
      C TWO PARAMETER SURFACES, ALL PAIRS WITH LEADING PARAMETER JONE PERMANENT
      C JONE SPT BY SUBR. GROUP1 FIRST
      C IN GROUP2 JONE CHANGED TO THE PARTNER THAT DECREASES M.S. ERROR MOST
      C IN GROUP3 JONE SELECTED TO MINIMIZE THE PRODUCT OF MS ERROR AND THE
      C SENSITIVITY OF THE MODEL
      C GROUP4 FITS ALL POSSIBLE REGRESSIONS OF TWO PARAM. QUADRATIC
      C
      *CALL COMS
      C      BEAT NAMEA,NAMEB
      C      REAL *8 ZP,BP,ZPP,AMAT,ZR,CP,CFA,X,DZJ,DZK
      C      COMMON/MFRIT/JONE,JTWO,JTHREE
      C      COMMON/TRANSF/NTAPA,NTACO,JTPA(7),LTPA(7),LTYPE(7),JTYPE(7),APA(
      17),BPA(7),ACO(7),BCO(7)
      C
      C
      C
      C      DIMENSION ZP(NKNOT,NCOEF2),BP(NCOEF2,1),ZPP(NCOEF2,NKNOT)
      C      DIMENSION AMAT(NCOEF2,NCOEF2),ZR(KNOTSV,NTOT),CF(KNOTSV,1),ZC(NTOT
      1)
      C      DIMENSION Z1(NTOT),Z2(NTOT)
      C      COMMON/ZETAR/ZETA(100,6)
      C      DATA IWRITE/6/
      C      DATA IOUT/0/
      C      DATA CROSSW/1.0/
      C      DIMENSION SFIRST(20),ERMS(20),JOPG(20)
      C      DIMENSION ERS(20)
      C      DIMENSION JORF(20)
      C
      C      DATA JPIFST,JLAST/1,150/
      C      IF(JPIFST.LE.0) JPIFST = 1
      C      IF(JLAST.LE.0) JLAST = JPIFST
      C      IF(JLAST.GT.NTOT) JLAST = NTOT
      C      IF(JPIFST.GT.JLAST) JPIFST=JLAST
      C
      C THE VALUE OF L (CONSEQUENCE INDEX) IS DETERMINED IN MAIN THRU COMS
      C PARAMETER CYCLING INSIDE GROUP2 WITH VARIABLE JP
      C
      C NCONS=1 IN THIS SUBROUTINE, NCONSV=NO. OF CONSEQUENCES, KNOWN TO MAIN ONLY
      C      WRITE(IWRITE,1670)
      1670 FORMAT('F1,3I,18H SUBROUTINE GROUP 4//')
      C
      C
      C      ERSMAJ = 1.0E+49
      C      JONESV = JONE
      C      JONE = JPIFST - 1
      C      NDELTA = NTOT
      C      NMAXP=NTNO(20,NDELTA)
      C      DO 110 I=1,NMAXP
      C      JORG(I)=0
      C      ERMS(I) = 1.0E+24
      C      SENS7(I) = 1.0E+24
      C      ERS(I) = 1.0E+49
      C      JORF(I) = 0

```

```

MPHBER NAME GROUP4
110 CONTINUE
1 CONTINUE
  JONE = JONE + 1
  DO 5 J = 1, NCOEF2
  DO 1 H = 1, NCOEF2
    1 ANAT(H, J) = 0.000
  DO 5 K = 1, NBRANKP
    ZF(K, J) = 0.000
  5 ZFP(J, K) = 0.000
  DO 7 H = 1, NCOEF2
  7 EF(H, 1) = 0.000
  DO 9 J=1, NBRANKP
  9 CF(J, 1) = ZETA(J, 1)
C
C
C
C DEFINE MATRIX ZF AND ZFP
C
  JPLOW = JONE + 1
  DO 800 JP=JPLOW, NTOT
    IF (JP.EQ.JONE) GO TO 800
    IF (IOUT.GT.?)
      1WRITE(1WRITE, 1680) JONE, JP
  1680 FORMAT(1H0, 3I, 10HPARAMETERS, I4, 1H, I4//)
    DO 2 KNOT=1, NBRANKP
C
C PARAMETER JONE IS PERMANENTLY THE FIRST (J=1), DETERMINED FIRST IN GROUP1
C
      ZF(KNOT, 1) = 1.000
      ZFP(1, KNOT) = 1.000
      J = 1
      J1 = J + 1
      J2 = J1 + NPARA
      J3 = NPARA + 1 + J * NPARA - J * J1 / 2
      DZJ = ZF(KNOT, JONE) - ZJ(JONE)
      ZF(KNOT, J1) = DZJ
      ZF(KNOT, J2) = DZJ * DZJ
      ZFP(J1, KNOT) = DZJ
      ZFP(J2, KNOT) = DZJ * DZJ
C
C
C
C
      K = J + 1
      K1 = J3 + K
      DZK = ZF(KNOT, JP) - ZJ(JP)
      ZF(KNOT, 3) = DZK
      ZF(KNOT, 5) = DZK * DZK
      ZFP(3, KNOT) = DZK
      ZFP(5, KNOT) = DZK * DZK
      ZF(KNOT, F1) = DZJ * DZK
      ZFP(F1, KNOT) = DZJ * DZK
  2 CONTINUE
C
C THE NEXT THREE STATEMENTS SOLVE LEAST SQUARES FITTING EQUATION
C (ZF'ZF)EF = ZF'CF FOR EF
C
C
C
      CALL MMULT(ZFP, CF, EF, NCOEF2, NBRANKP, NCONS, KNOTSV)

```

```

12482P NAME2 GROUP4
      CALL MTHSLT(ZFP,ZF,AMAT,BCOEF2,BRANKP,BCOEF2,BRANKP)
      CALL MATHINV(AMAT,BCOEF2,BF,MCC4S,DET2,ICOB)
      ICOP = ICOP * 30
      IF(ICUT.GE.1.0E.DET2.GT.1.0E+49)
        WRITE(IWRITE,2300) DET2,ICOB
      IF(IOUT.GE.1.0E.DET2.GT.1.0E+49)
        WRITE(IWRITE,1680) JONE,JP
      IF(DET2.PQ.0.) WRITE(IWRITE,1680) JONE,JP
2300 FORMAT('DETERMINANT OF ZFP*ZF = ',G15.6,' TIMES 1.0D',I4)
C
C CALCULATE AND OUTPUT FITTED SURFACE ZERO*Z: MAXIMUM AND MINIMUM,
C MEAN SQUARE ERROR, REFERENCE VALUE AND FRACTIONAL ERROR.
1690 FORMAT('F0,10X,23H*FITTED SURFACE ERRORS*/100,5X,48HNOT,6X,13HAPPR
10XINATION,8X,5HFXACT,10X,10HDIFFERENCE,5X,15HFOR CONSEQUENCE,10//)
C
C
C
      DM = BRANKP - BCOEF2
      IF(DM.LE.0.) WRITE(IWRITE,5500) DM
5500 FORMAT(35H * BCOEF2 IS GT OR EQ BRANKP, DM =,F6.1/)
      IF(DM.LE.0.) DM = 1.0E-10
      SUMSQ = 0.0
      BIG = -1.0E+49
      IBIG = 1
      SMALL = 1.0E+49
      ISMALL = 1
      IF(IOUT.EQ.2) WRITE(IWRITE,1690) L
      DO 21 IR=1,BRANKP
      CPA = 0.0
      DO 22 IC=1,BCOEF2
      CPA = CPA + ZF(IR,IC) * BF(IC,1)
22 CONTINUE
      X = CPA - CF(IR,1)
      IF(X.GT.BIG) IBIG = IR
      IF(X.GT.BIG) BIG = X
      IF(X.LT.SMALL) ISMALL = IR
      IF(X.LT.SMALL) SMALL = X
      IF(IOUT.PQ.2) WRITE(IWRITE,1700) IR,CPA,CF(IR,1),X
C
C
      SUMSQ = SUMSQ + X*X
21 CONTINUE
      IF(IOUT.GE.1)
        WRITE(IWRITE,1701) L,IBIG,BIG,ISMALL,SMALL
      IF(MTRACC.LE.0) GO TO 99
C
C MAX ERROR CONSEQUENCES TO BE INVERSE TRANSFORMED
C
      LTYP = 1
      DO 701 I=1,MTRACC
      LI = LTRA(I)
C
C
      IF(LI.NP.L) GO TO 701
      LTYP = ITYPE(I)
      AC = ACO(I)
      BC = BCO(I)

```

MEMBER NAME GROUP4

```

      CFBIG = CF(IBIG,1)
      CFABIG = CFBIG + BIG

```

```

C
C

```

```

      CFSMA = CF(SMAIL,L)
      CPASHA = CFSMA + SMAIL
      GO TO (101,200,300,400,500,600,700),LTYPE
101 BCC = 1./BC

```

```

C

```

```

      CFBIG = CFBIG**BCC + AC
      CFABIG = CFABIG**BCC + AC
      CFSMA = CFSMA**BCC + AC
      CPASHA = CPASHA**BCC + AC

```

```

C
C

```

```

      GO TO 701

```

```

200 CFBIG = EXP(CFBIG) + AC
      CFABIG = EXP(CFABIG) + AC
      CFSMA = EXP(CFSMA) + AC
      CPASHA = EXP(CPASHA) + AC
      GO TO 701

```

```

300 CFBIG = BC*ALOG(CFBIG) + AC
      CFABIG = BC*ALOG(CFABIG) + AC
      CFSMA = BC*ALOG(CFSMA) + AC
      CPASHA = BC*ALOG(CPASHA) + AC

```

```

C
C

```

```

      GO TO 701

```

```

400 CFBIG = BC*TAN(CFBIG) + AC
      CFABIG = BC*TAN(CFABIG) + AC
      CFSMA = BC*TAN(CFSMA) + AC
      CPASHA = BC*TAN(CPASHA) + AC

```

```

C
C

```

```

500 CONTINUE
600 CONTINUE
700 CONTINUE
701 CONTINUE

```

```

      IF(LTYPE.EQ.0) GO TO 99
      BIG = CFABIG - CFBIG
      SMAIL = CPASHA - CFSMA
      FRABIG = BIG/CFBIG
      FRASHA = SMAIL/CFSMA

```

```

      WRITE(UNIT,7001) CFABIG,CFBIG,BIG,FRABIG

```

```

      WRITE(UNIT,7002) CPASHA,CFSMA,SMAIL,FRASHA

```

```

7001 FORMAT(1H+,4X,20HINVERSE TR MAX,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HERROR=,F12.5,2X,9HFRACTION=,F10.6/)

```

```

C
C

```

```

7002 FORMAT(1H+,4X,20HINVERSE TR MIN,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HERROR=,F12.5,2X,9HFRACTION=,F10.6/)

```

```

99 CONTINUE

```

```

C
C

```

```

C ERRORS INVERSE TRANSFORMED

```

```

C

```

```

      FNSE = SQRT(SUMSQ/DN)
      IF(BF(1,1).EQ.0.) FRAPR = 0.0
      IF(FE(1,1).NE.0.0) FRAPR = FNSE / DABS(BF(1,1))

```


MEMBER NAME GROUP#

```

      IF (ICUT.GT.0)
        1WRITE (IMBITE,17C2) FMSE,BF(1,1),FRAZER,SUNSO
1700  FORMAT (1P,4X,I4,3X,F16.6,2X,E15.6,4X,E15.6)
1701  FORMAT (1H0,12H*CONSEQUENCE,I4,3X,15HMAX ERROR KNOT=,I4,7H VALUE=,E
      16.6,3X,15HMIN ERROR KNOT=,I4,7H VALUE=,E16.6/)
1702  FORMAT (1H,20H MEAN SQUARE ERROR=,E15.6,11H REF VALUE=,E15.6,3X,1
      10HFRACTION =,F9.5,3X,15HSUM OF SQUARES=,G13.5//)
      AA= BF(1,1)
      B1= BF(2,1)
      C1= BF(4,1)
      B2= BF(3,1)
      C2= BF(5,1)
      DD= BF(6,1)
      DZ1= Z1(JONE) - Z0(JONE)
      DZ2= Z2(JONE) - Z0(JONE)
C
C
      DK1= Z1(JP) - Z0(JP)

```

```

12482R NAME HISTO
      SUBROUTINE HISTO(NPLO,NIS,NOINT)
C
C  SUBROUTINE HISTO CALCULATES DISTRIBUTIONS (HISTOGRAMS) OF THE CONSEQUENCES
*CALL CONS
      DIMENSION NPLO(6,26)
      DIMENSION NIS(6,12),NOINT(6,6,12,12)
      DO 421 L=1,NCONS
        DEVL= (AFZETA(L)- AVZET(L))/(SCALE*SDZET(L))
        HISE=DEVL +7.
        PISE= DEVL*2. +14.
        NP=INT(PISE)
        IF(NP.LE.0) NP=1
        IF(NP.GT.26) NP=26
        NPLO(L,NP) = NPLO(L,NP) +1
        NL=INT(HISE)
        IF(NL.LT.1) NL=1
        IF(NL.GT.12) NL=12
        NIS(L,NL) = NIS(L,NL) +1
        IF(L.EQ.NCONS) GO TO 421
        LPI=L+1
        DO 422 M=LPI,NCONS
          DEVM = (APZETA(M)- AVZET(M))/(SCALE*SDZET(M))
          HISM = DEVM +7.
          NM=INT(HISM)
          IF(NM.LT.1) NM=1
          IF(NM.GT.12) NM=12
          NOINT(L,M,NL,NM) = NOINT(L,M,NL,NM) +1
        422 CONTINUE
      421 CONTINUE
      RETURN
C END HISTOGRAM SUBROUTINE
      END

```

```

*EXPER NAME INIT
      SUBROUTINE INIT(IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, ZR, NTOT, NKNOT)
C
C  SUBROUTINE INIT SETS INITIAL VALUE ZEROS
      REAL*8 ZF
*CALL COMS
      COMMON/TRANSP/NTBAPA, NTBACO, JTRA(7), JTYPE(7), LTRA(7), LTYPE(7), APA(
17), BPA(7), ACO(7), BCO(7)
      COMMON/ZETAR/ ZETA(100,6)
      DIMENSION IPARA(NTOT), IDIS(NTOT), ADIS(NTOT), BDIS(NTOT), CDIS(NTOT),
1DDIS(NTOT), ZR(NKNOT, NTOT)
3 DO 4 I=1, NTOT
      ADIS(I)=C.
      BDIS(I)=C.
      CDIS(I) = 0.
      DDIS(I) = 0.
      IDIS(I)=C
      IPAPA(I)=0
      DO 4 IL=1, NKNOT
      ZR(IL, I)=0.00
4 CONTINUE
      DO 5 L=1, NCONS
      DO 5 IL=1, NKNOT
5 ZETA(IL, I) = 0.
      DO 70 I=1, 7
      JTRA(I)=C
      LTRA(I)=C
      JTYPE(I) = 0
      LTYPE(I) = 0
70 CONTINUE
      RETURN
      END

```

```

INBEP NAME JOBS1
SUBROUTINE JOBS1(IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, ZO, Z1, Z2, ZR, NTOT, N
  KNOT)
  SPAL*8 ZF
  *CALL COMS
  COMMON/ZETA/ZETA(100,6)
  DIMENSION IPARA(NTOT), IDIS(NTOT), ADIS(NTOT), BDIS(NTOT), CDIS(NTOT),
  DDIS(NTOT), ZO(NTOT), Z1(NTOT), Z2(NTOT), ZR(NTOT), NTOT)
  DIMENSION IFLO(6,26), TP(26), XP(26)
  DIMENSION ICPLO(6,26), TC(26), XC(26)
  DIMENSION SUMA(6), SUMB(6), SUMC(6), SUMD(6)
  DIMENSION SASEAN(6), SASD(6)
  DIMENSION CSUMA(6), CSUMB(6), CSUMC(6), CSUMD(6)
  DIMENSION CSSEAN(6), CS3D(6)
  DIMENSION SAVZET(6)
  DIMENSION Z(1000)
  DATA ISAS/1/
1000 FORMAT(1H1,T40,'INPUT DATA - WORK',I6,3X,6H JOBS ,I2/)
1002 FORMAT(13,A4,A2,I2,4E11.5,1X,12I2)
1003 FORMAT(1H0,26H NUMBER OF PARAMETERS = ,I3/)
1004 FORMAT(7H ,I4,4X,A4,A2,I6,6X,4E11.5,4X,12I3)
1005 FORMAT(1H0,T8,'NUMBER',T17,'NAME',T24,'DISTRIBUTION',T43,'PARAMETER
  IPS',T94,'PAIRS IF LIMITED NUMBER'/)
1006 FORMAT(1H ,10X,I5,38H CORRELATIONS BETWEEN INPUT PARAMETERS/)
1010 FORMAT(29H INDEPENDENT INPUT PARAMETERS//)
1012 FORMAT(27H NUMBER OF CONSEQUENCES = ,I3/)
1014 FORMAT(20H PROBABILITY RANGE ,F12.8/)
1015 FORMAT(31H NUMBER OF SIMULATION CYCLES =,I10/18H CATEGORY WIDTH
  1=,F8.2,20H STANDARD DEVIATIONS/)
1016 FORMAT(52H CONSEQUENCES CALCULATED BY TEST SUBROUTINE (TEXAS)//)
1017 FORMAT(15,I5,E15.6,I5,E15.6)
1018 FORMAT(1H0,6X,16H CORRELATION TYPE,I4,11H LEAD PARA,I4,8H, VALUE=,
  1E14.6,3X,14H INDEPENDENT PARA,I4,15H SHIFTED MEAN=,E14.6/)
1019 FORMAT(1H0)
1020 FORMAT(91H0 DISTRIBUTION FIRST PARAMETER SECOND PARAMETER
  1 THIRD PARAMETER FOURTH PARAMETER/)
1021 FORMAT(86H 1=UNIFORM UPPER LIMIT LOWER LIMIT
  1 N/A N/A )
1022 FORMAT(86H 2=NORMAL MEAN VALUE STANDARD DEVIATION
  1 N/A N/A )
1023 FORMAT(86H 3=EXPONENTIAL LOWER LIMIT SCALE CONSTANT
  1 N/A N/A )
1024 FORMAT(86H 4=EXPONENTIAL UPPER LIMIT SCALE CONSTANT
  1 N/A N/A )
1025 FORMAT(86H 5=NORMAL MEAN VALUE STANDARD DEVIATION
  1 LOWER LIMIT N/A )
1026 FORMAT(86H 6=NORMAL MEAN VALUE STANDARD DEVIATION
  1 UPPER LIMIT N/A )
1027 FORMAT(92H 7=BETA LOWER LIMIT UPPER LIMIT
  1 MEAN STANDARD DEVIATION)
1028 FORMAT(86H 8=LOG NORMAL MEAN VALUE STANDARD DEVIATION
  1 N/A N/A )
1029 FORMAT(///4X,'FOR DISTRIBUTIONS 5 AND 6, THE VALUES FOR THE MEAN
  AND STANDARD DEVIATION ARE THOSE FOR THE UNTRUNCATED NORMAL DISTRI
  BUTIONS.',///4X,'FOR DISTRIBUTION 9, THE VALUES FOR MEAN AND STAN
  DARD DEVIATION ARE THOSE OF THE LOGARITHM OF THE PARAMETER.')
  DATA IREAD,IWRITE,IPUNCH/5,6,7/

```

```

MEMBER NAME JOBS1
COMMON/CONDIS/MSB, MSC, MCOND, TOLF
COMMON/CFIDIS/ICIS(4), ACIS(4), BCIS(4), CCIS(4), DCIS(4)

C
COMMON/NEWPEP/ZONEW(12)
COMMON/CCNTRL/JOBS1V
COMMON/TPANSP/NTRAPA, NTRACO, JTEA(7), JTYPE(7), LTEA(7), LTYPE(7), APA(
17), BPA(7), ACO(7), BCO(7)
COMMON/SVZC/ ZOSV(12)
CALL INIT(IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, ZR, NTOT, NKNOT)

C
WRITE(6, 1000) WORK, JOBS
WRITE(6, 1003) NPASA
IF(MCORR.GT.0) WRITE(6, 1006) MCONR
WRITE(6, 1014) PFOB
IF(MCONS.GT.0) WRITE(6, 1013) MCONS
IF(JOBS.EQ.6) WRITE(6, 1015) NSA, SCALE
IF(TEST.EQ.1) WRITE(6, 1016)
IF(NTRAPA.LE.0.AND.NTRACO.LE.0) WRITE(IWRITE, 1034)
IF(NTRAPA.GT.0.OR.NTRACO.GT.0) WRITE(IWRITE, 1033) NTRAPA, NTRACO
1033 FORMAT(1H0, 8H NTRAPA=, I4, 31H TRANSFORMATIONS FOR PARAMETERS/1H , 8H
1 NTRACO=, I4, 33H TRANSFORMATIONS FOR CONSEQUENCES/)
1034 FORMAT(1F0, 3X, 44HNO TRANSFORMATIONS OF PARAMS OF CONSEQUENCES//)
IF(MCORR.LE.0) WRITE(6, 1010)
WRITE(6, 1005)

C READ PARAMETER INFO AND ORGANIZE
DO 11 I=1, NPARA
READ(5, 1007) K, NAMEA, NAMEB, JDIS, UADIS, UBDIS, UCDIS, UDDIS, JJK
WRITE(6, 1004) K, NAMEA, NAMEB, JDIS, UADIS, UBDIS, UCDIS, UDDIS, JJK
IPARA(K) = K
IDIS(K)=JDIS
ADIS(K)=UADIS
BDIS(K)=UBDIS
CDIS(K)=UCDIS
DDIS(K)=UDDIS
11 CONTINUE
IF(MCORR.LE.0) GO TO 15
DO 18 I=1, MCONR
REAL(5, 1017) ITYPE(I), ILEAD(I), FLEAD(I), IDEP(I), FDEP(I)
18 WRITE(6, 1018) ITYPE(I), ILEAD(I), FLEAD(I), IDEP(I), FDEP(I)
16 WRITE(6, 1019)
WRITE(6, 1020)
WRITE(6, 1021)
WRITE(6, 1022)
WRITE(6, 1023)
WRITE(6, 1024)
WRITE(6, 1025)
WRITE(6, 1026)
WRITE(6, 1027)
WRITE(6, 1028)
WRITE(6, 1029)
WRITE(IWRITE, 1600)
1600 FORMAT(1H1, 6X, 24HRANGES OF THE PARAMETERS/1H , 9H PARA NO., 4H Z'S/)
CALL KNOTSS(IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, Z0, Z1, Z2, NTOT)
DO 15 I=1, NPAPA
WRITE(IWRITE, 1631) I, Z2(I), Z0(I), Z1(I)
15 CONTINUE
1631 FORMAT(1H , 5X, I4, 8X, 3E14.6)
C

```

```

ME1B29 NAME JORS1
C INPUT PARAMETER TRANSFORMATIONS
  IF (NTRAPA.LE.0) GO TO 801
  WRITE (IWFITF,1041) NTRAPA
1041 FORMAT(1H0,15,23H TRANSFORMED PARAMETERS/1H ,59HPAPA NO., TR. TYPE
1, APA =1ST TR. PARA., BPA =2ND TR. PARA./)
  DO 802 I=1,NTRAPA
    READ (IWPAD,1042) JTRA(I),JTYPE(I),APA(I),BPA(I)
    WRITE (IWPITE,1048) JTRA(I),JTYPE(I),APA(I),BPA(I)
  802 CONTINUE
1042 FORMAT(15,15,E15.6,E15.6)
1048 FORMAT(1H ,15,7X,14,7X,E15.6,6X,E15.6/)
  WRITE (IWRITE,1045)
1045 FORMAT(1H0,' PARAMETER TRANSFORMATION DEFINITIONS
11H0,' TR. TYPE EQUATION
21H ,1 X= (Z - APA)**BPA
31H ,2 X= LOG(Z - APA)
41H ,3 X= EXP((Z - APA)/BPA)
51H ,4 X= ATAN((Z - APA)/BPA)
C END OF PARAMETER TRANSFORMATION INPUT AND DEFINITIONS
801 CONTINUE
  IF (JOBS.GT.1) RETURN
C PUNCH AND PRINT KNOT - POINTS
C SAMPLE NRANKP RANDOF KNOT-POINTS AND EDIT
C INDEX = 50
  90 IF (NRANKP.LE.0) RETURN
  WRITE (IWFITF,1620) NRANKP
  INDEX = 50
  DO 91 I=1,NRANKP
    CALL SAMPLE(IDIS,ADIS,BDIS,CDIS,DDIS,ZR,NTOT,NKNOT,J)
  91 CONTINUE
  DO 92 J= 1,NPAPA
    IMIN = 0
    IMAX = 0
    ZMAX = -1.E+49
    ZMIN = +1.E+49
    DO 93 I=1,NRANKP
      ZRR = ZR(I,J)
      IF (ZRR.GT.ZMAX) IMAX= I
      IF (ZRR.GT.ZMAX) ZMAX= ZRR
      IF (ZRR.LT.ZMIN) IMIN = I
      IF (ZRR.LT.ZMIN) ZMIN= ZRR
    93 CONTINUE
    ZR(IMAX,J) = Z1(J)
    ZR(IMIN,J) = Z2(J)
  92 CONTINUE
  DO 95 I=1,NRANKP
    WRITE (IWPITE,1621) INDEX,I,(ZR(I,J),J=1,NPAPA)
C TEXASS CALCULATES TEST CONSEQUENCES AND KEEPS IN ZETA(100,6)
  DO 89 JJ=1,NTOT
    Z(JJ) = ZR(I,JJ)
  89 CONTINUE
  IF (TEST.EQ.1) CALL TEXASS(Z,I)
  95 WRITE (IPUNCH,1622) INDEX,I,(ZR(I,J),J=1,NPAPA)
  IF (ISAS.EQ.1) CALL SASIN(NKNOT,NTOT,ZR)
1620 FORMAT(1H1,10X,32H*RANDOM KNOT-POINT COORDINATES -,15,4HSETS/)
1621 FORMAT(1H ,6X,215,(6F16.6))
1622 FORMAT(12,14,2X,(6G12.5))

```

```
MEMBER NAME JOBS1
1601 FORMAT(4E ,14,3X,A4,A4,3E14.6)
1603 FORMAT(4H ,14,3X,A4,A4,5E14.6)
      $ETPPE
      END
```

```

MEMBER NAME KNOTSS
      SUBROUTINE KNOTSS(IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, Z0, Z1, Z2, NTOT)
      CC
      C CALCULATES INTERVALS Z2, Z0, Z1
      C OUTPUT IN SUBROUTINE JOBS1
      CC
      *CALL COMF
      DIMENSION IPARA(NTOT), IDIS(NTOT), ADIS(NTOT), BDIS(NTOT), CDIS(NTOT),
      11DIS(NTOT), Z0(NTOT), Z1(NTOT), Z2(NTOT)
      1501 FORMAT( 30HC UNKNOWN DISTRIBUTION IDIS = ,I4,20B PARAMETER NUMBER
      1= ,I4,8H NAME = ,2A4)
      1502 FORMAT(2CHO VALUES USED   Z0 = ,E14.6, 5H Z1 = ,E14.6, 5H Z2 = ,E14.6)
      1503 FORMAT(4EHOPROB TOO LARGE FOR EXPONENTIAL PARAMETER,I4,2A4)
      C
      DATA INPTE/6/
      DO 16 J=1, NPARA
      M=IDIS(J)
      IF (M.LT.1.OR.M.GT.8) GO TO 17
      GO TO (2C,30,40,9050,9060,9070,9080,9090), M
      C UNIFORM DISTRIBUTION IDIS =1
      20 Z1(I)= ADIS(I)
      Z2(I)= BDIS(I)
      Z0(I)= 0.5*(Z1(I)+Z2(I))
      GO TO 15
      C EXPONENTIAL DISTRIBUTION IDIS =3
      40 IF (PROB.GT.0.36) GO TO 41
      42 T= ALOG(1./PROB)
      TT = ALOG(1./(1.-PROB))
      Z0(I)= ADIS(I)+ BDIS(I)
      Z1(I)= ADIS(I)+ BDIS(I) * T
      Z2(I)= ADIS(I)+ BDIS(I) * TT
      GO TO 15
      41 WRITE(6,1503) IPARA(I)
      GO TO 42
      C NORMAL DISTRIBUTION IDIS =2
      30 T = ALOG(1./(PROB*PROB))
      T = SQRT(T)
      XUP = 2.515517 + (.802853 + .010328 * T) * T
      XLOW = 1. + (1.4327880 + (.189269 + .001308 * T)*T) * T
      X = T - XUP/XLOW
      Z0(I)= ADIS(I)
      Z1(I)= ADIS(I) + BDIS(I)*X
      Z2(I)= ADIS(I) - BDIS(I)*X
      GO TO 15
      C
      C
      C *** EXPONENTIAL DISTRIBUTION IDIS=4
      9050 IF (PROB.GT.0.36) GO TO 9010
      9011 T=ALOG(1./PROB)
      TT=ALOG(1./(1.-PROB))
      Z0(I)=ADIS(I)-BDIS(I)
      Z1(I)=ADIS(I)-BDIS(I)*TT
      Z2(I)=ADIS(I)-BDIS(I)*T
      GO TO 15
      9010 WRITE(6,1503) IPARA(I)
      GO TO 9011
      C *** NORMAL DISTRIBUTION WITH ZLL IDIS=5
      9060 T=ALOG(1./(PROB*PROB))
      T=SQRT(T)

```


1EMREP NAME KNOTSS

```

      XUP=2.51557+ (.802853+.010328*T)*T
      XLOW=1.+ (1.432788+ (.189269+.001308*T)*T)*T
      X=T-XUP/XLOW
      AK=1./(.5-.5*EXP((CDIS(I)-ADIS(I))/(SQRT(2.)*BDIS(I))))
      FACT=BDIS(I)*AK/SQRT(6.2832)*EXP(-(CDIS(I)-ADIS(I))**2/(2.*BDIS(I)
1**2))
      Z0(I)=ADIS(I)+FACT
      Z1(I)=ADIS(I)+BDIS(I)*X
      Z2(I)=ADIS(I)-BDIS(I)*X
      IF(Z2(I).LE.CDIS(I)) Z2(I)=CDIS(I)
      GO TO 15
C *** NORMAL DISTRIBUTION WITH ZUL IDIS=6
9070 T=ALOG(1./(PROB*PROB))
      T=SQRT(T)
      XUP=2.51557+ (.802853+.010328*T)*T
      XLOW=1.+ (1.432788+ (.189269+.001308*T)*T)*T
      X=T-XUP/XLOW
      BK=1./(.5+.5*EXP((CDIS(I)-ADIS(I))/(SQRT(2.)*BDIS(I))))
      FACT=-BDIS(I)*BK/SQRT(6.2832)*EXP(-(CDIS(I)-ADIS(I))**2/(2.*BDIS(I)
1)**2))
      Z0(I)=ADIS(I)+FACT
      Z1(I)=ADIS(I)+BDIS(I)*X
      Z2(I)=ADIS(I)-BDIS(I)*X
      IF(Z1(I).GE.CDIS(I)) Z1(I)=CDIS(I)
      GO TO 15
C *** BETA DISTRIBUTION IDIS=7
CC
C APPROXIMATIVE FORMULAS USED FOR CALCULATING Z1 AND Z2, VALID FOR SMALL PROB
CC
9080 Z0(I)=CDIS(I)
      BEEAY=BDIS(I)-ADIS(I)
      CEEAY=CDIS(I)-ADIS(I)
      GAMNEW=(CEEAY/BEEAY)*((CEEAY*(BDIS(I)-CDIS(I))/BDIS(I)**2)-1.)
      ETANEW=GAMNEW*(BEEAY/CEEAY-1.)
      GAMETA=GAMNEW+ETANEW
      IF(GAMNEW.LE.0.) WRITE(6,9501) IPARA(I)
      IF(GAMETA.GT.57.) WRITE(6,9502) IPARA(I)
9501 FORMAT(31H ****BETA DISTRIBUTED PARAMETER, I4,37H HAS TOO LARGE STA
1NDAFD DEVIATION****/)
9502 FORMAT(31H ****BETA DISTRIBUTED PARAMETER, I4,37H HAS TOO SMALL STA
1NDAFD DEVIATION****/)
      RATIO=(PROB*GAMMA(GAMNEW)*GAMMA(ETANEW))/GAMMA(GAMETA)
      Z1(I)=BDIS(I)-(RATIO*ETANEW*BEEAY**ETANEW)**(1./ETANEW)
      Z2(I)=ADIS(I)+(RATIO*GAMNEW*BEEAY**GAMNEW)**(1./GAMNEW)
      GO TO 15
C *** LOG NORMAL DISTRIBUTION IDIS=8
9090 T=SQRT(ALOG(1./PROB**2))
      XUP=2.51557+ (.802853+.010328*T)*T
      XLOW=1.+ (1.432788+ (.189269+.001308*T)*T)*T
      X=T-XUP/XLOW
      Z0(I)=EXP(ADIS(I)+.5*BDIS(I)**2)
      Z1(I)=EXP(ADIS(I)+BDIS(I)*X)
      Z2(I)=EXP(ADIS(I)-BDIS(I)*X)
      GO TO 15
C DISTRIBUTION UNKNOWN, ASSUMED UNIFORM, ADIS=MEAN, WIDTH=2*BDIS
17 Z0(I)=ADIS(I)
      Z1(I)=ADIS(I)+BDIS(I)
      Z2(I)=ADIS(I)-BDIS(I)

```

```

      1E48F8 NAME KNOTSS
      WRITE(6,1501) IDIS(I),IPARA(I)
      WRITE(6,1502) ZO(I),Z1(I),Z2(I)
      GO TO 15
      15 CONTINUE
      C 1P CORRELATED INPUT PARAMETERS, CALL COKNOT
      C IF (#CORR.GT.0) CALL COKNOT(IDIS)
      16 CONTINUE
      RETURN
      END

```

```

MEMBER NAME LISENS
      SUBROUTINE LISENS(ZF,BF,ZFP,AMAT,ZR,CF,ZO,Z1,Z2,NTOT,NKNOT,NCOEF1,
      1KNOTSV)
C CALCULATES LINEAR SENSITIVITIES WITH A MATRIX METHOD
C CALCULATES LINEAR SENSITIVITIES WITH A MATRIX METHOD
C
*CALL CONS
      REAL*8 ZF,BF,ZFP,AMAT,ZR,CF,DZ,DZR
      DIMENSION ZF(NKNOT,NCOEF1),ZFP(NCOEF1,NKNOT),BF(NCOEF1,1)
      DIMENSION AMAT(NKNOT,NKNOT),ZF(KNOTSV,NTOT),CF(KNOTSV,1),ZO(NTOT),
      1Z1(NTOT),Z2(NTOT)
      COMMON/ZETAB/ZETA(100,6)
      DATA IWRITE/6/
      WRITE(IWRITE,1001) AVZET(L)
1001 FORMAT(15H0 SAMPLE MEAN =,G14.6/21H LINEAR SENSITIVITIES/)
      DO 1 M=1,NKNOT
      DO 2 J=1,NKNOT
      2 AMAT(M,J) = 0.0D0
      1 CONTINUE
      DO 3 M=1,NCOEF1
      3 BF(M,1) = 0.0D0
      DO 9 J=1,NRANKP
      9 CF(J,1) = ZETA(J,L) - AVZET(L)
      DO 11 KNOT=1,NRANKP
      DO 12 J=1,NTOT
      DZR = ZR(KNOT,J) - ZO(J)
      DZ = Z1(J) - Z2(J)
      ZF(KNOT,J) = DZR/DZ
12 ZFP(J,KNOT) = DZR/DZ
      ZF(KNOT,NCOEF1) = 1.0D0
      ZFP(NCOEF1,KNOT) = 1.0D0
11 CONTINUE
      PFACT = FLOAT(NTOT) /FLOAT(NRANKP)
      CALL MXMULT(ZF,ZFP,AMAT,NRANKP,NCOEF1,NRANKP,NCOEF1)
      CALL MATINV(AMAT,NRANKP,CF,NCONS,DET1,ICOB)
      CALL MXMULT(ZFP,CF,BF,NCOEF1,NRANKP,NCONS,NRANKP)
C THE COMPONENTS OF BF ARE SENSITIVITY ESTIMATES * NKNOT/NTOT
      BJ = BF(NCOEF1,1) * PFACT
      WRITE(IWRITE,1002) BJ
1002 FORMAT(1E,3X,30HREFERENCE VALUE - MEAN VALUE =,G12.5/)
      NMAXP = MINO(100,NTOT)
      DO 22 JA=1,NMAXP
      JMA = J
      PMAJ = 0.0
      DO 21 J=1,NCOEF1
      BJ = BF(J,1)
      ABJ = ABS(BJ)
      IF(ABJ.GE.BMAX) JMA = J
      IF(ABJ.GE.BMAX) BMAX = ABJ
21 CONTINUE
      BJ = BF(JMA,1)
      BJ = BJ * PFACT
      WRITE(IWRITE,1003) JMA,BJ
1003 FORMAT(1H,8X,I4,4X,G12.5)
      BF(JMA,1)=0.0D0
22 CONTINUE
      RETURN
      END

```

MEMBER NAME MATINV

```

SUBROUTINE MATINV(A,NM,AUG,MH,DELTA,ICOR)
IMPLICIT REAL*8(A-H,O-Z),INTEGER*4(I-N)
DIMENSION A(NM,NM), AUG(NM,MH)
DIMENSION B(84),C(84),D(84),IZ(84)

```

MINV...3
MINV...4
MINV...5
MINV...6

```

DATA IWRITE/6/

```

MINV...7

```

MATRIX INVERSION SUBROUTINE FOR EQUATION OF THE FORM AX = Y.
RETURNS THE INVERSE OF A IN PLACE OF A AND X IN PLACE OF Y.

```

MINV...8
MINV...9

```

      A   GIVEN MATRIX, DIMENSIONED FOR NM X NM
      NM   ORDER OF A
      AUG  ", DIMENSIONED FOR NM X MH
      MH   NUMBER OF COLUMNS IN AUG
      DFITA DETERMINANT OF A

```

MINV...10
MINV...11
MINV...12
MINV...13
MINV...14
MINV...15

```

...IF ONLY THE INVERSE MATRIX IS SOUGHT, SET M = 0.

```

MINV...16

```

...IF X IS ALSO WANTED (AND Y GIVEN), SET M = 1.

```

MINV...17

```

...AUG MUST BE DIMENSIONED AND ENTERED IN THE

```

MINV...18

```

CALL STATEMENT WHETHER GIVEN OR NOT.

```

MINV...19

MINV...20

MINV...21

MINV...22

MINV...23

MINV...24

```

N = NM

```

```

M = MH

```

```

EPS = 1.0D-49

```

```

DELTA = 1.0D0

```

MINV...26

```

ICOR = 0

```

```

DO 1 I = 1,N

```

MINV...27

```

  JZ(I) = 1

```

MINV...28

```

CONTINUE

```

MINV...29

MINV...30

MINV...31

```

DO 11 I = 1,N

```

MINV...32

```

  K = I

```

MINV...33

```

  Y = A(I,I)

```

MINV...34

```

  IP = I + 1

```

MINV...35

```

  IF( IP .GT. M ) GOTO 3

```

MINV...36

MINV...37

MINV...38

MINV...39

MINV...40

MINV...41

MINV...42

MINV...43

MINV...44

```

DO 2 J = IP,M

```

```

  W = A(I,J)

```

```

  IF( DABS(W) .LE. DABS(Y) ) GOTO 2

```

```

    K = J

```

```

    Y = W

```

```

CONTINUE

```

```

ADELT = DABS(DELTA)

```

```

IF(ADELT .GT. 1.0D+30) ICOR = ICOR + 1

```

```

IF(ADELT .GT. 1.0D+30) DELTA = DELTA * 1.0D-30

```

```

IF(ADELT .LT. 1.0D-30) ICOR = ICOR - 1

```

```

IF(ADELT .LT. 1.0D-30) DELTA = DELTA * 1.0D+30

```

```

ABY = DABS(Y)

```

```

IF(ABY.GT.1.0D+30.AND.ADELT.GT.1.0D-15) ICOR = ICOR + 1

```

```

IF(ABY.GT.1.0D+30.AND.ADELT.GT.1.0D-15) DELTA = DELTA * 1.0D-30

```

```

IF(ABY.LT.1.0D-30.AND.ADELT.LT.1.0D+15) ICOR = ICOR - 1

```

```

IF(ABY.LT.1.0D-30.AND.ADELT.LT.1.0D+15) DELTA = DELTA * 1.0D+30

```

```

ADELT = DABS(DELTA)

```

```

TEXP = 0.00

```

```

IF(ADELT.GT.0.00) TEXP = DLOG(ADELT)

```

MEMBER NAME MATINV

```

      IF (APY.GT.0.00) TEXP = TEXP + OLCG(ABY)
      IF (TEXP.GT.160.00) WRITE(IWRITE,1000) DELTA,Y
      IF (TEXP.LT.-160.00) WRITE(IWRITE,1000) DELTA,Y
1000 FORMAT(2H *,3X,63HDETERMINANT CALCULATION IN MATINV LEADS TO EXTRA
      1 VALUES, DELTA=G12.4,3H Y=G12.4/13H DELTA RESET/)
      IF (TEXP.GT.160.00) DELTA = 1.000
      IF (TEXP.LT.-160.00) DELTA = 1.000
      DELTA = DELTA * Y
      IF (DABS(Y) .GE. EPS ) GOTO 4
      WRITE(IWRITE,1001) Y
1001 FORMAT(1H ,4X,31HSMALL ABS(Y) IN SUBR. MATINV,Y=G12.4,15H BUT I C
      1ONTINUE/)
      IF (DABS(Y) .EQ.0.) WRITE(IWRITE,1002)
1002 FORMAT(1H ,4X,34HY IS ZERO IN SUBR. MATINV,I RETURN/)
      IF (DABS(Y) .EQ.0.) RETURN
      Y = 1.000 / Y
      DO 5 J = 1,N
      C(J) = A(J,K)
      A(J,K) = A(J,I)
      A(J,I) = -C(J) * Y
      B(J) = A(I,J) * Y
      A(I,J) = B(J)
      CONTINUE
      IF (M .LT. 1) GO TO 7
      DO 6 J = 1,N
      D(J) = AUG(I,J) * Y
      AUG(I,J) = D(J)
      CONTINUE
      A(I,I) = Y
      J = IZ(I)
      IZ(I) = IZ(K)
      IZ(K) = J
      DO 10 K = 1,N
      IF (K .EQ. I) GOTO 10
      DO 8 J = 1,N
      IF (J .EQ. I) GOTO 8
      A(K,J) = A(K,J) - B(J)*C(K)
      CONTINUE
      IF (M .LT. 1) GO TO 10
      DO 9 J = 1,N
      AUG(K,J) = AUG(K,J) - D(J)*C(K)
      CONTINUE
      CONTINUE
      CONTINUE
      DO 16 I = 1,N
      K = IZ(I)
      IF (K .EQ. I) GOTO 16
      DO 13 J = 1,N
      W = A(I,J)
      A(I,J) = A(K,J)

```

MINV..45
MINV..46

MINV..49
MINV..50
MINV..51
MINV..52
MINV..53
MINV..54
MINV..55
MINV..56
MINV..57
MINV..58
MINV..59
MINV..60
MINV..61
MINV..62
MINV..63
MINV..64
MINV..65
MINV..66
MINV..67
MINV..68
MINV..69
MINV..70
MINV..71
MINV..72
MINV..73
MINV..74
MINV..75
MINV..76
MINV..77
MINV..78
MINV..79
MINV..80
MINV..81
MINV..82
MINV..83
MINV..84
MINV..85
MINV..86
MINV..87
MINV..88
MINV..89
MINV..90
MINV..91

MEMBER NAME	MATINV		
		$\lambda(I,J) = W$	MINV..92
13	CONTINUE		MINV..93
C			MINV..94
		IF(M .LI. 1) GO TO 15	MINV..95
		GO TO J = 1,M	MINV..96
		W = $\lambda(I,J)$	MINV..97
		$\lambda(I,J) = \lambda(K,J)$	MINV..98
		$\lambda(K,J) = W$	MINV..99
14	CONTINUE		MINV.100
C			MINV.101
15		IP = IZ(I)	MINV.102
		IZ(I) = IZ(K)	MINV.103
		IZ(K) = IP	MINV.104
		DELTA = -DELTA	MINV.105
		GOTO 12	MINV.106
16	CONTINUE		MINV.107
C			MINV.108
		RETURN	MINV.109
		END	MINV.110

```

HEADER NAME  MIMULT
      SUBROUTINE MIMULT(A,B,C,N1,M1,M2,M3)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(N1,1), B(M3,1), C(N1,1)
      DATA IWRITE/6/
C      SUBROUTINE MATXMULT RETURNS THE PRODUCT OF MATRICES A AND B
C      IN THE ARRAY C. (AB = C)
C      M1 IS THE NUMBER OF ROWS IN MATRIX A
C      M1 IS THE NUMBER OF COLUMNS IN MATRIX A
C      AND THE NUMBER OF ROWS IN MATRIX B
C      M2 IS THE NUMBER OF COLUMNS IN MATRIX B
C      C IS AN N1 X M2 MATRIX AND MUST BE DIMENSIONED AS SUCH IN
C      THE CALLING PROGRAM. M1,M1,M2 MUST BE INTEGERS GREATER THAN ZERO.
C 13.GE.M1
      DO 15 I = 1,M1
      DO 15 J = 1,M2
      4      SUM = 0.0DO
      DO 10 K = 1,M1
      6          PROD = A(I,K) * B(K,J)
      10      SUM = PROD + SUM
      15      C(I,J) = SUM
C      WRITE(IWRITE,220)
C 220 FORMAT(45H0 MIMULT EXECUTED. RETURN TO CALLING PROGRAM./)
      RETURN
      END

```

```

MEMBER NAME PACORF
      SUBROUTINE PACORF(ZR,Z0,NTOT,NKNOT,KNOTSV)
      REAL*8 ZR
      *CALL CONS
      DIMENSION ZR(KNOTSV,NTOT),Z0(NTOT)
      DIMENSION JA(30),JB(30),RHO(30)
      DATA IWRITE/6/
      FRA = 1./NBRANKP
      NMAXP=MINO(30,NTOT)
      DO 10 I=1,20
      JA(I) = 0
      JB(I) = 0
      RHO(I) = 0.
10 CONTINUE
      WRITE(IWRITE,1001)
1001 FORMAT(1H1,5X,44SAMPLE CORRELATIONS BETWEEN INPUT PARAMETERS//)
      DO 11 J=1,NTOT
      K1 =J+1
      IF(K1.GT.NTOT) GO TO 11
      SA =0.
      SSA=0.
      DO 23 KN=1,NBRANKP
      ZRA=ZR(KN,J) -Z0(J)
      SA = SA + ZRA
23 SSA= SSA+ ZRA*ZRA
      SSA= SSA - FRA*SA*SA
      DO 12 K=K1,NTOT
      SB =0.
      SSB=0.
      SC =0.
      DO 13 KN=1,NBRANKP
      ZRA=ZR(KN,J) -Z0(J)
      ZRB=ZR(KN,K) -Z0(K)
      SB = SB + ZRB
      SSB= SSB + ZRB*ZRB
      SC = SC + ZRA*ZRB
13 CONTINUE
      SC = SC - FRA*SA*SB
      SSB= SSB - FRA*SB*SB
      DIV = SQRT(SSA*SSB)
      CORJK = SC / DIV
      ABSJK = ABS(CORJK)
      DO 14 I=1,NMAXP
      ABSP = ABS(RHO(I))
      IF(ABSJK.LT.ABSP) GO TO 14
      INDMAX = NMAXP -I
      DO 15 IND=1,INDMAX
      IK=NMAXP+1-IND
      IKP=IK-1
      JA(IK) = JA(IKP)
      JB(IK) = JB(IKP)
15 RHO(IK)= RHO(IKP)
      JA(I) = J
      JB(I) = K
      RHO(I)=CORJK
      ABSJK = 0.
      CORJK = 0.
14 CONTINUE
12 CONTINUE

```



```

SUBROUTINE NAME PACORR
  11 CONTINUE
  DO 120 I=1,NMAXP
    KA =JA (I)
    KB =JB (I)
    KC =PHO(I)
    FCC=KC*RC
  120 WRITE (UNIT=1002) KA,KB,KC,FCC
1002 FORMAT(1P,5X,I4,I5,F10.5,F10.5)
  RETURN
END

```

```

MEMBER NAME  PLOTTP
              SUBROUTINE  PLOTTP(NPRINT,T,X)
C
C  SUBROUTINE PLOTTP PLOTS CONSEQUENCES                      DISTRIBUTIONS
C  OF THE CONSEQUENCES
      DIMENSION T(26),X(26),LINE(120)
      DATA ISEAD, IWRITE/5,6/
      DATA MBLANK,MSTAR,MINUS,LTRI/ 4H      ,4H*      ,4H-      ,4HI      /
      BIG= -1.0E+49
      SMALL=1.0E+49
      DO 40 I=1,NPRINT
      IF (X(I).GT.BIG) BIG= X(I)
      IF (X(I).LT.SMALL) SMALL=X(I)
40  CONTINUE
      DELT=BIG-SMALL
      TES=ABS(SMALL)/10000.+1.0E-49
      IF (DELT.LT.TES) DELT=TES
      P= 50.0/DELT
      DO 60 I=1, NPRINT
      DO 50 K= 2,51
      LINE(K) = MBLANK
      IF (I.EQ.1) LINE(K) =MINUS
50  CONTINUE
      LINE(1) = LTRI
      J= (( X(I) -SMALL)*P + 1.501 )
      LINE(J) = MSTAR
      WRITE(IWRITE,603) T(I),X(I), (LINE(L),L=1,51)
60  CONTINUE
603  FORMAT('7X,G11.4,2X,G11.4,2X,51A1')
      RETURN
      END

```

```

1E1BER N412 PRINTH
      SUBROUTINE PRINTH ( NIS,NOINT,NSIM)
C SUBROUTINE PRINTH
*CALL COMS
      COMMON/GEAVY/CRAVE(4)
      COMMON/CFIDIS/ICIS(4),ACIS(4),BCIS(4),CCIS(4),DCIS(4)
      COMMON/TRANSP/NTFAPA,NTRACO,JTFA(7),JTYPE(7),LTRA(7),LTYPE(7),APA(
17),BPA(7),ACO(7),BCO(7)
      DIMENSION NIS(6,12),NOINT(6,6,12,12)
C CATEGORY BOUNDARIES FOR CRITERIA CONSEQUENCES BASED ON AVERAGE CRITERIA
C CRAVE(N) -TO BE BETWEEN CATEGORIES 6 AND 7 FOR REALLY RANDOM CRITERIA
C -TO BE LL OF CATEGORY 1 IF ICIS(N)=0 AND LCR(N)=0
C -TO BE UL OF CATEGORY 12 IF ICIS(N)=0 AND LCR(N)=1
      IF(NTRACO.GT.0) WRITE(6,7001)
7001 FORMAT(1F0,2X,75HPOR TRANSFORMED CONSEQUENCES THE CATEGORY LIMITS
1ARE ALSO GIVEN IN TERMS OF/42H THE ORIGINAL UNTRANSFORMED CONSEQ
2UENCES/74H MOMENTS IN THE TITLES ARE ANAL. MOMENTS OF THE TRANSF
3ORMED CONSEQUENCES//)
      DO 371 L=1,NCONS
      WRITE(6,3003) L,AVZET(L),SDZET(L),SCALE
3003 FORMAT(14H0 CONSEQUENCE,14,4X,5HMEAN=,E14.6,3X,19HSTANDARD DEVIAT
1ION=,E14.6,8H SCALE=,F6.2/)
      WRITE(6,3004)
3004 FORMAT(90H CATEGORY LOWER B UPPER B COUNTS PROBA
1BILITY ACCURACY PERCENT/)
3005 FORMAT(3H ,13,E15.6,E14.6,18,8X,F10.8,7X,F10.8,3X,F7.3,4H P/C,2X
1,8HSTD CAT=,E13.6)
      DO 372 NI=1,12
      FNL=FLOAT(NI)
      FSA=FLOAT(NSIM)
      BLOW = AVZET(L) + (FNL-7.) * SCALE * SDZET(L)
C NEW CATEGORY LIMITS FOR CRITERIA FUNCTION
      IF(IFLAG) 470,470,471
471 DO 480 K=1,4
      IF(L.NE.NCR(K)) GO TO 480
      FREE = CRAVP(K)
      BLOW = FREE + (FNL - 7.) * SCALE * SDZET(L)
      IF(ICIS(K).EQ.0.AND.LCR(K).EQ.0) BLOW=FREE+(FNL-1.)*SCALE*SDZET(L)
      IF(ICIS(K).EQ.0.AND.LCB(K).EQ.1) BLOW=FREE+(FNL-1.)*SCALE*SDZET(L)
480 CONTINUE
473 BUUP = BLOW + SCALE * SDZET(L)
      COUNTS = FLOAT(NIS(L,NL))
      ICOUNT=INT(COUNTS)
      PROBAL = COUNTS / FSA
      IF(PROBAL) 375,375,374
375 PROS=100.
      ERROR = C.
      GO TO 373
374 ERROR = ((1.-PROBAL)*PROBAL/FSA)**.5
      PROS = 100.*ERROR/PROBAL
373 CONTINUE
      BAVF = (BLOW + BUUP) * 0.50
      WRITE(6,3005) NL,BLOW,BUUP,ICOUNT,PROBAL,ERROR,PROS,BAVF
      IF(NTRACO.LE.0) GO TO 372
C CATEGORY BOUNDARIES INVERSE TRANSFORMED IF CONSEQUENCE TRANSFORMED
      LTYP = 0
C
C BLOW,BAVF,BUUP DEFINED HERE BECAUSE THE OPTIMIZER TAKES THE LOGS
C OUT OF THE DO LOOP IN ANY CASE ,AND ARGUMENTS COULD BE NEGATIVE

```

MEMBER NAME PRINTH

```

C
  BBLOW=0.
  BBAVE=0.
  BBUPP=0.
  IF (BLOW.GT.0.) BBLOW= ALOG(BLOW)
  IF (BAVE.GT.0.) BBAVE= ALOG(BAVE)
  IF (BUPP.GT.0.) BBUPP= ALOG(BUPP)
  DO 701 I=1,NTRACO
    LA = LTRA(I)
    IF (LA.NE.L) GO TO 702
    LTYP = LTYPE(I)
    WRITE(6,2000) LA,L,LTYP
2000  FORMAT(1H0,3I5/)
    AC = ACO(I)
    BC = BCO(I)
    GO TO (100,200,300,400,500,600,700),LTYP
100  BCC = 1./BC
    BLOWS = BLOW**BCC + AC
    BAVES = BAVE**BCC + AC
    BUPPS = BUPP**BCC + AC
    GO TO 701
200  BLOWS = EXP(BLOW) + AC
    BAVES = EXP(BAVE) + AC
    BUPPS = EXP(BUPP) + AC
    GO TO 701
300  BLOWS= BC*BBLOW + AC
    BAVES = BC* BBAVE + AC
    BUPPS= BC* BBUPP + AC
    GO TO 701
400  BLOWS = BC * TAN(BLOW) + AC
    BAVES = BC * TAN(BAVE) + AC
    BUPPS = BC * TAN(BUPP) + AC
    GO TO 701
500  CONTINUE
600  CONTINUE
700  CONTINUE
    BLOWS = BLOW
    BUPPS = BUPP
    BAVES = BAVE
702  CONTINUE
701  CONTINUE
    IF (LTYP.EQ.0) GO TO 372
C  BLOW, BAVE AND BUPP HAVE BEEN INVERSE TRANSFORMED
    WRITE(6,7005) NL,BLOWS,BUPPS,BAVES
7005  FORMAT(3H ,I3,E15.6,E14.6,4X,04HARE INVERSE TRANSF CATEGORY LIMITS,
    1TS, 8I0 CAT=,E16.6/)
372  CONTINUE
371  CONTINUE
3011 FORMAT(52H1 JOINT DISTRIBUTIONS OF POLYNOMIAL CONSEQUENCES/)
3012 FORMAT(20H0 CONSEQUENCE NUMBER,I5,10H VERTICAL)
3013 FORMAT(20H CONSEQUENCE NUMBER,I5,12H HORIZONTAL/)
3014 FORMAT(49H0 PROBABILITY AND ACCURACY (STANDARD DEVIATION) /)
3015 FORMAT(111H CATEGORY 1 2 3 4 5
1 6 7 8 9 10 11 12//)
3016 FORMAT(1H ,I5,12F9.6)
3017 FORMAT(1H ,I5,12F9.6/)
    NCOI=NCONS-1
    IF (NCOI.LE.0) RETURN

```

```

MEMBER NAME PRINTH
      WRITE(6,3011)
      DO 381 L=1,NCOI
        LPI=L+1
        DO 382 M=LPI,NCOMS
          WRITE(6,3012) L
          WRITE(6,3013) M
          WRITE(6,3014)
          WRITE(6,3015)
          DO 383 NI=1,12
            DO 384 NM=1,12
              AJCINT(NM) = FLOAT( NOINT(1,1,NL,NM))/PSA
              PROBAL = AJCINT(NM)
              ERR(NM) = ((1.-PROBAL)* PROBAL/PSA)**.5
            384 CONTINUE
          WRITE(6,3016) NL, AJCINT
          WRITE(6,3017) NL, ERR
        383 CONTINUE
      382 CONTINUE
    381 CONTINUE
  C END OF PRINTH
    RETURN
  END

```

```

MEMBER NAME PROSIM
      SUBROUTINE PROSIM(NGPMAX)
      C
      C PREPARES RANDOM KNOT-POINT CARDS FOR PROSA FROM THOSE INPUT FOR SCREEN
      C
      C READS NGPMAX CARDS FIRST. EACH SPECIFY A PAIR OF IDENTIFICATION NUMBERS
      C FIRST NUMBER (15) IS THE IDENT. NO. FOR PROSA
      C SECOND NUMBER (15) IS THE IDENT. NO. OF THE SAME PARAMETER FOR SCREEN
      C NGPMAX SHOULD NOT EXCEED MAXIMUM VALUE
      C
      C THEN READS THE RANDOM KNOT-POINT COORDINATE CARDS OF SCREEN
      C AND PICKS THE VALUES OF THOSE PARAMETERS SELECTED FOR PROSA
      C AND OUTPUTS THE KNOT-POINT CARDS FOR PROSA-2 IN CORRECT FORMAT
      C
      C PROSIM (JOBS 6) USES ONLY VARIABLES NTOT,JOBS,WORK,NRANKP AND NGPMAX
      C FROM THE FIRST INPUT CARD
      *CALL COMS
      DIMENSION INDP(12),INDS(12),ZP(12)
      DIMENSION Z(1000)
      DATA IFRAD,IWRITE,IPUNCH/5,6,7/
      WRITE(IWRITE,1001)
      DO 2 J=1,NGPMAX
      READ(IFRAD,1002) INDP(J),INDS(J)
      2 WRITE(IWRITE,1012) INDP(J),INDS(J)
      1002 FORMAT(I5,I5)
      1012 FORMAT(1H ,10X,I5,5X,I5)
      1001 FORMAT(3CHOSCREENED PARAMETERS FOR PROSA//28H PROSA PARA NO.   SCR
      1SEN NO.//)
      WRITE(IWRITE,1011)
      1011 FORMAT(1H0,6X,28HSCREEN AND PROSA KNOT-POINTS//)
      1004 FORMAT(1H ,6X,I5,4X,I5,(6G16.6))
      1003 FORMAT(I2,I4,2X,(6G12.5))
      DO 3 I=1,NRANKP
      READ(IFRAD,1003) INDEX,KNOT,(Z(I),L=1,NPARA)
      WRITE(IWRITE,1004)INDEX,KNOT,(Z(I),L=1,NPARA)
      DO 4 JR=1,NGPMAX
      LOCP= INDP(JR)
      LOCS= INDS(JR)
      ZP(LOCP) = Z(LOCS)
      4 CONTINUE
      WRITE(IPUNCH,1003) INDEX,KNOT,(ZP(J),J=1,NGPMAX)
      WRITE(IWRITE,1004) INDEX,KNOT,(ZP(J),J=1,NGPMAX)
      3 CONTINUE
      WRITE(IWRITE,1005)
      1005 FORMAT(45H0 END OF KNOT-POINTS IN JOBS 6,SUBROUTINE PROSIM//)
      RETURN
      END

```

MEMBER NAME PUNCH

SUBROUTINE PUNCH(LOC,ZIN)

```

C
C PUNCHES INPUT CARDS FOR A DETERMINISTIC/MECHANISTIC CODE THAT CALCU-
C LATES OUTPUT VARIABLES
C
C IN THIS CASE SAS3D
C
DATA IPUNCH,IWHITE/7,6/
NSAS = 1
WRITE(IPUNCH,2003) LOC,NSAS,ZIN
2003 FORMAT(2I6,5E12.5)
WRITE(IWHITE,2004) LOC,NSAS,ZIN
2004 FORMAT(1H ,2I6,5E12.5)
RETURN
END

```

```

MEMBER NAME READIN
      SUBROUTINE READIN(ZR,CF,NTOT,NKNOP)
C
C READS CONSEQUENCES AND COORDINATES OF THE RANDOM KNOT-POINTS
C CF CONTAINS THE CONSEQUENCES, ZR THE COORDINATES (PARAMETER VALUES)
C
      REAL*8 Z,ZR,CF
*CALL COMS
      COMMON/ZPTAB/ZETA(100,6)
      COMMON/SAVE/ZAVE(1000),ZSS(1000)
      DIMENSION Z(1000)
      DIMENSION ZR(NKNOP,NTOT),CF(NKNOP,NCONS)
      DIMENSION SPCOR(20),JORG(20),SPVAR(20),SPMEAN(20)
      DIMENSION FMEAN(6),RKCM2(6),RKMAX(6),RKMIN(6)
C
      DATA IREAD,IWRITE,INIMA/5,6,5/
      COMMON/TRANSF/NTRAPA,NTRACO,JTRA(7),JTYPE(7),LTRA(7),LTYPE(7),APA(
17),BPA(7),ACO(7),BCO(7)
C
      COMMON/HISPL0/WHIS(6,12),NJOINT(6,6,12,12)
      DIMENSION IPLO(6,26),TP(26),XP(26)
      DIMENSION NEWKN(100)
      NKNOT = NKNOP
      SCALE = 0.50
C INITIAL ZEROS
C
      DO 9 L=1,NCONS
        RKMEAN(L) = 0.
        RKCM2(L) = 0.
        RKMAX(L) = -1.0E+49
        RKMIN(L) = +1.0E+49
      DO 5 IK=1,12
      DO 7 L2=1,NCONS
      DO 8 I*2=1,12
      9 NJOINT(L,L2,IK,I*2) = 0
      7 CONTINUE
      5 WHIS(L,IK) = 0
      DO 6 IP=1,26
      6 IPLO(L,IP) = 0
      9 CONTINUE
      DO 801 JJ= 1,NPAPA
        ZAVE(JJ) = 0.
        ZSS(JJ) = 0.
      801 CONTINUE
      FRA= 1./NRANKP
C
C KNOT-POINT (DATA-POINT) NO.S TO BE INCLUDED IN THIS WORK
      READ(IREAD,7001) NEWKN
      7001 FORMAT(I5)
      IF(NEWKN.EQ.0) GO TO 770
      READ(IRPAD,7002) (NEWKN(I),I=1,NEWKN)
      7002 FORMAT(16I5)
      WRITE(IWRITE,7003) NEWKN
      7003 FORMAT('H1,8X,I4,43H KNOT-POINTS INCLUDED, NUMBERING AS FOLLOWS//')
      WRITE(IWRITE,7004) (I,NEWKN(I),I=1,NEWKN)
      7004 FORMAT(I5,I5)
      770 CONTINUE
C READ CONSEQUENCES IN RANDOM KNOT-POINTS , NRANKP SETS
      WRITE(IWRITE,2000) JOBS,NCONS

```



```

MEMBER NAME READIN
2000 FORMAT(1F1,10X,74H*CONSEQUENCES IN RANDOM KNOT-POINTS INPUT IN
1SUBROUTINE READIN FOR JOBS,I4/1H ,7X,5HINDEX,10X,4HKNOT,6X,13,13H
2CONSEQUENCES//)
KIN = 0
DO 11 K = 1,NRANKP
  READ(IPEAD,2001) INDEX,KNOT,(CONS(I),I=1,NCONS)
  IF(NEWKNP.EQ.0) GO TO 712
  DO 711 IN = 1,NEWKNP
    KCOMP = NEWKN(IN)
    IF(KNOT.NE.KCOMP) GO TO 711
    KNOT = IN
    KIN = KIN + 1
  GO TO 712
711 CONTINUE
  GO TO 11
712 CONTINUE
C
  WRITE(IWRITE,2002) INDEX,KNOT,(CONS(I),I=1,NCONS)
C TRANSFORM KNOT-POINT CONSEQUENCES
C IF(NTRACC.GT.0) CALL TRACO(CONS)
C IF(NTRACC.GT.0) WRITE(IWRITE,2005) INDEX,J,K,(CONS(I),I=1,NCONS)
2005 FORMAT(21H TRANSFORMED VALUES/5H+ ,3I5,(6E16.6))
C
C CONSEQUENCES TRANSFORMED
C
C
C DEFINE MATRIX CF
C
DO 11 L=1,NCONS
  RKCONS = CONS(L)
  RKMEAN(L) = RKMEAN(L) + RKCONS
  RKCM2(L) = RKCM2(L) + RKCONS * RKCONS
  IF(RKCONS.GT.RKMAX(L)) RKMAX(L) = RKCONS
  IF(RKCONS.LT.RKMIN(L)) RKMIN(L) = RKCONS
  ZETA(KNOT,L) = CONS(L)
  CF(KNOT,I) = CONS(L)
11 CONTINUE
C
  IF(KIN.NE.NEWKNP) WRITE(IWRITE,7011) KIN,NEWKNP
7011 FORMAT(1H3,5X,17HINPUT ERROR, KIN=,I4,21H KNOTS FOUND, NEWKNP=,I4,
1//)
  IF(KIN.NE.NEWKNP) STOP
C
C CF IS A WORKING PLACE,ZETA PERMANENT STORAGE
C
2001 FORMAT(12,I4,2X,(6E12.6))
2002 FORMAT(1H ,6X,I5,8X,I4,(6E16.6))
C READIN 1
C
C
C READ RANDOM KNOT-POINT COORDINATES
C
10 WRITE(IWRITE,1621) JOBS
1621 FORMAT(1H1,10X,39H RANDOM KNOT-POINT COORDINATES FOR JOBS,I3//)
1622 FORMAT(12,I4,2X,(6E12.6))
1623 FORMAT(1H ,6X,I5,4X,I5,(6E16.6))
KIN = 0
DO 2 I=1,NRANKP

```

```

MEMBER NAME READIN
      READ(INTRA,1622) INDEX,KNOT,(Z(L), L = 1,NPARA)
      DO 802 JJ=1,NPARA
        ZBR = Z(JJ)
        ZSS(JJ) = ZSS(JJ) + ZBR*ZBR
        ZAVE(JJ) = ZAVE(JJ) + ZBR
      802 CONTINUE
      IF(NEWKN.EQ.0) GO TO 722
      DO 721 IN=1,NEWKN
        KCOMP = NEWKN(IN)
        IF(KNOT.NE.KCOMP) GO TO 721
        KNOT = IN
        KIN = KIN+1
        GO TO 722
      721 CONTINUE
      GO TO 2
      722 CONTINUE
      WRITE(IWRITE,1623) INDEX,KNOT,(Z(L), L = 1,NPARA)
C TRANSFORM KNOT-POINT COORDINATES
C   IF(NTRAPA.GT.0) CALL TRAPA(Z)
C   IF(NTRAPA.GT.0) WRITE(IWRITE,2623) INDEX,KNOT,(Z(L),L=1,NPARA)
2623 FORMAT(21H TRANSFORMED VALUES/1H+,6X,15,4X,15,(6E16.6))
C PARAMETERS TRANSFORMED
C
      DO 60 J=1,NPARA
        ZR(KNOT,J) = Z(J)
      60 CONTINUE
      2 CONTINUE
C
C ZAVE IS THE TOTAL SAMPLE MEAN VALUE
C ZSS IS THE SUM OF SAMPLE CORRECTED SQUARES
      DO 803 JJ=1,NPARA
        ZSS(JJ) = ZSS(JJ) - FRA* ZAVE(JJ) * ZAVE(JJ)
        ZAVE(JJ) = FRA * ZAVE(JJ)
      803 CONTINUE
      IF(KIN.NE.NEWKN) WRITE(IWRITE,7011) KIN,NEWKN
      IF(KIN.NE.NEWKN) STOP
      IF(NEWKN.NE.0) NRANKP = NEWKN
      IF(NEWKN.NE.0) NKNOT = NEWKN
C
C READIN 1
C
C
      WRITE(IWRITE,3000)
      DO 100 L = 1,NCONS
        RKAVE = PKMEAN(L) / NRANKP
        RKMPAN(L)=RKAVE
C
C
        RKVAR = PKM2(L) / NRANKP - RKAVE * RKAVE
        DN = NRANKP
        RKVAR = RKVAR * DN / DN
        RKCM2(L)=RKVAR
        RKSD = .0.
        IF(RKVAR.GT.0.) RKSD = SQRT(RKVAR)
        SDZPT(L) = RKSD
        WRITE(IWRITE,3001) L,RKAVE,RKSD,RKMAX(L),RKMIN(L)
C

```

MEMBER NAME READIN

```

      1*ZET(L) = PRAVE
C
      100 CONTINUE
C
C THIS PART OF READIN CALCULATES THE HISTOGRAMS OF RAW DATA
C
      3000 FORMAT('O CHARACTERISTICS OF RANDOM KNOT POINT SAMPLE CONSEQUENCES
      11/'C CONSEQUENCE      MEAN VALUE  STD DEVIATION  MAXIMUM VALUE  MI
      1MINUM VALUE'/)
C
      3001 FORMAT(1B0,6X,I4,4X,G14.5,1X,G14.5,1X,G14.5,1X,G14.5)
C
      DO 82 KI=1,NRANKP
      DO 81 L=1,NCONS
      APZETA(L) = ZETA(KI,L)
      81 CONTINUE
      CALL HISTO(IPLO,NHIS,NJOINT)
      82 CONTINUE
      CALL PRINTH(NHIS,NJOINT,NRANKP)
C
      DO 380 L=1,NCONS
      WRITE(IWRITE,4600) L
      DIVE = 1./(SCALE*SDZET(L))
      DO 381 K=1,26
      NC = NRANKP
      FNC=FLOAT(NC)
      XP(K) = FLOAT(IPLO(L,K))/FNC * 2.
      TP(K) = FLOAT(INT(FLOAT(K)/2.))
      PROUNT = XP(K) *DIVE
      WRITE(IWRITE,4601) TP(K),PROUNT
      381 CONTINUE
      WRITE(IWRITE,3201) L
      CALL PLOTFF(26,TP,XP)
      380 CONTINUE
      3201 FORMAT(1B0,10X,11HCONSEQUENCE,13/)
      4600 FORMAT(1B0,35HPROBABILITY PER UNIT OF CONSEQUENCE,13/)
      4601 FORMAT(17X,G11.4,2X,G11.4)
C
C READIN 2
C
C THIS PART OF READIN CALCULATES AND EDITS NMAXP LARGEST CORRELATION
C COEFFICIENTS BETWEEN A CONSEQUENCE AND THE PARAMETERS
      NMAXP=MINO(20,NTOT)
      DO 111 L=1,NCONS
      DO 110 I=1,NMAXP
      SPH*AN(I)=0.
      SPCOF(I)=0.
      SPVAB(I)=0.
      JORG(I)=0
      110 CONTINUE
      WRITE(IWRITE,4000) L
      4000 FORMAT(1B0,8X,40HCORRELATION COEFFICIENTS FOR CONSEQUENCE,14,12H.
      1PARAMETERS//3H      ,9HPARAMETER,2X,25HCOEFF. COEFF. SQUARE F/)
      DO 112 J=1,NPAPA
      SZM*AN=0.
      SZVAB=0.
      SCOR=0.
      DO 113 KN=1,NRANKP

```

12MPR PAGE READIN

```

      ZRR=ZP(KN,J)
      SZMEAN=SZMEAN +ZRR
      SZVAR=SZVAR + ZRR*ZRR
      SCOR= SCOR + ZRR*(CP(KN,L) - BKMEAN(L))
113  CONTINUE
      SZMEAN=SZMEAN/NRANKP
C FROM NOW ON Z(J) IS USED
C SAVE SZMEAN'S IN THIS SUBROUTINE
      Z(J)=SZMEAN
      SZVAR=SZVAR/NRANKP - SZMEAN * SZMEAN
      SCOR= SCOR/NRANKP
      ABSCOR= ABS(SCOR)
      DO 114 I=1,NMAXP
      ABSP= ABS(SPCOR(I))
      IF(ABSCOR.IT.ABSP) GO TO 114
      INDMAX=NMAXP - I
      DO 115 IND=1,INDMAX
      IK=NMAXP +1 - IND
      IKP=IK - 1
      SPMEAN(IK)=SPMEAN(IKP)
      SPCOR(IK)=SPCOR(IKP)
      SPVAR(IK)=SPVAR(IKP)
      JOFG(IK)=JORG(IKP)
115  CONTINUE
      SPMEAN(I)=SZMEAN
      SPCOR(I)=SCOR
      SPVAR(I)=SZVAR
      JORG(I)= J
      SCOR=0.
      ABSCOR=0.
114  CONTINUE
112  CONTINUE
      NDF=NRANKP - 2
      DO 120 I=1,NMAXP
      JB=JORG(I)
      SC=SPCOR(I)
      RSQ= SC * SC
      FVAR= NDF * RSQ
      WRITE(IWRITE,4001) JB,SC,RSQ,FVAR
4001  FORMAT(1H ,5X,I4,F10.5,F10.5,F10.5/)
120  CONTINUE
      WRITE(IWRITE,4002) NDF
4002  FORMAT(1H ,5X,30HCOMPARE LAST COLUMN TO AN F(1,,I3,9H) VARIABLE//)
      JB1 = JORG(1)
      SZSD1= SQRT(SPVAR(1))
      B1 = SPCOR(1) * SQRT(RKCH2(L)) / SZSD1
      WRITE(IWRITE,4003) JB1, SZSD1, B1
4003  FORMAT(1H0,5X,30HTHE MOST CORRELATING PARAMETER,I3,/1H ,5X,29HHAS
1SAMPLE STANDARD DEVIATION,G12.5/1H ,5X,24HREGRESSION COEFFICIENT B
2,5X,G12.5//)
C RESIDUAL CONSEQUENCES
      DO 200 K=1,NRANKP
      CP(K,L) = CP(K,L) - BKMEAN(L) - F1*(ZK(K,JB1) - Z(JB1))
200  CONTINUE
C CORRELATIONS WITH THE RESIDUAL CONSEQUENCE
      DO 210 I=1,NMAXP
      SPCOR(I)=0.

```

MEMBER NAME READIN

```

      SPVAR(I)=0.
      JORG(I) = 0
212  CONTINUE
      DO 212 J=1,NPARA
      SVAR=0.
      SCOR=0.
      SZVAR=0.
      DO 213 KN=1,NRANKP
      ZBR=ZR(KN,J) - Z(J)
      SEUR=CF(KN,L)
      SCOR=SCOF + ZBR*SEUR
      SVAR=SVAR + SEUR*SEUR
      SZVAR=SZVAR + ZBR*ZBR
213  CONTINUE
      DNP= NRANKP -1
      SVAR = SVAR/ NRANKP
      SZVAR = SZVAR / NRANKP
      SCOR = SCOR / NRANKP
      SCOR = SCOR/ SQRT(SVAR*SZVAR)
      ABSOR=ABS(SCOR)
      DO 214 I=1,NMAXP
      ABSP=ABS(SPCOR(I))
      IF(ABSP.CO.LT.ABSP) GO TO 214
      INDMAX = NMAXP - I
      DO 215 IND=1,INDMAX
      IK=NMAXP + 1 - IND
      IKP = IK - 1
      JORG(IK)= JORG(IKP)
      SPCOF(IK)= SPCOF(IKP)
      SPVAR(IK)= SPVAR(IKP)
215  CONTINUE
      JORG(I) = J
      SPCOF(I) = SCOR
      SPVAR(I) = SZVAR
      SCOR = 0.
      ABSOR = 0.
214  CONTINUE
212  CONTINUE
      SDEV = SQRT(SVAR)
      WRITE(IWRITE,4099) L,SDEV
4099  FORMAT(1H ,3X,11HCONSEQUENCE,13,2X,28HRESIDUAL STANDARD DEVIATION=
1,G12.5//)
      WRITE(IWRITE,4100) L
4100  FORMAT(1P0,6X,38HCORRELATIONS OF RESIDUAL CONSEQUENCE,14,16H WIT
1H PARAMETERS//37H PARAMETER CORR.COEF. SQUARE F/)
      DO 270 I=1,NMAXP
      JB=JORG(I)
      SC= SPCOF(I)
      RSQ = SC * SC
      FVAR = NDF * RSQ
      WRITE(IWRITE,4001) JB,SC,RSQ,FVAR
220  CONTINUE
      WRITE(IWRITE,4002) NDF
C
C
      JB2 = JORG(1)
      SZSD2 = SQRT(SPVAR(1))
      B2 = SPCOF(1) * SQRT(SVAR) / SZSD2

```

MEMBER NAME READIN

WRITE(IWRITE,4103) JB2, SZSD2, B2
 4103 FORMAT(1H0,5X,32HTHE SECOND CORRELATING PARAMETER,I4,/3H ,28HHAS
 1SAMPLE STANDARD DEVIATION,G12.5/1H ,5X,24HREGRESSION COEFFICIENT B
 2,5X,G12.5/)

C
 C SECOND RESIDUALS OF THE CONSEQUENCES
 DO 300 K=1,NRANKP
 CF(K,L) = CF(K,L) - B2*(ZR(K,JB2) - Z(JB2))
 300 CONTINUE

C CORRELATIONS WITH SECOND RESIDUALS

C
 C
 4109 FORMAT(1H0,6X,38HCORRELATIONS OF RESIDUAL CONSEQUENCE,I4,16H WITH
 1H PARAMETER,5X/37H PARAMETER CORR.COEF. SQUARE F/)

C
 DO 310 I=1,NMAXP
 SPCOR(I) = 0.
 SPVAR(I) = 0.
 JORG(I) = 0
 310 CONTINUE
 DO 312 J=1,NPAPA
 SVAR = 0.
 SCOR = 0.
 SZVAR = 0.
 DO 313 KM = 1, NRANKP
 ZRF = ZR(KM,J) - Z(J)
 SEUP = CF(KM,L)
 SCOR = SCOR + ZRF * SEUR
 SVAR = SVAR + ZRF * SEUR
 SZVAR = SZVAR + ZRF * ZRF
 313 CONTINUE
 DNP = NRANKP - 1
 SVAR = SVAR / NRANKP
 SZVAR = SZVAR / NRANKP
 SCOR = SCOR / NRANKP
 SCOR = SCOR / SQRT(SVAR * SZVAR)
 ABSCOR=ABS(SCOR)
 DO 314 J=1,NMAXP
 ABSP = ABS(SPCOR(I))
 IF(ABSCOR.LT.ABSP) GO TO 314
 INDMAX = NMAXP - J
 DO 315 IND=1,INDMAX
 IK = NMAXP + 1 - IND
 IKP = IK - 1
 JORG(IK) = JORG(IKP)
 SPCOR(IK) = SPCOR(IKP)
 SPVAR(IK) = SPVAR(IKP)
 315 CONTINUE
 JORG(I) = J
 SPCOR(I) = SCOR
 SPVAR(I) = SZVAR
 SCOR = 0.
 ABSCOR = 0.
 314 CONTINUE
 312 CONTINUE
 SDFV = SQRT(SVAR)
 WRITE(IWRITE,4099) L,SDEV
 WRITE(IWRITE,4109) I

424823 NA17 READIF

```

      DO 320 I=1,NMAXP
      JB = JORG(I)
      SC = SPCOR(I)
      RSQ = SC * SC
      PVAP = NDP * RSQ
      WRITE(17PITE,4001) JB,SC,RSQ,PVAP
320  CONTINUE
      WRITE(17PITE,4002) NDP
C
C
      JB2 = JORG(1)
      SZSD2 = SQRT(SPVAR(1))
      B2 = SPCOR(1) * SQRT(SVAR) / SZSD2
      WRITE(17PITE,4104) JB2,SZSD2,B2
4104  FORMAT(1H0,5X,11HTHE THIRD CORRELATING PARAMETER,13/1H,5X,29HHAS
1SAMPLE STANDARD DEVIATION,612.5/1H,5X,26HREGRESSION COEFFICIENT
2 B,5X,612.5/)
C
      DO 400 K=1,NRANKP
      CF(K,L) = CF(K,L) - B2*(ZB(K,JB2) - Z(JB2))
400  CONTINUE
      DO 410 I=1,NMAXP
      SPCOR(I) = 0.
      SPVAR(I) = 0.
      JORG(I) = 0
410  CONTINUE
      DO 412 J=1,NPABA
      SVAR = 0.
      SCOR = 0.
      SZVAR = 0.
      DO 413 KN = 1, NRANKP
      ZEF = ZP(KN,J) - Z(J)
      SEUR = CF(KN,L)
      SCOR = SCOR + ZEF * SEUR
      SVAR = SVAR + SEUR * SEUR
      SZVAR = SZVAR + ZEF * ZEF
413  CONTINUE
      DNP = NRANKP - 1
      SVAR = SVAR / NRANKP
      SZVAR = SZVAR / NRANKP
      SCOR = SCOR / NRANKP
      SCOR = SCOR / SQRT(SVAR * SZVAR)
      ABSCOR=ABS(SCOR)
      DO 414 J=1,NMAXP
      ABSP = ABS(SPCOR(J))
      IF(ABSCOR.LT.ABSP) GO TO 414
      INDMAX = NMAXP - I
      DO 415 IND=1,INDMAX
      IK = NMAXP + 1 - IND
      IKF = IK - 1
      JORG(IK) = JORG(IKP)
      SPCOR(IK) = SPCOR(IKP)
      SPVAR(IK) = SPVAR(IKP)
415  CONTINUE
      JORG(I) = J
      SPCOR(I) = SCOR
      SPVAR(I) = SZVAR
      SCOR = 0.

```

```

411 READIN
      ABSCOR = 0.
414 CONTINUE
412 CONTINUE
      SDEV = SQRT(SVAR)
      WRITE(IWRITE,4099) L,SDEV
      WRITE(IWRITE,41C9) L
      DO 420 I=1,NHAYP
        JB = JORG(I)
        SC = SPCOR(I)
        RSQ = SC * SC
        FVAR = NDP * RSQ
420 WRITE(IWRITE,40C1) JB,SC,RSQ,FVAR
      CONTINUE
      WRITE(IWRITE,4002) NDP
C
      JB2 = JORG(1)
      SZSD2 = SQRT(SPVAR(1) )
      B2 = SPCOR(1) * SQRT(SVAR) / SZSD2
      WRITE(IWRITE,51C4) JB2,SZSD2,B2
5104 FORMAT(1H0,5X,31H FOURTH CORRELATING PARAMETER,13/1H ,5X,29HHAS
1SAMPLE STANDARD DEVIATION,612.5/1H ,5X,26HREGRESSION COEFFICIENT
2 B,5X,612.5/)
C
C FOURTH RESIDUAL STANDARD DEVIATION
      DO 500 K=1,NFANKP
        CF(K,L) = CF(K,L) - B2*(ZR(K,JB2) - Z(JB2))
500 CONTINUE
C STANDARD DEVIATION OF THE FOURTH RESIDUALS
      SVAR = 0.
      DO 513 KN=1,NBANKP
        SEUR = CF(KN,L)
        SVAR = SVAR + SEUR*SEUR
513 CONTINUE
      SVAR = SVAR / NFANKP
      SDEV= SQRT(SVAR)
      WRITE(IWRITE,4099) L,SDEV
111 CONTINUE
      NKNOP = NKNOT
      RETURN
      END

```



```

ME18ER NAME SAMPLE
      SUBROUTINE SAMPLE(IDIS,ADIS,BDIS,CDIS,DDIS,ZR,WPOT,MKNOT,I)
C   SAMPLES INPUT PARAMETERS
C
C   *CALL COMS
      REAL*8 ZR
      DIMENSION IDIS(MTOT),ADIS(MTOT),BDIS(MTOT),CDIS(MTOT),DDIS(MTOT),Z
      1P(MKNOT,MTOT)
C
      COMMON/NEWREP/ZONE(12)
      COMMON/CONTRL/JOEISV
      DO 312 J=1,NPARA
      M=IDIS(J)
      U = FLTRNP(0)
      GO TO (320,325,330,330,9335,9340,9345,9350),M
320 U= FLTRNP(0)
      ZY = BDIS(J)+U*(ADIS(J)-BDIS(J))
C   IF(MCORR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
325 U=FLTRNP(0)
      V=FLTRNP(0)
      W= 1./U
      GA = ((2.*ALOG(W))**.5) * COS(6.2831853 * Z)
      ZY = ADIS(J) + GA * BDIS(J)
C   IF(MCORR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
330 U= FLTRNP(0)
      ZY = ADIS(J) - BDIS(J) * ALOG(U)
      IF(M.EQ.4) ZY =ADIS(J)+BDIS(J)*ALOG(U)
C   IF(MCORR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
C
C
9335 U=FLTRNP(0)
      V=FLTRNP(0)
      W=1./U
      GA = ((2.*ALOG(W))**.5) * COS(6.2831853 * V)
      ZY = ADIS(J) + GA * BDIS(J)
      IF(ZY .LT.CDIS(J)) GO TO 9335
C   IF(MCORR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
9340 U=FLTRNP(0)
      V=FLTRNP(0)
      W=1./U
      GA = ((2.*ALOG(W))**.5) * COS(6.2831853 * V)
      ZY = ADIS(J) + GA * BDIS(J)
      IF(ZY .GT.CDIS(J)) GO TO 9340
C   IF(MCORR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
C   THE SAMPLING GENERATED FOR THE BPTA DISTRIBUTION IS DONE USING A
C   PAIR OF GAMMA RANDOM VARIATES WHICH IN TURN USE EXPONENTIAL, AND
C   THEREFORE, THE UNIFORM RANDOM VARIATE.
9345 BEEAY=BDIS(J)-ADIS(J)
      CEEAY=CDIS(J)-ADIS(J)
      GAMNEW=(CEEAY/BEEAY)*((CEEAY*(BDIS(J)-CDIS(J)) /CDIS(J)**2)-1.)
      ETANEW=GAMNEW*(BEEAY/CEEAY-1.)
      Y=GAMRN(1.,GAMNEW)
      T=GAMRN(1.,ETANEW)
      ZY = (Y/(Y+T))*(BDIS(J)-ADIS(J))+ADIS(J)

```

MEMBER NAME SAMPLE

```

C      IF (NCOFR.GT.0) CALL MSHIFT(Z0)
      GO TO 311
9150  U=FLTRNF(0)
      V=FLTRNF(0)
      W=1./U
      GA = ((2.*ALOG(W))**.5) * COS(6.2831853 * V)
      BW = ADIS(J) + GA * BDIS(J)
      ZY = EXP(BW)
C      IF (NCOFR.GT.0) CALL MSHIFT(Z0)
311  CONTINUE
      ZR(I,J) = ZY
312  CONTINUE
      RETURN
      END
      FUNCTION GAMBN (ALAM,ETA)
      N=ETA
      F=ETA-N
      IF (F.EQ.0) GO TO 8100
8010  P=FLTRNF(0)
      IF (P.LT.F/(F+2.71828)) GO TO 8120
      Q=FLTRNF(0)
      Y=Q**(1./F)
      IF (P.GT.F*P(-Y)) GO TO 8100
      GO TO 8050
8100  Y=0.
      GO TO 8070
8120  S=FLTRNF(0)
      Y=1.-ALOG(S)
      IF (P.GT.Y**(F-1.)) GO TO 8010
8050  IF (N.EQ.0) GO TO 8150
8070  Z=1.0
      DO 8080 I=1,N
8080  Z=Z*FLTRNF(0)
      Y=Y-ALOG(Z)
8150  GAMBN=Y/ALAM
      RETURN
      END

```

***** NAME SASIM

SUBROUTINE SASIM(NKNOT,NTOT,ZR)

```

C
C PUNCH CARDS TO INPUT FOR VENUS , SENSITIVITY STUDY 1979.
C TAKE OUT THIS BLOCK IF VENUS IS NOT USED (200 SERIES STATEMENTS)
*CALI CONS
  REAL*8 ZP
  DIMENSION ZP(NKNOT,NTOT)
  DATA IWRITE,IPUNCH/6,7/
  DO 205 I=1,NKNOT
    VAPRES = ZP(I,1)
    CPFUEL = ZP(I,2)
    WRITE(IPUNCH,2001) VAPRES,CPFUEL
2001  FORMAT(2E12.4)
    RPRESS = ZP(I,3)
    TOTPR = 0.
    WRITE(IPUNCH,2002) RPRESS,TOTPR
2002  FORMAT(2E12.5)
    DELKO = ZP(I,4)
    RAMPK = ZP(I,5)
    SECBAM= 0.0
    AAMBDA= ZP(I,6)
    AEND = 0.98
    WRITE(IPUNCH,2003) DELKO,RAMPK,SECBAM,AAMBDA,AEND
2003  FORMAT(5E12.5)
    PFIRST = 1.0E+20
    PZERO = ZP(I,7)
    PEND = 2.5E+10
    PCRIT = 3.0
    WRITE(IPUNCH,2004) PFIRST,PZERO,PEND,PCRIT
2004  FORMAT(4E12.5)
    DO 20 JD=1,4
      AH=0.
      BH=0.
      CH=0.
      TMEIT= 3040.
      HFUSE= ZP(I,8)
20  WRITE(IPUNCH,2005) AH,BH,CH,TMEIT,HFUSE
2005  FORMAT(5E12.5)
      AD = 0.
      DOPLB= ZP(I,9)
      CD = 0.
      DD = 0.
      WT = 0.1750
      WRITE(IPUNCH,2006) AD,DOPLB,CD,DD,WT
      WT = 0.2560
      WRITE(IPUNCH,2006) AD,DOPLB,CD,DD,WT
      WT = 0.0924
      WRITE(IPUNCH,2006) AD,DOPLB,CD,DD,WT
      WT = 0.1633
      WRITE(IPUNCH,2006) AD,DOPLB,CD,DD,WT
2006  FORMAT(5E12.5)
      DO 30 JU=1,4
        RHCU = ZP(I,10)
        RHON = ZP(I,11)
        RHOS = ZP(I,12)
        FP = 0.3488
        FNA = 0.0
        PSS = 0.2345

```

```

MEMBER NAME SASIN
30 WRITE (TPUNCH,2007) RHOU,RHONA,RHCSS,PF,PNA,PSS
2007 FORMAT(6E12.5)
TB = 1200.
AVTMRP = 2R(I,13)
WRITE (TPUNCH,2008) AVTE4P,TB
2008 FORMAT(2E12.5)
205 CONTINUE
RETURN
END

```

```

12442P NAME SCRAM
      SUBROUTINE SCRAM(ZF,BF,ZFP,AMAT,ZR,CF,NTOT,NKNOT,NCOEF2,Z0,Z1,Z2,K
1NOTSV)
      REAL *8 ZF,BF,ZFP,AMAT,ZR,CF,CFA,X,DZJ,DZK
      REAL *8 CFNEW
      DIMENSION CFNEW(100,1)
      COMMON/JOB/JOBSV
      *CALL CONS
      COMMON/MPRII/JONE,JTWO,JTHREE
      COMMON/TRANSF/NTAPA,NTACO,JTRA(7),LTRA(7),LTYPE(7),JTYPE(7),APA(
17),BPA(7),ACO(7),BCO(7)
C
C
C
      COMMON/ZETAB/ZETA(100,6)
      DATA IWRITE/6/
      DATA IOUT/0/
      DIMENSION JGOBS(10,12),GERMS(10),GSENS(10,12)
      DIMENSION ZF(NKNOT,NCOEF2),BF(NCOEF2,1),ZFP(NCOEF2,NKNOT)
      DIMENSION AMAT(NCOEF2,NCOEF2),ZR(KNOTSV,NTOT),CF(KNOTSV,1),Z0(NTOT
1),Z1(NTOT),Z2(NTOT)
      DIMENSION JGP(12),SENS(12),SENSCR(12,12),SENST(12),ZGP(12)
      DIMENSION B(12),C(12),D(12,12)
C
C
C   THE VALUE OF L (CONSEQUENCE INDEX) IS DETERMINED IN MAIN THRU CONS
C   PARAMETER CYCLING INSIDE GROUP2 WITH VARIABLE JP
C
C   NCONCS=1 IN THIS SUBROUTINE, NCONSV=NO. OF CONSEQUENCES, KNOWN TO MAIN ONLY
C
C
C
      IF(NTOT.LT.NGP) WRITE(IWRITE,1500)
      IF(NTOT.LT.NGP) RETURN
1500  FORMAT('HO,10X,45HNTOT LESS THAN NGP IN SUBROUTINE SCRAM,I PASS//')
C
C
      DO 5 J = 1,NCOEF2
      DO 1 M = 1,NCOEF2
1  AMAT(M,J) = 0.000
      DO 5 K = 1,NRANKP
      ZF(K,J) = 0.000
5  ZFP(J,K) = 0.000
      DO 7 M = 1,NCOEF2
7  BF(M,1) = 0.000
      DO 9 J=1,NRANKP
9  CF(J,1)=ZETA(J,L)
C
C
      IF(NGP.EQ.NP) GO TO 40
      PGLIM = (NTOT - NP) / (NGP - NP) + 0.999
C
C
      NLLIM = YFIX(PGLIM)
      WRITE(IWRITE,2100) NLLIM
2100  FORMAT('HO,8X,22HTHE NUMBER OF GROUPS =,I4//')
40  CONTINUE
C

```

MEMBER NAME SCRAM

```

C
  IF (JOBS.EQ.4) NGLIN=NLIN
  IF (JOBS.EQ.5) NGLIN=1
  IF (JOBS.EQ.15) NGLIN=1
  NMAXG = MIN0(10,NGLIN)
  NMAXP = MIN0(12,NTOT)
  DO 110 IG = 1,NMAXG
    GERMS(IG) = 1.0E+09
C
C
  DO 110 IP = 1,NMAXP
    JGORG(IG,IP) = 0
    GSEWS(IG,IP) = 0.
110  CONTINUE
C
C  DEFINE MATRIX ZF AND ZFP
C
  JFLAG = 0
  JP = 0
  JPSV = 0
C
C  FILL JGP ARRAY
C
  NV = NGP - NP
C  JGP(I) CONTAINS THE NUMBERS OF THE PARAMETERS IN THE REGRESSION MODEL
C  I.E. GROUP THE FIRST NP ARE THOSE ACCEPTED FROM THE PREVIOUS GROUP
  DO 50 I = 1,NP
    KG = KORG(I)
C
C
  JGORG(1,I) = KG
50  JGP(I) = KG
C
C
  IF (JOBS.EQ.5) GO TO 59
51  CONTINUE
C  51 IS AN IMPORTANT STATEMENT NUMBER TO BE RETURNED TO WITH NEW G
C  JGORG(IG,IP) IS THE NUMBER OF THE IP' TH IMPORTANT PARAMETER IN THE IG' TH
C  GROUP. INITIAL VALUES FOR JGORG(1,I) ARE GIVEN INPUT BY KORG(I), I.I.E.NP
C
C
  DO 53 JV = 1,NV
    I = NP + JV
55  JP = JP + 1
    IF (JP.GT.NTOT) JFLAG = 1
C
    IF (JP.GT.NTOT) JP = JP - NTOT
C
C  JP HAS TO BE COMPARED TO THE NOS OF PARA ALREADY IN THE GROUP
C
  DO 54 K = 1,NP
    KTEST = JGP(K)
    IF (JP.EQ.KTEST) GO TO 55
54  CONTINUE
C
C
  JGP(I) = JP
53  CONTINUE

```

```

MEMBER NAME SCRAM
      JPSV = JP
C
C
59  CONTINUE
      IF (IOUT.GT.0.OP.JOBS.EQ.5)
1WRITE(IWRITE,2110) (JGP(IS),IS = 1,NGP)
2110  FORMAT(1H0,6X,32HTHE PARAMETERS OF THIS GROUP ARE,1215//)
C
C
      DO 2 KNOT=1,NRANKP
        ZP(KNOT,1) = 1.0D0
        ZFP(1,KNOT) = 1.0D0
C
C
      DO 3 J=1,NGP
        J1 = J + 1
        J2 = J1 + NGP
        J3 = NGP + 1 + J*NGP - J*J1/2
C
C
        JIND = JGP(J)
        DZJ = ZP(KNOT,JIND)
        DZJ = DZJ - Z0(JIND)
C
C
        ZP(KNOT,J1) = DZJ
        ZP(KNOT,J2) = DZJ * DZJ
        ZFP(J1,KNOT) = DZJ
        ZFP(J2,KNOT) = DZJ * DZJ
        IF (J.GE.NGP) GO TO 3
C
      DO 4 K = J1,NGP
        K1 = J1 + K
C
        KIND = JGP(K)
        DZK = ZP(KNOT,KIND)
        DZK = DZK - Z0(KIND)
C
C
        ZP(KNOT,K1) = DZJ * DZK
        ZFP(K1,KNOT) = DZJ * DZK
4      CONTINUE
1      CONTINUE
2      CONTINUE
C
C ZP AND ZFP AND CP ARE NOW DEFINED FOR THIS GROUP
C
C THE NEXT THREE STATEMENTS SOLVE LEAST SQUARES FITTING EQUATION
C (ZP'ZF)BP = ZP'CP FOR BP
C
C
      CALL MXMULT(ZFP,CP,BP,NCOEF2,NRANKP,NCONS,KNOTSV)
      CALL MXMULT(ZFP,ZF,AMAT,NCOEF2,NRANKP,NCOEF2,NRANKP)
      CALL MATINV(AMAT,NCOEF2,BP,NCONS,DET2,ICOR)
      ICCO = ICOR * 30
      IF (IOUT.GT.0)
1WRITE(IWRITE,2300) DET2,ICOR
2300  FORMAT('DETERMINANT OF ZP*ZF = ',G15.6,' TIMES 1.0D',I4)
C

```

MEMBER NAME SCRAM

C CALCULATE AND OUTPUT FITTED SURFACE ERRORS: MAXIMUM AND MINIMUM,
 C MEAN SQUARE ERROR, REFERENCE VALUE AND FRACTIONAL PROPR.
 1690 FORMAT (1H0,10X,23H*FITTED SURFACE ERRORS*/1H0,5X,4HKNOT,6X,13HAPPR
 10XIMATION,8X,5H2ACT,10X,10HDIFFERENCE,5X,15HFOR CONSEQUENCE,14//)

C
 C
 C

DN = NRANKP - NCOEF2
 IF (DN.LE.0.) DN = 1.0E-10
 SUMSQ = 0.0
 BIG = -1.0E+49
 IBIG = 1
 SMALL = 1.0E+49
 ISMALL = 1
 IF (IOUT.EQ.1) WRITE (IWRITE,1690) L
 DO 21 IR=1,NRANKP
 CFA = 0.0
 DO 22 IC=1,NCOEF2
 CFA = CFA + ZP (IR,IC) * BP (IC,1)
 22 CONTINUE
 X = CFA - CP (IR,1)
 IF (X.GT.BIG) IBIG = IR
 IF (X.GT.BIG) BIG = X
 IF (X.LT.SMALL) ISMALL = IR
 IF (X.LT.SMALL) SMALL = X
 IF (IOUT.GT.1) WRITE (IWRITE,1700) IR,CFA,CP (IR,1),X

C
 C

SUMSQ = SUMSQ + X*X
 CPNEW (IR,1) = 0.
 IF (JOBSV.EQ.15) CPNEW (IR,1) = -X
 21 CONTINUE
 IF (IOUT.GT.0.OR.JOBSV.EQ.5.OR.JOBSV.EQ.15)
 1WRITE (IWRITE,1701) L,IBIG,BIG,ISMALL,SMALL
 IF (NTRACO.LE.0) GO TO 99

C
 C
 C

C MAX ERROR CONSEQUENCES TO BE INVERSE TRANSFORMED

C

LTP = 0
 DO 701 J=1,NTRACO
 LL = LTRA (J)

C
 C

IF (LL.NP.L) GO TO 701
 LTP = LTYPE (I)
 AC = ACC (I)
 BC = BCO (I)
 CPBIG = CP (IBIG,L)
 CFBIG = CPBIG + BIG

C
 C

CPSMA = CP (ISMALL,L)
 CPASMA = CPSMA + SMALL
 GO TO (101,200,300,400,500,600,700),LTP
 101 BCC = 1./BC

C

CFBIG = CFBIG**BCC + AC


```

MEMBER NAME SCRAM
      CPABIG = CPABIG **BCC +AC
      CFSMA = CFSMA **BCC +AC
      CPASMA = CPASMA**BCC +AC
C
C
      GO TO 701
200 CPBIG = EXP(CPBIG) +AC
      CPABIG= EXP(CPABIG) +AC
      CFSMA = EXP(CFSMA) +AC
      CPASMA= EXP(CPASMA) +AC
      GO TO 701
300 CPBIG =BC*ALOG(CPBIG) + AC
      CPABIG=BC*ALOG(CPABIG) + AC
      CFSMA =BC*ALOG(CFSMA) + AC
      CPASMA=BC*ALOG(CPASMA) + AC
C
C
      GO TO 701
400 CPBIG = BC*TAN(CPBIG) + AC
      CPABIG= BC*TAN(CPABIG) + AC
      CFSMA = BC*TAN(CFSMA) + AC
      CPASMA= BC*TAN(CPASMA) +AC
C
C
500 CONTINUE
600 CONTINUE
700 CONTINUE
701 CONTINUE
      IF (ITYP.FQ.C) GO TO 90
      BIG = CPABIG - CPBIG
      SMALL = CPASMA - CFSMA
      PRABIG = BIG/CPBIG
      PRASMA = SMALL/CFSMA
      WRITE (IWRITE,7001) CPABIG,CPBIG,BIG,PRABIG
      WRITE (IWRITE,7002) CPASMA,CFSMA,SMALL,PRASMA
7001 FORMAT (1H+,4X,20HINVERSE TR MAX,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HERROR=,E12.5,2X,9HFRACTION=,F10.6/)
C
C
7002 FORMAT (1H+,4X,20HINVERSE TR MIN,APPR=,E12.5,2X,6HEXACT=,E12.5,2X,6
1HERROR=,F12.5,2X,9HFRACTION=,F10.6/)
99 CONTINUE
C
C ERRORS INVERSE TRANSFORMED
C
      IF (IOUT.GT.0.OR.JOBS.EQ.5)
1WRITE (IWRITE,1704) SUMSQ
1704 FORMAT (1H+,60X,22HSUM OF ERROR SQUARES =,G13.5/)
      FMSE= SORT(SUMSQ/DN)
      IF (RF(1,1).EQ.0.) FRAERR = 0.0
      IF (RF(1,1).NE.0.0) FRAERR = FMSE / DABS(BP(1,1))
      IF (IOUT.GT.0.OR.JOBS.EQ.5)
1WRITE (IWRITE,1702) FMSE,BP(1,1),FRAERR
1700 FORMAT (1H+,4X,14,3X,E16.6,2X,E15.6,4X,E15.6)
1701 FORMAT (1H0,12H*CONSEQUENCE,14,3X,15HMAX ERROR KNOT=,14,7H VALUE=,E
116.6,3X,15HMIN ERROR KNOT=,14,7H VALUE=,E16.6/)
1702 FORMAT (1H+,20H MEAN SQUARE ERROR=,E15.6,11H REF VALUE=,E15.6,3X,1
1HFRACTION =,F9.5/)

```

```

MEMBER NAME SCRAM
      CROSSW= 1.
      AA=BP(1,1)
C COEFFICIENTS FOR THE GROUP RESPONSE SURFACE
      DO 33 J= 1,NGP
        JA = J + 1
        JB = JA + NGP
        JC = JA*NGP + 1 - J*JA/2
C
C      B(J) = BP(JA,1)
      C(J) = BP(JB,1)
      IF(J.GP.NGP) GO TO 33
      DO 32 K=JA,NGP
        KPI = JC + K
32      D(J,K) = BP(KPI,1)
33      CONTINUE
C
C SENSITIVITIES FOR THE GROUP PARAMETERS
C
      DO 35 J=1,NGP
        BB = B(J)
        JIND = JGP(J)
        DZ1 = Z1(JIND) - Z0(JIND)
C
        DZJ2 = Z2(JIND) - Z0(JIND)
        CC = C(J)
        SENS(J) = ABS((BB + CC*DZ1)*DZ1) + ABS((BB+ CC*DZJ2)* DZJ2)
C
        J1 = J + 1
        IF(J.GE.NGP) GO TO 35
        DO 36 K=J1,NGP
          KIND = JGP(K)
          SENSCR(J,K) = CROSSW * ABS(D(J,K) * DZ1 * (Z1(KIND) - Z0(KIND)))
36      SENSCR(K,J) = SENSCR(J,K)
35      CONTINUE
C
C TOTAL SENSITIVITY MEASURE SENST(J)
C
      DO 37 J=1,NGP
        SENST(J) = SENS(J)
C
      DO 38 K=1,NGP
        IF(K.EQ.J) GO TO 38
        SENST(J) = SENST(J) + SENSCR(J,K)
38      CONTINUE
37      CONTINUE
C
C
C RANKING THE GROUP ACCORDING TO RESIDUAL ERROR
      DO 114 IG=1,NMAXG
        VERT= GERMS(IG)
        IF(FMSP.GT.VERT) GO TO 114
        IF(JOBS.EQ.5.OR.JOBS.EQ.15) GO TO 117
C
C      INDMAX = NMAXG -IG
      DO 115 IND=1,INDMAX
        IK= NMAXG + 1 - IND

```

```

MEMBER NAME  SCR148
      IKP = IK - 1
      GERMS(IK) = GERMS(IKP)
C
C
      DO 116 IP=1,NMAXP
      JGORG(IK,IP) = JGORG(IKP,IP)
      GSENS(IK,IP) = GSENS(IKP,IP)
116  CONTINUE
115  CONTINUE
117  CONTINUE
C
C
      GERMS(IG) = FMSE
      M=0
C RANKING THE PARAMETERS WITHIN THE GROUP THAT CHANGES GROUP RANKING
150  M=M+1
      SEMAX1 = 0.
      DO 152 J=1,NGP
      IF(SEMAX1.GT.SENST(J)) GO TO 152
C
C
      SEMAX1 = SENST(J)
      JMAX1 = JGP(J)
      JSV = J
      GSENS(IG,M) = SEMAX1
      JGORG(IG,M) = JMAX1
152  CONTINUE
C
C
      SENST(JSV) = - SEMAX1 - 1.0E-49
      IF(M.LT.NGP) GO TO 150
      M=0
      SEMAX1 = 0.
      FMSE = 1.1E+49
114  CONTINUE
      IF(JOBS.EQ.4.AND.JFLAG.NE.1) GO TO 51
C
C
30  CONTINUE
      DO 161 IG=1,NMAXG
      WRITE(IWRITE,4001) IG,(JGORG(IG,I),I=1,NMAXP)
      WRITE(IWRITE,4002) GERMS(IG)
      GPSENS = 0.
C
C
4001  FORMAT(1P0,6X,5HGROUP,I3,3X,10HPARAMETERS,12I6/)
4002  FORMAT(1H,8X,28HRESIDUAL MEAN SQUARE ERROR =,10X,G12.5/)
      FRAC2 = 0.
      IF(SDZPT(L).GT.0.)
      1FRAC2 = GERMS(IG) / SDZET(L)
C
      FMS = GERMS(IG)
      USS = DN * FMS * FMS
      WRITE(IWRITE,4003) WRANKP,MCOEF2,USS
4003  FORMAT(1H0,20X,7HWRANKP=,I4,5X,7HMC0EF2=,I4,5X,16HSUM OF SQUARES =
1,G13.5//)
C
      WRITE(IWRITE,4004) SDZET(L),FRAC2

```

```

MEMBER NAME SCRAM
4004 FORMAT(1H,8X,17HSAMPLE ST. DEV. =,G12.5,16HNORMALIZED ERROR,P8.5/
1//1H,9X,36HPARAMETERS IN THE ORDER OF SENSITIVITY/1H,4X,9HIDENT.
2NO.,2X,17HTOTAL SENSITIVITY,3X,11H //)
C
C GROUP MERIT INDEX = SAMPLE VARIANCE/(RESIDUAL M.S. ERROR*GROUP SENSITIVITY
C GROUP SENSITIVITY = SUM OF TOTAL PARAMETER SENSITIVITIES
C THE TOTAL SENSITIVITY IS = THE INDIVIDUAL SENSITIVITY + ALL INTERACTION
C TERMS OF THE PARAMETER
C
C HIGH GROUP SENSITIVITY WITH SMALL FITTING ERRORS (RESIDUALS)
C INDICATES THAT WE MAY BE FITTING AN 'ELEPHANT'
C
C ALSO A SUDDEN INCREASE IN THE SENSITIVITY OF AN INDIVIDUAL PARAMETER
C ALONG THE SCREENING PROCESS MAY BE SPURIOUS
      DO 162 IP = 1,NGP
      JG = JGORG(IG,IP)
      GPSENS = GPSENS + GSENS(IG,IP)
      WRITE(IWRITE,4005) JG,GSENS(IG,IP)
162 CONTINUE
      GPWT = SDZET(1)/(FRAC2 * GPSENS)
      WRITE(IWRITE,4007) GPSENS,GPWT
4007 FORMAT(1H0,6X,19HGROUP SENSITIVITY =,G12.5,25X,19HGROUP MERIT INDEX
2X =,G12.5)
4005 FORMAT(1H,4X,16,7X,G12.5,5X,G12.5/)
161 CONTINUE
      IF(JOBS.EQ.4) RETURN
C PRINT RESPONSE SURFACE COEFFICIENTS
C FOR THIS GROUP IN JOBS = 5
      WRITE(IWRITE,2050)
      WRITE(IWRITE,2051) (JGP(IP),IP= 1,NGP)
      WRITE(IWRITE,2052) AA
      WRITE(IWRITE,2053) (B(IP),IP=1,NGP)
C
C
      WRITE(IWRITE,2054) (C(IP),IP=1,NGP)
      DO 172 JIP = 1,NGP
      IF(JIP.EQ.NGP) GO TO 172
      NKI = JIP + 1
C
C
      JPP = JGF(JIP)
      WRITE(IWRITE,2055) JPP, (D(JIP,K),K=NKI,NGP)
2050 FORMAT(1H0,5X,48HTHE COEFFICIENTS OF THE FITTED POLYNOMIALS /
162H A /
262H + B(J) * ( Z(J) -Z0(J) ) ,SUM J /
362H + C(J) * ( Z(J) -Z0(J) )**2 ,SUM J /
462H + D(J,K) * (Z(J)-Z0(J)) * (Z(K)-Z0(K)) ,SUM J,K (K.GT.J) //)
C
C
2051 FORMAT(1H,5X,25HTHE PARAMETERS ARE 'J,K = ,12I5//)
2052 FORMAT(1H,7X,3HA =,G15.6//)
2053 FORMAT(1H,4X,6FB(J) =,(6G15.6)/)
2054 FORMAT(1H,4X,6HC(J) =,(6G15.6)/)
C
172 CONTINUE
C
2055 FORMAT(1H,1X,2HD(,I2,5H,K) =,(6G15.6)/)
      WRITE(IWRITE,2060)

```

```

1818EP PA12 SCRAM
      IF (NGP.EQ.1) GO TO 193
      NEP = NGP - 1
      DO 182 IP=1,NEP
      KP = IP + 1
C
C      WRITE(IWRITE,2061) JGP(IP),SENS(IP),(SENSCR(IP,K),K=KP,NGP)
182  CONTINUE
183  CONTINUE
      WRITE(IWRITE,2061) JGP(NGP),SENS(NGP)
C
      IF (JOBSP.EQ.15) CALL FITIN(ZR,CFNEW,NTOT,MKNOT)
C
2060  FORMAT(1H0,6X,48HSENSITIVITIES AND INTERACTION SENSITIVITIES /
160H  J ,      SENS(J) ,      SENSCE(J,K),K=J+1,,,NGP //
2061  FORMAT(1H ,I4,G14.6,(6G14.6)/)
      RETURN
      END

```

```

MEMBER NAME SSHIFT
      SUBROUTINE SSHIFT (IPARA, IDIS, ADIS, BDIS, CDIS, DDIS, Z0, Z1, Z2, Z3, NTOT,
      INKNOT, KNOTSV)
C
C CALCULATES THE DEVIATIONS OF THE INPUT PARAMETERS DISTRIBUTION CHARAC-
C TERISTICS
C ZAVE(J) IS THE SAMPLE MEAN VALUE OF THE PARAMETER Z(J), CALCULATED
C FROM THE TOTAL INPUT SET OF KNOTSV CASES IN SUBROUTINE READIN
C USED IN TESTING SUBSET AVERAGE DEVIATIONS, FOR DETECTING IMPORTANT
C PARAMETERS FOR THRESHOLD EFFECTS
C
C SAMPLE SMALLEST VALUE FROM Z2
C SAMPLE LARGEST VALUE FROM Z1
C IN COMPARABLE TERMS TO HAVE A PROBABILISTIC MEASURE
C FORMULAS DIRECTLY MEANINGFUL IF THE DISTRIBUTIONS OF THE INPUT PARA
C ARE UNIFORM
C USEFUL IN SEARCHING SENSITIVE INPUTS FOR SUBSETS
C
      REAL*8 Z,ZR,CP
*CALL COMS
      COMMON/ZPTAR/ZETA(100,6)
      COMMON/SAVE/ZAVE(1000),ZSS(1000)
      DIMENSION Z(1000)
      DIMENSION IPARA(NTOT),IDIS(NTOT),ADIS(NTOT),BDIS(NTOT),CDIS(NTOT),
      DDIS(NTOT),Z0(NTOT),Z1(NTOT),Z2(NTOT),ZR(KNOTSV,NTOT)
      DIMENSION JORG(20),SPMEAN(20),SPMIN(20),SPMAX(20),SPVAR(20)
      DIMENSION STUOT(20)
C
      DATA IPEAD,IWRITE,INIMA/5,6,5/
      COMMON/TRANSP/NTRAPA,NTFACO,JTRA(7),JTYPE(7),LIRA(7),LTYPE(7),APA(
      17),BPA(7),ACO(7),BCO(7)
C
      DIMENSION NEWKN(100)
      DIMENSION MORG(20)
C
C INITIAL ZEROS
C
      NMAXP=MINO(20,NTOT)
      DO 110 I=1,NMAXP
      SPMEAN(I)=0.
      SPVAR(I)=1.
      JORG(I)=0
      SPMIN(I)=0.
      SPMAX(I)=0.
      STUOT(I)=0.
110 CONTINUE
      FN=NRANKP
      FNSV=KNOTSV
C
      WRITE(IWRITE,4000)
4000 FORMAT(1H1,8X,36HSAMPLE STATISTICS FOR INPUT PARAMETERS/1H,8X,43H
      1FIRST DEVIATIONS OF THE SAMPLE MPAN FROM Z0,8H OF ZAVE/)
      WRITE(IWRITE,3999)
3999 FORMAT(1H,5X,5HPARAM,12H MEAN SHIFT,12H 1-VARIABLE,3X,7HREL.SD.
      1,3X,10H RATIO T/SE/)
      DO 112 J=1,NPARA
      SZMPAN=0.
      SZVAR=0.
      DO 113 FN=1,NRANKP

```

```

MEMBER NAME SSHIFT
      ZRR=ZR(KP,J)
      SZMEAN=SZMEAN + ZRR
      SZVAR=SZVAR + ZRR*ZRR
113  CONTINUE
      SZMPAN=SZMPAN/NRANKP
C   SAVE SZMEAN'S IN THIS SUBROUTINE
      Z(J)=SZMPAN
      SZVAR=SZVAR/NRANKP - SZMEAN * SZMEAN
      M = IDIS(J)
      IF (M.LT.1.OR.M.GT.8) GO TO 17
      GO TO (901,902,903,904,905,906,907,908),M
C   UNIFORM DISTRIBUTION
901  SDZ = (ADIS(J) - BDIS(J)) / SQRT(12.*FN)
      GO TO 15
C   NORMAL DISTRIBUTION
902  SDZ = BDIS(J)
      GO TO 15
C   EXPONENTIAL DISTRIBUTION
903  CONTINUE
904  CONTINUE
905  CONTINUE
906  CONTINUE
907  CONTINUE
908  CONTINUE
17   SDZ = (Z1(J) - Z2(J)) / SQRT(12.*FN)
15   CONTINUE
      COMPL = 0.
      IF (NRANKP.NE.KNOTSV) COMPL= ((FNSV*ZAVE(J) - FN*SZMEAN)**2)/(FNSV-FN
1)
      STZIN = FN*SZMEAN*SZMEAN - FNSV*ZAVE(J)*ZAVE(J) + COMPL
      SUMES = ZSS(J) - STZIN
      VARES = SUMES / (FNSV-2.)
      SDZSAM = SQRT(VARES)
      TSHIFT = (SZMEAN - ZAVE(J)) / SDZSAM
      IF (NRANKP.EQ.KNOTSV) TSHIFT= (SZMEAN - Z0(J)) / SDZSAM
      IF (NRANKP.NE.KNOTSV) TSHIFT = TSHIFT * SQRT(FN*(FNSV-FN)/FNSV)
      SUMA = SZVAR
      VARA = SUMA / (FN-1.)
      SDZSA = SQRT(VARA)
      ZSHIFT = (SZMEAN - ZAVE(J)) / SDZSA
      IF (NRANKP.EQ.KNOTSV)
1      ZSHIFT=(SZMEAN - Z0(J)) / SDZSA
      SZVAP = SDZSA/SDZ
      ABSZS = ABS(ZSHIFT)
      DO 114 I=1,NMAXP
      ABSP = ABS(SPMAN(I))
      IF (ABZS.LT.ABSP) GO TO 114
C
      INDMAX=NMAXP - I
      DO 115 IND=1,INDMAX
      IK=NMAXP +1 - IND
      IKP=IK - 1
      SPMAN(IK)=SPMAN(IKP)
      JOFG(IK)=JOFG(IKP)
      STUOT(IK) = STUOT(IKP)
115  CONTINUE
      SPMAN(I) = ZSHIFT
      STUOT(I) = TSHIFT

```

```

MEMBER NAME SSHIFT
      JORG(I)= J
      ZSHIFT = 0.
      ABSZS = 0.
114  CONTINUE
      ABVAR= ABS(SZVAR)
      IF(ABVAR.LT.1.0) SZVAL = -SZVAR
      IF(ABVAR.LT.1.0) ABVAR= 1./ABVAR
      DO 414 I=1,NMAXP
      ABVA = ABS(SPVAR(I))
      IF(ABVA.LT.1.0) ABVA = 1.0/ABVA
      IF(ABVAR.LT.ABVA) GO TO 414
C
      INDMAX=NMAXP - I
      DO 415 IND=1,INDMAX
      IK=NMAXP +1 - IND
      IKP=IK - 1
      SPVAR(IK)=SEVAR(IKP)
      MORG(IK)=MORG(IKP)
415  CONTINUE
      SPVAR(I)=SZVAR
      MORG(I) = J
      ABVAR = 0.
414  CONTINUE
112  CONTINUE
      FDIF = 1.
      IF(NFANKP.NE.KNOTSV) PDIF = FMSV/(FMSV-FN)
      DO 120 I=1,NMAXP
      JB=JORG(I)
      MB = MORG(I)
      SC = SPMPAN(I)
      SC = SC * SQRT(FDIF)
      SCC = STUDT(I) * PDIF
      SSD = SPVAR(I)
C SC = SURSET MEAN SHIFT FROM Z0/ SUSE1 S.D. TIMES SQRT(NBANKP - 1)
C SCC = STUDENT'S T-VARIABLE FOR TESTING TWO SAMPLE MEAN VALUES
      WRITE(IWRITE,4001) JB,SC,SCC,MB,SSD
4001 FORMAT(1H,5X,14,2F10.4,10X,4H,14,6X,P10.5/)
120  CONTINUE
4002 FORMAT(1H,5X,36HDEVIATIONS OF SMALLEST VALUE FROM Z2/)
      WRITE(IWRITE,4002)
      DO 210 I=1,NMAXP
      JORG(I) =0
210  CONTINUE
      DO 212 J=1,NPARA
      SZMIN = 1.0E+40
      DO 213 KN=1,NBANKP
      ZPR = ZR(KN,J)
      IF(ZPR.LT.SZMIN) SZMIN = ZPR
213  CONTINUE
      M= IDIS(J)
      GO TO(911,912,913,914,915,916,917,918),M
911  SMZ = ADIS(J) - BDIS(J)
      GO TO 25
912  SMZ = Z1(J) - Z2(J)
      GO TO 25
913  CONTINUE
915  CONTINUE
914  CONTINUE

```


MEMBER NAME SSHIFT

```

916 CONTINUE
917 CONTINUE
918 CONTINUE
27 SMZ = Z1(J) - Z2(J)
25 CONTINUE
ZSHIFT = (SZMIN - Z2(J)) / SMZ
DO 214 I=1,NMAXP
  ABSZ = SPMIN(I)
  IF(ZSHIFT.LT.ABSZ) GO TO 214
  INDMAX = NMAXP - I
  DO 215 IND =1,INDMAX
    IK=NMAXP +1 - IND
    IKP = IK -1
    SPMIN(IK) = SPMIN(IKP)
    JORG(IK) = JORG(IKP)
215 CONTINUE
  SPMIN(I) = ZSHIFT
  JORG(I) = J
  ZSHIFT =-1.
214 CONTINUE
212 CONTINUE
DO 220 I=1,NMAXP
  JB= JORG(I)
  SC = SPMIN(I)
  SCC = (1.-SC)**NRANKP
  WRITE(IWRITE,4011) JB,SC,SCC
220 CONTINUE
4011 FORMAT(1H,5X,I4,F10.4,F10.5/)
      WRITE(IWRITE,4012)
4012 FORMAT(1H0,5X,35HDEVIATIONS OF LARGEST VALUE FROM Z1/)
C
C SCC IS THE PROBABILITY OF GETTING MINIMUM VALUE DEVIATING THIS MUCH
C OF MORE FROM Z2, OR MAXIMUM VALUE FROM Z1
C
C
C MAXIMUM VALUE BLOCK
C
DO 310 I=1,NMAXP
  JORG(I) =0
310 CONTINUE
DO 312 J=1,NPAGA
  SZMAX = -1.0E+48
  DO 313 KN=1,NRANKP
    ZPR = ZP(KN,J)
    IF(ZPR.GT.SZMAX) SZMAX = ZPR
313 CONTINUE
  N= IDIS(J)
  GO TO(921,922,923,924,925,926,927,928),N
921 SMZ = ADIS(J) - BDIS(J)
    GO TO 35
922 SMZ = Z1(J) - Z2(J)
    GO TO 35
923 CONTINUE
925 CONTINUE
924 CONTINUE
926 CONTINUE
927 CONTINUE
928 CONTINUE

```

```

MEPPER NAME SSHIFT
37 SMZ = Z1(J) - Z2(J)
35 CONTINUE
  ZSHIFT = (SZMAX - Z1(J)) / SMZ
  DO 314 I=1, NMAXP
    ABSP = SPMAX(I)
    IF (ZSHIFT.GT.ABSP) GO TO 314
    INDMAX = NMAXP - I
    DO 315 IND =1, INDMAX
      IK = NMAXP +1 - IND
      IKP = IK -1
      SPMAX(IK) = SPMAX(IKP)
      JORG(IK) = JORG(IKP)
315 CONTINUE
    SPMAX(I) = ZSHIFT
    JORG(I) = J
    ZSHIFT = +1.
314 CONTINUE
312 CONTINUE
  DO 320 I=1, NMAXP
    JB = JORG(I)
    SC = SPMAX(I)
    SCC = (1.+SC) ** NBRANKP
    WRITE (INWRITE, 4011) JB, SC, SCC
320 CONTINUE
  RETURN
END

```

```

MEMBER NAME TEXASS
      SUBROUTINE TEXASS(Z,I)
C SUBROUTINE TEXAS FOR TESTING ONLY (TEST.GT.0)
*CALL CONS
      DIMENSION Z(1000)
      COMMON/ZETAB/ZETA(100,6)
C
      DATA BACK/0.25/
C
C NEW MODIFICATIONS FOR NEW TEXASS
C
      X1 = Z(1)
      X2 = Z(2)
      X3 = Z(3)
      X4 = Z(4)
      X5 = Z(5)
      CONS(1) = X1 + 2.*X2 + 3.*X3 + 4.*X4 + 5.*X5 -7.500
      CONS(2) = X1*X1 + 2.*X2*X2 + 3.*X3*X3 + 4.*X4*X4 + 5.*X5*X5
C
      SUMCO = 0.
      DO 5 JU=6,100
      SUMCO = SUMCO + Z(JU) - 0.500
5 CONTINUE
      SUMCO = BACK * SUMCO
      CONS(1) = CONS(1) + SUMCO
      CONS(2) = CONS(2) + SUMCO
      X1 = X1 - 0.5
      X2 = X2 - 0.5
      X3 = X3 - 0.5
      X4 = X4 - 0.5
      X5 = X5 - 0.5
      CONS(3) = X1*X1 + 2.*X2*X2 + 3.*X3*X3 + 4.*X4*X4 + 5.*X5*X5+ SUMCO
1*.25
      CONS(4) = X1*X2+ 2.*X2*X3 + 3.*X3*X4 +4.*X4*X5 +5.*X5*X1+SUMCO
1*.25
C
      DO 10 L = 1,NCONS
      ZETA(I,L) = CONS(L)
10 CONTINUE
      RETURN
      END

```


APPENDIX B

Sample Input/Output

This sample problem performs Task 4 (JOBS=4) for a problem of 13 input parameters and three consequence variables. This example is part of an application to the Venus-II code described in Chapter IV. The number of Venus-II runs (= the number of knot-points) in this case is 40.

The first three pages contain the listing of the input cards for Task 4. Five consequence variables are input on the consequence cards (cards 15-54) but only the first three are used since the variable NCONS is given value three on the first card. The last three input cards specify seed-groups of two input parameters (parameters no. 5 and 9) for each of the three consequence variables used, and the successive regression procedure seeks for the best third input variables.

In the output listing that follows, the first page indicates some input variables as well as sizes and locations of certain arrays important for the dynamic allocation of space (used internally by the code). The second page of the output also contains input information, and the third page gives the ranges of the input variables (lower limits, mean values and the upper limits).

The fourth output page contains the listing of the values of the three consequence variables in all 40 cases (knot-points). Pages five and six contain the co-ordinates (values of the 13 input variables) of those 40 knot-points. The following pages contain statistics calculated from the sample of 40 cases (moments, histograms, joint distributions and plots of the histograms).

The screening output starts with correlation coefficients between consequences no. 1 and all the input variables, ranked by the magnitude of the correlations. Results of four stages of the stagewise correlation analysis are output for all three consequences variables, revealing that input parameters five and nine correlate most with all three consequences.

After the correlation analysis a number of largest correlation coefficients between the input parameters are listed. This is provided as an information for the user to check if high correlation between particular input variables could be a reason for having them both correlating highly with an output variable. In this case the input variables five and nine do not appear to be highly correlated.

The next two pages of the output give results for the threshold effects testing. This part is not relevant in this example since the input card no. 15 is blank (i.e. all knot-points that are input are included in the analysis).

The rest of the output contains results of the successive regression analysis with input parameters five and nine as a seed-group. For each consequence variable the program lists ten combinations of three input variables that yield best fits of quadratic functions to the consequence data. The residual errors of the best fits are also given as well as the values of a "group merit index", the inverse of which is defined by Eq. (8). The program also prints out instructions on how to use statistical testing with F-variates to verify the significance of the parameters included.

The computer running time (CPU) for this example was 3s on IBM 370/195.

13	4	0.005	3	1	4	0	13	0	40	0	6
1	VAPRES	1	1.020	0.990							
2	CPFUEL	1	1.12	0.88							
3	APRESS	1	1.5E+05	0.5E+05							
4	DELKO	1	0.00353	0.00349							
5	RAMPR	1	0.3141	0.1745							
6	ALAMADA	1	6.0E-07	4.0E-07							
7	WZERO	1	7.59E+10	2.53E+10							
8	AMFUSE	1	294.0	266.0							
9	90UPL8	1	-0.00348	-0.00522							
10	10R5DU	1	2.33204	8.96896							
11	11R6NA	1	0.85103	0.83417							
12	12R6SS	1	7.86487	7.70913							
13	13AVERP	1	3100.	2100.							
50	1	143.30	1729.00			784.16	7850.	9902.			
50	2	328.60	2310.54			1251.24	8450.	10120.			
50	3	188.83	2123.51			1018.46	8930.	10070.			
50	4	305.37	2343.20			1236.48	6740.	10170.			
50	5	184.48	1969.62			904.95	8170.	10190.			
50	6	202.23	1921.39			921.39	7950.	9230.			
50	7	251.90	2363.43			1219.23	9230.	11120.			
50	8	82.34	1116.79			417.36	5920.	6430.			
50	9	266.09	2244.21			1111.14	8220.	9107.			
50	10	357.93	3030.47			1805.00	11400.	12710.			
50	11	142.21	1924.42			649.14	8410.	10180.			
50	12	226.50	2125.95			1053.70	8590.	10400.			
50	13	271.17	2079.05			1071.73	7980.	9179.			
50	14	136.50	1713.07			768.33	7820.	9106.			
50	15	308.98	2331.12			1209.86	8510.	10630.			
50	16	167.98	1598.27			717.24	6740.	8290.			
50	17	295.25	2436.50			1346.82	2310.	11340.			
50	18	169.43	1688.35			735.67	6800.	7460.			
50	19	178.89	2166.27			1054.15	9460.	10790.			
50	20	293.79	2153.50			1129.52	8010.	10330.			
50	21	238.68	2112.04			1079.11	8430.	9951.			
50	22	224.60	1951.82			966.66	7720.	9881.			
50	23	155.35	1827.79			824.47	8020.	10030.			
50	24	401.87	2956.83			1734.71	10600.	12220.			
50	25	485.20	3045.96			1858.92	10600.	11610.			
50	26	133.41	1407.96			569.53	6030.	7030.			
50	27	189.02	2160.19			1084.46	9190.	10980.			
50	28	188.49	1838.44			883.65	7730.	8800.			
50	29	181.46	1804.68			814.78	7420.	8496.			
50	30	203.73	1717.47			819.76	6900.	8547.			
50	31	251.99	1957.35			1000.39	7710.	8760.			
50	32	404.04	2688.89			1534.91	9510.	10420.			
50	33	102.67	1247.11			509.05	6260.	7382.			
50	34	183.10	1899.28			863.56	7740.	9274.			
50	35	162.77	1463.37			637.77	6210.	7324.			
50	36	168.02	1945.14			867.39	8030.	9692.			
50	37	137.12	1424.28			609.49	6460.	7653.			
50	38	102.84	1179.28			440.56	5450.	7628.			
50	39	245.09	2420.08			1260.22	9750.	11700.			
50	40	149.48	1551.00			649.37	6560.	7707.			
50	1	591.61	9464.6			14229.06	351840-02	25528.			
50	2	273.64	-464300-02			9.0441	84412	7.8123			
50	2	1.0134	96097			148420-06	352560-02	28827			
50	2	279.95	-398750-02			9.1933	83491	7.7461			

PARAMETER SCREENING WORK NO. 13, JUNE 4

TOTAL NUMBER OF PARAMETERS NTOT= 13
 PROBABILITY RANGE PROB=0.00500000
 NUMBER OF CONSEQUENCES NCONS= 3
 TEST OPTION TEST= 0
 NO. OF CORRELATIONS NCONR= 0
 NO. OF RANDOM KNOT-POINTS NRPKP= 40
 NO. OF PARAMETER TRANSFORMATIONS NTRAP= 0
 NO. OF CONSEQUENCE TRANSFORMATIONS NTRAC= 0
 MAXIMUM NO. OF PARAMETERS IN A GROUP, NGRMAX= 6

NR08P= 1403 I0FEFT= 303298 KLOC= 194566 JLOC= 732776

INPUT DATA - WORK 13 J085 0

NUMBER OF PARAMETERS = 13

PROBABILITY RANGE 0.00500000

NUMBER OF CONSEQUENCES = 3

NO TRANSFORMATIONS OF PARAMS OR CONSEQUENCES

INDEPENDENT INPUT PARAMETERS

NUMBER	NAME	DISTRIBUTION	PARAMETERS				PAIRS IF LIMITED NUMBER		
1	VAPRES	1	1.0200	.99000	.0	.0	0		
2	CPRES	1	1.1200	.88000	.0	.0	0		
3	RPRES	1	.15000E+06	50000.	.0	.0	0		
4	DELKO	1	.35300E-02	.34900E-02	.0	.0	0		
5	RAMPR	1	.31410	.17450	.0	.0	0		
6	LAMBDA	1	.60000E-06	.80000E-06	.0	.0	0		
7	PZERO	1	.75900E+11	.25300E+11	.0	.0	0		
8	MEUSE	1	284.00	266.00	.0	.0	0		
9	ODPLS	1	-.34800E-02	-.52200E-02	.0	.0	0		
10	RHOV	1	9.3350	8.9690	.0	.0	0		
11	RHOM	1	.85183	.83217	.0	.0	0		
12	RHOSS	1	7.8649	7.7091	.0	.0	0		
13	AVTEMP	1	3100.0	2700.0	.0	.0	0		

DISTRIBUTION	FIRST PARAMETER	SECOND PARAMETER	THIRD PARAMETER	FOURTH PARAMETER
1=UNIFORM	UPPER LIMIT	LOWER LIMIT	N/A	N/A
2=NORMAL	MEAN VALUE	STANDARD DEVIATION	N/A	N/A
3=EXPONENTIAL	LOWER LIMIT	SCALE CONSTANT	N/A	N/A
4=EXPONENTIAL	UPPER LIMIT	SCALE CONSTANT	N/A	N/A
5=NORMAL	MEAN VALUE	STANDARD DEVIATION	LOWER LIMIT	N/A
6=NORMAL	MEAN VALUE	STANDARD DEVIATION	UPPER LIMIT	N/A
7=BETA	LOWER LIMIT	UPPER LIMIT	MEAN	STANDARD DEVIATION
8=LOG-NORMAL	MEAN VALUE	STANDARD DEVIATION	N/A	N/A

FOR DISTRIBUTIONS 5 AND 6, THE VALUES FOR THE MEAN AND STANDARD DEVIATION ARE THOSE FOR THE UNTRUNCATED NORMAL DISTRIBUT

FOR DISTRIBUTION 8, THE VALUES FOR MEAN AND STANDARD DEVIATION ARE THOSE OF THE LOGARITHM OF THE PARAMETER.

RANGES OF THE PARAMETERS
PARA NO. Z'S

1	0.990000E+00	0.100500E+01	0.102000E+01
2	0.000000E+00	0.100000E+01	0.112000E+01
3	0.500000E+05	0.100000E+06	0.150000E+06
4	0.349000E+02	0.351000E+02	0.353000E+02
5	0.174500E+00	0.243000E+00	0.314100E+00
6	0.400000E+06	0.500000E+06	0.600000E+06
7	0.253000E+11	0.500000E+11	0.759000E+11
8	0.266000E+03	0.280000E+03	0.294000E+03
9	-0.520000E+02	-0.435000E+02	-0.348000E+02
10	0.898896E+01	0.915199E+01	0.933504E+01
11	0.834170E+00	0.842600E+00	0.851030E+00
12	-0.770913E+01	0.770700E+01	0.784487E+01
13	0.270000E+04	0.290000E+04	0.310000E+04

*CONSEQUENCES IF RANDOM KNUT-POINTS INPUT IN SUBROUTINE READIN FOR J089 4
INDEX KNUT 3 CONSEQUENCES

50	1	0.143300E+03	0.172800E+04	0.788160E+03
50	2	0.328600E+03	0.231054E+04	0.125124E+04
50	3	0.168830E+03	0.212351E+04	0.101846E+04
50	4	0.305370E+03	0.234320E+04	0.123848E+04
50	5	0.184840E+03	0.196962E+04	0.904950E+03
50	6	0.202230E+03	0.192139E+04	0.921390E+03
50	7	0.251900E+03	0.236343E+04	0.121923E+04
50	8	0.423400E+02	0.111679E+04	0.417360E+03
50	9	0.266000E+03	0.224421E+04	0.111111E+04
50	10	0.357930E+03	0.303047E+04	0.180500E+04
50	11	0.187210E+03	0.192462E+04	0.649140E+03
50	12	0.226500E+03	0.212595E+04	0.105370E+04
50	13	0.271170E+03	0.207905E+04	0.107173E+04
50	14	0.136400E+03	0.171307E+04	0.768330E+03
50	15	0.308900E+03	0.233112E+04	0.120986E+04
50	16	0.167980E+03	0.159627E+04	0.717240E+03
50	17	0.295250E+03	0.243380E+04	0.134689E+04
50	18	0.169430E+03	0.168835E+04	0.735670E+03
50	19	0.178800E+03	0.218627E+04	0.105615E+04
50	20	0.291790E+03	0.214598E+04	0.112952E+04
50	21	0.238680E+03	0.211204E+04	0.107511E+04
50	22	0.224600E+03	0.195182E+04	0.966600E+03
50	23	0.155350E+03	0.182779E+04	0.826870E+03
50	24	0.401870E+03	0.295683E+04	0.173471E+04
50	25	0.485200E+03	0.308596E+04	0.185892E+04
50	26	0.133418E+03	0.140796E+04	0.569530E+03
50	27	0.189020E+03	0.216019E+04	0.106486E+04
50	28	0.188490E+03	0.143644E+04	0.883450E+03
50	29	0.181440E+03	0.180446E+04	0.814780E+03
50	30	0.203730E+03	0.171747E+04	0.819760E+04
50	31	0.251900E+03	0.195733E+04	0.100039E+04
50	32	0.404040E+03	0.246889E+04	0.153891E+04
50	33	0.102670E+03	0.128711E+04	0.504050E+03
50	34	0.183100E+03	0.189928E+04	0.863568E+03
50	35	0.142745E+03	0.145927E+04	0.432320E+03
50	36	0.160200E+03	0.194514E+04	0.867390E+03
50	37	0.137120E+03	0.142428E+04	0.609490E+03
50	38	0.102480E+03	0.117924E+04	0.480560E+03
50	39	0.245090E+03	0.242808E+04	0.126022E+04
50	40	0.149880E+03	0.155180E+04	0.649370E+03

RANDOM POINT COORDINATES FOR JOBS 4

50	0.7273700+11	0.9916100+00	0.9406000+00	0.1422900+06	0.3510400-02	0.2552800+00	0.5711700-06
50	0.2024200+04	0.2750400+03	-0.4843000-02	0.9044100+01	0.8441200+00	0.7812300+01	
50	0.3511800+11	0.1013400+01	0.9607000+00	0.1484200+06	0.3525600-02	0.2082700+00	0.4894200-06
50	0.2072300+04	0.2799500+03	-0.3987500-02	0.9193300+01	0.8349100+00	0.7746100+01	
50	0.5053800+11	0.9952400+00	0.1052200+01	0.8146300+05	0.3503700-02	0.1927700+00	0.5486900-06
50	-0.3077300+04	0.2801500+03	-0.3619400-02	0.9221600+01	0.8349400+00	0.7802200+01	
50	0.6048700+11	0.1010200+01	0.1031800+01	0.6879600+05	0.3508900-02	0.2536900+00	0.5222300-06
50	-0.3016400+04	0.2871300+03	-0.3650300-02	0.9095700+01	0.8341700+00	0.7815700+01	
50	0.6637800+11	0.1003500+01	0.1073700+01	0.1470200+06	0.3523000-02	0.2711900+00	0.4778100-06
50	-0.2849300+04	0.2863000+03	-0.5025700-02	0.9225600+01	0.8380800+00	0.7811500+01	
50	0.5004300+11	0.1004300+01	0.9786300+00	0.9374900+05	0.3510700-02	0.2817700+00	0.4691600-06
50	-0.3034900+04	0.2916500+03	-0.4847100-02	0.9137000+01	0.8382700+00	0.7736500+01	
50	0.8831900+11	0.9992600+00	0.1064700+01	0.1376000+06	0.3492500-02	0.2237000+00	0.5806300-06
50	-0.2876000+04	0.2730700+03	-0.3926900-02	0.9067600+01	0.8378700+00	0.7849900+01	
50	0.5085900+11	0.1002000+01	0.9472300+00	0.9011100+05	0.3507600-02	0.1826500+00	0.4800000-06
50	-0.3190000+04	0.2868000+03	-0.4901300-02	0.8970100+01	0.8420500+00	0.7814200+01	
50	0.7283300+11	0.1014200+01	0.1109600+01	0.1024100+06	0.3521800-02	0.2918300+00	0.4898200-06
50	-0.3063400+04	0.2660000+03	-0.4925000-02	0.9142400+01	0.8402100+00	0.7832800+01	
50	0.6813100+11	0.9918100+00	0.1083700+01	0.1247200+06	0.3517800-02	0.3118700+00	0.4723400-06
50	-0.3057100+04	0.2784000+03	-0.3719600-02	0.9070100+01	0.8404000+00	0.7783300+01	
50	0.7050500+11	0.9970300+00	0.1111400+01	0.5663900+05	0.3491100-02	0.1932300+00	0.4548000-06
50	-0.2915400+04	0.2792300+03	-0.3866800-02	0.9223400+01	0.8409600+00	0.7733200+01	
50	0.5210400+11	0.1001600+01	0.1036200+01	0.6751900+05	0.3511400-02	0.2114800+00	0.5137400-06
50	-0.2948000+04	0.2919900+03	-0.3702300-02	0.9057000+01	0.8417500+00	0.7743800+01	
50	0.5505300+11	0.1011300+01	0.9403500+00	0.5000000+05	0.3490000-02	0.3141000+00	0.4587700-06
50	-0.3059600+04	0.2828800+03	-0.4508900-02	0.9193900+01	0.8344600+00	0.7794100+01	
50	0.4680400+11	0.9917200+00	0.9711100+00	0.7535300+05	0.3496500-02	0.1978100+00	0.4232000-06
50	-0.3037600+04	0.2733800+03	-0.3726700-02	0.8990700+01	0.8451800+00	0.7723800+01	
50	0.2728100+11	0.1015300+01	0.1055800+01	0.1006400+06	0.3491300-02	0.3037600+00	0.5813600-06
50	-0.2821600+04	0.2823300+03	-0.5220000-02	0.9259100+01	0.8368800+00	0.7712600+01	
50	0.3009600+11	0.1010500+01	0.9280800+00	0.1329800+06	0.3506800-02	0.2192600+00	0.4880000-06
50	-0.2912500+04	0.2757000+03	-0.5046100-02	0.9136700+01	0.8398700+00	0.7859100+01	
50	0.5082900+11	0.9979400+00	0.9586100+00	0.1358300+06	0.3521400-02	0.2541700+00	0.5346400-06
50	-0.2847400+04	0.2692200+03	-0.3880000-02	0.9054200+01	0.8433500+00	0.7864900+01	
50	0.5183400+11	0.1014600+01	0.1003300+01	0.1500000+06	0.3501200-02	0.2374400+00	0.4189300-06
50	-0.3043600+04	0.2693300+03	-0.4676700-02	0.9300300+01	0.8460500+00	0.7863600+01	
50	0.2530000+11	0.9900800+00	0.1037900+01	0.7118900+05	0.3500800-02	0.2883400+00	0.4987100-06
50	-0.3084100+04	0.2899000+03	-0.5165400-02	0.9335000+01	0.8396900+00	0.7829600+01	
50	0.7590800+11	0.1012000+01	0.9288700+00	0.6618800+05	0.3499500-02	0.2802600+00	0.4870800-06
50	-0.2926600+04	0.2723900+03	-0.3715600-02	0.9225600+01	0.8399100+00	0.7755600+01	

CHARACTERISTICS OF RANDOM KNOWN POINT SAMPLE CONSEQUENCES					CONSEQUENCE				
					MEAN VALUE STD DEVIATION MAXIMUM VALUE MINIMUM VALUE				
0.523270D-04	50	0.100160D+01	0.461330D+00	0.461330D+00	0.351330D-02	0.248530D+00	0.248530D+00	0.774950D+01	0.248530D+00
0.667050D+11	50	0.100570D+01	0.942530D+00	0.942530D+00	0.146530D+06	0.353000D-02	0.257760D+00	0.775020D+01	0.353000D-02
0.294890D+04	50	0.271590D+03	-0.452040D-02	0.902070D+01	0.845220D+00	0.845220D+00	0.775020D+01	0.775020D+01	0.845220D+00
0.276930D+04	50	0.996950D+00	0.995000D+00	0.995000D+00	0.612460D+05	0.349700D-02	0.215590D+00	0.215590D+00	0.349700D-02
0.667120D+13	50	0.277960D+03	-0.401210D-02	0.926410D+01	0.844560D+00	0.786110D+01	0.215590D+00	0.215590D+00	0.844560D+00
0.552500D+11	50	0.100310D+01	0.149700D+01	0.149700D+01	0.474550D+05	0.351790D-02	0.266770D+00	0.266770D+00	0.351790D-02
0.290960D+04	50	0.272290D+03	-0.355390D-02	0.916020D+01	0.648930D+00	0.781240D+01	0.266770D+00	0.266770D+00	0.648930D+00
0.565010D+11	50	0.100880D+01	0.108880D+01	0.108880D+01	0.492230D+05	0.349100D-02	0.308550D+00	0.308550D+00	0.349100D-02
0.363750D+04	50	0.276560D+03	-0.422180D-02	0.919240D+01	0.651030D+00	0.777240D+01	0.308550D+00	0.308550D+00	0.651030D+00
0.657800D+11	50	0.101810D+01	0.984400D+00	0.984400D+00	0.118120D+06	0.349550D-02	0.208390D+00	0.208390D+00	0.349550D-02
0.575460D-06	50	0.278120D+03	-0.519420D-02	0.929900D+01	0.836580D+00	0.776460D+01	0.208390D+00	0.208390D+00	0.836580D+00
0.575820D-06	50	0.990440D+00	0.100960D+01	0.100960D+01	0.948550D+05	0.34970D-02	0.205400D+00	0.205400D+00	0.34970D-02
0.317420D+11	50	0.262470D+03	-0.378730D-02	0.913620D+01	0.846650D+00	0.770910D+01	0.205400D+00	0.205400D+00	0.846650D+00
0.595920D+04	50	0.999930D+00	0.991410D+00	0.991410D+00	0.113200D+06	0.352450D-02	0.234010D+00	0.234010D+00	0.352450D-02
0.596680D+11	50	0.278900D+03	-0.4073320D-02	0.846900D+01	0.834470D+00	0.744860D+01	0.234010D+00	0.234010D+00	0.834470D+00
0.596680D+11	50	0.101030D+01	0.101200D+01	0.101200D+01	0.129460D+06	0.350950D-02	0.212010D+00	0.212010D+00	0.350950D-02
0.265350D+03	50	0.265350D+03	-0.446690D-02	0.927000D+01	0.643080D+00	0.785620D+01	0.212010D+00	0.212010D+00	0.643080D+00
0.101100D+01	50	0.101100D+01	0.903120D+00	0.903120D+00	0.725180D+05	0.352920D-02	0.252540D+00	0.252540D+00	0.352920D-02
0.2724880D+03	50	0.2724880D+03	-0.504200D-02	0.901230D+01	0.653650D+00	0.782490D+01	0.252540D+00	0.252540D+00	0.653650D+00
0.527250D+04	50	0.106690D+01	0.905110D+00	0.905110D+00	0.148520D+06	0.349400D-02	0.252810D+00	0.252810D+00	0.349400D-02
0.527250D+11	50	0.284330D+03	-0.362710D-02	0.916830D+01	0.848150D+00	0.781800D+01	0.252810D+00	0.252810D+00	0.848150D+00
0.308900D+04	50	0.101230D+01	0.107730D+01	0.107730D+01	0.133450D+06	0.352330D-02	0.275380D+00	0.275380D+00	0.352330D-02
0.331470D+11	50	0.280180D+03	-0.348860D-02	0.907780D+01	0.841180D+00	0.779120D+01	0.275380D+00	0.275380D+00	0.841180D+00
0.309240D+04	50	0.997870D+00	0.860000D+00	0.860000D+00	0.664980D+05	0.351410D-02	0.1744500D+00	0.1744500D+00	0.351410D-02
0.361010D+11	50	0.273000D+03	-0.466030D-02	0.909320D+01	0.653480D+00	0.7843080D+01	0.1744500D+00	0.1744500D+00	0.653480D+00
0.294840D+04	50	0.100680D+01	0.106570D+01	0.106570D+01	0.145020D+06	0.351270D-02	0.261440D+00	0.261440D+00	0.351270D-02
0.537760D+11	50	0.277740D+03	-0.487760D-02	0.912160D+01	0.836790D+00	0.775520D+01	0.261440D+00	0.261440D+00	0.836790D+00
0.285840D+04	50	0.101760D+01	0.917160D+00	0.917160D+00	0.446800D+05	0.349120D-02	0.206030D+00	0.206030D+00	0.349120D-02
0.551950D+11	50	0.289790D+03	-0.453810D-02	0.926650D+01	0.844840D+00	0.778760D+01	0.206030D+00	0.206030D+00	0.844840D+00
0.551950D+11	50	0.101760D+01	0.917160D+00	0.917160D+00	0.446800D+05	0.349120D-02	0.206030D+00	0.206030D+00	0.349120D-02
0.289790D+03	50	0.289790D+03	-0.453810D-02	0.926650D+01	0.844840D+00	0.778760D+01	0.206030D+00	0.206030D+00	0.844840D+00
0.746180D+04	50	0.112000D+01	0.112000D+01	0.112000D+01	0.965110D+05	0.352890D-02	0.183460D+00	0.183460D+00	0.352890D-02
0.746180D+11	50	0.270560D+03	-0.371940D-02	0.920030D+01	0.653520D+00	0.783640D+01	0.183460D+00	0.183460D+00	0.653520D+00
0.291620D+04	50	0.100740D+01	0.910020D+00	0.910020D+00	0.766400D+05	0.352130D-02	0.208020D+00	0.208020D+00	0.352130D-02
0.597590D+11	50	0.282540D+03	-0.460480D-02	0.919480D+01	0.837510D+00	0.782140D+01	0.208020D+00	0.208020D+00	0.837510D+00
0.298030D+04	50	0.102000D+01	0.100350D+01	0.100350D+01	0.546660D+05	0.352000D-02	0.184140D+00	0.184140D+00	0.352000D-02
0.526680D+11	50	0.292710D+03	-0.514480D-02	0.911390D+01	0.653810D+00	0.776340D+01	0.184140D+00	0.184140D+00	0.653810D+00
0.278800D+04	50	0.995240D+00	0.104340D+01	0.104340D+01	0.109100D+06	0.351750D-02	0.239480D+00	0.239480D+00	0.351750D-02
0.376030D+11	50	0.286600D+03	-0.346120D-02	0.929330D+01	0.838770D+00	0.774930D+01	0.239480D+00	0.239480D+00	0.838770D+00
0.291580D+04	50	0.101600D+01	0.103720D+01	0.103720D+01	0.746000D+05	0.213980D-02	0.213980D+00	0.213980D+00	0.746000D+05
0.710190D+11	50	0.294000D+03	-0.458420D-02	0.910550D+01	0.643830D+00	0.781140D+01	0.213980D+00	0.213980D+00	0.643830D+00

1 220.35 09.233 045.20 82.140
 2 1999.8 463.42 3046.0 1116.8
 3 990.01 342.60 1458.9 417.36

CONSEQUENCE 1 MEAN= 0.220352E+03 STANDARD DEVIATION= 0.092330E+02 SCALE= 0.50

CATEGORY	LOWER A	UPPER A	COUNTS	PROBABILITY	ACCURACY	PERCENT
1	-0.473472E+02	-0.273069E+01	0	0.0	0.0	100.000 P/C
2	-0.273087E+01	-0.418056E+02	0	0.0	0.0	100.000 P/C
3	0.418056E+02	0.865021E+02	1	0.02500000	0.02468552	98.742 P/C
4	0.865021E+02	0.131119E+03	2	0.05000000	0.03446012	68.920 P/C
5	0.131119E+03	0.175735E+03	11	0.27499996	0.07060008	25.473 P/C
6	0.175735E+03	0.220352E+03	9	0.22499996	0.06602556	29.345 P/C
7	0.220352E+03	0.264968E+03	6	0.14999998	0.03645793	37.439 P/C
8	0.264968E+03	0.309584E+03	6	0.14999998	0.03645793	37.439 P/C
9	0.309584E+03	0.354201E+03	1	0.02500000	0.02468552	98.742 P/C
10	0.354201E+03	0.398817E+03	1	0.02500000	0.02468552	98.742 P/C
11	0.398817E+03	0.443434E+03	2	0.05000000	0.03446012	68.920 P/C
12	0.443434E+03	0.488050E+03	1	0.02500000	0.02468552	98.742 P/C

CONSEQUENCE 2 MEAN= 0.199977E+04 STANDARD DEVIATION= 0.463410E+03 SCALE= 0.50

CATEGORY	LOWER B	UPPER B	COUNTS	PROBABILITY	ACCURACY	PERCENT
1	0.609514E+03	0.841223E+03	0	0.0	0.0	100.000 P/C
2	0.841223E+03	0.107293E+04	0	0.0	0.0	100.000 P/C
3	0.107293E+04	0.130465E+04	3	0.07499999	0.04144582	55.528 P/C
4	0.130465E+04	0.153635E+04	3	0.07499999	0.04144582	55.528 P/C
5	0.153635E+04	0.176806E+04	6	0.14999998	0.05645793	37.639 P/C
6	0.176806E+04	0.199977E+04	10	0.25000000	0.06602556	29.345 P/C
7	0.199977E+04	0.223148E+04	7	0.17499995	0.05007807	34.330 P/C
8	0.223148E+04	0.246318E+04	7	0.17499995	0.05007807	34.330 P/C
9	0.246318E+04	0.269489E+04	1	0.02500000	0.02468552	98.742 P/C
10	0.269489E+04	0.292660E+04	0	0.0	0.0	100.000 P/C
11	0.292660E+04	0.315831E+04	3	0.07499999	0.04144582	55.528 P/C
12	0.315831E+04	0.339002E+04	0	0.0	0.0	100.000 P/C

CONSEQUENCE 3 MEAN= 0.990008E+03 STANDARD DEVIATION= 0.342604E+03 SCALE= 0.50

CATEGORY	LOWER B	UPPER B	COUNTS	PROBABILITY	ACCURACY	PERCENT
1	-0.374040E+02	-0.133498E+03	0	0.0	0.0	100.000 P/C
2	0.133498E+03	0.308600E+03	0	0.0	0.0	100.000 P/C
3	0.308600E+03	0.476102E+03	2	0.05000000	0.03446012	68.920 P/C
4	0.476102E+03	0.647404E+03	4	0.09999996	0.04743414	47.434 P/C
5	0.647404E+03	0.816706E+03	6	0.14999998	0.05645793	37.639 P/C
6	0.816706E+03	0.990008E+03	9	0.22499996	0.06602556	29.345 P/C
7	0.990008E+03	0.114131E+04	9	0.22499996	0.06602556	29.345 P/C
8	0.114131E+04	0.133261E+04	5	0.12500000	0.03229125	41.833 P/C
9	0.133261E+04	0.152391E+04	1	0.02500000	0.02468552	98.742 P/C
10	0.152391E+04	0.171522E+04	1	0.02500000	0.02468552	98.742 P/C
11	0.171522E+04	0.190652E+04	2	0.05000000	0.03446012	68.920 P/C
12	0.190652E+04	0.209782E+04	1	0.02500000	0.02468552	98.742 P/C

3 0.0	0.0	0.025000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 0.0	0.0	0.024686	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 0.0	0.0	0.025000	0.025000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 0.0	0.0	0.024686	0.024686	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 0.0	0.0	0.0	0.075000	0.125000	0.075000	0.0	0.0	0.0	0.0	0.0	0.0
5 0.0	0.0	0.0	0.041646	0.052291	0.041646	0.0	0.0	0.0	0.0	0.0	0.0
6 0.0	0.0	0.0	0.0	0.025000	0.125000	0.075000	0.0	0.0	0.0	0.0	0.0
6 0.0	0.0	0.0	0.0	0.024686	0.052291	0.041646	0.0	0.0	0.0	0.0	0.0
7 0.0	0.0	0.0	0.0	0.0	0.025000	0.075000	0.050000	0.0	0.0	0.0	0.0
7 0.0	0.0	0.0	0.0	0.0	0.024686	0.041646	0.034460	0.0	0.0	0.0	0.0
8 0.0	0.0	0.0	0.0	0.0	0.0	0.075000	0.050000	0.025000	0.0	0.0	0.0
8 0.0	0.0	0.0	0.0	0.0	0.0	0.041646	0.034460	0.024686	0.0	0.0	0.0
9 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.025000	0.0	0.0	0.0	0.0
9 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024686	0.0	0.0	0.0	0.0
10 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.025000	0.0
10 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024686	0.0
11 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.025000	0.025000	0.0
11 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024686	0.024686	0.0
12 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.025000
12 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024686

CONSEQUENCE NUMBER 2 VERTICAL
CONSEQUENCE NUMBER 3 HORIZONTAL

PROBABILITY AND ACCURACY (STANDARD DEVIATION)												
CATEGORY	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.050000	0.025000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.034460	0.024686	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.075000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.041646	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.125000	0.025000	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.052291	0.024686	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.025000	0.200000	0.025000	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.024686	0.063246	0.024686	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.175000	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.060078	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.025000	0.125000	0.025000	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.024686	0.052291	0.024686	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.025000	0.0	0.0	0.0

[illegible]

PROBABILITY PER UNIT OF CONSEQUENCE 1

.0	.0
1.000	1.000
1.000	1.000
2.000	2.000
2.000	2.000
3.000	3.000
3.000	3.000
4.000	4.000
5.000	5.000
5.000	5.000
6.000	6.000
7.000	7.000
7.000	7.000
8.000	8.000
8.000	8.000
9.000	9.000
10.00	10.00
10.00	10.00
11.00	11.00
11.00	11.00
12.00	12.00
12.00	12.00
13.00	13.00

CONSEQUENCE 1

0	0
1,000	0
1,000	0
2,000	0
2,000	0
3,000	0
1,400	5000E-01
4,000	1,000
4,000	0
5,000	3000
5,000	2500
6,000	3500
6,000	1000
7,000	1500
7,000	1500
8,000	1000
8,000	2000
9,000	5000E-01
9,000	0
10,00	5000E-01
10,00	0
11,00	1000

CONSEQUENCE 3

CORRELATION COEFFICIENTS FOR CONSEQUENCE 1. PARAMETERS

163

8	-0.20835	0.04341	1.64959
7	-0.17525	0.03071	1.14708
11	0.16513	0.02727	1.03622
6	0.16079	0.02585	0.98247
12	-0.13269	0.01761	0.66904
3	0.11886	0.01413	0.53683
1	0.10576	0.01119	0.42506
13	0.07272	0.00529	0.20095
4	-0.03038	0.00092	0.03508
10	0.02378	0.00057	0.02149

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE MOST CORRELATING PARAMETER 5
 RESIDUAL STANDARD DEVIATION .40321E-01
 REGRESSION COEFFICIENT B 1621.7

CONSEQUENCE 1 RESIDUAL STANDARD DEVIATION= 59.948

CORRELATIONS OF RESIDUAL CONSEQUENCE 1 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
9	-0.64271	0.41308	18.23398
2	0.36110	0.13039	4.95498
11	0.34183	0.11685	4.44016
6	-0.24486	0.05996	2.27841
8	-0.19818	0.03927	1.49242
7	-0.15114	0.02284	0.86809
10	-0.06537	0.00427	0.16237
1	0.04114	0.00169	0.06431
12	-0.02850	0.00081	0.03087
3	-0.02101	0.00044	0.01677
13	0.01749	0.00031	0.01162
5	-0.01389	0.00019	0.00733
4	-0.01073	0.00012	0.00437

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE SECOND CORRELATING PARAMETER 9
 HAS SAMPLE STANDARD DEVIATION .55114E-03
 REGRESSION COEFFICIENT 9 75372.

CONSEQUENCE 1 RESIDUAL STANDARD DEVIATION= 43.250

CORRELATIONS OF RESIDUAL CONSEQUENCE 1 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
1	0.42972	0.18466	7.01708
6	0.41611	0.17314	6.57949
7	-0.38788	0.15045	5.71725
2	0.30804	0.09489	3.60585
11	0.22924	0.05255	1.99702
8	-0.07995	0.00639	0.24292
3	-0.05073	0.00257	0.09788
5	0.04472	0.00200	0.07600
10	0.04409	0.00194	0.07387
13	-0.03218	0.00103	0.03926
12	0.01510	0.00023	0.00866
4	-0.00266	0.00001	0.00027
9	0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE THIRD CORRELATING PARAMETER 1
 HAS SAMPLE STANDARD DEVIATION .83906E-02
 REGRESSION COEFFICIENT 8 2215.1

CONSEQUENCE 1 RESIDUAL STANDARD DEVIATION= 39.054

CORRELATIONS OF RESIDUAL CONSEQUENCE 1 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
6	0.88748	0.20020	7.60760
7	-0.44521	0.19821	7.53202
2	0.38848	0.15092	5.73485
11	0.33829	0.11444	4.34861
9	0.18866	0.03410	1.29576

6	-0.13935	0.01242	0.73804
10	-0.04898	0.00240	0.09115
3	0.04562	0.00208	0.07909
4	0.01848	0.00036	0.01355
12	0.00539	0.00003	0.00110
13	-0.00426	0.00002	0.00069
5	-0.00144	0.00000	0.00008
1	-0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

FOURTH CORRELATING PARAMETER 6
HAS SAMPLE STANDARD DEVIATION .54992E-07
REGRESSION COEFFICIENT B .31776E+09

CONSEQUENCE 1 RESIDUAL STANDARD DEVIATION= 34.926

CORRELATION COEFFICIENTS FOR CONSEQUENCE 2. PARAMETERS

PARAMETER	CORR. COEFF.	SQUARE	F
5	0.63265	0.40026	17.19334
2	0.53924	0.29078	11.04981
9	0.53298	0.28407	10.79459
8	0.21549	0.04643	1.76451
11	0.16948	0.02872	1.09144
12	0.14673	0.02153	0.81817
3	0.12163	0.01479	0.56219
7	-0.12001	0.01440	0.54725
6	-0.10234	0.01047	0.39800
10	0.07199	0.00518	0.19692
13	0.06772	0.00459	0.17427
4	0.03520	0.00124	0.04707

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE MOST CORRELATING PARAMETER 5
HAS SAMPLE STANDARD DEVIATION .40321E-01
REGRESSION COEFFICIENT B 7731.0

CONSEQUENCE 2 RESIDUAL STANDARD DEVIATION= 334.03

CORRELATIONS OF RESIDUAL CONSEQUENCE 2 WITH PARAMETERS

PARAMETER CORR. COEF. SQUARE F

9	0.70143	0.61125	23.22750
2	0.60457	0.36550	13.8911
1	-0.40065	0.16052	6.0983
11	0.31171	0.09716	3.6213
0	-0.20070	0.04031	1.53181
6	0.14546	0.02116	0.80390
7	-0.07242	0.00524	0.19920
12	-0.06142	0.00377	0.14337
13	0.01570	0.00025	0.00947
10	0.01342	0.00019	0.00736
5	-0.01174	0.00010	0.00527
3	-0.00084	0.00000	0.00003
4	0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1,36) VARIABLE

THE SECOND CORRELATING PARAMETER 9
 HAS SAMPLE STANDARD DEVIATION .55114E-03
 REGRESSION COEFFICIENT 0 -.40037E+06

CONSEQUENCE 2 RESIDUAL STANDARD DEVIATION= 211.14

CORRELATIONS OF RESIDUAL CONSEQUENCE 2 WITH PARAMETERS

PARAMETER CORR. COEF. SQUARE F

2	0.71015	0.51573	19.50704
7	-0.34045	0.12176	4.62105
6	0.33329	0.11100	4.22110
10	0.19822	0.03929	1.49303
11	-0.18045	0.03256	1.23737
1	-0.15604	0.02435	0.92521
3	0.10242	0.01059	0.40252
4	-0.04777	0.00000	0.00000

5 0.06464 0.00414 0.15875
 13 -0.00111 0.00233 0.00869
 12 -0.02721 0.00074 0.02813
 4 0.01560 0.00025 0.00966
 9 0.00000 0.00000 0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE THIRD CORRELATING PARAMETER 2
 HAS SAMPLE STANDARD DEVIATION .65032E-01
 REGRESSION COEFFICIENT B 2317.3

CONSEQUENCE 2 RESIDUAL STANDARD DEVIATION= 146.93

CORRELATIONS--OF RESIDUAL CONSEQUENCE 2 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
6	0.70825	0.50162	19.86171
7	-0.63776	0.40674	15.45612
11	0.20935	0.04383	1.66545
9	-0.20696	0.04284	1.62787
3	-0.13615	0.01854	0.70445
1	-0.12159	0.01476	0.56175
13	-0.10456	0.01093	0.41544
12	-0.09606	0.00923	0.35065
8	-0.06774	0.00459	0.17439
10	0.05098	0.00260	0.09876
4	-0.00772	0.00028	0.00654
5	-0.00650	0.00017	0.00230
2	-0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

FOURTH CORRELATING PARAMETER 6
 HAS SAMPLE STANDARD DEVIATION .54992E-07
 REGRESSION COEFFICIENT B .18928E+10

CONSEQUENCE 2 RESIDUAL STANDARD DEVIATION= 103.73

CORRELATIONS--OF RESIDUAL CONSEQUENCE 2 WITH PARAMETERS

PARAMETER	CORR. COEFF.	SQUARE	F
5	0.68649	0.47127	17.90819
9	0.52572	0.27638	10.50237
2	0.46397	0.21527	8.18033
8	-0.21794	0.04750	1.80495
11	0.19208	0.03690	1.40207
1	-0.17735	0.03145	1.19518
7	-0.14181	0.02011	0.76415
12	-0.14066	0.01978	0.75179
6	0.12414	0.01541	0.58560
3	0.11625	0.01351	0.51352
13	0.07613	0.00580	0.22024
4	0.04038	0.00163	0.06195
10	0.02366	0.00057	0.02164

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE MOST CORRELATING PARAMETER 5
HAS SAMPLE STANDARD DEVIATION .40321E-01
REGRESSION COEFFICIENT B. 5833.1

CONSEQUENCE 3 RESIDUAL STANDARD DEVIATION 286.03

CORRELATIONS OF RESIDUAL CONSEQUENCE 3 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
9	0.78674	0.61896	23.52037
2	0.50925	0.25934	9.85484
11	0.35425	0.12549	4.76860
1	-0.35393	0.12526	4.76002
8	-0.20485	0.04196	1.59463
6	0.12830	0.03179	1.20800
7	-0.10173	0.01035	0.39325
10	-0.05446	0.00297	0.11269
12	-0.04766	0.00227	0.08638
13	0.02653	0.00070	0.02675

5 -0.01214 0.00015 0.00560
 4 0.01212 0.00015 0.00558
 3 -0.01166 0.00014 0.00517

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE SECOND CORRELATING PARAMETER 9
 HAS SAMPLE STANDARD DEVIATION .55119E-03
 REGRESSION COEFFICIENT B .35120E+06

CONSEQUENCE 3 RESIDUAL STANDARD DEVIATION 151.67

CORRELATIONS OF RESIDUAL CONSEQUENCE 3 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
2	0.56936	0.32417	12.31057
7	-0.00142	0.16114	6.12325
6	0.39400	0.15247	5.79303
11	0.24915	0.06207	2.35882
10	0.09056	0.00820	0.31163
3	0.02700	0.00750	0.28016
1	-0.07882	0.00621	0.23610
0	-0.07333	0.00536	0.20433
5	0.04524	0.00424	0.16175
4	0.03504	0.00120	0.04801
13	-0.03185	0.00101	0.03856
12	-0.00476	0.00002	0.00086
9	0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

THE THIRD CORRELATING PARAMETER 2
 HAS SAMPLE STANDARD DEVIATION .05432E-01
 REGRESSION COEFFICIENT B 1321.5

CONSEQUENCE 3 RESIDUAL STANDARD DEVIATION 124.65

CORRELATIONS OF RESIDUAL CONSEQUENCE 3 WITH PARAMETERS

PARAMETER	CORR. COEF.	SQUARE	F
6	0.62806	0.39549	15.02879

7	-0.5707A	0.33615	12.77360
11	0.26954	0.07265	2.76075
9	-0.13090	0.01929	0.71310
3	0.09805	0.00961	0.36529
12	0.08892	0.00721	0.27402
6	-0.06901	0.00442	0.14306
13	-0.06233	0.00389	0.14743
4	-0.06025	0.00363	0.13793
10	-0.04679	0.00219	0.08320
1	-0.02709	0.00073	0.02770
5	-0.01421	0.00020	0.00767
2	-0.00000	0.00000	0.00000

COMPARE LAST COLUMN TO AN F(1, 38) VARIABLE

FOURTH CORRELATING PARAMETER 6
 HAS-SAMPLE-STANDARD-DEVIATION .58992E-07
 REGRESSION COEFFICIENT 8 .18270E+10
 CONSEQUENCE 3 RESIDUAL-STANDARD DEVIATIONS 97.071

SAMPLE CORRELATIONS BETWEEN INPUT PARAMETERS

4	10	-0.38987	0.15200
1	9	-0.38602	0.15056
6	7	-0.38256	0.11735
3	8	0.30138	0.09061
3	8	-0.30023	0.09014
4	11	-0.28985	0.08401
8	12	-0.28396	0.08064
9	11	0.25479	0.06492
2	10	-0.22661	0.05135
2	6	-0.22221	0.04938
4	8	-0.21014	0.04416
1	10	-0.20551	0.04223
3	12	0.20062	0.04187

SAMPLE STATISTICS FOR INPUT PARAMETERS
FIRST DEVIATIONS OF THE SAMPLE MEAN FROM 20 ON ZAVE

PARAM	MEAN SHIFT	T-VARIABLE	REL. SD.	RATIO T/SD
13	3.8573	0.6021	4	1.31986
11	-2.8499	-0.4431	3	1.11817
12	1.1193	0.1749	8	-0.89752
6	-1.0536	0.1684	9	1.11141
7	0.7146	0.1115	13	-0.89979
4	-0.3173	-0.0488	12	1.07769
2	-0.2755	-0.0430	11	-0.94084
5	-0.2539	-0.0396	2	-0.95728
8	0.1098	0.0171	10	-0.95733
9	-0.0985	-0.0154	6	-0.96486
10	-0.0181	-0.0028	7	-0.98446
1	-0.0069	-0.0011	5	1.01328
3	-0.0042	-0.0007	1	1.00857

DEVIATIONS OF SMALLEST VALUE FROM 22

10	0.0001	0.99563
13	0.0	1.00000
11	0.0	1.00000
9	0.0	1.00000
8	0.0	1.00000
6	0.0	1.00000
5	0.0	1.00000
3	0.0	1.00000
2	0.0	1.00000
0	0.0	1.00000
0	0.0	1.00000
0	0.0	1.00000
0	0.0	1.00000

DEVIATIONS OF LARGEST VALUE FROM 21

10	-0.0001	0.94552
1	-0.0000	0.99973
4	-0.0000	0.99977
5	-0.0000	0.99998
6	-0.0000	0.99999
13	0.0	1.00000
11	0.0	1.00000
9	0.0	1.00000
8	0.0	1.00000
7	0.0	1.00000
3	-0.0	1.00000
2	0.0	1.00000
0	0.0	1.00000

JORS = 4, NUMBERS OF INITIAL GROUPS FOR THE CONSEQUENCES ARE

1 1 1

SCREENING FOR CONSEQUENCE 1

INPUT GROUP

NSINGL NGP NP PARAMETERS
1 3 2 5 9 0 0 0 0 0 0 0 0

NSINGL = IDENTIFICATION NUMBER FOR THE INITIAL GROUP
NGP = NUMBER OF PARAMETERS IN EACH GROUP
NP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EACH STEP

NWDS = 1820 IEND = 1821 IOFFT = 301388 KLOC = 1938320 MLOC = 732768

THE NUMBER OF GROUPS = 11

GROUP 1 PARAMETERS 5 9 2 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 36.657

NRANK = 40 NCOEF2 = 10 SUM OF SQUARES = 40312.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.41080

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 316.18
9 199.43
2 146.20

GROUP SENSITIVITY = 663.77

GROUP MERIT INDEX = .32725

GROUP 2 PARAMETERS 5 9 6 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 37.144

NRANK = 40 NCOEF2 = 10 SUM OF SQUARES = 41390.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.41626

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 319.04
9 199.43

6 153.75
 GROUP SENSITIVITY = 72.30 GROUP MERIT INDEX = .31006
 GROUP 3 PARAMETERS 5 4 7 0 0 0 0 0 0 0
 RESIDUAL MEAN SQUARE ERROR = 37.606
 NPAKPK= 40 NCOEF2= 10 SUM OF SQUARES = 42425.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.42143

PARAMETERS IN THE ORDER OF SENSITIVITY
 IDENT.NO. TOTAL SENSITIVITY

5 341.32
 9 210.12
 7 143.21

GROUP SENSITIVITY = 722.65 GROUP MERIT INDEX = .29300
 GROUP 4 PARAMETERS 5 9 11 0 0 0 0 0 0 0
 RESIDUAL MEAN SQUARE ERROR = 30.423

NPAKPK= 40 NCOEF2= 10 SUM OF SQUARES = 44294.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.43061

PARAMETERS IN THE ORDER OF SENSITIVITY
 IDENT.NO. TOTAL SENSITIVITY

5 338.78
 9 160.63
 11 131.54

GROUP SENSITIVITY = 630.96 GROUP MERIT INDEX = .32843
 GROUP 5 PARAMETERS 5 9 1 0 0 0 0 0 0 0
 RESIDUAL MEAN SQUARE ERROR = 41.256

NPAKPK= 40 NCOEF2= 10 SUM OF SQUARES = 51061.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.46234

PARAMETERS IN THE ORDER OF SENSITIVITY
 IDENT.NO. TOTAL SENSITIVITY

5 277.95
 9 184.89
 1 89.001

GROUP SENSITIVITY = 551.84 GROUP MERIT INDEX = .31076

GROUP 6 PARAMETERS 5 9 4 0 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 44.096

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = 58333.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.49416

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 282.08
9 196.49
4 100.97

GROUP SENSITIVITY = 579.55

GROUP MERIT INDEX = .31157

GROUP 7 PARAMETERS 5 9 3 0 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 44.524

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = 59471.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.49896

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 286.17
9 178.54
3 97.647

GROUP SENSITIVITY = 563.36

GROUP MERIT INDEX = .31745

GROUP 8 PARAMETERS 5 9 13 0 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 44.887

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = 60444.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.50303

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 282.52
9 187.23
13 111.82

GROUP SENSITIVITY = 581.57

GROUP MERIT INDEX = .30502

GROUP 9 PARAMETERS 5 9 8 0 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 44.903

NRANK = 40 NCOEF2 = 10 SUM OF SQUARES = 60488.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.50321

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5	296.05
9	176.53
8	61.788

GROUP SENSITIVITY = 548.36

GROUP MERIT INDEX = .32338

GROUP	10	PARAMETERS	5	9	10	0	0	0	0	0	0	0
RESIDUAL MEAN SQUARE ERROR	45.551											

NRANK = 40

NCOEF2 = 10 SUM OF SQUARES = 62287.

SAMPLE ST. DEV. = 89.233 NORMALIZED ERROR 0.51087

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5	273.48
9	171.18
10	64.524

GROUP SENSITIVITY = 529.18

GROUP MERIT INDEX = .33020

THE REFERENCE GROUP FITTING IS NOW PERFORMED FOR THIS CONSEQUENCE 1 , GROUP NSINGL = 1

FOR TESTING THE SIGNIFICANCE OF THE ADDED PARAMETERS

(USS(NP) - USS(IG)) * (NWKMP - 4) / (K * USS(IG))

MAY BE COMPARED TO AN F(K, NRANKP-M) VARIABLE

USS(NP) = RESIDUAL SUM OF SQUARES FOR THE BASE GROUP OF NP PARAMETERS , NP = 2

USS(IG) = RESIDUAL SUM OF SQUARES FOR THE BASE GROUP, INCL. THE BASE GROUP, MGP = 3

USS(IG) = SAME-FOR A LARGER GROUP IG WITH MGP PARAMETERS.

M = (MGP+1)*(MGP+2)/2 = 10

K = M - (NP+1)*(NP+2)/2 = 4

NRANKP-M = 30

180

SCREENING FOR CONSEQUENCE 2

INPUT GROUP

NSINGL NGP NP PARAMETERS
2 3 2 5 9 0 0 0 0 0 0 0 0

NSINGL = IDENTIFICATION NUMBER FOR THE INITIAL GROUP
NGP = NUMBER OF PARAMETERS IN EACH GROUP
NP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EACH STEP

NWDS = 1820 IEND = 1821 IOFFT = 301388 KLDC = 1938320 MLOC = 732768

THE NUMBER OF GROUPS = 11

GROUP 1 PARAMETERS 5 9 2 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 110.50

NRANKP = 40 NCOEF2 = 10 SUM OF SQUARES = .36630E+06

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.23844

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1452.0
9 1125.3
2 1082.1

GROUP SENSITIVITY = 3650.4 GROUP MERIT INDEX = .53110

GROUP 2 PARAMETERS 5 9 11 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 188.76

NRANKP = 40 NCOEF2 = 10 SUM OF SQUARES = .10689E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.40732

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1934.0
9 1117.2
11 701.91

GROUP SENSITIVITY = 3253.8 GROUP MERIT INDEX = .30309

GROUP 3 PARAMETERS 5 9 6 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 192.30

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = .11802E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.42799

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1310.0
9 1101.1
6 618.99

GROUP SENSITIVITY = 3030.2

GROUP MERIT INDEX = .35733

GROUP 4 PARAMETERS 5 9 7 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 208.04

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = .12489E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.44029

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1281.4
9 1112.2
7 534.94

GROUP SENSITIVITY = 2898.5

GROUP MERIT INDEX = .36438

GROUP 5 PARAMETERS 5 9 3 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 208.73

NRANK= 40 NCOEF2= 10 SUM OF SQUARES = .12574E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.44178

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1291.2
9 978.79
3 658.07

GROUP SENSITIVITY = 2928.1

GROUP MERIT INDEX = .35825

GROUP 6 PARAMETERS 5 9 13 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 207.04

NRANKP= 40 NCOEF2= 10 SUM OF SQUARES = .12800E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.00677

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1212.9
9 907.00
13 810.66

GROUP SENSITIVITY = 2934.6 GROUP MERIT INDEX = .35346

GROUP 7 PARAMETERS 5 9 1 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 210.73

NRANKP= 40 NCOEF2= 10 SUM OF SQUARES = .12352E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.07199

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1390.1
9 1049.4
1 401.13

GROUP SENSITIVITY = 2861.1 GROUP MERIT INDEX = .34316

GROUP 8 PARAMETERS 5 9 10 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 221.55

NRANKP= 40 NCOEF2= 10 SUM OF SQUARES = .14726E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.47809

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1293.1
9 910.72
10 210.97

GROUP SENSITIVITY = 2851.8 GROUP MERIT INDEX = .39535

GROUP 9 PARAMETERS 5 9 8 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 223.59

NRANKP= 40 NCOEF2= 10 SUM OF SQUARES = .14998E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.00248

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1340.9
9 987.10
8 329.45

GROUP SENSITIVITY = 2677.4

GROUP MERIT INDEX = .35073

GROUP 10 PARAMETERS 5 9 4 0 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 223.94

NRANK= 00 NCOEF2= 10 SUM OF SQUARES = .15044E+07

SAMPLE ST. DEV. = 463.42 NORMALIZED ERROR 0.00323

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1278.5
9 1028.8
8 178.70

GROUP SENSITIVITY = 2481.6

GROUP MERIT INDEX = .36644

THE REFERENCE GROUP FITTING IS NOW PERFORMED FOR THIS CONSEQUENCE 2 , GROUP NSINGL = 2

FOR TESTING THE SIGNIFICANCE OF THE ADDED PARAMETERS

$(USS(NP) - USS(IG)) * (NRANKP - M) / (K * USS(IG))$

MAY BE COMPARED TO AN $F(K, NRANKP - M)$ VARIABLE

$USS(NP)$ = RESIDUAL SUM OF SQUARES FOR THE BASE GROUP OF NP PARAMETERS , NP = 2

$USS(IG)$ = SAME FOR A LARGER GROUP IG WITH NGP PARAMETERS, INCL. THE BASE GROUP, NGP = 3

$M = (NGP+1)*(NGP+2)/2 = 10$

$K = M - (NP+1)*(NP+2)/2 = 4$

$NRANKP = M = 30$

INPUT GROUP

NSINGL NGP NP PARAMETERS
 2 2 2 5 9 " 0 0 0 0 0 0 0
 NSINGL = IDENTIFICATION NUMBER FOR THE INITIAL GROUP
 NGP = NUMBER OF PARAMETERS IN EACH GROUP
 NP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EACH STEP

NHDS = 1064 IEND = 1045 IOFFT = 30216# KLOC = 198142# MLOC = 732768

THE PARAMETERS OF THIS GROUP ARE 5 9

*CONSEQUENCE 2 MAX ERROR KNOT# 20 VALUE= 0.467281E+03 MIN ERROR KNOT# 25 VALUE= -0.517891E+03
 SUM OF ERROR SQUARES = .15525E+07

MEAN SQUARE ERROR= 0.213687E+03 REF VALUE= 0.189662D+04 FRACTION = 0.11267

GROUP 1 PARAMETERS 5 9 0 0 0 0 0 0 0 0 0 0 0
 RESIDUAL-MEAN-SQUARE ERROR = 213.69

NRANK# 40 NCOEF2= 6 SUM OF SQUARES = .15525E+07

SAMPLE-ST, DEV. = 463.42 NORMALIZED ERROR 0.46111

PARAMETERS IN THE ORDER OF SENSITIVITY
 IDENT.NO, TOTAL SENSITIVITY

5 1196.8
 9 934.57

GROUP SENSITIVITY = 2131.3

GROUP MERIT INDEX = .47153

THE COEFFICIENTS OF THE FITTED POLYNOMIALS

A
 + B(J) * (Z(J) - Z0(J))
 + C(J) * (Z(J) - Z0(J))**2
 + D(J,K) * (Z(J) - Z0(J)) * (Z(K) - Z0(K))
 THE PARAMETERS ARE J,K = 5 9
 A = 1896.62

B(J) = 7892.75
 C(J) = 14889.5
 D(5,K) = -.132209E+07

SENSITIVITIES AND INTERACTION SENSITIVITIES
 J , SENS(J) , SENSCH(J,K),K=J+1,...,NGP

5 1116.49 80.2853
 9 457.500

SCREENING AND CONFIDENCE 3

INPUT GROUP

NSINCL NCP NP PARAMETERS
3 3 2 5 9 0 0 0 0 0 0 0 0
NSINCL = IDENTIFICATION NUMBER FOR THE INITIAL GROUP
NCP = NUMBER OF PARAMETERS IN EACH GROUP
NP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EACH STEP

NMDS = 1A20 IEND = 1021 IOFFT = 1013A9 KLOC = 1938320 HLOC = 732760

THE NUMBER OF GROUPS = 11

GROUP 1 PARAMETERS 5 9 2 0 0 0 0 0 0 0 0 0
RESIDUAL MEAN SQUARE ERROR = 86.605

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .22501E+06

SAMPLE ST. DEV. = 382.60 NORMALIZED ERROR 0.25278

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1108.6
9 833.62
2 775.91

GROUP SENSITIVITY = 2718.1 GROUP MERIT INDEX = .49936

GROUP 2 PARAMETERS 5 9 11 0 0 0 0 0 0 0 0 0
RESIDUAL MEAN SQUARE ERROR = 132.04

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .52333E+06

SAMPLE ST. DEV. = 382.60 NORMALIZED ERROR 0.38551

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5 1332.1
9 785.80
11 451.11

GROUP SENSITIVITY = 2520.0 GROUP MERIT INDEX = .35140

GROUP 3 PARAMETERS 5 9 6 0 0 0 0 0 0 0 0 0

```
RESIDUAL -FAN SCIENCE FORMS = 114.25
NBRANKS= 40 NCOEF2= 10 SUM OF SQUARES = .54067E+06
SAMPLE ST. DEV. = 342.60 NORMALIZED ERROR 0.39145
```

PARAMETERS IN THE ORDER OF SENSITIVITY									
IDENT. NO.	TOTAL SENSITIVITY								
5	1016.2								
9	802.31								
6	523.29								
GROUP SENSITIVITY =		2341.8		GROUP MERIT INDEX =		.37336			
GROUP	u	PARAMETERS	5	9	7	0	0	0	0
RESIDUAL MEAN SQUARE ERROR =						142.15			

```

NRANKP= 40      NCOEF2= 10      SUM OF SQUARES = .60621E+06
SAMPLE ST. DEV. = 342.40      NORMALIZED ERROR 0.41992

```

PARAMETERS IN THE ORDER OF SENSITIVITY					
IDENT.NO.	TOTAL SENSITIVITY				
5	1014.5				
-9	-885.55				
7	429.10				
 GROUP-SENSITIVITY = -2329.1					
GROUP 5	PARAMETERS	5	9	3	0
RESIDUAL MEAN SQUARE ERROR = 146.68					
GROUP MERIT INDEX = .38492					
0 0 0 0 0 0					

```

NRANKP= 40      MCOEF2= 10      SUM OF SQUARES = .64543E+06
SAMPLE ST. DEV. = 342.60      NORMALIZED ERROR 0.42013

```

PARAMETERS IN THE ORDER OF SENSITIVITY			
IDENT. NO.	TOTAL SENSITIVITY		
5	987.23		
9	713.20		
3	493.28		
GROUP SENSITIVITY = 2193.7		GROUP MERIT INDEX = .36479	
GROUP 6	PARAMETERS 5	9	13
		0	0
		0	0
		0	0
		0	0
RESIDUAL MEAN SQUARE ERROR =		150.86	

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .68247E+06

SAMPLE ST. DEV. = 342.60 NORMALIZED ERROR 0.44040

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT. NO. TOTAL SENSITIVITY

5 951.49
9 714.47
13 583.73

GROUP SENSITIVITY = 2249.9

GROUP MERIT INDEX = .34577

GROUP 7 PARAMETERS 5 9 1 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 159.57

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .76367E+06

SAMPLE ST. DEV. = 342.60 NORMALIZED ERROR 0.44576

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT. NO. TOTAL SENSITIVITY

5 969.72
9 726.29
1 271.21

GROUP SENSITIVITY = 1969.2

GROUP MERIT INDEX = .37396

GROUP 8 PARAMETERS 5 9 8 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 161.13

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .77884E+06

SAMPLE ST. DEV. = 342.60 NORMALIZED ERROR 0.47030

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT. NO. TOTAL SENSITIVITY

5 946.66
9 641.11
6 263.64

GROUP SENSITIVITY = 1851.6

GROUP MERIT INDEX = .39343

GROUP 9 PARAMETERS 5 9 4 0 0 0 0 0 0 0 0

RESIDUAL MEAN SQUARE ERROR = 162.61

NRANKS = 40 NCOEF2 = 10 SUM OF SQUARES = .79324E+06

SAMPLE ST. DEV. = 342.40 NORMALIZED ERROR 0.47042

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5	895.23
9	715.71
4	121.20

GROUP SENSITIVITY = 1732.1

GROUP MERIT INDEX = .41673

GROUP 10	PARAMETERS	5	9	10	0	0	0	0	0	0	0	0	0
----------	------------	---	---	----	---	---	---	---	---	---	---	---	---

REGIONAL MEAN SQUARE ERROR = 162.65

NRANKP= 40 NCOEF2= 10 SUM OF SQUARES = .79360E+06

SAMPLE S. DEV. = 342.60 NORMALIZED ERROR 0.47473

PARAMETERS IN THE ORDER OF SENSITIVITY
IDENT.NO. TOTAL SENSITIVITY

5	939.36
9	674.34
10	112.88

GROUP SENSITIVITY = 1726.6

GROUP MERIT INDEX = .41798

THE REFERENCE GROUP FITTING IS NOW PERFORMED FOR THIS CONSEQUENCE 3 , GROUP NSINGL = 3

FOR TESTING THE SIGNIFICANCE OF THE ADDED PARAMETERS

$$(USS(NP) - USS(IG)) * (NRANKP - 4) / (4 * USS(IG))$$

MAY BE COMPARED TO AN F(K, NRANKP-4) VARIABLE

USS(NP) = RESIDUAL SUM OF SQUARES FOR THE BASE GROUP OF NP PARAMETERS , NP = 2

USS(IG) = SAME FOR A LARGER GROUP IG WITH NGP PARAMETERS, INCL. THE BASE GROUP, NGP = 3

$$M = (NGP+1)*(NGP+2)/2 = 10$$

$$K = M - (NP+1)*(NP+2)/2 = 4$$

NRANKP = M - K = 30

INPUT GROUP

NSINGL NGP NP PARAMETERS
 3 2 2 5 9 0 0 0 0 0 0 0
 NSINGL= IDENTIFICATION NUMBER FOR THE INITIAL GROUP
 NGP = NUMBER OF PARAMETERS IN EACH GROUP
 NP = NUMBER OF PARAMETERS KEPT IN A GROUP AT EACH STEP

NHDS = 1044 IEND = 1045 IOFFT = 302164 KLNC = 1941824 HLDC = 732760

THE PARAMETERS OF THIS GROUP ARE 5 9

*CONSEQUENCE 3 MAX ERROR KNOT= 20 VALUE= 0.358387E+03 MIN ERROR KNOT= 25 VALUE= -0.432289E+03
 SUM OF ERROR SQUARES = .81198E+06

MEAN SQUARE ERROR= 0.154533E+03 REF VALUE= 0.9101280+03 FRACTION = 0.16979

GROUP 1 PARAMETERS 5 9 0 0 0 0 0 0 0 0 0 0 0
 RESIDUAL MEAN SQUARE ERROR = 154.53

NRANK= 40 NCOEF2= 6 SUM OF SQUARES = .81198E+06

SAMPLE ST. DEV. = 342.60 NORMALIZED ERROR 0.45105

PARAMETERS IN THE ORDER OF SENSITIVITY
 IDENT.NO. TOTAL SENSITIVITY

5 886.88
 9 667.58

GROUP SENSITIVITY = 1554.5

GROUP MERIT INDEX = .48863

THE COEFFICIENTS OF THE FITTED POLYNOMIALS

A
 + B(J) * (Z(J) - Z0(J))
 + C(J) * ((Z(J) - Z0(J)) ** 2)
 + D(J,K) * (Z(J) - Z0(J)) * (Z(K) - Z0(K))
 THE PARAMETERS ARE J,K = 5 9
 A. 0. 910.128 //

B(J) = 6097.12 362332.
 C(J) = 17123.8 .196626E+09
 D(5,K) = 611286.

SENSITIVITIES AND INTERACTION SENSITIVITIES
 J , SENS(J) , SENSRC(J,K),K=J+1,,NGP

5 889.762 37.1210
 9 611.286

ACKNOWLEDGEMENTS

The author wishes to thank R. B. Williams for his contributions in programming and testing parts of the SCREEN code, J. E. Cahalan and J. M. Kyser of their valuable support in solving computational problems, and E. E. Morris and D. L. Graff for their assistance in using the VENUS-II code.

REFERENCES

1. K. W. Lee, J. A. Gieseke and L. D. Reed, "Sensitivity Analysis of the HAARM-3 Code," NUREG/CR-0527 (BMI-2008), Battelle Columbus Laboratories (1978).
2. J. A. Marshall, et. al., "Additional Methodology Development for Statistical Evaluation of Reactor Safety Analysis", EPRI NP-483 (1977).
3. B. W. Sheron, Proc. of ANS Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety, Vol. 2, p. II.4 (1978).
4. M. D. McKay, J. W. Bolstad and D. E. Whiteman, Proc. of ANS Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety, Vol. 2, p. II.9 (1978).
5. T. Krieger, C. Dursten and D. C. Albright, Trans. Am. Nucl. Soc., 28, 515 (1978).
6. W. Beck, F. Schmidt and H. Unger, "Integral Estimation of the Influence of Data Inaccuracies on Reactor Safety Calculations by Means of Statistical Methods", NUREG/TR-0037, Institut fur Kernenergetik der Universitat Stuttgart/U. S. Nuclear Regulatory Commission (1977).
7. R. H. Myers, Response Surface Methodology, Allyn and Bacon (1971).

8. J. K. Vaurio, Proc. of ANS Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety, Vol. 2, p. II.2 (1978).
9. E. J. McGrath, D. C. Irving, "Techniques for Efficient Monte Carlo Simulation", ORNL-RSIC-38, Vol. III (1975).
10. N. R. Draper and H. Smith, Applied Regression Analysis, John Wiley, (1966).
11. G. O. Wesolowsky, Multiple Regression and Analysis of Variance, John Wiley (1976).
12. C. Durston, T. Krieger and D. C. Albright, Private Communication (BNL-NUREG-23430 Informal Report, 1977), Brookhaven National Laboratory.
13. J. K. Vaurio, Trans. Am. Nucl. Soc., 32, 296 (1979).
14. I. Miller and J. E. Freund, Probability and Statistics for Engineers, Prentice Hall (1977).
15. J. F. Jackson and R. B. Nicholson, "VENUS-II: An LMFBR Disassembly Program", ANL-7951, Argonne National Laboratory (1972).
16. B. D. Ganapol, Univ. Arizona at Tucson, and R. J. Henninger, LANL, Private communication (1979).
17. J. F. Marchaterre et al., Proc. Int. Meeting on Fast Reactor Safety and Related Physics, Vol. III., p. 1121 (1976).
18. R. W. Ostensen, Nucl. Technol. 43, 301 (1979).
19. J. K. Vaurio, "PROSA-2, and Probabilistic Response-Surface Analysis and Simulation Code", ANL/RAS-80-26, Argonne National Laboratory (1980).

20. J. K. Vaurio, Trans. Am. Nucl. Soc., 35, 263 (1980).
21. Subroutine Library Documentation, Vol. 8, Applied Mathematics Division, Argonne National Laboratory (1973).
22. C. V. Parks, E. T. Tomlinson and E. M. Oblow, Proc. ANS/ENS International Meeting on Fast Reactor Safety Technology, (p. 69), Seattle, Washington, August 19-23, 1979.