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A GENERALIZED TECHNIQUE FOR USING CONES AND DIHEDRAL ANGLES IN ATTITUDE DETERMINATION

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FOREWORD

Over the past several years the Attitude Determination and Control Section has provided support for a number of unmanned scientific and application satellites in the area of attitude determination and attitude control. The satellites have used a variety of sensors and combinations of sensors for use in attitude determination. As a result, an effort was made to develop an attitude determination technique which was capable of handling data from a variety of sensors and produced a general set of solutions from mission to mission. The effort was directed toward reducing the analytical and programming efforts required to support new missions. This document presents the technique which is presently being used by the Attitude Determination Office to meet many of the attitude determination requirements of various missions. The basic analytical work was performed by Mr. L. B. Schlegel of IBM, Federal Systems Division, Federal Systems Center, Gaithersburg, Maryland. The programming of the GCONES subroutine was performed by Mr. F. J. Knoop of IBM. Both efforts were under contract to the Attitude Determination Office. Submitted herein are excerpts from a document written by Mr. Schlegel and Mr. Knoop entitled "GCONES: A Least Squares Geometric Approach to Attitude Determination of a Spinning Satellite" (Reference 1).

Analytic development is presented for a general least squares attitude determination subroutine applicable to spinning satellites. The method is founded on a geometric approach which is completely divorced from considerations relating to particular types and configurations of onboard attitude sensors. Any mix of sensor measurements which can be first transformed (outside the program) to cone or dihedral angle data can be processed. A cone angle is an angle between the spin axis and a known direction line in space; a dihedral angle is an angle between two planes formed by the spin axis and each of two known direction lines. Many different kinds of sensor data can be transformed to these angles, which in turn constitute the actual program inputs, so that the subroutine can be applied without change to a variety of satellite missions. Either a constant or dynamic spin axis model can be handled. The program is also capable of solving for fixed biases in the input angles, in addition to the spin axis attitude solution.

This technique for attitude determination has been used by the Attitude Determination Office to support AE-B, RAE-1, ITOS-1, NOAA-I, SAS-1, IMP-6, San Marco-C (References 2, 3, 4, 5, 6, 7 and 8), SAS-2, IMP-7 and AEROS-1.

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A GENERALIZED TECHNIQUE FOR USING CONES AND DIHEDRAL ANGLES IN ATTITUDE DETERMINATION

1. INTRODUCTION

Since the early 1960's, the Attitude Determination and Control Section of Goddard Space Flight Center has had continuing responsibility for attitude determination of a variety of scientific satellites. Many of these satellites are spin stabilized in orbit, and the primary problem is that of determining the inertial orientation of the spin axis. A number of different types of onboard-measured sensor data are available for this purpose, depending on the particular satellite. Examples are solar aspect sensors, magnetometers, horizon scanners, and star slit scanners. The objective is to obtain a best estimate of the attitude from many individual sensor measurements over some span of the orbit. Although spin-stabilized, the attitude can in general change slowly in time because of disturbances and/or applied control torques. The possible presence of this motion over the data time span must be accounted for in the attitude estimation procedure by a dynamic spin axis motion model.

As described above, the attitude determination problem submits to a standard least squares solution which minimizes the sum of squares of residuals between measured and computed sensor data points. Whenever the relations between sensor observables and attitude state variables are nonlinear, an iterative differential correction procedure must be employed. The computed data are then based initially on an a priori estimated state, and at subsequent iterations on the updated (differentially corrected) state. In some cases, the observables can be linearly related to the state and a one-step, noniterative solution can be obtained without an initial estimate. In either situation, this solution approach usually requires a separate least squares program for each different satellite of interest, because of the distinct sensor complement associated with each. The practical outcome is a considerable duplication of programming work from one satellite attitude determination system to another.

To overcome this redundancy, a technique for attitude determination has been used which reduces the effort required to develop a new support system for each new mission. It was noticed that for many types of sensors flown on spin stabilized satellites, two types of angles were the fundamental measurements of data obtained from the sensors. The first of these angles is commonly referred to as a cone angle and is a measure of the angle between some reference vector and the spin axis. For example, the outputs of (i) a solar aspect sensor, (ii) a magnetometer collinear with the spin axis, and (iii) an infrared horizon scanner, can be transformed to angles between the spin axis and (i) the sun line, (ii) the earth's magnetic field direction, and (iii) the local vertical line. Each such angle can be regarded as the generating angle of a cone having the known direction as its axis. Thus, a single measurement constrains the spin axis to lie on a conical surface locus. The second of these angles is a dihedral angle demonstrated on the IMP series of satellites. The dihedral angle for those missions is a measurement of the angle between a plane formed by the spin axis and sun line, and the plane formed by the spin axis and the earth's horizon (as sensed by an optical telescope). A dihedral angle measurement defines a different kind of locus surface in space than the conical surface locus of a cone angle.

For a fixed spin axis, this technique (Reference 9) finds the inertial orientation of the least-squares common intersection line of all these loci, using as input only the generating cone-dihedral angles and the associated reference vectors. The method used is iterative differential correction to minimize a weighted sum of squares of residuals between "measured" (that is, transformable from measured sensor data) and computed cone and dihedral angles; an initial or a priori attitude estimate is required. The solution is taken as the best estimate of spin axis attitude using all measured sensor data.

The key idea behind this approach is that the least squares solution algorithm is completely divorced from individual sensor types, onboard mounting angles, etc. Rather, the solution is developed on a strictly geometric basis. Consequently, for each new application, only the transformations from fundamental measurements to cone and dihedral angles need to be specially developed. In this way the technique achieves a significant degree of generality as a fundamental attitude determination tool for spin stabilized spacecraft.

With the use of this technique, new programming is limited to sensor-measurement-to-cone angle-dihedral angle transformations. Solutions can be obtained for both static (inertially fixed) and dynamic spin axis motion models. For simplicity, dynamic models, at present are restricted to either linear or quadratic polynomials in time for each of the attitude angles which define spin axis orientation. Here the solution obtained includes attitude angles, rates (linear model), and accelerations (quadratic model) at some epoch time. To provide a better understanding of the data which is being used an option is available for estimating as an additional state parameter, a constant bias in one of the sensor types which contributes to the overall mix of input cone angles.

The ability to estimate bias in addition to attitude has proven to be a useful tool. Inclusion of this mode provides the estimation process with another "degree of freedom," and often results in a better solution "fit" in terms of overall reduction of residuals. In the case of this technique, adherence to the basic design philosophy does not permit particular sensor biases to be appended to the attitude estimation. Nonetheless, the technique does include full capability of optionally estimating constant biases in the derived cone or dihedral angles, which form the basic inputs. Indeed, separate biases in distinct types of angle data may be estimated simultaneously (see Section 3.1). This approach appears to be the simplest way to incorporate the feature of bias estimation in a technique which is fundamentally sensor-independent. To the extent, however, that sensor measurements may not transform linearly to cone or dihedral angles (prior to using this technique), each constant bias estimated should be cautiously interpreted as no more than a kind of overall or average bias effect of the associated sensor over the entire data span. This interpretation is put on a sounder basis when the data time span is reasonably short. In that case, the approximation of a linear transformation from sensor measurement to geometric angle is more nearly realized.

Differential equation models for dynamic spin axis behavior are included in the technique. This behavior is represented by simple polynomial models (linear, quadratic and cubic) to account for dynamic behavior of each of the attitude angles which define spin axis orientation. These models have proven adequate in past studies whenever the time span of the data being processed is relatively short. The reasoning is that over a sufficiently short span, the true dynamic behavior (of whatever complexity) can be approximated by low order polynomials in time. The polynomial models enjoy the computational advantage that the attitude angles at any time are linearly related to the attitude angles, rates, accelerations, etc. at epoch. These epoch values make up the state vector in the dynamic case. It is realized, however, that in particular situations where the processed data span is necessarily long, or where high disturbance or control torques are acting to change the attitude, another type of model may be needed. This might be based on other kinds of functions (non-polynomial), or more generally on differential equations of motion. The latter requires specification of all torques acting to change the attitude. In particular cases such models may be incorporated without difficulty into the structure to replace the built-in polynomials.

2. DATA CLASSES, TYPES, AND WEIGHTS

From now on the discussion will refer to "measured" or "observed" cone angle and dihedral angle inputs to the technique. It is understood that these angles are not necessarily themselves measured, but are usually transformed (prior to the use of the technique) from actual onboard sensor data.

The input is broken into two basic classes of data: cone angle data (Class 1) and dihedral angle data (Class 2). Within each class there may be any number of distinct types, as for example sun cone angles (cone axis = sun line), magnetic cone angles (cone axis = magnetic field direction), etc. within the class of cone angles; and similarly for the class of dihedral angles.* Lastly, for each type of data, there can be any number of individual angles. Each measured angle can have any assigned input weight, but each measurement is considered to be independent from all others. Any mixture of numbers, types, and classes of angles constitutes a valid input for a solution run.

The subparagraphs which follow develop the geometric relations between cone or dihedral angles and the spin axis attitude angles at the time of observation. These equations are needed later in the differential correction formulation. The attitude of unit spin axis $\underline{S}$ is consistently defined in terms of right ascension and declination angles α, δ, relative to the standard geocentric inertial system $\underline{X}$, $\underline{Y}$, $\underline{Z}$ referred to the vernal equinox. This geometry is shown in Figure 1, with

$$\underline{S} = S_1 \underline{X} + S_2 \underline{Y} + S_3 \underline{Z} \tag{1}$$

and

$$\left.\begin{aligned} S_1 &= \cos\alpha\cos\delta \; (0^\circ \le \alpha < 360^\circ, \; -90^\circ \le \delta \le 90^\circ) \\ S_2 &= \sin\alpha\cos\delta \\ S_3 &= \sin\delta \end{aligned}\right\} \tag{2}$$

2.1 Cone Angle Data (Class 1)

Cone angles are designated by θ throughout this report. A cone angle is a measure of the angle between $\underline{S}$ and some known unit vector $\underline{U}$ in inertial axes. The vector $\underline{U}$ is regarded as errorless. A single θ measurement constrains $\underline{S}$ to lie on a cone about $\underline{U}$ with generating angle θ, as shown in Figure 2a. A number of θ measurements, and associated cone axes, constrain $\underline{S}$ to lie simultaneously on a number of cones. In general, with imperfect measurements, all cones will not exactly intersect in a common line.† The program (with only Class 1 cone angle data input) finds the best common intersection line in the sense of weighted least squares minimization of cone angle residuals, and this line is taken as the solution for $\underline{S}$. A "top view" of this multiple intersection

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*In Section 4.2 of Reference 10, "classes" of data (cone and dihedral angles) are referred to as "types," but the present report will consistently use these designations in the way defined here.

†The discussion here assumes a fixed spin axis. In the dynamic case all the cones do not have a common intersection, even with perfect θ measurements.

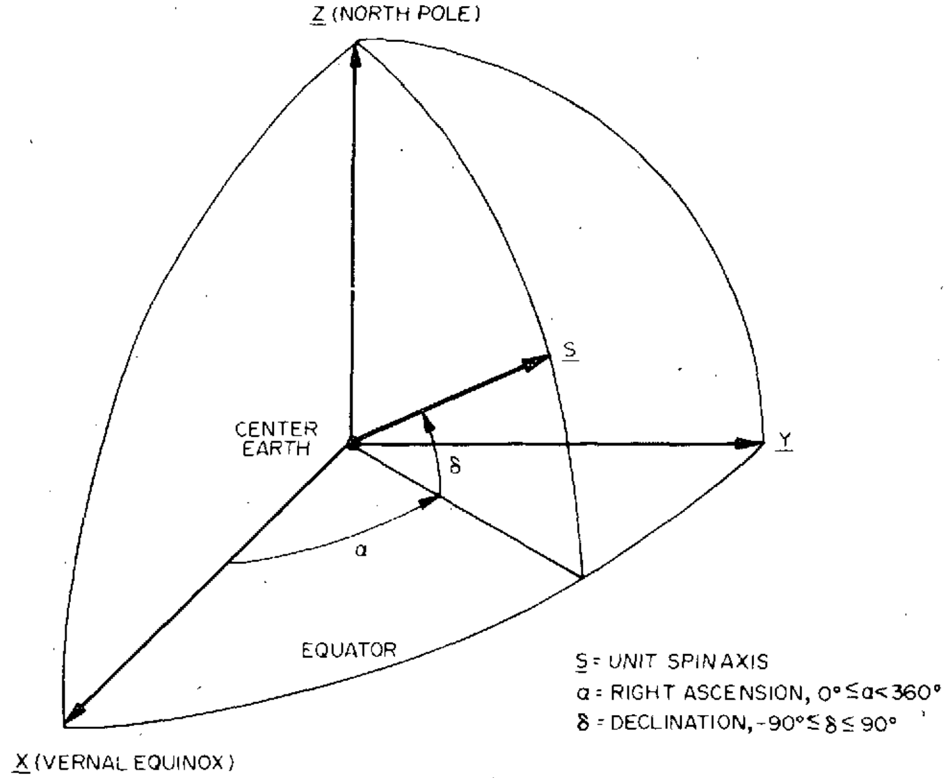

Figure 1. Spin Axis Orientation Angles

geometry is shown in Figure 2b. With only two cones, two equally valid solutions exist; in this case the program will converge to the intersection line which lies closest in angle separation to the input initial estimate of S.

The relation between θ and the spin axis attitude angles α, δ at the time of observation is

$$\theta = \cos^{-1} (U \cdot S) = \cos^{-1} (U_1 S_1 + U_2 S_2 + U_3 S_3) \left[+ b_\theta \right] \tag{3}$$

where $U_{1,2,3}$ are the known X, Y, Z components of U and $S_{1,2,3}$ are defined in (2). Whenever bias is to be estimated for a particular type of cone angle data, (3) is augmented by the addition of a bias term b_θ on the right, as indicated by the dashed block.

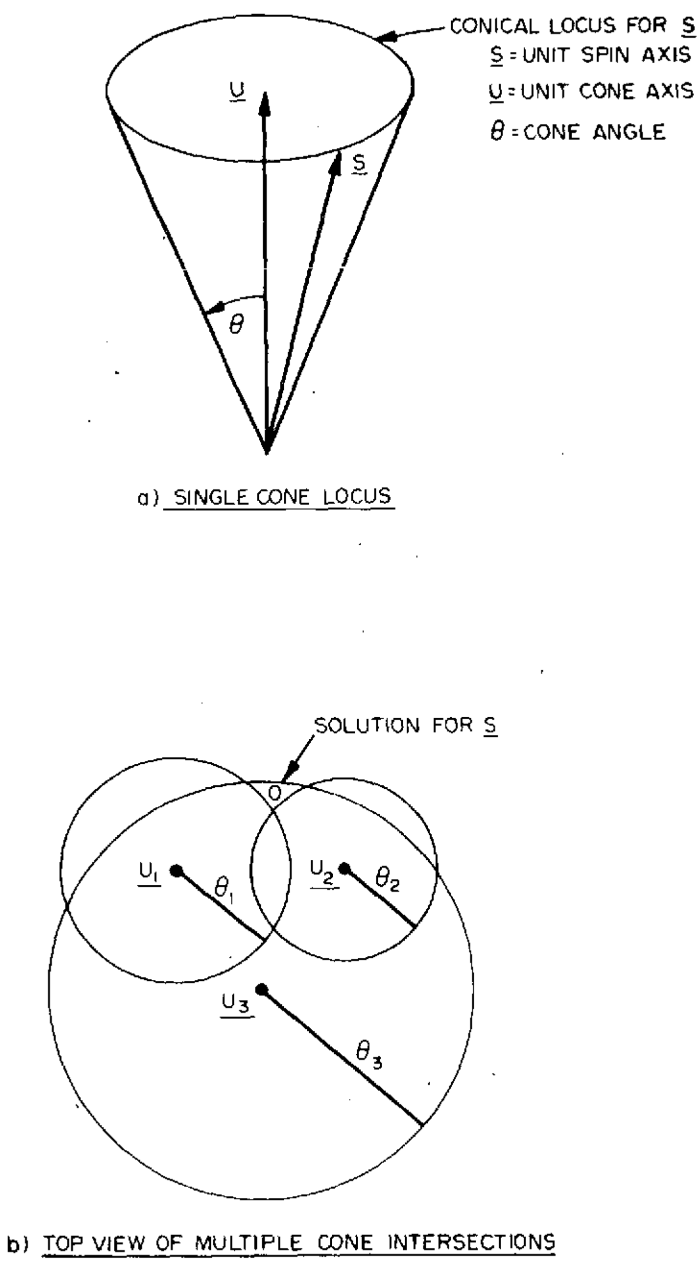

Figure 2. Cone Angle Geometry

2.2 Dihedral Angle Data (Class 2)

Dihedral angles are designated by Ψ throughout this report. A dihedral angle Ψ is a measure of the angle between two planes: the one defined by $\underline{S}$ and a first known unit direction line $\underline{V}$, the other defined by $\underline{S}$ and a second known unit direction line $\underline{W}$. The vectors $\underline{V}$ and $\underline{W}$ are regarded as errorless. It is understood that S is not coincident with either V or W. Geometry is illustrated in Figure 3. The key distinction between dihedral angles and cone angles is that now a single angle Ψ is associated with two inertial directions V and W, and S forms the line of intersection of the two planes of interest.*

The sense and range of Ψ, and the ordering of the associated unit vectors V and W, must be carefully defined for subsequent use. Referring to Figure 3, suppose the given ordering of the unit vectors is V, W (i.e., V "comes first"), and let V', W' be unit vectors along the projections of V and W in a plane normal to S. Then Ψ is uniquely defined in the range $0° \leq \Psi < 360°$ as the angle from V' around to W', positive in the sense of positive rotation about S. For any type of

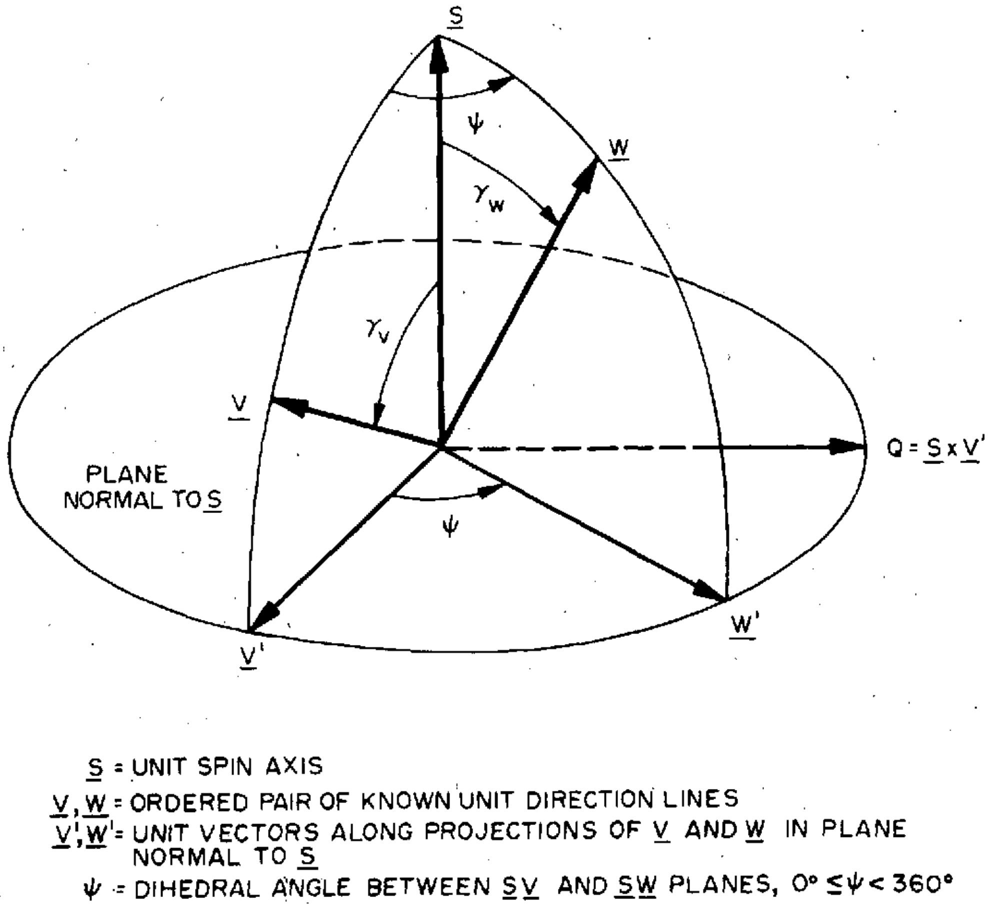

Figure 3. Dihedral Angle Geometry

*Note that a different kind of dihedral angle can be defined by S and two known inertial direction lines V and W, when either V or W rather than S is common to the two planes which intersect at the given angle. POLANG data from the ATS satellite series is an example of such a dihedral angle (Reference 11).

sensor data transformable to Ψ angles, an ordering of the known $\underline{V}$ and $\underline{W}$ direction lines must be specified, and the magnitude of measured Ψ must be in accord with this ordering and the above definition.

The relation between Ψ and the attitude angles α, δ of $\underline{S}$ at the time of observation can be developed from the geometry of Figure 3. First define the auxiliary angles γ_v, γ_w in the range 0° to 180° by

$$\cos \gamma_V = \underline{V} \cdot \underline{S}, \quad \cos \gamma_W = \underline{W} \cdot \underline{S} \tag{4}$$

and the auxiliary unit vector $\underline{Q}$ in the plane normal to $\underline{S}$ by

$$Q = \underline{S} \times \underline{V}' \tag{5}$$

Then

$$\underline{V}' = \frac{1}{\sin \gamma_V} (\underline{V} - \cos \gamma_V \underline{S}) \tag{6}$$

$$\underline{W}' = \frac{1}{\sin \gamma_W} (\underline{W} - \cos \gamma_W \underline{S}) \tag{7}$$

$$\underline{Q} = \underline{S} \times \underline{V}' = \frac{1}{\sin \gamma_V} \cdot (\underline{S} \times \underline{V}) \tag{8}$$

$$\Psi = \tan^{-1}\left(\frac{\underline{W}' \cdot \underline{Q}}{\underline{W}' \cdot \underline{V}'}\right), \quad 0° \leq \Psi < 360° \text{ unambiguously by sign of numerator and denominator} \tag{9}$$

Substituting from (4), (6), (7), and (8) into (9) and simplifying,

$$\Psi = \tan^{-1}\left[\frac{\underline{W}\cdot(\underline{S}\times\underline{V})}{\underline{V}\cdot\underline{W} - \cos\gamma_V\,\underline{W}\cdot\underline{S} - \cos\gamma_W\,\underline{V}\cdot\underline{S} + \cos\gamma_V\cos\gamma_W}\right]$$

$$= \tan^{-1}\left[\frac{\underline{S}\cdot(\underline{V}\times\underline{W})}{\underline{V}\cdot\underline{W} - (\underline{V}\cdot\underline{S})\,(\underline{W}\cdot\underline{S})}\right] \qquad (10)$$

where the factor ($\sin\gamma_V\ \ \sin\gamma_W$) has been divided out from the numerator and denominator without loss of quadrant selectivity, since both $\sin\gamma_V$ and $\sin\gamma_W$ are positive for $0° \le \gamma_V,\ \gamma_W \le 180°$. Finally, letting $V_{1,2,3}$ and $W_{1,2,3}$ be the known $\underline{X}$, $\underline{Y}$, $\underline{Z}$ components of $\underline{V}$ and $\underline{W}$, (10) reduces to

$$\Psi = \tan^{-1}\left[\frac{S_1(V_2W_3 - V_3W_2) + S_2(V_3W_1 - V_1W_3) + S_3(V_1W_2 - V_2W_1)}{(V_1W_1 + V_2W_2 + V_3W_3) - (V_1S_1 + V_2S_2 + V_3S_3)(W_1S_1 + W_2S_2 + W_3S_3)}\right]\ \boxed{+\,b_\Psi} \qquad (11)$$

where $S_{1,2,3}$ are defined in (2). Equation (11) is the desired relation between Ψ and α, δ. Whenever bias is to be estimated for a particular type of dihedral angle data, (11) is augmented by the addition of a bias term b_Ψ on the right, as indicated by the dashed block.

Before concluding this section, a few remarks on the concept of a "dihedral angle locus" are in order. In the same way that a single cone angle θ cannot uniquely determine the spin axis, but only defines a locus for $\underline{S}$, so also a single dihedral angle Ψ defines a different kind of locus. It is generally of more complicated character than the cone of Figure 2a. To demonstrate that a locus indeed exists, it is instructive to consider the specific case shown in Figure 4, where $\underline{V}$ and $\underline{W}$ are separated by 45° and $\Psi = 60°$. This figure is drawn differently from Figure 3, in that it is referenced to the plane of $\underline{V}$ and $\underline{W}$ as "equator" plane, with $\underline{N}$ the unit normal to this plane. Now along every meridian extending from $\underline{N}$ to the equator arc bounded by $\underline{A}$ and $\underline{B}$, there must exist a direction $\underline{S}$ such that the dihedral angle between planes $\underline{S}\ \underline{V}$ and $\underline{S}\ \underline{W}$ is equal to $\Psi = 60°$. This follows since as $\underline{S}$ proceeds from $\underline{N}$ down along every such meridian, Ψ opens up from $\Psi = 45°$ (when $\underline{S} = \underline{N}$) to either $\Psi = 180°$ (when $\underline{S}$ lies in the equator plane between $\underline{V}$ and $\underline{W}$) or $\Psi = 90°$ (when $\underline{S} = \underline{V}$ or $\underline{S} = \underline{W}$). Two particular points on this locus are shown as $\underline{S}_1$ and $\underline{S}_2$ on the meridian arcs NV and NW, and a segment of the locus is sketched between.

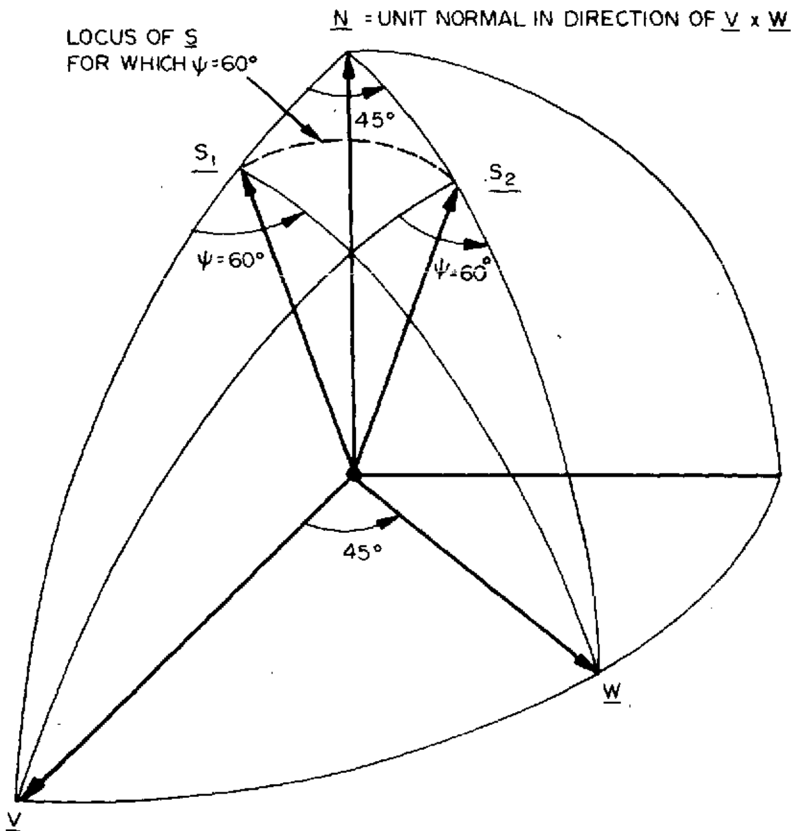

Figure 4. Spin Axis Locus (Single Dihedral Angle)

Note that this locus is not a "circle of latitude." Nor, apparently, is it part of a (right circular) cone. That is, there is no single direction line in space which could serve as cone axis; such a line must have the property that all S orientations along the locus are separated from it by a constant angle (the cone angle). Nevertheless, the surface swept out by S as it occupies all points on the locus can be considered in a general sense to be part of (non-right-circular) "cone."

A number of dihedral angles alone (without any additional cone angles) suffices for a solution, since all of the loci so defined have a nearly common intersection line.* With only Class 2 dihedral angle inputs, the technique finds the best common intersection in the sense of weighted least squares minimization of dihedral angle residuals. This is taken as the solution for S. In the most general case, any mixture of Class 1 and Class 2 data may be input, and the program finds the best common intersection of all cone angle and dihedral angle loci.

*The discussion here again assumes a fixed spin axis, but the program also handles the dynamic case (Section 3).

3. SPIN AXIS MOTION MODEL

3.1 Constant and Dynamic Models

The most common application of the technique is the case of constant S. That is, the acting torque levels are sufficiently small, or the data span is sufficiently short, that S can be regarded as inertially fixed over the span. The attitude state is then simply defined by α and δ. If these conditions are not well satisfied, a dynamic motion model based on low order polynomials in time is assumed for α and δ, viz.

$$\left.\begin{aligned} \alpha(t) &= a_0 + a_1 (t - t_0) + a_2 (t - t_0)^2 + a_3 (t - t_0)^3 \\ \delta(t) &= d_0 + d_1 (t - t_0) + d_2 (t - t_0)^2 + d_3 (t - t_0)^3 \end{aligned}\right\} \qquad (12)$$

where t_0 is a chosen epoch time and t is a general time within the data span. The advantage of polynomial models in the least-squares solution algorithm is that the attitude angles at times t are linearly related to the $a_0, a_1, \ldots, d_3$ state coefficients. Considerable computational simplicity is thereby realized (see Section 4).

Logic allows for truncations of (12) to quadratic, linear, or constant models at the option of the user, so that the case of constant S is also handled by the general form (12). To summarize, the state variables estimated by this technique for the various motion models are as follows:

STATE DEFINITION

Model	State Variables
Constant	a_0, d_0
Linear	a_0, d_0, a_1, d_1
Quadratic	$a_0, d_0, a_1, d_1, a_2, d_2$
Cubic	$a_0, d_0, a_1, d_1, a_2, d_2, a_3, d_3$

(13)

At option, constant biases on separate types of either cone angle (Class 1) or dihedral angle (Class 2) data may be included as additional state parameters and estimated along with the attitude variables. As many as five distinct biases may be simultaneously estimated, apportioned in any way among the separate data types of either data class.

3.2 Nutation Application

By their very nature, polynomial models tend to fit the general trend of a dynamic motion process, and to filter out short period oscillations. A particular instance of the latter, which is of some importance in practice, occurs when space nutation is present. Here $\underline{S}$ executes coning motion about the total angular momentum $\underline{H}$, and it is the attitude motion of $\underline{H}$ under various torques that is often well-approximated over a data span by polynomial models. The measured cone and/or dihedral angles, however, are relative to $\underline{S}$. Consequently, they will exhibit an oscillatory component at the nutation period, which is in accord with the actual motion of $\underline{S}$. Now if (i) the nutation cone angle is small, (ii) the nutation period is short compared to the period required for $\underline{H}$ to change appreciably in direction, and (iii) many measured data points occur over each nutation cycle, then the inherent smoothing action of this technique tends to give a good estimate of the motion of $\underline{H}$. The solution can then be interpreted as the average or smoothed motion of the nutating spin axis $\underline{S}$. This holds for both constant and dynamic models for $\underline{H}$. The above conditions (i), (ii), (iii) are indeed often satisfied in practice, which implies that the simple polynomial models are capable of providing at least average solutions for $\underline{S}$ in the presence of nutation. For a particular application of these considerations to the TIROS-M satellite, see pp. 4-37 to 4-41 of Reference 4.

4. LEAST SQUARES SOLUTION ALGORITHM

4.1 Basic Formulation

The attitude and optional bias solutions obtained by this technique are those which minimize a weighted sum J of squared residuals between measured and computed cone angles and dihedral angles. The minimization is carried out with respect to the attitude state variables (13), plus any specified bias parameters. In vector-matrix form, the sum J is

$$J = (\tilde{\underline{\theta}} - \underline{\theta})' \, [W_\theta] \, (\tilde{\underline{\theta}} - \underline{\theta}) + (\tilde{\underline{\Psi}} - \underline{\Psi})' \, [W_\Psi] \, (\tilde{\underline{\Psi}} - \underline{\Psi}) \tag{14}$$

where

$\tilde{\underline{\theta}}$ = vector of cone angle measurements (hereafter the tilde($\sim$) notation indicates a measured quantity; elements of $\tilde{\underline{\theta}}$ together with corresponding measurements times are input to the program)

$\underline{\theta}$ = vector of computed cone angles

$[W_\theta]$ = diagonal matrix of cone angle weights (input)

$\underline{\tilde{\Psi}}$ = vector of dihedral angle measurements (input together with corresponding measurement times)

$\underline{\Psi}$ = vector of computed dihedral angles

$[W_\Psi]$ = diagonal matrix of dihedral angle weights (input)

and prime (′) indicates transpose. The elements of $\underline{\theta}$ and $\underline{\Psi}$ are computed as functions of the attitude state (and possibly bias) parameters according to (3) and (11), together with the defining relations (2) and (12).

Following Reference 12, the minimization of J is achieved iteratively through the differential correction algorithm

$$\Delta \underline{x} = \{[H]' \ [W] \ [H]\}^{-1} [H]' \ [W] \ \underline{\rho} \tag{15}$$

where

$\underline{x}$ = state vector (consisting of components (13) plus specified biases to be estimated)

$[H]$ = matrix of partials of cone and dihedral angles with respect to the elements of the state vector

$[W]$ = diagonal weighting matrix whose diagonal partitions are $[W_\theta]$ and $[W_\Psi]$, i.e.,

$$[W] = \left[\begin{array}{c|c} [W_\theta] & 0 \\ \hline 0 & [W_\Psi] \end{array}\right] \tag{16}$$

$\underline{\rho}$ = vector of all cone and dihedral angles residuals,

$$\underline{\rho} = \begin{bmatrix} \underline{\tilde{\theta}} - \underline{\theta} \\ \underline{\tilde{\Psi}} - \underline{\Psi} \end{bmatrix} \tag{17}$$

In the above, [H] and ρ at each iteration are evaluated for the current state estimate $\hat{\underline{x}}$ at that iteration (hereafter the hat (^) notation indicates an estimate). The process begins at an input initial state estimate $\hat{\underline{x}}_0$, which is updated to $\hat{\underline{x}} = \hat{\underline{x}}_0 + \Delta \underline{x}$ after the first iteration, etc. (see Section 4.4) for additional details).

4.2 Partial Derivatives

The partial derivatives which go to make up the elements of [H] are obtained by chain-rule differentiations of (3) and (11) taken together with (2) and (12). A simple example will first be given to illustrate the procedure; extensions to more general cases follow. Suppose that (i) the dynamic model (12) is linear, (ii) only one type of Class 1 θ data is being processed, and (iii) bias in this data type is also to be estimated. Then the state parameters for the problem are a_0, d_0, a_1, d_1, and b_θ. The relation between θ and these parameters is therefore expressed by the system of equations

$$\theta = \cos^{-1} (U_1 \cos \alpha \cos \delta + U_2 \sin \alpha \cos \delta + U_3 \sin \delta) + b_\theta \tag{18}$$

$$\alpha = a_0 + a_1 (t - t_0) \tag{19}$$

$$\delta = d_0 + d_1 (t - t_0) \tag{20}$$

From (18-20) the appropriate partial derivatives are

$$\frac{\partial \theta}{\partial a_0} = \frac{-U_1 \sin \alpha \cos \delta + U_2 \cos \alpha \cos \delta}{-\sqrt{1 - (U_1 \cos \alpha \cos \delta + U_2 \sin \alpha \cos \delta + U_3 \sin \delta)^2}} \tag{21}$$

$$\frac{\partial \theta}{\partial d_0} = \frac{-U_1 \cos \alpha \sin \delta - U_2 \sin \alpha \sin \delta + U_3 \cos \delta}{-\sqrt{1 - (U_1 \cos \alpha \cos \delta + U_2 \sin \alpha \cos \delta + U_3 \sin \delta)^2}} \tag{22}$$

$$\frac{\partial \theta}{\partial a_1} = \frac{\partial \theta}{\partial a_0} (t - t_0) \tag{23}$$

$$\frac{\partial \theta}{\partial d_1} = \frac{\partial \theta}{\partial d_0} (t - t_0) \tag{24}$$

$$\frac{\partial \theta}{\partial b_\theta} = 1 \tag{25}$$

where α and δ are functions of a_0, a_1, d_0, d_1 given by (19) and (20).

For this example, assuming n data points $\tilde{\theta}_1, \ldots, \tilde{\theta}_n$ at measurements times $t_1, \ldots, t_n$, matrix [H] is of order nx5, with the i-th row consisting of the elements (21-25) evaluated at time t_i.

It is seen that (21) and (22) are the "fundamental" partials for a constant spin axis model, with (23) and (24) being obtained from them by multiplying by $(t - t_0)$. Extending this sample to a quadratic or a cubic motion model, the required additional partials are

$$\left.\begin{aligned}
\frac{\partial \theta}{\partial a_2} &= \frac{\partial \theta}{\partial a_0} (t - t_0)^2 \\
\frac{\partial \theta}{\partial a_3} &= \frac{\partial \theta}{\partial a_0} (t - t_0)^3 \\
\frac{\partial \theta}{\partial d_2} &= \frac{\partial \theta}{\partial d_0} (t - t_0)^2 \\
\frac{\partial \theta}{\partial d_3} &= \frac{\partial \theta}{\partial d_0} (t - t_0)^3
\end{aligned}\right\} \tag{26}$$

Following this same approach, the fundamental partials for dihedral angle data are $\partial \Psi / \partial a_0$, $\partial \Psi / \partial d_0$. These are obtained by differentiations of (11), with $S_{1,2,3}$ given by (2). The algebra is straightforward but somewhat lengthy, so only the final results are given here. For brevity of notion, define

$$\left.\begin{aligned}
E_1 &= V_2 W_3 - V_3 W_2 \\
E_2 &= V_3 W_1 - V_1 W_3 \\
E_3 &= V_1 W_2 - V_2 W_1
\end{aligned}\right\} \tag{27}$$

$$F = V_1 W_1 + V_2 W_2 + V_3 W_3 \tag{28}$$

$$\left.\begin{aligned} S_V &= V_1\,S_1 + V_2\,S_2 + V_3\,S_3 \\ S_W &= W_1\,S_1 + W_2\,S_2 + W_3\,S_3 \end{aligned}\right\} \tag{29}$$

$$\left.\begin{aligned} &\text{NUM (for "Numerator")} = S_1\,E_1 + S_2\,E_2 + S_3\,E_3 \\ &\text{DEN (for "Denominator")} = F - S_V\,S_W \end{aligned}\right\} \tag{30}$$

Thus (11) becomes

$$\Psi = \tan^{-1}\left(\frac{\text{NUM}}{\text{DEN}}\right) \boxed{+\ b_\Psi} \tag{31}$$

Further define

$$\begin{aligned} Q_1 &= \text{DEN}\cdot E_1 + \text{NUM}\,(S_V\,W_1 + S_W\,V_1) \\ Q_2 &= \text{DEN}\cdot E_2 + \text{NUM}\,(S_V\,W_2 + S_W\,V_2) \\ Q_3 &= \text{DEN}\cdot E_3 + \text{NUM}\,(S_V\,W_3 + S_W\,V_3) \end{aligned} \tag{32}$$

Then the fundamental dihedral partials are

$$\frac{\partial\Psi}{\partial a_0} = \frac{-\,Q_1 \sin\alpha\cos\delta + Q_2\cos\alpha\cos\delta}{(\text{NUM})^2 + (\text{DEN})^2} \tag{33}$$

$$\frac{\partial\Psi}{\partial d_0} = \frac{-\,Q_1\cos\alpha\sin\delta - Q_2\sin\alpha\sin\delta + Q_3\cos\delta}{(\text{NUM})^2 + (\text{DEN})^2} \tag{34}$$

where α and δ are functions of $a_0, \ldots, d_3$ given by (12). Additional partials to accommodate a dynamic motion model are obtained by multiplying (33) and (34) by appropriate powers to $(t - t_0)$, as in (23), (24), (26).

To summarize for all cases, the following table lists the partial derivative equations used in computing the elements of [H].

PARTIAL DERIVATIVE TABULATION

Cone Angle Partials	Equation	Dihedral Angle Partials	Equation	Model
$\frac{\partial \theta}{\partial a_0}$	(21)	$\frac{\partial \Psi}{\partial a_0}$	(33)	Constant
$\frac{\partial \theta}{\partial d_0}$	(22)	$\frac{\partial \Psi}{\partial d_0}$	(34)	
$\frac{\partial \theta}{\partial a_1}$	(21) $\cdot$ $(t - t_0)$	$\frac{\partial \Psi}{\partial a_1}$	(33) $\cdot$ $(t - t_0)$	Linear
$\frac{\partial \theta}{\partial d_1}$	(22) $\cdot$ $(t - t_0)$	$\frac{\partial \Psi}{\partial d_1}$	(34) $\cdot$ $(t - t_0)$	
$\frac{\partial \theta}{\partial a_2}$	(21) $\cdot$ $(t - t_0)^2$	$\frac{\partial \Psi}{\partial a_2}$	(33) $\cdot$ $(t - t_0)^2$	Quadratic
$\frac{\partial \theta}{\partial d_2}$	(22) $\cdot$ $(t - t_0)^2$	$\frac{\partial \Psi}{\partial d_2}$	(34) $\cdot$ $(t - t_0)^2$	
$\frac{\partial \theta}{\partial a_3}$	(21) $\cdot$ $(t - t_0)^3$	$\frac{\partial \Psi}{\partial a_3}$	(33) $\cdot$ $(t - t_0)^3$	Cubic
$\frac{\partial \theta}{\partial d_3}$	(22) $\cdot$ $(t - t_0)^3$	$\frac{\partial \Psi}{\partial d_3}$	(34) $\cdot$ $(t - t_0)^3$	

In addition to the above, [H] also contains partials of θ or Ψ with respect to biases for particular data types. If bias for a particular type of θ or Ψ data is being estimated, the appropriate partial (either $\partial\theta/\partial b_\theta$ or $\partial\Psi/\partial b_\Psi$) is unity; otherwise it is zero.

4.3 Computation Structure for Mixed Classes and Types of Data

As stated earlier, this technique can handle any number of different data types within each data class. Within each type there can be any number of individual cone or dihedral angles. For additional clarification, it is helpful to examine a specific case here, which also serves to illustrate how bias estimation on particular data types is processed.

Suppose that 5 cone angles of one type, 8 cone angles of another type, and 6 dihedral angles of one type are input. To avoid complicated subscripting, designate the cone angle types by θ and ϕ, and the dihedral angle type by Ψ. Thus, the input data sets are $\tilde{\theta}_1, \ldots, \tilde{\theta}_5$; $\tilde{\phi}_1, \ldots, \tilde{\phi}_8$; $\Psi_1 \ldots, \Psi_6$. Let the 19 corresponding measurement times be $t_{\theta 1}, t_{\theta 2}, \ldots, t_{\Psi 6}$. Also assume a linear dynamic model, and suppose that bias b_ϕ on just the second type of cone angle data is also to be estimated. Then the state vector is

$$\overset{5\times 1}{\underline{x}} = [a_0 \; d_0 \; a_1 \; d_1 \; b_\theta]' \tag{35}$$

and the vectors and matrices in the differential correction algorithm (15) are structured as follows:

$$\overset{5\times 1}{\Delta \underline{x}} = [\Delta a_0 \quad \Delta d_0 \quad \Delta a_1 \quad \Delta d_1 \quad \Delta b_\phi]' \tag{36}$$

$$\overset{19\times 5}{[H]} = \left[\begin{array}{ccc}
\frac{\partial \theta_1}{\partial a_0} \cdots & \frac{\partial \theta_1}{\partial d_1} & 0 \\
\vdots & \vdots & \vdots \\
\frac{\partial \theta_5}{\partial a_0} \cdots & \frac{\partial \theta_5}{\partial d_1} & 0 \\
\hdashline
\frac{\partial \phi_1}{\partial a_0} \cdots & \frac{\partial \phi_1}{\partial d_1} & 1 \\
\vdots & \vdots & \vdots \\
\frac{\partial \phi_8}{\partial a_0} \cdots & \frac{\partial \phi_8}{\partial d_1} & 1 \\
\hdashline
\frac{\partial \Psi_1}{\partial a_0} \cdots & \frac{\partial \Psi_1}{\partial d_1} & 0 \\
\vdots & \vdots & \vdots \\
\frac{\partial \Psi_6}{\partial a_0} \cdots & \frac{\partial \Psi_6}{\partial d_1} & 0
\end{array}\right] \tag{37}$$

$$\overset{19\times 19}{[W]} = \begin{bmatrix} W_{\theta 1} & & & & & & & & \\ & \ddots & & & & & & 0 & \\ & & W_{\theta 5} & & & & & & \\ & & & W_{\phi 1} & & & & & \\ & & & & \ddots & & & & \\ & & & & & W_{\phi 8} & & & \\ & 0 & & & & & W_{\Psi 1} & & \\ & & & & & & & \ddots & \\ & & & & & & & & W_{\Psi 6} \end{bmatrix} \tag{38}$$

$$\overset{19\times 1}{\underline{\rho}} = [\tilde{\theta}_1 - \theta_1 \cdots \tilde{\theta}_5 - \theta_5 \,\vdots\, \tilde{\phi}_1 - \phi_1 \cdots \tilde{\phi}_8 - \phi_8 \,\vdots\, \tilde{\Psi}_1 - \Psi_1 \cdots \tilde{\Psi}_6 - \Psi_6]' \tag{39}$$

The partials in (37) and computed angles θ, ϕ, Ψ in (39) are evaluated about the current state estimates $\hat{a}_0, \ldots, \hat{d}_1, \hat{b}_\phi$ at the iteration in question. Relevant equations are (2), (3), (11), and the linear version of (12), with t in (12) replaced by the appropriate measurement time from the set $t_{\theta 1}, \ldots, t_{\Psi 6}$.

4.4 Iterations and Convergence Criteria

Starting with an input state estimate $\hat{\underline{x}}_0$, (15) is implemented iteratively, with the estimate $\hat{\underline{x}}$ at each step replaced by $\hat{\underline{x}} + \Delta\underline{x}$ for the succeeding step. The process continues until the state corrections ($\Delta a_0, \ldots, \Delta d_1, \Delta b_\phi$ in the preceding example) are simultaneously less in absolute value than individually assigned input bounds. This defines convergence, and the updated state after addition of these final corrections is taken as the attitude (and bias) solution. The operation also ends if convergence has not occurred after a certain maximum number of iterations, which is assigned as an input parameters.

Because of the way in which a Ψ angle is defined (Section 2.2), a "boundary line" discontinuity exists at $\Psi = 0$ which can cause erroneously high residuals to occur near this point. For instance, if measured $\tilde{\Psi} = 1°$ and computed $\Psi = 359°$, then formally the residual is $\tilde{\Psi} - \Psi = 358°$, whereas actually a corrected residual of $+2°$ is desired. This condition is handled with proper logical control.

4.5 Data Rejection Procedures

Though the techniques used in GCONES and in DCCONS (graphics counterpart of GCONES) are similar, both will be described in this section for completeness.

4.5.1 Residual Editing Method of GCONES

Due to the variety and nature of sensors and types of data which can use this technique some method of screening input data for consistency is desirable. The following residual editing method has been incorporated to be exercised at user option.

The average angle residual for each type of data in both classes is calculated by

$$\rho_{AUG} = \frac{\sum_{i=1}^{n} |\rho_i|}{n} \qquad (40)$$

where n is the number of angles of the particular type.

Then these average angle residuals for all types are averaged to obtain an average residual for all data. The editing process continues by comparing the individual angle residuals to an input multiple of the computed average angle residual for all data. All angles whose residuals are higher than the specified multiple of the average have the associated weights set equal to 0.0 and are thus not considered in the remainder of the computations.

4.5.2 Residual Editing Method of DCCONS

The present writeup will use the symbol K to indicate any set of cone or dihedral angle data which contains at least one "useful" data point. The K notation will be convenient here because it eliminates the necessity of referring to the cone and dihedral angle data classes separately. Let M indicate the total number of such data sets. Then K = 1, 2 -- M. Let α_K indicate the "useful" data points in set K and let N_K be the total number of such points in set K. Then $\alpha_K = 1, 2,$ -- N_K. In the preliminary computations of its residual editing operation, DCCONS considers the "useful" data points to be those whose time is not flagged and (2) whose weight WGHT (K,α) is greater than or equal to zero.

Let RHO (K,α_K) be the residual of data point α_K. RHO (K,α_K) is defined to be

$$\text{RHO}\,(K,\alpha_K) = \text{GAMMA}\,(K,\alpha_K) - \text{THETA}\,(K,\alpha_K).$$

where GAMMA (K,α_K) and THETA (K,α_K) are the measured and estimated cone or dihedral angles respectively of point α_K.

The residual editing is performed in GSTAT1. The user specifies the residual editing option by setting IOC to 1. When the option is used, a quantity AVGRHO is computed for each data set. The AVGRHO of any data set which contains no useful points (i.e. no points whose times are not flagged) is set to zero. The AVGRHO's of the other sets (K) is computed by

$$\text{AVGRHO}\,(K) = \frac{1}{N_K} \sum_{\alpha_K = 1}^{N_K} \left|\text{RHO}\,(K,\alpha_K)\right| \tag{1}$$

The summation in Eq. (1), as well as N_K, includes all data points whose time is not flagged.

The next step in the current residual editing option of DCCONS is the computation of the numerical values of two quantities designated as SUMAV and AVG

$$\text{SUMAV} = \sum_{K \geqslant 1}^{M} \text{AVGRHO}\,(K) \tag{2}$$

$$\text{AVG} = \frac{1}{M} * \text{SUMAV} \tag{3}$$

The final step in the residual editing operation is to multiply by -1 the weights of all data points whose residual is greater in magnitude than ISMULT * AVG. All data points (including those whose weight previously was set negative) are checked. After the weight of a data point has once been set to less than zero, it can never be reset to a positive value. The weights of data points whose time is flagged are not necessarily set to less than zero by the residual editing operation; such points are eliminated from processing in COFSM by other logic.

4.6 Statistical Information

Many types of evaluative criteria can be associated with least squares differential correction processes. In order to keep the basic technique as simple as possible, however, the statistical parameters are confined to the following standard fundamental forms.

- Covariance matrix of errors in the converged state estimate. This is given by (see Reference 9)

$$[\Lambda] = \{[H]' \; [W] \; [H]\}^{-1} \tag{41}$$

  which is a direct by-product of the differential correction algorithm (15).

- Weighted mean of residuals for each data type in both Classes 1 and 2, given by (see Reference 13)

$$\bar{\rho} = \frac{\sum W_i \; \rho_i}{\sum W_i} \tag{42}$$

  Thus for the example of Section 4.3, the weighted means are

$$\bar{\rho}_\theta = \frac{\sum_{i=1}^{5} W_{\theta i} \; (\tilde{\theta}_i - \theta_i)}{\sum_{i=1}^{5} W_{\theta i}} \tag{43}$$

$$\bar{\rho}_\phi = \frac{\sum_{i=1}^{8} W_{\phi i} \; (\tilde{\phi}_i - \phi_i)}{\sum_{i=1}^{8} W_{\phi i}} \tag{44}$$

$$\bar{\rho}_\Psi = \frac{\sum_{i=1}^{6} W_{\Psi i} \, (\tilde{\Psi}_i - \Psi_i)}{\sum_{i=1}^{6} W_{\Psi i}} \tag{45}$$

- Weighted RMS (root-mean-square) of residuals for each data type in both Classes 1 and 2. Based on the material in Reference 13, this is defined in the program by

$$\sigma = \left[\frac{\sum W_i \, (\rho_i - \bar{\rho})^2}{\sum W_i} \right]^{1/2}$$
$$= \left(\frac{\sum W_i \, \rho_i^2}{\sum W_i} - \frac{2 \, \bar{\rho} \sum W_i \, \rho_i}{\sum W_i} + \frac{\bar{\rho}^2 \sum W_i}{\sum W_i} \right)^{1/2} \tag{46}$$

Using (42), Equation (46) becomes

$$\sigma = \left(\frac{\sum W_i \, \rho_i^2}{\sum W_i} - \bar{\rho}^2 \right)^{1/2} \tag{47}$$

For the example of Section 4.4,

$$\sigma_\theta = \left[\frac{\sum_{i=1}^{5} W_{\theta i} \, (\tilde{\theta}_i - \theta_i)^2}{\sum_{i=1}^{5} W_{= i}} - \bar{\rho}_\theta^2 \right] \tag{48}$$

where $\bar{\rho}_\theta$ is given by (43); and analogous expressions hold for σ_ϕ and σ_Ψ.

- Sum of weights ΣW_i for each data type in both Classes 1 and 2. When several different types of data are used, these sums give a general indication of the relative contribution of each data type to the final solution.

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APPENDIX A
GCONES

```
C.......................................................................
C.                                                                     .
C.   NAME: SUBROUTINE GCONES - GENERALIZED CONES                       .
C.                                                                     .
C.   AUTHOR: F. KNOOP, IBM                                             .
C.                                                                     .
C.   PURPOSE:                                                          .
C.                                                                     .
C.        THIS SUBROUTINE COMPUTES THE SPIN AXIS ATTITUDE OF A SPACE-   .
C.        CRAFT FROM SETS OF CONE ANGLES AND KNOWN AXES AND/OR SETS OF  .
C.        BE DETERMINED MAY, AT OPTION, BE THE COEFFICIENTS OF TIME DEP-.
C.        DIHEDRAL ANGLES AND KNOWN VECTORS.  THE SPIN AXIS ATTITUDE TO .
C.        ENDENT POLYNOMIALS IN ALPHA AND DELTA.  ANOTHER IMPORTANT     .
C.        FEATURE ALLOWS DETERMINATION OF CONSTANT BIASES IN THE CONE   .
C.        AND/OR DIHEDRAL ANGLES.  THE METHOD EMPLOYED IS ITERATIVE LIN-.
C.        EAR DIFFERENTIAL CORRECTION.                                  .
C.                                                                     .
C.   COMPUTER: S/360, CORE: 16K, COMPILER: FORTRAN-H                   .
C.                                                                     .
C.......................................................................
C.                                                                     .
C.   CALLING SEQUENCE EXPLANATION:                                     .
C.                                                                     .
C.        TZERO  - THE INPUT REFERENCE TIME FOR THE ALPHA AND DELTA     .
C.                 POLYNOMIALS, I.E.:                                   .
C.                 ALPHA(T)= A0 + A1*(T-TZERO) + A2*(T-TZERO)**2 + ...  .
C.                                                                     .
C.        ALP    - AN INPUT ARRAY CONTAINING THE INITIAL ESTIMATES OF   .
C.                 THE ALPHA COEFFICIENTS TO BE SOLVED FOR. ON RETURN   .
C.                 THIS ARRAY WILL CONTAIN THE FINAL VALUES DETERMINED  .
C.                 BY GCONES (UNITS OF DEGS, DEGS/TIME, DEGS/TIME**2,   .
C.                 ETC, WHERE THE UNIT OF TIME IS THE SAME AS FOR TIME1,.
C.                 TIME2, TZERO, DEL)                                   .
C.                                                                     .
C.        DEL    - SAME AS ALP BUT FOR DELTA COEFFICIENTS               .
C.                                                                     .
C.        ALPBND - AN INPUT ARRAY CONTAINING THE LOWER BOUNDS FOR CORR- .
C.                 ECTION TO THE ALPHA COEFFICIENTS.  CONVERGENCE OCCURS.
C.                 WHEN ALL CORRECTIONS ARE SIMULTANEOUSLY LESS THAN    .
C.                 THEIR CORRECTION BOUNDS                              .
C.                                                                     .
C.        DELBND - SAME AS ALPBND BUT FOR THE DELTA COEFFICIENTS        .
C.                                                                     .
C.        NCOF   - THE INPUT NUMBER OF COEFFICIENTS FOR ALPHA AND DELTA .
C.                 TO BE SOLVED FOR (MUST BE GE 1 AND LE 4)             .
C.                                                                     .
C.        MAXIT  - THE INPUT MAXIMUM NUMBER OF CORRECTION ITERATIONS TO .
C.                 BE PERFORMED                                         .
C.                                                                     .
C.        COEF   - AN OUTPUT ARRAY CONTAINING THE STATE COVARIANCE      .
C.                 AND CORRELATION ELEMENTS FOR THE FINAL SOLUTION.     .
C.                 CORRELATION ELEMENTS ARE IN THE UPPER TRIANGLE,      .
C.                 COVARIANCE ELEMENTS ARE IN THE LOWER TRIANGLE.       .
C.                 DIAGONAL ELEMENTS ARE COVARIANCE ELEMENTS.           .
C.
```

```
C.        IWRT    - THE INPUT LEVEL OF INFORMATIVE PRINTOUT DESIRED:       .
C.                     >= 1 - PRINTOUT ERROR MESSAGE IF PROCESS ABNORMAL-.
C.                            LY TERMINATES                                .
C.                     >= 2 - PRINTOUT ALL INPUT SCALERS AND INITIAL      .
C.                            STATE ESTIMATES AND BOUNDS                   .
C.                     >= 3 - PRINTOUT THE INPUT POINTER ARRAYS:           .
C.                            IFRST1, NTYPE1, IFRST2, NTYPE2               .
C.                     >= 4 - PRINTOUT FINAL STATE, COVARIANCE ELEMENTS   .
C.                            AND RESIDUALS AT END OF PROCESS              .
C.                     >= 6 - PRINTOUT SAME INFORMATION AS 4 ABOVE, BUT   .
C.                            AT THE END OF EACH ITERATION                 .
C.                     >= 8 - PRINTOUT ALL INPUT DATA ARRAYS               .
C.                     >=10 - PRINTOUT COEFFICIENTS OF MATRIX EQUATION    .
C.                            AT EACH ITERATION                            .
C.                     >=12 - PRINTOUT INTERMEDIATE VALUES DURING SUMMA-  .
C.                            TION STAGE OF EACH ITERATION                 .
C.                     >=14 - PRINTOUT ADDITIONAL INTERMEDIATE VALUES     .
C.                            DURING SUMMATION FOR DIHEDRAL ANGLE DATA    .
C.                                                                         .
C.        IOUT    - THE INPUT LOGICAL FORTRAN DEVICE NUMBER FOR SPECIFIED.
C.                  PRINTOUT (NORMALLY =6)                                 .
C.                                                                         .
C.        IRET    - RETURN INDICATOR:                                      .
C.                     = 0 - PROCESS CONVERGED                             .
C.                     = 1 - PROCESS TERMINATED DUE TO MAXIMUM ITERATIONS.
C.                           REACHED (MAXIT)                               .
C.                     = 2 - PROCESS DIVERGED, I.E. A CORRECTION ELEMENT .
C.                           EXCEEDED 360.0                                .
C.                     = 3 - A SINGULAR MATRIX WAS ENCOUNTERED - PROCESS .
C.                           COULD NOT CONTINUE                            .
C.                     = 4 - OVER 5 BIASES WERE SELECTED TO BE DETERMINED.
C.                     = 5 - NCOF IS OUTSIDE ALLOWABLE RANGE               .
C.                     = 6 - ALL DATA IS WEIGHTED 0.0                      .
C.                                                                         .
C.        ISMULT  - THE MULTIPLE OF THE AVERAGE RESIDUAL TO BE USED IN    .
C.                  RESIDUAL EDITTING                                      .
C.                                                                         .
C.        TIME1   - AN INPUT ARRAY CONTAINING THE OBSERVATION TIMES FOR   .
C.                  CLASS 1 DATA (UNITS MUST BE CONSISTENT WITH TIME2,    .
C.                  TZERO, ALP, DEL)                                       .
C.                                                                         .
C.        AXIS1   - A TWO DIMENSIONAL INPUT ARRAY - AXIS1(3,N) - CONTAIN-.
C.                  ING THE INERTIAL UNITIZED CONE AXIS VECTORS FOR CLASS.
C.                  1 DATA                                                 .
C.                                                                         .
C.        ANG1    - AN INPUT ARRAY CONTAINING THE CONE GENERATING ANGLES .
C.                  (IN DEGREES) IN THE RANGE 0-180 FOR CLASS 1 DATA      .
C.                                                                         .
C.        WGHT1   - AN INPUT ARRAY CONTAINING THE WEIGHTS TO BE APPLIED   .
C.                  TO THE OBSERVATIONS OF CLASS 1 DATA (NORMALLY THE     .
C.                  INVERSE VARIANCES IN DEGREES)                          .
C.                                                                         .
C.        IFRST1  - AN INPUT ARRAY OF POINTERS INDICATING THE START POSI-.
C.                  TIONS OF EACH TYPE OF CLASS 1 DATA WITHIN THE ARRAYS .
C.                  TIME1, AXIS1, ANG1, WGHT1. THUS THE FIRST ELEMENT OF .
C.                  IFRST1 IS THE INDEX NUMBER OF THE FIRST OBSERVATION   .
C.                  OF THE FIRST TYPE OF CLASS 1 DATA WITHIN THE ARRAYS   .
C.                  TIME1,..., WGHT1. THE SECOND ELEMENT OF IFRST1 IS     .
C.                  THE INDEX NUMBER OF THE FIRST OBSERVATION OF THE SEC-.
C.                  OND TYPE OF CLASS 1 DATA WITHIN THE ARRAYS TIME1,....,.
C.                  WGHT1. ETC.                                            .
```

```
C.                                                                          .
C.        NTYPE1 - AN INPUT ARRAY CONTAINING OBSERVATION COUNTS, ONE FOR.
C.                 EACH TYPE OF CLASS 1 DATA (=NCLAS1). THE VALUE OF       .
C.                 EACH ELEMENT IS THE NUMBER OF OBSERVATIONS OF THAT      .
C.                 TYPE IN THE DATA ARRAYS TIME1, AXIS1, ANG1, WGHT1       .
C.                                                                          .
C.        BIAS1  - AN INPUT ARRAY CONTAINING INITIAL ESTIMATES OF BIAS     .
C.                 IN DEGREES, ONE FOR EACH TYPE OF CLASS 1 DATA           .
C.                 (=NCLAS1). IF THE VALUE OF AN ELEMENT IS =9999999.,     .
C.                 BIAS IS NOT DETERMINED FOR THAT TYPE. IF IT IS NOT      .
C.                 =9999999., BIAS IS DETERMINED AND THE FINAL DETERMIN-.
C.                 ED VALUE IS RETURNED IN THE SAME ELEMENT.  NO MORE      .
C.                 THAN 5 BIASES IN TOTAL FROM CLASS 1 DATA AND CLASS 2 .
C.                 DATA MAY BE DETERMINED                                   .
C.                                                                          .
C.        BBND1  - AN INPUT ARRAY CONTAINING THE LOWER BOUNDS IN DEGREES.
C.                 FOR CORRECTION TO THE ASSOCIATED BIAS ELEMENTS FOR      .
C.                 EACH TYPE OF CLASS 1 DATA (=NCLAS1). IF THE ASSOC-      .
C.                 IATED BIAS ELEMENT =9999999.0, THE BBND1 ELEMENT IS     .
C.                 NOT USED                                                 .
C.                                                                          .
C.        RHOST1 - A TWO DIMENSIONAL OUTPUT ARRAY - RHOST1(3,N) - IN       .
C.                 WHICH FINAL RESIDUAL STATISTICS FOR EACH DATA TYPE      .
C.                 ARE RETURNED:                                            .
C.                 (1,N) = WEIGHTED SUM OF ANGLE RESIDUALS                  .
C.                 (2,N) = WEIGHTED SUM OF SQUARES OF ANGLE RESIDUALS      .
C.                 (3,N) = SUM OF WEIGHTS                                   .
C.                                                                          .
C.        NCLAS1 - THE NUMBER OF TYPES OF CLASS 1 DATA IN THE ARRAYS       .
C.                 TIME1, AXIS1, ANG1, WGHT1, IFRST1, NTYPE1, BIAS1,       .
C.                 BBND1, RHOST1                                            .
C.                                                                          .
C.        RHO1   - AN OUTPUT ARRAY CONTAINING THE ANGLE RESIDUALS FOR      .
C.                 ALL TYPES OF CLASS 1 DATA                                .
C.                                                                          .
C.        RESID1 - AN OUTPUT ARRAY CONTAINING THE MEAN RESIDUAL FOR        .
C.                 EACH TYPE OF CLASS 1 DATA                                .
C.                                                                          .
C.        STDV1  - AN OUTPUT ARRAY CONTAINING THE STANDARD DEVIATION       .
C.                 FOR EACH TYPE OF CLASS 1 DATA                            .
C.                                                                          .
C.                                                                          .
C.        TIME2  - SAME AS TIME1 BUT FOR CLASS 2 DATA                       .
C.                                                                          .
C.        AXIS2  - A TWO DIMENSIONAL INPUT ARRAY - AXIS2(6,N) - CONTAIN-.
C.                 ING THE TWO ORDERED, UNITIZED VECTORS FOR EACH DIHED-.
C.                 RAL ANGLE OBSERVATION; I.E. THE FIRST VECTOR IS IN      .
C.                 (1,N),(2,N),(3,N) AND THE SECOND VECTOR IS IN (4,N),   .
C.                 (5,N),(6,N)                                              .
C.                                                                          .
C.        ANG2   - AN INPUT ARRAY CONTAINING THE DIHEDRAL ANGLES (IN       .
C.                 DEGREES) IN THE RANGE 0-360 FOR CLASS 2 DATA            .
C.                                                                          .
C.        WGHT2  - SAME AS WGHT1 BUT FOR CLASS 2 DATA                       .
C.                                                                          .
C.        IFRST2 - SAME AS IFRST1 BUT FOR CLASS 2 DATA                      .
C.                                                                          .
C.        NTYPE2 - SAME AS NTYPE1 BUT FOR CLASS 2 DATA                      .
C.                                                                          .
C.        BIAS2  - SAME AS BIAS1 BUT FOR CLASS 2 DATA                       .
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C.                                                                    *
C.       BBND2  - SAME AS BBND1 BUT FOR CLASS 2 DATA                  *
C.                                                                    *
C.       RHOST2 - SAME AS RHOST1 BUT FOR CLASS 2 DATA                 *
C.                                                                    *
C.       NCLAS2 - SAME AS NCLAS1 BUT FOR CLASS 2 DATA                 *
C.                                                                    *
C.       RHO2   - SAME AS RHO1 BUT FOR CLASS 2 DATA                   *
C.                                                                    *
C.       RESID2 - SAME AS RESID1 BUT FOR CLASS 2 DATA                 *
C.                                                                    *
C.       STDV2  - SAME AS STDV1 BUT FOR CLASS 2 DATA                  *
C.                                                                    *
C.       TRESID - COMBINED TOTAL MEAN RESIDUAL (DEGREES)              *
C.                                                                    *
C.       TSTDV  - COMBINED TOTAL STANDARD DEVIATION (DEGREES)         *
C.                                                                    *
C.*********************************************************************
C.                                                                    *
C.    OPTIONS:                                                        *
C.                                                                    *
C.       A. DYNAMIC ATTITUDE MAY BE SPECIFIED WHERE ALPHA AND DELTA ARE.
C.          TIME DEPENDENT POLYNOMIALS (UP TO 3RD DEGREE) AND THE     *
C.          COEFFICIENTS ARE SOLVED FOR AS THE STATE VARIABLES.  WHEN *
C.          USING THIS OPTION, THE ALP AND DEL ARRAYS REPRESENT THE   *
C.          COEFFICIENTS: A0,A1,A2,A3, D0,D1,D2,D3, RESPECTIVELY, OF  *
C.          THE FOLLOWING EXPRESSIONS:                                *
C.                                                                    *
C.             A(T) = A0 + A1*(T-TZERO) + A2*(T-TZERO)**2 +           *
C.                    A3*(T-TZERO)**3                                 *
C.             D(T) = D0 + D1*(T-TZERO) + D2*(T-TZERO)**2 +           *
C.                    D3*(T-TZERO)**3                                 *
C.                                                                    *
C.       B. EACH CLASS OF DATA, CLASS 1 - CONE ANGLE AND CLASS 2 -    *
C.          DIHEDRAL ANGLE, MAY EACH BE COMPOSED OF ANY NUMBER OF     *
C.          TYPES OF DATA, I.E. NCLAS1 AND NCLAS2 MAY BE ANY NON-NEG- *
C.          ATIVE NUMBERS JUST SO LONG AS THERE ARE NCLAS1 ENTRIES IN *
C.          THE IFRST1 AND NTYPE1 ARRAYS AND NCLAS2 ENTRIES IN THE    *
C.          IFRST2 AND NTYPE2 ARRAYS                                  *
C.                                                                    *
C.       C. WITHIN THE INPUT DATA ARRAYS, UNDESIRED OBSERVATIONS CAN  *
C.          BE FLAGGED BY SETTING THE OBSERVATION TIME =9999999.      *
C.          SUCH OBSERVATIONS WILL BE COMPLETELY IGNORED              *
C.                                                                    *
C.       D. UP TO 5 CONE AND/OR DIHEDRAL ANGLE BIASES MAY BE SOLVED   *
C.          FOR IN ANY COMBINATION WITHIN THE VARIOUS DATA TYPES AND  *
C.          CLASSES                                                   *
C.                                                                    *
C.       E. ANY NUMBER OF DATA OBSERVATIONS MAY BE PRESENT WITHIN ANY *
C.          TYPE OF DATA AND ANY NUMBER OF TYPES MAY BE SPECIFIED     *
C.          WITHIN EITHER CLASS                                       *
C.                                                                    *
C.       F. A FULL RANGE OF INFORMATIVE PRINTOUTS MAY BE SPECIFIED    *
C.          BY THE INPUT PARAMETER IWRT                               *
C.                                                                    *
C.*********************************************************************
C.                                                                    *
C.    RESTRICTIONS:                                                   *
C.                                                                    *
C.       A. NCOF MUST BE GREATER THAN OR EQUAL TO 1 AND LESS THAN OR  *
C.          EQUAL TO 4                                                *
```

```
C.                                                                     .
C.       B. COEF MUST BE DIMENSIONED LARGE ENOUGH TO CONTAIN ALL       .
C.          COVARIANCE AND CORRELATION ELEMENTS. IT SHOULD BE          .
C.          DIMENSIONED COEF(N,N) WHERE N = 2*NCOF + NUMBER OF BIASES  .
C.          TO BE DETERMINED                                           .
C.                                                                     .
C.       C. AXIS1 AND AXIS2 MUST CONTAIN THE INERTIAL COORDINATES OF   .
C.          UNITIZED VECTORS                                           .
C.                                                                     .
C.       D. THE ANGLES IN THE ANG2 ARRAY MUST BE RANGED FROM 0 TO 360  .
C.          DEGREES                                                    .
C.                                                                     .
C.       E. THE VECTOR PAIRS IN THE AXIS2 ARRAY MUST BE ORDERED, I.E.  .
C.          THE DIHEDRAL ANGLE IS MEASURED FROM THE PROJECTION OF THE  .
C.          FIRST VECTOR ONTO A PLANE NORMAL TO THE SPIN AXIS, AROUND  .
C.          TO THE PROJECTION OF THE SECOND VECTOR ONTO THIS PLANE,    .
C.          POSITIVE IN THE SENSE OF POSITIVE ROTATION ABOUT THE SPIN  .
C.          AXIS                                                       .
C.                                                                     .
C.       F. THE UNITS OF TIME IN THE INPUT QUANTITIES TIME1, TIME2,    .
C.          TZERO, ALP, DEL MAY BE ARBITRARY BUT MUST BE CONSISTENT    .
C.          (THE SAME).  THE UNITS SHOULD, HOWEVER, BE SELECTED SO THAT.
C.          THE MAXIMUM EXPECTED STATE CORRECTIONS NEVER EXCEED 360.0, .
C.          WHICH IS DEFINED AS DIVERGENCE                             .
C.                                                                     .
C.       G. DIHEDRAL ANGLE (CLASS 2) OBSERVATIONS WHICH DIFFER FROM THE.
C.          COMPUTED DIHEDRAL ANGLE BASED ON THE CURRENT STATE BY MORE .
C.          THAN 90.0 DEGREES WILL BE IGNORED (WEIGHTED TO ZERO) FOR   .
C.          THAT ITERATION                                             .
C.                                                                     .
C.......................................................................
C.                                                                     .
C.    SUBROUTINES CALLED:                                              .
C.                                                                     .
C.       A. COFSUM - COEFFICIENT SUMMATION. THIS IS A SPECIALIZED ROUT-.
C.                   INE USED ONLY BY GCONES TO COMPUTE AND SUM THE    .
C.                   ELEMENTS OF THE MATRIX TO BE INVERTED FOR EACH    .
C.                   ITERATION.                                        .
C.                                                                     .
C.       B. MINV   - MATRIX INVERSION. THIS IS AN IBM ROUTINE FROM THE .
C.                   SCIENTIFIC SUBROUTINE PACKAGE (SSP)               .
C.                                                                     .
C.......................................................................
C.                                                                     .
C.    INPUT/OUTPUT DATA SETS                                           .
C.                                                                     .
C.       A. READ ONLY - NONE                                           .
C.                                                                     .
C.       B. READ AND WRITE - NONE                                      .
C.                                                                     .
C.       C. WRITE ONLY - FTXXF001 (XX IS SPECIFIED BY IOUT) CONTAINS   .
C.                         INFORMATIVE PRINTOUT SPECIFIED BY IWRT      .
C.                                                                     .
C.......................................................................
C.                                                                     .
C.    REMARKS:                                                         .
C.                                                                     .
C.       A. IF ONLY ONE CLASS OF DATA IS TO BE INPUT, THE ARGUMENTS    .
C.          FOR THE UNUSED CLASS MAY BE UNDIMENSIONED DUMMY VARIABLES  .
C.          JUST SO LONG AS NCLAS1 (OR NCLAS2) IS SET TO 0             .
```

```
C.                                                                      .
C.       B. IF BIAS IS NOT TO BE DETERMINED FOR A CERTAIN TYPE OF DATA,.
C.          THE ASSOCIATED VALUE IN THE BIAS1 OR BIAS2 ARRAY SHOULD BE .
C.          EQUAL TO 999999.                                            .
C.                                                                      .
C.       C. THE QUANTITIES RETURNED IN THE RHOST1 AND RHOST2 ARRAYS     .
C.          MAY BE USED TO COMPUTE THE MEAN DEVIATION AND STANDARD      .
C.          DEVIATION OF FIT FOR EACH TYPE OF DATA                      .
C.                                                                      .
C.       D. CONVERGENCE IS REACHED ONLY WHEN ALL STATE VARIABLE CORR-   .
C.          ECTIONS ARE SIMULTANEOUSLY LESS THAN THEIR CORRESPONDING    .
C.          BOUNDS, INCLUDING BIAS ELEMENTS                             .
C.                                                                      .
C.       E. IF DATA OBSERVATIONS ARE SCREENED PRIOR TO INPUT TO GCONES,.
C.          UNWANTED OBSERVATIONS MAY BE FLAGGED BY SETTING THE ASSOC- .
C.          IATED TIME =9999999.                                        .
C.                                                                      .
C.       F. THE ALP AND DEL ARRAYS CONTAIN COEFFICIENTS OF POLYNOMIALS .
C.          AND ARE NOT, STRICTLY SPEAKING, ACCELERATION AND JERK (RATE.
C.          OF CHANGE OF ACCELERATION) AS THEY ARE FOR SOME OTHER      .
C.          MODELS                                                      .
C.                                                                      .
C.......................................................................
C.                                                                      .
C.   REFERENCES:                                                        .
C.                                                                      .
C.       A. L.B. SCHLEGEL, "CONES: AN ITERATIVE DIFFERENTIAL CORRECTION.
C.          TECHNIQUE FOR ATTITUDE DETERMINATION OF A SPINNING SATEL-  .
C.          LITE", IBM FSC REPORT, CONTRACT NAS 5-10022, MAY 1967      .
C.                                                                      .
C.       B. "SURVEY AND EVALUATION OF ATTITUDE DETERMINATION TECHNI-   .
C.          QUES", IBM FSC REPORT TR-68-8, CONTRACT NAS 5-10022, MAY   .
C.          1968, PP. 4-14 TO 4-24                                      .
C.                                                                      .
C.       C. "RADIO ASTRONOMY EXPLORER ATTITUDE DETERMINATION SYSTEM    .
C.          (RAEADS), VOL III, SPIN AXIS ATTITUDE DETERMINATION PROGRAM.
C.          -CYCON", IBM FSC REPORT, CONTRACT NAS 5-10022, MARCH 1969  .
C.                                                                      .
C.       D. "SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE, VERSION II,     .
C.          PROGRAMMER'S MANUAL", IBM FORM NO. H20-0205-2              .
C.                                                                      .
C.......................................................................
C.                                                                      .
C.   REVISIONS:                                                         .
C.                                                                      .
C.       A. F. KNOOP (01 AUG 1969) - ORIGINAL CODING AND TESTING       .
C.                                                                      .
C.       B. F. KNOOP (20 JAN 1970) - MODIFICATION TO CHECK FOR DIVERG- .
C.          ENCE TO PREVENT IHC254I ERRORS DUE TO ABSURDLY LARGE CORR- .
C.          ECTION ELEMENTS                                             .
C.                                                                      .
C.       C. F. KNOOP (20 JAN 1970) - REORDERING OF ERROR RETURN CODES  .
C.          INTO ORDER OF SEVERITY                                      .
C.                                                                      .
C.       D. F. KNOOP (20 FEB 1970) - COMPLETE REVISION TO INCLUDE      .
C.          DIHEDRAL ANGLE DATA                                         .
C.                                                                      .
C.       E. A. GEELHAAR (15 SEPT 1972) - ADDITION OF SIGMA REJECTION   .
C.          CAPABILITY AND REVISION OF CALLING SEQUENCE                .
C.......................................................................
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```
C
      SUBROUTINE CCONES (TZERO, ALP, DEL, ALPBND, DELBND, NCOF, MAXIT,
     /      COEF,IWRT,IOUT,IRET,ISMULT,
     /      TIME1, AXIS1, ANG1, WGHT1, IFRST1, NTYPE1, BIAS1, BBND1,
     /      RHOST1,NCLAS1,RHO1,RESID1,STDV1,
     /      TIME2, AXIS2, ANG2, WGHT2, IFRST2, NTYPE2, BIAS2, BBND2,
     /      RHOST2,NCLAS2,RHO2,RESID2,STDV2,TRESID,TSTDV)
C
C
      DIMENSION ALP(4), DEL(4), ALPBND(4), DELBND(4), COVAR(91)
C ***** DIMENSIONS EQUAL TO 5 OR 500 IN THE FOLLOWING LIST ARE NOT
C ***** RESTRICTIVE, BUT ARE MEANT ONLY TO BE SUGGESTIVE OF THE STRUC-
C ***** TURE OF THE ARRAYS
      DIMENSION TIME1(500), AXIS1(3,500), ANG1(500), WGHT1(500),
     /          IFRST1(5), NTYPE1(5), BIAS1(5), BBND1(5), RHOST1(3,5)
      DIMENSION TIME2(500), AXIS2(6,500), ANG2(500), WGHT2(500),
     /          IFRST2(5), NTYPE2(5), BIAS2(5), BBND2(5), RHOST2(3,5)
C ***** INTERNALLY ALLOCATED SPECIFICATIONS
      DIMENSION ALPR(4), DELR(4), COEF(13,13), CHNG(13), DRHOSQ(13),
     /      RHO1(500),RHO2(500),STDV1(5),RESID1(5),STDV2(5),RESID2(5),
     /          STOR1(13),STOR2(13),CCF(169),AVGRHO(2,5),NAME(2,13)
      DATA RTOD,XBIAS / 57.29578,9999999./
      DATA NAME/' ALP','HA 1',' DEL','TA 1',' ALP','HA 2',' DEL',
     /  'TA 2',' ALP','HA 3',' DEL','TA 3',' ALP','HA 4',' DEL',
     / 'TA 4','  BI','AS 1','  BI','AS 2','  BI','AS 3','  BI','AS 4',
     / '  BI','AS 5'/
C
C
C ***** PRINTOUT AT OPTION ALL THE INPUT VARIABLES AND DATA ARRAYS
C
      IF(IWRT.LT.2) GO TO 100
C ***** WRITE HEADER LINE AND ALL INPUT NON-ARRAY ITEMS
      WRITE (IOUT,8000) NCLAS1, NCLAS2, TZERO, NCOF, MAXIT, IWRT, IOUT
C ***** WRITE INITIAL ATTITUDE COEFFICIENTS AND CORRECTION BOUNDS
      WRITE (IOUT,8010) (ALP(I), ALPBND(I), DEL(I), DELBND(I),I=1,NCOF)
C ***** WRITE INITIAL BIAS ESTIMATES AND CORRECTION BOUNDS
      IF(NCLAS1.LE.0) GO TO 30
      ITITLE = 1
      DO 20 I = 1,NCLAS1
      IF(BIAS1(I).EQ.XBIAS) GO TO 20
      IF(ITITLE.EQ.1) WRITE (IOUT,8020)
      ITITLE = 2
      WRITE (IOUT,8040) I, BIAS1(I), BBND1(I)
   20 CONTINUE
   30 CONTINUE
      IF(NCLAS2.LE.0) GO TO 60
      ITITLE = 1
      DO 50 I = 1,NCLAS2
      IF(BIAS2(I).EQ.XBIAS) GO TO 50
      IF(ITITLE.EQ.1) WRITE (IOUT,8030)
      ITITLE = 2
      WRITE (IOUT,8040) I, BIAS2(I), BBND2(I)
   50 CONTINUE
   60 CONTINUE
      IF(IWRT.LT.3) GO TO 100
      IF(NCLAS1.LE.0) GO TO 80
      DO 70 I = 1,NCLAS1
      J1 = IFRST1(I)
      N = NTYPE1(I)
      J2 = J1 + N - 1
      WRITE (IOUT,8050) I, N, J1, J2
      IF(IWRT.GE.8 .AND. N.GT.0) WRITE (IOUT,8070) (J, TIME1(J),
     /      (AXIS1(K,J),K=1,3), ANG1(J), WGHT1(J), J=J1,J2)
   70 CONTINUE
   80 CONTINUE
      IF(NCLAS2.LE.0) GO TO 100
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      DO 90 I = 1,NCLAS2
      J1 = IFRST2(I)
      N = NTYPE2(I)
      J2 = J1 + N - 1
      WRITE (IOUT,8060) I, N, J1, J2
      IF(IWRT.GE.8 .AND. N.GT.0) WRITE (IOUT,8080) (J, TIME2(J),
     /      (AXIS2(K,J),K=1,6), ANG2(J), WGHT2(J), J=J1,J2)
   90 CONTINUE
  100 CONTINUE
C ***** COMPUTE THE NUMBER OF ANGLE BIASES TO BE DETERMINED
      NBIAS = 0
      IF(NCLAS1.LE.0) GO TO 120
      DO 110 I = 1,NCLAS1
      IF(BIAS1(I).NE.XBIAS) NBIAS = NBIAS + 1
  110 CONTINUE
  120 CONTINUE
      IF(NCLAS2.LE.0) GO TO 140
      DO 130 I = 1,NCLAS2
      IF(BIAS2(I).NE.XBIAS) NBIAS = NBIAS + 1
  130 CONTINUE
  140 CONTINUE
C ***** CHECK FOR INVALID INPUT
      IF(NCOF.LT.1 .OR. NCOF.GT.4) GO TO 7000
      IF(NBIAS.GT.5) GO TO 7010
C ***** COMPUTE SOME CONSTANTS FOR THE SUMMATION
      N2 = NCOF + NCOF
      N3 = N2 + NBIAS
      N4 = N2 + 1
      N5 = N3 + 1
      IB1 = 9
      IB2 = IB1 + NBIAS - 1
      DO 150 J=1,N3
      CHNG(J)=0.0
  150 CONTINUE
C ***** INITIALIZE ITERATION COUNTER
      ISTEP = 0
C ***** INITIALIZE TERMINATION CONTROL
      ISTOP = 0
C
C ***** BEGIN PROCESSING FOR THIS ITERATION
C
  200 CONTINUE
      ISTEP = ISTEP + 1
C ***** CONVERT ATTITUDE COEFFICIENTS TO RADIANS
      DO 210 I = 1,NCOF
      ALPR(I) = ALP(I)/RTOD
      DELR(I) = DEL(I)/RTOD
  210 CONTINUE
C ***** ZERO OUT MATRIX OF COEFFICIENTS
      DO 230 I =1,N3
      DO 220 J =1,N3
      COEF(J,I) = 0.0
  220 CONTINUE
      DRHOSQ(I) = 0.0
  230 CONTINUE
      IBIAS = N2
C
C ***** BEGIN LOOP TO MAKE ALL SUMMATIONS FOR CLASS 1 DATA (CONE ANGLES)
C
      IF(NCLAS1.LE.0) GO TO 300
      DO 290 I = 1,NCLAS1
      J1 = IFRST1(I)
      N = NTYPE1(I)
C ***** ZERO OUT RESIDUAL SUMMATION VARIABLES
      RHOST1(1,I) = 0.0
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      RHOST1(2,I) = 0.0
      RHOST1(3,I) = 0.0
      IF(N.LE.0) GO TO 290
      IF(BIAS1(I).NE.XBIAS) IBIAS = IBIAS + 1
C ***** CALL COFSUM TO COMPUTE AND SUM COEFFICIENTS FOR THIS TYPE OF
C ***** CLASS 1 DATA
C...........................................................................
      CALL COFSUM (TIME1(J1), AXIS1(1,J1), ANG1(J1), WGHT1(J1), N, 1, 3,
     /             ALPR, DELR, BIAS1(I), IBIAS, NCOF, TZERO, IWRT, IOUT,
     /             COEF,CRHOSQ,RHOST1(1,I),AVGRHO(1,I),RHO1(J1))
C...........................................................................
  290 CONTINUE
  300 CONTINUE
C
C ***** BEGIN LOOP TO MAKE ALL SUMMATIONS FOR CLASS 2 DATA (DHED ANGLES)
C
      IF(NCLAS2.LE.0) GO TO 400
      DO 390 I = 1,NCLAS2
      J1 = IFRST2(I)
      N = NTYPE2(I)
C ***** ZERO OUT RESIDUAL SUMMATION VARIABLES
      RHOST2(1,I) = 0.0
      RHOST2(2,I) = 0.0
      RHOST2(3,I) = 0.0
      IF(N.LE.0) GO TO 390
      IF(BIAS2(I).NE.XBIAS) IBIAS = IBIAS + 1
C ***** CALL COFSUM TO COMPUTE AND SUM COEFFICIENTS FOR THIS TYPE OF
C ***** CLASS 2 DATA
C...........................................................................
      CALL COFSUM (TIME2(J1), AXIS2(1,J1), ANG2(J1), WGHT2(J1), N, 2, 6,
     /             ALPR, DELR, BIAS2(I), IBIAS, NCOF, TZERO, IWRT, IOUT,
     /             COEF,CRHOSQ,RHOST2(1,I),AVGRHO(2,I),RHO2(J1))
C...........................................................................
  390 CONTINUE
  400 CONTINUE
C ***** COFSMS COMPUTES ONLY DIAGONAL AND UPPER RIGHT OFF-DIAGONAL
C ***** ELEMENTS OF THE COEFFICIENT MATRIX BECAUSE IT IS A SYMMETRIC
C ***** MATRIX
C ***** COMPLETE LOWER LEFT OFF-DIAGONAL ELEMENTS OF SYMMETRIC MATRIX
      DO 480 I = 2,N3
      N = I - 1
      DO 480 J = 1,N
      COEF(I,J) = COEF(J,I)
  480 CONTINUE
      IF(IWRT.LT.10) GO TO 540
C ***** WRITE COEFFICIENTS OF SIMULTANEOUS EQUATIONS
      WRITE (IOUT,8100)
      DO 520 I = 1,N3
      WRITE (IOUT,8120) (COEF(I,J), J=1,N3), CRHOSQ(I)
  520 CONTINUE
  540 CONTINUE
C ***** RESTRUCTURE COEF MATRIX TO FORMAT EXPECTED BY IBM SSP - MINV
      K = 0
      DO 545 I = 1,N3
      DO 545 J = 1,N3
      K = K + 1
      COF(K)=COEF(J,I)
  545 CONTINUE
C ***** CALL IBM SSP ROUTINE MINV TO INVERT COEF MATRIX
C...........................................................................
      CALL MINV(COF,N3,DET,STOR1,STOR2)
C...........................................................................
      IF(DET.EQ.0.0) GO TO 7020
C ***** CALCULATE CORRELATION MATRIX, COMBINE WITH COVARIANCE MATRIX
      K=0
      DO 550 I=1,N3
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      DO 550 J=1,N3
      K=K+1
  550 COEF(J,I)=COF(K)
      N3M1=N3-1
      DO 555 I=1,N3M1
      II=I+1
      DO 555 J=II,N3
      T=COEF(I,I)*COEF(J,J)
      IF(T.LE.0.0)  GO TO 554
      COEF(I,J)=COEF(I,J)/SQRT(T)
      GO TO 555
  554 COEF(I,J)=999.
  555 CONTINUE
C ***** MULTIPLY COVARIANCE MATRIX BY VECTOR OF RHO
C ***** SQUARED DERIVATIVES TO OBTAIN ATTITUDE STATE CORRECTIONS
      K = 0
      DO 560 I = 1,N3
      CHNG(I) = 0.0
      DO 560 J = 1,N3
      K = K+1
      CHNG(I)=CHNG(I)+COF(K)*DRHOSQ(J)
  560 CONTINUE
      IF(ISTOP.NE.0) GO TO 610
C ***** SET INDICATOR TO 'CONVERGED'
      IRET = 0
      DO 600 I = 1,NCOF
C ***** CHECK FOR NON-CONVERGENCE
      IF(ABS(CHNG(2*I-1)).GT.ALPBND(I)) IRET = 1
      IF(ABS(CHNG(2*I))   .GT.DELBND(I)) IRET = 1
C ***** CHECK FOR DIVERGENCE
      IF(ABS(CHNG(2*I-1)).GT.360.0) GO TO 7030
      IF(ABS(CHNG(2*I))   .GT.360.0) GO TO 7030
  600 CONTINUE
C ***** CHECK FOR DIVERGENCE OR CONVERGENCE OF BIAS ELEMENTS
      IF(NBIAS.LE.0) GO TO 608
      K = N2
      IF(NCLAS1.LE.0) GO TO 604
      DO 602 I = 1,NCLAS1
      IF(BIAS1(I).EQ.XBIAS) GO TO 602
      K = K + 1
      IF(ABS(CHNG(K)).GT.BBND1(I)) IRET = 1
      IF(ABS(CHNG(K)).GT.360.0) GO TO 7030
  602 CONTINUE
  604 CONTINUE
      IF(NCLAS2.LE.0) GO TO 608
      DO 606 I = 1,NCLAS2
      IF(BIAS2(I).EQ.XBIAS) GO TO 606
      K = K + 1
      IF(ABS(CHNG(K)).GT.BBND2(I)) IRET = 1
      IF(ABS(CHNG(K)).GT.360.0) GO TO 7030
  606 CONTINUE
  608 CONTINUE
  610 CONTINUE
      IX=0
      IF(IWRT.LT.4.OR.(IWRT.LT.6.AND.ISTOP.EQ.0)) IX=1
      IF(IX.NE.0)  GO TO 625
C ***** WRITE COMBINED COVARIANCE - CORRELATION MATRIX
      IF(NBIAS.LE.0) WRITE (IOUT,8250) (NAME(1,I), NAME(2,I), I=1,N2)
      IF(NBIAS.GT.0) WRITE (IOUT,8250) (NAME(1,I), NAME(2,I), I=1,N2),
     /                      (NAME(1,I), NAME(2,I), I=IB1,IB2)
      DO 620 I = 1,N3
      II = I
      IF(I.GT.N2) II = I - N2 + 8
      WRITE(IOUT,8260) NAME(1,II),NAME(2,II),(COEF(J,I),J=1,N3)
  620 CONTINUE
C
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C ***** COMPUTE AND PRINTOUT STATISTICS OF RESIDUALS
C
C ***** STATISTICS FOR CLASS 1 TYPES
  625 WT1=0.0
      STA1 = 0.0
      STB1 = 0.0
      IF(NCLAS1.LE.0) GO TO 640
      ITITLE = 1
      DO 630 I = 1,NCLAS1
      RESID1(I)=0.0
      STDV1(I)=0.0
      W = RHOST1(3,I)
      IF(W.LE.0.0) GO TO 630
      S1 = RHOST1(1,I)/W
      S2=SQRT(AMAX1(0.,RHOST1(2,I)/W-S1*S1))
      IF(IX.EQ.0.AND.ITITLE.EQ.1) WRITE(IOUT,8270)
      RESID1(I)=S1
      STDV1(I)=S2
      ITITLE = 2
      IF(IX.EQ.0)  WRITE(IOUT,8290) I,S1,S2,W
      WT1 = WT1 + W
      STA1 = STA1 + RHOST1(1,I)
      STB1 = STB1 + RHOST1(2,I)
  630 CONTINUE
      IF(WT1.LE.0.0) GO TO 640
      S1 = STA1/WT1
      S2=SQRT(AMAX1(0.,STB1/WT1-S1*S1))
      IF(IX.EQ.0) WRITE(IOUT,8295)  S1,S2,WT1
  640 CONTINUE
C ***** STATISTICS FOR CLASS 2 TYPES
      WT2 = 0.0
      STA2 = 0.0
      STB2 = 0.0
      IF(NCLAS2.LE.0) GO TO 658
      ITITLE = 1
      DO 650 I = 1,NCLAS2
      RESID2(I)=0.0
      STDV2(I)=0.0
      W = RHOST2(3,I)
      IF(W.LE.0.0) GO TO 650
      S1 = RHOST2(1,I)/W
      S2=SQRT(AMAX1(0.,RHOST2(2,I)/W-S1*S1))
      IF(IX.EQ.0.AND.ITITLE.EQ.1) WRITE(IOUT,8280)
      RESID2(I)=S1
      STDV2(I)=S2
      ITITLE = 2
      IF(IX.EQ.0)  WRITE(IOUT,8290) I,S1,S2,W
      WT2 = WT2 + W
      STA2 = STA2 + RHOST2(1,I)
      STB2 = STB2 + RHOST2(2,I)
  650 CONTINUE
      IF(WT2.LE.0.0)  GO TO 658
      S1 = STA2/WT2
      S2=SQRT(AMAX1(0.,STB2/WT2-S1*S1))
      IF(IX.EQ.0) WRITE(IOUT,8295) S1,S2,WT2
  658 CONTINUE
C ***** COMBINED TOTAL STATISTICS
      TRESID=0.0
      TSTDV=0.0
      W = WT1 + WT2
      IF(W.EQ.0.0)  GO TO 7040
      S1 = (STA1+STA2)/W
      S2=SQRT(AMAX1(0.,(STB1+STB2)/W-S1*S1))
      IF(IX.EQ.0) WRITE(IOUT,8298) S1,S2
      TRESID=S1
      TSTDV=S2
```

```
  660 CONTINUE
C ***** IF PROCESS HAS ENDED JUMP OUT OF CORRECTION LOOP
      IF(ISTOP.NE.0)  GO TO 7500
C ***** CHECK IF PROCESS SHOULD TERMINATE NEXT TIME
      IF(IRET.EQ.0 .OR. ISTEP.GE.MAXIT) ISTOP = 1
C ***** UPDATE ATTITUDE STATE
      DO 700 I = 1,NOOF
      ALP(I) = ALP(I) + CHNG(2*I-1)
      DEL(I) = DEL(I) + CHNG(2*I)
  700 CONTINUE
      IF(NBIAS.LE.0) GO TO 708
      K = N2
      IF(NCLAS1.LE.0) GO TO 704
      DO 702 I = 1,NCLAS1
      IF(BIAS1(I).EQ.XBIAS) GO TO 702
      K = K + 1
      BIAS1(I) = BIAS1(I) + CHNG(K)
  702 CONTINUE
  704 CONTINUE
      IF(NCLAS2.LE.0) GO TO 708
      DO 706 I = 1,NCLAS2
      IF(BIAS2(I).EQ.XBIAS) GO TO 706
      K = K + 1
      BIAS2(I) = BIAS2(I) + CHNG(K)
  706 CONTINUE
  708 CONTINUE
      IF(IWRT.LT.4) GO TO 800
      IF(ISTOP.EQ.0) GO TO 710
C ***** WRITE PROCESS TERMINATION MESSAGE
      IF(IRET.EQ.0) WRITE (IOUT,8300)
      IF(IRET.EQ.1) WRITE (IOUT,8320)
  710 CONTINUE
      IF(IWRT.LT.6 .AND. ISTOP.EQ.0) GO TO 800
C ***** WRITE UPDATED ATTITUDE STATE
      WRITE (IOUT,8200) ISTEP
      DO 720 I = 1,NOOF
      AOLD = ALP(I) - CHNG(2*I-1)
      DOLD = DEL(I) - CHNG(2*I)
      WRITE (IOUT,8220) AOLD, CHNG(2*I-1),ALP(I), DOLD, CHNG(2*I),
     /      DEL(I)
  720 CONTINUE
      IF(NBIAS.LE.0) GO TO 760
      K = N2
      IF(NCLAS1.LE.0) GO TO 740
      ITITLE = 1
      DO 730 I = 1,NCLAS1
      IF(BIAS1(I).EQ.XBIAS) GO TO 730
      K = K + 1
      BOLD = BIAS1(I) - CHNG(K)
      IF(ITITLE.EQ.1) WRITE (IOUT,8230)
      ITITLE = 2
      WRITE (IOUT,8245) I, BOLD, CHNG(K), BIAS1(I)
  730 CONTINUE
  740 CONTINUE
      IF(NCLAS2.LE.0) GO TO 760
      ITITLE = 1
      DO 750 I = 1,NCLAS2
      IF(BIAS2(I).EQ.XBIAS) GO TO 750
      K = K + 1
      BOLD = BIAS2(I) - CHNG(K)
      IF(ITITLE.EQ.1) WRITE (IOUT,8240)
      ITITLE = 2
      WRITE (IOUT,8245) I, BOLD, CHNG(K), BIAS2(I)
  750 CONTINUE
  760 CONTINUE
  800 CONTINUE
```

```
C
C ***** WEIGHT OUT DATA WITH LARGE RESIDUALS, IF DESIRED
C
      IF(ISMULT.LE.0)  GO TO 200
      WRITE(IOUT,8246)  ISMULT
      N=0
      SUMAV=0.0
      IF(NCLAS1.LE.0)  GO TO 806
      DO 805 J=1,NCLAS1
      IF(NTYPE1(J).LE.0)  GO TO 805
      IF(IWRT.GT.10) WRITE(IOUT,8247) J,AVGRHO(1,J)
      IF(AVGRHO(1,J).GT.998.)  GO TO 805
      N=N+1
      SUMAV=SUMAV+AVGRHO(1,J)
  805 CONTINUE
  806 IF(NCLAS2.LE.0)  GO TO 811
      DO 810 J=1,NCLAS2
      IF(NTYPE2(J).LE.0)  GO TO 810
      IF(IWRT.GT.10) WRITE(IOUT,8248) J,AVGRHO(2,J)
      IF(AVGRHO(2,J).GT.998.)  GO TO 810
      N=N+1
      SUMAV=SUMAV+AVGRHO(2,J)
  810 CONTINUE
  811 AVG=SUMAV/N
      IF(IWRT.GT.10) WRITE(IOUT,8249) AVG
      IF(NCLAS1.LE.0)  GO TO 817
      DO 816 I=1,NCLAS1
      IF(NTYPE1(I).LE.0)  GO TO 816
      J1=IFRST1(I)
      N=NTYPE1(I)+J1-1
      DO 815 J=J1,N
      IF(ABS(RHO1(J)).GT.ISMULT*AVG)  WGHT1(J)=0.0
  815 CONTINUE
  816 CONTINUE
  817 IF(NCLAS2.LE.0)  GO TO 200
      DO 821 I=1,NCLAS2
      IF(NTYPE2(I).LE.0)  GO TO 821
      J1=IFRST2(I)
      N=NTYPE2(I)+J1-1
      DO 820 J=J1,N
      IF(ABS(RHO2(J)).GT.ISMULT*AVG)  WGHT2(J)=0.0
  820 CONTINUE
  821 CONTINUE
      GO TO 200
C
C ***** PROCESS HAS TERMINATED
C
C
C
C ***** ERROR RETURNS
 7000 CONTINUE
      IRET = 5
      GO TO 7800
 7010 CONTINUE
      IRET = 4
      GO TO 7800
 7020 CONTINUE
      IRET = 3
      GO TO 7800
 7030 CONTINUE
      IRET = 2
      GO TO 7800
 7040 CONTINUE
      IRET=6
 7800 CONTINUE
      IF(IWRT.GE.1) WRITE (IOUT,8999) IRET
```

```
 7900 CONTINUE
      IF(IWRT.GE.2) WRITE (IOUT,8340)
      RETURN
C
C ************************** FORMAT STATEMENTS **************************
C
 8000 FORMAT (1X, //, 1X, 44('-'),'1 SPECIFIED OUTPUT FROM SUBROUTINE G
     /CONES ',45('-'), /, 1X, '  NCLAS1  NCLAS2        TZERO     NCOF   MAX
     /IT    IWRT     IOUT', /, 1X, 2I8, F12.4, 4I8)
 8010 FORMAT (1X, /, 1X, 'INITIAL ATTITUDE COEFFICIENTS AND CORRECTION B
     /OUNDS:', /, 1X, '     ALPHA(DEG)    CORR BND(DEG)     DELTA(DEG)    C
     /RR BND(DEG)', /, (1X, F14.4, F16.6, F14.4, F16.6))
 8020 FORMAT (1X, /, 1X, 'CLASS 1 (CONE ANGLE) INITIAL BIASES', /,
     /     1X, 'TYPE        BIAS(DEG)    CORR BND(DEG)')
 8030 FORMAT (1X, /, 1X, 'CLASS 2 (DHEC ANGLE) INITIAL BIASES', /,
     /     1X, 'TYPE        BIAS(DEG)    CORR BND(DEG)')
 8040 FORMAT (1X, I4, F15.4, F16.4)
 8050 FORMAT (1X, /, 1X, 'CLASS 1 (CONE ANGLE) INPUT DATA TYPE', I2,
     /     ' HAS', I4, ' OBSERVATIONS, FROM', I4, ' TO', I4, ', IN THE D
     /ATA ARRAYS')
 8060 FORMAT (1X, /, 1X, 'CLASS 2 (DHEC ANGLE) INPUT DATA TYPE', I2,
     /     ' HAS', I4, ' OBSERVATIONS, FROM', I4, ' TO', I4, ', IN THE D
     /ATA ARRAYS')
 8070 FORMAT (1X, /,1X, '    I                 TIME        X-AXIS     Y-AXIS    Z
     /-AXIS    CONE ANGLE       WEIGHT', /, (1X, I4, F16.6, 2X, 3F10.6,
     /     F14.4, F12.4))
 8080 FORMAT (1X, /,1X, '    I                 TIME      X-AXIS-1  Y-AXIS-1  Z-A
     /XIS-1    X-AXIS-2  Y-AXIS-2  Z-AXIS-2     DHEC ANGLE       WEIGHT',
     /     /, (1X, I4, F16.6, 2X, 3F10.6, 2X, 3F10.6, F14.4, F12.4))
 8100 FORMAT (1X, //, 1X, 'SIMULTANEOUS ATTITUDE EQUATIONS COEFFICIENTS'
     /     , /, 2X)
 8120 FORMAT (1X, 10E13.6)
 8200 FORMAT (1X, //, 1X, 'ITERATION', I3, ' - ATTITUDE AND BIAS STATE:'
     /     , //, 1X, '   OLD ALPHA(DEG)       CHANGE(DEG)    NEW ALPHA(DEG
     /)      OLD DELTA(DEG)        CHANGE(DEG)    NEW DELTA(DEG)')
 8220 FORMAT (1X, 3F17.8, 4X, 3F17.8)
 8230 FORMAT (1X, /, 1X, 'CLASS 1 (CONE ANGLE) BIAS STATE:', /, 1X,
     /     'TYPE   OLD BIAS(DEG)   CHANGE(DEG)   NEW BIAS(DEG)')
 8240 FORMAT (1X, /, 1X, 'CLASS 2 (DHEC ANGLE) BIAS STATE:', /, 1X,
     /     'TYPE   OLD BIAS(DEG)   CHANGE(DEG)   NEW BIAS(DEG)')
 8245 FORMAT (1X, I4, F16.6, F14.6, F16.6)
 8246 FORMAT(1X,/,' ***** RESIDUAL EDITING IS USED.  ISMULT =',I5,/)
 8247 FORMAT('   THE AVERAGE RHC VALUE FOR CLASS 1, TYPE',I3,
     / ' DATA IS',F10.4)
 8248 FORMAT('   THE AVERAGE RHC VALUE FOR CLASS 2, TYPE',I3,
     / ' DATA IS',F10.4)
 8249 FORMAT(1X,/,'   THE AVERAGE RHC VALUE FOR ALL TYPES IS',F10.4,/)
 8250 FORMAT(1X,/,1X,'COVARIANCE-CORRELATION MATRIX ',/,1X,
     /     10X, 13(1X, 2A4))
 8260 FORMAT (1X, 2A4, 2X, 13E9.2)
 8270 FORMAT (1X, /, 18X, 'CLASS 1 (CONE ANGLE) ERROR STATISTICS:',
     /     /, 1X, ' TYPE    MEAN RESIDUAL(DEG)    STANDARD DEVIATION(DEG
     /)         TOTAL WEIGHT')
 8280 FORMAT (1X, /, 18X, 'CLASS 2 (DHEC ANGLE) ERROR STATISTICS:',
     /     /, 1X, ' TYPE    MEAN RESIDUAL(DEG)    STANDARD DEVIATION(DEG
     /)         TOTAL WEIGHT')
 8290 FORMAT (1X, I5, 4X, F13.4, 5X,  4X, F18.4, 5X,  8X, F12.4)
 8295 FORMAT (1X, 'TOTAL', 4X, F13.4, 5X,  4X, F18.4, 5X,  8X, F12.4)
 8298 FORMAT (1X, /, 1X,'COMBINED TOTAL:    MEAN RESIDUAL(DEG) = ',
     /     F9.4, '          STANDARD DEVIATION(DEG) = ', F9.4)
 8300 FORMAT (1X, /, 1X, '***** GCONES CONVERGED')
 8320 FORMAT (1X, /, 1X, '***** GCONES PERFORMED MAXIMUM NUMBER OF ITERA
     /TIONS WITHOUT CONVERGING')
 8340 FORMAT (1X,  130('-'))
 8599 FORMAT (1X, /, 1X, '***** ERROR TYPE', I3, ' DETECTED, GCONES TERM
     /INATED')
      END
```

```
C...........................................................................
C.
C.        THIS IS A SPECIAL SUBROUTINE CALLED BY GCONES TO COMPUTE THE
C.        CONTRIBUTION TO THE COEFFICIENTS OF THE SIMULTANEOUS EQUATIONS
C.        (INVERSE COVARIANCE MATRIX) FOR EACH TYPE OF DATA, ONE TYPE
C.        AT A TIME.  THE GCONES PREAMBLE AND COMMENTED LISTING PROVIDES
C.        A DESCRIPTION OF ALL ARGUMENTS PASSED TO THIS SUBROUTINE.
C.
C...........................................................................
C
      SUBROUTINE COFSUM (TIME, AXIS, ANG, WGHT, NUMB, ITYPE, NDIM, ALPR,
     /                   DELR, BIAS, IBIAS, NCOF, TZERO, IWRT, IOUT,
     /                   COEF,CRHOSQ,RHOST,AVGRHO,RHO)
C
C
      DIMENSION TIME(500), AXIS(NDIM,500), ANG(500), WGHT(500),
     /          ALPR(4), DELR(4)
      DIMENSION COEF(13,13), CRHOSQ(13), RHOST(3), DERIV(8)
      DIMENSION RHO(500)
      DATA RTOD,TFLAG,XBIAS/57.29578,9999999.,9999999./
C ***** INITIALIZATION
      IFRST = 1
      N2 = NCOF + NCOF
C ***** WRITE OUTPUT HEADER IF SPECIFIED
      IF(IWRT.GE.12) WRITE (IOUT,8000) ITYPE
1     CONTINUE
C
C ***** BEGIN SUMMATION LOOP
C
      DO 1000 I = 1,NUMB
      RHO(I)=0.0
C ***** IF TIME IS FLAGGED IGNORE THIS OBSERVATION
      IF(TIME(I).EQ.TFLAG) GO TO 1000
C ***** IF ATTITUDE IS INERTIAL (NCOF=1) AND HAS BEEN COMPUTED ONCE
C ***** (IFRST=2) SKIP ATTITUDE COMPUTATION FROM COEFFICIENTS
      IF(NCOF.LE.1 .AND. IFRST.EQ.2) GO TO 100
      IFRST = 2
      AR = 0.0
      DR = 0.0
      TDIFF = TIME(I) - TZERO
      DTIME = 1.0
C ***** COMPUTE ALPHA AND DELTA AT TIME(I)
      DO 40 J = 1,NCOF
      AR = AR + ALPR(J)*DTIME
      DR = DR + DELR(J)*DTIME
      DTIME = DTIME*TDIFF
   40 CONTINUE
      IF(ABS(AR).LT.10000.0 .AND. ABS(DR).LT.10000.0) GO TO 60
      IF(IWRT.GE.12) WRITE (IOUT,8120)
      GO TO 1000
   60 CONTINUE
C ***** SAVE SINES AND COSINES OF ALPHA AND DELTA AND CARTESIAN
C ***** COORDINATES OF UNIT SPIN AXIS VECTOR
      COSA = COS(AR)
      SINA = SIN(AR)
      COSD = COS(DR)
      SIND = SIN(DR)
      U1 = COSD*COSA
      U2 = COSD*SINA
      U3 = SIND
  100 CONTINUE
C
C ***** COMPUTE ANGLE AND DERIVATIVES W.R.T. ALPHAO AND DELTAO AT THE
C ***** CURRENT STATE
```

```
C
C ***** COMPUTE TRUE MEASURED ANGLE (WITHOUT BIAS)
      GAMMA = ANG(I)
      IF(BIAS.NE.XBIAS) GAMMA = GAMMA - BIAS
      W = WGHT(I)
      IF(ITYPE.EQ.2) GO TO 120
C ***** CLASS 1 DATA - CONE ANGLE
      COSTHE = AXIS(1,I)*U1 + AXIS(2,I)*U2 + AXIS(3,I)*U3
      IF(ABS(COSTHE).GT.1.0) COSTHE = SIGN(1.0,COSTHE)
      THERAD = ARCOS(COSTHE)
      SINTHE = SIN(THERAD)
      THETA = THERAD*RTOD
      RHO(I)=GAMMA-THETA
      IF(SINTHE.NE.0.0) GO TO 110
C ***** DERIVATIVES CAN'T BE COMPUTED, SKIP THIS POINT
      IF(IWRT.GE.12) WRITE (IOUT,8140)
      GO TO 1000
  110 CONTINUE
C ***** COMPUTE DERIVATIVES OF THETA W.R.T. ALPHAO AND DELTAO
      DERVA = (AXIS(1,I)*U2 - AXIS(2,I)*U1)/SINTHE
      DERVD=(SIND*(AXIS(1,I)*COSA+AXIS(2,I)*SINA)-AXIS(3,I)*COSD)/SINTHE
      GO TO 140
C ***** CLASS 2 DATA - DIHEDRAL ANGLE
  120 CONTINUE
      E1 = AXIS(2,I)*AXIS(6,I) - AXIS(3,I)*AXIS(5,I)
      E2 = AXIS(3,I)*AXIS(4,I) - AXIS(1,I)*AXIS(6,I)
      E3 = AXIS(1,I)*AXIS(5,I) - AXIS(2,I)*AXIS(4,I)
      F = AXIS(1,I)*AXIS(4,I) + AXIS(2,I)*AXIS(5,I) +AXIS(3,I)*AXIS(6,I)
      SV = U1*AXIS(1,I) + U2*AXIS(2,I) + U3*AXIS(3,I)
      SW = U1*AXIS(4,I) + U2*AXIS(5,I) + U3*AXIS(6,I)
      XNUM = U1*E1 + U2*E2 + U3*E3
      XDEN = F - SV*SW
      Q1 = XDEN*E1 + XNUM*(SV*AXIS(4,I) + SW*AXIS(1,I))
      Q2 = XDEN*E2 + XNUM*(SV*AXIS(5,I) + SW*AXIS(2,I))
      Q3 = XDEN*E3 + XNUM*(SV*AXIS(6,I) + SW*AXIS(3,I))
      IF(IWRT.GE.14) WRITE (IOUT,8080) E1,E2,E3, F,SV,SW, XNUM,XDEN,
     /      Q1,Q2,Q3
      IF(XNUM.NE.0.0 .OR. XDEN.NE.0.0) GO TO 130
C ***** THETA IS UNDEFINED AND THE DERIVATIVES CAN'T BE COMPUTED
      IF(IWRT.GE.12) WRITE (IOUT,8160)
      GO TO 1000
  130 CONTINUE
      THETA = ATAN2(XNUM,XDEN)*RTOD
      IF(THETA.LT.0.0) THETA = THETA + 360.0
C ***** COMPUTE RESIDUAL AND CHECK FOR NUMERICAL DISCONTINUITY AT 0-360
      RHO(I)=GAMMA- THETA
      IF(ABS(RHO(I)).GT.270.0)RHO(I)=RHO(I)-SIGN(360.0,RHO(I))
C ***** IF RHO IS STILL TOO LARGE ELIMINATE BY SETTING WEIGHT TO 0.0
      IF(ABS(RHO(I)).GE.90.0)W=0.0
C ***** COMPUTE DERIVATIVES OF THETA W.R.T. ALPHAO AND DELTAO
      DERVA = (-Q1*U2 + Q2*U1)/(XNUM*XNUM+XDEN*XDEN)
      DERVD=(-SIND*(Q1*COSA+Q2*SINA)+Q3*COSD)/(XNUM*XNUM+XDEN*XDEN)
  140 CONTINUE
C ***** COMPUTE VECTOR OF DERIVATIVES: A0, D0, A1, D1, ...
      DTIME = 1.0
      DO 160 J = 2,N2,2
      DERIV(J-1) = DERVA*DTIME
      DERIV(J) = DERVD*DTIME
      DTIME = DTIME*TDIFF
  160 CONTINUE
C ***** SUM STATISTICS
      RHOST(1) = RHOST(1) + RHO(I)*W
      RHOST(2) = RHOST(2) + RHO(I)*RHO(I)*W
      RHOST(3) = RHOST(3) + W
      IF(IWRT.LT.12) GO TO 150
C ***** OUTPUT INTERMEDIATE QUANTITIES IN SUMMATION PROCESS
```

```
      AD = AR*RTCD
      DD = DR*RTCD
      WRITE (IOUT,8100) I, TIME(I), TDIFF, W, AD, DD, DERVA, DERVD,
     /      THETA, GAMMA, RHO(I)
  150 CONTINUE
C ***** SUM WEIGHTED ALPHA AND DELTA COEFFICIENT DERIVATIVES CROSS
C ***** PRODUCTS INTO COEFFICIENT MATRIX (LOWER, LEFT, OFF-DIAGONAL
C ***** IS NOT SUMMED BECAUSE OF SYMMETRY)
      DO 200 J = 1,N2
      DO 180 K = J,N2
      COEF(J,K) = COEF(J,K) + DERIV(K)*DERIV(J)*W
  180 CONTINUE
C ***** SUM COEFFICIENTS IN VECTOR CONTAINING RIGHT SIDE OF SIMULTANEOUS
C ***** EQUATIONS
      DRHOSQ(J)  = DRHOSQ(J) + RHO(I)*DERIV(J)*W
  200 CONTINUE
      IF(BIAS.EQ.XBIAS) GO TO 1000
2     CONTINUE
C ***** COMPUTE ALL MATRIX ELEMENTS DEPENDENT ON BIAS
      DO 300 J = 1,N2
      COEF(J,IBIAS) = COEF(J,IBIAS) + DERIV(J)*W
  300 CONTINUE
      COEF(IBIAS,IBIAS) = COEF(IBIAS,IBIAS) + W
      DRHOSQ(IBIAS) = DRHOSQ(IBIAS) + RHO(I)*W
 1000 CONTINUE
C ***** COMPUTE AVERAGE RHO VALUE
      AVGRHO=999.
      RHOSUM=0.0
      NUM=0
      DO 1500 I=1,NUMB
      IF(TIME(I).EQ.TFLAG)  GO TO 1500
      IF(WGHT(I).EQ.0.0)  GO TO 1500
      RHOSUM=RHOSUM+ABS(RHO(I))
      NUM=NUM+1
 1500 CONTINUE
      IF(NUM.EQ.0)  GO TO 2000
      AVGRHO=RHOSUM/NUM
 2000 RETURN
C
C ************************ FORMAT STATEMENTS ************************
C
 8000 FORMAT (1X, /, 1X, 'SUBROUTINE COFSUM - ATTITUDE EQUATIONS COEFFIC
     /IENTS COMPUTATIONS FOR CLASS', I2, ' DATA:',
     /      //, 1X, '       I         TIME          TDIFF        WEIGHT         ALP
     /HA         DELTA          DERVA          DERVD          THETA          GAMMA
     /      RHO', /, 2X)
 8080 FORMAT (1X, 'E1,2,3=', 3F8.4, '  F,SV,SW=', 3F8.4, '  XNUM,XDEN=',
     /      2F8.4, '  C1,2,3=', 3F8.4)
 8100 FORMAT (1X, I6, 5F12.4, 5F12.6)
 8120 FORMAT (1X, '****** THE ABSOLUTE VALUE OF ALPHA AND/OR DELTA IS TO
     /O LARGE (>=100000.0 RADIANS)')
 8140 FORMAT (1X, '****** SIN(THETA)=0.0, DERIVATIVES OF THETA W.R.T. AL
     /PHA AND DELTA ARE UNDEFINED')
 8160 FORMAT (1X, '****** PSI IS UNDEFINED, DERIVATIVES OF PSI W.R.T. AL
     /PHA AND DELTA ARE ALSO UNDEFINED')
      END
```

APPENDIX B

This appendix describes a computer program written to enable a user to employ SUBROUTINE GCONES with relatively small groups of data. The program is designed to make use of an IBM 2260 display unit for interactive input entry and output viewing. Examples of input and output follow, with a definition of the parameters and data which are displayed. In addition, a short guide for operation of the program is included at the end.

```
*NCOF=1*MAXIT= 5*NCLAS1=0*NCLAS2=2*ISMULT=0*IRADEC=0*
*ALP(1)= 45.5*DEL(1)= -5.7*ALPBND(1)=.10*DELBND(1)=.10*
*NTYPE1= 0* 0* 0* 0* 0***NUM1= 0***** NTYPE2= 2* 2* 0* 0* 0***NUM2= 4*
*BIAS1= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 ***** BBND1= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 *
*BIAS2= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 ***** BBND2= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 *
 ANGLE  X1 OR A1   Y1 OR D1   Z1 OR A2   X2 OR D2      Y2          Z2      WGHT
 35.64* -0.916800* -0.350600* -0.191100* -0.786000* -0.522100*  0.330968* 1.00*
 35.23* -0.916800* -0.350600* -0.191100* -0.786000* -0.522100*  0.330968* 1.00*
 57.89* -0.786000* -0.522100*  0.330968* -0.532500* -0.716300*  0.451000* 1.00*
 57.70* -0.786000* -0.522100*  0.330968* -0.532500* -0.716300*  0.451000* 1.00*
```

Parameter	Format	Range of Values	Function or Definition
NCOF	(I1)	1	Number of coefficients to be used in attitude model
MAXIT	(I2)	1 to 99	Maximum number of iterations to be performed
NCLAS1	(I1)	1 to 5	Number of types of class 1 (cone angle) data
NCLAS2	(I1)	1 to 5	Number of types of class 2 (dihedral angle) data
ISMULT	(I1)	0	Do not use the residual edit data rejection process
		1 to 9	Weight to 0.0 all angles whose residuals are greater than ISMULT times the average residual
IRADEC	(I1)	0	Reference vectors are input in X, Y, Z coordinates
		1	Reference vectors are input in α, δ coordinates
ALP(1)	(F5.1)	0. to 360.	Initial estimate for spin axis right ascension

Parameter	Format	Range of Values	Function or Definition
DEL(1)	(F5.1)	-90. to 90.	Initial estimate for spin axis declination
ALPBND(1)	(F3.2)	>0.	Bound for convergence of right ascension
DELBND(1)	(F3.2)	>0.	Bound for convergence of declination
NTYPE1	(5I2)	0 to 50	Number of angles of each type of class 1 data
NUM1	(I2)	0 to 50*	Total number of angles of class 1 data
NTYPE2	(5I2)	0 to 50	Number of angles of each type of class 2 data
NUM2	(I2)	0 to 50*	Total number of angles of class 2 data
BIAS1	(5F5.2)	0.0	Do not compute bias for this type of class 1 data
		Other	Initial estimate of bias for this type of class 1 data
BBND1	(5F5.2)	⩾0.	Bound for convergence on bias for each type of class 1 data
BIAS2	(5F5.2)	0.0	Do not compute bias for this type of class 2 data
		Other	Initial estimate of bias for this type of class 2 data
BBND2	(5F5.2)	⩾0.	Bound for convergence on bias for each type of class 2 data
ANGLE	(F6.2)	0. to 360.	Cone angles and/or dihedral angles (cone angles must be first)
X1, Y1, Z1	(3F11.7)	-1. to 1.	X, Y, Z coordinates of first reference vector
X2, Y2, Z2	(3F11.7)	-1. to 1.	X, Y, Z coordinates of second reference vector (for dihedral angles only)

*At present the program is limited to processing only 50 angles or less. (NUM1 + NUM2 ⩽ 50)

Parameter	Format	Range of Values	Function or Definition
A1	(F11.7)	0. to 360.	Right Ascension of first reference vector
D1	(F11.7)	-90. to 90.	Declination of first reference vector
A2	(F11.7)	0 to 360.	Right ascension of second reference vector (for dihedral angles only)
D2	(F11.7)	-90. to 90.	Declination of second reference vector (for dihedral angles only)
WGHT	(F5.2)	$\geqslant 0.0$	Weights assigned to each input angle

```
***** GCONES CONVERGED

ALPHA=  45.387 *** DELTA=  -5.617  *****  TRESID=  0.25098 *** TSTDV=  0.25000

RESID1=  0.0      *  0.0      *  0.0    *  0.0    *  0.0    *
STDV1 =  0.0      *  0.0      *  0.0    *  0.0    *  0.0    *
RESID2= -0.00006* -0.00009*  0.0    *  0.0    *  0.0    *
STDV2 =  0.20500*  0.09500*  0.0    *  0.0    *  0.0    *
BIAS1 =  0.0      *  0.0      *  0.0    *  0.0    *  0.0    *
BIAS2 =  0.0      *  0.0      *  0.0    *  0.0    *  0.0    *

 I*ANGLE *RESIDUAL*WEIGHT*                    * I*ANGLE *RESIDUAL*WEIGHT*
 1* 85.64*  0.2049*  1.00*                    * 2* 85.23* -0.2051*  1.00*
 3* 57.89*  0.0949*  1.00*                    * 4* 57.70* -0.0951*  1.00*

*NCDF=1*MAXIT= 5*NCLAS1=0*NCLAS2=2*ISMULT=0*IRADEC=0*
*ALP(1)= 45.4*DEL(1)= -5.6*ALPBND(1)=.10*DELBND(1)=.10*
*NTYPE1= 0* 0* 0* 0* 0***NUM1= 0***** NTYPE2= 2* 2* 0* 0* 0***NUM2= 4*
*BIAS1= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 ***** BBND1= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 *
*BIAS2= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 ***** BBND2= 0.0 * 0.0 * 0.0 * 0.0 * 0.0 *
 ANGLE   X1 OR A1    Y1 OR D1    Z1 OR A2    X2 OR D2      Y2          Z2      WGHT
 85.64* -0.916800* -0.350600* -0.191100* -0.786000* -0.522100*  0.330968* 1.00*
 85.23* -0.916800* -0.350600* -0.191100* -0.786000* -0.522100*  0.330968* 1.00*
 57.89* -0.786000* -0.522100*  0.330968* -0.532500* -0.716300*  0.451000* 1.00*
 57.70* -0.786000* -0.522100*  0.330968* -0.532500* -0.716300*  0.451000* 1.00*
```

Output Description

***** message — error message from SUBROUTINE GCONES. If no error occurs, message is "GCONES CONVERGED"

ALPHA — computed spin axis right ascension

DELTA — computed spin axis declination

TRESID — computed mean residual based on all data

TSTDV — computed standard deviation based on all data

RESID1 — mean residuals computed for each type of class 1 data

STDV1 — standard deviations computed for each type of class 1 data

RESID2 — mean residuals computed for each type of class 2 data

STDV2 — standard deviations computed for each type of class 2 data

BIAS1 — bias computed for each type of class 1 data

BIAS2 — bias computed for each type of class 2 data

I — number of the angle within the input angle arrays

RESIDUAL — residual computed for this individual angle

WEIGHT — weight attached to this angle (if residual edit was used and the residual was large enough this weight will be 0.0).

Operating Guide

The normal procedure for operation is to: 1. enter all input parameter values and data on the input displays, 2. process the data using Subroutine GCONES, 3. review the output on the output displays, 4. proceed to the input display where more data can be entered or the same data can be reprocessed, 5. repeat previous procedure any number of times.

To facilitate these operations, several features have been incorporated into the program for input as well as for output.

Input Features

Shift/Enter — by depressing these keys the next page of input will be displayed. There are five pages of input. If shift/enter is depressed when page 5 is on the display, GCONES processing is initiated and the output display will appear.

BACK — by typing "BACK" in the first four spaces on the first line of any page and then depressing shift/enter the previous page of input will be displayed.

SKIPn — by typing "SKIP" in the first four spaces on the first line of any page and typing a "1", "2", or "3" in the fifth space, n pages of input can be skipped. Shift/enter must be depressed after typing SKIPn.

LOAD — by typing "LOAD" in the first four spaces on the first line of any page and then depressing shift/enter page 1 of the input will be displayed.

CONT — by typing "CONT" in the first four spaces on the first line of any page and then depressing shift/enter the GCONES processing will be initiated without further modification to the input data.

STOP — by typing "STOP" in the first four spaces on the first line of any page and then depressing shift/enter the program will be terminated.

Output Features

Shift/enter — same as with input

BACK — same as with input

LOAD — same as with input

STOP — same as with input

REDO — by typing "REDO" in the first four spaces on the first line of any page and then depressing shift/enter the first page of output will be displayed. There can be up to four pages of output.

Operating Notes

When the initial input has been processed, the output reviewed, and "LOAD" is used to reprocess several things should be noticed. First, the input attitude and bias estimates will be those computed by GCONES from the previous processing and may require modification. Second, the weights will be 0.0 if any of the angles were rejected by the residual edit process. Third, the line immediately following the last line of data from the previous processing will be blank. Data should be entered on this line if more angles are added (asterisks need not be typed).

```
//GHARGCO$ JOB (GH5001857A,T,G00402,005005),GHO,MSGLEVEL=1
// EXEC PGM=IEHPROGM
//SYSPRINT DD SYSOUT=A
//ATT DD UNIT=DISK,VOL=SER=ATTDET,DISP=SHR
//SYSIN DD *
 SCRATCH DSNAME=IMP.LAUNCH.GDR,VOL=2314=ATTDET,MEMBER=GCONESDR
// EXEC PGM=IEBCOPY,REGION=20CK
//SYSPRINT DD SYSOUT=A
//IN DD DSN=IMP.LAUNCH.GDR,UNIT=DISK,VOL=SER=ATTDET,DISP=SHR
//SYSIN DD *
 COPY INDD=IN,OUTDD=IN
// EXEC FORTRANH
//SOURCE.SYSIN DD *
C
C     THIS IS A GENERAL DRIVER FOR SUBROUTINE GCONES
C     WRITTEN 7/20/72 BY AL GEELHAAR -- CODE 542
C     REVISED 10/27/72 TO INCLUDE CALL TO LATEST VERSION OF GCONES
C
      DIMENSION ALP(4),DEL(4),ALPBND(4),DELBND(4),COEF(13,13),
     / TIME1(50),AXIS1(3,50),ANG1(50),IFRST1(5),NTYPE1(5),
     / BIAS1(5),BBND1(5),RHOST1(3,5),TIME2(50),AXIS2(6,50),
     / ANG2(50),WGHT2(50),IFRST2(5),NTYPE2(5),BIAS2(5),
     / BBND2(5),RHOST2(3,5),WGHT1(50),STDV1(5),RESID1(5),RHO1(50),
     / STDV2(5),RESID2(5),RHO2(50),ICOM(7),B1(5),B2(5)
      COMMON/GRAPH/ ICOM
      ISMULT=0
      IRADEC=0
      NCOF=1
      TZERO=0.
      MAXIT=5
      IWRT=14
      IOUT=6
      NCLAS1=0
      NCLAS2=0
      DUM1=0.0
      DUM2=0.0
      DUM3=0.0
      NUM1=50
      NUM2=0
      ALP(1)=0.0
      DEL(1)=0.0
      IFT=10
      IUNIT=9
      IDUM=0
      DO 1 I=1,4
      ALPBND(I)=.1
      DELBND(I)=.1
    1 CONTINUE
      DO 2 I=1,5
      RESID1(I)=0.0
      STDV1(I)=0.0
      RESID2(I)=0.0
      STDV2(I)=0.0
      IFRST1(I)=0
      IFRST2(I)=0
      NTYPE1(I)=0
      NTYPE2(I)=0
      BIAS1(I)=9999999.
      BIAS2(I)=9999999.
      B1(I)=0.0
      B2(I)=0.0
      BBND1(I)=0.0
      BBND2(I)=0.0
    2 CONTINUE
      DO 3 I=1,50
      ANG1(I)=0.0
```

```
      ANG2(I)=0.0
      WGHT1(I)=1.
      WGHT2(I)=1.
      TIME1(I)=I
      TIME2(I)=I
      DO 21 J=1,3
   21 AXIS1(J,I)=0.0
      DO 3 J=1,6
      AXIS2(J,I)=0.0
    3 CONTINUE
      CALL GOPEN(IFT,ICOM(1))
      CALL GSPAR(ICOM(1))
    4 REWIND 9
      WRITE(9,9000)NCOF,MAXIT,NCLAS1,NCLAS2,ISMULT,IRADEC,ALP(1),DEL(1),
     /ALPBND(1),DELBND(1),(NTYPE1(I),I=1,5),NUM1,(NTYPE2(I),I=1,5),
     /NUM2,(B1(I),I=1,5),(BBND1(I),I=1,5),(B2(I),I=1,5),(BBND2(I),I=1,5)
      IF(NUM1.NE.0)  GO TO 22
      WRITE(9,9020) (ANG2(I),(AXIS2(J,I),J=1,6),WGHT2(I),I=1,NUM2)
      GO TO 25
   22 IF(NUM2.NE.0)  GO TO 23
      WRITE(9,9020)(ANG1(I),(AXIS1(J,I),J=1,3),DUM1,DUM2,DUM3,
     / WGHT1(I),I=1,NUM1)
      GO TO 25
   23 WRITE(9,9020)(ANG1(I),(AXIS1(J,I),J=1,3),DUM1,DUM2,DUM3,
     / WGHT1(I),I=1,NUM1),(ANG2(I),(AXIS2(J,I),J=1,6),WGHT2(I),I=1,NUM2)
   25 CONTINUE
      IGO=1
      CALL DUMMY(IGO,IUNIT,IDUM)
      READ(9,9000) NCOF,MAXIT,NCLAS1,NCLAS2,ISMULT,IRADEC,ALP(1),DEL(1),
     /ALPBND(1),DELBND(1),(NTYPE1(I),I=1,5),NUM1,(NTYPE2(I),I=1,5),
     /NUM2,(B1(I),I=1,5),(BBND1(I),I=1,5),(B2(I),I=1,5),(BBND2(I),I=1,5)
      IF(NUM1.NE.0)  GO TO 32
      READ (9,9020) (ANG2(I),(AXIS2(J,I),J=1,6),WGHT2(I),I=1,NUM2)
      GO TO 35
   32 IF(NUM2.NE.0)  GO TO 33
      READ (9,9020)(ANG1(I),(AXIS1(J,I),J=1,3),DUM1,DUM2,DUM3,
     / WGHT1(I),I=1,NUM1)
      GO TO 35
   33 READ (9,9020)(ANG1(I),(AXIS1(J,I),J=1,3),DUM1,DUM2,DUM3,
     / WGHT1(I),I=1,NUM1),(ANG2(I),(AXIS2(J,I),J=1,6),WGHT2(I),I=1,NUM2)
   35 CONTINUE
      REWIND 9
      N=NUM1+NUM2
      NLINES=N/2+N/22+13
      NLINES=NLINES+MOD(N,2)
      IF(MOD(N,22).EQ.0)  NLINES=NLINES-1
      IF(IRADEC.LE.0)  GO TO 9
      IF(NCLAS1.LE.0)  GO TO 6
      DO 5 I=1,NUM1
      R=AXIS1(1,I)/57.29578
      D=AXIS1(2,I)/57.29578
      AXIS1(1,I)=COS(R)*COS(D)
      AXIS1(2,I)=SIN(R)*COS(D)
    5 AXIS1(3,I)=SIN(D)
    6 IF(NCLAS2.LE.0)  GO TO 9
      DO 8 I=1,NUM2
      RF=AXIS2(1,I)/57.29578
      DF=AXIS2(2,I)/57.29578
      RS=AXIS2(3,I)/57.29578
      DS=AXIS2(4,I)/57.29578
      AXIS2(1,I)=COS(RF)*COS(DF)
      AXIS2(2,I)=SIN(RF)*COS(DF)
      AXIS2(3,I)=SIN(DF)
      AXIS2(4,I)=COS(RS)*COS(DS)
      AXIS2(5,I)=SIN(RS)*COS(DS)
    8 AXIS2(6,I)=SIN(DS)
```

```
    9 CONTINUE
      DO 37 I=1,5
      BIAS1(I)=9999999.
      BIAS2(I)=9999999.
      IF(B1(I).EQ.0.0)  GO TO 36
      BIAS1(I)=B1(I)
   36 IF(B2(I).EQ.0.0)  GO TO 37
      BIAS2(I)=B2(I)
   37 CONTINUE
      IFRST1(1)=1
      IFRST2(1)=1
      DO 38 I=2,5
      IFRST1(I)=IFRST1(I-1)+NTYPE1(I-1)
      IFRST2(I)=IFRST2(I-1)+NTYPE2(I-1)
   38 CONTINUE
      CALL GCONES(TZERO,ALP,DEL,ALPBND,DELBND,NCOF,MAXIT,COEF,
     / IWRT,IOUT,IRET,ISMULT,TIME1,AXIS1,ANG1,WGHT1,IFRST1,NTYPE1,
     / BIAS1,BBND1,RHOST1,NCLAS1,RHO1,RESID1,STDV1,TIME2,AXIS2,ANG2,
     / WGHT2,IFRST2,NTYPE2,BIAS2,BBND2,RHOST2,NCLAS2,RHO2,RESID2,
     / STDV2,TRESID,TSTDV)
      DO 40 I=1,5
      B1(I)=BIAS1(I)
      B2(I)=BIAS2(I)
      IF(BIAS1(I).GE.99999.)  B1(I)=0.0
      IF(BIAS2(I).GE.99999.)  B2(I)=0.0
   40 CONTINUE
      I=IRET+1
      GO TO (11,12,13,14,15,16),I
   11 WRITE(9,9001)
      GO TO 20
   12 WRITE(9,9002)
      GO TO 20
   13 WRITE(9,9003)
      GO TO 20
   14 WRITE(9,9004)
      GO TO 20
   15 WRITE(9,9005)
      GO TO 20
   16 WRITE(9,9006)
   20 WRITE(9,9010) ALP(1),DEL(1),TRESID,TSTDV,(RESID1(I),I=1,5),
     / (STDV1(I),I=1,5),
     /(RESID2(I),I=1,5),(STDV2(I),I=1,5),(B1(I),I=1,5),(B2(I),I=1,5)
      IF(NUM1.NE.0)  GO TO 42
      WRITE(9,9030)     (I,ANG2(I),RHO2(I),WGHT2(I),I=1,NUM2)
      GO TO 45
   42 IF(NUM2.NE.0)  GO TO 43
      WRITE(9,9030)     (I,ANG1(I),RHO1(I),WGHT1(I),I=1,NUM1)
      GO TO 45
   43 WRITE(9,9030)  (I,ANG1(I),RHO1(I),WGHT1(I),I=1,NUM1),(I,ANG2(I),
     / RHO2(I),WGHT2(I),I=1,NUM2)
   45 CONTINUE
      IDUM=NLINES
      IGO=2
      CALL DUMMY(IGO,IUNIT,IDUM)
      IF(IDUM.EQ.-555)  GO TO 4
      CALL GDAR(ICOM(1))
      CALL GCLOS(IFT,ICOM(1))
 9000 FORMAT(' *NCOF=',I1,'*MAXIT=',I2,'*NCLAS1=',I1,'*NCLAS2=',I1,
     / '*ISMULT=',I1,'*IRADEC=',I1,'*'/' *ALP(1)=',F5.1,'*DEL(1)=',F5.1,
     / '*ALPBND(1)=',F3.2,'*DELBND(1)=',F3.2,'*'/' *NTYPE1=',5(I2,'*'),
     / '**NUM1=',I2,'***** NTYPE2=',5(I2,'*'),'**NUM2=',I2,'*'/
     /' *BIAS1=',5(F5.2,'*'),'**** BBND1=',5(F5.2,'*')/' *BIAS2=',
     / 5(F5.2,'*'),'**** BBND2=',5(F5.2,'*'))
 9020 FORMAT('  ANGLE  X1 OR A1   Y1 OR D1   Z1 OR A2   X2 OR D2',6X,
     / 'Y2',9X,'Z2',6X,'WGHT',6(/F7.2,'*',6(F10.6,'*'),F5.2,'*'),
     / 4(/'  ANGLE  X1 OR A1   Y1 OR D1   Z1 OR A2   X2 OR D2',6X,'Y2',
```

```
     / 9X,'Z2',6X,'WGHT',
     / 11(/F7.2,'*',F10.6,'*',F10.6,'*',F10.6,'*',F10.6,'*',F10.6,'*',
     / F10.6,'*',F5.2,'*')))
 9001 FORMAT(' ***** GCONES CONVERGED')
 9002 FORMAT(' ***** GCONES PERFORMED MAXIMUM NUMBER OF ITERATIONS',
     / ' WITHOUT CONVERGING')
 9003 FORMAT(' ***** GCONES DIVERGED (CORRECTION ELEMENT GREATER THAN',
     / ' 360.')
 9004 FORMAT(' ***** GCONES ENCOUNTERED A SINGULAR MATRIX')
 9005 FORMAT(' ***** GCONES - TOO MANY BIASES WERE SELECTED TO BE ',
     / 'DETERMINED')
 9006 FORMAT(' ***** GCONES - NCOF IS OUTSIDE OF ALLOWABLE RANGE')
 9010 FORMAT(/' ALPHA=',F8.3,' *** DELTA=',F8.3,'  *****  TRESID=',
     / F9.5,' *** TSTDV=',F9.5,//' RESID1=',F9.5,
     / '*',F9.5,'*',F9.5,'*',F9.5,'*',F9.5,'*'/' STDV1 =',5(F9.5,'*')/
     / ' RESID2=',5(F9.5,'*')/' STDV2 =',5(F9.5,'*'),
     / /' BIAS1 =',5(F9.5,'*'),/' BIAS2 =',5(F9.5,'*'))
 9030 FORMAT(//3('  I*ANGLE *',
     / 'RESIDUAL*WEIGHT*',14X,'* I*ANGLE *RESIDUAL*WEIGHT*'/11(I3,'*',
     / F6.2,'*',F8.4,'*',F6.2,'*',14X,'*',I2,'*',F6.2,'*',F8.4,
     / '*',F6.2,'*',/)))
      STOP                                                              00003900
      END                                                               00004000
      SUBROUTINE DUMMY(IGO,IUNIT,IDUM)
      IF (IGO .EQ. 1) CALL LOAD(IUNIT)
      IF (IGO .EQ. 2) CALL OUT60(IDUM,IUNIT)
      IF (IGO .EQ. 3) CALL COPY(IDUM,IUNIT)
      RETURN
      END
      SUBROUTINE COPY(IRECN,IUNIT)
      DIMENSION A(240),ICOM(7)
      COMMON /GRAPH/ICOM
      DATA ASTOP/'STOP'/
      DATA BLOAD/'LOAD'/
      DATA AUTO/'AUTO'/
      IFT=10
      REWIND IUNIT
      READ(IUNIT,10,END=25)A
   10 FORMAT(20A4)
   25 CALL GWBUF(ICOM(1),A(1),IFT)
      CALL GWAIT(ICOM(1))
      CALL GRBUF(ICOM(1),A(1),IFT)
      IF(A(1) .EQ. ASTOP) GO TO 30
      IF(A(1) .EQ. AUTO) IRECN=-444
      IF(A(1) .EQ. BLOAD) IRECN=-555
      REWIND IUNIT
      WRITE(IUNIT,10)A
      REWIND IUNIT
      RETURN
   30 CALL GDAR(ICOM(1))
      CALL GCLOS(IFT,ICOM(1))
      STOP
      END
      SUBROUTINE LOAD(IUNIT)
      DIMENSION ICOM(7),A(1200)
      DATA SKIP/'SKIP'/,STOP/'STOP'/
      DATA  CONT/'CONT'/,BACK/'BACK'/,BLOAD/'LOAD'/                     00003322
      INTEGER L(5)/1,241,481,721,961/
      COMMON /GRAPH/ICOM                                                00003330
      ISKIP=0
      IFT=10                                                            00003340
      REWIND IUNIT
      READ (IUNIT,10,END=24) A
   10 FORMAT(20A4)                                                      00003370
   24 I=0                                                               00003371
   25 I=I+1                                                             00003372
```

```
      IF(I.GT.5) I=5
      IF (I.EQ.0) I=1
      J=L(I)                                                            00003374
      R=A(J)
      S=A(J+1)
      CALL GWBUF(ICOM(1),A(J),IFT)                                      00003377
      ISKIP=ISKIP-1
      IF(ISKIP.GT.0) GO TC 25
      CALL GWAIT(ICOM(1))                                               00003378
      CALL GRBUF(ICOM(1),A(J),IFT)                                      00003400
   20 D=A(J)                                                            00003404
      Q=A(J+1)
      A(J)=R
      A(J+1)=S
      IF(D.EQ.SKIP) GO TO 92
      IF (D.EC.BLOAD) GO TO 24                                          00003407
      IF(D.EQ.BACK)I=I-2                                                00003408
      IF(D.EQ. CONT) GO TC 26                                           00003409
      IF(C.EQ.STOP) GO TO 27
      IF(I.NE.5) GO TO 25
   26 REWIND IUNIT                                                      00003411
      WRITE(IUNIT,10)A                                                  00003420
      REWIND IUNIT                                                      00003430
      RETURN                                                            00003440
   27 CALL GDAR (ICOM(1))
      CALL GCLOS(IFT,ICOM(1))
      CALL EXIT
   92 CALL INCORE(Q,ISKIP,5,1,1,0,0)
      ISKIP=ISKIP+1
      GO TO 25
      END
      SUBROUTINE OUT60(IRECN,IN)
      DIMENSION B(240),ICOM(7)
C     PROGRAM TO DISPLAY A DATA SET ON 2260
C     INPUT UNIT
      DATA R,BLANK/'REDO','    '/
      DATA STOP/'STOP'/
      DATA BACK/'BACK'/
      DATA BLOAD/'LOAD'/
      DATA AUTO/'AUTO'/
      COMMON /GRAPH/ICOM
      IFT=10
      REWIND IN
    5 LINEKT=0
    1 L=1
      K=20
      DO 2 I=1,12
      IF(LINEKT .EQ. IRECN) GC TO 90
      READ (IN,100,END=90,ERR=90) (B(J),J=L,K)
      BSAVE=B(1)
      LINEKT=LINEKT+1
      L=20*I+1
      K=L+19
    2 CONTINUE
  100 FORMAT(20A4)
C     WRITE 12 LINES ON 2260
      CALL GWBUF(ICOM(1),B(1),IFT)
      CALL GWAIT(ICOM(1))
      CALL GRBUF(ICOM(1),B(1),IFT)
      IF(B(1).EQ. STOP) GC TO 91
      IF (B(1) .EQ. BLOAD) GO TO 77
      IF (B(1) .NE. BACK) GO TO 200
  140 IF(LINEKT .LE. 12) GO TC 76
      KBACKS=24
      IF(MOD(LINEKT,12) .NE. C)KBACKS=MOD(LINEKT,12)+12
      DO 150 JJ=1,KBACKS
```

```
      LINEKT=LINEKT-1
  150 BACKSPACE IN
  200 IF (B(1) .NE. R) GO TO 1
   76 REWIND IN
      GO TO 5
   90 IF(MOD(LINEKT,12) .EQ. C) GO TO 11
      IS=(I-1)*20+1
      DO 3 I=IS,240                                                    00002420
    3 B(I)=BLANK
      GO TU 10
   11 B(1)=BSAVE
   10 CALL GWBUF(ICOM(1),B(1),IFT)
      BSAVE=B(1)
      CALL GWAIT(ICOM(1))
C     READ 12 LINES FROM 2260 + TEST FIRST CHARACTER
      CALL GRBUF(ICOM(1),B(1),IFT)
      IF(B(1) .EQ. BLOAD) GO TO 77
      IF(B(1) .EQ. AUTO) GO TC 75
      IF(B(1) .EQ. STOP) GO TC 91
      IF(B(1) .EQ. R) GO TO 76
      IF (B(1) .NE. BACK) GO TO 11
      GO TO 140
      75 IRECN=-444
         RETURN
      77 IRECN=-555
      91 CONTINUE
         RETURN
         END
// EXEC LINK
//SYSLIB DD DSN=OPRLIB,UNIT=DISK,VOL=SER=ATTDET,DISP=SHR
//SYSLMOD DD DSN=IMP.LAUNCH.GCR(GCONESDR),UNIT=DISK,VOL=SER=ATTDET,
// DISP=SHR,SPACE=(TRK,(1,4,1),RLSE)
// EXEC PGM=GCONESDR,REGION=120K
//STEPLIB DD DSN=IMP.LAUNCH.GCR,DISP=SHR,VOL=SER=ATTDET,UNIT=2314
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//FT09F001 DD DSN=&&ARGLIN,DISP=(NEW,DELETE),SPACE=(TRK,(3,1)),
//   DCB=(DSORG=PS,RECFM=F,LRECL=80,BLKSIZE=80),VOL=SER=G1SCR6,UNIT=2314
//FT10F001 DD UNIT=0A4
/*
```

APPENDIX C

SECTION 1
INTRODUCTION

DCCONS is the inter-active graphics counterpart of the non-interactive program; GCONES (Ref. 1). GCONES is a differential correction routine that minimizes the weighted sum of residuals squared between measured and computed angles. The measured angles may be obtained directly from spacecraft sensor readings or computed from other spacecraft observations such as time pulses, spin rates, or components of a reference vector. The minimization is achieved by differentially correcting an a priori estimate of the attitude state variables.

SECTION 2
MODULE DESCRIPTION

Section 2 contains the module descriptions of all subroutines accessed by the DCCONS subsystem. The following conventions should be noted:

- The standard IBM System/360 FORTAN IV Library Subprograms are used for nominal arithmetic and trigonometric calculations.
- All calls to graphics displays are accomplished through the MSAD routine, CHECK (see Ref. 14).
- Each module description contains six main parts

  a. CALLING SEQUENCE reflects the physical call to the subroutine;

  b. DESCRIPTION presents a brief overview of the function of the module;

  c. COMMON AREAS REFERENCED lists, in alphabetical order, the labeled common areas accessed by the module;

  d. EXTERNAL REFERENCES lists, in alphabetical order, all external routines called by the module;

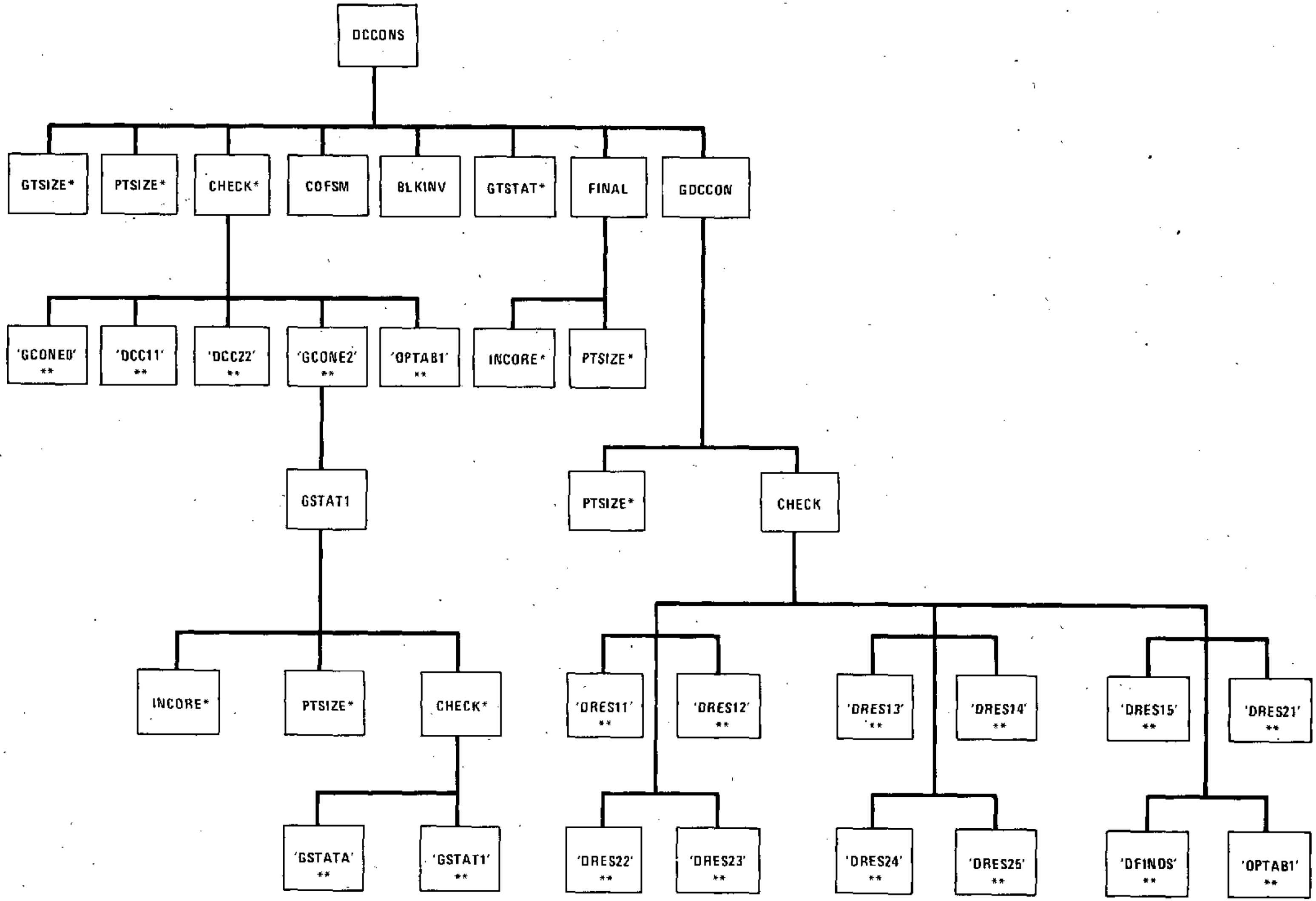
  e. STORAGE REQUIREMENTS delineates the amount of physical core storage, in decimal bytes, required by the module;

  f. VARIABLES defines the input parameters and output variables accessed by the module along with any labeled COMMON area variables utilized in the module.

- In addition to the six main parts, two parts are provided, where applicable

  a. DATA TRANSMISSION lists the unit of transmission, the type of transmission and a description of the data being transmitted. Data transmitted through MSAD display devices is listed as Control Point name, the module which calls the display, and the display description.

  b. RESTRICTIONS delineates the limitations imposed on the module.



LEGEND
* – MSAD SUBROUTINES
** – TABLE DISPLAY NAMES

SUBROUTINE DCCONS

CALLING SEQUENCE: CALL DCCONS (ALP, ALPBND, ALPCUM, DEL, DELBND, DELCUM, ARGCUM, TIME1, AXIS1, ANG1, WGHT1, IFRST1, NTYPE1, BIAS1, BBND1, RHOST1, RHO1, CALC1, SCOEF1, TIME2, AXIS2, ANG2, WGHT2, IFRST2, NTYPE2, BIAS2, BBND2, RHOST2, RHO2, CALC2, SCOEF2, AVGRHO, COEF, DRHOSQ, CHNG, STOR1, STOR2, ALPR, DELR, STYPE1, STYPE2, BTYPE, RL, WORK, GWORK0, GWORK4, GWORK5, B11CUM)

DESCRIPTION:
DCCONS is a version of GCONES designed to operate under the Multi-Satellite Attitude Determination (MSAD) executive system.

COMMON AREAS REFERENCED:
DSCOPT, GCN1, MASCOM, STVEC

EXTERNAL REFERENCES:
ABS, AMAX1, BLKINV, CHECK, COFSM, FINAL2, GDCCON, GTSIZE, GTSTAT, MAX0, MESAGE, MIN0, PTSIZE, SQRT

STORAGE REQUIREMENTS: 16,222 bytes of core storage

VARIABLES:

Variable Name	Type	Origin	I/O	Description
ALP	R*4	CS	I/O	On input a priori estimate of polynomial coefficients for right ascension, in degrees (i.e, R.A. = ALP(1) + ALP(2) * T + ALP(3) * T^2 + ALP(4) * T^3, where T = time of observation). On output, the final results.
ALPBND	R*4	CS	I	Convergence bounds for ALP, in degrees.
ALPCUM	R*4	CS	O	Cumulative results for ALP(1). (e.g., ALPCUM(5) contains the value of ALP(1) obtained for the fifth iteration).

Variable Name	Type	Origin	I/O	Description
DEL	R*4	CS	I/O	On input a priori estimate of polynomial coefficients for declination, in degrees, (i.e., D = DEL(1) + DEL(2) * T + DEL(3) * T^2 + DEL(4) * T^3, where T = time of observation). On output, the final results.
DELBND	R*4		I	Convergence bounds for DEL, in degrees.
DELCUM	R*4	CS	O	Cumulative results for DEL(1). (e.g., DELCUM(4) contains the value of DEL(1) obtained for the fourth iteration).
ARGCUM	I*4	CS	O	Iteration indicator for values in ALPCUM, and DELCUM
TIME1	R*4	CS	I	Reference times for Class 1 (cone angle) data.
AXIS1	R*4	CS	I	Reference unit vectors for Class 1 data (dimensioned 3* number of Class 1 observations).
ANG1	R*4	CS	I	Class 1 (cone angle) observations in degrees, (acceptable range 0° - 180°).
WGHT1	R*4	CS	I/O	Class 1 weights.
IFRST1	I*4	CS	I	Pointers indicating starting positions for each type of Class 1 data in the arrays: TIME1, AXIS1, ANG1, and WGHT1.
NTYPE1	I*4	CS	I	Number of observations of each type of Class 1 data.

Variable Name	Type	Origin	I/O	Description
BIAS1	R*4	CS	I/O	On input essential estimate of biases for each type of Class 1 data (the value 9999999. indicates that no bias is to be determined for the corresponding angle type). On output final bias results.
BBND1	R*4	CS	I	Convergence bounds for BIAS1 elements.
RHOST1	R*4	CS	O	Class 1 statistics defined as: RHOST1 (1, I) - weighted sum of angle residuals for type I data RHOST1 (2, I) - weighted sum of squares of angle residuals for type I data RHOST1 (3, I) - sum of weights for type I data RHOST1 (4, I) - mean residual for type I data RHOST1 (5, I) - standard deviation for type I data.
RHO1	R*4	CS	O	Residuals for Class 1 data defined as observed minus calculated.
CALC1	R*4	CS	O	Calculated angles for Class 1 data.
SCOEF1	R*4	CS	O	Derivatives of Class 1 angles with respect to state vector elements (dimensioned as NP x # of observations, where NP = # of elements in state vector).
TIME2	R*4	CS	I	Reference times for Class 2, dihedral angle, data

Variable Name	Type	Origin	I/O	Description
AXIS2	R*4	CS	I	Reference vectors for class 2 data. (Dimension 6 * number of observations, the ith dihedral angle is measured from vector ((1,i), (2,i), (3,i)) to vector ((4,i), (5,i), (6,i)).
ANG2	R*4	CS	I	Class 2 angles, in degrees (acceptable range (0° - 360°)).
WGHT2	R*4	CS	I	Weights for Class 2 data.
IFRST2	I*4	CS	I	Pointers indicating starting positions for each type of class 2 data in the arrays: TIME2, AXIS2, ANG2, and WGHT2.
NTYPE2	I*4	CS	I	Number of observations of each type of Class 2 data.
BIAS2	R*4	CS	I/O	Essential estimate of biases for each type of Class 2 data (the value 9999999. indicates that no bias is to be determined for the corresponding angle type).
BBND2	R*4	CS	I	Convergence bounds for BIAS2 elements.
RHOST2	R*4	CS	O	Class 2 statistics defined as: RHOST2 (1, I) - weighted sum of angle residuals for type I data RHOST2 (2, I) - weighted sum of squares of angle residuals for type I data RHOST2 (3, I) - sum of weights for type I data RHOST2 (4, I) - mean residual for type 2 data RHOST2 (5, I) - standard deviation for type I data.

Variable Name	Type	Origin	I/O	Description
RHO2	R*4	CS	O	Residuals for Class 2 data defined as observed minus calculated.
CALC2	R*4	CS	O	Calculated angles for Class 2 data.
SCOEF2	R*4	CS	O	Derivatives of Class 2 angles with respect to state vector elements. (Dimensioned as NP x # of observations, where NP = number of elements in the state vector.)
AVGRHO	R*4	CS	O	Used to store magnitude of average residual (dimensioned 2 x 5).
COEF	R*4	CS	O	Array used for coefficient, covariance, and correlation matricies. (Dimensioned NS x NS, where NS = number of elements in state vector.)
DRHOSQ	R*4	CS	O	Work array (dimensioned 13).
CHNG	R*4	CS	O	Work array used to store the updates to the state vector after each iteration (dimensioned 13).
STOR1	R*4	CS	O	Work array (dimensioned 13).
STOR2	R*4	CS	O	Work array (dimensioned 13).
ALPR	R*4	CS	O	Right ascension (ALP) coefficients, in radians.
DELR	R*4	CS	O	Declination (DEL) coefficients, in radians.

Variable Name	Type	Origin	I/O	Description
STYPE1	R*4	CS	O	Alpha-numeric work array (dimensioned 13).
STYPE2	R*4	CS	O	Alpha-numeric work array (dimensioned 13).
BTYPE	I*4	CS	O	Work array (dimensioned 13).
RL	L*1	CS	O	Logical work array (dimensioned 13).
WORK	R*4	CS	O	Work array (dimensioned 13).
GWORK0	R*8	CS	O	Alpha-numeric work array used to store final summary results for display (must be dimensioned as 224).
GWORK4	R*4	CS	O	Work array used to store observation number for plotting (dimensioned as N, where N = number of observations, or may be zero).
GWORK5	R*4	CS	O	Work array used to store (O-C) residuals for plotting (dimensioned as N, where N = number of observations or may be zero).
B11CUM	R*8	CS	O	Alpha-numeric work array used to store cumulative biases for display (must be dimensioned as 105).
OPTION	I*4	DCSOPT	I/O	Flag array for plotting options = 0, do not plot = 1, plot
FINISH	I*4	DCSOPT	I/O	Flag for terminating plot option table = 0, do not terminate = 1, terminate
FINALD	I*4	DCSOPT	I/O	Flag for displaying summary display = 0, do not display = 1, display

Variable Name	Type	Origin	I/O	Description
IOUT	I*4	GCN1	I	FORTRAN device unit for specified printout.
NCLAS1	I*4	GCN1	I	Number of Class 1 data types.
NCLAS2	I*4	GCN1	I	Number of Class 2 data types.
NCOF	I*4	GCN1	I	Number of polynomial coefficients for ALP and DEL (range: 1 - 4).
MAXIT	I*4	GCN1	I	Maximum number of iterations.
IRWT	I*4	GCN1	I	Intermediate printout level indicator (see references for various levels).
IOC	I*4	GCN1	I	Residual storage indicator = 0, do not store residuals = 1, store residuals for display and plotting.
ICALC	I*4	GCN1	I	Calculated values storage indicators = 0, do not store calculated values = 1, store calculated values for display.
SMULT	R*4	GCN1	I	Residual edit criteria (the weights of angles whose magnitude of residual is greater than SMULT * (average of residual magnitudes) is set to the negative of the residual thus deleting them.
NP	I*4	GCN1	I	Total number of elements in the state vector. (Defined as 2 * NCOF + number of biases.)
ISTEP	I*4	GCN1	O	Current iteration indicator.

Variable Name	Type	Origin	I/O	Description
IRET	I*4	GCN1	O	Return code = 0, process converged = 1, MAXIT exceeded, process terminated = 2, process diverged, correction element > 360° = 3, singular matrix = 4, number of biases > 5 = 5, NCOF out of range
CORMIN	I*4	GCN1	O	Display indicator for Class 1 data = 0, do not display = 1, display
CORMAX	I*4	GCN1	O	Display indicator for Class 2 data = 0, do not display = 1, display
IOPEN	I*4	MASCON	I	Graphics device indicator = 0, no graphics device active = 1, MSAD graphics device active
OLDALP	R*4	STVECT	O	Current value of ALP before iteration update.
OLDDEL	R*4	STVECT	O	Current value of DEL before iteration update.
OLDBS1	R*4	STVECT	O	Current value of BIAS1 before iteration update.
OLDBS2	R*4	STVECT	O	Current value of BIAS2 before iteration update.
NEWALP	R*4	STVECT	O	Value of ALP after iteration update.

Variable Name	Type	Origin	I/O	Description
NEWDEL	R*4	STVECT	O	Value of DEL after iteration update.
NEWBS1	R*4	STVECT	O	Value of BIAS1 after iteration update.
NEWBS2	R*4	STVECT	O	Value of BIAS2 after iteration update.

DATA TRANSMISSION:

Name	Read/Write/Check	Description
FTXXFOO1	Write	Intermediate printout, where XX = IOUT
GCONE0	Check	DCCONS initial parameter display
DCC1	Check	Class 1 data display
DCC2	Check	Class 2 data display
OPTAB1	Check	Option table display

RESTRICTIONS:

1 - The number of polynominal coefficients must be greater than or equal to 1 and less than or equal to 4.

2 - The number of biases determined, for both Class 1 and Class 2 data, must be less than or equal to 5.

3 - All calling sequence arrays are MSAD allocated, and hence, it is up to the user to ensure the allocation size of the arrays is not exceeded.

SUBROUTINE COFSM

CALLING SEQUENCE: CALL COFSM (TIME, AXIS, ANG, WGHT, NUMB, ITYPE, NDIM, ALPR, DELR, BIAS, IBIAS, COEF, DRHOSQ, RHOST, RH, CALC, SCOEF, JONE)

DESCRIPTION:

COFSM is similar to the GCONES routine COFSUM with the following added features: calculated values can be stored, derivatives can be stored, residuals can be stored.

COMMON AREAS REFERENCED:

GCN1

EXTERNAL REFERENCES:

ABS, COS, SIN

STORAGE REQUIREMENTS: 4884 bytes

VARIABLES:

Variable Name	Type	Origin	I/O	Description
TIME	R*4	CS	I	Array of observation times.
AXIS	R*4	CS	I	Reference vectors (dimensioned NDIM x (# of observations)).
ANG	R*4	CS	I	Observed angles, in degrees.
WGHT	R*4	CS	I/O	Weights for observed data.
NUMB	I*4	CS	I	Number of observations for class and type being processed.
ITYPE	I*4	CS	I	The class of data being processed.
NDIM	I*4	CS	I	Indicator for class reference vectors = 3, for Class 1 data = 6, for Class 2 data (i.e., NDIM = 3 * (number of reference vectors required to define ANG)).
ALPR	R*4	CS	I	Right ascension coefficients, in radians.

Variable Name	Type	Origin	I/O	Description
DELR	R*4	CS	I	Declination coefficients, in radians.
BIAS	R*4	CS	I	Bias for class and type of data being processed.
IBIAS	I*4	CS	I	Index to indicate bias under consideration.
COEF	R*4	CS	O	Vector [H]′ [W] ρ, where H is derivative matrix, W is weight matrix, ρ is the residual vector. (i. e., right side vector of simultaneous equations.)
RHOST	R*4	CS	O	Statistics: RHOST(1) - weighted sum of residuals RHOST(2) - weighted sum of squares of residuals RHOST(3) - sum of weights RHOST(4) - mean residuals RHOST(5) - standard deviations
RH	R*4	CS	O	Vector of residuals.
CALC	R*4	CS	O	Vector of calculated values.
SCOEF	R*4	CS	O	Matrix of partial derivatives (dimensioned number of elements in state vector x number of observations).
JONE	I*4	CS	I	Index indicating starting location of data in arrays TIME, AXIS, ANG, WGHT, RH, CALC, SCOEF for the class and type of data being processed.
IOUT	I*4	GCNI	I	Fortran device unit for specified printout.

Variable Name	Type	Origin	I/O	Description
NCOF	I*4	GCN1	I	Number of polynomial coefficients for ALP and DEL
IRWT	I*4	GCN1	I	Intermediate printout level indicator (see reference 1).
TZERO	R*4	GCN1	I	Reference time.
IOC	I*4	GCN1	I	Residual storage indicator = 0, do not store residuals = 1, store residuals for display and plotting
ICALC	I*4	GCN1	I	Calculated values storage indicator = 0, do not store calculated values = 1, store calculated values for display

DATA TRANSMISSION:

Name	Read/Write/Display	Description
FTXXFOO1	Write	Intermediate printout, where XX = IOUT

SUBROUTINE BLKINV

CALLING SEQUENCE: CALL BLKINV (COEF, I, J, NP, DET, IERR, STOR1, STOR2, RL)

DESCRIPTION:

BLKINV inverts a symmetric block diagonal matrix using a maximum pivot strategy.

COMMON AREAS REFERENCED:

None

EXTERNAL REFERENCES:

ABS

STORAGE REQUIREMENTS: 1408 bytes

VARIABLES:

Variable Name	Type	Origin	I/O	Description
COEF	R*4	CS	I/O	Symmetric matrix containing block to be inverted. On return, COEF contains inverted block.
I	I*4	CS	I	Starting row and column of block to be inverted.
J	I*4	CS	I	Stopping row and column of block to be inverted.
NP	I*4	CS	I	Size of the square matrix COEF (dimension of COEF is NP x NP).
DET	R*4	CS	O	Value of the determinant.
IERR	I*4	CS	O	Error code = 0, normal return = 1, zero pivot element, inverse cannot be obtained
STOR1	R*4	CS	O	Work array (size of NP or larger).
STOR2	R*4	CS	O	Work array (size of NP or larger).
RL	L*1	CS	O	Work array (size of NP or larger).

SUBROUTINE GSTAT1

CALLING SEQUENCE: CALL GSTAT1 (ALP, ALPBND, ALPCUM, DEL, DELBND, DELCUM, ARGCUM, TIME1, AXIS1, ANG1, WGHT1, IFRST1, NTYPE1, BIAS1, BBND1, RHOST1, RHO1, CALC1, SCOEF1, TIME2, AXIS2, ANG2, WGHT2, IFRST2, NTYPE2, BIAS2, BBND2, RHOST2, RHO2, CALC2, SCOEF2, AVGRHO, COEF, DRHOSQ, CHNG, STOR1, STOR2, ALPR, DELR, STYPE1, STYPE2, BTYPE, RL, WORK, B11CUM)

DESCRIPTION:

GSTAT1 stores cumulative iteration results for displaying and performs residual editing on the data.

COMMON AREAS REFERENCED:

FLAGG, GCN1, GDCON

EXTERNAL REFERENCES:

ABS, CHECK, INCORE, PTSIZE

STORAGE REQUIREMENTS: 5400 bytes

VARIABLES:

Variable Name	Type	Origin	I/O	Description
ALP	R*4	CS	I	A priori polynomial coefficients for right ascension, in degrees.
ALPBND	R*4	CS	I	Convergence bounds for ALP, in degrees.
ALPCUM	R*4	CS	O	Cumulative results for ALP(1) (dimensioned as 21).
DEL	R*4	CS	I	A priori polynomial coefficients for declination, in degrees.
DELBND	R*4	CS	I	Convergence bounds for DEL, in degrees.
DELCUM	R*4	CS	O	Cumulative results for DEL(1) (dimensioned as 21).
ARGCUM	I*4	CS	O	Iteration indicator for values in ALPCUM and DELCUM (dimensioned as 21).
TIME1	R*4	CS	I	Reference times for Class 1 (cone angle) data.

Variable Name	Type	Origin	I/O	Description
AXIS1	R*4	CS	I	Reference unit vectors for Class 1 data (dimensioned 3 * number of Class 1 observations).
ANG1	R*4	CS	I	Class 1 (cone angle) observations, in degrees.
WGHT1	R*4	CS	I/O	Class 1 weights.
IFRST1	I*4	CS	I	Pointers indicating starting positions for each type of Class 1 data in the arrays: TIME1, AXIS1, ANG1, WGHT1.
NTYPE1	I*4	CS	I	Number of observations of each type of Class 1 data.
BIAS1	R*4	CS	I	Essential estimate of biases for each type of Class 1 data.
BBND1	R*4	CS	I	Convergence bounds for BIAS1 elements.
RHOST1	R*4	CS	I	Class 1 statistics defined as: RHOST1(1,I) - weighted sum of angle residuals for type I data RHOST1(2,I) - weighted sum of squares of angle residuals for type I data RHOST1(3,I) - sum of weights for type I data RHOST1(4,I) - mean residuals for type I data RHOST1(5,I) - standard deviations for type I data.
RHO1	R*4	CS	I	Residuals for Class 1 data defined as observed minus calculated.
CALC1	R*4	CS	I	Calculated angles for Class 1 data.

Variable Name	Type	Origin	I/O	Description
SCOEF1	R*4	CS	I	Derivatives of Class 1 angles with respect to state vector elements (dimensioned as NP * number of observations where NP = number of elements in the state vector).
TIME2	R*4	CS	I	Reference times for Class 2, dihedral angle, data.
AXIS2	R*4	CS	I	Reference vectors for Class 2 data (dimensioned 6 x number of observations. The ith dihedral angle is measured from vector ((1, i), (2, i), (3, i)) to vector ((4, i), (5, i), (6, i)).
ANG2	R*4	CS	I	Class 2 angles, in degrees.
WGHT2	R*4	CS	I/O	Weights for Class 2 data.
IFRST2	I*4	CS	I	Pointers indicating starting positions for each type of Class 2 data in the arrays: TIME2, AXIS2, ANG2, WGHT2.
NTYPE2	I*4	CS	I	Number of observations of each type of Class 2 data.
BIAS2	R*4	CS	I	Essential estimate of biases for each type of Class 2 data.
BBND2	R*4	CS	I	Convergence bounds for BIAS2 elements.
RHOST2	R*4	CS	I	Class 2 statistics defined as: RHOST2(1, I) - weighted sum of angle residuals for type I data RHOST2(2, I) - weighted sums of squares of angle residuals for type I data

Variable Name	Type	Origin	I/O	Description
RHOST2	R*4	CS	I	RHOST2(3, I) - sum of weights for type I data RHOST2(4, I) - mean residuals for type I data RHOST2(5, I) - standard deviations for type I data.
RHO2	R*4	CS	I	Residuals for Class 2 data defined as observed minus calculated.
CALC2	R*4	CS	I	Calculated angles for Class 2 angles.
SCOEF2	R*4	CS	I	Derivatives of Class 2 angles with respect to state vector elements (dimensioned as NP x # of observ-vations, where NP = number of elements in state vector).
AVGRHO	R*4	CS	O	Used to store magnitude of average residual (dimensioned 2 x 5).
COEF	R*4	CS	I	Array used for coefficient, covariance, and correlation matrices (dimensioned NS x NS, where NS = number of elements in state vector).
DRHOSQ	R*4	CS	I	Work array (dimensioned 13).
CHNG	R*4	CS	I	Work array used to store the up-dates to the state vector after each iteration (dimensioned 13).
STOR1	R*4	CS	I	Work array (dimensioned 13).
STOR2	R*4	CS	I	Work array (dimensioned 13).
ALPR	R*4	CS	I	Right ascension (ALP) coefficients, in radians.

Variable Name	Type	Origin	I/O	Description
DELR	R*4	CS	I	Declination (DEL) coefficients, in radians.
STYPE1	R*4	CS	I	Alpha-numeric work array (dimensioned 13).
STYPE2	R*4	CS	I	Alpha-numeric work array (dimensioned 13).
BTYPE	I*4	CS	I	Work array (dimensioned 13).
RL	L*1	CS	I	Work array (dimensioned 13).
WORK	R*4	CS	I	Work array (dimensioned 13).
B11CUM	R*8	CS	O	Alpha-numeric work array used to store cumulative biases for display (dimensioned as 105).
IOUT	I*4	GCN1	I	Fortran device unit for specified output.
NCLAS1	I*4	GCN1	I	Number of class 1 data types.
NCLAS2	I*4	GCN1	I	Number of Class 2 data types.
IRWT	I*4	GCN1	I	Intermediate printout level indicator (see Reference 1 for various levels).
IOC	I*4	GCN1	I	Residual storage indicator = 0, do not store residuals = 1, store residuals for display and plotting.
SMULT	R*4	GCN1	I	Residual edit criteria (the weights of angles whose magnitude of residual is greater than SMULT * (average of residual magnitude) is set to the negative of the residual thus deleting them from the differential correction process.

Variable Name	Type	Origin	I/O	Description
ISTEP	I*4	GCN1	I	Current iteration indicator.
AVG	R*4	GDCON	O	Residual edit bound (i.e., average residual for Class 1 and Class 2 data).

DATA TRANSMISSION:

Name	Read/Write/Check	Description
FTXXFØØ1	Write	Intermediate printout, where XX = IOUT.
GSTATA	Check	Cumulative state vector display.
GSTAT1	Check	Residual edit data display.

SUBROUTINE FINAL2

CALL SEQUENCE: CALL FINAL2 (GWORK0, ALP, DEL, AI, DI, BIASI, BIAS1, BIAS2I, BIAS2, RHOST1, RHOST2, NTYPE1, NTYPE2, NCOF, IALL0, COVAR, NC)

DESCRIPTION:

FINAL2 converts the initial and current iteration values of the state vector into alpha-numeric characters for the summary display.

COMMON AREAS REFERENCED:

None

EXTERNAL REFERENCES:

INCORE, PTSIZE, SQRT

STORAGE REQUIREMENTS: 4224 bytes

VARIABLES:

Variable Name	Type	Origin	I/O	Description
GWORK0	R*8	CS	O	Work array where alpha-numeric equivalents of previous and current values of the state vector are stored.
ALP	R*4	CS	I	Right ascension polynomial coefficients, in degrees.
DEL	R*4	CS	I	Declination polynomial coefficients, in degrees.
AI	R*4	CS	I	Initial right ascension polynomial coefficients, in degrees.
DI	R*4	CS	I	Initial declination polynomial coefficients, in degrees.
BIASI	R*4	CS	I	Initial biases for each type of Class 1 data, in degrees.
BIAS1	R*4	CS	I	Biases for each type of Class 1 data, in degrees.
BIAS2I	R*4	CS	I	Initial biases for each type of Class 2 data, in degrees.
BIAS2	R*4	CS	I	Biases for each type of Class 2 data, in degrees.
RHOST1	R*4	CS	I	Class 1 statistics (see DCCONS module description for RHOST1 (1, I) - RHOST1(3, I)) RHOST1(4, I) - mean residual for type I data RHOST1(5, I) - standard deviation for type I data.

Variable Name	Type	Origin	I/O	Description
RHOST2	R*4	CS	I	Class 2 statistics (see DCCONS module description for RHOST2 (1, I) - RHOST2 (3, I)) RHOST2 (4, I) - mean residual for type I data RHOST2 (5, I) - standard deviation for type I data.
NTYPE1	I*4	CS	I	Number of Class 1 data types.
NTYPE2	I*4	CS	I	Number of Class 2 data types.
NCOF	I*4	CS	I	Number of polynomial coefficients for ALP and DEL.
IALL0	I*4	CS	I	Allocation size for GWORK0 array (must be 224).
COVAR	I*4	CS	I	Covariance matrix for state vector elements.
NC	I*4	CS	I	Number of elements in the state vector.

SUBROUTINE GDCCON

CALLING SEQUENCE: CALL GDCCON (IALL4, IALL5, IFRST1, IFRST2, NTYPE1, NTYPE2, RHO1, RHO2, GWORK4, GWORK5, IALL0)

DESCRIPTION:

GDCCON stores the computed residuals for plotting into work arrays and calls the MSAD related tables to display the plots.

COMMON AREAS REFERENCED:

DCSOPT, GCN1

EXTERNAL REFERECES:

CHECK, PTSIZE

STORAGE REQUIREMENTS: 1786 bytes

VARIABLES:

Variable Name	Type	Origin	I/O	Description
IALL4	I*4	CS	I	Allocation size of GWORK4 array.
IALL5	I*4	CS	I	Allocation size of GWORK5 array.
IFRST1	I*4	CS	I	Pointers indicating starting positions for each type of Class 1 data in the RHO1 array.
IFRST2	I*4	CS	I	Pointers indicating starting positions for each type of Class 2 data in the RHO2 array.
NTYPE1	I*4	CS	I	Number of observations of each type of Class 1 data.
NTYPE2	I*4	CS	I	Number of observations of each type of Class 2 data.
RHO1	R*4	CS	I	Residuals for Class 1 data defined as observed minus calculated.
RHO2	R*4	CS	I	Residuals for Class 2 data defined as observed minus calculated.
GWORK4	R*4	CS	O	Work array for storage of observation numbers for each class and type of data (dimensioned as # of observations).
GWORK5	R*4	CS	O	Work array for storage of residuals for each class and type of data (dimensioned as number of observations).
IALL0	I*4	CS	I	Allocation size of GWORK0 (must be 224 or 0).

Variable Name	Type	Origin	I/O	Description
OPTION	I*4	DCSOPT	I/O	Flag array for plotting options = 0, do not plot = 1, plot
FINISH	I*4	DCSOPT	I/O	Flag for terminating plot option table = 0, do not terminate = 1, terminate
FINALD	I*4	DCSOPT	I/O	Flag for displaying summary display = 0, do not display = 1, display
NCLAS1	I*4	GCN1	I	Number of Class 1 data types.
NCLAS2	I*4	GCN1	I	Number of Class 2 data types.
IOC	I*4	GCN1	I	Residual storage indicator = 0, do not store residuals = 1, store residuals for display and plotting

DATA TRANSMISSION:

Name	Read/Write/Check	Description
DRES11	Check	Residual plot for Class 1 type 1 data.
DRES12	Check	Residual plot for Class 1 type 2 data.
DRES13	Check	Residual plot for Class 1 type 3 data.
DRES14	Check	Residual plot for Class 1 type 4 data.
DRES15	Check	Residual plot for Class 1 type 5 data.

Name	Read/Write/Check	Description
DRES21	Check	Residual plot for Class 2 type 1 data.
DRES22	Check	Residual plot for Class 2 type 2 data.
DRES23	Check	Residual plot for Class 2 type 3 data.
DRES24	Check	Residual plot for Class 2 type 4 data.
DRES25	Check	Residual plot for Class 2 type 5 data.
DFINDP	Check	Summary display
OPTAB1	Check	Plot option table display

SECTION 3
RESOURCES

The DCCONS subsystem is designed to operate under the Multi-Satellite Attitude Determination (MSAD) system on either the IBM 360/75, 360/91, or 360/95.

3.1 Environment

DCCONS is a differential correction routine which minimizes the weighted sum of residuals squared between measured and computed angles to obtain corrections to the state vector through the facility of interactive graphics. The MSAD Executive system provides the interactive capabilities through a graphics display device. The operator can edit control parameters and data via the display device, thereby enhancing the otherwise noninteractive flow of the program.

3.1.1 Hardware Requirements

Hardware requirements for the DCCONS subsystem are as follows:

- Input:
  - none
- Output:
  - one line printer
  - one 2250 or 2260 graphics display unit
  - one tape drive (optional, if hard copy of the MSAD plots is required)

3.1.2 Storage Requirements

The DCCONS subsystem requires 32.5 K bytes of core storage on the IBM System/360-95 to operate in a graphics mode. Due to the dynamic allocation feature of the MSAD system, this figure does not include the allocation sizes of the work arrays which are user determined, nor does this figure include the amount of core storage required to store the DCCONS graphics tables.

3.2 Software Requirements

The DCCONS subsystem is written in the FORTRAN IV programming language, currently operational on OS Release 21.6. The following external libraries are assessed by DCCONS:

- IBM System/360 FORTRAN IV Library Subprograms
- Multi-Satellite Attitude Determination (MSAD) Executive System User's Guide (Ref. 14)

SECTION 4
INPUT

All user supplied input is passed to the DCCONS subsystem through the use of calling sequences and labeled COMMON areas. For a definition of input parameters, refer to Section 2, Module Descriptions.

The user may also alter control parameters and data through the interactive graphics facility. For a discussion of this feature, refer to Section 5, Graphics Output.

SECTION 5
GRAPHICS DISPLAYS

This section describes all the graphics displays generated by the DCCONS sub-system. These displays are designed to aid an operator at a 2250 graphics terminal in the immediate determination of attitude solutions and to insure data consistency. Controlled by user option, these displays permit an operator to alter the initial state vector variable estimates and variable error tolerances, to review input cone and dihedral angles with their associated weights and times, to observe the cumulative iteration results for each state vector update, to review the calculated residuals and to alter any, if needed, to choose observed minus computed (O-C) residual plots for observation, and to view the summary of the state vector updates for each iteration.

Several general comments should be noted. Each display is associated with an MSAD table which is called from the DCCONS sub-system. In accordance with the MSAD conventions, any display not required in a given pass through the data may be omitted by setting the status flag of the display control point to SKIP in the MSAD ARTCMM display. See Figure 5-1 for a list of all DCCONS related control point display names. The dimensions of all MSAD allocated arrays are user controlled; hence, the operator can alter the master numbers of all internal arrays via the MSAD XSTOPS display. See Figure 5-2 for an illustration of the available DCCONS arrays. In addition, the user has the opportunity to request any display from any display screen via the MSAD automatic call mechanism. The user should be cautioned that a display thus called will contain current information only if the display has been previously created within the same iteration as the display from which the call has been issued.

Short descriptions of the functions and options of the DCCONS displays are provided in this section. In addition, an illustration of the display as it would appear on the IBM 2250 graphics console is provided for user correlation.

5.1 DCCONS Coefficients and Parameters Display

This display permits an operator at the IBM 2250 console to observe the initial attitude estimates and the initial program tolerances, to alter these values through the IBM 2250 graphics display keyboard, and to redisplay them on the 2250 unit.

The DCCONS coefficients and parameter display consists of three groups. The first group contains the DCCONS control parameters (i.e., number of alpha/delta coefficients, maximum number of iterations, printed output level, printer unit, numbers of class 1 and class 2 data types, system reference time, residual edit criteria, and the number of elements in the state vector). If the number of alpha/delta coefficients, the numbers of class 1 and class 2 data types, or the number of biases to be solved (see group three) are altered, the number of elements in the state vector must also be altered to coincide. If this number has not been altered, the original display will reappear. When the numbers coincide, the augmented or deleted display will appear for user input into the third group.

The second group consists of option parameters. These options permit the operator to choose which data, if any, is pertinent for display purposes. If the user requests the storage of residuals for plotting, the DCCONS residuals plot arrays must be allocated. If this option is turned off, the operator cannot request any residual plots. The "store computed values for display" option allows the operator to observe the calculated angles. If this option is not activated, a series of EEEEEEE's will appear in the 'CALCULATED VALUES' column of the RESIDUALS and WEIGHTS display (see sections 5.6 and 5.7). The final option in this group permits the operator to review and edit class 1 and/or class 2 data.

The third group consists of the initial state vector estimates and convergence bounds. The user can alter any or all of the values present. To disregard a bias associated with a particular class and type of data, the number 9999999.0 should be entered into the bias slot. If the number of state parameter values has been previously altered, this third group will be changed to reflect the alteration. The user then should input into the variable slots.

Figure 5.3 illustrates the DCCONS Coefficients and Parameters Displays.

5.2 DCCONS Observed Data — Class 1

This display permits an operator at the IBM 2250 graphics console to observe all class 1 (cone angle) data input. The values displayed (i.e., time of observation, reference vector, cone angle, weight) can be altered by the user.

To obtain this display, the operator can either enter a YES into the 'EDIT CLASS 1 DATA' parameter, or he can exercise the MSAD automatic call mechanism and CALL this display (DC11) from any other MSAD display.

Figure 5-4 illustrates the DCCONS Observed Data — Class 1 Display

5.3 DCCONS Observed Data — Class 2

This display permits an operator at the IBM 2250 graphics console to observe all Class 2 (dihedral angle) data input. The values displayed (i.e., time of observation, reference vector, dihedral angle, weight) can be altered by the user.

To obtain this display, the operator can either enter a YES into the 'EDIT CLASS 2 DATA' parameter, or he can exercise the MSAD automatic call mechanism and CALL this display (DC22) from any other MSAD display.

Figure 5-4 illustrates the DCCONS Observed Data —Class 1 Display.

5.3 DCCONS Observed Data — Class 2

This display permits an operator at the IBM 2250 graphics console to observe all Class 2 (dihedral angle) data input. The values displayed (i.e., time of observation, reference vector, dihedral angle, weight) can be altered by the user.

To obtain this display, the operator can either enter a YES into the 'EDIT CLASS 2 DATA' parameter, or he can exercise the MSAD automatic call mechanism and CALL this display (DC22) from any other MSAD display.

Figure 5-5 illustrates the DCCONS Observed Data — Class 2 Display.

5.4 Error Statistics Display

This display allows the user at the 2250 graphics console to observe the computed mean residuals and standard deviations for each class and type of data being processed. This display can either be obtained by setting the status flag of the display (DCCONS RESIDUAL STATISTICS) to 'STOP', or it can be CALLed via the MSAD automatic call mechanism from any subsequent display (see Sections 5.5, 5.6, 5.7, 5.8, 5.9) within the same iteration.

Figure 5-6 illustrates the Error Statistics Display.

5.5 Cumulative State Vector Display

This display allows an operator at the IBM 2250 graphics console to observe, on an iteration by iteration basis, the updates to the state vector. The purpose of this display is to permit the operator to respond to any gross alteration in the state vector values. This display can either be obtained by setting the status flag of the display (DCCONS CUMULATIVE STATE RESULTS) to 'STOP', or it can be obtained by issuing a CALL via the MSAD automatic call mechanism from any subsequent display (see Sections 5.6, 5.7, 5.8, 5.9) in the same iteration.

Figure 5-7 illustrates the Cumulative State Vector Display.

5.6 Class 1 Residuals and Weights

This display permits an operator at a 2250 graphics console to observe the calculated residuals (observed minus computed) and their associated weights. The user has the option to alter any of the angle weights. If a negative weight is associated with an input angle, that data has been edited by the residual edit feature of

DCCONS. Those angles so edited will not be included in the current and subsequent calculations of the state vector updates, and will not appear in any of the (O-C) residual plots. If the user manually edits the data, the data so edited will included in the current iteration, but will be disregarded by subsequent iterations.

The residuals will only be displayed if the 'STORE RESIDUALS FOR PLOTTING' in the DCCONS COEFFICIENTS AND PARAMETERS Display (see Section 5.1)

Figure 5-8 illustrates the Class 1 Residuals and Weights.

5.7 Class 2 Residuals and Weights

The display permits an operator at a 2250 graphics console to observe the calculated residuals (observed minus computed) and their associated weights. The user has the option to alter any of the angle weights. If a negative weight is associated with an input angle, that data has been edited by the residual edit feature of DCCONS. Those angles so edited will not be included in the current and subsequent calculations of the state vector updates, and will not appear in any of the (O-C) residual plots. If the user manually edits the data, the data so edited will be included in the current iteration, but will be disregarded by subsequent iterations.

The residuals will only be displayed if the 'STORE RESIDUALS FOR PLOTTING' in the DCCONS COEFFICIENTS AND PARAMETERS Display (see Section 5.1)

Figure 5-9 illustrates the Class 2 Residuals and Weights.

5.8 Plot Option Table for DCCONS Display

This display permits an operator at an IBM 2250 graphics console to observe the status of DCCONS and to choose (O-C) residual plots for observation.

The PLOT OPTION TABLE consists of three groups. The first group reports on the status of DCCONS at the current iteration. If 'DID DCCONS CONVERGE ?' is set to 'NO', and all other status' are 'NO', then the user has the option to continue processing, to terminate, or to reprocess. If any of the other status questions are answered with a 'YES', the user has the option of terminating or reinitializing. If neither of these options (see group three) is chosen, then the termination of the display will result in the termination of DCCONS processing. This group is protected and cannot be altered by the user.

The second group consists of a list of plots available for user inspection and the attitude summary display option. The user may choose any plot, and/or the summary display by typing in 'YES' into the associated field. Any number of plots may be chosen, but the plots will appear in the order listed in the PLOT OPTION TABLE Display. If the user does not require any of the displays offered, and all of the status' in group one are set to 'NO' the operator can 'SKIP' out of PLOT OPTION TABLE Display. If, however, any display is requested or if any of the status' in group one is set to 'YES', the user must request termination of the PLOT OPTION TABLE Display (see group three). If this option is not set, the PLOT OPTION TABLE Display will continue to appear until this option has been set to 'NO' by the user.

The third group consists of options available to the user. The user may terminate DCCONS processing from this display; he may reinitialize DCCONS processing; or he may allow the program to flow normally by not setting any of the above options. Included in this third group is the option to 'EXIT THE PLOT OPTION TABLE'. When the user is finished observing a particular iteration of data, the user must set the exit option to 'YES'. DCCONS will continue processing the next iteration, or it will process according to the options in group three.

Figure 5-10 illustrates the PLOT OPTION TABLE.

5.9 Final State Vector Results from DCCONS Display

This display allows an operator at an IBM 2250 console to view the initial and intermediate iteration state vector values plus the mean residuals and standard deviations for each type and class of data.

The display can only be observed if the appropriate field in the PLOT OPTION TABLE (see Section 5.8, SUMMARY DISPLAY) is set to 'YES'.

Figure 5-11 illustrates the FINAL STATE VECTOR RESULTS FROM DCCONS Display.

```
************************************         M S A D         **********************************
****  ***************** ************   D I S P L A Y   ***********  73.179.12.12.26  ****
**                                                                                       **
**      XSTOFS          DISPLAY STATUS FLAGS AND KEY ASSIGNMENTS                         **
**                                                                                       **
**      XSTOFS DISPLAY                                  STOP                             **
**      ARTCOM DISPLAY                                  STOP                             **
**      DCCONS INITIAL CONDITIONS AND ESTIMATE          STOP                             **
**      EDIT CLASS 1 DATA WEIGHTS                       STOP                             **
**      EDIT CLASS 2 DATA WEIGHTS                       STOP                             **
**      DCCONS RESIDUAL STATISTICS                      STOP                             **
**      DCCONS CUMULATIVE STATE RESULTS                 STOP                             **
**      DCCONS RESIDUAL DATA DISPLAY                    STOP                             **
**      RESIDUAL CLASS 1 TYPE 1 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 1 TYPE 2 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 1 TYPE 3 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 1 TYPE 4 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 1 TYPE 5 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 2 TYPE 1 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 2 TYPE 2 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 2 TYPE 3 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 2 TYPE 4 STOP DISPLAY            STOP                             **
**      RESIDUAL CLASS 2 TYPE 5 STOP DISPLAY            STOP                             **
**      FINAL STATE CHARACTER DISPLAY                   STOP                             **
**      PLOT OPTION TABLE FOR DCCONS                    STOP                             **
**                                                                                       **
**    CPCINT=MSADE1 WHAT NOW    NEXT       CALL DISPLAY        DISP   1 OF   1           **
**                                                                                       **
************************************         M S A D         **********************************
************************************     D I S P L A Y     **********************************
```

Figure 5-1

```
************************************     M S A D     ************************************
****  **************** ************   D I S P L A Y   ***********  73.179.12.12.37   ****
**                                                                                     **
**      ARTCOM                       MASTER NUMBERS                                    **
**                                                                                     **
**      DIRECTORY ARRAYS                           45                                  **
**      DCCCNS CLASS 1 DATA ARRAYS                200                                  **
**      DCCCNS CLASS 2 DATA ARRAYS                200                                  **
**      DCCCNS ATTITUDE ARRAYS                      4                                  **
**      DCCCNS CLASSIFICATION AND BIAS ARRAYS       5                                  **
**      DCCCNS ARRAY AVGRED                         5                                  **
**      DCCCNS WORK ARRAYS (SIZE MUST BE 13)       13                                  **
**      DCCCNS CUMULATIVE ARRAYS                   21                                  **
**      CUMULATIVE BIAS ARRAY                     105                                  **
**      DCCCNS FINAL STATE SUMMARY ARRAY          224                                  **
**      DCCCNS RESIDUAL PLOT ARRAYS               200                                  **
**                                                                                     **
**     CFCINT=ARTCOMM WHAT NOW           CALL DISPLAY          DISP   1 OF   1         **
**                                                                                     **
************************************     M S A D     ************************************
************************************   D I S P L A Y   **********************************
```

Figure 5-2

```
************************************      M S A D      ************************************
****  ***************** ************    D I S P L A Y    ************  73.179.12.13.32  ****
**                                                                                        **
**      CCNO              DCCONS COEFFICIENTS AND PARAMETERS                              **
**                                                                                        **
**      NUMBER OF ALPHA/DELTA COEFFICIENTS           1                                    **
**      MAXIMUM NUMBER OF ITERATIONS                 5                                    **
**      PRINTED OUTPUT LEVEL                        14                                    **
**      SYSOUT UNIT FOR DCCONS                       6                                    **
**      NUMBER OF CLASS 1 DATA TYPES                 3                                    **
**      NUMBER OF CLASS 2 DATA TYPES                 2                                    **
**      REFERENCE TIME                                       0.0                          **
**      RESIDUAL EDIT CRITERIA                       0.0                                  **
**      NUMBER OF ELEMENTS IN STATE VECTOR           6                                    **
**                                                                                        **
**      STORE (O-C) RESIDUALS FOR PLOTTING        NO                                      **
**      STORE COMPUTED VALUES                     NO                                      **
**      COMPUTE COVARIANCE/CORRELATION MATRIX     NO                                      **
**      GRAPHICALLY EDIT CLASS 1 DATA             NO                                      **
**      GRAPHICALLY EDIT CLASS 2 DATA             NO                                      **
**                                                                                        **
**      ENTER INITIAL ESTIMATES OF STATE                                                  **
**      VECTOR AND CONVERGENCE BOUNDS                                                     **
**                                                                                        **
**     ALPHA    CONVRG   DELTA    CONVRG   BIASES  CONVRG   BIASES  CONVRG                **
**     COEFF    BOUNDS   COEFF    BOUNDS   CLASS 1 BOUNDS   CLASS 2 BOUNDS                **
**     275.000  0.00100  55.000   0.00100   0.0    0.00100   0.0    0.00100               **
**                                          0.0    0.00100   0.0    0.00100               **
**                                          0.0    0.00100                                **
**                                                                                        **
**                                                                                        **
**     CFLINT=GCONEO WHAT NOW                 CALL DISPLAY          DISP   1 OF   1       **
**                                                                                        **
************************************      M S A D      ************************************
************************************    D I S P L A Y    **********************************
```

Figure 5-3

```
**********************************        M S A D       **********************************
****  ****************  ************    D I S P L A Y    ***********  73.179.12.14.20  ****
**                                                                                       **
**      DCC1                   DCCINS OBSERVED DATA CLASS 1                              **
**                                                                                       **
**        TIME1        RES.       VECTOR                  CONE       WEIGHT              **
**                     X          Y          Z            ANGLE                          **
**      -5370.000    -0.947     -0.296     -0.128        89.10     0.10E 05              **
**      -5308.797    -0.947     -0.296     -0.128        88.97     0.10E 05              **
**      -5247.598    -0.947     -0.296     -0.128        89.09     0.10E 05              **
**      -5189.996    -0.947     -0.296     -0.128        89.12     0.10E 05              **
**      -5128.797    -0.947     -0.296     -0.128        88.93     0.10E 05              **
**      -5067.602    -0.947     -0.296     -0.128        89.09     0.10E 05              **
**      -5010.000    -0.947     -0.296     -0.128        89.10     0.10E 05              **
**      -4948.797    -0.947     -0.296     -0.128        88.87     0.10E 05              **
**      -4887.598    -0.947     -0.296     -0.128        88.97     0.10E 05              **
**      -4830.000    -0.947     -0.296     -0.128        89.26     0.10E 05              **
**      -4768.797    -0.947     -0.296     -0.128        88.96     0.10E 05              **
**      -4707.598    -0.947     -0.296     -0.128        89.09     0.10E 05              **
**      -4650.000    -0.947     -0.296     -0.128        89.22     0.10E 05              **
**      -4588.801    -0.947     -0.296     -0.128        88.91     0.10E 05              **
**      -4527.598    -0.947     -0.296     -0.128        89.14     0.10E 05              **
**      -4470.000    -0.947     -0.296     -0.128        89.25     0.10E 05              **
**      -4408.797    -0.947     -0.296     -0.128        89.00     0.10E 05              **
**      -4347.598    -0.947     -0.296     -0.128        89.14     0.10E 05              **
**      -4290.000    -0.947     -0.296     -0.128        89.08     0.10E 05              **
**      -4228.801    -0.947     -0.296     -0.128        88.38     0.10E 05              **
**      -4167.598    -0.947     -0.296     -0.128        89.00     0.10E 05              **
**      -4110.000    -0.947     -0.296     -0.128        89.05     0.10E 05              **
**      -4048.799    -0.947     -0.296     -0.128        88.92     0.10E 05              **
**      -3987.602    -0.947     -0.296     -0.128        88.89     0.10E 05              **
**      -3929.999    -0.947     -0.296     -0.128        89.09     0.10E 05              **
**      -3868.799    -0.947     -0.296     -0.128        88.89     0.10E 05              **
**      -3807.600    -0.947     -0.296     -0.128        89.16     0.10E 05              **
**      -3750.000    -0.947     -0.296     -0.128        89.04     0.10E 05              **
**      -3688.799    -0.947     -0.296     -0.128        89.01     0.10E 05              **
**      -3627.599    -0.947     -0.296     -0.128        88.86     0.10E 05              **
**      -3570.002    -0.947     -0.296     -0.128        88.97     0.10E 05              **
**      -3508.799    -0.947     -0.296     -0.128        89.04     0.10E 05              **
**      -3447.599    -0.947     -0.296     -0.128        88.94     0.10E 05              **
**      -3390.000    -0.947     -0.296     -0.128        89.08     0.10E 05              **
**      -3328.800    -0.947     -0.296     -0.128        89.16     0.10E 05              **
**      -3267.600    -0.947     -0.296     -0.128        89.12     0.10E 05              **
**       4591.199    -0.946     -0.297     -0.129        88.89     0.10E 05              **
**       4652.398    -0.946     -0.297     -0.129        89.10     0.10E 05              **
**       4710.000    -0.946     -0.297     -0.129        89.05     0.10E 05              **
**       4771.199    -0.946     -0.297     -0.129        89.01     0.10E 05              **
**       4832.398    -0.946     -0.297     -0.129        88.95     0.10E 05              **
**       4889.996    -0.946     -0.297     -0.129        89.11     0.10E 05              **
**       4951.199    -0.946     -0.297     -0.129        89.12     0.10E 05              **
**       5012.398    -0.946     -0.297     -0.129        88.90     0.10E 05              **
**       5069.996    -0.946     -0.297     -0.129        89.07     0.10E 05              **
**       5131.199    -0.946     -0.297     -0.129        89.06     0.10E 05              **
**                                                                                       **
**     CPOINT=DCC11  WHAT NOW   NEXT      CALL DISPLAY        DISP   1 OF    1           **
**                                                                                       **
**********************************        M S A D       **********************************
**********************************    D I S P L A Y     **********************************
```

Figure 5-4

M S A D

D I S P L A Y 73.179.12.14.24

DCC1 DCCONS OBSERVED DATA CLASS 1

TIME1	RES. X	VECTOR Y	Z	CONE ANGLE	WEIGHT
5192.398	-0.946	-0.297	-0.129	88.95	0.10E 05
5249.996	-0.946	-0.297	-0.129	89.01	0.10E 05
5311.199	-0.946	-0.297	-0.129	89.21	0.10E 05
5372.398	-0.946	-0.297	-0.129	88.90	0.10E 05
-5368.969	0.944	-0.286	-0.164	86.01	0.44E 03
-5368.180	0.944	-0.285	-0.164	89.23	0.85E 01
-5307.746	0.956	-0.254	-0.146	85.65	0.56E 03
-5306.957	0.956	-0.253	-0.145	82.94	0.34E 02
-5246.523	0.967	-0.221	-0.127	85.94	0.54E 03
-5245.734	0.967	-0.221	-0.127	81.67	0.64E 02
-5188.902	0.976	-0.191	-0.109	86.51	0.46E 03
-5188.113	0.976	-0.190	-0.109	87.11	0.34E 02
-5127.684	0.983	-0.158	-0.090	88.01	0.25E 03
-5126.891	0.983	-0.158	-0.090	89.69	0.27E 02
-5066.461	0.990	-0.125	-0.071	85.52	0.85E 03
-5065.668	0.990	-0.125	-0.071	84.16	0.14E 03
-5008.840	0.994	-0.094	-0.053	86.18	0.73E 03
-5008.047	0.994	-0.093	-0.053	84.95	0.17E 03
-4947.617	0.998	-0.060	-0.034	86.53	0.78E 03
-4946.828	0.998	-0.060	-0.034	87.56	0.12E 03
-4886.395	1.000	-0.027	-0.015	87.05	0.69E 03
-4885.605	1.000	-0.026	-0.014	88.98	0.84E 02
-4828.777	1.000	0.005	0.004	87.85	0.46E 03
-4827.980	1.000	0.005	0.004	85.37	0.39E 03
-4767.551	0.999	0.038	0.023	87.06	0.98E 03
-4766.762	0.999	0.039	0.023	87.10	0.36E 03
-4706.328	0.997	0.072	0.042	87.59	0.88E 03
-4705.535	0.996	0.072	0.043	86.49	0.62E 03
-4648.711	0.993	0.103	0.060	87.78	0.95E 03
-4647.918	0.993	0.103	0.061	88.02	0.41E 03
-4587.488	0.987	0.136	0.080	88.08	0.13E 04
-4586.695	0.987	0.136	0.080	87.27	0.12E 04
-4526.266	0.981	0.169	0.099	87.65	0.22E 04
-4525.473	0.981	0.169	0.099	87.68	0.14E 04
-4468.645	0.973	0.200	0.116	88.07	0.27E 04
-4467.852	0.973	0.200	0.117	87.70	0.25E 04
-4407.422	0.963	0.232	0.135	88.52	0.48E 04
-4406.629	0.963	0.233	0.135	88.36	0.48E 04
-4346.203	0.952	0.264	0.154	88.64	0.93E 04
-4345.410	0.952	0.265	0.154	88.60	0.94E 04
-4288.582	0.940	0.294	0.171	88.87	0.65E 04
-4287.785	0.940	0.295	0.171	89.06	0.55E 04
-4227.355	0.926	0.325	0.189	89.88	0.69E 03
-4226.566	0.926	0.326	0.189	89.68	0.10E 04
-4166.137	0.911	0.356	0.207	89.53	0.39E 03
-4165.344	0.911	0.357	0.207	88.90	0.12E 04

CFCINT=DCC11 WHAT NOW NEXT CALL DISPLAY DISP 1 OF 1

M S A D

D I S P L A Y

Figure 5-4 (Continued)

M S A D
D I S P L A Y   73.179.12.14.28

DCC1   DCCONS OBSERVED DATA CLASS 1

TIME1	RES. VECTOR X	Y	Z	CONE ANGLE	WEIGHT
-4107.723	0.895	0.385	0.223	89.11	0.45E 03
-4047.294	0.878	0.414	0.240	89.38	0.15E 03
-4046.502	0.878	0.415	0.241	89.29	0.23E 03
-3928.451	0.839	0.470	0.273	90.79	0.10E-07
-3927.660	0.839	0.471	0.273	89.22	0.50E 02
-3867.232	0.813	0.498	0.289	87.95	0.17E 03
-3866.438	0.817	0.498	0.289	89.17	0.79E 02
-3806.009	0.795	0.525	0.304	89.11	0.10E-07
-3805.218	0.795	0.525	0.304	88.10	0.26E 03
-3748.388	0.772	0.550	0.318	91.15	0.10E-07
-3747.597	0.772	0.550	0.319	92.46	0.49E 02
-3667.164	0.747	0.575	0.333	90.67	0.10E-07
-3686.373	0.747	0.576	0.333	93.08	0.15E 03
-3625.943	0.721	0.600	0.347	89.48	0.32E 02
-3625.151	0.720	0.600	0.347	92.36	0.10E-07
-3568.325	0.695	0.622	0.360	89.35	0.10E-07
-3507.101	0.667	0.645	0.373	87.38	0.25E 02
-3506.308	0.666	0.645	0.373	91.84	0.10E-07
-3445.877	0.637	0.667	0.386	89.71	0.10E-07
-3445.086	0.637	0.667	0.386	93.41	0.12E 03
-3327.035	0.578	0.706	0.409	91.46	0.10E-07
-3326.244	0.577	0.707	0.409	92.30	0.10E-07
-3265.812	0.546	0.725	0.420	94.56	0.33E 01
-3265.021	0.545	0.726	0.420	91.12	0.10E-07
4592.234	0.948	-0.277	-0.157	85.21	0.63E 03
4593.020	0.948	-0.277	-0.157	84.82	0.19E 02
4653.457	0.959	-0.246	-0.139	85.52	0.59E 03
4654.246	0.960	-0.245	-0.139	85.13	0.25E 02
4711.078	0.969	-0.215	-0.121	85.94	0.55E 03
4711.863	0.969	-0.215	-0.121	87.72	0.24E 02
4772.297	0.978	-0.183	-0.102	85.93	0.61E 03
4773.086	0.978	-0.182	-0.102	90.04	0.18E 02
4833.520	0.985	-0.150	-0.083	86.88	0.46E 03
4834.309	0.985	-0.149	-0.083	89.04	0.34E 02
4891.141	0.991	-0.119	-0.065	86.44	0.60E 03
4891.930	0.991	-0.118	-0.065	85.81	0.10E 03
4952.363	0.995	-0.085	-0.046	86.80	0.57E 03
4953.152	0.995	-0.085	-0.046	85.49	0.16E 03
5013.586	0.998	-0.052	-0.027	86.31	0.87E 03
5014.371	0.998	-0.051	-0.027	89.29	0.64E 02
5071.207	1.000	-0.020	-0.009	86.61	0.84E 03
5071.996	1.000	-0.020	-0.008	86.29	0.24E 03
5132.426	1.000	0.013	0.011	87.57	0.62E 03
5133.219	1.000	0.014	0.011	87.03	0.26E 03
5193.648	0.998	0.047	0.030	88.90	0.33E 03
5194.441	0.998	0.047	0.030	87.86	0.28E 03

CFCINT=DCC11   WHAT NOW   NEXT   CALL DISPLAY   DISP 1 OF 1

M S A D
D I S P L A Y

Figure 5-4 (Continued)

M S A D
D I S P L A Y 73.179.12.14.32

DCC1 DCCONS OBSERVED DATA CLASS 1

TIME1	RES. X	VECTOR Y	Z	CONE ANGLE	WEIGHT
5251.270	0.996	0.078	0.048	87.26	0.11E 04
5252.063	0.996	0.078	0.048	86.99	0.57E 03
5312.492	0.991	0.111	0.067	87.69	0.11E 04
5313.281	0.991	0.112	0.068	88.11	0.43E 03
5273.715	0.986	0.144	0.087	87.81	0.17E 04
5374.504	0.986	0.145	0.087	87.69	0.11E 04
-5368.574	0.944	-0.285	-0.164	85.49	0.69E 02
-5307.352	0.956	-0.253	-0.145	86.48	0.31E 02
-5246.129	0.967	-0.221	-0.127	88.16	0.10E-07
-5188.508	0.976	-0.191	-0.109	86.29	0.38E 02
-5127.289	0.983	-0.158	-0.090	87.18	0.10E-07
-5066.066	0.990	-0.125	-0.071	86.37	0.35E 02
-5008.445	0.994	-0.094	-0.053	87.19	0.10E-07
-4947.223	0.998	-0.060	-0.034	85.80	0.56E 02
-4886.000	1.000	-0.027	-0.014	85.75	0.58E 02
-4767.156	0.999	0.038	0.023	87.01	0.10E-07
-4648.316	0.993	0.103	0.061	87.31	0.10E-07
-4525.867	0.981	0.169	0.099	87.54	0.10E-07
-4226.961	0.926	0.326	0.189	88.13	0.10E-07
-4165.738	0.911	0.356	0.207	86.83	0.17E 02
-4108.117	0.896	0.385	0.223	86.51	0.30E 02
-4046.898	0.878	0.415	0.240	88.92	0.10E-07
-3928.056	0.839	0.470	0.273	92.32	0.10E-07
-3805.614	0.795	0.525	0.304	92.79	0.10E-07
-3747.992	0.772	0.550	0.319	92.43	0.10E-07
-3686.769	0.747	0.575	0.333	92.95	0.10E-07
-3445.482	0.637	0.667	0.386	92.72	0.10E-07
-3387.860	0.609	0.687	0.397	91.85	0.10E-07
-3326.640	0.578	0.707	0.409	92.12	0.10E-07
-3265.416	0.546	0.725	0.420	92.20	0.10E-07
4592.629	0.948	-0.277	-0.157	85.29	0.78E 02
4653.852	0.959	-0.245	-0.139	85.62	0.64E 02
4711.473	0.969	-0.215	-0.121	85.47	0.70E 02
4772.691	0.978	-0.182	-0.102	84.87	0.97E 02
4833.914	0.985	-0.149	-0.083	86.01	0.48E 02
4891.535	0.991	-0.118	-0.065	86.84	0.17E 02
4952.758	0.995	-0.085	-0.046	88.11	0.10E-07
5013.980	0.998	-0.052	-0.027	84.74	0.10E 03
5071.602	1.000	-0.020	-0.009	86.95	0.10E-07
5132.824	1.000	0.013	0.011	88.51	0.10E-07
5251.664	0.996	0.078	0.048	87.87	0.10E-07
5312.887	0.991	0.112	0.068	86.91	0.13E 02
5374.109	0.986	0.145	0.087	88.31	0.10E-07

CFCINT=DCC11 WHAT NOW CALL DISPLAY DISP 1 OF 1

M S A D
D I S P L A Y

Figure 5-4 (Continued)

```
************************************          M S A D        ************************************
****   **************** ************   D I S P L A Y   ***********  73.179.12.14.40   ****
**                                                                                             **
**      DCC2                    DCCONS OBSERVED DATA CLASS 2                                   **
**                                                                                             **
**      TIME2      REF.     VECTOR ONE      REF.     VECTOR TWO      DIHED    WEIGHT           **
**                                                                   ANGLE                     **
**      -5368.569 -0.947 -0.296 -0.128  0.944 -0.286 -0.164  142.33  0.30E 05                  **
**      -5368.180 -0.947 -0.296 -0.128  0.944 -0.285 -0.164  142.11  0.13E 04                  **
**      -5307.746 -0.947 -0.296 -0.128  0.956 -0.254 -0.146  144.63  0.28E 05                  **
**      -5306.957 -0.947 -0.296 -0.128  0.956 -0.253 -0.145  145.13  0.65E 03                  **
**      -5246.523 -0.947 -0.296 -0.128  0.967 -0.221 -0.127  146.81  0.26E 05                  **
**      -5245.734 -0.947 -0.296 -0.128  0.967 -0.221 -0.127  147.68  0.86E 03                  **
**      -5186.902 -0.947 -0.296 -0.128  0.976 -0.191 -0.109  148.83  0.25E 05                  **
**      -5186.113 -0.947 -0.296 -0.128  0.976 -0.190 -0.109  148.79  0.19E 04                  **
**      -5127.684 -0.947 -0.296 -0.128  0.983 -0.158 -0.090  150.91  0.21E 05                  **
**      -5126.891 -0.947 -0.296 -0.128  0.983 -0.158 -0.090  150.81  0.43E 04                  **
**      -5066.461 -0.947 -0.296 -0.128  0.990 -0.125 -0.071  153.48  0.22E 05                  **
**      -5065.668 -0.947 -0.296 -0.128  0.990 -0.125 -0.071  153.81  0.23E 04                  **
**      -5008.840 -0.947 -0.296 -0.128  0.994 -0.094 -0.053  155.47  0.21E 05                  **
**      -5008.047 -0.947 -0.296 -0.128  0.994 -0.093 -0.053  155.76  0.29E 04                  **
**      -4947.617 -0.947 -0.296 -0.128  0.998 -0.060 -0.034  157.70  0.19E 05                  **
**      -4946.828 -0.947 -0.296 -0.128  0.998 -0.060 -0.034  157.55  0.42E 04                  **
**      -4886.395 -0.947 -0.296 -0.128  1.000 -0.027 -0.015  159.83  0.18E 05                  **
**      -4885.605 -0.947 -0.296 -0.128  1.000 -0.025 -0.014  159.58  0.54E 04                  **
**      -4826.777 -0.947 -0.296 -0.128  1.000  0.005  0.004  161.74  0.17E 05                  **
**      -4827.980 -0.947 -0.296 -0.128  1.000  0.005  0.004  162.33  0.44E 04                  **
**      -4767.551 -0.947 -0.296 -0.128  0.999  0.038  0.023  164.21  0.16E 05                  **
**      -4766.762 -0.947 -0.296 -0.128  0.999  0.039  0.023  164.23  0.55E 04                  **
**      -4706.328 -0.947 -0.296 -0.128  0.997  0.072  0.042  166.31  0.15E 05                  **
**      -4705.535 -0.947 -0.296 -0.129  0.996  0.072  0.043  166.65  0.59E 04                  **
**      -4646.711 -0.947 -0.296 -0.128  0.993  0.103  0.060  168.34  0.14E 05                  **
**      -4647.918 -0.947,-0.296 -0.128  0.993  0.103  0.061  168.31  0.67E 04                  **
**      -4587.488 -0.947 -0.296 -0.128  0.987  0.136  0.080  170.61  0.13E 05                  **
**      -4586.695 -0.947 -0.296 -0.128  0.987  0.136  0.080  170.94  0.74E 04                  **
**      -4526.266 -0.947 -0.296 -0.128  0.981  0.169  0.099  172.98  0.12E 05                  **
**      -4525.473 -0.947 -0.296 -0.128  0.981  0.169  0.099  173.00  0.79E 04                  **
**      -4468.645 -0.947 -0.296 -0.128  0.973  0.200  0.116  174.92  0.12E 05                  **
**      -4467.852 -0.947 -0.296 -0.128  0.973  0.200  0.117  175.16  0.85E 04                  **
**      -4407.422 -0.947 -0.296 -0.128  0.963  0.232  0.135  177.14  0.11E 05                  **
**      -4406.629 -0.947 -0.296 -0.128  0.963  0.233  0.135  177.32  0.93E 04                  **
**      -4346.203 -0.947 -0.296 -0.128  0.952  0.264  0.154  179.27  0.10E 05                  **
**      -4345.410 -0.947 -0.296 -0.128  0.952  0.265  0.154  179.44  0.99E 04                  **
**      -4288.582 -0.947 -0.296 -0.128  0.940  0.294  0.171  181.37  0.97E 04                  **
**      -4287.785 -0.947 -0.296 -0.128  0.940  0.295  0.171  181.65  0.10E 05                  **
**      -4227.355 -0.947 -0.296 -0.128  0.926  0.325  0.189  183.84  0.10E 05                  **
**      -4226.566 -0.947 -0.296 -0.128  0.926  0.326  0.189  183.80  0.10E 05                  **
**      -4166.137 -0.947 -0.296 -0.128  0.911  0.356  0.207  185.85  0.96E 04                  **
**      -4165.344 -0.947 -0.296 -0.128  0.911  0.357  0.207  185.68  0.11E 05                  **
**      -4107.723 -0.947 -0.296 -0.128  0.895  0.385  0.223  187.82  0.11E 05                  **
**      -4047.294 -0.947 -0.296 -0.128  0.878  0.414  0.240  190.02  0.93E 04                  **
**      -4046.502 -0.947 -0.296 -0.128  0.878  0.415  0.241  190.03  0.11E 05                  **
**      -3928.451 -0.947 -0.296 -0.128  0.839  0.470  0.273  194.39  0.10E-07                  **
**                                                                                             **
**      CFCINT=DCC22  WHAT NOW   NEXT        CALL DISPLAY         DISP   1 OF   1              **
**                                                                                             **
************************************          M S A D        ************************************
************************************     D I S P L A Y       ************************************
```

Figure 5-5

M S A O

D I S P L A Y 73.179.12.14.43

ECC2 DCCONS OBSERVED CATA CLASS 2

TIME2	REF. VECTOR ONE			REF. VECTOR TWO			DIHED ANGLE	WEIGHT
-3927.660	-0.947	-0.296	-0.128	0.839	0.471	0.273	194.32	0.10E 05
-3867.232	-0.947	-0.296	-0.128	0.818	0.498	0.289	196.28	0.62E 04
-3866.438	-0.947	-0.296	-0.128	0.817	0.498	0.289	196.50	0.11E 05
-3806.009	-0.947	-0.296	-0.128	0.795	0.525	0.304	198.70	0.10E-07
-3805.218	-0.947	-0.296	-0.128	0.795	0.525	0.304	198.61	0.16E 05
-3746.388	-0.947	-0.296	-0.128	0.772	0.550	0.318	200.86	0.10E-07
-3747.597	-0.947	-0.296	-0.128	0.772	0.550	0.319	200.84	0.44E 05
-3687.164	-0.947	-0.296	-0.128	0.747	0.575	0.333	203.06	0.10E-07
-3686.373	-0.947	-0.296	-0.128	0.747	0.576	0.333	203.01	0.35E 05
-3625.943	-0.947	-0.296	-0.128	0.721	0.600	0.347	205.12	0.65E 04
-3625.151	-0.947	-0.296	-0.128	0.720	0.600	0.347	205.27	0.10E-07
-3568.325	-0.947	-0.296	-0.128	0.695	0.622	0.360	207.29	0.10E-07
-3507.101	-0.947	-0.296	-0.128	0.667	0.645	0.373	209.34	0.35E 04
-3506.308	-0.947	-0.296	-0.128	0.666	0.645	0.373	209.57	0.10E-07
-3445.677	-0.947	-0.296	-0.128	0.637	0.667	0.386	211.73	0.10E-07
-3445.086	-0.947	-0.296	-0.128	0.637	0.667	0.386	211.73	0.52E 05
-3327.035	-0.947	-0.296	-0.128	0.578	0.706	0.409	216.05	0.10E-07
-3326.244	-0.947	-0.296	-0.128	0.577	0.707	0.409	216.07	0.10E-07
-3265.812	-0.947	-0.296	-0.128	0.546	0.725	0.420	218.13	0.17E 03
-3265.021	-0.947	-0.296	-0.128	0.545	0.726	0.420	218.29	0.10E-07
4592.234	-0.946	-0.297	-0.129	0.948	-0.277	-0.157	142.97	0.29E 05
4593.020	-0.946	-0.297	-0.129	0.948	-0.277	-0.157	143.06	0.61E 03
4653.457	-0.946	-0.297	-0.129	0.959	-0.246	-0.139	145.14	0.28E 05
4654.246	-0.946	-0.297	-0.129	0.960	-0.245	-0.139	145.22	0.82E 03
4711.078	-0.946	-0.297	-0.129	0.969	-0.215	-0.121	147.19	0.26E 05
4711.863	-0.946	-0.297	-0.129	0.969	-0.215	-0.121	147.01	0.17E 04
4772.297	-0.946	-0.297	-0.129	0.978	-0.183	-0.102	149.44	0.24E 05
4773.086	-0.946	-0.297	-0.129	0.978	-0.182	-0.102	149.09	0.41E 04
4833.520	-0.946	-0.297	-0.129	0.985	-0.150	-0.083	151.54	0.22E 05
4834.309	-0.946	-0.297	-0.129	0.985	-0.149	-0.083	151.35	0.36E 04
4891.141	-0.946	-0.297	-0.129	0.991	-0.119	-0.065	153.69	0.22E 05
4891.930	-0.946	-0.297	-0.129	0.991	-0.118	-0.065	153.83	0.26E 04
4952.363	-0.946	-0.297	-0.129	0.995	-0.085	-0.046	155.87	0.20E 05
4953.152	-0.946	-0.297	-0.129	0.995	-0.085	-0.046	156.15	0.30E 04
5013.586	-0.946	-0.297	-0.129	0.998	-0.052	-0.027	158.25	0.19E 05
5014.371	-0.946	-0.297	-0.129	0.998	-0.051	-0.027	157.84	0.55E 04
5071.207	-0.946	-0.297	-0.129	1.000	-0.020	-0.009	160.28	0.18E 05
5071.996	-0.946	-0.297	-0.129	1.000	-0.020	-0.008	160.37	0.42E 04
5132.426	-0.946	-0.297	-0.129	1.000	0.013	0.011	162.33	0.16E 05
5133.219	-0.946	-0.297	-0.129	1.000	0.014	0.011	162.46	0.50E 04
5193.648	-0.946	-0.297	-0.129	0.998	0.047	0.030	164.35	0.14E 05
5194.441	-0.946	-0.297	-0.129	0.998	0.047	0.030	164.56	0.59E 04
5251.270	-0.946	-0.297	-0.129	0.996	0.078	0.048	166.78	0.15E 05
5252.063	-0.946	-0.297	-0.129	0.996	0.078	0.048	166.89	0.62E 04
5312.492	-0.946	-0.297	-0.129	0.991	0.111	0.067	168.87	0.14E 05
5313.281	-0.946	-0.297	-0.129	0.991	0.112	0.068	168.79	0.68E 04

CFCINT=DCC22 WHAT NOW NEXT CALL DISPLAY DISP 1 OF 1

M S A D

D I S P L A Y

Figure 5-5 (Continued)

```
****************************************        M S A D       *************************************
****  ****************  ************         D I S P L A Y    ***********   73.179.12.14.46    ****
**                                                                                                **
**     DCC2                       DCCCNS OBSERVED DATA CLASS 2                                     **
**                                                                                                **
**     TIME2       REF.     VECTOR ONE      REF.     VECTOR TWO      DIHED     WEIGHT              **
**                                                                   ANGLE                        **
**       5373.715 -0.946 -0.297 -0.129   0.986   0.144   0.087    171.20    0.13E 05              **
**       5374.504 -0.946 -0.297 -0.129   0.986   0.145   0.087    171.28    0.76E 04              **
**      -5368.574 -0.947 -0.296 -0.128   0.944  -0.285  -0.164    142.30    0.10E 05              **
**      -5307.352 -0.947 -0.296 -0.128   0.956  -0.253  -0.145    144.71    0.10E 05              **
**      -5246.129 -0.947 -0.296 -0.128   0.967  -0.221  -0.127    146.96    0.10E 05              **
**      -5186.508 -0.947 -0.296 -0.128   0.976  -0.191  -0.109    148.83    0.10E 05              **
**      -5127.289 -0.947 -0.296 -0.128   0.983  -0.158  -0.090    150.88    0.10E 05              **
**      -5066.066 -0.947 -0.296 -0.128   0.990  -0.125  -0.071    153.57    0.10E 05              **
**      -5008.445 -0.947 -0.296 -0.128   0.994  -0.094  -0.053    155.56    0.10E 05              **
**      -4947.223 -0.947 -0.296 -0.128   0.998  -0.060  -0.034    157.66    0.10E 05              **
**      -4886.000 -0.947 -0.296 -0.128   1.000  -0.027  -0.014    159.75    0.10E 05              **
**      -4767.156 -0.947 -0.296 -0.128   0.999   0.038   0.023    164.22    0.10E 05              **
**      -4648.316 -0.947 -0.296 -0.128   0.993   0.103   0.061    168.33    0.10E 05              **
**      -4525.667 -0.947 -0.296 -0.128   0.981   0.169   0.099    172.99    0.10E 05              **
**      -4226.961 -0.947 -0.296 -0.128   0.926   0.326   0.189    183.82    0.10E 05              **
**      -4165.738 -0.947 -0.296 -0.128   0.911   0.356   0.207    185.76    0.10E 05              **
**      -4105.117 -0.947 -0.296 -0.128   0.896   0.385   0.223    187.93    0.10E 05              **
**      -4046.898 -0.947 -0.296 -0.128   0.878   0.415   0.240    190.02    0.10E 05              **
**      -3928.056 -0.947 -0.296 -0.128   0.839   0.470   0.273    194.35    0.10E 05              **
**      -3805.614 -0.947 -0.296 -0.128   0.795   0.525   0.304    198.64    0.10E 05              **
**      -3747.992 -0.947 -0.296 -0.128   0.772   0.550   0.319    200.82    0.10E 05              **
**      -3686.769 -0.947 -0.296 -0.128   0.747   0.575   0.333    202.98    0.10E 05              **
**      -3445.482 -0.947 -0.296 -0.128   0.637   0.667   0.386    211.67    0.10E 05              **
**      -3387.660 -0.947 -0.296 -0.128   0.609   0.687   0.397    213.91    0.10E 05              **
**      -3326.640 -0.947 -0.296 -0.128   0.578   0.707   0.409    216.04    0.10E 05              **
**      -3265.416 -0.947 -0.296 -0.128   0.546   0.725   0.420    218.32    0.10E 05              **
**       4592.629 -0.946 -0.297 -0.129   0.948  -0.277  -0.157    143.00    0.10E 05              **
**       4653.852 -0.946 -0.297 -0.129   0.959  -0.245  -0.139    145.16    0.10E 05              **
**       4711.473 -0.946 -0.297 -0.129   0.969  -0.215  -0.121    147.16    0.10E 05              **
**       4772.691 -0.946 -0.297 -0.129   0.978  -0.182  -0.102    149.35    0.10E 05              **
**       4833.914 -0.946 -0.297 -0.129   0.985  -0.149  -0.083    151.49    0.10E 05              **
**       4891.535 -0.946 -0.297 -0.129   0.991  -0.118  -0.065    153.73    0.10E 05              **
**       4952.758 -0.946 -0.297 -0.129   0.995  -0.085  -0.046    155.95    0.10E 05              **
**       5013.980 -0.946 -0.297 -0.129   0.998  -0.052  -0.027    158.12    0.10E 05              **
**       5071.602 -0.946 -0.297 -0.129   1.000  -0.020  -0.009    160.31    0.10E 05              **
**       5132.824 -0.946 -0.297 -0.129   1.000   0.013   0.011    162.38    0.10E 05              **
**       5251.664 -0.946 -0.297 -0.129   0.996   0.078   0.048    166.82    0.10E 05              **
**       5312.887 -0.946 -0.297 -0.129   0.991   0.112   0.068    168.84    0.10E 05              **
**       5374.109 -0.946 -0.297 -0.129   0.986   0.145   0.087    171.24    0.10E 05              **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**                                                                                                **
**     CFCINT=DCC22  WHAT NOW                  CALL DISPLAY            DISP   1 OF    1           **
**                                                                                                **
****************************************        M S A D       *************************************
****************************************     D I S P L A Y    *************************************
```

Figure 5-5 (Continued)

```
************************************        M S A D        ************************************
****  ***************  ************   D I S P L A Y   ************  73.179.12.15.03   ****
**                                                                                          **
**      GCN21                        ERROR STATISTICS                                       **
**                                                                                          **
**      CURRENT ITERATION NUMBER                      1                                     **
**                                                                                          **
**          CLASS        TYPE        MEAN RES        STD. DEV        TOTAL WGT              **
**                                   (DEG)           (DEG)                                  **
**            1            1        -0.0068          0.1037          500000.13              **
**            1            2        -0.1045          0.4741           81704.88              **
**            1            3        -0.7565          0.8729             823.17              **
**            1          TOTL       -0.0216          0.2092          582528.13              **
**            2            1        -0.0149          0.1266         1031864.38              **
**            2            2        -0.0062          0.1044          370000.13              **
**            2          TOTL       -0.0126          0.1212         1401864.00              **
**          TOTL         STAT       -0.0153          0.1524         1984392.00              **
**                                                                                          **
**    CFCINT=GCONE2 WHAT NOW              CALL DISPLAY           DISP   1 OF   1            **
**                                                                                          **
************************************        M S A D        ************************************
************************************    D I S P L A Y      ************************************
```

Figure 5-6

```
*********************************************       M S A D       *********************************************
****  **************** **************       D I S P L A Y       ************  73.179.12.16.01   ****
**                                                                                                  **
**      CST3                         CUMULATIVE STATE VECTOR                                        **
**                                                                                                  **
**      CURRENT ITERATION NUMBER                          1                                         **
**                                                                                                  **
**     INTEG ALPHA      DELTA     BIAS1     BIAS2     BIAS3     BIAS4     BIAS5                     **
**       NUM  (DEG)     (DEG)     (DEG)     (DEG)     (DEG)     (DEG)     (DEG)                     **
**         0  275.000   55.000    0.0       0.0       0.0       0.0       0.0                       **
**         1  275.043   54.866    0.043    -0.134     0.069    -0.132    -0.727                     **
**                                                                                                  **
**                                                                                                  **
**     CFCINT=GSTATA WHAT NOW              CALL DISPLAY             DISP   1 OF   1                 **
**                                                                                                  **
*********************************************       M S A D       *********************************************
*********************************************    D I S P L A Y    *********************************************
```

Figure 5-7

```
*************************************      M S A D      ************************************
****   **************** ************   D I S P L A Y   ***********   73.179.12.16.08   ****
**                                                                                        **
**       GST1                  CLASS 1 RESIDUALS AND WEIGHTS                              **
**                                                                                        **
**     CURRENT ITERATION NUMBER                            1                              **
**                                                                                        **
**           CLASS 1            CLASS 1            CLASS 1           CLASS 1              **
**           ANGLES             CALCULATED         RESIDUALS         WEIGHTS              **
**             0.8910E 02         0.8905E 02         0.4721E-01        0.0                **
**             0.8897E 02         0.8905E 02        -0.7550E-01        0.0                **
**             0.8909E 02         0.8905E 02         0.3738E-01        0.0                **
**             0.8912E 02         0.8905E 02         0.6743E-01        0.0                **
**             0.8893E 02         0.8905E 02        -0.1208E 00        0.0                **
**             0.8909E 02         0.8905E 02         0.4630E-01        0.0                **
**             0.8910E 02         0.8905E 02         0.5623E-01        0.0                **
**             0.8887E 02         0.8905E 02        -0.1796E 00        0.0                **
**             0.8897E 02         0.8905E 02        -0.7951E-01        0.0                **
**             0.8926E 02         0.8905E 02         0.2148E 00        0.0                **
**             0.8896E 02         0.8905E 02        -0.8443E-01        0.0                **
**             0.8909E 02         0.8905E 02         0.4475E-01        0.0                **
**             0.8922E 02         0.8905E 02         0.1774E 00        0.0                **
**             0.8891E 02         0.8905E 02        -0.1410E 00        0.0                **
**             0.8914E 02         0.8905E 02         0.9741E-01        0.0                **
**             0.8925E 02         0.8905E 02         0.2018E 00        0.0                **
**             0.8900E 02         0.8905E 02        -0.4295E-01        0.0                **
**             0.8914E 02         0.8905E 02         0.9392E-01        0.0                **
**             0.8908E 02         0.8905E 02         0.3044E-01        0.0                **
**             0.8888E 02         0.8905E 02        -0.1678E 00        0.0                **
**             0.8900E 02         0.8905E 02        -0.4437E-01        0.0                **
**             0.8905E 02         0.8905E 02         0.7767E-02        0.0                **
**             0.8892E 02         0.8905E 02        -0.1247E 00        0.0                **
**             0.8889E 02         0.8905E 02        -0.1567E 00        0.0                **
**             0.8909E 02         0.8905E 02         0.4514E-01        0.0                **
**             0.8889E 02         0.8905E 02        -0.1510E 00        0.0                **
**             0.8916E 02         0.8905E 02         0.1123E 00        0.0                **
**             0.8904E 02         0.8905E 02        -0.3067E-02        0.0                **
**             0.8901E 02         0.8905E 02        -0.3853E-01        0.0                **
**             0.8886E 02         0.8904E 02        -0.1856E 00        0.0                **
**             0.8897E 02         0.8904E 02        -0.7016E-01        0.0                **
**             0.8904E 02         0.8904E 02        -0.3510E-02        0.0                **
**             0.8894E 02         0.8904E 02        -0.1084E 00        0.0                **
**             0.8908E 02         0.8904E 02         0.3622E-01        0.0                **
**             0.8916E 02         0.8904E 02         0.1105E 00        0.0                **
**             0.8912E 02         0.8904E 02         0.7475E-01        0.0                **
**             0.8889E 02         0.8903E 02        -0.1388E 00        0.0                **
**             0.8910E 02         0.8903E 02         0.6955E-01        0.0                **
**             0.8905E 02         0.8903E 02         0.1967E-01        0.0                **
**             0.8901E 02         0.8903E 02        -0.1859E-01        0.0                **
**             0.8895E 02         0.8903E 02        -0.7787E-01        0.0                **
**             0.8911E 02         0.8903E 02         0.8032E-01        0.0                **
**             0.8912E 02         0.8903E 02         0.9267E-01        0.0                **
**             0.8890E 02         0.8903E 02        -0.1297E 00        0.0                **
**                                                                                        **
**     CFCINT=GSTAT1 WHAT NOW   NEXT        CALL DISPLAY         DISP   1 OF   2          **
**                                                                                        **
*************************************      M S A D      ************************************
*************************************   D I S P L A Y   ************************************
```

Figure 5-8

```
***********************************       M S A D      ***********************************
****  **************** ************   D I S P L A Y   ***********  73.179.12.16.11   ****
**                                                                                      **
**        GST1                  CLASS 1 RESIDUALS AND WEIGHTS                           **
**                                                                                      **
**        CURRENT ITERATION NUMBER                        1                             **
**                                                                                      **
**           CLASS 1            CLASS 1            CLASS 1            CLASS 1           **
**           ANGLES             CALCULATED         RESIDUALS          WEIGHTS           **
**             0.8907E 02         0.8903E 02         0.3989E-01         0.0             **
**             0.8906E 02         0.8902E 02         0.3239E-01         0.0             **
**             0.8895E 02         0.8902E 02        -0.7793E-01         0.0             **
**             0.8901E 02         0.8902E 02        -0.1289E-01         0.0             **
**             0.8921E 02         0.8902E 02         0.1812E 00         0.0             **
**             0.8890E 02         0.8902E 02        -0.1249E 00         0.0             **
**             0.8601E 02         0.8564E 02         0.3672E 00         0.0             **
**             0.8923E 02         0.8564E 02         0.3591E 01         0.0             **
**             0.8565E 02         0.8578E 02        -0.1345E 00         0.0             **
**             0.8294E 02         0.8579E 02        -0.2850E 01         0.0             **
**             0.8594E 02         0.8593E 02         0.4272E-02         0.0             **
**             0.8167E 02         0.8594E 02        -0.4263E 01         0.0             **
**             0.8651E 02         0.8608E 02         0.4234E 00         0.0             **
**             0.8711E 02         0.8608E 02         0.1025E 01         0.0             **
**             0.8801E 02         0.8624E 02         0.1764E 01         0.0             **
**             0.8969E 02         0.8625E 02         0.3442E 01         0.0             **
**             0.8552E 02         0.8641E 02        -0.8957E 00         0.0             **
**             0.8416E 02         0.8641E 02        -0.2256E 01         0.0             **
**             0.8618E 02         0.8658E 02        -0.3954E 00         0.0             **
**             0.8495E 02         0.8658E 02        -0.1630E 01         0.0             **
**             0.8653E 02         0.8675E 02        -0.2246E 00         0.0             **
**             0.8756E 02         0.8676E 02         0.8062E 00         0.0             **
**             0.8705E 02         0.8694E 02         0.1169E 00         0.0             **
**             0.8898E 02         0.8694E 02         0.2037E 01         0.0             **
**             0.8785E 02         0.8711E 02         0.7430E 00         0.0             **
**             0.8537E 02         0.8711E 02        -0.1741E 01         0.0             **
**             0.8706E 02         0.8730E 02        -0.2397E 00         0.0             **
**             0.8710E 02         0.8731E 02        -0.2022E 00         0.0             **
**             0.8759E 02         0.8750E 02         0.8797E-01         0.0             **
**             0.8649E 02         0.8750E 02        -0.1010E 01         0.0             **
**             0.8778E 02         0.8769E 02         0.9076E-01         0.0             **
**             0.8802E 02         0.8769E 02         0.3311E 00         0.0             **
**             0.8808E 02         0.8789E 02         0.1918E 00         0.0             **
**             0.8727E 02         0.8789E 02        -0.6189E 00         0.0             **
**             0.8765E 02         0.8809E 02        -0.4469E 00         0.0             **
**             0.8768E 02         0.8810E 02        -0.4175E 00         0.0             **
**             0.8807E 02         0.8829E 02        -0.2244E 00         0.0             **
**             0.8770E 02         0.8829E 02        -0.5894E 00         0.0             **
**             0.8852E 02         0.8850E 02         0.1486E-01         0.0             **
**             0.8836E 02         0.8850E 02        -0.1458E 00         0.0             **
**             0.8864E 02         0.8871E 02        -0.7742E-01         0.0             **
**             0.8860E 02         0.8872E 02        -0.1175E 00         0.0             **
**             0.8887E 02         0.8892E 02        -0.4836E-01         0.0             **
**             0.8906E 02         0.8892E 02         0.1425E 00         0.0             **
**                                                                                      **
**        CFCIN1=GSTAT1 WHAT NOW    NEXT          CALL DISPLAY       DISP   1 OF   2    **
**                                                                                      **
***********************************       M S A D      ***********************************
***********************************   D I S P L A Y   ***********************************
```

Figure 5-8 (Continued)

```
*********************************          M S A D        **********************************
****  ************** ***********       D I S P L A Y      ***********  73.179.12.16.14   ****
**                                                                                          **
**      CST1                   CLASS 1 RESIDUALS AND WEIGHTS                                **
**                                                                                          **
**      CURRENT ITERATION NUMBER                      1                                     **
**                                                                                          **
**         CLASS 1              CLASS 1             CLASS 1             CLASS 1             **
**         ANGLES               CALCULATED          RESIDUALS           WEIGHTS             **
**           0.8988E 02           0.8913E 02          0.7500E 00          0.0               **
**           0.8968E 02           0.8913E 02          0.5483E 00          0.0               **
**           0.8953E 02           0.8935E 02          0.1845E 00          0.0               **
**           0.8890E 02           0.8935E 02         -0.4559E 00          0.0               **
**           0.8911E 02           0.8956E 02         -0.4442E 00          0.0               **
**           0.8938E 02           0.8977E 02         -0.3972E 00          0.0               **
**           0.8929E 02           0.8978E 02         -0.4857E 00          0.0               **
**           0.9079E 02           0.9020E 02          0.5881E 00          0.0               **
**           0.8922E 02           0.9020E 02         -0.9862E 00          0.0               **
**           0.8795E 02           0.9042E 02         -0.2471E 01          0.0               **
**           0.8917E 02           0.9042E 02         -0.1253E 01          0.0               **
**           0.8911E 02           0.9064E 02         -0.1529E 01          0.0               **
**           0.8810E 02           0.9064E 02         -0.2538E 01          0.0               **
**           0.9115E 02           0.9084E 02          0.3059E 00          0.0               **
**           0.9246E 02           0.9085E 02          0.1615E 01          0.0               **
**           0.9067E 02           0.9106E 02         -0.3918E 00          0.0               **
**           0.9308E 02           0.9106E 02          0.2020E 01          0.0               **
**           0.8848E 02           0.9128E 02         -0.2800E 01          0.0               **
**           0.9236E 02           0.9128E 02          0.1080E 01          0.0               **
**           0.8935E 02           0.9148E 02         -0.2125E 01          0.0               **
**           0.8738E 02           0.9169E 02         -0.4306E 01          0.0               **
**           0.9184E 02           0.9169E 02          0.1521E 00          0.0               **
**           0.8971E 02           0.9190E 02         -0.2187E 01          0.0               **
**           0.9341E 02           0.9190E 02          0.1510E 01          0.0               **
**           0.9146E 02           0.9229E 02         -0.8358E 00          0.0               **
**           0.9230E 02           0.9230E 02          0.5356E-02          0.0               **
**           0.9456E 02           0.9249E 02          0.2067E 01          0.0               **
**           0.9112E 02           0.9250E 02         -0.1376E 01          0.0               **
**           0.8521E 02           0.8558E 02         -0.3733E 00          0.0               **
**           0.8482E 02           0.8558E 02         -0.7672E 00          0.0               **
**           0.8552E 02           0.8573E 02         -0.2076E 00          0.0               **
**           0.8513E 02           0.8573E 02         -0.6011E 00          0.0               **
**           0.8594E 02           0.8587E 02          0.7382E-01          0.0               **
**           0.8772E 02           0.8587E 02          0.1848E 01          0.0               **
**           0.8593E 02           0.8603E 02         -0.9677E-01          0.0               **
**           0.9004E 02           0.8603E 02          0.4009E 01          0.0               **
**           0.8688E 02           0.8619E 02          0.6907E 00          0.0               **
**           0.8904E 02           0.8619E 02          0.2847E 01          0.0               **
**           0.8644E 02           0.8635E 02          0.8954E-01          0.0               **
**           0.8581E 02           0.8635E 02         -0.5373E 00          0.0               **
**           0.8680E 02           0.8652E 02          0.2774E 00          0.0               **
**           0.8549E 02           0.8652E 02         -0.1035E 01          0.0               **
**           0.8631E 02           0.8670E 02         -0.3932E 00          0.0               **
**           0.8929E 02           0.8670E 02          0.2589E 01          0.0               **
**                                                                                          **
**     CFCINT=GSTAT1 WHAT NOW    NEXT        CALL DISPLAY         DISP   1 OF   2           **
**                                                                                          **
*********************************          M S A D        **********************************
*********************************      D I S P L A Y      **********************************
```

Figure 5-8 (Continued)

M S A D

D I S P L A Y 73.179.12.16.16

GST1 CLASS 1 RESIDUALS AND WEIGHTS

CURRENT ITERATION NUMBER 1

CLASS 1 ANGLES	CLASS 1 CALCULATED	CLASS 1 RESIDUALS	CLASS 1 WEIGHTS
0.8661E 02	0.8697E 02	-0.2655E 00	0.0
0.8629E 02	0.8688E 02	-0.5832E 00	0.0
0.8757E 02	0.8706E 02	0.5047E 00	0.0
0.8703E 02	0.8707E 02	-0.3108E-01	0.0
0.8890E 02	0.8726E 02	0.1647E 01	0.0
0.8786E 02	0.8726E 02	0.6049E 00	0.0
0.8726E 02	0.8744E 02	-0.1780E 00	0.0
0.8699E 02	0.8744E 02	-0.4494E 00	0.0
0.8769E 02	0.8764E 02	0.4855E-01	0.0
0.8811E 02	0.8764E 02	0.4656E 00	0.0
0.8781E 02	0.8784E 02	-0.3355E-01	0.0
0.8769E 02	0.8785E 02	-0.1561E 00	0.0
0.8549E 02	0.8564E 02	-0.1492E 00	0.0
0.8648E 02	0.8579E 02	0.6923E 00	0.0
0.8816E 02	0.8594E 02	0.2219E 01	0.0
0.8629E 02	0.8608E 02	0.2095E 00	0.0
0.8718E 02	0.8625E 02	0.9355E 00	0.0
0.8637E 02	0.8641E 02	-0.4552E-01	0.0
0.8719E 02	0.8658E 02	0.6104E 00	0.0
0.8580E 02	0.8675E 02	-0.9504E 00	0.0
0.8575E 02	0.8694E 02	-0.1187E 01	0.0
0.8701E 02	0.8730E 02	-0.2943E 00	0.0
0.8731E 02	0.8769E 02	-0.3739E 00	0.0
0.8754E 02	0.8809E 02	-0.5591E 00	0.0
0.8813E 02	0.8913E 02	-0.1002E 01	0.0
0.8683E 02	0.8935E 02	-0.2523E 01	0.0
0.8651E 02	0.8956E 02	-0.3051E 01	0.0
0.8892E 02	0.8978E 02	-0.8509E 00	0.0
0.9232E 02	0.9020E 02	0.2114E 01	0.0
0.9279E 02	0.9064E 02	0.2152E 01	0.0
0.9243E 02	0.9085E 02	0.1587E 01	0.0
0.9295E 02	0.9106E 02	0.1890E 01	0.0
0.9272E 02	0.9190E 02	0.8186E 00	0.0
0.9185E 02	0.9209E 02	-0.2404E 00	0.0
0.9212E 02	0.9230E 02	-0.1729E 00	0.0
0.9220E 02	0.9250E 02	-0.2939E 00	0.0
0.8529E 02	0.8558E 02	-0.2919E 00	0.0
0.8562E 02	0.8573E 02	-0.1127E 00	0.0
0.8547E 02	0.8587E 02	-0.4033E 00	0.0
0.8487E 02	0.8603E 02	-0.1154E 01	0.0
0.8601E 02	0.8619E 02	-0.1790E 00	0.0
0.8684E 02	0.8635E 02	0.4881E 00	0.0
0.8811E 02	0.8652E 02	0.1586E 01	0.0
0.8474E 02	0.8670E 02	-0.1963E 01	0.0

CFCIN1=GSTAT1 WHAT NOW NEXT CALL DISPLAY DISP 1 OF 2

M S A D

D I S P L A Y

Figure 5-8 (Continued)

```
***********************************      M S A D      ***********************************
****  **************** ************    D I S P L A Y    ***********    73.179.12.16.20   ****
**                                                                                        **
**       GST1                   CLASS 1 RESIDUALS AND WEIGHTS                             **
**                                                                                        **
**       CURRENT ITERATION NUMBER                          1                              **
**                                                                                        **
**          CLASS 1            CLASS 1            CLASS 1            CLASS 1              **
**          ANGLES             CALCULATED         RESIDUALS          WEIGHTS              **
**            0.8695E 02         0.8688E 02         0.7716E-01         0.0                **
**            0.8851E 02         0.8706E 02         0.1448E 01         0.0                **
**            0.8787E 02         0.8744E 02        -0.4274E 00         0.0                **
**            0.8691E 02         0.8764E 02        -0.7296E 00         0.0                **
**            0.8831E 02         0.8785E 02        -0.4672E 00         0.0                **
**                                                                                        **
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**                                                                                        **
**     CFCINT=GSTAT1 WHAT NOW               CALL DISPLAY           DISP   1 OF   2        **
**                                                                                        **
***********************************      M S A D      ***********************************
***********************************   D I S P L A Y   ***********************************
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Figure 5-8 (Continued)

```
************************************          M S A D        **********************************
****  *************** ************          D I S P L A Y    ***********  73.179.12.16.35   ****
**                                                                                             **
**      GST2                  CLASS 2 RESIDUALS AND WEIGHTS                                    **
**                                                                                             **
**      CURRENT ITERATION NUMBER                          1                                    **
**                                                                                             **
**          CLASS 2             CLASS 2           CLASS 2           CLASS 2                    **
**          ANGLES              CALCULATED        RESIDUALS         WEIGHTS                    **
**            0.1423E 03          0.1424E 03       -0.6115E-01        0.0                      **
**            0.1421E 03          0.1424E 03       -0.3071E 00        0.0                      **
**            0.1446E 03          0.1446E 03        0.2983E-01        0.0                      **
**            0.1451E 03          0.1446E 03        0.5007E 00        0.0                      **
**            0.1468E 03          0.1468E 03       -0.6348E-02        0.0                      **
**            0.1477E 03          0.1468E 03        0.8401E 00        0.0                      **
**            0.1488E 03          0.1489E 03       -0.6879E-01        0.0                      **
**            0.1488E 03          0.1489E 03       -0.1421E 00        0.0                      **
**            0.1509E 03          0.1511E 03       -0.2078E 00        0.0                      **
**            0.1508E 03          0.1511E 03       -0.3329E 00        0.0                      **
**            0.1535E 03          0.1533E 03        0.1499E 00        0.0                      **
**            0.1538E 03          0.1534E 03        0.4465E 00        0.0                      **
**            0.1555E 03          0.1554E 03        0.5962E-01        0.0                      **
**            0.1558E 03          0.1554E 03        0.3178E 00        0.0                      **
**            0.1577E 03          0.1576E 03        0.7852E-01        0.0                      **
**            0.1576E 03          0.1577E 03       -0.1042E 00        0.0                      **
**            0.1598E 03          0.1598E 03       -0.6729E-02        0.0                      **
**            0.1596E 03          0.1599E 03       -0.2866E 00        0.0                      **
**            0.1617E 03          0.1619E 03       -0.1746E 00        0.0                      **
**            0.1623E 03          0.1619E 03        0.3826E 00        0.0                      **
**            0.1642E 03          0.1641E 03        0.7721E-01        0.0                      **
**            0.1642E 03          0.1642E 03        0.6802E-01        0.0                      **
**            0.1663E 03          0.1663E 03       -0.3262E-01        0.0                      **
**            0.1666E 03          0.1664E 03        0.2781E 00        0.0                      **
**            0.1683E 03          0.1684E 03       -0.7213E-01        0.0                      **
**            0.1683E 03          0.1684E 03       -0.1311E 00        0.0                      **
**            0.1706E 03          0.1706E 03       -0.1617E-01        0.0                      **
**            0.1709E 03          0.1707E 03        0.2832E 00        0.0                      **
**            0.1730E 03          0.1728E 03        0.1490E 00        0.0                      **
**            0.1730E 03          0.1729E 03        0.1361E 00        0.0                      **
**            0.1749E 03          0.1749E 03        0.1169E-01        0.0                      **
**            0.1752E 03          0.1749E 03        0.2231E 00        0.0                      **
**            0.1771E 03          0.1771E 03        0.2420E-01        0.0                      **
**            0.1773E 03          0.1771E 03        0.1735E 00        0.0                      **
**            0.1793E 03          0.1793E 03       -0.5240E-01        0.0                      **
**            0.1794E 03          0.1794E 03        0.8807E-01        0.0                      **
**            0.1814E 03          0.1814E 03       -0.2660E-01        0.0                      **
**            0.1816E 03          0.1814E 03        0.2194E 00        0.0                      **
**            0.1838E 03          0.1836E 03        0.2394E-00        0.0                      **
**            0.1838E 03          0.1836E 03        0.1668E 00        0.0                      **
**            0.1858E 03          0.1858E 03        0.3688E-01        0.0                      **
**            0.1857E 03          0.1858E 03       -0.1609E 00        0.0                      **
**            0.1878E 03          0.1879E 03       -0.8949E-01        0.0                      **
**            0.1900E 03          0.1901E 03       -0.7481E-01        0.0                      **
**                                                                                             **
**     CFCINT=GSTAT1 WHAT NOW    NEXT        CALL DISPLAY      DISP    2 OF    2               **
**                                                                                             **
************************************          M S A D        **********************************
************************************        D I S P L A Y -  **********************************
```

Figure 5-9

```
************************************    M S A D    ************************************
****  ***************  ************  D I S P L A Y  ***********  73.179.12.16.37  ****
**                                                                                  **
**      GST2                CLASS 2 RESIDUALS AND WEIGHTS                           **
**                                                                                  **
**      CURRENT ITERATION NUMBER                      1                             **
**                                                                                  **
```

CLASS 2 ANGLES	CLASS 2 CALCULATED	CLASS 2 RESIDUALS	CLASS 2 WEIGHTS
0.1900E 03	0.1901E 03	-0.8972E-01	0.0
0.1944E 03	0.1944E 03	0.1996E-01	0.0
0.1943E 03	0.1944E 03	-0.8043E-01	0.0
0.1963E 03	0.1966E 03	-0.2932E 00	0.0
0.1965E 03	0.1966E 03	-0.1052E 00	0.0
0.1987E 03	0.1988E 03	-0.7863E-01	0.0
0.1986E 03	0.1988E 03	-0.1971E 00	0.0
0.2009E 03	0.2009E 03	0.3357E-03	0.0
0.2008E 03	0.2009E 03	-0.4671E-01	0.0
0.2031E 03	0.2031E 03	-0.3220E-02	0.0
0.2030E 03	0.2031E 03	-0.8223E-01	0.0
0.2051E 03	0.2053E 03	-0.1415E 00	0.0
0.2053E 03	0.2053E 03	-0.1982E-01	0.0
0.2073E 03	0.2073E 03	-0.5157E-01	0.0
0.2093E 03	0.2095E 03	-0.2086E 00	0.0
0.2096E 03	0.2096E 03	-0.3052E-02	0.0
0.2117E 03	0.2118E 03	-0.2393E-01	0.0
0.2117E 03	0.2118E 03	-0.5617E-01	0.0
0.2161E 03	0.2160E 03	0.1154E-01	0.0
0.2161E 03	0.2161E 03	-0.5402E-02	0.0
0.2181E 03	0.2182E 03	-0.1144E 00	0.0
0.2183E 03	0.2183E 03	0.1711E-01	0.0
0.1430E 03	0.1429E 03	0.7294E-01	0.0
0.1431E 03	0.1429E 03	0.1314E 00	0.0
0.1451E 03	0.1451E 03	0.1781E-01	0.0
0.1452E 03	0.1451E 03	0.7498E-01	0.0
0.1472E 03	0.1472E 03	-0.1361E-01	0.0
0.1470E 03	0.1472E 03	-0.2199E 00	0.0
0.1494E 03	0.1494E 03	0.1791E-01	0.0
0.1491E 03	0.1495E 03	-0.3646E 00	0.0
0.1515E 03	0.1516E 03	-0.9055E-01	0.0
0.1513E 03	0.1517E 03	-0.3147E 00	0.0
0.1537E 03	0.1537E 03	-0.2892E-01	0.0
0.1538E 03	0.1537E 03	0.7950E-01	0.0
0.1559E 03	0.1559E 03	-0.6377E-01	0.0
0.1561E 03	0.1560E 03	0.1847E 00	0.0
0.1583E 03	0.1581E 03	0.1065E 00	0.0
0.1578E 03	0.1582E 03	-0.3316E 00	0.0
0.1603E 03	0.1602E 03	0.4660E-01	0.0
0.1604E 03	0.1603E 03	0.1172E 00	0.0
0.1623E 03	0.1624E 03	-0.1092E 00	0.0
0.1625E 03	0.1625E 03	-0.4425E-03	0.0
0.1644E 03	0.1646E 03	-0.2936E 00	0.0
0.1646E 03	0.1647E 03	-0.1165E 00	0.0

```
**                                                                                  **
**    CFCIN1=GSTAT1 WHAT NOW   NEXT        CALL DISPLAY         DISP   2 OF   2     **
**                                                                                  **
************************************    M S A D    ************************************
************************************  D I S P L A Y  **********************************
```

Figure 5-9 (Continued)

```
************************************     M S A D      ************************************
****  **************** ***********    D I S P L A Y   ***********  73.179.12.16.40     ****
**                                                                                        **
**     GST2                 CLASS 2 RESIDUALS AND WEIGHTS                                 **
**                                                                                        **
**     CURRENT ITERATION NUMBER                        1                                  **
**                                                                                        **
```

CLASS 2 ANGLES	CLASS 2 CALCULATED	CLASS 2 RESIDUALS	CLASS 2 WEIGHTS
0.1668E 03	0.1667E 03	0.5185E-01	0.0
0.1669E 03	0.1668E 03	0.1307E 00	0.0
0.1689E 03	0.1689E 03	-0.6677E-01	0.0
0.1688E 03	0.1690E 03	-0.1741E 00	0.0
0.1712E 03	0.1711E 03	0.5759E-01	0.0
0.1713E 03	0.1712E 03	0.1045E 00	0.0
0.1423E 03	0.1424E 03	-0.9785E-01	0.0
0.1447E 03	0.1446E 03	0.9895E-01	0.0
0.1470E 03	0.1468E 03	0.1322E 00	0.0
0.1488E 03	0.1489E 03	-0.8513E-01	0.0
0.1509E 03	0.1511E 03	-0.2500E 00	0.0
0.1536E 03	0.1533E 03	0.2233E 00	0.0
0.1556E 03	0.1554E 03	0.1304E 00	0.0
0.1577E 03	0.1576E 03	0.1944E-01	0.0
0.1597E 03	0.1599E 03	-0.1064E 00	0.0
0.1642E 03	0.1641E 03	0.7382E-01	0.0
0.1683E 03	0.1684E 03	-0.9634E-01	0.0
0.1730E 03	0.1728E 03	0.1433E 00	0.0
0.1838E 03	0.1836E 03	0.2027E 00	0.0
0.1858E 03	0.1858E 03	-0.6728E-01	0.0
0.1879E 03	0.1879E 03	0.3148E-01	0.0
0.1900E 03	0.1901E 03	-0.8284E-01	0.0
0.1944E 03	0.1944E 03	-0.3021E-01	0.0
0.1986E 03	0.1988E 03	-0.1526E 00	0.0
0.2008E 03	0.2009E 03	-0.4819E-01	0.0
0.2030E 03	0.2031E 03	-0.9065E-01	0.0
0.2117E 03	0.2118E 03	-0.1010E 00	0.0
0.2139E 03	0.2138E 03	0.5913E-01	0.0
0.2160E 03	0.2161E 03	-0.1367E-01	0.0
0.2183E 03	0.2183E 03	0.5502E-01	0.0
0.1430E 03	0.1429E 03	0.8125E-01	0.0
0.1452E 03	0.1451E 03	0.2672E-01	0.0
0.1472E 03	0.1472E 03	-0.5716E-01	0.0
0.1494E 03	0.1494E 03	-0.8572E-01	0.0
0.1515E 03	0.1516E 03	-0.1561E 00	0.0
0.1537E 03	0.1537E 03	-0.4863E-03	0.0
0.1560E 03	0.1559E 03	0.6653E-02	0.0
0.1581E 03	0.1582E 03	-0.4317E-01	0.0
0.1603E 03	0.1602E 03	0.6993E-01	0.0
0.1624E 03	0.1624E 03	-0.7016E-01	0.0
0.1668E 03	0.1667E 03	0.8301E-01	0.0
0.1688E 03	0.1690E 03	-0.1112E 00	0.0
0.1712E 03	0.1712E 03	0.7814E-01	0.0

```
**                                                                                        **
**                                                                                        **
**     CFCINT=GSTAT1 WHAT NOW            CALL DISPLAY          DISP   2 OF   2            **
**                                                                                        **
************************************     M S A D      ************************************
************************************   D I S P L A Y   ***********************************
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Figure 5-9 (Continued)

```
***********************************      M S A D      ***********************************
**** **************** ************  D I S P L A Y  ************  73.179.12.16.44  ****
**                                                                                      **
**      OPTABL                 PLOT OPTION TABLE FOR DCCONS                             **
**                                                                                      **
**      FOLLOWING ARE CONDITIONS ENCOUNTERED                                            **
**      IN THIS ITERATION OF DCCONS                                                     **
**      DID DCCONS CONVERG                          NO                                  **
**      DID DCCONS DIVERGE                          NO                                  **
**      WAS MAXIMUM NUM OF ITERATIONS EXCEEDED      NO                                  **
**      WAS NCOF OUT OF RANGE                       NO                                  **
**      WAS NUM OF BIASES GREATER THAN 5            NO                                  **
**      WAS THERE A SINGULAR MATRIX                 NO                                  **
**                                                                                      **
**      FOLLOWING ARE THE PLOT OPTIONS AVAILAB                                          **
**      RESIDUAL CLASS 1 TYPE 1 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 1 TYPE 2 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 1 TYPE 3 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 1 TYPE 4 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 1 TYPE 5 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 2 TYPE 1 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 2 TYPE 2 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 2 TYPE 3 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 2 TYPE 4 VS OBSER PLOT       NO                                  **
**      RESIDUAL CLASS 2 TYPE 5 VS OBSER PLOT       NO                                  **
**      SUMMARY DISPLAY                             NO                                  **
**      THE USER HAS THE OPTION TO SET                                                  **
**      THE FOLLOWING DCCONS OPERATING OPTIONS                                          **
**      IF THESE OPTIONS ARE NOT SET                                                    **
**      DCCONS WILL EXIT WHENEVER AN ERROR                                              **
**      IS ENCOUNTERED OR WHENEVER THE PROGRAM                                          **
**      CONVERGES                                                                       **
**                                                                                      **
**      REINITIALIZE DCCONS                         NO                                  **
**      CEASE PROCESSING IN DCCONS                  NO                                  **
**                                                                                      **
**      THE USER MUST TYPE IN YES IN THE FOLLO                                          **
**      FIELD TO EXIT FROM THE PLOT OPTION TAB                                          **
**                                                                                      **
**      EXIT PLOT OPTION TABLE                      NO                                  **
**                                                                                      **
**                                                                                      **
**                                                                                      **
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**                                                                                      **
**                                                                                      **
**     CPOINT=OPTTAB WHAT NOW              CALL DISPLAY          DISP   1 OF   1       **
**                                                                                      **
***********************************      M S A D      ***********************************
***********************************  D I S P L A Y   ***********************************
```

Figure 5-10

```
************************************      M S A D      ***********************************
****  ***************  ***********    D I S P L A Y    ***********  73.171.13.24.55  ****
**                                                                                      **
**       FINDIP          FINAL STATE VECTOR RESULTS FRCM CCCONS                         **
**                                                                                      **
**                                                                                      **
**       CURRENT ITERATION NUMBER                     3                                 **
**       MAXIMUM NUMBER OF ITERATIONS                 5                                 **
**       RESIDUAL EDITING CRITERIA                    0.0                               **
**       RESIDUAL EDIT BOUND                          1.72513                           **
**                                                                                      **
**       CONVENTIONS                                                                    **
**                                                                                      **
**       UNITS ARE IN DEGREES                                                           **
**       ALPHA(I),DELTA(I) ARE POLYNOMIAL COEFF                                         **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                     INITIAL   FINAL      EST.     INITIAL    FINAL      EST.         **
**                      ALPHA    ALPHA    ACCURACY    DELTA     DELTA    ACCURACY       **
**                                                                                      **
**       (0)          275.000   312.844    0.002     55.000    54.795     0.018         **
**       (1)                                                                            **
**       (2)                                                                            **
**       (3)                                                                            **
**                                                                                      **
**                                                                                      **
**                   CLASS 1  - CONE    ANGLES                                          **
**                                                                                      **
**       TYPE          INITIAL    FINAL      EST.      MEAN       RMS                   **
**                      BIAS      BIAS    ACCURACY   RESIDUAL  RESIDUAL                 **
**                                                                                      **
**        1             0.0      0.095     0.005     -0.067     0.104                   **
**        2             0.0     -0.121     0.008      0.040     0.234                   **
**        3             0.0     -0.060     0.051      0.644     0.206                   **
**        4             0.0      0.0       0.0        0.0       0.0                     **
**        5             0.0      0.0       0.0        0.0       0.0                     **
**                                                                                      **
**                                                                                      **
**                   CLASS 2   DIHEDRAL  ANGLES                                         **
**                                                                                      **
**       TYPE          INITIAL    FINAL      EST.      MEAN       RMS                   **
**                      BIAS      BIAS    ACCURACY   RESIDUAL  RESIDUAL                 **
**                                                                                      **
**        1             0.0     10.229     0.0       -7.729     0.123                   **
**        2             0.0     -0.013     0.002     -0.002     0.104                   **
**        3             0.0      0.0       0.0        0.0       0.0                     **
**        4             0.0      0.0       0.0        0.0       0.0                     **
**        5             0.0      0.0       0.0        0.0       0.0                     **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**      CPOINT=FINDIS WHAT NOW            CALL DISPLAY       DISP   1 OF   1            **
**                                                                                      **
************************************      M S A D      ***********************************
************************************    D I S P L A Y    *********************************
```

Figure 5-11

```
COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=60,SIZE=0000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      C
      C***********************************************************************
      C                                                                       *
      C                                                                       *
      C         SUBROUTINE DCCONS                                             *
      C                                                                       *
      C         CALLING SEQUENCE                                              *
      C                                                                       *
      C                   CALL DCCONS(ALP,ALPBND,ALPCUM,DEL,DELBND,DELCUM,    *
      C                   ARGCUM,TIME1,AXIS1,ANG1,WGHT1,IFRST1,NTYPE1,BIAS1,  *
      C                   BBND1,RHOST1,RHO1,CALC1,SCOEF1,TIME2,AXIS2,ANG2,    *
      C                   WGHT2,IFRST2,NTYPE2,BIAS2,BBND2,RHOST2,RHO2,CALC2,  *
      C                   SCOEF2,AVGRHO,COEF,DRHOSQ,CHNG,STOR1,STOR2,ALPR,DELR*
      C                   ,STYPE1,STYPE2,BTYPE,RL,WORK,GWORK0,GWORK4,GWORK5,  *
      C                   B11CUM)                                             *
      C                                                                       *
      C         DESCRIPTION                                                   *
      C                                                                       *
      C                   DCCONS IS A VERSION OF GCONES DESIGNED TO OPERATE   *
      C                   UNDER THE MULTI-SATELLITE ATTITUDE DETERMINATION    *
      C                   (MSAD) EXECUTIVE SYSTEM.                            *
      C                                                                       *
      C         COMMON AREAS REFERENCED                                       *
      C                                                                       *
      C                   DCSOPT,GCN1,MASCOM,STVEC                            *
      C                                                                       *
      C         EXTERNAL REFERENCES                                           *
      C                                                                       *
      C                   ABS,AMAX1,BLKINV,CHECK,COFSM,FINAL2,GDCCON,GTSIZE,  *
      C                   GTSTAT,MAX0,MESAGE,MIN0,PTSIZE,SQRT                 *
      C                                                                       *
      C         STORAGE REQUIREMENTS                                          *
      C                                                                       *
      C                   16,222 BYTES OF CORE STORAGE                        *
      C                                                                       *
      C         VARIABLES                                                     *
      C                                                                       *
      C         NAME      TYPE      I/O       DESCRIPTION                     *
      C                                                                       *
      C         ALP       R*4       I/O       A PRIORI POLYNOMIAL COEFFICIENTS*
      C                                       FOR RIGHT ASCENSION, IN DEGREES *
      C                                       (I.E., RA=ALP(1)+ALP(2)*T+ALP(3)*
      C                                       *T**2+ALP(4)*T**3, WHERE T =    *
      C                                       TIME OF OBSERVATION)            *
      C                                                                       *
      C         ALPBND    R*4       I         CONVERGENCE BOUNDS FOR ALP,     *
      C                                       IN DEGREES                      *
      C                                                                       *
      C         ALPCUM    R*4       O         CUMULATIVE RESULTS FOR ALP(1)   *
      C                                       (E.G., ALPCUM(5) CONTAINS THE   *
      C                                       VALUE OF ALP(1) OBTAINED FOR    *
      C                                       THE FIFTH ITERATION             *
      C                                                                       *
      C         DEL       R*4       I/O       A PRIORI POLYNOMIAL COEFFICIENTS*
      C                                       FOR DECLINATION, IN DEGREES     *
      C                                       (I.E., D=DEL(1)+DEL(2)*T+       *
      C                                       DEL(3)*T**2+DEL(4)*T**3, WHERE  *
      C                                       T = TIME OF OBSERVATION)        *
      C                                                                       *
      C         DELBND    R*4       I         CONVERGENCE BOUNDS FOR DEL,     *
      C                                       IN DEGREES                      *
      C                                                                       *
```

```
C        DELCUM     R*4       O          CUMULATIVE RESULTS FOR DEL(1)    *00003150
C                                        (E.G., DELCUM(4) CONTAINS THE    *00003200
C                                        VALUE OF DEL(1) OBTAINED FOR THE*00003250
C                                        FOURTH ITERATION)                *00003300
C                                                                         *00003350
C        ARGCUM     I*4       O          ITERATION INDICATOR FOR VALUES   *00003400
C                                        IN ALPCUM AND DELCUM             *00003450
C                                                                         *00003500
C        TIME1      R*4       I          REFERENCE TIMES FOR CLASS 1      *00003550
C                                        (CONE ANGLE) DATA                *00003600
C                                                                         *00003650
C        AXIS1      R*4       I          REFERENCE UNIT VECTORS FOR       *00003700
C                                        CLASS 1 DATA (DIMENSIONED 3 *    *00003750
C                                        NUMBER OF CLASS 1 OBSERVATIONS) *00003800
C                                                                         *00003850
C        ANG1       R*4       I          CLASS 1 (CONE ANGLE) OBSER-      *00003900
C                                        VATIONS, IN DEGREES(0-180)       *00003950
C                                                                         *00004000
C        WGHT1      R*4       I/O        CLASS 1 WEIGHTS                  *00004050
C                                                                         *00004100
C        IFRST1     I*4       I          POINTERS INDICATING STARTING     *00004150
C                                        POSITIONS FOR EACH TYPE OF CLASS*00004200
C                                        1 DATA IN THE ARRAYS             *00004250
C                                        TIME1,AXIS1,ANG1,AND WGHT1       *00004300
C                                                                         *00004350
C        NTYPE1     I*4       I          NUMBER OF OBSERVATIONS OF EACH   *00004400
C                                        TYPE OF CLASS 1 DATA             *00004450
C                                                                         *00004500
C        BIAS1      R*4       I/O        ESSENTIAL ESTIMATE OF BIASES FOR*00004550
C                                        EACH TYPE OF CLASS 1 DATA        *00004600
C                                        (THE VALUE 9999999. INDICATES    *00004650
C                                        THAT NO BIAS IS TO BE DETER-     *00004700
C                                        MINED FOR THE CORRESPONDING      *00004750
C                                        ANGLE TYPE)                      *00004800
C                                                                         *00004850
C        BBND1      R*4       I          CONVERGENCE BOUNDS FOR BIAS1     *00004900
C                                        ELEMENTS                         *00004950
C                                                                         *00005000
C        RHOST1     R*4       O          CLASS 1 STATISTICS               *00005050
C                                        RHOST1(1,I) - WEIGHTED SUM OF    *00005100
C                                         ANGLE RESIDUALS FOR TYPE I DATA*00005150
C                                        RHOST1(2,I) - WEIGHTED SUM OF    *00005200
C                                         SQUARES OF ANGLE RESIDUALS FOR *00005250
C                                         TYPE I DATA                     *00005300
C                                        RHOST1(3,I) - SUM OF WEIGHTS FOR*00005350
C                                         TYPE I DATA                     *00005400
C                                        RHOST1(4,I) - MEAN RESIDUAL FOR *00005410
C                                         TYPE I DATA                     *00005420
C                                        RHOST1(5,I) - STANDARD DEVIATION*00005430
C                                         FOR TYPE I DATA                 *00005440
C                                                                         *00005450
C        RHO1       R*4       O          RESIDUALS FOR CLASS 1 DATA       *00005500
C                                        DEFINED AS OBSERVED MINUS        *00005550
C                                        CALCULATED                       *00005600
C                                                                         *00005650
C        CALC1      R*4       O          CALCULATED ANGLES FOR CLASS 1    *00005700
C                                        DATA                             *00005750
C                                                                         *00005800
C        SCOEF1     R*4       O          DERIVATIVES OF CLASS 1 ANGLES    *00005850
C                                        WITH RESPECT TO STATE VECTOR     *00005900
C                                        ELEMENTS                         *00005950
C                                                                         *00006000
C        TIME2      R*4       I          REFERENCE TIMES FOR CLASS 2      *00006050
C                                        (DIHEDRAL ANGLE) DATA            *00006100
C                                                                         *00006150
```

```
C        AXIS2      R*4       I          REFERENCE VECTORS FOR CLASS 2    *00006200
C                                        DATA(DIMENSION 6*NUMBER OF       *00006250
C                                        OBSERVATIONS. THE I TH DIHEDRAL  *00006300
C                                        ANGLE IS MEASURED FROM VECTOR    *00006350
C                                        ((1,I),(2,I),(3,I)) TO VECTOR    *00006400
C                                        ((4,I),(5,I),(6,I))              *00006450
C                                                                         *00006500
C        ANG2       R*4       I          CLASS 2 ANGLES, IN DEGREES       *00006550
C                                        (0-360)                          *00006600
C                                                                         *00006650
C        WGHT2      R*4       I          WEIGHTS FOR CLASS 2 DATA         *00006700
C                                                                         *00006750
C        IFRST2     I*4       I          POINTERS INDICATING STARTING     *00006800
C                                        POSITIONS FOR EACH TYPE OF CLASS*00006850
C                                        2 DATA IN THE ARRAYS   TIME2,    *00006900
C                                        AXIS2,ANG2, AND WGHT2            *00006950
C                                                                         *00007000
C        NTYPE2     I*4       I          NUMBER OF OBSERVATIONS OF EACH   *00007050
C                                        TYPE OF CLASS 2 DATA             *00007100
C                                                                         *00007150
C        BIAS2      R*4       I/O        ESSENTIAL ESTIMATE OF BIASES     *00007200
C                                        FOR EACH TYPE OF CLASS 2 DATA    *00007250
C                                        (THE VALUE 9999999. INDICATES    *00007300
C                                        THAT NO BIAS IS TO BE DETER-     *00007350
C                                        MINED FOR THE CORRESPONDING      *00007400
C                                        ANGLE TYPE                       *00007450
C                                                                         *00007500
C        BBND2      R*4       I          CONVERGENCE BOUNDS FOR BIAS2     *00007550
C                                        ELEMENTS                         *00007600
C                                                                         *00007650
C        RHOST2     R*4       O          CLASS 2 STATISTICS               *00007700
C                                        RHOST2(1,I) - WEIGHTED SUM OF    *00007750
C                                         ANGLE RESIDUALS FOR TYPE I DATA*00007800
C                                        RHOST2(2,I) - WEIGHTED SUM OF    *00007850
C                                         SQUARES OF ANGLE RESIDUALS FOR *00007900
C                                         TYPE I DATA                     *00007950
C                                        RHOST2(3,I) - SUM OF WEIGHTS FOR*00008000
C                                         TYPE I DATA                     *00008050
C                                        RHOST2(4,I) - MEAN RESIDUAL FOR *00008060
C                                         TYPE I DATA                     *00008070
C                                        RHOST2(5,I) - STANDARD DEVIATION*00008080
C                                         FOR TYPE I DATA                 *00008090
C                                                                         *00008100
C        RHO2       R*4       O          RESIDUALS FOR CLASS 2 DATA       *00008150
C                                        DEFINED AS OBSERVED MINUS        C00008200
C                                        CALCULATED                       *00008250
C                                                                         *00008300
C        CALC2      R*4       O          CALCULATED ANGLES FOR CLASS 2    *00008350
C                                        DATA                             *00008400
C                                                                         *00008450
C        SCOEF2     R*4       O          DERIVATIVES OF CLASS 2 ANGLES    *00008500
C                                        WITH RESPECT TO STATE VECTOR     *00008550
C                                        ELEMENTS                         *00008600
C                                                                         *00008650
C        AVGRHO     R*4       O          USED TO STORE AVERAGE RESIDUAL   *00008700
C                                        MAGNITUDE(DIMENSIONED 2X5)       *00008750
C                                                                          00008800
C        COEF       R*4       O          ARRAY USED FOR COEFFICIENT,      *00008850
C                                        COVARIANCE, AND CORRELATION      *00008900
C                                        MATRICIES(DIMENSIONED NSXNS,     *00008950
C                                        WHERE NS = NUMBER OF ELEMENTS    *00009000
C                                        IN STATE VECTOR)                 *00009050
C                                                                         *00009100
C        DRHOSQ     R*4       O          WORK ARRAY(DIMENSIONED 13)       *00009150
C                                                                         *00009200
```

```
C          CHNG        R*4         O          WORK ARRAY USED TO STORE THE     *00009250
C                                             UPDATES TO THE STATE VECTOR      *00009300
C                                             AFTER EACH ITERATION(DIMENSIONED*00009350
C                                             13)                              *00009400
C                                                                              *00009450
C          STOR1       R*4         O          WORK ARRAY(DIMENSIONED 13)       *00009500
C                                                                              *00009550
C          STOR2       R*4         O          WORK ARRAY(DIMENSIONED 13)       *00009600
C                                                                              *00009650
C          ALPR        R*4         O          RIGHT ASCENSION(ALP) COEFFI-     *00009700
C                                             CIENTS, IN RADIANS               *00009750
C                                                                              *00009800
C          DELR        R*4         O          DECLINATION(DEL) COEFFICIENTS    *00009850
C                                             IN RADIANS                       *00009900
C                                                                              *00009950
C          STYPE1      R*4         O          ALPHA-NUMERIC WORK ARRAY         *00010000
C                                             (DIMENSIONED 13)                 *00010050
C                                                                              *00010100
C          STYPE2      R*4         O          ALPHA-NUMERIC WORK ARRAY         *00010150
C                                             (DIMENSIONED 13)                 *00010200
C                                                                              *00010250
C          BTYPE       I*4         O          WORK ARRAY(DIMENSIONED 13)       *00010300
C                                                                              *00010350
C          RL          L*1         O          LOGICAL WORK ARRAY (DIMENSIONED *00010400
C                                             13)                              *00010450
C                                                                              *00010500
C          WORK        R*4         O          WORK ARRAY(DIMENSIONED 13)       *00010550
C                                                                              *00010600
C          GWORKO      R*8         O          ALPHA-NUMERIC WORK ARRAY USED    *00010650
C                                             TO STORE FINAL SUMMARY RESULTS   *00010700
C                                             FOR DISPLAY                      *00010750
C                                                                              *00010800
C          GWORK4      R*4         O          WORK ARRAY USED TO STORE OBSER-  *00010850
C                                             VATION NUMBER FOR PLOTTING       *00010900
C                                                                              *00010950
C          GWORK5      R*4         O          WORK ARRAY USED TO STORE (O-C)   *00011000
C                                             RESIDUALS FOR PLOTTING           *00011050
C                                                                              *00011100
C          B11CUM      R*8         O          ALPHA-NUMERIC WORK ARRAY USED TO*00011150
C                                             STORE CUMULATIVE BIASES FOR      *00011200
C                                             DISPLAY                           00011250
C                                                                              *00011300
C          COMMON AREA VARIABLES USED IN ROUTINE                               *00011350
C                                                                              *00011400
C          VARIABLE    TYPE        ORIGIN     DESCRIPTION                      *00011450
C                                                                              *00011500
C          CPTION      I*4         DCSOPT     FLAG ARRAY FOR PLOTTING OPTIONS *00011550
C                                               =0, DO NOT PLOT                *00011600
C                                               =1, PLOT                       *00011650
C                                                                              *00011700
C          FINISH      I*4         DCSOPT     FLAG FOR TERMINATING PLOT OPTION*00011750
C                                             TABLE                            *00011800
C                                               =0, DO NOT TERMINATE           *00011850
C                                               =1, TERMINATE                  *00011900
C                                                                              *00011950
C          FINALD      I*4         DCSOPT     FLAG FOR DISPLAYING SUMMARY      *00012000
C                                             DISPLAY                          *00012050
C                                               =0, DO NOT DISPLAY             *00012100
C                                               =1, DISPLAY                    *00012150
C                                                                              *00012200
C          IOUT        I*4         GCN1       FORTRAN DEVICE UNIT FOR SPECI-   *00012250
C                                             FIED PRINTOUT                    *00012300
C                                                                              *00012350
C          NCLAS1      I*4         GCN1       NUMBER OF CLASS 1 DATA TYPES     *00012400
C                                                                              *00012450
C          NCLAS2      I*4         GCN1       NUMBER OF CLASS 2 DATA TYPES     *00012500
```

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C                                                                      *00012550
C       NCOF      I*4       GCN1      MAXIMUM NUMBER OF ITERATIONS     *00012600
C                                                                      *00012650
C       MAXIT     I*4       GCN1      MAXIMUM NUMBER OF ITERATIONS     *00012670
C                                                                      *00012680
C       IWRT      I*4       GCN1      INTERMEDIATE PRINTOUT LEVEL      *00012700
C                                     INDICATOR (SEE REFERENCES 1 & 2  *00012750
C                                     FOR VARIOUS LEVELS)              *00012800
C                                                                      *00012850
C       TZERO     R*4       GCN1      REFERENCE TIME                   *00012860
C                                                                      *00012870
C       IOC       I*4       GCN1      RESIDUAL STORAGE INDICATOR       *00012900
C                                       =0, DO NOT STORE RESIDUALS     *00012950
C                                       =1, STORE RESIDUALS FOR DIS-   *00013000
C                                           PLAY AND PLOTTING          *00013050
C                                                                      *00013100
C       ICALC     I*4       GCN1      CALCULATED VALUES STORAGE INDI-  *00013150
C                                     CATORS                           *00013200
C                                       =0, DO NOT STORE CALCULATED    *00013250
C                                           VALUES                     *00013300
C                                       =1, STORE CALCULATED VALUES    *00013350
C                                           FOR DISPLAY                *00013400
C                                                                      *00013450
C       IDER      I*4       GCN1      DERIVATIVE STORAGE FLAG          *00013460
C                                        =0, DO NOT STORE              *00013470
C                                        =1, STORE                     *00013480
C                                                                      *00013490
C       SMULT     R*4       GCN1      RESIDUAL EDIT CRITERIA (THE      *00013500
C                                     WEIGHTS OF ANGLES WHOSE MAGNI-   *00013550
C                                     TUDE OF RESIDUAL IS GREATER      *00013600
C                                     THAN SMULT*(AVERAGE OF RESID-    *00013650
C                                     UAL MAGNITUDES) IS SET TO THE    *00013700
C                                     NEGATIVE OF THE RESIDUAL         *00013750
C                                                                      *00013800
C       NP        I*4       GCN1      TOTAL NUMBER OF ELEMENTS IN THE  *00013850
C                                     STATE VECTOR(DEFINED AS 2*NCOF + *00013900
C                                     NUMBER OF BIASES)                *00013950
C                                                                      *00014000
C       IWHERE    I*4       GCN1      CURRENTLY NOT USED               *00014010
C                                                                      *00014020
C       ISTEP     I*4       GCN1      CURRENT ITERATION INDICATOR      *00014050
C                                                                      *00014100
C       ISTOP     I*4       GCN1      CURRENTLY NOT USED               *00014110
C                                                                       00014120
C       IRET      I*4       GCN1      RETURN CODE                      *00014150
C                                       =0, PROCESS CONVERGED          *00014200
C                                       =1, MAXIT EXCEEDED, PROCESS    *00014250
C                                           TERMINATED                 *00014300
C                                       =2, PROCESS DIVERGED, COR-     *00014350
C                                           RECTION ELEMENT GREATER    *00014400
C                                           THAN 360 DEGREES           *00014450
C                                       =3, SINGULAR MATRIX            *00014500
C                                       =4, NUMBER OF BIASES GREATER   *00014550
C                                           THAN 5                     *00014600
C                                       =5, NCOF OUT OF RANGE          *00014650
C                                                                      *00014700
C       ISTAT     I*4       GCN1      COVARIANCE/CORRELATION FLAG      *00014710
C                                        =0, DO NOT COMPUTE            *00014720
C                                        =1, COMPUTE                   *00014730
C                                                                      *00014740
C       CORMIN    I*4       GCN1      DISPLAY INDICATOR FOR CLASS 1    *00014750
C                                     DATA                             *00014800
C                                       =0, DO NOT DISPLAY             *00014850
C                                       =1, DISPLAY                    *00014900
C                                                                      *00014950
```

```
C     CORMAX      I*4        GCN1        DISPLAY INDICATOR FOR CLASS 2
C                                        DATA
C                                          =0, DO NOT DISPLAY
C                                          =1, DISPLAY
C
C     IOPEN       I*4        MASCON      GRAPHICS DEVICE INDICATOR
C                                          =0, NO GRAPHICS DEVICE ACTIVE
C                                          =1, MSAD GRAPHICS DEVICE
C                                              ACTIVE
C
C     DATA TRANSMISSION
C
C     NAME        READ/WRITE/CPOINT      DESCRIPTION
C
C     FTXXF001    WRITE                  INTERMEDIATE PRINTOUT, WHERE
C                                        XX = IOUT
C
C     GCONE0      CPOINT                 DCCONS INITIAL PARAMETER DISPLAY
C
C     DCC1        CPOINT                 CLASS 1 DATA DISPLAY
C
C     DCC2        CPOINT                 CLASS 2 DATA DISPLAY
C
C     OPTAB1      CPOINT                 OPTION TABLE DISPLAY
C
C     RESTRICTIONS
C     1-  THE NUMBER OF POLYNOMIAL COEFFICIENTS MUST BE GREATER OR
C         EQUAL TO 1 AND LESS THAN OR EQUAL TO 4
C
C     2-  THE NUMBER OF BIASES DETERMINED, FOR BOTH CLASS 1 AND
C         CLASS 2 DATA, MUST BE LESS THAN OR EQUAL TO 5
C
C     3-  ALL CALLING SEQUENCE ARRAYS ARE MSAD ALLOCATED, AND HENCE
C         , IT IS UP TO THE USER TO ENSURE THE ALLOCATION SIZE OF
C         WORK ARRAYS IS NOT EXCEEDED.
C
C     REFERENCES
C
C                 1.  L.R.SCHLEGEL, CONES AN ITERATIVE DIFFERENTIAL
C                     CORRECTION TECHNIQUE FOR ATTITUDE DETERMINATION
C                     OF A SPINNING SATELLITE, IBM FSD REPORT,
C                     CONTRACT NAS 5-10022, MAY 1697
C
C                 2.  SURVEY AND EVALUATION OF ATTITUDE DETERMINATION
C                     TECHNIQUES, IBM FSD REPORT TR-68-8, CONTRACT
C                     NAS 5-10022, MAY 1968, PP. 4-14 TO 4-24
C
C                 3.  RADIO ASTRONOMY EXPLORER ATTITUDE DETERMINATION
C                     SYSTEM (RAEADS), VOL III, SPIN AXIS ATTITUDE
C                     DETERMINATION PROGRAM-DYCON, IBM FSD REPORT,
C                     CONTRACT NAS 5-10022, MARCH 1969
C
C                 4.  SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE,
C                     VERSION II, PROGRAMMER'S MANUAL, IBM FORM NO.
C                     H20-0205-2
C
C     REVISIONS
C
C                 1.  F. KNOOP (01 AUG 1969) - ORIGINAL CODING AND
C                     TESTING
C
C                 2.  F. KNOOP (20 JAN 1970) - MODIFICATION TO CHECK
C                     FOR DIVERGENCE TO PREVENT IHC254I ERRORS DUE TO
C                     ABSURDLY LARGE CORRECTION ELEMENTS
C
C                 3.  F. KNOOP (20 JAN 1970) - REORDERING OF ERROR
C                     RETURN CODES INTO ORDER OF SEVERITY
```

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             C
             C                    4.  F. KNOOP (20 FEB 1970) - COMPLETE REVISION TO
             C                        INCLUDE DIHEDRAL ANGLE DATA
             C
             C                    5.  J. WHALEN (SUMMER 1972) - REVISION TO GCONES
             C                        TO INCLUDE LOGIC FOR INTER-ACTIVE GRAPHICS
             C                        CAPABILITIES UNDER THE MULTI-SATELLITE ATTITUDE
             C                        DETERMINATION SYSTEM.  THESE REVISIONS INCLUDE
             C                        ADDITION OF ARRAYS AND INSERTION OF CALLS TO
             C                        THE MSAD ROUTINES.
             C
             C                    6.  L. FEAKES (13 JULY 1973) - REVISION TO CODE TO
             C                        INCLUDE ADDITIONAL CALLS TO MSAD ROUTINES AND
             C                        CHANGE OF LOGIC FOR REINITIALIZATION OF DCCONS
             C
             C
             C*****************************************************************************
ISN 0002           SUBROUTINE DCCONS (ALP,ALPBND,ALPCUM,DEL,DELBND,DELCUM,ARGCUM,TIME
                  11,AXIS1,ANG1,WGHT1,IFRST1,NTYPE1,BIAS1,BBND1,RHOST1,RHO1,CALC1,SC0
                  2EF1,TIME2,AXIS2,ANG2,WGHT2,IFRST2,NTYPE2,BIAS2,BBND2,RHOST2,RHO2,C
                  3ALC2,SCOEF2,AVGRHO,COEF,DRHOSQ,CHNG,STOR1,STOR2,ALPR,DELR,STYPE1,S
                  4TYPE2,BTYPE,RL,WORK,GWORK0,GWORK4,GWORK5,B11CUM)
ISN 0003           COMMON/GCN1/ ICUT,NCLAS1,NCLAS2,NCOF,MAXIT,IWRT,TZERO,IOC,ICALC,
                  1            IDER,SMULT,NP,IWHERE,ISTEP,ISTOP,IRET,ISTAT,
                  2            CORMIN,CORMAX
ISN 0004           COMMON/STVECT/OLDALP(4),OLDDEL(4),OLDBS1(5),OLDBS2(5),
                  1 NEWALP(4),NEWDEL(4),NEWBS1(5),NEWBS2(5)
ISN 0005           REAL*4 NEWALP,NEWDEL,NEWBS1,NEWBS2
ISN 0006           COMMON/DCSOPT/ OPTION(10),FINISH,FINALD,IMESG(8)
ISN 0007           INTEGER*4 OPTION,FINISH,FINALD
ISN 0008           COMMON/MASCOM/ IDUMMY(24),IOPEN
ISN 0009           REAL*8 STAT1,STOP1
ISN 0010           DATA STOP1/'STOP    '/
             C
ISN 0011           DIMENSION ALP(1),ALPBND(1),ALPCUM(1),DEL(1),DELBND(1),DELCUM(1),
                  1          ARGCUM(1),TIME1(1),AXIS1(3,1),ANG1(1),WGHT1(1),
                  2          IFRST1(1),NTYPE1(1),BIAS1(1),BBND1(1),RHOST1(3,1),
                  3          RHO1(1),CALC1(1),SCOEF1(NP,1),TIME2(1),AXIS2(6,1),
                  4          ANG2(1),WGHT2(1),IFRST2(1),NTYPE2(1),BIAS2(1),BBND2(1),
                  5          RHOST2(3,1),RHO2(1),CALC2(1),SCOEF2(NP,1),AVGRHO(2,1),
                  6          COEF(NP,NP),DRHOSQ(NP),CHNG(NP),STOR1(NP),STOR2(NP),
                  7  ALPR(1),DELR(1),STYPE1(1),STYPE2(1),BTYPE(1),RL(1),WORK(1),
                  8  ANUM(6)
ISN 0012           DIMENSION BIAS1I(6),BIAS2I(6),AI(4),DI(4),RHOT1(5,6),RHOT2(5,6),
                  1  GWORK0(1),GWORK5(1),GWORK4(1)
ISN 0013           REAL*8 GWORK0,B11CUM
ISN 0014           INTEGER*4 BTYPE,CORMIN,CORMAX
ISN 0015           DATA TOTAL/'TOTL'/,BLANK/'    '/,ANUM/'  1 ','  2 ','  3 ','  4 ',
                  1'  5 ','  6 '/
ISN 0016           DATA STAT2/'STAT'/
ISN 0017           LOGICAL*1 RL
ISN 0018           DIMENSION NAME(2,13)
ISN 0019           REAL NAME
ISN 0020           DATA NAME / ' ALP','HA 1',' DEL','TA 1',' ALP','HA 2',' DEL',
                  1           'TA 2',' ALP','HA 3',' DEL','TA 3',' ALP','HA 4',
                  2           ' DEL','TA 4','  BI','AS 1','  BI','AS 2','  BI',
                  3           'AS 3','  BI','AS 4','  BI','AS 5' /
ISN 0021           DATA RTOD, XBIAS / 57.29578, 9999999. /
             C     EXTERNAL REFERENCES    COFSUM,  ELKINV,  CHECK
             C
ISN 0022           IF (IWRT.GT.0) WRITE (IOUT,890)
ISN 0024           IF (IWRT.LT.2) GO TO 170
             C ***** WRITE HEADER LINE AND ALL INPUT NON-ARRAY ITEMS
ISN 0026           WRITE (IOUT,900) NCLAS1,NCLAS2,TZERO,NCOF,MAXIT,IWRT,IOUT
             C ***** WRITE INITIAL ATTITUDE COEFFICIENTS AND CORRECTION BOUNDS
ISN 0027           WRITE (IOUT,910) (ALP(I),ALPBND(I),DEL(I),DELBND(I),I=1,NCOF)
             C ***** WRITE INITIAL BIAS ESTIMATES AND CORRECTION BOUNDS
ISN 0028           IF (NCLAS1.LE.0) GO TO 110
ISN 0030           ITITLE=1
ISN 0031           DO 100 I=1,NCLAS1
ISN 0032           IF (BIAS1(I).EQ.XBIAS) GO TO 100
ISN 0034           IF (ITITLE.EQ.1) WRITE (IOUT,920)
ISN 0036           ITITLE=2
ISN 0037           WRITE (IOUT,940) I,BIAS1(I),BBND1(I)
ISN 0038       100 CONTINUE
ISN 0039       110 CONTINUE
ISN 0040           IF (NCLAS2.LE.0) GO TO 130
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ISN 0042          ITITLE=1
ISN 0043          DO 120 I=1,NCLAS2
ISN 0044          IF (BIAS2(I).EQ.XBIAS) GO TO 120
ISN 0046          IF (ITITLE.EQ.1) WRITE (IOUT,930)
ISN 0048          ITITLE=2
ISN 0049          WRITE (IOUT,940) I,BIAS2(I),BBND2(I)
ISN 0050      120 CONTINUE
ISN 0051      130 CONTINUE
ISN 0052          IF (IWRT.LT.3) GO TO 170
ISN 0054          IF (NCLAS1.LE.0) GO TO 150
ISN 0056          DO 140 I=1,NCLAS1
ISN 0057          J1=IFRST1(I)
ISN 0058          N=NTYPE1(I)
ISN 0059          J2=J1+N-1
ISN 0060          WRITE (IOUT,950) I,N,J1,J2
ISN 0061          IF (IWRT.GE.8.AND.N.GT.0) WRITE (IOUT,970) (J,TIME1(J),(AXIS1(K,J)
                 1,K=1,3),ANG1(J),WGHT1(J),J=J1,J2)
ISN 0063      140 CONTINUE
ISN 0064      150 CONTINUE
ISN 0065          IF (NCLAS2.LE.0) GO TO 170
ISN 0067          DO 160 I=1,NCLAS2
ISN 0068          J1=IFRST2(I)
ISN 0069          N=NTYPE2(I)
ISN 0070          J2=J1+N-1
ISN 0071          WRITE (IOUT,960) I,N,J1,J2
ISN 0072          IF (IWRT.GE.8.AND.N.GT.0) WRITE (IOUT,980) (J,TIME2(J),(AXIS2(K,J)
                 1,K=1,6),ANG2(J),WGHT2(J),J=J1,J2)
ISN 0074      160 CONTINUE
ISN 0075      170 CONTINUE
ISN 0076          DO 180 I=1,5
ISN 0077      180 BTYPE(I)=0
ISN 0078          DO 190 I=1,13
ISN 0079          STYPE1(I)=BLANK
ISN 0080          STYPE2(I)=BLANK
ISN 0081          STOR1(I)=0.
ISN 0082      190 STOR2(I)=0.
ISN 0083          NONE=0
ISN 0084          NTWO=0
              C   STORE DATA FOR NSAD DISPLAY
              C ***** COMPUTE THE NUMBER OF ANGLE BIASES TO BE DETERMINED
ISN 0085          NLC=0
ISN 0086          NBIAS=0
ISN 0087          IF (NCLAS1.LE.0) GO TO 210
ISN 0089          DO 200 I=1,NCLAS1
ISN 0090          NONE=NONE+NTYPE1(I)
ISN 0091          IF (BIAS1(I).EQ.XBIAS) GO TO 200
ISN 0093          NBIAS=NBIAS+1
ISN 0094          NLC=2*NBIAS
ISN 0095          STOR1(NLC-1)=BIAS1(I)
ISN 0096          STOR1(NLC)=BBND1(I)
ISN 0097          BTYPE(I)=10+I
ISN 0098      200 CONTINUE
ISN 0099      210 CONTINUE
ISN 0100          IF (NCLAS2.LE.0) GO TO 230
ISN 0102          DO 220 I=1,NCLAS2
ISN 0103          NTWO=NTWO+NTYPE2(I)
ISN 0104          IF (BIAS2(I).EQ.XBIAS) GO TO 220
ISN 0106          NBIAS=NBIAS+1
ISN 0107          NLC=2*NBIAS
ISN 0108          STOR1(NLC-1)=BIAS2(I)
ISN 0109          STOR1(NLC)=BBND2(I)
ISN 0110          BTYPE(I)=20+I
ISN 0111      220 CONTINUE
ISN 0112      230 CONTINUE
              C ***** CHECK FOR INVALID INPUT
ISN 0113          IF (NCOF.GE.1.AND.NCOF.LE.4) GO TO 240
ISN 0115          IRET=3
ISN 0116          GO TO 780
ISN 0117      240 IF (NBIAS.LE.5) GO TO 250
ISN 0119          IRET=4
ISN 0120          GO TO 780
ISN 0121      250 CONTINUE
              C ***** COMPUTE SOME CONSTANTS FOR THE SUMMATION
ISN 0122          N2=NCOF+NCOF
ISN 0123          N3=N2+NBIAS
ISN 0124          N4=N2+1
ISN 0125          N5=N3+1
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ISN 0126          IB1=9
ISN 0127          IB2=IB1+NBIAS-1
           C      CALL PTSIZE FOR ARRYS TO BE DISPLAYED.
ISN 0128          CALL GTSIZE (GWORK0,IFLL0,IALL0,GWORK5,IFLL5,IALL5,GWORK4,IFLL4,IA
                 1LL4)
ISN 0129          CALL PTSIZE (NBIAS,BTYPE)
ISN 0130          CALL PTSIZE (NLC,STOR1)
ISN 0131          CALL PTSIZE (20,ALPCUM,DELCUM,ARGCUM)
ISN 0132          CALL PTSIZE (NCOF,ALP,DEL,ALPBND,DELBND)
ISN 0133          CALL PTSIZE (NONE,TIME1,ANG1,WGHT1)
ISN 0134          CALL PTSIZE (NTWO,TIME2,ANG2,WGHT2)
ISN 0135          NN3=3*NONE
ISN 0136          CALL PTSIZE (NN3,AXIS1)
ISN 0137          NN6=6*NTWO
ISN 0138          CALL PTSIZE (NN6,AXIS2)
ISN 0139          NP2=NP*NP
ISN 0140          CALL PTSIZE (NP2,COEF)
ISN 0141          CALL PTSIZE (NCLAS1,BIAS1,BBND1)
ISN 0142          CALL PTSIZE (NCLAS2,BIAS2,BBND2)
ISN 0143      260 IWHERE=0
ISN 0144          IF (NCLAS1.LE.0) GO TO 280
ISN 0146          DO 270 I=1,NCLAS1
ISN 0147          J1=IFRST1(I)
ISN 0148          N=NTYPE1(I)
ISN 0149          J2=J1+N-1
ISN 0150          DO 270 K=J1,J2
ISN 0151          WGHT1(K)=ABS(WGHT1(K))
ISN 0152      270 CONTINUE
ISN 0153      280 IF (NCLAS2.LE.0) GO TO 300
ISN 0155          DO 290 I=1,NCLAS2
ISN 0156          J1=IFRST2(I)
ISN 0157          N=NTYPE2(I)
ISN 0158          J2=J1+N-1
ISN 0159          DO 290 K=J1,J2
ISN 0160          WGHT2(K)=ABS(WGHT2(K))
ISN 0161      290 CONTINUE
ISN 0162      300 CONTINUE
           C      DISPLAY ALL INPUT DATA AND CONTROL PARAMTERS AT 'GCONE0'
ISN 0163          ONP=NP
ISN 0164          ONCOF=NCOF
ISN 0165          ONCLS1=NCLAS1
ISN 0166          ONCLS2=NCLAS2
ISN 0167          CALL CHECK ('GCONE0')
ISN 0168          IF (ONCOF.NE.NCOF.OR.ONCLS1.NE.NCLAS1.OR.ONCLS2.NE.NCLAS2) GO TO 1
                 170
ISN 0170          NBS=0
ISN 0171          IF (NCLAS1.LE.0) GO TO 320
ISN 0173          DO 310 I=1,NCLAS1
ISN 0174          IF (BIAS1(I).EQ.XBIAS) GO TO 310
ISN 0176          NBS=NBS+1
ISN 0177      310 CONTINUE
ISN 0178      320 IF (NCLAS2.LE.0) GO TO 340
ISN 0180          DO 330 I=1,NCLAS2
ISN 0181          IF (BIAS2(I).EQ.XBIAS) GO TO 330
ISN 0183          NBS=NBS+1
ISN 0184      330 CONTINUE
ISN 0185      340 CONTINUE
ISN 0186          IF (NBS+2*NCOF.NE.ONP) GO TO 170
ISN 0188          IF (IOC.EQ.1) CALL PTSIZE (NONE,RHO1)
ISN 0190          IF (ICALC.EQ.1) CALL PTSIZE (NONE,CALC1)
ISN 0192          IF (IOC.EQ.1) CALL PTSIZE (NTWO,RHO2)
ISN 0194          IF (ICALC.EQ.1) CALL PTSIZE (NTWO,CALC2)
ISN 0196          IF (CORMIN.EQ.1) CALL CHECK ('DCC11')
ISN 0198          IF (CORMAX.EQ.1) CALL CHECK ('DCC22')
ISN 0200          CALL PTSIZE (13,STOR1)
           C ***** INITIALIZE ITERATION COUNTER
ISN 0201          ISTEP=0
           C
           C ***** BEGIN PROCESSING FOR THIS ITERATION
           C
ISN 0202          DO 350 I=1,NCLAS1
ISN 0203      350 BIASI(I)=BIAS1(I)
ISN 0204          DO 360 I=1,NCLAS2
ISN 0205      360 BIAS2I(I)=BIAS2(I)
ISN 0206          DO 370 I=1,NCOF
ISN 0207          AI(I)=ALP(I)
ISN 0208      370 DI(I)=DEL(I)
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ISN 0209          DO 380 I=1,4
ISN 0210          OLDALP(I)=0.
ISN 0211          OLDDEL(I)=0.
ISN 0212          OLDBS1(I)=0.
ISN 0213          OLDBS2(I)=0.
ISN 0214          NEWALP(I)=0.
ISN 0215          NEWDEL(I)=0.
ISN 0216          NEWBS1(I)=0.
ISN 0217      380 NEWBS2(I)=0.
ISN 0218          OLDBS1(5)=0.
ISN 0219          OLDBS2(5)=0.
ISN 0220          NEWBS1(5)=0.
ISN 0221          NEWBS2(5)=0.
ISN 0222      390 CONTINUE
ISN 0223          IG3=0
ISN 0224          CALL MESAGE ('**** THE SUBPROGRAM DCCONS **** IS NOW IN OPERATION
                 1*=',0,0,1)
ISN 0225          CALL PTSIZE (NP,DRHOSQ)
ISN 0226          ISTEP=ISTEP+1
            C ***** CONVERT ATTITUDE COEFFICIENTS TO RADIANS
ISN 0227          DO 400 I=1,NCOF
ISN 0228          ALPR(I)=ALP(I)/RTOD
ISN 0229          DELR(I)=DEL(I)/RTOD
ISN 0230      400 CONTINUE
            C ***** ZERO OUT MATRIX OF COEFFICIENTS
ISN 0231          DO 420 I=1,N3
ISN 0232          DO 410 J=1,N3
ISN 0233          COEF(J,I)=0.0
ISN 0234      410 CONTINUE
ISN 0235          DRHOSQ(I)=0.0
ISN 0236      420 CONTINUE
ISN 0237          IBIAS=N2
            C
            C ***** BEGIN LOOP TO MAKE ALL SUMMATIONS FOR CLASS 1 DATA (CONE ANGLES)
            C
ISN 0238          IF (NCLAS1.LE.0) GO TO 440
ISN 0240          DO 430 I=1,NCLAS1
            C ***** ZERO OUT RESIDUAL SUMMATION VARIABLES
ISN 0241          RHOST1(1,I)=0.0
ISN 0242          RHOST1(2,I)=0.0
ISN 0243          RHOST1(3,I)=0.0
ISN 0244          J1=IFRST1(I)
ISN 0245          N=NTYPE1(I)
ISN 0246          IF (N.LE.0) GO TO 430
ISN 0248          IF (BIAS1(I).NE.XBIAS) IBIAS=IBIAS+1
            C ***** CALL COFSUM TO COMPUTE AND SUM COEFFICIENTS FOR THIS TYPE OF
            C ***** CLASS 1 DATA
            C.......................................................................
ISN 0250          CALL COFSM (TIME1,AXIS1(1,J1),ANG1(J1),WGHT1(J1),N,1,3,ALPR,DELR,B
                 1IAS1(I),IBIAS,COEF,DRHOSQ,RHOST1(1,I),RHO1,CALC1,SCOEF1,J1)
            C.......................................................................
ISN 0251      430 CONTINUE
ISN 0252      440 CONTINUE
            C
            C ***** BEGIN LOOP TO MAKE ALL SUMMATIONS FOR CLASS 2 DATA (DHED ANGLES)
            C
ISN 0253          IF (NCLAS2.LE.0) GO TO 460
ISN 0255          DO 450 I=1,NCLAS2
            C ***** ZERO OUT RESIDUAL SUMMATION VARIABLES
ISN 0256          RHOST2(1,I)=0.0
ISN 0257          RHOST2(2,I)=0.0
ISN 0258          RHOST2(3,I)=0.0
ISN 0259          J1=IFRST2(I)
ISN 0260          N=NTYPE2(I)
ISN 0261          IF (N.LE.0) GO TO 450
ISN 0263          IF (BIAS2(I).NE.XBIAS) IBIAS=IBIAS+1
            C ***** CALL COFSUM TO COMPUTE AND SUM COEFFICIENTS FOR THIS TYPE OF
            C ***** CLASS 2 DATA
            C.......................................................................
ISN 0265          CALL COFSM (TIME2,AXIS2(1,J1),ANG2(J1),WGHT2(J1),N,2,6,ALPR,DELR,B
                 1IAS2(I),IBIAS,COEF,DRHOSQ,RHOST2(1,I),RHO2,CALC2,SCOEF2,J1)
            C.......................................................................
ISN 0266      450 CONTINUE
ISN 0267      460 CONTINUE
            C ***** COFSUM COMPUTES ONLY DIAGONAL AND UPPER RIGHT OFF-DIAGONAL
            C ***** ELEMENTS OF THE COEFFICIENT MATRIX BECAUSE IT IS A SYMMETRIC
            C ***** MATRIX
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          C ***** COMPLETE LOWER LEFT OFF-DIAGONAL ELEMENTS OF SYMMETRIC MATRIX
          C        FOR PRINTED OUTPUT AND DISPLAY PURPOSES.
ISN 0268        DO 470 I=2,N3
ISN 0269        K=I-1
ISN 0270        DO 470 J=1,N
ISN 0271        COEF(I,J)=COEF(J,I)
ISN 0272    470 CONTINUE
ISN 0273        IF (IWRT.LT.10) GO TO 490
          C ***** WRITE COEFFICIENTS OF SIMULTANEOUS EQUATIONS
ISN 0275        WRITE (IOUT,990)
ISN 0276        DO 480 I=1,N3
ISN 0277        WRITE (IOUT,1000) (COEF(I,J),J=1,N3),DRHOSQ(I)
ISN 0278    480 CONTINUE
ISN 0279    490 CONTINUE
          C ***** CALL IBM SSP ROUTINE MINV TO INVERT COEF MATRIX
          C.....................................................................
ISN 0280        IWHERE=1
          C     DISPLAY COEFFICIENT MATRIX.
          C.....................................................................
          C     CALL SYMMETRIC MATRIX INVERTER.
ISN 0281        CALL BLKINV (COEF,1,N3,NP,DET,IERR,STOR1,STOR2,RL)
ISN 0282        IF (DET.NE.0.0) GO TO 500
ISN 0284        IRET=5
ISN 0285        GO TO 780
ISN 0286    500 CONTINUE
          C ***** MULTIPLY MATRIX INVERSE (COVARIANCE MATRIX) BY VECTOR OF RHO
          C ***** SQUARED DERIVATIVES TO OBTAIN ATTITUDE STATE CORRECTIONS
ISN 0287        DO 510 I=1,N3
ISN 0288        CHNG(I)=0.0
ISN 0289        DO 510 J=1,N3
ISN 0290        CHNG(I)=CHNG(I)+COEF(I,J)*DRHOSQ(J)
ISN 0291    510 CONTINUE
          C     USE STOR1 AND STOR2 FOR MSAD DISPLAYS.
ISN 0292        DO 520 I=1,13
ISN 0293        STOR1(I)=0.
ISN 0294    520 STOR2(I)=0.
ISN 0295        DO 530 I=1,NCOF
ISN 0296        STOR1(3*I-1)=CHNG(2*I-1)
ISN 0297    530 STOR1(3*I)=CHNG(2*I)
ISN 0298        DO 540 I=1,NBIAS
ISN 0299    540 STOR1(3*I-2)=CHNG(2*NCOF+I)
ISN 0300        NSTOR1=2*NCOF+MAX0(NCOF,NBIAS)+1
ISN 0301        CALL PTSIZE (NSTOR1,STOR1)
ISN 0302        IF (ISTOP.NE.0) GO TO 600
          C ***** SET INDICATOR TO 'CONVERGED'
ISN 0304        IRET=0
ISN 0305        DO 550 I=1,NCOF
          C ***** CHECK FOR NON-CONVERGENCE
ISN 0306        IF (ABS(CHNG(2*I-1)).GT.ALPBND(I)) IRET=1
ISN 0308        IF (ABS(CHNG(2*I)).GT.DELBND(I)) IRET=1
          C ***** CHECK FOR DIVERGENCE
ISN 0310        IF (ABS(CHNG(2*I-1)).LE.360.0.OR.ABS(CHNG(2*I)).LE.360.0) GO TO 55
               10
ISN 0312        IRET=2
ISN 0313        GO TO 780
ISN 0314    550 CONTINUE
          C ***** CHECK FOR DIVERGENCE OR CONVERGENCE OF BIAS ELEMENTS
ISN 0315        IF (NBIAS.LE.0) GO TO 590
ISN 0317        K=N2
ISN 0318        IF (NCLAS1.LE.0) GO TO 570
ISN 0320        DO 560 I=1,NCLAS1
ISN 0321        IF (BIAS1(I).EQ.XBIAS) GO TO 560
ISN 0323        K=K+1
ISN 0324        IF (ABS(CHNG(K)).GT.BBND1(I)) IRET=1
ISN 0326        IF (ABS(CHNG(K)).LE.360.) GO TO 560
ISN 0328        IRET=2
ISN 0329        GO TO 780
ISN 0330    560 CONTINUE
ISN 0331    570 CONTINUE
ISN 0332        IF (NCLAS2.LE.0) GO TO 590
ISN 0334        DO 580 I=1,NCLAS2
ISN 0335        IF (BIAS2(I).EQ.XBIAS) GO TO 580
ISN 0337        K=K+1
ISN 0338        IF (ABS(CHNG(K)).GT.BBND2(I)) IRET=1
ISN 0340        IF (ABS(CHNG(K)).LE.360.) GO TO 580
ISN 0342        IRET=2
ISN 0343        GO TO 780
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ISN 0344      580 CONTINUE
ISN 0345      590 CONTINUE
ISN 0346      600 CONTINUE
ISN 0347          IPRNT=1
ISN 0348          IF (IWRT.LT.4) IPRNT=0
            C     IF(IPRNT.EQ.0.AND.ISTAT.NE.1) GC TO 650
            C     COMPUTE THE CCVARIANCE/CORRELATICN MATRIX.
ISN 0350          N33=N3-1
ISN 0351          DO 610 I=1,N33
ISN 0352          II=I+1
ISN 0353          DO 610 J=II,N3
ISN 0354      610 COEF(J,I)=COEF(J,I)/SQRT(ABS(COEF(I,I)*COEF(J,J)))
ISN 0355          DO 620 I=1,39
ISN 0356      620 WORK(I)=0.
            C     STORE DATA FCR MSAD DISPLAYS IN ARRAYS STYPE AND WORK.
            C
            C ***** COMPUTE AND PRINTOUT STATISTICS OF RESIDUALS
            C
            C ***** STATISTICS FOR CLASS 1 TYPES
ISN 0357          WT1=0.0
ISN 0358          STA1=0.0
ISN 0359          STB1=0.0
ISN 0360          IF (NCLAS1.LE.0) GO TO 640
ISN 0362          NUM=NCLAS1+NCLAS2+3
ISN 0363          CALL PTSIZE (NUM,STYPE1,STYPE2)
ISN 0364          NUM=3*NUM
ISN 0365          CALL PTSIZE (NUM,WORK)
ISN 0366          DO 630 I=1,NCLAS1
ISN 0367          STYPE1(I)=ANUM(1)
ISN 0368          STYPE2(I)=ANUM(I)
ISN 0369          W=RHOST1(3,I)
ISN 0370          IF (W.LE.0.0) GO TO 630
ISN 0372          S1=RHOST1(1,I)/W
ISN 0373          S2=SQRT(AMAX1(RHOST1(2,I)/W-S1*S1,0.))
ISN 0374          RHOT1(4,I)=S1
ISN 0375          RHOT1(5,I)=S2
ISN 0376          WORK(3*I-2)=S1
ISN 0377          WORK(3*I-1)=S2
ISN 0378          WORK(3*I)=W
ISN 0379          WT1=WT1+W
ISN 0380          STA1=STA1+RHCST1(1,I)
ISN 0381          STB1=STB1+RHOST1(2,I)
ISN 0382      630 CONTINUE
ISN 0383          IF (WT1.LE.0.0) GO TO 640
ISN 0385          S1=STA1/WT1
ISN 0386          S2=SQRT(AMAX1(STB1/WT1-S1*S1,0.))
ISN 0387          WORK(3*NCLAS1+1)=S1
ISN 0388          WORK(3*NCLAS1+2)=S2
ISN 0389          WORK(3*NCLAS1+3)=WT1
ISN 0390          STYPE1(NCLAS1+1)=ANUM(1)
ISN 0391          STYPE2(NCLAS1+1)=TOTAL
ISN 0392      640 CONTINUE
            C ***** STATISTICS FOR CLASS 2 TYPES
ISN 0393          WT2=0.0
ISN 0394          STA2=0.0
ISN 0395          STB2=0.0
ISN 0396          IF (NCLAS2.LE.0) GC TO 660
ISN 0398          DO 650 I=1,NCLAS2
ISN 0399          STYPE1(NCLAS1+1+I)=ANUM(2)
ISN 0400          STYPE2(NCLAS1+1+I)=ANUM(I)
ISN 0401          W=RHOST2(3,I)
ISN 0402          IF (W.LE.0.0) GO TO 650
ISN 0404          S1=RHOST2(1,I)/W
ISN 0405          S2=SQRT(AMAX1(RHOST2(2,I)/W-S1*S1,0.))
ISN 0406          RHOT2(4,I)=S1
ISN 0407          RHOT2(5,I)=S2
ISN 0408          WORK(3*(NCLAS1+1+I)-2)=S1
ISN 0409          WORK(3*(NCLAS1+1+I)-1)=S2
ISN 0410          WORK(3*(NCLAS1+1+I))=W
ISN 0411          WT2=WT2+W
ISN 0412          STA2=STA2+RHCST2(1,I)
ISN 0413          STB2=STB2+RHCST2(2,I)
ISN 0414      650 CONTINUE
ISN 0415          IF (WT2.LE.0.0) GO TO 660
ISN 0417          S1=STA2/WT2
ISN 0418          S2=SQRT(AMAX1(STB2/WT2-S1*S1,0.))
ISN 0419          WORK(3*(NCLAS1+NCLAS2)+4)=S1
```

```
ISN 0420          WORK(3*(NCLAS1+NCLAS2)+5)=S2
ISN 0421          WORK(3*(NCLAS1+NCLAS2)+6)=WT2
ISN 0422      660 CONTINUE
ISN 0423          STYPE1(NCLAS1+NCLAS2+2)=ANUM(2)
ISN 0424          STYPE2(NCLAS1+NCLAS2+2)=TOTAL
            C ***** COMBINED TOTAL STATISTICS
ISN 0425          STYPE1(NCLAS1+NCLAS2+3)=TOTAL
ISN 0426          STYPE2(NCLAS1+NCLAS2+3)=STAT2
ISN 0427          IF (WT1.LE.0..OR.WT2.LE.0.) GO TO 670
ISN 0429          W=WT1+WT2
ISN 0430          S1=(STA1+STA2)/W
ISN 0431          S2=SQRT(AMAX1((STB1+STB2)/W-S1*S1,0.))
ISN 0432          WORK(3*(NCLAS1+NCLAS2)+7)=S1
ISN 0433          WORK(3*(NCLAS1+NCLAS2)+8)=S2
ISN 0434          WORK(3*(NCLAS1+NCLAS2)+9)=W
ISN 0435      670 IF (IPRNT.EQ.0) GO TO 710
            C ***** WRITE COVARIANCE ELEMENTS
ISN 0437          IF (NBIAS.LE.0) WRITE (IOUT,1060) (NAME(1,I),NAME(2,I),I=1,N2)
ISN 0439          IF (NBIAS.GT.0) WRITE (IOUT,1060) (NAME(1,I),NAME(2,I),I=1,N2),(NA
                 1ME(1,I),NAME(2,I),I=IB1,IB2)
ISN 0441          DO 680 I=1,N3
ISN 0442          II=I
ISN 0443          IF (I.GT.N2) II=I-N2+8
ISN 0445      680 WRITE (IOUT,1070) NAME(1,II),NAME(2,II),(COEF(I,J),J=1,N3)
ISN 0446          IF (NCLAS1.LE.0) GO TO 690
ISN 0448          WRITE (IOUT,1080)
ISN 0449          WRITE (IOUT,1100) (I,WORK(3*I-2),WORK(3*I-1),WORK(3*I),I=1,NCLAS1)
ISN 0450          WRITE (IOUT,1110) WORK(3*NCLAS1+1),WORK(3*NCLAS1+2),WORK(3*NCLAS1+
                 13)
ISN 0451      690 IF (NCLAS2.LE.0) GO TO 700
ISN 0453          WRITE (IOUT,1090)
ISN 0454          WRITE (IOUT,1100) (I,WORK(3*NCLAS1+1+3*I),WORK(3*NCLAS1+2+3*I),WOR
                 1K(3*NCLAS1+3+3*I),I=1,NCLAS2)
ISN 0455          WRITE (IOUT,1110) WORK(3*(NCLAS1+NCLAS2)+4),WORK(3*(NCLAS1+NCLAS2)
                 1+5),WORK(3*(NCLAS1+NCLAS2)+6)
ISN 0456          WRITE (IOUT,1120) WORK(3*(NCLAS1+NCLAS2)+7),WORK(3*(NCLAS1+NCLAS2)
                 1+8)
ISN 0457      700 CONTINUE
ISN 0458      710 CONTINUE
ISN 0459          IWHERE=2
ISN 0460          CALL CHECK ('GCONE2')
            C ***** IF PROCESS HAS ENDED JUMP OUT OF CORRECTION LOOP
            C ***** UPDATE ATTITUDE STATE
ISN 0461          DO 720 I=1,13
ISN 0462      720 STOR2(I)=0.
ISN 0463          NB=3*NCOF+NBIAS
ISN 0464          NB=MIN0(NB,13)
ISN 0465          CALL PTSIZE (NB,STOR2)
ISN 0466          DO 730 I=1,NCOF
ISN 0467          STOR2(2*I-1)=ALP(I)
ISN 0468      730 STOR2(2*I)=DEL(I)
ISN 0469          DO 740 I=1,NCOF
ISN 0470          OLDALP(I)=ALP(I)
ISN 0471          OLDDEL(I)=DEL(I)
ISN 0472          ALP(I)=ALP(I)+CHNG(2*I-1)
ISN 0473          DEL(I)=DEL(I)+CHNG(2*I)
ISN 0474          NEWDEL(I)=DEL(I)
ISN 0475          NEWALP(I)=ALP(I)
ISN 0476      740 CONTINUE
ISN 0477          IF (NBIAS.LE.0) GO TO 780
ISN 0479          K=N2
ISN 0480          IF (NCLAS1.LE.0) GO TO 760
ISN 0482          CALL PTSIZE (NBIAS,DRHOSQ)
ISN 0483          DO 750 I=1,NCLAS1
ISN 0484          IF (BIAS1(I).EQ.XBIAS) GO TO 750
ISN 0486          K=K+1
ISN 0487          STOR2(K)=BIAS1(I)
ISN 0488          OLDBS1(I)=BIAS1(I)
ISN 0489          BIAS1(I)=BIAS1(I)+CHNG(K)
ISN 0490          NEWBS1(I)=BIAS1(I)
ISN 0491          DRHOSQ(K)=BIAS1(I)
ISN 0492      750 CONTINUE
ISN 0493      760 CONTINUE
ISN 0494          IF (NCLAS2.LE.0) GO TO 780
ISN 0496          DO 770 I=1,NCLAS2
ISN 0497          IF (BIAS2(I).EQ.XBIAS) GO TO 770
ISN 0499          K=K+1
```

```
ISN 0500          STOR2(K)=BIAS2(I)
ISN 0501          OLDBS2(I)=BIAS2(I)
ISN 0502          BIAS2(I)=BIAS2(I)+CHNG(K)
ISN 0503          NEWBS2(I)=BIAS2(I)
ISN 0504          DRHOSQ(K)=BIAS2(I)
ISN 0505      770 CONTINUE
ISN 0506      780 CONTINUE
ISN 0507          IF (IRWT.LT.6) GO TO 840
              C ***** WRITE UPDATED ATTITUDE STATE
ISN 0509          WRITE (IOUT,1010) ISTEP
ISN 0510          DO 790 I=1,NCOF
ISN 0511          AOLD=ALP(I)-CHNG(2*I-1)
ISN 0512          DOLD=DEL(I)-CHNG(2*I)
ISN 0513          WRITE (IOUT,1020) AOLD,CHNG(2*I-1),ALP(I),DOLD,CHNG(2*I),DEL(I)
ISN 0514      790 CONTINUE
ISN 0515          IF (NBIAS.LE.0) GO TO 830
ISN 0517          K=N2
ISN 0518          IF (NCLAS1.LE.0) GO TO 810
ISN 0520          ITITLE=1
ISN 0521          DO 800 I=1,NCLAS1
ISN 0522          IF (BIAS1(I).EQ.XBIAS) GO TO 800
ISN 0524          K=K+1
ISN 0525          BOLD=BIAS1(I)-CHNG(K)
ISN 0526          IF (ITITLE.EQ.1) WRITE (IOUT,1030)
ISN 0528          ITITLE=2
ISN 0529          WRITE (IOUT,1050) I,BOLD,CHNG(K),BIAS1(I)
ISN 0530      800 CONTINUE
ISN 0531      810 CONTINUE
ISN 0532          IF (NCLAS2.LE.0) GO TO 830
ISN 0534          ITITLE=1
ISN 0535          DO 820 I=1,NCLAS2
ISN 0536          IF (BIAS2(I).EQ.XBIAS) GO TO 820
ISN 0538          K=K+1
ISN 0539          BOLD=BIAS2(I)-CHNG(K)
ISN 0540          IF (ITITLE.EQ.1) WRITE (IOUT,1040)
ISN 0542          ITITLE=2
ISN 0543          WRITE (IOUT,1050) I,BOLD,CHNG(K),BIAS2(I)
ISN 0544      820 CONTINUE
ISN 0545      830 CONTINUE
ISN 0546      840 CONTINUE
ISN 0547          DO 850 II=1,10
ISN 0548      850 OPTION(II)=0
ISN 0549          FINALD=0
ISN 0550          FINISH = 0
ISN 0551          DO 860 II=1,8
ISN 0552      860 IMESG(II)=0
ISN 0553          IF (IRET.EQ.0) IMESG(1)=1
ISN 0555          IF (IRET.EQ.2) IMESG(2)=1
ISN 0557          IF (ISTEP.NE.MAXIT) GO TO 870
ISN 0559          IMESG(3)=1
ISN 0560          IRET=6
ISN 0561      870 CONTINUE
ISN 0562          IF (IRET.EQ.3) IMESG(4)=1
ISN 0564          IF (IRET.EQ.4) IMESG(5)=1
ISN 0566          IF (IRET.EQ.5) IMESG(6)=1
ISN 0568          CALL GTSTAT ('OPTAB1',STAT1)
ISN 0569          IF (STAT1.NE.STOP1.OR.IOPEN.EQ.0) GO TO 880
ISN 0571          IF (IALLO.EQ.224) CALL FINAL2 (GWORK0,ALP,DEL,AI,DI,BIASI,BIAS1,BI
                 1AS2I,BIAS2,RHOT1,RHOT2,NCLAS1,NCLAS2,NCOF,IALLO,COEF,NP)
ISN 0573          CALL CHECK ('OPTAB1')
ISN 0574          CALL GOCCON (IALL4,IALL5,IFRST1,IFRST2,NTYPE1,NTYPE2,RHO1,RHO2,GWO
                 1RK4,GWORK5,IALLO)
ISN 0575      880 CONTINUE
ISN 0576          IF (IMESG(8).EQ.1.OR.(STAT1.NE.STOP1.AND.IRET.NE.1)) RETURN
ISN 0578          IF (IMESG(7).EQ.1) GO TO 260
ISN 0580          IF (IRET.NE.1) RETURN
ISN 0582          GO TO 390
              C
              C ************************* FORMAT STATEMENTS *************************
              C
ISN 0583      890 FORMAT (1X,20('*'),'DCCONS - V 2.0 - CREATED 7/23/73',20('*'))
ISN 0584      900 FORMAT (1X,//1X,45('-'),'SPECIFIED OUTPUT FROM SUBROUTINE DCCONS '
                 1,45('-'),/,1X,'  NCLAS1  NCLAS2        TZERO     NCOF    MAXIT    IWR
                 2T    IOUT',/,1X,2I8,F12.4,4I8)
ISN 0585      910 FORMAT (1X,/,1X,'INITIAL ATTITUDE COEFFICIENTS AND CORRECTION BOUN
                 1DS ',/,1X,'     ALPHA(DEG)    CORR BND(DEG)      DELTA(DEG)     CORR BND
                 2(DEG)',/,(1X,F14.4,F16.6,F14.4,F16.6))
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ISN 0586        920 FORMAT (1X,/,1X,'CLASS 1 (CONE ANGLE) INITIAL BIASES',/,1X,'TYPE  00050900
                   1     BIAS(DEG)    CORR BND(DEG)')                                  00050950
ISN 0587        930 FORMAT (1X,/,1X,'CLASS 2 (DHED ANGLE) INITIAL BIASES',/,1X,'TYPE  00051000
                   1     BIAS(DEG)    CORR BND(DEG)')                                  00051050
ISN 0588        940 FORMAT (1X,I4,F15.4,F16.4)                                         00051100
ISN 0589        950 FORMAT (1X,/,1X,'CLASS 1 (CONE ANGLE) INPUT DATA TYPE',I2,' HAS',I00051150
                   14,' OBSERVATIONS, FROM',I4,' TO',I4,', IN THE DATA ARRAYS')        00051200
ISN 0590        960 FORMAT (1X,/,1X,'CLASS 2 (DHED ANGLE) INPUT DATA TYPE',I2,' HAS',I00051250
                   14,' OBSERVATIONS, FROM',I4,' TO',I4,', IN THE DATA ARRAYS')        00051300
ISN 0591        970 FORMAT (1X,/,1X,'    I              TIME       X-AXIS     Y-AXIS     Z-A00051350
                   1XIS     CONE ANGLE        WEIGHT',/,(1X,I4,F16.6,2X,3F10.6,F14.4,F12.00051400
                   24))                                                                00051450
ISN 0592        980 FORMAT (1X,/,1X,'    I              TIME    X-AXIS-1  Y-AXIS-1  Z-AXI00051500
                   1S-1     X-AXIS-2  Y-AXIS-2  Z-AXIS-2    DHED ANGLE       WEIGHT',/,(00051550
                   21X,I4,F16.6,2X,3F10.6,2X,3F10.6,F14.4,F12.4))                      00051600
ISN 0593        990 FORMAT (1X,//,1X,'SIMULTANEOUS ATTITUDE EQUATIONS COEFFICIENTS',/,00051650
                   12X)                                                                00051700
ISN 0594       1000 FORMAT (1X,10E13.6)                                                00051750
ISN 0595       1010 FORMAT (1X,//,1X,'ITERATION',I3,' - ATTITUDE AND BIAS STATE ',//,100051800
                   1X,'   OLD ALPHA(DEG)        CHANGE(DEG)     NEW ALPHA(DEG)        OLD D00051850
                   2ELTA(DEG)        CHANGE(DEG)     NEW DELTA(DEG)')                  00051900
ISN 0596       1020 FORMAT (1X,3F17.8,4X,3F17.8)                                       00051950
ISN 0597       1030 FORMAT (1X,/,1X,'CLASS 1 (CONE ANGLE) BIAS STATE ',/,1X,'TYPE   OL00052000
                   1D BIAS(DEG)    CHANGE(DEG)     NEW BIAS(DEG)')                     00052050
ISN 0598       1040 FORMAT (1X,/,1X,'CLASS 2 (DHED ANGLE) BIAS STATE ',/,1X,'TYPE   OL00052100
                   1D BIAS(DEG)    CHANGE(DEG)     NEW BIAS(DEG)')                     00052150
ISN 0599       1050 FORMAT (1X,I4,F16.6,F14.6,F16.6)                                   00052200
ISN 0600       1060 FORMAT (1X,/,1X,'ATTITUDE STATE COVARIANCE/CORRELATION MATRIX ',/,00052250
                   11X,10X,13(1X,2A4))                                                 00052300
ISN 0601       1070 FORMAT (1X,2A4,2X,13E9.2)                                          00052350
ISN 0602       1080 FORMAT (1X,/,18X,'CLASS 1 (CONE ANGLE) ERROR STATISTICS ',/,1X,' T00052400
                   1YPE     MEAN RESIDUAL(DEG)     STANDARD DEVIATION(DEG)         TOTAL 00052450
                   2WEIGHT')                                                           00052500
ISN 0603       1090 FORMAT (1X,/,18X,'CLASS 2 (DHED ANGLE) ERROR STATISTICS ',/,1X,' T00052550
                   1YPE     MEAN RESIDUAL(DEG)     STANDARD DEVIATION(DEG)         TOTAL 00052600
                   2WEIGHT')                                                           00052650
ISN 0604       1100 FORMAT (1X,I5,4X,F13.4,5X,4X,F18.4,5X,8X,F12.4)                    00052700
ISN 0605       1110 FORMAT (1X,'TOTAL',4X,F13.4,5X,4X,F18.4,5X,8X,F12.4)               00052750
ISN 0606       1120 FORMAT (1X,/,1X,'COMBINED TOTAL      MEAN RESIDUAL(DEG) = ',F9.4,' 00052800
                   1     STANDARD DEVIATION(DEG) = ',F9.4)                             00052850
ISN 0607            END                                                                00052900
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COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=60,SIZE=0000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      C
      C*****************************************************************
      C                                                                *
      C                                                                *
      C          SUBROUTINE COFSM                                      *
      C                                                                *
      C          CALLING SEQUENCE                                      *
      C                    CALL COFSM(TIME,AXIS,ANG,WGHT,NUMB,ITYPE,NDIM,   *
      C                              ALPR,DELR,BIAS,IBIAS,COEF,DRHOSQ,RHOST,  *
      C                              RH,CALC,SCOEF,JONE)                *
      C                                                                *
      C          DESCRIPTION                                           *
      C                    COFSM IS SIMILAR TO THE GCONES ROUTINE COFSUM WITH *
      C                    THE FOLLOWING ADDED FEATURES   CALCULATED VALUES  *
      C                    CAN BE STORED, DERIVATIVES CAN BE STORED, AND    *
      C                    RESIDUALS CAN BE STORED.                    *
      C                                                                *
      C          COMMON AREAS REFERENCED                               *
      C                                                                *
      C                    GNC1                                        *
      C                                                                *
      C          EXTERNAL REFERENCES                                   *
      C                                                                *
      C                    ABS,COS,SIN                                 *
      C                                                                *
      C          STORAGE REQUIREMENTS                                  *
      C                                                                *
      C                    4884 BYTES OF CORE STORAGE                  *
      C                                                                *
      C          VARIABLES                                             *
      C                                                                *
      C          NAME      TYPE      I/O       DESCRIPTION             *
      C                                                                *
      C          TIME      R*4       I         ARRAY OF OBSERVATION TIMES   *
      C                                                                *
      C          AXIS      R*4       I         REFERENCE VECTORS(DIMENSIONED  *
      C                                        NDIM*(NUMBER OF OBSERVATIONS))  *
      C                                                                *
      C          ANG       R*4       I         OBSERVED ANGLES, IN DEGREES    *
      C                                                                *
      C          WGHT      R*4       I/O       WEIGHTS FOR OBSERVED DATA      *
      C                                                                *
      C          NUMB      I*4       I         NUMBER OF OBSERVATIONS FOR CLASS*
      C                                        AND TYPE BEING PROCESSED       *
      C                                                                *
      C          ITYPE     I*4       I         THE CLASS OF DATA PROCESSED    *
      C                                                                *
      C          NDIM      I*4       I         INDICATOR FOR CLASS REFERENCE  *
      C                                        VECTORS                 *
      C                                          =3, FOR CLASS 1 DATA  *
      C                                          =6, FOR CLASS 2 DATA  *
      C                                        (I.E., NDIM = 2*(NUMBER OF    *
      C                                        REFERENCE VECTORS REQUIRED TO *
      C                                        DEFINE ANG))            *
      C                                                                *
      C          ALPR      R*4       I         RIGHT ASCENSION COEFFICIENTS,  *
      C                                        IN RADIANS              *
      C                                                                *
      C          DELR      R*4       I         DECLINATION COEFFICIENTS, IN   *
      C                                        RADIANS                 *
      C                                                                *
      C          BIAS      R*4       I         BIAS FOR CLASS AND TYPE OF DATA *
      C                                        BEING PROCESSED         *
      C                                                                *
      C          IBIAS     I*4       I         INDEX TO INDICATE BIAS UNDER   *
      C                                        CONSIDERATION           *
      C                                                                *
      C          COEF      R*4       O         RIGHT SIDE VECTOR OF SIMUL-    *
      C                                        TANEOUS EQUATIONS       *
      C                                                                *
      C          RHOST     R*4       O         STATISTICS              *
      C                                          RHOST(1) - WEIGHTED SUM OF   *
      C                                                     RESIDUALS  *
      C                                          RHOST(2) - WEIGHTED SUM OF   *
      C                                                     SQUARES OF RESIDUALS
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C                                          RHOST(3) - SUM OF WEIGHTS       *00003800
C                                          RHOST(4) - MEAN RESIDUAL FOR    *00003810
C                                                     TYPE I DATA          *00003820
C                                          RHOST(5) - STANDARD DEVIATION   *00003830
C                                                     FOR TYPE I DATA      *00003840
C                                                                          *00003850
C        RH          R*4       O          VECTOR OF RESIDUALS              *00003900
C                                                                          *00003950
C        CALC        R*4       O          VECTOR OF CALCULATED VALUES      *00004000
C                                                                          *00004050
C        SCOEF       R*4       O          MATRIX OF PARTIAL DERIVATIVES    *00004100
C                                         (DIMENSIONED NUMBER OF ELEMENTS  *00004150
C                                         IN STATE VECTOR X NUMBER OF      *00004200
C                                         OBSERVATIONS)                    *00004250
C                                                                          *00004300
C        JONE        I*4       I          INDEX INDICATING STARTING LOCA-  *00004350
C                                         TION OF DATA IN ARRAYS TIME,     *00004400
C                                         AXIS,ANG,WGHT,RH,CALC,SCOEF FOR  *00004450
C                                         THE CLASS AND TYPE OF DATA BEING *00004500
C                                         PROCESSED                        *00004550
C                                                                          *00004600
C        COMMON AREA VARIABLES USED IN THE ROUTINE                         *00004650
C                                                                          *00004700
C        NAME        TYPE      ORIGIN     DESCRIPTION                      *00004750
C                                                                          *00004800
C        ICUT        I*4       GCN1       FORTRAN DEVICE UNIT FOR SPECI-   *00004850
C                                         FIED PRINTOUT                    *00004900
C                                                                          *00004950
C        NCOF        I*4       GCN1       NUMBER OF POLYNOMIAL COEFFIC-    *00005000
C                                         IENTS FOR ALP AND DEL            *00005050
C                                                                          *00005100
C        IRWT        I*4       GCN1       INTERMEDIATE PRINTOUT LEVEL      *00005150
C                                         INDICATOR (SEE REFERENCES 1 & 2  *00005200
C                                         FOR VARIOUS LEVELS)              *00005250
C                                                                          *00005300
C        TZERO       R*4       GCN1       REFERENCE TIME                   *00005350
C                                                                          *00005400
C        IOC         I*4       GCN1       RESIDUAL STORAGE INDICATOR       *00005450
C                                           =0, DO NOT STORE RESIDUALS     *00005500
C                                           =1, STORE RESIDUALS FOR        *00005550
C                                               DISPLAY AND PLOTTING       *00005600
C                                                                          *00005650
C        ICALC       I*4       GCN1       CALCULATED VALUES STORAGE        *00005700
C                                         INDICATOR                        *00005750
C                                           =0, DO NOT STORE CALCULATED    *00005800
C                                               VALUES                     *00005850
C                                           =1, STORE CALCULATED VALUES    *00005900
C                                               DISPLAY                    *00005950
C                                                                          *00006000
C        DATA TRANSMISSION                                                 *00006050
C                                                                          *00006100
C        NAME        READ/WRITE/CPOINT    DESCRIPTION                      *00006150
C                                                                          *00006200
C        FTXXF001    WRITE                INTERMEDIATE PRINTOUT, WHERE     *00006250
C                                         XX = IOUT                        *00006300
C        REVISIONS                                                         *00006350
C                                                                          *00006400
C                    1.  F. KNOOP (20 FEB 1970) - FINAL DATE AT WHICH      *00006450
C                        CODE WAS FROZEN                                   *00006500
C                                                                          *00006550
C                    2.  J. WHALEN (SUMMER 1972) - INCLUSION OF LOGIC      *00006600
C                        TO ALLOW FOR SAVING OF THE FOLLOWING VALUES       *00006650
C                        CALCULATED VALUES, DERIVATIVES, AND RESIDUALS     *00006700
C                        FOR MSAD DISPLAY                                  *00006750
C                                                                          *00006800
C                                                                          *00006850
C***********************************************************************00006900
C                                                                           00006950
C                                                                           00007000
C.       THIS IS A SPECIAL SUBROUTINE CALLED BY GCONES TO COMPUTE THE      .00007050
C.       CONTRIBUTION TO THE COEFFICIENTS OF THE SIMULTANEOUS EQUATIONS.00007100
C.       (INVERSE COVARIANCE MATRIX) FOR EACH TYPE OF DATA, ONE TYPE       .00007150
C.       AT A TIME.  THE GCONES PREAMBLE AND COMMENTED LISTING PROVIDES.00007200
C.       A DESCRIPTION OF ALL ARGUMENTS PASSED TO THIS SUBROUTINE.         .00007250
C.                                                                         .00007300
C......................................................................00007350
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ISN 0002          SUBROUTINE COFSM (TIME,AXIS,ANG,WGHT,NUMB,ITYPE,NDIM,ALPR,DELR,BIA
                 1S,IBIAS,COEF,DRHOSQ,RHOST,RH,CALC,SCOEF,JONE)
            C     EXTERNAL REFERENCES     NONE
ISN 0003          COMMON/GCN1/ICUT,NCLAS1,NCLAS2,NCOF,MAXIT,IWRT,TZERO,IOC,ICALC,
                 1             IDER,SMULT,NP,IWHERE,ISTEP,ISTOP,IRET,ISTAT,
                 2             CORMIN,CORMAX
ISN 0004          DIMENSION TIME(1),AXIS(NDIM,1),ANG(1),WGHT(1),ALPR(1),DELR(1),
                 1           COEF(NP,NP),DRHOSQ(1),RHOST(3),RH(1),CALC(1),DERIV(8),
                 2           SCOEF(NP,1)
            C
ISN 0005          DATA RTOD, TFLAG, XBIAS / 57.2957800,9999999.0D0, 9999999.0D0/
            C ***** INITIALIZATION
ISN 0006          J1=JONE-1
ISN 0007          IFRST=1
ISN 0008          N2=NCOF+NCOF
            C ***** WRITE OUTPUT HEADER IF SPECIFIED
ISN 0009          IF (IWRT.GE.12) WRITE (IOUT,230) ITYPE
            C
            C ***** BEGIN SUMMATION LOOP
            C
ISN 0011          DO 220 I=1,NUMB
            C ***** IF TIME IS FLAGGED IGNORE THIS OBSERVATION
            C     DATA FOR WHICH THE WEIGHT IS ZERO IS NOT PROCESSED.
ISN 0012          IF (WGHT(I).LT.0.0) GO TO 220
ISN 0014          IF (TIME(I+J1).EQ.TFLAG) GO TO 220
            C ***** IF ATTITUDE IS INERTIAL (NCOF=1) AND HAS BEEN COMPUTED ONCE
            C ***** (IFRST=2) SKIP ATTITUDE COMPUTATION FROM COEFFICIENTS
ISN 0016          IF (NCOF.LE.1.AND.IFRST.EQ.2) GO TO 120
ISN 0018          IFRST=2
ISN 0019          AR=0.0
ISN 0020          DR=0.0
ISN 0021          TDIFF=TIME(I+J1)-TZERO
ISN 0022          DTIME=1.0
            C ***** COMPUTE ALPHA AND DELTA AT TIME(I)
ISN 0023          DO 100 J=1,NCOF
ISN 0024          AR=AR+ALPR(J)*DTIME
ISN 0025          DR=DR+DELR(J)*DTIME
ISN 0026          DTIME=DTIME*TDIFF
ISN 0027      100 CONTINUE
ISN 0028          IF (ABS(AR).LT.10000.0.AND.ABS(DR).LT.10000.0) GO TO 110
ISN 0030          IF (IWRT.GE.12) WRITE (IOUT,260)
ISN 0032          GO TO 220
ISN 0033      110 CONTINUE
            C ***** SAVE SINES AND COSINES OF ALPHA AND DELTA AND CARTESIAN
            C ***** COORDINATES OF UNIT SPIN AXIS VECTOR
ISN 0034          COSA=COS(AR)
ISN 0035          SINA=SIN(AR)
ISN 0036          COSD=COS(DR)
ISN 0037          SIND=SIN(DR)
ISN 0038          U1=COSD*COSA
ISN 0039          U2=COSD*SINA
ISN 0040          U3=SIND
ISN 0041      120 CONTINUE
            C
            C ***** COMPUTE ANGLE AND DERIVATIVES W.R.T. ALPHA0 AND DELTA0 AT THE
            C ***** CURRENT STATE
            C
            C ***** COMPUTE TRUE MEASURED ANGLE (WITHOUT BIAS)
ISN 0042          GAMMA=ANG(I)
ISN 0043          IF (BIAS.NE.XBIAS) GAMMA=GAMMA-BIAS
ISN 0045          W=WGHT(I)
ISN 0046          IF (ITYPE.EQ.2) GO TO 140
            C ***** CLASS 1 DATA - CONE ANGLE
ISN 0048          COSTHE=AXIS(1,I)*U1+AXIS(2,I)*U2+AXIS(3,I)*U3
ISN 0049          IF (ABS(COSTHE).GT.1.0) COSTHE=SIGN(1.0,COSTHE)
ISN 0051          THERAD=ARCOS(COSTHE)
ISN 0052          SINTHE=SIN(THERAD)
ISN 0053          THETA=THERAD*RTOD
ISN 0054          RHO=GAMMA-THETA
ISN 0055          IF (IOC.EQ.1) RH(I+J1)=GAMMA-THETA
ISN 0057          IF (ICALC.EQ.1) CALC(I+J1)=THETA
ISN 0059          IF (SINTHE.NE.0.0) GO TO 130
            C ***** DERIVATIVES CAN'T BE COMPUTED, SKIP THIS POINT
ISN 0061          IF (IWRT.GE.12) WRITE (IOUT,270)
ISN 0063          GO TO 220
ISN 0064      130 CONTINUE
```

```
          C ***** COMPUTE DERIVATIVES OF THETA W.R.T. ALPHAO AND DELTAO
ISN 0065        DERVA=(AXIS(1,I)*U2-AXIS(2,I)*U1)/SINTHE
ISN 0066        DERVD=(AXIS(1,I)*COSA*SIND+AXIS(2,I)*SINA*SIND-AXIS(3,I)*COSD)/SIN
               1THE
ISN 0067        GO TO 160
          C ***** CLASS 2 DATA - DIHEDRAL ANGLE
ISN 0068    140 CONTINUE
ISN 0069        E1=AXIS(2,I)*AXIS(6,I)-AXIS(3,I)*AXIS(5,I)
ISN 0070        E2=AXIS(3,I)*AXIS(4,I)-AXIS(1,I)*AXIS(6,I)
ISN 0071        E3=AXIS(1,I)*AXIS(5,I)-AXIS(2,I)*AXIS(4,I)
ISN 0072        F=AXIS(1,I)*AXIS(4,I)+AXIS(2,I)*AXIS(5,I)+AXIS(3,I)*AXIS(6,I)
ISN 0073        SV=U1*AXIS(1,I)+U2*AXIS(2,I)+U3*AXIS(3,I)
ISN 0074        SW=U1*AXIS(4,I)+U2*AXIS(5,I)+U3*AXIS(6,I)
ISN 0075        XNUM=U1*E1+U2*E2+U3*E3
ISN 0076        XDEN=F-SV*SW
ISN 0077        Q1=XDEN*E1+XNUM*(SV*AXIS(4,I)+SW*AXIS(1,I))
ISN 0078        Q2=XDEN*E2+XNUM*(SV*AXIS(5,I)+SW*AXIS(2,I))
ISN 0079        Q3=XDEN*E3+XNUM*(SV*AXIS(6,I)+SW*AXIS(3,I))
ISN 0080        IF (IWRT.GE.14) WRITE (IOUT,240) E1,E2,E3,F,SV,SW,XNUM,XDEN,Q1,Q2,
               1Q3
ISN 0082        IF (XNUM.NE.0.0.OR.XDEN.NE.0.0) GO TO 150
          C ***** THETA IS UNDEFINED AND THE DERIVATIVES CAN'T BE COMPUTED
ISN 0084        IF (IWRT.GE.12) WRITE (IOUT,280)
ISN 0086        GO TO 220
ISN 0087    150 CONTINUE
ISN 0088        THETA=ATAN2(XNUM,XDEN)*RTOD
ISN 0089        IF (THETA.LT.0.0) THETA=THETA+360.0
          C ***** COMPUTE RESIDUAL AND CHECK FOR NUMERICAL DISCONTINUITY AT 0-360
ISN 0091        RHO=GAMMA-THETA
ISN 0092        IF (ABS(RHO).GT.270.0) RHO=RHO-SIGN(360.0,RHO)
ISN 0094        IF (IOC.EQ.1) RH(I+J1)=GAMMA-THETA
ISN 0096        IF (ICALC.EQ.1) CALC(I+J1)=THETA
          C ***** IF RHO IS STILL TOO LARGE ELIMINATE BY SETTING WEIGHT TO 0.0
ISN 0098        IF (ABS(RHO).GE.90.0) W=0.0
          C ***** COMPUTE DERIVATIVES OF THETA W.R.T. ALPHAO AND DELTAO
ISN 0100        DERVA=(-Q1*U2+Q2*U1)/(XNUM*XNUM+XDEN*XDEN)
ISN 0101        DERVD=(-Q1*COSA*SIND-Q2*SINA*SIND+Q3*COSD)/(XNUM*XNUM+XDEN*XDEN)
ISN 0102    160 CONTINUE
          C ***** SUM STATISTICS
ISN 0103        RHOST(1)=RHOST(1)+RHO*W
ISN 0104        RHOST(2)=RHOST(2)+RHO*RHO*W
ISN 0105        RHOST(3)=RHOST(3)+W
ISN 0106        IF (IWRT.LT.12) GO TO 170
          C ***** OUTPUT INTERMEDIATE QUANTITIES IN SUMMATION PROCESS
ISN 0108        AD=AR*RTOD
ISN 0109        DD=DR*RTOD
ISN 0110        WRITE (IOUT,250) I,TIME(I+J1),TDIFF,W,AD,DD,DERVA,DERVD,THETA,GAMM
               1A,RHO
ISN 0111    170 CONTINUE
          C ***** COMPUTE VECTOR OF DERIVATIVES  A0, D0, A1, D1, ...
ISN 0112        DTIME=1.0
ISN 0113        DO 180 J=2,N2,2
ISN 0114        DERIV(J-1)=DERVA*DTIME
ISN 0115        DERIV(J)=DERVD*DTIME
ISN 0116        DTIME=DTIME*TDIFF
ISN 0117        IF (IDER.NE.1) GO TO 180
ISN 0119        IF (N2.GT.13) GO TO 180
ISN 0121        SCOEF(J-1,I+J1)=DERIV(J-1)
ISN 0122        SCOEF(J,I+J1)=DERIV(J)
ISN 0123    180 CONTINUE
          C ***** SUM WEIGHTED ALPHA AND DELTA COEFFICIENT DERIVATIVES CROSS
          C ***** PRODUCTS INTO COEFFICIENT MATRIX (LOWER, LEFT, OFF-DIAGONAL
          C ***** IS NOT SUMMED BECAUSE OF SYMMETRY)
ISN 0124        DO 200 J=1,N2
ISN 0125        DO 190 K=J,N2
ISN 0126        COEF(J,K)=COEF(J,K)+DERIV(K)*DERIV(J)*W
ISN 0127    190 CONTINUE
          C ***** SUM COEFFICIENTS IN VECTOR CONTAINING RIGHT SIDE OF SIMULTANEOUS
          C ***** EQUATIONS
ISN 0128        DRHOSQ(J)=DRHOSQ(J)+RHO*DERIV(J)*W
ISN 0129    200 CONTINUE
ISN 0130        IF (BIAS.EQ.XBIAS) GO TO 220
          C ***** COMPUTE ALL MATRIX ELEMENTS DEPENDENT ON BIAS
ISN 0132        DO 210 J=1,N2
ISN 0133        COEF(J,IBIAS)=COEF(J,IBIAS)+DERIV(J)*W
ISN 0134    210 CONTINUE
ISN 0135        COEF(IBIAS,IBIAS)=COEF(IBIAS,IBIAS)+W
```

```
ISN 0136          DRHOSQ(IBIAS)=DRHOSQ(IBIAS)+RHO*W                                   00015050
ISN 0137          IF (IDER.EQ.1) SCOEF(IBIAS,I)=1.                                    00015100
ISN 0139      220 CONTINUE                                                            00015150
ISN 0140          RETURN                                                              00015200
            C                                                                         00015250
            C ************************ FORMAT STATEMENTS *************************00015300
            C                                                                         00015350
ISN 0141      230 FORMAT (1X,/,1X,'SUBROUTINE COFSW - ATTITUDE EQUATIONS COEFFICIENT00015400
             1S COMPUTATIONS FOR CLASS',I2,' DATA ',//,1X,'     I        TIME    00015450
             2    TDIFF      WEIGHT       ALPHA        DELTA        DERVA       DE00015500
             3RVD        THETA        GAMMA          RHO',/,2X)                   00015550
ISN 0142      240 FORMAT (1X,'E1,2,3=',3F8.4,'   F,SV,SW=',3F8.4,'   XNUM,XDEN=',2F8.400015600
             1,'   Q1,2,3=',3F8.4)                                                00015650
ISN 0143      250 FORMAT (1X,I6,5F12.4,5F12.6)                                        00015700
ISN 0144      260 FORMAT (1X,'****** THE ABSOLUTE VALUE OF ALPHA AND/OR DELTA IS TOO00015750
             1 LARGE ( =100000.0 RADIANS)')                                       00015800
ISN 0145      270 FORMAT (1X,'****** SIN(THETA)=0.0. DERIVATIVES OF THETA W.R.T. ALP00015850
             1HA AND DELTA ARE UNDEFINED')                                        00015900
ISN 0146      280 FORMAT (1X,'****** PSI IS UNDEFINED. DERIVATIVES OF PSI W.R.T. ALP00015950
             1HA AND DELTA ARE ALSO UNDEFINED')                                   00016000
ISN 0147          END                                                                 00016050
```

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=60,SIZE=0000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      C
      C***********************************************************************
      C                                                                      *
      C                                                                      *
      C         SUBROUTINE BLKINV                                            *
      C                                                                      *
      C         CALLING SEQUENCE                                             *
      C                   CALL BLKINV(COEF,I,J,NP,DET,IERR,STOR1,STOR2,RL)   *
      C                                                                      *
      C         DESCRIPTION                                                  *
      C                                                                      *
      C                   BLKINV INVERTS A SYMETRIC BLOCK DIAGONAL MATRIX    *
      C                   USING A MAXIMUM PIVOT STRATEGY                     *
      C                                                                      *
      C         COMMON AREAS REFERENCED                                      *
      C                                                                      *
      C                   NONE                                               *
      C                                                                      *
      C         EXTERNAL REFERENCES                                          *
      C                                                                      *
      C                   ABS                                                *
      C                                                                      *
      C         STORAGE REQUIREMENTS                                         *
      C                                                                      *
      C                   1408 BYTES OF CORE STORAGE                         *
      C                                                                      *
      C         VARIABLES                                                    *
      C                                                                      *
      C         NAME      TYPE      I/O       DESCRIPTION                    *
      C                                                                      *
      C         COEF      R*4       I/O       SYMETRIC MATRIX CONTAINING     *
      C                                       BLOCK TO BE INVERTED.  ON RETURN*
      C                                       COEF CONTAINS INVERTED BLOCK   *
      C                                                                      *
      C         I         I*4       I         STARTING ROW AND COLUMN OF BLOCK*
      C                                       TO BE INVERTED                 *
      C                                                                      *
      C         J         I*4       I         STOPPING ROW AND COLUMN OF BLOCK*
      C                                       TO BE INVERTED                 *
      C                                                                      *
      C         NP        I*4       I         SIZE OF SQUARE MATRIX COEF     *
      C                                       (DIMENSIONED NP X NP)          *
      C                                                                      *
      C         DET       R*4       O         VALUE OF THE DETERMINANT       *
      C                                                                      *
      C         IERR      I*4       O         ERROR CODE                     *
      C                                         =0, NORMAL RETURN            *
      C                                         =1, ZERO PIVOT ELEMENT,      *
      C                                             INVERSE CANNOT BE OBTAINED*
      C                                                                      *
      C         STOR1     R*4       O         WORK ARRAY(SIZE OF NP OR LARGER)*
      C                                                                      *
      C         STOR2     R*4       O         WORK ARRAY(SIZE OF NP OR LARGER)*
      C                                                                      *
      C         RL        L*1       O         WORK ARRAY(SIZE OF NP OR LARGER)*
      C                                                                      *
      C         REVISIONS                                                    *
      C                                                                      *
      C                   1.  J. WHALEN (SUMMER 1972) - ORIGINAL CODE AND    *
      C                       TESTING                                        *
      C                                                                      *
      C                                                                      *
      C***********************************************************************
      C
      C
            SUBROUTINE BLKINV (B,LO,HI,N,DET,IER,P,Q,R)
            DIMENSION B(N,N),P(1),Q(1),R(1)
            LOGICAL*1 R
            INTEGER HI
            DET=1.
            DO 100 I=LO,HI
        100 R(I)=.TRUE.
            DO 160 I=LO,HI
            BIG=0.
```

```
ISN 0011          DO 110 J=LO,HI
ISN 0012          IF ((.NOT.R(J)).OR.(ABS(B(J,J)).LT.BIG)) GO TO 110
ISN 0014          BIG=ABS(B(J,J))
ISN 0015          K=J
ISN 0016      110 CONTINUE
ISN 0017          DET=DET*B(K,K)
ISN 0018          IF (BIG.EQ.0.) GO TO 170
ISN 0020          R(K)=.FALSE.
ISN 0021          P(K)=1.
ISN 0022          Q(K)=1./B(K,K)
ISN 0023          B(K,K)=0.
ISN 0024          IF (K.EQ.LO) GO TO 130
ISN 0026          M=K-1
ISN 0027          DO 120 J=LO,M
ISN 0028          P(J)=B(J,K)
ISN 0029          Q(J)=B(J,K)*Q(K)
ISN 0030          IF (R(J)) Q(J)=-Q(J)
ISN 0032      120 B(J,K)=0.
ISN 0033          IF (K.EQ.HI) GO TO 150
ISN 0035      130 M=K+1
ISN 0036          DO 140 J=M,HI
ISN 0037          P(J)=-B(K,J)
ISN 0038          IF (R(J)) P(J)=-P(J)
ISN 0040          Q(J)=-B(K,J)*Q(K)
ISN 0041      140 B(K,J)=0.
ISN 0042      150 DO 160 J=LO,HI
ISN 0043          DO 160 K=J,HI
ISN 0044          B(J,K)=B(J,K)+P(J)*Q(K)
ISN 0045      160 B(K,J)=B(J,K)
ISN 0046          IER=0
ISN 0047          RETURN
ISN 0048      170 IER=1
ISN 0049          RETURN
ISN 0050          END
```

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=60,SIZE=0000K,
             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
C
C***********************************************************************
C
C
C        SUBROUTINE GSTAT1
C
C        CALLING SEQUENCE
C
C              CALL GSTAT1(ALP,ALPBND,ALPCUM,DEL,DELBND,DELCUM,
C                     ARGCUM,TIME1,AXIS1,ANG1,WGHT1,IFRST1,
C                     NTYPE1,BIAS1,BBND1,RHOST1,RHO1,CALC1,
C                     SCOEF1,TIME2,AXIS2,ANG2,WGHT2,IFRST2,
C                     NTYPE2,BIAS2,BBND2,RHOST2,RHO2,CALC2,
C                     SCOEF2,AVGRHO,COEF,DRHOSQ,CHNG,STOR1,
C                     STOR2,ALPR,DELR,STYPE1,STYPE2,BTYPE,
C                     RL,WORK,B11CUM)
C
C        DESCRIPTION
C
C              GSTAT1 STORES CUMULATIVE ITERATION RESULTS FOR
C              DISPLAYING AND PERFORMS RESIDUAL EDITING ON THE DATA*
C
C        COMMON AREAS REFERENCED
C
C              FLAGG,GCN1,GDCON
C
C        EXTERNAL REFERENCES
C
C              ABS,CHECK,INCORE,PTSIZE
C
C        STORAGE REQUIREMENTS
C
C              5400 BYTES OF CORE STORAGE
C
C        VARIABLES
C
C        NAME      TYPE      I/O       DESCRIPTION
C
C        ALP       R*4       I         A PRIORI POLYNOMIAL COEFFI-
C                                      CIENTS FOR RIGHT ASCENSION,
C                                      IN DEGREES
C
C        ALPBND    R*4       I         CONVERGENCE BOUNDS FOR ALP,
C                                      IN DEGREES
C
C        ALPCUM    I*4       O         CUMULATIVE RESULTS FOR ALP(1)
C
C        DEL       R*4       I         A PRIORI POLYNOMIAL COEFFI-
C                                      CIENTS FOR DECLINATION, IN
C                                      DEGREES
C
C        DELBND    R*4       I         CONVERGENCE BOUNDS FOR DEL,
C                                      IN DEGRESS
C
C        DELCUM    R*4       O         CUMULATIVE RESULTS FOR DEL(1)
C
C        ARGCUM    I*4       O         ITERATION INDICATOR FOR VALUES
C                                      IN ALPCUM, AND DELCUM
C
C        TIME1     R*4       I         REFERENCE TIMES FOR CLASS 1
C                                      (CONE ANGLE) DATA
C
C        AXIS1     R*4       I         REFERENCE UNIT VECTORS FOR CLASS*
C                                      1(DIMENSIONED 3*NUMBER OF CLASS
C                                      1 OBSERVATIONS)
C
C        ANG1      R*4       I         CLASS 1 (CONE ANGLE) OBSERVA-
C                                      TIONS, IN DEGREES
C
C        WGHT1     R*4       I/O       CLASS 1 WEIGHTS
C
C        IFRST1    I*4       I         POINTERS INDICATING STARTING
C                                      POSITIONS FOR EACH TYPE OF
C                                      CLASS 1 DATA IN THE ARRAYS
C                                      TIME1,AXIS1,ANG1,WGHT1
```

```
C                                                                        *00003800
C       NTYPE1     I*4       I         NUMBER OF OBSERVATIONS OF EACH  *00003850
C                                      TYPE OF CLASS 1 DATA            *00003900
C                                                                      *00003950
C       BIAS1      R*4       I         ESSENTIAL ESTIMATE OF BIASES FOR*00004000
C                                      EACH TYPE OF CLASS 1 DATA       *00004050
C                                                                      *00004100
C       BBND1      R*4       I         CONVERGENCE BOUNDS FOR BIAS1    *00004150
C                                      ELEMENTS                        *00004200
C                                                                      *00004250
C       RHOST1     R*4       I         CLASS 1 STATISTICS DEFINED AS   *00004300
C                                        RHOST1(1,I) - WEIGHTED SUM OF *00004350
C                                                      ANGLE RESIDUALS *00004400
C                                                      FOR TYPE I DATA *00004450
C                                        RHOST1(2,I) - WEIGHTED SUM OF *00004500
C                                                      SQUARES OF ANGLE*00004550
C                                                      RESIDUALS FOR   *00004600
C                                                      TYPE I DATA     *00004650
C                                        RHOST1(3,I) - SUM OF WEIGHTS  *00004700
C                                                      FOR TYPE I DATA *00004750
C                                        RHOST1(4,I) - MEAN RESIDUAL   *00004760
C                                                      FOR TYPE I DATA *00004770
C                                        RHOST1(5,I) - STD. DEVIATION  *00004780
C                                                      FOR TYPE I DATA *00004790
C                                                                      *00004800
C       RHO1       R*4       I         RESIDUALS FOR CLASS 1 DATA      *00004850
C                                      DEFINED AS OBSERVED MINUS       *00004900
C                                      CALCULATED                      *00004950
C                                                                      *00005000
C       CALC1      R*4       I         CALCULATED ANGLES FOR CLASS 1   *00005050
C                                      DATA                            *00005100
C                                                                      *00005150
C       SCOEF1     R*4       I         DERIVATIVES OF CLASS 1 ANGLES   *00005200
C                                      WITH RESPECT TO STATE VECTOR    *00005250
C                                      ELEMENTS                        *00005300
C                                                                      *00005350
C       TIME2      R*4       I         REFERENCE TIMES FOR CLASS 2 ,   *00005400
C                                      DIHEDRAL ANGLE, DATA            *00005450
C                                                                      *00005500
C       AXIS2      R*4       I         REFERENCE VECTORS FOR CLASS 2   *00005550
C                                      DATA (DIMENSIONED 6 * NUMBER    *00005600
C                                      OF OBSERVATIONS.  THE I TH      *00005650
C                                      DIHEDRAL ANGLE IS MEASURED FROM *00005700
C                                      VECTOR((1,I),(2,I),(3,I)) TO    *00005750
C                                      VECTOR((4,I),(5,I),(6,I))       *00005800
C                                                                      *00005850
C       ANG2       R*4       I         CLASS 2 ANGLES, IN DEGREES      *00005900
C                                                                      *00005950
C       WGHT2      R*4       I/O       WEIGHTS FOR CLASS 2 DATA        *00006000
C                                                                      *00006050
C       IFRST2     I*4       I         POINTERS INDICATING STARTING    *00006100
C                                      POSITIONS FOR EACH TYPE OF CLASS*00006150
C                                      2 DATA IN THE ARRAYS   TIME2,   *00006200
C                                      AXIS2,ANG2,WGHT2                *00006250
C                                                                      *00006300
C       NTYPE2     I*4       I         NUMBER OF OBSERVATIONS OF EACH  *00006350
C                                      TYPE OF CLASS 2 DATA            *00006400
C                                                                      *00006450
C       BIAS2      R*4       I         ESSENTIAL ESTIMATE OF BIASES    *00006500
C                                      FOR EACH TYPE OF CLASS 2 DATA   *00006550
C                                                                      *00006600
C       BBND2      R*4       I         CONVERGENCE BOUNDS FOR BIAS2    *00006650
C                                      ELEMENTS                        *00006700
C                                                                      *00006750
C       RHOST2     R*4       I         CLASS 2 STATISTICS DEFINED AS   *00006800
C                                        RHOST2(1,I) - WEIGHTED SUM OF *00006850
C                                                      ANGLE RESIDUALS *00006900
C                                                      FOR TYPE I DATA *00006950
C                                        RHOST2(2,I) - WEIGHTED SUMS OF*00007000
C                                                      SQUARES OF ANGLE*00007050
C                                                      RESIDUALS FOR   *00007100
C                                                      TYPE I DATA     *00007150
C                                        RHOST2(3,I) - SUM OF WEIGHTS  *00007200
C                                                      FOR TYPE I DATA *00007250
C                                        RHOST2(4,I) - MEAN RESIDUAL   *00007260
C                                                      FOR TYPE I DATA *00007270
```

```
C                                            RHOST2(5,I) - STD. DEVIATION  *00007280
C                                                     FOR TYPE I DATA *00007290
C                                                                      *00007300
C      RHO2        R*4        I          RESIDUALS FOR CLASS 2 DATA     *00007350
C                                        DEFINED AS OBSERVED MINUS      *00007400
C                                        COMPUTED                       *00007450
C                                                                       *00007500
C      CALC2       R*4        I          CALCULATED ANGLES FOR CLASS 2  *00007550
C                                        DATA                           *00007600
C                                                                       *00007650
C      SCOEF2      R*4        I          DERIVATIVES OF CLASS 2 ANGLES  *00007700
C                                        WITH RESPECT TO STATE VECTOR   *00007750
C                                        ELEMENTS                       *00007800
C                                                                       *00007850
C      AVGRHO      R*4        O          USED TO STORE AVERAGE RESIDUAL *00007900
C                                        MAGNITUDE                      *00007950
C                                                                       *00008000
C      COEF        R*4        I          ARRAY USED FOR COEFFICIENT     *00008050
C                                        COVARIANCE, AND CORRELATION    *00008100
C                                        MATRICIES                      *00008150
C                                                                       *00008200
C      DRHOSQ      R*4        I          WORK ARRAY(DIMENSIONED 13)     *00008250
C                                                                       *00008300
C      CHNG        R*4        I          WORK ARRAY USED TO STORE THE   *00008350
C                                        UPDATES TO THE STATE VECTOR    *00008400
C                                        AFTER EACH ITERATION           *00008450
C                                                                       *00008500
C      STOR1       R*4        I          WORK ARRAY(DIMENSIONED 13)     *00008550
C                                                                       *00008600
C      STOR2       R*4        I          WORK ARRAY(DIMENSIONED 13)     *00008650
C                                                                       *00008700
C      ALPR        R*4        I          RIGHT ASCENSION(ALP) COEFFI-   *00008750
C                                        CIENTS, IN RADIANS             *00008800
C                                                                       *00008850
C      DELR        R*4        I          DELCINATION(DEL) COEFFICIENTS  *00008900
C                                        IN RADIANS                     *00008950
C                                                                       *00009000
C      STYPE1      R*4        I          ALPHA-NUMERIC WORK ARRAY       *00009050
C                                                                       *00009100
C      STYPE2      R*4        I          ALPHA-NUMERIC WORK ARRAY       *00009150
C                                                                       *00009200
C      BTYPE       I*4        I          WORK ARRAY(DIMENSIONED 13)     *00009250
C                                                                       *00009300
C      RL          L*1        I          WORK ARRAY(DIMENSIONED 13)     *00009350
C                                                                       *00009400
C      WORK        R*4        I          WORK ARRAY(DIMENSIONED 13)     *00009450
C                                                                       *00009500
C      B11CUM      R*8        O          ALPHA-NUMERIC WORK ARRAY USED TO*00009550
C                                        STORE CUMULATIVE BIASES FOR    *00009600
C                                        DISPLAY                        *00009650
C                                                                       *00009700
C      COMMON AREA VARIABLES USED IN ROUTINE                            *00009750
C                                                                       *00009800
C      NAME        TYPE       ORIGIN     DESCRIPTION                    *00009850
C                                                                       *00009900
C      IOUT        I*4        GCN1       FORTRAN DEVICE UNIT FOR SPECI- *00009950
C                                        FIED OUTPUT                    *00010000
C                                                                       *00010050
C      NCLAS1      I*4        GCN1       NUMBER OF CLASS 1 DATA TYPES   *00010100
C                                                                       *00010150
C      NCLAS2      I*4        GCN1       NUMBER OF CLASS 2 DATA TYPES   *00010200
C                                                                       *00010250
C      IRWT        I*4        GCN1       INTERMEDIATE PRINTOUT LEVEL    *00010300
C                                        INDICATOR(SEE REFERENCES 1 & 2 *00010350
C                                        FOR VARIOUS LEVELS)            *00010400
C                                                                       *00010450
C      IOC         I*4        GCN1       RESIDUAL STORAGE INDICATOR     *00010500
C                                          =0, DO NOT STORE RESIDUALS   *00010550
C                                          =1, STORE RESIDUALS FOR      *00010600
C                                              DISPLAY AND PLOTTING     *00010650
C                                                                       *00010700
C      SMULT       R*4        GCN1       RESIDUAL EDIT CRITERIA.(THE    *00010750
C                                        WEIGHTS OF ANGLES WHOSE MAGNI- *00010800
C                                        TUDE OF RESIDUAL IS GREATER THAN*00010850
C                                        SMULT*(AVERAGE OF RESIDUAL MAG- *00010900
C                                        NITUDE) IS SET TO THE NEGATIVE *00010950
C                                        OF THE RESIDUAL                *00011000
C                                                                       *00011050
C      ISTEP       I*4        GCN1       CURRENT ITERATION INDICATOR    *00011100
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C
C        AVG         R*4         GCN1         RESIDUAL EDIT BOUND(I.E..AVERAGE*
C                                             RESIDUAL FOR CLASS 1 AND CLASS 2*
C                                             DATA)                           *
C                                                                             *
C                                                                             *
C        DATA TRANSMISSION                                                    *
C                                                                             *
C        NAME        READ/WRITE/CPOINT        DESCRIPTION                     *
C                                                                             *
C        FTXXF001    WRITE                    INTERMEDIATE PRINTOUT, WHERE    *
C                                             XX = IOUT                       *
C                                                                             *
C        GSTATA      CPOINT                   CUMULATIVE STATE VECTOR DISPLAY *
C                                                                             *
C        GSTAT1      CPOINT                   RESIDUAL EDIT DATA DISPLAY      *
C                                                                             *
C        REFERENCES                                                           *
C                                                                             *
C                    1.  L.R.SCHLEGEL, CCNES AN ITERATIVE DIFFERENTIAL        *
C                        CORRECTION TECHNIQUE FOR ATTITUDE DETERMINATION *
C                        OF A SPINNING SATELLITE, IBM FSD REPORT,             *
C                        CONTRACT NAS 5-10022, MAY 1697                       *
C                                                                             *
C                    2.  SURVEY AND EVALUATICN OF ATTITUDE DETERMINATION *
C                        TECHNIQUES, IBM FSD REPORT TR-68-8, CONTRACT         *
C                        NAS 5-10022, MAY 1968, PP. 4-14 TO 4-24              *
C                                                                             *
C        REVISIONS                                                            *
C                    1.  J. WHALEN (SUMMER 1972) - ORIGINAL CODE AND          *
C                        TESTING                                              *
C                                                                             *
C                    2.  L. FEAKES (13 JULY 1973) - MODIFICATIONS TO          *
C                        LOGIC TO ALLOW FOR BETTER DISPLAY OF CUMULATIVE *
C                        ITERATION RESULTS AND ALTERATICN OF LOGIC OF         *
C                        OF RESIDUAL EDITING FROM ZERO WEIGHTS TO             *
C                        NEGATIVE WEIGHTS TO ALLOW FOR REINITIALIZATION *
C                        OF THE SYSTEM                                        *
C                                                                             *
C                                                                             *
C******************************************************************************
ISN 0002      SUBROUTINE GSTAT1 (ALP,ALPBND,ALPCUM,DEL,DELBND,DELCUM,ARGCUM,TIME
             11,AXIS1,ANG1,WGHT1,IFRST1,NTYPE1,BIAS1,BBND1,RHOST1,RHO1,CALC1,SCO
             2EF1,TIME2,AXIS2,ANG2,WGHT2,IFRST2,NTYPE2,BIAS2,BBND2,RHOST2,RHO2,C
             3ALC2,SCOEF2,AVGRHO,COEF,DRHOSQ,CHNG,STOR1,STOR2,ALPR,DELR,STYPE1,S
             4TYPE2,BTYPE,RL,WORK,B11CUM)
C     COMBINED RESIDUAL EDITTING, CUMULATIVE DISPLAYS OF ALP(1)  AND DEL
C     COMBINED RESIDUAL EDITTING, CUMULATIVE DISPLAYS OF ALP(1)  AND DEL
C     AND PRINTING OF DERIVATIVES IN SCOEF1 AND SCOEF2.
ISN 0003      DIMENSION ALP(1),ALPBND(1),ALPCUM(1),DEL(1),DELBND(1),DELCUM(1),
             1            ARGCUM(1),TIME1(1),AXIS1(3,1),ANG1(1),WGHT1(1),
             2            IFRST1(1),NTYPE1(1),BIAS1(1),BBND1(1),RHOST1(3,1),
             3            RHO1(1),CALC1(1),SCOEF1(NP,1),TIME2(1),AXIS2(6,1),
             4            ANG2(1),WGHT2(1),IFRST2(1),NTYPE2(1),BIAS2(1),BBND2(1),
             5            RHOST2(3,1),RHO2(1),CALC2(1),SCOEF2(NP,1),AVGRHO(2,1),
             6            COEF(NP,NP),DRHOSQ(NP),CHNG(NP),STOR1(NP),STOR2(NP),
             7 ALPR(1),DELR(1),STYPE1(1),STYPE2(1),BTYPE(1),RL(1),WORK(1)
ISN 0004      INTEGER*4 BTYPE,CORMIN,CORMAX,ARGCUM
ISN 0005      REAL*8 BLANK8,B11CUM(5,21),DUMMY(5),DUMMY1(5)
ISN 0006      DATA BLANK8/'        '/
ISN 0007      LOGICAL*1 RL
ISN 0008      COMMON/GCN1/IOUT,NCLAS1,NCLAS2,NCOF,MAXIT,IWRT,TZERO,IOC,ICALC,
             1            IDER,SMULT,NP,IWHERE,ISTEP,ISTOP,IRET,ISTAT,
             2            CORMIN,CORMAX
ISN 0009      COMMON /FLAGG/ FLAG,TEST
ISN 0010      COMMON/GDCON/ AVG
ISN 0011      DATA TFLAG/9999999./
ISN 0012      N2=NCOF*2
ISN 0013      IF (ISTEP.GT.1) GO TO 160
ISN 0015      DO 100 I=1,5
ISN 0016      DO 100 J=1,21
ISN 0017      B11CUM(I,J)=BLANK8
ISN 0018  100 CONTINUE
ISN 0019      ARGCUM(1)=0
ISN 0020      ALPCUM(1)=ALP(1)
ISN 0021      DELCUM(1)=DEL(1)
ISN 0022      K=0
ISN 0023      IF (NCLAS1.LE.0) GO TO 120
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ISN 0025          DO 110 I=1,NCLAS1
ISN 0026          IF (BIAS1(I).EQ.TFLAG) GO TO 110
ISN 0028          K=K+1
ISN 0029          DUMMY(K)=BIAS1(I)
ISN 0030      110 CONTINUE
ISN 0031      120 IF (NCLAS2.LE.0) GO TO 140
ISN 0033          DO 130 I=1,NCLAS2
ISN 0034          IF (BIAS2(I).EQ.TFLAG) GO TO 130
ISN 0036          K=K+1
ISN 0037          DUMMY(K)=BIAS2(I)
ISN 0038      130 CONTINUE
ISN 0039      140 IF (K.LE.0) GO TO 160
ISN 0041          CALL INCORE (DUMMY,DUMMY1,15,K,8,3)
ISN 0042          DO 150 I=1,5
ISN 0043      150 B11CUM(I,1)=DUMMY1(I)
ISN 0044      160 II=ISTEP+1
ISN 0045          IF (II.GT.21) GO TO 220
ISN 0047          ARGCUM(II)=ISTEP
ISN 0048          ALPCUM(II)=ALP(1)+CHNG(1)
ISN 0049          DELCUM(II)=DEL(1)+CHNG(2)
ISN 0050          K=0
ISN 0051          IF (NCLAS1.LE.0) GO TO 180
ISN 0053          DO 170 I=1,NCLAS1
ISN 0054          IF (BIAS1(I).EQ.TFLAG) GO TO 170
ISN 0056          K=K+1
ISN 0057          DUMMY(K)=BIAS1(I)+CHNG(N2+K)
ISN 0058      170 CONTINUE
ISN 0059      180 IF (NCLAS2.LE.0) GO TO 200
ISN 0061          DO 190 I=1,NCLAS2
ISN 0062          IF (BIAS2(I).EQ.TFLAG) GO TO 190
ISN 0064          K=K+1
ISN 0065          DUMMY(K)=BIAS2(I)+CHNG(N2+K)
ISN 0066      190 CONTINUE
ISN 0067      200 IF (K.LE.0) GO TO 300
ISN 0069          CALL INCORE (DUMMY,DUMMY1,15,K,8,3)
ISN 0070          DO 210 I=1,K
ISN 0071      210 B11CUM(I,II)=DUMMY1(I)
ISN 0072          GO TO 300
ISN 0073      220 DO 240 I=2,21
ISN 0074          ARGCUM(I-1)=ARGCUM(I)
ISN 0075          ALPCUM(I-1)=ALPCUM(I)
ISN 0076          IF (K.LE.0) GO TO 240
ISN 0078          DO 230 J=1,K
ISN 0079      230 B11CUM(J,I-1)=B11CUM(J,I)
ISN 0080      240 CONTINUE
ISN 0081          ARGCUM(21)=ISTEP
ISN 0082          ALPCUM(21)=ALP(1)+CHNG(1)
ISN 0083          DELCUM(21)=DEL(1)+CHNG(2)
ISN 0084          K=0
ISN 0085          IF (NCLAS1.LE.0) GO TO 260
ISN 0087          DO 250 I=1,NCLAS1
ISN 0088          IF (BIAS1(I).EQ.TFLAG) GO TO 250
ISN 0090          K=K+1
ISN 0091          DUMMY(K)=BIAS1(I)+CHNG(N2+K)
ISN 0092      250 CONTINUE
ISN 0093      260 IF (NCLAS2.LE.0) GO TO 280
ISN 0095          DO 270 I=1,NCLAS2
ISN 0096          IF (BIAS2(I).EQ.TFLAG) GO TO 270
ISN 0098          K=K+1
ISN 0099          DUMMY(K)=BIAS2(I)+CHNG(N2+K)
ISN 0100      270 CONTINUE
ISN 0101      280 IF (K.LE.0) GO TO 300
ISN 0103          CALL INCORE (DUMMY,DUMMY1,15,K,8,3)
ISN 0104          DO 290 I=1,K
ISN 0105      290 B11CUM(I,21)=DUMMY1(I)
ISN 0106      300 ISZE=II
ISN 0107          IF (ISZE.GT.21) ISZE=21
ISN 0109          CALL PTSIZE (ISZE,ALPCUM,DELCUM,ARGCUM)
ISN 0110          CALL PTSIZE (105,B11CUM)
ISN 0111          CALL CHECK ('GSTATA')
ISN 0112          CALL PTSIZE (21,ALPCUM,DELCUM,ARGCUM)
ISN 0113          AVG=0.0
ISN 0114          IF (IOC.NE.1) GO TO 470
ISN 0116          NCLAS=NCLAS1
ISN 0117          DO 320 I=1,2
ISN 0118          IF (I.EQ.2) NCLAS=NCLAS2
ISN 0120          IF (NCLAS.LE.0) GO TO 320
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ISN 0122          DO 310 J=1,NCLAS
ISN 0123      310 AVGRHO(I,J)=0.
ISN 0124      320 CONTINUE
ISN 0125          NUM=0
ISN 0126          NSET=0
ISN 0127          IF (NCLAS1.LE.0) GO TO 350
ISN 0129          DO 340 I=1,NCLAS1
ISN 0130          J1=IFRST1(I)
ISN 0131          N=NTYPE1(I)+J1-1
ISN 0132          DO 330 J=J1,N
ISN 0133          IF (TIME1(J).EQ.TFLAG) GO TO 330
ISN 0135          IF (WGHT1(J).LT.0.0) GO TO 330
ISN 0137          AVGRHO(1,I)=AVGRHO(1,I)+ABS(RHO1(J))
ISN 0138          NUM=NUM+1
ISN 0139      330 CONTINUE
ISN 0140          IF (NUM.NE.0) AVGRHO(1,I)=AVGRHO(1,I)/NUM
ISN 0142          IF (NUM.NE.0) NSET=NSET+1
ISN 0144      340 CONTINUE
ISN 0145      350 NUM=0
ISN 0146          IF (NCLAS2.LE.0) GO TO 380
ISN 0148          DO 370 I=1,NCLAS2
ISN 0149          J1=IFRST2(I)
ISN 0150          N=NTYPE2(I)+J1-1
ISN 0151          DO 360 J=J1,N
ISN 0152          IF (TIME2(J).EQ.TFLAG) GO TO 360
ISN 0154          IF (WGHT2(J).LT.0.0) GO TO 360
ISN 0156          AVGRHO(2,I)=AVGRHO(2,I)+ABS(RHO2(J))
ISN 0157          NUM=NUM+1
ISN 0158      360 CONTINUE
ISN 0159          IF (NUM.NE.0) AVGRHO(2,I)=AVGRHO(2,I)/NUM
ISN 0161          IF (NUM.NE.0) NSET=NSET+1
ISN 0163      370 CONTINUE
              C
              C   RESIDUAL EDITING.
              C
ISN 0164      380 SUMAV=0.
ISN 0165          IF (NCLAS1.LE.0) GO TO 400
ISN 0167          DO 390 J=1,NCLAS1
ISN 0168          IF (IWRT.GT.20) WRITE (IOUT,530) J,AVGRHO(1,J)
ISN 0170      390 SUMAV=SUMAV+AVGRHO(1,J)
ISN 0171      400 IF (NCLAS2.LE.0) GO TO 420
ISN 0173          DO 410 J=1,NCLAS2
ISN 0174          IF (IWRT.GT.20) WRITE (IOUT,540) J,AVGRHO(2,J)
ISN 0176      410 SUMAV=SUMAV+AVGRHO(2,J)
ISN 0177      420 AVG=SUMAV/NSET
ISN 0178          IF (IWRT.GT.20) WRITE (IOUT,550) AVG,SUMAV,SMULT
ISN 0180          IF (NCLAS1.LE.0.OR.SMULT.LE.0) GO TO 440
ISN 0182          DO 430 I=1,NCLAS1
ISN 0183          J1=IFRST1(I)
ISN 0184          N=NTYPE1(I)+J1-1
ISN 0185          DO 430 J=J1,N
ISN 0186          IF (ABS(RHO1(J)).GT.SMULT*AVG) WGHT1(J)=-WGHT1(J)
ISN 0188          IF (IWRT.GT.21) WRITE (IOUT,560) J,RHO1(J)
ISN 0190      430 CONTINUE
ISN 0191      440 IF (NCLAS2.LE.0.OR.SMULT.LE.0) GO TO 460
ISN 0193          DO 450 I=1,NCLAS2
ISN 0194          J1=IFRST2(I)
ISN 0195          N=NTYPE2(I)+J1-1
ISN 0196          DO 450 J=J1,N
ISN 0197          IF (ABS(RHO2(J)).GT.SMULT*AVG) WGHT2(J)=-WGHT2(J)
ISN 0199          IF (IWRT.GT.21) WRITE (IOUT,570) J,RHO2(J)
ISN 0201      450 CONTINUE
ISN 0202      460 CONTINUE
ISN 0203      470 CONTINUE
ISN 0204          IF (IDER.NE.1) GO TO 520
              C   WRITE OUT THE DERIVATIVES IF COMPUTED.
              C   THE GCONESR EDITING OPTION CAN BE ADDED AT THIS POINT IF DESIRED.
ISN 0206          IF (NCLAS1.LE.0) GO TO 490
ISN 0208          DO 480 I=1,NCLAS1
ISN 0209          J1=IFRST1(I)
ISN 0210          N=NTYPE1(I)+J1-1
ISN 0211      480 WRITE (IOUT,580) (SCOEF1(1,J),J=J1,N)
ISN 0212      490 IF (NCLAS2.LE.0) GO TO 510
ISN 0214          DO 500 I=1,NCLAS2
ISN 0215          J1=IFRST2(I)
ISN 0216          N=NTYPE2(I)+J1-1
ISN 0217      500 WRITE (IOUT,580) (SCOEF2(2,J),J=J1,N)
ISN 0218      510 CONTINUE
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ISN 0219      520 CONTINUE
ISN 0220          CALL CHECK ('GSTAT1')
ISN 0221          RETURN
              C
ISN 0222      530 FORMAT (' AVGRHO(1,',I1,')= ',F10.5)
ISN 0223      540 FORMAT (' AVGRHO(2,',I1,') = ',F10.5)
ISN 0224      550 FORMAT (' AVG = ',F10.5,' SUMAV = ',F10.5,' SMULT = ',F10.6)
ISN 0225      560 FORMAT (' RHO1(',I5,')= ',F10.5)
ISN 0226      570 FORMAT (' RHO2(',I5,')= ',F10.5)
ISN 0227      580 FORMAT (' ',10E12.4)
ISN 0228          END
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COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=60,SIZE=0000K,
              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
C                                                                       00000050
C***********************************************************************00000100
C                                                                      *00000150
C                                                                      *00000200
C        SUBROUTINE FINAL2                                             *00000250
C                                                                      *00000300
C        CALLING SEQUENCE                                              *00000350
C                                                                      *00000400
C              CALL FINAL2(GWORK0,ALP,DEL,AI,DI,BIASI,BIAS1,BIAS2I,*00000450
C                     BIAS2,RHOST1,RHOST2,NTYPE1,NTYPE2,NCOF,          *00000500
C                     IALLO,COVAR,NC)                                  *00000550
C                                                                      *00000600
C        DESCRIPTION                                                   *00000650
C                                                                      *00000700
C              FINAL2 CONVERTS THE INITIAL AND CURRENT ITERATION       *00000750
C              VALUES OF THE STATE VECTOR INTO ALPHA-NUMERIC           *00000800
C              CHARACTERS FOR THE SUMMARY DISPLAY                      *00000850
C                                                                      *00000900
C        COMMON AREAS REFERENCED                                       *00000950
C                                                                      *00001000
C              NONE                                                    *00001050
C                                                                      *00001100
C        EXTERNAL REFERENCES                                           *00001150
C                                                                      *00001200
C              INCORE,PTSIZE,SQRT                                      *00001250
C                                                                      *00001300
C        STORAGE REQUIREMENTS                                          *00001350
C                                                                      *00001400
C              4224 BYTES OF CORE STORAGE                              *00001450
C                                                                      *00001500
C        VARIABLES                                                     *00001550
C                                                                      *00001600
C        NAME      TYPE      I/O       DESCRIPTION                     *00001650
C                                                                      *00001700
C        GWORK0    R*8       O         WORK ARRAY WHERE ALPHA-NUMERIC  *00001750
C                                      EQUIVALENTS OF PREVIOUS AND CUR-*00001800
C                                      RENT VALUES OF THE STATE VECTOR *00001850
C                                      ARE STORED                      *00001900
C                                                                      *00001950
C        ALP       R*4       I         RIGHT ASCENSION POLYNOMIAL COEF-*00002000
C                                      FICIENTS, IN DEGREES            *00002050
C                                                                      *00002100
C        DEL       R*4       I         DECLINATION POLYNOMIAL COEFFI-  *00002150
C                                      CIENTS, IN DEGREES              *00002200
C                                                                      *00002250
C        AI        R*4       I         INITIAL RIGHT ASCENSION POLYNO- *00002300
C                                      MIAL COEFFICIENTS, IN DEGREES   *00002350
C                                                                      *00002400
C        DI        R*4       I         INITIAL DECLINATION POLYNOMIAL  *00002450
C                                      COEFFICIENTS, IN DEGREES        *00002500
C                                                                      *00002550
C        BIASI     R*4       I         INITIAL BIASES FOR EACH TYPE    *00002600
C                                      OF CLASS 1 DATA, IN DEGREES     *00002650
C                                                                      *00002700
C        BIAS1     R*4       I         BIASES FOR EACH TYPE OF CLASS 1 *00002750
C                                      DATA, IN DEGREES                *00002800
C                                                                      *00002850
C        BIAS2I    R*4       I         INITIAL BIASES FOR EACH TYPE OF *00002900
C                                      CLASS 2 DATA, IN DEGREES        *00002950
C                                                                      *00003000
C        BIAS2     R*4       I         BIASES FOR EACH TYPE OF CLASS 2 *00003050
C                                      DATA, IN DEGREES                *00003100
C                                                                      *00003150
C        RHOST1    R*4       I         CLASS 1 STATISTICS              *00003200
C                                      (FOR RHOST1(1,I)-RHOST1(3,I)    *00003210
C                                      SEE DCCONS PROLOGUE)            *00003220
C                                        RHOST1(4,I) - MEAN RESIDUAL   *00003250
C                                                      FOR TYPE I DATA *00003300
C                                        RHOST1(5,I) - STANDARD DEVIA- *00003350
C                                                      TION FOR TYPE I *00003400
C                                                      DATA            *00003450
C                                                                      *00003500
C        RHOST2    R*4       I         CLASS 2 STATISTICS              *00003550
C                                      (FOR RHOST2(1,I)-RHOST2(3,I)    *00003560
C                                      SEE DCCONS PROLOGUE             *00003570
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          C                                         RHOST2(4,I) - MEAN RESIDUAL
          C                                                       FOR TYPE I DATA
          C                                         RHOST2(5,I) - STANDARD DEVIA-
          C                                                       TION FOR TYPE I
          C                                                       DATA
          C
          C        NTYPE1      I*4         I          NUMBER OF CLASS 1 DATA TYPES
          C
          C        NTYPE2      I*4         I          NUMBER OF CLASS 2 DATA TYPES
          C
          C        NCOF        I*4         I          NUMBER OF POLYNOMIAL COEFFICIENTS
          C                                           FOR ALP AND DEL
          C
          C        IALLO       I*4         I          ALLOCATION SIZE FOR GWORKO ARRAY
          C                                           (MUST BE 224 OR 0)
          C
          C        COVAR       I*4         I          COVARIANCE MATRIX FOR STATE
          C                                           VECTOR ELEMENTS
          C
          C        NC          I*4         I          NUMBER OF ELEMENTS IN THE
          C                                           STATE VECTOR
          C
          C        REVISIONS
          C
          C                 1. L. FEAKES (13 JULY 1973) - ORIGINAL CODING AND
          C                    TESTING
          C
          C
          C*************************************************************************
ISN 0002        SUBROUTINE FINAL2 (GWORKO,ALP,DEL,AI,DI,BIASI,BIAS1,BIAS2I,BIAS2,R
               1HOST1,RHOST2,NTYPE1,NTYPE2,NCOF,IALLO,COVAR,NC)
ISN 0003        DIMENSION ALP(NCOF),DEL(NCOF),AI(4),DI(4),BIASI(NTYPE1),
               1 BIAS1(NTYPE1),BIAS2I(NTYPE2),BIAS2(NTYPE2)
ISN 0004        DIMENSION RHOST1(5,NTYPE1),RHOST2(5,NTYPE2)
ISN 0005        REAL*8 BLANK8,DUMMY(30),BIA(30),TAI,TAF,TDI,TDF,ERA,ERD,ATT(24),
               1 GWORKO(7,32)
ISN 0006        REAL*4 COVAR(NC,NC)
ISN 0007        REAL*8 XBIAS/9999999./
ISN 0008        DATA BLANK8/'        '/
ISN 0009        DATA ZERO/'(0)     '/,ONE/'(1)     '/,TWO/'(2)     '/,
               1 THREE/'(3)     '/,TYPE/'TYPE    '/,
               2 ONE1/' 1      '/,TWO1/' 2      '/,THREE1/' 3      '/,
               3 FOUR1/' 4      '/,FIVE/' 5      '/,
               4 DIHED/'DIHEDRAL'/,ERROR/' EST.   '/,ANGLES/'ANGLES  '/,
               5 CONE/'- CONE  '/,CLASS2/'CLASS 2 '/,CLASS1/'CLASS 1 '/,
               6 INITIL/' INITIAL'/,FINALS/' FINAL  '/,AALP/'  ALPHA '/,
               7 DDLP/'  DELTA '/,BIAS/'  BIAS  '/,MEAN/'  MEAN  '/,
               8 RESD/'RESIDUAL'/,RMS/'   RMS  '/
ISN 0010        DATA ACC/'ACCURACY'/
ISN 0011        REAL*8 ZERO,ONE, TWO,THREE,TOTAL,TYPE,ONE1,TWO1,THREE1,FOUR1,
               1 FIVE,SIX,CLASS1,CLASS2,DIHED,ERROR,ANGLES,CONE
ISN 0012        REAL*8 INITIL,FINALS,AALP,DDLP,BIAS,MEAN,RESD,RMS,ACC
ISN 0013        DATA INIT/0/
ISN 0014        IF (INIT.NE.0) GO TO 110
ISN 0016        INIT=1
ISN 0017        DO 100 I=1,7
ISN 0018        DO 100 J=1,32
ISN 0019    100 GWORKO(I,J)=BLANK8
ISN 0020        GWORKO(1,4)=ZERO
ISN 0021        GWORKO(1,5)=ONE
ISN 0022        GWORKO(1,6)=TWO
ISN 0023        GWORKO(1,7)=THREE
ISN 0024        GWORKO(1,8)=BLANK8
ISN 0025        GWORKO(1,12)=TYPE
ISN 0026        GWORKO(1,15)=ONE1
ISN 0027        GWORKO(1,16)=TWO1
ISN 0028        GWORKO(1,17)=THREE1
ISN 0029        GWORKO(1,18)=FOUR1
ISN 0030        GWORKO(1,19)=FIVE
ISN 0031        GWORKO(1,24)=TYPE
ISN 0032        GWORKO(1,27)=ONE1
ISN 0033        GWORKO(1,28)=TWO1
ISN 0034        GWORKO(1,29)=THREE1
ISN 0035        GWORKO(1,30)=FOUR1
ISN 0036        GWORKO(1,31)=FIVE
ISN 0037        GWORKO(2,1)=INITIL
ISN 0038        GWORKO(2,2)=AALP
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ISN 0039          GWORKO(2,10)=CLASS1                                     00007450
ISN 0040          GWORKO(2,12)=INITIL                                     00007500
ISN 0041          GWORKO(2,13)=BIAS                                       00007550
ISN 0042          GWORKO(2,22)=CLASS2                                     00007600
ISN 0043          GWORKO(2,24)=INITIL                                     00007650
ISN 0044          GWORKO(2,25)=BIAS                                       00007700
ISN 0045          GWORKO(3,1)=FINALS                                      00007750
ISN 0046          GWORKO(3,2)=AALP                                        00007800
ISN 0047          GWORKO(3,10)=CONE                                       00007850
ISN 0048          GWORKO(3,12)=FINALS                                     00007900
ISN 0049          GWORKO(3,13)=BIAS                                       00007950
ISN 0050          GWORKO(3,22)=DIHED                                      00008000
ISN 0051          GWORKO(3,24)=FINALS                                     00008050
ISN 0052          GWORKO(3,25)=BIAS                                       00008100
ISN 0053          GWORKO(4,1)=ERROR                                       00008150
ISN 0054          GWORKO(4,2)=ACC                                         00008200
ISN 0055          GWORKO(4,10)=ANGLES                                     00008250
ISN 0056          GWORKO(4,12)=ERROR                                      00008300
ISN 0057          GWORKO(4,13)=ACC                                        00008350
ISN 0058          GWORKO(4,22)=ANGLES                                     00008400
ISN 0059          GWORKO(4,24)=ERROR                                      00008450
ISN 0060          GWORKO(4,25)=ACC                                        00008500
ISN 0061          GWORKO(5,1)=INITIL                                      00008550
ISN 0062          GWORKO(5,2)=DDLP                                        00008600
ISN 0063          GWORKO(5,12)=MEAN                                       00008650
ISN 0064          GWORKO(5,13)=RESD                                       00008700
ISN 0065          GWORKO(5,24)=MEAN                                       00008750
ISN 0066          GWORKO(5,25)=RESD                                       00008800
ISN 0067          GWORKO(6,1)=FINALS                                      00008850
ISN 0068          GWORKO(6,2)=DDLP                                        00008900
ISN 0069          GWORKO(6,12)=RMS                                        00008950
ISN 0070          GWORKO(6,13)=RESD                                       00009000
ISN 0071          GWORKO(6,24)=RMS                                        00009050
ISN 0072          GWORKO(6,25)=RESD                                       00009100
ISN 0073          GWORKO(7,1)=ERROR                                       00009150
ISN 0074          GWORKO(7,2)=ACC                                         00009200
ISN 0075      110 J=0                                                     00009250
ISN 0076          DO 120 I=1,4                                            00009300
ISN 0077          IF (I.GT.NCOF) GO TO 130                                00009350
ISN 0079          J=J+1                                                   00009400
ISN 0080          ATT(J)=AI(I)                                            00009450
ISN 0081          J=J+1                                                   00009500
ISN 0082          ATT(J)=ALP(I)                                           00009550
ISN 0083          J=J+1                                                   00009600
ISN 0084          ATT(J)=SQRT(COVAR(2*I-1,2*I-1))                         00009650
ISN 0085          J=J+1                                                   00009700
ISN 0086          ATT(J)=DI(I)                                            00009750
ISN 0087          J=J+1                                                   00009800
ISN 0088          ATT(J)=DEL(I)                                           00009850
ISN 0089          J=J+1                                                   00009900
ISN 0090          ATT(J)=SQRT(COVAR(2*I,2*I))                             00009950
ISN 0091      120 CONTINUE                                                00010000
ISN 0092      130 I=I*J                                                   00010050
ISN 0093          CALL INCORE (ATT,DUMMY,15,I,8,3)                        00010100
ISN 0094          DO 150 J=1,4                                            00010150
ISN 0095          DO 150 I=2,7                                            00010200
ISN 0096          IF (J.GT.NCOF) GO TO 140                                00010250
ISN 0098          GWORKO(I,J+3)=DUMMY(I-1+(J-1)*6)                        00010300
ISN 0099          GO TO 150                                               00010350
ISN 0100      140 GWORKO(I,J+3)=BLANK8                                    00010400
ISN 0101      150 CONTINUE                                                00010450
ISN 0102          GWORKO(2,8)=BLANK8                                      00010500
ISN 0103          GWORKO(3,8)=BLANK8                                      00010550
ISN 0104          GWORKO(4,8)=BLANK8                                      00010600
ISN 0105          GWORKO(5,8)=BLANK8                                      00010650
ISN 0106          GWORKO(6,8)=BLANK8                                      00010700
ISN 0107          GWORKO(7,8)=BLANK8                                      00010750
ISN 0108          J=0                                                     00010800
ISN 0109          IF (NTYPE1.LE.0) GO TO 170                              00010850
ISN 0111          DO 160 I=1,NTYPE1                                       00010900
ISN 0112          J=J+1                                                   00010950
ISN 0113          BIA(J)=0.D0                                             00011000
ISN 0114          IF (BIASI(I).LT.XBIAS) BIA(J)=BIASI(I)                  00011050
ISN 0116          J=J+1                                                   00011100
ISN 0117          BIA(J)=0.D0                                             00011150
ISN 0118          IF (BIASI(I).LT.XBIAS) BIA(J)=BIASI(I)                  00011200
ISN 0120          J=J+1                                                   00011250
ISN 0121          BIA(J)=0.D0                                             00011300
```

```
ISN 0122          IF (BIAS1(I).LT.XBIAS) BIA(J)=SQRT(COVAR(2*NCOF+I,2*NCOF+I))
ISN 0124          J=J+1
ISN 0125          BIA(J)=RHOST1(4,I)
ISN 0126          J=J+1
ISN 0127          BIA(J)=RHOST1(5,I)
ISN 0128      160 CONTINUE
ISN 0129          IF (NTYPE1.GE.6) GO TO 190
ISN 0131      170 NSBIAS=NTYPE1+1
ISN 0132          DO 180 IK=NSBIAS,5
ISN 0133          DO 180 IL=1,5
ISN 0134          J=J+1
ISN 0135          BIA(J)=0.
ISN 0136      180 CONTINUE
ISN 0137      190 CONTINUE
ISN 0138          I=25
ISN 0139          CALL INCORE (BIA,DUMMY,15,I,8,3)
ISN 0140          DO 200 J=1,5
ISN 0141          DO 200 I=2,6
ISN 0142          GWORKO(I,J+14)=DUMMY(I-1+(J-1)*5)
ISN 0143      200 CONTINUE
ISN 0144          J=0
ISN 0145          IF (NTYPE2.LE.0) GO TO 220
ISN 0147          DO 210 I=1,NTYPE2
ISN 0148          J=J+1
ISN 0149          BIA(J)=0.D0
ISN 0150          IF (BIAS2I(I).LT.XBIAS) BIA(J)=BIAS2I(I)
ISN 0152          J=J+1
ISN 0153          BIA(J)=0.D0
ISN 0154          IF (BIAS2(I).LT.XBIAS) BIA(J)=BIAS2(I)
ISN 0156          J=J+1
ISN 0157          BIA(J)=0.D0
ISN 0158          IF (BIAS2(I).LT.XBIAS) BIA(J)=SQRT(COVAR(2*NCOF+NTYPE1+I,2*NCOF+NT
                 1YPE1+I))
ISN 0160          J=J+1
ISN 0161          BIA(J)=RHOST2(4,I)
ISN 0162          J=J+1
ISN 0163          BIA(J)=RHOST2(5,I)
ISN 0164      210 CONTINUE
ISN 0165          IF (NTYPE2.GE.6) GO TO 240
ISN 0167      220 NSBIAS=NTYPE2+1
ISN 0168          DO 230 IK=NSBIAS,5
ISN 0169          DO 230 IL=1,5
ISN 0170          J=J+1
ISN 0171          BIA(J)=0.
ISN 0172      230 CONTINUE
ISN 0173      240 CONTINUE
ISN 0174          I=25
ISN 0175          CALL INCORE (BIA,DUMMY,15,I,8,3)
ISN 0176          DO 250 J=1,5
ISN 0177          DO 250 I=2,6
ISN 0178          GWORKO(I,J+26)=DUMMY(I-1+(J-1)*5)
ISN 0179      250 CONTINUE
ISN 0180          CALL PTSIZE (224,GWORKO)
ISN 0181          RETURN
ISN 0182          END
```

COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=60,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF

```
C
C**********************************************************************
C                                                                     *
C                                                                     *
C        SUBROUTINE GOCCON                                            *
C                                                                     *
C        CALLING SEQUENCE                                             *
C                                                                     *
C                 CALL GOCCON(IALL4,IALL5,IFRST1,IFRST2,NTYPE1,NTYPE2,*
C                             RHO1,RHO2,GWORK4,GWORK5,IALLO)          *
C                                                                     *
C                                                                     *
C        DESCRIPTION                                                  *
C                                                                     *
C                 GOCCON STORES THE COMPUTED RESIDUALS INTO WORK      *
C                 ARRAYS FOR PLOTTING AND CALLS THE MSAD RELATED      *
C                 TABLES TO DISPLAY THE PLOTS                         *
C                                                                     *
C        COMMON AREAS REFERENCED                                      *
C                                                                     *
C                 DCSOPT,GCN1                                         *
C                                                                     *
C        EXTERNAL REFERENCES                                          *
C                 CHECK,PTSIZE                                        *
C                                                                     *
C        STORAGE REQUIREMENTS                                         *
C                                                                     *
C                 1786 BYTES OF CORE STORAGE                          *
C                                                                     *
C        VARIABLES                                                    *
C                                                                     *
C        NAME     TYPE     I/O     DESCRIPTION                        *
C                                                                     *
C        IALL4    I*4      I       ALLOCATION SIZE OF GWORK4 ARRAY    *
C                                                                     *
C        IALL5    I*4      I       ALLOCATION SIZE OF GWORK5 ARRAY    *
C                                                                     *
C        IFRST1   I*4      I       POINTERS INDICATING STARTING       *
C                                  POSITIONS FOR EACH TYPE OF CLASS*
C                                  1 DATA IN THE RHO1 ARRAY           *
C                                                                     *
C        IFRST2   I*4      I       POINTERS INDICATING STARTING       *
C                                  POSITIONS FOR EACH TYPE OF CLASS*
C                                  2 DATA IN THE RHO2 ARRAY           *
C                                                                     *
C        NTYPE1   I*4      I       NUMBER OF OBSERVATIONS OF EACH     *
C                                  TYPE OF CLASS 1 DATA               *
C                                                                     *
C        NTYPE2   I*4      I       NUMBER OF OBSERVATIONS OF EACH     *
C                                  TYPE OF CLASS 2 DATA               *
C                                                                     *
C        RHO1     R*4      I       RESIDUALS FOR CLASS 1 DATA         *
C                                  DEFINED AS OBSERVED MINUS          *
C                                  CALCULATED                         *
C                                                                     *
C        RHO2     R*4      I       RESIDUALS FOR CLASS 2 DATA         *
C                                  DEFINED AS OBSERVED MINUS          *
C                                  CALCULATED                         *
C                                                                     *
C        GWORK4   R*4      O       WORK ARRAY FOR STORAGE OF OBSER-*
C                                  VATION NUMBERS FOR EACH CLASS      *
C                                  AND TYPE OF DATA                   *
C                                                                     *
C        GWORK5   R*4      O       WORK ARRAY FOR STORAGE OF RESID-*
C                                  UALS FOR EACH CLASS AND TYPE OF *
C                                  DATA                               *
C                                                                     *
C        IALLO    I*4      I       ALLOCATION SIZE OF GWORKO          *
C                                  (MUST BE 224 OF O)                 *
C                                                                     *
C        COMMON AREA VARIABLES USED IN ROUTINE                        *
C                                                                     *
C        NAME     TYPE     ORIGIN  DESCRIPTION                        *
C                                                                     *
C        OPTION   I*4      DCSOPT  FLAG ARRAY FOR PLOTTING OPTIONS *
C                                     =0, DO NOT PLOT                 *
C                                     =1, PLOT                        *
```

```
C
C        FINISH     I*4        DCSOPT     FLAG FOR TERMINATING PLOT
C                                         OPTION TABLE
C                                           =0, DO NOT TERMINATE
C                                           =1, TERMINATE
C
C        FINALD     I*4        DCSOPT     FLAG FOR DISPLAYING SUMMARY
C                                         DISPLAY
C                                           =0, DO NOT DISPLAY
C                                           =1, DISPLAY
C
C        NCLAS1     I*4        GCN1       NUMBER OF CLASS 1 DATA TYPES
C
C        NCLAS2     I*4        GCN1       NUMBER OF CLASS 2 DATA TYPES
C
C        ICC        I*4        GCN1       RESIDUAL STORAGE INDICATOR
C                                           =0, DO NOT STORE RESIDUALS
C                                           =1, STORE RESIDUALS FOR
C                                                PLOTTING
C
C        DATA TRANSMISSION
C
C        NAME       READ/WRITE/CPOINT     DESCRIPTION
C
C        DRES11     CPOINT                RESIDUAL PLOT FOR CLASS 1 TYPE
C                                         1 DATA
C
C        DRES12     CPOINT                RESIDUAL PLOT FOR CLASS 1 TYPE
C                                         2 DATA
C
C        DRES13     CPOINT                RESIDUAL PLOT FOR CLASS 1 TYPE
C                                         3 DATA
C
C        DRES14     CPOINT                RESIDUAL PLOT FOR CLASS 1 TYPE
C                                         4 DATA
C
C        DRES15     CPOINT                RESIDUAL PLOT FOR CLASS 1 TYPE
C                                         5 DATA
C
C        DRES21     CPOINT                RESIDUAL PLOT FOR CLASS 2 TYPE
C                                         1 DATA
C
C        DRES22     CPOINT                RESIDUAL PLOT FOR CLASS 2 TYPE
C                                         2 DATA
C
C        DRES23     CPOINT                RESIDUAL PLOT FOR CLASS 2 TYPE
C                                         3 DATA
C
C        DRES24     CPOINT                RESIDUAL PLOT FOR CLASS 2 TYPE
C                                         4 DATA
C
C        DRES23     CPOINT                RESIDUAL PLOT FOR CLASS 2 TYPE
C                                         5 DATA
C
C        DFINDR     CPOINT                SUMMARY DISPLAY
C
C        DBTAB1     CPOINT                PLOT OPTION TABLE DISPLAY
C
C        REVISIONS
C
C                   1.  L. FEAKES (13 JULY 1973) - ORIGINAL CODING AND
C                           TESTING
C
C
C**************************************************************************
ISN 0002        SUBROUTINE GOCCON (IALL4,IALL5,IFRST1,IFRST2,NTYPE1,NTYPE2,RHO1,RHO
               1O2,GWORK4,GWORK5,IALLO)
ISN 0003        DIMENSION GWORK4(1),GWORK5(1),RHO1(1),RHO2(1),IFRST1(1),IFRST2(1)
ISN 0004        DIMENSION NTYPE1(1),NTYPE2(1)
ISN 0005        COMMON/GCN1/ ICUT,NCLAS1,NCLAS2,NCOF,MAXIT,IRWT,TZERO,ICC,ICALC,
              1  IDER,
              2  SMULT,NP,IWHERE,ISTEP,ISTOP,IRET,ISTAT,CORMIN,CORMAX
ISN 0006        COMMON/DCSOPT/ OPTION(10),FINISH,FINALD,IMESG(8)
ISN 0007        INTEGER*4 OPTION,FINISH,FINALD,CORMIN,CORMAX
ISN 0008        IFINSH=0
ISN 0009    100 IF (IFINSH.NE.0.AND.FINISH.EQ.1) GO TO 320
ISN 0011        IFINSH=1
```

```
ISN 0012          IF (IOC.EQ.0.OR.IALL4.EQ.0.OR.IALL5.EQ.0) GO TO 300
ISN 0014          IF (NCLAS1.LE.0) GO TO 200
ISN 0016          DO 190 I=1,NCLAS1
ISN 0017          IF (OPTION(I).NE.1) GO TO 190
ISN 0019          ICOUNT=0
ISN 0020          K=0
ISN 0021          IFRES=0
ISN 0022          JJ1=IFRST1(I)-1
ISN 0023          NN=NTYPE1(I)
ISN 0024          IF (NN.LE.0) GO TO 190
ISN 0026          NN1=1
ISN 0027      110 DO 120 J=NN1,NN
ISN 0028          ICOUNT=ICOUNT+1
ISN 0029          K=K+1
ISN 0030          GWORK5(K)=RHC1(JJ1+J)
ISN 0031      120 GWORK4(K)=ICOUNT
ISN 0032          IF (K.EQ.IALL5) IFRES=1
ISN 0034          CALL PTSIZE (K,GWORK4,GWORK5)
ISN 0035          GO TO (130,140,150,160,170), I
ISN 0036      130 CALL CHECK ('DRES11')
ISN 0037          GO TO 180
ISN 0038      140 CALL CHECK ('DRES12')
ISN 0039          GO TO 180
ISN 0040      150 CALL CHECK ('DRES13')
ISN 0041          GO TO 180
ISN 0042      160 CALL CHECK ('DRES14')
ISN 0043          GO TO 180
ISN 0044      170 CALL CHECK ('DRES15')
ISN 0045      180 IF (IFRES.NE.1.OR.J.EQ.NN) GO TO 190
ISN 0047          IFRES=0
ISN 0048          NN1=K+1
ISN 0049          K=0
ISN 0050          GO TO 110
ISN 0051      190 CONTINUE
ISN 0052      200 IF (NCLAS2.LE.0) GO TO 300
ISN 0054          DO 290 I=1,NCLAS2
ISN 0055          IF (OPTION(5+I).NE.1) GO TO 290
ISN 0057          JJ1=IFRST2(I)-1
ISN 0058          K=0
ISN 0059          ICOUNT=0
ISN 0060          NN=NTYPE2(I)
ISN 0061          NN1=1
ISN 0062          IF (NN.LE.0) GO TO 290
ISN 0064          IFRES=0
ISN 0065      210 DO 220 J=NN1,NN
ISN 0066          K=K+1
ISN 0067          ICOUNT=ICOUNT+1
ISN 0068          GWORK5(K)=RHC2(JJ1+J)
ISN 0069      220 GWORK4(K)=ICOUNT
ISN 0070          IF (K.EQ.IALL5) IFRES=1
ISN 0072          CALL PTSIZE (K,GWORK4,GWORK5)
ISN 0073          GO TO (230,240,250,260,270), I
ISN 0074      230 CALL CHECK ('DRES21')
ISN 0075          GO TO 280
ISN 0076      240 CALL CHECK ('DRES22')
ISN 0077          GO TO 280
ISN 0078      250 CALL CHECK ('DRES23')
ISN 0079          GO TO 280
ISN 0080      260 CALL CHECK ('DRES24')
ISN 0081          GO TO 280
ISN 0082      270 CALL CHECK ('DRES25')
ISN 0083      280 IF (IFRES.NE.1.OR.J.EQ.NN) GO TO 290
ISN 0085          IFRES=0
ISN 0086          NN1=K+1
ISN 0087          K=0
ISN 0088          GO TO 210
ISN 0089      290 CONTINUE
ISN 0090      300 IF (IALL0.EQ.224.AND.FINALD.EQ.1) CALL CHECK ('DFINDS')
ISN 0092          DO 310 IOPT=1,10
ISN 0093      310 OPTION(IOPT)=0
ISN 0094          FINALD=0
ISN 0095          CALL CHECK ('CPTAB1')
ISN 0096          GO TO 100
ISN 0097      320 RETURN
ISN 0098          END
```