COMPUTER PROGRAM LIBRARY

USER'S GUIDE

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PREFACE

COMPUTER PROGRAM LIBRARY USER'S GUIDE

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PREFACE

This manual provides instruction in the use of the department's computer program library as well a descriptive directory of the programs in the library.

If you have any questions, consult the department's Programmer/ Analyst in E-19.

USING THE LIBRARY

The computer program library is a set of algorithms that perform functions frequently required by surveying engineers. It is highly recommended that the user read each routine's function in the following directory so that, in future work, he/she might recall a routine to perform a desired task, thus avoiding having to "re-invent the wheel".

Additions to the library are always welcome.

The first example below shows how to produce a program listing: following the "//SYSIN..." line, the user enters the name of the program to be listed - in the example given, we want a listing of the ALERT program. The most common instance when one might want to generate a program listing is in the case of a program where the instructions on how to use it consist of comments embedded in the code.

Example 2 shows how to use library subprograms in your program; the "//LKED.USERLIB" line following your program informs the computer to go looking into the program library to resolve references to subprograms not included in your program.

In example 3, the user is running one of the library's main programs: the desired program is specified in the "GOPGM=" parameter (ALERT in this case). In the following directory, the "How to Use" section for main programs will always refer you to a user's manual or a listing of the program.

Finally, example 4 shows how to access the library from a WATFIV job. WATFIV programmers, however, should familiarize themselves with the differences between WATFIV and FORTRAN, and start programming in FORTRAN (see the Computing Center's User's Guide Volume 3, FORTRAN compilers).

WATFIV was designed primarily as a pedagogical tool, while FORTRAN is used to solve problems in the 'real world'. Moreover, the library programs are written in FORTRAN and a given routine may or may not run under WATFIV.

If your JCL (the lines in the examples that start with '/') is a bit shaky, the Computing Center's User's Guide Volume 2, JCL concepts, is highly recommended reading.

```
//                       JOB ,SE1234
/*JOBPARM                S=5,L=99,R=512
//*
//                       EXEC PGM=PDSLISTR
//SYSPRINT               DD   SYSOUT=*
//SYSUT1                 DD   DSN=A.M12129.SELIBSRC,DISP=OLD
//SYSIN                  DD   *
ALERT
//
```

Example 1. Producing a program listing.

```
//                    JOB ,SE1234
/*JOBPARM             S=5,L=99,R=1024
/*SERVICE             -4
//*
//                    EXEC FORTVCLG
//FORT.SYSIN          DD   *
```

User written main program

```
//LKED.USERLIB        DD   DSN=A.M12129.SELIBOBJ,DISP=OLD
//GO.SYSIN            DD   *
```

Data for the program

```
//
```

Example 2. Accessing library subprograms.

```
//              JOB ,SE1234
/*JOBPARM       S=5,L=99,R=512
/*SERVICE       -4
//*
//              EXEC FORTVG,RG=512K,GOPGM=ALERT
//STEPLIB       DD   DSN=A.M12129.SELIBOBJ,DISP=SHR
//SYSIN         DD   *

Data for the program

//
```

Example 3. Using a main program from the library.

```
//                    JOB ,SE1234
/*JOBPARM             S=5,L=99,R=512
/*SERVICE             -4
//*
//                    EXEC WATFIV
//USERLIB             DD   DSN=A.M12129.SELIBSRC,DISP=SHR
//SYSIN               DD   DATA

Your WATFIV Program

/*
//
```

Example 4. Using the library in a WATFIV job.

ALERT

PURPOSE: Computes transit satellite alerts for up to 10 satellites.

HOW TO USE: Produce a listing of the program and read the instructional comments.

APPROX

PURPOSE: Perform a least-squares approximation.

HOW TO USE: Produce a listing of the program and read the instructional comments.

CHISQ

PURPOSE: Computes the percentiles of the chi-square distribution X(N)

HOW TO USE: varname = CHISQ (A,N)

ARGUMENTS: A = probability integral from zero to CHISQ

N = number of degrees of freedom

CHISQ = computed abscissa value of X(N) corresponding to probability A. Accuracy better than 0.04 for N>1.

DEPS

PURPOSE:	Set functional value DEPS and argument DARG both equal to the smallest double precision number so that 1.+DEPS.GT.1.
HOW TO USE:	X = DEPS (DARG)
INPUT ARGUMENTS:	none
OUTPUT ARGUMENTS:	DARG = the smallest double precision number such that 1.+DEPS.Gt.L. (REAL*8)

DINVINC

PURPOSE: Computes the direct and inverse problems of geodesy using Vincenty's formulas from Survey Review, April 1975.

HOW TO USE: Produce a listing of the program and read the instructional comments.

DMSRAD

PURPOSE: Converts an angle from degrees, minutes, and seconds to radians.

HOW TO USE: CALL DMSRAD (IDEG, IMIN, SEC, RAD)

INPUT ARGUMENTS: IDEG = degrees (INTEGER *4)

IMIN = minutes (INTEGER *4)

SEC = seconds (REAL *8)

OUTPUT ARGUMENTS: RAD = the angle in radians (REAL *8)

EIGEN

PURPOSE: Computes the eigen values and eigen vectors for a 3-D case. Calls 'EIGENZ' which computes the eigen values and vectors and then prints the final result.

HOW TO USE: CALL EIGEN (A,S)

INPUT ARGUMENTS: A = The variance-covariance matrix (REAL *8)

OUTPUT ARGUMENTS: A = An array containing the eigen vectors (REAL *8)

S = the semi-major axis (REAL *8)

NOTE: The variance-covariance matrix is destroyed. A is a 3x3 array, S is a vector of length 3.

EIGEN3

PURPOSE: Computes the eigen values and eigen vectors for a 3-D case.

HOW TO USE: CALL EIGEN3(A, PROB, U, DF, S)

INPUT ARGUMENTS:

A = the variance-covariance matrix (REAL*8)

PROB = the probability requested in the exclusive range (0,1)

U, DF = first and second degrees of freedom, respectively (REAL*8)

OUTPUT ARGUMENTS:

A = an array containing the eigen vectors

NOTE: The variance-covariance matrix is destroyed.

S = the semi-major axes

IFLAG = Though not an input/output parameter of EIGEN3 it is used as an input/output error parameter in MDFI (called by EIGEN3) terminal error = 128 + N; warning error = 32 - N

N = 1 means an error occured in MDBETI

N = 2 means PROB was not in range (0,1)

N = 3 means computed value of TVAL would produce an overflow. TVAL is set to machine infinity.

ELLDIR

PURPOSE: Solves the direct problem on the ellipsoid using Puissant's formulas.

HOW TO USE: CALL ELLDIR(PHI,AMB,ALP,DIS,ALP2,PHI2,AMB2,A,B)

ARGUMENTS: (all REAL*8)

INPUT:

PHI: Geodetic latitude of point 1 (radians).

AMB: Geodetic longitude of point 1 (radians).

ALP: Given geodetic azimuth from point 1 to point 2 (radians).

DIS: Given ellipsoid distance (metres).

A: Semi-major axis of reference ellipsoid (metres).

B: Semi-minor axis of reference ellipsoid (metres).

OUTPUT:

ALP2: Computed geodetic azimuth from point 2 to point 1 (radians)

PHI2: Geodetic latitude of point 2 (radians)

AMB2: Geodetic longitude of point 2 (radians).

ELLINV

PURPOSE: Solves the inverse problem on the ellipsoid using Puissant's formulas.

HOW TO USE: CALL ELLINV(PHI1,AMB1,PHI2,AMB2,ALP,DIS,ALP2,A,B)

ARGUMENTS: (all REAL*8)

INPUT:

PHI1: Geodetic latitude of point 1 (radians)

AMB1: Geodetic longitude of point 1 (radians)

PHI2: Geodetic latitude of point 2 (radians)

AMB2: Geodetic longitude of point 2 (radians)

A: Semi-major axis of reference ellipsoid (metres)

B: Semi-minor axis of reference ellipsoid (metres)

OUTPUT:

ALP: Geodetic azimuth from point 1 to point 2 (radians)

DIS: Ellipsoid distance (metres)

ALP2: Computed geodetic azimuth from point 2 to point 1 (radians)

ELTSP

PURPOSE: Transforms ellipsoidal coordinates PHI, ELAM to spherical (conformal sphere) coordinates CHI, SLAM and computes the corresponding point scale factor ESK (ellipsoid to sphere). The point scale factor at the origin of this conformal projection is unity.

HOW TO USE: CALL ELTSP (PHI, ELAM, E, A, C1, C2, R, CHI, SLAM)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

PHI = Ellipsoidal latitude of the point, in radians

ELAM = Ellipsoidal longitude of the point, in radians (positive east of Greenwich)

E = First eccentricity of the ellipsoid (computed in STGINL)

A = Semi-major axes of the ellipsoid

C1 = Constant computed in SIGINL

C2 = Constant computed in SIGINL

R = Radius of the conformal sphere (computed in SIGINL)

OUTPUT ARGUMENTS: CHI = Spherical latitude of the point, in radians

SLAM = Spherical longitude of the point, in radians.

ERRTM

PURPOSE: Computes the covariance matrix CM of the transverse mercator coordinates x,y given the covariance matrix DM of the ellipsoidal coords PHI, LAMDA (ICODE=1). If ICODE=-1, compute DM from CM.

HOW TO USE: CALL ERRTM (A,B,PHI,DLAM,KNOT,ICODE,CM,DM)

INPUT ARGUMENTS:

PHI = Ellipsoidal latitude in radians.

DLAM = Longitude of the point minus the longitude of the central meridian (radians) (Longitude positive east)

KNOT = Scale factor at the central meridian

ICODE = 1 PHI, LAMDA to x, y
-1 x, y to PHI, LAMDA

CM = covariance matrix of the transverse mercator coordinates (in metres^2), or

DM = covariance matrix of the ellipsoidal coordinates (in radians^2)

OUTPUT ARGUMENTS: CM or DM

ERR3D

PURPOSE: Computes the covariance matrix CM (3x3) of the cartesian coordinates X, Y, Z given the covariance matrix DM of the ellipsoidal coordinates PHI, RLAM, H (of the same point) when ICODE is 1. If ICODE is -1 the subroutine computes DM from the given CM.

HOW TO USE: CALL ERR3D (PHI, RLAM, H, A, B, ICODE, CM, DM)

INPUT ARGUMENTS: (All arguments except ICODE are REAL*8 values. ICODE is an INTEGER*4 value)

PHI = Ellipsoidal latitude of the point (in radians)

RLAM = Ellipsoidal longitude of the point in radians (positive east of Greenwich)

H = Ellipsoidal height of the point in metres

A,B = Semi-major and semi-minor axes of the reference ellipsoid in metres

ICODE= 1 if CM is desired from the given DM

-1 if DM is desired from the given CM

OUTPUT PARAMETERS: CM - 3X3 covariance matrix of the cartesian coordinates in metres squared.

DM - 3x3 covariance matrix of the ellipsoidal coordinates in radians squared for PHI, RLAM and metres squared for H.

In radian metres for the covariances between PHI, RLAM and H.

NOTE: Space must be provided in the calling routine for CM and DM.

EVALUE

PURPOSE: Computes eigenvalues and eigenvectors from the symmetric strain tensor.

HOW TO USE: See "Strain as a Diagnostic Tool to Identify Inconsistant Observations and Constraints in Horizontal Geodetic Networks" by K. Thapa (M.Sc.E. thesis, 1980).

FPLAT

PURPOSE: Computes the foot-point latitude required in transforming transverse mercator plane coordinates X,Y to ellipsoidal coordinates.

HOW TO USE: CALL FPLAT (A, B, Y, PHI1)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

A = Semi-major axes of the reference ellipsoid.

B = Semi-minor axes of the reference ellipsoid.

Y = Northing of the point for which the foot-point latitude is to be computed.

OUTPUT PARAMETERS: PHI1 = Foot-point latitude in radians.

GEODOP

PURPOSE:	Given satellite receiver data in the form of Doppler counts and associated satellite positions, compute geocentric observing station positions.
HOW TO USE:	See "Program GEODOP" by J. Kouba and T.D. Boal.

GEOID

PURPOSE: Generates a geoid for a small area on the surface of the earth.

HOW TO USE: Produce a listing of the program and read the instructional comments.

GEOID2

PURPOSE: Computes geoidal heights, meridian and prime vertical components and free-air anomalies from spherical harmonic coefficients.

HOW TO USE: Produce a listing of the program and read the instructional comments.

GEOPAN

PURPOSE: Perform least-squares adjustment and analysis of small plane horizontal geodetic networks.

HOW TO USE: See T.R. 54.

N.B.: GEOPAN can handle up to 60 stations; to handle up to 200, specify GEOPAN2 instead of GEOPAN as the GOPGM.

GEOPOC

PURPOSE: Computes geoid from potential coefficients.

HOW TO USE: Produce a listing of the program and read the instructional comments.

LEGDRE

PURPOSE: Computes the associated Legendre functions up to and including degree and order N. The dimension of PN is (N+1, N+1). The associated Legendre polynomial of degree A and order B is stored in PN (A+1, B+1) if A ≠ B (zonal and tesseral) and in PN (A+1, A+1) if A = B (sectorial).

HOW TO USE: CALL LEGDRE (INORM,PHI,PN,NROW,NP1)

INPUT ARGUMENTS:

INORM = Flag normalization: 1 = YES; 0 = NO

PHI = Latitude in degrees

NROW = Low dimension of PN in the calling program

NP1 = N+1 = The dimension of PN in the subroutine. See N below.

N = Degree of Legendre polynomial.

OUTPUT ARGUMENTS: PN = Matrix of associated Legendre polynomials.

LSA

PURPOSE: Solves $X = (P_X + A^T P_F A)^{-1} A^T P_F F$ via least-squares approximation.

HOW TO USE: CALL LSA (LU,F,PF,A,PX,NF,IRPF,ICPF,NX,IRPX,ICPX,IRA, IRAPA,X,APA,R,RNORN,APB,DET,IERR)

INPUT ARGUMENTS:

LU	= Listing LU
F(NF)	= Function to be approximated (observations)
PF(NF,NF)	= Weight matrix of F
A(NF,NX)	= Design matrix
PX(NX,NX)	= Apriori weight matrix of X
NF	= Number of observations
IRPF	= P_F row dimension in calling program
ICPF	= P_F row dimension in calling program
NX	= Number of unknowns
IRPX	= P_X row dimension in calling programs
ICPX	= P_X row dimension in calling programs
IRA	= A row dimension in calling routine
IRAPA	= AP_A row dimension in calling routine.

OUTPUT:

X(NX)	= Approximating coefficients (unknowns)
APA(NX,NX)	= $(P_X + A^T P_F A^T)^{-1}$ = Relative covariance of X
R(NF)	= P(NF) - F(NF) = Residuals
RNORN	= Quadratic norm of R
APB(NX)	= $A^T P_F F$ = Normal equation vector

DET = Determinant of AP_A^{-1}

IERR = 0 Successful return

1 $(P_X + A^T P_F A)$ is singular

2 NX is zero

3 NF < NX and P_X is null

4 IRPF must be 1 or $\geq$ NF

5 ICPF must be 1 or NF

6 IRPX must be 1 or $\geq$ NX

7 ICPX must be 1 or NX

8 IRA must be $\geq$ NF

9 IRAPA must be $\geq$ NX

LSSA

PURPOSE: Performs a least-squares spectral analysis for a given time series.

HOW TO USE: Produce a listing of the program and read the instructional comments.

MATMPY

PURPOSE: To compute the product of two matrices in any allowable transpose combination as follows:

OPTION ICODE	PRODUCT M3
1	M1*M2
2	(M1)T*M2
3	M1*(M2)T
4	(M1)T*(M2)T

HOW TO USE: CALL MATMPY (M1,M2,M3,L,M,N,JL,JM,JN,ICODE)

INPUT ARGUMENTS:

M1,M2 - Input matrices (REAL*8)

(L,M),(M,N),(L,N) - Dimensions of the pre-, post-, and product matrices respectively.

JL - Declared row dimension in calling routine of the pre-matrix M1.

JM - Declared row dimension in calling routine of the post-matrix M2.

ICODE - as described above.

OUTPUT ARGUMENTS:

M3 - The specified product of the input matrices M1 and M2 (REAL*8)

MERARC

PURPOSE: Computes the meridian arc length from the equator to latitude PHI on an ellipsoid of revolution defined by its semi-major axis A and its semi-minor axis B. The computed arc length is accurate to approximately 10 micrometres over the entire range (equator to pole).

HOW TO USE: CALL MERARC (PHI, A, B, S)

INPUT ARGUMENTS: (all arguments are REAL*8)

PHI = Ellipsoidal latitude in radians (may be positive (north) or negative (south) of equator).

A,B = Semi-major and semi-minor axes of the ellipsoid (the computed arc length will be in the same units as A and B).

OUTPUT ARGUMENTS: S = meridian arc length.

MERGE

PURPOSE: Merge GEODOP input files into a multistation file, or with Naval Weapons Laboratory (fitted) Precise Ephemeris files.

HOW TO USE: See "GEODOP Utilities Programs" by P.G. Lawnikanis.

MPDIR

PURPOSE: Solves the direct problem of geodetic positioning on the mapping plane.

HOW TO USE: CALL MPDIR (X1, Y1, GDIST, GAZ, MC, LSK, TT, MPDIST, MPAZ, X2, Y2)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

X1,Y1 = X,Y coordinates of the initial point

GDIST = Geodetic distance

GAZ = Geodetic azimuth (in radians)

MC = Meridian convergence (in radians)

LSK = Line scale factor

TT = T - T correction (in radians)

OUTPUT ARGUMENTS: MPDIST = Distance from point 1 to point 2 on the mapping plane.

MPAZ = Azimuth on the mapping plane (in radians)

X2,Y2 = X,Y coordinates of the observed point

NALERT

PURPOSE: Computes transit satellite alerts for up to 10 satellites.

HOW TO USE: Produce a listing of the program and read the instructional comments.

NETPLOT

PURPOSE: Plots the strait ellipses as well as the values of average differential rotation.

HOW TO USE: See "Strain as a Diagnostic Tool to Identify Inconsistent Observations and Constraints in Horizontal Geodetic Network" by K. Thapa (M.Sc.E. thesis, 1980).

NWLFIT

PURPOSE: Given Naval Weapons Laboratory precise satellite XY2 orbit coordinates, curve fit them to a Chebyshev time polynomial by least squares.

HOW TO USE: See "GEODOP Utilities Programs" by P.G. Lawnikanis.

ORTHO

PURPOSE: To orthogonalize a matrix PHI using the Gram-Schmidt Orthogonalization procedure.

HOW TO USE: CALL ORTHO (N,M,SIGMA,PHI,IRMAX,SIGMAF,VFC,NPC,INDEX,V, SUMD,ICMAX,F,W,D,ALPHA,C,SUMC,SC2,STDP)

INPUT ARGUMENTS: (Arguments beginning with letters I-N are INTEGER*4, all others are REAL*8)

PHI - an N by M matrix containing the base functions evaluated at each observation point (optional - can be a function subprogram instead)

N - number ob observation points

M - number of base functions

IRMAX - declared row dimension of PHI at calling program

F - vector of functional values

W - vector of weights

INDEX - test option for statistically significant fourier coefficients

0 - no test performed

1 - coef. tested against its standard deviation

2 - coef. tested against two times its std. dev.

3 - coef. tested against three times its std. dev.

SIGMA - a priori variance factor

OUTPUT ARGUMENTS: C - Fourier coefficients of the orthogonalized matrix

D - original coefficients of phi

SUMC - associated covariance matrix of C

SUMD - associated covariance matrix of D

V - vector of residuals

NPC - number of coefficients of the original polynomial recovered from the statistically tested fourier coefficients

VFC - a posteriori variance factor of the original polynomial

SIGMAF - variance factor for the fourier coefficients

PLHXYZ

PURPOSE: Computes the cartesian coordinates X, Y, Z given the ellipsoidal coordinates PHI, RLAM, H.

HOW TO USE: CALL PLHXYZ (PHI,RLAM,H,XO,YO,ZO,A,B,X,Y,Z)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

PHI - Ellipsoidal latitude in radians

RLAM - Ellipsoidal longitude in radians (positive east of Greenwich)

H - Ellipsoidal height in metres

XO,YO,ZO - Translation components from the origin of the cartesian coordinate system (X,Y,Z) to the center of the reference ellipsoid (metres)

A,B - Semi-major and semi-minor axes of the reference ellipsoid in metres.

OUTPUT ARGUMENTS: X,Y,Z - Cartesian coordinates of the point in metres

PLTSP

PURPOSE: Transforms stereographic grid coordinates X, Y to spherical coordinates CHI, SLAM.

HOW TO USE: CALL PLTSP (X,Y,XO,YO,KO,R,CHIO,SLAMO,CHI,SLAM)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

X = Stereographic grid easting

Y = Stereographic grid northing

XO = False easting

YO = False northing

KO = Point scale factor at the origin (from sphere to plane)

R = Radium of the sphere

CHIO = Spherical latitude of the origin (in radians)

SLAMO = Spherical longitude of the origin (in radians) (positive east of Greenwich)

OUTPUT ARGUMENTS: CHI = Spherical latitude of the point (in radians)

SLAM = Spherical longitude of the point (in radians)

POT1

PURPOSE: Computes geoid undulations, deflections of the vertical, and gravity disturbances from potential coefficients using Tscherning's harmonic model.

HOW TO USE: CALL POT1 (PHI,DLON,HT,UN,XI,ETA,DIST)

INPUT ARGUMENTS: (all are REAL*8)

PHI - latitude (geodetic) in degrees

DLON - longitide (positive east) in degrees

HT - height in metres

OUTPUT ARGUMENTS: (all are REAL*8)

UN - height anomaly in metres

XI - N-S deflection in seconds of arc

ETA - E-W deflection in seconds of arc (west positive)

DIST - gravity disturbance in mgals

Your main program must include the following code:

```
      LOGICAL   FIRST
      REAL*4    C,CO
      REAL*8    G1,G,CM3,CM2,CM1
      DIMENSION G1(3),G(3,3),C(32760)
      COMMON    /CM/ G1,G,CM3,CM2,CM1,CO,C
      COMMON    /ENTRY/ FIRST,NMAX
C
      FIRST = .FALSE.
      NMAX   = Maximum degree of expansion in the potential
       coefficient field
```

In addition, you must specify the file containing the potential coefficients, this requires you to supply the following card (immediately following the JOB card is a good place to put it):

```
/*SETUP       SLOT=5172       VOLUME=SE001
```

as well as one of the following, depending on the set of coefficients you wish to use:

```
//GO.FT12F001 DD DSN=RAPP180.UNFMD,UNIT=3480,VOL=SER=SE0001,
//    LABEL=166,DISP=(OLD,DELETE)
```

or

```
//GO.FT12F001 DD DSN=GEM10C.UNFMD,UNIT=3480,VOL=SER=SE0001,
//    LABEL=69,DISP=(OLD,DELETE)
```

PREDOP

PURPOSE: Reads and decodes formatted majority-voted (MJV) input data which is a series of satellite passes. The orbit for each pass is computed and the receiver Doppler counts are checked before writing the data out unformatted for subsequent processing by GEODOP.

HOW TO USE: See "Program PREDOP" by P. Lawnikanis.

RADMS

PURPOSE: Converts an angle from radians to degrees, minutes and seconds.

HOW TO USE: CALL RADMS (RAD,IDEG,IMIN,SEC)

INPUT ARGUMENTS: RAD - The angle in radians (REAL*8)

OUTPUT ARGUMENTS: IDEG - Degrees (INTEGER*4)

IMIN - Minutes (INTEGER*4)

SEC - Seconds (REAL*8)

ROTREF

PURPOSE: To compute the product matrix resulting from a sequence of rotations and reflections

HOW TO USE: CALL ROTREF (NUM,NAXIS, ANGLE,ROT)

INPUT ARGUMENTS:

NUM - Number of rotations and reflections in sequence (no limit)(INTEGER*4)

NAXIS - Vector of rotation and reflection axes (for rotations use 1,2 or 3) (for reflections use -1,-2, or -3) (INTEGER *4)

ANGLE - Vector of rotation angles in radians (for reflections this angle is ignored, i.e., assumed zero) (REAL*8)

OUTPUT ARGUMENTS:

ROT - 3 x 3 product matrix (REAL*8) (initially ROT is the identity matrix)

SPIN

PURPOSE: Inverts a symmetric positive definite matrix. The matrix inverted is the upper left N x N portion of the input matrix Q which is dimensioned MM x MM in the calling routine.

HOW TO USE: CALL SPIN (Q,N,MN,DET,IDEXP)

INPUT ARGUMENTS:

Q - the matrix dimensioned MM x MM which contains the matrix to be inverted (REAL*8)

N - the dimension of the actual part (upper left) of Q which is to inverted $N \leq MM$ (INTEGER*4)

MM - the dimensioned size of Q in the calling routine (INTEGER*4)

OUTPUT ARGUMENTS:

Q - the upper left N x N portion contains the inverse of the input N x N portion (REAL*8)

DET - the non-exponent portion of the determinant of the input N x N upper left portion of Q (REAL*8)

IDEXP - the exponent (of 10) part of the determinant described above

Thus the determinant is returned in two parts corresponding to

Determinant = DET*10**IDEXP

This is done to avoid under or overflow in the computation of the determinant. The user should print both numbers as follows (for example)

```
PRINT 10, DET, IDEXP
10 FORMAT (',','DETERMINANT = ',F17.4,'D', I4)
```

SPTEL

PURPOSE: Transforms spherical (conformal sphere) coordinates CHI, SLAM to ellipsoidal coordinates PHI, ELAM using a Newton-Raphson iteration

HOW TO USE: CALL SPTEL (CHI,SLAM,C1,C2,E,PHI,ELAM)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

CHI - spherical latitude of the point, in radians

SLAM - spherical longitude of the point, in radians

E - first eccentricity of the ellipsoid (computed in subroutine STGINL)

C1 - constant computed in STGINL

C2 - constant computed in STGINL

OUTPUT ARGUMENTS: PHI - ellipsoidal latitude of the point, in radians

ELAM - ellipsoidal longitude of the point, in radians

SPTPL

PURPOSE: Transforms spherical coordinates CHI,SLAM to stereographic grid coordinates X,Y

HOW TO USE: CALL SPTPL (CHI,SLAM,XO,YO,KO,CHIO,SLAMO,R,X,Y,K,C)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

CHI - spherical latitude of the point, in radians

SLAM - spherical longitude of the point, in radians (positive east of Greenwich)

XO - false easting of the origin of the projection

YO - false northing of the origin of the projection

KO - point scale factor at the origin of the projection (from sphere to plane)

CHIO - spherical longitude of the origin, in radians

SLAMO- spherical longitude of the origin, in radians

R - Radius of the sphere

OUTPUT ARGUMENTS: X - stereographic grid easting

Y - stereographic grid northing

K - point scale factor at the point, going from the sphere to the plane

C - meridian convergence at the point, in radians

STGINL

PURPOSE: Computes the initial values to be used in the stereographic double projection subroutines

HOW TO USE: CALL STGINL (PHIO,ELAMO,A,B,R,C1,C2,E,CHIO,SLAMO)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

PHIO - ellipsoidal latitude of the origin of the projection, in radians

ELAMO - ellipsoidal longitude of the origin of the projection in radians (positive east of Greenwich)

A,B - semi-major and semi-minor axes of the reference ellipsoid, in metres.

OUTPUT ARGUMENTS: R - radius of the conformal sphere, in metres

C1 - constant used in transformations between the ellipsoid and the conformal sphee

C2 - constant for the same use as C1

E - first eccentricity of the ellipsoid

CHIO - spherical latitude of the origin of the projection, in metres

SLAMO - spherical longitude of the origin of the projection, in metres

STRAIN

PURPOSE: Computes displacement gradients and various other components of strain.

HOW TO USE: See "Strain as a Diagnostic Tool to Identify Inconsistent Observations and Constraints in Horizontal Geodetic Networks" by K. Thapa (M.Sc.E. thesis, 1980)

SVY078

PURPOSE: Calculates azimuth and distance for long lines by Robbins' formulae between up to 10 stations

HOW TO USE: See "Azimuth and Distance on the Spheroid Using Robbins' Formulae" by M.M. Nassar

TAURE

PURPOSE: Computes the rejection level for normalized residuals for a given number of observations, degrees of freedom and desired level of type I error parameters

HOW TO USE: CALL TAURE (NT,NU,ALPH,CRTAU)

INPUT ARGUMENTS:
NT - number of observations (INTEGER#4)
NU - degrees of freedom (INTEGER*4)
ALPH- desired probability of type I error (REAL*8)

OUTPUT ARGUMENTS: CRTAU - Critical value produced by the subroutine (REAL*8)

TMPLXY

PURPOSE: Computes the X,Y coordinates for the transverse mercator projection given the geographic coordinates (latitude and longitude). The equations used to compute X and Y are from Thomas (1952). Subroutine MERARC is used to compute the meridian arc length.

HOW TO USE: CALL TMPLXY (PHI,DLAM,A,B,SF,XO,CMRAD,X,Y)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

PHI - latitude in radians

DLAM - longitude of point minus longitude of central meridian (in radians) for longitude positive east of Greenwich

A - semi-major axes of the reference ellipsoid

B - semi-minor axes of the reference ellipsoid

XO - false easting of the central meridian

SF - scale of the central meridian

CMRAD- the central meridian, in radians

OUTPUT ARGUMENTS: X - easting coordinate of the Transverse Mercator projection

Y - northing coordinate of the transverse mercator projection

TMSFMC

PURPOSE: Computes the point scale factor and meridian convergence (for a point defined by PHI, DLAM) for a transverse mercator projection defined by the scale factor SFO at the central meridian.

HOW TO USE: CALL TMSFMC (PHI,DLAM,SFO,A,B,SF,C)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

PHI - ellipsoidal latitude of the point, in radians

DLAM - ellipsoidal longitude of the point minus the ellipsoidal longitude of the central meridian of the projection (longitude positive east), in radians

SFO - scale at the central meridian

A,B - semi-major and semi-minor axes of the reference ellipsoid respectively, in metres

OUTPUT ARGUMENTS: SF - Point scale factor at the point

C - Meridian convergence at the point, in radians.

TMXYPL

PURPOSE: Computes the geographic coordinates (latitude and longitude) given the X,Y coordinates of the transverse mercator projection. The equations used to compute the latitude and longitude are from Thomas (1952). Subroutine FPLAT is used to compute the foot-point latitude.

HOW TO USE: CALL TMXYPL (X,Y,A,B,SF,XO,CMRAD,PHI,OLAM)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

X - easting coordinate of the transverse mercator projection

Y - northing coordinate of the transverse mercator projection

A - semi-major axes of the reference ellipsoid

B - semi-minor axes of the reference ellipsoid

SF - scale of the central meridian

XO - false easting of the central meridian

CMRAD - the central meridian, in radians

OUTPUT ARGUMENTS: PHI - latitude of the point, in radians

OLAM - longitude of the point, in radians

TRANS

PURPOSE:	Computes station translation components from geoidal heights referred to 2 different ellipsoids
HOW TO USE:	Produce a listing of the program and read the instructional comments

TTLS

PURPOSE: Compute the T-T and line scale corrections in a transverse mercator projection.

HOW TO USE: CALL TTLS (A,B,PHI1,DIST,X1,Y1,X2,Y2,XO,SF,TT,LS)

INPUT ARGUMENT: (all arguments are REAL*8 values)

A,B - semi-major and semi-minor axes of the reference ellipsoid

PHI1 - geodetic latitude of point 1

DIST - geodetic distance from point 1 to point 2

X1,Y1,X2,Y2 - X,Y coordinates of points 1 and 2

XO - false easting at the central meridian

SF - scale factor at the central meridian

OUTPUT ARGUMENTS: TT - T-T correction from point 1 to point 2

LS - line scale for the distance from point 1 to point 2

UPDATE

PURPOSE: Computes the apparent place of a star at any given epoch

HOW TO USE: See "Computer Programs for First-Order Astronomic Position Determination" by A. Umoru (M.Sc.E. thesis, 1972)

VINDI

PURPOSE: Solves the direct geodetic problem using the algorithm of T. Vincenty

HOW TO USE: CALL VINDI (AE,F,XLAT1,XLONG1,FAZ,LINE,LAT2,LONG2,BA)

INPUT ARGUMENTS: (all are REAL*8)

AE - semi-major axis of the ellipsoid (metres)

F - inverse of ellipsoid flattening

XLAT1- latitude of western point (deg)

XLONG1-longitude of western point (deg)

FAZ - forward azimuth (deg)

LINE - geodetic distance (metres)

OUTPUT ARGUMENTS: (all are REAL*8)

LAT2 - latitude of eastern point (deg)

LON2 - longitude of eastern point (deg)

BA - backward azimuth (deg)

VININ

PURPOSE: Solves the inverse geodetic problem using the algorithm of T. Vincenty

HOW TO USE: CALL VININ (AE,F,XLAT1,XLONG1,SLAT2,XLONG2,DIST,AZ1)

INPUT ARGUMENTS: (all are REAL*8)

AE - semi-major axis of the ellipsoid (metres)

F - inverse of ellipsoid flattening

XLAT1-latitude of western point (deg)

XLONG1-longitude of western point (deg)

XLAT2-latitude of eastern point (deg)

XLONG2-longitude of eastern point (deg)

OUTPUT ARGUMENTS: DIST - geodetic distance (metres) REAL*8

AZ1 - forward azimuth (deg) REAL*8

XNORM

PURPOSE: Computes the percentiles of the normal distribution N(XMEAN,SIG)

HOW TO USE: varname = XNORM (ALF,XMEAN,SIG)

ARGUMENTS: (N is INTEGER*4; all others are REAL*8)

ALF - probability integral from negative infinity to XNORM

XMEAN- population mean

SIG - population standard deviation

XNORM- computed abscissa value of N (XMEAN,SIG) corresponding to probability ALF

Accuracy better than 0.01045

XYZPLH

PURPOSE: Computes the ellipsoidal coordinates PHI, RLAM, H given the cartesian X,Y,Z

HOW TO USE: CALL XYZPLH (X,Y,Z,XO,YO,ZO,A,B,PHI,RLAM,H)

INPUT ARGUMENTS: (all arguments are REAL*8 values)

X,Y,Z - cartesian coordinates of the point in metres

XO,YO,ZO- translation components from the origin of the cartesian coordinate system (X,Y,Z) to the center of the reference ellipsoid (in metres)

A,B - semi-major and semi-minor axes of the reference ellipsoid in metres

OUTPUT ARGUMENTS: PHI - ellipsoidal latitude in radians

RLAM - ellipsoidal longitude in radians (positive east of Greenwich)

H - ellipsoidal height in metres

XYZPLH2

PURPOSE: Convert (X,Y,Z) to/from (PHI,LAMBDA,H)

HOW TO USE: Produce a listing of the program and read the instructional comments

NGS SOFTWARE PACKAGES

The Department has recently acquired three software packages from the U.S. National Geodetic Survey (NGS). These programs are now ready for use on the computer here at UNB. This circular will explain how to access these programs.

The three software packages are:

1) TRAV10 Horizontal Network Adjustment Program. (See NOAA Technical Memorandum NOS NGS-12). This package is the most sophisticated of the three. Its purpose is to adjust horizontal survey networks on the ellipsoid. This package has been used extensively by NGS to adjust the North American networks. The only limitation to the size of the network it can handle is the size of the computer it is running on. The JCL to access TRAV10 is given on below.

2) HAVAGO Three Dimensional Adjustment Program (see NOAA Technical Memorandom NOS NGS-17). This package is useful for adjusting numerous kinds of geodetic observations in three dimensions. It is not intended for handling very large networks, but is well suited for special surveys of highest precision and often with unusual configurations, as well as for ordinary survey projects. The JCL to access HAVAGO is given below.

3) A COMPUTER PROGRAM TO ADJUST A STATE PLANE COORDINATE TRAVERSE BY THE METHOD LEAST SQUARES (see NGS preprint with the same name). This program computes a plane-coordinate traverse adjustment using the method of least squares. Either the Lambert or Transverse Mercator projections may be used. Corrections are applied for the reduction of observed data to grid data. The JCL for accessing this program is given below.

```
 10 //TEST   JOB   ,SE1234
 20 //*
 30 //*  USE TRAV10 PREPROCESSOR TO CHECK INPUT DATA
 40 /*SERVICE -4
 60 /*JOBPARM  S=3,L=99,R=1024
 70 //PROCLIB  DD DSN=A.M12129.NGS.PROCLIB,DISP=SHR
 80 //ST1      EXEC  CCTRAVED,REGION=1024K
 90 //CARDIN   DD  *
100
110 ...DATA
120
130 //
```

```
 10 //TEST   JOB   ,SE1234
 20 //*
 30 //*  USE PREPROCESSOR AND TRAV10
 40 /*SERVICE -4
 60 /*JOBPARM  S=9,L=99,R=1024
 70 //PROCLIB  DD  DSN=A.M12129.NGS.PROCLIB,DISP=SHR
 80 //ST1      EXEC  CCTRAV10,REGION=1024K
 90 //CARDIN   DD  *
100
110      ...DATA
120
130 //
```

For an example run of either of these programs replace lines 90 thru 120 with //CARDIN DD DSN=A.M12129.DATA.TRAV10,DISP=SHR

```
 10 //TEST   JOB   ,SE1234
 20 //*
 30 //*  USE HAVAGO
 40 /*SERVICE -4
 60 /*JOBPARM  S=9,L=99,R=1024
 70 //PROCLIB  DD  DSN=A.M12129.NGS.PROCLIB,DISP=SHR
 80 //ST1      EXEC CCHAVAGO,REGION=1024K
 90 //CARDIN   DD  *
100
110    ...DATA
120
130 //
```

For an example run, replace lines 90 thru 120 with
//CARDIN DD DSN=A.M12129.DATA.HAVAGO,DISP=SHR

```
 10 //TEST   JOB  ,SE1234
 20 //*
 30 //*  USE TRAVERSE
 40 //*
 50 /*SERVICE -4
 60 /*JOBPARM  S=9,L=99,R=1024
 70 //PROCLIB  DD DSN=A.M12129.NGS.PROCLIB,DISP=SHR
 80 //ST1      EXEC CCTRAVRS,REGION=1024K
 90 //CARDIN   DD  *
100
110     ...DATA
120
130 //
```

For an example run, replace lines 90 thru 120 with
//CARDIN DD DSN=A.M12129.DATA.TRAVERSE,DISP=SHR