AD-A044 649 AEROSPACE CORP EL SEGUNDO CALIF SPACE SCIENCES LAB F/G 17/8
SOURCE LOCATING PROCEDURE.(U)
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UNCLASSIFIED TR-0077(2632)-1 SAMSO-TR-77-137 NL

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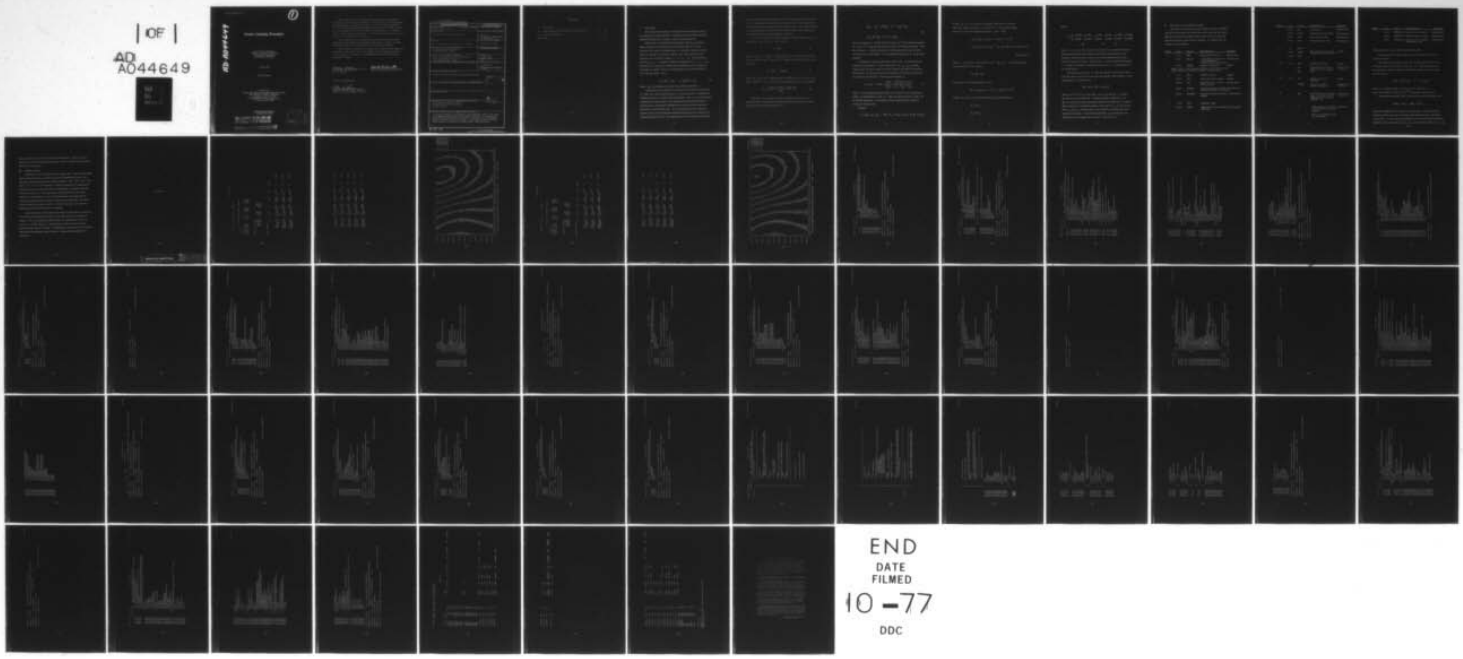

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REPORT SAMSO-TR-77-137

Source Locating Procedure

Space Sciences Laboratory
The Ivan A. Getting Laboratories
The Aerospace Corporation
El Segundo, Calif. 90245

15 July 1977

Interim Report

Prepared for
SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
Los Angeles Air Force Station
P.O. Box 92960, Worldway Postal Center
Los Angeles, Calif. 90009

This interim report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under Contract No. F04701-76-C-0077 with the Space and Missile Systems Organization, Deputy for Advanced Space Programs, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by G. A. Paulikas, Director, Space Sciences Laboratory. Lieutenant Dara Batki was the project Officer for Advanced Space Programs.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Dara Batki
Dara Batki, 2nd Lt, USAF
Project Officer

Robert W. Lindemuth
Robert Lindemuth, Lt Col, USAF

FOR THE COMMANDER

Floyd R. Stuart
Floyd R. Stuart, Colonel, USAF
Deputy for Advanced Space Programs

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Least Squares Fitting Technique
Measurement of Photo Emission
Target Location

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A computer program is presented for estimating the location of a target from satellite measurements of its photon emission. The satellite is assumed to have a number of detectors mounted at various orientations which monitor the photon count rates. From these the most probable target location is inferred by a least squares fitting technique.

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CONTENTS

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I. ANALYSIS

We consider the problem of inferring the most probable location of a target given measurements of its photon emission collected from a satellite equipped with a number of planar photon detectors.

Specifically, we assume that the satellite carries n_D detectors whose respective orientations are given by the angle of elevation from the nadir and the azimuthal angle α measured counter-clockwise from the satellite's direction of motion. The count rates from the detectors are recorded at times t_i, $i = 1, 2, \ldots, n_T$. This provides a total of $n_S = n_D \cdot n_T$ positive numbers designated by C_i, $i = 1, \ldots, n_S$. Because the C_i include an unknown factor depending on the strength of the target we replace then by a *corresponding* set of scaled quantities S_i having unit mean. Thus,

$$S_i = \kappa(C_i - C_B); \qquad \kappa = n_S/\Sigma(C_i - C_B) \tag{1}$$

where C_B is the background count rate (assumed isotropic).

The position of the satellite is assumed to be known at each instant t_i. Thus, for a given target location it is clearly possible to compute the scaled quantities S_i purely from the geometry: each S_i will be inversely proportional to the distance to the target and directly proportional to a known function of the angle subtended at the detector by the target and the normal to the detector face. For an ideal detector this function is just the cosine, but an empirical response function given in tabular form can equally well be used. The actual location of the target is taken to be

the one that minimizes the differences between the computed and measured S_i. The computation takes the form of a series of successive approximations starting from an initial 'guessed' target location. This initial location is conveniently taken to be at the point on the surface of the earth that is viewed by the detector with the highest count rate.

We describe the location of the target by giving its latitude λ_T, and its longitude μ_T. Then, in vector notation

$$S = f(\Gamma) \tag{2}$$

where $S = \left|S_i,\ i = 1,\ n_S\right|$, $\Gamma = \left|\lambda_T, \mu_T\right|$ and f is a non-linear function given by the geometry. Equation (2) is approximated locally by the linear equations

$$S = f(\Gamma_0) + G(\Gamma_0)\Delta\Gamma \tag{3}$$

where Γ_0 is the current approximation and $\Delta\Gamma$ the first correction, and $G(\Gamma) = \partial f/\partial\Gamma$ is a $n_S \times 2$ matrix of forward differences. For example

$$G_{12} = \frac{f_1(\lambda_T, \mu_T + \Delta\mu_T) - f_1(\lambda_T, \mu_T)}{\Delta\mu_T} \tag{4}$$

Equations (3) constitute a set of n_S algebraic equations in 2 unknowns whose least-squares solution forms the basis for the iterative solution of the non-linear equations (2)

$$\Gamma_{k+1} = \Gamma_k + [G^T(\Gamma_k) \cdot C^{-1} \cdot G(\Gamma_k)]^{-1} E_k$$

$$E_k = G^T(\Gamma_k) \cdot C^{-1} \cdot [S - f(\Gamma_k)] \qquad (5)$$

Here the subscript k denotes the kth iteration, G^T is the matrix transpose of G and C^{-1} is the inverse of the covariance of the measurements. Since the variance is equal to the mean for a Poisson process and since the count rates are uncorrelated, C is a diagonal matrix with C_i on the main diagonal.

It remains to determine the form of $f(\Gamma)$ in Eq. (2) from which the elements of the matrix G can be calculated. Let r_T, r_S, r_D denote respectively the radius vectors from the center of the earth to the target, the satellite, and the intersection of the surface of the earth with the line-of-sight from the detector. Then for each estimate f_i

$$f_i = \kappa \cos \sphericalangle \mathrm{TSD} = \kappa \frac{[(r_S)_i - r_T]\,[(r_S)_i - (r_D)_i]}{|(r_S)_i - r_T|\;|(r_S)_i - (r_D)_i|} \qquad (6)$$

where κ is a normalizing factor which, for any given set of n_S measurements, is determined as in Eq. (1). Here the cosine function is used, but, as already mentioned, it can equally well be replaced by an empirical function in tabular form.

Clearly

$$r_T = |x_T, y_T, z_T| = |\cos \lambda_T \cos \mu_T, \cos \lambda_T \sin \mu_T, \sin \lambda_T| .$$

To find r_S, r_D it is convenient to express them first in a primed coordinate system such that r_S is along the x' axis and the angular velocity vector of the satellite along the z' axis. Then

$$r'_S = \left| x'_S, y'_S z'_S \right| = (a + h_S) \left| 1, 0, 0 \right|$$

$$r'_D = \left| x'_D, y'_D, z'_D \right| = \left| a + h_S - SD \cos\epsilon, SD \sin\epsilon \cos\alpha, \right.$$

$$\left. SD \sin\epsilon \sin\alpha \right|$$

where a is the radius of the earth and $SD = \left| r_D - r_S \right|$ is readily obtained by squaring the vector relation

$$\vec{r}_S + \vec{SD} = \vec{r}_D$$

and solving the resulting quadratic to get

$$SD = (a + h_S) \cos\epsilon - [a^2 - (a + h_S)^2 \sin^2\epsilon]^{1/2} .$$

Finally, the values in the unprimed system can be obtained by

$$r_S = T\, r'_S$$

$$r_D = T\, r'_D$$

where

$$T = \begin{pmatrix} u_x\cos\alpha + u_y\sin\alpha, & v_x\cos\alpha + v_y\sin\alpha, & w_x\cos\alpha + w_y\sin\alpha \\ -u_x\sin\alpha + u_y\cos\alpha, & -v_x\sin\alpha + v_y\cos\alpha, & -w_x\sin\alpha + w_y\cos\alpha \\ u_z, & v_z, & w_z \end{pmatrix}$$

Here u, v, w are a triad of unit vectors given by the satellite ephemeris program which specify the position and velocity of the satellite in an inertial coordinate system, and α is the corresponding angle through which the earth has rotated. In particular, u points towards the satellite, v is along its horizontal component of motion and w is perpendicular to its orbital plane.

The result given by Eq. (6) must be checked in each case to make sure the target is not over the horizon with respect to the satellite. From the geometry it is clear that if

$$HI = \cos \sphericalangle \text{ TOS} - \sin(\delta - \beta)$$

where $\cos\delta = a/(a + h_T)$ and $\sin\beta = a/(a + h_S)$, then $HI < 0$ implies the target is over the horizon. Similarly negative values for f_i in Eq. (6) indicate radiation entering the detector from the rear. In both of these cases the corresponding entries in the matrix G_{ij} are set to zero. Here h_S and h_T are the heights of the satellite and target above the surface of the earth. (Unless input differently, h_T is assumed to be 50 km, above which height there is about 1 g/cm^2 of air.)

II. Description of data input and output.

The data are read by subroutines DATIN, START and EPHM. The latter subroutines are called from DATIN and read the orbital element sets provided by GWC; DATIN reads the input cards that specify the detector positions and readings. A complete data set consists of the following:

CARD	COL	VALUE	DESCRIPTION	FORMAT
1	1-10	ERR	Background count rate	floating point
	11-20	EFLAG	= 0 (or blank), means read orbit element set ≠ 0, new flight not specified	floating point
	21-22	MAXIT	number of iterations	integer
(cards 2 and 3 are read when EFLAG = 0 and are the 2-line orbit element set formatted by Space Defense Center)				
2	3-7	ISAT	satellite number	integer
	19-20	IYR	epoch year (last 2 digits)	integer
	21-32	DAY	epoch day (day + fraction of day of year)	floating point
	34-43	XNDOT	1 st time derivative of mean motion or Ballistic coefficient.	floating point
	45-52	XNDDOT	2 nd time derivative of mean motion.	floating point
3	9-16	XIO	inclination (deg)	
	18-25	ASNO	right ascension of ascending node (deg)	floating point

CARD	COL	VALUE	DESCRIPTION	FORMAT
	27-33	EO	eccentricity	floating point
	35-42	ARGO	argument of perigee (deg)	floating point
	44-51	XMO	mean anomaly (deg)	floating point
	53-53	XNO	mean motion (rev/day)	floating point
4	1-5	KDAY		
	6-10	KMON	day, month and year (last 2 digits) of data acquisition	integer
	11-15	KYR		
5*	1-2	ND	number of detectors	integer
		AZ	azimuth and elevation of detectors, read in pairs (deg)	floating point (8F7.0)
		EL		
6*	1-2	NT	number of detector readings	integer
		TIMES	time(s) (seconds) of detector readings	floating point (8F7.0)
7*		SM	NT x ND detector readings input so that the first NT readings are for the first detector, etc.	floating point (8F10.0)
8	1	D	= 1HD, program calculates initial estimate of target location	alphabetic
			= 1H , use following values as initial guess	

CARD	COL	VALUE	DESCRIPTION	FORMAT
	2-11	TARLOC (1)	latitude (deg) of target	floating point
	12-21	TARLOC (2)	longitude (deg) of target	floating point
	22-31	TARLOC (3)	altitude (km) if different from preset value	floating point

*Additional cards may be necessary for these inputs.

The program ends when a blank card is encountered as the first card of a data set.

The output of the program at the kth iteration will consist of the current estimate of the target location λ_T, μ_T representing latitude and longitude in degrees together with the determinant of the covariance of error matrix

$$COV = \kappa [G^T(\Gamma_k) \cdot C^{-1} \cdot G(\Gamma_k)]^{-1}$$

where κ is defined in Eq. (1) and G, and C after Eq. (5).
Also, the residual $R = [\sum(S_i - f_i)^2]^{1/2}$ is printed at each iteration.

Note that the procedure tries to minimize the positive definite form

$$Q(\lambda_T, \mu_T) = \sum(S_i - f_i)^2/S_i$$

giving the weighted sum of squares of the residuals. In some cases the iteration scheme may fail to converge if the data and/or the initial guess are too poor. In such cases it is helpful to have an isoresidual contour plot obtained from a tabulation of $Q(\lambda_T, \mu_T)$ over a grid of values of λ_T, μ_T.

Such a tabulation is provided at the end of the printout. From it one can determine if any well defined minima exist, and if so select the most likely one as the initial guess.

III. Sample Problem

Following are the printouts from two sample runs. The first uses ideal data to test the program, and the second uses simulated real data. Four detectors are placed at azimuth, elevation angles of (45°, 30°), (135°, 30°), (225°, 30°), (315°, 30°); the target is placed at latitude 30°, longitude 20°. In the first run count rates are input corresponding to 3 satellite locations taken 2 seconds apart. The count rates are proportional to the number obtained by computing the cosine of the angle between the target and the detector normal and then dividing it by the square of the range. The background count rate is taken to be zero. From the printout it is clear that the program finds the target after 2 iterations.

In the second run a set of physically realistic count rates are selected from Poisson's distribution having the count rates of the first example as means. This is accomplished approximately by replacing the count rate C_i by $C_i + Z_i\sqrt{C_i}$ where Z_i is taken from a table of normal deviates with zero mean and unit variance. A background count rate of 10 is assumed. We see that the program comes to within 1 degree of the target after 2 iterations.

APPENDIX

LOCATOR RUN 1

DETECTOR COUNT RATES PER 8710774

UT	70582.00	70702.00	70822.00
(AZ,EL)			
(45.0, 30.0)	196.8	514.6	173.7
(135.0, 30.0)	76.1	441.3	322.9
(225.0, 30.0)	84.7	450.8	316.3
(315.0, 30.0)	205.4	524.2	167.1

SATELLITE POSITION

UT	LAT	LON
70582.00	32.44	22.59
70702.00	31.49	20.49
70822.00	24.51	18.60

TARGET ESTIMATE

LAT 26.67 LON 16.21 ALT 15.00

ITER 0 LAT 26.67 LON 16.21 HT 15.00
DETERMINANT= 0.10932E 06 0.16214E 02
RESIDUAL= 3.905

ITER 1 LAT 30.10 LON 19.72 HT 15.00
DETERMINANT= 0.74849E 05 0.19719E 02
RESIDUAL= 3.930

ITER 2 LAT 30.00 LON 20.00 HT 15.00
DETERMINANT= 0.61263E 05 0.19999E 02
RESIDUAL= 3.929

```
ITER     3     LAT      30.00     LON      20.00     HT      15.00
DETERMINANT=    0.81216E 05    0.20000E 02
RESIDUAL=      3.929

ITER     4     LAT      30.00     LON      20.00     HT      15.00
DETERMINANT=    0.81234E 05    0.20000E 02
RESIDUAL=      3.929

ITER     5     LAT      30.00     LON      20.00     HT      15.00
DETERMINANT=    0.81217E 05    0.20000E 02
RESIDUAL=      3.929

ITER     6     LAT      30.00     LON      20.00     HT      15.00
DETERMINANT=    0.81226E 05    0.20000E 02
RESIDUAL=      3.929

ITER     7     LAT      30.00     LON      20.00     HT      15.00
DETERMINANT=    0.81226E 05    0.20000E 02
RESIDUAL=      3.929
```

ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LON) OF 28.00 16.00 DEGREES

DETECTOR COUNT RATES FOR 8710774

UT 70582.00 70702.00 70822.00

(AZ,EL)

(45.0, 30.0)	188.0	541.0	155.0
(135.0, 30.0)	79.0	461.0	337.0
(225.0, 30.0)	81.0	463.0	316.0
(315.0, 30.0)	167.0	561.0	161.0

SATELLITE POSITION

UT	LAT	LON
70582.00	36.44	22.59
70702.00	31.49	20.49
70822.00	24.51	18.00

TARGET ESTIMATE

LAT 28.67 LON 16.21 ALT 15.00

ITER 0 LAT 28.67 LON 16.21 HT 15.00
DETERMINANT= 0.10932E 06 0.16214E 02
RESIDUAL= 3.905

ITER 1 LAT 30.17 LON 20.12 HT 15.00
DETERMINANT= 0.75871E 05 0.20115E 02
RESIDUAL= 3.437

ITER 2 LAT 30.00 LON 20.08 HT 15.00
DETERMINANT= 0.60759E 05 0.20077E 02
RESIDUAL= 3.430

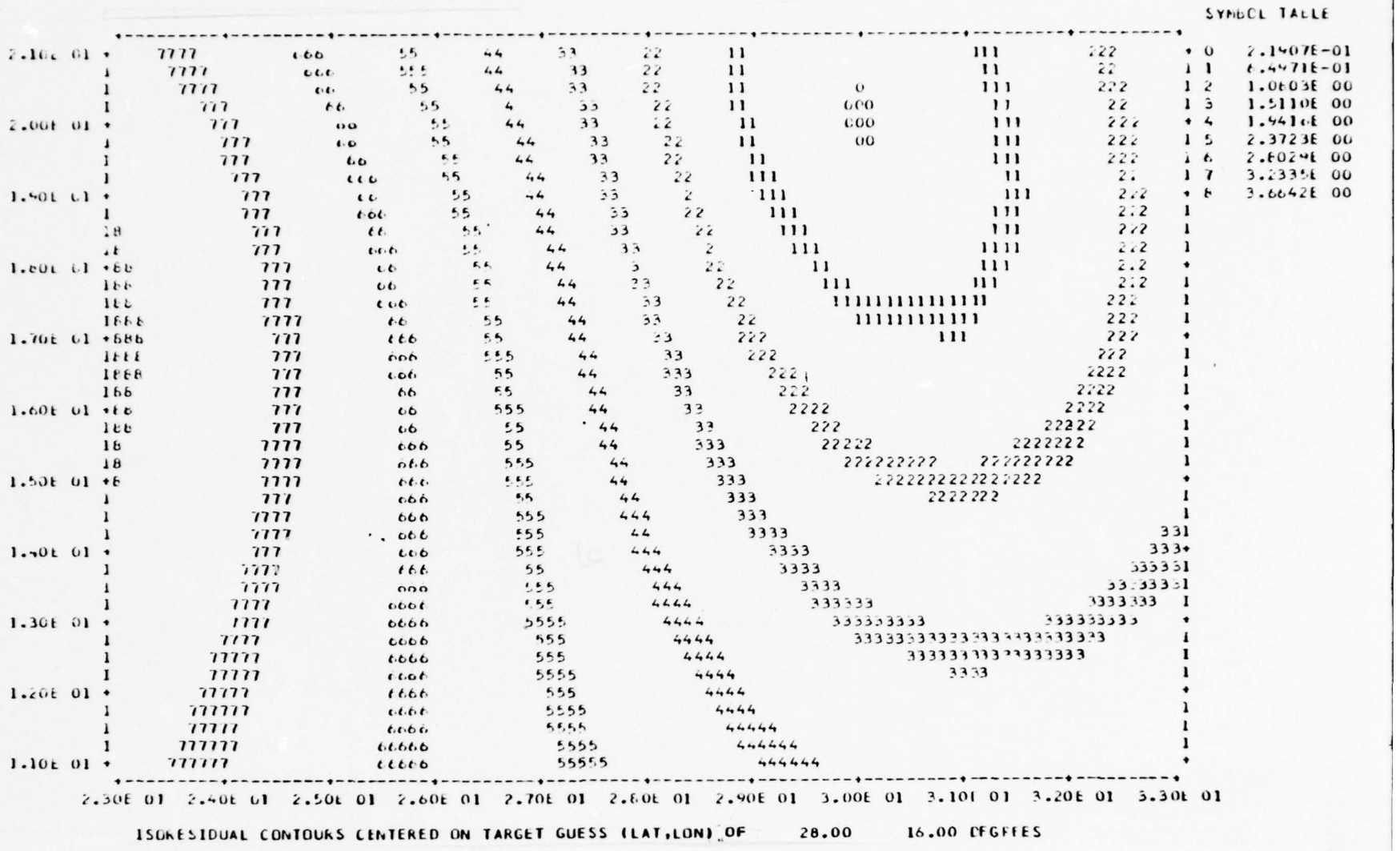
```
ITER    3     LAT      30.02     LON      20.08     HT      15.00
DETERMINANT=   0.80059E 05    0.20079E 02
RESIDUAL=      3.931

ITER    4     LAT      30.02     LON      20.08     HT      15.00
DETERMINANT=   0.80159E 05    0.20060E 02
RESIDUAL=      3.931

ITER    5     LAT      30.02     LON      20.08     HT      15.00
DETERMINANT=   0.80139E 05    0.20060E 02
RESIDUAL=      3.931

ITER    6     LAT      30.02     LON      20.08     HT      15.00
DETERMINANT=   0.80129E 05    0.20060E 02
RESIDUAL=      3.931

ITER    7     LAT      30.02     LON      20.08     HT      15.00
DETERMINANT=   0.80113E 05    0.20080E 02
RESIDUAL=      3.931
```



ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LON) OF 28.00 16.00 DEGREES

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          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,ECLIPIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            COMMON SATURB(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                      *T/ABCC(3),CRR
   ISN 0003            COMMON/CONST/RADS,DEG,PI,RF
   ISN 0004            COMMON/VEC/D(3,20),V(3,20),R(3,20),ALT(20),ALPHA(20)
   ISN 0005            COMMON/DAY/IDAYP
   ISN 0006            COMMON/CUESS/CUESSO(3)
   ISN 0007            PI=4.*ATAN(1.)
   ISN 0008            RADS=PI/180.
   ISN 0009            DEG=180./PI
   ISN 0010            RF=10800./PI
   ISN 0011          1 CALL DATIN
   ISN 0012            CALL REFINE
   ISN 0013            CALL ORIB
   ISN 0014            GO TO 1
   ISN 0015            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,ECLIPIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      14 ,PROGRAM SIZE =      334

*STATISTICS*  NO  DIAGNOSTICS GENERATED

*****  END OF COMPILATION  *****                          557K BYTES OF CORE NOT USED
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LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.51.01

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE ELEPM
   ISN 0003            REAL*8 DD,VV,WW,DDAYS
   ISN 0004            COMMON SATURDS,NO,AZ(10),EL(10),NT,TIMES(20)
   ISN 0005            COMMON/VEC/D(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
   ISN 0006            COMMON/CONST/RADS
   ISN 0007            COMMON/DAY/TSELP
   ISN 0008            COMMON/UVW/DD(3),VV(3),WW(3)
   ISN 0009            COMMON/SATPOS/SATPOS(20,2)
                       C
                       C GENERATE SATELLITE POSITION VECTORS FOR EACH TIME READINGS ARE MADE
                       C
   ISN 0010            DO 5 I=1,NT
   ISN 0011            CALL EPHMX1(TIMES(I),SATPOS(I,2),ALT(I),SATPOS(I,1))
   ISN 0012            DO 4 J=1,3
   ISN 0013            D(J,I)=DD(J)
   ISN 0014            V(J,I)=VV(J)
   ISN 0015          4 W(J,I)=WW(J)
   ISN 0016            DDAYS=TSELP+TIMES(I)/86400.D0
   ISN 0017            ALPHA(I)=ARIES(DDAYS)
   ISN 0018          5 CONTINUE
   ISN 0019            RETURN
   ISN 0020            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       19 ,PROGRAM SIZE =      526

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  553K BYTES OF CORE NOT USED
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                            SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE DATIN
ISN 0003            COMMON SATORB(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                   *TABLE(3),ERR
ISN 0004            COMMON/CONST/RADS,DEG,PI,RE
ISN 0005            COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
ISN 0006            COMMON/ITER/MAXIT
ISN 0007            COMMON/SATPOS/SATPOS(20,2)
ISN 0008            COMMON/ODESS/ODESSO(3)
ISN 0009            DIMENSION XYZ(3)
ISN 0010            DATA CLARK/1H /
ISN 0011            DATA NRUN/0/
                  C GIVEN BACKGROUND COUNT RATE DEFINED BY...
ISN 0012            READ(5,499)ERR,EPLAG,MAXIT
ISN 0013            IF(ERR .LT. 0.) GO TO 1000
ISN 0015            NRUN=NRUN+1
ISN 0016            WRITE(6,504) NRUN
                  C EPLAG=0 MEANS REAL SATELLITE ELEMENT SET
ISN 0017            IF(EPLAG .EQ. 0.) CALL START
ISN 0019            IF(EPLAG .NE. 0.) SATORB(3)=SATORB(3)*DEG
ISN 0021          2 CALL EPHM(SATORB(1),SATORB(2),SATORB(4),SATORB(5))
ISN 0022            SATORB(2)=SATORB(2)*RADS
ISN 0023            SATORB(3)=SATORB(3)*RADS
ISN 0024            SATORB(5)=SATORB(5)*RADS
                  C ...AND GIVEN AZIMUTH AND ELEVATION PAIRS FOR ND DETECTORS...
ISN 0025            READ(5,502) ND,(AZ(I),EL(I),I=1,ND)
                  C REAL TIMES...
ISN 0026            READ(5,502) NT,(TIMES(I),I=1,NT)
ISN 0027            CALL ALLEPH
                  C...AT WHICH DETECTORS TAKE NS (=NT*ND) READINGS...
ISN 0028            NS=NT*ND
ISN 0029            READ(5,500) (SM(I),I=1,NS)
                  C SUBTRACT BACKGROUND
ISN 0030            DO 6 I=1,NS
ISN 0031          6 SM(I)=SM(I)-ERR
ISN 0032            WRITE(6,501) (TIMES(I),I=1,NT)
ISN 0033            WRITE(6,505)
ISN 0034            DO 7 I=1,ND
```

```
ISN 0035            WRITE(6,503) AZ(I),EL(I),(SM(J+I*NT-NT),J=1,NT)
ISN 0036            AZ(I)=AZ(I)*RAD$
ISN 0037          7 EL(I)=EL(I)*RAD$
ISN 0038            WRITE(6,505) (TIMES(I),SATPOS(I,1),SATPOS(I,2),I=1,NT)
ISN 0039            SUM=0.
ISN 0040            RMAX=0.
ISN 0041            DO 5 I=1,NS
ISN 0042          5 SUM=SUM+SM(I)
ISN 0043            ERR=ERR/SUM*NS
                C FINALLY, READ ZEROTH ESTIMATE OF TARGET LOCATION (OR USE
                C DEFAULT)
ISN 0044            READ(5,507) E,TARLOC
                C NORMALIZE COUNT RATES
ISN 0045            DO 6 I=1,NS
ISN 0046            SM(I)=SM(I)/SUM*NS
ISN 0047            IF(SM(I) .LE. RMAX) GO TO 6
ISN 0049            RMAX=SM(I)
ISN 0050            MAX=I
ISN 0051          6 CONTINUE
ISN 0052            IF(E .EQ. ERRM) GO TO 10
                C ZEROTH ESTIMATE OF TARGET LOCATION IS SPOTVIEWED BY DETECTOR
                C WITH MAXIMUM RESPONSE
ISN 0054            I1=1+MAX/NT
ISN 0055            IF(MOD(MAX,NT) .EQ. 0) I1=I1-1
ISN 0057            I2=MOD(MAX,NT)
ISN 0058            IF(I2 .EQ. 0) I2=NT
ISN 0060            CALL SPOTVU (AZ(I1),EL(I1),XYZ,ALT(I2))
ISN 0061            CALL ROTS(XYZ,I2)
ISN 0062            X=XYZ(1)
ISN 0063            Y=XYZ(2)
ISN 0064            Z=XYZ(3)
ISN 0065            TARLOC(1)=ATAN2(Z,ABS(X*(1.+Y*Y/X/X)**.5))*DEG
ISN 0066            TARLOC(2)=ATAN2(Y,X)*DEG
ISN 0067            IF(TARLOC(2) .LT. 0.) TARLOC(2)=TARLOC(2)+360.
                C TARGET ALTITUDE IS SET AT 15 NM
ISN 0069          10 CONTINUE
ISN 0070            IF(TARLOC(3) .EQ. 0) TARLOC(3)=50.
ISN 0072            WRITE(6,506) TARLOC
ISN 0073            GUESS0(I)=TARLOC(I)
```

```
ISN 0074            COEFSC(2)=TABLEC(2)
ISN 0075            COEFSC(3)=TABLEC(3)
ISN 0076            TABLEC(1)=TABLEC(1)*RADS
ISN 0077            TABLEC(2)=TABLEC(2)*RADS
ISN 0078            RETURN
ISN 0079         1000 WRITE(6,1001)
ISN 0080              STOP 1000
ISN 0081         1001 FORMAT(10X,17HE N D  O F  R U N  )
ISN 0082          495 FORMAT(2F10.0,I10)
ISN 0083          500 FORMAT(8F10.0)
ISN 0084          501 FORMAT(I13,'01',10F10.2)
ISN 0085          502 FORMAT(I2,6F7.6))
ISN 0086          503 FORMAT(2X,I4,F5.1,1H,,F5.1,1H),10F10.1)
ISN 0087          504 FORMAT(1H1,15C,'LOCATOR RUN',1')
ISN 0088          505 FORMAT(////,1X,'SATELLITE POSITION'/119,'UT',128,'LAT',138,'LON'/
                     *  (10X,3F10.2))
ISN 0089          506 FORMAT(////1X,'TARGET ESTIMATE'/T1E,'LAT',F10.2,5X,'LON',F10.2,
                     *   5X,'ALT',F10.2)
ISN 0090          507 FORMAT(A1,3F10.0)
ISN 0091          508 FORMAT(/4X,'(AZ,EL)'/)
ISN 0092              END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =  92 ,PROGRAM SIZE =     2214

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    541K BYTES OF CORE NOT USED
```

```
      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002              SUBROUTINE DETECT(AZ,EL,S,MS,INX)
                  C RETURNS OUTPUT OF A SINGLE DETECTOR
ISN 0003              COMMON DUM(247),RLAMT,RMUT,RT
ISN 0004              COMMON/CONST/RADS,DEG,PI,PI2
ISN 0005              DIMENSION XT(3),S(3),ST(3),XD(3)
ISN 0006              DIMENSION XS(3)
ISN 0007              DIMENSION DR(3)
ISN 0008              S=0.
ISN 0009              CALL SPDIVD (AZ,EL,XD,MS)
ISN 0010              CALL ROT3(XD,INX)
ISN 0011              REMT=RE+MT
ISN 0012              REMS=RE+MS
ISN 0013              XS(1)=REMS
ISN 0014              XS(2)=0.
ISN 0015              XS(3)=0.
ISN 0016              CALL ROT3(XS,INX)
ISN 0017              COSL=COS(RLAMT)
ISN 0018              XT(1)=REMT*COSL*COS(RMUT)
ISN 0019              XT(2)=REMT*COSL*SIN(RMUT)
ISN 0020              XT(3)=REMT*SIN(RLAMT)
ISN 0021              RI=DOT(XT,XS)/(REMT*REMS)
ISN 0022              EPS=SIN(ASIN(RE/REMS)-ACOS(RE/REMT))
ISN 0023              IF(EPS .GT. RI) RETURN
ISN 0025              DO 5 I=1,3
ISN 0026              DR(I)=XS(I)-XT(I)
ISN 0027              SD(I)=XD(I)-XS(I)
ISN 0028            5 ST(I)=XT(I)-XS(I)
ISN 0029              RACOSR=1./DOT(DR,DR)
ISN 0030              S=DOT(SD,ST)/SQRT(DOT(SD,SD)*DOT(ST,ST))
ISN 0031              ANGLE=ACOS(S)
ISN 0032              S=RACOSR*RESPLN(ANGLE)
ISN 0033              IF(S .LT. 0.) S=0.
ISN 0035              RETURN
ISN 0036              END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.26

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION EQT(X,Y)
   ISN 0003            DIMENSION X(1),Y(1)
   ISN 0004            EQT=X(1)*Y(1)+X(2)*Y(2)+X(3)*Y(3)
   ISN 0005            RETURN
   ISN 0006            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        5 ,PROGRAM SIZE =       284

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          457K BYTES OF CORE NOT USED
```

```
*STATISTICS*      SOURCE STATEMENTS =      34 ,PROGRAM SIZE =      1224
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                          553K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.31

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE OUTPUT(S)
   ISN 0003            COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
   ISN 0004            COMMON SAT0RE(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                      *TABLE(3),ERR
   ISN 0005            DIMENSION S(1),
   ISN 0006            SUM=0.
   ISN 0007            DO 10 I=1,NT
   ISN 0008            DO 10 J=1,ND
   ISN 0009            K=I+NT*(J-1)
   ISN 0010            CALL GETOUT(AZ(J),EL(J),S(K),ALT(I),1)
   ISN 0011         10 SUM=SUM+S(K)
   ISN 0012            NS=ND*NT
   ISN 0013            DO 20 I=1,NS
   ISN 0014            IF(SUM .EQ. 0.) GO TO 20
   ISN 0015            S(I)=AMAX1(0.,S(I)/SUM)*NS
   ISN 0017         20 CONTINUE
   ISN 0018            RETURN
   ISN 0019            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       16 ,PROGRAM SIZE =      578

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          553K BYTES OF CORE NOT USED
```

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE REFINE
ISN 0003            COMMON SATERR(5),NE,AZ(10),EL(10),NT,TIMES(20),SM(200),
                   *TABLOC(3),ERR
ISN 0004            COMMON/CONST/RADS,DEG,PI,RE
ISN 0005            DIMENSION SC(200),SPL(200),SPM(200),GRAD(200,2),
                   * COV(2,2),TEMP(3),EE(2)
ISN 0006            DIMENSION TERR(2),IW1(2),IW2(2)
ISN 0007            COMMON/ITER/MAXIT
ISN 0008            DATA TERR/2*0.0/
ISN 0009            ITER=0
ISN 0010            NS=NE*NT
ISN 0011            RINC=0.1*RADS
ISN 0012            WRITE(6,101)
ISN 0013          1 CONTINUE
ISN 0014            TEMP(1)=TABLOC(1)*DEG
ISN 0015            TEMP(2)=TABLOC(2)*DEG
ISN 0016            TEMP(3)=TABLOC(3)
ISN 0017            WRITE(6,101)
ISN 0018            WRITE(6,100) ITER,TEMP
ISN 0019            CALL OUTPUT(SC)
ISN 0020            TABLOC(1)=TABLOC(1)+RINC
ISN 0021            CALL OUTPUT(SPL)
ISN 0022            TABLOC(1)=TABLOC(1)-RINC
ISN 0023            TABLOC(2)=TABLOC(2)+RINC
ISN 0024            CALL OUTPUT(SPM)
ISN 0025            TABLOC(2)=TABLOC(2)-RINC
ISN 0026            DO 10 I=1,NS
ISN 0027            GRAD(I,1)=(SPL(I)-SC(I))/RINC
ISN 0028            GRAD(I,2)=(SPM(I)-SC(I))/RINC
ISN 0029         10 SC(I)=SM(I)-SC(I)
ISN 0030            DO 20 I=1,2
ISN 0031            DO 20 J=1,2
ISN 0032            COV(I,J)=0.
ISN 0033            DO 20 K=1,NS
ISN 0034            COV(I,J)=COV(I,J)+GRAD(K,I)*GRAD(K,J)
ISN 0035         20 CONTINUE
ISN 0036            CALL MINV(COV,2,TEMP,IW1,IW2)
```

```
ISN 0037            DO 50 I=1,2
ISN 0038            DEL(I)=0.
ISN 0039            DO 40 J=1,NS
ISN 0040            DO 40 K=1,2
ISN 0041            DEL(I)=DEL(I)+COEF(I,K)*GRAD(J,K)*SC(J)
ISN 0042         40 CONTINUE
ISN 0043         50 CONTINUE
ISN 0044            RSDL=0.
ISN 0045            DO 55 I=1,NS
ISN 0046         55 RSDL=RSDL+(SN(I)-SC(I))**2
ISN 0047            RSDL=SQRT(RSDL)
ISN 0048            WRITE(6,110) TEMP(1),TEMP(2),RSDL
ISN 0049            ITER=ITER+1
ISN 0050            IF(ITER .GT. MAXIT) RETURN
ISN 0052            DO 60 I=1,2
ISN 0053         60 TABLOC(I)=TABLOC(I)+DEL(I)
ISN 0054            GO TO 1
ISN 0055        100 FORMAT(10X,4HITER,I5,5X,4HLAT ,F10.2,5X,4HLON ,F10.2,5X,
                   *5HMT ,F10.2)
ISN 0056        101 FORMAT(/)
ISN 0057        110 FORMAT(10X,'DETERMINANT=',2F15.5/10X,'RESIDUAL=',F10.3)
ISN 0058            END
```

```
                ERROR NO   LEVEL        ERROR MESSAGE

   NAME    IERR   IER5071       04       THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.

*OPTIONS IN EFFECT*      NAME = MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      57 ,PROGRAM SIZE =     5522

*STATISTICS*    1 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4

****** END OF COMPILATION ******                                    541K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.45

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION RESPEN(A)
   ISN 0003            RESPEN=COS(A)
   ISN 0004            RETURN
   ISN 0005            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        4 ,PROGRAM SIZE =       226

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.49

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE ROT3(X,T)
   ISN 0003            DIMENSION X(3)
   ISN 0004            COMMON/VEC/C(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
   ISN 0005            DIMENSION T(3),S(3)
   ISN 0006            COSAL=COS(ALPHA(I))
   ISN 0007            SINAL=SIN(ALPHA(I))
   ISN 0008            T(1)=U(1,I)*COSAL+U(2,I)*SINAL
   ISN 0009            T(2)=V(1,I)*COSAL+V(2,I)*SINAL
   ISN 0010            T(3)=W(1,I)*COSAL+W(2,I)*SINAL
   ISN 0011            S(1)=DOT(T,X)
   ISN 0012            T(1)=-U(1,I)*SINAL+U(2,I)*COSAL
   ISN 0013            T(2)=-V(1,I)*SINAL+V(2,I)*COSAL
   ISN 0014            T(3)=-W(1,I)*SINAL+W(2,I)*COSAL
   ISN 0015            S(2)=DOT(T,X)
   ISN 0016            T(1)=C(3,I)
   ISN 0017            T(2)=V(3,I)
   ISN 0018            T(3)=W(3,I)
   ISN 0019            S(3)=DOT(T,X)
   ISN 0020            DO 11 II=1,3
   ISN 0021         11 X(II)=S(II)
   ISN 0022            RETURN
   ISN 0023            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =     22 ,PROGRAM SIZE =      690

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.58

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE EPHM(TIME,RLON,ALT,RLAT)
   ISN 0003            REAL*8 LX,LY,LZ,VX,VY,VZ,WX,WY,WZ
   ISN 0004            REAL*8 RX,RY,RZ,R,TDAY
   ISN 0005            COMMON/LVW/LX,LY,LZ,VX,VY,VZ,WX,WY,WZ
   ISN 0006            COMMON/RR/RX,RY,RZ,R
   ISN 0007            COMMON/DAY/TDAYP
   ISN 0008            REAL*8 A,RTOD
   ISN 0009            DATA RTOD/57.29577951308/
   ISN 0010            DATA AE/6378.166/
                       C
                       C
   ISN 0011            READ(5,1) RDAY,RMON,RYR,RHR,RMN,RSC
   ISN 0012          1 FORMAT(3I5,3F10.0)
   ISN 0013            WRITE(6,2) RMON,RDAY,RYR
   ISN 0014          2 FORMAT(//,5X,'ELECTRON COUNT RATES FOR',I5,1H/,I2,1H/,I2///)
   ISN 0015            TIME=RSC+RMN*60.+RHR*3600.
   ISN 0016            ENTRY EPHM1(TIME,RLON,ALT,RLAT)
   ISN 0017            TDAYP=DAYS(RYR,RMON,RDAY)
   ISN 0018            TDAY=TDAYP+TIME/86400.D0
   ISN 0019            CALL TRACK(TDAY)
   ISN 0020            A=DARSIN(RZ/R)
   ISN 0021            A=A+DSIN(A+A)/(300.D0*R)
   ISN 0022            RLAT=A*RTOD
   ISN 0023            ER=.99832D0+.00168D0*DCOS(A+A)
   ISN 0024            ALT=(R-ER)*AE/1.852
   ISN 0025            RLON=ARIES(TDAY)
   ISN 0026            A=(DATAN2(RY,RX)-RLON)*RTOD
   ISN 0027            RLON=DMOD(A,360.D0)
   ISN 0028            IF(RLON .LT. 0.) RLON=RLON+360.
   ISN 0030            RETURN
   ISN 0031            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       30 ,PROGRAM SIZE =     9220
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.31.53

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE SPCIVO (AZ,EL,XYZ,MS)
   ISN 0003            COMMON/CONST/PAES,DEG,PI,RE
   ISN 0004            DIMENSION XYZ(1)
   ISN 0005            REMS=RE+MS
   ISN 0006            SEL=SIN(EL)
   ISN 0007            CEL=COS(EL)
   ISN 0008            SAZ=SIN(AZ)
   ISN 0009            CAZ=COS(AZ)
   ISN 0010            R=REMS*CEL-SQRT(RE*RE-(REMS*SEL)**2.)
   ISN 0011            XYZ(1)=REMS-R*CEL
   ISN 0012            XYZ(2)=R*SEL*CAZ
   ISN 0013            XYZ(3)=R*SEL*SAZ
   ISN 0014            RETURN
   ISN 0015            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       14 ,PROGRAM SIZE =       536

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          557K BYTES OF CORE NOT USED
```

STATISTICS NO DIAGNOSTICS GENERATED

****** END OF COMPILATION ******

553K BYTES OF CORE NOT USED

```
LEVEL 21.7 ( JAN 73 )                          OS/360  FORTRAN H                                DATE  77.021/09.32.05

             COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                                SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002            SUBROUTINE START
  ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)
  ISN 0004            REAL*4 KINC,EDM
  ISN 0005            COMMON/ELEIT/TC,XMO,XNO,XNDOT,XNDDOT,ASNO,ASNDOT,ARGO,ARGDOT,
                     1 SINIO,COSIO,AO,EO,XIO
  ISN 0006            COMMON EDM(2),KINC
  ISN 0007            DATA XMU,AJ2,TWOPI,DTOR/11467.67422600,.00108248DO,
                     1 6.2831853071800,.0174532925199DO/
  ISN 0008            READ(5,100) ISAT,IYR,DAY,XNDOT,XNDDOT
  ISN 0009        100 FORMAT(2X,I5,11X,I2,F12.8,1X,F10.8,1X,E8.5)
  ISN 0010            READ(5,101) XIO,ASNO,EO,ARGO,XMO,XNO
  ISN 0011        101 FORMAT(7X,2(1X,F8.4),F8.7,1X,2(F8.4,1X),F11.8)
  ISN 0012            XIO=XIO*DTOR
  ISN 0013            XMO=XMO*DTOR
  ISN 0014            ASNO=ASNO*DTOR
  ISN 0015            ARGO=ARGO*DTOR
  ISN 0016            SINIO=DSIN(XIO)
  ISN 0017            COSIO=DCOS(XIO)
  ISN 0018            XNO=XNO*TWOPI
  ISN 0019            XNDOT=XNDOT*TWOPI
  ISN 0020            XNDDOT=XNDDOT*TWOPI
  ISN 0021            AO=(XMU/XNO**2)**.33333333333333DO
  ISN 0022            ADEL=-1.5DO*AJ2*(1.DO-1.5DO*SINIO**2)/DSQRT(1.DO-EO**2)**3
  ISN 0023            AO=AO*(1.DO+ADEL*              (1.DO-ADEL/3.DO))
  ISN 0024            TO=DAYS(IYR,1,0)+DAY
  ISN 0025            CON=1.5DO*AJ2*XNO/(AO*(1.DO-EO**2))**2
  ISN 0026            ASNDOT=-CON*COSIO
  ISN 0027            ARGDOT=CON*(2.DO-2.5DO*SINIO**2)
  ISN 0028            KINC =XIO  /DTOR
  ISN 0029            RETURN
  ISN 0030            END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      29 ,PROGRAM SIZE =      984
```

```
*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******

                                                    555K BYTES OF CORE NOT USED
```

```
      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002              SUBROUTINE TRACK(TIME)
ISN 0003              IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004              NAMELIST/CHECK/T,XMM,ASNM,ARGM,XNM,AM,EM,CONE,AXNE,AYNE,ELSQ,EL,
                     * ARGE,XME,E,SINE,COSE
ISN 0005              COMMON/CRST1/TD,XME,XNO,XNDOT,XNDDOT,ASNO,ASNDOT,ARGO,ARGDOT,
                     1 SINIO,COSIE,AE,EO,XIO
ISN 0006              COMMON/OVW/CX,CY,CZ,VX,VY,VZ,WX,WY,WZ
ISN 0007              COMMON/RK/RX,RY,RZ,R
ISN 0008              DATA AJ2,AJ3,TWOPI,PTOD/.0010E248D0,-2.5e2D-6,6.2831853071800,
                     1 57.2957795130D/
ISN 0009              T=T-ME-TO
ISN 0010              XMM=XMO+T*(XNO+T*(XNDOT+T*XNDDOT))
ISN 0011              ASNM=ASNO+ASNDOT*T
ISN 0012              ARGM=ARGO+ARGDOT*T
ISN 0013              XNM=XNO+T*(2.D0*XNDOT+3.D0*T*XNDDOT)
ISN 0014              AM=AO*(XNO/XNM)**.6666666666700
ISN 0015              EM=1.D0-(1.D0-EO)*AO/AM
ISN 0016              IF(EM.LE.0.D0)EM=1.D-6
ISN 0018              CONE=.25D0*(AJ3/AJ2)*SINIO/(AM*(1.D0-EM**2))
ISN 0019              AXNE=EM*DCOS(ARGM)
ISN 0020              AYNE=EM*DSIN(ARGM)-2.D0*CONE
ISN 0021              ELSQ=AXNE**2+AYNE**2
ISN 0022              EL=DSQRT(ELSQ)
ISN 0023              ARGE=DATAN2(AYNE,AXNE)
ISN 0024              XME=XMM+ARGM-ARGE-CONE*AXNE*(3.D0+5.D0*COSIO)/(1.D0+COSIO)
ISN 0025              XME=DMOD(XME,TWOPI)
ISN 0026              IF(XME.LT.0.D0)XME=XME+TWOPI
ISN 0028              E=XKEPL(XME,EL)
ISN 0029              SINE=DSIN(E)
ISN 0030              COSE=DCOS(E)
ISN 0031              U=DATAN2(SINE*DSQRT(1.D0-ELSQ),COSE-EL)+ARGE
ISN 0032              R=AM*(1.D0-EL*COSE)
ISN 0033              P=AM*(1.D0-ELSQ)
ISN 0034              CONS=.25D0*AJ2/P**2
ISN 0035              SIN2U=DSIN(U+U)
ISN 0036              COS2U=DCOS(U+U)
ISN 0037              R=R+CONS*SINIO**2*COS2U*P
```

```
ISN 0038            U=U-CONS*SIN2U*(3.D0-3.5D0*SINI0**2)
ISN 0039            XIS=XIO+5.DO*CONS*SINIO*COSIO*COS2U
ISN 0040            ASNS=ASNM+3.DO*CONS*COSIO*SIN2U
ISN 0041            SINASN=DSIN(ASNS)
ISN 0042            COSASN=DCOS(ASNS)
ISN 0043            SINI=DSIN(XIS)
ISN 0044            COSI=DCOS(XIS)
ISN 0045            SINU=DSIN(U)
ISN 0046            COSU=DCOS(U)
ISN 0047            UX=COSU*COSASN-SINU*SINASN*COSI
ISN 0048            UY=COSU*SINASN+SINU*COSASN*COSI
ISN 0049            UZ=SINU*SINI
ISN 0050            VX=-SINU*COSASN-COSU*SINASN*COSI
ISN 0051            VY=-SINU*SINASN+COSU*COSASN*COSI
ISN 0052            VZ=COSU*SINI
ISN 0053            WX=SINASN*SINI
ISN 0054            WY=-COSASN*SINI
ISN 0055            WZ=COSI
ISN 0056            RX=R*UX
ISN 0057            RY=R*UY
ISN 0058            RZ=R*UZ
ISN 0059            RETURN
ISN 0060            END
```

```
                ERROR NO   LEVEL        ERROR MESSAGE

    NAME    FTOD   IER3071       04       THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.

*OPTIONS IN EFFECT*      NAME= MAIN,OPT=02,LINECNT=41,SIZE=0000K,
*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
*STATISTICS*     SOURCE STATEMENTS =      59 ,PROGRAM SIZE =     2148
*STATISTICS*    1 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4
****** END OF COMPILATION ******                                    945K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.32.20

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION DAYS(IYR,MON,NDAY)
   ISN 0003            DIMENSION MDAY(12)
   ISN 0004            DATA MDAY/0,31,59,90,120,151,181,212,243,273,304,334/
   ISN 0005            NDAYS=365*(IYR-1977)+(IYR-1973)/4+MDAY(MON)+NDAY
   ISN 0006            LEAP=MOD(IYR,4)
   ISN 0007            IF(LEAP .EQ. 0 .AND. MON .GT. 2) NDAYS=NDAYS+1
   ISN 0009            DAYS=NDAYS
   ISN 0010            RETURN
   ISN 0011            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       10 ,PROGRAM SIZE =       434

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION. ******                          557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/09.32.24

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION EXANM(XM,ECC)
   ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)
   ISN 0004            EXANM=XM
   ISN 0005            DO 10 I=1,50
   ISN 0006            AA=ECC*DSIN(EXANM)
   ISN 0007            DELM=XM-EXANM+AA
   ISN 0008            ZZ=1.D0-ECC*DCOS(EXANM)
   ISN 0009            DELE=DELM/(ZZ+.5D0*DELM*AA/ZZ)
   ISN 0010            IF(DABS(DELE) .GT. 1.) DELE=DELE/DABS(DELE)
   ISN 0012            EXANM=EXANM+DELE
   ISN 0013            IF(DABS(DELE) .LT. 1.D-8) RETURN
   ISN 0015         10 CONTINUE
   ISN 0016            WRITE(6,11)
   ISN 0017         11 FORMAT(10X,27HITERATION DOES NOT CONVERGE )
   ISN 0018            RETURN
   ISN 0019            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       18 ,PROGRAM SIZE =       568

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.32.29

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION ARIES(DAYS)
   ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)
   ISN 0004            DATA TWOPI/6.2831853071800/
   ISN 0005            T=(DAYS+2016.500)/36525.00
   ISN 0006            ARIES=(23925.836+8640001*T+(.542E0+.0929D0*T))/86400.00
                      1  *DMOD(DAYS,1.E0)
   ISN 0007            ARIES=DMOD(ARIES,1.D0) *TWOPI
   ISN 0008            RETURN
   ISN 0009            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        6 ,PROGRAM SIZE =       360

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/09.32.33

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION ACOS(X)
   ISN 0003            ACOS=ARCOS(X)
   ISN 0004            RETURN
   ISN 0005            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        4 ,PROGRAM SIZE =      226

*STATISTICS*  NO DIAGNOSTICS GENERATED

****** END OF COMPILATION. ******                          557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/04.32.37

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION ASIN(X)
   ISN 0003            ASIN=ARSIN(X)
   ISN 0004            RETURN
   ISN 0005            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        4 ,PROGRAM SIZE =       226

*STATISTICS*  NO  DIAGNOSTICS GENERATED

*****  END OF COMPILATION.  *****                          557K BYTES OF CORE NOT USED
```

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE RANVEC(A,N,D,E,M)
                    C
                    C     ------------------------------------------------------------------
                    C
                    C        FUNCTION RECP
                    C
                    C        PURPOSE
                    C           CALCULATE RECIPROCAL OF AN ELEMENT. THIS IS A FORTRAN
                    C           FUNCTION SUBPROGRAM WHICH MAY BE USED AS AN ARGUMENT BY
                    C           SUBROUTINE RPEN.
                    C
                    C        USAGE
                    C           RECP(E)
                    C
                    C        DESCRIPTION OF PARAMETERS
                    C           E - MATRIX ELEMENT
                    C
                    C        REMARKS
                    C           RECIPROCAL OF ZERO IS TAKEN TO BE 1.0E75
                    C
                    C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
                    C           NONE
                    C
                    C        METHOD
                    C           RECIPROCAL OF ELEMENT E IS PLACED IN RECP
                    C
                    C     ------------------------------------------------------------------
                    C
                    C
                    C
                    C        TEST ELEMENT FOR ZERO
                    C
                    C
                    C        IF NON-ZERO, CALCULATE RECIPROCAL
                    C
                    C
                    C        IF ZERO, SET EQUAL TO INFINITY
```

```
C
C
C     ...................................................................
C
C        SUBROUTINE MINV
C
C        PURPOSE
C           INVERT A MATRIX
C
C        USAGE
C           CALL MINV(A,N,D,L,M)
C
C        DESCRIPTION OF PARAMETERS
C           A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY
C               RESULTANT INVERSE.
C           N - ORDER OF MATRIX A
C           D - RESULTANT DETERMINANT
C           L - WORK VECTOR OF LENGTH N
C           M - WORK VECTOR OF LENGTH N
C
C        REMARKS
C           MATRIX A MUST BE A GENERAL MATRIX
C
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C           NONE
C
C        METHOD
C           THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT
C           IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT
C           THE MATRIX IS SINGULAR.
C
C     ...................................................................
C
ISN 0003      DIMENSION A(1),L(1),M(1)
C
C        ...................................................................
C
C        IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE
C        C IN COLUMN 1 SHOULD BE REMOVED FROM THE DOUBLE PRECISION
```

```
C         STATEMENT WHICH FOLLOWS.
C
C     DOUBLE PRECISION A,C,BIGA,HOLD
C
C         THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS
C         APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS
C         ROUTINE.
C
C         THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO
C         CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS.  ABS IN STATEMENT
C         10 MUST BE CHANGED TO DABS.
C
C         ..................................................................
C
C         SEARCH FOR LARGEST ELEMENT
C
ISN 0004        I=1.0
ISN 0005        NK=-N
ISN 0006        DO 80 K=1,N
ISN 0007        NK=NK+N
ISN 0008        L(K)=K
ISN 0009        M(K)=K
ISN 0010        KK=NK+K
ISN 0011        BIGA=A(KK)
ISN 0012        DO 20 J=K,N
ISN 0013        IZ=N*(J-1)
ISN 0014        DO 20 I=K,N
ISN 0015        IJ=IZ+I
ISN 0016     10 IF( ABS(BIGA)- ABS(A(IJ))) 15,20,20
ISN 0017     15 BIGA=A(IJ)
ISN 0018        L(K)=I
ISN 0019        M(K)=J
ISN 0020     20 CONTINUE
C
C         INTERCHANGE ROWS
C
ISN 0021        J=L(K)
ISN 0022        IF(J-K) 35,35,25
ISN 0023     25 KI=K-N
```

```
ISN 0024            DO 30 I=1,N
ISN 0025            KI=KI+N
ISN 0026            HOLD=-A(KI)
ISN 0027            JI=KI-K+J
ISN 0028            A(KI)=A(JI)
ISN 0029         30 A(JI) =HOLD
                 C
                 C        INTERCHANGE COLUMNS
                 C
ISN 0030         35 I=NK(K)
ISN 0031            IF(I-K) 45,45,36
ISN 0032         36 JK=NK(I-1)
ISN 0033            DO 40 J=1,N
ISN 0034            JK=JK+J
ISN 0035            JI=JK+J
ISN 0036            HOLD=-A(JK)
ISN 0037            A(JK)=A(JI)
ISN 0038         40 A(JI) =HOLD
                 C
                 C        DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS
                 C        CONTAINED IN BIGA)
                 C
ISN 0039         45 IF(BIGA) 48,46,48
ISN 0040         46 D=0.0
ISN 0041            RETURN
ISN 0042         48 DO 55 I=1,N
ISN 0043            IF(I-K) 50,55,50
ISN 0044         50 IK=NK+I
ISN 0045            A(IK)=A(IK)/(-BIGA)
ISN 0046         55 CONTINUE
                 C
                 C        REDUCE MATRIX
                 C
ISN 0047            DO 65 I=1,N
ISN 0048            IK=NK+I
ISN 0049            HOLD=A(IK)
ISN 0050            IJ=I-N
ISN 0051            DO 65 J=1,N
ISN 0052            IJ=IJ+N
```

```
ISN 0055            IF(I-K) 60,65,60
ISN 0056         60 IF(J-K) 62,65,62
ISN 0057         62 KJ=IJ-I+K
ISN 0058            A(IJ)=HOLD*A(KJ)+A(IJ)
ISN 0059         65 CONTINUE
                 C
                 C        DIVIDE ROW BY PIVOT
                 C
ISN 0060            KJ=K-N
ISN 0061            DO 75 J=1,N
ISN 0062            KJ=KJ+N
ISN 0063            IF(J-K) 70,75,70
ISN 0064         70 A(KJ)=A(KJ)/BIGA
ISN 0065         75 CONTINUE
                 C
                 C        PRODUCT OF PIVOTS
                 C
ISN 0066            D=D*BIGA
                 C
                 C        REPLACE PIVOT BY RECIPROCAL
                 C
ISN 0067            A(KK)=1.0/BIGA
ISN 0068         80 CONTINUE
                 C
                 C        FINAL ROW AND COLUMN INTERCHANGE
                 C
ISN 0069            K=N
ISN 0070        100 K=(K-1)
ISN 0071            IF(K) 150,150,105
ISN 0072        105 I=L(K)
ISN 0073            IF(I-K) 120,120,108
ISN 0074        108 JC=N*(K-1)
ISN 0075            JK=N*(I-1)
ISN 0076            DO 110 J=1,N
ISN 0077            JK=JC+J
ISN 0078            HOLD=A(JK)
ISN 0079            JI=JK+J
ISN 0080            A(JK)=-A(JI)
ISN 0081        110 A(JI) =HOLD
```

```
ISN 0080        120 J=K(I)
ISN 0081            IF(J-K) 100,100,125
ISN 0082        125 K1=K-K
ISN 0083            DO 130 I=1,N
ISN 0084            K1=K1+N
ISN 0085            HOLD=A(K1)
ISN 0086            J1=K1-K+J
ISN 0087            A(K1)=A(J1)
ISN 0088        130 A(J1) =HOLD
ISN 0089            GO TO 100
ISN 0090        150 RETURN
ISN 0091            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      90 ,PROGRAM SIZE.=     1572

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    541K BYTES OF CORE NOT USED
```

```
      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE CRTE
ISN 0003            COMMON/CONST/RATS
ISN 0004            COMMON/VEC/DIS,20,,VI(3,20),N(3,20),ALT(20),ALPHA(20)
ISN 0005            COMMON/GUESS/GUESSO(3)
ISN 0006            COMMON SATURE(5),NE,AZ(10),EL(10),NT,TIMES(20),SM(200),TARLOC(3)
ISN 0007            DIMENSION S(200),XX(11),YY(11),RES(11,11)
                  C GENERATE LATITUDE AND LONGITUDE GRID WHICH SPANS +- 5 DEG OF INITIAL
                  C TARGET GUESS
ISN 0008            NS=NT*NE
ISN 0009            LATE=MAX1(GUESSO(1)-5.,0.)
ISN 0010            LONE=MAX1(GUESSO(2)-5.,0.)
ISN 0011            LONE=LONE*10.
ISN 0012            TARLOC(3)=GUESSO(3)
                  C FIND SUM OF MEASURED RATES TO USE IN SCALE FACTOR
ISN 0013            S1=0.
ISN 0014            DO 15 I=1,NS
ISN 0015         15 S1=S1+SM(I)
ISN 0016            DO 100 I=1,11
ISN 0017            XX(I)=I-1+LATE
ISN 0018            TARLOC(1)=XX(I)*RATS
ISN 0019            DO 75 J=1,11
ISN 0020            YY(J)=J-1+LONE
ISN 0021            TARLOC(2)=YY(J)*RATS
ISN 0022            CALL OUTPUT(S)
ISN 0023            S2=0.
ISN 0024            DO 40 K=1,NS
ISN 0025         40 S2=S2+S(K)
ISN 0026            SF=S1/S2
ISN 0027            SUM=0.
ISN 0028            DO 50 K=1,NS
ISN 0029         50 SUM=SUM+(SM(K)-SF*S(K))**2
ISN 0030            RES(I,J)=SQRT(SUM)
ISN 0031         75 CONTINUE
ISN 0032        100 CONTINUE
ISN 0033            CALL CONTOR (XX,YY,RES,11,11,11)
ISN 0034            RETURN
ISN 0035            END
```

```
*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
*STATISTICS*     SOURCE STATEMENTS =       34 ,PROGRAM SIZE =      2324
*STATISTICS*  NO  DIAGNOSTICS GENERATED
*****  END OF COMPILATION  *****                                549K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                    DATE  77.021/20:35:10

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE CONTUR (X,Y,Z,NX,NY,ND1MZ)
ISN 0003            DIMENSION X(2),Y(2),Z(ND1MZ,2)
ISN 0004            DIMENSION ZNC(10),ISYM(37),CONV(37),XLABEL(11),
ISN 0005            DATA ISYM/37*1H /
ISN 0006            DATA ISYM(1),ISYM(5),ISYM(9),ISYM(13),ISYM(17),ISYM(21),ISYM(25),
                   * ISYM(29),ISYM(33),ISYM(37)/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,
                   * 1H9/
ISN 0007            NCON=33
ISN 0008            ZMAX=Z(1,1)
ISN 0009            ZMIN=Z(1,1)
ISN 0010            DO 100 IX=1,NX
ISN 0011            DO 100 IY=1,NY
ISN 0012            ZZ=Z(IX,IY)
ISN 0013            IF(ZZ.GT.ZMAX)ZMAX=ZZ
ISN 0015            IF(ZZ.LT.ZMIN)ZMIN=ZZ
ISN 0017        100 CONTINUE
ISN 001E            IF(ZMAX.EQ.ZMIN)RETURN
ISN 0020            XMIN=X(1)
ISN 0021            XMAX=X(NX)
ISN 0022            YMIN=Y(1)
ISN 0023            YMAX=Y(NY)
ISN 0024            DX=(XMAX-XMIN)/100.0
ISN 0025            DY=(YMAX-YMIN)/40.0
ISN 0026            DELC=(ZMAX-ZMIN)/FLOAT(NCON-1)
ISN 0027            CONV(1)=ZMIN
ISN 002E            DO 110 I=2,NCON
ISN 0029        110 CONV(I)=CONV(I-1)+DELC
ISN 0030            WRITE(6,90)
ISN 0031         90 FORMAT(1H1,T119,12HSYMBOL TABLE,/15X,10('+---------'),'+')
ISN 0032            II=1
ISN 0033            YY=YMAX+DY
ISN 0034            DO 540 LY=1,41
ISN 0035            YY=YY-DY
ISN 0036            XX=XMIN-DX
ISN 0037            DO 500 LX=1,101
ISN 0038            XX=XX+DX
ISN 0039            IA=1
```

```
ISN 0040          IM=XX
ISN 0041      300 IL=IM
ISN 0042      310 IF((IL-IA).LE.1)GO TO 320
ISN 0044          IM=(IA+IL)/2
ISN 0045          IF(X(IM).GE.XX)GO TO 300
ISN 0047          IA=IM
ISN 0048          GO TO 310
ISN 0049      320 IPX=IA
ISN 0050          IA=1
ISN 0051          IM=NY
ISN 0052      400 IL=IM
ISN 0053      410 IF((IL-IA).LE.1)GO TO 420
ISN 0055          IM=(IA+IL)/2
ISN 0056          IF(Y(IM).GE.YY)GO TO 400
ISN 0058          IA=IM
ISN 0059          GO TO 410
ISN 0060      420 IPY=IA
ISN 0061          FRX=(XX-X(IPX))/(X(IPX+1)-X(IPX))
ISN 0062          FRY=(YY-Y(IPY))/(Y(IPY+1)-Y(IPY))
ISN 0063          ZU=Z(IPX,IPY+1)+FRX*(Z(IPX+1,IPY+1)-Z(IPX,IPY+1))
ISN 0064          ZL=Z(IPX,IPY)+FRX*(Z(IPX+1,IPY)-Z(IPX,IPY))
ISN 0065          ZZ=ZL+FRY*(ZU-ZL)
ISN 0066          IZ=(ZZ-ZMIN)/DELC+1.5
ISN 0067          IZ=MINO(NCOL,MAXO(1,IZ))
ISN 0068      500 LINE(LX)=ISYM(IZ)
ISN 0069          IF(MOD(LY-1,4) .NE. 0) GO TO 518
ISN 0071          IF(II .LE. NCOL) GO TO 511
ISN 0073          WRITE(6,510)YY,LINE
ISN 0074      510 FORMAT(1PE13.2,' +',101A1,'+')
ISN 0075          GO TO 540
ISN 0076      511 WRITE(6,512)YY,LINE,ISYM(II),CONV(II)
ISN 0077      512 FORMAT(1PE13.2,' +',101A1,'+',1X,A1,2X,E11.4)
ISN 0078          II=II+4
ISN 0079          GO TO 540
ISN 0080      518 IF(II .GT. NCOL) GO TO 520
ISN 0082          WRITE(6,519)LINE,ISYM(II),CONV(II)
ISN 0083      519 FORMAT(14X,'1',101A1,'1',1X,A1,2X,1PE11.4)
ISN 0084          II=II+4
ISN 0085          GO TO 540
```

```
ISN 0086        520 WRITE(6,530)LINE
ISN 0087        530 FORMAT(15X,'1',10(A1,'1'))
ISN 0088        540 CONTINUE
ISN 0089            XLABEL(1)=XMIN
ISN 0090            DX=(XMAX-XMIN)/10.0
ISN 0091            DO 550 I=2,11
ISN 0092        550 XLABEL(I)=XLABEL(I-1)+DX
ISN 0093            WRITE(6,560)XLABEL
ISN 0094        560 FORMAT(15X,10(1H+,9H---------),1H+/10X,11(1PE10.2))
ISN 0095            WRITE(6,220)X(6),Y(6)
ISN 0096        220 FORMAT(/17X,'ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LO
                   *G) OF',2F10.2,' DEGREES')
ISN 0097            RETURN
ISN 0098            ENTRY PREPLT
ISN 0099            RETURN
ISN 0100            ENTRY STPLOT
ISN 0101            RETURN
ISN 0102            ENTRY ARCTAT
ISN 0103            RETURN
ISN 0104            ENTRY EXPLOT
ISN 0105            RETURN
ISN 0106            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =     105 ,PROGRAM SIZE =     3220

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    541K BYTES OF CORE NOT USED

*STATISTICS*    2 DIAGNOSTICS THIS STEP, HIGHEST SEVERITY CODE IS  4
```

```
F64-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED MAP,LIST
        DEFAULT OPTION(S) USED -  SIZE=(126976,24576)
```

MODULE MAP

CONTROL SECTION

NAME	ORIGIN	LENGTH
MAIN	00	14E
ALLEPH	150	20C
LATIN	360	1AC
PLTOUT	C0E	4C6
DD1	1000	11C
OUTPUT	11F0	242
REFINE	1438	14CA
RESPON	2906	C2
NOTE	29F0	2F2
SPCTVU	2CAE	2AA
EPHM	2EF8	4C4
START	33C0	368
TRACK	3796	664
DAYS	3000	1E2
EXANM	31E8	238
ARIES	43F0	182
ACOS	4578	E2
ASIN	4660	E2
MINV	4746	624
GRID	4D70	514
CONTOR	5EEE	C94
IHCSATN2*	6320	10E
IHCSSCN *	64F0	1D9
IFCLATN2*	66D0	251
IHCLSCN *	6928	26C
IHCFRXPR*	6E98	183
IHCECOMH*	6D20	F61

ENTRY

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
EPHM1	3324						
PRPLOT	620C	STPLOT	6250	ANNTAT	6294	ENPLOT	62D8
ATAN2	6320	ATAN	6334				
COS	64F0	SIN	6508				
DATAN2	66D0	DATAN	66E8				
DCOS	6928	DSIN	6942				
FRXPR=	6E98						
IBCOM=	6D20	FDIOCS=	6D0C	INTSWTCH	7C66		

INCCOMM2*	7C8F	0FE
INCSSWRT*	6FEE	145
INCFCVTM*	6430	119E
INCSEDC *	95D0	1E6

SRCBASE	E000						
SCRT	82E8						
ADCONF	8430	FCVADUTP	84DA	FCVECUTP	65FA	FCV2OUTP	66EA
FCV1OUTP	8466	FCVEOUTP	FF6A	FCVCOUTP	91F4	INT6SWCH	944E
ALOG10	95D0	ALOG	95E6				

NAME	LOCATION	LENGTH
IHCSASIN*	97EE	1E1
IHCLASIN*	99CE	24F
IHCLSQRT*	9BEE	15E
IHCSEXP *	9E1E	1A2
IHCFDXPE*	9EC0	1A0
IHCFFIOS*	A050	F26
IHCFIOSE*	AF7E	52C
IHCERRM *	E4AE	5D4
IHCFMATH*	EA80	542
IHCLEXP *	EFCE	2E6
IHCLLOG *	C250	200
IHCTRCH*	C450	2EC
IHCUATBL*	C6E0	636
IHCUCPT *	CE1E	500
$ELARKCOM	D01E	3EC
CONST	D408	10
VCC	D418	370
DAY	D7BE	4
GUESS	D790	C
ITER	D7A0	4
LVM	D7AE	4E
SAVPOS	D7F0	A0
ER	DE90	20
DRETT	DBE0	70

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
ARCOS	97BE	ARSIN	97CE				
DARCOS	9968	DARSIN	9980				
DSQRT	9BB8						
EXP	9D1E						
FDXPD=	9EE0						
FIOCS=	A050	FIOCSBEF	A056				
ERRMON	E4AB	IHCSFRE	B4C0				
ARITH=	EA60	ADJSWTCH	EE1C				
DEXP	EFC8						
DLOG10	C250	DLOG	C268				
IHCTRCH	C450	ERRTRA	C456				

ENTRY ADDRESS 00

TOTAL LENGTH D920

***MAIN DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET AUTHORIZATION CODE IS 0.

THE IVAN A. GETTING LABORATORIES

The Laboratory Operations of The Aerospace Corporation is conducting experimental and theoretical investigations necessary for the evaluation and application of scientific advances to new military concepts and systems. Versatility and flexibility have been developed to a high degree by the laboratory personnel in dealing with the many problems encountered in the nation's rapidly developing space and missile systems. Expertise in the latest scientific developments is vital to the accomplishment of tasks related to these problems. The laboratories that contribute to this research are:

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Chemistry and Physics Laboratory: Atmospheric reactions and atmospheric optics, chemical reactions in polluted atmospheres, chemical reactions of excited species in rocket plumes, chemical thermodynamics, plasma and laser-induced reactions, laser chemistry, propulsion chemistry, space vacuum and radiation effects on materials, lubrication and surface phenomena, photosensitive materials and sensors, high precision laser ranging, and the application of physics and chemistry to problems of law enforcement and biomedicine.

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Materials Sciences Laboratory: Development of new materials; metal matrix composites and new forms of carbon; test and evaluation of graphite and ceramics in reentry; spacecraft materials and electronic components in nuclear weapons environment; application of fracture mechanics to stress corrosion and fatigue-induced fractures in structural metals.

Space Sciences Laboratory: Atmospheric and ionospheric physics, radiation from the atmosphere, density and composition of the atmosphere, aurorae and airglow; magnetospheric physics, cosmic rays, generation and propagation of plasma waves in the magnetosphere; solar physics, studies of solar magnetic fields; space astronomy, x-ray astronomy; the effects of nuclear explosions, magnetic storms, and solar activity on the earth's atmosphere, ionosphere, and magnetosphere; the effects of optical, electromagnetic, and particulate radiations in space on space systems.

THE AEROSPACE CORPORATION
El Segundo, California

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