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**PALLOT: A FORTRAN CODE THAT PRODUCES
GRAPHICAL REPRESENTATIONS OF NUCLEAR
BLACKOUT EFFECTS ALONG A REENTRY TRAJECTORY**

M. D. Maples

August 17, 1973

Prepared for U.S. Atomic Energy Commission under contract No. W-7405-Eng-48

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PALLOT: A FORTRAN CODE THAT PRODUCES GRAPHICAL REPRESENTATIONS OF NUCLEAR BLACKOUT EFFECTS ALONG A REENTRY TRAJECTORY

Abstract

The PALLOT code was developed to simplify the assimilation of data relating to effects of nuclear blackout on particular reentry trajectories. This code operates in three modes: azimuth, elevation, and inline. In the azimuth and elevation modes, the PALLOT picture represents a family of trajectories that only vary, respectively, in approach azimuth and

impact elevation angle. The inline mode depicts a set of reentry vehicles approaching on the same trajectory through a nuclear environment. The code, written in Fortran IV, was developed on the CDC 7600 computer; it will run on the CDC 6600 without modification although the run times may be excessively long.

Introduction

PALLOT^{1,2} (PONDER ALong Locus Of Trajectories) is an extension of the code PONDER³⁻⁶ (Pictures Of Nuclear Device Effects From RANC), which provides a convenient means of displaying data from the RANC⁷ (Radar Absorption Noise and Clutter) code. The PALLOT code is documented in this report.

The PALLOT code relates blackout absorption and refraction to system, geometric, and weapon parameters. PALLOT provides pictorial representations of the time-dynamic effects of blackout on a radar beam; it uses the RANC code for blackout calculations. The spatial extent and degree of blackout can be determined by systematically selecting a number of target sample points on a prescribed surface.

PALLOT has four modes of operation: the azimuth, elevation, inline, and complete time history modes. In the first two modes the PALLOT code generates a surface of sample points described by a set of trajectories, with common impact points distributed in azimuth and elevation, respectively. Time can be allowed to advance for the burst phenomenology as one samples each line on this surface. The rate of time advance is determined by the reentry vehicle (RV) parameters chosen. Thus, the time dynamic blackout for a number of RV trajectories can be observed on one picture. In contrast, the inline mode provides a picture of the blackout history along a trajectory as a function of phenomenology time. In this case a number of RV's can be observed moving

along the same trajectory. The complete time history mode holds a set of RV's stationary along a selected trajectory while phenomenology time is allowed to increment. This mode allows the accumulation of the total phenomenology effects on a selected trajectory and encompasses the information produced in the inline mode. The tradeoff between these two modes is between their associated run times (the complete time history mode runs five to six times longer than the equivalent inline mode) and their respective information content.

Pictures can be obtained for signal/noise, signal/noise-plus-clutter, signal/clutter, and clutter/noise ratios. The cause of the blackout (e.g., fireball ioni-

zation, γ -ray ionization, etc.) is identified on a picture. The area blacked out on the surface is calculated and can be used for doing trend analysis and parameter sensitivity studies. PALLOT is also useful as a visual aid in understanding the RANC phenomenology.

The remainder of this report is divided into three sections. In the following section the four modes of the PALLOT code are covered in detail. The next section consists of a brief explanation of the overlays presently being used at the Lawrence Livermore Laboratory. The last section contains the appendices, which include program listings, descriptions of input variables, and sample overlays.

PALLOT Modes

PALLOT utilizes the RANC IVA⁷ package developed by GE-TEMPO. The block diagram in Fig. 1 shows the relationship between PALLOT and RANC IVA.

Figure 2 lists the general subroutine flow in PALLOT. An asterisk denotes a subroutine written or modified (from RANC) for PALLOT; all other subroutines are RANC IVA subroutines. Refer to Appendix 1 for subroutine listings.

Fig. 1. Block diagram of the relationship between PALLOT and RANC IVA.

Figure 3 shows RANC IVA's unmodified input format, while Fig. 4 shows PALLOT's

Fig. 2. Subroutine flow in PALLOT. The asterisks denote subroutines written or modified for PALLOT.

input format. The two formats are identical with the exception of cards 5, 7, 8, and

9 (see Appendix 2). The RANC IVA variables are documented in Ref. 7.

Card columns									
1	10	20	30	40	50	60	70	72	75-80
1	Radar frequency (MHz)	Peak power (MW)	Range resolution (m)	Velocity resolution (m/sec)	Transmitter antenna gain (dB)	3 dB beamwidth (deg)	Sidelobe level (dB down)	k_i	Optional alpha label
2	Minimum S/N (b)	Sys noise temperature ($^{\circ}$ K)	Receiver noise bnwth (kHz)	Pulse compression ratio	Receiver antenna gain (dB)	3 dB beamwidth (deg)	Sidelobe level (dB down)		Optional alpha label
3	Antenna sidelobe spec	Array scan limit (deg)	Array face elevation (deg)	First face azimuth (deg)	Second face azimuth (deg)	Third face azimuth (deg)	Fourth face azimuth (deg)		
4	N latitude of origin (deg)	E longitude of origin (deg)	Day or night (1 or 0)	Calculation option	Normal output option	Beam-pointing option	Detailed output option		
Radar location									
5	X(N)	Y(N)	Z(N)	Magnetic dip at radar (deg)	Magnetic variation at radar (deg)			N	Optional alpha label
Burst location (up to 50 bursts)									
6	X(N)	Y(N)	Z(N)	Detonation time (sec)	Total yield (Mt)	Fission fraction	Device type	N	Optional alpha label
Trajectory parameters				Impact location					
7	Nominal surface range (km)	Nominal launch/impact elev (deg)	Nominal launch/impact vel (km/sec)	Final approach az (deg)	Surface range	True azimuth	Earth rotation (0=yes, 1=no)	1	Optional alpha label
					N latitude	E longitude		0	
RV parameters									
8	Radar cross sec (m^2)	Ballistic coefficient (lb/ft^2)	Reference altitude (km)	Time at reference (sec)	Reference on descent or ascent (1 or 0)				Optional alpha label
Calculation times (sec) (up to 100 times, 7 per card)									
9	t_1	t_2	t_3	etc.					

Blank card at end of each case

Fig. 3. RANC IVA input format.

Card columns									
1	10	20	30	40	50	60	70	72	75-80
1	Radar frequency (MHz)	Peak power (MW)	Range resolution (m)	Velocity resolution (m/sec)	Transmitter antenna gain (dB)	3 dB beamwidth (deg)	Sidelobe level (dB down)	k _i	Optional alpha label
2	Minimum S/N (b)	Sys noise temperature (°K)	Receiver noise bwnth (kHz)	Pulse compression ratio	Receiver antenna gain (dB)	3 dB beamwidth (deg)	Sidelobe level (dB down)		Optional alpha label
3	Antenna sidelobe spec	Array scan limit (deg)	Array face elevation (deg)	First face azimuth (deg)	Second face azimuth (deg)	Third face azimuth (deg)	Fourth face azimuth (deg)		
4	N latitude of origin (deg)	E longitude of origin (deg)	Day or night (1 or 0)	Calculation option	Normal output option	Beam-pointing option	Detailed output option		
Radar location					Impact point				
5	X(N)	Y(N)	Z(N)	Magnetic dip of radar (deg)	Magnetic variation at radar (deg)	Ground range	Azimuth	N	Optional alpha label
Burst location (up to 50 bursts)									
6	X(N)	Y(N)	Z(N)	Detonation time (sec)	Total yield (Mt)	Fission fraction	Device type	N	Optional alpha label
7	TSEC(NT)	MAXNMX	NCRCT	SIGMA (RCS)	MROTE	QREF	DLTH	I F L	Optional alpha label
8	ATIFO	GRANGE	VFPEO	VVEL	HREF	TREFO	BETA	T M A D Y	Optional alpha label
9	PLDEN	RDEN	UNITHO	UNITVO	NMXO	NPXO	NHR NHR1		
9A	SBOCRIT	DSNBOCR	THCLTR	DTHCLTR	THDIFF	DTHDIFF		I	

Blank card at end of each case

Fig. 4. PALLOT input format.

Fig. 5. PALLOT azimuth mode.

AZIMUTH MODE

When IFL^{*} is set equal to zero, PALLOT runs in the azimuth mode. The azimuth mode keeps the trajectory ground range and elevation angle constant while varying the azimuth angle to the impact point (see Fig. 5). The azimuth mode operates in two formats: constant phenomenology time and changing

phenomenology time. The TMADV switch in column 72 of card eight controls these two formats. When TMADV equals zero, the azimuth surface will be produced at a constant phenomenology time. When TMADV equals one, the azimuth surface will be produced with changing phenomenology time. The difference between these two formats is that in the constant phenomenology format, RANC IVA calculates the blackout only at the given TSEC (NT) time for the complete azimuth mode surface; but, when TMADV equals

^{*}Definitions of terms may be found in Appendix 2.

Fig. 7. PALLOT elevation mode.

ELEVATION MODE

The elevation mode keeps the trajectory ground range and azimuth angle constant while varying the elevation angle. (See Fig. 7.) The elevation mode is selected when the switch IFL is set equal to two. Like the azimuth mode, the elevation mode operates in two formats: phenomenology time constant and phenomenology time changing. The operation of these formats is analogous to the operation of the phenomenology time formats in the azimuth mode. If TMADV equals zero, the phenomenology time, TSEC (NT), is frozen for all PALLOT calculations. If,

however, TMADV equals one, then phenomenology time changes from RV time frame to RV time frame (see Fig. 8). The phenomenology time is represented by the relationship

$$TSEC (NT) = TREF0 - NX * UNITV0$$

where NX indicates the time frame in which the RV is located. It can be seen from Fig. 8 that for a negative NX, TSEC (NT) represents an increasing phenomenology time as the RV approaches the impact point. Similarly, for a positive NX, phenomenology time decreases as the RV moves away from the burst point

reference trajectory intercept – until, of course, TSEC (NT) becomes zero, whereupon the RV glides through a benign environment.

The elevation angle in this mode is controlled by the input variables NMX0 and NPX0. Using the trajectory with launch angle equal to VFPE0 deg as the reference trajectory, this mode moves NMX0 * UNITH0 deg (NMX0 printout columns to the left) below the reference trajectory and NPX0 * UNITH0 deg (NPX0 printout columns to the right) above the reference trajectory.

INLINE MODE

The most complicated of the three PALLLOT modes is the inline mode (IFL=1). (See Fig. 9.) This mode was written to study the effects of multiple RV's located on the same trajectory, but spaced a certain time (UNITH0) apart. The RV's are allowed to move along the trajectory in constant time increments (UNITV0) (see Figs. 9, 10, and 11). RANC IVA calculations are performed on the RV's along the trajectory after each incrementation of UNITV0. Further detail is needed to

Fig. 8. Detailed view of the PALLLOT elevation mode.

Fig. 9. PALLOT inline mode.

Fig. 10. PALLOT inline mode RV configuration.

explain the intricate workings of the inline mode. First, the inline mode with phenomenology time frozen will be described, then the case with changing phenomenology time will be discussed.

Constant Phenomenology Time

PALLOT's pictures represent a set of RV's on a particular trajectory for a constant phenomenology time (TSEC = constant). An inline mode picture is formed by the following process:

(1) The RV's are taken as they are positioned along the trajectory at time TREF0, and these conditions are considered as defining a reference trajectory. The reference RV is located at HREF at time TREF0. (Refer to Fig. 11.)

(2) PALLOT then moves up the trajectory $NHR * UNITV0$ sec from the

impact point and relocates the reference RV at this position with NMX0 RV's below it and NPX0 RV's above it.

(3) Next, PALLOT proceeds to move this set of RV's down the trajectory in increments of UNITV0 sec until it has completed NHR1 increments. Thus, PALLOT produces an $n * m$ matrix of RANC IVA calculations where

$$n = NHR1 \text{ and } m = NPX0 + NMX0.$$

Incrementing Phenomenology Time

This mode, as would be expected, is similar to the preceding mode. The phenomenology time TSEC (NT) is set equal to TREF0 - DVT, where DVT is the number of rows above the reference trajectory row. (See Fig. 11b.) Then, concurrent with the movement of the RV's

down the trajectory in increments of UNITV0 sec, the phenomenology time is increased in increments of UNITV0 sec.

COMPLETE TIME HISTORY MODE

When it is desirable to observe the effects of a burst along a specific trajectory

(a) inline mode reference trajectory

(b) PALLOT picture output matrix

Fig. 11. Detailed view of the PALLOT inline mode.

(a) Complete time history mode
RV positions remain constant
while phenomenology time
increments.

(b) PALLOT picture output matrix

Fig. 12. PALLOT complete time history mode RV breakdown.

Fig. 13. PALLOT complete time history mode.

for a particular set of phenomenology times, the complete time history mode is used (setting IFL=3). This mode allows the user to select portions of the RV's trajectory and freeze that trajectory for any set of phenomenology times. The controlling variables of this mode are shown in Fig. 12. Figure 13 shows the OZ overlay of a complete time history run. NHR is the number of RV's above

the reference altitude HREFO (km). UNITH0 is the RV separation in seconds. NPX0 is the number of phenomenology calculations to be made after TREF0 sec; NMX0 is set equal to zero in this mode. Finally, UNITVO is the increment of time between phenomenology calculations, and it must equal UNITH0 in this mode. The complete time history mode sweeps time from TREF0 sec to TREF0 + NHR

* UNITVO sec, and the altitude from HREF0 km to HREF0 + NPX0 * UNITH0 * (X km/sec) km. (X is a factor dependent on the selected trajectory and is internally calculated in the code.) This mode has

been found extremely useful in analyzing the blackout effects of a burst on reentry trajectories. A sample of PALLOT's complete time history mode is shown in Appendix 3.

Overlays

PALLOT has two overlays (OZ and TY) that operate on its various outputs; overlay OZ can be used with all four modes. The only rule that need be remembered in using these overlays is that the rows to be printed (using the dd80, a display device at the Lawrence Livermore Laboratory) do not exceed 80 in number and 60 columns in length.

Samples of OZ working on the various

modes are shown in the appendices. However, a second overlay was written for the inline mode because the OZ overlay for this mode is confusing. The TY overlay performs a matrix manipulation of the final PALLOT pictures to present constant altitude lines horizontally on the dd80 plots. A comparison of the two overlays for this mode will give the user a quick appreciation of this second overlay.

Acknowledgments

The author wishes to acknowledge the invaluable assistance of Ross Castleton, who programmed the PALLOT code, in the collection and composition of the in-

formation contained in this document. The author also greatly appreciated the constant reviews, critiques, and suggestions of D. R. Dunn and W. A. Turin.

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Appendix 1

PALLOT Listing

PALLOT

This program uses RANC IVA as a subroutine to calculate nuclear blackout effects along a family of reentry trajectories. Subroutines SPRAY and TRAJECTORY are used to produce this family of trajectories.

```

PROGRAM PALLOT(INPUT,TAPE5=INPUT,OUTPUT,TAPE6=OUTPUT,POUT,
1TAPE7=POUT,PLOTSN,TAPE8=PLOTSN,PLOTCL,TAPE9=PLOTCL,PLOTDF,
2TAPE10=PLOTDF,PLOTPC,TAPE11=PLOTPC)
CALL CHANGE(7H+PALLOT)
ILEN=10000
CALL CREATE(6HOUTPUT,ILEN,M1WD)
ILEN=10000
CALL CREATE(4HPOUT,ILEN,M1WD)
ILEN=40000
CALL CREATE(6HPLOTSN,ILEN,M1WD)
ILEN=40000
CALL CREATE(6HPLOTCL,ILEN,M1WD)
ILEN=40000
CALL CREATE(6HPLOTDF,ILEN,M1WD)
ILEN=40000
CALL CREATE(6HPLOTPC,ILEN,M1WD)
COMMON /EXEC/CLTR(50),SRCL(50),DSRCL(50),VC(50),DVC(50),
1SIGMAC(50),ETA(50),FPNE(50),FBUB(50),FBRHO(50),
2KEYC(50),TANT(50),AZFB(50),ELFB(50),DBTOFB(50),
3DBS(50),OMEGAB(50),KEYN(50),ACLTR,SRAC,DSRAC,VAC,
4DVAC,ASIGMA,ETAA,ENEA,ADBPKM,KEYA,AZAC,ELAC,DBAC,
5TASUM
COMMON /BURST/NB,W(50),TSX(50),FF(50),HB(50),XBR(50),YBR(50),
1ZBR(50),TB(50),COSCLB(50),RDZERO(50),RHZERO(50),
2RUZERO(50),LHVB(50),RHOB(50),HSB(50),PKTERM(50),
3RLK(50),RTK(50),DISTK(50),XKR(50),YKR(50),ZKR(50),
4TILTK(50),WUV(3,50),HR,COSCLR,SINCLR,KALCH,KALCN,
5KALCR,DAY,CIRAX,TEM150,NSW1,NSW2,NSW3,NSW4,NSW5,NSW6
COMMON /RADAR/FREQ,POWER,DELTAR,DELTAV,TAG,TBW,TSL,SNMDB,TSYS,BWN,
1PCOMP,RAG,RBW,RSL,KSPEC,SCAN,EFACE,AFACEM(4),NF#CE
COMMON/TARGET/RCS,STR,ATR,ETR,VTR,TSEC(1),SIGNAL,SNCTRC,DBTAR,
1AER,EER,RER,DISP,KEYT,DOUT,LFOUT
COMMON/REGION/NF,INDEX(50),FLABL(50),KINDF(50),RFB(50),AFB(50),
1HF(50),XFR(50),YFR(50),ZFR(50),RLF(50),RTF(50),
2TILTF(50),HMINF(50),HMAXF(50),TF0(50),TF(50),
3RHOF(50),HSNF(50),HDOF(50),RDOF(50)
COMMON/PNCIN/PLDEN,RDEN,NMXX,NPXX,NHR1,NHR,UNITH,UNITV,ATIFO,
1TREFO,VFPEO,IFL,RTG,MAXNMX,NCRCT,VARR,SBOCRIT,DSNBOCR,THCLTR,
2DTHCLTR,DTHIFF,DTHDIFF
COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1RTI,ATI,HT,VT,BT,ELV,RANGE,GAMA,VZ,A,E,HAPD,TAPO,RL1,ALI,TL,HDRAG,
2EDRAG,VDRAG,TDRAG,EIMP,VIMP,TIMP,KLOSS
COMMON/CONST/RE,PI,RADIAN
COMMON/RNC/1CONF
COMMON/CNTMADV/TMADV
COMMON/TARCNT/ITOT
COMMON/DELLTAH/DLTH
COMMON/RAZMDD/IIFL

```

```

    DIMENSION SNPRES(500),SNPREV(500),CLPRES(500),DFPRES(500),
    1 PCPRES(500),KYT(500),S(150)
    NPGUT=7
    NPLTSA=8
    NPLTCL=9
    NPLTDF=10
    NPLTPL=11
    ICCNF=1
    GO TO 3
1   ICCNF=2
3   CALL KANC
    RTG=100000.
    IAREA=0
    AREA1=0.
    AREA0=0.
    MXTANT=0.
    MXDBTF=0.
    MXDBS=0.
    MXTF=0.
    MXFBR=0.
    MXFBE=0.
    MXFBD=0.
    ITOT=0
    SNBOCR=SBOCRIT+DSNBOCR
    CLBOCR=THCLTR-DTHCLTR
    DFBOCR=THOIFF+DTHOIFF
    UNITVO=PLDEN*UNITV
    UNITHO=PLDEN*UNITH
    UNITVR=RDEN*UNITVO
    UNITHR=RDEN*UNITHO
    WRITE(NPGUT,3003)UNITHR,UNITVR,UNITHO,UNITVO,UNITH,UNITV,NMXR,
    1 NPXR,NHRI,NHR,MAXNM,ATIFO,RDEN,DLTH,TREFO,HREF,QREF,GRANGE,
    2 VFPEO,VVEL,BETA,CLI,MROTE,SBOCRIT,DSNBOCR,THCLTR,DTHCLTR,
    3 THOIFF,DTHOIFF,IFL
    IPLDEN=PLDEN
    IRDEN=RDEN
    IRP=IRDEN*IPLDEN
    NMXIRD=NMXR*IRDEN
    NPXIRL=NPXR*IRDEN
    MAXNRV=(NMXR+NPXR)*IRP+1
    DO 8100 I=1,MAXNRV
    PCPRES(I)=0.
    CLPRES(I)=0.
    DFPRES(I)=0.
    SNPRES(I)=0.
8100 SNPREV(I)=0.
    IPLOT=2
    IRUN=2
    NPRES=0
    NLPRES=0
    NRPRES=0
    ELREF=NR1*UNITVR
    DO 6000 I1=1,NHR
    GO TO(7001,7002),IRUN
7002 GO TO(7701,7702),IPLUT
7702 CONTINUE
    IPLOT=1
    IRUN=1
    NMX=NMXR
    NPX=NPXR
    UNH=UNITHR
7001 CONTINUE
    ELREF=ELREF-UNITVR

```

```

      IO=1
      GO TO 7003
7701  CONTINUE
      ELR=ELREF
      UNH=UNITH
      IO=IRP
7003  DO 6003 I2=1,IO
      GO TO(7006,7005),IRUN
7005  ELREF=ELR+(IRP-I2)*UNITV
      ILNCT=0
      IRNCT=0
7006  CONTINUE
      IL=0
      IR=0
      ILEFT=1
      NR=NMX+1
      NRV=NMX+NPX+1
      NRVPREV=0
      IF(IIFL.EQ.1) GO TO 9999
      IF(TMADV.NE.0.) TSEC(1)=TREFO-ELREF+DLTH
9999  CONTINUE
7702  CONTINUE
      DO 309 ITRGT=1,NRV
      ICGNF=3
      IF((ITRGT.EQ.1).AND.((NCRCT.EQ.0).OR.((NCRCT.GT.0).AND.(NTL.EQ.0)
      1.AND.(NTR.EQ.0)))AND.(TMADV.NE.0.)) ICONF=4
      GO TO(5001,5002,5003),ILEFT
5001  CONTINUE
      NR=NR-1
      GO TO 5004
5002  CONTINUE
      NR=-NPX
      ILEFT=3
      GO TO 5004
5003  CONTINUE
      NR=NR+1
5004  CONTINUE
      CALL SPRAY(RTG,UNH,NR,ELREF,ATIFO,TREFO,VFPEO,IFL,VARR,RCS)
      IF(RTG.GT.0.) GO TO 1901
      SIGNAL=SNBOCR+1000.
      SNCTRC=CLBOCR-1000.
      GO TO 1902
1901  CONTINUE
      IF(IIFL.EQ.1) TSEC(1) = TREFO+(ITRGT-1)*UNITVO
      CALL RANC
      DO 8800 INB=1,NF
      MXTANT=MAX1F(MXTANT,TANT(INB))
      MXDBTF=MAX1F(MXDBTF,DBTOFB(INB))
      MXDBS=MAX1F(MXDBS,DRS(INB))
      MXTF=MAX1F(MXTF,TF(INB))
      MXFBR=MAX1F(MXFBR,FBRHO(INB))
      MXFBE=MAX1F(MXFBE,FBNE(INB))
      MXFBD=MAX1F(MXFBD,FBDB(INB))
8800  CONTINUE
1902  CONTINUE
      DIFF= SIGNAL-SNCTRC
      SNPC= 10.**((-DIFF/10.)+10.**(-SIGNAL/10.))
      SNPC=-10.*LOG10F(SNPC)
      GO TO(5005,308),IRUN
5005  CONTINUE
      IF((SNPC-SNBOCR).GE.0.).AND.((SIGNAL-SNBOCR).GE.0.)) GO TO 309
5006  GO TO(5007,5008,5008),ILEFT
5007  ILEFT=2

```

```

      IL=ITRGT
      GO TO 309
5008  ITRGT=NRV
      IR=NPX+NR+1
      GO TO 309
308   CONTINUE
      SNPRES(ITRGT+NPVPREV)=SIGVAL
      PCPRES(ITRGT+NRVPREV)=SNPC
      CLPRES(ITRGT+NRVPREV)=SNLTRC
      DFPRES(ITRGT+NRVPREV)=DIFF
      KYT(I:RGT+NRVPREV)=KEYT
309   CONTINUE
      GO TO(7007,7008), IRUN
7007  CONTINUE
      IF((IL.GT.0).AND.(IR.EQ.0)) IR=NRV+1-IL
      CALL FIT(NPRES,NLPRES,NRPRES,IRUN,NMXR,NPXR,NMXO,NPXO,NMX,NPX,
      I1PLDEN,IRDEN,MAXNMX,IL,IR)
      GO TO 6003
7008  CONTINUE
      IF(NCRCT.EQ.0) GO TO 9003
      IF(IRNCT.EQ.1) GO TO 7801
      IF(ILNCT.EQ.1) GO TO 7802
      ILCT=0
      IF(((PCPRES(1)-SNBOCR).LT.0.).OR.((SNPRES(1)-SNBOCR).LT.0.))
      IILCT=1
      IRCT=0
      IF(((PCPRES(NRV)-SNBOCR).LT.0.).OR.((SNPRES(NRV)-SNBOCR).LT.0.))
      IIRCT=1
      IF((ILCT.EQ.0).AND.(IRCT.EQ.0)) GO TO 9003
      CALL CRCT(NMXIR,NPXIRD,NMXO,NPXO,NMX,NPX,NPXR,I1PLDEN,NCRCT,ILCT,
      IIRCT,NRVL,NRVR,NRL,NRR)
      ILNCT=1
      IF(NRVL.GT.0) GO TO 7803
7804  CONTINUE
      IRNCT=1
      IF(NRVR.GT.0) GO TO 7805
7806  CONTINUE
      ILCT=0
      IF(((PCPRES(1)-SNBOCR).LT.0.).OR.((SNPRES(1)-SNBOCR).LT.0.))
      IILCT=1
      IRCT=0
      IF(((PCPRES(NRV)-SNBOCR).LT.0.).OR.((SNPRES(NRV)-SNBOCR).LT.0.))
      IIRCT=1
      CALL ANALYZE(NRVL,NRVR,ILCT,IRCT,ELREF)
      GO TO 9003
7801  CONTINUE
      NRV=NMX+NPX+1
      GO TO 7806
7802  CONTINUE
      NRV=NMX+NPX+1
      GO TO 7804
7803  CONTINUE
      NRVPREV=NRV
      NR=NRVL
      DO 7900 I=1,NRVPREV
      SNPRES(NRVPREV+NRV+1-I)=SNPRES(NRVPREV+1-I)
      CLPRES(NRVPREV+NRV+1-I)=CLPRES(NRVPREV+1-I)
      DFPRES(NRVPREV+NRV+1-I)=DFPRES(NRVPREV+1-I)
      PCPRES(NRVPREV+NRV+1-I)=PCPRES(NRVPREV+1-I)
      KYT(NRVPREV+NRV+1-I)=KYT(NRVPREV+1-I)
7900  CONTINUE

```

```

      NRVPREV=0
      GO TO 7703
7805  CONTINUE
      NRVPREV=NRV
      NRV=NRVR
      NR=NRH
      NPX=NPXR1
      GO TO 7703
9003  I3=MOD(I2,IPLDEN)
      IF(I3)8001,8000,8001
8000  CALL PLCTSN(SNPRES,KYT,SNBOCR,USNBOCR,NPX0,NMX0,0,0,MAXNMX,IPLDEN,
      INPLTSN)
      CALL PLCTSN(PCPRES,KYT,SNBOCR,USNBOCR,NPX0,NMX0,0,0,MAXNMX,IPLDEN,
      INPLTPC)
      CALL PLOTSN(DFPRES,KYT,DFBOCR,DTHDIFF,NPX0,NMX0,0,0,MAXNMX,IPLDEN,
      INPLTUF)
      CALL PLCTC(CLPRES,KY1,CLBOCR,0,HCLTR,NPX0,NMX0,0,0,MAXNMX,IPLDEN,
      INPLTCL)
      IPLOT=2
8001  CALL AREA(PCPRES,SNPREV,SBOCRIT,UNITH,UNITV,NMX,NPX,NRV,MAXNRV,
      IIAREA,AREA1,AREA0)
6003  CONTINUE
      IF((IRUN.EQ.2).AND.(IPLOT.EQ.1)) GO TO 7701
6000  CONTINUE
      AREAAV=(AREA1+AREA0)/2.
      AA=AREAAV*(STR**2)
      IF(AREA1)3501,3502,3501
3502  APPERR=100.
      GO TO 3507
3501  APPERR=(AREA0/AREAAV-1.)*100.
3507  AI=AREA1*(STR**2)
      AC=AREAC*(STR**2)
      IF(TMADV.EQ.0.) WRITE(NPOUT,3005) TSEC(1)
      DO 3503 I=1,NB
      IF(TB(I)-TSEC(1))3504,3504,3503
3504  CONTINUE
      CALL CGORDX(0.,2,XBR(I),YBR(I),ZBR(I),X1,ABR,X2,X3,X4,X5,
      ISBR,EBR)
      WRITE(NPOUT,3006)TB(I),W(I),FF(I),TSX(I),HB(I),SBR,EBR,ABR
3503  CONTINUE
      WRITE(NPOUT,3007)SBOCRIT,RCS,FREQ
      WRITE(NPOUT,3008)AREAAV,APPERR
      MRTE=ABSF(MRTE-1)
      MADV=TMADV
      WRITE(NPOUT,3030)MRTE,GRANGE,VFPEC,VVEL,HREF,TREFC,BETA
      WRITE(NPOUT,3031)HDRAG,TDRAG,VDRAG,EDRAG
      WRITE(NPOUT,3040) ITOT
      TANT(1)=MXTANT
      DBTOFB(1)=MXDBTF
      DBS(1)=MXDBS
      TF(1)=MXTF
      FBRHO(1)=MXFBR
      FBNE(1)=MXFBE
      FBDB(1)=MXFBDB
      CALL RNCOT
      WRITE(NPLTSN,3009)
      WRITE(NPLTCL,3009)
      WRITE(NPLTDF,3009)
      WRITE(NPLTPC,3009)
      WRITE(NPOUT,3009)
      GO TO 1
3001  FORMAT(120A1)
3003  FORMAT(3(/2F20.10),/5I10,3(/3F20.10),/2F20.10,I10,3(/2F20.10),/110
1)

```


3005 FORMAT(F51.10)
3006 FORMAT(F52.3,/F57.5,/F60.3,/F56.3,/F57.3,/F57.3,/F52.3,/F55.3)
3007 FORMAT(F57.3,/F40.3,/F56.3)
3008 FORMAT(F54.0,/F41.3)
3009 FORMAT(3HEND)
3030 FORMAT(////12,2X,0F12.4)
3031 FORMAT(/4X,4F12.4)
3040 FORMAT(110)
END

RANCIN

This subroutine reads the input for PALLOT calculations.

```

SUBROUTINE RANCIN(KASE)
COMMON /RADAR/FREQ,POWER,DELTAR,DELTAV,TAG,TBW,TSL,SNMDB,TSYS,BWN,
1      PCOMP,RAG,RBW,RSL,KSPEC,SCAN,EFACE,AFACEM(4),NFACE
COMMON/TARGET/RCS,STR(1),ATR(1),ETR(1),VTR(1),TSEC(1),SIGNAL(1),
1SNCTRC(1),DBTAR(1),AER(1),EER(1),RER(1),DISP(1),KEYT(1),KOUT,LFCUT
COMMON /BURST/NB,W(50),TSX(50),FF(50),HB(50),XBR(50),YBR(50),
1      ZBR(50),TB(50),COSCLB(50),KDZERO(50),RHZERU(50),
2      RUZERO(50),LHVB(50),RHDB(50),HSB(50),PKTERM(50),
3      RLK(50),RTK(50),DISTK(50),XKR(50),YKR(50),ZKR(50),
4      TILTK(50),WUV(3,50),HR,COSCLR,SINCLR,KALCH,KALCN,
5      KALCR,DAY,CIRAX,TEM150,NSW1,NSW2,NSW3,NSW4,NSW5,NSW6
COMMON /CONST/RE,PI,RADIAN
COMMON/RNCIN/PLDEN,RDEN,NMXX,NPXX,NHR1,NHR,UNITH,UNITV,ATIFO,
1TREFO,VFPEO,IFL,RTG,MAXNMX,NCRCT,VARR,SBCRIT,DSNBDCR,THCLTR,
2DTHCLTR,THDIFF,DTDIFF
COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1RTI,ATI,HT,VT,BT,ELV,RANGE,GAMA,VZ,A,E,HAPO,TAPO,RLI,ALI,TL,HDRAG,
2EORAG,VORAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
COMMON/CSPPRY/XRI,YRI,ZRI,COSCLI,SINCLI,HHR,CSCCLR,SNCLR,SIGMA
COMMON/CMTADV/TMADV
COMMON/DELTAT/DTLTH
COMMON/RAZMOD/IIFL
DIMENSION X(7),AFACE(4)
DIMENSION RBO(50),ABO(50),XBO(50),YBO(50),ZBO(50),SBO(50),EBO(50),
1GLATB(50),GLONB(50),KL8(50),ALPHA6(50)
DIMENSION RTO(1),ATO(1),HT(1),XTO(1),YTO(1),ZTO(1),STO(1),ETO(1),
1GLATT(1),GLONT(1),KLT(1),ALPHA7(1)
LOGICAL ENFIL
LFIN=5
LFOUT=6
GO=980.0
RGAS=8.3143E+7
NHLP=0
IN6=0
NRV=0
NT=1
1 READ(LFIN,1001) NCARD,(X(I),I=1,7),KODE,ALPHA
IF(EOF,5) 4,5
4 CONTINUE
NPOUT=7
WRITE(NPOUT,3009)
CALL EXIT
5 IF(NCARD)2,101,2
2 GO TO (11,21,31,41,51,61,71,81,91),NCARD
11 FREQ=X(1)
POWER=X(2)
DELTAR=X(3)
DELTAV=X(4)
TAG=X(5)
TBW=X(6)
TSL=X(7)
ALPHA1=ALPHA
IF(KODE)12,1,12
12 CALL DATAIN(KODE,AFACE)
ALPHA2=ALPHA
GO TO 1
21 SNMDB=X(1)

```

```

TSYS=AMAX1(X(2),1.)
BWN=AMAX1(X(3),1.E-3)
PCOMP=X(4)
RAG=X(5)
RBW=X(6)
RSL=X(7)
ALPHA2=ALPHA
GO TO 1
31 KSPEC=X(1)
SCAN=X(2)
EFACE=X(3)
AFACE(1)=X(4)
NFACE=1
DO 33 I=5,7
IF(X(1))32,33,32
32 NFACE=NFACE+1
AFACE(NFACE)=X(1)
33 CONTINUE
IF(SCAN)34,34,1
34 NFACE=0
GO TO 1
41 GLATO=X(1)
GLONO=X(2)
DAY=X(3)
KALC=X(4)
KALCH=MAX0(1-MOD(KALC,1000)/100,0)
KALCN=MAX0(1-MOD(KALC,100)/10,0)
KALCR=MAX0(1-MOD(KALC,10),0)
KOUT=X(5)
KTRACK=MIN1(ABS(X(6)),10.)
KODE=X(7)
NSW1=MOD(KODE,1000000)/100000
NSW2=MOD(KODE,100000)/10000
NSW3=MOD(KODE,10000)/1000
NSW4=MOD(KODE,1000)/100
NSW5=MOD(KODE,100)/10
NSW6=MOD(KODE,10)
IF(NSW6.EQ.1) NSW5=1
IF(NSW5.EQ.1) NSW4=1
IF(NSW4.EQ.1) NSW3=1
GO TO 1
51 IF(KODE)52,53,52
52 CALL COORDX(0.,KODE,X(1),X(2),X(3),RRO,ARO,HR,XRO,YRO,ZRO,SRO,ERO)
GO TO 54
53 GLATR=X(1)
GLONR=X(2)
HR=X(3)
54 KLR=KODE
DIPR=X(4)
VARR=X(5)
CALL COORDX(0.,1,X(6),X(7),0.0,RIO,AIO,DUM1,XIO,YIO,ZIO,SIO,EIO)
ALPHA5=ALPHA
HHR=HR
GO TO 1
61 IF(IN6)62,65,62
62 IF(IN6-50)63,69,63
63 IF(X(4)-TB(NB))64,65,65
64 NHELP=63
65 IN6=IN6+1
NB=IN6
IF(KODE)66,67,66
66 CALL COORDX(0.,KODE,X(1),X(2),X(3),RBO(NB),ABO(NB),HBO(NB),XBO(NB),
1YBO(NB),ZBO(NB),SBO(NB),EBO(NB))

```

```

GO TO 68
67 GLATB(NB)=X(1)
   GLONB(NB)=X(2)
   HB(NB)=X(3)
68 KLB(NB)=KODE
   TH(NB)=X(4)
   W(NB)=X(5)
   FF(NB)=X(6)
   TSX(NB)=X(7)
   ALPHA6(NB)=ALPHA
   GO TO 1
69 NHLP=62
   GO TO 1
71 TSEC(NT)=X(1)
   MAXNMX=X(2)
   NCRCT=X(3)
   SIGMA=X(4)
   MRTE=X(5)
   QREF=X(6)
   DLTH=X(7)
   IFL=KODE
   IIFL=0
   IF(IFL.EQ.3) IIFL=1
   IF(IIFL.EQ.1) IFL=1
   GO TO 1
81 ATIFO=X(1)
   GRANGE=X(2)
   VFPEO=X(3)
   VVEL=X(4)
   HREF=X(5)
   TREFO=X(6)
   BETA=X(7)
   TMADV=KCODE
   GO TO 1
91 CONTINUE
   IF(KODE.NE.0) GO TO 92
   PLDEN=X(1)
   RDEN=X(2)
   UNITH=X(3)
   UNITV=X(4)
   NMXR=X(5)
   NPXR=X(6)
   NHR=X(7)
   UNITH=UNITH*PLDEN
   UNITV=UNITV*PLDEN
   NMXR=NMXR/RDEN
   NPXR=NPXR/RDEN
   NHR=NHR/RDEN
   PLDEN=1./PLDEN
   NHR1=NHR
   IF(NHR.LT.100000) GO TO 1
   NHR1=NHR/100000
   NHR=NHR-NHR1*100000
   GO TO 1
92 CONTINUE
   SBOCRIT=X(1)
   DSNBOCR=X(2)
   THCLTR=X(3)
   DTHCLTR=X(4)
   THDIFF=X(5)
   DTHDIFF=X(6)
   GO TO 1
101 CONTINUE

```

```

WRITE OUTPUT TAPE 6,4009
IF(NCRCT.EQ.0) WRITE OUTPUT TAPE 6,4015
IF(KLR)102,103,104
102 CALL LATLON(GLATD,GLOND,0.,XRD,YRD,ZRD,GLATR,GLGNR,X(1))
GO TO 104
103 CALL XYZ(GLATD,GLOND,0.,GLATR,GLGNR,HR,XRD,YRD,ZRD)
CALL CORDRX(0.,2,XRD,YRD,ZRD,RXD,ARD,X(1),XRD,YRD,ZRD,SRC,ERU)
104 IF(NB)105,110,105
105 DO 108 I=1,NB
IF(KLB(I))106,107,106
106 CALL LATLON(GLATD,GLOND,0.,XBD(I),YBD(I),ZBD(I),GLATB(I),GLGNB(I),
1X(1))
GO TO 108
107 CALL XYZ(GLATD,GLOND,0.,GLATB(I),GLGNB(I),HBB(I),XBD(I),YBD(I),
1ZBD(I))
CALL CORDRX(0.,2,XBD(I),YBD(I),ZBD(I),RBD(I),ABD(I),X(1),XBD(I),
1YBD(I),ZBD(I),SBD(I),ERD(I))
108 CONTINUE
110 IF(NRV)111,115,111
111 DO 114 I=1,NRV
IF(KLT(I))112,113,112
112 CALL LATLON(GLATD,GLOND,0.,XTD(I),YTD(I),ZTD(I),GLATT(I),GLCNT(I),
1X(1))
GO TO 114
113 CALL XYZ(GLATD,GLOND,0.,GLATT(I),GLCNT(I),HT(I),XTD(I),YTD(I),
1ZTD(I))
CALL CORDRX(0.,2,XTD(I),YTD(I),ZTD(I),RTD(I),ATD(I),X(1),XTC(I),
1YTD(I),ZTD(I),STD(I),ETD(I))
114 CONTINUE
115 CONTINUE
CALL LATLON(GLATD,GLOND,0.,X10,Y10,Z10,GLAT1,GLON1,X(1))
CL1=(90.-GLAT1)*RADIAN
COSCL1=COS(CL1)
SINCL1=SIN(CL1)
CLR=(90.-GLAT1)*RADIAN
COSCLR=COS(CLR)
SINCLR=SIN(CLR)
CSCLR=CCSCLR
SNCLR=SNINCLR
CLO=(90.-GLAT0)*RADIAN
COSCLO=COS(CLO)
SINCLO=SIN(CLO)
CALL ASPECT(COSCLO,SINCLO,0.,XRD,YRD,ZRD,1,X10,Y10,Z10,X1R,Y1R,
1Z1R)
CALL ASPECT(COSCLR,SINCLR,HR,X1R,Y1R,Z1R,1,0.,0.,0.,X1I,Y1I,Z1I)
IF(NB)303,311,303
303 CALL ASPECT(COSCLO,SINCLO,0.,XRD,YRD,ZRD,NB,XBD,YBD,ZBD,XBR,YBR,
1ZBR)
DO 308 I=1,NB
CALL CORDRX(HR,2,XBR(I),YBR(I),ZBR(I),RBR,ABR,X(1),X(2),X(3),X(4),
1SBR,EBR)
308 CONTINUE
311 IF(NRV)312,400,312
312 DO 317 I=1,NRV
CALL ASPECT(COSCLO,SINCLO,0.,XRD,YRD,ZRD,1,XTD(I),YTD(I),ZTD(I),
1XTR,YTR,ZTR)
CALL CORDRX(HR,2,XTR,YTR,ZTR,RTR,ATR(I),X(1),X(2),X(3),X(4),STR(I),
1FTR(I))
317 CONTINUE
400 CONTINUE
402 CALL ATMUSD(-LFOUT,0.,X(1),X(2),X(3),X(4),X(5),X(6),X(7))
CALL CIRA65(-LFOUT,150.,X(1),X(2),TEM150,X(3),X(4),X(5),EM150)
GL150=GO*(RE/(RE+150.))**2

```

```

CIRAX=1.+150.E+5*G150*EM150/RGAS/TEM150
X(1)=SIN(DIPR*RADIAN)
COSCLR=X(1)/SQRT(4.-3.*X(1)**2)
SINCLR=SQRT(1.-COSCLR**2)
VMR=VARR*RADIAN
COSVMR=COS(VMR)
SINVMR=SIN(VMR)
IF(NB)702,711,702
702 DO 703 I=1,NB
  X(1)=XBR(I)*COSVMR-YBR(I)*SINVMR
  YBR(I)=XBR(I)*SINVMR+YBR(I)*COSVMR
703 XBR(I)=X(1)
711 IF(NRV)712,721,712
712 DO 713 I=1,NRV
713 ATR(I)=ATR(I)-VARR
721 IF(NFACE)722,724,722
722 DO 723 I=1,NFACE
723 AFACEM(I)=AFACE(I)-VARR
724 CONTINUE
  IF(NHELP.NE.0) CALL HELP(6HRANCIN,NHELP,1)
  RETURN
1001 FORMAT(I1,E9.0,6E10.0,1X I1,2XA6)
3009 FORMAT(3HEND)
4009 FORMAT(13H1RUN COMMENTS)
4015 FORMAT(41HNO FINE CORRECTIONS MADE TO TAILORED GRID)
END

```

SPRAY

This subroutine produces the target matrix point by point, from left to right, and row by row. Each target point produced by SPRAY is then checked by RANC to find its signal/noise ratio.

RTG = target shell radius.
 UNH = grid horizontal increment.
 NR = position along horizontal line at which target is now located.
 ELREF = elevation angle (degrees cona = 0, km cona = 2) set to topmost row of PONDER picture and decremented by the vertical print grid increment until desired region of sky plotted.
 AZREF = azimuth from radar to grid center column (for case cona = 0).
 VARR = magnetic variation.
 ATR = azimuth to target relative to radar.
 STR = slant range to target relative to radar.
 ERT = elevation angle to target relative to radar.

```

SUBROUTINE SPRAY(RTG,UNH,NR,ELREF,ATIFO,TREFO,VFPEO,IFL,VARR,
IRCS)
COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
IRTI,ATI,HT,VT,BT,ELV,RANGE,GAMA,VZ,A,E,HAPD,TAPD,RLI,ALI,TL,HDRAG,
ZEDRAG,VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
COMMON/TARGET/RCS,STR,ATR,ETR,VTR,TSEC(1),SIGNAL,SNCTRC,DBSTAR,
IAER,EER,RER,DISP,KEYT,DOUT,LFOUT
COMMON/CSPPRY/XRI,YRI,ZRI,COSCLI,SINCLI,HHR,CSCCLR,SNCLR,SIGMA
COMMON/CONST/RE,PI,RADIAN
COMMON/DELTAA/DLTH
COMMON/TARCNT/ITOT
COMMON/RAZMOD/IFL
NT=1
LFOUT=6
RTG=1.
ITOT=ITOT+1
IO=((IFL-1)*(IFL-2))/2
I1=IFL*(2-IFL)
I2=(IFL*(IFL-1))/2
IO=XABSF(IO)
I1=XABSF(I1)
I2=XABSF(I2)
ATIF=ATIFO-IO*NR*UNH
TREF=TREFO-I1*NR*UNH
VFPE=VFPEO-I2*NR*UNH
IF(IIFL.EQ.1) TREF = TREFO
AA=TREF-ELREF+DLTH
CALL TRAP(NT,AA,LFOUT)
IF(AA.LT.TIMP) GO TO 1
RTG=-1.
GO TO 99
1 CONTINUE
CALL CGORDX(0.,1,RTI,ATI,HT,X1,X2,X3,XTI,YTI,ZTI,X4,X5)
CALL ASPECT(COSCLI,SINCLI,0.,XRI,YRI,ZRI,1,XTI,YTI,ZTI,XTR,YTR,ZTR
1)

```

```

CALL CGCRDX(0.,2,XTR,YTR,ZTR,X1,ATR,X2,X3,X4,X5,STR,ETR)
ATR=ATR-VARR
CALL ASPECT(CSCLR,SNCLR,HHR,XTR,YTR,ZTR,1,0.,0.,0.,XRT,YRT,ZRT)
X1=VT*CCSF(ELV*RADIAN)
VTR=(X1*SINF(BT*RADIAN)*XRT+X1*CSF(BT*RADIAN)*YRT+VT*SINF(ELV*
IRAQIAN)*ZRT)/STR
AVTR=ACCSF(VTR/VT)/RADIAN
RCS=RVCS(SIGMA,AVTR)
99 CONTINUE
RETURN
END
FUNCTION RVCS(SIGMA,AVTR)
DIMENSION RS(30),ASPA(30)
DATA RS /.005,.005,.0053,.0059,.0071,.0092,.0174,.049,.089,.182,
1 .355,.631,.955,1.696,1.288,.813,.742,.204,.071,.071,
2 .0605,.05,.0303,.0105,.01,.0091,.0076,.00517,.005,
3 .005/
DATA ASPA /0.,40.,45.,50.,55.,60.,65.,70.,72.,74.,76.,78.,79.,80.,
1 81.,85.,90.,95.,99.,100.,101.,102.,104.,106.,108.,
2 110.,115.,120.,125.,180./
IF(SIGMA.GT.0.) GO TO 1
IA=2
DO 2 I=2,30
IF(AVTR.GT.ASPA(I)) GO TO 2
IA=I
I=30
2 CONTINUE
RVCS=((AVTR-ASPA(IA-1))/(ASPA(IA)-ASPA(IA-1)))*(RS(IA)-RS(IA-1))
1+RS(IA-1)
GO TO 99
1 CONTINUE
RVCS=SIGMA
99 RETURN
END

```


RANC

This is an excerpt from the RANC routine showing the modifications needed to run PALLOT.

```

SUBROUTINE RANC
COMMON /EXEC/CLTR(50),SRCL(50),DSRCL(50),VC(50),DVC(50),
1 SIGMA(50),ETA(50),FBNE(50),FBUB(50),FBRHO(50),
2 KEYC(50),TANT(50),AZFB(50),ELFB(50),CLTOFB(50),
3 CBS(50),OMEGAB(50),KEYN(50),ACLTR,SRAC,DSRAC,VAC,
4 CVAC,ASIGMA,ETAA,ENEA,ADBPKE,KEYA,AZAC,ELAC,OBAC,
5 TASLM
COMMON /RADAR/FREQ,POWER,DELTAR,DELTAV,TAG,TBW,TSL,SNMDB,TSYS,BW,
1 PCOMP,RAG,KBW,RSL,KSPEC,SCAN,EFACE,AFACEM(4),AFACE
COMMON/TARGET/RCS,STR(1),ATRI(1),ETR(1),VIR(1),TSEC(1),SIGNAL(1),
ISNCTRC(1),DBTAR(1),AER(1),EER(1),KER(1),DISP(1),KEYT(1),KOUT,LFCUT
COMMON /BURST/NB,W(50),TSX(50),FF(50),HB(50),XBR(50),YBR(50),
1 ZBR(50),TB(50),CUSCLB(50),RDZKO(50),RHZERD(50),
2 RUZERD(50),LHVB(50),RHOB(50),HSB(50),PKTERM(50),
3 RLK(50),RTK(50),DISTK(50),XKR(50),YKR(50),ZKR(50),
4 TILTK(50),WUV(3,50),HR,COSCLR,SINCLR,KALCH,KALCN,
5 KALCR,DAY,CIRAX,TEM150,NSW1,NSW2,NSW3,NSW4,NSW5,NSW6
COMMON/REGION/NF,INDXF(50),FLABL(50),KINDF(50),RFB(50),AFB(50),
1 HF(50),XFR(50),YFR(50),ZFR(50),RLF(50),RTF(50),
2 TILTF(50),HMINF(50),HMAXF(50),TF0(50),TF(50),
3 RHUF(50),HSNF(50),HDOF(50),RDOF(50)
COMMON/CEBRIS/ND,INDXD(50),DLABL(50),RDB(50),ADB(50),HD(50),
1 XDR(50),YDR(50),ZDR(50),RLD(50),RTD(50),CUSCLD(50),
2 DISTD(50),WD(50),PD(50),RHOD(50),HSD(50),HBETA(50)
COMMON /PARAM/ALPHAR,GAMMA,UKDEA,UN,UBETA,UGAMMA,N1,N2,DMAX,HBMAX,
1 CHSTEP,RSTOP,DBSTOP,DEL,EDMIND,ENMINF,KINT,DENRAT,
2 FTKAIN,HTRAIN
COMMON/CNEXEC/GXMTR,BXMTR,XXMTR,KXMTR,GRCVR,BRCVR,SRCVR,KRCVR,
1 GTH,GRM,GM,COSCAN,PHIB,TAMB,NFB,BEAM,SNTERM
COMMON /CONST/RE,PI,RADIAN
COMMON/RNC/ICONF
COMMON/CMTADV/TMADV
COMMON/RAZMOD/II-L
DIMENSION INCEXT(50)
J=1
GO TO(81,1,80,82),ICONF
81 CONTINUE
RE = 6370.
PI = 3.14159265
RADIAN = 1.74532925E-2
ALPHAR = 1.E-12
GAMMA = 1.5
UKDEA = 1.E4
UN = 0.015
UBETA = 2.0
UGAMMA = 0.025
N1 = 3
N2 = 3
DMAX = 100.
HBMAX = 200.
DHSTEP = 2.5
RSTEP=0.01
DBSTOP=0.1
UEL = 0.001
EDMIND = 5.4E-9

```

```

ENMINF = 5.E4
KINT=1
DENRAT=2.
FTRAIN=1.
HTRAIN=1.
KASE=0
KSPEC=0
NFACE=0
NB=0
BOLTZ=1.3805E-20
C=2.998E+5
DBCON=4.34294482
FOURPI=4.*PI
TAMB=250.
HACMIN=90.
HACMAX=130.
RHOAC=1.E-10
1 CALL RANCIN(KASE)
  IF(POWER)2,730,2
2 SNMIN=10.**(SNMDB/10.)
  GXMTR=10.**(TAG/10.)
  BXMTR=TBW*RADIAN
  SXMTR=10.**(-TSL/10.)
  KXMTR=MOD(KSPEC,100)/10
  GRCVR=10.**(RAG/10.)
  RRCVR=RBW*RACIAN
  SRCVR=10.**(-RSL/10.)
  KRCVR=MOD(KSPEC,10)
  DELRC=1.E-3*DELTAR
  DELRU=DELRC*PCOMP
  SNTerm=POWER*(C/FREQ)**2*PCOMP/(FOURPI)**3
  IF(NB)11,20,11
11 DO 12 I=1,NB
12 COSCLB(I)=(COSCLR*(RE+HR+ZBR(I))+SINCLR*YBR(I))/(RE+HB(I))
20 CONTINUE
  IF(TMADV.GT.0.) GO TO 83
62 CONTINUE
  JTIME=1
  TIME=TSEC(JTIME)
  CALL PHENOM(TSEC,JTIME)
  IF(ICDNF.EQ.4) GO TO 80
83 CONTINUE
  RETURN
80 CONTINUE
  IF(IIFL.NE.1) GO TO 9998
  JTIME=1
  TIME=TSEC(JTIME)
  CALL PHENOM(TSEC,JTIME)
9998 CONTINUE
  TASUM=TSYS
  AZBEAM=ATR(J)
  ELBEAM=ETR(J)
  END

```

COORDX

This routine accepts coordinates of a point in any of five systems and transforms them to all of the other systems.

Inputs:

HO = altitude or origin of coordinate systems (km).
 MODE = 1 2 3 4 5
 RXSE = gnd rng (km) X (east, km) slnt rng (km) elev (deg) slnt rng (km)
 AYAA = azimuth (deg) Y (north, km) azimuth (deg) azimuth (deg) azimuth (deg)
 HZEH = altitude (km) Z (up, km) elev (deg) altitude (km) altitude (km)

Outputs:

R, A, H = surface range, azimuth, altitude coordinates of point.
 X, Y, Z = rectangular tangent-plane coordinates of point.
 S, E = slant range, elevation coordinates of point.

```
SUBROUTINE COORDX(HO,MODE,RXSE,AYAA,HZEH,R,A,H,X,Y,Z,S,E)
COMMON /CONST/RE,PI,RADIAN
RE=RE+HO
GO TO(11,21,31,41,51),MODE
51 U1=(HZEH+RE)**2+RE**2-RXSE**2
   U2=2.*RE*(HZEH+RE)
   RXSE=ACCS(U1/U2)*RE
11 R=RXSE
   A=AYAA
   H=HZEH
   U0=R/RE
   U2=A*RADIAN
   U3=RE+H
   U1=U3*SIN(U0)
   X=U1*SIN(U2)
   Y=U1*COS(U2)
   Z=U3*COS(U0)-RE
   IF(U0.EQ.0.) Z=H-HO
   IF(U1)23,25,23
21 X=RXSE
   Y=AYAA
   Z=HZEH
   U1=X**2+Y**2
   IF(U1)22,24,22
27 U2=RE+Z
   U3=SQRT(U1+U2**2)
   U1=SQRT(U1)
   R=ASIN(U1/U3)*RE
   IF(U2.LT.0.) R=PI*RE-R
   A=ASIN(X/U1)/RADIAN
   IF(Y.LT.0.) A=180.-A
   H=U3-RE
3 S=SQRT(U1**2+Z**2)
  E=ASIN(Z/S)/RADIAN
GO TO 99
24 R=0.
   A=0.
   H=H+Z
```

```

25 S=ABS(Z)
   E=90.
   IF(Z.LT.0.0) E=-90.
   GO TO 99
31 S=RXSE
   A=AYAA
   E=HZEH
   U2=A*RACIAN
   U3=E*RACIAN
   U1=S*COS(U3)
   X=U1*SIN(U2)
   Y=U1*COS(U2)
   Z=S*SIN(U3)
   U2=REH+Z
   U3=SQRT(U1**2+U2**2)
   R=ASIN(U1/U3)*RE
   IF(U2.LT.0.0) R=PI*RE-R
   H=U3-RE
   GO TO 99
41 E=RXSE
   A=AYAA
   H=HZEH
   U2=A*RACIAN
   U3=E*RACIAN
   COSE=COS(U3)
   SINE=SIN(U3)
   S=HTOS(HO,H,COSE,SINE)
   U1=S*COSE
   X=U1*SIN(U2)
   Y=U1*COS(U2)
   Z=S*SINE
   U3=RE+H
   R=ASIN(U1/U3)*RE
   IF(REH+Z.LT.0.0) R=PI*RE-R
99 RETURN
   END

```

CRCT

This subroutine performs horizontal grid corrections as specified by NCRCT. When the blackout region extends past the PONDER picture limits, subroutine CRCT sets in and extends the bounds by NCRCT number of grids to see if it can reach the outer limit of the blackout region.

NMX = (NMXR) number of targets per row to the left of center column.
 NPX = (NPXR) number of targets per row to the right of center column.
 NCRCT = grid correction factor (in units of print grid increments).

```

SUBROUTINE CRCT(NMXIRD,NPXIRD,NMXO,NPXO,NMX,NPX,NPXRI,IPLDEN,NCRCT
1,ILCT,IRCT,NTL,NTR,NRL,NRR)
  NTL=0
  NTR=0
  IF(ILCT.EQ.0) GO TO 1
  NMXPVR=NMXO
  NMXO=MIN0F(NMXIRD,NMXO+NCRCT)
  IF(NMXPVR.EQ.NMXO) GO TO 1
  NMX=NMXO*IPLDEN
  NTL=(NMXO-NMXPVR)*IPLDEN
  NRL=NMX+1
1 CONTINUE
  IF(IRCT.EQ.0) GO TO 2
  NPXPVR=NPXO
  NPXO=MIN0F(NPXIRD,NPXO+NCRCT)
  IF(NPXPVR.EQ.NPXO) GO TO 2
  NRR=-NPX
  NPXRI=NPXO*IPLDEN
  NTR=(NPXO-NPXPVR)*IPLDEN
2 CONTINUE
  RETURN
END

```

ANALYZE

This subroutine checks for the horizontal corrections made by subroutine CRCT and prints out the appropriate information concerning each correction.

ELREF = increment in the vertical direction. ELREF is set to the topmost point to be observed and decremented to the lowest point to be observed.

```

SUBROUTINE ANALYZE(NTL,NTR,ILCT,IRCT,ELREF)
  IF(NTL.EQ.0) GO TO 1
  IF(ILCT.EQ.0) GO TO 3
  WRITE OUTPUT TAPE 6,102,ELREF
  GO TO 4
3 CONTINUE
  WRITE OUTPUT TAPE 6,101,ELREF
4 CONTINUE
  IF(NTR.EQ.0) GO TO 2
  IF(IRCT.EQ.0) GO TO 5
  WRITE OUTPUT TAPE 6,104,ELREF
  GO TO 6
5 CONTINUE
  WRITE OUTPUT TAPE 6,103,ELREF
6 CONTINUE
  GO TO 99
1 CONTINUE
  IF(ILCT.EQ.1) WRITE OUTPUT TAPE 6,105,ELREF
  GO TO 4
2 CONTINUE
  IF(IRCT.EQ.1) WRITE OUTPUT TAPE 6,106,ELREF
99 CONTINUE
  RETURN
101 FORMAT(47HSUCCESSFUL CORRECTION MADE ON LEFT AT ELEVATION,F10.5)
102 FORMAT(49HUNSUCCESSFUL CORRECTION MADE ON LEFT AT ELEVATION,F10.5)
103 FORMAT(48HSUCCESSFUL CORRECTION MADE ON RIGHT AT ELEVATION,F10.5)
104 FORMAT(50HUNSUCCESSFUL CORRECTION MADE ON RIGHT AT ELEVATION,
  IF10.5)
105 FORMAT(73HCORRECTION ATTEMPTED ON LEFT BUT STOPPED BY S. G. BOUNDARY.
  ELEVATION IS,F10.5)
106 FORMAT(74HCORRECTION ATTEMPTED ON RIGHT BUT STOPPED BY S. G. BOUNDARY.
  ELEVATION IS,F10.5)
END

```

FIT

This subroutine plots blank horizontal lines for the PONDER picture for cases in which no blackout was found at that elevation. FIT defines the boundaries of the print and area grids using the search grid calculations. The flag IRUN, which switches the executive routine from search to area grid calculations and vice versa, is set in this routine.

IRUN = grid selection flag (IRUN = 1 for search grid, IRUN = 2 for area grid).
 NMX0 = number of targets on print grid row to the left of center column.
 NPX0 = number of targets on print grid row to the right of center column.
 NMX = number of targets on area grid row to the left of center column.
 NPX = number of targets on area grid to the right of center column.
 NMXR = number of targets on search grid row to the left of center column.
 NPXR = number of targets on search grid row to the right of center column.
 UNITH0 = print grid horizontal increment.
 UNITV0 = print grid vertical increment.
 UNITH = area grid horizontal increment.
 UNITV = area grid vertical increment.
 UNITHR = search grid horizontal increment.
 UNITVR = search grid vertical increment.

```

SUBROUTINE FIT(NPRES,NLPRES,NRPRES,IRUN,NMXR,NPXR,NMX0,NPX0,NMX,
1INPX,IPLDEN,IRDEN,MAXNMX,IL,IR)
  DIMENSION S(150)
  NPREV=NPRES
  NLPREV=NLPRES
  NRPREV=NRPRES
  IF(IL)3,4,3
4  NPRES=1
  IF(NPREV-2)5,6,5
6  NMX0=NLPREV*IRDEN
  NPX0=NRPREV*IRDEN
  NMX=NMX0*IPLDEN
  NPX=NPX0*IPLDEN
  IRUN=2
  RETURN
5  DO 13 I=1,IRDEN
  IO=MOD(I,IRDEN)
  IF(IO)14,15,14
14 S(I)=IH
  WRITE(8,3001) S(I)
  WRITE(9,3001) S(I)
  WRITE(10,3001) S(I)
  WRITE(11,3001) S(I)
  GO TO 13
15 JO=MAXNMX+1
  DO 16 J=1,JO
16 S(J)=IH
  J1=JO+1
  S(J1)=IH-
```

```

      WRITE(8,3001) (S(J),J=1,J1)
      WRITE(9,3001) (S(J),J=1,J1)
      WRITE(10,3001) (S(J),J=1,J1)
      WRITE(11,3001) (S(J),J=1,J1)
13  CONTINUE
3001  FORMAT(120A1)
      NMX=NMXR
      NPX=NPXR
      IRUN=1
      RETURN
3  IF(NPRES)11,12,11
12  WRITE OUTPUT TAPE 6,3009
3009  FORMAT(28H VERTICAL ESTIMATE TOO SMALL)
11  NPRES=2
      NL=NMXR+2-IL
      NR=NPXR+2-IR
      NLPRES=MINOF(NL,NMXR)
      NRPRES=MINOF(NR,NPXR)
      IF(NPREV-2)9,10,9
9  NMXO=NLPRES*IRDEN
      NPXO=NRPRES*IRDEN
      NMX=NMXO*IPLDEN
      NPX=NPXO*IPLDEN
      IRUN=2
      RETURN
10  NMXO=MAXOF(NLPREV,NLPRES)*IRDEN
      NPXO=MAXOF(NRPREV,NRPRES)*IRDEN
      NMX=NMXO*IPLDEN
      NPX=NPXO*IPLDEN
      IRUN=2
      RETURN
END

```


SLCT

This subroutine reduces the number KEYT to one digit representing its most significant digit. It then returns this digit to the plotting subroutine for appropriate action.

KEYT = number generated by RANC for target presently being observed (target calculation code).

```
SUBROUTINE SLCT(KEY)
  IF(KEY.LT.100) GO TO 10
  DC 1 I=1,9
  KEY=KEY-100
  IF(KEY.LT.100) I=9
1  CONTINUE
10 CONTINUE
  IF(KEY.LT.10) GO TO 99
  DO 2 I=1,9
  KEY=KEY-10
  IF(KEY.LT.10) I=9
2  CONTINUE
99 CONTINUE
  RETURN
END
```

PLOTSN

This is a plotting subroutine. It takes the signal/noise calculations produced elsewhere, codes them alphanumerically, point by point, and stores them in a row matrix, left to right, for one row. The coded line is next written into output file PLOTSN.

SIGNAL = number generated by RANC for target presently being observed (this is the completed signal/noise ratio).
 KEYT = number generated by RANC for target presently being observed (target calculation code).
 BOCR = signal/noise increment between output contours.
 NPX = number of targets per row in unrotated system to the right of center column.
 NMX = number of targets per row in unrotated system to the left of center column.
 NPY = number of rows in unrotated system above the row containing reference point.
 NMY = number of rows in unrotated system below the row containing reference point.

```

SUBROUTINE PLOTSN(SIGNAL,KEYT,BOCR,DBOCR,NPX,NMX,NPY,NMY,MAXNMX,IP
  ILDEN,KTAPE)
  DIMENSION SIGNAL(2),KEYT(2),R(150)
  NO=MAXNMX-NMX+1
  NI=MAXOF(1,NO)
  J1=NPY+NMY+1
  K1=NPX+MAX+1
  K2=NI+K1
  I=1
  DO 1016 J=1,J1
  DO 1017 N=1,NI
101' R(N)=1H
  DO 1015 K=1,K1
  N=NI+K
  SIG=SIGNAL(I)-BOCR
  IF(SIG.LT.500.) GO TO 1903
  R(N)=1H*
  GO TO 1015
1903 CONTINUE
  IF(SIG)1001,1002,1002
1002 R(N)=1H
  GO TO 1015
1001 IF(SIG+CBOCR)1003,1004,1004
1004 R(N)=1H.
  GO TO 1015
1003 IF(SIG+2.*DBOCR)1005,1006,1006
1006 R(N)=1HC
  GO TO 1015
1005 IF(SIG+3.*DBOCR)1007,1008,1008
1008 R(N)=1HB
  GO TO 1015
1007 IF(SIG+4.*DBOCR)1009,1010,1010
1010 R(N)=1HA
  GO TO 1015

```

```

1009 CONTINUE
      KEY=KEYT(1)
      CALL SLCT(KEY)
      KEY=KEY+3
      GO TO(2001,2002,2003,2004,2005,2006,2007,2008,2009),KEY
2001 R(N)=1H8
      GO TO 1015
2002 R(N)=1H7
      GO TO 1015
2003 R(N)=1H0
      GO TO 1015
2004 R(N)=1H1
      GO TO 1015
2005 R(N)=1H2
      GO TO 1015
2006 R(N)=1H3
      GO TO 1015
2007 R(N)=1H4
      GO TO 1015
2008 R(N)=1H5
      GO TO 1015
2009 R(N)=1H6
1015 I=I+1PLCEN
1016 WRITE(TAPE,3001) (R(K),K=1,K2)
      RETURN
3001 FORMAT(120A1)
      END

```

TRAP

This subroutine computes target position and velocity as a function of time for an elliptical ballistic trajectory over a spherical rotating earth. Keplerian motion is assumed with transformations made to a rotating coordinate system. If atmospheric drag becomes important on the terminal portion of the trajectory, computations are transferred to subroutine RVDRAE and earth rotation is ignored.

```

SUBROUTINE TRAP(NT, TSEC, LFOUT)
COMMON /CONST/RE, PI, RADIAN
COMMON/TRAJEC/MROTE, GRANGE, VFPE, VVEL, HREF, TREF, QREF, BETA, CLI, ATIF,
1      RTI(1), AT1(1), HT1(1), VT1(1), BT1(1), ELV(1),
2      RANGE, GAMA, VZ, A, E, HAPD, TAPD, RLI, AL1, TL, HDRAG, EDRAE,
3      VDRAG, TDRAG, EIMP, VIMP, TIMP, KLOSS
DIMENSION TSEC(1)
RANGE=GRANGE
VZ=VVEL
GAMA=VFPE
G=0.0098
SPIN=7.292E-5
IF(MROTE.NE.0) SPIN=0.
GAMMA=GAMA*RADIAN
VZMAX=2.*G*RE
GR02=G*RE*RE
IF(-RANGE)2,7,7
2 THO=RANGE/RE*0.5
CTHO=COS(THO)
STHO=SIN(THO)
IF(GAMMA)3,3,31
3 IF(VZ)4,4,21
4 IF(CTHO)5,5,6
5 WRITE(LFOUT,1005)
NHLP=4
GO TO 9
6 A=(1.+STHO)*RE*0.5
E=(1.-STHO)/CTHO
CGAMMA=SQRT(A/RE)
VZ=SQRT(VZMAX*STHO/(1.+STHO))
GO TO 29
7 IF(GAMMA.GT.0.0.AND.VZ.GT.0.0) GO TO 11
NHLP=7
9 WRITE(LFOUT,1001)
CALL HELP(6HTRAP ,NHLP,1)
11 V2=VZ**2
TEST=VZMAX-V2
NHLP=11
IF(TEST)12,12,13
12 WRITE(LFOUT,1002)
GO TO 9
13 A=GR02/TEST
CGAMMA=COS(GAMMA)
E=SQRT(1.-V2*CGAMMA**2/(A*G))
THO=ACOS((1.+A*(E*E-1.)/RE)/E)
RANGE=2.*RE*THO
GO TO 39
21 V2=VZ**2
TEST=VZMAX-V2
NHLP=21
IF(-TEST)22,12,12

```

```

22 IF (V2-V2MAX*STHO/(1.+STH)) 23, 24, 24
23 WRITE (LFCUT, 1003)
NHLP=22
GC TO 9
24 A=GRO2/TEST
TFST=SQRT((RE/A)*CTHO*0.5)**2+1.-(RE/A))
IF (GAMMA) 25, 28, 25
25 IF (0.5*V2MAX-V2) 26, 26, 27
26 WRITE (LFCUT, 1006)
NHLP=25
GC TO 9
27 TEST=-TEST
28 E=0.5*RE/A*CTHO+TEST
CGAMMA=SQRT(A*G*(1.-E*E)/V2)
29 GAMMA=ACOS(CGAMMA)
GO TO 39
31 CGAMMA=COS(GAMMA)
VZ=G*RE*STHO/(CGAMMA*SIN(THO+GAMMA))
TEST=V2MAX-V2
IF (TEST) 32, 32, 33
32 WRITE (LFCUT, 1004)
NHLP=31
GO TO 9
33 A=GRO2/TEST
E=SQRT(1.-V2*CGAMMA**2/(A*G))
VZ=SQRT(V2)
39 AE=A*E
AEZ=A-AE*E
VCON=SQRT(AEZ*GRO2)
ECC=ACOS((RE-A)/AE)
CI=A/RE*SQRT(A/G)
TAPO=CI*(ECC+E*SIN(ECC))
HAPU=A+AE-RE
GAMA=GAMMA/RADIAN
HREFI=AMAX1(AMIN1(HREF, HAPU), 0.)
HDRAG=5.*AINT(-7.3*ALOG(1.E-5*BETA*SIN(GAMMA)/VZ**2)/5.+0.5)
HDRAG=AMAX1(AMIN1(HDRAG, HAPU, 120.), 0.)
ZDRAG=RE+HDRAG
ECC=ACOS((ZDRAG-A)/AE)
TDRAG=TAPO+CI*(ECC+E*SIN(ECC))
VDRAGI=SQRT(GRO2*(2./ZDRAG-1./A))
EDRAGI=ACOS(VCON/ZDRAG/VDRAGI)
RDRAG=RE*(THO-ACOS((ZDRAG-AE2)/(ZDRAG*E)))
COSCLI=COS(CLI)
SINCLI=SIN(CLI)
X1=AT IF *RACIAN
COSADI=COS(X1)
SINADI=SIN(X1)
RDI=RDRAG
J=1
41 X1=RDI/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLD=COSCLI*COSR+SINCLI*SINR*COSADI
SINCLD=SQRT(1.-COSCLD**2)
CBDRAG=(COSCLI*SINR-SINCLI*COSR*COSADI)/SINCLD
SBDRAG=-SINADI*SINCLI/SINCLD
BDRAG=ASIN(SBDRAG)
IF (CBDRAG.LT.0.) BDRAG=PI-BDRAG
VATMOS=SPIN*ZDRAG*SINCLD
X1=VDRAGI*COS(EDRAGI)
BDRAGI=BDRAG+ASIN(VATMOS*CBDRAG/X1)

```

```

VDRAG=SQRT(VDRAGI**2+VATMOS**2-2.*VATMOS*X1*SIN(BDRAGI))
EDRAG=ASIN(VDRAGI*SIN(EDRAGI)/VDRAG)
IF(HREF1-HDRAG)51,52,52
51 IF(QREF)55,52,55
52 ECC=ACOS((RE+HREF1-A)/AE)
TDEL=C1*(ECC+E*SIN(ECC))
IF(QREF-EQ.0.) TDEL=-TDEL
TDEL=TAPO+TDEL
TI=TDAG
HI=HDRAG
VI=VDRAG
FI=EDRAG
KI=RD1
GO TO 56
55 TDEL=1.E10
CALL RVDRAG(G,BETA,TDRAG,HDRAG,VDRAG,EDRAG,RD1,TDEL,HREF1,VI,EI,
RI)
TI=TDEL
HI=HREF1
56 TL=TREF-TDEL
TI=TI+TL
TIMP=1.E10
HF=0.0
CALL RVDRAG(G,BETA,TI,HI,VI,EI,RI,TIMP,HF,VIMP,EIMP,RLOSS)
IF(1001-ABS(RLOSS))57,58,58
57 RDI=RD1-RLOSS
J=J+1
IF(J.GT.10) CALL HELPI(6HTRAP ,57,1)
GO TO 41
58 TAPO=TAPO+TL
TDRAG=TCRAG+TL
RLOSS=RDAG-RD1
CALL COORDX(0.,1,RD1,ATIF,HDRAG,X1,X2,X3,XD1,YD1,ZD1,X4,X5)
CALL ASPECT(COSCL1,SINCL1,0.,XD1,YD1,ZD1,1,0.,0.,0.,XID,YID,ZID)
ATD=(BDRAGI-PI)/RADIAN
TP=TL
I=0
IF(NT)60,95,60
60 I=I+1
TI=TSEC(I)
61 EM=(TI-TAPO)/C1
IF(TI-TL)62,62,63
62 ZI=RE
HI=0.0
VI=VZ
EI=GAMMA
RI=RANGE
GO TO 68
63 IF(TI-TDRAG)64,64,8C
64 ECC=EM
65 FCC1=ECC
EM1=ECC1+(*SIN(ECC1))
ECC=ECC1+(EM-EM1)/(1.+E*COS(ECC1))
IF(ABS(ECC-ECC1)-1.E-6*ABS(ECC))66,66,65
66 ZI=A*(1.+E*COS(ECC))
HI=ZI-RE
VI=SQRT(GRO2*(2./ZI-1./A))
EI=ACOS(VCON/ZI/VI)
RI=RE*(THD-SIGN(ACOS((ZI-AE2)/(ZI*E)),EM))
68 RTD=RI-RDRAG
CALL COORDX(HDRAG,1,RTD,ATD,HI,X1,X2,X3,XTD,YTD,ZTD,X4,X5)
CALL ASPECT(COSCLD,SINCLD,HDRAG,XID,YID,ZID,1,XTD,YTD,ZTD,XTI,YTI,

```

```

1ZTI)
DLONG=SPIN*(TDRAG-AMAX1(TI,TL))
X1=ASIN(SINCL1*SIN(0.5*DLONG))
A11=-ASIN(COS(0.5*DLONG)/COS(X1))/RADIAN
IF(COSCL1.LT.0.) A11=180.-A11
R11=2.*RE*X1
CALL COORDX(0.,1,R11,A11,0.,X1,X2,X3,X11,Y11,Z11,X4,X5)
CALL ASPECT(COSCL1,SINCL1,0.,X11,Y11,Z11,1,X11,Y11,Z11,X11,Y11,
1ZTI)
CALL COORDX(0.,2,X11,Y11,Z11,R1,A1,X1,X2,X3,X4,X5,X6)
IF(TL-TI)71,71,87
71 COSA=-CCS(BDRAG1)
X1=RTU/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLT=COSCLD*COSR+SINCLD*SINR*COSA
SINCLT=SQRT(1.-COSCLT**2)
COSB=(COSCLD*SINR-SINCLD*COSR*COSA)/SINCLT
SINB=SINCLD*SIN(BDRAG1)/SINCLT
VATMOS=SPIN*Z1*SINCLT
X1=V1*CCS(E1)
VTI=SQRT(V1**2+VATMOS**2-2.*VATMOS*X1*SINB)
ET1=ASIN(V1*SIN(E1)/VTI)
X2=VTI*COS(ET1)
SINBT1=(X1*SINB-VATMOS)/X2
COSBT1=X1*COSB/X2
GO TO 91
80 IF(TI-TIMP)81,81,86
81 HF=0.0
IF(TP-TDRAG)82,82,83
82 TP=TDRAG
HI=HDRAG
VTI=VDORAG
ETI=EDRAG
RI=RDI
83 CALL RVDORAG(G,BETA,TP,HI,VTI,ETI,RI,TI,HF,VTI,ETI,RI)
HI=HF
TP=TI
AI=ATIF
X1=RI/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLT=COSCL1*COSR+SINCL1*SINR*COSADI
SINCLT=SQRT(1.-COSCLT**2)
COSBT1=(COSCL1*SINR-SINCL1*COSR*COSADI)/SINCLT
SINBT1=-SINADI*SINCL1/SINCLT
GO TO 91
86 R1=0.0
A1=0.0
H1=0.0
87 VTI=0.0
SINBT1=0.0
COSBT1=1.0
ETI=0.0
91 IF(I-NT)92,92,96
92 RTI(I)=RI
ATI(I)=AI
HT(I)=HI
VT(I)=VTI
BT(I)=ASIN(SINBT1)/RADIAN
IF(COSBT1.LT.0.) BT(I)=180.-BT(I)
ELV(I)=SIGN(ETI,-EM)/RADIAN

```

```

      IF(TI-TIMP)93,94,94
93  IF(I-NT)60,95,60
94  NT=I
95  I=NT+1
      TI=TL
      GC TO 61
96  RL=RI
      ALI=A1
      EDRAG=-EDRAG/RADIAN
      EIMP=-EIMP/RADIAN
      RETURN
1001 FORMAT(28H0TRAJECTORY DATA INPUT ERROR)
1002 FORMAT(40H0LAUNCH VELOCITY EXCEEDS ESCAPE VELOCITY)
1003 FORMAT(50H0LAUNCH VELOCITY LESS THAN MINIMUM-ENERGY VELOCITY)
1004 FORMAT(27H0LAUNCH ELEVATION TOO LARGE)
1005 FORMAT(89H0MINIMUM-ENERGY TRAJECTORY REQUESTED FOR SURFACE RANGE E
      IXCEEDING HALF EARTH CIRCUMFERENCE)
1006 FORMAT(38H0DEPRESSED TRAJECTORY INTERSECTS EARTH)
      END

```


PLOTC

This is another plotting subroutine. It takes the clutter/noise calculations produced elsewhere, codes them alphanumerically, point by point, and stores them in a row matrix, left to right, for one row. The coded line is next written into output file PLOTC.

CLTR = number generated by RANC for the target presently being observed (this is the completed clutter/noise ratio).

KEYT = number generated by RANC for target presently being observed (target calculation code).

BOCR clutter/noise increment between output contours.

NPX = number of targets per row in unrotated system to the right of center column.

NMX = number of targets per row in unrotated system to the left of center column.

NPY = number of rows in unrotated system above the row containing reference point.

NMY = number of rows in unrotated system above the row containing reference point.

```

SUBROUTINE PLOTC(CLTR,KEYT,BOCR,DBOCR,NPX,NMX,NPY,NMY,MAXNMX,
11PLDEN,KTAPE)
DIMENSION CLTR(2),KEYT(2),R(150)
NO=MAXNMX-NMX+1
N1=MAXOF(1,NO)
J1=NPY+NMY+1
K1=NPX+NMX+1
K2=N1+K1
I=1
DO 1016 J=1,J1
DO 1017 N=1,N1
1017 R(N)=1H
DO 1015 K=1,K1
N=N1+K
CL=CLTR(1)-BOCR
IF(CL.GT.(-500.)) GO TO 1904
R(N)=1H*
GO 1015
1904 CONTINUE
IF(CL.GE.0.) GO TO 1001
R(N)=1H
GO TO 1015
1001 IF((CL-DBOCR).GE.0.) GO TO 1002
R(N)=1H.
GO TO 1015
1002 IF((CL-2.*DBOCR).GE.0.) GO TO 1003
R(N)=1HI
GO TO 1015
1003 IF((CL-3.*DBOCR).GE.0.) GO TO 1004
R(N)=1HH
GO TO 1015
1004 IF((CL-4.*DBOCR).GE.0.) GO TO 1005
R(N)=1HG
GO TO 1015
1005 IF((CL-5.*DBOCR).GE.0.) GO TO 1006
R(N)=1HF
GO TO 1015

```

```

1006 IF((CL-6.*DBDCR).GE.0.) GO TO 1007
      R(N)=1HE
      GO TO 1015
1007 IF((CL-7.*DBDCR).GE.0.) GO TO 1008
      R(N)=1HD
      GO TO 1015
1008 IF((CL-8.*DBDCR).GE.0.) GO TO 1009
      R(N)=1HC
      GO TO 1015
1009 IF((CL-9.*DBDCR).GE.0.) GO TO 1010
      R(N)=1HB
      GO TO 1015
1010 IF((CL-10.*DBDCR).GE.0.) GO TO 1011
      R(N)=1HA
      GO TO 1015
1011 CONTINUE
      KEY=KEYT(1)
      CALL SLCT(KEY)
      KEY=KEY+3
      GO TO(2001,2002,2003,2004,2005,2006,2007,2008,2009),KEY
2001 CONTINUE
      R(N)=1H8
      GO TO 1015
2002 CONTINUE
      R(N)=1H7
      GO TO 1015
2003 CONTINUE
      R(N)=1H0
      GO TO 1015
2004 CONTINUE
      R(N)=1H1
      GO TO 1015
2005 CONTINUE
      R(N)=1H2
      GO TO 1015
2006 CONTINUE
      R(N)=1H3
      GO TO 1015
2007 CONTINUE
      R(N)=1H4
      GO TO 1015
2008 CONTINUE
      R(N)=1H5
      GO TO 1015
2009 CONTINUE
      R(N)=1H6
1015 I=I+1PLDEN
1016 WRITE(KTAPE,3001) (R(K),K=1,K2)
      RETURN
3001 FORMAT(120A1)
      END

```

AREA

This subroutine calculates the area of radar blackout on the target surface.

```

SUBROUTINE AREA(SIGNAL,SSIGNAL,BOCRIT,UNITH,UNITV,NMX,NPX,NT,MAXNT
1,IAREA,AREAI,AREAO)
DIMENSION SIGNAL(2),SSIGNAL(2)
NTP1=NT+1
MXNTP1=MAXNT+1
DO 100 I=1,NT
IF(SIGNAL(I)-BOCRIT)101,102,102
101 SIGNAL(I)=1.
GO TO 100
102 SIGNAL(I)=0.
100 CONTINUE
DO 103 I=NTP1,MXNTP1
103 SIGNAL(I)=0.
IF(IAREA)1,2,1
2 NMXPREV=NMX
NPXPREV=NPX
1 IGAP=NMX-NMXPREV
IF(IGAP)10,13,12
12 DO 20 I=1,NTPREV
20 SSIGNAL(NTPREV+IGAP+I-I)=SSIGNAL(NTPREV+I-I)
DO 30 I=1,IGAP
30 SSIGNAL(I)=0.
13 ISHIFT=0
GO TO 11
10 IGAP=-IGAP
DO 40 I=1,NT
40 SIGNAL(NT+IGAP+I-I)=SIGNAL(NT+I-I)
DO 50 I=1,IGAP
50 SIGNAL(I)=0.
ISHIFT=IGAP
11 NM=MAXOF(NMX,NMXPREV)+MAXOF(NPX,NPXPREV)
NMP2=NM+2
DO 120 I=1,NM
NO=SIGNAL(I)+SIGNAL(I+1)+SSIGNAL(I)+SSIGNAL(I+1)
GO TO(120,121,121,121,122),NO
121 IFLAG=1
GO TO 123
122 IFLAG=2
123 CONTINUE
A=UNITV*UNITH
GO TO(127,128),IFLAG
128 AREAI=AREAI+A
127 AREAO=AREAO+A
120 CONTINUE
NTPREV=NT
NMXPREV=NMX
NPXPREV=NPX
IAREA=1
DO 60 I=1,NT
60 SSIGNAL(I)=SIGNAL(ISHIFT+I)
DO 70 I=NTP1,NMP2
70 SSIGNAL(I)=0.
RETURN
END

```

RNCOT

This subroutine is documented in the RANC IVA manual. (See Ref. 6 of this document.)

SUBROUTINE RNCOT
END

Appendix 2

Description of PALLOT Input Cards 5, 7, 8, and 9

This description will deal first with the impact point location parameters (fields 6 and 7 of card 5), and then the four modified cards (7, 8, 9, 9a) of the input package will be described. (Refer to Fig. 4.)

CARD 5

FORMAT (I1, E9.0, 610.0)

NCARD = card identifier (equals five).

X(5) = ground range from origin to impact point.

X(7) = azimuth from origin to impact point.

CARD 7

FORMAT (I1, E9.0, 6E10.0, 1Y11)

NCARD = card identifier (equals seven).

TSEC(NT) = RANC calculation time relative to burst (NT).

MAXNMX = number of columns to the left of the center column on the printout
(horizontal translation of the picture).

NCRCT = print grid correction (zero disables) for blackout projections on the
PONDER picture; i.e., used to try and encompass complete blackout
area by extending the print area at the appropriate portions of the
PONDER picture.

SIGMA = radar cross-section (meters square).

MROTE = term for the earth's rotation:

0 = yes, use model with rotating earth.

1 = no, don't use model with rotating earth.

QREF = trajectory reference:

1 = use descent portion of trajectory.

0 = use ascent portion of trajectory.

DLTH = correction factor needed to place print grid (vertical) increment exactly
on the burst trajectory intersection point.

IFL = mode switch:

IFL value	PALLOT mode	Increment
0	azimuth	ATIF
1	inline like	TREF
2	elevation	VFPE
3	complete time history	UNITV0

CARD 8

FORMAT (I1, E9.0, 6E10.0, 1X11)

NCARD = card identifier (equals eight).
ATIFO = the reference azimuth of the RV's trajectory to be calculated (deg).
GRANGE = the ground range between the RV's launch point and its impact point (km).
VFPE0 = The RV's launch angle (deg).
VVEL = the RV's launch velocity (km/sec).
HREF = the reference altitude at which the burst and the reference trajectory intersect (km).
TREFO = the reference time that the RV intersects the burst's center; relative to burst time (sec).
BETA = ballistic drag coefficient for RV (lb/ft^2).
TMADV = time advance switch:
0 = time constant over PALLOT surface.
1 = time change over PALLOT surface.

CARD 9

FORMAT (I1, E9.0, 6E10.0)

- NCARD = card identifier (equals seven).
- PLDEN = ratio print grid increments/area grid increments.
- RDEN = ratio search grid increments/area grid increments.
- UNITHO = print grid increment (depends on mode of operation) in horizontal direction.
- UNITVO = print grid increment in vertical direction (sec).
- NMX0 = the number of columns to the left of the center column, where the center column of the plane is located by the normal line at the point of tangency.
- NPX0 = the number of columns to the right of the center column.
- NHR = this variable is located in columns 66 through 70. NHR is the total number of seconds from the earth's surface to the topmost point to be observed on the RV's trajectory. NHR is specified in units of UNITVO (i.e., NHR = 20 means that the topmost point = 20 times UNITVO sec to the topmost point of the PALLOT picture).
- NHR1 = this variable is located in columns 61-65. NHR1 is the total number of seconds to be covered in the PALLOT picture, from the topmost point (NHR) to the bottom of the picture. NHR1 is also given in terms of UNITVO and, therefore, designates the number of print rows that will compose the PALLOT picture. If NHR1 is set to zero or blank, the program automatically sets NHR1 equal to NHR, causing NHR number of print rows.

CARD 9A

FORMAT (I1, E9.0, 6E10.0, 1 X11, 2XA6)

- NCARD = card identifier (equals eight).
- SBOCRIT = maximum threshold of signal/noise and of signal/(noise plus clutter) (in dB) for radar recognition.
- DSNBOCR = the separation (in dB) between the final PONDER picture signal/noise and signal/(noise + clutter) contours.
- THCLTR = minimum threshold for clutter (in dB) for radar recognition.
- DTHCLTR = the separation between the final PONDER picture clutter contours.
- THDIFF = the maximum threshold for signal/noise minus clutter/noise for radar recognition.
- CONA = switch that signifies that card is to be read as card nine (CONA = 0) or as card nine A (CONA = 1).

Appendix 3

Examples of OZ and TY Overlays

EXAMPLE OF OZ OVERLAY OPERATING ON A PALLOT AZIMUTH MODE RUN

2.0000000000	3.0000000000	
2.0000000000	3.0000000000	
2.0000000000	3.0000000000	
20 20	70 70	20
-33.0000000000	1.0000000000	0.
560.0000000000	600.0000000000	1.0000000000
6500.0000000000	0.	0.
2300.0000000000	1.5184364475	0
20.0000000000	5.0000000000	
0.	0.	
0.	0.	
0

.0
 1.00000
 .930
 1.000
 400.000
 574.449
 42.306
 -41.000
 20.000
 100.000
 213.000
 11085.00000
 4.682

0	6500.0000	.0	-.0	600.0000	560.0000	2300.0000
	60.0000	763.4116	6.3412	-29.7172		
3133						

I I I I

)))FAACD

FFC	TCN (DB)	R (KM)	EX (KM)	V (KS)	SPRO (KS)
IMAG	39.592	485.834	95.332	.0	.811
AJ	23.125	280.276	97.508	.0	.300

EPT (M2)	SC	SOLID ANGLE (STERAD)	RR (KS)	
1.532E+01	3.596E-06	2.824E+00	.0E+00	243
2.172E-02	6.889E-09			43

)))FNTD

FFC	N-T (K)	MAG AZ(DEC)	FB 1-W ABS EL(DEC)	DB	BS-ABS DB
IMAG	584.000	-1.932	23.244	.0	.0
AJ		-1.702	21.920	.789	

FB-T (K)	D (CGS)	E-D (CGS)	ABS (DB/KM)	
2.193E+03	.0E+00	8.672E+07	.0E+00	243
		1.589E+05	1.923E-04	

))))FP

FFC	LOCATION RANGE(KM)	A MAG AZ(DEC)	RADIUS T	RADIUS L
IMAG	.0	.0	498.974	257.772
			5797.101	

AXIS TILT (RAD)	MIN A	MAX A	
4.840E-01	2.200E+02	6.296E+03	SPHEROID

))))DP

DDC	LOCATION RANGE(KM)	A MAG AZ(DEC)	RADIUS T	RADIUS L
1 CN	.0	.0	412.957	244.929
			249.308	

FY	DISTRIBUTION PARAMETER	B-A
9.000E-01	3.872E+00	4.130E+02

1	213	15	836	1.E5	21.9	5.3	19
2	-10	410	410	175	33	4.1	19
3	1	60	22.5	295	325		
4	3	34	1	0	1	0	0
5	5000000000	00000000	0	60	9		0
6	400	-33	400	0	1	.9	1 1
7	0	20	0	100	0	0001	0 0
8	-33	6500	0		600	560	2300 1
9	1	1	2	3	20	20	70
0	20	5					1

EXAMPLE OF OZ OVERLAY OPERATING ON A PALLOT INLINE MODE RUN

10.0000000000	7.0000000000	
10.0000000000	7.0000000000	
10.0000000000	7.0000000000	
0 20	80 80	20
-33.0000000000	1.0000000000	0.
570.0000000000	0.	1.0000000000
6500.0000000000	0.	0.
2300.0000000000	1.5184364475	0
20.0000000000	5.0000000000	
0.	0.	
0.	0.	
J

5,000+ 2
5,000+ 1

5,000+ 2
5,000+ 1
5,000+ 0
5,000+ -1
5,000+ -2

.0
 1.00000
 .900
 1.000
 400.000
 574.449
 42.306
 -41.000
 20.000
 100.000
 213.000
 108920.000000
 1.221

0	6500.0000	.0	-.0	.0	570.0000	2300.0000
	60.0000	748.7033	6.0770	-31.1495		
	1853					

1 1 1 1

)))FAACD

FFC	TCN (DB)	R (KM)	EX (KM)	V (KS)	SPRD (KS)
IMAG	41.255	441.684	141.952	.0	.807
AU	18.127	254.267	89.270	.0	.300

EPT (M2)	SC	SOLID ANGLE (STERAD)	RR (KS)
1.146E+01	2.738E-06	2.849E+00	.0E+00
5.105E-03	2.770E-09		43

)))FNTD

FFC	N-T (K)	MAG	AZ(DEC)	EL(DEC)	DB	BS-A95 DB
IMAG	1812.000	-40.761	24.576		.0	.0
AU		-40.761	24.576		.765	

FB-T (K)	D (CGS)	E-D (CGS)	ABS (DB/KM)
2.170E+03	.0E+00	8.680E+07	.0E+00
		1.730E+05	2.216E-04

))))FP

FFC	LOCATION RANGE(KM)	MAG	AZ(DEC)	A	RADIUS T	RADIUS L
IMAG	.0	.0	498.974	257.772	5897.101	

AXIS TILT (RAD)	MIN A	MAX A	
4.845E-01	2.200E+02	6.396E+03	SPHEROID

))))DP

DDC	LOCATION RANGE(KM)	MAG	AZ(DEC)	A	RADIUS T	RADIUS L
1 CN	.0	.0	412.957	244.929	249.308	

FY	DISTRIBUTION PARAMETER	B-A
9.000E-01	3.855E+00	4.130E+02

1	213	15	836	1.65	21.9	5.3	19
2	-10	410	410	175	33	4.1	19
3	1	60	22.5	295	325		
4	3	34	1	0	1	0	0
5	0	0	0	60	8		1
6	400	-33	400	0	1	.9	1 1
7	0	20	0	100	0	0001	0 1
8	-33	6500	0		0000000	570	2300 1
9	1	1	10	7	0	20	80
0	20	5					1

EXAMPLE OF TY OVERLAY OPERATING ON A PALLOT INLINE MODE RUN

10.0000000000	7.0000000000	
10.0000000000	7.0000000000	
10.0000000000	7.0000000000	
0 20	80 80	20
-33.0000000000	1.0000000000	0.
570.0000000000	0.	1.0000000000
6500.0000000000	0.	0.
2300.0000000000	1.5124364475	0
20.0000000000	5.0000000000	
0.	0.	
0.	0.	
1

.0
 1.00000
 .900
 1.000
 400.000
 574.449
 42.306
 -41.000
 20.000
 100.000
 213.000
 108920.000000
 1.221

0	6500.0000	.0	- .0	.0	570.0000	2300.0000
	60.0000	748.7033	6.0770	-31.1495		
1853						

1 1 1 1

111FAACO

FFC	TCN (DB)	R (KM)	EX (KM)	V (KS)	SPRD (KS)
IMAG	41.255	441.684	141.952	.0	.807
AU	18.127	254.267	89.270	.0	.300

EPT (M2)	SC	SOLID ANGLE (STERAD)	RR (KS)
1.146E+01	2.738E-06	2.849E+00	.0E+00
5.105E-03	2.770E-09		243

111)FNTD

FFC	N-T (K)	MAG AZ(DEG)	FB 1-W ABS EL(DEG)	DB	BS-ABS DB
IMAG	1812.000	-40.761	24.576	.0	.0
AU		-40.761	24.576	.765	

FB-T (K)	D (CGS)	E-D (CGS)	ABS (DB/KM)
2.170E+03	.0E+00	8.680E+07	.0E+00
		1.730E+05	2.216E-04

11111)FP

FFC	LOCATION RANGE(KM)	A MAG AZ(DEG)	RADIUS T	RADIUS L
IMAG	.0	.0	498.974	257.772
				5897.101

AXIS TILT (RAD)	MIN A	MAX A
4.840E-01	2.200E+02	6.396E+03

SPHEROID

11111)DP

DDC	LOCATION RANGE(KM)	A MAG AZ(DEG)	RADIUS T	RADIUS L
1 CN	.0	.0	412.957	244.929
				249.308

FY	DISTRIBUTION PARAMETER	B-A
9.000E-01	3.855E+00	4.130E+02

1	213	15	836	1.E5	21.9	5.3	19
2	-10	410	410	175	33	4.1	19
3	1	60	22.5	295	325		
4	3	34	1	0	1	0	0
5	0	0	0	60	8		1
6	400	-33	400	0	1	.9	1
7	0	20	0	100	0	0001	0
8	-33	6500	0		0000000	570	2300
9	1	1	10	7	0	20	80
0	20	5					1

**EXAMPLE OF THE OZ OVERLAY OPERATING ON THE
COMPLETE TIME HISTORY MODE**

5.0000000000	5.0000000000	
5.0000000000	5.0000000000	
5.0000000000	5.0000000000	
0 50	50 50	20
-33.0000000000	1.0000000000	0.
0.	0.	1.0000000000
6500.0000000000	0.	0.
2300.0000000000	1.5184364475	0
20.0000000000	5.0000000000	
0.	0.	
0.	0.	
1

.0
 1.00000
 .900
 1.000
 400.000
 574.449
 42.306
 -41.000
 20.000
 100.000
 213.000
 42137.500000
 6.319

0	6500.0000	.0	-.0	.0	.0	2300.0000
	60.0000	-21.2967	6.0770	-31.1495		
	2698					

1 1 1 1

)))FAACD

FFC	TCN (DB)	R (KM)	EX (KM)	V (KS)	SPRD (KS)
1 T1	73.342	405.134	51.913	.0	1.865
AU		203.953	72.707	.0	.300

EPT (M2)	SC	SOLID ANGLE (STERAD)	RR (KS)
9.667E+06	9.912E-01	4.727E-01	.0E+00
4.493E-07	2.548E-13		0

)))FMTD

FFC	N-T (K)	MAG AZ(DEC)	FB I-W ABS EL(DEC)	DB	BS-ABS DS
1 T1	220.000	-41.000	31.846	17.000	.0
AU		-41.000	31.846		

FB-T (K)	D (CGS)	E-D (CGS)	ABS (DB/KM)
1.160E+04	.0E+00	3.609E+09	1.290E+06
		2.056E+06	2.550E-03

))))FP

FFC	LOCATION RANGE(KM)	MAG AZ(DEC)	A	RADIUS T	RADIUS L
1 T1	.0	.0	486.018	257.772	257.772

AXIS TILT (RAD)	MIN A	MAX A
.0E+00	.0E+00	.0E+00

SPHEROID

))))DP

DDC	LOCATION RANGE(KM)	MAG AZ(DEC)	A	RADIUS T	RADIUS L
1 FZ	.0	.0	400.000	242.995	242.995

FY	DISTRIBUTION PARAMETER	B-A
9.000E-01	4.557E+00	4.000E+02

1	213	15	836	1.E5	21.9	5.3	19
2	-10	410	410	175	33		19
3	1	60	22.5	295	325	4.1	
4	3	34	1	0	1	0	0
5	000000	0000000	0	60	8	000000	0000000 1
6	400	-33	400	0	1	.9	1 1
7	0	20	0	100	0	0001	0 3
8	-33	6500	0		0000000	000	2300 1
9	1	1	5	5	0	50	50
0	20	5					1

Appendix 4

Listings of the OZ and TY Overlays

THE OZ OVERLAY LISTING

```

PROGRAM OV(INPUT,TAPE5=INPUT,POUT,TAPE7=POUT,PLOTSN,TAPE8=PLOTSN,
1PLOTCL,TAPE9=PLCTCL,PLOTDF,TAPE10=PLOTDF,PLOTPC,TAPE11=PLUTPC,
2TAPE59,TAPE100)
  CALL CHANGE(3H+GV)
  COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFO,TREFO,VFPEO,IFL,
  IABADD,TI,IO,I1,I2,FFRM
  COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1  RTI(100),ATI(100),HT(100),VT(100),BT(100),ELV(100),
2  RANGE,GAMA,VZ,FA,E,HAPO,TAPO,RLI,ALI,TL,MDRAG,EDRAG,
3  VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
  COMMON/CONST/RE,PI,RADIAN
  COMMON/MINCOM/MM(94)
  LCM (STORE)
  COMMON/STORE/STRE(6000)
  DIMENSION N60(5),N36(5)
  DIMENSION DI(2)
  WRITE(59,401)
  READ(59,402)DI
  CALL UD80IDID(1,1)
  CALL KEEP80(1)
  CALL DDERS(1)
  CALL SETPCH(1,0,1,0)
  RE=6370.
  PI=3.14159265
  RADIAN=1.74532925E-2
  LFOUT=59
  IFILEO=8
  IFILE1=11
  AMRG=.04
  AMRG1=1.+AMRG
  FFRM=.078125
  NO=70
1 CONTINUE
  READ(7,1001)UNITHR,UNITVR
  IF(EOF,7) 99.5
5 CONTINUE
  READ(7,1002)UNITHO,UNITVO,UNITH,UNITV,NMXR,NPXR,NHR1,NHR,MAXNMX,
  IATIFO,RDEN,DLTH,IREFO,HREF,QREF,GRANGE,VFPEO,VVEL,BETA,CLI,MROTE,
  2SBOCKIT,DSNBOCR,THCLTR,DTHCLTR,THDIFF,DTHDIFF,IFL
  CALL FRAME(1)
  CALL SETCH(1.,128.,1,0,1,0,0)
  WRITE(100,1003)UNITHR,UNITVR,UNITHO,UNITVO,UNITH,UNITV,NMXR,
  1NPXR,NHR1,NHR,MAXNMX,ATIFO,RDEN,DLTH,IREFO,HREF,QREF,GRANGE,
  2VFPEO,VVEL,BETA,CLI,MROTE,SBOCKIT,DSNBOCR,THCLTR,DTHCLTR,
  3THDIFF,DTHDIFF,IFL
  IF(MM(23).EQ.9) CALL PLOTE
  NMXO=NMXR*RDEN
  NPXO=NPXR*RDEN
  NCOL=MAXOF((MAXNMX+NPXO+2),80)
  IO=((IFL-1)*(IFL-2))/2
  I1=IFL*(2-IFL)
  I2=(IFL*(IFL-1))/2
  IO=XABSF(IO)
  I1=XABSF(I1)

```

```

I2=XABS(I2)
ABADD=ATIFO*10+TRCFO*11+VFPEO*12
NT=1
ATIF=ATIFO-10*NMXO*UNITHO
TREF=TREFO-11*NMXO*UNITHO
VFPE=VFPEO-12*NMXO*UNITHO
CALL TRAP(NT,TREFO,LCOUT)
TI=TIMP
AO=ABADD-(MAXNMX+1)*UNITHO
A2=AO+NCOL*UNITHO
A2M=A2+UNITHO
AOM=AO
TP=-(NHR1*RDEN-1)*UNITVO+TREFO+DLTH
TP=TI-TP
NS=NHR*RDEN
NI=NS/NO
NR=NS-NI*NO
NI=MINOF(NI,5)
IGOTO=0
IF(NR.GT.0) GO TO 11
IF(NI.GT.0) IGOTO=2
GO TO 12
11 CONTINUE
IGOTO=1
12 CONTINUE
IF(IGOTO.EQ.0) GO TO 1
DO 30 IFILE=IFILEO,IFILE1
GO TO (10,20),IGOTO
10 CONTINUE
T1=TP
TO=T1+(NO-NR)*UNITVO
T2=TO-(NO-1)*UNITVO
T2M=T2-AMRG*(TO-T2)
CALL FRAME(1)
CALL MAP(AOM,A2M,T2M,TO,FFRM,1.,FFRM,1.)
IF(IFILE.GT.IFILEO) GO TO 31
CALL PLOTEA
CALL AXIS(AOM,A2M,T2M,TO)
CALL SAVED(N60(1),STRE(1),N36(1))
31 CONTINUE
CALL PLOTEA
CALL DPLLOT(N60(1),STRE(1),N36(1))
NRD=NR
IF(NI.EQ.0) NRD=NR+1
CALL UDPICT(IFILE,NRD,T1,AO)
IF(NI.GT.0) GO TO 20
GO TO 30
20 CONTINUE
TO=TP-NR*UNITVO+NO*UNITVO
DO 21 I=1,N1
IP1=I+1
NSTRE=I*1200+1
TO=TO-NO*UNITVO
T2=TO-(NO-1)*UNITVO
T2M=T2-AMRG*(TO-T2)
CALL FRAME(1)
CALL MAP(AOM,A2M,T2M,TO,FFRM,1.,FFRM,1.)
IF(IFILE.GT.IFILEO) GO TO 22
CALL PLOTEA
CALL AXIS(AOM,A2M,T2M,TO)
CALL SAVED(N60(IP1),STRE(NSTRE),N36(IP1))
22 CONTINUE
CALL PLOTEA

```



```

CALL (PLCT(N60(IP1),STRE(NSTRE),N36(IP1))
NRD=4
IF(1.L.N1) NRD=NC+1
CALL DDPCTG(IFIL,NRL,TO,AD)
21 CONTINUE
30 CONTINUE
  IFIL=7
  CALL FRAME(1)
  CALL DDPCTG(IFIL)
  GO TO 1
99 CONTINUE
  CALL FRAME(1)
  IFIL=5
  CALL DDPCTG(IFIL)
  CALL PLCTE
  CALL EXIT
401 FORMAT(2HID)
402 FORMAT(2A10)
1001 FORMAT(2F20.10)
1002 FORMAT(2F20.10,/5I10,3(/3F20.10),/2F20.10,I10,3(/2F20.10)
1, /I10)
1003 FORMAT(3(/2F20.10),/5I10,3(/3F20.10),/2F20.10,I10,3(/2F20.10),/I10)
END

```

```

SUBROUTINE TICK(X1,X2)
COMMON/TCK/Z(100),NTCK
SIGNS=X1*X2
A=X2-X1
AL=ALOG10(A)
N=AL
IF(AL.LT.0.) N=N-1
C=A/(10.**N)
NC=C
IF(NC.GT.5) NC=5
IF(NC.LT.1) NC=1
TS=NC*(10.**N-1)
IF(SIGNS.LT.0.) GO TO 7
NX1=C
IF(X1.NE.0.) NX1=ALOG10(ABS(X1))
E=X1/(10.**NX1)
NE=E
IF(X1.LT.0.) NE=NC-1
E=NE
F=E*(10.**NX1)-TS
I=0
5 CONTINUE
E=E+TS
IF(E.LT.X1) GO TO 5
IF(E.GT.X2) GO TO 6
I=I+1
Z(I)=E
GO TO 5
6 CONTINUE
NTCK=1
RETURN
7 CONTINUE
NTS1=-X1/TS
DO 15 J=1,NTS1
Z(J)=- (NTS1+1-J)*TS
15 CONTINUE
I=NTS1
E=-TS

```

```

8 CONTINUE
E=E+TS
IF(E.GT.X2) GO TO 6
I=I+1
Z(I)=E
GO TO 8
END

```

```

SUBROUTINE DDPICT(NTAPE,NO,TO,AO)
COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFO,TREFO,VFREO,IFL,
IABADD,TI,IO,I1,I2,FFRM
INTEGER AA
DIMENSION AA(85)
T=TO+UNITVO
DO 20 J=1,NO
READ(NTAPE,101)AA
101 FORMAT(85A1)
IF(AA(2).NE.1HN) GO TO 5
J=NO
GO TO 20
5 CONTINUE
A=AO-UNITHO
T=T-UNITVO
ITP=MINOF((MAXNMX+NPXO+2),85)
DO 6 I=1,ITP
A=A+UNITHO
CALL TRACEC(AA(I),A,T)
6 CONTINUE
20 CONTINUE
RETURN
END

```

```

SUBROUTINE EFORM(ZP,ZN,N)
INTEGER ZN
N=0
IF(ZP.NE.0.) N=ALOG10(ABSF(ZP))
ZN=1H+
IF(N.LT.0) ZN=1H-
ZP=ZP/(10.**N)
N=XABSF(N)
RETURN
END

```

```

SUBROUTINE DDPICTO(NTAPE)
INTEGER AA
DIMENSION AA(85)
B=43.
2 CONTINUE
READ(NTAPE,101)AA
IF(EOF,NTAPE) 99,1
1 CONTINUE
IF(AA(2).EQ.1HN) GO TO 99
IF(AA(1).EQ.1H1) B=43.
B=B-1.
IF(B.GE.0.) GO TO 3
CALL FRAME(1)
B=42.
3 CONTINUE
CALL SETCH(1.,B,1,0,1,0,0)
WRITE(100,101)AA
GO TO 2

```

```

99 CONTINUE
RETURN
101 FORMAT(85A1)
END

```

```

SUBROUTINE HELP(SUBNAM,NSTATE,KOPT)
DIMENSION HOLRTH(2)
DATA HOLRTH/3H ,3HNDN/
WRITE(59,10)HOLRTH(KOPT),SUBNAM,NSTATE
IF(KOPT.EQ.1) CALL EXIT
RETURN
10 FORMAT(1H0A3,37H+ATAL ERROR DISCOVERED IN SUBROUTINE A6,20H AT STA
ITEMENT NUMBER16)
END

```

```

SUBROUTINE TRAP(IN,TSEC,LFOUT)
COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1 RTI(100),ATI(100),HT(100),VT(100),BT(100),ELV(100),
2 RANGE,GAMA,VZ,A,E,HAPD,TAPO,RLI,ALI,TL,HDRAG,EDRAG,
3 VURAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
COMMON/CONST/RE,PI,RADIAN
DIMENSION TSEC(100)
RANGE=GRANGE
VZ=VVEL
GAMA=VFPE
G=0.0098
SPIN=7.292E-5
IF(MROTE.NE.0) SPIN=0.
GAMMA=GAMA*RADIAN
VZMAX=2.*G*RE
GRO2=G*RE*RE
IF(1-RANGE)2,7,7
2 THO=RANGE/RE*0.5
CTHO=COS(THO)
STHO=SIN(THO)
IF(GAMMA)3,3,31
3 IF(VZ)4,4,21
4 IF(CTHO)5,5,6
5 WRITE(LFOUT,1005)
NHLP=4
GO TO 9
6 A=(1.+STHO)*RE*0.5
E=(1.-STHO)/CTHO
CGAMMA=SQRT(A/RE)
VZ=SQRT(VZMAX*STHO/(1.+STHO))
GO TO 29
7 IF(GAMMA.GT.0.0.AND.VZ.GT.0.0) GO TO 11
NHLP=7
9 WRITE(LFOUT,1001)
CALL HELP(6HTRAP ,NHLP,1)
11 VZ=VZ**2
TEST=VZMAX-VZ
NHLP=11
IF(TEST)12,12,13
12 WRITE(LFOUT,1002)
GO TO 9
13 A=GRO2/TEST
CGAMMA=COS(GAMMA)
E=SQRT(1.-VZ*CGAMMA**2/(A*G))
THO=ACOS((1.+A*(E+E-1.)/RE)/E)
RANGE=2.*RE*THO
GO TO 39

```

```

21 VZ=VZ**2
TEST=VZ*MAX-VZ
NHLP=21
IF(-TEST)22,12,12
22 IF(VZ-VZ*MAX*STHO/(1.+STHO))23,24,24
23 WRITE(LFOUT,1003)
NHLP=22
GO TO 9
24 A=GR02/TEST
TEST=SQRT(((RE/A)*CTHO*0.5)**2+1.-(RE/A))
IF(GAMMA)25,28,25
25 IF(0.5*VZ*MAX-VZ)26,26,27
26 WRITE(LFOUT,1006)
NHLP=25
GO TO 9
27 TEST=-TEST
28 F=0.5*RE/A*CTHO+TEST
CGAMMA=SQRT(A*G*(1.-F*E)/VZ)
29 GAMMA=ACOS(CGAMMA)
GO TO 30
31 CGAMMA=COS(GAMMA)
VZ=G*RE*STHO/(CGAMMA*SIN(THO+GAMMA))
TEST=VZ*MAX-VZ
IF(TEST)32,32,33
32 WRITE(LFOUT,1004)
NHLP=31
GO TO 9
33 A=GR02/TEST
F=SQRT(1.-VZ*CGAMMA**2/(A*G))
VZ=SQRT(VZ)
39 AE=A*F
AE2=A-AE*E
VCON=SQRT(AE2*GR02)
ECC=ACOS((RE-A)/AE)
CL=A/RE*SQRT(A/G)
TAPO=CL*(ECC+E*SIN(ECC))
HAPO=A+AE-RE
GAMA=GAMA/RADIAN
HREF1=AMAX1(AMIN1(HKEF,HAPO),0.)
HDRAG=5.*AINT1-7.3*ALOG(1.E-5*BETA*SIN(GAMMA)/VZ**2)/5.+0.5)
HURAG=AMAX1(AMIN1(HDRAG,HAPO,120.),0.)
ZDRAG=RE+HURAG
ECC=ACOS((ZDRAG-A)/AE)
TDAG=TAPO+CL*(ECC+E*SIN(ECC))
VDRAG=SQRT(GR02*(2./ZDRAG-1./A))
EDRAG=ACOS(VCON/ZDRAG/VDRAG)
RDRAG=RE*(THO-ACOS((ZDRAG-AE2)/(ZDRAG*E)))
COSCL=COS(CL)
SINCL=SIN(CL)
X1=A/IF*RADIAN
COSAD=COS(X1)
SINAD=SIN(X1)
RDI=RE*FRAG
J=1
41 X1=RDI/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLD=COSCL*COSR+SINCL*SINR*COSAD
SINCLD=SQRT(1.-COSCLD**2)
CBDRAG=(COSCL*SINR-SINCL*COSR*COSAD)/SINCLD
HURAG=-SINAD*SINCL/SINCLD
HURAG=ASIN(SBDRAG)
IF(CBDRAG.LT.0.) BDRAG=PI-BDRAG

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```

VATMOS=SPIN*ZDRAG*SINCLD
X1=VDRAG*COS(EDRAG)
HDRAG=HDRAG+ASIN(VATMOS*CBDRAG/X1)
VDRAG=SQRT(VDRAG**2+VATMOS**2-2.*VATMOS*X1*SIN(EDRAG))
EDRAG=ASIN(VDRAG*SIN(EDRAG)/VDRAG)
IF(HREF1-HDRAG)51,52,52
51 IF(QREF)55,52,55
52 ECC=ACOS((RL+HREF1-A)/AE)
TDEL=C1*(ECC+E*SIN(ECC))
IF(QREF.EQ.0.) TDEL=-TDEL
TDEL=TAPO+TDEL
TI=TDLAG
HI=HDRAG
VI=VDRAG
EI=EDRAG
RI=RDI
GO TO 56
55 TDEL=1.E10
CALL RVDRAG(G,BETA,TDLAG,HDRAG,VDRAG,EDRAG,RDI,TDEL,HREF1,VI,EI,
IRI)
TI=TDEL
HI=HREF1
56 TL=TREF-TDEL
TI=TI+TL
TIMP=1.E10
HF=0.0
CALL RVDRAG(G,BETA,TI,HI,VI,EI,RI,TIMP,HF,VIMP,EIMP,RLOSS)
IF(0.001-ABS(RLOSS))57,58,58
57 RDI=RDI-RLOSS
J=J+1
IF(J.GT.10) CALL HELP(6HTRAP ,57,1)
GO TO 41
58 TAPO=TAPO+TL
TDLAG=TDLAG+TL
RLOSS=RDRAG-RDI
CALL COORDX(0.,1,RDI,ATIF,HDRAG,X1,X2,X3,XDI,YDI,ZDI,X4,X5)
CALL ASPECT(COSCL1,SINCL1,0.,XDI,YDI,ZDI,1,0.,0.,C.,XID,YID,ZID)
ATD=(BDRAG-PI)/RADIAN
TP=TL
I=0
IF(NT)60,95,60
60 I=I+1
TI=TSEC(I)
61 EM=(TI-TAPO)/C1
IF(TI-TL)62,62,63
62 ZI=RE
HI=0.0
VI=VZ
FI=GAMMA
RI=RANGE
GO TO 68
63 IF(TI-TDRAG)64,64,80
64 ECC=EM
65 ECC1=ECC
FM1=ECC1+E*SIN(ECC1)
ECC=ECC1+(EM-EM1)/(1.+E*COS(ECC1))
IF(ABS(ECC-ECC1)-1.E-6*ABS(ECC))66,66,65
66 ZI=A*(1.+E*COS(ECC))
HI=ZI-RE
VI=SQRT(GRO2*(2./ZI-1./A))
FI=ACOS(VCON/ZI/VI)
RI=RE*(THD-SIGN(ACOS((ZI-AE2)/(ZI*E)),EM))
68 RTD=RI-RDRAG

```

```

CALL COORDX(HDRAG,1,RTD,ATD,HI,X1,X2,X3,XTD,YTD,ZTD,X4,X5)
CALL ASPECT(COSCLD,SINCLD,HDRAG,XID,YID,ZID,1,XTD,YTD,ZTD,XTI,YTI,
1ZTI)
DLONG=SPIN*(TDAG-AMAX1(TI,TL))
AL=ASIN(SINCLD*SIN(0.5*DLONG))
AII=-ASIN(COS(0.5*DLONG)/COS(X1))/RADIAN
IF(COSCLD.LT.0.) AII=180.-AII
RII=2.*RE*X1
CALL COORDX(0.,1,RII,AII,0.,X1,X2,X3,XII,YII,ZII,X4,X5)
CALL ASPECT(COSCLD,SINCLD,0.,XII,YII,ZII,1,XTI,YTI,ZTI,XTI,YTI,
1ZTI)
CALL COORDX(0.,2,XTI,YTI,ZTI,R1,A1,X1,X2,X3,X4,X5,X6)
IF(TL-TI)71,71,87
71 COSA=-COS(BDRAG1)
X1=RTD/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLT=COSCLD*COSR+SINCLD*SINR*COSA
SINCLT=SQRT(1.-COSCLT**2)
COSB=(COSCLD*SINR-SINCLD*COSR*COSA)/SINCLT
SINB=SINCLD*SIN(BDRAG1)/SINCLT
VATMOS=SPIN*ZI*SINCLT
X1=V1*COS(E1)
VTI=SQRT(VI**2+VATMOS**2-2.*VATMOS*X1*SINB)
ETI=ASIN(VI*SIN(E1)/VTI)
X2=VTI*COS(ETI)
SINBTI=(X1*SINB-VATMOS)/X2
COSBTI=X1*COSB/X2
GO TO 91
80 IF(TI-TIMP)81,81,86
81 HF=0.0
IF(TP-TDRAG)82,82,83
82 TP=TDAG
HI=HDRAG
VTI=VDRAG
ETI=EDRAG
RI=RDI
83 CALL RVDRAG(G,BETA,TP,HI,VTI,ETI,RI,TI,HF,VTI,ETI,RI)
HI=HF
TP=TI
AI=ATIF
X1=RI/RE
COSR=COS(X1)
SINR=SIN(X1)
COSCLT=COSCLD*COSR+SINCLD*SINR*COSADI
SINCLT=SQRT(1.-COSCLT**2)
COSBTI=(COSCLD*SINR-SINCLD*COSR*COSADI)/SINCLT
SINBTI=-SINADI*SINCLD/SINCLT
GO TO 91
86 RI=0.0
AI=0.0
HI=0.0
87 VTI=0.0
SINBTI=0.0
COSBTI=1.0
ETI=0.0
91 IF(I-NT)92,92,96
92 RTI(I)=RI
ATI(I)=AI
HTI(I)=HI
VTI(I)=VTI
BTI(I)=ASIN(SINBTI)/RADIAN
IF(COSBTI.LT.0.) BTI(I)=180.-BTI(I)

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      FLV(I)=SIGN(ETI,-LM)/RADIAN
      IF(TI-TI*PI)93,94,94
93  IF(I-NT)60,95,60
94  NT=I
95  I=NT+1
      TI=TL
      GO TO 61
96  RLI=RI
      ALI=AI
      EDLAG=-EDLAG/RADIAN
      FIMP=-FIMP/RADIAN
      RETURN
1001 FORMAT(28H0TRAJECTORY DATA INPUT ERROR)
1002 FORMAT(40H0LAUNCH VELOCITY EXCEEDS ESCAPE VELOCITY)
1003 FORMAT(50H0LAUNCH VELOCITY LESS THAN MINIMUM-ENERGY VELOCITY)
1004 FORMAT(27H0LAUNCH ELEVATION TOO LARGE)
1005 FORMAT(89H0MINIMUM-ENERGY TRAJECTORY REQUESTED FOR SURFACE RANGE E
      IXCEEDING HALF EARTH CIRCUMFERENCE)
1006 FORMAT(38H0DEPRESSED TRAJECTORY INTERSECTS EARTH)
      END

```

```

      SUBROUTINE KVDLAG(GO,BETA,TI,HI,VI,EI,RI,TF,HF,VF,EF,RF)
      COMMON /CONST/RE,PI,RADIAN
      DELTAH=0.5
      T=TI
      H=HI
      V=VI
      E=EI
      R=RI
11  DELTAT=TF-T
      SINE=SIN(E)
      DH=AMIN1(DELTAH,H-HF,1.01*V*SINE*DELTAT)
      IF(-DH)12,21,21
12  HBAR=H-DH/2.
      GBAR=GO*(RE/(RE+HBAR))**2
      CALL ATMOSD(0,HBAR,RHOBAR,DUM1,DUM2,DUM3,DUM4,DUM5,DUM6)
      B=47.88E-9*RVBETA(BETA,HBAR,RHOBAR,V,E)
      V2EQ=2.*B*SINE/RHOBAR
      DV=GBAR*(1./V-V/V2EQ)*DH
      IF(DV)13,15,15
13  IF((V+DV)*ABS(V+DV)-V2EQ)14,15,15
14  DV=SQRT(V2EQ)-V
15  VBAR=V+DV/2.
      COSE=COS(E)
      DE=GBAR*COSE/SINE/VBAR/VBAR*DH
      EBAR=AMIN1(E+DE/2.,PI/2.)
      SEBAR=SIN(EBAR)
      CEBAR=COS(EBAR)
      CTNE=CEBAR/SEBAR
      DR=DH*CTNE
      X=RE+H-DH
      DY=DH+DR*DR/2./X
      DR=DY*CTNE/X
      DE=DE-DR
      DR=DR*RE
      DT=DY/VBAR/SEBAR
      IF(DELTAT-DT)16,17,17
16  X=DELTAT/DT
      DH=DH*X
      DV=DV*X
      DE=DE*X
      DR=DR*X

```

```

      DT=DELTAT
17  T=T+DT
      H=H-DH
      V=V+DV
      E=AMIN1(E+DE,PI/2.)
      R=R-DR
      GO TO 11
21  TF=T
      HF=H
      VF=V
      EF=E
      RF=R
      RETURN
      END

```

```

      SUBROUTINE COORDX(HO,MODE,RXSE,AYAA,HZEH,R,A,H,X,Y,Z,S,E)
      COMMON /CONST/RE,PI,RADIAN
      REH=RE+HO
      GO TO (11,21,31,41),MODE
11  R=RXSE
      A=AYAA
      H=HZEH
      UO=R/RE
      UZ=A*RADIAN
      U3=RE+H
      U1=U3*SIN(UO)
      X=U1*SIN(UZ)
      Y=U1*COS(UZ)
      Z=U3*COS(UO)-REH
      IF(UO.EQ.0.) Z=H-HO
      IF(U1)23,25,23
21  X=RXSE
      Y=AYAA
      Z=HZEH
      U1=X**2+Y**2
      IF(U1)22,24,22
22  U2=REH+Z
      U3=SQRT(U1+U2**2)
      U1=SQRT(U1)
      R=ASIN(U1/U3)*RE
      IF(U2.LT.0.0) R=PI*RE-R
      A=ASIN(X/U1)/RADIAN
      IF(Y.LT.0.0) A=180.-A
      H=U3-RE
23  S=SQRT(U1**2+Z**2)
      E=ASIN(Z/S)/RADIAN
      GO TO 99
24  R=0.
      A=0.
      H=HO+Z
25  S=ABS(Z)
      E=90.
      IF(Z.LT.0.0) E=-90.
      GO TO 99
31  S=RXSE
      A=AYAA
      E=HZEH
      U2=A*RADIAN
      U3=E*RADIAN
      U1=S*COS(U3)
      X=U1*SIN(U2)
      Y=U1*COS(U2)

```



```

Z=S*SIN(U3)
U2=RE+Z
U3=SQRT(U1**2+U2**2)
R=ASIN(U1/U3)*RE
IF(U2.LT.0.0) R=PI*RE-R
H=U3-RE
GO TO 99
41 C=RKSL
A=AYAA
H=PZEH
U2=A*RADIAN
U3=C*RADIAN
COSE=COS(U3)
SINE=SIN(U3)
S=HTDS(HO,H,COSE,SINE)
U1=S*COSE
X=U1*SIN(U2)
Y=U1*COS(U2)
Z=S*SINE
U3=RE+H
R=ASIN(U1/U3)*RE
IF(RFH+Z.LT.0.0) R=PI*RE-R
99 RETURN
END
FUNCTION RVBETA(BETA,H,RHO,V,E)
RVBETA=BETA
RETURN
END

```

SUBROUTINE ATMOSD

This subroutine is listed in Ref. 6.

```

SUBROUTINE ASPECT(COSCLO,SINCLO,H0,X1,Y1,Z1,NPOINT,X2,Y2,Z2,X21,
Y21,Z21)
DIMENSION X2(2),Y2(2),Z2(2),X21(2),Y21(2),Z21(2)
COMMON /CONST/RE,PI,RADIAN
REH=RE+H0
U1=X1**2+Y1**2
IF(U1)1,2,1
1 U2=REH+Z1
U3=SQRT(U1+U2**2)
U1=SQRT(U1)
SINR1=U1/U3
COSR1=U2/U3
SINA1=X1/U1
COSA1=Y1/U1
SINA11=SINCLO*SINA1/SQRT(1.0-(COSCL0*COSR1+SINCLO*SINR1*COSA1)**2)
IF(SINA11.GT. 1.0) SINA11=1.0
IF(SINA11.LT. (-1.0)) SINA11=-1.0
COSA11=SQRT(1.-SINA11**2)
IF(SINCLO*COSR1*COSA1-COSCL0*SINR1.LT. 0.0) COSA11=-COSA11
GO TO 3
2 U3=REH+Z1
3 DO 9 N=1,NPOINT
X=X2(N)-X1
Y=Y2(N)-Y1
Z=Z2(N)-Z1
IF(U1)4,5,4

```

```

4 YYY= X*SINA1 + Y*COSA1
  XX = X*COSA1 - Y*SINA1
  YY =YYY*COSR1 - Z*SINR1
  X  = XX*COSA11+YY*SINA11
  Y  = YY*COSA11-XX*SINA11
  Z  =YYY*SINR1 + Z*COSR1
5 XZ1(N)=X
  YZ1(N)=Y
  ZZ1(N)=Z
9 CONTINUE
  RETURN
  END
  FUNCTION HTUS(H1,H2,COSE,SINE)
  COMMON /CONST/RE,PI,RADIAN
  R1=RE+H1
  R2=R1+H2
  SIND=R1*COSE/R2
  COSD=SQRT(1.-SIND**2)
  HTCS=R2*COSD-R1*SINE
  RETURN
  END

  SUBROUTINE AXIS(A,B,T2,TO)
  COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFO,TREFO,VFPEO,IFL,
  LABADD,T1,I0,I1,I2,FFRM
  COMMON/TCK/Z(100),NTCK
  COMMON/TRAJEC/MROUTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1      RTI(100),ATI(100),HT(100),VTI(100),BTI(100),ELV(100),
2      RANGE,GAMA,VZ,FA,E,HAPD,TAPD,RLL,ALI,TL,HDRAG,EDRAG,
3      VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
  COMMON/CONST/RE,PI,RADIAN
  INTEGER ZN
  DIMENSION TSEC(100)
  DIMENSION HTT(100)
  LFOUT=59
  NTT=1
  NT=100
  NTM1=NT-1
  X1=ABADD-NMXO*UNITHO
  X2=ABADD+NPXO*UNITHO
  Y1=T2
  Y2=T2
  CALL LINE(X1,Y1,X2,Y2,1,0)
  CALL TICK(X1,X2)
  Y2=.01*(T0-T2)+T2
  Y=T2-(1.9*FFRM*(T0-T2))/(1.-FFRM)
  CALL PLOTV(ARAOD,Y,ABADD,T2)
  DO 10 I=1,NTCK
  X1=Z(I)
  X2=Z(I)
  CALL LINE(X1,Y1,X2,Y2,1,0)
  X=Z(I)
  ZP=Z(I)
  CALL EFORM(ZP,ZN,N)
  CALL SETLCH(X,Y,1,0,0,1,0)
  WRITE(100,701)ZP,ZN,N
10 CONTINUE
  X1=A-(FFRM*(B-A))/(1.-FFRM)
  X2=X1
  Y2=T0
  Y1=T2
  CALL LINE(X1,Y1,X2,Y2,1,0)

```

```

CALL TICK(Y1,Y2)
X2=X1+.015*(B-A)
DO 20 I=1,NTCK
Y1=Z(I)
Y2=Z(I)
CALL LINE(X1,Y1,X2,Y2,1,0)
20 CONTINUE
X=A-(1.1*FFRM*(B-A))/(1.-FFRM)
Y=T2-.025*(T0-T2)
ZP=Z(I)
CALL EFORM(ZP,ZN,N)
CALL SETLCH(X,Y,1,0,0,0,0)
WRITE(100,701)ZP,ZN,N
ZP=Z(I)-Z(1)
CALL EFORM(ZP,ZN,N)
WRITE(100,701)ZP,ZN,N
D=(T0-T2)/NTM1
ATIF=ATIF0-I0*NMX0*UNITHO
TREF=TREF0-I1*NMX0*UNITHO
VFPE=VFPE0-I2*NMX0*UNITHO
DO 30 I=1,NT
TSEC(I)=TI-T0+(I-1)*D
CALL TRAP(NT,TSEC(I),LFOUT)
HTT(I)=HT(I)
30 CONTINUE
DO 31 I=1,NT
HT(I)=HTT(I)
31 CONTINUE
JO=1
CALL TICK(HT(NT),HT(1))
X1=ATIF*I0+TREF*I1+VFPE*I2
X=X1-(.9*FFRM*(B-A))/(1.-FFRM)
X2=X1-.01*(B-A)
CALL LINE(X1,T0,X1,T2,1,0)
YRFALT=TI-TREF
IF((YRFALT.GE.T2).AND.(YRFALT.LE.T0)) CALL PLOTV(X,YRFALT,X1,
1YRFALT)
DO 40 I=1,NTCK
DO 50 J=JO,NTM1
IF((Z(I).GT.HT(J)).OR.(Z(I).LT.HT(J+1))) GO TO 50
F=(HT(J)-Z(I))/(HT(J)-HT(J+1))
Y=TI-TSEC(J)-F*(TSEC(J+1)-TSEC(J))
Y1=Y
Y2=Y1
CALL LINE(X1,Y1,X2,Y2,1,0)
ZP=Z(I)
CALL EFORM(ZP,ZN,N)
CALL SETLCH(X,Y,1,0,0,0,0)
WRITE(100,701)ZP,ZN,N
J=NTM1
50 CONTINUE
40 CONTINUE
ATIF=ATIF0+I0*NPX0*UNITHO
TREF=TREF0+I1*NPX0*UNITHO
VFPE=VFPE0+I2*NPX0*UNITHO
DO 61 I=1,NT
CALL TRAP(NT,TSEC(I),LFOUT)
HTT(I)=HT(I)
61 CONTINUE
DO 62 I=1,NT
HT(I)=HTT(I)
62 CONTINUE
JO=1

```

```

X1=ATIF*I0+TREF*I1+VF+PE*I2
X2=X1+.01*(B-A)
CALL LINE(X1,T0,X1,T2,1,0)
DO 60 I=1,NTCK
DO 70 J=J0,NTM1
IF((Z(I).GT.HT(J)).OR.(Z(I).LT.HT(J+1))) GO TO 70
F=(HT(J)-Z(I))/(HT(J)-HT(J+1))
Y=T1-TSEC(J)-F*(TSEC(J+1)-TSEC(J))
Y1=Y
Y2=Y1
CALL LINE(X1,Y1,X2,Y2,1,0)
J=NTM1
70 CONTINUE
60 CONTINUE
RETURN
701 FORMAT(F6.3,A1,I2)
END

```

THE TY OVERLAY LISTING

```

PROGRAM DV(INPUT,TAPE5=INPUT,POUT,TAPE7=POUT,PLOTSN,TAPE8=PLOTSN,
1PLOTCL,TAPE9=PLOTCL,PLOTDF,TAPE10=PLOTDF,PLOTTC,TAPE11=PLOTTC,
2TAPE59,TAPE100)
CALL CHANGE(3H+DV)
COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFO,TREFO,VFPEO,
1TIMPO,FFRM
COMMON/TRAJEC/MRUTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1RTI(100),ATI(100),HT(100),VT(100),BT(100),ELV(100),
2RANGE,GAMA,VZ,A,E,HAPD,TAPD,RLI,ALI,TL,HDRAG,EDRAG,
3VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
COMMON/CONST/RE,PI,RADIAN
COMMON/MINCOM/MM(94)
LCM (STORE)
COMMON/STORE/STRE(6000)
DIMENSION N60(5),N36(5)
DIMENSION TB11(100)
DIMENSION DI(2)
WRITE(59,401)
READ(59,402)DI
CALL DD80ID(DI,1)
CALL KEEP80(1)
CALL DDERS(1)
CALL SETPCH(1,0,1,0)
LFOUT=59
IFILE0=8
IFILE1=11
RE=6370.
PI=3.14159265
RADIAN=1.74532925E-2
AMRG=.04
AMRG1=1.+AMRG
FFRM=.078125
USRST=1024.*(1.-FFRM)
NO=85
1 CONTINUE
READ(7,1001)UNITHR,UNITVR
IF(EOF,7) 99,5
5 CONTINUE
READ(7,1002)UNITHO,UNITVO,UNITH,UNITV,NMXR,NPXR,NHR1,NHR,MAXNMX,
1ATIFO,RDEN,DLTH,TREFO,HREF,QREF,GRANGE,VFPEO,VVEL,BETA,CLI,MROTE,
2SBDCRIT,DSNBDCR,THCLTR,OTHCLTR,THDIFF,OTHDIFF,IFL
CALL FRAME(1)
CALL SETCH(1.,128.,1,0,1,0,0)
WRITE(100,1003)UNITHR,UNITVR,UNITH,UNITV,NMXR,
1NPXR,NHR1,NHR,MAXNMX,ATIFO,RDEN,DLTH,TREFO,HREF,QREF,GRANGE,
2VFPEO,VVEL,BETA,CLI,MROTE,SBDCRIT,DSNBDCR,THCLTR,OTHCLTR,
3THDIFF,OTHDIFF,IFL
IF(MM(23).EQ.9) CALL PLOTE
NMXO=NMXR*RDEN
NPXO=NPXR*RDEN
TP=-(NHR1*RDEN-1)*UNITVO+TREFO+DLTH
NS=NHR*RDEN
NI=NS/NO
NR=NS-NI*NO
IF((NR+NI).EQ.0) GO TO 1
SLT=(NMXO+NPXO)*UNITHO
HC=USRST/((NO+1)*UNITVO)
TANG=(USRST*UNITVO*(NO+1))/(AMRG1*(USRST*SLT+(NO**2-1)*HC*
1(UNITVO)**2))
VC=(USRST-AMRG1*(NO-1)*UNITVO*HC*TANG)/(AMRG1*SLT)

```

```

NT=1
ATIF=ATIFO
TREF=TREFO
VFPE=VFPEO
CALL TRAP(NT,TREFO,LFOUT)
TIMPO=TIMP
N1P1=N1+1
DO 71 I=1,N1P1
TB11(I)=TIMPO-(TP+NMXO*UNITHO+(I-1)*(NO+1)*UNITVO)
71 CONTINUE
DO 72 IFILE=IFILEO,IFILE1
DO 73 I=1,N1P1
NSTRE=(I-1)*1200+1
TO=TP+(I-1)*NO*UNITVO
T2=TO+(NO-1)*UNITVO
TOM=TO-UNITVO
T2M=T2+UNITVO
TB10=TB11(I)+SLT
TB13=TB10-AMRG1*(SLT+((NO-1)*UNITVO*HC*TANG)/VC)
CALL FRAME(1)
CALL MAP(TOM,T2M,TB13,TB10,FFRM,1.,FFRM,1.)
IF(IFILE.GT.IFILEO) GO TO 74
CALL PLOTEA
CALL AXIS(TOM,T2M,TB13,TB10)
CALL SAVED(N60(I),STRE(NSTRE),N36(I))
74 CONTINUE
CALL PLOTEA
CALL DPLOT(N60(I),STRE(NSTRE),N36(I))
NRD=NO
IF(I.EQ.N1P1) NRD=NO+1
CALL DDPICT(IFILE,NRD,TO,TB11(I))
73 CONTINUE
72 CONTINUE
IFILE=7
CALL FRAME(1)
CALL DDPICTO(IFILE)
GO TO 1
99 CONTINUE
CALL FRAME(1)
IFILE=5
CALL DDPICTO(IFILE)
CALL PLOTE
CALL EXIT
401 FORMAT(2H10)
402 FORMAT(2A10)
1001 FORMAT(/2F20.10)
1002 FORMAT(2F20.10,/2F20.10,/5I10,3(/3F20.10),/2F20.10,1I0,3(/2F20.10)
1,/I10)
1003 FORMAT(3(/2F20.10),/5I10,3(/3F20.10),/2F20.10,1I0,3(/2F20.10),/I10)
END

```

```

SUBROUTINE EFORM(ZP,ZN,N)
INTEGER ZN
N=0
IF(ZP.NE.0.) N=ALUG10(ABSF(ZP))
ZN=1H+
IF(N.LT.0) ZN=1H-
ZP=ZP/(10.**N)
N=XABSF(N)
RETURN
END

```

```

SUBROUTINE DDPICT(NTAPE,NO,TO,TBIO)
COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFO,TREFO,VFPEO,
1TIMPO,FFRM
INTEGER AA
DIMENSION AA(85)
I1=MAXNPX-NMXO+2
I2=I1+NPXO+NPXO
T=TO-UNITVO
JS=NO
DO 20 J=1,NO
  READ(NTAPE,101)AA
  IF(AA(2).NE.1HN) GO TO 5
  JS=J
  J=NO
  GO TO 20
5 CONTINUE
  T=T+UNITVO
  TBI=TBI0-(J-1)*UNITVO-UNITHO
  DO 6 I=1,12
    TBI=TBI+UNITHO
  CALL TRACEC(AA(I),T,TBI)
6 CONTINUE
20 CONTINUE
  TC1=TO
  TC2=T
  TBC1=TBIO
  TBC2=TBC1-(JS-1)*UNITVO
  TFC3=TBC2+(NMXO+NPXO)*UNITHO
  TBC4=TBC1+(NMXO+NPXO)*UNITHO
  JDASH=12528
  CALL LINE(TC1,TBC1,TC2,TBC2,1,JDASH)
  CALL LINE(TC2,TBC2,TC2,TBC3,1,0)
  CALL LINE(TC2,TBC3,TC1,TBC4,1,0)
  CALL LINE(TC1,TBC4,TC1,TBC1,1,0)
  JDASH=17776
  CALL LINE(TC1,TBC1,TC1,TC1,1,1,JDASH)
  RETURN
101 FORMAT(85A1)
END

```

```

SUBROUTINE AXIS(TO,T2,TB13,TB10)
COMMON/TRJT/UNITHO,UNITVO,NMXO,NPXO,MAXNMX,ATIFC,TREFO,VFPEO,
1TIMPO,FFRM
COMMON/TCK/Z(100),NTCK
COMMON/TRAJEC/MROTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CLI,ATIF,
1 RTI(100),ATI(100),HT(100),VT(100),BT(100),ELV(100),
2 RANGE,GAMA,VZ,A,E,HAPO,TAPO,RLI,ALI,TL,HDRAG,EDRAG,
3 VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
INTEGER ZN
DIMENSION TSEC(100)
DIMENSION HTT(100)
LFOUT=59
NT=100
NTT=1
NTM1=NT-1
CALL LINE(TO,TB13,TO,TB10,1,0)
C=(TB10-TB13)/NTM1
ATIF=ATIFC
TREF=TREFO
VFPE=VFPEO
DO 10 I=1,NT
  TSEC(I)=TIMPO-TB10+(I-1)*D

```



```

      CALL TRAP(NT,TSEC(I),LEFT)
      HT(I)=PT(I)
10  CONTINUE
      GO 31 I=1,NT
      HT(I)=HT(I)
31  CONTINUE
      CALL TICK(HT(NT),I(1))
      TTCK=T0+.01*(T2-T0)
      DO 20 I=1,NTCK
      DO 30 J=1,NTMI
      IF((Z(I).GT.HT(J)).OR.(Z(I).LT.HT(J+1))) GO TO 30
      F=(HT(I)-Z(I))/(HT(J)-HT(J+1))
      TB=TIMPO-TSEC(J)-F*(TSEC(J+1)-TSEC(J))
      CALL LINE(T0,TB,T2,TB,1,0)
      ZP=Z(I)
      CALL EFORM(ZP,ZN,N)
      TPKN=T0-(.9*FFRM*(T2-T0))/(1-FFRM)
      CALL SETLCH(TPRNT,TB,1,0,0,0,0)
      WRITE(100,701)ZP,ZN,N
      J=NTMI
30  CONTINUE
20  CONTINUE
      TLFTM=T0-(FFRM*(T2-T0))/(1-FFRM)
      TTCK=TLFTM+.01*(T2-T0)
      CALL LINE(TLFTM,TB13,TLFTM,TB10,1,0)
      CALL TICK(TB13,TB10)
      DO 40 I=1,NTCK
      CALL LINE(TLFTM,Z(I),TTCK,Z(I),1,0)
40  CONTINUE
      ZP=Z(I)
      CALL EFORM(ZP,ZN,N)
      TBPRNT=TB13-.025*(TB10-TB13)
      TPRNT=T0-(1.1*FFRM*(T2-T0))/(1-FFRM)
      CALL SETLCH(TPRNT,TBPRNT,1,0,0,0,1)
      WRITE(100,701)ZP,ZN,N
      ZP=Z(2)-Z(1)
      CALL EFORM(ZP,ZN,N)
      WRITE(100,701)ZP,ZN,N
      CALL LINE(T0,TB13,T2,TB13,1,0)
      CALL TICK(T0,T2)
      TBTK=TB13+.01*(TB10-TB13)
      DO 50 I=1,NTCK
      CALL LINE(Z(I),TB13,Z(I),TBTK,1,0)
      ZP=Z(I)
      CALL EFORM(ZP,ZN,N)
      TBPRNT=TB13-(.9*FFRM*(TB10-TB13))/(1-FFRM)
      CALL SETLCH(Z(I),TBPRNT,1,0,0,1,0)
      WRITE(100,701)ZP,ZN,N
50  CONTINUE
      RETURN
701 FORMAT(F6.3,A1,I2)
      END

```

```

SUBROUTINE LDPICTL(NTAPE)
  INTEGER AA
  DIMENSION AA(85)
  N=43.
2  CONTINUE
  READ(NTAPE,101)AA
  IF(EOF,NTAPE) 99,1
1  CONTINUE
  IF(AA(2).EQ.1HN) GO TO 99

```

```

      IF(AA(1).EQ.1H1) C=43.
      B=B-1.
      IF(B.GE.0.) GO TO 3
      CALL FRAME(1)
      B=42.
3    CONTINUE
      CALL SETCH(1.,B,1,0,1,0,0)
      WRITE(100,101)AA
      GO TO 2
99   CONTINUE
      RETURN
101  FORMAT(85A1)
      END

```

```

SUBROUTINE TICK(X1,X2)
COMMON/TCK/Z(100),NTCK
SIGNS=X1*X2
A=X2-X1
AL=ALOG10(A)
N=AL
IF(AL.LT.0.) N=N-1
C=A/(10.**N)
NC=C
IF(NC.GT.5) NC=5
IF(NC.LT.1) NC=1
TS=NC*(10.**N-1)
IF(SIGNS.LT.0.) GO TO 7
NX1=0
IF(X1.NE.0.) NX1=ALOG10(ABSF(X1))
E=X1/(10.**NX1)
NE=E
IF(X1.LT.0.) NE=NE-1
E=NE
E=E*(10.**NX1)-TS
I=0
5    CONTINUE
E=E+TS
IF(E.LT.X1) GO TO 5
IF(E.GT.X2) GO TO 6
I=I+1
Z(I)=E
GO TO 5
6    CONTINUE
NTCK=I
RETURN
7    CONTINUE
NTS1=-X1/TS
DO 15 J=1,NTS1
Z(J)=- (NTS1+1-J)*TS
15   CONTINUE
I=NTS1
E=-TS
8    CONTINUE
E=E+TS
IF(E.GT.X2) GO TO 6
I=I+1
Z(I)=E
GO TO 8
END

```

```

SUBROUTINE TRAP(NT,TSEC,LFOUT)
COMMON/TRAJEC/MRUTE,GRANGE,VFPE,VVEL,HREF,TREF,QREF,BETA,CL1,ATIF,
1      RTI(100),ATI(100),HT(100),VT(100),BT(100),ELV(100),
2      RANGE,GAMA,VZ,A,E,HAPO,TAPO,RLI,ALI,TL,HDRAG,EDRAG,
3      VDRAG,TDRAG,EIMP,VIMP,TIMP,RLOSS
COMMON/CONST/RE,PI,RADIAN
DIMENSION TSEC(100)
RANGE=GRANGE
VZ=VVEL
GAMA=VFPE
G=0.0098
SPIN=7.292E-5
IF(MRUTE.NE.0) SPIN=0.
GAMMA=GAMA*RADIAN
V2MAX=2.*G*RE
GR02=G*RE*RE
IF((-RANGE)/2,7,7
2 TH0=RANGE/RE*0.5
CTHO=COS(TH0)
STHO=SIN(TH0)
IF(GAMMA)3,3,31
3 IF(VZ)4,4,21
4 IF(CTHO)5,5,6
5 WRITE(LFOUT,1005)
NHLP=4
GO TO 9
6 A=(1.+STHO)*RE*0.5
E=(1.-STHO)/CTHO
CGAMMA=SQRT(A/RE)
VZ=SQRT(V2MAX*STHO/(1.+STHO))
GO TO 29
7 IF(GAMMA.GT.0.0.AND.VZ.GT.0.0) GO TO 11
NHLP=7
9 WRITE(LFOUT,1001)
CALL HELP:GHTRAP ,NHLP,1)
11 VZ=VZ**2
TEST=V2MAX-VZ
NHLP=11
IF(TEST)12,12,13
12 WRITE(LFOUT,1002)
GO TO 9
13 A=GR02/TEST
CGAMMA=COS(GAMMA)
E=SQRT(1.-V2*CGAMMA**2/(A*G))
TH0=ACOS((1.+A*(E*E-1.)/RE)/E)
RANGE=2.*RE*TH0
GO TO 39
21 VZ=VZ**2
TEST=V2MAX-VZ
NHLP=21
IF(-TEST)22,12,12
22 IF(VZ-V2MAX*STHO/(1.+STHO))23,24,24
23 WRITE(LFOUT,1003)
NHLP=22
GO TO 9
24 A=GR02/TEST
TEST=SQRT(((RE/A)*CTHO*0.5)**2+1.-(RE/A))
IF(GAMMA)25,28,25
25 IF(0.5*V2MAX-VZ)26,26,27
26 WRITE(LFOUT,1006)

```

```

NHLP=25
GO TO 9
27 TEST=-TEST
28 E=0.5*RE/A*CTHO+TEST
  CGAMMA=SQRT(A*G*(1.-E*I)/V2)
29 GAMMA=ACOS(CGAMMA)
  GO TO 39
31 CGAMMA=COS(GAMMA)
  V2=G*RE*STHO/(CGAMMA*SIN(THO+GAMMA))
  TEST=V2*AX-V2
  IF(TEST132,32,33)
32 WRITE(1,FOUR,1004)
  NHLP=31
  GO TO 9
33 A=GRO2/TEST
  E=SQRT(1.-V2*CGAMMA**2/(A*G))
  VZ=SQRT(V2)
39 AE=A*E
  AE2=A-AE*E
  VCON=SQRT(AE2*GRO2)
  ECC=ACOS((RE-A)/AE)
  C1=A/RE*SQRT(A/G)
  TAPU=C1*(ECC+E*SIN(ECC))
  HAPU=A+AE-RE
  GAMA=GAMMA/RADIAN
  HREF1=AMAX1(AMIN1(HREF,HAPU),0.)
  HDRAG=5.*AINT(-7.3*ALOG(1.E-5*BETA*SIN(GAMMA)/VZ**2)/5.+0.5)
  HDRAG=AMAX1(AMIN1(HDRAG,HAPU,120.),0.)
  ZDRAG=RE+HDRAG
  ECC=ACOS((ZDRAG-A)/AE)
  TDRAG=TAPU+C1*(ECC+E*SIN(ECC))
  VDRAG1=SQRT(GRO2*(2./ZDRAG-1./A))
  EDKAG1=ACOS(VCON/ZDRAG/VDRAG1)
  EDKAG=RE*(THO-ACOS((ZDRAG-AE2)/(ZDRAG*E)))
  COSCLI=COS(CLI)
  SINCLI=SIN(CLI)
  X1=ATIF*RADIAN
  COSADI=COS(X1)
  SINADI=SIN(X1)
  RDI=RDAG
  J=1
41 X1=REI/RE
  COSR=COS(X1)
  SINR=SIN(X1)
  COSCLU=COSCLI*COSR+SINCLI*SINR*COSADI
  SINCLD=SQRT(1.-COSCLU**2)
  CBDKAG=(COSCLI*SINR-SINCLI*COSR*COSADI)/SINCLD
  SBDKAG=-SINADI*SINCLI/SINCLD
  BDRAG=ASIN(SBDKAG)
  IF(CBDKAG.LT.0.) BDRAG=PI-BDRAG
  VATMOS=SPIN*ZDRAG*SINCLD
  X1=VDRAG1*COS(EDKAG1)
  BDRAG1=BDRAG+ASIN(VATMOS*CBDKAG/X1)
  VDRAG=SQRT(VDRAG1**2+VATMOS**2-2.*VATMOS*X1*SIN(BDRAG1))
  EDKAG=ASIN(VDRAG1*SIN(EDKAG1)/VDRAG)
  IF(HREF1-HDRAG)51,52,52
51 IF(QREF)55,52,55
52 ECC=ACOS((RE+HREF1-A)/AE)
  TDEL=C1*(ECC+E*SIN(ECC))
  I1=(QREF.EQ.0.) TDEL=-TDEL
  TDEL=TAPU+TDEL
  TI=TDRAG

```

```

HI=HDRAG
VI=VDRAG
FI=EDRAG
RI=RDI
GO TO 56
55 TDEL=1.E10
CALL RVDRAG(G,BETA,TDRAG,HDRAG,VDRAG,EDRAG,RDI,TDEL,HREF1,VI,EI,
IRI)
TI=TDEL
HI=HREF1
56 TL=TREF-TDEL
TI=TI+TL
TIMP=1.E10
HF=0.0
CALL RVDRAG(G,BETA,TI,HI,VI,EI,RI,TIMP,HF,VIMP,EIMP,RLOSS)
IF(0.001-ABS(RLOSS))57,58,58
57 RDI=RDI-RLOSS
J=J+1
IF(J.GT.10) CALL HELP(6HTRAP ,57,1)
GO TO 41
58 TAPD=TAPD+TL
TDRAG=TDRAG+TL
RLOSS=RDRAG-RDI
CALL COORDX(0.,1,RDI,ATIF,HDRAG,X1,X2,X3,XDI,YDI,ZDI,X4,X5)
CALL ASPECT(COSCL1,SINCL1,0.,XDI,YDI,ZDI,1,0.,0.,0.,XID,YID,ZID)
ATD=(EDRAG-PI)/RADIAN
TP=TL
I=0
IF(NT)60,95,60
60 I=I+1
II=TSEC(I)
61 EM=(TI-TAPD)/C1
IF(TI-TL)62,62,63
62 ZI=RE
HI=0.0
VI=VZ
EI=GAMMA
RI=RANGE
GO TO 68
63 IF(TI-TDRAG)64,64,80
64 ECC=EM
65 FCC1=ECC
EM1=ECC1+E*CTR(ECC1)
ECC=ECC1+(EM-EM1)/(1.+E*COS(ECC1))
IF(ABS(ECC-ECC1)-1.E-6*ABS(ECC))66,66,65
66 ZI=A*(1.+E*COS(ECC))
III=ZI-RE
VI=SQRT(CR02*(2./ZI-1./A))
EI=ACOS(VCON/ZI/VI)
RI=RE*(TH0-SIGN(ACOS((ZI-AE2)/(ZI*E)),EM))
68 RTD=RI-RDRAG
CALL COORDX(HDRAG,1,RTD,ATD,HI,X1,X2,X3,XTD,YTD,ZTD,X4,X5)
CALL ASPECT(COSCL1,SINCL1,HDRAG,XID,YID,ZID,1,XTD,YTD,ZTD,X1I,Y1I,
1ZTI)
DLONG=SPIN*(TDRAG-A*AX1(TI,TL))
Y1=ASIN(SINCL1*SIN(0.5*DLONG))
A11=-ASIN(COS(0.5*DLONG)/COS(X1))/RADIAN
IF(CUSCL1.L1.0.) A11=180.-A11
R11=2.*RF*X1
CALL COORDX(0.,1,R11,A11,0.,X1,X2,X3,X1I,Y1I,Z1I,X4,X5)
CALL ASPECT(COSCL1,SINCL1,0.,X1I,Y1I,Z1I,1,X1I,Y1I,Z1I,X1I,Y1I,
1ZTI)
CALL COORDX(0.,2,X1I,Y1I,Z1I,RI,A1,X1,X2,X3,X4,X5,X6)

```

```

      IF(TL-TI)71,71,87
71  COSA=-CCS(BDRAG)
      X1=RTD/RE
      COSR=COS(X1)
      SINR=SIN(X1)
      COSCLT=COSCLD*COSR+SINCLD*SINR*COSA
      SINCLT=SQRT(1.-COSCLT**2)
      COSB=(COSCLD*SINR-SINCLD*COSR*COSA)/SINCLT
      SINB=SINCLD*SIN(BDRAG)/SINCLT
      VATMOS=SPIN*Z1*SINCLT
      X1=V1*COS(E1)
      VT1=SGRT(V1**2+VATMOS**2-2.*VATMOS*X1*SINB)
      ET1=ASIN(V1*SIN(E1)/VT1)
      X2=VT1*COS(ET1)
      SINBT1=(X1*SINB-VATMOS)/X2
      COSBT1=X1*COSB/X2
      GO TO 91
80  IF(TI-TIMP)81,81,86
81  HF=0.0
      IF(TP-TDRAG)82,82,83
82  TP=TORAG
      HI=HDRAG
      VT1=VDRAG
      ET1=EDRAG
      RI=RDI
83  CALL RVDRAG(G,BETA,TP,HI,VT1,ET1,RI,TI,HF,VT1,ET1,RI)
      HI=HF
      TP=TI
      AI=ATIF
      X1=RI/RE
      COSR=COS(X1)
      SINR=SIN(X1)
      COSCLT=COSCLI*COSR+SINCLI*SINR*COSADI
      SINCLT=SQRT(1.-COSCLT**2)
      COSBT1=(COSCLI*SINR-SINCLI*COSR*COSADI)/SINCLT
      SINBT1=-SINADI*SINCLI/SINCLT
      GO TO 91
86  RI=0.0
      AI=0.0
      HI=0.0
87  VT1=0.0
      SINBT1=0.0
      COSBT1=1.0
      ET1=0.0
91  IF(I-NT)92,92,96
92  RT1(I)=RI
      AT1(I)=AI
      HT1(I)=HI
      VT1(I)=VT1
      BT1(I)=ASIN(SINBT1)/RADIAN
      IF(COSBT1.LT.0.) BT1(I)=180.-BT1(I)
      FLV1(I)=SIGN(ET1,-EM)/RADIAN
      IF(TI-TIMP)93,94,94
93  IF(I-NT)96,96,96
94  NT=I
95  I=NT+1
      TI=TL
      GO TO 61
96  RT1=RI
      AT1=AI
      FDRAG=-EDRAG/RADIAN
      IMP=-EIMP/RADIAN
      RETURN

```

```

1001 FORMAT(26H0TRAJECTORY DATA INPUT ERROR)
1002 FORMAT(40H0LAUNCH VELOCITY EXCEEDS ESCAPE VELOCITY)
1003 FORMAT(50H0LAUNCH VELOCITY LESS THAN MINIMUM-ENERGY VELOCITY)
1004 FORMAT(27H0LAUNCH ELEVATION TOO LARGE)
1005 FORMAT(89H0MINIMUM-ENERGY TRAJECTORY REQUESTED FOR SURFACE RANGE E
  XCEEDING HALF EARTH CIRCUMFERENCE)
1006 FORMAT(38H0DEPRESSED TRAJECTORY INTERSECTS EARTH)
  END

```

```

SUBROUTINE COORDX(HO,MODE,RXSE,AYAA,HZEH,R,A,H,X,Y,Z,S,E)
COMMON /CONST/RE,PI,RADIAN
REH=RE+HO
GO TO (11,21,31,41),MODE
11 R=RXSE
  A=AYAA
  H=HZEH
  UO=R/RE
  U2=A*RADIAN
  U3=RE+H
  U1=U3*SIN(UO)
  X=U1*SIN(U2)
  Y=U1*COS(U2)
  Z=U3*COS(UO)-REH
  IF(UO.EQ.0.) Z=H-HO
  IF(U1)23,25,23
21 X=RXSE
  Y=AYAA
  Z=HZEH
  U1=X**2+Y**2
  IF(U1)22,24,22
22 U2=REH+Z
  U3=SQRT(U1+U2**2)
  U1=SQRT(U1)
  R=ASIN(U1/U3)*RE
  IF(U2.LT.0.0) R=PI*RE-R
  A=ASIN(X/U1)/RADIAN
  IF(Y.LT.0.0) A=180.-A
  H=U3-RE
23 S=SQRT(U1**2+Z**2)
  E=ASIN(Z/S)/RADIAN
  GO TO 99
24 R=0.
  A=0.
  J+Z
25 S=.5S(Z)
  F=90.
  IF(Z.LT.0.0) E=-90.
  GO TO 99
31 S=RXSE
  A=AYAA
  F=HZEH
  U2=A*RADIAN
  U3=E*RADIAN
  U1=S*COS(U3)
  X=U1*SIN(U2)
  Y=U1*COS(U2)
  Z=S*SIN(U3)
  U2=REH+Z
  U3=SQRT(U1**2+U2**2)
  R=ASIN(U1/U3)*RE
  IF(U2.LT.0.0) R=PI*RE-R
  H=U3-RE

```

```

GO TO 99
41 E=RXSE
A=AYAA
H=HZFH
U2=A*RADIAN
U3=E*RADIAN
COSE=COS(U3)
SINE=SIN(U3)
S=HTOS(HO,H,COSE,SINE)
U1=S*COSE
X=U1*SIN(U2)
Y=U1*COS(U2)
Z=S*SINE
U3=RE+H
R=ASIN(U1/U3)*RE
IF(RE+Z.LT.0.0) R=PI*RE-R
99 RETURN
END

```

```

SUBROUTINE HELP(SUBNAM,NSTATE,KOPT)
DIMENSION HOLRTH(2)
DATA HOLRTH/3H ,3HNON/
WRITE(59,10)HOLRTH(KOPT),SUBNAM,NSTATE
IF(KOPT.EQ.1) CALL EXIT
RETURN
10 FORMAT(11H0A3,37HFATAL ERROR DISCOVERED IN SUBROUTINE A6,20H AT STA
17EPEN: NUMBER16)
END

```

```

SUBROUTINE RVDRAQ(GO,BETA,TI,HI,VI,EI,RI,TF,HF,VF,EF,RF)
COMMON /CONST/RE,PI,RADIAN
DELTAH=0.5
T=TI
H=HI
V=VI
E=EI
R=RI
11 DELTAT=TF-T
SINE=SIN(E)
DH=AMINI(DELTAH,H-HF,1.01*V*SINE*DELTAT)
IF(-DH)12,21,21
12 HBAR=H-DH/2.
GBAR=GO*(RE/(RE+HBAR))**2
CALL ATMOD(0,HBAR,RHOBAR,DUM1,DUM2,DUM3,DUM4,DUM5,DUM6)
B=47.881-9*RVBETA(BETA,HBAR,RHOBAR,V,E)
V2EQ=2.*B*SINE/RHOBAR
DV=GBAR*(1./V-V/V2EQ)*DH
IF(DV)13,15,15
13 IF((V+DV)*ABS(V+DV-V2EQ))14,15,15
14 DV=SQRT(V2EQ)-V
15 VBAR=V+DV/2.
COSE=COS(E)
DE=GBAR*COSE/SINE/VBAR/VBAR*DH
EBAR=AMINI(E+DE/2.,PI/2.)
SEBAR=SIN(EBAR)
CEBAR=COS(EBAR)
CTNE=CEBAR/SEBAR
DR=DH*CTNE
X=RE+H-DH
DY=DH+DR*DR/2./X
DR=DY*CTNE/X

```



```

DE=DE-DR
CR=CR*RE
DT=DY/VBAR/SFBR
IF (DELTA-T-DI)16,17,17
16 A=DELTA/T/DT
DH=DH*X
DV=DV*X
DE=DE*X
DR=DR*X
DT=DELTAT
17 T=T+DT
H=H-DT
V=V+DV
E=AMIN1(E+DE,PI/2.)
R=R-DR
GO TO 11
21 TF=T
HF=H
VF=V
EF=E
RF=R
RETURN
END
FUNCTION RVBETA(BETA,H,RHO,V,E)
RVBETA=BETA
RETURN
END

```

```

SUBROUTINE ASPECT(COSCLO,SINCLU,HO,X1,Y1,Z1,NPOINT,X2,Y2,Z2,XZ1,
Y21,Z21)
DIMENSION X2(2),Y2(2),Z2(2),XZ1(2),Y21(2),Z21(2)
COMMON /CONST/RE,PI,RADIAN
REH=RE+HU
U1=X1**2+Y1**2
IF(U1)1,2,1
1 U2=(EH+Z1
U3=SQRT(U1+U2**2)
U1=SQRT(U1)
SINR1=U1/U3
COSR1=U2/U3
SINA1=X1/U1
COSA1=Y1/U1
SINA11=SINCLU*SINA1/SQRT(1.0-(COSCLO*COSR1+SINCLU*SINR1*COSA1)**2)
IF(SINA11.GT. 1.0) SINA11=1.0
IF(SINA11.LT. (-1.0)) SINA11=-1.0
COSA11=SQRT(1.-SINA11**2)
IF(SINCLU*COSR1*COSA1-COSCLO*SINR1.LT. 0.0) COSA11=-COSA11
GO TO 3
2 U3=REH+Z1
3 DO 9 N=1,NPOINT
X=X2(N)-X1
Y=Y2(N)-Y1
Z=Z2(N)-Z1
IF(U1)4,5,4
4 YYY= X*SINA1 + Y*COSA1
XX= X*COSA1 - Y*SINA1
YY=YYY*COSR1 - Z*SINR1
X=XX*COSA11+YY*SINA11
Y=YY*COSA11-XX*SINA11
Z=YYY*SINR1 + Z*COSR1
5 XZ1(N)=X

```

```

Y21(N)=Y
Z21(N)=Z
9 CONTINUE
RETURN
END
FUNCTION HTOS(H1,H2,CUSE,SINE)
COMMON /CONST/RE,PI,RADIAN
R1=RE+H1
R2=RE+H2
SIND=R1*CUSE/R2
COSD=SQRT(1.-SIND**2)
HTOS=R2*COSD-R1*SINE
RETURN
END

```

SUBROUTINE ATMOSD

This subroutine is listed in Ref. 6.