# DEVELOPMENT OF ACCURATE STANDARDIZED ALGORITHMS FOR CONVERSION BETWEEN SRP GRID COORDINATES AND LATITUDE/LONGITUDE (U)

WSRC Contact

G. Stejskal

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

A technical report for the EPA, SCDHEC,
and for the DOE reading room

**Technical Division**
**Savannah River Laboratory**

**DPST-87-724**

cc: C. R. Sherman, SRP
J. L. Steele
J. D. Heffner
T. V. Crawford, SRL
J. C. Corey
D. B. Moore
H. E. Mackey, Jr.
J. B. Gladden
Geotechnical Group
SRL Records (4)

October 12, 1987

To: D. E. Gordon and R. W. Benjamin

From: B. B. Looney, J. T. Marsh, Jr., and D. W. Hayes

**DEVELOPMENT OF ACCURATE STANDARDIZED ALGORITHMS FOR CONVERSION BETWEEN SRP GRID COORDINATES AND LATITUDE/LONGITUDE**

**Background**

The Savannah River Plant (SRP) is a nuclear production facility operated by E. I. du Pont de Nemours and Co. for the United States Department of Energy. SRP is located along the Savannah River in South Carolina. Construction of SRP began in the early 1950's. At the time the plant was built, a local coordinate system was developed to assist in defining the locations of plant facilities. Over the years, large quantities of data have been developed using "SRP Coordinates." These data include: building locations, plant boundaries, environmental sampling locations, waste disposal area locations, and a wide range of other geographical information. Currently, staff persons at SRP are organizing these data into automated information systems to allow more rapid, more robust and higher quality interpretation, interchange and presentation of spatial data. A key element in this process is the ability to incorporate outside data bases (e.g., remote sensing data from NASA) into the systems, as well as to share SRP data with interested organizations outside of SRP. Most geographical information outside of SRP is organized using latitude and longitude. Thus, straightforward, accurate and consistent algorithms to convert SRP Coordinates to/from latitude and longitude are needed. Appropriate algorithms are presented in the following sections.

**Summary of Methods**

The algorithms derived and presented in the attachments are an extension of those in the Oak Ridge Geographical Information Systems Software on the SRP mainframe computer. The conversions are straightforward and can be carried out using any reasonable handheld calculator, or they can be incorporated into larger programs as procedures, functions or subroutines. The conversions are carried out through the state plane. Seventy-three locations were checked by SRP technical staff and an independent subcontractor and the resulting calculated coordinated were exactly the same. We recommend that the listed (or functionally identical) algorithms be used for all conversions of SRP coordinates to/from latitude and longitude.

**List of Attachments**

Several items are attached to facilitate use of these algorithms:

Attachment 1 - Equations Used (brief derivation)
Attachment 2 - PASCAL Procedures
Attachment 3 - C Functions
Attachment 4 - FORTRAN Subroutines
Attachment 5 - Documentation of Program SRPCOOR

---

A disk containing the various procedures, functions and subroutines, as well as the utility program SRPCOOR is available from the authors. Please specify if you need a disk for the IBM family of computers or the MacIntosh family of computers.

# ATTACHMENT 1

## Equations Used / Brief Derivation

General Constants used in the conversion algorithms:

```
RB   = 32.67688765E+06
C    = 2.0E+06
R0   = 32.16147986E+06
XLAM = 81.0
XL   = 0.54465157
PHI0 = 33.25
PHI1 = 2.7484455E-06
PHI2 = 2.91131E-08
GPI  = PI
CD   = 180.0
GSIN = 0.5885655
GCOS = 0.80844953
```

The equations to convert SRP grid coordinates to latitude and longitude are exactly the same as those used in the subroutine SRP(ID,A1,A2,A3,A4) on the Oak Ridge Geographic Data Systems software on the SRP mainframe (when ID = 'NELL'). To convert SRP grid coordinates (in feet) to latitude and longitude (in degrees.decimal degrees) use the following equations:

```
x = 1.79563077E+06 - (GSIN * SRPN) + (GCOS * SRPE)

y = 0.43447163E+06 + (GCOS * SRPN) + (GSIN * SRPE)

theta = ARCTAN( (C - x) / (RB - y) )

rad = (RB - y) /  (COS( theta ))

latitude = PHI0 - (PHI1 * (rad - R0)) - ((PHI2 * (rad - R0))^2)

longitude = XLAM + ((theta * CD) / (GPI * XL))
```

The equations to convert latitude and longitude to SRP grid coordinates were derived from those above using algebraic manipulations and the quadratic formula. First, the equations for latitude and longitude were converted into a quadratic form in terms of the variable "rad." Then, the equations for "theta," "x" and "y" were manipulated to eliminate variables and final equations were developed for the conversion. To convert latitude and longitude (in degrees.decimal degrees) to SRP grid coordinates (in feet) use the following equations:

```
theta = (longitude - XLAM) * XL
qa    = - PHI2^2
qb    = (2 * PHI2^2 * R0) - PHI1
qc    = PHI0 + (PHI1 * R0) - (PHI2^2 * R0^2) - latitude
rad   = (-qb - (qb^2 - (4 * qa * qc))^0.5) / (2 * qa)
y     = -(rad * COS( (theta * GPI) / CD )) + RB
x     = -(TAN( (theta * GPI) / CD) ) * (RB - y)) + C
SRPN  = -(x - 1795630.77 - ((GCOS*(y-434471.63))/GSIN)) /
           (GSIN + (GCOS^2 / GSIN))
SRPE  = (y - 434471.63 - (GCOS * SRPN)) / GSIN
```

**ATTACHMENT 2**

**PASCAL Procedures**

```
{**********************************************************
 PASCAL procedures to convert SRP grid coordinates to latitude
 and longitude through the state plane}

Const
  RB   = 3.267688765E+07;
  C    = 2.000000E+06;
  R0   = 3.216147986E+07;
  XLam = 81.0;
  Xl   = 0.54465157;
  Phi0 = 33.2500000;
  Phi1 = 2.7484455E-06;
  Phi2 = 2.91131E-08;
  Cd   = 180.0;
  GSin = 0.5885655;
  GCos = 0.80844953;
  GPi  = Pi;


Function Tan(Rad : Real) :Real;
Begin
   Tan := Sin(Rad)/Cos(Rad);
End;                  { Tan }


Procedure SRP_2_LL(N,E : Real; Var Lat, Long : Real);

{This procedure uses the algorithms from the Oak Ridge
 Geographical System on the SRP mainframe}

Var   X, Y, Theta, Rad : Real;

Begin
   X := 1795630.77-(GSin*N)+(GCos*E);
   Y := 434471.63+(GCos*N)+(GSin*E);
   Theta := ArcTan((C-X)/(Rb-Y));
   Rad := (Rb-Y)/Cos(Theta);
   Theta := CD*Theta/GPi;
   Rad := Rad-R0;
   Lat := Phi0-(Phi1*Rad)-Sqr(Phi2*Rad);
   Long := XLam + (Theta/Xl);
End;               { SRP2LL }
```

```
Procedure LL_2_SRP(Var N, E : Real; Lat, Long : Real);

{This procedure was derived from the algorithm used in
 SRP_2_LL using algebraic manipulations and the
 quadratic formula}

Var   Rad, Theta, X, Y, Qa, Qb, Qc : Real;

Begin
   Theta := (Long-XLam)*XL;
   Qa := -1*Sqr(Phi2);
   Qb := (2*Sqr(Phi2)*R0)-Phi1;
   Qc := Phi0+(Phi1*R0)-(Sqr(Phi2)*Sqr(R0))-Lat;
   Rad := (-Qb-Sqrt(Sqr(Qb)-(4*Qa*Qc)))/(2*Qa);
   Theta := (Theta*GPi)/Cd;
   Y := -(Rad*Cos(Theta))+Rb;
   X := -(Tan(Theta)*(Rb-Y))+C;
   N := -(X-1795630.77-((GCos*(Y-434471.63))/GSin))/
          (GSin+(Sqr(GCos)/GSin));
   E := (Y-434471.63-(GCos*N))/GSin;
End;              { LL_2_SRP }


{*************************************************************}
```

# ATTACHMENT 3

## C Functions

```
/* ************************************************************ */
/* C functions to convert SRP grid coordinates to latitude      */
/* and longitude through the state plane.                       */


#include "stdio.h"
#include "math.h"

#define rb    32676887.65
#define c     2000000.0
#define r0    32161479.86
#define xlam        81.0
#define xl           0.54465157
#define phi0        33.25
#define phi1         0.0000027484455
#define phi2         2.91131e-8
#define cd         180.0
#define gsin         0.5885655
#define gcos         0.80844953
#define gpi          3.14159265

double sqr(num)
  double num;
{ return(num*num);
}                /* sqr */

/* This function uses the algorithms from the Oak Ridge        */
/* Geographical System on the SRP mainframe.  Note that        */
/* the parameters lat and lng are pointers (i.e. pass as       */
/* &varname in the main program.)                              */

void srp_2_ll(n,e,lat,lng)
  double n,e,*lat,*lng;
{ double x,y,theta,rad;
  x=1795630.77-(gsin*n)+(gcos*e);
  y=434471.63+(gcos*n)+(gsin*e);
  theta=atan((c-x)/(rb-y));
  rad=(rb-y)/cos(theta);
  theta*=(cd/gpi);
  rad-=r0;
  *lat=phi0-(phi1*rad)-sqr(phi2*rad);
  *lng=xlam+(theta/xl);
}                /* srp_2_ll */
```

```
/* This function was derived from the algorithm used in      */
/* SRP_2_LL using algebraic manipulations and the            */
/* quadratic formula.  Note that the parameters n and e      */
/* are pointers (i.e. pass as &varname in the main program.) */

void ll_2_srp(n,e,lat,lng)
  double *n,*e,lat,lng;
{ double rad,theta,x,y,qa,qb,qc;
  theta=(lng-xlam)*xl;
  qa=-1*sqr(phi2);
  qb=(2*sqr(phi2)*r0)-phi1;
  qc=phi0+(phi1*r0)-(sqr(phi2)*sqr(r0))-lat;
  rad=(-qb-sqrt(sqr(qb)-(4*qa*qc)))/(2*qa);
  theta*=(gpi/cd);
  y=-(rad*cos(theta))+rb;
  x=-(tan(theta)*(rb-y))+c;
  *n=-(x-1795630.77-((gcos*(y-434471.63))/gsin))/
       (gsin+(sqr(gcos)/gsin));
  *e=(y-434471.63-(*n*gcos))/gsin;
}                 /* ll_2_srp */

/* ************************************************************  */
```

**ATTACHMENT 4**

**FORTRAN Subroutines**

```
C
C ***************************************************************
C FORTRAN subroutines to convert SRP grid coordinates to latitude
C and longitude through the state plane)
C
C
C This subroutine uses the algorithms from the Oak Ridge
C Geographical System on the SRP mainframe
C
      SUBROUTINE SRP2LL(N,E,LAT,LONG)
      IMPLICIT REAL*8 (A-Z)
      PARAMETER (RB=32676887.65,C=2000000.0,R0=32161479.86,XLAM=81.0)
      PARAMETER (XL=0.54465157,CD=180.0,GSIN=0.5885655,GCOS=0.80844953)
      PARAMETER (PHI0=33.25,PHI1=2.7484455E-06,PHI2=2.91131E-8)
      PARAMETER (GPI=3.14159265)
      X=1795630.77-(GSIN*N)+(GCOS*E)
      Y=434471.63+(GCOS*N)+(GSIN*E)
      THETA=ATAN((C-X)/(RB-Y))
      RAD=(RB-Y)/COS(THETA)
      THETA=CD*THETA/GPI
      RAD=RAD-R0
      LAT=PHI0-(PHI1*RAD)-(PHI2*RAD)**2
      LONG=XLAM+THETA/XL
      END
C
C This subroutine was derived from the algorithm used in
C SRP2LL using algebraic manipulations and the
C quadratic formula.
C
      SUBROUTINE LL2SRP(N,E,LAT,LONG)
      IMPLICIT REAL*8 (A-Z)
      PARAMETER (RB=32676887.65,C=2000000.0,R0=32161479.86,XLAM=81.0)
      PARAMETER (XL=0.54465157,CD=180.0,GSIN=0.5885655,GCOS=0.80844953)
      PARAMETER (PHI0=33.25,PHI1=2.7484455E-06,PHI2=2.91131E-8)
      PARAMETER (GPI=3.14159265)
      THETA=(LONG-XLAM)*XL
      QA=-1*(PHI2**2)
      QB=(2*(PHI2**2)*R0)-PHI1
      QC=PHI0+(PHI1*R0)-((PHI2**2)*(R0**2))-LAT
      RAD=(-QB-SQRT((QB**2)-(4*QA*QC)))/(2*QA)
      THETA=THETA*GPI/CD
      Y=-RAD*COS(THETA)+RB
      X=-(TAN(THETA)*(RB-Y))+C
      N=-(X-1795630.77-((GCOS*(Y-434471.63))/GSIN))/
     1          (GSIN+(GCOS**2)/GSIN)
      E=(Y-434471.63-(GCOS*N))/GSIN
      END
C
C ***************************************************************
C
```

**ATTACHMENT 5**

**Documentation of Program SRPCOOR**

SRPCOOR is a program to convert between SRP coordinates and latitude/longitude. The program uses the procedures documented in DPST-87-724 to make the conversions. The algorithms were derived from the Oak Ridge Geographical Systems Software on the SRP Mainframe. The SRP coordinate system is a local grid that is measured in feet. Grid north is approximately 36.4 degrees west of true north at SRP. Latitude and Longitude are entered and written in "degrees.decimal degrees".

SRP is a simple utility program written for the IBM and MacIntosh families of microcomputers. The program was written in TURBO PASCAL. You will be prompted for the type of conversion you wish (SRP to LL, or LL to SRP), and then for the type of input desired (keyboard or files). If you select files, you will be prompted for the names of the input and output files and the organization of the input file. Note that this is intended to be a handy utility program; little effort was expended in I/O checking (if you have blank lines or illegal items in the input file the program will not run).

To run SRPCOOR on the IBM family of computers, type:

SRPCOOR

followed by a [return] at the prompt for the drive where SRPCOOR.COM is located. To run SRPCOOR on the MacIntosh family of computers, double click on the SRPCOOR file.

**Technical Division**
**Savannah River Laboratory**

**DPST-87-724**

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## Equations Used / Brief Derivation

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The equations to convert SRP grid coordinates to latitude and longitude are exactly the same as those used in the subroutine SRP(ID,A1,A2,A3,A4) on the Oak Ridge Geographic Data Systems software on the SRP mainframe (when ID = 'NELL'). To convert SRP grid coordinates (in feet) to latitude and longitude (in degrees.decimal degrees) use the following equations:

```
x = 1.79563077E+06 - (GSIN * SRPN) + (GCOS * SRPE)

y = 0.43447163E+06 + (GCOS * SRPN) + (GSIN * SRPE)

theta = ARCTAN( (C - x) / (RB - y) )

rad = (RB - y) /  (COS( theta ))

latitude = PHI0 - (PHI1 * (rad - R0)) - ((PHI2 * (rad - R0))^2)

longitude = XLAM + ((theta * CD) / (GPI * XL))
```

The equations to convert latitude and longitude to SRP grid coordinates were derived from those above using algebraic manipulations and the quadratic formula. First, the equations for latitude and longitude were converted into a quadratic form in terms of the variable "rad." Then, the equations for "theta," "x" and "y" were manipulated to eliminate variables and final equations were developed for the conversion. To convert latitude and longitude (in degrees.decimal degrees) to SRP grid coordinates (in feet) use the following equations:

```
theta = (longitude - XLAM) * XL
qa    = - PHI2^2
qb    = (2 * PHI2^2 * R0) - PHI1
qc    = PHI0 + (PHI1 * R0) - (PHI2^2 * R0^2) - latitude
rad   = (-qb - (qb^2 - (4 * qa * qc))^0.5) / (2 * qa)
y     = -(rad * COS( (theta * GPI) / CD )) + RB
x     = -(TAN( (theta * GPI) / CD) ) * (RB - y)) + C
SRPN  = -(x - 1795630.77 - ((GCOS*(y-434471.63))/GSIN)) /
           (GSIN + (GCOS^2 / GSIN))
SRPE  = (y - 434471.63 - (GCOS * SRPN)) / GSIN
```

**ATTACHMENT 2**

**PASCAL Procedures**

```
{*****************************************************************
 PASCAL procedures to convert SRP grid coordinates to latitude
 and longitude through the state plane}

Const
  RB   = 3.267688765E+07;
  C    = 2.000000E+06;
  R0   = 3.216147986E+07;
  XLam = 81.0;
  Xl   = 0.54465157;
  Phi0 = 33.2500000;
  Phi1 = 2.7484455E-06;
  Phi2 = 2.91131E-08;
  Cd   = 180.0;
  GSin = 0.5885655;
  GCos = 0.80844953;
  GPi  = Pi;


Function Tan(Rad : Real) :Real;
Begin
   Tan := Sin(Rad)/Cos(Rad);
End;                { Tan }


Procedure SRP_2_LL(N,E : Real; Var Lat, Long : Real);

{This procedure uses the algorithms from the Oak Ridge
 Geographical System on the SRP mainframe}

Var   X, Y, Theta, Rad : Real;

Begin
   X := 1795630.77-(GSin*N)+(GCos*E);
   Y := 434471.63+(GCos*N)+(GSin*E);
   Theta := ArcTan((C-X)/(Rb-Y));
   Rad := (Rb-Y)/Cos(Theta);
   Theta := CD*Theta/GPi;
   Rad := Rad-R0;
   Lat := Phi0-(Phi1*Rad)-Sqr(Phi2*Rad);
   Long := XLam + (Theta/Xl);
End;              { SRP2LL }
```

```
Procedure LL_2_SRP(Var N, E : Real; Lat, Long : Real);

{This procedure was derived from the algorithm used in
 SRP_2_LL using algebraic manipulations and the
 quadratic formula}

Var   Rad, Theta, X, Y, Qa, Qb, Qc : Real;

Begin
   Theta := (Long-XLam)*XL;
   Qa := -1*Sqr(Phi2);
   Qb := (2*Sqr(Phi2)*R0)-Phi1;
   Qc := Phi0+(Phi1*R0)-(Sqr(Phi2)*Sqr(R0))-Lat;
   Rad := (-Qb-Sqrt(Sqr(Qb)-(4*Qa*Qc)))/(2*Qa);
   Theta := (Theta*GPi)/Cd;
   Y := -(Rad*Cos(Theta))+Rb;
   X := -(Tan(Theta)*(Rb-Y))+C;
   N := -(X-1795630.77-((GCos*(Y-434471.63))/GSin))/
          (GSin+(Sqr(GCos)/GSin));
   E := (Y-434471.63-(GCos*N))/GSin;
End;              { LL_2_SRP }


{*************************************************************}
```

# ATTACHMENT 3

## C Functions

```
/* ************************************************************ */
/* C functions to convert SRP grid coordinates to latitude      */
/* and longitude through the state plane.                       */


#include "stdio.h"
#include "math.h"

#define rb    32676887.65
#define c     2000000.0
#define r0    32161479.86
#define xlam        81.0
#define xl           0.54465157
#define phi0        33.25
#define phi1         0.0000027484455
#define phi2         2.91131e-8
#define cd         180.0
#define gsin         0.5885655
#define gcos         0.80844953
#define gpi          3.14159265

double sqr(num)
  double num;
{ return(num*num);
}                /* sqr */

/* This function uses the algorithms from the Oak Ridge        */
/* Geographical System on the SRP mainframe.  Note that        */
/* the parameters lat and lng are pointers (i.e. pass as       */
/* &varname in the main program.)                              */

void srp_2_ll(n,e,lat,lng)
  double n,e,*lat,*lng;
{ double x,y,theta,rad;
  x=1795630.77-(gsin*n)+(gcos*e);
  y=434471.63+(gcos*n)+(gsin*e);
  theta=atan((c-x)/(rb-y));
  rad=(rb-y)/cos(theta);
  theta*=(cd/gpi);
  rad-=r0;
  *lat=phi0-(phi1*rad)-sqr(phi2*rad);
  *lng=xlam+(theta/xl);
}                /* srp_2_ll */
```

```
/* This function was derived from the algorithm used in      */
/* SRP_2_LL using algebraic manipulations and the            */
/* quadratic formula.  Note that the parameters n and e      */
/* are pointers (i.e. pass as &varname in the main program.) */

void ll_2_srp(n,e,lat,lng)
  double *n,*e,lat,lng;
{ double rad,theta,x,y,qa,qb,qc;
  theta=(lng-xlam)*xl;
  qa=-1*sqr(phi2);
  qb=(2*sqr(phi2)*r0)-phi1;
  qc=phi0+(phi1*r0)-(sqr(phi2)*sqr(r0))-lat;
  rad=(-qb-sqrt(sqr(qb)-(4*qa*qc)))/(2*qa);
  theta*=(gpi/cd);
  y=-(rad*cos(theta))+rb;
  x=-(tan(theta)*(rb-y))+c;
  *n=-(x-1795630.77-((gcos*(y-434471.63))/gsin))/
        (gsin+(sqr(gcos)/gsin));
  *e=(y-434471.63-(*n*gcos))/gsin;
}                 /* ll_2_srp */

/* ************************************************************  */
```

**ATTACHMENT 4**

**FORTRAN Subroutines**

```
C
C ***************************************************************
C FORTRAN subroutines to convert SRP grid coordinates to latitude
C and longitude through the state plane)
C
C
C This subroutine uses the algorithms from the Oak Ridge
C Geographical System on the SRP mainframe
C
      SUBROUTINE SRP2LL(N,E,LAT,LONG)
      IMPLICIT REAL*8 (A-Z)
      PARAMETER (RB=32676887.65,C=2000000.0,R0=32161479.86,XLAM=81.0)
      PARAMETER (XL=0.54465157,CD=180.0,GSIN=0.5885655,GCOS=0.80844953)
      PARAMETER (PHI0=33.25,PHI1=2.7484455E-06,PHI2=2.91131E-8)
      PARAMETER (GPI=3.14159265)
      X=1795630.77-(GSIN*N)+(GCOS*E)
      Y=434471.63+(GCOS*N)+(GSIN*E)
      THETA=ATAN((C-X)/(RB-Y))
      RAD=(RB-Y)/COS(THETA)
      THETA=CD*THETA/GPI
      RAD=RAD-R0
      LAT=PHI0-(PHI1*RAD)-(PHI2*RAD)**2
      LONG=XLAM+THETA/XL
      END
C
C This subroutine was derived from the algorithm used in
C SRP2LL using algebraic manipulations and the
C quadratic formula.
C
      SUBROUTINE LL2SRP(N,E,LAT,LONG)
      IMPLICIT REAL*8 (A-Z)
      PARAMETER (RB=32676887.65,C=2000000.0,R0=32161479.86,XLAM=81.0)
      PARAMETER (XL=0.54465157,CD=180.0,GSIN=0.5885655,GCOS=0.80844953)
      PARAMETER (PHI0=33.25,PHI1=2.7484455E-06,PHI2=2.91131E-8)
      PARAMETER (GPI=3.14159265)
      THETA=(LONG-XLAM)*XL
      QA=-1*(PHI2**2)
      QB=(2*(PHI2**2)*R0)-PHI1
      QC=PHI0+(PHI1*R0)-((PHI2**2)*(R0**2))-LAT
      RAD=(-QB-SQRT((QB**2)-(4*QA*QC)))/(2*QA)
      THETA=THETA*GPI/CD
      Y=-RAD*COS(THETA)+RB
      X=-(TAN(THETA)*(RB-Y))+C
      N=-(X-1795630.77-((GCOS*(Y-434471.63))/GSIN))/
     1          (GSIN+(GCOS**2)/GSIN)
      E=(Y-434471.63-(GCOS*N))/GSIN
      END
C
C ***************************************************************
C
```

**ATTACHMENT 5**

**Documentation of Program SRPCOOR**

SRPCOOR is a program to convert between SRP coordinates and latitude/longitude. The program uses the procedures documented in DPST-87-724 to make the conversions. The algorithms were derived from the Oak Ridge Geographical Systems Software on the SRP Mainframe. The SRP coordinate system is a local grid that is measured in feet. Grid north is approximately 36.4 degrees west of true north at SRP. Latitude and Longitude are entered and written in "degrees.decimal degrees".

SRP is a simple utility program written for the IBM and MacIntosh families of microcomputers. The program was written in TURBO PASCAL. You will be prompted for the type of conversion you wish (SRP to LL, or LL to SRP), and then for the type of input desired (keyboard or files). If you select files, you will be prompted for the names of the input and output files and the organization of the input file. Note that this is intended to be a handy utility program; little effort was expended in I/O checking (if you have blank lines or illegal items in the input file the program will not run).

To run SRPCOOR on the IBM family of computers, type:

SRPCOOR

followed by a [return] at the prompt for the drive where SRPCOOR.COM is located. To run SRPCOOR on the MacIntosh family of computers, double click on the SRPCOOR file.