SEISPLN

REFERENCE MANUAL FOR THE SEISPLN EARTHQUAKE ANALYSIS PACKAGE ON THE DEC MICROVAX II

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By: Eric Rieken
NORCUS Appointee to Battelle
Washington State University
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MASTER

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PURPOSE AND BRIEF DESCRIPTION OF SEISPLN PACKAGE

The SEISPLN software package for the DEC MicroVAX II was originally written for the author's Master's thesis at Washington State University (WSU). This software is intended to be a subsidiary component of the Geologic Spatial Analysis system (GSA) under development at the WSU Department of Geology. The GSA authors are Dr. Jay Eliasen and Dr. Richard Thiessen. The broad scope of GSA applications will not be covered in this manual.

All source code is written in VAX FORTRAN and is broken down into 5 discrete programs. The individual programs will be discussed in proper sequential order with simulated user input given by capital characters enclosed within double quotes. Your actual program input does not need to be upper case characters. Program prompts are lower case characters.

For example: Please type in your input file name.   (program prompt)
                  "CAJON_20_17_1"   (this is what you type into the program)

The SEISPLN package will allow you to generate statistically significant fault surfaces for subsets of an earthquake database. The parameters used are up to the discretion of the user, but the package is based primarily on the geometric relationships of the foci locations and the location errors of the foci. However, the data base can be filtered with respect to temporal characteristics as well.

The technique employed to locate subsets of foci which are considered to be subplanar concentrations of foci is as follows: First, a three dimensional grid system is created with elongated cells which will ultimately count the number of foci per cell for every possible strike and dip orientation of the grid system (fig.1). A table is output which gives the number of foci per cell for every strike orientation (5 degree increments). Each table represents a different 5 degree dip orientation of the grid system (fig. 2a). Also, there is a corresponding table for each frequency table which calculates the relative change in frequency between neighboring cells (fig. 2b). These tables are very useful since they tend to provide a simple contoured representation of the frequency table. Also, these tables bring out the relative concentrations of foci regardless of how many foci are in the cell. In other words, a cell with only 5% of the total foci in the region may still be a localized subplanar concentration of events if the neighboring cells are relatively absent of events. This is a significant benefit compared to the Fehier, Lutz, and Michelinni and Bolt techniques, which tend to wash out such low frequency foci concentrations.

Second, the user can run the next program to pull out subsets of the foci which are considered to be good "picks" from the frequency tables. Third, the next program will take the subset of foci and find the best fit surface to the data using a multiple linear regression technique. The calculated surface can be planar (first order), arcuate (second order), or of very complex surface geometry (third order). If a first order fit is selected, the fault trace (surface fit intersection with topography) is also determined, and considers topography to be flat and at sea level. Finally, the last program plots all the foci, along with the foci pick, surface fit, and fault trace, in a stereographic projection which can be rotated and manipulated in an al-

most infinite variety of ways (fig. 3).

SETTING UP:

Logon to my home directory, which is [err], and type:

"@SEIS"

This command will put you into the master SEISPLN subdirectory. Then, any time you want to run a particular program, just set the default directory to the one specified under that program's information block, given at the back of this manual.

When you are finished with your analysis, be sure to clean up the subdirectories by moving all the files you generated into their own data subdirectories. If you don't do this, you risk losing all of your files!

Figure 1. The elongate grid system with up to 23 cells. The number of earthquake foci which fall into each cell are counted and displayed in a frequency table. The grid is rotated at 5 degree increments first with respect to strike, then the entire sequence is repeated for every 5 degree dip orientation.

TABLE FOR BETA = 40.0 (DIP= 50.0) DIP DIRECTION =WEST										
INPUT DATA SET IS : [rieken.seispln.prepare]cajon.utm										
ROTATION CELL NUMBER (WEST=1 EAST=10)										
AGL	1	2	3	4	5	6	7	8	9	10
0.	7	21	25	8	4	4	3	3	0	0 75
5.	4	21	19	14	6	5	2	4	0	0 75
10.	7	19	14	18	7	5	1	5	0	0 76
15.	8	16	18	16	8	5	2	5	0	0 78
20.	9	16	14	16	11	6	2	5	0	0 79
25.	10	14	14	11	15	9	1	6	0	0 80
30.	9	17	13	7	18	9	3	6	0	0 82
35.	6	16	16	5	19	11	3	6	0	0 82
40.	3	18	14	7	16	15	3	5	1	0 82
45.	2	15	18	8	10	21	3	5	1	0 83
50.	2	12	20	7	5	25	6	5	1	0 83
55.	2	9	21	8	4	26	7	6	0	0 83
60.	2	4	24	10	3	26	8	6	0	0 83
65.	1	4	23	11	4	22	13	5	0	0 83
70.	0	3	21	13	6	12	24	4	0	0 83
75.	0	3	19	12	7	16	23	3	0	0 83
80.	0	2	18	12	8	13	27	3	0	0 83
85.	0	1	16	12	10	14	26	4	0	0 83
90.	0	1	15	10	10	19	24	4	0	0 83
95.	1	1	12	13	14	15	24	4	0	0 84
100.	2	1	12	12	13	17	24	4	0	0 85
105.	2	1	9	13	13	16	26	5	0	0 85
110.	1	1	9	10	21	14	23	6	0	0 85
115.	0	2	8	10	23	14	21	7	0	0 85
120.	0	2	7	12	22	14	22	6	0	0 85

Figure 2a. Partial frequency table for a grid system with 10 cells. This table is for a grid system oriented at a dip of 40 degrees to the west with strike being incremented from 0 to 180 degrees in 5 degree increments. The user tabulates the strike, dip, cell number, and number of foci of the pick for future program runs. Note that the strike range only includes up to 120 degrees (range normally continues up to 180 degrees).

TABLE FOR BETA = 40.0 (DIP= 50.0) DIP DIRECTION =WEST										
INPUT DATA SET IS : [rieken.seispln.prepare]cajon.utm										
A>=.90 B>=.80 C>=.70 D>=.60 O<.60										
ROTATION CELL NUMBER (WEST=1 EAST=10)										
AGL	1	2	3	4	5	6	7	8	9	10
0.	-	-	-	-	-	-	-	-	-	-
5.	-	-	-	-	-	-	-	D	-	-
10.	-	-	-	-	-	-	-	C	-	-
15.	-	-	-	-	-	-	-	D	-	-
20.	-	-	-	-	-	-	-	D	-	-
25.	-	-	-	-	-	-	-	B	-	-
30.	-	-	-	-	-	-	-	D	-	-
35.	-	-	-	-	-	-	-	D	-	-
40.	-	-	-	-	-	-	-	-	-	-
45.	-	-	-	-	-	D	-	-	-	-
50.	-	-	-	-	-	D	-	-	-	-
55.	-	-	-	-	-	C	-	-	-	-
60.	-	-	D	-	-	C	-	-	-	-
65.	-	-	D	-	-	-	-	-	-	-
70.	-	-	-	-	-	-	D	-	-	-
75.	-	-	-	-	-	-	-	-	-	-
80.	-	-	-	-	-	-	D	-	-	-
85.	-	-	-	-	-	-	-	-	-	-
90.	-	-	-	-	-	-	-	-	-	-
95.	-	-	-	-	-	-	-	-	-	-
100.	D	-	-	-	-	-	-	-	-	-
105.	D	-	-	-	-	-	-	-	-	-
110.	-	-	-	-	-	-	-	-	-	-
115.	-	-	-	-	-	-	-	-	-	-
120.	-	-	-	-	-	-	-	-	-	-

Figure 2b. A letter scheme contour representation of the sample table in figure 2a. The 'A' represents a better than 90% foci concentration, while 'B' is better than 80%, 'C' is better than 70%, 'D' is better than 60%, and '-' means lower than 60% concentration. Some potentially good picks are circled. Again, the strike range shown excludes the tabulations from 125 to 180 degrees.

Figure 3. A typical plot for any particular pick. This stereo view shows the border of the study area with all of the foci shown as small spheres. The fishnet represents the first order best fit fault surface and the line at the top of the box is the fault trace. Normally, the foci which are part of the pick are displayed on the screen as a different color for immediate recognition.

SAMPLE RUN OF SEISPLN PROGRAMS

You begin the SEISPLN analysis by logging into the SEISPLN directory. If you begin from my home directory, then you can just type "@SEIS" to get into it. If you are starting from another directory just set the working directory by typing the following; "SD [ERR..SEISPLN]". Once you are in, you can type "DIR" to get a listing of the subroutines. Figure 4 shows the result of this action. The order in which you will use each of these subdirectories is shown in the following table;

<u>Order</u>	<u>Subdirectory</u>	<u>Program</u>
First	Prepare	Process_Seis_Data*
Second	Grid	Romult
Third	Pick	Scrn2
Fourth	Fit	Eqfit
Last	View	Pt3d

*This program may require modifications if your data format is different.

You can set the default directory by typing "SD [RIEKEN.SEISPLN.SUBNAME]". I will go through an entire run of the program sequence and examples of the terminal output will be supplied along the way.

```
HEY HO, LET'S GO! >>> @seis
SEISPLN >>> dir
```

```
Directory $DISK2: [RIEKEN.SEISPLN]
```

FIT.DIR; 1	7	17-MAY-1989 08:45
GRID.DIR; 1	3	17-MAY-1989 08:44
HOME.COM; 1	1	17-MAY-1989 08:37
PICK.DIR; 1	4	17-MAY-1989 08:44
PREPARE.DIR; 1	3	17-MAY-1989 08:43
VIEW.DIR; 1	5	23-MAY-1989 17:03

Figure 4: Subdirectories under the SEISPLN directory.

Process Seis Data

First set the default to ".PREPARE". Then type "RUN PROCESS_SEIS_DATA". Your screen will look like figure 5. Input the data file name, including the ".DAT" extension. Use the same filename for your output file, making sure that the extension is ".UTM". Your 7 options for trimming down the file are listed, and all you have to do is select the option number and then type in the parameter values you desire. The only thing worth noting here is that the longitude option will require you to input any longitudes which are west of the Principle Meridian as negative values. For instance, a sample response to such a prompt would be to enter the minimum (west) longitude and the maximum (east) longitude as "-119,-117".

```

SEISPLN >>> run process_seis_cajon
Input filename ----->
cajon.dat
Output filename ----->
cajon.utm
Sort options

(1) Sort by Latitude
(2) Sort by Longitude
(3) Sort by Magnitude
(4) Sort by RMS Error
(5) Sort by Depth
(6) Sort by Number of Sittings
(7) Go

```

Figure 5: Sample run of the PROCESS program to filter the data.

Presently, there is a minor bug with one of the values this program outputs; namely the minimum longitude. You must edit the output file so that the minimum longitude value is correct and resave the output file. The value you need to change is the first value on the second line. You can determine the proper value by looking on a standard USGS topo. Figure 6 shows the front end of the output (.utm) file. This value will be very obviously erroneous will you first spot it.

```

85
0.44600000E+06 0.47703788E+06 0.37732698E+07 0.38030145E+07
0.45218016E+06 0.37827618E+07 0.48200000E+04
0.47137153E+06 0.37773983E+07 0.97400000E+04
0.47489194E+06 0.37792178E+07 0.56900000E+04
0.45689969E+06 0.37781928E+07 0.14040000E+05
0.45821359E+06 0.37767640E+07 0.76300000E+04
0.45743284E+06 0.37772293E+07 0.52200000E+04
0.45551591E+06 0.37872915E+07 0.96900000E+04
0.45930472E+06 0.37770363E+07 0.84900000E+04
0.45780038E+06 0.37770800E+07 0.45600000E+04
0.45492216E+06 0.37849840E+07 0.14970000E+05
0.45777213E+06 0.37776715E+07 0.52500000E+04

```

Figure 6: Sample .utm file with erroneous value (minimum longitude) boxed in. This value has been rectified in this example.

Romult

Set the directory to ".GRID" and "RUN ROMULT". From the program onward in the program sequence, you will not need to specify the subdirectory that your input file resides. Each one of the programs assumes that the input file needed is to be found in the previous subdirectory. Also, you will not need to specify the suffix (dot extension) to any of the input or output files, so the program will append these automatically. Your output file should have a trailing integer embedded in the filename so you know that this particular run utilizes a grid system with that number of cells.

In this example, we used a grid with 12 cells. Make sure that you specify the same number of cells as is in your filename to avoid any confusion. A recent addition to this program will now prompt you at this point for a desire to output a .copp file. If you type "y" or "Y" then the program will generate a file which will be in the correct format to use with the COPLANEP programs. After you set this option the screen will look like figure 7.

```
I AM NOW READING IN THE DATA.....

      85      0.37638E+07      0.38747E+07      0.19268E-24      0.68232E+06
PLEASE INPUT THE NUMBER OF CELLS YOU WISH
TO HAVE FOR YOUR GRID NETWORK (max of 23)
# CELLS? 12
      12
      0.56860E+05      0.68232E+06
PLEASE NOTE THAT YOUR BLOCK SIZE IS      0.68232E+06 UTM
AND YOUR CELL WIDTH IS      0.56860E+05 UTM
AND THE NUMBER OF CELLS IN THE GRID IS      12

Would you like to save this data in a
COPLANEP readable format (y,n)?
y
Saving the .copp file for you ....
Done saving dummy_12.copp
FORTRAN STOP
```

Figure 7: Sample run of ROMULT using 12 cells and saving a COPOUT file.

Before going on to the next program, open up the .freq output file. Sort through the tables as directed earlier in this document to find your picks. Tabulate the picks on the supplied sheet at the end of this manual. Keep track of individual file names, strikes, dips, cell numbers, and the number of foci found in the cell. There is also additional room on the form for the regression coefficient, order of fit, and other notes you will make once you have calculated fault surfaces for each of the picks.

Scrn2

Set the default to ".PICK" and "RUN SCR2". Supply the filenames as specified in the program and enter the strike, dip, and cell number of your pick. Run the program for each individual pick you want to make, making sure to embed the pick number into the output filename so you keep things organized. Note that when I ask you to input the dip, I am really asking for the beta angle which will be the complement of the dip. Remember to include a negative sign if the dip is to the east. This information is supplied in the .freq output file from Romult. The screen will look like figure 8 after you make this run.

```
SEISPLN >>> sd -.pick
          $DISK2: [RIEKEN.SEISPLN.PICK]

SEISPLN >>> run scrn2
WHAT IS THE INPUT FILE NAME ?
(Remember that [rieken.seispln.grid] will be put
 at the front of the file name and that .pic
 will be appended to the file name also.)
dummy_12
WHAT IS THE OUTPUT FILE NAME FOR THE EVENTS CHOSEN?
dummy_12_1
~~~~~
Your input file is: [rieken.seispln.grid]dummy_12.pic

Your output file is: dummy_12_1.tran

~~~~~

PLEASE INPUT THE STRIKE AND DIP OF THE CELL
WHICH COUNTS THE FOCI (IN DEGREES)
      STRIKE (PHI) ?
120
      DIP (BET) ?
10
WHICH CELL NUMBER DO YOU WANT TO WORK WITH?
9
FORTRAN STOP
SEISPLN >>> █
```

Figure 8: Sample run of SCR2. Remember to input strike, beta (complement to the dip), and the proper cell number from the frequency tables.

Eqfit

Set the default to ".FIT" and "RUN EQFIT". Generate your file names making sure to embed the order of the trend surface fit will select into the name of the output files. After you select to order of the fit the screen will look like figure 9. You can open the .anova file any time to look at the statistics which correspond to the fit you selected.

```
SEISPLN >>> sd -.fit
$DISK2: [RIEKEN.SEISPLN.FIT]

SEISPLN >>> run eqfit
=====
***** EQFIT *****
=====
THIS PROGRAM WILL FIND BEST FIT FAULT SURFACES

WHAT IS THE INPUT FILE NAME (OF CHOSEN CELL)?
(remember prefix dir [rieken.seispln.pick]
 is put at beginning of the file name and
 suffix .tran is appended to the file name)
dummy_12_1
WHAT IS THE OUTPUT FILE NAME FOR ANOVA/FIT?
(remember suffix .anova is appended to name
 of the ANOVA output file and .fit is
 appended to the surface FIT output file)
dummy_12_1_1
~~~~~
Your input file is: [rieken.seispln.pick]dummy_12_1.tran

Your ANOVA output file is: dummy_12_1_1.anova

Your SURFACE FIT file is: dummy_12_1_1.fit
~~~~~
WHAT ORDER OF TREND SURFACE DO YOU DESIRE?
INPUT 1,2,OR 3: 1
THE STRIKE OF THE CELL IS: 110.
ANGLE FROM VERTICAL OF CELL IS: 10.

FORTRAN STOP
```

Figure 9: Sample run of EQFIT. Remember that the statistics of the trend surface fit are stored in a separate .anova file.

Pt3d

Set the default to ".VIEW" and "RUN PT3D". Supply the name of both the actual pick (.fit file) and the entire data set (.pic file). Then select whether you want to view the pick with all the data or just the pick events shown. Finally, select "W" (for window) and you are off and running. The input window will now look like figure 10. You can, at any time, change the scale, orientation, and stereoscopic factors of the three dimensional view by typing in the options in the program window and selecting the parameter values you desire. You can get a screen dump of the plot by choosing the print portion of screen option from a new VMS window. Usually, the plots are too big to fit onto the same page. So, it is best to print first the left view, then the right view.

```
SEISPLN >>> sd -.view
$DISK2: [RIEKEN.SEISPLN.VIEW]

SEISPLN >>> run pt3d
input the eqfit file name you wish to view
dummy_12_1_1
-341158.5      341158.5      -55454.25      55454.00
      1.00      0.16      0.05
Select Desired Output
-W- Window -F- Files -X- Calcomp
Selection -->
```

Figure 10: Sample run of PT3D. This only shows the input window. The stereoscopic output windows will look like figure 3.

Note that there are some dimensional parameters printed in the right graphics window, which is initially overlapped by the left view window. Hence, you may not see these values until you click on the right view window to bring it on top.

If you want to view just the box with all the events, without any surface fit, run the PT3D_NOFIT program instead. All you have to do is supply the .pic file name to view. Or, if you want to compile a set of fault traces for the study area, use the PT3D_TRACES program. This will repeatedly prompt you for all the .fit file names until you type "DONE".

PROGRAM DETAILS

PROCESS SEIS DATA

Author: Mary Ann Glennon, Battelle, PNL, Richland, WA.
Home Directory: [rieken.seispln.prepare] - (automatically attached to supplied file name).
Input File: All input files should use a .dat suffix.
Output File: The converted file should have a .utm suffix.
Purpose: To offer the user an opportunity to filter the foci with respect to location, location error, magnitude, and time of event. Also, all locations are converted into utm coordinates from lat/long.

Notes: Respond to the input file prompt with the name of your file. The suffix should have a .dat convention. Also make sure that the output file denotes the location of the delineated area and has the proper .utm suffix. The home directory prefix is automatically included to your file name by the program.

ROMULT

Author: Eric Rieken
Home Directory: [rieken.seispln.grid] - (automatically attached to supplied file name).
Input File: The program will automatically append a .utm suffix to the input file.
Output Files: One output file is a table of cell frequencies and has a .freq suffix.
The other file contains the data in a more accessible format for the next program and it has a .pic suffix.
Purpose: To generate a table of the count of foci per cell for every possible orientation of the grid system. The user can make picks from this table before continuing the analysis.

Notes: Tabulate your results by recording filename/strike/dip/cell#/#foci on a separate sheet of paper, so that you can input into the next program.

SCRN2

Author: Eric Rieken
Home Directory: [rieken.seispln.pick] - (automatically attached to supplied file name).
Input File: The program will automatically append a .pic suffix to the input file.
Output File: The output file will contain the foci from your pick as well as all of the foci (so you can view all the data on the final output). The file will have a .tran suffix automatically appended to it.
Purpose: To generate a table of the number of foci which is found in each cell for every possible orientation of the grid system. The user can make picks from this table before continuing the analysis.

EQFIT

Author: Eric Rieken
Home Directory: [rieken.seispln.fit] - (automatically attached to supplied file name).
Input File: The program will automatically append a .tran suffix to the input file.
Output File: This program will output all the data of the SCRIN2 program, but will add to it the best statistical surface fit to the foci pick, as well as the topographical expression of the fault trace (if the fit is chosen to be a planar one). This file is used for the plotting program and will have a .fit suffix appended to it.
The other output file has a .anova appended to the same output file name, and contains statistical information regarding the fit.
Purpose: To generate the best fit surface to the foci pick based on the user selected order. A first order fit corresponds to a plane, while a second order fit corresponds to a curved surface (hyperbola), and a third order fit produces a complex surface (eg. a saddle). More often than not, the most statistically valid fits tend to be the simple first order (planar) fits.

Notes: The output file name you choose will be used as a prefix to both the .fit file, which is used for the input to the next program, and to the .anova file which will contain pertinent statistical information.

PT3D

Author: Eric Rieken (WSU) / Larry Gerhardstein (Battelle)
Home Directory: [rieken.seispln.view] - (automatically attached to supplied file name).
Input File: The program will automatically append a .tran suffix to the input file.
Output File: None.
Purpose: To view the selected pick foci (red) along with all of the seismic data (blue), the best fit surface (dark green), and the fault trace (red) if the fit is a planar one. The grid system parameters are given in the right window only. The view is stereographic and can be viewed with a standard wide format stereoscope held up to the screen. Complete adjustments to the 3D view can be made by supplying the necessary parameters interactively.

Notes: The output file name you choose will be used as a prefix to both the .fit file, which is used for the input to the next program, and to the .anova file which will contain pertinent statistical information. There is another version of this program which plots only the original foci without any of the surface fitting and is called PT3D_NOFIT. This version uses the file found in the [rieken.seispln.grid] directory with a .pic suffix.

I/O FILE FORMATS AND NAMING CONVENTIONS

<u>SEISPLN PROGRAM</u>	<u>IN FILE</u>	<u>OUT FILE(S)</u>	<u>CONTENT(FORMAT)</u>
PROCESS_SEIS_DATA	x.dat	x.utm	num_points (i4) xmin,xmax,ymin,ymax (4e16.8) x,y,z (array 3e16.8)
ROMULT	x.utm	x_#.freq	ascii table
		x_#.pic	num,yd,yu,xl,xr (i4,4e16.8) ncells,factor,blksz (i4,2e16.8) x,y,z (array 3e16.8)
		x_#.copp (unformatted)	num (integer) x,y,z (array real)
SCRN2	x.pic	x_#_\$.tran	ntot,phi,bet (i4,2e16.8) yd,yu,xl,xr (4e16.8) picknum (i4) x,y,z (array of pick foci, 3e16.8) xp,yp,zp (rotated pick 3e16.8) comment line x,y,z (array of all data, 3e16.8)
	(these 2 arrays alternate lines)		
EQFIT	x_#_\$.tran	x_#_\$_*.anova	ascii file
		x_#_\$_*.fit	picknum,ntot,order (3i4) yd,yu,xl,xr (4e16.8) x,y,z (array pick 3e16.8) comment line x,y,z (surface fit 50 pts 3e16.8) xt1,yt1,zt1 (2 lines for fault trace) xt2,yt2,zt2 (3e16.8) x,y,z (array all foci 3e16.8)
PT3D	x_#_\$_*.fit	NA	NA
PT3D_TRACES	x_#_\$_*.fit	NA	NA
PT3D_NOFIT	x_#.pic	NA	NA

Symbols

- x = filename (usually signifies location - and the xy extent if possible)
- # = number of cells in rotating grid system
- \$ = pick number
- * = order of trend surface fit

END

**DATE
FILMED**

01/10/92