SOFTWARE VALIDATION TEST PLAN FOR EARTHVISION™, VERSION 5.1

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1 SCOPE OF THE VALIDATION

This document establishes the Software Validation Test Plan for validating the functionality of the code EarthVision™, Version 5.1 through minimum tension gridding of a steeply dipping plane and a shallowly dipping plane, and comparison of a grid created by EarthVision 5.1 to one calculated by Surfer®, Version 6.04 given the same input data points. EarthVision 5.1 is a visualization program that is used by many government, industrial, and research agencies to display and manipulate three-dimensional geospatial data. Data sets are maintained in discrete files, where numerical attributes can be assigned geographic coordinates that reference common spatial coordinate systems. Data can be displayed directly as discrete points, or as interpolated surfaces. EarthVision does not perform process modeling.

2 REFERENCES

Dynamic Graphics, Inc. "User's Guide 5.1." Alameda, California, 1997.

Golden Software, Inc. "User's Guide, Surfer® for Windows." Golden, Colorado, 1994.

3 ENVIRONMENT

3.1 Software

EarthVision 5.1 is commercial software developed by Dynamic Graphics Inc. (DGI) which runs on IRIX 6.2 or higher on SGI. Surfer 6.04 is commercial software developed by Golden Software, Inc. which runs on Windows NT. The following software items are required to perform the testing activities:

1) EarthVision 5.1 software
2) Solaris 8 or higher operating system
3) Surfer 6.04
4) Windows NT 4.00.1381

3.2 Hardware

EarthVision 5.1 runs on a Sun Microsystems server; it was installed on the Sun Microsystems SunFire V880Z server, Solaris 9 by the IMS group administrator, who reported a normal installation. Surfer 6.04 runs on a Windows NT operating system. Input information is in existing data files. Output information is saved on the computer hard drives. No peripherals (e.g., tape drives, printers, plotters) are necessary to execute the tests.

4 PREREQUISITES

Running EarthVision 5.1 and Surfer 6.04 requires installation of the commercially available software, per the developers' User's Manuals.

5 ASSUMPTIONS AND CONSTRAINTS

The user is assumed to be familiar with EarthVision, Surfer, structural geology, geospatial data sets, and the UNIX operating system.

6 TEST CASES

EarthVision is primarily used for three-dimensional visualization of geologic data that describe surfaces. EarthVision calculates grids from input data points using a minimum tension algorithm (User's Guide 5.1, 2DG, 1-34) that is good for reproducing shapes of naturally occurring geologic structures:

> Minimum tension gridding is the primary gridding technique used in EarthVision and the only technique used to calculate representational surface models from scatted data (User's Guide 5.1, 2DG, 1).
>
> The main goals of a representational gridding technique are to represent (honor) the values of the input data as closely as possible and also to calculate a plausible, "natural" looking model for grid nodes that are not on or adjacent to input data points. The minimum tension gridding technique is currently the best solution, reconciling these two, sometimes conflicting, goals. It permits gridding computation times suitable to a working environment and modeling accuracy appropriate to almost every type of input data (User's Guide 5.1, 2DG, 1).

The software is intended to render consistent, geometrically reasonable shapes from scatter data. Because of the natural variation in geologic data, it is acceptable that minimum tension gridding does not necessarily honor every data point; the user must judge, based on their geologic training and experience, the acceptable proximity of individual input points to calculated grids. To assess whether the EarthVision program adequately and reproducibly displays geospatial relationships for digital geologic data we will perform the following validation tests:

6.1 Test 1: Three-Dimensional Representation of a Steeply Dipping Plane

6.1.1 Test Input

Input will be a data file consisting of discrete points lying on a steeply dipping plane.

Data file: steep.dat
Type: scattered data
Version: 5
Description: steeply dipping plane data

```
# Format:  free
# Field:  1 x
# Field:  2 y
# Field:  3 z meters
# Projection:  Universal Transverse Mercator
# Zone:  12
# Units:  meters
# Ellipsoid:  GRS 1980
# End:
369000          4497000     -1000
369086.8125     4497000     -1492.40380859
368913.1875     4497000     -507.596130371
369173.65625    4497000     -1984.80773926
368826.34375    4497000     -15.1922607422
369000          4498000     -1000
369086.8125     4498000     -1492.40380859
368913.1875     4498000     -507.596130371
369173.65625    4498000     -1984.80773926
368826.34375    4498000     -15.1922607422
369000          4499000     -1000
369086.8125     4499000     -1492.40380859
368913.1875     4499000     -507.596130371
369173.65625    4499000     -1984.80773926
368826.34375    4499000     -15.1922607422
369000          4500000     -1000
369086.8125     4500000     -1492.40380859
368913.1875     4500000     -507.596130371
369173.65625    4500000     -1984.80773926
368826.34375    4500000     -15.1922607422
```

6.1.2 Test Procedure

1) Use EarthVision to interpolate a surface through the input points with the following input parameters. Name the output file steep.2grd. The following shell script will be used for this step.

Input parameters:

	X	Y	Z
Minimum	368826.34375	4497000	No Z limits
Maximum	369173.65625	4500000	
Range	347.3125	3000	
Grid spacing	16.53869048	142.8571429	
Grid size	22	22	

Extrapolate outside data areas: yes
Multiple point gridding level: 4

Shell script: steep.2grd.sh

```
#!/bin/sh -e
```

```
FEATURE=ev_ps
ev_2grid -o steep.2grd -F $FEATURE -r
“368826.343750,369173.656250,4497000.000000,4500000.000000”
 -s 22,22 -d steep.dat -f “z” -G steep.2grpt -m 4
```

2) Use EarthVision to display the plane.

3) Use EarthVision to overlay the input data file (steep.dat) on the steeply dipping plane (steep.2grd) in the three-dimensional representation. Do the input data points appear reasonably close to the plane?

6.1.3. Validation Criteria

The grid should be a simple representation of the planar surface, and the input data points should appear reasonably close to the plane. The input data points should appear to be at the right location based on the x, y, and z axes labels. The plane should have a N-S strike with a dip of ~80°E.

6.2. Test 2: Residuals of Input Data Points and Grid of a Steeply Dipping Plane

6.2.1. Test Input

The input file is steep.dat, described in Section 6.1.1.

6.2.2. Test Procedure

Copy the input file steep.dat to residual_steep.dat. Use the EarthVision formula processor to calculate the residuals of the interpolated grid and input data points by subtracting the input data z values from the grid z values at the same x, y location. Residuals should be printed to column z of residual_steep.dat. The following shell script will be used to accomplish this:

Shell script: residual_steep_points.fml.sh

```
#!/bin/sh -e

cp steep.dat residual_steep.dat
ev_fpfp -u -F ev_ps  << ‘EOF’
residual_steep.dat<z>=bakint(steep.2grd,steep.dat<x>,steep.dat<y>)-steep.dat<z>;
EOF
```

6.2.3. Validation Criteria

The residuals should be within 2.5 percent of the input elevation range for all data points.

6.3. Test 3: Reproducibility of Calculation of a Steeply Dipping Plane

6.3.1. Test Input

Use the input file steep.dat, described in Section 6.1.1.

6.3.2. Test Procedure

1) Repeat the steps outlined in Section 6.1.2, using the input parameters specified in Section 6.1.2. Name the new output file steep2.2grd. The following shell script will be used for this step:

Shell script: steep2.2grd.sh

```
#!/bin/sh -e

FEATURE=ev_ps
ev_2grid -o steep2.2grd -F $FEATURE -r
“368826.343750,369173.656250,4497000.000000,4500000.000000”
 -s 22,22 -d steep.dat -f “z” -G steep2.2grpt -m 4
```

2) Use EarthVision’s formula processor to create a difference grid by subtracting z values of grid steep.2grd from z values of grid steep2.2grd, and view. The following shell script will be used to accomplish this:

Shell script: residual_steep_grids.fml.sh

```
#!/bin/sh -e

ev_fpfp -u -F ev_ps  << ‘EOF’
residual_steep_grids.2grd=steep2.2grd-steep.2grd;
EOF
```

Are z values of the difference grid reasonably close to zero at all grid nodes (i.e. are the grids calculated in tests 1 and 3 consistent)?

6.3.3. Validation Criteria

The residuals should be within 2.5 percent of the input elevation range for all data points.

6.4 Test 4: Three-Dimensional Representation of a Shallowly Dipping Plane

6.4.1 Test Input

Input will be a data file consisting of discrete points lying on a shallowly dipping plane.

Data file: shallow.dat

```
# Type:  scattered data
# Version:  5
# Description:  shallowly dipping plane data
# Format:  free
# Field:  1 x
# Field:  2 y
# Field:  3 z meters
# Projection:  Universal Transverse Mercator
# Zone:  12
# Units:  meters
```

```
# Ellipsoid:  GRS 1980
# End:
368000          4498000     -700
369000          4498000     -700
370000          4498000     -700
368000          4497000     -900
369000          4497000     -900
370000          4497000     -900
```

6.4.2. Test Procedure

Use EarthVision to interpolate a planar surface through the input points with the following input parameters. Name the output file shallow.2grd. The following shell script will be used for this step:

Input parameters:

	X	Y	Z
Minimum	368000	4497000	No Z limits
Maximum	370000	4498000	
Range	2000	1000	
Grid spacing	66.66666667	66.66666667	
Grid size	31	16	

Extrapolate outside data areas: yes
Multiple point gridding level: 4

Shell script: shallow.2grd.sh

```
#!/bin/sh -e

FEATURE=ev_ps
ev_2grid -o shallow.2grd -F $FEATURE -r
"368000.000000,370000.000000,4497000.000000,4498000.00000
0" -s 31,16 -d shallow.dat -f "z" -G shallow.2grpt -m 4
```

2) Use EarthVision to display the plane.

3) Use EarthVision to overlay the input data file (shallow.dat) on the shallowly dipping plane (shallow.2grd) in the three-dimensional representation. Do the input data points appear reasonably close to the plane?

6.4.3. Validation Criteria

The grid should be a simple representation of the planar surface, and the input data points should appear reasonably close to the plane. The input data points should appear to be at the right location based on the x, y, and z axes labels. The plane should have a E-W strike with a dip of ~10°S.

6.5. Test 5: Residuals of Input Data Points and Grid of a Shallowly Dipping Plane

6.5.1. Test Input

The input file is shallow.dat, described in Section 6.4.1.

6.5.2. Test Procedure

Copy the input file shallow.dat to residual_shallow.dat. Use the EarthVision formula processor to calculate the residuals of the interpolated grid and input data points by subtracting the input data z values from the grid z values at the same x, y location. Residuals should be printed to column z of residual_shallow.dat. The following shell script can be used to accomplish this:

Shell script: residual_shallow_points.fml.sh

```
#!/bin/sh -e

cp shallow.dat residual_shallow.dat
ev_fpfp -u -F ev_ps  << 'EOF'
residual_shallow.dat<z>=bakint(shallow.2grd,shallow.dat<x>,shallow.dat<y>)-shallow.dat<z>;
EOF
```

6.5.3. Validation Criteria

The residuals should be within 2.5 percent of the input elevation range for all data points.

6.6. Test 6: Reproducibility of Calculation of a Shallowly Dipping Plane

6.6.1. Test Input

Use the input file shallow.dat, described in Section 6.4.1.

6.6.2. Test Procedure

a) Repeat the steps outlined in Section 6.4.2, using the input parameters specified in Section 6.4.2. Name the new output file shallow2.2grd. The following shell script will be used for this step:

Shell script: shallow2.2grd.sh

```
#!/bin/sh -e

FEATURE=ev_ps
ev_2grid -o shallow2.2grd -F $FEATURE -r
"368826.343750,369173.656250,4497000.000000,4500000.000000"
 -s 22,22 -d shallow.dat -f "z" -G shallow2.2grpt -m 4
```

b) Use EarthVision's formula processor to create a difference grid by subtracting z values of grid shallow.2grd from z values of grid shallow2.2grd, and view. The following shell script will be used to accomplish this:

Shell script: residual_shallow_grids.fml.sh

```
#!/bin/sh -e

ev_fpfp -u -F ev_ps  << 'EOF'
residual_shallow_grids.2grd=shallow2.2grd-shallow.2grd;
EOF
```

Are z values of the difference grid reasonably close to zero at all grid nodes (i.e. are the grids calculated in tests 4 and 6 consistent)?

6.6.3. Validation Criteria

The residuals should be within 2.5 percent of the input elevation range for all data points.

6.7 Test 7: Comparison of a Grid Calculated with EarthVision 5.1 to a Grid Calculated with Surfer 6.04

6.7.1 Test Input

Input data file 1: test_data.dat

-10	-10	0.041494292
-7.5	-10	-0.68475576
-5	-10	-0.999784662
-2.5	-10	-0.714405912
0	-10	0
2.5	-10	0.714405912
5	-10	0.999784662
7.5	-10	0.68475576
10	-10	-0.041494292
-10	-7.5	0.041494292
-7.5	-7.5	-0.68475576
-5	-7.5	-0.999784662
-2.5	-7.5	-0.714405912
0	-7.5	0
2.5	-7.5	0.714405912
5	-7.5	0.999784662
7.5	-7.5	0.68475576
10	-7.5	-0.041494292
-10	-5	0.041494292
-7.5	-5	-0.68475576
-5	-5	-0.999784662
-2.5	-5	-0.714405912
0	-5	0
2.5	-5	0.714405912
5	-5	0.999784662
7.5	-5	0.68475576
10	-5	-0.041494292
-10	-2.5	0.041494292
-7.5	-2.5	-0.68475576

-5	-2.5	-0.999784662
-2.5	-2.5	-0.714405912
0	-2.5	0
2.5	-2.5	0.714405912
5	-2.5	0.999784662
7.5	-2.5	0.68475576
10	-2.5	-0.041494292
-10	0	0.041494292
-7.5	0	-0.68475576
-5	0	-0.999784662
-2.5	0	-0.714405912
0	0	0
2.5	0	0.714405912
5	0	0.999784662
7.5	0	0.68475576
10	0	-0.041494292
-10	2.5	0.041494292
-7.5	2.5	-0.68475576
-5	2.5	-0.999784662
-2.5	2.5	-0.714405912
0	2.5	0
2.5	2.5	0.714405912
5	2.5	0.999784662
7.5	2.5	0.68475576
10	2.5	-0.041494292
-10	5	0.041494292
-7.5	5	-0.68475576
-5	5	-0.999784662
-2.5	5	-0.714405912
0	5	0
2.5	5	0.714405912
5	5	0.999784662
7.5	5	0.68475576
10	5	-0.041494292
-10	7.5	0.041494292
-7.5	7.5	-0.68475576
-5	7.5	-0.999784662
-2.5	7.5	-0.714405912
0	7.5	0
2.5	7.5	0.714405912
5	7.5	0.999784662
7.5	7.5	0.68475576
10	7.5	-0.041494292
-10	10	0.041494292
-7.5	10	-0.68475576
-5	10	-0.999784662
-2.5	10	-0.714405912
0	10	0
2.5	10	0.714405912
5	10	0.999784662
7.5	10	0.68475576

10 10 -0.041494292

Input data file 2: test_data.csv. This data file is the same as test_data.dat except that it contains a header line “X,Y,Z” and is comma- rather than tab-delimited.

```
X,Y,Z
-10,-10,0.041494292
-7.5,-10,-0.68475576
-5,-10,-0.999784662
-2.5,-10,-0.714405912
0,-10,0
2.5,-10,0.714405912
5,-10,0.999784662
7.5,-10,0.68475576
10,-10,-0.041494292
-10,-7.5,0.041494292
-7.5,-7.5,-0.68475576
-5,-7.5,-0.999784662
-2.5,-7.5,-0.714405912
0,-7.5,0
2.5,-7.5,0.714405912
5,-7.5,0.999784662
7.5,-7.5,0.68475576
10,-7.5,-0.041494292
-10,-5,0.041494292
-7.5,-5,-0.68475576
-5,-5,-0.999784662
-2.5,-5,-0.714405912
0,-5,0
2.5,-5,0.714405912
5,-5,0.999784662
7.5,-5,0.68475576
10,-5,-0.041494292
-10,-2.5,0.041494292
-7.5,-2.5,-0.68475576
-5,-2.5,-0.999784662
-2.5,-2.5,-0.714405912
0,-2.5,0
2.5,-2.5,0.714405912
5,-2.5,0.999784662
7.5,-2.5,0.68475576
10,-2.5,-0.041494292
-10,0,0.041494292
-7.5,0,-0.68475576
-5,0,-0.999784662
-2.5,0,-0.714405912
0,0,0
2.5,0,0.714405912
5,0,0.999784662
7.5,0,0.68475576
10,0,-0.041494292
-10,2.5,0.041494292
```

-7.5,2.5,-0.68475576
-5,2.5,-0.999784662
-2.5,2.5,-0.714405912
0,2.5,0
2.5,2.5,0.714405912
5,2.5,0.999784662
7.5,2.5,0.68475576
10,2.5,-0.041494292
-10,5,0.041494292
-7.5,5,-0.68475576
-5,5,-0.999784662
-2.5,5,-0.714405912
0,5,0
2.5,5,0.714405912
5,5,0.999784662
7.5,5,0.68475576
10,5,-0.041494292
-10,7.5,0.041494292
-7.5,7.5,-0.68475576
-5,7.5,-0.999784662
-2.5,7.5,-0.714405912
0,7.5,0
2.5,7.5,0.714405912
5,7.5,0.999784662
7.5,7.5,0.68475576
10,7.5,-0.041494292
-10,10,0.041494292
-7.5,10,-0.68475576
-5,10,-0.999784662
-2.5,10,-0.714405912
0,10,0
2.5,10,0.714405912
5,10,0.999784662
7.5,10,0.68475576
10,10,-0.041494292

6.7.2. Test Procedure

Use Surfer to interpolate a surface through the input points and spline-smooth the grid. Calculate the residuals between the Surfer grid and a minimum tension grid created by EarthVision.

(a) Interpolate a surface through the input points using Surfer and the following input parameters. Name the output grid file TEST_DATA.GRD.

Input parameters:

Direction	Minimum	Maximum	Increment	Number of lines
X	-10	10	2.5	9
Y	-10	10	2.5	9

Method: inverse distance to a power

Inverse distance options:

Power: 2
Smooth: 0
Anisotropy ratio: 1
Anisotropy angle: 0
Duplicates: average
Ignore data outside grid: not selected
Search options: search all data

(b) Use spline smoothing in Surfer with the following parameters to smooth the grid TEST_DATA.GRD. Name the output file in ASCII format SURF_SPLINE.DAT.

Input parameters:

Input grid file: TEST_DATA.GRD
Spline smooth settings:

Recalculate grid: yes
Output grid size number of rows: 25
Output grid size number of columns: 25

(c) Interpolate a surface through the input points located in test_data.dat using EarthVision and the following input parameters. Name the output grid file test_data.2grd. The following shell script will be used for this step.

Input parameters:

	X	Y	Z
Minimum	-10	10	No Z limits
Maximum	-10	10	
Range	20	20	
Grid spacing	0.8333333	0.8333333	
Grid size	25	25	

Extrapolate outside data areas: yes
Multiple point gridding level: 4

Shell script: test_data.2grd.sh

```
#!/bin/sh -e

FEATURE=ev_ps
ev_2grid -o test_data.2grd -F $FEATURE -r "-10.000000,10.000000,-10.000000,10.000000" -s
25,25 -d test_data.dat -f "z" -G test_data.2grpt -m 4
```

(d) Compare the ASCII Surfer grid (SURF_SPLINE.DAT) to the EarthVision grid (test_data.2grd).

Use EarthVision to calculate the z value at each x, y point from the grid test_data.2grd with the following shell script.

bakint_ev2surfernodes.sh

```
#!/bin/sh -e
```

```
ev_fpfp -u -F ev_ps  << 'EOF'
SURF_SPLINE.DAT<ev_z>=bakint(test_data.2grd, SURF_SPLINE.DAT<x>,
SURF_SPLINE.DAT<y>);
EOF
```

Use EarthVision to calculate the residuals between the EarthVision z values and the Surfer z values with the following shell script.

Shell script: z_residual.sh

```
#!/bin/sh -e

ev_fpfp -u -F ev_ps  << 'EOF'
SURF_SPLINE.DAT<z_residual>=SURF_SPLINE.DAT<z>-SURF_SPLINE.DAT<ev_z>;
EOF
```

What is the maximum residual value of z? How does this compare to the range of z?

6.7.3. Validation Criteria

The maximum residual value of z should be less than 5 percent of the z range.