Lesson 4:
Modeling in Three Dimensions

Lesson Goal: Take the two-dimensional Bright Angel model created in Lesson 3 and generate a TIN, drape two-dimensional line features over the TIN, and improve the legend for this project.

What You Will Need: A Pentium class PC with 32 MB of RAM (minimum) and 100 MB of free hard drive space, ArcView GIS 3.1 or higher, and the ArcView 3D Analyst extension.

Data and/or Utilities: The project and data from Lesson 3 and the MAPLAYER database from the *ArcUser Online* Web site.

This lesson models data describing a portion of the Grand Canyon in three dimensions using ArcView 3D Analyst.

In this lesson will describe how to enhance the two-dimensional model of the Bright Angel area built in Lesson 3. Joining a dBASE file containing descriptive text will create a more meaningful legend. Using ArcView 3D Analyst extension, the next step will be to create a triangular irregular network (TIN) to add vertical relief to Bright Angel topography. This TIN will be pasted into a three-dimensional view and two-dimensional line features will be draped onto the TIN.

Build a Thematic Legend Using Table Join

Start an ArcView GIS session and load the Bright Angel project. If you have a paper copy of the Grand Canyon East 1:100,000-scale quadrangle, you can use the map to refresh your memory of the data and to help you build a properly coded model. In the menu bar, go to File, then Extension to load the CAD Reader and ArcView 3D Analyst extensions. Open a two-dimensional view and verify that all data sets have loaded properly.

In the previous exercise, we downloaded data from GC4 Tile 08 and renamed and converted six data sets. The DXF files should still be available in the project directory. Table 1 lists the the six data sets.

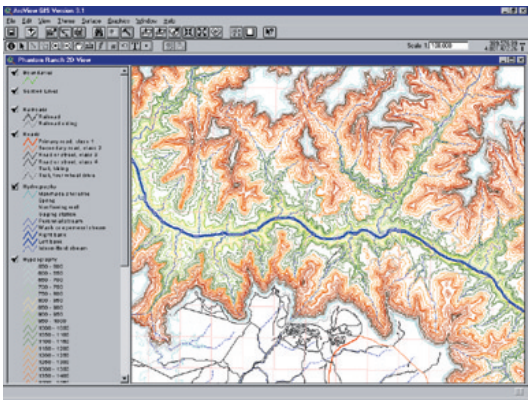
Look closely at the legends for hydrography, railroads, and roads themes. These themes were built by typing in specific labels from a list provided in the last issue and are specific to data within Tile 08. Now, using MAPLAYER.DBF, a dBASE table, we can create a legend that should work for DLG-O data in all areas. Using the Table Join command to link MAPLAYER.DBF to the attribute tables for several data sets will add friendlier, more meaningful names than the ones provided in the original label field. You can download a copy of MAPLAYER.DB now. This file is less than 75 kb and should download quickly. Place one copy of the file in your project directory and another in your utilities directory so you can use it again and again.

Turn off all themes except hydrography. With the

Table 1

Data Category	Data Description	Long GZ File Name	Short GZ File Name
Boundaries (bdf)	Political Boundaries	GC4.BDF08.opt.gz	GC4BDF08.gz
Hydrography (hyf)	Lakes, Rivers, Streams	GC4.HPF08.opt.gz	GC4HPF08.gz
Hypsography (hpf)	Contour Lines	GC4.HYF08.opt.gz	GC4HYF08.gz
Public_lands (plf)	Section Lines	GC4.PLF08.opt.gz	GC4PLF08.gz
Transportation (rdf)	Roads	GC4.RDF08.opt.gz	GC4RDF08.gz

hydrography theme visible and active, click the Open Theme Table button to display the attributes of the rivers and springs. The attributes used to create this thematic legend reside in the layer field and are not easily understood. The layer names loaded through the CAD Reader extension represent major/minor codes developed by professional cartographers. MAPLAYER.DBF will join these codes with more descriptive names.

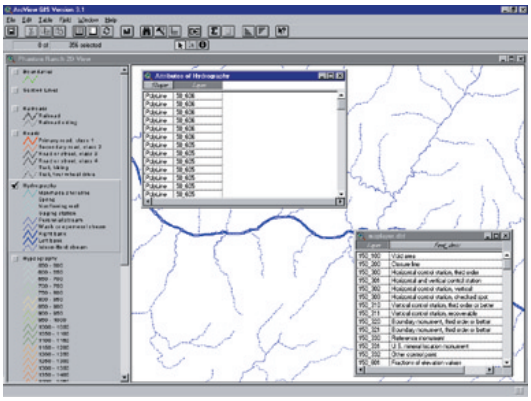


The previous lesson modeled CAD format data in two dimensions.

Joining Two Tables

Go to the main Project window and select Tables. Verify that dBASE is the selected file type and that MAPLAYER.DBF is stored in your project directory. Use the Add button to add MAPLAYER.DBF in the model. This table contains over 500 records and its fields contain layer codes plus information about line color, style, and text descriptions.

1. Choose Table then Properties from the menu.
2. In the Properties dialog box, hide all fields except Layer and Feat_desc (feature_description) by toggling off the check marks in the Visible column. Close the Properties dialog box.
3. With the table for MAPLAYER.DBF displayed, click on the Layer field name to select it. The column header will change to a darker shade of gray.
4. Make the main menu window active, then click on Attributes of Hydrography (or GC4HYF08.dxf, if not aliased) in the list to bring up this table. Two tables should now be visible.
5. Click on Attributes of Hydrography to make it the active table. The title bar for this table will be blue, not gray.
6. Click on the Layer field of Attributes of Hydrography to select this table for a join.
7. Be certain that Attributes of Hydrography is selected (i.e., the title bar is blue) and that the Layer field is selected in both tables as evidenced by the dark gray shading of the Layer field label.
8. Select Table Join from the main Table window.
9. The MAPLAYER.DBF table will close. The Attributes of Hydrography table now contains descriptive labels.
10. Returning to the view, double click on the hydrography legend to bring up the Legend Editor. Select Unique Value as a Legend Type, Feat_desc as Classification Field, and click the Apply button.



Join the MAPLAYER database to the Attributes of Hydrography table to make the legend more understandable.

A new, easily understood legend will appear. Select a color ramp for this legend using shades of blue. You can with individual colors and line thicknesses. Several data types, such as wells and springs, are truly point data and are not converted correctly.

Reopen the MAPLAYER.DBF table and repeat the above procedure to join MAPLAYER to the railroads and roads tables. Create

thematic legends for these data sets also. You do not need to add MAPLAYER.DBF again since it should be available when you return to Tables in the main Project window. In the previous article, hypsography was mapped using elevation as a classification field and graduated color as a legend type. If you like this color scheme, do not change a thing.

The boundaries and public lands data sets do not convert and load as consistently as other data sets such as hydrography or hypsography. If you experiment with table joins using these data sets don't get too frustrated. They are probably mapped using a unique value legend type. You may notice that many records contain the original DXF file name as a layer code. As we find consistent ways to handle these data sets, we will publish them. Save your project and get ready for three-dimensional fun!

Creating a Topography TIN

After remapping several data types using a table join, the ArcView 3D Analyst extension can be used to generate a really neat three-dimensional model. The first step in three-dimensional modeling creates a TIN to support data that does not contain built-in elevation information. Follow these steps to build the TIN.

1. Select hypsography as the only active theme.
2. Open the data table and sort the Elevation field.
3. Inspect the data to find "outliers" (i.e., data that is too low [typically 0], too high, or blank.) If necessary, exclude improper data by using the Query tool.
4. Choose Surface then Create TIN from Features from the menu. The TIN function will show hypsography as the only layer available to TIN.
5. In the Create New TIN dialog, specify Height Source as Elevation, change Input As from Hard Breaklines to Mass Points, and leave the Value field set to «none».
6. Click OK to build the TIN.

A large TIN may take a while to build. The status line at the bottom of the screen will let you know how things are going. After the TIN is built it will load into the current view, at the top of the legend window, with a topographic color ramp built. The TIN data type is similar to a polygonal type.

A mass points process will break the topographic contour lines into many short vector segments. Endpoints of the vectors will build into vertices of triangles spanning between adjacent contour lines. Since each triangle's vertices will have several elevations, the triangle will display slope and aspect in three-dimensional space.

Make the TIN the last theme in the legend so two-dimensional line data will be visible. With the TIN active, choose Theme then Properties from the menu. Note the number of triangles in this TIN. Due to its complex topography, this Grand Canyon TIN contains a large number of triangles. Triangle counts over 300,000 render slowly and can be hard to manage. This is where having a computer with a fast processor and enhanced graphic card pays off!

Click the legend box to activate the TIN and watch it grow before your eyes! A hill shade pattern with the sun low in the northeast is applied. Turn on the other line theme—boundaries, hydrology, public lands, railroads, and roads. Inspect your model to make any changes in the legends or color ramps of each theme. Changes made while working in two dimensions are more quickly accomplished. Your two-dimensional model could look similar to the screen capture shown here. Save your project and close all other unnecessary programs before moving on to three-dimensional modeling.

Draping and Modeling 2D Data in 3D

Now the real fun begins, but be patient. First, open a new three-dimensional view by returning to the main Project window and selecting 3D Scenes, located at the bottom just below Scripts. Rearrange your workspace by placing the 3D legend window in the upper left corner and expand the three-dimensional view to cover most of the remaining screen. Notice the three-dimensional display area and the three-dimensional Legend are represented as two separate objects on your desktop. The three-dimensional display takes over the desktop and can be closed or pushed to the bottom of the screen. It cannot be

minimized like a two-dimensional view.

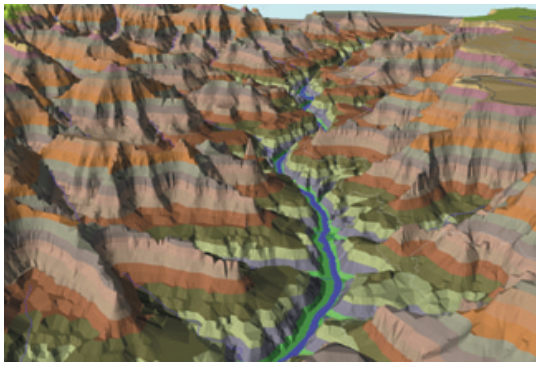
Study the menu selection for 3D Scene Properties. Set the Map Units to meters. Just for fun, change the background color from black to sky blue and set the Sun Azimuth to southeast. Leave the Sun Altitude and Vertical Exaggeration factor unchanged for now. Return to your two-dimensional view. Select only the TIN and if it is visible, turn it off. Use Edit Copy Themes to copy the nonvisible TIN to the Theme Clipboard.

Make the 3D Scene active and paste the TIN into the Legend window. After pasting the TIN, turn it on and wait patiently (possibly several minutes) as it loads and renders. This operation tests the computing and graphics performance of your computer. If your system chokes at this point, it may be necessary to build a smaller TIN by clipping out a small portion of the topographic contour lines. If the model renders properly, experiment with navigating, panning, and zooming through the model. Use the left mouse button to navigate, the right button to zoom, and the center button (or on two-button mice, left and right buttons together) to pan. If you are not familiar with these procedures, you may want to practice on a smaller, more easily managed model. In any case, **be patient**—this is a large model! Next, turn off the 3D TIN and save your project with the TIN off.

ArcView GIS Tips

Turn off all visible themes at once by holding down the CONTROL key while clicking on any visible theme.

Show only needed fields by opening the Table Properties and turning off unwanted fields by clicking on them.



Use ArcView 3D Analyst extension to generate a TIN of this area.

Return to the two-dimensional view and select the hydrography theme. Turn the hydrography theme off and copy it to Theme Clipboard. Switch back to the 3D Scene and paste hydrography into the Legend window. Turn the hydrography theme on.

Make it the only active theme and use the Zoom to Active Theme(s) button. Now, use navigate, pan, and zoom to explore the streams. Don't be too disappointed if they look flat. This theme has not been assigned to any base height source. We will fix that next.

1. With only the hydrography theme active, choose Themes then 3D Properties.
2. In the section of the 3D Properties dialog box titled Assign Base Heights By, click the radio button next to Surface and navigate the directory to select the TIN you created.
3. In the same dialog, in the box next to Offset Heights by Value or Expression, enter 15.
4. Click the Apply button and wait.

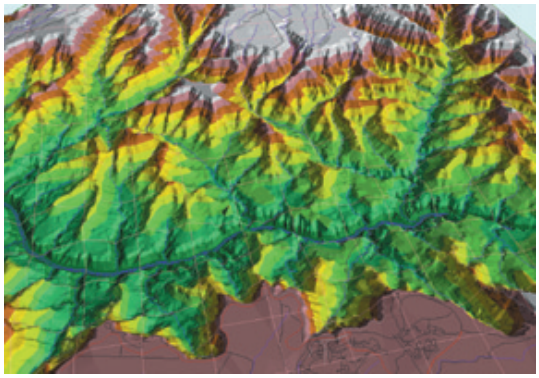
ArcView 3D Analyst Trick

To make themes open more quickly in ArcView 3D Analyst, save the project before copying a theme and turn them themes off when copying.

After the streams redraw, move to the active theme and navigate through it. The hydrography lines are now draped on the TIN, positioned 15 meters above average height of the triangles in the TIN for visibility. Save your project again, then turn on the TIN. If all goes well, you will have an amazing Grand Canyon model in your 3D Scene!

To load other line themes from the two-dimensional view, turn the TIN off and return to the two-dimensional view. Copy the boundaries, public lands, railroads, and roads themes to the Theme Clipboard. Move to the 3D Scene and paste this group of themes. Choose Theme then 3D Properties and follow the

procedure above to drape each theme. Set these themes 15 to 25 meters above the TIN theme. Turn these themes on individually and in groups. If everything looks reasonable, save your project. Navigate to a neat looking spot in the view, turn on the TIN, and wait. Navigation through a large model is done most effectively with the TIN turned off. Your completed model might look similar the screen capture shown here.



Drape boundary, publica lands, railroad and road themes over the three-dimensional model to complete this lesson .

Now it's time to step back and really admire this three-dimensional model of Bright Angel! As with the two-dimensional model, you can observe relationships between hiking trails and canyons. Visually estimate the steepness of drainages. Imagine the elevation differences between the Colorado River and the canyon rims. Compare calculations made with the two-dimensional model to this model. Trace the Bright Angel trail as it follows the Bright Angel Fault across the Grand Canyon. Now you know why pioneers often followed fault zones when building a trail.

Summary

The three steps presented in this article have taught you how to enhance a DLG-based, two-dimensional model using ArcView GIS and how to create a complex three-dimensional terrain model with ArcView 3D Analyst. Now that you are a master Grand Canyon modeler, download data for other favorite areas from the USGS Earth Resources Observation Systems (EROS) site and build your own models.

This lesson is based on an article written by Mike Price of ESRI that originally appeared in the January–March 1999 issue of *ArcUser* magazine.