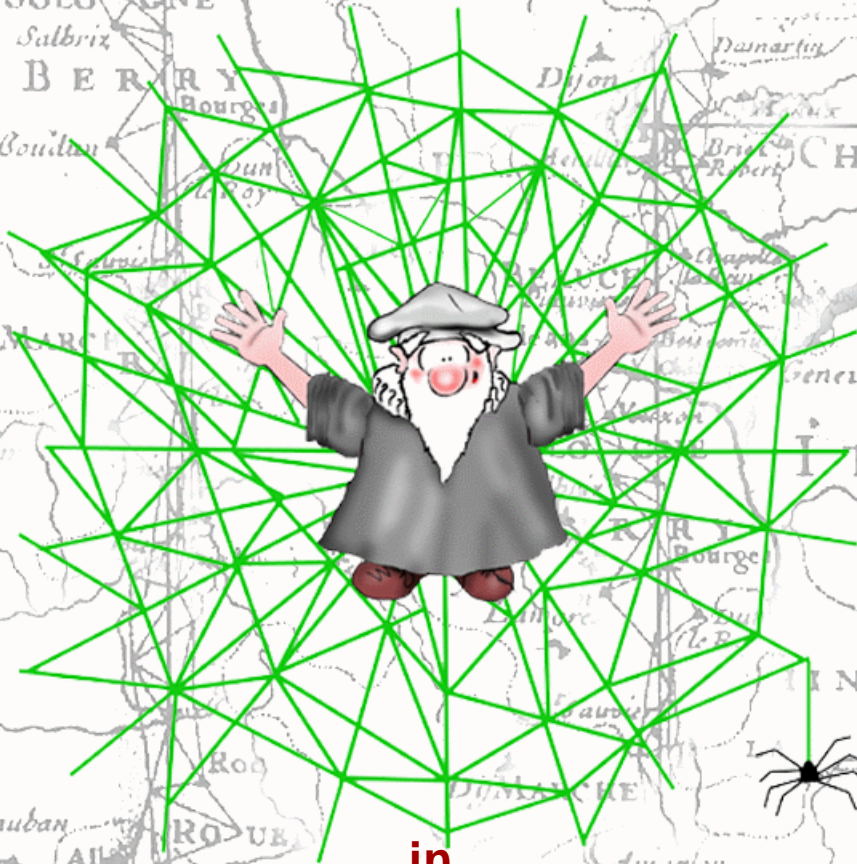E
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Editing TIN Geodata

in

TNTmips®
and TNTedit™

Before Getting Started

This booklet introduces techniques for creating, altering, and updating TIN geospatial objects in the powerful Spatial Data Editor in TNTmips® and TNTedit™. TIN objects that you make or import contain node, edge, and triangle elements that define a 3D surface. Each element may have associated attributes and can be connected with complex databases. The exercises in this booklet introduce you to the basic editing tools for TIN elements. The Spatial Data Editor also has tools for editing your vector, raster, database, and CAD geodata.

Prerequisite Skills This booklet assumes that you have completed the exercises in *Getting Started: Displaying Geospatial Data* and *Getting Started: Navigating.* Those exercises introduce essential skills and basic techniques that are not covered again here. Please consult those booklets and the TNTmips reference manual for review. Also, *Getting Started: Editing Vector Geodata* is recommended, since many editing operations are the same.

Sample Data The exercises presented in this booklet use sample data that is distributed with the TNT products. If you do not have access to a TNT products CD, you can download the data from MicroImages' web site. In particular, this booklet uses objects in the TINLITE Project File in the SF_DATA data collection. Make a read-write copy of that file on your hard drive; you may encounter problems if you work directly with the sample data on the CD-ROM.

More Documentation This booklet is intended only as an introduction to TIN editing in the Spatial Data Editor. Consult the TNT reference manual, which includes over 200 pages on the Spatial Data Editor, for more information.

TNTmips and TNTlite® TNTmips comes in two versions: the professional version and the free TNTlite version. This booklet refers to both versions as "TNTmips." If you did not purchase the professional version (which requires a software license key), TNTmips operates in TNTlite mode, which limits object size, and enables data sharing only with other copies of TNTlite.

The Spatial Data Editor is not available in TNTview or TNTatlas. All the exercises can be completed in TNTlite using the sample geodata provided.

Keith Ghormley, 20 September 2000

Editing TIN Geodata

The TNT Spatial Data Editor (Edit / Spatia Data) offers a flexible, editing environment that can be used for simple one-object tasks or complex multi-layer, multi-object manipulations. You can have a single object in one layer, or a combination of read-only reference layers with other editable layers. You can have multiple types of objects open at the same time, stacked in any front-to-back order.

Editing operations apply to the currently "active" layer. As you switch from layer to layer, the editing tools automatically change according to the data type of the active layer (raster, vector, CAD, or TIN).

A TIN ("Triangulated Irregular Network") is a set of irregularly spaced three-dimensional nodes that represent a surface as a set of adjacent, conterminous triangles. Every node is part at least one triangle, and every triangle satisfies the Delaunay criterion.
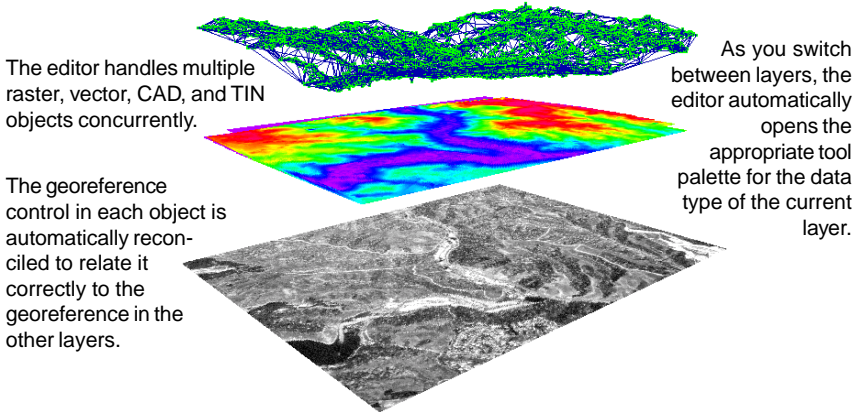
The editor handles multiple raster, vector, CAD, and TIN objects concurrently.

The georeference control in each object is automatically reconciled to relate it correctly to the georeference in the other layers.

As you switch between layers, the editor automatically opens the appropriate tool palette for the data type of the current layer.

You may see editing tools like those in TNT in other software products, but the important advantage of the TNT Spatial Data Editor is the way you can edit *multiple geospatially related* objects of different types easily and intuitively. You can concurrently edit project materials of all types while TNT automatically retains and reconciles their map registrations. This means that all the new objects you create can automatically derive their map registration from other layers, so all of your project materials have a correct geospatial relationship.

The exercises on pages 4 - 10 introduce basic editing techniques for TIN elements. Pages 11-14 present different ways to use reference objects, including 3D perspective and stereo 3D views.

Understanding TIN Topology

Vocabulary: the **hull** of a TIN object defines the x-y extents of the object and the shape of the 3D surface within that area. Some editing operations are not supported outside the hull. For example, in this version of the Spatial Data Editor, you cannot add new nodes outside the extents of the hull.

A TIN object is a three-dimensional surface defined by a set of x,y,z coordinate points. The points are joined by a network of lines such that the lines all act as edges of triangles, and the triangles all meet the Delaunay criterion. The important thing to remember is that the edge and triangle elements are completely derivative. That is, they are uniquely determined by the location of the nodes. Thus you cannot directly edit an edge or triangle in a TIN object. Rather, you will always edit the node elements, and the edges and triangles will be automatically adjusted according to the nodes.

TIN objects offer many advantages of speed and efficiency for computer processes that manipulate 3D surfaces. You will use TINs for elevation data (for hydrology, watersheds, erosion, surface flow, and orthophoto generation), and for other functional surfaces where 3D representations help in visualization and analysis. Thus you can create a TIN object from point observations and take the z value from any significant study variable, such as crop yield, soil contamination, signal strength, or total event observations.

A **node** is an x,y,z coordinate point.

An **edge** connects two nodes.

Every edge belongs to one or two **triangles**.

The triangle elements in TIN objects are formed by a method that guarantees that the triangles are as small and equilateral as possible, given that set of input nodes. There is always one and only one proper TIN structure that can be formed from a given set of nodes. When you change one node, the Object Editor automatically reconstitutes the local structure of the TIN.
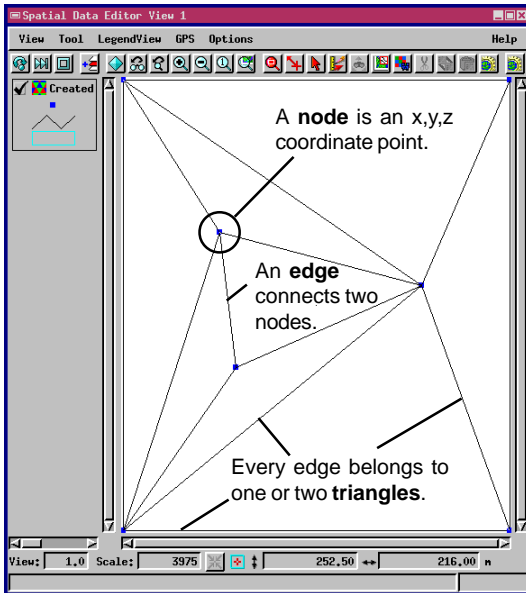
Create a TIN Object

Start the TNTmips Spatial Data Editor by selecting Spatial Data from the Edit menu. TNTmips opens the Spatial Data Editor window and an associated View window. Click the Create New Object icon button and select TIN from the drop down menu. TNTmips opens a New Object Values window.

Accept the default values in the New Object Values window. In later exercises we will change Name and Georeference values as we tell the Editor how our new TIN object relates spatially to other layers. For now, click the OK button at the bottom of the window. The editor opens a NEWTIN object, opens the TIN Tools window (described on the next page), and adds a new TIN object to the layer list in the Spatial Data Editor window.

The Spatial Data Editor View 1 window contains a minimal TIN object: 4 nodes, 5 edges, and 2 triangles. The tools in the TIN Tools window are described in the following exercises.
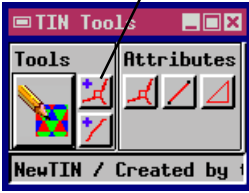
STEPS
- ☑ start the Spatial Data Editor by selecting Spatial Data from the Edit menu
- ☑ in the TNTmips Spatial Data Editor window, click Create New Object and select TIN from the drop down menu
- ☑ observe that the Name field says NEWTIN and the default georeference is User Defined
- ☑ click [OK] to complete the new object setup

The New Object Values window opens when you select TIN from the Create New Object icon button in the Spatial Data Editor window. In a subsequent lesson we will select Name and Georeference values. For this exercise, click the [OK] push-button to accept the default name ("NEWTIN") and georeference ("User Defined.").
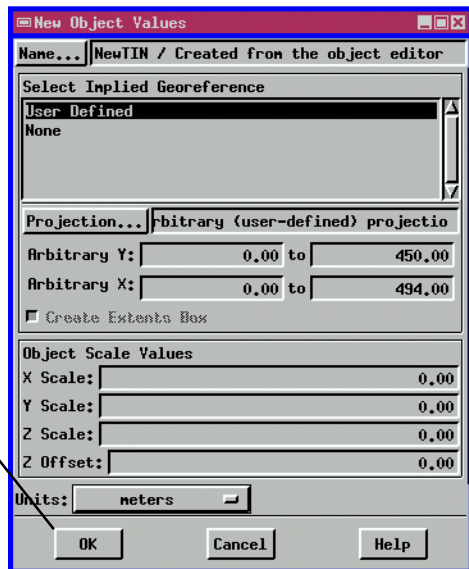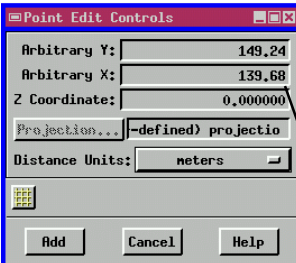
The TIN Tools Palette

Add Node

NewTIN / Created by

STEPS
- ☑ click the Add Node tool
- ☑ click the left mouse button in the Spatial View window to position the crosshair tool
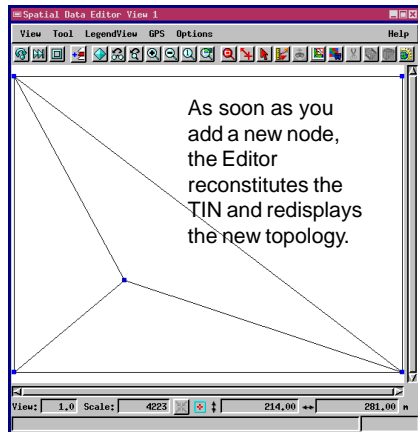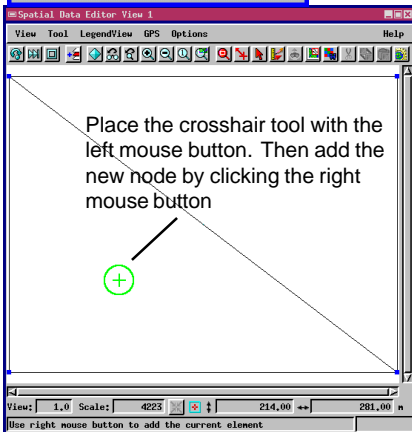- ☑ click the right mouse button to add a new node at the crosshair location

The Point Edit Controls window shows the coordinates of the crosshair tool.

The tool palette in the TIN Tools window offers three tools: Add Node, Add Line, and Edit. If you have used the tool palettes that the Spatial Data Editor presents for other object types (raster, vector, and CAD), you are familiar with a wider variety of editing tools: such as add polygon. But remember that the edges and triangles in TIN objects are strictly functions of the node elements and so they have no existence apart from nodes. Thus when you add a node, you automatically add connecting edges and you automatically trigger a reconstitution of all local triangles. You cannot add triangles directly, but you can add lines, which the editor immediately incoporates as edges in new triangles.

Click the Add Node tool button in the TIN Tools window. Then position the mouse cursor in the Spatial View window and click the left mouse button to place the crosshair tool. The crosshair marks the position of the new node. You can drag and reposition the crosshair with the left mouse button, and then add your new node by clicking the right mouse button.

Place the crosshair tool with the left mouse button. Then add the new node by clicking the right mouse button

As soon as you add a new node, the Editor reconstitutes the TIN and redisplays the new topology.

Adding Node Elements

After adding one node, the NEWTIN object has 5 nodes, 8 edges, and 4 triangles (refer to the illustration on the previous page). Apply the Add Node tool several more times to add nodes across the object. Observe that after you add each node with the right mouse button, the Editor reconstitutes the TIN object and redisplays the new topology. Observe also that you cannot add nodes outside the extents of the existing hull area

Since TIN objects are designed to represent 3D surfaces, each node has a z-coordinate value. The default z value is zero, but you can type in an actual elevation value before you add a new node in the Point Edit Controls window. Position the crosshair, type in the z value, and then click the right mouse button to add the 3D node. Elevation values can be positive or negative, including decimal values.

The standard View window display tools are all available as you add nodes. Use the zoom and pan tools to try different viewpoints as you add nodes.

STEPS
- ☑ add several new nodes
- ☑ type in z coordinate values for some new nodes in the Point Edit Controls window
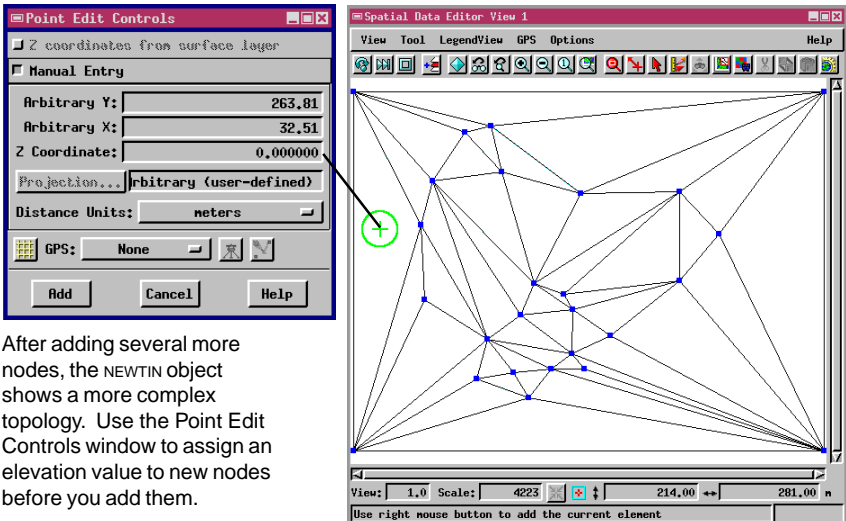
After adding several more nodes, the NEWTIN object shows a more complex topology. Use the Point Edit Controls window to assign an elevation value to new nodes before you add them.

The Editing Mode
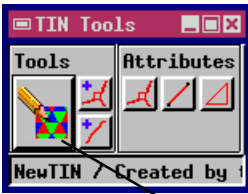
STEPS

☑ click the Edit tool in the TIN Tools palette

☑ click the Show Details icon button in the TNTmips Spatial Data Editor window to expose the element selection rows

☑ click the Select icon button in the edge and triangle rows to turn off selection for those elements

☑ click the Edit Element tool in the Operation panel of the Element Selection window

In this exercise we will switch to the editing mode in order to go back to some of the nodes you added to the NEWTIN object and modify them. First, select the Edit tool in the TIN Tools palette. The Spatial Data Editor closes the Point Edit Controls window that you used for adding nodes, and opens the Element Selection window.

In this exercise we want to select and modify node elements only, so turn off selection for edge and triangle elements. Click the Show Details icon button in the object list in the Spatial Data Editor window to expose the element control rows. Then click the select icon button on the edge and triangle rows to turn off selection for those elements. (When the Select icon is blue, selection is enabled; when it is red, selection is disabled.)

Click the Edit Element tool in the Operations panel of the Element Selection window. In the next exercise we will use this tool to select node elements and change their x, y, and z coordinate values.

When you select the Edit tool from the TIN Tools palette, the Spatial Data Editor opens the Element Selection window. Click the Edit operation icon button.

Expose the element control rows in the Object Editor window.
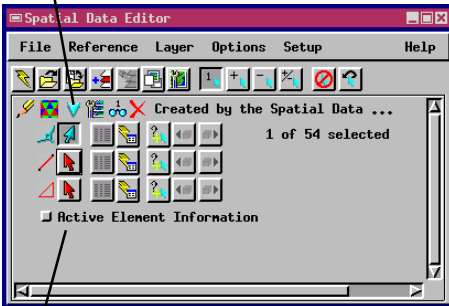
Turn off the selection icons for node and triangle elements.
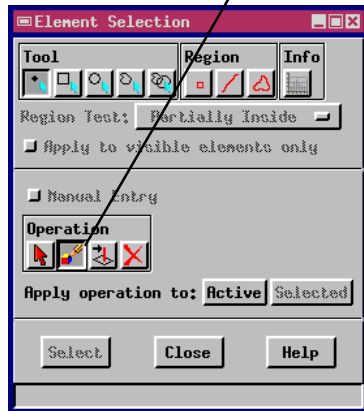
Move and Delete Nodes

Click on a node element in the View window. The element becomes active and is displayed in the active highlight color. (You can change active and selected colors with Options / Colors in the View window; you can change node, edge, and triangle colors with Layer / Controls in the Spatial Data Editor window.)
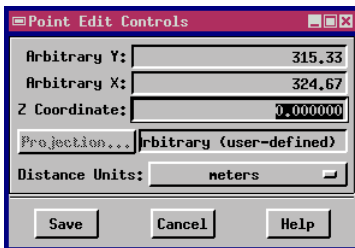
Click the right mouse button to activate the selected node for editing. The Editor puts the crosshair tool on the selected node and opens the associated Point Edit Controls window. Use the left mouse button to drag the crosshair tool, and click the right mouse button to apply the change. When a node is active for editing, you can also change the z coordinate value in the Point Edit Controls window.

The Delete operation is similar. Select the Delete icon button in the Operation panel of the Element selection window. Select a node element to delete with the left mouse button. Apply the delete operation with the right mouse button.

Every time you move or delete a node element, the Editor reconstitutes the TIN object.

STEPS
- ☑ click the left mouse button on a node element to select it
- ☑ click the right mouse button to open the Point Edit Controls window for the selected node
- ☑ drag the crosshair tool or type in new coordinate values
- ☑ click the right mouse button to apply the edits
- ☑ select the Delete Element icon in the Operation panel
- ☑ click the left mouse button to select a node to delete
- ☑ click the right mouse button to apply the delete operation

When you click the right mouse button for a selected node, the Point Edit Controls window opens and the crosshair tool appears in the Spatial View window.
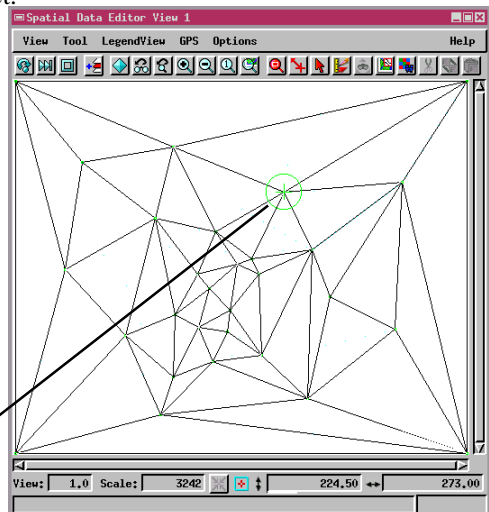
Quick Z Value Traversal

STEPS
- ☑ click the Z Value tool in the Element Selection window
- ☑ select a node element in the Spatial View window
- ☑ type in a new Z Value in the drop down panel in the Element Selection window

After this exercise, you do not need the NEWTIN object we have been using. Click the Remove icon button in the NEWTIN row in the Spatial Data Editor window. TNT asks if you want to save your changes or discard them. Since we have no further use for this practice object, you can discard it.

You can change the z value for each node element as in the previous exercise by selecting it and opening its associated Point Edit Controls window. A quicker way to traverse all the nodes in your TIN object is to select the Z Value tool in the Operation panel of the Element Selection window. The Z Value tool opens a drop down panel in the Element Selection window where you can type in the z value for a selected node element directly. This one-step z value editing is easier than the two-step method presented in the previous exercise, but it does not offer the crosshair tool or any coordinate fields for the x,y coordinate values. Thus, if you want to change more than the z value for a node, use the Point Edit Controls method. But if you want to review and modify z values only, use the Z Value tool.

Click the Z Value tool in the Element Selection window. Select one of the node elements in the Spatial View window. Click on the Z Value field in the Element Selection window and type in a new z value.
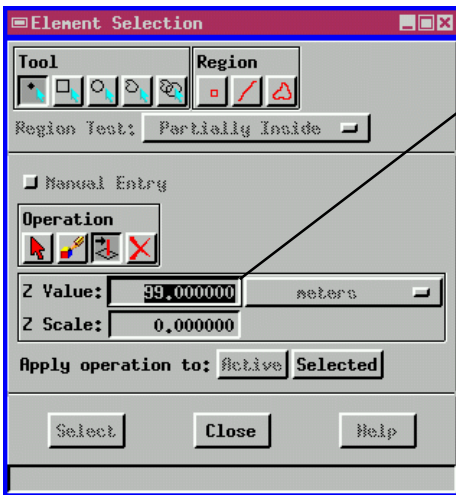
When you click the Z Value tool in the Operations panel, a drop down panel opens and lets you change the Z Value and Z Scale for the selected node element.

NOTE on the Delete tool: This booklet does not treat the use of the Delete tool except with node elements. It is possible to delete edge and (depending on the local topology) triangle elements, but such an operation is useful only in rare circumstances. If you delete an edge element, you create a hole in the TIN hull where you cannot add or move further node elements.

Use a Reference Layer

The TNT Spatial Data Editor proves its real useful-
ness when you use multiple layers in the View win-
dow. You can edit a TIN layer using one or more
reference layers for information and control. In this
exercise we will use an extracted piece of a USGS
topo sheet to compare and adjust z values for node
elements. You could also use ToolTips to read z
values from an elevation raster object, or an airphoto
as a reference for tracing break lines (see page 15).

First add the HAYWARD1 raster object from the TINLITE
Project File in the SF_LITE folder. This downsampled
extract from the full Hayward topo sheet will provide
visual reference for elevation values. Open the
TINLITE TIN object in the same folder for editing. This
TIN object was generated by the DEM extraction
process from a pair of stereo airphotos. Use the Z
Value tool (see the previous exercise) to compare
the derived z values of the nodes to the elevation
values printed on the topo map.

Using a reference layer behind your TIN object lets you
compare and correct elements. The printed elevation
values on a topo map can be used to check the z values
of node elements. Read the
elevation contours , select a node,
and adjust its z value.

The HAYWARD1 topo sheet
used in this example was
resampled for illustration
purposes to fit TNTlite size
constraints. The resulting
low resolution would make
extended use of this
reference object tedious.
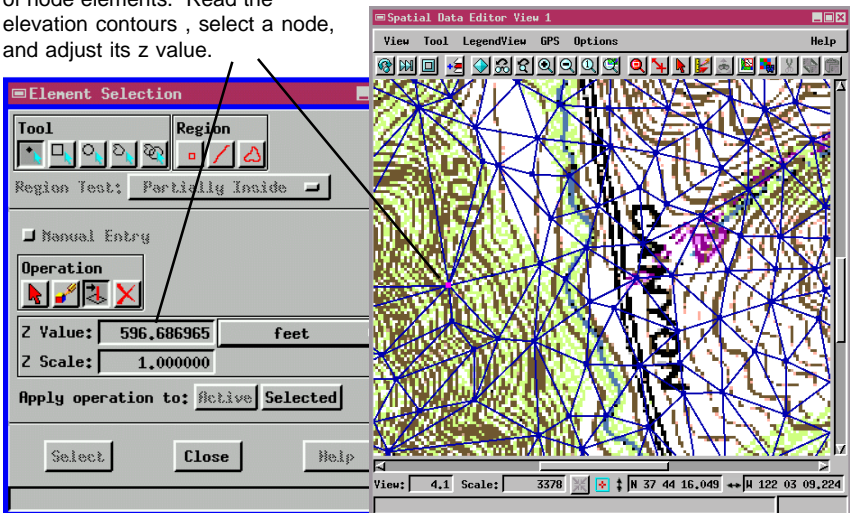
Examine Your TIN in 3D Perspective

At the same time that you are using the Spatial Data Editor to modify a TIN object, you can use the TNT Display process to view the TIN in 3D perspective. You can have both processes open at the same time and use the 3D perspective view in the Display process to identify features in the TIN object that you want to modify. For example, a TIN surface generated from stereo airphotos may have "posts and holes" that you want to bring into conformity with the surrounding surface.

Be aware that the Spatial Data Editor keeps the changes you make to a TIN object in temporary storage so that you can decide at the end of a session whether to keep or discard your edits. Therefore, the changes you make are not immediately available to the 3D Perspective view in the Display process. (A future version of the process may offer a 3D perspective view as part of the Spatial Data Editor.)

If you need review, refer to the Getting Started booklet *3D Perspective Visualization.*
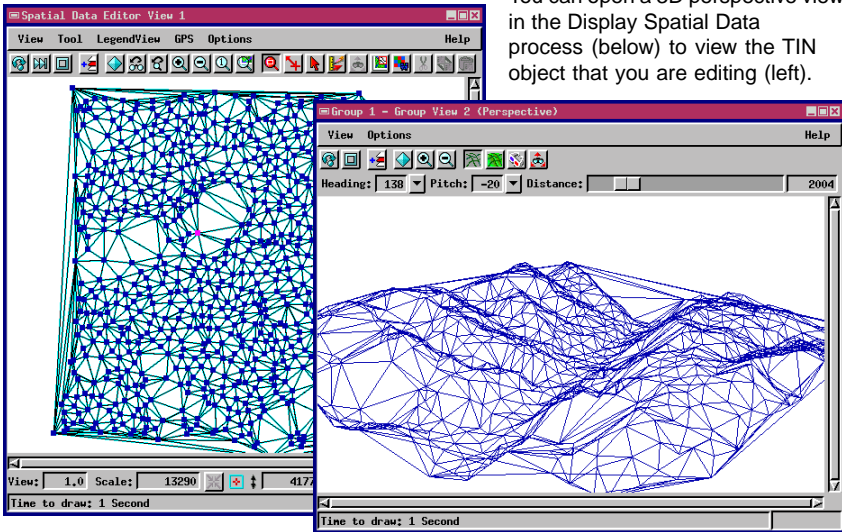
You can open a 3D perspective view in the Display Spatial Data process (below) to view the TIN object that you are editing (left).

Use a Stereo 3D Reference Image

An even more powerful editing trick lets you view a stereo 3D reference image while you edit a TIN object. (Note: this exercise requires you to use the technique of "cross-eyed stereo" viewing, which is difficult for some people. A future version of the Editor will add direct support for other stereo 3D methods of viewing reference images.)

As in the previous exercise, use the TNT display process to open a 2D view alongside the Editor's View window. As illustrated below, add the TINLITE / LEFTLITE airphoto to the Display process window on the left, and add the TINLITE / RIGHTLITE airphoto as a reference layer in the Editor's View window on the right. When the windows are sized and positioned as illustrated, you should be able to see a stereo 3D image by using the cross-eyed stereo technique. You may need to change the drawing style of the TIN layer or hide it temporarily if it interferes with the stereo 3D effect. You can use such stereo 3D reference information to edit break lines in the TIN to conform to ridge and drainage features.

STEPS
- ☑ close the 3D perspective view in the Display process from the previous exercise
- ☑ open a new 2D Group in the Display process
- ☑ click the Add Layer icon button for the Display process and select LITEDATA / TINLITE / LEFTLITE
- ☑ click the Add Layer icon button for the Editor and select RIGHTLITE from the TINLITE Project File
- ☑ resize and position the windows as illustrated
- ☑ adjust the display to achieve stereo 3D cross-eyed effect, hiding the TIN layer temporarily if necessary
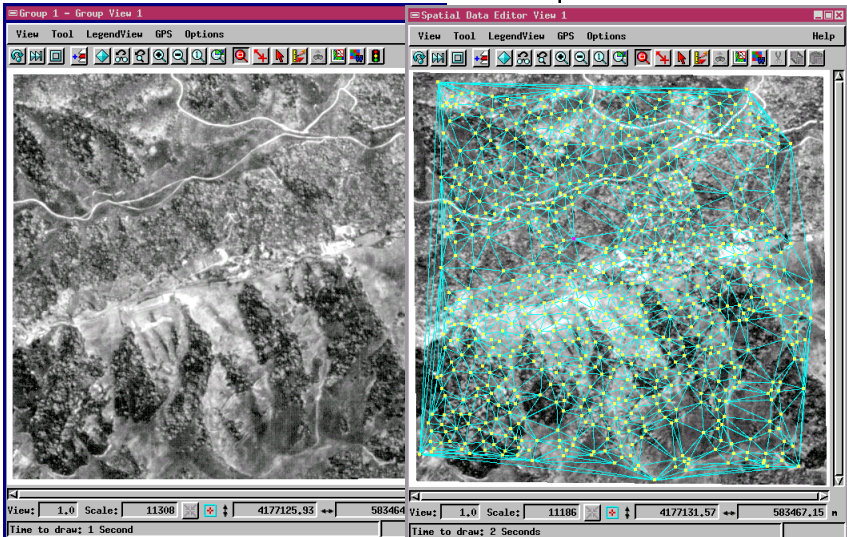
Working with TIN Attributes

STEPS
- ☑ exit the Display process used in the previous exercise
- ☑ select Update Standard Attributes from the TINLITE Tools icon menu in the Spatial Data Editor window
- ☑ click the Show Tables icon button for edges and triangles
- ☑ click the View Table icon button for the TRISTDATTRIB table listed for the triangle elements
- ☑ click on a triangle element in the Spatial

Node, edge, and triangle elements can have any number of related attribute tables associated with them just as elements in CAD and vector objects can. (Refer to *Getting Started: Editing Geospatial Vectors*). The special properties of TIN elements can be especially useful in query and analysis operations. To generate the standard attributes for a TIN object, select Update Standard Attributes from the Tools icon menu in the Spatial Data Editor window. To view the tables, click the Show Tables icon button associated with each element type. Then click the View Table icon to open a database view window for each table you want to see.

In the illustration below, a triangle element has been selected in the View window, and both the Active Element Information and the associated record from the TRISTDATTRIB table are exposed.

In addition to the standard attribute tables (below), you can view Active Element Information in a drop down panel in the Spatial Data Editor window.
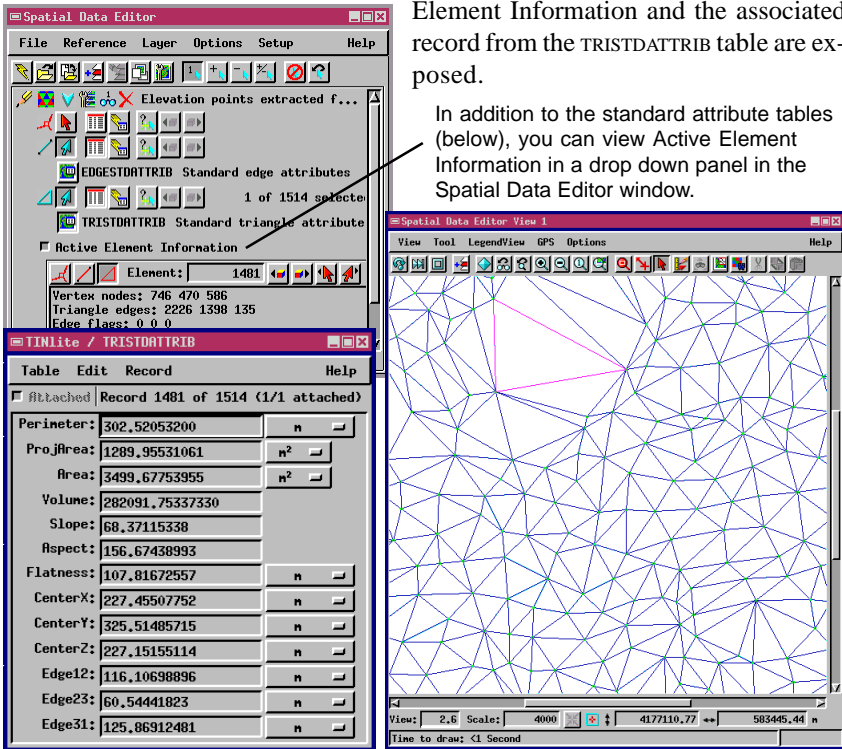
Drawing Break Lines

It is best to think of a TIN object as a set of 3D nodes from which a network of edges and triangles are generated. The nodes determine the edges and triangles. The edges and triangles are derived from the nodes. Thus, the most natural way to edit a TIN object is to work with node elements, and let the Editor manage the edge and triangle network.

The Spatial Data Editor also allows you to perform a limited number of editing operations on edge elements. Drawing edge elements directly lets you trace break lines in an elevation surface so that the TIN's ridges and valleys will strictly conform to the actual surface.

You can **add edge elements** by drawing with the standard line tool. The Editor breaks your new line into discrete edge segments by adding nodes where the line changes directions, and then it reconstitutes the TIN topography in the local area.

You can **delete edge elements** by selecting them and applying the Editor's delete operation, but note that deleting an edge creates a hole in the TIN hull and you cannot thereafter add node or edges in the hole.

You cannot **reshape edge elements**.

STEPS
- ☑ create a new TIN object
- ☑ select the Add Edge tool in the TIN Tools palette
- ☑ use the standard line drawing techniques to draw a complex break line
- ☑ click the right mouse button to add the break line
- ☑ examine the newly reconstituted TIN structure

Below left: use the line tool to draw a break line.
Below right: The Editor adds node elements along the breakline and reconstitutes the TIN topography.
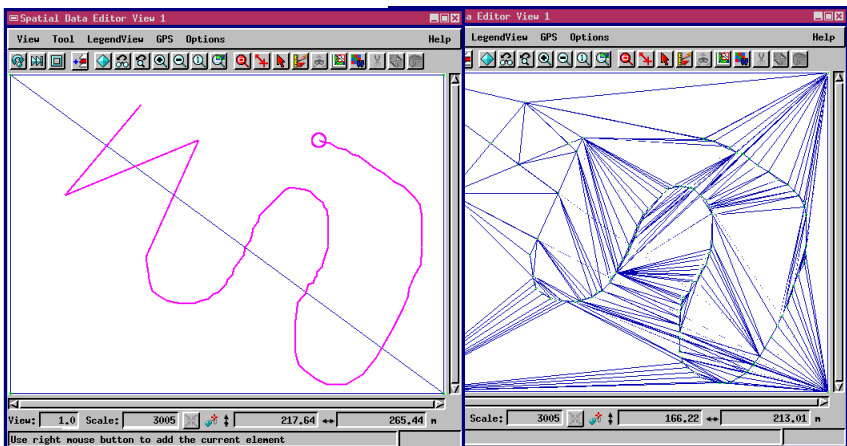
Advanced Software for Geospatial Analysis

MicroImages, Inc. publishes a complete line of professional software for advanced geospatial data visualization, analysis, and publishing. Contact us or visit our web site for detailed product information.

TNTmips   TNTmips is a professional system for fully integrated GIS, image analysis, CAD, TIN, desktop cartography, and geospatial database management.

TNTedit   TNTedit provides interactive tools to create, georeference, and edit vector, image, CAD, TIN, and relational database project materials. TNTedit can access geospatial data in a wide variety of commercial and public formats.

TNTview   TNTview has all the same powerful display features for complex visualization and interpretation of geospatial materials as TNTmips. TNTview is perfect for those who need flexible access to the TNT project materials but do not need the technical processing and preparation features of TNTmips.

TNTatlas   TNTatlas lets you publish and distribute your spatial project materials on CD-ROM at low cost. TNTatlas CDs contain multiple versions of the TNTatlas software so that a single CD can be used on any popular computing platform.

TNTserver   TNTserver lets you publish TNTatlases on the Internet or on your intranet. Navigate through massive geodata atlases with your web browser by using the free, open-source TNTclient Java applet (or any custom applet you create) to communicate with TNTserver.

TNTlite   TNTlite is a free version of TNTmips, TNTedit, and TNTview for students and professionals with small projects. You can download TNTlite for your computer (about 100MB) from MicroImages' web site, or you can order TNTlite on CD-ROM with the current set of *Getting Started* tutorial booklets (shipping and reproduction charges apply).

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