TNTsim3D

Tutorial

Using TNTsim3D™

for Windows

Covers new features added since the release of TNT V6.60.

Before Getting Started

TNTsim3D™ for Windows provides you with the ultimate way to explore your geospatial data: real-time, interactive, 3D viewing. Use your joystick, keyboard, or mouse to move over and around a simulated 3D landscape and view your geospatial data from any vantage point. You prepare data for use in TNTsim3D with the Landscape Builder process in TNTmips®. Each landscape file contains a texture raster object precisely matched to a terrain raster; the texture raster layer can include any visual combination of geospatial data.

Prerequisite Skills TNTsim3D is easy to use even if you have no previous experience with geospatial analysis software. If you have used a flight simulator software program and have a joystick, you are already familiar with moving through a simulated 3D scene. But even those without a joystick can use the keyboard to easily control movement, speed, and attitude.

Sample Data The exercises presented in this booklet use sample data 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 sample files BIGPINE.SIM and CRATERLK.SIM in the SIMDATA directory on the TNT V6.6 products CD. You can also use any of the other landscape files on the CD (or on MicroImages web site) with TNTsim3D.

More Documentation This booklet is intended only as an introduction to the features of TNTsim3D for Windows. A companion Tutorial Exercises booklet covering the Landscape Builder in TNTmips is in preparation.

TNTmips and TNTlite® TNTmips comes in two versions: the professional version and the free TNTlite version. 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. TNTsim3D can be used only on Windows computers by licensed users of the professional TNTproducts.

Randall B. Smith, Ph.D.,22 January 2002
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It may be difficult to identify the important points in some illustrations without a color copy of this booklet. You can print or read this booklet in color from MicroImages' Web site. The Web site is also your source for the newest Getting Started booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTlite.

http://www.microimages.com

Welcome to TNTsim3D

Most geospatial data that you work with is a selective representation of a complex three-dimensional landscape, but flat maps and images frequently convey little sense of the vertical dimension. Contours and relief shading can be included with the map data for this purpose, but the ideal way to visualize the true shape of your geospatial data is to combine the data with an elevation model and "fly" over and around a 3D scene, examining features from any vantage point in real time.

TNTsim3D for Windows provides this capability for users of the TNT professional products. It allows you to move over 3D terrains using joystick, keyboard, or mouse controls. You can control all aspects of the viewer orientation (attitude), height above the surface, and speed. Special visual effects are also available, such as automatic texture smoothing and atmospheric effects (fog / haze).

You create the data for the simulator using the Landscape Builder process in TNTmips, which creates a terrain raster object and a texture raster object that are specially optimized for real-time interactive 3D rendering. Both of these objects are stored together in a landscape file, a specialized type of TNT Project File with the file extension *.sim.

TNTsim3D is similar in many respects to flight simulator software products. It uses similar 3D rendering principles and techniques and provides the same real-time 3D movement. But the purpose of flight simulator software is to mimic the experience of flight, including different weather conditions and the flight characteristics of different types of aircraft; the background landscape is secondary. The purpose of TNTsim3D, on the other hand, is to allow you to view your geospatial data as a landscape. Its emphasis is on allowing you to move around and over the simulated landscape in real time while maintaining the quality of the landscape rendering.

☑ Copy the files in the SIMDATA folder on the TNT V6.6 products CD to your local drive

The exercises on pages 4-5 cover hardware and software requirements, launching TNTsim3D, and loading data. Default keyboard motion controls and instructions for configuring other input devices are found on pages 6-10. Pages 11-12 cover other input options and adjusting the tradeoff between terrain quality and frame rate. Texture smoothing, fog, and other special effects are discussed on pages 13-15.

Launching TNTsim3D

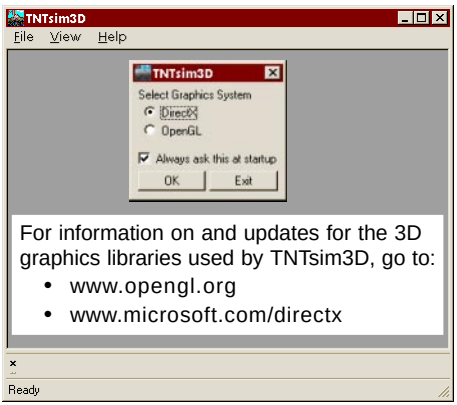
TNTsim3D is installed automatically when you install TNTmips. A shortcut to the program is created in the MicroImages \ TNTproducts folder shown in the Windows Start menu. You can launch TNTsim3D from the Start menu, or copy this shortcut to the Windows desktop. You can also double-click on any TNTsim3D landscape file to launch the program and load the data from that file.

STEPS

- ☑ launch TNTsim3D
- ☑ if a Select Graphics System window opens, select either DirectX or OpenGL and click [OK]

Before running TNTsim3D, make sure that either OpenGL v1.1 or Microsoft DirectX 8.0 (or a later version) is installed in your Windows system. OpenGL is a cross-platform program library for 3D rendering and 3D hardware acceleration. Support for OpenGL v1.1 is included with Windows98, NT 4.0, and later versions of the Windows operation system. DirectX is a suite of Microsoft multimedia program libraries that include Direct3D for 3D rendering and hardware acceleration and DirectInput for configuring motion controls for input devices (such as keyboard and joystick). The TNTsim3D page on the MicroImages web site provides links to instructions on how to determine what version of DirectX is installed and how to download and install updates.

If only DirectX or OpenGL is installed on your computer, TNTsim3D will open directly using that graphics system. If both DirectX and OpenGL are installed, before TNTsim3D opens you will be presented with a window asking you to select which graphics system to use. In principle, DirectX and OpenGL provide similar capability and performance in 3D rendering. Both systems can take advantage of any 3D rendering capabilities built into your display board to accelerate performance, which means higher frame rates and smoother movement. However, some display boards and drivers may not provide equal support for DirectX and OpenGL, so one may perform better than the other on your computer. You will need to experiment to determine which system works best for you. For best performance, make sure that you have the most recent Windows-certified driver for your video display board, and follow the manufacturer's instructions to adjust hardware acceleration settings.



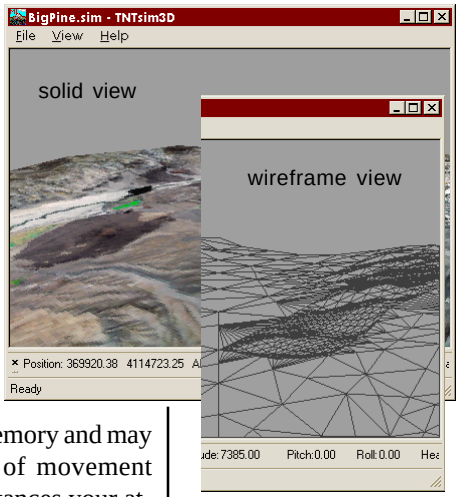
Loading a Landscape File

TNTsim3D opens by default with a single window on your desktop. The File and View menus provide access to most of the program controls. The File menu is used to open a landscape file and to exit the program. This menu also shows the last four landscape files you have used, providing easy loading of recently-used data.

When you open a landscape file, TNTsim3D reads the terrain raster in the file and constructs a 3D model of the terrain surface. The surface model is a mesh of interlocking 3D triangles that provides an efficient approximation of the terrain surface. The texture raster object is then draped over this surface model. To see the surface model alone, choose View / Wireframe; this menu option acts as a toggle between solid and wireframe view modes. The state you have set when you exit the program is used by default when you next open it.

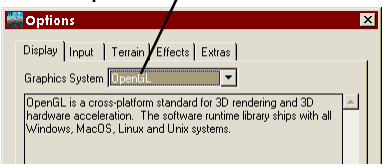
STEPS

- ☑ choose Open from the File menu
- ☑ navigate to the directory into which you copied the landscape files (*.SIM) from the TNTproducts 6.6 CD
- ☑ select BIGPINE.SIM
- ☑ choose Wireframe from the View menu
- ☑ repeat the previous step to return to solid view
- ☑ select Options from the View menu and examine the Display panel, then click [OK]



You can resize the TNTsim3D window by dragging any edge or corner, or use the standard Windows maximize/restore button on the right side of the window title bar. Keep in mind, though, that increasing the window size puts a larger demand on video memory and may reduce the speed and smoothness of movement through the simulation. In some instances your attempt to enlarge the window may exceed the amount of available video memory. TNTsim3D in that case returns to the previous window size and displays an error message explaining the problem. DirectX appears to be more demanding of video memory than OpenGL. If both graphics systems are available on your computer, you can switch between them using the Graphics System menu on the Display panel of the Options window.

You can switch between DirectX and OpenGL on the fly using the Graphics System menu on the Options / Display panel.



First Flight: Using Keyboard Controls

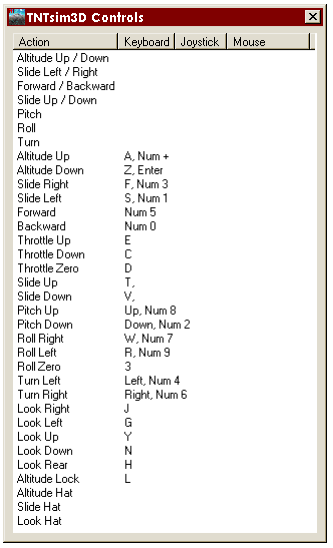
STEPS

- ☑ choose Show Controls from the View menu
- ☑ using the keyboard motion controls shown, experiment with moving through the 3D scene

The normal view direction is straight ahead in the direction of flight. Use the Look Right/Left/Up/Down keys to temporarily look in other directions.

Although you may already have a joystick or other flight control device installed on your computer, let's use the keyboard for your first flight, because a number of actions have been pre-assigned to specific keys. These default input control settings are shown the first time that you open the TNTsim3D Controls window. You can keep this window open on your desktop as a quick reference to the keyboard controls while you try them out.

The keyboard controls allow you to move in various directions through the scene, control forward and backward speed, and change your viewing orientation (attitude). The attitude controls use the same motions that would apply to an aircraft: pitch, roll, and turn. If you are not familiar with these terms, pitch affects the vertical angle in the direction of flight, roll affects the angle of the wings relative to the horizontal, and turn affects the heading (the horizontal direction of flight).



Default input control settings. If DirectX is installed there are no Num key assignments.

The way in which you use a key on the keyboard depends upon which control is assigned to it. The general motion controls (Altitude Up/Down, Forward/Backward, Slide Right/Left/Up/Down, Pitch Up/Down, Roll Right/Left, Turn Left/Right) move you at a specified speed (discussed later) as long as the key is held down. To move forward without having to continue holding a key down, use the Throttle Up Key, which increases your speed by a fixed amount each time it is pressed. The Throttle Down key slows your forward speed and, if you slow down to a stop, moves you backward at increasing speed. The Throttle 0 key stops the motion begun by the other Throttle keys, while Roll 0 levels the wings of the virtual plane. The Look Right/Left/Up/Down keys direct your view in a particular direction as long as they are held down. The Altitude Lock key acts as an on/off toggle for maintaining the current altitude.

Keeping Track of Where You Are

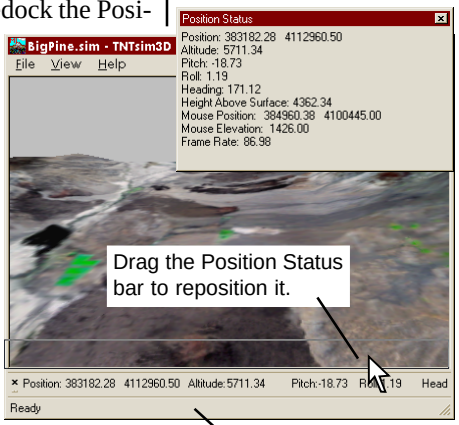
A simulation opens with a default viewer position above the upper left corner of the scene, pointing toward the scene center. As you fly around, information on your viewing position is shown by default in a Position Status bar at the bottom of the TNTsim3D window. This bar shows your horizontal (x y) position (in map coordinates if the simulation objects are georeferenced), altitude above sea level and height above the terrain surface (both in meters), and angles in degrees for pitch, roll, and heading. You can use the mouse to drag and redock the Position Status bar at the other edges of the window or move it outside the TNTsim3D window to form a separate auxillary window. An option on the View menu also allows you to toggle the Position Status bar on and off.

In some situations, especially if you are flying relatively fast, you may get disoriented and lose track of where you are and of your attitude. You may find yourself pointing up to the sky and not know where the terrain is, or fly right through the terrain surface and end up underneath it. The position status information can help you figure out where you are. In the latter case, for example, the Height Above Surface parameter would show a negative value. You could then use the Altitude Up control to move back above the surface.

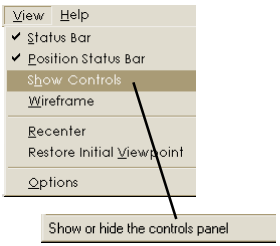
If you can't get yourself reoriented manually, or don't want to bother, there are two short cuts available on the View menu. You can use the Recenter option to maintain your current position but reorient the view toward the center of the scene. If that is not sufficient, you can choose Restore Initial Viewpoint, which jumps the viewer position and orientation back to those of the starting point.

STEPS

- ☑ use the left mouse button to drag the Position Status bar outside the TNTsim3D window, forming a separate window
- ☑ select Recenter from the View menu
- ☑ select Restore Initial Viewpoint from the View menu



The Status Bar at the bottom of the TNTsim3D window shows the current program status and also acts as a tool tip when you open a menu, providing a description for the menu option you have currently highlighted.



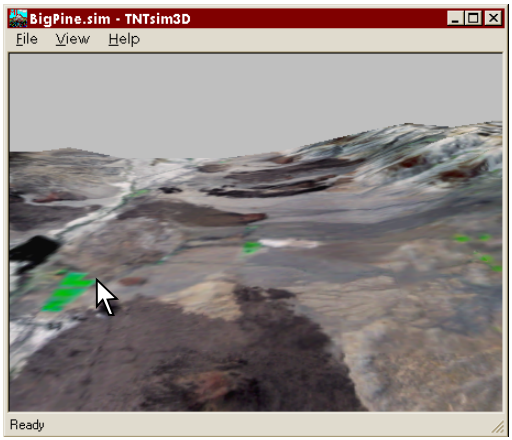
Find Surface Coordinates with the Mouse

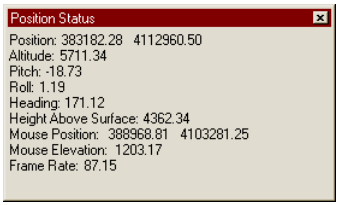
STEPS

- ☑ move the mouse cursor within the TNTsim3D window
- ☑ note how the Mouse Position and Mouse Elevation values in the Position Status list update continuously update

As we have seen, knowing your viewing position in the simulation is important. But TNTsim3D enables you to view georeferenced spatial data, so you may be more interested in finding the map coordinates and surface elevation of particular locations on the landscape surface. With TNTsim3D you can use the mouse to determine point coordinates for any visible portion of the scene.

When you place the mouse over some point on the scene in the TNTsim3D window, the program projects a sight line from the viewer position through the screen position of the cursor and on to the corresponding position on the landscape surface. The horizontal (x y) map coordinates of this position are reported as the Mouse Position item in the Position Status list. (If the landscape objects are not georeferenced, the line and column numbers of the corresponding terrain raster cell are shown.) The Mouse Elevation entry shows the corresponding surface elevation, which is interpolated from the closest terrain raster cells along the sight line. These coordinate readouts are updated continuously as you move the mouse cursor over the scene. Determining the positions of any number of scene locations is quick and easy.



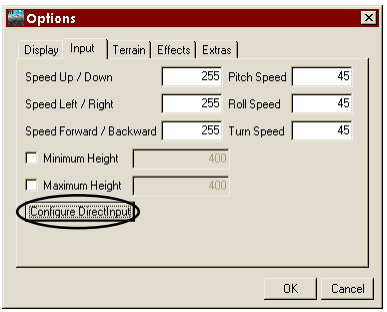


Configuring Input Controls

TNTsim3D uses the DirectInput software component of DirectX to allow you to configure the flight controls for your keyboard or other input device. You can reconfigure the controls while operating the simulator in either DirectX or OpenGL, but DirectX must be installed on your system in order for you to do so. (OpenGL does not provide an input configuration utility.) If you do not have DirectX installed, there will be no DirectInput push button on the Options window Input panel, and you will be limited to using the default keyboard controls. If so, this would be a good time to download and install the latest version of DirectX from Microsoft (see page 4).

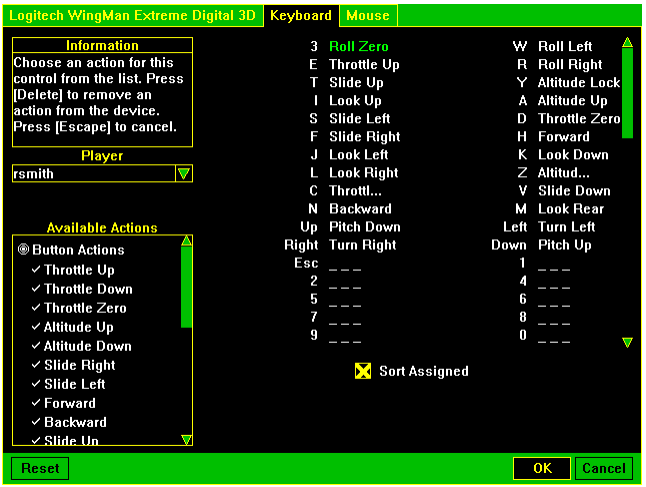
STEPS

- ☑ from the View menu select Options
- ☑ click on the Input tab
- ☑ if you have a Configure DirectInput button at the bottom of the panel, press it
- ☑ click on the Keyboard tab and edit the keyboard controls if you wish
- ☑ click [OK] on the DirectInput window and the Options window



DirectInput control window

The DirectInput window has a tabbed panel for a joystick or other game controller (if one is installed in your system), the keyboard, and the mouse. The right side of the keyboard panel lists the keys and the currently assigned action for each. To change the assignment for a key, click on its entry in the list or press the key on the keyboard. Either action highlights the control entry and shows a scrolling list of available actions in the lower left portion of the panel. To activate the action list, press Enter (or double-click on the control entry) and select a new action from the scrolled list.



Configuring a Joystick

STEPS
If you have a joystick or other game controller, make sure that it is:

- ☑ plugged into your computer
- ☑ set up and calibrated in Microsoft Windows

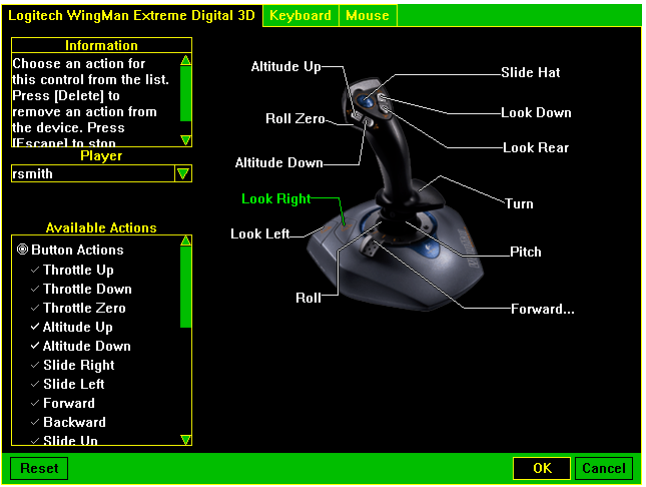
Then proceed to

- ☑ press the Configure DirectInput button on the Options window Input panel
- ☑ select the tabbed panel for your controller
- ☑ configure the stick (axis) controls and the button controls
- ☑ close the DirectInput and Options windows
- ☑ practice moving with the joystick, supplemented by keyboard controls as needed

A joystick, yoke, or similar game controller gives you more realisitic, intuitive control over your movements in TNTsim3D. The lowest-cost joysticks have only two rotation axes, so you must change roll and pitch (bank the plane) to make turns. Higher-priced (but still inexpensive) joysticks allow the stick to twist, providing three axes of rotation and independent control of turn, roll, and pitch. They also have a separate throttle control that can be operated with your other hand, as well as a number of buttons that can control other motions.

You can also use the mouse as a motion control, but only in a very limited way. The mouse is better used to interact with the data in the TNTsim3D window, as described later.

TNTsim3D allows simultaneous use of different input devices. So even if you have a joystick, you may still want to use the keyboard to control some actions. For example, if your joystick does not have a throttle control, you can use the throttle up, throttle down, and throttle 0 controls on the keyboard to control your speed.



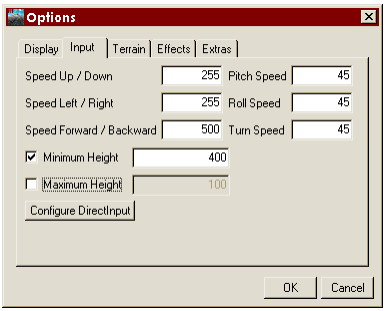
Sample action assignments that I have set for the 3-axis joystick I use at MicroImages. I move the stick forward or back to change pitch, side to side to roll, and twist it to turn.

Setting Other Input Options

The Input panel on the Options window also provides other settings that affect your movement through the simulation. In the upper left part of the panel are three linear speed settings: Up / Down, Left / Right, and Forward / Backward. All are initially set to the same velocity (in meters per second), which is based on the areal dimensions of the landscape. The default speed is computed to traverse the maximum extent (height or width) of your landscape in 120 seconds. Each of these linear speed values sets the speed used by the associated motion control. When you use the throttle controls to increment speed, the Speed Forward / Backward value sets an upper velocity limit. You can change any of these linear speeds to move more quickly. But keep in mind that at faster speeds the scene changes rapidly, forcing TNTsim3D to read more data more quickly, and the image information held in memory must be updated more frequently. Your movements may become less smooth, and you may see more transient rendering artifacts.

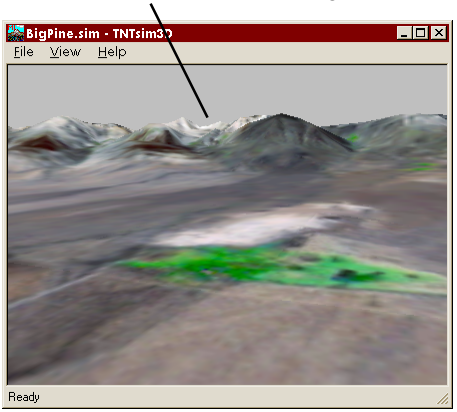
STEPS

- ☑ from the View menu select Options
- ☑ click on the Input tab
- ☑ change the value in the Speed Forward / Backward field to 500
- ☑ turn on the Minimum Height check box and change the height value to 400
- ☑ click [OK] on the Options window
- ☑ use any controls to move closer to the terrain surface until you reach the minimum height you have set



The settings in the upper right part of the panel control the angular speeds (in degrees per second) for pitch, roll, and turn. The default values are independent of the landscape characteristics, and any changes you make are retained for use in later sessions. You can also set both minimum and maximum height values, which are also retained until reset. Setting a minimum height prevents you from flying through and then under the terrain surface. If you set the same value for minimum and maximum height, you can maintain a constant height above the surface while flying in any direction.

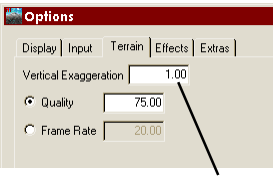
Flight following the ups and downs of terrain at minimum height of 400 m.



Terrain Quality and Frame Rate

STEPS

- ☑ turn on the Wireframe view mode (View / Wireframe)
- ☑ select Options from the View menu
- ☑ click on the Terrain tab
- ☑ increase the Quality setting to 90 and click [OK], and note the increased detail in the wireframe
- ☑ reset the Quality percentage to 75



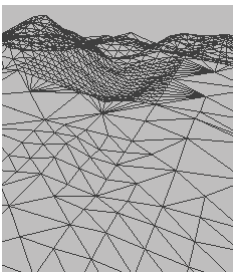
You can also set a Vertical Exaggeration scaling factor for the terrain model to vary the vertical scale.

A new terrain model is built for each frame using only the visible part of the terrain. The level of terrain detail varies spatially in each frame. More detail is shown (by smaller terrain triangles) in the foreground and in areas of greater local relief. As you move through the simulation, the amount of detail for a particular area may change, but height values are automatically adjusted to produce gradual rather than abrupt visual changes in local detail.

As you use TNTsim3D, you will likely want to move through each landscape smoothly and realistically and at the same time see the maximum possible scene detail. But achieving these twin goals may exceed the resources available on your computer, so you may need to choose which of them is more important to you for a particular simulation session.

You can make that choice in TNTsim3D by using the settings on the Options window's Terrain panel, where a pair of radio buttons allow you to give preference to either quality or frame rate. Quality refers to the amount of detail in the surface model created from the terrain raster in the landscape file. Quality is expressed numerically as a percentage; setting a higher percentage produces a surface model that shows more of the detail in the terrain raster. Frame rate is the number of times the scene is redrawn each second. A higher frame rate produces smoother, more natural movement through the landscape.

If you choose the Quality preference, TNTsim3D uses available resources to maintain your target terrain quality and reduces the frame rate if necessary. If you choose the Frame Rate preference, the program instead attempts to maintain your target frame rate and lets the terrain quality vary as needed. The effects of these selections depend greatly on the hardware capabilities of your computer; they are more significant for newer, faster computers and graphics cards.



To improve both quality and frame rate, try the following:

- ☑ shut down other programs to free computer resources for TNTsim3D
- ☑ make the TNTsim3D window smaller
- ☑ make sure your graphics card's 3D acceleration options are turned on
- ☑ get a graphics card with faster 3D acceleration and more video memory
- ☑ get more random access memory (RAM) for your computer

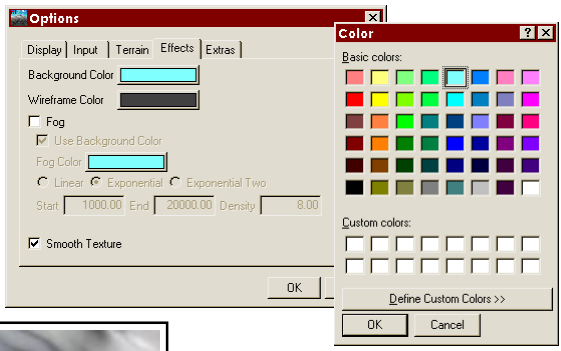
Texture Smoothing

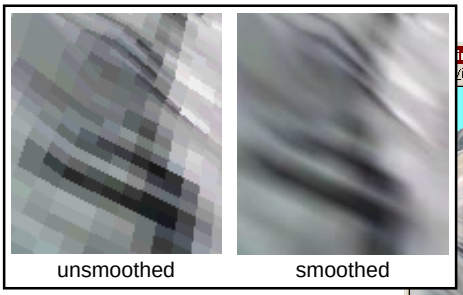
The Effects panel of the Options window lets you control a number of visual effects for your simulations, including background color, fog, and texture smoothing. The Background Color control allows you to pick the background color from a standard palette or define one or more custom colors for use as backgrounds.

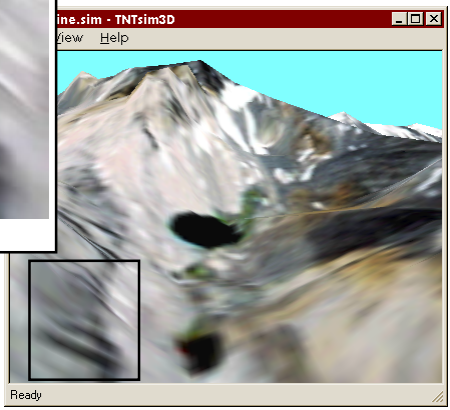
The Smooth Texture option is available only when you are using DirectX as the graphics rendering system for TNTsim3D. Smoothing has two major advantages: it reduces the blocky appearance of foreground texture cells viewed at close range, and it reduces "sparkle" in the more distant portions of the moving image. If you have a modern graphics board with 3D acceleration, the smoothing is performed by the graphics hardware itself, so there is minimal impact on frame rate. (If your board does not support hardware smoothing, the DirectX software performs the smoothing, though more slowly).

STEPS

- ☑ turn off the Wireframe view mode (View / Wireframe)
- ☑ select Options from the View menu and click on the Effects tab
- ☑ left-click on the Background Color color sample button
- ☑ use the resulting Color window to select a light blue background color and click [OK]
- ☑ if the Smooth Texture checkbox on the Effects panel is active (not dimmed), turn it on
- ☑ click OK on the Options window







TNTsim3D window with new background color and DirectX texture smoothing enabled. Magnified views of boxed area are shown above with and without texture smoothing.

Using Fog

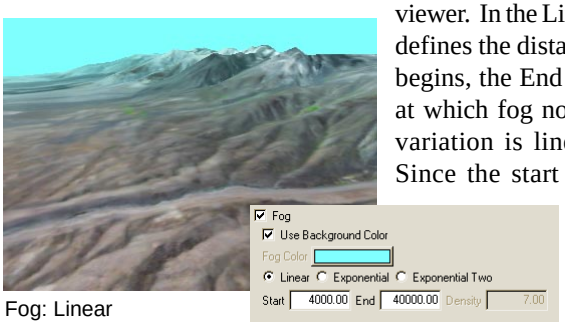
STEPS

- ☑ select Options from the View menu and click on the Effects tab
- ☑ turn on the Fog check box, accept the default settings, and click [OK]
- ☑ note the change in scene visibility
- ☑ reopen the Options window Effects panel, change the Start value to 2000 and the End value to 20000, then click [OK]
- ☑ note the change in scene visibility
- ☑ reopen the Options window Effects panel and change the Fog method to Exponential Two
- ☑ set the Density value to 7.0 and click [OK]

When you view a natural landscape, detail and color become less distinct in more distant parts of the scene because of the effects of water vapor and particulates in the atmosphere. Haze is almost always present to some extent, and fog is an extreme example.

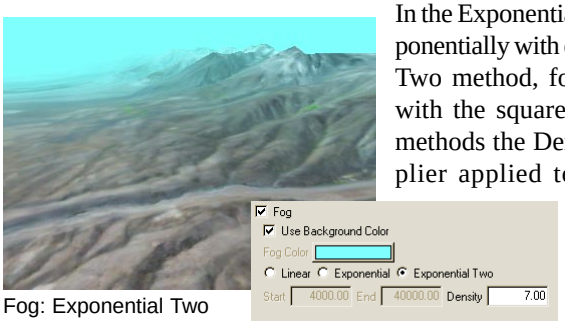
To add realism to a landscape in TNTsim3D, you can simulate the reduction of visibility with distance by using the Fog controls. The fog effect is achieved by blending texture colors with varying amounts of a designated fog color. The background color is the default fog color, which lets the hazy or foggy terrain blend naturally into the sky. For special effects you can turn off the Use Background Color check box and use the Fog Color control to select any color for the color blending.

Three methods are available to control the variation in fog density with increasing distance from the viewer. In the Linear method, the Start value defines the distance at which the fog effect begins, the End value defines the distance at which fog no longer increases, and the variation is linear between these limits. Since the start and end distances are in meters, the same pair of values will produce differing effects for landscapes of different areal extents.



Fog: Linear

In the Exponential method, fog increases exponentially with distance. In the Exponential Two method, fog increases exponentially with the square of the distance. In both methods the Density parameter is a multiplier applied to the distance exponent. Increasing the Density parameter makes the fog thicken more rapidly with increasing distance.



Fog: Exponential Two

Using the Compass Graphic

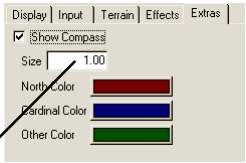
The Extras panel on the Options window lets you turn on a rotating compass graphic that is shown in the lower right corner of the simulation window. The compass graphic can help you keep track of your direction of view in three dimensions.

The graphic consists of a central sphere, arrows that point in the four cardinal directions (north, east, south, and west), and arrows for the four intermediate directions (northwest and so on). The north arrow, other cardinal arrows, and intermediate arrows are shown in separate colors. (Color controls let you change the arrow colors if you wish.) If the landscape objects are georeferenced, the north arrow points in the north direction; otherwise it points parallel to the column direction in the rasters.

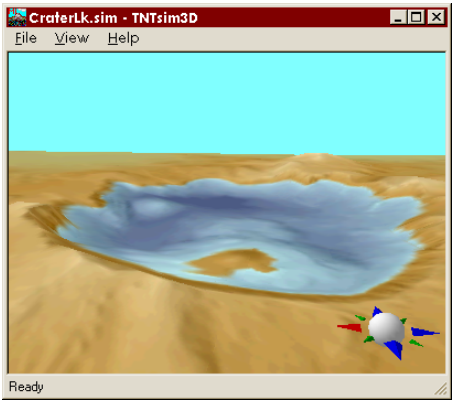
The compass points are drawn to lie in the horizontal plane, so the compass image provides a visual cue to your attitude relative to the horizontal. This attitude information is enhanced by shading effects on the points and central sphere, which are illuminated from above.

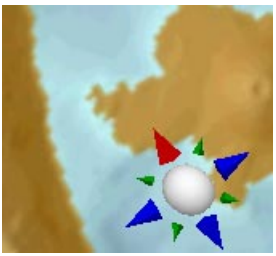
STEPS

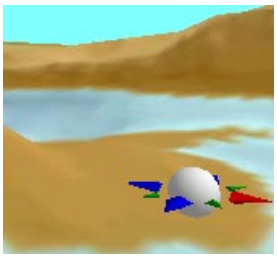
- ☑ reopen the Options window Effects panel, turn off the Fog check box, then click [OK]
- ☑ choose Open from the File menu
- ☑ navigate to the directory into which you copied the landscape files (*.SIM) from the TNTproducts 6.6 CD
- ☑ select CRATERLK.SIM
- ☑ choose Options from the View menu and click on the Extras tab
- ☑ turn on the Show Compass checkbox
- ☑ notice how the compass rotates as you move through the landscape

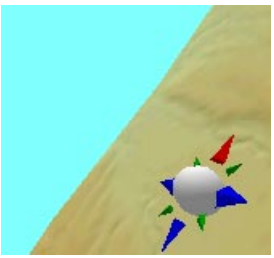


Enter a new Size value to change the size of the compass graphic.









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