# **Digital Terrain Model**

## 3.1 Introduction

Objectives	Learn how to display and analyze DTMs for use in roadway design.
Project Manager	Existing Ground
Tools	
Menu Bar Application	GEOPAK Road > DTM Tools

A **Digital Terrain Model (DTM)** represents the topography of a project in the form of a triangulated network. The DTM can be drawn in a 2D or 3D file, and then rotated to see the existing surface of the project area.

Digital Terrain Models can be generated from various sources including MicroStation Elements, survey data, photogrammetry data, **GEOPAK** cross-sections, and geometry data.

**Triangulation** is a mathematical process applied to ground points and vertices along longitudinal features to create planar surfaces. The result of triangulation is the creation of triangles connecting these points. These triangles are included in the GEOPAK TIN file from which existing ground profiles and existing ground cross sections can be generated.

## 3.2 Accessing

Clicking the **Existing Ground** button from the Road Project: Road1.prj dialog box within Project Manager invokes the tool frame shown to the right. All of the DTM tools can be accessed from the tool frame or from the DTM menu that can be accessed from the top/left icon on the tool frame.

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Settings	Extract	<u>B</u> uild	<u>E</u> dit	<u>D</u> rape	<u>L</u> oad	<u>R</u> eports	<u>A</u> nalysis	<u>U</u> tilities	0100000



## 3.3 Load DTM Features

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Menu Bar	Load > DTM Feature

Load is the process by which we can visualize the DTM data, TIN model, lattice model, and contours. By selecting the Load DTM Feature icon, the following dialog box appears.

Display Preference Load Extent	ences –	🔽 Displa	ay Only 🗖	Graphic (	àroup	//
Feature	Level	Color	Weight	Style	Display	
Spots	1	0	0	0	OFF	
Break Lines	1	1	0	0	OFF	
Extd.Contours	1	2	0	0	OFF	-
Voids	1	3	0	0	OFF	
Islands	1	4	0	0	OFF	-
Holes	1	5	0	0	OFF	-

The user can choose to load the DTM data (.dat), the TIN file (TIN), or the Lattice file (.lat). Each of these files can be loaded for the model extents, within a fence, or selected view.

Activating the **Display Only** toggle enables the user to view the elements without writing them to the MicroStation file (temporary display). Conversely, deactivating the toggle writes the DTM features to the MicroStation design file at the defined symbology. These elements can be placed as a graphic group when **Display Only** is deactivated.

Feature	Level	Color	Weight	Style	Display
Triangles	1	4	2	0	ON
Tin Hull	2	4	2	0	ON
Contours			-	-	ON
Major Lines	9	5	2	3	ON
Major Label	17	5	4	0	ON
Minor Lines	10	7	2	0	ON

Activates the display of all Features.

**Pt** Turns off the Display of all Features.

Turns on only the selected Feature. This can also be accomplished by activating the toggle (below the list box) or double-clicking on an item that is turned off within the list box.

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Will turn off only the selected item. This can also be accomplished by activating the toggle (below the list box) or double-clicking on an item that is turned on within the list box.

# 3.4 Analysis Tools

Tools	Analysis
Menu Bar	Analysis > Height         Analysis > Profile         Analysis > Volumes         Analysis > Elevation Differences         Analysis > Slope Area         Analysis > Themes         Analysis > Drainage Tools         Analysis > Visibility         Analysis > Trace Slope Path

The **Analysis** tools allow the user to visually analyze the digital terrain model utilizing numerous tools as a profile analysis, thematic analysis, drainage flow patterns, and visual portions on the model from any given location.

Height	To determine the height and other associated data dynamically based on user-defined data points within the model.
Profile	View a profile based on a user defined MicroStation element.
Volumes	To compute the volume between two TIN models, the volume between a TIN model and a plane, or the cut and fill totals between two TIN models while applying a shrinkage/swell factors.
Elevation Differences	Will display the elevation difference, or the amount of cut and fill between two TIN models, or a TIN model and a plane of constant elevation.
Slope Area	The Slope Area tool displays the horizontal area and actual slope area (area following the terrain of the Model).
Themes	Displays the digital terrain model based on different user definable themes such as elevation ranges, slope percentage, slope degree, or aspect.
Drainage	Displays and analyzes drainage patterns within a TIN model. Tools include delineating watersheds, drawing flow arrows, determining upstream and downstream traces, finding high and low points, and ridge and sump lines.
Visibility	Based on a user-defined point of origin, GEOPAK visually displays which triangles can and cannot be seen, or what is visible between two points.
Trace Slope Path	Traces a path along a TIN file using a user specified slope and method.

# Lab 3: Digital Terrain Modeling

## 3.1 Accessing DTM Tool via Project Manager

- Step 1. Execute C:\data\geo\VDOT\road1\LAB3.EXE.
- Step 2. Open the MicroStation file c:\data\geo\VDOT\road1\d17682dtm.dgn.

Access **Project Manager**. It should automatically access the Road workflow dialog box since we "remembered" the options in Exercise 2.

- Step 3. Select the Existing Ground tool from the Project Manager Road dialog box.
- Step 4. Create a new run ground1.

		New Run Name
Select Run		
<u>B</u> un		Run Name: ground1
<u>N</u> ew	Time	Description Existing Ground from Surveys
<u>C</u> opy ► <u>M</u> odify <u>D</u> elete	08/19/2002 14:13:48	<u>D</u> K Cancel

**Step 5.** After creating the run, select the run by highlighting the name of the run in the dialog list box and click **OK**.

Select Run			
<u>R</u> un			
Name	Time		20
Untitled		/2002 14:13:48	
ground1	08/19.	/2002 14:20:28	
Description			
Existing Ground fro	m Surveys		
ſ	ОК	Cancel	
10	UK	Cancer	

This invokes the DTM Tool Frame.



## 3.4 Load DTM Features



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- Step 1. Select the Load DTM Features icon from the tool frame to invoke the following dialog box.
- Step 2. Change the Load File option to TIN.
- Step 3. Select the TIN file 'SURVEY.TIN' by clicking the Files button.
- Step 4. Enable the toggles for Graphic Group but leave the Display Only disabled.

bad File <u>Data</u> Fisplay Preference Load Extent	ences –	Displa	ay Only 🗖	Graphic G		Load
Feature	Level	Color	Weight	Style	Display	
Spots	1	0	0	0	OFF	
Break Lines	1	1	0	0	OFF	
Extd.Contours	1	2	0	0	OFF	
Voids	1	3	0	0	OFF	
Islands	1	4	0	0	OFF	
Holes	1	5	0	0	OFF	-

**Step 5.** Select the **Triangles** Feature by highlighting in the list box. Notice that initially the display is set to OFF. You can control the display of an item three ways:

Use the "lightbulb" icons to the right of the dialog box

#### Double-click on an item

#### Use the "display" toggle in the lower right corner of the dialog box

Set the Triangles display to ON. At this point your dialog box should resemble the following:

oad File TIN Display Prefer		luala lycu	vdot\road1	(survey.)	Files	Load
Load Extent	-	🔲 Displa	ay Only 🔽	Graphic (	àroup	
Feature	Level	Color	Weight	Style	Display	
Triangles	1	0	0	0	ON	í 📥 💡
Tin Hull	1	1	0	0	OFF	
Contours	-	-	-	-	OFF	-
Major Lines	1	3	0	0	OFF	115
Major Label	1	4	0	0	OFF	
Minor Lines	1	5	0	0	OFF	-

**Step 6.** Set the display symbology for the Triangles as indicated below:

Feature	Level	Color	Weight	Style	Display	
Triangles	1	2	0	0	ON	
Tin Hull	30	0	0	0	ON	
Contours	27	73		22	ON	
Major Lines	4	2	2	0	ON	-
Major Label	4	2	2	0	ON	
Minor Lines	5	12	0	0	ON	F.

- **Step 7.** Select the **Tin Hull** (the boundary of the surface model) feature. Activate the Display of the feature and set the symbology as follows; Level = 30, Color = 0, Weight = 0, Style = 0.
- Step 8. Click Load and review the results. When complete, toggle OFF the triangles and tin hull.
- Step 9. Select the Contours feature. Activate the Display Feature.

Verify that **On** is set in the Display field.

**Step 10.** Complete the bottom of the dialog box as indicated below. To complete the Minimum and Maximum Z, Click the **Read** button, which will review the active TIN file and determine these values.

Enable the **Display Only** toggle since we only want to "preview" our contours but not actually write them to the design file.

oad File TIN		\data\geo\	vdot\road1	\survey.t	Files	Loa
Display Prefere Load Extent	ences —	🔽 Displa	ay Only 🔽	Graphic (	àroup	
Feature	Level	Color	Weight	Style	Display	
Tin Hull	1	1	0	0	OFF	1
Contours	192	23		1958	ON	
Major Lines	1	3	0	0	ON	
Major Label	1	4	0	0	ON	
Minor Lines	1	5	0	0	ON	
Minor Label	1	6	0	0	ON	-
	м	inor Interva	a [1.000	Maior	nterval 5.	000

**Step 11.** Activate the Display of the Contour **Lines** and **Labels** and set the symbology as indicated below:

	Level	Color	Weight	Style	Font	TH / TW	Distance
Major Lines	10	4	3	0			
Major Labels	10	5	3	0	0	TH=3, TW=3	200
Minor Lines	9	1	1	0			



The contour symbology standards should be the same as Survey's and are documented in CAICE\_2000.doc.

Step 12. Click the Load button to initiate the process.

Step 13. Close the Load DTM Features dialog box and Save Settings.

## 3.5 Analysis Tools

We will review several analysis tools in the following exercises. These include the height, themes and profiles tools.

### 3.5.1 Height Tool

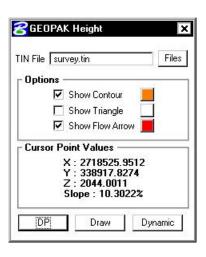


Analysis		 				×
	9	*	2	٨Ï	***	

Step 1. Select the **Height** icon from the tool frame to invoke the following dialog box.

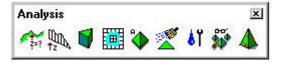
Options Show Contour Show Triangle Show Flow Arrow Cursor Point Values X : Y : Z : Slope :	N File surve	ey.tin	File
Show Triangle Show Flow Arrow Cursor Point Values X: Y: Z: Z:	Options —		10.55
Cursor Point Values X : Y : Z :	۲ S	ihow Contour	
Cursor Point Values	🗖 S	ihow Triangle	
X: Y: Z:	<b>[</b> ] S	how Flow Arro	w 🔲
	x	:	

- Step 2. Activate the Show Contour and Show Flow Arrow toggles. The color may be altered to your choice of colors from the active color table on the Height dialog box. The weight of the contour line and arrow are controlled by the active Microstation settings.
- **Step 3.** Click the **Dynamic** button and scan the surface model with the cursor to display the values for xyz and the slope on the model at the cursor point.
- **Step 4.** The **DP** option can be utilized to review this information at a specific location and the **Draw** option will label the elevation at the selected data point.
- **Step 5.** Close the Height dialog box.



### 3.5.2 Themes Tool





**Step 1.** Select the **Themes** icon from the Analysis tool box to invoke the dialog box depicted below.

- Step 2. Ensure that all graphic elements are Fit in View 1.
- **Step 3.** We will determine the Elevation Range first for the **TIN File** 'SURVEY.TIN'. (This is the first icon on the dialog box).
- Step 4. Activate the Display Only toggle and the Fill toggle.

<b>S</b> GE	OPAK Themes -> Elevation Ran
tin Fil	e survey.tin Files
Г	Number of Grid Points 100
- Disp	lay
V	Display Only Level 🚺 🔻
	Load Within Fence 🛛 🚽 🔍 🔻
<u> </u> 	Set Graphic Group      ▼ Fill
- Opti	ons
	Planarize at Elevation 0.000
	Polygonize Results
Ĭ.	Set Range Process

Step 5. Next, click the Set Range button to access the following dialog box.

	Range Auto Ra	ange Increment	•
	Range Options		- 20
Ran	ge Increment 0.0	000	
Minim	um Elevation 0.0	00 198	38.418
Maxim	um Elevation 0.0	000 213	35.845
	Set Range	Create Legen	4
Low	High	Color Activ	
			×

As shown on the right of the **Minimum** and **Maximum** Elevation Fields, the values for the active TIN elevations are listed. By clicking these buttons individually, the elevation fields will automatically be populated.

- Step 6. Set the Range option to Auto Range Increment.
- **Step 7.** Set the Auto Range Options as shown below:

Range Increment	5.000	
Minimum Elevation	1985.000	1988.418
Maximum Elevation	2140.000	2135.845
Set Range	Create	Legend

Step 8. Click the Set Range button to populate the list box on the bottom portion of the dialog box.

Selection of any list of elevations will populate the fields at the bottom.

Low	High	Cole	or Active		
1985.000	1990.000	0	YES		
1990.000	1995.000	1	YES		
1995.000	2000.000	2	YES		
2000.000	2005.000	3	YES		X
2005.000	2010.000	4	YES	-	

Utilizing the buttons on the right side of the list box will permit additional ranges to be included in the list, modifications to be made to elevation ranges (or the color display of this range), or deleting a particular elevation range.

- **Step 9.** Close the Elevation Range dialog box (select the X in the upper right hand corner of the dialog box).
- **Step 10.** Click the **Process** button to initiate the display of the Elevation Ranges for the surface model.
- **Step 11.** Close the Themes dialog box and Save Settings.

## 3.5.3 Profile Tool



Analysis						×
	1	*	1	41	00'	

**Step 1.** Select the Profile icon from the Analysis tool box to invoke the following dialog box.

election Profile Preferences Type Feature	Level	Color	Weight	Stule	Extract	
	LUVU	000	weight	otyle	ENGOG	1
						2
	36	2	1	ų.	6	3
TIN File survey.tin		Files	Lv 1			
Create Legend						

- **Step 2.** Use the **Selection** tab to identify your surface model (TIN File) which you will generate a profile from, and the symbology for your profile.
- Step 3. Select the Tin File "SURVEY.TIN" by using the Files button.

Step 4.	Double-click on the symbology box (field	Site Profile
	to the right of the	Profile Preferences
	Files push button) to	eature Level Color Weight Style Extract
	set the symbology representing the	
	ground surface profile. You may	Add List Ite
	choose any symbology you wish.	
	Once the symbology	
	has been set, click <b>OK</b> .	
Step 5.	Click the <b>Add</b> icon (top icon next to the list box) to add the	IN File Survey.tin Files Lv 1 V egend
	feature to the collection box.	

- Step 6. Select the Profile Tab.
- **Step 7.** Click the **Place Element** button to cut your actual profile at any desired area by just placing two data points (i.e. a line) or a series of data points (i.e. a line-string) across your surface model at any location.

election Profi	e Preferences
Select Element	Place Element Place Profile Curve Stroking 0.000
Extracted Profi	
1	<b>`</b> 3
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- Step 8. You can use the **Preferences** tab to set up a grid for your profile if desired.
- **Step 9.** Close the Profile dialog box and remove the DTM Tools tool frame.

## 3.6 Working Alignment

Before leaving this exercise, let's go ahead and begin to set the stage for further design via the Project Manager by defining the **Working Alignment**. You will usually create a **Working Alignment** for each alignment on your project, but because of time constraints we'll only do it for alignment MAINLINE on our sample project.

To do this, we'll need to use the **Select** and **Define** buttons on the Project Manager Workflow dialog box. The Project Manager workflow dialog box should still be active (we 'sank' it earlier in the lab). Access the dialog box by selecting **Window > Road Project: 17682.prj** from the MicroStation menu bar.

**Step 1.** Click the **Select** button to create a new Working Alignment. This will be very similar to creating a run as we did earlier in this exercise. The Working Alignment is the active chain that we are designing for.

elect Workir	ng Alignment
<u>R</u> un	N
<u>N</u> ew	Time
<u>C</u> opy ► <u>M</u> odify <u>D</u> elete	08/19/2002 13:53:28
Description	
Untitled	

Step 2. Create a new Working Alignment called **MAINLINE** as shown below and click **OK**.

Ne <del>w</del> Run Nar	ne		
Run Name:	MAINLINE		
Description			
	<u>D</u> K	Cancel	

**Step 3.** After creating the run, select the run by highlighting it in the dialog box and clicking **OK**.

Name	Time
MAINLINE	10/16/2002 11:16:20
Untitled	10/16/2002 10:23:14
cription	

- **Step 4.** You will now return to the main Workflow dialog box. Click the **Define** button to access the Working Alignment Definition dialog box.
- **Step 5.** Select the DTM item in the list box and complete the DTM definitions as shown below:

Plan View Pattern Shapes Profile View Location Cross Section View Existing Ground Proposed Finish Grade DTM	Existing Ground TIN: survey.tin File Portview TIN: survey.tin File Portview Horizontal Scale: 1 Portview Vertical Scale: 1
OK Cancel	

- **Step 6.** Click **OK** to exit the Working Alignment Definition dialog box.
- **Step 7. Exit** MicroStation.