Digital Terrain Model

3.1 Introduction

Objectives	Learn how to create, display and analyze DTMs.
Tools	
Menu Bar Application	GEOPAK Road > DTM Tools

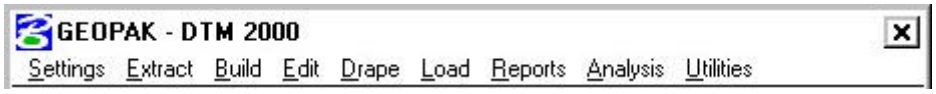
A **Digital Terrain Model (DTM)** represents the topography of a project in the form of a triangulated network. The DTM can be drawn in a 2D or 3D file, and then rotated to see the existing surface of the project area.

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

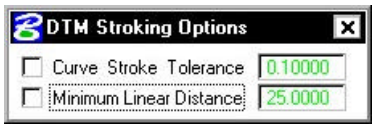
Pressing the **Existing Ground** button from the Road Project: SR95.prj dialog within Project Manager invokes the tool frame shown to the right. All of the DTM tools can be accessed from the tool frame or from the DTM menu that can be accessed from the top/left icon on the tool frame.



3.3 Settings

Tool	
Menu Bar	**Settings > Stroking**

When the Stroking Options tool is opened, the dialog depicted below is displayed.



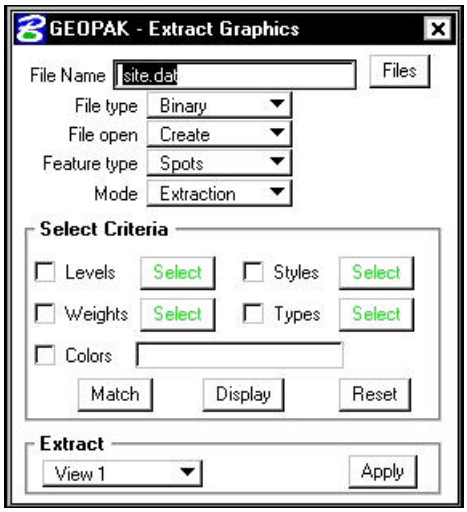
Two user-defined stroking values can be defined before graphics can be extracted to create a DTM. Stroking is the process of automatically adding shots to the DTM Input file by interpolating new shots from the linear and curved sections of the data. If the source topography data is mapped in a **3D-design** file, stroking may be applied. Stroking is not available if the topography data resides in a 2D-design file.

Curve Stroke Tolerance	The maximum distance between the arc and the chord used to approximate the arc in the DTM. Stroking is only applied to breaks and contours.
Minimum Linear Distance	If a linear segment is greater than the Minimum Linear Distance, points are interpolated and added to the segment such that the distance between the points in not greater than the Minimum Linear Distance.

3.4 Extract Graphics

Tool	
DTM Menu Bar	**Extract > Graphics**

The Extract Graphics tool reformats MicroStation elements into DTM input data. When accessed, the dialog shown below is displayed.



The fields/options are detailed in the table below.

File Name — The name of the file to be created for storing the input data.

The **.dat** extension is automatically assigned so the user is not required to key this in; however, an alternate extension may be defined.

If file already exists, it may be found using the **Files** button.

File Type — Format of the new file. Either format produces the same results. The difference between the two is **ASCII** files can be viewed and edited with any text editor while **Binary** files process faster, but cannot be viewed.

For ASCII file designation, the user must define the number of decimal places for the data.

File Open — Indicates whether a file is being created **(Create)** or the user is appending data **(Append)** to an existing .dat file.

Feature Type This notifies GEOPAK of the feature type that the extract graphics will put in the DTM.

Spots – Random survey points. Can also be vertices of a Line or a Line String.

Breaks – Designate linear features such as edges of pavement, ditch bottoms, ridges, etc. No triangle leg will cross a Break.

Boundary – The external boundary of the digital terrain model – only per .dat file.

Contours – For use in extracting digitized or otherwise imported contours.

Void – Closed shapes representing an area with missing data or obscure areas. (I.e. ponds, headwalls, concrete pads, etc.) The void coordinates determine void lines, which are inserted as drape lines on the triangulated surface and do not alter the slope or elevations of the TIN.

Island – Area within a void that contain data and should be included in the model.

Graphic Triangle – For use in extracting triangles from a TIN model that has been otherwise created or imported.

Drape Void – Same as Void, except the Void's vertex elevations are ignored and the triangulated model elevations at these vertex points are utilized.

Break Void – Same as Void, except the void elevations are included in the triangulated model at it's x y coordinates; therefore, the slope and elevations are modified on the TIN surface.

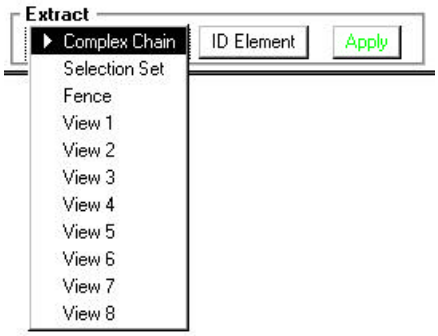
Mode

The **Extraction** mode calculates XYZ data directly from the coordinate values of 3D MicroStation elements. The **Interpolation** mode produces XYZ data by interpolating between spot elevations along linear MicroStation elements. This mode works in both 2D and 3D files wherein the elements are not represented with a defined Z value.

Select Criteria

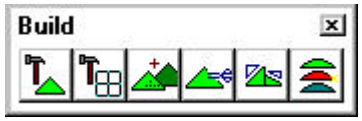
The **Select Criteria** group box provides options to specify the features to be extracted. When a "check" is placed in the box next to **Levels**, the **Select** box is activated. Then press the **Select** button to invoke the Level Mask dialog wherein only those levels you want GEOPAK to search for when extracting data can be selected. If the Levels box is *not* turned on, GEOPAK searches **all** levels. The same procedure is utilized for other criteria selections. The three buttons located at the bottom of the **Select Criteria** group box **Match, Display** and **Reset** enable the user to interactively define, highlight elements that match the search criteria or clear the search criteria respectively.

Extract



The **Extract** group box has several options for data extraction. **Complex Chain** reads those elements along adjoining MicroStation elements. **Selection Set** uses the MicroStation selection set tools to identify elements to extract. **Fence** extracts all elements within a fence boundary. **View1, View2, View3, etc.** extracts all selected elements displayed in the selected view.

3.5 Build Tools

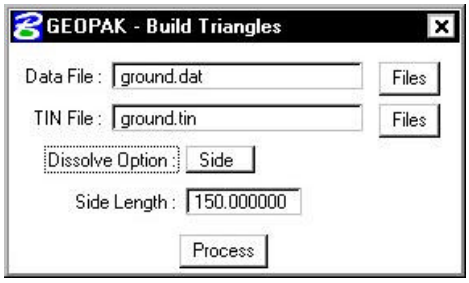
Tools	
Menu Bar	**Build > Triangle** **Build > Lattice** **Build > Merge TINs** **Build > Clip TIN** **Build > Pad** **Build > Delta Surface**

Included under the **Build** pull down and icons are options for creating, manipulating and merging DTM models. This class addresses, in detail, *only* those options utilized in routine DTM operations.

3.5.1 Build Triangles

Tool	
DTM Menu Bar	**Build > Triangle**

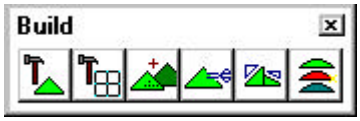
The Build Triangle tool processes the information stored in a DTM input file (**.dat**) to create a triangulated model (**TIN**). The file extension **TIN** (which is automatically assigned) represents a *triangulated irregular network*. When invoked, the dialog depicted below is displayed.



The fields/options in the dialog are detailed in the table below.

Data File	The DTM input file where the extracted topological features are stored. The file can also be selected via the **Files** button. If the full path is not given, GEOPAK utilizes the working directory to locate the file.
TIN File	The filename in which the DTM data will be stored in a binary format. The file can also be selected via the **Files** button if the file exists. If the full path is not given, GEOPAK utilizes the working directory to locate the file.
Dissolve Option	This option will allow the elimination of external triangles based on the selected option. Note that internal triangles are not affected. The three options are: **None** - no external triangles are deleted. **Sliver** - long, thin triangles based on a hard-coded formula within the software are deleted. **Side** - external triangles where a side is longer than the user specified length are deleted.
Process	Commences the TIN creation process.

3.5.2 Additional Build Options

Tool	
Menu Bar	**Build > *Additional Tools***

Several additional Build tools are supported, which are detailed in the table below.

Lattice	Creates a gridded mesh (**.lat**) of the triangulated data (TIN) to create a three dimensional visual display of the topography.
Merge TINs	Two triangulated models to be merged together as long as the boundaries of one model overlaps the other at a minimum of one point. This process creates a third model (**TIN**) from the combination of the two existing models.
Clip TIN	Creates a new model (**TIN**) from a portion of an existing model. The area is defined as internal or external to a user defined polygon.
Build Pad	Defines a pad (such as a building) and integrates the pad into the existing terrain with a variety of slope options.
Build Delta Tin	Creates a new model based on the difference between two other models or a model and elevation surface.

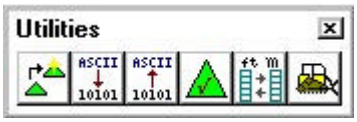
3.6 Reports

Tools	
Menu Bar	**Reports > Duplicate Points** **Reports > Crossing Features** **Reports > Tin Statistics** **Reports > Lattice Statistics**

Options under the **Reports** pull down and tool frame include a way to check for duplicate points or crossing breaklines, and the ability to generate statistics associated with a **TIN** or **Lattice** file. Each report is described in the table below.

Duplicate Points	Reports points with the same x and y coordinates
Crossing Features	Reports intersecting (same xy location, varying z) breaklines or contours.
Triangle Statistics **Lattice Statistics**	Displays a summary indicating the total count of each element type and minimum and maximum X, Y, Z ranges for the specified TIN or LAT file.

3.7 Utilities

Tools	
Menu Bar	**Utilities > Convert TIN** **Utilities > ASCII to Binary** **Utilities > Binary to ASCII** **Utilities > Check Triangulation** **Utilities > Metric to English** **Utilities > Export Lattice to Trimble**

Tools under the **Utilities** pull down and tool frame include a way to check the validity of a triangulated file, converting triangulated files from previous versions of GEOPAK, converting the DTM data file between ASCII and binary format; as well as exporting the LATTICE information to the Trimble DTX format. They are detailed in the table below.

Convert TIN	Converts a pre-GEOPAK 98 triangulated file to the current format.
ASCII to Binary **Binary to ASCII**	Reformats the DTM data file (**.dat)**.
Check Triangulation	Verifies the integrity of the triangulated file. A message appears indicating "Triangulation Valid" if the file structure is intact.
English to Metric	GEOPAK TIN files are neither English nor metric. English and metric

Metric to English
Metric to Imperial
Custom

preference settings within GEOPAK are for volume purposes and do not affect the TIN. This utility converts an entire TIN file with optional translation and rotation tools.

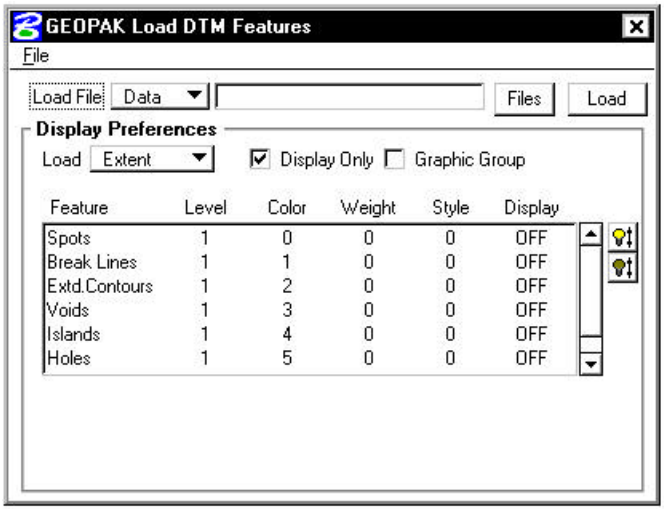
Export Lattice to Trimble

This tool utilizes a lattice file to generate a Trimble DTX file suitable for use in Trimble field equipment.

3.8 Load DTM Features

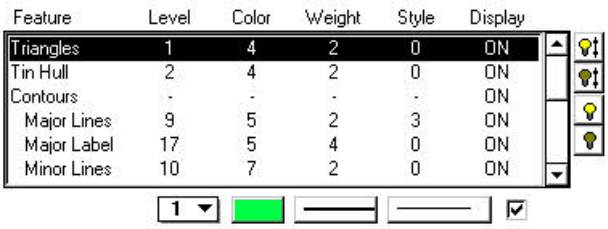
Tool	
Menu Bar	**Load > DTM Feature**

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 appears.



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.



Activates the display of all Features.

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.

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.

3.9 Edit Tools

Tools	
Menu Bar	**Edit > Triangles** **Edit > Duplicate Points** **Edit > Crossing Features** **Edit > Filter Vertices** **Edit > Join Linear Features** **Edit > Z Range Clip**

GEOPAK supports an extensive range of powerful editing tools, both pre- and post TIN generating. The tools are detailed in the table below.

Triangles — The triangulated model can be dynamically edited in terms of adding, deleting or moving spot elevations. Break lines can be added, draped or deleted.

Duplicate Points — Interactive editing of points in a DTM data file with the same X and Y coordinates within the data (DAT) file.

Crossing Features — Interactive editing of crossing break lines and extracted contours within the data (DAT) file.

Filter Vertices — Removes vertices from break lines or extracted contours within the data (DAT) file when located within the specified Tolerance of another vertex.

Join Linear Features — The Join Linear Feature is useful when the source break line or contour line consists of several elements containing numerous vertices. In these cases, the end of one break line is the beginning of the next break line, so the software utilizes this as two separate break lines. During the Joining process, GEOPAK changes these from the beginning and end of individual elements to the beginning and subsequent shots of one element.

Z Range Clip — Deletes individual vertices from the data file (**.DAT**) based on a user defined elevation range.

3.10 Analysis Tools

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

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).

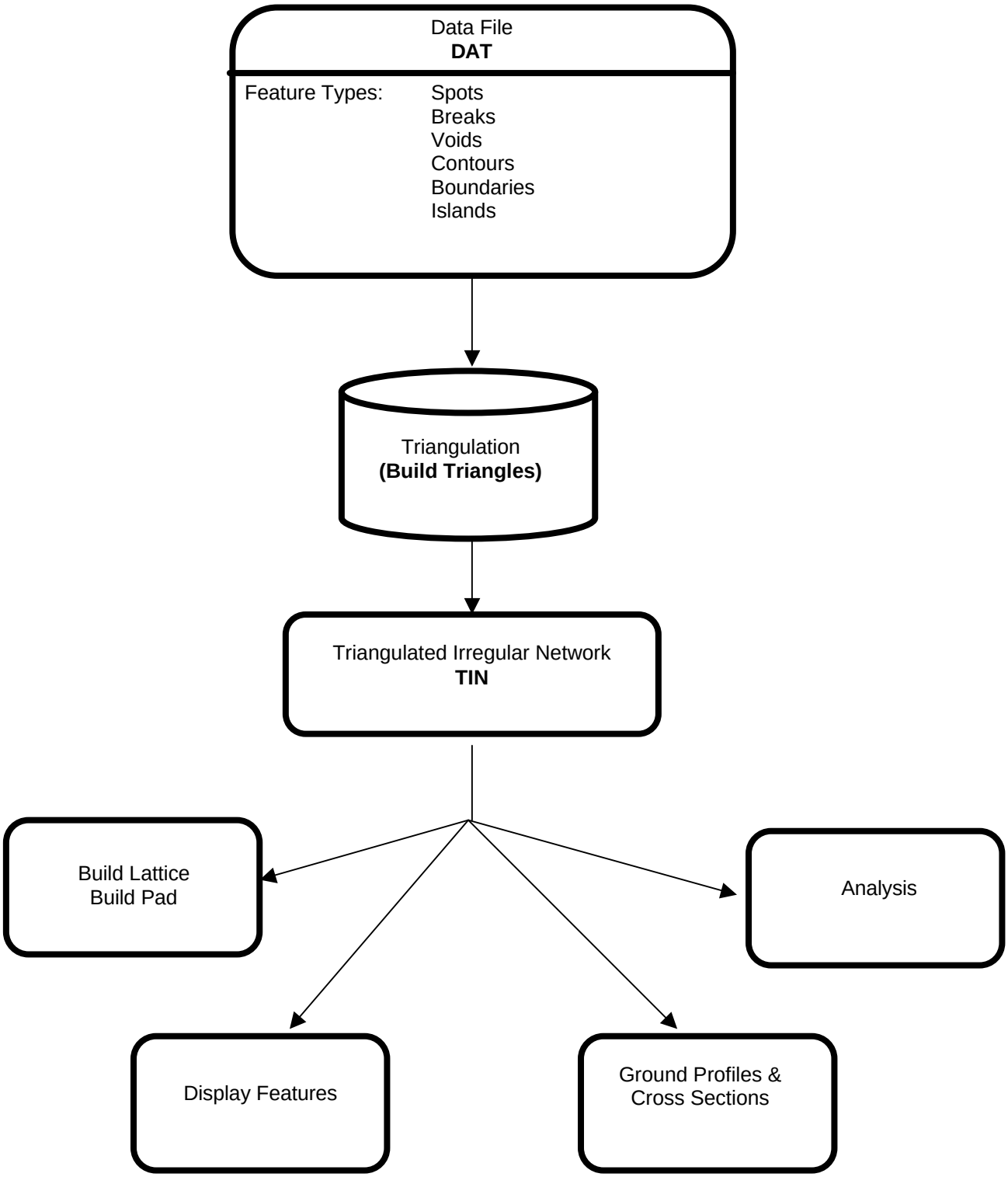
Themes — Displays the digital terrain model based on different user definable themes such as elevation ranges, slope percentage, slope degree, or aspect.

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.

Review of the steps required in creating a surface model and its subsequent output.

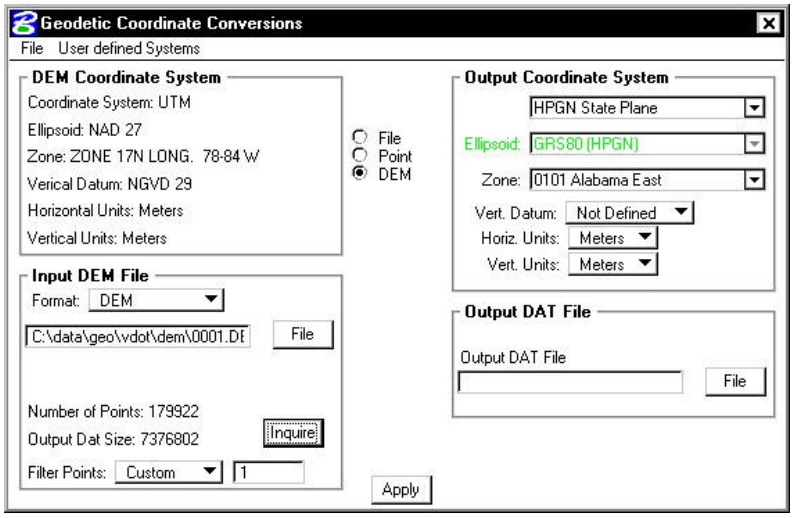
Digital Terrain Model (TIN)



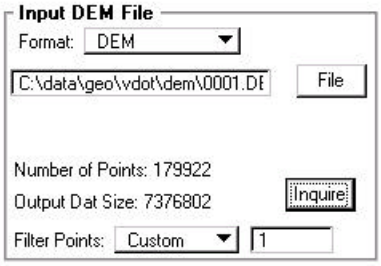
Digital Elevation Models

3.11 Importing DEM Files

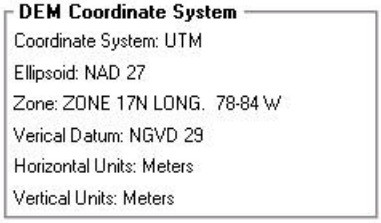
A **Digital Elevation Model** (DEM), consists of a sampled array of elevations for ground positions that are normally at regularly spaced intervals. The basic elevation model is produced by or for the Defense Mapping Agency (DMA), but is distributed by the USGS, EROS Data Center, in the DEM data record format. A wealth of information on DEM formatted data can be obtained from www.usgs.gov. When the DEM option is selected in the center section of the dialog, the dialog changes to reflect the selection.



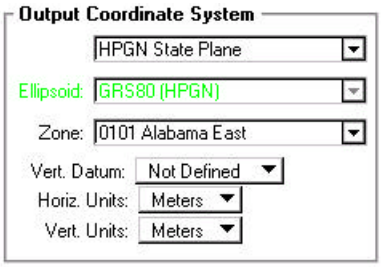
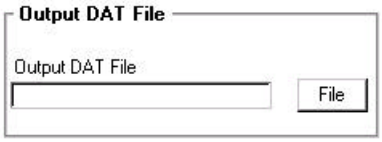
Within the **Input DEM File** group box, the data format is selected. The group box changes based on the selection. Once the selection is made, the File Name may be typed in, or selected via the Files button. This portion of the dialog also provides control for filtering the number of points to import. This is necessary due to the raw DEM file having a tremendous amount of point data. The filter facilitates a more manageable file size based on a user definition.



Once the file is read, the **DEM** Coordinate system group box is populated automatically. Therefore, the **DEM Coordinate System** group box is display only and the values cannot be edited.



The **Output Coordinate System** box includes System type, Ellipsoid, and Zone. As each system is selected, the ellipsoid and zone unghost as needed.



The **Output DAT File** group box has a single key-in field for the file name of the DAT file to be created. This file can be used within the Build Triangles dialog in the DTM tools. Manually enter the file name or select via the File button.