

Chapter 4 - Surface Fundamentals

A digital terrain model (DTM) is a mathematical representation of topography that includes points and triangles and is often referred to as a surface. The triangles allow the DTM to provide elevation information at any location by interpolating the elevations of the three points making up the triangle in question.

Using Delauney's criteria, InRoads calculates the smallest triangles possible for a given set of point data. Delauney's criteria states that any triangle formed may be circumscribed and no other point will fall within the circle. Linear features must sometimes violate Delauney's criteria in order to hold a constant slope between points. In other words, linear features will not allow triangles to cross them.

You may load as many DTMs as you need into memory when using InRoads. It is typical to have several DTMs loaded, since you will have an original and several design surfaces (such as multiple finished grades or alternative surfaces). At any given time, only one surface is active, meaning it will be the default when using any command requiring a surface.

When a digital terrain model is saved to the hard drive, it takes on an extension of *DTM*.

Chapter Objectives:

- To learn what a DTM is and how it is used in the CDOT design process.
- To learn the capabilities of an intelligent DTM and what it means for a DTM's use in design.
- To learn how to manipulate DTMs after they have been created.

Introduction to DTMs

Before working with either existing or design surfaces, a basic understanding is needed of what is contained in a surface. This section introduces you to the different DTM point types and the purpose of these points. It also explains the concept of intelligent features in a surface and the proper use of features styles and named symbologies associated with these features.

Section Objectives:

- To become familiar with the point types used in a DTM and how they affect triangulation.
- To learn the make-up of an intelligent DTM including how *Features*, *Styles* and *Named Symbologies* work together.
- To learn the basics of how a DTM is created.

DTM Point Types

Everything that is used in a DTM is a feature, and each feature is assigned a point type. The point type determines how the feature reacts during triangulation. Random points triangulate to the closest point around them, while the other, linear, features will not allow triangles to cross meaning they hold a constant slope between their points.

The following point types can be used in an InRoads' DTM.

Random

- Normal topo shots

- Often used for spot shots, local highs and lows

Breakline

- Used to represent linear features such as ditches, ridges, and edges of pavement, and named accordingly
- No triangles cross breaklines — they take precedence over random points
- Must have at least two points to form a breakline (lines, linestrings, curvestrings and complex chains are acceptable for import)
- Can be densified or thinned

Contour Points

- Use when data comes from contours, e.g., digitized from aerial maps
- Work much like breaklines with a constant elevation
- Converts lines, linestrings, curvestrings and complex chains into DTM points
- Can be densified or thinned
- Inferred breaklines
- Only used with contour points
- Generated by the software
- Eliminate flat spots by forcing a slope on every triangle
- Add overhead to your surface

Interior

- Used to model holes in your surface where there is unknown survey data or areas you do not want considered in the DTM
- Requires at least three points to model a closed shape
- No triangles are formed inside an interior boundary
- You can have more than one interior boundary per surface, but they can not overlap

Exterior

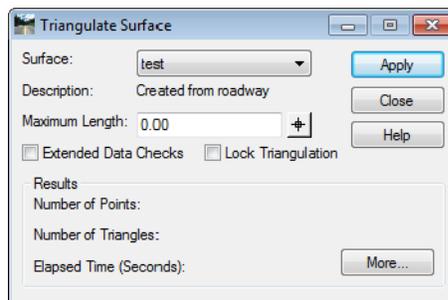
- Define limits of triangulation
- Requires at least three points to model a closed shape
- There is only one exterior boundary per surface

Surface Triangulation

In order for a surface to be used for contouring, modeling, etc., it must be triangulated. The original ground surface received from Survey will already be triangulated, however, if any changes or edits are made to a surface it will have to be triangulated again before the changes show up in displays of the surface either in Plan, Profile or Cross Section.

To triangulate a surface:

1. Select **Surface > Triangulate Surface**



Note: A surface may also be triangulated by right-clicking it in the *InRoads Explorer* menu and selecting **Triangulate** from the list of available commands.

2. Choose the *Surface* from the drop-down list

The *Maximum Length* prevents the formation of any triangles with a leg longer than what is specified. This is useful for eliminating long, slender extraneous triangles that often appear around the edges of a surface, but care must be taken that the value entered is not small enough to prevent the formation of 'good' triangles in the middle of the surface. If the value is set to **0.00**, it is ignored and all triangles are formed.

Extended Data Checks evaluate the surface for crossing or overlapping features. Leave this toggle off for faster processing unless you receive an error when triangulating.

3. **Apply** and the surface is triangulated.
4. Results show you the numbers of points and triangles formed, as well as the elapsed time. For more information, <D> the *More* button to access the Surface Properties dialog box.

Intelligent DTMs

InRoads' digital terrain models are intelligent models. By using *Feature Names*, *Feature Styles* and *Named Symbologies* as described below, the models will know what types of features can be displayed in which views as well as the symbology to use for displays.

Feature Name
Unique identifier for each feature in a DTM.
Surface > Ftr > Ftr Prop.

Feature Style
Tells the feature what it can display and where.
Tools > Feature Style Mgr

Named Symbology
Gives the feature its level and other graphical attributes.
Tools > Symbology Mgr

The screenshot displays four overlapping software windows from InRoads:

- Feature Properties:** A table listing features with columns for Name, Style, and Description. The feature 'T_Edge of Gravel Road' is highlighted.
- Style Manager:** A dialog box with various options like 'Show Styles with Properties', 'Include Surface', and 'Display Plan'. It also has a table of styles.
- Named Symbology Manager:** A dialog box with options like 'Show Symbologies with Properties' and 'Include Default'. It contains a table of named symbologies.
- Edit Named Symbology:** A dialog box for editing a specific named symbology, showing fields for Name, Description, and a list of symbology attributes like 'Use', 'Level', 'Default Line', etc.

Feature Names

Everything in a DTM is a feature and every feature must have a unique name. Often, when creating new features, you will be asked to supply a *Seed Name*. This seed name is used as the base for a unique feature name. For example, if you use *creek* as the *Seed Name*, and you load more than one (with a level or selection set, for example) the second will be named *creek1*, third *creek2*, etc.

A feature can be either triangulating, such as breaklines representing ditches, centerlines, etc. or it can be non-triangulating, such as utilities that are below or above the ground surface. These types of non-triangulating features can be shown on cross section, profiles and in plan view without affecting the triangulated network.

Feature names are stored within the DTM.

Feature Styles

Feature Styles are assigned to features in the DTM. They control where and what the features is “allowed” to display, as well as assigning a named symbology. For example, when you assign a feature style to a feature, you are determining if it can be displayed in plan using lines, points and/or annotation; if it can be displayed in sections using points and/or annotation, etc.

Feature Styles are stored in *CDOT-Preferences.ini*.

Named Symbology

Named Symbologies are just what they sound like — setups, such as color, weight, line style, font that can be saved by name. They even go one step farther allowing these setups to share a name while establishing different symbologies for plan, cross sections and profiles. This way, one entity that uses a named symbology can still display using different setups in plan vs. cross section vs. profile. Just about anywhere you assign symbology, you can use a named symbology instead. CDOT named symbologies are setup to use ByLevel symbology.

Named Symbologies are stored in *CDOT-Preferences.ini*.

Creating a DTM

In the CDOT Process, the existing ground DTM is provided by Survey and proposed DTMs are created by InRoads tools such as Roadway Designer. However, there may be times when you may have to create or supplement one of these DTMs. If so, the data used to create the DTM may be in one of several formats. The most common formats are described below.

ASCII (text) Files

ASCII data can be loaded from several different formats. Using **File > Text Import Wizard**, you can specify the format for your data. This wizard takes you through the import process step by step. Some commonly used formats include:

- x,y,z
- northing, easting, elevation
- station, offset, elevation (baseline alignment required)

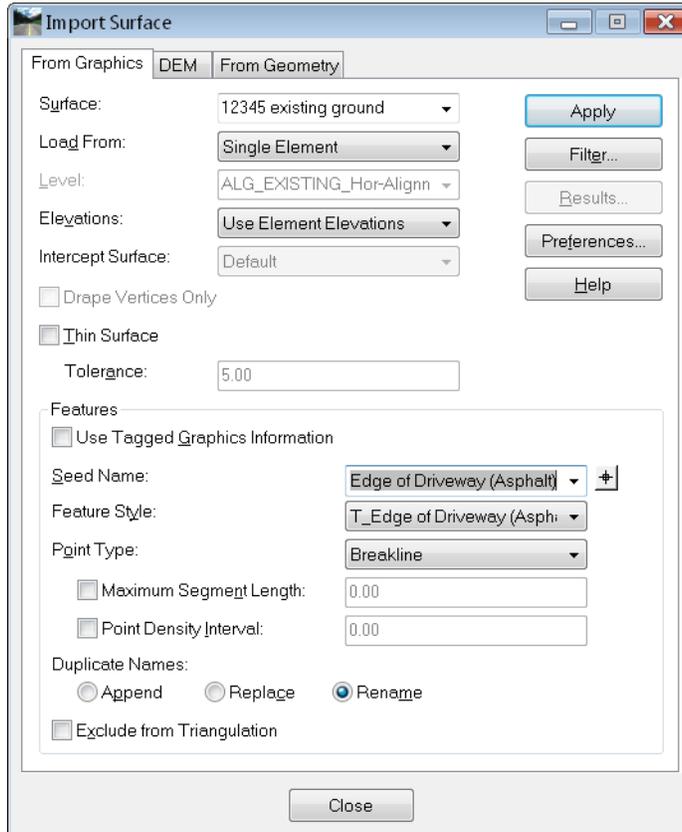
Note: These formats can have additional columns for ‘pen-up, pen-down’ to define separate linear elements in one file, for feature names, features styles, etc.

See the *InRoads Online Help* for additional information.

Surface from graphics

Graphical data is sometimes used to generate existing or proposed surfaces using **File > Import > Surface > From Graphics**. When using graphics, some key points are listed below.

- Elevations may be taken from the element or from surface (if the surface has been triangulated already).
- Elevations may be taken from text if you're loading random points that are graphically displayed in the correct location, with text listing the elevations.
- Linear features that contain curves can be densified using the chord height tolerance (set under **Tools > Options > Tolerances**).
- Linear elements can be densified by setting a maximum segment length or a point density interval.
- Points on linear elements can be thinned upon input using the **Thin** (and **Tolerance**) option.



See the **InRoads Online Help** for additional information.

In the **Surface Editing Tools** chapter of this document, you will find additional information on creating features using a variety of tools.

Section Summary:

- Random points are for local high/low topo shots.
- Linear features in a DTM ensure a constant slope between the feature points.
- Exterior and Interior features limit the location of triangles (an exterior forms a boundary and an interior forms a hole).
- Each feature in a DTM has a unique name.
- Features are named to make them intelligent.
- Styles control where a feature can display and assign it a named symbology for its graphical attributes.
- *Feature Styles* and *Named Symbologies* are stored in *CDOT-Preferences.ini*.
- You can supplement a DTM with data from text files (ASCII) or from MicroStation graphics.

DTM Utilities

There are several DTM utilities that allow you to manipulate the DTM after it has been created, both internally in InRoads memory and externally on the hard drive.

Section Objectives:

- To learn how to manipulate a DTM as a whole.

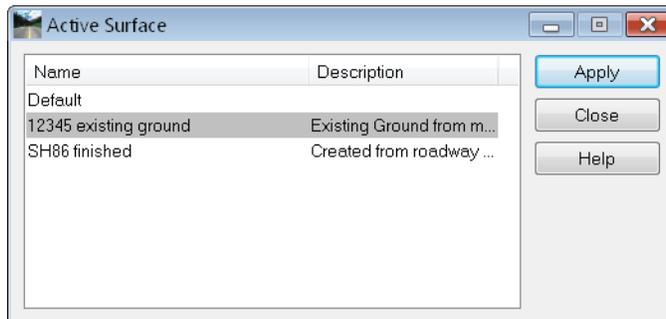
Active Surface

When you access commands in InRoads that require a surface, they always default to the *Active* surface. In most cases, you can simply use a drop-down in the command's dialog box to change to a different surface. However, in some circumstances you are not given that opportunity. Two examples include:

- when *Style* lock is on and you use a *View Surface* command, and
- when you use *Apply Template* with a template whose end condition seeks the *Active* Surface.

In these cases, you must first set the Active surface.

1. Select **Surface > Active Surface**.



2. From the list of loaded surfaces, highlight the one you want.
3. Choose **Apply**.
4. Choose **Close**.

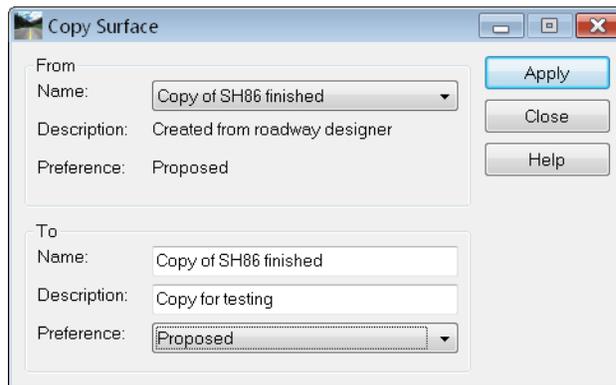
An alternate method is to right-click on the surface in the workspace or explorer portion of the menu and select *Set Active*.

Note: The active surface is shown in the menu with a red box around the surface icon.

Copy Surface

InRoads' surfaces have a name that is used in all the dialog boxes (the internal name) and a name that is used on the hard drive (the external name). Although it is recommended, these two names are not required to match. However, you cannot have two surfaces loaded that are seen as being the same. Therefore, if you copy a surface on the hard drive, InRoads does not realize that it is a separate surface. If you load the original and the copy, it will assume you're loading the same surface twice and will ask if you want to overwrite the first one loaded. Instead of making the copy in this manner, use the *Copy Surface* command inside InRoads.

1. Select **Surface > Copy Surface**.



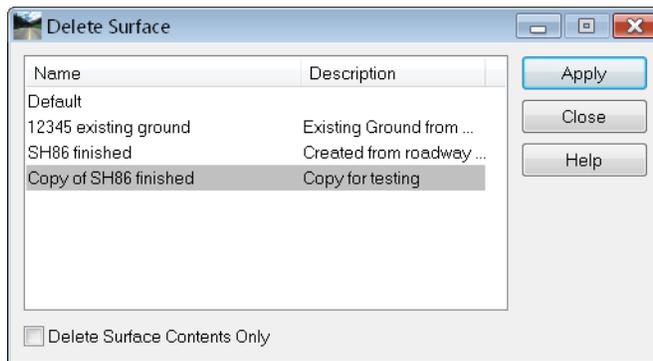
2. Select the Surface you want to copy with the drop-down list in the *From* category.
3. In the *To* category, specify a *Name*, *Description* and *Preference* for the copy. (This is the internal name.)
4. Choose **Apply**.
5. Choose **Close**.

The new surface should now be saved to the hard drive. See the section on *Saving Surfaces* for additional details.

Delete Surface

The *Delete Surface* command removes a surface from memory, but does not affect the surface on the hard drive. If you are using the *Create Surface* option within Roadway Designer, you do not have to delete the surface. Instead toggle on *Empty Surface* and it will remove the data from the surface before creating the new model. The *Delete Surface* command should be used when you are through with a surface but are not ready to exit InRoads, or if you want to re-use the name of a surface, but do not need its current contents.

1. Select **Surface > Delete Surface**.



2. Select the *Surface* you want to remove from memory from the list of loaded surfaces.
3. Toggle on *Delete Surface Contents Only* if you want to keep the name and other surface attributes but not the features.
4. Choose **Apply**.
5. Choose **Close**.

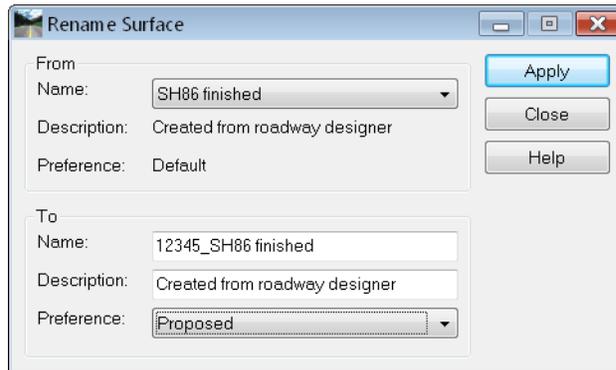
An alternate method is to right-click on the surface in the workspace or explorer portion of the menu and select *Close* to completely remove the surface from memory, or *Empty* to remove only the contents.



Rename Surface

The **Rename Surface** command is used to change the internal name of a surface. It also allows you to change the **Description** and **Preference** associated with a surface.

1. Select **Surface > Rename Surface**.



2. Select the **Surface** you want to rename from the drop-down list in the **From** category.
3. Key in the new name in the **To** category.
4. Change the **Description** and/or **Preference** as desired.
5. Choose **Apply**.
6. Choose **Close**.

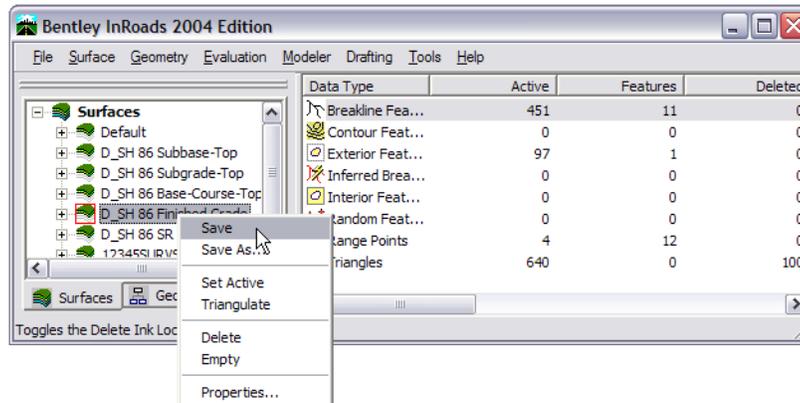
The surface should be saved to the hard drive after making the change.

Important! Do not use the rename command to make a copy of a surface. For example, do not rename a surface and then try to load the original surface again. InRoads still sees the surfaces as the same and will not allow both to be loaded. Instead, use **Surface > Copy Surface**.

Save Surface

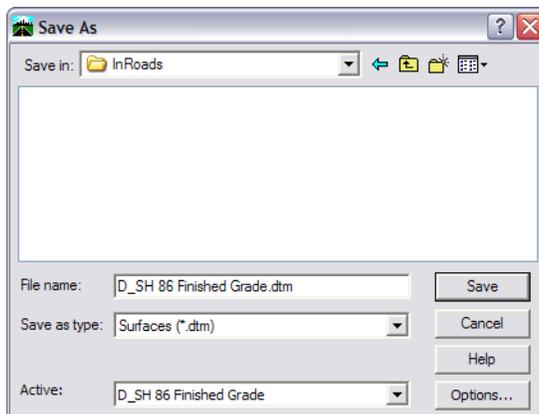
Surfaces can be saved using several methods including:

- Choose **File > Save > Surface**
The active surface is saved.
- Right-click on the Surface in the *Explorer* menu and chose **Save**



The surface you highlighted is saved.

If the surface has never been saved, either of the above methods will bring up the **Save > As** box as shown below.



1. Choose **File > Save As**
2. Set the *Files of Type* to ***.dtm**
3. Choose the *Active* surface you want to save
4. The *File name* field should populate with the active surface name. If you want the hard drive name to be different, key in the *File name*
5. **<D> Apply.**

Note: Surfaces have both an internal name that appears in the dialog boxes in InRoads and a name on the hard drive that has a *.dtm* extension. It is recommended that these names be the same, and care should be taken to make certain you have chosen the correct surface name to match the file name you specify. Otherwise, you could accidentally save over a file on the hard drive with the wrong surface.

The surface may also be saved as part of the project or **RWK** file.

Section Summary:

- The active surface is the default one used in many commands, but can typically be changed with a Surface drop-down option in the command.
- If **Style** lock is on, the active surface is more critical for **View** commands, since the command only works on the active surface.
- Surfaces can be renamed, but InRoads still sees the surface as the same one.
- Surfaces can be copied, in which case InRoads sees them as different surfaces.

Chapter Summary:

- Intelligent DTMs are critical to the CDOT design process.
- Existing DTMs are created by survey and provide the basis for modeling proposed surfaces.
- Existing and proposed DTMs are used to compute volumes.