This exercise uses a small portion of the data used in previous tutorials that modeled the service areas of the Burnaby Fire Department.

Using 9.3 Functionality and Scripts

Calculating transportation network slope and travel parameters

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Recent tutorials in *ArcUser* modeled time-based travel on steeply sloping streets in Burnaby, British Columbia. This exercise shows how new geometry calculation features in ArcGIS Desktop 9.3 can be used for generating average slope values on short street segments from starting point to endpoint.

This calculation was used in "Slopes, Sharp Turns, and Speed—Refining emergency response networks to accommodate steep slopes and turn rules" in the Summer 2008 issue of *ArcUser* to adjust travel time on steep Burnaby hills. Slope values were provided as part of the exercise and were determined using third-party software and outside data management in an Excel spreadsheet.

However, with the Calculate Geometry function in ArcGIS 9.3, the x and y coordinates can be calculated for segment endpoints. These endpoints may be converted to two 3D point files and their elevation determined. Using the x, y, and z coordinates of endpoints and the segment length, approximate slope can be generated by dividing the change in elevation by the segment length—a simple ratio of rise over run. This procedure requires the ArcGIS 3D Analyst extension to create three-dimensional street segments. The rest of the calculations are handled using core functionality in ArcGIS Desktop 9.3.

What You Will Need
- ArcGIS Desktop 9.3 (ArcView, ArcEditor, or ArcInfo license level)
- ArcGIS 3D Analyst extension
- An unzipping utility such as WinZip

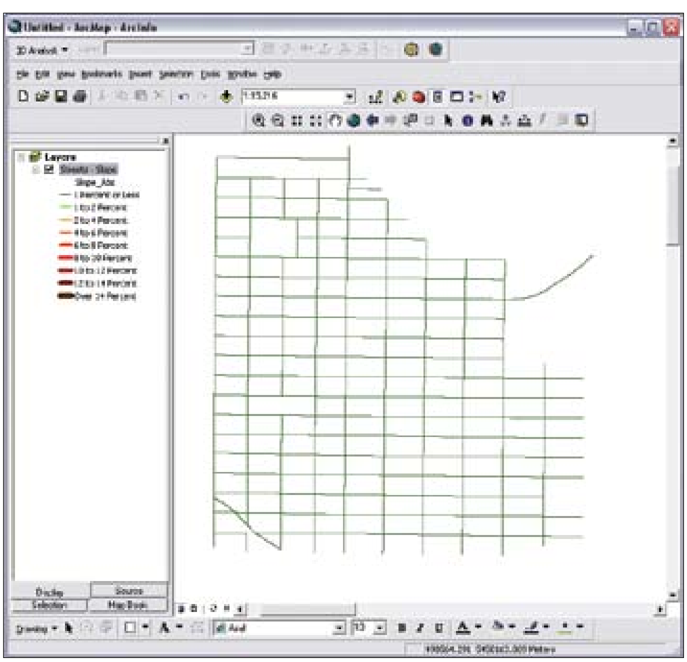
A file supplied in the sample dataset for this exercise, Slope_Time_Formulas.rtf, contains all necessary formulas for this exercise. These formulas can be copied and pasted to eliminate typing and possible typos; just be careful with field selection and do not change field names without editing the appropriate scripts.

Getting Started

Download the sample dataset and unzip it in a folder. The training dataset is contained in a folder named Burnaby2 and includes a file geodatabase containing a feature dataset named Transportation_Model. Inside this dataset is a single feature class named Streets_Slope_Calc.

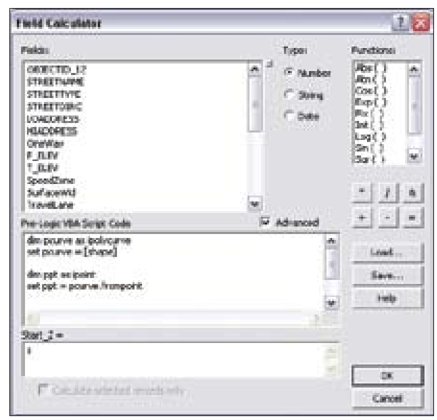
Open the table for this feature class in ArcCatalog and inspect the data fields. This dataset is a three-dimensional representation of the northwest part of the Burnaby streets used in a previous exercise but has six additional columns that will be used to store x, y, and z values for street segment endpoints. Because the elevation values require three-dimensional geometries obtained from a large TIN, this dataset was created using the high-resolution Burnaby engineering TIN as a reference surface.

1. Close ArcCatalog, start ArcMap, and open a new map document. Load the Streets–Slope.lyr from \Burnaby2\GDBFiles\UTM83Z10\. If necessary, repair the data links by setting the data source to the Streets_Slope_Calc feature class. Save the map document as SlopeCalcu.
2. Zoom to the data extent and notice that all streets display as thin dark green lines. This line type suggests that they all have zero slope, but this exercise will fix that situation.



Initially, the street network displays as thin green lines indicating a slope value of zero.

3. First, calculate the x and y coordinates of the segment endpoints by opening the attribute table for Streets_Slope_Calc. Locate the Start_X field. Right-click on the field name and select Calculate Geometry.
4. Click the Property dropdown and select X Coordinate of Line Start. Notice that endpoint coordinates and centroid coordinates can also be calculated.
5. Because the data source and data frame use the same coordinate system, either coordinate system radio button can be clicked. Leave units as meters.
6. Repeat this procedure to calculate the Y Coordinate of Line Start for Start_Y, the X Coordinate of Line End for the End_X field, and Y Coordinate of Line End for the End_Y field.
7. Next, use Calculate Geometry once more to calculate the Length for the Length_Km field. Be sure to set units to kilometers. Save the map document.



Calculate start and endpoint elevations using the Field Calculator and the advanced VBScripts included with the sample dataset.

Calculating START_Z and END_Z

Because the Calculate Geometry functions do not directly calculate start and endpoint elevations, we need to calculate them separately. This calculation requires that line segments be three-dimensional entities, built using a grid or a TIN. Verify that these lines are true three-dimensional vectors by inspecting the Shape field in the attribute table, which contains a value of Polyline ZM. If you wish, you may also view them in ArcScene.

1. Calculate Z values for endpoints using the advanced VBScript provided in Listing 1 in a Map Calculator window. Locate [Start_Z] and right-click its header. Select Field Calculator and check the Advanced box.
2. In the Field Calculator, check the Advanced box. In the Pre-LogicVBA Script Code window, type or paste the contents of Listing 1.
3. In the box below Start_Z=, type z. Click OK.

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```
dim pcurve as ipolycurve
set pcurve = [shape]
dim ppt as ipoint
set ppt = pcurve.frompoint
dim z as double
z = ppt.z
```

Listing 1: START_Z calculation

4. Repeat this calculation for [End_Z] using the script in Listing 2.

```
dim pcurve as ipolycurve
set pcurve = [shape]
dim ppt as ipoint
set ppt = pcurve.topoint
dim z as double
z = ppt.z
```

Listing 2: END_Z calculation

5. Again, set the field value in the bottom window to z and click OK. (Hint: Preserve the advanced calculation, change "pcurve.frompoint" to "pcurve.topoint," and recalculate.) Save the map document. This procedure was provided by the ArcGIS 3D Analyst development team.

Calculating Relative and Absolute Slope

With the x, y, and z coordinates calculated for the segment's start and endpoints, modeling relative slope is really quite easy. A combination of Pythagorean theorem and the rise over run slope formula will calculate percent slope between the two segment endpoints.

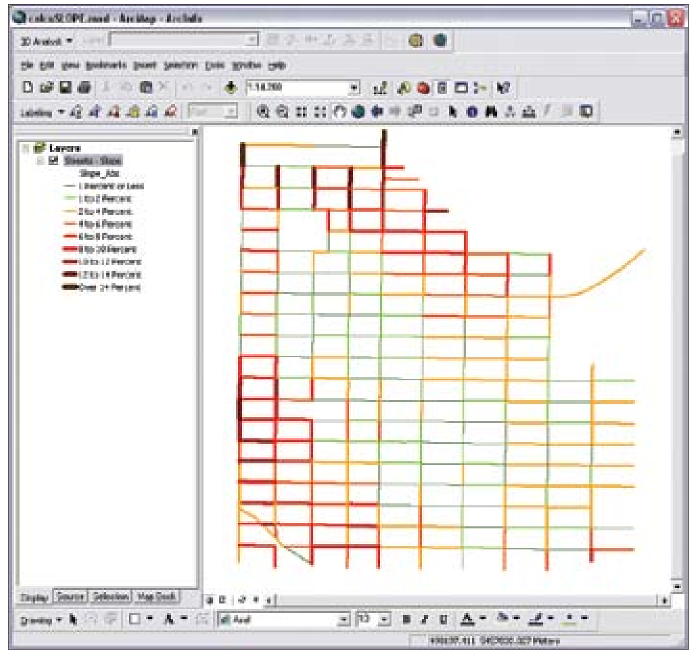
This procedure works well for short city street segments with a consistent slope. It does not work well for continuous looped features (although these can be split), long road intervals, or streets that traverse a sudden ridge or creek without a break. Investigations for the best ways to model these situations are ongoing.

Select [Slope1]; open another Field Calculator; and in the calculation window type, the expression in Listing 3.

```
(([End_Z] - [Start_Z]) / (([Start_X] -
[End_X])^2 + ([Start_Y] - [End_Y])^2)^0.5)*100
```

Listing 3: Calculate percent slope between two endpoints.

Notice that some slope values are positive (uphill travel) and some are negative (going downhill). Remember that the best way to think of slope as a percentage is that each value represents the number of meters (or feet) traveled up or down along a consistent 100-meter (feet) segment. Slopes of more than 6 percent require significant horsepower to travel up and considerable effort braking to go down.



After calculating the values for the absolute slope field, the street network will be symbolized based on values in the Slope_Abs field.

Calculate absolute slope for the Slope_Abs field with the Field calculator, using the formula in Listing 4. Save the map document.

```
Abs ([Slope1])
```

Listing 4: Calculating absolute slope

Now that the Slope_Abs field contains slope values, the street segments will be symbolized based on absolute slope.

Conclusion

This workflow demonstrates how new geometry calculation features in ArcGIS 9.3 can calculate endpoint coordinates. It also highlights three-dimensional data conversion and several uses for tabular joins.

Acknowledgment

Special thanks to the Engineering Department staff of the City of Burnaby; the ESRI 3D Analyst team; and ESRI's Charlotte, North Carolina, Technical Support staff who helped develop the procedure for calculating elevation values with ArcGIS Desktop 9.3 and the ArcGIS 3D Analyst extension. Investigations of advanced procedures for modeling complex slope, both up and down hills, are continuing.