Agenda

• Preparing street data for use in a network dataset
  - Oneway streets
  - Hierarchy
  - RoadClass attribute
• Using turns, signposts, and historical traffic data
• Creating a multi-modal network dataset
• Parameterized attributes
• Evaluators tips and tricks
• Support & Resources
• Questions
Do I need to create my own network dataset?

- **StreetMap network datasets available**
  - SDC format
  - Ready to use
  - Network dataset already created

- **StreetMap data on Data & Maps**
  - Comes with ArcGIS
  - Data for North America

- **StreetMap Premium data**
  - Data is more current
  - Data for North America or Europe
Know Your Street Data

- What information can be used as a setting in the network dataset?
Review – What is in a Network Dataset?

Sources
- Line features
- Point features
- Turn features

Connectivity
- End Point / Any Vertex
- Z-Elevation fields
- Connectivity groups

Attributes
- Cost
- Descriptor
- Restriction
- Hierarchy

Directions
- Primary street names
- Alt. street names
- Highway shields
- Boundary field
- Signpost data
Know Your Street Data

- View data – geometry and attributes
- Read the documentation for data
- How is street geometry represented?
  What street information is provided?
  In what layers is this information located?
  How is this information formatted?
- What information can be used as a setting in the network dataset?
Coincident Geometries

- To enable network connectivity to be modeled
  - Points of coincidence should exist where line features cross or intersect

Case 1

Case 2
Creating Coincident Geometry

- Include sources in a Topology
- Use the Integrate Tool (Geoprocessing)
- Both methods compare features and makes vertices within the cluster tolerance coincident
  - Inserts vertices where features intersect
  - Snaps features that are not coincident
<table>
<thead>
<tr>
<th>Field</th>
<th>Data type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>Integer</td>
<td>Ensures proper connectivity</td>
</tr>
<tr>
<td>Oneway</td>
<td>Text</td>
<td>Helps determine one way streets</td>
</tr>
<tr>
<td>Length</td>
<td>Double</td>
<td>Calculate shortest route</td>
</tr>
<tr>
<td>Travel time</td>
<td>Double</td>
<td>Calculate fastest route</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Integer</td>
<td>Ranking of streets for routing on large network datasets</td>
</tr>
<tr>
<td>Speed</td>
<td>Integer</td>
<td>May be used to calculate travel time</td>
</tr>
<tr>
<td>Road class</td>
<td>Integer</td>
<td>Classification of roads – used for formatting directions text</td>
</tr>
<tr>
<td>Street name or address data</td>
<td>Text</td>
<td>Helps generate network locations and directions</td>
</tr>
</tbody>
</table>
Connectivity using Elevation Fields

- Attribute that enables network dataset to represent multiple “levels” for line features
- Applied to line features with coincident endpoints
- Planar and non-planar features are supported
- Commonly called z-elevation or z-levels

<table>
<thead>
<tr>
<th>NAME</th>
<th>F_ZLEV</th>
<th>T_ZLEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>State St</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Elevation Fields – Overpass/Underpass Scenario

- Four lines with coincident endpoints

0-1 lines do not intersect 0-0 lines at the same junction
Oneway field – Most common method

- Text field containing values: FT, TF, < >, N
  - “FT” – one-way in digitized direction
  - “TF” – one-way against digitized direction
  - <empty> – two-way street
  - “N” – No travel

If other field values, change expression
Hierarchy

- Minimizes impedance while favoring higher order roads
- Basic assumption:
  - **Higher order roads are “faster” (time), not necessarily “shorter” (distance)**
- Hierarchy classifies network edges into multiple levels when the network dataset is built
  - Levels: lower number = higher order road
Hierarchy Considerations

- Highest level needs to be connected to each other
  - Take restrictions into consideration
- Composition of highest level hierarchy dictates performance vs. accuracy of route returned
  - Larger: more optimal routes, but is slower
  - Smaller: faster performance, but route is less optimal
- Values derived from road classification (e.g., CFCC)
- Edges per hierarchy guide:

<table>
<thead>
<tr>
<th>Hierarchy</th>
<th>Regional % of edges</th>
<th>National % of edges</th>
<th>Edge count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5%</td>
<td>3%</td>
<td>~100,000 max</td>
</tr>
<tr>
<td>2</td>
<td>15%</td>
<td>17%</td>
<td>Percentage of total</td>
</tr>
<tr>
<td>3</td>
<td>80%</td>
<td>80%</td>
<td>Percentage of total</td>
</tr>
</tbody>
</table>
RoadClass attribute

- Used for formatting the text of driving directions
- Has no effect on network analysis
- Descriptor attribute, five possible integer values:

<table>
<thead>
<tr>
<th>RoadClass Value</th>
<th>RoadClass Description</th>
<th>Driving Directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Local road</td>
<td>“Turn left on Main St”</td>
</tr>
<tr>
<td>2</td>
<td>Limited access highway</td>
<td>“Go East on I 44”</td>
</tr>
<tr>
<td>3</td>
<td>Ramp</td>
<td>“Take ramp and go on US-7 N”</td>
</tr>
<tr>
<td>4</td>
<td>Ferry</td>
<td>“Take Lake Expy ferry”</td>
</tr>
<tr>
<td>5</td>
<td>Roundabout</td>
<td>“Take roundabout and proceed South on Main St”</td>
</tr>
</tbody>
</table>
Dissolve Network

- **Input:** Network dataset
- **Output:** New network dataset with fewer line features
  - North America: 43.8M lines → 15.7M lines

- Fewer line features – Faster network analysis
Dissolve Network

- Speeds up network analysis for large networks
- Geoprocessing tool in Network Dataset toolset

- Creates a new dissolved network dataset
  - Original network dataset is unedited
- Only fields used by network dataset are present in dissolved data
  - Use dissolved dataset for network analysis
  - Keep original data for maintenance and other work
Demonstration

Adding fields for routing to TIGER/Line® street data
Turns in the Network Dataset

- Describe transitions between two or more edges
- Used to model cost and/or restrictions in the network
- Incorporating turn elements – more realistic network solver results
- Two options:
  - Turn features
  - Global (default) turns
  - Or Both
Turn Feature

- Polyline geometry
- Turn references edges by:
  - Feature class ID
  - Feature ID
  - Position
- Turn elements built by edge references

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ObjectID</td>
<td>1</td>
</tr>
<tr>
<td>Shape</td>
<td>Polyline</td>
</tr>
<tr>
<td>Edge1End</td>
<td>Y</td>
</tr>
<tr>
<td>Edge1FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge1FID</td>
<td>104</td>
</tr>
<tr>
<td>Edge1Pos</td>
<td>0.5</td>
</tr>
<tr>
<td>Edge2FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge2FID</td>
<td>102</td>
</tr>
<tr>
<td>Edge2Pos</td>
<td>0.6</td>
</tr>
<tr>
<td>Edge3FCID</td>
<td>42</td>
</tr>
<tr>
<td>Edge3FID</td>
<td>103</td>
</tr>
<tr>
<td>Edge3Pos</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Editing Turn Features

- Create and edit turn features in the ArcMap Editor
- Edit as you would any other line feature
- Snap geometry to each street in turn
- Network dataset must be built before editing turn features
Global Turns

- For example – adding a penalty for all left turns
- Consist of:
  - All implied two-edge turning sequences in network
  - No need to create a turn feature for every two-edge sequence in the network
- Specify attribute values for global turns
  - VB Script evaluator –or– Global Turn Delay evaluator
Sample VB Script Code for Global Turn Penalty

Pre-Logic VB Script Code:

```vbnet
a = Turn.Angle
If a > 210 And a < 330 Then
    turnTime = 0.5
Else
    turnTime = 0
End If
```

Expression:

```
turnTime
```

---

0/360 90 180 210 270 330

Straight

Left turn Right turn U-turn
...or use the Global Turn Delay evaluator
Signposts

- Text seen on highway signs
  - Typically includes exit number, street name, and/or destination
- Has no effect on network analysis
- Enhances text of driving directions:
  - “At exit 73B, take ramp to US-421 North toward N Wilkesboro”
### Signpost Data – Two tables

- **Signpost feature class**
  - Actual text on sign

<table>
<thead>
<tr>
<th>Exit number</th>
<th>Street name(s)</th>
<th>Direction</th>
<th>Destination(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73 B</td>
<td>US-421</td>
<td>North</td>
<td>N Wilkesboro</td>
</tr>
</tbody>
</table>

- **Signpost streets table**
  - Streets traversed when following the sign

<table>
<thead>
<tr>
<th>Feature class ID</th>
<th>Feature ID</th>
<th>Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>41</td>
<td>0.0 to 1.0</td>
</tr>
</tbody>
</table>

*For Vendor data use “Import Signposts” .NET SDK Developer sample*
Adding Signposts to the Network Dataset

- Signpost tables specified in the Directions Settings

![Network Directions Properties](image)
Historical Traffic

- Travel time varies by time of day and/or day of week
  - Travel at 8am:
  - Travel at 5pm:

- Used by Network Analyst when a Start Time is specified for the route
## Historical Traffic Data – Two tables

- **Traffic Profiles table**
  - Contains free-flow speed multipliers by time of day
    | Profile | 1 am | 5 am | 9 am | 1 pm | 5 pm | 9 pm |
    |---------|------|------|------|------|------|------|
    | 16      | ×1.0 | ×1.1 | ×2.3 | ×1.2 | ×1.4 | ×1.1 |

- **Streets-Traffic Profiles join table**
  - Specifies free-flow travel times and profiles to use
    | Feature class ID | Feature ID | Positions | Free-flow travel | Sunday Profile | Monday Profile |
    |------------------|------------|-----------|------------------|----------------|----------------|
    | 12               | 41         | 0.0 to 1.0| 10 seconds      | Profile 10    | Profile 16    |
Historical Traffic in the Network Dataset

- Specify when creating the network dataset

![New Network Dataset dialog box]

- Do you want to use historical traffic data with this network dataset?
  - No
  - Yes

**Historical Traffic Tables:**

<table>
<thead>
<tr>
<th>Table</th>
<th>Field Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Time Slice Field</td>
<td>TimeFactor_0400</td>
</tr>
<tr>
<td>Last Time Slice Field</td>
<td>TimeFactor_2155</td>
</tr>
<tr>
<td>Minutes For Time Slice</td>
<td>5</td>
</tr>
<tr>
<td>First Time Slice Start Time</td>
<td>4 AM</td>
</tr>
<tr>
<td>Last Time Slice Finish Time</td>
<td>10 PM</td>
</tr>
</tbody>
</table>

**Streets - Traffic Profiles Join Table**

<table>
<thead>
<tr>
<th>Table</th>
<th>Field Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Travel Time Field</td>
<td>FreeflowMinutes</td>
</tr>
<tr>
<td>Base Travel Time Units</td>
<td>Minutes</td>
</tr>
<tr>
<td>Sunday ProfileID Field</td>
<td>PROFILE_1</td>
</tr>
<tr>
<td>Monday ProfileID Field</td>
<td>PROFILE_2</td>
</tr>
</tbody>
</table>
Demonstration

Using Turns, Signposts, and Historical Traffic Data
Connectivity for Multi-Modal Network Dataset

- Connectivity groups “connect” at transfer points
  - Example: Rail stations
- Non-connecting edge sources in separate connectivity groups
Multi-Modal – considerations for Road & Rail

- Road & Rail example – two common scenarios:
  - Railroad station not on rail track
  - Railway station entrance along middle of road
- For Railroad stations not along the road
  - Create “transfer edges”
- For station entrances not at the road ends
  - Create junction with Override policy at entrance
  - Insert vertex on street feature at station entrance
Network Attributes – Multi-Modal Network Dataset

• Create a cost attribute for each scenario you are modeling
  - Automobile
  - Pedestrian (walk only)
  - Pedestrian using light rail
  - etc.

• Create restriction attributes to prevent invalid traversals
  - Example: Restrict driving on the rail lines
Demonstration

- A multi-modal network dataset

- Streets
- Walking paths
- Railway
Parameterized Attributes

- Network attribute that accepts a parameter
- Used to model dynamic aspect of an attribute’s value

Parameterized attribute

Input Parameter value(s)

(Optional)
Other Network Attribute(s)
Example – implementing a height limit

- Requires both a Descriptor and a Restriction attribute
  - Descriptor attribute
    - Specifies height limits for each road
  - Restriction attribute
    - Stores vehicle height parameter
- Performs the appropriate restriction
- May use Function evaluator or VB Script evaluator
  - Function evaluator – faster & easier

Bridge clearance: 12'6”

Restriction evaluates to True (Restricted) if vehicle height exceeds 12 ft, 6 in
Using Height restriction during solve

- **When using solver:**
  - Set attribute restriction on Analysis Settings tab
  - Specify actual vehicle height on Attribute Parameters tab

- **Solver Result:**
  - Street is restricted when the actual Vehicle Height is greater than street’s MaxHeight attribute value

- **Truck height:** 16’
- **Bridge clearance:** 12’6”
- **Car height:** 6’
Evaluators – review

- A function that determines attribute values for network elements in a network dataset
- Six different types available with ArcGIS:
  - Field
  - Constant
  - Global Turn Delay
  - Function
  - Edge Traffic
  - VB Script

- Example usages:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Evaluator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td><em>Field</em> – assign the [meters] field</td>
</tr>
<tr>
<td>TravelTime</td>
<td><em>Edge Traffic, Global Turn Delay</em> – use historical traffic, turn delays</td>
</tr>
<tr>
<td>TurnRestriction</td>
<td><em>Constant</em> – “true” (implies all turns restricted)</td>
</tr>
<tr>
<td>MaxHeight</td>
<td><em>Field</em> – assign the [Height_Limit] field</td>
</tr>
<tr>
<td>HeightRestriction</td>
<td><em>Function</em> – specify MaxHeight attribute &lt; VehicleHeight parameter</td>
</tr>
</tbody>
</table>

- Custom evaluators can be developed
Efficiency of calling evaluators

- **Field evaluator (including Field Expressions)**
  - Fast: Attribute values stored when network is built; Retrieved at solve time
- **Constant, Function, & Global Turn Delay evaluators**
  - Fast: Attribute values generated at solve time using precompiled logic
- **Edge Traffic evaluator**
  - Fast: Multipliers & free-flow values stored when network is built; Travel time determined during solve
- **VB Script evaluator**
  - Can be slow: Invokes scripting at solve time
- **Custom evaluator:** Depends on implementation
Evaluators – Tips and Tricks

• Field evaluator
  - Read in values from a field; and/or
  - Perform calculations using multiple field values
    - Example attributes: Length, DriveTime, Oneway

• Constant evaluator
  - Same attribute value across all network elements
    - Example attribute: TurnRestriction

• Custom logic
  - Initial prototyping with VB Script evaluator
  - Final implementation using Custom evaluator
    - Better performance
Support & Resources
Esri Support Center

- Online portal to technical information
- Knowledge Base
  - Technical articles
  - White papers
- Community
  - Discussion Forums
  - E-mail lists
- Downloads
  - Patches & service packs
  - ArcScripts and samples
  - Data models

http://support.esri.com
For more information

- **Network Analyst product page**
  - Links to Demos, Brochures/White Papers, Success Stories

- **Free recorded training seminar**
  - Using Network Analyst in ArcGIS Desktop 10
Network Analyst Technical Workshops

• Network Analyst – An Introduction
  - Tuesday 8:30 AM,   Room 3
  - Wednesday 1:30 PM,   Room 4

• Network Analyst – Performing Network Analysis
  - Tuesday 10:15 AM,   Room 3
  - Thursday 10:15 AM,   Room 4

• Network Analysis with ArcGIS for Server
  - Tuesday 1:30 PM,   Room 3

• Automating Workflows with Geoprocessing
  - Wednesday 8:30 AM,   Room 10
Network Analyst Demo Theater Presentations

- **Modeling Real-World Problems with the VRP Solver**
  - Tuesday 9:00 AM, Analysis & Geoprocessing Island

- **Routing with Open Source Data (OSM)**
  - Tuesday 10:00 AM, Esri Labs Island
  - Wednesday 1:00 PM, Esri Labs Island

- **What’s New in Network Analyst 10.1**
  - Tuesday 5:00 PM, Analysis & Geoprocessing Island

- **Routing in Buildings with 3D Networks**
  - Thursday 11:00 AM, Analysis & Geoprocessing Island
Steps to evaluate UC sessions

- My UC Homepage > “Evaluate Sessions”
- Choose session from “My Planner”
- Search for session by Offering ID:
  748

www.esri.com/ucsessionsurveys
• Thank you for attending
• Have fun at UC2012
• Open for Questions

• Please fill out the evaluation:

www.esri.com/ucsessionsurveys

First Offering ID: 748
Second Offering ID: 912