Esri International User Conference | San Diego, CA
Technical Workshops | Analysis and Geoprocessing

Network Analyst
Creating Network Datasets

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Agenda

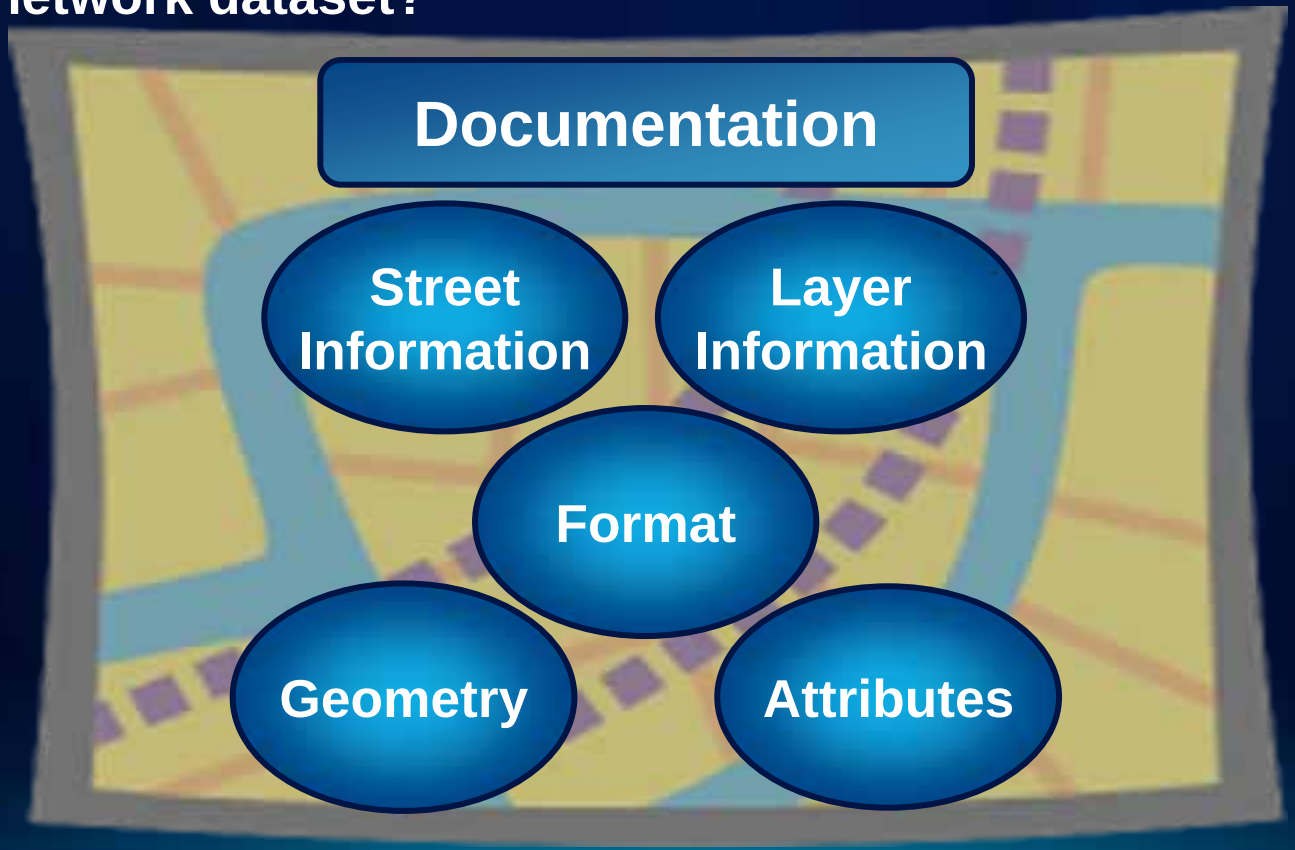
- Preparing street data for use in network dataset
  - Oneway streets
  - Hierarchy
  - RoadClass attribute
- Using turns, signposts, and historical traffic data
- Creating a multi-modal network dataset
- Parameterized Attributes
- Evaluators tips and tricks
- Support & Resources
- Questions

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

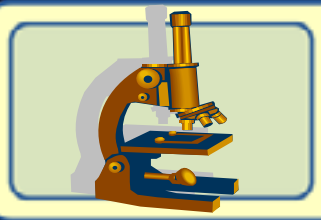
Know Your Street Data

- What information can be used as a setting in the network dataset?



Review – what is in a Network Dataset?

Know Your Street Data



View data – geometry and attributes

Read the documentation for data

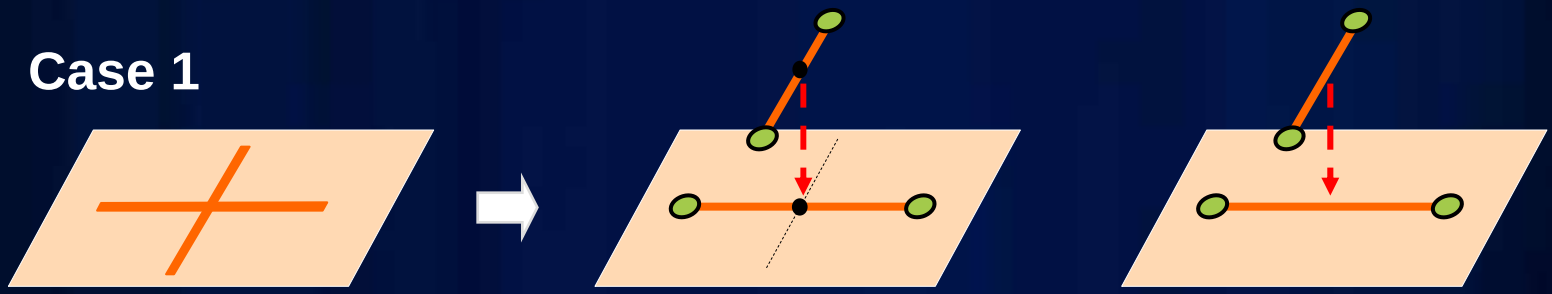
How is street geometry represented?
What street information is provided?
In what layers is this information located?
How is this information formatted?

What information can be used as a setting in the network dataset?

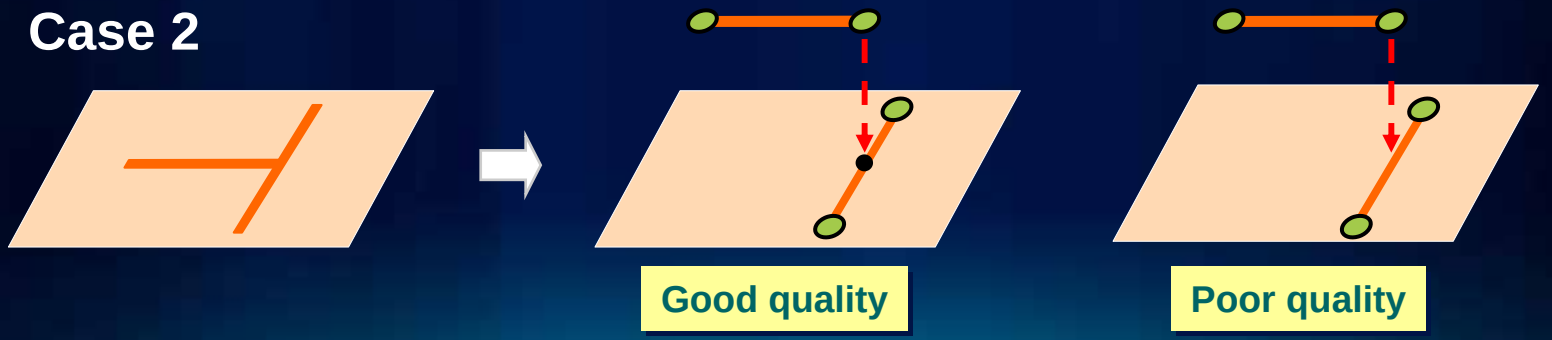
Coincident Geometries

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

Case 1

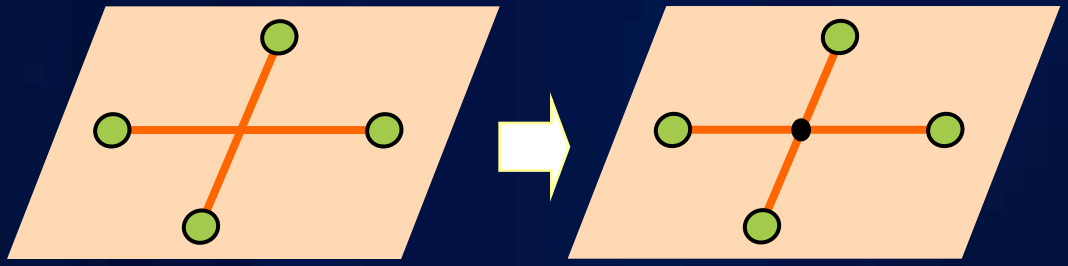


Case 2

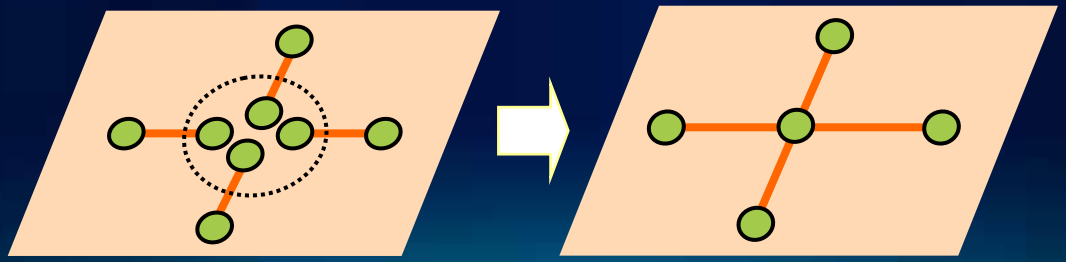


Creating coincident geometry

- Include sources in a Topology
- Use the Geoprocessing Integrate Tool
- Both methods compare features and makes vertices within the cluster tolerance coincident
  - Inserts vertices where features intersect



  - Snaps features that are not coincident



Common fields for street data

Field	Data type	Application
Elevation	Integer	Ensures proper connectivity
Oneway	Text	Helps determine one way streets
Length	Double	Calculate shortest route
Travel time	Double	Calculate fastest route
Hierarchy	Integer	Ranking of streets for routing on large network datasets
Speed	Integer	May be used to calculate travel time
Road class	Integer	Classification of roads – used for formatting directions text
Street name or address data	Text	Helps generate network locations and directions

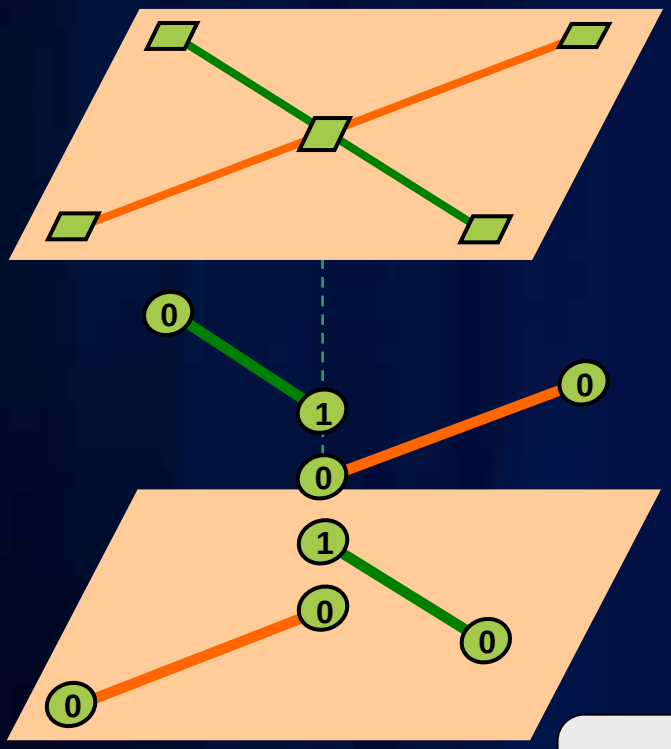
Connectivity using Elevation Fields

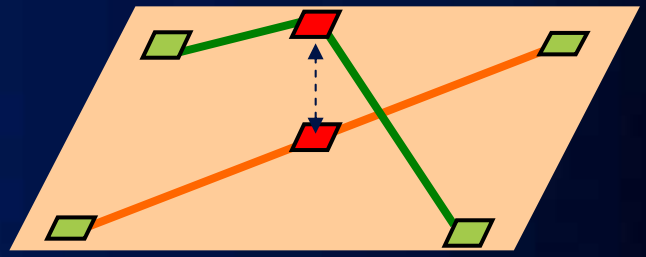
- Attribute that enables network dataset to represent multiple “levels” for line features
- Applied to line features with coincident endpoints
- Planar and non-planar features are supported
- Commonly called z-elevation or z-levels

NAME	F_ZLEV	T_ZLEV
State St	0	0

Elevation fields – Overpass/underpass scenario

- Four lines with coincident endpoints





Junction

Endpoint

0-1 lines do not intersect 0-0 lines at the same junction

Oneway field – Most common method

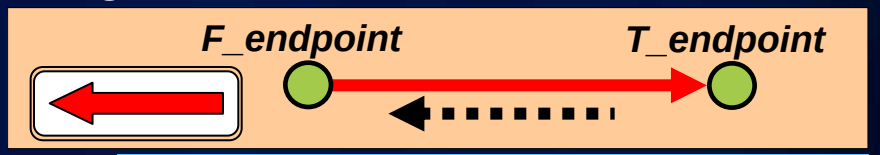
- Text field containing values: FT, TF, < >, N
  - "FT" – one-way in digitized direction

NAME	Oneway
State St	FT

FT = traffic only allowed in this direction

  - "TF" – one-way against digitized direction

NAME	Oneway
State St	TF



TF = traffic only allowed in this direction

  - <empty> – two-way street

NAME	Oneway
State St	< >

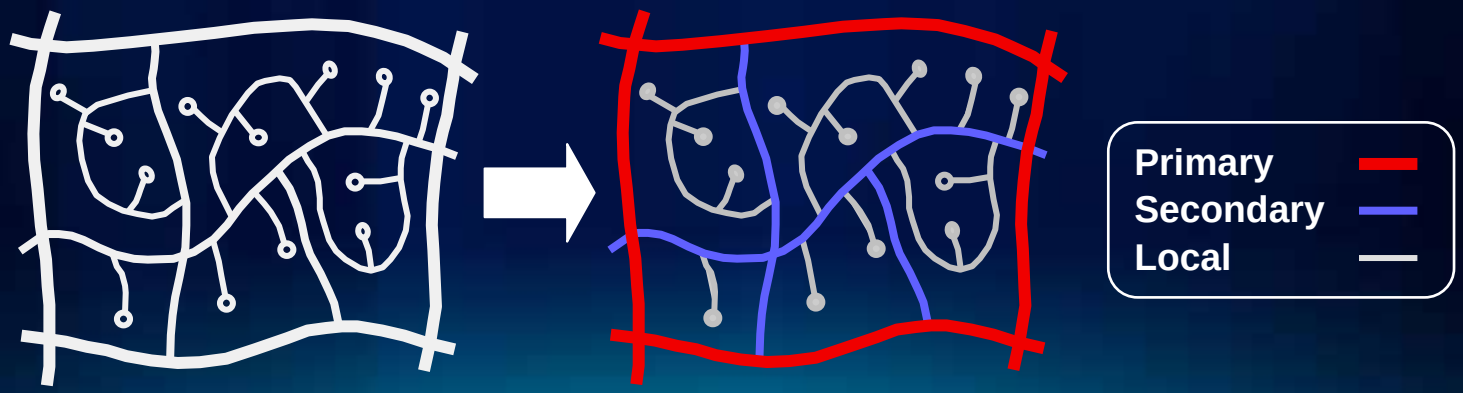
"N" – No travel

NAME	Oneway
State St	N

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:

Hierarchy	Regional  % of edges	National  % of edges	Edge count *better guide*
1	5%	3%	~100,000 max
2	15%	17%	Percentage of total
3	80%	80%	Percentage of total

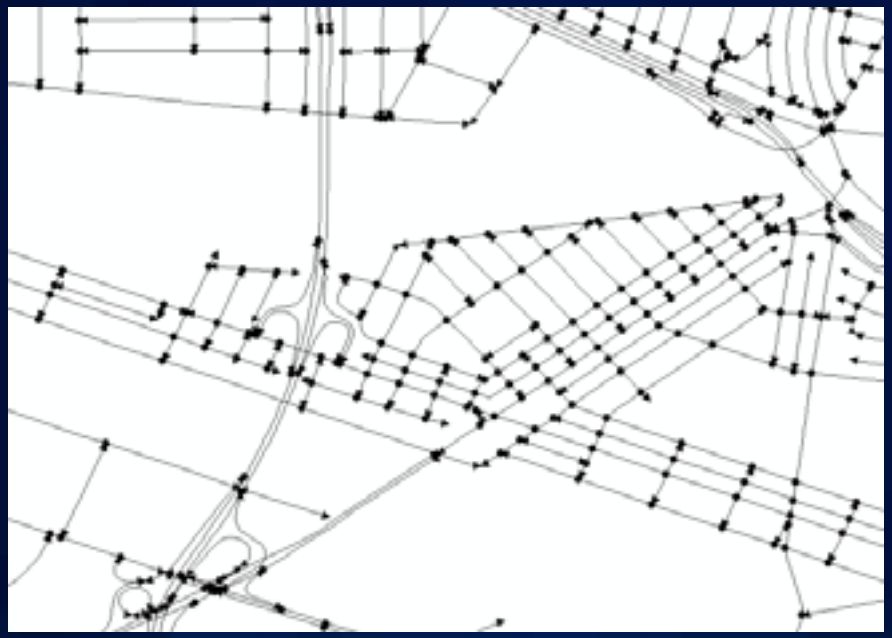
RoadClass attribute

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

RoadClass Value	RoadClass Description	Driving Directions
1	Local road	“Turn left on Main St”
2	Limited access highway	“Go East on I 44”
3	Ramp	“Take ramp and go on US-7 N”
4	Ferry	“Take Lake Expy ferry”
5	Roundabout	“Take roundabout and proceed South on Main St”

Dissolve Network (new at ArcGIS 10)

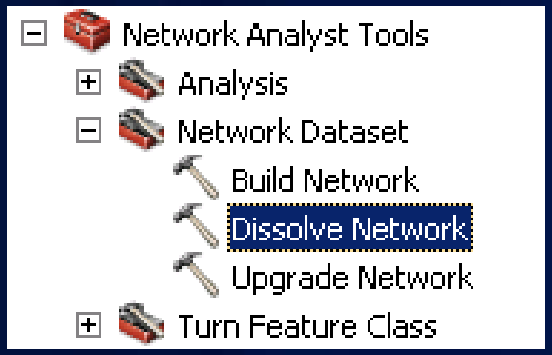
- Input: Network dataset
- Output: New network dataset with fewer line features
  - North America: 43.8M lines –» 15.7M lines



- Fewer line features – Faster network analysis

Dissolve Network

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



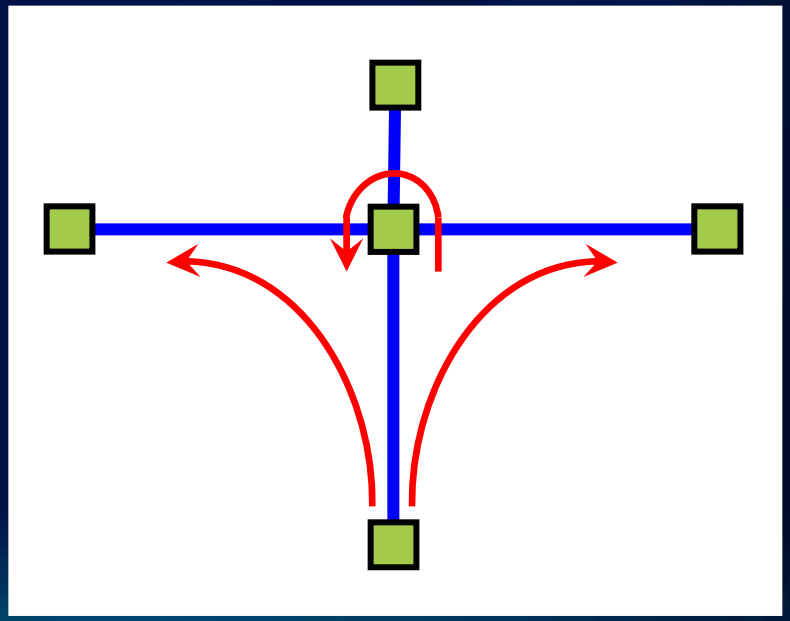
- Creates a new dissolved network dataset
  - Original network dataset is unedited
- Only fields used by network dataset are present in dissolved data
  - Use dissolved dataset for network analysis
  - Keep original data for maintenance and other work

Demonstration

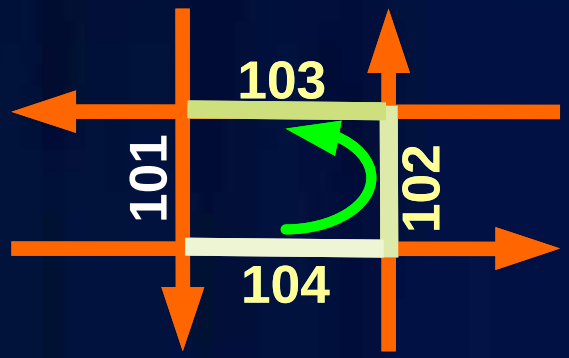
Adding fields for routing to TIGER/Line® street data

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

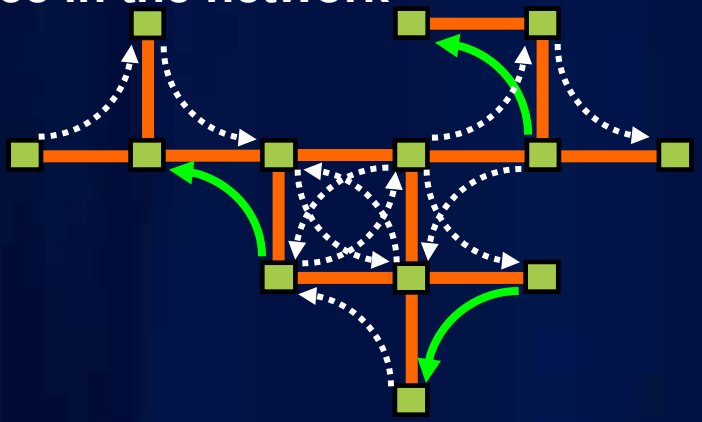
Field	Value
ObjectID	1
Shape	*Polyline*
Edge1End	Y
Edge1FCID	42
Edge1FID	104
Edge1Pos	0.5
Edge2FCID	42
Edge2FID	102
Edge2Pos	0.6
Edge3FCID	42
Edge3FID	103
Edge3Pos	0.4

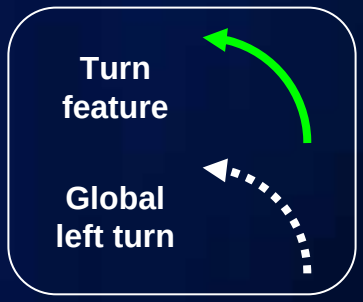
Editing Turn Features

- 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

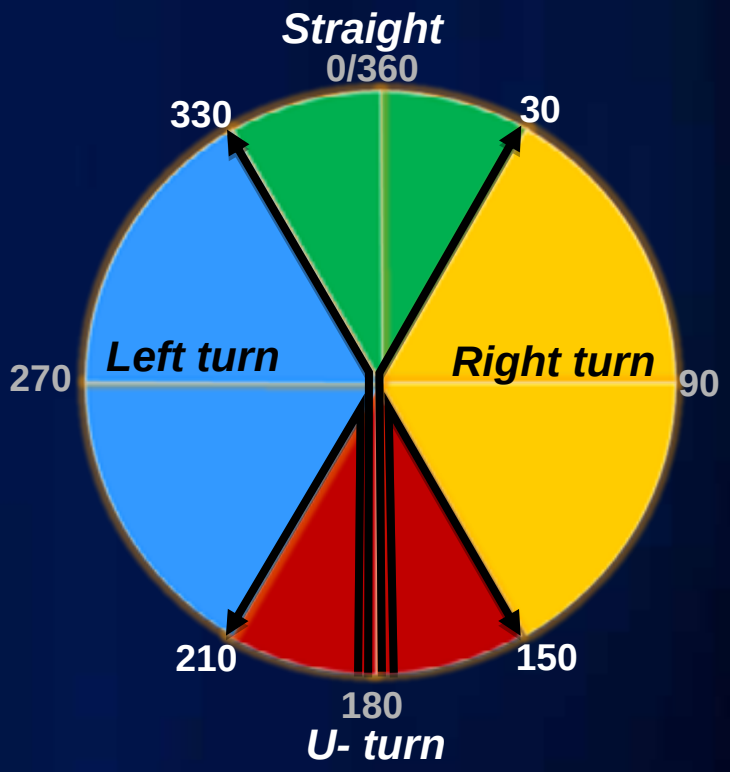
Sample VB Script Code for Global Turn Penalty

Pre-Logic VB Script Code:

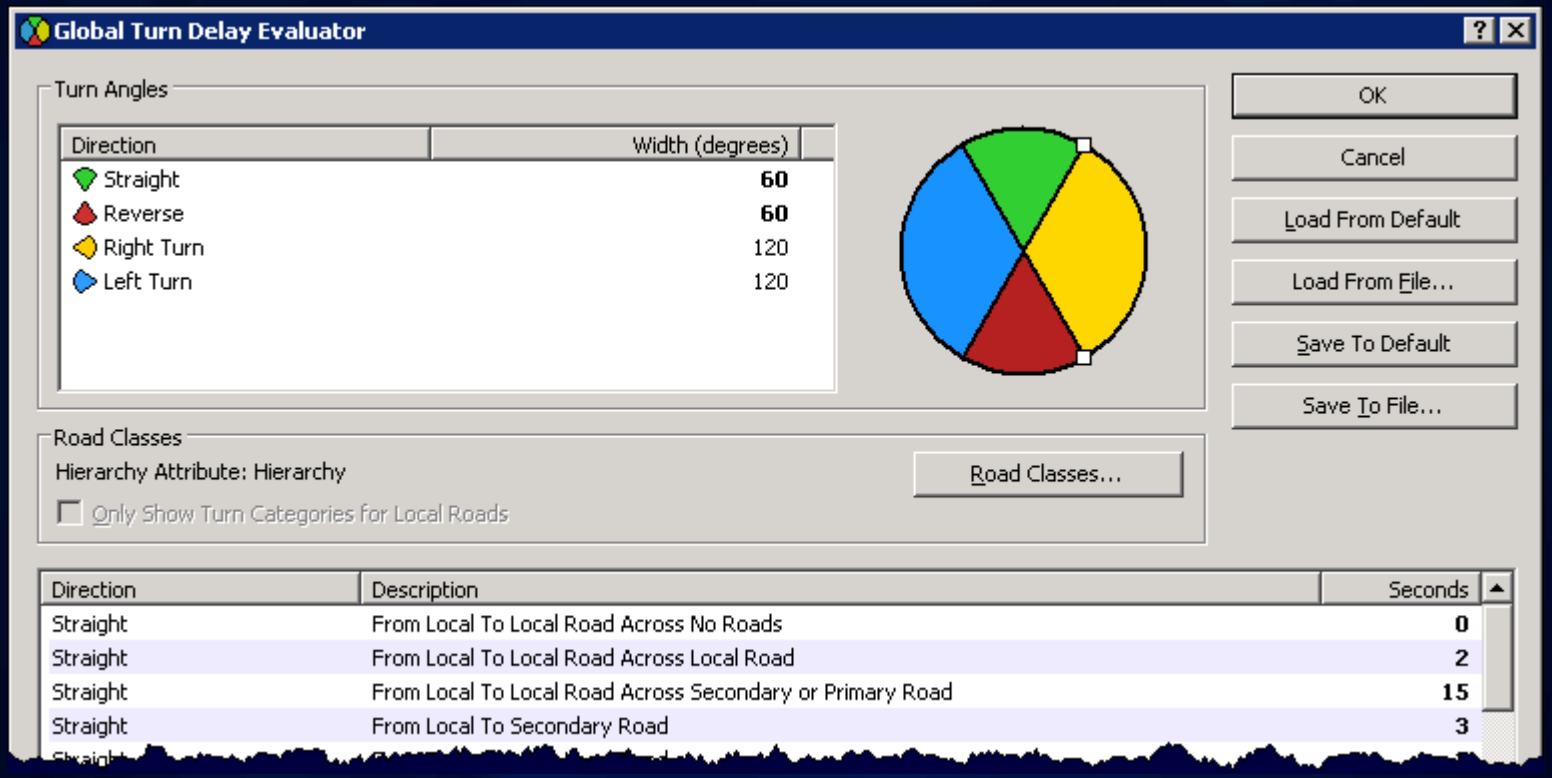
```
a = Turn.Angle
If a > 210 And a < 330 Then
  turnTime = 0.5
Else
  turnTime = 0
End If
```

Expression:

```
turnTime
```

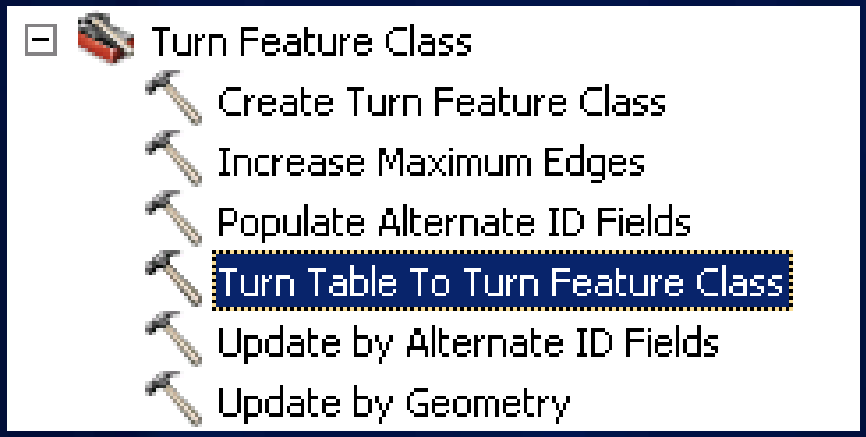


…or use the Global Turn Delay evaluator



Converting Existing Turn Data

- **ArcView 3.x or ArcInfo Workstation data**
  - **Convert streets with Feature Class To Feature Class geoprocessing tool**
  - **Convert turn table with Turn Table To Turn Feature Class geoprocessing tool**

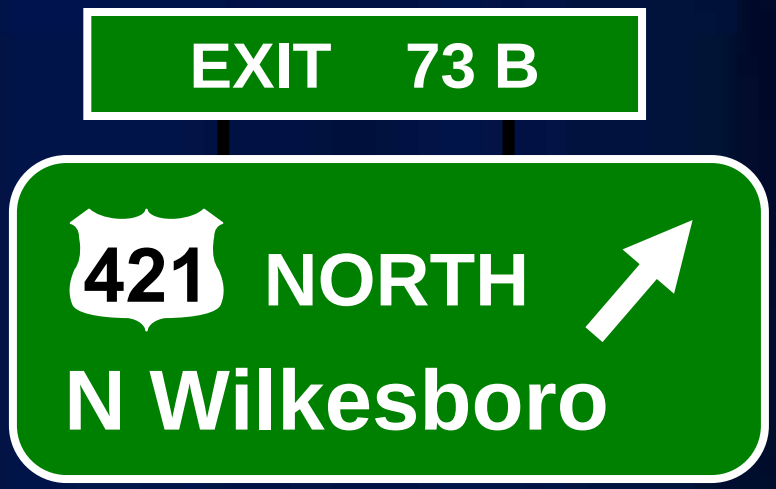


- **Commercial data with multi-edge turns**
  - **Use the Create Turn Feature Class from Multi-Edge Turn Table script from the Resouce Center**

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

Exit number	73 B
Street name(s)	US-421
Direction	North
Destination(s)	N Wilkesboro

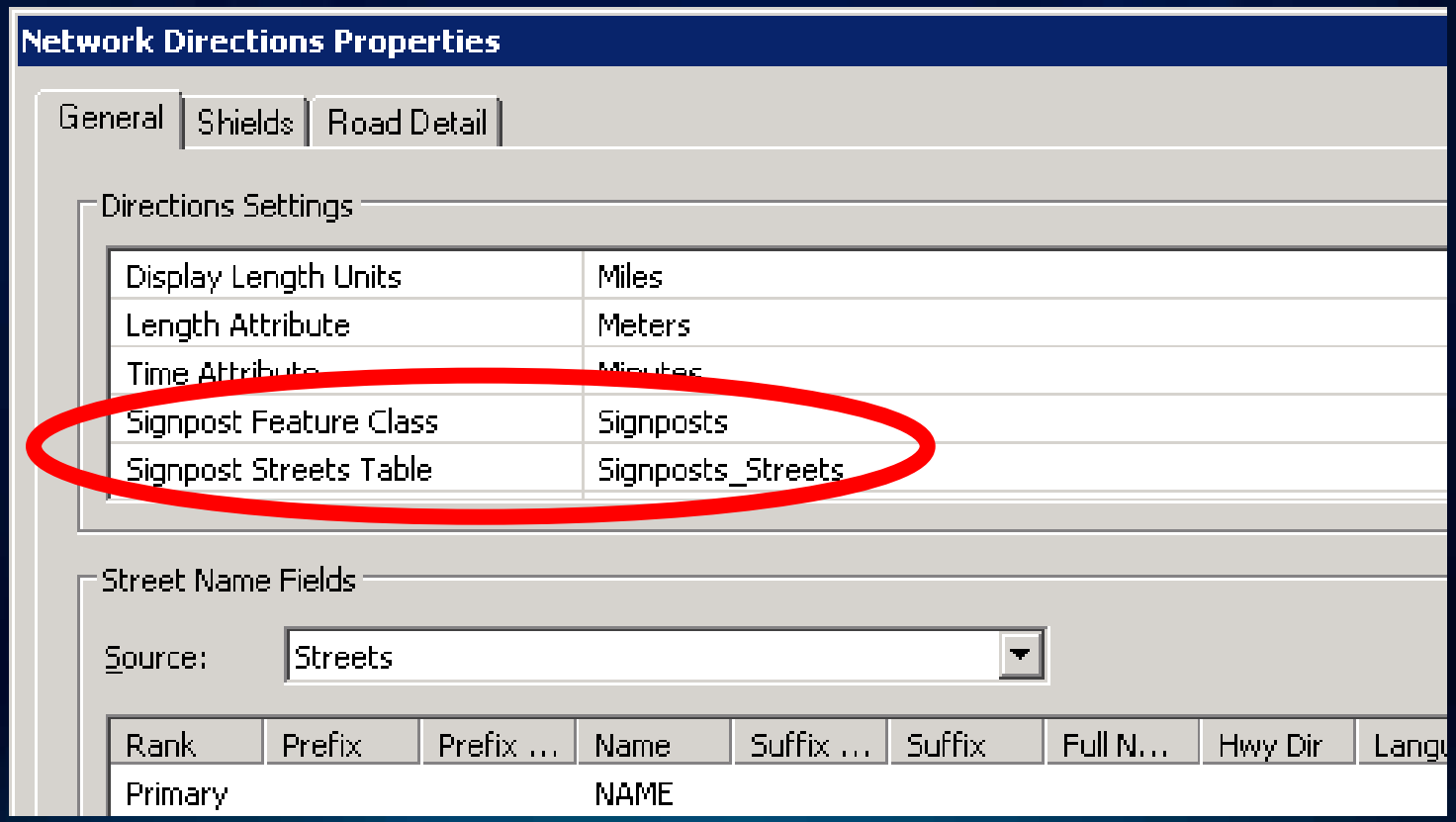
- **Signpost streets table**
  - Streets traversed when following the sign

Feature class ID	12
Feature ID	41
Positions	0.0 to 1.0

For Vendor data use "Import Signposts" .NET SDK Developer sample

Adding Signposts to the Network Dataset

- **Signpost tables specified in Directions Settings**



Historical Traffic

- New at ArcGIS 10
- 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

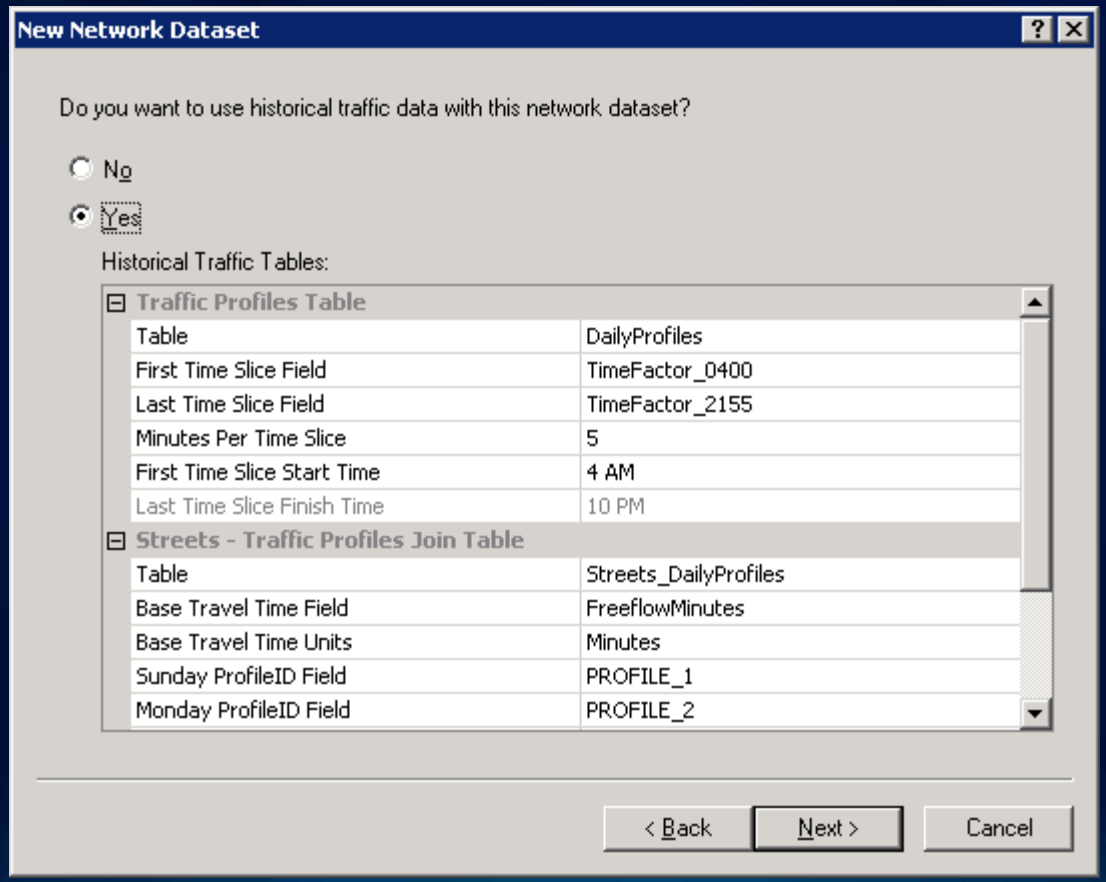
Profile	1 am	5 am	9 am	1 pm	5 pm	9 pm
16	×1.0	×1.1	×2.3	×1.2	×1.4	×1.1

- **Streets-Traffic Profiles join table**
  - Specifies free-flow travel times and profiles to use

Feature class ID	12
Feature ID	41
Positions	0.0 to 1.0
Free-flow travel	10 seconds
Sunday Profile	Profile 10
Monday Profile	Profile 16
…	…

Historical Traffic in the Network Dataset

- **Specify when creating the network dataset**

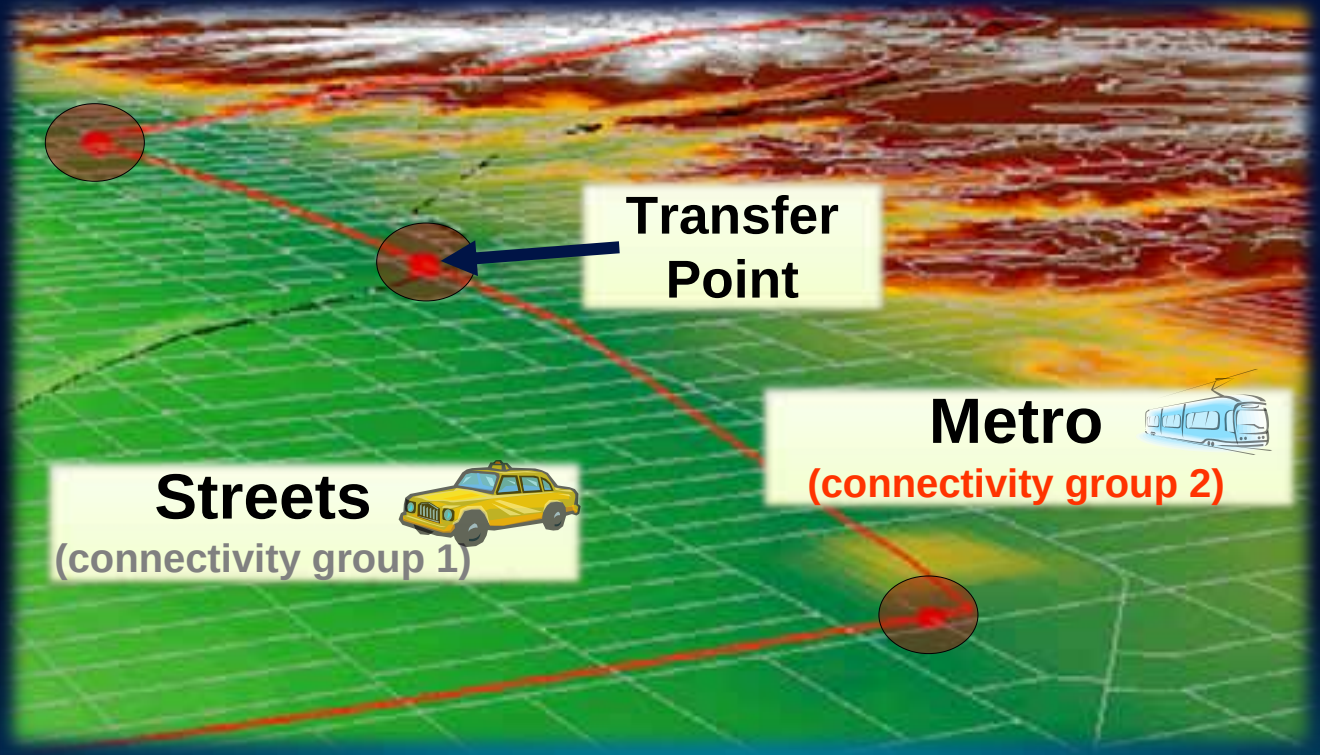


Demonstration

Using Turns, Signposts, and Historical Traffic Data

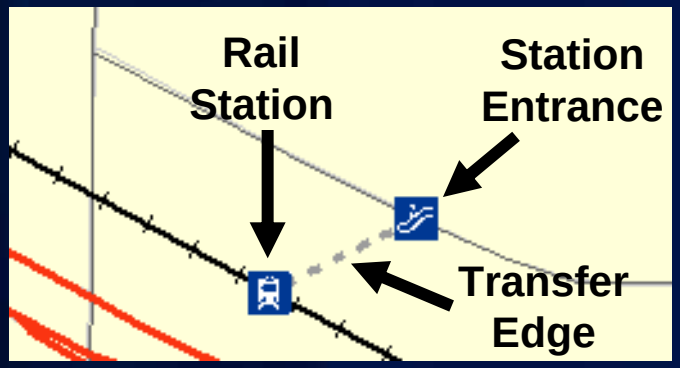
Connectivity for Multi-Modal Network Dataset

- 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”



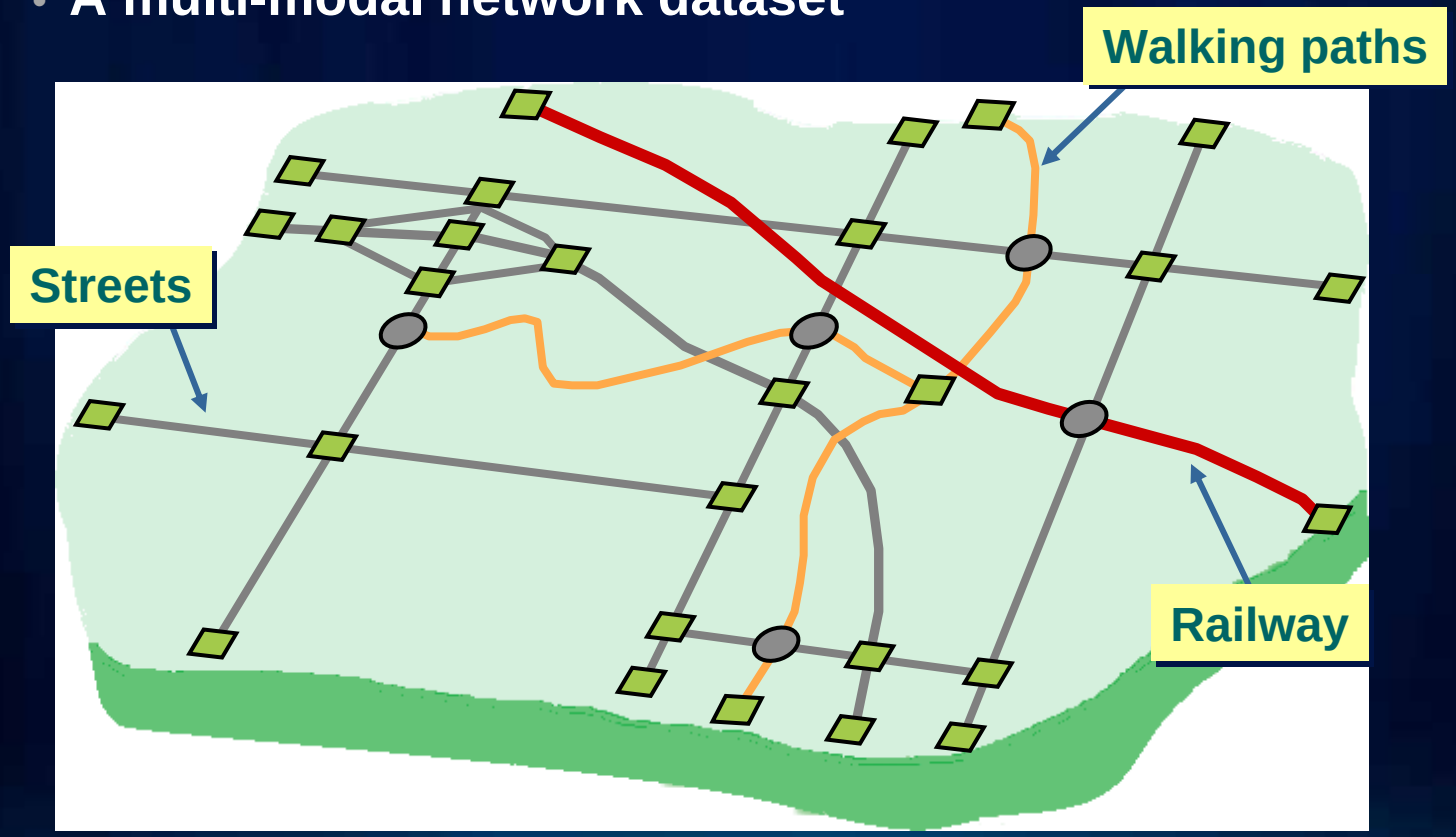
- For station entrances not at the road ends
  - Create junction with Override policy at entrance
  - Insert vertex on street feature at station entrance

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



Parameterized Attributes

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

Parameterized attribute

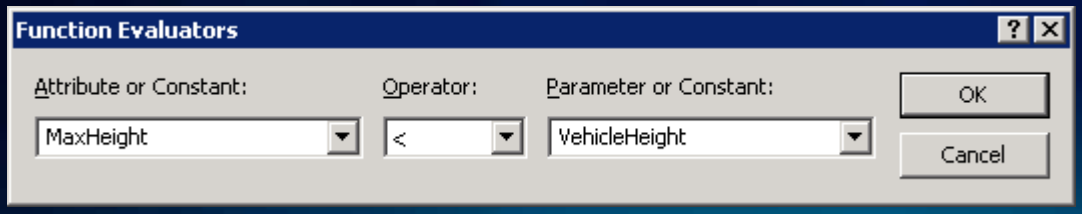
Input Parameter value(s)

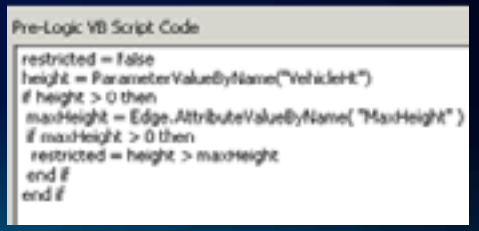
(Optional)
Other Network Attribute(s)

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

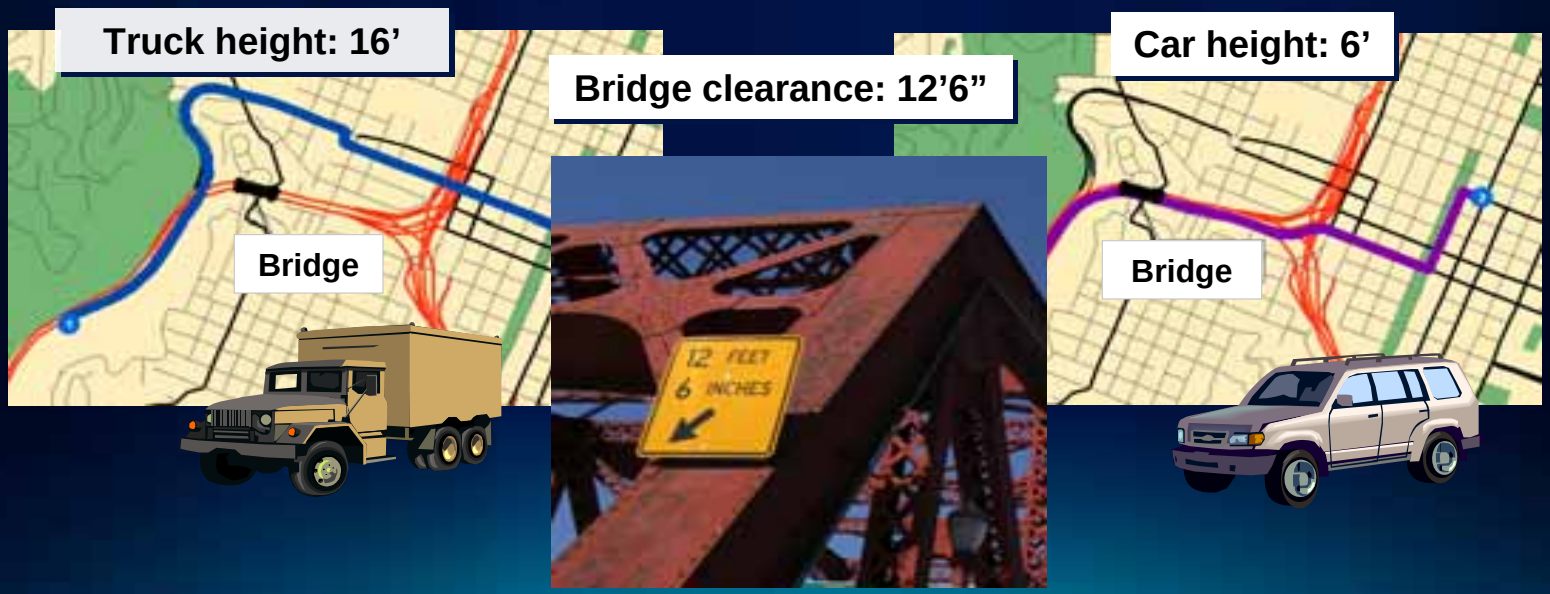
Restriction evaluates to True (Restricted) if vehicle height exceeds 12 ft, 6 in





Using Height restriction during solve

- When using solver:
  - Set attribute restriction on Analysis Settings tab
  - Specify actual vehicle height on Attribute Parameters
- Solver Result:
  - Street is restricted when the actual Vehicle Height is greater than street's MaxHeight attribute value



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:

Attribute	Evaluator(s)
Length	*Field* – assign the [meters] field
TravelTime	*Edge Traffic*, *Global Turn Delay* – use historical traffic, turn delays
TurnRestriction	*Constant* – "true" (implies all turns restricted)
MaxHeight	*Field* – assign the [Height_Limit] field
HeightRestriction	*Function* – specify MaxHeight attribute < VehicleHeight parameter

- 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

Esri Support Center

- Online portal to technical information

- Knowledge Base
  - Technical articles
  - White papers
  - System requirements
- Downloads
  - Patches, service packs
  - Data models
  - ArcScripts and samples
- User forums
  - Discussion groups
  - E-mail lists

http://support.esri.com

For more information

- Network Analyst Product Page
  - Links to Demos, Brochures/White Papers, Success Stories
  - http://www.esri.com/software/arcgis/extensions/networkanalyst/
- Free webcast
  - Using Network Analyst in ArcGIS Desktop 10
  - http://training.esri.com/acb2000/showdetl.cfm?DID=6&Product_ID=981
- Free Podcasts – Instructional Series
  - http://www.esri.com/news/podcasts/

Network Analyst Technical Workshops – Tuesday

- **Network Analyst – An Introduction**
- **8:30AM~9:45AM Room 3**

- **Network Analyst – Performing Network Analysis**
- **10:15AM~11:30PM Room 3**

- **Performing Network Analysis with ArcGIS Server**
- **3:15PM~4:30PM Room 3**

- **What is ArcGIS Network Analyst and Why Should I Use It?**
- **4:05PM~4:25PM Room 6B**

Network Analyst Technical Workshops – Wed/Thu

- **Network Analyst – Automating Workflows**
- **Wednesday 8:30AM~9:45AM Room 9**

- **Network Analyst – An Introduction (Offering II)**
- **Wednesday 1:30PM~2:45PM Room 9**

- **Network Analyst – Performing Network Analysis (Offering II)**
- **Thursday 8:30AM~9:45AM Room 9**

Network Analyst Demo Theater Presentations

- **Modeling Real-World Problems with the VRP Solver**
- **Tuesday 1:00PM~2:00PM Spatial Analysis Island**

- **Routing Inside Buildings with 3D Networks**
- **Wednesday 3:00PM~4:00PM Spatial Analysis Island**

- **Location-Allocation and Accounting for competition in site selection**
- **Wednesday 4:00PM~5:00PM Spatial Analysis Island**

Thank you for attending!

- Please complete the Session Evaluation:
- http://www.esri.com/sessionevals/

- Questions?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