



Network Analyst Creating Network Datasets

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Agenda

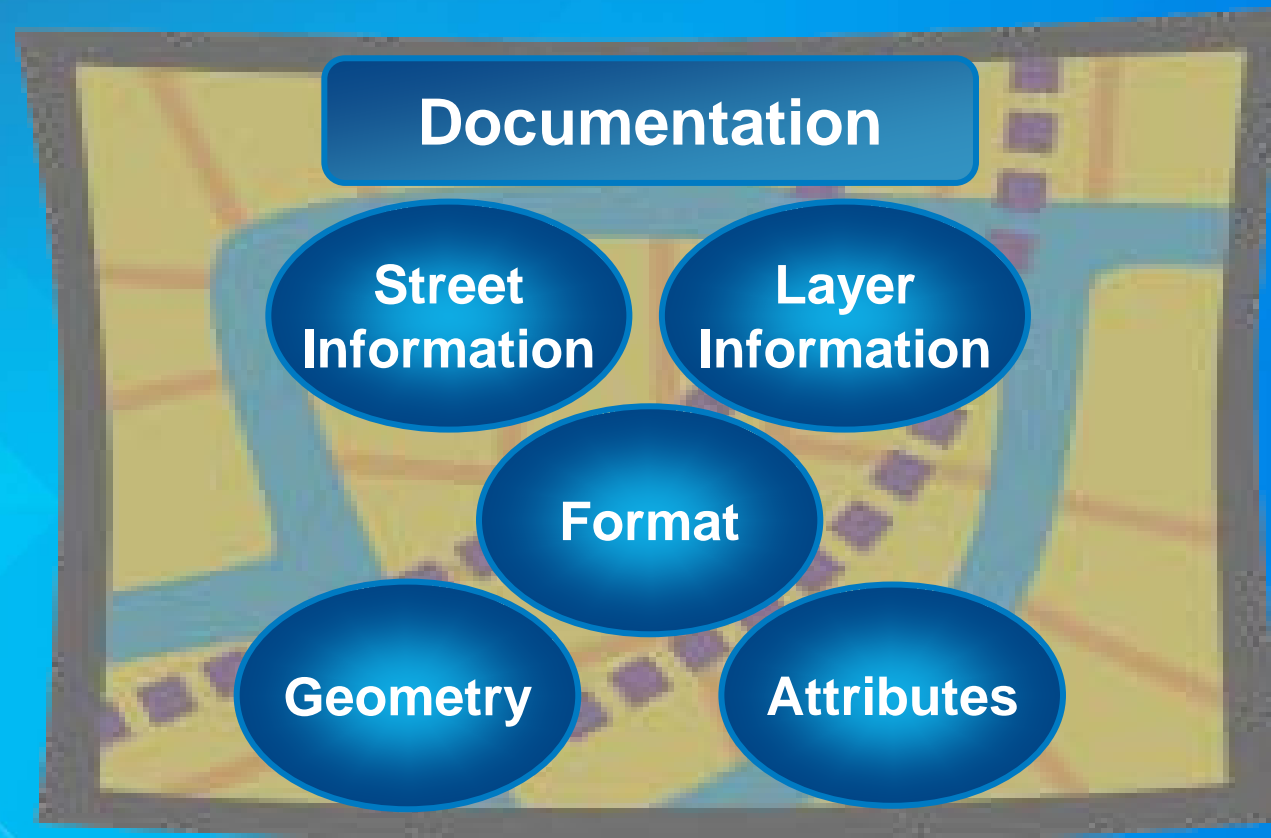
- **Preparing street data for use in a network dataset**
 - Oneway streets
 - Hierarchy
 - RoadClass attribute
- **Using turns, signposts, and historical traffic data**
- **Creating a multi-modal network dataset**
- **Parameterized attributes**
- **Evaluators tips and tricks**
- **Support & Resources**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

Do I need to create my own network dataset?

- **Network analysis services on ArcGIS Online**
 - Route, Closest Facility, Service Area, VRP
 - Generates Driving Directions
 - Analysis performed on up-to-date street data
 - Much of the world is covered
 - Incorporates historical, live, and predicted traffic where available
 - No network dataset required
- **StreetMap Premium network datasets available**
 - Compressed File Geodatabase format
 - Ready to use
 - Network dataset already created

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

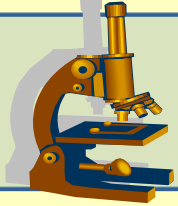
Attributes

- 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



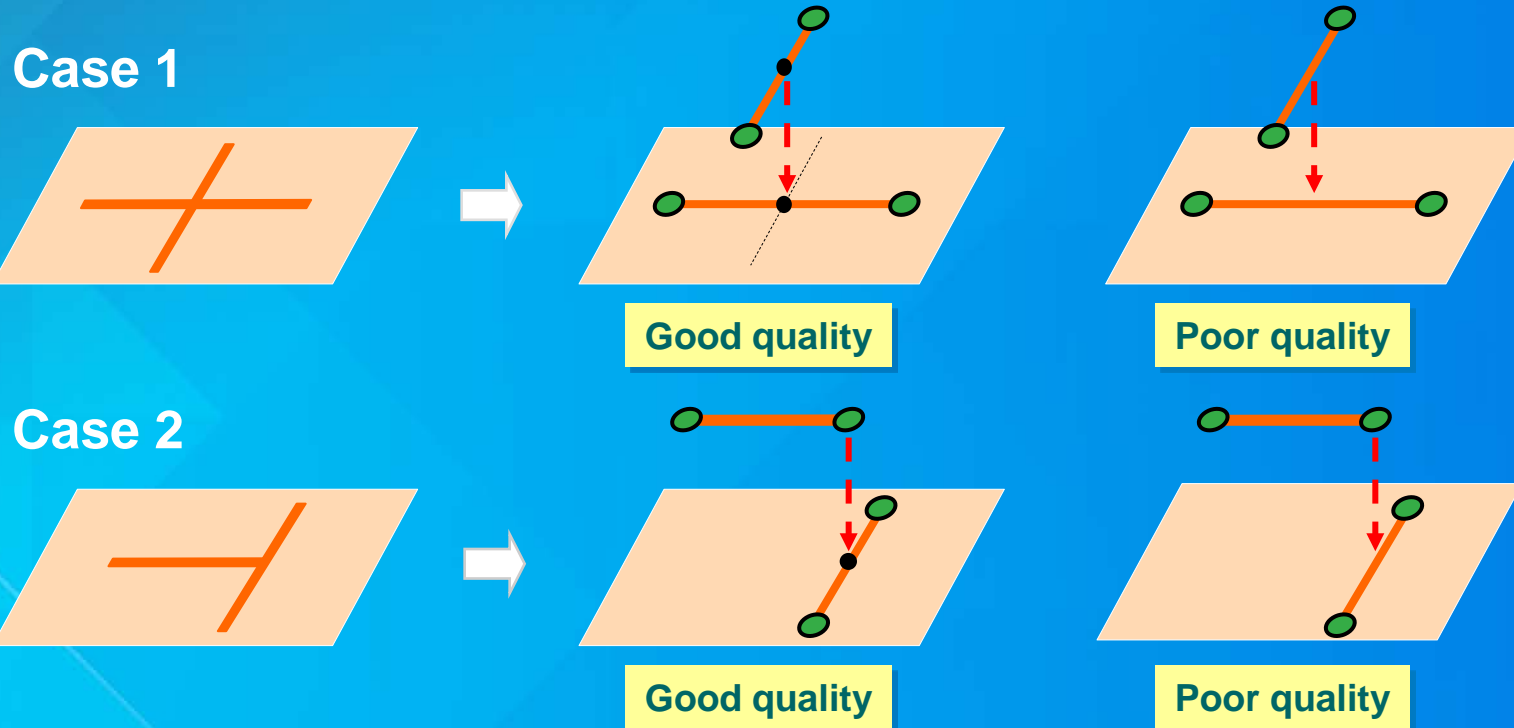
**How is street geometry represented?
What street information is provided?
In what layers is this information located?
How is this information formatted?**



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

Coincident Geometries

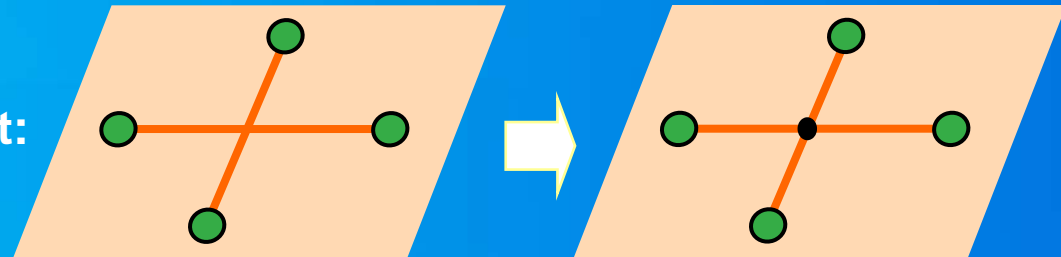
- To enable network connectivity to be modeled
 - Points of coincidence should exist where line features cross or intersect



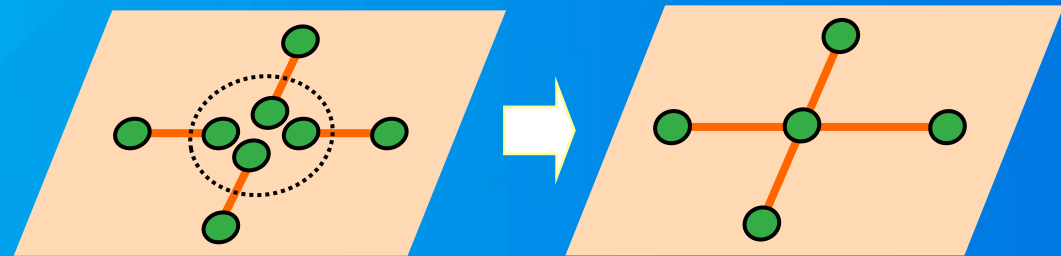
Creating Coincident Geometry

- Include sources in a Topology
- Use the Integrate Tool (Geoprocessing)
- Both methods compare features and makes all vertices within the cluster tolerance coincident

- Inserts vertices where features intersect:



- Snaps features that are not coincident:

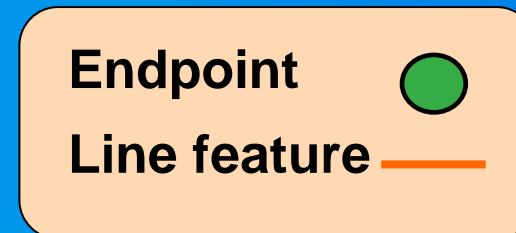


Common Fields for Street Data

Field	Data Type	Application
Elevation	Integer	Ensures proper connectivity
Oneway	Text	Helps determine one way streets
Length	Double	Calculate the shortest route
Travel time	Double	Calculate the 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

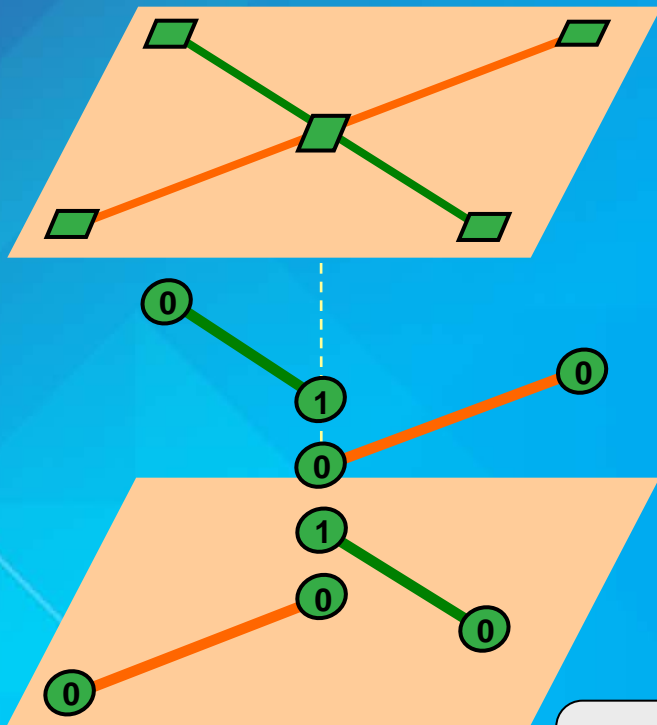
- Attribute that enables network dataset to represent multiple “levels” for line features
- Applied to line features with coincident endpoints
- Planar and non-planar features are supported
- Commonly called z-elevation or z-levels





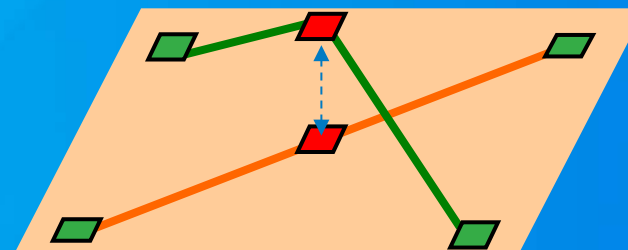
NAME	F_ZLEV	T_ZLEV
State St	0	0

Elevation Fields – Overpass/Underpass Scenario

- Four lines with coincident endpoints



Junction 
Endpoint 



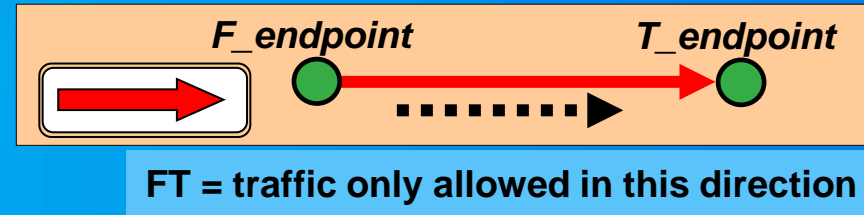
0-1 lines do not intersect 0-0 lines at the same junction

Oneway field – Most common method

- Text field containing values: FT, TF, < >, N

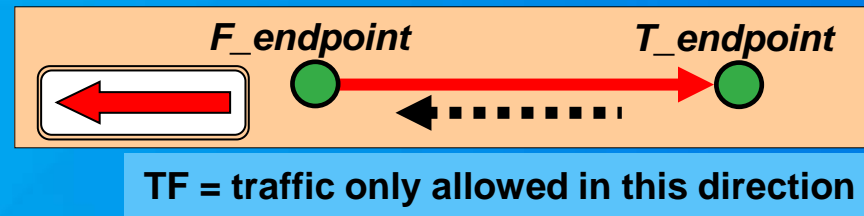
- “FT” – one-way in digitized direction

NAME	Oneway
State St	FT



- “TF” – one-way against digitized direction

NAME	Oneway
State St	TF



- <empty> – two-way street

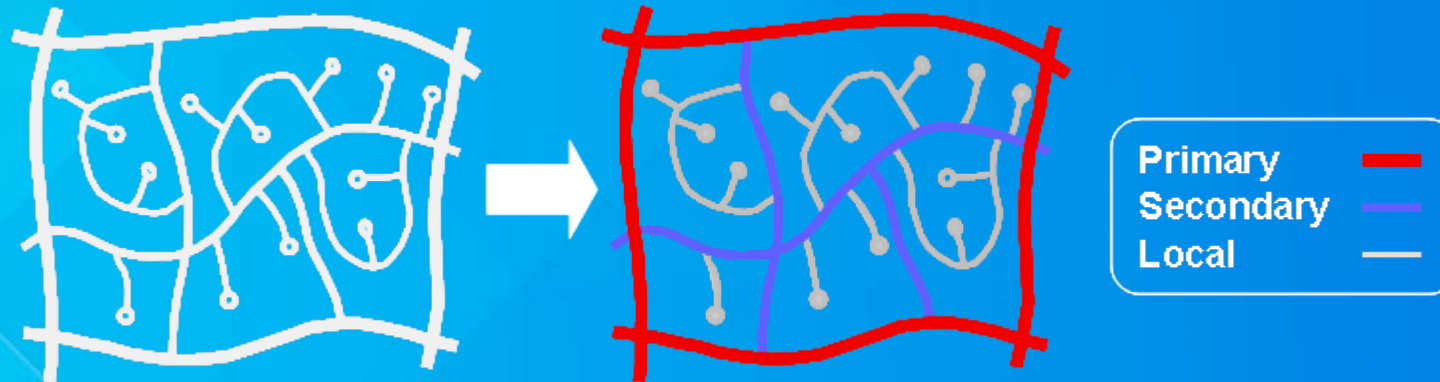
NAME	Oneway
State St	

- “N” – No travel

NAME	Oneway
State St	N

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 numeric value = 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)

Guide for Edges per Hierarchy:

Hierarchy	Regional % of Edges		National % of Edges		Edge count <i>better guide</i>
1	5%		3%		~100,000 max
2	15%		17%		Percentage of total
3	80%		80%		Percentage of total

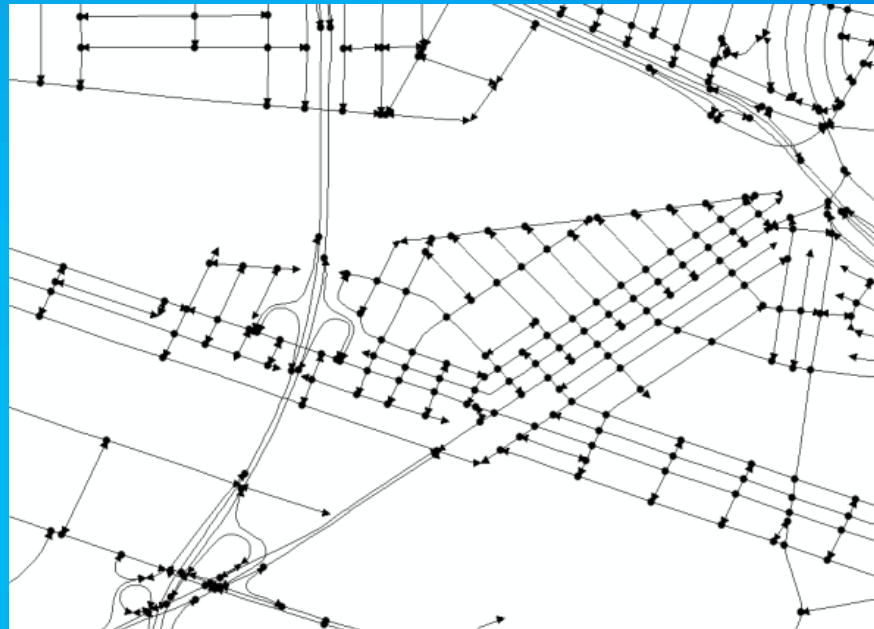
RoadClass attribute

- 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 Text
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

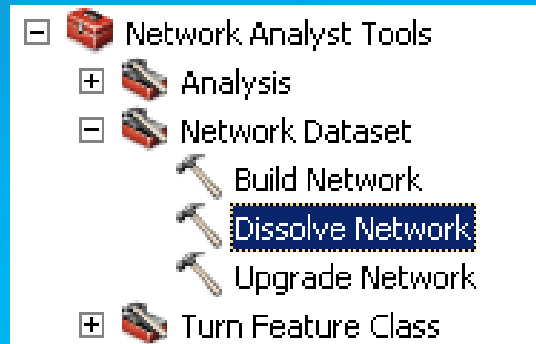
- **Input: Network dataset**
- **Output: New network dataset with fewer line features**
 - North America: 43.8M lines –» 15.7M lines



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

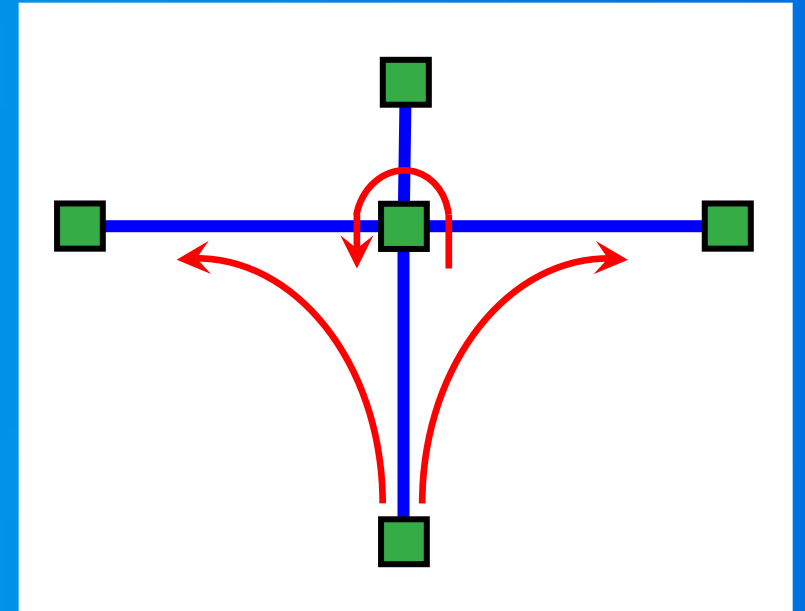
Demo

Adding fields for routing to
TIGER/LINE® street data

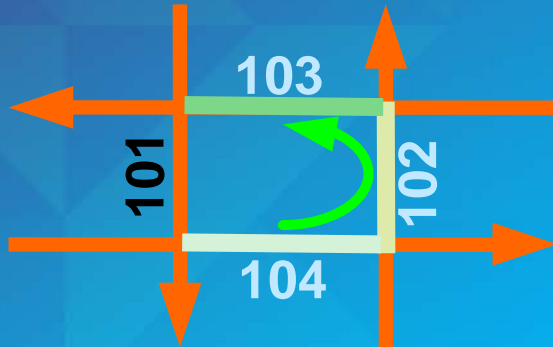


Turns in the Network Dataset

- 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

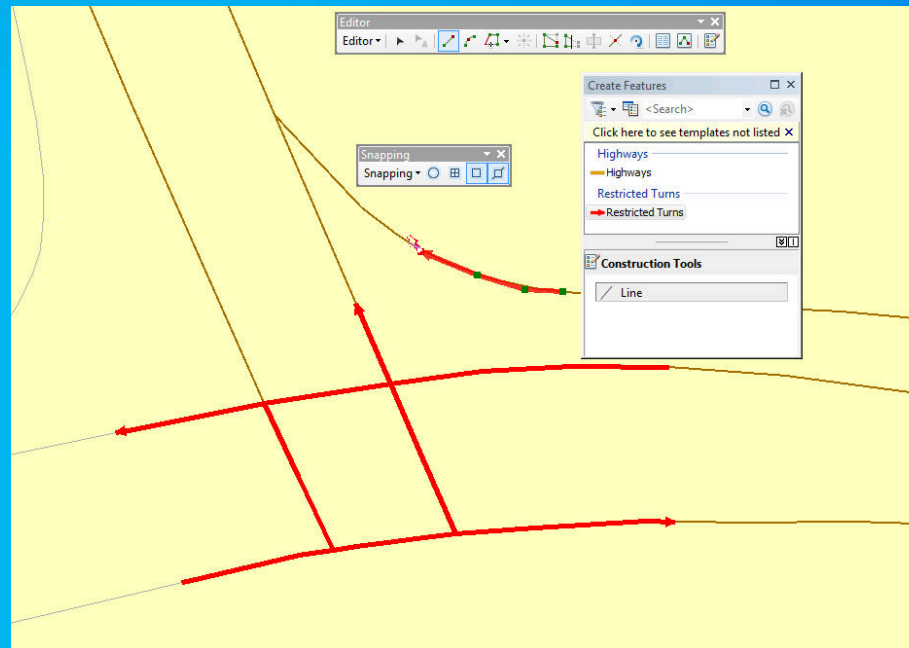


- Polyline geometry
- Turn references edges by:
 - Feature class ID
 - Feature ID
 - Position
- Turn elements built by edge references

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

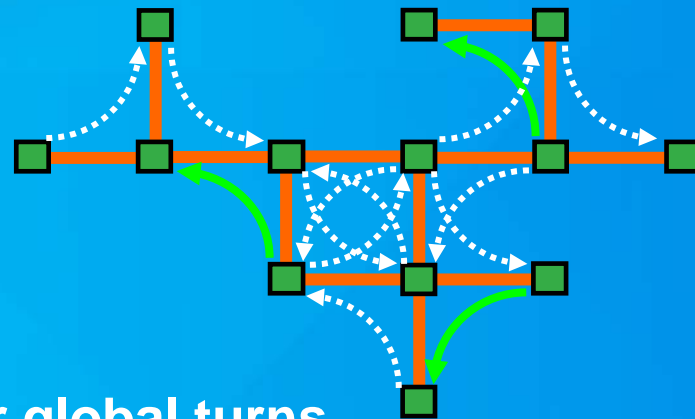
Editing Turn Features

- 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

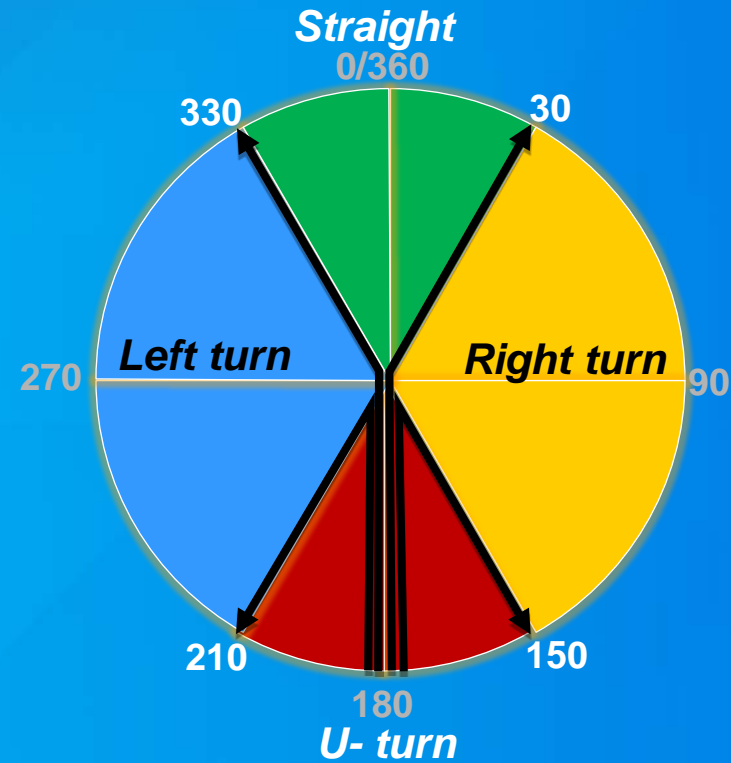
Sample VB Script code for Global Turn Penalty

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

Global Turn Delay Evaluator [?] [X]

Turn Angles

Direction	Width (degrees)
 Straight	60
 Reverse	60
 Right Turn	120
 Left Turn	120



OK
Cancel
Load From Default
Load From File...
Save To Default
Save To File...

Road Classes

Hierarchy Attribute: Hierarchy

Only Show Turn Categories for Local Roads

Road Classes...

Direction	Description	Seconds
Straight	From Local To Local Road Across No Roads	0
Straight	From Local To Local Road Across Local Road	2
Straight	From Local To Local Road Across Secondary or Primary Road	15
Straight	From Local To Secondary Road	3

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:
 - Example: “At exit 73B, take ramp to US-421 North toward N Wilkesboro”



Signpost data – Two tables

- **Signpost feature class**

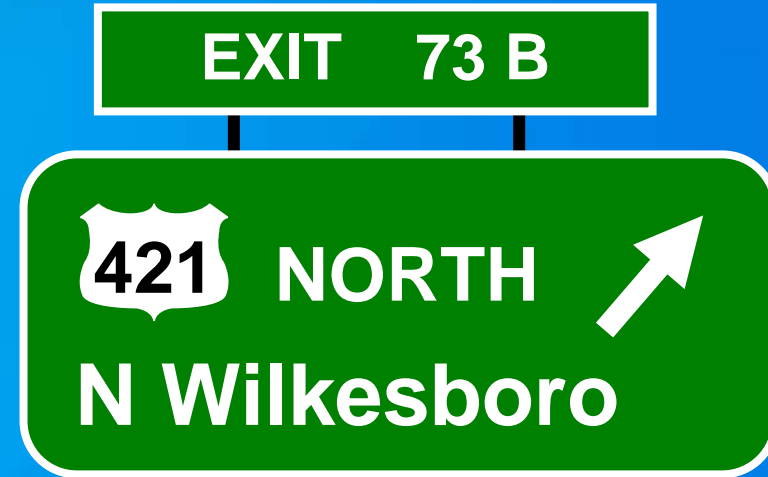
- **Actual text on sign**

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



Adding Signposts to the Network Dataset

- Signpost tables specified in the Network Directions Properties:

Network Directions Properties

General | Shields | Road Detail

Directions Settings

Display Length Units	Miles
Length Attribute	Meters
Time Attribute	Minutes
Signpost Feature Class	Signposts
Signpost Streets Table	Signposts_Streets

Street Name Fields

Source: Streets

Rank	Prefix	Prefix ...	Name	Suffix ...	Suffix	Full N...	Hwy Dir	Lang
Primary			NAME					

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	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

- Must be specified when *creating* the network dataset

New Network Dataset

Do you want to use historical traffic data with this network dataset?

No

Yes

Historical Traffic Tables:

Traffic Profiles Table	
Table	DailyProfiles
First Time Slice Field	TimeFactor_0400
Last Time Slice Field	TimeFactor_2155
Minutes Per Time Slice	5
First Time Slice Start Time	4 AM
Last Time Slice Finish Time	10 PM

Streets - Traffic Profiles Join Table	
Table	Streets_DailyProfiles
Base Travel Time Field	FreeflowMinutes
Base Travel Time Units	Minutes
Sunday ProfileID Field	PROFILE_1
Monday ProfileID Field	PROFILE_2

< Back Next > Cancel

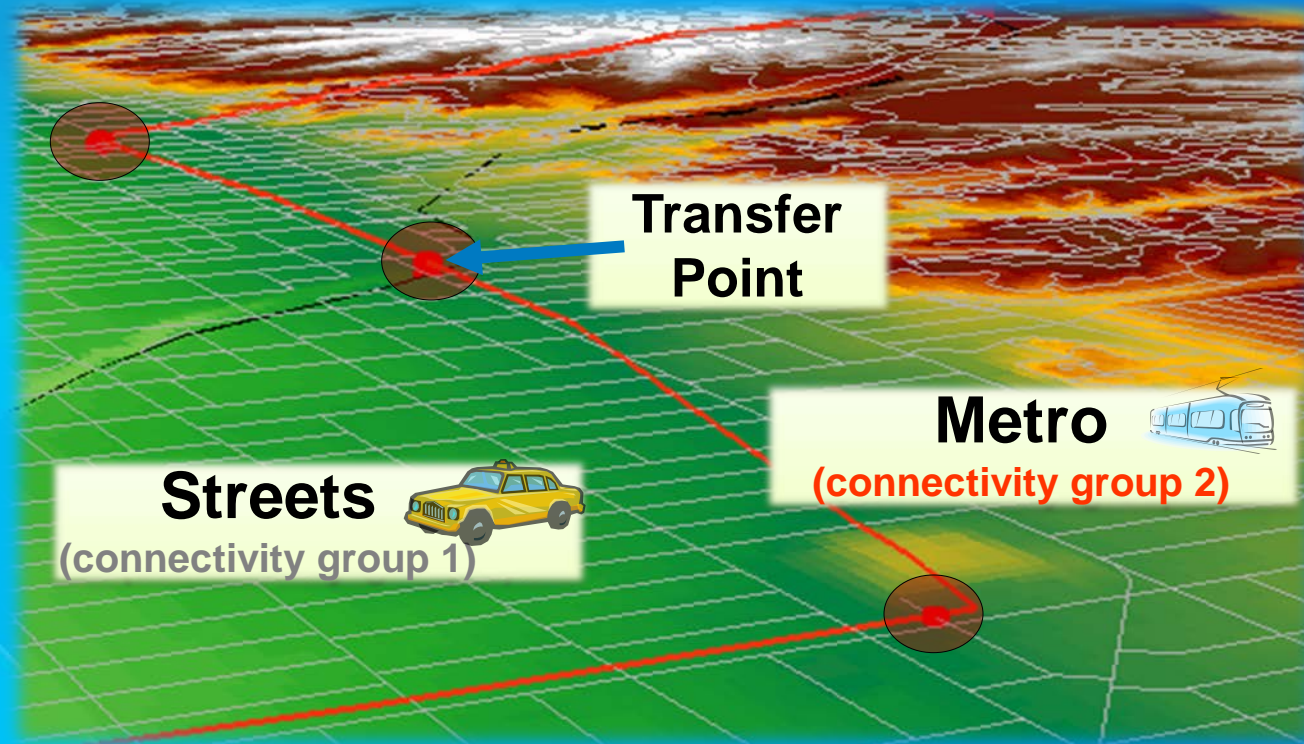
Demo

Using Turns, Signposts, and
Historical Traffic Data



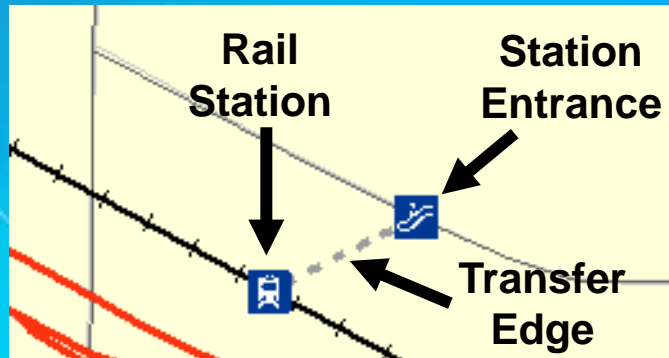
Connectivity for a Multi-Modal Network Dataset

- Connectivity groups “connect” at transfer points
 - Example: Rail stations
- Non-connecting edge sources in separate connectivity groups



Multi-Modal Networks: Considerations for Road and Rail

- Road and 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 for a 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

Demo

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

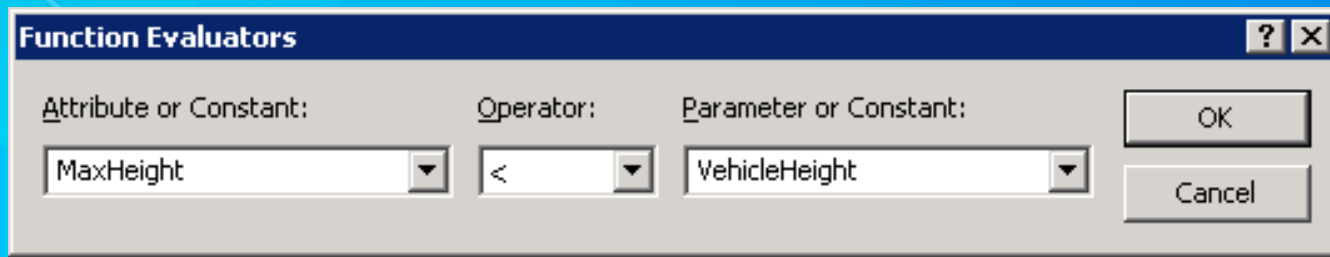
Input Parameter value(s)

**(Optional)
Other Network Attribute(s)**



Example – implementing a height limit

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



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

Pre-Logic VB Script Code

```
restricted = false
height = ParameterValueByName("VehicleHt")
if height > 0 then
  maxHeight = Edge.AttributeValueByName("MaxHeight")
  if maxHeight > 0 then
    restricted = height > maxHeight
  end if
end if
```


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 prohibited when the actual Vehicle Height is greater than street's MaxHeight attribute value





Evaluators

in the Network Dataset

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	<i>Field</i> – assign the [meters] field
TravelTime	<i>Edge Traffic, Global Turn Delay</i> – use historical traffic, turn delays
TurnRestriction	<i>Constant</i> – “true” (implies all turns are prohibited)
MaxHeight	<i>Field</i> – assign the [Height_Limit] field
HeightRestriction	<i>Function</i> – 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 is determined during solve

- VB Script evaluator

 Can be slow: Invokes scripting at solve time

- Custom evaluator

- Depends on implementation

Evaluators – Tips and Tricks

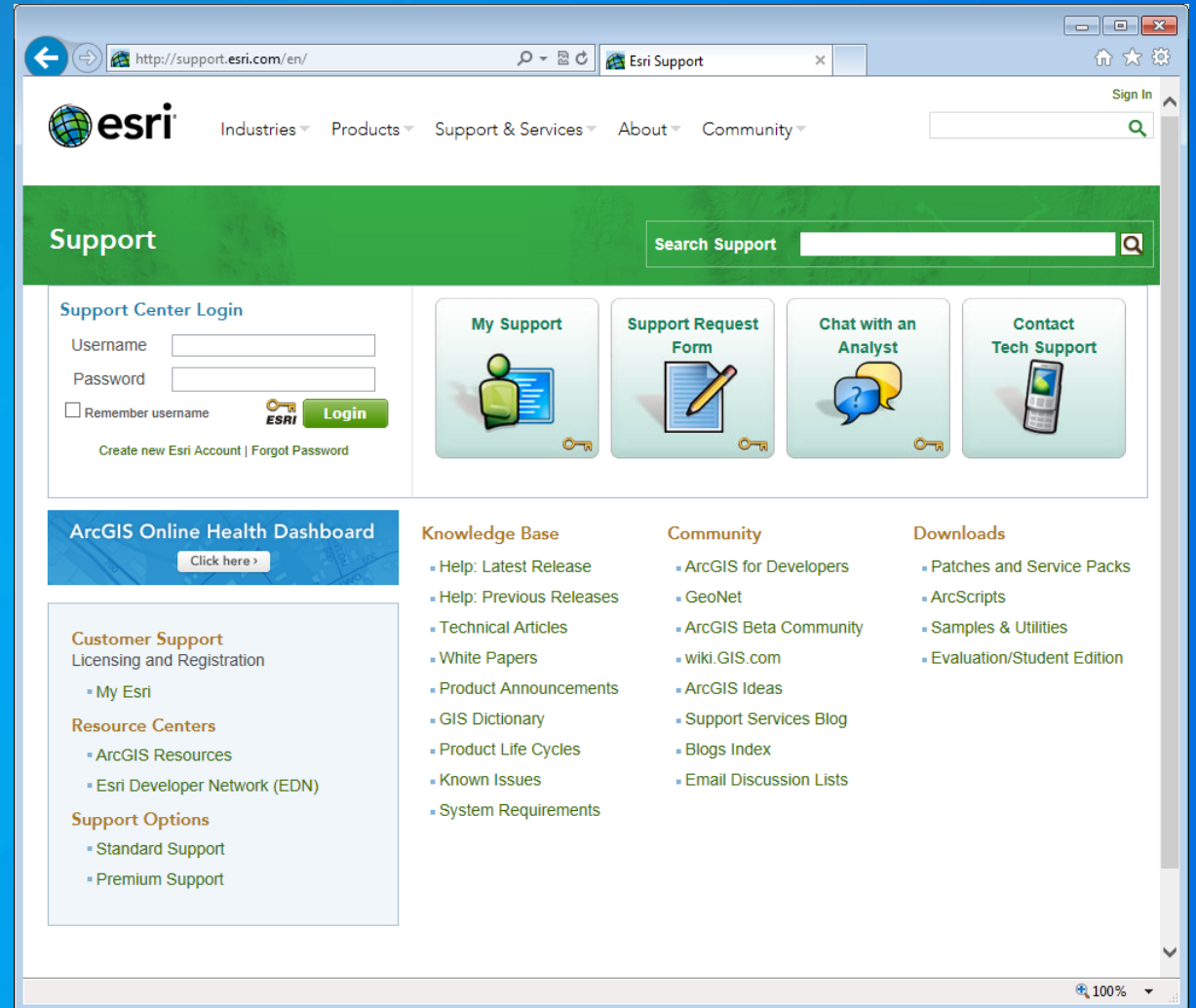
- **Field evaluator**
 - Read in values from a field; and/or
 - Perform calculations using multiple field values
 - Example attributes: Length, DriveTime, Oneway
- **Constant evaluator**
 - Same attribute value across all network elements
 - Example attribute: TurnRestriction
- **Custom logic**
 - Initial prototyping with VB Script evaluator
 - Final implementation using Custom evaluator
 - Better performance



Support and Resources

Esri Support Center

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



<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 recorded training seminar**
 - Using Network Analyst in ArcGIS Desktop 10
 - <http://training.esri.com/gateway/index.cfm?fa=catalog.webCourseDetail&CourseID=1955>

Network Analyst 30-Minute Technical Workshops

- **Network Analyst – Performing Network Analysis**
 - Tuesday 3:00pm-3:30pm, General Theater 3
 - Wednesday 3:00pm-3:30pm, General Theater 3
- **Network Analyst – Network Analysis with ArcGIS Online**
 - Tuesday 4:00pm-4:30pm, General Theater 3
 - Wednesday 12:00pm-12:30pm, General Theater 1

All General Theaters are located downstairs in Exhibit Hall A

Other Network Analyst 75-Minute Technical Workshops

- **Network Analyst – An Introduction**
 - Wednesday 8:30am-9:45am, Room 16B
 - Thursday 10:15am-11:30am, Room 15A
- **Network Analyst – Automating Workflows with Geoprocessing**
 - Wednesday 10:15am-11:30am, Room 16B
 - Thursday 1:30pm-2:45pm, Room 15A

Network Analyst Demo Theater Presentations

- **Network Analysis with Python**
 - Wednesday 10:30am-11:15am, Analysis and Geoprocessing Theater
- **Network Analyst in ArcGIS Pro**
 - Wednesday 2:30pm-3:15pm, Analysis and Geoprocessing Theater
- **Using GTFS Public Transit Data in ArcGIS**
 - Thursday 11:30am-12:15pm, Analysis and Geoprocessing Theater

All Demo Theaters are located downstairs in Exhibit Hall B



Understanding our world.