Traversing the Time Dimension in GIS

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Time is Essential to Transportation

• Transportation is the movement of people or goods from one location to another.

• Each transportation movement takes place over some period of time.

• Time is a fixed resource that is the same for everyone.

• The primary objective of nearly all transportation systems is to minimize time spent in transit.
Historically, transportation planning practice has dealt with the time dimension very simplistically:

- Planning forecasts typically compare scenarios for a fixed “horizon year” with a single set of defined demographic conditions.
- Scheduling of transportation improvement activities is often not coordinated across offices or agencies, resulting in unnecessary disruption of traffic and cost duplication.
- Travel demand models utilize travel times based on “average congestion levels” for a small number of daily time periods (e.g., peak, off-peak, mid-day).
- Real-time traffic conditions used for traveler information and operations have not typically been used to develop travel time variables for travel demand models.
Emerging Planning Tools that Better Address Time Dimension

- **Dynamic Traffic Assignment**
  - Accounts for variations in traffic volume over time throughout the day

- **Master Networks**
  - All changes to a base-year network are managed as time-based activities with start and end dates

- **Traffic Simulation Models**
  - Visualize individual vehicle movements through a transportation network over time

- **Real-Time Traffic Data**
  - Continuously collected travel times can be aggregated/averaged to various time periods
Focus of Today’s Presentation

1. Developing planning scenarios within a master network

2. Utilizing real-time traffic data for planning applications

3. Applying traffic simulation models for analyzing projects
MASTER NETWORKS
Characteristics of a Master Network:

- Topologically connected polyline geospatial database
- “Base network” contains line segments and nodes representing existing transportation infrastructure
- Proposed projects are represented as edits to the base network.
- Specific edits are grouped into a common activity, with start and end dates for each activity.
- Related activities are grouped into a project, which represents a complete identifiable infrastructure improvement.
- A scenario is a collection of projects that depicts a complete, topologically connected network that is used for forecasting.
  - Projects may be assigned to different scenarios
  - Projects can appear in more than one scenario
Example: Upgrade US 44 in Massachusetts

Base-Year Network
- At-grade intersection
- US 44 is undivided hwy
Project 1: Add center median along US 44

Activity 1 (6/30/2018)
Add median to US 44

Single Node

Dual, one-way centerlines on US 44
Scenario 1: Create grade-separated interchange at MA 118

Activity 2  (6/30/2019)  
Convert US 44 - MA 118 to Diamond Interchange

Remove node and merge line segments

Add 4 new one-way line segments

Add nodes where new ramps intersect US 44 and MA 118
Scenario 2: Create traffic circle at interchange with MA 118

Scenario 2: Replace diamond interchange with traffic circle

- Remove node at intersection
- Remove line segments within traffic circle
- Add 6 nodes where traffic circle joins existing road segments
- Add 12 new line segments for traffic circle and approach lanes
Summary

• Activity
  - Represents a change to base network topology
  - Includes a time stamp indicating when network change becomes effective
  - Stored as an independent “piece” of the network in the master network

• Project
  - Collection of one or more activities
  - Effective project date is the date of the last activity

• Scenario
  - Collection of one or more projects
  - Projects can appear in more than one scenario
  - Represents a complete topological network that can be used for traffic assignment
REAL-TIME TRAFFIC DATA
REAL-TIME TRAFFIC DATA (ARCHIVED)

Example using NPMRDS data:

- One month of archived data for travel time for a daily period
- Traffic Message Channel (TMC) geography conflated to desired line layer (planning network)
- Tens of millions of data records processed on the fly using SQL query
- Travel time data stored, accessed, and aggregated via SQL database
- Tool enables querying of data by day of week, time of day, vehicle class, and desired performance measure (delay, speeds, congestion index)
- Query result is joined to GIS layer and thematically displayed
- Data easily refreshed utilizing monthly updates from NPMRDS program
- Process can be implemented using similar third party data from HERE, INRIX, or other providers
Display Results Using Thematic Mapping

PM Period Traffic Congestion

AM Period Delay
TRAFFIC SIMULATION MODELS
GIS-based Traffic Microsimulation

- Time plays critical roles in traffic microsimulation
- Lane-based network initially derived from street centerline files with temporal capabilities
- Traffic demand, signal timing, and vehicle positions are all highly time dependent and vary by time
- Advanced applications, such as managed lanes and work zone analysis are also heavily reliant on temporal relationships, as is dynamic traffic assignment
GIS-based Traffic Microsimulation

Real-time Traffic Density

Temporal Travel Demand

Signal Controller State