Presentation at DTALite/AgBM Training Workshop
7/2/2015, University of Maryland

DTALite/NEXTA

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DTALite/NEXTA Introduction

Part 1: Introduction & Project Overview

Outline

1. **Introduction & Project Overview**
2. DTALite Capabilities & Modeling Approach
3. Software Demonstration
4. Introduction to Workshop Exercises

Project Objective

Enhance DTALite to provide a rigorous and computationally efficient tool to evaluate road pricing and crash-reduction strategies

The enhanced tool will enable practitioners to:

- Assess corridor and network-wide effects
- Conduct numerous alternatives analyses
- Evaluate recurring and non-recurring congestion
- Calculate performance measures that can be applied in investment-level planning and decision making

Workshop Purpose and Objectives

Purpose

- Educate workshop attendees on Dynamic Traffic Assignment modeling through hands-on exercises using the open-source DTALite software tool

Learning Objectives

- Understand basic modeling approaches in DTALite
- Import data to code and modify a subarea network
- Analyze toll facilities, work zones, and predict crashes
- Evaluate simulation results using the visualization and reporting features in NeXTA

Motivations

- Existing technical barriers: (based on DTA user survey, TRB network modeling committee, 2009)
  - Require too many input data: 47%
  - Take too long to run: 35%
  - Model is unclear: 35%

Our goals

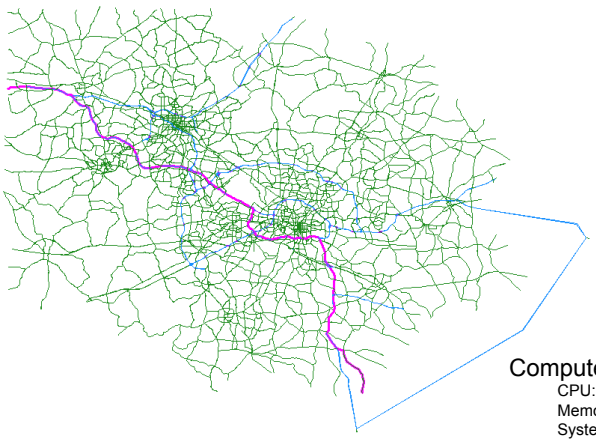
- Simplified data input from static traffic assignment
- Use parallel computing capability, simplified routing and simulation
- Open-source
  Visualization: Seeing is believing
  Excel Tools: Start from basics

What NeXTA/DTALite Can Do

1. Open-source traffic simulation/modeling Data Hub
   1. Connection with signal optimization (Synchro) or microscopic simulation (VISSIM)
   2. Integrated simulated and measured data management tools
2. Large-scale dynamic traffic assignment
   1. Typical network size: 2000 zones, 20K links,1-2 Million vehicles
3. Network scenario analysis
   1. Road pricing application: Consider time-dependent toll, Heterogeneous Value of times
   2. Emission study: Fast simulation for emission analysis (with MOVES Lite)
   3. Safety planning: Predict annual crash rates based on link type and traffic volume

1. Fast Simulation

– A rigorous and computationally efficient tool to evaluate numerous alternatives analyses



Network Statistics
Triangle Corridor Network (NC, USA)

Zones = 2,389
Nodes = 9,528
Links = 20,258
Signals = 1,914
AM Trips = 1,064,703
Households = 490,000

2 min. 45 sec. / iteration
1hour for 20 iterations

Computer System Specification:
CPU: Intel i7-2960XM @ 2.70 GHz *8
Memory: 16.0 GB
System Type: 64-bit Windows 7

2. Rich Output

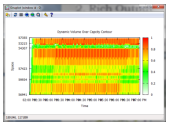
NeXTA

Large-scale Dynamic Traffic Assignment & Simulator

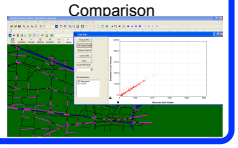
Google Earth/Maps

Other Visualization

Corridor-level VOC contour

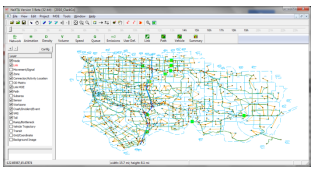


Simulation vs. Observation Comparison

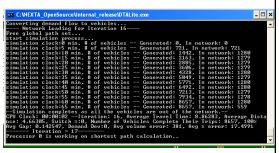


Open-source Free Software Package

- NEXTA: front-end GUI (C++)
  - Version 2: GUI for TRANSIMS and DYNASMART
  - Version 3: GNU Open-source data hub
    - Import
      - Other regional planning models (TransCAD, VISSUM, Cube)
      - GIS shape files (household data without node layer)
      - Traffic volume, speed, GPS data, Google Public Transit Feed
    - Export
      - Google Earth, Google fusion tables
      - Prepare network and signal data for Synchro and VISSIM (through QEM)



- DTALite: Open-source computational engine (C++)
  - Light-weight and agent-based DTA
  - Built-in OD demand matrix estimation (ODME) program



System Overview

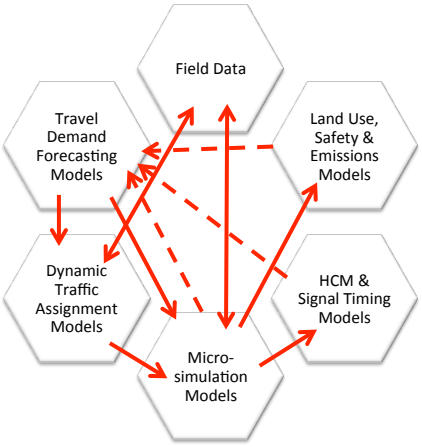
1. NeXTA as Open-source data hub
2. DTALite Models
   a. Traffic flow models
   b. Agent-based modeling
3. Streamlined work flow

Overview 1: Open-source Data Hub

- Problem Statement
  - Transportation decision making is complex; requires consideration of multiple levels of analysis or domains
  - Many integrated modeling practices are ad-hoc

Integrated Modeling Practice

Current Practice
Ad Hoc



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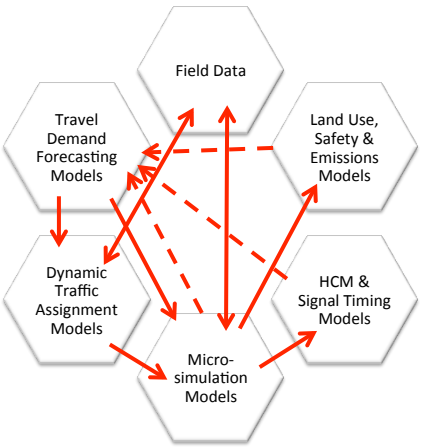
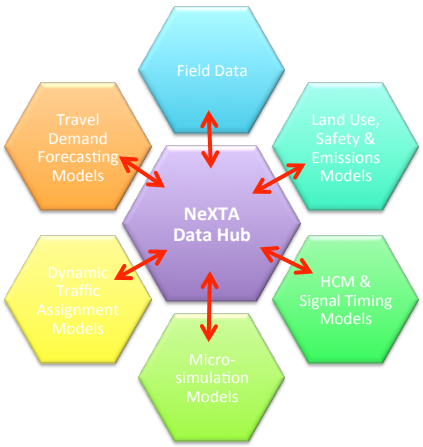


With NeXTA Data Hub
Systematic



Overview 2: Brief Introduction to DTALite

- Agent-based simulation
- Capacity-constrained model
- Traffic simulation models
  - BPR, volume-delay functions
  - Point Queue
  - Spatial Queue (with jam density)
  - Newell's Model (Kinematic wave model)

Common Assignment Methods

- Traffic Analysis Zone (TAZ)-based
  - From zone centroid to zone centroid
  - The same value of time for each type of vehicles
- Agent-based
  - From activity location to activity location
  - Each vehicle has its own value of time, value of information
  - Important for road tolling analysis, traveler information provision study

Agent-Based Routing

- Routing performed for each individual agent
- Each agent has multiple dimensions of travel decisions
  - Origin, destination, departure time, path
  - Demand class (LOV, HOV, truck) or (HBW, HBO, NHB)
  - Information class (Historical, Pre-trip, En-route)

Agent-Based Routing

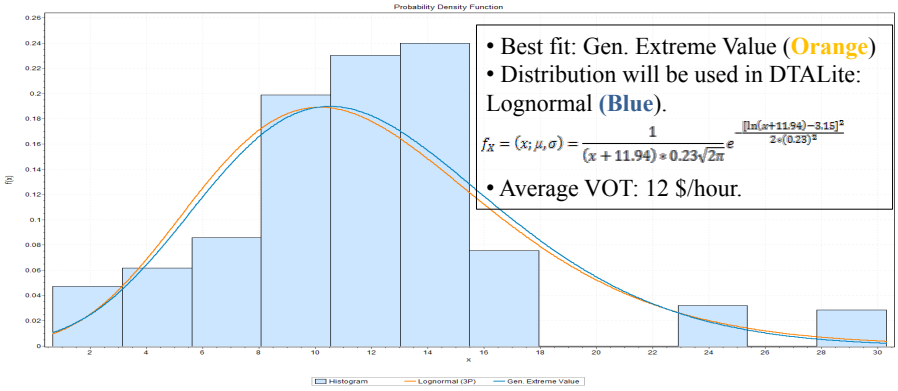
- Individual generalized cost function

$$Cost = Travel\ Time * VOT + Toll$$

  - Can consider multiple factors
    - Value of time, Value of reliability, Value of safety
  - Perform routing algorithm individually for each vehicle/agent
  - Can adjust origin/destination/departure time/ path at each iteration (day)

Example: VOT Distribution

- Assumption:
  - VOT : 50% of hourly rate (Concas and Kolpakov, 2009)

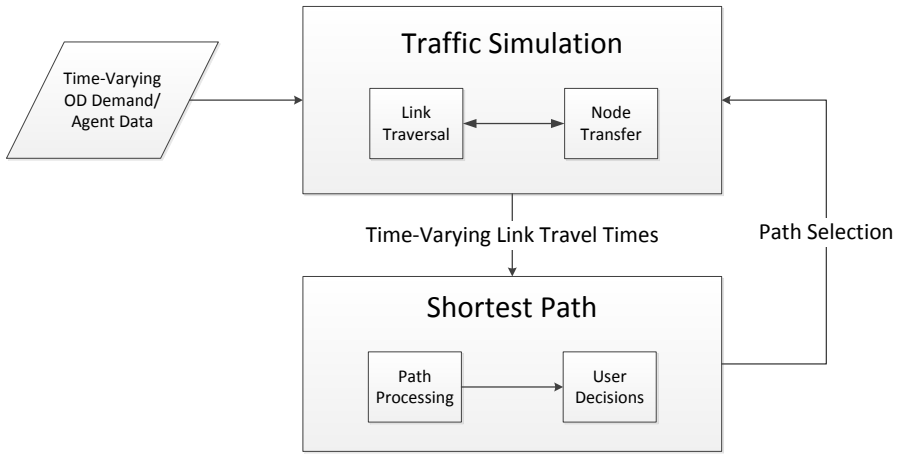


- Best fit: Gen. Extreme Value (Orange)
- Distribution will be used in DTALite: Lognormal (Blue).

$$f_X = (x;\mu,\sigma) = \frac{1}{(x+11.94)*0.23\sqrt{2\pi}} e^{\frac{-[\ln(x+11.94)-3.15]^2}{2*(0.23)^2}}$$

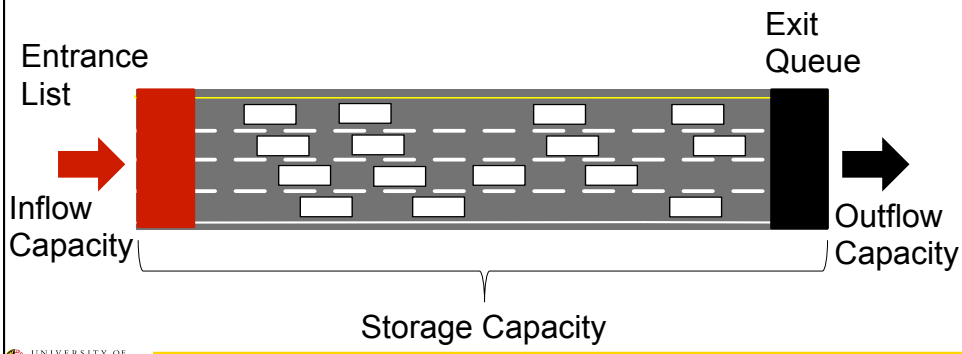
- Average VOT: 12 $/hour.

Traffic Simulation



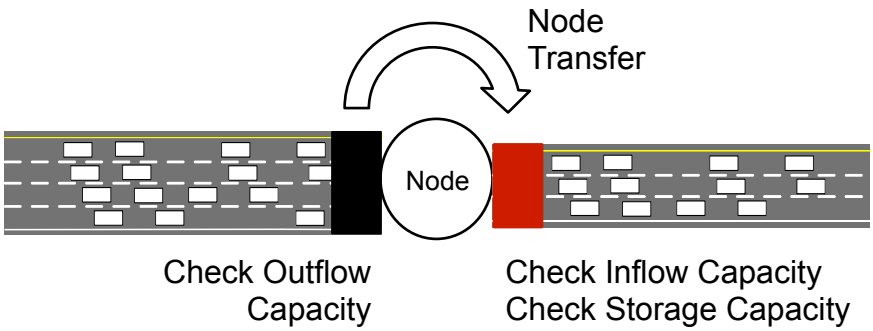
Traffic Simulation Details

- Outflow capacity
- Inflow capacity
- Storage capacity



Traffic Simulation Details

- Node transfer

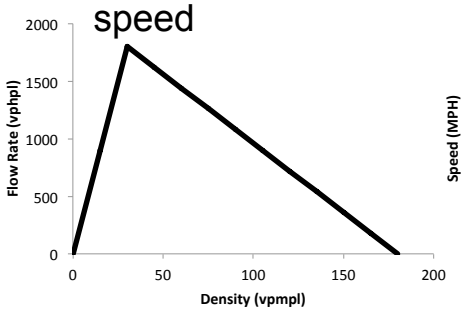


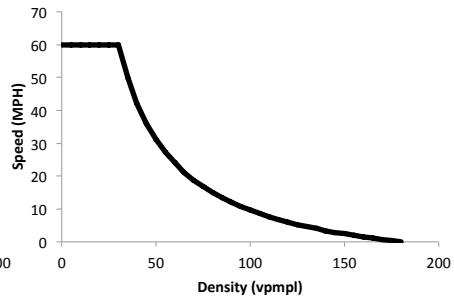
Multiple Traffic Flow Models

- BPR travel time functions
- Point queue (relaxed storage constraints)
- Spatial queue (similar to DYNASMART-P/Dynus-T model)
- Newell's model (similar to Cell Transmission Model)
  - Shockwave propagation

Traffic Flow Model (on the Link)

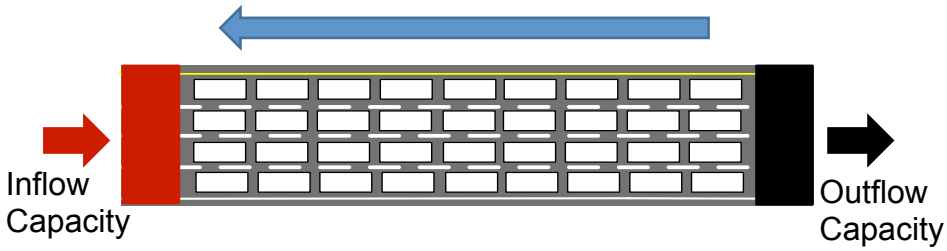
- Newell's simplified kinematic wave model
  - Triangular flow-density relationship
  - Free flow speed, jam density, backward wave speed





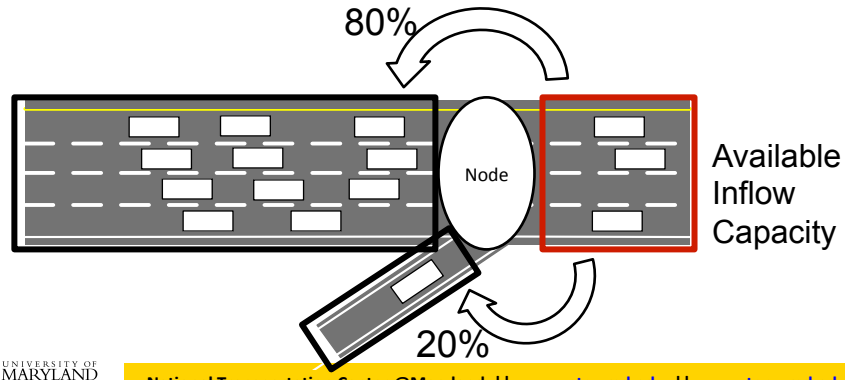
Traffic Flow Model (on the Link)

- Queue propagation
  - Inflow capacity = outflow capacity



Merge Models

- Distribute inflow capacity to upstream links
  - Lane & demand-based methods

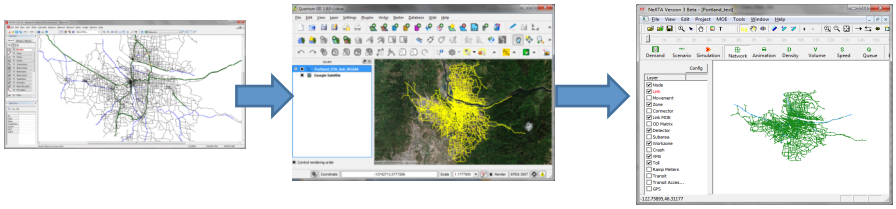


Overview 3: Streamline Workflow

1. Network Import
2. Demand Preparation
3. Simulation and Calibration
4. Data Visualization and Analysis
5. Signal Timing Estimation

Step 1: Network Data Importing

- Import GIS node/link/zone shape files
- Utilize Open-source Geospatial Data Abstraction Library (GDAL) library
- Script for mapping planning data set to NEXTA data hub



VISUM | Open-Source Q-GIS | Open-Source NEXTA GUI

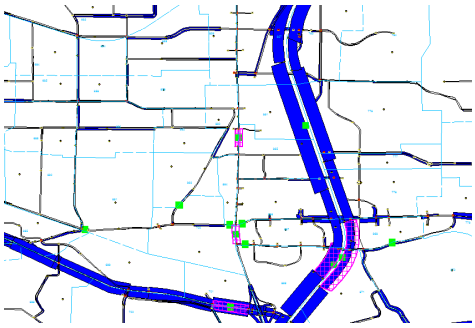
Step 2: Meta Demand Database Management

- Allow a flexible number of demand files
- Allow different formats
- Allow user-defined loading period, departure time profile

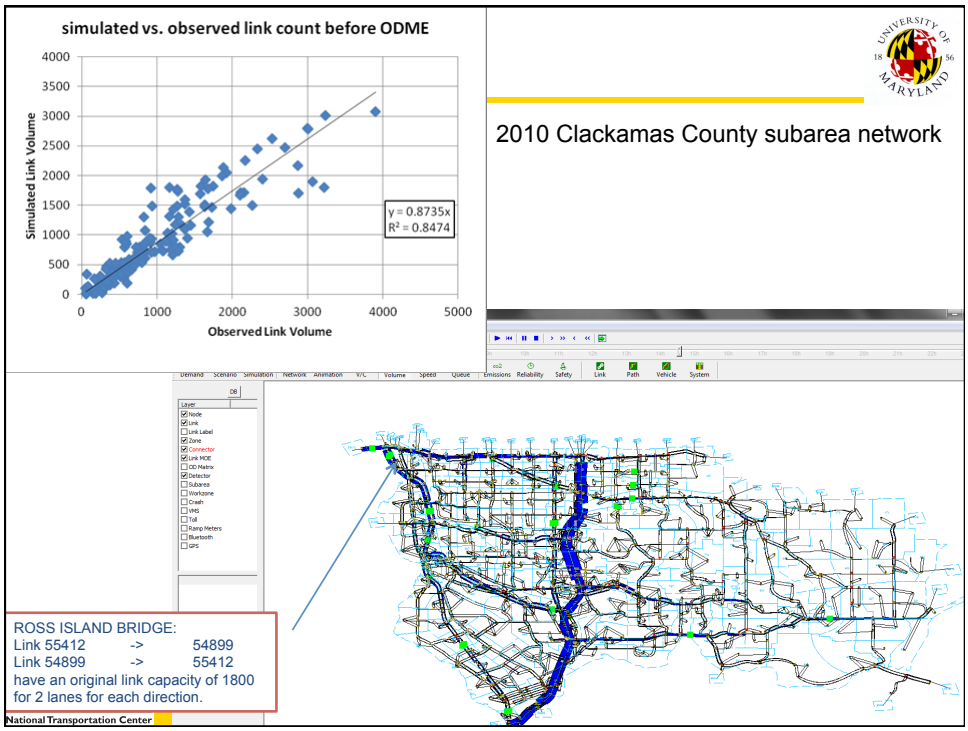
file_name	format_ type	start_time in_min	end_time in_min	14:00	14:15	14:30	14:45
Demand_Data\\SOV_14_15.csv	matrix	840	900	0.2	0.2	0.3	0.3
Demand_Data\\HOV_14_15.csv	matrix	840	900	0.1	0.3	0.3	0.3
Demand_Data\\HPCE_14_15.csv	matrix	840	900	0.2	0.2	0.3	0.3
Demand_Data\\MPCE_14_15.csv	matrix	840	900	0.2	0.2	0.3	0.3

Step 3: Network Coding/ Debugging/ Calibration

- Reduce editing and debugging efforts
- Visualization and validation



Purple band: observed volume vs. Dark blue band: simulated volume

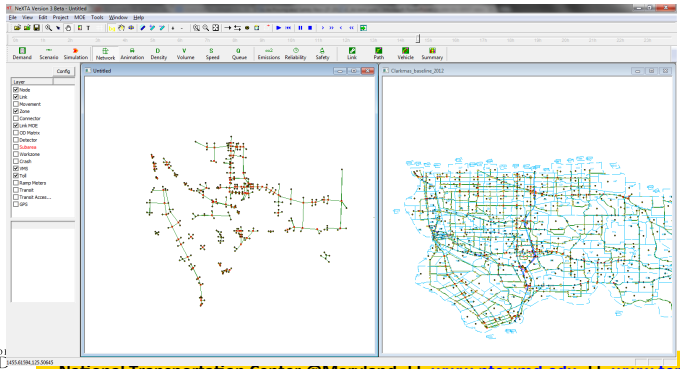


Step 4: Use Visualization to Compare Multi-scenario Runs and Understand MOEs

- Enable multiple scenario runs
  - Each scenario can have different values of pricing, capacity reduction, route choice parameters, demand levels
- Multiple types of MOEs
  - Network, vehicle type, demand type, link-based, path based, OD based…
- User defined paths to produce path travel times

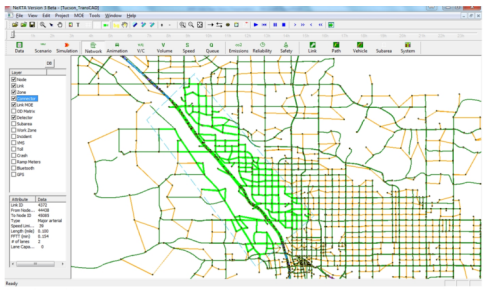
Step 5: Connection to Synchro and QEM

1. Import Synchro data directly to NEXTA
2. Match nodes using two layers
3. Fetch signal data from Synchro layer for DTALite



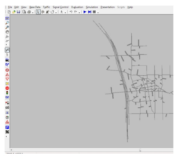
Signal Model: From Simplified Model to Microscopic Simulation

- QEM Spreadsheet Model:
- HCM 2010 methodology
- Estimate signalized intersection capacities
- 1 min execution time for estimating phasing data for 60 intersections, using given movement volume from DTA



NEXTA

QEM



Export to Synchro and VISSIM

Outline

1. Introduction & Project Overview
2. **DTALite Capabilities & Modeling Approach**
3. Software Demonstration
4. Introduction to Workshop Exercise

DTALite/NEXTA WorkShop Exercise

Introduction to Workshop Exercise

Useful Materials

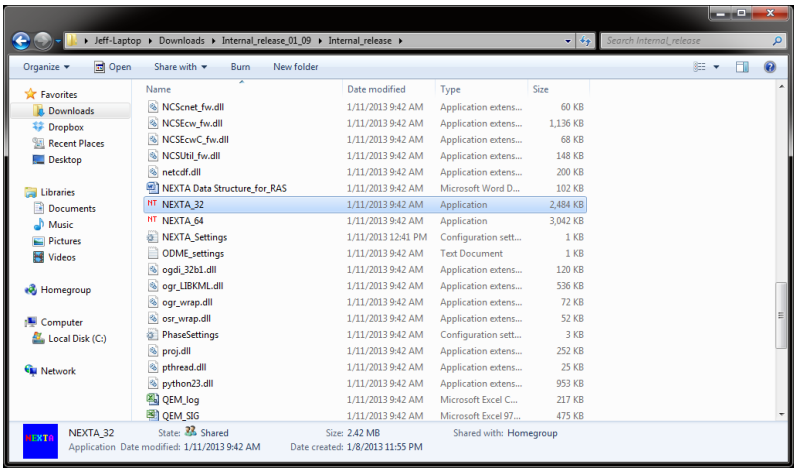
- Project Development Website
  - https://code.google.com/p/nexta/
- NeXTA/DTALite Training Materials
  - https://sites.google.com/site/nextadtalitetraining/
- Support: User's Forum
  - https://groups.google.com/forum/#!forum/nexta-dtalite

Workshop Exercise

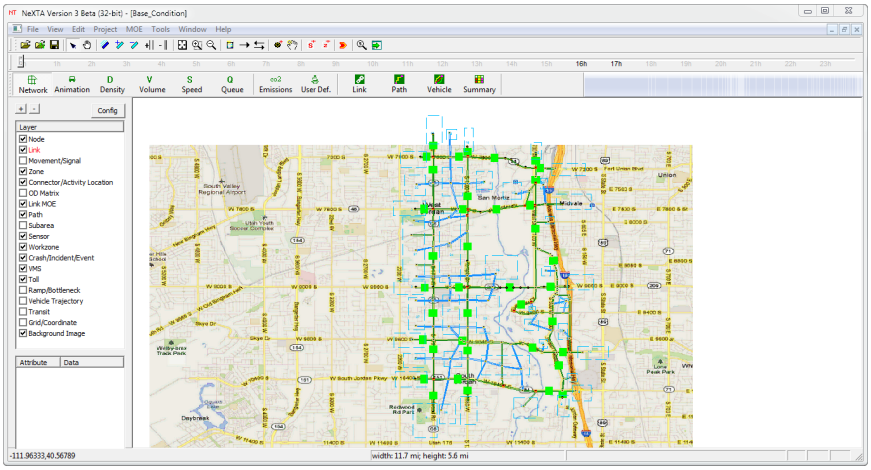
- Lesson 1.1: Importing & Exporting Networks
  - https://sites.google.com/site/nextadtalitetraining/course-materials/lesson1/lesson-1-1
  - Alternative: Instructions on Google Drive
    - http://www.learning-transportation.org
- Learning Objectives
  1. Understand how to view/edit network attributes in NeXTA and GIS
  2. Run a basic traffic simulation, comparing two different scenarios
  3. Understand how basic network attributes affect traffic simulation results

Steps 1.1-1.2: Download & Open NeXTA

– Project Website: https://code.google.com/p/nexta/

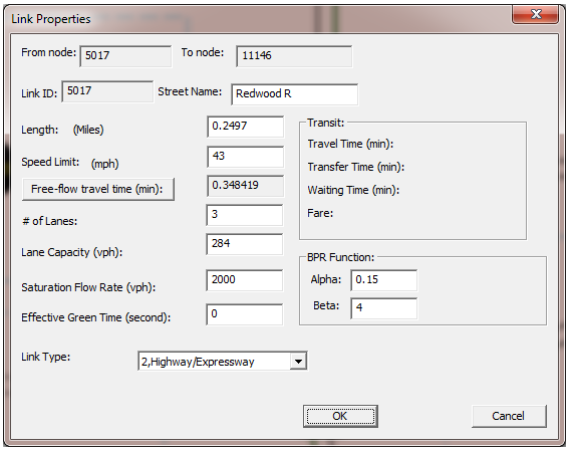


Step 1.3: Open West Jordan Network



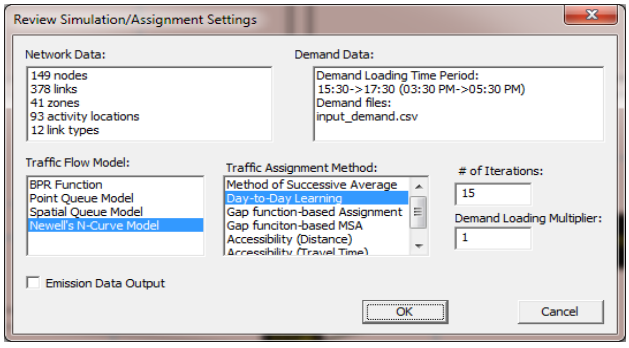
Step 2: Viewing Attributes in NeXTA

- Right-click near links to view attributes



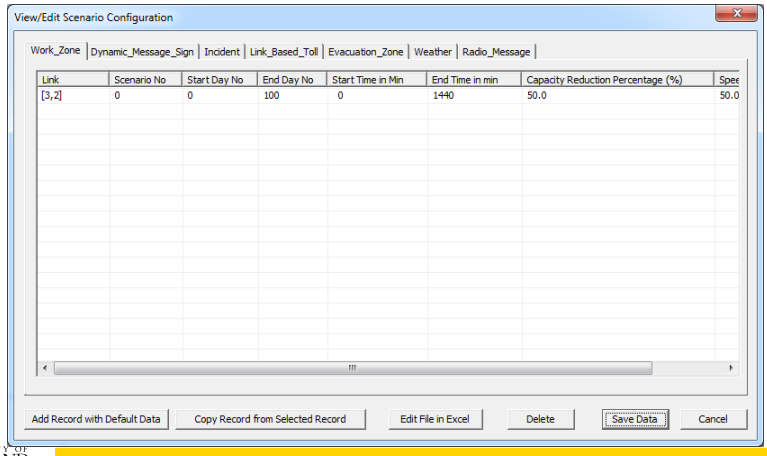
Step 3: Traffic Simulation with DTALite

- Objective: Subarea analysis for work zone comparison
- Establish baseline conditions without work zone



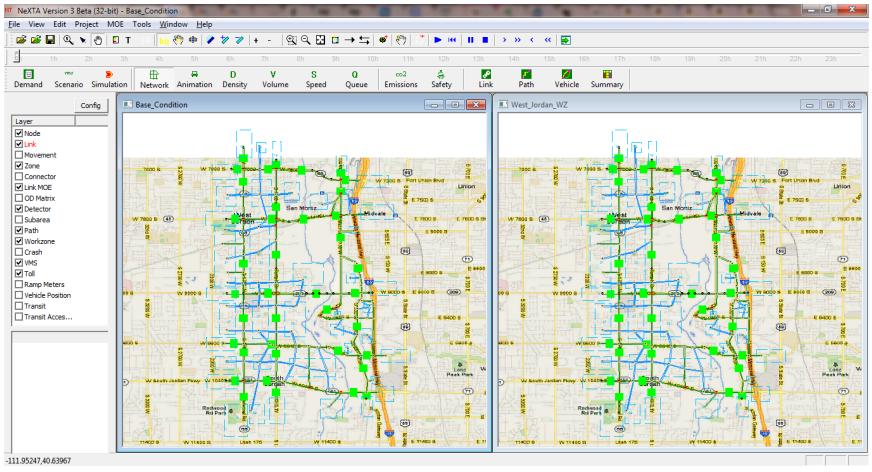
Step 4: Create a Work Zone

- Define work zone attributes, and run assignment again



Step 5: Comparing Simulation Results

- Synchronized display in NeXTA



Module 3: Modeling Approach

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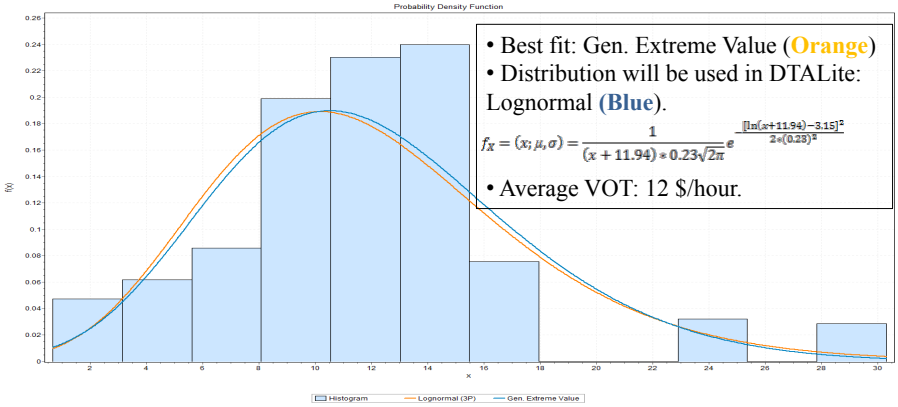
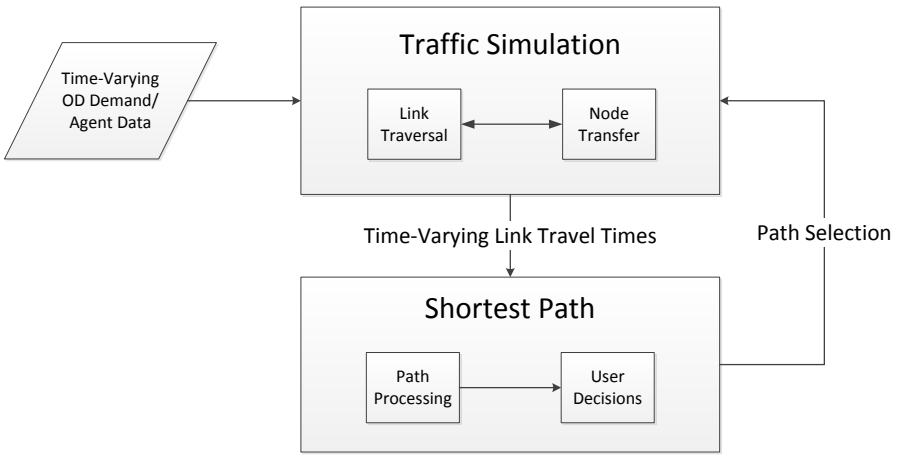
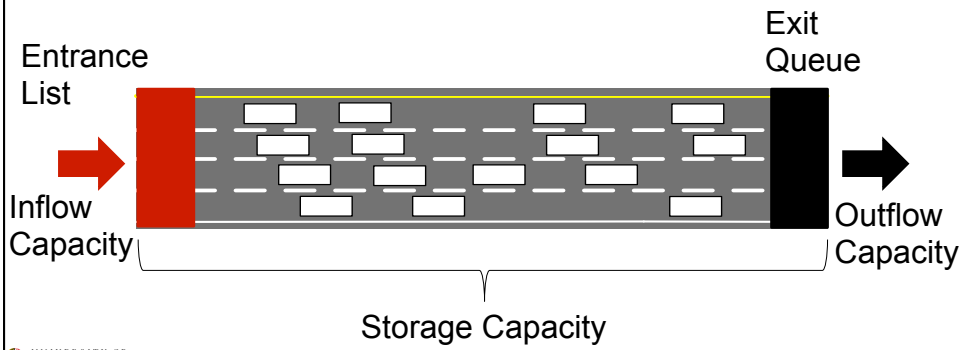


Traffic Simulation



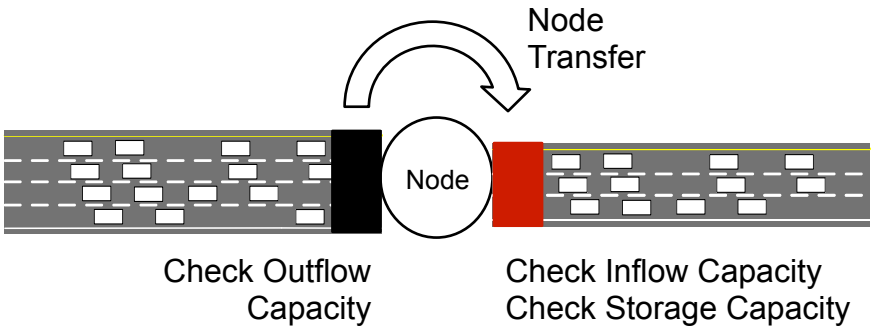
Traffic Simulation Details

- Outflow capacity
- Inflow capacity
- Storage capacity



Traffic Simulation Details

- Node transfer



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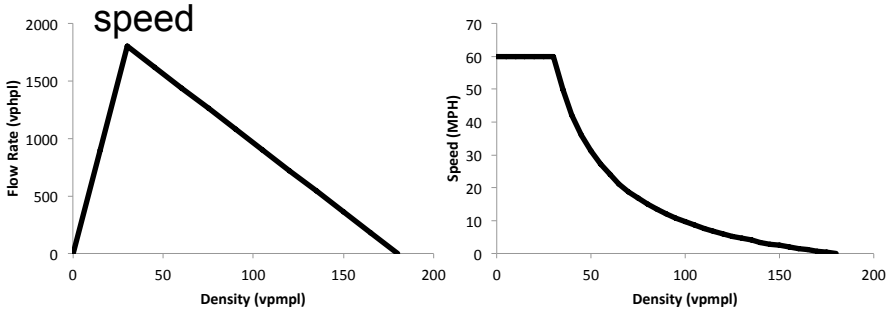
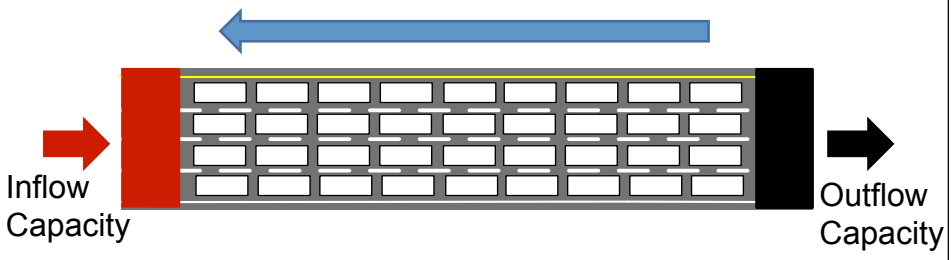


Traffic Flow Model (on the Link)

- Queue propagation
  - Inflow capacity = outflow capacity

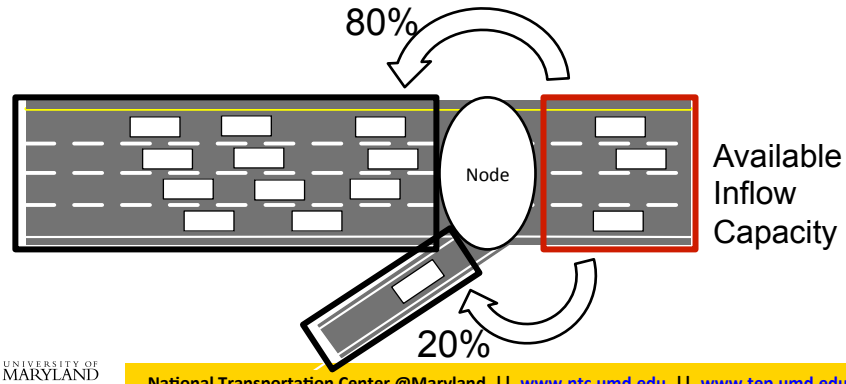


Special Conditions

- Merge/diverge points
- Intersections

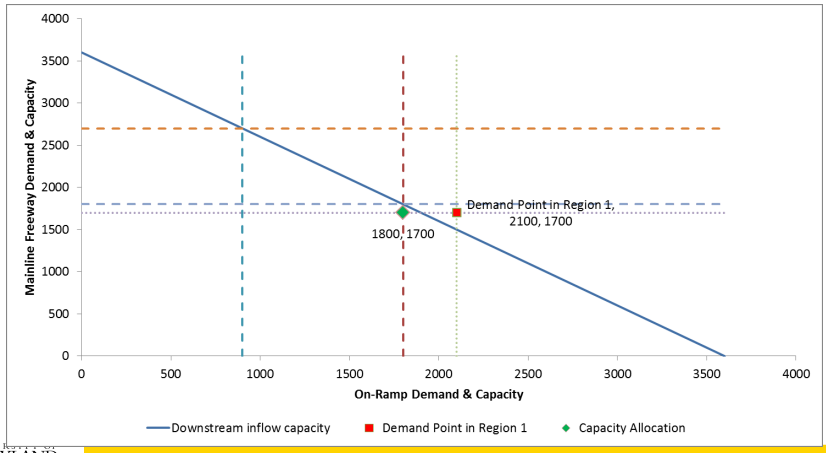
Merge Models

- Distribute inflow capacity to upstream links
  - Lane & demand-based methods



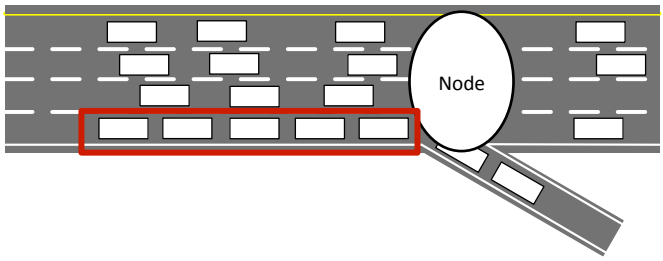
Inflow Capacity Distribution

- Dynamic capacity distribution



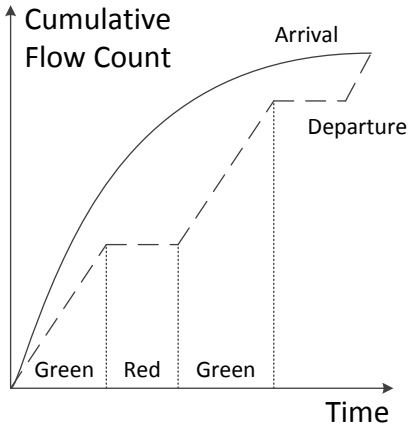
Diverge Models

- Different conditions by lane
- First-In-First-Out (FIFO) constraint
  - Relaxation to prevent extreme bottlenecks



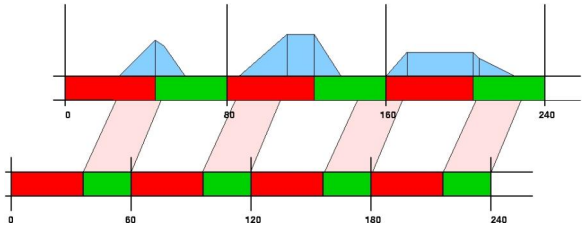
Signalized Intersections

- Simplified representation in DTALite
  - Effective green time, saturation flow rate, movement-based capacity
  - Relaxed inflow constraints



Signal Timing & Hourly Capacity

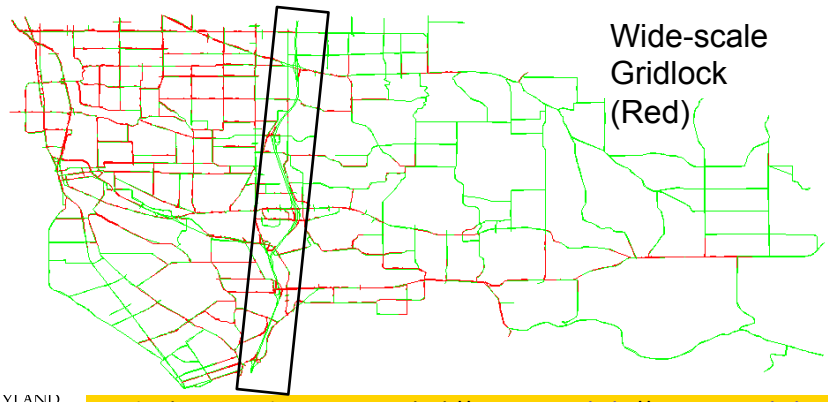
- Input: Average hourly capacity, cycle time, offset at node
- Output: Effective green time per cycle (capacity/saturation flow rates)



Clackamas Network Modeling

Converting from Macro to Meso

- Directly import important network attributes
  - Capacity, speed, number of lanes, etc.



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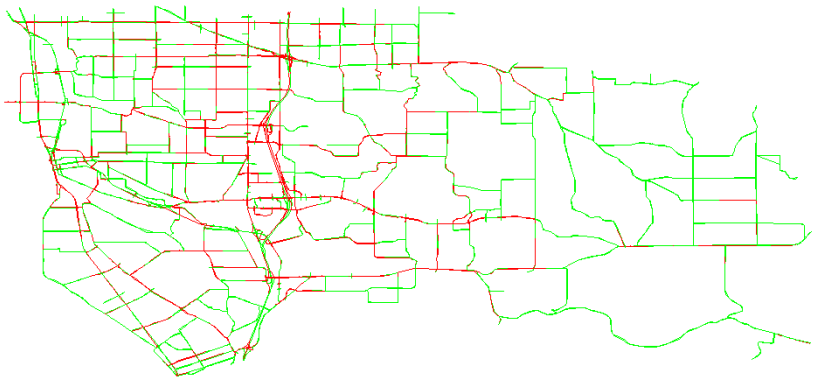
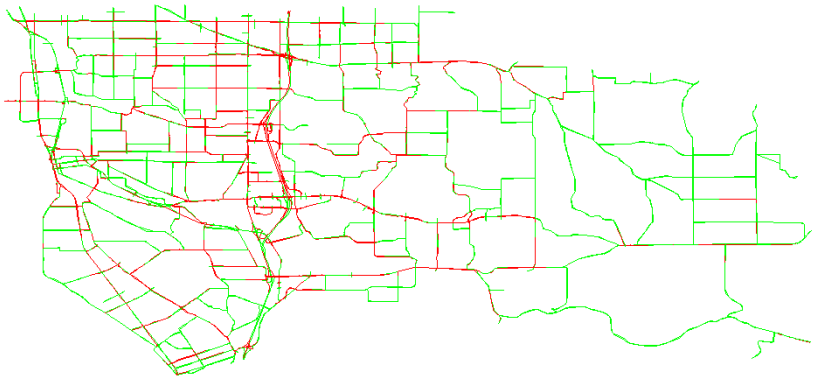
Second Attempt

- Increased ramp outflow capacity
  - Still experiencing significant queuing



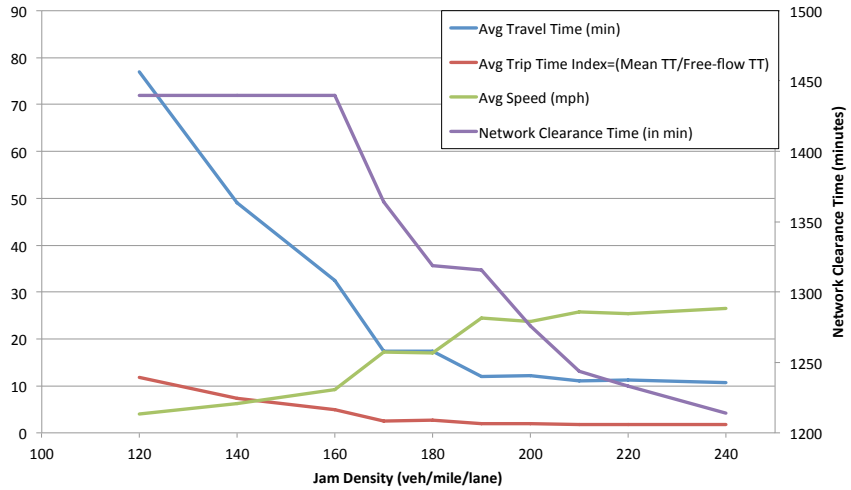
Inflow/Storage Capacity?



Geometry Details

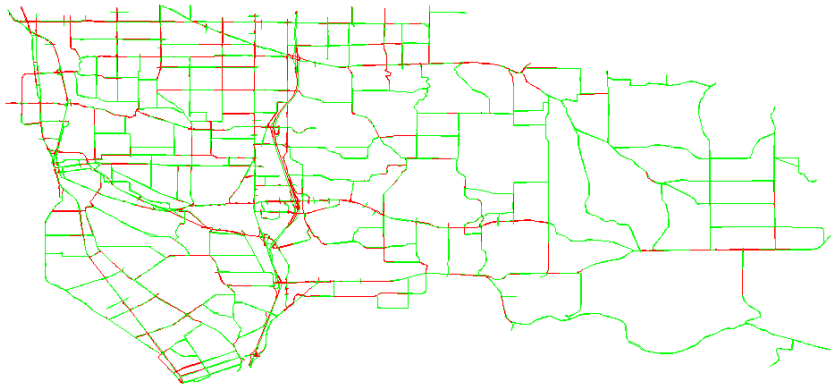
- Two-lane ramp, coded with one lane
  - Reasonable outflow capacity
- Potential issues
  - Underestimated inflow capacity
  - Underestimated storage capacity

Traffic Flow Model Sensitivity



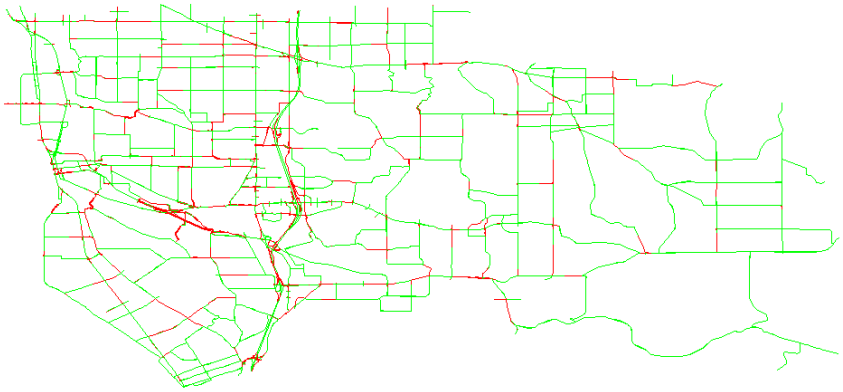
Third Attempt

- Reset outflow capacity, adjusted inflow & storage capacity



Combined Modifications

- Combination of adjusting outflow and storage capacity appears more reasonable



Recommended Diagnostic Procedures

1. Macroscopic capacity may not be appropriate for mesoscopic capacity constraints
2. Understand the traffic flow model
   – Understand limitations, special cases
3. Adjust capacity before OD demand, path flow
4. Start with fewer capacity constraints to remove possible unrealistic bottlenecks
   – Point queue → Spatial queue → Shock wave → Speed-density relationships

Thank You!

Questions, Comments, and Suggestions are Welcome. Please Contact:

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