High Performance Computing Traffic Simulations for Real-time Traffic Control of Mobility in Chattanooga Region

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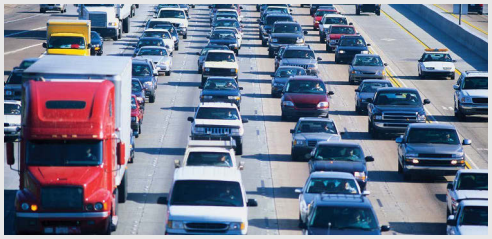
Introduction

In 2019, highway congestion wasted 3 billion gallons of fuel and caused 8.8 billion hours of lost productivity.[1] Research shows that near-real time traffic controls can significantly reduce congestion.



Congested Highway in Tennessee

Validated and calibrated simulations enable:

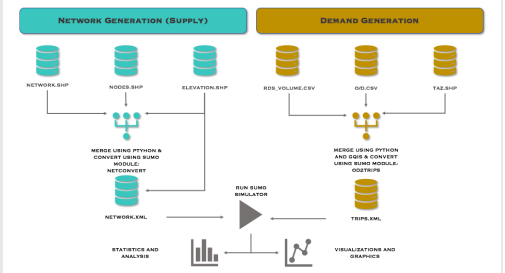
- Modeling of transportation systems
- Evaluating different traffic control actions and schemes
- Inform deployment of near real-time controls to improve traffic congestion and energy use.

SUMO Simulations:

We used Simulation of Urban Mobility (SUMO) software to build simulations to:

- Model traffic in Chattanooga region
- Allow development and assessment of traffic control strategies to increase mobility energy efficiency.

Traffic simulation pipeline involved 2 main sub-tasks: network generation and demand generation, as shown below.

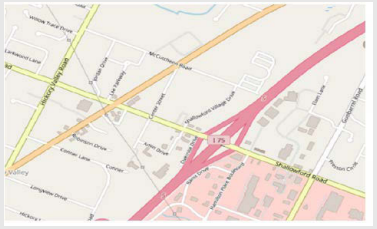


1. Schrank, David, et al. "urban mobility scorecard. 2019.", https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2019.pdf

SUMO Microscopic Simulation

Microscopic model in SUMO simulates the behavior and dynamics of each individual vehicle in traffic including acceleration, deceleration and lane changing. The vehicle model is based on Krauß car-following model.

Research team and Chattanooga DOT identified Shallowford Rd. arterial as candidate for the microscopic simulations.

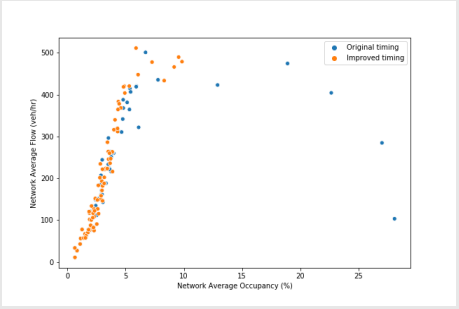


Shallowford Rd. Region

- Signal timing provided by Chattanooga DOT
- Demand calibrated hourly with SUMO Calibrator using network volume estimates.
- Simulation conducted for seven hours.
- Edge-level traffic flow characteristics evaluated throughout the simulation.

Simulation Results:

To visualize the traffic state of the whole arterial, we plotted the Network Fundamental Diagrams (NFDs).

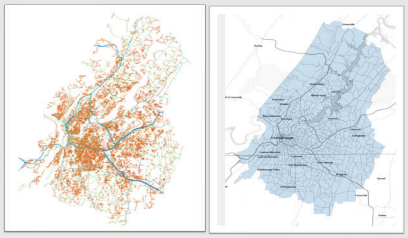


Comparison of NFDs for Shallowford Rd: Original Signal Timing vs Improved Timing

SUMO Mesoscopic Simulation

Mesoscopic model simulates single vehicles with simplified traffic dynamics, where road lanes are represented by queues:

- Accurate representation of aggregate traffic measures
- Estimated to run 100 faster than microscopic model
- More appropriate for regional simulations

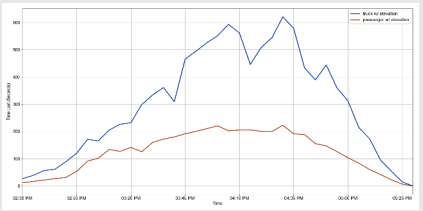


Chattanooga Regional Network

- Simulated Afternoon peak 2:30pm – 5:30pm

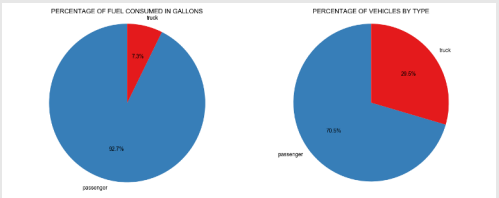
Simulation Results:

Elevation has a greater impact on trucks than passenger as anticipated, shown through time loss:



Time Loss of Trucks and Passenger Vehicles

Trucks contributes 29% of fuel even though they make up about 7% of the total traffic:



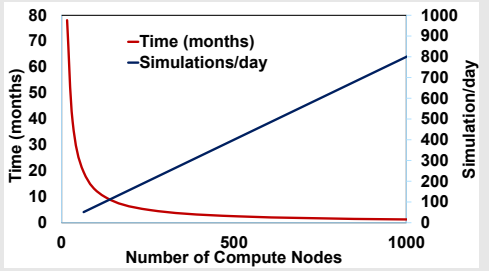
Fuel Consumption of Trucks and Passenger

High Performance Computing (HPC)

HPC is the application of supercomputers to computational problems that are too large or take too long on standard computers.

A supercomputer is at least 100 more powerful than a PC. We used Eagle supercomputer at NREL for fast simulations.

Eagle Supercomputer at NREL



HPC: performance improves with more nodes can solve larger problem in less time

Next Steps

- Simulation validation and calibration
- Develop a Ring-Barrier controller module for SUMO
- Develop responsive and adaptive traffic control strategies to reduce fuel consumptions
- Extend simulation to evaluate traffic control decisions
- Run ensemble simulation on HPC that simulate likely future scenarios

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