Measuring the Emissions Impact of a Traffic Control Change

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TRB Workshop on Simulation Modeling and Analysis of the Effect of Operational Strategies on GHG Emissions

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Overview

- Motivation
- Other Efforts at Microsimulation-Air Emissions Modeling
- The Analysis Testbed – An Intersection Control Change
  - Signalized Intersection – Roundabout – All Way Stop
- Connecting a Microsimulation Model to MOVES Using a Link Drive Schedule
- Results and Recommendations

Motivation – Why Connect Operational Models with Emission Models

- Regulatory requirement: EPA May 2010 guidance for performing "project-level" transportation conformity analysis (CO, PM)
- Increasing Need from Other Quarters of Society for Tools to Estimate Emissions Impacts of Traffic Operational Changes
  - CMAQ requirement of the emissions benefits of a proposed project
  - City of Portland, OR – CO2 offsets from signal optimization
  - State regulations (e.g. Massachusetts Environmental Policy Act)
  - Sustainability initiatives (e.g. University of New Hampshire)
  - "In recent years,…analysis needs have expanded in response to statutory requirements that demand development of finer-scale modeling approaches to support more localized emission assessments." *EPA's Onboard Analysis Shootout, 2002*
  - Green Design?

Microsimulation – Emissions Modeling Software Pairings

Microsimulation Software			Emissions Software
AIMSUN	AIMSUN	⟷ Versit+micro	Versit+micro
INTEGRATION	INTEGRATION	⟷ VT-Micro	VT-Micro
Paramics	Paramics	⟷ CMEM	CMEM
VISSIM	VISSIM	⟷ Versit	Versit
VISSIM	VISSIM	⟷ PHEM	PHEM
TRANSIMS	TRANSIMS	⟷ MOVES	MOVES
CORSIM			VeTESS
Synchro/SimTraffic			TREMOVE
			COPERT (EEA)
			ModEM

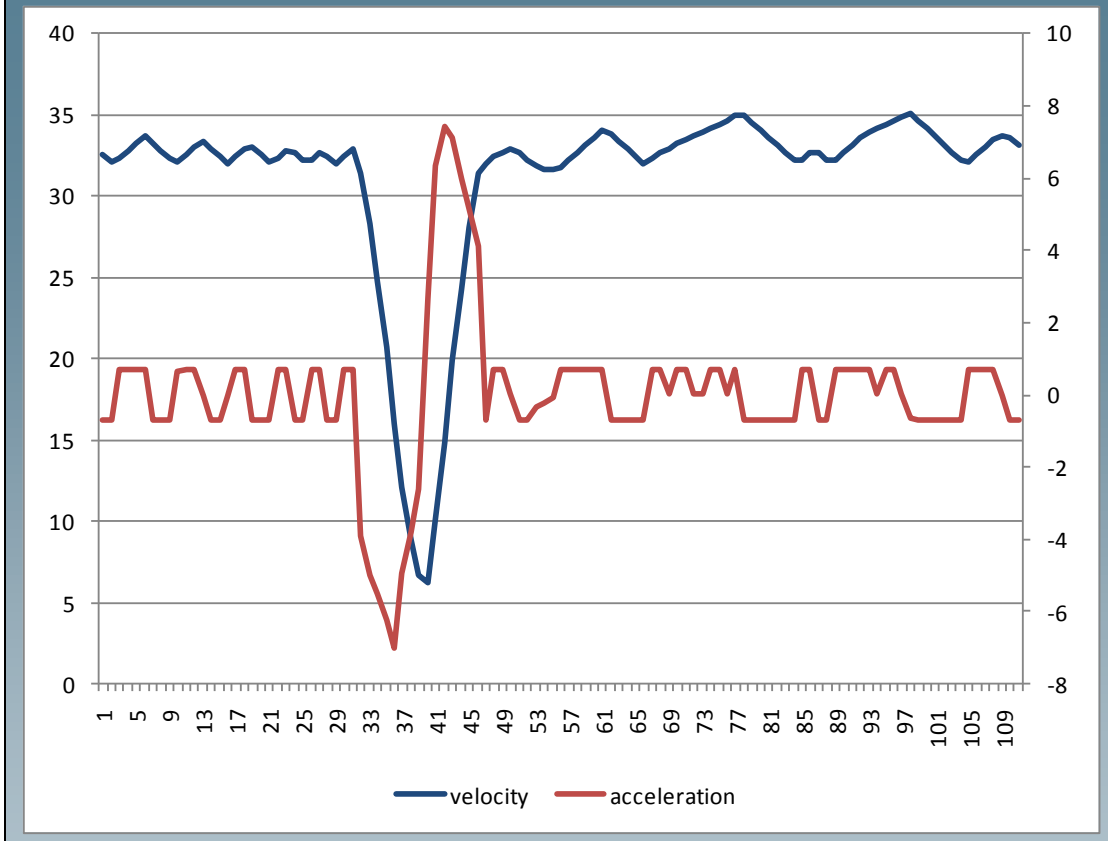
- Points of connection:
  - Vehicle characteristics (fleet age mix, power/weight)
  - Environmental characteristics (meteorological)
  - Network characteristics (functional class, grade)
  - Vehicle trajectories (speed/accel profiles)

Synchro/SimTraffic
TREMOVE
COPERT (EEA)
ModEM

The "Coming Together" of Capabilities - MOVES

- The Profession Has Developed Multiple Tools that Generate a Range of Results
- Widespread recognition that the "average speed approach" is insufficient to capture the environmental impacts of vehicle travel.
  - "…for the same average speed, one can observe widely different instantaneous speed and acceleration profiles, each resulting in very different fuel consumption and emission levels." *Rakha and Ahn*
  - "Two "trips" that have the same average speed can have drastically different emissions results depending on whether the trip was made on free flowing arterials or on a congested freeway." *Barth, et al NCHRP 25-11*

The “Coming Together of Capabilities” -- Vehicle Trajectory Files



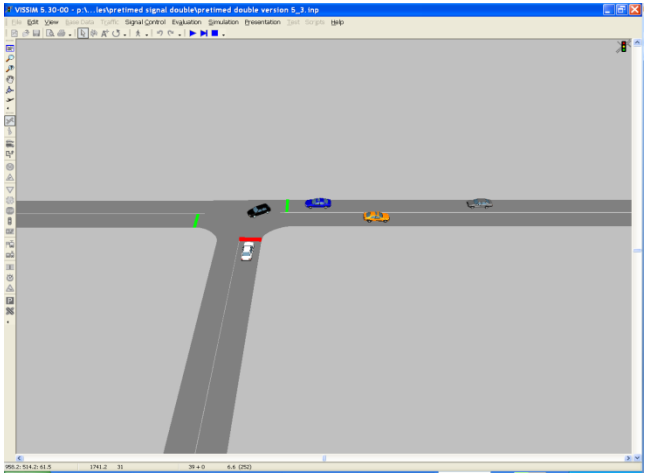
Sample vehicle trajectory from VISSIM

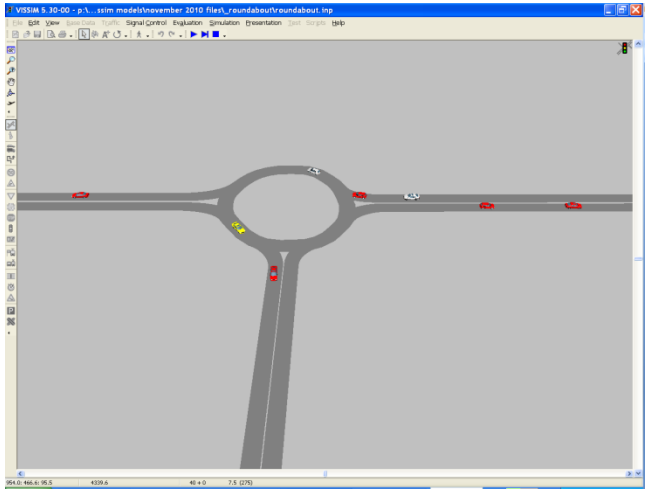
VISSIM Vehicle Record File (.fzp)

t	VehNr	DistX	a	v
3600	846	496	-0.58	29.87
3600	841	3020	0.51	31.73
3600	833	3654	-0.72	31.6
3600	829	3734	0.77	32.6
3600	824	3822	0.3	32.48
3600	819	3987	0.77	30.91
3600	832	4500	-0.76	31.68
3600	831	4792	0.53	29.57
3600	827	5354	-0.04	30.46
3600	826	5429	0.7	30.94
3600	825	5517	-0.63	31.41
3600	822	6127	0.89	31.5
3600	818	6195	0.81	31.78
3600	814	6274	0.41	32.21
3600	813	6527	-0.48	32.71
3600	848	359	0.65	28.94

The Analysis Testbed

- 3-Leg Intersection Modeled as Pretimed Signal, Roundabout, and All Way Stop
- 0.5 mile approach link, 30 mph
- Two sets of traffic volumes
  - 850 vehicles/hour (LOS B, 11 seconds/vehicle)
  - 1700 vehicles/hour (LOS D, 35 seconds/vehicle)
- One vehicle type – Passenger Car (ID=21)

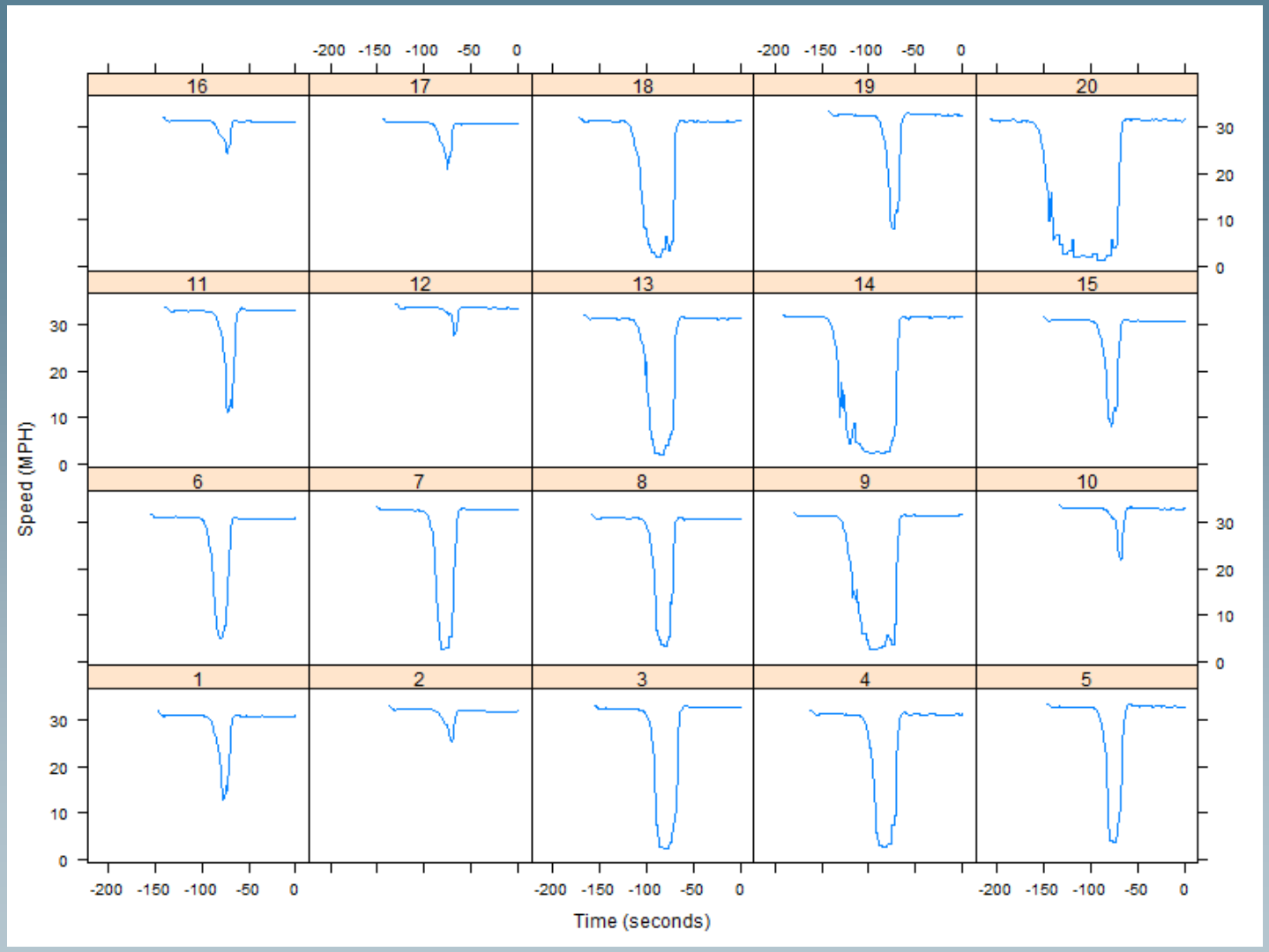




How to Process the Traffic Model Output for Input to MOVES?

- How to manage thousands of records? Two steps:
  - Step 1: K-Means Algorithm to Cluster “Like” Trajectories
  - Step 2: LOESS Curve Fitting

What the K-Means Algorithm Produces

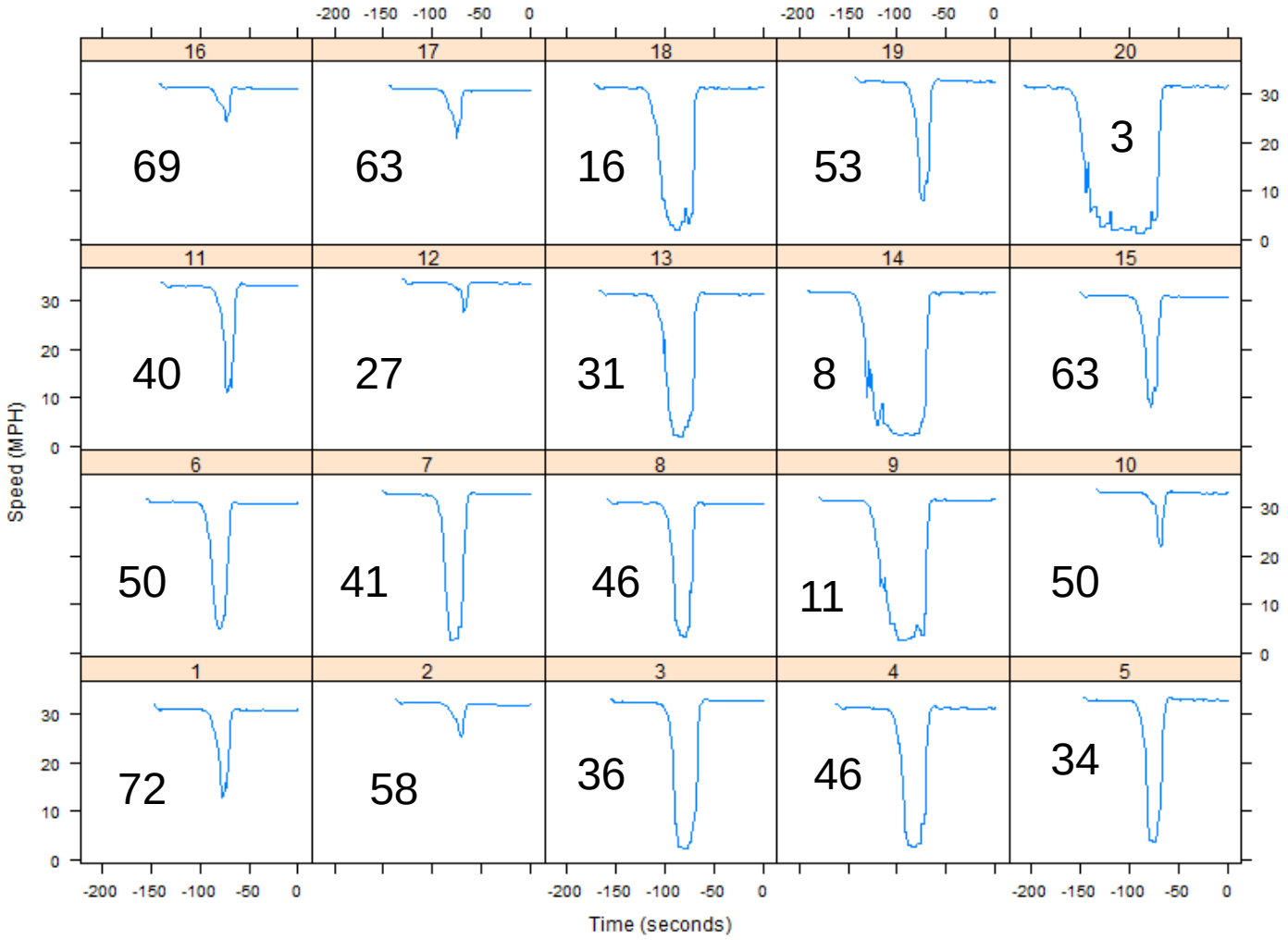


Pretimed Signal

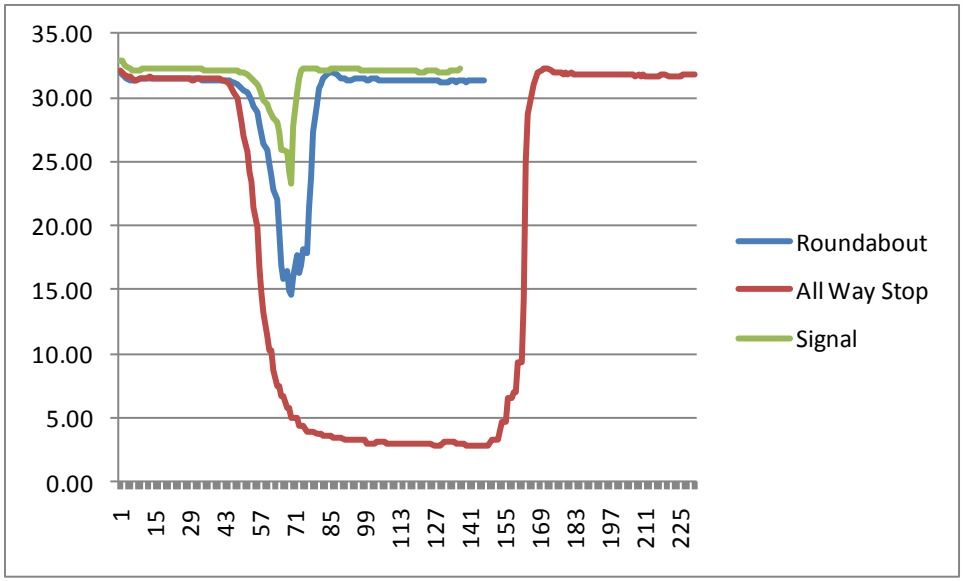
RSG INC. RESOURCE SYSTEMS GROUP, INC.

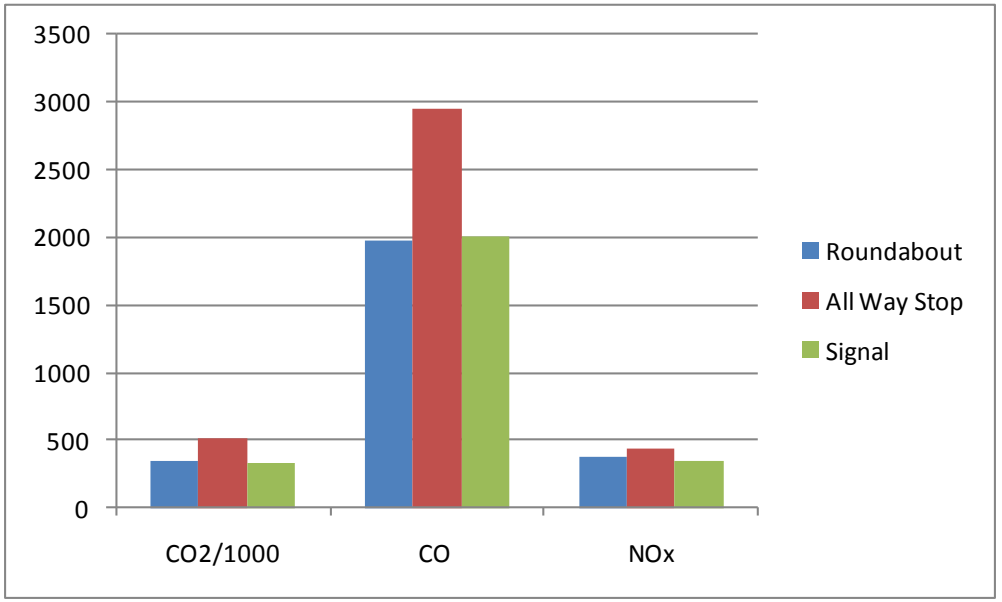
Every Bin is a MOVES Drive Schedule

What Else You Need -- # of Vehicles per Bin and Average Speed of Bin

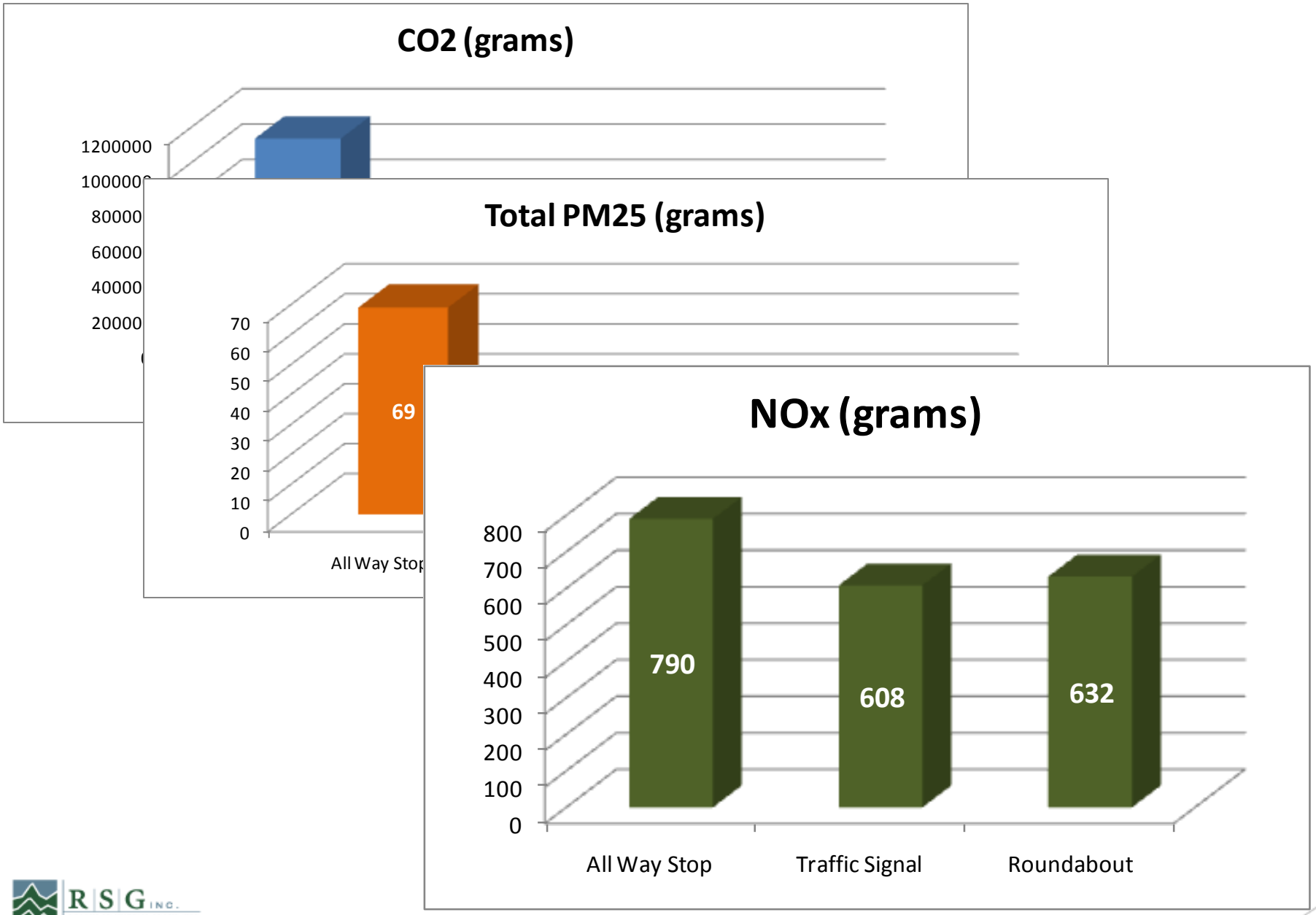


Exemplary Drive Schedules by Control Type

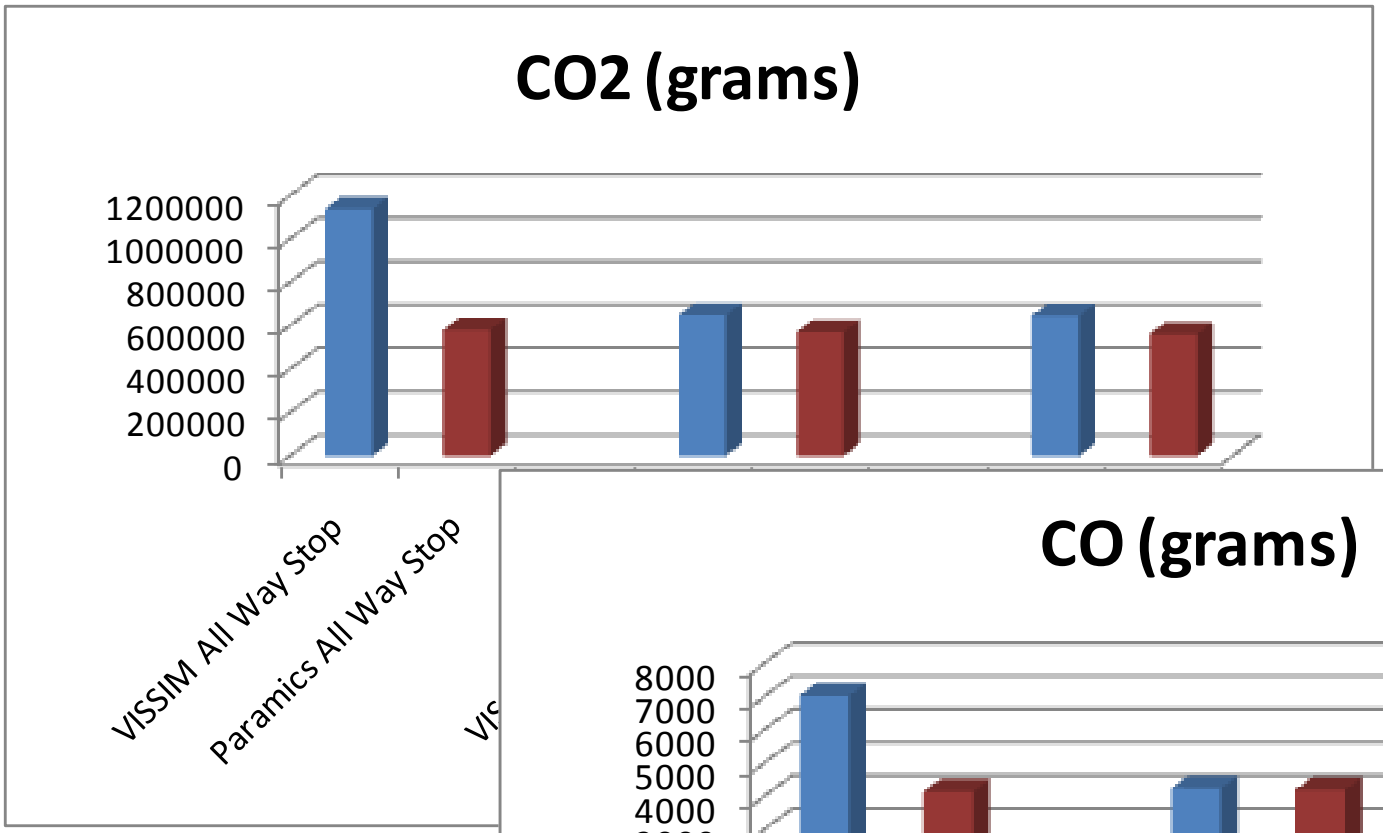


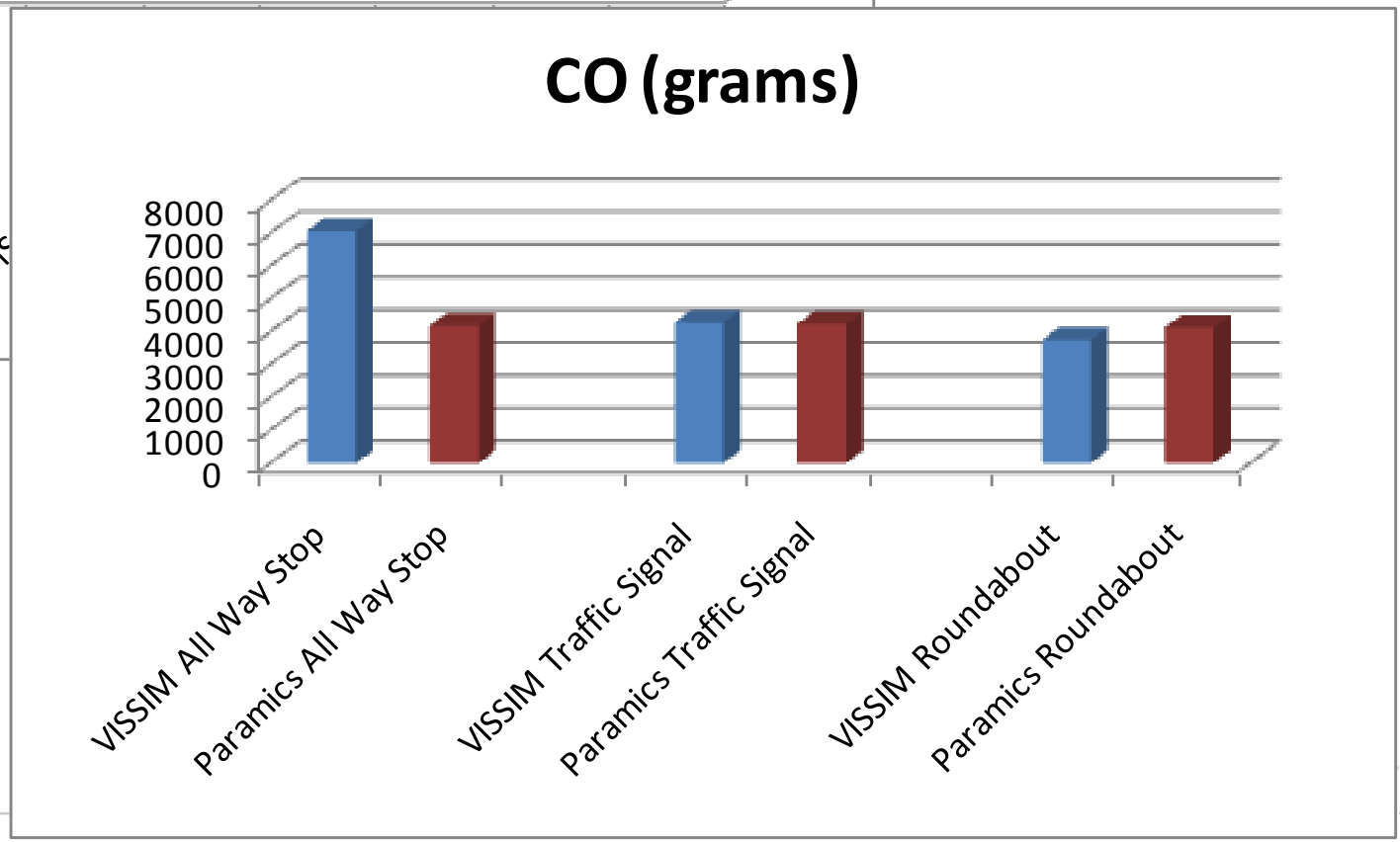


Results – VISSIM High Volume (1700 vph)



Results – Comparison Across Different Microsimulators





Findings and Future Work

- **Findings**
  - In Using the Link Drive Schedule Approach:
    - Utilize a k-means algorithm to classify vehicle trajectories into MOVES "links"
    - Utilize Locally Weighted Scatterplot Smoothing (LOESS) to reduce a bin of similarly-classified trajectories into a characteristic Drive Schedule
  - There is a practical way of using MOVES for evaluating the emissions impacts of a traffic control change
- **Methodological Questions**
  - How to appropriately define the geographic bounds of the "project area"?
  - How to best manage the many "degrees of freedom"? i.e. differences in traffic simu**lation packages?**
  - What is the correct number of bins to minimize sampling error? Latent cluster analysis.
- **Future Research**
  - What is the practical limit of modeling vehicle trajectories? How many unique trajectories can MOVES handle?
  - Are there significant differences in vehicle trajectory files produced by different microsimulation packages that affect their pre-processing into Link Drive Schedules?

For More Information…

- **Session 479 – Current Environmental Issues in Transportation**
  - Poster Session (Paper 11-0673)
  - Tuesday 25 January, 9:30-12:30
  - Hilton International Center