The Role and Benefit of Traffic Simulation in TSMO

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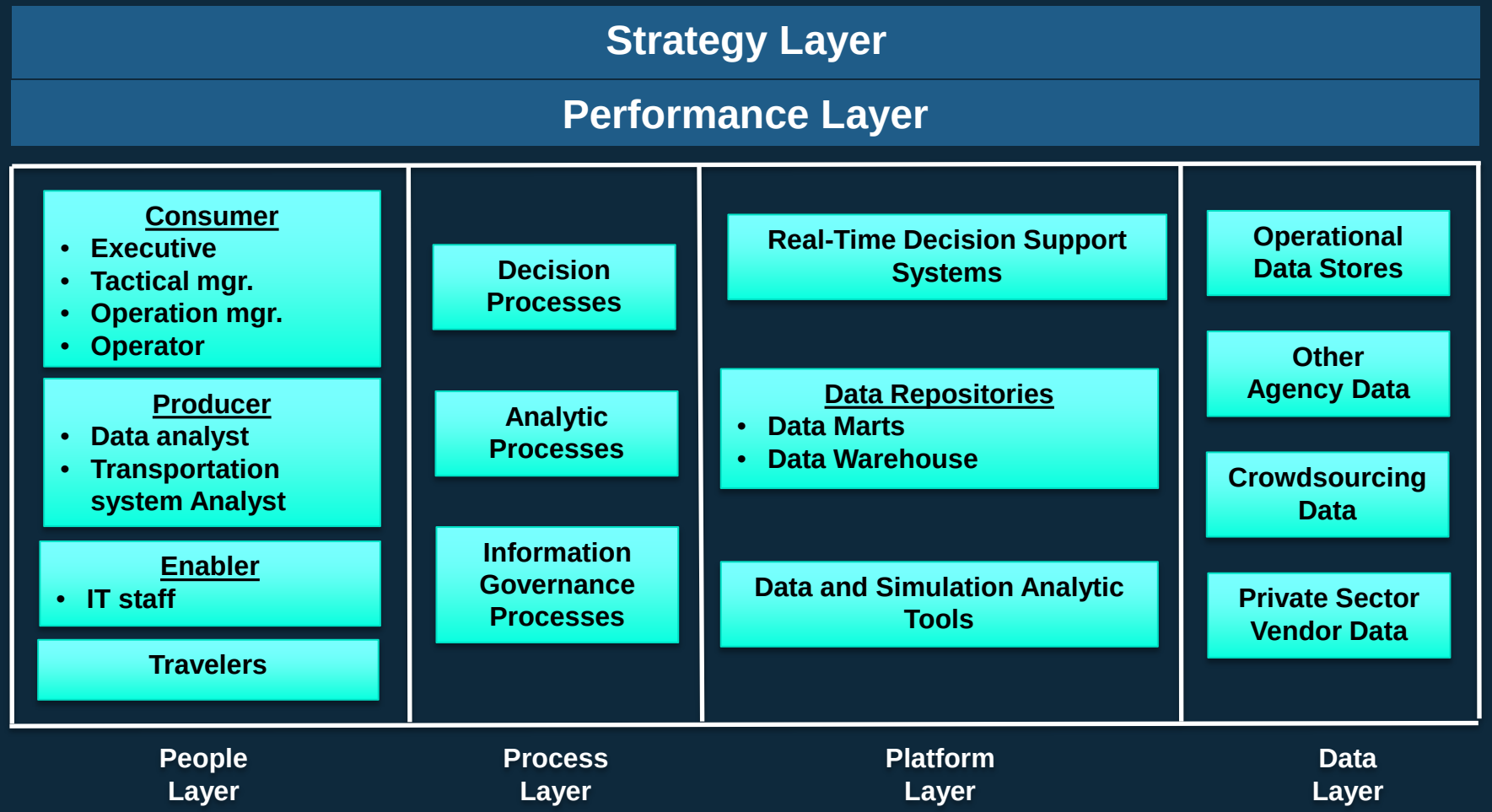
1 Simulation in TSMO

I Background and Purpose

- Simulation can be used as an important element to support TSMO.
- Combining data analytics and simulation as part of an integrated management support system (IMSS) will improve agency decisions
  - Strategic decisions: setting direction and understanding.
  - Tactical decisions: identifying priority services, activities, and projects.
  - Operational decisions : developing response plans and deciding when the plans should be activated

Framework for Integrated Management Support System (IMSS)



Source: FHWA

Analysis Processes: Advanced Analytics Category

- Descriptive analytics: describe current conditions by identifying patterns, trends, and relationships in the data
- Diagnostic analytics: Identify cause and effect relationships
- Predictive analytics: predict future based on past event.
- Prescriptive analytics: assess “what-if” scenarios.

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Overview of Analysis Tools

- Descriptive statistics.
- Visualization.
- Statistical regression.
- Associations and correlation rules.
- Decision trees and tree ensembles.
- Bayesian classifiers.
- Support vector machine (SVM).
- Artificial neural networks (ANN).
- K-nearest neighbor (KNN).
- Clustering.
- Analysis, modeling, and simulation.
- Return-on-investment.
- Multi-criteria decision analysis.
- Expert rules and fuzzy logic.
- Post-deployment evaluation.

Simulation Uses in TSMO

- Pre-deployment and post-deployment evaluation
- Off-line design and update of response plans and activation rules
- Determining the causes of congestion and safety issues
- Training traffic management center personnel
- Predicting the performance in real-time operations
- Supporting the design and assessment of CAV applications
- Providing data on parts of the network that do not have sensors
- Generate data to train machine learning algorithms

VI

Specific Considerations for TSMO Simulation

- Multi-resolution analysis (Macro, meso, and micro)
- Multi-scenario analysis (recurrent congestion levels, incidents, weather) – Clustering analysis
- Calibration of strategic, tactical, and operational model parameters
- For traditional, connected, automated, and cooperative vehicles
- Replicating TSMO and CAV applications
- Data analytics and model integration
- Tool selection and extension

VII

Replicating TSMO and CAV

- Software-in-the-loop
- Co-simulation
- Hardware-in-the-loop
- Vehicle-in-the-loop
- Human-in-the-loop

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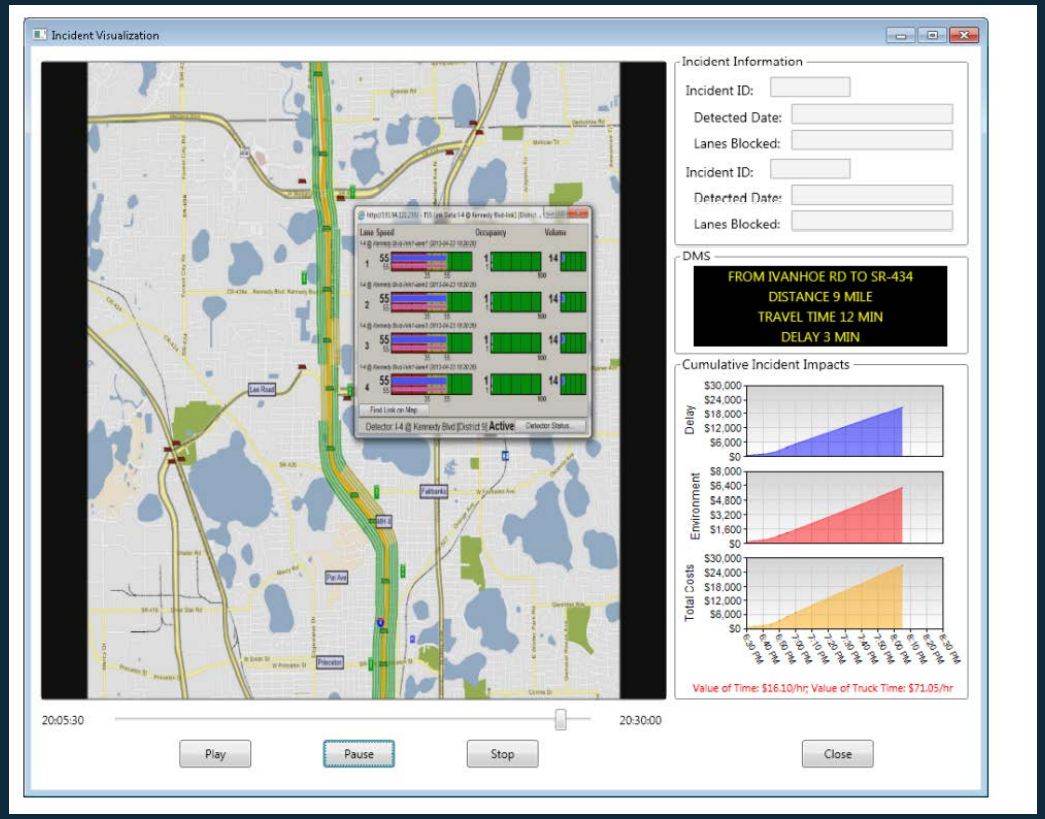
Examples from FIU Projects

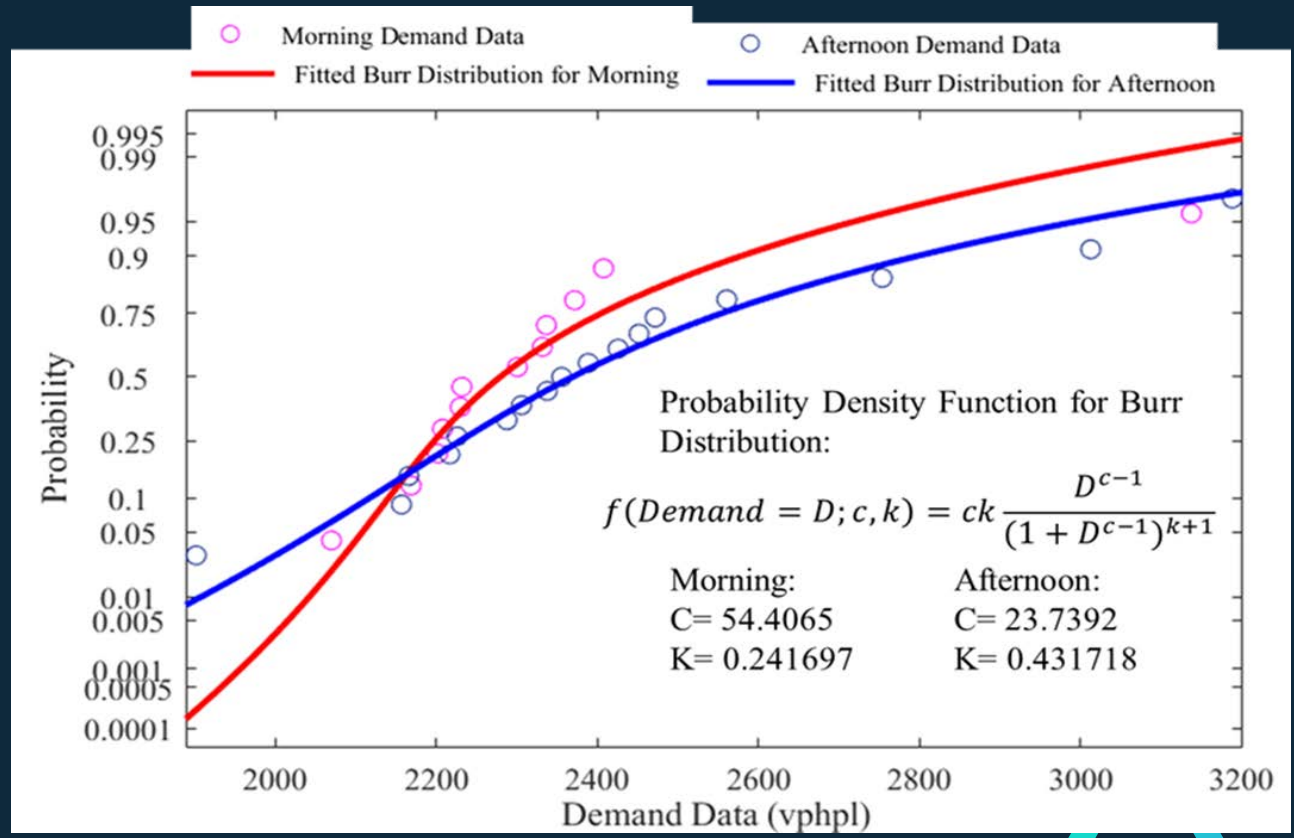
Testing of TMC Software and Training of Operators

- 2010-2011 FDOT Project.
- Interface virtual sensors from simulation with the FDOT SunGuide℠ software.
- Allow operator training and software update diagnostic.



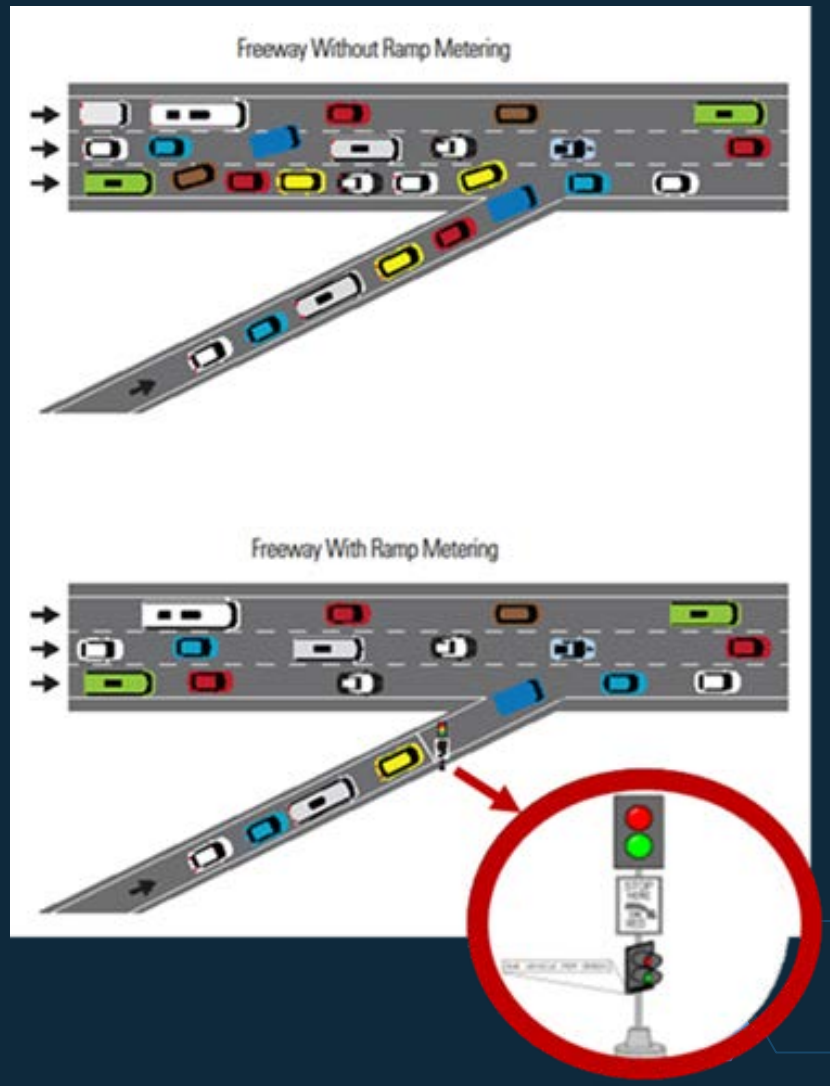
Freeway Management Applications

- Real time activation ramp metering and variable speed limits based on probability of breakdown
- Assessing truck acceleration requirements on metered ramps
- Activation of signal plans to prevent queueing from the metered ramps
- Assessing merge area safety impacts using surrogate safety measures

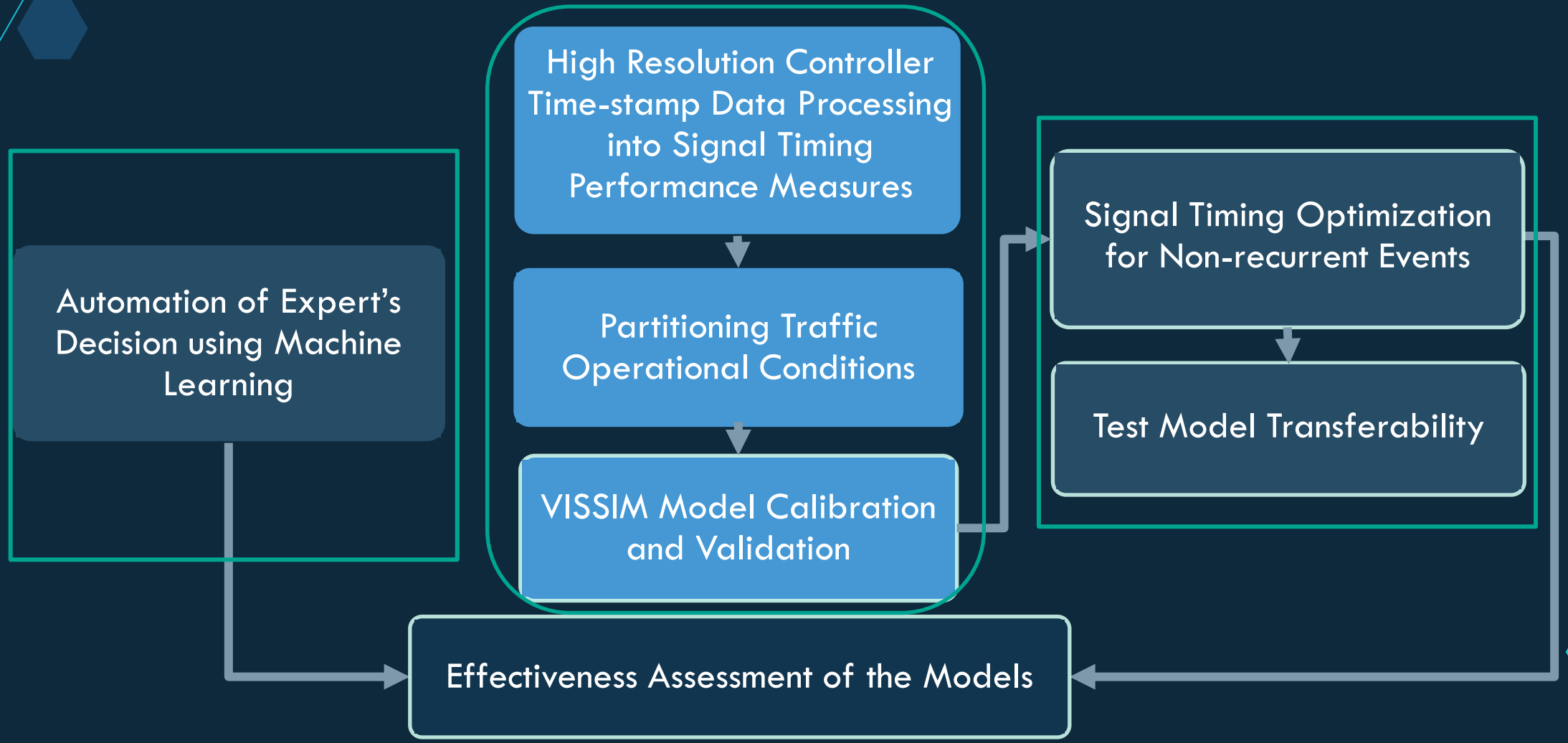


Example - Approaches to Address Truck Acceleration Issue

- Alt 1: Pushing the metering stop line back on the on-ramp
- Alt 2: Providing truck preemption on the on-ramp to turn the ramp metering signal to allow the truck to accelerate
- Alt 3: Dedicating a lane for truck by-pass at a distance that allows the truck to accelerate
  - 3A: Adding a new lane for this purpose
- Alt 4: Diverting the truck traffic to other ramps
- Alt 5: Not metering the ramps with acceleration lane constraints



III Signal Timing Plan during Arterial Events



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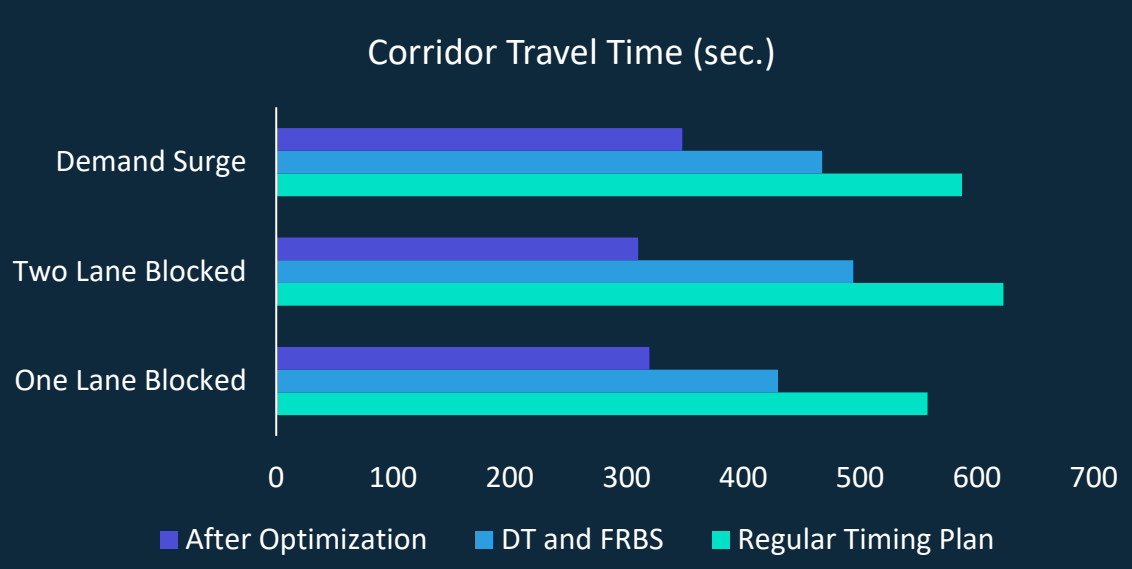
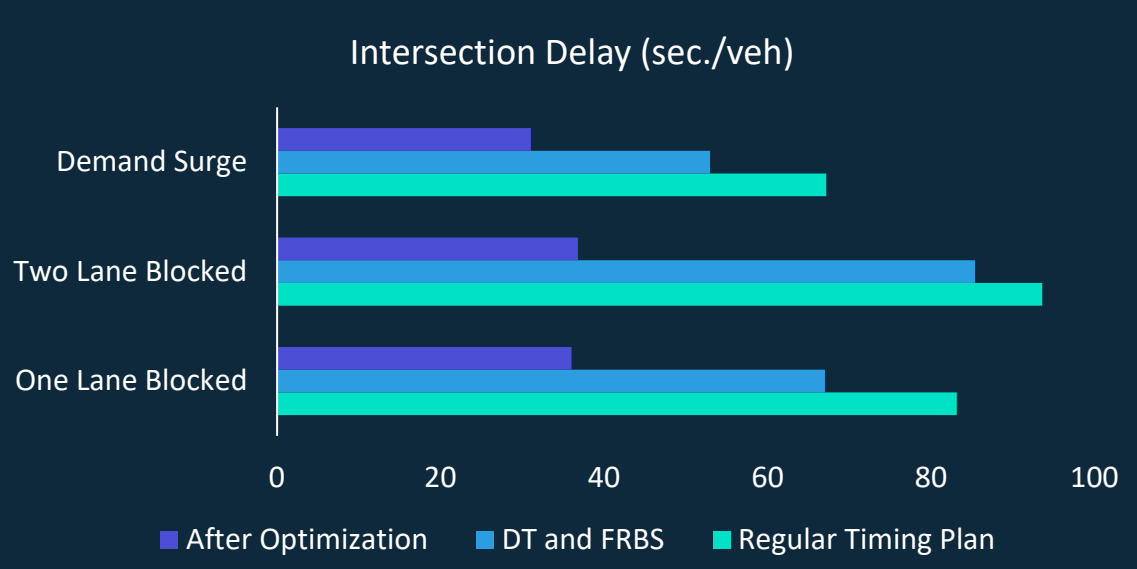
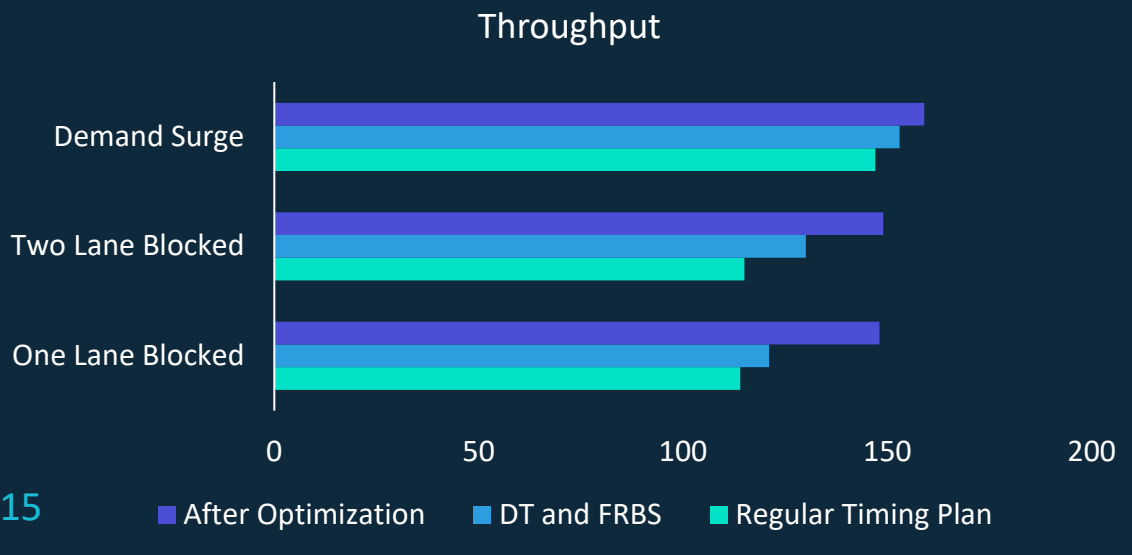
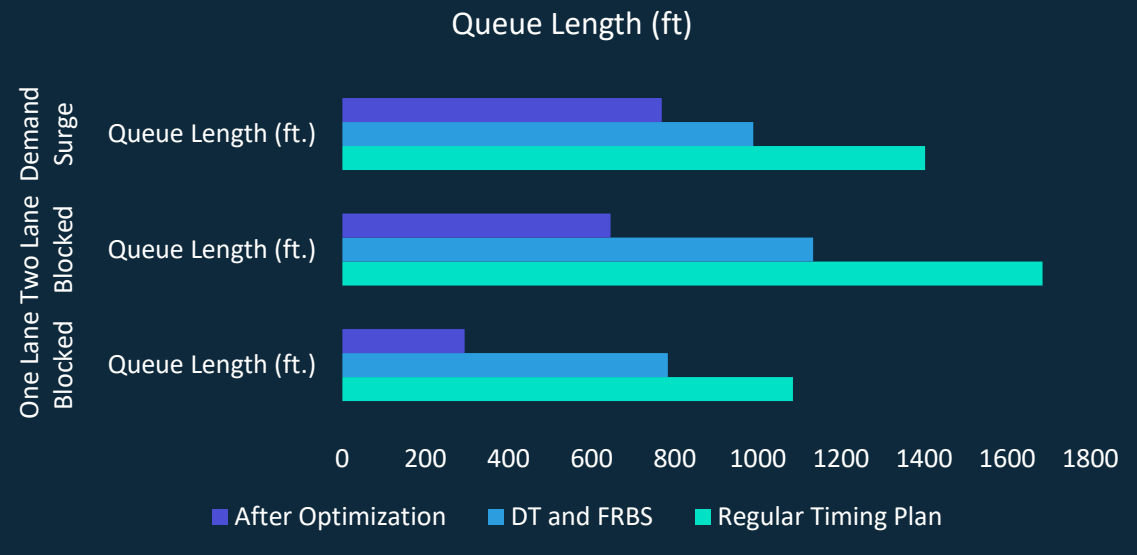
Performance Assessment of the Developed Models









Integrating Data and Modeling for Signal Management on Diversion Routes

Prediction of Alternative Routes and Scenarios

Machine Learning and Clustering Analysis

Estimation of Traffic Demand on Alternative Routes

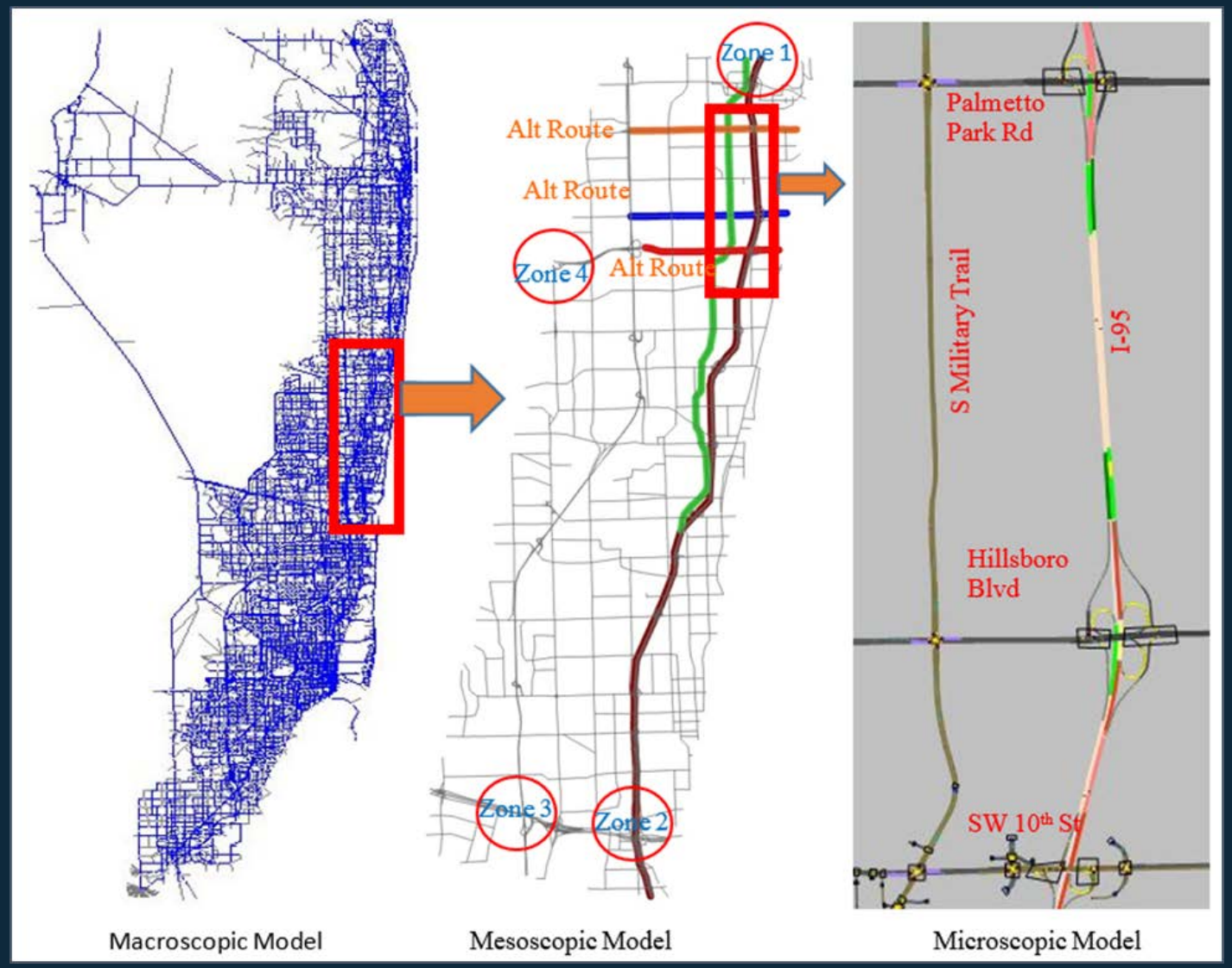
Multi-Resolution Modeling (MRM) Combined with Data Analytics

Special Signal Plan Development

Simulation-Based Multi-Objective Optimization

VI

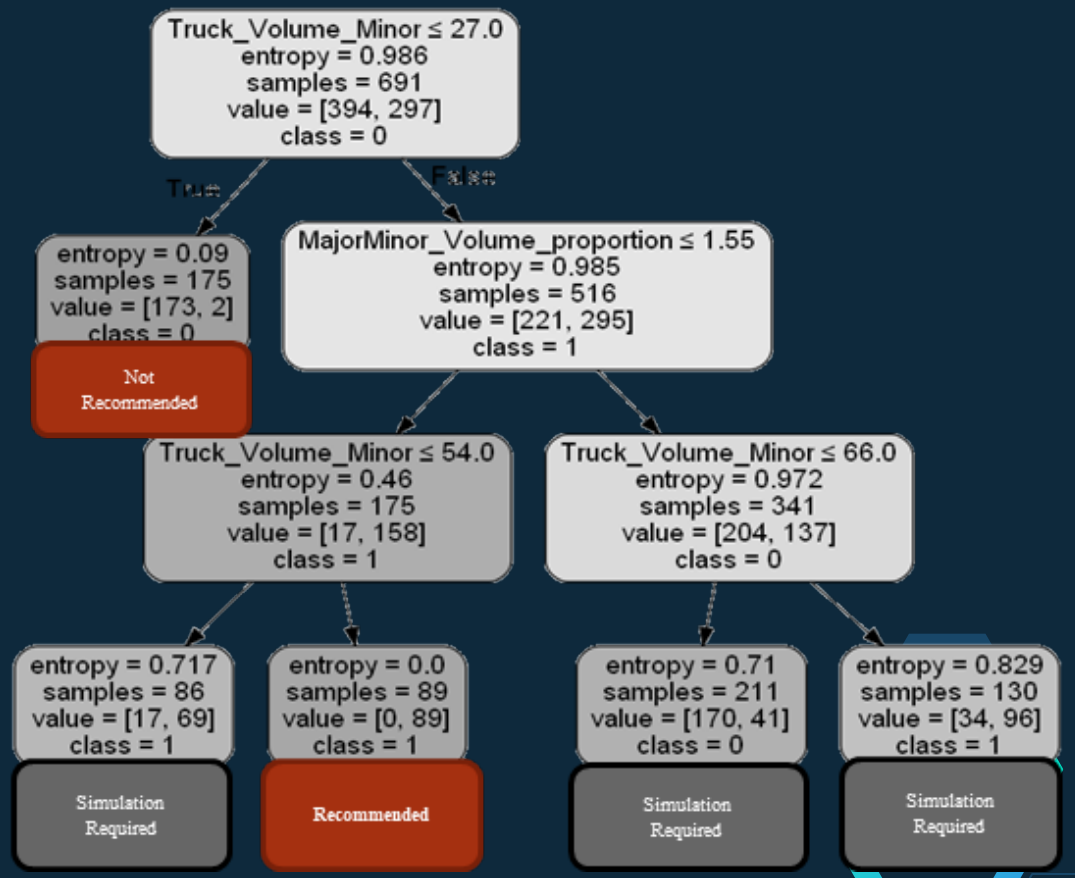
Optimization and Multi-Resolution Modeling



VII

Heavy Vehicle Acceleration Characteristics

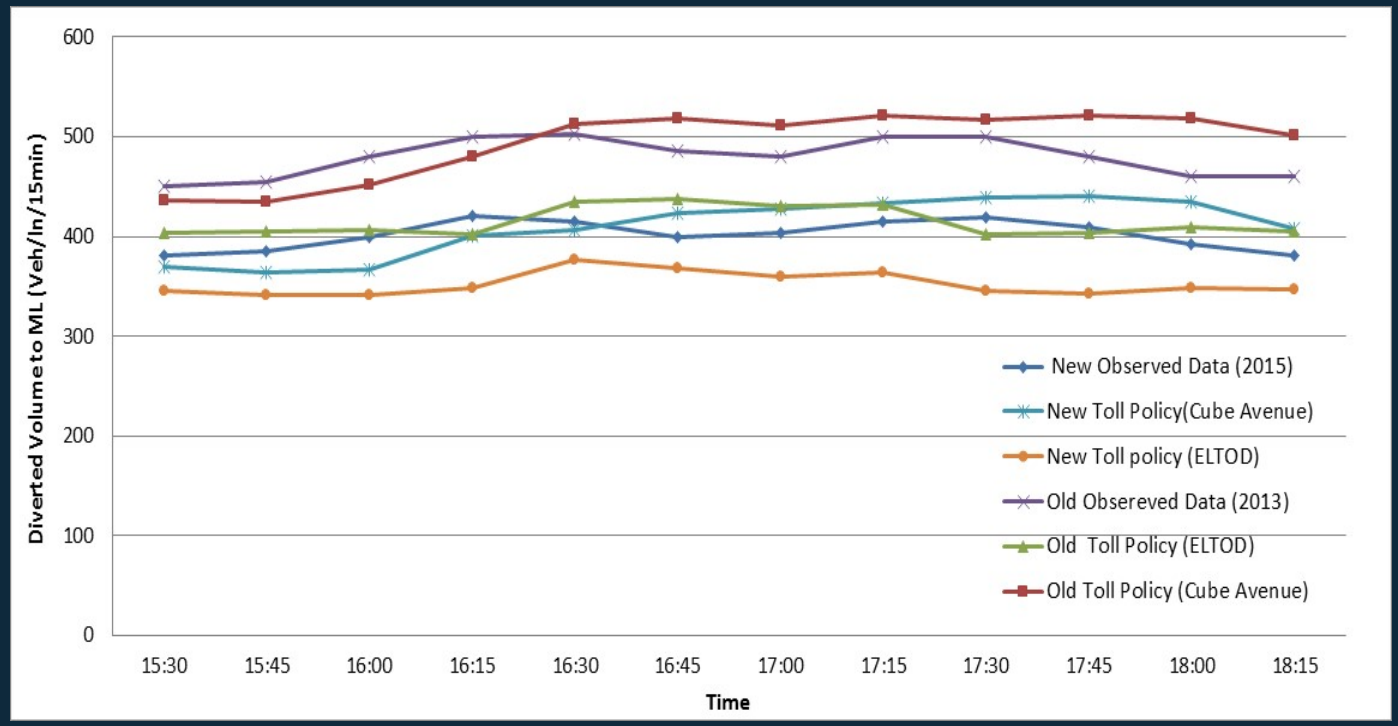
Speed	HGV1	HGV2	HGV3	HGV4	HGV5
0	3.4	3.4	3.7	3.4	3.4
10	3.3	3.3	3.3	3	3
20	2.8	2.8	2.8	2.5	2.5
30	2.7	2.7	2.7	2.4	2.4
40	2.5	2.5	2.5	2.3	2.3
50	2.4	2.4	2.4	2.2	2.2
60	2.3	2.3	2.3	1.5	1.5
70	1.9	1.9	2	1	1.2
80	1.5	1.5	1.5	0.8	0.8
90	1	1	1	0.5	0.5
100	0.6	0.6	0.6	0.3	0.3
110	0.2	0.2	0.3	0	0
120	0	0	0	0	0



VIII

Prediction of Managed Lane Demand Shift

Goodness-of-Fit Statistics		Fixed Pricing and Static Assignment (ELTOD)	Dynamic pricing with Dynamic Assignment (Avenue)
New Toll Policy	RMSE (veh/ln/15min)	51.42	25.15
	MAPE (%)	12.22	5.87
Old Toll policy	RMSE (veh/ln/15min)	67.39	31.04
	MAPE (%)	13.48	5.90



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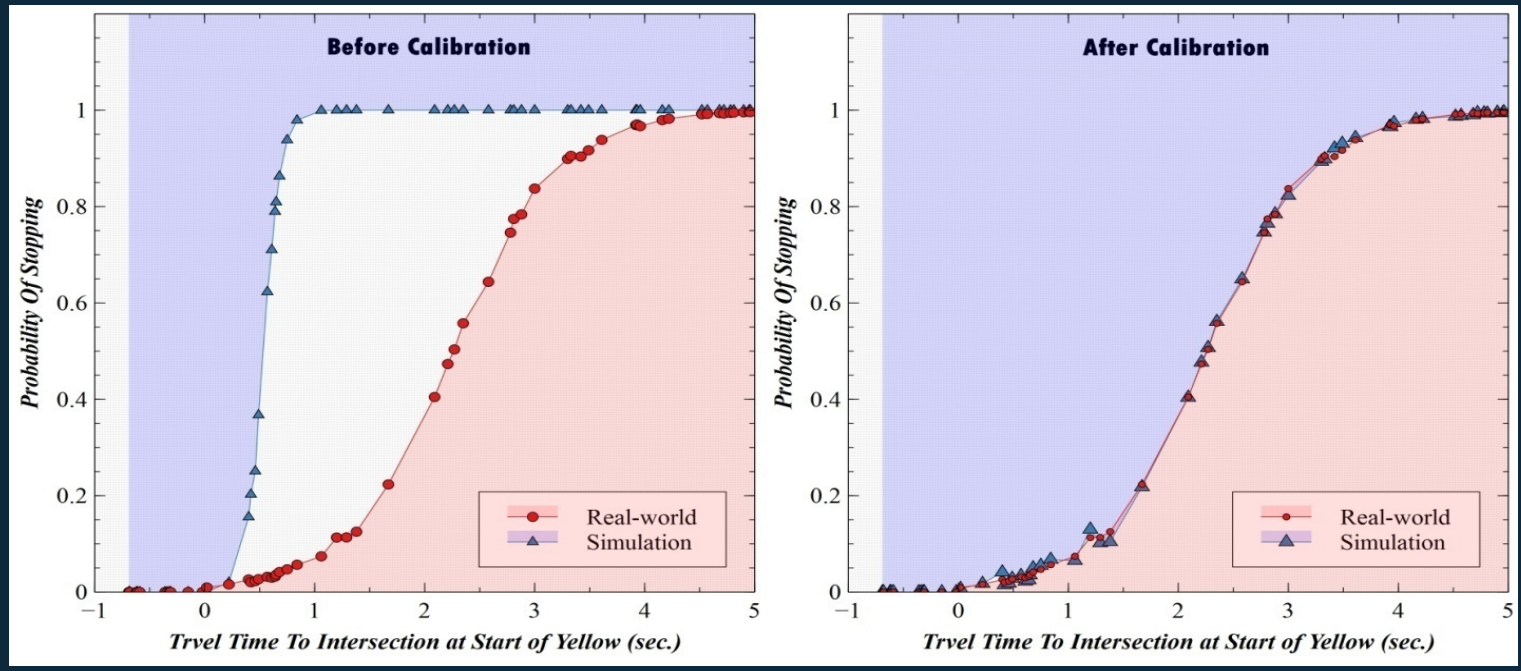
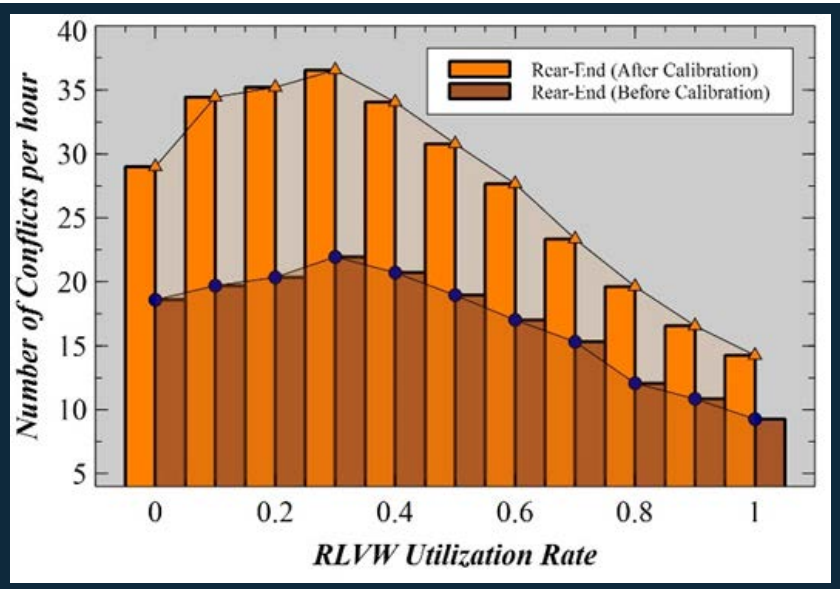
CV-Based Red Light Violation Warning





Hardware, Driver, and Vehicle-in-the-loop Simulation

XI

Dimensions of TA CMM

TSMO CMM

1. Business processes.
2. Systems and technology.
3. Performance measurement.
4. Culture.
5. Organization and workforce.
6. Collaboration.

Traffic Analysis CMM

1. Business processes.
2. Supporting data.
3. Analysis process and documentation.
4. Tool availability and capability.
5. Performance estimation and measures.
6. Culture.
7. Workforce.
8. Collaboration.

Thanks