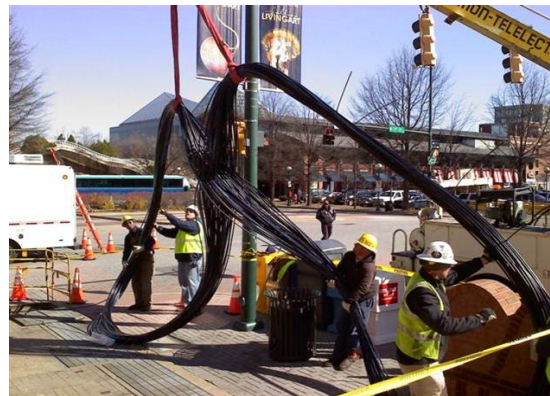




Scenic City



Gig City



Smart City

Vision: Chattanooga be the city-wide testbed to next-generation transportation (electric, connected, and automated vehicles)



Partners/ Collaborators

- City of Chattanooga
- Hamilton County
- Electric Power Board (EPB) of Chattanooga
- CDOT/ TDOT
- The Enterprise Center in Chattanooga
- Tennessee Valley Authority (TVA)
- Tennessee American Water
- Siskin Hospital for Physical Rehabilitation
- Erlanger Health Systems
- Co-Lab
- US Ignite
- MetroLab Networks
- South Big Data Hub
- Next Generation Internet (NGI) - European Commission initiative to shape the development and evolution of the Internet into an Internet of Humans
- University of Pittsburgh
- Georgia Tech
- Colorado School of Mines
- Virginia Tech
- Oak Ridge National Lab (ORNL)
- Vanderbilt University
- University of Tennessee at Knoxville
- University of Tennessee Health Science Center
- University of Memphis
- LeMoyne-Owen College
- University of Texas Austin
- Georgia Tech Research Institute (GTRI)
- I3s Research Center - Leibniz University (Germany)

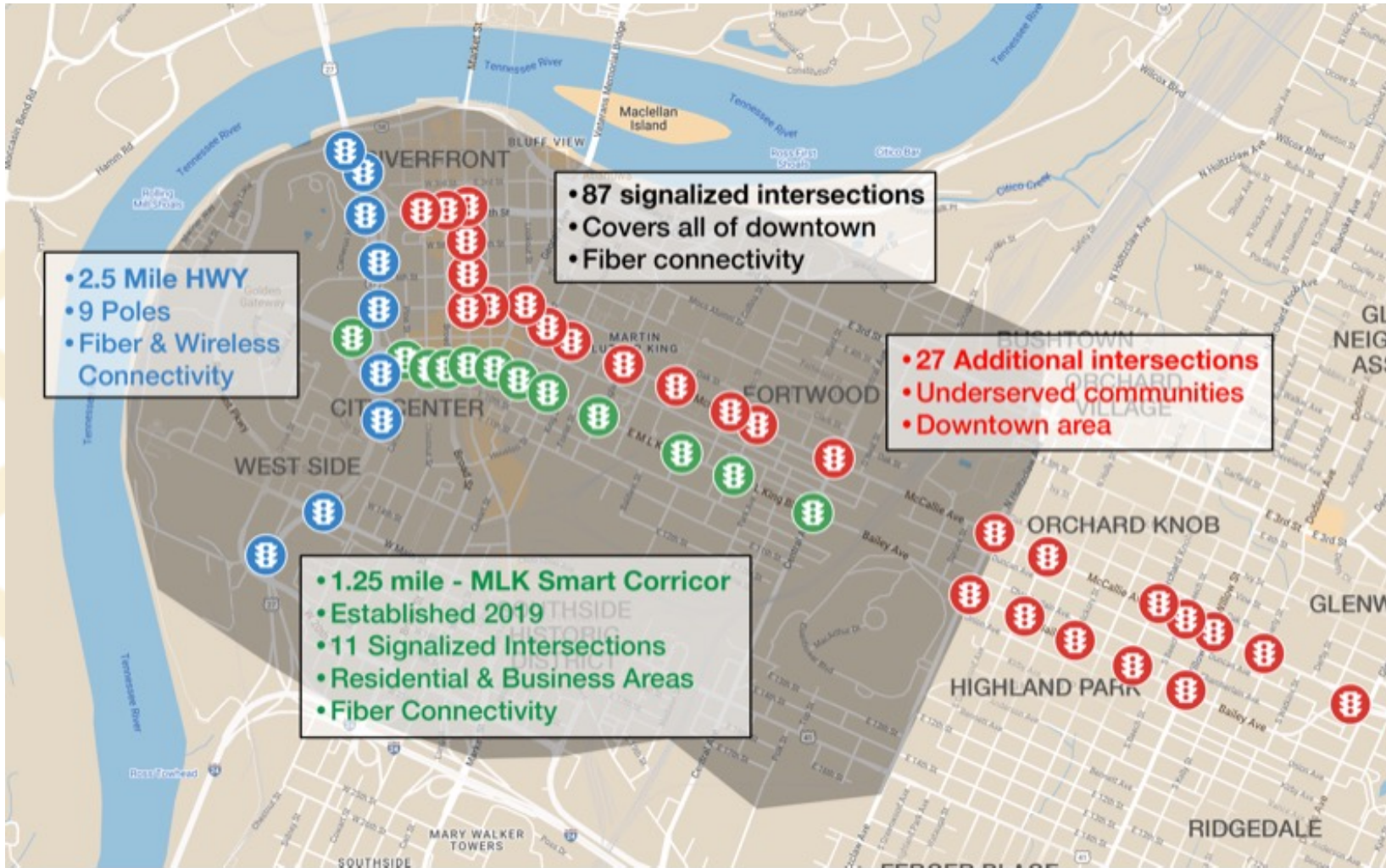


Testbeds in Chattanooga, TN

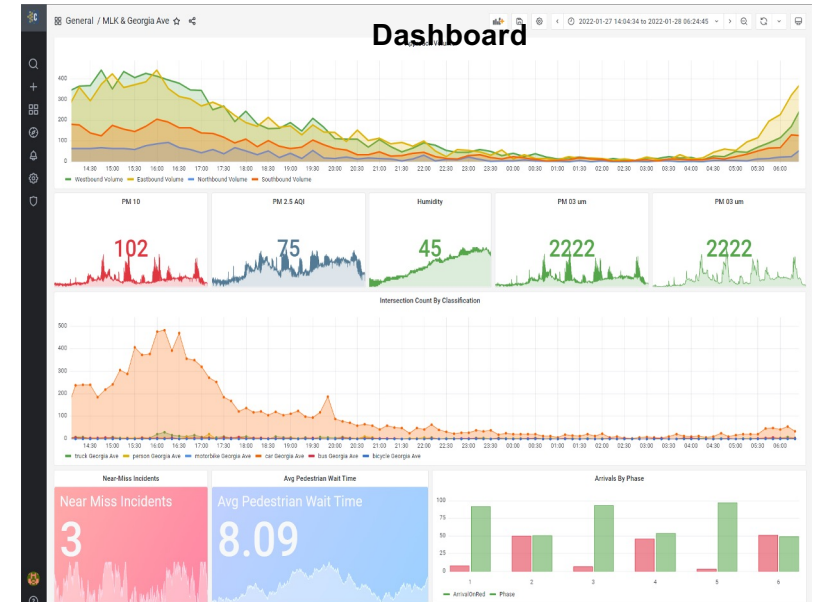
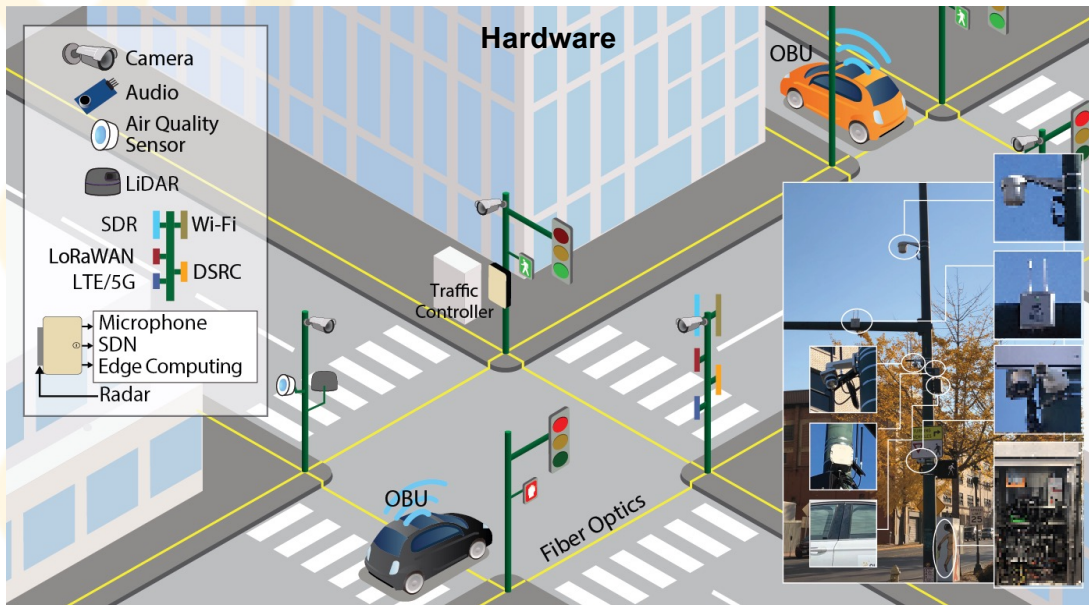
- 2.5 Mile HWY
- 9 Poles
- Fiber & wireless connectivity

- 27 Additional intersections
- Underserved communities
- Downtown area

- 1.25 Mile - MLK Smart Corridor
- Established 2019
- 11 Signalized Intersections
- Residential & Business areas
- Fiber connectivity



Testbed-As-A-Service



Data Infrastructure

- Automated data cleaning and formatting
- Daily ingestion
 - ~ 10,000,000+ event messages /day
 - Includes 2,000,000,000+ data points /day

- Data sources
 - Signal Phasing & Timing (SPaT)
 - High Resolution Lidar events, Cameras, and other IoT devices



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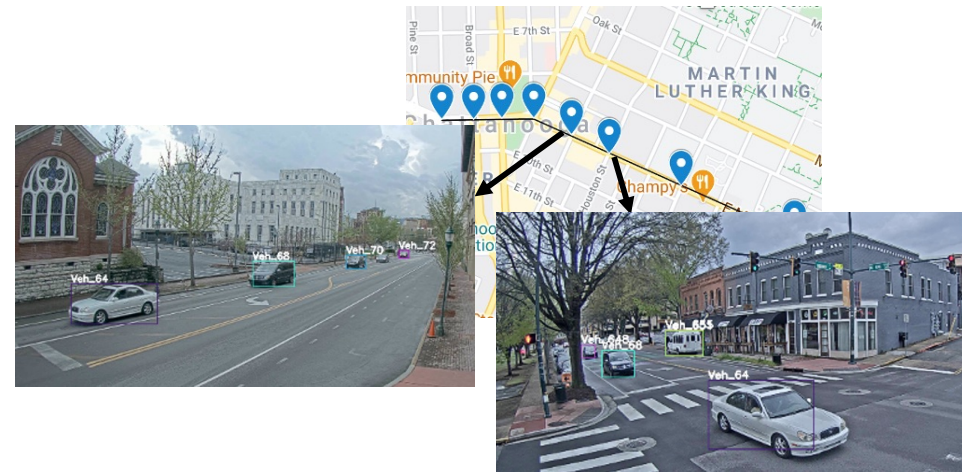
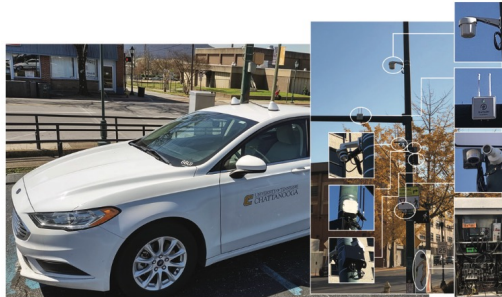


Connected Infrastructure



Digital Twin (Transportation and Energy)

- Real-time data on traffic flow and traffic state using AI/ ML
 - object detection & object tracking
 - multi-target multi-camera tracking
- Real-time speed and travel time data
- Real-time data from all traffic controllers
- Collecting data from connected infrastructure and connected vehicles
 - DSRC
 - CV2X
- Real-time data from transit

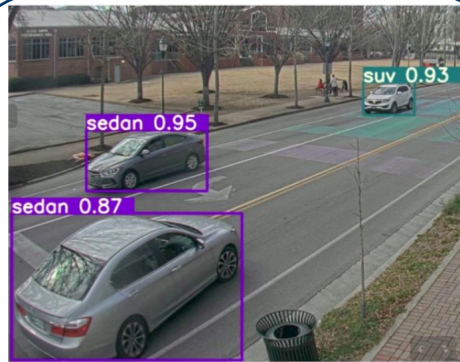


Computer Vision and Speed Detection

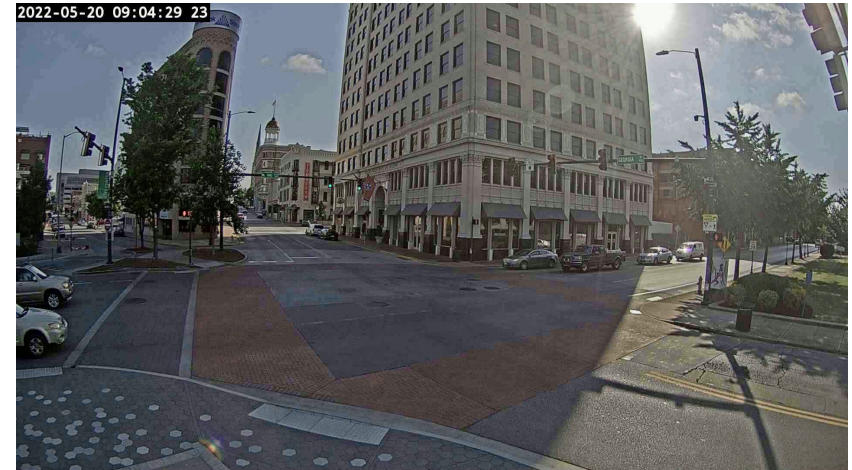
Capturing real-time videos from the MLK Smart Corridor



Object Detection and Tracking



Speed results



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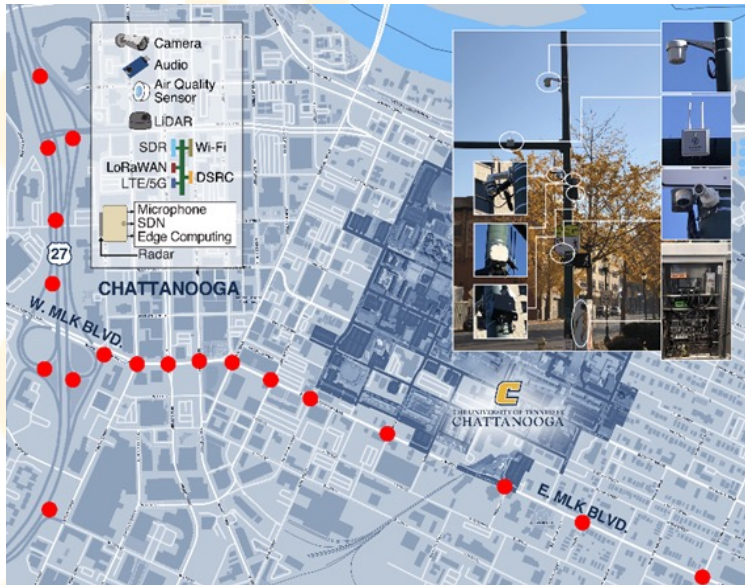




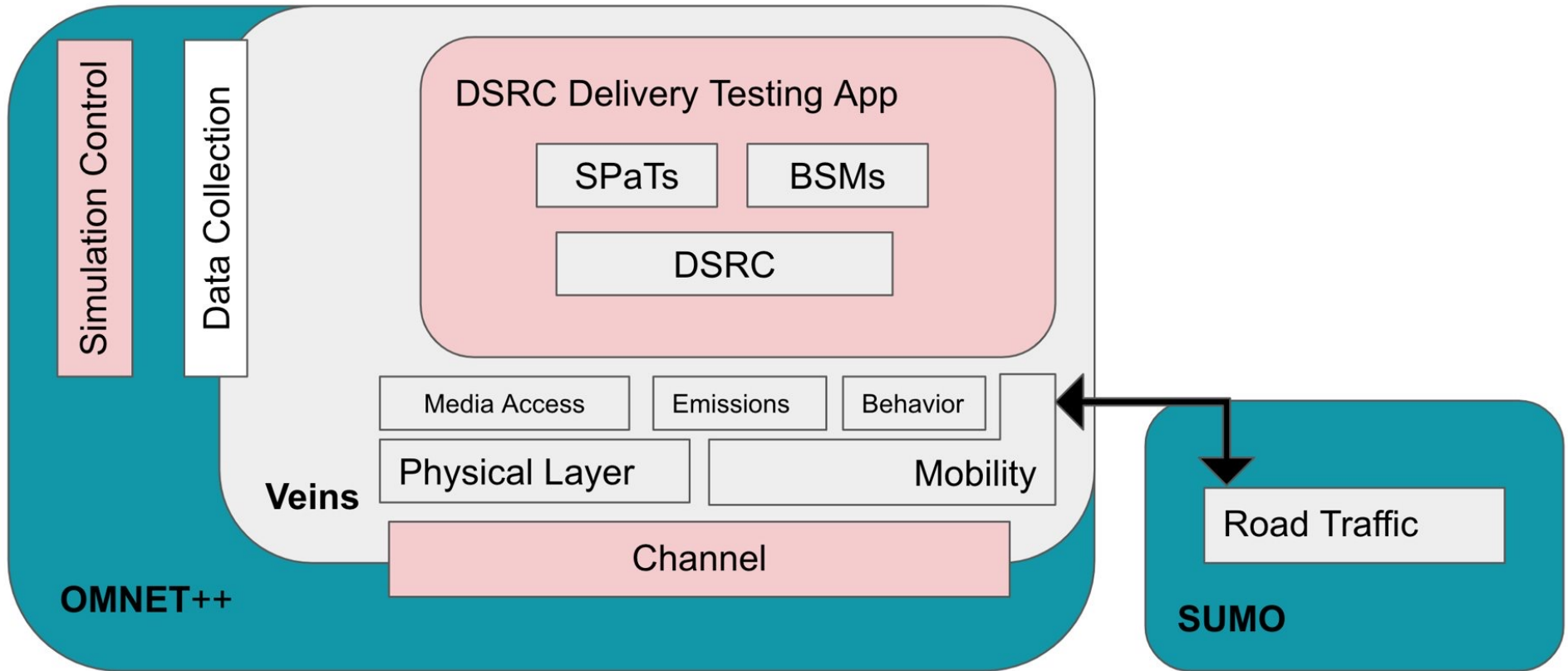
Connected Vehicle



Testbed Data Collection



Simulation Setup

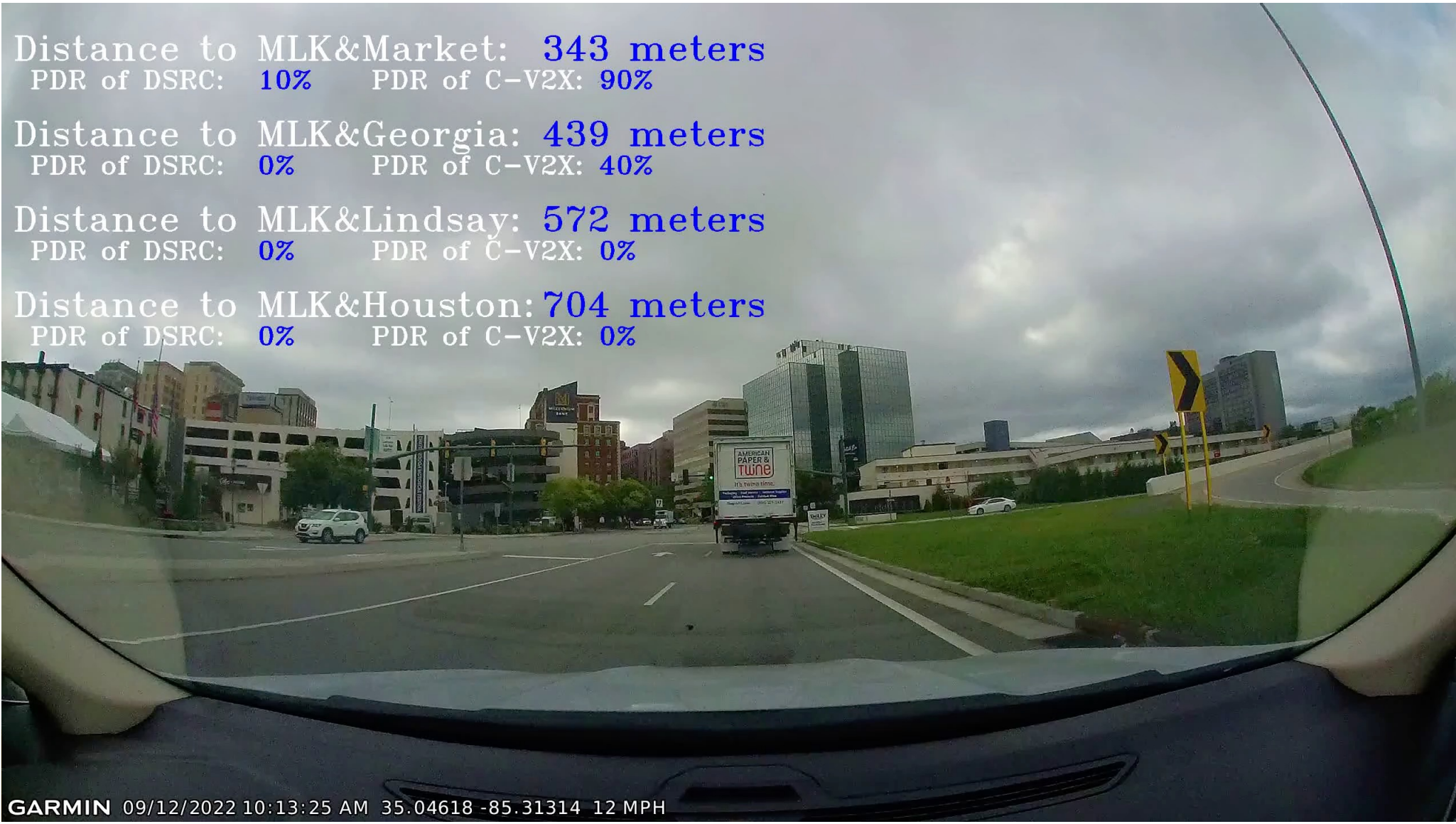


Distance to MLK&Market: 343 meters
PDR of DSRC: 10% PDR of C-V2X: 90%

Distance to MLK&Georgia: 439 meters
PDR of DSRC: 0% PDR of C-V2X: 40%

Distance to MLK&Lindsay: 572 meters
PDR of DSRC: 0% PDR of C-V2X: 0%

Distance to MLK&Houston: 704 meters
PDR of DSRC: 0% PDR of C-V2X: 0%



Packet Delivery Rate

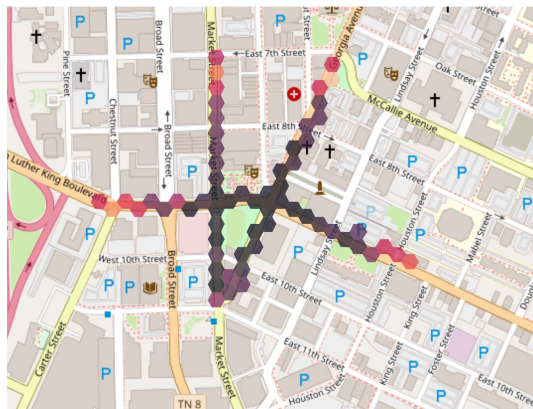
Channel model in the simulation environment



Added noise



Calibrated channel



Real-world data





Eco-ATCS

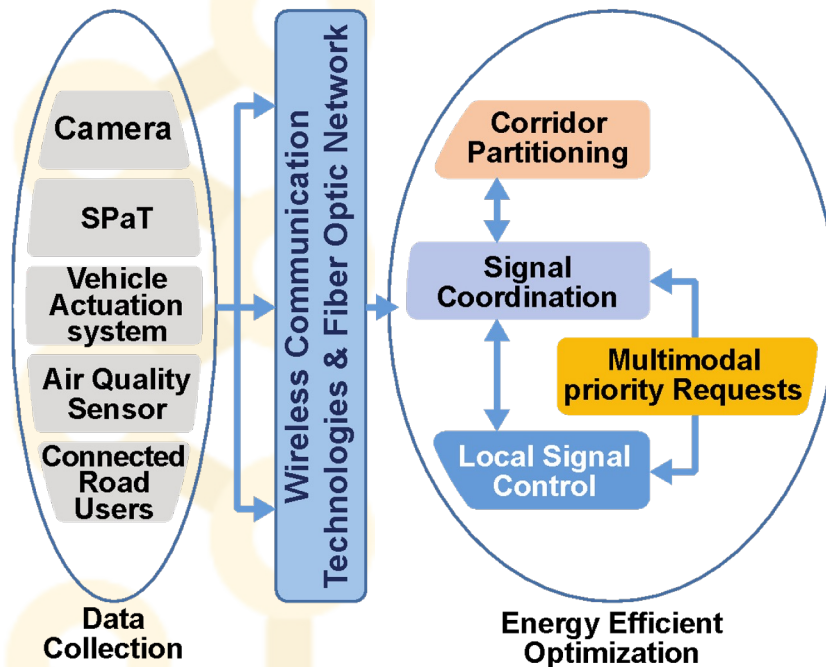


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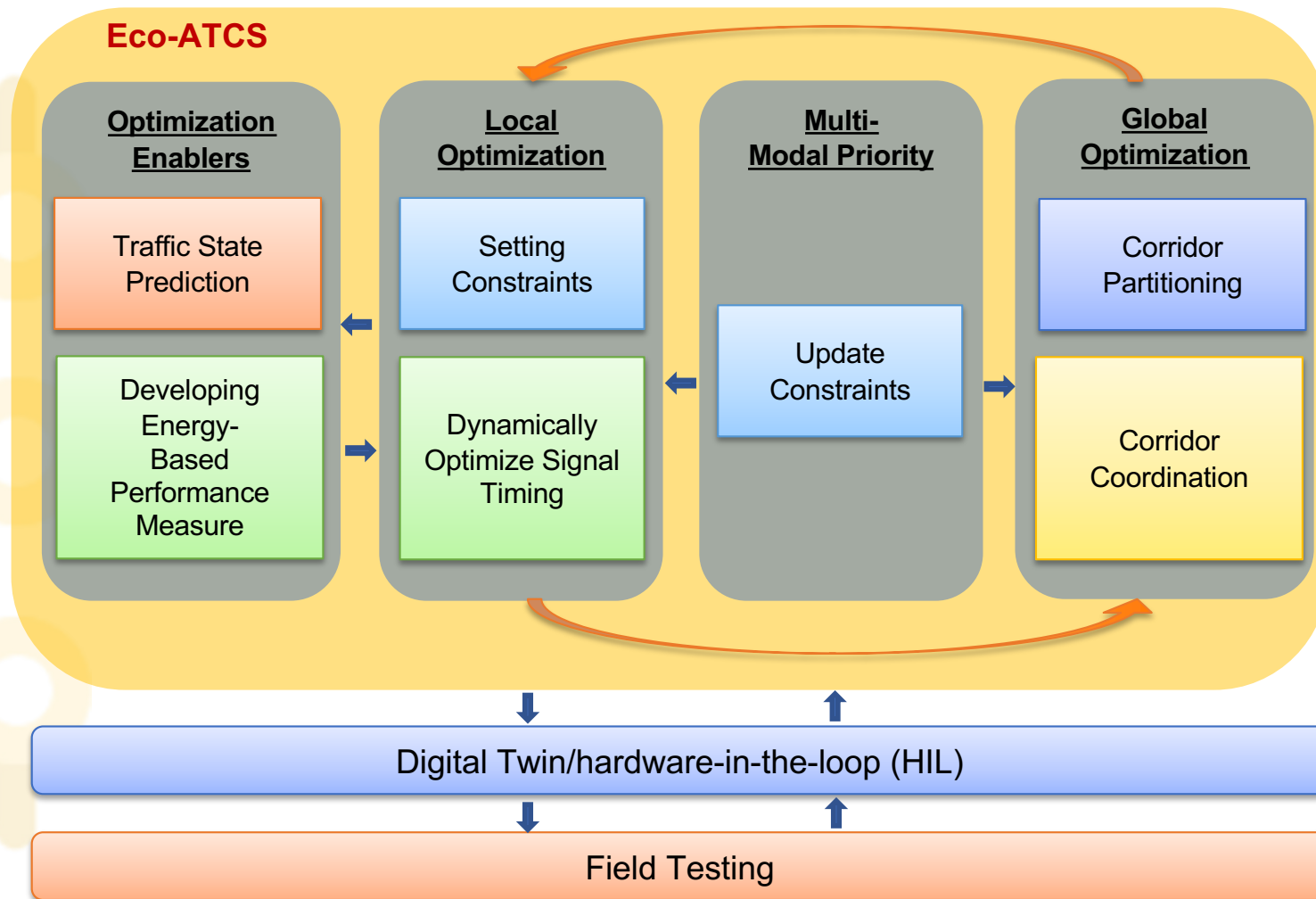


CUIP Center for Urban Informatics & Progress

Eco-ATCS

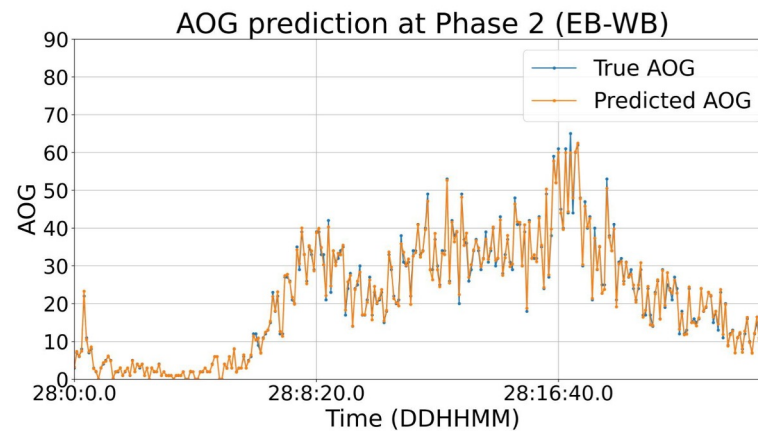
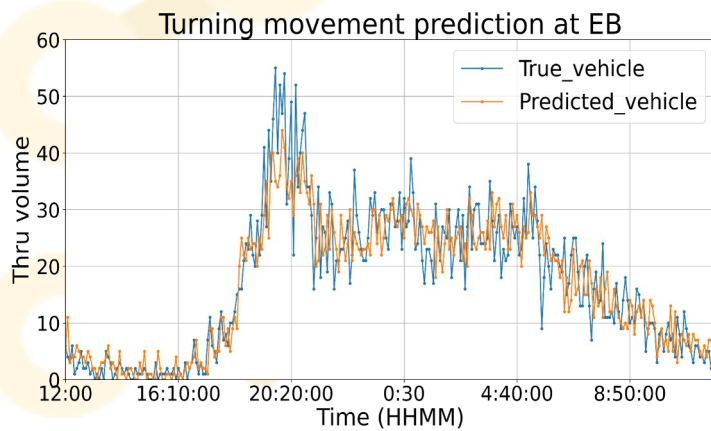
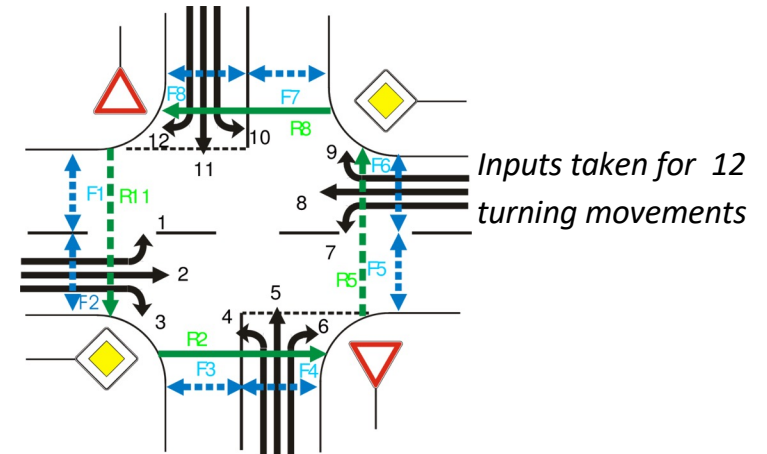


- Energy-efficient signal control algorithms leveraging connected infrastructure and connected vehicles
- A bi-level signal control system: lower-level at local intersections and global-level enables coordination
- A flexible priority system ready to accommodate transit signal priority (TSP), emergency vehicle preemption (EVP), and vulnerable road users (VRU)



Traffic State Prediction

- **Model:** Graph Neural Network (GNN) & Light Gradient Boosting (LGB)
- **Input:** Turning volume, Arrival of Green (AOG), Arrival of Red (AOR), Green Time, Red Time, Speed.
- **Output:** Turning volume (GNN), AOG (LGB), AOR (LGB).
- **Training Data:** 20 days of June 2021: 1-min., 5-min. and 10-min.
- **Testing Data:** June 28th, Georgia: 5 min aggregation.



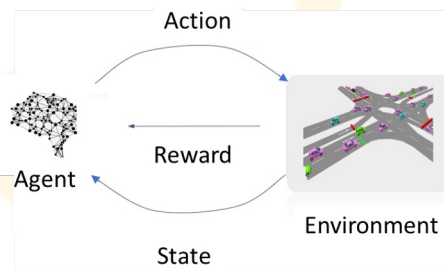
Performance Measures

Loss	Turn. Volume	AOG	AOR
MSE	7.71	0.07	0.19
RMSE	2.52	0.27	0.43
MAE	1.40	0.15	0.26

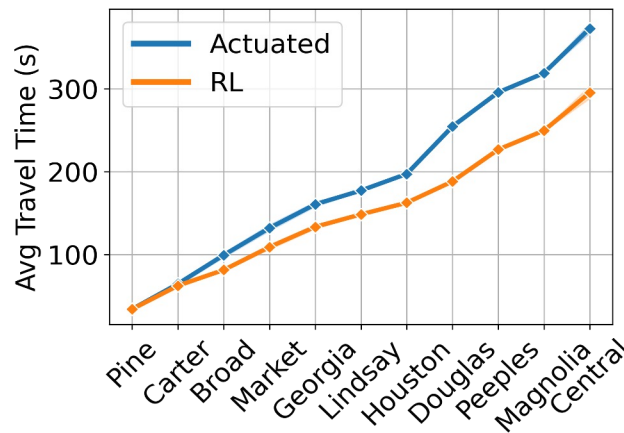
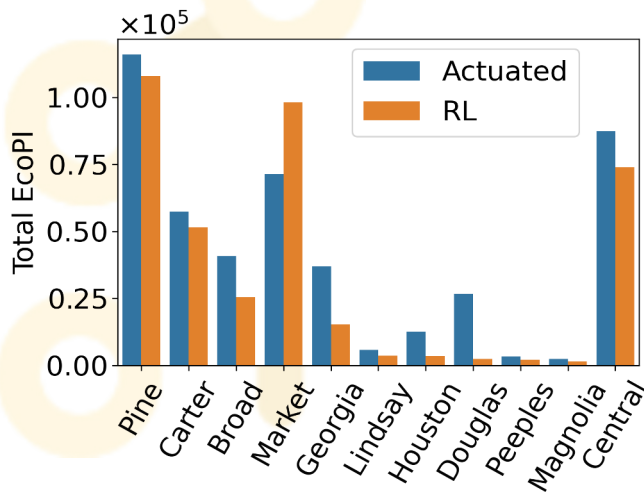


Local Optimization Using RL

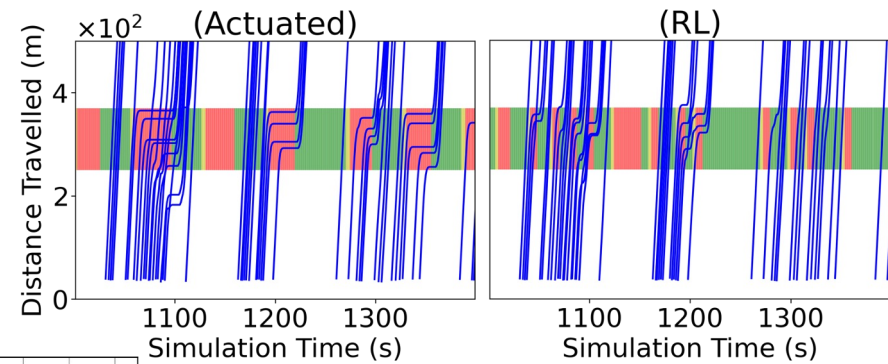
RL Algorithm: Proximal Policy Optimization



State: # of vehicles & queue lengths
Action:
 0 - Keep the current phase
 1 - Switch to the next phase
Reward: $-1 * EcoPI$



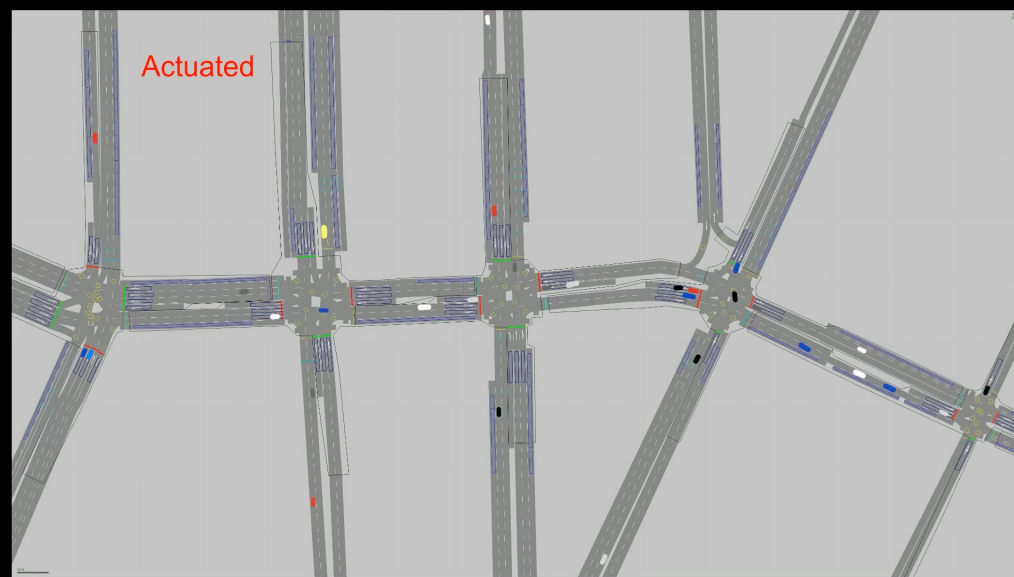
Trajectories at Houston & MLK



Results:

- Total EcoPI improved by 15.78%
- Total stop delay improved by 27.56%
- Average travel time from Pine to Central improved by 20.81%







VRU Safety



Pedestrian Safety - Near Crash



Required parameters from trajectory: time, distance, speed.

Indicators to quantify and characterize near-crash event:

- Time-to-collision (TTC)
- Post Encroachment Time (PET)
- Proportion of Stopping Distance (PSD)

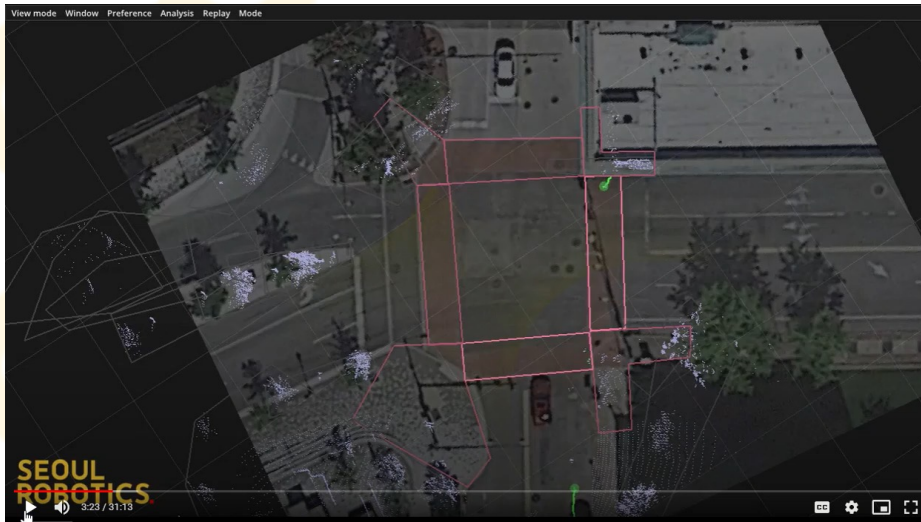


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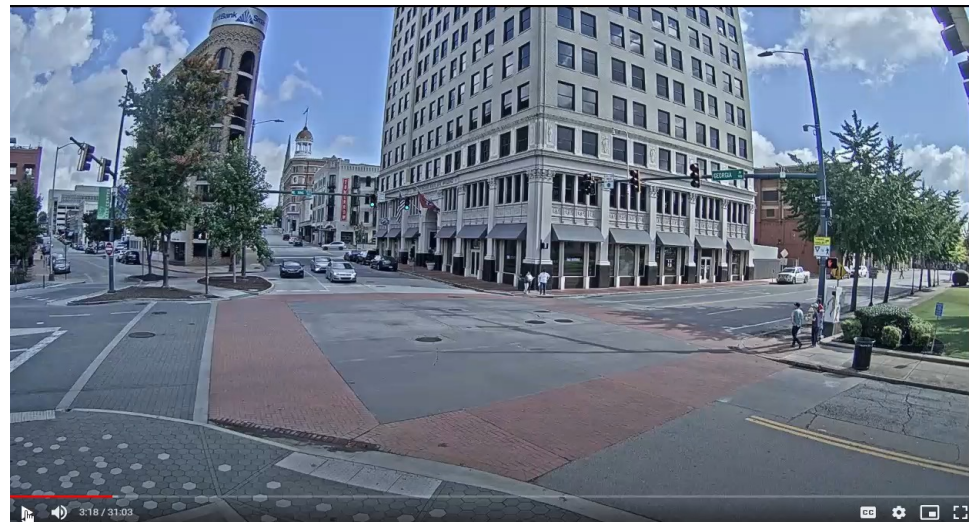


Identification of Near-Crash Event

LiDAR



Video



Sensor Fusion for More Accurate Results

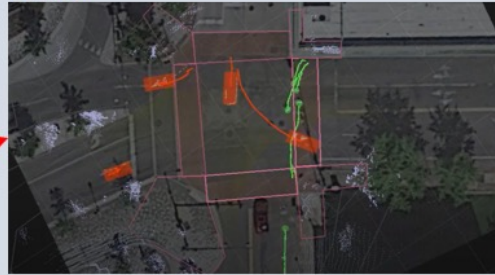
Detection Sensors

MLK Smart Corridor



Individual Detection

LiDAR



- No privacy issue
- Not light sensitivity
- Accurate 3D distance

Camera



- Privacy issue
- Light sensitivity
- Good for scene interpretation

Sensor Fusion

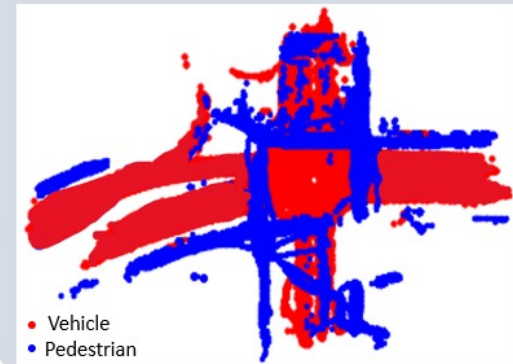
Performance of Detection

- Camera: High false positive
- LiDAR: High false negative



Improve

- ✓ Larger detection coverage
- ✓ Higher detection accuracy & reliability
- ✓ Better trajectory continuity
- ✓ Daytime and nighttime



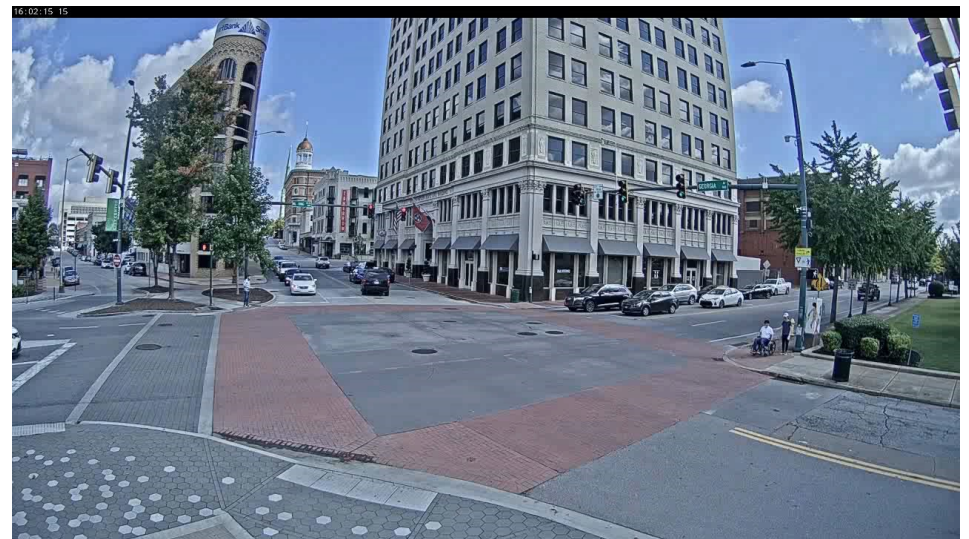
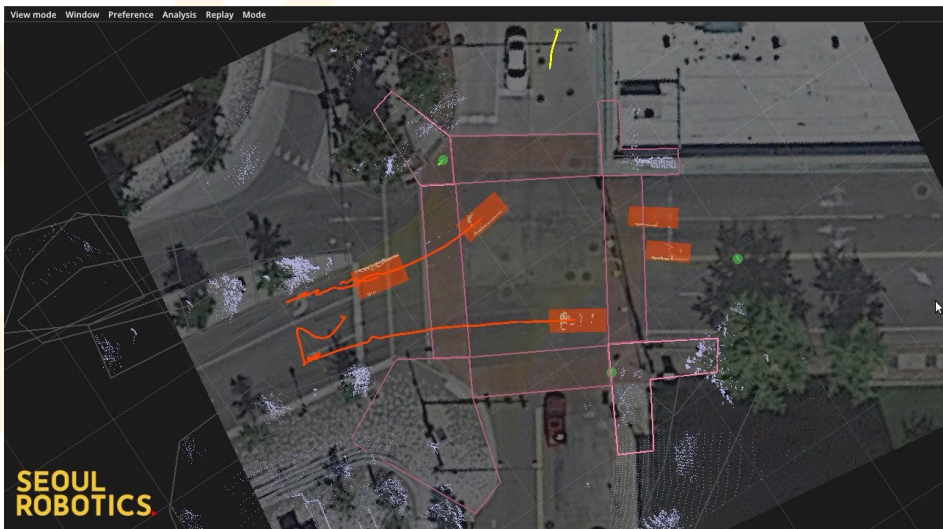
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Lidar Based Traffic and Pedestrian Safety Monitoring – Accessibility for All





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