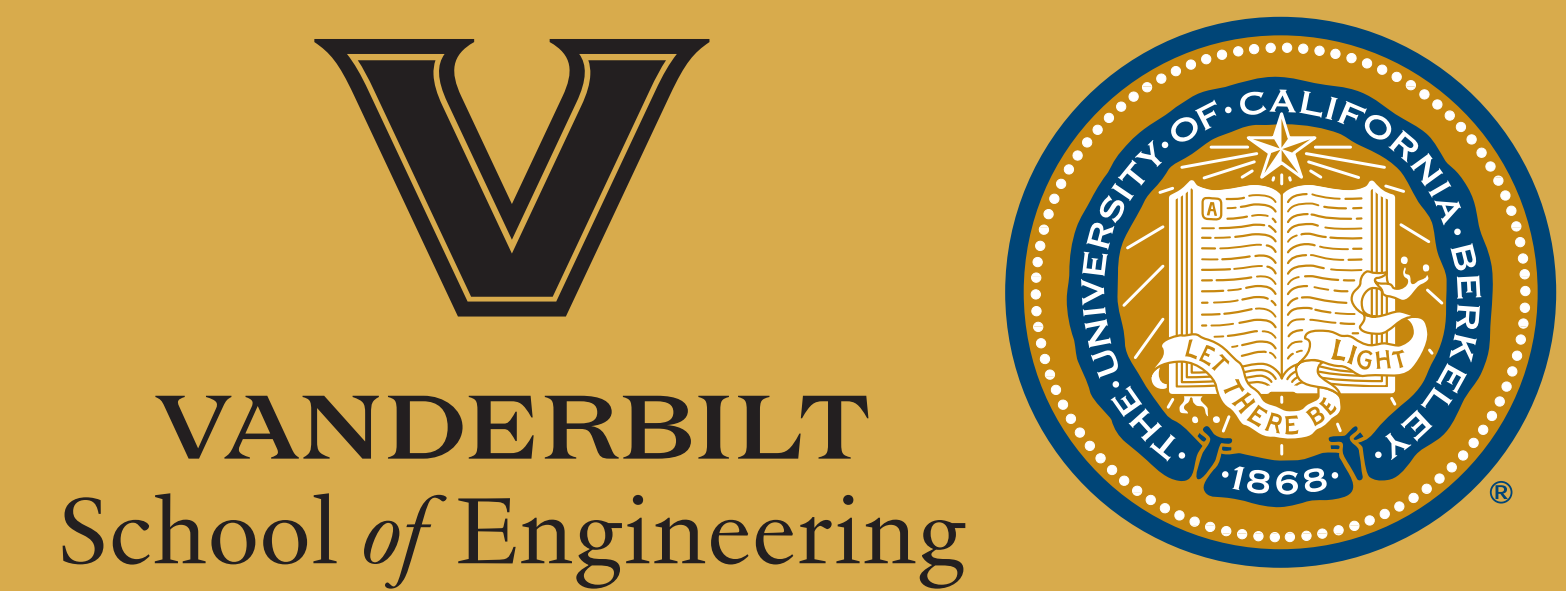# Coordinating Actors via Learning for Lagrangian Systems (CALLS)

Jonathan Sprinkle, Dan Work, Alexandre Bayen, Jonathan Lee, Matthew Nice, Alex Richardson
(Vanderbilt University, UC Berkeley)

VANDERBILT School of Engineering

Motivation

Improve the ability to build artificial intelligence algorithms for Cyber-Physical Systems (CPS) that incorporate communications technologies, by developing methods of learning from simulation environments.
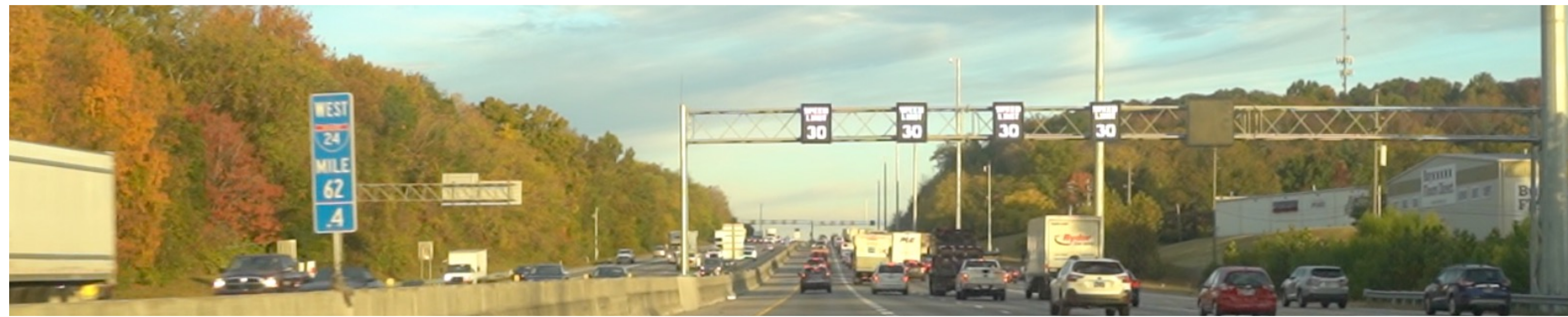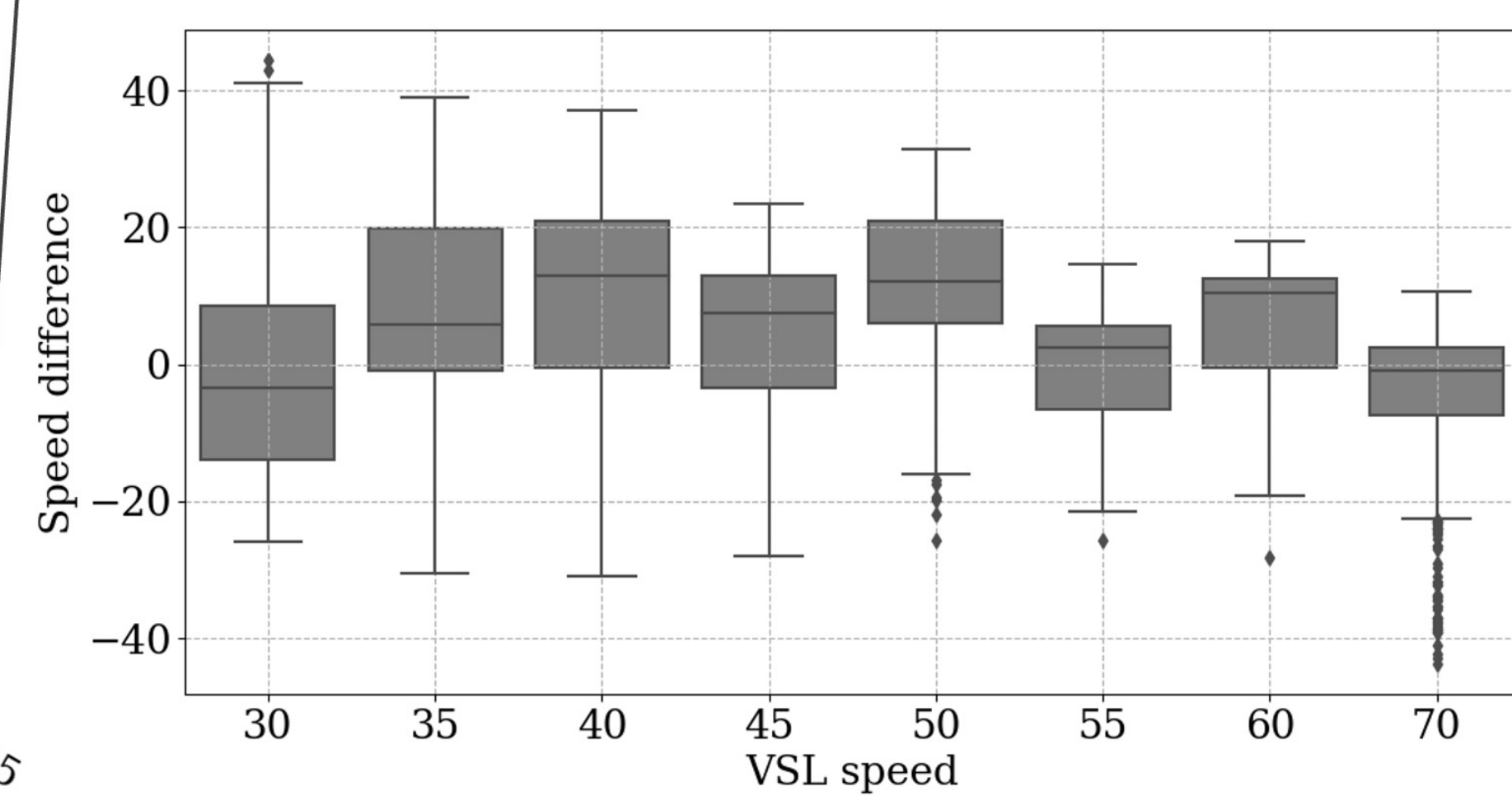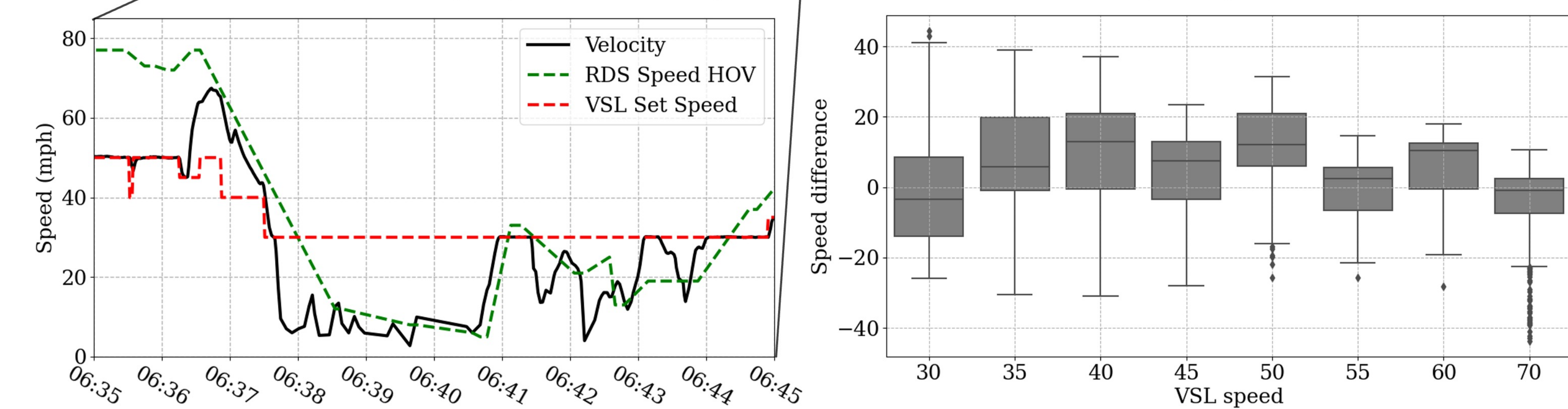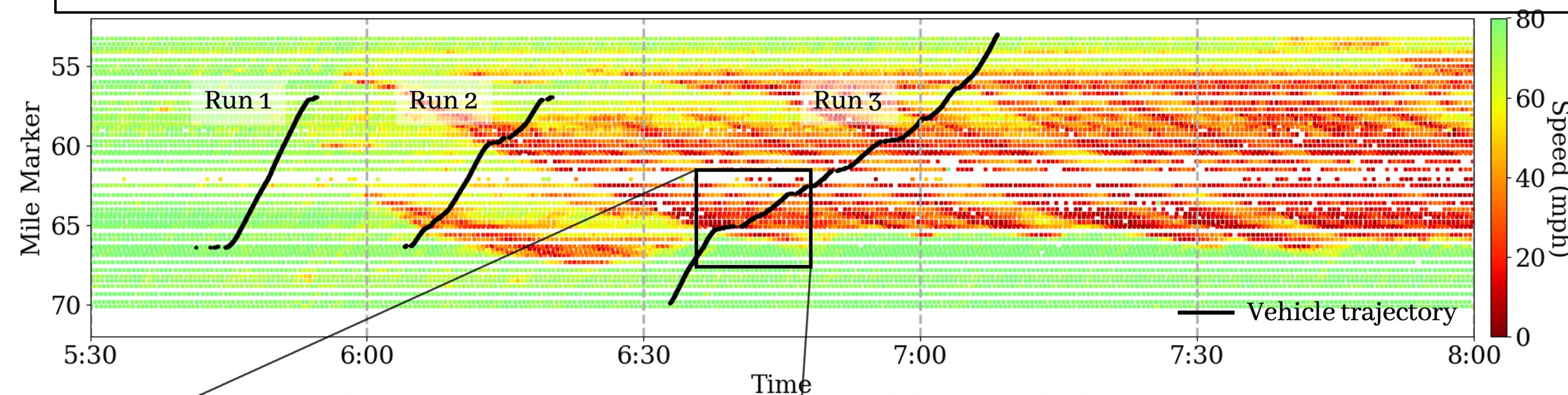

(Pictured left): Roadside sensors, Gantry with Variable Speed Limits, Lane Control System. Co-located with TDOT's I-24 MOTION Camera Poles
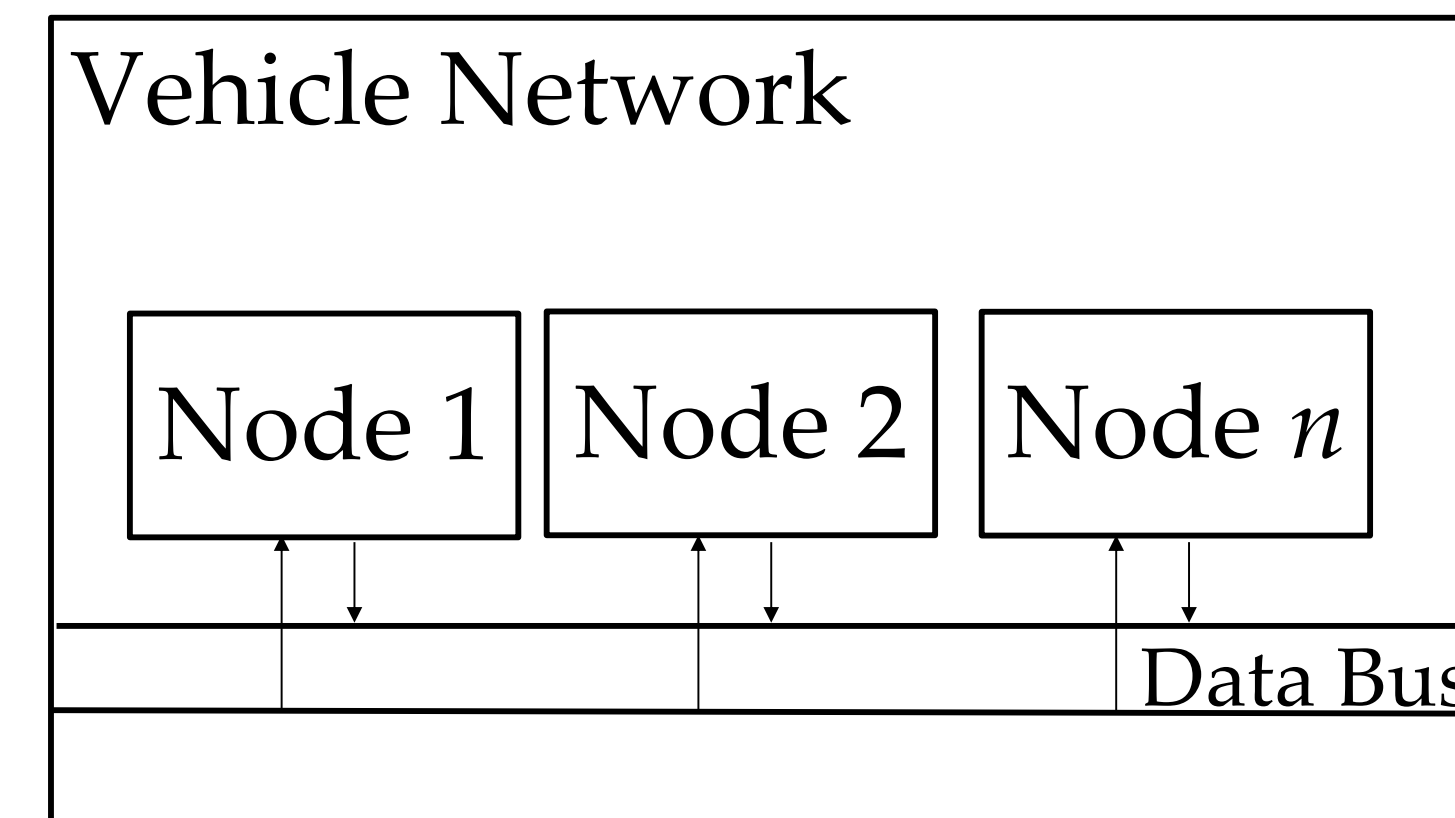
TDOT's I-24 SMART Corridor

New Result:

Question: *How can we design a controller to follow variable speed limits when it can, and keep up with the prevailing speeds when it needs to?*

Contribution: design, implementation, and field test of a new cooperative automated vehicle control algorithm that complies with variable speed limits when other human drivers do, blending in with human drivers when they violate the posted speeds.

(a) SAILing experiment RDS speed data and the test vehicle trajectory

(b) Speed profile: vehicle, RDS, VSL comparison

(c) RDS speed v.s. VSL control speed

Prevailing Speeds are Fast, Making Recommended Speeds Feel Too Slow

ACC Setpoint
Radar
Control Car
Local Traffic
Downstream Traffic
RDS
VSL Algorithm
VSL Gantry

Integrating Infrastructure Enables CAVs to Avoid Speeding into a Stop

Methods and Experimentation

Vehicle Network
Node 1   Node 2   Node n
Data Bus

- App-based software accelerates the develop-deploy cycle
- GPS and 4G LTE are used for location and connectivity from vehicle
- Low-cost reversible installation
- OEM drive modes for on-the-fly parameters
- On-board stock radar to estimate prevailing speeds of traffic

$$v_{\text{mid}}=min(max(v_{pr}-v_{offset},v_{g_r}),v_{des_{max}})$$

Transition to Practice is underway with industry partner Nissan, as part of a large-scale test planned in California for Summer 2024.
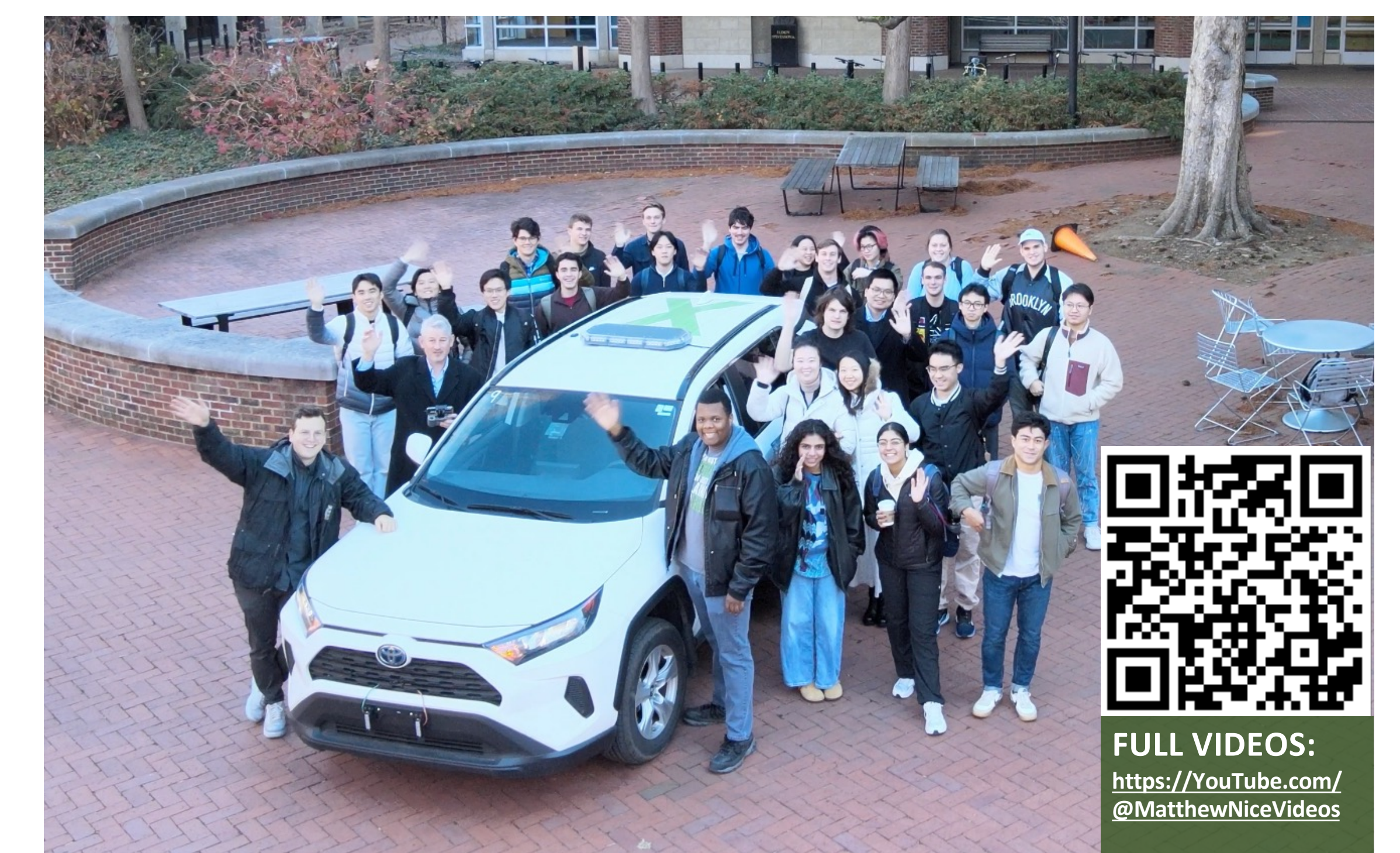
Field Testing
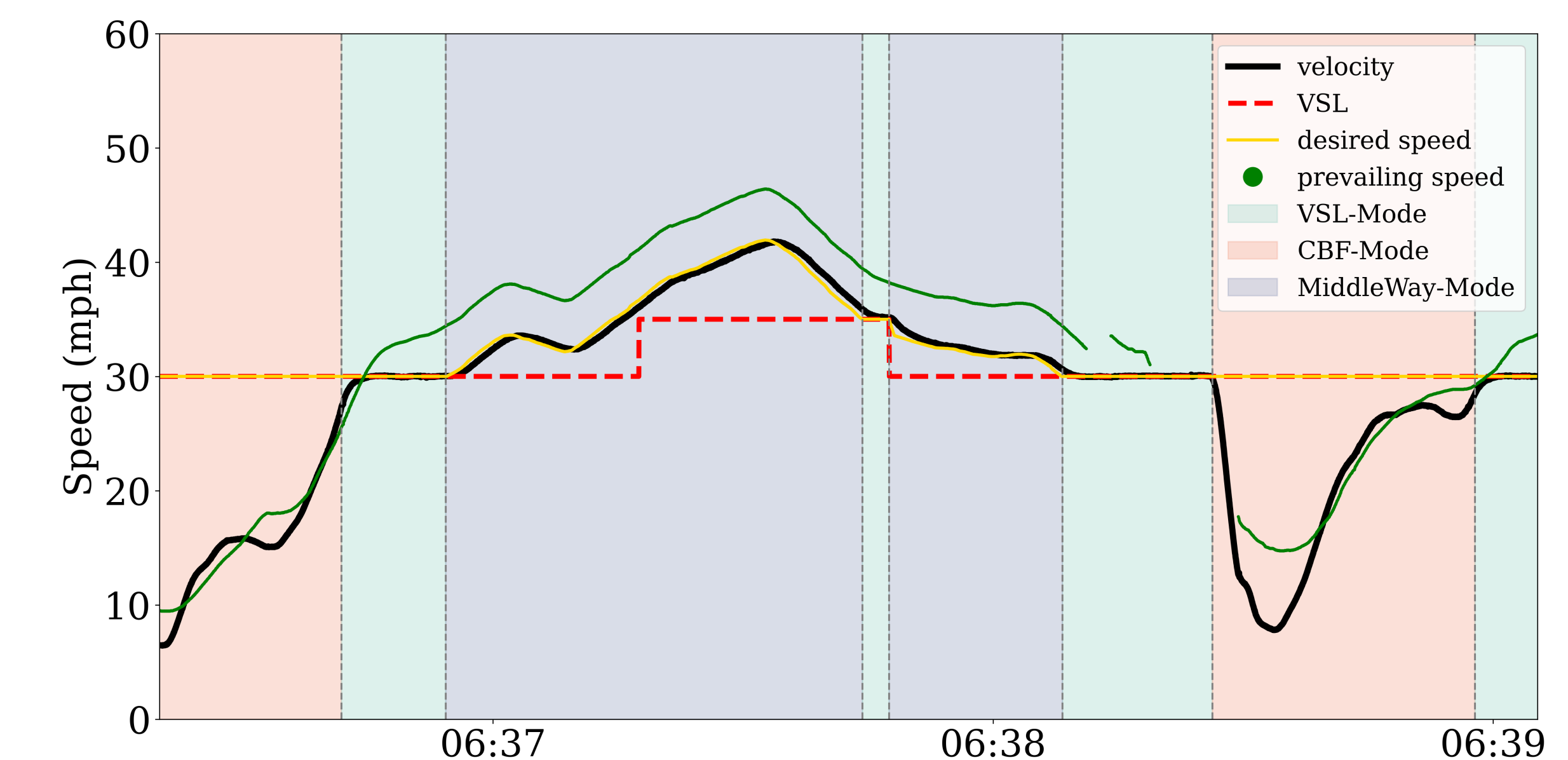
Via media control strategy "in the wild": 16.6% at VSL, 24.0% at Middle Way, 54.6% in CBF car-following.

Broader Impacts

(Pictured below): Vanderbilt undergraduate and graduate students learn the tools to develop and deploy their own control algorithms on our CAV. By the end the semester, we fielded 11 student controllers on the open-road.
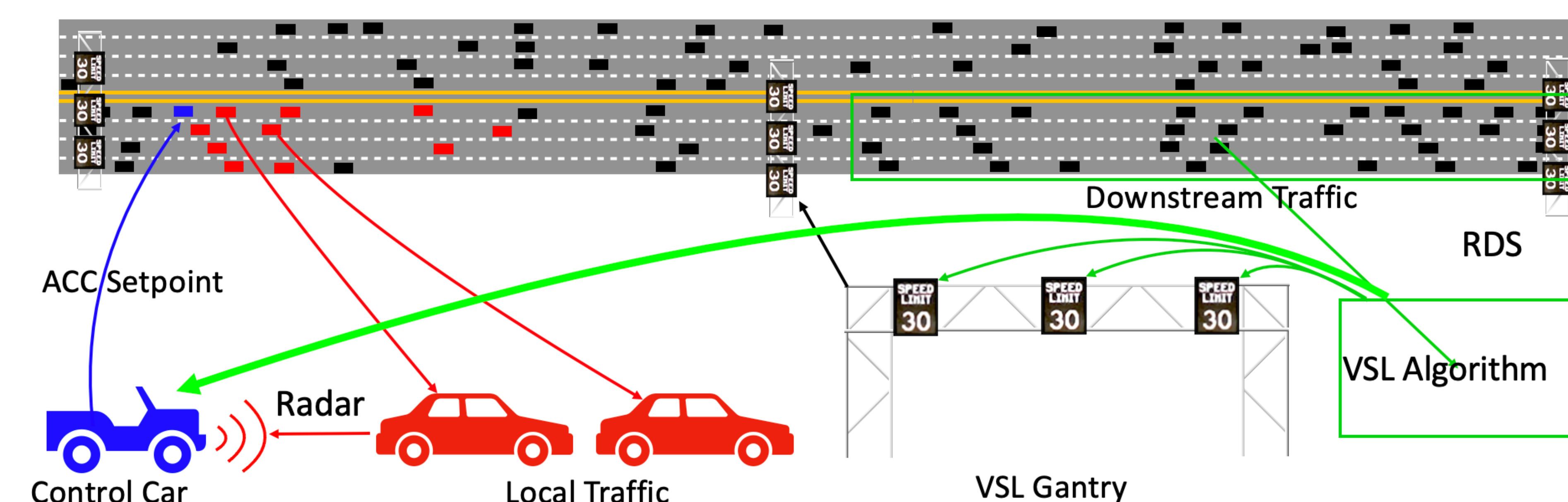

FULL VIDEOS:
https://YouTube.com/@MatthewNiceVideos

Recent Papers

[1] Nice, Matthew W., George Gunter, Junyi Ji, Yuhang Zhang, Matthew Bunting, Will Barbour, Jonathan Sprinkle, and Dan Work. "A Middle Way to Traffic Enlightenment." arXiv preprint arXiv:2401.15818 (2024). (Accepted: ICCPS)
[2] Nice, Matthew, Matt Bunting, Alex Richardson, Gergely Zachar, Jonathan W. Lee, Alexandre Bayen, Maria Laura Delle Monache et al. "Enabling Mixed Autonomy Traffic Control." arXiv preprint arXiv:2310.18776 (2023).

Acknowledgements

TN TDOT Department of Transportation