ARPA-E NextCAR Project
Live Oak Corridor Pilot

NEXTCAR Project

SENSYS networks

Agenda

- Overview of Program
  - Vehicle Level
  - Road Level
  - Cloud Level
- Technologies
  - Roadside subsystems
  - Vehicle subsystems
- Pilot Overview
  - Agency Requests
  - Vehicle Operation
  - Vehicle Tests
- Discussion and Next Steps

ARPA-E NEXTCAR program
April 2017 – April 2020

PREDICTIVE DATA-DRIVEN VEHICLE DYNAMICS AND POWERTRAIN CONTROL

Hyundai Motor Group

UC Berkeley
Department of Mechanical Engineering

Sensys Networks Inc.

Live Oak NEXTCAR Pilot

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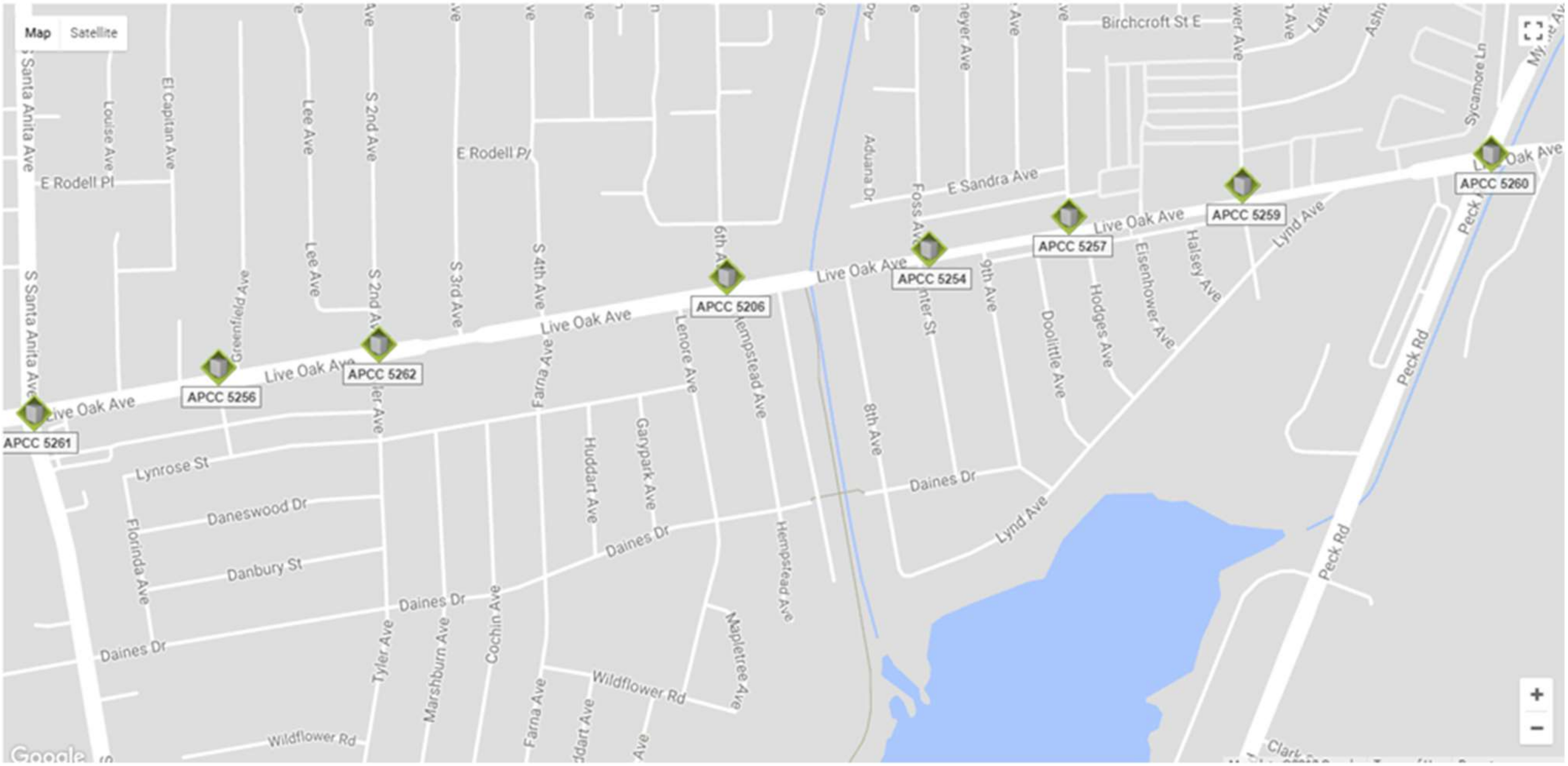
- Objective:
  - Pilot the NEXTCAR Vehicle Dynamics & Power Train (VD&PT) technology in a real-world environment
  - Use fleet of equipped vehicles and upgraded traffic infrastructure using V2V and V2X communications
- Timeframe: 6 months starting in 1Q19
- Scenarios
  1. Adaptive cruise-control using V2V communications
     - No infrastructure
  2. Eco-approach using V2I communications
     - SPaT/MAP messages from individual intersections
  3. Eco-routing using V2C communications
     - Traffic flow data from ITM Advanced cloud

Live Oak Corridor

8 intersections equipped with ITM Advanced system



Demonstrate 20% energy saving in real-world driving

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Highway Driving → Eco-CACC & SPD-HARM

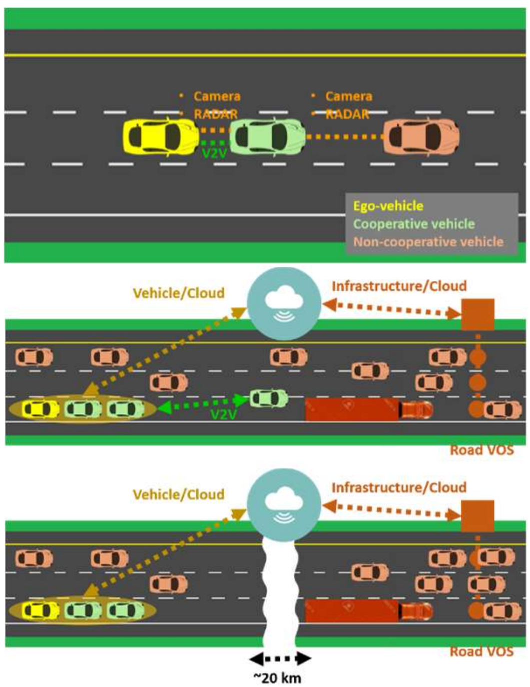
- **V2V communication**
- **Cloud connectivity**

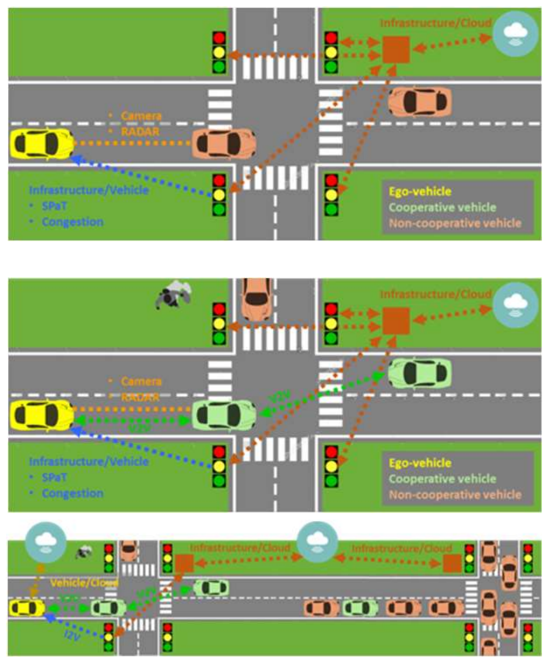
Urban Driving → Eco-approach/departure at signalized intersections

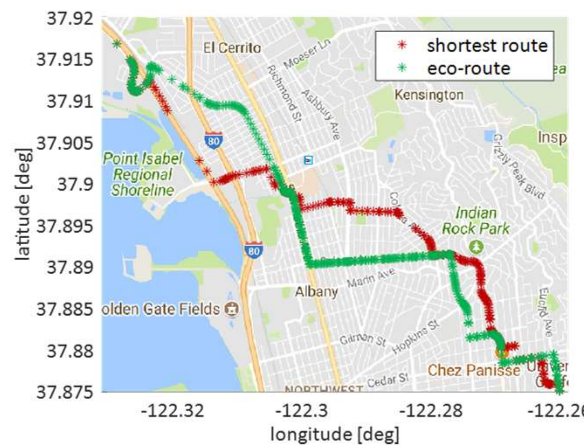
- **V2V/I2V communication**
- **Cloud connectivity**

Eco Routing

- **V2V/I2V communication**
- **Cloud connectivity**







[Images from www.pexels.com]

Table of savings from VD&PT control

Original estimates based on the literature

Scenario	VD saving	PT saving	Tot. saving
1. Urban	7-12%	13-15%	≥20%
2. Highway	10-15%	10-15%	≥20%
3. Eco-routing	5-15%	15-20%	≥20%

Current estimates based on our simulations

Scenario	VD saving	PT saving	Tot. saving
1. Urban	Up to 50%	10-15%	≥20%
2. Highway	10-15%	10-15%	≥20%
3. Eco-routing	15-25%		≥20%

Current estimates based on our experiments

Scenario	VD saving	PT saving	Tot. saving
1. Urban	-	-	-
2. Highway	-	-	-
3. Eco-routing	-	-	-

Roadside Subsystems

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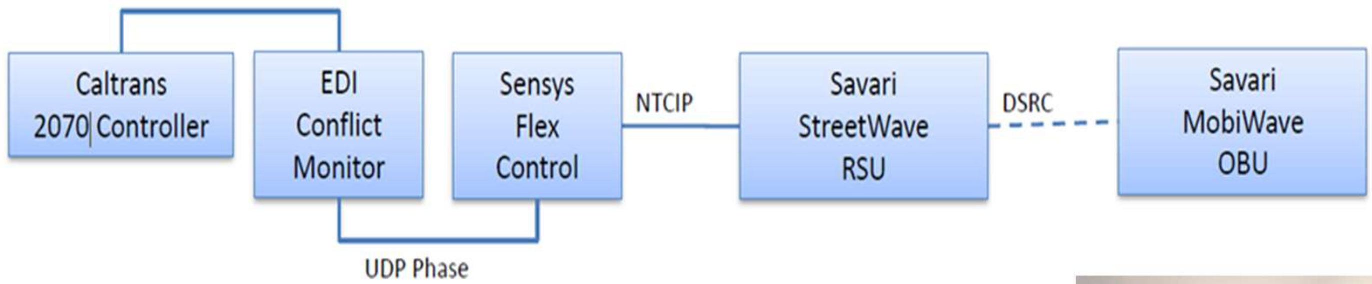
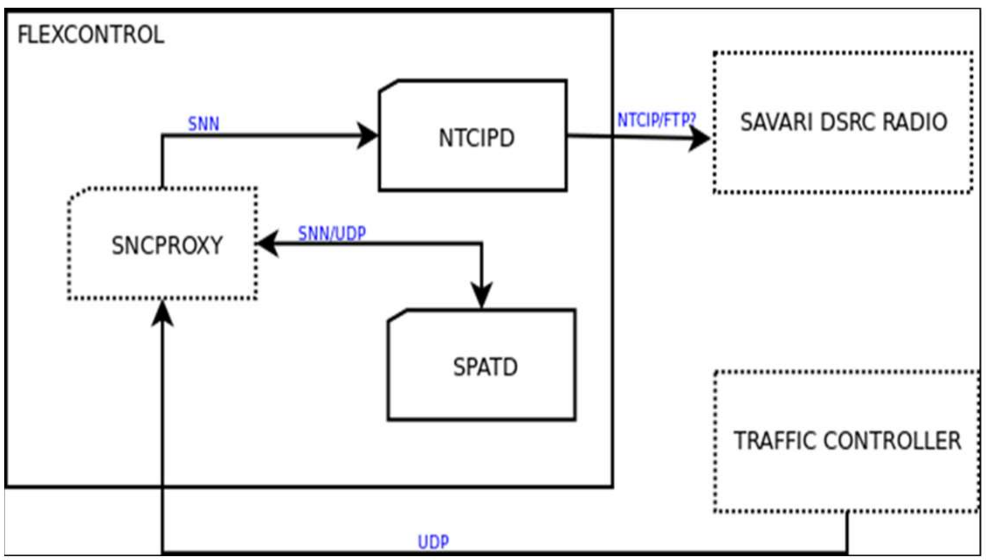
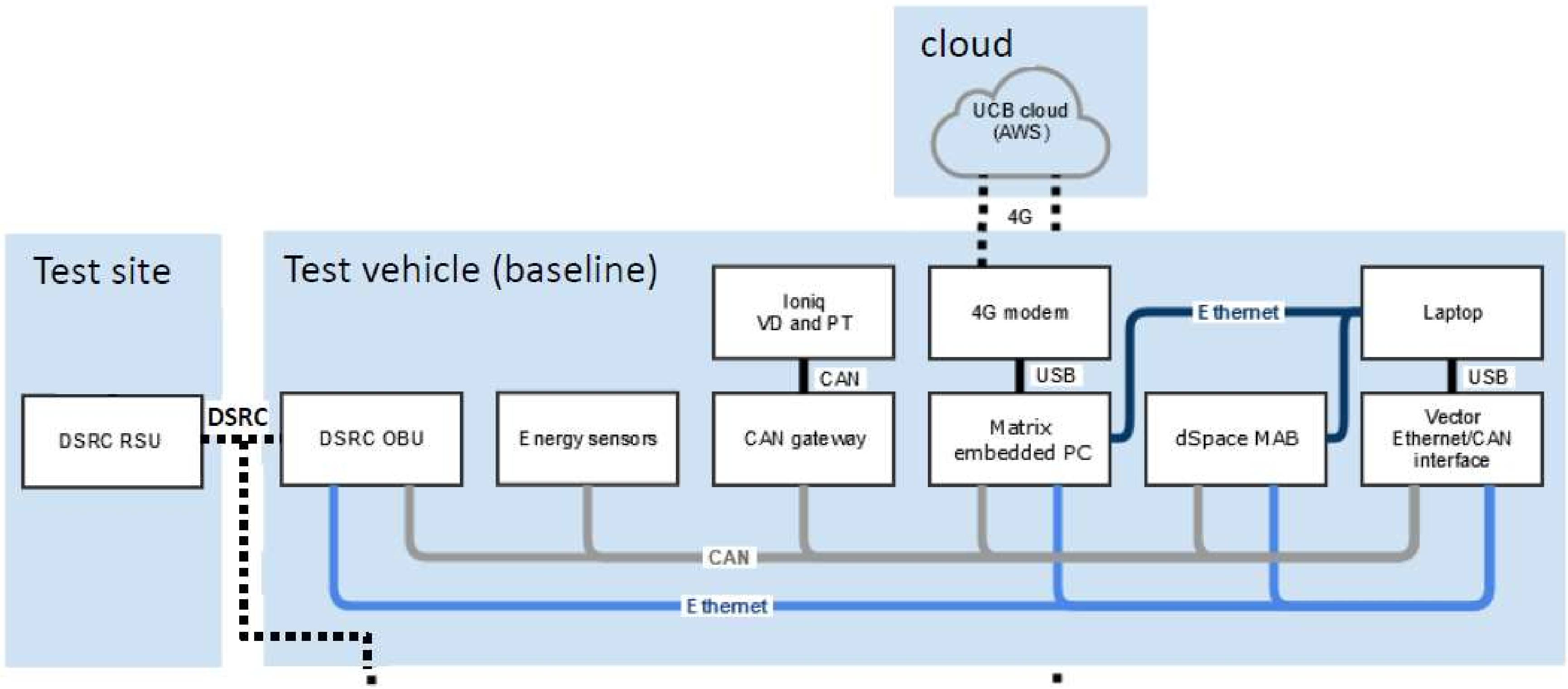
Deployed at each intersection





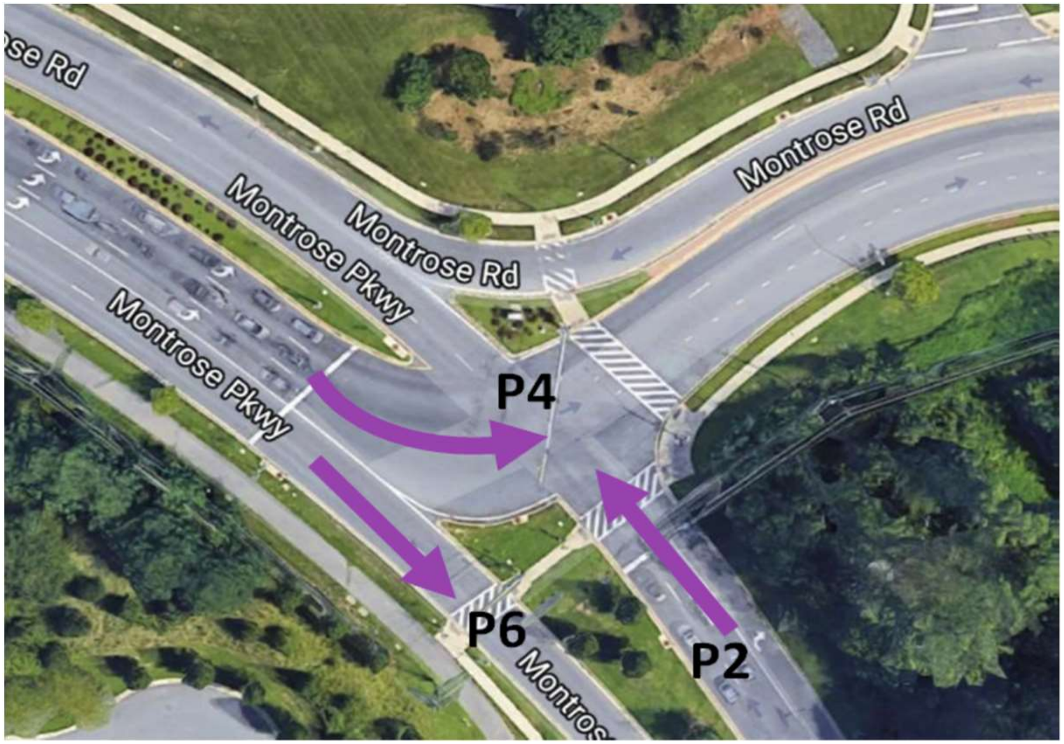
Vehicle Subsystems

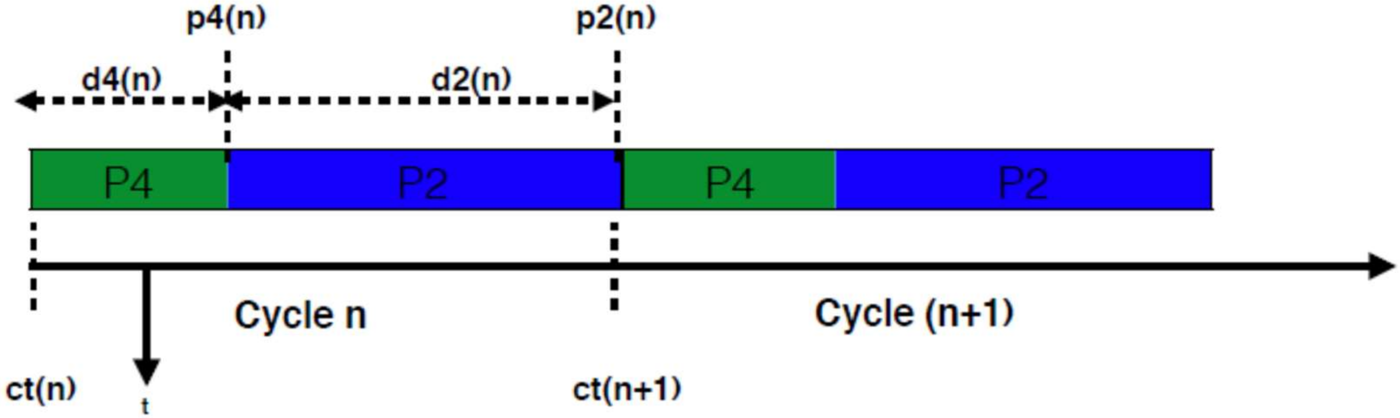


SPaT Problem

Montrose Rd. and Montrose Pkwy in Montgomery County, MD,

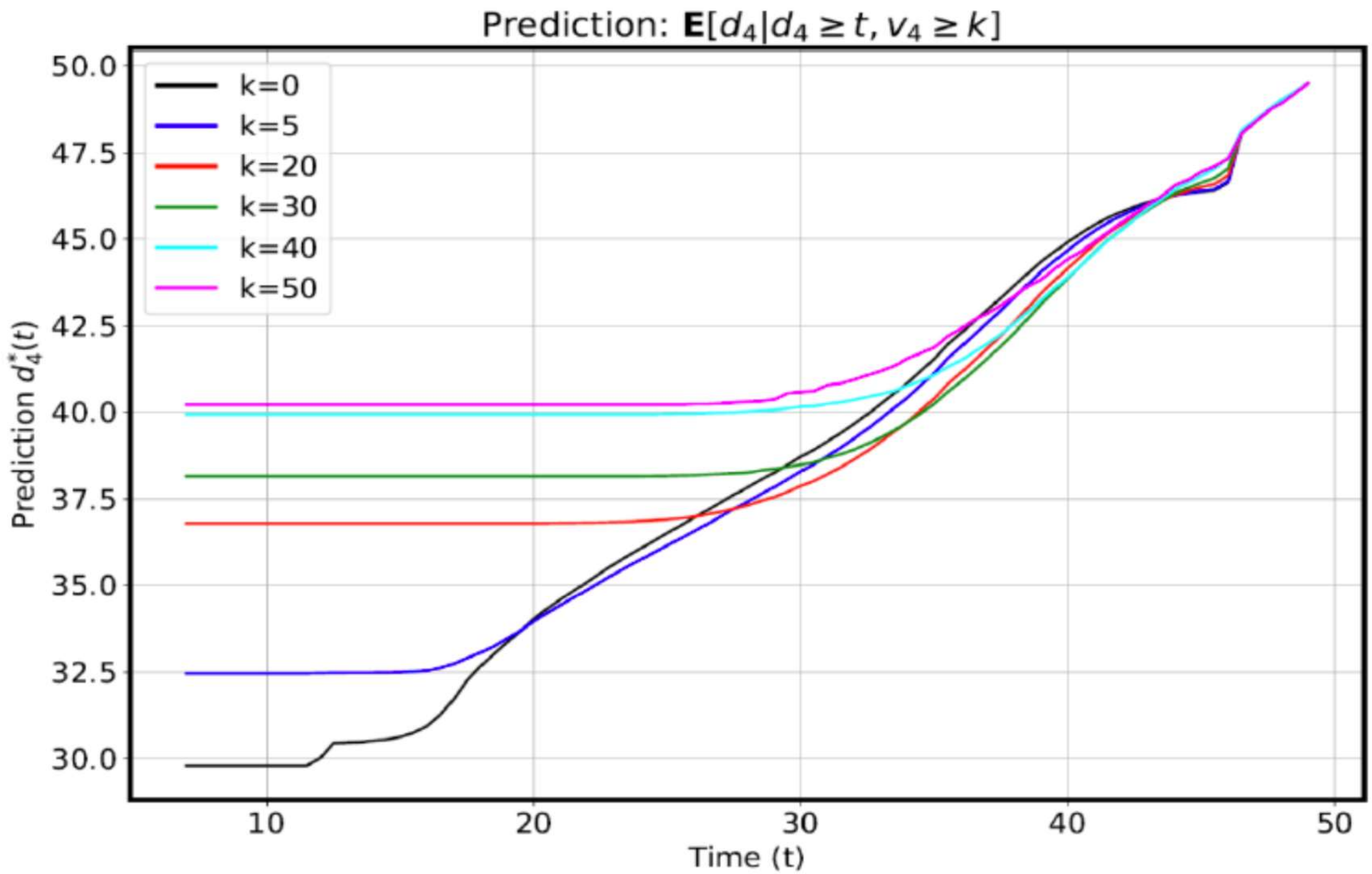
• Data from April 2016 to April 2017 - 13 months
• Phase duration measurements, vehicle detection measurements





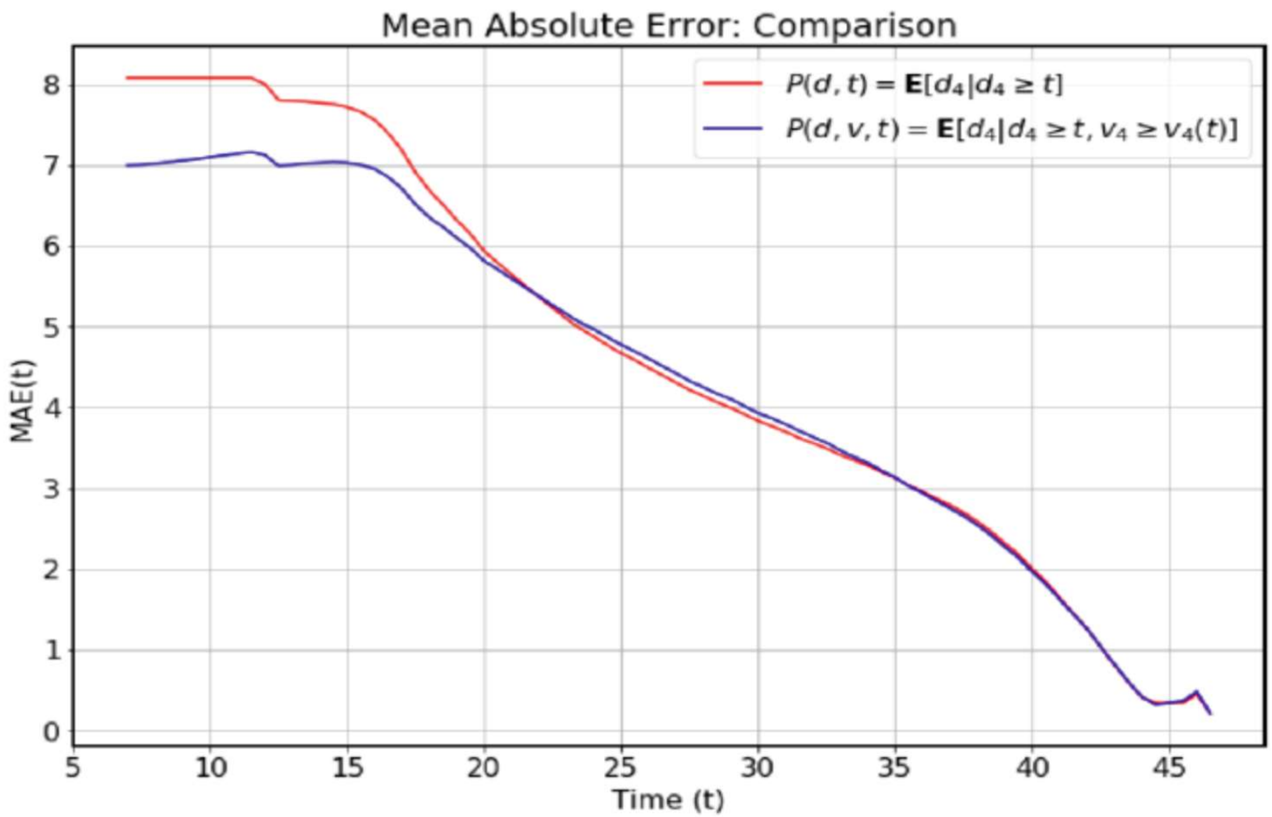
SPaT Prediction

Prediction using Phase Duration and Vehicle Flow



SPaT Prediction Performance

MAE Comparison: with and without vehicle detection



Data from April 2016

RFS Testing: On-board setup

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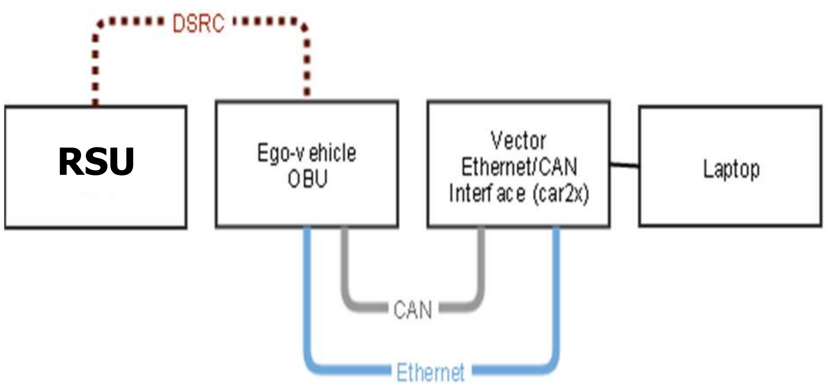
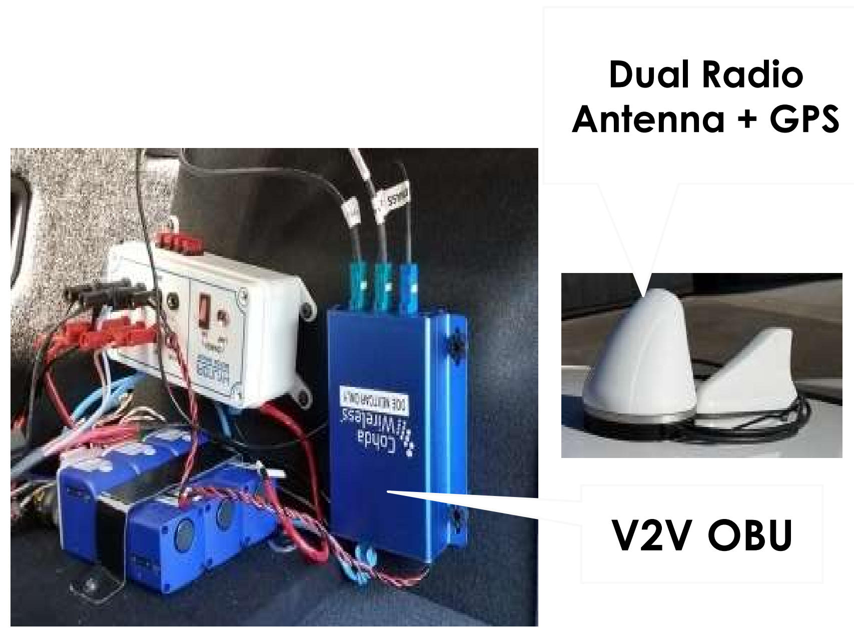
- Cohda MK5 DSRC module integrated in test vehicle
- Using Vector.Car2x interface confirmed SAE J2735 V2I SPaT and MAP Rx functionality between Siemens RSU and Cohda OBU



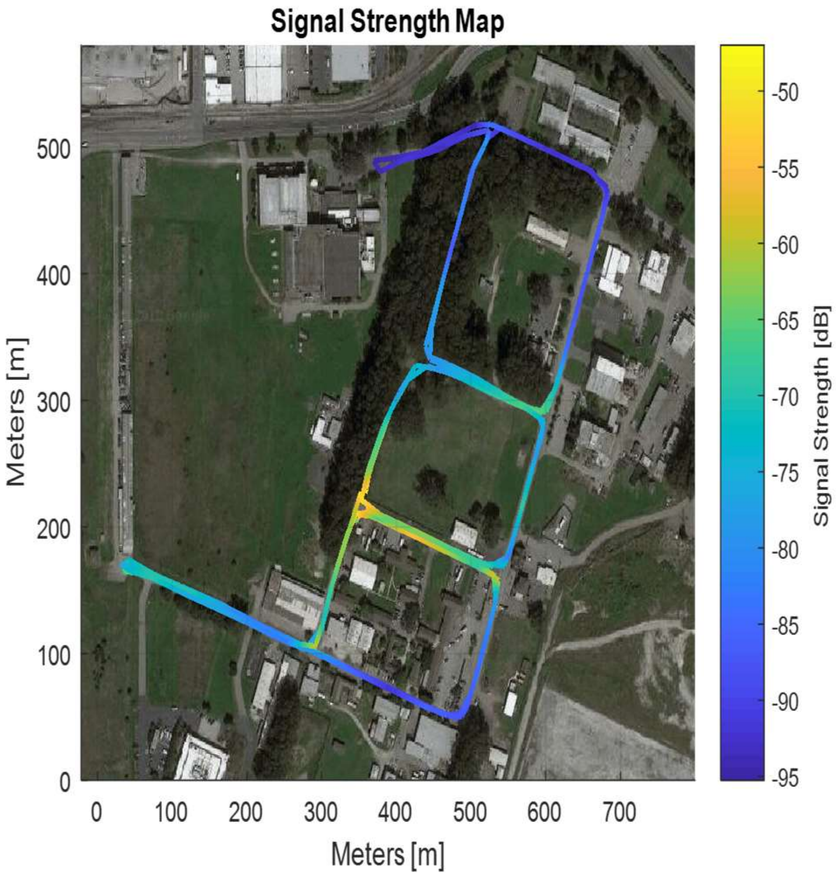


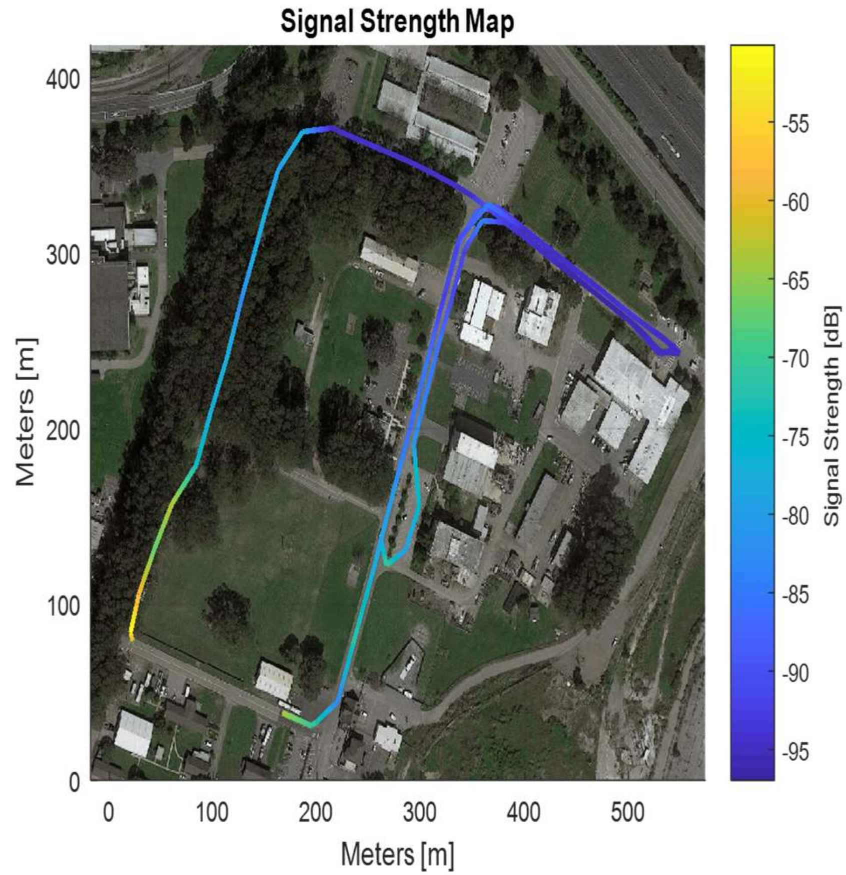
RFS Testing: SPaT signaling demo

Includes geo-fencing with MAP messages and displaying relevant phase timing

RFS Testing: RSU → OBU communication range

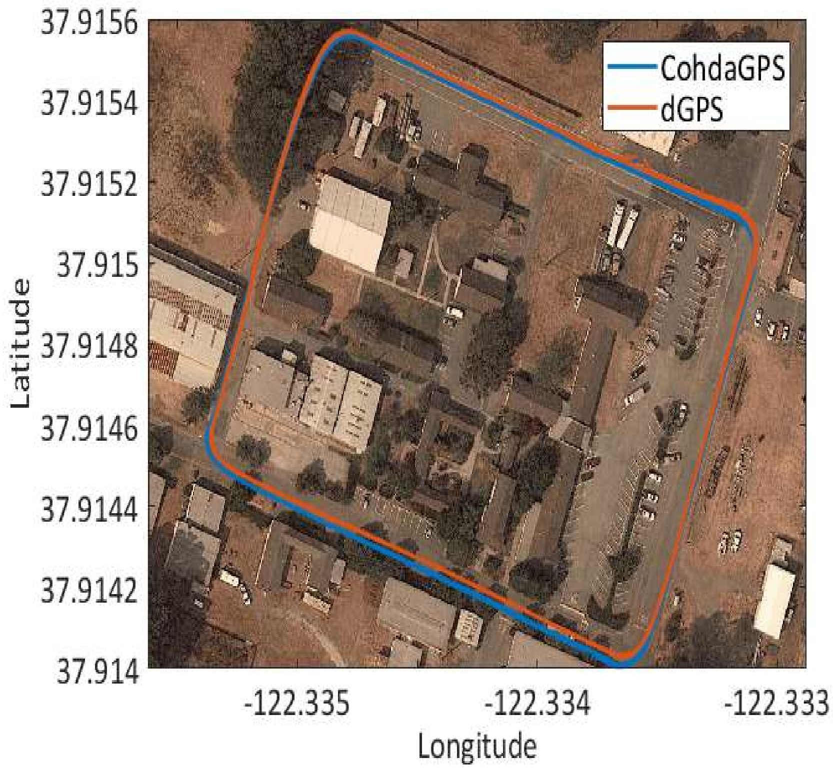
- Strength of the RSU signal received from Cohda OBU (signal lost below -95dB)

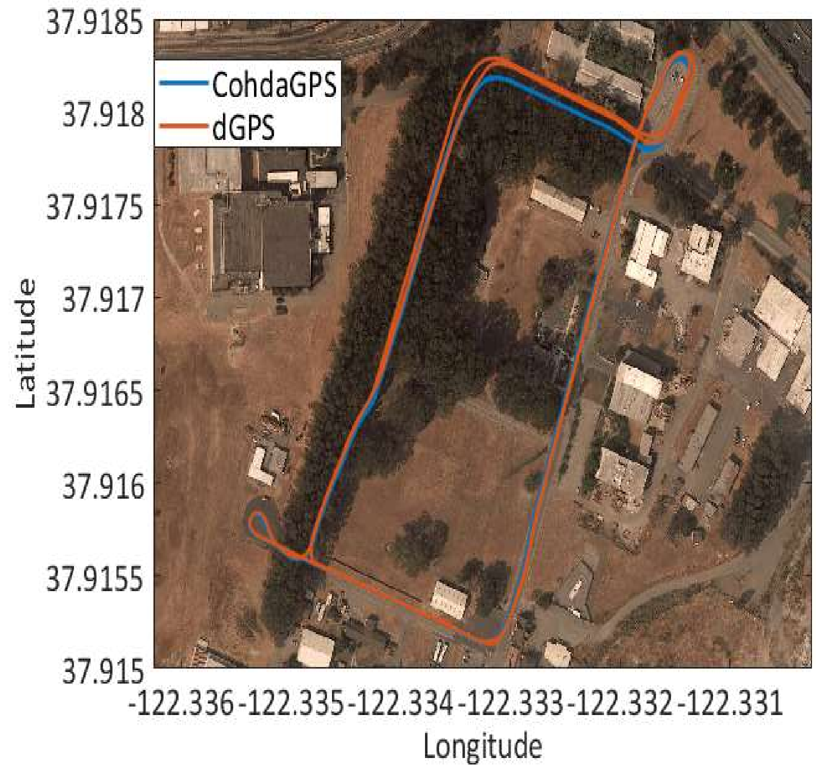




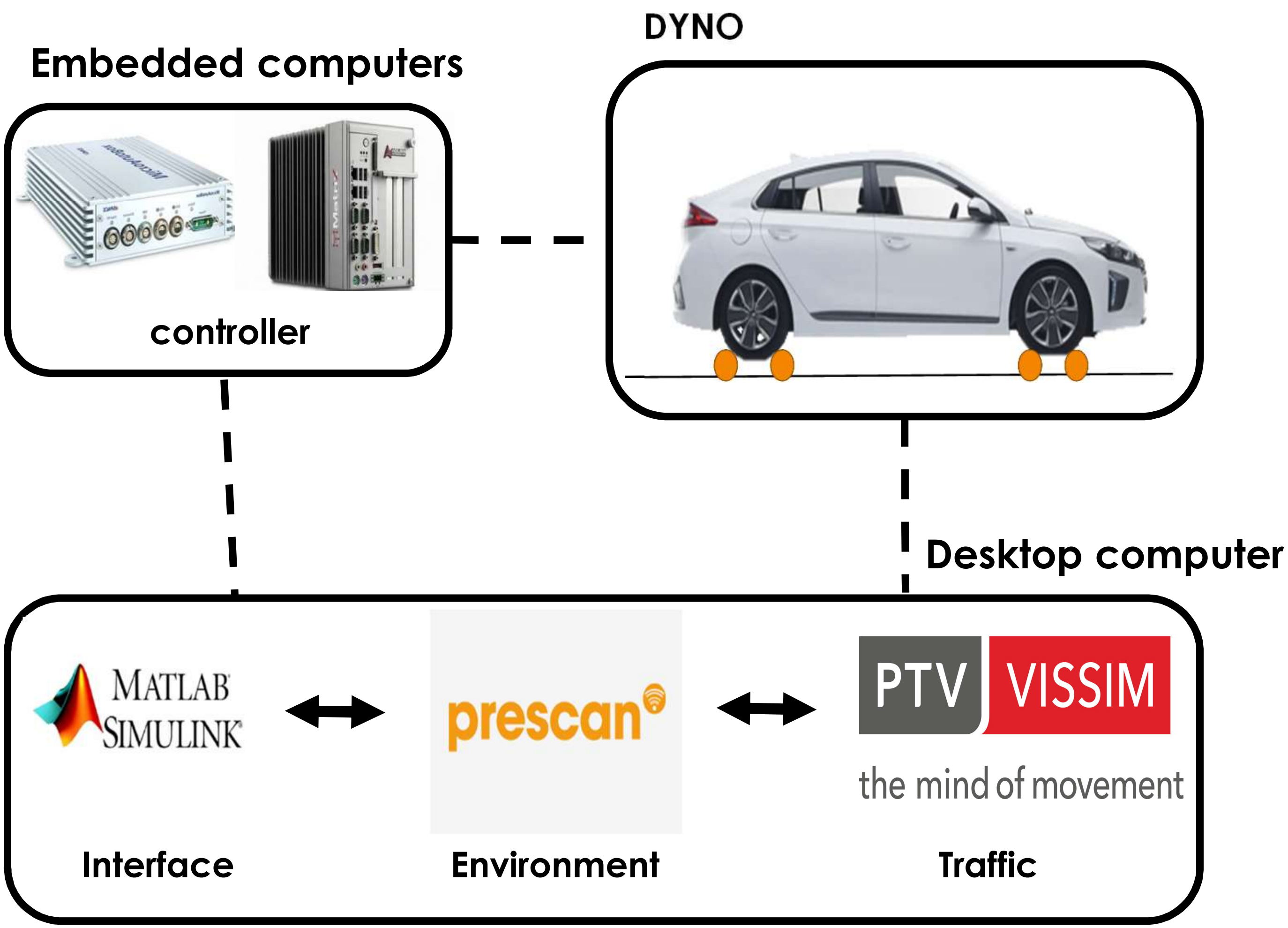
RFS Testing: Cohda OBU GPS accuracy

- Comparison with Oxford Technical Solutions (centimeter-level) differential GPS





Vehicle-in-the-loop architecture



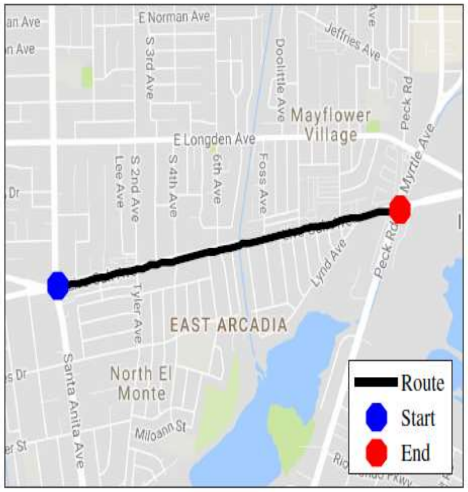
Live Oak corridor: simulation setup

- **2.5 km urban corridor with 8 adaptive traffic lights, located in the city of Arcadia, CA**

- **GOAL: minimize vehicle's energy consumption using driving automation and connectivity**

- **2 level approach:**

  1. **Eco-drive level → optimize velocity trajectory to green-wave through the corridor, based on historical SPaT data**
  2. **Adaptive Cruise Control level → track the eco-drive trajectory while avoiding collisions and signal violations**



Live Oak : dyno experiment results WITHOUT traffic

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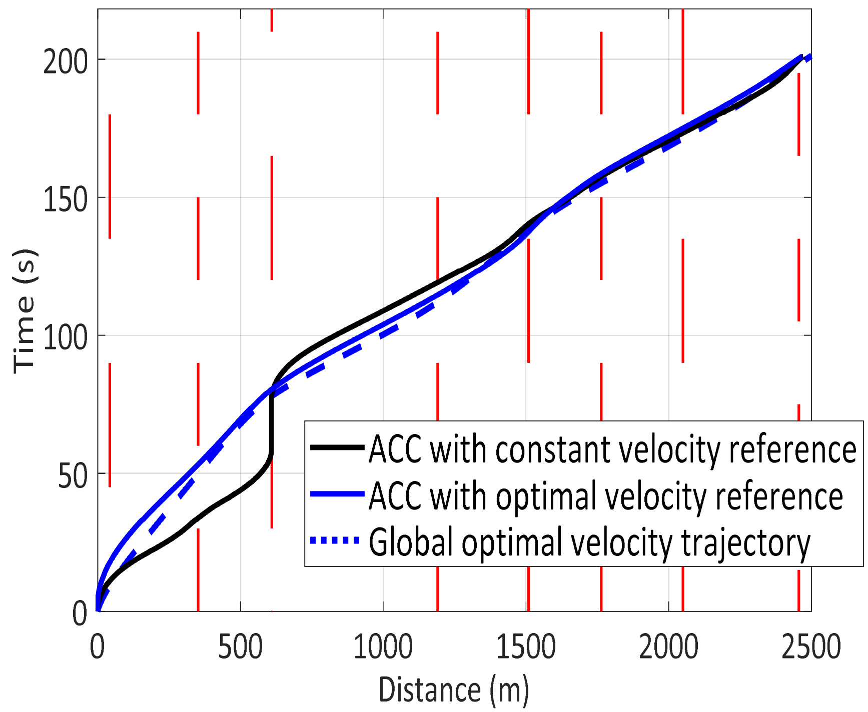
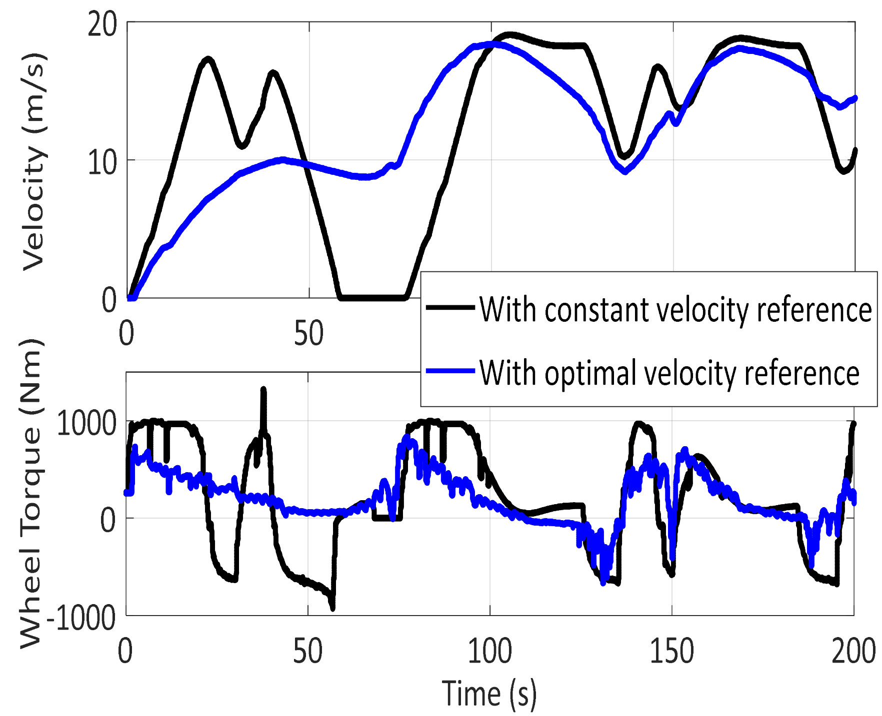
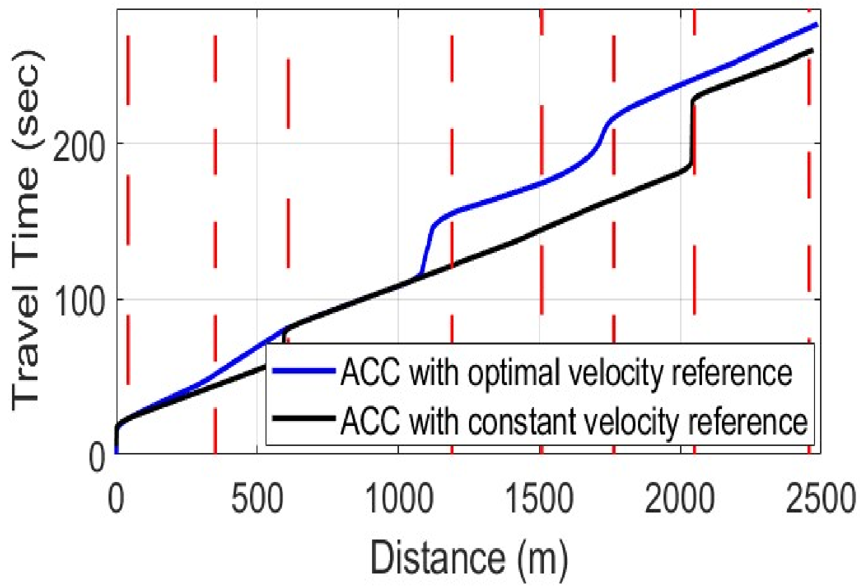
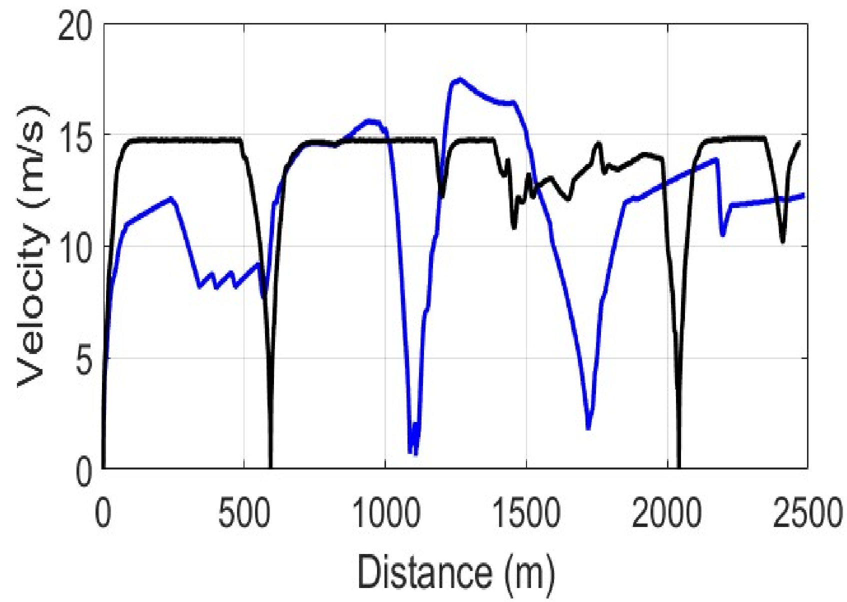




	ACC with constant velocity reference	ACC with optimal velocity reference	Delta
Wheel energy	315 Wh	231.6 Wh	-26%
Total time	209.5 s	221.8 s	+6%

Live Oak : dyno experiment results WITH traffic





	ACC with constant velocity reference	ACC with optimal velocity reference	Delta
Wheel energy	290.8 Wh	195.1 Wh	-33%
Total time	260.6 s	277.4 s	+6%

Summary

- SPaT prediction for actuated intersection
  - Real time information dramatically improves predictions
  - Residual duration can exhibit jumps
  - Potential to weight 'time to red' and 'time to green' differently
- Eco-Driving using SPaT
  - System architecture for vehicle and infrastructure
  - Promising dyno test results
  - Pilot testing planned along Live Oak

Thank you!

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