Truck AUtonomy

Auburn's Truck Automation Work

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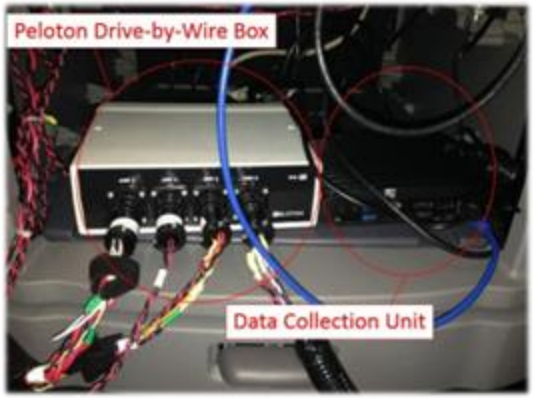
Auburn NCAT Test Track and Garage

2 vehicle bay garage

1.7 mile two lane track

AU Truck Vehicle Instrumentation



- Two Peterbilt 579 Trucks
- One Freightliner Cascadia
- Radar
  - Primary ranging source
- GPS
  - Secondary ranging source
- V2V Comms
  - DSRC Dedicated inter-vehicle communication
- Cameras and Tablets
  - Driver situational awareness
- Drive-by-Wire Kit
- Computing Hardware

Truck Automation

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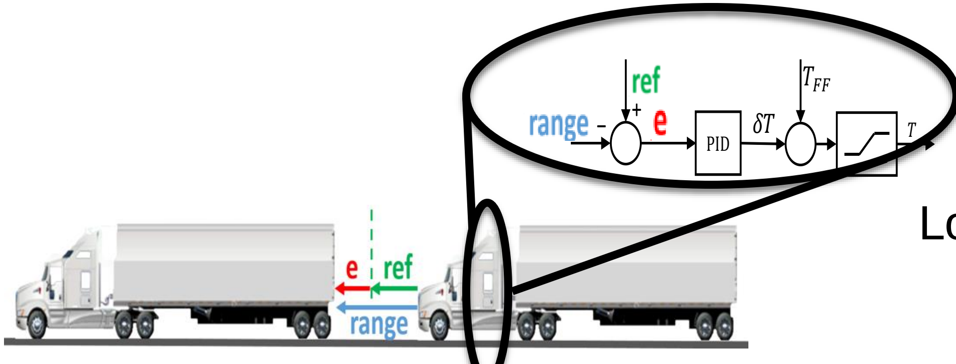
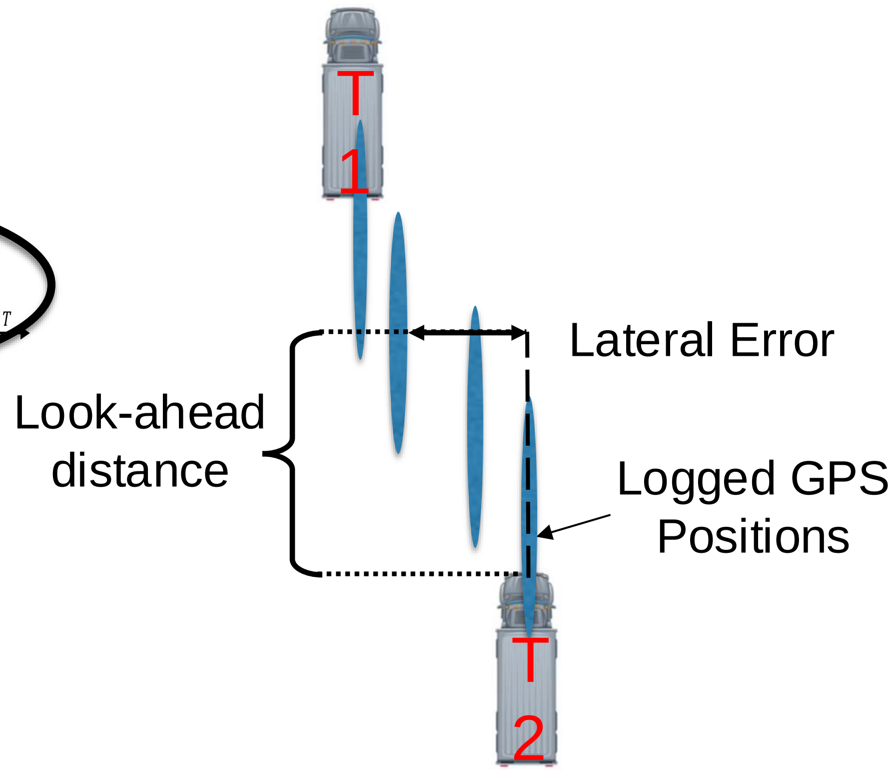
- Large mileage driving (50,000 more miles than the next vehicle type)
  - $105B in 2015 on Diesel
  - 30-40% of operating costs
- Truck accidents are generally catastrophic
- Decline of truck drivers
  - Especially in remote areas (i.e. the Canadian forestry industry)
- Utilizing V2X
- Testing of both
  - Throttle/Brake
  - Throttle/Brake/Steering

Level 1-2 Platooning



Level 1:

Longitudinal Control



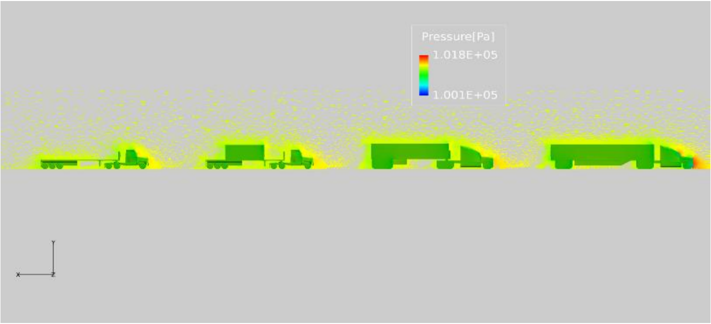
Level 2:

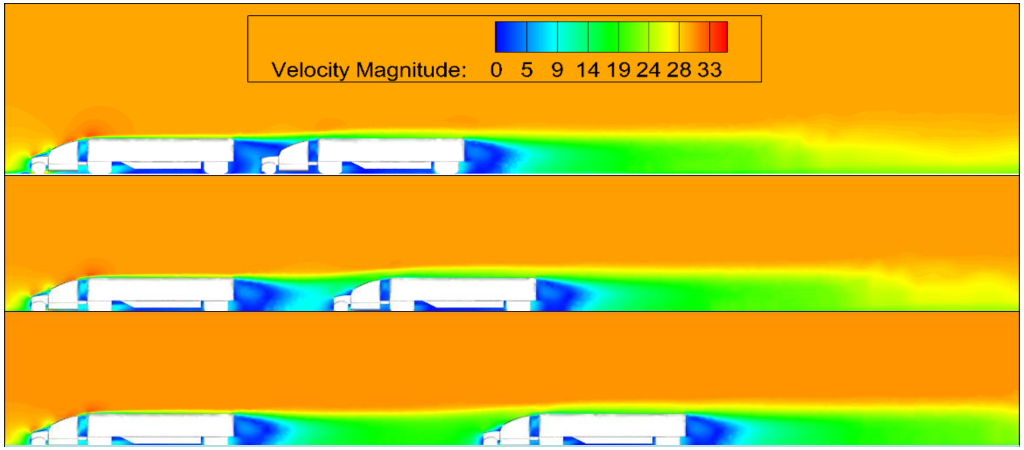
Lateral and Longitudinal Control

Driver Assisted Truck Platooning

http://eng.auburn.edu/~dmbevly/FHWA_AU_TRUCK_EAR/

- Study feasibility of implementing driver assisted truck platooning (DATP)
- Investigate:
  - Fuel Saving Potential
  - Effects on Traffic Flow
  - Communication Protocols
  - Reliability
  - HMI Issues

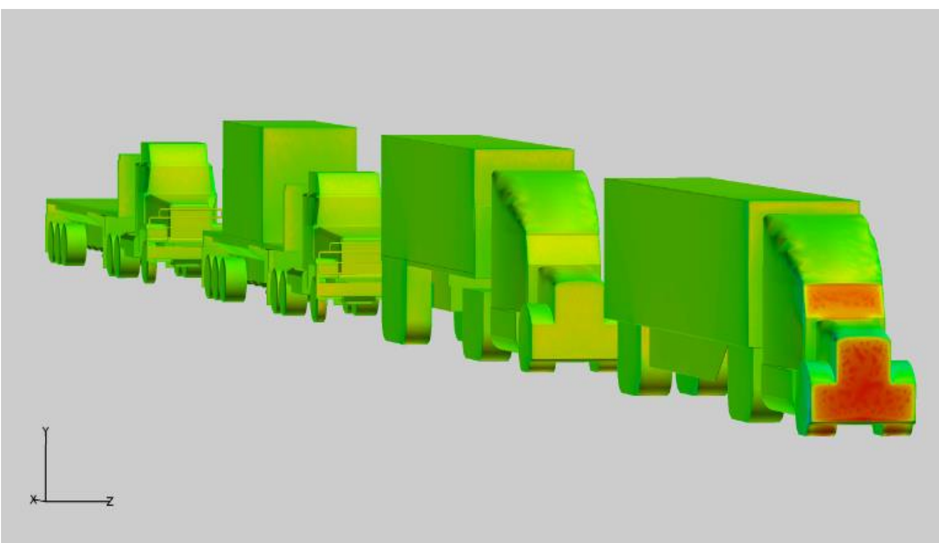




Two vehicle velocity profile, top to bottom: 10 ft, 36 ft, 90 ft spacing

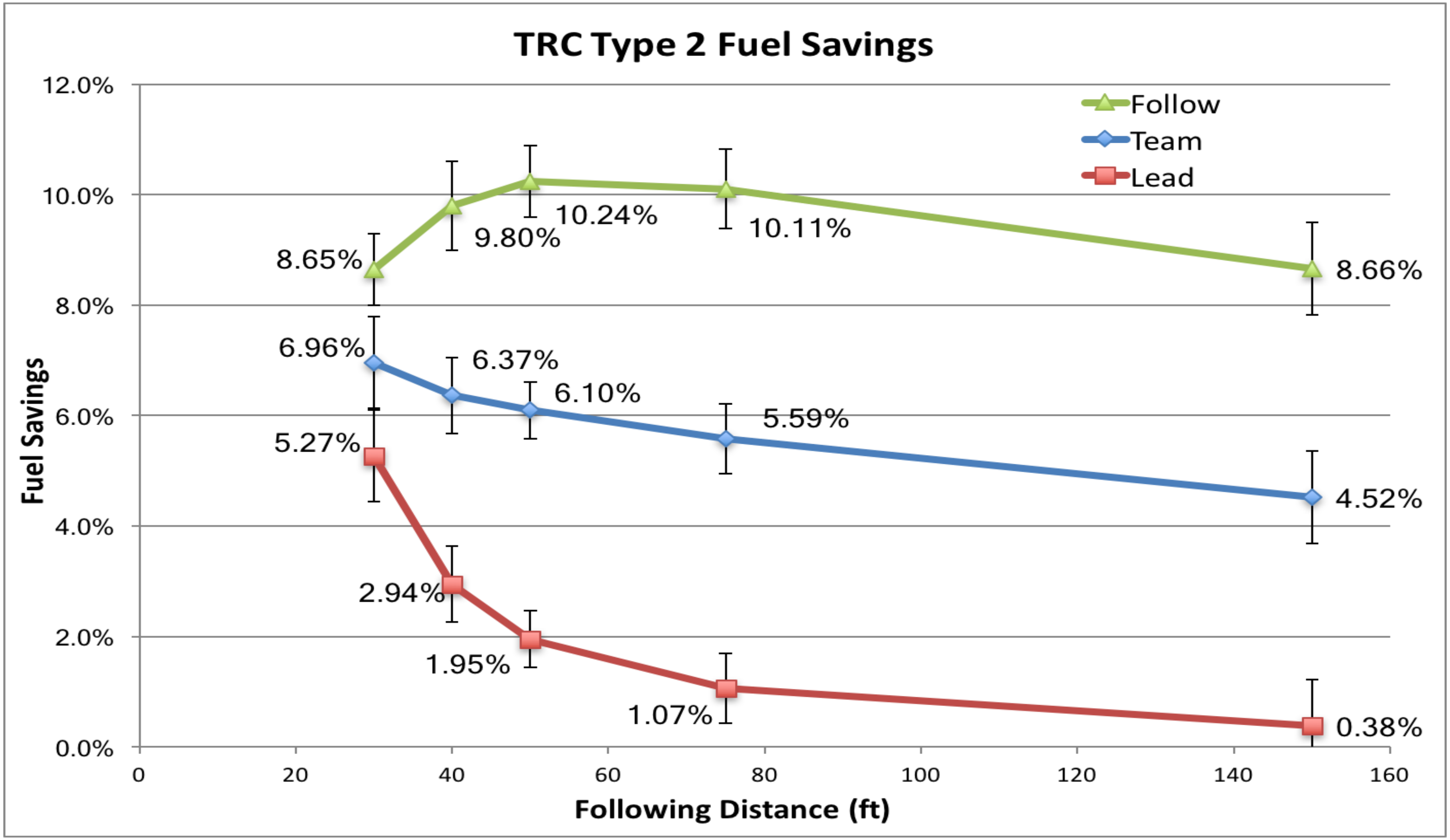
Automation Development Approach

- Utilize CFD analysis, simulation and experimentation for development and verification of research



Two Truck Platoon Fuel Savings

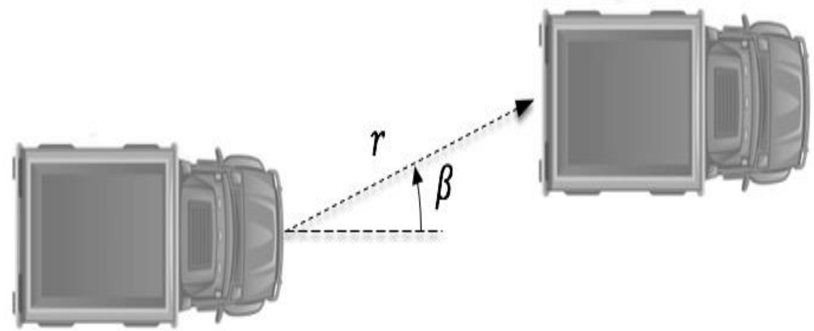
- Average of 5-7% fuel savings per truck

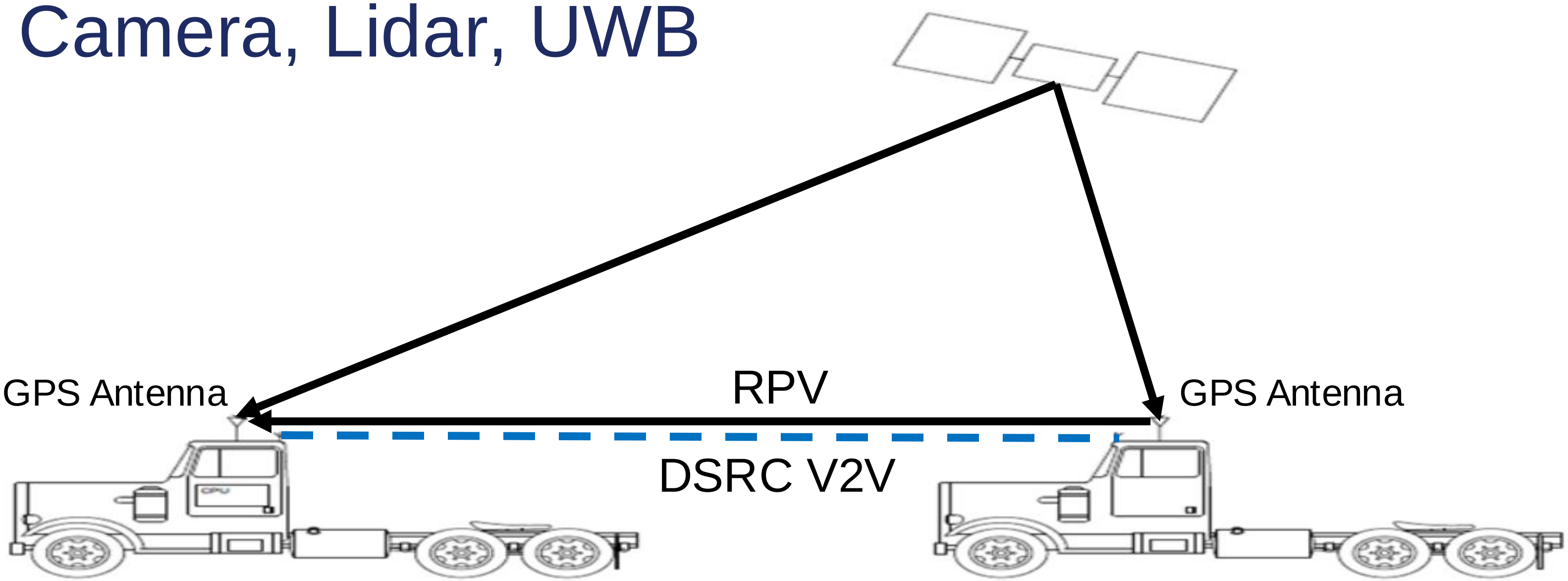


Sensor Based Following

Multiple Sensors provide range an bearing between vehicles for following

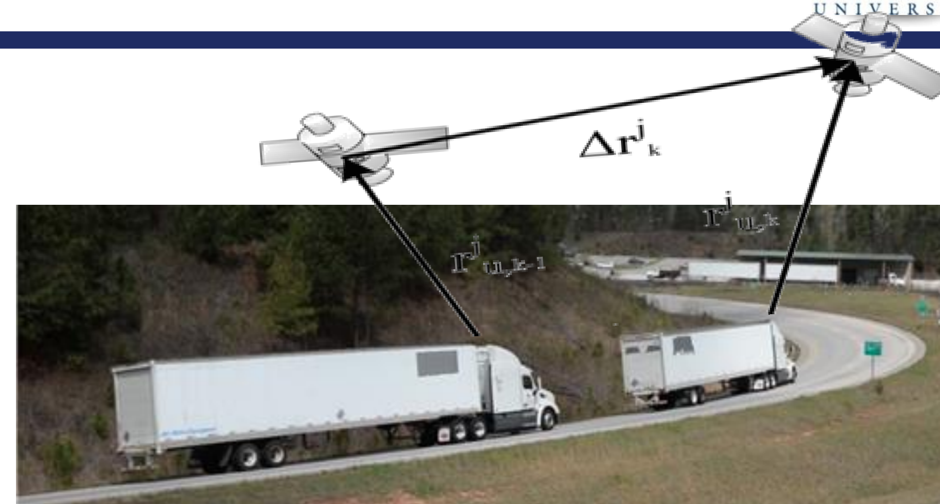
- DRTK GPS, Radar
- Camera, Lidar, UWB





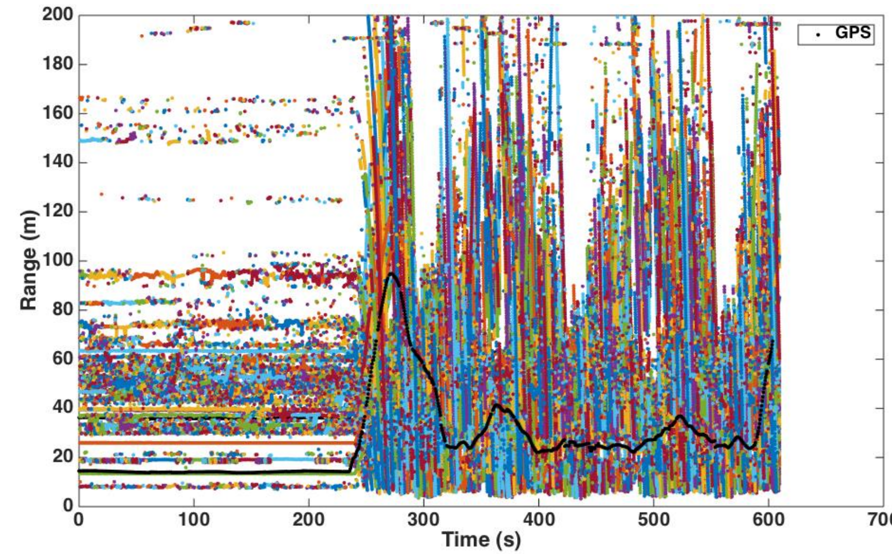
GPS/Radar Fusion for Platooning

- Vehicle convoys reduce driver fatigue and improve fuel efficiency
- Accurate localization of leader vehicle is critical
- Radar tracks are difficult to distinguish in isolation
- GPS/Radar fusion minimizes deficiencies of individual solutions



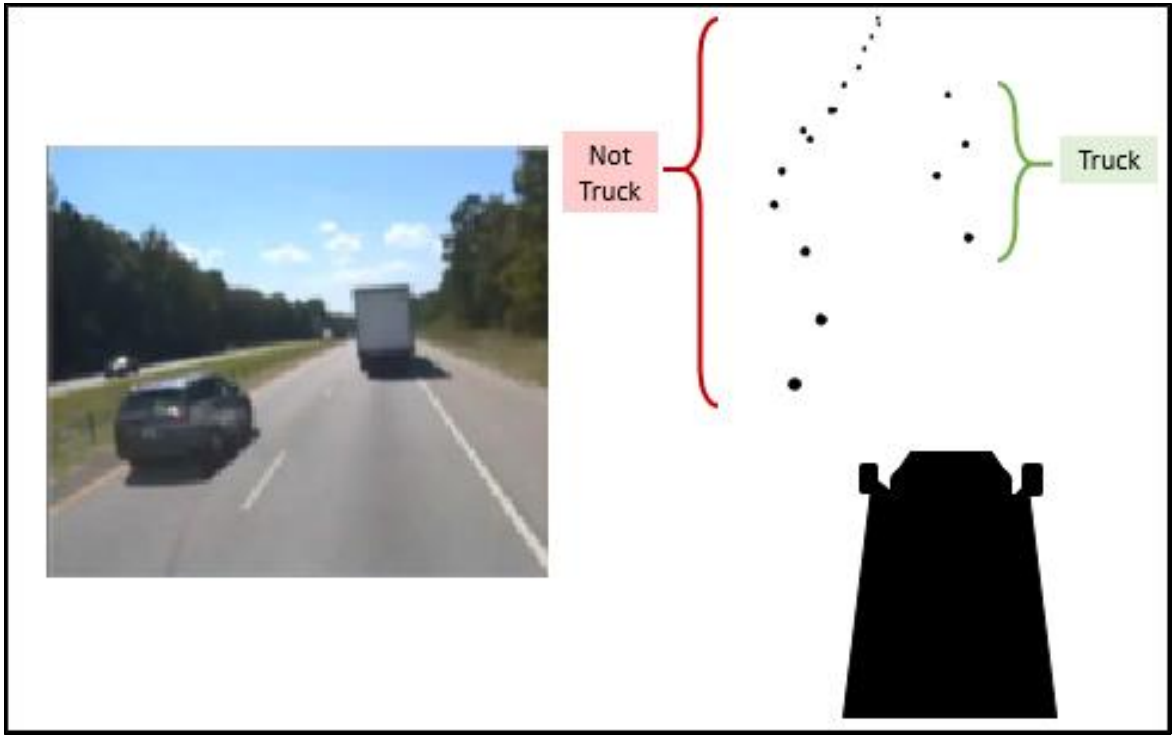
Differential GPS Provides Precise Positioning

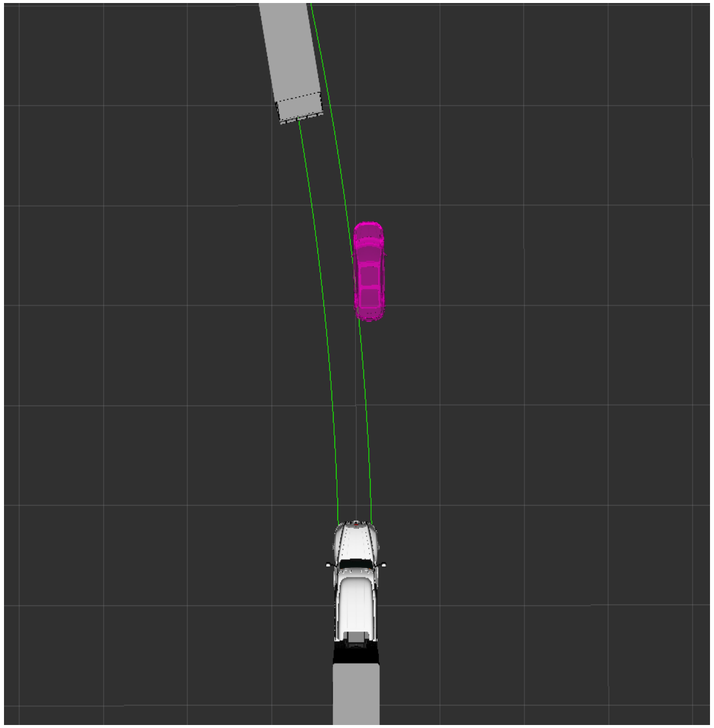
Delphi ESR Reported Range Measurements



RADAR Cut-In Detection

- RADAR also used to detect non-cooperating vehicle and cut-ins
- Cut-ins occur in heavy traffic regardless of spacing



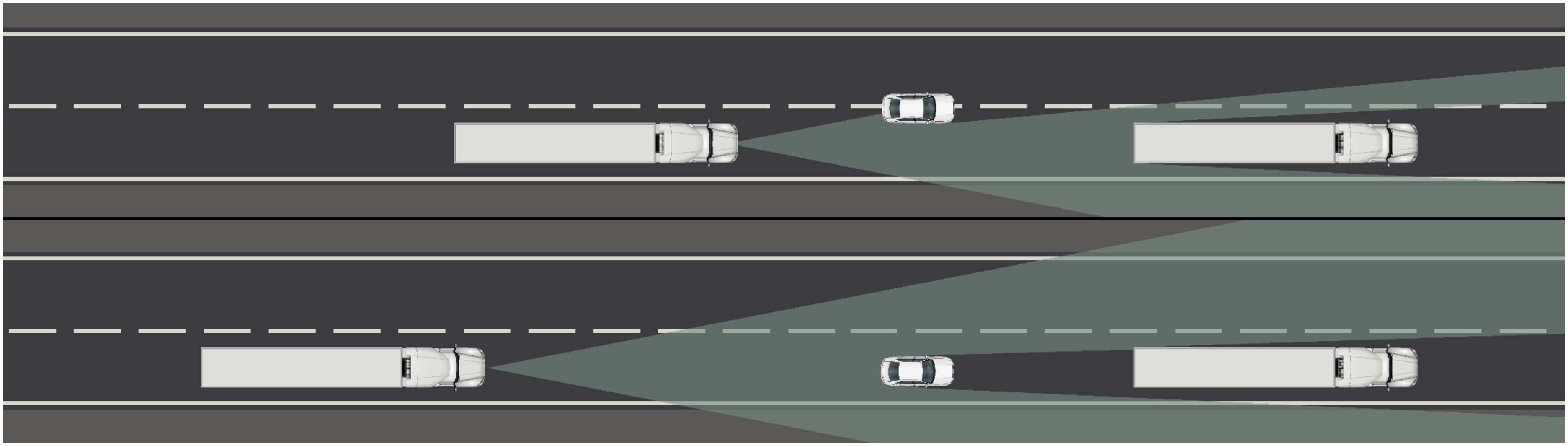


Hardware in the Loop Simulations

- Developed test-bed to include virtual assets for testing
  - Allows for repeatable test
  - Can safely test various scenarios
- Virtual assets are simulated and then sensor data injected to emulate real data from the virtual vehicle

Example Cut-in Test Matrix

	Level 1	Level 2
Platoon IVD	16 m (0.8 s)	40 meters (2 s)†
Cut-In Location (% IVD)	30%†	50%†
Steady-State Distance	6 m†	16 m†
Time to Change Lane	1 s	5 s



V2V Truck Platoon Demonstrations

- Blue Water Bridge Crossing
- I69 in Northern Michigan
- American Center For Mobility (ACM) Track
- I85 in Alabama
- Canada Highway and Forestry Roads

Michigan Testing

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- Demonstration totals during testing:
  - Operation time: ~3.5 hours
  - Distance: >170 miles

Platoon Test on Canadian Roads

Fuel Test on PMG Test Track

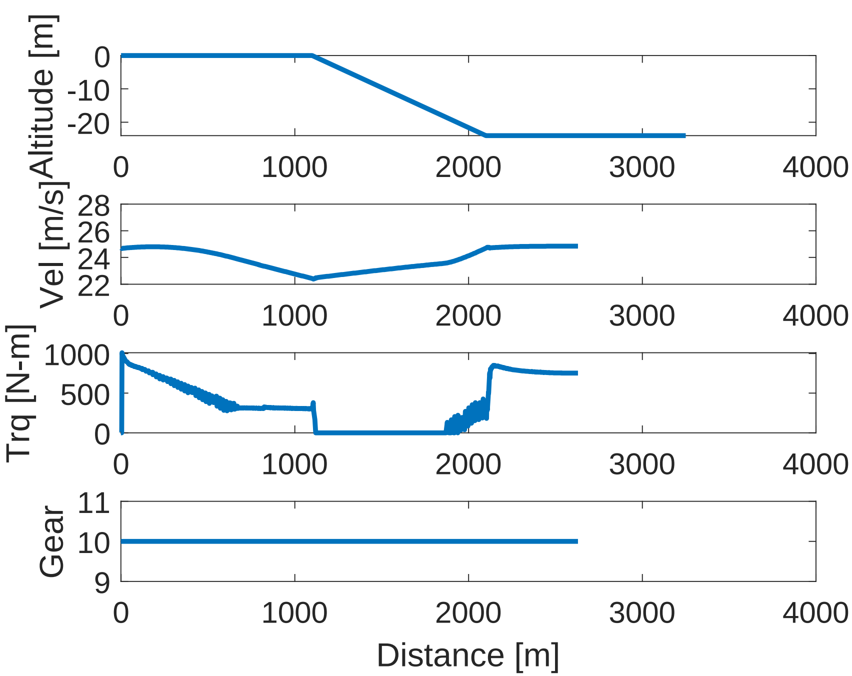
Canadian Interstate (40)

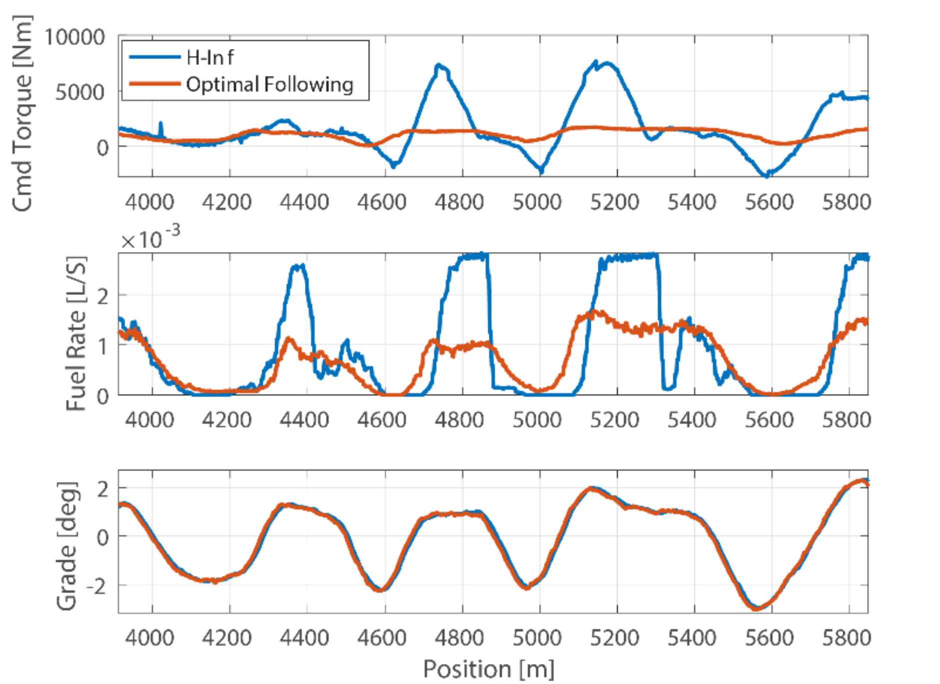
Testing on Canadian Forestry Roads

Autonomous Truck Following

Advanced Platooning Strategies

- Variations in road grade had a negative effect on platooning control algorithms
  - Power limitations caused large oscillations in following distances
- Including terrain and vehicle model, improved controller was developed to recover fuel savings from drafting on uneven terrain





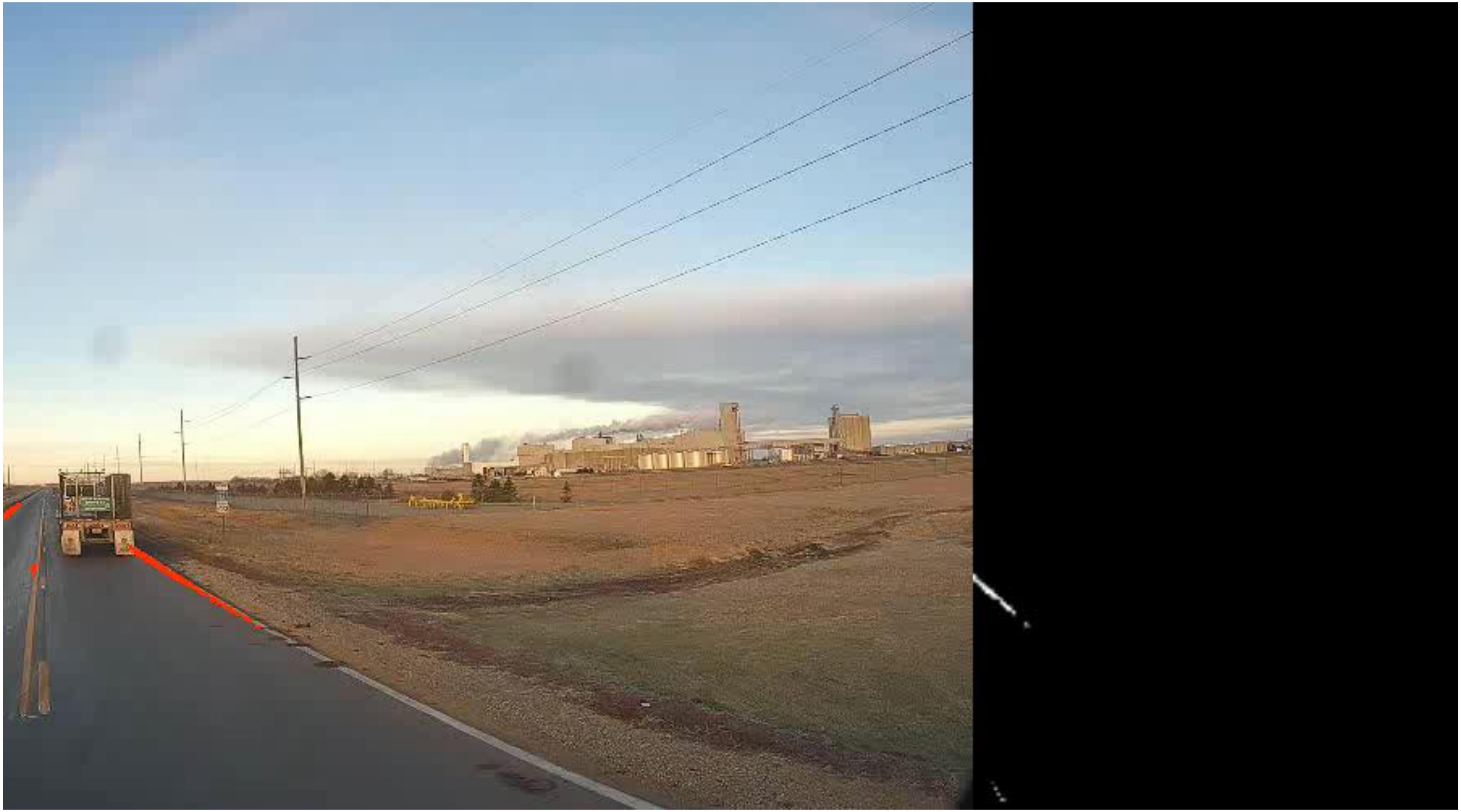
Back-up using Lane Tracking

- Using on-board camera to track lane markings
  - Allows for following during GPS outages
- Using Inverse Prospective Mapping (IPM)
  - Generate position of vehicle within the lane

Original Image

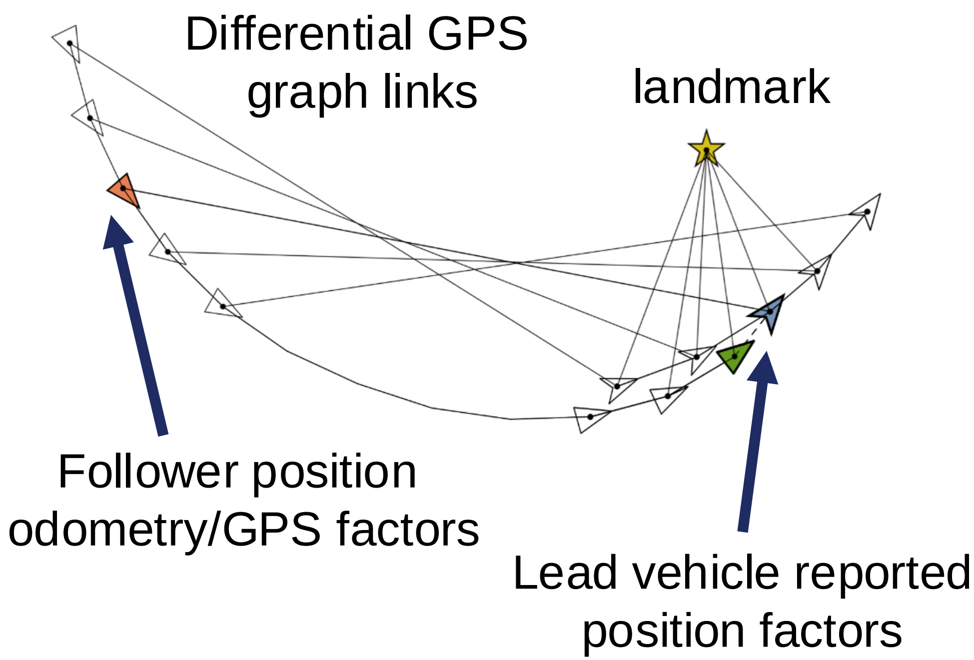
After IPM

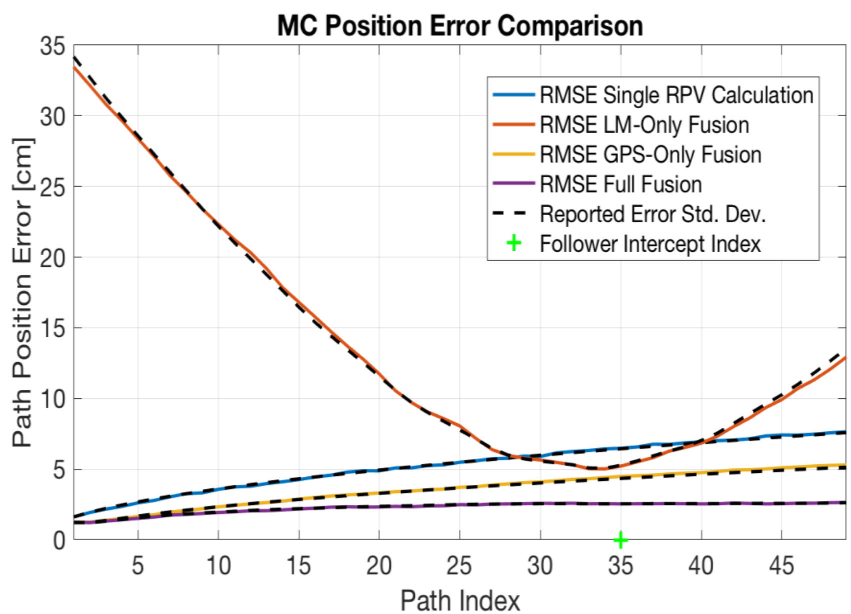
Initial Results



Using additional Landmarks (LM)

- Use multiple data sources such as GPS/Odometry/INS AND landmarks fused together in a graph to generate robust and accurate paths between vehicles
  - GPS-based solutions: error increases with following distance
  - LM-only: least amount of error near the “follower intercept index”
  - Full fusion: Result in lower error over entire following distance

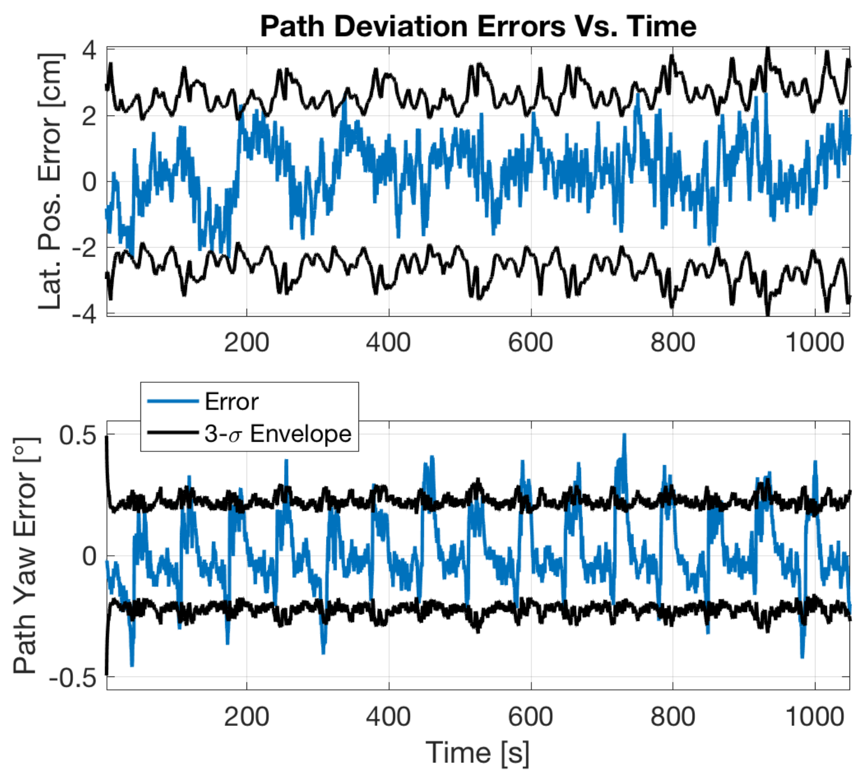




Experimental Results at NCAT

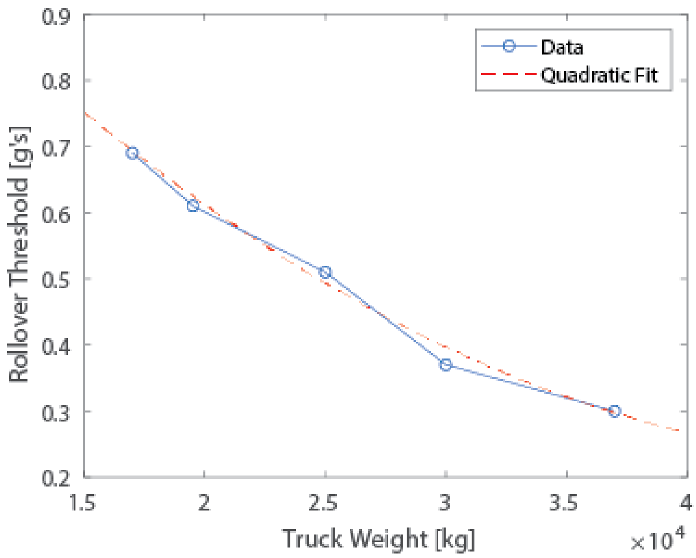
- Errors in lateral position and path yaw over time along with 3σ confidence
- RMS error satisfies target accuracy
- 3σ mostly envelops errors
- Notable spikes every 70 seconds (correlates to banked turns)

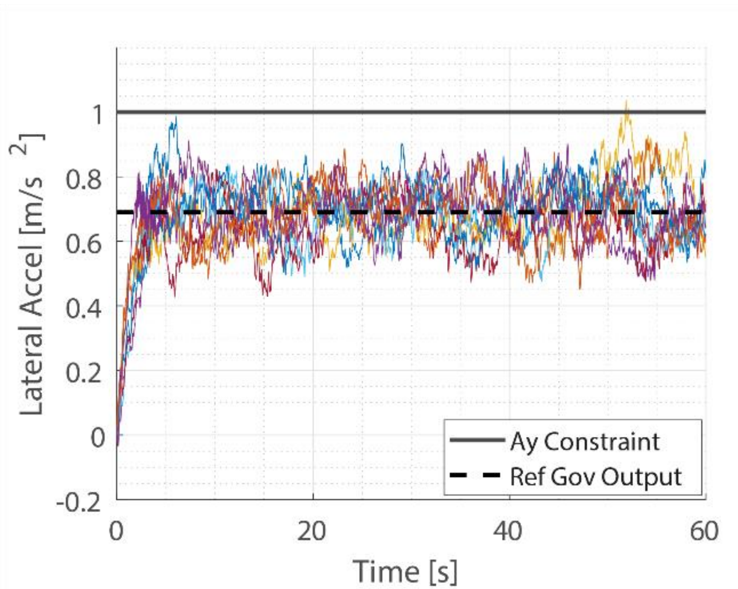
	Lat. Pos. (cm)	Path Yaw (degrees)
RMS Error (Target)	0.94 (7)	0.14 (0.25)
Mean Error	0.26	0.01
Max Error	2.68	0.51



Trailer Safety

- Developing tractor steering control algorithms to prevent rollover
  - Many systems utilize brakes on the trailer
  - Overly conservative
- Developing a low-cost sensor suite for trailer monitoring





http://gavlab.auburn.edu

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