

Northern Colorado Bike & Ped Collaborative

Executive Summary – Wednesday, April 14, 2021

GoToMeeting Virtual Meeting

Front Range Trail Update

Bryan Harding, City of Loveland Parks and Recreation Planning Manager, updated the group on progress of the Front Range Trail in and around Loveland. Berthoud is making progress connecting the town to southern Loveland. A temporary on-street connection through some Loveland and Larimer County streets will provide immediate connections, as will developer contributions for an underpass and easements near the King Soopers. The City is also working on designs for the trail through Eagle Vista Natural Area.

Kelly Zuniga discussed the City of Loveland's potential land purchase near Dakota Ridge using a GOCO Resilient Communities grant. The City already has a conservation easement for about half of the property, but a new water tower and potential development is putting pressure on conserving the open space land.

Summer Bike/Walk Event Updates

The group discussed different biking and walking events happening throughout the region throughout 2021. These events include:

- Fort Collins: Bike to Work Day, combining virtual and in-person events; National Bike to School Week; Remington Bike Number Challenge
- Severance: Rangeview Elementary will be doing a Bike and Walk to School Safety Day
- DRCOG/Brighton: Bike to Work Day in September, Nighttime Bike Rides
- Poudre Trail: senior programming by Cycling without Age
- Loveland: Bike and Walk Month, combining virtual and in-person events; first bike corral being installed at Desk Chair Workspace

Regional Wayfinding Signage/Manual on Uniform Traffic Control Devices

The group discussed the online map with updates for the regional wayfinding signage along the Poudre River Trail and Great Western Trail. The map is an ongoing project. The group also discussed the MUTCD Proposed Amendments, which has a deadline for comments of May 15, 2021.

Upcoming Agenda Items

- Local plans for Bike to Work Day, Bike and Walk to School Day, and Bike/Walk Month
- Colorado Front Range Trail updates: Loveland to Berthoud
- Regional Wayfinding Signage
- MUTCD Comments
- NFRMPO One Call/One Click Center Project (RideNoCo)
- Fort Collins Hampshire Bikeway Project
- Innovative bike/ped ideas and highlights from local plans

Mobility and Energy Improvements Realized through Prediction-Based Vehicle Powertrain Control and Traffic Management (ti101)

Thomas H. Bradley, PI, Colorado State University, thb@colostate.edu

2020 DOE Vehicle Technologies Office Virtual Annual Merit Review (AMR), June 1-4, 2020



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Overview

- Timeline
 - Project start date 11/30/2018
 - Project end date 12/31/2020
 - 66% completed
- Budget
 - Govt. Share: \$628,663
 - Cost Share : \$207,168
 - Total : \$835,831
- Barriers (U.S. DRIVE – VMSATT 2019 Roadmap)
 - Data collection
 - Artificial intelligence and machine learning for CAV development
 - Quantify with real-world data the energy savings benefits of optimized advanced vehicle controls
- Partners
 - Colorado State University (CSU, lead)
 - Western Michigan University (WMU)
 - National Renewable Energy Laboratory
 - Northern Colorado Clean Cities Coalition
 - Denver Metro Clean Cities Coalition



Acknowledgements

- Thomas H. Bradley, Ph.D., Professor, Colorado State University (CSU)
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- Zachary D. Asher, Ph.D., Assistant Professor, Western Michigan University (WMU)
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- Suren Chen, Ph.D., Professor, Colorado State University (CSU)
 - Kaisen Yao
- Edwin Chong, Ph.D., Professor, Colorado State University (CSU)
- Venu M. Garikapati, Ph.D., Project Leader, National Renewable Energy Lab. (NREL)
- Eric Wood, Research Scientist, National Renewable Energy Laboratory (NREL)
- Jacob R. Holden, Research Engineer, National Renewable Energy Laboratory (NREL)
- Diego Lopez, Northern Colorado Clean Cities Coalition
- Bonnie Trowbridge, Denver Metro Clean Cities Coalition



Relevance

To reduce travel time and travel time variance while minimizing energy consumption and human health-specific emissions exposure due to transportation.

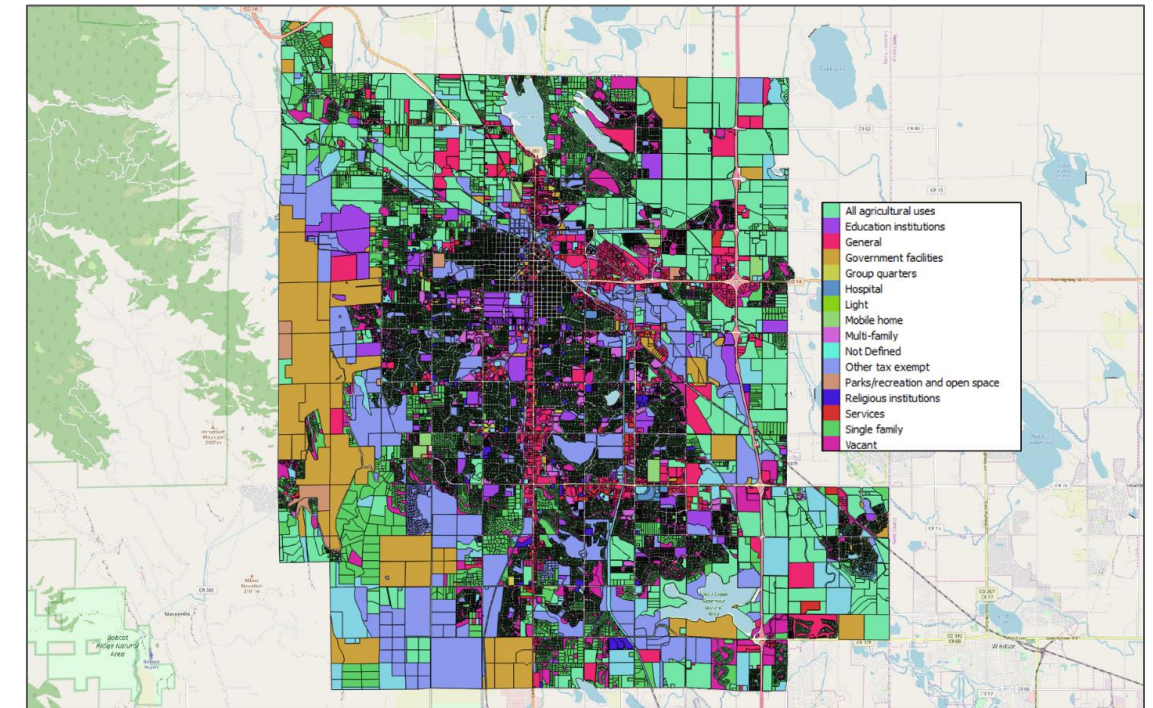
Objectives

A data driven approach requires development of a set of coordinated traffic, vehicle (FE and emissions), and infrastructure data using connected vehicle probe data collection techniques.

Optimize traffic management systems *and* connected/automated vehicle powertrain control to test scenarios demonstrating the synergistic benefits of system-level data sharing, infrastructure management and CAV controls optimization.

Measure and evaluate the multi-objective results using a transportation system level metric of *Mobility Energy Productivity*. The results of these studies are then tested for their extensibility through a partnership with the City and County of Denver, CO.

Map of Fort Collins, CO by land use classification



Milestones

Milestones for Budget Period 1 (CY 2019)

Milestones	Type	Description	Status
FE and emissions data gathered for all considered vehicle classes	Technical	At least one set of emissions and FE data associated with each vehicle class of interest is collected	Pass
Data collection	Technical	All data collection tasks are completed	Pass
Direct, quantitative comparison of simulation and experiment – traffic	Technical	A direct, quantitative comparison of simulation and experiment for the microscopic traffic simulation toolset is completed	Pass
Direct, quantitative comparison of simulation and experiment – vehicles	Technical	A direct, quantitative comparison of simulation and experiment for the vehicle fuel economy and emissions simulation toolset is completed	Pass
Model Validation	Go/No Go	Models are determined to be fit for use for quantification and optimization.	Pass

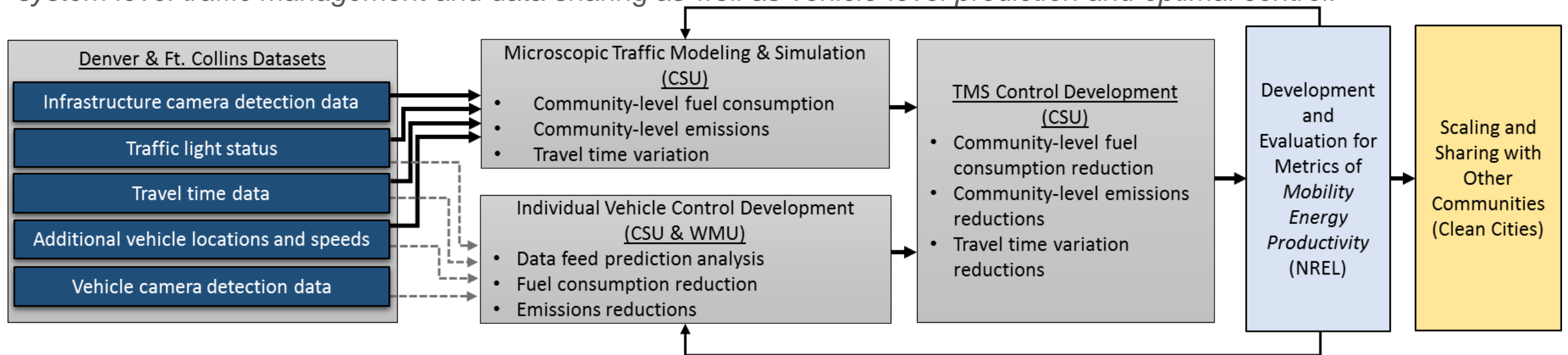
Milestones for Budget Period 2 (CY 2020)

Milestones	Type	Description	Status
Optimization operational for vehicles demonstrated	Technical	Optimization of one or more design variable for the metric of Mobility Energy Productivity for the vehicle EMS model demonstrated	Pass
Optimization operational for transportation system model demonstrated	Technical	Optimization of one or more design variable for the metric of Mobility Energy Productivity for the transportation system model demonstrated	Pass
Optimization comparison	Technical	Direct, quantitative comparison of baseline and optimized transportation system Completed	Ongoing
Simulation of City and County of Denver	Technical	A functional microscopic simulation of key transportation corridors completed	Ongoing
Quantification of Mobility Energy Productivity Metric	Technical	The calculation of Mobility Energy Productivity Metric for a specific use case and optimization completed	Ongoing



Approach

This project proposes a set of hypotheses for improving novel metrics of Mobility Energy Productivity through improved *system level traffic management* and data sharing as well as *vehicle-level prediction and optimal control*.



Real-world datasets + Optimized microscopic simulations + optimized optimal CAV control

Evaluated using multi-objective metrics of transportation system quality



Approach

- Problem and scope definitions
 - The problem of **traffic congestion along major transportation corridors** of the municipality (College Ave. Fort Collins, Spear Blvd. Denver) and the potential to use TMS and CAVs to improve throughput on these corridors without modification of the physical roadway.
 - The problem of **the interface between bus rapid transit (BRT) and traffic at intersections** (Mason St. Ft Collins, Colfax Ave. Denver). BRT uses dedicated lanes to skip queues and congestion along major transportation corridors, but BRT must still participate in signalized intersections at cross streets. Enabling prioritization and vehicle-level energy management control of these BRT vehicles is hypothesized to improve metrics of mobility energy productivity.
 - The problem of **through-town Class 8 freight truck transport** (Shields Ave., Fort Collins, I-70/Colorado Blvd, Denver). Due to the growth of Class 8 truck transport, these municipalities face noise pollution, emissions, human health, and safety considerations due to a high volume of Class 8 trucks moving through town on surface streets. Enabling signal prioritization (which also enables platooning) and vehicle-level energy management control for these high-energy consumption, high emissions vehicles is hypothesized to improve metrics of mobility energy productivity



Technical Accomplishments and Progress

- Data collection and synthesis
 - Along key routes and for samples of all vehicle types
 - LD Diesel
 - LD Gasoline
 - BRT Diesel
 - Class 8 Diesel
 - Multi-channel data is collected and processed to make coherent datasets



Data Streams Successfully Measured via Probe Vehicles and Assembled into a Coherent Dataset

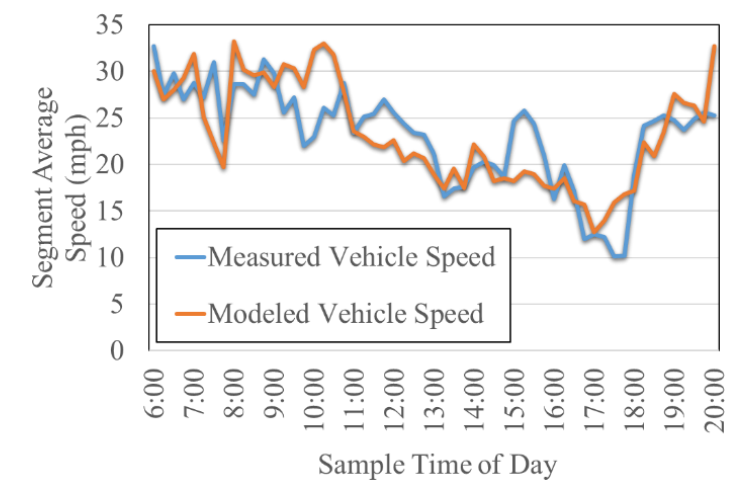
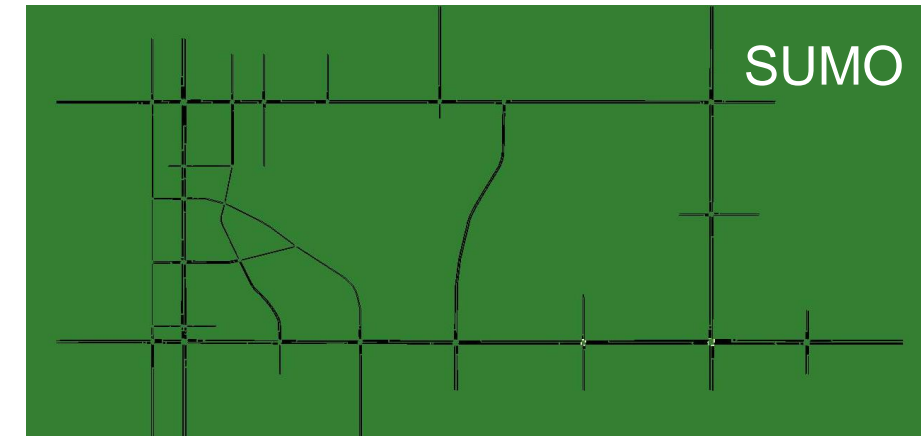
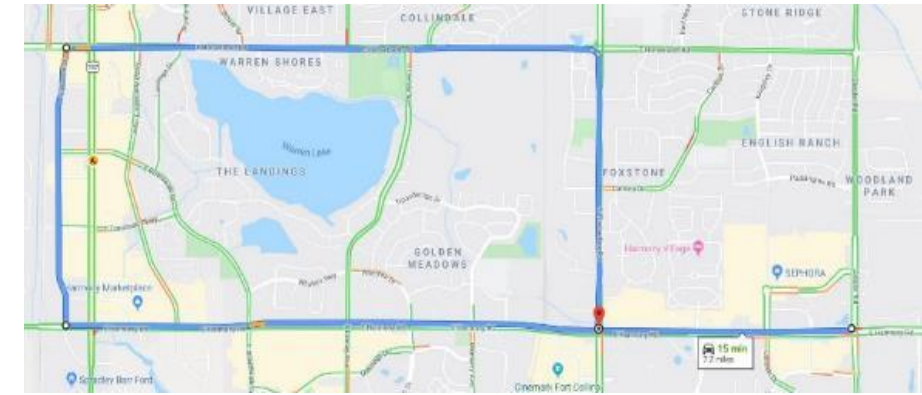
Data Treatment	Description	Data Stream
Driver Inputs	Steering, accelerator and brake pedal traces, drive mode selection, turn signal, etc.	VEH
Vehicle Performance	Vehicle speed, engine load and speed, transmission gear, accelerations, etc.	VEH
Vehicle Position and Motion	GNSS position and motion information	COMM
Object Tracks	Relative locations and classifications of detected and tracked objects	ADAS, COMM
Lane Information	Information about vehicle position and trajectory relative to the vehicle's current lane	ADAS, COMM
Condition Information	Lighting and weather conditions in the vehicle environment	ADAS, COMM
Signal Phase and Timing	Phase and timing information for traffic signals	COMM
Segment Speeds	Average vehicle speeds for segments of road	COMM
Lead Vehicle	Relative position and motion of the vehicle most immediately in front of the ego vehicle	ADAS, COMM
Historical Speeds	Speeds which vehicles have historically travelled at specific locations	VEH, COMM

These datasets are then used as inputs to the model validation and testing processes



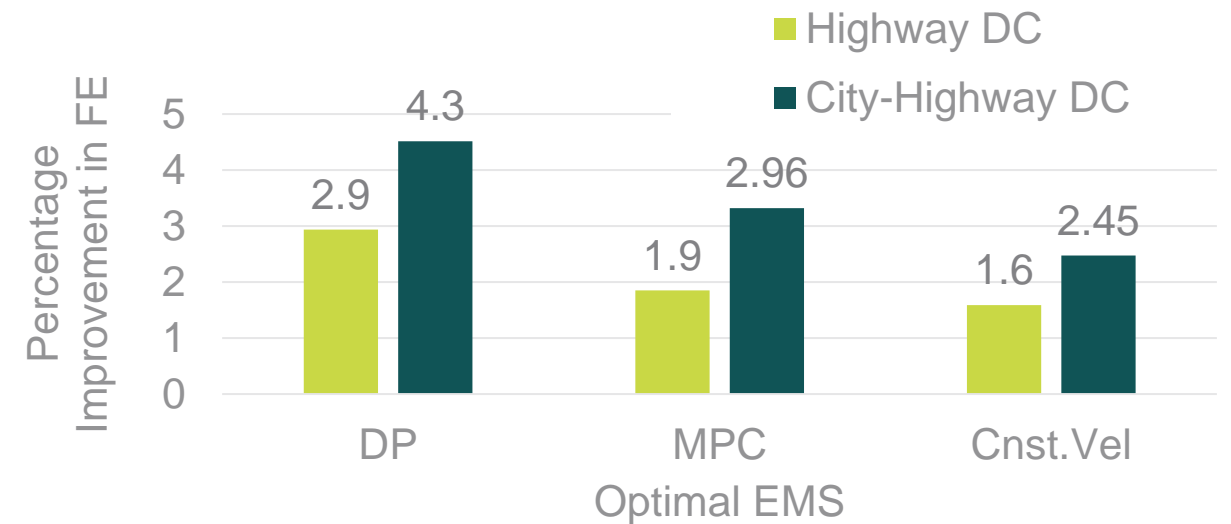
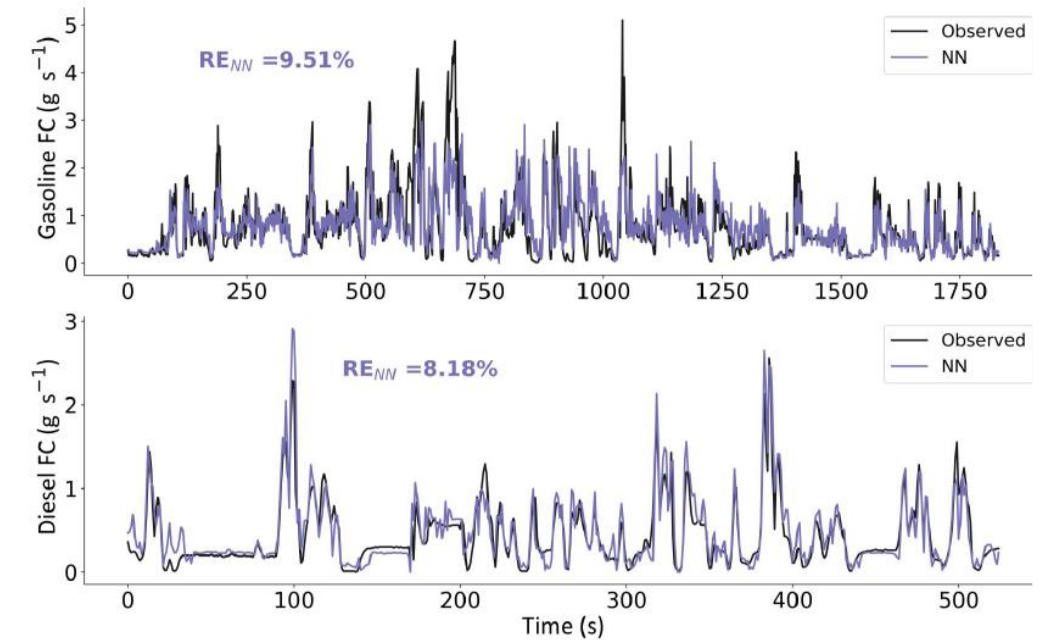
Technical Accomplishments and Progress

- Microscopic Traffic Simulation
 - Performed in SUMO and CORSIM
 - Modeling of two artery networks
 - Harmony Rd.
 - College Ave. & Mason St.
 - Validated to real-world datasets across multiple metrics of performance
 - Temporal dynamics, Segment speeds, Travel times
- Throughput can be very mildly improved (1-2%) through rigorous SPAT optimization
 - Tradeoffs are omni-present (throughput vs. emissions, FE vs. emissions, uptown vs. crosstown throughput)



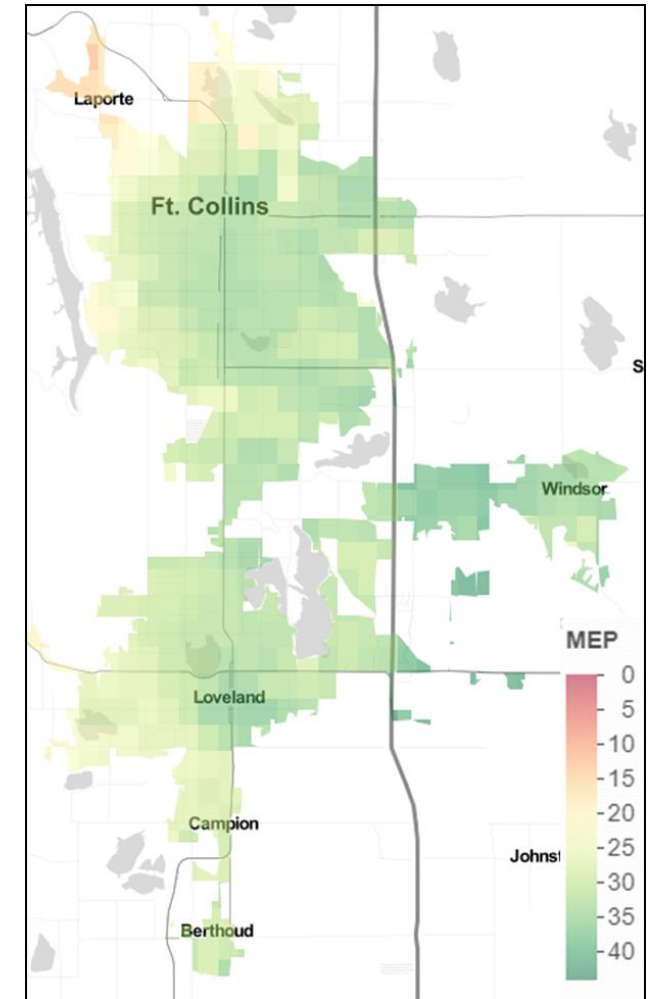
Technical Accomplishments and Progress

- Vehicle-level optimal energy management is performed using predictive powertrain control
 - Fuel economy and emissions assessments are performed using ANN fits to PEMS datasets (n=13)
 - Prediction of future vehicle operation is used to optimize vehicle powertrain control for FE and emissions
 - Various optimization schemes realize a 2% - 4% improvement in FE



Technical Accomplishments and Progress

- Costs and benefits are traded off in a metric at transportation system level (Mobility Energy Productivity)
 - MEP is a spatially realized metric of accessibility, assessing the number of jobs, goods, and service opportunities which are available within prescribed travel times from a location.
 - Allows for tradeoffs among considerations of
 - Transportation system efficiency
 - Vehicle efficiency and cost to operate
 - System-level emissions/energy consumption



Remaining Challenges and Barriers

Remaining challenges are the processes of integration and synthesis



Outcomes will include:

- Quantifying the value of making TMS data publicly available for light-duty vehicles
- Roadmaps for realizing FE, emissions and safety benefits of CAV BRT/Class 8 in suburban networks
- Evaluation of the scalability of TMS/EMS integration in Denver, CO
- Outreach to commercial and government stakeholders



Collaboration and Coordination

Project Coordination among Awardees

- **Colorado State University Engines and Energy Conversion Laboratory** – data acquisition and synthesis, fuel economy and emissions modeling
- **Colorado State University Center for Sustainable Intelligent Transportation Systems** – traffic micro simulation and optimal control
- **Western Michigan University Energy Efficient and Autonomous Vehicles Lab** – vehicle optimal energy management and control
- **NREL** – Mobility Energy Productivity metric evaluation and refinement

Collaboration between Stakeholders

- NREL and Universities (CSU and WMU)
 - Summer internships (2019)
- Universities and Local Stakeholders
 - Data sharing and presentations to:
Colorado DOT, Fort Collins Traffic, TransFort, Clean Cities Coalitions, Michigan DOT, Colorado Energy Office, Denver Regional Council of Govts



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Proposed Future Research

FY 2021

- We now know the individual benefits, we must quantify the synergistic benefits of system-level data sharing, infrastructure management and CAV controls optimization
- Application to the situated 3 transportation problem sets (congestion, BRT prioritization, Class 8 preemption), tested for replicability in Denver
- Quantifying changes to Mobility Energy Productivity synthetically and spatially

Any proposed future work is subject to change based on funding levels



Summary

- Gathered and synthesized a synchronized, real-world dataset including infrastructure, vehicle, on-vehicle camera, radar, SPaT, and traffic cameras.
- Validated second-by-second FE and emissions simulations of multiple vehicle types and scales
- Developed new algorithms and integration to enable optimization of traffic system-level, and vehicle level control
- Evaluated using novel & holistic transportation system metrics



Thank you



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