Heavy-Duty Electric Vehicle Integration and Implementation (HEVII) Tool

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Annual Merit Review and Peer Evaluation Meeting

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Project ID: van048

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Project Overview

Timeline

Project Start Date: 10/1/2020

Project End Date: 12/31/2022

Percent Complete: 75%

Budget

Total Project Funding:

DOE Share = $399,449

Contractor = $52,403

FY 2021 Funding = $150,896

FY 2022 Funding* = $67,476

* through 5/1/2022

Barriers Addressed

Heavy-duty commercial vehicle fleet electrification:

- Tools to determine heavy-duty vehicle energy consumption on-route require known vehicle mass, which is typically not measured
- On-route charging is typically required to serve electric heavy-duty commercial fleets
- Predictive models that can use irregularly sampled time-series vehicle data from telematics systems are challenging

Partners

University of Minnesota

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PEPSICO

GEOTAB

Relevance/Objectives

Overall Objectives

Develop an innovative, accurate, and easy-to-use tool to evaluate the electrification potential of commercial fleets.

Objectives in this Period

1) Conduct a vehicle duty cycle analysis of two regional Class 6-8 commercial vehicle fleets (M3.1)
2) Develop a model using a novel mass prediction algorithm that uses fleet trajectory data to estimate EV range and applicability (M4.1)
3) Develop an integrated charger location estimation tool to determine infrastructure requirements for fleets and municipal corridors (M4.2)

Approach

What is HEVII?

HEVII is the **H**eavy-Duty **E**lectric **V**ehicle **I**ntegration and **I**mplementation Tool

Leverages multi-fidelity in-use vehicle data to provide owners with customized electrification requirements including:

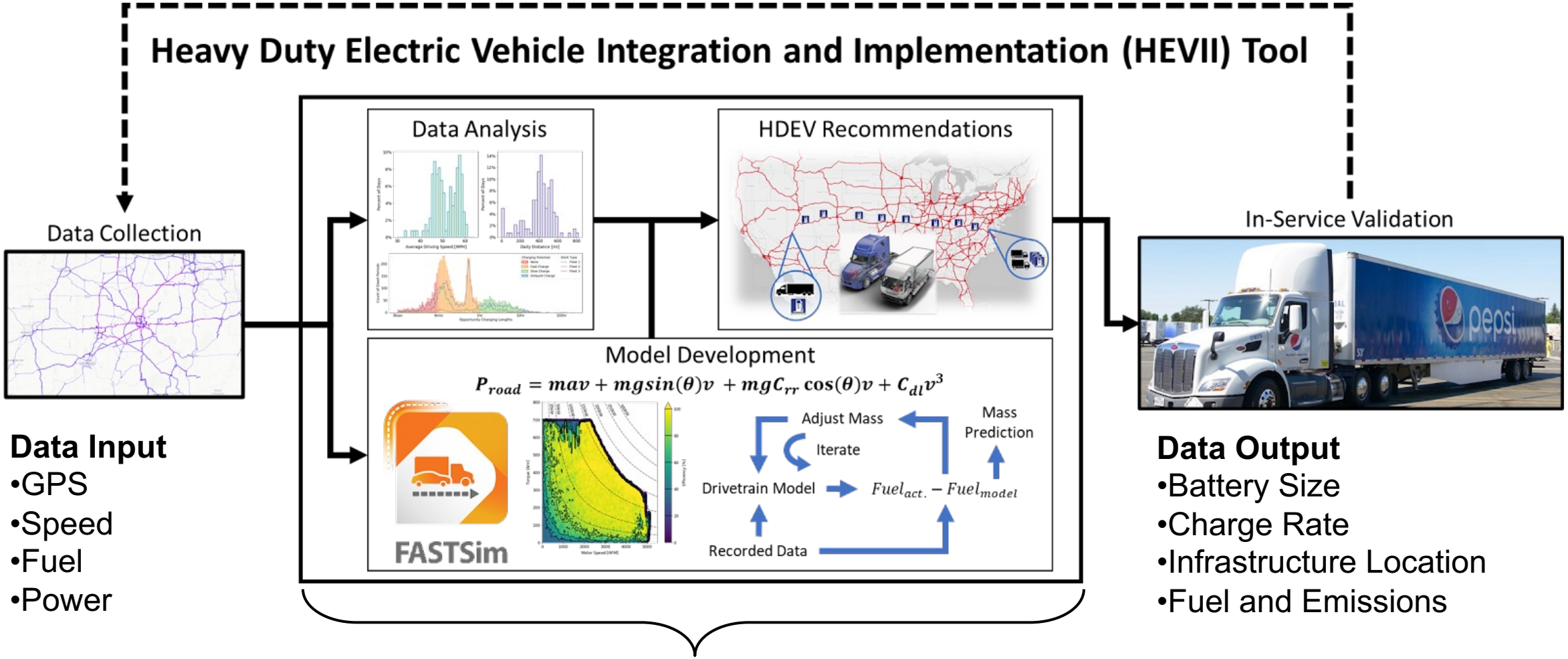
- Battery Size
- Charge Rate
- Infrastructure Placement

What makes this tool better?

- Auto-generates a physics-based vehicle model
- Predicts vehicle mass to improve accuracy
- Simultaneously identifies component sizing and charging infrastructure requirements
- Works with many types of data
- Open source

GitHub

Approach



Data Input
- GPS
- Speed
- Fuel
- Power

Data Output
- Battery Size
- Charge Rate
- Infrastructure Location
- Fuel and Emissions

Technical Accomplishments

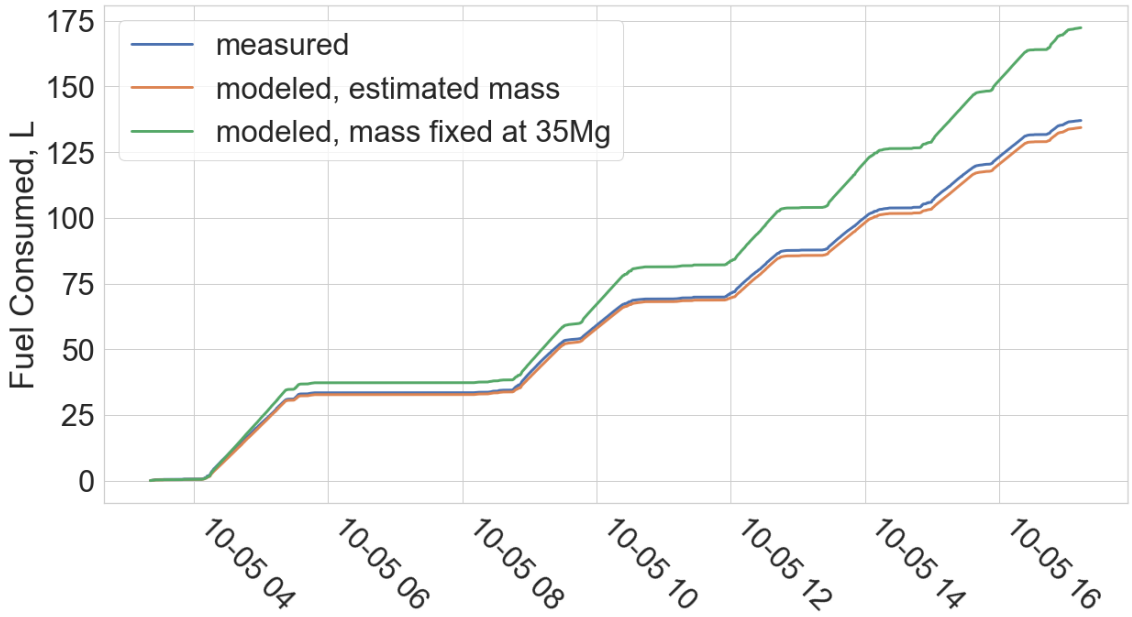
Milestone M1.1: Collect baseline data, >24 vehicles in 2 regions

- Commercial diesel trucks in 2 areas
- Geotab loggers
- Some have scale (wgt.) data at start of day
- Twenty-four analysis vehicles
  - Class 6–8 vehicles
  - 12 Pepsi
  - 12 Frito-Lay
- Location data from Nov. 2020 to present
- Includes scale data for subset of vehicles

Technical Accomplishments

M2.1 Mass prediction model shown to be accurate

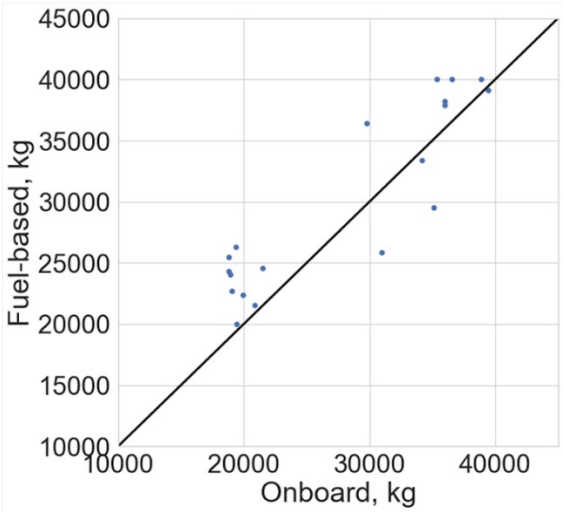
Electric vehicle models more accurate as a result of mass estimation



Two methods developed: physics model using high speed data and data-oriented model

Physics model-based mass calculation

$$P_{road} = mav + mg\sin(\theta)v + mgC_{rr}\cos(\theta)v + C_{dl}v^3$$



Required Data

- Fuel consumption over trip (2 data points)
- 1Hz wheel speed on first 30 seconds of moving data
- Elevation or road grade over first 30 seconds of moving data

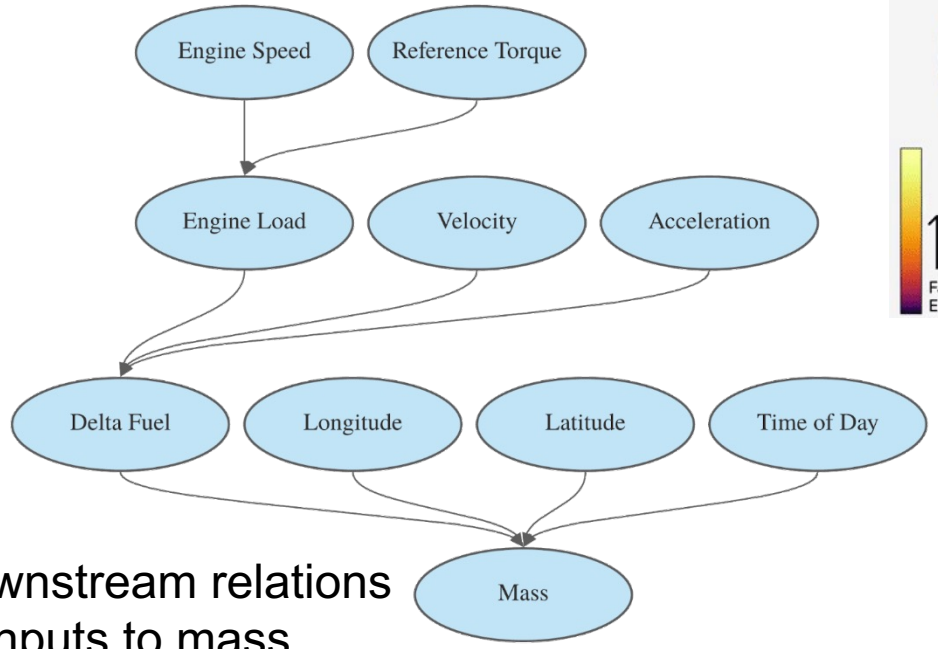
Technical Accomplishments

M2.1 Mass prediction model shown to be accurate

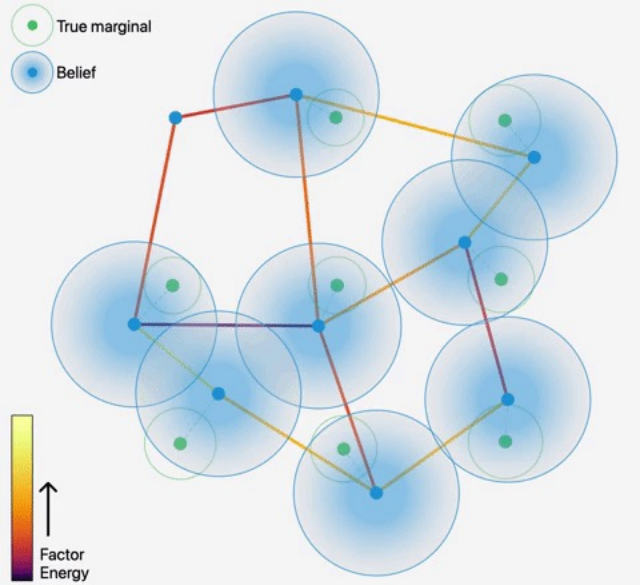
Gaussian Belief Propagation (GBP) mass calculation

Gaussian Belief Propagation (GBP)

- Fit belief nodes to available mass data
- Each belief node represents the mass of nearby datapoints (not chronological)

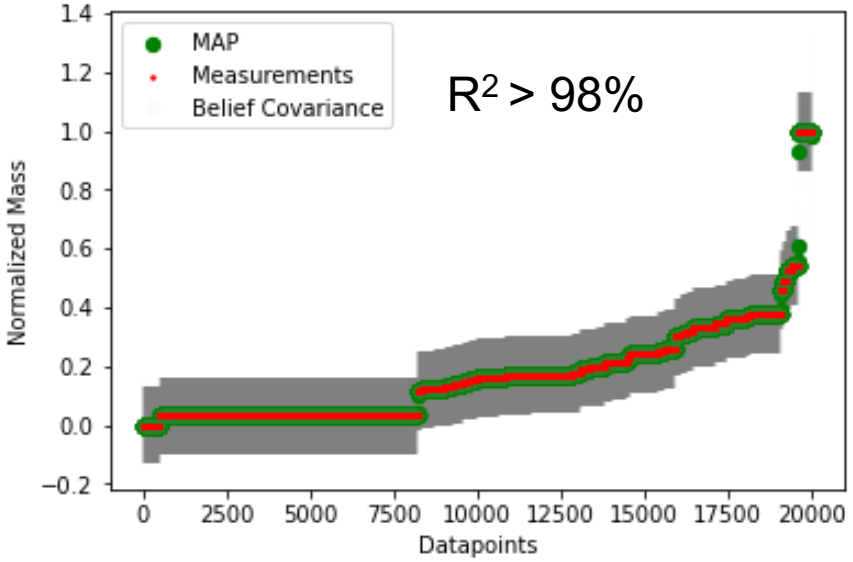


Downstream relations of inputs to mass



Convergence of beliefs

- Results show excellent accuracy for the entire dataset

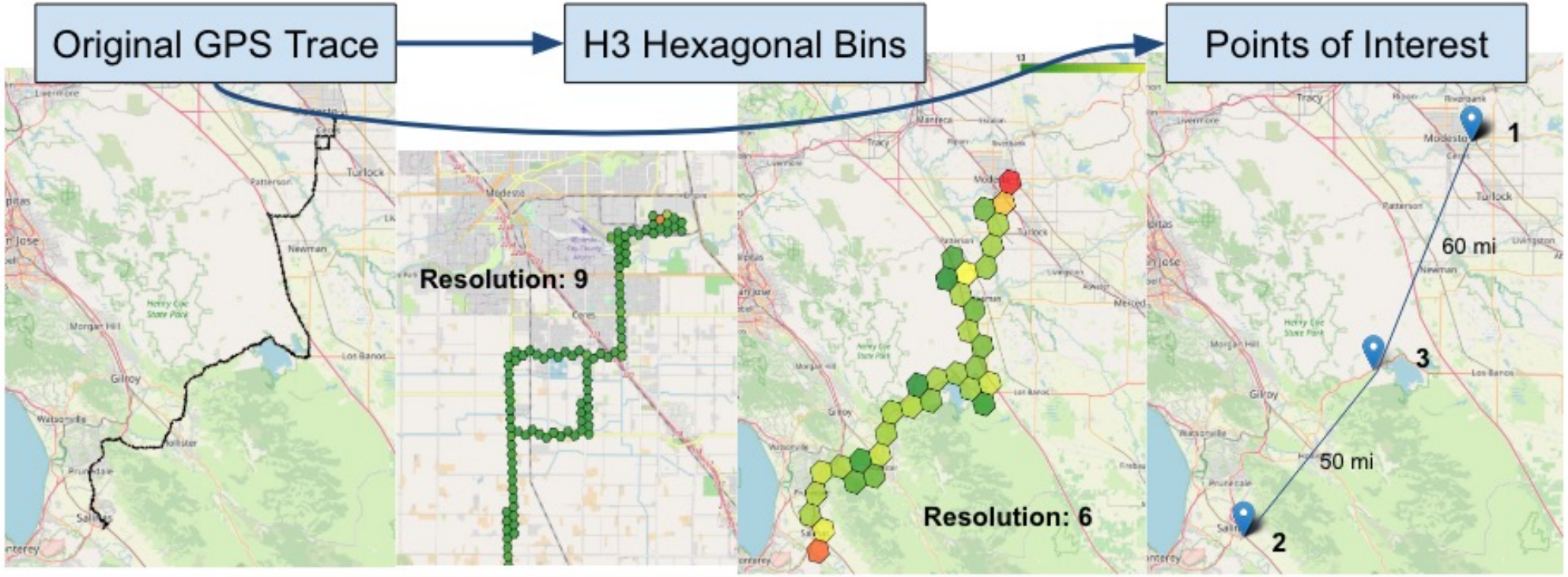


Technical Accomplishments

M3.1 Baseline fleet charger locations determined

Hexagonal Hierarchical Spatial Index Method

- Geospatial indexing system to partition GPS coordinates into hexagonal cells with Map APIs
  - Hexagonal cells scaled up or down by changing the resolution layer
  - Hexagonal cells with higher levels of activity are color coded
- Geospatial data and vehicle driving patterns from database to assist charger station placement optimization



Response to Previous Comments

This is the first AMR during which this project is up for review

Partnerships/Collaborations

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

- Vehicle mass calculation using physics-based approach
- Software to determine electrification potential software for HEVII tool

PEPSICO

- Provides vehicle fleet data from Sacramento and Modesto regions
- Provides mass data from selected vehicles
- Source of electric vehicle validation data

GEOTAB®

- Telematics provider to Pepsico
- Provides access to database for selected vehicles
- Firmware configuration for higher data rate for mass calculations

Proposed Future Research

To be completed in FY22 and FY23:

- Collect and receive electric vehicle (EV) data from Pepsico
- Validate HEVII tool with EV data
- Implement 30 second 1 Hz telematics for physics model-based mass algorithm
- Use HEVII tool with secondary dataset from additional fleet
- Refine code and publish in accessible repository

Future*:

- Seeking to further refine the tool to other vehicle data sets and to create an accessible graphical user interface on a website for fleets to use

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

Summary

- HEVII tool fills important gap in understanding electrification potential for commercial fleets
- Mass detection plays important role in accurate energy consumption modeling. Two methods developed:
  - Physics-based method using higher resolution vehicle data
  - Gaussian belief propagation method using sparse dataset
- Charger placement can be accomplished by examining fleet vehicle data
  - Hexagonal Hierarchical Spatial Index Method is effective at estimating where chargers should be placed

Thank You

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