

Fleet DNA

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Bringing Fleet Data to Life with Fleet DNA

Objectives:

- Capture and quantify drive cycle and technology variation for the array of medium- and heavy-duty vocations
- Provide a common data storage warehouse for medium- and heavy-duty vehicle data across DOE activities and labs – www.nrel.gov/fleetdna
- Integrate existing DOE tools, models, and analyses to provide data driven decision making capabilities

For Government : Provide in-use data for standard drive cycle development, R&D, tech targets, and rule making

For OEMs: Real-world usage datasets provide concrete examples of customer use profiles

For Fleets: Vocational datasets help illustrate how to maximize return on technology investments

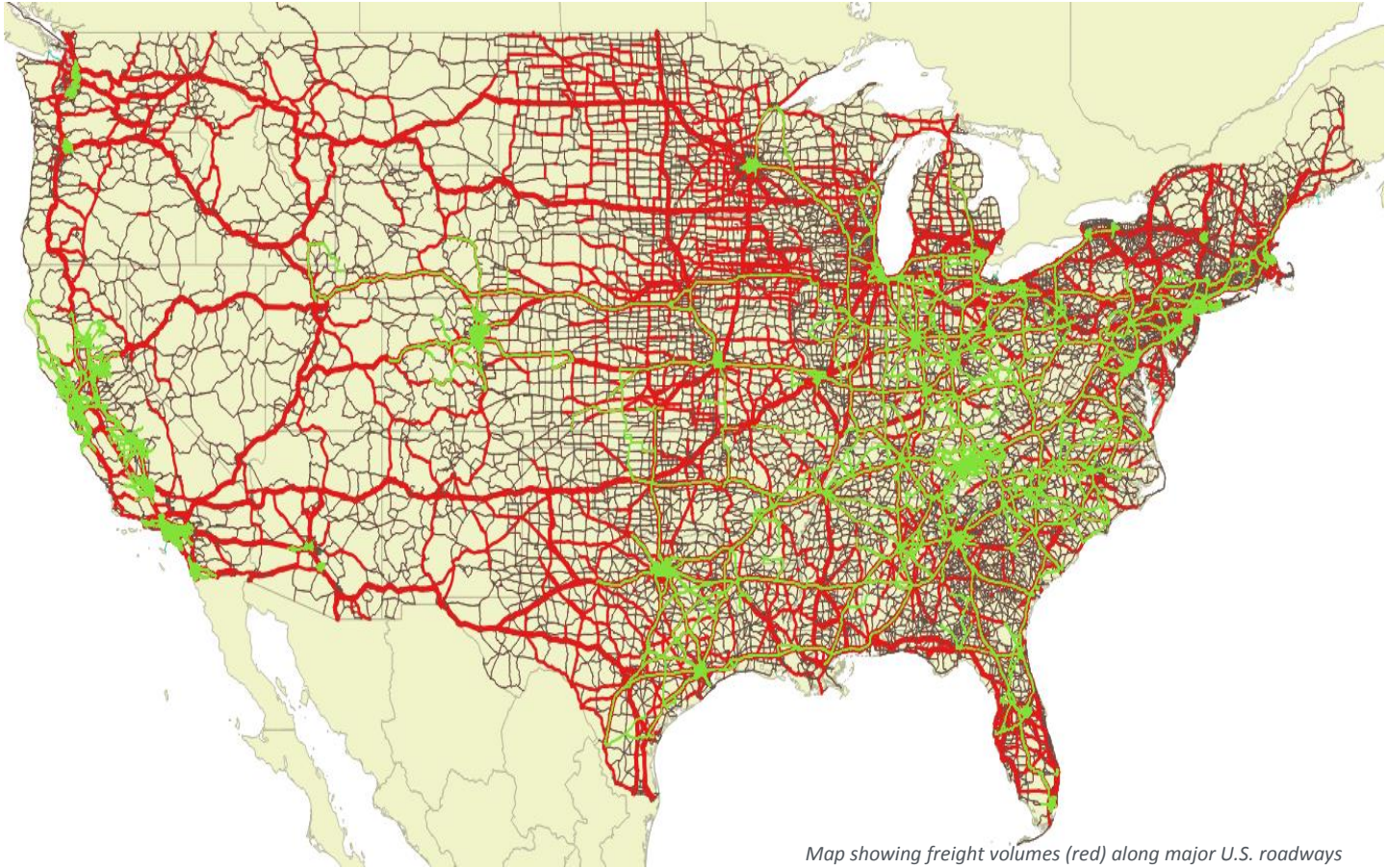
For Funding Agencies: Reveal ways to optimize impact of financial incentive offers

For Researchers: Provides a data source for modeling and simulation

The screenshot shows the NREL website interface for Fleet DNA. At the top, there is a search bar and navigation tabs for RESEARCH, IMPACTS, PUBLICATIONS, DATA & TOOLS, FACILITIES, and WORK WITH US. The main heading is 'Fleet DNA: Commercial Fleet Vehicle Operating Data'. Below this, there is a list of tools and calculators, with 'Commercial Fleet Vehicle Operating Data' highlighted. A 'Contribute Data' box encourages users to share their data. A grid of vehicle categories is displayed, including Delivery Vans, Delivery Trucks, School Buses, Transit Buses, Bucket Trucks, Service Vans, Tractors, and Refuse Trucks. Below the grid, there is a section for 'Composite Data for All Categories' with four charts and a 'SHOW MORE CHARTS' button.

www.nrel.gov/fleetdna

Fleet DNA National Data Coverage

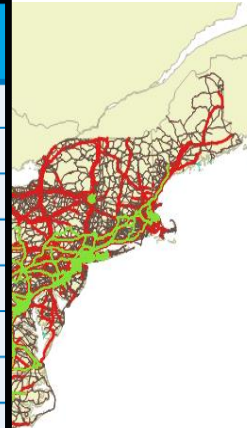


Map showing freight volumes (red) along major U.S. roadways and Fleet DNA data coverage (green) along those routes.

Fleet DNA – Data Coverage



	Vehicles	Days	Miles
Local Delivery	419	123,166	3,069,150
Line Haul	85	5,213	2,107,655
Food & Beverage Delivery	227	66,732	1,779,335
Package Delivery	186	32,688	834,764
Regional Haul	29	1,243	452,471
Tanker	25	1,067	377,207
Other Class 8 Trucks	73	5,549	270,367
Mass Transit	50	2,386	234,955
Utility	120	7,970	122,364
Drayage	34	805	85,574
School Bus	247	1,466	85,454
Refuse Pickup	82	1,474	70,747



Fleet DNA – Data Types

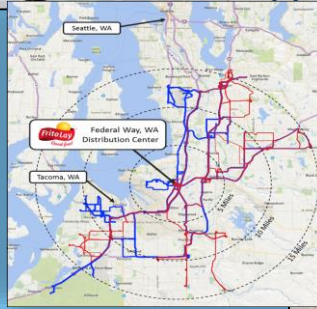


GPS and Route Data

- Latitude / Longitude
- Elevation
- Route Profiles
- Time / Speed
- Ambient Conditions

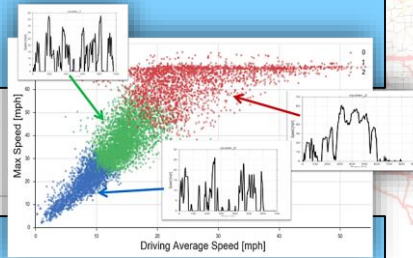
Derived Parameters

- Vehicle Speed Statistics
- Acceleration / Deceleration Rates
- Idle Time
- Road Grade
- Drive Cycles



Supplemental Data

- Vehicle Specifications
- Chassis Dyno Test Results
- Charging profiles / building load data
- Weather, Road Grade, Registration, ...

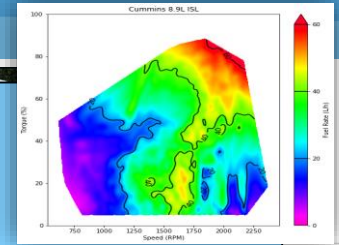


Vehicle and Engine CAN

- Engine Speed / Torque
- Engine Fuel Rate
- NOx Sensor
- Exhaust Temperatures
- Engine Coolant and Oil Temperatures...

Derived Parameters

- Power Demand
- In-use Fuel Economy / Consumption
- In-use Engine Maps...

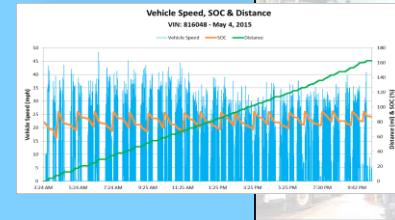
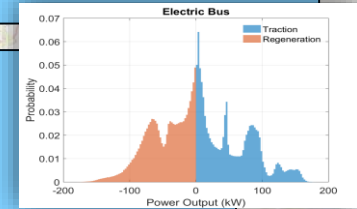


Electric Drive

- Battery SOC
- Voltage
- Current
- Temperatures
- Component Temperatures

Derived Parameters

- In-use efficiency
- Energy demand / Range
- Power / SOC cycles
- Charge profiles...



Recent Fuel Cell Application

Collaboration with ANL using Fleet DNA drive cycle data for fuel cell commercial truck component sizing study

*EVS29 Symposium
Montréal, Québec, Canada, June 19-22, 2016*

Driving an Industry: Medium and Heavy Duty Fuel Cell Electric Truck Component Sizing

J.Marcinkoski¹, R.Vijayagopal², J.Kast¹, A.Duran³

Vehicle Class	Vocation/ Description
class 2b, 6000 – 10000 lbs	Small Van
class 3, 10001 – 14000 lbs	Enclosed Van
class 3, 10001 – 14000 lbs	School Bus
class 3, 10001 – 14000 lbs	Service, Utility Truck
class 4, 14001 – 16000 lbs	Walk In, Multi Stop, Step Van
class 5, 16001 – 19500 lbs	Utility, Tow Truck
class 6, 19501 – 26000 lbs	Construction, Dump Truck
class 7, 26001 – 33000 lbs	School Bus
class 8, 33001 lbs or heavier	Construction, Dump Truck
class 8, 33001 lbs or heavier	Line haul
class 8, 33001 lbs or heavier	Refuse, Garbage Pickup, Cab over
class 8, 33001 lbs or heavier	Tractor Trailer

¹Fuel Cell Technologies Office, Department of Energy, USA, Jason.Marcinkoski@ee.doe.gov, James.Kast@ee.doe.gov

²Argonne National Laboratory, 9700 S. Cass Ave, Lemont, IL, USA, ram@anl.gov

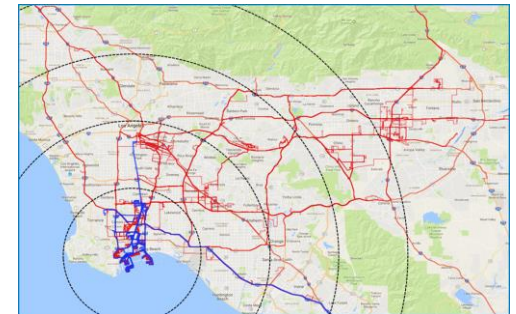
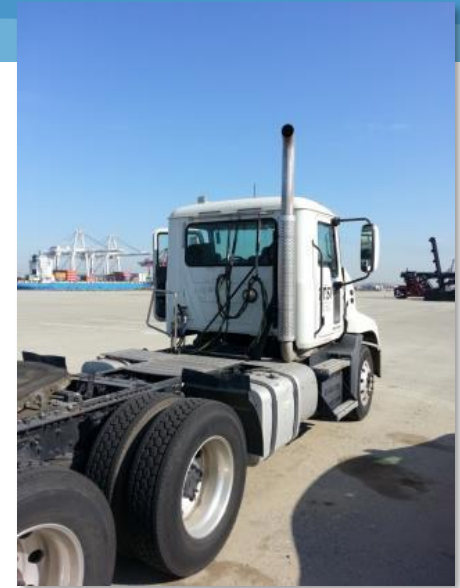
³National Renewable Energy Laboratory, USA, Adam.Duran@nrel.gov



FIGURE 1. Fuel Cell and Hydrogen Tank Sizing Result for FCETS

Example: Port Drayage

- 71,243 Miles
- 557 Operating Days
- 30 Unique Vehicles
- 3 Operating Companies
- Port of Long Beach & Port of Los Angeles



Vocation	Operator	Locations	Weeks	Vehicles	Operating Days
Port Drayage	TTSI	Compton, CA	16	2	166
	Container Freight (California Cartage)	Long Beach, CA	4	14	180
	Dependable Highway Express	Wilmington, CA	4	14	211

10 mi

20 mi

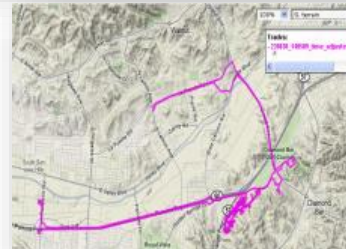
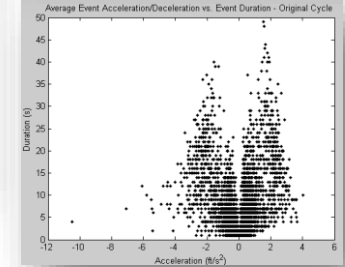
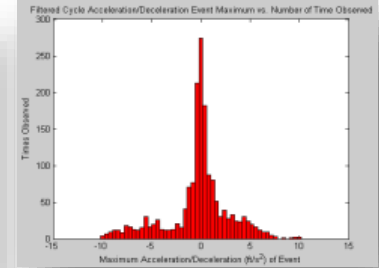
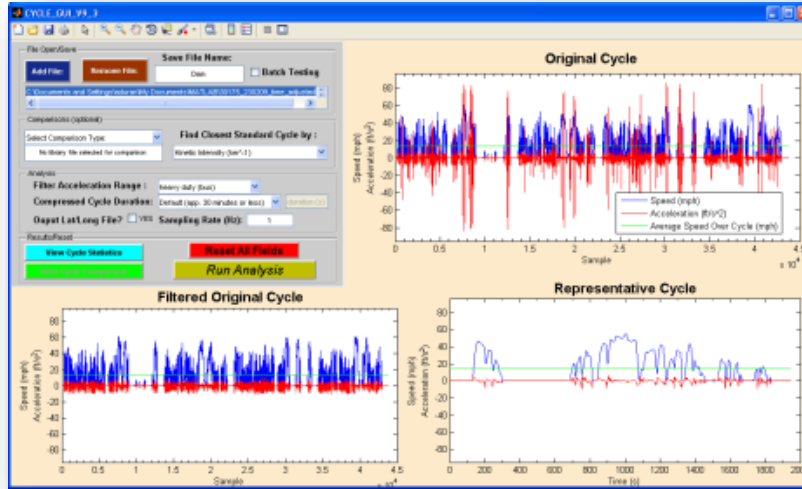
30 mi

40 mi

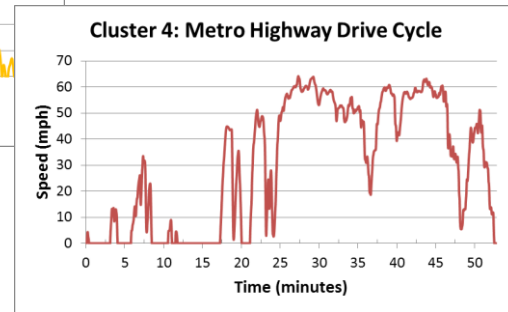
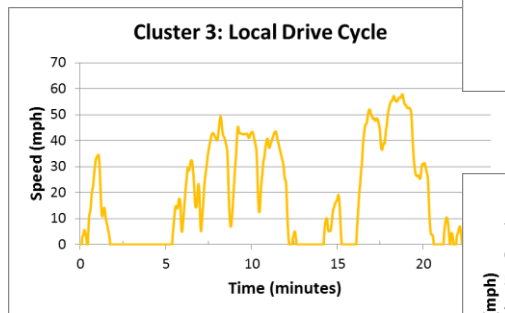
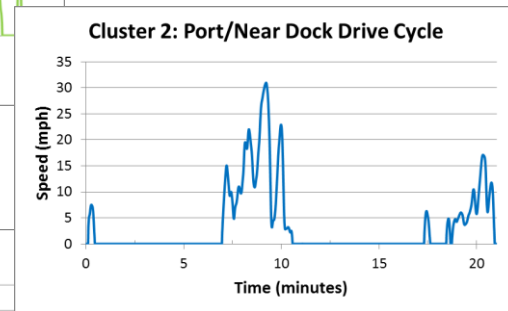
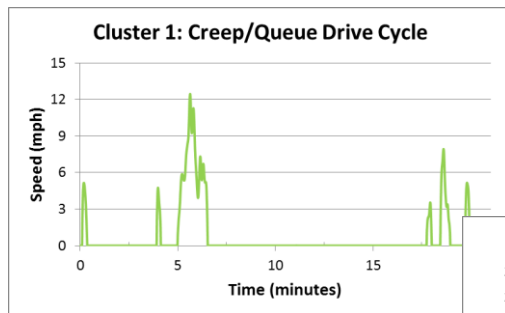
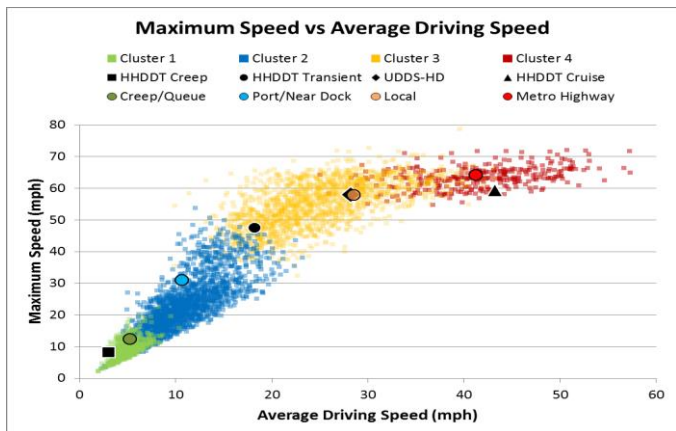
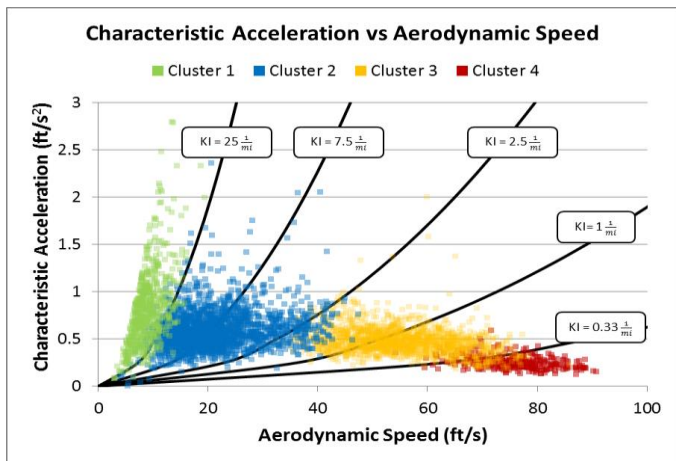
Applying Fleet DNA – NREL's DRIVE Tool

Drive-cycle Rapid Investigation, Visualization and Evaluation Tool (DRIVE™)

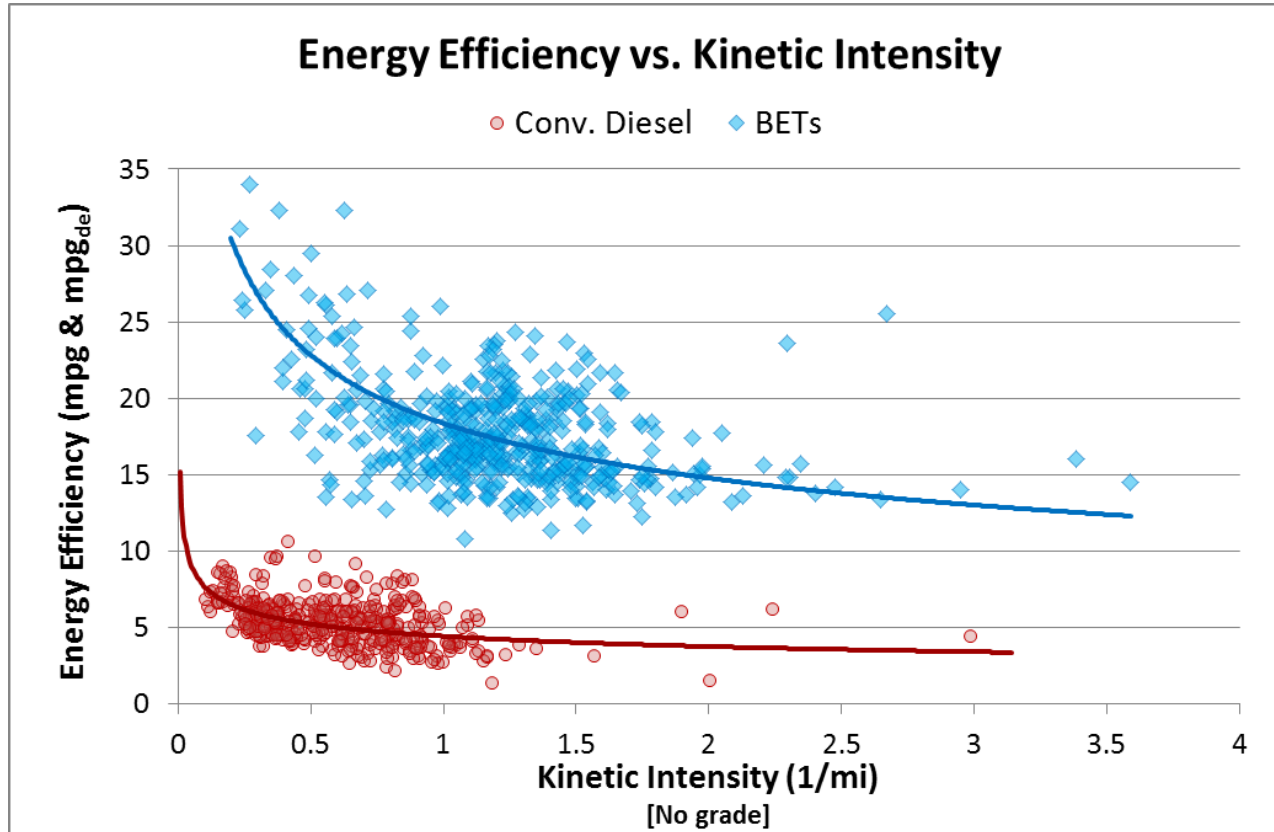
- Created to help fleets and OEMs analyze vehicle usage data for proper vehicle placement, design and testing
- Combines large amounts of user data then filters, creates new cycles & identifies best fitting existing cycle
- Quickly processes and analyzes data :
 - Over 250 metrics
 - Histograms
 - Scatter plots
 - Creates custom cycle
 - Recommends standard cycles



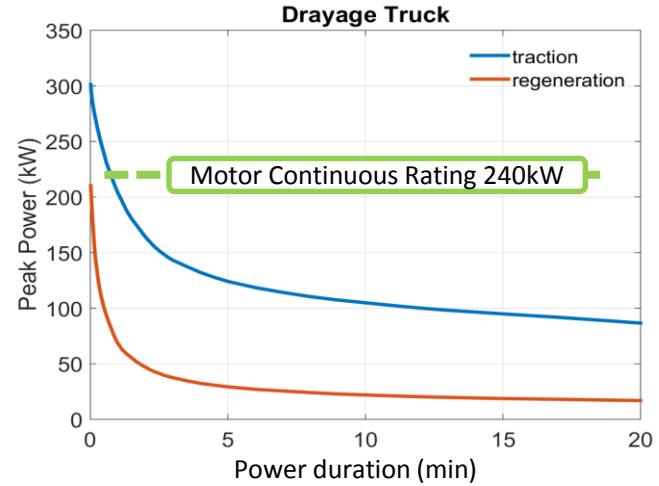
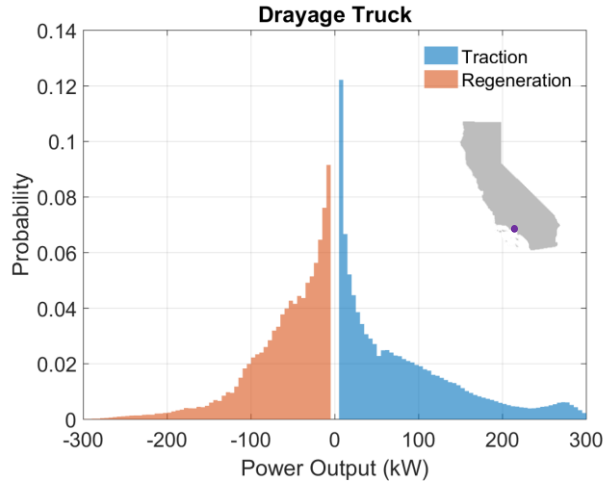
Representative Drive Cycles from Clustering Analysis



Class 8 Drayage Tractor - Diesel vs. EV Efficiency

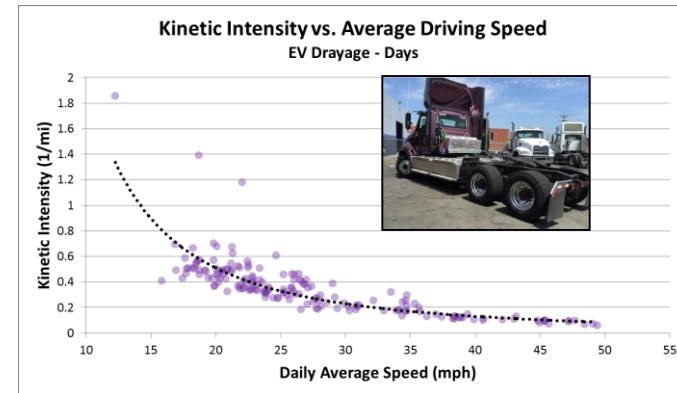


Class 8 Drayage Tractor EV Power Demand Distribution



Duty Cycle Statistics:

Driving Days	173
Kinetic Intensity (1/mi)	0.96
Stops per mile	1.18
Avg Acceleration (ft/s ²)	0.84
Average Speed (mph)	27.4



Drive Cycle Analysis Tool - DriveCAT

Objectives:

- Provide a common, publically available, easy to use site for standard and custom drive cycles for medium- and heavy-duty vehicles
- Capture , quantify and compare drive cycle variation across the spectrum of medium- and heavy-duty vocations
- Allows users to download raw time series data of drive cycles for their own use

Drive Cycle Analysis Tool – DriveCAT



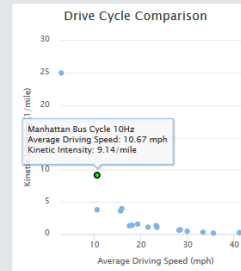
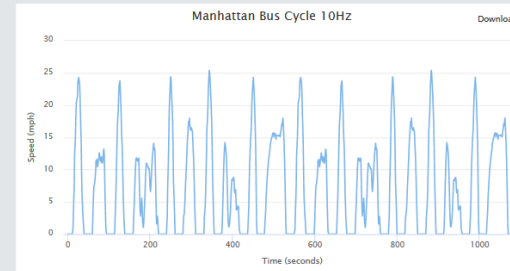
Use the Drive Cycle Analysis Tool (DriveCAT) to find drive cycle data for modeling, simulating, and testing vehicle systems and components, or to understand the real-world benefits of drive cycles for specific vehicle applications.

This tool was created by NREL's fleet test and evaluation team, which conducts in-service performance evaluations of advanced medium- and heavy-duty fleet vehicles. Evaluation results help vehicle manufacturers fine-tune their designs and help fleet managers select fuel-efficient, low-emission vehicles that meet their needs. Learn more about NREL's fleet test and evaluation research.

Contact Us

Let us know if you have any questions about the data, need assistance, or would like to contribute test cycles. We also welcome your feedback on the tool.

CONTACT US



Select a Drive Cycle

Search:

[DOWNLOAD CSV](#)

Cycle	Time (minutes)	Distance (mi)	Max Speed (mph)	Avg Speed (mph)	Avg Driving Speed (mph)	PKE (ft/sec ²)	KI (1/mi)	Stops (#)
CARB HHDDT Composite	60.08	26.05	59.30	26.01	35.59	0.35	0.17	13
CARB HHDDT Creep Segment	4.23	0.12	8.20	1.76	3.00	0.43	24.93	3
CARB HHDDT Cruise Segment	34.73	23.07	59.30	39.86	43.22	0.27	0.12	6
CARB HHDDT Transient Segment	11.13	2.85	47.50	15.36	18.20	0.98	1.38	4
Central Business District - CBD	9.35	2.05	20.00	13.13	15.94	1.12	3.97	14
Manhattan Bus Cycle 10Hz	18.15	2.07	25.40	6.83	10.67	0.19	9.14	20
NREL Baltimore Parcel Delivery	64.23	20.46	61.70	19.11	23.37	1.53	1.33	41

Drive-Cycle Description

A transient, chassis dynamometer test cycle for urban transit buses in Manhattan, New York, with frequent stops and low average speed.

Other Related Resources

- Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles



Discovering Novel Structures

- Characterizing subpopulations
 - kmeans, kmediods, DBSCAN, OPTICS
- Finding representative members
 - Multidimensional depth statistics
- Identifying outliers/anomalies
 - Robust PCA, MDS, Autoencoders
- Exploring lower dimensional structure
 - PCA, t-SNE, ISOMAP
 - Autoencoders

Exploring Known Relationships

- Identifying key variables
 - Regression Models
 - Lasso/Elastic Net
 - Bayesian hierarchical models
- Predicting target output
 - Deep Neural Networks
 - Random Forests
 - Gradient Boosting
- Advanced Use Cases
 - Time Series Forecasting
 - Geospatial
 - Images
 - Text Analysis

Communicating and Visualization

- Lightweight interactive dashboards
- Robust web applications
- Immersive 3D environment for data exploration

Generating Realistic Vehicle Behaviors

- Bayesian hierarchical models
- Variational Auto-encoders
- Generative Adversarial Networks

Example: EPA Phase II GHG and MOVES

Interagency Agreement with EPA

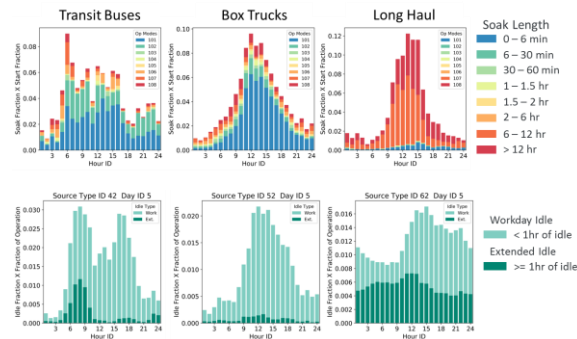
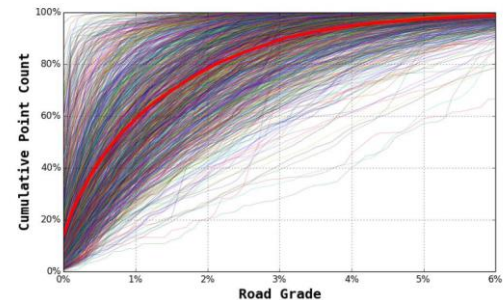
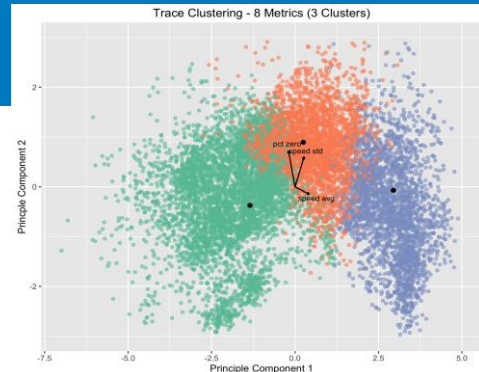
- Vocation vehicle duty-cycle segmentation analysis for Phase II GHG
- National Activity-weighted road grade
- MOVES commercial vehicle activity characterization
- On-road NOx data analysis for future certification

Project Questions:

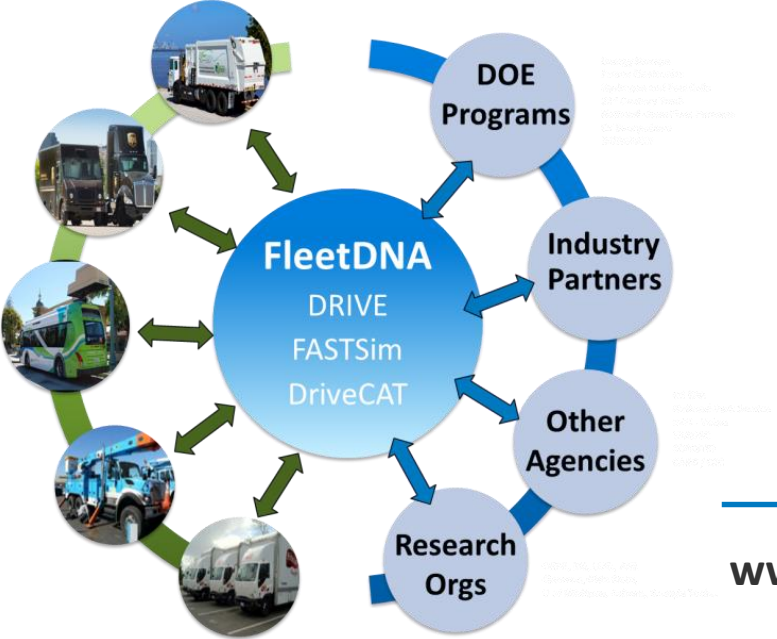
- Can vocational vehicles be segmented by usage profiles?
- How should road grade be accounted for in EPA HD GHG certification?
- What are work-day idle and speed distributions for vocational vehicles?

Approach

- Fleet DNA, Tom-Tom, MOVES, USGS and EMA
- Eight-dimensional Duty-Cycle Cluster Analysis
 - K-means, hierarchical, K-medoids
- Predictive Modeling
 - Pair-wise Correlation across 8 duty-cycle metrics
- Logistic Regression Model
 - Correlate driveline parameters with cluster membership
- Work day idle, soak, and speed distributions by vocation, class, region



NREL Medium and Heavy-Duty Commercial Vehicle Technologies



For more information:

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Thank you

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

