



Medium- and Heavy-Duty Vehicle Field Evaluations

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National Renewable Energy Laboratory

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Project ID: GI001

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Overview

Timeline

- **Multiple Sites**: varies by project
- **Project Length:** typically 12–18 months start to finish (including startup and report)
- **Percent Complete:** FY16–FY18 lab-call award (60%)

Project ID	FY17 Q1	Q2	Q3	Q4	Notes
Frito-Lay EV					Complete - final technical report published FY17 Q1
Miami-Dade Refuse HHV					Planned FY17 completion
Foothill Transit EV					Planned FY17 completion
EV V2G School Bus					Planned FY17 completion
Duke Energy / Odyne PHEV					Kicked off in FY17 - ending in FY18
UPS / Workhorse extended range PHEV					Kicked off in FY17 - ending in FY18
Long Beach Transit EV with wireless charging					Kicked off in FY17 - ending in FY18

Budget

- **DOE Share: FY16 Lab Call $3.3M – 3 years (planned)**
    - o Participant cost share: in-kind support (vehicle loans, technical support, data access, data supplied to NREL); varies by individual project
- **DOE Funding Received in FY16: $1,100K**
- **DOE Funding Received in FY17: $850K**

Barriers

- **Unbiased Data:** Commercial users and original equipment manufacturers (OEMs) need unbiased, 3rd-party new technology evaluations for better understanding of state-of-the-art technology performance to overcome technical barriers
- **Variable Commercial Vehicle Use:** Variable performance by technologies due to multiple and wide-ranging duty cycles (makes data and analysis of data valuable in overcoming this barrier)

Partners

- **Industry collaboration required for successful studies. Past partners include:**
  New Flyer, Freightliner, Workhorse, International, Orion, Allison Transmission, Eaton, Enova, Azure, Cummins, International, FedEx, Caterpillar, Coke, NYC Transit, Verizon, Frito-Lay, Peloton, PG&E, Efficient Drivetrains Inc., Altec
- **Current partners in FY17:**
  UPS, Workhorse, Parker Hannifin, Proterra, Foothill Transit, Long Beach Transit, BYD, Odyne, Duke Energy, Miami-Dade, TransPower, Eaton, Cummins, Bosch, Clean Cities/National Clean Fleet Partnership
- **Project Lead:** National Renewable Energy Laboratory

Relevance: Providing Unbiased Data and Analysis

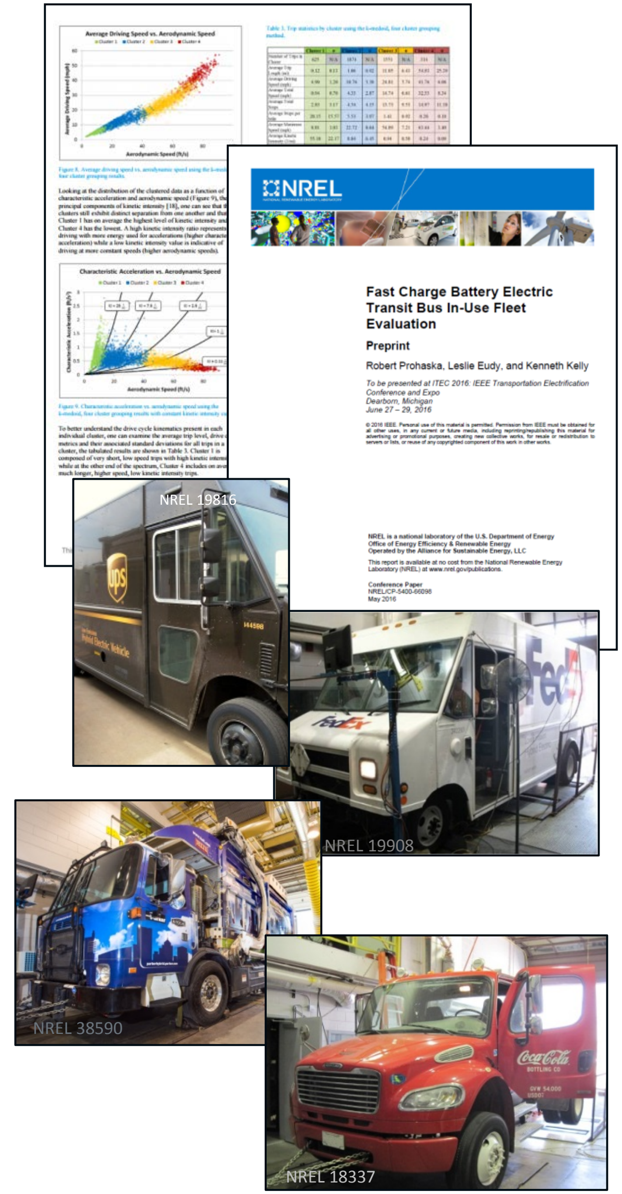
This project provides medium-duty (MD) and heavy-duty (HD) test results, aggregated data, and detailed analysis.

- **3rd party unbiased data:** Provides data that would not normally be shared by industry in an aggregated and detailed manner

- Over 11.5 million miles of advanced technology MD and HD truck data have been collected, documented, and analyzed on over **1,700** different vehicles since 2002

- **Data, Analysis, and Reports** are shared within DOE, national laboratory partners, and industry for R&D planning and strategy.

- **Results help:**
  - Guide R&D for new technology development
  - Help define intelligent usage of newly developed technology
  - Help fleets/users understand all aspects of advanced technology



Relevance: Widespread Application of Data & Analysis
- *Delivery Vehicle Example***

Project Partners

UPS
Frito-Lay
FedEx
Coke
Aramark
Shamrock

** Baseline conventional data also included*

DOE Vehicle Technology Evaluations*

HEV, HHV, REEV

EV

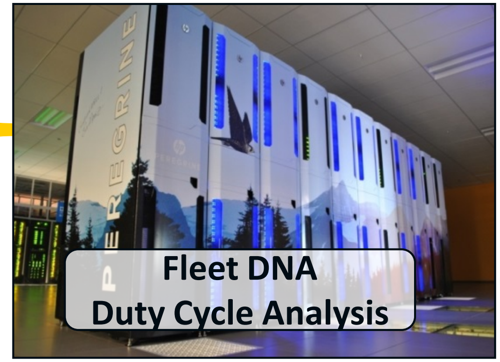
HEV & EV

HEV

HEV

Conventional

Expanded Uses



Fleet DNA Duty Cycle Analysis

Supporting Current DOE Industry FOA Awards

- **Eaton** Multi-Speed EV Gearbox
- **Bosch** Medium-Duty Urban Range Extended Connected Powertrain
- **Cummins** - Electric Truck with Range Extending Engine
- **Blossman Gas** Propane DI Engine

*** Several other FOAs, DOE programs, and other partners are supported beyond these examples*

Federal Agencies
<u>US EPA</u>
- HD Phase II GHG
- MOVES Model

Representative Test Cycles

Model Development and Validation

State Agencies

California Air Resources Board	Hybrid Voucher Incentive Program
South Coast Air Quality Management District	SCAQMD Fleet DNA Roadmap

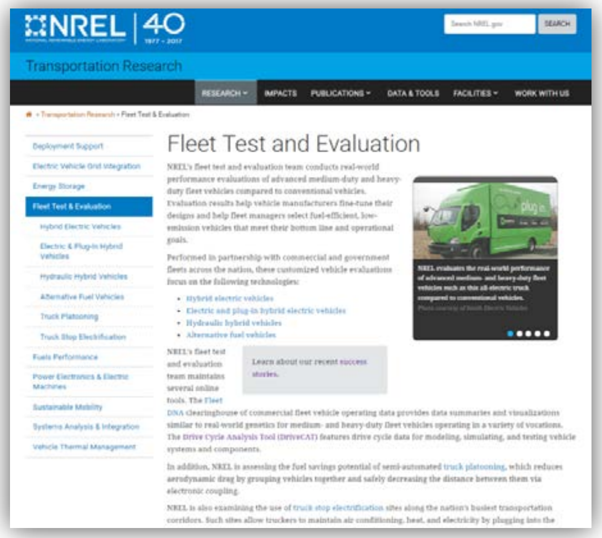
Milestones and Deliverables

Reports highlighting fleet data collection efforts and analysis of data:

Month / Year	Milestone or Go/No-Go Decision	Description	Status
FY16 Q3	Milestone	Status Report on all Projects	Complete
FY16 Q4	Milestone	Annual Report on all Projects	Complete
FY17 Q1	Milestone	Status Report on all Projects	Complete
FY17 Q2	Milestone	Status Report on all Projects	Complete

In addition to the above reports, the following publications, presentations, and web-based tools have been completed since the 2016 AMR with data made available through Fleet DNA:

- *Frito-Lay EV Field Evaluation, Final Technical Report* – Dec 2016
- "The Evaluation of the Impact of New Technologies for Different Powertrain Medium-duty Trucks on Fuel Cons.," SAE COMVEC – Sep 2016
- "Heavy-duty Drayage Drive Cycle Clustering," SAE COMVEC – Sep 2016
- "Evaluating Options in Today's Market: How to Select the Best Fuels & Technology for your Fleet," Midwest Green Fleets, Sep 2016
- "Vocational Duty Cycle Analysis for Powertrain Optimization," SAE Range Extenders for Electric Vehicles Symposium, Nov 2016
- "Electric Drayage Truck In-use Evaluation," EEVC 2017 – Mar 2017
- "Bayesian Parameter Estimation for HD Vehicles," SAE WCX – Apr 2017
- Drive Cycle Analysis Tools - www.nrel.gov/transportation/drive-cycle-tool/



Approach: FY16/17 Projects and Selection Process

Active Fleet Evaluation Projects

UPS: Workhorse RE-PHEV

Duke Energy: Odyne PHEV Utility Fleet

Long Beach Transit: BYD EV bus with Wave WPT

EV School Bus with Vehicle-to-Grid Capability

Projects to be Completed in FY17

Foothill Transit: Proterra EV Bus with Fast Charging

Miami-Dade: Parker Hydraulic Hybrid Refuse Trucks

FY17 Technical Accomplishments highlighted in this presentation include:

1. Miami-Dade, Gen 2 Parker-Hannifin hydraulic hybrid refuse haulers
2. Foothill Transit – Proterra EV transit bus with Eaton 500-kW fast-chargers

Short summaries on the status of the other active projects are also provided.

Project Selection Criteria

- New and emerging technology with active fleet demonstration
- Technology supports DOE program research and deployment mission & interests
- Fleet and industry partners as willing and active participants – i.e., providing data, vehicles, technical data and information
- Fleet has adequate number of advanced vehicles, controls in similar service, and robust data collection processes

Project Selection Process

- NREL maintains awareness of fleet and industry trends through active participation in technical community and stakeholder relationships
- NREL identifies 8–10 possible evaluation projects annually
- NREL reviews candidate project with DOE technology managers to set priorities and down select projects

Photos by NREL Staff

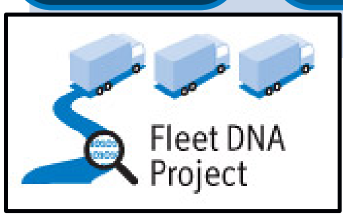
Approach: NREL Field Data, Testing, & Analysis Tools

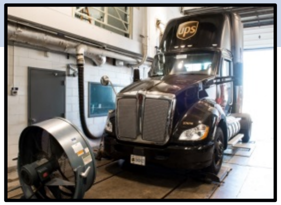
Data from Field Evaluations helps populate Fleet DNA database

DOE Fleet Tools (DRIVE, FASTSim, AFleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Collect Lab and Field Data → **Capture, Store and Analyze** → **Laboratory Testing** → **Explore & Optimize** → **Communicate & Inform** → **Identify Barriers, New R&D Opportunities, Validate Efforts**





Partnership with Fleets and Technology Providers = Relevant Results & Optimized Solutions for Real World Applications

Photos by NREL Staff

Parker Hannifin/ Miami-Dade Refuse: Hydraulic Hybrid

Background / Relevance

- Miami-Dade is the 7th most populous county in the United States and 3rd largest municipal hybrid fleet
- Miami-Dade County currently operates 35 Autocar E3 refuse trucks with Parker Hannifin's "Run Wise" Gen 1 hydraulic hybrid system and recently purchased an additional 29 Gen 2 HHVs
- Claimed 43% fuel savings needs to be independently evaluated

FY17 Accomplishments

- Completed all on-board vehicle data collection, analysis of duty cycles, and on-road fuel efficiency
- Developed representative drive cycles from field data
- Completed chassis dynamometer testing of HHV and baseline

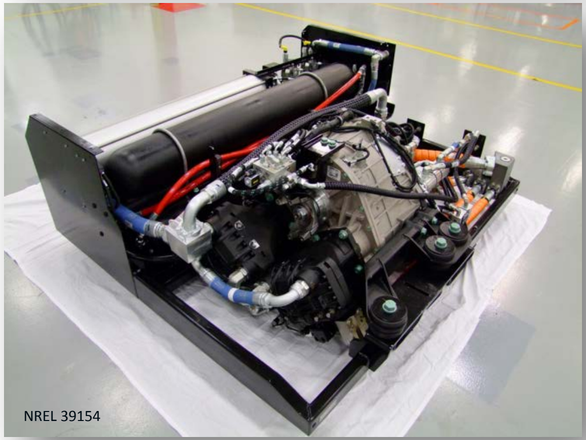
Future Plans

- Complete analysis of field data and dynamometer results analysis in FY17
- Collect "end point" maintenance repair data from Miami-Dade fleet
- Calculate total cost of operation including reliability and maintenance considerations
- Complete all analysis and publish Final Technical Report FY17

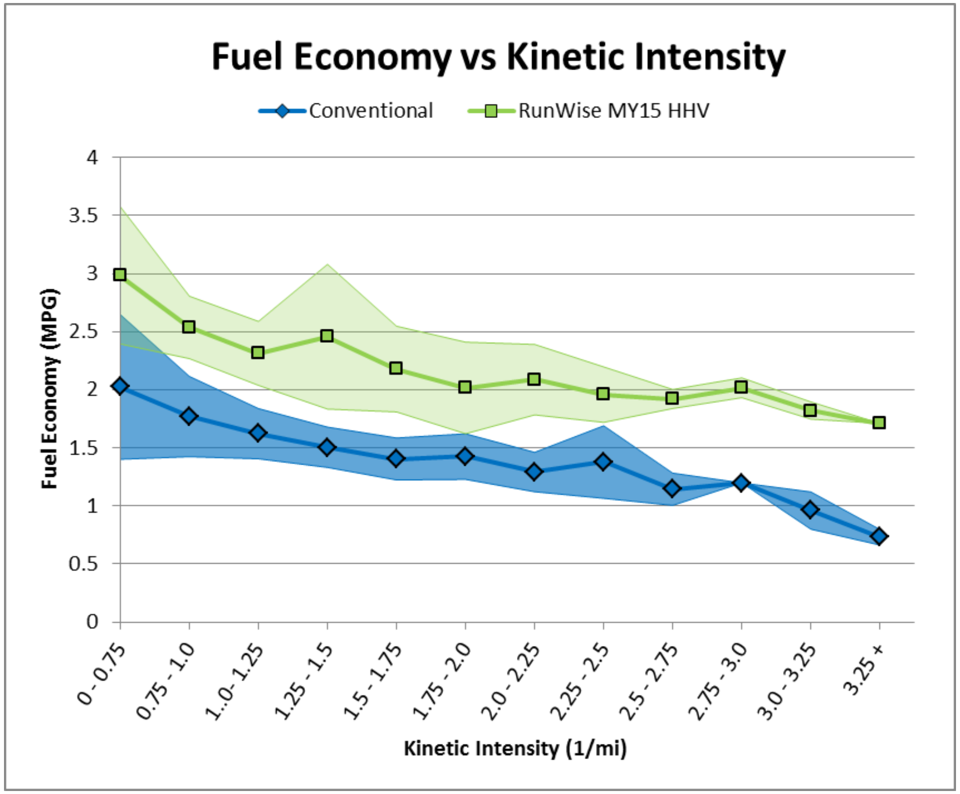
Any proposed future work is subject to change based on funding levels.

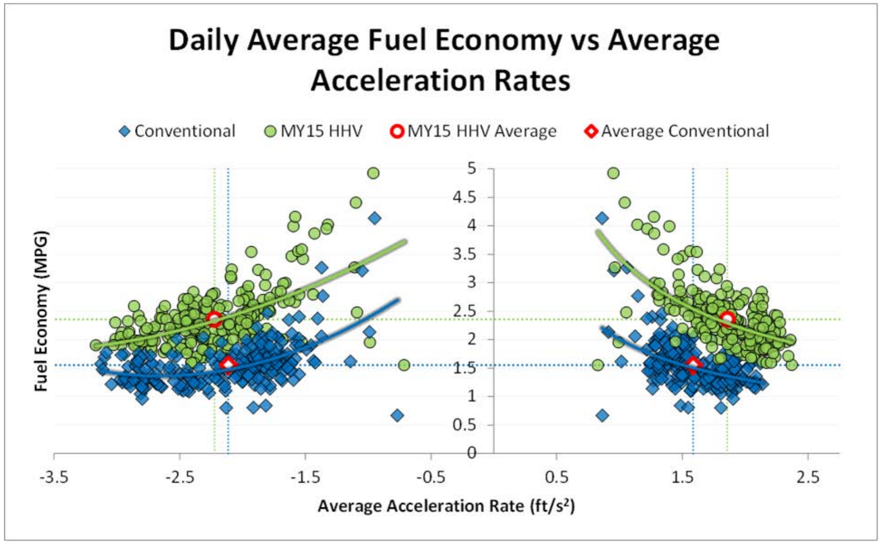

NREL 32784

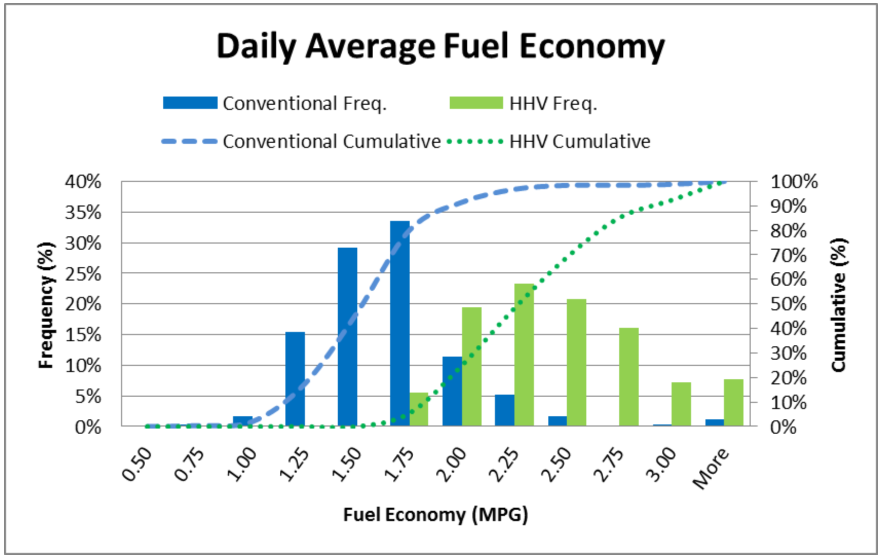

NREL R. Prohaska


NREL 39154

Miami-Dade Field Results



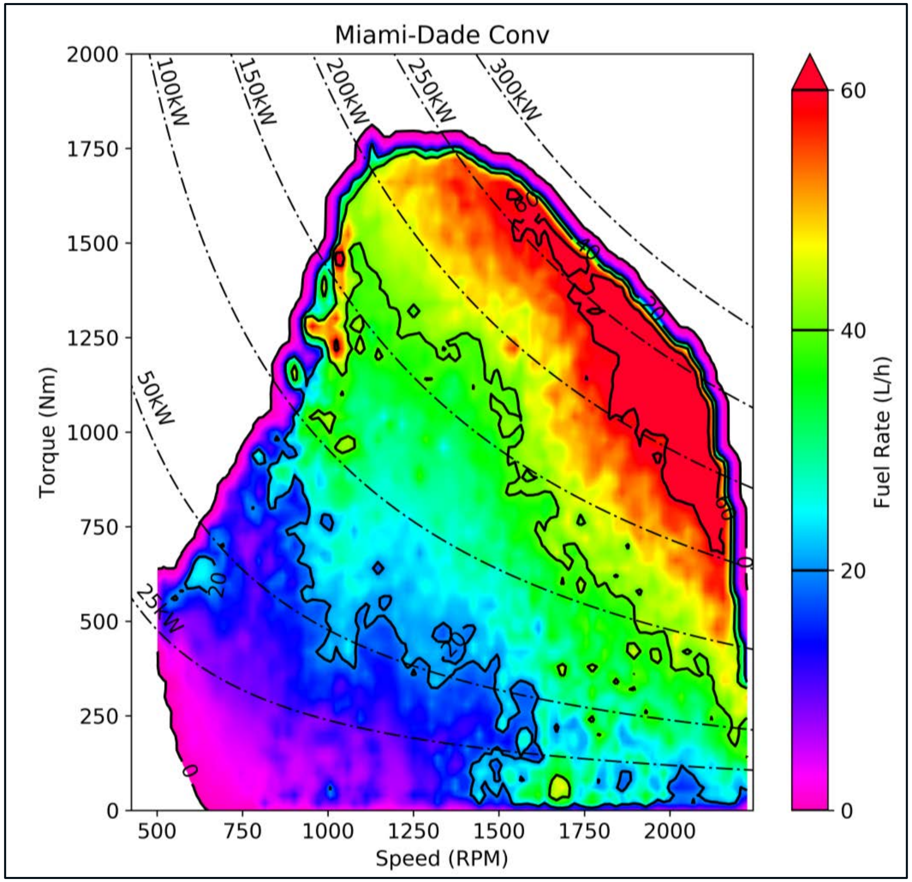




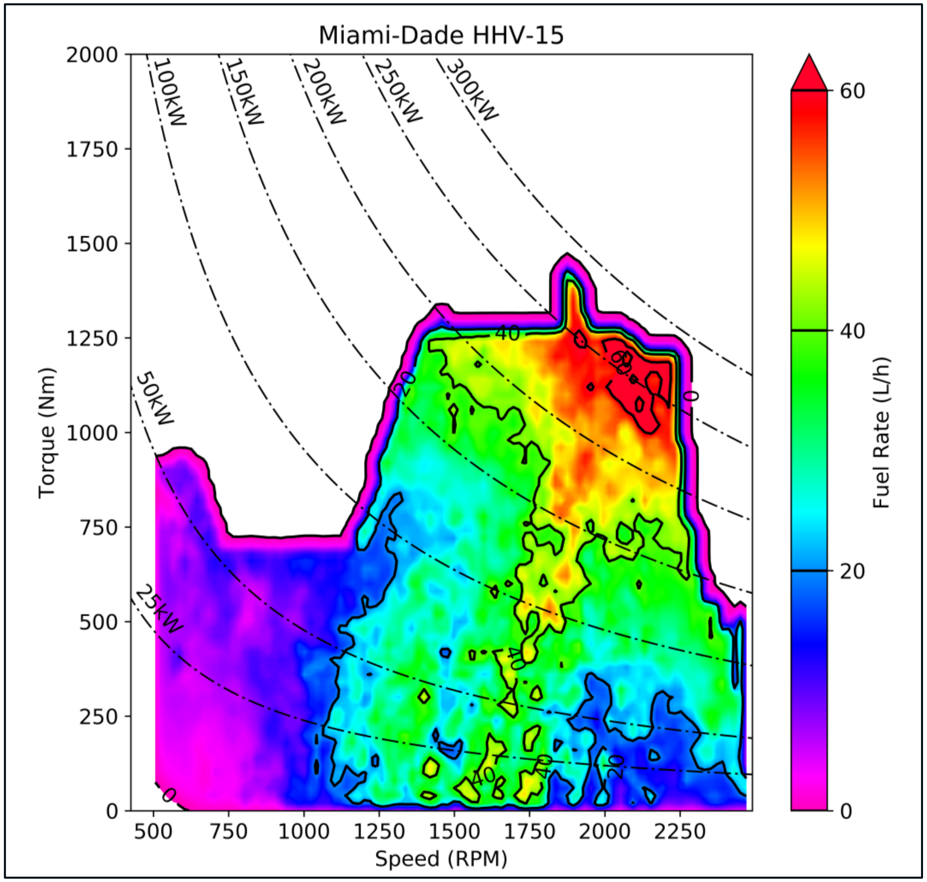
- HHVs demonstrate 52% improvement in fuel economy *[1.55 →2.36 mpg]*
- HHVs accelerate quicker than conventional vehicles, leading to an increase in productivity

Miami-Dade Field Results

- Fueling maps differ between conventional and hybrid vehicles



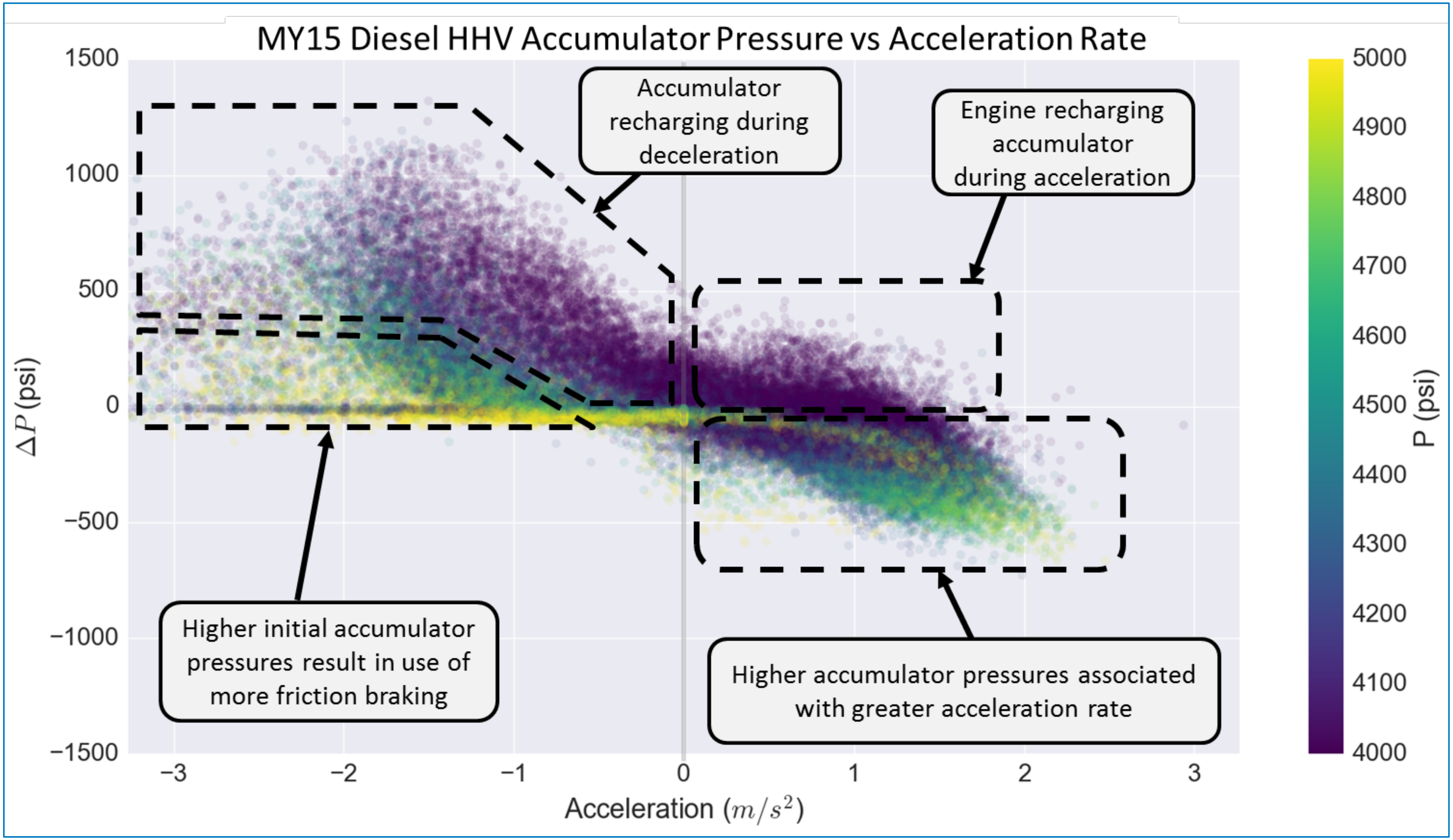
MY07 Conv. Diesel



MY15 Diesel HHV

Miami-Dade Field Results

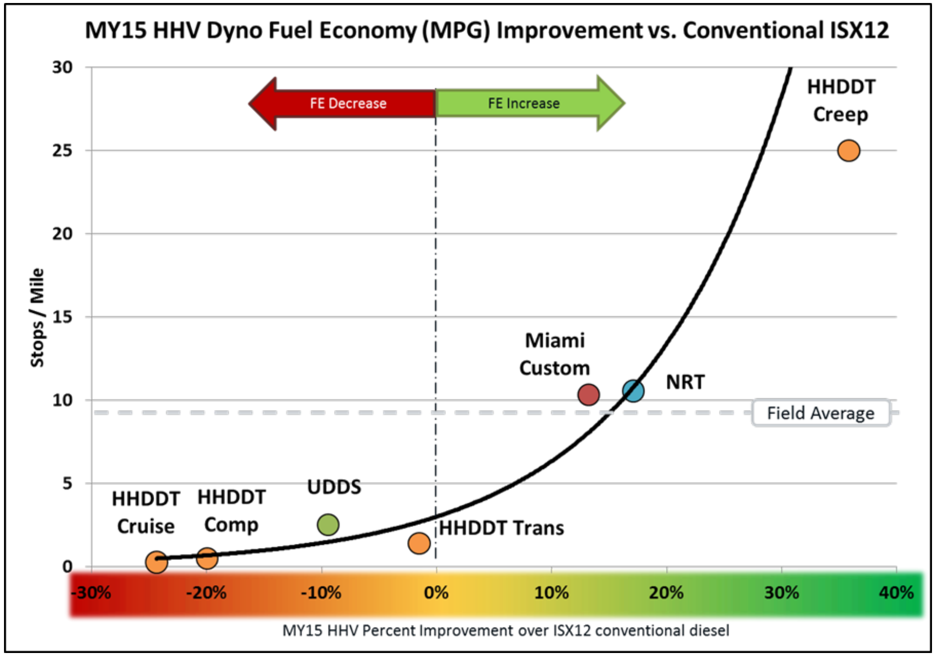
- Each point represents an acceleration or deceleration event



Miami-Dade Dyno Testing Results

- MY15 HHV compared to conventional MY15 Cummins ISX12

	Conventional	MY15 HHV
Engine Fuel Type	Diesel	Diesel
Hybrid System	N/A	Parker RunWise Hydraulic Hybrid
Engine	MY15 Cummins ISX12	MY12 Cummins ISL9
Engine Displacement	11.9 L	8.9 L
EPA Cert. Family Emissions Limit (FEL)	0.20 g/hp-hr	0.33 g/hp-hr
Horsepower Rating	350 hp	380 hp
Transmission	Allison 4500 RDS	Parker RunWise
Transmission Fwd. Gears	6 with 2 Overdrive	2 Hydrostatic, 1 Mechanical
Rear Axle Rating	4.56:1	4.33:1



	Diesel Conventional (MPG)	Diesel HHV (MPG)	Diesel HHV vs. Diesel Conventional
UDDS	4.104	3.717	-9.44%
NRT	2.600	3.045	+17.08%
Miami Custom	2.321	2.628	+13.22%
HHDDT Comp	5.701	4.563	-19.96%
HHDDT Creep	0.804	1.092	+35.82%
HHDDT Trans	3.514	3.460	-1.52%
HHDDT Cruise	6.701	5.069	-24.36%

Proterra / Foothill Transit: Fast Charge EV Transit Bus

Background / Relevance

- Project kick-off in FY2015, leveraged existing CARB-funded project
- U.S. transit authorities are beginning to incorporate all-electric transit buses into their fleets at significant numbers.
- Transit duty cycles may be well suited or exceedingly tough on lithium-ion batteries
- HD EV fast charging adds significant electricity demand to transit facilities buses in Pomona, CA

FY17 Accomplishments

- Completed all on-board vehicle data collection from EV and CNG baseline buses
- Developed representative drive cycles from field data
- Completed analysis of CNG baseline and EV duty cycles and on-road fuel efficiency

Future Plans

- Develop FASTSim EV and CNG transit bus models and evaluate other Foothill Transit routes for electrification potential
- Complete project with comprehensive final technical report in FY17

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

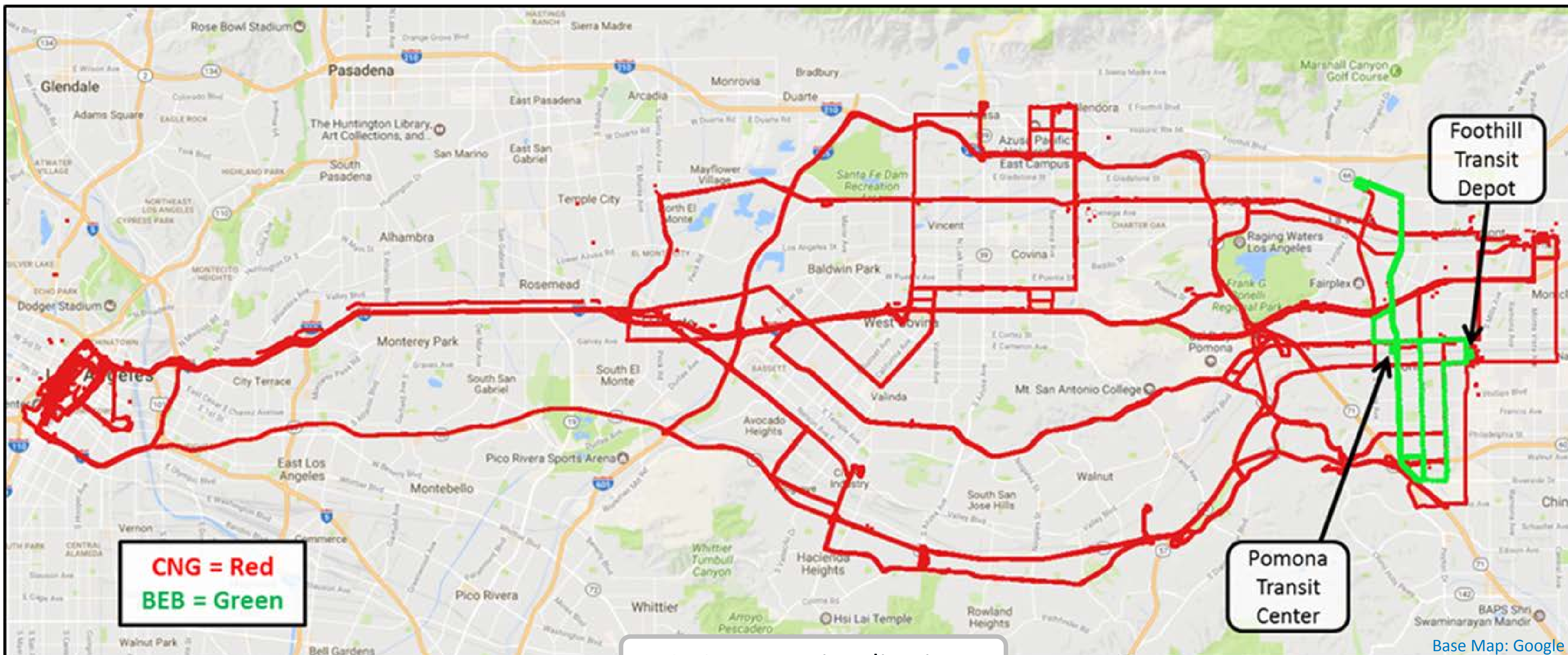
NREL 36044

NREL L. Eudy

Foothill Transit Field Data Collection

- Battery electric buses (BEBs) operating on Line 291 are 3.8x higher in terms of diesel equivalent fuel economy
- CNG vehicles operate across a much broader geographic range

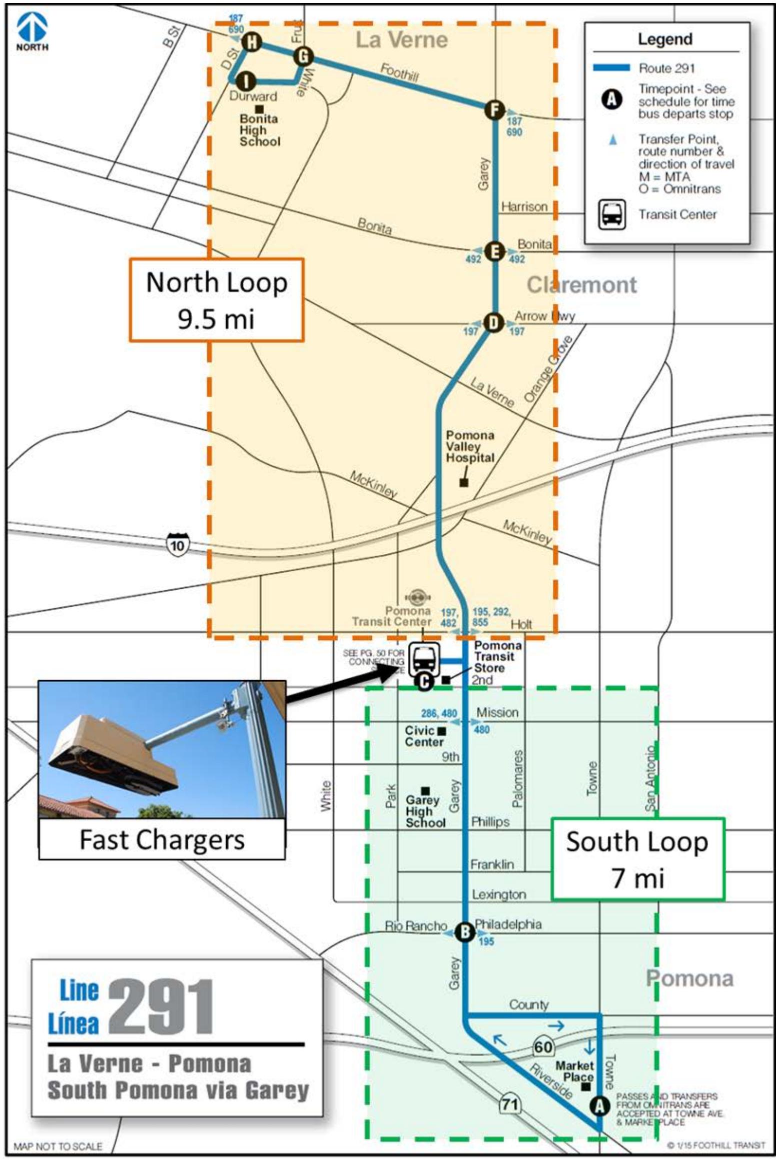
	CNG	BEB
Total Distance	37,892 miles	92,339 miles
Driving Days	212 days	775 days
Energy Efficiency	2.15 kWh/mi	8.35 kWh/mi[a]
Fuel Economy (Diesel Equiv.)	17.5 mpg_{de}[a]	4.5 mpg_{de}[a]

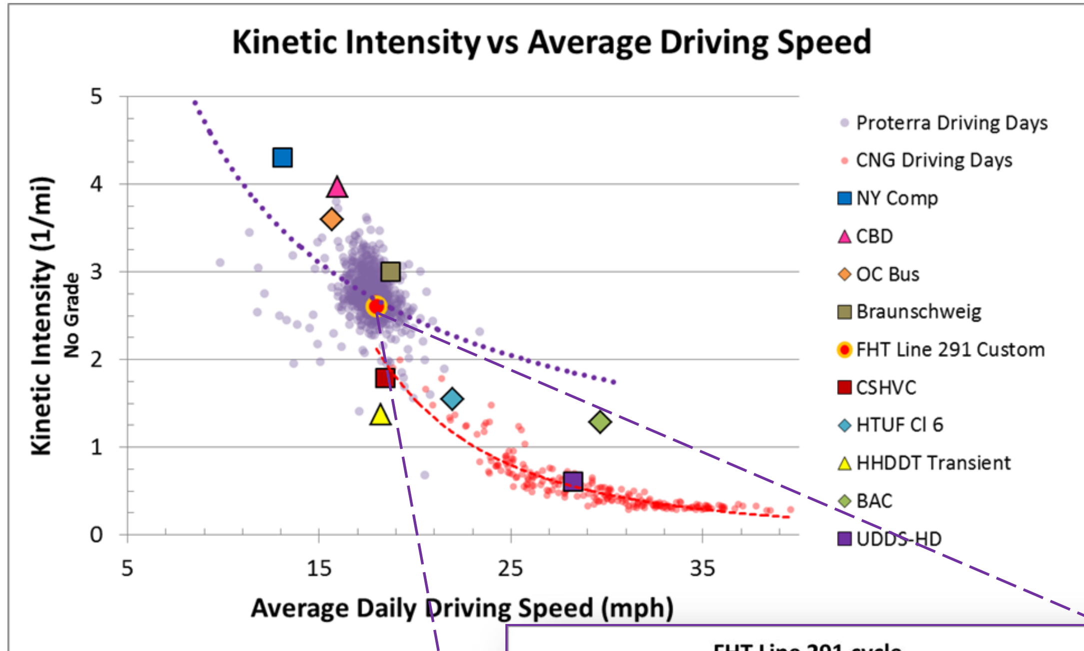


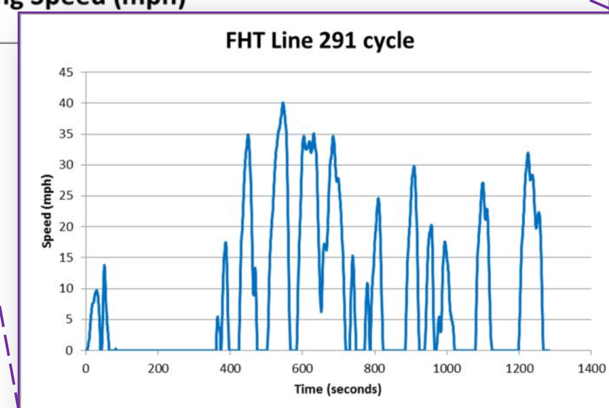
GPS Route Visualization

(a) 37.656 kWh/gallon of low-sulfur diesel fuel

Foothill Transit Custom Cycle



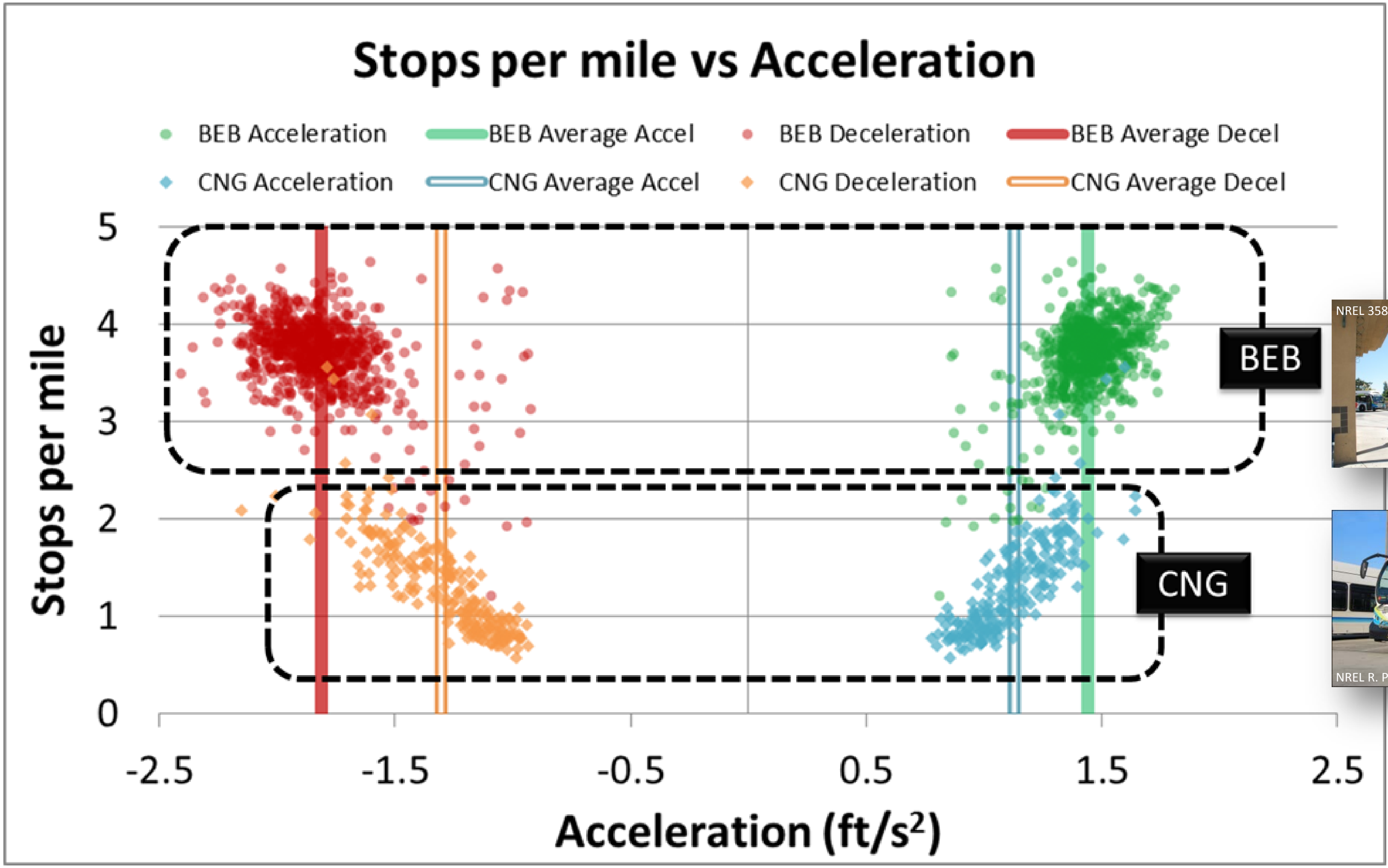




- Custom cycle developed using NREL's DRIVE tool specific to Foothill Transit's Line 291 route

- Route to be used for modeling and simulation

Foothill Transit Driving Characteristics



- BEBs were driven on routes with more stops per mile and driven with both high acceleration and deceleration rates

TransPower / CA School Districts: V2G EV School Bus

Background / Relevance

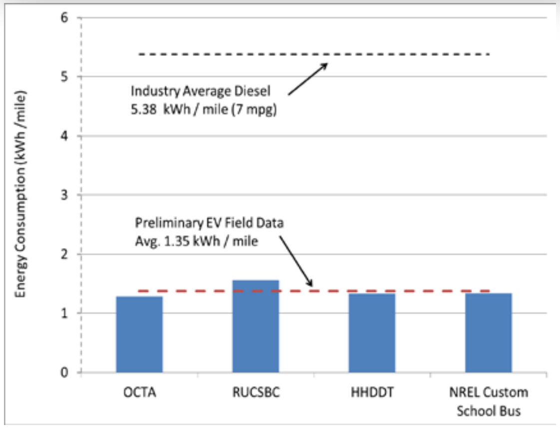
- Project kick-off in FY2015, leveraged California Energy Commission and Clinton Global Initiative funding
- Zero-emissions school bus with potential opportunities for vehicle-to-grid integration
- On-road data and results support DOE 1535 FOA EV school bus award to Blue Bird

EV School Bus Vehicle Details	
Chassis	International / Blue Bird DT466 retrofits
System Integrator	TransPower
Motor	150 kW peak / 110 kw continuous
Battery	115 kWh LiFePO4
Bi-directional inverter	EPC Power Epic 150 150kW inverter / 70kW charger

FY17 Accomplishments

- Field data collected on conventional diesel school buses in Napa and Torrance Unified School Districts in California
- Completed IEEE 1547/SAE J3068 testing relative to grid interconnection standards
- Performed charger efficiency characterization—AC charge to DC discharge efficiency evaluation
- Developed representative drive cycles and completed EV school bus chassis dynamometer testing

Photo by NREL Staff



Future Plans

- Complete building / grid impact analysis from FASTSim outputs
- Develop FASTSim EV and diesel school bus models and evaluate other routes for electrification potential
- Conduct analysis and compile findings into a final technical report in CY 2017

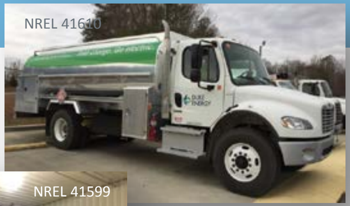
Any proposed future work is subject to change based on funding levels.

Future Plans:

Projects Kicked Off in FY17 – Wrapping up in FY18

Duke Energy – Odyne PHEV Utility Trucks

- Project kicked off in FY2017
- Multiple utility vocations leveraging same Odyne hybrid platform
- Completed initial on-board data collection from 20 aerial lift trucks, utility vans, and fuel tankers in Ohio, North Carolina, and South Carolina



UPS – Workhorse Range Extended EV

- Workhorse PEV with BMW range extender and Panasonic battery pack
- Project kicked-off in FY2017: UPS recently purchased 125 vehicles currently being deployed – first test vehicle instrumented in Atlanta
- Opportunities to evaluate geo-fencing with route-based controls

Photo by NREL Staff

Long Beach Transit – BYD Battery Electric Transit Bus

- BYD BEB with wireless charging
- Project kicked off in FY2017 in collaboration with Federal Transit Administration
- First BYD buses put into revenue service in March 2017 (10 total)
- Buses equipped with conductive charging at depot and 50-kW WAVE on-route wireless charging

Photo by NREL Staff

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

Response to Previous Year Reviewers’ Comments

Many reviewer comments were very positive – thank you. The following replies are to a representative sample of the more constructive reviewer comments – mostly from the Approach section of the review.

Comment #1: The reviewer believed that analysis derived from the MD and HD data collection would have increased accuracy if the data collection included frequent direct measurements of the total mass of the vehicles. Several of the fleet data collection involved vehicles that frequently change the mass of their payloads.

Response: We agree with your comment and recognize the value of payload data, but have found it very difficult to obtain accurate payload data from fleets operating in real-world revenue service. Most modern vehicles broadcast engine speed and torque data, so we can correlate fuel consumption with load, but this is complicated by other factors, including road grade. As an alternative, NREL has been developing a methodology using data mining techniques to derive vehicle mass from in-service data. Initial results were published in an SAE paper presented at the 2017 SAE World Congress entitled “Bayesian Parameter Estimation for Heavy-Duty Vehicles," E. Miller et al.

Comment #2: The reviewer noted that the way in which fleets/applications were targeted could possibly be more methodical. The reviewer questioned where the holes were in terms of possible applications. Still, the reviewer commented that it was a good approach chosen of characterizing the data and then testing on the dynamometer. Also using a validated vehicle model to do what if scenarios was a very good idea. However, the reviewer commented that power characteristics would be helpful.

Response: We continue to refine our selection of vehicle technologies and fleets within the constraints of the program. That process currently attempts to match new emerging technologies, vehicle availability in sufficient quantities, DOE program priorities, and fleets’ willingness to participate. NREL is using aspects of duty-cycle power characteristics in some of the new FOA awards, working with vehicle/technology developers to apply data from the program to optimize new power train development to real-world duty cycle performance requirements. We also presented a study of on-road power demand distributions from various MD and HD EVs at the 2016 Applied Power Electronics Conference.

Response to Previous Year Reviewers' Comments

Comment #3: The reviewer commented that the presenter provided evidence to support the idea that the data collection benefited the fleet owners, but did not support the idea that it significantly benefits R&D planning, and strategy for DOE at the national laboratories.

Response: We agree that there is potential for further use of results from this project within the DOE. Currently, data, results, and analytical tools stemming from this project are being applied on seven industry-led DOE FOA awards and one ARPAe NEXTCAR award. In the past two years, NREL has also leveraged results of this project with DOE R&D programs, including Energy Storage, Hydrogen and Fuel Cells, Clean Cities National Clean Fleet Partnership, Super Truck, 21st Century Truck, and GREET modeling. Many of these applications resulted in published milestone reports within the DOE technology area.

Comment #4: The reviewer stated that there was an excellent focus on future work for existing fleets, but identification of future fleets was lacking

Response: Under the current funding plan through FY18, we will be working with UPS / Workhorse and a range extended EV, Duke Energy and Odyne on PHEV utility trucks, and Long Beach Transit with BYD on EV transit buses with WAVE 50-kW wireless charging. We are currently reviewing publically available information on technology development to identify potential new fleets/technologies for evaluation beyond FY18.

Comment #5: The reviewer liked the idea of collaborating with the other DOE institutions. However, the reviewer believed that more effort should have been made to target possible other killer applications by modeling in advance. The reviewer asked what power takeoff (PTO) applications are out there that could provide fuel savings and if there are certain cities with terrain, traffic, or other conditions that make hybrids pay off more quickly. The reviewer wondered how the next killer application could be found. Finally, if the project team would be able to make targets for technologies, routes, types of fleets, etc. based on results so far and modeling.

Response: In addition to some of the exciting FOA awards such as EV school bus with V2G, this project has spawned work outside the DOE VTO program with organizations like the ARPAe NEXTCAR, SCAQMD Fleet DNA Roadmap, and California Energy Commission's V2G Electrification—perhaps one of these will be the next "killer application."

Collaboration and Coordination with Other Institutions

FY16/17 Collaborations & Coordination with Others				
Partner	**Relationship**	**Type**	**VT Program or Outside?**	**Details**
Miami-Dade County	Fleet Partner	Local Gov't Fleet	VT Program	Provided vehicles and data
Proterra	OEM Support	Industry	VT Program	Provided vehicles and data
Foothill Transit	Fleet Partner	Transit Operator	VT Program	Provided vehicles and data
Parker Hannifin	OEM Support	Industry	VT Program	Provided vehicles, data, and support for testing
TransPower	OEM Support	Industry	VT Program	Providing data and hardware to enable testing
US Hybrids	OEM Support	Industry	VT Program	Providing data and hardware to enable testing
Odyne	OEM Support	Industry	VT Program	Providing access to battery data & vehicle data
Duke Energy	Fleet Partner	Industry	VT Program	Provided vehicles, data, and support for testing
Walmart	Fleet Partner	Industry	VT Program	Providing line-haul and regional-haul vehicle data
Long Beach Transit	Fleet Partner	Transit Operator	VT Program	Provided vehicles and data
BYD	OEM Support	Industry	VT Program	Provided vehicles and data
US Environmental Protection Agency	Funding Partner	Gov't Collaboration	Outside	Providing funding to analyze vocational vehicle data for Phase II Heavy-Duty Greenhouse gas regulations
California Energy Commission	Funding Partner	Gov't Collaboration	Outside	Providing funding for fleet evaluation
California Air Resource Board	Funding Partner	Gov't Collaboration	Outside	Providing funding for fleet evaluation
South Coast Air Quality Management District	Funding Partner	Gov't Collaboration	Outside	Providing funding for fleet evaluation, assistance with access to fleets, coordination with
DOE Clean Cities	Coordination	Gov't Collaboration	VT Program	Providing funding to assess fleet-specific technology options for National Clean Fleets Partnerships (Verizon, City of Indianapolis, PG&E)

Remaining Challenges and Barriers

1. **Continuing need for unbiased information, data, and analysis**
   - Fleets are faced with a long menu of alternatives, including propane, natural gas, electric, fuel cells, aerodynamics devices, connected and autonomous vehicles, low rolling-resistance tires, etc.
   - Fleets are also faced with changing economic drivers and technology implementation issues such as demand charges, charge management, wireless charging, green routing, etc.
   - Fleets need objective information on the performance of these technologies within the context of their operations
   - Technology developers need detailed duty cycle and performance information to optimize energy efficiency solutions that meet vocational requirements
2. **Availability of technology solutions that are reliable and cost effective for economically viable commercial applications**
   - Limited rollout of EVs, HEVs, PHEVs, and fleets need suppliers that can provide reliable, long-term maintenance and support.
3. **Vehicle emissions performance requirements and changing GHG regulations may impact industry requirements and available technologies**
   - Focus on energy savings while relying on engine emissions certification may lead to in-use emissions challenges: root-cause analysis and solutions are needed along with information potential regulatory/process requirements;
   - New EPA HD GHG rules likely to cause demand for new cost-effective energy saving technologies, and better unbiased data on technology- and application-specific efficiency performance.

Summary

- MD and HD vehicle technology evaluations provide test results, detailed on-road performance data, analysis, and published reports that help drive design improvements, guide deployment decisions, inform regulatory processes, and provide field data for researchers.

- Key technical accomplishments in FY16/FY17 include:
  - Published 16 technical papers/presentations from fleet evaluation activities, including at key forums such as SAE Commercial Vehicle Engineering Congress, SAE World Congress, SAE Range Extenders Symposium, IEEE Transportation Electrification Conference, Electric Vehicle Symposium & Exhibition EVS29, Automate Vehicles Symposium and NTEA Green Truck Summit
  - Published final technical report on Frito-Lay EV evaluation – and completed data collection and analysis activities on Foothill Transit EV bus, Miami-Dade HHV refuse hauler evaluations;
  - Kicked-off three new fleet evaluations including: Duke Energy fleet evaluation of Odyne PHEV utility trucks, UPS / Workhorse extended range EVs, and Long Beach Transit BYD EV transit bus with wireless power transfer
  - Applied results of fleet evaluations and Fleet DNA to DOE RD&D programs, including Energy Storage, Hydrogen and Fuel Cells, Power Electronics, National Clean Fleet Partnership, Clean Cities National Parks, Super Truck II, and EV Everywhere
  - Fleet evaluation data and analysis are contributing to seven industry-led FOA vehicle electrification, Super Truck II awards, and an ARPAe NEXTCAR award
  - Fleet evaluation data and analysis used by other Federal and State agencies, including EPA, U.S. Department of Transportation (DOT), National Park Service, CARB, CEC, SCAQMD

Acknowledgements and Contacts

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Additional thanks to all the fleet and industry partners without whom this work would not be possible

For more information contact:

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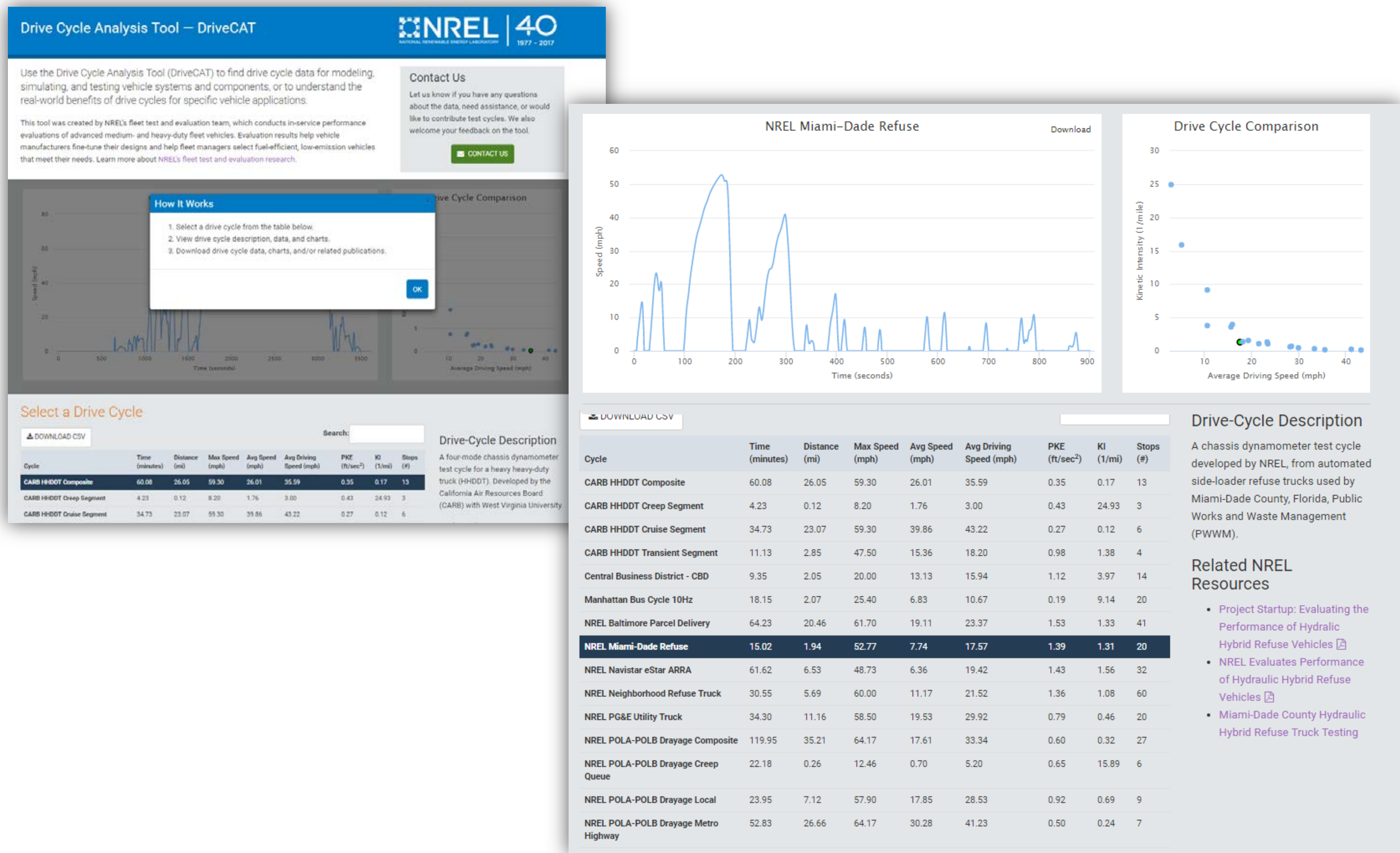
Technical Backup Slides

Drive Cycle Analysis Tool — DriveCAT



Cycle	Time (minutes)	Distance (mi)	Max Speed (mph)	Avg Speed (mph)	Avg Driving Speed (mph)	PKE (ft/sec²)	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
NREL Miami-Dade Refuse	15.02	1.94	52.77	7.74	17.57	1.39	1.31	20
NREL Navistar eStar ARRA	61.62	6.53	48.73	6.36	19.42	1.43	1.56	32
NREL Neighborhood Refuse Truck	30.55	5.69	60.00	11.17	21.52	1.36	1.08	60
NREL PG&E Utility Truck	34.30	11.16	58.50	19.53	29.92	0.79	0.46	20
NREL POLA-POLB Drayage Composite	119.95	35.21	64.17	17.61	33.34	0.60	0.32	27
NREL POLA-POLB Drayage Creep Queue	22.18	0.26	12.46	0.70	5.20	0.65	15.89	6
NREL POLA-POLB Drayage Local	23.95	7.12	57.90	17.85	28.53	0.92	0.69	9
NREL POLA-POLB Drayage Metro Highway	52.83	26.66	64.17	30.28	41.23	0.50	0.24	7

https://www.nrel.gov/transportation/drive-cycle-tool/

Collaboration and Coordination with Other Institutions

This project *absolutely requires* industry collaboration required for successful studies.

Past industry partners included:

New Flyer, Freightliner, Workhorse, International, Orion, Allison Transmission, Eaton, Enova, Azure, Cummins, International, Caterpillar, Coke, NYC Transit, and Verizon

FY15/16 Collaborations & Coordination with Others

Partner	Relationship	Type	VT Program or Outside?	Details
FedEx Corporation	Fleet Eval Partner	Industry	VT Program	Provided vehicles and data
UPS	Fleet Eval Partner	Industry	VT Program	Provided vehicles and data
Eaton Corporation	OEM Support	Industry	VT Program	Provided data access and hardware to enable testing
Peloton	OEM Support	Industry	VT Program	Provided vehicles and hardware to test
Parker Hannifin	OEM Support	Industry	VT Program	Provided vehicles, data, and support for testing
Frito-Lay	Fleet Support	Industry	VT Program	Provided vehicles, data, and installed infrastructure (Servidyne/Chateau)
Momentum Dynamics	OEM Support	Industry	VT Program	Providing data and hardware to enable testing
XL Hybrids	OEM Support	Industry	VT Program	Providing data and hardware to enable testing
Smith Electric Vehicles	OEM Support	Industry	VT Program	Providing access to battery data & vehicle data
S. Coast Air Quality Mgt. District / CARB	Funding Partner	Gov't Collaboration	Outside	Providing funding for projects to supplement DOE advanced vehicle technology testing (CARB = HVIP assessment)
Clean Cities Program	Coordination	Gov't Collaboration	VT Program	Providing funding to assess fleet-specific technology options for National Clean Fleets Partnerships (Verizon, City of Indianapolis, PG&E)
NTEA/GTA	Advisory	Industry	VT Program	Providing access and advisement on tools and protocols
Oak Ridge National Laboratory	Coordination	Gov't Collaboration	VT Program	Coordination of data analysis tools, captured data, and development of test protocol and procedures
And More….				

Data and Information Exchange