



**MT017: Medium Duty Parcel Delivery Truck**  
**Thomas Griffin**  
**June 2016**

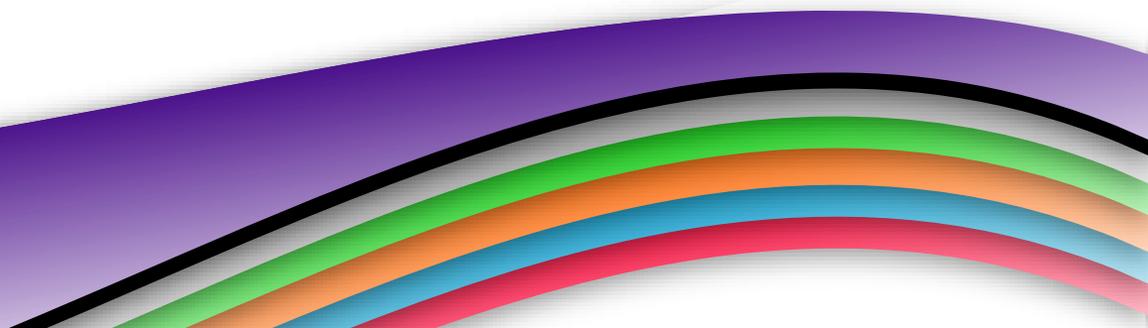
**Connect the world responsibly and resourcefully**

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# Program Overview

## Hydrogen Fuel Cell Extended-Range Battery Electric Vehicles Demonstration

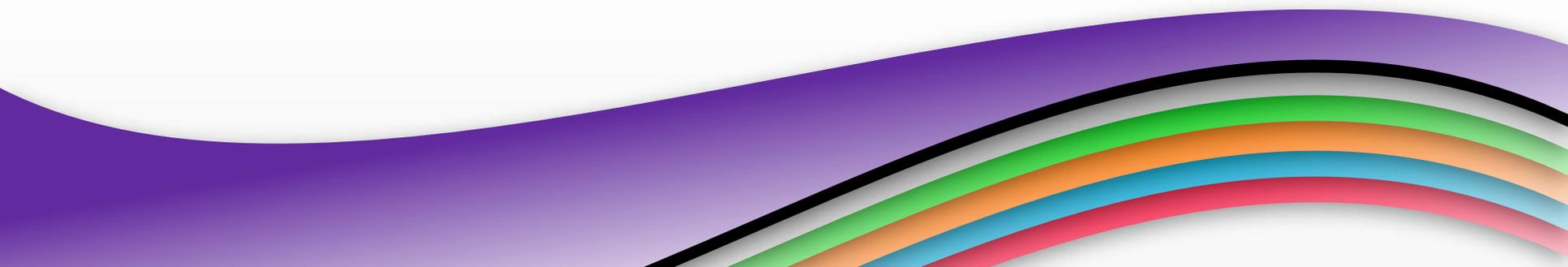
- \$3.0 million from Department of Energy
- Integration of fuel cells into 20 battery electric pickup and delivery vehicles, PUDs
  - BP1 – 1 truck
    - Design
    - Integrate & test fuel cell systems
      - Safety
      - Communication
      - Performance
      - Reliability
    - Validate in revenue service
  - BP2 – 19 trucks
    - Integrate hydrogen fuel cell systems
    - Operate in revenue service in Memphis, TN and several locations in CA



# Project Main Objectives

<b>DOE Project Objectives</b>	<b>Project Impact</b>
Demonstrate / deploy hydrogen and fuel cell technologies in real-world environments.	20 parcel delivery trucks will operate one shift 260 days annually for approximately 10 hours per day.
<b>Ancillary Objectives</b>	
Operate 5,000+ hours	Over approx. 1.92 years, this amounts to approximately 5,000 hours per truck. Total fleet activity is 100,000 hours annually. (Numbers represent minimum.)
Reduce petroleum consumption	Each diesel truck uses 2,600 gallons per year. The program will reduce diesel consumption by 100,000 gallons over ~1.92 years.
Reduce emissions	A net of 270 metric tons of CO2 will be prevented.

<b>Potential Expansion</b>	
Similar Assets & Duty Cycles (count)	7000
Annual Utilization Range (miles)	20k - 50k
Approx Annual Fuel Displaced (gal)	14M
Annual CO2 Avoided (Metric Tons)	69,500



# Program Overview

## Timeline

- Grant awarded – October 2015
- Kickoff meeting – May 2016
- Project end – October 2019
- Project completion - < 5%

## Budget

- DOE – \$3.0M
- Partners – \$3.367M

## Barriers

- Unknown ability to meet safety, performance & reliability needs
- Variable energy requirements
  - Route differences
  - Parasitic losses (HVAC, ancillary systems, effects of temperature)
- EV & FC control systems integration
- Fuel availability

## Partners

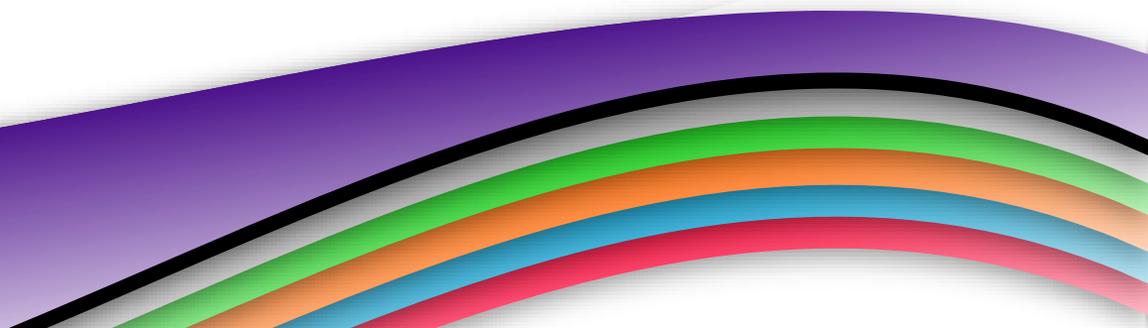
- U.S. Department of Energy
- FedEx Express – Prime rec
- Plug Power – Fuel cell manufacturer
- Workhorse Group – Truck manufacturer



# Relevance: DOE Strategy

## DOE Goals

- Office of Energy Efficiency and Renewable Energy
  - Fuel Cell Technology Office
    - Provide clean, safe, secure, affordable and reliable energy
    - Diversify domestic resources, provide energy security, reduce petroleum use, lower GHG emissions and criteria pollutants



# Relevance: FedEx Express Strategy



Connect the world responsibly and resourcefully

- **Business case**
  - » Reduce fuel use
  - » Sustainability
  - » Energy independence
  - » Lower Total Cost of Ownership
- Desire for long-range zero emission PUD
- Continued need for zero emissions alternative to traditional battery EV
  - » Weight reduction
  - » Cost reduction
  - » Refueling time reduction
- Evaluation of Hydrogen Fuel Cells as an On-Board Traction Battery Charger



# Relevance: FedEx Express Fleet Size 71,309

## The 2<sup>nd</sup> Largest Fleet in North America

### WORLD WIDE VEHICLE COUNT

Walk-In	29,610
GSE (powered)	15,007
Panel Van	11,440
Straight	3,572
Tractor	3,259
Other	8,421



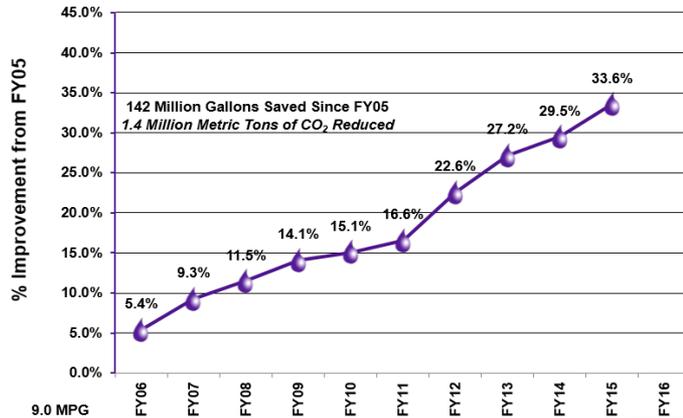
### ALTERNATIVE VEHICLE COUNT

GSE	3,300
HEV	424
EV	190
CNG	57
LPG	32

# Relevance: FedEx Goals

## Vehicle Fuel Economy

2020 Fuel Economy Goal - 30%



FedEx Express®

## Relevance: Committed to Improving

**REDUCE**  
Optimize routing and driving habits to reduce mileage and fuel use



**REVOLUTIONIZE**  
Identify and invest in future technologies such as alternative fuel, hybrid-electric and electric vehicles

**REPLACE**  
Upgrade vehicles to more efficient ones wherever possible

FedEx Express®

## FY15 Efficiency Gains and Cost Savings

Environmental objective	FedEx initiative	FY15 cost savings	FY15 emissions avoided
Reduce aircraft emission intensity 30% from a 2005 baseline by 2020	Aircraft fleet modernization, FedEx® Fuel Sense operational improvements	\$296 million	1.15 million metric tons of CO <sub>2</sub> e avoided
Increase FedEx Express vehicle fuel efficiency 30% from a 2005 baseline by 2020	Fuel-efficient driving, vehicle technology improvements and alternative fuel usage	\$65 million	215,000 metric tons of CO <sub>2</sub> e avoided

FedEx Express®

# Relevance: Mileage Management

**Right Vehicle  
Right Route**

Mileage Bands – Miles Per Year



HYBRID

15,000 – 30,000



COMPOSITE BODY REACH

10,000 – 40,000



EXISTING W700

UP TO 20,000



SPRINTER TYPE

10,000 – 50,000



PANEL VAN

> 40,000



EV

UP TO 16,000



eREV

> 16,000



RANGE – SPEED – TIME  
 Right Technology  Right Duty Cycle  
 PAYLOAD – STOPS – VOLUME

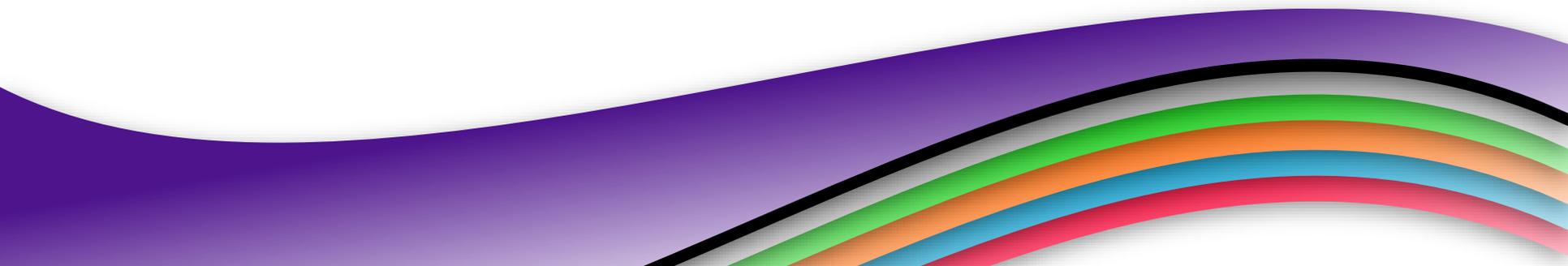


# Approach/Milestones

Task Title (Milestone Description)	Task or Milestone Completion Date			
	Original Planned	Revised Planned	Actual Completed	Current % Complete (0-100)
<b>Budget Period 1 Demonstration</b>				
Task 1: Program Management (3+ years)				
Completed Quarterly and Final Reports	Quarterly and 10/1/19	Quarterly and 10/1/19		12.5
Task 2: Optimization Analysis and Safety Planning (4 weeks)				
Optimization Analysis Completed/Safety Plan Draft Submitted to PNNL Hydrogen Safety Panel	11/1/2015	6/30/2016		10
Task 3: First Fuel Cell Unit Build (8 weeks)				
Fuel Cell System Pass Factory Acceptance Test	2/1/2016	8/31/2016		
Task 4: First Unit Integration (8 weeks)				
Integrated Truck Performs per Stated Specifications	4/1/2016	10/31/2016		
Task 5: First Unit Validation (4-8 weeks)				
Evaluation Document of First Unit Performance	6/1/2016	1/31/2016		
<b>Budget Period 1 Go/No-Go Decision Point</b>				
Task 1 (continued): Program Management (3+ years)				
Completed Quarterly and Final Reports				
Task 6: Remaining Fleet Builds (8 weeks)				
FC Systems Pass Factory Acceptance Testing				
Task 7: Remaining Fleet Integration (8 weeks)				
Integrated Trucks pass FAT				
Task 8: Full Deployment (4 weeks)				
Trucks Deployed and Operating in PUD Application				
Task 9: Continued Deployment (152 weeks)				
Deployment Exceeds 5000 hours in PUD application				

# Accomplishments

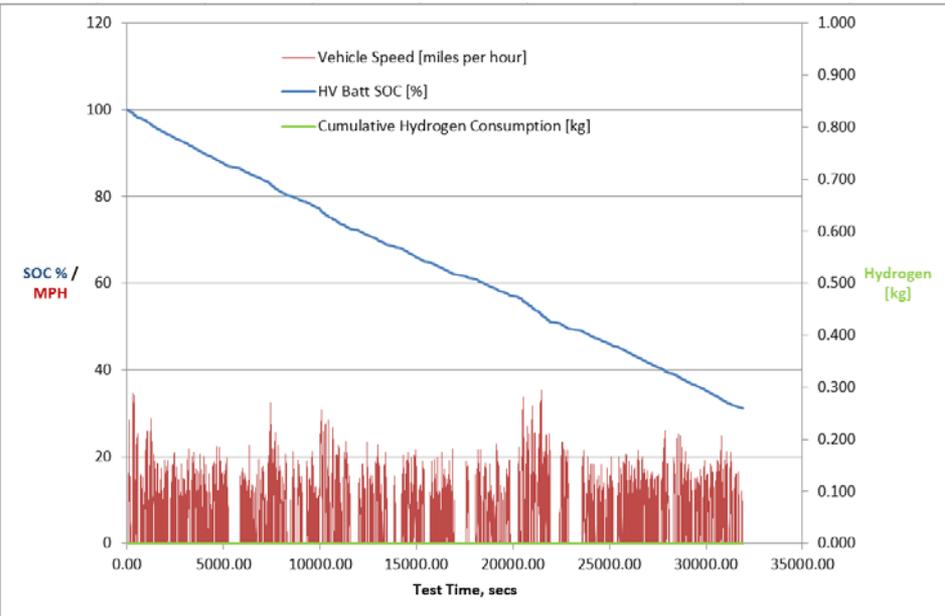
- Identified replacement EV OEM
  - Already has experience with range extension
- Technical kick-off meeting among program partners at manufacturing facility
- Program kick-off meeting among program partners at Memphis Superhub
- Analysis of worst case drive cycle (150 mile total route length with 60 mile stem length at beginning and end)
- Preliminary mechanical layout of batteries, fuel cell, converter H2 storage
- Planning in process for dyno testing



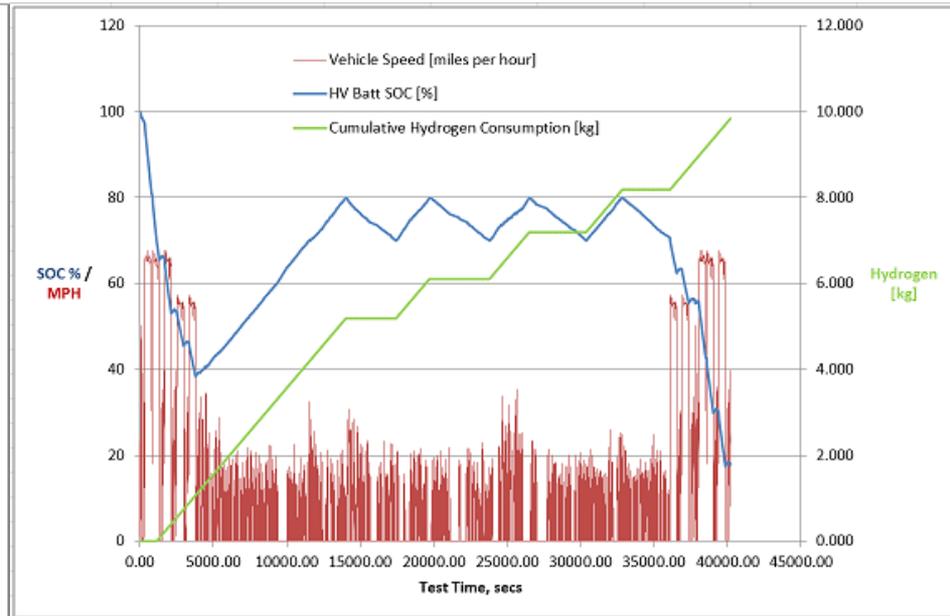
# Accomplishments

Usage profile simulation to confirm right sizing  
Includes drive cycle, parasitic losses, regenerative braking

## Baseline Electric Vehicle

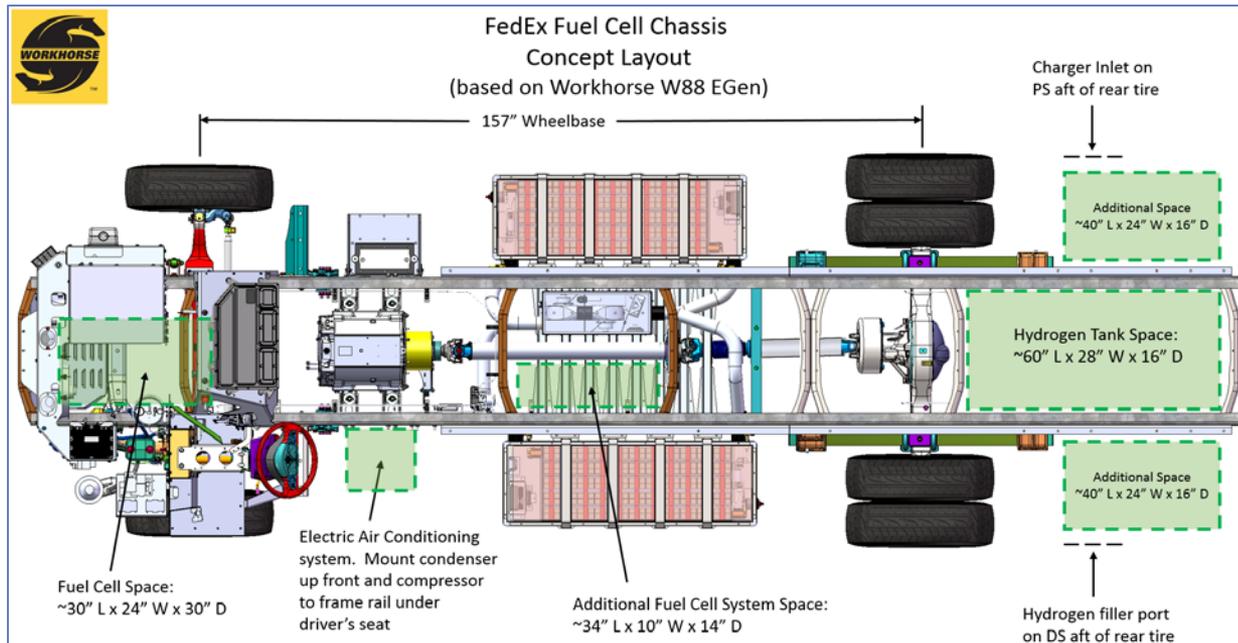


## Fuel Cell Extended Range Electric Vehicle



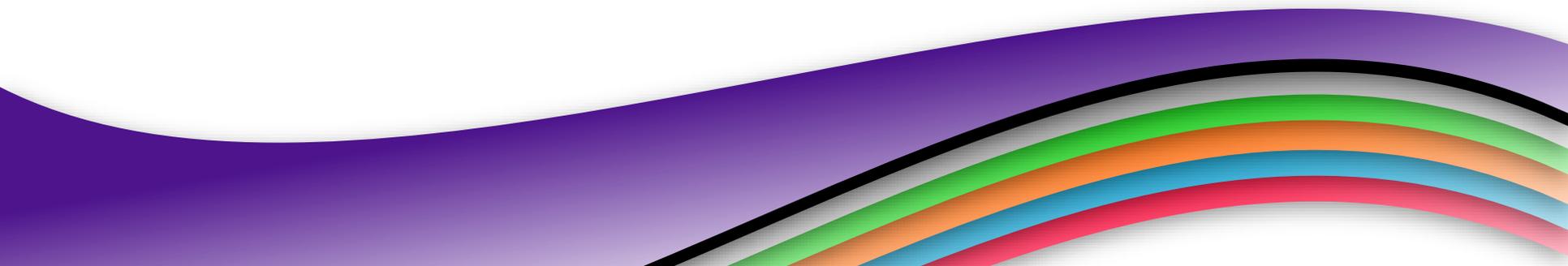
# Accomplishments

## Preliminary mechanical layout of batteries, fuel cell, converter H2 storage



# Accomplishments

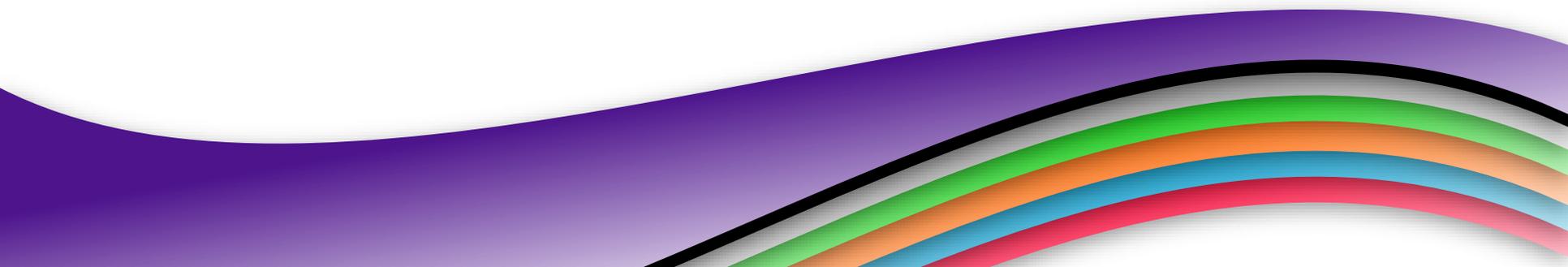
- Identified replacement EV OEM
  - New EV subrecipient has experience with range extension
- Technical kick-off meeting among program partners at manufacturing facility to discuss component requirements and placement
- Program kick-off meeting among program partners at Memphis Headquarters
- Analysis of 150 mile drive cycle with up to 60 mile stem length at beginning and end
- Planning in process for dyno testing
  - Variable payloads
  - Temperature effects
  - Parasitic loads



# Future Work

## Budget Period 1

- Safety Planning
- First Fuel Cell Unit Build
- First Unit Integration
- Verify Optimization Analysis
  - Dyno Testing
  - Durability Testing
- First Unit Validation



# Project Phase BP2

## Budget Period 2

- Fuel system design
- Safety planning

## Optimization modeling

- Battery capacity (kW-hr)
- Fuel Cell Power (kW)
- Hydrogen Tank capacity (kg H<sub>2</sub>)

## Safety Planning

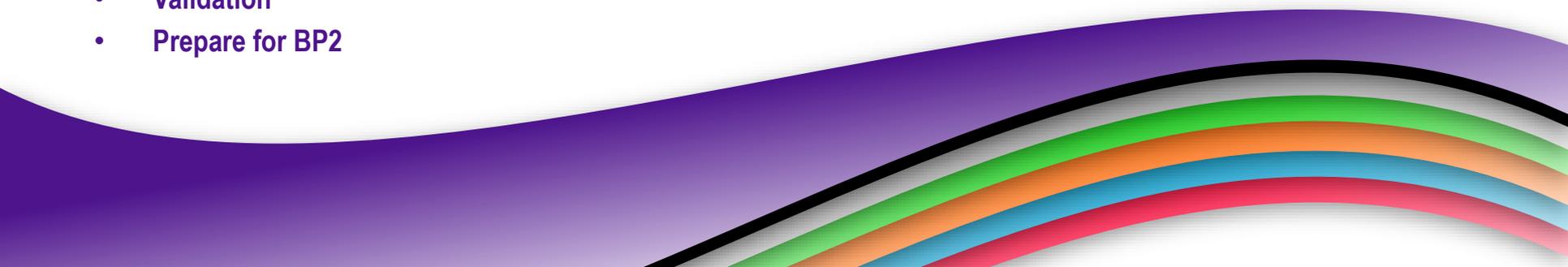
- Communications and Control Strategies
- Leak detection and fuel isolation or purging

## Integration of fuel cell into first truck

- Performance testing
- Shock and vibration testing

## Commissioning

- Place into revenue service
- Validation
- Prepare for BP2



# Collaborations

*U.S. Department  
of Energy  
Project Sponsor*



*Vehicle and Fuel Cell  
Data Collection*



*Vehicle Safety Regulations*



*Pacific Northwest  
NATIONAL LABORATORY*

*Hydrogen Safety Advisors*



*Subrecipients*



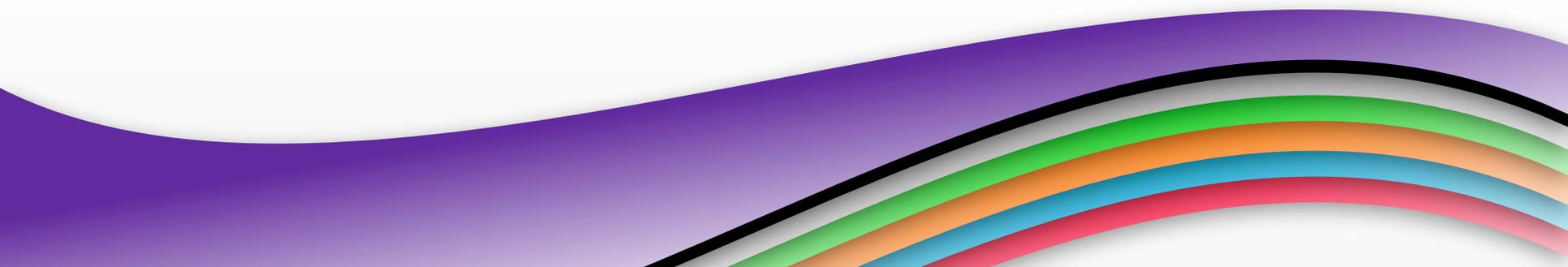
*Fuel Cell Manufacturer*



*EV chassis and Powertrain  
Manufacturer*



*Truck Body Manufacturer*



# Thank You

earthsmart  
FedEx Low Emission  
Hybrid Electric

earthsmart  
FedEx Zero Emission  
All Electric

earthsmart  
FedEx solutions for a  
more sustainable world

earthsmart  
FedEx Extended Range Electric

earthsmart  
FedEx Fuel Sense

