2022 Annual Merit Review
Cummins/Peterbilt SuperTruck II

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23 June 2022

Project ID:ACE102

Overview

Timeline

- Begin: 10/1/2016
- End: 9/30/2022
- 92% complete

Budget

- Total Project: $40M
- $20M DoE + $20M Partners
- Total Spent: $39M
  - $19.5 = Partners
  - $19.5 = DoE

Barriers

- Engine Efficiency ≥ 55% BTE
- Freight Efficiency ≥ 100% FTE
- Cost effective solutions

Partners

- Cummins – Powertrain
  - Eaton - Transmission
- Peterbilt - Vehicle
- Bridgestone – Tires
  - Walmart – Customer counsel

Relevance: Objectives

- Demonstrate a *minimum* of 55% BTE at a 65 mph cruise, on an engine dynamometer test stand
  - Same engine systems also demonstrated in vehicle, operating on real world drive cycles
- Achieve a *minimum* of 125% Freight Ton Efficiency (FTE).
  - FTE = MPG*Tons of Freight
- Track, promote and report on cost effective solutions
  - Prioritize solutions that have ~3-year payback period
  - Utilize customer counsel for understanding payback variables

Relevance: Energy Consumption

- Approximately 20% of U.S. transportation petroleum goes to the production of heavy truck fuel. Proposed improvements would save more than 400 million barrels of oil per year.*
  - Reduce imports and improve energy security
  - Reduce the cost of moving goods
- Heavy Truck GHG emissions account for a CO2 equivalent 420.7 MMT per year (35th edition of the Transportation Energy Data Book).
  - Improve air quality
  - Protect the public health and environment

* https://energy.gov/eere/vehicles/vehicle-technologies-office-moving-america-forward-energy-efficient-vehicles

Milestones by Quarter

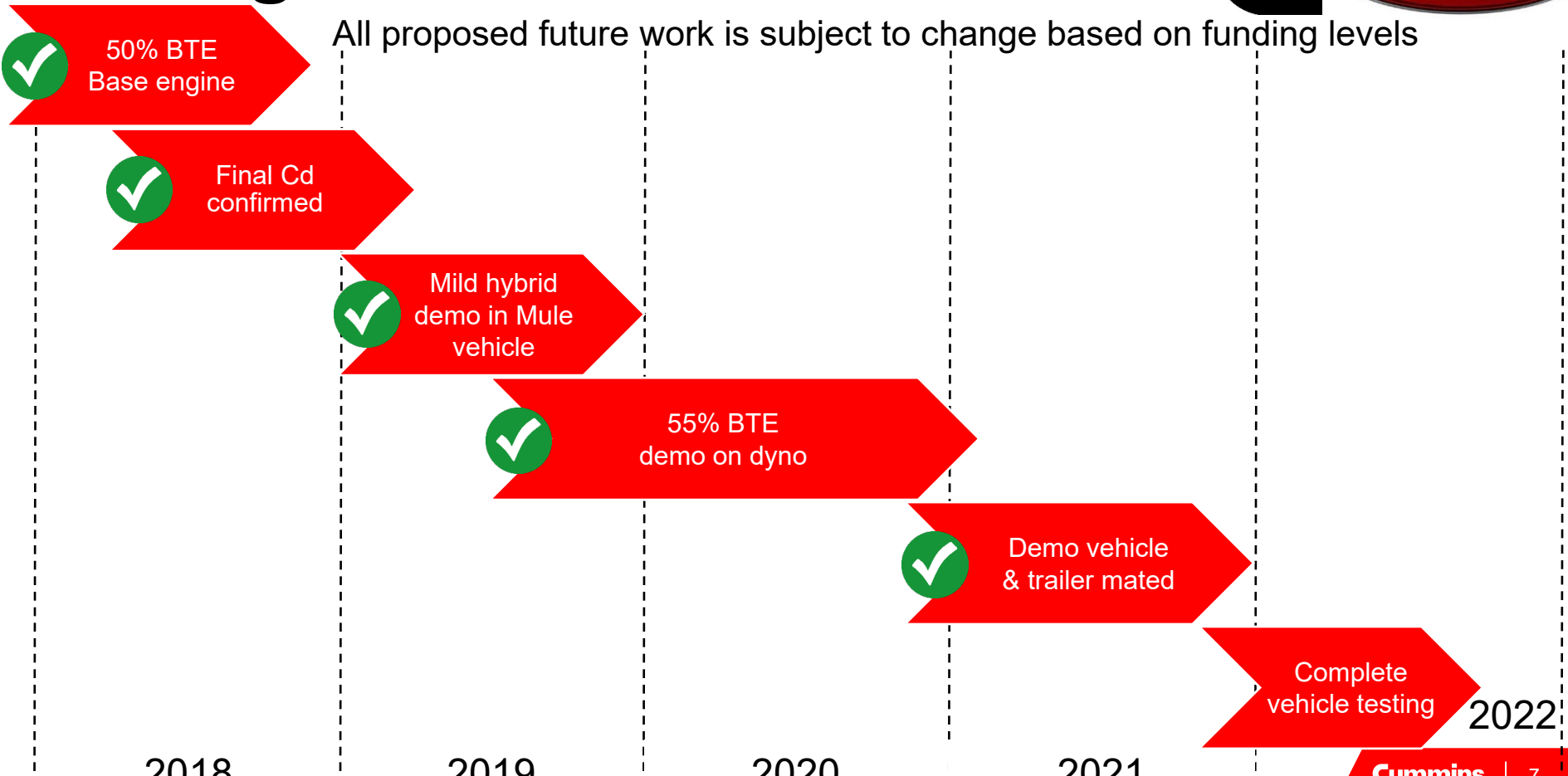
FY 2021	Description
Complete Freight Efficiency Demonstration Engine Build	Ready the engine for final calibration
Begin Freight Efficiency Demo Chassis Build	Begin assembly and population of the frame system
Complete Freight Efficiency Demo Engine Calibration	Prepare the engine, WHR system, and 48V mile hybrid system for the demonstration vehicle
Complete engine installation into FTE Demo chassis	Installation of the engine into the freight efficiency demonstration vehicle

Milestones by Quarter

FY 2022	Description
Complete Freight Efficiency Demo Truck Build 	Truck built and ready for calibration
Complete on road calibration 	Adjustments to powertrain and active aero for demo vehicle
Completion final freight efficiency demonstration	Demo route and performance tests
Complete final report	Full system final report

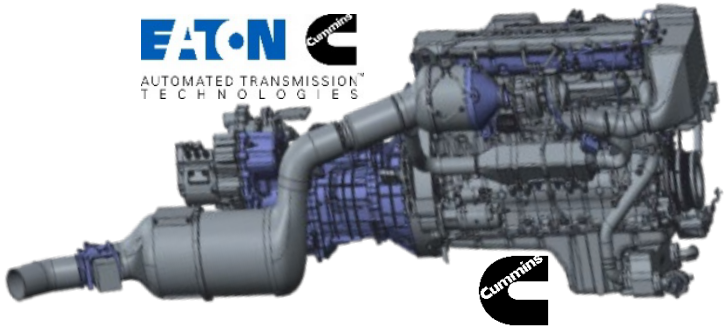
Program Level Milestones

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



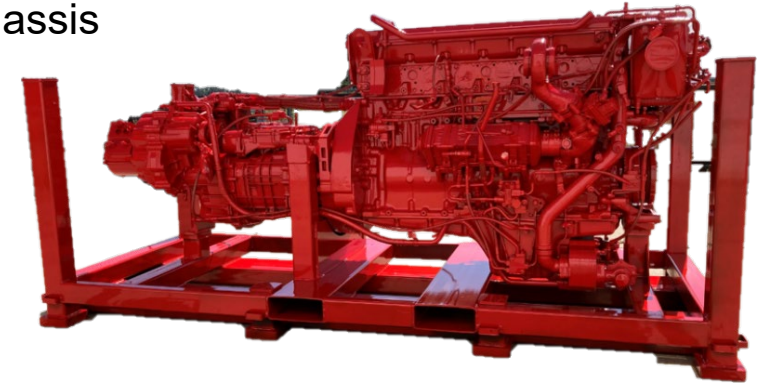
Technical Approach

- Reduce Work/Mile on test route
  - Vehicle aerodynamics & tire improvements
  - Reduce losses in engine and accessories
    - Enable engine-off-coasting (EOC) to reduce motoring losses
    - Electrify accessories for EOC
  - Enable 48V hybridization to minimize brake losses
- Enable high Engine + WHR efficiency
  - Maximize efficiency on test route
  - Advanced Cycle Efficiency Manager (ACEM) to favor high load engine operation
- Maximize freight capacity via weight reduced powertrain/truck/trailer



Accomplishment- Demo Powertrain

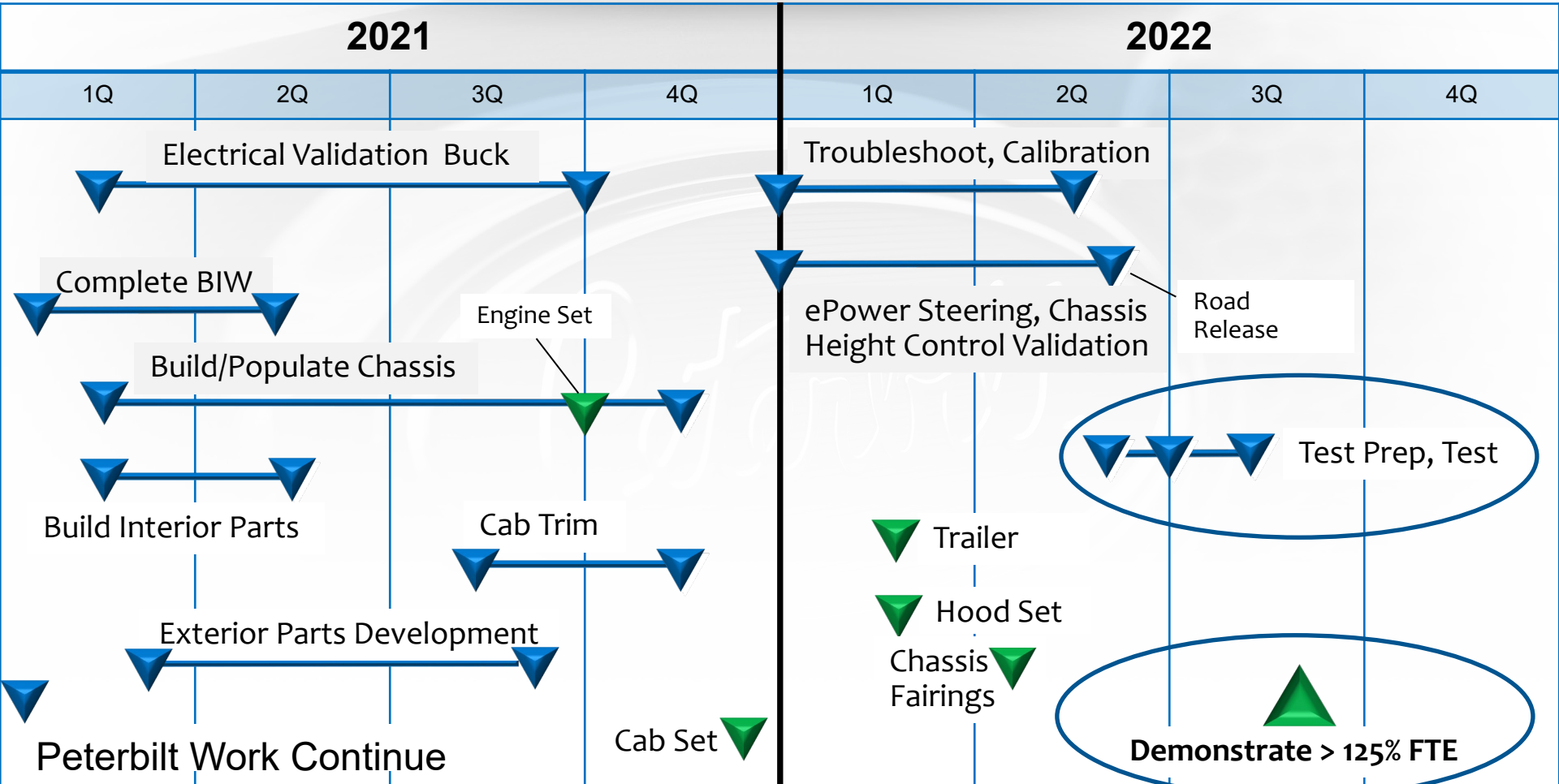
- Demo Powertrain delivered and installed in Demo chassis
- Successful Integration of the following sub-systems:
  - 48V mild hybrid with Electrification Thermal Management, M/G, Power Electronics, and DC/DC
  - Transmission integral WHR turbine expander and gearbox
  - Cooling module integration of WHR Condenser with 48V fans and topping radiator
  - Advanced Cycle Efficiency Manager
  - 6x4 Disconnect axle system
- Key activities for success:
  - Mule development
  - Electrical buck used for controls integration
  - Powertrain installation and startup prior to cab set
  - Final integration with cab and startup



David Mielke

Project Engineer

Program Schedule



Technical Approach: Path to Target

Engine

Aerodynamics

Transmission/Axle

Downspeeding

Lightweighting

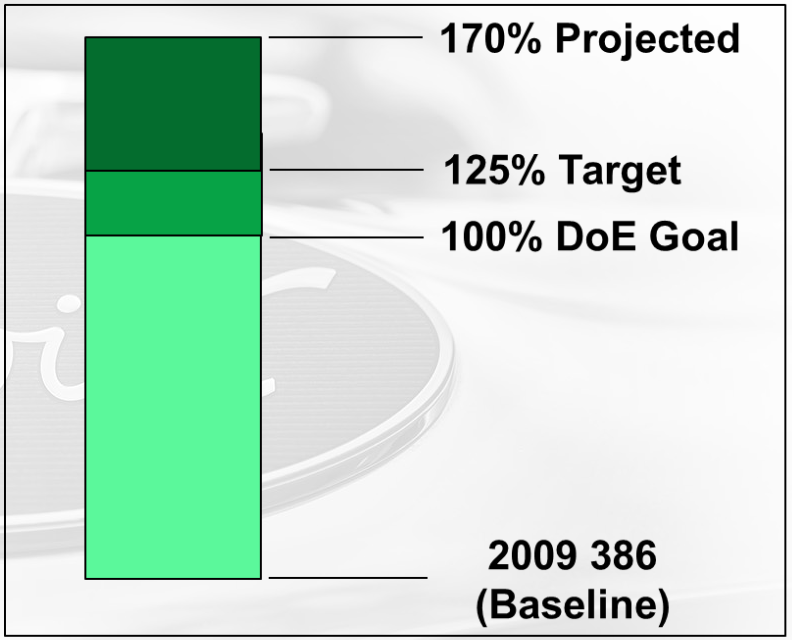
Route Management

Rolling Resistance

Mild Hybrid/Solar

Technical Approach: Path to Target

- 55% Engine Efficiency
  - Dyno Demonstration Complete ✓ !
- Goals vs. 2009 Baseline
  - Goal: 56% Aerodynamic Drag Reduction
  - 63% Achieved ✓ +
  - Goal: 3800lb Weight Reduction
  - 4700lb Achieved ✓ +
  - Goal: 30% Reduced Rolling Resistance
  - 33% Achieved ✓ +



Freight-Ton Improvement

Technical Approach: Applied Technologies

- Active Extenders
- Aerodynamic Body
- Forward-Looking Yaw Sensor
- 6x4/6x2 Disconnect Tandems
- Cameras/Displays
- MMC Brake Drums
- 48v ePower Steer
- Chassis Height Control
- Lightweight Chassis
- Low Crr Tires
- High Efficiency Engine/Transmission
- 24.5” Aluminum Wheels
- 48v eHVAC
- Advanced Cycle Efficiency Manager
- Mild Hybrid Driveline

Technical Progress: Chassis and Powertrain Systems

48v ePower Steer

- Reduced Engine Parasitics
- Control During Engine-Off Coast
  - Functional Prototype In Operation
  - Final Software Available End of May ’22

Chassis Fairings

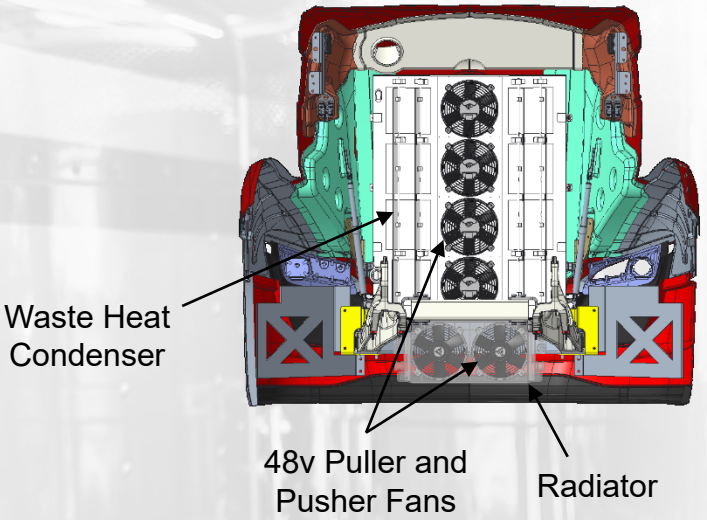
- Improved Aerodynamic Closeouts
- Lightweight Construction
  - Completed March ‘22
  - Final Installation Expected April ‘22

48v ePower Steer

Technical Accomplishments: Chassis Systems

Cooling Module and 48v Fans MAHLE

- Waste Heat Condenser
- Radiator and HVAC Condenser
  - Installed and Operational March ‘22



Technical Accomplishment: Lightweight/Aerodynamic Trailer

Trailer

- Solar Panels Integrated
- Light Weight Construction
  - 1500lb Weight Reduction
  - 500lb Overweight
- Aerodynamics
  - Modified Commercial Tail
  - Previous: Trailer Sail Plates
    - Maturity Not Yet Ready
- Delivered Feb ‘22

Trailer Solar Panels

Technical Progress: Active Aerodynamics

- Dynamic Sleeper Extender
  - Pneumatically Controlled Surface
  - Input from Roof-Mounted Yaw Sensor
  - High Yaw Drag Mitigation (Trailer Gap)
    - Installed and Validated March ‘22

Multi-Position Control Surface

Technical Accomplishments: Cab

- Cab Body in White MAGNA
  - Facilitates Aerodynamic Layout
  - Lightweight Design
    - Cab set Dec ‘21
- Vehicle Completed Technologies
  - Interior Trim POINT INNOVATION Product Development
  - Driver Seat
  - Wiper System Valeo
  - Roof and Outer Body Panels RMC A NANOXPLORE COMPANY
  - Windshield and Side Glass PILKINGTON
  - 48V HVAC Bergstrom Climate Control Systems

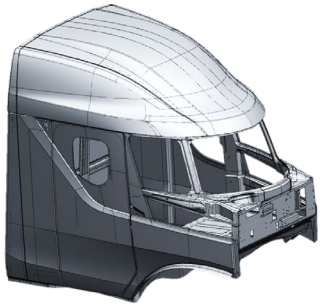
Camera System

Cab Interior

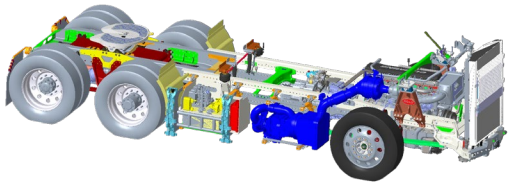
Peterbilt

2022 Vehicle Schedule Summary

3Q-4Q21

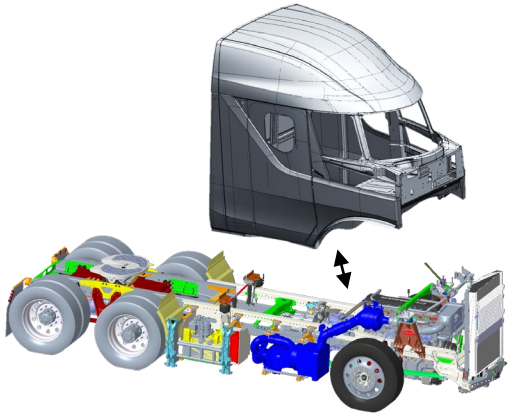


Cab Trim



Chassis Trim

4Q21-1Q22



Cab Set/Troubleshoot

1Q-2Q22

Complete Outer Body

Demonstration Testing

Collaboration: Walmart Application

Data Collection

- Road Grade
- Max Elevation
- Major vs. Local Roads
- Duty Cycle
  - Long & Short Term
  - % Time at Speed, Load
- Aftertreatment
  - Regeneration
  - Maximum Soot
  - DPF Out Temp/Parameters

NREL Data Collection and Analysis (2017)

Location	Trucks	OEM	Engine	Total Mileage
Loveland, CO	8	Peterbilt 579	Cummins ISX15	40,895
Sanger, TX	24	Peterbilt 579	Cummins ISX15	131,605
Grove City, CO	17	Brand X	Brand Y	101,238
	7	Brand X	Cummins ISX15	
Total	**56**			**273,738**

Program Summary

- Powertrain
  - Powertrain development in mule vehicle completed and system installed in Demo
  - Cummins has achieved the engine 55% BTE objective

- Vehicle
  - Aerodynamic System, Weight Reduction, Tire CRR Ahead of Target
  - Demonstration Tractor and Trailer Initial Build Completed
  - Final Troubleshooting and Calibration to be Completed in Q2 2022
  - Final Demonstration Testing will begin in July 2022

- Cummins and Peterbilt will exceed the 125% Freight Efficiency objective

Proposed Future Research

- Demonstrate >125% FTE improvement
  - Freight Efficiency Demonstrator is built
  - Complete on-road testing and confirm Freight Efficiency objective in Q3
- Testing planned beyond
  - Use local Texas Route developed by NREL from Walmart duty cycle data to demonstrate technology applicability
  - Test SuperTruck II Demo performance vs. current production baseline vehicle
- Complete Final Report
- The project will complete this fiscal year, with no follow-on funding/work expected

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

THANK YOU!

QUESTIONS