DoE SuperTruck Program
Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks

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This presentation does not contain any proprietary, confidential, or otherwise restricted information
Relevance - Program Objectives
(DoE Vehicle Technologies Goals)

Objective 1: Engine system demonstration of 50% or greater BTE in a test cell at an operating condition indicative of a vehicle traveling on a level road at 65 mph.

Objective 2
a: Tractor-trailer vehicle demonstration of 50% or greater freight efficiency improvement (freight-ton-miles per gallon) over a defined drive cycle utilizing the engine developed in Objective 1.

b: Tractor-trailer vehicle demonstration of 68% freight efficiency improvement (freight-ton-miles per gallon) over a defined 24 hour duty cycle (above drive cycle + extended idle) representative of real world, line haul applications.

Objective 3: Technology scoping and demonstration of a 55% BTE engine system. Engine tests, component technologies, and model/analysis will be developed to a sufficient level to validate 55% BTE.

Baseline Vehicle and Engine: 2009 Peterbilt 386 Tractor and Cummins 15L ISX Engine
Overview - Schedule and Budget

**Budget**
DoE Share $38.8M (48%)
Contractor Share $42.1M (52%)

4 Year Program: April 2010 to April 2014

- **Objective 1** - Engine Demo.
  50% or Greater BTE Engine Demonstration

- **Objective 2a** - Drive Cycle Vehicle Demo.
  Vehicle Demonstration of 50% or Greater Freight Efficiency Improvement

- **Objective 2b** - 24 hour Duty Cycle Vehicle Demon.
  Vehicle Demonstration of 68.5% or Greater Freight Efficiency Improvement

- **Objective 3** - 55% BTE Engine
  55% BTE Engine Demonstration

Program Close-Out
Relevance - American Recovery and Reinvestment Act (ARRA) Goals

- Create and/or Retain Jobs
  
<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Time Equivalent</td>
<td>75.5</td>
<td>107.5</td>
<td>131.0</td>
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</table>

- Spur Economic Activity:
  - Greater than $13M Total Spend to Date

- Invest in Long-Term Economic Growth
  - Commercial Viability Assessment
  - Demonstrate Technologies with Acceptable Payback Period
  - Adopt Technologies into Product Plans to Meet GHG and CO₂ Regulations for 2017 and beyond

States: Indiana, Texas, Michigan, Wisconsin, Tennessee, Illinois, California
Comprehensive Approach

- **Cummins**
  - Engine Losses
    - Urban: 58-60%
    - Interstate: 58-59%

- **Modine**
  - Aerodynamic Losses
    - Urban: 4-10%
    - Interstate: 15-22%

- **Peterbilt & Utility**
  - Inertia / Braking
    - Urban: 15-20%
    - Interstate: 0-2%

- **Delphi (APU)**
  - Auxiliary Loads
    - Urban: 7-8%
    - Interstate: 1-4%

- **Eaton & Dana**
  - Drivetrain
    - Urban: 5-6%
    - Interstate: 2-4%

- **Bridgestone**
  - Rolling Resistance
    - Urban: 8-12%
    - Interstate: 13-16%

Analysis of 27 Drive Cycles of Class 8 Vehicles
Variety of Seasons (Summer, Winter, etc)
Overview - Program Barriers

- Underhood Cooling with Waste Heat Recovery
- Vehicle and Engine System Weight Reduction
- Engine Downspeed (Reduced Engine Speed)
  - Powertrain Components
  - Vibration/Customer Acceptance
- Trailer Aerodynamic Devices that Meet Operational Requirements
- Vehicle and Powertrain Communication Speed
Comprehensive Approach with Enabling Technology

- Idle Management (APU)
- Enhanced Tractor and Trailer Aerodynamics
- Transmission/Axle Technology
- Weight Reduction
- Highly Efficient Engine/Aftertreatment
- Route Performance Management
- Next Generation LRR Tires
- Driver Display with Fuel Economy Tools
## Approach – Freight Efficiency Path to Target

<table>
<thead>
<tr>
<th>Technology</th>
<th>Drive Cycle Vehicle Demonstration</th>
<th>24 Hour Duty Cycle Vehicle Demonstration</th>
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<tbody>
<tr>
<td>Vehicle Aerodynamics</td>
<td>14%</td>
<td>24%</td>
</tr>
<tr>
<td>Engine</td>
<td>25.5%</td>
<td>27%</td>
</tr>
<tr>
<td>Transmission/Axles</td>
<td>3.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Rolling Resistance</td>
<td>3.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Route Performance Management</td>
<td>2.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Idle Management</td>
<td>N/A</td>
<td>10%</td>
</tr>
<tr>
<td>Vehicle Weight</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52%</strong></td>
<td><strong>73.5%</strong></td>
</tr>
<tr>
<td><strong>Target</strong></td>
<td><strong>50%</strong></td>
<td><strong>68.5%</strong></td>
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Peterbilt Participants

- Contract Lead - Cummins
- Suppliers
  - Modine – Cooling Module
  - Eaton – Transmissions
  - Dana – Drivetrain
  - Bridgestone – Fuel Efficient Tires
  - Alcoa - Wheels
  - Delphi – Solid Oxide Fuel Cell APU
  - Bergstrom – eSHVAC
  - Garmin – 3D Map and Display
  - Exa – CFD Analysis
- OEM
  - Utility Trailer Manufacturing
- End User
  - US Xpress
End User Participation – Collaboration/Partnerships

- **US Xpress** – will provide:
  - Feedback on the 24 hour duty cycle used for fuel efficiency testing
  - Comments on the practicality of the trailer configuration and aero devices
  - Comments on the business aspects of the technology being investigated
  - Driver feedback on the appearance, performance and drivability of the new technology in the development trucks
Aerodynamic Improvements – Technical Progress

Baseline w/Ideal Trailer
Baseline w/Real Trailer
Baseline
Truck #1 28% Target
Truck #2 48% Target
Truck #1 w/Rev. C Aero = 36%
Truck #2 w/Rev C Aero = .350
Truck #2 w/Trlr Rear Opt 7 = 43%

* Cd's Shown Are Adjusted to SAE J1252 Baseline Using % Average Deltas From 0 and 6 Degree CFD Runs
Truck/Trailer Weight – Technical Progress

Baseline

Pounds

-2500 -2000 -1500 -1000 -500 0 500 1000 1500 2000

Aero Devices Idle Systems Truck Savings Trailer Savings Net Weight Difference
Vehicle and Powertrain Communication Architecture – Technical Progress

- Establish Requirements For Future Vehicle Communication Architecture

- New Level Of Vehicle And Powertrain Optimization For Fuel Efficiency (Algorithms Completed And Simulation Completed: Hardware-in-the-loop Testing On-going)
Trailer Development – Technical Progress

- Trailer Build In Process
- Devices Support Industry
  - Swing Doors, Not Roll-Up
  - Not Obstruct Trailer Opening
- End Customer Input

Six-in.-wide panels smooth air flow without blocking rear roll-up door.

Run 7 – IsoSurface CpT
Milestones and Technical Accomplishments

- March 2010 to March 2011 – **Technical Accomplishments**
  - Simulation of Path to Target for Engine and Vehicle Efficiencies
  - Baseline Vehicle Testing
  - CFD Analysis of Vehicle Demo. #1 Aero
  - Design of Advanced Transmission
  - Performance Assessment of SOFC APU
  - Integration of Cummins Waste Heat Recovery System

- March 2011 to March 2012 – **Future Work**
  - Design Freeze for Vehicle Demonstration #1 (Objective 2a)
  - Truck #1 and Trailer Build
  - Testing of Tractor – Trailer Aerodynamics Solution
  - Vehicle Testing of Advanced Transmission
  - Complete Design of Second Generation of SOFC APU
**Summary**

- Program Remains On Schedule With 100% Milestone Completion
- Meeting The Goals For American Recovery And Reinvestment Act (ARRA)
- Completed Baseline Vehicle Testing
- Completed CFD Analysis Of Tractor-trailer Aerodynamic Design For Vehicle #1 (Objective 2a)
- Engine Efficiency And Vehicle Freight Efficiency Roadmaps Updated With Evidence To Meet Or Exceed Targets
- Vehicle Packaging And Integration Proceeding Without Any Major Issues
- Completed Design Of Advanced Transmission – Part Procurement On-going
Technical Back-Up Slides
Baseline Testing – Technical Progress

- Baseline Testing Complete
- Strong Simulation Tool Correlation
  - Within 4.6% of Actual
  - Weather Variables
  - Additional Testing to Increase Confidence
Vehicle and Engine Cooling System Design
Underhood Air Flow and Temperature Analysis

Successful Packaging of the Engine + Waste Heat Recovery
In the Aerodynamic Vehicle Design

Velocity Profile
Pressure Differential