Cummins SuperTruck Program
Technology Demonstration of Highly Efficient Clean, Diesel Powered Class 8 Trucks

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Program Objectives

Objective 1:

Demonstrate 20% engine efficiency improvements in test cell

Objective 2

a: Demonstrate a 50% drive cycle freight efficiency improvement

b: Demonstrate >50% freight efficiency improvement on 24hr cycle

Objective 3:

Scope & demonstrate improvements for 30% engine efficiency gain

Baseline: Peterbilt 386 truck & conventional van trailer with 2009 Cummins ISX
Program Participants - Collaborations

- Cummins Inc.
  - Cummins Fuel Systems
  - Cummins Turbo Technologies
  - Cummins Emissions Solutions
  - Cummins Electronics
  - Cummins Filtration
  - Modine
  - VanDyne SuperTurbo Inc.
  - Oak Ridge National Lab.
  - Purdue University

- Peterbilt Motors Company
  - Eaton
  - Delphi
  - Modine
  - Utility Trailer Manufacturing
  - Bridgestone
  - U.S. Xpress
  - Dana
  - Bergstrom

Program Lead
SuperTruck Demonstration Plan

4 Year Program: April 2010 to April 2014

Drive Cycle
Freight Efficiency Demo

Dec 2011
50% BTE Demonstration

Dec 2012

Dec 2013

50% BTE Demosntration

Dec 2014

Apr 2014
55% BTE Scoping & Demonstration

Drive & 24hr Cycle
Freight Efficiency Demo
Innovation You Can Depend On

Approach to Technology Improvements

Cummins ← Modine → Peterbilt & Utility

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

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

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

- **Auxiliary Loads**
  - Urban: 7-8%
  - Interstate: 1-4%

- **Drivetrain**
  - Urban: 5-6%
  - Interstate: 2-4%

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

- **Bridgestone**

Note: Analysis of 27 Drive Cycles for Class 8 Vehicles with a Variety of Seasons (Summer, Winter, etc.)
Vision Roadmap to Target Freight Efficiency

Freight Efficiency Improvement

- **Demo #1**: Baseline 10, Engine 25.5, Route Performance Management 3.5, Transmission/axle 3, Idle Management 3, Vehicle Weight 3
- **Demo #2**: Baseline 10, Engine 3, Route Performance Management 3.5, Transmission/axle 2.5, Idle Management 3, Vehicle Weight 3

- **Drive Cycle**: Baseline 0, Engine 14, Route Performance Management 1.5, Transmission/axle 3.5, Idle Management 3.5, Vehicle Weight 3
- **24hr duty cycle**: Baseline 10, Engine 3, Route Performance Management 3.5, Transmission/axle 2.5, Idle Management 3, Vehicle Weight 3
Approach – Engine Technology Roadmap

- Base Engine: PCP, Friction/Parasitics
- Fuel System
- Advanced Combustion
- Controls
- Materials
- EGR Loop
- Variable Valve Actuation
- Turbo Technology
- Aftertreatment
- Waste Heat Recovery
Roadmap to 50% Engine Efficiency

Cummins Advanced Engine + High Efficiency AT + WHR*

Program Baseline 42%

Status

Program Requirement 50% BTE

Gas Flow
- Lower \( \Delta P \) EGR loop
- Volumetric \( \eta \) Gains
- Aftertreatment

WHR
- Cooling System Design
- Turbine Expander

Parasitics
- Friction
- Pump Power

Powertrain Optimization
- Turbocompound

Engine Brake Thermal Efficiency (%)

42 43 44 45 46 47 48 49 50

*WHR - Cummins Organic Rankine Cycle Waste Heat Recovery
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
Comprehensive Tractor/Trailer Enabling Technologies

- Idle APU Management
- Transmission & Axle Technology
- Highly Efficient Engine/Aftertreatment
- Enhanced Tractor and Trailer Aerodynamics
- Weight Reduction
- Route Performance Management
- Driver Display with Fuel Economy Tools
- Next Generation Tires
Baseline Freight Efficiency Testing

- Drive cycle route
  - 311 mile roundtrip
  - 8 controlled starts/stops
  - 550ft elevation change
- Baseline drive cycle freight efficiency test complete
Vehicle Aerodynamic Results

- Demo #1: 18% Drag Reduction vs 14% Target
- Demo #2: 21.5% Analytical Potential Drag Reduction vs 24% Target

*Cd's Shown Are Adjusted to SAE J1252 Baseline Using % Average Deltas From 0 and 6 Degree CFD Runs
Vehicle Weight Reduction  
– Freight Efficiency Improvement

>3% Freight Efficiency Improvement With Vehicle Weight Reduction

Freight Efficiency Gains/Losses (%)
Solid Oxide Fuel Cell APU

- Next generation fuel cell APU unit builds are in progress
  - Proceeding with calibration & test activities
  - Conducting vehicle electrical integration analysis
    - Drive cycle & 24hr cycle
  - Key next step: Efficiency model validation
Summary

• Program remains on schedule
• Program roadmaps meet or exceed targets
• Current engine BTE status is 48%.
  – Implementing technology for 50% BTE target
• Completed integration of a Waste Heat Recovery capable truck cooling module with system design & analysis
• Designed drive cycle route
• Completed baseline vehicle testing
• CFD results exceeding truck/trailer aerodynamic goals for Demo #1 (Objective 2a)
• Fuel cell APU in testing phase
• Vehicle system integration proceeding without any major issues