# DoE SuperTruck Program

## *Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks*

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Peterbilt Motors Company

Project ID: ARRAVT081

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# ***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

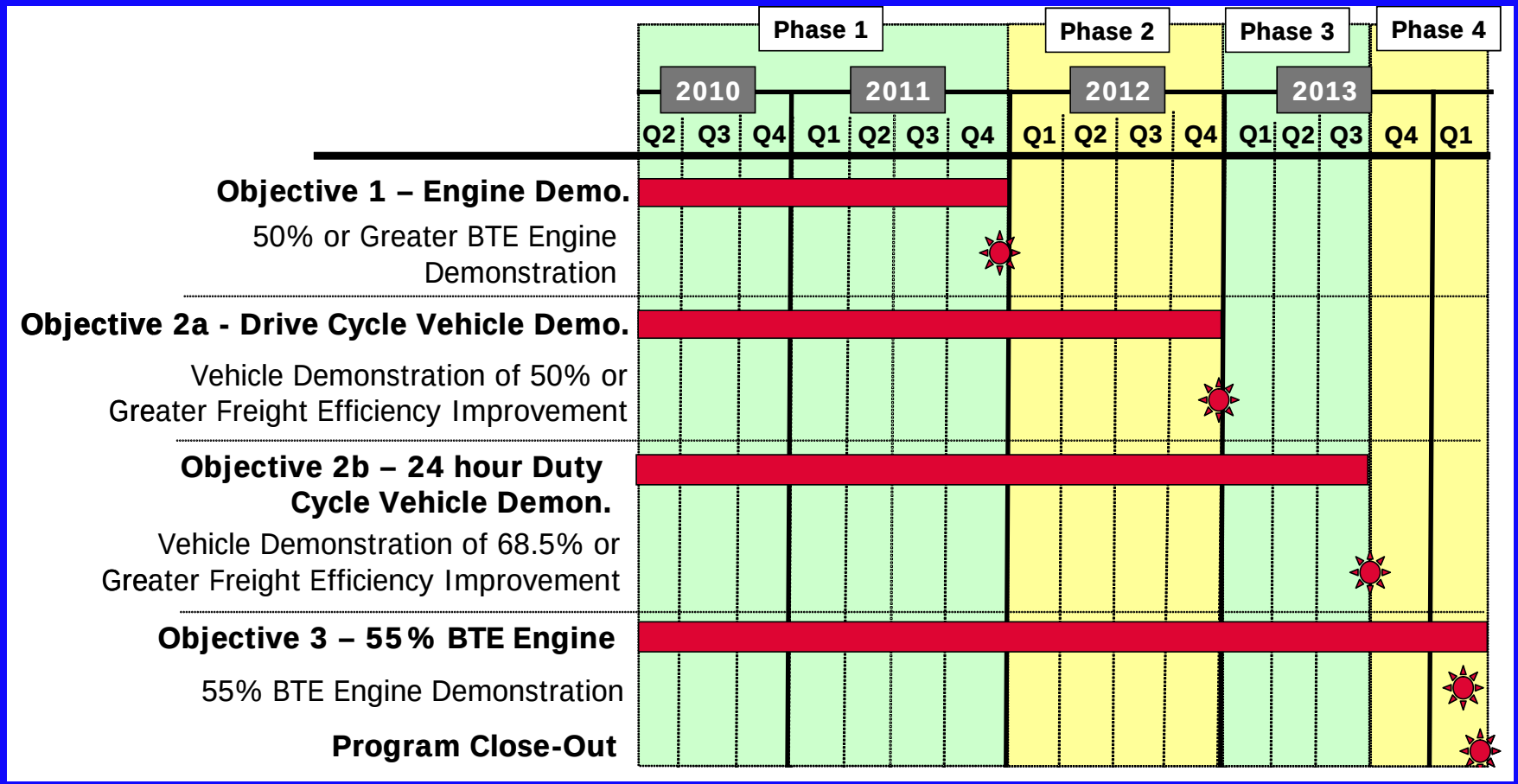
# Overview - Schedule and Budget

## Budget

DoE Share $38.8M (48%)

Contractor Share $42.1M (52%)

**4 Year Program: April 2010 to April 2014**



# Relevance - American Recovery and Reinvestment Act (ARRA) Goals

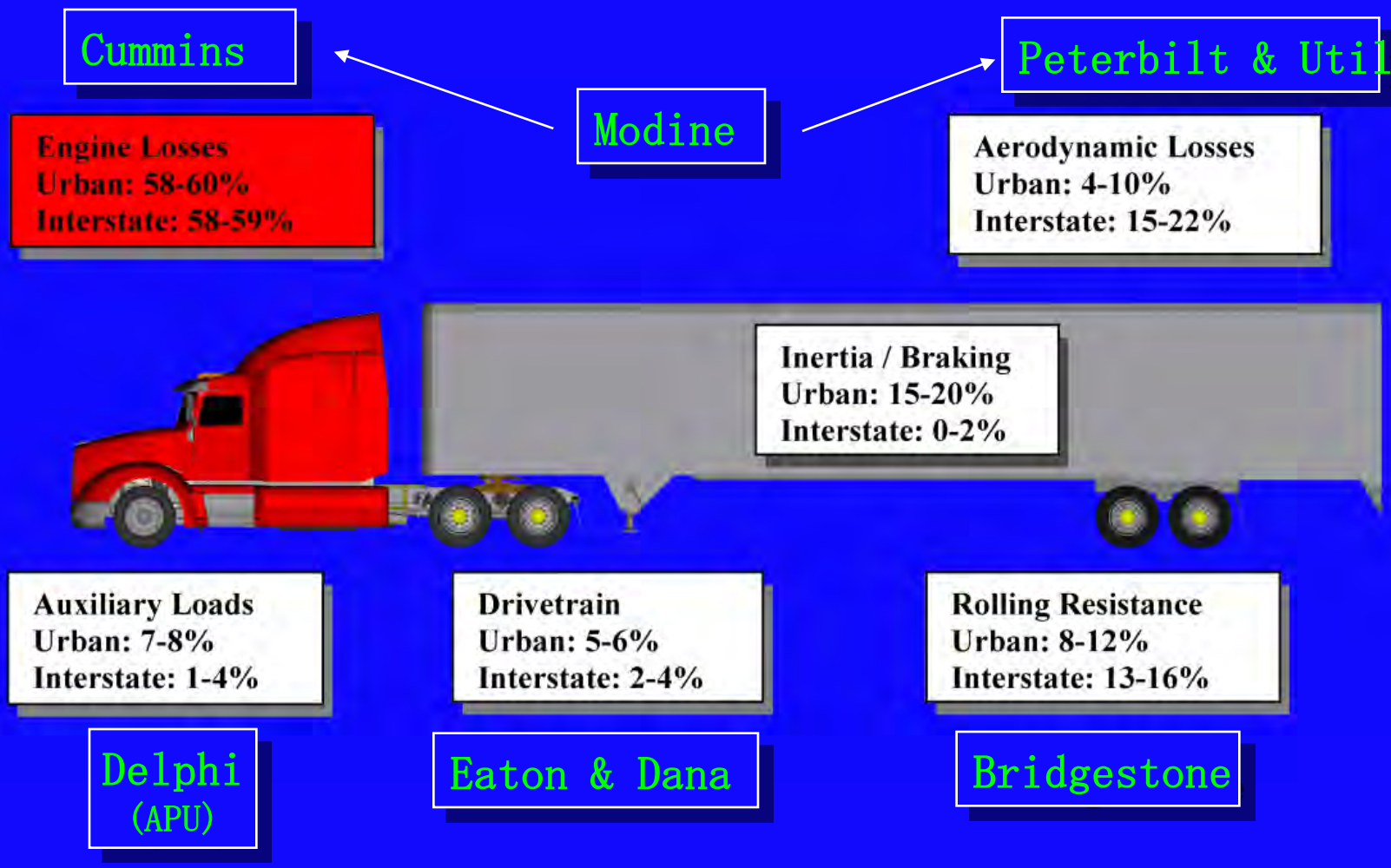
- Create and/or Retain Jobs

| | | Projections | |
|---|---|---|---|
| **Year** | **2010** | **2011** | **2012** |
| Full Time Equivalent | 75.5 | 107.5 | 131.0 |

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

- 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 $CO_2$ Regulations for 2017 and beyond

# Comprehensive Approach




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

| Technology | Drive Cycle Vehicle Demonstration<br>Freight Efficiency Improvement (%) | 24 Hour Duty Cycle Vehicle Demonstration<br>Freight Efficiency Improvement (%) |
|---|---|---|
| Vehicle Aerodynamics | 14% | 24% |
| Engine | 25.5% | 27% |
| Transmission/ Axles | 3.5% | 3.5% |
| Rolling Resistance | 3.5% | 3.5% |
| Route Performance Management | 2.5% | 2.5% |
| Idle Management | N/A | 10% |
| Vehicle Weight | 3% | 3% |
| **Total** | **52%** | **73.5%** |
| **Target** | **50%** | **68.5%** |

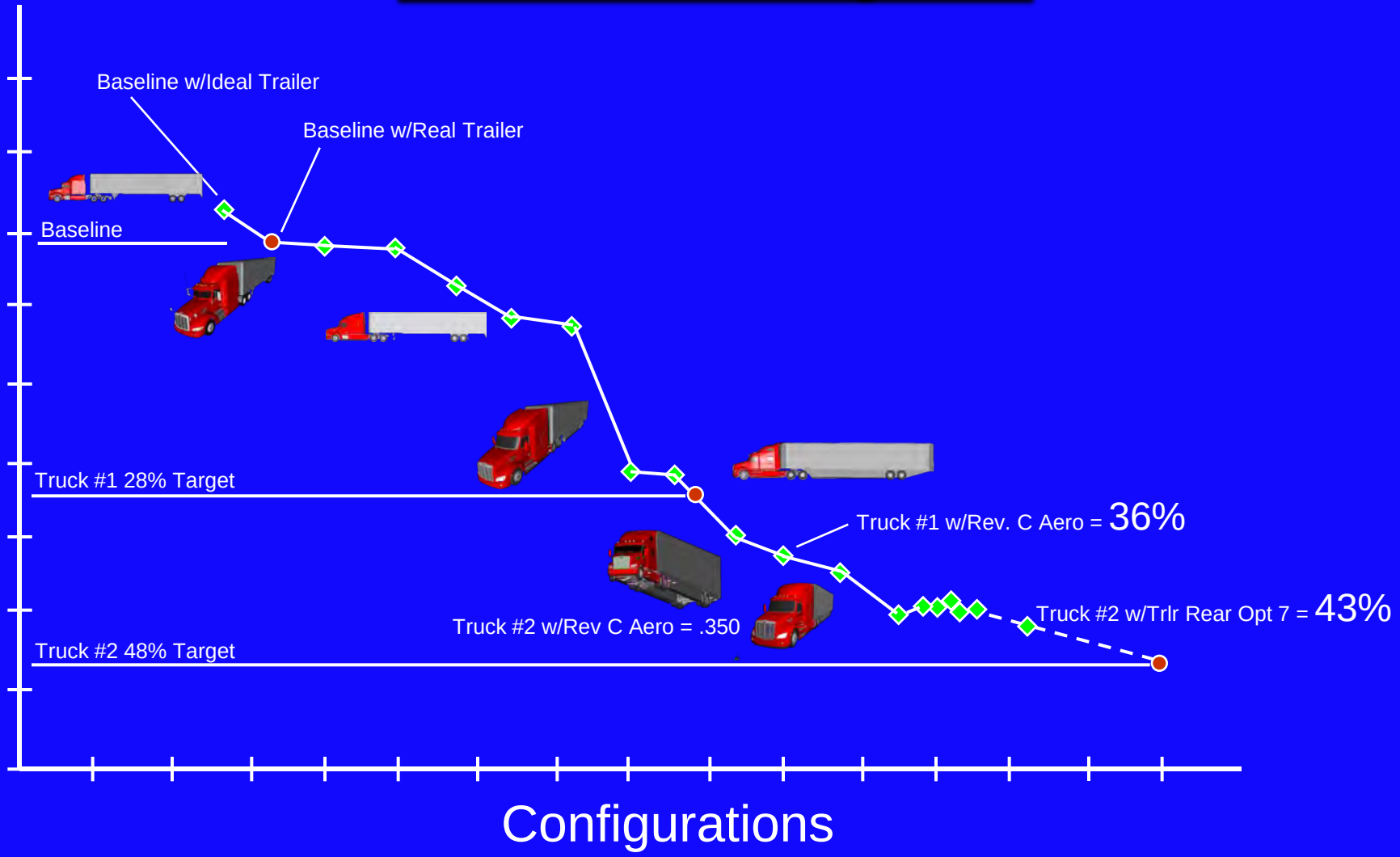
# Peterbilt Participants

- 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*

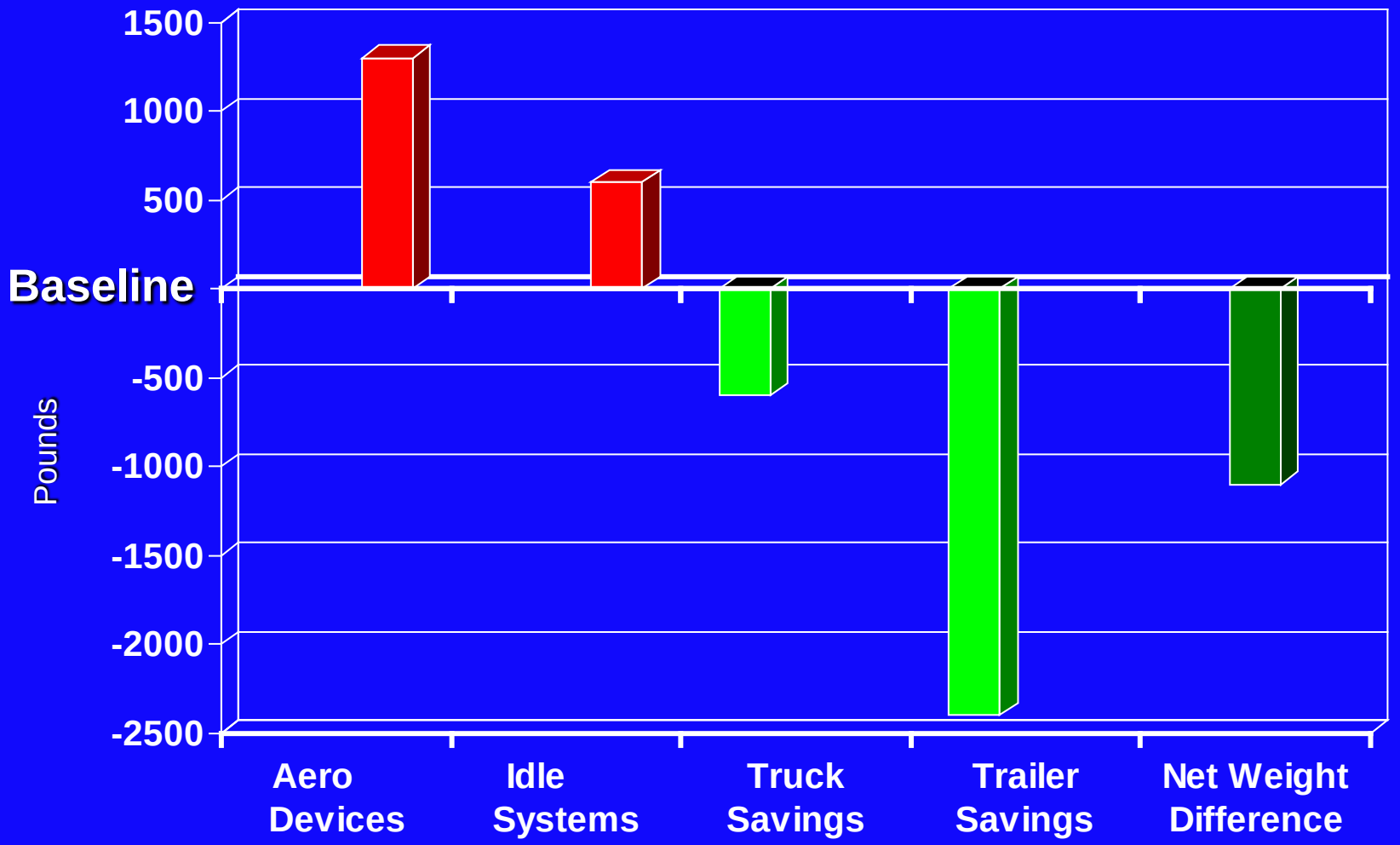
- US Xpress – will provide:
  - Feedback on the 24 hour duty cycle used for fuel efficiency testing
  - Comments on the practicality of the trailer configuration and aero devices
  - Comments on the business aspects of the technology being investigated
  - Driver feedback on the appearance, performance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

# Aerodynamic Improvements – Technical Progress

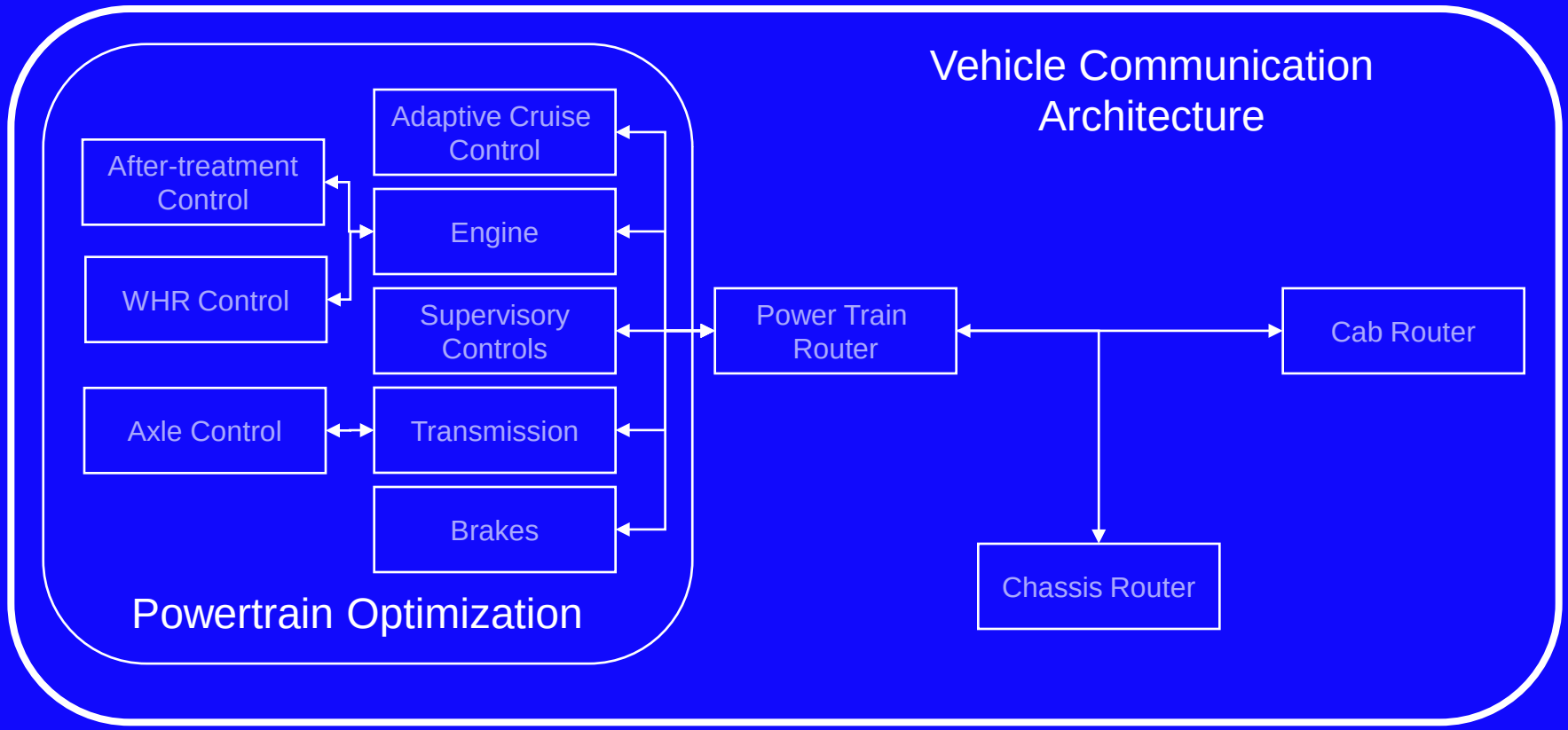



* Cd's Shown Are Adjusted to SAE J1252 Baseline Using
% Average Deltas From 0 and 6 Degree CFD Runs

# Truck/Trailer Weight – Technical Progress



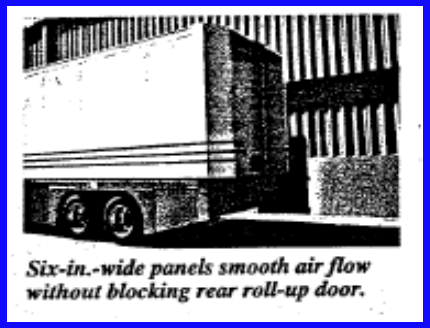
# Vehicle and Powertrain Communication Architecture – Technical Progress

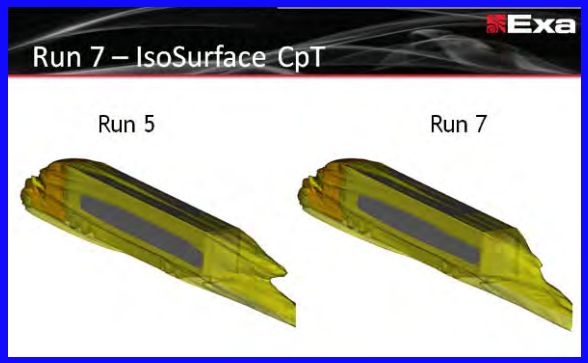



- Establish Requirements For Future Vehicle Communication Architecture
- New Level Of Vehicle And Powertrain Optimization For Fuel Efficiency (Algorithms Completed And Simulation Completed: Hardware-in-the-loop Testing On-going)

# 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.*



# *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

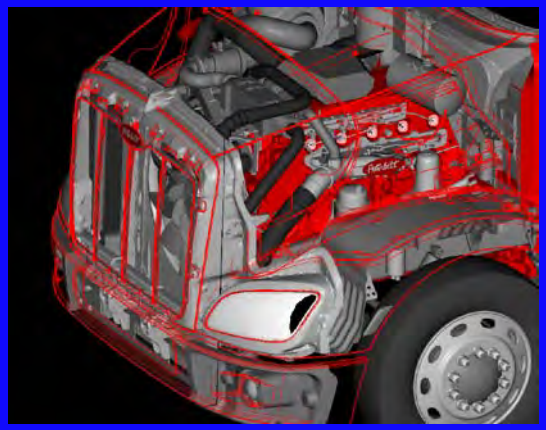
# *Technical Back-Up Slides*

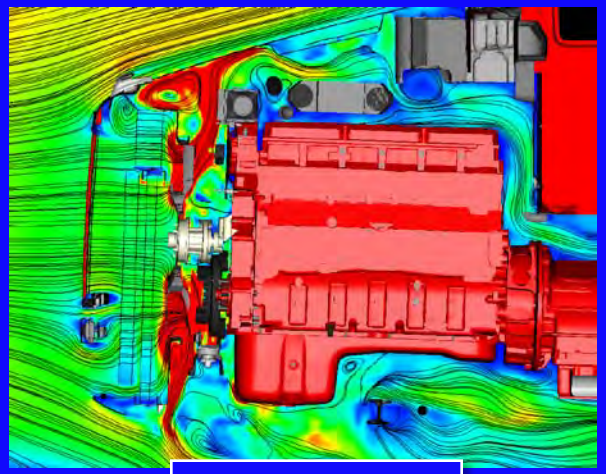
# Baseline Testing – Technical Progress

- Baseline Testing Complete
- Strong Simulation Tool Correlation
  - Within 4.6% of Actual
  - Weather Variables
  - Additional Testing to Increase Confidence

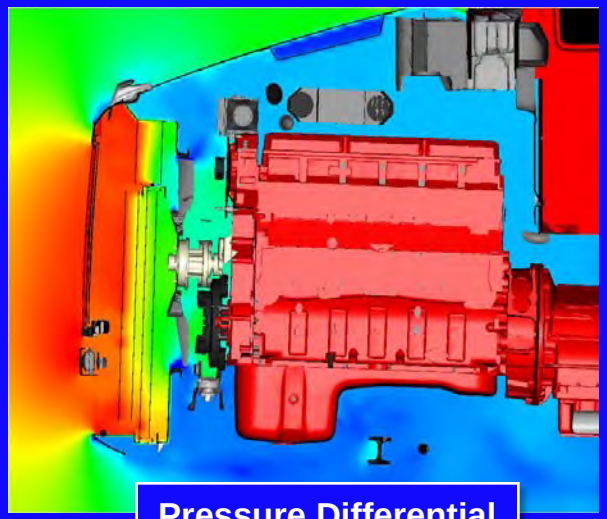
# *Vehicle and Engine Cooling System Design*
# *Underhood Air Flow and Temperature Analysis*

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





**Velocity Profile**



**Pressure Differential**