
# Cummins SuperTruck Program

## Technology Demonstration of Highly Efficient Clean, Diesel Powered Class 8 Trucks

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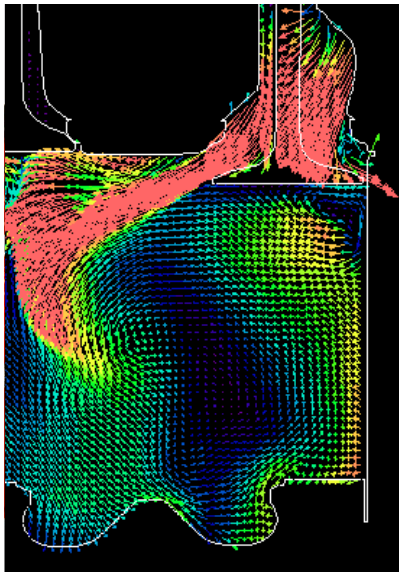
Principal Investigator
3 October 2011




# 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

Program Lead

**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

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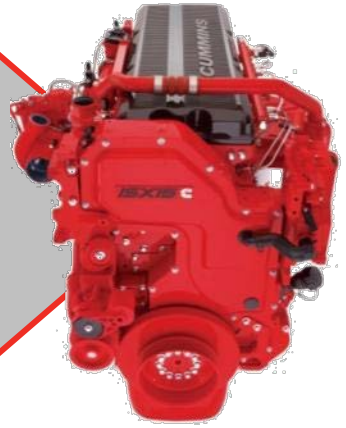
# SuperTruck Demonstration Plan

4 Year Program:
April 2010 to April 2014

Dec2012

Drive Cycle
Freight Efficiency Demo

50% BTE
Demonstration



Dec2011

Dec2013

Drive & 24hr Cycle
Freight Efficiency Demo

Apr2014

55% BTE
Scoping &
Demonstration

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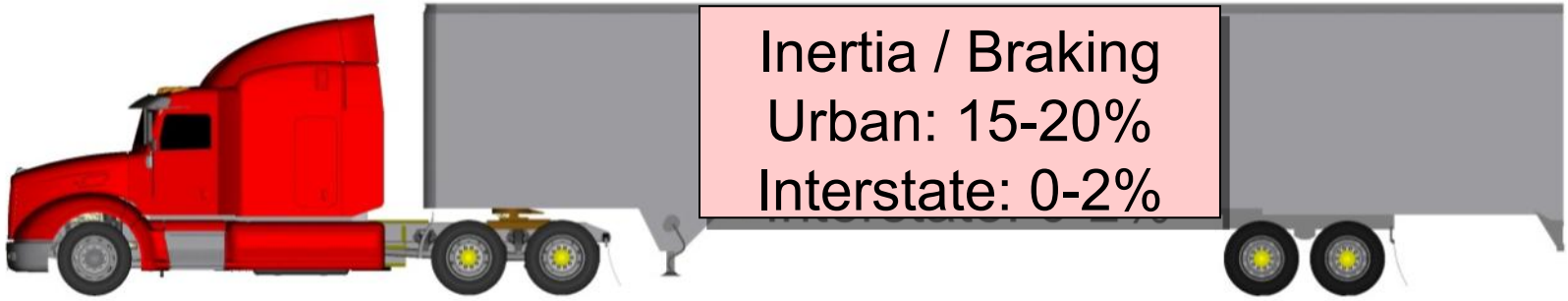
# Approach to Technology Improvements

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%

Delphi

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

Eaton & Dana

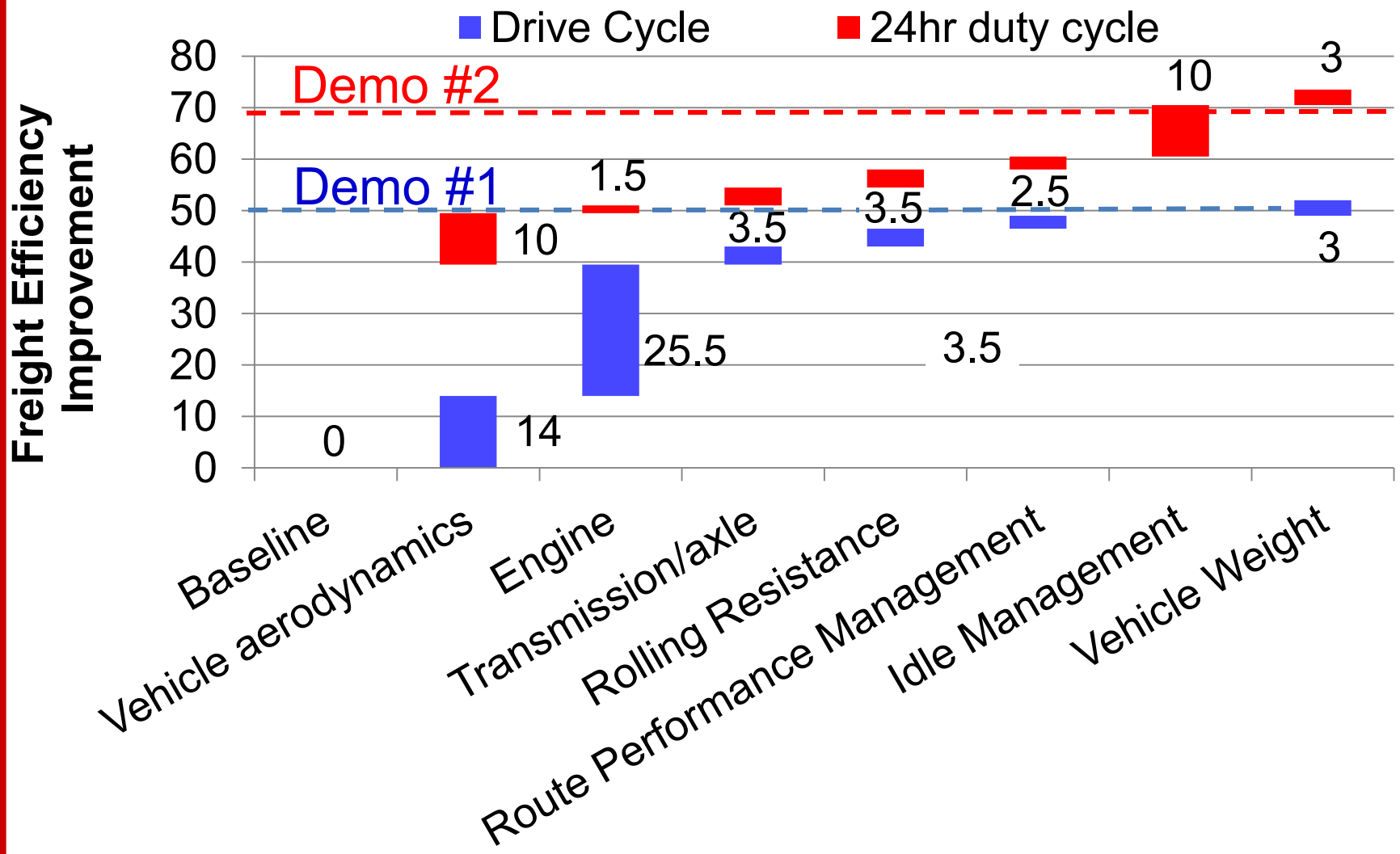
Rolling Resistance
Urban: 8-12%
Interstate: 13-16%

Bridgestone

Weight Reduction

Note: Analysis of 27 Drive Cycles for Class 8 Vehicles with a Variety of Seasons (Summer, Winter, etc.)

# Vision Roadmap to Target Freight Efficiency



# Approach – Engine Technology Roadmap

Base Engine
-PCP
- Friction/Parasitics

Fuel System

Advanced Combustion

Variable Valve Actuation

Controls

EGR Loop

Materials

Turbo Technology

Aftertreatment

Waste Heat Recovery

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# Roadmap to 50% Engine Efficiency

Program Baseline 42%


Status

Program Requirement 50% BTE

Cummins Advanced Engine + High Efficiency AT + WHR*

42 43 44 45 46 47 48 49 50

**Engine Brake Thermal Efficiency (%)**

- Gas Flow
  - Lower ΔP EGR loop
  - Volumetric η Gains
  - Aftertreatment
- WHR
  - Cooling System Design
  - Turbine Expander
- Parasitics
  - Friction
  - Pump Power
- Powertrain Optimization
- Turbocompound

*WHR - Cummins Organic Rankine Cycle Waste Heat Recovery

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

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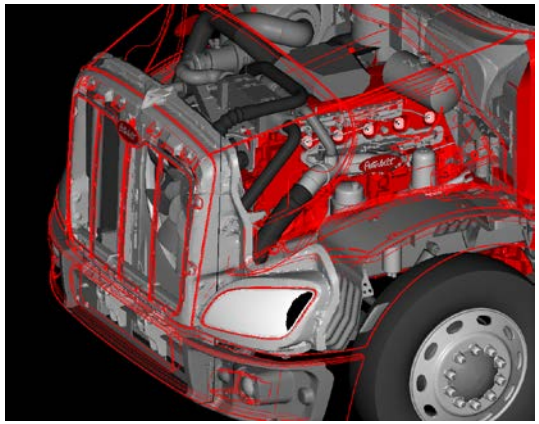
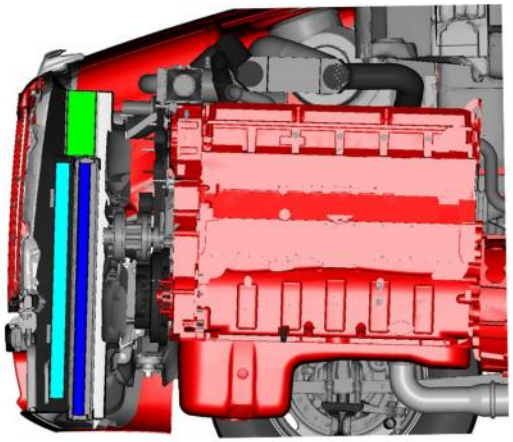
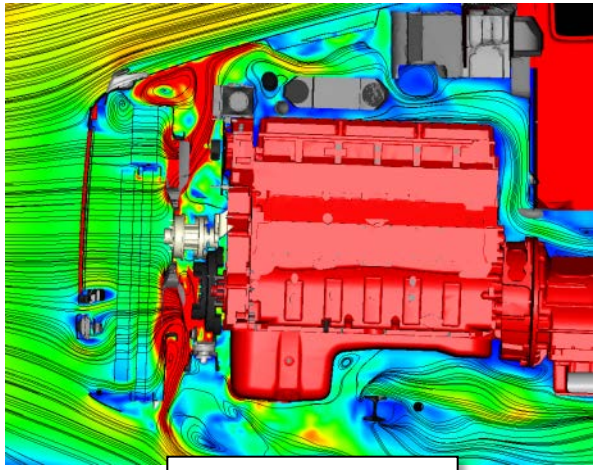
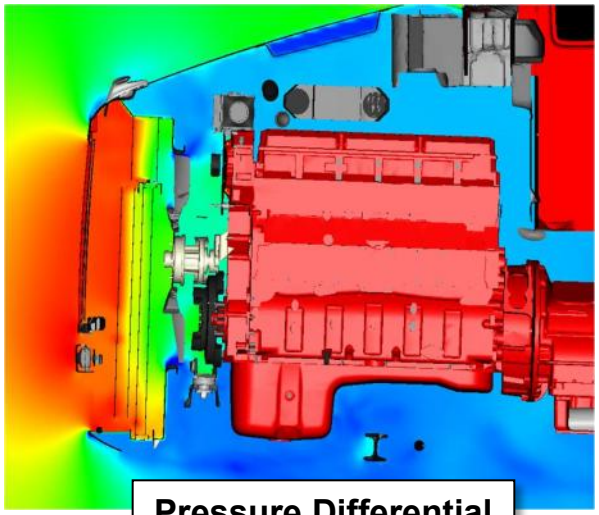
## Successful Packaging of the Engine + Waste Heat Recovery In the Aerodynamic Vehicle Design





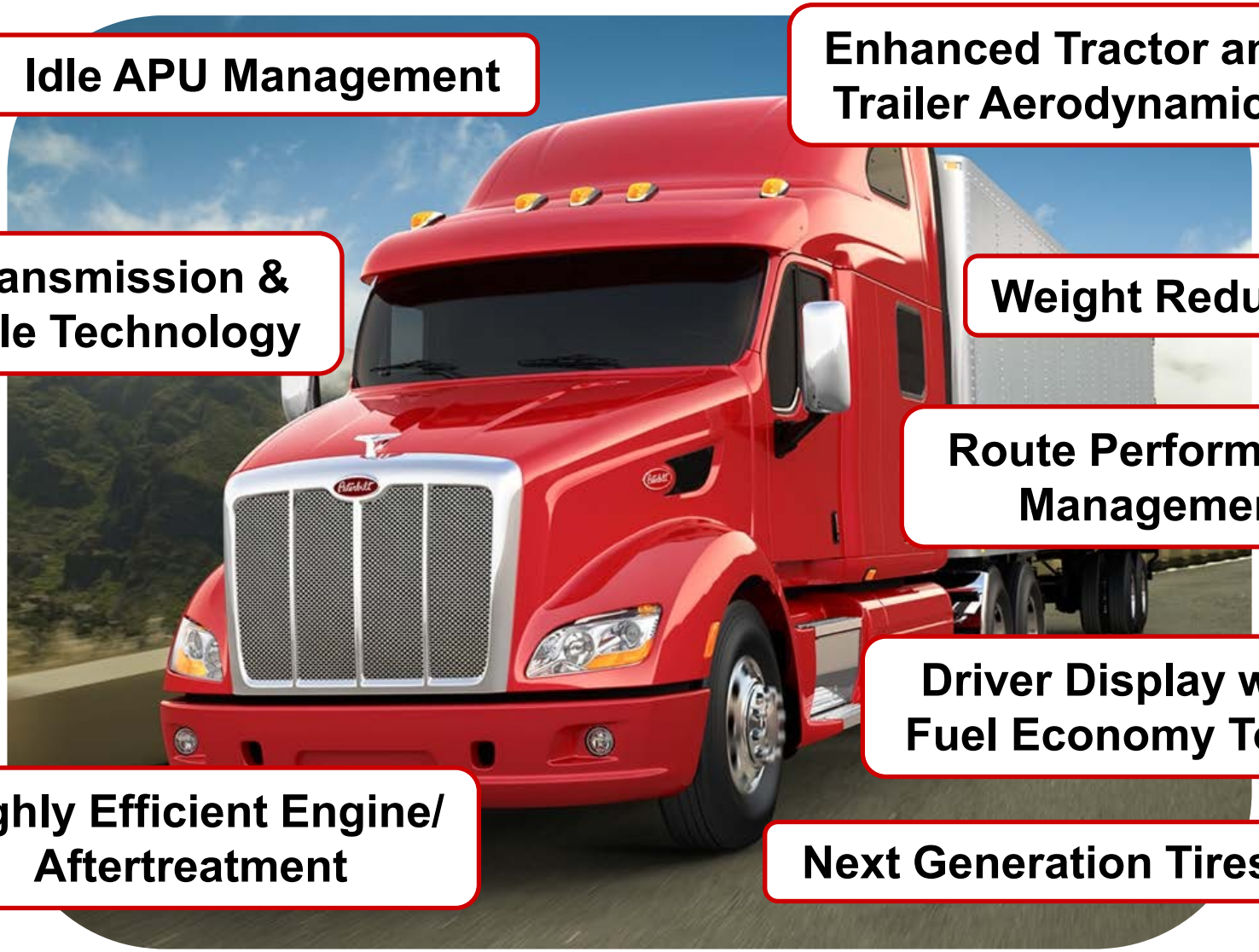


Velocity Profile



Pressure Differential

# Comprehensive Tractor/Trailer Enabling Technologies



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

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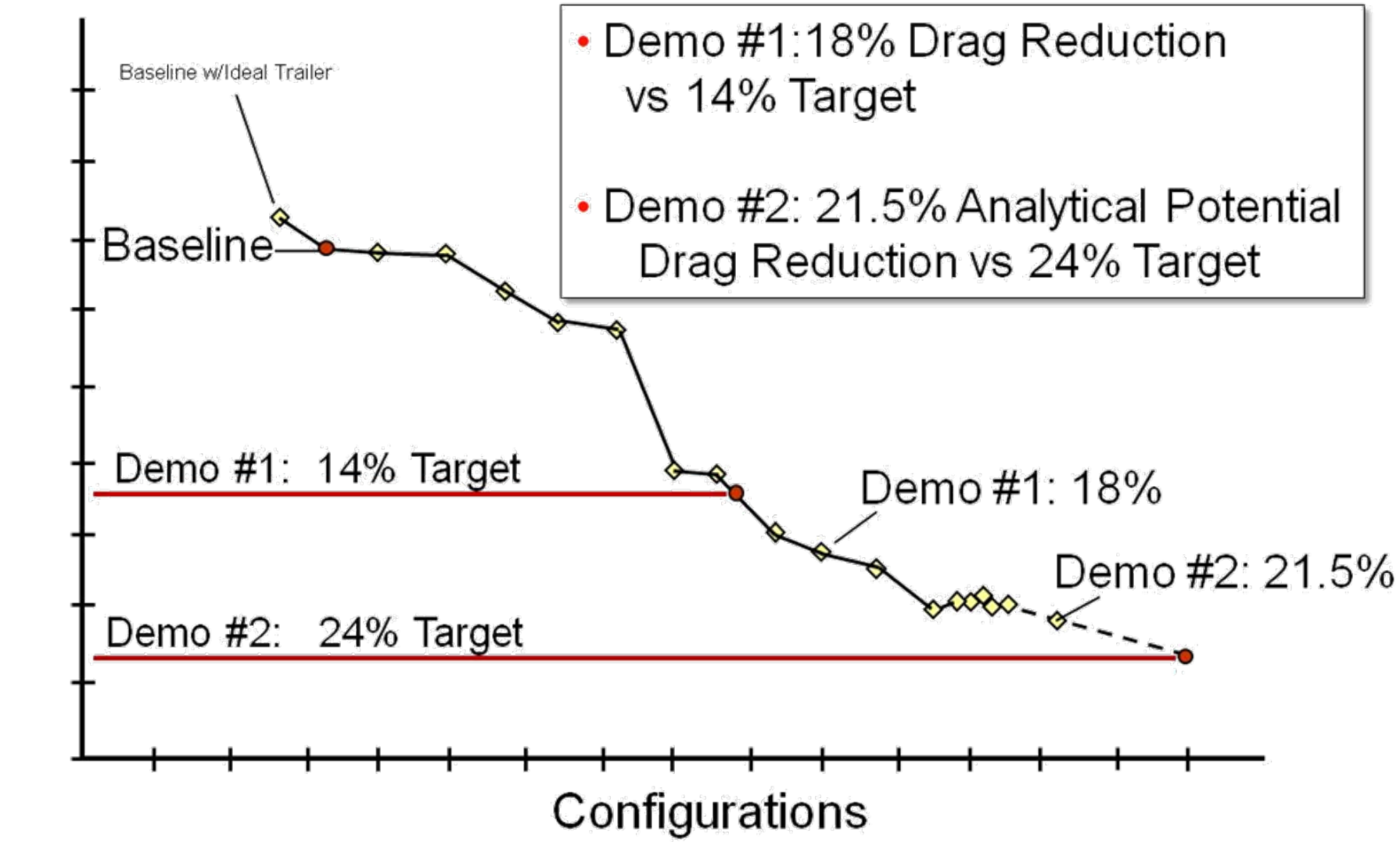
# Baseline Freight Efficiency Testing

- 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

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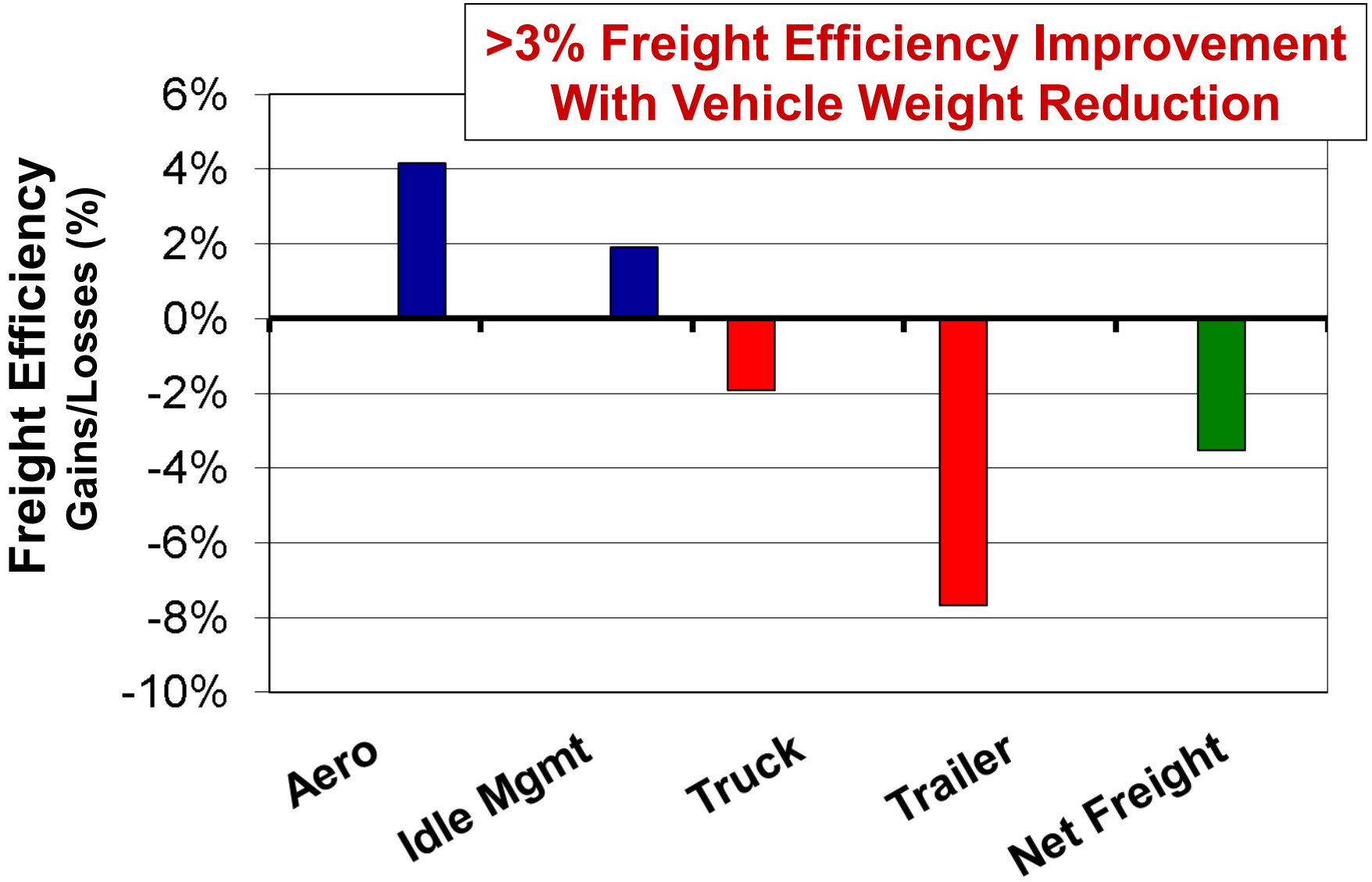
# Vehicle Weight Reduction – Freight Efficiency Improvement

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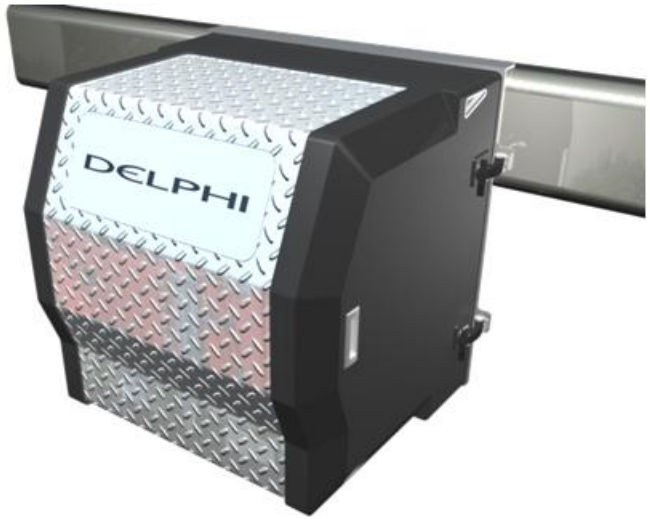
# Solid Oxide Fuel Cell APU

- 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

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# 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