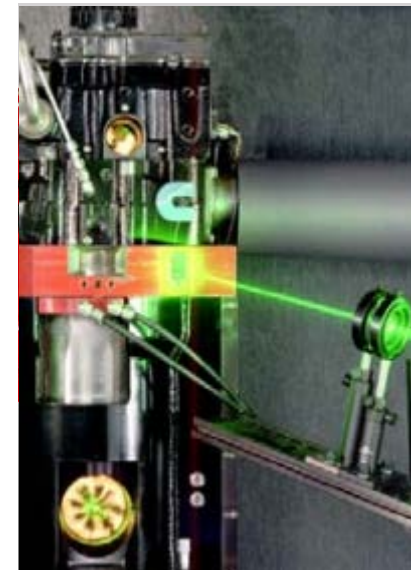
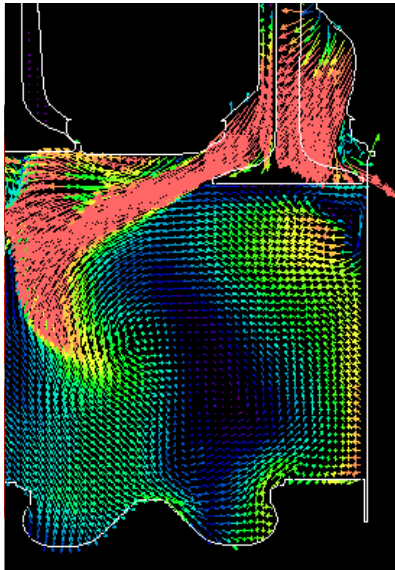


# Supertruck technologies for 55% thermal efficiency and 68% freight efficiency

David Koeberlein  
Principal Investigator  
16 October 2012





# Program Objectives



## Objective 1:

Demonstrate 50% thermal efficiency improvements in test cell

## Objective 2

a: Demonstrate a 50% drive cycle freight efficiency improvement

b: Demonstrate 68% freight efficiency improvement on 24hr cycle

## Objective 3:

Scope & demonstrate improvements for a 55% engine efficiency

Baseline: Peterbilt 386 truck & conventional van trailer with 2009 Cummins ISX



# Program Partners



Program Lead



## Cummins Inc.

- Cummins Fuel Systems
- Cummins Electronics
- Cummins Turbo Technologies
- Cummins Emissions Solutions
- 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
- Logena
- Bendix
- Garmin
- Goodyear



# SuperTruck Demonstration Plan



4 Year Program:  
April 2010 to April 2014



Dec2012

50% Drive Cycle  
Freight Efficiency  
Demonstration

50% BTE  
Demonstration



Dec2013

68% 24hr Cycle  
Freight Efficiency  
Demonstration

Dec2011



Apr2014

55% BTE  
Scoping &  
Demonstration





# Approach to Technology Improvements



Cummins ← Modine → Peterbilt & Utility

Engine Losses  
 Urban: 58-60%  
 Interstate: 58-59% **1**

Aerodynamic Losses  
 Urban: 4-10%  
 Interstate: 15-22% **2**



Inertia / Braking  
 Urban: 15-20%  
 Interstate: 0-2% **6**



Auxiliary Loads  
 Urban: 7-8%  
 Interstate: 1-4% **5**

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

Rolling Resistance  
 Urban: 8-12%  
 Interstate: 13-16% **3**

Delphi

Eaton & Dana

Bridgestone

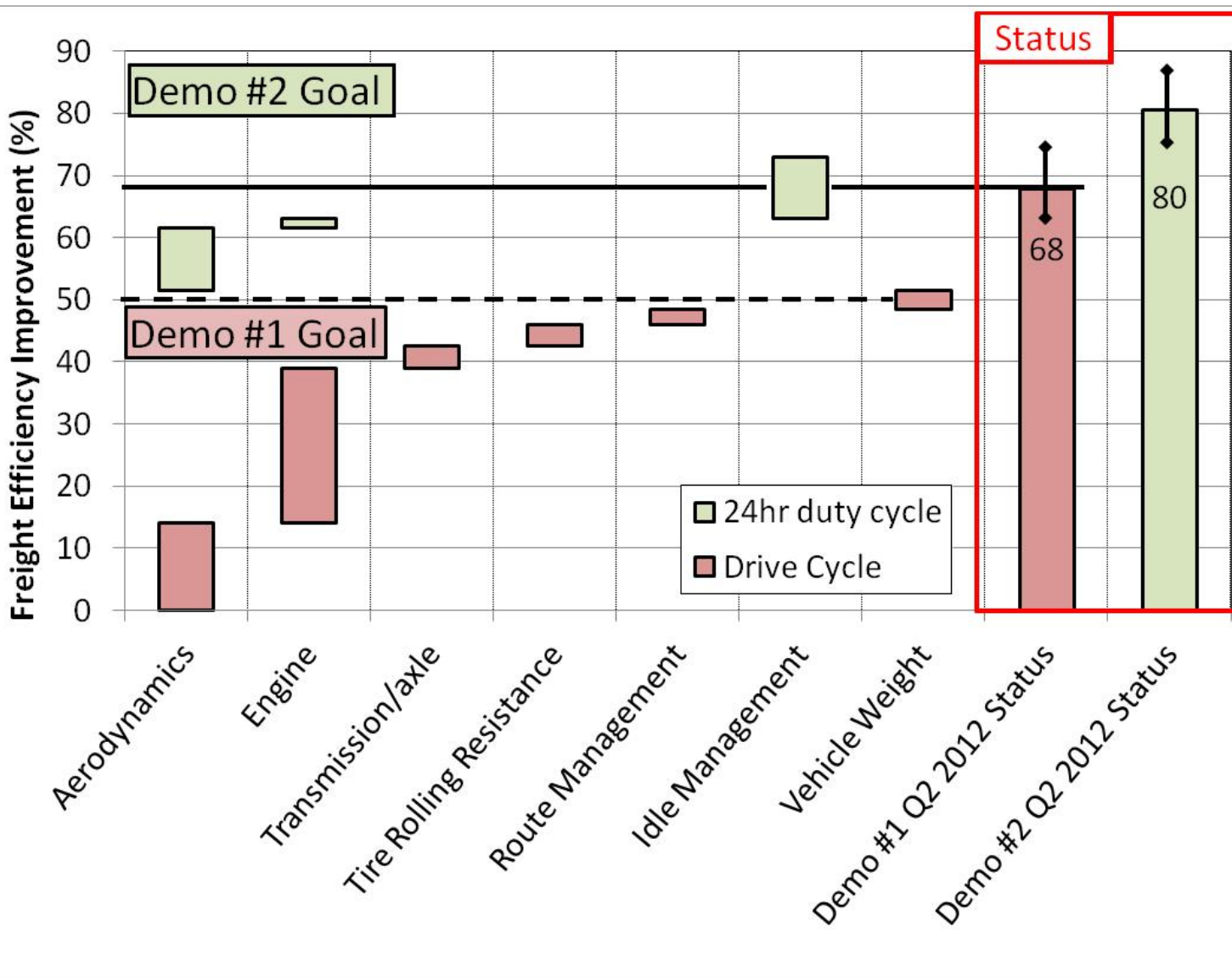
Weight Reduction

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

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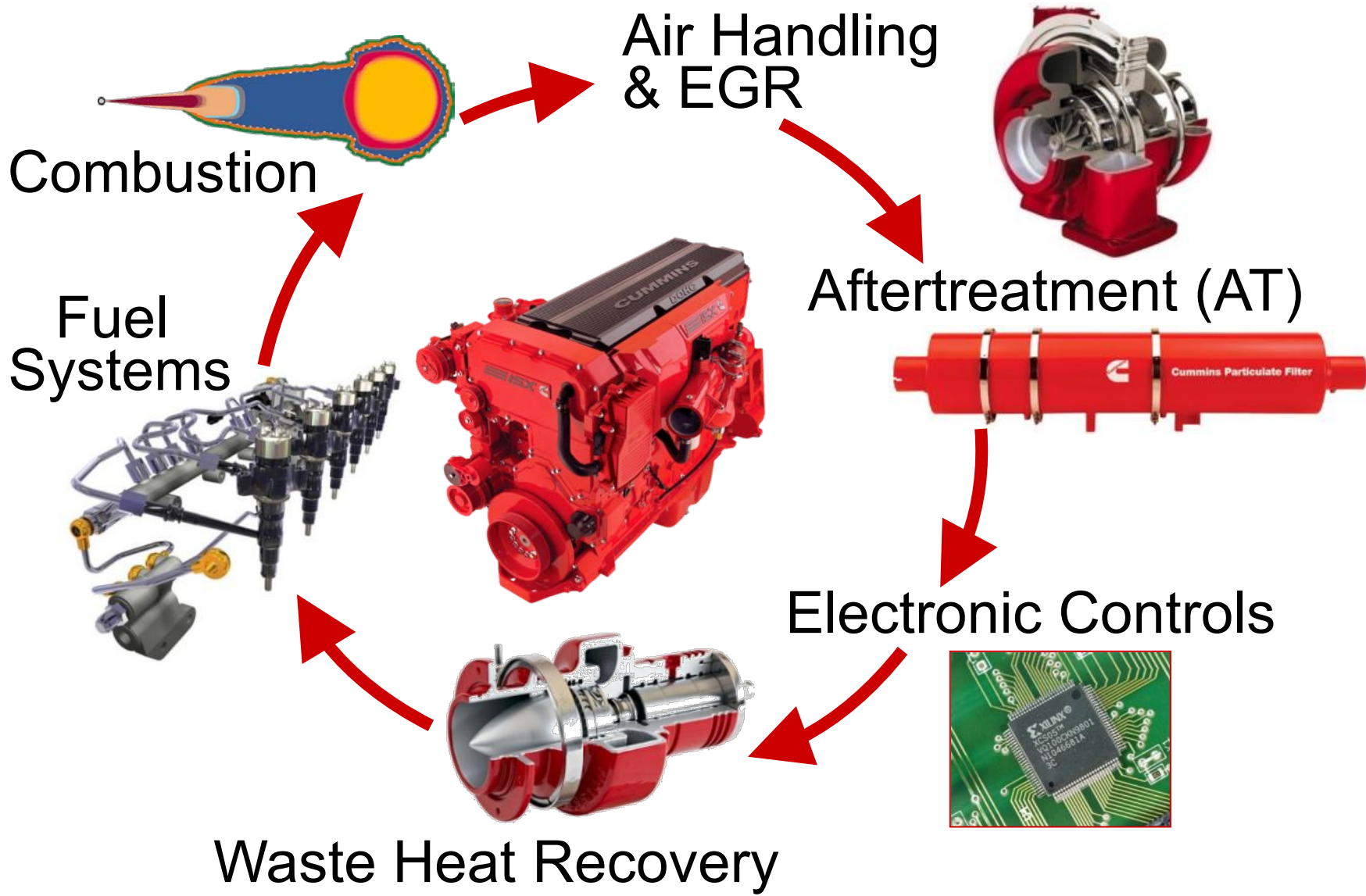
# Freight Efficiency Projections



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# Component Technology Integration



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# Enabling technologies for 50% Engine Thermal Efficiency



## Gross indicated gains

- Compr ratio increase
- Piston bowl shape
- Injector specification
- Calibration optimization

## Gas flow improvements

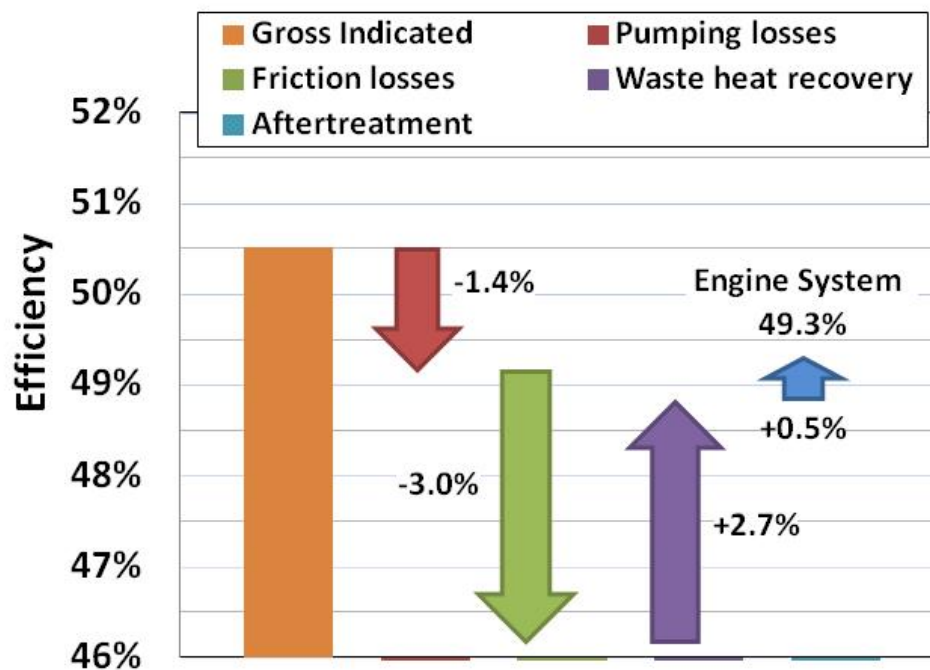
- Lower dP EGR loop
- Turbocharger match

## Parasitic reductions

- Cylinder kit friction
- Cooling pump power

## WHR system

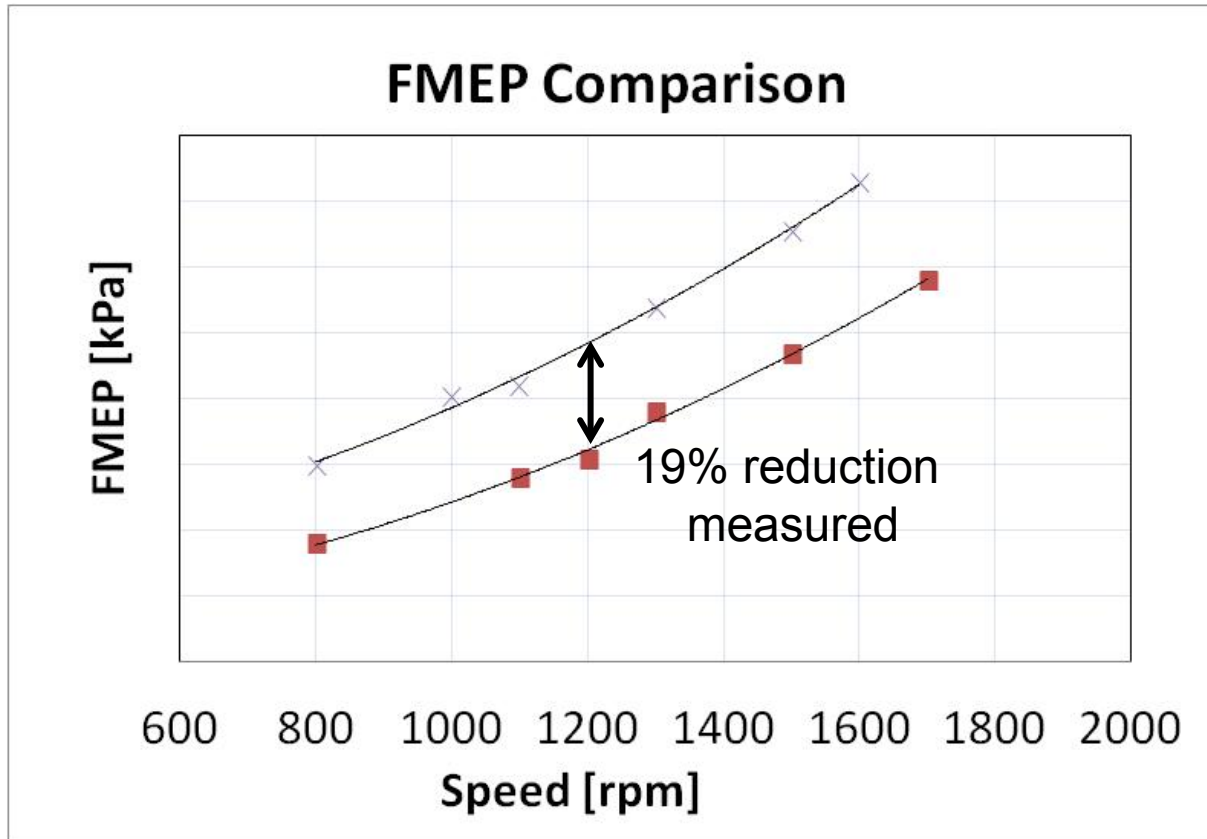
- EGR boiler/superheater
- Exhaust boiler
- Recuperator







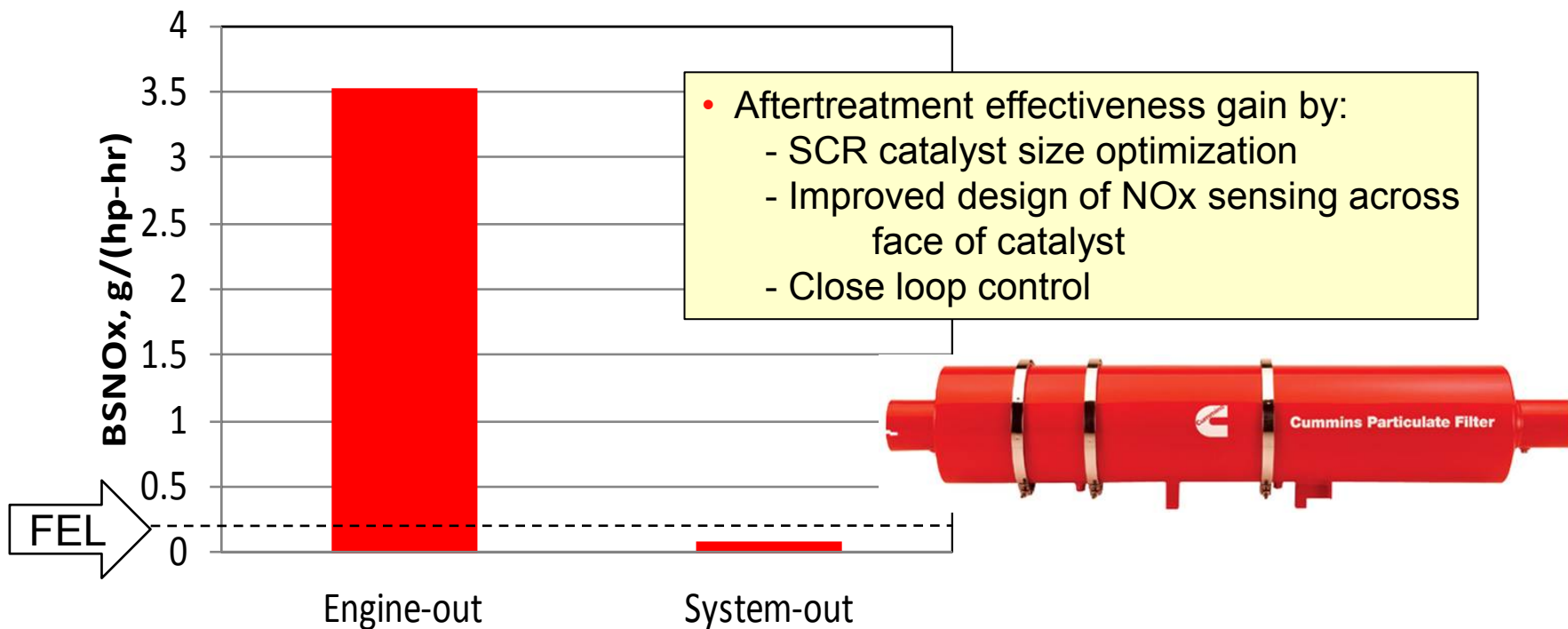
# Engine Friction Reduction



- Progress made to reduce engine friction
  - Reductions of 19% measured
- Further reductions are being tested



# Technical Accomplishment – Supplemental Emission Test (SET) Weighted Modal Cycle NO<sub>x</sub> Emissions



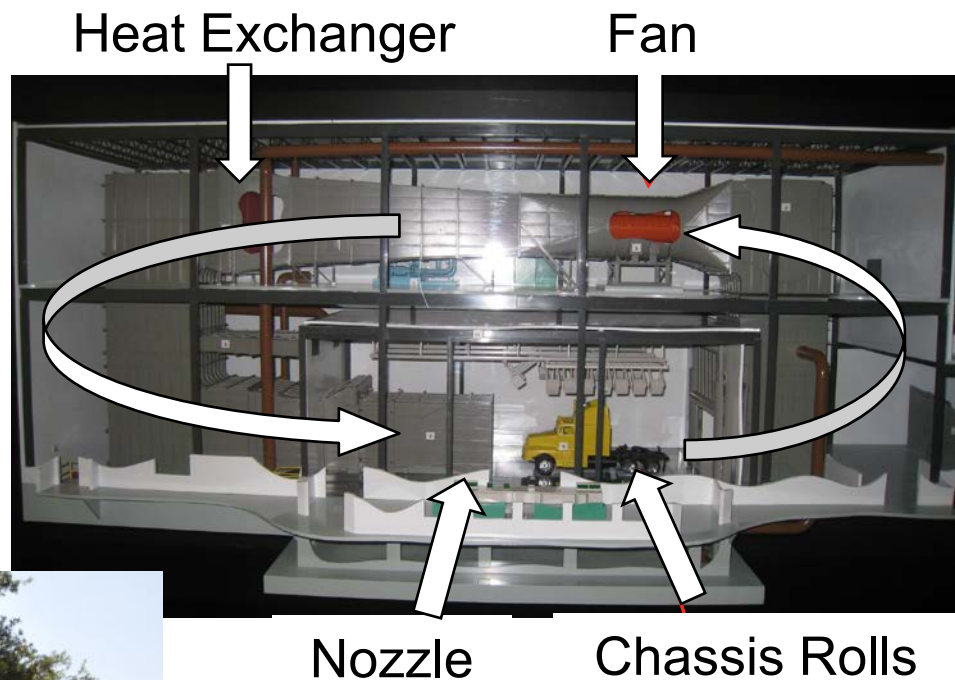
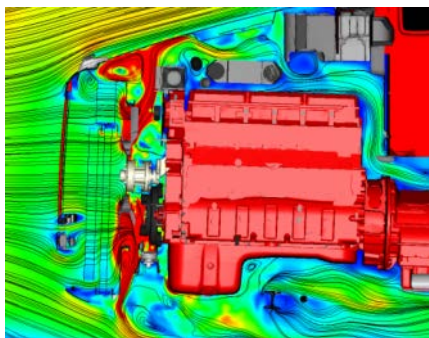
- Compliance to prevailing emissions 0.2 g/(hp-hr) demonstrated
- FTP requires additional calibration effort with optimized components



# WHR Vehicle Cooling Tests



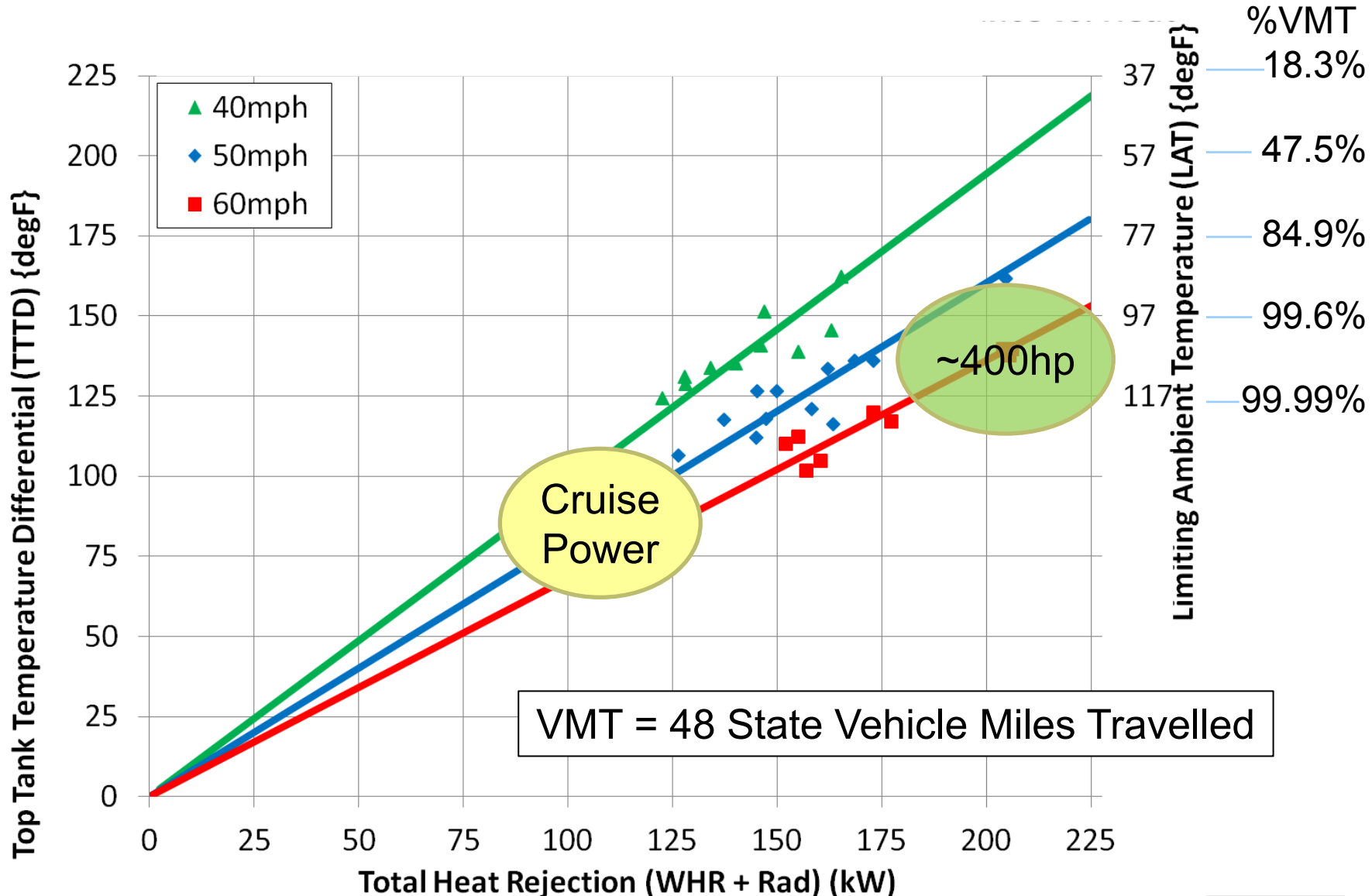
- Successful Packaging of technologies
- No Increase in Frame Length



- WHR system tested
- Performance as expected



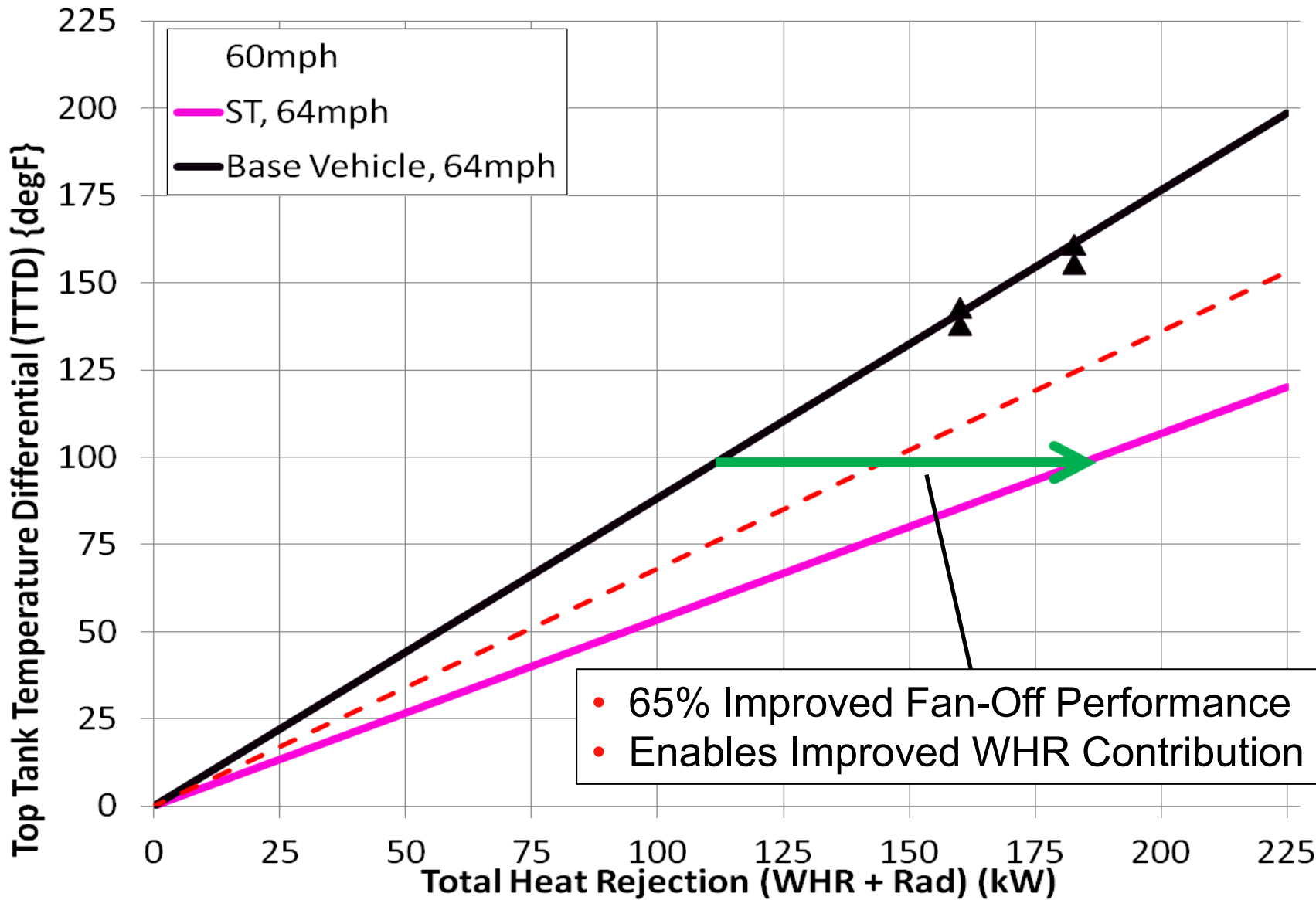
# Fan-Off Cooling System Performance



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# Improvements to Vehicle Cooling Enable WHR System Performance





# Freight Efficiency Enabling Technologies



**Idle Management  
(APU)**

**Advanced  
Aerodynamics**

**Transmission/Axle  
Technology**

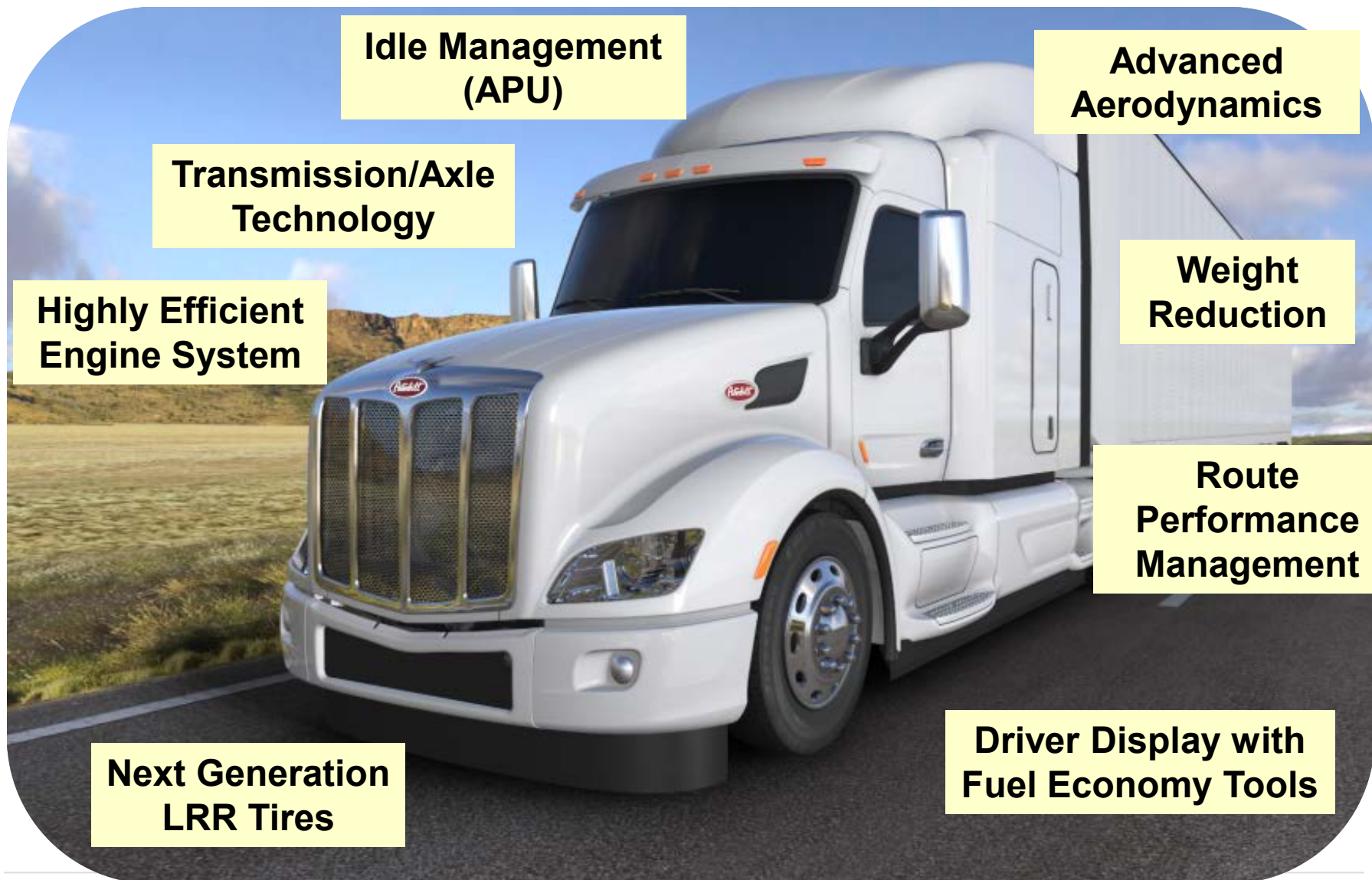
**Weight  
Reduction**

**Highly Efficient  
Engine System**

**Route  
Performance  
Management**

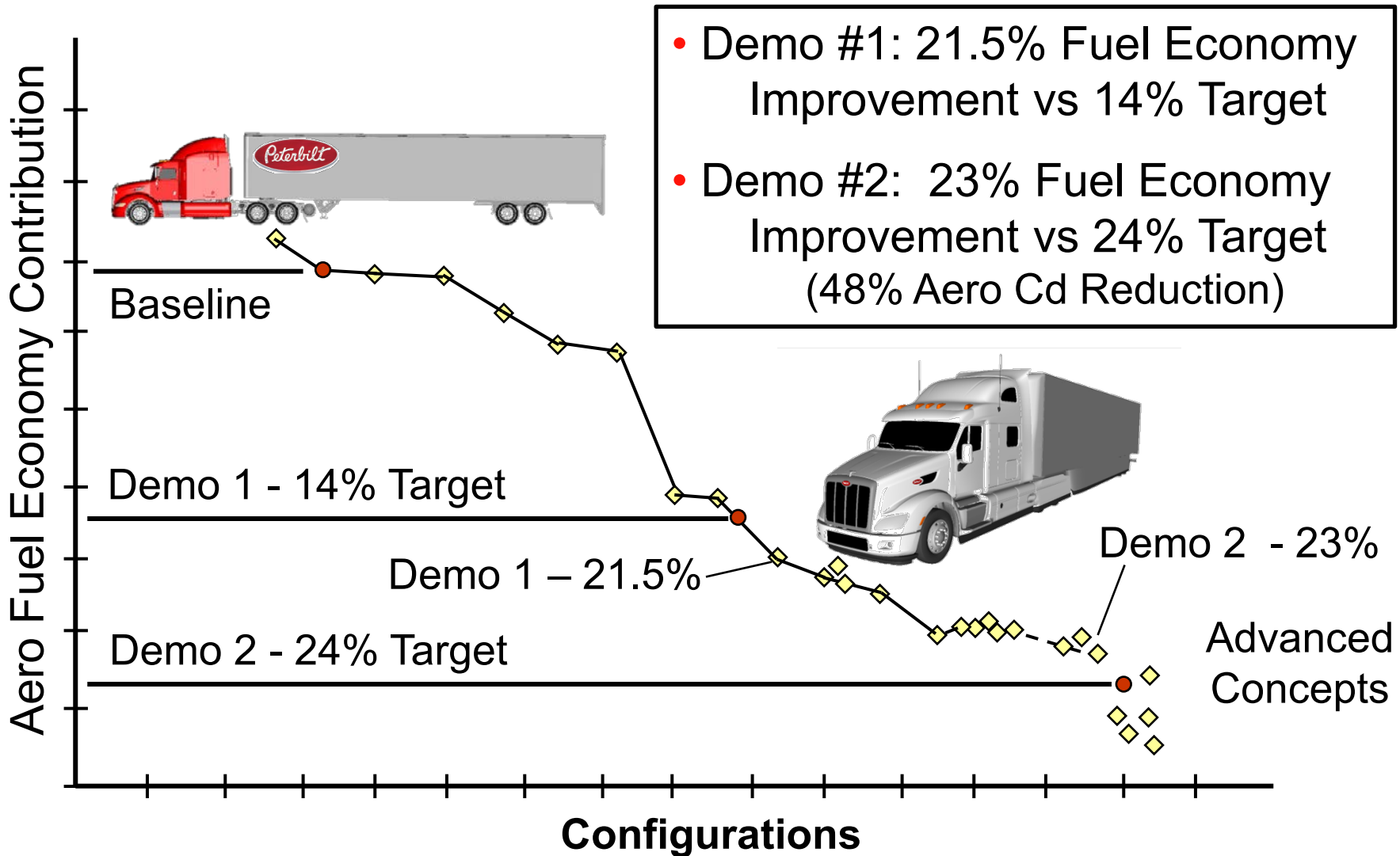
**Next Generation  
LRR Tires**

**Driver Display with  
Fuel Economy Tools**





# Aerodynamic Progress



- Demo #1: 21.5% Fuel Economy Improvement vs 14% Target
- Demo #2: 23% Fuel Economy Improvement vs 24% Target (48% Aero Cd Reduction)

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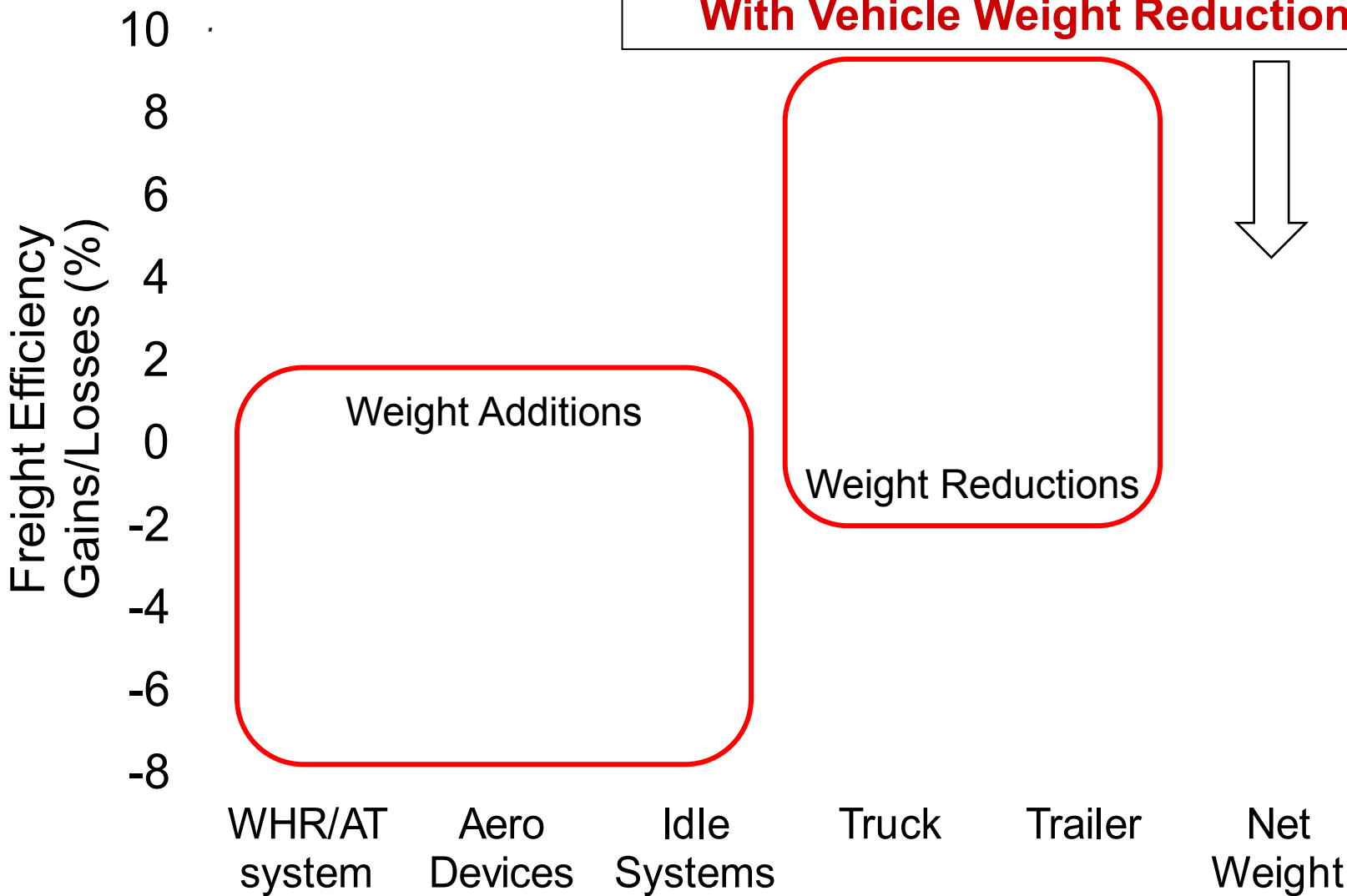
\* Cd's Shown Are Adjusted to SAE J1252 Baseline Using  
— % Average Deltas From 0 and 6 Degree CFD Runs



# Vehicle Weight Reduction Projections



**~4% Freight Efficiency Improvement  
With Vehicle Weight Reduction**



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# Trailer Development



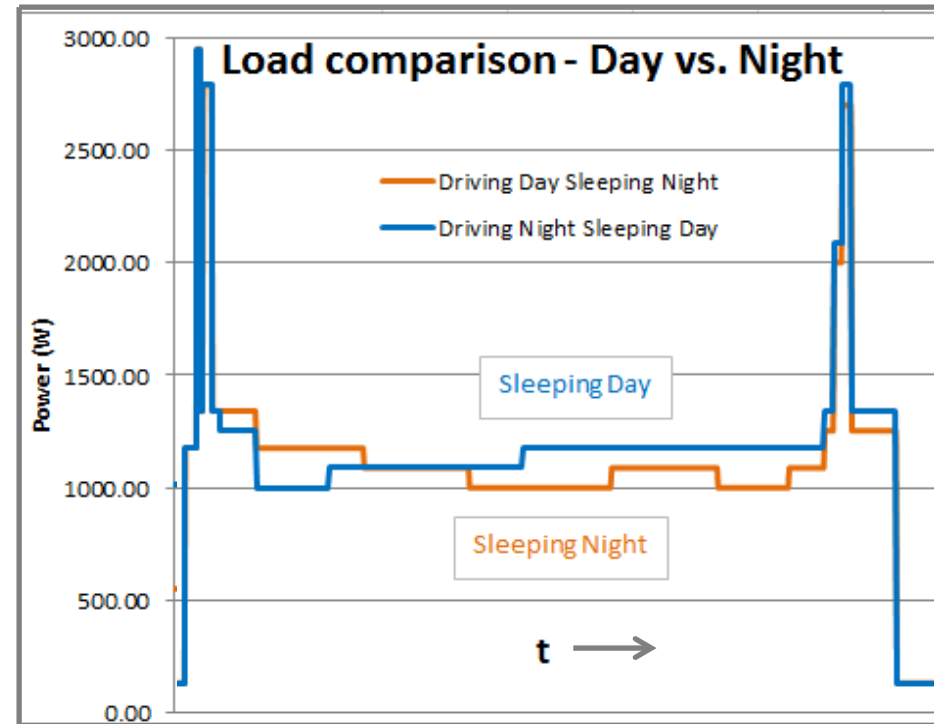
- Trailer build complete
- Preliminary aerodynamic road tests complete
- End customer input on-going



# Hotel Loads



- Baseline Load Assumptions:
  - 1500w Nominal
  - 2500w Peak
- Revised Loads:
  - 1100w Nominal
  - 2900w Peak
- Change Based On:
  - Driver Surveys
  - Fleet Feedback
  - Measured Requirements (by component )





# Summary



- Program remains on schedule
- Program roadmaps meet or exceed targets
- Implementing technology for 50% BTE
- WHR on-vehicle performance meets expectations
- Aero trailer preliminary development testing complete
- Completed baseline vehicle testing
- CFD results exceeding truck/trailer aerodynamic goals for Demo #1 (Objective 2a)
- Hotel loading assumptions verified
- Fuel cell APU efficiency quantified
- Vehicle system integration proceeding without any major issues