SuperTruck

Development and Demonstration of a Fuel-Efficient Class 8 Highway Vehicle

Vehicle Systems

DOE Contract: DE-EE0004232

P.I.: Pascal Amar, Volvo Technology of America

2012 Annual Merit Review

Washington, DC

May 17, 2012

Project ID: VSS081

Overview

Timeline

Start: June 2011

End: June 2016

17% complete

Barriers

- Rapid increase in system complexity
- Conflicting impacts of new technologies
- Availability of analytical tools & methods

Budget

Total Cost: $37.99M

Cost share: $19.07M

FY11 funding: $3.82M

FY12 funding: $4.40M

Lead: Volvo Technology of America

Partners

Collaborations

Relevance

- **In support of DOE's mission**

"[…] more energy efficient and environmentally friendly highway transportation […]"

- **Project Objectives**

Objective 1	50% better freight efficiency than 'best in class' 2009 highway truck
Objective 1a	50% Brake Thermal Efficiency
Objective 2	55% Brake Thermal Efficiency Concept

- **Reporting Period Objectives**
  - Define baseline
  - Develop tools & methods
  - Refine technology roadmap

Relevant Research

This material is based upon work supported by

- DOE & NETL under Award Number DE-EE0004232
- DOE & NETL under Award Number DE-FC26-07NT43222
- DOE Project ID VSS006, Reduce Truck Aerodynamic Drag w/ LLNL
- DOE Project ID VSS022, CoolCab Thermal Load Reduction project w/ NREL

Timeplan

2011	2012	2013	2014	2015	2016

Baseline Tests

Virtual Development

Engine & combustion Modeling — *Concepts Evaluation* — *55% BTE Demo*

Complete vehicle modeling — *Validation* — *Optimization*

Technology Development

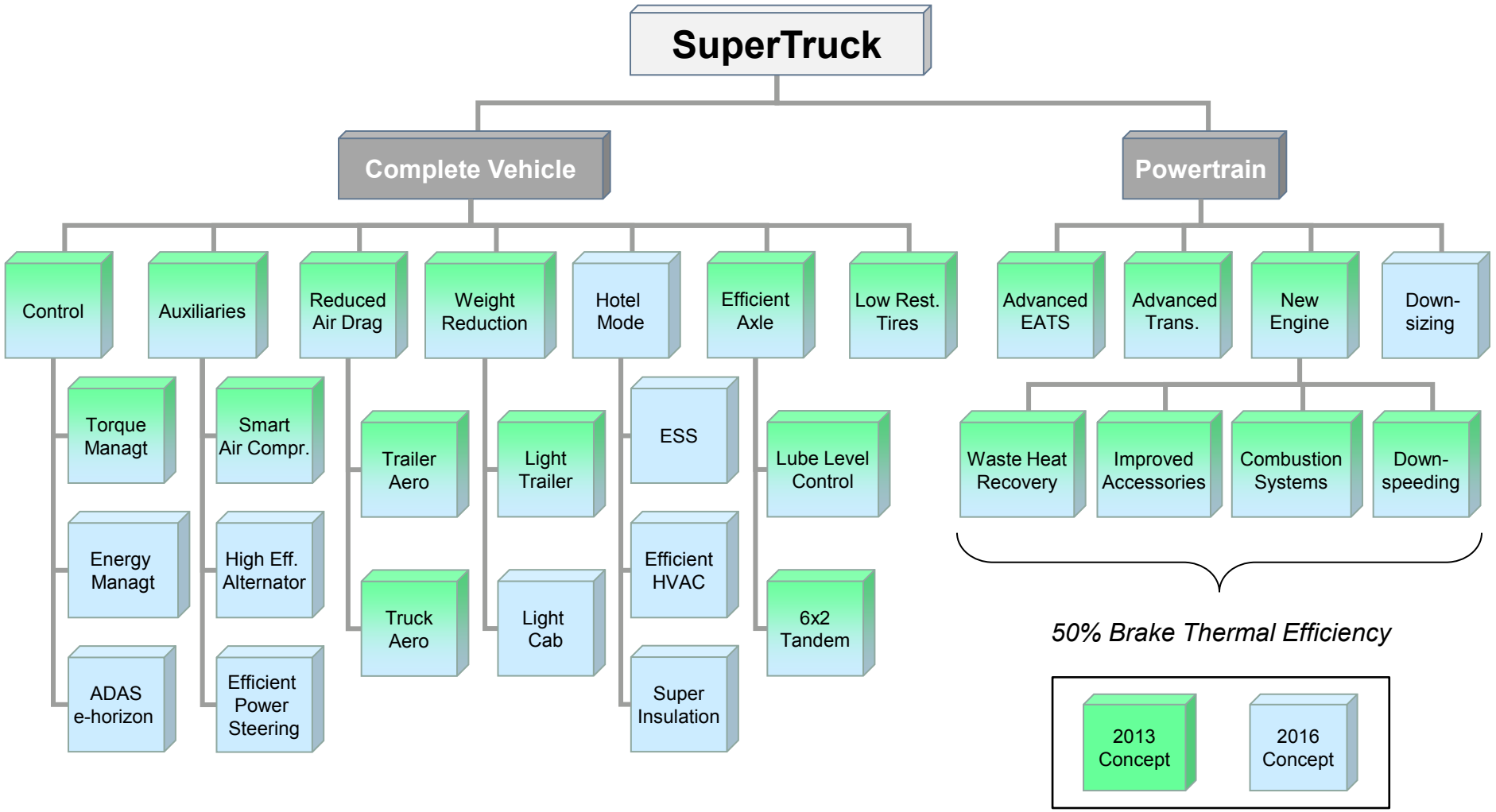
Concepts Evaluation

Complete Vehicle Integration

Optimization

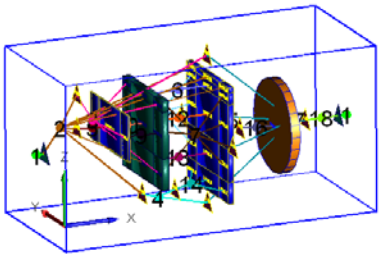
Demo

Approach – Technology Roadmap



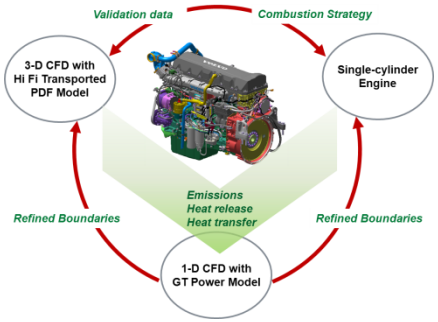
Approach – System Simulations

- **Global Simulation Platform**
  - Detailed physical or empirical component models
  - Evaluate complete vehicle concepts



- **Complete Vehicle Aerodynamics**
  - Balance powertrain and aero requirements
  - Optimize complete vehicle geometry

- **Advanced Combustion Simulation**
  - Evaluate new combustion concepts



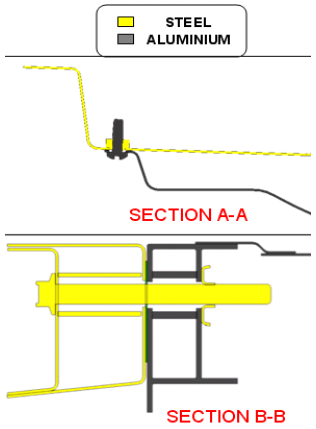
Approach – Lightweight Materials

- **Aluminum/Steel cab concept**
  - Investigate new bonding techniques

  > 100lb lighter
- **Axle & suspension**
  - Smart 6x2 carrier
  - Lighter and composite materials

  Up to 800lb lighter
- **Aluminum 1-piece driveshaft**

  ~ 100lb lighter



Approach – Reduced Parasitic Losses

- **Advanced Lighting Concepts**
  - LightForm™
    - Energy Efficient
    - Aerodynamic
  - LED lighting

Enables new harness concepts

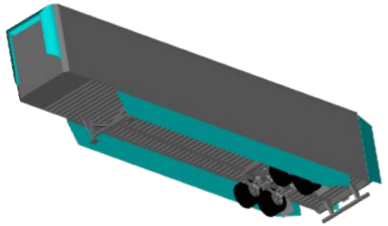
→ lighter & less copper

- **Low-friction tires**
- **Low viscosity oils & lubricants**
- **Carrier lube level control**
- **Complete vehicle integration**

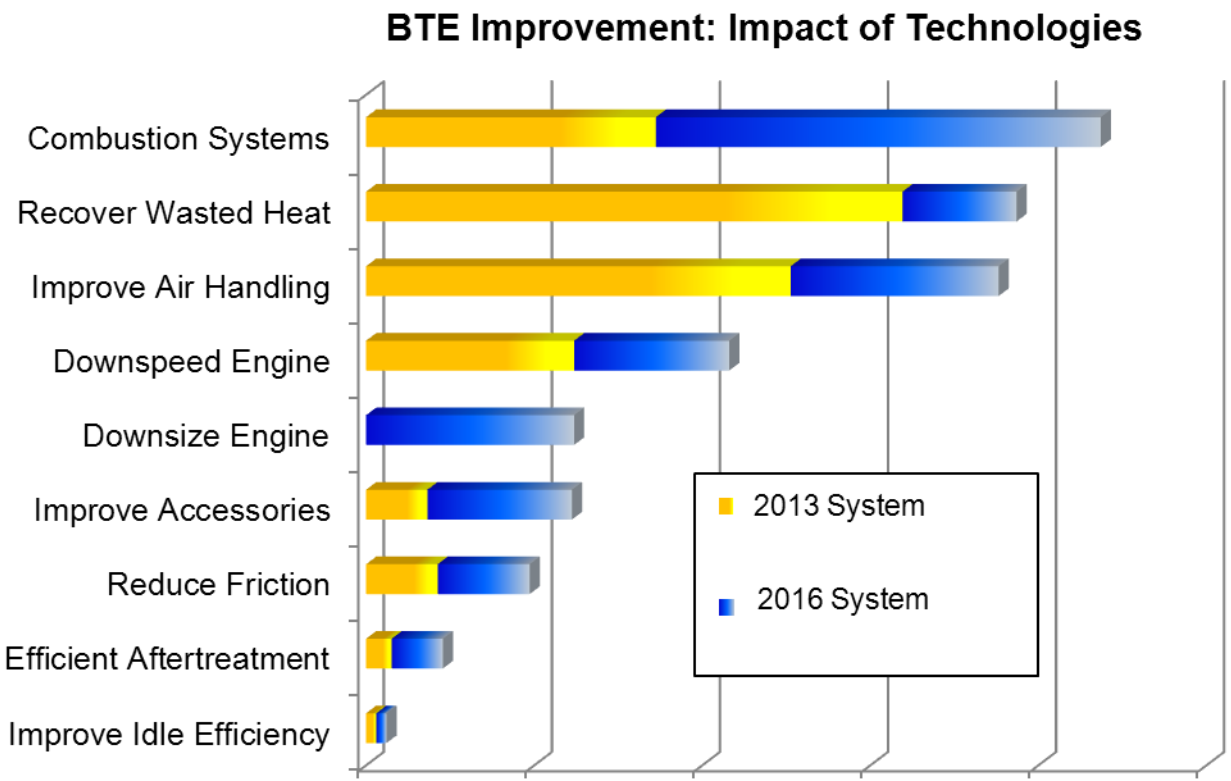
Approach – Aerodynamics

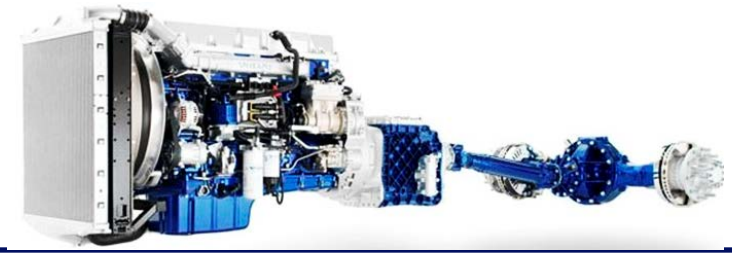
- **Mitigate conflicting trends**
  - Increased powertrain cooling requirements
  - Need for lower tractor aerodynamic drag
  - Increased packaging complexity

- **Optimize complete vehicle**
  - Leverage results from prior DOE grant projects and proprietary studies
  - Select tractor/trailer geometries for optimal combined performance
- **Verify selected geometries**
  - on-road fuel economy and operation testing



Approach – Powertrain Improvements

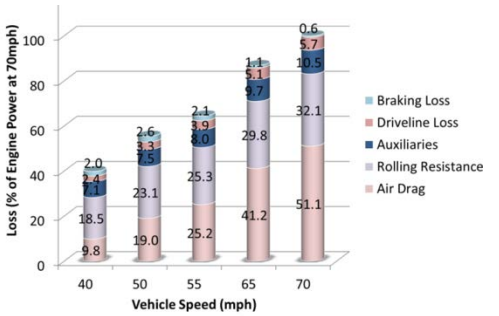


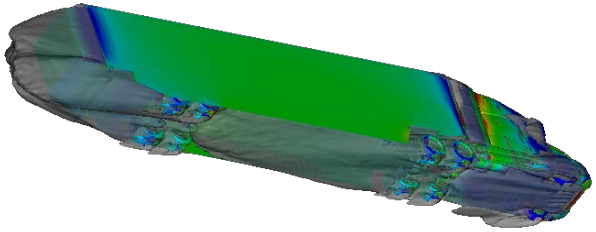


- Evaluate portfolio of technologies enabling increased engine efficiency
- Each bin includes many sub-sets of technologies
- Select concepts for optimal powertrain efficiency
- Integrate complete powertrain into concept evaluation vehicles

Achievements – System Simulations

- **Global Simulation Platform**
  - Baseline and concept vehicles modeled
- **Complete Vehicle Aerodynamics**
  - First results with current vehicle configuration
- **Advanced Combustion Simulation**
  - Method for 55% thermal efficiency concepts evaluation established



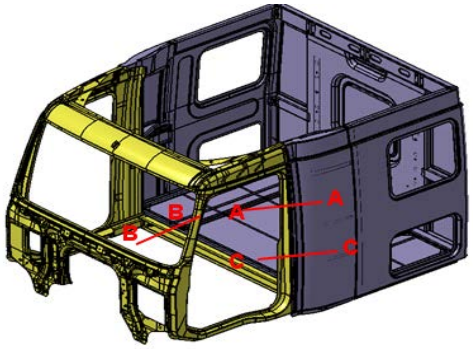


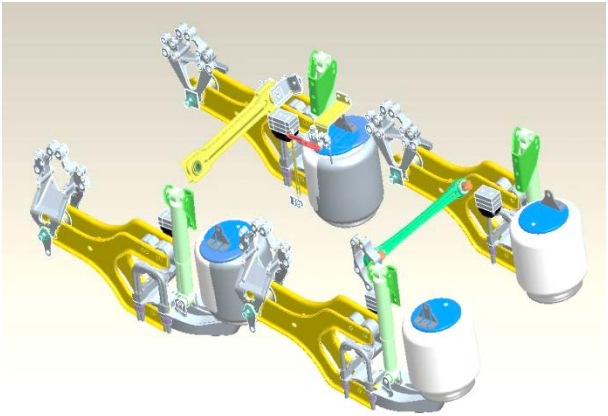
→ These tools will be fully verified and running by mid 2012

Achievements – Lightweight Materials

- **Steel Cab/ Aluminum Sleeper concept**
  - Concept defined & prototype material on order
- **Axle & suspension**
  - Concept truck conversion complete

  → *improved safety with better ride & handling*
  - Ultra-lightweight trailer build in progress with prototype axle & suspension
- **Aluminum 1-piece driveshaft**
  - Concept truck conversion planned in April 2012



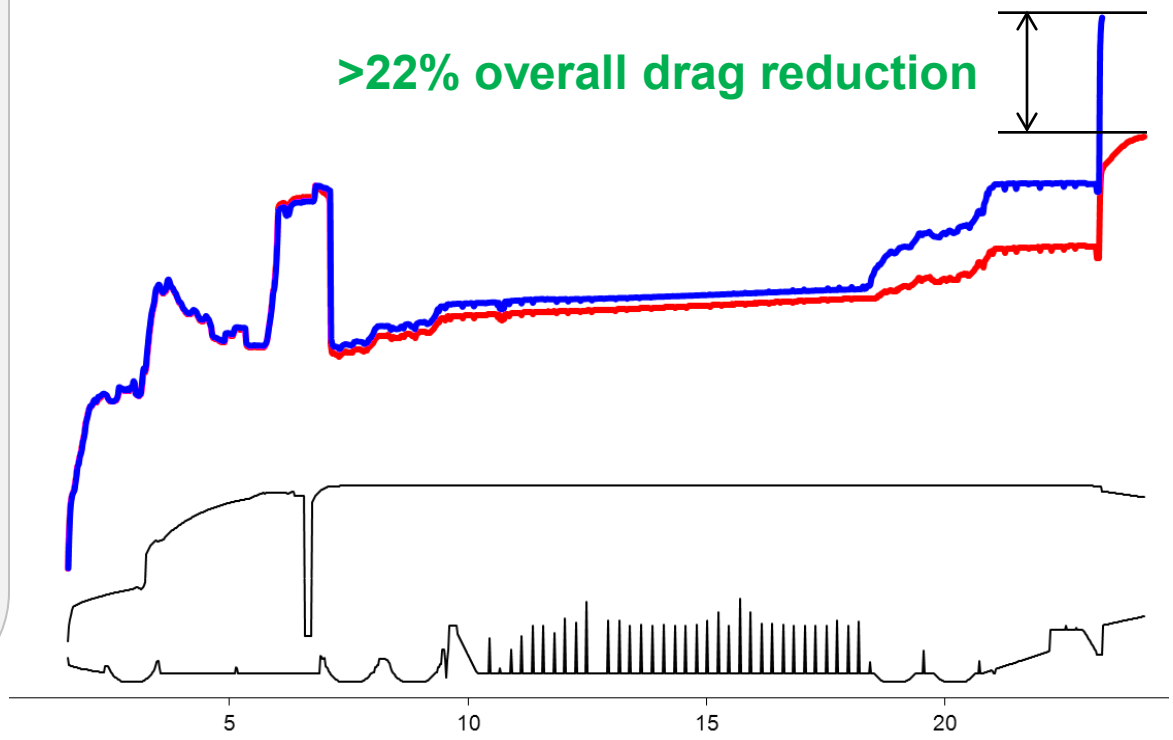


Achievements - Reduced Parasitic Losses

- **Advanced Lighting Concepts**
  - LightForm marker & side turn lamps designed
  - Lightweight prototype harness designed and built
  - LED lighting concepts defined, prototype parts on order
  - Components will be installed on ultra-lightweight trailer in April
- **Concept Truck Conversion**
  - 1st generation low-friction tires
  - 6x2 SMARTandem with Lube Level Control
  - Low viscosity oils and lubes

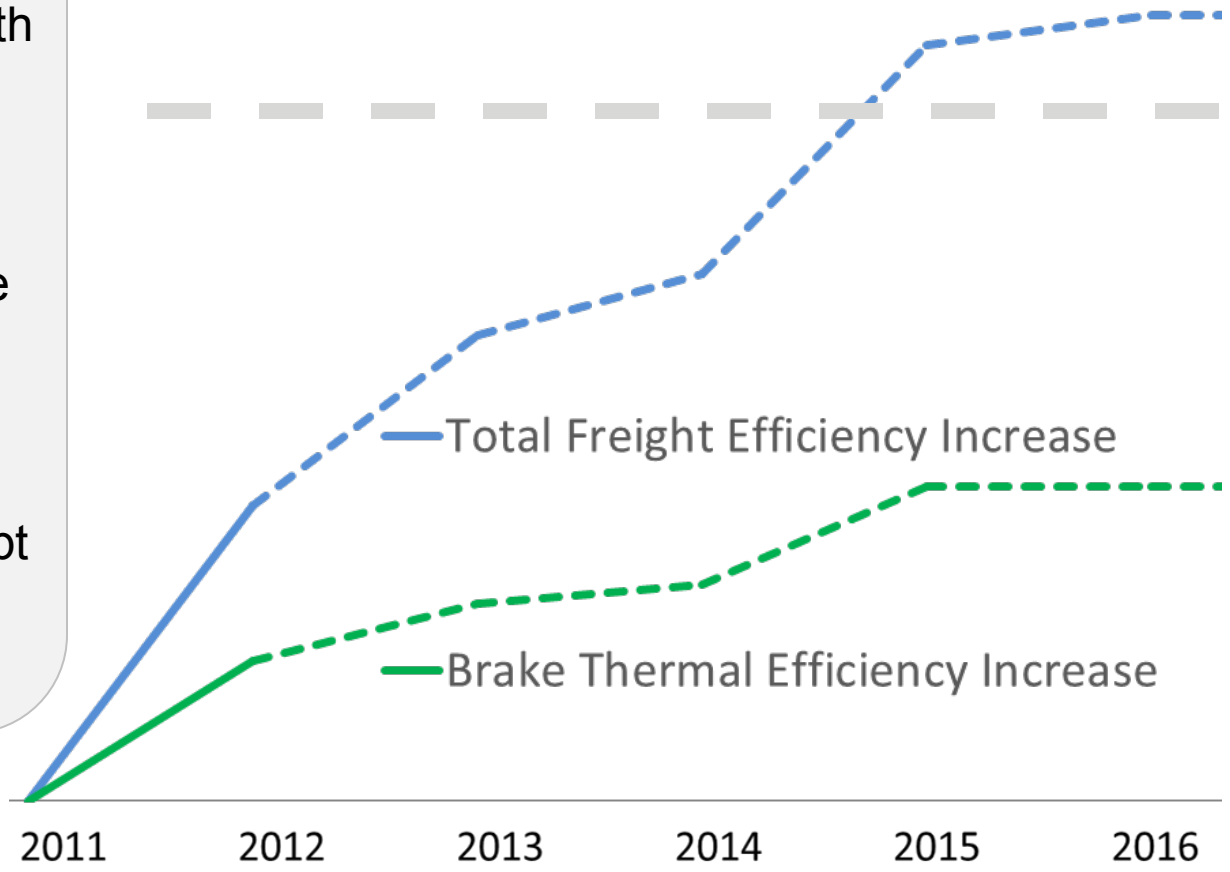
Achievements – Aerodynamics

- Packaging & cooling study shows no negative impact of new powertrain concepts on aero drag
- CFD results exceed expected improvements compared with baseline
- 1st gen optimized aero devices are designed and being fabricated for on-road validation with concept vehicle



Achievements – Efficiency Increase

- Current simulation results are aligned with Efficiency Roadmap
- Powertrain efficiency improvements so far confirmed with engine bench test
- Improvements will be verified through on-road testing of concept vehicle during 2012 - 2013



Milestones

Milestone	Status
Baseline vehicle defined	Completed
Concept Evaluation Vehicle 2012 - 2013	
Concept selection – Complete Powertrain selection	Completed
Concept selection – Weight Reduction	Completed
Concept selection – Parasitic Loss reduction	Completed
Concept selection – Idle Reduction	Delayed
Concept selection – Aerodynamic Optimization	Completed
Technology for Power Steering Pump	Completed
Concept Evaluation Vehicle Built	Completed
Upcoming Milestones	
Baseline tests completed	On track
55% Thermal Efficiency: 1st concept selection	On track
Powertrain ready for vehicle installation	On track

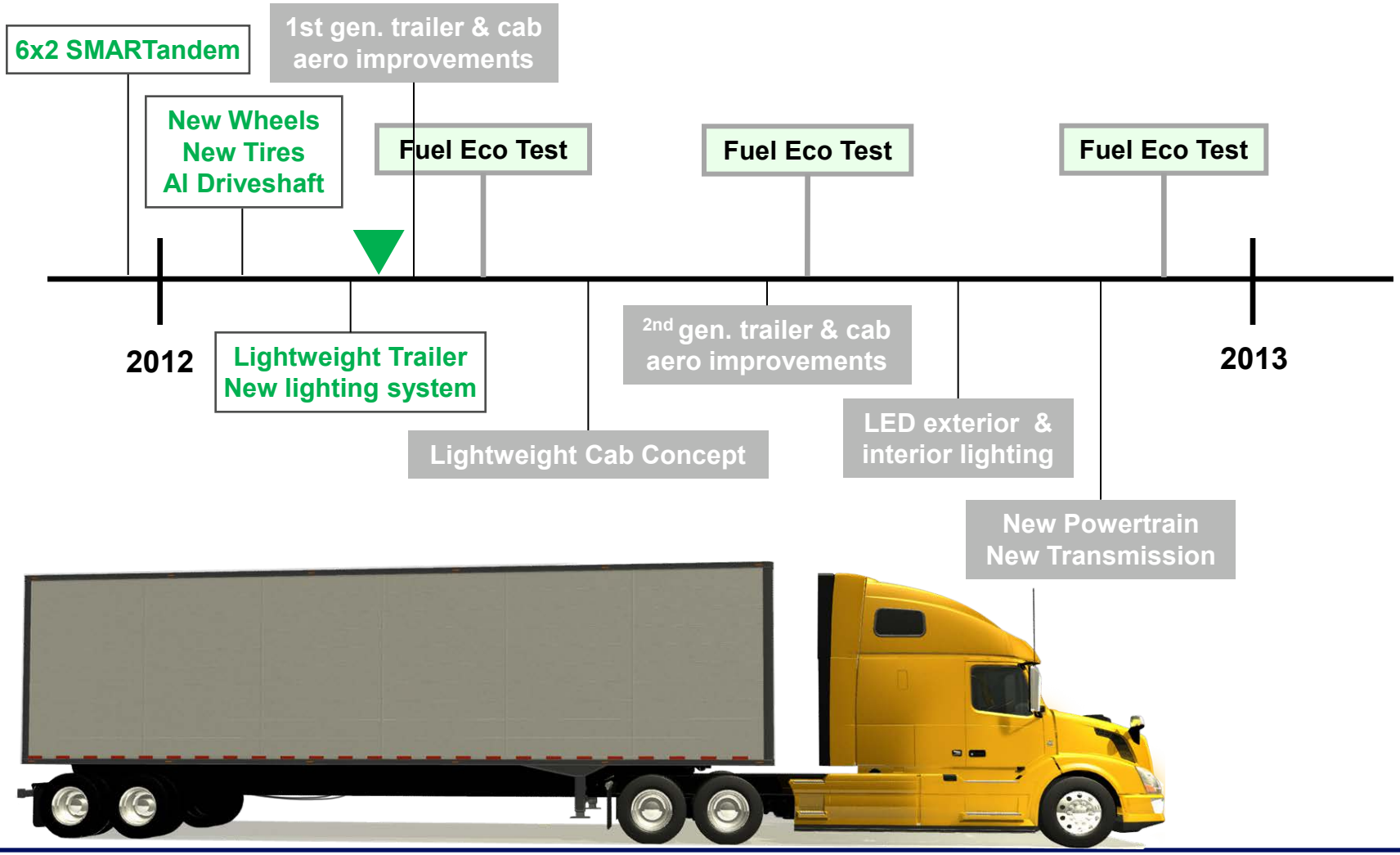
Future Work

- Validate **simulation** tools with on-road test measurements
- Verify **aerodynamic** improvements on full scale concept vehicle
- Complete **powertrain** testing and integration for concept evaluation
- Verify accumulated **weight savings**
- Collect data to persuade Industry of the benefits
  - light gauge harness systems
  - operation of aerodynamic trailer geometries

→ Determine optimal geometry for SuperTruck demonstrator

→ Determine powertrain concept for SuperTruck demonstrator

Future Work – Concept Evaluation



VOLVO FREIGHT WING Grote PENNSTATE

Summary

- **Relevance**
  - Project objectives are key enablers to energy efficient highway transportation
  - Approach to date has focused on method development to address barriers
- **Achievements**
  - Engine bench testing confirms expected thermal efficiency gains
  - CFD simulation results exceed planned aero drag improvements
  - Concept vehicle is ready for first evaluation in April
  - Milestone Completion on target
- **Future Work**
  - Validate analytical tools with measurements from baseline & concept vehicles
  - Complete evaluation of technologies in roadmap
  - Freeze concept selection for SuperTruck demonstrator

Partners & key collaborations

Volvo Technology of America: Principal Investigator, Project Office, concept simulations

Volvo Group Truck Technology: Complete vehicle integration & optimization, vehicle testing

Volvo Group Powertrain Engineering: Efficient complete powertrain solutions

Freight Wing: Optimized aerodynamic geometries and devices

Grote: Advanced lighting systems

Penn State University: Advanced combustion modeling and simulation

Hendrickson: Lightweight trailer axle and suspension concept

ExxonMobil: Advanced fuels and lubricants

Alcoa Wheels: Lightweight wheels

Michelin: Advanced low-friction tires

Meritor: high-efficiency tractor axles