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

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Overview

Timeline
Start: June 2011
End: June 2016
17% complete

Budget
Total Cost: $37.99M
Cost share: $19.07M
FY11 funding: $3.82M
FY12 funding: $4.40M

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

Lead: Volvo Technology of America

Partners
- VOLVO
- Grote
- PENNSTATE
- FREIGHT WING

Collaborations
- HENDRIX
- MICHELIN
- ArvinMeritor
- ExxonMobil
- ALCOA WHEELS
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

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### Timeplan

<table>
<thead>
<tr>
<th>Year</th>
<th>Baseline Tests</th>
<th>Technology Development</th>
<th>Engine &amp; combustion Modeling</th>
<th>Concepts Evaluation</th>
<th>Complete vehicle modeling</th>
<th>Validation</th>
<th>Optimization</th>
<th>55% BTE Demo</th>
<th>Complete Vehicle Integration</th>
<th>Optimization</th>
<th>Demo</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
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</table>
Approach – Technology Roadmap

SuperTruck

Complete Vehicle
- Control
  - Torque Management
  - Energy Management
  - ADAS e-horizon
- Auxiliaries
  - Smart Air Compressor
  - High Eff. Alternator
  - Efficient Power Steering
- Reduced Air Drag
- Weight Reduction
- Hotel Mode
- Efficient Axle
- Low Rest. Tires
- Advanced EATS
- Advanced Trans.

Powertrain
- Advanced Engine
- Down-sizing
- Waste Heat Recovery
- Improved Accessories
- Combustion Systems
- Down-speeding
- 6x2 Tandem
- Super Insulation

50% Brake Thermal Efficiency

2013 Concept
2016 Concept
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
- **Low-friction tires**
- **Low viscosity oils & lubricants**
- **Carrier lube level control**
- **Complete vehicle integration**

Enables new harness concepts
→ lighter & less copper
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

**BTE Improvement: Impact of Technologies**

- Combustion Systems
- Recover Wasted Heat
- Improve Air Handling
- Downspeed Engine
- Downsize Engine
- Improve Accessories
- Reduce Friction
- Efficient Aftertreatment
- Improve Idle Efficiency

- 2013 System
- 2016 System
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
  
  \[improved \textit{ safety with better ride & handling}\]
  
  - 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
  – 1\textsuperscript{st} 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

>22% overall drag reduction
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

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Status</th>
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<tbody>
<tr>
<td>Baseline vehicle defined</td>
<td>Completed</td>
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<tr>
<td>Concept Evaluation Vehicle 2012 - 2013</td>
<td></td>
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<tr>
<td>Concept selection – Complete Powertrain selection</td>
<td>Completed</td>
</tr>
<tr>
<td>Concept selection – Weight Reduction</td>
<td>Completed</td>
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<tr>
<td>Concept selection – Parasitic Loss reduction</td>
<td>Completed</td>
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<tr>
<td>Concept selection – Idle Reduction</td>
<td>Delayed</td>
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<tr>
<td>Concept selection – Aerodynamic Optimization</td>
<td>Completed</td>
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<tr>
<td>Technology for Power Steering Pump</td>
<td>Completed</td>
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<tr>
<td>Concept Evaluation Vehicle Built</td>
<td>Completed</td>
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### Upcoming Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Status</th>
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<tbody>
<tr>
<td>Baseline tests completed</td>
<td>On track</td>
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<tr>
<td>55% Thermal Efficiency: 1&lt;sup&gt;st&lt;/sup&gt; concept selection</td>
<td>On track</td>
</tr>
<tr>
<td>Powertrain ready for vehicle installation</td>
<td>On track</td>
</tr>
</tbody>
</table>
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
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