Volvo SuperTruck

Powertrain Technologies for Efficiency Improvement

DOE Contract DE-EE0004232

2012 Annual Merit Review
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### Overview: Volvo Supertruck Program

#### Timeline
- June 2011 - June 2016
- 17% complete to date

#### Barriers
- Added weight, packaging, and complexity of technologies
- High cost of lightweight and stronger materials
- Reduced aftertreatment efficiency at low temperatures
- Integration of interdependent technologies

#### Budget
- Total Project Funding: 38 MUSD
  - Cost Share: 19 MUSD
- Funding received in FY 01: 3.8M USD
- Funding for FY 02: 4.4 M USD

#### Project Partners:
- **Lead**: Volvo Technology of America
  - Volvo Group Truck Technology
  - Volvo Group Powertrain Engineering
  - Penn State University
  - Grote
  - Freight wing

#### Collaborations / key Suppliers:
- University of California Los Angeles
- Ricardo, Inc.
- Hendrickson
- ArvinMeritor
Relevance to Program Goals

- Bring technologies that enable lower customer operational cost and reduced environmental impact and time to market
- Develop more efficient highway transportation technologies to reduce petroleum consumption

Project Objectives

Objective 1:
Develop powertrain technologies to contribute to 50% freight efficiency improvement in vehicle testing

Objective 1a:
Develop powertrain technologies capable of 50% engine BTE in vehicle environment

Objective 2:
Investigate engine technologies capable of 55% BTE through simulation and scoping studies

Reporting Period Project Objectives

Objective 1:
Define powertrain concepts for technology demonstrators

Objective 1a:
Test first generation technologies and systems and select concept for integrated testing

Objective 2:
Define BTE Workpackage technology investigation methods and build simulation and test tools
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Total Powertrain Workflow Approach

55% BTE Combustion Technologies (Objective 2)
- Combustion
- PPC/RCCI
- Alternative cycles
- Simulation tool
- Fuels Optimization
- Demonstrate in Simulation and Single Cylinder Scoping

50% BTE Powertrain Technologies (Objective 1a)
- Engine System(s)
  - Combustion
  - WHR
  - Air Handling
  - …
  - Aftertreatment
  - Driveline
- Demonstrate in test cell

50% Freight Efficiency Improvement Technologies (Objective 1)
- Powertrain Improvements
- Aerodynamics
- Light weighting
- Rolling Resistance
- Driver Aides
- Auxiliaries
- …
- Chassis Test 2012 and 2015

Requirements and Feedback

+ New Technology
Transfer Technology

Technology to Customer
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TRANSFER TECHNOLOGY

Requirements

Technology to Customer
Approach for 55% BTE Engine Concept Evaluation (Objective 2)

- **Combustion strategy & simulation**
  - 3-D CFD with Hi Fi Transported PDF Model
  - 1-D CFD with GT Power Model

- **Validated data**
  - Refined Boundaries
  - Emissions
  - Heat release
  - Heat transfer

- **Single-cylinder Engine**
Accomplishments – Fuel Combustion and Emissions Study (Objective 2)

- 3-D In-Cylinder Combustion CFD Study
  - Developed Transported PDF model for turbulent combustion
  - Validated fuel chemical mechanisms for chemistry model
    - Single-component fuels validated using data from Engine Combustion Network under diesel-relevant conditions
    - PRF (Primary Reference Fuel) blends validated using experimental data from Penn State Diesel Combustion and Emissions Laboratory (DCEL)
  - Verified combustion CFD model using single-cylinder engine data

- Engine Experimental Study
  - Advanced combustion studies using “proprietary fuels” at VTEC
  - Developed Soot nanostructure and reactivity capability at DCEL, for alternative combustion modes.
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Requirements and Feedback

Technology to Customer

Requirements and Feedback

Requirements and Feedback

Requirements
Strategy for 50% BTE Powertrain Demonstration (Objective 1a)

- Develop powertrain components that enable 50% engine BTE.
- Each bin of improvements displayed represents many sub-sets of technologies.
- Integrate systems into 2013 and 2016 concept vehicles.
Accomplishments towards 50% BTE Powertrain Demonstration (Objective 1a)

Engine test: built and tested engine(s) with prototype combustion, air handling, fuel injection, and EATS as integrated unit.

Rankine system test: power generation mapped steady state.
Accomplishments towards 50% BTE Powertrain Demonstration (Objective 1a)

- Significant progress on realized BTE improvement from project inception
Total Powertrain Workflow Approach

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Requirements and Feedback

+ New Technology

Transfer Technology

Requirements and Feedback

Requirements

Technology to Customer

Requirements and Feedback
Approach and Strategy for 50% Freight Efficiency Improvement (Objective 1)

Powertrain Concept Evaluations in 2012-2013:
- Engine System
  - Combustion, WHR, EATS, Cooling, …
- Transmission Technology
- Axle Technology
- Accessory and Parasitic Losses
- Advanced Driver Aide Systems

Powertrain Deliveries to 2016 Demonstrator Chassis
- Refined powertrain systems for efficiency improvement
- Weight reduction of powertrain
- Improved system integration and powertrain management
Powertrain Accomplishments towards 50% Freight Efficiency Improvement (Objective 1)

- Defined technologies from BTE projects to transfer for 2013 concept vehicle
- Advanced axles, wheels and tires
  - Installed in 2012 Demonstrator Chassis, ready for calibration
- Next generation transmission
  - Prototype built and ready for installation
- Co-ordinated powertrain requirements and developments for packaging and total system optimization
Collaborators to Powertrain System Development

- Volvo Group Powertrain Engineering
  - 55% BTE and 50% BTE, Engine, Transmission, and Axle Technologies
- Volvo Group Truck Technology
  - Aerodynamics, Lightweight, Chassis Auxiliaries, APU, …
- Ricardo
  - Rankine System integration and test towards 2013 powertrain concept
- University of California Los Angeles (UCLA)
  - Rankine WHR dynamic simulation and model generation
- Pennsylvania State University (PSU)
  - 55% BTE simulation and test
Future Plans for Powertrain Development

- 55% BTE (Objective 2)
  - Investigation and survey of alternative cycles and technology
  - Continue development of simulation methods
  - Combustion modeling and verification of proposed regimes and fuels
- 50% BTE (Objective 1a)
  - Test integrated system in test cell 2012
  - Test integrated system in evaluation chassis 2013
- 50% Freight Efficiency (Objective 1)
  - Incorporate 50% BTE methods
  - Integrate chassis improvements into powertrain system development
Milestone Update

7/7 milestones passed for FY01 to date. Project on track to complete future milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline test completed</td>
<td>Completed</td>
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<tr>
<td>WHR Technology Freeze</td>
<td>Completed</td>
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<tr>
<td>Engine Platform Freeze</td>
<td>Completed</td>
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<tr>
<td>Fuel injection Hardware Freeze</td>
<td>Completed</td>
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<tr>
<td>Concept Definition for Complete Powertrain</td>
<td>Completed</td>
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<tr>
<td>Technology Chosen for Coolant Pump</td>
<td>Completed</td>
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<tr>
<td>Technology Chosen for Power Steering Pump</td>
<td>Completed</td>
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<tr>
<td>Upcoming Milestone: 55% Thermal Efficiency: 1st concept selection</td>
<td>On track</td>
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<tr>
<td>Upcoming Milestone: 2013 Concept Evaluation Truck Built</td>
<td>On track</td>
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<tr>
<td>Upcoming Milestone: 2013 Concept Evaluation Truck Results</td>
<td>On track</td>
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Summary of Volvo Supertruck Project Status

- **Relevance:** Develop more efficient highway transportation technologies to reduce petroleum consumption, reducing operating cost, fuel consumption, environmental impact, and time to market.

- **Approach:** Through simulation and testing, develop technologies that meet or exceed 55% BTE scoping, 50% BTE of powertrain system in chassis, and 50% Freight Efficiency improvement.

- **Technical Accomplishments:** Initiated projects to meet program criteria for long term goals. Developed and tested new and promising technologies, meeting or exceeding planned project deliverables.

- **Collaborations:** Suppliers and research partners have developed methods to integrate all new technologies in simulation and test phase, striving to deliver an optimized powertrain and chassis for maximum return on investment.

- **Future Plans:** Technologies selected as viable will be tested as part of integrated concept evaluation vehicle in 2012-2013. Simulation and test of next generation components will progress through upcoming funding year.
End of presentation.

Thank you for your attention.