# Project Overview

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Barriers</th>
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<tbody>
<tr>
<td>Start: June 2011</td>
<td>➢ Cost effective &amp; timely evaluation of advanced components and configurations</td>
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<tr>
<td>End: June 2016</td>
<td>➢ Operational effectiveness &amp; end-user acceptance of advanced concepts</td>
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<tr>
<td>55% complete</td>
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<table>
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<tr>
<th>Budget</th>
<th>Team</th>
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<tbody>
<tr>
<td>Total Cost: $38M</td>
<td>Lead: Volvo Technology of America</td>
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<td>Cost share: $19M</td>
<td>Partners: <a href="#">Volvo</a>, <a href="#">Grote</a>, <a href="#">Penn State</a>, <a href="#">Freight Wing</a></td>
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<td>Cost to date: $18.3M</td>
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<td>Funds to date: $9.1M</td>
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Relevance

- In support of DOE’s mission
  “[…] more energy efficient and environmentally friendly highway transportation […]”

- Project Objectives
  Objective 1  50% more ton-miles per gallon than a ‘best in class’ 2009 truck
  Objective 1a 50% Brake Thermal Efficiency
  Objective 2  55% Brake Thermal Efficiency Concept

- Reporting Period Objectives
  - Evaluate candidate technologies on concept vehicle
  - Complete technology selection (Phase I)
  - Start development & integration of technologies into demonstrator (Phase II)
**Approach: Technology Selection & Integration**

### Phase I - Concept Selection
- Baseline Tests
- Techn. Development
  - Concepts Evaluation
    - engine bench
    - mule truck
  - Concept Truck
- Model Development
  - Validation
  - Energy Management Dev.
  - Virtual Optimization

### Phase II - Development & Integration
- Techn. Refinement
  - Validation
  - Integration
    - demonstrator chassis
  - Optimization
  - Demo Truck

**Identify, evaluate and select most promising technologies**
Designing for real operating conditions

System Simulations

>1 billion miles of logged data

Customer Duty Cycles

Speed distribution (%) Simulated vs. log data

VOLVO

FREIGHT WING

Grote

PENNSTATE
Typical Fuel Energy Analysis (Long-Haul)

- Air Drag
  - Trailer add-on devices
  - Tractor redesign
- Rolling Resistance
  - Next gen. tires
  - Weight reduction
  - Intelligent controls
  - Smart 6x2
- Heat to Coolant
  - Combustion improvements
  - Rankine Cycle
  - Friction reduction
- Exhaust Heat
  - Turbo compounding
- Downsizing
  - Driveline loss
- Friction reduction
  - Brake loss

Next gen. tires

Volvo
Freight Wing
Grote
Importance of Integrated Design
Vehicle vs. Powertrain Improvements

Packaging, Cooling Needs,
...

Road Load, Heat Rejection,
...
Accomplishments: Phase I Testing Complete

- 16 configurations of Tractors & Trailer Modifications
- > 6,000 miles of on-road testing
- Correlated to chassis dynamometer & simulations
Phase I Results

- **On-road**
  - Chassis Dyno

- **Phase I**
  - Fuel Economy % imp
  - Freight Efficiency % imp
  - Payload Capacity Change %

- **Phase II**
  - 43% improvement
  - 41% improvement
Complete Vehicle Aerodynamic Optimization

Target > 40% lower drag

“best in class” MY2009

Fleet testing on-going to verify operational performance

Status: 30% drag reduction

Trailer add-on devices

Tractor tweaks

Integrated design

Co-optimization

Target > 40% lower drag
Accomplishments: Powertrain Improvements

- Demonstrator engine running in test cell
  - 11liter engine capable of same power as the 13liter
  - Targeting ~400lbs powertrain weight reduction
- 50% BTE technologies in test on component test rigs
Accomplishments: Ultra Light Frame Assembly

Q3’2012
- Evaluate Concepts
  - Bending
  - Innovation
  - Weight savings
  - Manufacturing
  - ...

Q2’2013
- Detailed Design & Stress Analysis
  - FEA
  - Virtual test track
  - ...

Q1’2014
- Prototype Fabrication
  - From idea to prototype in 18 months

> 40% lighter
New Opportunities for **Energy Management**

- **Intelligent Controls** leverage vehicle improvements to achieve further fuel efficiency gains
- **Auxiliary Integration** maximizes use of free energy
- **Powertrain Management** minimizes fuel use
Future Work: Demonstrator Build Plan

- **2014**
  - Axles, Brakes, Wheels, Tires, etc ordered
  - Axle Installation In Chassis
  - Exterior Chassis components ordered
  - Assembly begins for Chassis components
  - Cab BIW assembly Begins
  - Chassis Built and Delivered to VOLVO

- **2015**
  - APU Delivered
  - Engine Transmission Installation
  - Hood/Bumper, Roof, Ground Effects, Chassis Fairings, Side Deflectors Ordered
  - Cab Installed on Chassis
  - Chassis Components Complete
  - Chassis Built and Delivered to VOLVO
  - APU Delivered
  - Engine Transmission Installation
  - Hood/Bumper, Roof, Ground Effects, Chassis Fairings, Side Deflectors Ordered
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  - Chassis Built and Delivered to VOLVO
Summary: Reporting Period Objectives

• Accomplishments at 55% Project completion
  – Candidate technologies evaluated on concept vehicle
    – Demonstrated 43% Freight Efficiency Improvements
    – Demonstrated 48% BTE powertrain in vehicle
  – Completed Concept selection (Phase I) on schedule
  – Started development & integration of technologies into demonstrator (Phase II)

• Next Steps
  – Integrate technologies in Demonstrator vehicle for initial tests by next AMR
  – Continue on-going operational testing of trailer aero improvements
## Partners & key Collaborations

<table>
<thead>
<tr>
<th>Organization</th>
<th>Key Contribution</th>
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<tbody>
<tr>
<td>Volvo Technology of America</td>
<td>Project lead &amp; concept simulations</td>
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<tr>
<td>Volvo Group Truck Technology</td>
<td>Complete vehicle integration &amp; vehicle testing</td>
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<td>Volvo Group Powertrain Engineering</td>
<td>Efficient complete powertrain solutions</td>
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<td>Ridge/Freight Wing</td>
<td>Advanced aerodynamic devices for trailers</td>
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<tr>
<td>Grote</td>
<td>Advanced lighting systems</td>
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<tr>
<td>Penn State University</td>
<td>Advanced combustion modeling &amp; simulation</td>
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<tr>
<td>Hendrickson</td>
<td>Lightweight trailer axle &amp; suspension components</td>
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<tr>
<td>ExxonMobil</td>
<td>Advanced fuels &amp; lubricants</td>
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<tr>
<td>Alcoa Wheels</td>
<td>Lightweight wheels</td>
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<tr>
<td>Michelin</td>
<td>Advanced low-friction tires</td>
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<tr>
<td>Metalsa</td>
<td>Ultra-Light Frame Assembly</td>
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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 – Reduce Thermal Load w/ NREL

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