Volvo SuperTruck

Powertrain Technologies for Efficiency Improvement

DOE Contract DE-EE0004232

2012 Annual Merit Review
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ACE060

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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

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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

Relevant Research

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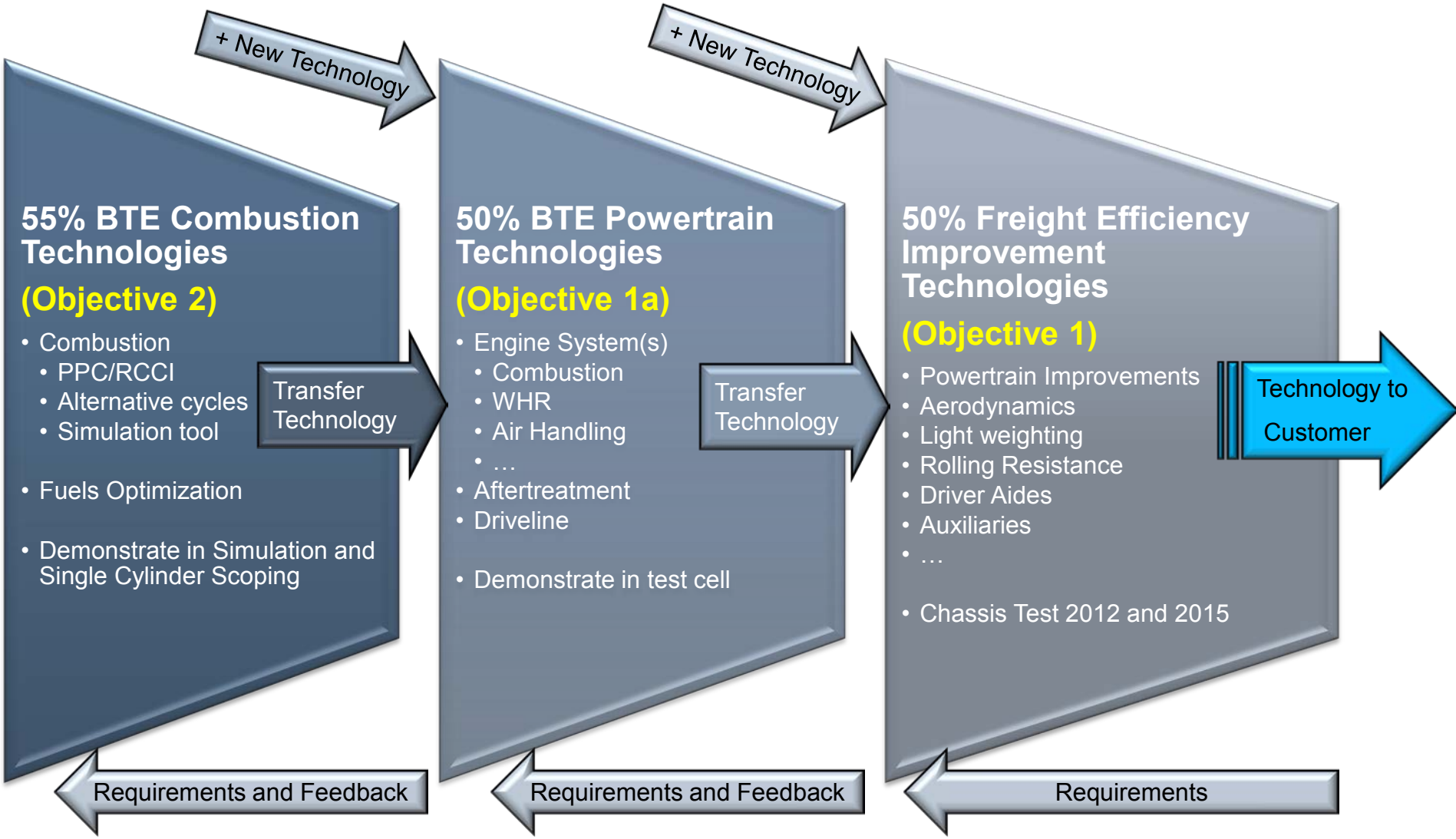
Total Powertrain Workflow Approach



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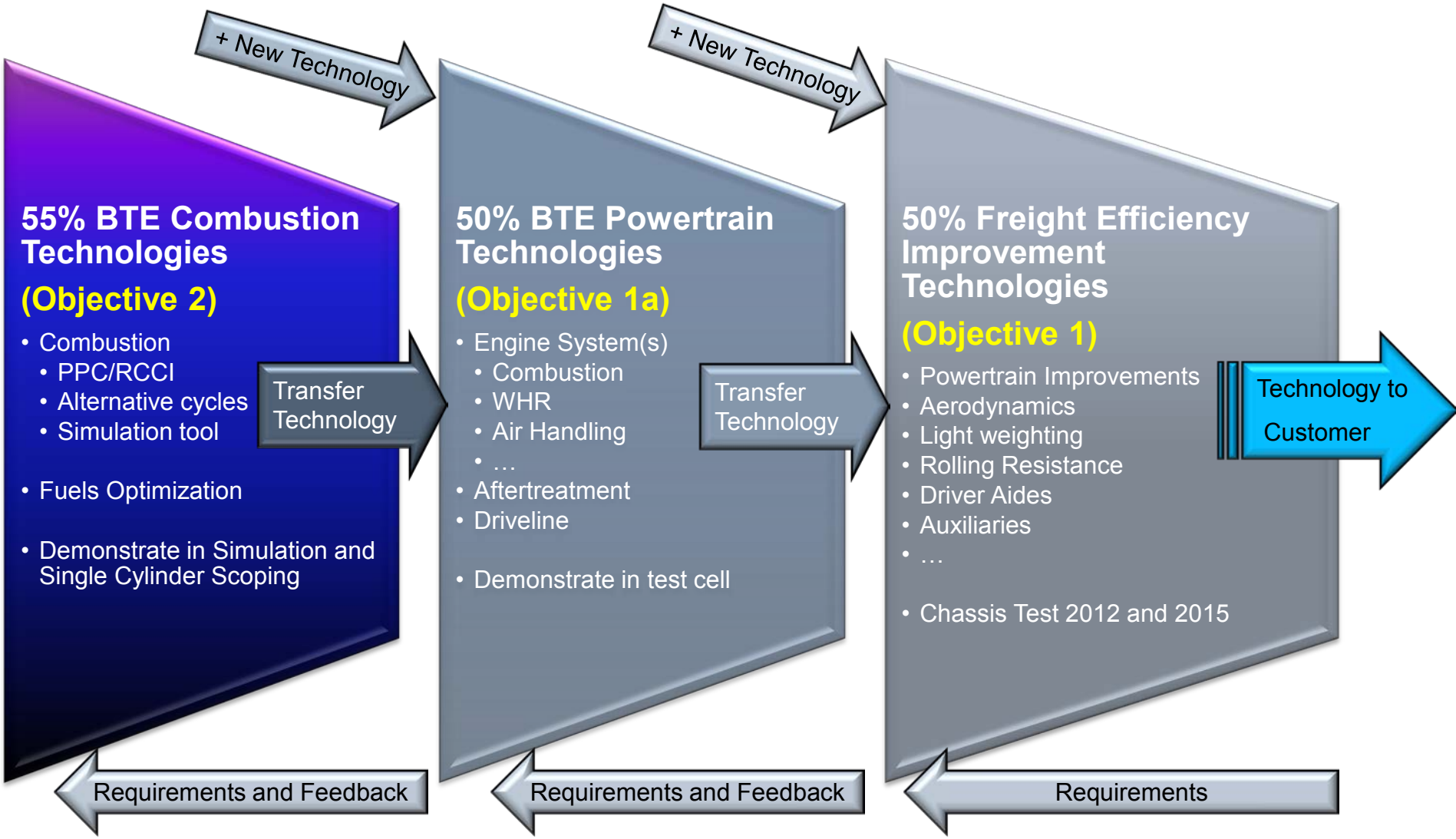
Total Powertrain Workflow Approach



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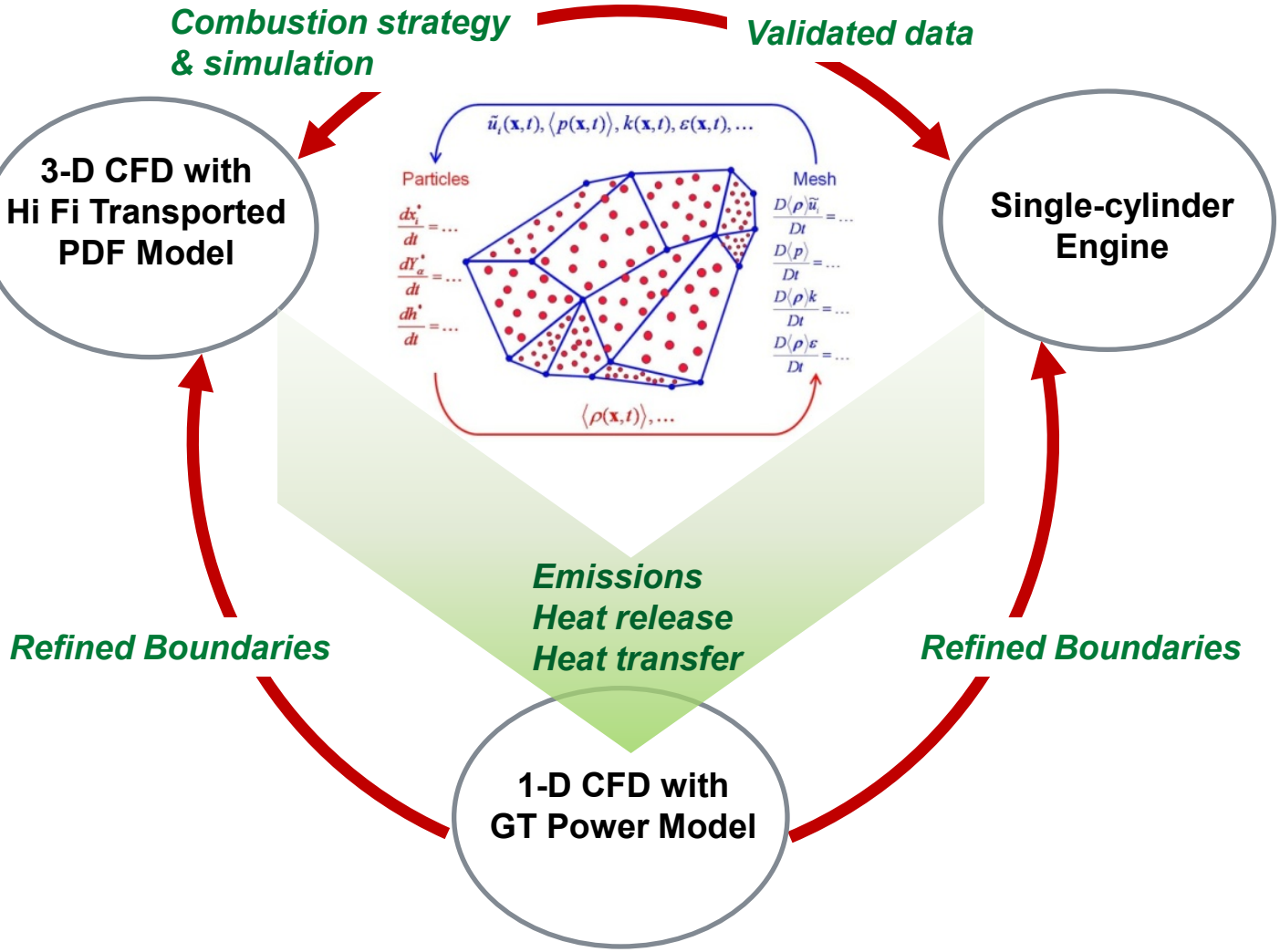
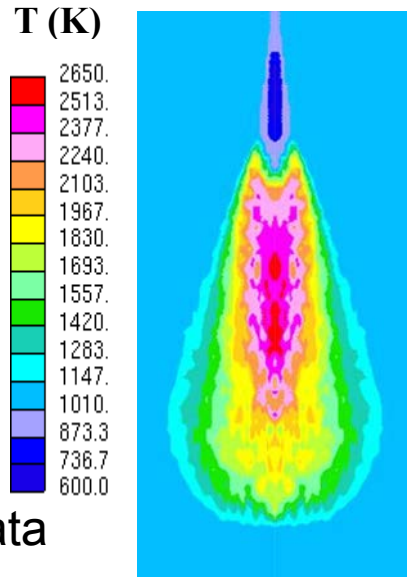
Approach for 55% BTE Engine Concept Evaluation (Objective 2)



Accomplishments – Fuel Combustion and Emissions Study (Objective 2)

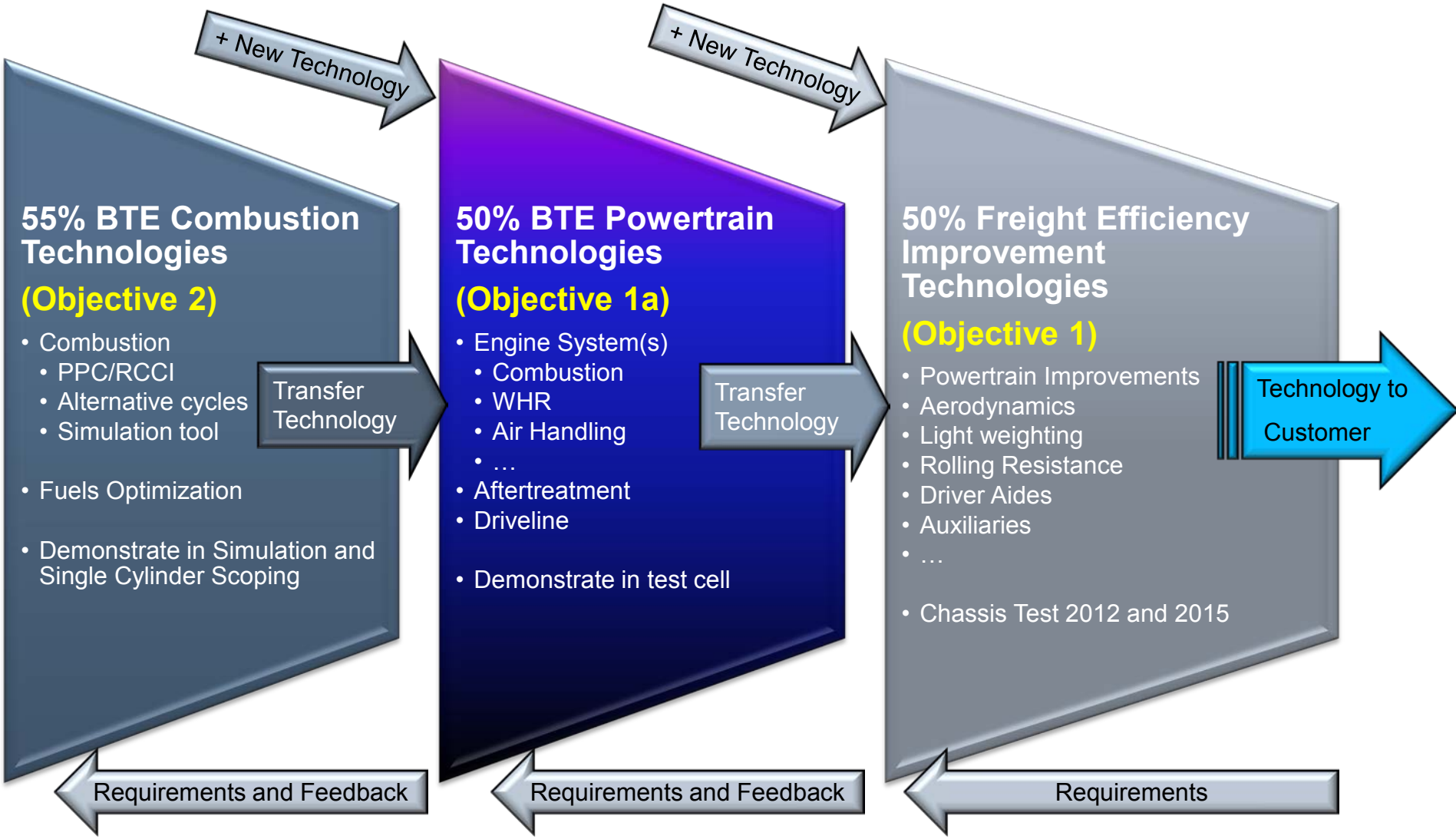
- 3-D In-Cylinder Combustion CFD Study
  - Developed Transported PDF model for turbulent combustion
  - Validated fuel chemical mechanisms for chemistry model
    - Single-component fuels validated using data from Engine Combustion Network under diesel-relevant conditions
    - PRF (Primary Reference 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.

Spray Flame Simulation



Ref: PDF model results from Penn State University

Total Powertrain Workflow Approach



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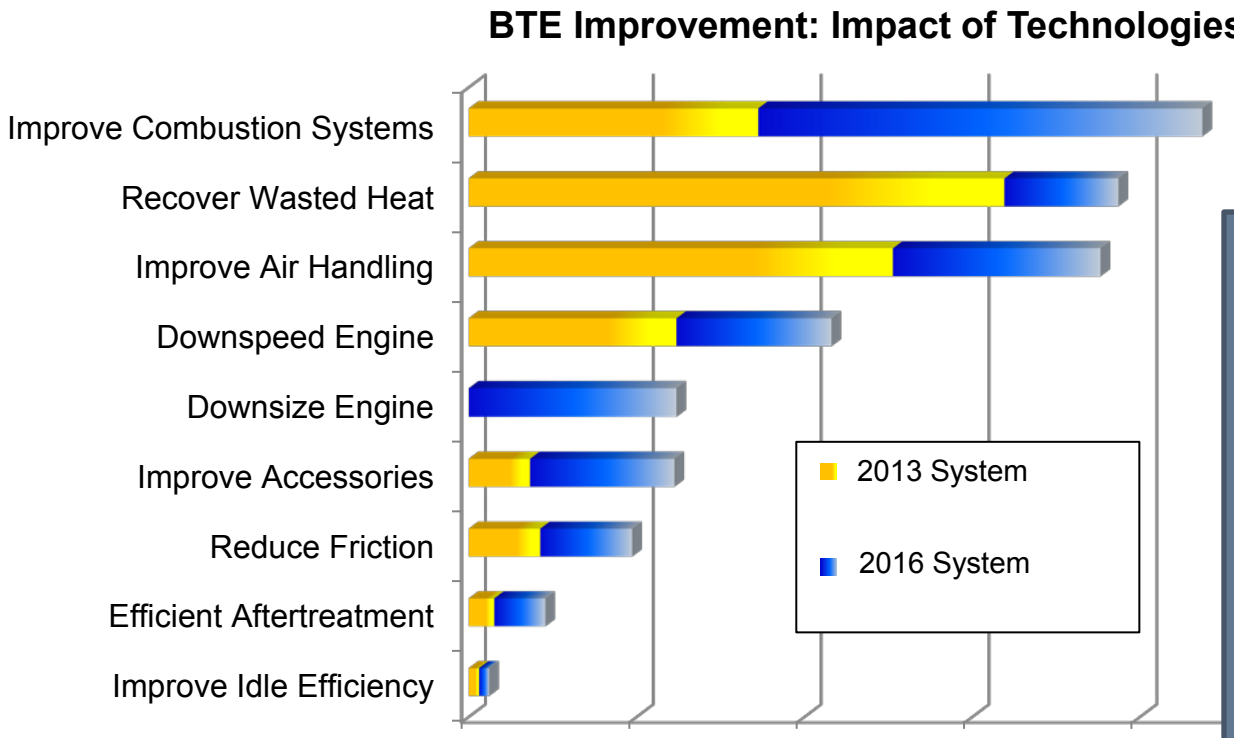
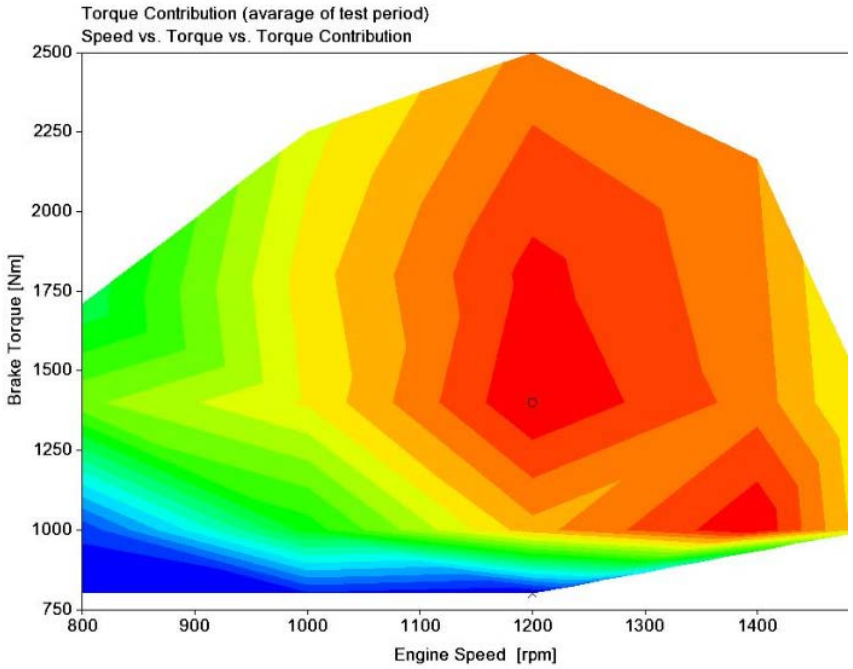
Strategy for 50% BTE Powertrain Demonstration (Objective 1a)



- 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)

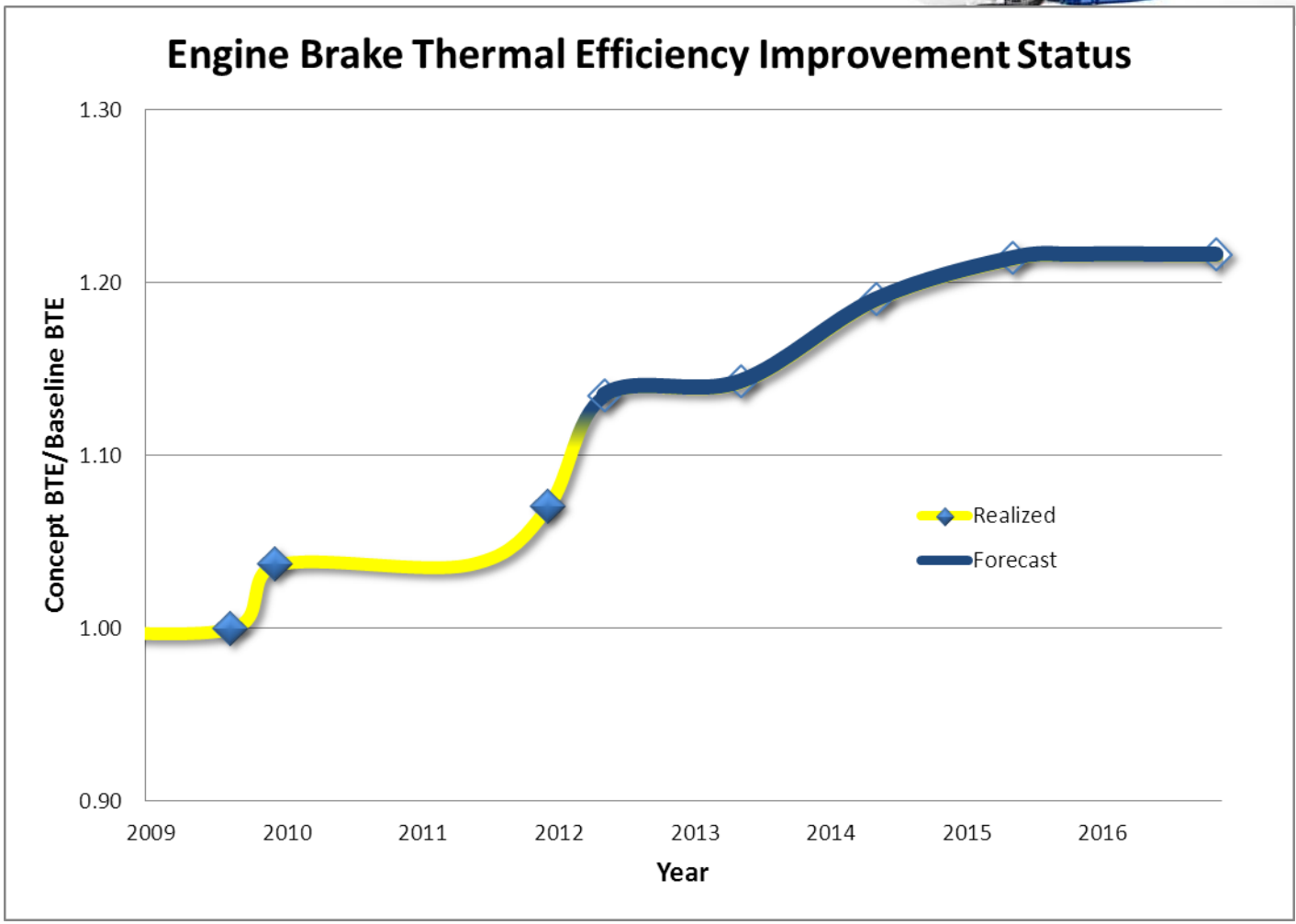
Engine test: built and tested engine(s) with prototype combustion, air handling, fuel injection, and EATS as integrated unit



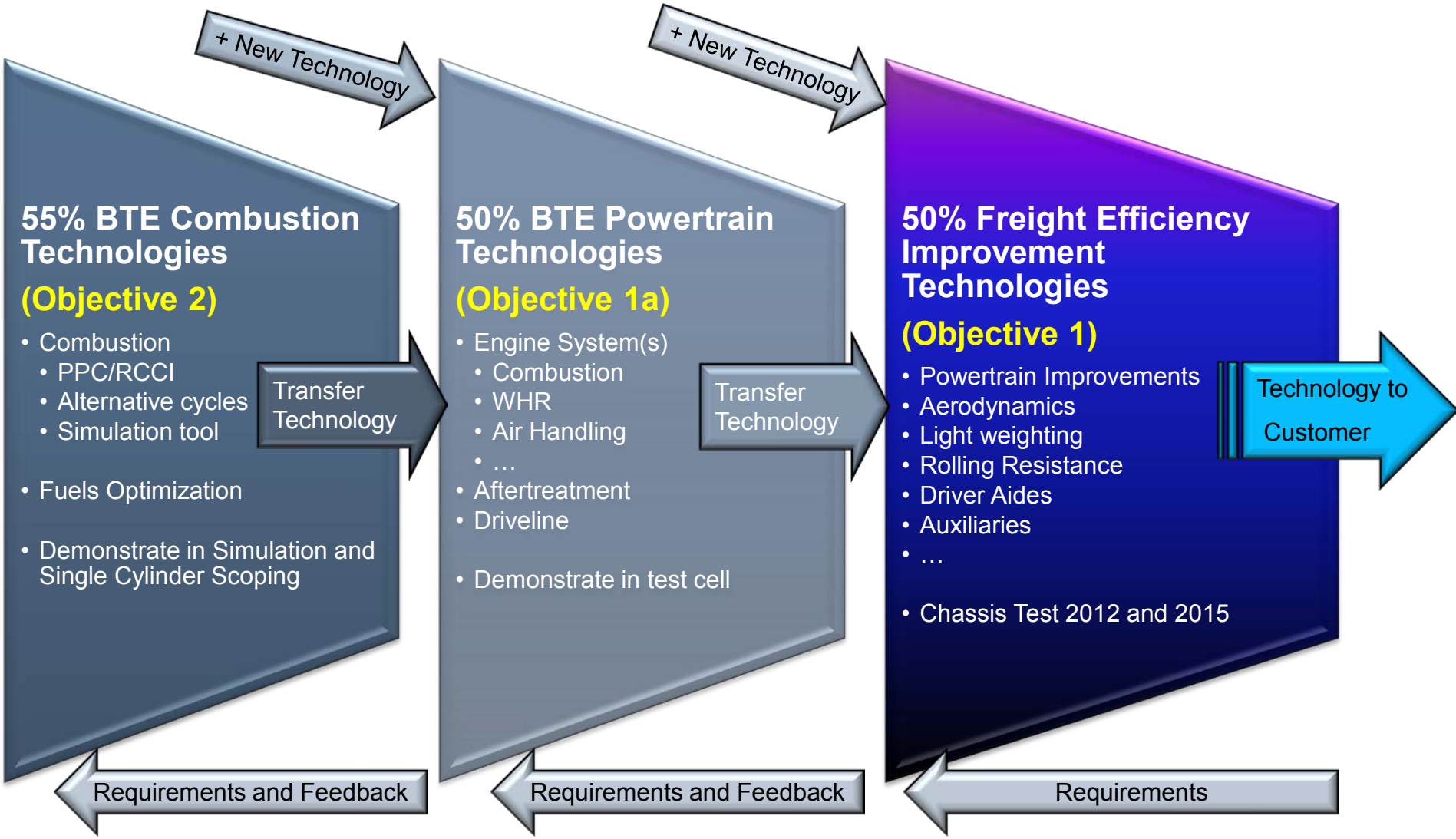
Rankine system test: power generation mapped steady state

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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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

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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

Milestone	Status
Baseline test completed	Completed
WHR Technology Freeze	Completed
Engine Platform Freeze	Completed
Fuel injection Hardware Freeze	Completed
Concept Definition for Complete Powertrain	Completed
Technology Chosen for Coolant Pump	Completed
Technology Chosen for Power Steering Pump	Completed
Upcoming Milestone: 55% Thermal Efficiency: 1st concept selection	On track
Upcoming Milestone: 2013 Concept Evaluation Truck Built	On track
Upcoming Milestone: 2013 Concept Evaluation Truck Results	On track

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.