Impact of Vehicle Efficiency Improvements on Powertrain Design

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SuperTruck

Project Overview

- **Objective#1**: Improve Freight Efficiency by 50%
  - Requires a powerplant capable of 50% Brake Thermal Efficiency
- **Objective#2**: Demonstrate a 55% Brake Thermal Efficiency Concept

  Baseline = MY2009 ‘best in class’ highway vehicle

- **Duration**: 5 years
- **Project Cost**: $38M (cost share: $19M)

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SuperTruck: a Complete Vehicle Effort

Advanced Driver Aids

High Efficiency Combustion

- Waste Heat Recovery
- Turbo-Compound
- Downspeeding
- …

Idle Reduction

Auxiliary System Improvements

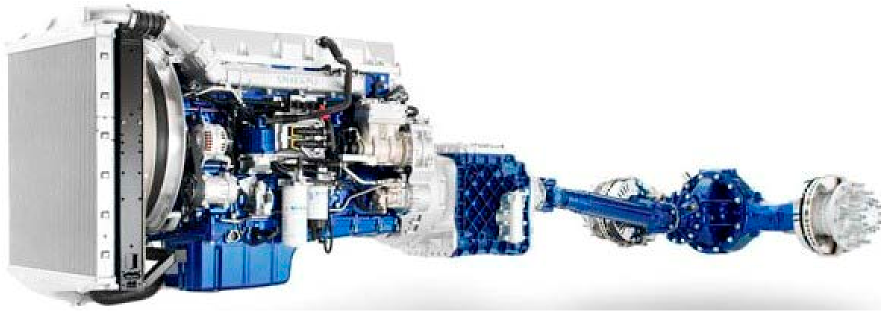
Advanced Materials

Rolling Resistance Reduction

Aero. Drag Reduction

Vehicle and Powertrain Descriptions

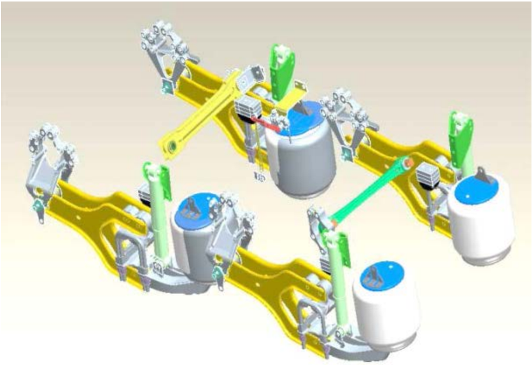
	Baseline 2009 VNL Truck	VEV1 Updated VNL Trailer Aero	VEV2 Complete truck & Trailer re-design
Aero Cd	--	22% reduction	39% reduction
Rolling Resistance	--	12% improvement compared to baseline	20% improvement compared to baseline
Rankine	--	Gen 1	Gen 2
Auxiliaries	--	25% reduction	25% reduction
Engine	13L	13L	11L
Axle Config	6 x 4	6 x 2	6 x 2



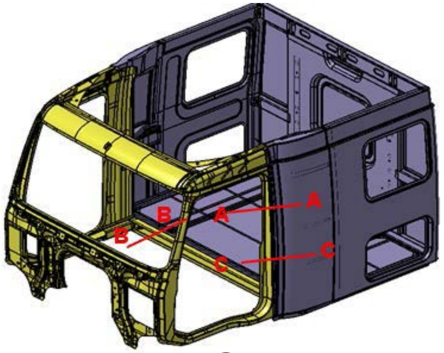
Total Vehicle System Design

Lightweight intelligent efficient drivetrain

Parasitic Loss Reduction

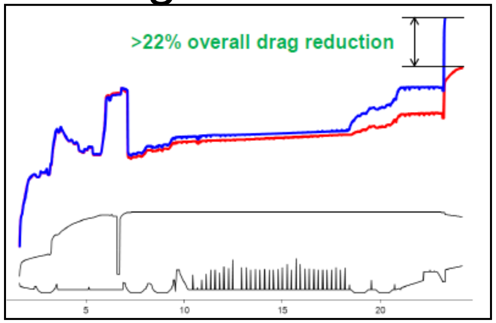


High Strength Lightweight Suspension

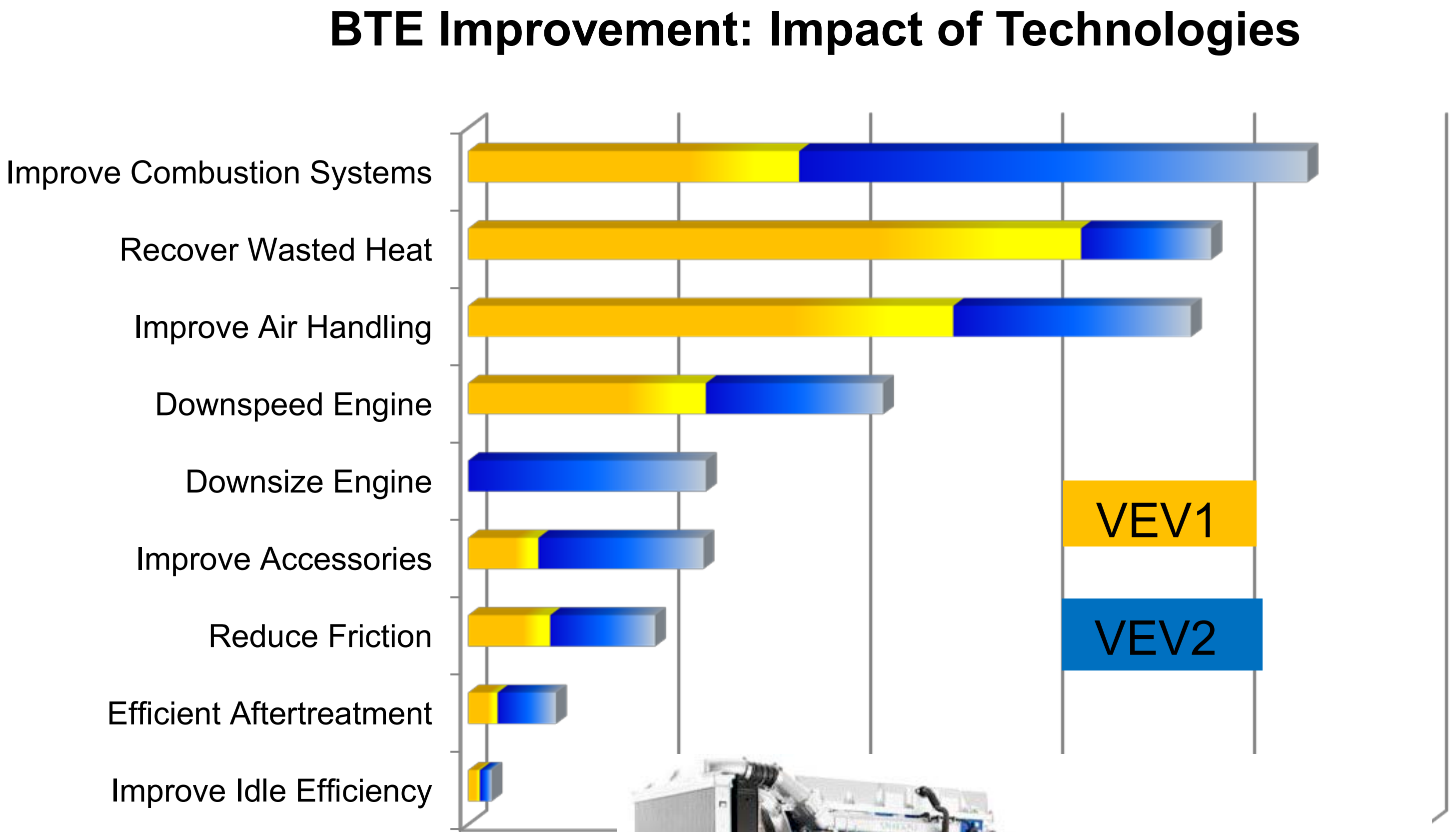


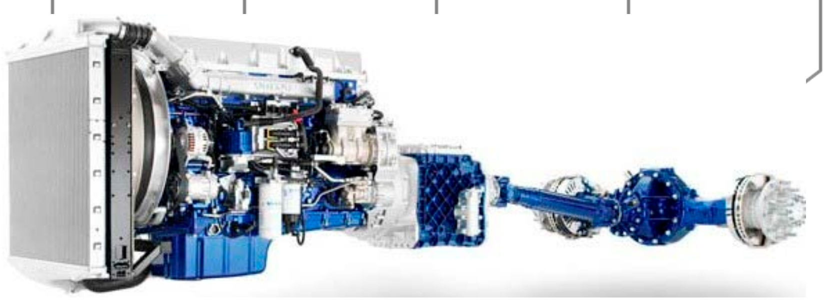
Lightweight Chassis and Cab Materials

Vehicle Aerodynamic Drag Reduction



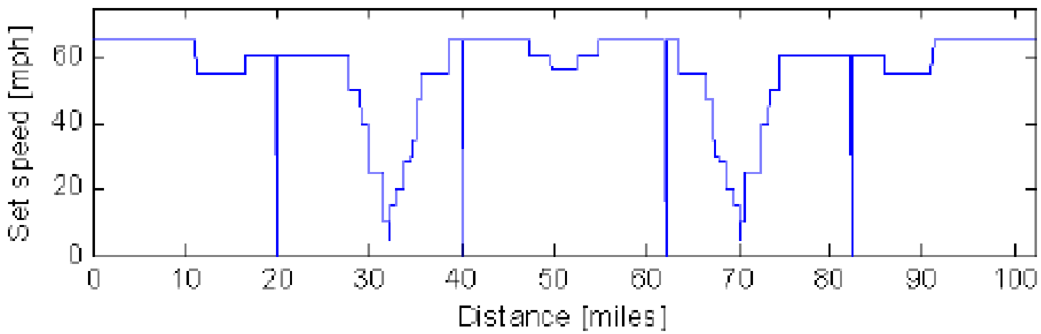
Powertrain Design for 50% BTE





Simulating real-life conditions

Virtual Duty cycles match >1,000,000,000 miles of data



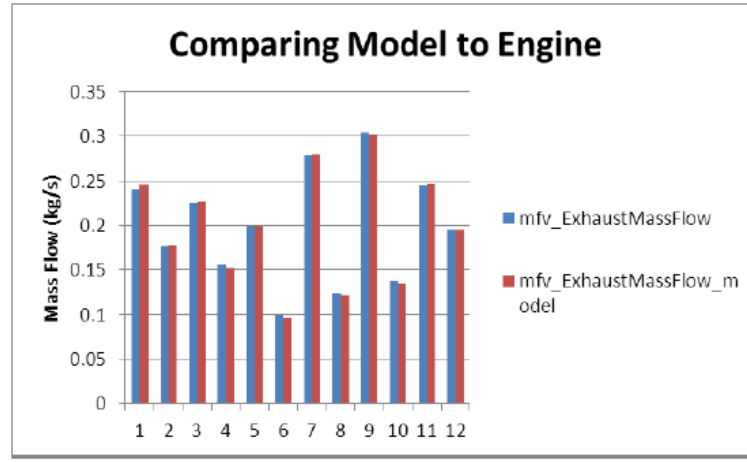
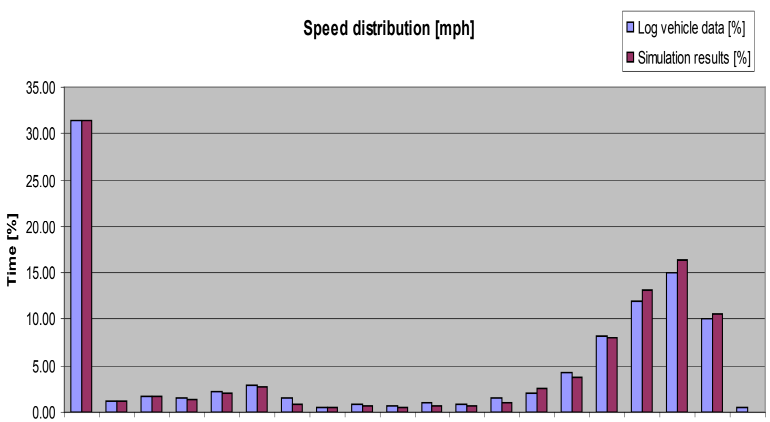
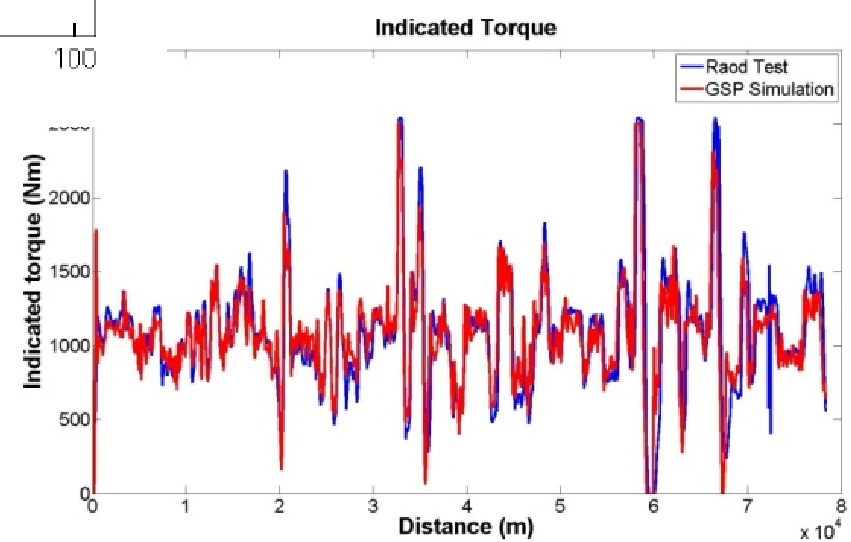


Figure 52 Comparison of Engine Exhaust Mass Flow versus Model Output





Global Simulation Platform

Total Vehicle

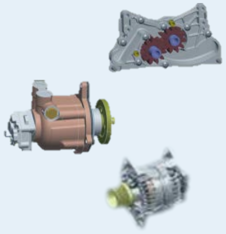
Operation Profiles → Driver → Powerplant → Transmission → Auxiliaries → Chassis

System Models

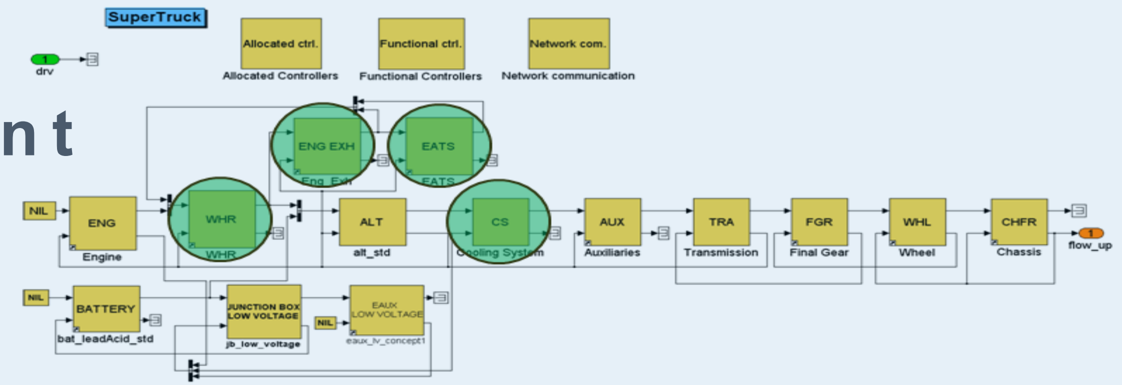
Dynamic Engine

WHR APU

EATS

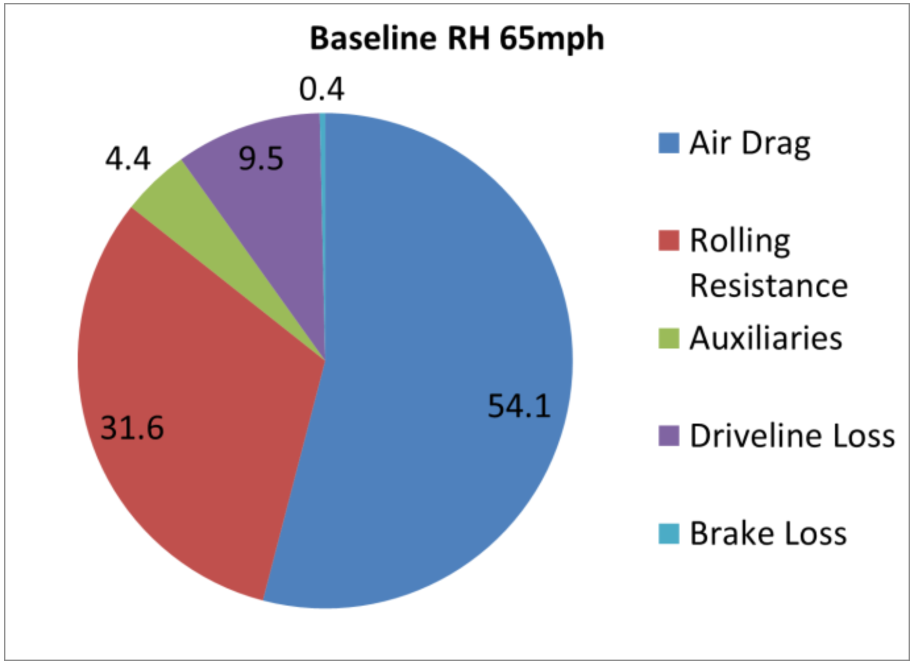


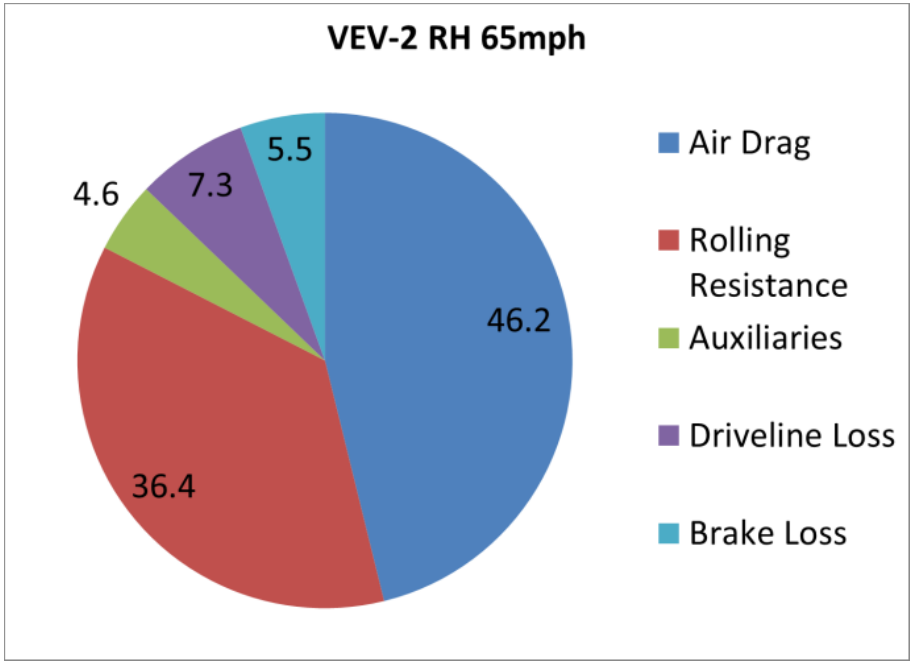
Component Models



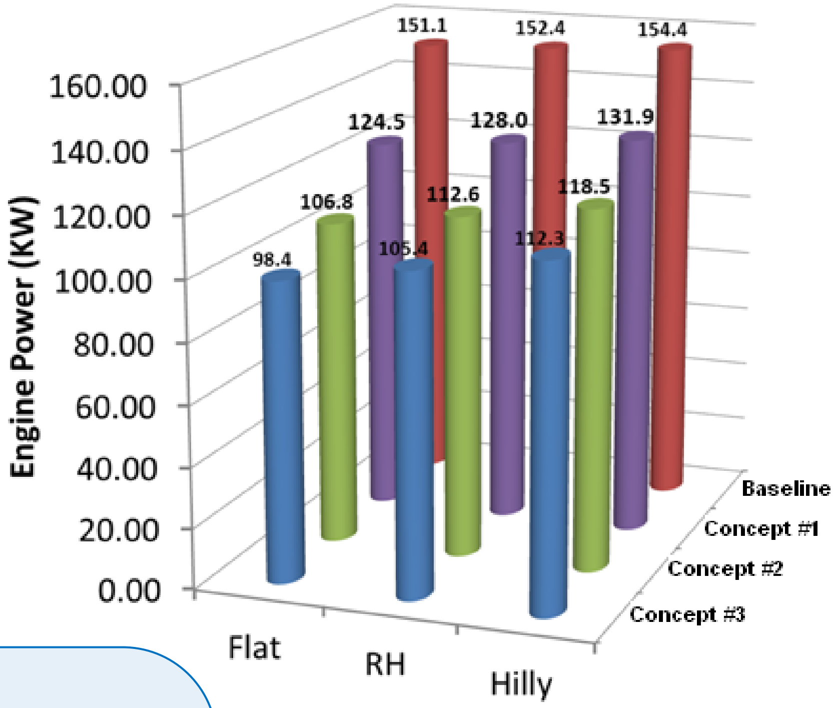
Impact of Vehicle Efficiency Improvements on Powertrain Design

Simulation results have been used to identify and quantify the effect of reduced aerodynamic drag, improved PT efficiency and rolling resistance on the road load conditions for a highway truck





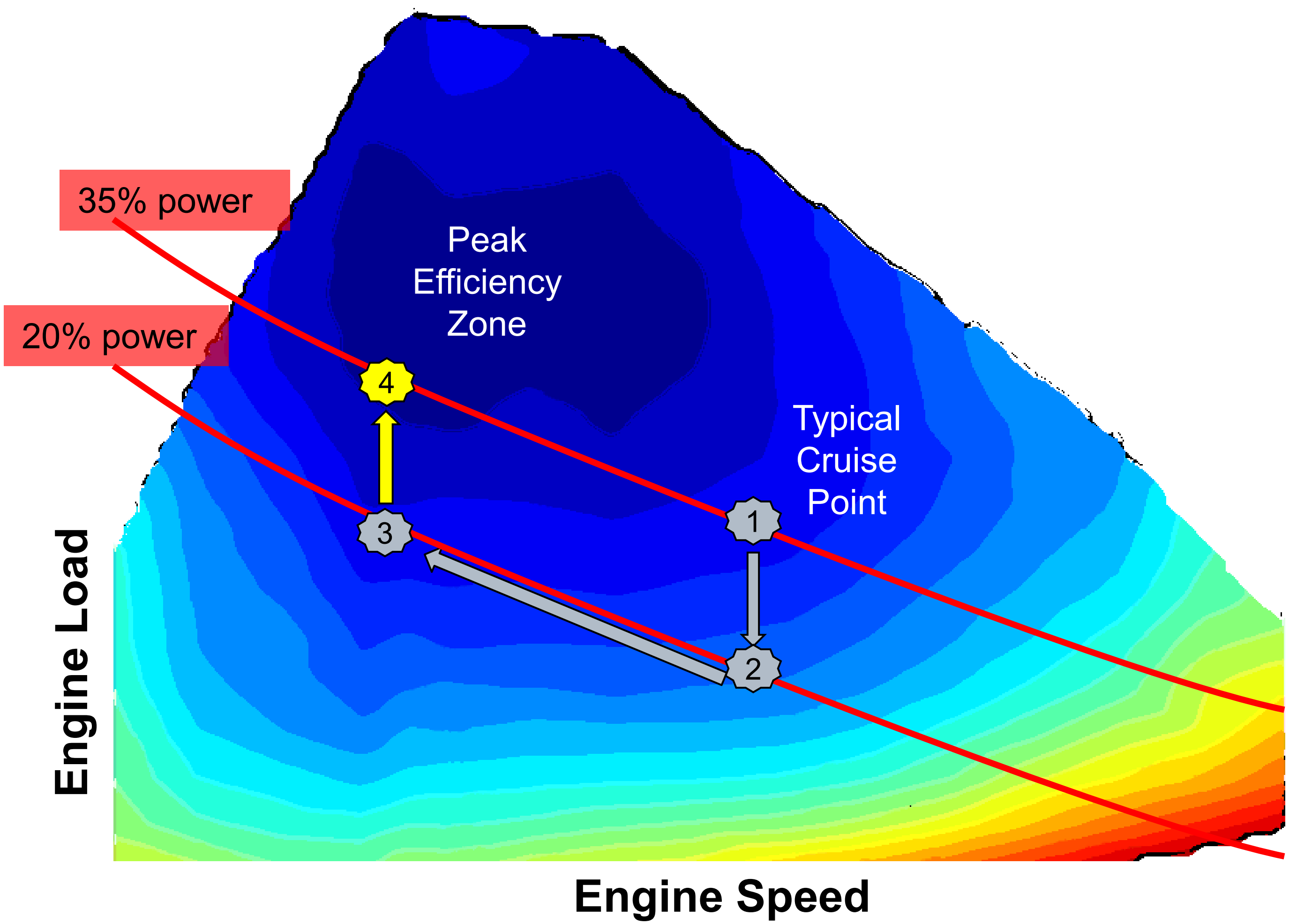
Influence on Power Demand



<u>Sample of Sensitivity Analysis</u>

- If we assume improvements that are aggressive enough to meet the SuperTruck project goals, average power demand could be reduced by as much as 35%.
- Requirements on acceleration & gradeability limit the degree of engine size reduction

Engine Efficiency Impact at Cruise Condition



Analysis of typical diesel engine efficiency profile.

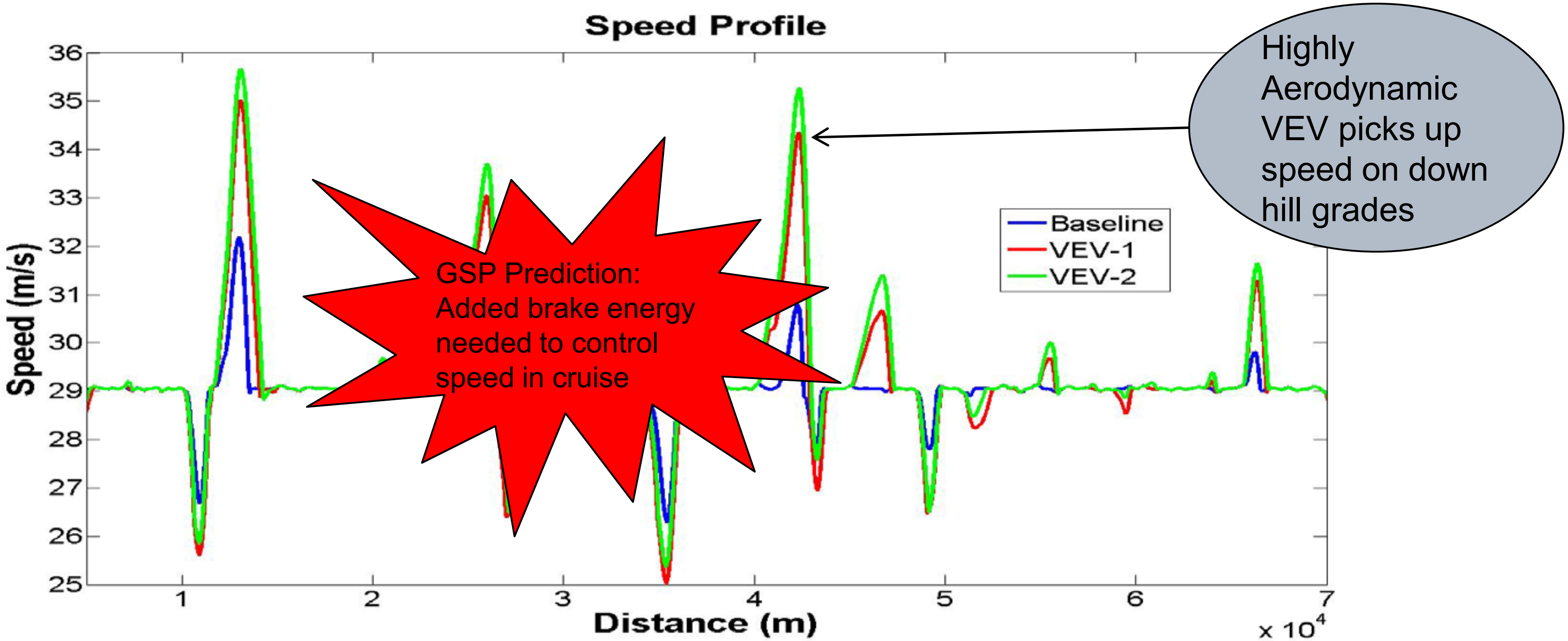
- 1-2: Chassis improvements reduce load (areo, friction)
- 2-3 Downspeeding improves efficiency
- 3-4 Downsizing increases percent load

RESULT:

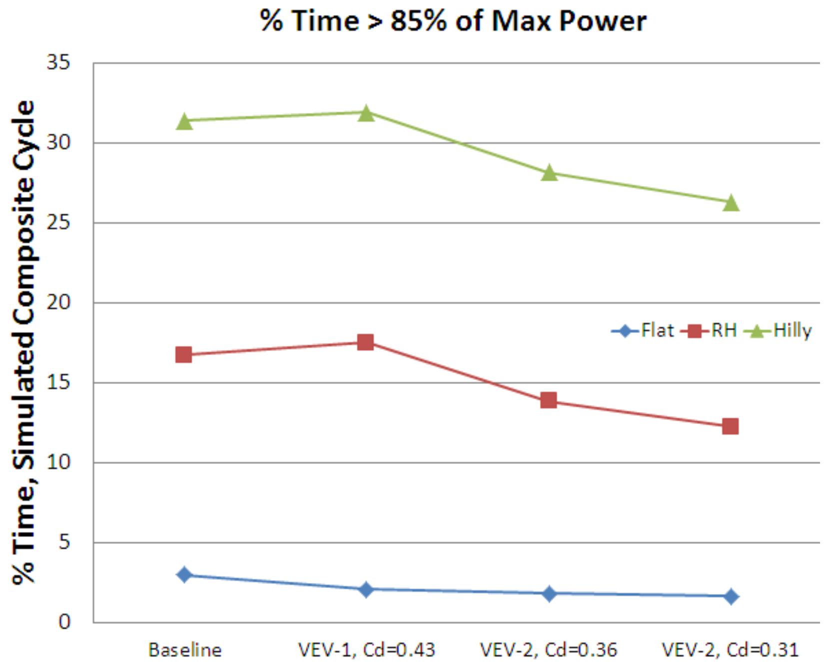
- Overall improvement in engine brake specific efficiency
- Major improvement in vehicle fuel consumption

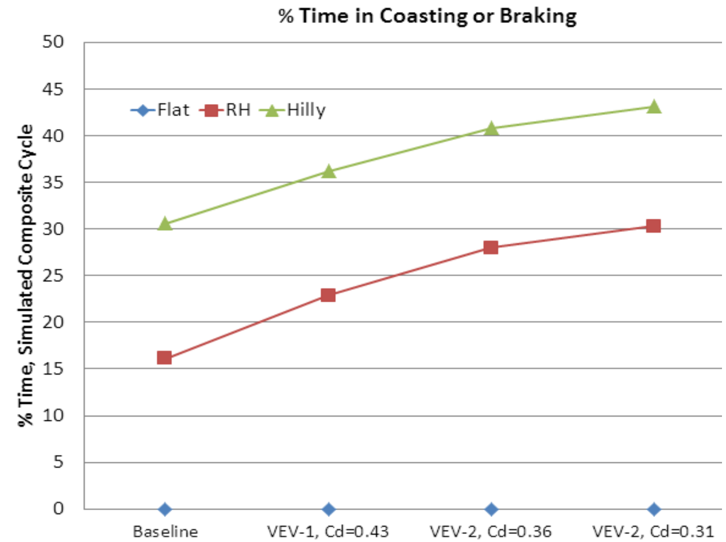
Influence on Vehicle Speed Management

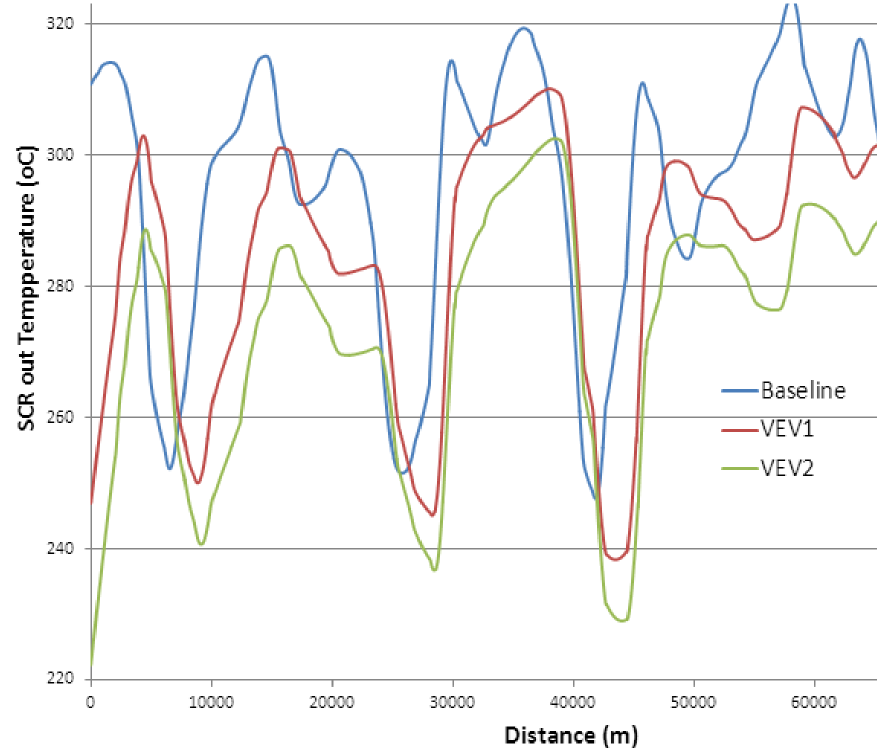
- The braking energy required to regulate cruise speed of the vehicle over hilly terrain will increase due to lower drag, rolling resistance and friction forces.
- And advanced vehicle controls become more valuable (e.g. terrain predictions, vehicle communication, torque management, etc)



Influence on EATS Management







- The distribution of <u>power and brake</u> demand is affected by complete vehicle improvements.
- Both trends result in lower EATS temps (one attribute among many)

Designing an Integrated Solution

Volvo is successful in using simulations to:

- minimize the predicted increase in brake energy for concept trucks
- design advanced control strategies e.g. using “Look-ahead” and terrain based torque controls
- quantify potential fuel savings with various concepts
- pre-size components and systems for the new concepts

Conclusions

- Complete vehicle integration and system analysis is key to achieving the SuperTruck efficiency goals.
- Initial VEV prototype data and simulations indicate:
  - Reduced power demand for long haul duty-cycle cruise conditions
  - Challenges for future EATS application
  - Opportunity to optimize vehicle brake energy
  - Highlighted need for terrain based, torque management tools

Acknowledgments

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