New ICE age?
New I C E age!
Total Truck life Costs matters – fuel economy still dominating


- Cyclical Fuel Market Trends To Be Considered and Optimized for A Best NO\textsubscript{x}/BSFC Customer Value Ensuring Regulatory Compliance.

- Fuel Economy Continue To Be #1 Priority For Our Customers.
DAIMLER

Market Trends in the US Trucking Industry

Market Factors
- Rising Fuel Prices
- Urbanization of Population
- 75% of Consumption is in the East
- GHG Legislation – Efficiency is Key

- Freight Efficiency
- Improved Aerodynamics
  - Lightweight
- Flexibility in Logistics
- Emphasis on Spoke & Hub Operations

U.S. Truck Demand
Classes 6-8
monthly sales, in ‘000, seasonally adjusted, Ward’s

Projected population growth will increase volume and capacity requirements

Eastern U.S. region holds 66% of the U.S. population
Approximately 75% of U.S. consumption takes place in the East

Population in Major Metropolitan Areas

GT 10,000,000
5,000,000 - 10,000,000
2,500,000 - 5,000,000
1,500,000 - 2,500,000
1,000,000 - 1,500,000

'07 '08 '09 '10 '11 '12

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Step 1: Requirements for MY 2013-2014 finalized and being implemented.
Step 2 Early stage of development with guiding principle “global harmonization”
First step: Early fulfillment of GHG2014

- EPA’s GHG 2014 standard must be met beginning model year 2014
- Daimler has decided to certify its 2013 vehicle fleet with GHG2014 one year early!

Fuel Economy

- Asymmetric Turbo
  - Simplified design

- ACRS Gen. II
  - Optimized injection process

- Advanced Cooling
  - Clutched, variable speed

- Fuel Filter Module
  - Simplified and extended maintenance

- Integrated Engine Brake
  - Quiet 3 stage braking

- DDEC
  - Optimized engine management
Future improvements

- Optimized Aftertreatment
- Advanced integrated Transmission Concepts
- Hybrid Concepts
- Advanced turbocharger Technologies next generation
- Predictive Torque & Auxiliary Management
- Next Generation Controller

- Engine
- Motor
- Clutch
- T/M
- Inverter
- Battery
- Optimized Combustion
- Enhanced High Pressure Fuel Injection System
- Waste Heat Recovery
- Asymmetric twin scroll turbine
- Large Scroll
- Small Scroll
- Optimized Aftertreatment
- Advanced integrated Transmission Concepts
- Hybrid Concepts
- Predictive Torque & Auxiliary Management

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Parasitic Management

- Smarter Use Of Optimized Accessories And Pumps
- Optimized piston / rings/ liner geometries designed to low friction
- Low viscosity oil
- Feedback Control System of accessories for optimal operation
Larger Engine Displacement Required To Offset EGR

Cylinder Pressure Progression

Parametric Trends: NAFTA Truck Engines

<table>
<thead>
<tr>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Pressure</td>
</tr>
<tr>
<td>Injection Pressure</td>
</tr>
<tr>
<td>BMEP</td>
</tr>
<tr>
<td>Engine-Out NOx</td>
</tr>
<tr>
<td>Turbocharger Efficiency</td>
</tr>
<tr>
<td>Engine Breathing Efficiency</td>
</tr>
<tr>
<td>Engine Displacement</td>
</tr>
<tr>
<td>Brake Specific Air Consumption</td>
</tr>
<tr>
<td>EGR Rate</td>
</tr>
<tr>
<td>Engine Speed</td>
</tr>
</tbody>
</table>
Powertrain = Engine + transmission + Axle

- Load Response
- Drive Time
- Drivability
- Low Speed Maneuvering
- NVH
- Thermal/Mechanical Stress
- Surge Margin
- Emission Compliance

Gradeability

Shiftability

Max. Acceleration

Max. Power

Light weight

Powertrain Engineering – Daimler Trucks NAFTA
Complete Detroit Powertrain

The Detroit Transmission is the latest component in the completely integrated Detroit powertrain.

- Optimized Powertrain Interface in future
  - Torque
  - Cooling & Heating Flows
  - Data Exchange
  - Engine - Exhaust Aftertreatment Thermal Marriage
- Waste Heat Recovery System
- Hybrid concepts
Improved and optimized engine for Super Truck

Demonstrate 50% brake thermal efficiency via:

- Engine downsizing (higher BMEP)
- Higher compression ratio
- Improved combustion system
- Air system optimizations, reduced EGR
- Reduced parasitic
- Waste heat recovery

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### Complexity of Engine technologies over decades

<table>
<thead>
<tr>
<th>Key engine technologies 1992</th>
<th>Key engine technologies &gt; 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Fuel injection System</td>
<td>□ Fuel injection System</td>
</tr>
<tr>
<td>□ Turbocharging System</td>
<td>□ Turbocharging System</td>
</tr>
<tr>
<td></td>
<td>□ EGR-Cooler</td>
</tr>
<tr>
<td></td>
<td>□ Mechatronics (i.e. EGR-valve, var. coolant pump, ... )</td>
</tr>
<tr>
<td></td>
<td>□ Aftertreatment System</td>
</tr>
<tr>
<td></td>
<td>□ ECU</td>
</tr>
<tr>
<td></td>
<td>□ Sensors</td>
</tr>
<tr>
<td></td>
<td>□ OBD specific sensors</td>
</tr>
<tr>
<td></td>
<td>□ WHR Systems.........</td>
</tr>
</tbody>
</table>

Collaboration with suppliers on key technologies will be even more important than in the past
Early involvement in new Technologies with i.e. aftertreatment suppliers

<table>
<thead>
<tr>
<th>Technical Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airless DEF delivery system</td>
<td>Better fuel Economy from elimination of air assist</td>
</tr>
<tr>
<td>Reduced number of parts in system</td>
<td>Contributes to lower weight, reduced complexity and improved serviceability</td>
</tr>
</tbody>
</table>

Early knowledge of ATS performance and aging is the key factor to develop a sophisticated, integrated System meeting future OBD requirements. Again, important is an early collaboration with key suppliers.
The New ICE Age has started....

Combined Efficiencies with Engine and Truck

Developed with Future Emissions in Mind

GHG14

The Right Engine for Every Job

All Detroit Engines built with pride in our factory in Michigan

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Summary

- Future Powertrain improvements will be more complex. Technologies which translate to over the road freight efficiency improvements will be crucial for future Heavy Duty Vehicle customer and regulatory demands.
- Freight efficiency improvements require an optimized system integration.
- Close Supplier collaboration is crucial in the Powertrain R&D phase to fulfill future market and legislation demands.
- Future worldwide harmonization of GHG limits is beneficial to environment and customers.
- Super Truck is a key demonstrator helping to continue The New ICE Age.
Thank you for your attention!