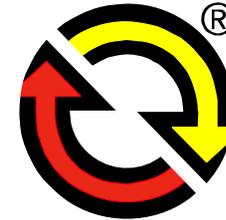


DETROIT DIESEL



Integrated Vehicle and Powertrain Technology for EPA 2010 and Beyond

Rakesh Aneja, Sathish Sankara Chinthamony, Min Sun and Guangsheng Zhu

2007 Diesel Engine-Efficiency and Emissions Research (DEER) Conference
Detroit, August 14, 2007



Contents

- **EPA 2010 Requirements**
- **Powertrain Technology**
- **Vehicle Integration**
- **Diesel Exhaust Fluid (DEF) – SCR Certification Requirements**



EPA 2010 Requirements

- **Regulatory**
 - **83% Reduction in NOx Compared to EPA '07**
 - **From 1.20 to 0.20 g/hp-hr**
 - **On-board Diagnostics (OBD) Requirements**
 - **Not-to-exceed (NTE) Enforced Through In-use Emissions Test Run by Manufacturer**

- **Customer**
 - **Key Metrics Comparable or Better Relative to EPA '07**
 - **Fuel Economy**
 - **Performance**
 - **Heat Rejection**
 - **Durability / Reliability**
 - **Cost**

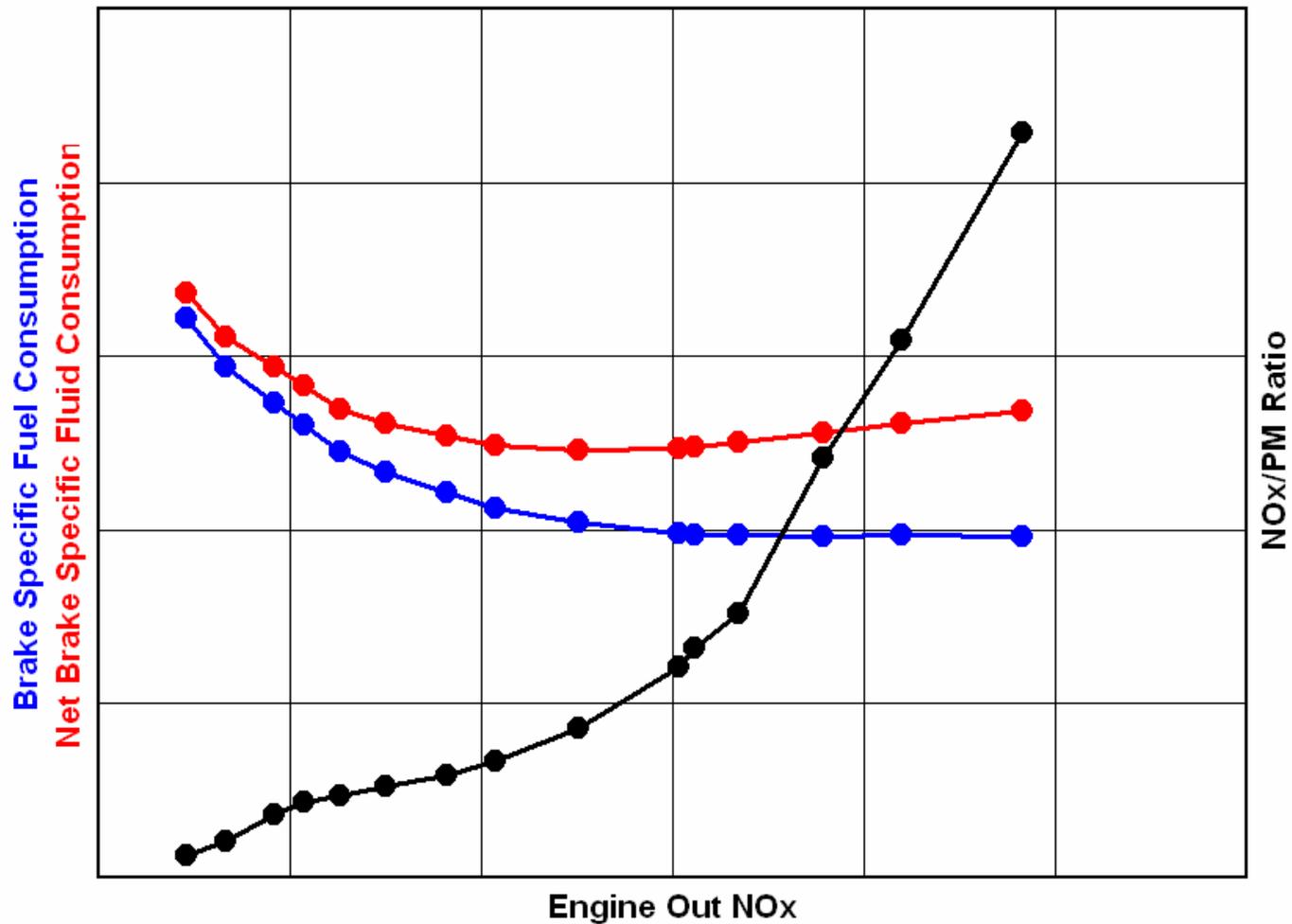


SCR Remains the Lead NOx Aftertreatment Technology for 2010 Heavy-Duty

- **Mature Technology**
 - ➔ **Durability and Reliability for End-Customer**
- **Opportunity to Maintain / Improve Fuel Economy**
- **Low Lifecycle Cost**
- **Minimal Impact on Vehicle Cooling System**
- **Requires Secondary Fluid - DEF**
 - ➔ **DEF Infrastructure Required**
 - ➔ **Compliance / Anti-Tampering Measures Required**
- **Progress is being made on both the Infrastructure and the Compliance Issues in Collaboration with other Stakeholders Including other Engine and Vehicle OEMs**
 - ➔ **SCR Certification Guidance Document Issued by EPA on March 27, 2007**



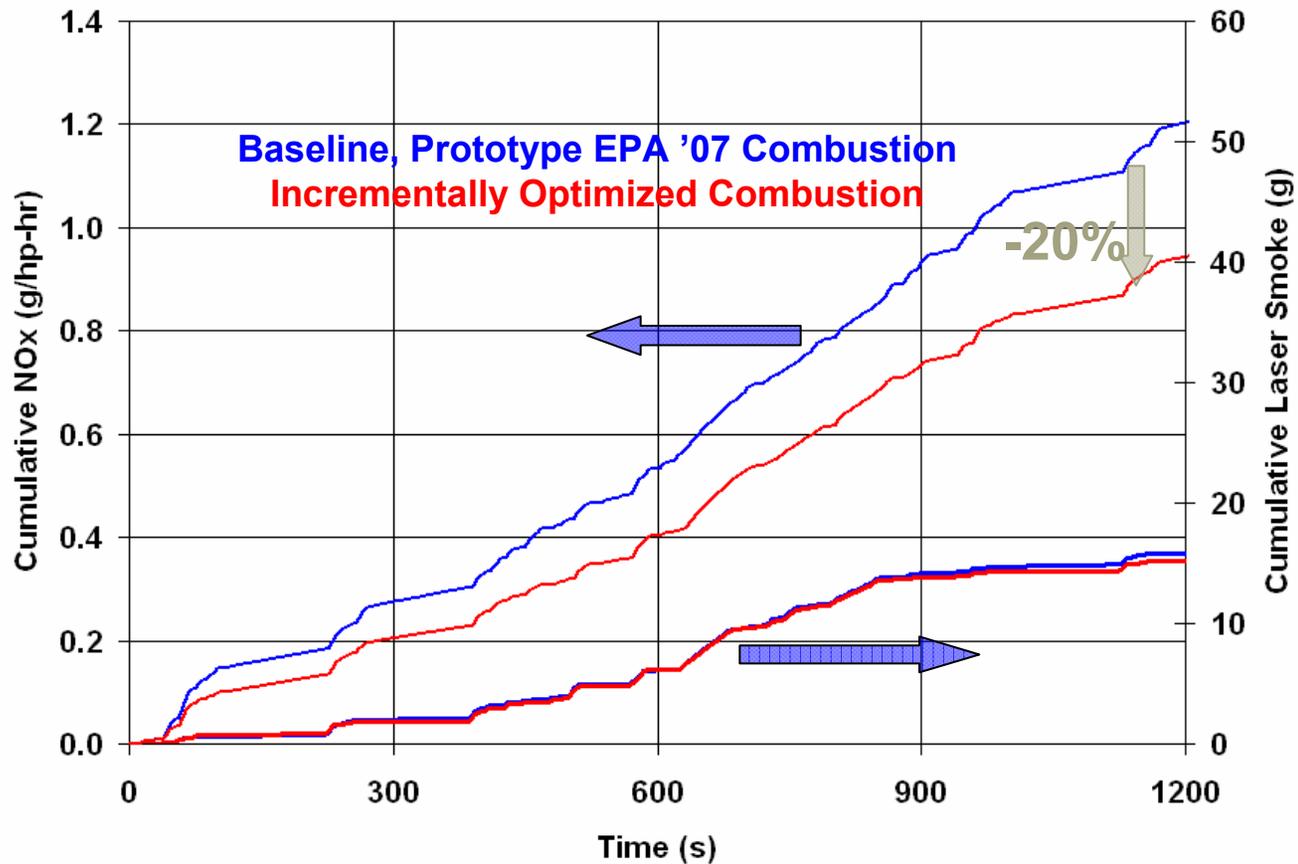
DEF-SCR Offers Potential to Improve Fuel Economy Magnitude Depends on Combustion System Characteristics





Selective Implementation of Low Emissions Combustion over Transient Hot FTP Cycle

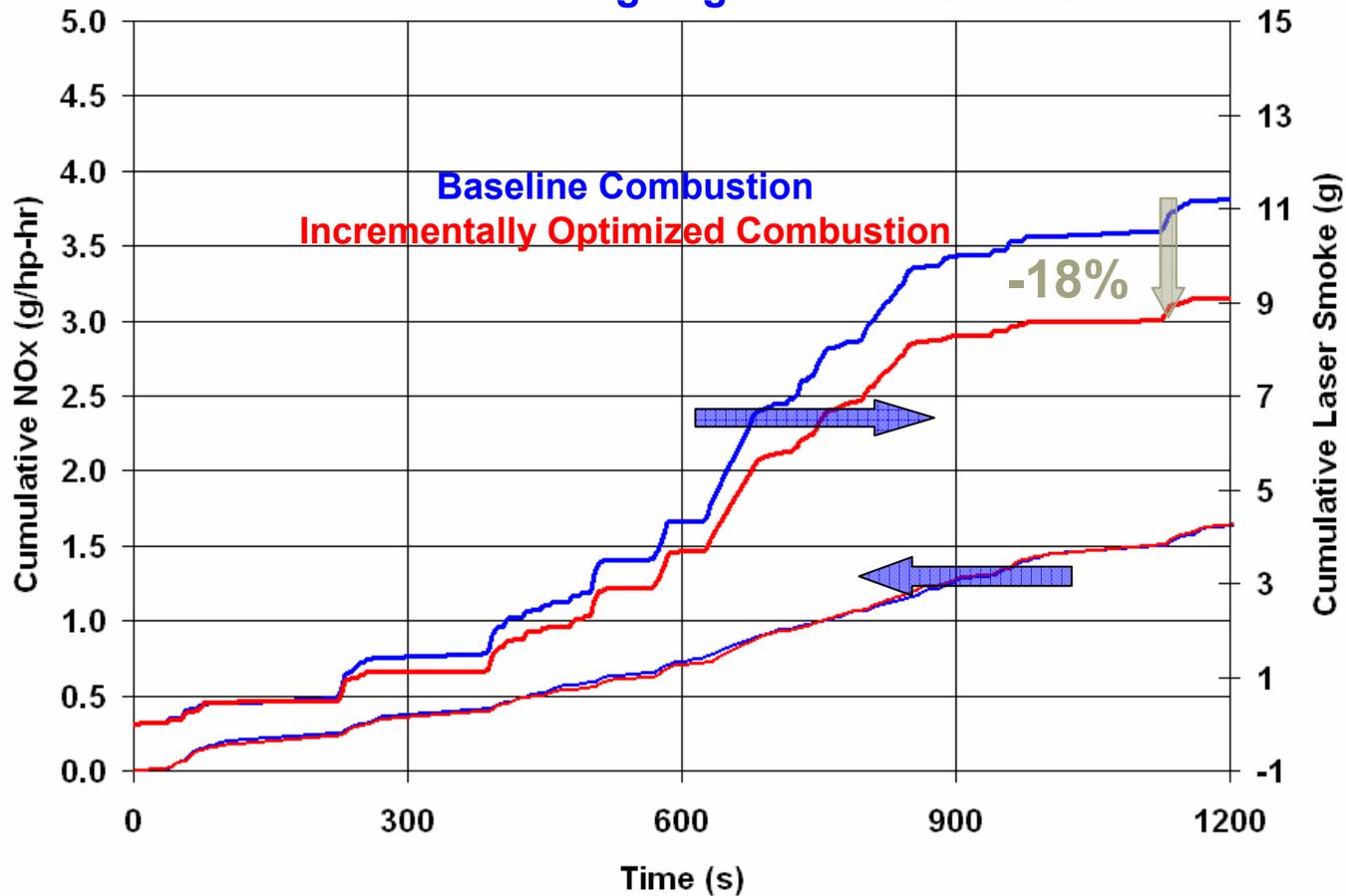
20% Reduction in engine-out FTP NO_x, relative to prototype EPA '07 reference baseline, while maintaining engine-out PM





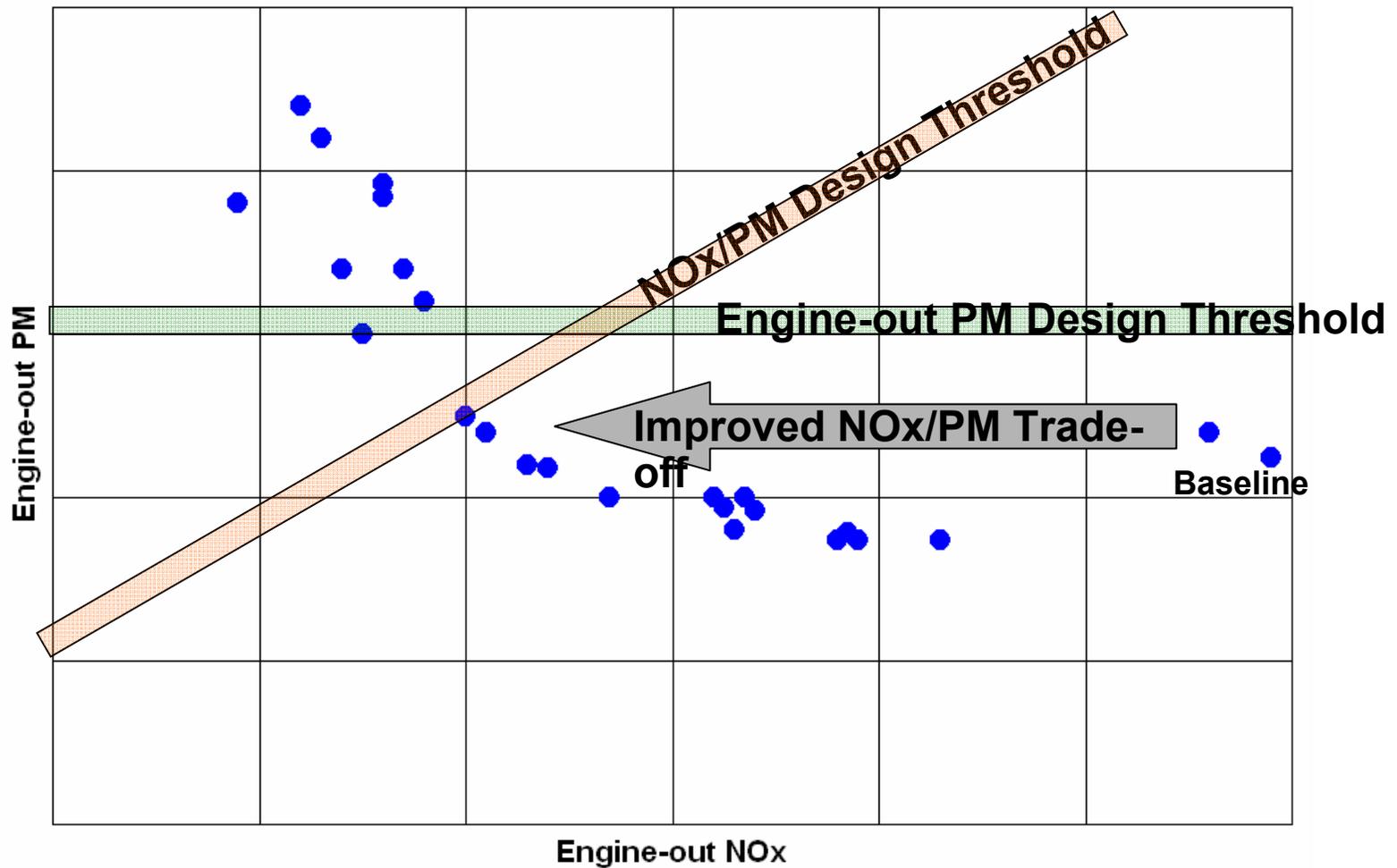
Selective Implementation of Low Emissions Combustion over Transient Hot FTP Cycle

18% Reduction in engine-out FTP PM, relative to baseline, while maintaining engine-out NOx levels



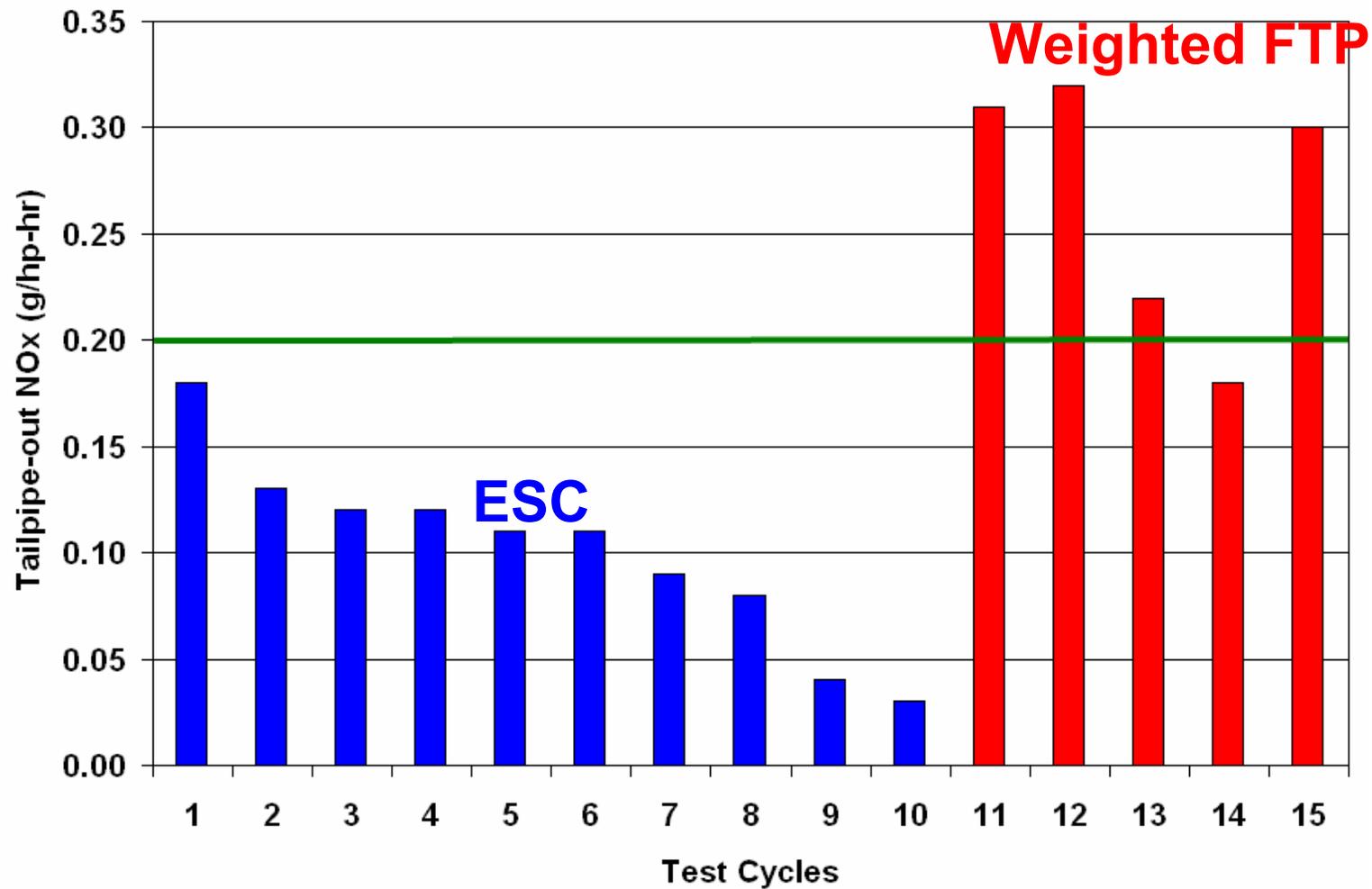


Multiple-Mode, Low-Emissions Combustion Implemented over Transient FTP



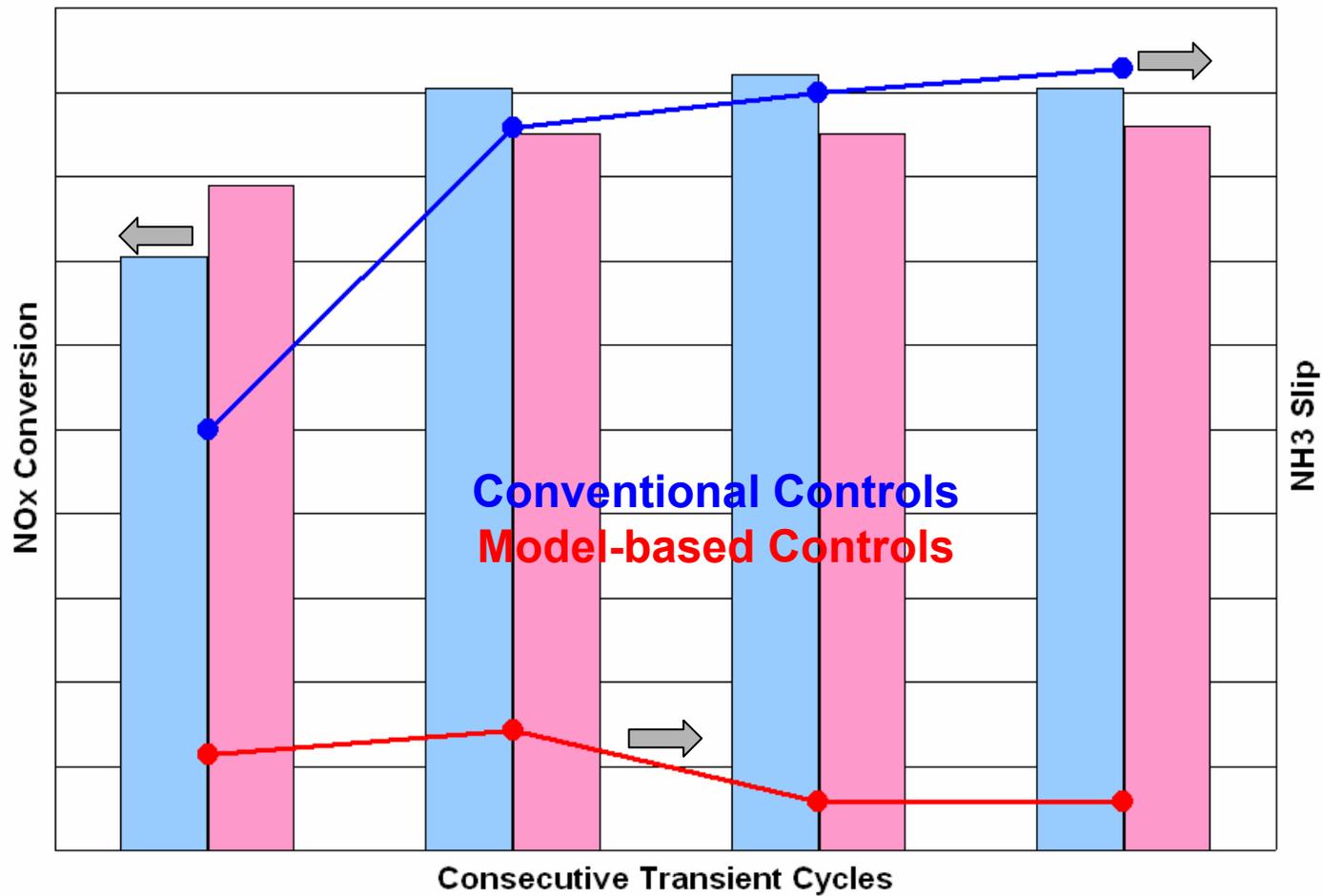


Technical Demonstration of EPA 2010 Emissions





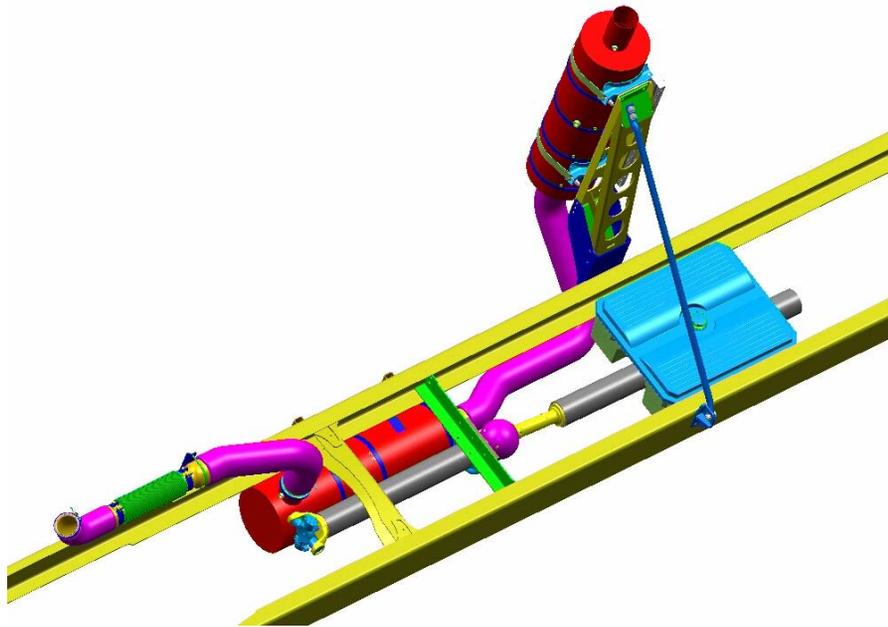
Model-based Control Systems Remain a Key Enabling Technology to Optimize the Integrated Performance of Multiple, Flexible Sub-systems





Low Emissions Combustion, DPF and DEF-SCR Integrated on a Vehicle Test-bed

**Example System Integration
Installation for Long Sleeper Cabs**



**2010 Technology Vehicle at
the DEER 2006 Vehicle Display**



EP
A **2010**

A SAMPLE OF HD FREIGHTLINER & STERLING PRODUCT LINES & VOCATIONS

FREIGHTLINER
LLC

A DaimlerChrysler Company



Confidential and Proprietary to Freightliner LLC.

DaimlerChrysler Truck Group



DEF-SCR Certification

- **EPA's SCR Certification Guidance Issued on March 27th, 2007**
- **Detroit Diesel (through its parent company Freightliner LLC), Volvo and Mack have teamed up to address non-competitive issues related to DEF-SCR certification**
- **Key topics being addressed by the consortium include collaboration with the EPA, development of DEF infrastructure, facilitating DEF distribution to fuel retailers and truck stop chains and creating and enforcing DEF quality standards**
- **The consortium is open to any manufacturer with a declared intention to use SCR**
- **Invitations to join the consortium have been extended to all members of the Engine Manufacturers' and Truck Manufacturers' Associations**



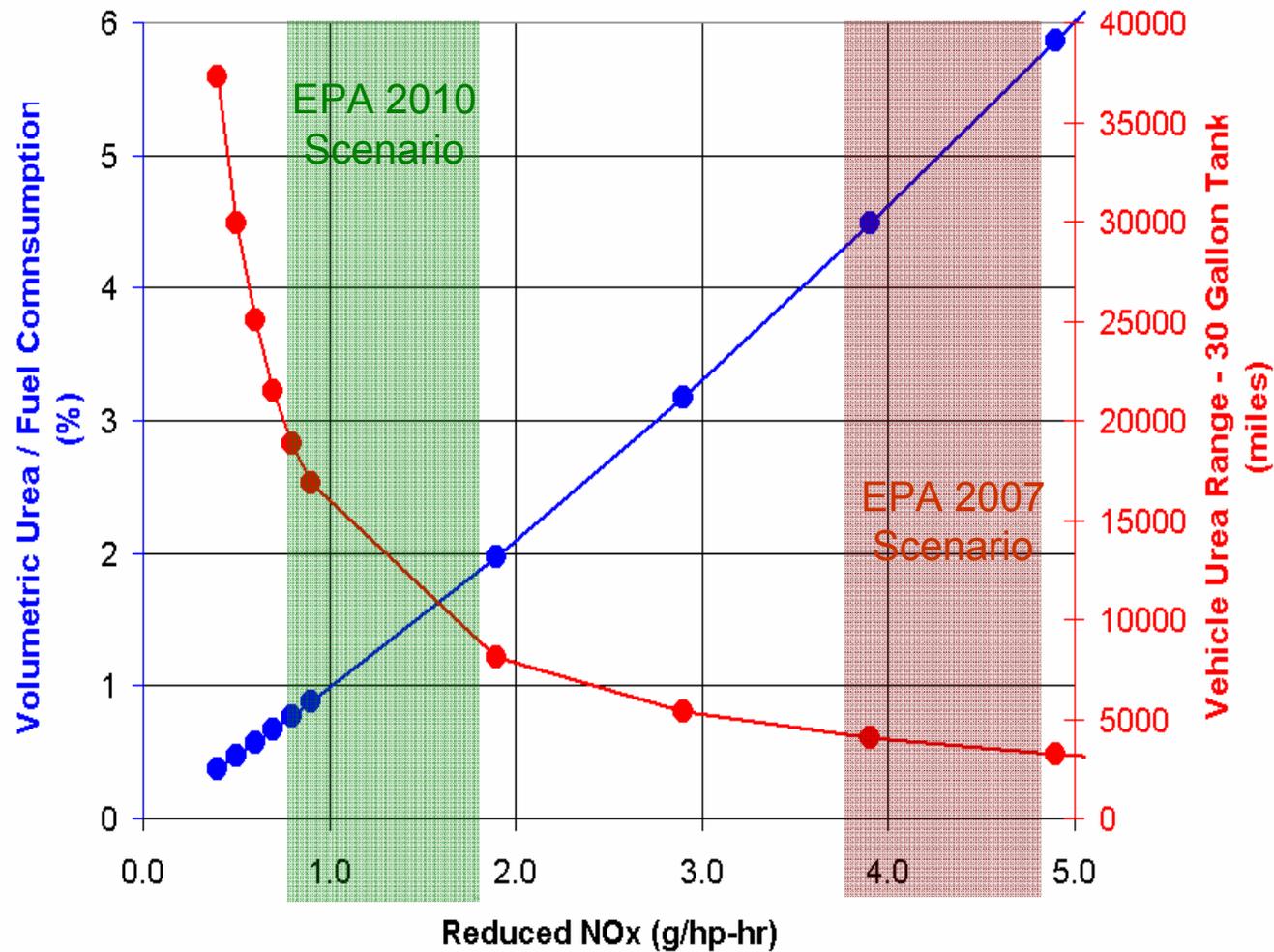
Specific Topics being Addressed

- **DEF standards**
 - **Nozzle**
 - **Fluid quality**
- **DEF infrastructure**
- **DEF tank sizing**
- **Low DEF driver warning and inducement**
- **DEF thawing and refreeze protection**
- **Tamper resistance**
- **Education and outreach**



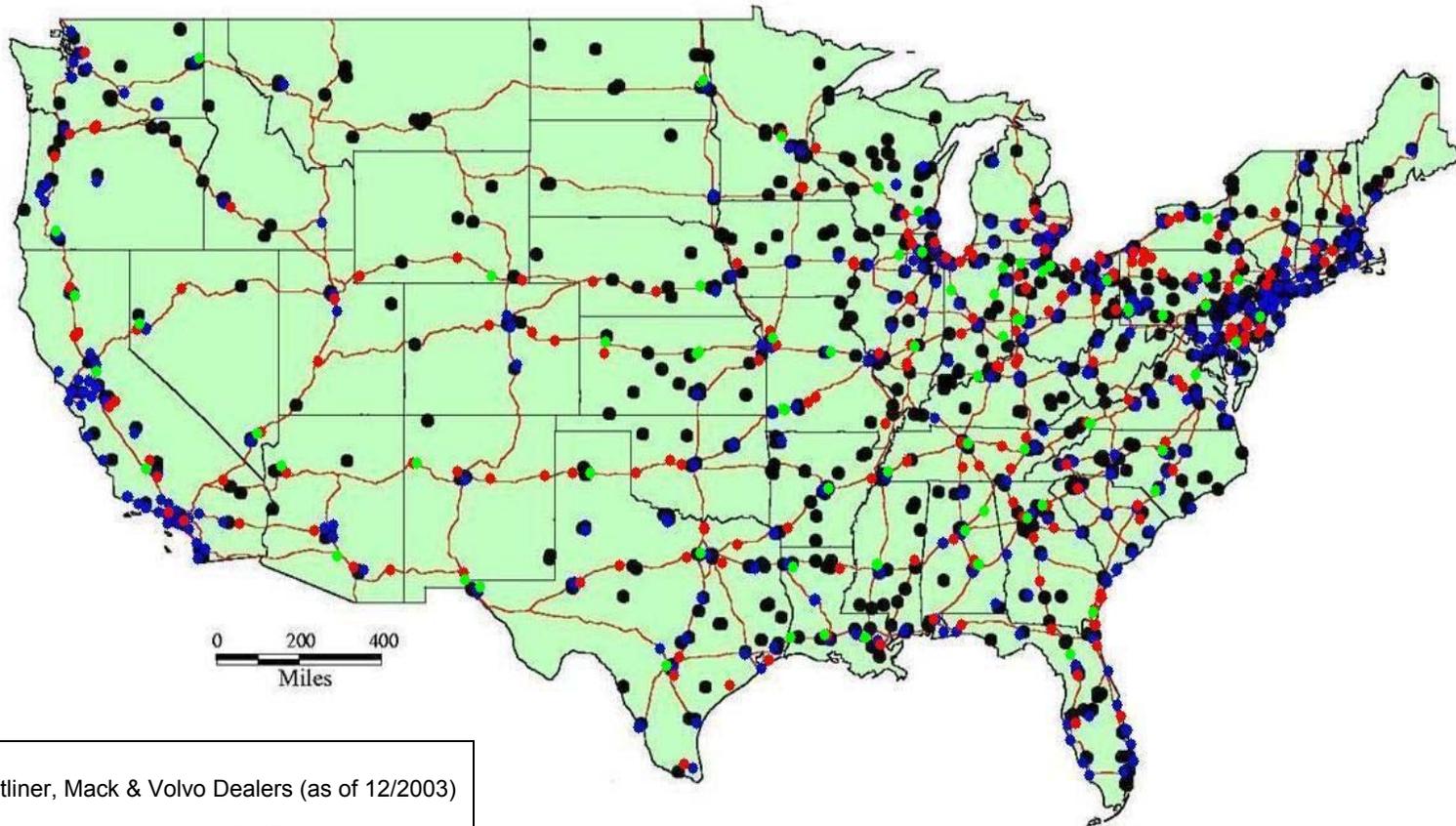
EPA 2010 DEF Consumption ~1-2% of Fuel Consumption

EPA 2010 Driving Range 8-16k Miles between DEF Refills for 30 Gallon Tank
 EPA 2010 Driving Range 2.5-5k Miles between DEF Refills for 10 Gallon Tank





DEF Infrastructure through Truck Stops and Dealerships

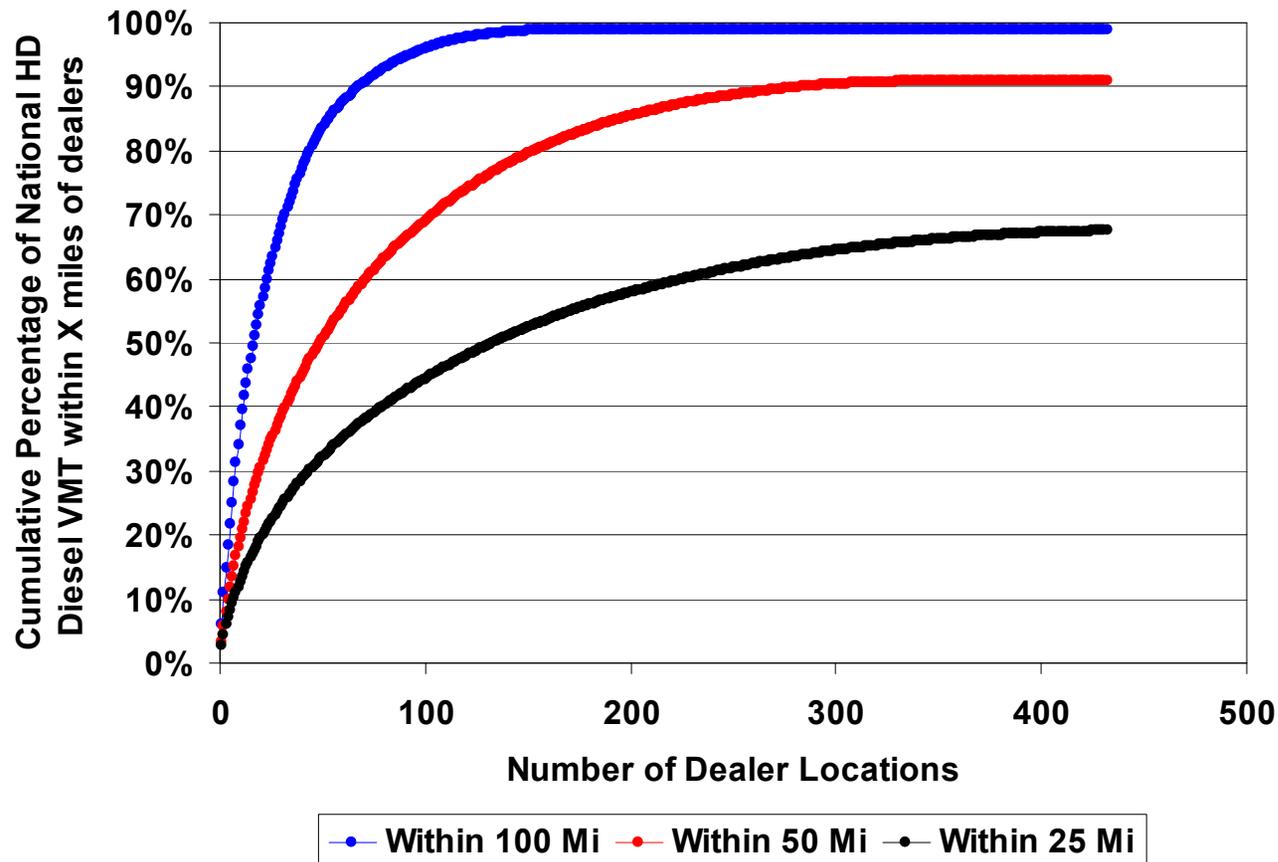


- DDC, Freightliner, Mack & Volvo Dealers (as of 12/2003)
- Travel Centers of America (as of 6/2007)
- Petro Truck Stops (as of 6/2007)
- Mercedes-Benz Dealers (as of 6/2007)

Air Improvement Resource, Inc



Proximity of DEF at Volvo, Mack, Freightliner, DDC dealers based upon HD Diesel VMT





Summary

- **SCR Remains the Lead NOx Aftertreatment Technology for 2010 Heavy-Duty**
- **Model-based Controls are a Key Enabling Technology to Optimize the Integrated Performance of Multiple, Flexible Sub-systems**
- **Progress is being made on both the Infrastructure and the Compliance Issues Related to DEF, in Collaboration with Multi-Stakeholder Group Including Other Engine and Vehicle OEMs**
- **Detroit Diesel (through its Parent Company Freightliner LLC), Volvo and Mack have Teamed up to Address Non-Competitive Issues Related to DEF-SCR Certification**
- **The Consortium is Open to any Manufacturer with a Declared Intention to use SCR**
- **Invitations to Join the Consortium have been Extended to all Members of the Engine Manufacturers' and Truck Manufacturers' Associations**