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DaimlerChrysler Powersystems

Analytical Tool Development for Aftertreatment Sub-Systems Integration

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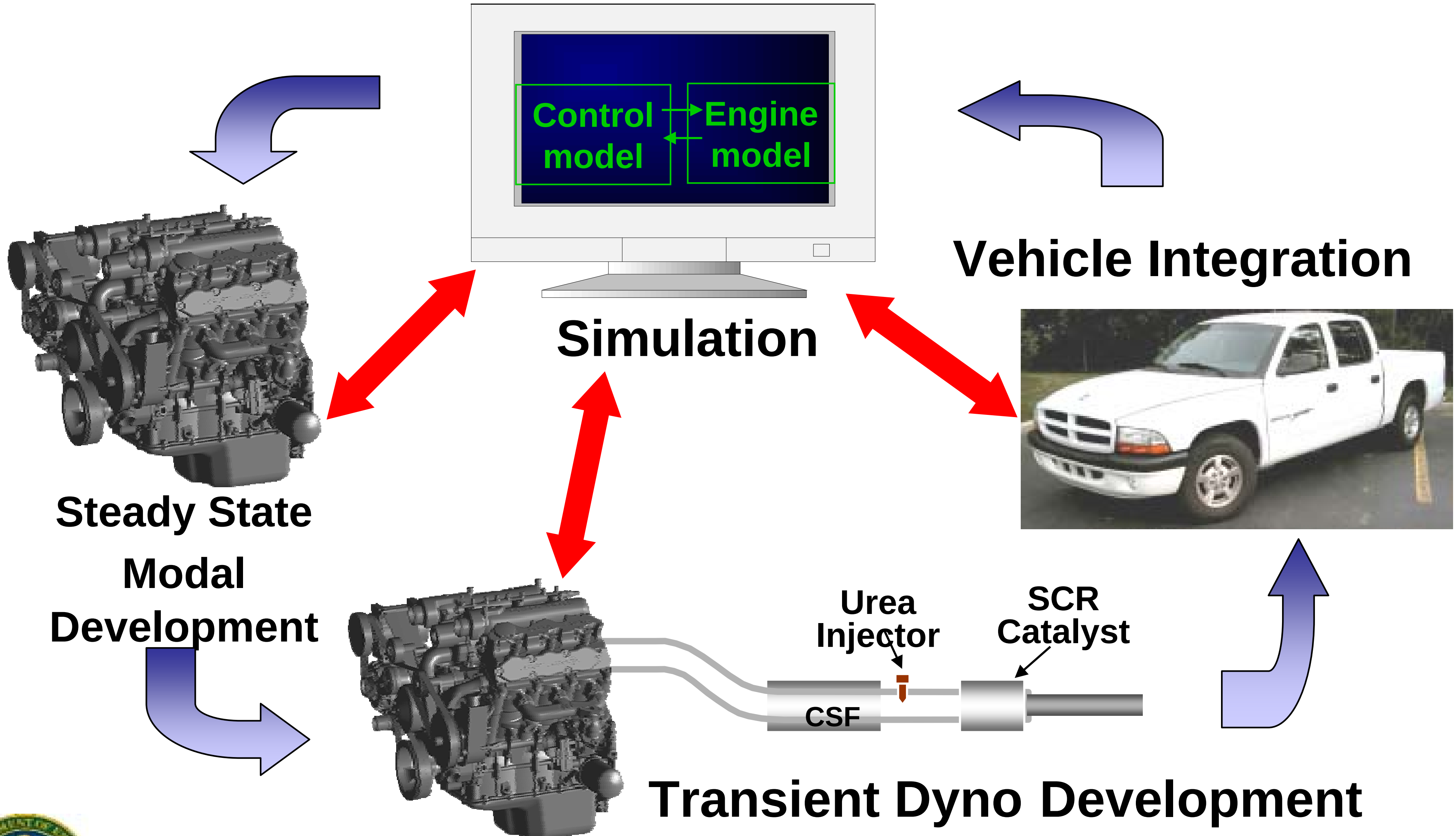
Detroit Diesel Corporation

Outline

- Engine and Sub-System Integration Strategy
- Aftertreatment Model Development Strategy
- Model Applications for System Integration and Control Strategy Development
- Conclusions

System Development Methodology



Aftertreatment Model Philosophy

- Plug & Play
  - Simulink and Fortran Based Models
  - Common Framework
  - Can Be Combined Freely
- Variable Resolution - Adaptable
  - Prime Path A.T. Models are 1D
  - 0D and 3D Also Developed
- Common Framework
  - Sub-Models for
    - ✓ Flow
    - ✓ Chemical Kinetics
    - ✓ Thermal Modeling
    - ✓ Storage

DDC's Tool Box Description

- Engine
  - » Mapped Data
  - » Mean Value (MV) Model
  - » Cycle Simulation
  - » Multi-Dimensional Models
- Vehicle Model
  - » Simple
  - » Complex
- Aftertreatment Models
  - » DPF
  - » SCR
  - » LNT
  - » DOC

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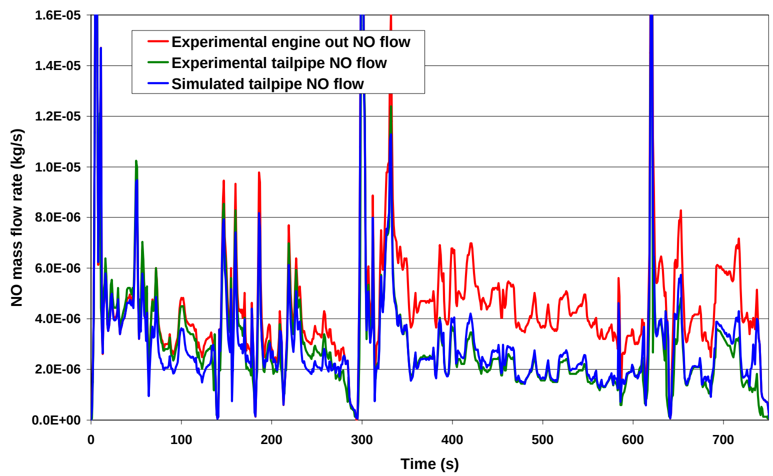
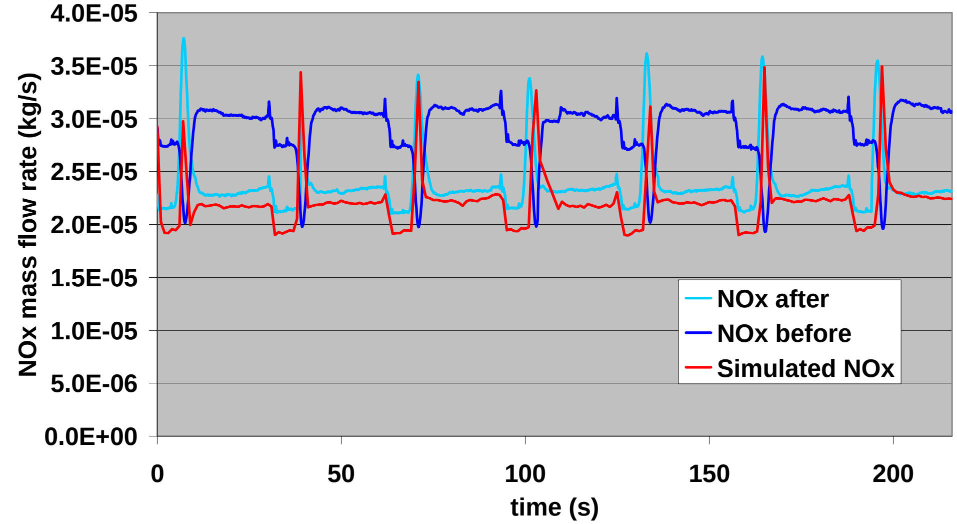
Individual Models Have Been Extensively Validated

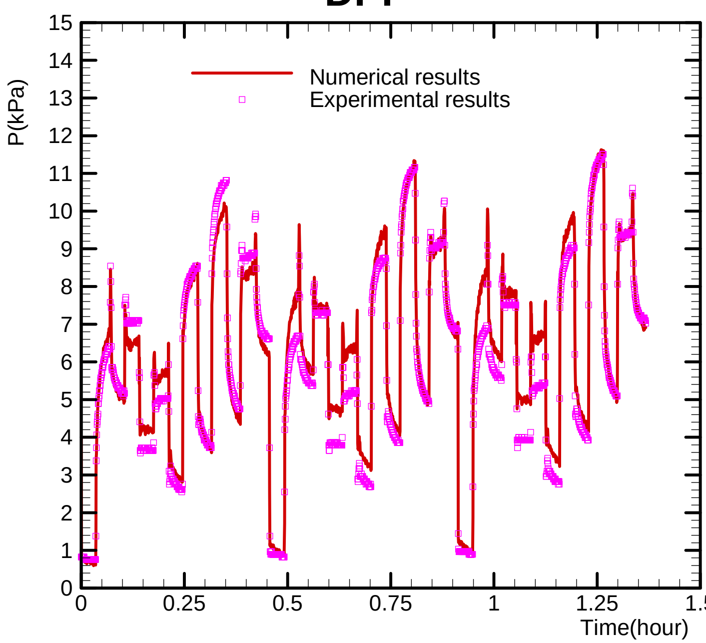
SCR



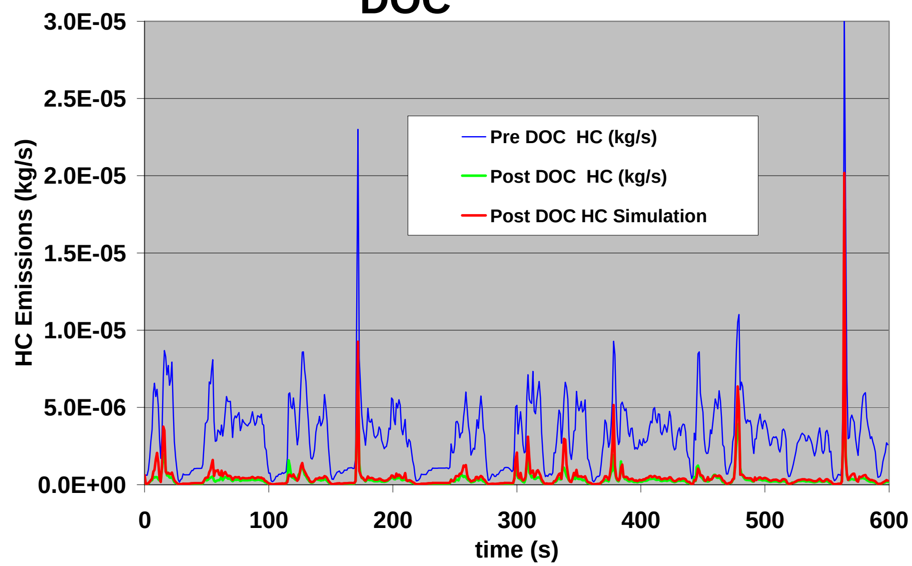
LNT



DPF



DOC



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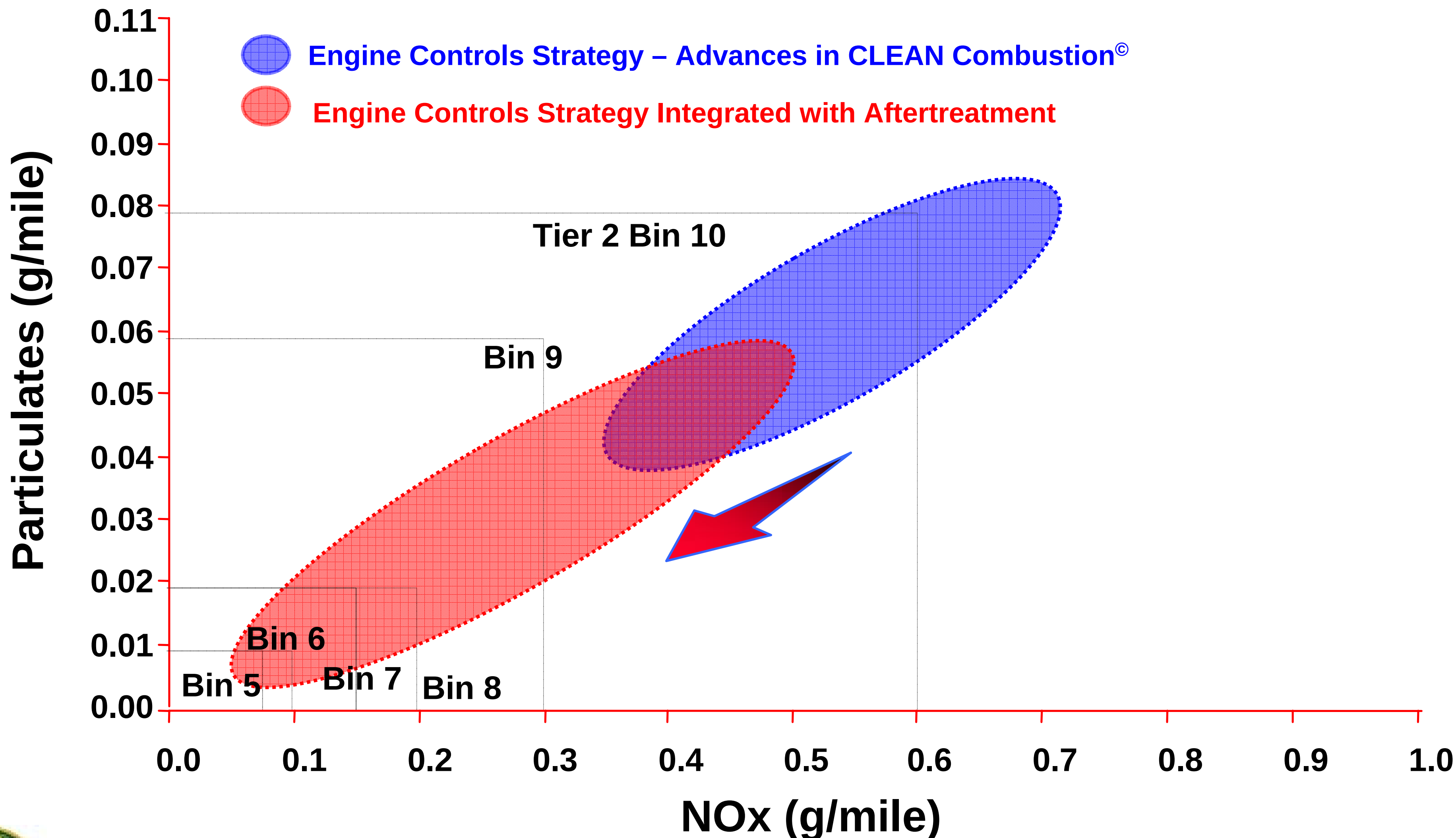
Outline

- Engine System Integration Strategy
- Aftertreatment Model Development Strategy
- **Model Applications to System Integration and Control Strategy Development**
- Conclusions

Integrated Emissions Reduction Roadmap
Light Truck / SUV Platform



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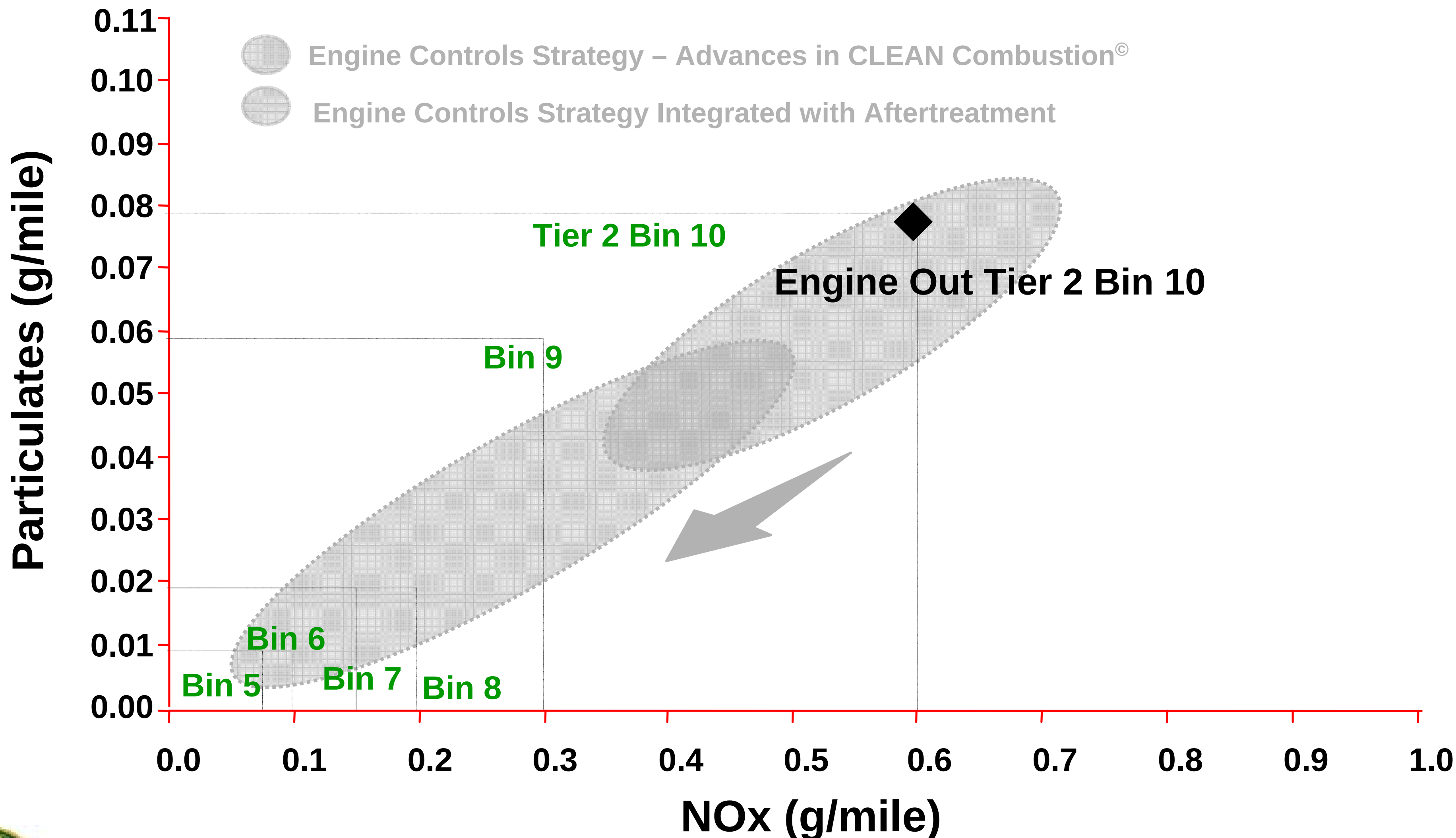
Integrated Emissions Reduction Roadmap
Light Truck / SUV Platform



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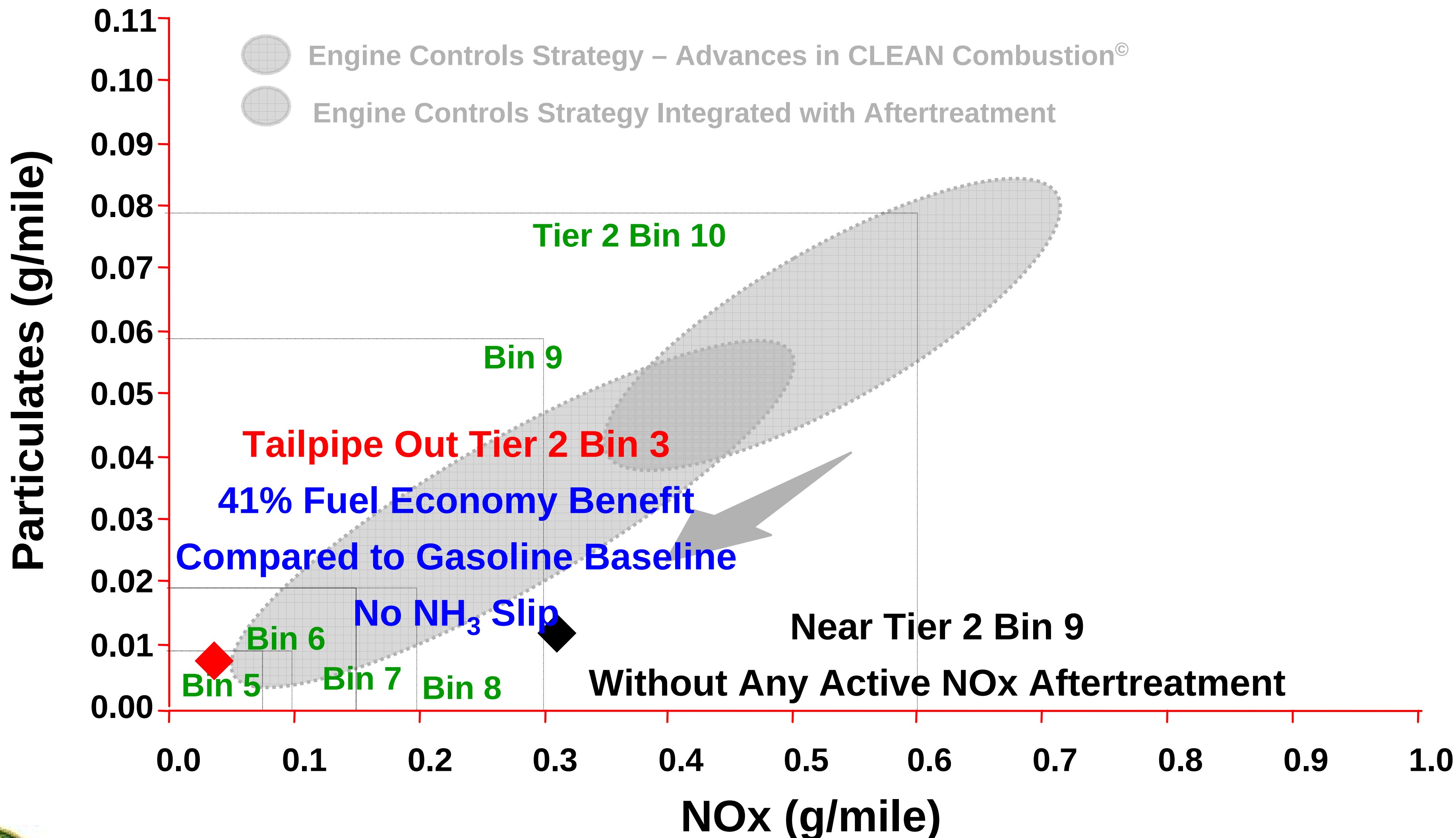
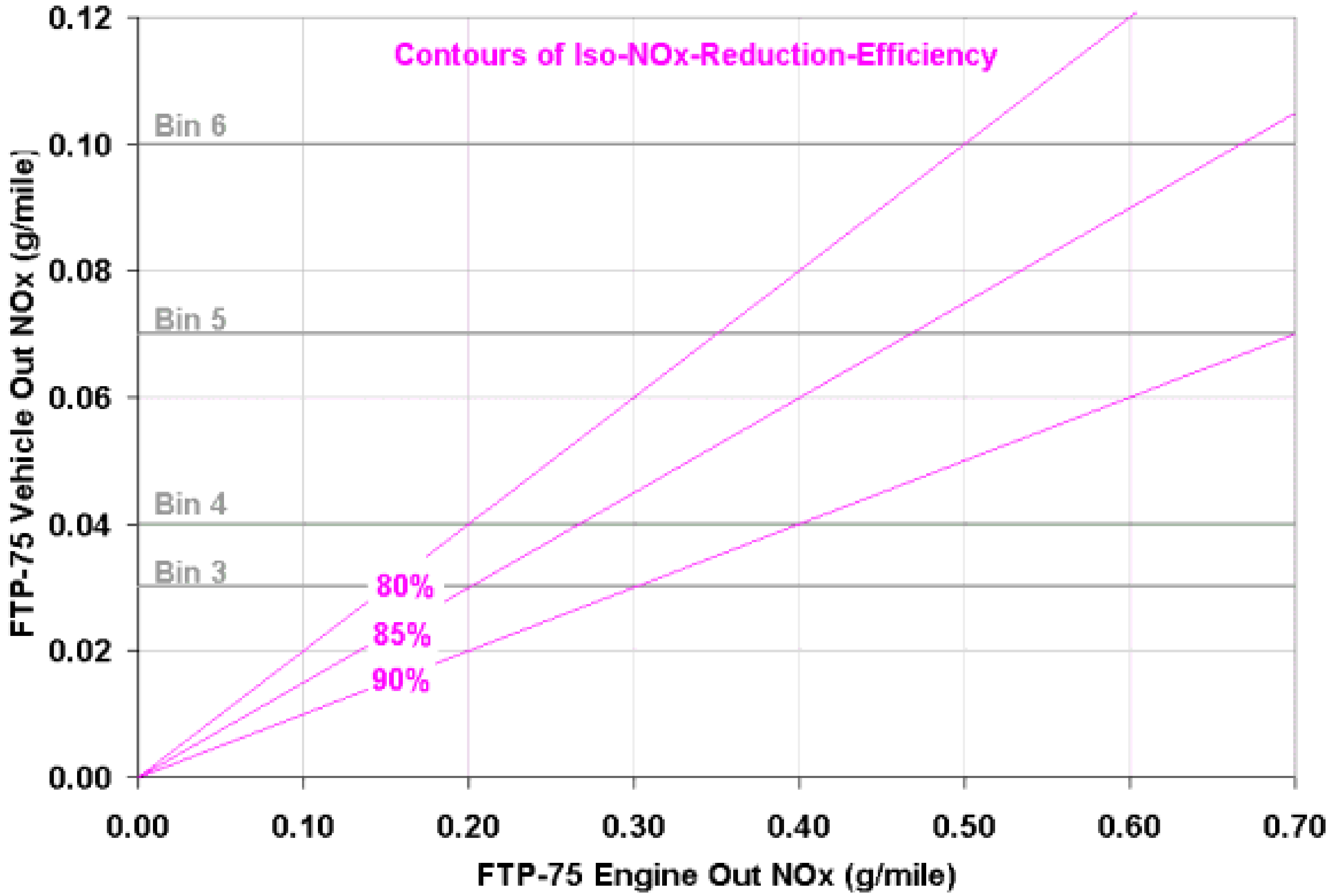
Integrated Emissions Reduction Roadmap
Light Truck / SUV Platform



NOx Reduction Via Combustion and Aftertreatment Development Light Truck / SUV Platform



NOx Reduction Via
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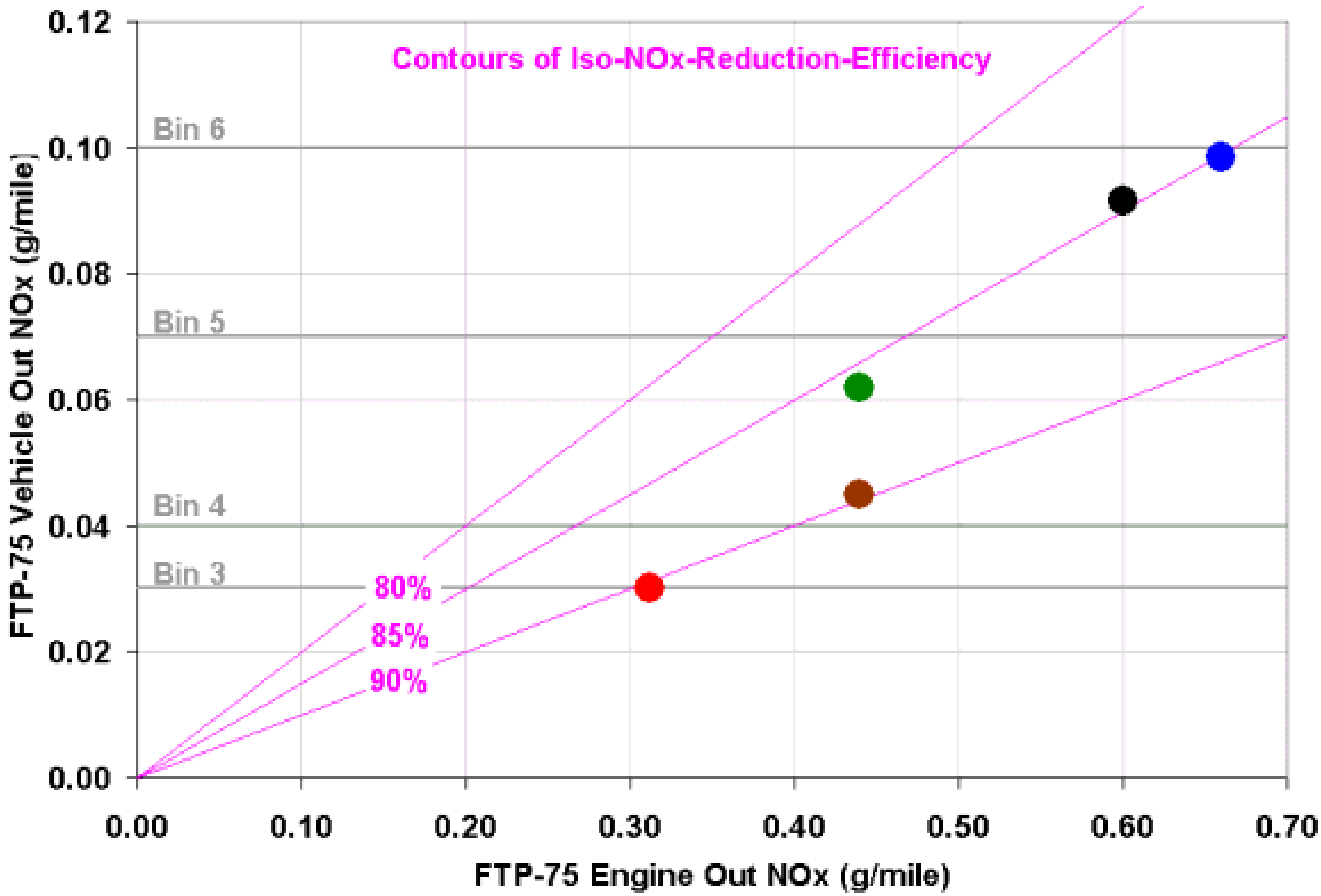
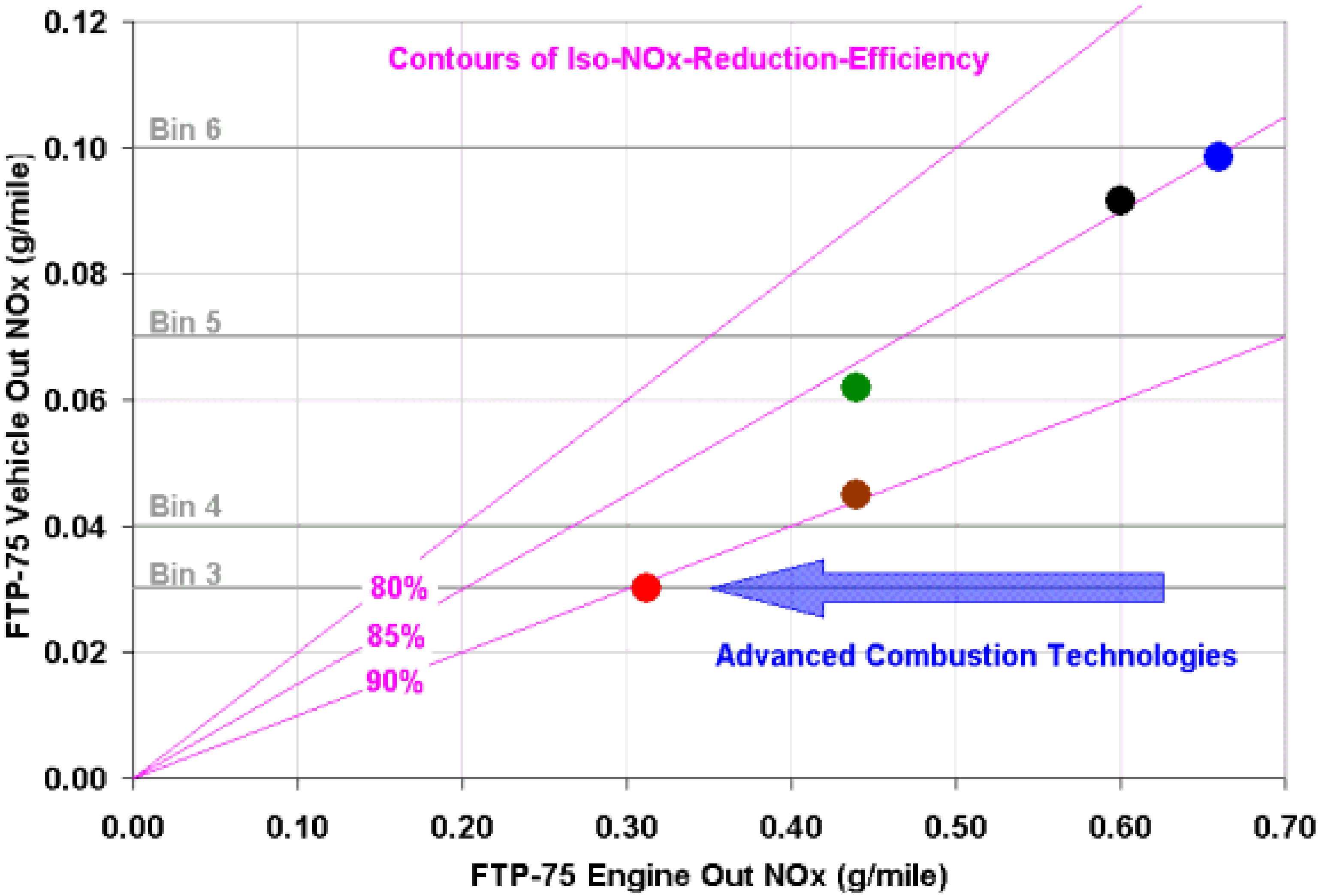


NOx Reduction Via Combustion and Aftertreatment Development Light Truck / SUV Platform



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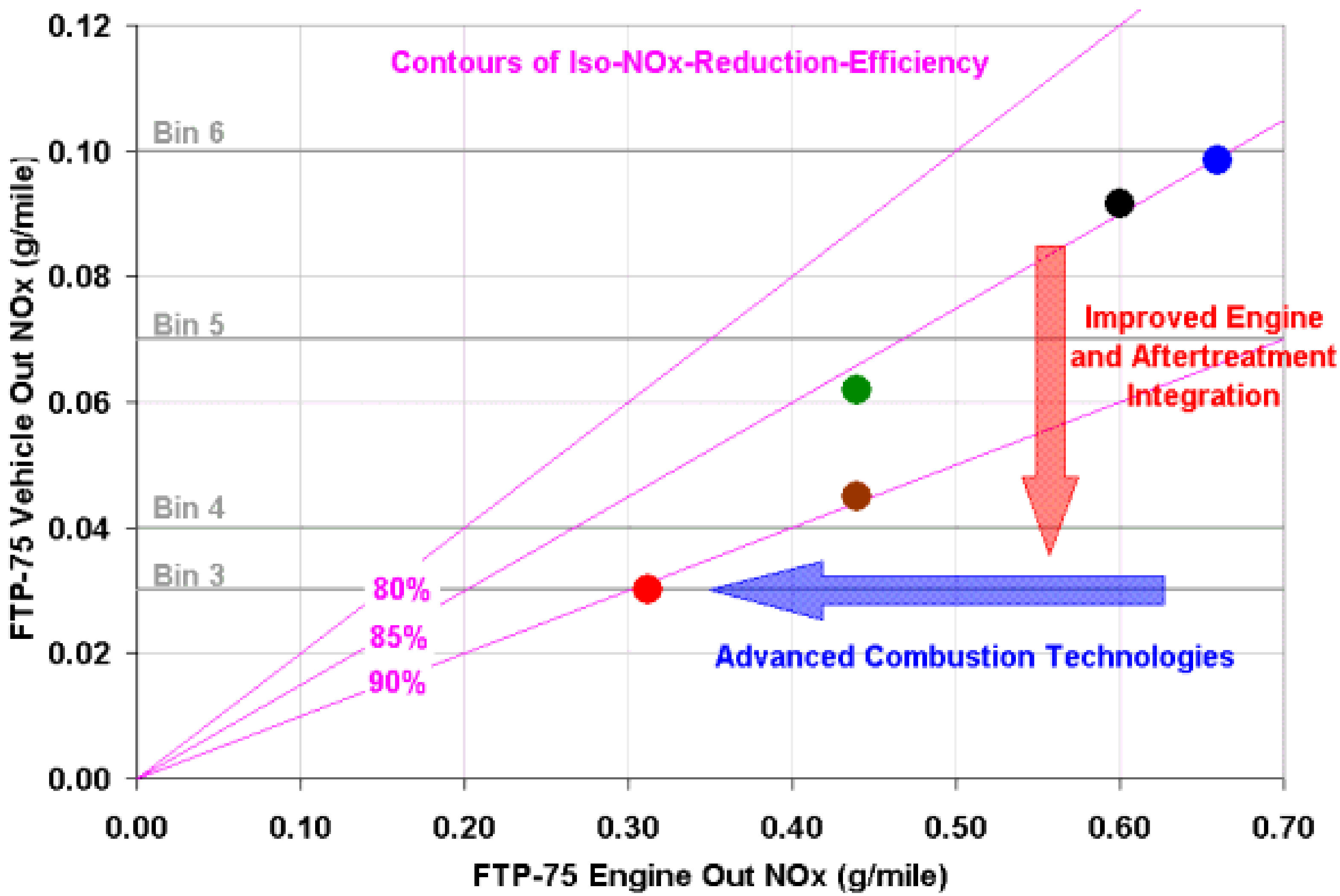
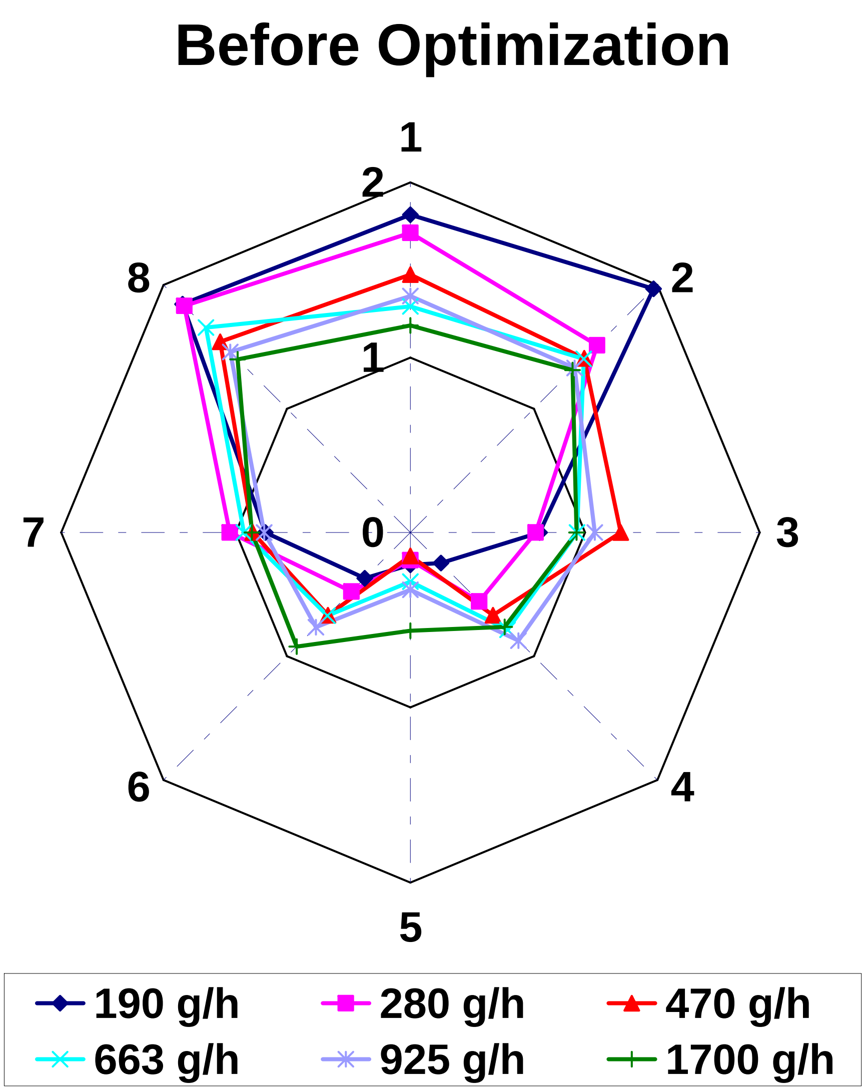
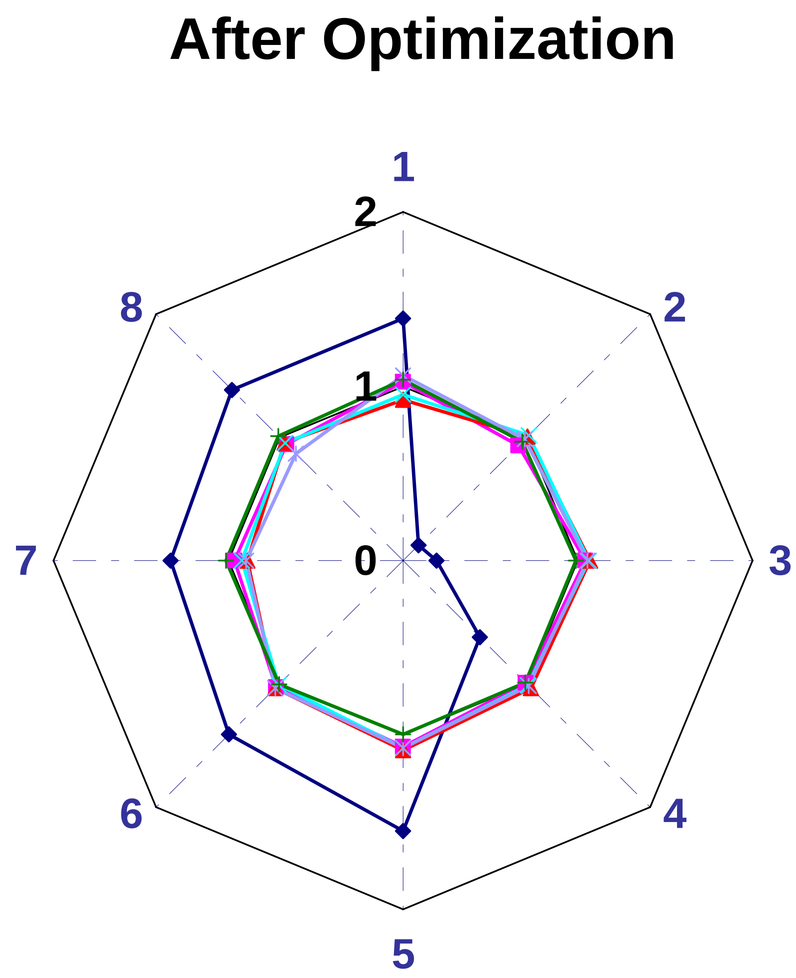
NOx Reduction Via Combustion and Aftertreatment Development Light Truck / SUV Platform



Urea Injection Mixing and Spray Development

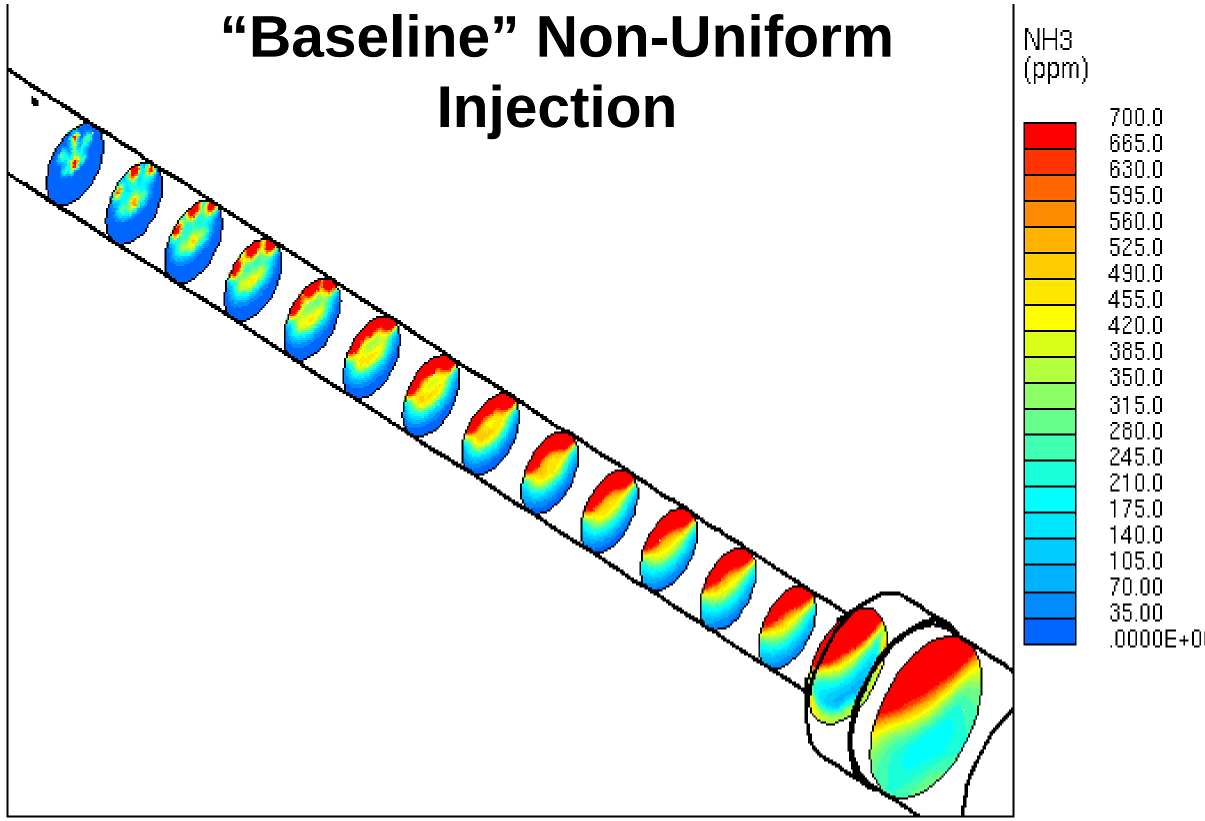
Urea Injection Control Issue
Hole-to-Hole Flow Rate Variation



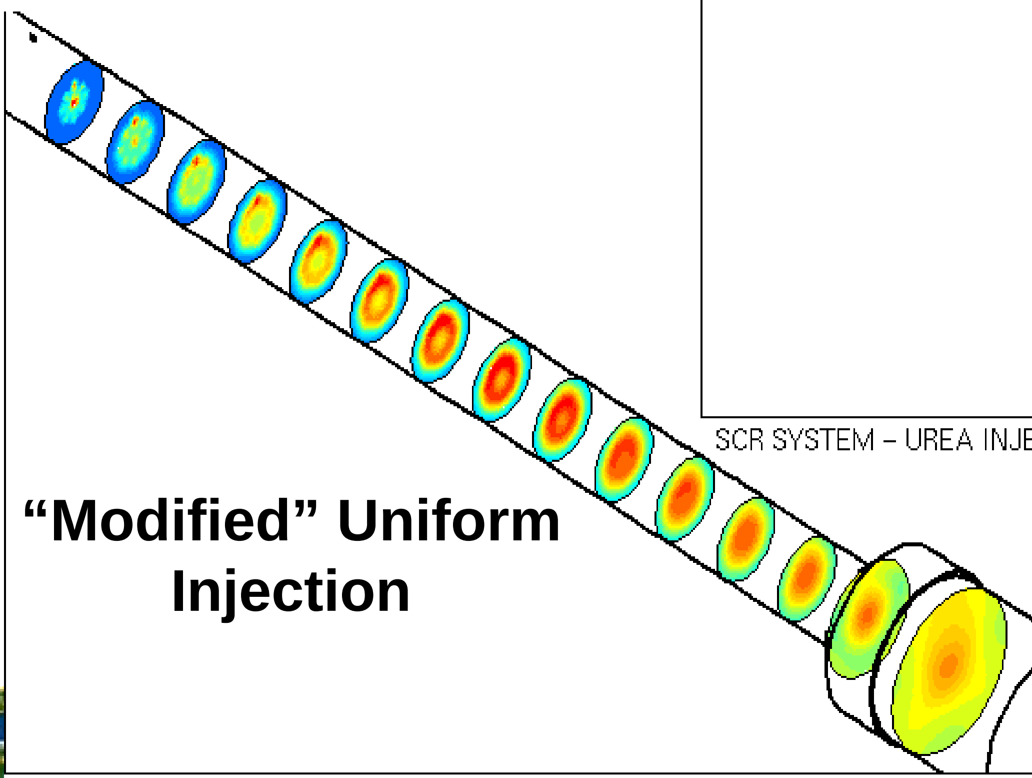


3D CFD for NH3 Distribution

“Baseline” Non-Uniform Injection

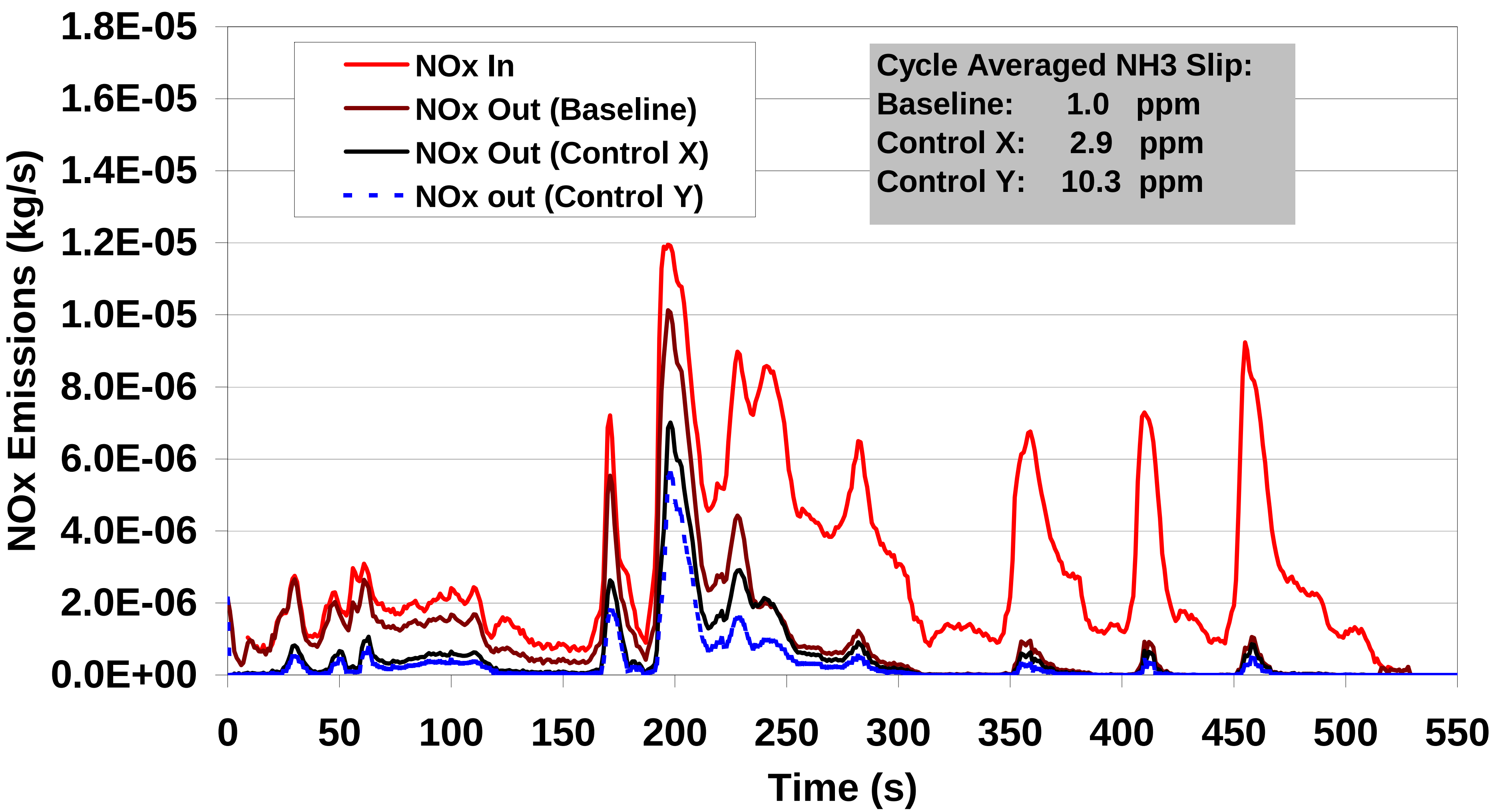


“Modified” Uniform Injection

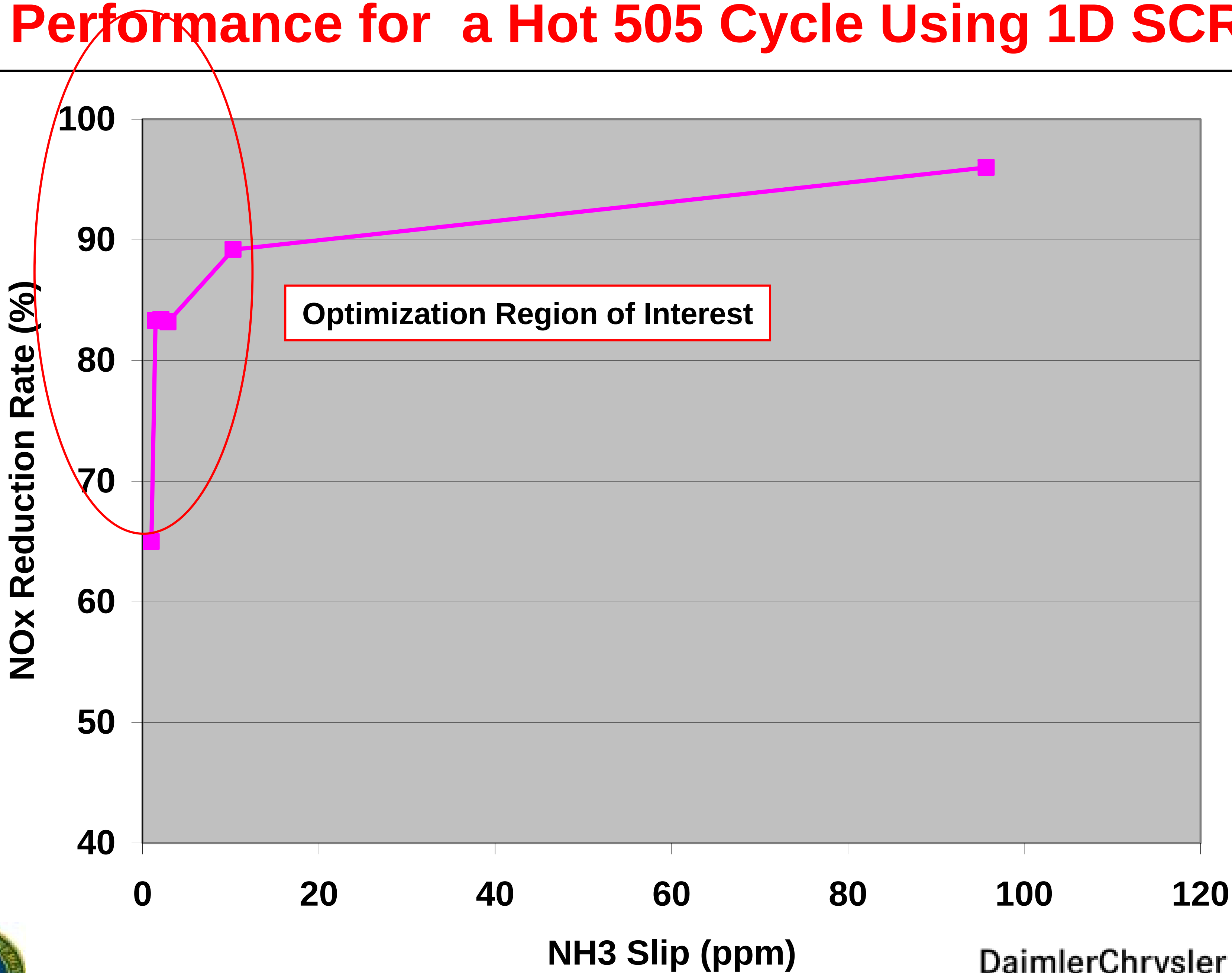


Urea Injection Control Strategy Development

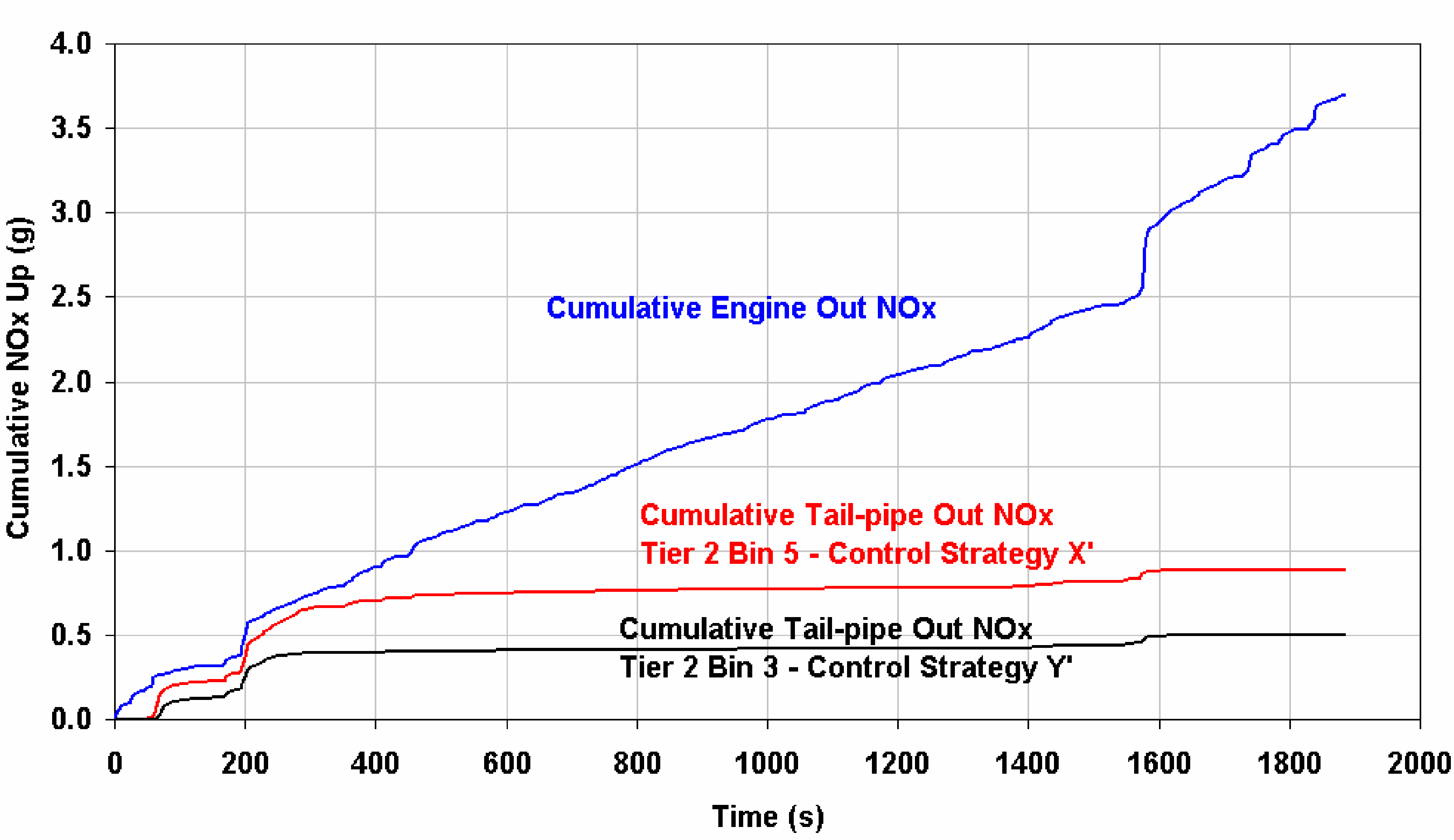
Urea Control Strategies over Hot 505 Transient Cycle Using 1D SCR Model



Urea Injection Control Strategies on SCR Performance for a Hot 505 Cycle Using 1D SCR Model



System Integration Experimental Validation
Urea Injection Control Strategy Development



Technical Challenges and Issues

- Reduce AT System Complexity
  - » Require Multiple AT Model Integrations
    - ✓ Model Fidelity when They are Integrated Together
- Sophisticated Controls Technology Integration
  - » Soot Filter Regeneration Strategy
    - ✓ Model Fidelity to Different Types of Soot Oxidation Mechanisms
    - ✓ Kinetic Data
  - » Urea Injection and Mixing Improvement
    - ✓ Small Urea Flow Rate Control
    - ✓ Uniform Urea Distribution
  - » Virtual Sensors and Control (Soot Loading, NH3 Slip)
    - ✓ How Can a Complicated 1D System Model Be Simplified to a 0D for On-board Virtual Sensor?
- Effect of Aging on Aftertreatment Performance
  - » How Modeling Can Capture Aging Effects?
    - ✓ Correlation Type or Physical Type?
- <u>More/Better Kinetic Data Is Required</u>
  - » Industry, Catalyst Suppliers, National Laboratories, and Universities Can Work Together To Fill This Pre-Competitive Void

Concluding Remarks

- Modeling Framework Has Been Further Enhanced.
- Individual Models Have Been Developed and Validated.
- Models Have Been Applied to System Integration, and Control Strategy Development, Providing Valuable Design and Testing Directions.
  - » Tier 2 Milestone Results Have Been Achieved
- Significant Challenges are Ahead

Acknowledgments

- DOE-Freedom Car and Vehicle Technologies
- DDC Engineering Technologies Team
- Engelhard Corporation
- Michigan Tech University
- Adapco, Gamma Technologies, Ricardo
- DCX Research & Technology