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DaimlerChrysler Powersystems

Analytical Tool Development for Aftertreatment Sub-Systems Integration

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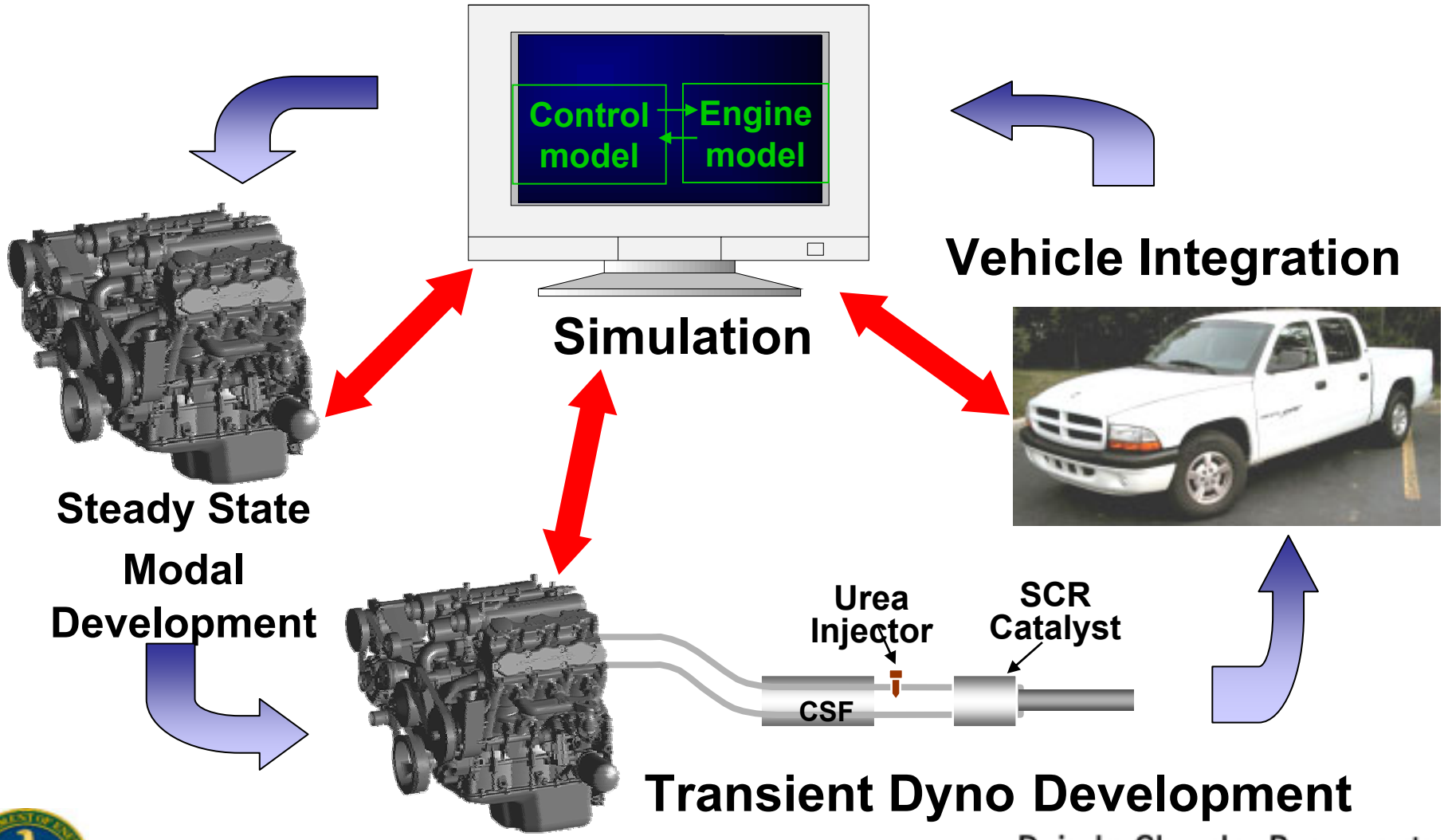
Detroit Diesel Corporation

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

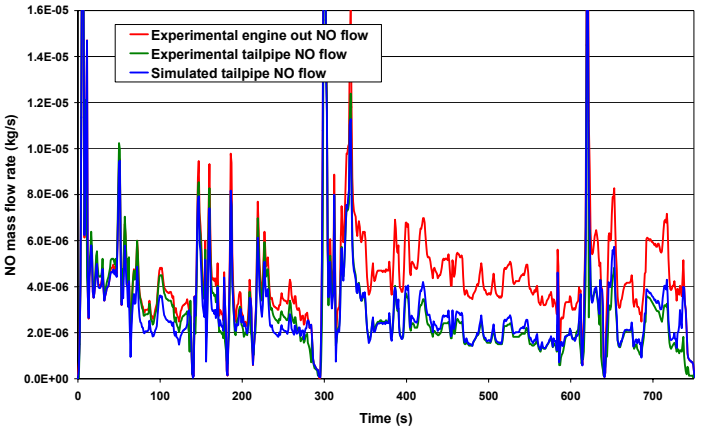
- Plug & Play
  - » Simulink and Fortran Based Models
  - » Common Framework
  - » Can Be Combined Freely
- Variable Resolution - Adaptable
  - » Prime Path A.T. Models are 1D
  - » 0D and 3D Also Developed
- Common Framework
  - » Sub-Models for
    - ✓ Flow
    - ✓ Chemical Kinetics
    - ✓ Thermal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

DDC's Tool Box Description

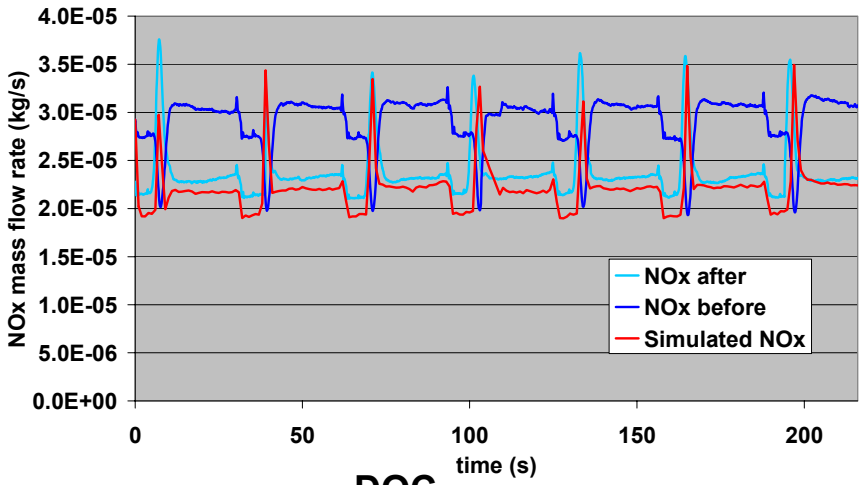
- Engine
  - Mapped Data
  - Mean Value (MV) Model
  - Cycle Simulation
  - Multi-Dimensional Models
- Vehicle Model
  - Simple
  - Complex
- Aftertreatment Models
  - DPF
  - SCR
  - LNT
  - DOC

Individual Models Have Been Extensively Validated

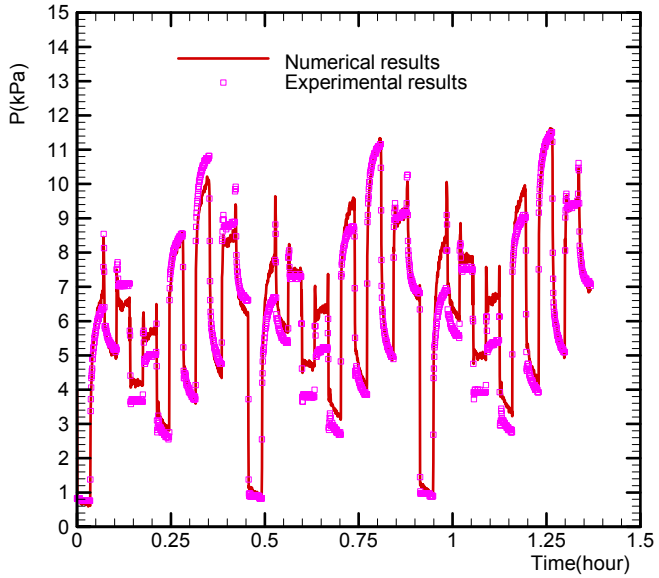
SCR



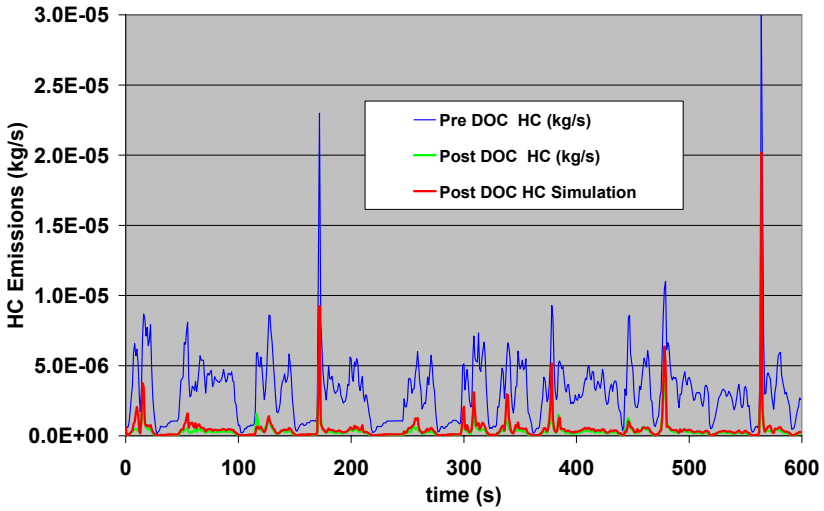
LNT



DPF



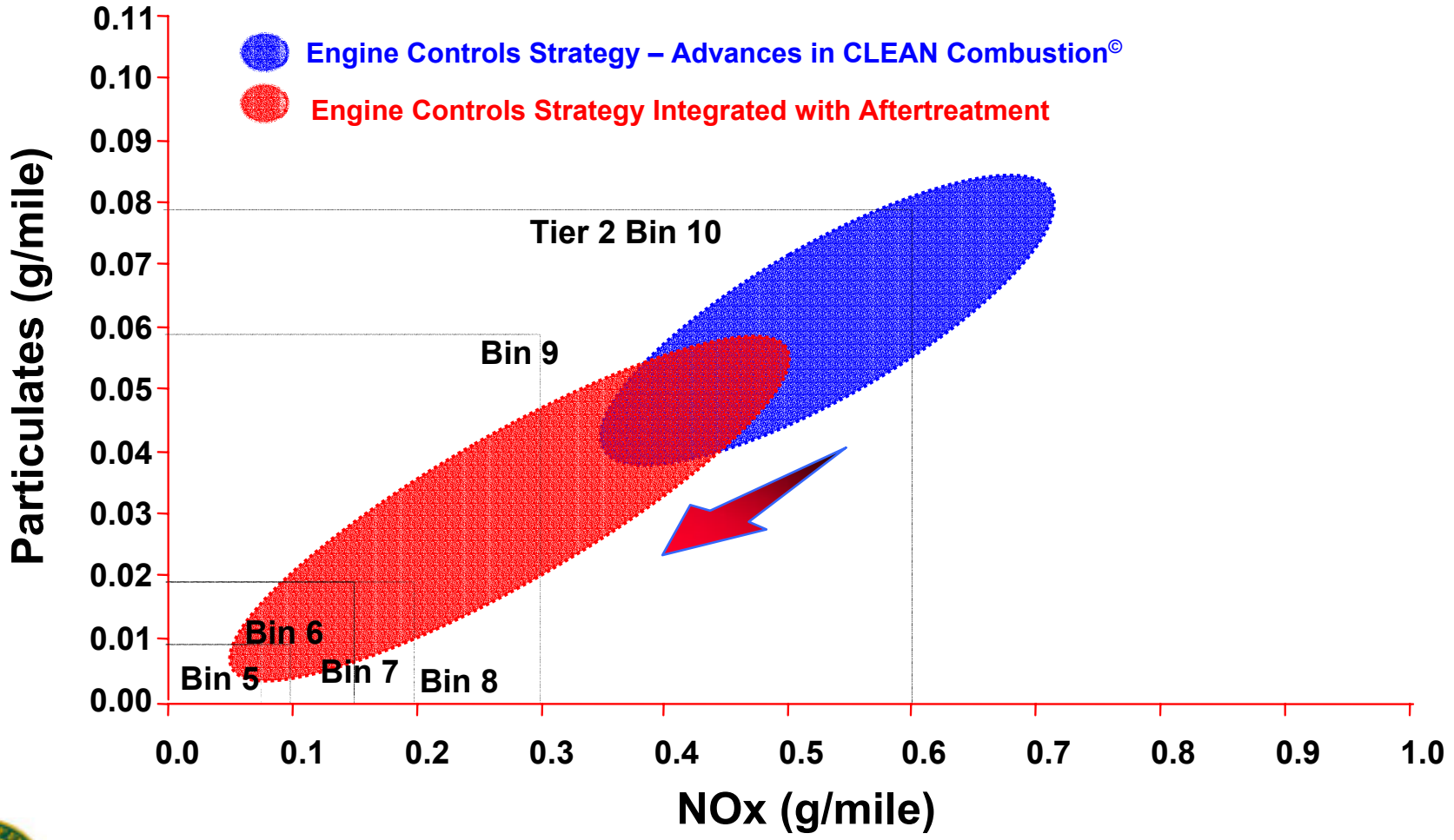
DOC



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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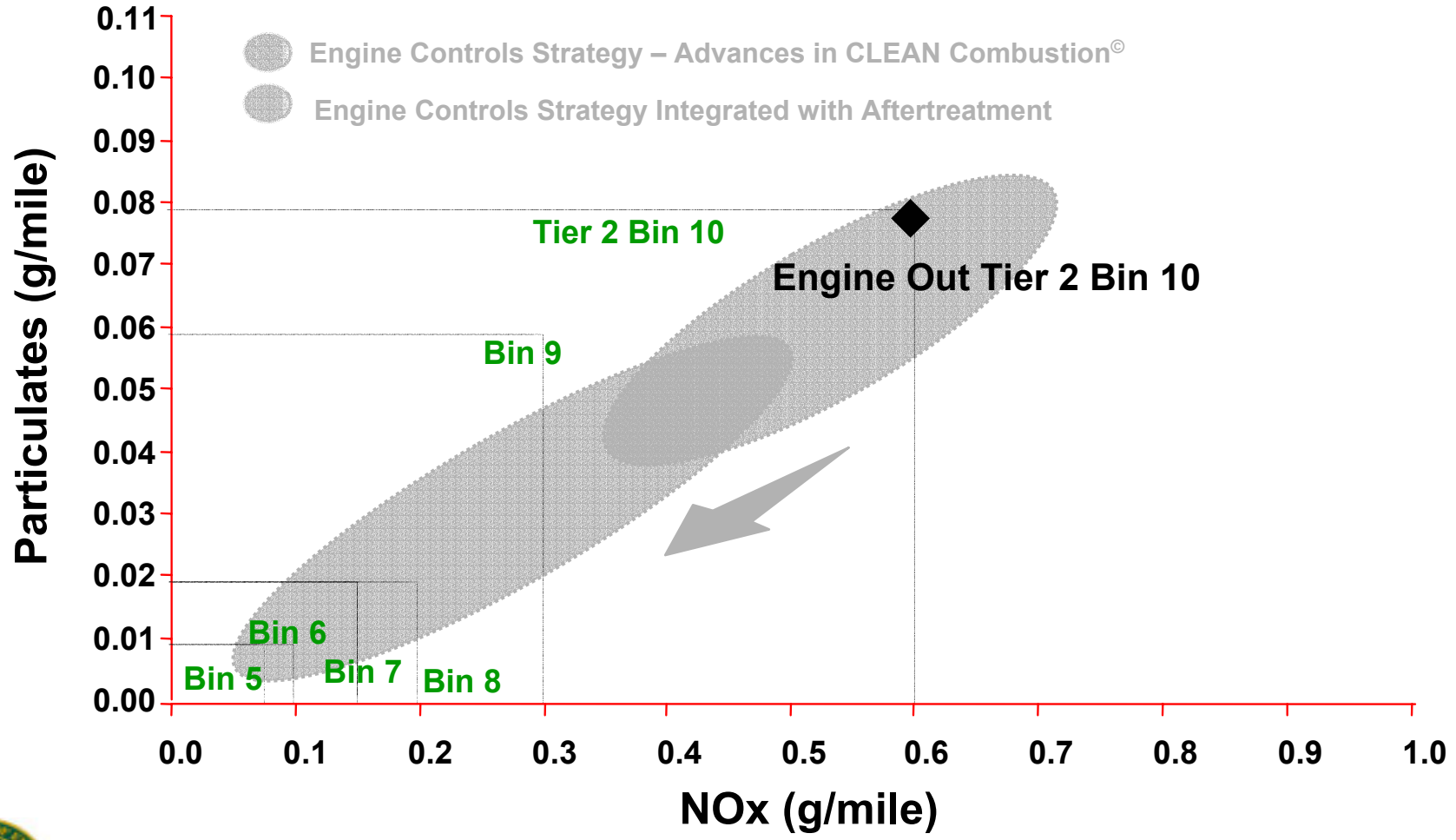
Integrated Emissions Reduction Roadmap
Light Truck / SUV Platform



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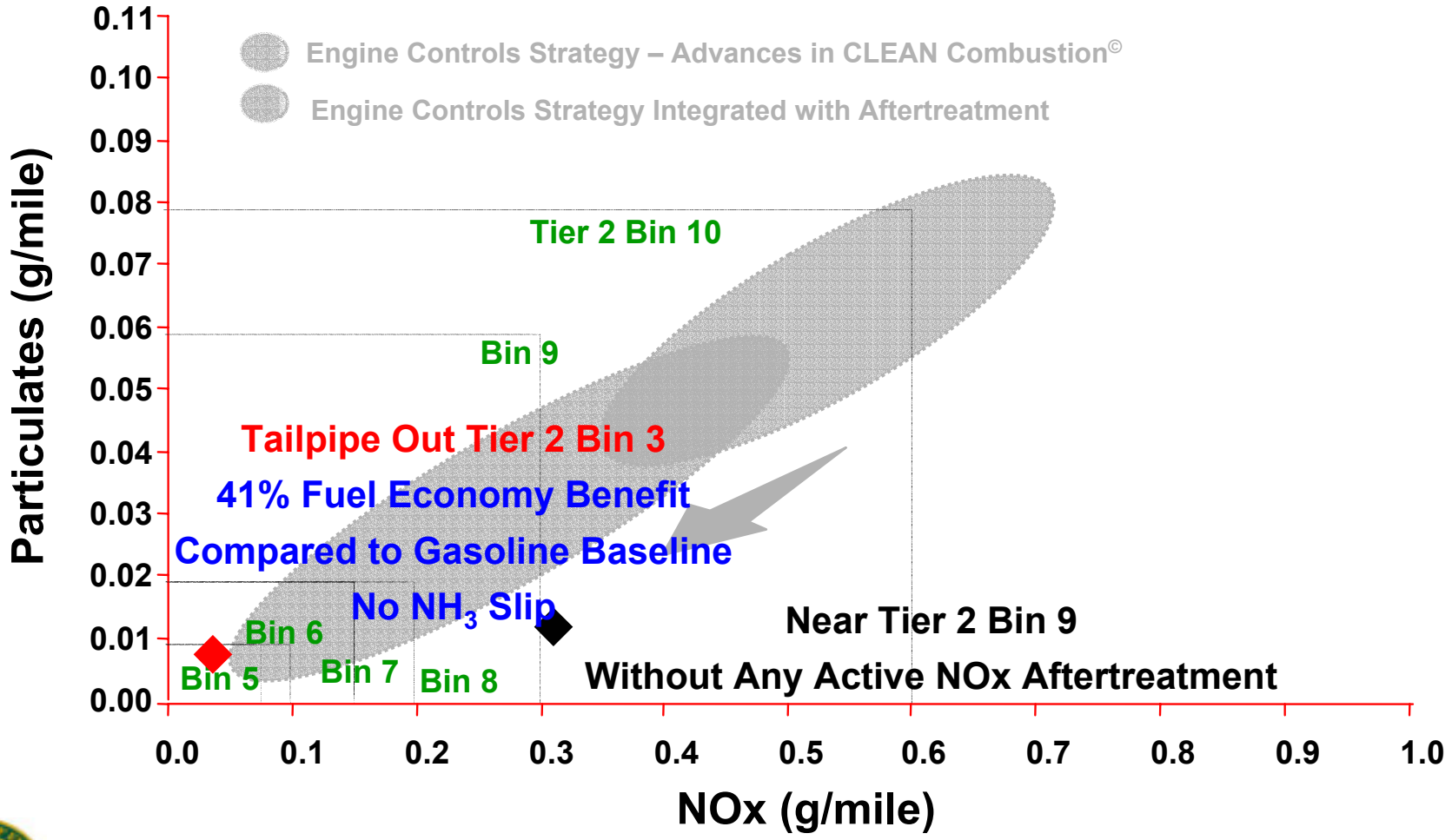
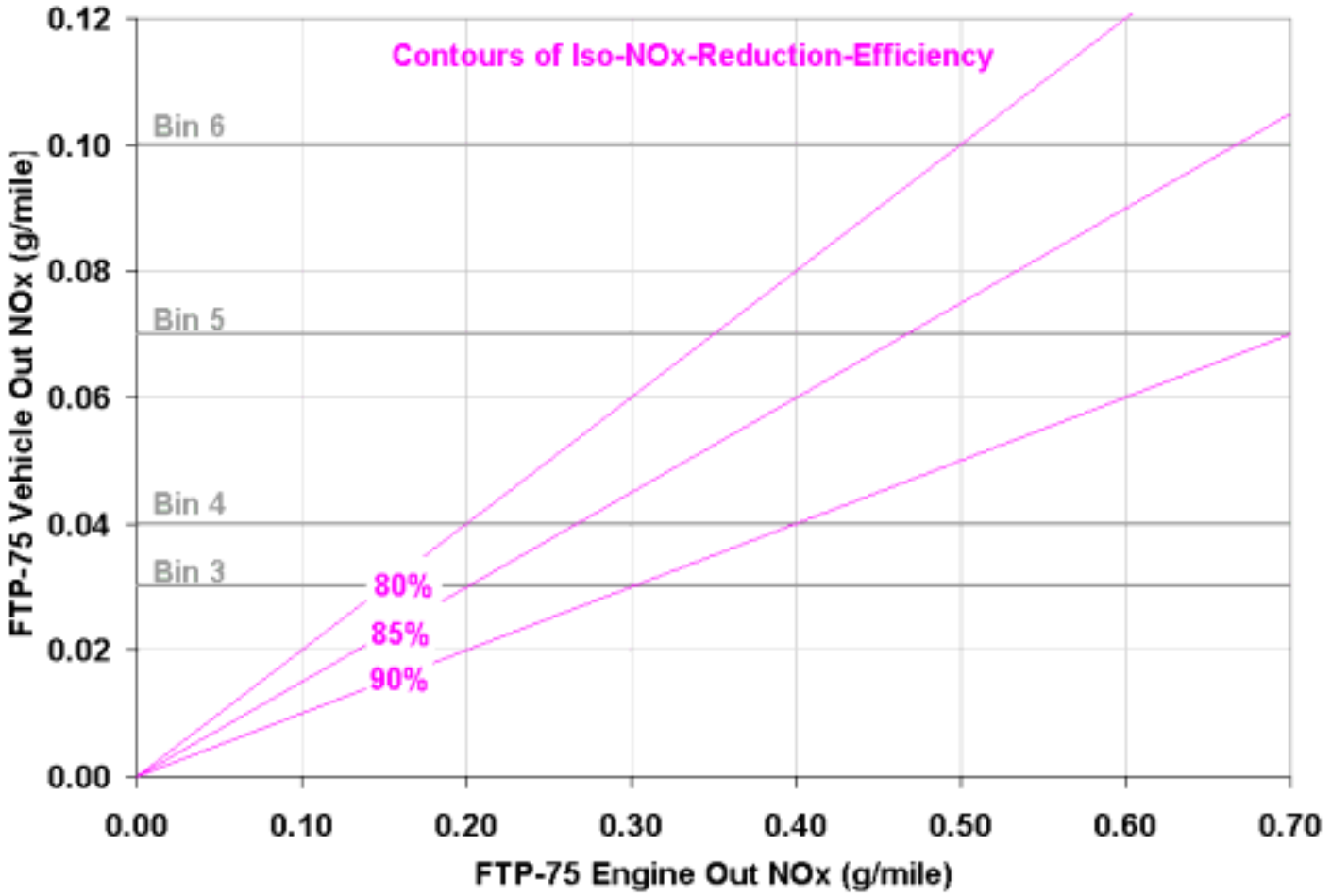
Integrated Emissions Reduction Roadmap
Light Truck / SUV Platform



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



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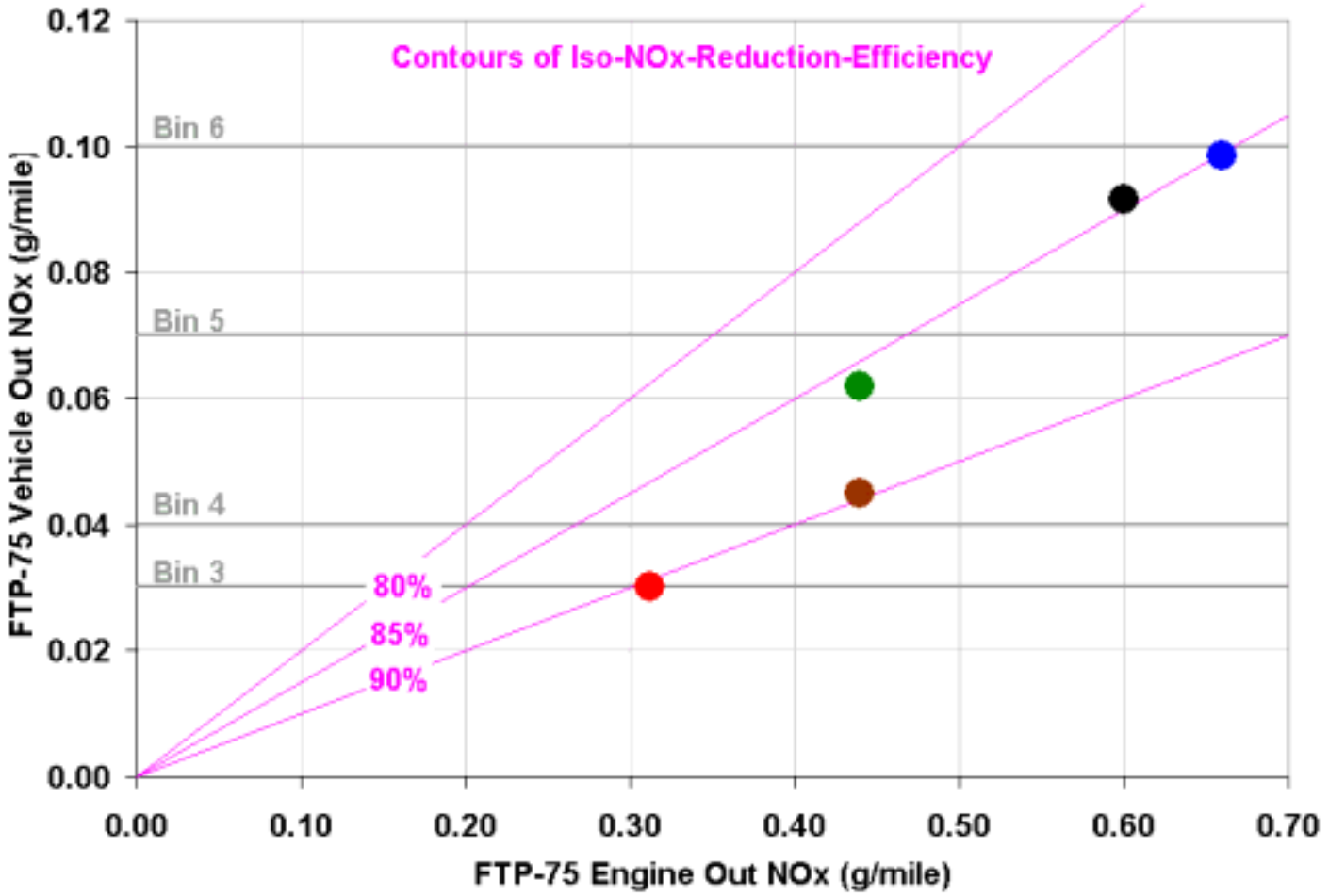

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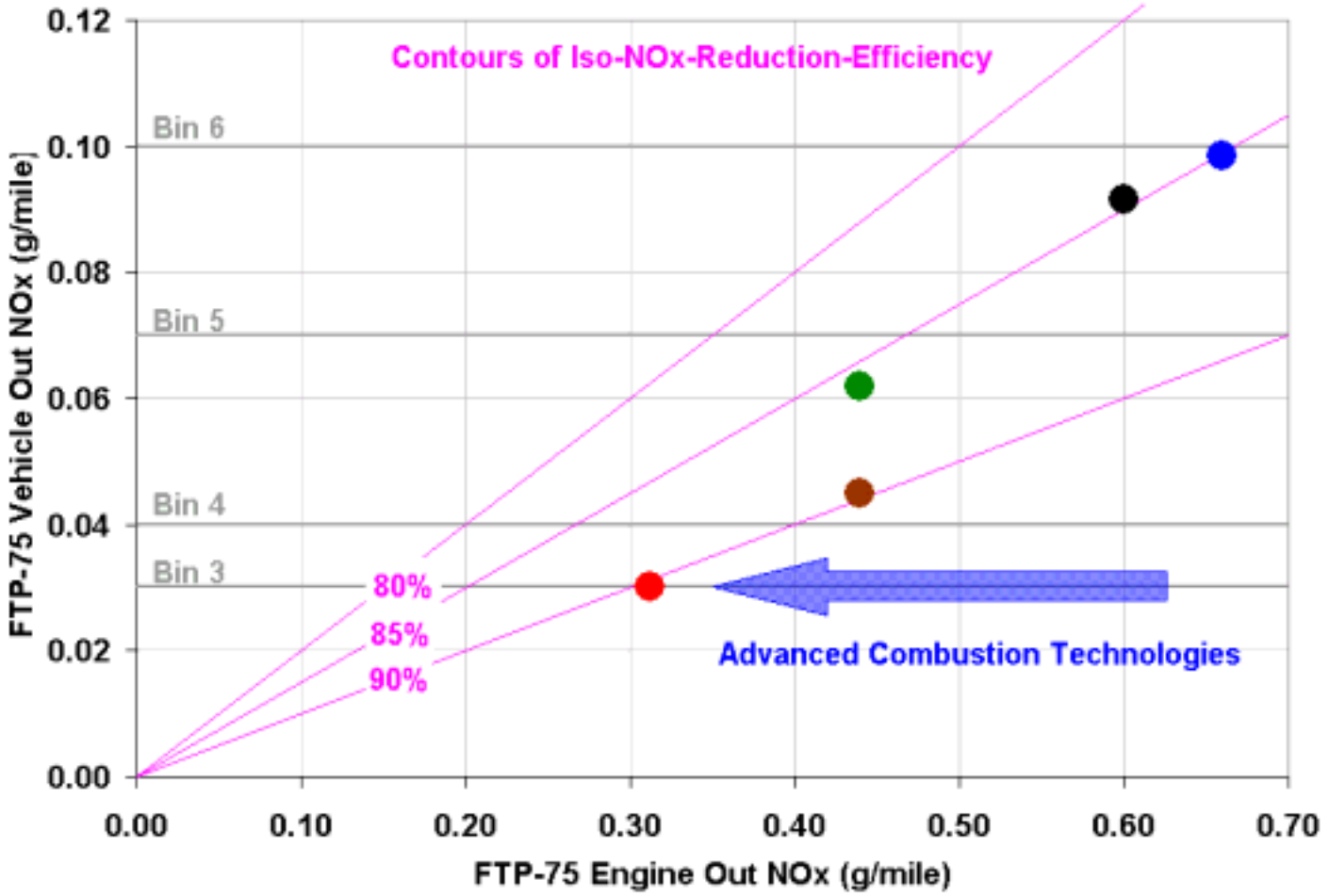

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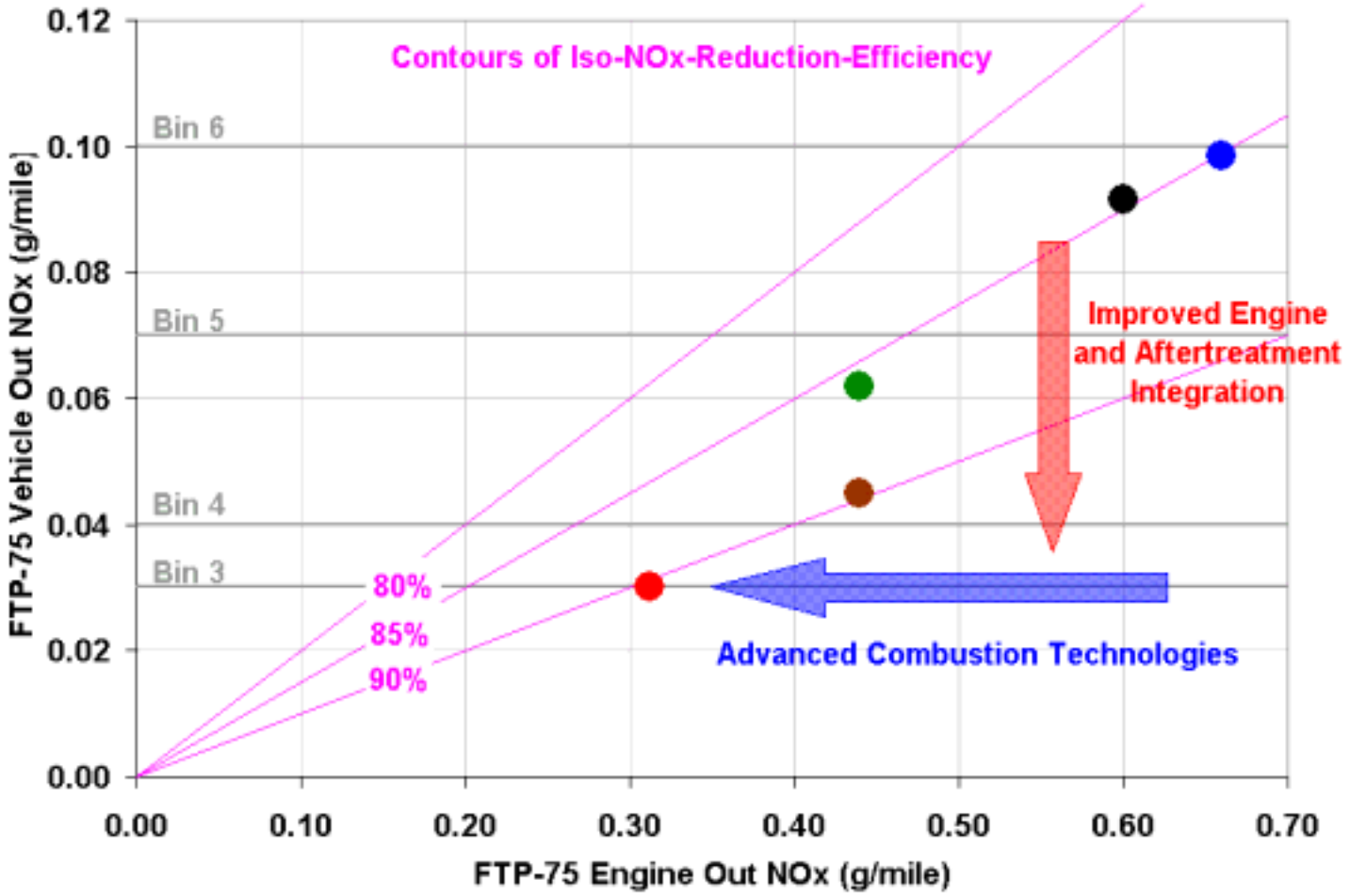
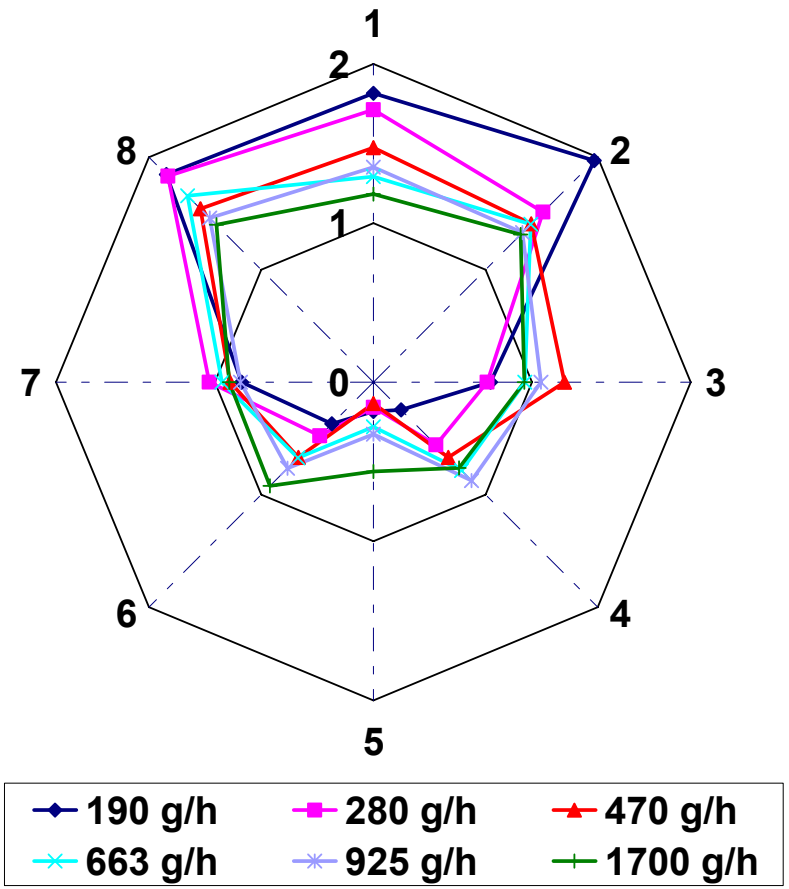


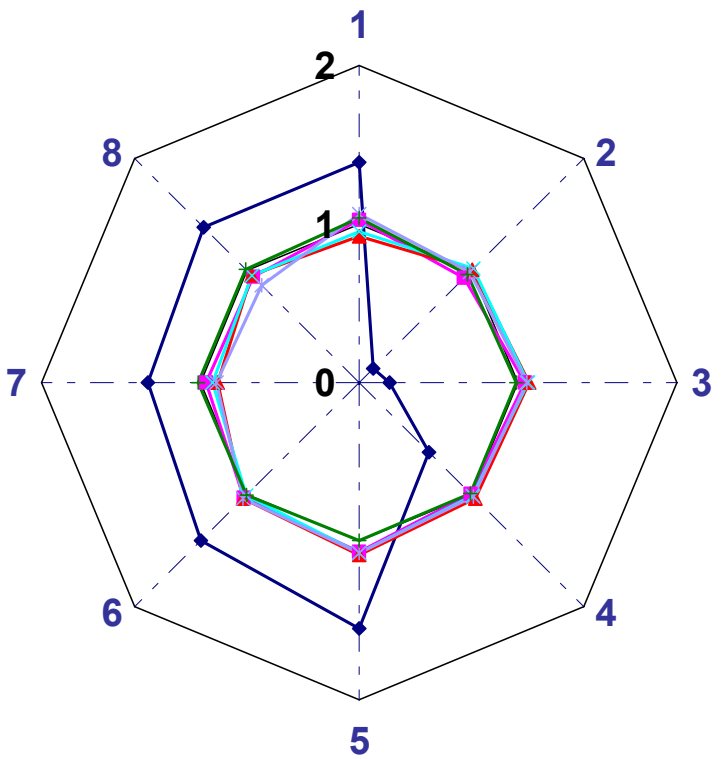
Urea Injection Mixing and Spray Development

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

Before Optimization



After Optimization



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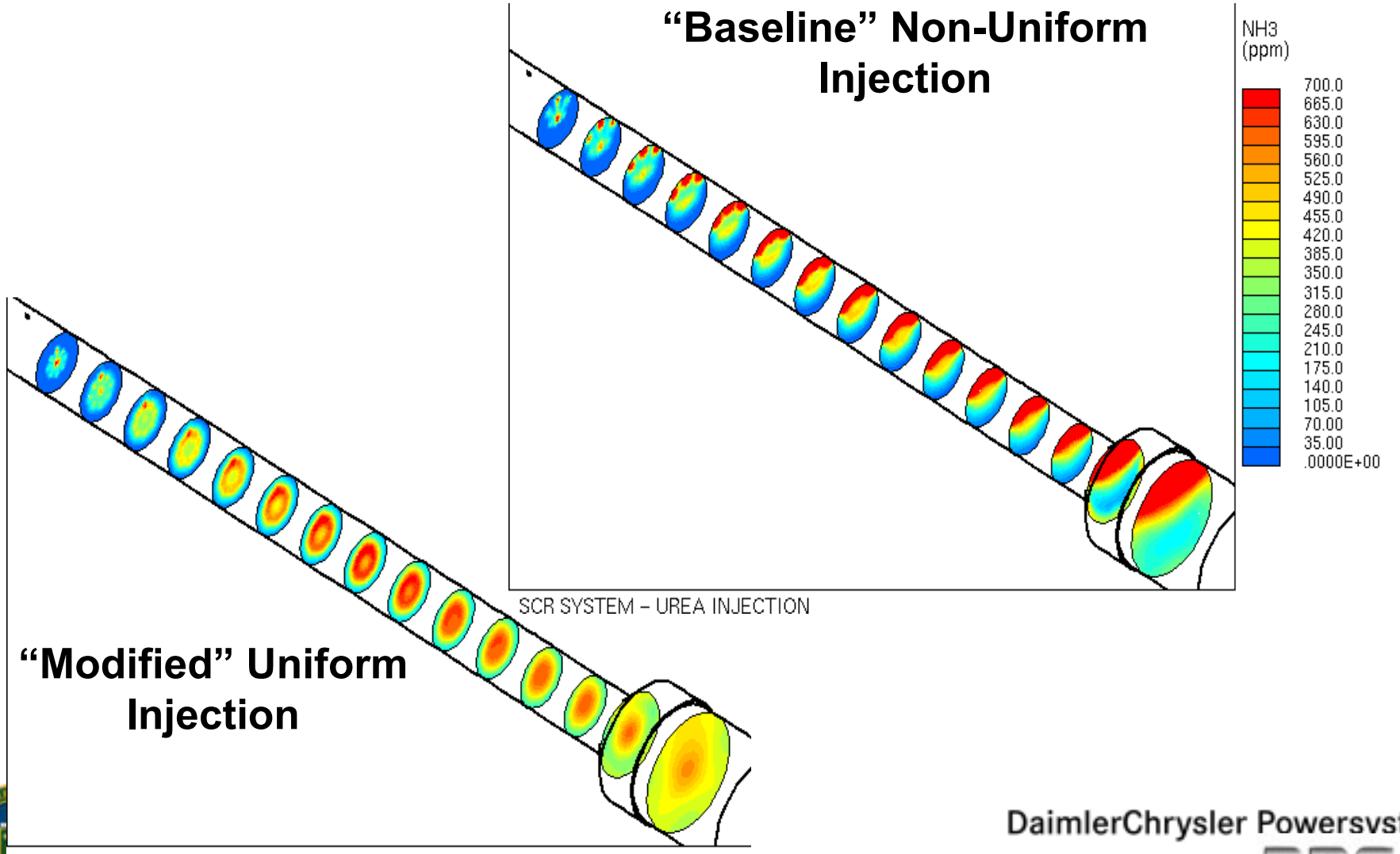
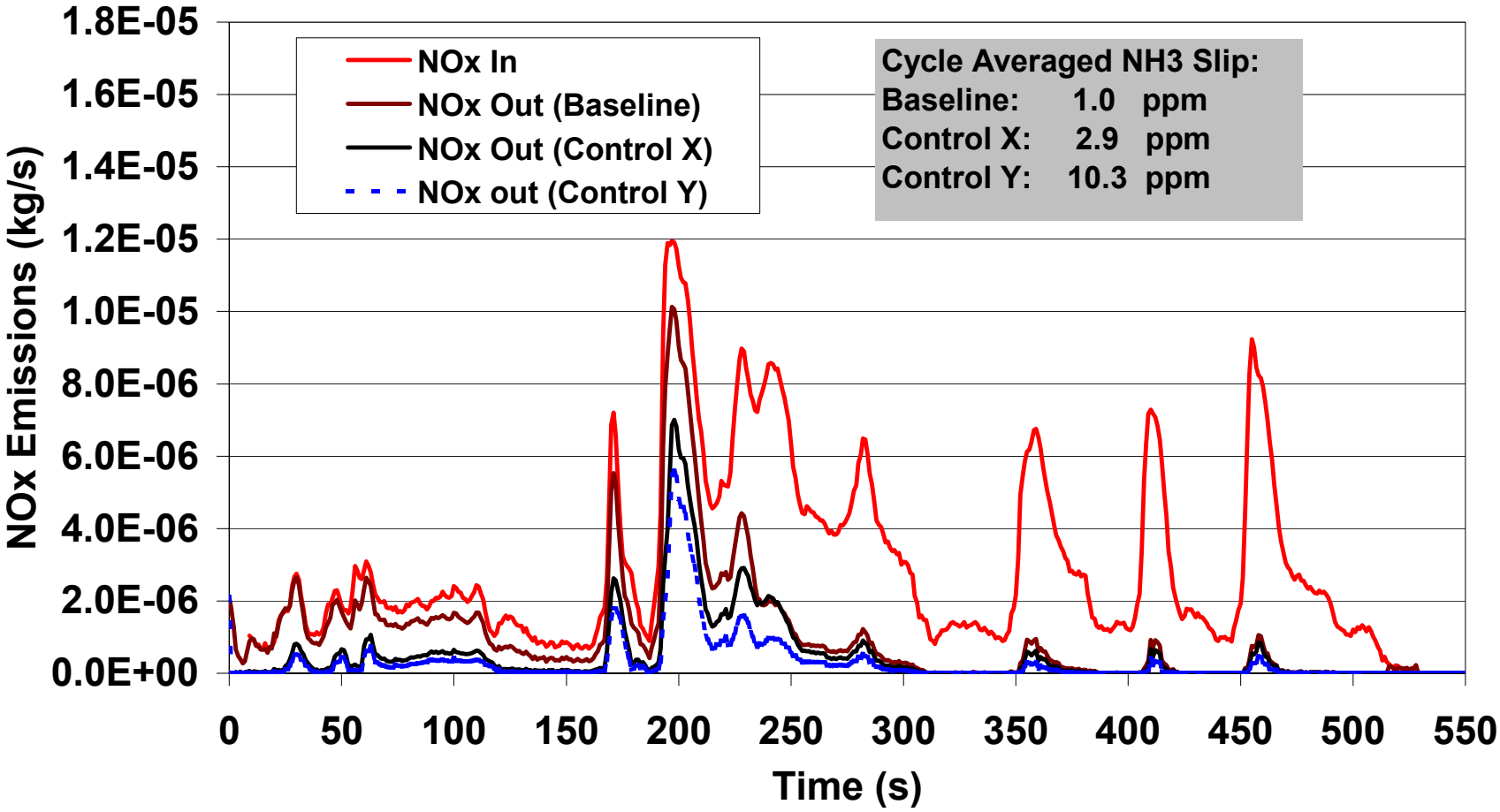
3D CFD for NH3 Distribution

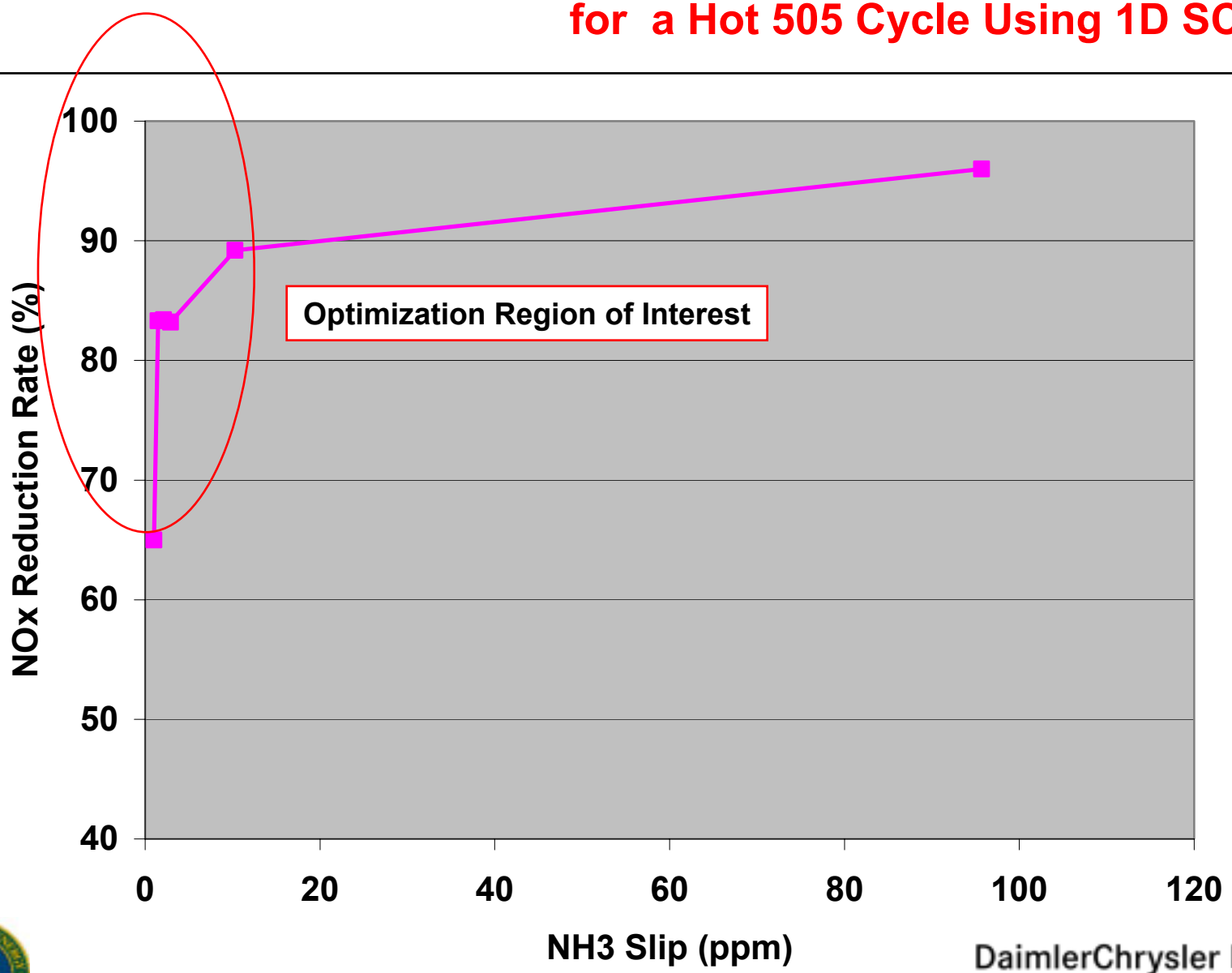


Urea Injection Control Strategy Development

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

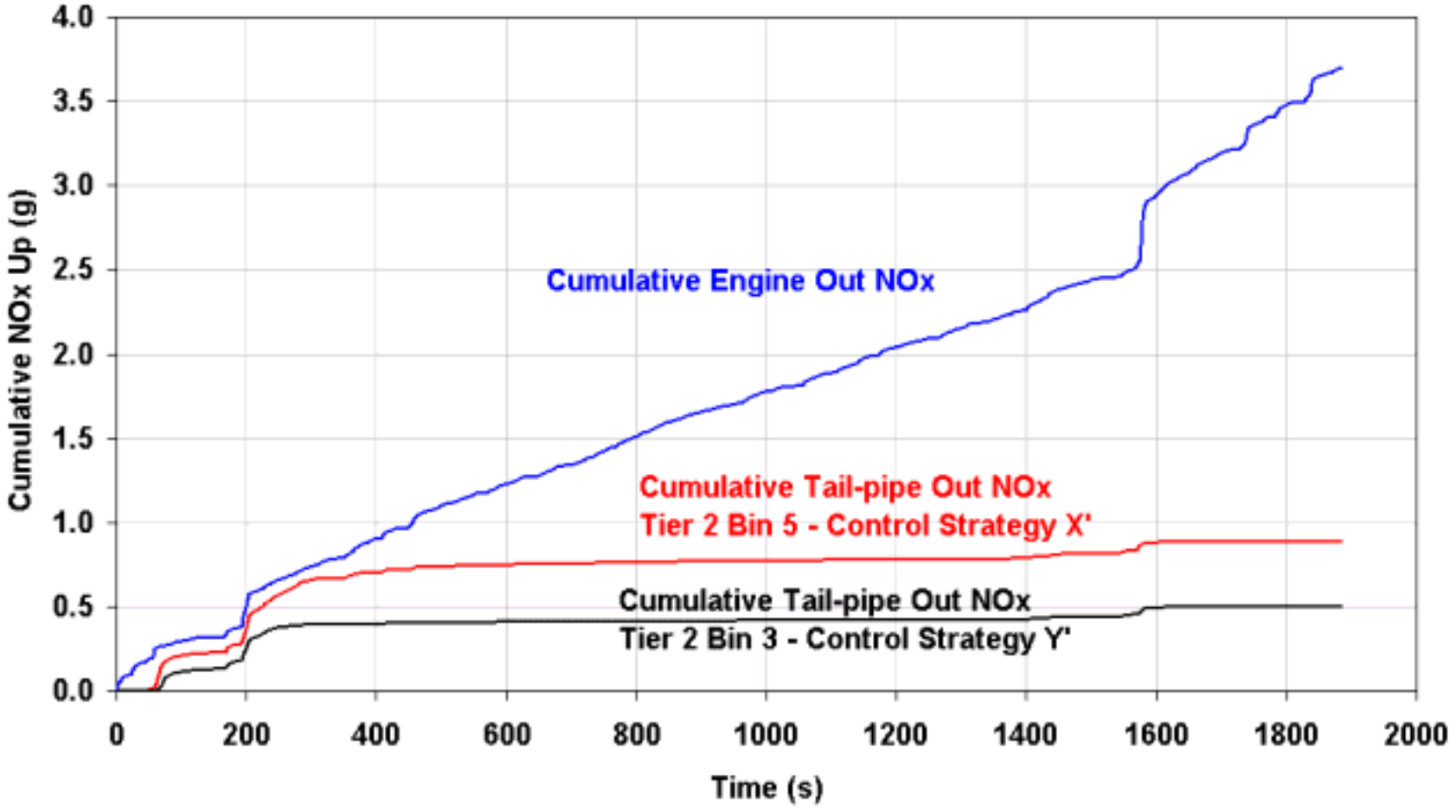


Urea Injection Control Strategies on SCR Performance for a Hot 505 Cycle Using 1D SCR Model



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

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