DaimlerChrysler

DaimlerChrysler NAFTA Truck Business Unit

Aftertreatment Modeling Status, Future Potential, and Application Issues

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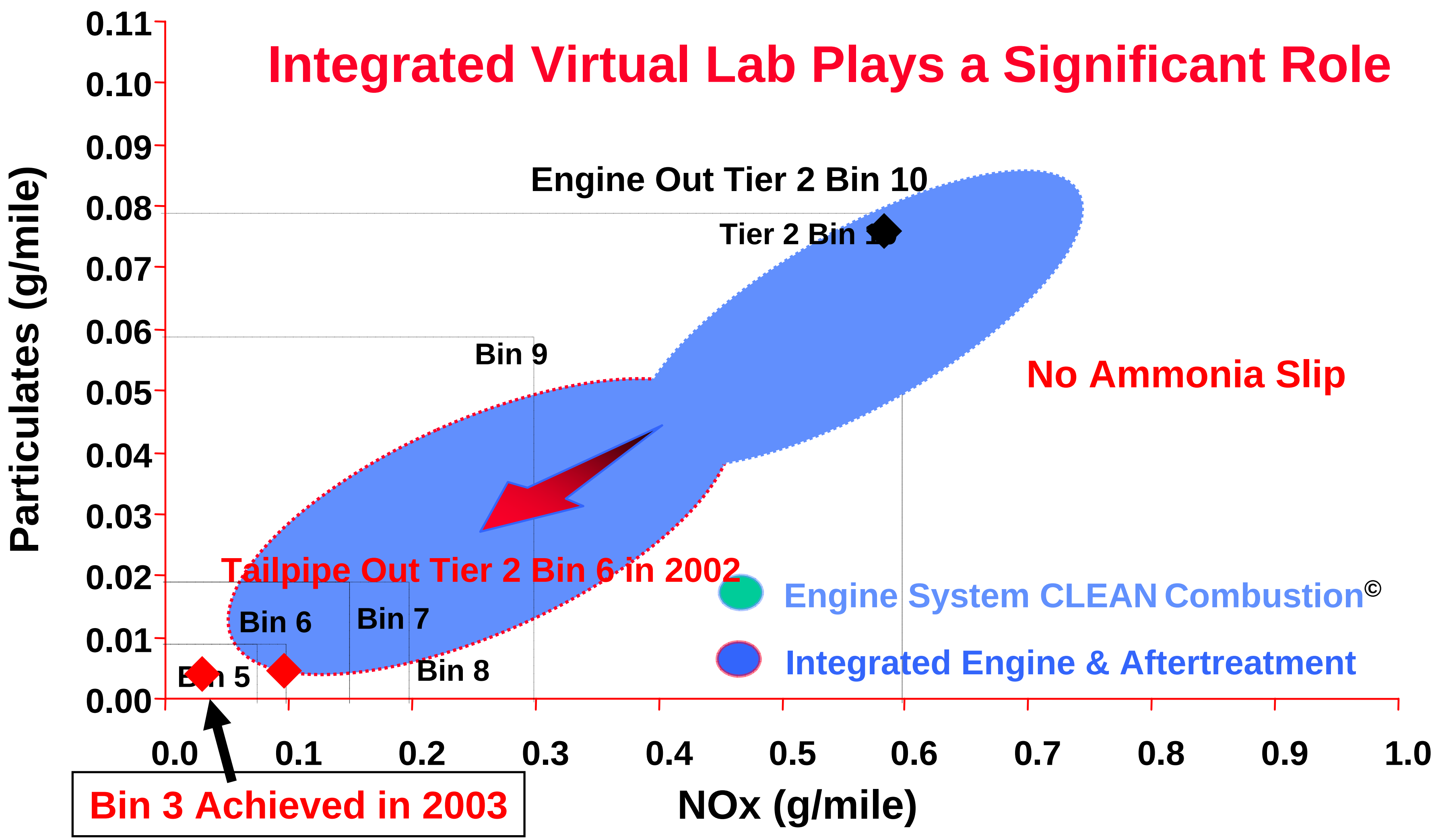
Aftertreatment Modeling Status, Future Potential, and Application Issues

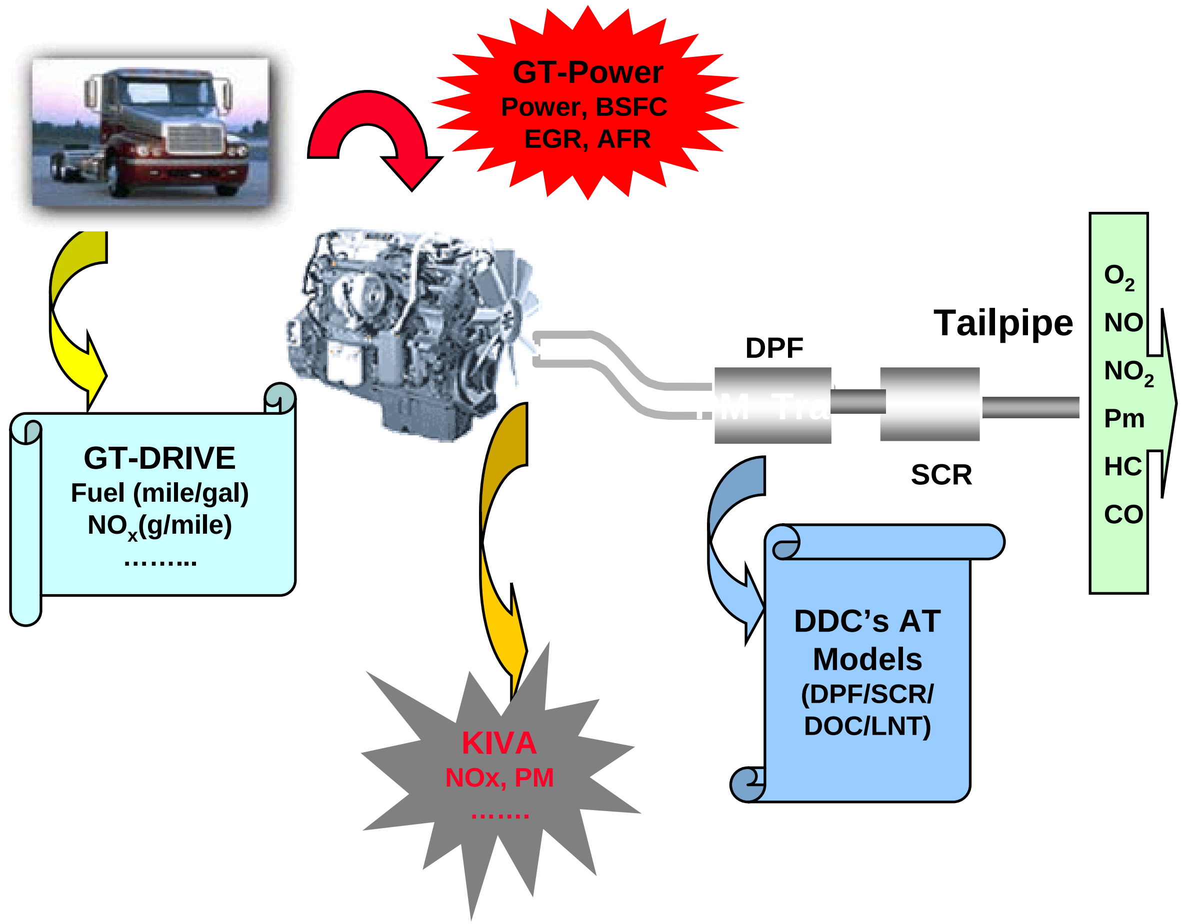
- **Aftertreatment Modeling Status**
  - ➔ **Modeling Development**
  - ➔ **Applications**
- **Catalyst Map Along Turbocharger Analogy**
- **Future Potential and Application Issues**
- **Summary**

Integrated Emissions Reduction Roadmap
LD Truck / SUV Platform



Concurrent Virtual Lab Integration

- **System Integration**
  - ➔ Vehicle/ Engine/ Aftertreatment
  - ➔ All Levels (0-D, 1-D, and 3D)
- **Real World Driving Cycles**
  - ➔ Tool Calibrations
  - ➔ Tool Applications
    - ☐ Steady State
    - ☐ Transient – FTP Cycles
    - ☐ Real Life Driving Cycles



Aftertreatment Model Philosophy

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

Example: 3 Layer Diesel Particulate Filter (DPF) Model

	Flow Channel	Flow Wall	Thermal Channel	Thermal Wall	Filtration	DP
Lumped 0-D Model	0D	0D	0D	0D	0D	0D
1-D model	1D	Quasi 1D	1D	Quasi 1D	Quasi 1D	Quasi 1D
2-D Model	2D	Quasi 1D	2D	2D	1D	1D
3-D Model	3D	3D	3D	3D	2D	2D

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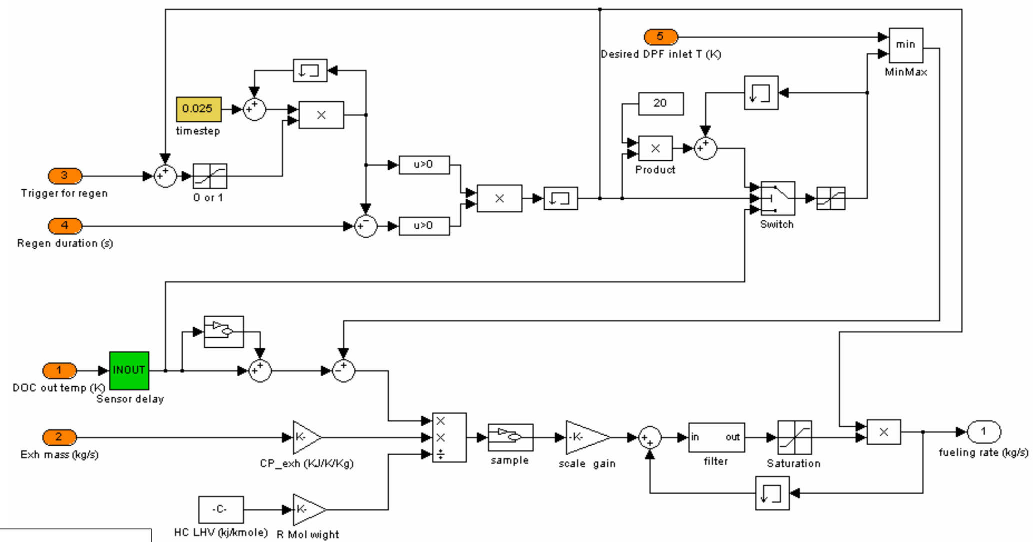
DPF Regeneration Control Strategy
0-D DPF Model Applications

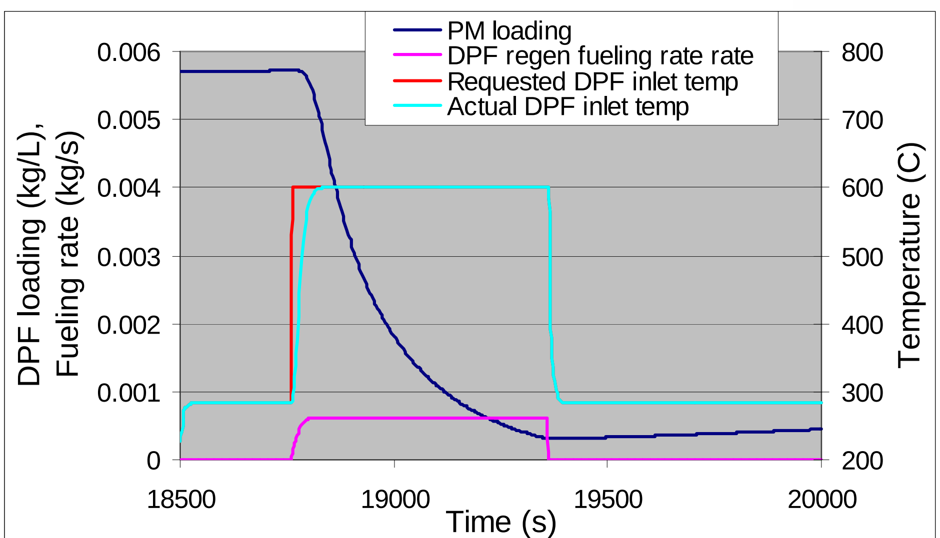
1. Start/Stop Logic
2. Late Post Injection Rate Control Logic
3. Filter Protection Logic
4. Intake/Exhaust Throttle Control Logic
5. Aging/Ash Compensation Logic
6. BSFC Optimization Logic

Late Post Injection Control Logic

- Model-Based Feedback Control Logic Built
- Ready for Online Test

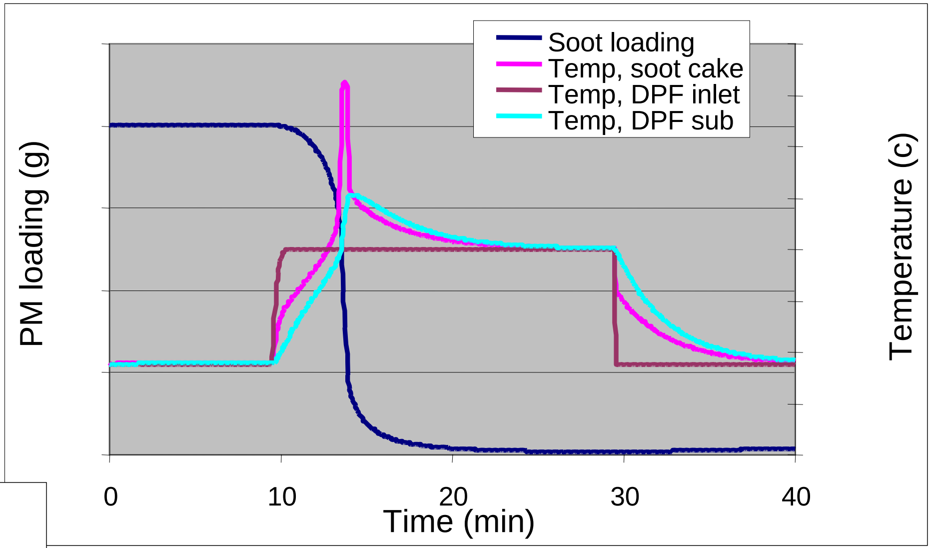


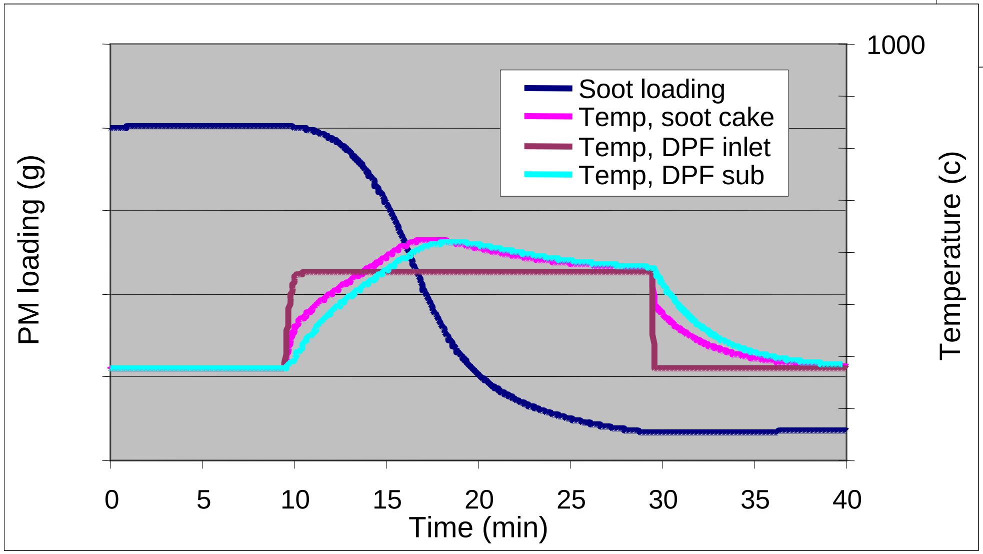
Validated Off-Line



Inlet Temperature Effect on Regeneration

Regeneration at higher temperature



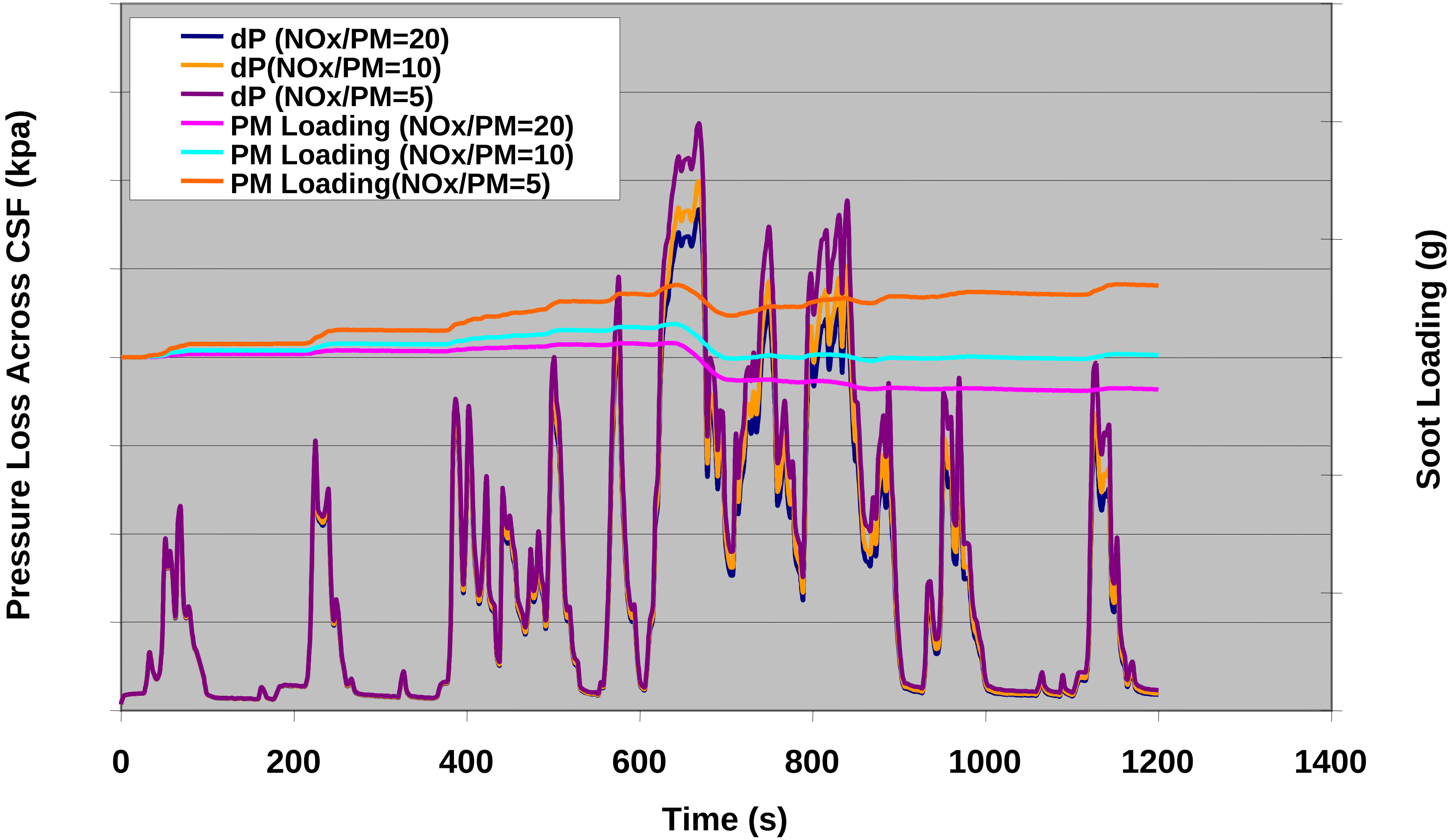


Regeneration at lower temperature

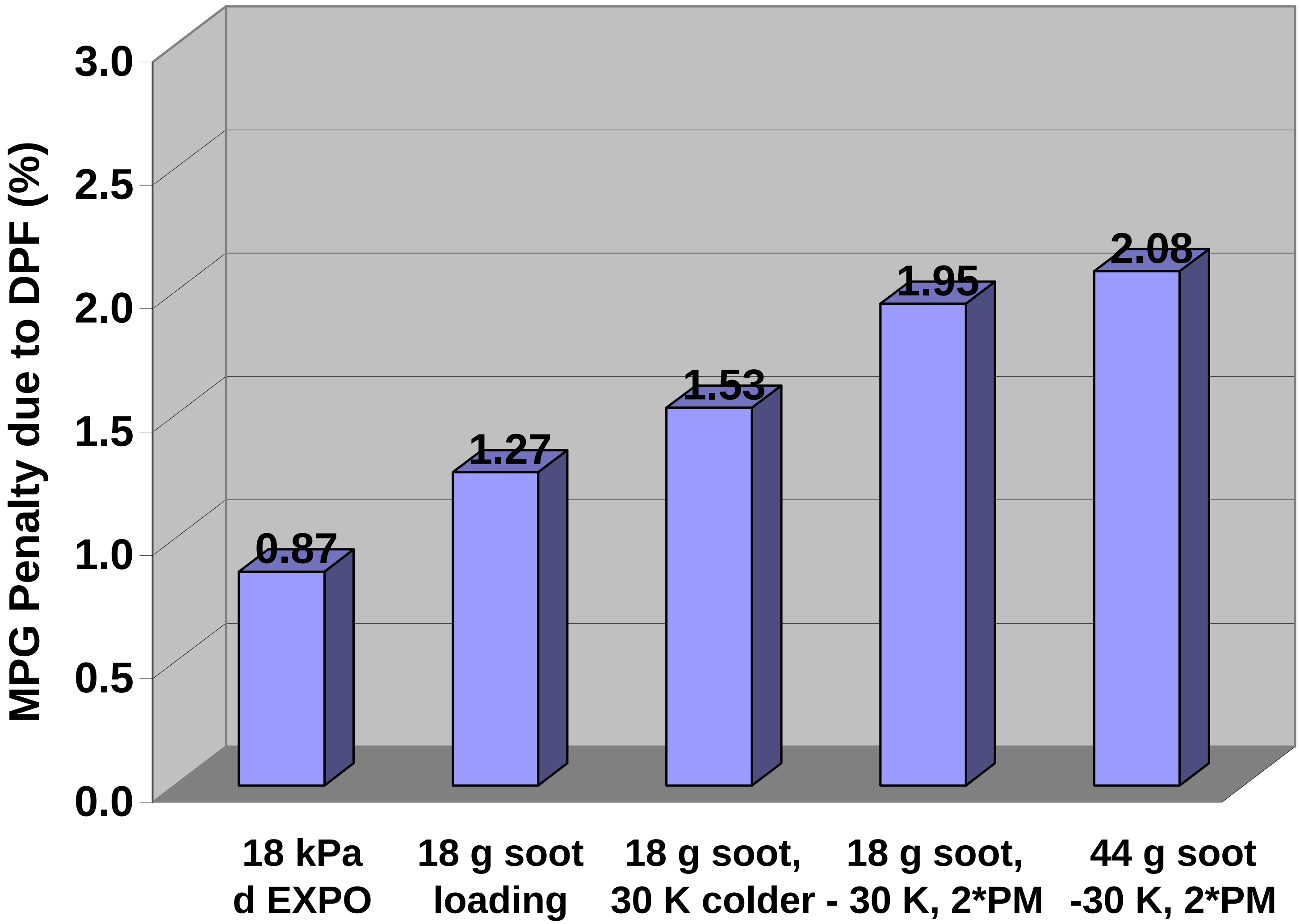
DPF/Engine System Integration
1-D and 2-D DPF Model Applications

- Understand Nature of DPF Characteristics
- Transient FTP Applications
  - ➔ Pressure drop estimation across DPF during FTP as a function of
    - NOx / PM ratio
    - Initial DPF soot loading
    - Exhaust gas temperature
  - ➔ Instantaneous DPF filtration efficiency estimation
  - ➔ DPF soot loading / soot oxidation rate estimation

Effects of NOx/PM Ratio on DPF



2007 Vehicle MPG Evaluation
A Driving Cycle - Ann Arbor to Toledo



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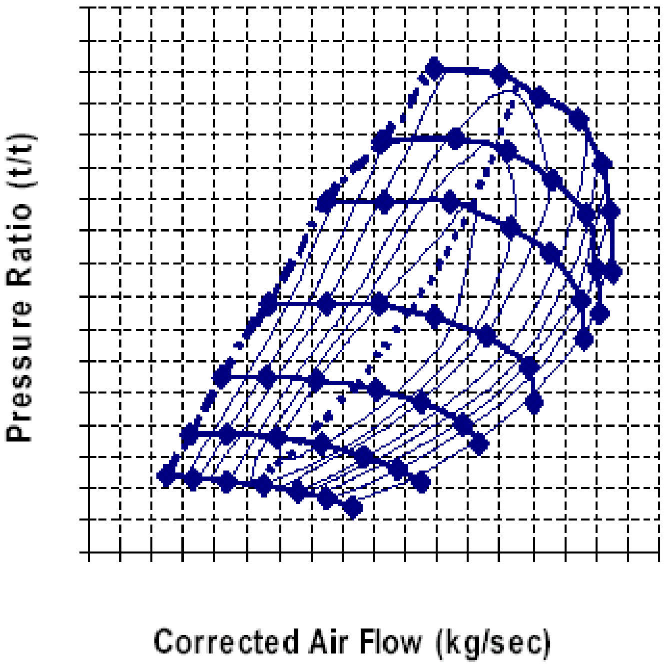
Turbocharger Map Analogy

- **Background Information**
  - ➔ **First proposed in CLEERS workshop in November, 2003**
    - ☐ **Laid down a foundation for future simulation path**
  - ➔ **Follow-up in CLEERS Workshop in June, 2004**
- **Turbocharger Map Analogy**
  - ➔ **Suppliers provide turbo maps**
    - ☐ **Standard format**
    - ☐ **Cover speed range, pressure ratio, flow ranges and efficiency**
    - ☐ **No need to know the turbo details**
      - **Nozzle size, blade geometry**
- **It is a Win-Win Situation**
  - ➔ **Suppliers do not need to provide sensitive data**
  - ➔ **Engine companies treat the maps as proprietary information**

Typical Compressor Performance Map



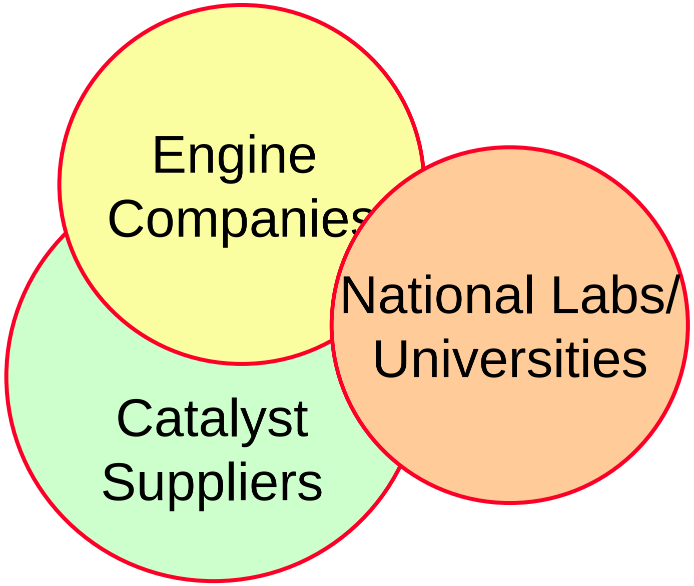
Aftertreatment Modeling
Catalyst Maps

- **Aftertreatment modeling will be similar to engine modeling with turbocharger**
  - ➔ **Aftertreatment device will be part of engine component library**
  - ➔ **Engine manufacturers do not have to know the details of the catalyst formulation**
    - **Industry needs key performance characteristics – emission species reduction rate, pressure drop for a filter, substrate sizing, etc.**
- **It should be Also Win-Win Situation**

Roles in Map Generation

Engine Companies, Suppliers and National Labs/Universities

- Engine Companies
  - System integrator (engine and aftertreatment devices)
- Catalyst Suppliers
  - Map generator with a standard format
  - Require substantial input from Industries
- National Labs/Universities:
  - Assist in developing more physically-based maps
  - Detailed micro-kinetics for a better understanding of catalyst performance



Technical Challenges and Issues

- **More/Better Kinetic Data Is Required**
  - ➔ **Effective alternatives must be considered**
    - ☐ **Catalyst Map is one effective approach**
    - ☐ **CLEERS Sub-Groups Are Working in This Direction**
- **Sophisticated Controls Technology Integration**
  - ➔ **Soot filter regeneration strategy**
  - ➔ **Urea injection and mixing improvement**
  - ➔ **Virtual sensors and control (soot loading, DP, NH3 slip)**
- **Effect of Aging on Aftertreatment Performance**

Summary

- Developed and Validated Individual at Simulation Models, Ranging From 0D, 1D to 3D.
- Integrated Models With Existing Engine and Vehicle Simulations Tools.
- Applied Integrated Simulation Tool, Featuring Engine, AT, and Vehicle Models, to Provide Design and Testing Directions.
- Top Issue is How to Get Testing or Kinetic Data to Calibrate Models.
- Initiated Catalyst Map Approach to Break Barriers In order to Get Valuable Kinetic Data

Acknowledgments

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