SAE 2009 **On-Board Diagnostics** Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

2013 Diesel OBD Challenges

Panelists:

Michiel van Nieuwstadt, Ford Motor Company

Joan Wills, Cummins

Cheryl Stark, GM

Michael Read, Navistar

Moderator:

Ben Zwissler, Cummins

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2013 Diesel OBD Challenges
Algorithm design challenges

Michiel van Nieuwstadt

Ford Motor Company

Uncontrolled/poorly controlled noise factors

With the increased requirements on OBD system capability, the effect of uncontrolled noise factors becomes more significant

There are several important external factors that affect system/OBD operation that are poorly known.

Among those:

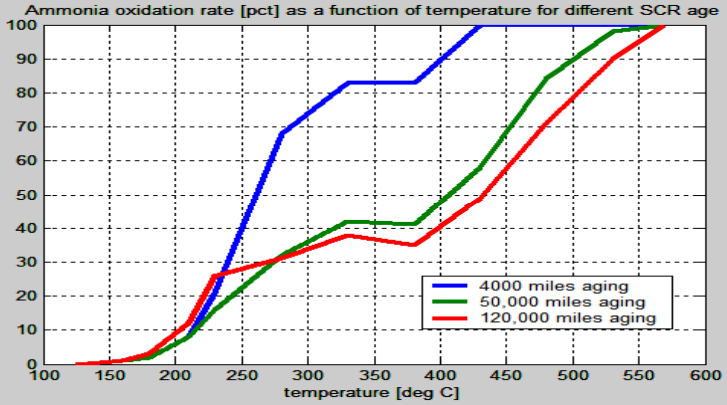
1. Aftertreatment catalyst age:
   - Model, or noise factor?
2. Fuel properties
   - Cetane
   - Biodiesel content

When is modelling too much?

1. SCR age

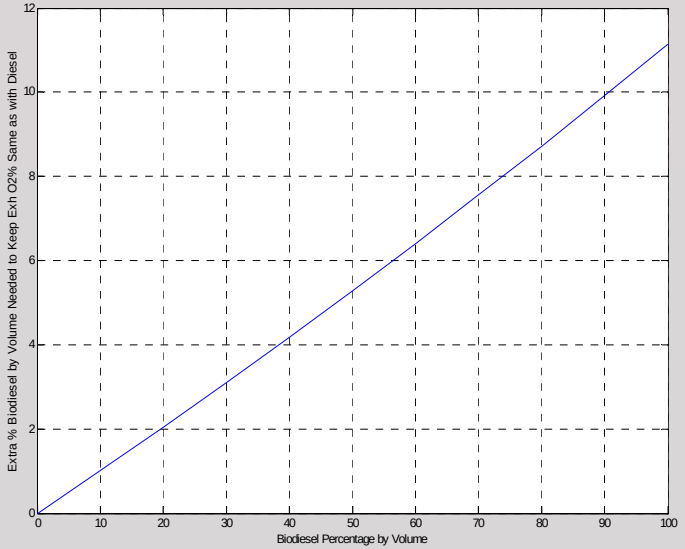
NH3 oxidation in SCR catalysts depends on age
NH3 oxidation to N2 does not directly contribute to legislated emissions, but is an important factor when deciding on the correct urea injection quantity, adaptive features, NH3 spill predictions
Approaches:

1. Include a model for oxidation rate as a function of SCR age
    1. Hard to model over all possible aging profiles
    2. Hard to validate
2. Treat as a noise factor
    1. Will increase uncertainty margins on feedback authority
    2. Will increase uncertainty margins on NOx sensor monitors



2. Fuel properties

- Biodiesel contains 8% less energy by volume
- B20 requires 2% more fuel (by volume) to maintain same O2 level in exhaust
- Monitors affected:
  - DOC exotherm monitor
  - Small fuel quantity adaptation and monitor
  - O2 sensor monitor
- For illustration: Percent fuel required to maintain O2 level as a fcn of BXX content:



Algorithms that correlate O2 to air and Fuel will have to allow an extra 2% error (B20).

Algorithms that correlate fuel quantity to trq will have to allow an extra 8% error

Summary

- OBD monitors can in principle by made more accurate by including models of noise factors
- The cost of including these noise factors can include:
  - Added sensors
  - Extensive validation
- This can make the cost of modeling prohibitive

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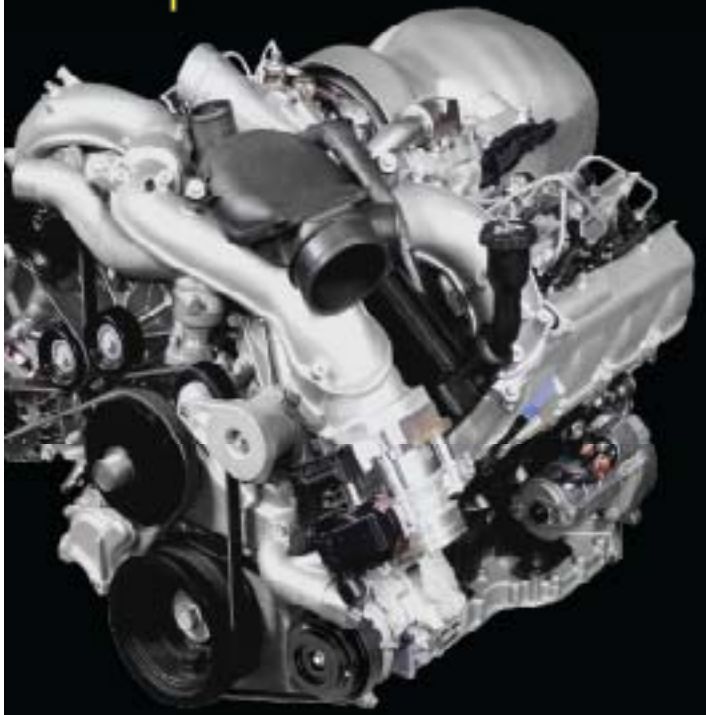

2013 Diesel OBD Challenges
Future Sensor Needs

Joan Wills

Director-Cummins Adv. Engineering Controls and Diagnostics

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Technology Forcing Monitors Requiring new sensing solutions

- DPF Efficiency
- SCR Efficiency & Reductant Delivery
- DPF NMHC
- DOC Feedgas
- Rail Pressure Rationality
- Injector Trimming

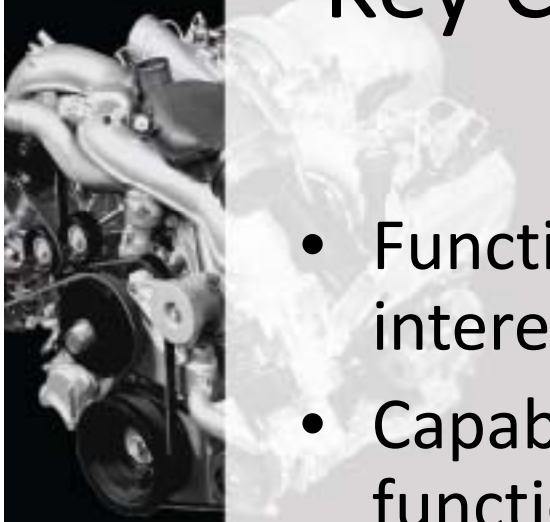
Sensor Risks for 2013

- Tailpipe NOx sensor accuracy/durability/cost
- PM sensor options for DPF Efficiency
  - Will they be ready for production?
  - Accuracy?
  - Durable to HD useful life?
  - Rationality?
  - Cost?
- No sensor available for NMHC (DPF NHMC)
- No sensor available for NO/NO2 (DOC Feedgas, possibly needed)
- Ability of datalink sensor suppliers to deliver OBD compliant products including documentation

Some Potential Sensing Technologies for 2016-2020 timeframe

- PM sensor technology that is NOT only for post-DPF
- Engine out and Exhaust NO_x sensors without cross-sensitivity to NH_3
- Fuel quantity sensor
- Catalyst condition sensors (NH3 storage or SCR/DPF soot loading)

- Electron-spin resonance based
- Optical/NDIR based
- Carbon nano-tubes
- MEMS sensor to measure pressure modifications
- Surface property sensing
- RF based sensing



Key Criteria for Acceptance of New Sensing Technologies

- Functionality of the sensor for the variable of interest
- Capability to diagnose rationality and functionality
- Durability for HD-type engine operation
- Cost
- Difficulty in installation, operation and, replacement

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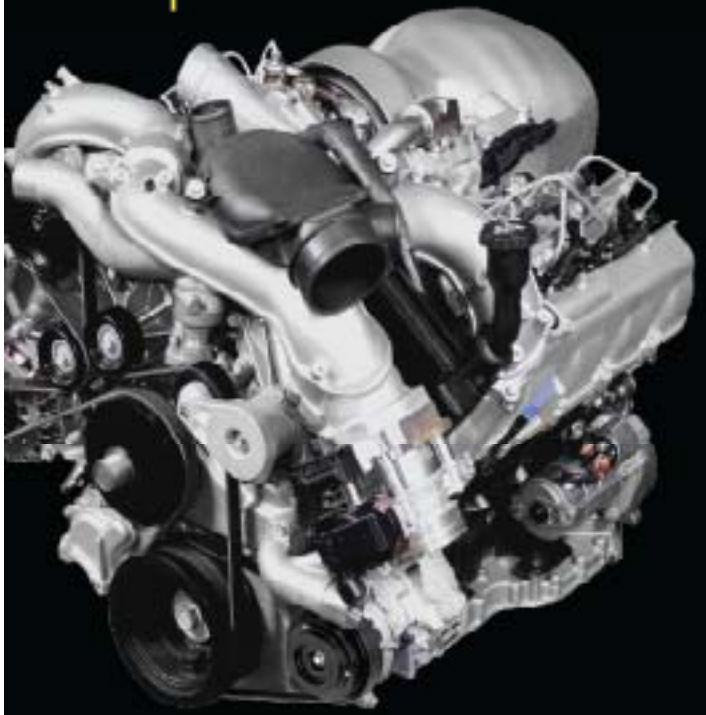

2013 Diesel OBD Challenges
Development Timing Concerns

Cheryl Stark

Engineering Group Manager – OBD

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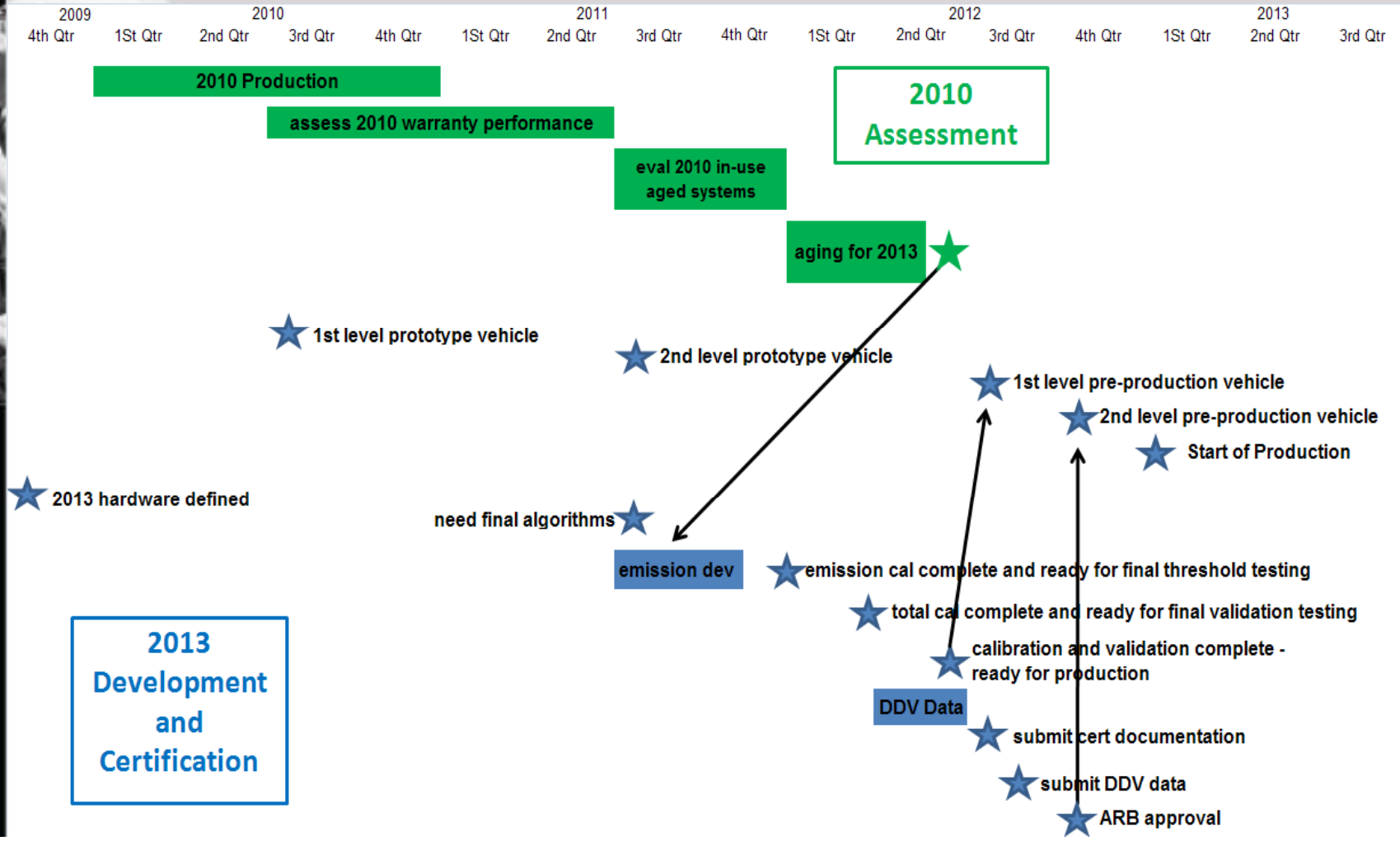
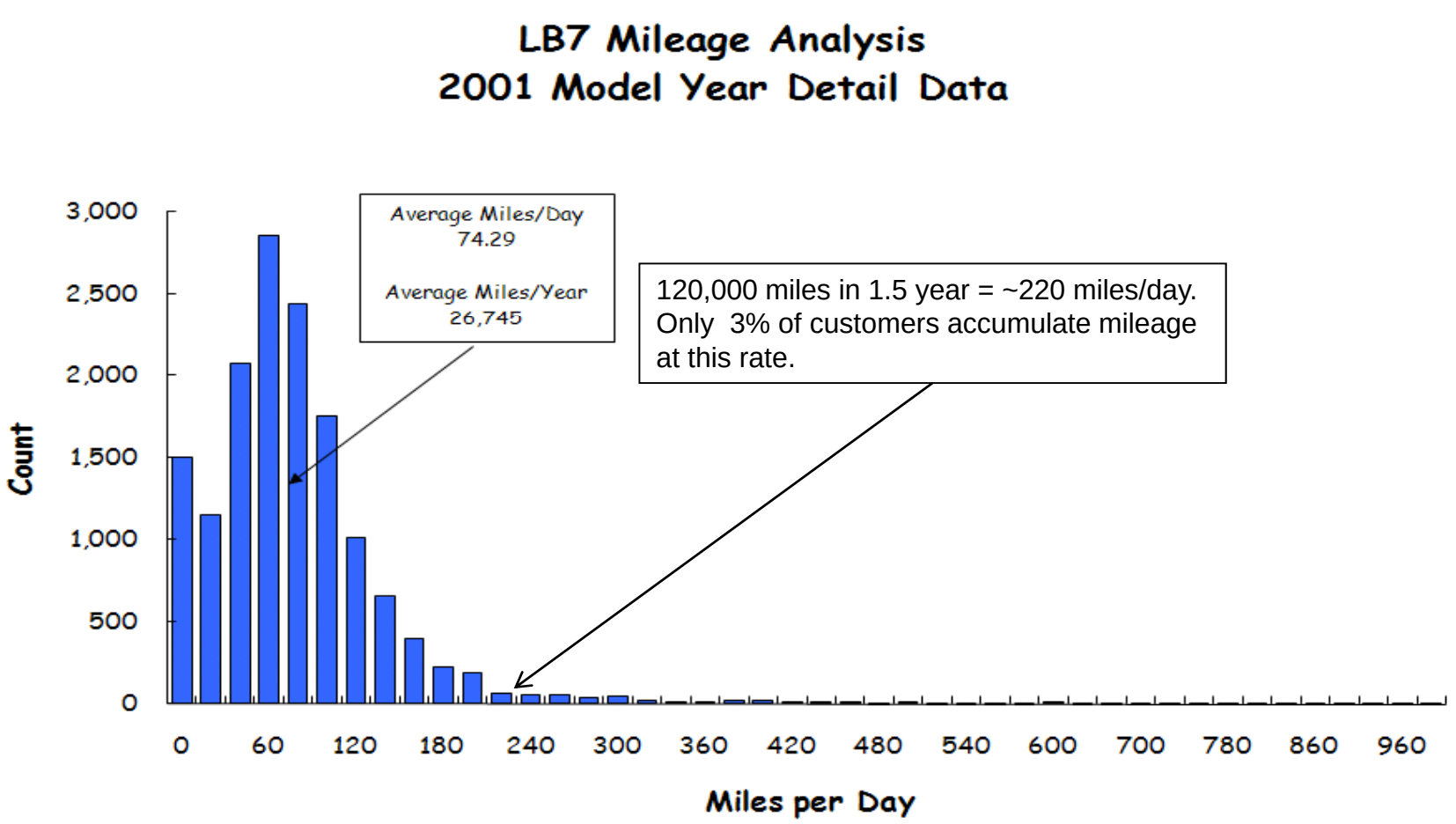
2013 Diesel OBD Development Timing Concerns



Real World Customer Mileage Accumulation



2013 Diesel OBD Challenges

- Based upon estimated mileage accumulation, real-world aged full useful life (120K) systems (engine, engine emission controls, and aftertreatment) are not available until 18 months after start of 2010 production.
  - This does not support timing of tailpipe emission and diagnostic threshold development for 2013 model year.
  - Need regulatory relief allowing sufficient time to collect systems from the field, characterize aging, develop an accelerated aging cycle, and age systems for development.

2013 Diesel OBD Challenges

- 2013 hardware requirements must be known before 2010 program is complete.
  - The need for new hardware is largely based upon monitoring capability concerns identified during and after 2010 development.
- Algorithms for 2013 will require refinement based upon 2010 warranty performance and reduced emission thresholds.
  - 12 Month In Service data becomes available too late to develop 2013 algorithms on time.

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Heavy Duty Hybrid OBD Challenges

Michael Read

Navistar's Global Vehicle/Powertrain Regulations, Certification & Compliance Group, OBD

Why Heavy Duty Hybrids

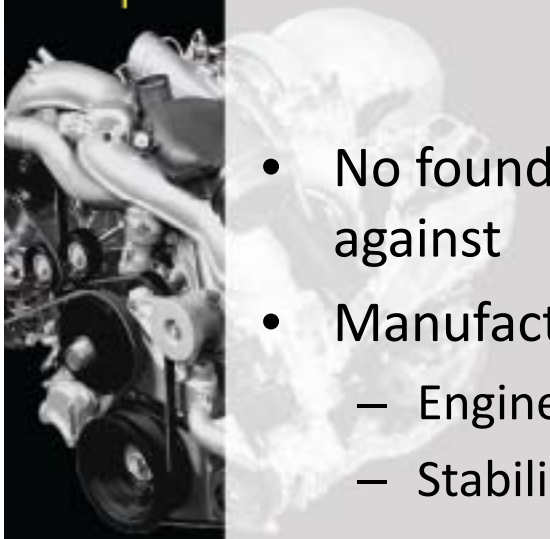
- Reduction of Green House Gas (GHG) Emissions
  - CO_2, Methane, N_2O
- Reduction of constituent tail pipe emissions
- Certain application duty cycles are ideal
  - Fleets using class 3-6
  - School bus
  - Local pick-up and delivery

What does this mean?

- Currently no Federal Test Procedure (FTP)
- California Air Resources Board 'Interim Procedure'
  - Developed without regard to advanced aftertreatment strategies, SCR or OBD
  - Not prime path
    - Supplemental test to the current HDDE FTP
  - Other battery management systems
    - Protection Strategies
- Current process for OEM is existing certification (emission/OBD)
  - Must have secondary vehicle approval that demonstrates hybrid technology does not adversely affect the operation of OBD monitors
  - No synergy with the spirit of certification or OBD

Impacts

- Current OBD regulations based on light duty hybrid experience
  - Start/stop strategies
    - Fuel system and Misfire monitors
- Heavy duty applications much different than light duty
- Ideal hybrid configuration not yet defined for all applications
  - Charge sustaining (parallel)
  - Charge depleting (parallel)
  - EV w/ HDDE back up (series/genset)



Solutions

- No foundation for certification means nothing to validate OBD against
- Manufacturers must have clear certification procedure
  - Engine only or vehicle only certification options
  - Stabilization of the powertrain solution & technologies
  - Proper verification process and tools
    - HIL's development with chassis verification as opposed to FTP's
- Without clear direction of the above, HD-OBD cannot move forward