




SAE 2009 **On-Board Diagnostics** Symposium

Update on Light and Heavy Duty Vehicle

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



# Smart Sensors and Diagnostic Critical Electronic Control Units: Design Update

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## What is the OBD definition of a controller?

- The OBD and emissions warranty regulations contain several requirements that apply exclusively to emissions related control units (or modules). In 1968.2, these are called “***Diagnostic or emission critical electronic powertrain control units.***”





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## What is the OBD definition of a controller?

When these rules were written, there was a wide technology gap between automotive control units (ECM, TCMs etc.) and sensors (MAP, IAT, etc) or actuators (fuel injectors, fan relays, etc.). This gap made it easy to distinguish between “control units” and “sensors” or “actuators”.





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## What is different now?

- The trend toward “smarter” sensors and actuators is driven by:
  - Improved sensor accuracy/precision. In some cases it is essential to use multiple sensed values to calculate a single value (Classic example: hot wire anemometer mass air flow sensor)
  - Data transmission via E(lectro)M(agnetic)C(ompatibility) robust methods (SENT, serial data, PWM, etc.) These same methods are also more robust to circuit resistance changes (aging contacts, etc.)



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## What is different now (cont.)?

- The trend toward “smarter” sensors and actuators is driven by:
  - System Design Flexibility
  - Reducing wiring and connectors (improved reliability)
  - Smart actuators can reduce the current draw and heat dissipation requirements for controllers, improving controller reliability and package size.



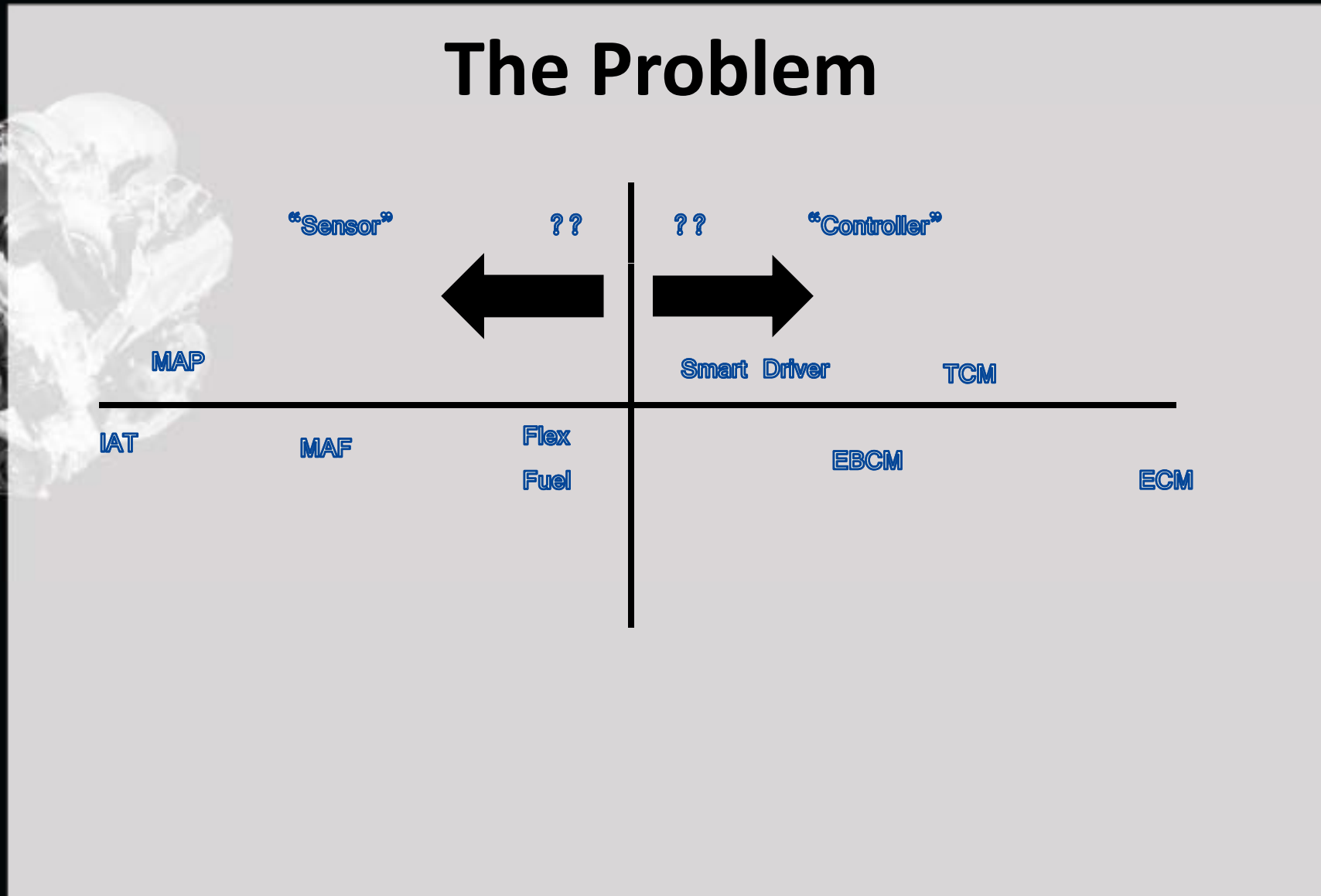


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## The Problem





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## Requirements exclusive to emissions related control units

- Calibration ID - CALID
- Calibration Verification Number – CVN
- Controller self diagnostics
- Emissions controller warranty – 8yr/80,000 mi

**Note:** This discussion is not about what controllers respond to various J1979 functions. That is what the distributed OBD system is about. I covered that issue at the 2008 SAE OBD Symposium.



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## Purpose of CALID

- Permits I/M to verify that the controller contains the “correct” software and calibration
- Permits I/M to enforce OBD recalls
- Permits CARB/EPA Certification and enforcement of aftermarket software and calibration functions



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## Purpose of CVN

- Permits I/M to verify that the controller calibration has not been “tampered” with or otherwise corrupted





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## Additional CALID & CVN Requirements

- **Must be exported via J1979 Service \$09**
- **An Excel database of allowed CALID/CVN pairs for all emissions critical controllers must be provided to CARB (ref MSC #06-23 & MSC #09-22)**



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## US EPA Emissions Warranty Requirements

**Specified major components**

- Catalyst
- on-board computer
- diagnostic device
- new emission parts > \$200

**There is not a regulatory relationship between CARB's definition of "emissions critical" controller and EPA's "diagnostic device".**



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## OBD Regulatory Language – 1968.2

*“Diagnostic or emission critical”* electronic powertrain control unit refers to the **engine and transmission control unit(s)**. For the 2005 and subsequent model years, it also includes any other on-board electronic powertrain control unit **containing software that has primary control over any of the monitors** required by sections (e)(1.0) through (e)(14.0), (e)(16.0), (f)(1) through (f)(14), and (f)(16) or, excluding anti-lock brake system (ABS) control units or stability/traction control units, has **primary control over the diagnostics** for more than two of the components required to be monitored by sections (e)(15.0) and (f)(15).



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## What is important about this definition?

**“... containing software that has primary control over any of the (*major*) monitors ...”**

This means any portion of any major monitor.

**“... primary control over the diagnostics for more than two of the (*comprehensive*) components ...”**

This means any of the required monitors for a comprehensive component.



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## Primary Control of a Diagnostic?

Proposed definition:

- Determination of enable criteria
- Calculation of the diagnostic decision statistic (the calculation that is compared to a fault threshold)
- Pass/fail determination for the diagnostic (Comparison to pass and/or fail thresholds)



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## What is NOT Included?

- Instantaneous (short term) system state determination.
- For example:
  - “Raw” A/D variables
  - Output driver functional determination (fail, pass, indeterminate)
  - Open or short to ground results from individual sensors



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## Example of Primary Control:

```
IF KbdMDD_SwitchDiagEnbl == TRUE
THEN
  INCREMENT VeDMDD_Cnt_OutOfRangeLow_Samples
  IF (VeDMDI_e_EcoModeSwRaw = CeDMDI_e_EcoModeSwFltLow)
  THEN INCREMENT VeDMDD_Cnt_OutofRangeLow_Failures
  ELSE No Action
  ENDIF
  IF (VeDMDD_Cnt_OutofRangeLow_Failures ≥ KeDMDD_Cnt_OORLow_Fail_Limit)
  THEN
    PerfmDFIR_ReportTestFail(CeDFIR_e_FuelEconModeSwCktLo)
    RESET VeDMDD_Cnt_OutofRangeLow_Failures
    RESET VeDMDD_Cnt_OutOfRangeLow_Samples
  ELSE
    IF (VeDMDD_Cnt_OutOfRangeLow_Samples >=
    KeDMDD_Cnt_OORLow_Sampl_Limit)
    THEN
      PerfmDFIR_ReportTestPass(CeDFIR_e_FuelEconModeSwCktLo);
      RESET VeDMDD_Cnt_OutofRangeLow_Failures
      RESET VeDMDD_Cnt_OutOfRangeLow_Samples
    ELSE No Action
    ENDIF
  ENDIF
ENDIF
ENDIF
```





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## In this example:

- The state determination function **(VeDMDI\_e\_EcoModeSwRaw = CeDMDI\_e\_EcoModeSwFltLow)** can be the result of logic in the smart sensor and still not violate my proposed definition of a diagnostic.
- The diagnostic functions in slide #14 and 15 are color coded to the example in slide #16





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## Issue: Minimize the number of Emissions Critical Controllers

- There are already many Cal IDs and CVNs to track. There are benefits to limiting Cal IDs/CVNs to major controllers.
- Other than PZEVs, the California emissions warranty is longer for controllers than for components.



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## **Design Constraints – Existing Language for Sensors**

**Design the interfaces to transfer raw data to the controller and the controller conducts all diagnostics (out of range high, low, and rationality).**

**It is acceptable (but risky) to allow the sensor to scale the data and determine if it is out of range as long as the controller handles the main diagnostic as defined as above. Diagnostics are prohibited in the “smart” sensors.**



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## Design Constraints – Existing Language for Actuators

Design the interfaces to transfer the results of the output driver diagnostics to the controller and the controller conducts the diagnostics, including functional diagnostics. Diagnostics are prohibited in the “smart” actuator.





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## Proposed New Regulatory Language

- Increase the number of inputs to 4 and the number of actuators to 2. This would allow limited diagnostic content in smart sensors and smart actuators. (Note that many smart actuators also contain sensing elements.)
- Smart devices would not be field reprogrammable.
- Why? A device with more content may result in an incentive to tamper and should support CAL IDs and CVNs.



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## Summary

- Emissions critical controllers are burdened with OBD and warranty requirements that sensors and actuators are not.
- There are sound reasons behind the industry trend toward “smart” sensors/actuators.
- The OBD regulation should be revised to be more flexible in the definition of diagnostic or emissions critical control units to relieve smart devices of burdensome and unnecessary requirements.