Welcome & Symposium Opening
Bernard Challen, Shoreham Services

Federal Regulation in a World of Rapidly Evolving Technology
Federal regulations implement the laws of the land as authored by Congress and signed into law by the President. Often these laws are adopted years in advance of the actual regulations implementing the law. How do regulations adapt to the ever evolving technology landscape and anticipate future developments without constraining technical innovation?

Robert Larson, US Environmental Protection Agency, Retired

Light Duty OBD Update
John Ellis, California Air Resources Board

BREAK

Historical OBD Presentation
Paul A. Baltusis, Ford Motor Company

Exhibitor Introductions
Darlene C. Waychoff, SAE International

Tuesday Networking Lunch with Exhibits

OBD Experiences, an FCA US LLC Perspective
This presentation will cover two topics of interest. The first topic covers our Variable Valve Lift (2 step lift) diagnostics and discloses our requirements discussions with CARB, our diagnostics coverage, our in-progress improvements and our service routine intended to allow pinpointing of the problem valve. The second topic discusses three issues we have had with our brake switch diagnostics, namely: 1) Brake Switch Stuck Off is subject to false failures during uphill stops, emergency brake stops or trailer brake stops - when the customer does not use the service brake to bring the vehicle to a stop, 2) Customer riding the brake pedal can result in a false fail for Brake Switch Stuck On, and 3) IUMPR results for Stuck On/Stuck Off are sometimes less than optimal. The presentation further reviews alternative methodologies intended to resolve these issues.

Hal Zatorski, FCA US LLC

Ford OBD Experiences
Paul A. Baltusis, Ford Motor Company
2:15 p.m. ORAL ONLY SCR Diagnostic Challenges for Current and Future North American Emissions Regulations & GM Perspective
Current and future North American Emissions and CO2 regulations are presenting new challenges for SCR diagnostics. This presentation highlights concerns based on GM experience about SCR efficiency BPU definition shifting to smaller and smaller fault sizes. As a result, existing diagnostic methods must be improved to guarantee adequate statistical separation between WPA and BPU systems when detecting a smaller fault. Furthermore, with the proliferation of SCR based aftertreatment system architectures, SCR efficiency monitoring becomes more complex. In addition to SCR efficiency monitoring, concerns related to Reductant Injection Control requirements are discussed.
Igor Anilovich, Sarah Funk, General Motors LLC

2:45 p.m. ORAL ONLY Toyota OBD Experiences
Morton M. Smith, Toyota

3:15 p.m. BREAK

3:45 p.m. ORAL ONLY Monitoring for Gasoline Particulate Filters
While not widespread in current production applications, gasoline particulate filters are being considered to meet particulate number emissions standards for gasoline engines in Europe, China, and even to meet particulate matter emissions standards in North America.
In many regards the operating principles of the gasoline particulate filter are orthogonal to their diesel counterparts. Most distinctly, gasoline particulate filters operate mostly in stoichiometric exhaust gas and at fairly elevated temperatures.
Just as for diesel particulate filters, the operation can be controlled with the use of pressure and temperature sensors. In this talk we propose to give an overview of the monitoring requirement and potential solutions for gasoline particulate filters and the sensors used to operate them. We focus on the differences in monitoring solutions dictated by the different operating principles. While particulate matter sensors are finding use in the diagnostics for diesel particulate filters, we show some limitations of these sensors when operating in a gasoline exhaust environment. Lastly, we present the potential use of future particulate sensing technologies as a monitoring solution for gasoline particulate filters.
Michiel Van Nieuwstadt, Ford Motor Company

4:15 p.m. ORAL ONLY Cummins Experience & Diesel Misfire Monitoring
Justin Owen, Cummins Inc.

4:45 p.m. ORAL ONLY Measuring Misfire Detection Performance using PID $04 Calculated Load Value
Misfire Probability of Detection Charts (Pd) are used to quantify the Misfire Monitor’s performance versus standard increments of Engine Speed and Load (as specified in California ARB Mail-Outs MSC 09-22 and MSC 06-23). Pd values are reported versus Engine speed increments every 500 rpm from idle to redline and at engine load values of Zero Torque, 15%, 30%, 50%, 65%, 80%, and Wide Open Throttle. The engine calculated load variable to use to sample Pd is specified to be SAE J1979 PID $04 Calculated Load Variable. In some ways, PID $04 is a good variable to use to sample Pd data. Using PID $04, data can be collected to fill in the standard load axis points in the chart, regardless of Altitude or Temperature Variation that the Monitor runs at. However, in reality using PID $04 there is significant variation in what is actually being measured depending on time of year or altitude at which the data is collected. If PID $04 is used for development, the issue compounds. Using an alternative load variable for misfire development gives better calibrations leading to more consistent results.
David Mathews, General Motors LLC
### On-Board Diagnostics Symposium - Day Two

**Session Code:** OBD2  
**Room:** Marriott 5  
**Session Time:** ALL DAY

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<tr>
<td>8:00 a.m.</td>
<td>ORAL ONLY</td>
<td>OBD &amp; Worldwide Requirements</td>
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|           |            | OBD system requirements were first developed by the California Air Resources Board, the U.S. Environmental Protection Agency, and the European Commission. New OBD requirements from around the world are briefly reviewed and recent discussions about future China 6 OBD requirements will also be reviewed. OBD Worldwide OBD requirements are being further harmonized under the United Nations, Economic Commission for Europe, World Forum for Harmonization of Vehicle Regulations (WP29).  
David H. Ferris, General Motors LLC |
| 8:45 a.m. | ORAL ONLY  | OBD Standards Review                                       |
|           |            | Paul A. Baltusis, Ford Motor Company; Robert Gruszczynski, Volkswagen of America |
| 9:30 a.m. | ORAL ONLY  | Electrification Update (Safety Systems)                    |
|           |            | Andrew Zettel, General Motors LLC                          |
| 10:15 a.m.| ORAL ONLY  | Exhibitor Introductions                                    |
|           |            | Darlene C. Waychoff, SAE International                     |
| 10:30 a.m.|            | Break                                                      |
| 11:00 a.m.| ORAL ONLY  | Breakout Sessions                                          |
|           |            | The following Breakout Sessions will be offered:  
Electrification, moderated by Andrew Zettel, GM  
Communication Standards, moderated by Paul Baltusis, Ford  
Diesel Misfire, moderated by Mike Vawter, Cummins  
Diesel Aftertreatment, moderated by Hal Zatorski, FCA US LLC and John Van Gilder, GM |
| 12:30 p.m.| ORAL ONLY  | Wednesday Networking Lunch with Exhibits                   |
| 1:30 p.m. | ORAL ONLY  | Breakout Session Summaries with Q&A                        |
| 2:30 p.m. | ORAL ONLY  | Design Validation Methodologies for J1979/J1699 Requirements|
|           |            | The presentation would focus on methodology and lessons learned for Design validation of Mode $01$-$0A$ and the data contained within these modes. J1699 usage would be discussed, and an analysis of what is covered and what is not covered by J1699 testing would be presented, including specific requirements for each service mode. Examples of lessons learned would be provided, and how these issues were addressed in testing, as well as methods for detecting issues not covered by J1699. Gasoline and Diesel topics will be discussed.  
Mark Robert Laleman, Ford Motor Company |
3:00 p.m.  ORAL ONLY  What’s needed for LEV III In-Use OBD? Will Prognostics Work?

Compliance to LEV III In-Use requirements poses a unique challenge to the modern diesel powertrain technologies. Especially considering the introduction of OBD-LEV III, more so now than ever before the need for sensitive and robust technologies to distinguish WPA and BPU within a small margin have become a corner stone for a successful product launch. This work focuses on simulation based case studies of LEV III OBD challenges for a few critical monitors, with intent to seek the necessary data accuracy, effectiveness of the algorithm design and the need for novel diagnostic approaches. The investigation aims to develop a test case to assess the degree of OBD LEV III challenge and how the integrated controls, sensors, actuators and strategies need to evolve in addressing In-Use robustness. The application of prognostics has also been investigated, with its merits and demerits evaluated relative to a cost sensitive automotive market.

Harsha K. Nanjundaswamy, FEV Inc.

3:30 p.m.

Networking Break with Exhibits and STEM Student Activity

SAE International and Cummins Inc. invite OBD Symposium attendees to join us in a fun and active STEM-related event with local Indianapolis-area middle school students. This will be a chance to invest in young impressionable students who may be interested in an area of science or engineering by working directly with them to build something tangible from scratch!

4:30 p.m.  ORAL ONLY  Use of Large Data in Validating Diesel Air Path Monitors

Modern diesel powertrains have a large number of emissions control devices each with several OBD monitors, that need to be validated for robustness against multiple powertrain configurations, very differing environmental conditions, and a wide variety of drive styles. A typical product has 150 monitors that need to be validated. During development, there is an added degree of freedom in the calibration of the enabling conditions for the monitor and the fault threshold. This leads to the task of evaluating many gigabytes of data over several tens of calibration settings in a reasonable amount of time. To facilitate this task, Ford has developed a computational environment that allows automatic processing of large amounts of data. It calculates monitor metrics and robust separation margins as a function of the monitor enabling and threshold calibration. It summarizes the monitor robustness and quality metrics in an automated report, that can be configured to suit the needs of the user. In this presentation we show the tool, the calculations it can perform, and the stream lined output on a set a relevant diesel airpath OBD monitors. We account for the difficulties and pitfalls of the development and present the solutions we found.

Nahid Pervez, Ford Motor Company
5:00 p.m.  ORAL ONLY  On-Board Particulate Filter Failure Prevention and Failure Detection using Radio Frequency Sensing

The increasing use of diesel and gasoline particulate filters requires advanced on-board diagnostics (OBD) to prevent and detect filter failures and malfunctions. Early detection of upstream (engine-out) malfunctions is paramount to preventing irreversible damage to downstream aftertreatment system components. Such early detection can mitigate not only the failure of the particulate filter resulting in the escape of emissions exceeding permissible limits, but also significantly reduce system replacement costs and extend component life. Despite best efforts at early detection and filter failure prevention, the OBD system must also be able to detect filter failures when they occur.

This presentation covers recent developments applying a fast-response radio frequency-based (RF) sensor to detect both early signs of upstream malfunctions to prevent filter failures, as well as the direct diagnosis of filter failures on the vehicle. Case studies covered in the presentation include results from a three-year, heavy-duty fleet test applying RF sensors to provide early warning of impending filter failures and fast response measurements of engine-out PM on light-duty applications for upstream malfunction detection. Additional results with failed filters further show a high sensitivity to detect conditions resulting in soot leakage from the particulate filter, as well as direct detection of structural failures including internal cracks and melted regions.

Unlike conventional approaches, RF sensing provides a direct interrogation of the entire filter volume via the transmission of a radio frequency signal through the filter itself. The results indicate significant potential to perform advanced diagnostic functions, to both minimize the occurrence of failure conditions and their associated excess emissions, as well as detect such conditions when they do occur.

Alexander Sappok, CTS Corporation

5:30 p.m.  ORAL ONLY  OBD Calibration Workflow: Numerical Approach

Plastic Omnium provides controlled plastic fuel systems and emission reduction related fluid systems to car manufacturers (incl. SCR). Plastic Omnium is a global automotive Tier-1 supplier which designs systems globally to meet local OBD regulatory requirements.

In the framework of the development of OBD system for new innovative mechatronic products, Plastic Omnium encounters many challenges such as: the lack of data in earlier development stages, and the large number of tolerances and noise factors to take into account.

In order to overcome these challenges and to ensure world-wide OBD system robustness, Plastic Omnium is continuously improving its processes.

This presentation emphasizes on the integration of numerical techniques (Physical model simulation, Monte Carlo simulation) in the OBD calibration workflow. The new workflow is allowing Plastic Omnium to overcome the challenges mentioned above and to improve the OBD system robustness. Besides, it reduces time to market by having the right balance between test activities and simulation activities.

The lessons learned during the calibration of the urea consumption monitoring algorithm will be shared with the OBD community.

Issam DJEMILI, Plastic Omnium Advanced Innovation & Res.
Room Marriott 5

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<td>8:00 a.m.</td>
<td>ORAL ONLY</td>
<td>Heavy Duty OBD Update</td>
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<td>Mike Regenfuss, California Air Resources Board</td>
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<td>8:45 a.m.</td>
<td>ORAL ONLY</td>
<td>Heavy Duty OBD Update  Intrusive Diagnostic Overview</td>
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<td>This presentation is intended to share application and guidance for the utilization of intrusive diagnostics for Heavy Duty OBD compliance. This presentation will cover items such as the benefits, issues, concerns, and application of intrusive OBD diagnostics. It will also provide the ARB perspective of intrusive diagnostics.</td>
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<td>9:15 a.m.</td>
<td>ORAL ONLY</td>
<td>J1939 Standards Update</td>
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<td>The SAE J1939 family of standards has an active history of supporting HD OBD concepts for 2010, 2013, and 2016 MY engines. Eric Swenson will comment on the past year’s and forthcoming publications for SAE J1939 et. al. and their relationship to California’s HD OBD regulation. ARB challenged industry at last year’s (2015’s) OBD symposium to define and provide SAE J1939-73-based In Use Monitor Performance Ratio [IUMPR] data collection aids for 13 CCR 1971.1 (l)(2). Eric will summarize industry’s response to ARB’s challenge and show key artifacts documenting the consensus achieved. This will be followed a discussion of the on-going SAE J1939-84 (re-)development for 2013 and 2016 MY engines, including the test precepts and vehicle integration concepts to support the requirements in 13 CCR 1971.1 (h), 13 CCR 1971.1(d) and 13 CCR 1971.1 (l)(1).</td>
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<td>9:45 a.m.</td>
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<td>Euro VI-C Urea Consumption Deviation Monitor Development and Calibration</td>
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<td>With the introduction of Euro VI-C legislation from 1/1/2016 manufacturers of On-Highway Medium and Heavy Duty vehicles have had to introduce complex OBD monitors, often for the first time. In particular the exhaust after-treatment system has been subjected to significant diagnostic effort because of its key role in reducing engine out pollutants down to legally acceptable tailpipe levels. In the after-treatment system, the SCR plays a key role in reducing NOx and does so managing the injection of liquid ammonia, in the form of Urea (AdBlue, Diesel Exhaust Fluid), into the exhaust gas stream. In order to accurately monitor if the consumed Urea is deviating from expected values, for instance because of a clogged injector, the Consumption Deviation Monitor (CDM) uses an hydraulic test of the injection line. This presentation covers the monitoring principles and details of the calibration process including the use of a bespoke hydraulic model that helps understanding some of the system dynamics.</td>
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<td>10:15 a.m.</td>
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DPF Efficiency Monitoring Using a Virtual PM Sensor
With the introduction of more stringent OBD legislations, the use of a specific sensor becomes required to monitor the efficiency of the Particulate Matter Filter. Delphi strategy proposes to monitor the number of PM sensor accumulation cycles as a measure of Particulate Matter Filter efficiency. The strategy determines a soot indicator representative of the amount of soot having accumulated upstream of the Particulate Matter Filter since the beginning of the respective sensor cycle of the downstream PM sensor. Delphi strategy proposes a diagnostic concept that does not require a limit Particulate Matter Filter model but relies on the soot indicator to assess the Particulate Matter Filter performance. The diagnostic status is determined based on the information given by the downstream soot sensor and the modelled soot indicator.

Philippe Bovi, DELPHI Automotive Systems Luxembourg SA

Cyber Security Presentation
Robert Gruszczynski, Volkswagen of America

The Role of OBD in the Context of Protecting On-Road Vehicles and Non-Road Mobile Machinery Against Cyber Attacks
OBD is a system on-board a vehicle which has the capability of detecting malfunctions, and, if applicable, of indicating their occurrence by means of an alert system, or identifying the likely area of the malfunction by means of information stored in computer memory, and/or communicating that information off-board [1].</p>
Current OBD requirements cover the monitoring of emission-related components and functions. It makes sense to extend these OBD requirements to detect malfunctions of safety-related functions. </p>Currently, there are no requirements to detect in-vehicle malfunctions that are caused by manipulation of functions thru external intrusion, e.g. over the internet. In the context of this paper, an external intrusion is a criminal act with the objective to steal data, or even worse, to take over functions of a vehicle or a machine, for what reason ever. </p>Not only for security reasons, a protection against cybercrime that fits the special technology of road-vehicles and non-road mobile machinery, is a must. Measures have to be taken to prevent an intrusion and/or unwanted manipulation detect an intrusion and/or unwanted manipulation by OBD create a fail-safe situation in case of a detected intrusion / unwanted manipulation
The detection of an intrusion and/or unwanted manipulation requires a (r)evolution of the established OBD system, the communication protocol and the external test equipment.<br>

Peter Subke, Softing Automotive Electronics GmbH

Thursday Networking Lunch with Exhibits

OBD II Development: a Bosch Perspective on CNG Application
This presentation is intended to share Bosch experiences with respect to the impacts of alternative fuel sources (e.g. CNG). These experiences are shared to assist others in understanding the impacts of a CNG system on a Passenger Car application as it pertains to the impact on the OBD system. </p> This presentation will cover items such as algorithm changes developed for CNG, and the OBD calibration impacts of alternatively fueled systems in a passenger car applications.

Kevin John Respondek, Robert Bosch LLC
Comparison of OBD Communication Protocols ISO OBD (ISO 15031), SAE OBD (SAE J1939) and WWH-OBD (ISO 27145) and Their Description in ODX 2.2.0 (ISO 22901)

OBD is a system on-board a vehicle which has the capability of detecting malfunctions, and, if applicable, of indicating their occurrence by means of an alert system, or identifying the likely area of the malfunction by means of information stored in computer memory, and/or communicating that information off-board [1].</p>

The first part of this paper covers the currently available protocols for the communication between an OBD system and external test equipment. The relevant standards are ISO 15031, SAE J1939, and ISO 27145. </p>

The second part of this paper explains, how the communication protocols are described in the machine readable, standardized data format ODX, which is base for ISO 22900 (MVCI) compatible external test equipment. </p>


Peter Subke, Softing Automotive Electronics GmbH

Adopting UDS Over J1939 Diagnostics In Off Highway Industry

Diagnostics has become very important in the off-highway world as the Machine’s (E.g Tractor, Sprayer, Harvesters, Loader, Excavators, etc.) breakdown and hence machine’s down time is not affordable as it directly impacts productivity of the farming or construction or forestry work. The first part of the paper discusses various reasons why Off Highway industry need UDS like protocol.

The second part of the paper draws the comparison between J1939 Diagnostics and ISO14229 diagnostics, discusses various J1939 diagnostic services and how UDS can replace some of them.

At the end, the paper covers various scenarios and challenges and possible solutions while adopting UDS over J1939 diagnostics in vehicles.

Bhalchandra Padwal, John Deere
Selective Catalytic Reaction (SCR) of ammonia (NH₃) and nitrogen-oxides (NOx) is a predominant technology used in current diesel automotive applications as an exhaust aftertreatment technology to reduce NOx emissions below regulatory limits. One of the key solutions to improve the selective reaction of NOx with NH₃ is the presence of optimal concentration of NO2 in the exhaust gas; many research papers have indicated ~30-50% NO2/NOx ratio would be required as feed gas to maximize the SCR catalyst's NOx reduction efficiency. This led to numerous innovative exhaust oxidation catalyst formulations to produce sufficient NO2 as SCR feed gas. As a result, the OBD legislative requirements have followed the technology advancement demanding the monitoring of the NO2 production by oxidation catalysts.

This presentation will introduce a new concept to utilize dynamic ammonia storage measurement to diagnose the SCR system. We will discuss in detail how the different reaction rates due to feedgas deterioration result in corresponding ammonia storage levels among wellcontrolled conditions and how this can be exploited for OBD purposes via an intrusive DEF dosing strategy. Furthermore design and calibration strategy considerations will be presented to complete the overall strategy to present the current design challenges related to aftertreatment technologies.

Tamas Szailer, FEV Inc.