Sunday, September 29

Overview of Regulatory Issues

Session Code: HEHDV1

Room 48

This session will include an overview of pending regulatory issues currently under consideration for both the on-road and off-road markets with a focus on increasing fuel efficiency and minimizing GHG emissions for medium and heavy duty vehicle applications. May also include manufacturer and end-user perspectives.

Organizers - Craig Puetz, John Deere; David Smith, David Smith, Robert M. Wagner, Oak Ridge National Laboratory

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<tr>
<td>1:00 p.m.</td>
<td>ORAL ONLY</td>
<td>Looking Ahead to the Next Phase of Heavy-Duty Greenhouse Gas and Fuel Efficiency Standards</td>
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<td>Mr. Spears will provide an overview of EPA’s and NHTSA’s ongoing work to develop the second phase of medium- and heavy-duty GHG and fuel efficiency standards (Phase 2). Mr. Spears will also discuss the agencies' current technical work to investigate how best to test and simulate heavy-duty engines and vehicles for the purposes of GHG and fuel efficiency certification in Phase 2.</td>
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<td>Matthew W. Spears, US EPA</td>
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<td>1:30 p.m.</td>
<td>ORAL ONLY</td>
<td>Establishing a Framework for Representative Testing of Greenhouse Gas Emissions and Fuel Consumption from Line-haul Vehicles</td>
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<td>In September of 2011, the U.S. EPA and NHTSA published greenhouse gas and fuel efficiency standards for medium- and heavy-duty vehicles. As an early certifier to these standards, DTNA would like to share some experiences with this new program. In addition, these experiences have provided a window into opportunities to design a program more reflective of real-world reductions in particular on the Line-haul application that emits some 70% of all heavy-duty on-road CO2.</td>
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<td>Gregory Fadler, Navistar</td>
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<td>2:00 p.m.</td>
<td>ORAL ONLY</td>
<td>Phase 2 Framework for the Regulation of Greenhouse Gases from Commercial Vehicles</td>
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<td>A framework is described for regulating GHG for commercial vehicles in model years 2020 and beyond. This framework preserves the solid regulatory foundation already put in place by the Environmental Protection Agency and National Highway Traffic Safety Administration for model year 2014 - 2018 vehicles and engines, commonly known as the Phase 1 regulation, while at the same time expanding the framework for a new Phase 2 to recognize the benefit of a more integrated, system-based approach to improving GHG. The Phase 2 framework recognizes the GHG benefits of engine and transmission integration through a powertrain certification option using similar test procedures and cycles as engine certification.</td>
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<td>Morgan Andreea, Cummins Inc.</td>
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Sunday, September 29

Hybrids (Electirc and Hydraulic)

Session Code: HEHDV2

Room 48

Session Time: 3:30 p.m.

Technologies addressed by this session will include both electric and hydraulic technologies for increasing fuel economy and reducing greenhouse gas emissions. Topics could address energy recuperation, hybrid powertrain and transmission architectures, control systems, supplemental combustion strategies, battery energy storage, hydraulic accumulator storage, system integration and more.

Organizers - Long-Kung Hwang, Cummins Inc.; Ashok Nedungadi, Southwest Research Institute; Craig Puetz, John Deere; David Smith, Robert M. Wagner, Oak Ridge National Laboratory

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<td>2:30 p.m.</td>
<td>ORAL ONLY</td>
<td>Current and Future US Greenhouse Gas Regulations for Trucks</td>
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<td>EPA and NHTSA (National Highway Traffic Safety Administration) have joint regulations covering fuel economy and GHG emissions of medium and heavy-duty vehicles. There are separate regulations for engine efficiency and for vehicle efficiency (power demand). The first stage of regulation takes effect in 2014, with an additional step in engine targets in 2017. SwRI is now working on projects for EPA and NHTSA looking at a potential 2nd phase of regulations to take effect around 2020. This presentation will summarize the current regulations and the effect we expect to see in the market. We will also describe the work being done on future regulations, and provide information on the options being considered by the regulators.</td>
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<td>3:30 p.m.</td>
<td>ORAL ONLY</td>
<td>Power-pack Testing with a Vehicle Perspective: Hardware-In-the-Loop Technology Applied to Heavy-Duty Vehicle Powertrain Development</td>
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<td>With the increased complexity of advanced powertrains, both conventional and hybrid electric, testing the complete “power-pack” (engine and transmission) is necessary to quantify its benefits and to fully optimize its operation as a system in a transient environment. For those purposes, Oak Ridge National Laboratory has commissioned the Vehicle Systems Integration (VSI) laboratory: a facility capable of testing heavy-duty vehicle hybrid powertrains utilizing twin 500kW dynamometers and a 400kW battery emulation system. The laboratory was designed to evaluate and optimize engines and powertrains at the vehicle level in a transient environment representative of real world driving conditions using a hardware-in-the-loop (HIL) platform to emulate a virtual vehicle as well as its driver behavior and road/load conditions, such that the powertrain-under-test behaves as if it were in a real vehicle. The ORNL VSI laboratory is currently being utilized to support two different projects: the optimization of a class 8 line haul truck hybrid powertrain, and the development of medium and heavy-duty emissions and fuel consumption test procedures.</td>
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Darius Mehta, Southwest Research Institute

Paul Chambon, Oak Ridge National Laboratory
**Monday, September 30**

**Modeling & Simulation (Part 1)**  
**Session Code:** HEHDV4  
**Room 48**  
**Session Time:** 8:00 a.m.

This session will address modeling and simulation technologies for both on- and off-road heavy duty vehicles with a view toward improving efficiency and reducing emissions. Topics could include simulation of combustion and emissions, aerodynamics, thermodynamics and cooling systems, and system-level models for vehicle fuel economy and emissions predictions as well as chassis, suspension, tires, and dynamics.

**Organizers:** Long-Kung Hwang, Cummins Inc.; Ashok Nedungadi, Southwest Research Institute; Craig Puetz, John Deere; Robert M. Wagner, Oak Ridge National Laboratory

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**4:30 p.m. ORAL ONLY**  
**Design of Shift Select Mechanism For Automation of Manual Transmission**

The transmission adapts the output of the internal combustion engine to the drive wheels. For maximizing fuel economy and minimizing emissions, it is recommended to perform the integrated control of engine, motor and transmission by using an automated transmission. Today, several automated transmissions are developed such as an Automatic Transmission (AT), a Continuously Variable Transmission (CVT). But these transmissions are expensive. In manual transmission, due to variations in driving skills, gear utilization is not always optimal. Automation of manual transmission can help us maintain efficiency and increase the performance of a manual transmission.

An automatic manual transmission can be created by elimination the need of manual shifting of gears in a manual transmission. Automatic Manual Transmission (AMT) provides driver comfort by relieving the driver of gear changes and use of clutch like an automated transmission while retaining the efficiency of a manual transmission. Further the shift points can be tuned to the particular drive train to maximize fuel economy. Life of gearbox and clutch is also increased. It is much more cost effective than an automatic transmission or a Continuous Variable Transmission (CVT).

This work deals with the design of low cost pneumatic shift select mechanism, which forms a part of the automation of manual transmission. The main focus of the work presented in this paper is the implementation of electro-pneumatic based control system in a manual transmission for automatic shift and gate selection in a manual transmission. Pneumatic system aids for better control and lesser maintenance costs compared to hydraulics. This paper presents design and developmental steps involved in the automation of shift-select mechanism of a manual transmission.

Sriram Muralidharan, University of Wisconsin Madison; Suryanarayana A N Prasad

**5:00 p.m. ORAL ONLY**  
**Effects of Driveline Hybridization on Fuel Economy and Dynamic Performance of Hybrid Telescopic Heavy Vehicles**

With the rise of air travels, the greenhouse gas emissions due to the aviation is likely to grow sharply. One solution to reduce it, might be to use biofuels in order to replace fossil fuels that have a strong stress on climate change. However the biofuels generation processes also have a sizeable environmental impacts. Therefore it seems legitimate to study global environmental impacts of a significant share of biofuels in transports by 2020. Thus, a macro consequential approach was followed to include indirect effects of biofuels policies on agriculture and other economic sectors.

Aurelio Somà, University Politecnico di Torino
8:00 a.m.  ORAL ONLY  Development of Representative Regional Delivery Drive Cycles for Heavy-Duty Truck Tractors

Although several drive cycles have been developed to describe heavy-duty truck tractor operations, regional delivery operations have not been well described. With funding from the U.S. Army National Automotive Center, the High-efficiency Truck Users Forum developed two drive cycles better suited for the evaluation of the fuel efficiency and emissions benefits of high-efficiency truck technologies such as hybrid electric, plug-in hybrid electric and compressed or liquefied natural gas.

Jean-Baptiste Gallo, Calstart

8:30 a.m.  ORAL ONLY  Modeling of Li-ion Battery to Predict its Performance & Impacts on Fuel Economy

This paper describes the steps performed in the development of mathematical model of Li-ion battery energy storage systems to predict the performance at different ages over life and at different temperatures. An equivalent circuit model has been implemented to the capture voltage and internal resistance characteristics of the battery. Experiments were conducted to capture RC parallel circuit components values and the thermal behavior of battery systems. We used air cooling systems to obtain the variations in battery temperature during fan on and fan off conditions. The coulomb counting method has been used to calculate the State of Charge (SOC) and measured impacts on fuel economy because of capacity fading at different temperatures. Model uses fundamental heat transfer equations to predict the temperature in the battery packs. This model was integrated with HEV model and obtained fuel economy simulation results for various ageing and temperature conditions to provide an overview of effective usage of battery systems to get better fuel economy and also to predict the life of a battery system.

Surendra Chandawarkar, Eaton Corporation; Sathish Vijayaraghavan, Eaton Technologies Pvt, Ltd.; Brent H. Hoerman, Eaton Truck Component Operations

9:00 a.m.  ORAL ONLY  Vehicle Interior and Exterior Noise Simulation

With increasing use of efficient combustion systems, powertrain-induced vehicle noise will continue to pose technical challenges. Use of advanced processes to optimize the interior as well as exterior (pass-by) noise will be needed. This presentation will highlight the use of advanced methodologies to synthesize and optimize the interior noise character and exterior noise behavior of vehicles. Examples from case studies will be provided.

Kiran Govindswamy, FEV Inc.
9:30 a.m. ORAL ONLY Evaluation of Greenhouse Gas Emission Certification Options for Phase 2: Full Vehicle Simulation

Building on the success of the first-ever regulation to reduce greenhouse gas emissions (GHG) and improve the fuel efficiency of the medium- and heavy-duty vehicles issued in 2011, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) are looking ahead to the next phase of rulemaking. Considering that the next phase is a highly technical rule, the agencies are actively conducting various technical projects in order to lay out a strong foundation to support this rulemaking. One of the technical projects is to evaluate different options to demonstrate compliance with the standards. At the present, six certification options are under consideration. They are full vehicle simulation, vehicle simulation with a separate engine standard, controller-in-loop simulation, engine-in-loop simulation, vehicle simulation with powertrain-in-loop and separate engine standard, and full vehicle chassis dynamometer testing. This presentation will briefly describe each of these options, but the focus will be on vehicle simulation. It will be shown that the next generation of the Greenhouse gas Emission Model (GEM) has been developed to achieve significant refinement compared to the model used in the first phase of regulations. This new GEM features many technical enhancements including a new automatic transmission module, automated manual transmission module, and a more sophisticated engine controller with better idle speed control and engine fuel cut-off during deceleration. This enhanced GEM has been extensively validated against various trucks, ranging from different vocational vehicles to Class 8 on-highway tractors. This presentation will also discuss the pros and cons of the use of GEM as a certification.

Houshun Zhang, EPA; Matthew W. Spears, Angela Cullen, US EPA

Monday, September 30

Modeling & Simulation (Part 2)

Session Code: HEHDV4

Room 48 Session Time: 10:30 a.m.

This session will address modeling and simulation technologies for both on- and off-road heavy duty vehicles with a view toward improving efficiency and reducing emissions. Topics could include simulation of combustion and emissions, aerodynamics, thermodynamics and cooling systems, and system-level models for vehicle fuel economy and emissions predictions as well as chassis, suspension, tires, and dynamics.

Organizers - Long-Kung Hwang, Cummins Inc.; Ashok Nedungadi, Southwest Research Institute; Craig Puetz, John Deere; Robert M. Wagner, Oak Ridge National Laboratory

Time Paper No. Title

10:30 a.m. ORAL ONLY Tire Modeling and Simulation for Tractor Engineering

Tire is an important part of tractor engineering. Tractors are connected to the road through tires, they dissipate energy, and sometimes they are only suspensions for tractors. Tractor performance heavily relies on tires. This presentation covers the methods of agricultural tire modeling and the effect of tire on tractor performance.

Nohoon Ki, John Deere Product Engineering Center

11:00 a.m. ORAL ONLY John Deere 644K Hybrid Drivetrain Overview, Performance, & Developmental Analysis

John Deere has developed and is producing an electric drive transmission for wheel loaders that has demonstrated a significant improvement in fuel economy without affecting productivity. In this presentation we provide an overview of the transmission topology and general performance targets. Additionally, we discuss alternative analytical approaches and their trade-offs for development.

Eric Anderson, John Deere Des Moines Works
11:30 a.m.   ORAL ONLY

Transcendent Optimization of Control and Calibration for High Efficiency Engines

High-efficiency engines are complex by design with ever-increasing numbers of highly interdependent air, fuel, exhaust, combustion and energy transfer subsystems. As a result, engine and powertrain control is becoming significantly more sophisticated and difficult to optimize, especially under transient operating conditions. The high cost of developing engines and powertrain systems that demonstrate greater fuel efficiency and emissions benefits beyond the status quo is undeniable. The increased calibration burden and the complexity of optimization require the development and adoption of entirely new methods of controlling engines and vehicles for maximum fuel efficiency and lowest regulated emissions.

Model-based methods offer significant advantages over traditional testing-intensive methods of algorithm development and calibration. Transferring a significant proportion of the engine control strategy development, refinement and calibration optimization tasks from the high-cost engine and vehicle test cell to the computational environment reduces costs and development time, and increases the robustness of the final product. These methods will be introduced, described and demonstrated in heavy-duty applications.

Christopher Atkinson, Atkinson LLC

Monday, September 30

IC Engine System and Other Efficiency Enhancing Technologies (Part 1)

Session Code: HEHDV3

Room 48   Session Time: 1:00 p.m.

This session will address IC Engine System technologies in use and under development for increasing fuel efficiency and decreasing GHG emissions for heavy duty applications. Technologies could include but are not limited to engine downsizing, intake charge preparation, low temperature combustion, waste heat recovery, flexible valve systems, advanced fuel systems, friction reduction and other developing technologies.

Organizers - Long-Kung Hwang, Cummins Inc.; Ashok Nedungadi, Southwest Research Institute; Craig Puetz, John Deere; David Smith, Robert M. Wagner, Oak Ridge National Laboratory

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Exceeding SuperTruck Efficiency Goals with Opposed-Piston, Two-Stroke Engines

Over the last nine years, Achates Power has applied modern engine technologies, state-of-the-art engineering analytical and experimental tools, and numerous innovations to develop a clean and significantly more fuel efficient opposed-piston, two-stroke (OP2S) engine. This OP2S has successfully demonstrated a step-function improvement in fuel efficiency when compared to conventional, medium-duty engines\(^1\), all while meeting the most stringent emissions requirements and lowering manufacturing costs.

Recently, Achates Power has shown how this improvement can be applied to heavy-duty applications, creating an engine that exceeds the Department of Energy\(^2\)'s SuperTruck brake thermal efficiency goals without expensive waste heat recovery.

Included in this presentation is:
- A brief summary of the inherent OP2S engine efficiency advantages (thermodynamics, pumping work, transient operation and combustion).
- An explanation of how these advantages translate to heavy-duty applications.
- A detailed discussion of the new Achates Power heavy-duty engine performance and emissions results, including low heat rejection-to-coolant, a favorable fuel map and best-point brake thermal efficiency of 51.5%.
- A roadmap for applying SuperTruck technologies, like waste heat recovery, to the Achates Power engine in order to enable brake thermal efficiency in excess of 55%.

David Johnson, Achates Power Inc.; John Koszewniki, Laurence Fromm, Fabien Redon, Gerhard Regner, Achates Power Inc

Utilization of Waterless Coolants to Improve Thermal Efficiency and Increase Engine Durability

Water has long been a popular component of engine coolants. It is economical, non-toxic, and has excellent heat transfer properties in its liquid state. Unfortunately, high loads on heavy-duty engines from increased EGR, stop and go driving cycles, etc. can generate heat loads that create significant water vapor in systems using an aqueous coolant. Because water vapor has almost no thermal conductivity, damage to engine and cooling system components can result. Considerable energy must be expended in an effort to keep aqueous-based coolant temperatures low enough so they remain functional.

Conversely, non-aqueous coolants are not prone to vapor formation issues. The large separation between their boiling point and the operating temperature of the engine causes any vapor that may form to immediately condense. Consequently, engine manufacturers could safely increase operating temperatures and realize benefits from better thermal efficiency.

This presentation first discusses the advantages of using water in engine coolants, and compares the properties of aqueous and non-aqueous fluids. It explains water vapor\(^2\)'s role in heavy duty engine and cooling system problems, e.g., wet sleeve liner cavitation erosion and EGR cooler failures, and how these are avoided with non-aqueous coolants. Fuel economy results are presented from studies in which non-aqueous coolants have been used to reduce fan-on time. The presentation finishes with examples of on-road, off-road, stationary, and military applications in which this technology has been proven.

Mark Alexander, Mark Joseph Stone, Evans Cooling Systems Inc.
Monday, September 30

IC Engine System and Other Efficiency Enhancing Technologies (Part 2)

Session Code: HEHDV3

Room 48  
Session Time: 3:00 p.m.

This session will address IC Engine System technologies in use and under development for increasing fuel efficiency and decreasing GHG emissions for heavy duty applications. Technologies could include but are not limited to engine downsizing, intake charge preparation, low temperature combustion, waste heat recovery, flexible valve systems, advanced fuel systems, friction reduction and other developing technologies.

Organizers - Long-Kung Hwang, Cummins Inc.; Ashok Nedungadi, Southwest Research Institute; Craig Puetz, John Deere; David Smith, Robert M. Wagner, Oak Ridge National Laboratory

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2:00 p.m.  ORAL ONLY  Modern Low Viscosity Crankcase Lubricants Delivering Fuel Economy and Durability

Advances in heavy duty diesel engine lubricant have allowed blending of lower viscosity lubricants for improved fuel economy, that can meet the latest requirements for modern engines including durability. This talk will focus on engine test and field experience with these lower viscosity lubricants, the growth of the use of 10W-30 and 5W-30 oils in the heavy duty engine oil category and the engine oil specifications that allow for the use of these viscosity grades.

Discussion will focus on currently available product categories, as well as, future advances coming with next generation categories.

Keith C. Corkwell, Lubrizol Corp.

2:30 p.m.  ORAL ONLY  Heavy Truck Tire Freight & Efficiency Progress

Advances in construction and materials have allowed heavy truck tire performance envelopes to expand dramatically over many years, especially along the axis of improved rolling resistance and mass, thus contributing to improvements in vehicle fuel efficiency and payload. The North American market introduction of New Generation Wide Base Singles (WBS) in 2001 provided yet another significant expansion, typically improving rolling resistance by an additional 10% and reducing mass by 800 pounds on a class 8 vehicle versus equivalent dual assemblies. The subsequent rate of market penetration of WBS assemblies has been reasonably steady, and most of the initial retarding factors such as concerns for a competitive supply base, an adequate emergency roadside service network, etc. have been overcome. However, to further accelerate the progress and fully exploit all the characteristics offered by this technology, a complete system design approach is needed. For example, the dimensional characteristics of WBS assemblies provide significant additional design space versus traditional dual tires, and taking a system design approach could allow for the addition of full coverage tractor fairings while maintaining track width and at the same time staying within maximum vehicle width limitations. There are numerous other system possibilities to consider.

Van Teeple, Michelin Americas Research Co.

3:30 p.m.  ORAL ONLY  SAE J1321 Stop & Go Cycle Fuel Economy Testing

With the tighter tolerances established within the latest revision to SAE J1321, moderate stop & go driving cycles have become difficult to achieve. This presentation highlights some practices TRC Inc. has implemented in a recent series of testing that had good success at achieving repeatable runs within the allowed tolerance. The stop & go cycle performed was 52 miles in total length, with 12 starts & stops, and a total run time of 1 hour and 51 minutes. Speeds ranged from 15 MPH to 45 MPH during the completion of a 4-mile closed loop with 13 total loops completed per 52 mile run.

Kenneth W. Webster, Transportation Research Center Inc.
When it comes to the topic of advancing fuel alternatives, Volvo’s vision is to become a world leader in sustainable transport solutions. Therefore we are earnestly working with a variety of alternative fuels in the context of:

- Conserving natural resources and reducing dependence on fossil fuels
- Reducing the impact the transportation industry has on climate change
- Minimizing any affect that exhaust emissions has on society

So in this context, DME is one of the best alternatives as a compression-ignition fuel.

Samuel L. McLaughlin, Volvo Group