• **9h00-9h30: Development of Look-Ahead Powertrain Control to Improve Commercial Vehicle Fuel Efficiency and Safety**
  - Ben Saltsman, Manager - Intelligent Truck, Vehicle Technology and Innovation, Eaton Corporation, USA
  - Abstract: This talk will describe recent developments of Look-ahead Powertrain control technology for heavy commercial vehicles, which relying on-board sensors, takes into account environment information such as 3D topographical maps, traffic conditions and traffic signal information and processes it in real time to optimize vehicle fuel efficiency. In parallel, it results in increased vehicle safety as following distance is enforced and the driver is warned about possible side collisions due to implemented vehicle-to-vehicle communications. Modeling and simulation results for Class 8 tractor-trailer will be presented and compared to pilot vehicle on-road testing, demonstrating fuel economy benefit of approximately 3%.

• **9h30-10h00: Safety Dynamics of Partly-Filled Road Tankers**
  - Subhash Rakheja, CONCave Research Center, Concordia University, Canada
  - Abstract: Large amplitude slosh can be induced within a partly-filled road tank vehicle under mild to severe directional manoeuvres leading to additional stresses on the container, and reduced vehicle stability and control limits. The magnitudes of slosh-induced forces and moments depend upon a number of tank design factors such as tank cross-section, baffles and fill volume, apart from various operating factors. In this presentation, the role of tank design factors on the steady-state and transient fluid slosh are highlighted through analysis of three-dimensional models of the partly-filled tanks. The steady-state fluid slosh model is applied to derive the dynamic response and stability characteristics of a partly-filled articulated liquid cargo vehicle with tanks of arbitrary cross-section under steering and braking-in-a-turn maneuvers. The directional dynamic characteristics under a braking-in-a-turn maneuver are evaluated in terms of moments induced by the moving cargo, wheel dynamic load factor, load transfer ratio, yaw and roll response, and braking performance of the vehicle. An alternate “Reuleaux triangular” tank cross-section is suggested to minimize the slosh loads in the roll plane. The results of the study reveal that a partly-filled articulated tank vehicle, subject to braking-in-a-turn, is more susceptible to rollover on dry roads, while it exhibits a higher propensity of trailer swing on slippery roads. A three-dimensional computational fluid dynamic slosh model of the tank is further presented for analysis of
forces and moments caused by transient fluid slosh. A comprehensive experiment is designed to study fluid slosh within a scale model tank with and without the baffles under continuous as well as single-cycle sinusoidal lateral and longitudinal acceleration excitations. The measured data are used to examine the validity of the fluid slosh model in terms of the slosh natural frequencies, and three-dimensional components of slosh forces and moments. The fluid slosh characteristics are analyzed considering a full-size tank under different fill volumes corresponding to a constant load and excitations representing steady-turning, straight-line braking, braking-in-turn and path change maneuvers. The fluid slosh analyses are also carried out to explore the anti-slosh effectiveness of different designs of transverse baffles such as full, partial, single and multiple orifices, oblique and an alternating baffles arrangement.

The influences of transient fluid slosh on tank vehicle safety dynamics are studied by incorporating fluid slosh model to an in-plane vehicle model. The roll stability analyses are performed for circular and “Reuleaux triangular” tanks under conditions of constant and variable cargo loads. The results attained are compared with the quasi-static solutions to demonstrate the role of transient slosh loads on the roll stability limits. The three-dimensional slosh model of a partly-filled tank with and without baffles is also integrated to a 7-DOF pitch plane model of a tridem truck to analyze its straight-line braking characteristics in the presence of fluid slosh. A degradation of the braking performance of the partly filled tank truck was evident in the presence of transient fluid slosh, particularly in the absence of baffles. The braking performance, however, is highly dependent upon fill volume, presence of baffles, and severity of the braking input. For a clean-bore tank truck, the stopping distance increases monotonically with decreasing fill volume, while the addition of transverse baffles in general results in considerably shorter stopping distance. Although the analyses are limited to conventional single-orifice baffles, the proposed coupled vehicle–tank model could serve as an important tool for exploring alternative baffle designs and layouts.

- **10h00-10h30: Vehicle Electrification - Future Challenges and Options**
  o Bo Gao, Department Manager, Electronics and Controls, AVL Powertrain UK Ltd, UK
  o Abstract: With the increasing fuel price and tightening government regulations, automotive industry is under unprecedented pressure to improve vehicle fuel economy and tailpipe emissions. Electrification is becoming a major trend in the industry to address this issue. Although various options and technologies are available, there are still many challenges in this area. In this presentation an overview of vehicle electrification is given, with the focus on five key elements - engine, transmission, electrical machine, battery and controls strategy. To address the robustness and safety aspects in vehicle electrification, integration and safety are also discussed. At the end of this presentation a case study on a heavy-duty vehicle application is given.

- **10h30-11h00: Energy Efficiency Potentials by Transmission Control and Hybridization**
  o Benedikt Weiler, Institute of Automotive Engineering, Technical University of Brunswick, Germany
  o Abstract: The cost effectiveness of hybrid commercial vehicles is increasing with increasing fuel prices, but it also depends on the vehicle, its use and the driver’s driving style. This paper focuses on the systematic analysis of energy consumptions and statistical driver
actions which are directly related to the energy consumption of the vehicle. The 3D method, which was developed at the Institute of Automotive Engineering, is used to identify representative customer behaviour and hence develop measures to reduce fuel consumption. The 3D parameter space is a three-dimensional, orthogonal space in which the major influences on the vehicle are specified independently. The axes of the 3D parameter space represent driver, driven vehicle and driving environs. In terms of powertrain and load on the chassis of commercial vehicles, the method differentiates between economical and dynamic driving styles for ‘driver’. ‘Driven vehicle’ comprises light, average and heavy (load of the vehicle), while ‘driving environs’ refers to the use of the vehicle: distribution, short-distance transport, long-distance transport and off road. A tool was developed at the Institute of Automotive Engineering (IAE) and verified by measurements to identify the representative range of vehicle use. It is based on statistics and can be used to optimize the components or to design them specifically to the requirements as well as to generate driver statistics for a simulation model that is based on a statistical approach. It is possible to evaluate new vehicle concepts, make statements about the load on components (if depth of simulation is sufficient) and identify energy flows by using the simulation model and its 3D parameter space. They are generated based on energy balances, the commercial vehicle powertrain and a statistical driver model suitable for the vehicle class. This paper will show that, depending on the amount of investment, electric commercial vehicle powertrains can reduce fuel consumption significantly. The optimization of the shift strategy shows further potential, which requires the adjustment of the transmission control unit. The optimum shift strategy for each customer is defined in the 3D parameter space. For this purpose, an ‘estimator’ needs to be implemented that assigns the driver to a customer in the 3D parameter space while driving. The occurring driving manoeuvres are evaluated and used as the basis for the optimization of the shift strategy. Furthermore, the fuel consumption of the vehicle was measured on a roller dynamometer. The optimization result comprises the optimum shift sequence and the optimum engine speeds for shifting for each customer in the 3D parameter space. An unloaded commercial vehicle was measured and evaluated at the IAE for this purpose. Compared to the standard, the fuel consumption can be reduced by up to 2.3 % (depending on the customer). Hybrid vehicles as well as the optimization of the shift strategy can reduce energy consumption significantly. The costs for these measures will be amortized quickly with increasing energy costs and the respective products will be increasingly available.

- **11h00-11h30**: Coffee break

- **11h30-12h00**: Rollover Risk Evaluation of Heavy Vehicle Via Global Bifurcation Analysis
  - Hocine Imine, LEPSIS/IFSTTAR, France
  - Abstract: In a general context, the talk concerns the study and the resolution of the problems of observation and control of the complex systems. We privilege in particular the problems concerning the bifurcation analysis of the hybrid non linear systems. As application, the safety of heavy vehicles (HV) in interaction with the infrastructure will be studied. The used method is based on bifurcation approach and chaos. The unknown parameters of the system HV/Infrastructure will be identified and the rollover risk will be predicted. The developed algorithm will be simulated and the results will be given in order to show the quality of the proposed method.
• **12h00-12h30: Heavy Vehicle Pitch Dynamics and Suspension Control**
  o Dongpu Cao, Lancaster University, UK
  o Abstract: Heavy vehicle pitch dynamics and control have received minimal concern in the vehicle dynamics and suspension community. However, the increasing demands on enhanced ride quality of heavy vehicles and thus improved comfort and health of professional drivers necessitate a systematic investigation of heavy vehicle pitch dynamics. This talk starts with a general discussion on the heavy vehicle pitch dynamics and limitations of conventional suspension systems. A range of novel passive fluidic suspension designs are then explored for improving heavy vehicle pitch performance without affecting the handling performance and roll stability. Semi-active control of novel fluidic suspension systems is further investigated so as to realize an enhanced compromise among the conflicting vehicle performance measures.

• **12h30-: Open discussion**