

# Future Heavy Commercial Vehicle Drives: Opportunities with Hydrocarbon and Renewable Fuels and Control Challenges <sup>★</sup>

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**Abstract:** Control systems play a fundamental role in today's vehicles and are necessary for achieving clean and efficient propulsion of vehicles. In particular, they are critical for achieving the emission legislations, without the onboard control systems the legislations on low emissions could not be achieved and we wouldn't be allowed to drive cars and trucks on the road. Commercial vehicles are efficient and need a lot of energy for propulsion which means that there are great challenges in the future when we need to replace the Diesel fuel. The presentation will look at different options for the replacement and discuss how control will continue to play a key role for the development of future clean commercial vehicles. New fuels open up new possibilities for combustion control giving cleaner engine exhaust emissions. Furthermore, the impact of hybridization and electrification of long haul trucks have on fuel economy and emissions from trucks will be discussed, in this application there is a particularly important interplay between the vehicle and the control system that manages the energy conversion and the emission abatement.

*Keywords:* Control, Emissions, Certification, Trucks, Diesel.

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## 1. INTRODUCTION

This is first rough draft for an extended abstract for a presentation planned for the IFAC World Congress that will collect a set of challenges in the commercial vehicle business. The presentation will highlight that control sciences are critical for current vehicles and also show that the control sciences will continue to play a key role in the development of future vehicles.

Control has played an key role in the development of clean and efficient technologies for our transportation systems. For example, control is necessary for reaching the legislated emissions and no vehicle would be allowed to be sold without controls. This is valid for all vehicles both cars, commercial vehicles, and ships.

The list of papers given below have been scouted for information and used as an inspiration for the presentation: Eberhardt et al. (2002); Burns (2013); Gao et al. (2015); Dressler and Gleisberg (2009); Chu and Majumdar (2012); Askin et al. (2015); Åhman and Nilsson (2008); Fulton et al. (2015); Vyas et al. (2003); Romm (2006); Yang and Yeh (2011); Tyner (2008); Mulholland et al. (2018); Howey et al. (2010); Liimatainen et al. (2015); Johansson et al. (1993); Earl et al. (2018); Schnepf and Yacobucci (2010); Hunter and Penev (2019); Ortner et al. (2018); Kluschke et al. (2019); Heintzel and Liebl (2019); Lajunen et al. (2018); Cohn and Bromberg (2019); Burkert (2019); Fuchs

(2019); Appl-Scorza et al. (2018); Gelmini and Savaresi (2018) .

### 1.1 Outline

The presentation will cover current technologies that rely on control science and then move to the future by looking at technology drivers and how control will play an important role in helping us meet the demands and associated engineering challenges. This documents highlights the structure and some elements in the presentation.

## 2. IMPACT OF CONTROL IN CURRENT VEHICLES

In this part we'll walk through a set of technologies that have been crucial in the development of today's vehicles and that all rely on control. There are many examples where control is of importance, so only a few can be covered in the presentation:

- Detailed combustion control with multiple injections.
- Control of complex gas flow systems such as turbochargers and exhaust gas recirculation.
- Feedback control of the engine and powertrain system for comfort.
- Engine cruise control, enhanced with optimal control based look ahead control.
- Emission abatement systems and their inherent need for control.

## 3. THE FUTURE AND ITS NEED FOR CONTROL

It is difficult to make accurate predictions of the future but some things are fairly certain from the trends and

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the technology drivers that are pushing the need for more engineering work.

### 3.1 Technology Drivers

There are several drivers for new technologies: Customers have requests for features, comfort, and safety, and for commercial vehicles there is also a request for a reduced fuel cost that is a driver. Legislators are also important drivers for technology especially the are requiring reduced emissions which drives the technical development.

### 3.2 Trends

We know that more data will be available for the control system when it makes the decisions. For example, more sensors become available and they also become cheaper, so does the communication system, together they will give more information available internally and also about the external conditions. Sensor and information fusion is an important technology for extracting the right information to the controllers.

The quests for lowered CO<sub>2</sub> and reduced levels of emissions, will continue, in addition there is also a desire to introduce green zones.

Another trend is to see mobility and transport as services, instead of owning your own systems. This is now transforming the industry and new business models are searched for.

### 3.3 Challenges and Opportunities

The drivers and trends are met by introducing new technologies and these need to be handled and integrated into the systems and it is here that the controls community plays a key role. In the hunt for lowered CO<sub>2</sub> emissions there is a trend of increasing electrification of the powertrain and vehicle. The introduction of electric propulsion components in hybrids give new degrees of freedom in the powertrain and its successful application relies on a control system that can use these components in the best way, and here optimal control is useful.

Another direction for reducing the CO<sub>2</sub> is to replace the fossil fuel with natural gas or renewable fuels, i.e. bio fuels and synthetic fuels that can be produced from electricity. These new fuels have both challenges and opportunities. A successful utilization of the new fuels potential relies on proper control of the engine and after treatment, which is challenging. Many of the renewable fuels that are investigated, have been demonstrated to have beneficial impact on the emissions, for example shorter alcohols like Butanol blends can give a reduction in the particulate emissions. The presentation will give examples of where control comes in and plays a role for the successful application of these new technologies. There are powertrains based on hydrocarbon fuels, and hybrid electric vehicles to hydrogen based and battery based electric vehicles.

## 4. CONCLUSION

It is difficult to predict the details of the future vehicle and powertrain technologies, but what we know is that the

desire for improvements will put higher demands on the vehicles and this will continue to drive the development of more complex and tuneable systems. This development will rely on the availability of control systems and control engineers that can solve the associated complex and important problems.

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