

**Continuous Improvement**

The fourth and last unit deals with continuous improvement as an intrinsic element of successful automotive development and production processes. The key elements are tools and methods for problem finding, analyzing, and solving, Lean manufacturing (i.e., the minimization of non-value-adding activities in the manufacturing process), quality awareness, as well as approaches to sustaining improvements.



Sustaining improvements

**Experiences from Pilot Trainings**

In the Netherlands, France, Austria, and Slovenia the Automotive Engineer training was offered to several hundreds of trainees in VET, higher education, and industry. Based on the experiences collected in these trainings, we may conclude that the Automotive Engineering curriculum had a warm welcome in VET and industry. Moreover, around 150 trainees have taken their exams in order to obtain the ECQA certificate associated with this curriculum. A comprehensive text book, exercise book, as well as training slides, a teachers' guide, and a pool of exam questions have been created. The training material is available in English, Dutch, German, and French.

**Acknowledgements**

The "Automotive Engineer" project is financially supported by the European Commission in the Erasmus+ Programme under the project number 2014-1-NL01-KA200-001189. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein. The author wants to thank all the involved (industry) partners from Austria, Germany, France, Spain, Slovenia, and the Netherlands for their valuable contributions.

**Literature**

- [1] Kollenhof M.; Riel A.; Messnarz R.: Empowering Graduates for Engineering Jobs in the Automotive Industry. In: Proceedings of the 22nd EuroAsiaSPI<sup>2</sup> Conference 2015, Whitebox, ISBN 978-87-998116-5-6, pp. 9.3-9.12.
- [2] The European Qualification and Certification Association (ECQA), www.ecqa.org.



Monique Kollenhof is a Lean Six Sigma Black Belt consultant and Symbol's Programme Manager for international innovative projects.

She is specialized in "Research Methodology, Measurement & Data Analysis" and "Curriculum Design & Educational Innovation".

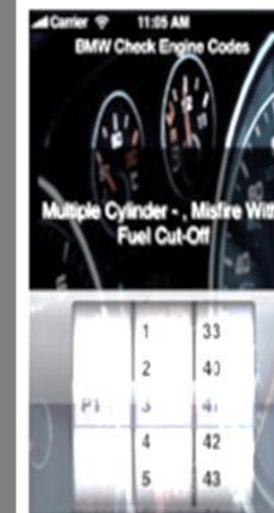
Being a Lean Six Sigma Black Belt consultant she is specialized in guiding and advising service oriented organizations. She also guides Master Black Belts in "Training Design and Delivery".

She manages multiple complex international and multidisciplinary EU projects – like Lean Six Sigma for Healthcare, several automotive projects, and Lean New Product Development – with a focus on innovation and training development for over 20 years.

Her strength is being able to level with all those involved.

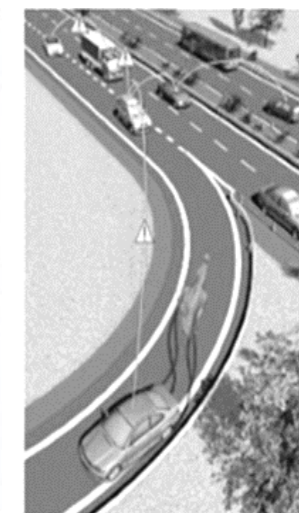
**A COMPACT INTRODUCTION TO AUTOMOTIVE ENGINEERING KNOWLEDGE**

**SHORT TERM**



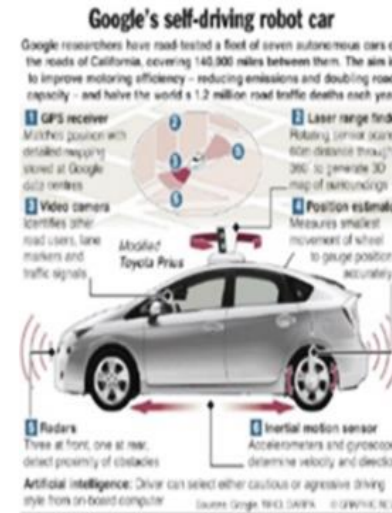
- ✓ iPhone/android apps
- ✓ Wifi connectivity
- ✓ Remote ECU flashing

**MEDIUM TERM**



- ✓ Car-to-car communication
- ✓ Car-to-roadside
- ✓ Cars as sensors

**LONG TERM**



- ✓ Self-driving cars
- ✓ Vehicle mesh networks
- ✓ Modular cars

MONIQUE KOLLENHOF



*This project has been funded with support from the European Commission. This publication (communication) reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.*



Training and consulting organizations from the Netherlands, Austria and France, in very close cooperation with major automotive OEMs and Tiers, as well as the international ECQA certification association have developed a training that prepares recent graduates for successfully making their first steps in the automotive industry as an automotive engineer. As published [1] the objective was to come up with a concise curriculum that delivers fundamental knowledge and skills that form the basis of the growing variety of engineering job roles in the automotive industry. This collaborative activity has been inspired by major industry stakeholders who have been observing that engineering graduates without prior practical experience in the automotive domain have hardly any specific knowledge about the automotive industry, which is after all one of the key pillars of the European and worldwide economy.



Automotive Engineer

The automotive industry has developed rapidly over the last decades. It was only "yesterday" that a car (literally) was delivered with a tool box! Nowadays a car is like a computer consisting of several networked electronic controls, almost a hundred in modern middle-class cars, and far more than that in luxury cars. This "computerization" of cars has huge consequences on the variety of job roles in the modern automotive industry and their associated skills and consequences. In particular, the spectrum of relevant engineering skills has widened up significantly from purely mechanical engineering to electrics, electronics, and software engineering, as well as material engineering (lightweight construction), not to mention more traditional domains such as design and acoustics engineering.

Automotive industry – OEMs and Tiers alike – therefore recruit engineering graduates from an increasingly large variety of engineering backgrounds. Doing so, they report huge investments in delivering to these graduates the required basic knowledge about the automotive industry and related engineering skills. Therefore, if teaching the basic knowledge and the skills required in the modern automotive development and manufacturing processes were part of the students' curricula, they would have a significant gain in time and investment. This is even more necessary today as companies are striving for mastering the customer demand of a total life cycle care for their products in the form of value-added services, a tendency that widens up again the need for different job roles to have an understanding of the key processes in automotive industry.

Developing a Training Course

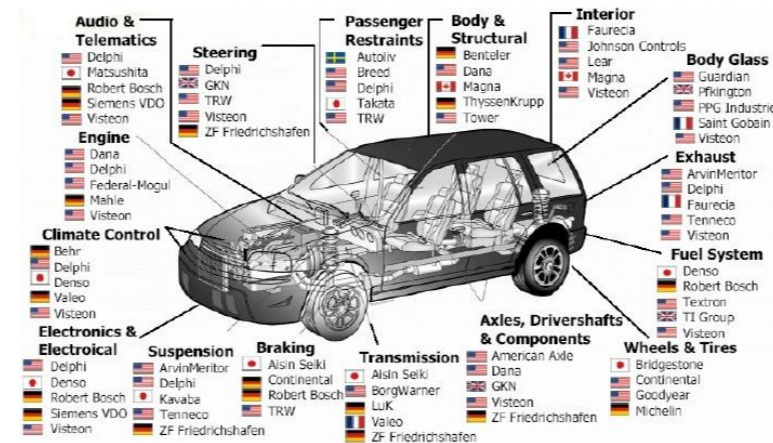
Professionals from the automotive industry were consulted multiple times in developing the skill set. Not only surveys were conducted but also interviews were held, and pilot trainings were offered for free. Overall Europe, 30 companies in automotive - OEM and Tiers – answered questions of which topics and content should be covered in the skill set and training material. Also the Bloom level of cognition was discussed. It took more than one year of collaboration and pilot testing before the skill sets were definitive.

As the skill sets are the bases of the training material the development of these skill sets was one of the most crucial outputs in developing this training.

Based on the results two skill sets for foundation and practitioner levels of knowledge were developed. These skill sets provide the fundamental basis for the creation of a curriculum and related training materials comprising a comprehensive text book "First Steps into the Automotive Industry", an exercise book, a trainers' guide, as well as training slides. The skill sets are also the basis for the development of a pool of test questions used for the certification of competences by the ECQA [2]. The released skill sets are the result of mutual agreements of education organizations, the automotive industry, as well as training and consulting organizations. They are the basis for the definition of a curriculum that is aimed at being integrated fully or partly in major European VETs. The following sections will elaborate further on this curriculum.

Introduction to the Automotive Industry Sector

The program starts with a training unit giving an introduction to the automotive sector in terms of its history, evolution and future, as well as the supply chain, key terms and key challenges.



Source: Myrill Lynch 2005

Characteristics of the sector are discussed, in particular the supplier structure, product and releases, and the importance of customer focus. Typical automotive engineering job roles are introduced to help learners orient themselves towards specific fields of interest. A learning element giving an overview of a small selection of the most important legal documents, regulations and standards relevant for the sector. The importance and essence of processes and process thinking in the automotive sector is also elaborated in this introductory module. The increasing dominance of mechatronic subsystems in modern vehicles implies an outstanding of the role of multidisciplinary challenges in engineering organizations and processes. This is also discussed in this introductory module, as is the important concept of simultaneous engineering.

Product and Process Development

The second unit focusses on selected engineering aspects of product and process development in the automotive sector. Departing from the explanation of the notion of the product life cycle and sustainability, a closer look is taken at the development phase of the product life cycle by discussing the development process, as well as the typical activities carried out in the context of this process. The notion of systems engineering is explained, as it is of particular importance in modern vehicles where system-level functions are implemented by numerous cooperating subsystems. The explanation of the V-cycle establishes the link between system-level and component-level development activities.

"The only thing that is certain is that the system is going to fail"

Murphy's Law of Fault Tolerance

Functional safety, i.e., the safe behavior of subsystems in case of failure, is discussed in the context of a module on risk management. This module also contains an introduction to FMEA, i.e., Failure Mode and Effect Analysis, which is one of the most important methods of risk management on both product and process levels in automotive.

Production

The third training unit deals with the automotive production process, with a particular focus on the quality assurance measures based on Six Sigma principles. The key topics here include the Process Capability (a measure for the variation in the process) and Process Control, mainly based on statistical tools applied to data measured in the process.



Process Capability & Process Performance

Since the suppliers have a key role in the automotive development and production process, the assurance of the quality they deliver is essential to the total quality management of the product creation process. This training element therefore discusses supplier control and assessment schemes, in particular Automotive SPICE®, which is used by automotive OEMs to assess their suppliers' mechatronics development process quality worldwide.

Management of change is an important activity throughout the entire product creation process, because changes can happen at every moment, and therefore is one of the training's elements.