Challenges for automotive engineering

How to cope with escalating complexity…

Automotive engineering has always been driven by the challenges that arose with the realisation of individual mobility. Efforts to improve the vehicle safety and fuel consumption in the 1970s were followed by the reduction of pollution in the 1980s. Starting with first investigations into the greenhouse effect in the 1990s, the reduction of CO_2 emissions has become the most dominant engineering goal in public perception to date.

Nevertheless, while the achievement of legal CO_2 emission goals is an extremely demanding task for the automotive sector, many other new and fundamental challenges risk being forgotten in the public debate. Globalisation, the ageing of industrial societies, individualisation, interconnectedness, increasing competition between manufacturers and suppliers are buzzwords that will greatly influence the automotive sector as we know it today. All of these topics require new technical solutions that will make the overall 'system' automobile more and more complex.

Modern Advanced Driver Assistance Systems (ADAS) have established a standard of driving comfort and safety unknown so far. Vehicles have become increasingly 'intelligent' allowing the driver to delegate specific sub-tasks of vehicle guidance to these systems or to let the automation take over vehicle guidance completely in emergency situations. However, the scientifically proven advantages of ADAS are accompanied by an important disadvantage: increasing complexity. Today, most ADAS are developed separately, with the consequence that each of these systems has its own user interface and interaction concept. Indeed, the uncountable number of buttons placed all over the dashboard in a modern car almost recalls the cockpit of an aircraft. This complexity runs counter to the original goal of enhanced comfort and safety.

Fig. 1: Multidisciplinarity in systems engineering

Another example of the rising complexity observed today is the growing product variety an automobile manufacturer must offer in order to satisfy a customer's demand for individualisation and thus to compete with other makers. Manufacturers contend to find the last gap in the product portfolio. The challenge to the automotive sector is to satisfy the market demand for a high product variety as efficiently as possible by developing just a few vehicle platforms that are able to generate the different model variants, comply with the diverse country-specific legal or market requirements and be modularly extendable. These demanding requirements have to be met within a time-to-market pressure that necessitates a reduced development time. Ever more model variants of increasingly complex automobiles have to be developed within a shorter development time. The negative results this kind of complexity produces are visible in the growing number of recalls because of engineering problems. The number has more than doubled in the past 10 years and affects nearly every manufacturer.

Only automotive companies that can cope with complexity will be able to create value and thus prosper in the future. Managing complexity will be a key factor for the European automotive industry in order to stay one step ahead of global competitors.

Development and design methodologies are needed in order to identify valid requirements, develop adequate system designs for these requirements, and run effective and efficient test procedures and system evaluations. The conventional engineering disciplines will not be sufficient to cover the entire solution space. Rather, multidisciplinary engineering (Fig. 1) that follows a solution-independent methodology is needed – 'systems engineering' is the avenue to tread. The key element of this approach is to abstract the entire system into a system architecture that makes it possible to manage complexity and develop new test and assessment methods as market enablers for new technologies. Individual and safe

mobility for the future can only be guaranteed with methods that are able to test and prove the safe functionality of the complex systems.

The Institute of Automotive Engineering (Fahrzeugtechnik Darmstadt, FZD) at Technische Universität Darmstadt follows the systems engineering approach in many current research projects, incorporating the driver-vehicle-environment system as an inseparable element. The different research fields (eg ADAS, vehicle dynamics and safety) are not isolated from each other, but are closely interconnected.

The automation of driving might be a solution to some of the challenges of future mobility concepts. Work on fully autonomous cars has undeniably made extensive advances in the last 10 years. But fundamental challenges, for example the question of possible approval processes for road traffic, are still unsolved. On the other hand, ADAS capabilities are increasing rapidly and many have already proven themselves in real road traffic and in usage by customers. FZD's research activities are interlinked within a development roadmap, depicting a step-by-step approach from today's ADAS to fully automated driving (Fig. 2). A major step towards solving the described problems of greater user complexity when combining multiple assistance systems might be 'cooperative automation'. The technical feasibility of this concept is being assessed at FZD using the 'Conduct-by-Wire' approach that consists of replacing today's control elements by a single manoeuvre interface. This allows a maximum degree of automation, while – unlike fully automated concepts – still keeping the driver responsible for vehicle guidance in line with the Vienna Convention on Road Traffic.

A good example where systems engineering opens doors to new technical solutions is FZD's 'eco_2DAS' research project. The aim here is to raise the efficiency of mobility by building bridges between functionally separated islands, for example by providing the engine management with information from the ADAS environment sensors. Then, for example, the vehicle could react earlier to a traffic jam and – eg by charging the batteries of a hybrid vehicle – decelerate the vehicle more efficiently than is the case today.

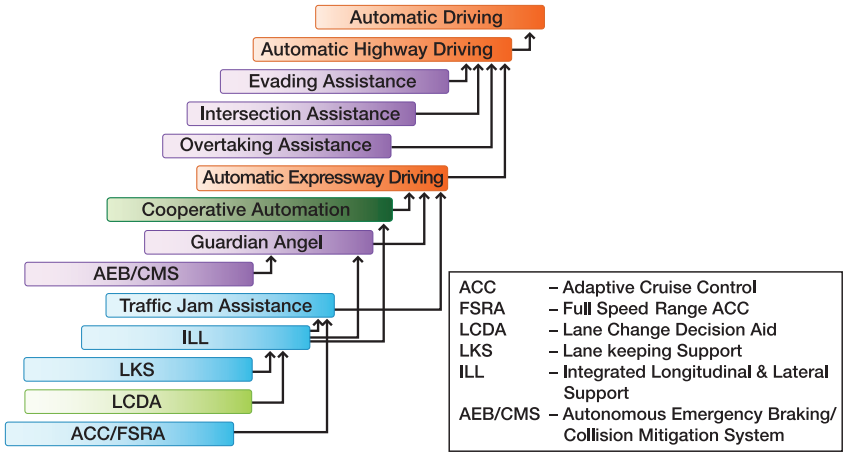

Fig. 2: Evolution of driver assistance systems[1]

These are only two examples of FZD research projects that are directly linked to the ADAS roadmap and follow the systems engineering approach.

Universities will play a significant role in realising the systems engineering approach in the automotive industry. The interdisciplinary academic network will be essential to develop the scientific basis for understanding and synthesising complex systems and to provide an education that will sustainably breed future generations of engineers that have internalised the systems engineering approach. And finally, the knowledge exchange between universities and the automotive industry has to be guaranteed by appropriate partnerships. German universities might play a leading role in this sector thanks to their unique, practice-oriented focus of research and education.

In this context, FZD is founder member of two academic associations: 'Automotive Systems Engineering Darmstadt', a cooperation of several institutes at the Technische Universität Darmstadt to develop solutions to complex problems of vehicle development, and 'Uni-DAS', a cooperation between academic institutes from different universities in the field of ADAS research. Both associations collaborate with the European automotive industry in different research projects.

Over the past decade, FZD has successfully contributed to the progress of systems engineering in research and education. As a founder member of interdisciplinary associations, FZD is a predestined partner for future research activities in collaboration with industry and politics.

[1] Based on: H Winner, G Wolf: Quo vadis, FAS? in: H Winner, S Hakuli, G Wolf (Editors): Handbuch Fahrerassistenzsysteme, Vieweg + Teubner, 2009, pp. 644–673

FZD COMPREHENSION DRIVING INNOVATION

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