The Effects of Digital Transformation on Vehicle Development

Prof. Dr.-Ing. Eric Sax, Karlsruhe Institute of Technology (KIT)

At the Karlsruhe Institute of Technology (KIT), Prof. Dr.-Ing. Eric Sax was interviewed by Henning Kemper and Jan Stehle from IPG Automotive. As Director at the Institut fuer Technik der Informationsverarbeitung (ITIV) and at the Research Center for Information Technology (FZI), he provided a multitude of fascinating insights into the current challenges for research, the use of systems engineering and the role of simulation.

We are very pleased that you are taking the time to talk with us. Could you introduce us to your field of work?

Sax: Of course. Among other topics, I am responsible for systems engineering at the Department of Electrical Engineering and Information Technology. Over 50 PhD candidates are currently part of my research group focusing on systems engineering in the automotive field. Until about eight years ago, I was in charge of electrics and electronics worldwide at a large automotive and heavy-duty vehicle manufacturer, I am thus not only oriented academically.

What are the goals your institute pursues?

Sax: It is of course the prior task of a university institute to promote scientific topics. In our case, they include validation and testing of driving functions, model-based development as well as the application of simulation tools and E/E architectures. We are also looking at how we can create additional value from the amount of data that we collect in the vehicle.

In applied and research-oriented science it is our task to comprehensively impart highly integrated topics to students. Our science plays an important role for graduates who just completed their Abitur* as well as for people who are already working professionals. We have even established a master's program at our Business School – the International Department – and are now additionally working on more compact courses. We are increasingly placing an emphasis on qualifications at an academic level. Especially with young research fellows, I consider it important to not only support their technical qualification but also their personal development to prepare them for positions with greater responsibility in the industry.

In this field of research, the ITIV is one of the pioneers on the subject of processes and methods for automated driving. How has your work changed in this dynamic field over the last years?

Sax: That is a very good question. To give you a sense of time: It has already been 10** years since the famous highly automated Mercedes S-Class drove on the Bertha Benz Memorial Route – time really is flying. Looking back at it rationally, it was a showcase project which raised high expectations.

The entire focus on automated driving is shifting significantly. Under good weather conditions for example, these driving functions represent only a small challenge. Assistance systems such as lane keeping assist can already keep a vehicle in the lane on the freeway, as long as no exceptional situations occur. Extreme weather conditions and demanding traffic situations however entail completely different requirements. And when we start looking at areas where the human driver is completely omitted, safety remains a critical factor.

This is currently being discussed intensively in the area of heavy-duty vehicles where the starting point for validation is fundamentally changing. I feel like the industry is slowly realizing the enormous automation potential that presents itself specifically in this area. There is an enormous lack of qualified drivers and, in addition, recruiting young people is a huge problem. Today we can see that flu epidemics quickly result in buses not driving anymore and strongly compromise public transport.

You previously mentioned validation – have there been significant changes here as well in the past years?

Sax: Yes, but far too few in my opinion. With the HIL systems, which have been introduced many years ago, the motto was: no requirements without testing and no testing without requirements. Due to the topic of sensor fusion, we are now on a completely different system level: on the logical level. The challenge we are facing here is that we need to think in scenarios. The incredible variety of variants in the urban environment leads to the fact that test kilometers cannot be driven solely on the road anymore. What is really helpful here of course is simulation and scenario-based testing, especially combined with new and innovative tool landscapes.

Even though the software portion in modern vehicles is increasing rapidly, ever-shorter development cycles need to be observed at the same time. How does this digital transformation impact your everyday work?

Sax: For one thing, we are noticing that the inquiries from industry partners are changing. They are now asking much more about how software can be released and how over-the-air updates should be dealt with. As these topics are certified and meticulously safeguarded in Germany, while other countries may not be as strict in this regard, we accordingly have many inquiries.

If, for example, an automated vehicle needs to recognize whether a pedestrian wants to use a crosswalk, one method is to establish some sort of "eye contact". In this case, the GDPR plays a crucial role. We have PhD theses that look at communication with light sources, texts and arrows on the vehicle. A considerable effort is

* Translator's note: German high-school diploma
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Fig. 01: Interview with Prof. Dr.-Ing. Eric Sax

involved in proving that the faces of pedestrians are not being used for identification and personal rights are hence not violated. Bringing all these new developments onto the market still demands a lot of work.

But to get back to the initial question: In general, I believe that the more software-oriented work becomes and the more we are moving away from the actual vehicle, the more possibilities we have to work in an agile way and to conduct an incremental functional setup.

In this context, virtual test driving also plays a decisive role. You are using the open integration and test platform CarMaker to this end. How are you using it and what are the benefits?

Sax: As I have already mentioned, the richness in variants in automated driving cannot be mastered only with conventional kilometer-based test drives anymore. To validate according driving functions, it is absolutely necessary to deliberately induce critical situations using virtualization. Exhausting tolerances is extremely important and this is where a simulation platform like CarMaker helps us immensely. In addition to a high efficiency, it also has the enormous advantage that accidents in the simulation environment have no severe consequences.

Furthermore, we are convinced that it is fundamentally important to use this type of software to directly introduce students to the established standards in the automotive industry and to prepare them in the best way for their professional life.

What exactly do you mean by systems engineering that you mentioned in the beginning, and how can it help to handle the digital transformation optimally?

Sax: For me, systems engineering is divided into two major elements. On the one hand, we have systemic thinking, meaning the integration of components into a network of systems and subsystems. On the other hand, we have engineering as a conventional engineering method. For us, software development is also part of it.

To ensure a continuous engineering process, we definitely need an understanding of handover points and interfaces. This means that we need to move away from components that are, casually speaking, thrown over the fence one after the other, and that we rather have to develop the system on a superordinate level.

We can use systems engineering as a means of description in specification as well, for example with SysML as a modeling language. If we follow the classical V from the V-model and work through the left side from top to bottom, we are also looking at systems engineering of course.

This allows us to achieve high precision already in early development stages. If this modeling and description using mathematical and model-based means is designed with such precision that we are able to simulate, systems engineering allows to achieve a high maturity and high clarity in an early stage of development.

With the new virtual vehicle development tool suite VIRTO, it is now possible to make virtual test driving and systems engineering accessible to a broad audience in an easy and intuitive way. Why is this fundamentally important?

Sax: Virtualization or simulation plays a role for so many occupational groups that we cannot assume that there are specialists for the application of simulation environments everywhere. The majority can only be reached with an intuitive access to simulation that delivers results fast.

From my point of view, a great comparison is that the use of such a tool has to be as simple as taking a seat in a physical prototype and driving away. Many people can do this easily because they can drive regular cars as well. In the

same way, the use of simulation tools should become a standard with which we can easily generate results.

We will probably not be able to cover all areas of specialization with them. But we will reach a much broader audience if we enable easy access to simulation.

Can you explain which benefits continuous simulation offers, especially with regard to systems engineering?

Sax: I can give you an example from my professional experience. It was the first time I was sitting down with system houses that sold me HIL models and simulation tools. And afterwards, a seamless transition took place and the same persons took care of the SIL topic. That is exactly the point: When you do not have to reinvent everything again every single time, you can save a lot of time and money and create synergies instead of building isolated expertise. Experiencing this continuous approach and traceability first hand inspired me sustainably.

In this way, the level of maturity can also be quantified, correct?

Sax: Yes, exactly, this is very important for me: measurable maturity levels! I am very familiar with this because I had release responsibility for many years. In my experience, everybody is happy when a metric is available to measure the development of deltas. As a prerequisite we still need reliable and authentic results of course.

We also would like to speak about your current projects. For a while now, the KIT is one of the partners in the TEMPUS project as well as in the follow-on project MINGA. What is this project aiming at, and how does your research contribute to the successful implementation?

Sax: They are projects to automate public transport in Munich. The aim is to increase flexibility in urban bus services by coupling trailers licensed to carry passengers to the vehicle. This has been working for buses with conventional diesel engines for years – the flexibility here is given through a mechanical tow bar.

When we are looking at purely electrified vehicles, such a trailer is not ideal for the range. You could now consider electrifying long articulated buses instead. But this takes away the flexibility of coupling and decoupling to be able to adapt the transportation capacity dynamically. Electrification of such niche products is a challenge since the entire vehicle needs to be optimized. Alternatively, the trailer can be equipped with a separate drivetrain that is also controlled and continues to drive with the tow bar. This would be a niche in the niche – development costs would not be manageable anymore. What is more: When driving a narrow curve with a trailer, there is always the risk that the trailer drives over the curbstone because it pulls over the tow bar.

Instead, the idea is as follows: It has been proven that conventional 12-meter city buses are the most efficient vehicle for electrification in this setting. To be able to react to strongly fluctuating passenger numbers, we further need maximum flexibility – this is why we are not using trailers and articulated trains. Talks with the board of the Munich transport association birthed the idea of designing the following vehicle in a way that it follows the exact trajectory of the lead vehicle and can be used as an independent lead vehicle, too. The vehicle is an independent bus and identical to the lead vehicle.

It is decisive here that the trajectory of the rear axle is precisely followed. The appropriate sensor technology and monitoring of the distance between the buses are currently in an experimental stage. The necessary driving signals of the lead vehicle regarding acceleration, steering angle, braking, etc. are redundantly transferred to the back.

Very interesting and much more challenging than you would think in the beginning...

Sax: ...but it is an intermediate step that might one day lead us to SAE level four or five. Due to the fact that the lead vehicle is controlled by a human and only the following vehicle is driverless, the whole thing is less challenging than a completely autonomous automated shuttle. For me, this is a very charming solution and a great starting point for modern urban public transport.

With the implementation of this project as well, simulation has helped us tremendously, we worked a lot with CarMaker here. Rear end detection, trajectory handover, the setup of the city scenario – all these areas are ideal for simulation.

Could you already provide us a short outlook on future projects?

Sax: Firstly, we are in the process to fully move functions to the backend and to take individual ECUs that are not critical for real time out of the vehicle – especially when looking at self-learning functions in the fleet. I personally believe that integrating these E/E architectures and infrastructures is a very strong topic for the future, enabling us to talk about real-time critical driving functions and communication as well.

Secondly, I am convinced that we are still at the beginning of transforming the huge amounts of data in the vehicle into added

value and services that can in the end result in business cases. We are still lacking a bit of creativity here and there. I believe that if this will not happen here in the central European region, others will quickly show us which business models are possible.

Furthermore, I am convinced that we will have an incremental approach on the path to automation, we do not always need a business case behind it right away. We are looking for projects in niche areas. For example with automated driving, we are always talking about lateral control, but longitudinal control as well can be a fascinating topic. An energetic approach for example can play a role here for range optimization.

Let me share one last interesting anecdote to finish: We are also active in the field of animal observation, more specifically, we are observing elephants in the zoo. This might sound odd at first, but many conclusions can be drawn with regard to the behavior of pedestrians or vulnerable road users in traffic, without, as mentioned before, having to keep the GDPR in mind all the time. If you observe an elephant for an entire night, specific patterns can be derived and anomalies can be detected. If a pedestrian acts hectic, the behavior is quite similar.

Fig. 02: Prof. Dr.-Ing. Eric Sax in front of the model of an automated bus depot

Thank you for taking the time and for this insightful interview.