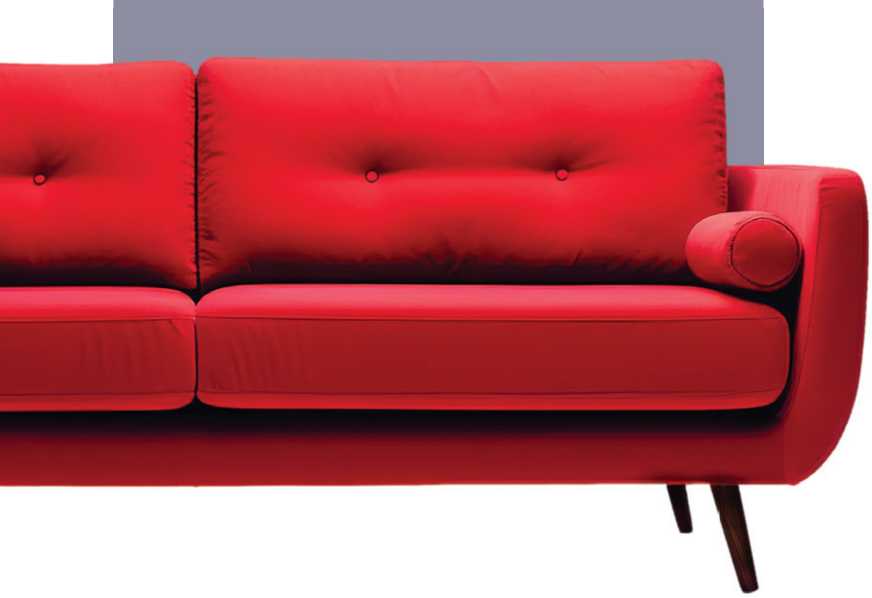
EXECUTIVE SUMMARY

automotiveIT Salon #3 AUTONOMOUS DRIVING – VIRTUAL VALIDATION AND AI INTEGRATION

SUPPORTING EVENT OF IAA TRANSPORTATION 2024



PANELISTS:

- Pascal Nagel (Moderator)
- Yannick Tiedemann (Moderator)
- Gilles Gallee
- Prof. Dr. Joachim G. Taiber
- Dr. Reinhard Ernst
- Ramzi Yakoubi
- Andreas Lauringer

QUOTES:

- The core technology is the ability to simulate millions of scenarios at scale within a reasonable time frame.
  Gilles Gallee, Director of AV Simulation Solution, Ansys

- AI can generate results quickly, but achieving 100% precision is still a significant challenge. AI requires a lot of data to learn and train models, and while the first 80% can be achieved relatively easily, optimizing the last 20% comes at a high cost.
  Ramzi Yakoubi, A. General Manager & Head of EE ADAS, Chassis & E-Mobility, Magna Engineering & Infotainment

- It's not about more regulation, but the right regulation. The right regulation enables engineers rather than hindering them.
  Andreas Lauringer, CEO, Kontrol GmbH

POWERED BY Ansys

> You will never get such a complex product out without virtual validation. That's a fact. The question is how much you rely on it.
> **Dr. Reinhard Ernst, Senior Engineering Manager, Head of ADAS System Validation Germany, ZF Active Safety GmbH Electronics & ADAS Division**

> What we're seeing is that getting people together to agree on standards requires collaboration. Some stakeholders try to push their own approach, but collaboration is essential.
> **Prof. Dr. Joachim G. Taiber, Founder and Managing Director, IAMTS**

KEY TAKEAWAYS

01 Slower-than-Expected Progress in Autonomous Driving

Despite high expectations, autonomous driving has progressed slower than anticipated. Key obstacles include technical limitations, such as sensor fusion and computational challenges, as well as regulatory and homologation issues that must be addressed before mass adoption is feasible.

02 Impact of Industry Crises

The automotive industry's focus has shifted towards electric vehicles due to market pressures, which has slowed down investments in autonomous driving technology. This trade-off, along with delayed returns on electric vehicle investments, has contributed to the slower progress in autonomous driving.

03 Complexity of Autonomous Driving Technology

Developing autonomous driving systems, especially Level 3 and Level 4, is highly complex. Challenges arise from the need for sophisticated software, real-time sensor fusion, and large-scale validation processes. Validation, both virtual and real-world, remains a critical bottleneck.

04 The Role of Collaboration and Standardization

A lack of early collaboration between OEMs, suppliers, and regulatory bodies has delayed advancements. Going forward, more collaboration is essential, especially in the areas of standardization and shared testing environments, to ensure that innovations can be integrated across the ecosystem.

05 Regulatory Frameworks: Necessary but Often Vague

While regulatory frameworks are essential for the deployment of autonomous vehicles, they are often too open to interpretation, leading to uncertainty and delayed implementation. More industry involvement is needed to refine and improve these regulations, ensuring they are clear and actionable.

06 Importance of Virtual Validation

Virtual validation through scenario-based testing is becoming a standard practice. This method allows for large-scale testing of autonomous systems in virtual environments, significantly reducing costs and development time. It complements, but cannot fully replace, real-world testing.

Dr. Reinhard Ernst

07 AI's Role in Autonomous Driving Development

AI is increasingly integrated into the development process, particularly in areas like sensor data processing and simulation. However, its non-deterministic nature and precision challenges make it unsuitable for all applications, requiring careful and cautious implementation.

08 Societal Acceptance and Ethical Challenges

The widespread adoption of autonomous vehicles depends heavily on societal acceptance. Ethical questions, such as how autonomous systems should behave in unavoidable crash situations, and public trust in the technology, are critical for moving forward.

09 Future of Autonomous Driving

The panel agreed that technology alone will not drive adoption. A shift toward mobility as a service, coupled with increased societal acceptance, will be key factors. Autonomous driving solutions will need to demonstrate clear value and reliability to both consumers and regulators.

10 Conclusion

To unlock the full potential of autonomous driving, the industry must overcome technical, regulatory, and societal challenges. Collaboration, both within the industry and with regulators, will be crucial to advancing this technology. Virtual validation, AI integration, and public trust-building are central to accelerating the adoption of autonomous vehicles.

ROUNDTABLE DISCUSSION

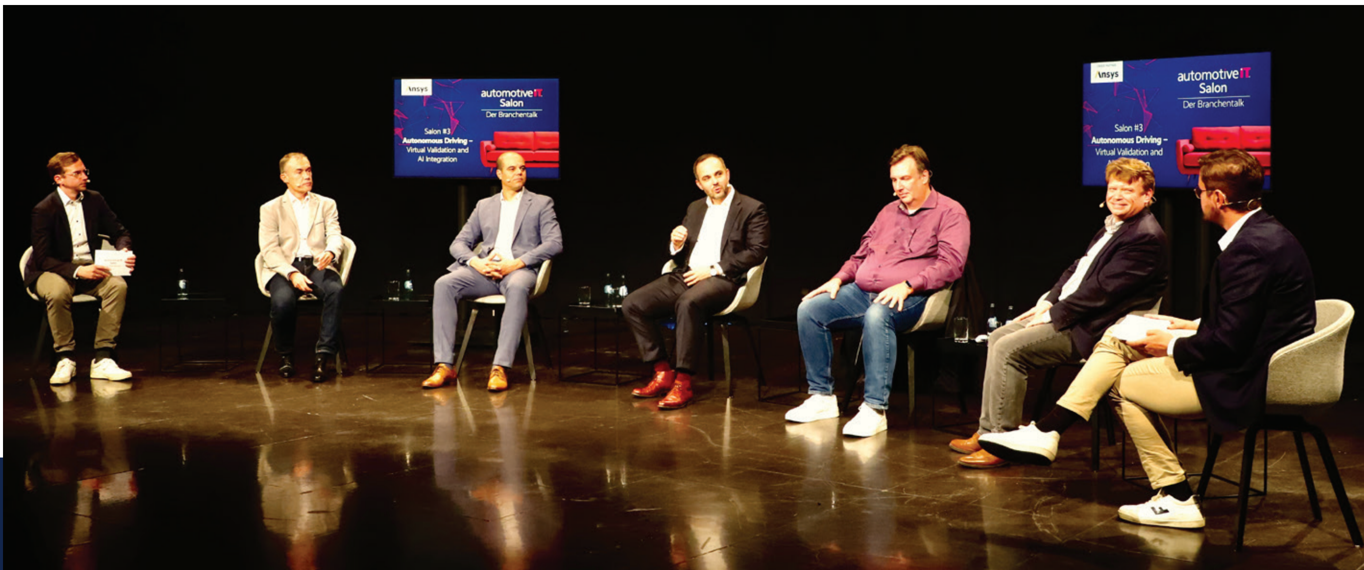
TIEDEMANN: Gilles, autonomous driving is currently far from where it was expected to be by 2025, at least based on predictions made a few years ago. What, in your view, were and continue to be the critical roadblocks behind what I would describe as this slow progress?

GALLEE: Great question. A few years ago, we certainly expected to be living in a world surrounded by self-driving cars by now, and you're right—it's been a longer journey than anticipated. Several roadblocks exist in the market, and if we focus on a few of them today, I think some are tied to the technology not yet being at the required level, considering the complexity of the sensors, computing power, and so on. But beyond that, the issues of regulation and homologation are also critical. These are important aspects to ensure that the industry can deliver safe and efficient self-driving vehicles for various business applications.

TIEDEMANN: Do you think the current crisis in the automotive industry is also contributing to the slowdown in the development of this technological area?

GALLEE: I think so. Perhaps some of my colleagues here can provide more insight into the crisis that is unfolding, but I believe the automotive industry is accustomed to facing regular crises. However, the long journey towards autonomous driving is still ongoing, progressing through the different levels of ADAS. Right now, we are seeing highly effective ADAS Level 2 and 2+ systems available on the market, which are already proving to enhance safety for the end users.

ERNST: Ithink the current situation is partly related to the crisis, but it's also important to understand that this is not an easy task. If I may use an analogy, it's like teaching a student driver. Just as a child needs to learn how to perceive and interpret the environment, gaining experience in how everything behaves both in and around the car, the development of autonomous driving technology also takes time. Setting ambitious goals is essential for progress, and I believe it was the right move to push the boundaries. We have famous examples from our OEM partners, but it comes at a significant cost. Moreover, closely supervising what the cars are doing is a crucial factor. That's why we're here, discussing



validation—not just testing everything in the real world, but also in the virtual world, with the aim of making the process faster and more secure. But of course, this too presents its own challenges.

TAIBER: I wanted to comment on what some are calling a crisis. One of the key issues is that many OEMs had to make a choice between prioritizing electric vehicles and autonomous vehicles, and a lot of them chose to focus on electric vehicles. However, the expected demand for these vehicles didn't materialize as quickly as anticipated, which means many of the investments made are not yet paying off. Another point relates to validation. At IAMTS, my organization, we've been active since 2019, and we've spoken to many stakeholders about investing in standardization. Often, we had the impression that companies wanted to try things out independently before engaging in standardization efforts. By the time issues arose, they realized the need for standardization, but by then, significant money had already been spent. Additionally, many start-ups received substantial funding, but this funding wasn't sustainable. I've noticed that suppliers often expect returns within five years. Many of these activities started around 2017 or 2018, and now in 2024, when returns haven't materialized, senior management is beginning to say it's taking too long. These are just a few observations.

Prof. Dr. Joachim G. Taiber

NAGEL: I just want to add to that—you've already mentioned that several players are involved in this process. Autonomous driving is certainly a field where many stakeholders must collaborate to bring it to life and make it a reality. What would you say is happening right now in terms of action? And who are the key players driving the development the most at this moment?

TAIBER: I think we need to distinguish between the different levels of autonomy or automation. When you talk to legacy OEMs and traditional manufacturers, it seems their focus is primarily on Level 2+ systems. Some OEMs have invested heavily in Level 3 systems, but the volumes are still low, and the adoption rate is limited. However, there has been an interesting development, perhaps triggered by Tesla's Full Self-Driving, which is technically a Level 2 system but gives the impression of a Level 4 system. In markets like China and the U.S., there seems to be an interest in experimenting with this. Once you're on that path, it opens the door to pushing for robotaxis. Interestingly, this push for robotaxis is not coming from legacy manufacturers but from newer OEMs who see this as a market opportunity or a way to differentiate themselves. So, we have what you might call a conservative camp and a progressive camp, and these two camps are, in a way, competing with each other.

TIEDEMANN: Reinhard, just a quick question. Do you agree with Joachim on this point? And as a supplier like ZF, do you see ADAS and AD technologies as a window of opportunity to perhaps evolve beyond your core business with OEMs, becoming more open to working with other players and creating new business models or products? Is this a chance for you as a supplier in the current landscape?

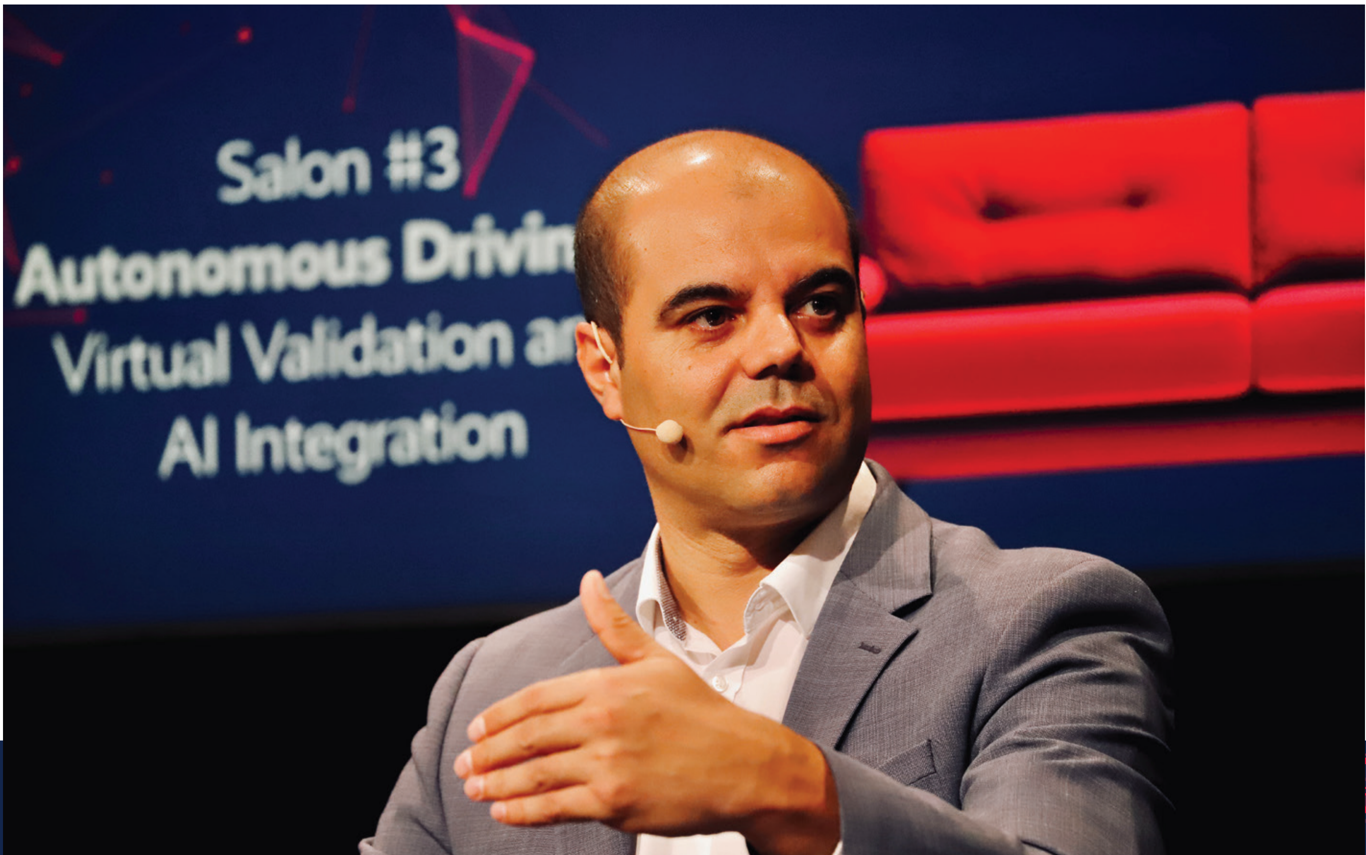
ERNST: That's definitely the case. Traditionally, we've been strongly tied to OEMs, that's clear. But our portfolio and offerings in support of autonomous driving are growing significantly. When we talk about validation, which is key here, the challenge lies in managing very complex systems with multiple sensor sets and multimodal data that need to be merged and fused together. Validating these systems is incredibly complex, and that's a big challenge. As a result, we're moving towards more modern technologies. In my area, I've been pushing hard to ensure we're ready for Level 3 and beyond, but currently, most OEMs are focusing on Level 2 and 2+ systems. In the press, there's always hype around autonomous driving and robotaxis, and yes, there are companies actively driving this forward, which is great. But validating these systems requires an immense amount of effort. That's why we've also prepared ourselves to integrate reference systems that use modern AI technologies to create what I might call a 'superset' of the surrounding environment—essentially, something that describes the environment with a very high degree of accuracy, better than any live system could. This is crucial to qualifying and securing autonomous vehicles. If we don't push forward with these kinds of technologies, we won't have any chance of securing such systems. And if you can't prove that these systems are secure and safe, you won't convince people to trust them, and they won't reach the market—especially not in Germany, where people need to feel safe.

YAKOUBI: I want to comment on the two perspectives. I liked the point about Tesla and the revolutionary system they introduced. It pushed everyone to set new goals. The problem, however, is that many of these goals became just buzzwords. I remember being part of a project where, at that time, I was working at a Tier 1 supplier, and we developed the first LIDAR system in the world, which was integrated at Audi. Everyone was saying that Level 3 would be here before 2020, and then it was pushed to 2022, 2023, and Mercedes came into the picture. But what everyone underestimated was the complexity, especially starting with software and sensor fusion. From 2011 to 2016, I don't recall ever seeing ultrasonic sensors and surround-view cameras being fused together. Even that level of complexity wasn't ready. Yet, we were already talking about integrating radar, LIDAR, and now even supersets of different sensors. The most important lesson I took from that time was that the problem wasn't just technical—it was the lack of cooperation within the ecosystem. Suppliers, OEMs, Tier 1s, Tier 2s, even consultants with valuable knowledge weren't working together. Everyone was focused on being the first to market, which delayed progress by at least a decade. Now, some cooperation is beginning to happen, like Mercedes working with others, and I hope that this lesson is understood by everyone because it's incredibly costly. No single company can do this alone.

TIEDEMANN: Do you think the decisions made back in 2017 or so—both within your company and others—were too ambitious? Did they underestimate the complexity of the technological implementation, especially when it comes to the fusion of different sensor sets?

YAKOUBI: For me, that was the main issue, but it's not the only one. Gilles also mentioned other challenges, like the enormous effort required from infrastructure, which is still not ready. They need things like lane markings and many other components that are essential. Even the legacy systems you mentioned have gaps. But I think those are solvable. The real challenge is building the core system, and that's not something one company can tackle on its own. It has to be a collaborative effort within the entire ecosystem.

TAIBER: What we're seeing, and I've observed this within our organization, is that getting people together to agree on standards requires collaboration. However, some stakeholders try to push their own approach and dominate. When facing a complex problem, though, collaboration is essential. The delay we've experienced, in my view, stems from a lack of sufficient collaboration. I've personally been involved in large, expensive proving ground developments where the goal was to design environments that multiple users, including competitors, could use jointly. You quickly realize that creating a separate validation environment for each user isn't feasible. Instead, there needs to be an agreed-upon validation environment. This speaks to the importance of collaboration, but it requires careful management to ensure confidentiality while still working together.

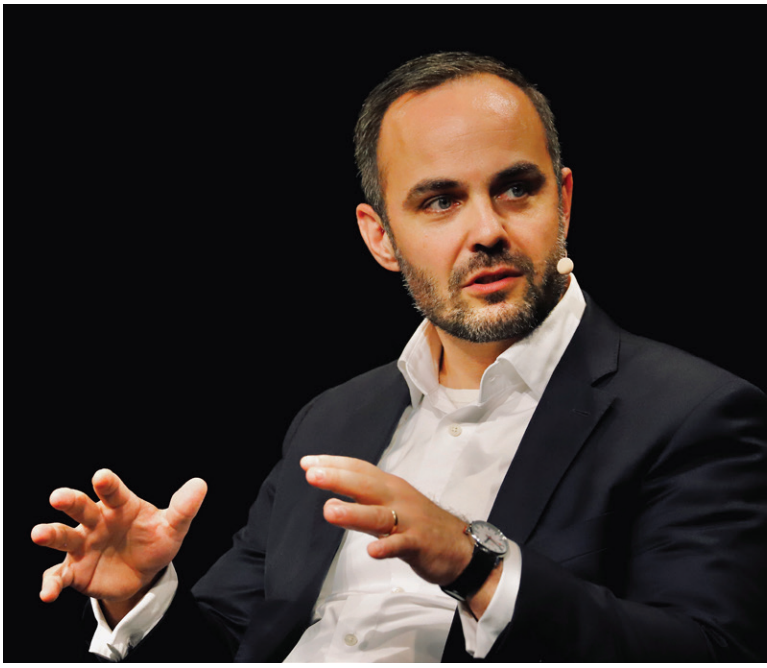


Ramzi Yakoubi

LAURINGER: I really like the analogy of children learning and growing up, because if we started in 2010, then a child would soon be around 18 years old and should know the rules. So, by that analogy, in four years, we should be driving more autonomously. It's a great metaphor for how development progresses. Just like kids, when they want to do things on their own, they also need to learn how to collaborate. I think we're in that phase now. I appreciate that excellent example because it also shows how we as humans, who are ultimately the ones driving technological development, are progressing. When we look at the market, especially here in Germany, we have one of the most progressive transportation authorities, led by Richard Damm, which is allowing many innovations to move forward. Joachim, you mentioned the difference between new and legacy players, and I think that's an important point. One issue we often encounter is that new tech companies sometimes see technology as the product, but that's not how it works. Building a vehicle as a piece of technology is a completely different game from building a product. In Silicon Valley, a lot of technology is being developed, but here in Europe, we focus on products—and products get bought, not just technology. You don't buy a piece of technology and expect it to work perfectly; you buy a product that's functional, reliable, and safe. That's a fundamental difference. I always say, there's Silicon Valley, but there's also the Donau Valley. We should pay more attention to what's happening in the Donau Valley in terms of product expectations. As Joachim mentioned, Tesla hypes its technology, but where is the product? Tesla projects an image of Level 4, but in reality, the product is Level 2. So, in that sense, they aren't actually ahead. On the contrary, as Mercedes and even BMW have shown with recent announcements, the products here in Europe are more mature. That's where the legacy players are starting to challenge the new tech companies.

TIEDEMANN: As you mentioned, you and your company are deeply involved with legal requirements and regulatory frameworks for autonomous driving functions, and you have significant expertise in this field. When you look at the speed and rate of adoption, do you think we're all aligned when it comes to the regulatory framework, or is there still a lot of work to be done?

LAURINGER: In Germany, technically, you could already release a Level 3 or even Level 4 vehicle on highways. The framework is in place, and the industry has successfully pushed the KBA (Federal Motor Transport Authority) to develop the necessary regulations. In fact, at the VDA Congress in February, Richard Damm said, 'Where is the industry? I've made the frameworks.' It's a bold statement, but it raises an important point—how do you prove that a computer driver is better than the average human driver? And who among us is the 'average driver'? This leads into the challenge of statistics, where you quickly realize that new technologies like simulation need to be used extensively. You simply can't drive millions of kilometres in



Andreas Lauringer

real life to gather the necessary data. So, while the regulatory framework is there, the question now is how we adapt to meet those requirements. And ultimately, the challenge we face is harmonizing computer-driven systems with human drivers. The Straßenverkehrsordnung (German Road Traffic Regulations), which was created in 1932, was designed to harmonize all traffic participants. Now, we're trying to integrate computers into that mix with humans, which is no easy task. This brings up societal acceptance as well—how do we as a society handle the fact that fatalities will still happen, even with autonomous systems? I believe the ethical dilemmas often discussed in recent years, while important, have been a bit overhyped. The real issue is not about determining who to hit—whether it's an elderly person or a child—but simply detecting that something is there in the first place. Up until recently, distinguishing between who or what was present wasn't even possible with sensors. The focus was on whether an object was detected at all. So, I think the ethical debate has overshadowed the more practical challenges we face, such as collision avoidance and improving the technology itself. It's like the analogy of kids maturing. We're at a point now where the technology is almost ready to take off. I'd say we're just on the cusp of the race, so to speak.

NAGEL: Before we get into regulation, standardization, and harmonization later in the discussion, let's take a deeper dive into the technological side of things. We're here today to focus on topics like virtual validation and AI integration. So, to start, what new technologies and approaches are emerging to validate autonomous driving functions? Could you give us an introduction on the technological side of virtual validation?

GALLEE: Yes, I'd be happy to. I'll build on some of the points mentioned earlier, particularly by Andreas, who brought up important concepts like statistical validation. This is especially crucial when it comes to ADAS and higher levels of autonomous driving. Validation must be done statistically. Andreas also mentioned millions of scenarios, and depending on the target, these millions of scenarios are impossible to replicate through real-world driving alone. This is where virtual testing comes in. Virtual testing is now becoming a new standard approach known as scenario-based testing, which is increasingly adopted by regulatory bodies. Scenario-based testing requires large-scale simulation to provide statistical proof of the system's safety. The core technology here is the ability to simulate millions of scenarios at scale, within a reasonable time frame. And, of course, this is all about simulation, something that Ansys has specialized in for decades. Everyone has likely worked with simulation at some point, even during their engineering studies, and as we all know, simulation is 'garbage in, garbage out.' What you put in is what you get out, and the key is having good models as well as accurate inputs. With good inputs and good models, you get reliable, credible results. At Ansys, we've been working on credible simulation for years, particularly with sensor suppliers. Our goal has been to develop high-fidelity models that can be used in scenario-based testing at scale. This involves ensuring that sensor vendors, whether for radar, lidar, or ultrasonic sensors, provide the right inputs and models specific to their technology. What we've built is a virtual simulation platform capable of running millions of scenarios in the cloud, using trusted models that OEMs, suppliers, and regulatory bodies can rely on to prove the safety and homologation of autonomous vehicles. The market is evolving in this direction. Ansys has brought these solutions to the market in recent years, but they stem from years of collaboration with major players like BMW, as well as agile startups like Kontrol. This ability to foster collaboration within the ecosystem is crucial for developing standard methods and tools that everyone, including OEMs and regulatory bodies, can trust.

NAGEL: Reinhard, perhaps you could give us some insights into your work at ZF, particularly in the area of virtual validation.

ERNST: Yes, it's a lot more complex than just saying, 'I have a virtual representation or digital twin,' and everything magically works. It's not a matter of simply integrating everything virtually, building up the car, re-simulating it, and being done. That would be a dream, but it's not the reality. There will always be a certain amount of real-world testing needed. You have to physically sit in the car and drive it. But before that, you need to carefully plan what's necessary to include in the vehicle, such as which sensor sets to use. Even looking at a single sensor, like a radar, it's built from multiple components—an antenna, signal processing, and then perception. From there, the data is sent to a central compute unit that may perform fusion, either with the same type of sensors or different sets of sensors. There's an entire stack of processes that need to happen. And you can imagine how challenging it is to take all of that, downsize it to fit into a car, and still ensure that the system operates reliably. It's like looking into the brain of a student driver to understand how it works—this is the essence of validation. You start by virtualizing individual sensors, seeing what the sensor interprets, and checking the data being fed into it. This depends on external physics as well. For example, a camera detects light, while a radar senses electromagnetic waves, which behave differently in various environments. So, it's not just the sensor that needs to be validated, but also the environment and the physics affecting it. Just describing it briefly shows how complex this area is, with so many potential pitfalls. The real challenge is finding the right balance of complexity to ensure that the system is 'good enough' or safe enough, as the Americans say. At ZF, we're dealing with this complexity by combining multiple levels of virtualization and simulation. We also verify these simulations by conducting real-world tests, driving the car, measuring the environment with reference systems, and then comparing those results to the virtual tests. Maybe I've gone a bit fast on some of these topics, but I hope this gives you an idea of just how much effort and complexity is involved in virtual validation.

GALLEE: I think you explained it very well, Reinhard. What I was getting at is that the foundation is scenario-based testing, which you then apply to different levels of validation. Customers typically define their test strategy, and now with virtual testing, we're introducing a new approach that allows for more testing in the same or less time. There are different levels of simulation, each with varying degrees of complexity. But it all relies on trust in the simulation—whether it's a radar or a camera, light and electromagnetic waves behave differently.

ERNST: Exactly, and that's why you need a combination of sensors. If you rely solely on cameras, what happens at night or in heavy rain? You need multiple sensor types working together to meet regulations and ensure safety in the end.

NAGEL: Ramzi, what's your take on this?

YAKOUBI: I just want to comment, because in the end, we're all essentially saying the same thing. I see it as a list of tasks that need to be completed—whether it's integration tests, qualification, validation, and so on. Moving from one level to the next requires tests. The idea behind using virtual environments is to reduce costs, speed up the process, and facilitate collaboration, especially in international organizations with teams spread across different locations. Virtual testing helps us, but it won't solve everything. It's not just about driving the car virtually. You also have the mechanical aspects, the signal side, and even the driver's reactions. For example, when you're driving and braking, the car will make certain movements that you don't think about in virtual simulations. We've encountered these issues, where the car keeps braking because the sensor is picking up something incorrectly, like thinking there's an obstacle when there isn't.

ERNST: Actually, we're already working on that. We have car models that simulate these types of scenarios.

YAKOUBI: Exactly. There are many tools we need to use to run all the tests, and while virtual testing is one of them, real-world driving and validation are still necessary. The question is, where's the balance? Is it 80% virtual and 20% real-world? 70% and 30%? Personally, I don't have an exact number because it depends on the system and the specific project.

ERNST: I think we can make a bold statement: you will never get such a complex product out without virtual validation. That's a fact. The question is how much you rely on it. But it's essential. Another important point is the use of statistics. We talked about the different scenarios you might encounter—not just fitting the car, but identifying the scenarios. You can also reduce the amount of real-world mileage you need to collect, and thus the money you spend, by using a hybrid approach. That means you take real-world scenarios, bring them into the virtual world, and then modify them. For example, you can take a real-world scenario and simulate it in different conditions—add rain, snow, another car, or remove a car that might be interfering in the scenario. This allows you to generate multiple scenarios from just one, which is a huge advantage. Even if the sensor model isn't always perfect, the benefits of this approach far outweigh the limitations, in my view.

NAGEL: Andreas, one more question I had in mind is: how can we bridge the gap between physical testing and virtual validation, and how can both enhance the efficiency of AD function development?

LAURINGER: That's a great question. When we talk about the average driver, it really becomes a statistical question. At another conference, we discussed the massive number of kilometers needed for validation—10 to the power of eight, which is quite a lot. In aviation, it's a standard, but when you look at the average car fleet in Germany and put those numbers in relation, it becomes clear that it's nearly impossible to drive that amount. If we relied purely on physical testing, we might only see full ADAS functions in 30 or 40 years. That's why credible simulation is so critical. For me, the ultimate proof that an autonomous system works is when someone like my mom—who isn't an early adopter or interested in the technology—can get into the car and trust it for her daily use. It's about creating trust, not just in the technology itself, but also in the simulations and validations we perform. We are all very technical people here, and we understand what's going on 'under the hood.' But we need to address two key groups: regulators and society. Regulators aren't in the 'machine room' with us—they work in their own domain. At Control, we try to bridge the gap between regulators and technology, and it's not always easy because they speak different languages. We often have challenging conversations about how to align the two worlds, especially with governments. Then there's society. People often ask, 'What about the rules?' and bring up specific cultural behaviors like the 'Boston left,' where drivers allow left turns even though the system might not recognize it. Autonomous systems will follow the rules strictly, but humans don't always act according to the letter of the law. This is a challenge: how do we balance regulatory compliance with human behavior, especially when it comes to aggressive driving, as we've seen in places like San Francisco? If an autonomous vehicle strictly follows the rules, it could become a roadblock rather than a help. We need to focus on three things: technology, adapting regulations to fit real-world driving habits, and building trust within society. Ultimately, the question becomes: how will society react to the first accidents involving autonomous vehicles? Because accidents will happen, and how regulations handle these situations is crucial to ensuring that the massive investments made in this technology aren't wasted. We also need to think about adoption rates. There's a regulatory push for safety features like AEB systems and pedestrian detection, but how many people actually use and activate Level 3 systems? Volume is what will drive down costs and improve safety. I really liked Waymo's recent statement that, statistically, their autonomous driver is now safer than a human driver. That's an important milestone. We have to bridge the gap between our highly technical world and the everyday users—the 'grandmothers,' so to speak. Elderly people, for example, would greatly benefit from autonomous shuttles, as it would allow them more mobility and reduce the environmental impact by optimizing resource use.

NAGEL: Maybe we can stay on the technical side for a bit, and Yannick, I think we should bring artificial intelligence into the equation.

TIEDEMANN: Yes, we can do that, but first, just a quick question for you, Reinhard. You mentioned digital twins, and you seemed to imply they're more like buzzwords for you right now. But do you think the digital twin concept can actually help bridge different aspects and reduce costs, especially in terms of combining physical and virtual testing?

ERNST: I didn't mean to downplay it. I just wanted to point out that there are multiple terms for the same thing. Whether you call it a digital twin or a virtual representation, simulating sensor sets and systems is a must—there's no doubt about that. We've discussed statistical effects and scenario-based testing, and these are absolutely necessary, from my point of view. However, this also needs to be proven, not just for the end driver, but for the developers themselves. The developers need to trust that the inputs they receive from a single sensor or a set of sensors are reliable because they're making decisions based on that data—decisions that impact longitudinal and lateral control. Software developers, in particular, need to trust these virtual environments, and they benefit greatly from having a virtual platform where they can test their functions early on. This shift to virtual testing, or 'shift left,' allows them to validate their software before the physical car is even built, ensuring that it behaves as expected.

TIEDEMANN: Alright, now let's talk about another digital tool that's having a huge impact on validation, and it's a big topic in our Automotive IT Salon: AI integration. Gilles, how does AI contribute to processing data and improving simulations? What's the big effect of AI integration in this field?

GALLEE: At Ansys, the way we leverage AI for our customers is by enabling much more extensive use of simulation. For example, some of our customers are using AI for aerodynamics optimization or mechanical design optimization. By integrating AI with physics-based simulations, we're able to perform significantly more design analysis and optimization in a shorter period of time. When we apply this concept to the virtual validation of autonomous driving, AI becomes a key technology that helps the industry meet the challenges it faces. Our approach is to use AI to enhance the usage of statistical simulations, which provides the necessary proof of safety for AI components embedded in the car. The goal is to achieve the required level of confidence that ensures safety. From a high-level perspective, that's how we approach it. AI is mainly integrated into perception and signal processing technologies, and it helps improve the overall validation process.

Gilles Gallee

TIEDEMANN: Ramzi, Magna is heavily involved in automotive engineering with AI. What do you think AI can contribute in terms of efficiency and accuracy to the development of autonomous driving functions?

YAKOUBI: At Magna, we are using AI in several areas, particularly in sensor sets, object detection, and other products. However, we are approaching it cautiously. You mentioned precision—AI can generate results quickly, but achieving 100% precision is still a significant challenge. AI requires a lot of data to learn and train models, and while the first 80% can be achieved relatively easily, optimizing the last 20% comes at a high cost. This is something we are carefully evaluating. I'm also not fully convinced that we should rely solely on AI. One of the issues we face is the non-deterministic nature of AI. For example, if you give the same input five times, you might get different results. This leads to questions about accountability in case of an accident—who is responsible? How do we analyze what happened if we don't fully understand the state of the machine at the time? That's why we've placed certain limitations on AI use in our products. However, beyond product development, we are exploring AI for generating requirements, test cases, and even code. We're making progress, but we're not at the point where everything is fully integrated. We're in discussions with partners, including you and other suppliers, to push forward with AI, but we're doing so cautiously.

TIEDEMANN: Reinhard, are you using prompt engineering to create synthetic simulation scenarios at ZF? Is that something you're already working with or considering?

ERNST: Prompt engineering, as I understand it, involves learning how to ask AI systems the right questions to get the solutions you need. We're not exactly doing that at ZF, but I want to comment on Ramzi's point. I both agree and disagree with some of what was said. I completely agree that AI systems as a product in a car aren't quite feasible yet. You can develop with AI methods, but once the system is in the car, it's not continuously learning. You need to find ways to secure it. I'm cautious about the learning aspect of AI, too. It's like having a bad teacher—if the AI is trained poorly, it will perform poorly. AI is often hyped, but in reality, it's based on massive datasets. You train a neural net to interpret inputs and generate patterns, but the danger is in training it too perfectly for one situation, leading to unexpected behavior in others. The system could do something entirely unpredictable in a different scenario. That's why it's crucial to be careful in training, and right now, the solution is to collect and use large amounts of data. That's why data collection is so vital at this stage.

TIEDEMANN: And in autonomous driving, you deal with a vast amount of data...

ERNST: Exactly, but you have to be careful. It's not just a matter of placing a camera or LIDAR somewhere, recording the data, and then feeding it into a neural net. No, that's not how it works. You need to synchronize the data with your system and ensure it's properly qualified. I'm totally on board with using AI systems for validation, especially when it comes to detecting defects, whether before or after they occur. The key is allowing the AI system to learn and continuously improve the qualification of the product. This is exactly what we're focused on. We're investing heavily in AI systems for validation, particularly in integrating real-world data with virtual data and processing it. For example, when it comes to environment model generation—if you did this manually with humans, you'd need thousands of people, and even then, you'd have to train them to ensure they all have the same understanding of the environment. That alone is a huge challenge. You get so many different perspectives and results from training humans. However, when we use neural nets—what we also refer to as AI—combined with a tracker algorithm, we achieve nearly the same results but at a fraction of the cost and 10 to 12 times faster. This is where AI really makes sense, particularly in virtual validation. That's why we're fully committed to going full speed ahead with AI in this area.

LAURINGER: Yeah, I found that factor of 12 very interesting. We recently achieved a factor of 15 in our work. I also agree with what you said about data—it's not just about the amount, but the quality of data is absolutely critical. At Magna, we deal with very different data than what we handle for regulations, where the sample size can be just one. AI is often more of a classification problem. For example, we tested 11 or 12 large language models to determine which

Andreas Lauringer / Dr. Reinhard Ernst / Prof. Dr. Joachim G. Taiber

gives the best results for specific tasks. Choosing the right model for the right data is a major challenge. Many people told me AI would make traditional companies obsolete, and I was skeptical at first. Now, we're starting to use AI to some degree, but it requires a lot of engineering know-how to reach the quality levels that Ramzi mentioned. It's not easy, and AI won't replace engineers. Instead, it's a tool that requires good toolchains and expertise. The real challenge is interpreting the data—choosing the right data, interpreting the results, and understanding them as an engineer. In the automotive industry, you can't afford to be 'close enough.' As Ramzi said, you need to hit the mark, not just be in the ballpark.

NAGEL: I'm sorry to interrupt, but we promised the audience the opportunity to ask some questions. Since we've already hit the 60-minute mark and still want to cover regulation for a few minutes, are there any questions from the audience?

QUESTION FROM THE AUDIENCE: Yes, I've been working with ADAS systems for the past 30 years across various sensor technologies. There have been multiple cycles of what works and what doesn't. I believe autonomous driving goes beyond just passenger cars—it also involves transportation, like short-range and long-range trucking. For instance, in many countries, there's a shortage of truck drivers, and the industry is asking for solutions like truck platooning, where one truck follows another autonomously. We also have autonomous driving applications in harbors, airports, and other controlled environments where it's less of a challenge because you're dealing with consistent, repetitive distances. But when we talk about autonomous driving in public, there are three main aspects: the technical side, the cost side, and the legal side. The legal side is where I have concerns, especially when it comes to decision-making in critical situations. For example, if you're driving and suddenly have a tree on the right, a woman with a stroller crossing the street in front of you, and an elderly person on the left, and you can't avoid the crash, what decision does the car make? This dilemma, to my knowledge, remains unsolved. I'd like to hear your thoughts on this, particularly in terms of legislation.

NAGEL: Thank you so much. That's an excellent segue into the next part of our discussion, focusing on regulation, standardization, and the legal aspects of autonomous driving. It's a great question to dive into. Maybe we can start with a comment on this from the panel.

LAURINGER: I'd like to thank you for the example because it highlights a useful ethical dilemma. Ramzi and Reinhard can probably relate to this challenge. When a human driver is in a critical situation, they're making decisions under stress, and regulation accounts for that—it acknowledges the human factor and exempts the driver from being a murderer in such cases. Whether you hit the tree or the woman, it's considered an emergency decision, made in a split second. With autonomous systems, we need to bridge this gap between technology and society because if we let technology take the blame for something it couldn't control, we risk holding it to an unfair standard. If, for example, autonomous vehicles save millions of lives but one incident causes a backlash that shuts down the technology, then we've failed in managing the broader societal implications. This is where proving grounds, like the ones Joachim and IAMTS are working on, play a vital role. We need to show how these systems work in controlled environments and involve authorities in the process, educating them on simulation, proving grounds, and the capabilities of the technology. By doing this, we can build trust and help policymakers understand how to navigate the risks without stifling the benefits of the technology.

TAIBER: I'd like to say a few words about regulation since our organization works closely with regulators. The ethical dilemma raised by the audience is an important consideration, and there are many papers discussing ethics in autonomous driving—specifically, how much regulators should implement these ethical standards into the regulations. However, before we dive into exceptional cases, we need to ensure that the regular scenarios, the day-to-day cases that the system has to manage, are functioning reliably. It's not useful to focus on exceptions until we know that the basic functionality is working properly. One issue I've noticed in regulation is that, as Andreas mentioned earlier, there's often a waiting game—where the industry waits for regulations to be established before acting. At the same time, there's a lack of collaboration. The problem is that many OEMs and suppliers are waiting for the regulations to tell them what to do, and only then do they start their development efforts. What's missing is active, technical contribution from the industry into the regulatory process itself. If regulations are vague or leave too many things unclear, you can't expect them to solve all the problems. What I'm saying is that active participation in shaping the regulations is crucial. Regulations often refer to standards, and those standards need to be of high quality. Without sufficient input from the industry in a collaborative way, we end up with long-term problems. We need more industry involvement in defining these regulations.

TIEDEMANN: Maybe we can bring our two industry partners into the discussion here. Do you see it the same way—that companies, especially in Europe, are waiting for regulations to be finalized before acting? Or are there a lot of patents and innovations already on the market, with companies pushing forward despite regulatory uncertainty?

ERNST: I see it more like how law works. You need to meet regulations; otherwise, you're not allowed to bring a product to market, and if you can't sell it, you don't make money. So yes, regulations are definitely important. As a human being, I'm also interested in addressing the ethical dilemmas, like the one we're all familiar with. But from my perspective, sorry to say, I'm more driven by requirements. If regulations set certain requirements that I need to meet, I will absolutely do that. A few years ago, my team and I were discussing some things, and I asked one of my engineers, 'Would you feel safe letting your family sit in the car we're currently testing?' He said no. I replied, 'Then you know what to do.' That's the role of regulations—they give us the framework to ensure that, at the end of the day, we deliver a safe car.

TIEDEMANN: I wanted to bring Ramzi into the conversation at this point. Magna is a very international company, operating in different markets with various players and at different speeds. What's your opinion on this regulation topic?

YAKOUBI: As you mentioned, at Magna, we have the advantage of playing the role of both an OEM and a Tier 1 supplier. As a Tier 1, we're always closely aligned with the roadmaps of OEMs, looking ahead to the next 10 years or so. Based on their direction, we build our requirements and products. We're also involved in various regulatory frameworks like Euro NCAP, US NCAP, and many other standards and requirements. Additionally, we try to anticipate what the market needs, what's missing, and how we can outperform competitors like A or B. However, despite this, there's still not enough collaboration. We're not as present as we should be in discussions and collaborations, especially in groups like IAMTS, and that needs to change.

TAIBER: To add to that, one issue with regulation is that it sometimes leaves too much room for interpretation. For example, the current EU regulation, 1426 for L4 autonomy, states that the OEM and authorities must agree on a test facility. However, it doesn't clearly specify what the test facility should do or what its capabilities need to be. We're working to help bring more clarity to the regulations, which would make the industry more efficient and help streamline type approval processes. Moreover, AI, which we talked about earlier, can be used not only in product innovation but also to improve and speed up processes, such as workflow tools and approval procedures. So, we need to focus on both the regulatory framework and how AI can accelerate these processes.

TIEDEMANN: I mean, the AI Act from the EU is similar to what you mentioned about L4, as there's a lot of room for interpretation—like what exactly constitutes an autonomous driving system or whether it's considered a high-risk system. This, too, leaves a lot open to interpretation.

LAURINGER: Exactly. The regulation Joachim mentioned reminded me of a funny incident with a lawyer and a technical service. The lawyer said, 'Yes, we have something to work with,' while the technical service responded, 'Oh no, how do we deal with this?' That reflects both of your points. Ramzi, you mentioned something very valuable—engineers want to fulfill the requirements, but what if those requirements are fuzzy? At Kontrol, we try to formalize regulations, turning them into a mathematical model. How do you simulate that? It's something we'll be showcasing next week with Ansys. But the more ambiguity in the regulation, the harder it becomes. You end up not only dealing with scenarios but also individual cases, like court rulings, which generate even more data. This can be a real hindrance. What Joachim said is crucial: the quality of regulations and standards needs to improve, and that requires collaboration. We need to make them repeatable. Credible simulation relies on the ability to replicate results. A safety engineer needs to prove consistently that they did the right thing because, in the end, that's what matters for product liability. We need to push for clearer, more concrete regulations. For example, regulations like R 156 are very specific, while others just say 'you need to do something,' leaving you wondering, 'What exactly is that something?'

TAIBER: One quick comment on regulation and innovation. In the U.S., at the federal level, there's definitely less regulation for autonomous driving than in Europe. But with less regulation comes more risk in innovation. It's always about maintaining a balance—allowing the industry enough room to innovate while protecting society from potential harm. Over-regulation can stifle innovation, so you need to find that balance and continuously reassess.

TIEDEMANN: But this is also a very sensitive issue because it's about safety, and at the end of the day, it's about saving lives. Autonomous driving isn't just an app on my smartphone; it's far more complex.

TAIBER: Every country wants to achieve zero accidents, but different markets have different approaches to get there.

LAURINGER: Exactly, and we need to learn from that. It's not about more regulation, but the right regulation. The right regulation enables engineers rather than hindering them. We have a tendency to over-regulate everything, and that's not the solution. What we need is a framework that allows engineers to apply virtual methods, provides guidance on how to do things right, and supports innovation. Just because you have 20 or, in some cases, 280 new cybersecurity acts doesn't mean you're solving the problem. Engineers are left wondering, 'How do I comply with all this?' For example, there are around 1.2 million regulations that a self-driving vehicle (SDV) has to meet. I wouldn't want to be the person who has to read all of that—it translates to about two or three terabytes of PDFs! That's where AI can help. But more regulation doesn't necessarily mean better regulation. Quality matters.

Gilles Gallee / Ramzi Yakoubi

ERNST: Exactly, and I liked your point—quality is key. You don't want to regulate every detail of the car's architecture. If you did that, you might as well develop the car yourself.

GALLEE: I'd like to comment on the differences between Europe and the U.S. when it comes to homologation and regulation. As industrial players—whether it's Ansys, Magna, or ZF—we're all addressing the technology behind this. The higher the level of autonomy, the more critical virtual validation becomes in delivering safe, high-performance systems on time and within budget. But, as Ryan mentioned, it's always a question of credibility—what's considered 'safe enough' or 'performance enough'? This is tied to methodology and approach. There's ongoing collaboration around new initiatives like VMAD (Virtual Methods for Autonomous Driving), which define how to use simulation and implement virtual testing. Of course, there's still a lot of missing information that would make the industry's job easier. But efforts like this are contributing to the creation of industry standards, and they help ensure that the products and simulation platforms we offer are supporting these upcoming standards, ultimately making engineers' lives easier.

TIEDEMANN: Alright, everyone, we can see that there's a lot to discuss here. The technology is complex, the engineering is complex, and the overall topic of autonomous driving is full of open questions. But thank you all very much for your interesting insights. Before we wrap up, I have one last question for each of you. Looking to the future, what do you think will be the central aspect that gives autonomous driving the boost we're all hoping for? Is it a question of technology, regulation, or could it be something political, economic, or societal?

TAIBER: In my view, it will come down to the shift from car ownership to using mobility as a service. Once we make that shift, I think autonomous driving will become extremely important, and I'm hopeful that this will happen.

ERNST: I agree. I think we already have all the technology we need—the toolbox is there. It's really about society accepting autonomous driving.

LAURINGER: Yes, I agree with Reinhard. It's about reliability and building trust. People need to start using it and gradually accept it. It might be a bit bumpy at first, like the brake example we talked about, but ultimately, it's about robustness and how well it collaborates with humans as we move from assistance to autonomy.

YAKOUBI: I totally agree. Society plays a big role here. Acceptance is crucial, and it's up to us to improve the quality and reliability of the technology. Once that happens, I believe acceptance will follow.

GALLEE: Yes, it's about the market and consumer acceptance. People need to see the value in the technology, whether it's through car-sharing or other mobility services. We need to figure out what that value is for consumers in the end.

NAGEL: Thank you very much! This has been an exciting and insightful panel discussion. I want to thank all of you — Gilles Gallee, Ramzi Yakoubi, Andreas Lauringer, Reinhard Ernst, and Joachim Taiber — for being here with us today.


Self-Driving