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**With the future programmed in:**
**Bosch is taking its software business forward.**

Dr. Stefan Hartung,

chairman of the board of management, Robert Bosch GmbH,

Dr. Markus Heyn,

member of the board of management,

at the Bosch Tech Day on June 18 and 19, 2024.

Check against delivery.

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Ladies and gentlemen,

The Library of Congress in Washington D.C. is one of the biggest libraries in the world. Its digital collection comprises well over 900 million files with a total size of some 21 petabytes. One petabyte is just over one million gigabytes. That number of files alone will keep you busy for quite a while. For example, by watching high-definition television non-stop for more than 13 years. Yet the traffic data we have now recorded at Bosch using our sensor technology take up somewhat more space than 21 petabytes – well over ten times more, in fact.

This doesn't only show how frequently we travel the world's roads together with our partners. It is also a symbol of how, at Bosch, the digital and physical worlds have merged and are mutually dependent. It is only with the help of these vast volumes of data, for example, that we can develop our solutions for tomorrow's mobility – hardware such as sensors and braking systems, and above all new and intelligent software for tomorrow's mobility.

Today, you will be able to see and experience some of these solutions for yourself on our proving ground here. I'm very glad that this has persuaded you to join us, and would like to extend a warm welcome to our Bosch Tech Day here in Renningen.

Especially in mobility, the speed of software development is extremely high. One might even be tempted to dig out the old "data highway" cliché – but this time in a new, almost literal, sense: on the roads of the future, after all, software will have a greater influence on traffic than any other technology. For Bosch, the fast-moving nature of this field is an advantage: after all, across all our business sectors, software is

already the decisive factor behind all our areas of future growth – whether the smart control of factories, smart home appliances, or our new growth area of medical technology.

Yet while software is nothing new for Bosch, our focus so far has mainly been on programs for products, such as software for airbag control units, for e-bikes, or for efficient heat pumps. But another area is now growing alongside this – our business with “standalone software” that can be developed and marketed independently of any product. For example, we offer software for a video function that allows vehicles to detect their surroundings better. The decisive thing here is that the software is hardware-agnostic, and can run on chips made by different manufacturers.

Demand for standalone software and for digital services will pick up rapidly over the next few years. By the end of the decade, we want our software to generate sales running into the billions.

And that’s not even counting the software embedded in our products. To illustrate how important this embedded software is, I’d like to take a brief look at our very first software product: Bosch Motronic. This was a control unit that controlled ignition and gasoline injection at the same time. It did so digitally, with a microcontroller and memory. Forty-five years ago, Motronic debuted in a production vehicle, the BMW 732i. With this, Bosch heralded the automotive software age. What began with very modest volumes for one vehicle model has now taken on a completely different dimension. Each year, we supply our customers worldwide with more than 250 million control units that we have coded.

Since the debut of Motronic, therefore, Bosch has developed from a purely hardware company to one of the biggest software providers in Europe, if not the world. In all, 48,000 people are currently working on software at Bosch – many of them in Germany, but also at our Indian subsidiary Bosch Global Software Technologies, which has grown by leaps and bounds over the past 25 years and now runs branch operations in Mexico and Vietnam.

All around the world, Bosch software can be found in countless production lines, car repair shops, and medical appliances. It alerts to the danger of wrong-way drivers and surveils landmarks such as the Elbphilharmonie concert hall and Neuschwanstein Castle, where it guards valuable cultural assets against fire and vandalism. It can be found in industrial technology, where we have developed the fastest-growing factory-automation ecosystem in the shape of the ctrlX Automation control platform. And in our Building Technologies division, our Nexospace software offers a digital service solution for efficient and sustainable building management. Indeed, until very recently, algorithms developed by us were even to be found in outer space, in software that analyzed noises on board the ISS and alerted to possible anomalies.

So as you can see, “Invented for life” applies to our software as well. And unlike purely software companies, we are even in a position to integrate lines of code directly into products – into people’s lives, if you like. At all times, the basis for our “Invented for life” ethos has been our strengths in the precise and reliable manufacture of complex physical objects. We want to continue to dynamically build on these strengths, as well as on our profound domain knowledge in mobility, manufacturing, and building technology. It is precisely these strengths

that are now making us increasingly attractive for partners who have traditionally played a leading role in the world of software.

As it is, barely any company will be able to exploit the huge potential of software and AI on its own. Instead, what is needed is alliances between equal partners. In this context, open source software offers an especially useful way of pooling expertise across company boundaries, of saving costs, and of creating standardized solutions. In AI for its part, which is becoming increasingly important for software development, we now need planning certainty. The *AI Act* passed by the EU must now be rapidly translated into standards, so that expensive and complex case-by-case assessments can be avoided. Regulation is necessary. But it must not unnecessarily throttle the pace of technology or even prevent innovation.

Especially in the area of mobility, this pace is increasingly picking up. The triumphant march of software will revolutionize the automotive industry more fundamentally than any new type of powertrain. Justifiably, more and more customers expect their vehicle to synchronize smoothly with their digital world. This also includes its updatability. In the future, it will not just be the case that the software in cars, trucks, motorbikes, and e-bikes will be state of the art when they are made. Instead, it will keep pace with developments. With software under the hood, cars will become out of date more slowly. It will then be possible to integrate improved convenience features and new safety functions over the air, without any fuss – just like in a smartphone. Bosch technology will make software updates possible for e-bikes, motorbikes, cars, and trucks. Since the debut of our smart system for e-bikes at the end of 2021 alone, we have used software updates to roll out roughly 70 new features and modifications via the

*eBike Flow* app – from an alarm and tracking function to new riding modes.

However, the growing demands made of software-defined mobility are pushing conventional vehicle architectures to their limits. This is why Bosch is now developing a centralized, cross-domain IT and electronics architecture featuring a high-performance software stack and powerful vehicle computers and sensors. Our advantage here is that we know our way around hardware AND software – and are thus one of the few companies that are fully proficient in the interplay of automotive electronics and the cloud.

McKinsey estimates that the global market for automotive software and electronics may reach 462 billion dollars by 2030. That is the equivalent of 5.5 percent average annual growth from 2019 – and thus significantly more than the growth of automotive production. We want to be the number-one choice for automakers worldwide in this area as well. On top of that, there is hardware. Without it, the new software world will not be practicable. This is an area where we are already successful. With our modern vehicle computers alone, we have generated sales of just under 4 billion euros over the past three years.

Ladies and gentlemen, software is not just an add-on for Bosch, but one of the mainstays of our success. Software determines our processes, our manufacturing operations, and the way we think. For a long time now, software has been just as much a part of our everyday work as the five red letters at our factory gates. Together with AI, it is the foundation for future innovation. And in all our business sectors, it will become increasingly important for value creation. But it is especially in mobility that we have a very clear goal: Just as there is

barely any car today that does not feature a Bosch part, in the future there won't be any cars on the road that do not feature Bosch software.

To explain to you how we are shaping the future of mobility in the process, I'd now like to hand over to my colleague Markus Heyn. Thank you!

**A new chapter in automaking history: Markus Heyn on the age of the software-defined vehicle**

Ladies and gentlemen,

A warm welcome to Renningen from me as well. On your way here, it's likely that some of you already spent a few minutes in one of the traffic jams around Stuttgart this morning. Ten meters forward – brake – stop – jolt. Then another ten meters, and again: brake, stop, jolt. This could soon be a thing of the past. Not the traffic jams, unfortunately. But the constant jolts every time you brake. This is because Bosch has developed software – which we'll be demonstrating to you later – that lets vehicles brake very softly, without any jolts.

Now you might say that soft braking like this is nothing more than a fun gimmick in the car of the future. But have you ever actually tried to bring your vehicle to a halt completely smoothly, without any jolts, like a real chauffeur? It really isn't that easy, even if you concentrate hard! And apart from that, you might like to ask your passengers, and your children on the rear seat, what they think. Anyone who is reading something on their cellphone, or who is prone to travel sickness, will be

very grateful for ultra-smooth braking. We can ensure jolt-free stop-and-go driving with software that brakes as smoothly as a professional chauffeur. Not only does this solution make for an especially smooth ride, it is also part of a new chapter in the history of automaking. We are standing at the dawn of the age of the software-defined vehicle.

As Stefan has already made clear, Bosch is just as much a software company as a hardware one. This is especially true of our mobility sector, where 42,000 people worldwide are working to develop software for current and future vehicles. That's more than in any other company in the automotive industry. And with that, we are already part of the change in our industry. Increasingly, the starting point for designing and developing new vehicle models is software.

That said, the software-defined vehicle, or SDV, won't appear overnight, and there are very few fully software-defined vehicles on our roads right now. The ones that are come almost exclusively from completely new players in the market. As fully software-defined vehicles gradually become more common, the share of software in vehicles will triple. In some cases, one single car may currently feature more than one hundred control units, made by different manufacturers. Even now, orchestrating this cacophony is a very demanding task. And updating it while preserving the necessary safety and reliability is a headache. But for an SDV to be updatable, its electrical and electronic architecture must not be too complex. So what we need is a high-performance software stack and ever fewer, but more powerful, vehicle computers.

In an SDV, therefore, we have to merge many of the functions that have so far been domain-specific: together with Qualcomm, we have already debuted a system-on-chip that can simultaneously process infotainment and driver assistance functions – and were the first supplier to do so. In the future, other domains could be integrated on one chip. In this way, the number of control units could be reduced to less than ten by 2030. The result would be installation that takes up less space, fewer cables, and less weight. In short, costs would be lower and flexibility higher. Merging driver assistance and infotainment control units alone can reduce costs by as much as 30 percent. Depending on the vehicle class, this can mean a saving of more than 100 euros in some cases – and this in just one component. This will also make automated driving functions more affordable, and thus attractive for price-conscious vehicle segments.

So as you can see, the *software defined vehicle* will also mean more changes in hardware requirements than the name may suggest. For its part, the required software will be developed in close collaboration between OEMs and suppliers. One challenge here is connecting the many software packages in the vehicle, which have to communicate with each other across brand boundaries. The Bosch subsidiary ETAS provides the middleware for this. If you like, this is the translation software between the vehicle's physical components and its application software, even if they are made by different suppliers.

But above all, what is new here is that individual software functions can now be marketed as licensed products, independently of hardware. One good example of this is our Vehicle Motion Management. And that brings us back to jolts when braking. Vehicle Motion Management, or VMM for short, is a comprehensive systems solution that makes the

driving experience safer, smoother, more efficient, and also a bit more unusual. Both the suspension and the powertrain, braking, and steering systems are managed optimally and in concert by the software. This allows handling characteristics, such as acceleration and braking behavior, to be individually determined – all the way to a jolt-free halt. I warmly recommend you to see for yourself later on how this improves smoothness, safety, and vehicle dynamics.

Vehicle Motion Management is also evidence of the success of the Mobility business sector and its new organization. I'm sure you have already heard that we have completely reorganized this sector, especially with respect to three future cross-domain areas of mobility: software, semiconductors, and vehicle computers. Our top priority here is the best possible market and customer focus. Our response to geopolitical developments is to significantly step up our international collaboration. To achieve this, we have been working even more intensively across divisional, regional, and functional boundaries since the beginning of the year. Without this new structure, it is unlikely that Vehicle Motion Management could have debuted so quickly. And our customers also appreciate this new speed: for VMM alone, we expect sales running into the hundreds of millions by 2030. Standalone software will account for a significantly greater share of the future sales revenue than classic embedded software.

With our mobility solutions as a whole, we want our newly restructured business to achieve global sales of more than 80 billion euros by 2029. And of course, we also want automated driving solutions to play a part in this. In this context, the SDV is essential for future developments. For privately owned vehicles, Bosch is focusing on gradually taking driver assistance forward. Right now, we are the only established

Tier 1 supplier developing driver assistance software for Levels 2+ and beyond. For the various levels, Bosch can supply the crucial products: sensors, cameras, and radar, as well as the vehicle computers, software, and services to go with them.

Especially in automated driving, advances in AI are opening up completely new possibilities. This is because generative AI will be capable of describing the visual world more precisely and translating it into code. In this way, vehicles will be able to deal much better with complex situations. So if, say, a ball suddenly rolls onto the road ahead, cars will soon no longer register the mere object, but also anticipate the child that may come running after it. Widening context in this way allows the system to react significantly faster and more appropriately in comparable situations.

Such a scenario is made possible by combining what are known as *foundation models* with our profound knowledge of vehicle systems. With our huge volumes of traffic data, we can train the AI. And because you can never have enough material for this purpose, we are working to collect even more traffic data with various automakers the world over – also with the VW software subsidiary Cariad. In the future as well, therefore, our store of data will likely be bigger than the Library of Congress's – a kind of digital library for the mobility of the future.

And now we're looking forward to your questions. Following them, you will be able to try out in practice a lot of the things we have only talked about here. And that includes soft braking. I wish you all a fascinating – and jolt-free – afternoon.

Thank you!