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Beneficial AI – building trust together in the digital world

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Check against delivery.

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2001: A Space Odyssey.
The Terminator.
The Matrix.
Ex Machina.
It sounds like we're sharing a list of our favorite movies. But actually, all these movies have something in common.

They all depict a future in which machines have learned to think for themselves – with disastrous consequences for humanity. Whether the machines manipulate, enslave, or replace us, the message in the movies is the same: by developing artificial intelligence, we're opening Pandora's box.

I like science fiction as much as anyone, and portraying AI as the villain has kept audiences entertained for decades. But the time has come to talk about the technology's true potential – the potential to provide real value, for real people. "How can we make artificial intelligence beneficial? How can it be used to complement human intelligence?" These are some of the big questions at CES this year. So what's our answer?

Artificial intelligence is not science fiction anymore – it's already an integral part of our daily lives. It's fundamentally changing how we drive, how we work, how we learn, how we shop, how we travel. At Bosch, it's also becoming part of the products we make – products that will assist and support us, and make life easier overall. Whether it's being used in manufacturing, in smart homes, or in self-driving cars, one thing is for sure – in line with our "Invented for life" ethos, we want to make AI safe, robust, and explainable.

Where the world of work is concerned, we're not just facing a technological shift, we're also facing a critical shortage of skilled workers. So it's also against this backdrop that it will be essential for

humans and machines to work together. At Bosch, we believe this is self-evident. And with this in mind, we're trying to shape the digital transformation by educating and upskilling our workforce, and investing in our associates as well as in the intelligence of our products and machines.

As a society, we must learn to accept a technology that is capable of learning itself. One way to do this is to invest more in our own learning – and that's exactly what we're doing.

Over the next two years, we will be introducing wide-ranging training programs aimed at making nearly 20,000 of our associates AI-savvy. I'll tell you more about that later.

But the societal benefits of AI go far beyond our daily lives and work. It also holds tremendous potential to benefit our planet and its climate. We intend to use this potential to realize our goal to maintain a balance between our economic, ecological, and social responsibilities.

At the end of 2019, we achieved carbon neutrality for all our locations in Germany. By the end of this year, all 400 Bosch locations worldwide will be completely carbon neutral. When this happens, we will be the first major industrial enterprise to have achieved this ambitious goal, all within a little over a year.

And to do this, we will be making use of our own solutions as well: our energy platform, for example, already uses intelligent algorithms to monitor consumption in manufacturing. It quickly identifies deviations in individual machines' energy use and offsets load peaks. This alone has reduced CO_2 emissions at individual plants by more than ten percent over the last two years. For a company that has 270 manufacturing sites, that's some significant savings potential! Our success here has prompted us to market the energy platform

externally. And it won't end there: AI means we'll be able to forecast and reduce energy consumption over the long term as well.

AI is creating markets, but digital trust is indispensable

This example underlines that artificial intelligence also offers considerable business potential. A number of different studies support this notion. For example, AI is expected to boost GDP substantially in major economies across the globe by the end of this decade – PWC estimates a 15 percent boost in North America alone. At the same time, global AI software revenue is projected to reach nearly 120 billion dollars by 2025, a twelve-fold increase compared to 2018. And the World Economic Forum predicts that global job losses as a result of AI will actually be offset by the creation of new ones, resulting in a net gain of nearly 60 million new jobs by 2022. As mentioned earlier, these jobs will require significantly new competency profiles, which will necessitate a strong push to reskill and upskill people.

It's indisputable that the impact of artificial intelligence will be huge. However, we must make the benefits of AI comprehensible for people, and even more importantly, establish trust in the digital world. Our CES slogan captures our approach here nicely: "Beneficial AI – building trust together." In this endeavor, Bosch is pursuing a two-pronged approach.

On the one hand, we're doing the technical groundwork, developing solutions, and using our innovations to open up new areas of business. On the other hand, we will use AI to realize our strategic imperative of creating technology that is "Invented for life," and in doing so, convince society of the benefits of AI.

Remember, it was our engineers that developed lifesaving inventions such as electronic stability control, airbag control units, and anti-lock

braking systems for vehicles ranging from passenger cars to motorcycles to e-bikes. This is what we mean by technology “Invented for life” – and our work with AI is no exception. By putting it to use in automated vehicles, for example, it too will be a technology that saves lives, as we will explain in more detail later on.

Trust, responsibility, and ethics in AI

We take entrepreneurial responsibility seriously, and it defines our approach to new technologies like artificial intelligence.

The decisive factor for responsibility in the digital world is trust. This trust will be just as important for our digital business as product quality is for our traditional business. We have to work on developing both AI and trust in AI – without the latter, the former will not be successful in the long run. But how can we establish this trust? By creating AI that is transparent, safe, secure, and robust.

When it comes to building trust, another key aspect is data security and data privacy – especially where personal data is concerned. At Bosch, our approach is simple: when it comes to all our smart products and services, users have full transparency and control over the data collected and who gets to use it.

Moreover, in order to build trust among our customers and partners, as early as 2015 we established guiding principles for data protection in our IoT business. This was several years before the GDPR regulatory framework was introduced as European standard. We’re now working on a similar set of principles for our future use of artificial intelligence: an AI code which sets out ethical guidelines for the development and usage of AI, especially in cases of doubt and dilemma.

Going forward, it will be essential that people remain in control of systems that use AI. Take the example of driver assistance: here, we want to integrate AI in such a way that it can always be overridden by the driver. We don't want to lock the algorithms from our AI models in a little black box. The rules and parameters behind decisions must remain comprehensible, at the very least for specialists.
That said, Bosch and the big tech players differ in our approaches to AI in one fundamentally important way: our focus is on the application of AI for physical objects. Whether it's deployed in an automotive emergency braking system or in factory production, our AI explains the physical world to machines. Our latest camera for automated driving uses AI to understand what it sees – to infer, say, whether a pedestrian is going to step out into the road or not. This will improve object recognition and make automatic emergency braking more reliable, thereby increasing safety.

At Bosch, we want to harness the power of artificial intelligence to improve technology and the performance of our products and machines. We call this industrial AI, and we're using it to develop smart solutions in three key domains: mobility, residential, and manufacturing.

It's no coincidence that we emphasize the "things" when talking about IoT. We're bringing connectivity and intelligence to our own products and machines. We know cars and traffic, factories and buildings, inside and out – no other tech company can match the breadth and depth of our cross-domain expertise.

Our own sensors provide us with a massive amount of data. And if we apply AI methods to that data, we can create new services and applications. By the middle of this decade at the latest, each and every one of our products will either have artificial intelligence itself, or have been developed or manufactured with its help. Ultimately, we plan to

teach our products to function as assistants – for our customers, and for our own developers.

Investing in AI research and development

To achieve this, we want to become one of the global leaders in AI innovation as well. Our research and development activities are all geared toward this goal. Bosch currently invests more than 4 billion dollars annually in software development, and employs around 30,000 software engineers. Established in 2017, the Bosch Center for Artificial Intelligence is already working on more than 150 projects. It employs some 250 AI specialists at seven locations around the globe including two here in the U.S. – in Pittsburgh, Pennsylvania, and Sunnyvale, California. Our U.S. research teams play a key role in our AI development activities, above all in robotics and automated driving.

But we're not working in a vacuum here. Especially where AI is concerned, a technology company like Bosch sees itself as part of the larger scientific community. In Germany, for example, we're a founding member of the "Cyber Valley" initiative – an AI research alliance between academia and industry. Among other things, as part of this we're investing more than 110 million dollars in an AI campus, which from late 2022 will be home to 700 AI experts from Bosch as well as from external startups and research groups.

Here in the U.S., we're collaborating closely with Carnegie Mellon University on AI research. Carnegie Mellon has been working on artificial intelligence for 60 years, since the technology's earliest days. They have been responsible for pioneering innovations in areas like self-driving cars, facial recognition, and language processing.

As we see it, industry and academia each have an essential contribution to make. And we highly value the transfer of knowledge between our developers on both sides of the Atlantic.

SoundSee hears what's broken in space – with AI from Bosch

A great example of an exciting collaboration with one of our U.S. partners is currently deployed about 240 miles above the Earth's surface.

It's an innovative AI-based sensor system called SoundSee. This little device will be playing quite a big role in outer space. The SoundSee technology will be used to perform deep audio analytics on the ISS. Using highly-sensitive microphones, it will capture ambient noise emitted from the station's systems and equipment, and then use AI to spot potential anomalies from the audio patterns. Basically, SoundSee will hear if something on the station is broken – and can tell whether it needs to be repaired or replaced.

We developed this system together with the aerospace company Astrobotic Technology Inc. In November, it was sent into orbit and will be integrated into the Astrobee robot shortly. Of course, the new sensor system will also be very useful down here on earth. In manufacturing, for example, it can improve predictions about machine downtimes, thus helping to reduce maintenance costs and increase productivity. But on board the ISS, this technology could even be lifesaving.

Virtual visor – a U.S. idea is a "Best of Innovation" award winner

We're showcasing another example of the ingenuity of our American workforce here at CES – and this world premiere also underlines their lateral thinking. Some of our engineers came up with a digital solution

for a common and often dangerous hazard that drivers frequently face. It's an innovation that replaces a nearly 100-year-old automotive product: the sun visor.

According to a study by NHTSA, sun glare causes nearly twice as many accidents as any other type of weather-related condition. But we now have a solution: our "virtual visor." At first glance, it looks like a see-through LCD display mounted at eye level. The special thing about it, though, is that it's connected with a driver-facing camera equipped with AI facial detection and analysis. Its software calculates both the driver's line of sight and the angle of the sun in order to strategically darken individual sections of the display. Everything else remains transparent.

We think the Virtual Visor is another great example of technology "Invented for life," and the CTA apparently thought so too. The product was honored with a prestigious CES 2020 Best of Innovation Award – you can test it out for yourself at our booth.

3D vehicle display – our second Best of Innovation Award

Our new 3D vehicle display also won a CES Best of Innovation Award – and I've been told it's no small feat to win two of those.

Vehicle displays in general offer huge business potential – after all, the global market volume is set to more than double by 2025, to 30 billion dollars. Our award-winning display uses a multi-view 3D technology which is especially affordable, since it works without the need for eye tracking and 3D glasses.

To describe how it works, let's go back to the movies for a moment. We've all seen 3D films, where the technology makes our experience more vivid and entertaining. Inside a vehicle, 3D performs a similar but

more useful function: it helps people understand information more quickly. The display's depth of field means drivers can grasp important visual information faster, whether it's an alert from an assistance system or a hazard warning. Alerts seem to jump out of the display and are much more obvious and urgent, as well as far harder to overlook. I don't know about you, Michael, but anything that tells me what I really need to be paying attention to is a win in my book.

Interior monitoring – technology that can help keep children safe

Think of the dangers posed by fatigue and distraction – the longer we're behind the wheel and the more technology is present in the cockpit, the greater they are. Here, our driver monitoring system uses artificial intelligence to identify these distractions through cameras which recognize the driver's line of sight, head position, and blink rate. When it determines a critical point has been reached, it reacts by sounding an alarm or providing driving assistance, depending on the automaker's wishes, and also legal requirements. In the EU, this kind of system is set to be standard in new vehicles from 2022. This technology will also play an important role in automated driving. After all, the next few development stages will still require drivers to remain alert and ready to take over in critical or tricky situations. To ensure drivers are able to do this, the monitoring system calculates how ready they are to respond at any given time, and the transfer of driving responsibility is then timed accordingly.

Depending on the design, some systems can also monitor the car's other occupants and enhance their safety, for example by detecting changes in passengers' sitting positions and adjusting their airbags and seatbelt tensioners for optimal crash protection. Or by identifying the presence of children inside parked cars. In 2018, parked cars claimed the lives of more than 50 children in the United States, either because they had been left inside for longer than intended or had

climbed in unnoticed. Bosch's new system can recognize the presence of children and warn parents in a flash by sending a message to their smartphone. In a critical situation, it can also alert the emergency services. As the Hot Cars Act currently being debated in Congress shows, there is considerable interest in solutions to prevent these tragedies. Once again, our technology doesn't just make life better, it can help to save lives. Looking ahead, we plan to extend our interior monitoring systems to encompass in-vehicle sensing and deploy this in ridesharing fleets. In-vehicle sensing will allow us to detect when a passenger leaves something behind in a shared car, for example, or if they need help in a critical situation.

For us, offering real benefits is what it's all about. Nearly all our driver assistance systems enhance both safety and convenience. We are one of the automotive industry's leading suppliers in this field. In 2019, our sales rose by 12 percent to some 2.3 billion dollars. From a technical point of view, we're using driver assistance as a stepping stone to automated driving. By 2022, we will have invested some 4.7 billion dollars in developing this technology and increased our workforce of dedicated engineers to 5,000. To this end, we're working on making lidar sensors production-ready. Alongside our new video camera with AI and radar and ultrasonic sensors, Bosch will soon offer the complete sensor portfolio needed for automated driving. Few automotive suppliers worldwide have as much expertise in this area as Bosch.

Our lidar will be the first of its kind that is suitable for use in automotive applications, since it's scalable and can be manufactured in large volumes. It's also the first lidar technology to be suitable for automated driving functions at SAE levels 3-5, offering long-range sensing capabilities in combination with a wide field of view and an exceptionally high resolution. Working together, our multiple sensor types will help to ensure extremely reliable environment recognition. To

surmount the many challenges on the road to fully-automated driving, Bosch is bringing together its profound expertise in sensors and systems and that's the type of expertise that only an automotive company can have.

We're already testing automated driving in a range of environments, including one that is widely regarded as the final frontier: city streets. I'm happy to report that our pilot project with Mercedes-Benz for an on-demand ride-hailing service with automated vehicles is now up and running. Automated S-Class vehicles are now providing an app-based shuttle service in California between West San José and downtown for selected users. Ultimately, the aim of this project is to gain valuable insights for the development of automated driving, and to answer the question of how self-driving cars can best be integrated into a multimodal mobility system. Our development work on this project encompasses both the use of AI as well as simulations and tests designed to address the kind of driving situations that occur very rarely in road traffic.

We're not just using our mobility solutions to teach cars how to drive. We're also using them to make electric and connected driving a reality. This is enabling us to open up new areas of business and forge partnerships with new customers. For example, we're developing a hydrogen powertrain for the heavy-duty trucks made by U.S. startup Nikola Motor Company. We're also suppling our solutions to mobility service providers such as DiDi and Lyft. For DiDi, we'll soon be providing a cloud service that helps to extend the service life of car batteries. When it comes to urban mobility for the future, you can experience our vision in an IoT concept shuttle at our booth. This year we're showcasing what we offer mobility service providers to help them operate safe and efficient automated ridesharing and ride-hailing businesses.

Bosch MEMS technology – for smart glasses without the sci-fi look

Beyond this, we're also using our expertise in everything related to mobility as the basis for innovation in other domains. The best example of this is sensors based on micromechanical systems – called MEMS for short. We're the market leader for these sensors, which are used for automotive applications as well as smartphones. Our latest development in this area is being showcased here at CES: our light drive system for smart glasses. The smallest of its kind, it's nearly a third slimmer than existing ones on the market and can be integrated into nearly any type of frame, becoming part of your everyday glasses. It uses a MEMS-based laser scanner and holographic mirror to project an image on the wearer's retina. This image can contain any kind of text message – for example from the navigation system or your personal calendar. And you, in turn, can be kept constantly up to date – without looking like you're on the way to a Star Trek convention every time you put them on.

Another domain where AI has the potential to deliver enormous benefits is healthcare. Here, our Indian engineers have developed a cutting-edge innovation called Vivascope, which is a CES® innovation award honoree. In a nutshell, it's a smart pathology platform for medical diagnostics powered with advanced machine learning algorithms. With the help of AI, it analyzes human cells' form, shape, and structure for deviations, thus providing physicians with information on possible diseases. And it does so in minutes, which dramatically shortens the testing process. Helping people diagnose health issues quicker and more accurately – this is also what we mean by technology "Invented for life."

AIoT to benefit everyone – training for tomorrow's work

As we see it, the IoT and AI should benefit everyone. To do this, they must be more than technological gimmicks and actually make people's daily life and work easier. This is true for all our domains: connected mobility, connected homes, and also connected industry. Especially in the world of manufacturing, artificial intelligence can supplement human creativity, and more crucially, relieve workers of routine tasks.

On every new path we tread, we take our workforce with us. On our way to creating the factories of the future, we want to prepare our associates for the work they'll be doing in the future. This brings us full circle to our AI training program, which I mentioned earlier. It consists of three parts:

First, we're training roughly 16,000 executives on the business aspects of AI. Our digital transformation is enabling us to master a balancing act: on the one hand, remaining an industrial enterprise, and on the other, becoming a leading IoT and AI provider. For this, our leadership will have to be capable of making the right decisions, which is why we're building up their AI expertise.

Second, we're expanding our AI learning platform. This platform is similar to an online university, but uses examples and exercises from real-life operations at Bosch. More than 1,500 of our engineers are already using the platform, a number that will likely double by next year. Some of its notable features are the exchange of experience our AI learning platform facilitates, as well as the use of best-practice examples and competitions.

Third, we're training nearly 500 experienced engineers in AI development methodology. This is the highest level of our training

program, what is effectively a supplemental course of study in things like data engineering and data analysis. We're not just increasing the number of AI engineers by hiring dedicated specialists; we're also doing it by reskilling our existing people.

All told, this will get 20,000 of our associates up to speed on the technology. As we see it, it's not only part of our corporate responsibility to offer this kind of training, it's also in our strategic interest.

Conclusion

Ladies and gentlemen, it's clear that developing artificial intelligence will require us to focus on more than just technological innovation. On one hand, we need to invest heavily in human intelligence, and on the other, we need to convince people of the true potential of this technology. "Beneficial AI: building trust together" – it's more than just a nice catchphrase we're using here at CES. We truly believe that AI holds the key to making our lives safer, easier, and more eco-friendly. Please come visit our booth in the Central Hall to see some examples of this in action. And together, let's work to dispel any doubts and usher in a new era of real-life science fiction, where AI is the hero.