BMW
Corporate Communications

Press release
17 April 2018

BMW Group Digital Day 2018.

1. BMW Group Digital Day 2018.
Introduction.

Digitalisation is the dominant element in the radical transformation of personal mobility. It paves the way to a new mobility experience, expands the possibilities for enhancing safety and comfort out on the road, and opens up new opportunities for efficient yet customer-focused development and manufacture of vehicles. The BMW Group is systematically forging ahead with digitalisation across all areas. Thanks to its capacity for innovation, not only does it develop cars and motorcycles for the premium segment that stir the emotions, it also devises customer-centric services that optimise the mobility experience as a whole. As part of the Digital Day 2018, the BMW Group is offering an insight into current product developments, technological concepts, innovations and manufacturing processes that will enable it to shape the future of mobility.

Today, the BMW Group is already blazing a trail for intelligent vehicle connectivity and the integration of digital mobility services. It is exploiting the potential of digitalisation to further strengthen its status as the leading provider of personal mobility at premium level. The BMW Group has defined the key areas that will form the stepping stones to digitalised and emission-free mobility in the future with its corporate strategy NUMBER ONE > NEXT. In the process, it is driving forward the ACES themes (Autonomous, Connected, Electrified and Services) with particular vigour through considerable investment in research and development. The innovations and initiatives presented at the Digital Day 2018 exemplify the company's transformation into a mobility tech company.

2. The mobile network is turning into a high-speed information highway:
The BMW Group leads the way in the integration of 5G technology.

The forthcoming fifth-generation mobile network will be more powerful than ever. Compared to the present 4G standard, data transfer rates will increase many times over while latency will drop to one millisecond. This new quality of connectivity is underpinned by a new, exceptionally close-knit infrastructure of radio masts, new transfer protocols with high spectral efficiency, and a widely

spread and powerful cloud infrastructure. Once it becomes commercially available (est. 2019), 5G will therefore be capable of handling the growing volume of data involved in the mobile use of digital services. In its capacity as a new function enabler, 5G represents a vast improvement on what is technically possible today. The BMW Group is developing technologies and systems that harness this potential now, so that it can start to offer 5G-based functions in production vehicles as early as 2020.

5G technology opens up new possibilities for vehicle connectivity. The data rates it achieves will take the quality of in-car online entertainment to a whole new level, while connectivity between vehicles and with transport infrastructure can also be stepped up in this way. Last but not least, sharing the volume of data required for autonomous driving is only possible with the necessary speed and reliability using the new 5G high-speed information highway.

The BMW Group was quick to recognise the potential of the 5G standard and assumed a leading role in the development of technologies that fully capitalise on the advantages of extremely high data rates, service-specific QoS management and new possibilities for vehicle connectivity. At Digital Day 2018, the BMW Group is showcasing some of the possibilities offered by a particularly innovative feature of 5G mobile networks known as network slicing. This involves making parts of the network infrastructure available on demand in a way that suits specific applications and their respective requirements. An interactive demonstration at the event allows visitors to experience the resulting benefits. This technology was developed together with network supplier Nokia, which is playing a prominent role in the advancement of 5G. The customer has access to a virtual network made up of individual slices, each of which have specific properties in terms of the guaranteed data rate, latency and reliability.

In the demonstration, one slice is used for updating HD maps and guarantees a defined data rate over longer periods of time for this purpose. A second slice with high availability and low latency is geared towards the sharing of time-sensitive data between vehicles, otherwise known as vehicle-to-vehicle communication. And the third slice is optimised – thanks to the best possible data quality – for streaming videos in HD quality, which can then be played on mobile devices connected to the vehicle's WiFi hotspot or on the Control Display

when the car is stationary. By utilising network slicing technology, the BMW Group also ensures that the exchange of critical data for safety, for example, always has top priority.

The technologies for processing the large volumes of data needed for autonomous driving are also set to benefit from the 5G mobile standard. One of the key elements here is the combination of cellular communication and network-based direct communication between vehicles. Today, connected vehicles already receive live information – e.g. on filling stations, charging stations and car parks – as well as hazard warnings sent out in real time via BMW ConnectedDrive. The BMW Group is at the forefront of the drive to provide safety-related information, such as warnings of accidents, fog or heavy rain, by means of backend-based mobile technology. Additional connectivity and information services will be offered from mid-2019. As part of its commitment to drive forward the development of connected and cooperative automated driving, the BMW Group is also working on the implementation of wireless C-V2X (Cellular Vehicle-to-Everything) technology for two-way communication between road users. This will produce unique benefits for the development of the 5G ecosystem at an early stage.

3. Artificial intelligence makes driving safer: Die BMW Group is developing adaptive systems for mobility in tomorrow's world.

The collation, evaluation and usage of vast quantities of data is playing an increasingly important role when it comes to enhancing safety and comfort out on the road. The quality of the systems behind this progress depends not just on the quantity of data processed, but primarily on the ability to evaluate the amassed information and factor it into making decisions on an appropriate course of action for the vehicle. A vital cog in the system here are algorithms – computational models that provide the basis for determining how a vehicle reacts to the incoming information – and artificial intelligence is of instrumental importance in their development. The BMW Group is leading the way in the technological transition to digitalised mobility, and also boasts outstanding development expertise in the field of artificial intelligence.

The BMW Group is harnessing artificial intelligence in the development of systems for automated driving. Initially, these systems will be refined to the point where the vehicles equipped with them can safely cope with even the most complex driving situations in urban areas. The development goal for the longer term is fully autonomous driving, when all of a vehicle's occupants can ride as passengers without any driving tasks to fulfil. In a self-driving car, artificial intelligence is the key to safe and comfortable mobility for all.

Artificial intelligence helps with organising and evaluating the data gathered. The information registered by cameras, radar, lidar and ultrasonic sensors is classified in terms of its importance in a data centre. This "labelled" data then feeds into computational models that serve to analyse the current traffic situation accurately and predict the actions of other road users. Where exactly is the other vehicle? In what direction is it moving? Is a cyclist coming too close to the car? Will the pedestrian cross the road or stay on the pavement? Questions such as these can be answered quickly and correctly thanks to the algorithms created using AI.

In an evaluation process, the algorithms are applied to more and more new datasets, resulting in a learning process that constantly optimises the quality of the algorithms. This enables the BMW Group to implement the best computational models for its vehicle systems at all times.

One of the benefits of AI-equipped systems is their limitless capacity for work. Unlike humans, an intelligent system delivers constant performance. It doesn't get tired or distracted and is able to concentrate fully even in confusing situations. The BMW Group therefore employs artificial intelligence in the development of systems designed to help drivers enjoy their personal mobility even more safely.

4. Faster results, less work, more complete impressions:
Mixed reality speeds up and streamlines the development process.

The BMW Group is using an intelligent combination of real-life prototypes and virtual simulations to speed up and streamline vehicle development. The Mixed Reality Experience system is used, among other things, for developing vehicle interiors. By allowing components that actually exist to be supplemented by digitally generated information and experiences, it is possible to create an all-round impression of the driving experience in the interior of a future production model at an early stage of development.

The BMW Group is playing a pioneering role within the automotive industry when it comes to using mixed reality. This involves employing technologies from the consumer electronics and video game industries along with the latest-generation virtual reality headsets. Together, these make it possible to visualise an increasing number of components and vehicle functions with remarkable realism. The result is a realistic customer experience based solely on initial geometrical data and vehicle concepts in the early phases of development. In the process, different variants and alternative concepts can be depicted digitally and compared with one another. This entails far less work than constructing multiple physical prototypes. What's more, the virtual experience can even be shared by several developers over long distances.

The complete impression of the driving experience is achieved through the interaction between the simulation and an interior hardware model produced using a rapid prototyping technique. Factors such as seat position, climate control settings, fragrancing and the massage function are therefore experienced for real, while visual and acoustic stimuli are conveyed by means of the VR content. So that the overall impression can be experienced in various driving situations, the hardware model includes four actuators to simulate vehicle movement. This configuration allows mixed reality to be used not just for development, but also for customer surveys. For example, new interaction

concepts can be tried out flexibly and efficiently under a variety of conditions and in different driving situations. Being able to experience them so realistically at an early stage makes it easier for the developers to meet customers' requirements as precisely as possible.

5. Fully digital and perfectly tuned to the driver – BMW Operating System 7.0:
The future of display and control systems.

The next generation of the display and control concept for BMW cars is digital and highly sophisticated in nature and is designed around the user's personal requirements more closely than ever. BMW Operating System 7.0 is the name that has been given to the latest incarnation of the iDrive system, which was first introduced in 2001 and has blazed a trail for the car industry as a whole ever since. The standout features of the new system are its clear, puristic layout, intuitive structuring and operation, the close interaction between the Information Display in the driver's field of vision and the Control Display in the centre console, as well as new customisation options for the displays. The new display and control concept lends itself even more effectively to optimum attention management, so the driver is always provided with the appropriate information for the driving situation at hand at just the right time. The all-digital design combines 2D and 3D graphics and is perfectly tailored to the user's needs. Situational information that is relevant for the driver stands out prominently, while animations help to structure the system even more clearly.

Instead of simulating traditional analogue dials, the Information Display of BMW Operating System 7.0 replaces them with arc-shaped design elements that are open on their inner circumferences. Their shape and arrangement echoes the appearance of a BMW vehicle's classic four-eyed front end. The new design frees up space in the centre of the Information Display for navigation content that shows the vehicle's present position and the area of relevance for the upcoming section of the journey. All information on driver assistance systems is grouped together within the left-hand speedometer arc, while additional content such as entertainment and consumption functions and the G-meter can be called up inside the rev counter's arc on the right using a selection button on the steering wheel. Together with the enlarged and more

clearly structured BMW Head-Up Display on the windscreen, this ensures that all the relevant content for the current driving situation appears in the driver's line of sight when looking at the road.

The Control Display has increased in size to 12.3 inches and is geared even more heavily towards visualising infotainment and extended vehicle functions, with an orientation map now incorporated into the Information Display. For the first time, intuitive touch operation serves as the primary input method for the Control Display. Drivers are able to configure the content as they please: layouts with two, three or four pads (tiles) can be chosen for the main menu pages, and the pads can in turn be composed individually from a wide variety of content. The pad content is shown in real time. Up to ten pages can be customised in this way. The new, flatter menu structure enables far quicker access to content when drivers wish to open vehicle settings and functions that have not been preset with a pad.

The Information Display, the Control Display and the Rear Seat Entertainment screens have a coordinated graphic design, resulting in a uniform visual impression that is shared by all displays. A switch of driving mode causes the colour scheme and feel of all displays to change accordingly.

With BMW Operating System 7.0, content is adapted according to context and can also be personalised. As soon as the customer opens the vehicle's door, it welcomes them by name in the Information Display as well as showing a vehicle graphic indicating its model name, equipment package and base colour. This view also appears in the menu under My Vehicle. The welcome scenario also includes showing suggested content in the Control Display, such as a route to the journey's destination that has been sent to the car via BMW Connected.

BMW Operating System 7.0 further enhances multimodal interaction between the driver and vehicle. The customer has a choice of iDrive Controller, touch control, voice control and gesture control for operating, and the displays are adapted to the method used. Navigation destinations can be entered in the Control Display by touch using a digital keyboard, but if the customer uses the iDrive Controller instead, the display will switch to a circular speller. The voice control system based on Natural Language Understanding has undergone

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further improvement, while two more gestures have been added to the gesture control's range of functions, bringing the total to seven.

Another special feature of BMW Operating System 7.0 is its ability to show additional information addressing the driver's situation-related requirements. When the vehicle is about to reach the journey's destination, for example, the Control Display opens the parking map, which indicates parking options close by and also allows the driver to book a space directly.

BMW Operating System 7.0 shows the way forward for the display and control concept by using the potential offered by digital design to always provide the driver with the right information at the right time. BMW Operating System 7.0 will be presented in a vehicle for the first time before the end of this year when the new BMW X5 is unveiled.

6. Intelligently connected fleet of vehicles prevents accidents:
Optimising safety with targeted real-time hazard warnings.

The BMW Group is increasing safety and comfort when driving with intelligently connected vehicles that share information on road conditions and traffic situations with one another. By processing anonymously collected data centrally then relaying it in a targeted manner, it is possible to send out local hazard warnings. The BMW Group uses intelligent connectivity to help customers drive safely and avoid accidents by providing them with the necessary information in real time. Warnings of both weather-related hazards – such as fog, black ice, heavy rain and aquaplaning – and broken-down vehicles have been transmitted to BMW vehicles using connectivity technology since November 2016.
The range of messages sent to cars in real time is due to be further expanded this year; registered instances of emergency braking will then be used to issue even more accurate congestion reports in order to reduce the risk of collisions at the tail end of traffic jams. Requests to form emergency vehicle corridors sent out by police traffic report centres will also be transmitted to any affected BMW vehicles. The message "Attention! Form emergency vehicle corridor" will

then appear in the Control Display (and, if fitted, the Head-Up Display) of connected BMW cars when they are caught in a tailback caused by an accident.

The data gathered is gleaned from the cameras and other sensors installed in the vehicles, from where it is transmitted in entirely anonymous form via the built-in SIM card. All data is evaluated and processed centrally. To produce a completely digital image of the local traffic situation, the fleet data is then synchronised with data from other sources. This includes the high-precision navigation maps created in real time by the world's leading mapping and location service HERE, in which the BMW Group has held a stake since 2015. This also opens up access to data from other vehicle fleets.

By evaluating and synchronising data in this way, a precise picture emerges of the prevailing weather conditions (snowing, black ice, heavy rain, fog), traffic conditions (traffic jam, slow-moving traffic, road closure, diversion) and potential hazard situations (muddy or slippery road surface, accident, need to form an emergency vehicle corridor) at the location in question. Warning messages generated as a result are transmitted as required and sent specifically to those vehicles in the connected fleet that are in the same location as the hazard situation or nearing it.

The swift and accurate processing of information on road conditions and traffic situations also provides an important basis for optimising the operation of automated driving systems. The knowledge shared within the connected vehicle fleet supplements the data collected from sensors and cameras and therefore enhances the ability to analyse situations and anticipate what is going to happen – an essential ingredient in automated driving.

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7. The BMW Group IT backend as a key component for connected mobility:
Technical basis for the digital services of today and tomorrow.

Thanks to BMW ConnectedDrive, the BMW Group has been a pioneer of intelligent connectivity and the use of online-based in-car services for a long time now. The vehicle's built-in SIM card is the key to connected, comfortable motoring. By creating a secure and permanently available backend environment, the BMW Group is making the most of the potential offered by mobile data transfer. The secure mobile connection makes it possible to transmit live information to the vehicle and both receive data and send data from the car to the IT backend over the air

There are currently intelligently connected vehicles from the BMW Group in 46 markets. Advanced technologies from the fields of cloud computing and artificial intelligence are employed for this, along with state-of-the-art development processes for creating new services quickly and efficiently and optimising existing functions.

Security and availability are guaranteed at all times thanks to the coordinated interaction between specialised systems that are controlled by the BMW Group. This approach also enables regulated opening of the backend to integrate services from external partners. It is therefore possible to make effective use of the internet's rapid pace of innovation to the benefit of BMW Group customers.

One such specialised system is the Open Mobility Cloud, which is used for providing personalised services that give a great deal of consideration to the user context and allow customers to keep an eye on relevant information at all times and wherever they happen to be.

Another system is the Location Platform that already allows hazard warnings to be shared among connected BMW vehicles today and transmits map updates for the navigation system into the vehicle at regular intervals. This technology will also be employed for automated vehicles.

The BMW Group's strategy of systematically advancing vehicle connectivity and its investment in the backend architecture together play a vital role in shaping the future face of mobility.

8. Fast, flexible and individual with additive manufacturing:
Digital manufacturing processes for development and production.

Digitalisation is not only transforming the experience of mobility, it is also changing the development and production processes that go into the creation of new vehicles. One of the key innovations in this area is additive manufacturing, also commonly referred to as 3D printing, where three-dimensional parts made from plastic or metal take shape layer by layer. Additively manufactured parts offer a high degree of freedom in terms of their design, and they can be produced quickly and to the requisite quality. There is no need for traditional production tools such as press or casting moulds; the geometry of the parts is determined entirely by a digital dataset.

Today, classic examples of additive manufacturing can be found mainly in areas where custom-made and sometimes highly complex components are needed in small numbers. This is the case especially in pre-development, vehicle validation and vehicle road testing. Additive manufacturing offers exceptional flexibility, which is then harnessed in prototype manufacture for quick iterative cycles to optimise component geometry.

Additive manufacturing is an integral element of the BMW Group's production system. The BMW Group considers it one of the key manufacturing methods of the future and a highly promising one. A great deal of its potential lies in series production. The technology was successfully used in small-scale production for the first time in 2010, when the additively manufactured water pump wheel still fitted in DTM racing cars was introduced. The integration of additively manufactured parts into series production at Rolls-Royce is another major milestone on the road to use in large-scale production.

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The new BMW i8 Roadster features a soft-top cover whose aluminium mounting is produced by means of metal powder laser melting, a cutting-edge technique that has never been used before in car manufacture. The mounting's standout characteristics include its optimised geometry, lower weight and higher rigidity compared to an equivalent plastic component.

Additive manufacturing is also playing an increasingly important role when it comes to customised vehicle parts. The new MINI Yours Customised product line enables customers to personalise the design of selected components, such as side scuttles and trim strips, and then have them produced by means of 3D printing.

The Additive Manufacturing Centre housed in the BMW Group's Research and Innovation Centre in Munich already supplies around 140,000 prototype parts a year to the company's various development departments. These range from design samples to plastic mounts and chassis components made from metal. The primary benefit for the developers is that the requested parts are usually available within the space of a few days once the relevant design data has been provided.

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The BMW Group

With its four brands BMW, MINI, Rolls-Royce and BMW Motorrad, the BMW Group is the world's leading premium manufacturer of automobiles and motorcycles and also provides premium financial and mobility services. The BMW Group production network comprises 30 production and assembly facilities in 14 countries; the company has a global sales network in more than 140 countries.

In 2017, the BMW Group sold over 2,463,500 passenger vehicles and more than 164,000 motorcycles worldwide. The profit before tax in the financial year 2017 was € 10.655 billion on revenues amounting to € 98.678 billion. As of 31 December 2017, the BMW Group had a workforce of 129,932 employees.

The success of the BMW Group has always been based on long-term thinking and responsible action. The company has therefore established ecological and social sustainability throughout the value chain, comprehensive product responsibility and a clear commitment to conserving resources as an integral part of its strategy.

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