THE CONNECTED VEHICLE
From Communications to Collective Knowledge
**“We’re Facing the Challenges”**

Dr Volkmar Tanneberger on Innovation as the Key to Success

Volkswagen has recently received five awards in categories including (among others) the ‘most innovative company’, ‘connected car’ and ‘security systems’ at the Automotive INNOVATIONS Award. What does this mean for Volkswagen?

These prizes are a welcome impetus to continue on our chosen path. In the past decade, Volkswagen has developed 1,251 individual innovations, 212 of which were world debuts. We have great employees whose creativity has made this success possible, and we can face the technological challenges of the years ahead because their innovation is the key to our success.

Networking cars creates more data that must be stored. How does Volkswagen treat this data?

Since the 70s, Volkswagen has been dealing with the issue of data protection. Through this experience, we have learned to deal with data in a very sensitive and confidential manner. We can transfer this know-how to the handling and protection of any new customer data. We inform any purchaser of a Volkswagen transparently about what happens with their data. The customer must be able to control their data, particularly when it comes to connectivity.

How will Volkswagen integrate the control of vehicle functions with increasingly popular smartwatches?

As of now, the ‘Car-Net e-Remote’ app will also be available for smartwatches that use these operating systems; watchOS by Apple, Android Wear by Google and Tizen by Samsung. This is a good thing, since phones are getting larger. You can leave your phone in your pocket and still quickly check if, for example, your vehicle’s doors are closed. The functionality of this app on smartwatches and smartphones is gradually increasing. In the future, for example, smartwatches will warn drivers when their parking meter runs out.
**Facts and Figures**

**Connected World**

The digitisation of life has long since reached our cars. So-called connected cars, meaning vehicles that are interconnected to one another and to the internet, play a major role in customers’ desires. They demand modern infotainment services, intelligent networking and control as well as features that increase driving safety. The prerequisite for all of these things: a well-developed, fast, mobile internet.

### Number of smartphone users:

( worldwide in billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Users (in billions)</th>
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<tbody>
<tr>
<td>2012</td>
<td>1.06</td>
</tr>
<tr>
<td>2013</td>
<td>1.31</td>
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<td>2014</td>
<td>1.64</td>
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<tr>
<td>2015</td>
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<tr>
<td>2016</td>
<td>2.16</td>
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<tr>
<td>2017</td>
<td>2.38</td>
</tr>
<tr>
<td>2018</td>
<td>2.56</td>
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</tbody>
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Nearly two of the more than seven billion people on earth currently use a smartphone. According to forecasts, this number will grow again by 600 million over the next three years.

*Figures forecast; Source: Statista*

### Share of vehicles connected to the internet:

(percent of global fleet)

<table>
<thead>
<tr>
<th>Year</th>
<th>Share (%)</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>3%</td>
</tr>
<tr>
<td>2013</td>
<td>5%</td>
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<tr>
<td>2014</td>
<td>8%</td>
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<td>2015</td>
<td>10%</td>
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<td>2016</td>
<td>12%</td>
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<tr>
<td>2017</td>
<td>14%</td>
</tr>
<tr>
<td>2018</td>
<td>17%</td>
</tr>
</tbody>
</table>

The number of vehicles with internet connectivity is rising steadily – by a few percentage points since 2012. Currently about ten percent of the world’s cars are internet enabled. Forecasts for 2020 assume that more than a quarter of vehicles globally will be connected to the internet.

*Figures forecast; Source: Statista*

### These technologies are behind it:

- **GSM** (Global System for Mobile Communications) is the world’s most widely used standard for mobile communications. It was introduced in Germany in 1992 and, in contrast to the analogue networks used until then, enabled the transfer of data as well as enabling mobile telephone services.

- The **Long Term Evolution Frequencies (LTE)** were freed up in 2010, with the digitisation of terrestrial television. This standard has a wide reach and thus also opens up remote areas. Speeds have increased even further, unlike with UMTS.

- The **Universal Mobile Telecommunications System (UMTS)** was introduced in Germany in 2004. The original rate of speed was increased by a further development called HSDPA. This standard made the transmission of moving images possible.

- **WLAN** stands for Wireless Local Area Network and denotes a local radio network, with which a plurality of terminal devices can connect. A router can take over the coordination of the different devices or alternatively they can communicate directly. Wi-Fi, which is used in homes, operates on a different frequency than that of transport infrastructure. **ETSI ITS-G5** is the wireless standard for intelligent traffic systems (Intelligent Transport Systems, ITS) in Europe. The technology ensures reliable transmission at high speeds and allows direct communication between individual vehicles, and between vehicles and infrastructure, without a router.

- **The Global Positioning System (GPS)** refers to a satellite system that allows the positioning of a signal, with an accuracy of up to ten metres. Through the difference method (called **dGPS**), this positioning can be performed with an accuracy within a range of centimetres.


Intelligent Services
Infotainment in the Vehicle

Almost half of all car buyers in Europe want faster internet in their car – a requirement for new technical services such as intelligent navigation or networking with one’s own home. The following overview shows the features and practical services on offer.

**Car-Net**

The Car-Net online platform provides access to various infotainment and service functions and apps. It includes the following mobile online services:

- **Three smartphone interfaces** – MirrorLink™, Android Auto™ (Google) and Apple CarPlay™ – are available via App Connect in a connected car. These three technologies transfer any smartphone apps selected using the touchscreen of the vehicle’s infotainment system and can be easily controlled while driving using voice commands.

- **Guide & Inform** displays information such as what petrol stations and attractions are in the area, the latest traffic information direct from the internet, news, parking spaces and the weather forecast – all on the move. In addition, personal favourite destinations can be saved and transferred to the car’s navigation system.

- **With e-Remote**, the driver can access the essential functions of his electric car from his PC, smartphone or smartwatch. He can, for example, start or stop charging, set departure times or display his last parking position. The ‘driving data’ function displays information about average fuel consumption.

- **Security & Service** is the new Car-Net service package planned by Volkswagen. It includes, among others, e-Remote services and emergency services that establish a connection between the driver, vehicle and Volkswagen backend. This way, an emergency, accident or breakdown call can be triggered by pressing a button. An automatic message is sent to the VW Emergency Call Centre when a sensor (airbag or belt tighter) reports an accident.

In combination with the Car-Net functions mentioned, ‘favourite routes’ provides additional options: this service stores regularly traveled routes, such as the way to work or school. Navigation is silent – only traffic disruptions and the proposed alternative routes are announced. For doing so, the system accesses the online traffic services via Car-Net Guide & Inform.

**Online Connectivity Unit**

Even from a distance, is it possible to obtain information about the vehicle or to control it? How much is in the tank? Are the doors locked? If not, they can be locked via the web or app, as long as the car is equipped with an Online Connectivity Unit (OCU) with SIM card handling. The OCU reads out the signals of the so-called CAN bus (Controller Area Network) that links the control units in cars together. This component, firmly embedded in the Volkswagen strategy, ensures a secure and stable connection between the vehicle and the back-end.
Mobile devices can be connected to the vehicle via wireless. This provides passengers with an internet connection while driving. The transmission is established with the car phone, connected via Bluetooth, a SIM card or a surf stick. Up to seven mobile terminal devices can be coupled in this manner.

**Wi-Fi Hotspot**

The Discover Media and Discover Pro navigation systems offer a colour touchscreen, Bluetooth for hands-free telephony, USB port and many more convenient services on the go that drivers can use to get to their desired destination in a well-informed and safe manner. The map update service can download the latest navigation maps free of charge from the internet.

**Permanently Installed Navigation**

The e-Station Guide helps drivers of electric cars to find the optimum charging station. The service provides information on properties such as location, direction and methods of payment. It detects if a charging station is, for example, difficult to access, defective or does not have the required connector system – and so avoids any unnecessary waste of time. The background: electric vehicles can rate the facilities at each charging station. The results are made available to other drivers through the cloud, which steadily improves the digital road map.

**e-Station Guide**

All main infotainment functions can be comfortably controlled from the backseat via Media Control. By connecting a tablet or smartphone via Wi-Fi with the onboard system; the radio, the navigation system and all media sources such as CD or DVD can be operated remotely via the app. It’s not only the volume, balance and fader settings or basic operating functions such as ‘Play’ and ‘Pause’ that can be controlled from the rear. Calendar entries saved on the tablet or addresses retrieved from the internet can be set as the destination, radio stations and frequencies can all be changed. The device can be supplied with power using a tablet holder. In the future, it will also be possible to operate the media library using a smartwatch.

**Media Control**

A Digital Key app is planned for the future, which can turn your own smartphone and smartwatch into electronic vehicle keys. With it, one can start and then stop the motor, open and close windows, and lock and unlock the vehicle doors – and the trunk – individually. The Digital Key will also be transferable to the smartphones and watches of third parties. Using either temporary or permanent access they could, for example, perform maintenance or unload the trunk without the real key ever changing hands. Volkswagen first presented this app earlier this year on the e-Golf Intelligent Charge.

**Digital Key**
STAYING CONNECTED
How Cars and Infrastructure Grow Together

The car of the future is in constant exchange with other vehicles: about road conditions, traffic flow or safety-relevant events and situations. This is called vehicle-to-vehicle communication (V2V). This localised data exchange can also be undertaken with infrastructure such as traffic lights, construction sites and variable message signs. This is called vehicle-to-x communication, where x represents any other communication partner. The aim of vehicle-to-x communication is to increase road safety and efficiency. At this moment, there are two stages of this technology in development, and the realisation of the third is currently being worked towards.

COMMUNICATION BASIS
A special WLAN standard (ITS G5 or WLANp), designed for vehicles, was developed for vehicle-to-vehicle communication; in order to exchange information regularly with the immediate vicinity. In addition, sudden events or hazardous situations can be communicated by the environment within a few milliseconds.

FIRST DEVELOPMENT STAGE
In the first vehicle-to-vehicle development stage, the local hazard warning, vehicles communicate hazards they have identified in their surroundings. Existing systems in the car are extended by the vehicle-to-vehicle communication component. The function that warns of accident sites, for example, immediately warns other vehicles in the event an airbag is triggered, to avoid secondary accidents. This is particularly helpful if there are hidden hazards or in the event of reduced visibility.

SECOND DEVELOPMENT STAGE
Vehicle-to-vehicle communication’s second stage will enable new vehicle functions and improve existing vehicle safety systems. For this purpose, vehicle-to-vehicle information is used that is not detectable by existing sensors such as cameras and radar. Information about the dimensions of vehicles with which you could potentially collide, for example, could serve to prepare the safety systems in your own vehicle in good time. In addition, by using information about traffic light phases, the driver can be warned about another driver unintentionally passing a red light. Thus vehicle-to-vehicle acts as a 360° sensor, providing information about vehicles or traffic infrastructure around the vehicle.
In the third development stage vehicle-to-vehicle information, received in addition to the information from the onboard sensors, is incorporated into the vehicle’s perception of its surroundings. This way, driver assistance features are further improved. In addition, researchers are working on the next step of using the information provided by other vehicles. This will contribute to the realisation of reliable, automated driving; even in difficult situations. To this end, information about objects that are detected by a vehicle’s sensors is exchanged with other vehicles or the local infrastructure. This way, V2V vehicles further improve their perception of their surroundings by harnessing this collective knowledge.

Improved perception of surroundings using collective knowledge:

Vehicle-to-vehicle communication can also help to facilitate cooperative behaviour and to realise new cooperative functions. This increases comfort, improves security and is an important building block towards the further development of automated driving. In the future, it will additionally allow automatic driving functions to respond cooperatively to other vehicles.

Cooperative behaviour:

The red car wants to merge onto the highway. It indicates its intention to merge to the other vehicles. The white vehicle behaves cooperatively. It sends a message of its willingness to lengthen the gap so that the red vehicle can merge. Both vehicles carried out the merging procedure in cooperation. This increases safety and comfort.

Popular V2X functions (in percent)*:

* Multiple selection possible

Traffic Jam Warning: 78%
Traffic Light Assist: Red Light: 75%
Electronic Brake Light: 72%
Obstacle Warning: 69%
Parking Situation: 66%
Recommended Detour: 61%
Dynamic Route Planning: 60%
Traffic Situation in Construction: 56%

A user survey within the framework of simTD shows motorists want vehicle-to-x functions for their vehicle. Warnings about traffic jam tailbacks are especially popular, followed by Traffic Light Assist which specifies how long the driver will have to wait at a red light.
MATTER OF TRUST
What Happens with the Vehicle's Data?

Whether more and more connected vehicles will be traveling on our roads in future also depends on whether car drivers trust this new technology. Some are sceptical of the large volume of data generated: what data is actually collected? Is it stored? And what control does the driver have over it?

Whom consumers trust (in percent)*:

- Vehicle manufacturers: 55%
- Dealer / workshop: 48%
- Car insurance: 13%
- Internet service provider: 7%
- Automobile club: 4%

Confidence through Security

When developing vehicles and introducing new systems, Volkswagen takes account of international guidelines such as the Alliance of Automotive Manufacturers in the US and the European Statement of Principles of the European Commission. They provide recommendations on the design of interactions between driver and vehicle, especially while driving, in order to minimise driver distraction – in spite of the increasing use of various services. Integrated monitors, for example, must not distract during driving; important information must be visible at a glance, and complex functions inaccessible. The responsibility of the driver to make conscious use of the opportunities offered by the network and give priority to the task at hand – driving – remains untouched by these measures.

No Fear of Always-On

Concerns about data security and the protection of personal rights play a role whenever it comes to personal data: what happens to the information about the driver and their driving behaviour gathered by the car? How great is the risk of hackers gaining access through cars which are ‘always-on’? These questions concern the public, manufacturers and politicians alike. To address the concerns of customers when it comes to the topic of networked vehicles, car manufacturers approach a solution through collaboration with the IT industry, business and politics.

VDA Data Protection Principles

In 2014, the members of the Association of the German Automotive Industry (VDA) have created a joint statement as a commitment to data protection in networked vehicles. These “data protection principles for networked vehicles” complement existing legal regulations and focus on three core statements:

- Data security:
  Suitable technical and organisational security measures must be established and developed for networked driving, to ensure appropriate data security and integrity and, for example, protect against malfeasance.

- Self-determination:
  The customer should be able to regulate the processing and use of their personal data for certain services. A transfer of such data for other services can only happen either on the basis of a statutory authorisation or consent.

- Transparency:
  The customer receives adequate information on the categories of data held by a networked vehicle and the purpose of the processed data, for example, for use with online services, portals or documents onboard.

Confidence through Security

Confidence through Security

In response to the question of who may store their data, the readers of the automotive industry publication Automotive News have indicated their trust primarily in vehicle manufacturers, followed closely by dealers and workshops. *Multiple answers possible