

# DESIGNING THE **CONNECTED** CAR OF THE FUTURE

Discover how the automotive industry is utilising 5G and C-V2X technologies to enable autonomous driving applications and the commercialisation of the "car of the future"

## INSIDE THIS REPORT

- > Testing solutions to accelerate the deployment of 5G and C-V2X technologies, and enable advanced AV capabilities
- > How to refine the modern car by connecting them to networks, other vehicles, pedestrians, infrastructure, and mobility services
- > The future landscape of 5G C-V2X technology and connected driving

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# Foreword

What was once considered exclusively a human function, driving is increasingly becoming a hotbed for technology integration and control. With parking assist and cruise control now considered common features of a new car by consumers, automakers are looking at new ways they can use technology to create the “car of the future” – “a car that is autonomous, connected, electrified, and has shared mobility (ACES),” Guido Gehlen, Head of Connected Mobility Technology at Vodafone Business describes.

The ACES evolution holds greater promise for improved road safety, transport accessibility for the elderly and disabled, ease in traffic congestion, fuel saving, and lower harmful emissions. A [report by the University of Texas at Austin](#) found if 10% of cars in the US were fully autonomous, for example, the US economy could save approximately US\$30bn in fuel costs each year, and smooth freeway congestion delays by 15%.

Yet barriers to implement autonomous vehicles (AVs) into the mass-market remain. Implementation costs of AV technology is high, which hampers large-scale production and mass consumer availability, and the ambiguity around regulation and testing standards are prevalent across the industry. In a [survey conducted by Automotive IQ and Keysight Technologies](#), 67% of automotive leaders in research and development, manufacturing, and testing,

found protocols and regulatory standards for validating software systems was their top challenge in AV development (see Figure 1). The second most prominent challenge was around ensuring the system performance met the design objectives, with 52% of respondents pinpointing this.

Additionally, the emergence of technologies such as fifth-generation wireless technology (5G) and cellular vehicle-to-everything (C-V2X) has caused the industry to move away from powertrain controls to concentrate on the car’s entire technology stack, creating new challenges in how to define the right business model for connectivity.



## >> Foreword

Johannes Springer, Lead 5G Automotive Programme at Deutsche Telekom Group and Director-General of the 5G Automotive Association (5GAA), says: "Often, you cannot make a clear distinction between connectivity and automation. To a certain degree, for automation to work you need connectivity."

"A recent German law, which is also being discussed on a wider European level, says that an automated driving vehicle needs to be supervised by a remote-control entity. This interconnection between the remote-control entity and the AV is made via a cellular connection."

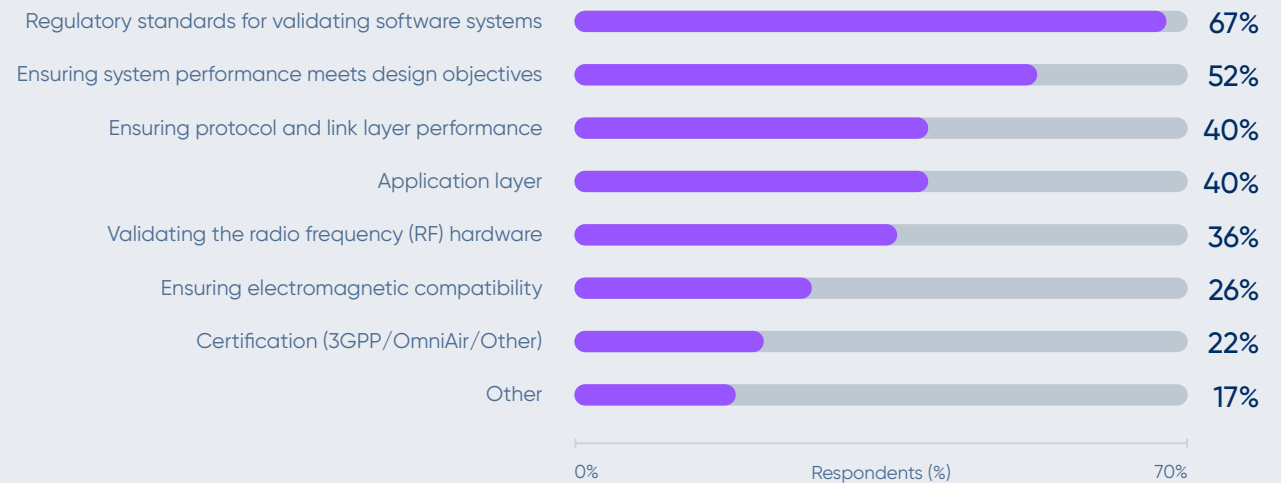
Going forward, Springer emphasises that the industry needs a business model to sell autonomous driving (AD). "While, for example, 5GAA members such as Volkswagen charge per automated driving hour, another solution is envisaged by fleet operators, which are going in the direction of an automated taxi experience where you pay a set sum of money to get them from A to B"

Enabling the future promises of connected cars will require significant investments in time and testing of network infrastructures such as 5G and C-V2X. In this report, *Automotive IQ* – in collaboration with Keysight Technologies – will explore the benefits of using C-V2X technology in the stack architecture of vehicles, how its implementation will provide automotive leaders with an end-to-end solution and market advantage, and how automakers can make the transition to 5G C-V2X to get them closer to achieving the connected car of the future.

FIGURE 1:

### Top three challenges for the development of AVs\*

\*Each respondent was able to select three challenges



"Often, you cannot make a clear distinction between connectivity and automation. To a certain degree, for automation to work you need connectivity."

### Johannes Springer

Lead 5G Automotive Programme at Deutsche Telekom Group

# The Importance of C-V2X Applications

C-V2X, first specified as part of the 3GPP Release 14 in 2017 using 4G Long-Term Evolution (LTE) as opposed to Wi-Fi-based dedicated short-range communications (DSRC), ensures that a vehicle can function with greater situational awareness: observing, predicating, and automatically taking action. This means the companies integrating C-V2X technology will be able to “increase the capacity to handle a larger volume of cars “talking” to each other simultaneously, as well as improving the safety features and wireless communication infrastructure of the vehicle; all without the fear of congestion or interruptions in service,” notes Thomas Goetzl, VP and General Manager of Automotive and Energy Solutions at Keysight Technologies.

With clear signs that the global automotive market is veering towards greater connectivity ubiquity – 34% of respondents from the *Automotive IQ* and Keysight Technologies survey indicated advanced driver assistance systems (ADAS) and autonomous systems are among the key functionalities they are currently working on (see Figure 2) – there is an opportunity here for the industry to drive deployment costs down for C-V2X and advance AD into the mass-market. For example, leveraging already deployed cell towers is quicker and cheaper than building Wi-Fi-based DSRC technology into existing infrastructure.

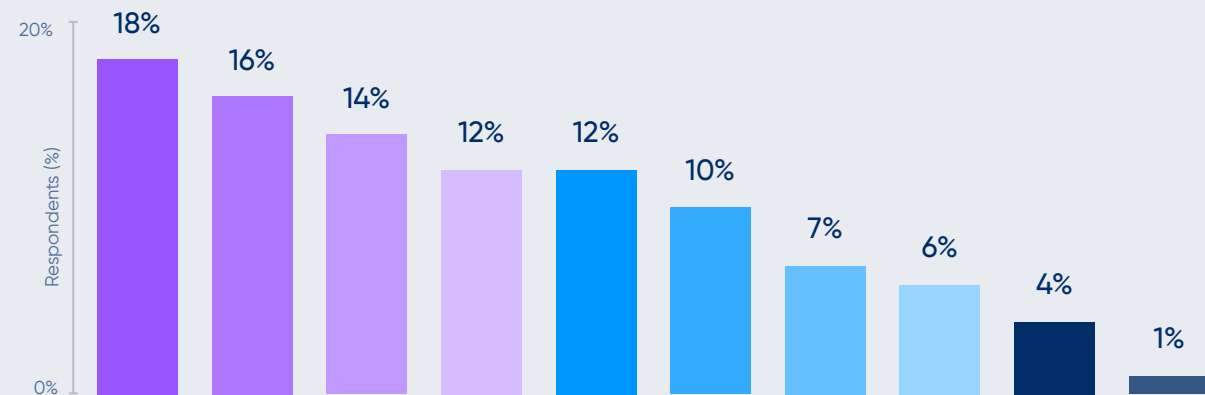
China is also helping to pave the way for the worldwide roll out of C-V2X, with the Chinese government **deploying**

**several C-V2X development policies** that will strengthen their aim to make their roads fully autonomous by 2035. In addition, with many Chinese automakers using 5G technology to underpin the rapid growth of the C-V2X industry in China, many other national automakers are looking into how they can use 5G to meet the goal of enabling the commercialisation of C-V2X at scale.

Goetzl says: “5G will form a key cornerstone for the future of C-V2X, where all cars are constantly in communication with one another, with pedestrians, and even with the city and road infrastructure. It will enable benefits such as optimal route planning, reduced congestion, and lower carbon emissions.”

**FIGURE 2:**  
**Connectivity functionalities automotive companies are working on**

- ADAS
- Autonomous systems
- V2X systems
- In-vehicle infotainment
- Security
- Other
- Integrated vehicle dynamics control
- Hardware-in-the-loop
- Automotive chipset development
- Antenna design



## >> The Importance of C-V2X Applications



### Spotlight on the Experts

#### **Automotive IQ:** What are the benefits of using C-V2X in the automotive ecosystem?

**Gehlen:** We need open Internet-like technologies to enable cooperative applications across all vehicle original equipment manufacturers (OEMs) and road operators. C-V2X can be just that, connecting the cars with the infrastructure of the cities and other cars on the road. With more advanced C-V2X you can start to advise the car of different behaviours. The more information the vehicle gets from C-V2X applications the better the vehicle will be at making decisions about safety and sustainability. For example, if the car can optimise its route, it can determine when a traffic light will turn red and when the car should brake to smooth traffic flow and save on energy.

**Springer:** C-V2X is a great use case for quality-of-service in mobile network connectivity. If you want to control your vehicle remotely your mobile network traffic needs to get priority against the same traffic or cell of someone downloading a video on Netflix, for example. If you are competing for the same resources, mission critical

services and safety needs to be delivered, and this is something 5G C-V2X can deliver.

The ultra-reliable, low latency use case, multi-access edge computing that puts computer infrastructure deeply into our mobile networks is a second feature set we can use to communicate with vehicles. With C-V2X you can also combine communication with positioning to know the precise time and location of your vehicle.

While we are widely talking about C-V2X from an automotive or driver's perspective, you cannot forget there are also various other traffic participants on the road that are already connected to mobile networks – cyclists, buses, motorcycles, scooters, and pedestrians. We have a responsibility from an ecosystem perspective to include everyone in the car's mobility scheme, for safety, convenience, traffic flow, and sustainability.



#### **Automotive IQ:** Now that the US Federal Communications Commission has decided to split the 5.9 GHz spectrum between Wi-Fi and transportation, what will the future hold for C-V2X applications?

**Goetzl:** I predict we will see a lot more C-V2X applications hit the market soon. Some cities are already testing emergency vehicle pre-emption systems together with intelligent transit signal priority algorithms. These systems will be able to detect the routes of first responders such as ambulances and switch their on-route traffic lights from red to green, guiding the emergency vehicle through traffic junctions swiftly and safely.

There is also an emerging market targeted at making roads safer for cyclists who are considered vulnerable road users (VRU). This involves cyclists equipping themselves with mobile C-V2X enabled devices, which can warn cyclists of traffic hazards from other C-V2X enabled vehicles, or vice-versa, warning these vehicles of the VRU even if the cyclist is not within line of sight.

# Building C-V2X on the Evolving 5G Standard

There are multiple technologies available on the market that can be used for direct and network-based communications such as 4G LTE, satellites, and DSRC. However, 5G has the potential to achieve higher levels of autonomous operations as the technology provides more bandwidth, lower latency, and higher resiliency, which in turn increases the vehicle's reliability as it is in constant communication.

According to **Gartner**, by the end of 2024, 60% of communications service providers (CSPs) will commercialise 5G services in Tier 1 cities (cities that have developed or established real estate market), which is up from only 10% of CSPs providing 5G services in 2020.

Results from the *Automotive IQ* and Keysight Technologies survey mirrors the rapid growth of 5G network infrastructures predicted by Gartner with 38% of respondents already working on implementing 5G into their connectivity strategies (see Figure 3). Following the spike in demand for optimised and ultrafast broadband connectivity to support working from home environments, video streaming, online gaming, and social interactions in a virtual setting during the COVID-19 pandemic, it is unsurprising that consumer demand in the automotive industry is also following suit on this trend.

With C-V2X being built around the ever-evolving design of 5G, regulation standards are in constant motion,

and test targets are ever-changing. In addition, the technology, equipment, and expertise needed to build and maintain a test setup that addresses all the latest standards and specifications can be costly and time consuming.

To accelerate the testing time of 5G C-V2X and continue to improve the safety of AVs, Keysight Technologies has introduced "**SA8700A C-V2X**", a test solution that is able to stay in step with evolving C-V2X requirements, support RF, and application-layer testing, as well as provide underlying platform support for future 5G C-V2X releases.

Goetzl says: "Keysight Technologies actively collaborates with industry-leading test houses to ensure we can verify new 5G use cases and meet C-V2X standards.

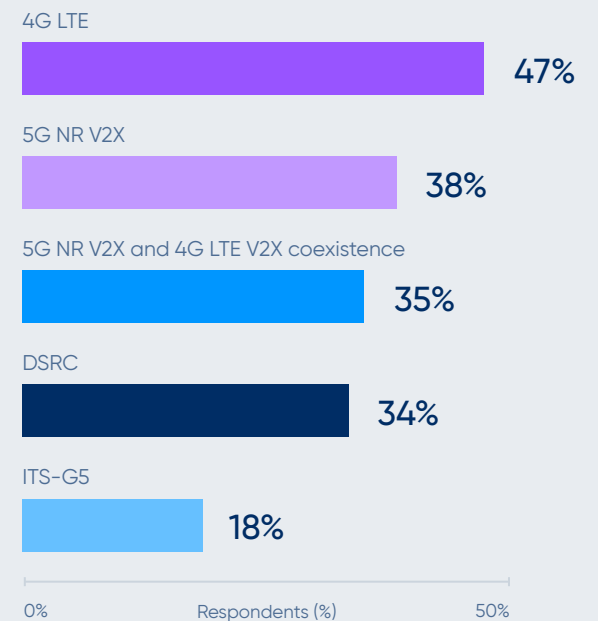
"The SA8700A C-V2X test solution, first to **gain status as OmniAir Qualified Test Equipment** in April 2021, now enables DEKRA – an international expert organisation for test, inspection, and certification – to access a broad range of C-V2X test cases defined by the OmniAir Consortium. This enables onboard unit and roadside unit vendors to quickly certify designs equipped with C-V2X technology."

To further support the acceleration of 5G C-V2X and AV capabilities, the testing solution can also be applied

to other Keysight Technologies solutions for 4G LTE or 5G testing as the C-V2X solution leverages the same X-Apps and the same measurement algorithms used in the company's signal analysers and wireless test sets.

**FIGURE 3:**  
**Areas of V2X automotive leaders are currently working on\***

\*Each respondent was able to select three challenges





### Spotlight on the Experts

#### **Automotive IQ: How can automotive leaders transition to 5G C-V2X?**

**Gehlen:** Automotive companies need to get the 5G capabilities included in their specified vehicles early on. This can be challenging because upcoming technologies that are not yet deployed are difficult to test. When you release a car capable of 5G connectivity, for example, the network is not always universally available, so you need to get access to test networks that have the latest technologies on offer.

I would also advise car OEMs to work closely with the telecommunication industry, so they are aligned on future requirements and are able to design solutions that fit industry demand.

**Springer:** Every car manufacturer and road operator are already making decisions about investments into connectivity, but connectivity is just a means to provide data. So, companies need to consider the actual standards for devices to make that smooth transition from 4G to 5G. Based on these devices, you can

exchange the data to create an efficient, eco-friendly, and safe mobility system.

#### **Automotive IQ: How will 5G V2X real-life use cases evolve and what other examples can the automotive industry witness to help its acceleration?**

**Goetzl:** When 5G wireless connectivity is combined with the Internet of Things technology, we can develop new capabilities and applications based on the "5G Triangle". This triangle features enhanced mobile broadband (eMBB), ultra-reliable low-latency communications (URLLC), and massive machine-type communications (mMTC) to enable superfast 5G eMBB.

Communications will be almost instantaneous with URLLC. There will be minimal delays – one or five milliseconds on a 5G network as opposed to 20 milliseconds of our current 4G networks. For AVs, low latency is mission critical to provide users with safety information even before it is in the car's line of sight.

Plus, we can connect a great number of devices reliably with the mMTC feature. Cars will be able to exchange information that can be used for traffic control or to warn drivers of dangers.

3GPP froze the R16 specification in June 2020, after delays due to the COVID-19 pandemic, but since then, chip set vendors have been working hard to issue chips that support this release, which introduces 5G new radio (NR) in the PC5 Sidelink. Per various press releases, we can expect to see chipsets and modules with R16 support to become available in 2022.

Applications enabled by 5G NR-V2X, include the creation of ad-hoc groups which allow for traffic to merge onto a highway safely, vehicle platooning, and sharing of sensor information with surrounding vehicles (called groupcast). It also enables communicating with an individual vehicle (called unicast), which are in addition to the normal broadcast mode.

# Forming a New Mobility Ecosystem with Technology

The technology trends surrounding the “connected car of the future” represents a new wave of automotive innovation and mobility that connects the car with its environment in new and efficient ways.

For the automotive industry to accelerate its digital transformation journey to the next level, automakers need to ensure their AV strategies are defined by the software and all the technologies included in the vehicle’s anatomy are tested to fulfil the promise of improved road safety and mobility.

Vodafone’s Gehlen, says: “Vehicles need to be less constricted by its hardware and more software driven. Over-the-air (OTA) updates are essential for keeping software-driven vehicles up-to-date, secure and safe. The industry needs to find a way to close the loop between testing and deployment with OTA updates to create more flexibility in AV distribution.”

Springer concludes bringing trends of the connected car to fruition goes back to finding the right business model, “because in the end you need to monetise the services”.

“Mobility is complex, and the industry needs to use the technologies on offer, for example: 5G and C-V2X, to exchange information and data on a broader scale,” Springer says. “In my perspective, this is the next step of the digital transformation journey for the automotive industry as we need to be realistic in how quickly we can get AVs onto the road, not everybody in the industry can develop and adopt at the same speed.”

“The industry needs to find a way to close the loop between testing and deployment with OTA updates to create more flexibility in AV distribution.”

## Guido Gehlen

Head of Connected Mobility Technology  
at Vodafone Business



# About Keysight Technologies

Bringing new technologies to market requires the ability to see the unseen, to imagine entirely new approaches, and to test the untestable. Throughout our history, we have shared a sense of curiosity with our customers

at the potential of technology and the power of engineering to solve seemingly intractable measurement challenges, collaborating with them to turn their visions into reality.



Learn more visit



# About Automotive IQ

*Automotive IQ* is a global online community of more than 70,000 automotive industry professionals and experts. Our focus is on sharing essential and valuable insights in four major trends that are shaping the automotive industry right now – connected cars, autonomous drive, shared mobility, and electric vehicles.

By joining our growing network, you will be able to connect, learn, and interactive with other likeminded

industry professionals and keep up to date with industry inside advice to help you achieve your business goals.

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**If you are interested in becoming an *Automotive IQ* contributor, please get in touch with *Automotive IQ's* Editor, Emily Uwemedimo, on [LinkedIn](#).**



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# Featured Contributors

Leading automotive thought-leaders selected for their experience and ability to deliver valuable insights into the industry's most critical issues.



**Johannes Springer**  
Lead 5G Automotive Programme at Deutsche Telekom Group and Director-General of 5GAA



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**Thomas Goetzl**  
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