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V2X AS A COMPLETE SYSTEM IN THE CONNECTED VEHICLE

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Communication is essential in a connected vehicle. Data must be transmitted quickly and reliably both inside and outside of the car. External communication from the vehicle to other road users and infrastructures i.e. Vehicle to Everything (V2X) currently plays a major role in the development and research of connected mobility. This is because it is critical for vehicle suppliers to provide new use cases and concepts to integrate V2X into their models. It is becoming clear that only a holistic approach to V2X integration makes sense in order to address all of the challenges and explore the full potential of the technology to provide seamless autonomous driving.

COMMUNICATION WITH INFRASTRUCTURE AND OTHER VEHICLES

V2X is an umbrella term that represents the communication of the vehicle with its environment. This can consist of other road users such as cars, cyclists or pedestrians, the traffic infrastructure such as traffic lights, but also other networks such as the smart home. The latter aspect is excluded from the present article as this article will focus on the communication of vehicles with other road users and the infrastructure.

Currently, there are two different radio technologies in the V2X range that compete with each other. The Dedicated Short-Range Communication (DSRC) in the USA and ITS-G5 in Europe, which are based on an 802.11p WIFI standard and Cellular V2X, that those are based on 4G and 5G cellular standards. Neither the legislator nor the car manufacturers have yet to agree which of these two V2X technologies will be preferred and declared the standard. DSRC or ITS-G5 is the more proven technology, as it has been available for some time and several long-term test series have already been carried out. Cellular V2X is considered to be more future-proof since it also enables use cases that will only become relevant in the coming years. In addition, Cellular V2X as a mobile telephony-based technology that offers the advantage of being an integral part of the telematics unit. DSRC or ITS-G5, on the other hand, would be a system that can only be used for car-to-car or car-to-infrastructure communication and would therefore have to be integrated as an add-on module, which in turn would increase system costs for OEMs.

SAFETY, EFFICIENCY IMPROVEMENT, ENVIRONMENT - USE CASES FOR V2X

V2X is primarily intended to increase road safety. The technology is designed to expand the senses of the vehicle and as a result provide the driver with information that couldn't be otherwise predicted or even captured by camera or lidar systems. This already applies to current use cases, in which drivers are warned of dangerous situations, but even more so to future application examples. In addition to safety, V2X should also contribute long term to improving the efficiency of traffic flow. For example, by allowing vehicles to communicate with traffic lights and influence their switching could have a positive effect on environmentally relevant aspects such as reduced pollutant emissions.

In general, a distinction is made between Day 1 and advanced use cases for V2X application examples. Day 1 use cases are those that have been tested over a long period of time and some of them

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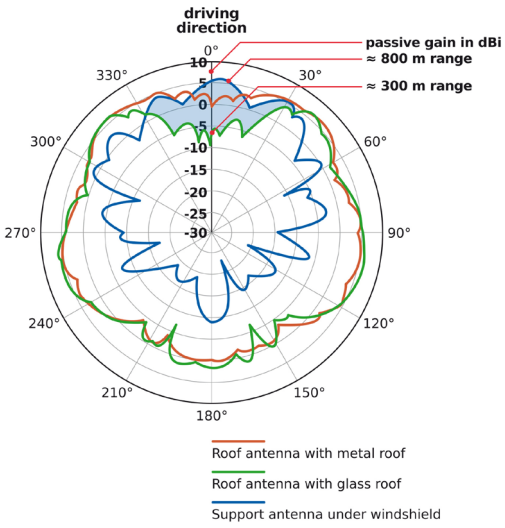
are already rolled out. They are warnings to the driver about dangerous situations that might not be perceived or that are misjudged without external help. Examples of this are the messages that an emergency vehicle is approaching, a broken-down vehicle is on the road ahead or a vehicle in front is applying emergency braking. State-of-the-art blind spot messages alert when a pedestrian or cyclist is approaching or to provide assistance when turning to inform the driver about oncoming vehicles and their speed are already on the market.

Advanced use cases are those that usually involve direct intervention in the vehicle that go beyond the pure warning function. The incoming signals are then processed in driver assistance systems or semi-autonomous driving systems. Examples include sensor data sharing to implement swarm intelligence or so-called see-through where vehicles driving behind other vehicles that obstructs their view are fed the front vehicle's data.



IMPLEMENTATION CHALLENGES

Currently, there are two major challenges in implementing V2X. First, the specification of the cybersecurity requirements that ensures data security is not yet complete. The transmission must be tightly secured so that no false information from the outside enters the network. In addition, the connections must also be established and able to react reliably, quickly and safely, even in high-density traffic scenarios, such as traffic jams. A second critical challenge is the unclear legal situation as to which technology should be used in which region. This lack of specifications creates uncertainty in the market. For manufacturers there are several scenarios, each of which carries a certain risk. One scenario is to wait, risking the chance of being left behind technologically speaking. Another scenario is for the vehicle manufacturers to decide to implement a particular technology and risk selecting the wrong one. The final option is to implement both V2X technologies, but then incur increased costs versus a company that only supports the winning technology. The challenge that poses the biggest risk for manufacturers is the uncertain timetable for when state-of-the-art technology regulations will be in place. It is critical that the technology regulation gap is resolved to ensure the market is aligned with the industry.

All of these challenges are expected to be solved in the near future as a solution is foreseeable. The key point is for vehicle manufacturers to start the integration of V2X technology into their vehicle's overall system.

V2X AS AN OVERALL SYSTEM INTEGRATION

Initial test series have shown that it makes sense for vehicle manufacturers to consider the integration of the V2X module not in isolation but in the context of the overall system. Therefore, it is not enough to consider only the integration of the V2X module (whether cellular or DSRC) - vehicle manufacturers must consider the associated system consisting of V2X modem, V2X antennas, the distribution of antennas in the vehicle and the resulting aspects such as compensation for antenna losses. If they ignore this, V2X may not have the desired functionality because individual components are not compatible. For example, antenna power loss without compensation may cause the overall system to function less effectively. Therefore, the V2X overall system must be completely adapted to the vehicle and optimized to the specific model series in order to guarantee maximum performance.

So, why exactly is it important to consider not only the installation of the V2X module, but also its effect and interaction with the overall system?

One purpose of the module is to improve communication with other vehicles and the infrastructure. This requires antennas, whose interaction with the V2X module is in turn relevant for the communication performance. This is because the antenna requires a 360-degree panoramic view around the vehicle without "blind spots" so, that consistently superior performance can be achieved in receiving and transmitting data. Usually the (primary) antenna is connected to the TCU and positioned in the roof area of the vehicle. By testing in an antenna test chamber (Anechoic Chamber - see box 1a) it can now be examined whether 360-degree coverage is achieved. If this is not the case, an additional antenna is required, which is usually installed as a front antenna in the area of the windscreen or in the bumper, thus ensuring maximum coverage. These blind spots e.g. through a panoramic glass roof can reduce the range by more than 50% in the direction of travel. This may mean that the functional requirements can no longer be met. However, the front antenna must be connected to the TCU by cable, which in turn leads to losses of up to 18 dB through the cable connection. These losses can be compensated for with the aid of a compensator, something that car manufacturers must consider at the design stage. If fact, when planning the V2X integration, car manufacturers must take all these points into account and when choosing their suppliers and partners, they must ensure that they also consider the overall system of the vehicle.

APPROACHES TO V2X INTEGRATION

When it comes to the actual integration of the V2X solution, there are several approaches that manufacturers can take. One approach it to install V2X as part of the telematics unit. Another approach is to isolate V2X and implement it as a stand-alone solution in a separate control unit. The solution that the vehicle manufacturers choose heavily depends on several factors

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and perhaps the most important factor is the regional or global range of the V2X. The solution might only be introduced in certain vehicle models or regions versus being implemented on a global level. The stand-alone option allows the manufacturer to integrate V2X regionally, but not globally. On the other hand, if it is rolled out comprehensively in all vehicle models worldwide, it is expected that there will be a cost benefit if the V2X is integrated into the telematics unit. Functional safety beyond warning alerts is another important aspect that raises concern for future use cases. When sensor information is used for assistance systems or autonomous driving there are different demands on functional safety than with warning systems. In situations where the V2X system is used to assist autonomous activity, it may make sense to separate the V2X module and the telematics unit in order to ensure superior functional safety and redundancy.

Another approach to V2X integration is to use a combo solution that supports both Cellular V2X and DSRC. This offers vehicle manufacturers maximum flexibility for all markets at all times, but results in higher costs. The core criterion for decision making is therefore which solution the car manufacturer wants to implement, how it fits into the vehicle architecture and the overall system and which use cases the vehicle manufactures want to cover in the future with V2X applications.

INDOOR ANECHOIC CHAMBER

In order to ensure optimum antenna coverage and to enable data transmission at a 360- degree angle around the vehicle, the antenna power is measured in a so-called anechoic chamber. This anechoic chamber is specially designed to measure antennas, either stand-alone or integrated into subsystems, and is intended for measuring antennas on complete vehicles. The arch equipped for antenna tests with measuring probes is built into the space and is shielded from external radio waves to ensure maximum measurement repeatability. Thanks to a high-precision control system, measurements can be performed “on the fly”. The test system can test vehicle systems with integrated or connected antennas and its configuration can be adapted to specific needs and requirements and therefore to different types of vehicles.

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