Trends in connected cars – at a glance

V2X
V2V, V2I, V2P,
C-V2X, 3GPP LTE-V2X,
DSRC, WAVE, ITS-G5,
IEEE 802.11p

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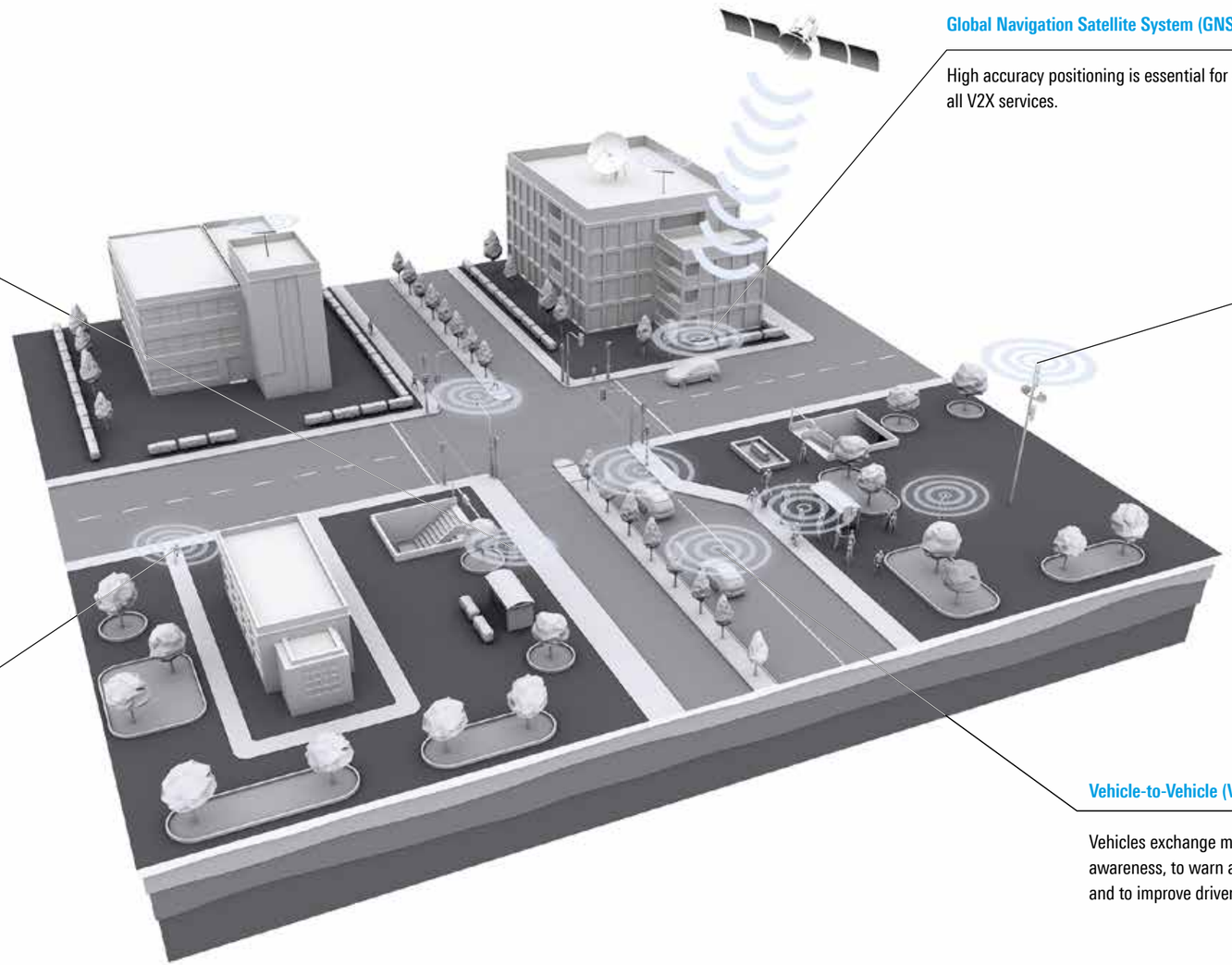
What´s coming

We are on the verge of a new generation of mobility. Development of highly or fully automated vehicles holds the promise of extremely high travel convenience and safety for vehicle users. To allow drivers to devote their full attention to other activities while underway, the vehicle must always be able to interpret the traffic situation and predict how it will develop. Current advanced driver assistant systems (ADAS) are based on a wide variety of sensors, but in the future, communications technology will play a role in the overall system and provide essential support for traffic situation analysis. The current practice of reacting to the behavior of other traffic participants can develop into a complete understanding of their intentions and further cooperation between traffic participants. Systems for vehicle-to-everything (V2X) networking are a basic prerequisite for this. All over the world, the industry now recognizes the importance of communications technology.

Your challenge ...

The challenges in the development of an overall system between different industry domains are manifold. It is still unclear whether the main driver for the adoption of V2X technology will be the market itself or provided by legislation, extending as far as the legally prescribed introduction of specific V2X technology. The basis for this development has been established by the allocation of a frequency band at 5.9 GHz for intelligent transportation systems (ITS). Communications technology is transitioning from an optional to a mandatory component of vehicle technology. We support the industry with suitable V2X measurement solutions for bringing radio components to commercial maturity, in accordance with the current high standards of the automobile industry.



Vehicle-to-Infrastructure (V2I)

Road infrastructure e.g. traffic lights, road signs provides information for traffic and speed management. Specific infrastructure offers additional services like parking management and road toll collection.

Global Navigation Satellite System (GNSS)

High accuracy positioning is essential for almost all V2X services.

Vehicle-to-Network (V2N)

Communications with backend systems establish automotive specific services like precise navigation maps and software updates, offer access to almost unlimited internet based applications.

Vehicle-to-Pedestrian (V2P)

Message exchange between vehicles and vulnerable road users encompassing e.g. pedestrian, cyclist etc. holds the promise of reduced road fatalities and serious injuries.

Vehicle-to-Vehicle (V2V)

Vehicles exchange messages to achieve cooperative awareness, to warn about road hazardous conditions and to improve driver assistance systems.

A tale of two important technologies: 802.11p and LTE-V

Dedicated short-range communications (DSRC) based on IEEE 802.11p

The IEEE 802.11p amendment was ratified in 2010. This standard for the wireless access protocols of the physical layer (PHY) and the medium access control (MAC) layer forms the basis for wireless access in vehicular environments (WAVE) in the USA and the intelligent transportation system at 5.9 GHz (ITS-G5) in Europe. Based on the internationally accepted WLAN protocols, IEEE 802.11p provides a wireless standard for V2X communications that is specifically adapted to the needs of the automobile industry for deployment in a highly dynamic environment. By employing fully distributed wireless coordination of channel access, this standard meets the automobile industry's demand for wireless network operation without a central coordinator by means of ad-hoc networks. The combination of orthogonal frequency division multiple access (OFDM) and expanded subcarrier spacing for easier compensation of Doppler shifts means the IEEE 802.11p standard is technically ideally sound for V2X communications.

Cellular V2X based on 3GPP LTE-V2X Release 14

Publication of Release 14 in 2016 by 3GPP, the standardization organization for mobile telecommunications systems around the world, laid the foundation for the wide-ranging development of cellular V2X (C-V2X) communications. The specific wireless protocols for device-to-device (D2D) communications in Release 12 have been fundamentally extended to fulfill the diverse requirements of V2X communications. The previously centralized coordination of mobile telecommunications networks is now complemented by ad-hoc communications. The fully self-coordinated C-V2X Mode 4 is specified as the completely cellular alternative to WLAN-based IEEE 802.11p.

Furthermore, LTE-V2X offers the coordinated Mode 3, which combines the advantages of a centrally coordinated mobile telecommunications network with those of direct vehicle-to-vehicle communications. In addition, C-V2X communications after Release 14 can be implemented just as completely via a centralized mobile telecommunications network, similar to current cell phone services. The 3GPP intends to further develop LTE-V2X into a 5G New Radio (5G NR) V2X. Currently, Release 15 LTE-based extensions are discussed in 3GPP. OFDMA, in combination with the TDMA and FDMA multiple access methods, enables efficient allocation of radio resources, taking into account time and frequency-dependent changes in the wireless channel. Among other things, the „resource pool" concept allows the coexistence of LTE V2X and 5G NR V2X in the same frequency band. Overall, the 3GPP technology is ideally suited to V2X communications, as it provides a uniform concept for vehicle networking, with a strong ecosystem and technological evolution.

Download our new App card and new white paper, please see www.rohde-schwarz.com/v2x

Testing the physical layer

Conformance testing

The physical layer of 802.11p is based on the 802.11a standard and specifies 5, 10 and 20 MHz bandwidths. The 5 MHz and 10 MHz bandwidths can be achieved by using a reduced clock / sampling rate. 802.11a uses the full clocked mode with 20 MHz bandwidth while 802.11p uses the half clocked mode with 10 MHz bandwidth. Regardless of the bandwidth, the FFT size is 64 and the number of subcarriers is 52 (48 data subcarriers and 4 pilot subcarriers). There are two important changes to the TX and RX specifications to support 11p/ITS- a much stricter spectrum mask and stricter adjacent and non-adjacent channel rejection requirements.

For more information:

www.rohde-schwarz.com/v2x_conformance

For WLAN 802.11p, the R&S®TS-ITS100 RF test system contains the complete package of test cases for Europe (ETSI EN 302 571), USA (IEEE 802.11-2012) and Japan (TELEC T257 and ARIB STD-T109).

Benefits

- Fully automated RF test solution
- Reproducible test results
- RF filter for out-of-band test cases included in OSP-ITS
- R&D benefits:
  - Many parameters can be changed for each test case individually
  - Easy to use R&S®Contest GUI
  - Extensive test, report and analysis functionalities

For more information:

www.rohde-schwarz.com/automotive

Testing transmitter accuracy

Transmitter measurements are important in a wireless communication system. Some measurements verify that the signal at transmission will be what a receiver would expect to see (ignoring degradations that will occur due to fading, noise, etc.) and to verify that the signal will not interfere with devices operating in adjacent spectral bands. For safety critical systems like 11p these tests become even more important.

Transmitter tests can be divided into two main categories: modulation accuracy and spectrum quality. Spectrum quality would include, for example, spectrum mask, spurious emissions, and occupied bandwidth. Modulation accuracy tests would include, for example, EVM, spectral flatness, and center frequency leakage. Fortunately, modern signal spectrum analyzers, such as the R&S®FSW and R&S®FSV using the R&S®FSx-K91p option, are able to perform these measurements quickly and easily. The R&S®FSx-K91p option automatically detects the signal bandwidth and modulation type. This way a mixed signal configuration can be analyzed.

Benefits

- Frequency range from 2 Hz to 8/13.6/26.5/43.5/50/67/85/90 GHz (with external harmonic mixers from Rohde&Schwarz up to 500 GHz)
- Low phase noise of –137 dBc (1 Hz) at 10 kHz offset (1 GHz carrier)
- Real-time analysis up to 512 MHz bandwidth
- High-resolution 12.1" (31 cm) touchscreen for convenient operation
- Multiple measurement applications can be run and displayed in parallel

The R&S® TS-ITS100 is an integrated test system for testing IEEE 802.11p conformity and the performance of user equipment.

R&S®FSW Signal and Spectrum Analyzer
Setting standards in RF performance and usability.

Testing in varying conditions

Reproducible receiver tests under fading conditions

In car-to-car communications scenarios, fading is always present and has an enormous impact on the received signal. To ensure a good wireless link, receivers must be able to detect signals such as IEEE 802.11p even under the worst conditions, e.g. low signal-to-noise ratio (SNR), poor error vector magnitude (EVM) and heavy fading.

The R&S®SMW200A vector signal generator lets you perform the most accurate and reproducible receiver tests under car-to-car fading conditions. The required car-to-car radio channel models have been extracted from real field trials and specified by the CAR 2 CAR Communication Consortium. Now it is possible to verify receiver performance under controlled conditions in the lab.

Benefits

- Supports all five car-to-car radio channel models
- Brings real-world, car-to-car radio channels to the lab
- Lets you create reproducible receiver test cases under controlled fading conditions in car-to-car communications scenarios
- Simplifies signal generation under car-to-car fading conditions
- Allows engineers to fully focus on receiver testing

Download our App card:

www.rohde-schwarz.com/v2x-receivertesting

Powerful protocol testing of C-V2X 3GPP Rel. 14

The LTE based version of vehicle-to-vehicle communications builds upon the device-to-device features of release 12 with improved handling of high speed fading through an increased number of reference signals and support for high density environments by using new transmission structures and more efficient resource allocation. There is support for out of coverage mode with synchronization of the vehicles using the existing GNSS satellite signals, and in network mode, which takes advantage of the existing LTE network.

All of these new features need testing, for example, how well does your receiver work when there are hundreds of other signals present?

With the R&S®CMW500 3GPP Release 14 LTE-V2X test package it is possible to modify a number of sidelink parameters and to verify successful V2X IP Data transmission from the DUT over the PC5 interface.

Benefits

- Sidelink TM4 according to 3GPP Rel.14 (only PSCCH, PSSCH)
- out-of-coverage operation with GNSS synchronization
- PC5 communication, only
- Sidelink and GNSS-Simulation controlled via MLAPI test scenario
- MLAPI test scenario package: R&S®CMW-KU514 – LTE Rel.-14 V2X TM4 out of coverage
- R&S®CMW as SyncRefUE with PSSS, SSSS, MIB-SL-V2X planned

R&S®SMW200A Vector Signal Generator
The fine art of signal generation.

The R&S®CMW500 and the R&S®SMBV100A
are your solution for testing C-V2X.

Accuracy and repeatability

High accuracy positioning with GNSS simulation

Whether you are simulating a very accurate position for the V2X basic safety messages (BSM) or a precise synchronization signal for out-of-network communication in C-V2X, GNSS simulation is important.

Typical tests include the determination of the receiver's time to first fix, acquisition and tracking sensitivity, reacquisition time and its ability to provide an accurate positioning solution. Such location accuracy tests are typically performed assuming a static or a moving receiver. In addition to these standard tests, it is often required to test the receiver's performance under special conditions or in dedicated environments such as interference or multipath environments or under the influence of atmospheric effects and dynamic stress.

Benefits

- Support of GPS, Glonass, BeiDou, Galileo, SBAS and QZSS, including GPS P-Code
- Signal generation in the L1 and L2 frequency bands for up to 24 satellites

Powerful solutions production test

Today's production lines for wireless services require an optimal combination of flexibility, performance and capacity utilization. As the leading supplier of T&M equipment for the production of wireless devices, Rohde & Schwarz meets these stringent requirements with the R&S®CMW platform. The R&S®CMW500 wideband radio communication tester and the R&S®CMW100 communication manufacturing test set are ideal for use in production.

The R&S®CMW500 as a standard production solution meets all these requirements. It is the global market leader for wireless device production tests and is used by nearly every top manufacturer.

The R&S®CMW100 can perform receiver and transmitter tests for cellular and non-cellular technologies. Like the R&S®CMW500, the R&S®CMW100 features high measurement accuracy.

Benefits

- High flexibility when designing production concepts thanks to horizontal or vertical mounting
- Short implementation time and ramp-up phase thanks to R&S®CMW500 - Production test compatible T&M and remote control concept
- High accuracy and throughput thanks to fully automatic level correction

The R&S®SMBV100A is a general purpose vector signal generator that can be turned into a full-featured GNSS simulator.

The R&S®CMW family is the ideal solution for production testing.

Service that adds value

- Worldwide
- Local and personalized
- Customized and flexible
- Uncompromising quality
- Long-term dependability

Rohde&Schwarz

The Rohde&Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

Certified Quality Management ISO 9001

Certified Environmental Management ISO 14001

Certified Quality Management AQAP-2110

Certified Quality Management EN 9100

Rohde&Schwarz GmbH&Co. KG
www.rohde-schwarz.com

Regional contact

- Europe, Africa, Middle East | +49 89 4129 12345
  customersupport@rohde-schwarz.com
- North America | 1 888 TEST RSA (1 888 837 87 72)
  customer.support@rsa.rohde-schwarz.com
- Latin America | +1 410 910 79 88
  customersupport.la@rohde-schwarz.com
- Asia Pacific | +65 65 13 04 88
  customersupport.asia@rohde-schwarz.com
- China | +86 800 810 82 28 | +86 400 650 58 96
  customersupport.china@rohde-schwarz.com

PD 5215.8535.32, englisch, Version 01.00 | April 2018
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5215853532

5215.8535.32 01.00 PDP 1 en