Spirent V2X

Agenda

- Spirent V2X Video
- V2X, its trends and how does it work
- V2X Standardisation History
- C-V2X, what is the advantage?
- Will there be a „winner“?

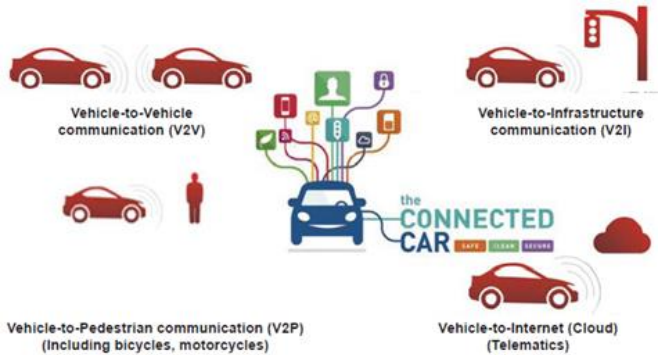


Fig. 3: What is V2X?

Demo Video

What are the trends?

- Mainly security
- Improving travel times
- Reducing pollusion
- Providing traffic, weather and other informations to vehicles and drivers
- Integrating the vehicle into the smart city of tomorrow
- Enabling the autonomus car in the future

V2X, how does it work?

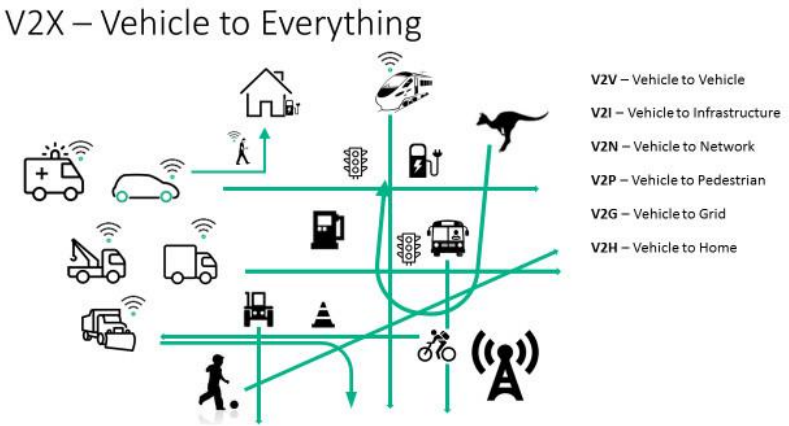
- V2X communication is based on WLAN technology and works directly between vehicles or the infrastructure, which form a vehicular ad-hoc network. As two V2X senders come within each other's range. Hence it does not require any infrastructure for vehicles to communicate, which is key to assure safety in remote or little areas.

- It is particularly well-suited for V2X communication, due to its low latency and the ability to communicate instantly. It transmits messages known as Common Awareness Messages (CAM) and Decentralised Notification Messages (DENM) or Basic Safety Message (BSM).

- The data volume of these messages is very low. The radio technology is standardised as part of the WLAN IEEE 802.11 family of standards and known in the US as WAVE (Wireless Access in Vehicular Environments) and in Europe as ITS-G5.

V2X, what is it used for?

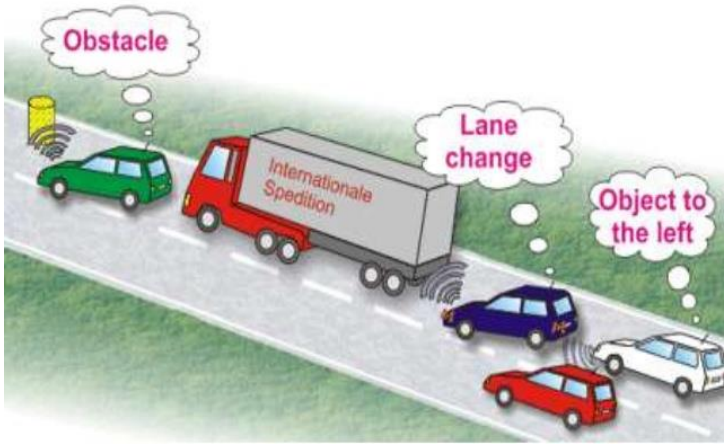
- V2X or Vehicle to everything communication is the passing of information from a vehicle to any entity that may affect the vehicle, and vice versa. It is a vehicular communication system that incorporates other, more specific types of communication as V2I (Vehicle-to-Infrastructure), V2V (Vehicle to vehicle), V2P (Vehicle to Pedestrian) as well as V2G (Vehicle to Grid).



V2V, what is it used for?

- Vehicle-to-vehicle (V2V) is an automobile technology designed to allow automobiles to "talk" to each other.
- Automobiles form a wireless ad-hoc network on the roads. Such networks are also referred to as vehicular ad hoc networks.
- What are cars „talking“ about?

  - Forward collision waring
  - Blind spot/ Lane change warning
  - Emergency Electric Brake Light Warning
  - Intersection collision waring

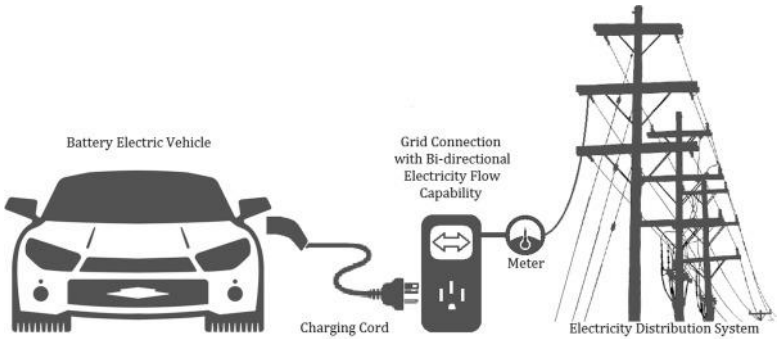


Information sharing between vehicles

V2G, what is it used for?

- Vehicle-to-grid(V2G) describes a system in which plug in electric vehicles, such as electric cars, plugin hybrids or hydrogen Fuel Cell Electric Vehicles, communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

- Vehicle-to-grid can be used with *gridable* vehicles, that is, plug-in electric vehicles (BEV and PHEV), with grid capacity.



V2X Standardisation History

- WLAN-V2X communication is based on a set of standards drafted by the Amrerican Society of Testing and Materials (ASTM). The ASTM E 2213 series of standards looks at wireless communication for high-speed information exchange between vehicles themselves as well as road infrastructure. The first standard of this series was published 2002. Here the acronym Wireless Access in Vehicular Environments (WAVE) was first used for V2X communication.

- From 2004 onwards the Institute Electrical and Electronics Engineers (IEEE) started to work on wireless access for vehicles under the umbrella of their standards family IEEE 802.11 for Wireless Local Area Networks (WLAN). Their initial standard for wireless communication for vehicles is known as IEEE 802.11p. Later on in 2012 IEEE 802.11p was incorporated in IEEE 802.11.

V2X Standardisation History

- Around 2007 IEEE started to develop the 1609.x standards family standardising applications and a security framework (for WAVE), and soon after SAE started to specify standards for V2V communication applications.

- In parallel at ETSI (European Telekommunikation Standardisation Institute) the technical committee for ITS (Intelligent Transport Systems) was founded and started to produce standards for protocols and applications (ETSI coined the term ITS-G5). All these standards are based on IEEE 802.11p technology.

- Between 2012 and 2013, the Japanese Association of Radio Industries and Businesses (ARIB) specified, also based on IEEE 802.11, a V2V and V2I communication system in the 700 MHz frequency band.

- In 2015 ITU published as summary of all V2V and V2I standards that are world wide in use, comprising the systems specified by ETSI, IEEE, ARIB, and TTA (Republic of Korea, Telecommunication Technology Association).

… and finally

- 3GGP announced for 2017 a first set of LTE-V physical layer standards for V2I and V2V communication that uses a radio technology different from IEEE 802.11 WLAN.

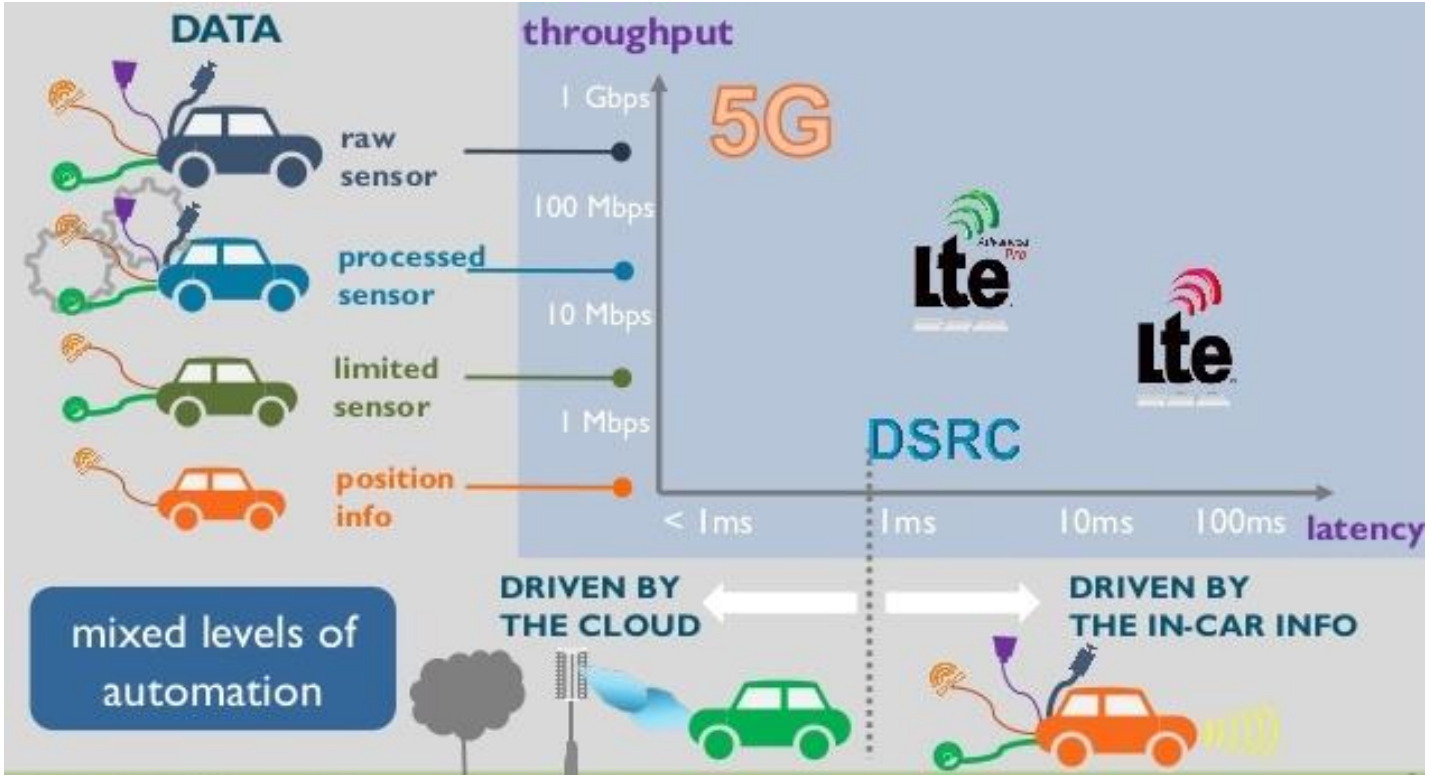
C-V2X, how it works

- C-V2X is designed to complement and extend existing cellular capabilities. Like 802.11p, C-V2X direct communications support active safety and enhance situational awareness by detecting and exchanging information using low-latency transmission in the 5.9-GHz ITS band for vehicle-to-vehicle (V2V) as well as V2I and V2P scenarios. It can function without network assistance and has a range that exceeds two kilometers, even in areas where mobile network connections aren't available.

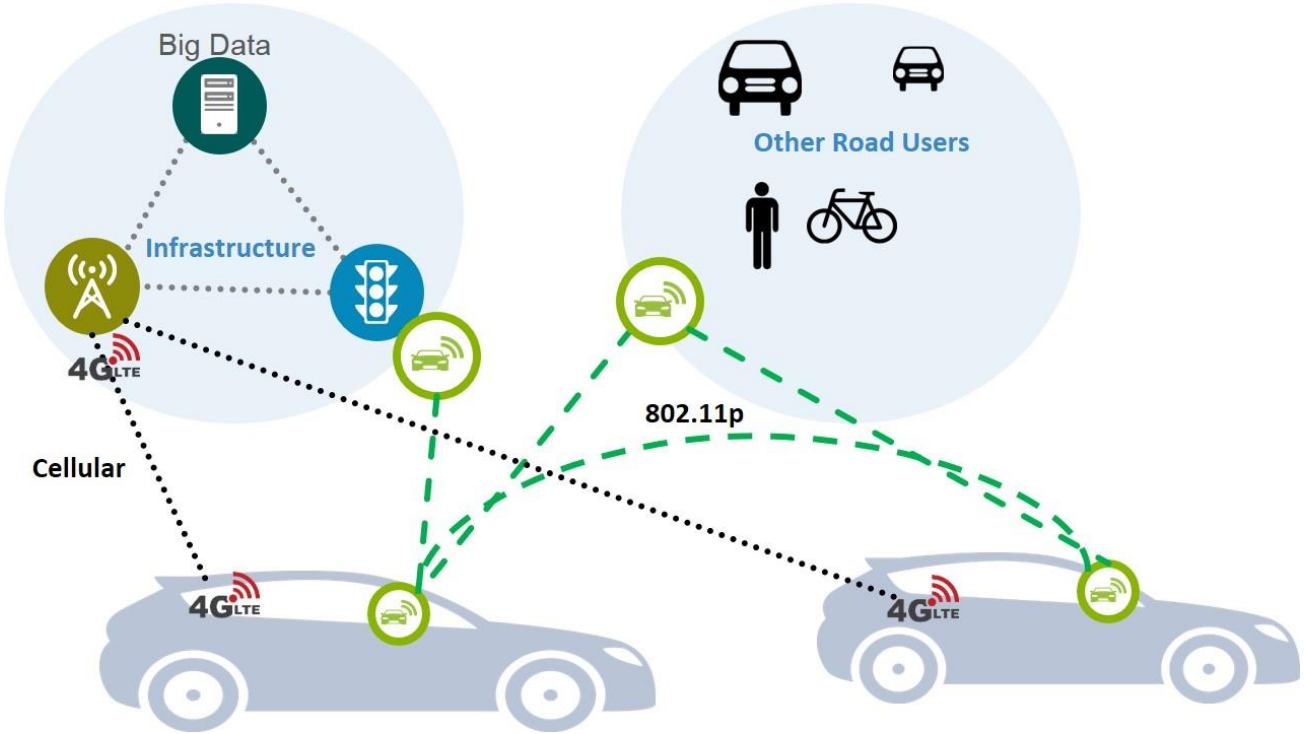
- C-V2X can combine the capabilities of roadside units (RSUs) and the cellular network to help improve safety and support autonomous driving. RSUs are radio base stations installed at intersections or along theside of the road (they can be on lamp poles, traffic light poles, andelectronic toll collectors) that allow communications between vehicles(V2I or I2V) within a localized area. The roadside units will use ahigh-throughput connection with other cars on the road to build local, dynamic HD maps using camera and sensor data, and distribute them as needed.

DSRC vs C-V2X

- Main difference is the range/communication distance, communication speed and data throughput
- While DSRC operates on a short distance between vehicles, C-V2X provides a wider range for C2X communication
- Cars will be able to communicate with the world around them without having to use a cellular network. C-V2X Direct communications enhance LTE Direct device-to-device communications with innovations to exchange real-time information between vehicles traveling at high speed, in high-density traffic, and even outside of mobile network coverage areas – enabling safer driving through true direct communications on a designated radio spectrum.


DATA
throughput
1 Gbps
5G
raw sensor
100 Mbps
processed sensor
10 Mbps
limited sensor
1 Mbps
position info
DSRC
< 1ms
1ms
10ms
100ms
latency
mixed levels of automation
DRIVEN BY THE CLOUD
DRIVEN BY THE IN-CAR INFO

Cellular and IEEE 802.11p for C-ITS



Proponent of C-V2X

- The ability to use all features provided by the existing cellular LTE network.
- It allowes to connect the car to all types of objects that either have sensors or cellular connectivity (including people via their smartphones).
- Improvements over 802.11p such as better alert latency and 2x the range.
- 5G-based C-V2X will be a key step toward autonomous cars, because it can help cars detect obstructions that aren’t visible to the driver.
- Since C-V2X can offer both device-to-device (V2V, V2I, and V2P) and device-to-network (V2N) services, it’s better suited to new and connected transportation systems around the globe.

Proponent of C-V2X

- C-V2X is being designed to work now, and a decade from now.
- Unlike older V2X technologies, C-V2X has a technology evolution roadmap, providing a unified connectivity platform for the safer vehicles of tomorrow.
- TheC-V2X roadmap will benefit enormously from the strong LTE evolution path and the introduction of 5G technologies in the coming years, and from the mobile ecosystem as a whole.
- The evolution of C-V2X is already being discussed, and we envision a growing set of use cases, including ultra-low latency vehicle platooning, high throughput sensor sharing, video see-through, and other automated driving requirements.

Will there be a „winner“?

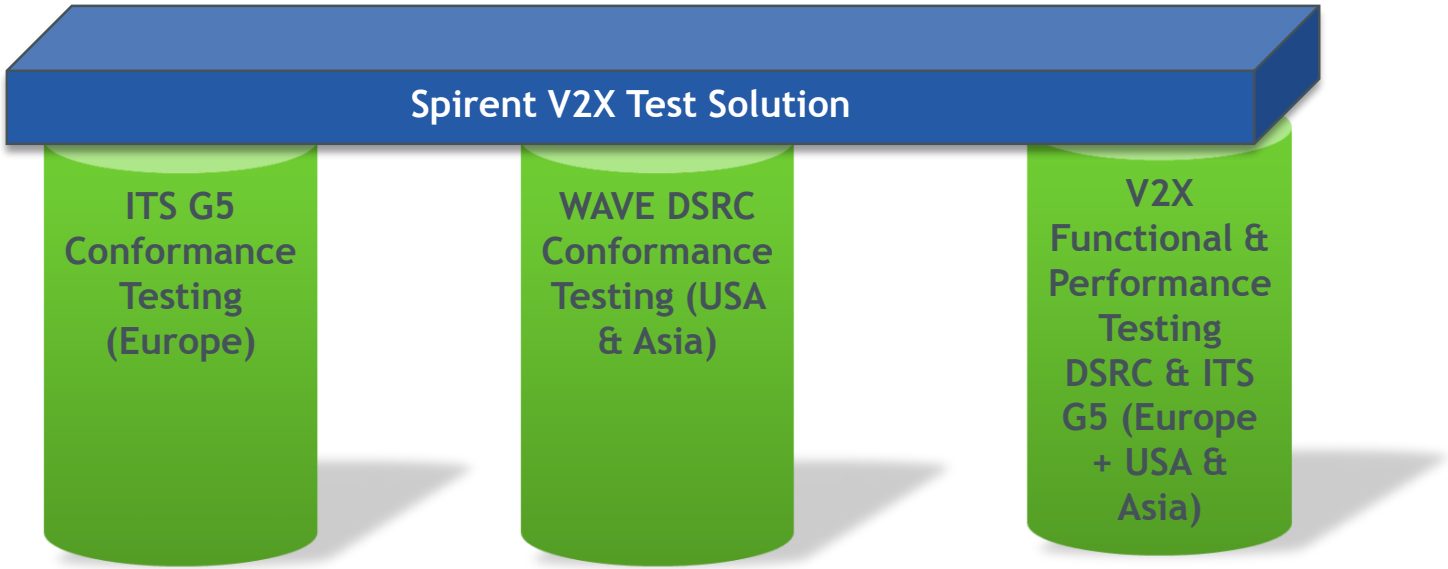
- It’s difficult to say at this point.
- At the moment, 802.11p has an advantage, because the 5.9-GHz band made available in the U.S. more than a decade ago remains reserved for DSRC. Unless the C-V2X contingent, led by its chief trumpeter the 5GAutomotive Association (5GAA), can convince government regulators thatC-V2X offers a potentially technically superior and more flexible alternative.
- In Europe, the EU plans to roll out System (C-ITS) in 2019. It, too, initially intended to make 802.11p the basis of the radio standard for safety-related messages between vehicles within the C-ITS framework called ITS-G5.

So what do we test?

- Conformance
  - To check the bits and bytes of the hard- and software implementation a specified standard.
- Performance
  - To check if the hard ware acts and reacts as we expect it.

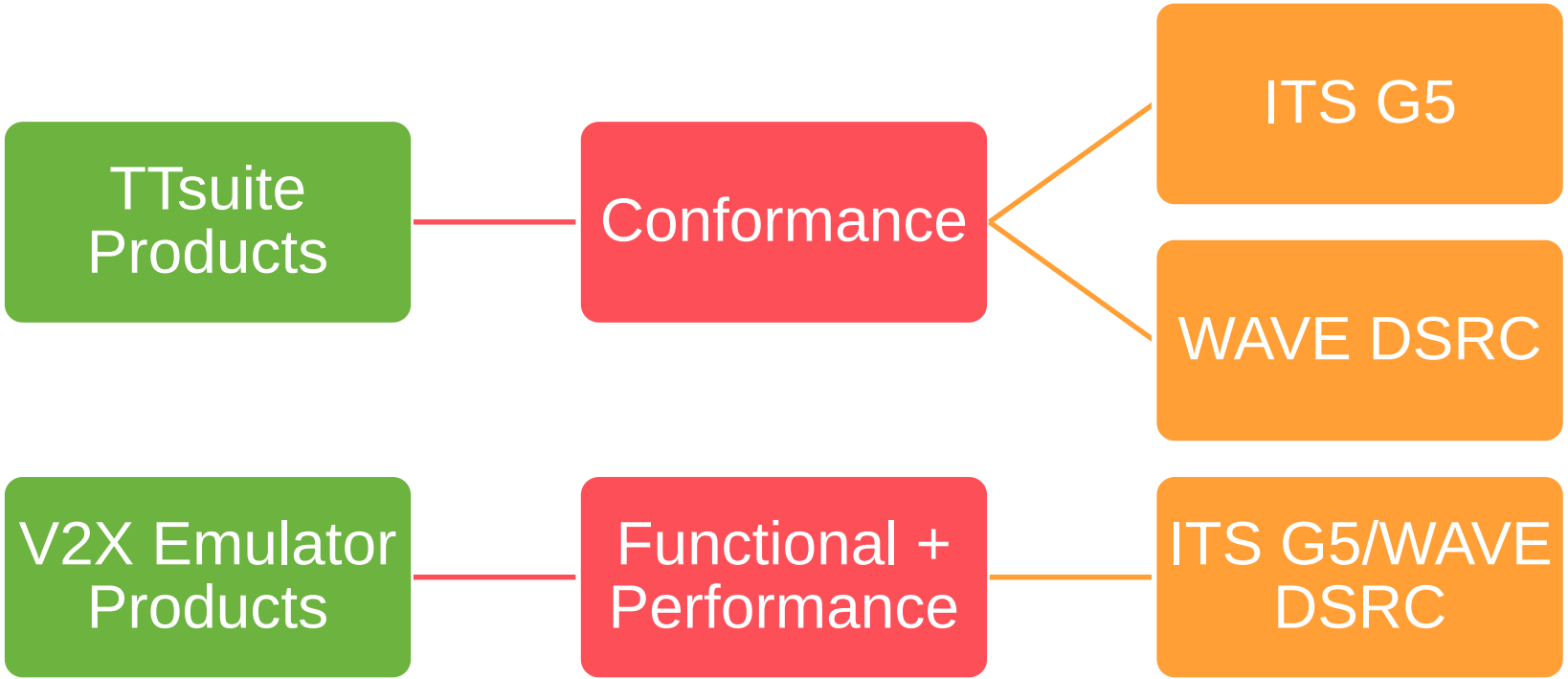
Spirent
V2X Test Solutions

V2X Test Solution Product Architecture



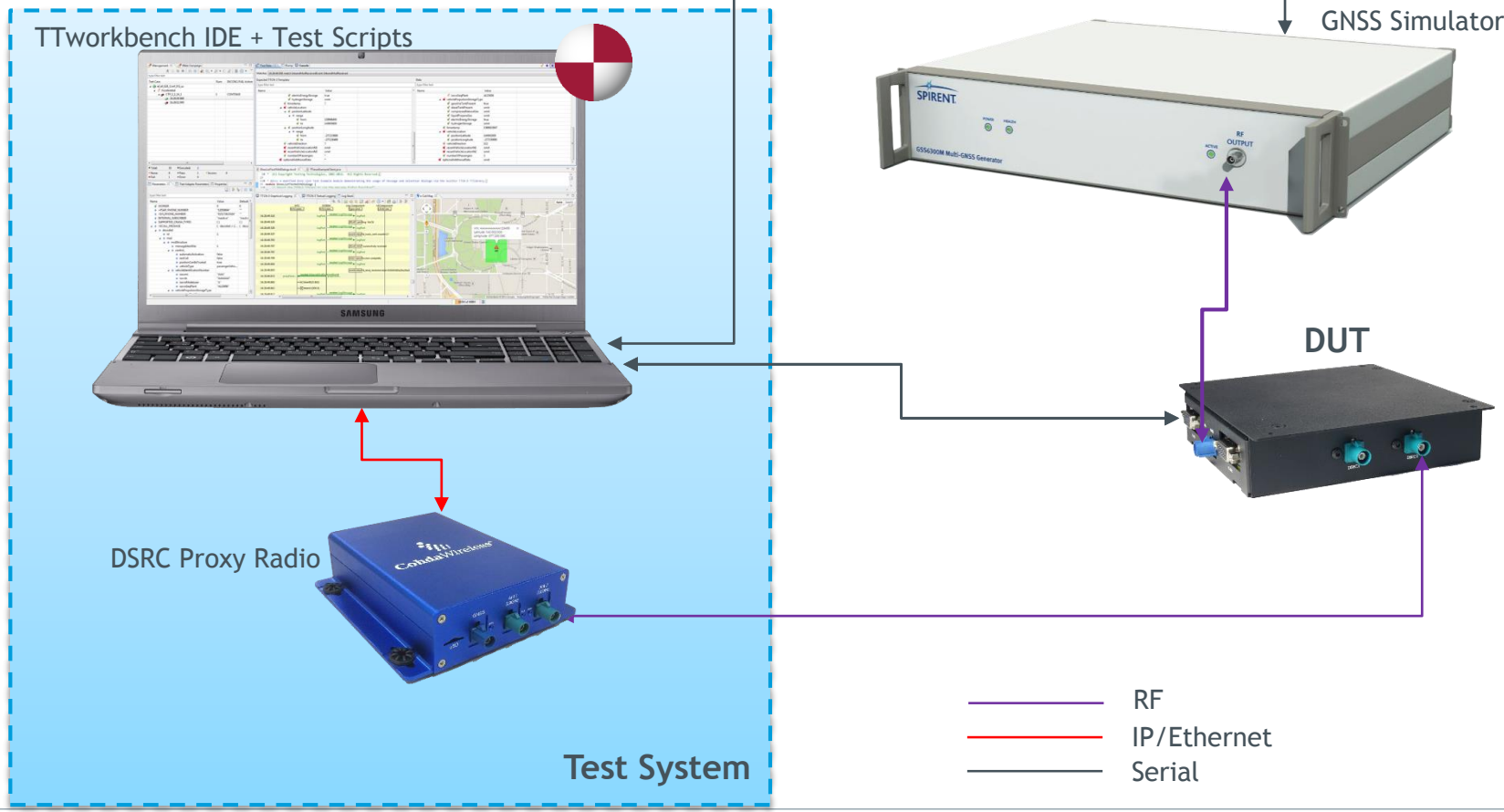
Recommended Test Process Overview

Spirent V2X Product Hierarchy



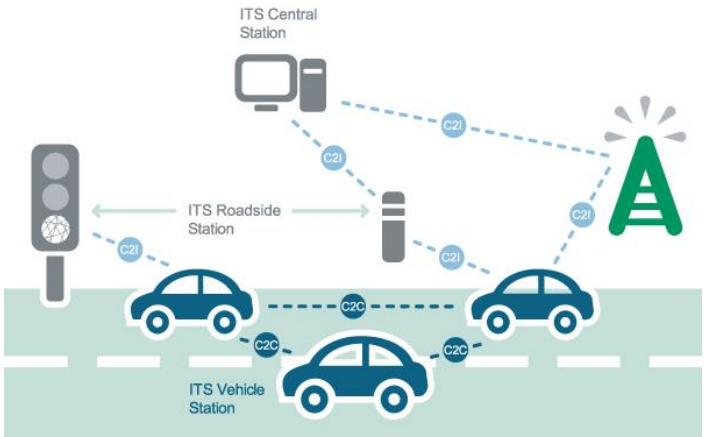
TTsuite V2X: Conformance Testing

Solution Overview



ITS-G5 Test Suite Pack

- Protocol conformance test suites for the European V2X ITS-G5, according to the ETSI test specification
- Uses Cohda Wireless MK5 as Proxy for 802.11p radio, supporting different DCC profiles or optionally directly over Ethernet
- All test suites are prepared for full test automation via UDP and include frameworks for individual adaptation
- Included test suites (264 test cases)
  - GeoNetworking ITS-G5 (GN)
  - GeoNetworking Basic Transport Protocol (BTP)
  - Transmission of IP packets over GeoNetworking (GN6)
  - Co-operative Awareness Messages (CAM)
  - Decentralized Environmental Notification Messages (DENM)
  - Signal Phase And Timing (SPAT) and Map (MAP)
  - Security Testing



Spirent WAVE-DSRC Test System

- USDOT DSRC certification program driven by 7Layers, DanLaw, Southwest Research Institute (SwRI)
- Close collaboration with 7Layers to implement test cases according to USDOT test specifications for
  - IEEE 1609.3 34 test cases for WAVE Short Messages (WSM), WAVE Service Advertisements (WSA), Internet Protocol
  - IEEE 1609.2 22 test cases for Basic Safety Messages (BSM) und WSA
  - IEEE 1609.4 test cases for Upper MAC
  - SAE J2945/1 2016 test cases
- Running on a Cohda Wireless MK5 802.11p radio supporting different DCC profiles
- All test suites are prepared for full test automation via UDP and include frameworks for individual adaptation

CERTIFICATE OF QUALIFIED TEST EQUIPMENT

OMNIAIR CONSORTIUM

SPIRENT Communications

OMNIAIR CERTIFIED

QUALIFIED TEST EQUIPMENT

2017101101

Spirent Communications plc

Model: **TTsuite-WAVE-DSRC** Software Version: **1.0.2**

For passing the audit requirements to become an OmniAir Qualified Test Equipment Provider

Connected Vehicle V2X–DSRC Conformity Assessment Release 1

CERTIFICATE # 2017101101 Awarded this 11th day of October 2017

and expires in two years unless product or scope changes occur

OMNIAIR CERTIFIED

Randy Roebuck / Technical Director
OmniAir Consortium, Inc.

Jason M. Conley

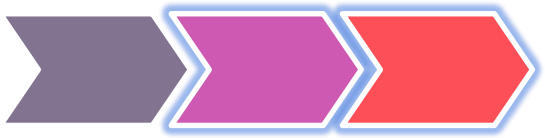
Jason Conley / Executive Director
OmniAir Consortium, Inc.

V2X Emulator: Functional and Performance Testing

Use Cases

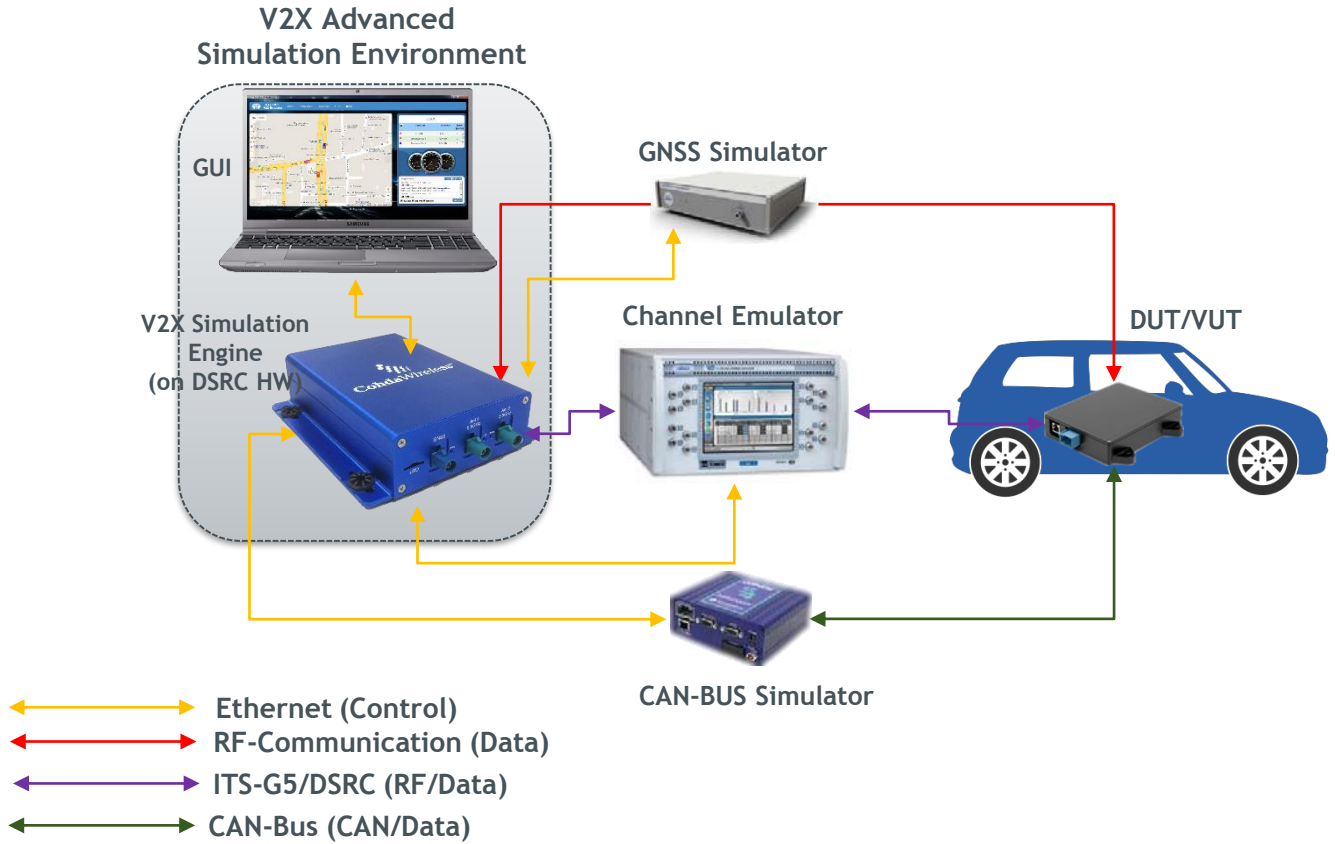
- Use Cases
  - Functional Testing
    - RSU/OBU Behaviour in safety application scenario
  - Performance Testing
    - RSU Benchmarking
    - RSUs Scalability Testing
    - OBU Performance / Robustness Testing
      - Latencies
      - Behaviour under channel impairments
- Scalability Testing
  - Each VSE runs on a DSRC HW device and emulates more than one ITS unit (OBU/RSU)
  - Currently a maximum of 10 units (OBUs/RSUs) can be emulated by each VSE
  - Final version to support scenarios with hundreds of emulated units (25 units per DSRC HW)

V2X Emulator Features



- Supports both WAVE (US) and ITS-G5 (Europe) standards
- Many emulated OBUs/ RSUs on single DSRC hardware
  - GNSS signal simulation
  - CAN emulation
  - Wireless channel emulation
- V2X security testing
- Functional and performance testing supported
- Assessment of V2V and V2I/I2V Safety applications
- Test report generation

V2X Emulator Architecture



V2X Functional & Performance Solution - Roadmap

- 50 Emulated vehicles
- 13 Safety Applications
- Record & Playback support
- Advanced V2X Security Support

- 100+ Emulated vehicles
- 15 Safety Applications
- Vertex Channel Emulator Integration

- Advanced Channel Emulator integration
- China-ITS Standard Support
- C-V2X (LTE-V) Support

- C-V2X (5G) Support

Thank you !