CELLULAR VEHICLE TO EVERYTHING (C-V2X)

TESTING CONNECTED VEHICLES IN THE LAB


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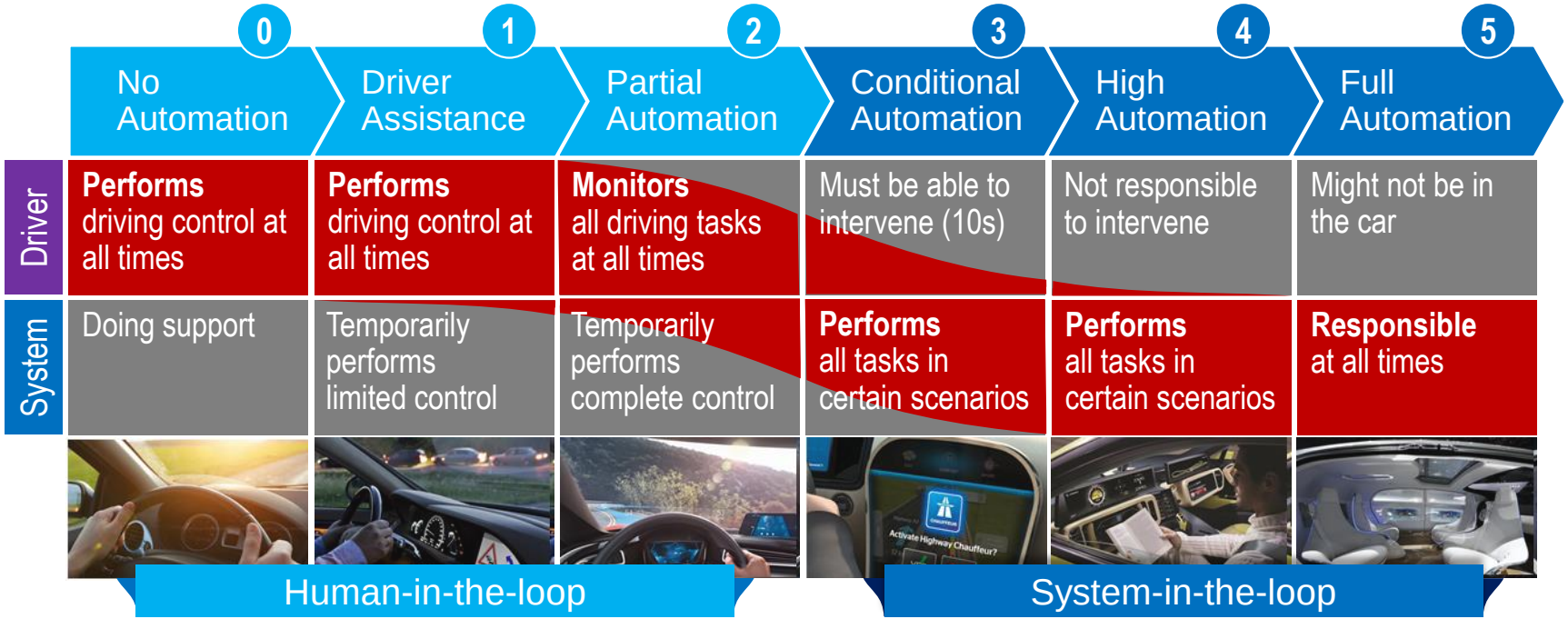
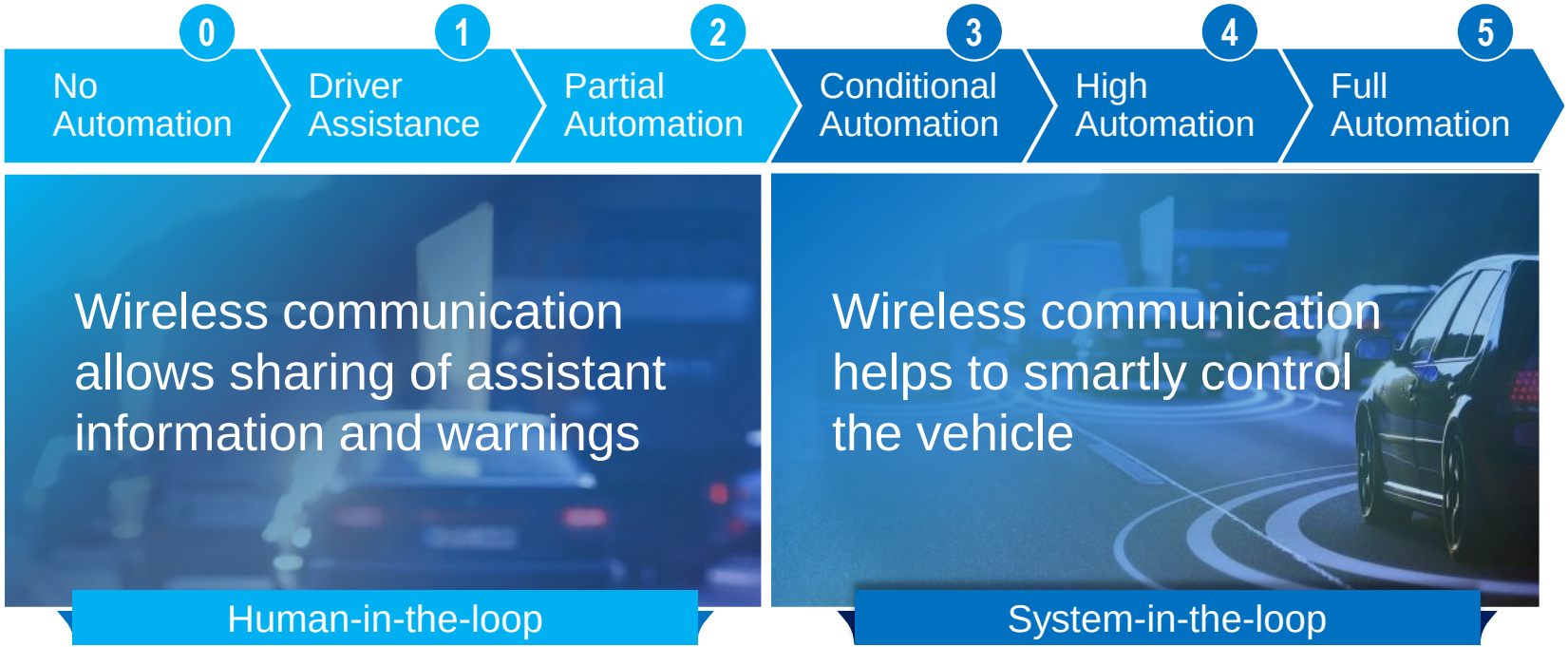
ROHDE&SCHWARZ
Make ideas real

SIX LEVELS OF DRIVING AUTOMATION



SAE J3016 Level of Automation (LoA) specified by Society of Automobile Engineers(SAE)

SIX LEVELS OF DRIVING AUTOMATION
THE ROLE OF WIRELESS COMMUNICATION

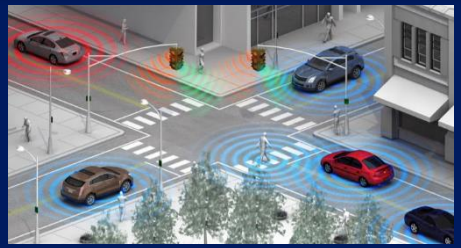


SAE J3016 Level of Automation (LoA) specified by Society of Automobile Engineers(SAE)

COOPERATIVE INTELLIGENT TRANSPORTATION SYSTEM (C-ITS) SHORT-TERM DEPLOYMENT

Emergency Electronic Brake Lights

Intersection Movement Assist



Left Turn Assist

Queue Warning

COOPERATIVE INTELLIGENT TRANSPORTATION SYSTEM (C-ITS) MID-TERM DEPLOYMENT

See-Through

Real-Time Awareness

Vulnerable Road User Discovery

Speed Harmonization

Sensor Sharing

COOPERATIVE INTELLIGENT TRANSPORTATION SYSTEM (C-ITS) LONG-TERM DEPLOYMENT

Cooperative Maneuver

Remote Controlled Parking

Data Sharing for Autonomous Driving

Data Offloading

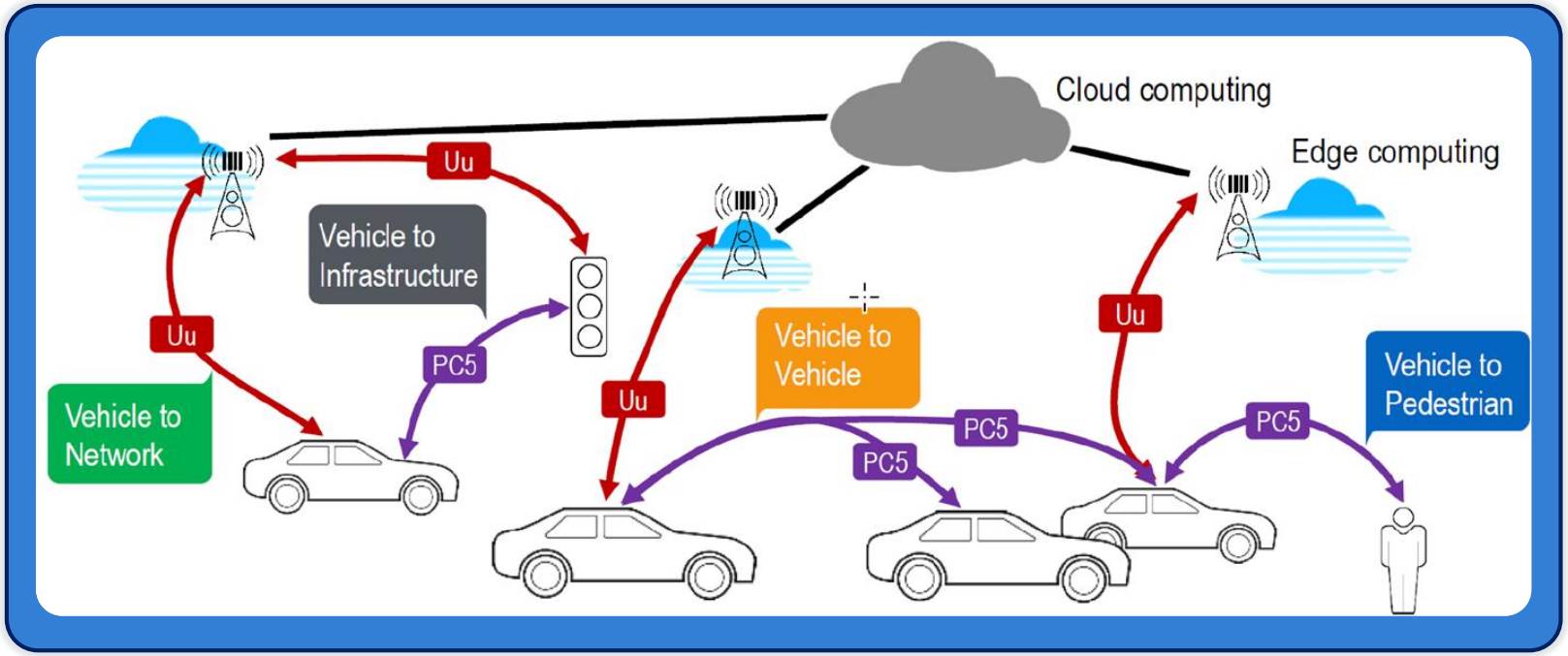
3GPP LTE-V2X

- 3GPP LTE-V2X Release 14
- V2V published in 2016, V2X in 2017
- Industry term: Cellular V2X (C-V2X)
- Peer-to-peer ad-hoc communication:
  - service continuity, to operate independent of any centralized system
- Backend connectivity through mobile network
- V2V targets 5.9GHz ITS frequency band

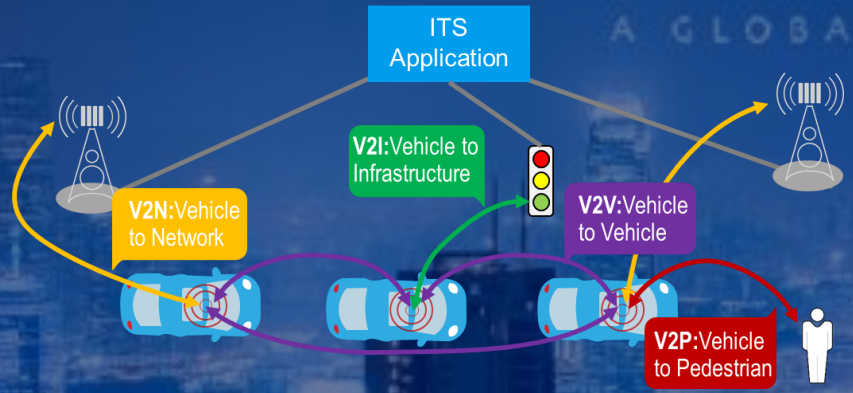
IEEE 802.11p

- Amendment to IEEE 802.11 (derived from 11a)
- Ratified in 2010
- EU: Car-to-Everything (C2X), ITS-G5
- U.S: Dedicated Short Range Communication (DSRC), WAVE
- Peer-to-peer ad-hoc communication
- Backend connectivity through Road Side Units
- 5.9GHz ITS frequency band

3GPP C-V2X NETWORK ARCHITECTURE



COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS (C-ITS): 3GPP APPROACH



Application	Safety US	Safety EU	Safety China
	BSM	CAM / DENM	BSM
Transport	WSMP	BTP	DSMP
Network		GeoNet	ADLayer
MAC	Packet Data Convergence		
	Radio Link Control		
	Medium Access Control		
PHY	SC-FDMA		
	USA	EU	China

COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS (C-ITS): 3GPP APPROACH

BSM **B**asic **S**afety **M**essage

SC-FDMA **S**ingle **C**arrier **F**requency **D**ivision **M**ultiple **A**ccess

DENM **D**ecentralized **E**nvironment **N**otification **M**essage

CAM **C**ooperative **A**wareness **M**essage

ADLayer **A**daptation **L**ayer

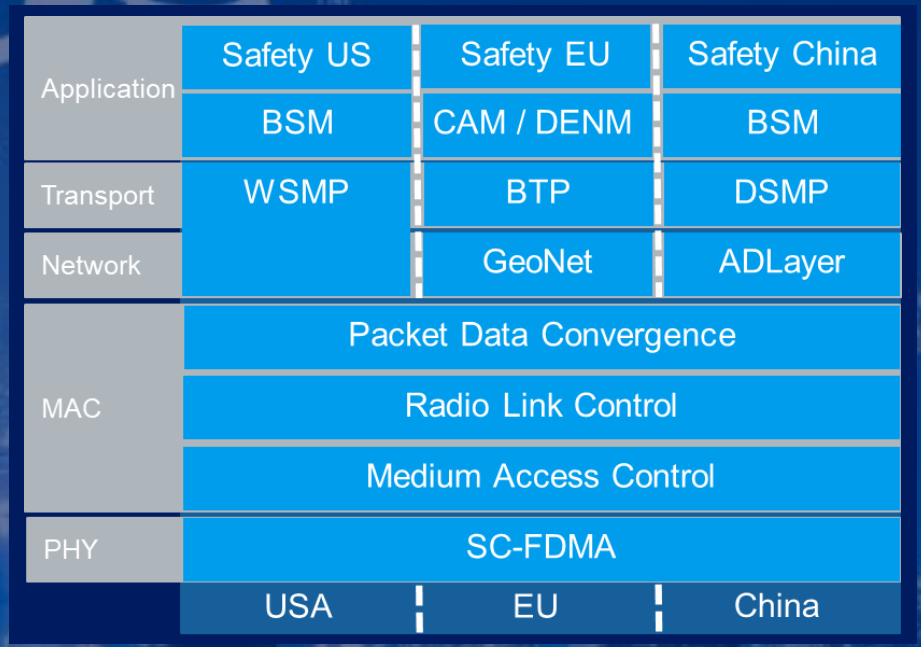
WSMP – **W**AVE **S**hort **M**essage **P**rotocol

WAVE **W**ireless **A**ccess in **V**ehicular **E**nvironments

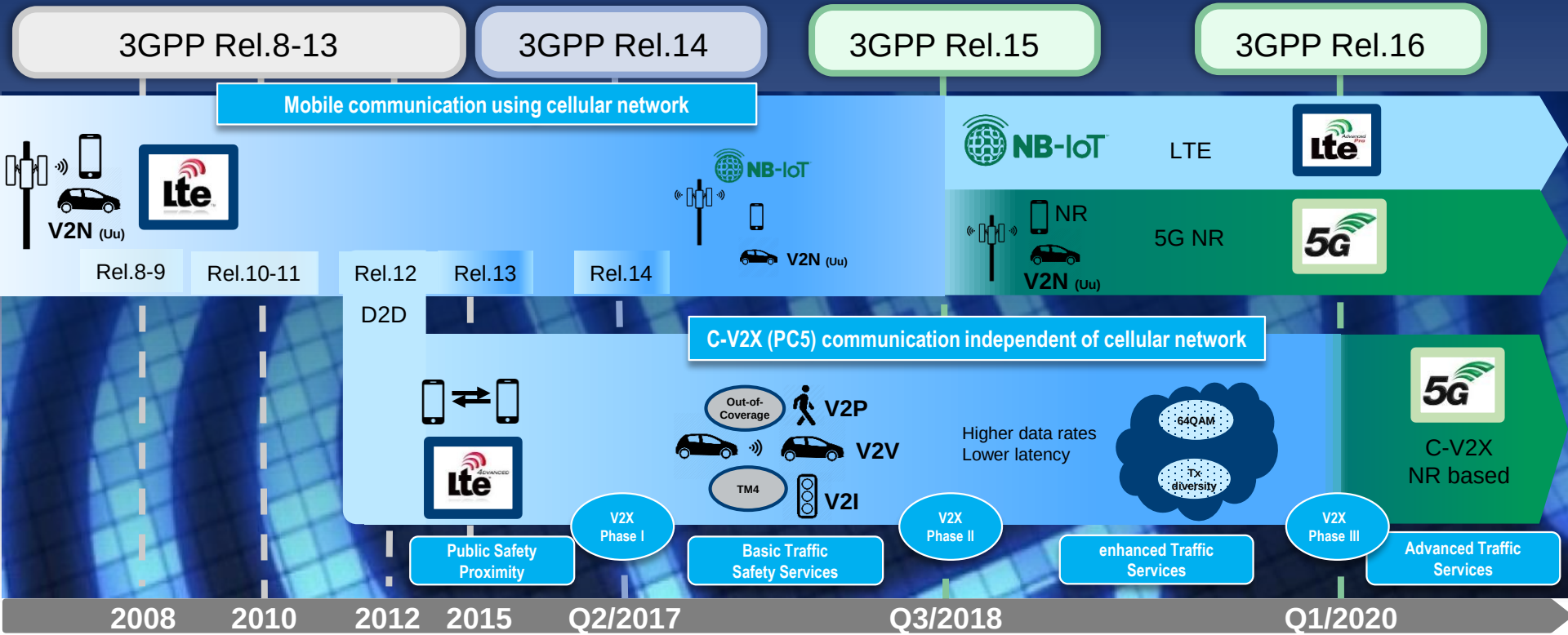
BTP **B**asic **T**ransport **P**rotocol

GeoNet **Geo** **Net**working

DSMP **D**SRC **S**hort **M**essage **P**rotocol



3GPP MOBILE COMMUNICATIONS STANDARD
C-V2X ON THE WAY TO 5G NR



3GPP RELEASE 14: PHASE I LTE-V2X

Collaborative Awareness

Extended Visual Horizon

Support direct V2X communication, distributed random and reservation based resource usage to exchange basic traffic safety information

Traffic Warning

Hazardous Information

- Broadcast transmission service w/o network subscription
- Direct PC5 and mobile network Uu communication
- Operation in licensed-exempt ITS 5.9GHz frequency spectrum
- Semi-persitant scheduling yields spectral efficiency

3GPP RELEASE 15: PHASE II LTE-V2X

Vehicle Platooning

Extended Sensors

Support of low latency, high data rate links to exchange data for enhanced automotive applications

Advanced Driving

Collaborative Perception

- Transmit diversity
- Support of 64QAM for higher data rate
- Reduce the max. time between L1 packet arrival and resource selected for transmission from 20 to 10 ms
- Aggregation of up to 8 PC5 carriers (TM3 & TM4)

3GPP RELEASE 16: PHASE III 5G NR V2X

High Density Platooning

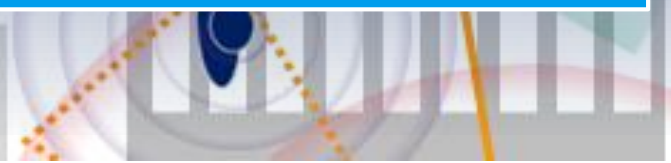
Advanced Sensors Data Sharing

Support broadcast, groupcast, unicast communications for advanced automotive applications

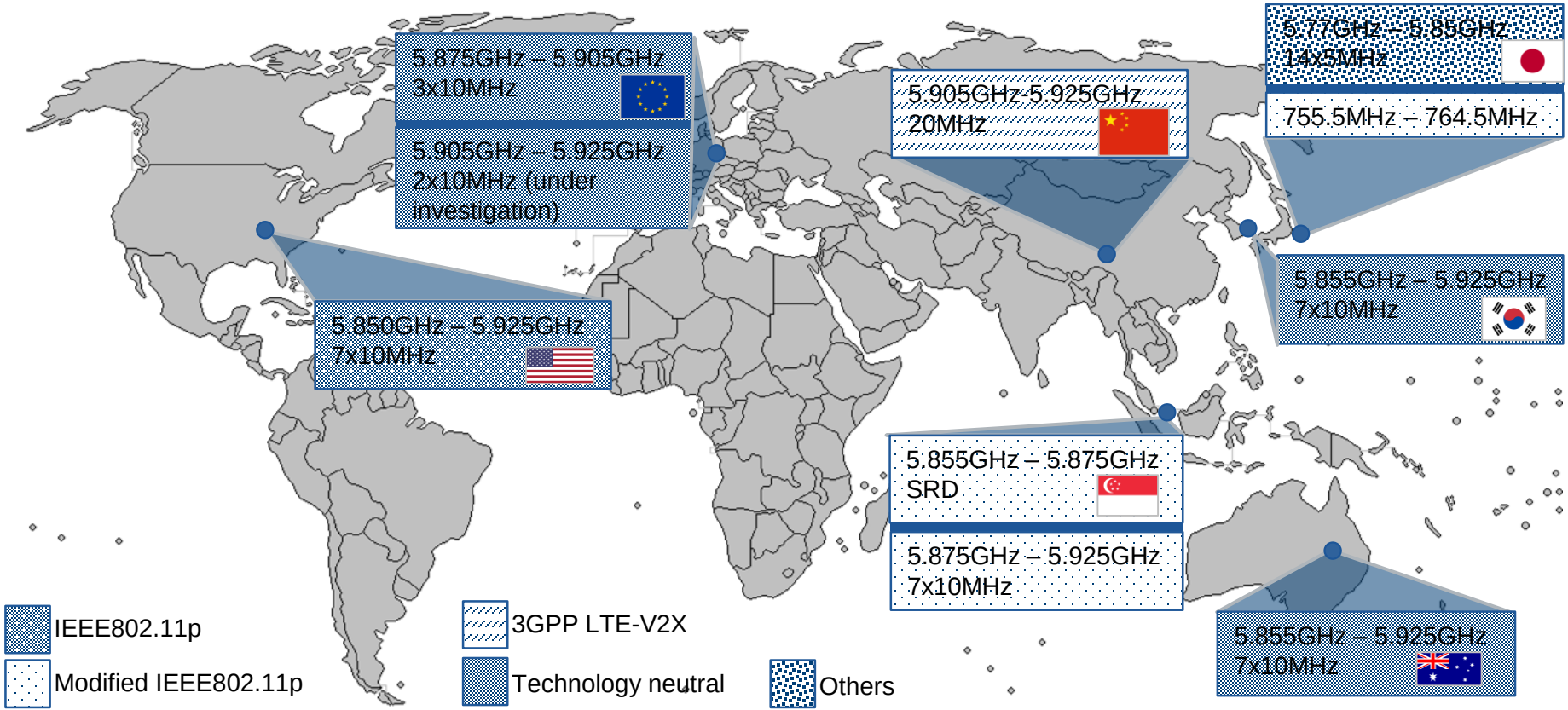
Intention Sharing

Remote driving

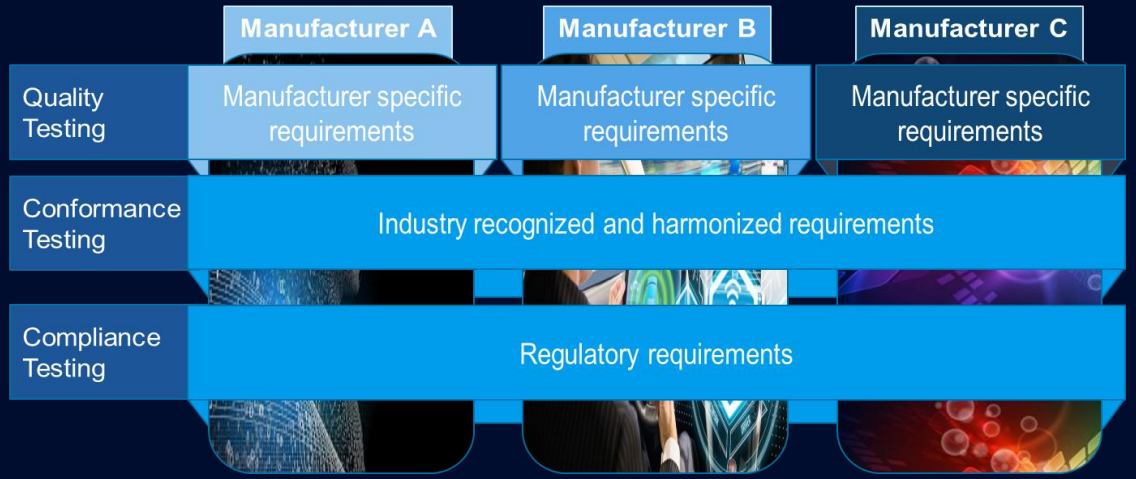
- Flexible numerology
- Operates Multiple Input Multiple Output (MIMO) transmission
- Distance based Hybrid Automatic Repeat Request (HARQ)
- V2X communication in FR1 and FR2



V2X – The global view

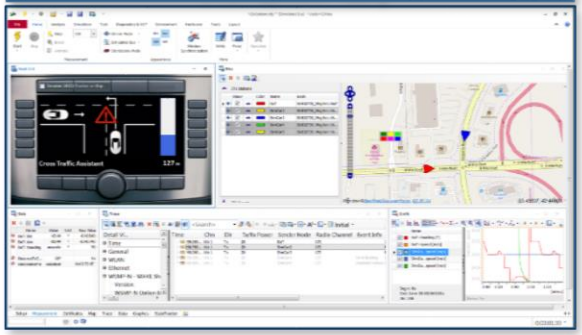


C-V2X CERTIFICATION



R&S C-V2X TEST SOLUTIONS

C-V2X Application Testing



Munich | 19-Jun-2018 | Test & Measurement

Rohde & Schwarz delivers 3GPP C-V2X device testing for GCF protocol conformance

Automakers are now well positioned to accelerate cellular vehicle-to-everything (C-V2X) device verification with Global Certification Forum (GCF) protocol conformance testing supported in the R&S CMW500 wideband radio communication tester.

R&S at the 5GAA C-V2X Plugfest

Munich | 18-Feb-2019 | Test & Measurement

Rohde & Schwarz collaborates with Vector to deliver Cellular-V2X end-to-end application layer test solution

Munich | 27-Feb-2018 | Test & Measurement

Rohde & Schwarz demonstrates test capability of 3GPP C-V2X technology in preparation for GCF certification toward commercialization

At Mobile World Congress 2018 in Barcelona, Rohde & Schwarz will showcase their CMW500 wideband radio communication tester and a pre-commercial Qualcomm® 9150 C-V2X chipset solution, that implements 3rd Generation Partnership Project (3GPP) Release 14 cellular vehicle-to-everything (C-V2X) direct communications technology. Rohde & Schwarz, working with companies including Qualcomm Technologies, aim to support an official global certification scheme based on 3GPP standardized conformance tests selected by the Global Certification Forum (GCF) in preparation of commercialization.

C-V2X Protocol and Protocol Conformance Testing

Vehicle Testing, Chambers (EMC, OTA, Radar)

R&S C-V2X TEST SOLUTIONS

PRODUCTION

ROHDE&SCHWARZ

CONFORMANCE

ROHDE&SCHWARZ

APPLICATION

ROHDE&SCHWARZ VECTOR

CMW100 K06

PRODUCTION TEST

- Frequency range up to 6GHz,
- 160MHz Bandwidth
- High accuracy
- Parallel test up to 8 RF ports
- CMW-KM570 C-V2X PC5 Meas.

CMW500 PT + SMBV100A

PROTOCOL TEST

- Data Transmission
- Data Reception
- Performance Testing (Fading)

GCF PROTOCOL CONFORMANCE

- GCF Work Item 281(V2V)
- GCF Work Item 282 (V2X)

CMW500 PT + SMBV100B + CANoe .Car2x

C-V2X SCENARIO BASED TESTING

- Development and Test of C-V2X Scenarios
- Graphical Scenario Editor
- Reproducible test scenarios
- Test of all layers
- Support of all common automotive bus connectivity

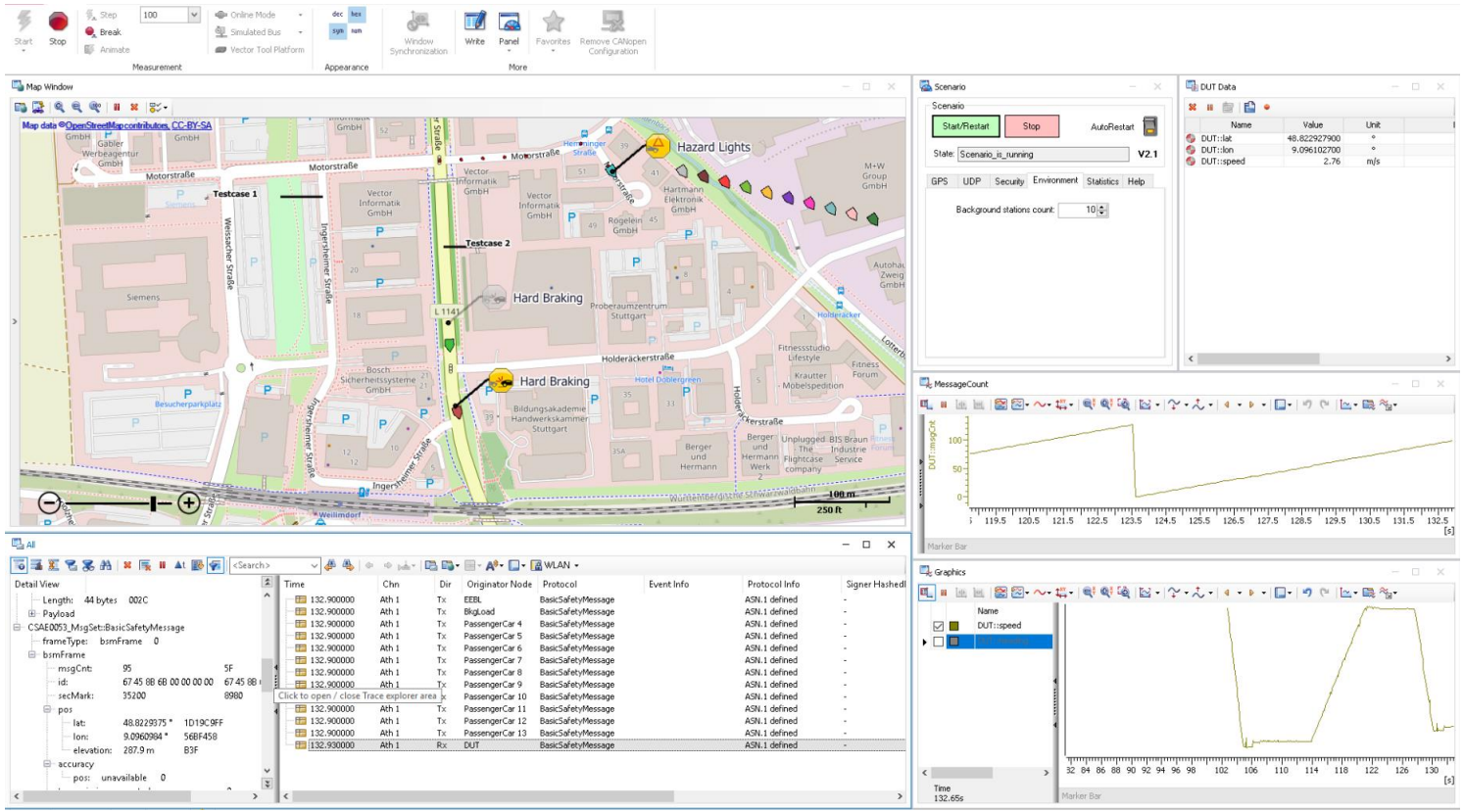
CHINA DAY-1-USE CASES

- Forward Collision Warning (FCW)
- Intersection Collision Warning (ICW)
- Left Turn Assist (LTA) / Right Turn Assist (RTA)
- Blind Spot Warning (BSW) / Lane Change Warning (LCW)
- Do Not Pass Warning (DNPW)
- Emergency Brake Warning (EBW / Electronic Emergency Brake light (EEBL)
- Abnormal Vehicle Warning (AVW)
- Control Loss Warning (CLW)
- Hazard Location Warning (HLW)
- Speed Limit Warning (SLW)
- Red Light Violation Warning (RLVW)
- Vulnerable (VRUCW)
- Green Light Optimization Speed (GLOSA)
- In-vehicle signage (IVS)
- Traffic Jam Ahead Warning (TJW)
- Emergency Vehicle Warning (EVW)

Emergency Electronic Brake Lights

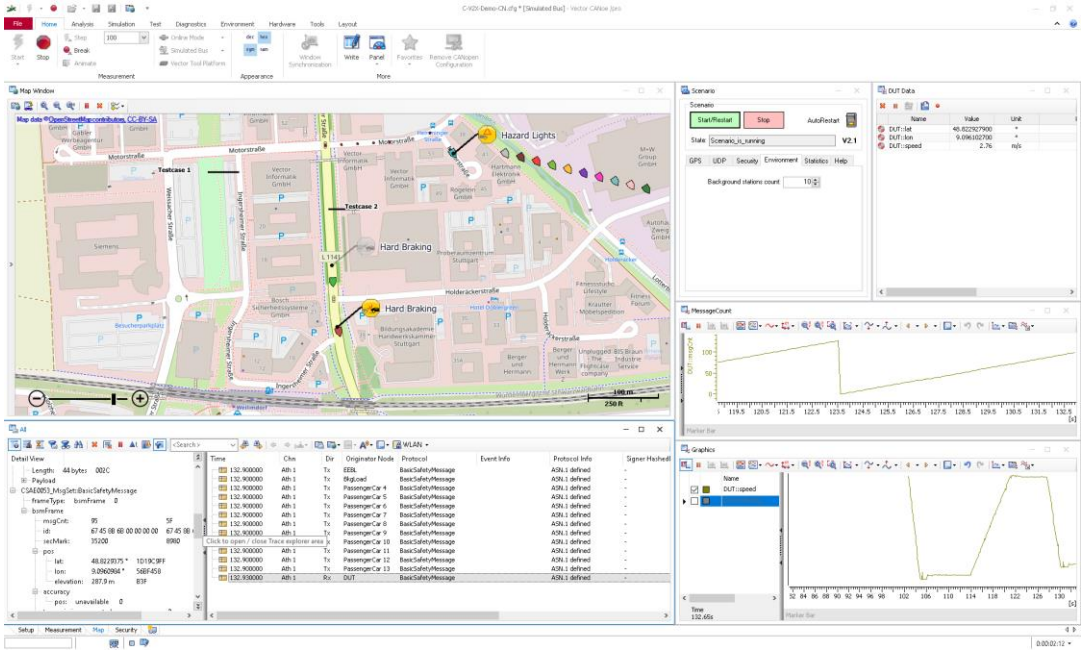
Left Turn Assist

CANOE LOOK AND FEEL



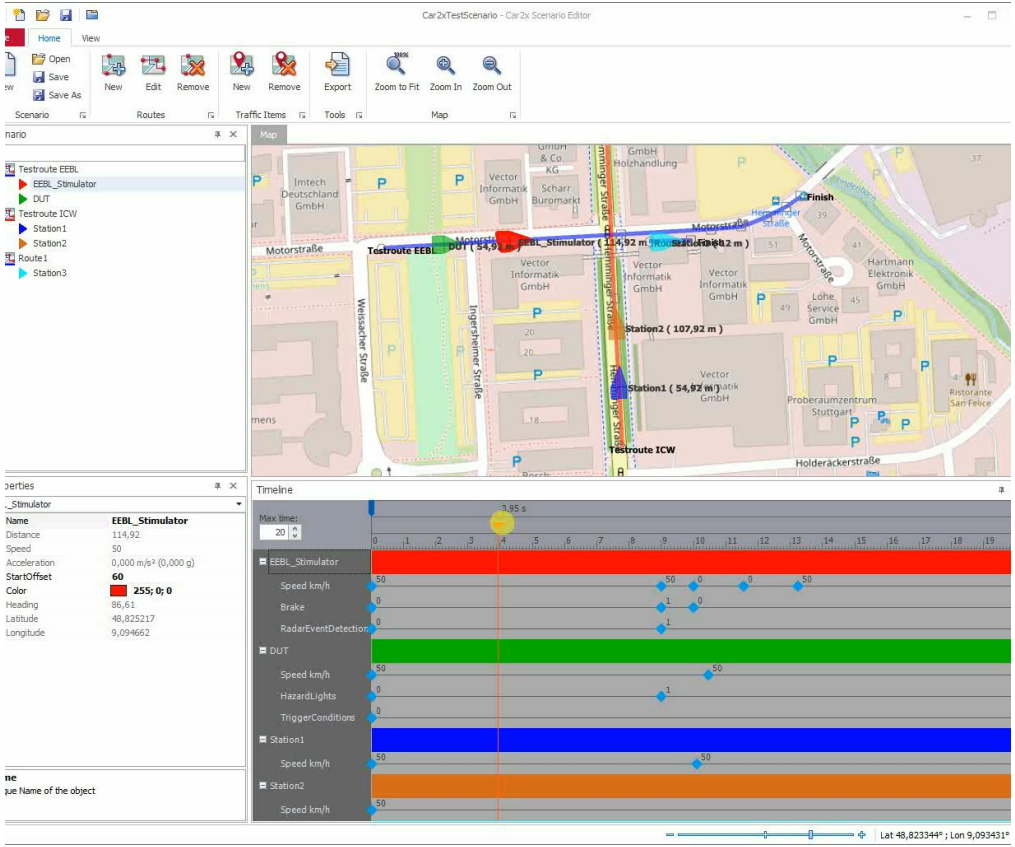
SIMULATION AND TEST

- CANoe imports scenario file
  - **Start and stop** a scenario
  - **Callback functions** if keypoints changes or scenario status changes
- Interpretation of ITS relevant protocols
- Support of relevant standards
  - ETSI (EU), WAVE/SAE (US), GB31024 (CN)
  - Security header generation
- Application message support
  - CAM, DENM, Spat/MAP, IVI, BSM,…
- Map window for visualization of the scenario
- Trace/Graphic/Data window for specific measurement and DUT specific data
- Internal programming environment for advanced stimulation and analyzing (CAPL)
- The test solution allows bus connectivity
  - CAN, LIN, FlexRay, Ethernet to analyze results or stimulate the ECU remotely



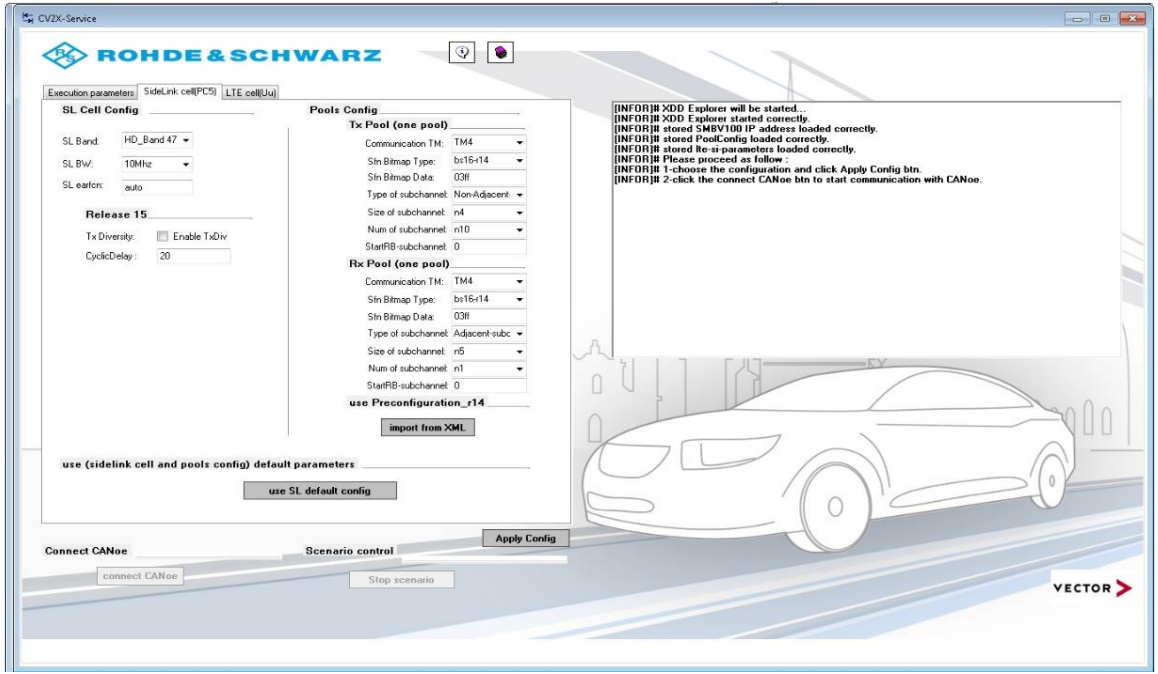
SCENARIO EDITOR

- GUI for easy and fast traffic scenario configuration
- Multiple virtual cars
- GNSS route definition
- Flexible parameter configuration (speed, signal strength…)
- CAPL interface for fine adjustment of the scenario
- Scenario loaded and played back by CANoe – C-V2X communication and waypoints created according to scenario

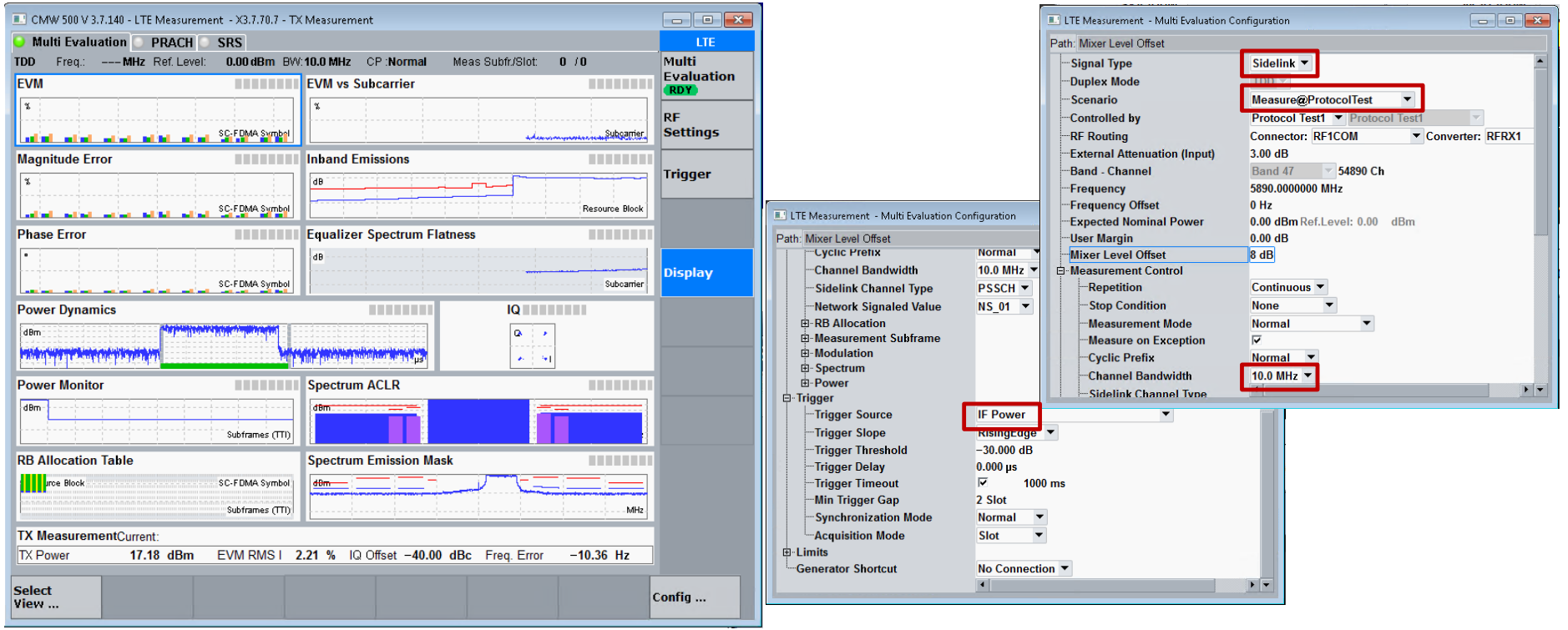


C-V2X SERVING SCENARIO
CMW-KAA550

- Abstract the CMW500 and SMBV to *"Callbox like operation"*
  - Offers a dedicated interface to Vector's CANoe .car2x
  - Features on the interface will grow over time
  - Customer feedback and requirements is required



LTE SIDELINK TX MEASUREMENTS – KM570



REPRODUCIBLE TESTING OF C-V2X IN A LAB ENVIRONMENT

100% REPRODUCIBLE

R&S CMW500 Wideband Communication Tester

- C-V2X Signaling LTE Rel-14 TM4 (3GPP Rel.14, PSCCH, PSSCH)
- Multi-technology protocol tester with a layer 1 to layer 3 stack implementation
- Extendable with CMX500 for 5G
- Verify Transmitter characteristics under signaling conditions in combination with KM570 measurements (power, EVM…) and ready to use test packages for transmitter, receiver and performance verification

R&S SMBV100B

- GNSS synchronization and route simulation
- Frequency range from 8 kHz to 3 GHz or 6 GHz
- Signal generation for all major digital communication standard incl. 5G NR, LTE and WLAN
- GNSS simulator with GPS, Glonass, Galileo, BeiDou and QZSS/SBAS

VECTOR CANoe .car2x

- Simulation, analysis and test of C-V2X applications following EU, US and CN standards
- Quick and easy scenario design with CANoe .car2x scenario editor

QUESTIONS???