

R&S CMW500

# C-V2X TEST SOLUTIONS INTRODUCTION

Wesker Liu  
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**ROHDE & SCHWARZ**

Make ideas real



# R&S C-V2X TEST SOLUTIONS

## PRODUCTION



## CONFORMANCE



## APPLICATION



### 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/B

#### 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

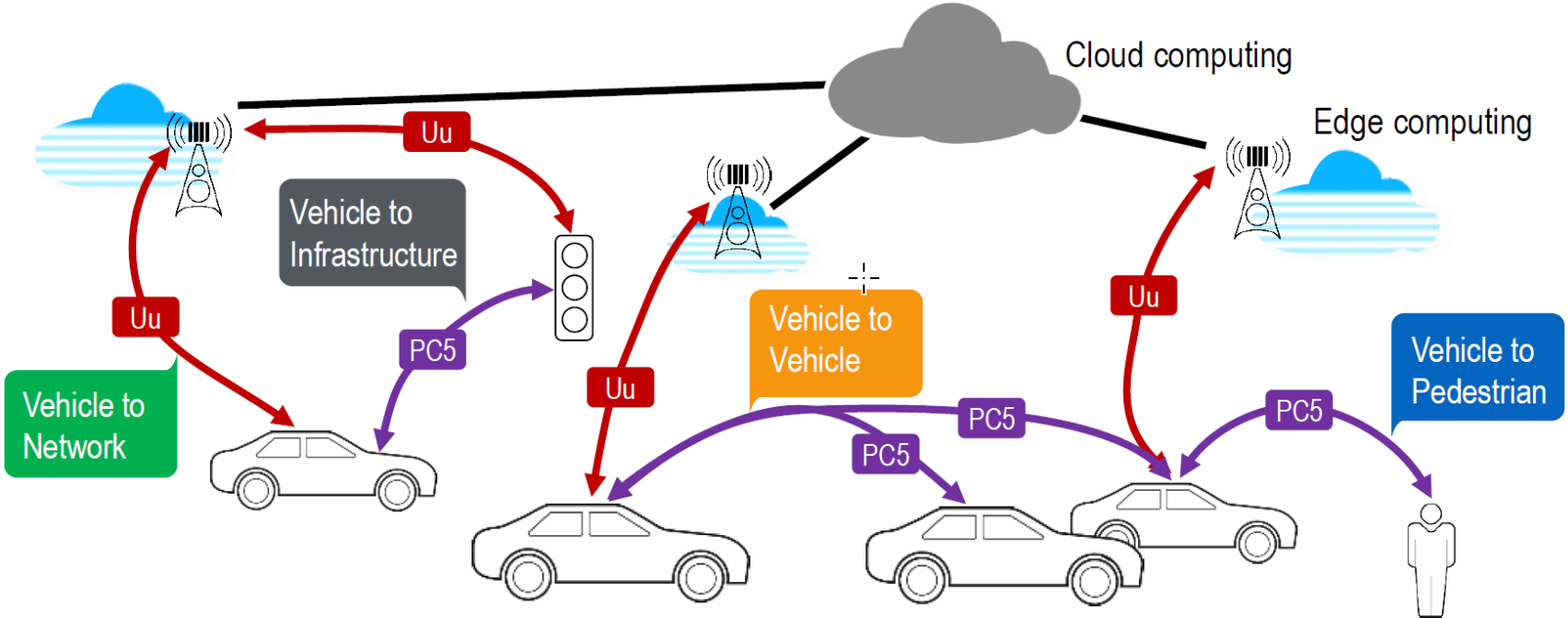
#### C-V2X SCENARIO BASED TESTING

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

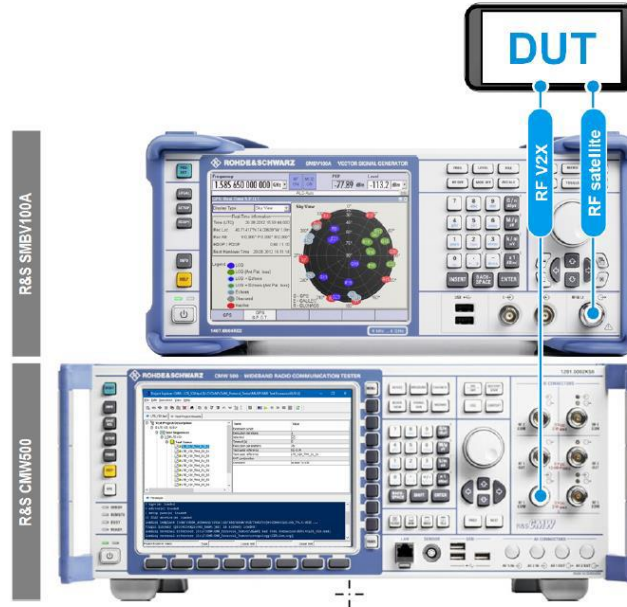
# OUTLINES

- ▶ **Conformance testing**
- ▶ Application testing
- ▶ Production testing

# V2X COMMUNICATION ARCHITECTURE: V2V, V2N, V2I, V2P



# TEST SETUP



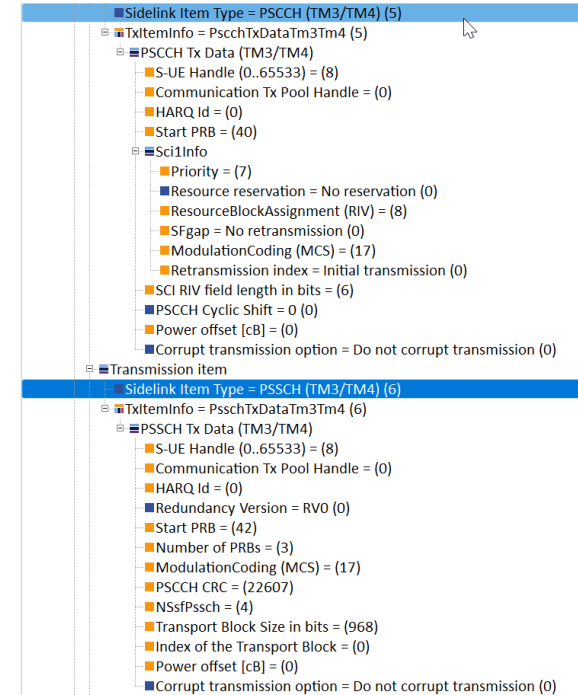
**Figure 2-2: Front panel RF connections**

RF satellite = RF connection for the positioning signal

RF V2X = LTE V2X RF connection

# FLEXIBILITY AND CONTROL OVER CONFIGURATION

- ▶ CMW500 is simulating side link UE(s)
  - Flexible PC5 configuration
  - Scheduling pattern
  - Resource allocation
  - Modulation Coding Scheme
  - Periodicity
- ▶ SMBV is simulating GNSS signals:
  - Common time reference, UTC Time
- ▶ Fading and Noise
  - Apply fading profiles (EPA5, LTEEVA5, EVA70, ETU70, ETU300)
  - Apply AWGN noise
  - Inject fading profile & noise per UE simulation



# PROTOCOL TEST (MLAPI) (KU514)

Available

Scenario	Test Purpose	R&S Product	R&S Status
<b>C M W - K U 5 1 4 LTE V2X TM4 Out of coverage Test Scenarios</b>			
<b>LTE-V2X Data Transmission</b>			
LTE_V2X_TM4_01_01	Successful IP Multicast Data transmission over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Adjacent PSCCH-PSSCH	CMW-KU514	implemented
LTE_V2X_TM4_01_02	Successful IP Multicast Data transmission over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Non-Adjacent PSCCH-PSSCH	CMW-KU514	implemented
LTE_V2X_TM4_01_03	Successful IP Multicast Data transmission over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Zone Selection	CMW-KU514	planned
LTE_V2X_TM4_01_04	Successful IP Multicast Data transmission over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Carrier Sensing testing	CMW-KU514	implemented
LTE_V2X_TM4_01_05	Successful Non-IP Multicast Data transmission over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Adjacent PSCCH-PSSCH / Non-IP Type of Data	CMW-KU514	verified
<b>LTE-V2X Data Reception</b>			
LTE_V2X_TM4_02_01	Successful IP Multicast Data reception over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Adjacent PSCCH-PSSCH	CMW-KU514	implemented
LTE_V2X_TM4_02_02	Successful IP Multicast Data reception over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Non-Adjacent PSCCH-PSSCH	CMW-KU514	implemented
LTE_V2X_TM4_02_03	Successful IP Multicast Data reception over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Transmission on Multiple Rx Resource Pools	CMW-KU514	implemented
LTE_V2X_TM4_02_04	Successful Non-IP Multicast Data reception over PC5 using UE Selected resources (TM4) / Synchronization provided over GNSS / Adjacent PSCCH-PSSCH / Non-IP Type of Data	CMW-KU514	verified
<b>Performance Tests with Fading</b>			
LTE_V2X_TM4_03_01	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the fading profile EPA5(1x1)	CMW-KU514	implemented
LTE_V2X_TM4_03_02	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the fading profile LTEEVA5(1x1)	CMW-KU514	implemented
LTE_V2X_TM4_03_03	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the fading profile LTEEVA70(1x1)	CMW-KU514	implemented
LTE_V2X_TM4_03_04	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the fading profile LTEETU70(1x1)	CMW-KU514	implemented
LTE_V2X_TM4_03_05	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the fading profile LTEETU300(1x1)	CMW-KU514	implemented
LTE_V2X_TM4_03_06	Sidelink HARQ reception over PSSCH test (TM4), BLER vs SNR / Synchronization provided over GNSS / using the V2X ETH2700 fading profile (with 2700Hz doppler speed)	CMW-KU514	implemented

# GCF PROTOCOL CONFORMANCE (KK550)

PCT	LTE	3GPP TS 36.523-1	24.1.15	LTE	E47(20)	V2X Sidelink Communication / Pre-configured authorisation / UE out of coverage on the frequency used for V2X sidelink communication / Operation with/without SyncRef UE/ Transmission SLSS	KK550	WI-282
PCT	LTE	3GPP TS 36.523-1	24.1.16	LTE	E47(20)	V2X Sidelink Communication/ Pre-configured authorisation / Utilisation of the pre-configured resources / CBR measurement	KK550	WI-282
PCT	LTE	3GPP TS 36.523-1	24.1.18	LTE	E47(20)	V2X Sidelink Communication / Pre-configured authorisation / UE out of coverage on the frequency used for V2X sidelink communication and without inter-frequency V2X configuration on anchor carriers/ Operation with/without SyncRef UE/ SLSS and MasterInformationBlock-SL-V2X message Transmission/ syncPriority in SL-V2X-Preconfiguration is set to eNB	KK550	WI-282
PCT	LTE	3GPP TS 36.523-1	24.1.19	LTE	E47(20)	V2X Sidelink Communication/ Pre-configured authorisation / Utilisation of the pre-configured resources / CBR measurement/Transmission based on CR limit	KK550	WI-282
PCT	LTE	3GPP TS 36.523-1	24.1.2	LTE	E47(20)	V2X Sidelink Communication / Pre-configured authorisation / Utilisation of the pre-configured resources / Transmission	KK550	WI-281
PCT	LTE	3GPP TS 36.523-1	24.1.4	LTE	E47(20)	V2X Sidelink Communication/ Pre-configured authorisation / Utilisation of the pre-configured resources / Reception	KK550	WI-281
PCT	LTE	3GPP TS 36.523-1	24.1.9	LTE	E47(20)	V2X Sidelink Communication/ Pre-configured authorisation / UE in RRC_IDLE or RRC_Connected on an E-UTRAN cell not operating on the carrier frequency provisioned for V2X / UE out of coverage on the frequency used for V2X sidelink communication / Utilisation of the pre-configured resources / Transmission based on zoning	KK550	WI-281



# OUTLINES

- ▶ Conformance testing
- ▶ **Application testing**
- ▶ Production testing

# Inside Vehicle

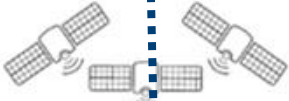
..... Possible extension

# TEST SETUP

SMBV100B  
IP – 172.22.1.199



R&S SMBV100B or  
R&S SMBV100A



GNSS signal



COM/ETH  
CAN IF



Laptop with  
CANoe.car2x  
IP – 172.22.1.240

VECTOR > VN5640  
needed to monitor vehicle data

PC5  
cellular  
network



R&S CMW500 with  
R&S CMW-KAA550

CMW500  
5G ready HW  
172.22.1.xx

LAN switch

LAN



# ON CMW500

- ▶ Use C-V2X application layer testing manual for
  - Checking hardware requirements
  - Checking software requirements
  - Software installation
    - ❑ Use installation manager to search KAA550 and install all dependencies (Version 35.43 or the latest available)
      - ❑ **KAA550**
      - ❑ **V2X GUI (KAA550)**

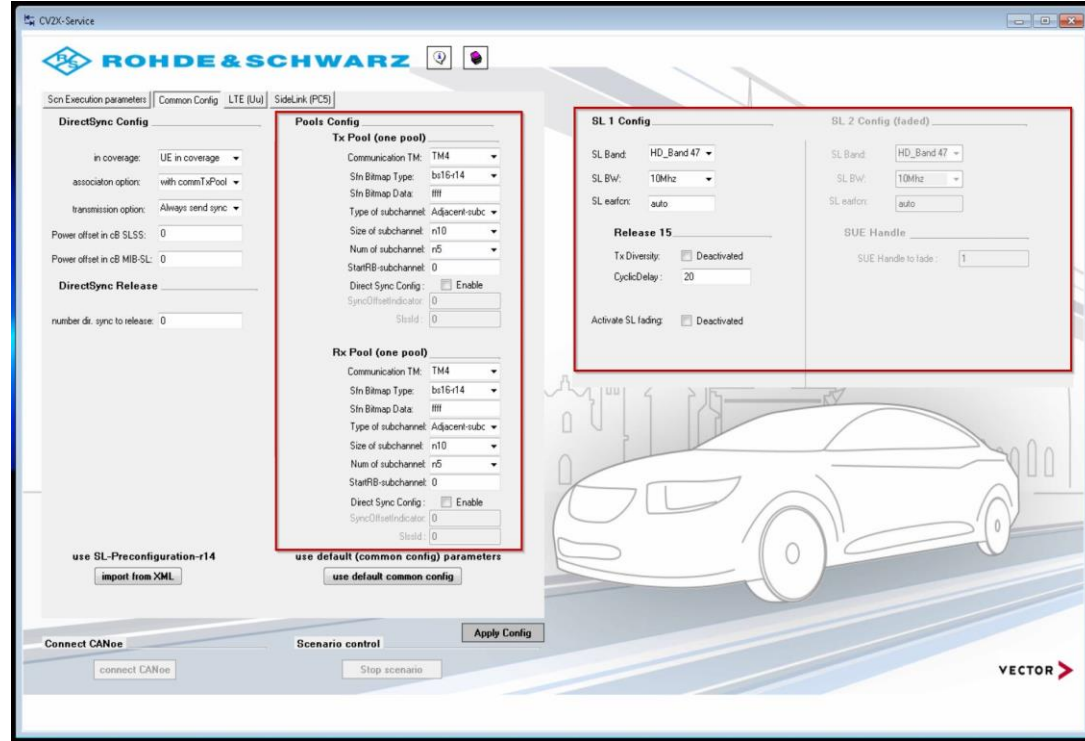
# ON CMW500

## ► Start V2X GUI

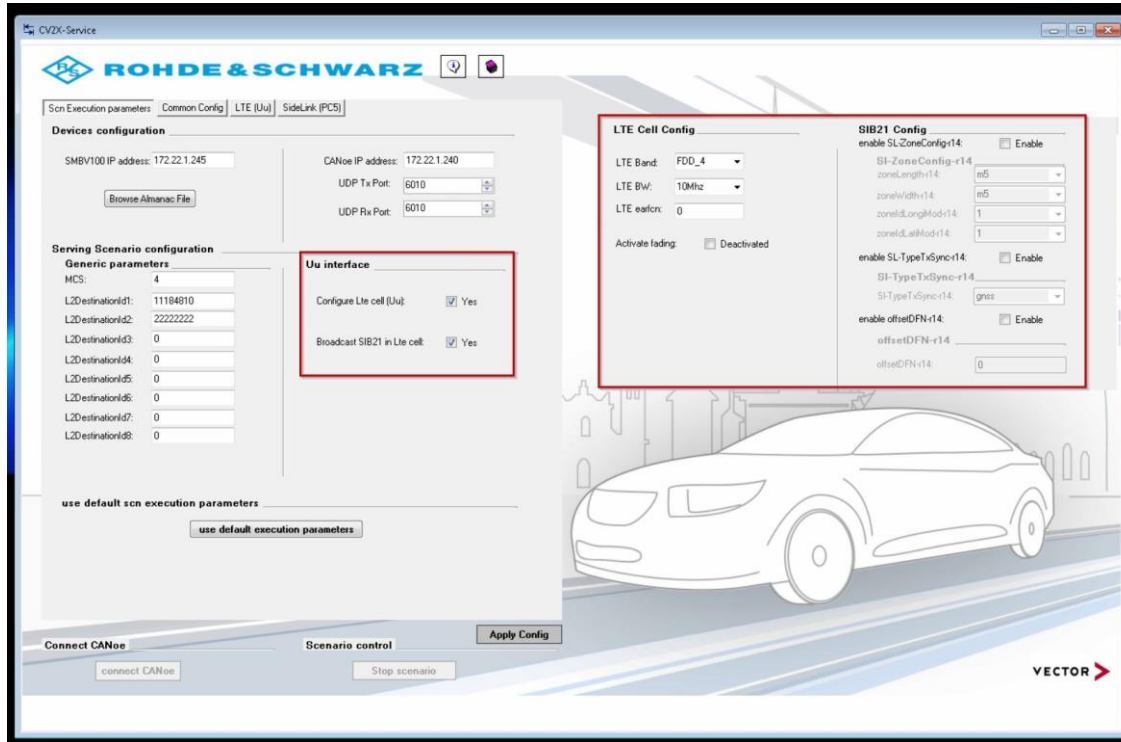
Project explorer (i.e. blue window) will start in the background

## ► Configure V2X GUI

- Set SMBV IP to 172.22.1.199
- Set CANoe IP to 172.22.1.240
- Leave UDP Tx/Rx Ports as it is
- **Set pool config compatible to DUT**
  - Picture shows settings compatible to QC 9150 reference device that we have in RSNA.
  - **This will be different for customer's device.**
- Hit Apply Configuration
- Hit connect CANoe



# SIMULTANEOUS TESTING OF PC5 & UU ALSO SUPPORTED



# CMW LOGS TO CHECK NUMBER OF VEHICLES SIMULATED

E.g. 250 cars: Source layer ID starts at 45001 and ends at 42252

Lte	SRC	CSRC		CSRC_COMMTXBEARERCONFIG	Cnf					
UPLANE	UPC	MNUPC_V2	🚩	Flow State	Ind				250	
Lte	SRC	CSRC		CSRC_V2XCOMM_SIDELINK_SUE_RESOURCE	Req	45249				
Lte	SMAC	CSMAC		CSMAC_V2X_COMMGRANT_CONFIG	Req	45249				
Lte	SMAC	CSMAC		CSMAC_V2X_COMMGRANT_CONFIG	Cnf					
Lte	SRC	CSRC		CSRC_V2XCOMM_SIDELINK_SUE_RESOURCE	Cnf					
Sys	GUI	TestCase		Status	Ind					
Sys	GUI	TestCase		Status	Ind					
UPLANE	UPC	MNUPC_V2	🟢	Activate Proxy	Req		348; V2X; 172.22.1.240; 9000		None(0)	1250
UPLANE	UPC	MNUPC_V2	🚩	Activate Proxy	Cnf		172.22.1.201; 9000		251	
Sys	GUI	TestCase		Status	Ind					
Lte	SRC	CSRC		CSRC_COMMTXBEARERCONFIG	Req					
Lte	SRLC	CSRLC		CSRLC_CONFIG	Req	45250			1250	
Lte	SRLC	CSRLC		CSRLC_CONFIG	Cnf					
Lte	SRLC	CSRLC		CSRLC_LOG_CONFIG	Req				1250	
Lte	SRLC	CSRLC		CSRLC_LOG_CONFIG	Cnf				1250	
Lte	SPDCI	CSPDCP		CSPDCP_CONFIG	Req	45250			1250	
Lte	SRLC	SRLC_UCTH	🟢	SRLC_DISCARD_TIMER	Req				1250	
Lte	SPDCI	SPDCP_U_C	🚩	SPDCP_U_MAPPING	Ind	45250			1250	
UPLANE	UPC	CUDA_V2	🚩	Update Flows	Ind					1250
UPLANE	UPC	CUDA_V2	🟢	Update Flows	Rsp				251	1250
Lte	SPDCI	SPDCP_U_C	🟢	SPDCP_U_MAPPING	Rsp					
Lte	SPDCI	CSPDCP		CSPDCP_CONFIG	Cnf					
Lte	SPDCI	CSPDCP		CSPDCP_LOG_CONFIG	Req				1250	
Lte	SPDCI	CSPDCP		CSPDCP_LOG_CONFIG	Cnf				1250	
Lte	SMAC	CSMAC		CSMAC_STCH_CONFIG	Req	45250			1250	
Lte	SMAC	CSMAC		CSMAC_STCH_CONFIG	Cnf					

Lte	SPHY	SPHY_LOG	🟢	SPHY_DATA	Req			Mac Sidelink Pdu(3)	
Lte	SRLC	SRLC_LOG	🟢	SRLC_LOG_DATA	Req	45240		Transparent - PDCP	
Lte	SRLC	SRLC_LOG	🟢	SRLC_LOG_DATA	Req	45241		Transparent - PDCP	
Lte	SRLC	SRLC_LOG	🟢	SRLC_LOG_DATA	Req	45242		Transparent - PDCP	

# CANOE LOOK AND FEEL

The screenshot displays the CANOE software interface, which is used for CAN bus simulation and analysis. The interface is divided into several main sections:

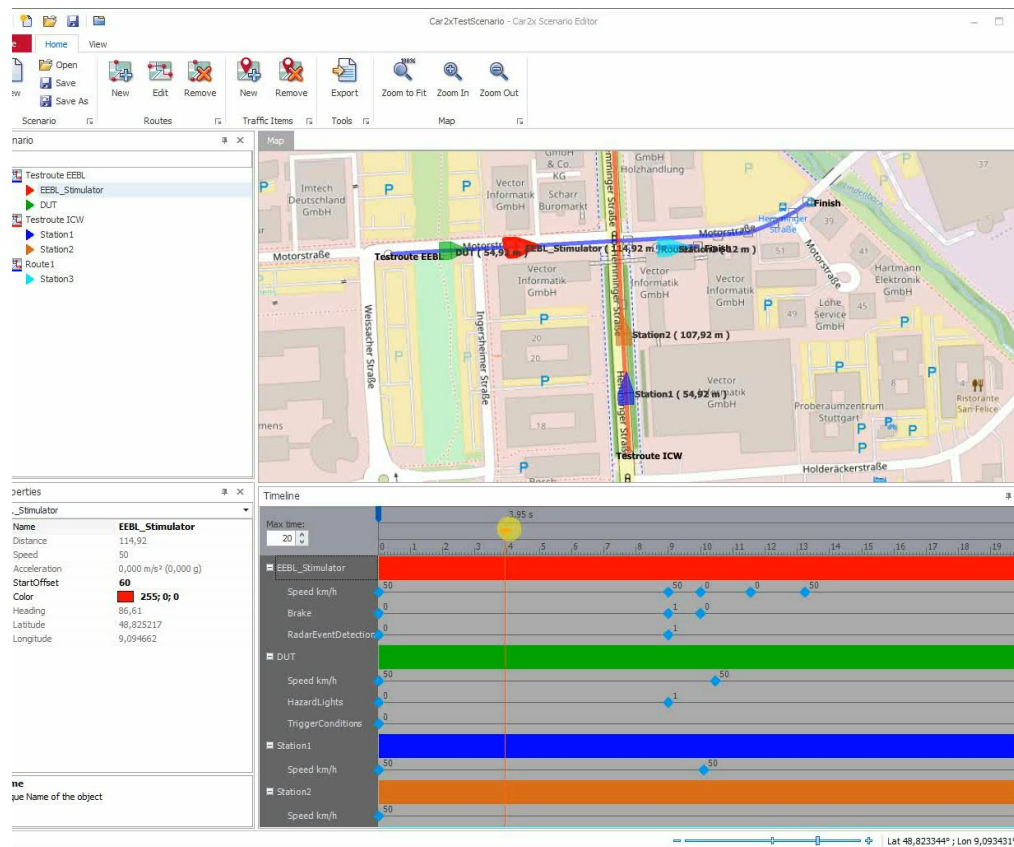
- Top Panel:** Contains various tool icons and buttons such as 'Start', 'Stop', 'Break', 'Animate', 'Measurement', 'Appearance', 'Window Synchronization', 'Write Panel', 'Favorites', and 'Remove CAOpen Configuration'.
- Map Window:** Shows a street map of an urban area with several test scenarios marked: 'Testcase 1', 'Testcase 2', 'Hazard Lights', and 'Hard Braking'. A scale bar indicates 100m and 250ft.
- Scenario Panel:** Includes a 'Scenario' dropdown, 'Start/Restart' and 'Stop' buttons, 'AutoRestart' checkbox, and a 'State' dropdown set to 'Scenario\_is\_running'. It also shows 'Background stations count: 10'.
- DUT Data Panel:** A table showing data for the Under Test (DUT) component.
 

Name	Value	Unit
DUT:lat	48.822927900	°
DUT:lon	9.096102700	
DUT:speed	2.76	m/s
- MessageCount Panel:** A line graph showing the number of DUT messages over time. The x-axis represents time in seconds (from 119.5 to 132.5), and the y-axis represents the number of messages (from 0 to 100). The graph shows a step increase in message count around 123.5s.
- Trace Explorer Panel:** Displays a list of CAN messages with columns for Time, Chn, Dir, Originator Node, Protocol, Event Info, and Signer Hashed. The messages are all BasicSafetyMessages sent from various PassengerCar nodes (Car 4 to Car 13) to the DUT.
 

Time	Chn	Dir	Originator Node	Protocol	Event Info	Signer Hashed
132.900000	Ath 1	Tx	EEBL	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	BlgLoad	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 4	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 5	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 6	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 7	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 8	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 9	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 10	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 11	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 12	BasicSafetyMessage	ASN.1 defined	-
132.900000	Ath 1	Tx	PassengerCar 13	BasicSafetyMessage	ASN.1 defined	-
132.930000	Ath 1	Rx	DUT	BasicSafetyMessage	ASN.1 defined	-
- Detail View Panel:** Shows the structure of a received message, including payload (CSAE0053\_MsgSet:BasicSafetyMessage), bsmFrame, msgCnt, id, secMark, pos (lat, lon, elevation, accuracy), and pos availability.
- Graphics Panel:** A graph showing the speed of the DUT over time. The x-axis is time in seconds (from 32 to 130), and the y-axis is speed. The speed starts at 0, increases to a peak of approximately 2.76 m/s around 110s, and then returns to 0.

# 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





# 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



The screenshot displays the CANoe software interface for a simulation. The main window shows a map of a city street with several vehicles and their communication paths. Key features include:

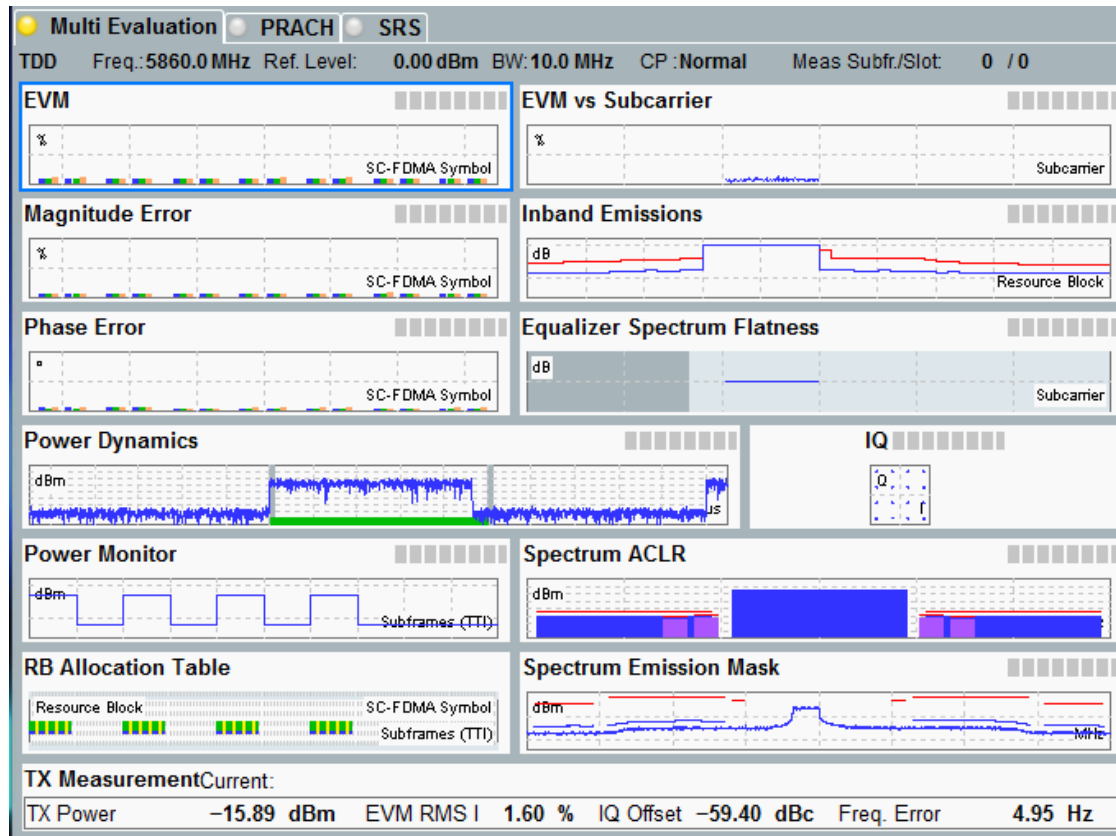
- Map Window:** A central map showing a street layout with vehicles and their communication paths. Labels include "Testlane 1", "Testlane 2", "Hard Braking", and "Hazard Lights".
- Scenario Window:** Located at the top right, it shows the current scenario name "Scenario\_1\_Scenario" and a "Start/Restart" button. It also displays "Background status count" set to 10.
- DUT Data Window:** Located at the top right, it shows a table of DUT data with columns for Name, Value, and Unit. The data includes "DUT-lat" (46.822527900) and "DUT-speed" (0.984302760).
- MessageCount Window:** Located in the middle right, it shows a line graph of message count over time, with a peak around 100.
- Trace Window:** Located at the bottom, it shows a list of messages with columns for Time, Ch, Dir, Originator Node, Protocol, Event Info, Protocol Info, and Signer Hashcode. The messages are filtered by "BasicSafetyMessage".

# OUTLINES

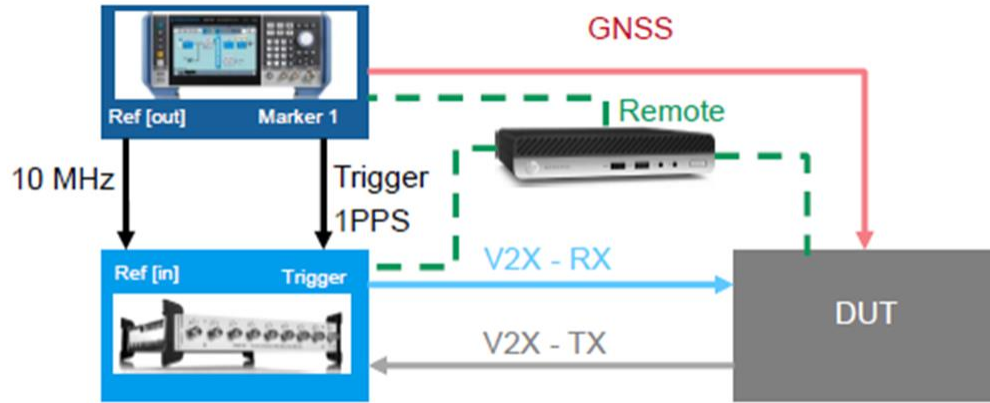
- ▶ Conformance testing
- ▶ Application testing
- ▶ **Production testing**

# LTE R14 C-V2X TX MEASUREMENTS CMW-KM570

- ▶ Error Vector Magnitude (EVM)
- ▶ EVM vs. Subcarrier
- ▶ Magnitude Error
- ▶ Inband Emissions
- ▶ Phase Error
- ▶ Equalizer Spectrum Flatness
- ▶ Power Dynamics
- ▶ IQ Constellation
- ▶ Power Monitor
- ▶ Spectrum ACLR
- ▶ RB Allocation Table
- ▶ Spectrum Emission Mask
- ▶ TX Power
- ▶ Frequency Error



# C-V2X PC5 RF MEASUREMENTS USING CMW100



\*Recommended setup

\*\*Setup will depend on chipset vendor's suggested method of testing

## TX-Test:

- CMW-KM570 LTE R14 C-V2X PC5 Measurements

## RX-Test:

- CMW-KW570 LTE R14 C-V2X PC5 WINIQSIM2
  - Require CMW-KW500 WINIQSIM2
  - Generate your own waveform (ARB) files
  - Play CMW-KV1xxA C-V2X pre-defined ARB-files

## Chipset specific

- CMW-KV110A (Qualcomm)
- CMW-KV118A (Hisilicon)

## Support CMW100 K06

## Also supported on CMW500 (requires MUA/TRX160)

CMW100  
5G NR / C-V2X



LTE-A, WCDMA, GSM, CDMA2000, TD-SCDMA, WLAN, Bluetooth, ZigBee, GNSS, Broadcast technologies (Arb files), **Non-Signaling mode,**