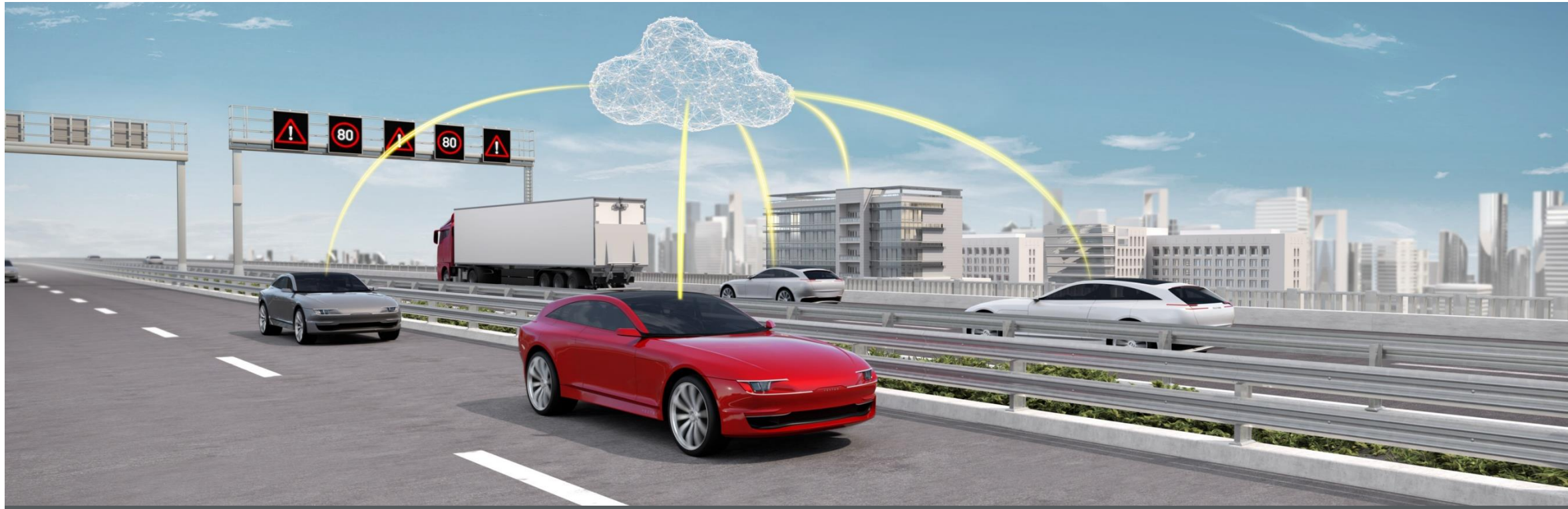
VECTOR



C-V2X usage and China Protocols with CANoe .Car2x

Analysis, Test and Simulation of V2X-based System

V0.1 | 2021-04-14

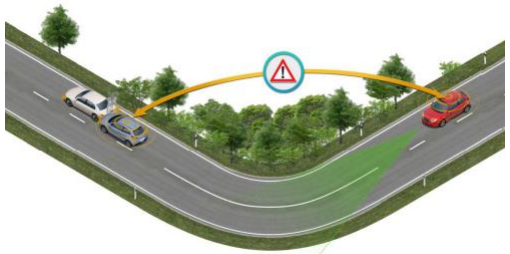
Agenda

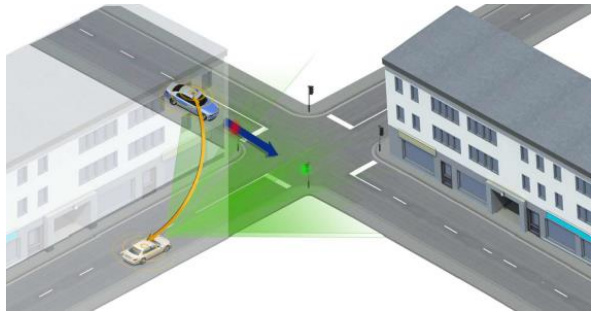
- **C-V2X Overview**
- Physical Layer Solution
- CANoe Option Car2X

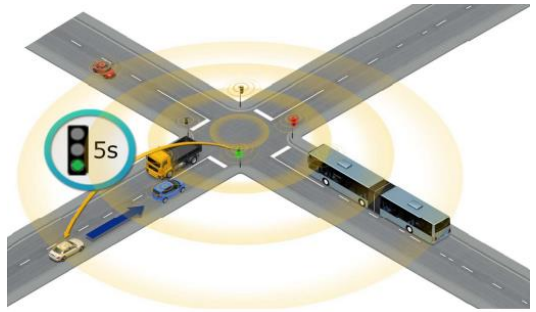
Motivation

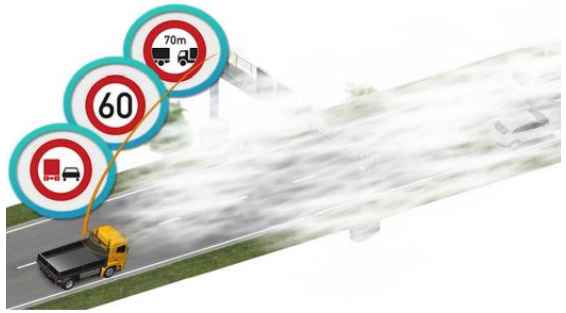
C-V2X: LTE-PC5 link – **direct communication** between vehicles/infrastructure on cellular standards

- **Active road safety :** Driving assistance - Cooperative awareness , Driving assistance - Road Hazard warning
- **Cooperative traffic efficiency:** Speed management, Cooperative navigation

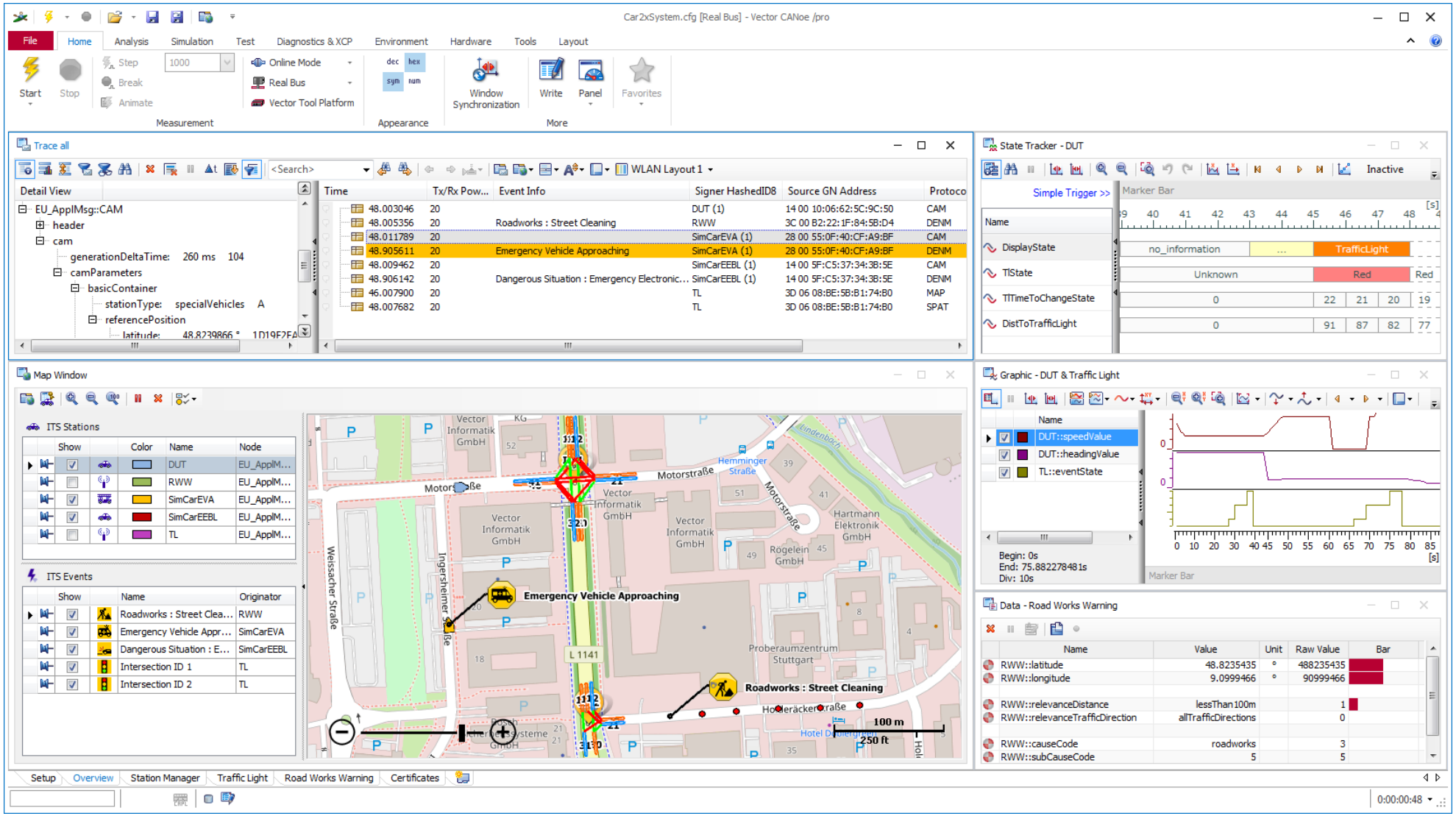






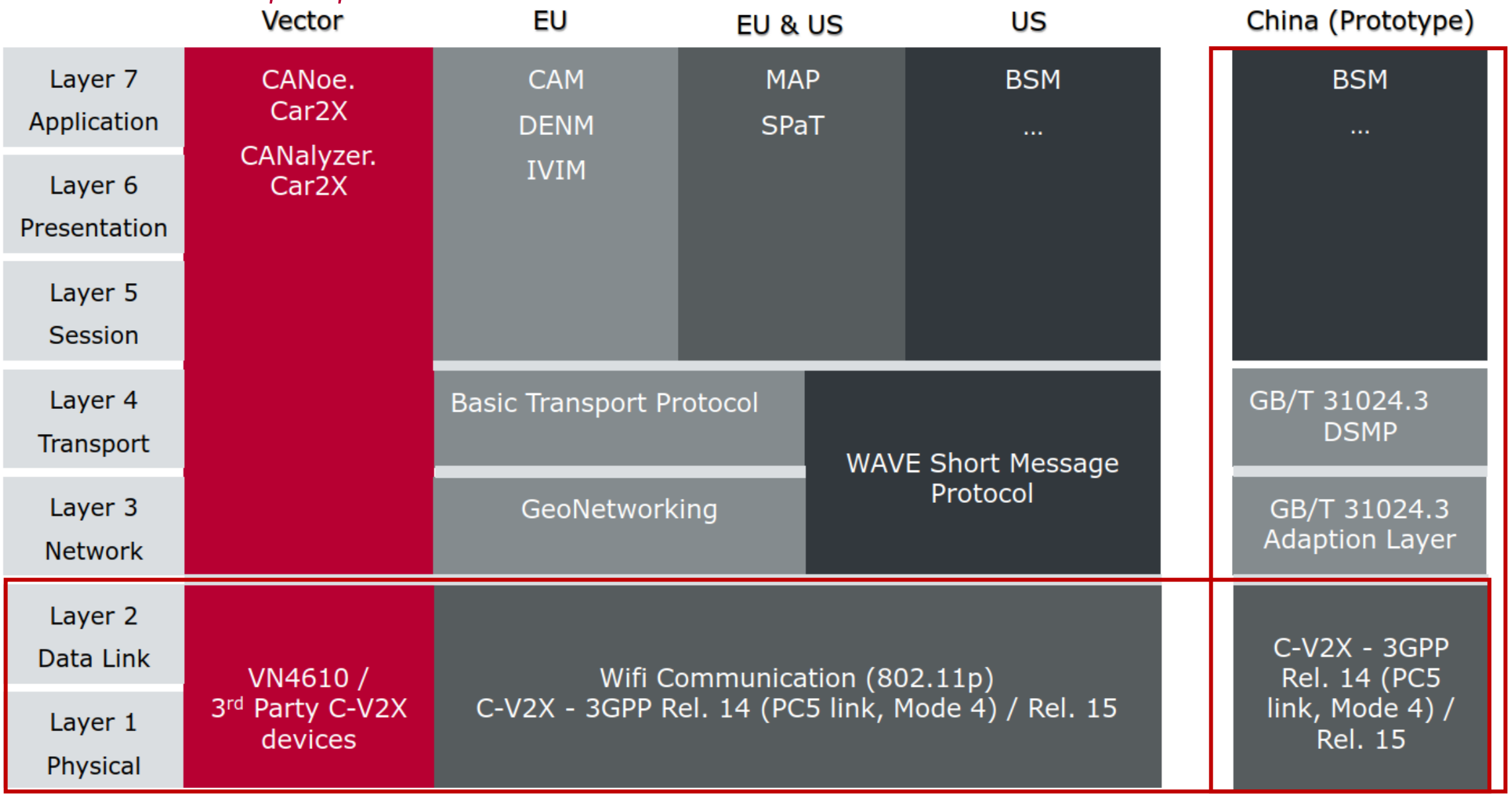


The Tool for Development, Analysis, Simulation and Testing of V2X Applications

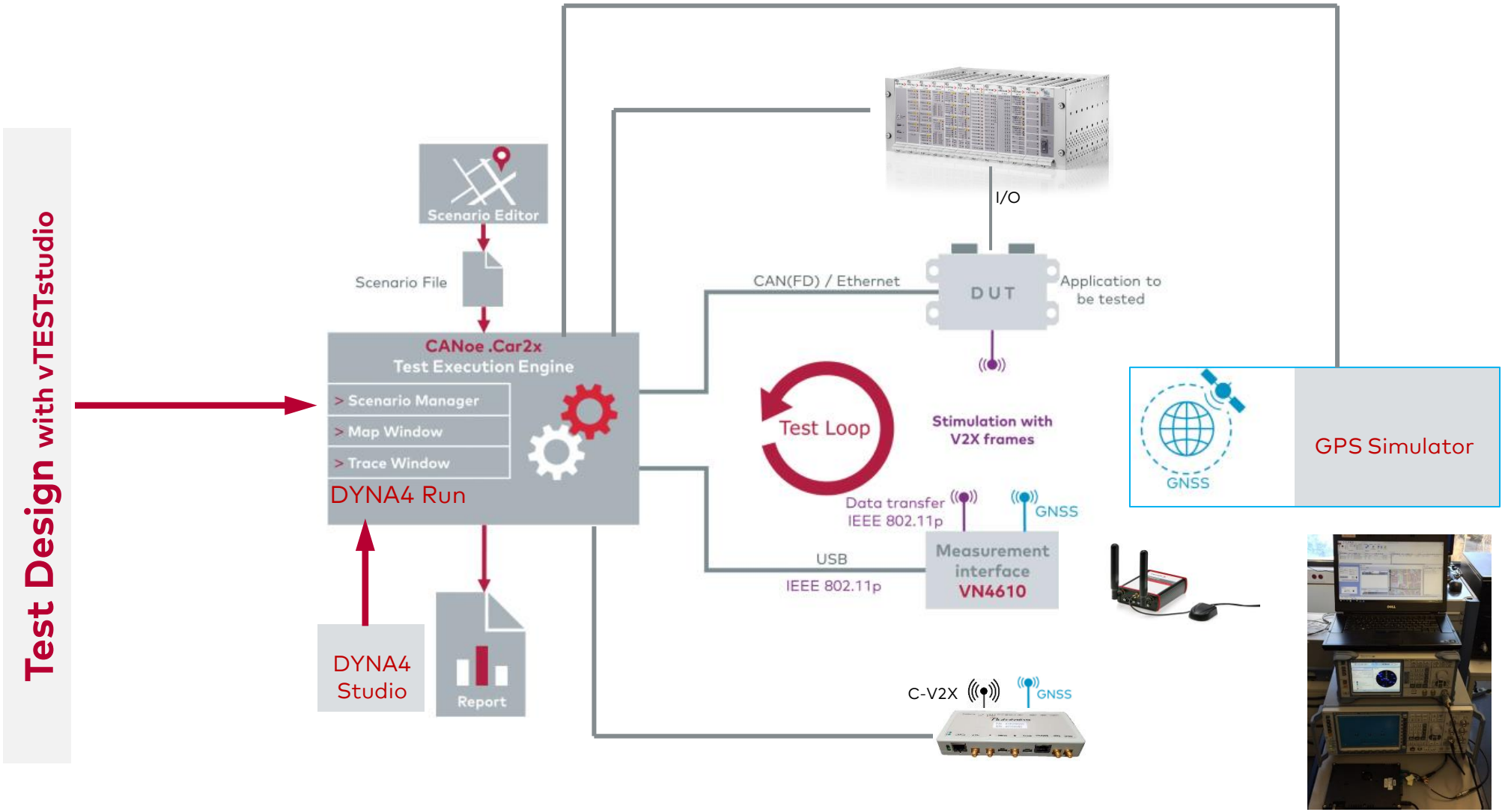


VECTOR

C-V2X in China, EU, US



C-V2X/DSRC Test System Overview



Agenda

- C-V2X Overview
- **Physical Layer Solution**
- CANoe Option Car2X

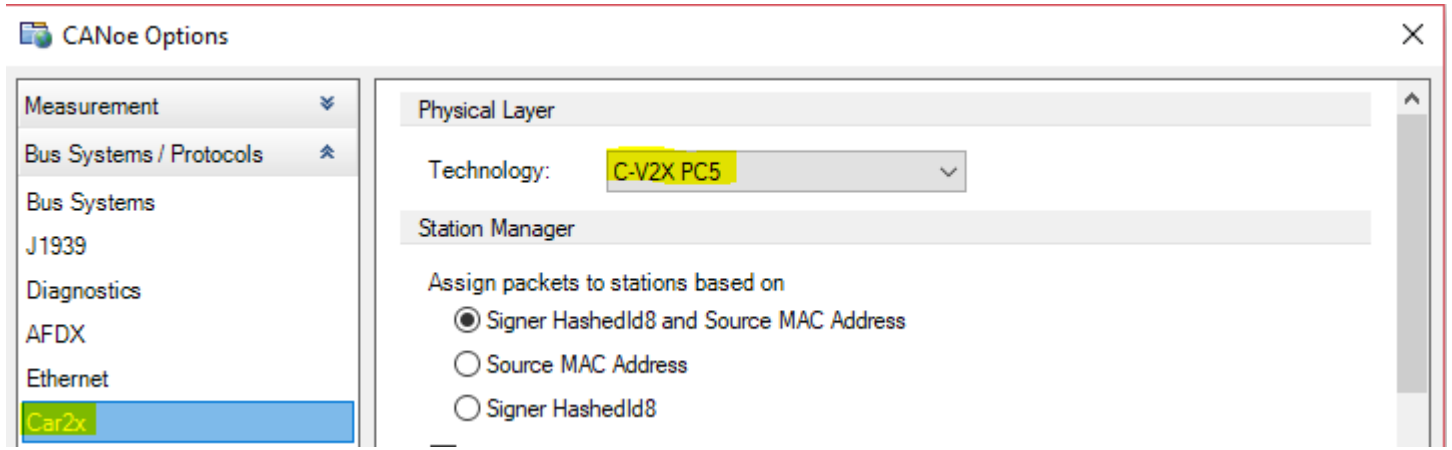
Physical Layer

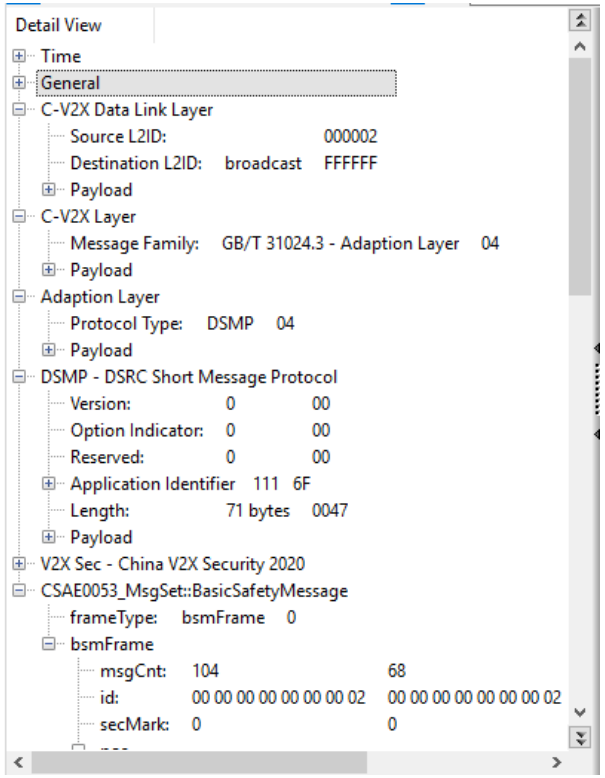
C-V2X Support

Since CANoe .Car2x 14, C-V2X is supported.

The C-V2X mode can be activated in the Options dialog.

This is necessary to start the decoding of the protocols with the C-V2X physical layer.

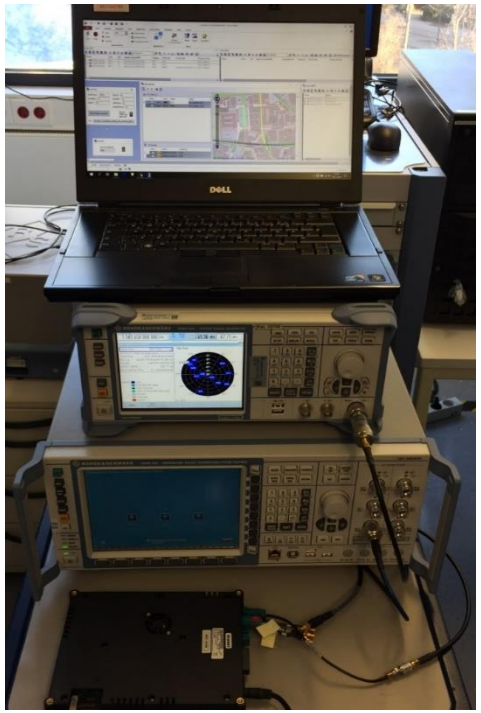




Please note:
It is not possible to configure the networks as
802.11p **and** C-V2X in **one** measurement configuration.

Supported of Rohde & Schwarz CMW500

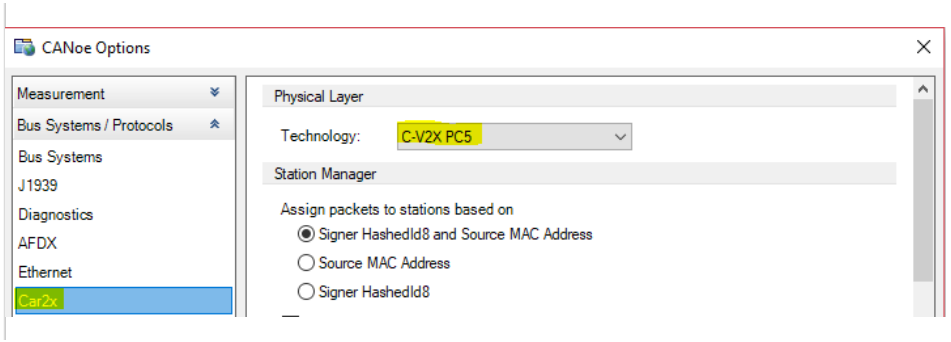
- The R&S CMW500 and CANoe .Car2x can be connected to have an end-to-end scenario-based test solution
  - > Test focus is on physical layer and C-V2X performance
- In the Vector knowledge base the according configuration can be downloaded
  https://kb.vector.com/entry/1648/



Supported Interfaces

- Generic UDP Interface
  - Socket Communication – inject V2X data frames in CANoe
    - > Programming Example included in demos shows how to inject packets from other sources
    - > Usage of C2xDispatchPacket (...) function to inject V2X frames from any source

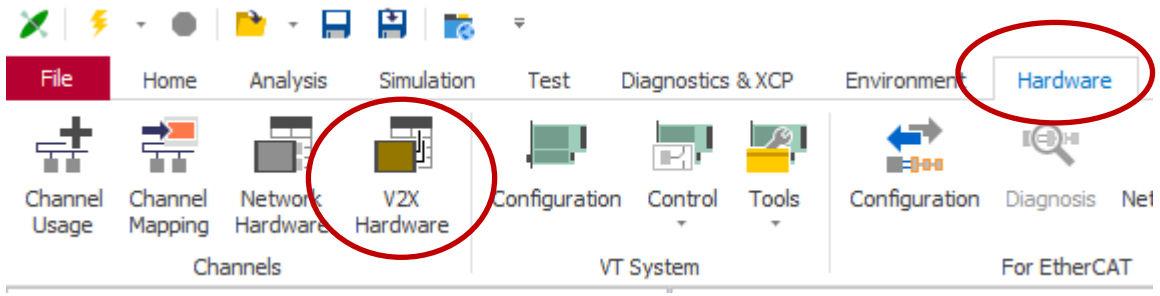
Meta Data	C-V2X Payload	
User defined	Message Family	Region Specific C-V2X Payload
0 Bytes	1 Byte	n Bytes



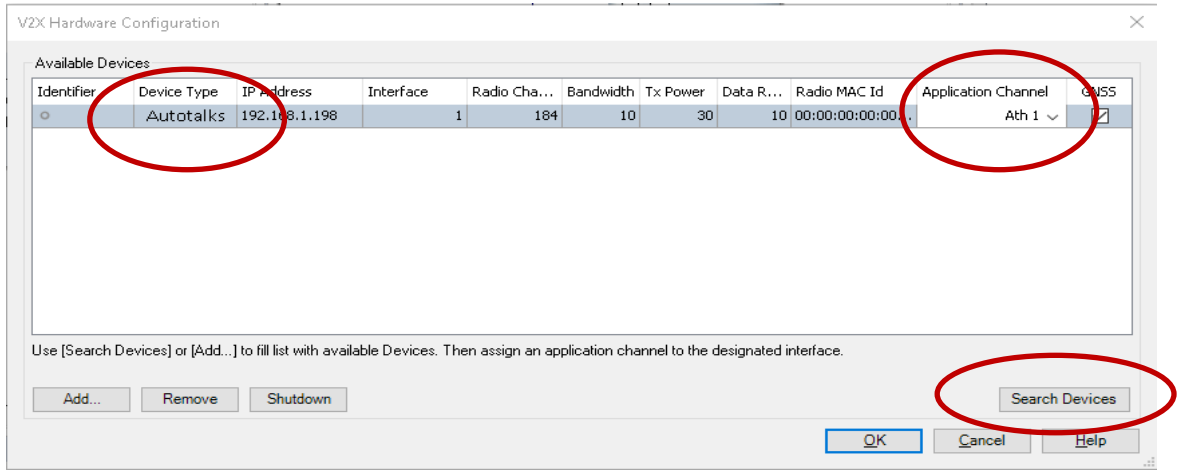
- Advantage
  - > Possibility to connect any device or external software to CANoe

Support of Autotalks Craton2 EVK for C-V2X (PC5 Link)

- Connected via Ethernet
- Integrated in CANoe/CANalyzer .Car2x



- V2X Hardware Button in Ribbon Bar is shown when C-V2X Technology is activated
- The Autotalks devices can be detected in the network when according firmware is installed



Agenda

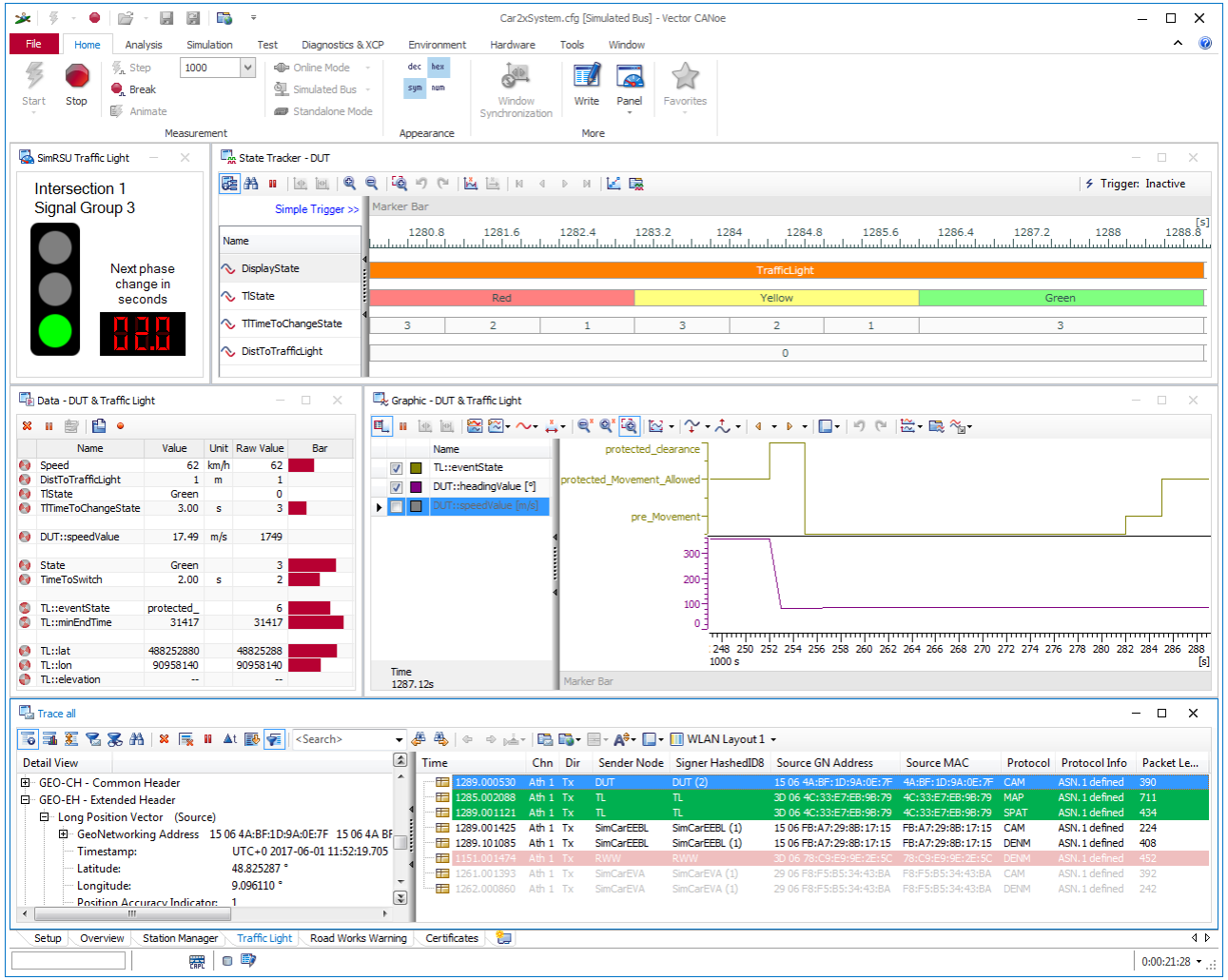
- C-V2X Overview
- Physical Layer Solution
- **CANoe Option Car2X**

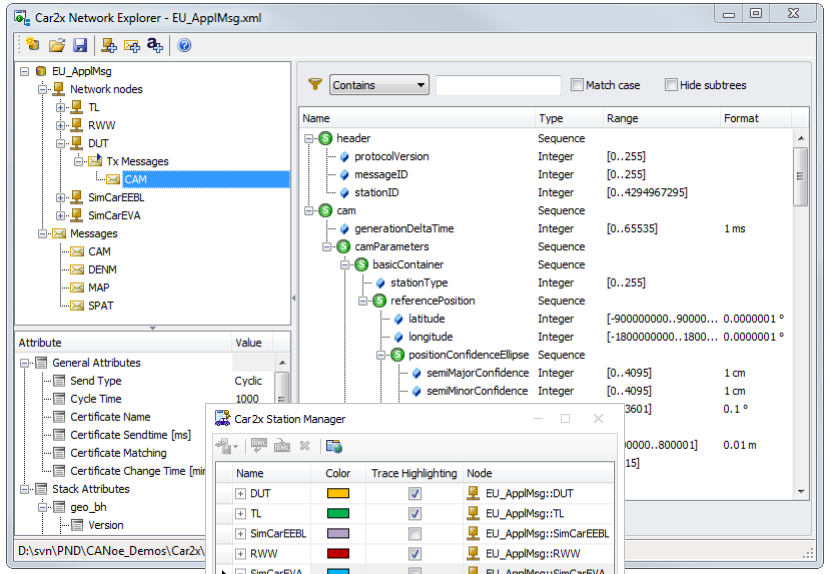
VECTOR

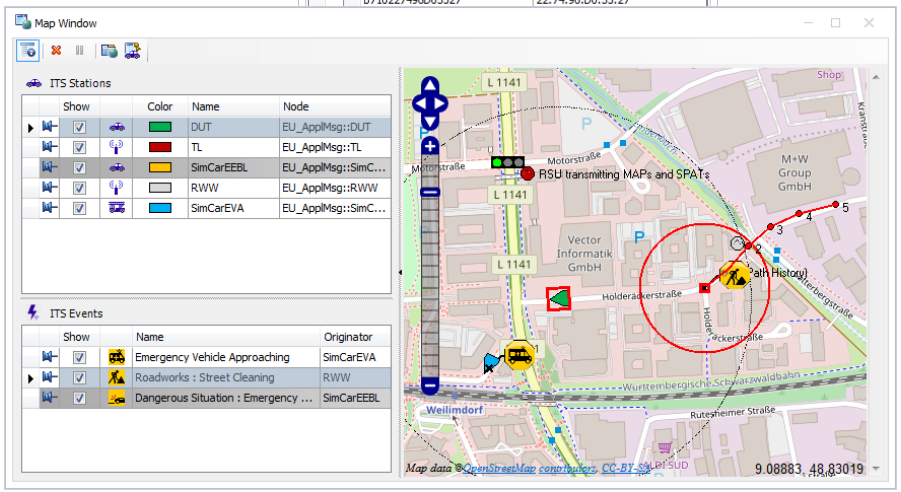
Option .Car2x

- Enables a wireless "network" for CANoe
  - Receiving and sending of 802.11p WLAN packets
    - > Support of multiple 802.11p WLAN radio channels
    - > Use of Vector VN4610
  - Receiving and sending of Cellular-V2X (C-V2X) packets
    - > LTE/4G or 5G mobile communication (3GPP Rel. 14 Mode 4 (PC5))
    - > Use of third-party C-V2X devices
  - Protocol interpretation of ITS relevant protocols
    - > Supports the relevant Chinese, European and US standards
  - Secured Packets interpretation and validation
    - > Handling of certificates and private keys
  - ASN.1 support for improved signal interpretation
  - Map Window to visualize spatial aspects of driving scenarios and infrastructure data
  - Testing of Car2x scenarios by setting up an environment simulation
    - > Interaction Layer (IL) for easy configuration of V2x communication
    - > Car2x Scenario Editor to setup V2x scenarios by help of a GUI

Option .Car2x



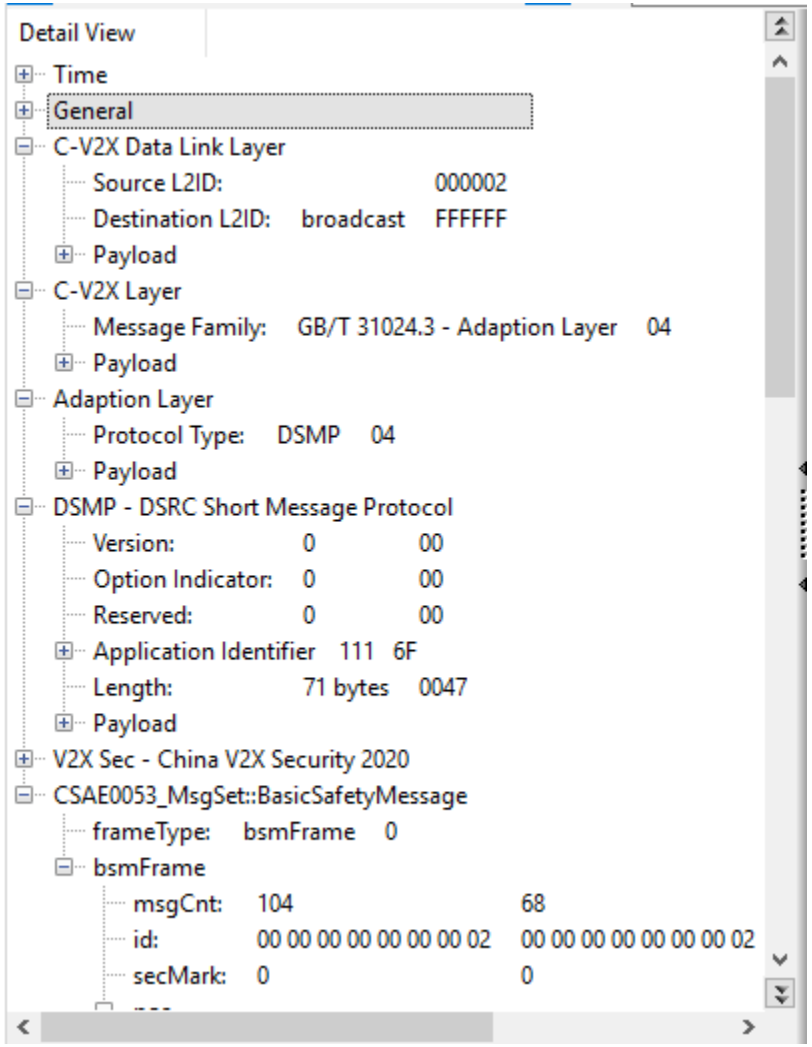




V2X China Protocol Stack

Supported Chinese V2X Protocols

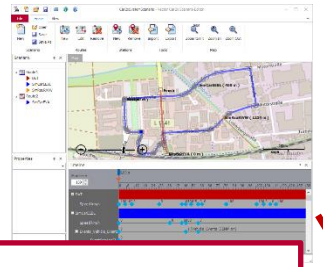
- C-V2X Data Link Layer
- Message Family GB/T 31024.3
- Adaption Layer
- DSMP (DSRC Short Message Protocol - GB/T 31024.3) Network layer and application layer specification.
- Security Header (incl. signing + verification)
- Support of T/CSAE 53-2017: C-ITS Application layer specification and data exchange standard (message set).



Feature Overview - Simulation

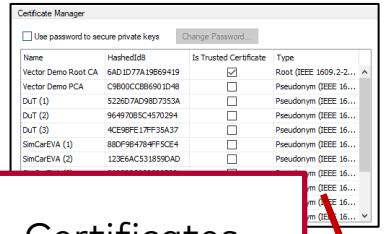
- Overview how the various components interact with each other:

Scenario Editor



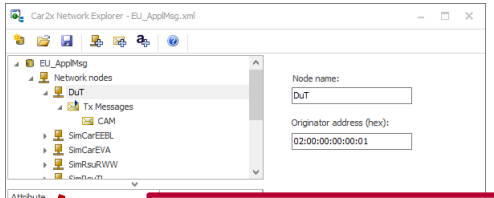
- Position data
- Events
- Attributes

Certificate Manager

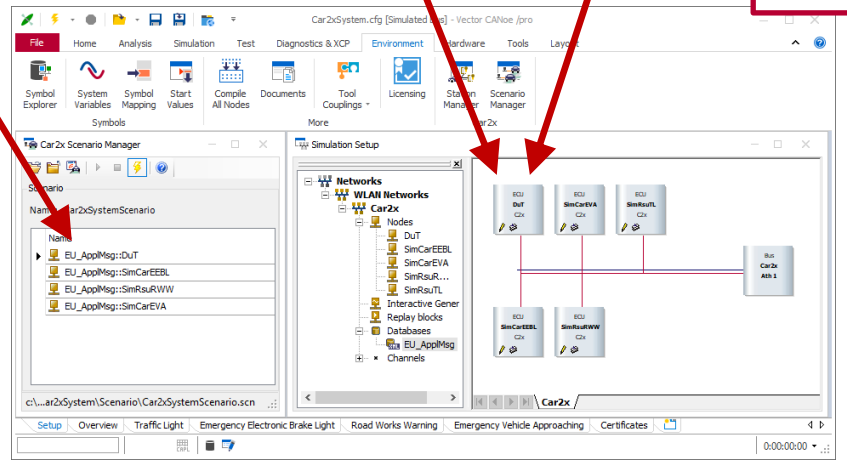


- Certificates
- Private Keys

Car2x Database



- Protocol data
- Stack behavior
- Certificate name

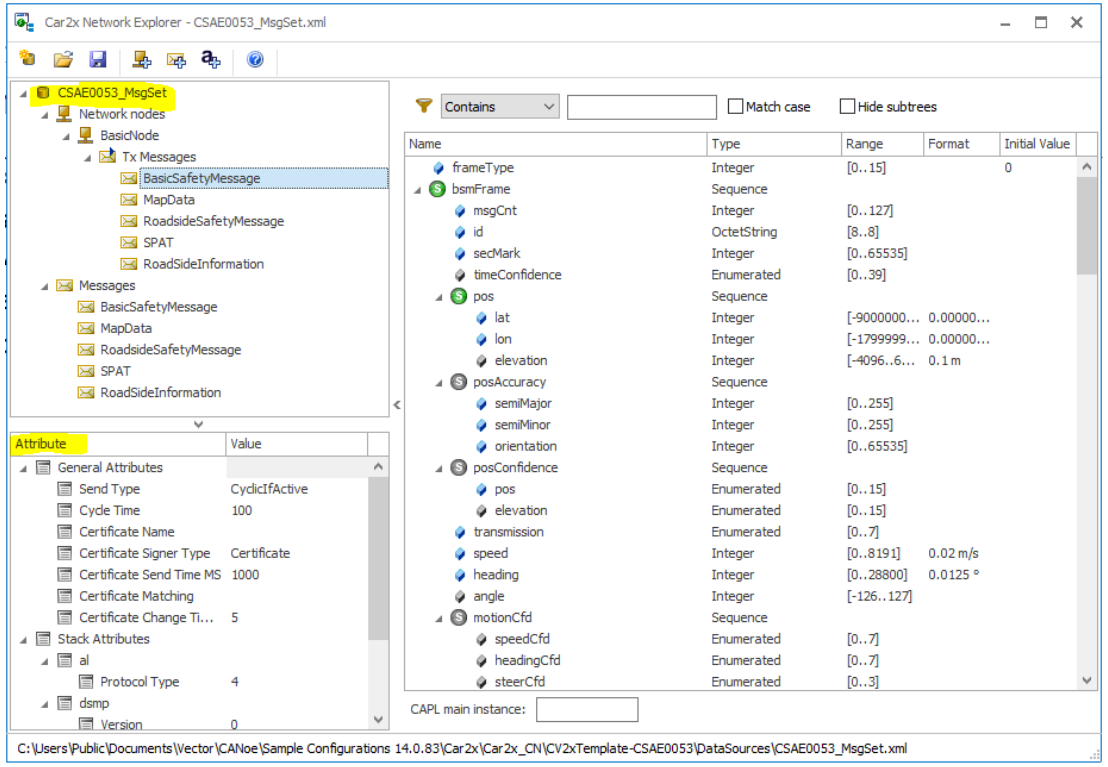


CANoe .Car2x with
Car2x Scenario Manager and
simulated network nodes

V2X China Protocol Stack - Database

Features related to Chinese protocol stack

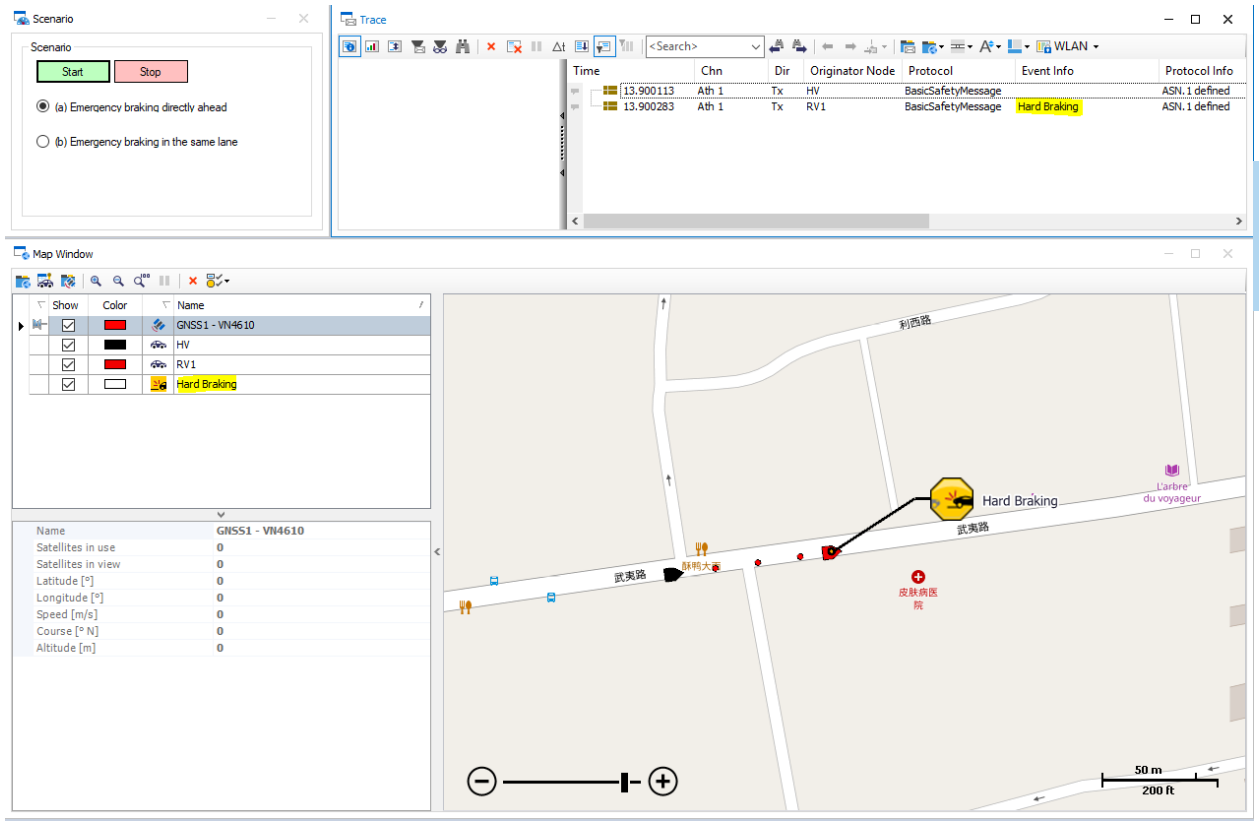
- Database for application messages (BSM, MAP/SPaT, etc.) available in Demo
  - C-SAE 0053, Draft from 09-2020
- The Car2x Interaction Layer can be configured for the Chinese protocol stack.

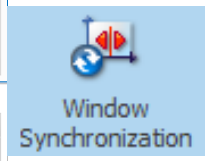


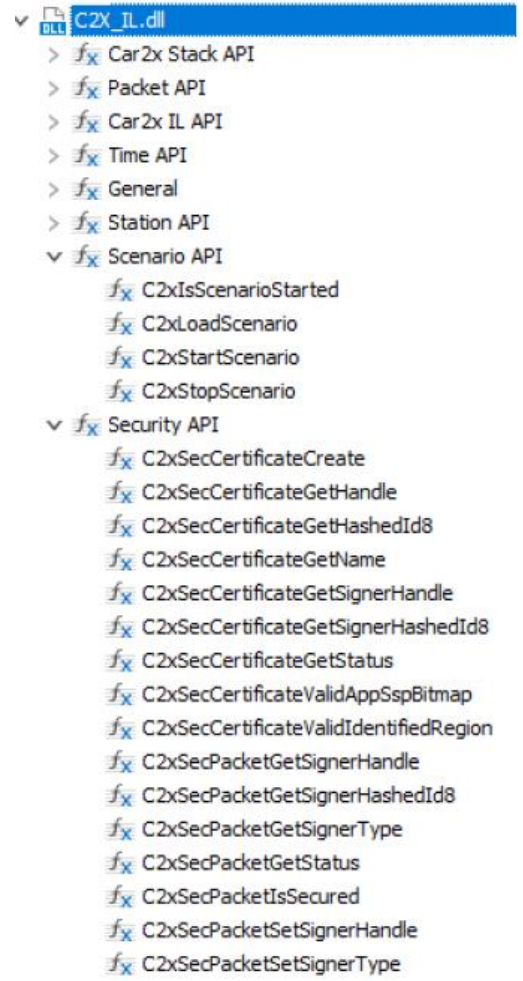
V2X China Protocol Stack – Event visualization

Features related to Chinese protocol stack

- BSM as well as MAP/SPaT are visualized in the Map Window automatically.
- Events will be interpreted in Trace Window

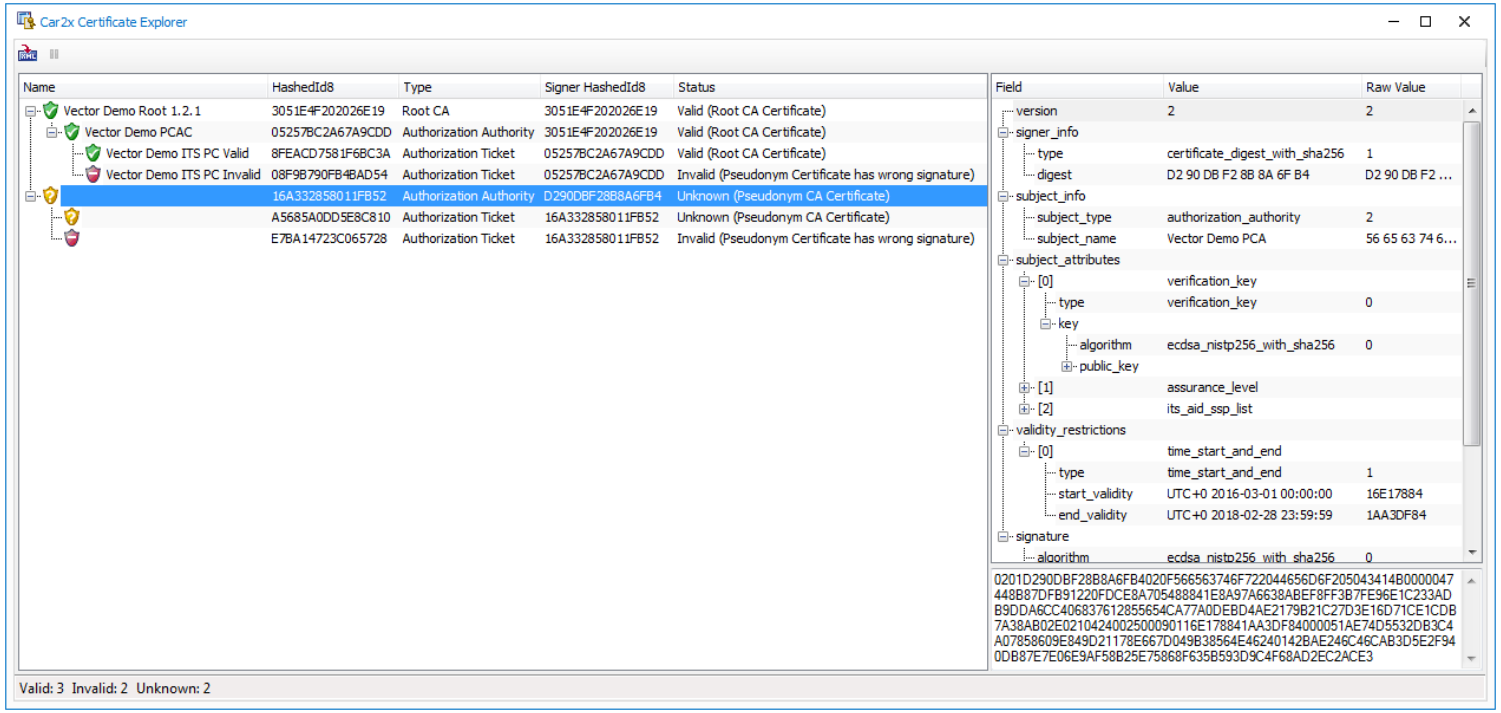






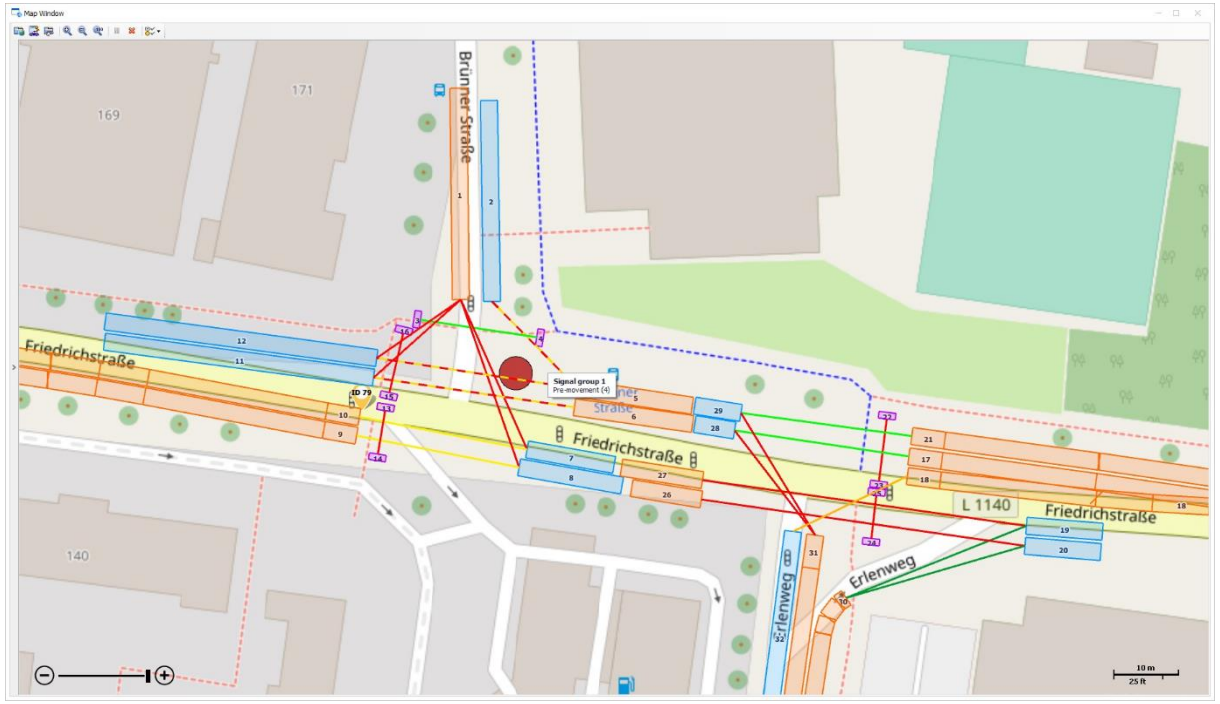
Feature Overview - Security

- Chinese Security
  - Validation of received frames (security header)
  - Signing of generated frames
  - PKI Creation (CANoe 14 SP2)
  - Security CAPL functions library
  - Certificate Explorer



Visualization of infrastructure-related application messages

- Automatic visualization of MAP and SPaT in the Map Window
  - Content is automatically visualized.
  - Vehicle ingress and egress lanes are differentiated by color.
  - Traffic light signals are visualized.
  - Tooltips and Detail view provide further information.
  - Synchronization with other analysis windows can be used as well.

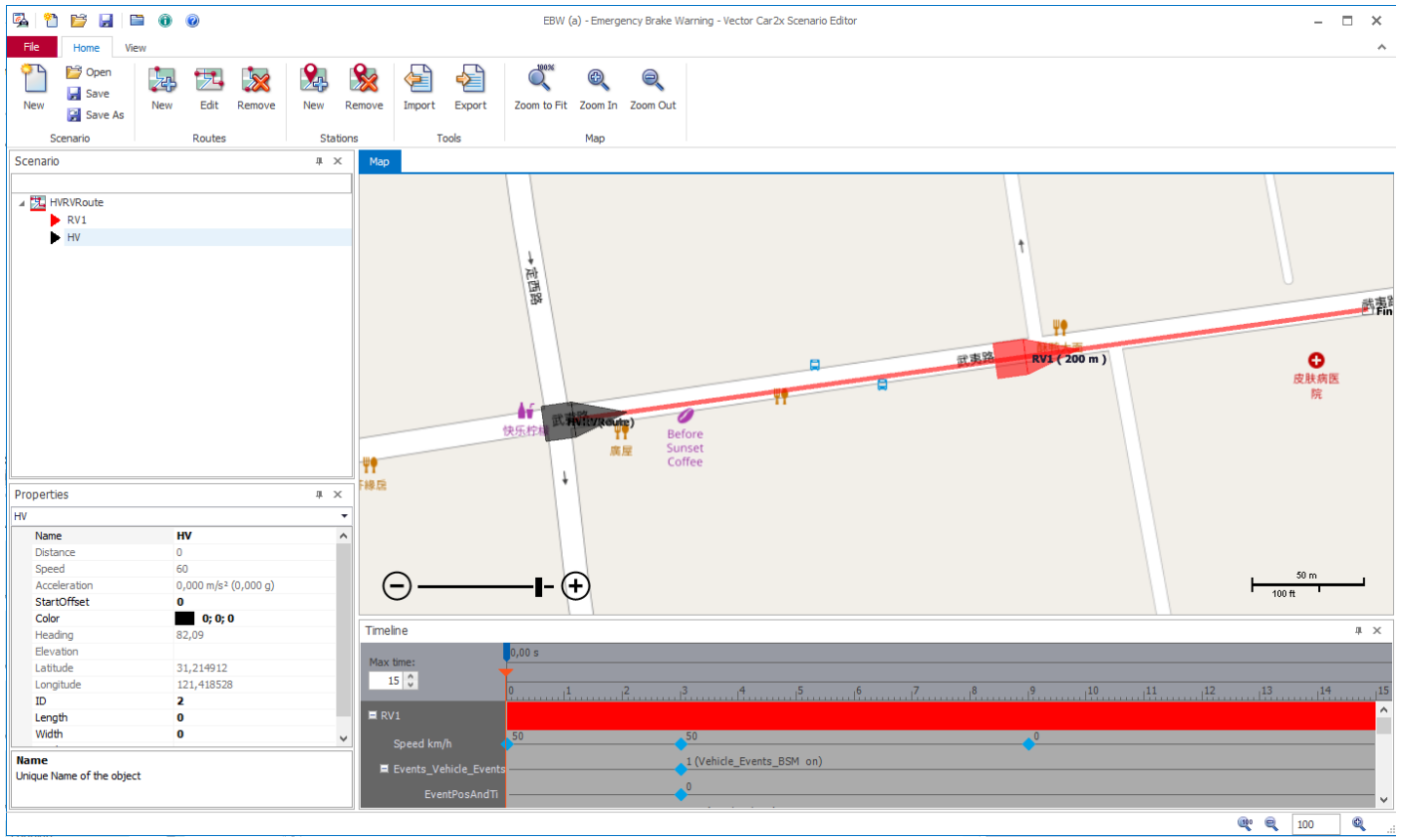


Code	MovementPhaseState	Display
0	unavailable	
1	dark	
2	stop-Then-Proceed	
3	stop-And-Remain	
4	pre-Movement	
5	permissive-Movement-Allowed	
6	protected-Movement-Allowed	
7	permissive-clearance	
8	protected-clearance	
9	caution-Conflicting-Traffic	

Predefined Scenarios

Features related to Chinese protocol stack

- The Scenario Editor can be used as basis for scenarios.
- Predefined scenarios are available as separate CANoe configurations

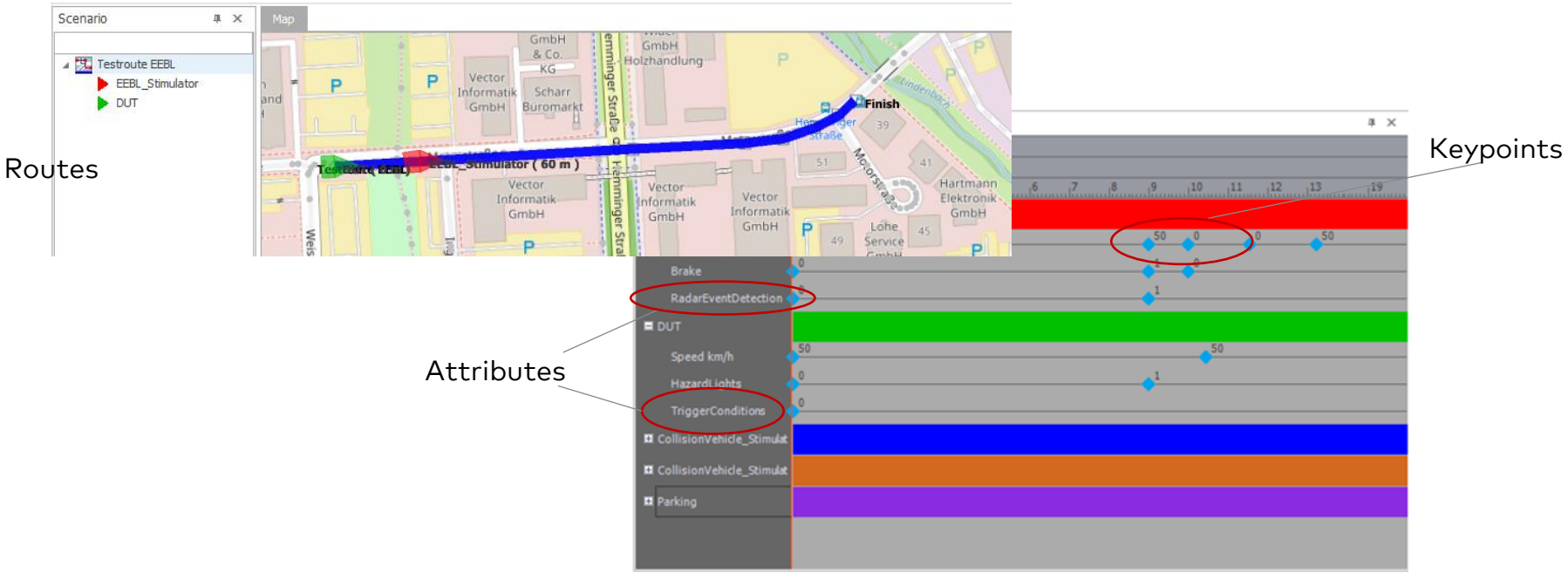


Car2x - CN (GB/T, CSAE)

- Basic Connector (CV2x)
- Template Configuration CSAE0053 (CV2x)
- Scenario AVW – Abnormal Vehicle Warning (CV2x)
- Scenario BSW, LCW – Blind Spot and Lane Change Warnings (...
- Scenario CLW – Control Loss Warning (CV2x)
- Scenario DNPW – Do Not Pass Warning (CV2x)
- Scenario EBW – Emergency Brake Warning (CV2x)
- Scenario EVW – Emergency Vehicle Warning (CV2x)
- Scenario FCW – Forward Collision Warning (CV2x)
- Scenario GLOSA – Green Light Optimal Speed Advisory (CV2x)
- Scenario HLW – Hazardous Location Warning (CV2x)
- Scenario ICW – Intersection Collision Warning (CV2x)
- Scenario IVS – In-Vehicle Signage (CV2x)
- Scenario LTA – Left Turn Assist (CV2x)
- Scenario RLVW – Red Light Violation Warning (CV2x)
- Scenario SLW – Speed Limit Warning (CV2x)
- Scenario TJW – Traffic Jam Warning (CV2x)
- Scenario VRUCW – Vulnerable Road User Collision Warning (CV...

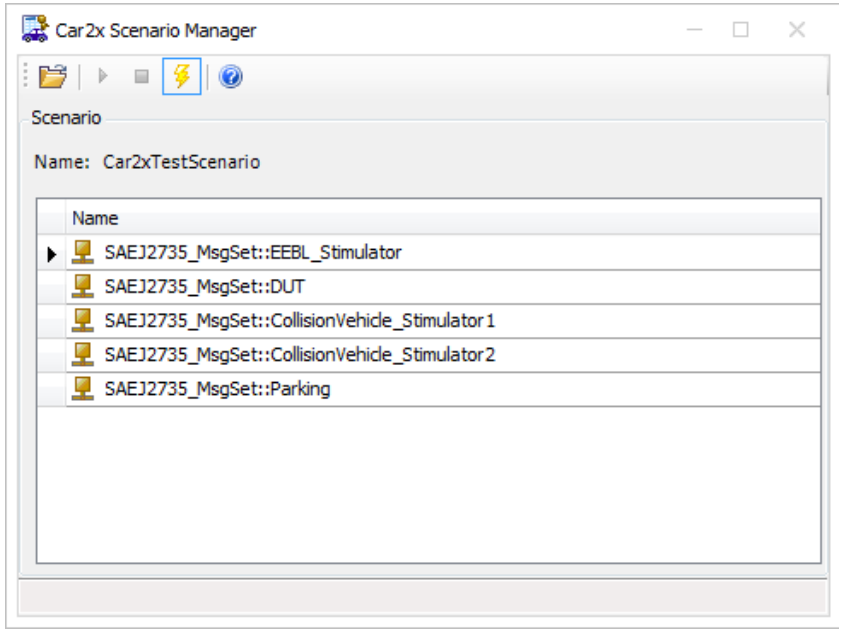
Car2x Scenario Editor

- Car2x scenario editor provides GUI to easy and fast configure a traffic scenario
  - GUI to create routes and ITS stations on a map
  - Configuration of speed and position of the ITS stations
  - Timeline Window allows to scroll to a specific time or waypoint
  - Attributes allows to configure scenario specific behavior
  - Key points to define values of attributes at a specific time
  - Moving a defined scenario to any other location during runtime



Car2x Scenario Manager

- Car2x Scenario Manager imports the scenario file, which has been created by means of the Scenario Editor.
  - Car2x IL can access the scenario data
    - Scenario nodes are automatically mapped to database nodes
    - Automatic assignment of scenario data to Car2x application messages
  - GUI provides controls to start and stop the scenario or start it automatically on measurement start.
  - Specific Nodelayer functions available
    - To start and stop a scenario from CAPL
    - To access the configured scenario data
    - To load additional scenario project files
    - To move existing scenario to any position worldwide with a configurable heading
    - Callback functions which are called if keypoint changes or scenario status changes



Virtual Test Driving with DYNA4

Test Design with vTESTstudio

Closed-Loop Test Execution in CANoe

CANoe Car2X
Remaining bus simulation

System Variables

OSI

DYNA4
Vehicle and environment simulation

Actor signals

Sensor signals

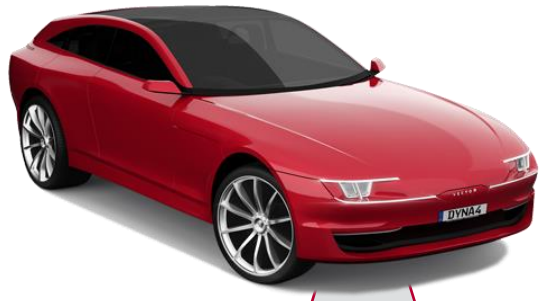
V2X System

AUTOSAR

ROS

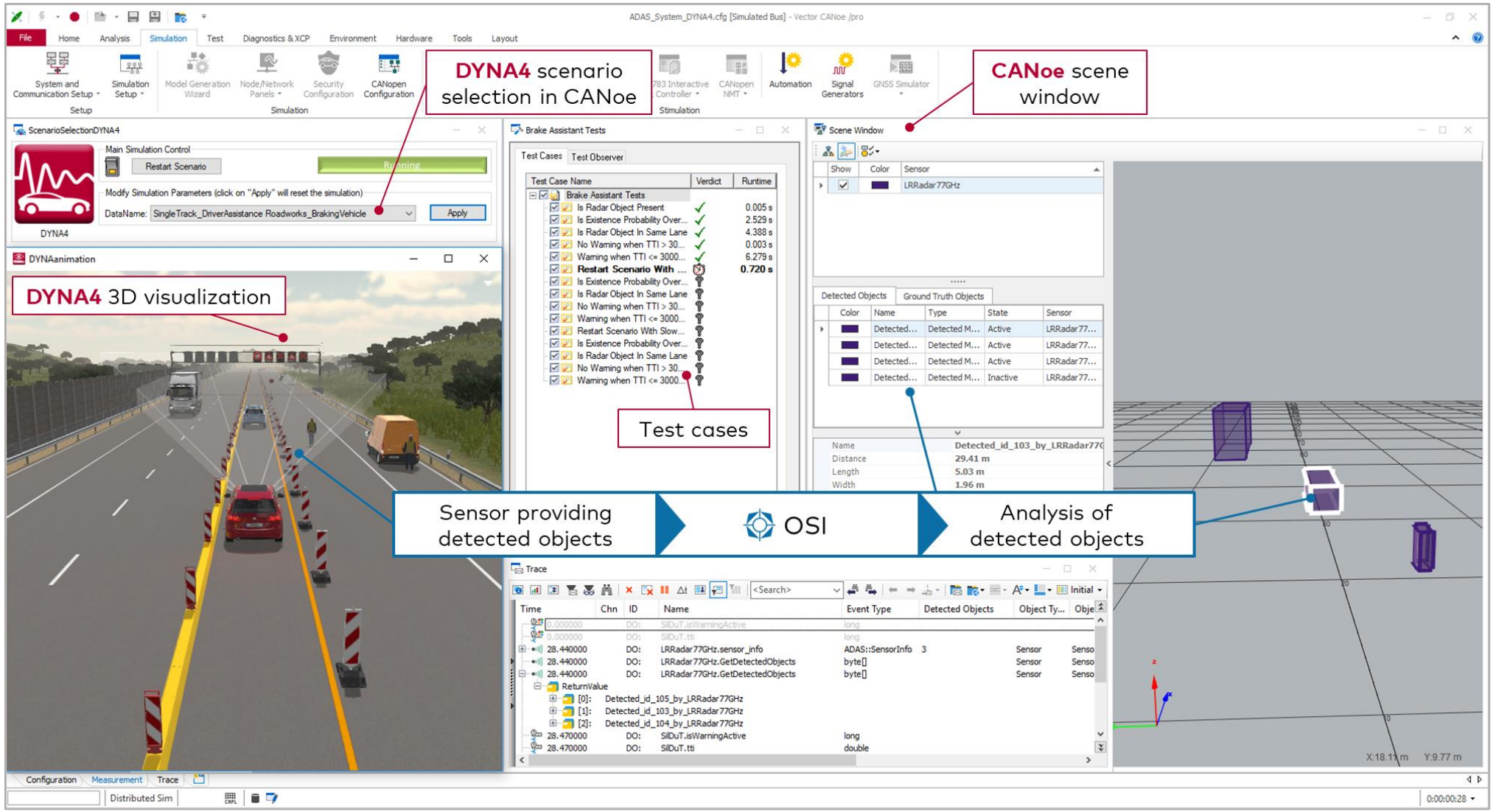
Driver Model

Vehicle Model

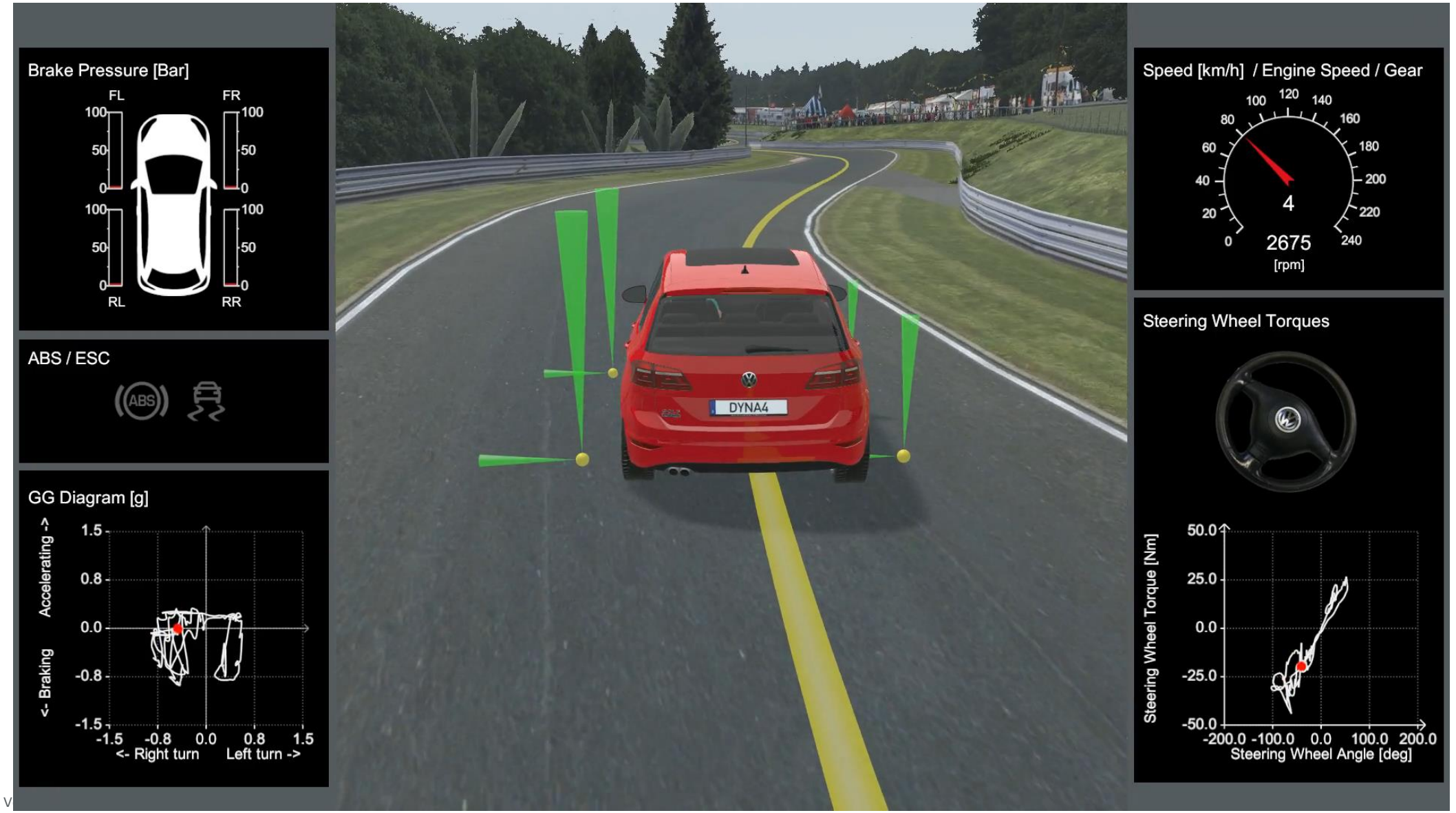


Environment Model

CANoe with DYNA4



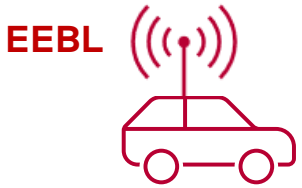
DYNA4


Brake Pressure [Bar]
FL
FR
RL
RR
100
50
0
ABS / ESC
ABS
GG Diagram [g]
Accelerating ->
<- Braking
<- Right turn
Left turn ->
1.5
0.8
0.0
-0.8
-1.5
DYNA4
Speed [km/h] / Engine Speed / Gear
4
2675
[rpm]
Steering Wheel Torques
Steering Wheel Torque [Nm]
Steering Wheel Angle [deg]
50.0
25.0
-25.0
-50.0
-200.0
-100.0
100.0
200.0

Real Driving tests

- Start a scenario at the current position of your real V2X vehicle.

Real
V2X Vehicle



Simulated
V2X Vehicle

- Upgrade a normal vehicle with V2X functionality.

Normal
Vehicle

+

C-V2X HW + CANoe.Car2x

=

V2X Vehicle

Vector ECU Testing tool chain

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