

## C-V2X usage and China Protocols with CANoe .Car2x

Analysis, Test and Simulation of V2X-based System

## Agenda

- ▶ **C-V2X Overview**

  - Physical Layer Solution

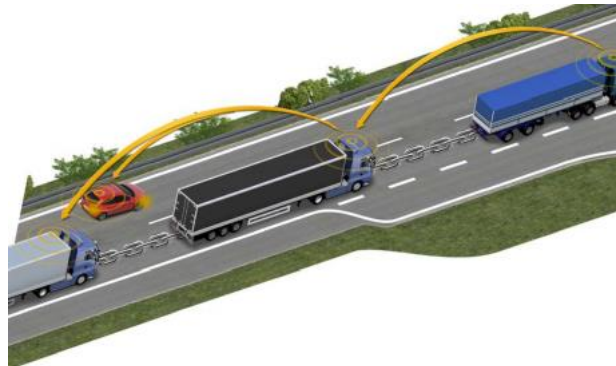
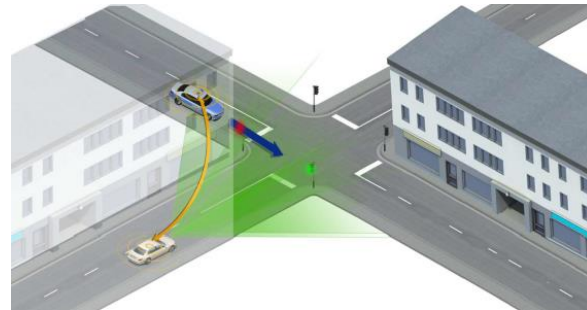
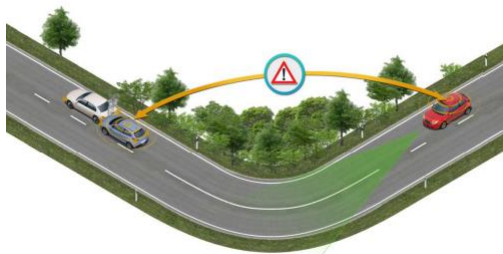
  - CANoe Option Car2X



## 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

The screenshot displays the Vector CANoe software interface, titled "Car2xSystem.cfg [Real Bus] - Vector CANoe /pro". The interface is divided into several functional areas:

- Top Menu and Toolbar:** Includes File, Home, Analysis, Simulation, Test, Diagnostics & XCP, Environment, Hardware, Tools, and Layout. The Simulation step is set to 1000.
- Trace all (Top Left):** A table showing communication events. The selected event is "Emergency Vehicle Approaching" at 48.905611 seconds.
 

Time	Tx/Rx Pow...	Event Info	Signer HashedID8	Source GN Address	Protocol
48.003046	20		DUT (1)	14 00 10:06:62:5C:9C:50	CAM
48.005356	20	Roadworks : Street Cleaning	RWW	3C 00 B2:22:1F:84:5B:D4	DENM
48.011789	20		SimCarEVA (1)	28 00 55:0F:40:CF:A9:BF	CAM
48.905611	20	Emergency Vehicle Approaching	SimCarEVA (1)	28 00 55:0F:40:CF:A9:BF	DENM
48.909462	20		SimCarEEBL (1)	14 00 5F:C5:37:34:3B:5E	CAM
48.906142	20	Dangerous Situation : Emergency Electronic...	SimCarEEBL (1)	14 00 5F:C5:37:34:3B:5E	DENM
46.007900	20		TL	3D 06 08:BE:5B:81:74:80	MAP
48.007682	20		TL	3D 06 08:BE:5B:81:74:80	SPAT
- State Tracker - DUT (Top Right):** A table showing the state of various parameters over time.
 

Name	Value	Color
DisplayState	no_information	Yellow
TISState	Unknown	Red
TITimeToChangeState	0, 22, 21, 20, 19	Red
DistToTrafficLight	0, 91, 87, 82, 77	Red
- Map Window (Bottom Left):** A map view showing the vehicle's position and various ITS events. A table lists the events:
 

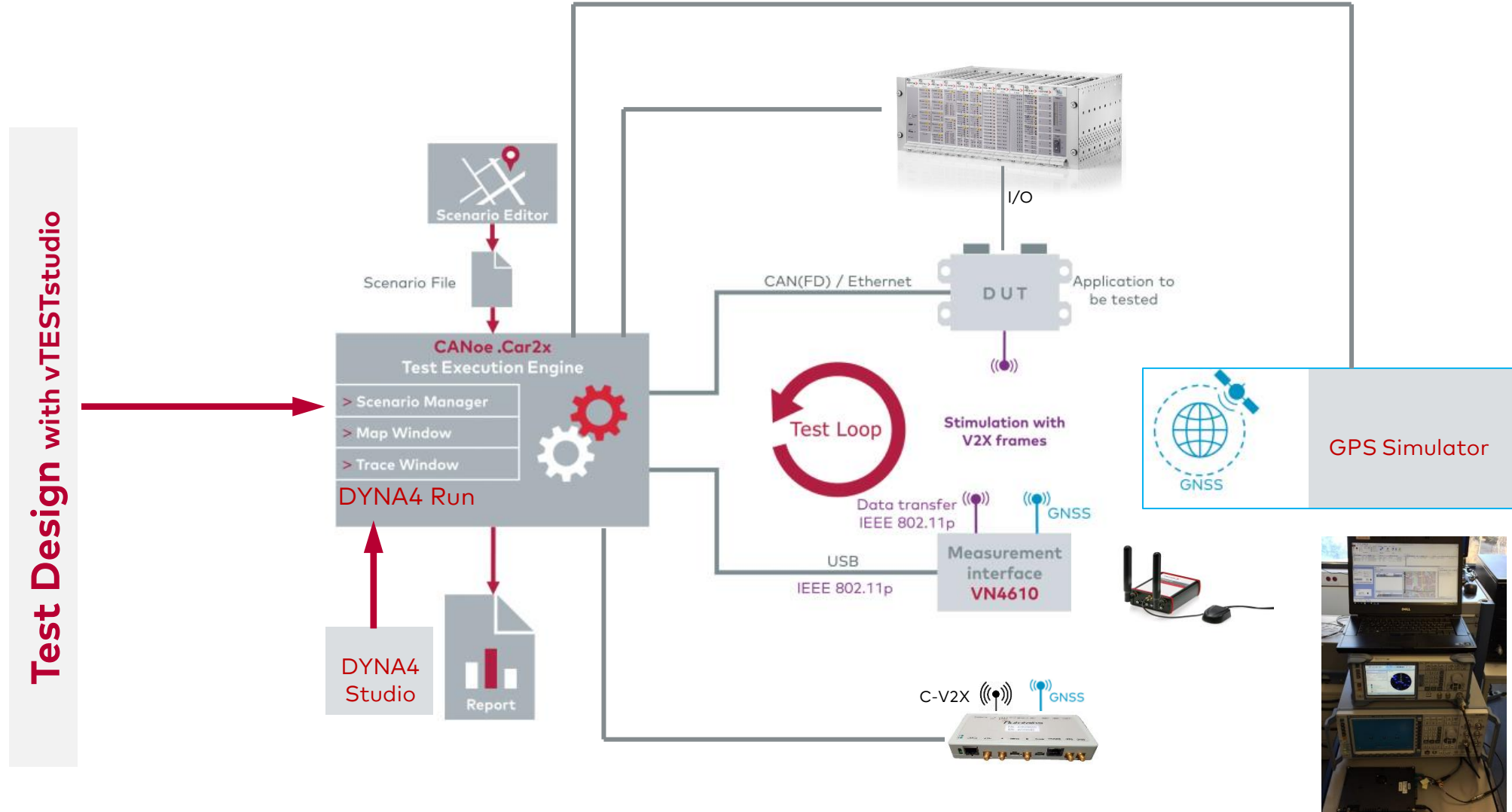
Show	Name	Originator
<input checked="" type="checkbox"/>	Roadworks : Street Clea...	RWW
<input checked="" type="checkbox"/>	Emergency Vehicle Appr...	SimCarEVA
<input checked="" type="checkbox"/>	Dangerous Situation : E...	SimCarEEBL
<input checked="" type="checkbox"/>	Intersection ID 1	TL
<input checked="" type="checkbox"/>	Intersection ID 2	TL
- Graphic - DUT & Traffic Light (Bottom Right):** A graph showing the speed and heading values of the DUT and the state of the traffic light over time. The x-axis represents time in seconds from 0 to 85.
- Data - Road Works Warning (Bottom Right):** A table showing the raw data for the Road Works Warning event.
 

Name	Value	Unit	Raw Value	Bar
RWW::latitude	48.8235435	°	488235435	Red
RWW::longitude	9.0999466	°	90999466	Red
RWW::relevanceDistance	lessThan100m		1	Red
RWW::relevanceTrafficDirection	allTrafficDirections		0	Red
RWW::causeCode	roadworks		3	Red
RWW::subCauseCode			5	Red

C-V2X in China, EU, US

	Vector	EU	EU & US	US	China (Prototype)
Layer 7 Application	CANoe. Car2X  CANalyzer. Car2X	CAM	MAP	BSM	BSM  ...
Layer 6 Presentation		DENM	SPaT	...	
Layer 5 Session		IVIM			
Layer 4 Transport		Basic Transport Protocol		WAVE Short Message Protocol	GB/T 31024.3 DSMP
Layer 3 Network		GeoNetworking			GB/T 31024.3 Adaption Layer
Layer 2 Data Link	VN4610 / 3 <sup>rd</sup> Party C-V2X devices	Wifi Communication (802.11p)			C-V2X - 3GPP Rel. 14 (PC5 link, Mode 4) / Rel. 15
Layer 1 Physical		C-V2X - 3GPP Rel. 14 (PC5 link, Mode 4) / Rel. 15			

# C-V2X/DSRC Test System Overview



## Agenda

C-V2X Overview

▶ **Physical Layer Solution**

CANoe Option Car2X



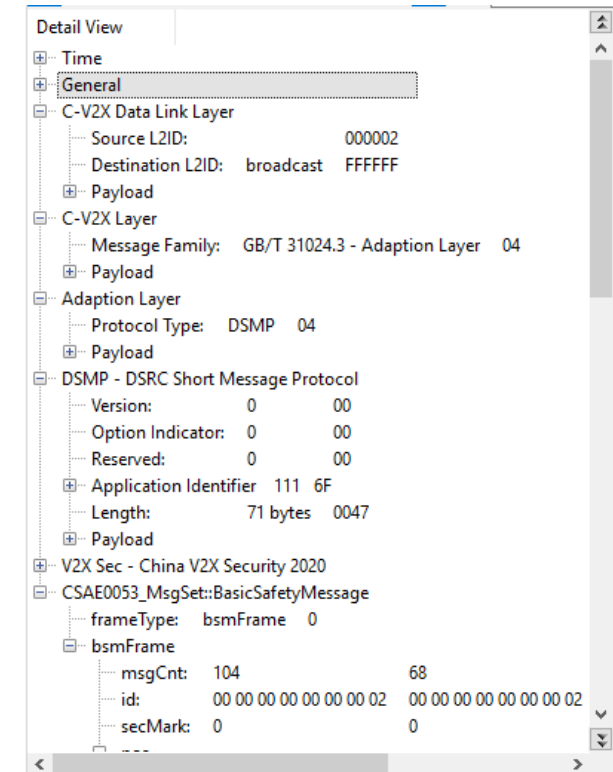
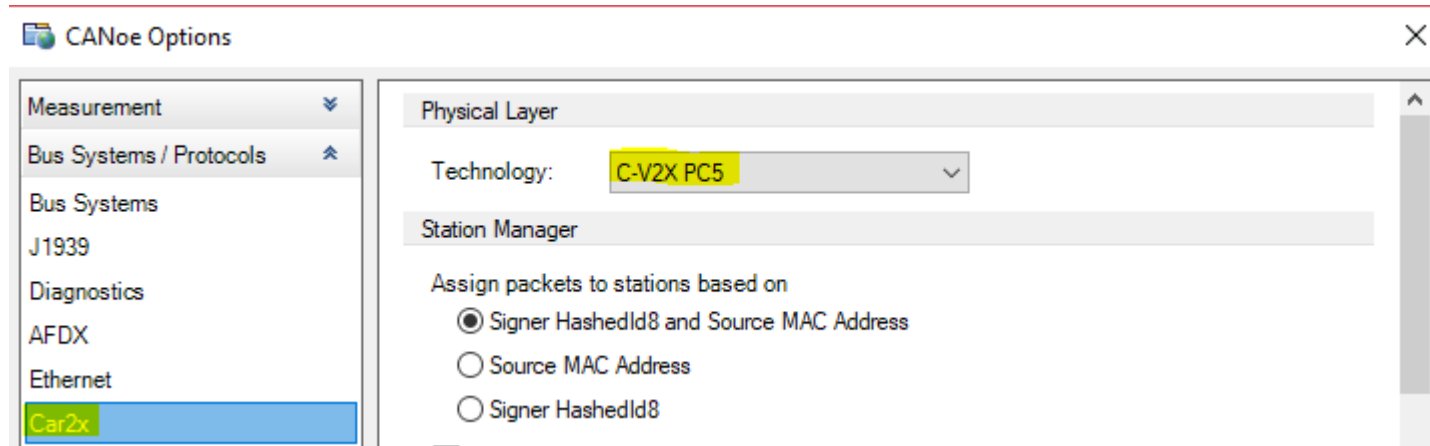
## Physical Layer

### 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:

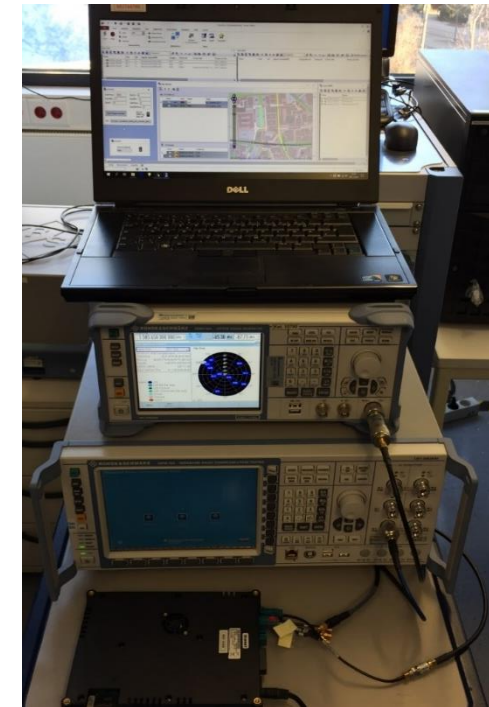
It is not possible to configure the networks as 802.11p **and** C-V2X in **one** measurement configuration.



## Supported of Rohde & Schwarz CMW500

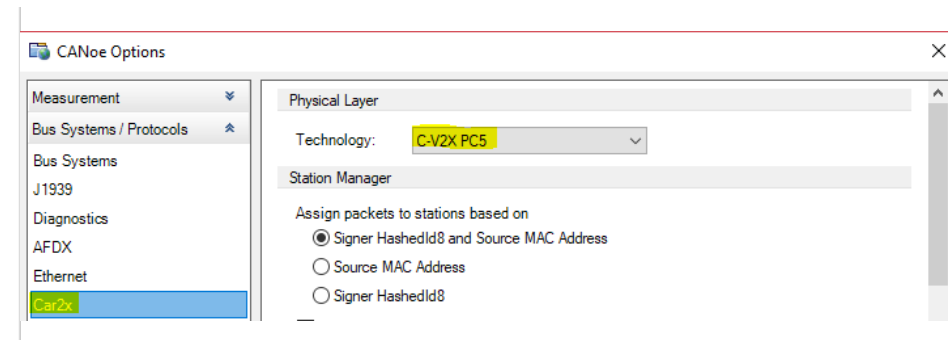
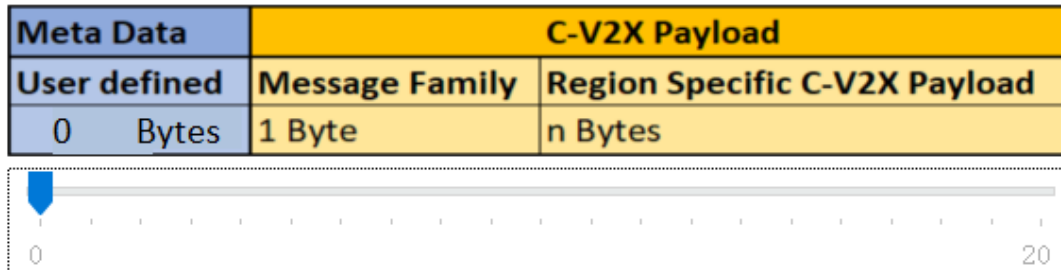
- ▶ The R&S CMW500 and CANoe .Car2x can be connected to have an end-to-end scenario-based test solution
  - > Test focus is on physical layer and C-V2X performance
- ▶ In the Vector knowledge base the according configuration can be downloaded

<https://kb.vector.com/entry/1648/>



## Supported Interfaces

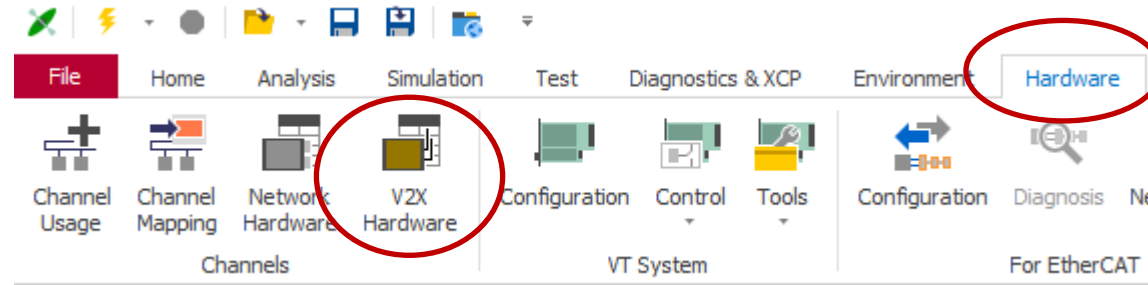
- ▶ Generic UDP Interface
  - ▶ Socket Communication – inject V2X data frames in CANoe
    - > Programming Example included in demos shows how to inject packets from other sources
    - > Usage of C2xDispatchPacket (...) function to inject V2X frames from any source



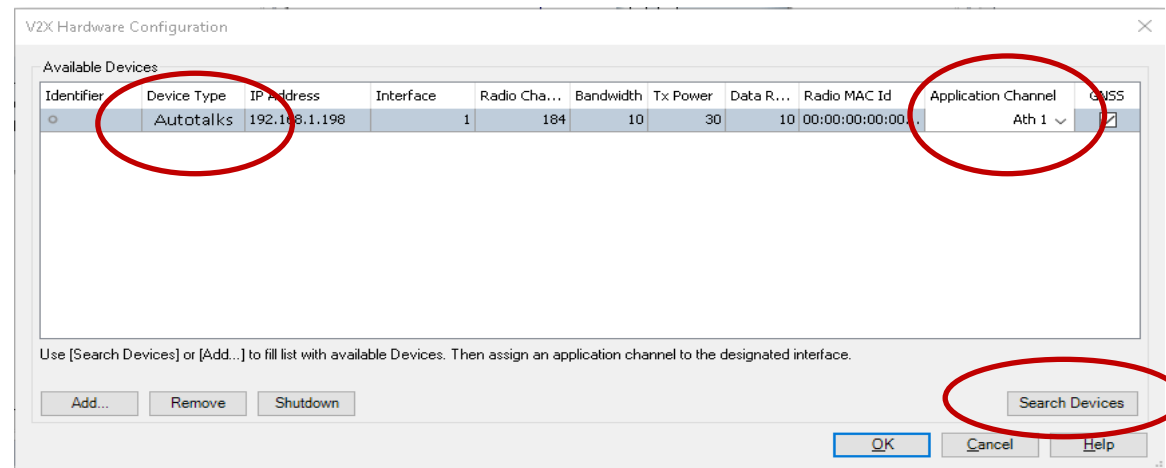
- ▶ Advantage
  - > Possibility to connect any device or external software to CANoe

## 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**



## 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

**Simulation Controls:** Start, Stop, Break, Step (1000), Online Mode, Simulated Bus, Standalone Mode.

**State Tracker - DUT:** Shows traffic light phases: Red (3s), Yellow (2s), Green (3s).

**Data - DUT & Traffic Light:**

Name	Value	Unit	Raw Value	Bar
Speed	62	km/h	62	Bar
DistToTrafficLight	1	m	1	Bar
TlState	Green		0	Bar
TlTimeToChangeState	3.00	s	3	Bar
DUT::speedValue	17.49	m/s	1749	Bar
State	Green		3	Bar
TimeToSwitch	2.00	s	2	Bar
TL::eventState	protected_		6	Bar
TL::minEndTime	31417			Bar
TL::lat	488252880		48825288	Bar
TL::lon	90958140		90958140	Bar
TL::elevation	--		--	Bar

**Trace all:**

Time	Chn	Dir	Sender Node	Signer HashedID8	Source GN Address	Source MAC	Protocol	Protocol Info	Packet Len
1289.000530	Ath 1	Tx	DUT	DUT (2)	15 06 4A:BF:1D:9A:0E:7F	4A:BF:1D:9A:0E:7F	CAM	ASN.1 defined	390
1285.002088	Ath 1	Tx	TL	TL	30 06 4C:33:E7:EB:98:79	4C:33:E7:EB:98:79	MAP	ASN.1 defined	711
1289.001121	Ath 1	Tx	TL	TL	30 06 4C:33:E7:EB:98:79	4C:33:E7:EB:98:79	SPAT	ASN.1 defined	434
1289.001425	Ath 1	Tx	SimCarEEBL	SimCarEEBL (1)	15 06 FB:A7:29:88:17:15	FB:A7:29:88:17:15	CAM	ASN.1 defined	224
1289.101085	Ath 1	Tx	SimCarEEBL	SimCarEEBL (1)	15 06 FB:A7:29:88:17:15	FB:A7:29:88:17:15	DENM	ASN.1 defined	408
1151.001474	Ath 1	Tx	RWW	RWW	30 06 78:C9:E9:9E:2E:5C	78:C9:E9:9E:2E:5C	DENM	ASN.1 defined	452
1261.001393	Ath 1	Tx	SimCarEVA	SimCarEVA (1)	29 06 F8:F5:B5:34:43:BA	F8:F5:B5:34:43:BA	CAM	ASN.1 defined	392
1252.000860	Ath 1	Tx	SimCarEVA	SimCarEVA (1)	29 06 F8:F5:B5:34:43:BA	F8:F5:B5:34:43:BA	DENM	ASN.1 defined	242

**Car2x Network Explorer - EU\_ApplMsg.xml**

**Message Details:**

Name	Type	Range	Format
header	Sequence		
protocolVersion	Integer	[0..255]	
messageID	Integer	[0..255]	
stationID	Integer	[0..4294967295]	
cam	Sequence		
generationDeltaTime	Integer	[0..65535]	1 ms
camParameters	Sequence		
basicContainer	Sequence		
stationType	Integer	[0..255]	
referencePosition	Sequence		
latitude	Integer	[-90000000..90000000]	0.0000001 °
longitude	Integer	[-1800000000..1800000000]	0.0000001 °
positionConfidenceEllipse	Sequence		
semiMajorConfidence	Integer	[0..4095]	1 cm
semiMinorConfidence	Integer	[0..4095]	1 cm
		3601	0.1 °
		15	0.01 m

**Car2x Station Manager:**

Name	Color	Trace Highlighting	Node
DUT	Yellow	<input checked="" type="checkbox"/>	EU_ApplMsg::DUT
TL	Green	<input checked="" type="checkbox"/>	EU_ApplMsg::TL
SimCarEEBL	Red	<input checked="" type="checkbox"/>	EU_ApplMsg::SimCarEEBL
RWW	Blue	<input checked="" type="checkbox"/>	EU_ApplMsg::RWW
SimCarEVA	Light Blue	<input checked="" type="checkbox"/>	EU_ApplMsg::SimCarEVA

**HashedID8 Originator address:**

HashedID8	Originator address
B-4BCF8F5B3443BA	F8:F5:B5:34:43:BA
B710227496D03527	22:74:96:D0:35:27

**Map Window**

**ITS Stations:**

Show	Color	Name	Node
<input checked="" type="checkbox"/>	Green	DUT	EU_ApplMsg::DUT
<input checked="" type="checkbox"/>	Red	TL	EU_ApplMsg::TL
<input checked="" type="checkbox"/>	Yellow	SimCarEEBL	EU_ApplMsg::SimC...
<input checked="" type="checkbox"/>	Blue	RWW	EU_ApplMsg::RWW
<input checked="" type="checkbox"/>	Light Blue	SimCarEVA	EU_ApplMsg::SimC...

**ITS Events:**

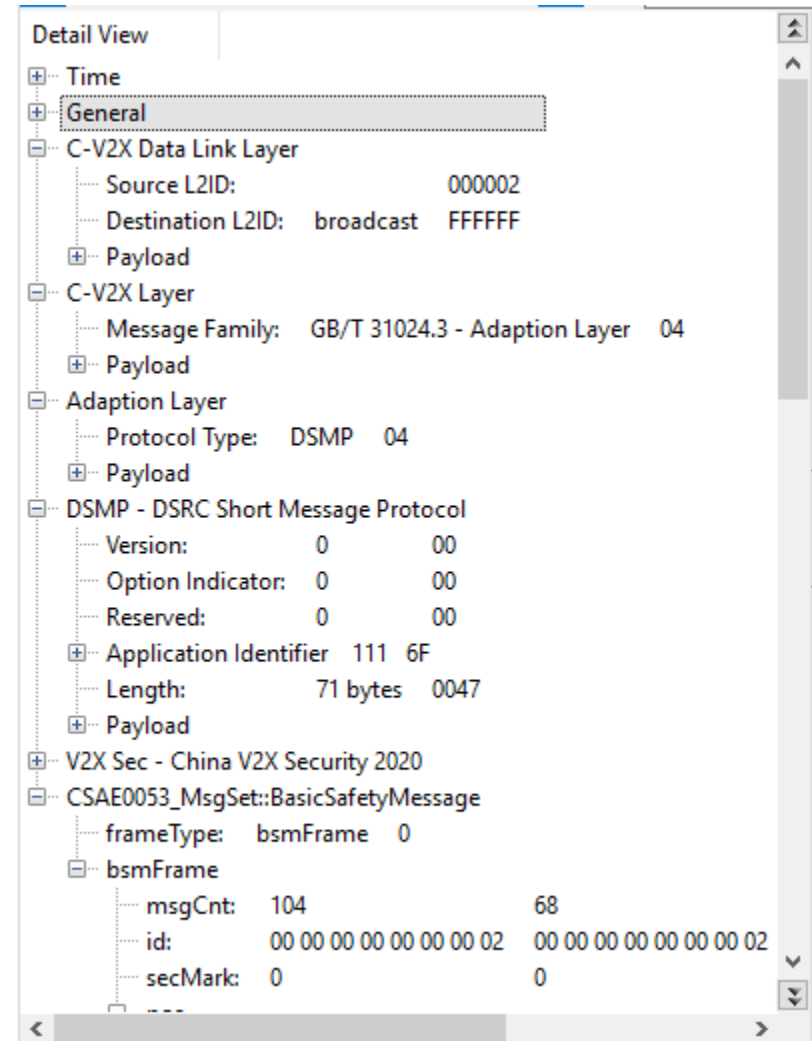
Show	Name	Originator
<input checked="" type="checkbox"/>	Emergency Vehicle Approaching	SimCarEVA
<input checked="" type="checkbox"/>	Roadworks : Street Cleaning	RWW
<input checked="" type="checkbox"/>	Dangerous Situation : Emergency ...	SimCarEEBL

Map data © OpenStreetMap contributors, CC-BY, Imagery © Mapbox

## V2X China Protocol Stack

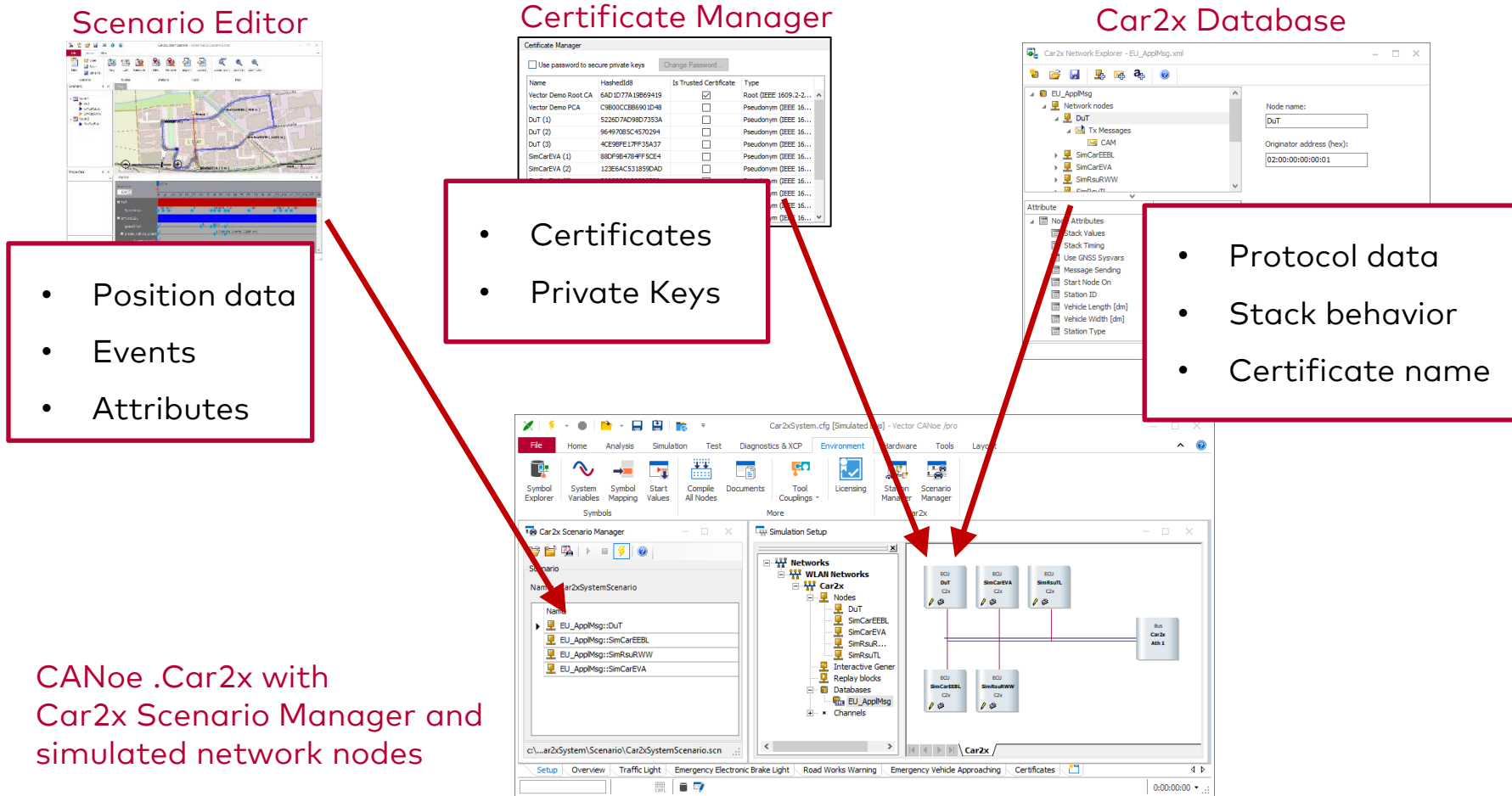
### Supported Chinese V2X Protocols

- ▶ 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:



- Position data
- Events
- Attributes

- Certificates
- Private Keys

- Protocol data
- Stack behavior
- Certificate name

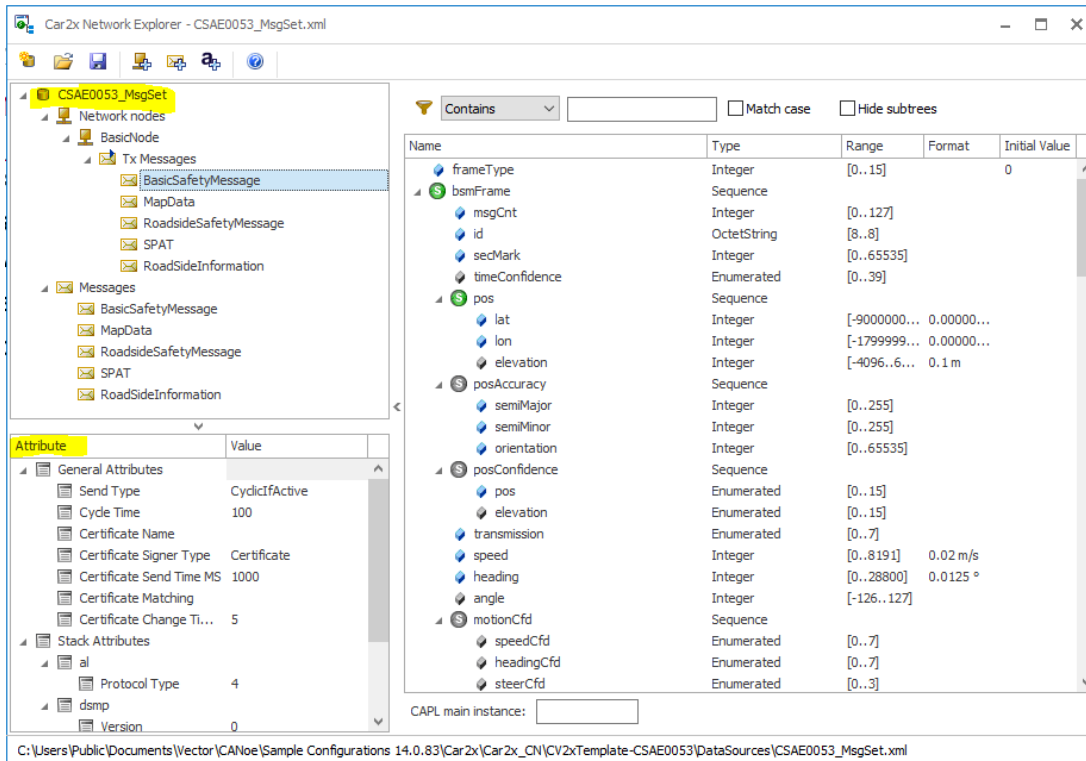
CANoe .Car2x with Car2x Scenario Manager and simulated network nodes



## 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.



The screenshot displays the 'Car2x Network Explorer - CSAE0053\_MsgSet.xml' interface. The left pane shows a tree view of the database structure under 'CSAE0053\_MsgSet', including 'Network nodes', 'BasicNode', 'Tx Messages', and 'Messages'. The 'BasicSafetyMessage' is selected. The right pane shows a detailed view of the 'pos' message structure, listing its fields, types, ranges, and initial values.

Name	Type	Range	Format	Initial Value
frameType	Integer	[0..15]		0
bsmFrame	Sequence			
msgCnt	Integer	[0..127]		
id	OctetString	[8..8]		
secMark	Integer	[0..65535]		
timeConfidence	Enumerated	[0..39]		
pos	Sequence			
lat	Integer	[-9000000... 0.00000...]		
lon	Integer	[-1799999... 0.00000...]		
elevation	Integer	[-4096..6... 0.1 m]		
posAccuracy	Sequence			
semiMajor	Integer	[0..255]		
semiMinor	Integer	[0..255]		
orientation	Integer	[0..65535]		
posConfidence	Sequence			
pos	Enumerated	[0..15]		
elevation	Enumerated	[0..15]		
transmission	Enumerated	[0..7]		
speed	Integer	[0..8191]	0.02 m/s	
heading	Integer	[0..28800]	0.0125 °	
angle	Integer	[-126..127]		
motionCfd	Sequence			
speedCfd	Enumerated	[0..7]		
headingCfd	Enumerated	[0..7]		
steerCfd	Enumerated	[0..3]		

Attribute table:

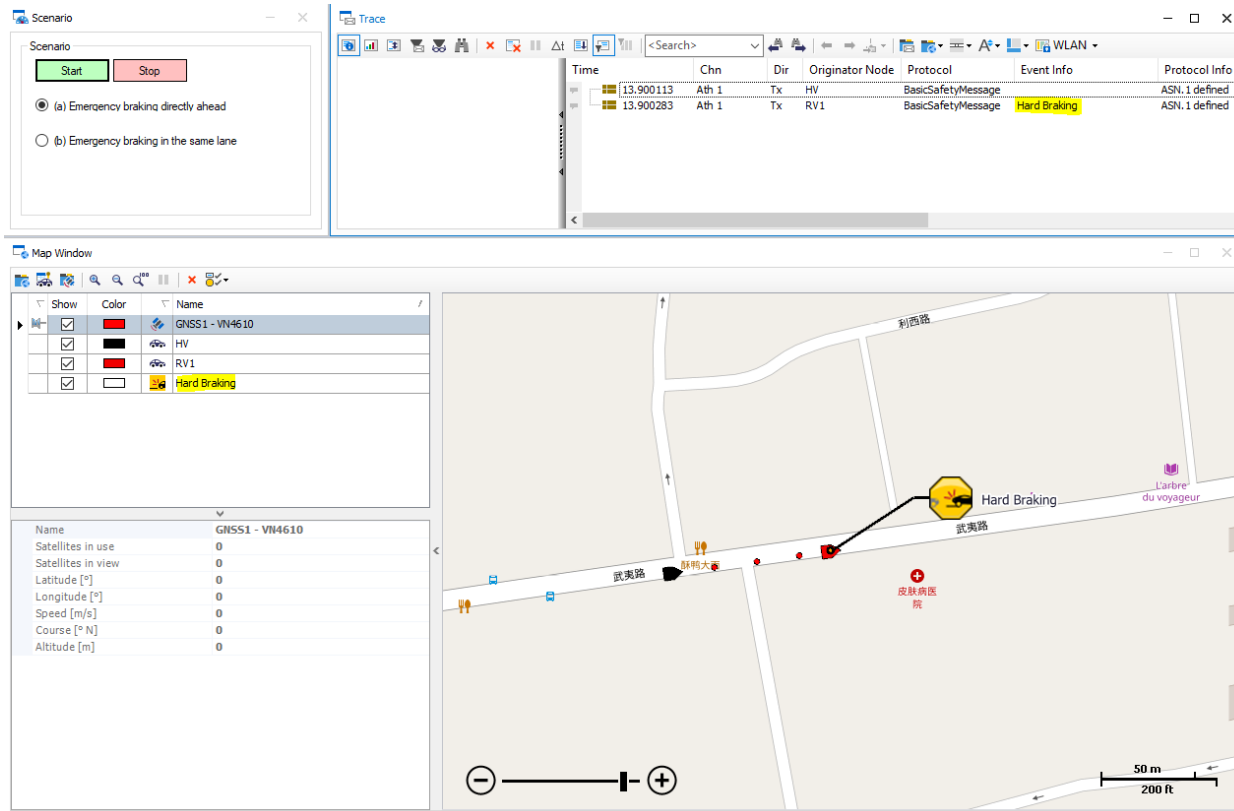
Attribute	Value
General Attributes	
Send Type	CyclicActive
Cycle Time	100
Certificate Name	
Certificate Signer Type	Certificate
Certificate Send Time MS	1000
Certificate Matching	
Certificate Change Ti...	5
Stack Attributes	
al	
Protocol Type	4
dsmp	
Version	0

Path: C:\Users\Public\Documents\Vector\CANoe\Sample Configurations 14.0.83\Car2x\Car2x\_CN\CV2xTemplate-CSAE0053\DataSources\CSAE0053\_MsgSet.xml

## V2X China Protocol Stack – Event visualization

### Features related to Chinese protocol stack

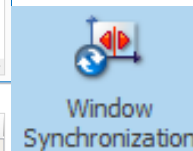
- ▶ BSM as well as MAP/SPaT are visualized in the Map Window automatically.
- ▶ Events will be interpreted in Trace Window



The screenshot displays three windows from the CANoe software:

- Scenario Window:** Shows a scenario named "Emergency braking directly ahead" selected. It has "Start" and "Stop" buttons.
- Trace Window:** Displays a table of captured data. The table has columns for Time, Chn, Dir, Originator Node, Protocol, Event Info, and Protocol Info. Two entries are visible:

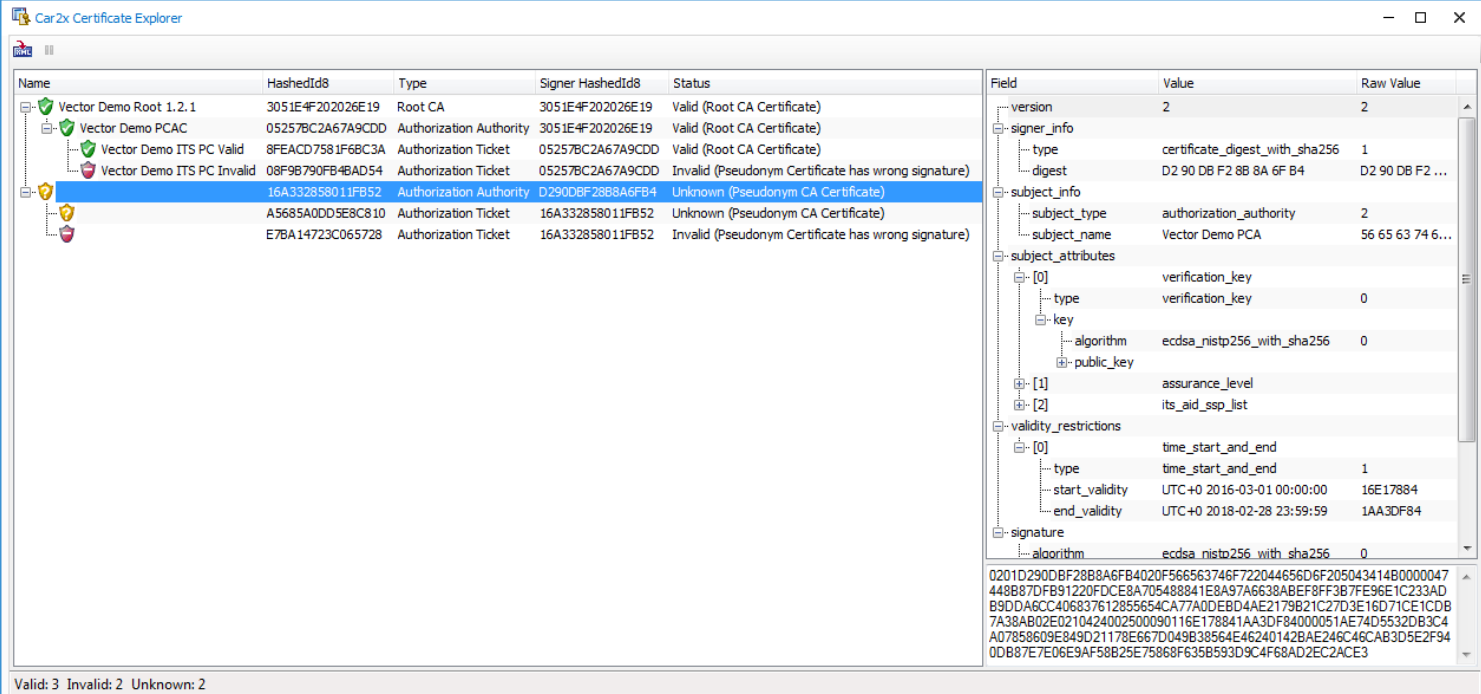
Time	Chn	Dir	Originator Node	Protocol	Event Info	Protocol Info
13.900113	Ath 1	Tx	HV	BasicSafetyMessage		ASN.1 defined
13.900283	Ath 1	Tx	RV1	BasicSafetyMessage	Hard Braking	ASN.1 defined
- Map Window:** Shows a map with a vehicle icon labeled "GNSS1 - VM4610" and a yellow "Hard Braking" event icon. The map includes a legend, a list of objects (GNSS1 - VM4610, HV, RV1, Hard Braking), and a status panel with various parameters like Name, Satellites in use, Latitude, Longitude, Speed, Course, and Altitude.



- ▼ DLL C2X\_IL.dll
  - > fX Car2x Stack API
  - > fX Packet API
  - > fX Car2x IL API
  - > fX Time API
  - > fX General
  - > fX Station API
  - ▼ fX Scenario API
    - fX C2xIsScenarioStarted
    - fX C2xLoadScenario
    - fX C2xStartScenario
    - fX C2xStopScenario
  - ▼ fX Security API
    - fX C2xSecCertificateCreate
    - fX C2xSecCertificateGetHandle
    - fX C2xSecCertificateGetHashedId8
    - fX C2xSecCertificateGetName
    - fX C2xSecCertificateGetSignerHandle
    - fX C2xSecCertificateGetSignerHashedId8
    - fX C2xSecCertificateGetStatus
    - fX C2xSecCertificateValidAppSspBitmap
    - fX C2xSecCertificateValidIdentifiedRegion
    - fX C2xSecPacketGetSignerHandle
    - fX C2xSecPacketGetSignerHashedId8
    - fX C2xSecPacketGetSignerType
    - fX C2xSecPacketGetStatus
    - fX C2xSecPacketIsSecured
    - fX C2xSecPacketSetSignerHandle
    - fX C2xSecPacketSetSignerType

## 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



The screenshot shows the 'Car2x Certificate Explorer' window. It contains a table of certificates and a detailed view of the selected certificate.

Name	HashedId8	Type	Signer HashedId8	Status
Vector Demo Root 1.2.1	3051E4F202026E19	Root CA	3051E4F202026E19	Valid (Root CA Certificate)
Vector Demo PCAC	05257BC2A67A9CDD	Authorization Authority	3051E4F202026E19	Valid (Root CA Certificate)
Vector Demo ITS PC Valid	8FEACD7581F6BC3A	Authorization Ticket	05257BC2A67A9CDD	Valid (Root CA Certificate)
Vector Demo ITS PC Invalid	08F9B790FB4BAD54	Authorization Ticket	05257BC2A67A9CDD	Invalid (Pseudonym Certificate has wrong signature)
16A332858011FB52	16A332858011FB52	Authorization Authority	D290DBF288A6FB4	Unknown (Pseudonym CA Certificate)
A5685A0DD5E8C810	A5685A0DD5E8C810	Authorization Ticket	16A332858011FB52	Unknown (Pseudonym CA Certificate)
E7BA14723C065728	E7BA14723C065728	Authorization Ticket	16A332858011FB52	Invalid (Pseudonym Certificate has wrong signature)

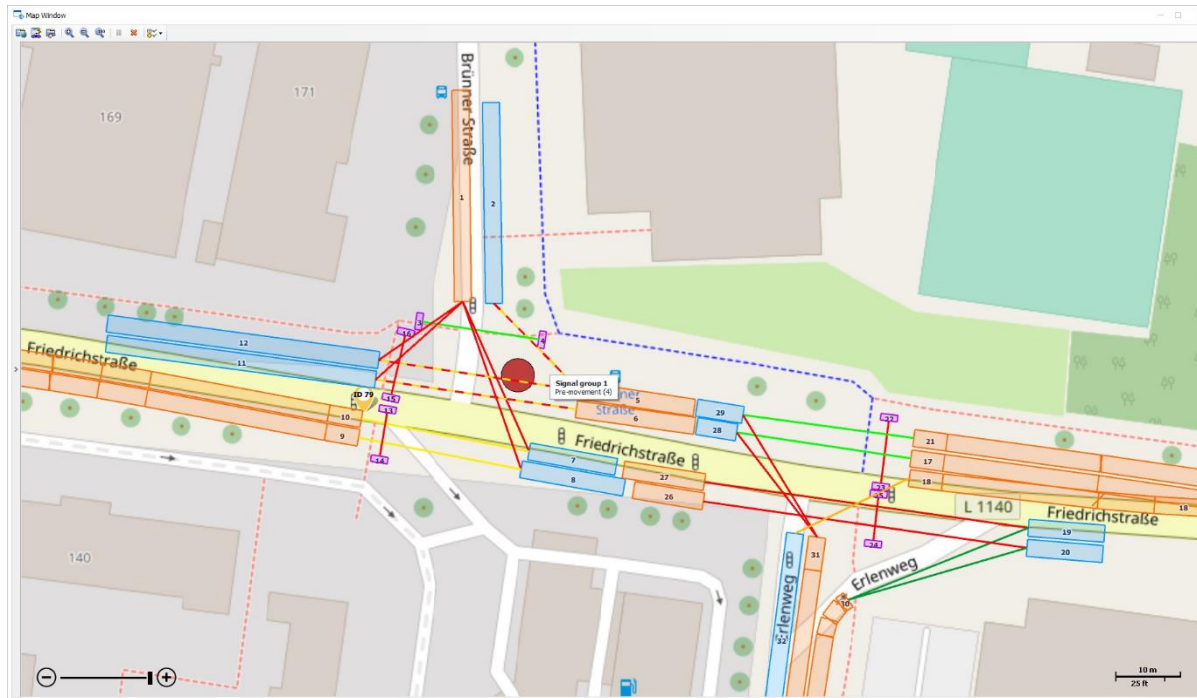
Field	Value	Raw Value
version	2	2
signer_info		
type	certificate_digest_with_sha256	1
digest	D2 90 DB F2 8B 8A 6F B4	D2 90 DB F2 ...
subject_info		
subject_type	authorization_authority	2
subject_name	Vector Demo PCA	56 65 63 74 6...
subject_attributes		
[0]	verification_key	
type	verification_key	0
key		
algorithm	ecdsa_nistp256_with_sha256	0
public_key		
[1]	assurance_level	
[2]	its_aid_ssp_list	
validity_restrictions		
[0]	time_start_and_end	
type	time_start_and_end	1
start_validity	UTC+0 2016-03-01 00:00:00	16E17884
end_validity	UTC+0 2018-02-28 23:59:59	1AA3DF84
signature		
algorithm	ecdsa_nistp256_with_sha256	0











0201D290DBF288A6FB4020F566563746F722044656D6F205043414B0000047  
 448B87DFB91220FDC8E8A705488841E8A97A6838ABEF8FF3B7FE36E1C233AD  
 B9DDA6CC406837612855654CA77ADDEBD4AE2179B21C27D3E16D71CE1CDB  
 7A38AB02E021042400250090116E178841AA3DF84000051AE74D5532DB3C4  
 A07858609E849D21178E667D049B38564E46240142BAE246C46CAB3D5E2F94  
 0DB87E7E06E9AF58B25E75868F635B593D9C4F68AD2EC2ACE3

Valid: 3 Invalid: 2 Unknown: 2

## 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.

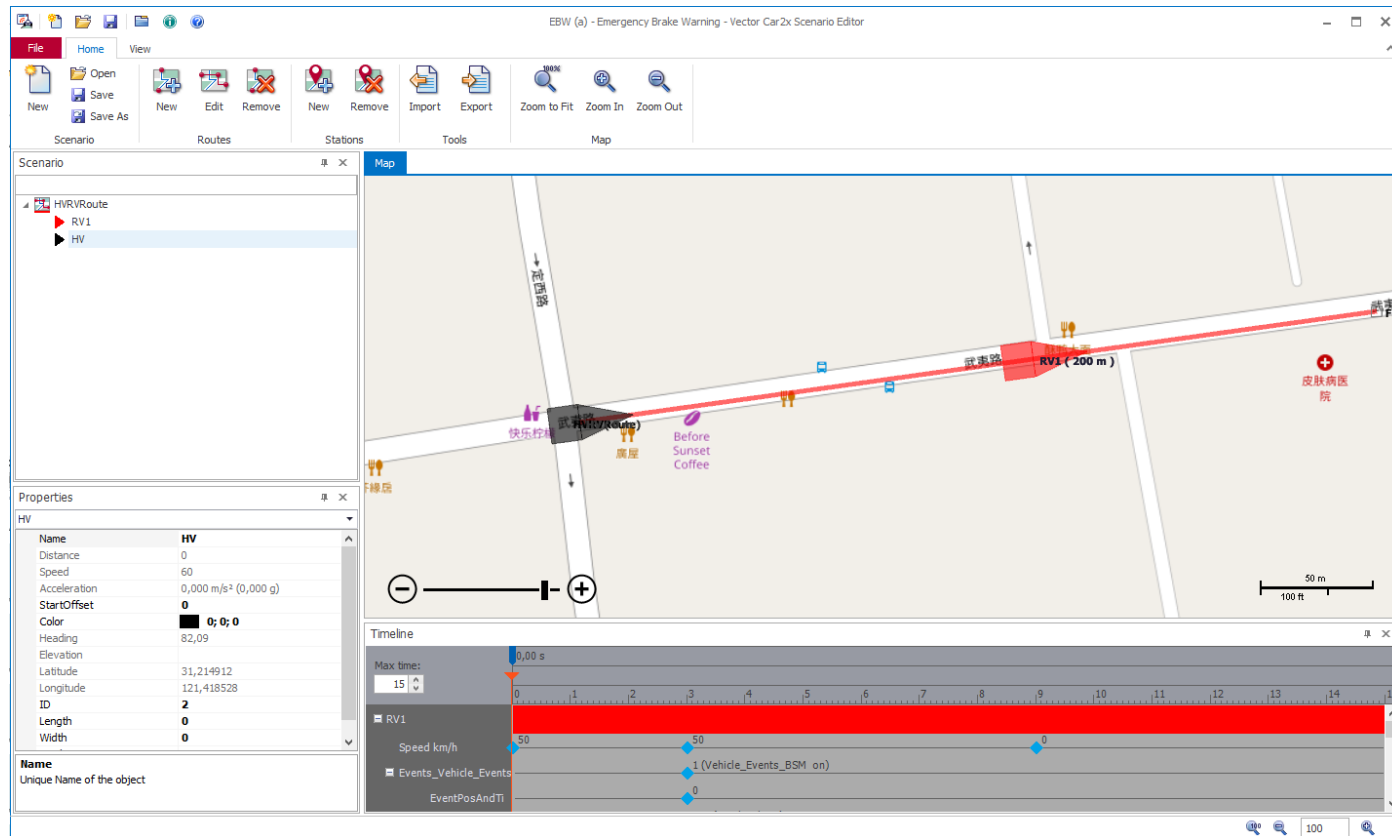


Code	MovementPhaseState	Display
0	unavailable	
1	dark	
2	stop-Then-Proceed	
3	stop-And-Remain	
4	pre-Movement	
5	permissive-Movement-Allowed	
6	protected-Movement-Allowed	
7	permissive-clearance	
8	protected-clearance	
9	caution-Conflicting-Traffic	




## 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

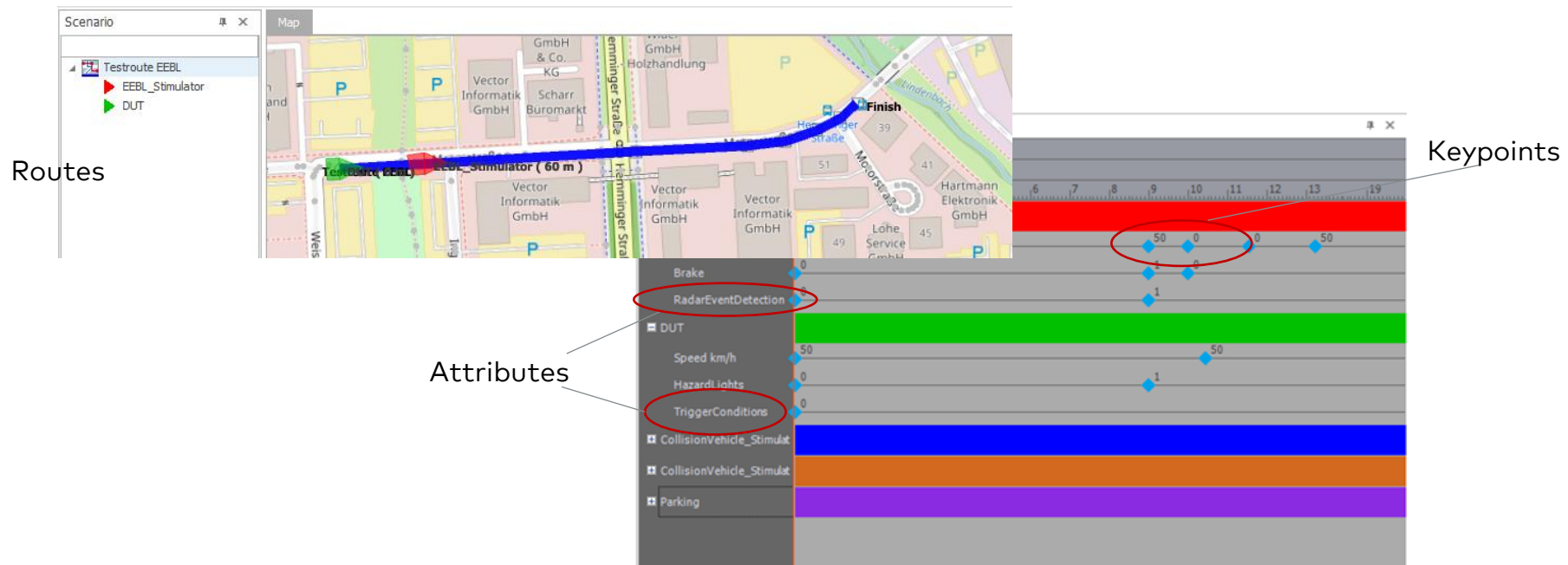


#### Car2x - CN (GB/T, CSAE)

-  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 RLWV – 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...)

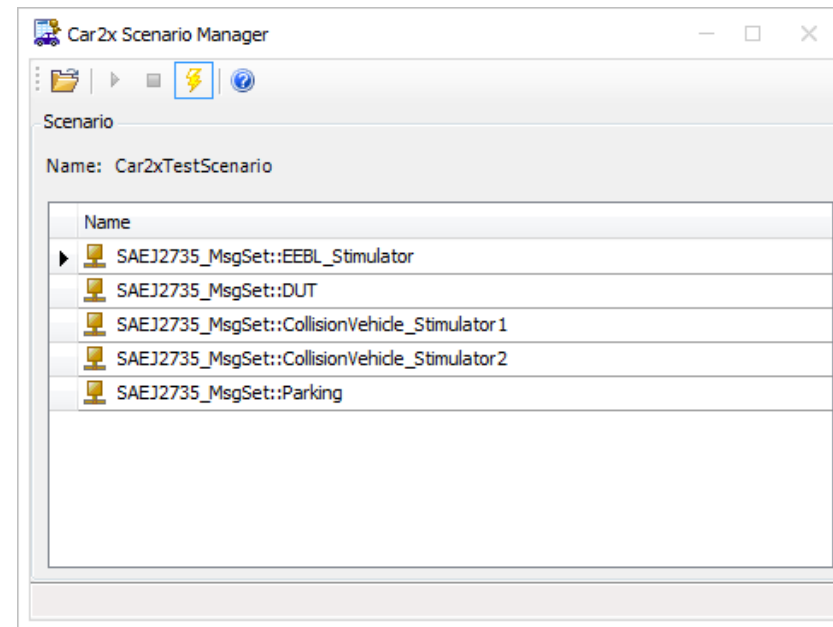
## Car2x Scenario Editor

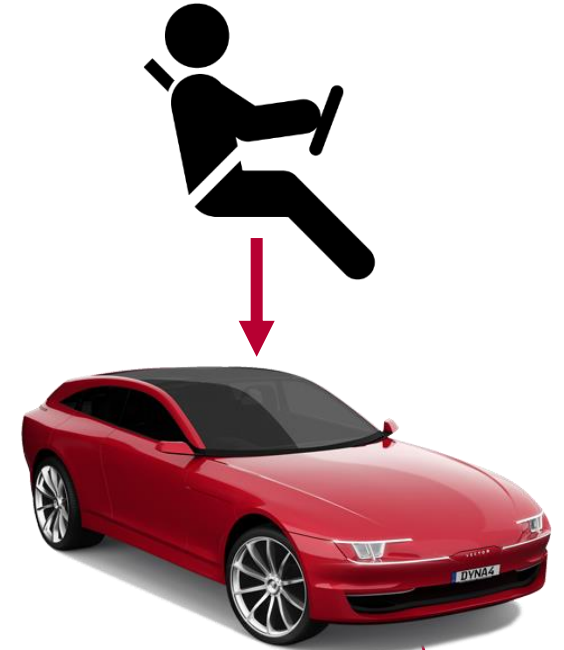
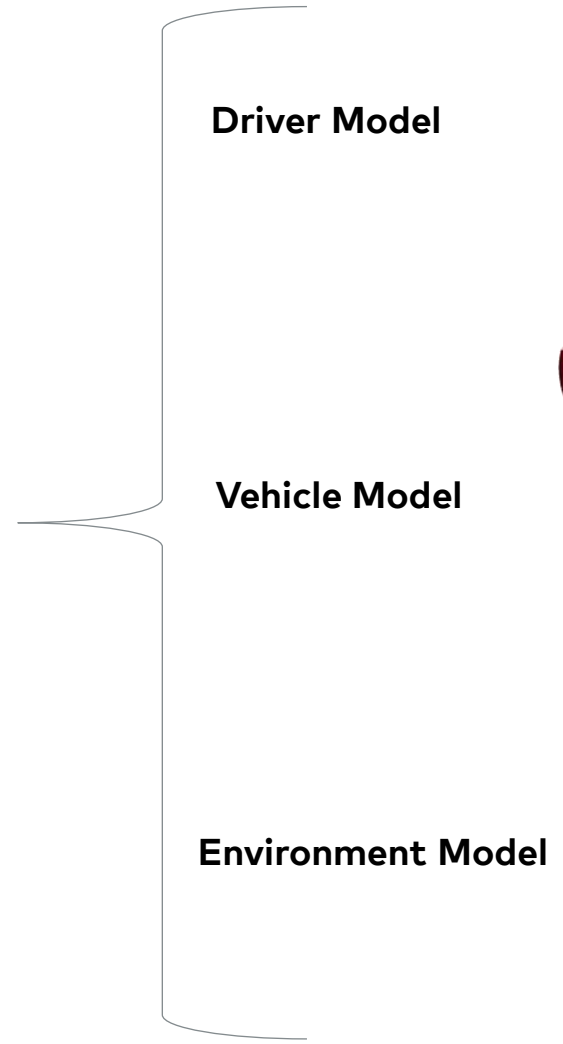
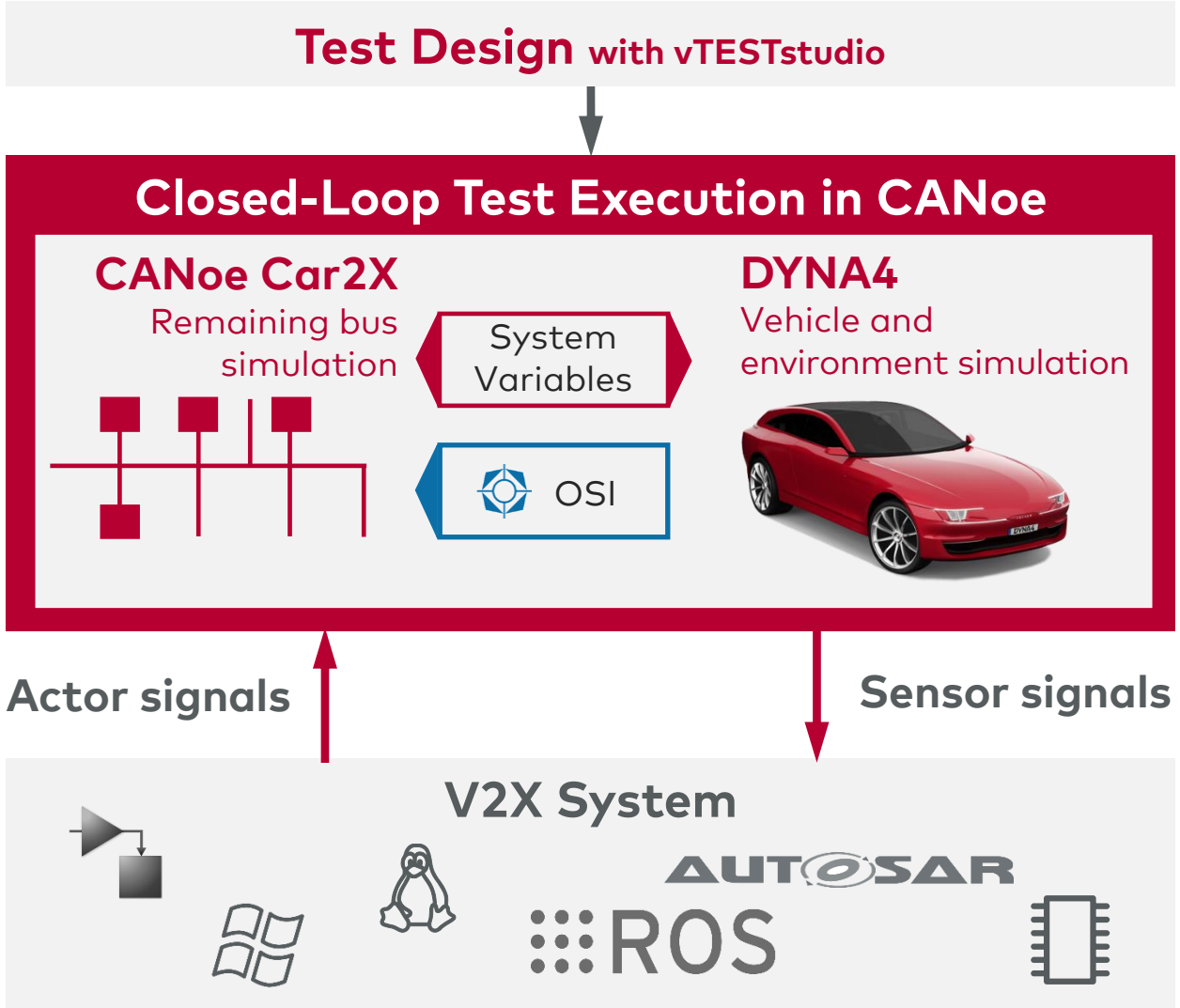
- ▶ Car2x scenario editor provides GUI to easy and fast configure a traffic scenario
  - ▶ GUI to create routes and ITS stations on a map
  - ▶ Configuration of speed and position of the ITS stations
  - ▶ Timeline Window allows to scroll to a specific time or waypoint
  - ▶ Attributes allows to configure 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







# CANoe with DYNA4

The screenshot displays the Vector CANoe software interface with several key components highlighted:

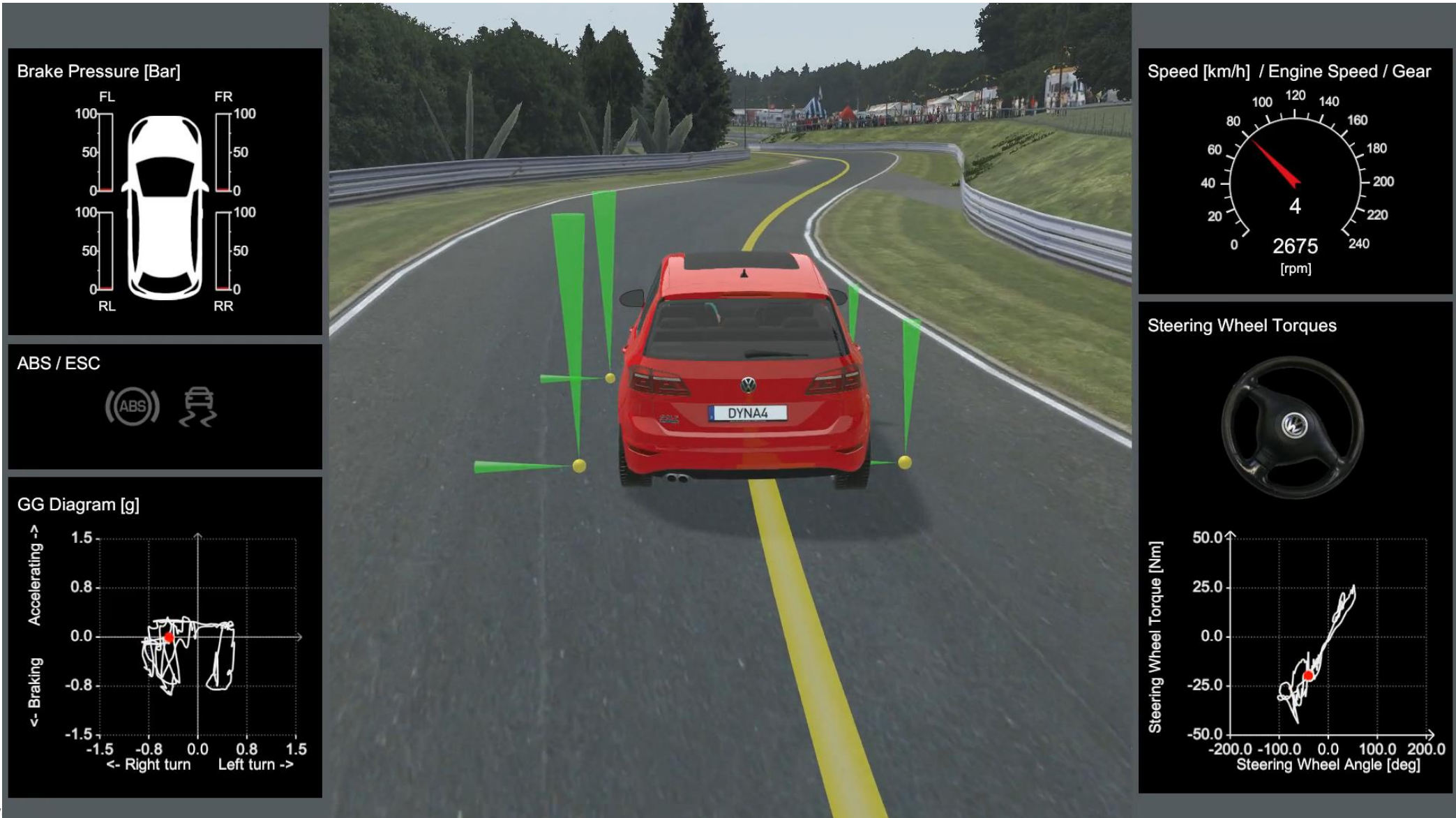
- Scenario Selection:** A window titled "ScenarioSelectionDYNA4" shows a "DYNA4" scenario being selected and simulated. The "Main Simulation Control" includes a "Restart Scenario" button and a "Running" status indicator.
- Test Cases:** A "Test Observer" window lists various test cases under "Brake Assistant Tests" with their respective verdicts (green checkmarks for pass, red X for fail) and runtimes. A callout points to this list with the text "Test cases".
- 3D Visualization:** The "DYNAanimation" window shows a 3D perspective view of a road simulation with vehicles and sensors. A callout points to this view with the text "DYNA4 3D visualization".
- Scene Window:** A "Scene Window" displays detected objects from an "LRRadar77GHz" sensor. It includes a table of detected objects and their properties.
- Trace Window:** A "Trace" window shows a list of CAN messages and return values, including sensor data and warnings.
- OSI Integration:** A central diagram shows a flow from "Sensor providing detected objects" to "OSI" (On-Site Interface) and then to "Analysis of detected objects".

Test Case Name	Verdict	Runtime
Brake Assistant Tests		
Is Radar Object Present	✓	0.005 s
Is Existence Probability Over...	✓	2.529 s
Is Radar Object In Same Lane	✓	4.388 s
No Warning when TTI > 30...	✓	0.003 s
Warning when TTI <= 3000...	✓	6.279 s
Restart Scenario With ...	✗	0.720 s
Is Existence Probability Over...	✓	
Is Radar Object In Same Lane	✓	
No Warning when TTI > 30...	✓	
Warning when TTI <= 3000...	✓	
Restart Scenario With Slow...	✓	
Is Existence Probability Over...	✓	
Is Radar Object In Same Lane	✓	
No Warning when TTI > 30...	✓	
Warning when TTI <= 3000...	✓	

Color	Name	Type	State	Sensor
Blue	Detected...	Detected M...	Active	LRRadar77...
Blue	Detected...	Detected M...	Active	LRRadar77...
Blue	Detected...	Detected M...	Active	LRRadar77...
Blue	Detected...	Detected M...	Inactive	LRRadar77...

Time	Chn	ID	Name	Event Type	Detected Objects	Object Ty...	Obj...
0.000000	DO:		SIOUT.isWarningActive	long			
0.000000	DO:		SIOUT.tti	long			
28.440000	DO:		LRRadar 77GHz.sensor_info	ADAS::SensorInfo	3	Sensor	Senso
28.440000	DO:		LRRadar 77GHz.GetDetectedObjects	byte[]		Sensor	Senso
28.440000	DO:		LRRadar 77GHz.GetDetectedObjects	byte[]		Sensor	Senso
			ReturnValue				
			Detected_id_105_by_LRRadar77GHz				
			Detected_id_103_by_LRRadar77GHz				
			Detected_id_104_by_LRRadar77GHz				
28.470000	DO:		SIOUT.isWarningActive	long			
28.470000	DO:		SIOUT.tti	double			

# DYNA4

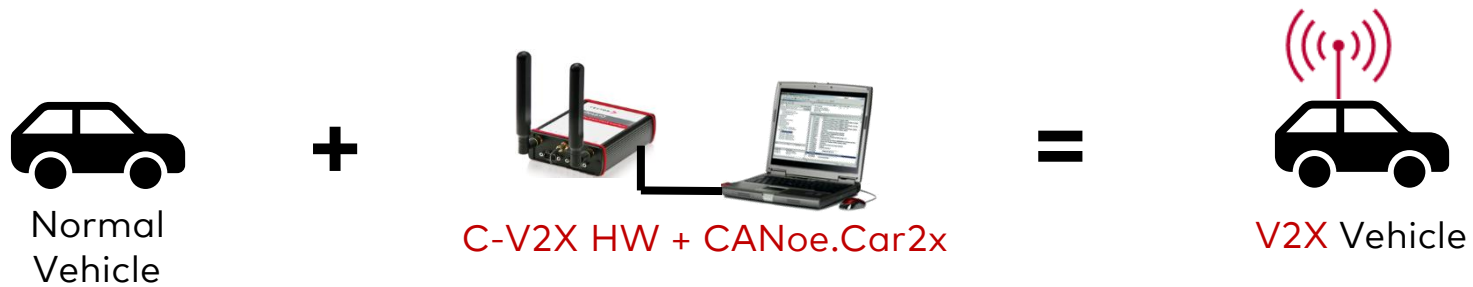


## Real Driving tests

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



- ▶ Upgrade a normal vehicle with V2X functionality.



Vector ECU Testing tool chain

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