

V2X Day 1 Use Case Testing with IPG CarMaker



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www.sea-gmbh.com/v2x

Topics

- S.E.A. Company Introduction
- V2X Basics
- Challenges of V2X Testing
- SEA V2X Test System and Tools Portfolio
- Scenario Based Testing
 - CarMaker as Scenario Simulator
 - Open Loop – Replay
 - Closed Loop - HIL
- Day 1 Use Case Test Catalog
- Conclusion and Key Take Aways

S.E.A Datentechnik GmbH

- Company introduction -

S.E.A. Datentechnik GmbH

- German system engineering company
 - System engineering
 - Test & measurement solutions
 - Hardware & software development
 - Hardware & software products
- Founded 1995, 45+ employees
- NI Specialties
 - RF & Wireless Specialty Partner
 - Embedded Specialty Partner
- Multiple NI Awards



Germany, Cologne Area



Wireless Competence



RF-Measurement systems	Customized RF-Test systems	V2X & ADAS test products & solutions
<ul style="list-style-type: none"> • Hardware products for drive testing of mobile and Wifi networks • Software for data management and visualization of geo-mapped telemetry data (SpaceMaster® GEO) 	<ul style="list-style-type: none"> • Automated test systems validation of ECUs with proprietary wireless communication protocols • Signal analysis implementation • Protocol implementation • Customer specific test & measurement systems for RF & LF 	<ul style="list-style-type: none"> • RF measurement systems • Signal analysis • Test and validation of V2X communication • HIL ADAS test systems



V2X Engagement

- Member of
 - Car-2-Car Communication Consortium (C2CC)
 - VDT Alliance
 - IWPC
 - OmniAir Consortium
- Participation in various research projects (e.g. *SAFIR*)
- Foundation member of ADAS iiT – Innovation in Test for Autonomous Driving



Gobal Partners

Regional Integration Partners

- China
- Japan, Singapore, Vietnam..
- United States

Technology Partner

- NI
- M3 Systems
- IPG
- ADAS iiT partners



V2X Direct Connected Traffic

- Basics -

V2X Concept

Vehicle-to-Everything with Everything

- **V2V** **V**ehicles
- **V2I** **I**nfrastructure
 - traffic signs
 - traffic lights
 - RSU
- **V2M** **M**otorbike
- **V2P** **P**edestrian



V2X Approach

- Share traffic specific information between all traffic objects
- Increase of safety
- Improvement of traffic flow
- Mandatory information for sensor fusion autonomous driving
 - No line-of-sight required
 - Mid-to-long range sensor
 - Independent of weather and light



V2X Implementation

V2X Day 1 Use Cases



ETSI TS 101 539-1



J2945 (US)



T/CSAE 53-2017 (China)

V2X Protocol & Signaling Standards



ETSI ITS-G5 (EU)



WAVE IEEE 1609 (US)



ARIB STD-T109 (Japan)



CSAE/CCSA (China)

V2X Communication Standards



Wifi based
802.11p/DSRC

LTE-based
LTE-V / c-V2X



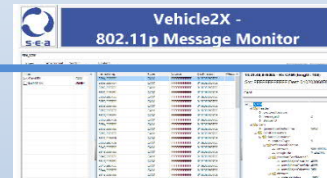
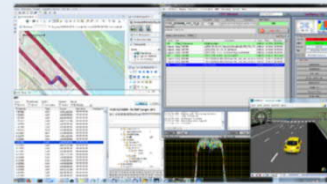
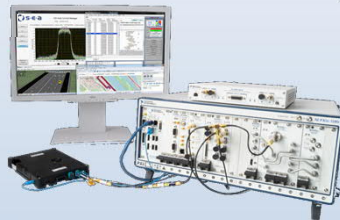
V2X Test Challenges



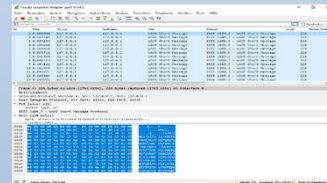
V2X Products and Services



- ✓ Day 1 Test Catalogs
- ✓ Open Loop
- ✓ Closed Loop (HIL)

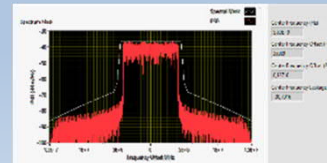


- ✓ Protocol Test
- ✓ Conformance



- ✓ Mobile Sniffer
- ✓ Mobile Logger

- ✓ RF-Measurement
- ✓ RF-Conformance



- ✓ Channel Emulation

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Day 1 Use Cases

Application Layer

Speed, Longitude, Latitude...

Signaling Layer

WAVE, ITS-G5, CSAE

Protocol Layer

802.11p, DSRC, LTE-V, C-V2X

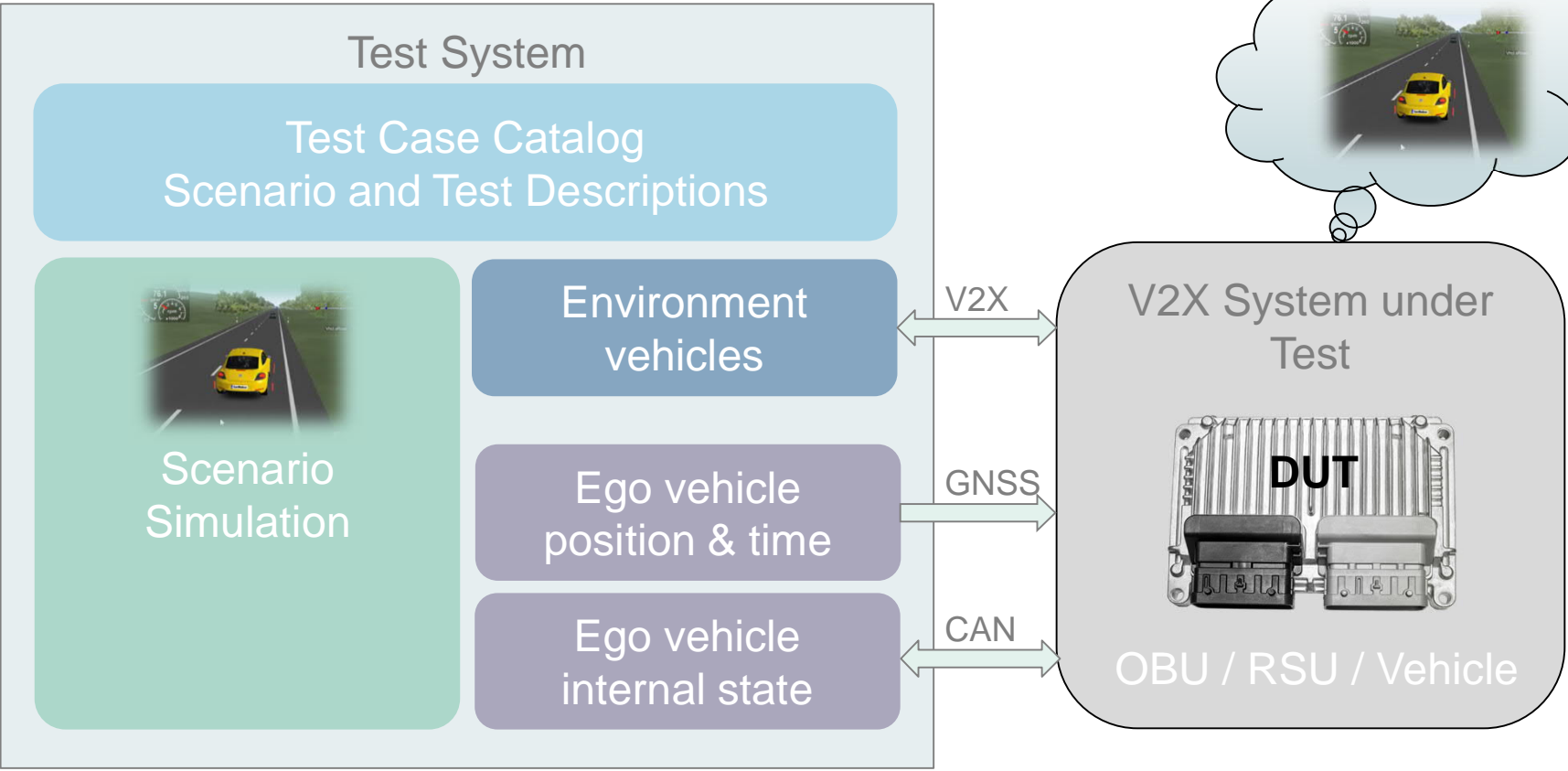
RF-Layer



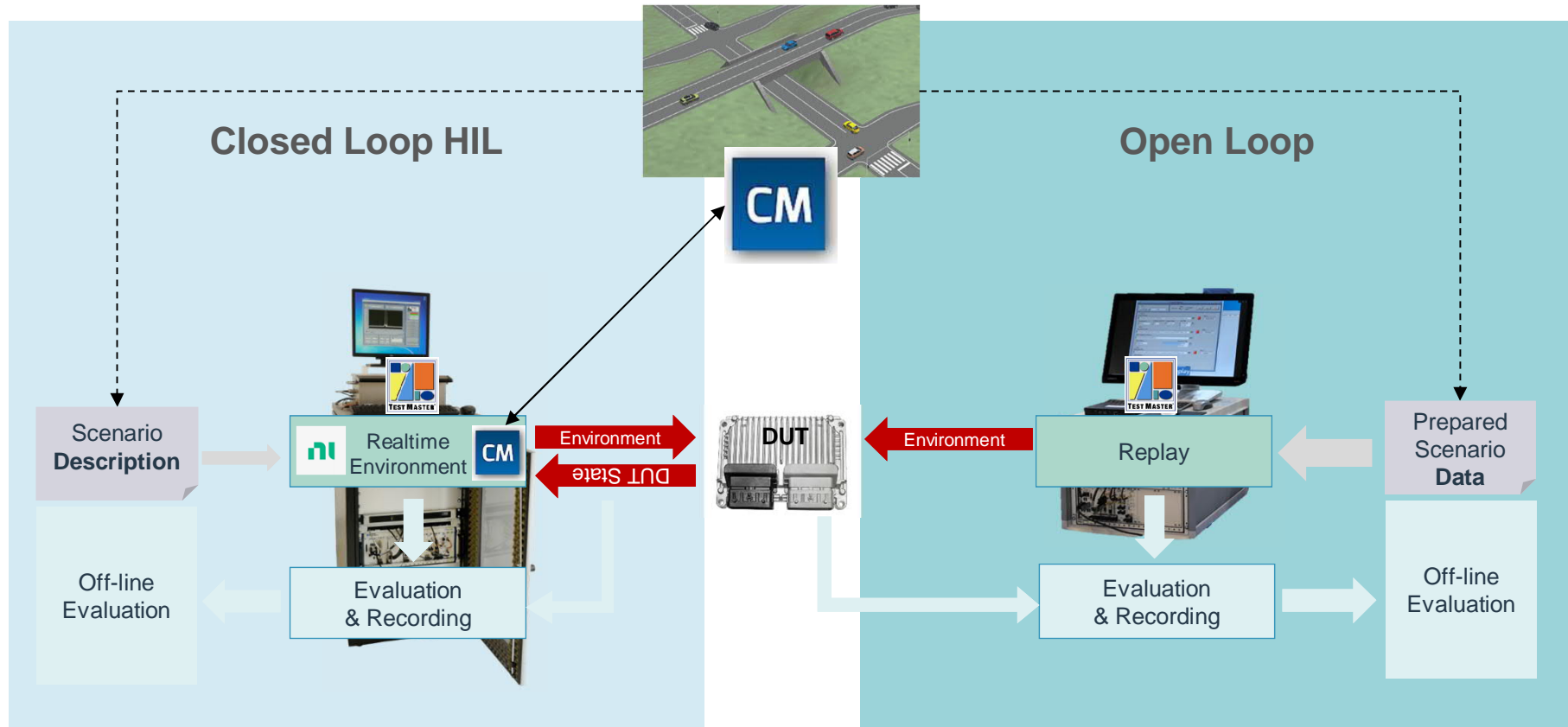
Scenario Based Testing

- Open Loop and Closed Loop/HIL -

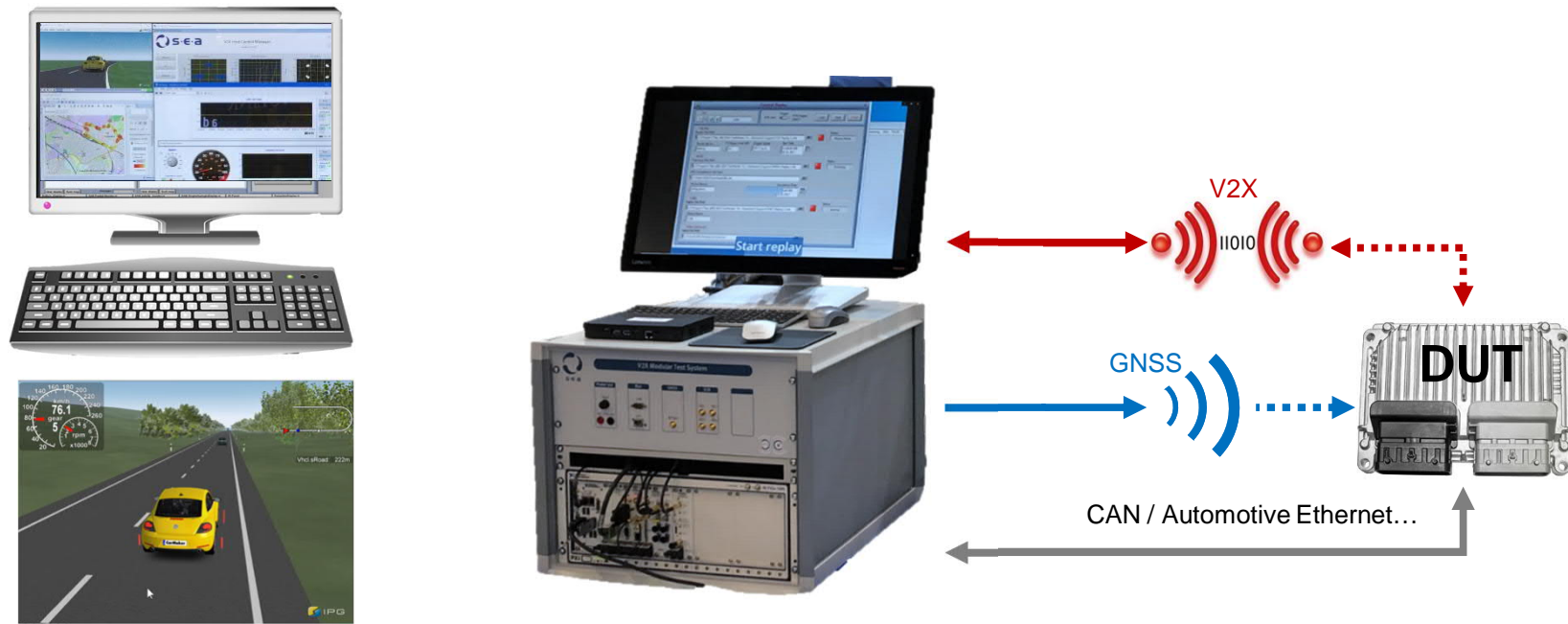
Emulation for Functional Application Level Testing



IPG CarMaker Scenario Generation



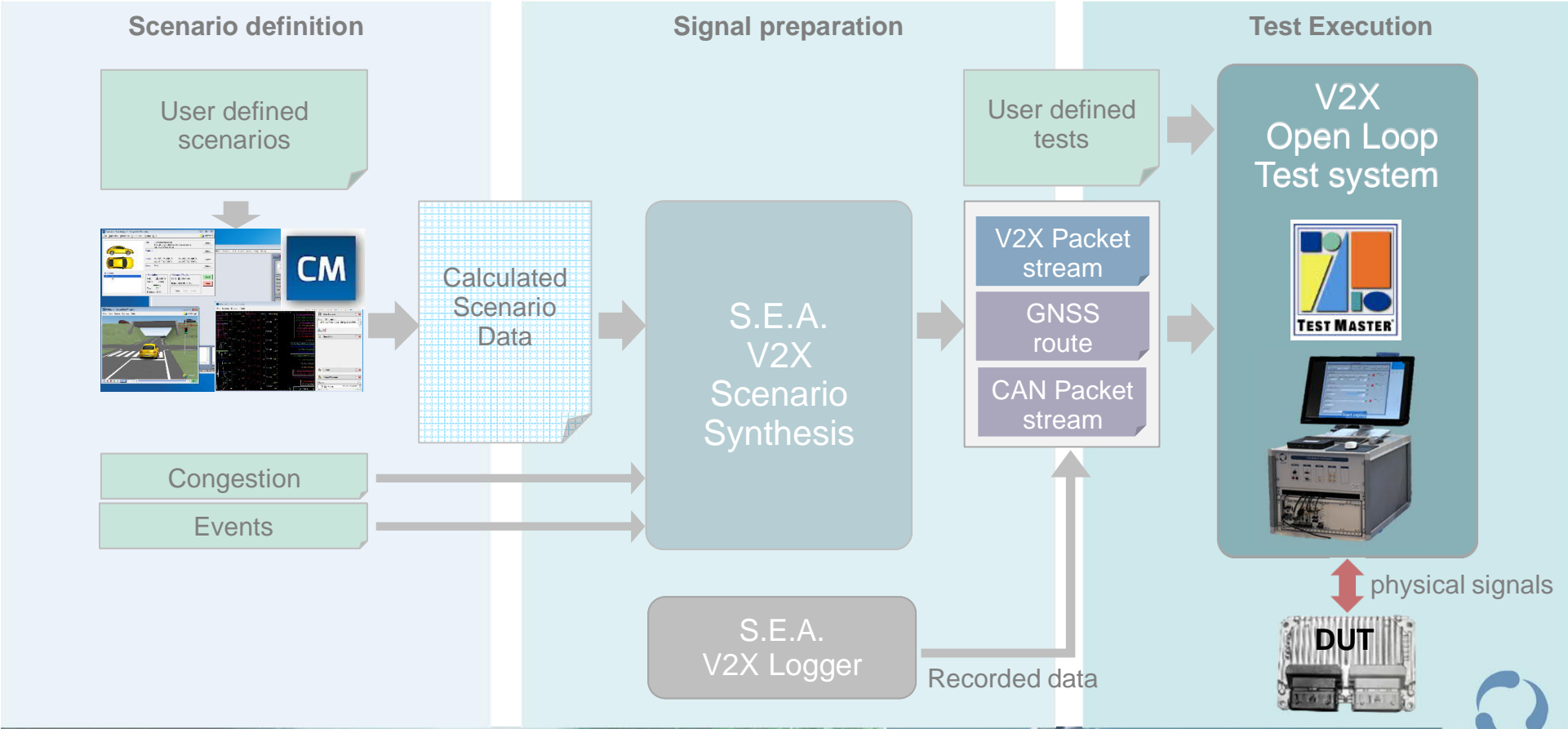
V2X Test System



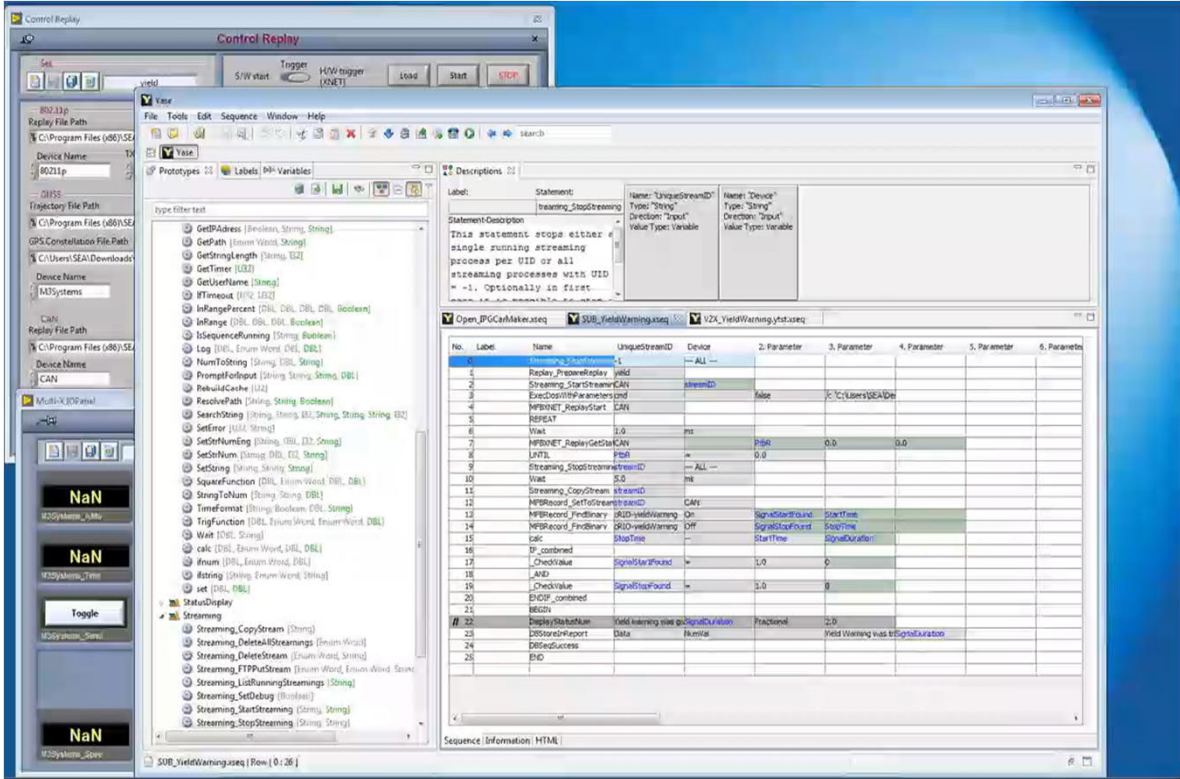
Automated and interactive simulation and evaluation



Open Loop Test

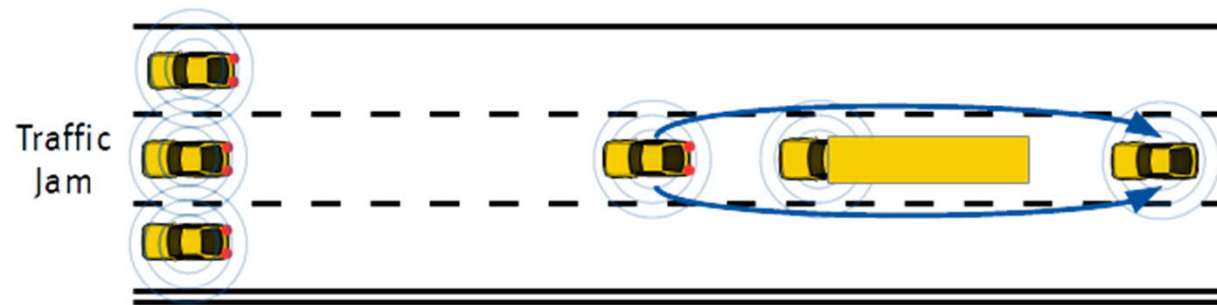


Open Loop Test Example

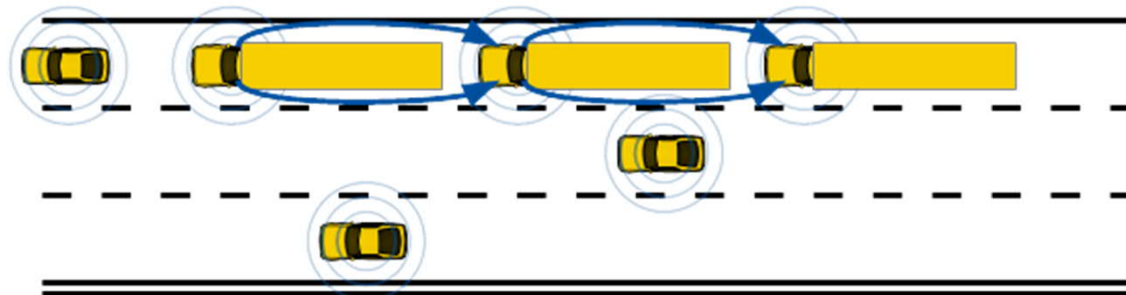


ITS Example Use Cases

Virtual Brake Light
(decentralized)



Platooning



Example Day 1 Test Case

Emergency Brake Light (ITS-G5 EU)

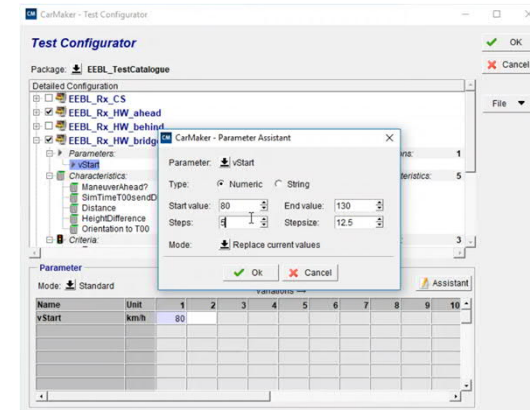
Test case TX	Simulated scenario triggering condition	DUT's reaction
EEBL (EU)	In vehicle <ul style="list-style-type: none">• Strong deceleration• Emergency brake light	Send DENM with correct use case specific parameters within tolerated lag time after event

Test case RX	Simulated scenario triggering condition	DUT's reaction
EEBL (EU)	Received from other vehicle <ul style="list-style-type: none">• DENM with valid position and time and• EEBL cause code received	Driver information after relevance check (position, time, lane, driving direction)

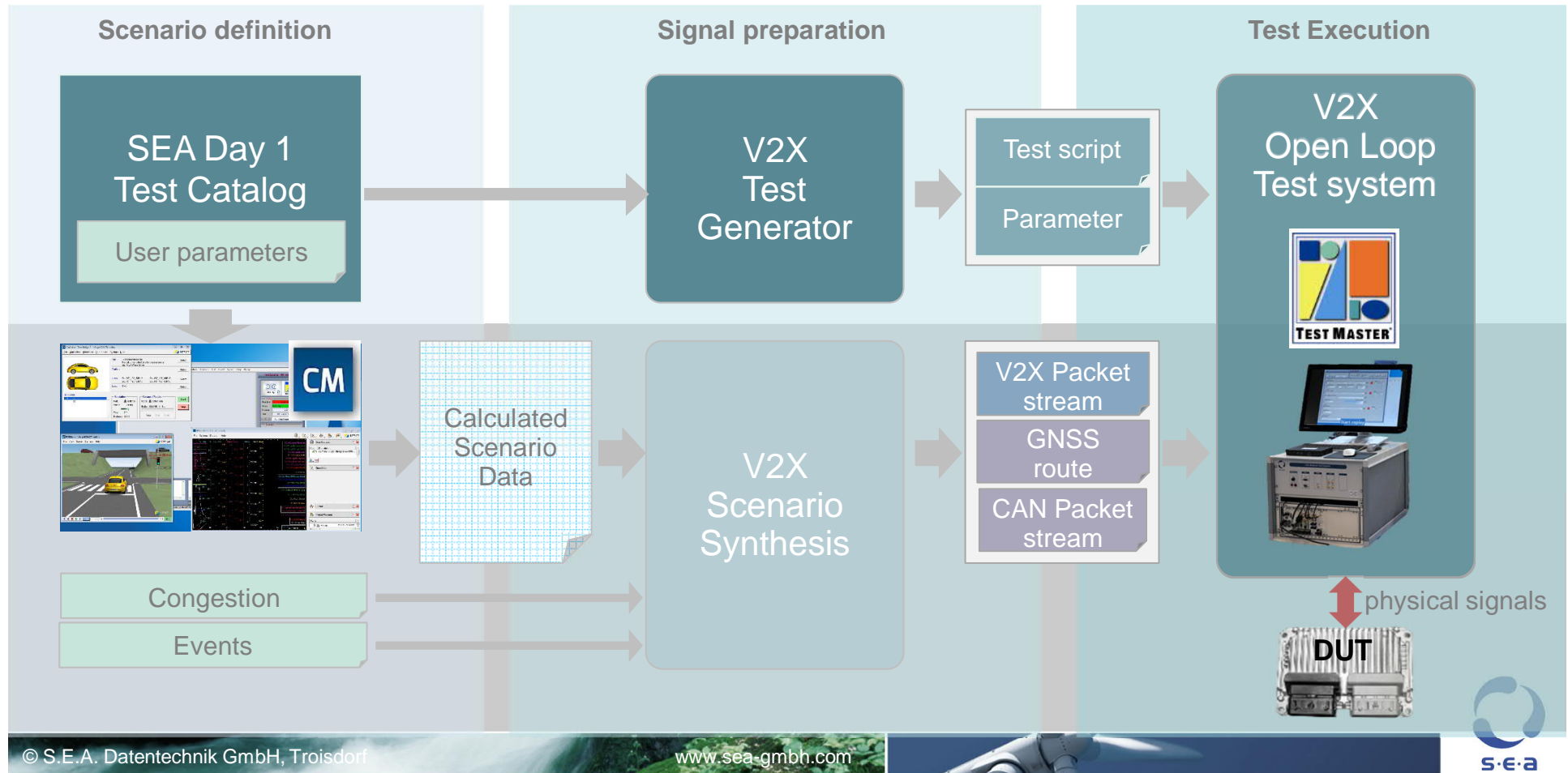
V2X Application Testing

S.E.A. V2X Application Test Case Catalog

- Predefined, executable test cases for standard V2X Day 1 applications
- Covers V2X reaction (V2X Rx) and action (V2X Tx) of DUT with permutations of scenario parameters
- For functional test of OBU's and Applications
- Simply configurable for customer DUT CAN Bus assignments
- Applicable with S.E.A. Open Loop and Closed Loop test products



S.E.A. Day 1 Test Catalog – Open Loop



Coverage of SEA V2X Day 1 Use Case Test Catalog

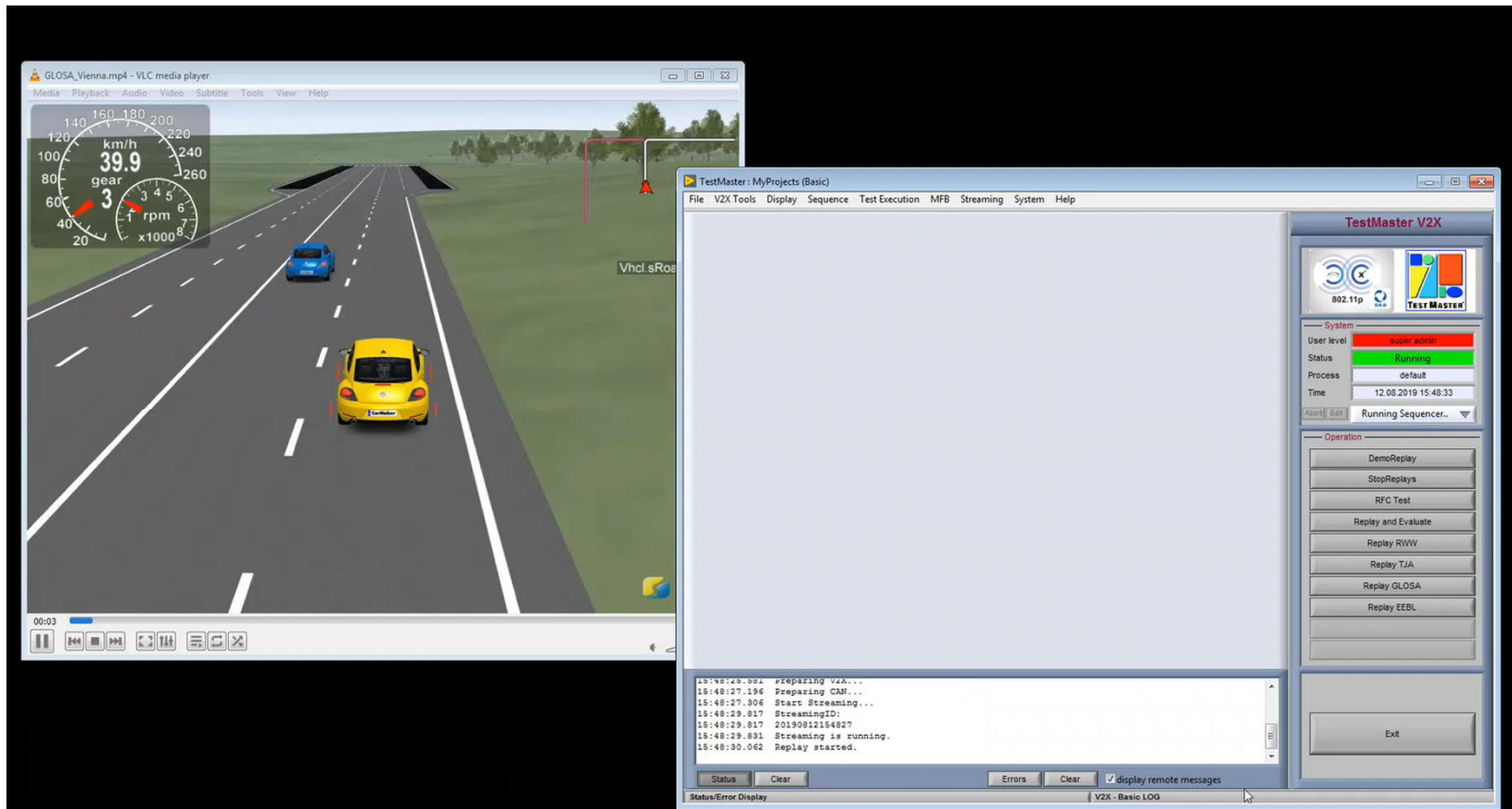
Use Case	ETSI	SAE	CSAE
FCW	-	✓	✓
ICW / IMA	-	✓	✓
LTA	-	✓	✓
BSW/LCW	-	✓	✓
DNPW	-		✓
EBW /EEBL	✓	✓	✓
AVW	✓	-	✓
CLW	-	✓	✓
HLW	✓	-	✓
SLW	-	-	✓
EVW / EVA	✓	-	✓
VRUCW	-	-	✓
IVS	-	-	✓
TJW	✓	-	✓
RWW	✓	-	-
AWC	✓	-	-

Test Catalog – Test Case Selection

The screenshot displays the Test Manager software interface. At the top, there are simulation and storage controls. The main window shows a test catalog with a tree view on the left and a table of test cases on the right. The 'TEST CONFIGURATION' item is highlighted in the tree view. The table below shows the details for this configuration.

Item Description	Part1	Par2	Par3	Par4	Res.Date	Result
Global Settings						
v_thresh_startBraking	TS	20				
l_thresh_durationHB	TS	0.5				
a_thresh_HardBrake	TS	7				
a_thresh_HardBrake	Nvalue	7				
ScriptFile	CM	WriteResFile.tcl				
StartProc	CM	StartProc_WriteFile				
EndProc	CM	EndProc_WriteFile				
distance_threshDENreact	TS	500				
ScriptControl Commands	SaveMode	save_all				
	SetResultFName	%s/%i/%D/%T_%L_%v				
TEST CONFIGURATION						
Export Report	Report create	%s/%i/%D/Report_%c_				

Test Catalog – Test Case Selection



Conclusion and Take Aways

- Comprehensive tool set based on the modular NI platform
- Complete test catalog for immediate results and fast ramp-up
- Extendable turn-key solutions for different V2X test goals, future requirements, standards and adaptations
- SDR based implementation advantages
 - ensures support of changed and upcoming communication standards
 - Additional capabilities (Congestion, Failure injection....)
 - Reasonable cost and footprint
 - Early availability of new standards, 5G
- S.E.A. is available for implementation and integration of customer specific test systems

Thank you very
much for your
attention!



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