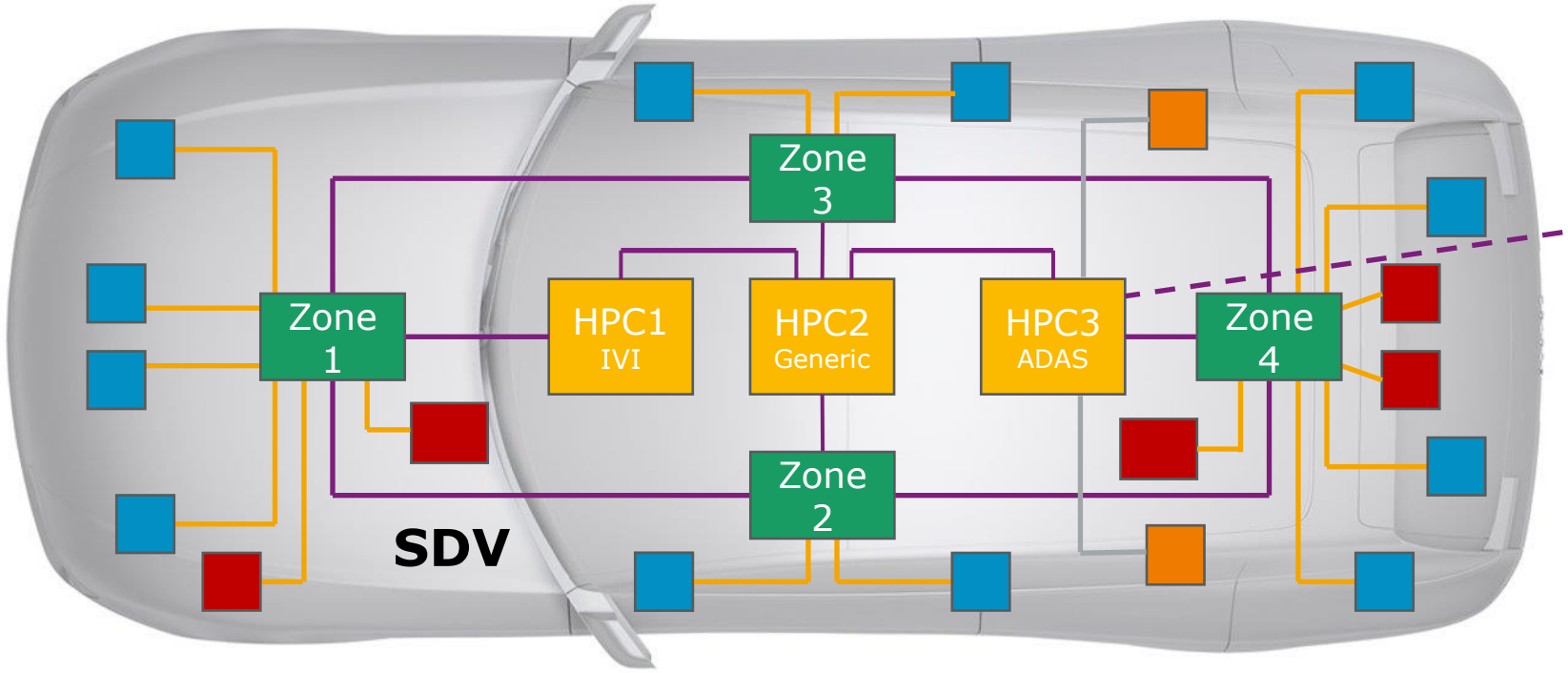
电动、智能、网联系统HiL及通信一致性测试

Based On CANoe and vTESTstudio Open Platform

V1.0 | 2024-02-01

Let’s Assume the Future Topology Looks Like This



Simple Sensor Actuator	Complex Sensors Actuator	Control	Zonal	HPC	Backend
Light, Rain Headlight Trailer	Radar, Lidar Camera Headlight	Powertrain Battery Chassis	Left, Right Front, Rear	IVI ADAS Generic	SW update Data collect. Diagnostics
- µController - AUTOSAR Small - Signal comm.	- µController or µProcessor - Various OS - Prop. middleware - Raw data; services	- µController - AUTOSAR OS - AUTOSAR Classic - Signal comm.	- µController or SoC - Hypervisor, POSIX-OS - AUTOSAR - Signal/service comm.	- µProcessor or SoC - Hypervisor, POSIX-OS - AUTOSAR, … - Service comm.	- IT frameworks - Services, µServices, libs - Vehicle connector

Tier1 driven / owned → **OEM driven / owned**

HIL Test Systems

- What are the characteristics of a powerful test system?
  - Type of PCs, processor?
  - Automotive network channels?
  - Number of electrical I/O channels?
  - Sampling rates?
  - Capability of simulated loads?

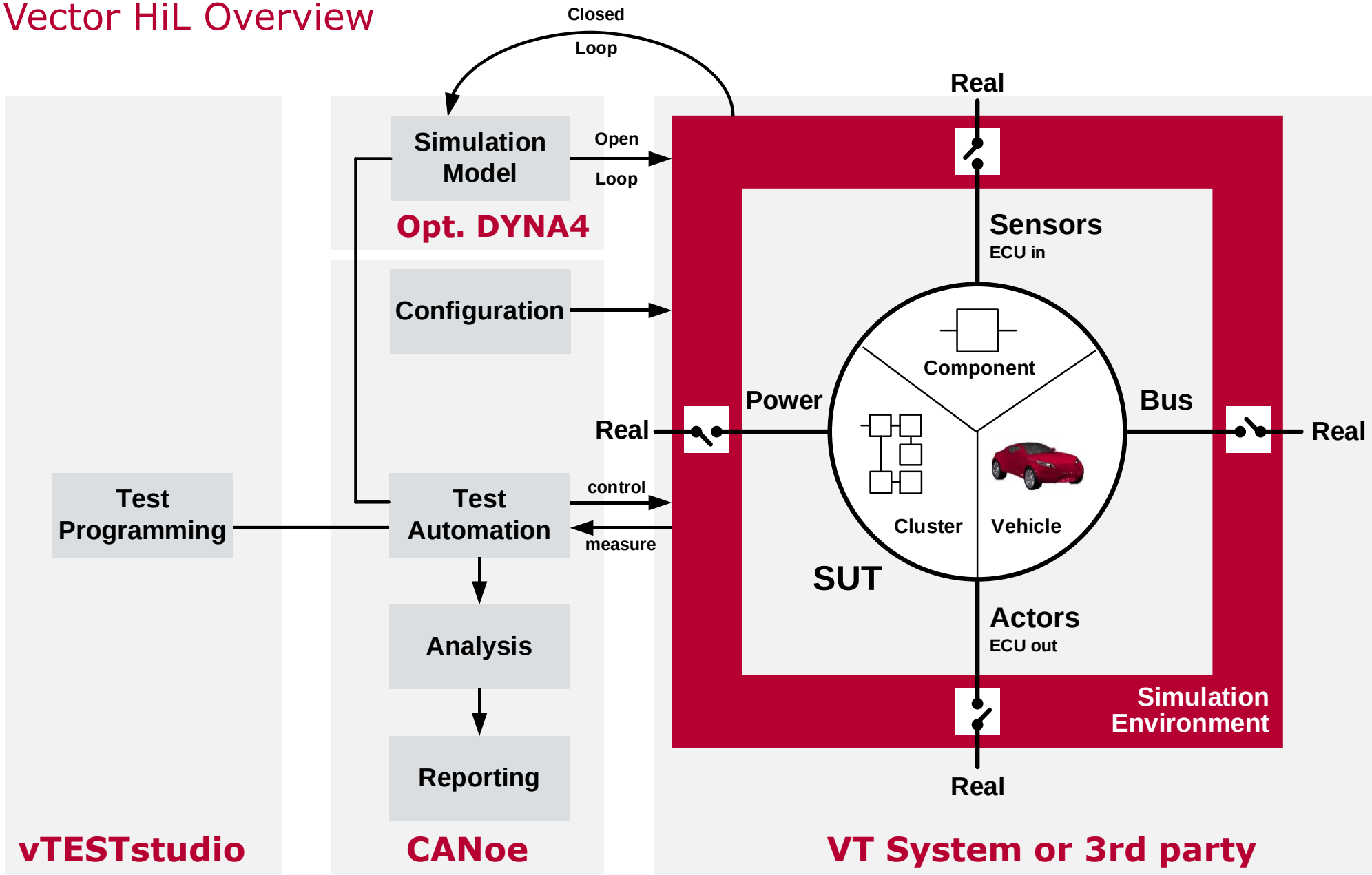
- Each test system has a specific test objective
- Power of a test system refers always to the assigned objective

Test Objective A

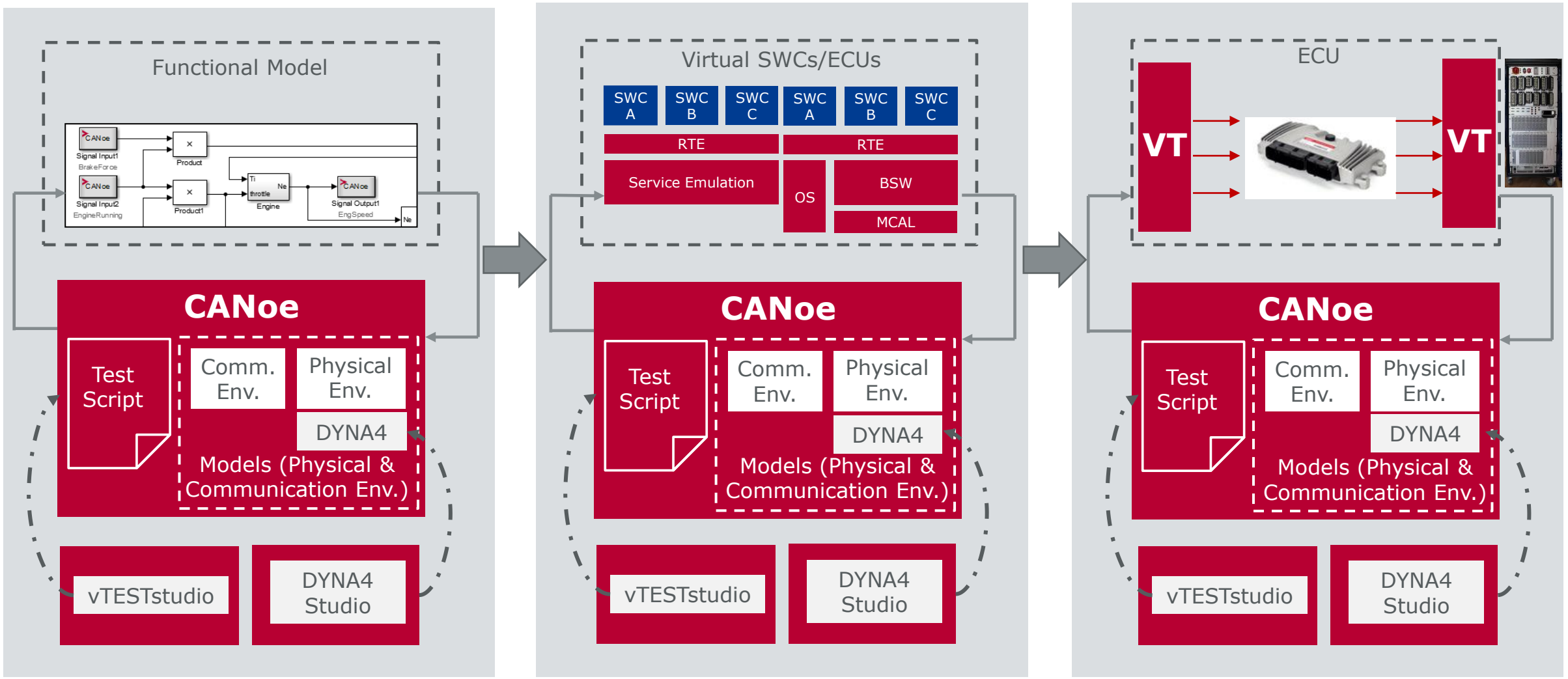
Test Objective B

- Power of a Test System = Ability to achieve the test objective completely, reliably and reproducibly

Vector HiL Overview



CANoe for XIL



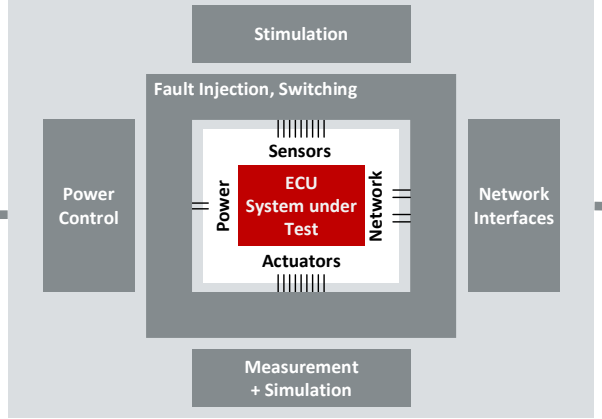
VT System for HIL

Stimulation Modules
analog VT2004A
digital VT2516A

Rotation Sensor Module VT7820
Smart Charging Module
VT7970 / VT7971

Network Interface Modules
VT6104B / VT6204B
VT2710 / VT6306B

Power Modules
VT7001A (40V)
VT7101 (60V)



General Purpose Modules
current VT2808
analog VT2816A
digital VT2848
Relais VT2820
Matrix VT2832
Multi VT5838

Load + Measurement Modules
VT1004A (40V)
VT1104 (60V)

Real-Time Modules
Atom VT6020
Core i7 VT6060

XiL Testing Design - vTESTstudio

Coding-based Design

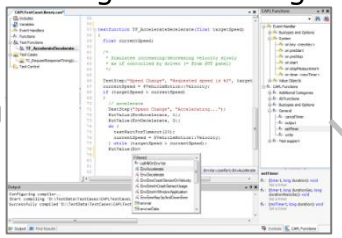
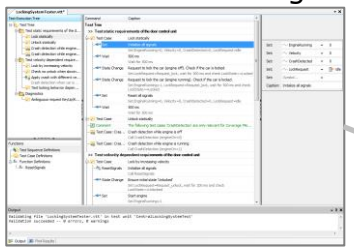
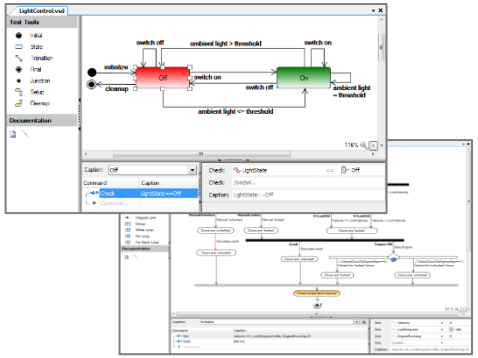


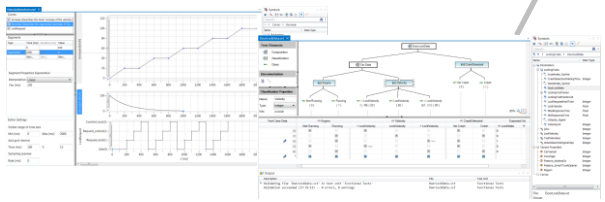
Table-based Design



Model-based Design



Data-driven Design



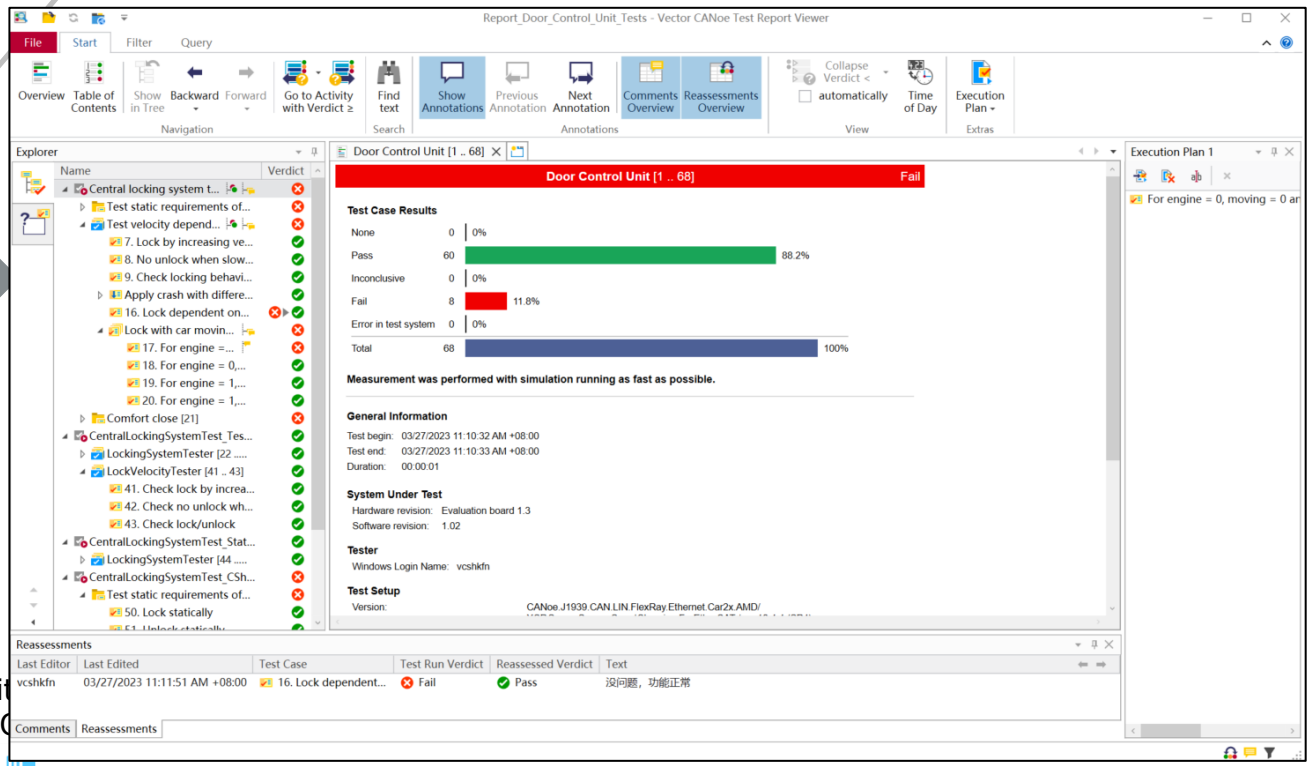
MiL,SiL,PiL,HiL,
ViL,Fuzzy,TC8...

AUTOSAR, C,
C++, Python

ADAS,HPC,ZCU,
HMI,OTA...

vTESTstudio

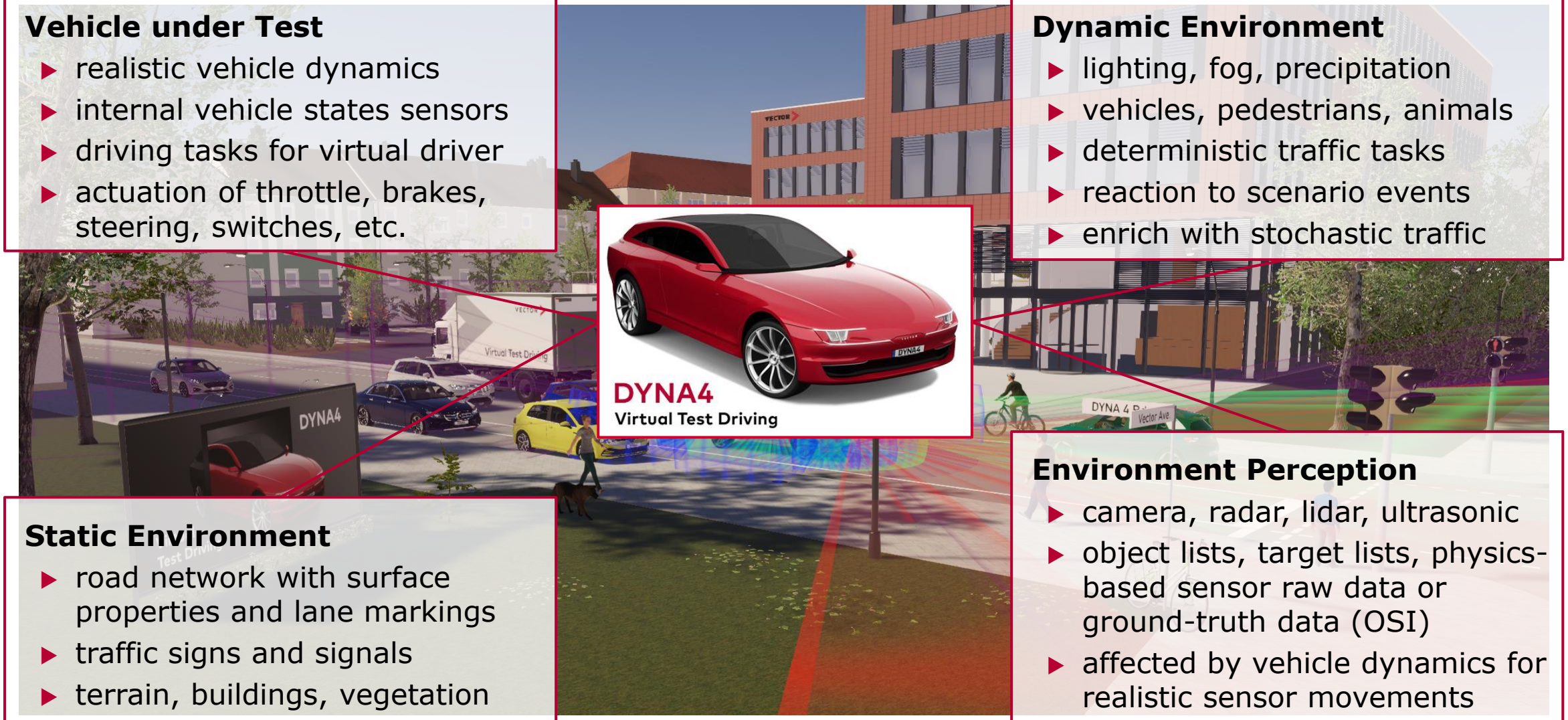
Traceabilit
26262,ISO



Virtual Test Drives– DYNA4

Vehicle under Test
- realistic vehicle dynamics
- internal vehicle states sensors
- driving tasks for virtual driver
- actuation of throttle, brakes, steering, switches, etc.

Dynamic Environment
- lighting, fog, precipitation
- vehicles, pedestrians, animals
- deterministic traffic tasks
- reaction to scenario events
- enrich with stochastic traffic



Static Environment
- road network with surface properties and lane markings
- traffic signs and signals
- terrain, buildings, vegetation

Environment Perception
- camera, radar, lidar, ultrasonic
- object lists, target lists, physics-based sensor raw data or ground-truth data (OSI)
- affected by vehicle dynamics for realistic sensor movements

Agenda

1.	How does HiL cover Automotive Trends?
2.	HiL Solutions for future testing
3.	Network Conformance Test HIL
4.	Vector Open HiL Test Environment

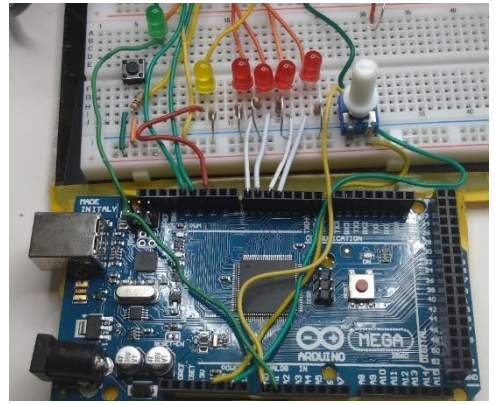
Simple Sensor and Actuator

Simple Sensor Actuator	Light, Rain Headlight Trailer

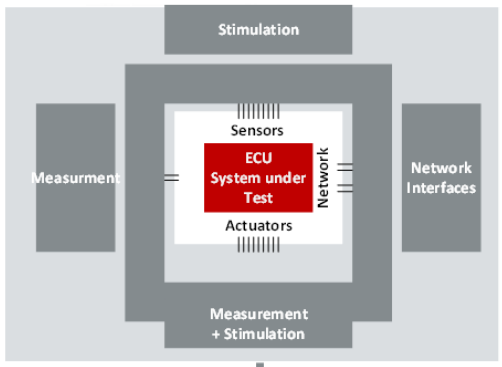
- µController
- AUTOSAR Small
- Signal comm.

Housing

Stimulation cards
analog VIO2004



Measurement cards
analog VIO1008
current VIO1804



Network Interface cards
VX1161.41A / VX1161.41B

VX1161.41A VX1161.41B

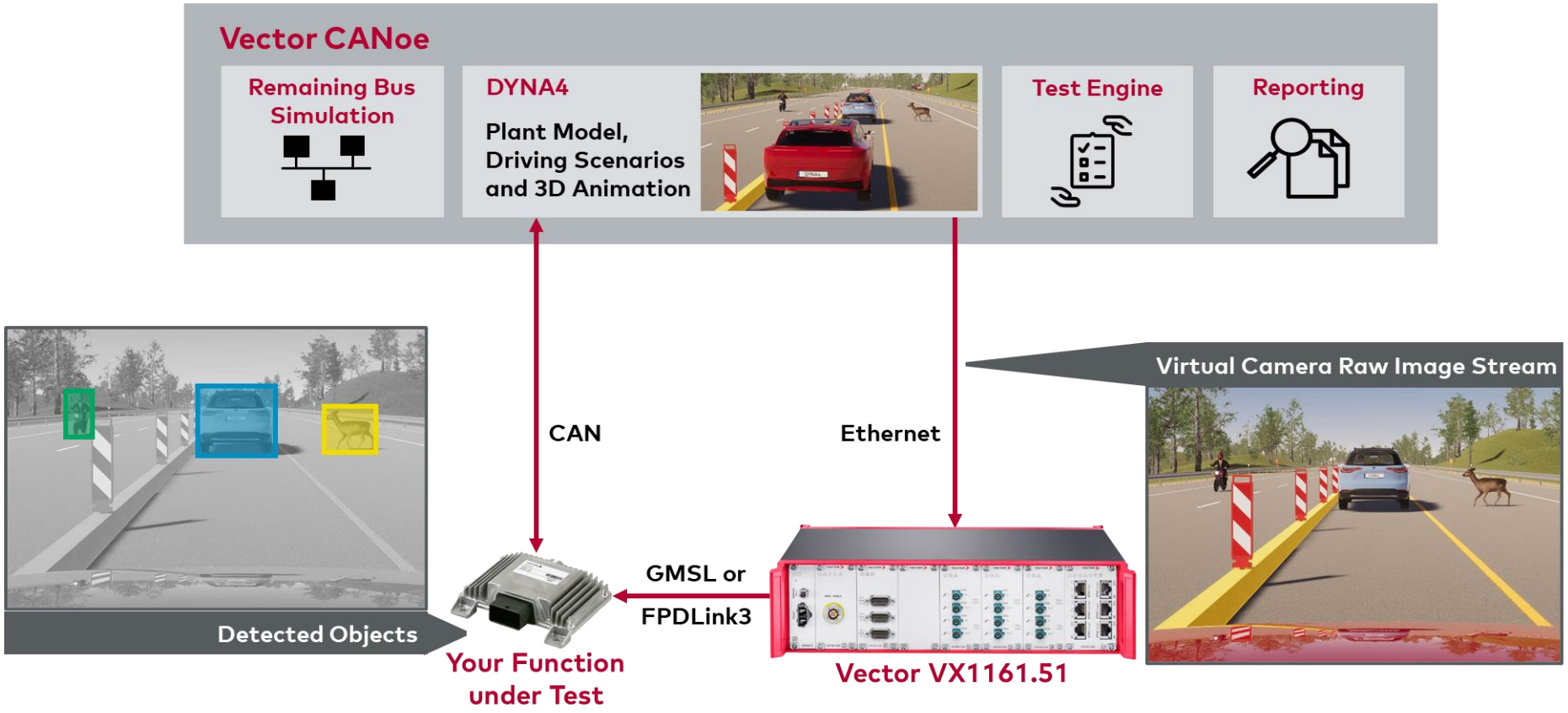
Measurement & Stimulation cards
digital VIO4028

Infrastructure

Complex Sensor and Actuator - 1

Complex Sensors Actuator	Radar, Lidar Camera Headlight

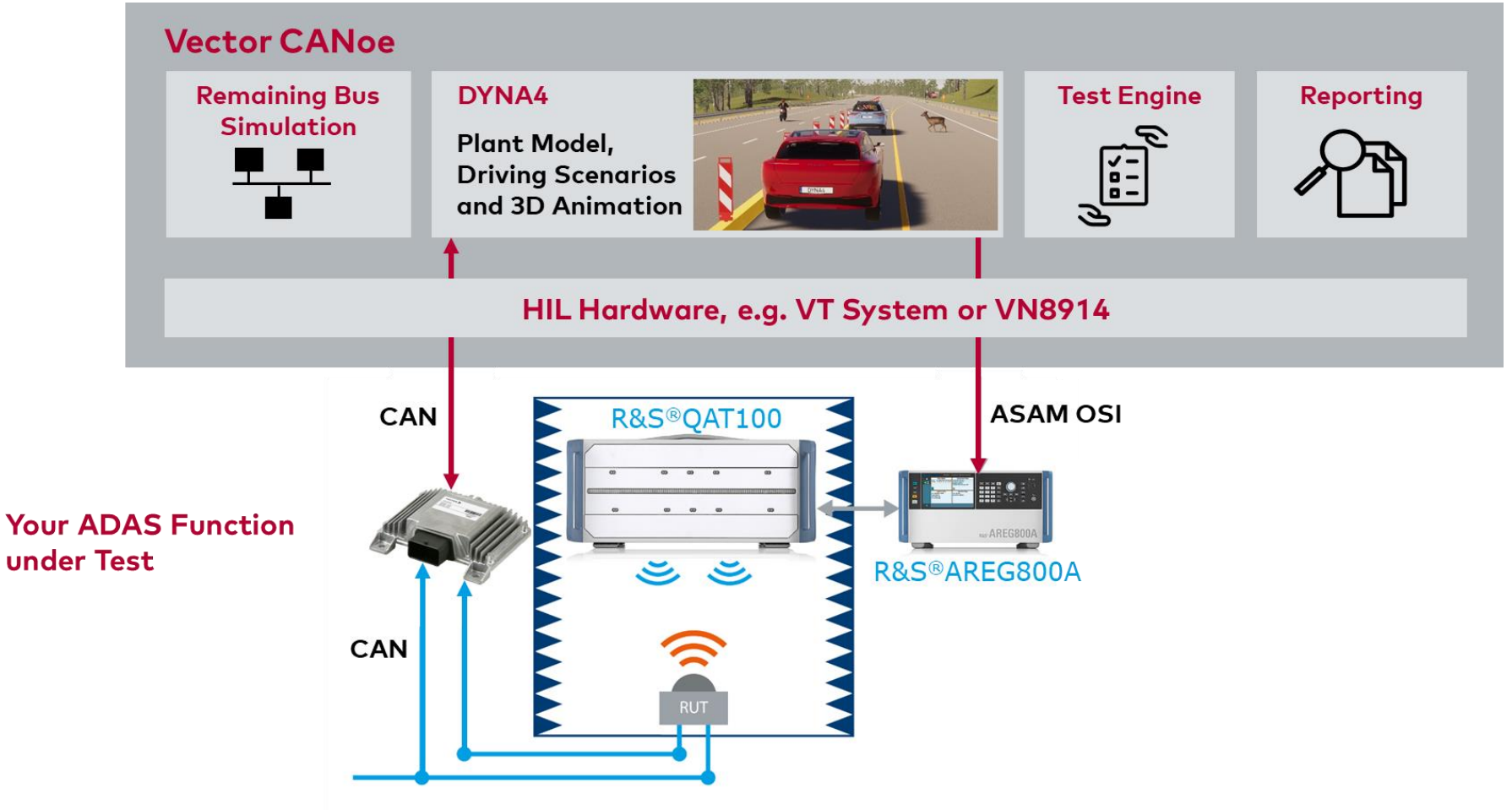
- µController or µProcessor
- Various OS
- Prop. middleware
- Raw data; services



Complex Sensor and Actuator - 2

Complex Sensors Actuator	Radar, Lidar Camera Headlight

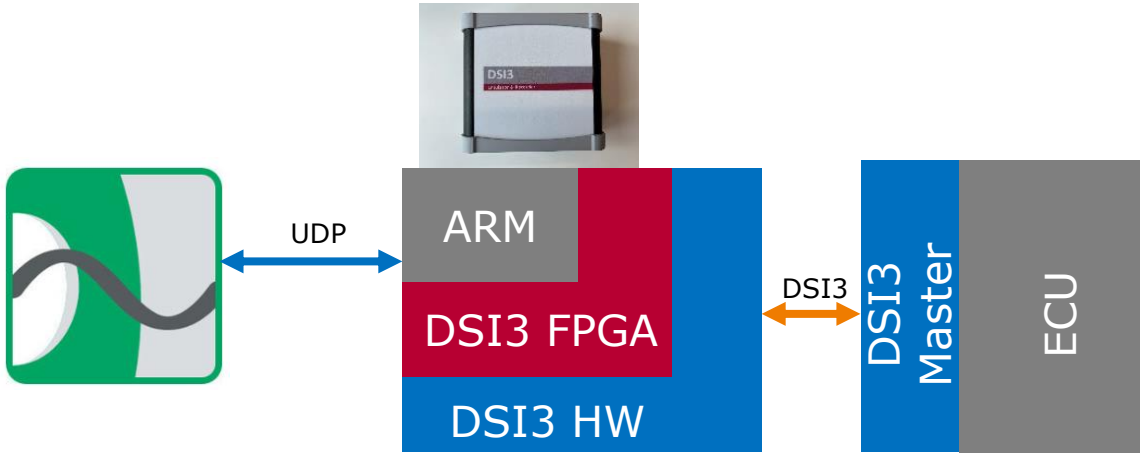
- µController or µProcessor
- Various OS
- Prop. middleware
- Raw data; services

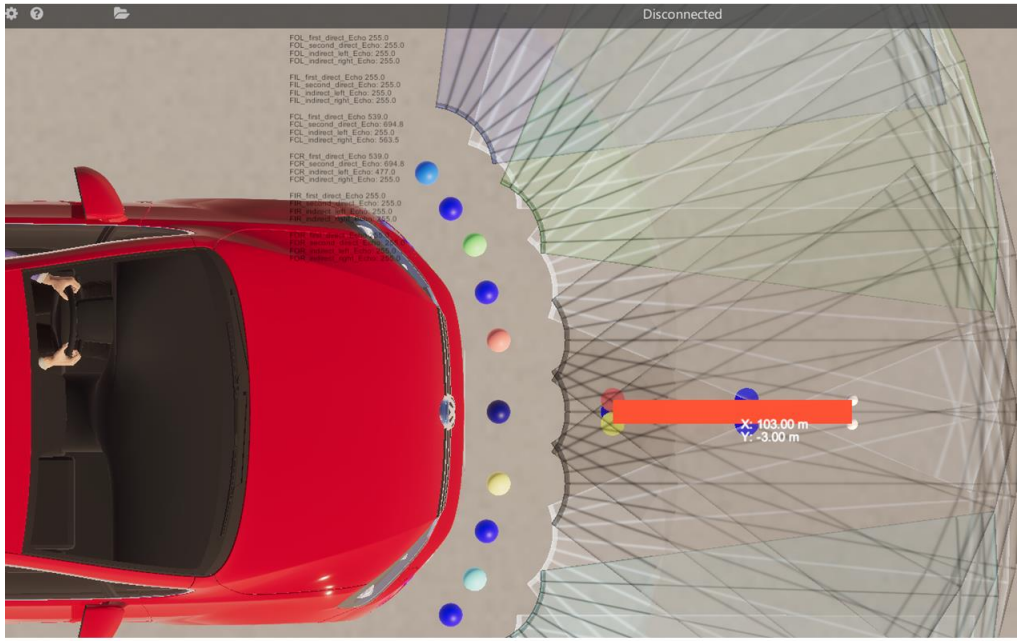


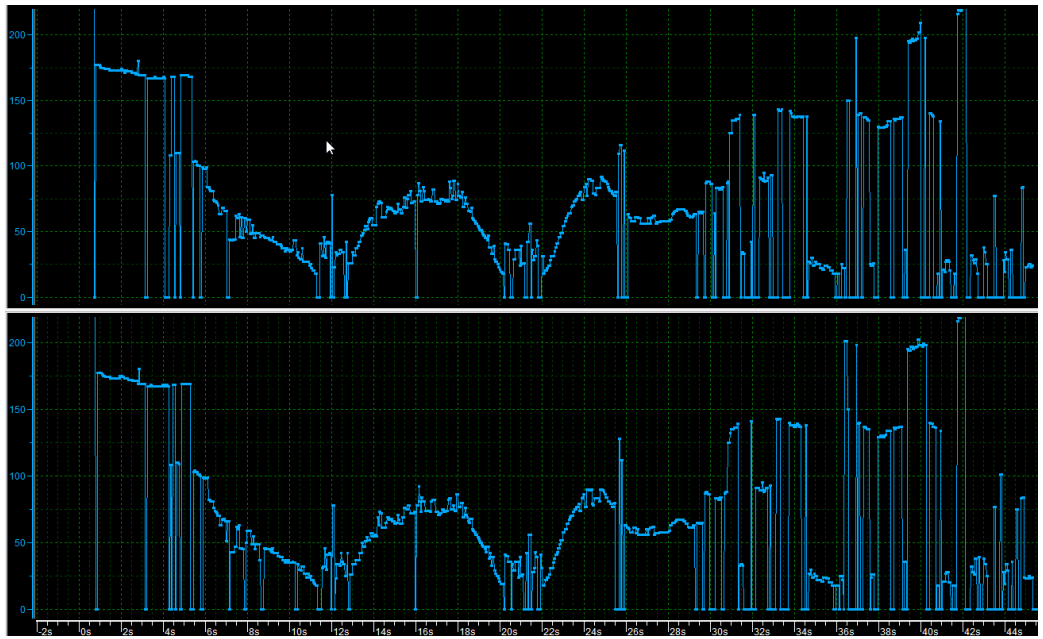
Complex Sensor and Actuator - 3

Complex Sensors Actuator	Radar, Lidar Camera Headlight

- µController or µProcessor
- Various OS
- Prop. middleware
- Raw data; services



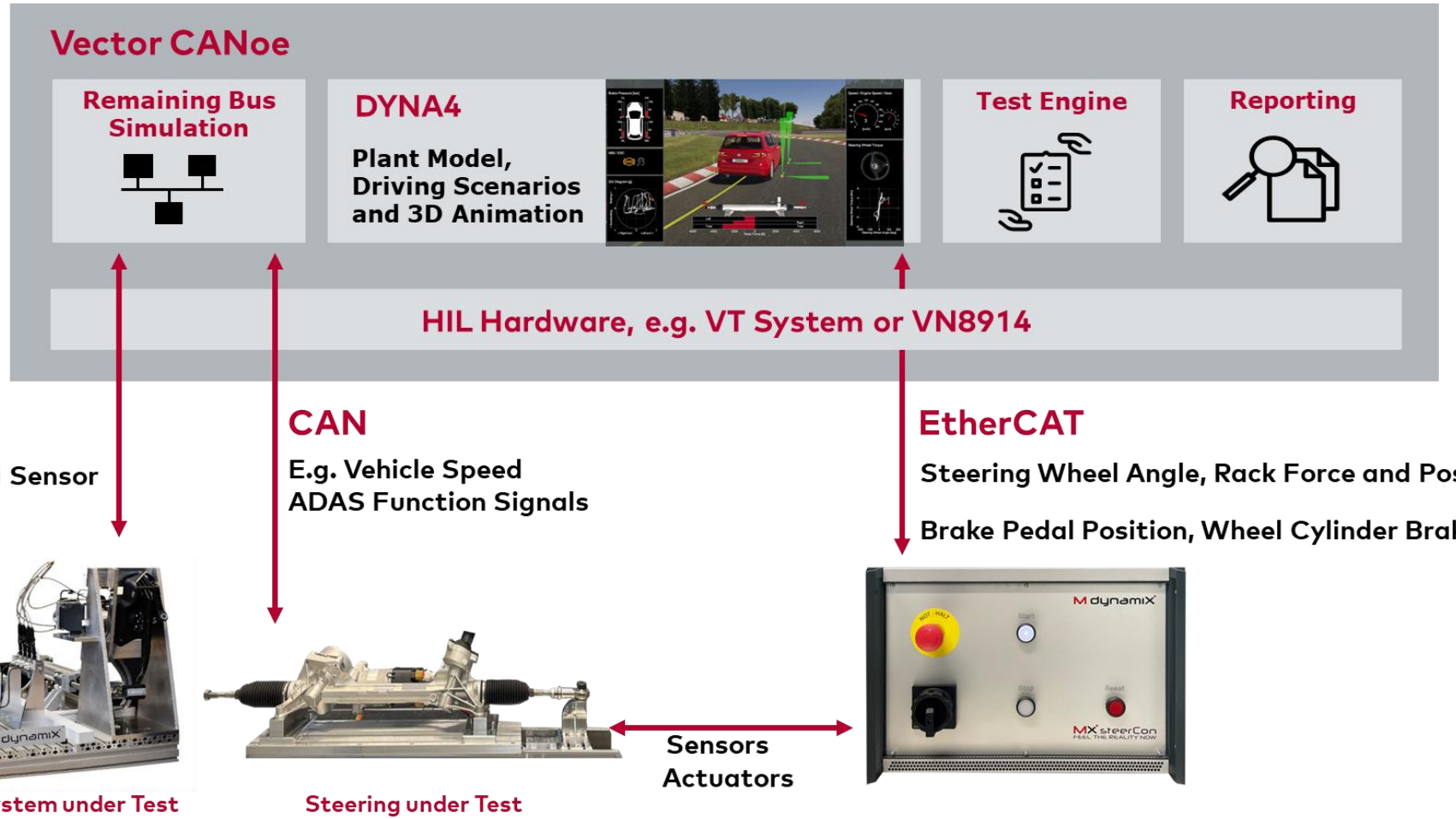




Control - 1

Control | Powertrain | Battery | Chassis

- µController
- AUTOSAR OS
- AUTOSAR Classic
- Signal comm.

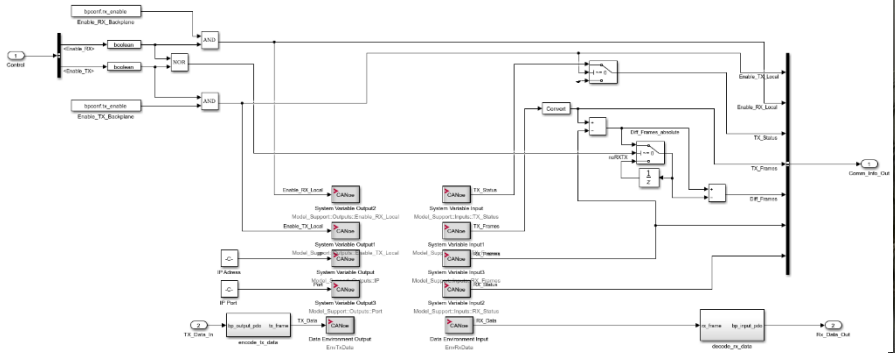


Control - 2

Control | Powertrain | Battery | Chassis

- µController
- AUTOSAR OS
- AUTOSAR Classic
- Signal comm.

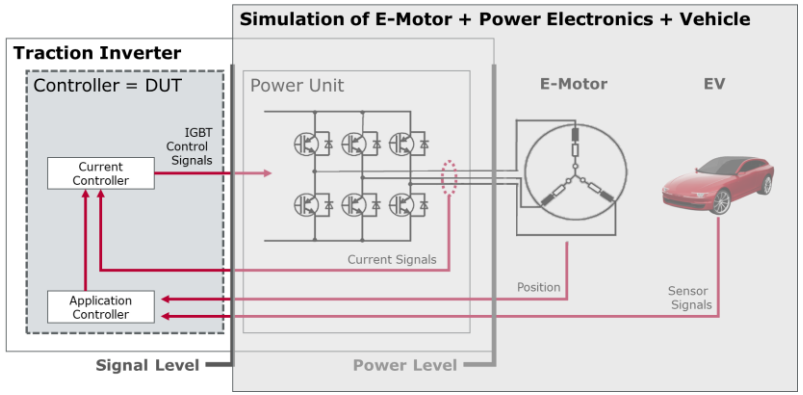
- CANoe based solution
- VT System for BMU I/Os
- Specialized cell simulator HW Battery cell simulation model runs on CANoe RT in robust 1ms timing
- Example:
  108 cells in 480µs
  on Vector RT IPC
- Full use of vTESTstudio



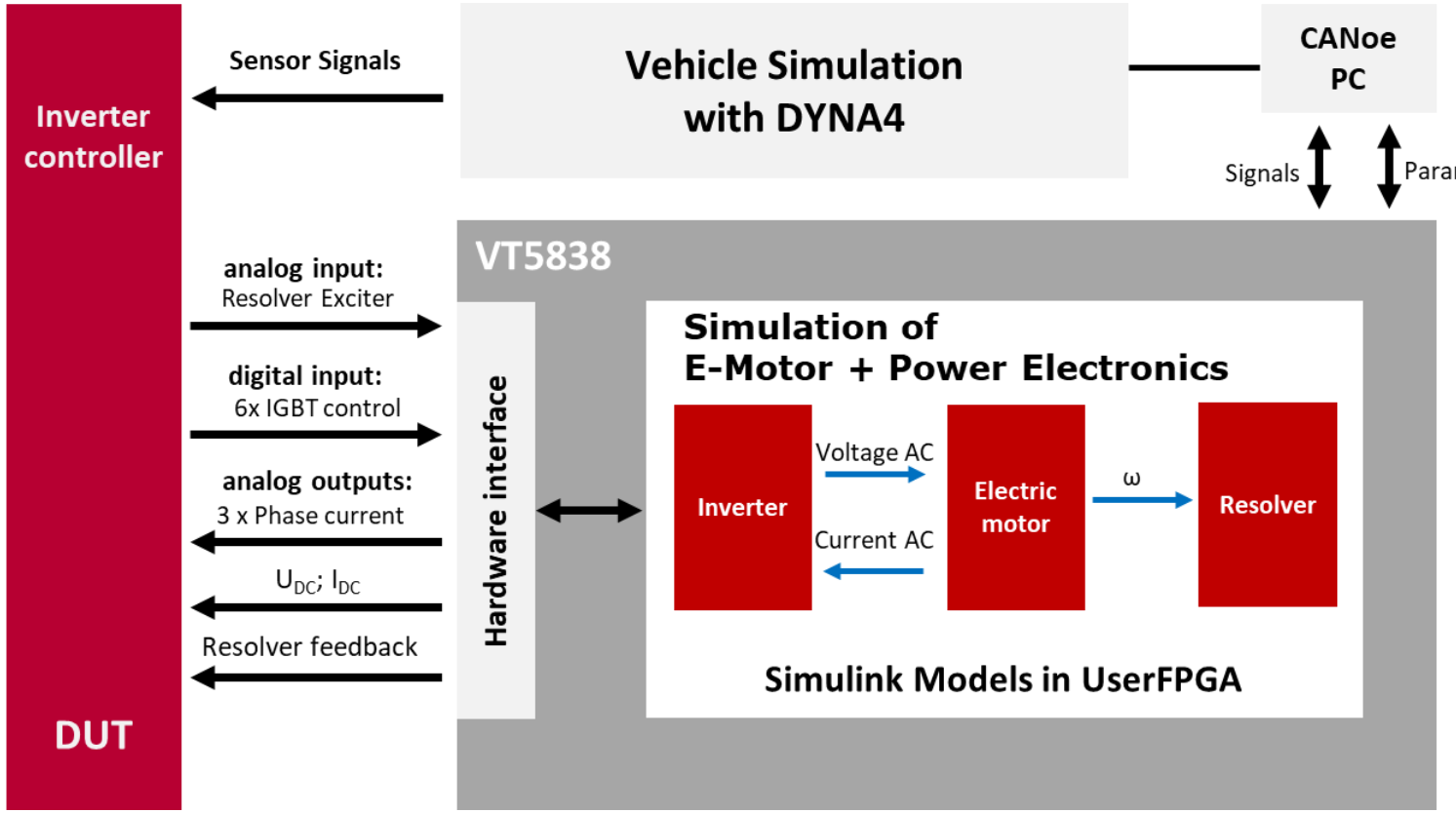
Control - 4

Control | Powertrain | Battery | Chassis

- µController
- AUTOSAR OS
- AUTOSAR Classic
- Signal comm.



MCU HiL

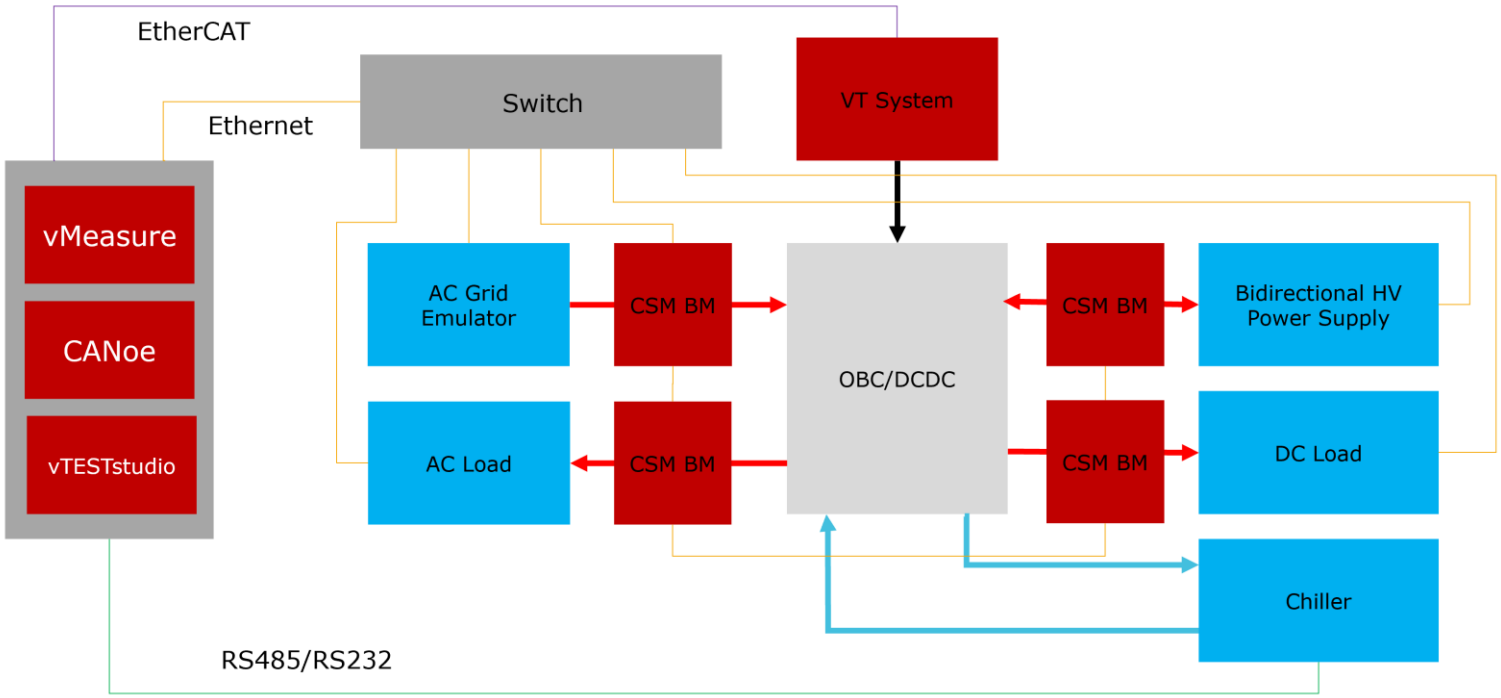


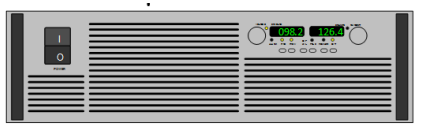
Control - 5

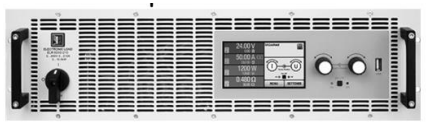
Control | Powertrain | Battery | Chassis

- µController
- AUTOSAR OS
- AUTOSAR Classic
- Signal comm.

- Simulation of high voltage and power components
  - AC grid, HV battery, LV battery
- Fault injection:
  - AC grid disturbance simulation
  - Short circuit of HV and LV battery
- High speed synchronized data acquisition with RBS
  - AC DC voltage, current and power
  - Harmonic analysis
  - Power factor
  - Pulse and overshot measurement



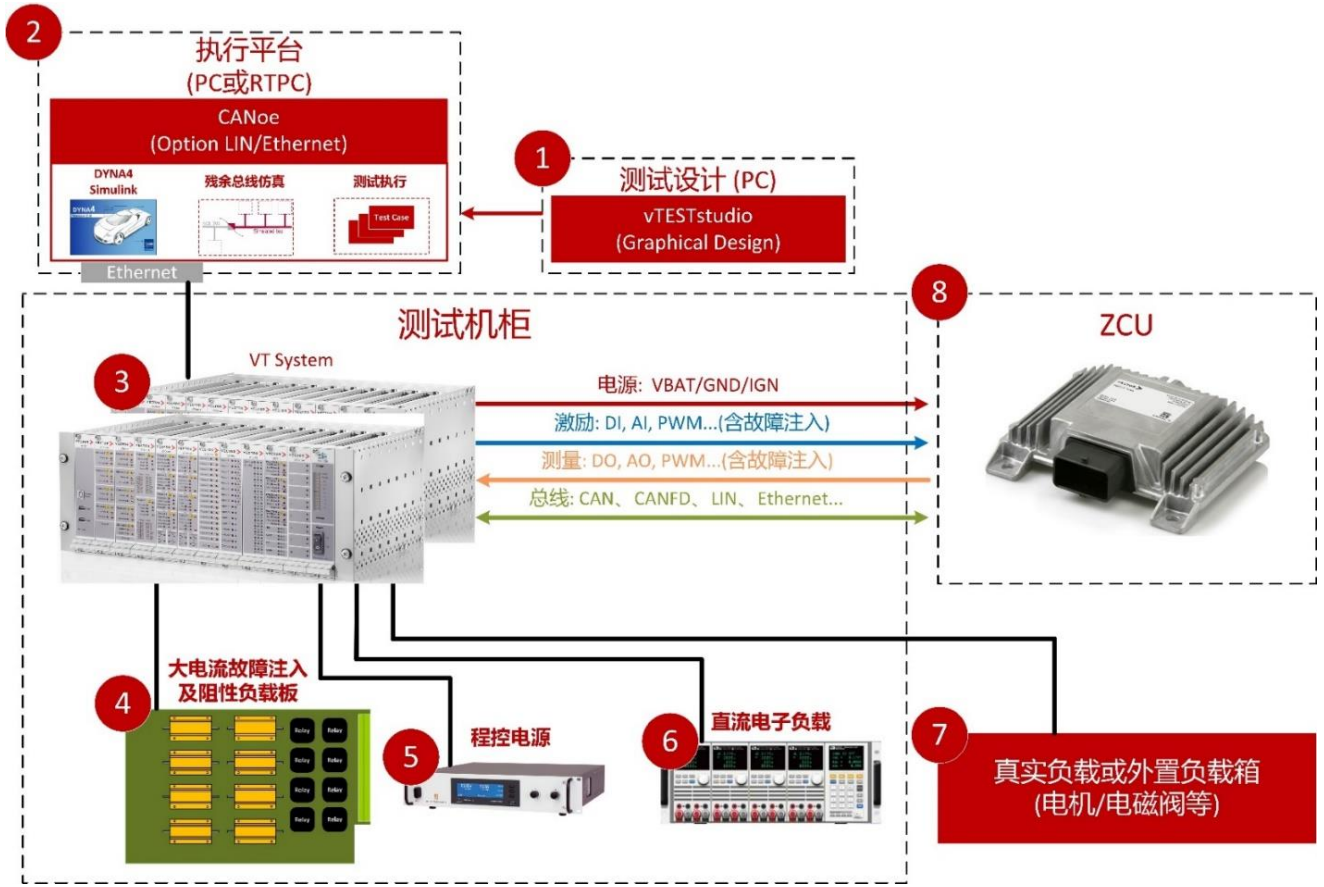




Zonal

Zonal	Left, Right Front, Rear

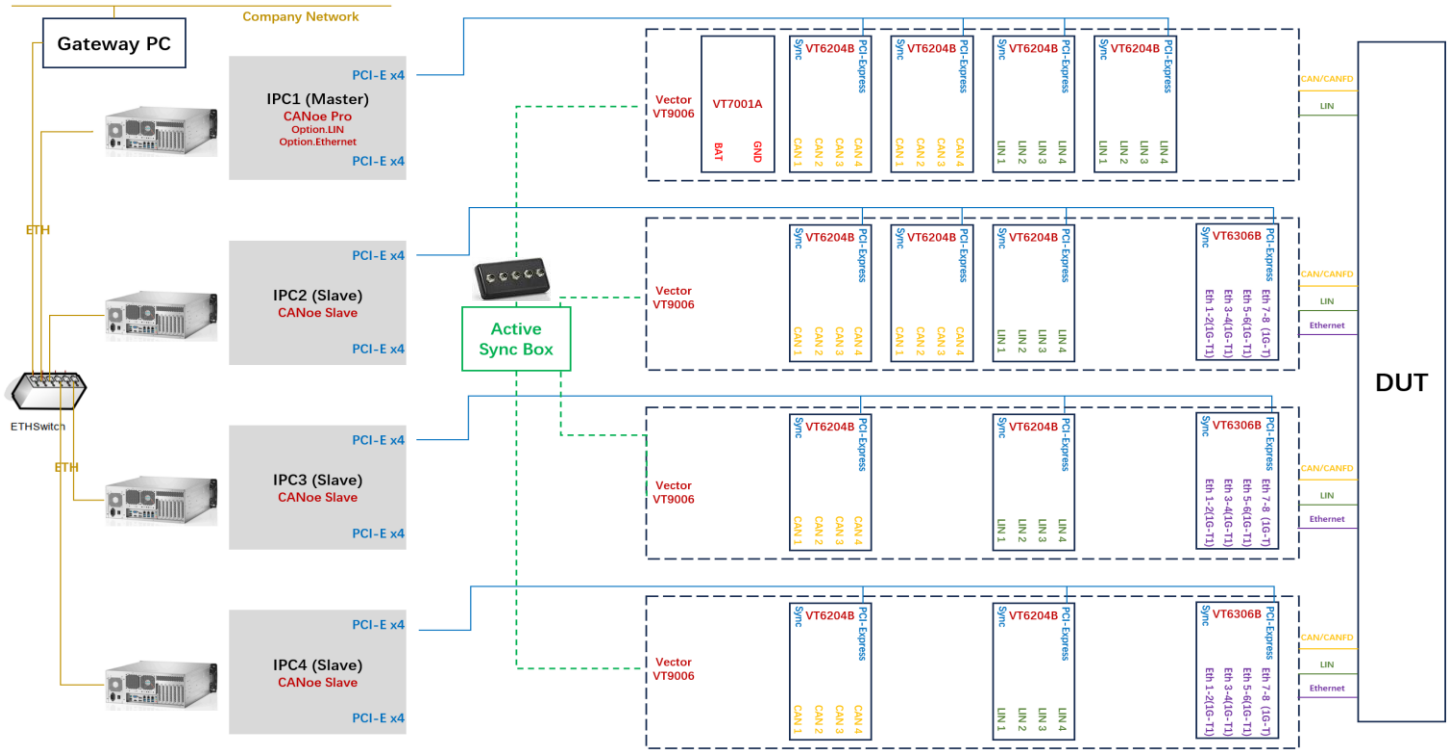
- µController or SoC
- Hypervisor, POSIX-OS
- AUTOSAR
- Signal/service comm.



HPC - Generic

HPC IVI ADAS Generic

- µProcessor or SoC
- Hypervisor, POSIX-OS
- AUTOSAR, …
- Service comm.

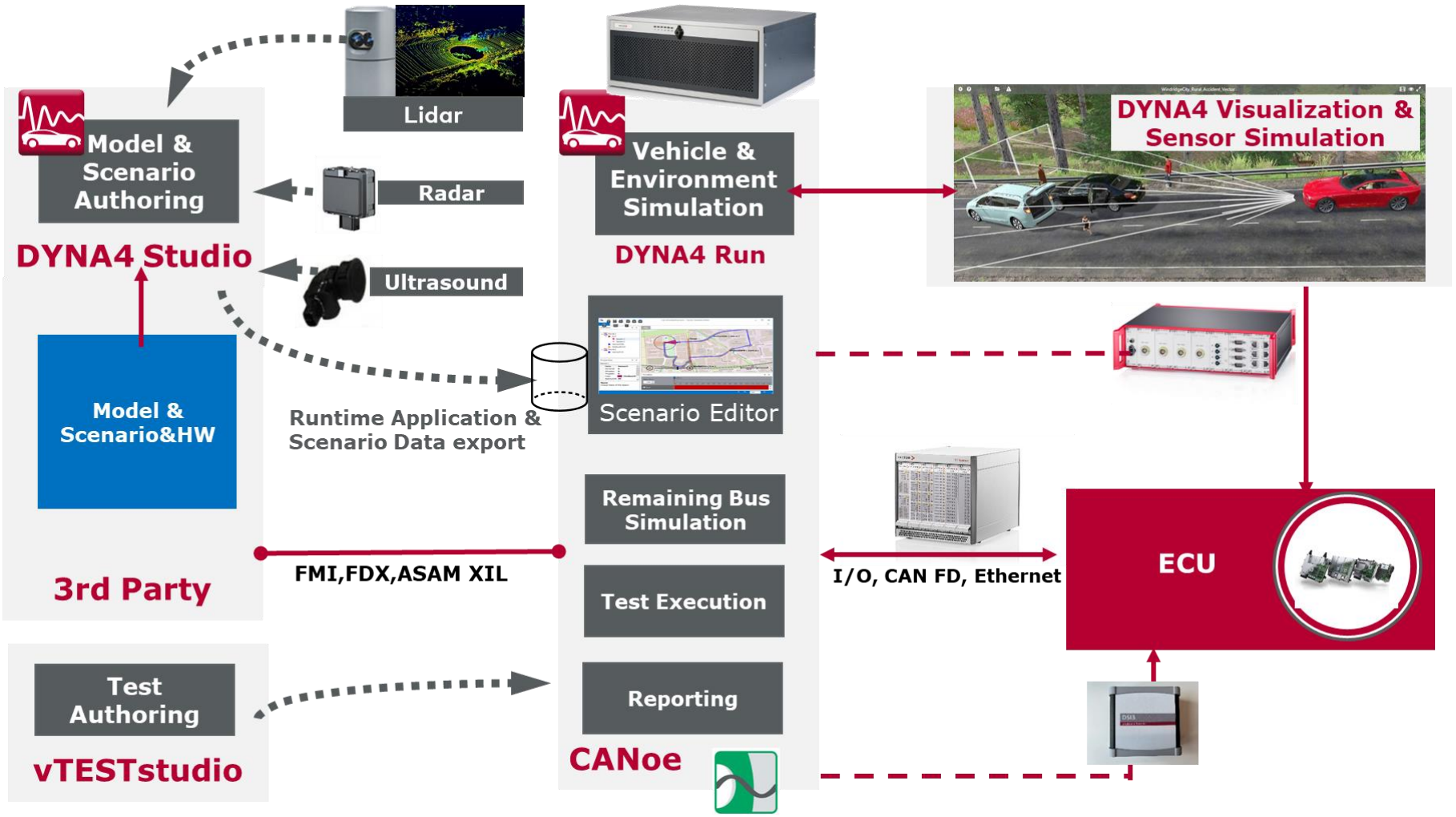


HPC – ADAS-1

HPC

IVI
ADAS
Generic

- µProcessor or SoC
- Hypervisor, POSIX-OS
- AUTOSAR, …
- Service comm.

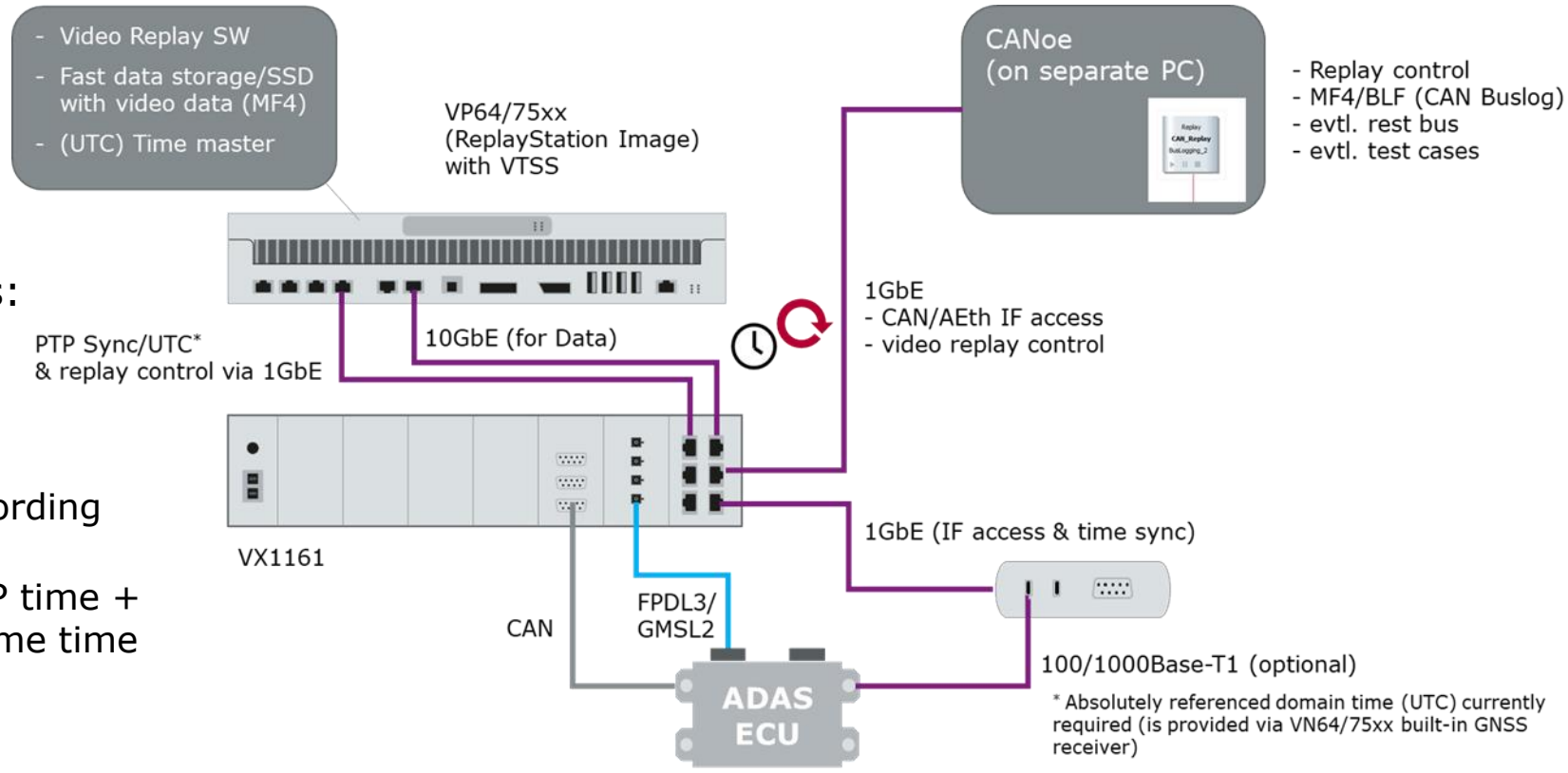


HPC – ADAS-2

HPC | IVI ADAS Generic

- µProcessor or SoC
- Hypervisor, POSIX-OS
- AUTOSAR, …
- Service comm.

- Three synchronization approaches:
  - Free running
  - Tool time replay
    - Time base is PTP
    - StreamProvider plays frames according MDF4 timestamps
      - Presentation time = CANoe PTP time + commissioning time + MDF frame time stamp
  - ECU time replay
    - ECU outputs frame trigger signal
    - frames sent on trigger

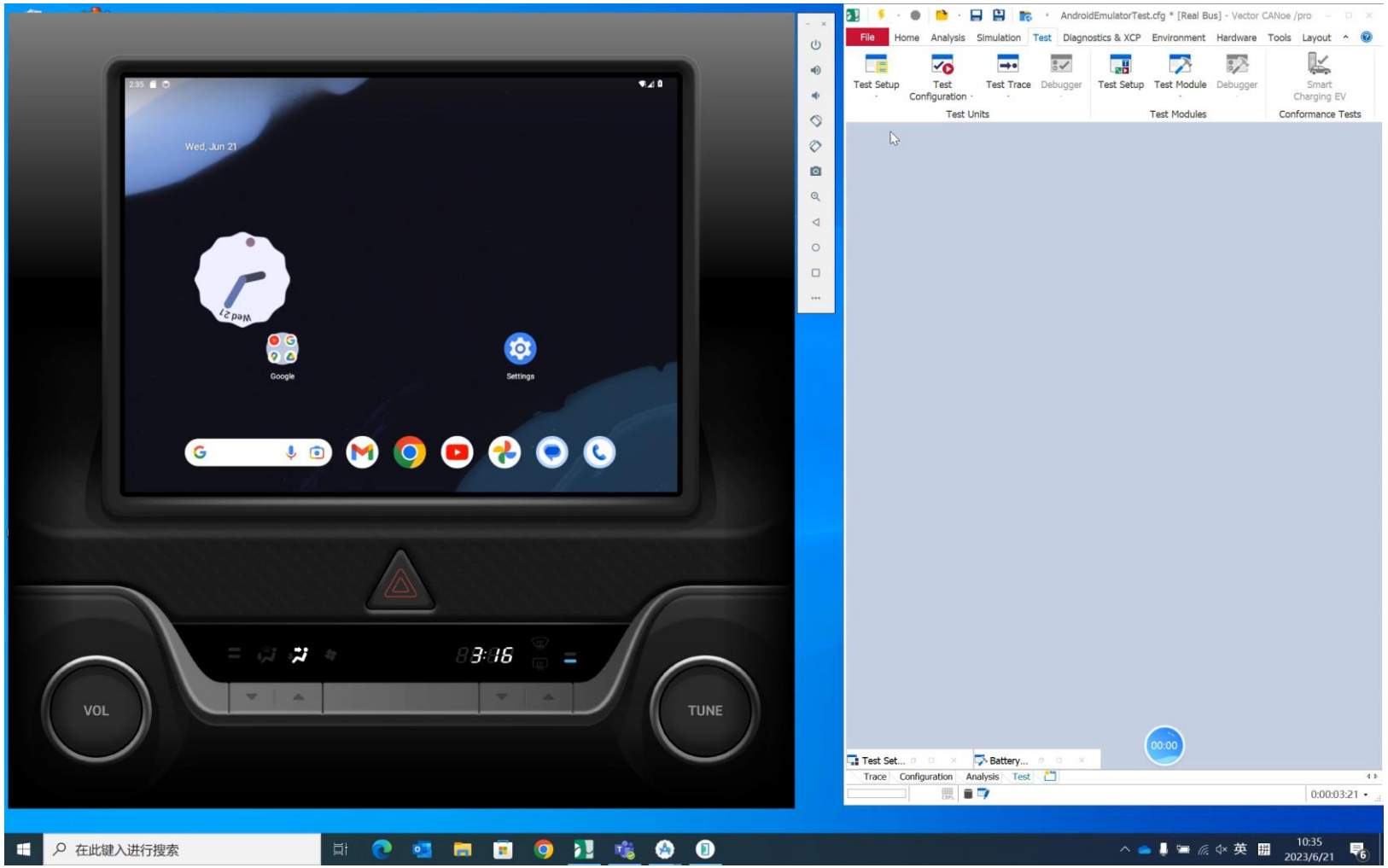


HPC - IVI

HPC

IVI
ADAS
Generic

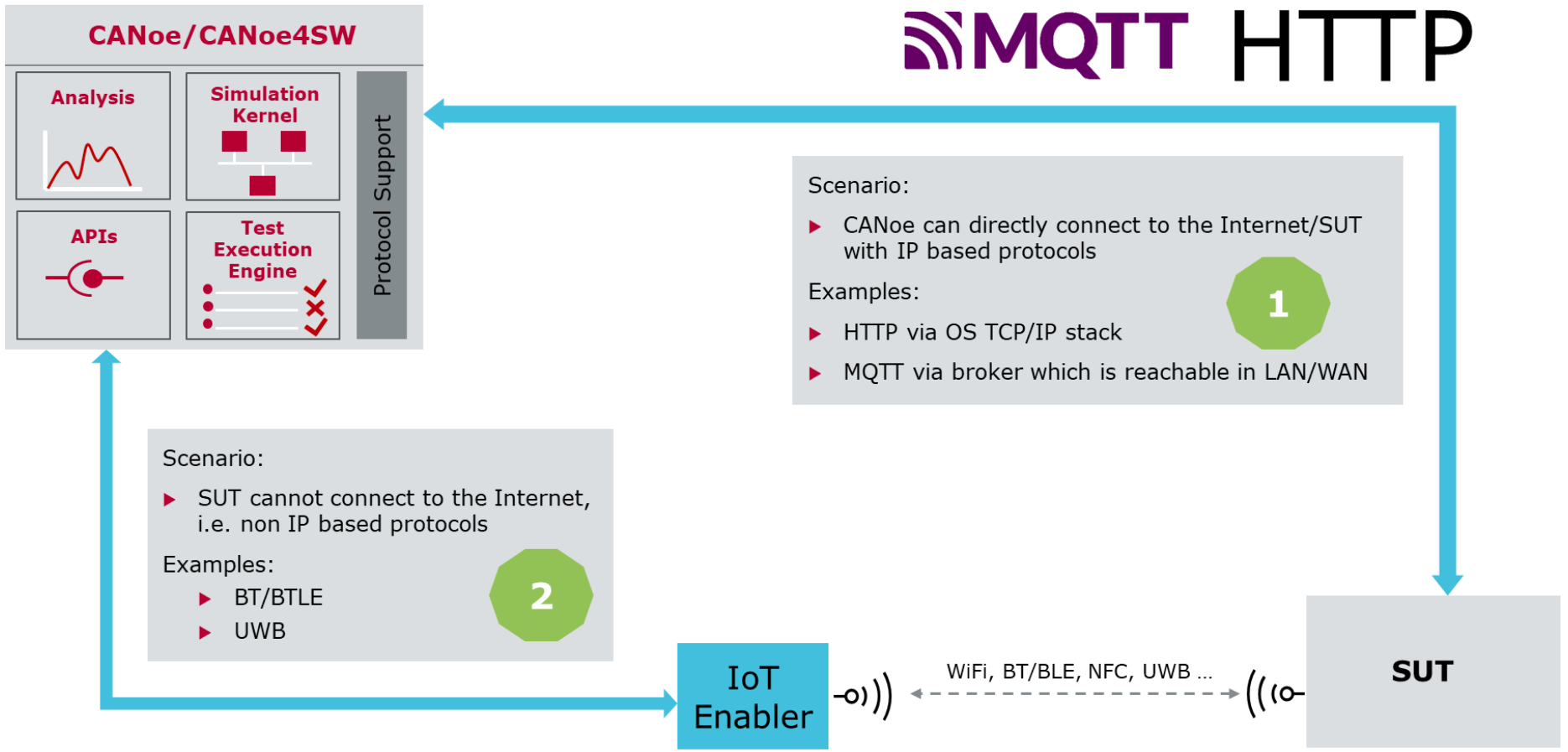
- µProcessor or SoC
- Hypervisor, POSIX-OS
- AUTOSAR, …
- Service comm.



Backend

Backend SW update Data collect. Diagnostics

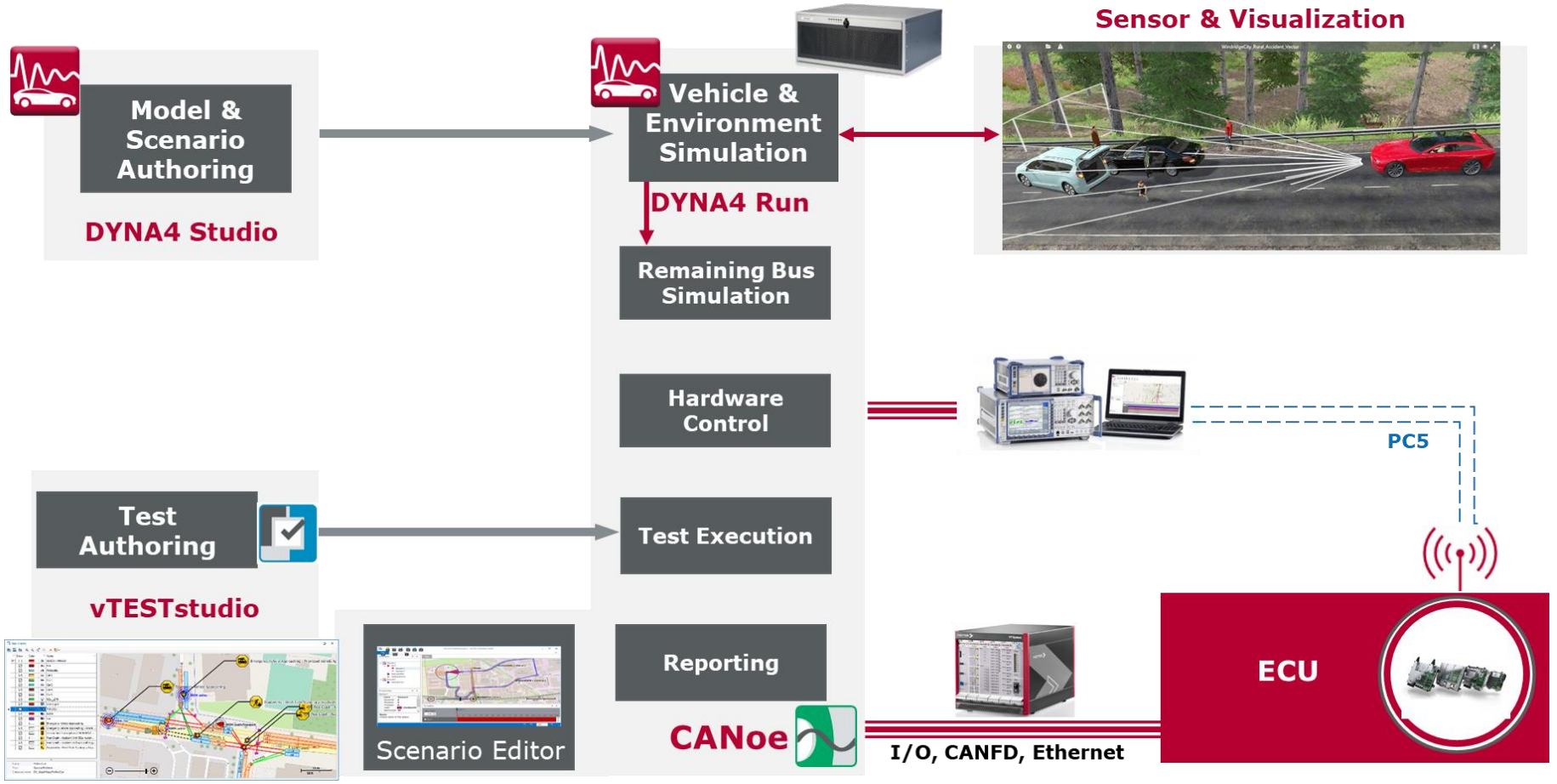
- IT frameworks
- Services, µServices, libs
- Vehicle connector



Backend – V2X

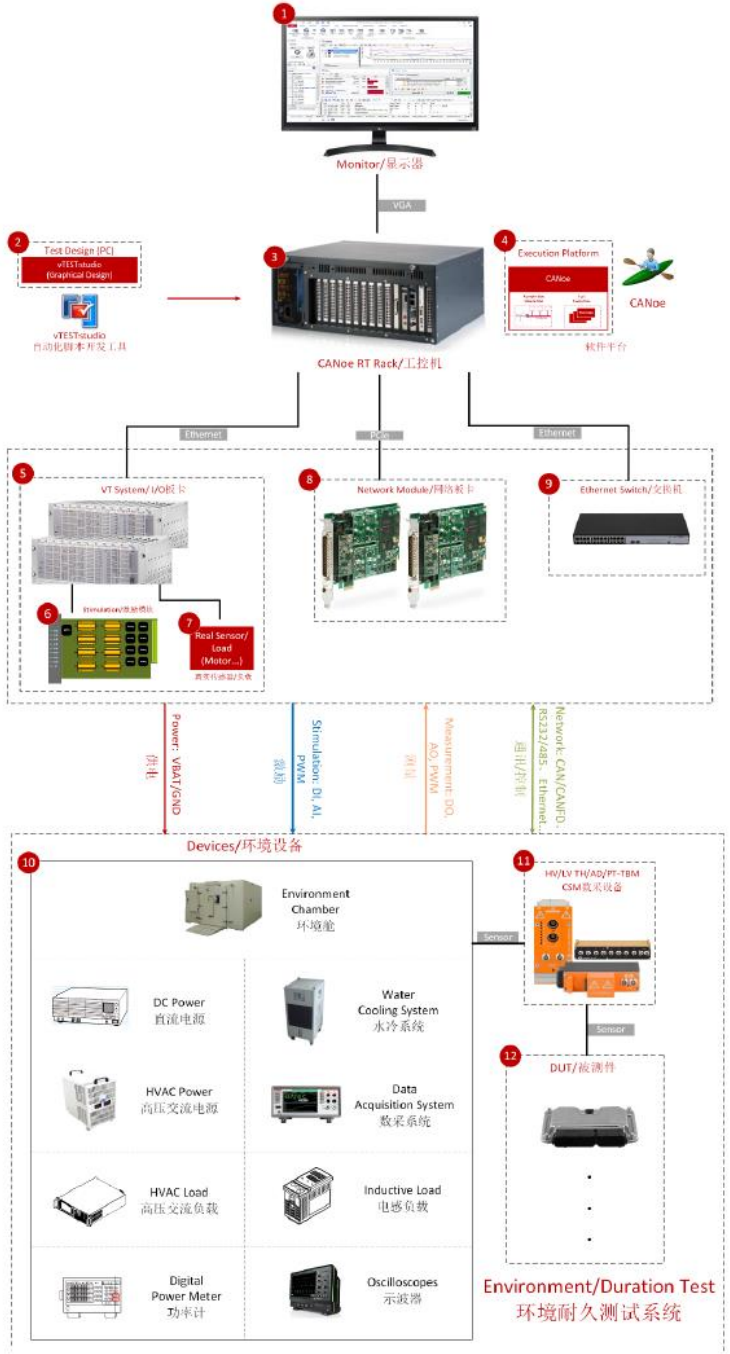
Backend SW update Data collect. Diagnostics

- IT frameworks
- Services, µServices, libs
- Vehicle connector



DV/PV Testing

设备类别	通信接口	远程控制功能
环境箱	以太网	设定温度/湿度、读取温度/湿度设定值、读取温度/湿度实际值、设定温变速率、设定温箱运行/停止、以及读取故障信息；
	CAN	
	模拟量	
	RS 232/485	
直流电源	以太网	设定输出电压/电流、读取电压/电流、设定设备开关、设定输出限值，调用设备中已保存的波形，以及读取故障信息；
	RS 232/485	
	模拟量	
HVAC电源	以太网	设定输出电压/电流/频率、读取电压/电流/频率/功率因数、设定设备开关、设定输出限值，调用设备中已保存的程序，以及读取故障信息 ；
HVAC负载	以太网	设备运行/关断、模式选择（恒流，恒压，恒功率等）、设定电流/电压/功率值、读取电流/电压/功率值/功率因数、保护限值设定和故障信息反馈；
功率计	以太网	读取电压、电流、有功功率、无功功率、效率、功率因数、频率、谐波 ；
数采系统	CAN	实现量程设定、电压读取功能、实现传感器类型设置、温度读取等功能 ；
	以太网	
水冷系统	以太网	设定流量、温度、进出水口压力、压差，读取流量、温度、进出水口压力、压差设定值，读取流量、温度、进出水口压力、压差实际值，读取故障信息；
	RS 232/485	
电感负载	RS 232/485	读取每项温度，读取设备反馈故障信息；
示波器	USB	远程操作示波器波形时间轴调节、纵轴调节、ZOOM功能、STOP功能、数据保存、波形图片保存功能；
	以太网	



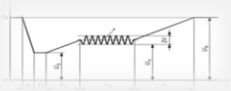
Agenda

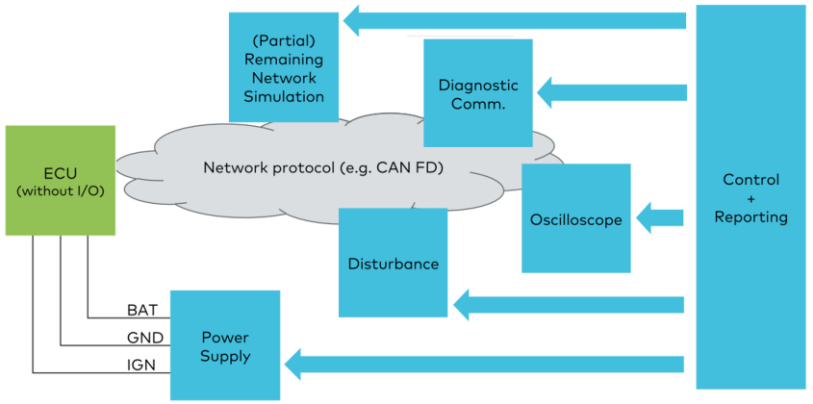
1.	How does HiL cover Automotive Trends?
2.	HiL Solutions for future testing
3.	Network Conformance Test HIL
4.	Vector Open HiL Test Environment

Conformance Tests for CAN/CAN FD/CAN XL

Conformance Testing

- Physical Layer
  - Bus output voltage/Bit Time
  - Rising and Falling edges time
  - Capacity and Resistance characteristics
  - Bus failure behavior
- Data Link Layer
  - ID/DLC According to [CMX]
  - Extended Data Frames check
  - Remote Frames check
- Interaction Layer
  - Cyclic Transmission
  - Fast Cycle of Periodic and If Active Messages
- Network Management
  - OSEK NM
  - AUTOSAR NM/PN
  - Others(e.g. NM High)
- Electrical testing
  - Over/Under voltage
  - Ground shift tolerance

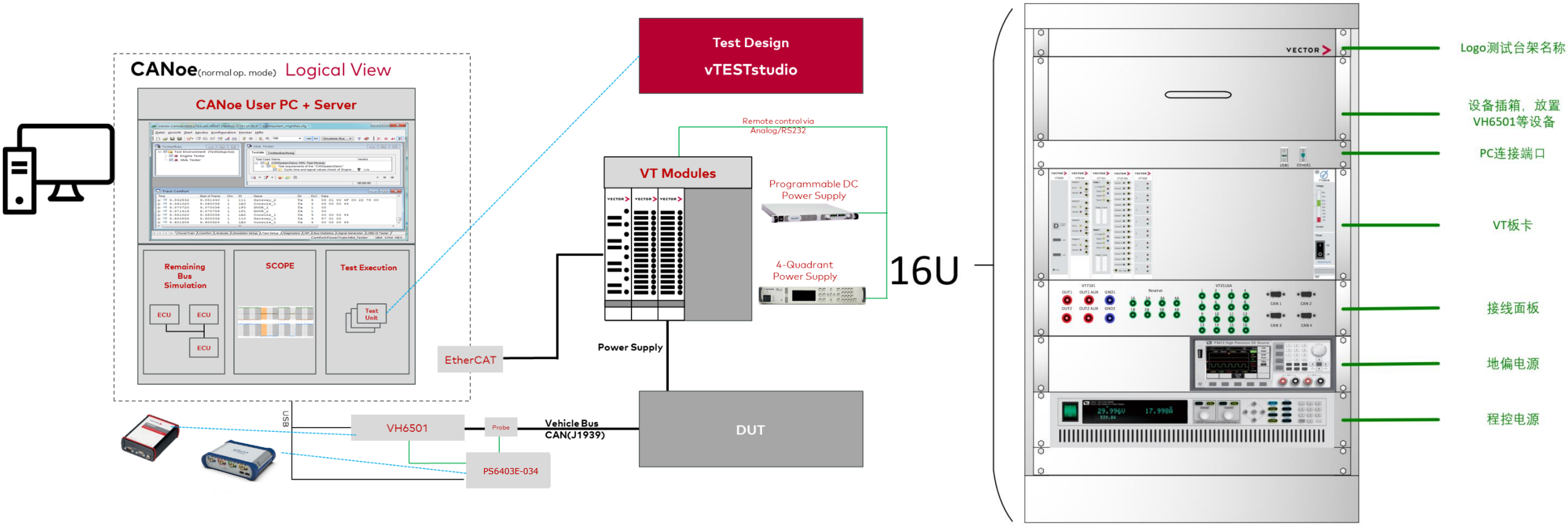




Diagnostic Testing

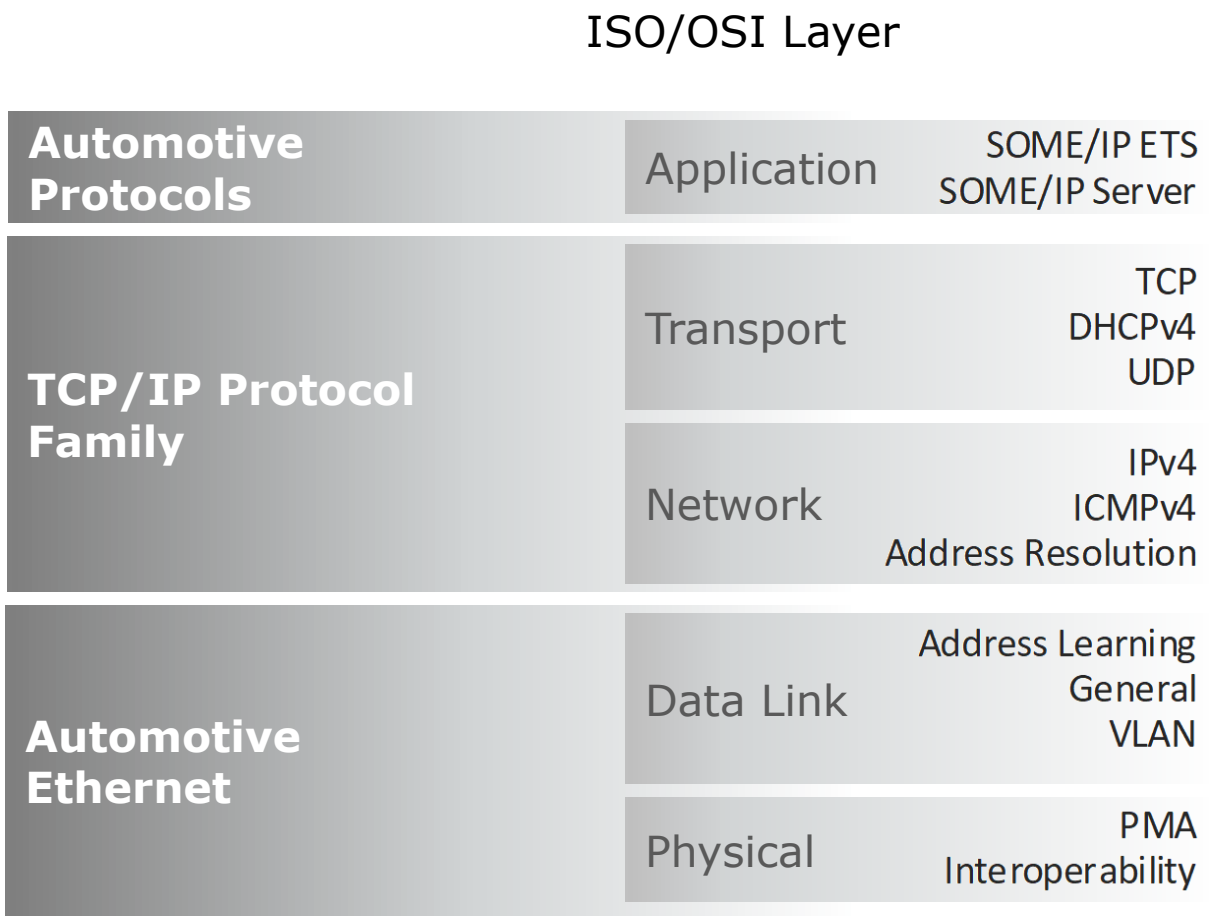
- Protocol Testing
  - Diagnostic Message Flow
    - Addressing and timing
  - Diagnostic Protocol Format
    - Valid, Combined and Invalid Requests
    - Response (single, none, multiple)
  - Data Type Checks
  - Sessions and Security Levels
    - Session and security state transitions
- Software Download testing
  - Valid Flashing
  - Cancel data transfer (stop transmission or clamp reset)
- Application testing
  - Diagnostic Parameters
    - Passive parameter validation
    - Active control of I/Os to validate diagnostic parameter content
  - Fault Memory
    - Provoke network signal failures
    - Provoke hardware failures using the I/Os
    - Any other failures using user scripts

Example: CAN/CAN FD/CAN XL Conformance Test Bench



- CANoe
  - Control + Reporting
  - Remaining Bus Simulation
  - Diagnostic Communication
- vTESTstudio
  - Test library
- Power Supply
- Oscilloscope
- Disturbance

Conformance Tests for Automotive Ethernet



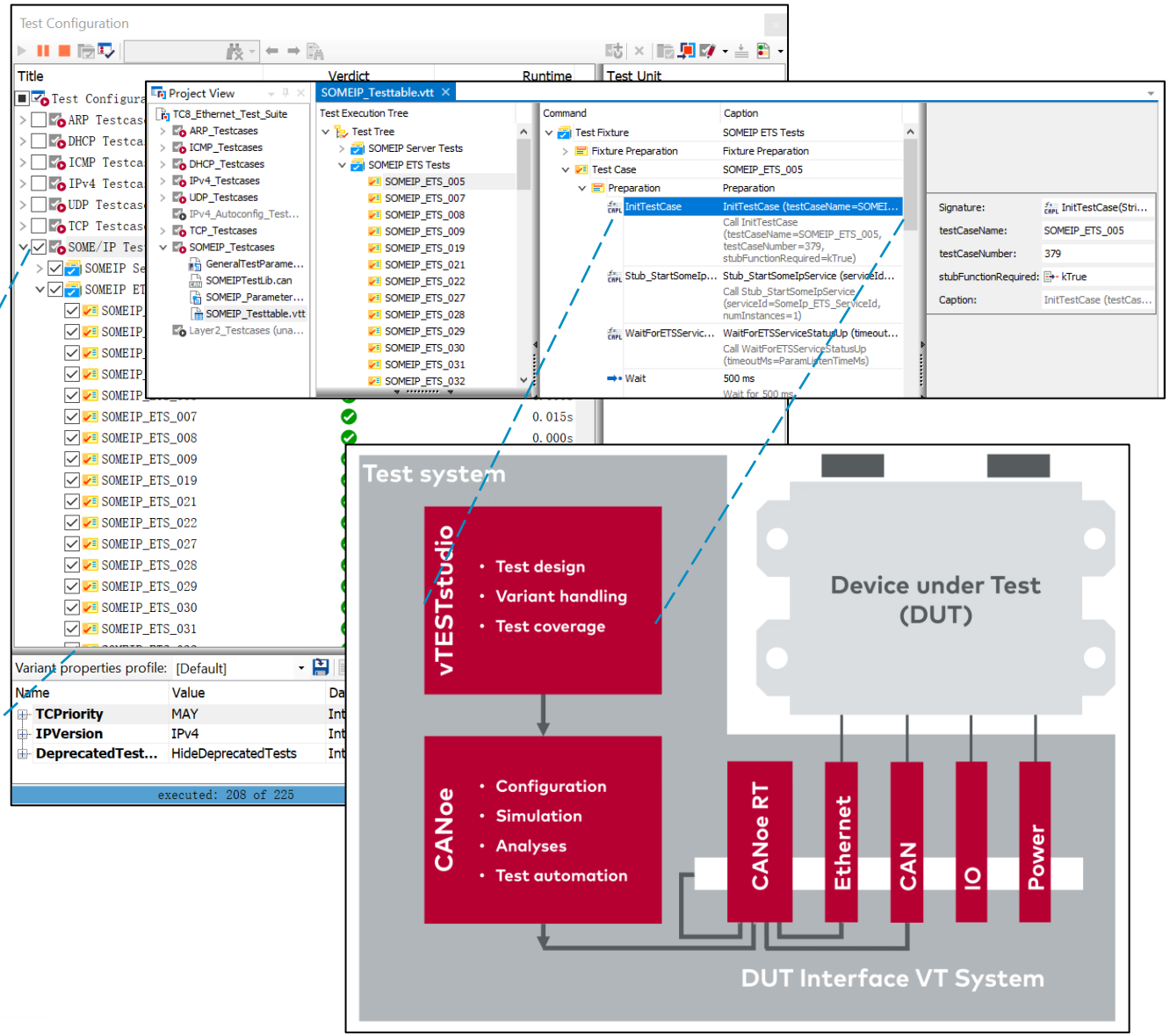
VECTOR

OPEN Alliance ECU Test Specification for Automotive Ethernet

- CANoe Option Ethernet supports **TC8** test specification
- The configuration does **not** require extra licensing
- A simulation of the DUT (Golden Device) is included
- Source code with vTESTstudio for **free**

OPEN Alliance Automotive Ethernet ECU Test Specification Layer 3-7
TC8 ECU Test
OPEN ALLIANCE

	Test Group	CANoe.Ethernet
Layer 1	Physical Layer	
Layer 2	TC8 Switch Tests	
	ARP	✓
Layer 3	ICMPv4	✓
	IPv4	✓
	Dynamic IPv4 Link Local Address	
Layer 4	UDP	✓
	TCP	✓
Layer 7	DHCPv4	✓
	SOME/IP Server	✓
	SOME/IP ETS	✓



EV Testing HIL

- Electrical Tests incl. fault injection on charging connector pins
- Simulation of the complete charging behavior of the EVSE
- Analysis + Modification of SCC communication (Ethernet or CAN)
- **Conformance / Interoperability EV Tests**
  - Test cases from DIN 70122, ISO 15118-4/-5
  - Test cases from GB/T 34658
  - Self-developed test cases for CHAdeMO

EVSE Testing HIL

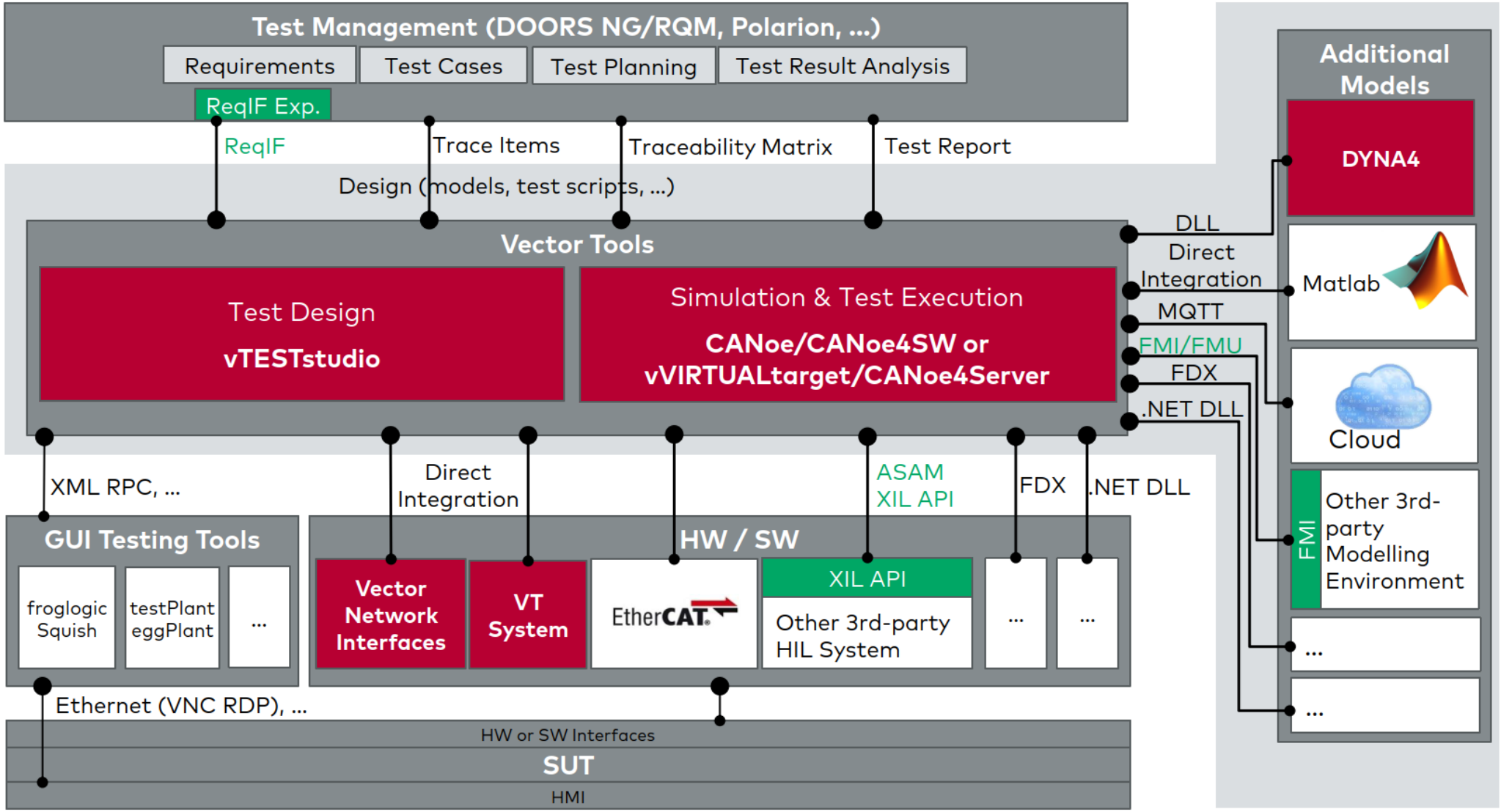
- Electrical Tests incl. fault injection on charging connector pins
- Simulation of the complete charging behavior of the EV
- Analysis + modification of SCC communication (Ethernet or CAN)
- Conformance / Interoperability Tests
  - CCS: ISO 15118-4/-5 (AC, DC, EIM, PnC)
  - GB/T 34658
  - IEC 61851-1/-23 *
  - CHAdeMO *
  - More test cases for DIN 70122 *

* Planned

Agenda

1.	How does HiL cover Automotive Trends?
2.	HiL Solutions for future testing
3.	Network Conformance Test HIL
4.	Vector Open HiL Test Environment

CANoe + vTESTstudio + VT System + DYNA4



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