Measuring Everything

White Paper

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1 Really Measuring Everything

To be able to evaluate the functionality of a single algorithm or an entire system, the relevant properties must be measured and recorded. This is performed through the use of measurement and calibration systems such as CANape in laboratories, on test benches or during vehicle testing.

The measurement data must be recorded synchronously. In the automotive field there are many different sources:

> ECU-internal quantities for which data can accumulate at rates of up to 50 MByte/s for each ECU

> Sensors such as radar, lidar, video or ultrasound are used for complete sensing of the vehicles environment. These sensors can generate data streams up to 100 MByte/s per sensor.

> Communication buses for monitoring the cooperation between the ECUs using long established systems including CAN, LIN, MOST, FlexRay and the new adopted Automotive Ethernet which is increasing rapidly in vehicle use.

> Analog/digital measurement values such as temperatures or voltage characteristics. When viewing inverter voltage characteristics for example, very high scanning rates, several hundred kilohertz, are often necessary for detecting harmonics.

> Cameras for recording the driving situation or for observing the driver. The data rate of a camera is heavily dependent on the resolution, the number of images per second and any compression.

> Position data via GPS for determining the relationship between the measurement data and the vehicle position. The more precise the localization of the GPS receiver, the higher the data rate.

> Diagnostic information from the vehicle that can be tapped via the OBD interface.

Depending on the combination and the number of sources, there are often several hundred thousand signals to acquire. The varying character of the interfaces and the temporal behavior of the sources pose special challenges on a measurement tool for synchronous recording.

This document provides you with an overview of how you can measure really everything with CANape and how other products can be integrated to form a complete solution.

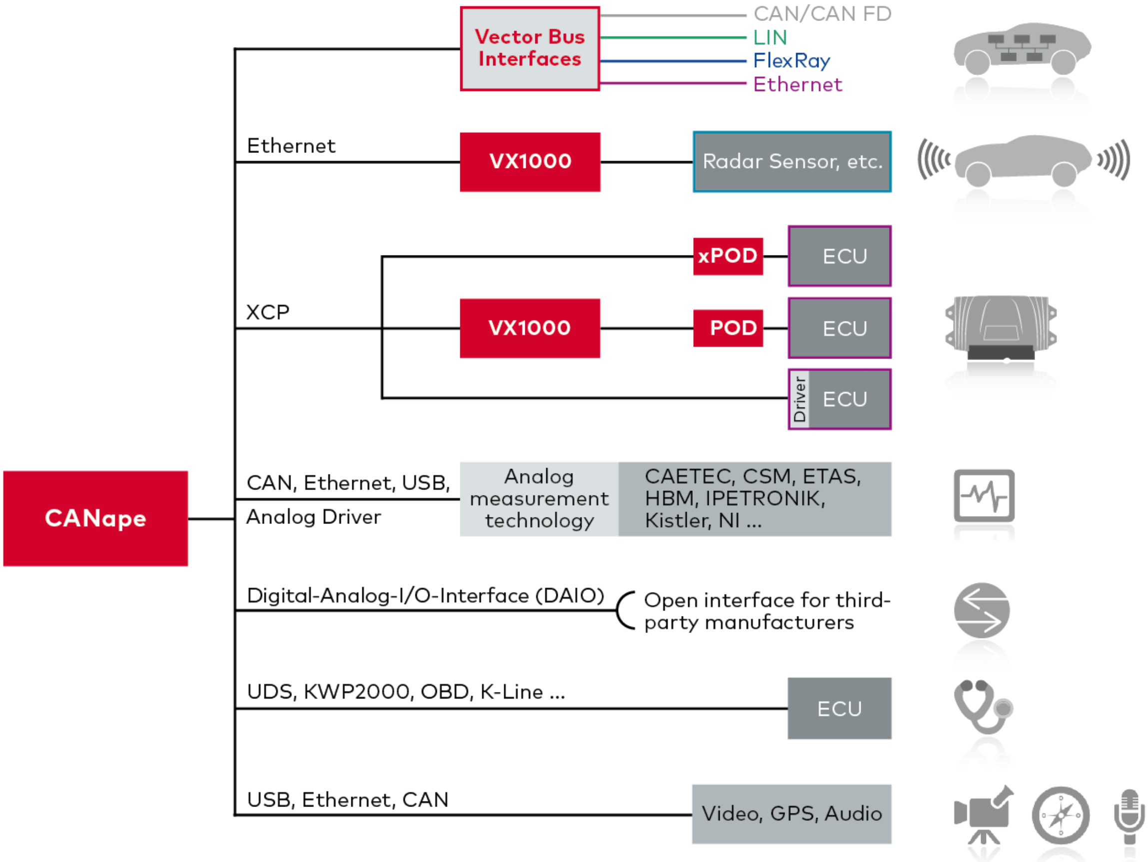

Figure 1: CANape synchronously captures measurement data from a wide range of sources

CANape acquires the data in the form of signals and messages, handles the synchronization and records it in measurement files in the standard ASAM format MDF. The recordings are organized in CANape using "recorders". These recorders can be event-triggered or continuously recording.

An Overview of the Various Measurement Solutions:

Sensor measurement technology: Various sensors, such as radar, video, lidar, etc., can be acquired with CANape and the data stored. There is sensor raw data as well as data that is processed in the sensors and typically measured with XCP. The raw data from the sensors is not transmitted via standardized protocols; instead, the sensor data is accessed via adapted recorders.

Bus measurement technology: The typical vehicle buses – CAN, CAN FD, FlexRay, LIN and Ethernet – are connected to CANape via the Vector interfaces. CANape accesses both the transmitted signals as well as the complete messages.

ECU measurement technology: The flexible read and write access of variables or memory contents of the ECU facilitate CCP or XCP. With XCP it makes no difference if an XCP driver in the ECU processes the data or if access takes place via the VX1000 measurement and calibration hardware.

Analog measurement technology: Analog quantities can be acquired via various interfaces. Because the requirements on the scanning rates e.g., up to several hundred kHz thus, data quantities can vary widely. The solutions make use of various interfaces such as CAN, USB and Ethernet.

Digital-analog input/output: The DAIO interface is an open programming interface for integrating nearly any measurement solutions.

Diagnostic measurement technology: The diagnostic data of an ECU is accessed via KWP2000 or UDS. Vehicle-specific data is available via OBD.

Position data: During road tests, it is often necessary to be able to precisely understand the relationship between vehicle position and measurement values. The interpretation of the recorded measurement data is made significantly easier as the geographic circumstances are thereby taken into consideration in the evaluation. CANape records the position data from the CAN bus data or via a separate GSP receiver.

Reference cameras: Video cameras are used as reference cameras; these are generally connected via USB and record the driving situation. Unlike video-based sensors, which also perform data processing, the reference cameras supply only video data. CANape acquires and stores the data in a video format (AVI) synchronously with other measurement files.

Audio recordings: In addition to video data, CANape also records audio data using microphones and stores the data synchronously with the measurement data.

1.1 Measurement Concept in CANape

The various data sources are defined with description files and created in CANape as "devices". The user selects the desired signals and messages from the description file, selects whether they are to be visualized and is then ready to perform measurements, as the "default recorder" has accepted the selections.

Multiple recorders can be used in parallel in CANape. Recorders store the measurement values in measurement files. Each recorder writes its own measurement files. As the primary measurement format MDF is available in various versions for signals and messages. BLF is used for bus messages and AVI for video/audio recordings.

Up to 16 different recorders can be defined in a CANape project. A recorder records either continuously beginning at the start of measurement or via individual trigger events. The signal sources/devices are assigned to the recorders.

Some device types can be switched to the "Distributed High Performance Recording" mode. These are devices that deliver a high data rate, for example ECUs via XCP on Ethernet, radar, video sensors and reference cameras. A device in this mode is assigned its own measurement instance via the recorders. This measurement instance can run on the same computer as CANape or on an additional PC that is connected to the CANape computer via Ethernet. The total load is thereby optimally distributed over one or more PCs. As a result, nearly any data volumes can be acquired using the scalable PC cluster or DHPR (Distributed High Performance Recording).

All instances are managed and controlled from within CANape. The triggering of actions, such as measurement start and stop and the initiating of triggers take place synchronously.

The new DHPR mode was specially developed for the measurement of ADAS technologies. ADAS sensors are equipped with individual protocols for transferring their raw data, each sensor type must be integrated via an appropriately adapted instance. The DHPR architecture allows another sensor type to be supported in CANape at any time.

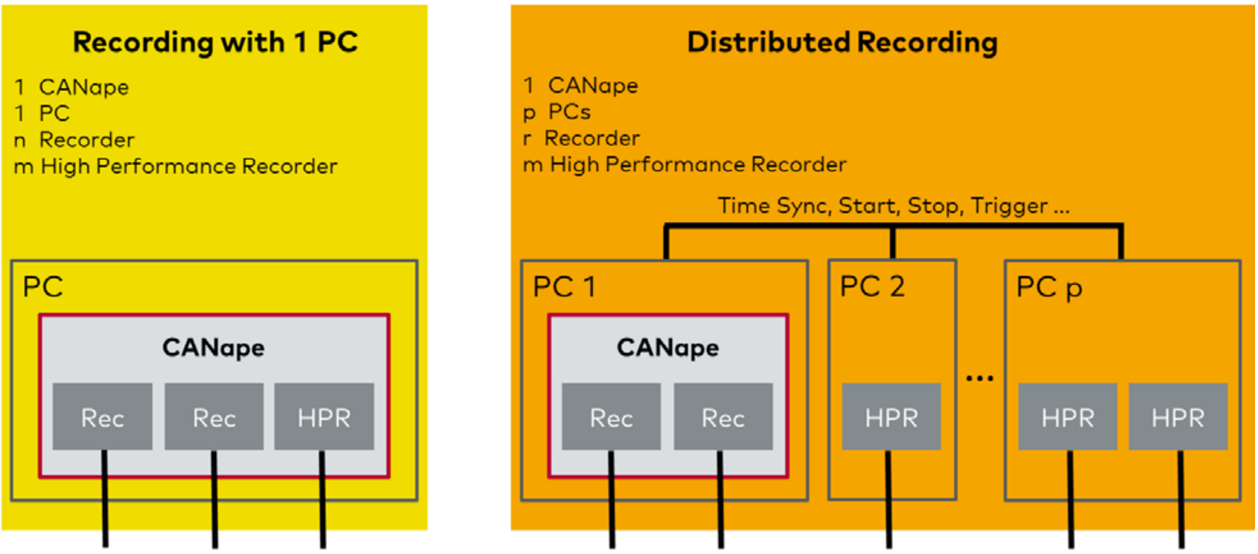

Figure 2: Scalable solution through "Distributed High Performance Recording"

This solution offers the following advantages:

> The standard recorders allow the total measurement task to be divided: For example, a recorder can be used to write all signals that belong to a gear shifting operation, shifting from 1–2, into a single measurement file. With a lead time of x seconds before the gear switching operation and a follow-on time of y seconds.

> The High Performance Recorders offer an individual interface for the sensor technology and for XCP on Ethernet devices. They fully utilize the PC resources and are also available for digital recording across multiple computers.

> You need just a single CANape license, regardless of the number of PCs that are used.

- All recorders are configured via CANape, which is installed on one of the PCs.
- The synchronization and initiating of trigger events occurs precisely with CANape.
- Each recorder writes its data in a separate measurement file. As a result the individual files are smaller and easier to process. Should it be necessary to share the data of a sensor with the manufacturer or a development partner, there is no need to separate the signals and store them in separate files.
- All measurement files for a given measurement are synchronized.

1.2 Recorder PC Hardware

To realize the any application cases possible with just one PC, a complete solution consisting of PC hardware and CANape is available. To optimize the solution, both components were matched to one another with respect to energy management, hard disk handling and measurement performance via the Ethernet ports. The result is a complete solution that can record up to 1 GByte/s of measurement data.

This solution offers the following advantages:

- High-performance modular PC platform with CANape installation
- Hard disk capacity distributed over up to eight hard disks as a RAID system (e.g., SSD disks with a total of 16 terabytes) in one slot
- Hard disk slot is easily accessible and replacement can be performed in just a few steps. Alternatively, 10 GB Ethernet interfaces, USB 3.0 interfaces or a separate readout station are available for quickly downloading the measurement data.
- Connection of the VX1000 base module via Gigabit Ethernet
- Simple mounting of the complete system
- Low cabling expense

Relevant Vector products are:

Product name	Function
CANape	Universal measurement and calibration tool. "Distributed High Performance Recording" is included standard beginning with Version 15.0. You can purchase a complete system consisting of CANape and PC platform. CANape is preinstalled on the hardware and the complete system is optimized for use as a data logger (energy management, Ethernet settings, configured RAID system ...).

2 Accessing Internal ECU Data

This chapter focuses on accessing ECU data without diagnostic protocols. Accessing via Diagnostic data is discussed separately.

There are three different ways to directly access the internal data of an ECU.

- The XCP protocol is implemented as a driver in the ECU. Communication takes place via a bus interface, such as CAN or FlexRay.
- Data access can also be realized via microcontroller-specific interfaces, such as DAP, Aurora or JTAG. This is performed via the VX1000 measurement and calibration hardware, which consists of a POD (plug-on device) and a base module. The POD is located in the immediate vicinity of the ECU and transmits the interface-specific data stream to the base module. The base module converts the data stream of the POD to XCP on Ethernet.
- The XPOD (XCP-POD) directly delivers XCP on Automotive Ethernet data. As a result, no base module is necessary, rather only a converter from Automotive Ethernet to USB/Ethernet.

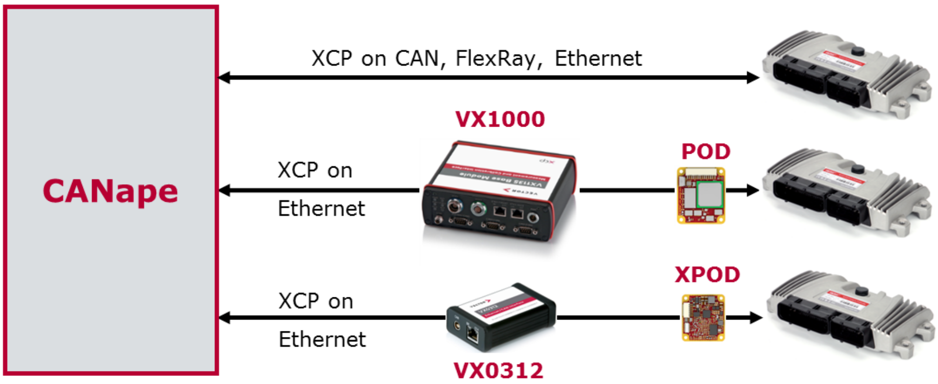

Figure 3: Various connections between PC and ECUs

Access via XCP and bus interface has the advantage that ECU data can, in principle, also be accessed in series vehicles. The measurement data throughput is limited, with respect to both the minimum sampling rate as well as the maximum data quantity. With CAN this is approx. 50 kBps and a minimum sampling rate of 1 ms. This assumes that the CAN bus is not used for other bus communication. Furthermore system resources such as CPU time and memory in the ECU are needed.

With the VX1000 solutions, considerably higher sampling rates and larger data quantities are available. Decisive for the performance here is the controller-specific ECU interface:

ECU interface	CPU type examples	Interface frequency	Pins to connect	~ DAQ data rate	Min. cycle time	POD
JTAG/ Nexus Cl.2+	Renesas V850E2 Renesas RH850 FSL MPC55/56xx FSL MPC57xx	20 MHz 20 MHz 20 Mhz 40 MHz	5 JTAG	0,7 MB/s 1,2 MB/s	100 µs	Serial POD Size: 23mm*24mm VX1543A
AUDII	Renesas SHx Renesas RH850	4 x 20 MHz	8 AUD	1,5 MB/s	100 µs	
DAP	Infineon TriCore Aurix / XC2000	80 MHz	2 DAP	2 MB/s	40 µs	
LFAST/ DigRF	FSL MPC57xx Infineon Aurix	320 MHz	6 DigRF	3 MB/s	40 µs	VX1544
DAP2	Infineon AurixPD Infineon AurixED	2 x 160 MHz	3 DAP	3 MB/s Copy 10 MB/s Trace	40 µs 15 µs	
Nexus Cl.3 **RTP_DMM**	FSL MPC55/6xx TI TMS570	12/16 x 80 16 x 80 MHz	JTAG + 15 AUX 25 RTP/DMM	40 MB/s Trace **VX1451/52**	15 µs	HSSL POD Size: 41mm*33mm
Aurora	FSL 57xx ED IFX Aurix ED REN RH850	4 x 1,2 GHz 1 x 2,5 GHz 2 x 3,1 GHz	JTAG/ DigRF / DAP + Aurora LVDS	40 MB/s Trace **VX1452**	15 µs	

Table 1: Selection of possible controller interfaces and performance data

The controller interface is connected to the POD. This is located either in or in the immediate vicinity of the ECU. There are three different types of POD: HSSL, POD and serial. The names are derived from the respective connection technology of the POD.

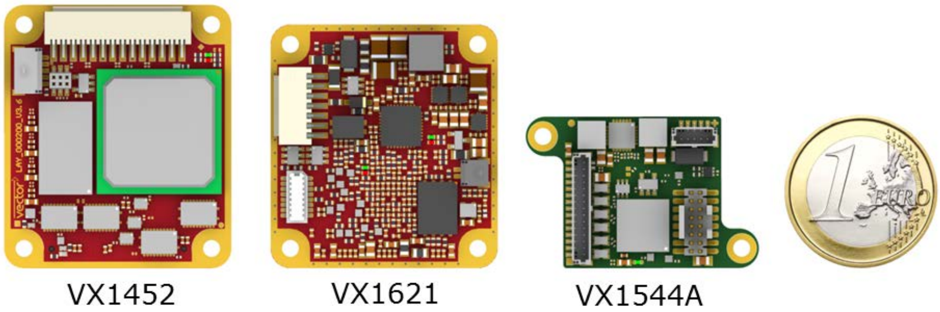

Figure 4: True-to-scale overview of the POD types: HSSL, XPOD and serial

The HSSL-POD VX1452 makes use of data trace interfaces such as Aurora, Nexus Class 3 or RTP on the ECU controller. Its maximum data rate is dependent on the interface, up to – several MByte/s. This data is transmitted without any additional load on the controller.

The serial POD VX1544 makes use of the serial interfaces on the controller e.g., JTAG or DAP. When transmitting measurement data from the controller, there is a certain amount of CPU load. The maximum data rate is in the single-digit MByte/s range.

These PODs are connected to a base module. The base module then converts the data to an XCP on Ethernet data stream that can be used by an XCP master, such as CANape, CANoe or Etas INCA.

There are a number of base module designs that are also equipped with CAN, FlexRay and Ethernet/Automotive Ethernet interfaces.

Figure 5: VX1000 Base Modules and PODs

The XPOD VX1621 differs from the base modules as it directly delivers an XCP on Ethernet data stream, therefore a VX1000 base module for the connection to the PC is not necessary. A physical conversion from Automotive Ethernet to a PC interface suffices. An XPOD can be connected to any Automotive Ethernet interface of the Vector hardware e.g., using a VX0312 or VN5640.

For example the VX0312 converts Ethernet/Automotive Ethernet to USB. When using CANape or CANoe no network or firewall setting is required on the PC allowing easy access the hardware/data without administration rights.

Figure 6: VX0312 (USB to Automotive-Ethernet/Ethernet converter), VN5640 Ethernet with 16 channels, VN5610A with two Ethernet channels

More information on VX1000:

> **Website**

> **Overview poster with all system components**

Relevant Vector products are:

Product name	Function
VX1060, VX1132, VX1135	Base module for converting POD data to XCP on Ethernet
VX1452	HSSL POD for high-speed connection to controller trace interface (e.g., Aurora, NEXUS Cl.3, RTP)
VX1544	Serial POD for high-speed connection to controller interface (e.g., JTAG, AUD, DAP)
VX1621A	XPOD for implementing controller-specific interfaces to XCP on BroadR-Reach
VX0312	USB-to-Ethernet converter with CAN interface, functions with CANape and CANoe without firewall or network configuration
VN5610A/VN5640	Two or 16 independent Ethernet channels for IEEE standards 10BASE-T, 100BASE-TX and 1000BASE-T. Also two CAN (FD) high-speed channels.

2.1 Example: ECU

The VX1000 solutions are used in both the diesel and gasoline sector as well as in the electric sector. Most combustion engine application engineers need approximately 3,000 – 4,000 signals and a data quantity of approximately 3 – 5 MByte/s. The overall complexity of the ECUs is very high, since topics such as cold start measurements or page switching between RAM and flash memory must also be covered. Special requirements on temperature range that arise due to the positioning of the PODs near the ECU must be taken into account.

2.2 Example: Transmission ECU

If the transmission ECU is located in the oil pan then traditionally access is limited to CCP or XCP on CAN. This greatly limits the measurement bandwidth available.

To achieve a considerably higher data rate of up to 5 MByte/s a VX1000-based solution is available. In the special oil pan the controller interface can be located on the wall of the oil pan by means of an extension. The POD integrated in the connection cable is now connected via a connector in the oil pan housing.

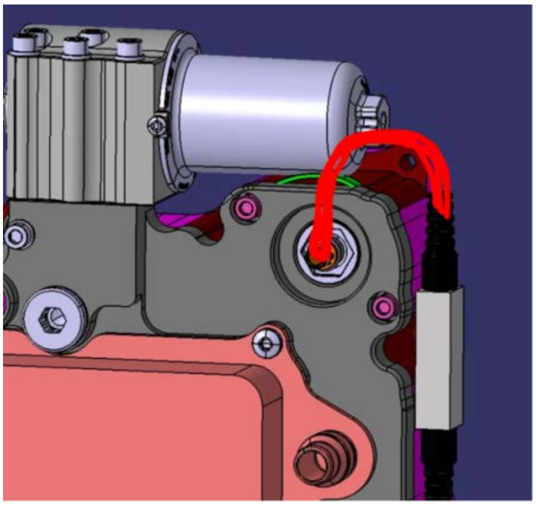

Figure 7: Cable with integrated POD is connected to a special oil pan

3 Acquiring Sensor Data for Autonomous Driving

Autonomous driving vehicles need sensors for detecting the surroundings. Very often radar and video sensors are used. During the development phase it is required to acquire and store the sensor data. The data quantity is considerable large, up to100 MByte/s can be generated per sensor.

You can find further information on the ADAS solution from Vector on the **website**.

3.1 Acquiring Raw Data From Radar Sensors

Radar measurement technology poses a number of challenges on data transmission. No XCP-standard protocol is used for acquiring raw data. For this reason CANape uses the high-performance recorders, which are precisely adapted to the respective sensors.

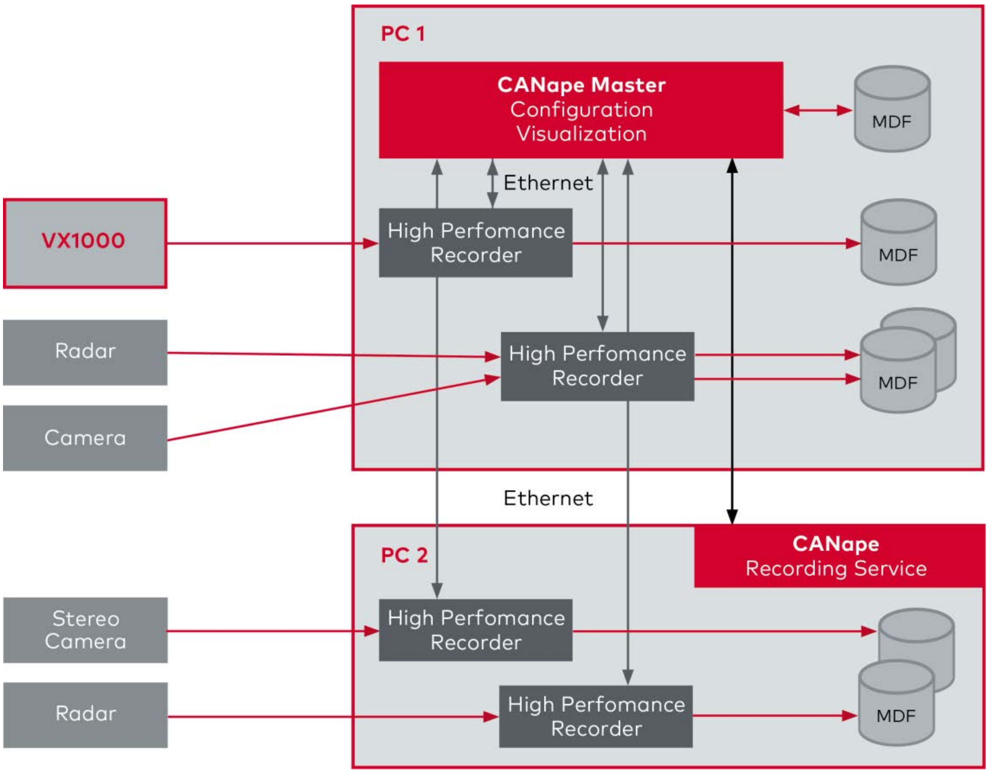

Figure 8: Measurement setup with High-Performance Recorders, distributed over two computers

3.1.1 Practical Example With More Than Two GByte/s

The following setup is based on two industrial PCs and one tablet. The industrial PCs are connected to a complete system with a total of seven radar sensors, via VX1000, an ECU, via VX1000, and four reference cameras. The data is recorded using the High-Performance Recorders (HPR). CANape is installed on the tablet PC, which is used to configure and control the complete setup. The connection between tablet and industrial PC is realized via Ethernet (WLAN). The HPRs deliver control signals and an adjustable number of video images per second to the tablet so that the user can see whether the system is running.

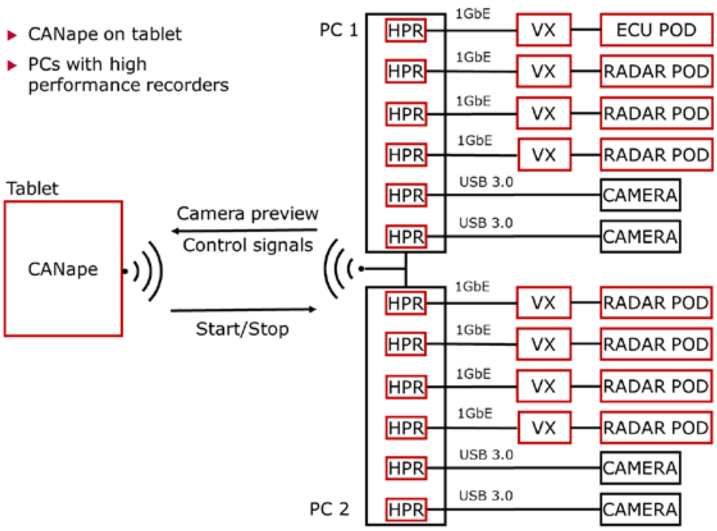

Figure 9: Overview of the setup with more than 2 GByte/s measurement data rate

Figure 10: Setup with aluminum frame, the green number on the table shows the current write rate of 2019.893 MByte/s

3.2 Data Acquisition from Video Sensors

CANape has supported the integration of cameras since 2003 making it possible to record driving situations or even driver activities. These cameras are referred to as "reference cameras". You can find more information in chapter "Recording Driving Situations Using Video".

Unlike reference cameras, camera systems are used as video sensors in the field of autonomous driving. Their job is to record the surroundings and through image analysis, identify objects e.g. to recognize traffic signs or evaluate driving situations. Video sensor does not generally supply image material to other systems, instead the sensors deliver data on the detected objects. CANape supports video systems including the MobileEye camera modules, which detect objects and supply information about the objects as CAN signals.

Relevant Vector products are:

Product name	Function
CANape	CANape supports different video sensors from various manufacturers. The list is constantly growing.
Driver Assistance option	With the optional expansion of CANape, you can verify the results of the ADAS algorithms. Objects detected from the vehicle are depicted as graphic objects (e.g., rectangles or lines) from a bird's eye perspective and superimposed on the video image.

4 Bus Access

Vector offers a vast range of physical interfaces for all automotive-typical bus connections such as CAN, CAN FD, FlexRay, LIN, Ethernet and Automotive Ethernet.

CANape supports the physical interfaces by integrating the respective hardware and the description files, you are able to access the bus data. CANape displays the data in both a signal- as well as message-oriented manner and stores it.

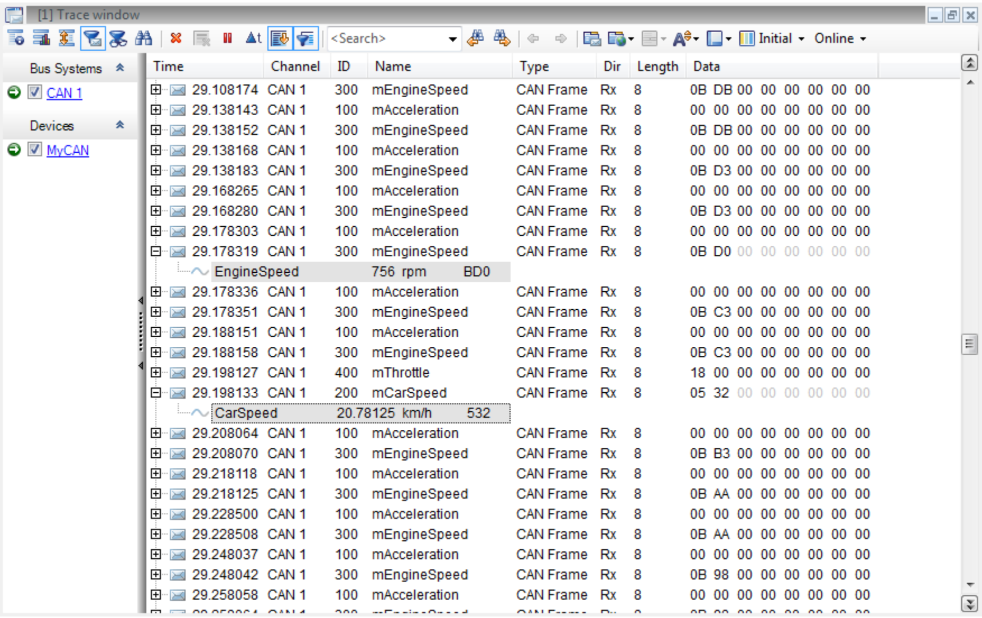

Figure 11: CAN-bus display in the Trace window of CANape

Additional information on the Vector network interfaces can be found on the **Internet**.

Relevant Vector products are:

Product name	Bus system
VN8900 (VN8950), VN1600 family	CAN, CAN FD, LIN
VN5610, VN6540, VX0312	Ethernet, Automotive Ethernet, CAN, CAN FD
VN8970, VN8972, VN7600, VN7610, VN7572	FlexRay, CAN, CAN FD, LIN
VX1000 product family	ECU access for PODs, CAN, CAN FD, FlexRay

5 Acquiring Analog Measurement Data

Analog measurement values must first be digitized before they can be recorded. The analog quantities are acquired using sensors and converted to messages via measurement modules.

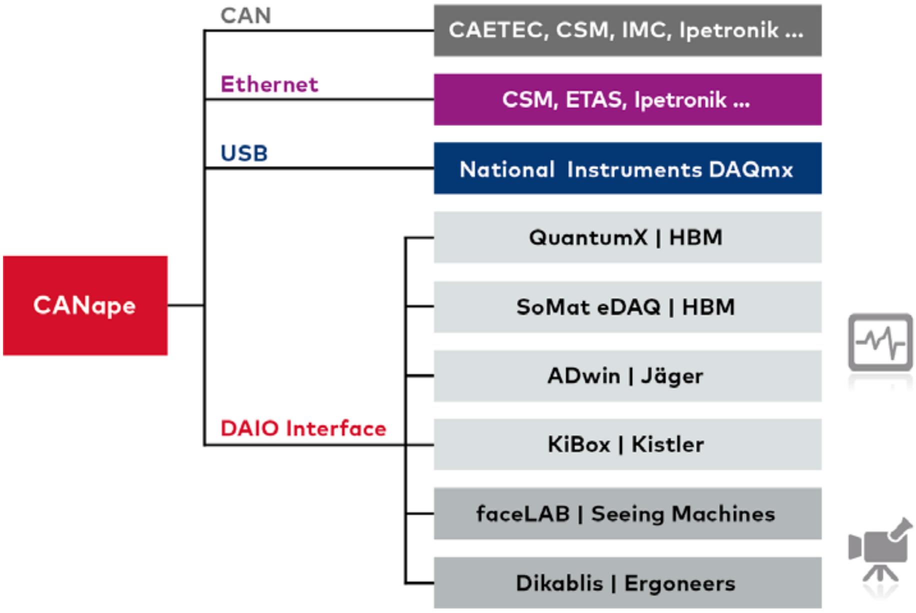

Figure 12: Various possibilities for acquiring analog/digital measurement values

CANape supports many different manufacturers of measurement technology, for example CAETEC, CSM, ETAS, HBM, Ipetronik, National Instruments and many others. Measurement modules from select manufacturers can be configured directly from within CANape. Physical access is possible directly via standard interfaces such as CAN or XCP on Ethernet.

Figure 13: Example of a measurement with 800 kHz sampling rate with CSM modules

CANape is not limited to this value. CANape is equipped with a universal interface for the integration of I/O measurement technology. Additional measurement technology solutions can be integrated via the DAIO interface "digital/analog input/output". You can develop the necessary drivers yourself or purchase them as a service from Vector.

Further information can be found on the website.

Relevant Vector products are:

Product name	Function
CANape	Measurement data acquisition for the various manufacturers
vMeasure CSM	Measurement software for using CSM measurement modules
vMeasure exp	Measurement software for acquiring analog sensor signals of any measurement modules and ECU measurement values

6 Measurements on Combustion Engines

In addition to the commonly used measurement technology for voltages and temperatures, there are also specific measurement technologies for exhaust systems for example NOx and lambda.

The CSM-OEM variant LambdaCANc supplies the lambda measurement values via CAN messages. The standard series probes (LSU 4.2, 4.9, ADV ...) can be used as probes.

Figure 14: Lambda measurement system

You can find further information on the **CSM website**.

7 High-Voltage Measurements According to DIN EN 61010

Measuring directly on the high-voltage vehicle network e.g. in high voltage battery packs, high-voltage rechargeable batteries or in power electronics, requires special safety measures. This includes an HV-safe measurement chain from the sensor/batteries to data acquisition system. The HV measurement technology from CSM offers a multi-level safety concept in accordance with DIN EN 61010 that includes measurement modules, cables and connectors.

Through the seamless integration of the measurement modules from CSM in the Vector measurement software, reliable solutions for temperature and voltage measurement are available to you.

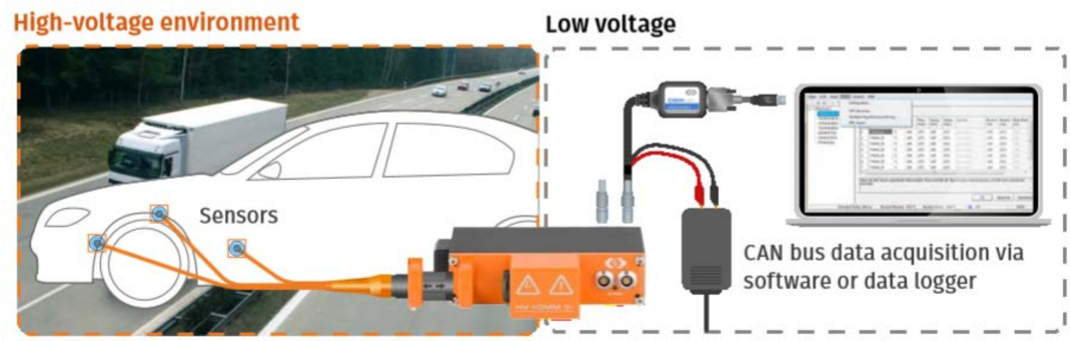

Figure 15: Example of a measurement setup in an HV setting with CSM measurement system

You can find further information on the **CSM website**.

Relevant Vector products are:

Product name	Function
CANape	Complete measurement and analysis software for solutions from various manufacturers
vMeasure CSM	Measurement software for the use of CSM measurement modules
vMeasure exp	Measurement software for measurement solutions from various manufacturers

8 Diagnostic Data

CANape offers symbolic access to diagnostic data in the ECU or vehicle. The diagnostic data and services are defined in description files. CANape supports various description formats such as CDD and ODX, available as diagnostic protocols UDS (CAN, FlexRay, Ethernet) and KWP2000 (CAN, K-Line).

For the use of ODB, CANape supplies the description file internally so that it is only necessary to create an OBD device in the device configuration to access the ODB data.

Read and write access of diagnostic data is transparent for the user. CANape manages the necessary services for acquiring and changing data in the background.

Besides the standard windows for the display and use of signals and parameters, other diagnostic-specific windows are available including Diagnostic window, Fault Memory window and OBD window.

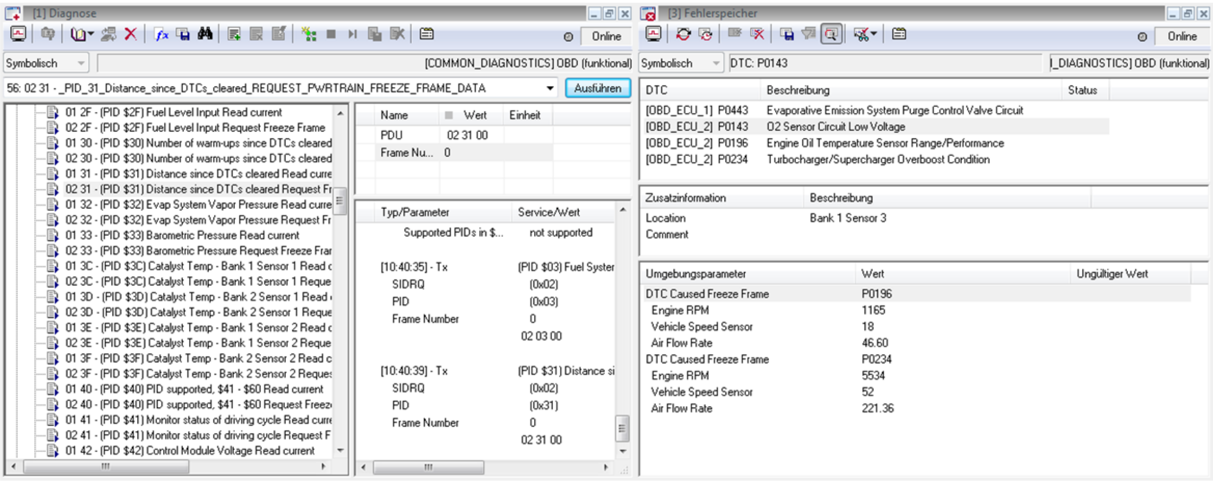

Figure 16: Special diagnostic window for accessing data, services and fault memory

You can find further information on the **website**.

Relevant Vector products are:

Product name	Function
CANape	Measurement and calibration tool with extensive diagnostic functionality
ODXStudio	Viewer for ODX files Is delivered together with CANape, also available as an editor.
CANdelaStudio	Viewer for CDD files Is delivered together with CANape, also available as an editor.

9 Acquiring Driver Data via GPS

GPS position data is available either via separate GSP receivers or via CAN messages. This data can be recorded and visualized or be used for offline data analysis. Combining the data with service like OpenStreetMap you can easily depict test routes and tracks.

You can represent the data as signals in display windows as well as use the data in functions, scripts or display the data as a route in the GPS window. Using the windows that are synchronized with respect to time, you can obtain an overview of the temporal and spatial relations of your measurement run.

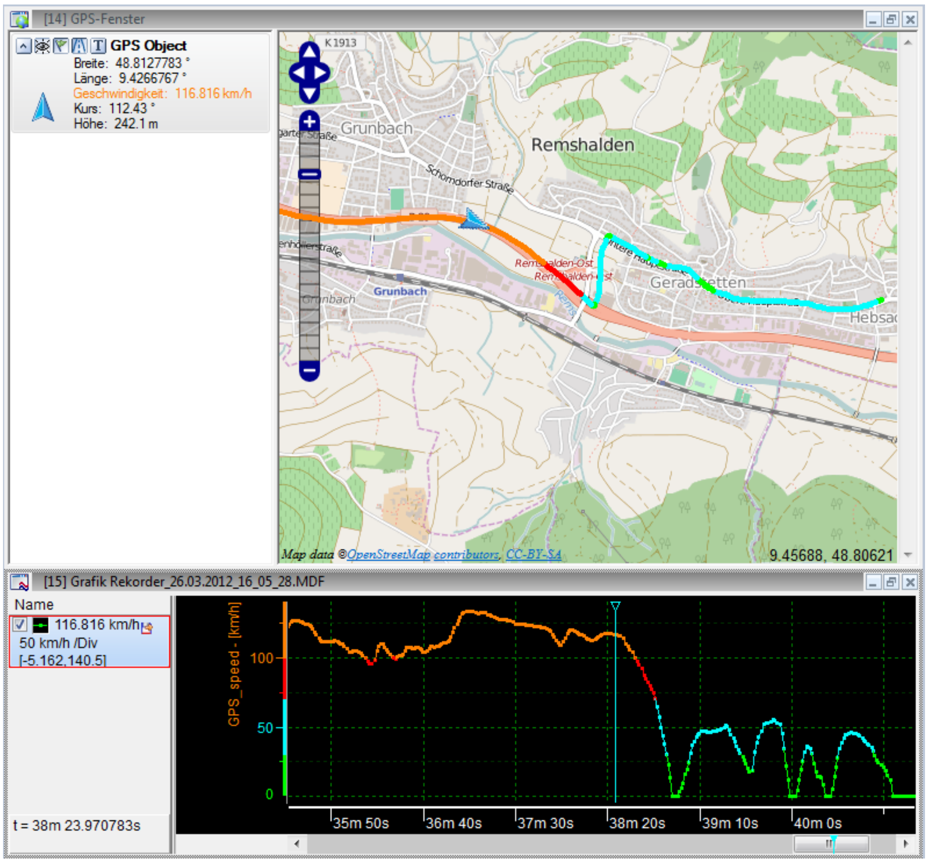

Figure 17: Route display in the GPS and Graphics window with display of the speed in the color gradient of both windows

Relevant Vector products are:

Product name	Function
CANape, vMeasure CSM, vMeasure exp	All three products support the recording and display of position data.

10 Recording Driving Situations Using Video

Video recordings from reference cameras can help to properly interpret measurement data. You can use these in a vehicle to record the activities of the driver or the driving situation in front or behind the vehicle. With CANape the video data is recorded synchronously with all other measurement data and saved into a separate AVI file.

You can integrate reference cameras in various ways in CANape:

> DirectShow: If the camera is already equipped with a DirectShow interface, CANape directly accesses the image data.

> AVB (Audio Video Bridging) cameras can be created as a device and used directly in CANape.

> Via the SDK (software development kit) of the camera, Vector has developed a driver to support the camera in CANape.

If the driver is available, the camera is created as a device in the device manager in CANape and can be used immediately.

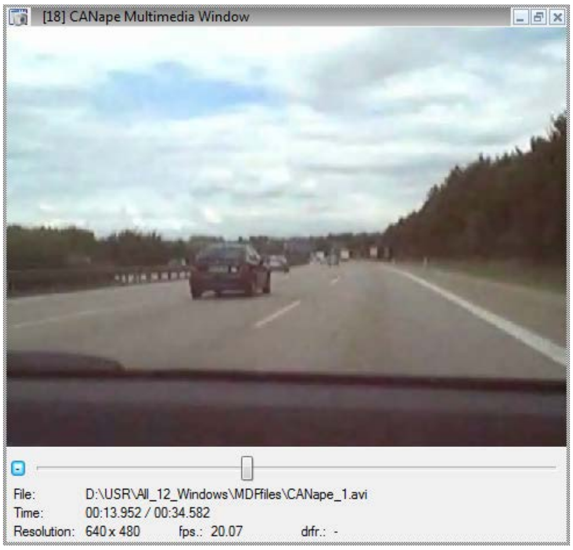

Figure 18: Video display of a reference camera in CANape

For the development of driver assistance systems, CANape offers the possibility to overlay the video image with additional information using the **"Driver Assistance" option**. A display from a bird's eye perspective in which the objects are displayed with the distance values is also available.

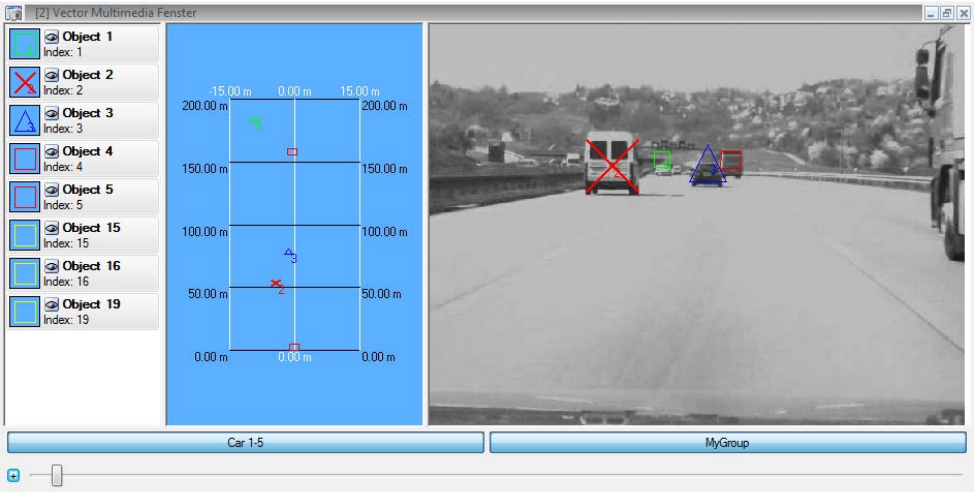

Figure 19: Video display of a reference camera in CANape with overlaid objects that are detected by sensors. Display from a bird's eye perspective and the video image.

Additional information on the:

> **ADAS solution**

> CANape "**Driver Assistance**" option

Relevant Vector products are:

Product name	Function
CANape	CANape accesses all video data that is available on the PC via DirectShow. No further option is necessary for this.
Driver Assistance option	With the optional expansion of CANape, you can verify the results of the ADAS algorithms. Environmental information is depicted as graphic objects (e.g., rectangles or lines) from a bird's eye perspective and superimposed on the video image.
vADASdeveloper	vADASdeveloper makes available the infrastructure necessary for developing algorithms (e.g., sensor data fusion) for driver assistance systems. The runtime environment includes sensor data from cameras, radar, CAN, etc., records it and can replay it for stimulation.
vADASdeveloper run	The runtime license allows all applications that were developed with the vADASdeveloper to be executed, for example, the recording of live data in many vehicles.

11 Acquiring Measurement Data From Virtual ECUs

In addition to the typical data sources such as ECUs and bus systems, data from PC-based runtime environments can also be measured. The runtime environments are used for the calculation of the virtual ECUs

The synchronization between CANape and the virtual ECU pose a challenge. While actual ECUs operate in real time, PC-based environments can operate significantly faster or slower than in real time. CANape can fully adapt itself to the temporal behavior of the virtual ECU by transmitting the time stamps of the virtual ECU via XCP and using them as the time basis of CANape.

11.1 Virtual ECU in Simulink

In a phase prior to code generation the developer tests his algorithm in Simulink. It is necessary here that:

> Input values be present as stimulation of the algorithm,

> Signal sequences be acquired and displayed,

> Parameter values be optimized.

If the Simulink XCP Server is added to the Simulink model, direct XCP access to the model is available. The server also directly generates an A2L file of the objects contained in the model and a CANape project so that everything is available in CANape for directly measuring signal sequences and adjusting parameters.

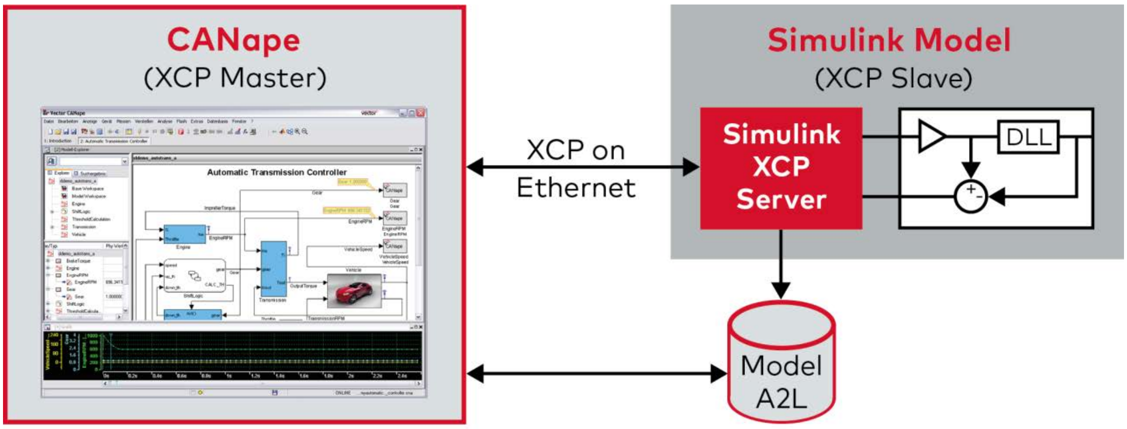

Figure 20: Simulink XCP Server is integrated in the Simulink model and makes the XCP connection available.

Your benefits:

> You can use this to acquire all measurement values of the model.
> The XCP on Ethernet interface allows CANape and Simulink to run on two different PCs.
> The parameters, such as maps, can easily be changed in CANape and written in the model.
> You simply load existing parameter sets in the model (MATLAB workspace).
> Data can also be transferred directly from CANape to the model via the interface. You can thereby link the input vector directly from a measurement file with the inputs of the model without concerning yourself with the integration of measurement files in the model.
> In addition to the model visualization in Simulink, you can also display the model in CANape.

You can find further information on the **website**.

Relevant Vector products are:

Product name	Function
CANape	Uses the XCP interface to the model in the same way as to an ECU CANape completely adapts itself to the timing of the Simulink model.
Simulink XCP Server option	Makes available the XCP interface between CANape and the model. In addition, it generates the A2L of the model and a CANape project at the press of a button.

11.2 Virtual ECU in CANape

CANape supports the possibility of integrating DLLs, example code for the CANape target platform can be generated from Simulink models for mapping a network node. The same functions, without the model-based approach, can be directly written using code for CANape.

The DLL is integrated as a device in CANape and described by means of A2L. CANape is equipped with direct XCP access to DLL. The user can directly link the inputs of the model with signals from CANape. As a result the algorithm in the DLL receives the data necessary for the calculation via the XCP connection. The user then sets the parameters to the desired values or measures all desired quantities directly from the DLL.

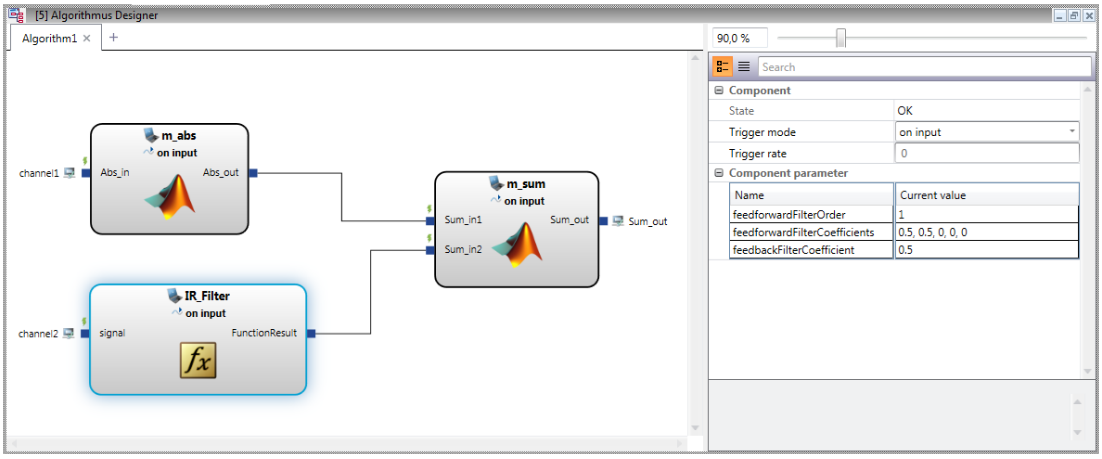

Figure 21: The DLLs can be supplied with input signals and linked to one another using the Algorithm Designer.

During a measurement, the DLL also runs and the user can display and compare the results of the DLL in parallel with the results of the ECU. This allows direct evaluation of the new algorithm in the DLL compared to the algorithm in the ECU.

To prevent the operating behavior of the DLL from being dependent on the timing of the PC, one can use the VN8900 real-time platform. If a VN8900 is connected to CANape, the user can simply move the DLL to be executed to the VN8900. The algorithm is now calculated on the VN8900-internal real-time core.

Relevant Vector products are:

Product name	Function
CANape	Runtime environment for virtual ECUs in the form of DLLs. You can access the virtual measurement values and parameters at runtime to examine and optimize the processes in the models even during this development phase.
VN8900	Runtime environment for virtual ECUs on a real-time platform

11.3 Virtual ECU in CANoe

Similar to CANape, CANoe also supports the possibility of integrating DLLs. For example, code for the CANoe target platform can be generated from Simulink models for mapping a network node. In this case the network node is a virtual ECU that operates together with other real or virtual ECUs.

After code generation and compiler run, a DLL is available that can be seamlessly embedded in CANoe. During the code generation process it is ensured that the DLL is provided with an XCP interface with which CANape can establish a measurement and calibration connection to the DLL in CANoe at runtime.

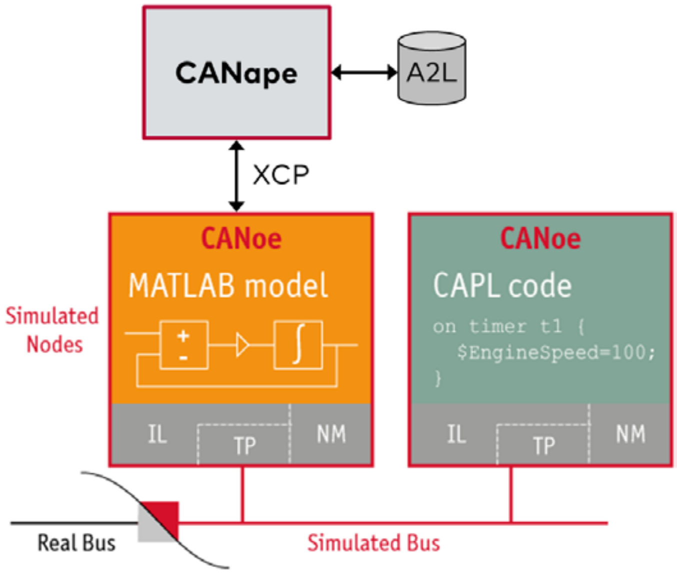

Figure 22: Model runs in CANoe and has a direct XCP connection to CANape

Relevant Vector products are:

Product name	Function
CANape	You can access the virtual measurement values and parameters at runtime in CANoe to examine and optimize the processes in the models even during this development phase.
CANoe	CANoe is a versatile software tool for the development of individual ECUs and entire networks. It reliably supports network designers as well as development and test engineers during the entire **development process** from planning to the final system test.

11.4 Virtual ECU in Silver

Silver, from QTronic, helps to move development tasks from road tests, test benches and HiLs to Windows PCs by porting the ECU code to windows. The result is a virtual ECU that can be operated on the PC in a closed loop with a simulated vehicle.

The virtual ECU is accessed via XCP on Ethernet. As a result you directly change the parameters of the virtual ECU and immediately record the effects by means of measurements.

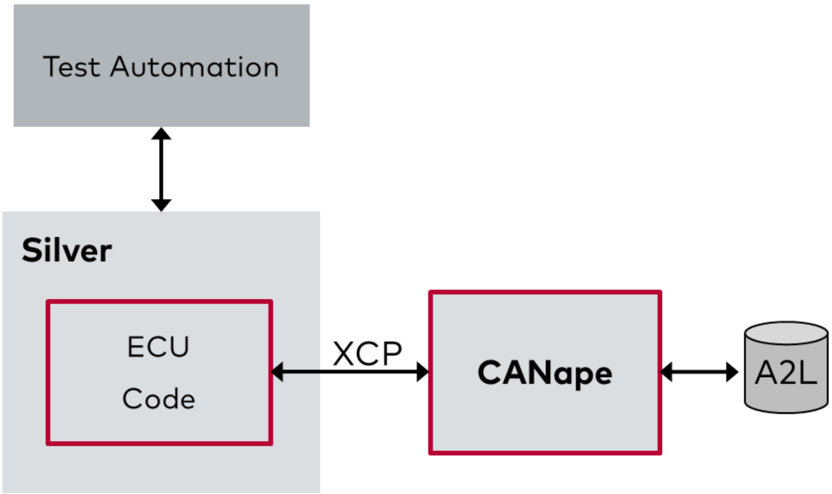

Figure 23: As with CANoe, it is also possible with the QTronic solution to directly connect to the model via XCP

You can find further information in the **technical article** (PDF).

12 Engineering Services

To allow you to concentrate fully on ECU calibration, Vector supports you with both know-how as well as customized complete solutions for your specific tasks.

The service offerings include:

> Consultation on how to optimally use available features to increase the efficiency of your work processes
> Automation of measurement data evaluations
> Support in integrating model-based development with MATLAB/Simulink
> Transition from internal tool chains to Vector solutions
> Creation and maintenance of complex configurations
> Migration support and technical expertise when switching over to new technologies such as FlexRay or XCP.
> Addition of an A2L generation process
> Integration of existing analog measurement technology in CANape
> Integration of the ECU measurement technology solution in your ECU on the basis of the VX1000 family
> Set up of complete bypassing solutions
> On-site project support by field application engineers
> Integration in test benches

You can find further information on the **Internet**.

13 Glossary

ADAS	Advanced Driver Assistance Systems
Automotive Ethernet	IEEE 100Base-T1, previously BroadR-Reach Differs on the physical level from the Ethernet used in office communication It offers full-duplex transmission from point-to-point on a simple twisted cable pair
DHPR	Distributed High Performance Recording Especially in the field of ADAS development and autonomous driving, ever larger quantities of data have to be gathered and recorded more and more often. For these use cases, CANape now offers the possibility of measuring XCP on Ethernet devices in a "high-performance mode". In addition, this extension permits measurement data, video streams and radar raw data to be recorded synchronously by several PCs. With this setup, measured data rates of over 1 GByte/s are achieved.
SDK	A software development kit includes software (e.g., libraries) and documentation for developing a driver for a specific piece of hardware.
Virtual ECU	The ECU code is calculated on a PC platform.

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