VECTOR

CANape

Product Information

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Valid for CANape as of version 23.0

Product information and technical data for CANape options are provided in separate documents.

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1. Overview

1.1 Introduction

The origin of CANape (CAN Application Programming Environment) lies in the optimization of controller tuning in ECUs. To do this, you change the parameters in the ECU at runtime. By measuring the signals, you directly record the effects of the change. Because of the demands placed on measurement technology, CANape has become an all-round measurement tool. In recent years, it has been further improved, especially for the development of driver assistance systems and electric drives.

CANape offers a comprehensive solution for ECU developers and application engineers. The solution spectrum ranges from measuring a wide variety of signals and objects, calibrating, and managing parameters in ECUs, to accessing bus data and ADAS sensors, to automated data analysis.

Derived from CANape, other tools are available to you:

- **vSignalyzer** offers the same extensive data visualization capabilities and manual and automated analysis and reporting functions as CANape
- **vMeasure** is a flexible measurement software for the comfortable acquisition of physical quantities. Internal signals of the control units as well as signals sent via the vehicle bus.
- **CANape log** is software and hardware optimized for logging use case that allows a CANape measurement configuration to be taken directly and executed as a logger.

A cloud service for sharing projects is available via the Vector Team Area. CANape gives you direct access to the vMDM measurement data management system. You can upload and download data and run data analyses in the cloud. The vCDM option gives you direct access from CANape to calibration data in the cloud or on the server.

1.2 The advantages at a glance

- Open and flexible platform through use of standards and open interfaces
- High-performance connection to ECUs, HPC and sensors (radar, LIDAR, video ...) with high measurement data rates
- Reliable ADAS logging solution for complete tests incl. visualization of point clouds, video data and much more
- Acquire measurement data from a wide variety of sources synchronously in time and store it in a compact ASAM standard format (MDF/MF4)
- Conveniently calibrate parameters, manage locally, or submit directly to server- or cloud-based calibration data management systems
- Convenient integration of analog measurement technology with very high sampling rates
- Calculations of specific data, e.g., active power of an inverter in the electric vehicle during measurement and offline
- Measurement data evaluation from convenient visualization to fully automated data evaluation including report generation. On the local disk and in the vMDM Cloud
- Seamless integration into model-based development with MATLAB / Simulink
- Access to measured variables and parameters in Simulink models without instrumenting the model
- CANape as a rapid prototyping platform and efficient runtime environment for code and models
- Complete solution, as e.g. A2L files can be generated directly from the linker MAP file and powerful tools like ASAP2 Studio are already integrated
- The 64-bit architecture allows the use of the entire RAM memory of the computer. This makes it possible to read in very large databases without any problems
- Automate processes in CANape using the internal programming language "CASL". Extend the range of functions with your own libraries from Simulink, for example
- Comfortable collaboration across company boundaries. Create a Team Area on your own and define your team by email addresses. All projects that you upload to the Team Area can be used by the entire team.

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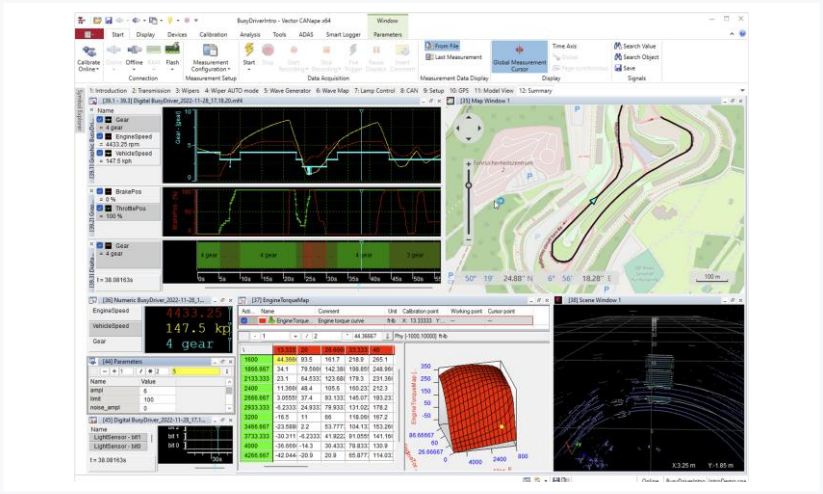


FIGURE 1: Example of the CANape user interface

1.3 Fields of application

CANape is the all-round tool for ECU calibration. All tasks in this environment can be solved conveniently and reliably with CANape:

- from the functional development of the software via rapid prototyping solutions to the control unit ready for series production
- at the workplace, on the test bench or on test drives for trials
- in data recording, parameter calibration, ECU and vehicle diagnostics or verification and visualization of object recognition algorithms for driver assistance systems

1.4 Features

During the measurement, CANape captures all data from ECUs, HPCs, ADAS sensors, electric drives, buses, and much more. In the process, you calibrate the parameters of the ECUs and directly observe the changes. Communication between CANape and the ECUs takes place via protocols such as XCP or via microcontroller-specific interfaces with the VX1000 measurement and calibration hardware. CANape provides diagnostic access, bus analysis, and integration of analog measurement technology, video and GNSS data. Calibration data management and convenient measurement data evaluation including reporting make CANape a complete tool for ECU calibration.

1.5 System Requirements

The system requirements can be found on the **CANape page** on our website.

1.6 Functional expansion through additional options

- Option Driver Assistance for the verification of object recognition algorithms in the development of driver assistance systems (ADAS) including high performance data acquisition from ADAS sensors. More info in chapter 7
- The vCDM option gives you access to conflict-free data management in vCDM (Vector Calibration Data Management) from the familiar CANape environment. More info in chapter 10.3
- Option Bypassing with the VN8900 network interface and the VX1000 measurement and calibration hardware provides a powerful all-in-one solution for bypassing. At runtime of the model on the VN8900 real-time hardware, the necessary input data is collected from the ECU via the VX1000 system, XCP on Ethernet, XCP on CAN, CAN, FlexRay or I/O
- Thermodynamic State Charts option for displaying thermodynamic state diagrams and meaningful data for online and offline analysis

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1.7 License terms

1.7.1 CANape as a stand-alone solution

CANape is a single-user solution that is used on Windows computers. Different licensing methods are available for this purpose. To find out which licensing method best suits your requirements, please contact your Vector sales representative.

1.8 Further information

Various documents are available on the Internet for CANape. With the demo version, you receive sample configurations for the various application areas as well as detailed help that describes all CANape functions. You also benefit from valuable know-how in the form of technical articles, product videos and application notes. You can find more information on the **CANape website**.

2. Basic functions

CANape's basic functions include:

- Time-synchronous real-time acquisition of all input variables
- High-performance collection of whole-vehicle data with sensors for ADAS development, such as video, LIDAR and radar sensors, bus data, ECU data and much more
- The function library "eMobilityAnalyzer" calculates all relevant data of an electric drive at runtime (with over 1MHz sampling rate).
- Visualization of detected objects in display windows and map representations by graphical symbols
- Online calibration via CCP/XCP, real-time stimulation and bypassing via XCP
- Offline calibration of HEX and other binary file formats
- Powerful management of calibration data, comparing and merging parameter sets via vCDMstudio. For small teams up to globally distributed companies, the database-driven platform vCDM is the optimal solution for professional management of calibration data
- Seamlessly integrated diagnostics via UDS, DoIP and KWP2000. Support for certificates and other security mechanisms
- Full access to the OBD data of the vehicle
- Offline measurement data evaluation from manual evaluation to automated data mining with the integrated function language "CASL" (Calculation and Scripting Language) or self-developed DLLs. The DLLs are generated from manual code or from Simulink models.
- Run-time environment for "software-in-the-loop" solutions - algorithms that will later run in the ECU can be integrated in CANape as DLLs
- FMI/FMU integration: The FMI interface (2.0 and 3.0) allows you to conveniently integrate your algorithms into CANape and connect the inputs and outputs of your model with real variables from the ECU
- Fast and secure flashing of binary files and parameter sets
- Automation interface for measurement and calibration via C-API, COM, ASAP3 or iLinkRT
- Integration of analog measurement technology via e.g., CAN and Ethernet
- Universal I/O interface for integration of any measuring systems by individual drivers. The integration includes both the configuration and the actual measurement data transmission
- Automation of processes through the integrated function language CASL
- Integrated function library enables, among other things, real-time evaluations, calculation of virtual signals at runtime and filtering of noisy signals
- Convenient visualization of Simulink and Stateflow models incl. value display, navigation through model levels, search mechanisms and direct calibration of parameters
- Direct coupling between CANape and Simulink for measuring and calibrating models at runtime
- Direct access from MATLAB to ECU data via the CANape API
- Easy creation and integration of specific display and control elements
- Visualization of the current GNSS/GPS vehicle position on electronic maps (also for offline use) significantly facilitates the interpretation of the recorded measurement data
- Extensive printing and reporting functionalities

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2.1 Efficient collaboration across company boundaries

With the help of Vector Team Services, you can easily share your CANape projects with others. Create a Vector Team Area. Invite other participants and share your CANape projects with them. The invitation is made via e-mail addresses, so that you can also exchange projects with people from other companies - such as development partners. You do not need to set up or operate your own IT infrastructure.

3. Measurement data acquisition

CANape uses the CCP and XCP measurement and calibration protocols to record ECU-internal measurement variables synchronously with ECU processes. The measurement data from the ECUs is recorded synchronously in time with the other measurement data (from serial bus systems, GPS, video or other measurement devices) and displayed in a wide variety of ways. With the multi-recorder concept, different measurements can be configured and simultaneously started and stopped independently of each other. Each recorder saves the measured values in a separate file.

Features of measurement data acquisition and visualization in CANape:

- The ASAM measurement data format MDF 4.1 supports measurement files without size limitation and offers compression of measurement data.
- Bus messages are recorded either in BLF or MDF 4.x format
- Analysis of the bus communication in the trace window
- Various window types and user-definable panels are available for graphical display
- Structures defined in the ECU source code can be used as measurement objects
- Virtual signals can be calculated online using the internal scripting language, the included function library or with MATLAB/Simulink models from the linkage of real quantities from a wide variety of sources
- Extensive trigger options for targeted data recording incl. pre- and post-trigger times (also for audio and video)
- Time-synchronous acquisition of scalar values, arrays, structures, and objects
- Decryption of encrypted CAN frames
- Configuration of Vector fleet loggers for CCP and XCP measurements incl. seed & key handling
- For the acquisition of very high data rates, the VX1000 measurement and calibration hardware is available
- Video sensors are captured via video grabbers (e.g., from the VX1161 series)
- Video cameras are integrated via USB or Ethernet
- Secure and time-synchronous documentation of driving situations via video and image recording without keyboard input
- Detailed representation of DAQ list utilization (XCP, CCP) in the measurement configuration.
- Optimized DAQ list configuration that ensures maximum data transfer regardless of data types

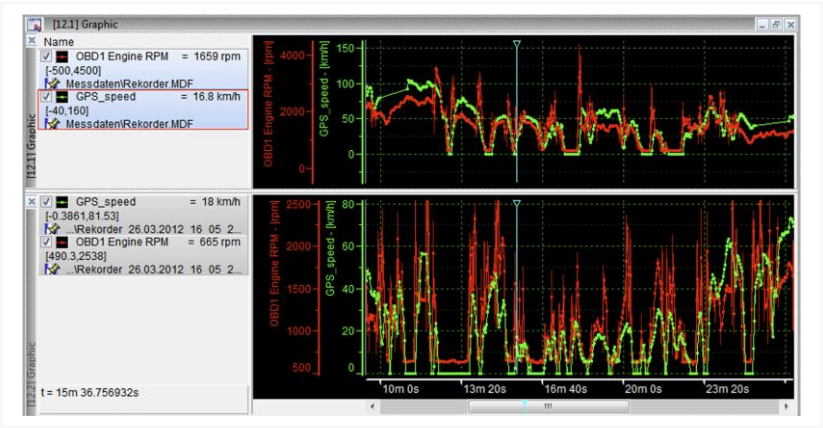


FIGURE 2: Visualize and compare signals from different measurement files in one or more windows

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3.1 Distributed High-Performance Recorder (DHPR)

Especially in ADAS development and autonomous driving, large amounts of data must be captured and recorded. Via a DHPR, the various Ethernet protocols of the sensors are integrated into CANape and recorded synchronously with the other sources. The solution is scalable. If the performance of one computer is no longer sufficient, additional computers can be integrated via Ethernet and the DHP recorders distributed to the computers. The solution is managed from within CANape, so you don't have to worry about it. Configuration as well as start, stop and trigger control is done as usual centrally via the CANape interface

> Optimal utilization of computer resources due to the new mode
> Distribution of measurement data to different storage media
> Time-synchronous distribution of measurement tasks to several computers
> Visualization of control signals from the distributed measurement recorders
> Only one CANape license required for all computers involved

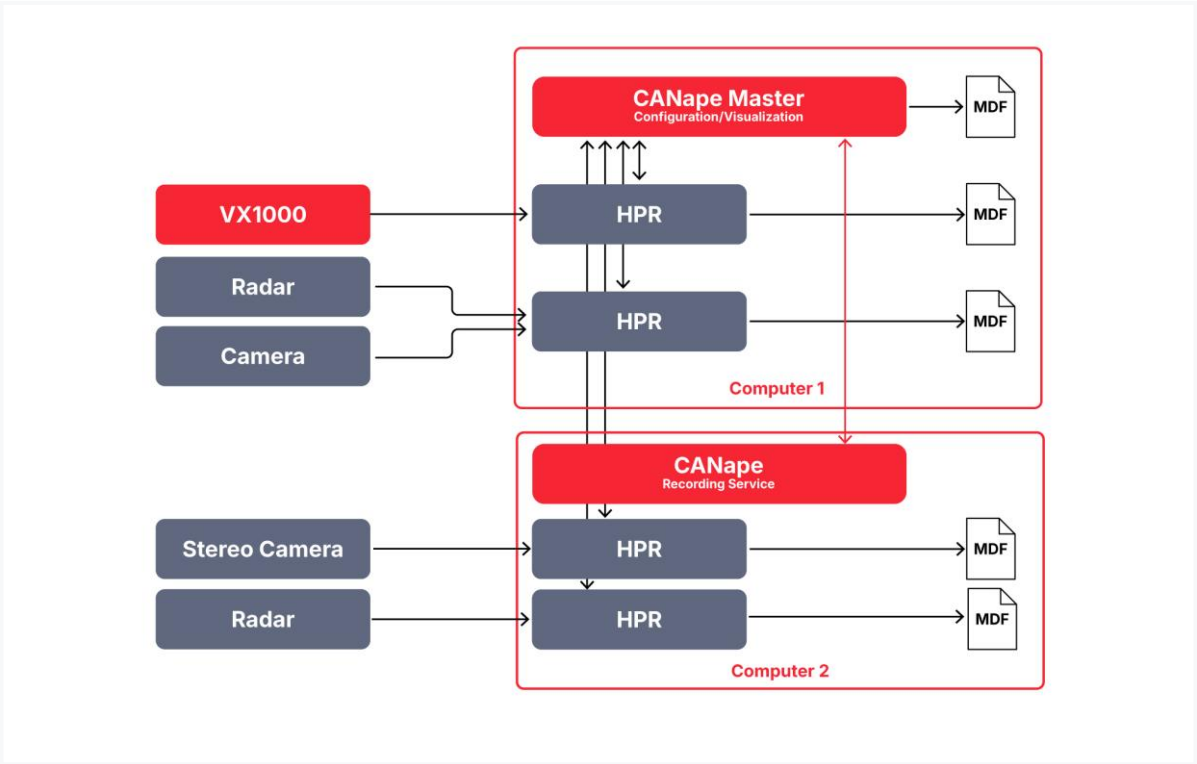


FIGURE 3: Scalable decentralized recorder solution for very large data rates in the ADAS environment

3.2 Measurement and calibration hardware with high transmission rates

The VX1000 system is a modular solution to access internal ECU data. A so-called POD (Plug On Device) is directly connected to a debugging or data trace interface (Aurora, DAP2, Nexus, JTAG ...) of the microcontroller. The data of the controller is forwarded to the VX1000 base module via the POD and converted into an XCP-on-Ethernet data stream.

By using the standardized XCP-on-Ethernet protocol, you also connect other measurement and calibration tools in addition to CANape. Depending on the controller used, measurements practically do not affect the runtime of the controller.

Depending on the VX1000 base module used, network and streaming interfaces are also available.

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FIGURE 4: VX1000 Family Hardware - High Performance Measurement Data Processing Modules with XCP on Ethernet Interface

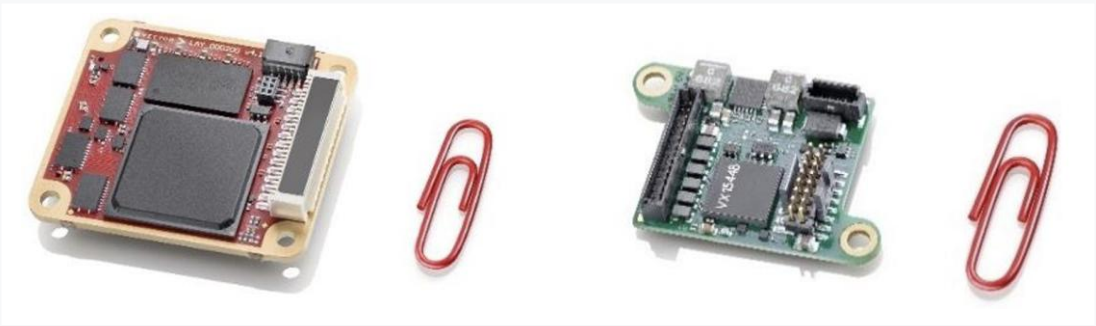


FIGURE 5: The VX1000 measurement hardware is connected to the control unit via a compact POD (Plug-On Device).

3.3 Analog measurement to complete the measurement task

The VIO System is a modular, measurement card-based analog / digital measurement hardware. The individual VIO System measurement cards can either be equipped in dedicated VIO System housing or as an extension to the VX1161, to measure analog signals synchronized to the ECU data (as depicted in Figure 4).

The configuration of VIO Systems is fully integrated in CANape. The VIO System is self-describing, meaning that an update of the VIO System portfolio does not require an update of CANape. CANape automatically updates the supported VIO System cards, when a new VIO System hardware is connected.

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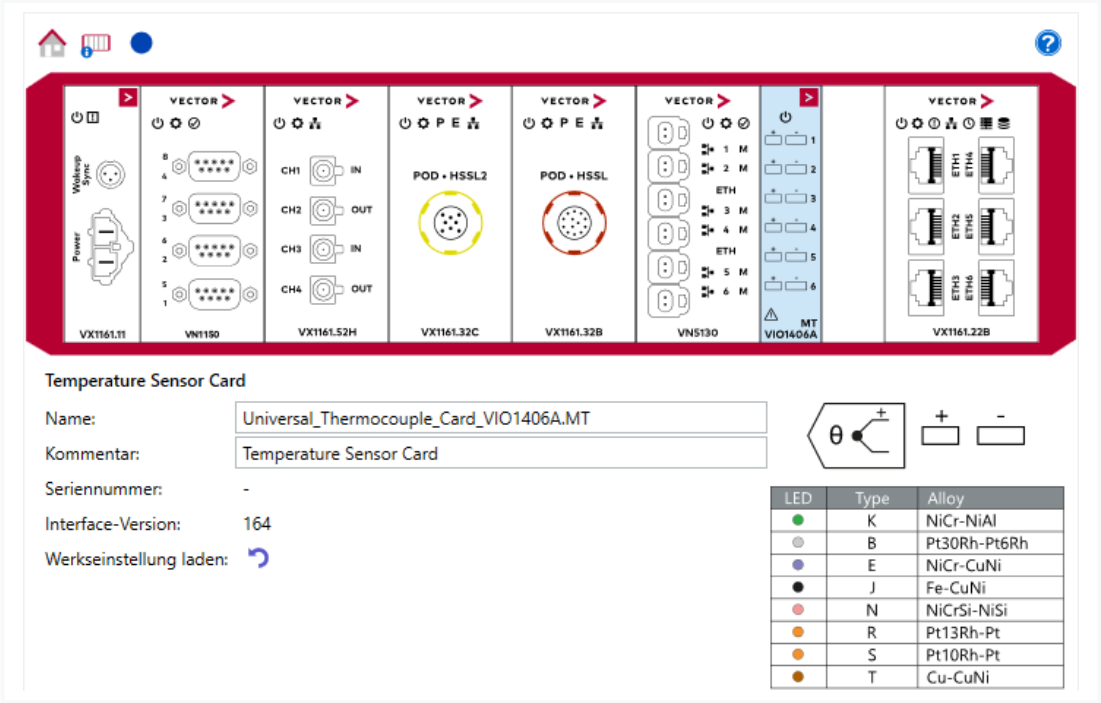


FIGURE 6: Hardware configuration dialog for VIO System in CANape. The depicted hardware is a VX1161 with network interface, streaming, POD and a VIO1406A.MT card.

3.4 Supported measuring systems for analog/digital measured variables

The following measurement systems can be integrated into CANape:

- Vector I/O solutions in the different network interfaces
- Vector VIO System
- All CSM measurement and high-voltage modules connected to the computer via CAN or Ethernet
- In the electric motor environment, you need highly sampled values of voltages and currents. Depending on the computer hardware used, you record e.g., 40 and more 1 MHz measurement channels. The data is calculated online and you receive precise information about the performance data of the battery, the inverter and the motor already during the measurement.
- All measurement data acquisition devices that are connected to the computer via the CAN bus, e.g. devices from CSM, CAETEC, IMC or IPETRONIK
- ETAS Measuring Module Series ES400 and ES600
- Mx-SENS 8 via XCP on Ethernet from IPETRONIK
- Analog and digital DAQmx series measurement cards
- DEWE-xxx and DEWE2 from DEWETRON
- QuantumX and SoMat eDAQ from HBM
- ADwin Systems from Jäger Computerized Measurement Technology
- KiBox from Kistler
- Inertial systems from GeneSys and OXTS for vehicle dynamics and position measurements

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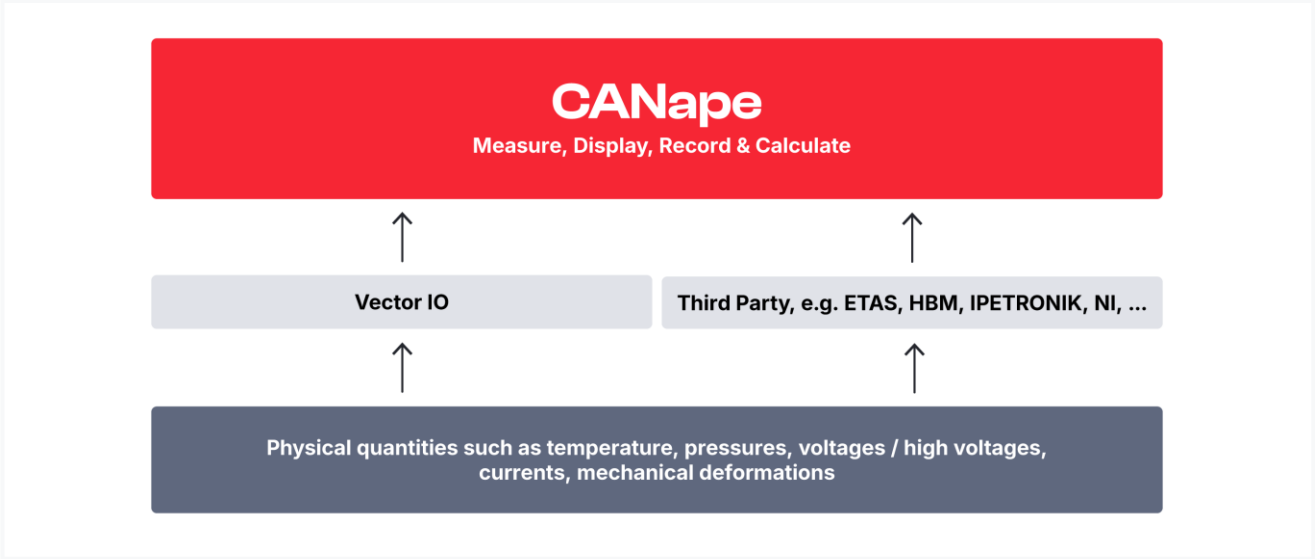


FIGURE 7: CANape supports many measurement solutions from a wide range of manufacturers. The DAIO interface is an open interface for connecting almost any input and output system.

An open interface is available for the integration of further measuring systems: The DAIO interface (digital/analog I/O) for high-performance measurement solutions. You can create the necessary drivers yourself. Vector supports you during development with sample programs, documentation, and services.

4. Measurement data visualization

CANape provides many different display windows. In the configuration that you use to record measurement data, you can also display existing measurement data or carry out evaluations. Of course, you can also create other configurations for visualization and evaluation.

View the measurement or individual measurement files

During a measurement, a recorder records data in the form of a measurement file. For long measurements or large amounts of data, the recorder writes several measurement files in succession. If you are working with more than one recorder for a measurement, each recorder can write several files in succession. CANape allows you to view the measurement as a whole during visualization and evaluation. You do not have to worry about the relationships between the recorders and the files.

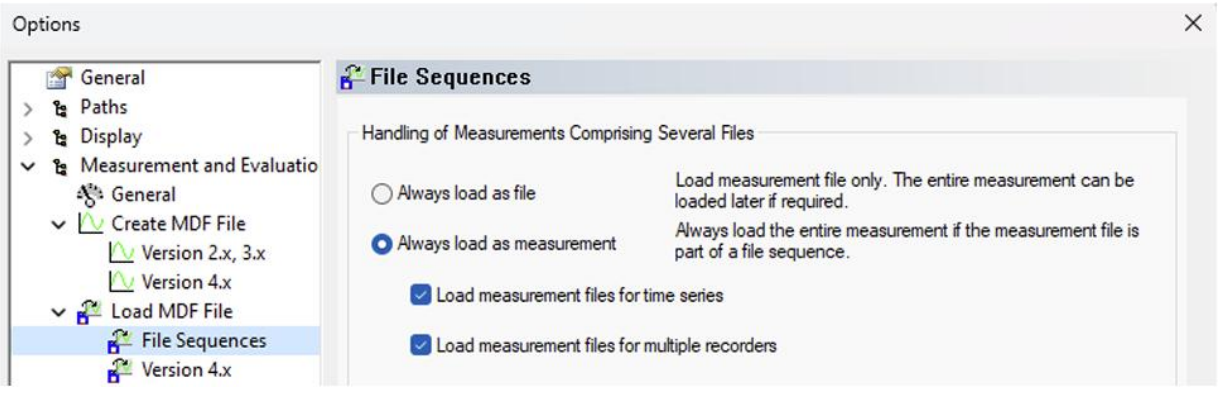


FIGURE 8: Specify whether you want to see individual files or the entire measurement.

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5. Measurement data management and analysis

CANape offers a wide range of options for data evaluation. From manual evaluation, the use of existing functions for filtering and calculating, to the development of your own functions, to completely automated evaluations with functions and scripts. The measurement data can be stored on the local hard disk or in the cloud. The evaluations created with CANape can be used directly in the vMDM cloud.

In order to select the correct measurement files for the evaluation, an indexing of the signal names and metadata (e.g. license plate number of the vehicle, specification of the test bench, weather conditions, ...) is performed.). This metadata is freely configurable and is written directly to the measurement files by CANape when the measurements are recorded.



FIGURE 9: Depiction of a time series of measurement files. The sum of all files provides complete insights in the measurement.

Different methods are available as evaluation options:

- Support of different measurement data formats (e.g., ASCII, ATFX, BLF, CSV, GLX, XLS, TDMS ...) by import and export. CANape works directly on the formats MDF/MF4, HDF5 and Excel without conversion
- Supplied function libraries provide extensive possibilities for logical and arithmetic evaluation
- You can develop your own evaluation functions. Be it via the integrated function language CASL, own C/C++ code or with Simulink models
- Convenient browsing and analysis of many and large measurement files via the data mining user interface
- Convenient linking of search conditions enables efficient description and automated execution of complex analyses
- Signal display over time or in XY representation
- Manual examination of signal curves using zoom and search functions as well as measurement markers
- Comparison of measurement events through the superimposed display of events. If measurement files are available that were recorded time-synchronously by means of GPS receivers, you can also conveniently compare data from different vehicles with each other
- Inserting comments for offline analysis
- Use customizable print templates
- Export sequences from measurement files with synchronous video editing

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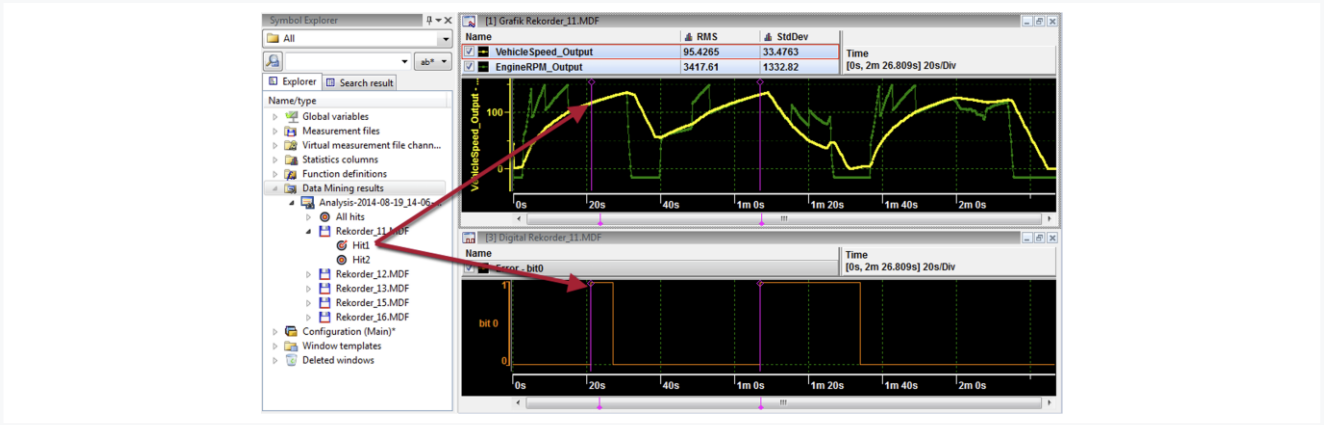


FIGURE 10: Convenient data mining user interface for automatic analysis of measurement data.

No programming knowledge is required to run ready-made evaluations. When creating evaluations, you also do not need any programming knowledge in simple cases that are limited to the use of existing mathematical functions. Programming knowledge is required to create elaborate and complex evaluations.

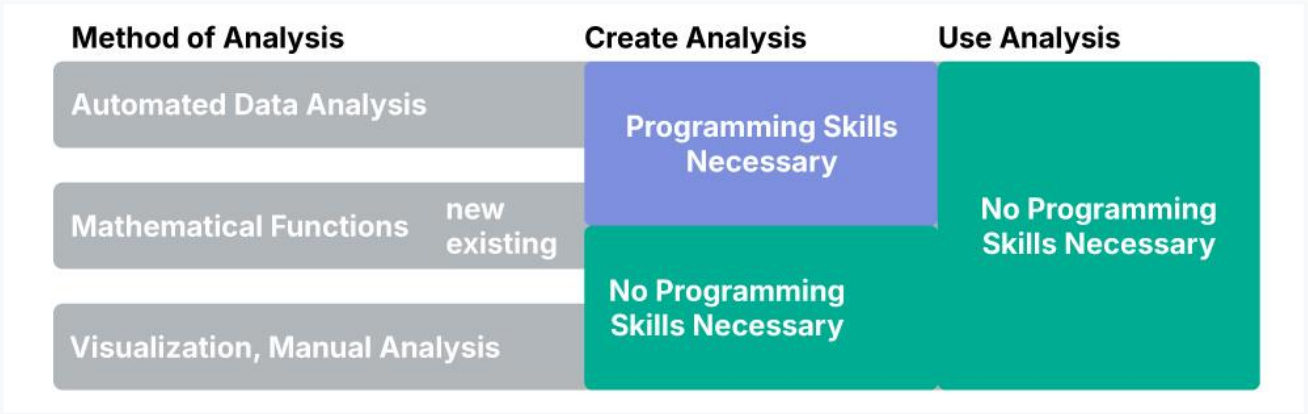


FIGURE 11: Programming skills are only required for extensive evaluations

5.1 Search and find measurement files

In order to be able to apply the evaluation options to the correct measurement data, you use extensive search and filter options. A search engine for your measurement data is available via the vMDM Explorer integrated in CANape. You can search for different information: Measurement file comments, events, signals, min and max values and much more. To avoid having to search through all possible measurement files first for each search query, the vMDM search engine builds an index. Search queries can then be answered quickly and efficiently from the index contents. Measurement files with the extensions MDF, MF4 and DAT (ETAS Inca measurement data format, which corresponds to the MDF format) are taken into account.

Indexing can take place locally on the computer or in the cloud solution vMDM. vMDM is the data management and analysis platform for your measurement data.

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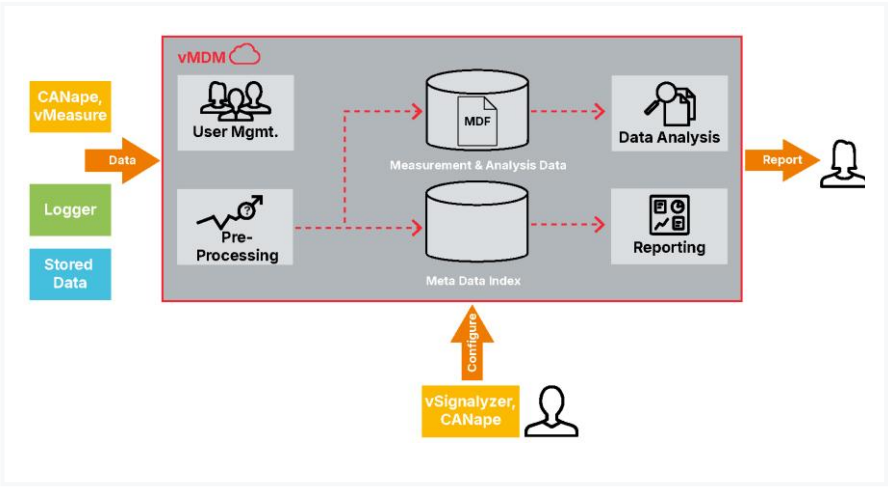


FIGURE 12: The most important vMDM components at a glance

From CANape, you work directly with the measurement data in the vMDM cloud. The data analyses that you have developed in CANape can be executed directly in vMDM so that extensive analyses do not block your desktop PC. You can see the measurement data and analysis results from vMDM in CANape.

6. Scalable logging solution with CANape log

CANape log is the powerful combination of the CANape calibration and measurement tool with the Vector Logger hardware and part of the new Vector Smart Logger family. Use your CANape project unchanged in development and also directly in testing. There is no configuration step for the logger and therefore no source of errors. It is a robust and easy-to-use solution for time-synchronous, high-performance recording of measurement data from a wide variety of sources. You benefit from CANape's wide range of functions, very high data rates, and flexible scalability as a standalone logger in the automotive environment, especially for ADAS development.

CANape log supports two operating modes. In each operating mode you access the vehicle buses, ADAS sensors and ECUs connected to the logger hardware.

Standalone mode

CANape log autonomously and automatically performs the measurement and recording. To monitor the autonomously running measurement, the driver uses a web-based application on their smartphone or tablet. In addition to status outputs, such as data rate and available memory, individual signal values can also be visualized. Interrupting and resuming the recording is also possible via the mobile devices.

Interactive mode

With a laptop and CANape installed on it, you can connect to CANape log via Ethernet at any time. This means that the full CANape interface is available to you on the laptop. You then work as usual with CANape while the project is running on the logger hardware. There is no need to change the cabling.

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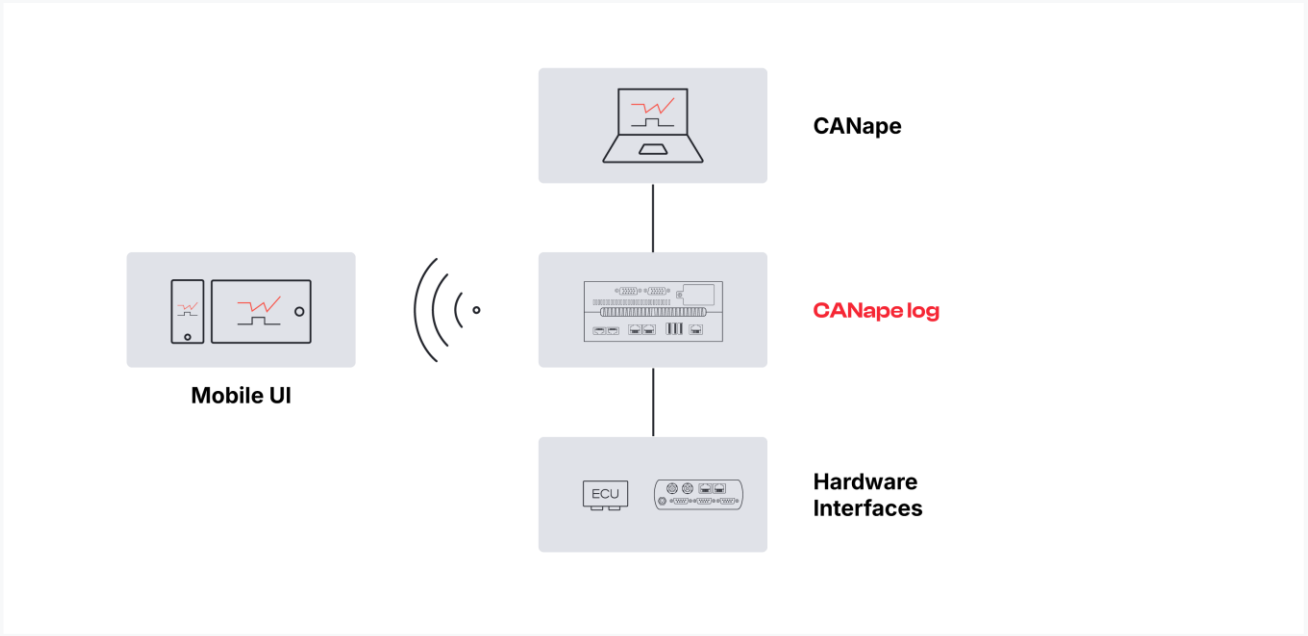


FIGURE 13: CANape log is a member of the new Vector Smart Logger family. The powerful combination of CANape and dedicated logger hardware enables time-synchronous and high-performance recording of measurement data.

Depending on the application, various hardware platforms are available. Please refer to the data sheet for technical details.

7. Development of driver assistance systems (ADAS/AD)

CANape supports time-synchronous recording of radar, LIDAR, video, inertial and vehicle data. Reference cameras additionally record the environments and provide video data.

The Driver Assistance option allows developers of ADAS systems to record and visualize sensor data in various windows. The sensors are integrated via DHPRs (see 3.1).

In the video window, the sensor data is superimposed as graphical objects (e.g. rectangles and lines) on the video image of the reference camera. In addition, the data is displayed in a side view or from a bird's eye view. Based on the video image, you verify the acquired data and thus evaluate the reliability and operational safety of the system.

Especially for the display of the point clouds of the LIDAR systems the scene window is available.

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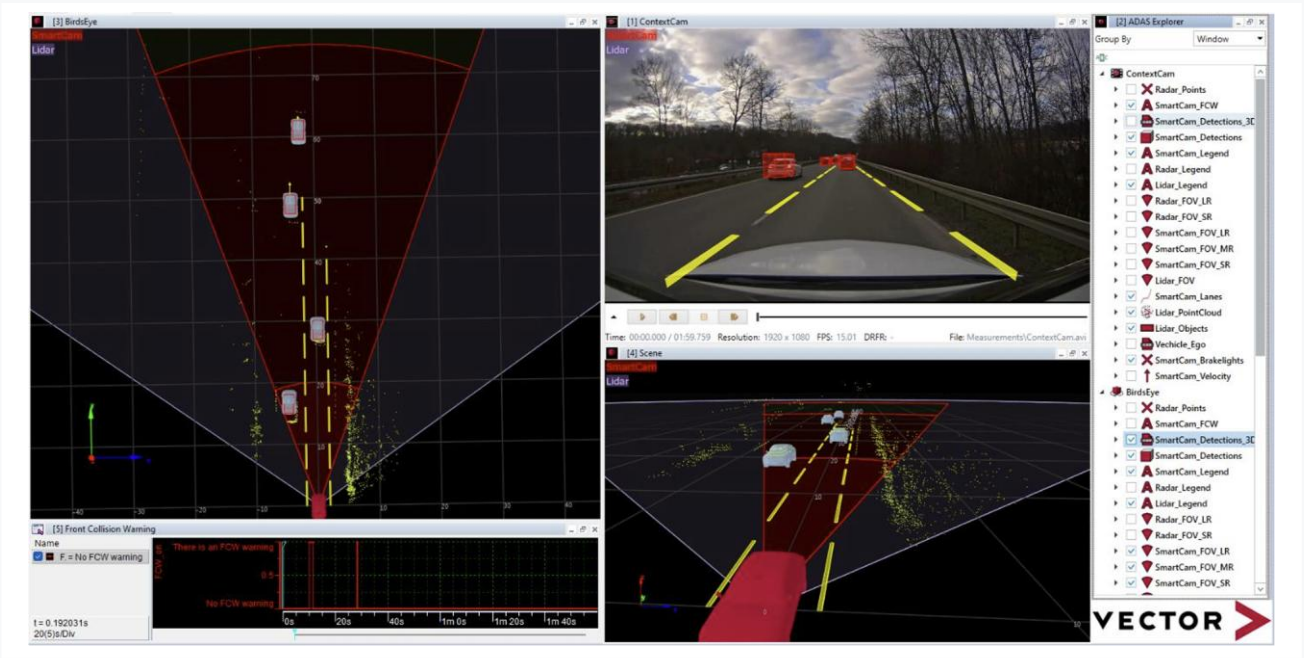


FIGURE 14: Driver Assistance Option - Object verification for checking driver assistance development algorithms.

7.1 Dynamic object detection

A special feature when detecting objects, such as road users and road signs from the surroundings, is the fact that the number and positions of the objects change dynamically during a measurement. This is a very different behavior than signals, which are typically configured before a measurement and are always present during the measurement.

To simplify the handling of objects, they are defined with their properties (e.g., position and relative velocity) in CANape and linked to the measured quantities. You then deal only with the objects and no longer with the individual measured variables.

8. E-mobility analysis in the high-voltage network

The new function library eMobilityAnalyzer is the core of scalable measurement solutions in the high-voltage environment. The voltage and current signals recorded by CSM measurement modules with a sampling rate of more than 1 MHz are converted online into the relevant parameters of the drive, the HV components or the on-board network. Among other things, you can very precisely calculate the efficiency and the effective, apparent and reactive powers.

9. Status monitoring

Status monitoring supports the troubleshooting and function monitoring of systems by analyzing states, state transitions and events that originate from different information sources, such as ECU, bus, I/Os, etc. The focus is especially on the analysis of AUTOSAR ECUs, which contain a large number of software components. Status monitoring is structured similarly to a logic analyzer and offers, among other things, the possibility to monitor the states of AUTOSAR runnables and to conveniently analyze binary signals.

10. Calibration / Parameter Settings

The parameter values are displayed either alphanumerically or graphically. The calibration of parameters offers the following functionality:

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> You calibrate parameter values either online in the ECU's memory or offline in CANape's mirror memory. Offline mode allows you to preprocess or postprocess ECU parameters without connecting to the ECU
> Parameter calibration parallel to measurement data acquisition
> All parameters of an ECU can be calibrated in a single window, the Parameter Explorer
> Structures with parameters can be viewed holistically in the Parameter Explorer
> From the measurement file, a parameter set can be generated with the parameter values valid at the respective measuring time
> Summarizing parameter sets to new version levels and feeding the data back into software development via C-, H- or MATLAB M-files
> Parameter set files are managed in vCDMstudio
> Parameter set files can be loaded and visualized and edited in calibration windows. This also allows mass operations on parameter set files.

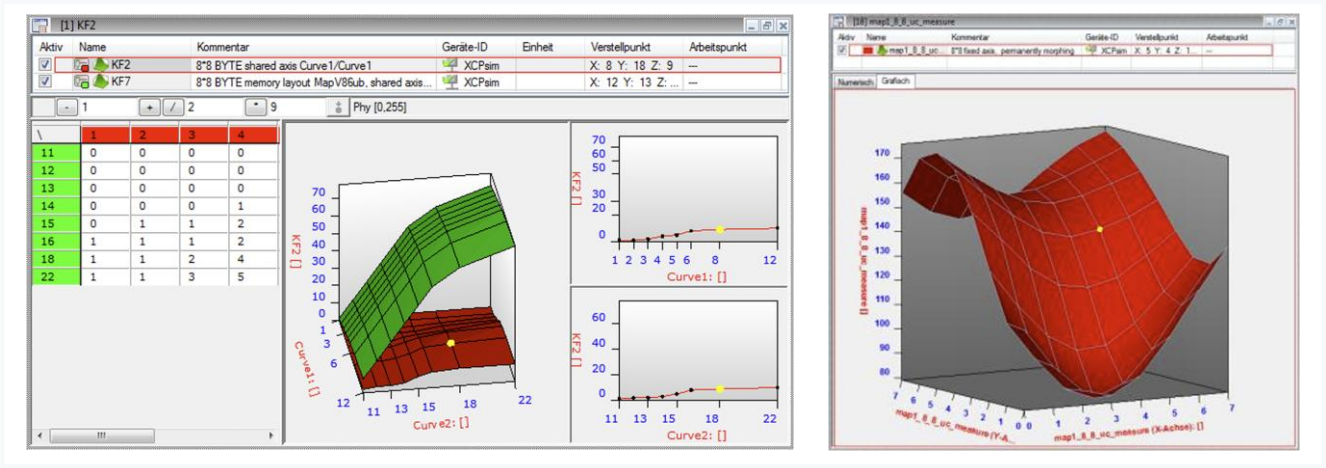


FIGURE 15: Numerical and graphical calibration windows allow convenient adjustment of parameter curves and fields.

10.1 Calibration Data Management (vCDMstudio)

A parameter set contains the values of the characteristics specified in the ECU description file. The integrated vCDMstudio manages these parameter sets and supports different file formats. CANape offers the following functionality:

> Parameter sets are stored in symbolic, address-independent parameter set files. Processing is thus independent of the ECU program status with which they were generated.
> Visualize and edit the contents of parameter sets
> Multiple parameter sets can be opened at the same time for comparing, summarizing, or editing
> Automation interface for merging, exporting, and comparing parameter set files
> Generating flashable binary files from parameter sets
> Support of the XML-based PaCo as well as the CDF format, where additional meta information can be stored for each parameter value, e.g., maturity level, value history, processor, date and comments
> Interpolation when copying characteristic curves and maps with different numbers of interpolation points
> Sophisticated filter mechanisms for defining views on parameter sets
> Generation of reports in different formats, including Excel
> Export and import configurations
> Via plug-ins: to create a data state project for the "Variant Coding" service class from a Vector CANdela diagnostic file
> Plug-in for import & export of data sets to ETAS INCA
> Review process for parameter changes after a software change with a new A2L
> New stand-alone application to access the central vCDM project database

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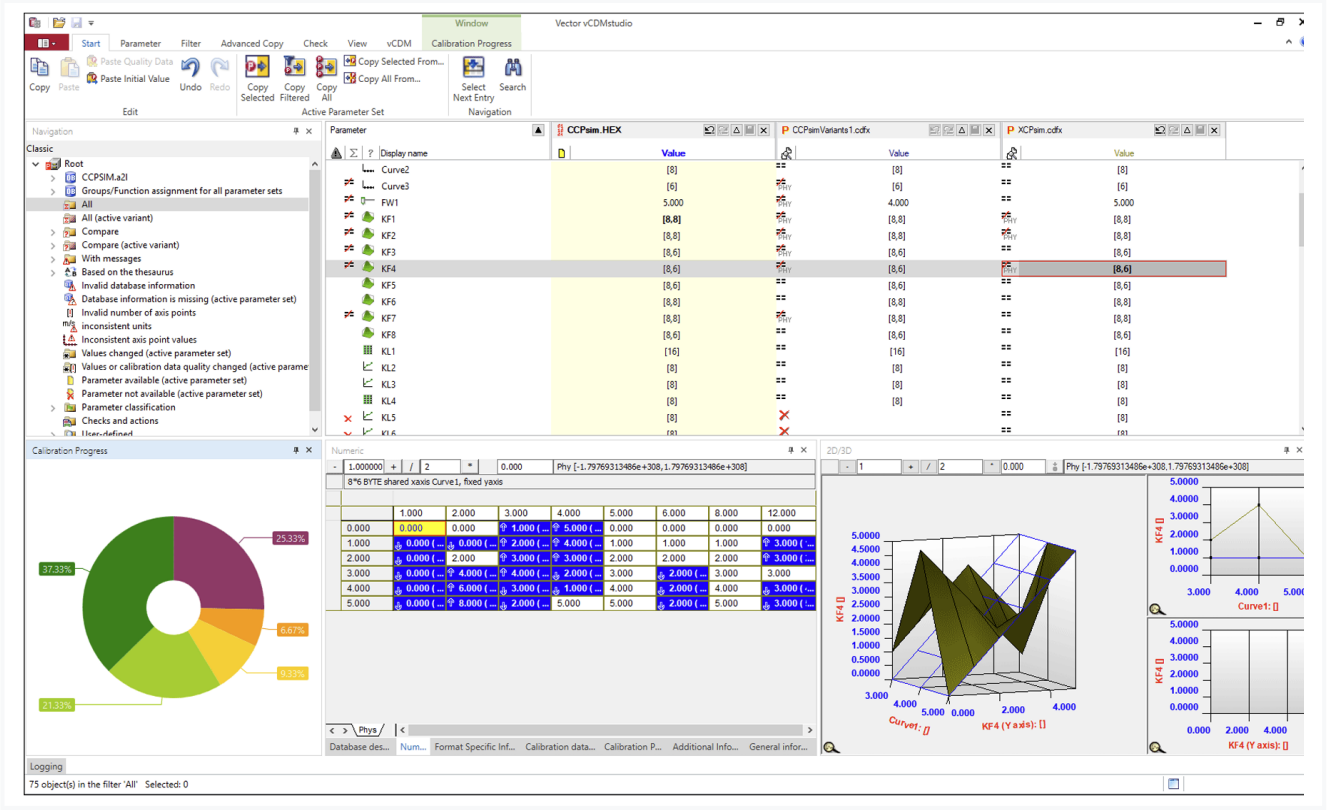


FIGURE 16: With vCDMstudio, you can manage the extensive parameter sets of your ECUs easily and comprehensibly at any time.

10.2 Convenient exchange of parameters in the team

Calibration is teamwork. Therefore, it is necessary to exchange parameter sets comfortably between team members and to edit them together. An exchange purely on file level bears the risk that parameter values are lost due to conflicts. With the vCDM solution, management takes place at the parameter level and not at the file level. This means that conflicts are displayed and resolved. Nothing is lost.

- > With the CANape Option vCDM, you ensure convenient and lossless exchange of parameters within your team. Access takes place directly in CANape, without another application.
- > Each released user can access the data statuses, edit them locally and compare them with the central data status.
- > Conflicts arising from multiple users changing the same parameter are displayed and resolved.
- > Server-based mobile database solution for use, for example, on trials without access to the central CDM system.

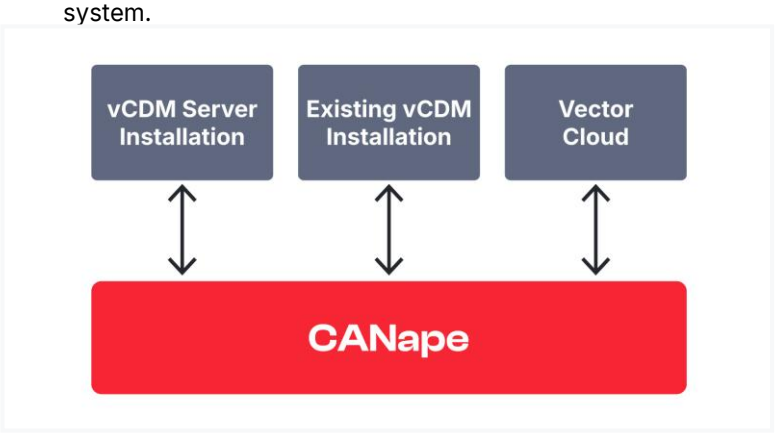


FIGURE 17: Cloud and on-premise solutions for calibration data management

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The team thus always works on the same data status. An existing vCDM server or a new installation can be used to store the data centrally. Or you can use the Vector Cloud solution, where the entire operation is ensured by Vector.

10.3 Server- or cloud-based calibration data management with vCDM

The data generated during calibration (program and data statuses, description files, documentation) can be managed in a process-safe manner in a database with the stand-alone software tool vCDM (Vector Calibration Data Management) and stored for reuse across projects. By managing variants, versions and configurations, the high complexity of calibration projects is safely mastered.

Without having to change tools, you can download your work packages from the database directly to CANape and conveniently return finished parameter set files directly to the database system.

Vector also offers vCDM as a cloud or software-as-a-service solution. Vector takes over the complete operation. This relieves the burden on your IT and makes it easier to work on shared data sets for cross-company collaboration.

11. Flashing

Flashing of new program versions is supported via CCP/XCP as well as via diagnostic protocols.

Diagnostics-based flashing is most easily done with the help of vFlash projects. Vector's flash tool supports more than 50 different flash specifications with user-friendly templates. It is designed for all users at vehicle manufacturers and suppliers whose tasks include the (re-)programming of ECUs. vFlash allows you to flash ECUs very efficiently in the lab, at programming stations, on the lab vehicle and in the vehicle. The ECU-specific processes are implemented in vFlash projects. In CANape you can select them and use them directly for flashing.

12. Support of Model-Based Software Development with MathWorks

There is a variety of interaction between CANape and the MathWorks tool chain. Basic functionality in CANape:

- Export of measurement files to MAT formats (e.g., the HDF5-based format 7.3)
- Export of parameter files to M-Script (for transfer of parameter values to the workspace)
- Export of A2L and parameter file as M-script (for initial creation of already defined A2L objects in the workspace)
- Visualization of Simulink/Stateflow models in CANape for convenient search of objects, display of measured values and calibration of parameters
- MATLAB has read and write access to object information from ECUs, buses, etc. via CANape's C-API. M-script functions are available in MATLAB for this purpose
- You can use Simulink algorithms as DLLs in CANape to calculate signals
- Export your Simulink model as an FMU (Functional Mock-up Unit) and import it into CANape

12.1 Rapid Prototyping with Simulink

Use CANape as a measurement, calibration, and visualization tool for models in Simulink. During function development, data is transferred to CANape at runtime of the model in Simulink via XCP-on-Ethernet protocol. Internal variables are accessed in the same way as in an ECU.

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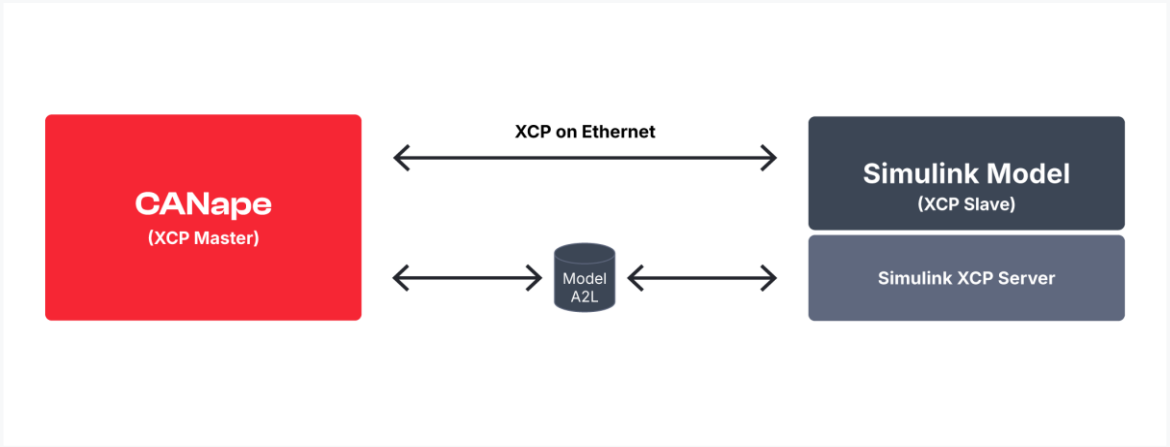


FIGURE 18: Simulink runtime does not occur in real time. CANape fully adapts to the temporal behavior of the model.

After a calculation cycle, you analyze the data in CANape and use Calibration Window or vCDMstudio to change the parameters of your model directly in CANape. Then the next calculation cycle runs with the new parameterization. Since the calculation of models often runs faster than in real time (depending on their complexity and computing power), short iteration cycles can be realized. Measurement and parameter variables within the DLLs can be accessed via XCP.

12.2 Rapid prototyping on computer platforms

CANape allows the use of standard PCs instead of cost-intensive rapid prototyping hardware. Function development is done with MATLAB/Simulink. After code generation and the compiler run, the Simulink model can run as a DLL in CANape on any computer. Even without using code generators, existing code or code generated by TargetLink can be used for DLL generation via a supplied C++ project. XCP is then used to access all model-internal measured variables and parameters (including integrated binary components). To stimulate the algorithms, you use both current measured values and content from previously recorded measurement files.

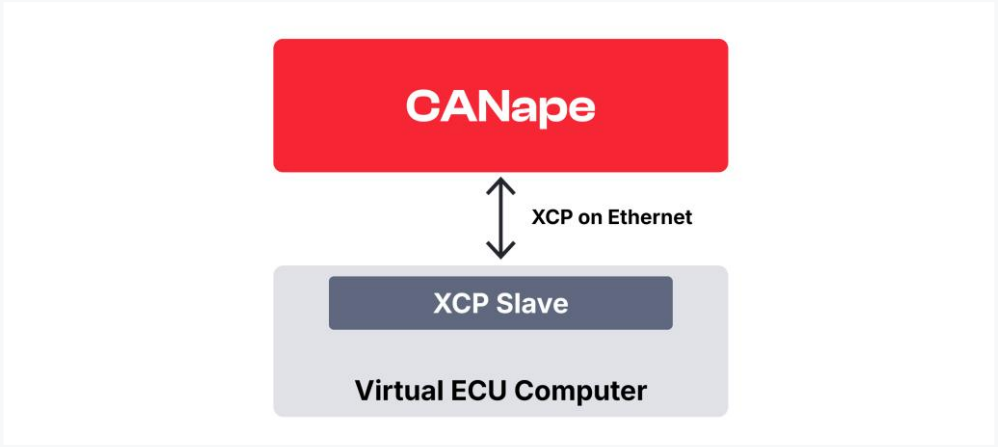


FIGURE 19: Virtual ECU runs as DLL in CANape or as EXE on computer

12.3 Visualization of Simulink / Stateflow models

With the Simulink Model Explorer, you visualize the Simulink / Stateflow model directly in CANape - regardless of the code's runtime environment. The coupling between the model and the A2L file lets you navigate conveniently through the model and access parameters and measured values directly.

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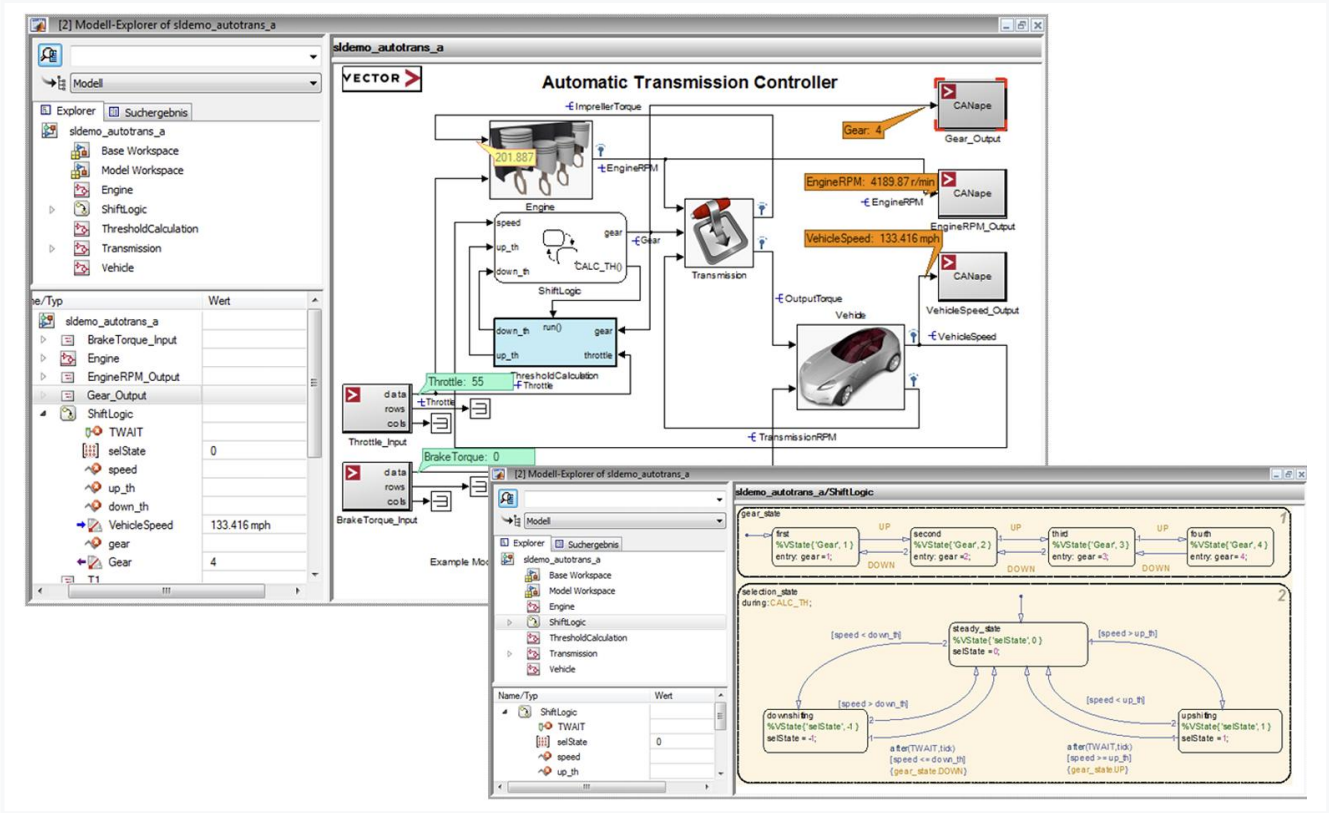


FIGURE 20: Integrated model explorer to display Simulink and Stateflow models.

12.4 Simulink algorithms in CANape

Generate code from a Simulink model for the target platform CANape. After compiling and linking, a DLL is available that can be executed in CANape. Use the functionality in the DLL just as you would a function you have written in CASL, for example.

In the "Function Window" you can graphically connect existing DLLs and CANape functions to signals and to each other.

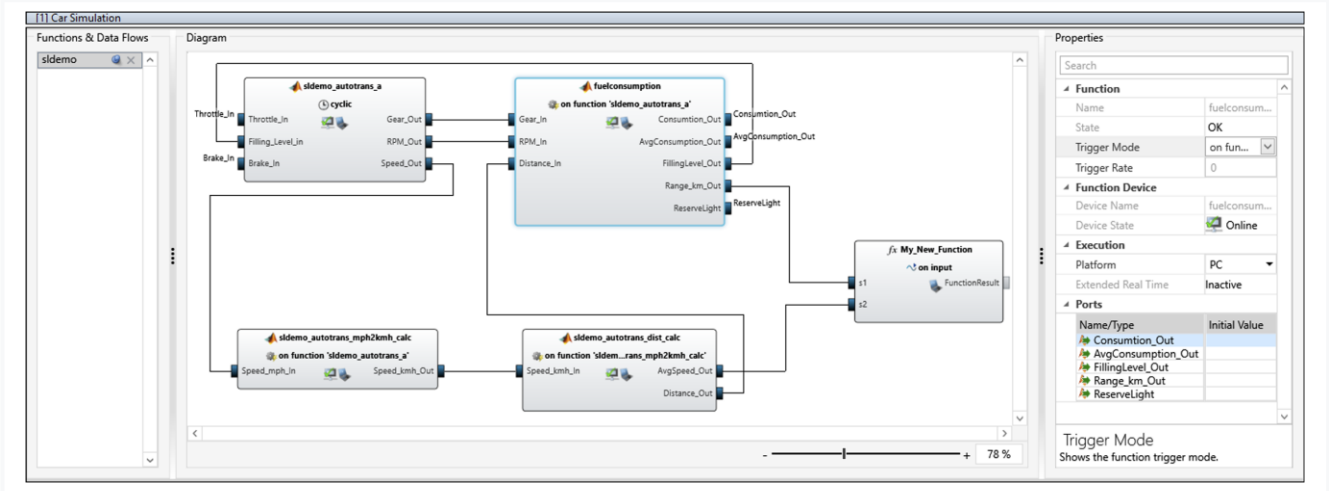


FIGURE 21: The linking of the ports with signals or other ports is similar to Simulink.

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13. Bypassing

With the XCP mechanisms DAQ/STIM you realize computer-based bypassing. The input variables of the relevant ECU function are measured via XCP. The output variables are calculated on the computer with the aid of the Simulink model and transferred synchronously back to the ECU via XCP stimulation. For short roundtrip times, the bypass is calculated on the Vector network interface with integrated VN8900 real-time computer and the measurement and stimulation access via the VX1000 hardware.

Calculating multiple bypass functions for different or the same control unit is possible in parallel on the VN8900. The VN8900 can also be used as a stand-alone solution. In this case, the bypass is first configured with CANape and downloaded to the VN8900. After disconnection from CANape, the calculation is performed autonomously on the VN8900. Stand-alone use is limited to one control unit.

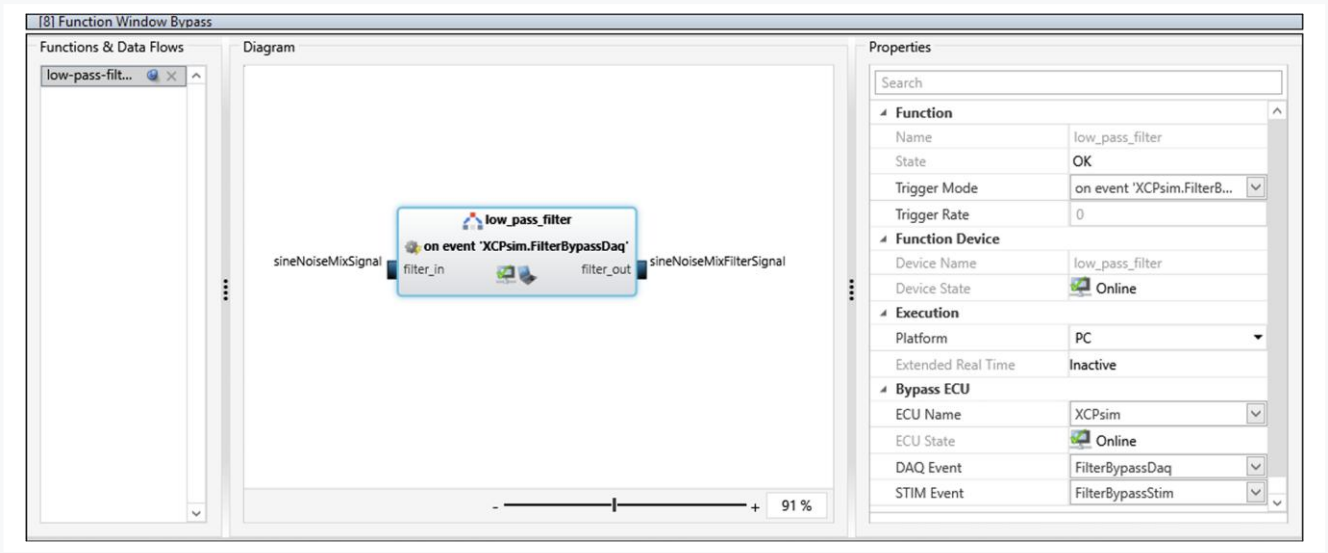


FIGURE 22: Manage the signal assignments for the bypass.

The "Vector Tool Platform" is a system extension for computer-based Vector network interfaces for CANape and CANoe.

Bypassing algorithms that are integrated in CANape can be outsourced to a VN8900 for execution. This significantly improves real-time behavior. Due to the more constant calculation time with significantly reduced maximum deviations, smaller guaranteed time limits can be adhered to and response time improved at the same time. This is a significant advantage, especially when executing time-critical bypass calculations with very low timeout tolerances.

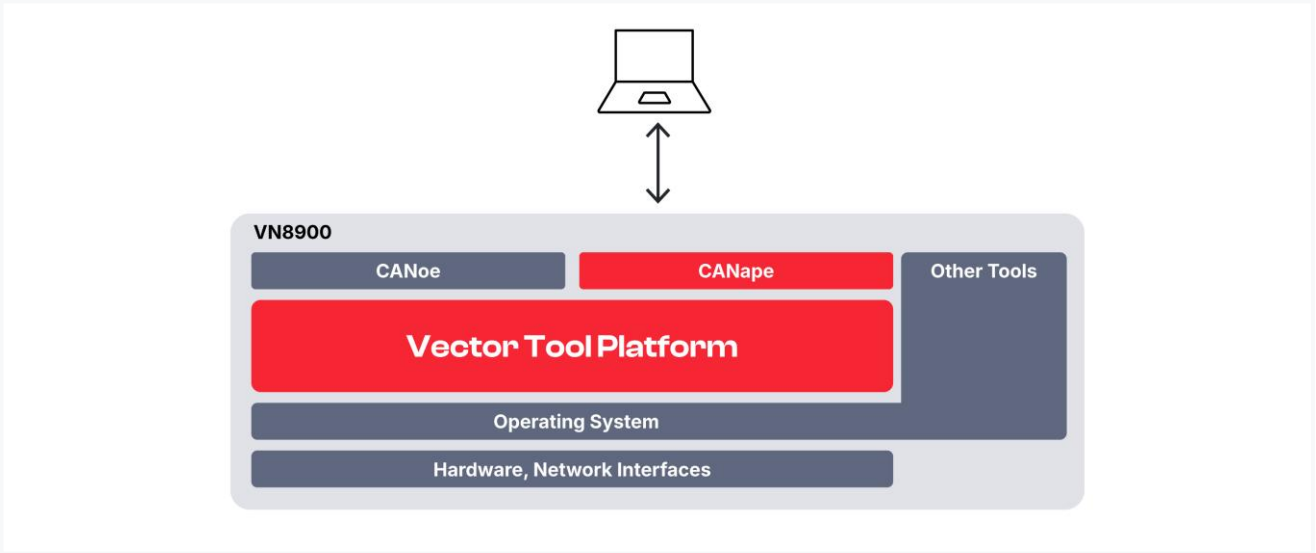


FIGURE 23: Manage the signal assignments for the bypass.

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14. Integrated function and script language

The C-like function and scripting language CASL (Calculation And Scripting Language) can be used both to calculate virtual signals and to automate processes in CANape. The integrated editor offers a convenient development environment including script debugger.

15. Automation interfaces

To enable client applications to access ECU data, CANape offers various powerful automation interfaces, e.g. ASAP3, COM, API and iLinkRT. Typical use cases are test benches or applications for automatic parameter calibration.

16. Database editors

To be able to edit the different description files conveniently, CANape offers editors for:

- ECU description files in ASAP2 format A2L
- CAN description files in DBC format

and viewers for:

- FlexRay description files in FIBEX format
- LIN description files in LDF format
- Diagnostic descriptions in ODX format
- CANdela diagnostic descriptions in CDD format
- Ethernet, SOME/IP, FlexRay and CAN description files in AUTOSAR System Description Format

17. Calibration concepts

The calibration concept answers the question of how parameters in the ECU can be changed during the development and calibration phase. There is not only one calibration concept, but several. Which concept comes into question usually depends strongly on the possibilities and resources of the microcontroller used.

CANape supports the following methods:

- Parameters in flash
- Parameters in RAM
- Flash overlay
- Dynamic Flash Overlay Allocation
- RAM pointer-based calibration concept according to AUTOSAR
- Single pointer concept
- Flash pointer-based calibration concept

Detailed information on XCP and the individual calibration concepts can be found in the reference book "XCP - The standard protocol for ECU development", which can be downloaded free of charge from Vector: www. vector.com/xcp-buch

18. Diagnosis

In addition to diagnosing individual ECUs, CANape enables a cross- ECU view of vehicle functions by means of functional addressing. CAN, FlexRay, Ethernet and K-Line are supported as physical interfaces. The description files

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can be either in ODX format or in Vector-specific CDD format. If no specific diagnostic description is available, the supplied generic files for UDS and KWP2000 allow symbolic access to functions and raw data.

As a diagnostic tester, CANape offers the following functions:

> Selecting, parameterizing, and executing diagnostic functions in the diagnostic console
> Window for displaying and erasing the error memory, symbolic display of the DTCs and the environmental data.
> Integrated access to measurement, calibration, and diagnostic data, e.g. with visualization of error memory entries in the graphics window
> ODX-controlled flash programming
> Analysis of all aspects of diagnostic communication in the Trace Window: messages, transport protocol data, protocol data and diagnostic data
> Address-oriented access to A2L-defined ECU data via diagnostic functions
> Scripts for the automation of diagnostic processes
> Easy-to-use automation interface for running diagnostic services
> Functional addressing, e.g. to query the ECU identification of several ECUs with a diagnostic function.
> Access to OBD data with specific display in OBD window
> Support of DoIP (Diagnostics over Internet Protocol, ISO 13400)

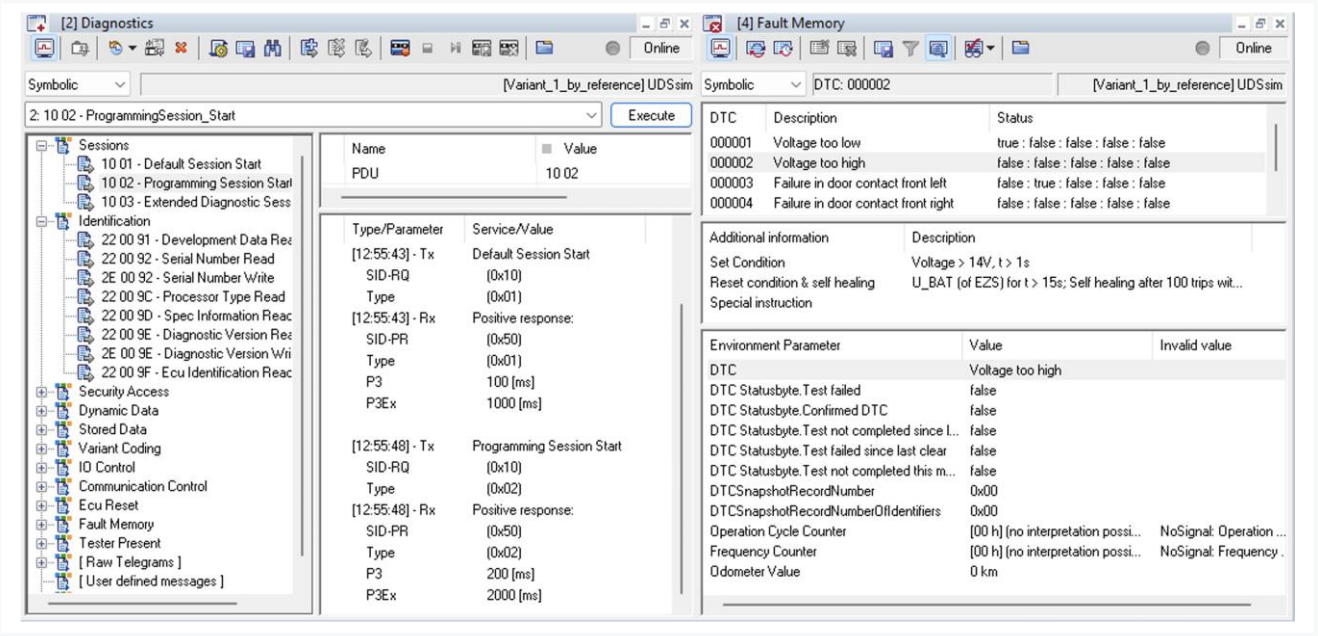


FIGURE 24: Structured display of the diagnostic functions supported by the control unit. All error codes - including environmental data - are displayed symbolically.

18.1 Secured diagnostic access through the Vector Security Manager

Security mechanisms in the control unit protect the vehicle and its functions against manipulation and unauthorized access. For testing and diagnostic purposes, however, it must be possible for authorized persons to participate in vehicle communication during development and later operation.

The Security Manager gives the CANape user access to the secured diagnostic data.

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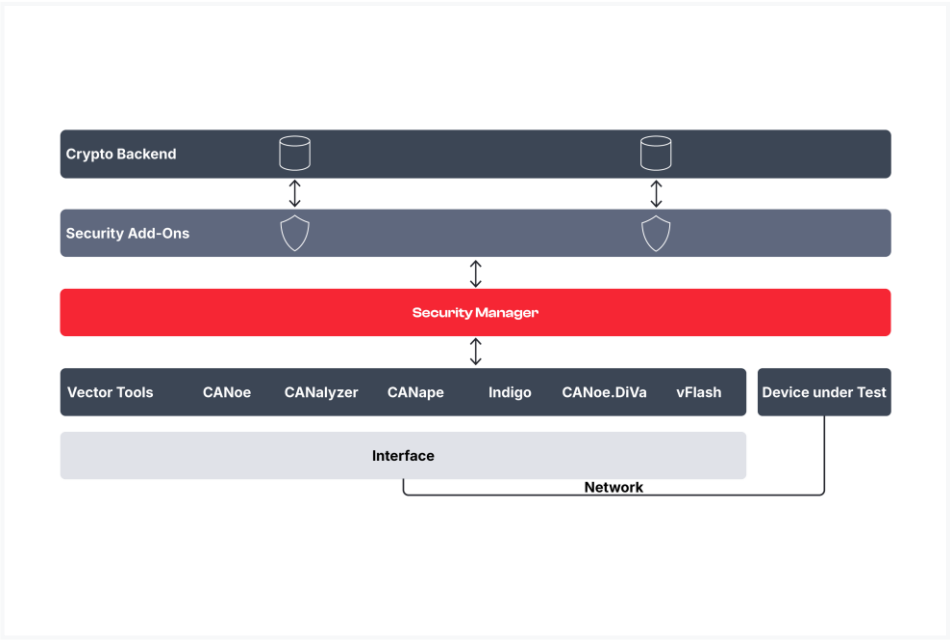


FIGURE 25: Use the Security Manager to access secured diagnostic data.

19. Visualize the vehicle position in a map

For in-vehicle measurements, CANape records the position data and visualizes the vehicle's current position on a map. In offline evaluation, the vehicle position is displayed time-synchronously with the measurement data. Interpretation of the recorded measurement data is made much easier because the geographic conditions can be taken into account in the evaluation. For developing Car2x applications, the CANape Map Window supports you by visualizing multiple objects in the map.

If ADAS objects are available, they can also be plotted on the map with positional accuracy.

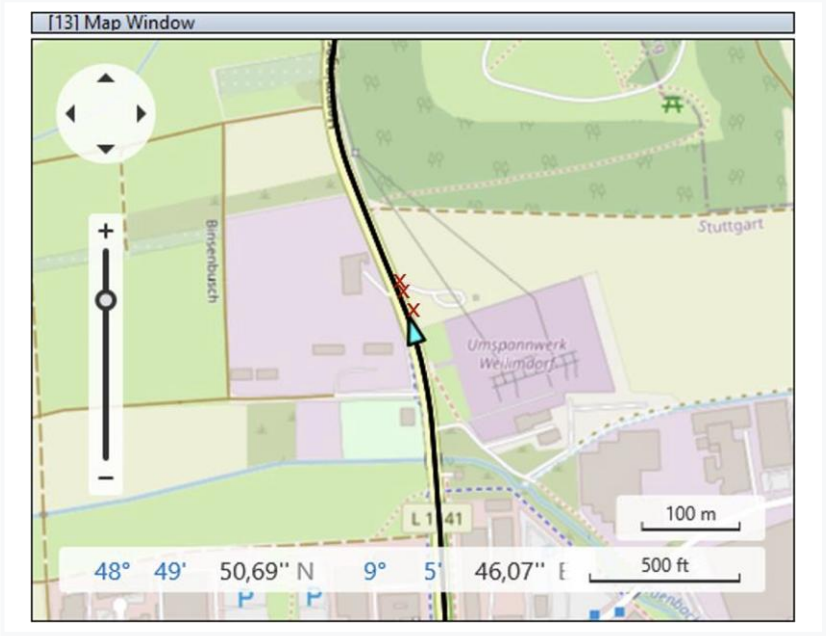


FIGURE 26: The total distance with the current position of the vehicle is displayed. The red crosses represent detected vehicles.

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19.1 Fields of application

The option of synchronizing measurement data from a test drive with a geographical position and displaying this on a map makes it much easier to assign certain events. The behavior of your control unit can be reliably tracked with this additional information, for example when shifting up on a hill.

19.2 Supported map material

The following map material is supported:

> OpenStreetMap (also allows offline use of the previously downloaded map material, e.g. for test drives without an Internet connection).
> HERE
> Embedding your own maps in the form of graphic files

19.3 Functions

> Create freely configurable and scalable Map display windows
> Displaying the vehicle position in the Map window
> Configurable display of the distance driven so far
> Simultaneous visualization of geographical and vehicle-specific data in the various display windows
> Synchronization of the measurement cursor with the vehicle position on the map
> Simultaneous display of several vehicles (e.g., with Car2x communication) or objects
> Level of detail of the map display changes depending on the zoom setting

20. Hardware interfaces and protocols

CANape supports all standard interfaces and protocols relevant in the automotive sector (others on request) via the Vector hardware families:

> Bus monitoring of CAN, CAN FD, Automotive Ethernet, FlexRay, LIN, SAE J1939, and CANopen
> Service Oriented Middleware over IP SOME/IP
> Data Distribution Service DDS
> AUTOSAR Debug Log and Trace DLT
> Capture Module Protocol CMP
> XCP on CAN, CAN FD, FlexRay, Ethernet, Automotive Ethernet, UART
> Fast controller interfaces such as JTAG, DAP, LFAST, RTP/DMM, Nexus AUX and AURORA via Vector's VX1000 measurement and calibration hardware
> Fast processor interface with PCIe via VX1000
> Video sensors are integrated via the frame grabbers (FPD-Link and GMSL) in the VX1000 product family
> Analog measurement technology with sampling rates of 1 MHz via Ethernet
> Diagnostic protocols
  > DoIP (Diagnostics over Internet Protocol)
  > ISO 14229 (UDS) via FlexRay with the ISO transport protocol and other transport protocols on request
  > ISO 14230 (KWP2000 on CAN) and ISO 14229 (UDS), transport protocol ISO 15765
> CAN Calibration Protocol CCP
> Video: Webcams, Axis, GigE, GMSL, FPD-Link, ...
> Integration of measurement technology and hardware interfaces from third-party manufacturers

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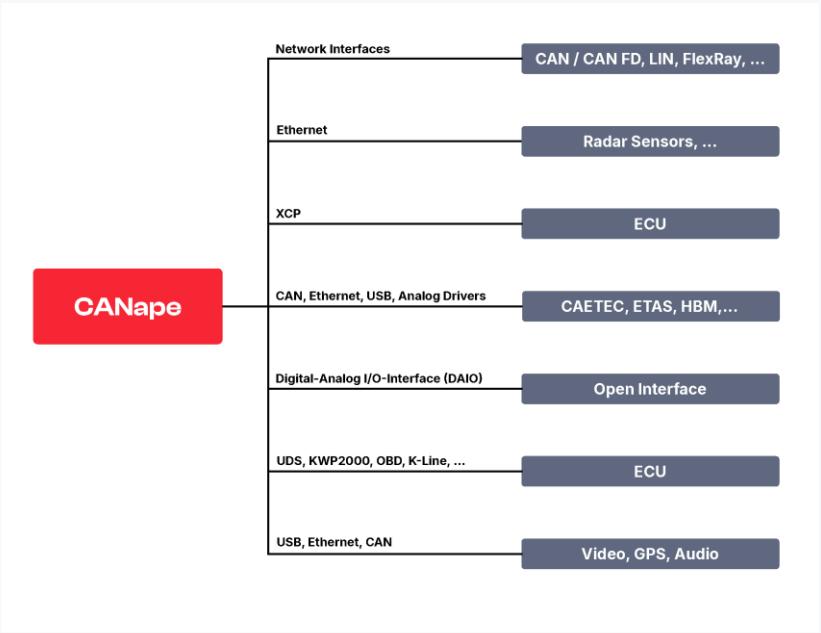


FIGURE 27: High flexibility due to versatile hardware interfaces

20.1 Integration of ADAS sensors via protocol decoders and DHPRs

Radar and LIDAR sensors deliver high data streams and are therefore integrated via Ethernet. Since the data is transmitted via manufacturer-specific protocols, integration in CANape is done via Distributed High Performance Recorders (DHPRs). They receive the Ethernet data from the sensor and, if necessary, interpret the data to the extent required for visualization or storage in CANape. CANape is thus able to acquire any sensor data.

Video sensors deliver their data primarily via specific video interfaces, which are recorded via frame grabbers (for example in VX1161) and also forwarded as an Ethernet data stream. The frame grabber data is integrated in CANape via DHPR to provide sufficient computer resources for the high data rate.

20.2 AUTOSAR Adaptive Control Units

AUTOSAR Adaptive is particularly suitable for high-performance ECUs such as in-vehicle application servers, HPCs, Zones and ADAS ECUs, and infotainment systems. These ECUs usually have a combination of processors and controllers. CANape supports different ways of accessing the internal data: via XCP, VX1000, DLT, SOME/IP, DDS.

20.3 ECU integration via third-party manufacturer

The FETK and xETK solutions from ETAS also support measurement and calibration via XCP on Ethernet. This makes them compatible with CANape.

21. Engineering services

So that you can concentrate fully on your ECU development, Vector supports you both with know-how and with customized complete solutions for your tasks. Our services range from consulting services, e.g. for the development process of an A2L file, to the development of data evaluations, to a field application engineer at your site.

22. Trainings

As part of our training offering, we provide training and workshops for our products and various technologies.

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For information on training, visit: https://academy.vector.com.

You can also use our free e-learning platform at https://elearning.vector.com.

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