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1 Introduction to vCDM

vCDM (Vector Calibration Data Management) is the database-supported collaboration solution for calibration teams. Work results are efficiently merged and potential data conflicts are avoided, detected and resolved. All changes to data can be tracked. Data versions are consistent and have a high level of data quality. With vCDM, you can manage large numbers of variants securely and reliably.

Data mining and report functions ensure effective monitoring of project progress and quality, and they increase the efficiency of the calibration process. The calibration data can be graphically displayed and manually edited using the vCDMstudio Editor.

Figure 1: Navigation in vCDM and vCDMstudio Editor

1.1 Overview of Advantages

- Scalable solution: vCDM supports the specific requirements of calibration engineers, small teams and globally distributed enterprises alike. The processes and workflows can be adapted to the size of the company.
- vCDM is extremely versatile and can be used for a range of different ECU architectures and calibration concepts.
- The modern system architecture supports globally distributed teams and meets the needs of IT departments.
- With the vCDM Software-as-a-Service solution, you do not need to worry about operating the application. The application can be licensed using the attractive subscription model.
- The convenient vCDMstudio is part of vCDM and can also be used without database connection for file-based operations.
- Domain-specific views visualize certain aspects of the calibration data in a clearly structured way.
- vCDM is very closely integrated with the CANape calibration tool and the two tools are harmonized to optimize the workflow. Integration in INCA is also possible.
- All changes to the data can be traced without interruption.
- All operations are optimized for a wide range of variants.
vCDM offers a number of different methods that ensure very high data quality: Innovative concepts ensure that the variants remain consistent and the data is checked automatically.

- Extensive programming interfaces are available.
- Web access and a simplified operating mode help new and occasional users with the most important use cases.
- All commonly used data formats are supported.

### 1.2 Various Methods for Accessing the System

- **CANape vCDM option**: The use cases handled by calibration engineers can be performed extremely easily and conveniently from within CANape. The two applications are closely harmonized and their strengths complement one another perfectly.

![vCDM integration in CANape](image)

**Figure 2: vCDM integration in CANape**

- **MCD Tool Integration Add-On**: This add-on can be used to call the most frequently used functions of vCDM directly from the calibration tool INCA.

- **Programming interfaces**: Nearly all vCDM functions are available via a scripting interface and can be used for automation. The vCDM server offers a SOAP-based web service interface for integration in enterprise applications. Both of these interfaces are supplied with the product and can be used without incurring additional costs.

- **Web Frontend**: The vCDM server offers a way to access frequently used functions via a web browser. This is the ideal way to connect external organizations or occasional users. Use of the web frontend requires separate licensing.

- **Local Repository Server**: To efficiently access data from remote sites, it is possible to replicate the data to these sites. A separate license of the vCDM repository servers is also necessary for each of the sites.

- **Collaboration on the road**: Projects and datasets can be exported to a local database and taken along for testing, and all vCDM functions can be used “on the road.” The changes are later imported back into the central database.

### 1.3 Further Information

Various documents on vCDM are available on the Internet. Benefit from valuable know-how in the form of technical articles or product videos. For more information, visit the Vector Download Center.
2 The Calibration Process in vCDM

2.1 Overview

The functions of vCDM support all phases of the calibration process:

- Create calibration projects
- Define calibration variants and their attributes (features)
- Set up work packages and permissions
- Import parameter files
- Review changes
- Merge changes
- Detect and resolve conflicts
- Generate updated ECU files
- Transform existing calibration data to new ECU software
- Graphically compare and manually manipulate data with vCDMstudio
- Establish consistency criteria and checks
- Calibration history and overview of incorporated work packages
- Prepare ECU software for production
- Access to all functions via automation interfaces
- Reporting and data mining functions
- Guided mode for new and sporadic users
- Export and import of projects to support test states
- Management of component libraries
- Documentation of calibration expertise
- Special views for special tasks (e.g. OBD blocking behavior)
2.2 Project and Variant Management

vCDM offers an array of functions for managing projects and data variants. These functions are normally executed by a project manager or data integrator:

- **Managing projects and data variants:** vCDM can be used to manage any number of projects. In each project, there may be any number of independent data variants, each of which contains the defined range of parameters.

- **Product properties:** Product properties such as engine displacement, legal emission limits or gearbox properties may be assigned to the data variants. The list of product properties can be supplemented in any desired way.

![Figure 4: Definition of product properties](image)

- **Structuring of data variants:** Project managers can structure the variants in folders in any way they want. Alternatively, the tree structure can also be calculated from the product properties. These views can be configured to meet user-specific requirements.

![Figure 5: Data variants in calculated folders](image)

- **Automatic history tracking:** All changes to the data variants are automatically tracked in a history. Development over time and parameter set imports are tracked precisely and can be retrieved later in a few seconds.

- **Defining work packages and rights:** To coordinate the import of calibration data in a team, work packages and rights can be defined. Rights may be assigned in a scaled way – from the project to the variant to the even individual parameter.
Figure 6: Work packages can be easily defined in the editor

2.3 Import and Merge Calibration Data

These actions are performed by the calibrators or data integrators.

Figure 7: Import wizard for parameter sets
Consistency check at parameter set import: When importing calibration data, consistency conditions such as permissions, work packages, value ranges and other properties are checked.

Optimizing for large numbers of variants: Filters and intuitive user controls help the user to identify all the variants needed for a parameter set import.

Merging the data: Imports by calibration engineers can be conveniently compared and merged. If conflicts occur, they are detected and resolved.

Quality data: When a parameter set is imported, status information and comments can be added and attachments included. It is also possible to link imports to issue tracker and requirements management systems.

Optimized user interface: The complexity of the user interface can be reduced to a minimum for the data import. This lets occasional users quickly learn how to use it.

Integration in calibration tools: A supplemental feature is the direct parameter set import from the CANape and INCA calibration tools.

Excel import and export: Import templates can be exported and reused in Excel.

2.4 Generate ECU Files

Once all the necessary calibration data has been imported and merged; the project manager or data integrator generates a new, updated revision of the ECU software:

Consistency checks: Configurable consistency checks are also performed for Intel-HEX and Motorola S-Record generation.

Naming rules: New HEX file names can be generated automatically based on configurable rules.

Preparation for production: The new ECU software can be generated in a form which allows it to flow directly into the production process. Checksums and signatures may be inserted in the ECU file for this purpose (HEX post treatment).

2.5 Software Changes

If the ECU base software changes, all calibration data must be adapted to the new calibration software.

Optimized for mass operation: This operation can be executed on many dozens or even hundreds of variants simultaneously.

Parameter renaming: Renaming of parameters is supported.

Seamless history: The software change does not interrupt the history.

Parallel work on different software versions: Even after the software change, older software versions can still be worked on. Software versions are managed as parallel lines of development.

Reports: Differences between A2L files can be exported into a report.

Rule based data migration: vCDM and vCDMstudio feature an integrated wizard which enables suppliers, software developers and experienced calibration engineers to define complex acceptance rules for when parameter properties are changed. These rules are then imported and executed when the software is changed. This enables calibration data to be accepted automatically even when extensive changes are made to the ECU software.

Possible scenarios that can be handled in this way:

Unit changes: Automatic conversion of seconds to milliseconds.

Parameter type changes: Convert curve to map.

2.6 Reports and Data Mining

vCDM offers an array of reports which can provide important information within a few seconds:

Data comparison: Different variants can be compared to one another. The result can be presented graphically in vCDMstudio and exported as an Excel report. The report includes A2L properties, parameter values, quality information, maturity levels, work packages, permissions and lots more information. A template mechanism can be used for application to different use cases without repeated configuration.
Parameter value instances: This analysis shows the different values of a parameter occurring in different variants and projects. This analysis can be used to optimize parameters or for a consistency check.

Parameter history: This report answers the question: Who made what change when and from which source? What was the initial value, and to what value was the parameter changed?
Figure 10: Parameter history

- **List of work imports:** This report provides the sum of imports making up a variant. The history is tracked over as many revision levels as desired.

- **Calibration quality:** The quality of the calibration can be tracked over time or across variants.

Figure 11: Calibration maturity for data variants

- **Data review with vCDMstudio:** vCDMstudio is used for offline data reviews. By utilizing the filter and search functions, complicated matters can also be responded to. Possible changes can be conveniently merged back into vCDM.
3 Efficient Variant Management

3.1 Methods for Efficient Calibration Variant Management

vCDM offers various methods for keeping a large number of calibration variants consistent. These mechanisms can be applied independently or combined as needed:

- **Attribute**: Attributes can be attached to variants to define their semantics more precisely. These attributes are used later on to filter data and for automatic assignment of data from libraries.

- **Calibration matrix**: The calibration matrix clearly presents the available work packages, their instances and where they are used. Work packages can be exchanged from the calibration matrix. Exporting to Excel and the import of changes from Excel are possible.

- **Derived variants**: If there are only minimal differences between variants, this can be handled using derived variants (e.g. test bench versus street test variants). Most parameters in a derived variant originate from the basic variant. Only a small number of parameter values are managed within the derived variant. The values from the basic variant are determined dynamically, and changes are immediately available in the derived variant as well.

- **Component libraries**: Work packages which could serve as a good basis for new variants can be managed in component libraries. Through assignment of the attributes, the libraries can be aligned with the data sets.
3.2 Managing Parameter Dependencies

You use this function to manage the dependencies between parameters and variant properties and boost the efficiency of the calibration process:

- **Dependency management of parameters**: This function is elaborated on in the following chapter.

- **Data distribution to variants**: Data can automatically be distributed to variants. The individual calibration engineer only requires a little knowledge about the structuring of the variants.

- **Consistency check**: Automatic checking of variants for consistency.

- **Automatic filling of variants**: New variants can be pre-filled from ongoing project data to the greatest extent possible. Inconsistent variants are automatically repaired.

- **Calculating dependency relations**: The dependency relations in a project can be calculated by means of a correlation analysis based on existing data. The results are used to configure dependency management and validate new data variants in the light of the dependencies.
4 Parameter Processing

4.1 vCDMstudio Editor

vCDMstudio is part of CANape and vCDM and is also available as a standalone product. The editor offers an array of important functions in the context of vCDM:

- **Graphic display of characteristic curves and maps**: Characteristic maps can be compared to one another and even placed within one another graphically.

![vCDMstudio with two characteristic maps inserted in one another](image)

- **Manipulating data**: Data can be manipulated graphically or numerically. Refined functions such as interpolation and value range checks are available during input.

- **Standalone mode**: vCDMstudio can also be used as a standalone tool for file-only operations.

You can find more details in the separate product description and on the corresponding website: [www.vector.com/vCDMstudio](http://www.vector.com/vCDMstudio).
Collaboration in the Team and with Partners

5.1 Simple Access for Occasional Users

Occasional users benefit from support functions that help them get to know vCDM quickly and use it productively:

- **Welcome Pages**: By default, new users see a “Welcome Page” when they launch the vCDM Client. This gives them fast access to the use cases. The available actions are restricted depending on the user’s role. Thus, for example, calibration engineers can import or export data and generate reports at a single click. There is a wizard to help users configure each action.

  ![Start screen for calibration engineers](image)

- **Import via e-mail**: Calibration engineers can also import data into the system via e-mail. For this to be possible, the vCDM Server must be connected to an e-mail account. If a calibration engineer sends data to this account then it is imported into vCDM. The user is sent a response message indicating whether the data has been transferred correctly.

- **CANape vCDM option**: with this option, vCDM can be seamlessly integrated in CANape. You can then import all modified data into vCDM with a single click. Many extremely convenient functions are available, such as attachments, progress monitoring, updating of local data variants and consideration of rights and work packages.

5.2 E-Mail Notification

- For many events in vCDM, it is possible to generate E-mail notifications. Recipients of the E-mail do not necessarily require an account for vCDM. In this way, occasional users can be prompted to log in again and managers can receive information on the availability of a release.

- Using a template mechanism, important information can be added to the e-mail. If axes values have changed, for example, their names and the affected variants are noted in the e-mail.
5.3 Collaboration on the Road

> To support calibration engineers during testing as well, a project and its datasets can be imported into a local database system. In this system, all the functions of the central system are available. Calibration engineers merge their data, generate new data sets and migrate existing data sets to new software versions. All team, reporting and data mining functions are available.

> All changes are imported back into the central system after the completion of testing.

> Importing and exporting are only started by the user – they occur asynchronously between the databases following this. The client application can be closed, and the user does not need to wait until the operation is completed.

5.4 Data Exchange OEM / Supplier

> If supplier and OEM operate a vCDM system, they can automatically synchronize the calibration data between the calibration variants.

> Synchronization is time-triggered and does not require user interaction.

> To ensure maximum decoupling of the system, the files are transferred using a removable-media drive or via FTP. To protect the data, the transfer can be encrypted. Data which is not to be exchanged can be excluded from the transfer (e.g. calibration comments).

6 Special Functions

6.1 Support for Different ECU Architectures

vCDM is extremely versatile and can be used for different ECU architectures, calibration concepts and specialized domains. You manage your ECU projects without Intel-HEX or Motorola S-Record files. Thanks to the ECU-independent management of the calibration data, all import, merge and report functions are performed in the internal database format. vCDM then exports the results in a proprietary format, as source code files or in the form of parameter sets.

It is also possible to manage projects without an A2L file. In this case, the parameter declaration is created in ASAP2 Studio. It is possible to import the declarations from Excel and other formats. vCDM supports different calibration methods and memory allocations in the ECUs. If the A2L file contains RAM addresses then these can be mirrored to the flash addresses.

A range of options allow you to adapt the behavior of vCDM to the employed ECU or calibration tool. These options are set centrally and are invisible to the majority of users. In this way, vCDM covers a vast range of applications from drivetrain development, through ADAS ECUs with Adaptive AUTOSAR and on to sectors outside the automotive industry.

6.2 Domain-specific Views

Certain aspects of the calibration data require a transposed representation for better recognition by specialists. One example is the memory-optimized storage of the parameterization of diagnostic functions, which can be read only from the parameter-oriented display.

In this case, vCDM and vCDMstudio provide a clear representation of the situation with the Function Inhibition Matrix.
Other domain-specific views can be integrated in vCDM as part of the standard product or on a customer-specific basis.

6.3 Documentation

Calibration data can be documented in various ways:

> Import of quality information from the CDF 2.0 or PaCo format.
> Post-documentation of parameter values when importing data sets or on the basis of datasets.
> Documentation of application expertise in parameter definitions, functions, groups, or trouble codes.
> Import of documentation from Excel or a programming interface.
> Use of documentation in standard or customer-specific reports.
6.4 Efficient OBD Documentation with the CARB Summary Sheet

Using the parameter documentation, it is possible to generate a basis for the CARB Summary Sheet.

The basic structure of the CARB Summary Sheet is stored in an Excel template. The individual rows in this template contain a reference to the documentation in the vCDM database.

Because it would be extremely laborious and time-consuming to create this template manually, it can be generated by means of an intelligent Excel import from an existing Summary Sheet. The existing information from the CARB Summary Sheet is also imported into vCDM at the same time.

The documentation may also contain references to calibration values or A2L properties. These are then substituted on a data version-specific basis when the CARB Summary Sheet is generated.

In this scenario, vCDM offers:

- Collaborative editing of the documentation for the CARB Summary Sheet
- Automated generation of the sheet for many data variants
- Reduced work effort through import from existing CARB Summary Sheets
- Seamless linking of calibration data and OBD documentation
- Progress monitoring and history tracking

6.5 Automation

- Extensive programming interfaces are available. They can be used in Visual Basic or C# programs to automate vCDM.
- The vCDM server offers web service interfaces for integration in corporate applications such as product life-cycle management systems.
- Updated HEX file names can be generated based on rules.
- Using scripts, parameter values can be checked and changed, e.g. to fill in logistics parameters automatically.
7  Supported File Formats
Calibration tools generate and require a number of file formats.

7.1  Object Files
Object files contain the ECU code and calibration data. vCDM can update this calibration data without having to recompile the ECU software.
Supported formats:
  > Intel-HEX
  > Motorola S-Record

7.2  Parameter Set Files
These files transport the calibration data in a physical form, a representation which corresponds to the numerical and graphical display in the calibration tools.
Supported formats:
  > DAMOS DCM
  > CSV/CVX
  > MSR PaCo
  > ASAM CDF 2.0
  > CANape PAR
  > MATLAB m files

7.3  ECU Description Files
ECU description files contain the structure of the ECUs. These files are necessary for transformation of the data between object files and parameter set files.
Supported formats:
  > ASAM A2L
  > CANape DB (read only)

7.4  Report Formats
vCDM generates different types of reports. Depending on the purpose of the report, the data can be generated in a format for further processing, such as Excel, or more static formats such as PDF.
Supported formats:
  > Excel, Word and PowerPoint
  > PDF
  > HTML
File extensions for the formats can be configured in any desired way. Other formats may be added upon request.

8  Training Classes
As part of our training program, we offer various training courses and workshops on vCDM at our classrooms in Stuttgart and locally at our customers’ locations.
You can find more information on individual training classes and dates at: www.vector-academy.com