You will find the figures mentioned in this article in the German issue of Automotive Electronics beginning on page 44.

Auf solider Basis
– Effiziente Entwicklung von Diagnosefunktionen im Automobil

On a Solid Base

Efficient Development of Diagnostic Functions in the Automobile

In an effort to meet the challenges posed by the growing importance of motor vehicle diagnostics, in recent years Vector Informatik GmbH and DaimlerChryler AG have expanded their strategic partnership in developing diagnostic tools. This relationship is based on many years of collaboration in the 1990s related to networking tools for CAN between these two companies, each with headquarters in Stuttgart Germany. Vector and DaimlerChrysler now have tools developed and customized for the special area of motor vehicle diagnostics. Application of these tools involves more initial effort, but in the final analysis it proves to be extremely effective in terms of quality and cost.

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1 Introduction

At the end of the 1990s DaimlerChrysler gave new direction to its diagnostic development tools to accomplish future tasks. One important goal was to make the new tools easier to use and understand, and data relevant to diagnostics were to be described in a uniform format. This was the only way to assure a high level of acceptance in its use by all involved business units and partners, including ECU and software suppliers, and to assure re-usability of the data.

In support of this effort, DaimlerChrysler consolidated and focused its diagnostic know-how with its GSP/TD Center (Center for Diagnostic and Flash Technologies). At this center, new diagnostic and flash concepts are developed comprehensively together with their associated processes for corporate-wide implementation in development, production and service. Furthermore, the center also offers corporate-wide support in introducing the concepts, processes and tools in these different business areas.

2 Universal Implementation of Diagnostic Functions

As partners in this process,the diagnostic experts at Vector Informatik designed a tool solution based on the "Single Source Principle". That is, all diagnostic functions are specified formally just once in machine-readable XML description files, and all users can then use these data universally.

Since DaimlerChrysler wanted to preserve its use of the DIOGENES description format and its proprietary run-time system CAESAR (internal DC project name for Com-

mon Access to Electronic Systems of Automotive Requirements) in Development, Production and Service, Vector designed its CANdela diagnostic product line (CAN diagnostic environment for lean applications) with the flexibility required to integrate OEM-specific export formats too.

Besides DaimlerChrysler, Vector's strategic alliances with OPEL and Claas (producer of agricultural machinery) also influenced the development of these tools. In the meantime Vector has also entered into working relationships with companies such as Fiat, Ford and many automotive suppliers worldwide. Today, CANdela tools are used in nearly all countries with automotive and supplier industries. These tools give users significant support in acquiring and editing diagnostic data, and exporting them in various data formats. The acquired data can also be used to automatically generate diagnostic software for ECUs.

3 Saving Time by Frontloading

The governing principle of the diagnostic development process at DaimlerChrysler is to obtain a comprehensive and dependable database by creating a complete specification very early in the process. This database prevents misunderstandings and errors in working relationships with suppliers, and the need for optimization cycles is avoided for the most part as well. As soon as DaimlerChrysler selects ECU suppliers for a development project, engineers from Development, Production and Service begin to define diagnostic functions for the ECUs together with these suppliers.

The user-friendly input interface of CANdelaStudio, the requirements engineering tool, allows suppliers and ECU developers create the diagnostic specification in the form of a formal description. Representing the basis for this description are so-called templates that contain the requirements for the diagnostic protocol and the specific requirements and data of the vehicle model. The GSP/TDE department, as the development-oriented department at the Center for Diagnostic and Flash Technologies, coordinates and checks parameter configurations based on internal DaimlerChrysler standards and guidelines. Then the specification is automatically generated from the formal description in Microsoft Word format. This is how DaimlerChrysler ensures that ECUs produced by different suppliers will satisfy all requirements in the same way. Whenever a new ECU sample is delivered its diagnostic specification level can be clearly identified.

DaimlerChrysler obtains data for its internal DIOGENES format by Export from the ECU description in CANdelaStudio, **Figure 1**. The DIOGENES data are transformed into the run-time optimized binary format CBF (CAESAR Binary Format), and the next step utilizes these binary data to parameterize testers. Since a new variant is described within the CANdela file whenever a diagnostic change is made to the ECU, customized test environments can be prepared immediately for the latest ECU samples.

Diagnostic tester functionalities are also included in the Vector Tools CANoe, **Figure 2**, CANape Graph and CANdito. If ECU specifications exist the user can test ECU samples using these tools.

With the constantly rising number of electronic functions in the vehicle, the ability to perform diagnostics on them is becoming increasingly important. Shifting diagnostic software development to early development stages ("Frontloading") prevents "last minute" development of diagnostics of inferior quality from flowing into the ECU software.

4 Developing Quality

The use of CANdela is firmly anchored in DaimlerChrysler's development process. The goal is to not only have the ECU supplier develop diagnostic functions, but also supply the associated formal descriptions. In doing so, besides using internal DC diagnostic development testers to implement and verify data descriptions, they can also rely on proven tools of the Vector tool chain to develop high-quality ECUs and description files. The goal here is to have suppliers fully test the diagnostics before submitting new ECU samples to DaimlerChrysler.

To further enhance software quality, DaimlerChrysler is requiring suppliers to use standard software components in implementing diagnostics in ECUs. Such components can be automatically generated from the CANdela data using Vector's ECU diagnostics software component CANdesc (CAN diagnostic embedded software component). The automatically generated component allows ECU producers and OEMs to achieve a uniform implementation of the diagnostic protocol across products.

After the supplier has implemented the software in the ECU and tested it, DaimlerChrysler conducts tests of all diagnostic services based on the diagnostic description. DaimlerChrysler engineers export the relevant parameters from CANdela to the DIOGENES format. Afterwards, the data are converted to the run-time optimized CAESAR Binary Format and are fed into the automotive OEM's proprietary testing tools, **Figure 3**. Mercedes-Benz now develops nearly all CAN-based ECUs in this manner. The CANdela and DIOGENES combination is also being used at Smart and MMC (Mitsubishi Motor Company). Lead projects have been started for the Chrysler, Freightliner, Detroit Diesel and Mitsubishi Fuso brands.

5 ODX - Standardized Exchange Format for Diagnostic Data

ODX is an international standard developed within the ASAM advisory body (Association for Standardisation of Automation- and Measuring Systems); it is currently awaiting final release as an ISO standard (ISO 22901-1) which is expected at the end of 2006. It supports automotive OEMs and suppliers in their work with various test tools [1].

In the data-driven, communication systems interconnecting ECUs in today's vehicle networks, engineers no longer develop diagnostic software in isolation. Therefore, individual data and description blocks from CANdela's XML database have been designed to be reusable. CANdela's future ODX Import feature will also make it possible to use diagnostic data from other sources

Another step by DaimlerChrysler will be to replace its proprietary DIOGENES format with the standardized ODX (Open Diagnostic EXchange) data format for formal description of diagnostic functionalities. By importing and exporting ODX data into and out of CANdela, DaimlerChrysler will guarantee a uniform diagnostic data description that is robust in its processes. The first application is already in use today in a joint development with a competitor.

ODX Export has been integrated in CANdela since the end of 2004, and it enables each automotive OEM and supplier to make a smooth transition from proprietary formats to a standardized exchange format. Nothing changes for the user at the computer screen or test bench in this process.

6 Equipped for Future Requirements

Vector attaches a lot of importance to diagnostic software and is therefore continually expanding the CANdela product line. This is because the significance of early integration and reliable verification of diagnostic and flash functions at suppliers will continue to grow. Automated hardware-in-the-loop tests are on the rise as well. Furthermore, Vector already supports the new UDS diagnostic protocol (ISO 14229) with its CANoe, CANape Graph, CANdito and CANdelaStu-

dio products. Mercedes-Benz will introduce this protocol sequentially in all of its model changes beginning with the next C-Class; it will replace the KWP2000 protocol that has been used until now.

7 Optimizing the Diagnostic Development Process

Using CANdelaStudio Mercedes engineers enter data about 6 to 7 times quicker than before, **Figure 4** [2]. It is extremely difficult to reach a conclusion regarding time savings over the entire development process; this is because processes are constantly adapting themselves. However, it is clear that diagnostic functions today are often already fully developed with B-Samples, while previously they were available at the earliest with C-Samples or even later. This is due to the user-friendly diagnostic description and early implementation. A positive benefit is that more intensive tests are possible, and these can be used to improve the quality of ECUs interconnected in the network even more.

Semi-automatic translation of diagnostic data in CANdelaStudio (e.g. into English, French, Italian or Japanese) guarantees a consistent work process, even with globally distributed development sites.

8 Implementing CANdela in the Flash Environment

The CANdela product line includes a CANdelaFlash editor that is available for describing flash data, see **Figure 5**. The actual software to be flashed, i.e. the HEX or binary data, must be supplemented by other information. Some of this information describes the software to be flashed, e.g. its software version and the size of segments. Other information relates to the process, e.g. part numbers. Since most process-related information is OEM-specific, CANdelaFlash templates are used to represent these individual properties.

In designing the user interface for CANdelaFlash, special care was taken to making inputs simple and user-friendly. Therefore CANdelaFlash and CANdelaStudio have similar appearances and user interface philosophies. It is easy to take flash-relevant diagnostic data acquired by CANdelaStudio and apply it in various ways.

DaimlerChrysler takes the flash data description in CANdelaFlash and by export obtains the data for their internal XML format named ECU_MEM/FLADEN. In turn, the ECU_MEM/FLADEN data are transformed to the run-time optimized binary format CFF (CAESAR Flash Format) and are flashed in the ECUs. In the future DaimlerChrysler will rely on the standardized ODX data format to describe flash data. This data format will replace the internal ECU_MEM/FLADEN format.

Today CANdelaFlash already supports export to the ODX format. In the next release an ODX Import function will also be available, so that flash data can be exchanged between suppliers and DaimlerChrysler in ODX format. This facilitates complete description of the flash data at an early point in time. Analogous to the situation in diagnostics, in flashing it is also necessary to describe the flash data early in the development process. These data are used to check whether the ECU can be flashed by diagnostics according to the flash specification.

9 Outlook

The uniform ODX standard offers the capability of reusing diagnostic data, i.e. later projects can have access to qualitatively mature diagnostic implementations and descriptions. In the future, standardization of the hardware interface (ISO 22900-2 MVCI Part 2: D-PDU API), diagnostic data model (ISO 22901-1 ODX Part 1: Data Model Specification) and interface between the run-time system and test application (ISO/CD 22900-3 MVCI Part 3: D-Server API) will make it possible to combine the best hardware on the desired run-time system and the best application for each type of use.

The universality of diagnostics that has already been achieved with CANdela and DIOGENES inspires visionary scenarios: For example, will it be possible in just a few years to automatically send fault reports to a central diagnostic center, evaluate the faults there, determine repair needs, initiate contact with the nearest service center and order the necessary replacement parts?

References

[1] The ODX Format Committee Draft of ISO/CD 22901-1 ODX Part 1: Data model specification ASAM (Association for Standardization of Automation and Measuring Systems, www.asam.net)

[2] Stimmler, S.; Rätz, C.: Vector Kongress 2002,: "Diagnostic Process for Future Requirements"

[3] Bodensteiner, F., Blanz, M., Feiter, G.: SAE World Congress 2002, ISO, SAE, JSAE, ASAM Standardization – A Joint Step Forward, "Common Interfaces and Architecture of Diagnostic & Programming Tools"

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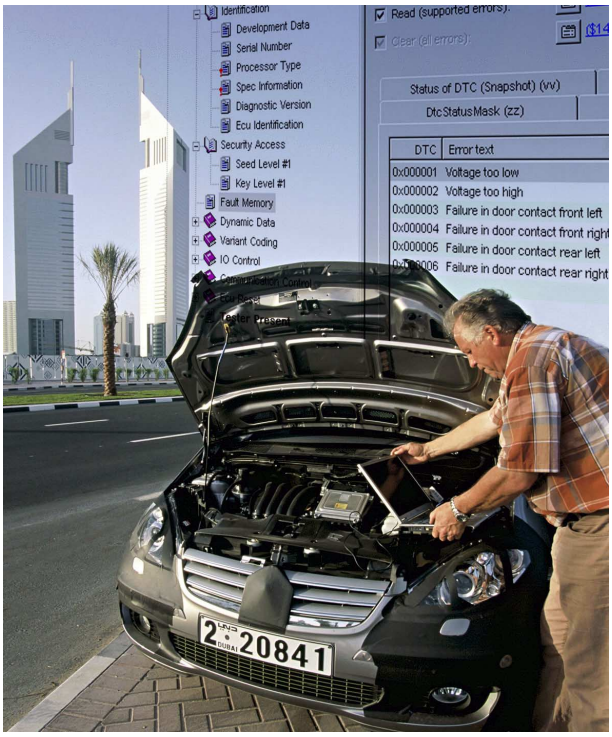
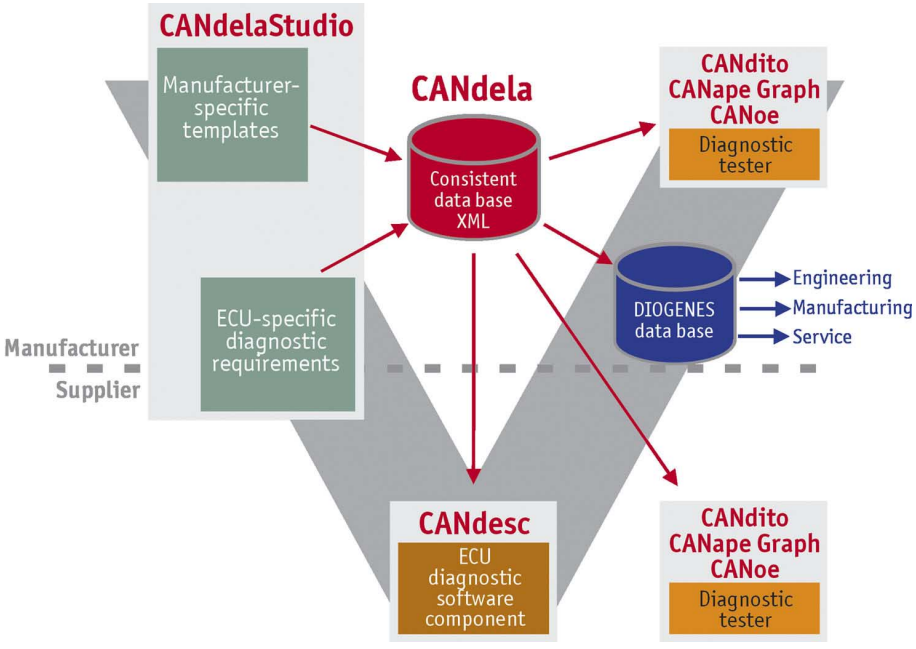


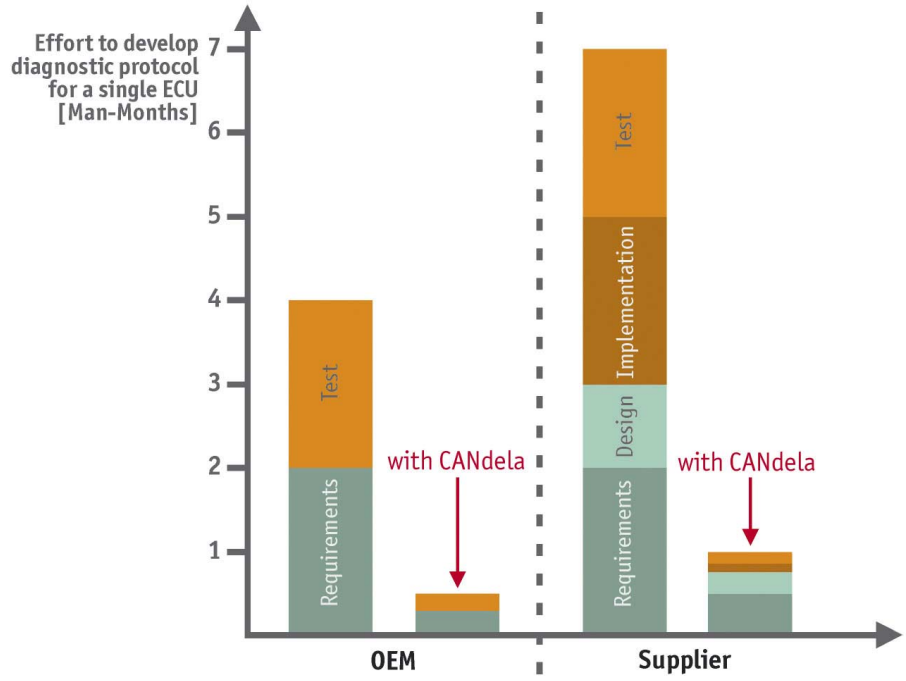
[Lead photo]



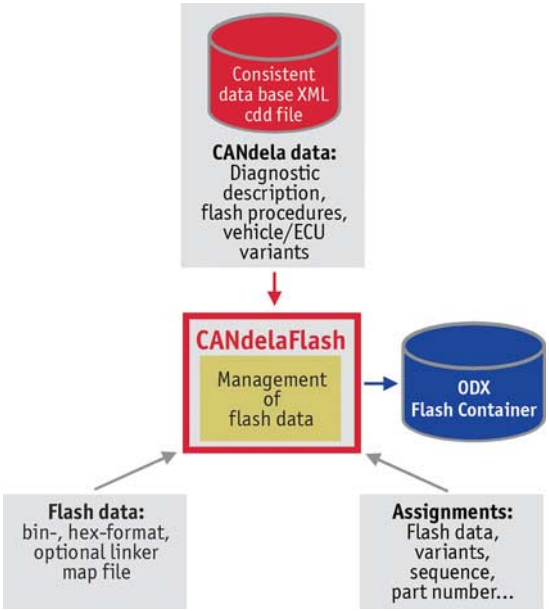
[Figure 1: Description of ECU-specific diagnostic requirements by CANdelaStudio and export of data to DIOGENES database via CANdela database]

[Figure 2: Testing diagnostic functionality with CANoe, the tool for professional network development]

[Figure 3: Electronic components for the A-Class vehicle are tested on an integration test bench]



[Figure 4: Cost savings by a factor of 6-7 due to description of diagnostic data using CANdelaStudio and the resulting quicker implementation of the diagnostic protocol]



[Figure 5: Management of Flash data and generation of ODX Flash Containers with CANdelaFlash]

Lead photo and Figure 3: DaimlerChrysler AG
Figures 1, 2, 4 and 5: Vector Informatik GmbH