Calibration Data Management for Porsche Chassis Systems

At chassis development, one of the fundamental challenges is to master the large number of variants in the calibration process. For example, the customer can select from 37 chassis options for the Cayenne SUV and from 16 variants for the 911 sports car. Porsche and AVL developed a sustainable calibration data management system, which comes from the combustion engine development and could be integrated smoothly into the existing tool landscape.

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DEVELOPMENT STRATEGY

Whether Cayenne or 911 – the maximum spread between performance and driving comfort is the main driver of Porsche's development engineers. The development strategy to achieve this is to build on a perfect mechanical chassis as well as to keep improving the vehicle dynamics and the comfort by electrical control systems [1]. This makes it possible to solve or to compensate the trade-off in an optimal way and to fulfil the sometimes contradictory demands.

The quality standards for the software of control systems are high. They do not only refer to the functions. Equally important is a high-quality data entry of the controller software, thus a good quality of calibration: Only the right tuning allows taking full advantage of the new technologies. A reproducible and consistent calibration for every single vehicle variant is essential for the quality of the overall system. Just like defective functions, mistakes in the process and thus in the final calibration can have fatal consequences. And, even smaller inconsistencies can mean that the ambitious development goals cannot be achieved.

CHALLENGES IN THE CALIBRATION PROCESS

The main challenge in the calibration process at Porsche is the extremely large number of variants resulting from the combination of different engines, transmissions, bodies, equipment features and drive concepts. Porsche offers, for example 37 chassis variants for the Cayenne Sport Utility Vehicle (SUV) to meet the customer's requirements. For the 911 sports car, the customer can choose between 16 derivatives. In addition, drivers can customise the vehicle's driving character by a drive mode selection. For all these derivatives and their specific characteristics specially adapted data sets have to be generated. Every data set has to be processed in a reliable and traceable way and calibrated for each particular variant.

The adaptive functions of the Porsche chassis are distributed among many control units. They are working on the principle of "peaceful coexistence", that is the control systems are stand-alone, but networked with each other. Usually one

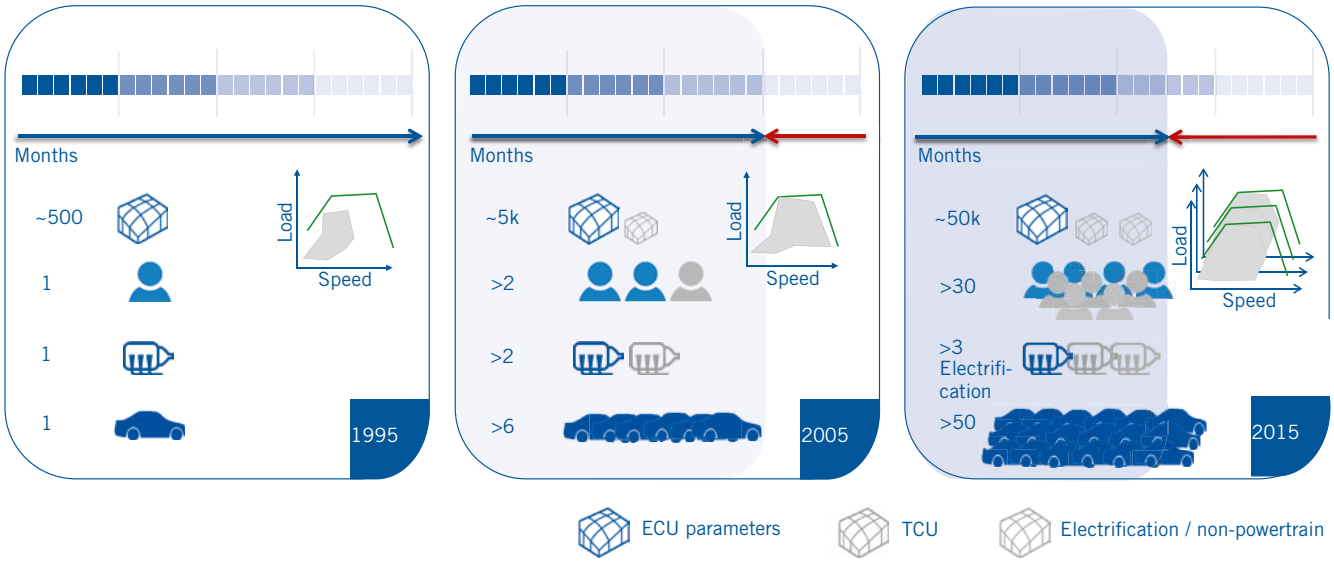

FIGURE 1 Strong increase of parameters, variants and functions in engine calibration – motive for introducing a data management system (© AVL)

expert team is responsible for one control unit. They are working in the office, on the test bench and, largely, on the test track. The work of these teams and of external development partners has to be merged time and again during the development. The special challenge of this part is to harmonise the control systems and to avoid negative interactions. Plenty of parameters have contradictory objectives because of the overlapping effects of the different systems. The parameterisations found can be quite contradictory in the context of the overall vehicle. These conflicts must be resolved by taking into account all individual objectives.

At the end of a development period, which lasts about two or three years in chassis calibration, a vast amount of data has accumulated, but only the last data set of a respective variant may be transferred to series production. The responsible persons have to make sure that all parameters have been calibrated and checked for correctness. They also have to verify if all parameters still have the values that have been defined for series production.

MANAGING CALIBRATION DATA IN THE RIGHT WAY

Until a few years ago, the calibration data of Porsche's chassis development department were managed manually. The data sets of the control units were saved decentralised – for example in Excel tables – and exchanged by e-mail. The administrative efforts for data management were extensive – and it was foreseeable that this effort would rise with the increase of systems and parameters. Moreover, the manual management of data was not very reliable: In particular, the data managers, who are responsible for merging the data, had problems to ensure the data consistency until the release. Under the pressure of deadlines, it was difficult to control the calibration progress while struggling with different data types and names.

Looking beyond departmental boundaries induced the solution. Twenty years ago, powertrain development was confronted with similar challenges [2]: The number of functions and calibration parameters (labels) in the engine control units increased enormously and had to be processed by a growing number of calibration engineers, **FIGURE 1**. Powertrain development has responded to this by using professional calibration data management systems. They help to coordinate the work and to achieve a complete calibration data set at every point of the development without painful mistakes in the parameterisation.

In this way, since 2012, the powertrain development at Porsche has been using the Creta calibration data management system by AVL List GmbH which ensures a traceable and flexible calibration process. During the last two years, this system has also been applied to manage the chassis calibration data at Porsche. During their daily calibration work all team members use the central data management system to check their data in and out. The automatic version management makes it clear at a glance, which parameter set has been assigned to which vehicle variant. When the working results are integrated into the system, the data is automatically checked for any conflicts resulting from wrong or double parameterisations. Clearly defined responsibilities or rules will solve these conflicts. Additionally it is checked if the entered parameters are within the defined limits. This means it checks if their values are not too high or too small or if the monotonicity properties are kept. Formal checks done by the system, for example the proof of naming conventions, are protecting the user from incorrect entries.

CALIBRATION PROCESS AT PORSCHE

The Creta calibration data management system is supporting the application process at Porsche from the first parameterisation to the final data release: The initial data set is, if possible, deduced from an existing series calibration of a similar project. The calibration has not to start from scratch and the knowledge from finished projects can be reused successfully. The system offers helpful support

when doing the initial parameterisation. Already completed projects are searched for attributes that are similar to the actual project. New parameterisations are generated automatically by means of data mining algorithms based on existing application data.

The (n-1) status is allocated to the development teams by defining the project members and the responsibilities for the labels. The calibration engineers make the first parameterisation on the basis of PC simulations. The working results are always checked in and out in the system. When the calibration engineers are going to the test track, they can access the data – regardless of where they are –, for example during summer and winter tests abroad. The workshop employees who are responsible for the setup of the prototypes can also access these data via the system in order to prepare the vehicles for the tests.

Since the implementation of Creta, Porsche developers are able to generate their own data sets. This brought more flexibility to their work. Previously, the data sets were generated by the suppliers and flashed on the ECU afterwards. The suppliers delivered the software on the ECU with a temporary data set. This data set was optimised by the calibration engineers at Porsche and sent back to the supplier as a parameter file. The supplier generated the required ODX data container out of this file. This process led to delays and higher costs.

Now, through the integration of Creta management system into a new Porsche tool chain, the engineers can generate the data containers on their own and flash them on the control unit, **FIGURE 2**. Time-intensive loops between car manufacturer and supplier are not necessary any more. In collaboration with the engineering services provider IAV GmbH, this function has been realised by setting up a so-called add-on in the system. Similar to an app in a smart phone, users can extend the functionality of Creta by generating/adding such an add-on for their own requirements, in this case for the automatic generation of the uniform group-wide ODX container format. Another example for the use of an add-on is the automatic sending of e-mails when the calibration engineers have checked in a new status into the system.

The data manager merges all results that have been checked in by the teams at fixed times and proves the overall result. Conflicts that may occur, for example, because different values are optimal for the specific objectives of the single teams, are de-escalated or solved. Afterwards, the data manager releases the new data to the further processing via the system, **FIGURE 3**.

SUMMARY AND OUTLOOK

The central use of the AVL Creta calibration data management system in the chassis development at Porsche supports a transparent and flexible calibration process. The scalable solution could be integrated smoothly into the existing processes and tool landscape. Although the system has its origin in engine and transmission calibration it can be customised without any problems to the working methods of chassis calibration. The ease of use and the automatic protection against wrong entries make sure that engineers intuitively find correct parameterisations. Therefore the persons in charge can trust their data quality.

In collaboration with AVL and the engineering partner IAV, Porsche is working to anchor its variant handling and configuration management more firmly into Creta. The variants are planned to be mapped in the tool on the basis of defined mixing instructions. This will allow to directly connect the respective ODX container with the respective variant. A flashable data set for a specific variant can then be generated out of the latest parameterisation by simply pushing a button. It is also planned to connect the system to the group's own Product Lifecycle Management (PLM) system. This will allow,

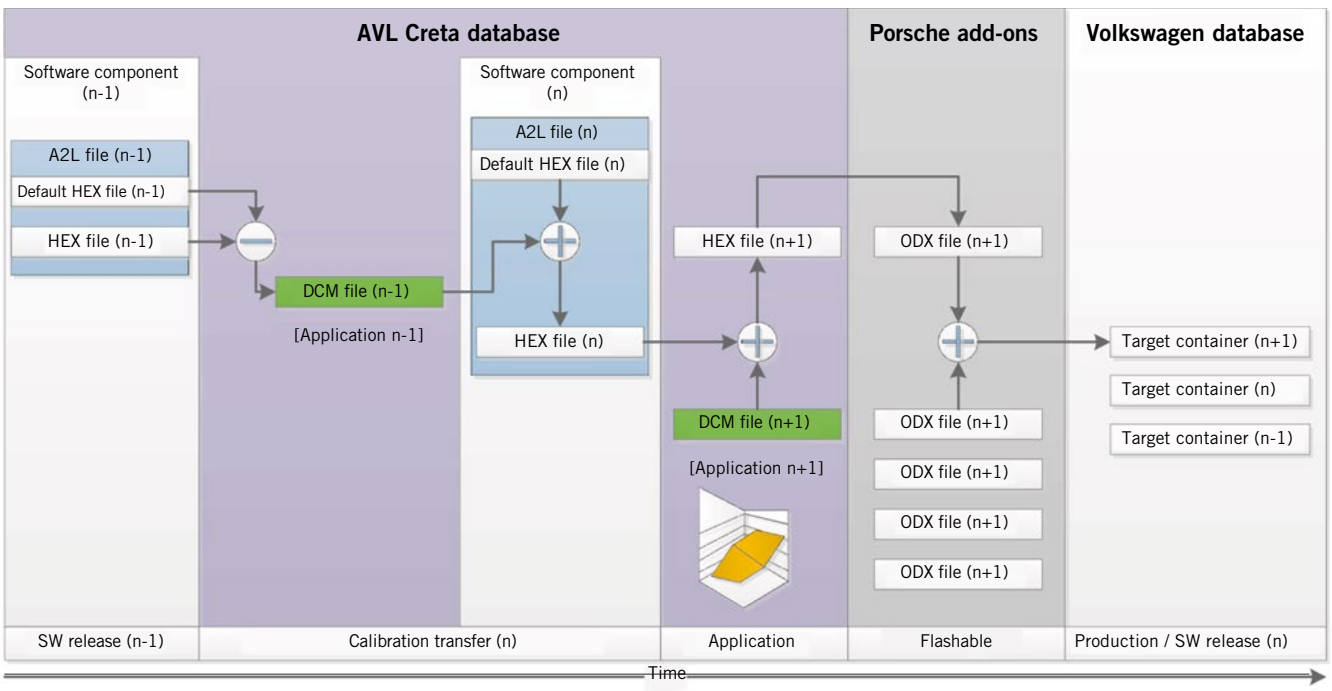

FIGURE 2 Calibration workflow for a software release at Porsche (© Porsche)

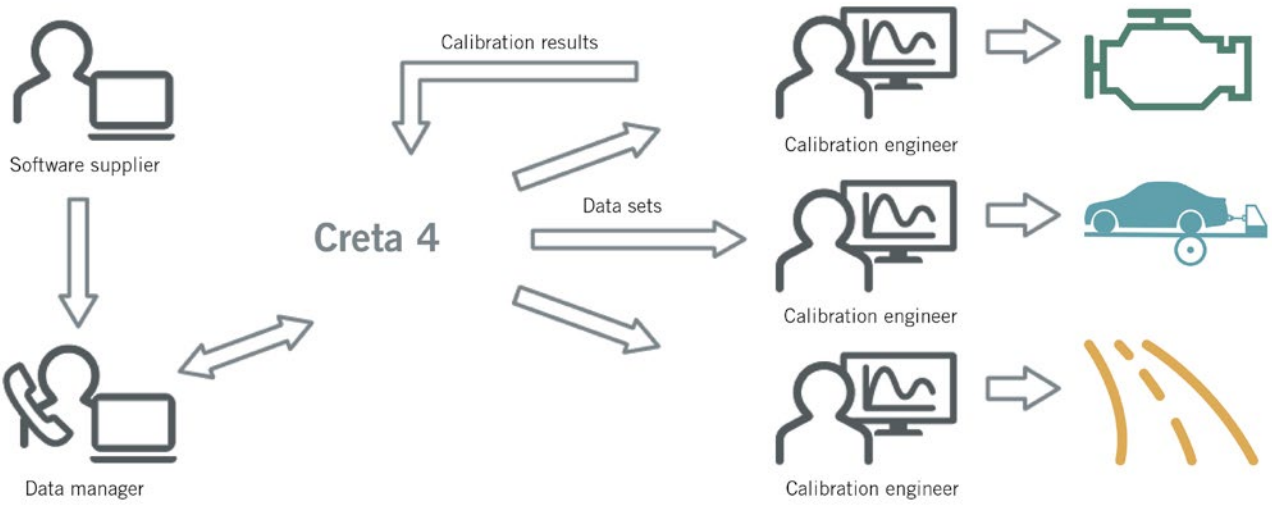

FIGURE 3 Calibration process with data manager (left bottom) and Creta 4 calibration data management system (© AVL)

among other things, to import the generated ODX files into the PLM data base and to remind the application persons in charge of process connected deadlines.

The professional computerised calibration data management, as it has been presented here by Porsche and AVL, will become more and more important in the chassis development; this is not only because of the nearly endless number of functions, labels and variants. The main future challenge will be to support the people working with these data in the best possible way. They have to keep deadlines and work together in teams, which go beyond the boundaries of departments due to the increased networking of the systems.

A current example at Porsche is a new all-wheel ECU that will be parameterised by two teams from powertrain and chassis development in the future. It will be very beneficial that both groups are already working with the same calibration data system. The Creta system offers a common platform, which allows to coordinate and merge the work of all involved persons across different locations, functions and domains on the test track or in the laboratory.

REFERENCES

[1] Reichenbach, M.: Maximale Spreizung zwischen Performance und Fahrkomfort. Interview with M. Harrer. In: ATZ 117 (2015), No. 6, pp. 22-25

[2] Schick, B.; Paulweber, M.: Model-based development methods – What can chassis and powertrain development learn from each other? In: Proceedings of 6th International Munich Chassis Symposium 2015, P. Pfeffer (Ed.), Springer Fachmedien Wiesbaden, 2015, pp. 35-36

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