Volkswagen is master of its simulation data

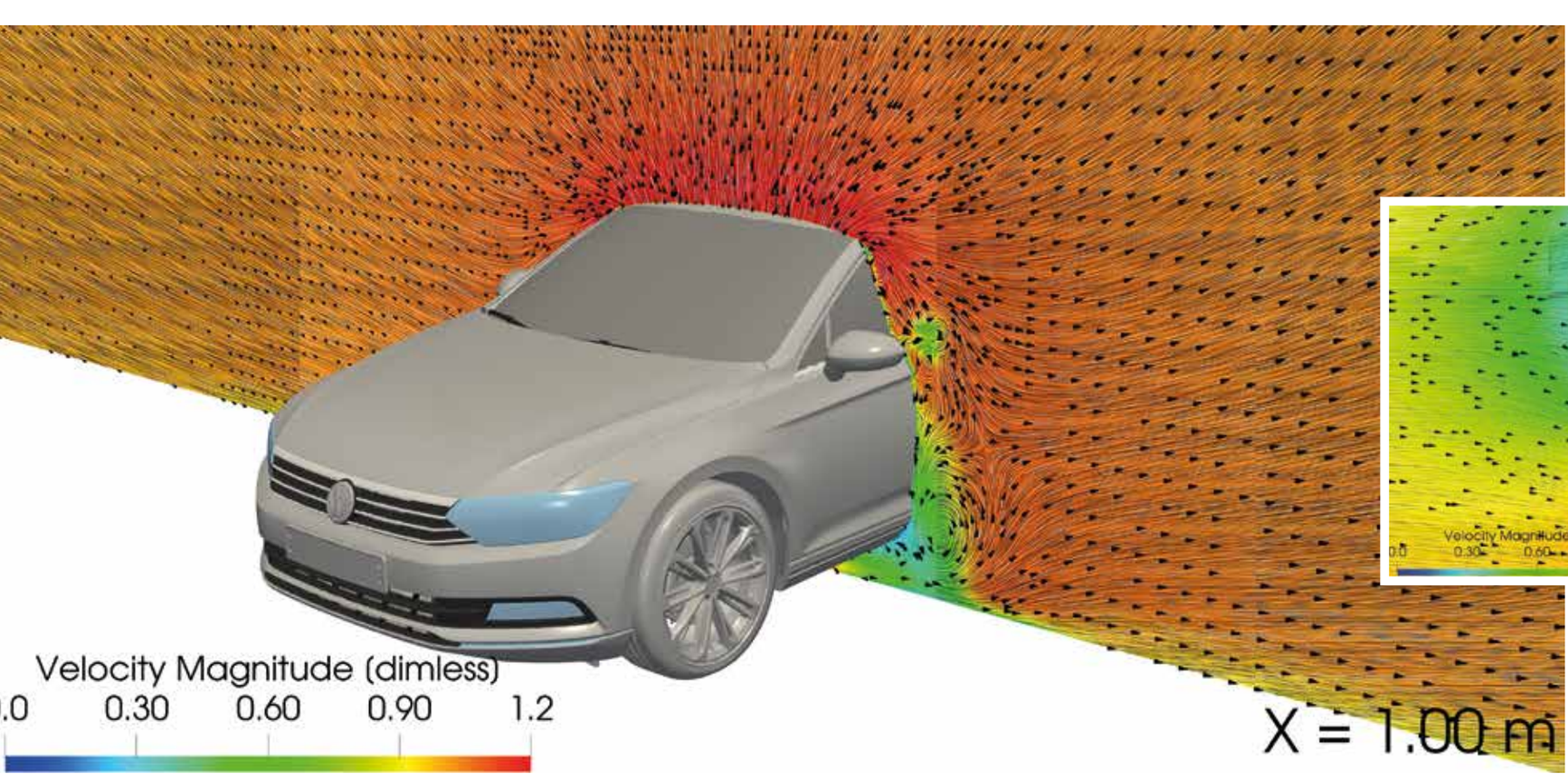
Volkswagen Passenger Cars (Volkswagen Pkw) uses PDTec's SimData Manager for structured storage and collaborative work on projects with CAE data. The calculation engineers can work completely aligned with compliance specifications without any effort on their part. The effort involved in project coordination is significantly reduced because everyone involved has a complete overview / SDM as a door opener to the professional use of machine learning.

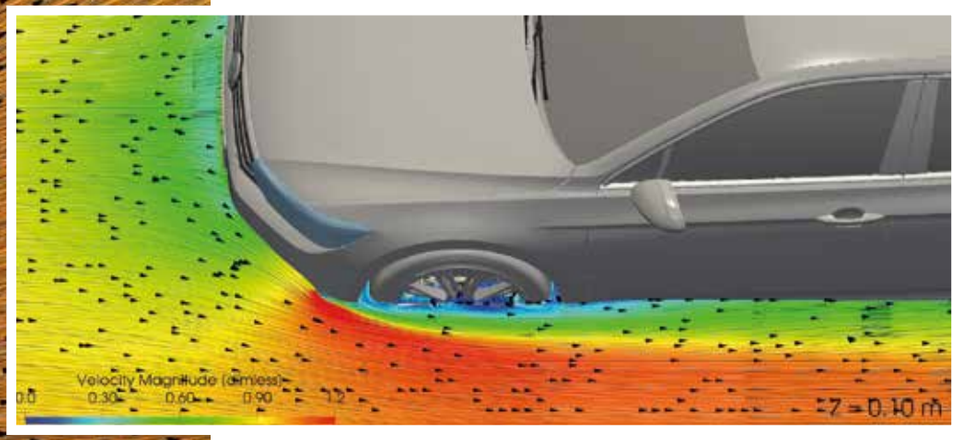
By BERNHARD D. VALNION

Functional validation based on digital prototypes has become indispensable in modern automotive development. And the hunger for more and more CAE (computer-aided engineering) is almost immeasurable, as the example of Volkswagen shows (see text box). However, so much simulation and calculation cannot manage without dedicated management of data and processes. Not only with regard to the enormous amounts of data involved, the underlying processes also have to be carefully designed and executed in a stable and compliant manner. This is why the Volkswagen Pkw brand is avant-garde in terms of the roll-out of a simulation data management system (SDM system), not only within the VW Group but also among the automotive OEMs.

To begin with, a note that will help to classify the system in the following: In the Volkswagen Group, there are three installations of SimData Manager from PDTec AG in Karlsruhe — one at Porsche, one at VW and one at Audi. This allows the targeted utilization of synergies, for example to bundle requirements and commission PDTec to implement them. The installations were not introduced at the same time, so they build on different IT infrastructures and fulfill different tasks. The success story began with the implementation of SimData Manager at Porsche (1).

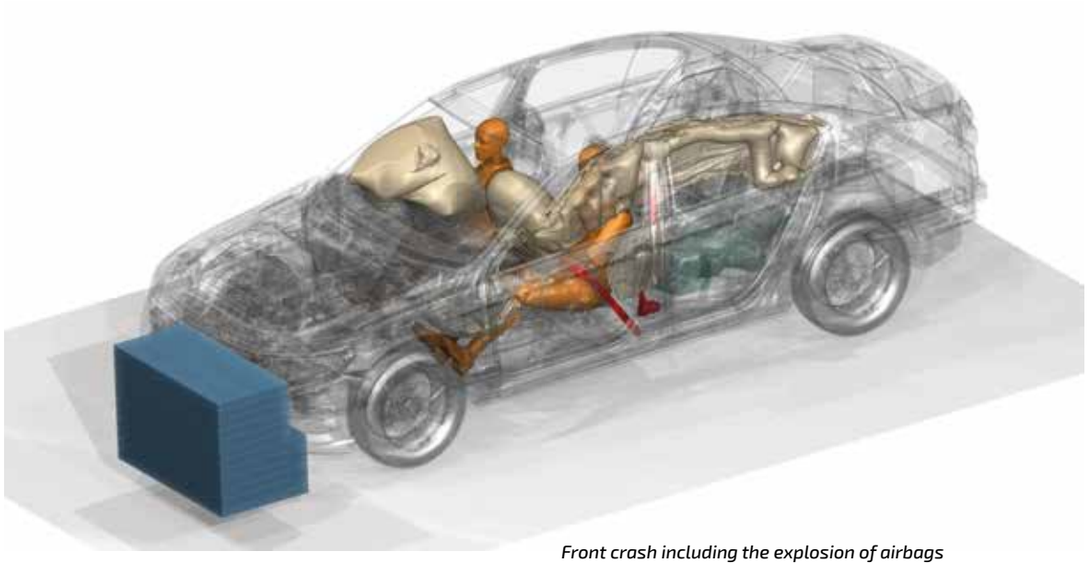
In an interview with this magazine, Dr Marcus Renner and Dr Kilian Lackhove, representing the SDM-using departments of Volkswagen Pkw Technical Development, explain the process chain and the underlying data management for calculation and simulation. As product owners, they represent the entire user community within VW. After all, a larger, double-digit number of calculation disciplines are now integrated via SimData Manager. In dialog with the users, the doctor of engineering (Lackhove) and doctor of physics (Renner) formulate the requirements and prioritize them in the form of a roadmap.





CFD with ESI OpenFOAM

Pictures: Volkswagen



Front crash including the explosion of airbags

Picture: Volkswagen

SimData Manager impresses with its modular structure

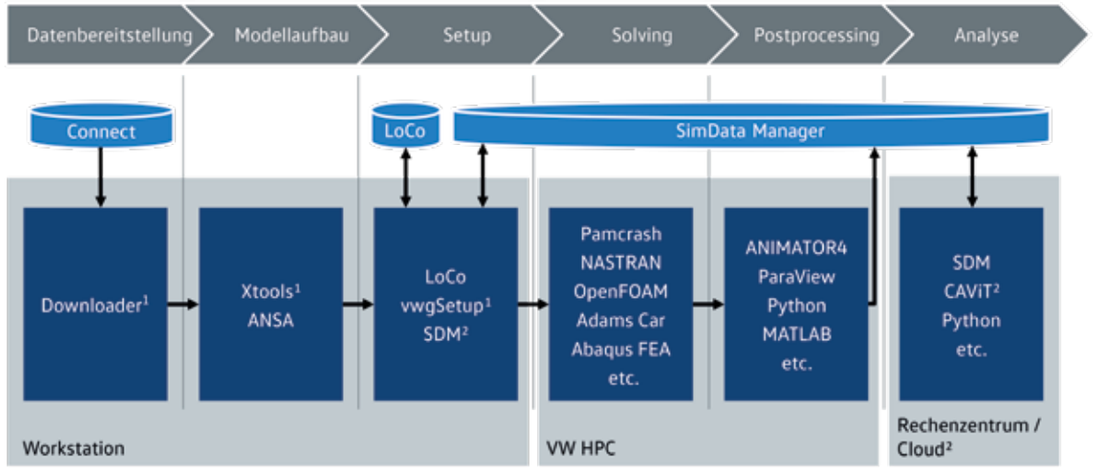
Basically, SimData Manager allows efficient, continuous access to all simulation-relevant data throughout the entire CAE process chain enabling bidirectional tracking in the sense of complete data consistency — from the underlying CAD data to the final simulation reports. PDTec has designed the SDM system in a modular way. There is a CAE offline client (for exporting and importing CAE models), a CAD import client (for importing CAD data and PDM structures), CAE part manager (for reusing CAE objects and creating work packages for service providers), to name just a few SDM modules. Volkswagen is pushing the modularity of its complex CAE process infrastructure further, using a selection of SimData Manager's components to sharply delineate data and process management. "At our company, SimData Manager serves as an organized storage system for the calculation inputs and the calculation results, and supports efficient cooperation within the teams and with partner companies. In the case of crash calculation, however, there is a special situation: For Crash, namely, the calculation inputs are assembled via another system. I assume that CAE workflows will always involve the use of several data management systems," says Dr Renner. As with other automotive OEMs, the data management infrastructure for CAE is not black and white, as is typically the case for MCAD or ERP. It is all the more remarkable that SimData Manager was selected by VW as the central CAE repository with a clearly defined roadmap. SimData Manager is used to manage the results of various CAE calculation processes. The CAE process chain at VW is divided into the following steps:

- Data provision
- Model setup
- Setup
- Calculation (solving)
- Result preparation (post-processing)
- Evaluation / Analysis.

The first three steps can also be summarized as 'preprocessing'. The starting point for CAE is design data from the Volkswagen PLM system.

CAE process chain at VW

After the CAD data has been derived, the model setup (surface and solid models) and meshing is performed. This setup takes place on workstations, and the actual calculation is finally performed on the VW High Performance Computing (HPC) cluster. Result processing also takes place in the HPC. The data is then stored in SimData Manager. Dr Lackhove adds: "To set-up the crash simulations, we use another data-holding system that is primarily used in the area of body design and safety." Only after HPC post-processing does it go to SDM. There, further plots are generated, for example for value comparisons. Summing up: SimData Manager holds the input data (pre-processing) and the output data (post-processing).



Schematic representation of the CAE data flow at Volkswagen Pkw. SimData Manager can be seen on the right as a data management system

Source: Lackhove / VW 2023

Every simulation result has a history

The Volkswagen Group has a classification system for documents called 'KSU'. KSU provides for various main classes, for example for 'temporary' data. Temporary data has a lifetime of up to four years and can also be changed during this time.

Simulation results with a higher maturity come into higher KSU classes. These data are frozen after four years, so they cannot be changed. After the retention periods specified in the KSU class have expired, they are automatically deleted. Or, to put it another way, every simulation result also has a lifecycle.

The KSU system is implemented in SimData Manager as part of customizing based on the lifecycle status functionality. Dr Lackhove elaborates on what has been described: "At VW, we understand a simulation as a 'document'. And all these details in it have a certain level of maturity, which is mapped in SimData Manager Lifecycle Status."

The data is incrementally upgraded by the user as part of a KSU table. However, if a calculation fails, it remains in the temporary data class and is then automatically deleted in a timely manner. The KSU table makes statements about the time period after which data is deleted. The KSU class of a data set in turn depends on the expected use, for example for the current or even a subsequent vehicle project.

"Our computational engineers run many simulations, of which they only want to continue using a certain part. These are given a higher lifecycle status. For example, 'fixed' can no longer be downgraded to 'approved'. The data is locked, so at most you can upgrade it," explains Dr Lackhove, and Dr Renner adds, "Today, our highest class has a retention period of ten years." This was a pragmatic decision, says the IT expert, because technically SimData Manager can also manage higher classes. If acceptance tests are ever

actually carried out on the basis of virtual prototypes, this would be a reason to stockpile calculation results for longer.

Access rights and data visibility are associated with each lifecycle status: Initially, a run can only be viewed by the originator (calculation engineer) and project manager. From the 'Working' status, this data can also be viewed by all other team members of the project.

Successful replacement of the legacy system

During the migration from the predecessor SDM system to SimData Manager, all relevant meta data such as the KSU class were migrated. Particular attention was also paid to the completeness and correctness. In view of the huge volume of data, this was an enormous task that was successfully accomplished. Volkswagen currently has a three-digit number of active users who benefit from the SDM system on a daily basis, partly because it is very stable even with very high data throughput.

High productivity

Currently, SDM imports in the five-digit range are carried out each week, with a focus on crash simulations. With such volumes, the need to introduce as many automatisms as possible and to keep the processes as stable as possible quickly becomes clear. All critical SDM components are therefore distributed redundantly on physical hardware. Multiple SDM vault and application servers, as well as com servers for data import, are available. You can think of this as a kind of 'multi-threading', just as it is used in GPUs for rendering. Dr Lackhove says: „In this way, we can absorb peak loads, guarantee maximum availability and enable maintenance during ongoing operation." The SQL database on its own, as the central component for storing metadata in SimData Manager, cannot be parallelized.

Where does the greatest exchange of CAE information take place in terms of multi-disciplinarity and data storage? Dr Lackhove answers:

"Specifically, I can imagine that the prepared geometries and grids are reused in different simulation disciplines. There is potential here for further synergies in everyday computational work. In any case, SimData Manager is prepared for this split of work. The implemented rights-role system ensures this."

"In simulation data management, flexibility is key to keep up with ever-changing processes, methods, and tools."

Dr Kilian Lackhove, Simulation Data Management, Technical Development, Volkswagen Pkw

"With virtual approval, the importance of simulation data management will increase significantly."

Dr Marcus Renner, Simulation Data Management, Technical Development, Volkswagen Pkw

Mass storage system

The extensive use of simulation and computation calls for high-performance data storage. When using SimData Manager, simulation data is currently hosted via a GPFS mass data storage system on a time-based basis using tapes and disks. Newly ingested data resides on disks with fast access. After a period of time, they are automatically swapped out to tapes. Since a tape robot has to be used to retrieve older data, this access takes a comparatively long time. This is to be shortened considerably by migrating completely to a Simple Storage Service, also known as S3.

As a general rule, files stored via SimData Manager will no longer be modified. Modified files are uploaded again and exist as another version of the data object. "We currently cannot apply machine learning to older data for an AI because access would simply be too slow. However, this will change with the new S3 infrastructure," says Dr Lackhove, and Dr Renner adds: "Basically, we consider our SDM system infrastructure as a gateway to new insights. New management systems can be added to the existing ones. In connection with this, there may also be redundancies in data storage. We consciously accept this, because the different requirements from the various departments would make monolithic data management infinitely slow."

In the future, PDTec will launch a fully native cloud version. But a so-called S3 cloud vault is expected to be installed at VW before the end of this year. The mass data storage ('vault') will be operated locally. The SDM installation, however, will continue to run on-premises as before.

David and Goliath pull together

Dr Renner pays tribute: „It's remarkable how a relatively small IT vendor like PDTec has managed to set up an SDM solution that can handle such large volumes of data as those generated at Volkswagen. After all, the VW installation of SimData Manager already manages well over a petabyte of data." Dr Lackhove is also enthusiastic: "We expect a scale-out from the cloud version so that the current hardware-related redundancies will be a thing of the past. The beauty of it is also that we can then basically use the same environment in operation as PDTec runs for its prototype versions." After all, the network infrastructure and network zone concept

of the respective customer is difficult to replicate by the vendor. But with a native cloud connection, this would no longer be an issue.

The team meets every other week as part of a jour fixe, where current topics from operations are talked through and further developments discussed. PDTec's key account manager acts as the first point of contact. In addition, an exchange with VW's SDM users takes place every four weeks. A PDTec expert is also present at these meetings. Dr Renner explains: "It is very important to create transparency in order to bring up the actual needs of the end-users. We named a key user for each discipline in our company. They are the contact persons for me and my colleague Dr Lackhove. The key users keep in touch with the users in their own discipline." As important as powerful, process-supporting technology is, in the end it has to efficiently assist engineers in their daily work. "An added benefit of SDM is that it's much easier to work with partner companies. And also with the company's own employees in the home office. For example, it is visible directly in SimData Manager whether a simulation has been completed. For the user, a lot of additional work is eliminated because the system organizes the data for them," says Dr Renner, citing further advantages.

What's next — AI is around the corner

In the near future, vehicle derivatives are to receive road approval purely on the basis of simulation results. To this end, talks are already being held with the relevant authorities, such as the Federal Motor Transport Authority, about virtual vehicle approvals. "SimData Manager will manage the calculation results and, via our process automation, we will establish the necessary traceability to be able to provide continuous proof of how the data was generated." There is no question, therefore, that dedicated SDM increases the 'innovation space' in which engineers can design their solutions.

Added to this is the possibility of being able to comprehensively support AI scenarios through SDM. This is because it is crucial to compare only truly relevant data sets. The structured data storage in SimData Manager makes exactly this possible.

References

(1) „Ein Mehr an Analyse verlangt nach einem Mehr an Management", d1g1tal AGENDA 1/2022, 54–59, Baden-Baden

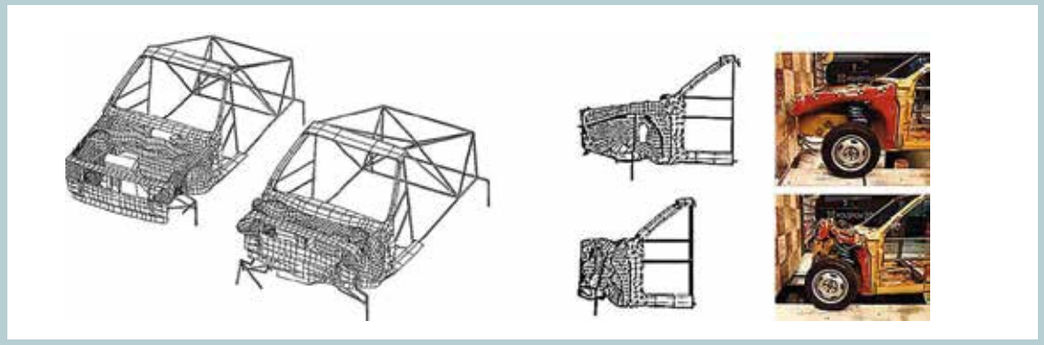
(2) „Das Goldene Zeitalter für Berechnung und Simulation ist eingeläutet", Nachbericht zum ESI Forum Deutschland 2019, d1g1tal AGENDA 1/2020, 78–85, Baden-Baden

(3) „Mission Zero", d1g1tal AGENDA 3/2021, 12–20, Baden-Baden

Avant-garde in terms of simulation

The avant-garde includes movements — mostly in the 20th century, by the way — that have a strong orientation towards the idea of progress. Volkswagen belongs to this genre, because it is one of the pioneers with regard to the widespread use of simulation and calculation. The goal is thus to continue to push the quality of its products to the top, entirely in the spirit of a sustainable orientation to the future. In 1985, the world's first crash simulation was carried out on the Polo model in Wolfsburg. Using PamCrash code and 5 661 finite elements, an impressive 800 hours of computing time were required to simulate a physical frontal impact with convincing accuracy. A year later, however, the job was done in just twelve hours (2). Not only the dramatic reduction in the time required for the computational runs are an expression of the considerable progress made in engineering and IT in general. Added to this are methodological advances through the integration of several physical disciplines simultaneously in the calculation runs and the leap in the size of the calculation models. In conjunction with this, the level of detail increased significantly. While there were around five million elements in the VW Golf 6 in 2013, there were already ten million in the development of the ID.3. Even tires that lose air during a crash or the fuel sloshing back and forth in the tank are included in the analysis — and, of course, there is now a virtual human model at the volant. Whereas in 1985 a maximum of two crash jobs were performed per day, today there are 40 000 such calculation runs per week!

In other words, CAE used to be merely an accompanying check to the tests with expensive physical prototypes, which were considered the measure of all things in function assurance, but in the meantime simulation and calculation have become an integral part of the daily business in vehicle development at the VW Group and, of course, at other automotive OEMs. The common goal: Zero Physical Prototyping (3).



Since 2019, Volkswagen Group Innovation has formed the basis for a global innovation ecosystem for sustainable and client-oriented innovations. The cross-border cooperation and the close connection between different sites enable new ways of technology development in the deep-tech area

Source: www.volkswagenag.com/de/group/group-innovation.html