Virtual Product Development with an SDM System Demonstrated by Playing with LEGO® Car Models as Examples

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Abstract

CAE processes are an integral part of virtual product development since they allow to assess the product properties without expensive physical prototypes. Setting up a continuous CAE-process, which involves every aspect, is a complex task. It usually involves managing the requirements for the desired product, working with CAD data to create a virtual prototype, meshing the geometry for preparing the finite element analysis, dealing with a multitude of sparse CAE solver files to create actual simulation runs, submitting jobs to the HPC or cloud for solving and subsequent monitoring of the simulation runs, handling the result files, deriving key-results and finally creating reports for the simulations. For real world car development projects, where hundreds of experts must work and collaborate in such a process, this can be an overwhelming task.

To explain the basic principles how such a workflow could look like, we created an example using simple LEGO® car models. With this we are going to show how requirements and targets as well as milestones are defined upfront and based on these requirements how a prototype can be created using a CAD system and how CAE-models are derived from the CAD data for different simulation disciplines. For the purpose of this demonstration, we will showcase crash and car to car simulations as well as a CFD example and how to manage these simulations in the SDM system. With respect to the results, we will explain how key-values, curves, pictures and movies can be extracted automatically and used for interactive web reports. Furthermore, we show how to generate a design of experiments directly within the SDM system and how tools for data analysis can be used on all data gathered within the SDM system. Another aspect of this process is the seamless integration of physical test results for analysis and validation purposes. Finally, the key results will be compared to the initially set target values to monitor whether the requirements are already met. With the outcome of the assessment, another development cycle can be started to improve on requirements that are not fulfilled until the final product is ready for delivery.

The goal of this presentation is to give a small excurse into the complexity of virtual product development and how SDM systems can help to manage the challenges by using simplified example models.

1. CAE LEGO® Models

Given that in our professional lives we are dealing with highly sophisticated crash models on a daily basis, it seems obvious that we instantly thought we should be able to simulate a crash of a Technic Porsche Model after seeing a video of a physical crash of this model on YouTube [1]. However, it turns out that creating and handling a FEA model for this is not as trivial as one might expect.

For example, when we initially tried to download and mesh the CAD data for the Porsche model, we found that dealing with such a huge number of parts in a model is rather challenging. Especially the problem that the same bricks were used at multiple locations in the model repeatedly, made it obvious that we needed to use a more structured approach to handle the simulation models. Starting with small models we build up a process within an SDM system where we use a library of meshed parts which can be automatically assembled to a complete FEM model directly from the CAD data. In the end, by using this approach, we were able to assemble the whole Technic Porsche model which consist of 2704 individual bricks and in total 18 million elements and with the existing test videos from ADAC[1] we were able to validate the simulation models.

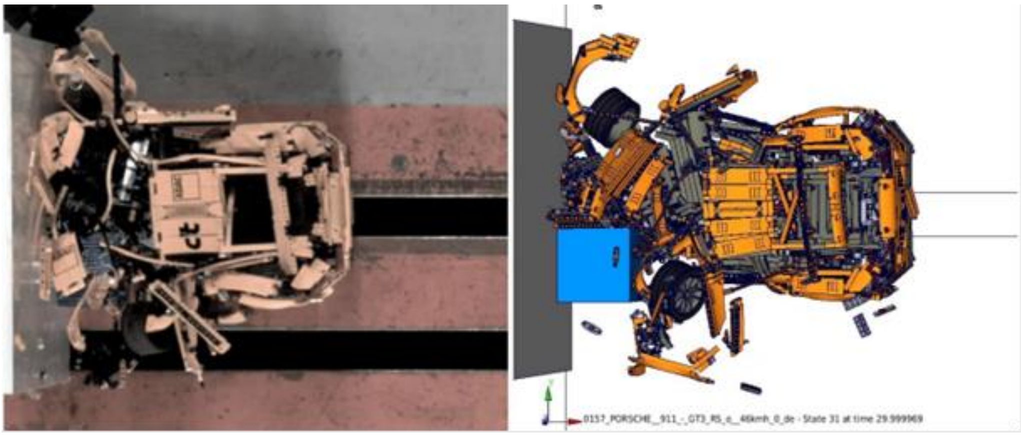

Figure 1: Physical crash of Porsche 911 Technic (#42056) model conducted at 46kph with an 40% offset barrier compared to simulation at 30ms

The simulation process and the setup of the simulation models has been described in detail in our publication at the 12th European LS-DYNA conference [2].

2. Project and requirement management

In virtual product development the initial step is to create a project and define project responsibilities and milestones. The project specific requirements are taken out of a general database with technical targets. With that project configuration at hand, the assessment of test results and continuous status tracking and documentation becomes possible.

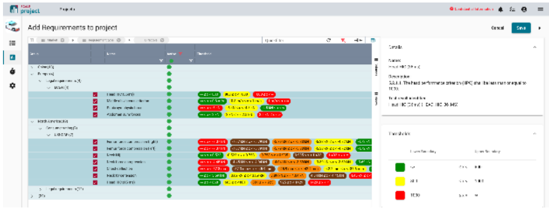

Figure 1: Definition of project and requirements

For our demo example we created a small project with various models and individual target values. Exemplary the requirements for the level of destruction as well as the maximum acceleration for front crash load cases are configured. For the load cases we considered velocities of 20 and 30 kph and three different barrier overlap configurations.

3. CAD and CAE Data Management

When it comes to simulation, the goal would be to have a CAE process that can directly work with the CAD data. However, in currently ongoing simulation projects of car crash simulations, the process of getting from a CAD model to a simulation model still involves a lot of manual steps. Some possible approaches to overcome this are to automatize as much as possible of the meshing process, reuse already meshed parts whenever possible and distribute the workload to many team members. All of these can be addressed with SDM systems.

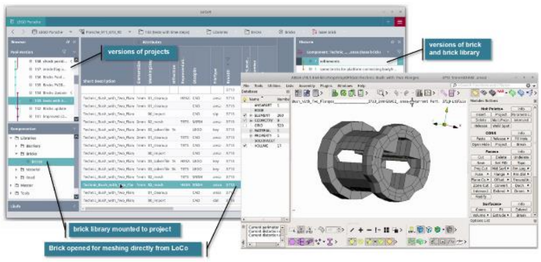

Figure 2: Meshing of CAD data and managing a library of meshed bricks in SDM

For our demo setup we imported the CAD data directly into the SDM system and integrated the CAD software LeoCAD such that users can work directly with the CAD models.

For the meshing, each brick is meshed only once and maintained together with the original geometry in a library of meshed bricks. These meshed bricks are used upon model assembly to automatically create the solver models from the CAD models. In consequence the users can work directly with the CAD models and start simulations right away without any further meshing.

4. Results and Data Analysis

Being able to do a quick review of the results, even without having to download the complete result files can save valuable time. To address this the process is setup in a way that key-results such as curves, pictures and videos are extracted right after solving is completed on the HPC system and stored in the SDM system. All of these can then be reviewed instantly after the simulation finishes from the web interface of the SDM system.

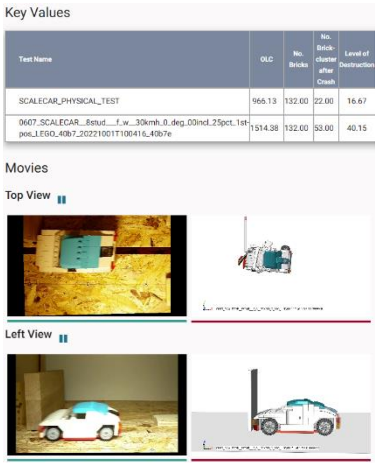

Figure 3: comparing physical with simulation results

Beside from comparing simulation results with other simulation results one major use case is to compare simulation results with results from physical tests. For this purpose, it is possible to upload test results into the SDM system using the ISO-MME format.

Within the SDM system there are many archived simulation results. This makes it possible to use methods of data analysis to investigate trends within the simulation results. Furthermore, the parameterized models within the SDM system make it very convenient to create DOEs to study the effects of numerous parameter constellations.

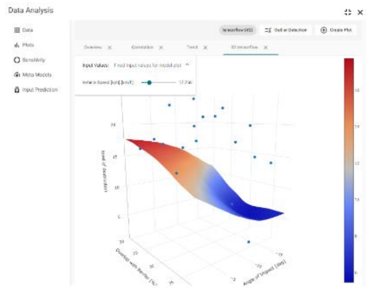

Figure 4: metamodel for level of destruction

For example, for the crash models, we have parameterized the vehicle velocity, the angle of impact and the overlap to the side with the barrier. Once all jobs are terminated and stored in the SDM system scatter plots, sensitivity analyses, outlier analysis or even a TensorFlow machine learning model can be created and 3D visualizations for these meta models can be generated.

5. References

[1] “LEGO® crash tests by ADAC with a Porsche model” www.youtube.com. https://youtu.be/dCPWPj4JHqg (May. 23, 2017).

[2] M. Thiele, T. Gerlinger, D.Koch, A. Haufe, N. Karajan, T. Weckesser, P. Glay, A. Saharnean; Simulation Data Management from CAD to Results with LoCo and CAViT for Large Scale LS-DYNA® LEGO® Crash Models; 16th International LS-DYNA® Users Conference 2020