A Great Team, Numerical Simulation and Experimental Testing

Figure 1 – Eng. Peter Pirro

Numerical simulations are increasingly used in most industries. So why do companies still spend so much money for experimental testing? I would like to give some explanations about the reasons of building expensive test equipment, which is much more expensive than software for numerical simulations, and how to utilize the different methods.

Will the customer be satisfied with the performance and the quality of the product? This is one of the major tasks during the development process. Today, numerical simulation and experimental testing are used to qualify products in different stages of the development process. Simulation models or experimental models are designed to simulate the real behavior of the product in the hand of the customer. In this context, it should be emphasized that experiments try to simulate customer usage, too. Both methods have to be validated.

In the early phase of the design, the numerical simulation has the great advantage of no need for a physical prototype. Virtual models are the prototypes of the simulation engineer. Together with the designer and other contributing members of the development team, all the existing knowledge of customer needs of the product can be included in the model. Feeding experiments are mostly needed to supply the simulation with the necessary parameters,

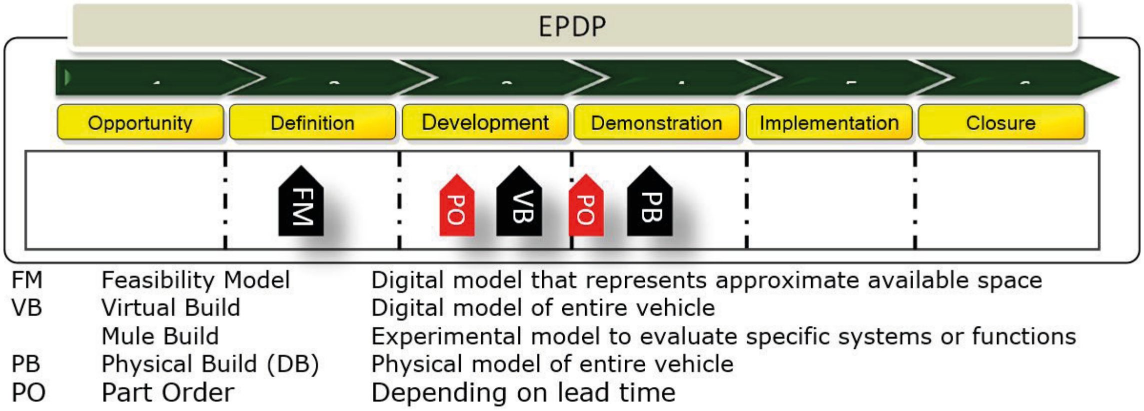

Figure 2 – The way to use simulation and experiment in the right sequence

like boundary conditions and loads. This should be done, starting on the subsystem level, depending on the knowledge of the product and the confidence level of the simulation.
Simulation uses basic physic principals and the used virtual model should represent the product. The results of the simulation depend the restrictions and loads. Here, a high confidence level is needed, because of the strong influence on the simulation result. Experimental tests can help to understand these effects and can increase the confidence in the output of the simulation.
If the test and the simulation engineers work as a team, both parties will benefit. Loading conditions and restrictions measured on a test bench give the input to the simulation model and the model gives back visibility of effects, that is how changes of conditions will influence the output. Experimental tests and simulations should be as close as possible to reality, to drive the outputs to be more close to real customers usage.

Especially in the early phases of the design, simulations help to sort out ineffective ideas very fast and lead to a first optimum of the product, and this without expensive physical prototypes.
The further the design evolves to the next development phase, the more physical prototypes play an important role. They naturally include a lot of special details, which are not included in the simulation model.
Some managers think that everything can be simulated, but there are a lot of arguments, that this cannot be done efficiently. Issues like the complexity of the physical interactions, the time to build and verify these complex models, and the visibility of the real influencing parameters of the product usage can be "road blocks" for "only" simulation. Complementary experimental testing is therefore the right choice. Real products have details included, which are not "designed", but produced.

How to use simulation and experiment in the right sequence and for the right reason will be explained in the next section (see Figure 2).
In my previous job, we executed a development process named Enterprise Product Development Process EPDP.

We can distinguish between two phases in early EPDP with different demands.
The first one is Virtual concept evaluation and it lasts until the Part Order or design freeze for Virtual Build. Turnaround is crucial in this phase for speed of concept generation, to maximize concept quality and to allow for DFSS (Design for Six Sigma).
Further improvements could be done by frontloading of concept evaluation to TDP/CCDP (Technology Development Process/ Critical Component Development Process) and we were working on continuous analysis efficiency improvement to gain speed.
The second phase is Virtual Verification. Competency gap closure is crucial here to reduce the need for full vehicle mules. We need high confidence level analysis and DFSS to achieve 100% Test FPY (First Pass Yield) with expensive physical prototypes.
Our approach to competency gap closure was described in the first chapter; I will now give an outlook on the continuous analysis efficiency improvement efforts.

Process improvements have already been achieved to date.
In the past, the usual builds were FB (Functional Build), DB (Durability Build) and LPB (Limited Production Build). The design, build, test, break, redesign cycle was standard. Analysis was used, but was not optimally integrated into the design process.
Today the FB is replaced by a VB (virtual build) and a Mule plus system or component tests. Analysis is an integral part of the development.
The current EPDP process allowed us to start to analyze based on the feasibility model or space claim. VB/Mule and PB have part order milestones, which we needed to take into account for the delivery of analysis results depending on part or system lead time.

Conclusion:
Numerical simulation and experimental testing can be a great team if their different strengths are used for the right tasks and in the right phase of the development.

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