Write your review and reflections about the article

The article “Simulation-Based Engineering for Industrial Competitive Advantage” by Loren Miller describes the Goodyear-Sandia success story of transitioning from real life testing to simulation-based engineer to achieve a competitive edge. The author emphasizing obstacles that were overcome and critically asks the question of how to learn from this experiment to benefit the US industry today.

The two companies, Goodyear as a tire manufacturer and Sandia as a nuclear weapons laboratory, seem to be very different but their efforts could be combined in a way that benefits both parties. Additionally, the risk was kept low as the beginning stages of the collaboration were almost entirely funded by the Department of Energy. Both factors were crucial to the success. Another important factor was the good timing of starting the effort which ultimately led to an outstanding advantage over all competitors.

On the way to achieve this success many obstacles had to be overcome. Goodyear struggled financially and was dependent on the DOE funding. Furthermore, the problem of simulating tire performance is of complex nature and engineers were initially skeptical of the new simulation-based approach. For the new approach to succeed in practice, subjective validation criteria had to be put into mathematical equations. Additionally, computational resources were scarce and growth required to carefully plan ahead which resulted in a challenge for IT to overcome. On top of these practical issues of intellectual property had to be overcome as well.

The author agrees that the SBE switch is very important for the US industry to be internationally competitive but there needs to be some further discussion of how to approach the issue. According to him all the factors leading up to the outlined success story have to be considered carefully for future advances.

Do your own research and explain the following terms

Finite Element Method

The Finite Element Method is a numerical technique to approximately solve complex and large physical systems, mostly used by engineers. The basic idea is to divide the system into elements using mesh generation. Each element represents a classical PDE boundary problem

that is solved using traditional methods from computational physics, afterwards the solutions for each element are combined by minimizing the approximation error for the entire system.

Mesh Generation

In this context Mesh Generation is the process of dividing a large physical system into small, discrete spatial volumes (that can move over time as they are usually coupled to specific objects of interest within the domain). Individual cells can vastly vary in size and geometry, which is important when taking computational time for simulations using the mesh into account.

Verification and Validation

In the context of computer software and engineering, verification usually refers to checking whether or not the stated problem has been solved correctly in terms of logic and maths. In this case this could for example mean debugging the software. Validation however is concerned with making sure the formulated mathematical problem is actually appropriate to solve the overarching real world problem. In this context this would mostly mean cross checking the simulation results with real life tests and making sure the model accurately describes reality.

Petaflops

Simply defined as a unit of computing speed equal to 10^{15} floating-point operations per second.

Exascale Computing

Exascale Computing involves computer systems capable of performing at least one exaflop, so 10^{18} floating-point operations per second.