ROLE OF SIMULATION GOVERNANCE IN THE DEMOCRATIZATION OF SIMUALATION – ACCELERATING THE ADOPTION OF SMART SIMULATION APPS

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Democratization of numerical simulation through the development and dissemination of expert-designed *Smart Engineering Simulation Apps* is gaining momentum; however such apps must satisfy the technical requirements of Simulation Governance to ensure the level of reliability needed for widespread adoption.

What are Smart Engineering Simulation Apps?

By Smart Engineering Simulation Apps we mean FEA-based software tools for standardization and automation of recurring analysis tasks and process workflows for use by non-specialists. Designed to fit into existing analysis processes, simulation apps capture institutional knowledge, best practices and design rules, and can be archived and shared by engineering groups at different geographic locations to produce consistent results by tested and approved analysis procedures. When designed to meet the requirements of Simulation Governance, simulation applications for engineering use are "smart" because their embedded intelligence enables simple, accurate, efficient, robust, and reliable simulations with built-in quality assurance.

What is Simulation Governance?

Simulation should be understood as the imitative representation of the functioning of one system or process by means of the functioning of another. We are concerned with the functioning of mechanical and structural systems and their imitative representation by mathematical models.

Because mathematical models formulated to represent some aspects of physical reality are generally complicated, they must be solved numerically. Numerical simulation seeks to find an approximate solution to the exact solution of the mathematical model. To support engineering decisions based on the approximate solution, it is essential to have assurance that the errors of approximation are reasonably small.

Simulation Governance is the exercise of command and control over all aspects of numerical simulation through the establishment of processes for the systematic improvement of the tools of engineering decision-making over time. This includes the proper formulation of mathematical models, the selection and adoption of the best available simulation technology, the management of experimental data, solution and data verification procedures, and the revision of mathematical models in the light of new information collected from physical experiments and field observations.

The key elements of simulation governance are Verification, Validation and Uncertainty Quantification (VVUQ). Verification is concerned with the accuracy of the numerical solution of the mathematical model. Validation is concerned with objective assessment of the predictive

performance of mathematical models by comparing simulation results with the outcome of experiments, taking into account the effects of uncertainties on the data of interest.

What is the role of Simulation Governance in the creation of simulation apps?

In the application of established design rules, data verification and solution verification are very important. The goal is to ensure that the data are used properly and the numerical errors in the quantities of interest are reasonably small. Simulation Governance provides the framework for the development and deployment of engineering simulation apps which are ideally suited for standard analysis processes. They must be developed by FEA analysist for users who need not have FEA expertise; they must possess built-in safeguards to prevent use outside of the range of parameters for which they were designed; they must incorporate automatic procedures for solution verification; and must be deployed with detailed description of all assumptions incorporated in the mathematical model and the scope of application.

To ensure their proper use, engineering simulation apps must incorporate rules and automatic quality assurance measures. Estimation of relative errors in the quantities of interest is an essential technical requirement of Simulation Governance needed for the deployment of engineering simulation apps. One argument often used to justify not including solution verification is that the "user can always consult with an expert if the results are wrong". The problem with this argument is that if the assessment of the quality of a solution depends on the subjective opinion of the expert analyst, the same expert opinion is needed to determine when the solution is wrong. A non-expert user is not qualified to make that determination. Having an automatic solution verification feedback for all the quantities of interest however, allows non-expert users to consult with experts when the computed data does not converge to within the prescribed tolerance. Engineering simulation apps should not be deployed without objective measures of quality for all results presented to the user.

At the 2016 NAFEMS Americas Conference (June 7-9, Seattle, WA) there will be a Democratization track for those of you interested in learning more about engineering simulations apps. I hope to see you there and to have the opportunity to talk more about this exciting new development in democratization of simulation.

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