Incorporating historical data in a validation process

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Abstract. A validation process for a numerical model is usually built upon comparing results from simulation and physical testing. We suggest incorporating historical data into the validation process in order to reduce the need for both extensive simulations and dedicated validation experiments.

Introduction

The overall aim of validating a computational model is to establish confidence that it produces realistic results to predict the behaviour of a system in situations that are derived from its specified intended use. At one point in the process, model behaviour has to be evaluated against these objectives by comparing simulation results to measurement data obtained from a real system when both simulation and testing are conducted under nominally identical conditions. A recent guideline published by CEN recommends the use of full-field measurement data for the purpose of validating a numerical model [1]. The guideline demonstrated its usefulness in laboratory environments on different representative test objects [2]. Typically, the validation process is therefore presented in a flowchart that splits into parallel strands of activities for computational and experimental modelling and recombines with the quantitative comparison between simulation and experimental outcomes. While this approach is based on well accepted grounds [3], it is not viable in many situations in industrial environments, be it because of the high cost a test may incur for sub-components and components on a higher level of the test pyramid, or be it because the number of useful tests to cover the range of the intended use would be far too high to be practical.

Historical Data

Consequently, ways are sought to push towards virtual testing and to ideally obviate the need for dedicated validation experiments. The H2020 Clean Sky 2 Joint Undertaking project MOTIVATE [4] addresses “Matrix Optimization for Testing by Interaction of Virtual and Test Environments”. To incorporate this trend, the generic validation flowchart was redesigned [5] and is shown in its latest version in Fig. 1. The coloured boxes represent the processes involved. These include the well-known activities of “Modelling & Simulation”, “Physical Testing”, “Quantitative Comparison” and “Decision Maker’s Review” found in all validation flowcharts.

A key novel feature, however, are the processes to evaluate “historical data” early in the validation flowchart, from which several branches of the process originate. Hence, the development of the model takes priority, and routes to validation are open that bypass Physical Testing. In our presentation we will focus on these processes and relate them to the concepts of virtual testing and test matrix optimization.

In some cases, model validation can be performed through comparison with results from a model previously validated for similar conditions. Such data from simulations performed previously might be available from validation databases (historical data). However, only models of evolutionary design with incremental changes can be evaluated in this way, whereas this is not applicable for models with a radical design change. On the other hand, data from experiments performed previously and included in databases might also be available. These can lead to adequate confidence levels, if information on the accuracy of the experimental results is sufficient, and complete data are complete to describe the testing and boundary conditions. In such a case, the need for new experiments can be reduced. In turn, when a validation experiment may finally not yield a preferred decision for the use of a computational model, the data generated might still be useful in a different context or under more relaxed requirements of use. In such a case, the data should be available for later use and could be harvested in a further validation process.

Conclusion

It is felt appropriate to incorporate the use of “historical data” into the validation process to reflect the fact that industry is very cost-sensitive. The incorporation of the extended flowchart into an advanced structural test in an industrial environment, as it is currently undertaken in the H2020 Clean Sky 2 project MOTIVATE, would constitute a step up from Technology Readiness Level 4 to 6. We expect to update the CEN guideline to support its use in industrial environments based on the extended flowchart.

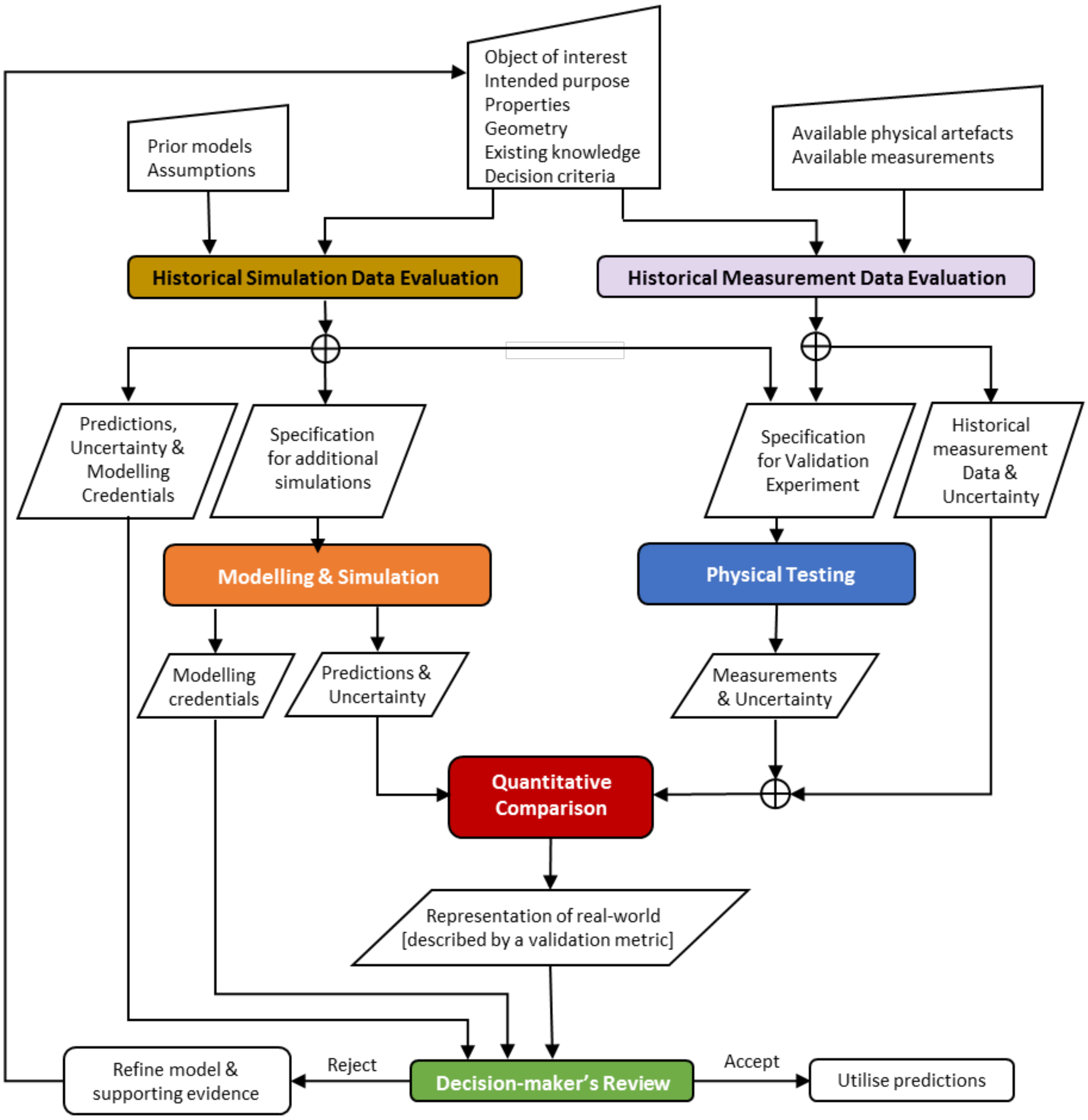

Fig. 1: Extended validation flowchart. The coloured boxes represent processes including the evaluation of historical data.

Acknowledgement

This research has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under Gant Agreement No 754660 (MOTIVATE). The views expressed are those of the authors and not the Clean Sky 2 Joint Undertaking.

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