A common workflow for the validation of simulations using datasets from point and full-field measurement techniques

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Abstract. A generic correlation workflow which can be applied to the comparison of data from both point and full-field measurement techniques for validation of finite element models has been produced. This workflow includes the consideration of uncertainties associated with data, and the long-term usability of datasets through the use of a Data Management Plan informed by the FAIR principles.

Introduction

Quantitative comparison and correlation of datasets is useful for a range of applications including the validation of computational models [1]. In order for simulations to be exploited in industrial environments, where they can be used to replace or augment current physical tests, they must be shown to be reliable through validation against appropriate measurement data [1], [2].

The ASME Guide for Verification and Validation in Computational Solid Mechanics (CSM) [1] and the corresponding standard [3] guide the design of simulations and experiments to determine if there is an acceptable agreement between the two datasets.

The ASME approach has been extended for practical engineering applications in the MOTIVATE project [4], producing a workflow which would lead a responsible engineer through the process of data collection, correlation and decision making [2], [5]–[7]. This protocol focusses on the comparison of data from full-field techniques such as digital image correlation with numerical simulations. However, a large amount of relevant measurement data is collected using point-source techniques (e.g., resistance strain gauges). Here, a generic workflow is developed which is applicable to the correlation of data from both point and full-field techniques.

Generic correlation workflow

A high-level workflow has been identified (Figure 1), determining which processes are common to correlation of both point-source and field data. It is important that for datasets from all sources, there is consideration of whether the comparison is sensible (i.e., are the datasets from the same region, are they of the same measurand) and that uncertainties are considered.

The detail of the processes which occur at each of these steps will be different for different datasets, so there will be decision points to lead the user through the correct pathway at given times. For example, the "Correlate" process will likely be different for point-source and full-field data, or for measurement data which has been collected as a time- or load-series.

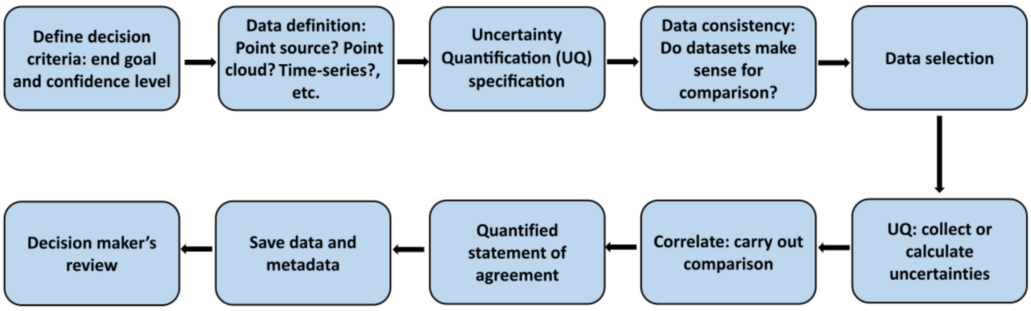

Figure 1. Correlation workflow summary for data from point source and full-field techniques.

Long-term usability of data

When expanding this high-level workflow, it is necessary to consider the long-term use of data and the outputs of correlation. The collection of measurement and simulation data is often time, labour, capital and/or computationally expensive. It is therefore important that the best returns on these investments are made. To increase the chance that a dataset can be useful for future applications, it is necessary that data is well archived, and well described. Adherence to the FAIR guiding principles [8], so that data is Findable, Accessible, Interoperable and Reusable is one way to achieve this.

For engineering datasets, data must be saved with sufficient metadata, the contents of which should be defined using a Data Management Plan before measurement or simulation design begins. This consideration is shown in a revised version of the MOTIVATE flowchart in Figure 2. The accompanying protocol, which details the steps to be taken at each stage, would also include explicit instruction of documentation steps where data should be supported with detailed metadata.

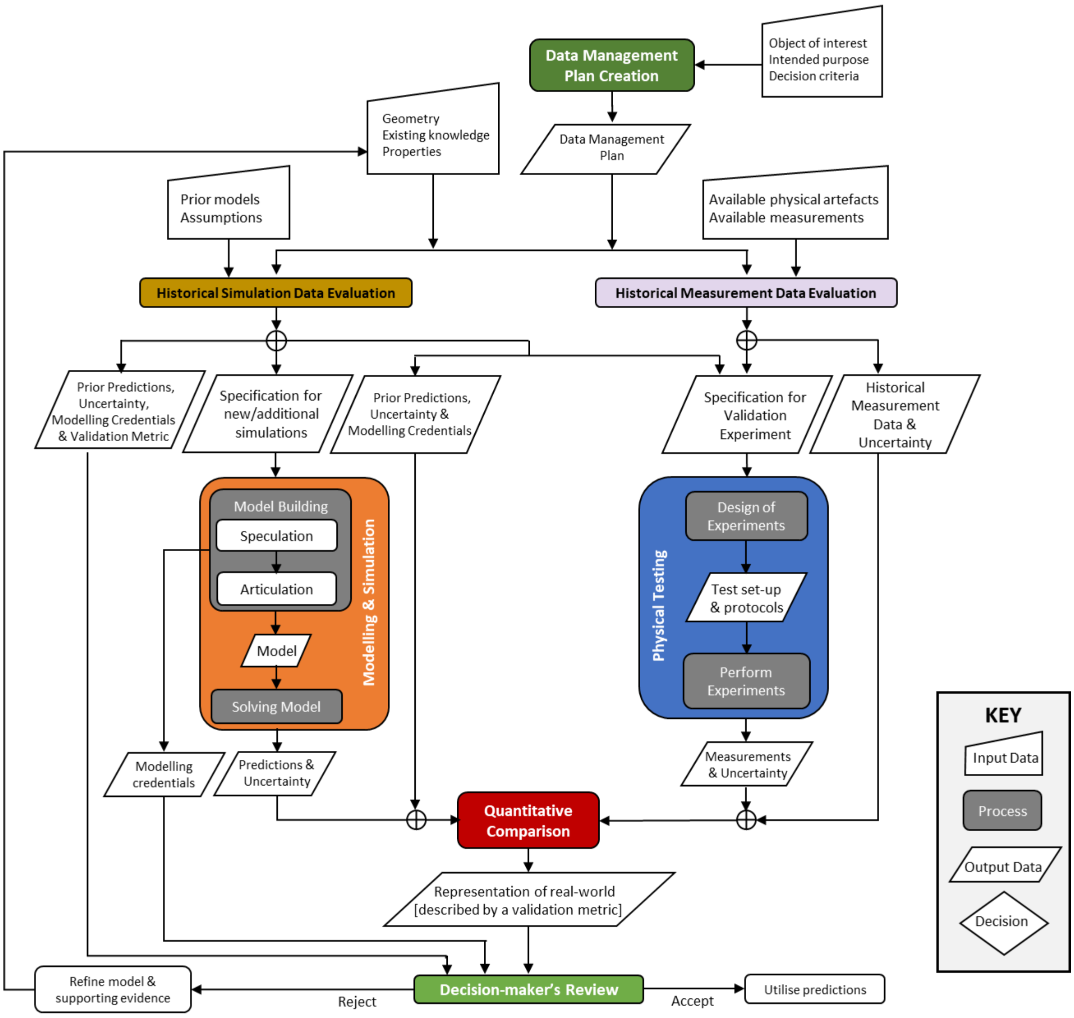

Fig. 2. Flowchart for validation of FE simulations, including consideration of Data Management. Differences between correlation approaches for point and full-field data would be expanded in the red "Quantitative Comparison" process. Adapted from [6].

Conclusion

A correlation workflow has been developed which combines approaches to data comparison for point-source and for full-field data, resulting in a consistent approach to the comparison of data from different sources. Combining this stream-lined approach to correlation with the informed re-use of datasets through data management planning would have positive financial and time-saving impacts on correlation processes for model validation and other quantitative comparison applications.

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