Simulation Data Management - Enabling Engineers to do More Engineering

Mark Norris, of the NAFEMS Simulation Data Management Working Group, Discusses the Challenges and Successes of SDM.

Keeping track of our simulation data and results becomes more challenging every year as the number of files we need to manage grows at an ever increasing rate. Audi (1) estimate that their analysts are generating a hundred and twenty times as many files as a decade ago while model granularity has grown by an order of magnitude. So we are all drowning in data. We can do more and more sophisticated simulations to more closely represent the physics of the problems we are studying. But the bad news is that this is going to create even more data and more complex, interlinked data sets. Simulation data sets are also becoming harder to manage manually. It's difficult to keep track of what we changed in a complex data set for each iteration that we made.

Technology for managing large simulation data sets has been around for a long time. The first COTS SDM platform was put into production by BMW(2) more than a decade ago. So there is now a substantial body of knowledge describing what early adopters have achieved. However the survey carried out by the NAFEMS Simulation Data Management Working Group found that SDM is not widely deployed, with less than half of all companies using any SDM at all. Neither were respondents using other types of systems to manage their simulation data. NAFEMS members cited a lack of evidence demonstrating the benefits of SDM for not adopting this technology, so the NAFEMS SDMWG has developed a White Paper on the Value of SDM to address this issue.

The good news is that SDM solutions can off load analysts of many routine data manipulation and data management tasks. Audi and BMW applied SDM to automatically document which input files were used in a particular vehicle simulation. They also automated the extraction of key results, the storage of these results in the SDM system and insertion of the key results into report templates. This has enormously reduced repetitive, tedious and error prone work, enabling engineers to do more engineering. The CAE guy rightly pointed out in last July's issue of benchmark that it would be really helpful to automatically create both a report and a presentation of a set of results. The core capability of an SDM solution to programmatically access the all simulation data in context enables any type of report or presentation template to be populated for any simulation or set of simulations. Several vendors now offer report generation modules for their SDM solutions.

I have avoided implying that reports can be created automatically because it's definitely necessary for the analyst to add their interpretation of the results. But it's great for the solution to perform the basic chores of extracting and inserting all the standard sections, curves and even 3D viewables into a report or presentation template. An SDM solution also enables you to annotate information items, for example to add comments to qualify results. This means that it becomes less necessary to generate a report as a document since the results of a simulation and the analysts' comments can be consulted directly from the database.

While the core capability of a PDM system is to manage tree structures of assemblies, parts, documents and data items, the core capability of an SDM solution is to manage complete sets of simulation items and the linkages which connect them. This is known as a graph structure in data-management-speak. For a finite element analysis,

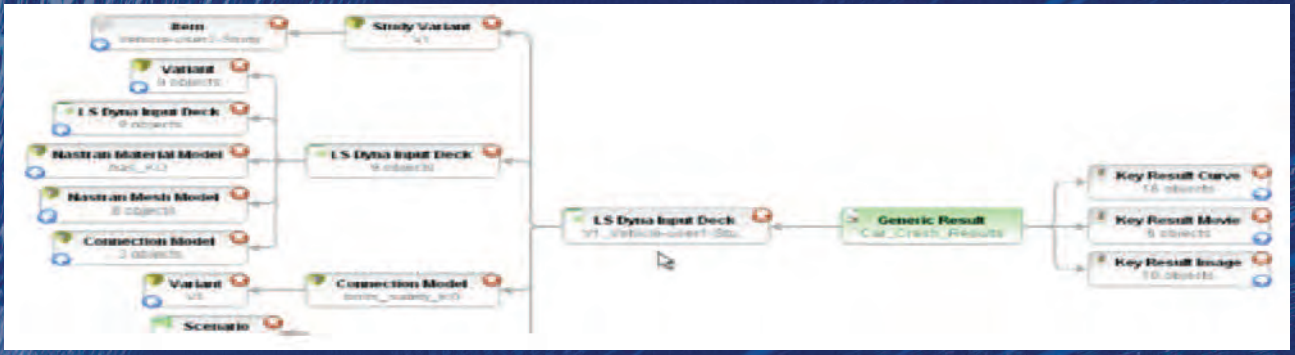

Figure 1: Display of a Set of Simulation Data in an SDM Solution (Courtesy of MSC Software)

this graph structure starts with geometry, loads and materials on the left, progressing through meshing, assembly into an input deck, solution, post-processing, key results and finally reporting on the right side of the screen. The graph structure provides traceability and enables you to navigate from input data through process steps to results.

Like PDM solutions, SDM solutions track information items and associated metadata as well as the data files. Several representations of the same data can be attached to, and accessed from an information item. For simulation outputs, in addition to the bulk data file, these representations can include numeric values stored as metadata, viewable graphs, an Excel file, a lightweight viewable 3D file and a compressed version of the output file. The original bulk data file can be archived or even deleted whilst retaining the information derived from the simulation and the traceability back to the inputs through the graph structure.

An SDM solution provides the capability to provide controlled access to simulation data sets so that they can be consulted by anyone with appropriate access rights, inside or outside the organisation. This can lead to significant time savings in searching for and imparting information. Different studies (3) (4) have found that analysts spend between 30 and 50 % of their time searching for or imparting information. So an accessible and largely self-explanatory mechanism for searching, navigating and accessing sets of simulation data allows engineers to do more engineering.

Typical early adopters of SDM are CAE departments in Aerospace and Automotive OEMs developing complex, high performance products which are refined iteratively. Multiple iterations make it worthwhile to invest in a solution that enables automation and reduces the effort to re-run simulations with modified inputs. Early adopters have been able to retain the Intellectual Property(IP) from their simulation-based experimentation just as they retain their test results. Audi (1) reported that they had accumulated the results of 500,000 vehicle simulations by the end of 2010 and can access both physical and numeric test results for any simulation through a web browser. The NAFEMS SDM Business Value White Paper incudes an extensive bibliography of papers describing end user experiences. In addition, the papers from the 2011 European SPDM conference are now available to NAFEMS members.

So is SPDM the same as SDM? Growing interest in getting simulation data under control has led to acronym wars around what is an SDM system. The NAFEMS white paper sets out the core capabilities of an SDM system based on the experience of early adopters. These include the capability to capture process information which is the necessary complement to the input data files to fully define what was done and why. A range of CAE process implementation solutions are widely used in industry, from scripting through process definition solutions to stochastic iteration engines. The author argues that it's the ability to integrate an analyst's preferred CAE automation solution and capture the inputs and outputs that matters, rather than the need to contain a process manager. It's clear that the capability of an SDM solution to enable process automation can yield large productivity gains.

The world of simulation is highly heterogeneous with many organisations using tens to hundreds of applications, whereas the CAD world is now reduced to a handful of systems. So another core SDM capability is to deal with a diverse range of data types and applications. Peter Bartholomew presented an interesting paper (5) on the topic of the capabilities required to manage simulation data to the RAeS in 2009. He pointed out that the capabilities required of SDM by an analyst investigating complex aerospace phenomena are very similar to the capabilities required by an Aerospace OEM.

Since the SDM solution requirements are similar from the OEM to the individual consultant, it's in the OEM's interest to provide access to their SDM system to their suppliers to ensure the traceability of externally sourced simulation work. In the case of Audi, half the analysts registered on the SDM system are external third parties. In aerospace, a 50M€ project led by Airbus called CRESCENDO (6) is investigating the implementation of SDM solutions across the virtual

enterprise. CRESCENDO is demonstrating the feasibility and value of SDM to improve aircraft development processes. Another key benefit of SDM is the ability to access remote simulation resources (7), both physical and human, with lower supervision and collaboration costs.

If SDM can deliver all these benefits, why are relatively few organisations using SDM today? One reason has been solution costs. In the PDM space, capable and affordable PDM solutions like Smarteam emerged to meet the needs of small and medium businesses; even open source PLM solutions are available. Because of the complex requirements of an SDM solution and the relatively small number of analysts worldwide, compared to CAD designers for example, few dedicated SDM solutions have been developed and not all PLM vendors propose an SDM solution on their platform. Some CAE vendors offer data management solutions tightly integrated with their solutions. These latter solutions are attractive as long as you only need to manage the data types included in the integrated SDM solution. Nissan (8), Ford (9) and Petrobras (10) reported significant gains from such specific, mono-vendor implementations.

Continued vendor investment in OOTB core functionality and value-added capabilities is decreasing the costs of implementation and increasing Return On Investment. BMW (11) announced that they are swapping out their custom developments for OOTB SDM applications. This means that other organisations will now be able to acquire as configurable applications, high end SDM capabilities such as simulation generators that previously had to be built as bespoke developments. Simulation generators are an advanced, add-on, SDM capability that enables load-cases and data-sets to be organised so that simulations can be re-run on modified input data with minimal effort. This is extremely valuable for iterative investigations on complex data-sets or problems like pedestrian impact on cars where many possible positions of the pedestrian need to be considered.

SDM is a dynamic and evolving domain that can bring real value to analysts and enterprises alike. NAFEMS has an SDM conference planned for the USA this year where end users will present their experiences. The NAFEMS SDM Business Value White Paper that was distributed in draft form at the 2011 SDM conference will be published shortly. Watch this space.

Mark Norris is an Industry Principal with Infosys, an engineering, simulation & PLM services provider and systems integrator. He has too many years' experience of PLM consulting and solution design around Teamcenter, ENOVIA and SimManager. He is the author of the SDMWG White Paper on the Business Value of SDM and can be reached at em_norris@infosys.com

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AUTHOR INFORMATION

Mark Norris | Infosys
em_norris@infosys.com