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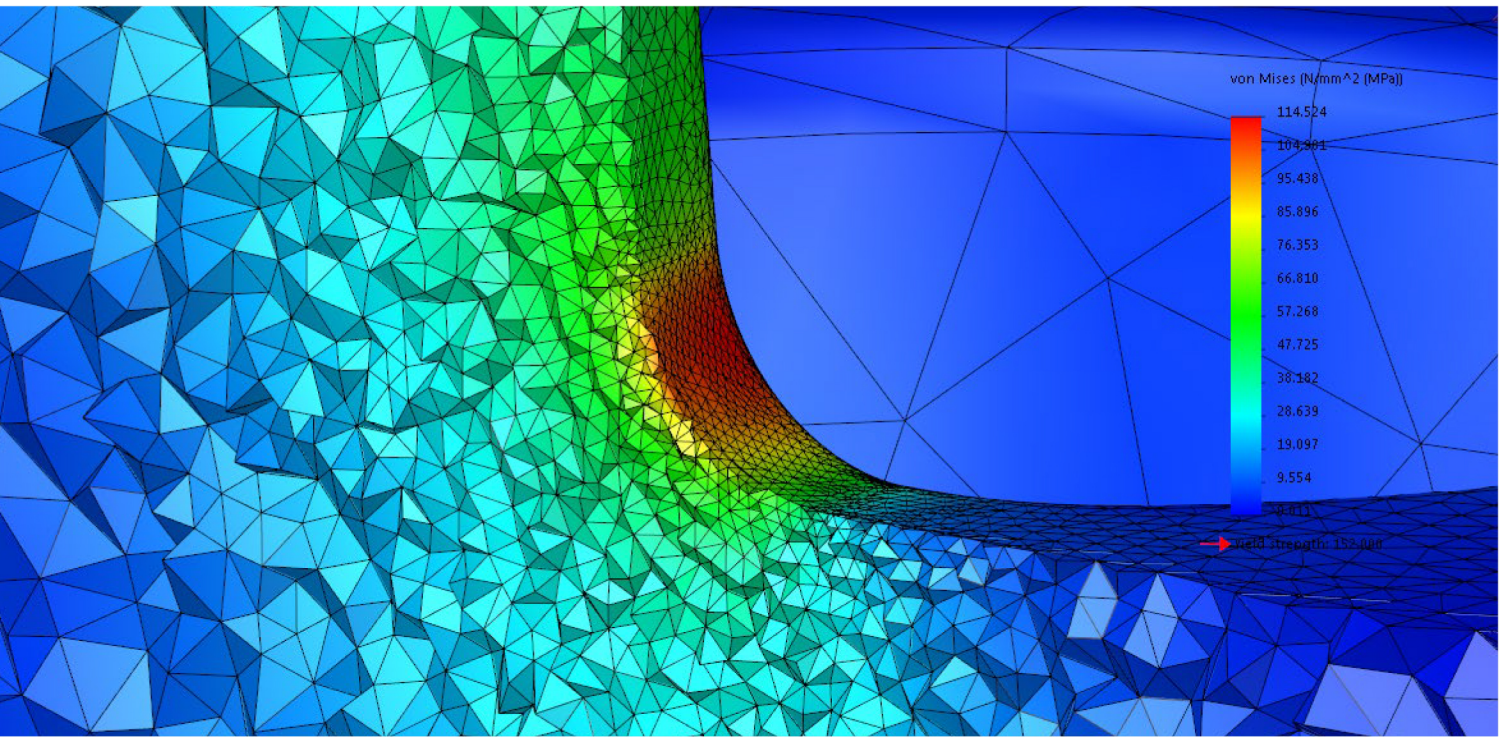
ENHANCING DATA MANAGEMENT WORKFLOWS THROUGH CAD-INTEGRATED SIMULATION

White Paper



OVERVIEW

Design and manufacturing companies today rely heavily on simulation results as the basis for business decisions. Managing an expanding simulation environment of tools, data, and processes is becoming more and more important. Simulation results need to be integrated with the enterprise's overall product development environment; however, companies of all sizes are still struggling to manage their simulation data, which is increasing in size and complexity by orders of magnitude as more simulations are performed over time.

This paper proposes a novel approach to managing simulation data workflows. Processes can be enhanced through the use of integrated CAD tools so that the data management, CAD, and simulation tools can talk to each other. This system provides a powerful platform for companies to leverage and effectively implement the key data management practices.

THE IMPORTANCE OF EFFECTIVE MANAGING SIMULATION DATA

Managed simulation data can be a competitive advantage but unmanaged data can become a huge liability. Simulation data management processes and workflows do exist. They start with these five key data management best practices:

- Provide a more collaborative environment
- Improve traceability of design simulation
- Increase data security
- Eliminate barriers between various groups and departments
- Enable improved assessment of risks and informed decisions

Many companies have adopted this strategy by implementing engineering workflows using data management, CAD, and simulation tools. They are more successful than laggards in their respective industries. However, they are still looking for a more integrated system to organize, control, find, share, and secure intellectual data.

Manufacturing industries are under continuous pressure to deliver innovative, competitive products faster. To meet this goal, they are increasing the use of simulation to better understand and validate product behavior up front in the design cycle. This approach allows for more information and insights to be captured early on, which in turn leads to making more informed design decisions. The key question is whether there is a simulation workflow process in place to capture and manage all of this data. Equally important, can intellectual simulation data somehow be reused to avoid duplicate efforts and save time for designers and engineers, both new simulation users and expert users? Do companies have some sort of best practices for this? Effective management of simulation data is increasingly important as simulation becomes a core business process and organizations rely on simulation results as the basis for business decisions.

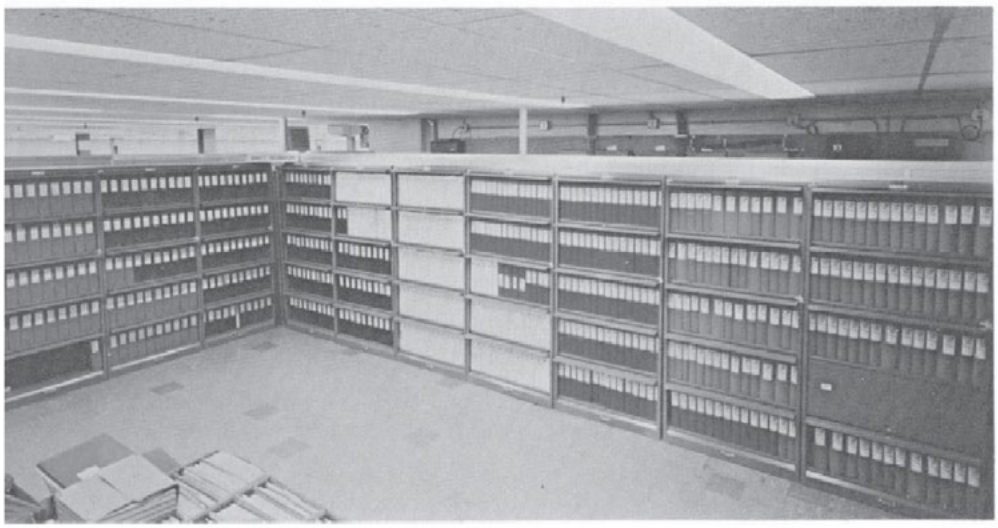


Figure 1: The pedigree of just one Apollo spacecraft took this many books.

THE BACKBONE OF SIMULATION DATA MANAGEMENT

The simulation process itself consists of multiple steps as shown in Figure 2. It starts off with the CAD design data: preprocessing of information such as materials, loads, restraints, and mesh; solving the simulation setup; post-processing of engineering results data; and final collaboration in the form of reports.

When so many of these simulation runs are done on a multitude of designs and on different variations of the same design, it is inevitable to have vast amounts of data generated either locally or on a network computer. Many times, these data are simply created and destroyed or overwritten while moving from one design to the next, or even from one simulation iteration to the next. The challenge is not only in taming the enormous quantities of data, but also in building intelligence to improve consistency, reliability, and repeatability. To do so, the following needs to be addressed in a simulation data management workflow:

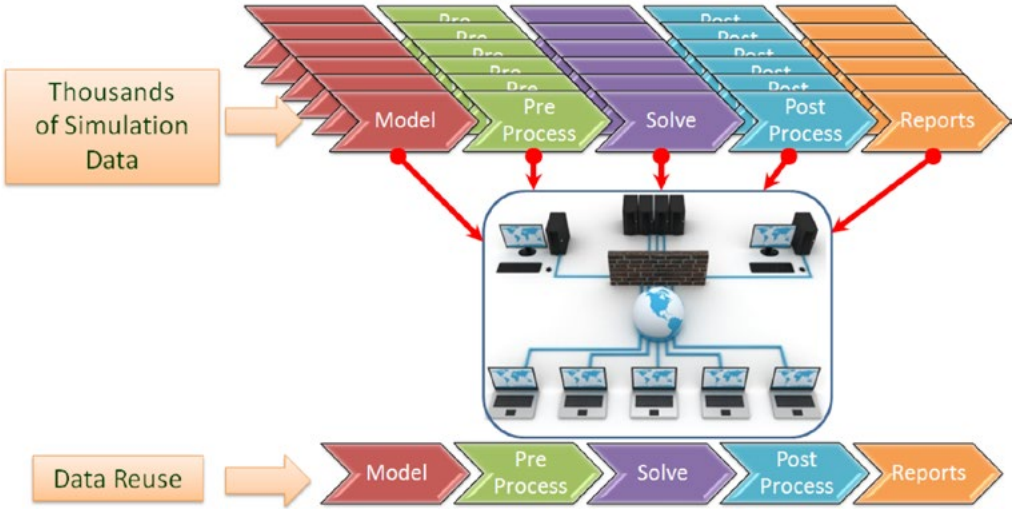


Figure 2: Simulation stages leading to enormous generation of data

- Document simulation activities efficiently to manage the process, procedures, and files for better communication
- Retrieve and track all inputs and results to replicate and repeat simulation
- Store enough data to recreate simulation conditions
- Ease growing data management overhead on analysts
- Build a knowledge base to rapidly retrieve simulation information
- Share simulation methods across departments
- Manage and archive the process for audit trails

There are data management tools capable of being able to integrate the simulation workflow into the main engineering workflow in which simulation files can be managed for different versions of the design and simulation as well as the type of simulation done. However, addressing the key challenges above requires more than just setting up a workflow. An intelligence framework needs to be integrated into the workflow process that allows simulation users to quickly look up a CAD model for any analysis information and be able to reuse existing data as a template or reference for doing a new analysis. Some simulation tools also offer unique and intuitive functionality, like library features for loads, fixtures, and virtual connectors,that provide a powerful platform for reusing information.

CREATING AN INTELLIGENT SIMULATION FRAMEWORK

Figure 3 highlights a flow chart of a data management tool framework in which existing simulation data can be recaptured to build a knowledge base and intelligence to reuse information. For such a framework to work effectively, an integrated environment is required where the data management tool, the CAD software, and simulation tools can communicate with each other. A typical data management system contains an archive server where all the files are stored and an SQL server where all the metadata of the files are stored. The key is to exploit the integration between the CAD and simulation tools using the metadata information as a means to search and retrieve simulation data from CAD files. The data management tool now becomes the bridge between managing simulation files and also querying simulation-specific information from the CAD files.

For example, a linear static simulation is performed on a particular design. This generates CAD files with simulation setup, solver files, mesh files, reports, images, videos, and more, that all go into the data management system and serve as a knowledge base. The integrated CAD and simulation environment allows the data management tool to not only archive these files as a source of knowledge, but also retrieve and store simulation information such as simulation type, materials, loads and fixtures, the mesh. A simulation library and a family of CAD files with searchable simulation data are now created. These can be retrieved anytime, anywhere, by anyone to perform future simulations.

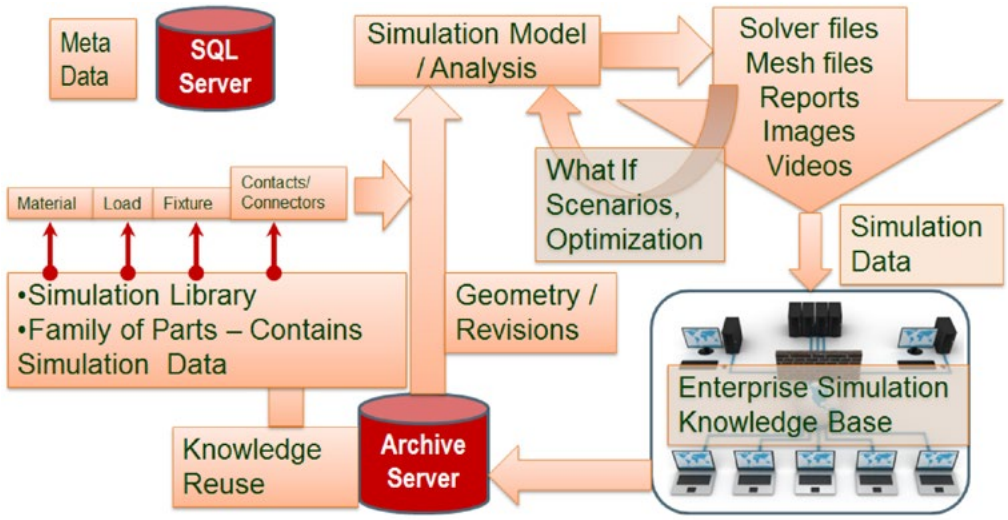


Figure 3: Intelligent simulation framework in a data management system

THE FIVE Ws OF THE SIMULATION WORKFLOW

The intelligent simulation framework can be easily incorporated into a simulation workflow. Figure 4 illustrates a typical flowchart for a simulation workflow. This flowchart requires creating more visibility among different levels of users without reinventing the wheel or wasting time reviewing requirements.

For this workflow to be effective, some core elements must be incorporated based on the five Ws below:

- Who performed the simulation?
- What type of simulation(s) was performed?
- When was the simulation done?
- Where did the simulation data, such as geometry, material properties, load conditions originate?
- Why was the simulation done?

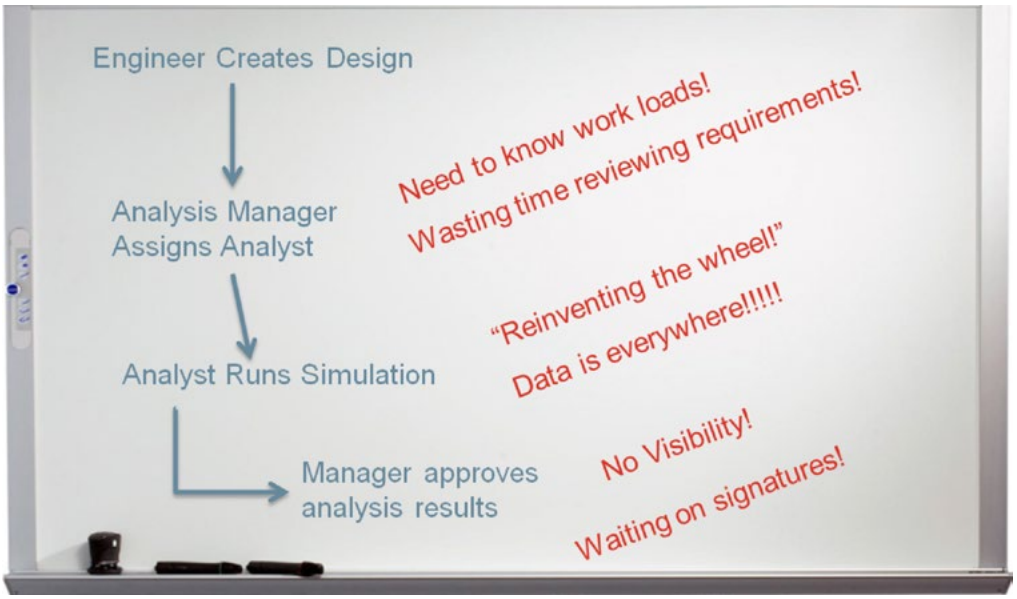


Figure 4: Typical flowchart for a simulation workflow

The simulation workflow now becomes a branch of the main engineering workflow. The result of this approach is that now, we can not only manage but share simulation methods across cross-functional departments to improve reliability, consistency, and communication. Figure 5 represents an outline of what an entire engineering workflow with the integrated simulation workflow might look like. Figure 6 is a close-up detail of the simulation workflow.

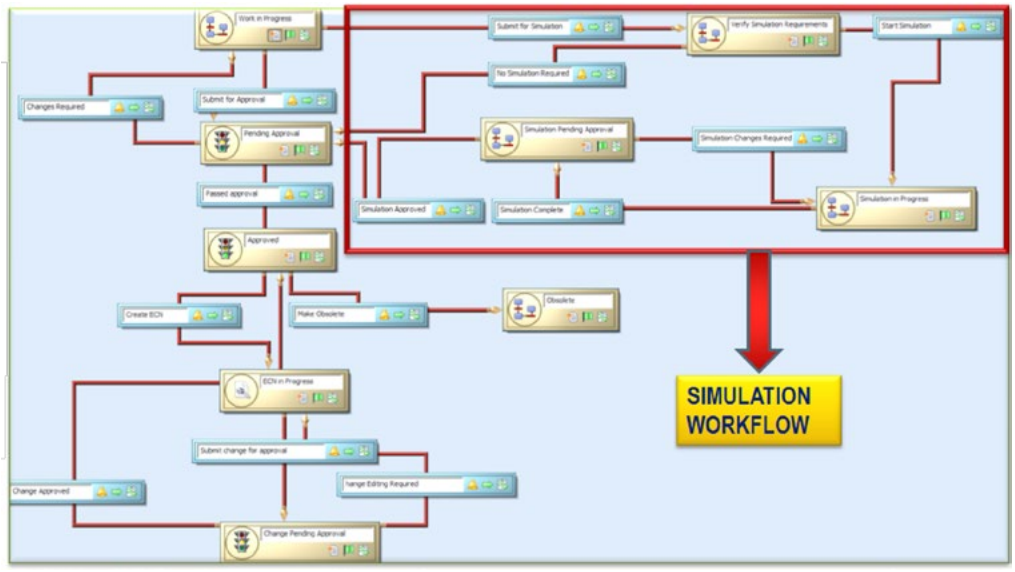


Figure 5: Outline of an engineering workflow including simulation workflow

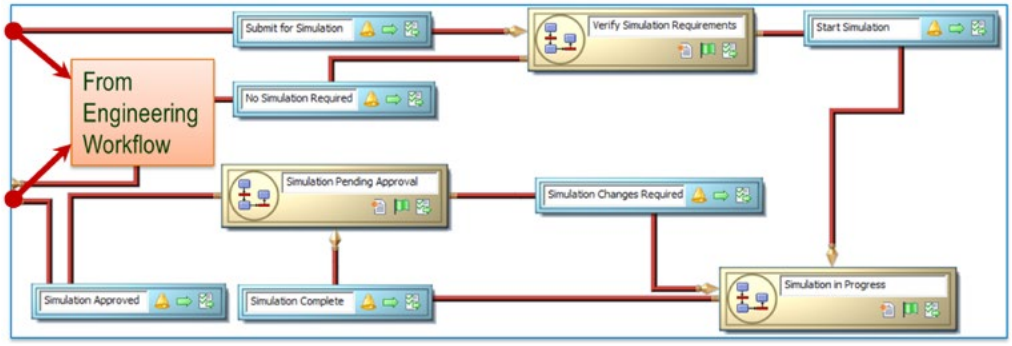


Figure 6: Simulation workflow branched off the engineering workflow

Figure 7 illustrates a detailed simulation workflow incorporating building the intelligence framework during each stage.

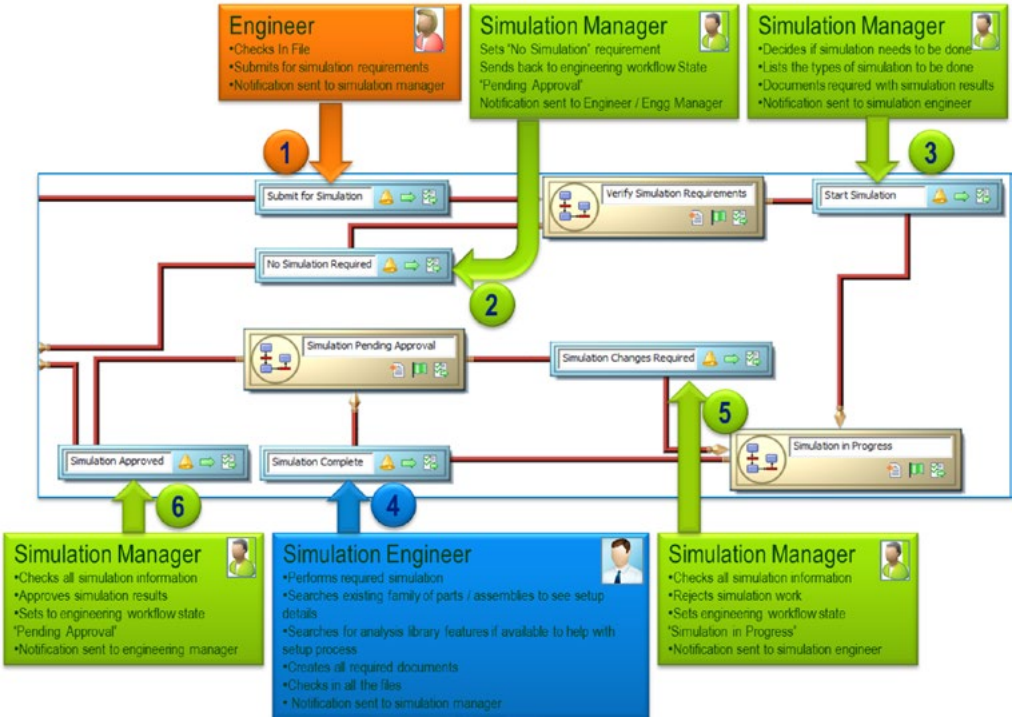


Figure 7: Detailed simulation workflow

In the workflow shown in Figure 7, six process steps are executed among three users—the engineer, the simulation engineer, and the simulation manager. Each user of this workflow can be assigned different usage rights to different portions of the workflow. The workflow itself is designed and executed as follows:

Step 1: The engineer creates CAD files (new design or a new version of an existing design) and submits them for simulation requirements.

Step 2: The simulation manager gets an automatic notification from the data management workflow and reviews the design and simulation requirements. If no simulation needs to be performed, then the simulation manager submits the CAD file back to the engineering workflow in the data management system. A notification is sent automatically to the appropriate person (example: engineering manager) for final approval on the design.

Step 3: If the simulation manager decides that the design needs to go through the simulation workflow, then it is assigned to the specific simulation engineer. The simulation manager can also create specific simulation requirements. Figure 8 shows an example of how the data management tool can be customized to capture and track the desired requirements set by the simulation manager. For example, the simulation manager can check off "Linear Statics" and a flag for linear statics is created in the CAD file, which becomes searchable.

A notification is sent automatically to the simulation engineer by the data management workflow system. The simulation engineer can then access the custom interface to review the simulation requirements.

Figure 8: Example of custom interface in data management tool

Step 4: The simulation engineer reviews the requirements and gets ready to do the simulation. This is where the intelligent simulation framework discussed earlier plays a crucial role. The simulation engineer uses the data management system to search for similar CAD files that have simulation information already built into them. Powerful search options can be built inside the data management system, such as the one shown in Figure 9.

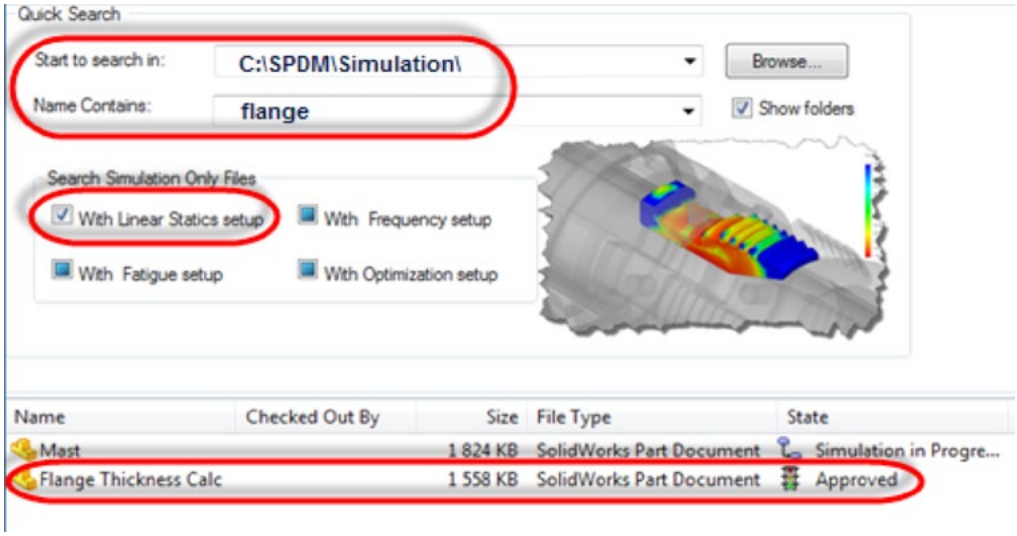


Figure 9: Example of custom interface in data management tool

For example, the simulation engineer can search for a CAD file that contains the keyword "flange" and contains a "Linear Statics" setup. The search comes back with a file that has already been through the workflow approval process. The simulation engineer can simply preview or open the CAD file and see the contents to get an idea of what the material, fixture, loads, mesh size, and other elements look like, so that they can be easily replicated on the new design. This is shown in Figure 10.

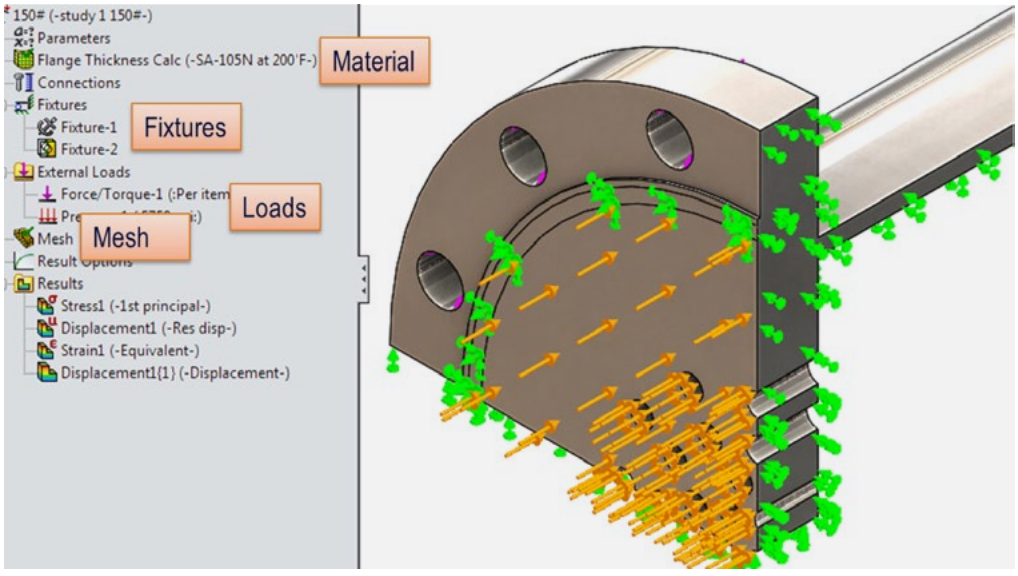


Figure 10: Searchable CAD file with Simulation setup

Another way the simulation engineer can reuse simulation data is a smart library feature that can reside in the data management system. Some of the CAD-integrated simulation tools offer this technology. For example, if a new user needs to know which faces of the CAD geometry have a load or where a fixture needs to be applied and how to apply it, library features offer very powerful options. Figures 11, 12, and 13 show how this might work in a CAD-integrated simulation environment.

- The simulation input, such as load or fixture, is first saved to a folder residing in the data management system using the "Add to Library" option.

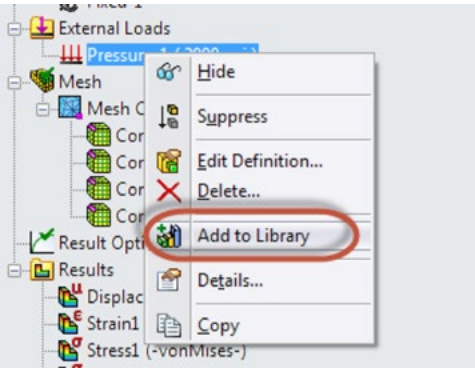


Figure 11: Creating a simulation library feature

- The saved library feature can be simply dragged and dropped onto the CAD graphics window. The appropriate dialog box opens up and the user simply needs to complete the geometry selections. Figure 12 shows an example of a force load on a flange design. Note that the library feature already has a predefined value for the load.

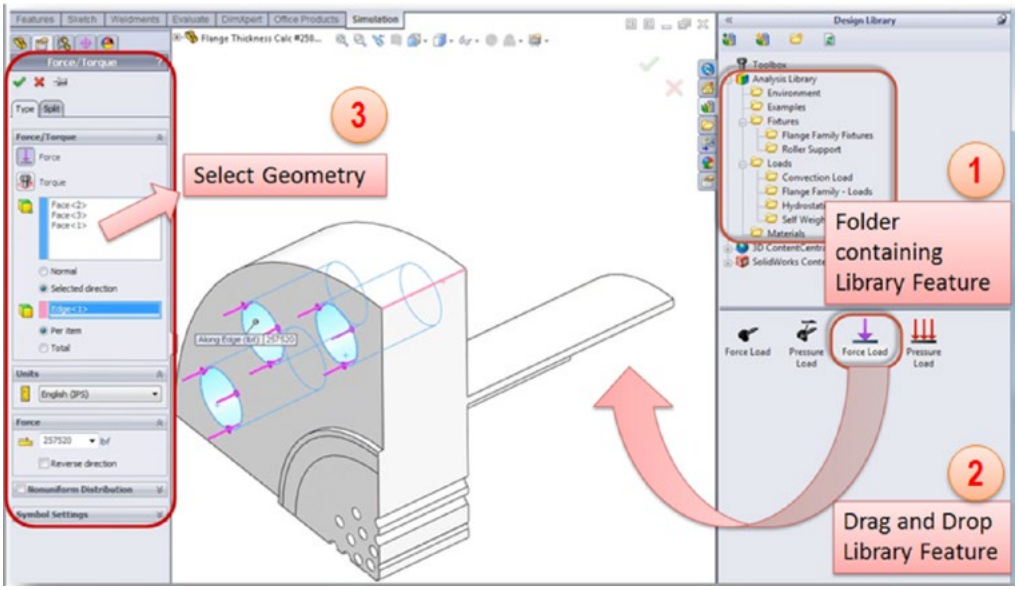


Figure 12: Reusing a simulation library feature using drag and drop

Simulation library features can also be created such that the drag and drop actually shows a preview on the geometry selections to be made.

Figure 13 shows an example of dragging and dropping a symmetry fixture library feature. A preview shows what geometry needs to be selected on the current design to apply that symmetry fixture.

Simulation library features serve as templates and are a great means of enforcing standard simulation

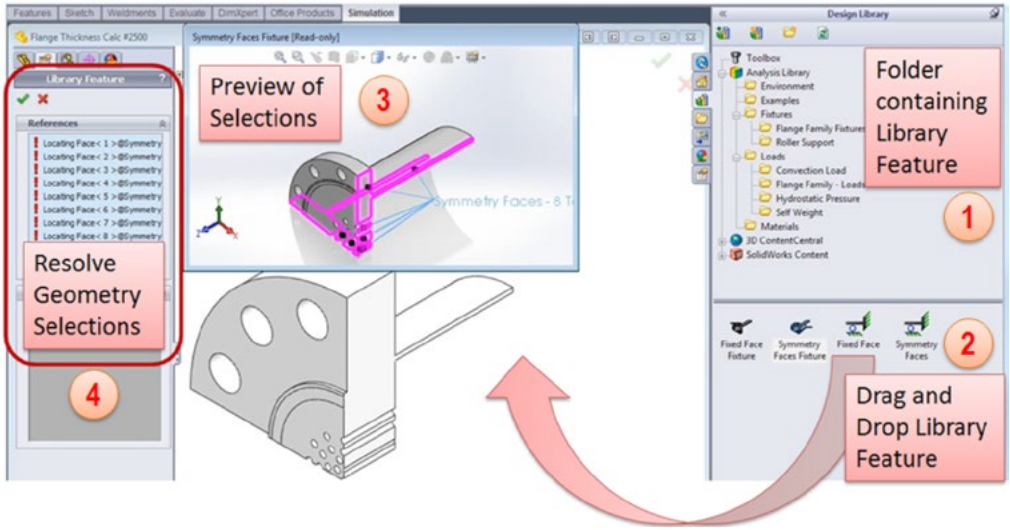


Figure 13: Reusing a simulation library feature using drag and drop

guidelines and best practices set forth by an organization. Most importantly, intelligent simulation data have now become a knowledge base that can be reused anytime, anywhere, by anyone in an organization.

After the simulation is done, the simulation engineer can create additional supporting documents such as reports or videos, and make these part of the simulation workflow process as well. Figure 14 shows a Microsoft® Word file report referenced with the CAD file on which the simulation was done.

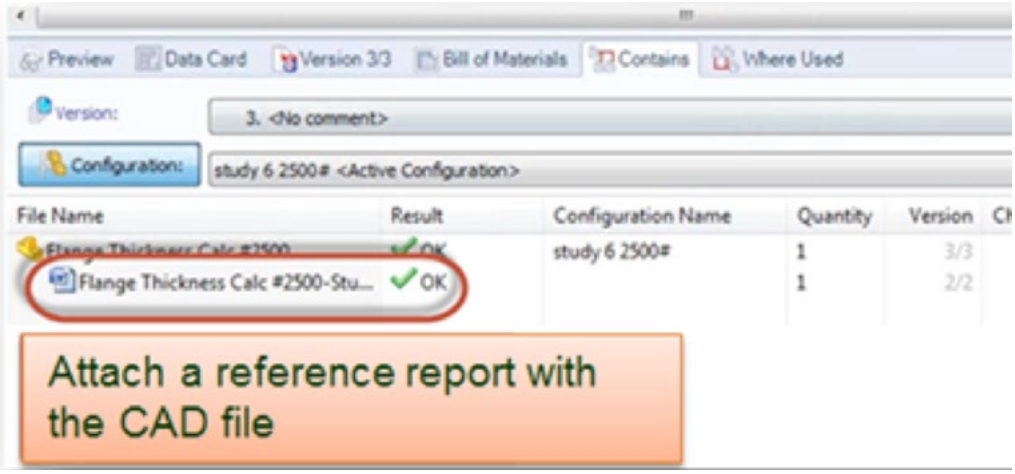


Figure 14: A report file referenced with CAD file in data management system

The simulation engineer then submits the CAD file along with simulation data back into the simulation workflow. A notification is automatically sent to the simulation manager.

Step 5: The simulation manager reviews whether all the simulation requirements have been completed by the simulation engineer. If not, the CAD file is resubmitted to the simulation workflow and a notification is automatically sent to the simulation engineer.

Step 6: If all requirements are completed, the simulation manager signs and approves the simulation work and submits the CAD file and simulation data along with any supporting documentation to the main engineering workflow. A notification is sent to the appropriate person (example: engineering manager) for final design approval. Figure 15 shows the last stage of the simulation workflow where the simulation manager sets the workflow status to "Simulation Approved."

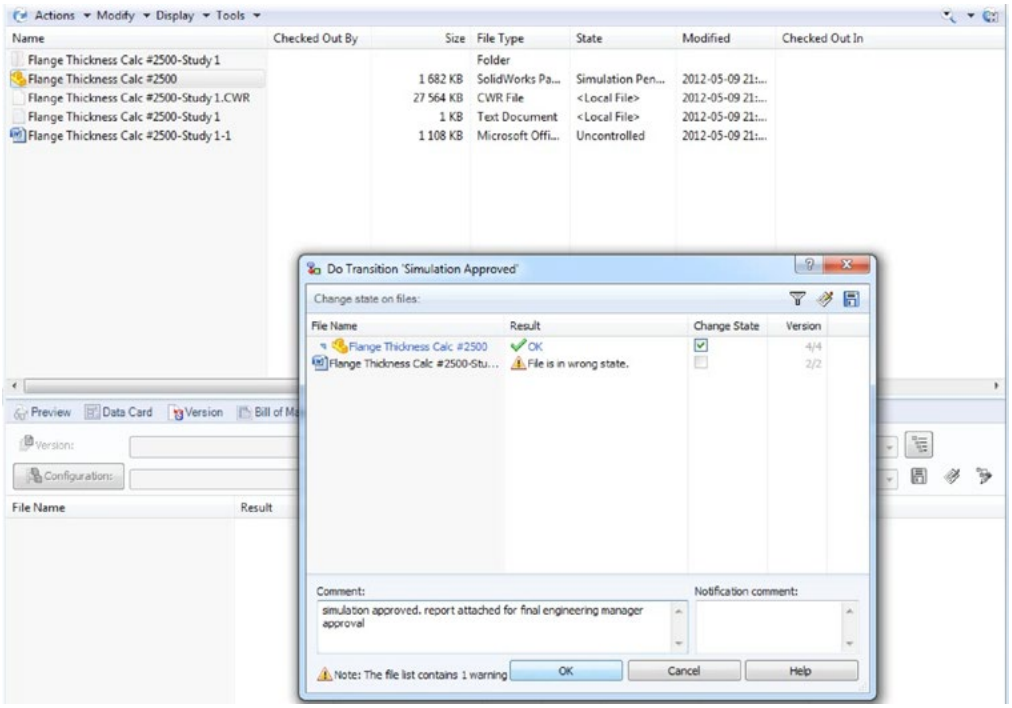


Figure 15: Simulation status set to "Simulation Approved" by simulation manager

Figure 16 illustrates the simulation workflow history as recorded by the data management system. All information and activity, from the initial stages to the final stages of the workflow, is tracked and monitored. The five Ws of simulation data management have been addressed.

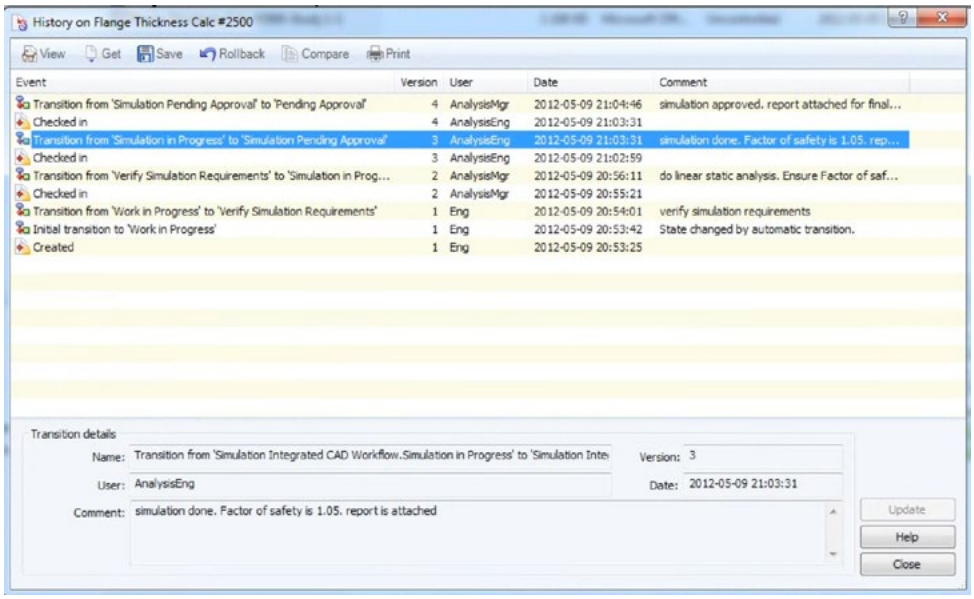


Figure 16: Simulation workflow history

CONCLUSION

Effective management of simulation data is becoming increasingly important as simulation becomes a core business process and organizations rely on simulation results as the basis for business decisions.

This paper presents an enhanced approach to the Who, When, What, Where, and Why of a simulation data management process in the context of building an intelligent framework around the simulation workflow. The success of this approach is highly dependent upon using a CAD-integrated simulation environment that leverages the data management system to bridge the gap between managing CAD files and simulation data. The methodology proposed aims to help provide a powerful and unique platform to companies for addressing the following key simulation data management challenges:

- Provide a more collaborative environment
- Improve traceability of design simulation
- Increase data security
- Eliminate barriers between various groups and departments
- Enable improved assessment of risks and informed business decisions

ACKNOWLEDGEMENTS

The author acknowledges contributions by many Dassault Systèmes SOLIDWORKS colleagues whose input and guidance on many fronts helped shape the development of this paper, "Enhancing Data Management Workflows Through CAD-Integrated Simulation."

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