Simulation Lifecycle Management in the real world: Practical application in PRIME aerostructures

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Abstract: *Simulation has become a key factor in the development of competitive and innovative products. However, the implementation of simulation in an efficient way goes further than choosing the most powerful analysis tools or working with the best engineers: Managing simulation data, the usage of non-standard methods or communication problems, are some of the issues that need to be solved.*

In Prime Aerostructures, the implementation of the Simulation Lifecycle Management System from Simulia has given numerous benefits. Sometimes it is difficult to see the necessity of SLM if not from a practical application. Therefore the objective of this discussion is to show through some of our projects from the aeronautical and automotive industries how SLM is being used and how it has improved our simulation processes.

During the development of airplane components with composite materials collaborative work between design and simulation is needed. This is accomplished by the composites modeling tools from Catia and Abaqus, which offer bi-directional data transfer links between design and analysis. SLM guarantees an easy up-to-date management of these data, including geometry revisions, laminate definitions or testing results among others, with total traceability.

We also present our success analyzing sports car exhaust systems, where different analyses such as a heat transfer, a thermo-mechanical or a dynamic simulation are performed for every new project. Scenario definition tools help us standardizing the methods, giving the engineer the steps to follow. In this way it is easier to follow the state of a project and accessing to its data.

Keywords: *Simulation Lifecycle Management, SLM, FEM, Composites…*

1. Introduction

1.1. The need for Simulation Lifecycle Management (SLM)

Importance of simulation tools in the development of products has increased in the last years and continuous growing is expected (CIMdata, 2011). A change from verification to design purposes can be observed in the use of FEM or CFD analyses. Due to the improvement in computing technology, nowadays more integrated tools exist that help in the product development phase, whereas in earlier times simulations were mainly done with verification purposes. It is one of the goals of PRIME aerostructures GmbH (PRIME hereafter) to serve as reliable partner in those design and development activities, delivering analysis and simulation solutions, as well as in certification tasks.

A problem of the role of simulation in the product development, where virtual prototyping has gained great importance, is the management of the data. Large amounts of data are created during the simulations, including geometry or specifications needed to perform the analyses, calculation files themselves, results or reports, etc.

In Figure 1 can be seen an example that depicts it. For the analysis of a sportscar exhaust system several inputs are needed, as material or geometry data. In order to study the mechanical behavior on the car several calculations need to be performed. Among them there is a G-Shock static analysis, a thermo-mechanical analysis, or a dynamic analysis, all requiring its FEM model. For the definition of the loads another inputs would be necessary, as for example vibrational data from the motor. At the right side of Figure 1 some possible result outputs are shown.

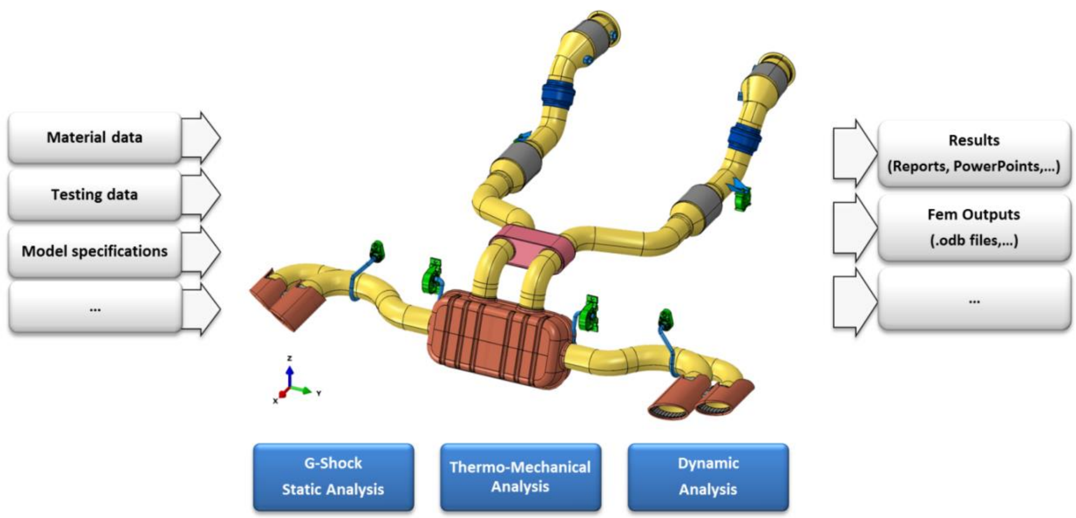


Figure 1 – Sketch of the multiple data sources in the analysis of a sportscar exhaust system.

This input/output data example can be regarded to a single case. If new revisions are involved during the design process, the amount of files to control scales and their management becomes a complex task. In addition, when different teams work together, communication problems occur frequently. Therefore, the management of all that intellectual property becomes a crucial point.

If typical ways for data storage are used, as was the case of PRIME before implementing SLM, following problems are implied (CIMdata, 2011):

- loss of data,
- use of non-standard methods,

– communication problems.

Companies identify insufficient focus on knowledge capture, being data sharing and reuse major constraints on the value available from simulation and analysis. Data needed by collateral and downstream project functions is too often unavailable, outdated, or captive to error-prone manual methods of dissemination and re-entry.

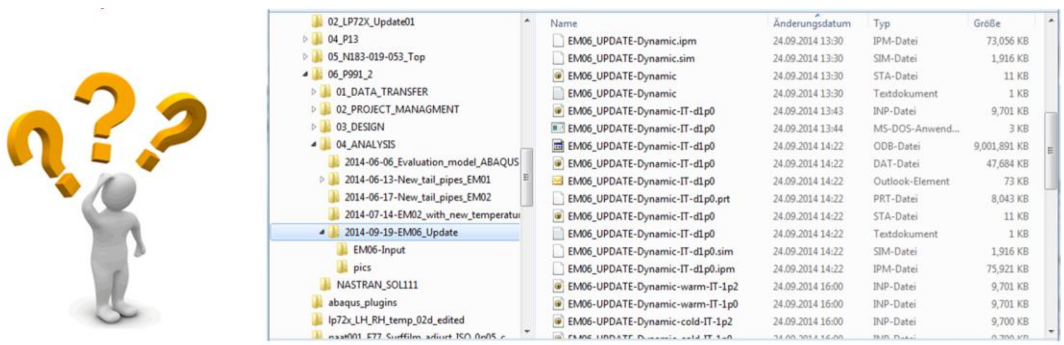


Figure 2 – Loss of data and communication problems occur frequently in absence of a management system.

If we analyze the efficiency of simulation and analysis activities, it is dependent on four factors: simulation technology, people, integration in the process, and data management. Regarding the first two points, companies are aware of the importance of using the latest simulation technology, both software and hardware, and also of working with the analysis engineers. These factors can be considered straightforward to solve.

However, a good integration of the simulation activities in a company is not so simple. By that can be understood the function of the simulation activities with verification or development purposes, and how the simulation team works and communicate with the rest of the company. For PRIME, mainly focused on the simulation side, it means to have an efficient and reliable communication with the clients with no problems or misunderstandings in sharing data.

The last efficiency factor is the data management itself. Finding the right information in less time is a challenge given the large amount of data, but still worse problems can appear with an inadequate data management. Cases of simulations done with wrong design revisions or using wrong input data are known by anyone, being the cost of such "mistakes" critical.

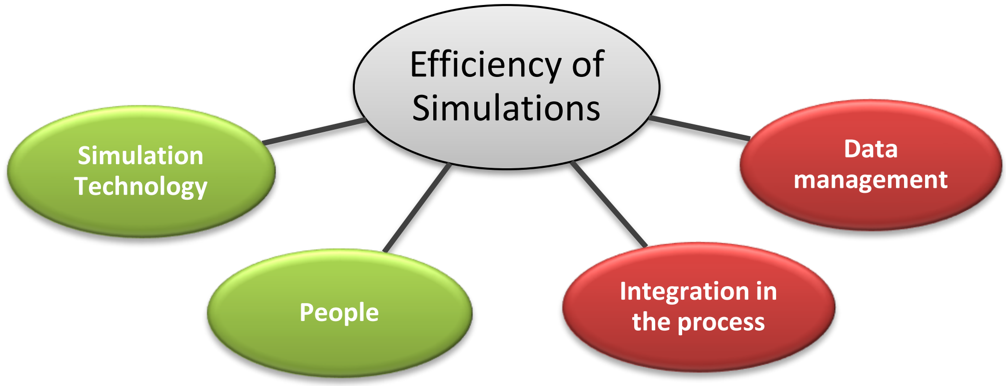


Figure 3 - Efficiency factors of simulation.

1.2. Hierarchical structure

Systems like PDM or SLM have been massively used since its integration several decades ago, and they have become necessary for an efficient product development. But in the case of simulation environments similar systems are only partially used. Many companies still do not rely on those technologies for the management of CAE (Computer Aided Engineering) tasks.

One of the reasons of this lack of implementation is given by the higher complexity of simulation processes. Contrary to CAD data that is organized according to a hierarchical physical assembly, simulation data is more complex and have different sources as shown before. The structure of a management system should not be based on physical hierarchy but on the simulation process, creating a product structure from a CAE point of view.

1.3. Case of small enterprises

When speaking about SLM the picture of a large company arises: innumerable employees working in team from different departments on the same enterprise and accessing to the same data and information. That is the focus that Dassault Systèmes seems to be targeting, as in so a large environment a management system is essential.

But what is the case of small enterprises? Even with a small number of users, as in the case of PRIME, the same problems exist. Likewise the amount of data and its management its critical. Besides, the risk factor in simulation engagements of small/medium companies is higher since the loss of IP or time are critical factors that put the profitability of projects in danger. It cannot be afford to not have the data under control and spend too much time looking for information or understanding where the things come from.

As this was the case of our company, the chosen solution was the implementation of SLM for the simulation environment management. In this manuscript we report on our experience in the use of

SLM as solution for the above commented problems. Advantages and disadvantages of SLM are depicted with practical examples from simulations done in PRIME.

2. Implementation of Dassault Systèmes SLM Solution

SLM solution from Simulia has the traceability and possibilities of a typical data management system together with special features for simulation works. In PRIME the SLM version V6R2013X was implemented, which is based on ENOVIA.

ENOVIA is the system already established in other Dassault Systèmes brands. It serves as base for capturing, managing, and securing the intellectual property. Figure 4 shows an example of how the data is accessed. Revisions of the documents are secured, and information as who made a change, when, or why, is available. Other possibilities can be seen at the upper side of Figure 4 that are common to each document. For example, under "Lifecycle" the state of a document can be changed or followed. In "History" a list of changes is presented. Or it is possible to create a "Route", which essentially is a series of tasks that can be assigned to different persons. These are some of the capabilities.

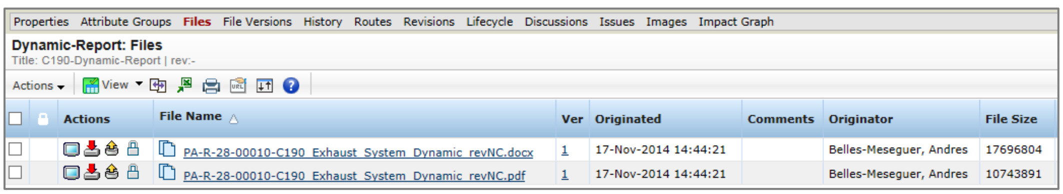


Figure 4 – Example of document view in ENOVIA: Data management capabilities as revision control, traceability, or data security are assured.

The benefit of SLM for simulation activities reside in its specialized tools:

- Live Simulation Review: serves as navigation tool for search and access to simulation data in context of 3D design data. It is an extension of 3DLive, allowing the users to access to 3D representation of simulation data.
- Model Editor: is an environment in which the preferred modeling tools are available to directly work with, even with 3rd party simulation models and representations. It enables a more cohesive editor for collaborative work.
- Scenario definition: Processes can be defined as templates and simulations with different steps can be independently run, creating the so called scenarios. In addition, it creates a representative view for organizing the data involved in the analyses. Automated tasks can also be defined and controlled.

A certain number of companies are already are using SLM, but compared with the amount of CAE users, its impact is relatively small. Some examples of companies that are already using SLM are DANA (DANA, 2013), Borg Warner Turbo Systems, or Kimberly-Clark Corp (Pieper, 2011), among others.

Figure 5 – View of Live Simulation Review used in DANA, extracted from (DANA, 2013).

3. SLM success in PRIME

The main goal of implementing SLM in PRIME was an improvement in the management of analysis and simulation data. To have all data under control and to know where the things come from, while assuring a quick access to it, were some of the challenges to be addressed. For that purpose SLM seemed to be appropriate. Especially of importance is the Scenario Definition module, which has been the principal tool for our purpose.

One of the situations most subjected to possible errors is when plenty of revisions are made during the development of a product. Misunderstandings can easily happen and wrong data used, or false results can be supplied. This was exactly the case of the design of a lightweight arm for an automated robot of the company ENGEL, developed together with PRIME (see Figure 6).

In a first sight the arm does not look much complex. However, the robot operates a high speeds and the movements need to be very precise. Thus, the technical requirements were a very light and stiff component at the same time. Several proposals were studied and analyzed, ending up with a composite/aluminum design as the best solution.

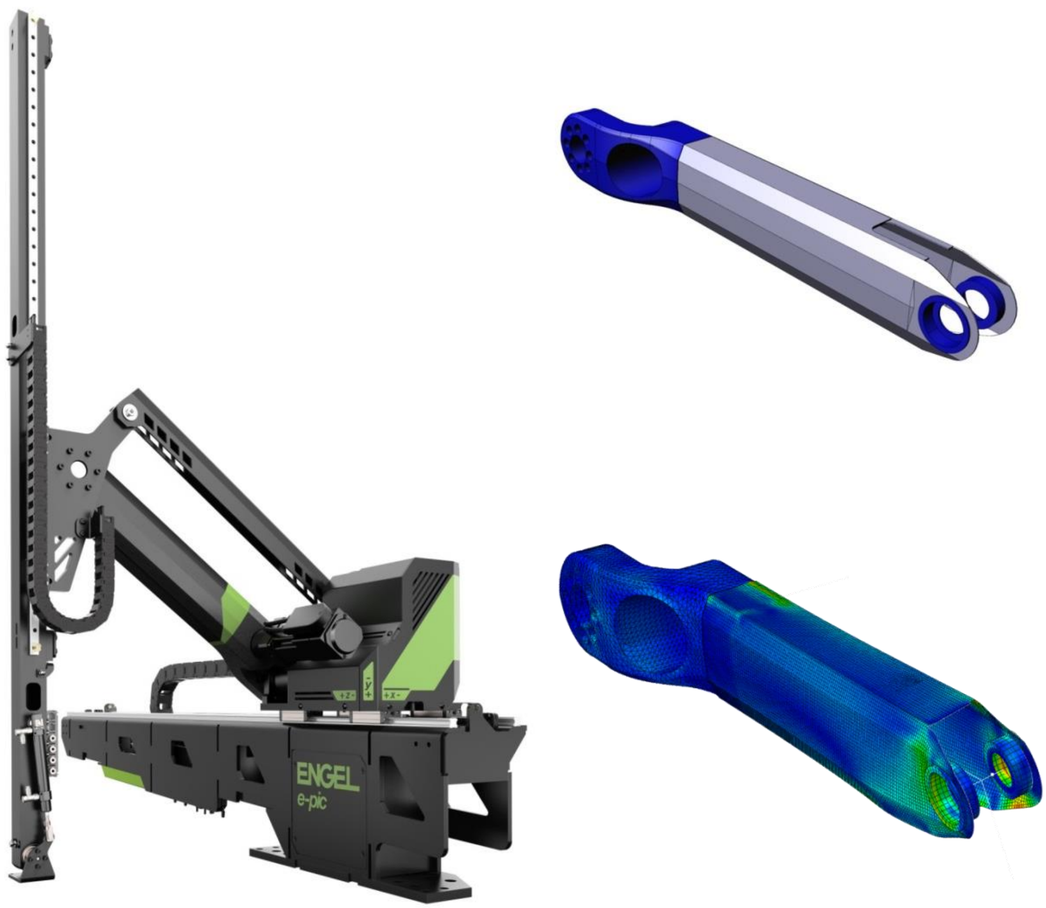


Figure 6 – Composite arm in ENGEL automated robot. Left: 3D image of the robot, courtesy of ENGEL Gmbh. Right: CAD and FEM views of the composite arm.

For that project the organization of data was done with SLM using the Scenario Definition Features. In Scenario Definition a “Process” can be defined, which in this case corresponds to the project itself. The “Process” shows a is made as a structured tree in order to organize information and analysis tasks. In Figure 7 the structure is shown using the graphical view, called “Impact Graph”. It can be seen how a tree composed of different categories with links between them creates an input/output hierarchical structure. The inputs of the process box, in dark blue, are called “Activities”. In the ENGEL project they represent the design revision, but the system leaves the user to choose what they specifically mean. An “Activity” can represent a single task or an automated task as well. Here it was used to represent a revision cycle, each cycle gathering its CAD data and analysis results.

A total of eight revisions were performed, as shown in Figure 7. For each revision (Activity) the inputs can be expanded and the information followed, being organized under different predetermined categories as Product, Specifications, or Internal Data, among others. An important point is that the CAD geometry under Product is based on a link. It is not a copy, but a connection to the original assembly made by the designer. In this way it is always know from which geometry a simulation is, even from which revision. At the right side of the outputs can be seen, as for example the FEM solutions or the reports.

There are situations in which a person not directly working on the project would need to look for some information in it. An example would be a manager that wants to see the final results. Or it could be a new analyst who is going to work in future developments. In those cases the graphic representation from Figure 6 is an easy and understandable way to access to the needed data.

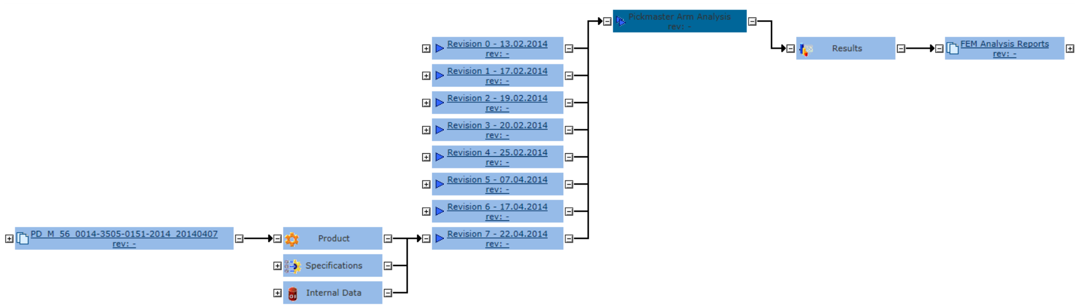


Figure 7 – Impact Graph of ENGEL lightweight arm simulation process.

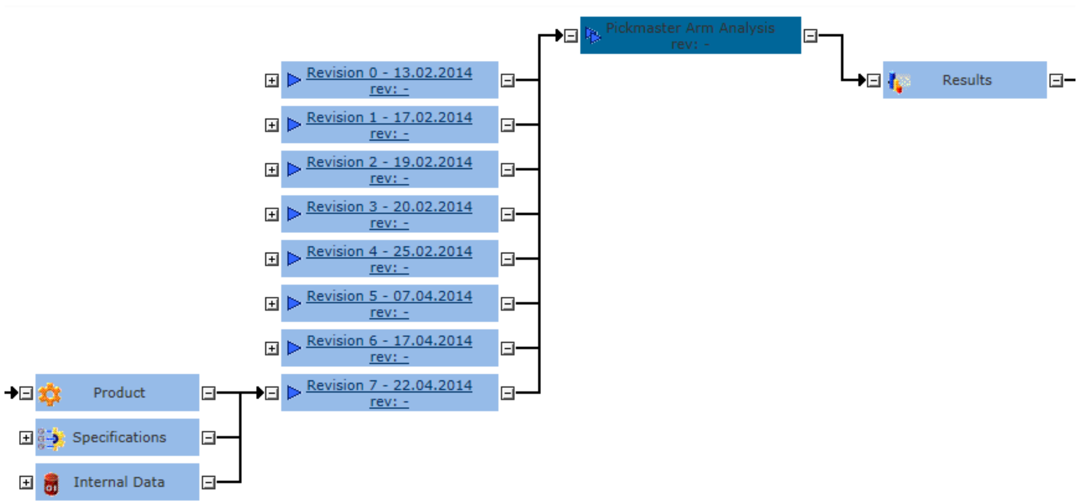


Figure 8 – Impact Graph of ENGEL lightweight arm simulation process (detail).

The strategy of using Scenario Definition has been followed for other projects in PRIME. The analysis of sportscar exhaust systems represents one of them. Since several simulations need to be performed for each different exhaust in a more or less similar way, it was an adequate case for creating a template. For each project similar simulations with the same type of inputs/outputs exists, as sketched in Figure 2. The graphical representation of the template (Figure 9) depicts how the single simulations are defined as "Activities", and how the inputs/outputs are organized in them. The heat transfer the inputs are expanded, showing the two categories used in it: Product and Specifications. Under Specifications information like the material database or testing results are to be found/linked.

Similar information is to be found in the other three single simulations: G-Shock static analysis, Thermo-Mechanical analysis, and Dynamic analysis. Again, necessary information to perform a simulation or used to evaluate results is available and organized. The whole structure is then saved in form of a template that will be used for each new exhaust to be analyzed, having the same structure. We have noted that in this way the knowledge is no longer so heavily dependent on the person who initially performed the analyses, as the use of templates makes easier to follow the same methodology and to separate tasks among the team.

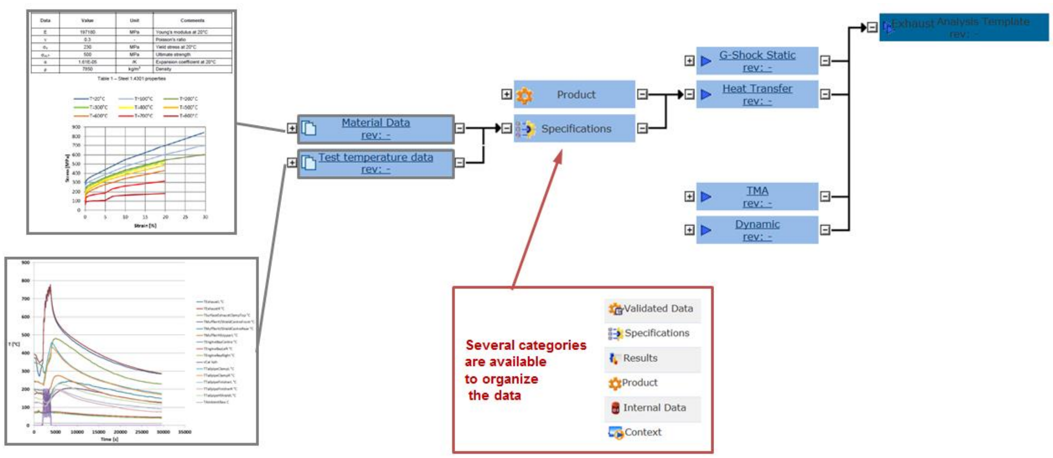


Figure 9 – Impact Graph view of an exhaust system analysis.

One option that in PRIME has considered important is the types of documents for the storage of revisions in SLM. It is desired to have revisions of the data, but when the files are large, as the FEM results can be, storage capacity can be a problem. SLM gives the possibility of choosing if every revision is saved or only the latest, which is suitable for very large data.

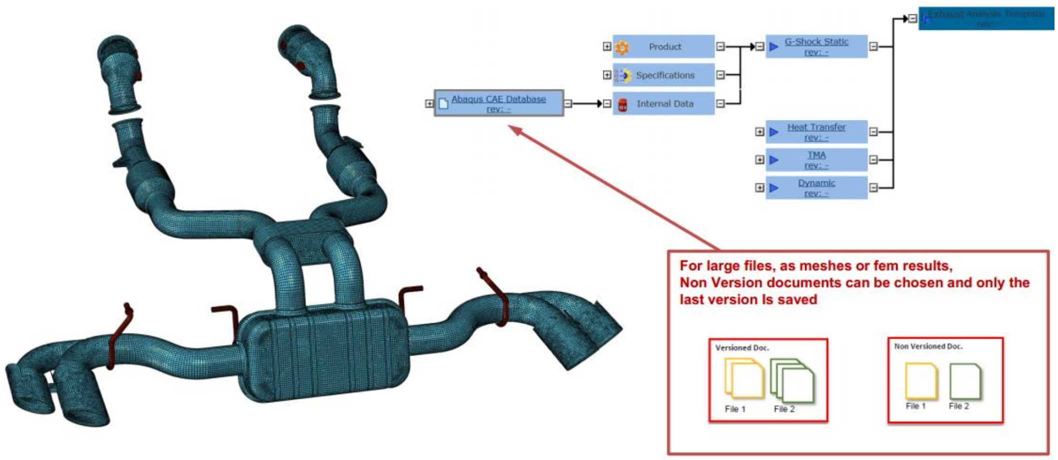


Figure 10 – Location of FEM database in Scenario Definition structure.

Above the graphical view has been shown, but in order to have a better understanding of how SLM works, some explanation is necessary: The highest unit of organization in the system is in "Workspaces". In our company they represent projects, although it could be differently arranged. Once the workspaces exist, users can be assigned to have access to them and the rights they have can be selected. In them folders and documents are created, as well as processes or activities of the Scenario Definition tool. Each of them needs to be understood as a metadata object which has many other possibilities and properties than a typical document.

Figure 11 shows some options that a Process document type has. The Impact Graph would give as similar views as in Figure 7 or Figure 9. Other options like the creation of a task assignment, the management of a lifecycle, or looking for a revision history, are easy to access.

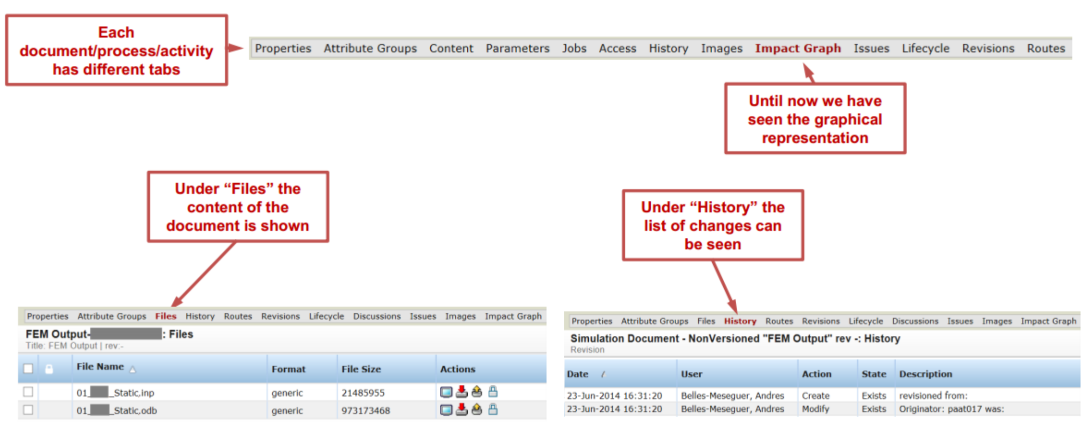
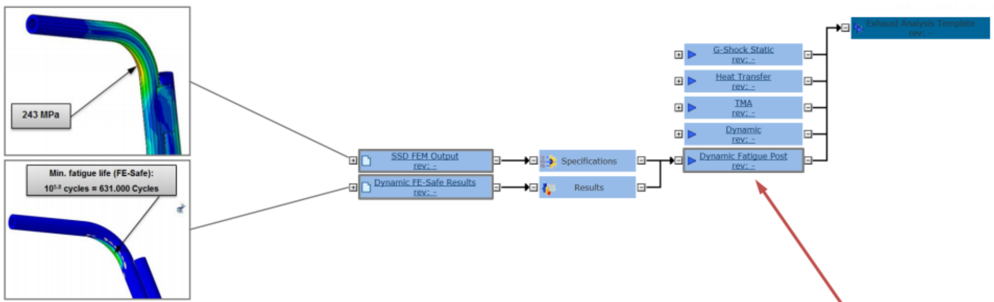


Figure 11 – Properties of a Process in SLM.

Coming back to the exhaust project, Figure 12 shows a situation where a new analysis is done and a Route is created. That project was created using a template but an extra analysis was done. The steps necessary to perform that extra analysis were controlled by a Route, which is very straightforward to define.



Title	Order	State	Assignee	Action	Due Date
FE-Safe Analysis from SSD	1	Pending	Beising, Thomas	Comment	12/8/2014 5:00:00 AM
Check Fatigue Analysis	2	Pending	Belles-Meseguer, Andres	Approve	12/17/2014 5:00:00 AM
Add fatigue results to report	3	Pending	Beising, Thomas	Notify Only	12/31/2014 5:00:00 AM

Figure 12 – Creation of Route (set of tasks) related to an Activity.

A key option of Scenario Definition is the creation of automated tasks. Figure 13 depicts a case where an automated task is used to extract plots directly from the FEM results. The Activity uses a “connector” in order to call an application, which executes the given script. Inputs and outputs of that script lie on the system, and the task is performed with automatically. This particular script calls Abaqus/Viewer and uses the FEM results from the dynamic analysis to create the desired graphs. Once the graphs are created, they are automatically saved in the system. In case new results are calculated, with a single click the updated plots can be created again.

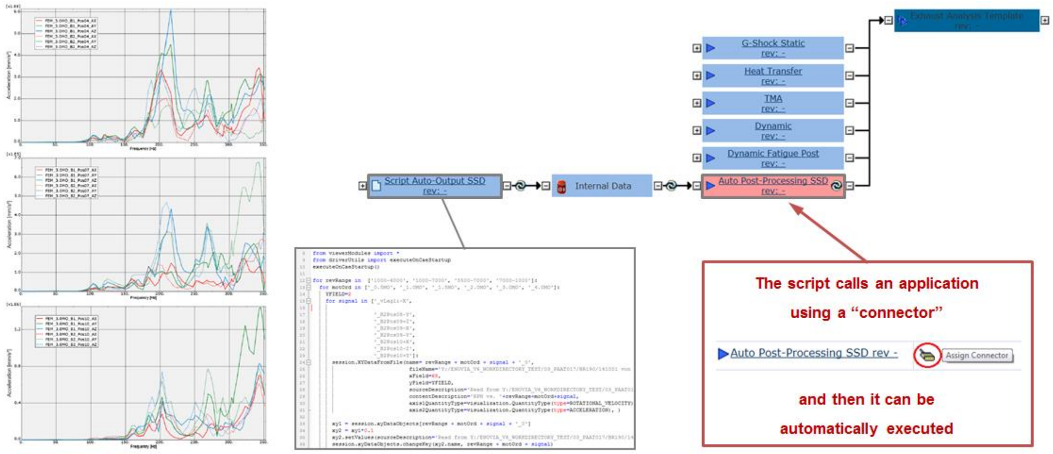


Figure 13 – Automated task for extraction result plots using Abaqus/Viewer.

4. Conclusion and outlook

It has been some more than a year since SLM in its version V6R2013X was adapted in PRIME. After this time a clear beneficial effect of its implementation has been observed. Especially the simulation data, including inputs of results of the analyses, are secured and located. In contrast, some negative points related with the degree of maturity of the software can be found.

Projects and simulations managed with SLM are no longer so dependent on the persons who work on them. The reason is a much more structured organization, having located all information involved in the calculations. After a period of adaptation, working in the system has been efficient. Less time is used looking for data and confusions about design revisions have disappeared.

5. References

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