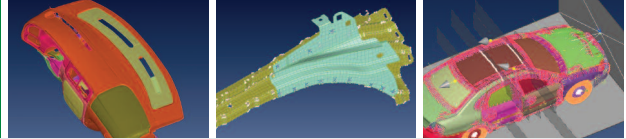


Integrating Teamcenter Simulation Process Management with ANSA

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white paper



- ▶ In most companies, engineers use tens or even hundreds of different tools to perform various types of simulations. Integration of these various CAE applications in a common product lifecycle management (PLM) environment will enhance communication, accelerate the PLM process and increase the impact of simulation on all product development phases. This white paper presents a general framework, based on the open PLM XML protocol, to integrate external CAE applications with a PLM system that supports simulation data and processes. While the framework is applicable to a wide range of industries, the paper describes how it has been used to integrate Teamcenter® software's simulation process management capabilities with the ANSA CAE pre-processor for a major automotive manufacturer.

PLM Software

Answers for industry.

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▶ Executive summary

In recent years, the need to satisfy diverse consumer demands has forced vehicle manufacturers to create better, safer and greener cars. This has inevitably impacted all phases of vehicle product development, increasing the complexity at the design, validation and manufacturing stages.

The role of CAD has been elevated from a traditional mechanical design tool to a major product definition process. Evolution of 3D CAD applications has helped designers to produce and handle large numbers of component variations in shorter times. Furthermore, the design process itself has been improved with the use of product data management (PDM) applications that support CAD complexity by introducing efficient data management, versioning and configuration methods.

The use and importance of simulation has been elevated as well. The demand for more vehicle models with more variations and options, satisfying tighter regulations and prepared at shorter time-to-market intervals, drives the need for an increased number of credible simulations delivered in shorter times and at reduced cost. Simulation now plays an active role in the identification and definition of vehicle properties in the early design stages so as to accurately predict vehicle behavior and assist decision making.

The different phases of simulation-driven product development generate significant and increasing amounts of diverse data whose loose management leads to error prone procedures that delay crucial decisions. Integration of the various CAE disciplines in a common PLM environment will help enhance communication, accelerate PLM process and increase the impact of simulation on all product development phases.

Simulation data management challenges

With the increasingly important role being played by simulation, companies are looking for solutions to manage their simulation data and processes. In most companies, engineers use tens, and for complex products even hundreds, of different tools to perform various types of simulations. Bringing all of these tools into a managed process is a challenge. Furthermore, the number of specialized simulation methods for various disciplines has increased significantly. As a result, it is a challenge for the CAE process to ensure that all disciplines work on the same up-to-date model data.

Existing PDM/PLM environments do not have the specialized integral tools required for the completion of CAE work. As a result, these environments rely on external software for the preparation, verification and execution of CAE analyses.

The CAE process usually starts with gathering information related to the simulations that will follow. This information consists of the vehicle product structure and related CAD and metadata, extends to simulation scenarios and finally covers simulation results and post-processing evaluation reports. Since the bulk of this information is already handled by PDM systems, it would be beneficial to communicate it to the CAE environment in order to serve downstream processes. The motivation is to accelerate the PLM process, increase confidence in CAE and enhance the impact of simulation throughout the vehicle development cycle.

To address these needs, Siemens PLM Software and BETA CAE Systems S.A. have taken the initiative to bring Teamcenter Simulation Process Management (henceforth referred to as Teamcenter) together with the ANSA CAE pre-processing tool, in order to offer an attractive solution that combines the efficiency of these well established applications in the PLM and CAE fields respectively.

The Teamcenter-ANSA integration is facilitated through PLM XML files. PLM XML is a protocol created by Siemens PLM Software to boost PLM interoperability by defining a set of XML schemas and associated services that facilitate open, high-content product lifecycle data sharing. It is open, published and compliant with the W3C XML schema recommendations. PLM XML file and associated data serve as input to ANSA. In turn, ANSA performs all required pre-processing actions based only on the information residing inside the PLM XML file. Finally, ANSA reports the result back to Teamcenter through PLM XML.

The development of the Teamcenter-ANSA integration is an ongoing process. It is expected that the collaboration will result in an “out-of-the-box” solution for CAE model preparation in the context of a managed design and simulation environment.

► Integration framework

Teamcenter's CAE data model

Teamcenter provides an out-of-the-box data model specifically designed to manage CAE data. The data model consists of item types to store CAE geometry and CAE models such as meshes, analysis models that may include definitions of loads and boundary conditions, results, and structure maps that contain rules which can be applied to a product structure to create a CAE structure. Relationships between these different items are used to answer questions, such as “What CAE model is the basis for this analysis result?”

With this generic data model Teamcenter can manage data authored in a wide variety of pre-processors (NX™ software, ANSYS, Mechanica, ANSA), solvers (NASTRAN, ABAQUS, ANSYS) or post processors for a FEA type of analysis. Teamcenter can also manage data authored by mathematical and analytic tools (Matlab, Excel, Maple).

Teamcenter's external process launch framework

Launching applications in an integrated environment requires a number of factors to be addressed, such as gathering all the input files, launching the applications locally or on a remote cluster, gathering the data generated and finally storing the data back into the data management system with the correct relationships. Teamcenter's simulation process management capabilities include a framework that allows external CAE applications to be integrated and launched with minimal effort. This is accomplished through a process wherein a simulation administrator can configure external simulation tools by specifying the file types, launch scripts and other information. Configurations can then be shared across multiple sites. The external applications can be organized hierarchically (for instance to support multiple versions of a solver) and can inherit properties from a parent for even faster setup.

Teamcenter-ANSA interaction

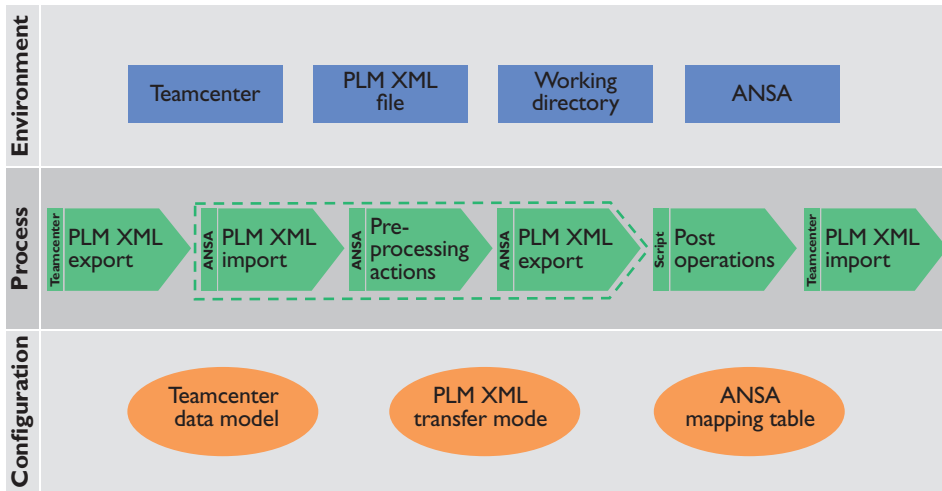



Figure 1: The framework for Teamcenter-ANSA interaction.

Figure 1 depicts the three blocks that set up the framework for the Teamcenter-ANSA interaction, including the environment block, configuration block and process block. In the *environment* block, Teamcenter functions as the application that handles the product and analysis information and ANSA as the pre-processor that is called to execute CAE-related actions. The means to facilitate the information exchange between the two applications include a working directory, into which data are placed, and a PLM XML file describing the content of this data.

The configuration actions that need to be taken in each application to enable their communication are shown in the configuration block. On the Teamcenter side, users first leverage a CAE-specific data model and a framework to launch external applications that will identify ANSA as an external tool and make it directly accessible. Then, again in Teamcenter, a new PLM XML transfer mode dictates the rules that control the amount and depth of product and/or analysis information that will be extracted from Teamcenter and will be included in the exported PLM XML file. Finally, in ANSA, a mapping table defines the correspondence between Teamcenter and ANSA keywords, so that ANSA will know how to act when this information is communicated. As the list of dataset types used in Teamcenter can vary from company to company, the PLM XML transfer mode and the ANSA mapping table can be tuned or configured for each implementation.

With respect to the configuration process, the Teamcenter-ANSA interaction covers a number of typical CAE use cases. These can be simple cases such as CAD data translation and batch meshing, or cases of higher complexity such as full-vehicle assembly with connections, the handling of component updates, the re-use of common content (meshes) and the build-up of ready-to-run solver input decks. Since every use case has a different starting point and requires different pre-processing actions, an *easy* solution would have been to use a dedicated PLM XML transfer mode for each use case and have ANSA read/act differently depending on the use case at hand. However, by placing more *intelligence* in the pre-processor side, all use cases are covered using a *single* PLM XML transfer mode, thereby minimizing the need for extensive configuration on the Teamcenter side. The aim is to standardize the amount and level of



information that is exchanged between Teamcenter and ANSA, as well as the actions that Teamcenter and ANSA will take during this interaction, in order to cover as many use cases as possible.

The last building block of the framework gives an overview of the interaction process. It begins in Teamcenter by exporting a PLM XML file and related product data into the working directory. Then, ANSA is launched, reads the PLM XML file and proceeds to the required pre-processing actions using the data residing in the working directory. The actions that ANSA follows are dictated by the contents of the PLM XML file. In the end, ANSA exports a PLM XML file describing the modifications that were applied to the data. Post operations can follow, if necessary, and finally Teamcenter imports the newly created PLM XML file and stores the CAE models in the Teamcenter CAE-specific data model.

It is worth noting that the same process is applied for *all* use cases. This relieves users from having to know *what should be done* in each use case and leaves all actions under the full control of the pre-processor. Moreover, users have the choice of starting the pre-processing actions either directly from Teamcenter or manually from the working directory. The latter characteristic allows users to work in offline mode with ANSA and when ready bring back the modified PLM XML file and import it into Teamcenter. This mechanism also supports OEMs interacting with suppliers who don't have access to the OEM's PLM system, as the contents of the working directory can be packaged and transferred from the OEM to a supplier site. Suppliers in turn can carry out the pre-processing actions off-line and deliver the modified data and the respective PLM XML file to the OEM, to be placed back into the Teamcenter database.

► Preparation of product data for CAE work

Usually, product data representing a new vehicle is brought into Teamcenter directly from a CAD program. The product structure at this stage covers all possible vehicle variations and options and is usually called *the unconfigured structure*. As such it is not suitable for CAE work. The CAE engineer needs to *trim down* the unconfigured structure within Teamcenter, remove redundant information and derive a discipline-dependant, configured structure that will be used by all downstream CAE processes.

Figure 2 outlines the data preparation process. The first step for the derivation of a CAE-ready configured structure begins in the structure manager (also known as the product structure editor or PSE). Inside the structure manager, the original CAD structure is configured based on a set of variant and revision rules. The variant rules dictate which components are used in a specific vehicle variant (such as a sedan) and the revision rules indicate which CAD revision (version) of each component is to be used for the CAE evaluation. This procedure produces a structure that is configured in the sense of the components that it contains, even though it is still not ready for CAE work. The final step of the preparation is achieved in the CAE manager (also known as the CAE structure editor or CAE SE) with the aid of structure maps.

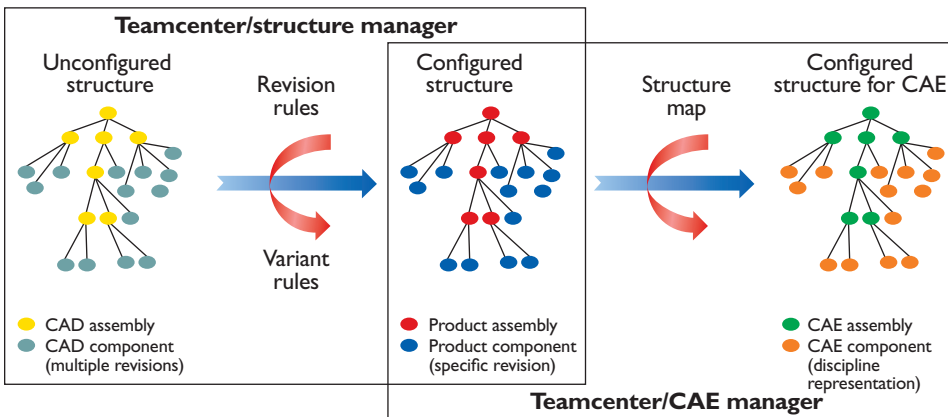


Figure 2: Preparation of product data for CAE work in Teamcenter.

A structure map is a set of user-defined rules to change an input product structure into a CAE analysis structure suitable for a particular discipline. For example, a structure map for crash analysis would dictate the meshing characteristics or FE-representation that the components should take in order to prepare a model for crash analysis. The structure map could also filter out components from the product structure that are not critical for a crash analysis while adding other components, such as a barrier, that may not exist in the product structure. Structure maps themselves are part of the Teamcenter data model and as such can be managed, revised and shared. After the structure map is applied to the incoming product structure, the resulting CAE analysis structure can be exported for pre-processing.

► Teamcenter – ANSA interaction points

The interaction points between Teamcenter and ANSA are shown in figure 3. The first and simplest interaction point refers to component meshing and covers the translation of the product CAD data into the native ANSA format and the subsequent batch meshing of the components according to the directions given in the PLM XML file. The derived ANSA file for each component is placed back into Teamcenter.

The cases of building a sub-assembly from its components and the building of a complete vehicle assembly from its sub-assemblies are covered in the second and third interaction points respectively. The difference between the two is the way ANSA handles the connectivity information. In the former case, ANSA treats a sub-assembly by realizing only its *internal* connections, i.e. the connections among its components. In the latter case, it is assumed that all sub-assemblies are properly connected, so that ANSA realizes only the *external* connections between the sub-assemblies. It is worth noting that, in both cases, if the connectivity information is missing, the CAE engineer can easily create it in ANSA. When ANSA exports the PLM XML file back to Teamcenter, a new CAE item containing the connections is automatically created.

Point 1 – Component meshing

- Translation of CAD components
- Batch meshing of components

Point 2 – Create CAE sub-assemblies

- Assignment of component attributes
- Component positioning and instantiation
- Application of sub-assembly connections

Point 3 – Create complete CAE assembly

- Build-up from sub-assemblies and components
- Application of model connections

Capabilities within each interaction point

- Process new data
- Handle component updates
- Re-use existing data
- Re-use common content



Figure 3: Teamcenter-ANSA interaction points.

All of the above interaction points use a configured CAE structure, the respective data and the PLM XML file exported from Teamcenter as a starting point for all ANSA actions. Upon completion, the CAE engineer has the option of saving the ANSA result in Teamcenter either as a monolithic file, containing the complete assembly, or on an individual component level. Moreover, the CAE engineer does not have to modify the process in any of the interaction points in order to handle component updates, re-use existing data or accommodate content that is common between assemblies. These cases are all handled inherently either by Teamcenter or by the intelligence put in the ANSA PLM XML reader.

► A simple use case: CAD data translation and batch meshing

The following use case describes a simple CAD data translation and batch meshing example where the PDM data for a complete vehicle resides in the structure manager (also known as the product structure editor or PSE) as shown in figure 4a. You can isolate the small assembly of the dashboard, as shown in figure 4, and place it under control of the CAE manager (also known as the CAE structure editor or CAE SE) in order to build a CAE-ready configured structure.

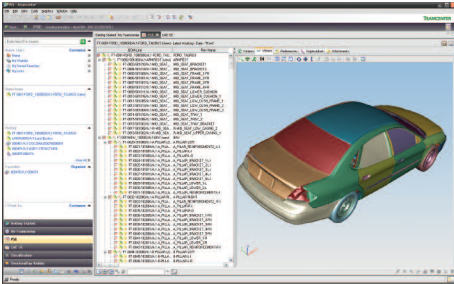


Figure 4(a): PDM data for complete vehicle.

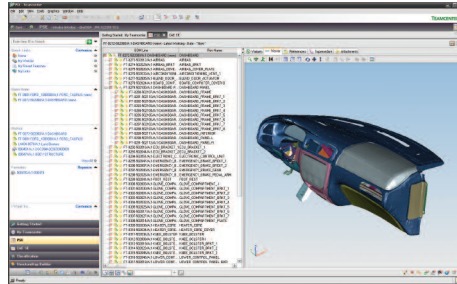


Figure 4(b): Dashboard sub-assembly.

Symmetric and multi-instanced components of the dashboard, and consequently of the vehicle, are defined in their CAD form only once in the PDM system and their actual locations are reproduced based on transformation matrices.

The application of a discipline-specific structure map to the sub-assembly will inherently dictate the way these components should be meshed by ANSA. At this stage, if other engineering data are available (e.g. properties, materials), they would populate the respective columns appearing in the CAE manager (figure 5).

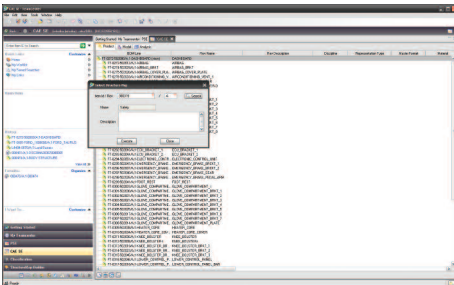


Figure 5(a): Application of structure map.

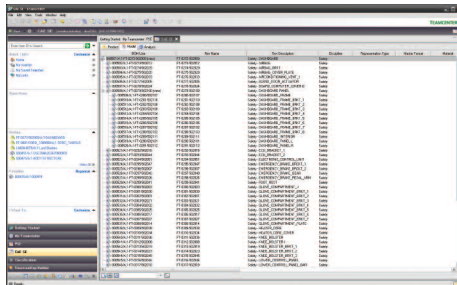


Figure 5(b): CAE-ready configured structure.

The export process (figure 6) will place a PLM XML file containing all information regarding the configured product or analysis structure, as well as the corresponding CAD files of the components comprising the dashboard assembly into the working directory that facilitates the data exchange.

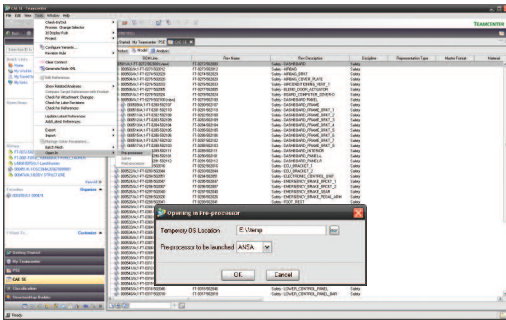


Figure 6(a): Export of configured structure.

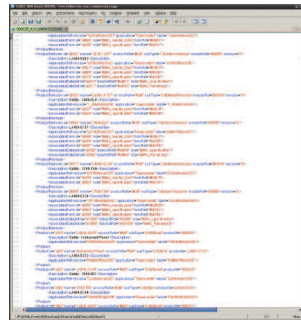


Figure 6(b): PLM XML file.

ANSYS is then launched, imports the PLM XML file and begins to translate, position and instantiate every component (figure 7). Subsequently, when all components are ready, the batch mesh manager is invoked, with a session populated by the dashboard components and with meshing and quality parameters based on the representation decided in the structure map.

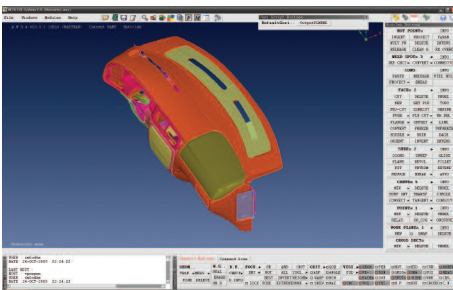


Figure 7(a): Import of sub-assembly CAD data.

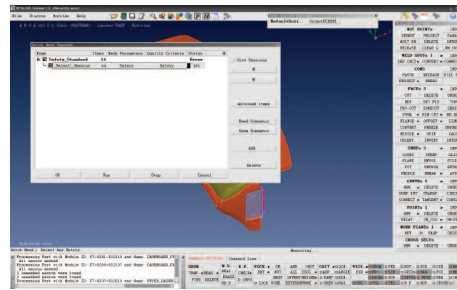


Figure 7(b): Batch meshing of components.

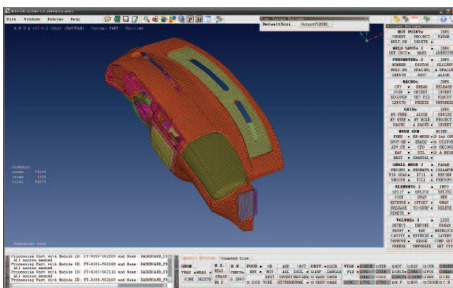


Figure 8(a): Meshed sub-assembly.

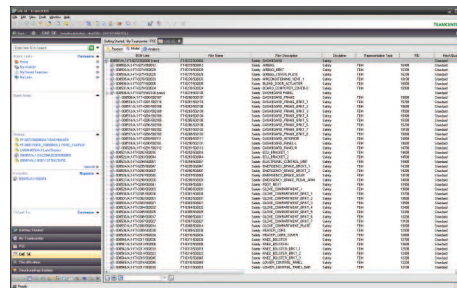


Figure 8(b): Import of sub-assembly into Teamcenter.

The CAE engineer can modify any of the CAE properties of the components at any time. When finished, the PLM XML export process from ANSA will: (a) store the components in ANSA format, (b) store a top-level single assembly file and (c) produce a PLM XML file containing all modifications.

Teamcenter then imports the PLM XML file, attaches the corresponding ANSA files to the components of the instrument panel and updates the analysis structure accordingly (figure 8). The next time that the instrument panel, or any of its components, is called to participate in the build-up of a configured CAE structure, the CAD data translation process will not be repeated, whereas the batch meshing process will be repeated only if the existing mesh cannot satisfy the requirements of the discipline at hand.

It is also worth mentioning that the component meshing process is always accomplished in the context of the sub-assembly. As a result, the transformation matrices and even available point connections are considered at this stage. Once this task is done, the component meshes are stored back in the Teamcenter data model in their original component position to ensure reusability in other sub-assemblies.

► Handling connections

The connectivity information that accompanies a structure is usually exported from the CAD system and resides along with the other PDM data in Teamcenter. This information can have various formats, but within the framework of the Teamcenter-ANSA integration, the standardized form of master connections file (MCF) is used as the preferred way of storing and communicating connectivity information.

When a CAE *connections* item of MCF form is included in a configured CAE structure that is exported from Teamcenter, ANSA automatically identifies these connections. The connection type is dictated inherently in the MCF file. The CAE engineer can now proceed to the realization of the connections. Moreover, if the CAE engineer uses ANSA to create or modify connectivity information, the exported PLM XML file from ANSA back to Teamcenter dictates the creation of a new dataset containing the corresponding master connections file.

Figure 9 presents a case of a configured structure of a small sub-assembly that is exported from Teamcenter to ANSA for the purpose of realizing the connection between its components. The connectivity information is given in a *connections* item in MCF form. There are two possibilities regarding the contents of the *connections* item: (a) to contain the connections for just this small sub-assembly or (b) to contain the connections for the complete vehicle.

In either case, when this structure is exported to ANSA, ANSA will identify and process only the connections that are *internal* to the sub-assembly and create an MCF file containing the external connections. ANSA exports a monolithic ANSA file containing the properly connected sub-assembly and its corresponding connectivity information, as well as the created MCF file, back to Teamcenter.

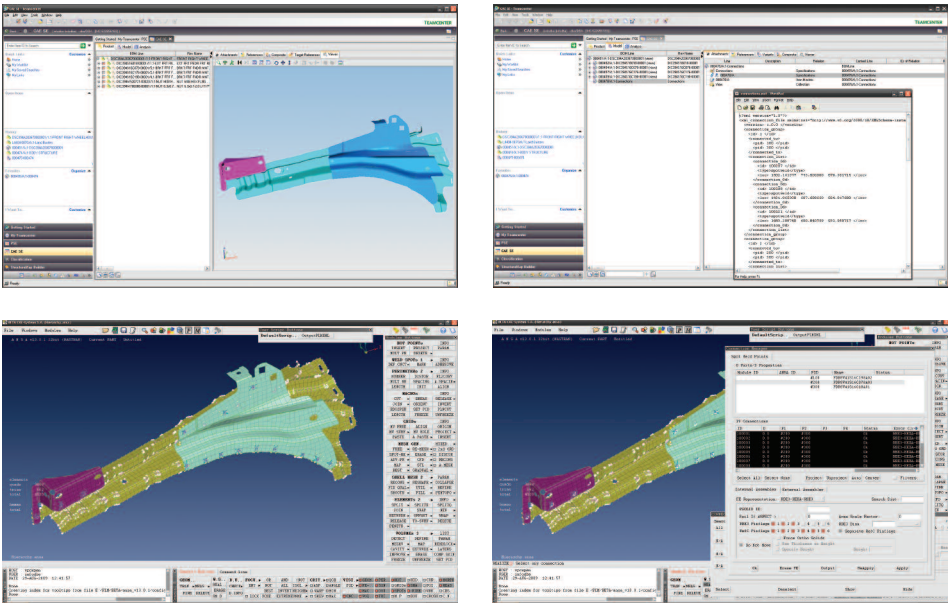


Figure 9: Handling connections through a master connection file.

When the above process is applied on the complete car, all connections are considered since now they are *internal* to the vehicle top-level assembly.

► Full model build-up using ANSA DM and ANSA task manager

The Teamcenter-ANSA integration has so far covered the build-up of a vehicle assembly, starting from its original CAD structure, stored as PDM data in Teamcenter, and moving on to the suitable CAE configured structure in Teamcenter that is exported to ANSA for pre-processing.

The next level of integration will focus on the build-up and management of a ready-to-run solver input file, by leveraging the already existing capabilities of ANSA to realize this in an automated way. What was built so far corresponds, in ANSA CAE language, to the *common model*. A common model defines the physical model that will participate in an analysis. It is called “common” because it consists of all the components, connections, connectors and mass-trim items that are common to all disciplines. The common model is stripped of any solver specific features; it is, however, ready to adopt any form suitable for the analysis that will follow (figure 10).

This use case will leverage the common model to derive the solver common model through enhanced integration between Teamcenter and ANSA. The solver common model dictates how the common model should be transformed in order to render it more meaningful for the particular CAE analysis at hand. In this sense, the solver common model may be essentially the same for all analyses under the same CAE discipline and can be seen as a link between the common model and the actual solver load case that follows.

For example, to perform front impact analysis using an explicit solver, you need to read the common model, give the suitable representation to model connections and connectors, add the necessary mass trim items, define the output requests and verify that the model is indeed valid for the explicit solver being used.

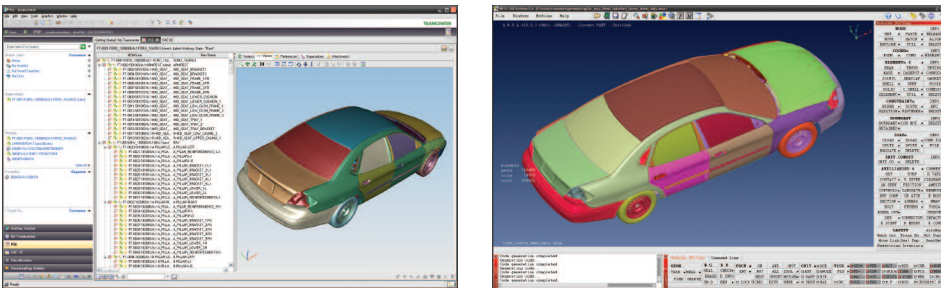


Figure 10(a): Configured CAE structure in Teamcenter.. Figure 10(b): ANSA common model.

The preparation of the solver common model is achieved by utilizing two integral parts of ANSA: ANSA data management and ANSA task manager. ANSA DM lies in the background and provides all the required auxiliary and library items, while ANSA task manager reflects all distinct modelling actions that must be followed for the preparation of the solver common model. These task templates are also stored in ANSA DM. In figure 11, ANSA loads the common model exported from Teamcenter, assigns the solver common model task and executes its actions. The result is communicated back to Teamcenter for storage.

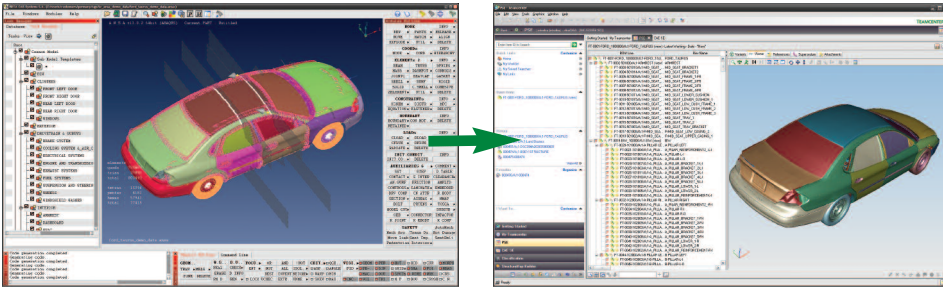


Figure 11: The solver common model in ANSA exported to Teamcenter.

In a fashion similar to the above discussion, the solver common model can be exported from Teamcenter for the purpose of preparing a solver input deck. All that is now missing is the application of the specific loadcases that need to be analyzed. A loadcase contains all solver definitions that make the model suitable for the investigation of a standardized or company-specific loading scenario. ANSA task manager, having ANSA DM always in the background, will apply the desired loadcase(s) and proceed to the output of a ready-to-run file that can be submitted for solution (figure 12).

The described approach to the build-up of solver input files exploits all benefits of the integral functionality of ANSA task manager. All actions leading to the final output can be defined by CAE experts and, executed in a stepwise fashion, can be repeated by inexperienced users and help capture and diffuse knowledge among members of the same group. Moreover, task templates are repeatable, can be used with different sets of data and can easily accommodate changes in model parameters. Finally, with all items under the control of the task manager, the identification of inter-dependencies among modelling actions and the subsequent resolution of conflicts safeguards model integrity.

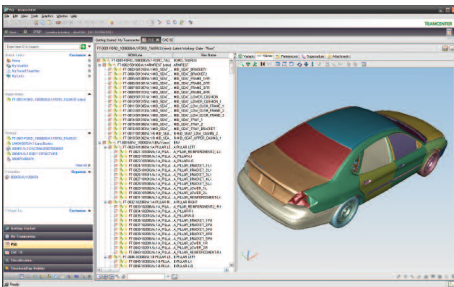


Figure 12(a): Export of ANSA solver common model.

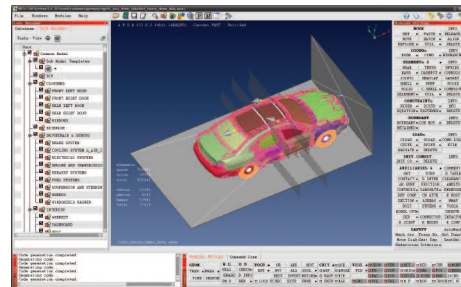


Figure 12(b): Application of the loadcase.

► Conclusion

The Teamcenter-ANSA integration brings the worlds of PLM and CAE closer and satisfies the need for faster, efficient CAE workflows, so as to actually impact product development.

The integration framework requires minimum configuration for the two applications. Data exchange is facilitated through a common working space and a single PLM XML file describing the product/analysis structure and the content of the exchanged data. At the beginning of the process, the data and the PLM XML file are exported by Teamcenter. ANSA then imports the PLM XML file and performs the required pre-processing actions on the product data. In turn, a PLM XML file is exported by ANSA and subsequently used by Teamcenter to bring the modified data back, update the analysis information and store the results in-context of the product data.

A major advantage of the PLM XML approach is that no interface utility (translator) is required to establish the communication between Teamcenter and ANSA. As a result, the two applications can be released and maintained independently of each other.

The Teamcenter-ANSA interaction use cases currently include CAD data translation and subsequent batch meshing, the build-up of sub-assemblies and the build-up of a complete vehicle assembly. In combination with ANSA DM and ANSA task manager, a next level of integration will cover the build-up of a ready-to-run input solver file.

It is expected that the collaboration between Siemens PLM Software and BETA CAE Systems S.A. will result in an out-of-the-box solution for the CAE engineer, as it combines the capabilities of Teamcenter and ANSA in a simple and straightforward manner.

About BETA CAE Systems S.A.

BETA CAE Systems S.A., headquartered in Thessaloniki, Greece, is a private engineering software company committed to the development of best-in-class pre- and post- processing solutions for multidisciplinary CAE applications. The BETA CAE Systems flagship product suite, comprised of the ANSA pre-processor and μ ETA post-processor, holds a worldwide leading position in the CAE software. This product suite sets the standard in CAE pre-processing and post-processing in many sectors, including automotive, railway, aerospace, motor sports, chemical processes, energy, electronics, heavy machinery, power tools and biochemical. For more information on the company, its products and services, visit www.beta-cae.gr

About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with 6.7 million licensed seats and 63,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with companies to deliver open solutions that help them turn more ideas into successful products. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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