

Efficient CAE data and process management, for virtual product development and verification, in LS-DYNA simulations

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Summary:

In modern automotive industry, the distance between conceptual design and production consists of an ever increasing number of CAE-cycles that involve the collection / manipulation of huge amount of diverse data. In addition, the growing complexity of simulation and analyses leads to error-prone procedures tends to delay crucial decisions and prolongs the CAE turnaround time. The remedy to this is *process automation* and the challenge is to achieve it by keeping the procedure cost-efficient and error proof.

To improve CAE productivity, it is suggested that a centralized Data Management system is used to store / retrieve and provide engineering data to a Task Manager that contains all steps required for the generation of alternative vehicle simulation models. Tasks in Task Manager are set by CAE experts, thereby making CAE experience and expertise inherent in the process.

It is believed that the adoption of the proposed workflow process will compress the overall CAE turnaround cycle and help keeping the CAE process cost efficient and error proof.

Keywords:

CAD, CAE process workflow, CAE productivity, impact CAE, ANSA, Data Management, Task Manager, Common Model, Impact specific common model, Loadcase, LS-DYNA

1 Introduction

In present-day automotive industry CAD and CAE have become integral parts in the design and development process of a vehicle. New CAD tools and parametric design has helped designers to produce large number of component / vehicle variations in shorter time. This, in combination with the increased number of standard and OEM specific loadcases that should be analyzed, has brought CAE engineers in front of a new challenge: to improve CAE productivity and make CAE fast, flexible and efficient enough, not only to investigate all vehicle alternatives, but also to identify deficiencies in-time and suggest to CAD possible ways of improvement.

To improve CAE productivity, *CAE Process Automation* seems to be an appealing and promising answer that will reduce the CAE turnaround time, while keeping the overall procedure cost efficient and error proof. Within this framework, BETA CAE Systems S.A. introduces an **integrated CAE process workflow manager** that promotes knowledge transfer and exploits the cumulative CAE experience and expertise.

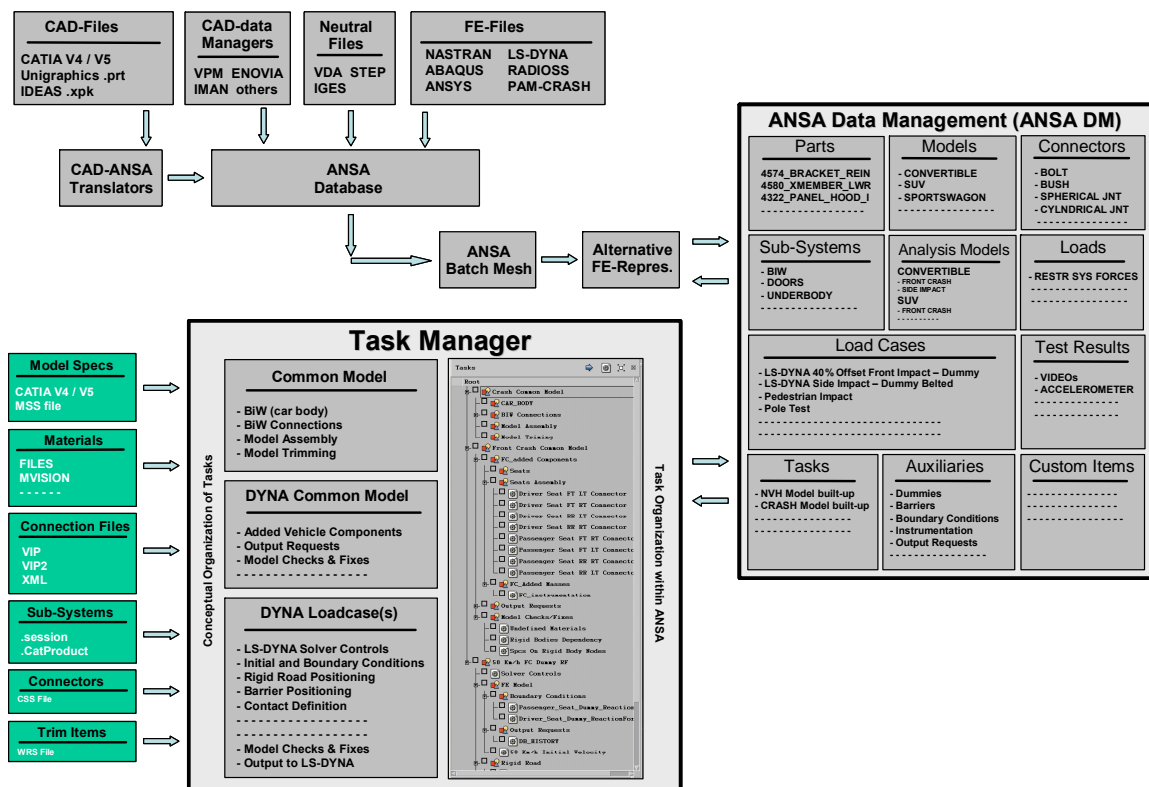


Fig. 1: Task Manager and Data Management as integral parts of CAE process workflow

In the heart of this integrated workflow manager lays **Task Manager**, a tool where all individual tasks of the development of a vehicle simulation model are included. Tasks in Task Manager are built up from CAE experts who set the order and boundaries between distinct modeling actions and predetermine all modeling parameters that must be respected at each stage. Once the task list is completed, it can be used by inexperienced users to generate the required analysis models. In addition, although the task list may lead to a particular simulation model the tasks themselves are not bind with any particular set of data; they just set the relationship of actions that must be followed in order to build a model and they can be used in the same sequence for a number of different vehicle data.

To facilitate the completion of modeling tasks, a data management system called **ANSA DM** is used to store or retrieve, engineering data, synchronize multi-instantiated parts and, by monitoring CAD changes, inform CAE teams of any model component updates. This provides a close link between the analysis model and the actual vehicle CAD data and assures that all CAE teams work on the same version of the vehicle.

Unlike other process automation tools, the Task Manager and ANSA DM are both integral parts of the preprocessor, in this case ANSA. This allows full exploitation of ANSA core functionality and provides visual feedback of all modeling actions.

Focusing on impact CAE, this paper suggests a new way of approaching CAE process workflow automation. The two main ingredients of this process, ANSA DM and Task Manager are discussed in detail in the following paragraphs.

2 ANSA Data Management (ANSA DM)

ANSA DM is a centralized data management system. Its purpose is to collect and store in a structured and hierarchical form, all engineering data that are used during the development process of a vehicle simulation model. Typical members of the ANSA DM are:

- the individual vehicle parts / sub-systems and their FE-representation,
- connectors and connectivity information
- batch meshing sessions
- boundary conditions and output requests
- trim items
- loads
- auxiliary components as dummies, impactors and barriers
- tasks
- material databases
- ready to run models, respective simulation results and reports
- other custom items

Under ANSA DM, all engineering data are stored in the same physical location. This location is made known to ANSA so that all communication related to the storage / retrieval of engineering data is managed automatically.

By using a simple example, the following paragraphs demonstrate the generation and utilization of ANSA DM members.

2.1 Part Representation Manager

Part Representation Manager is an integral ANSA tool that is used for the creation of alternative FE-representations for a part. Consider for example that the CAD department releases a design version of a vehicle part. The respective CAD file is then translated into an ANSA database. During the translation process several data are extracted from the CAD file like the part's name and ID, position, instantiation, target weight, property & material information as well as the version and maturity of the design. Of these data the name, ID and design version form the unique **signature** of the part.

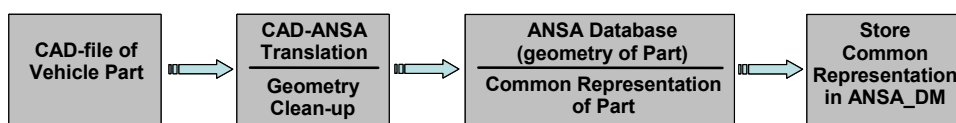


Fig. 2: CAD-file to ANSA translation

As depicted in figure 2, the result of the translation process is the actual cleaned-up geometry of the part. This geometry constitutes the **common representation** of this part and is stored within ANSA DM under a location dictated by the part's signature.

Starting from the common representation of each part, ANSA uses the Part Representation Manager to produce a series of discipline specific "mesh" representations as well as additional "reduced" representations (fig. 3). All representations can be saved in ANSA DM for sharing with other engineering teams.

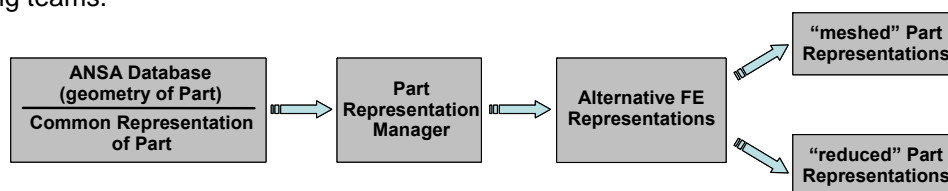


Fig. 3: Generation of alternative FE-representations

When the same process is applied on a collection of parts that form a sub-assembly, then the result is a "meshed" or a "reduced" representation of the sub-assembly. This in turn can be saved in ANSA DM for team sharing or for reference. The example that follows demonstrates this process on the rear right door assembly of a vehicle.

Note that regarding part instantiation, the relationship between parts created as "instances" of a "master" part is recognized and kept in ANSA. The respective transformation matrix of each part instance is applied automatically during the import of the CAD-data and the Part Representation Manager handles the synchronization of the FE-representation.

2.2 Generation of crash representations for a rear door sub-assembly

This example assumes that the parts comprising the door module have been individually translated from their original CAD format into ANSA files. These files reside in their respective location within ANSA DM. The process that will be followed is outlined in figure 4.

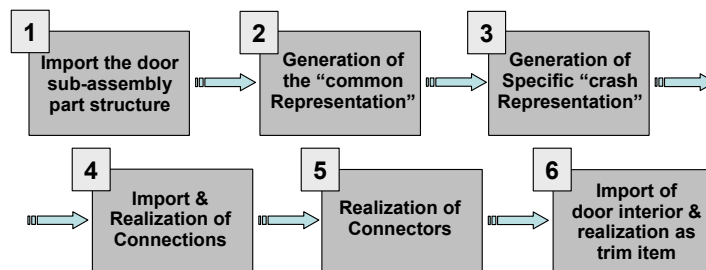


Fig. 4: Generation of a crash FE-representation of a door module

Starting from an empty file, the first step of the process is to import the part structure of the door module in ANSA. Part structure is provided by the OEM's CAD-data Management System, for example VPM, ENOVIA, etc. Once read, this structure is reflected in ANSA Part Manager (fig. 5):

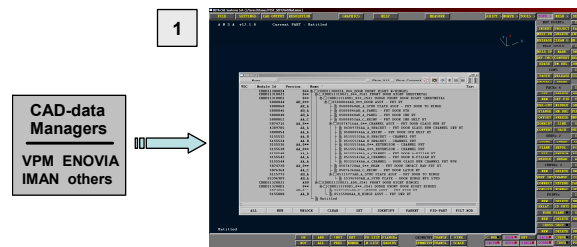


Fig. 5: Import of door part structure

Next, a request to check for any available part "updates" is made to ANSA DM. As "updates" are considered the file versions that are newer from the ones existing in ANSA. Since this is still an empty ANSA file, the request for updates is actually a request to load the latest version of each part of the door module. The request can be made individually on each of the parts residing in the Part Manager, or can be made for a collection of parts, e.g. the door group. In other words, we can ask ANSA DM to check and update the complete door module in a single step. This is the step where the geometry of physical door data is loaded into ANSA (fig. 6).

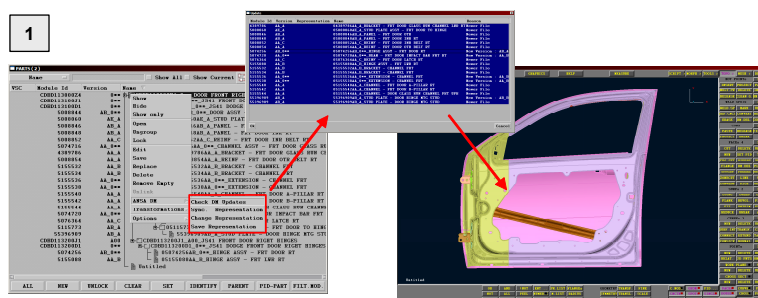


Fig. 6: Load latest updates of parts

At this stage, the loaded clean geometry can be saved in ANSA DM as the "common representation" of each part, or as the "common representation" of the entire door module (fig. 7).

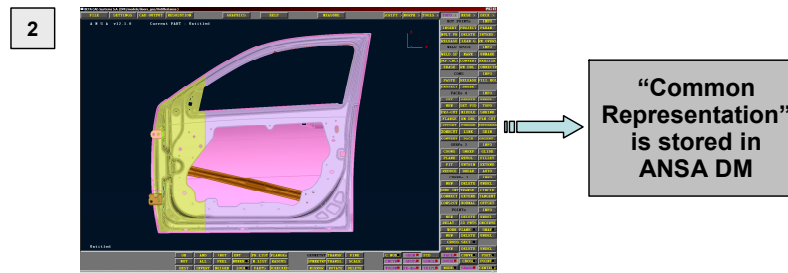


Fig. 7: Generation of the common representation / storage in ANSA DM

Using the common representation just created, ANSA will invoke the Part Representation Manager in order to create alternative FE-representations. To do so, we ask ANSA DM to "change representation" of the door group (fig. 8)

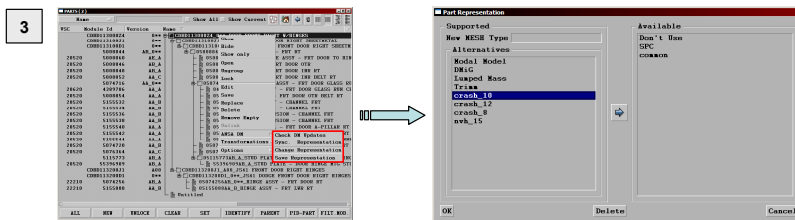


Fig. 8: Launching of Part Representation Manager

Part Representation Manager lists the **supported** and **available** representations. The "available" are the ones already existing in ANSA DM, i.e. the "common" (created just earlier) and the two default representations: **SPC** (where all locations where the part connects to the model are constrained) and **Don't Use** (where the part is ignored from the specific analysis but is not deleted from the model tree). On the other hand, the "supported" representations are the ones that can be created automatically. These are either "mesh dependant" or "reduced" representations. For now the "crash 10mm" representation is selected. By doing so, the Part Representation Manager will perform the following actions:

- check to see which parts of the door have a "crash 10" representation within ANSA DM
- substitute the common representation of these parts with the "crash 10" representation
- for those without a "crash 10" in ANSA DM, create a Batch Mesh session using the respective "crash 10" mesh and quality criteria already stored in ANSA DM.
- create "crash 10" representation and then substitute the common representation (see the door reinforcement bar in fig. 9).

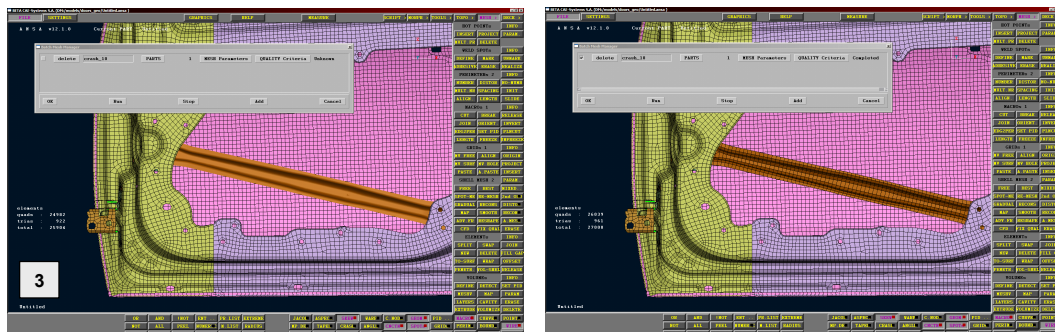


Fig. 9: Automatic generation of crash mesh representation

Having got a crash 10 representation for the complete door assembly, the next step is to import the respective BiW connection information from ANSA DM. In this example connections are read through an XML file, describing the most common types found in impact models, for example: spot weld points, spot weld lines, seam lines, gum drops and bolts.

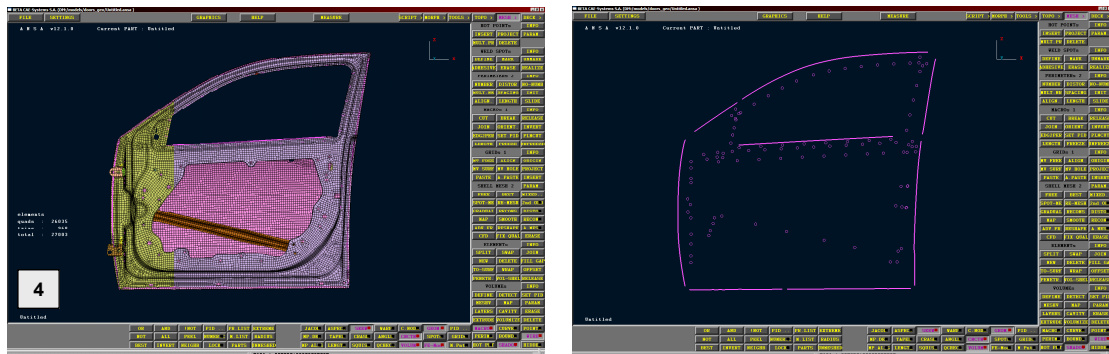


Fig. 10: Import of connection information from ANSA DM

BiW connections are realized through the Connection Manager using suitable FE-representations for LS-DYNA impact analysis, with automatic generation of the required CONTACT interface.

The kinematic connectivity type between parts or sub-assemblies, such as the BiW frame with the closures and suspensions, is modeled using **connectors**. Connectors are generic entities used as library items within ANSA DM to model joints, bushings or other user-defined kinematic connection types. To operate correctly a connector needs the following information: the location of connection, orientation vector(s), parts connected with the connector, search pattern used for the connection (e.g. holes, circular features, and nodes), interface representing the connectivity (e.g. rigid, interpolated) and the FE-representation of the connection.

Although connectors are originally designed with specific length and orientation, ANSA changes the connector length and orients the connector along the direction defined by the attachment points lying on the opposite connecting parts.

In our example, connectors are used to model the connection between the door module and the BiW frame. Figure 11 depicts two different FE-representations for the joint at the lower hinge, one as a revolute and one as a cylindrical joint.

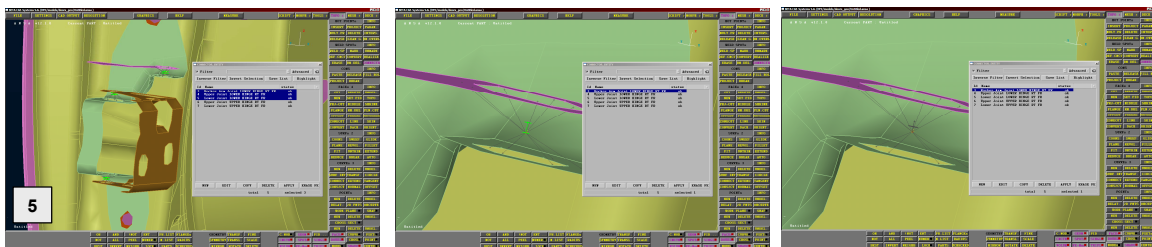


Fig. 11: Realization of connectors

Up to now the door module consists of parts having a "crash 10" representation, properly connected with different connection types and kinematic connectors. At this stage, the door interior is imported and two different representations of the resulting assembly will be produced: (a) the door module plus the interior as a separate part connected to the module, and (b) the door module with plus the interior represented as distributed trim masses to nearby parts of the door module.

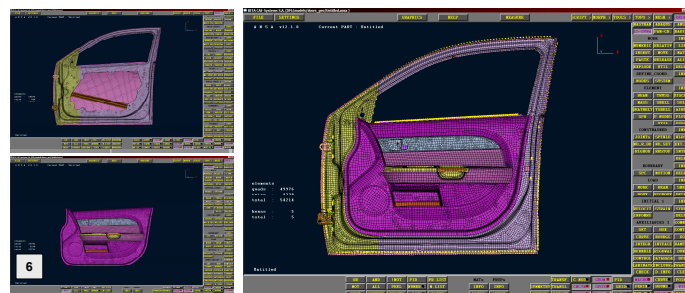


Fig. 12: Attachment of door interior to door module

The representation of figure 12 is used in side impact loadcases, where the interior is significant and should be modeled with a complete mesh-representation. However, in front crash simulations we only need to take into account the mass and inertia of the interior. To change the representation of the interior, the "trim" representation must be selected from the Part Representation Manager (fig. 13)

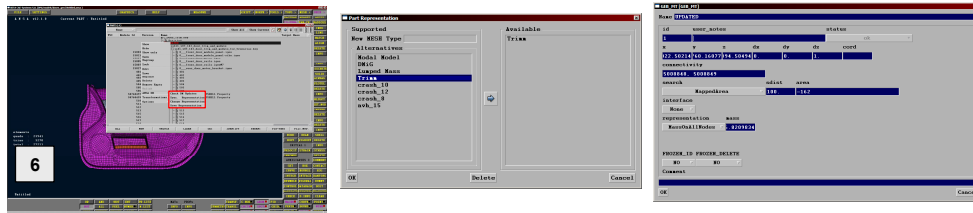


Fig. 13: Generation of tri item representation of door interior

Once the interior has been represented as a trim item, its mass can be distributed to adjacent parts of the door module. This is achieved by through the Trim Item Manager (fig. 14)

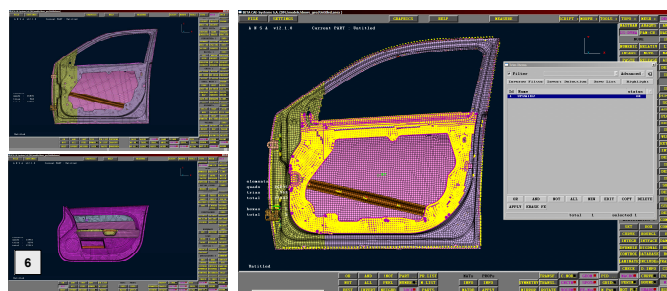


Fig. 14: Distribution of door interior to door module

2.3 Additional ANSA DM library items used in loadcases

Apart from connectors and trim items, other loadcase specific library items stored in ANSA DM are the Boundary Conditions (BC) and Output Requests (OR). The BC-Item is considered in applying constraints or loads using different kinds of patterns for their realization. Figure 15 depicts the application of a dynamic load to the shock absorber attachment point.

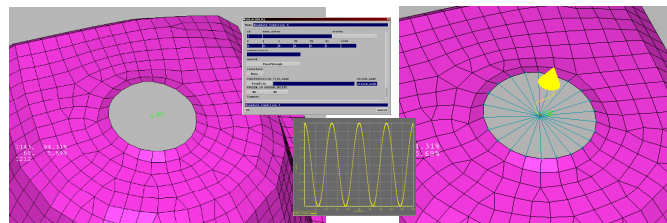


Fig. 15: Application of dynamic load as a BC item

The OR-item is used to assist post-processing standardization. Most of the analysis cases require the definition of entities (e.g. database cross-sections, accelerometers), from which certain attributes are important for post-processing. Using OR-items, ANSA allows the definition of these as Generic Entities, in order to assure the validity of comparable results.

3 Task Manager

All individual tasks of the development of a vehicle simulation model are included in Task Manager. Tasks are built from CAE experts who set the order and boundaries between distinct modeling actions and predetermine all modeling parameters that must be respected at each stage. When the vehicle data are placed under the control of the Task Manager and tasks are executed in turn, a ready-to-run vehicle impact simulation model is built automatically (figure 16).

This paragraph describes the automated process for building an LS-DYNA front crash impact model using the Task Manager. The process is broken down in three steps (figure 17):

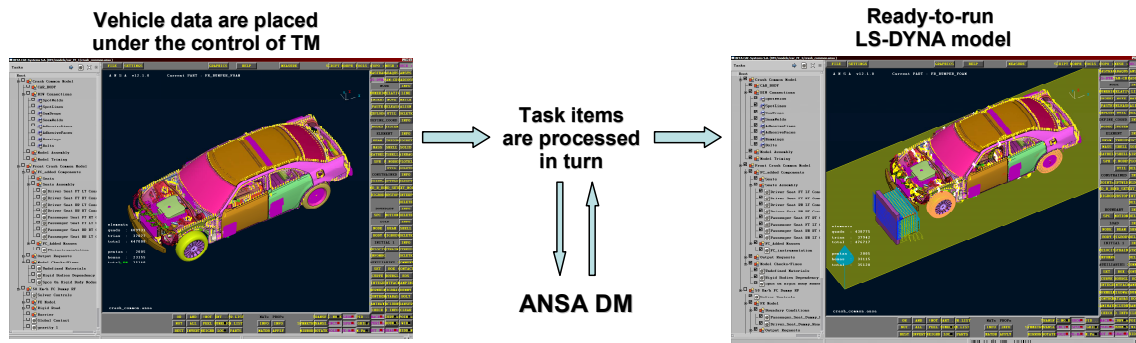


Fig. 16: The process of model build-up using Task Manager

1. the generation of the **common model**, that is a model stripped of solver and analysis specific data, ready to adopt any form needed for the analysis at hand
2. the implementation of the **impact specific common model**, i.e. the specialized abstraction of the common model that will be used on all different impact analyses, and finally
3. the application of the **LS-DYNA loadcase** specifications under investigation. This is followed by outputting a ready-to-run model, solution monitoring, post-processing and reporting.

These steps represent individual items within the Task Manager and are processed in sequence, using the vehicle data communicated through ANSA DM.

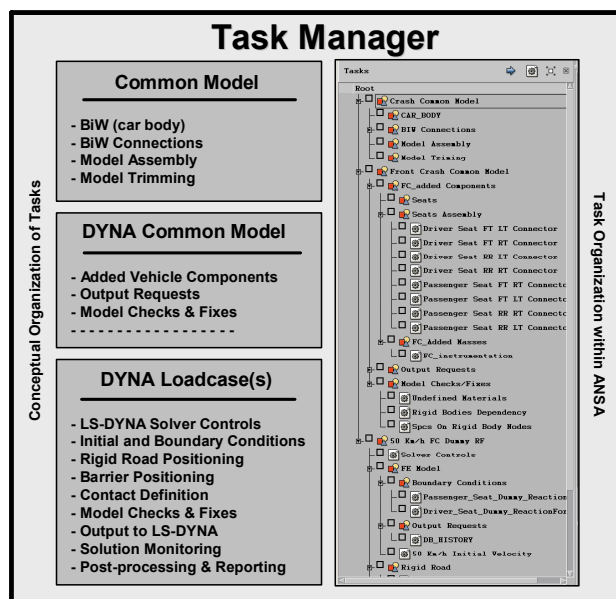


Fig. 17: The process of model build-up using Task Manager

3.1 The Common Model

The **common model** step contains the **definition of the model** that will participate in the analysis. This definition is actually whatever the CAE expert has defined as being **common** to all disciplines; in other words it is just the BiW parts of the vehicle and the respective connection information.

The FE-representation of the BiW parts depends on the analysis that will follow. Since this example is a front crash impact, the "crash 10mm" FE-representation of the BiW parts is placed under the control of TM.

The next task is the realization of connections. The Connection Manager appears and a suitable LS-DYNA representation is applied. Finally, additional assembly or trim items (if any) are brought into the model. Figure 18 illustrates the task flow.

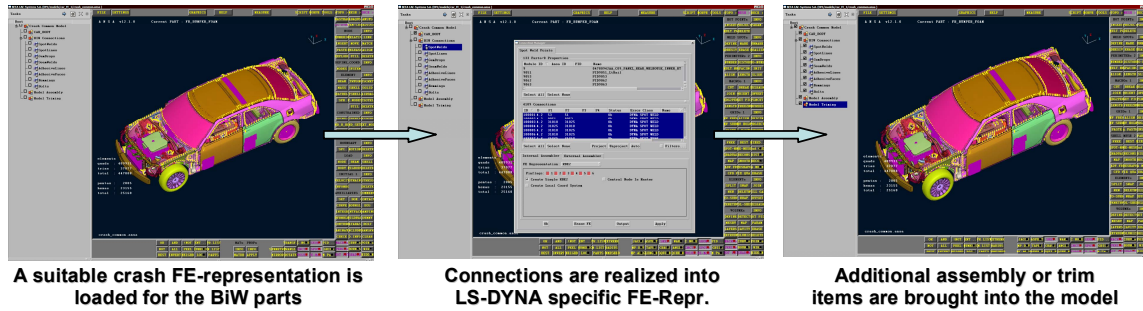
Common Model Step

Fig. 18: Execution of the Common Model step of TM

3.2 The Impact Specific Common Model

The second step contains the **impact specific common model**. This is the specialized abstraction of the common model that will be used on all different impact analyses (e.g. front impact, side impact, impact under US regulations, under EU regulations etc). In our case the front crash common model begins by inserting and connecting the driver and passenger seats of the vehicle. Then, the front crash instrumentation is modeled as a point mass at the rear of the car. These tasks are shown in figure 19.

Impact Specific Common Model Step

Fig. 19: Execution of the Front Crash Common Model step of TM

As the process flows (see figure 20), output requests are defined as database cross sections and accelerometers to specific areas of the BiW, followed by the application of model checks and fixes, e.g. for undefined materials, rigid body dependencies, SPCs on rigid bodies etc.

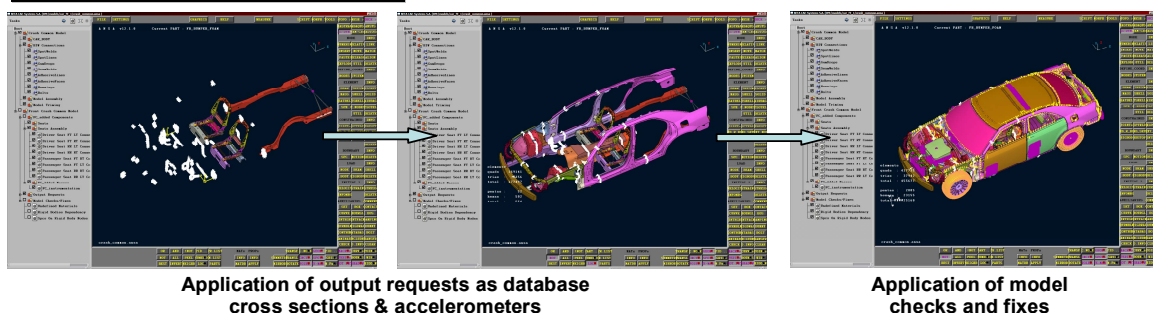
Impact Specific Common Model Step

Fig. 20: Execution of the Front Crash Common Model step of TM

All library items (sub-models, connectors, trim items, etc.) needed for the completion of the above tasks are communicated to the Task Manager from ANSA DM.

As mentioned earlier, the impact specific common model is to be used on all different kinds of impact analyses. However, depending on the analysis type, some of the vehicle parts should acquire a FE-representation that differs from the representation of other parts in the same model. For example, in

the side impact simulation model of figure 21, the representation of the door modules may be "complete" on the impact side but "reduced" on the opposite side. This is achieved by picking suitable representations using the Part Representation Manager.

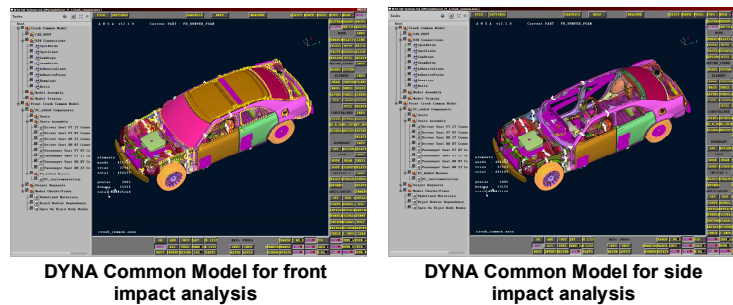


Fig. 21: Different FE-representation of door modules

3.3 Application of the Loadcase

The final step in the Task Manager is **application of the loadcase** that is under investigation. In this case a 50 km/h front impact with dummies as reaction forces is used. This loadcase plus the impact specific common model of the second step will form the final analysis model that will be delivered to the solver.

Tasks of this loadcase are depicted in figure 22 and used for the setting of solver controls, the definition of dummy reaction forces, the definition of database history results, and application of initial velocity.

Application of the loadcase

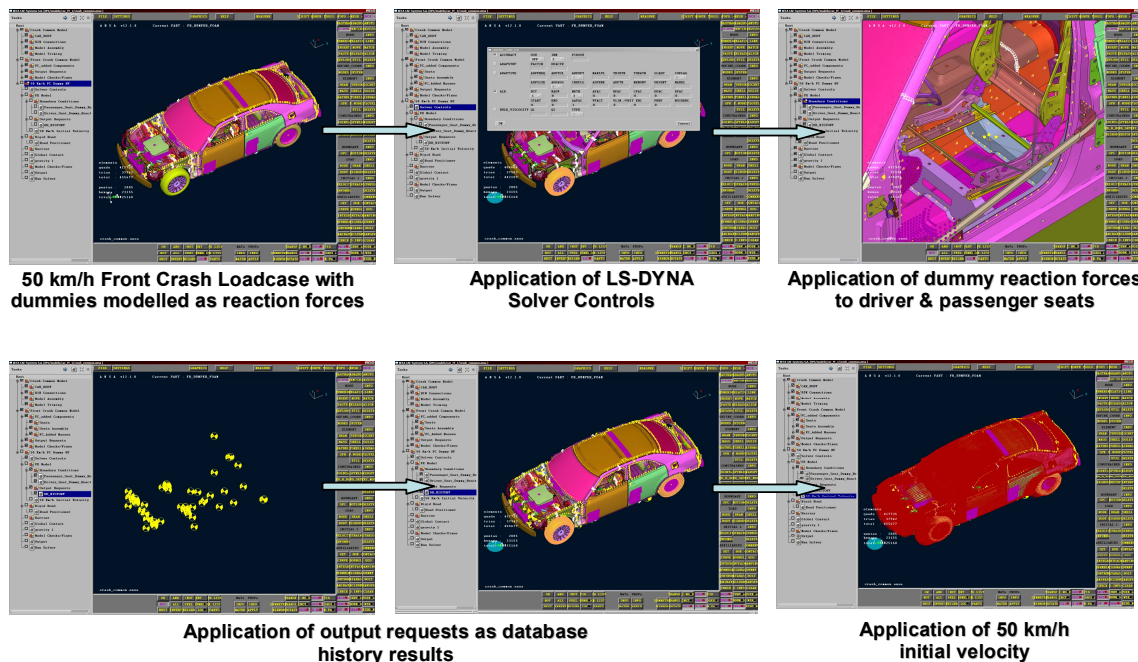


Fig. 22: Definition of DYNA loadcase

Additional tasks seen on figure 23 refer to the positioning of a rigid road and of a barrier, the definition of contacts as well as any other necessary checks & fixes that would verify the validity and compliance of the impact model. Solution monitoring along with post-processing and reporting can also be members of the loadcase and subsequently stored in ANSA DM for reference.

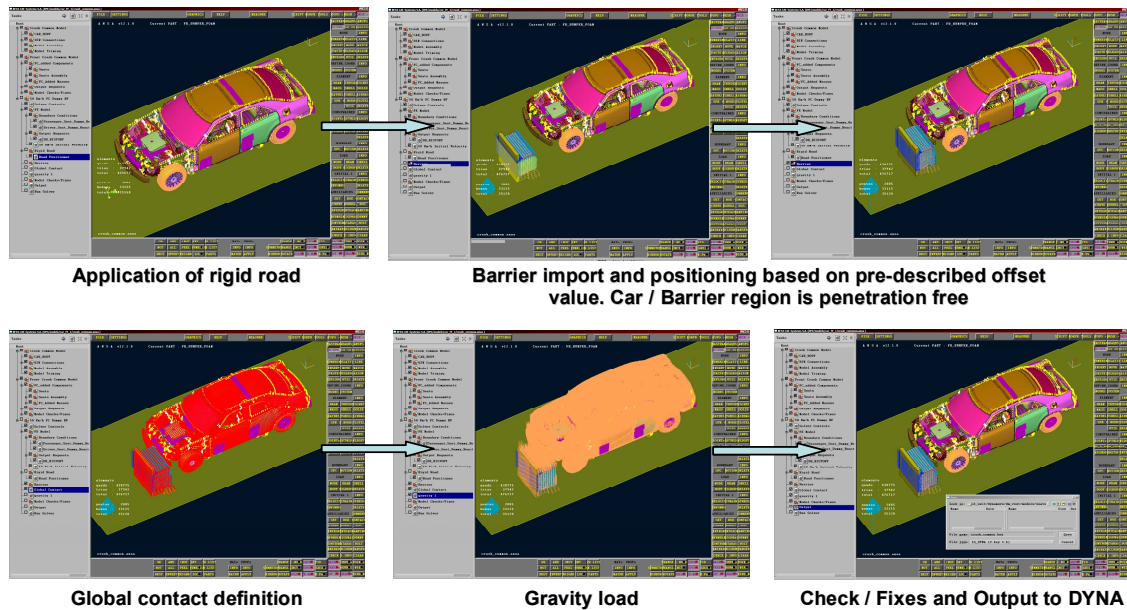


Fig. 23: Definition of DYNA loadcase

Engineers can investigate a multitude of different models just by adding to the task list the respective loadcase. Any task items that are affected by the inclusion of the new loadcase are automatically flagged and get updated when the process is run to generate a fresh model output.

3.4 Solution monitoring, Post-processing and Reporting

Following model output, an LS-DYNA solution job is submitted and monitored. Results are fed downstream to μ ETA POST and are post-processed automatically based on discipline-driven procedures. Subsequently, an HTML report containing engineering and model evaluation data is generated. These are stored in ANSA DM for future reference/comparison with model alternatives.

Result post-processing & Reporting with μ ETA POST

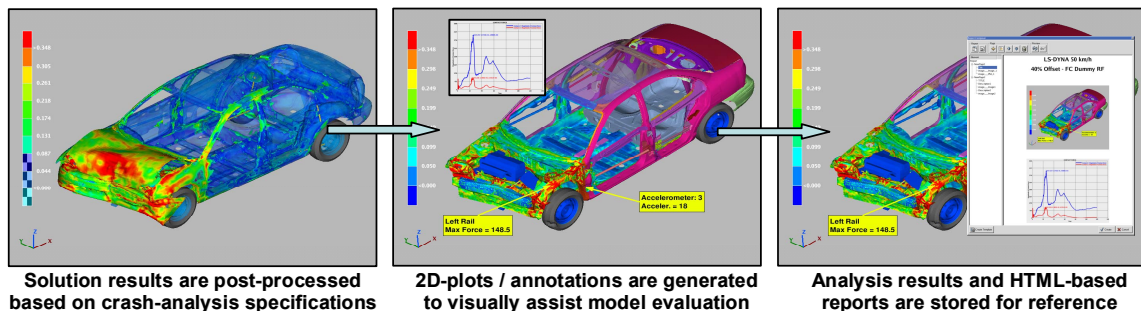


Fig. 24: Results' post-processing & reporting

4 Summary

CAD design today is no longer a slow process; using modern design tools and software, CAD designers produce a large number of component alternatives in very short time. This presents two major problems for the CAE analysts: (a) there is not enough time to check / verify the behavior of all model alternatives, and (b) CAE analysts from different departments (crash, nvh, durability) are no longer sure that they discuss and compare results for the same vehicle, since different alternatives may be used for the same component by different departments.

ANSA DM assures the effective and efficient data handling throughout projects, by streamlining updated model data to engineering teams, allowing the easy sharing of common data and offering the access to library items for the analysis dependant solution settings. Task manager integrates all modeling actions in a single process that must be followed in a stepwise fashion, allowing minimum

(or none) user interaction and decision making. This safeguards the quality of the model and makes CAE expertise inherent in the process.

Using the suggested methodology CAE becomes fast, flexible and efficient. Having ANSA DM and Task Manager as integral parts of ANSA, engineers benefit from the use of single software throughout the CAE process, avoiding migration to other tools and minimizing the possibility of errors.