

Latest Developments in ANSA for Model Assembly and Loadcase Management based on LS-DYNA Include Files.

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Summary:

The research and development phase in the area of Crash and Safety simulations are interwoven by continuously increasing demands in various ways. First of all the number of the FE-elements used for the model discretization as well as the model complexity that is being introduced, in order to achieve higher convergence with the test results, is constantly getting higher. Another factor is the number of the simulation models that is increasing as well. This happens due to the existence of many variations of a OEM's product that need to be analyzed, as well as the variety of the crash and safety test regulations that need to be examined.

So the handling of different model configurations, as well as the load case build up is a procedure that involves a huge amount of data, by taking also into account that the FE-model is divided into several include files created by various members of the engineering team. Since the target is the performance of high quality crush test simulations, the engineers needs to have assurance that the FE-model is of high quality, fully assembled and with those ingredients that are needed, in order to analyze the component's behavior and to proceed to design improvements.

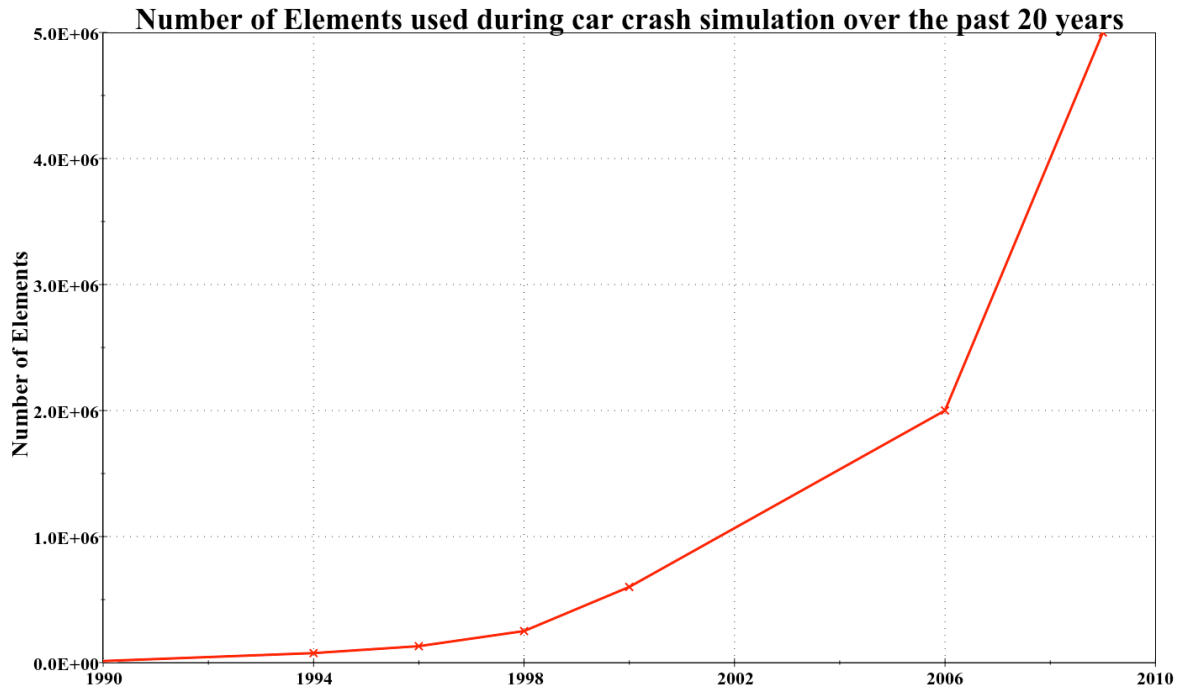
New technologies are being introduced in the latest version of the pre processor ANSA in the area of the Model Assembly and Load-case Management, that assist the simulation engineer in the includes management as well as the automatic creation of the final "ready-to-run"-deck. In cooperation with the Data Management features, the overview of the project data is achieved serving information of cross-disciplinary documented include files.

Keywords:

Model Assembly, Load-case Management, Include Files, Simulation Data Management, ANSA

1 Introduction

The demands of the safety features in the automotive sector are rapidly increasing. Not only that the number of car crush regulations are getting higher, but also the targets that need to be met in every test are constantly moving into to safer limits. And especially in years in which global economics are facing a tremendous low, every OEM is seeking time and cost savings more than ever, by decreasing as much as possible the real development prototypes crush tests, and at the same time produce safe vehicles while taking advantage by the confidence in crush simulations using Finite Element Analysis (FEA).

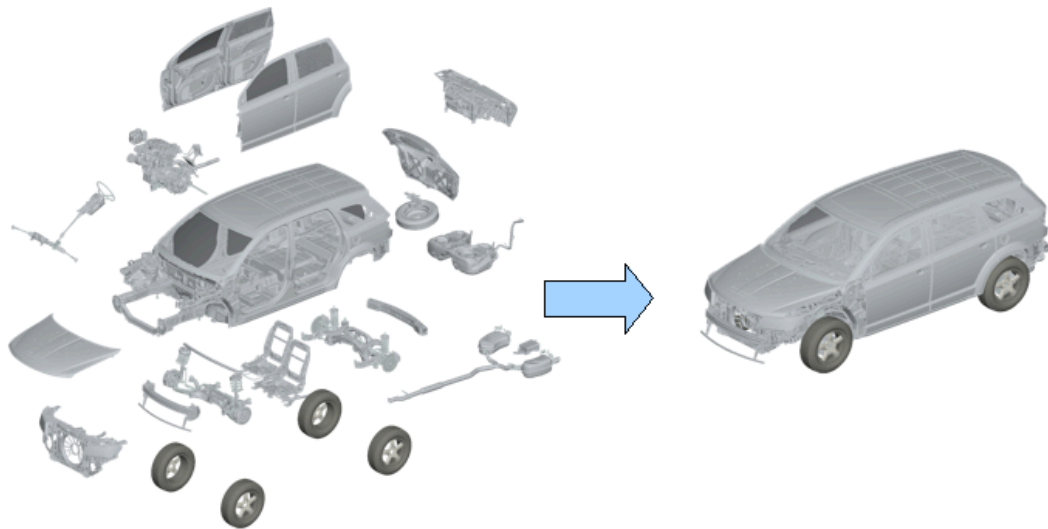


Picture 1: Number of elements used during car crash simulation over the past 20 years [1]

When FEA was applied in Crash & Safety 20 years ago, the simulation model consisted of 12.000 elements, all of them part of only one input deck [1]. But these times are long gone now. Today's simulation models consist of several millions of elements, as shown in Picture 1. In parallel, the complexity of the FE-models has become highly sophisticated as well.

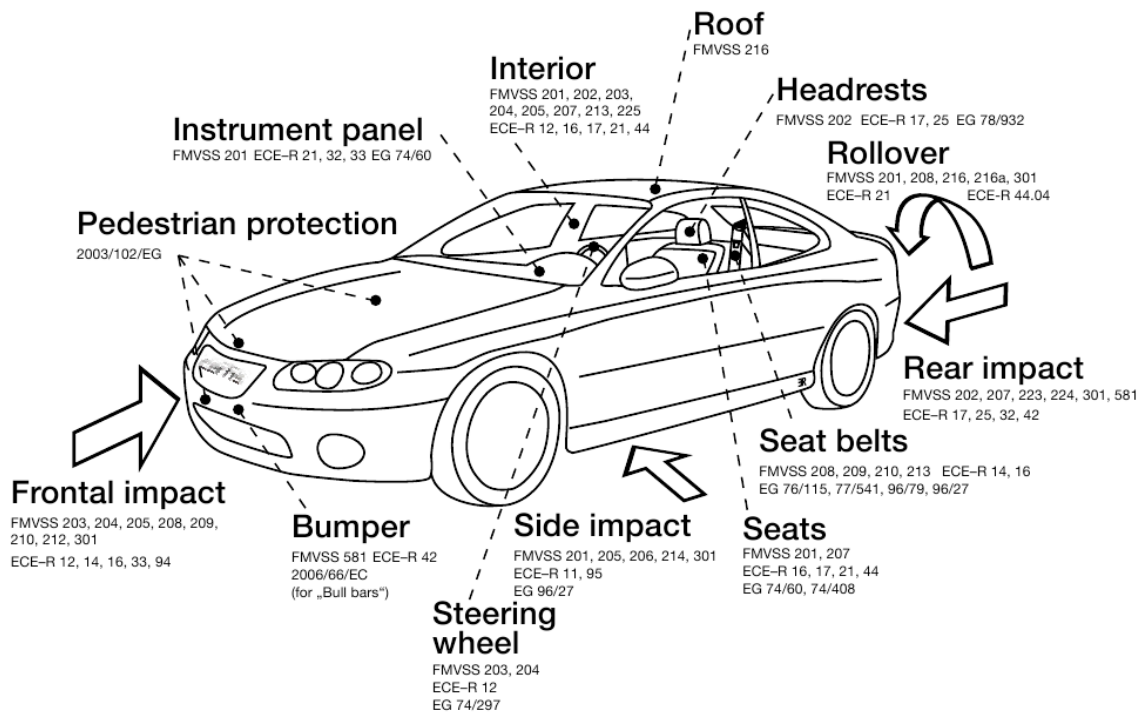
Along with the fact that FE-models have grown that fast, the several vehicle configurations that are being applied for crush tests have increased as well. Several roof types that are being used or the left hand/right hand drive are just few examples to give an idea of the variety of product configurations, that are being produced within the environment of an automotive manufacturer and all of them need to be analyzed. Therefore, common practice among the engineering teams has become the buildup of the simulation model in a modular manner, see Picture 2. Each subassembly is a stand-alone input deck and contains FE-attributes that will be used during the assembly procedure and will contribute to the coherence of the final model.

The same stands for those ingredients that build the load case scenario. The dummy models or the barrier impactor models are as well handled as separate include files. These differ per load case, in order to match the various regulation requirements, see Picture 3. Since the target is the performance of high quality crush simulations, the assembly procedure in this case becomes a very important and difficult task, in order to assure the high model quality of the final submitted deck.



Picture 2: The simulation model buildup is modular based on the usage of include files

Crash-Regulations in Europe and USA



Picture 3: High number of regulation tests that need to be examined during the product development in the automotive sector [2]

In order to improve the crush behavior of the model, the engineers introduce design improvements in geometry level (changing the shape of model's parts) as well as in the FE-properties, in terms of thicknesses or materials etc. These are applied to parts at include file level, using a text editor or tools with full preprocessing capabilities, according to the complexity of the modifications. It is important to be able to keep track of the evolution of includes as well as to compare them, in order to assist during the decision making or just help to continue the work of another engineer.

2 The Tools

2.1 Data Management System

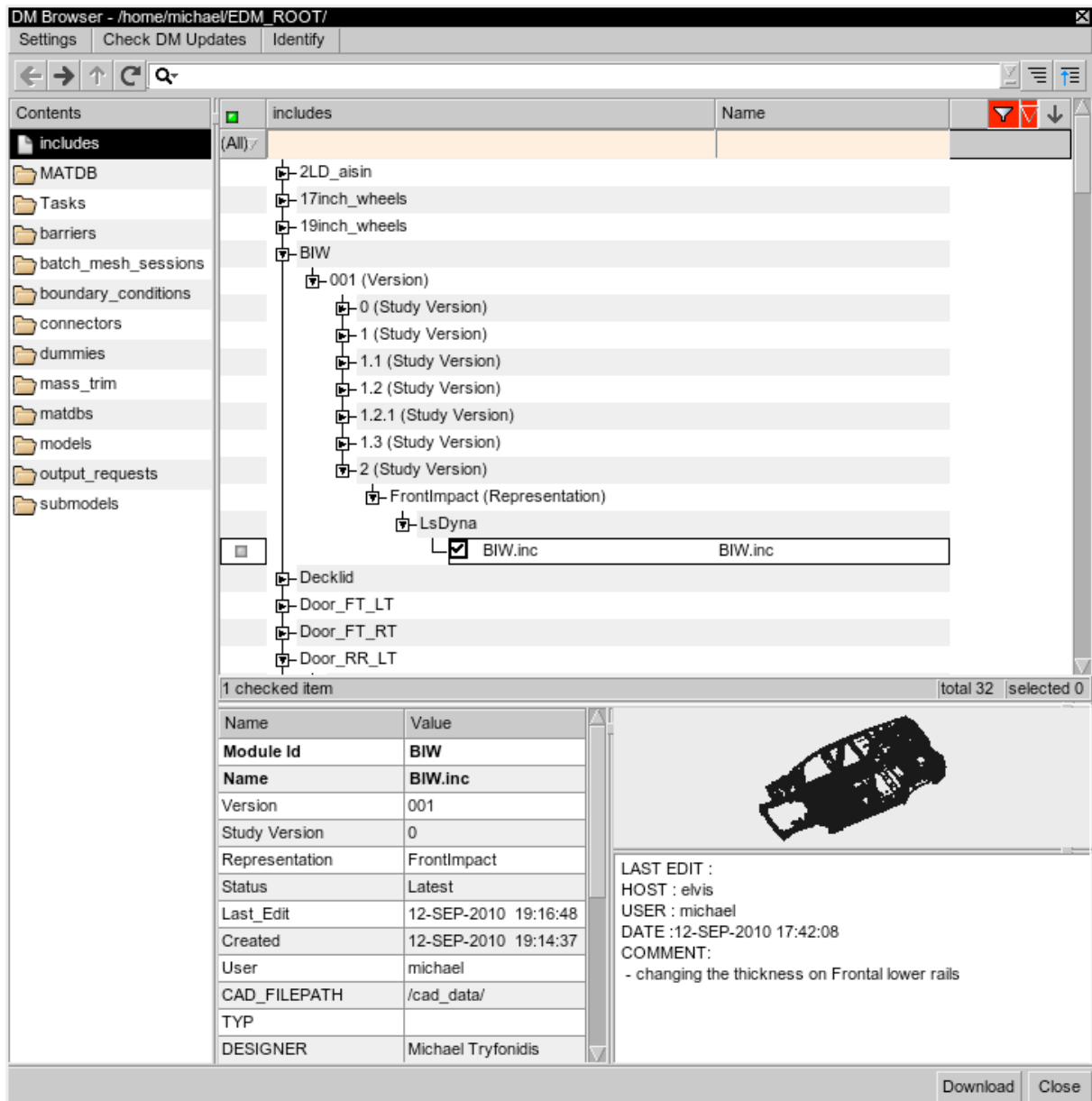
The necessity arises of being able to manage this huge amount of data required in the Crash and Safety simulation sector. This data management system should have the following characteristics:

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- It should serve the capability to track include file versions, to document them as well as to provide information about them.
- Queries should be made possible, in order to find updates or just the include file that is necessary for the run.
- The file browser of the operating system should be applicable to navigate within the system data, if needed.
- Serve advanced browsing tools that have direct communication with the preprocessor, in order to perform modeling tasks or just for checking the model quality.
- Representation management of includes. Many times, certain include files are not represented in a full FE manner, but on demand in a lighter FE-model (for instance the lumped mass model of the door). So, the tool should assist in their creation, storage and management as well.

The proposed solution of the Data Management system served by the ANSA preprocessor (ANSA DM) fulfills the above requirements and will be further examined. The basic browsing utility, called DM Browser, can be seen in Picture 4. The ANSA DM is a structured and centralized Data Management system. It assures that all engineering data, which are used during the building process of a vehicle simulation model, are securely stored and can be retrieved at any time by all CAE engineers, working on various fields of developments. Typical data residing in DM are:

- The individual sub-systems, such as seats/dummies, walls/barriers, in their FE representations.
- Library items, such as connectors, boundary conditions and output requests, reusable during the build up of each subassembly.
- Files containing engineering, connection and trim data.
- Load case templates, such as Front, Side and Pedestrian impacts.
- Material databases and
- A number of different custom items.

In the case of Part and the Subassembly Data at include file level, information is organized in a structured way, corresponding to the release sequence of the designing departments. The optimization process begins based on the first Study Version, which represents the initial design state of the module. All other representation models that are to be developed, constitute optimized variations of the first study version. They will thus be stored accordingly as later study versions, as it can be seen in the tree-like view of Picture 4. Once saved in ANSA DM all versions are available to the members of the engineering team, for reference as well as for further optimization. Through DM, model design changes are effectively monitored, while CAE teams are notified the moment component updates are available, thus greatly facilitating all optimization work [3].



Picture 4: The GUI of the DM-Browser showing the history of the include file versions, as well as attributes and comments of the editor

2.2 Include Files Configurator

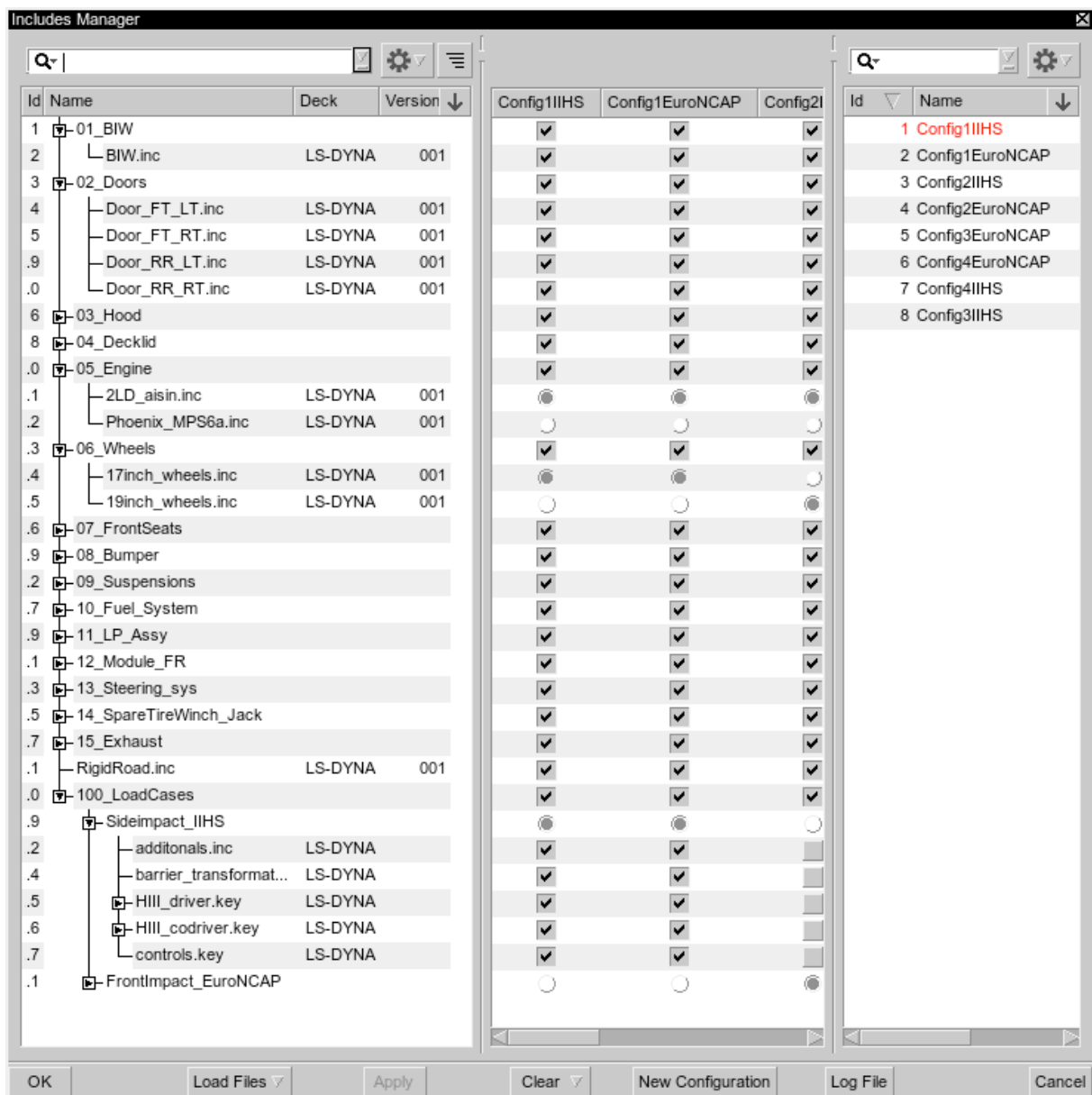
A tool in which the engineer gathers and assembles the include files into the final ready-to-run main include file, should fulfill the following requirements:

- The model assembly should be available at include files level.
- Include file configurations handling should be applicable in model as well as in load-case level.
- Filtering capabilities in order to identify the currently used includes in a specific configuration.
- Dependencies definition between includes.
- Import of the model into the preprocessor should be optional.
- Massive main-include files generation.
- Generation of additional keywords that are required for the load case or the vehicle assembly, based - on existing FE-attributes.
- Definition of user defined activities, that will be executed during each exporting activity.
- Comparison of model configurations.
- Optionally coupled with the ANSA DM.

- Model quality assurance with the execution of checking templates, following the internal modeling guidelines, as well as the syntax required by the solver.

The Include Files Configurator (Configurator) is a tool that has been made available within ANSA preprocessor for the assembly of ready-to-run solver input decks at include file level. Picture 5 shows the GUI of the Configurator, depicting also a typical example of a vehicle separated in include files. The model tree consists of several includes structured in such a way, that it represents the modular build up of the car, for example the body in white (BIW), doors, under-bodies etc. Each of them is part of the model tree with a certain version and study version. Version can be considered as the major CAE-Version of the include, while the study version is a more private level of versions during the optimization process.

The different include configurations can be seen in a detailed view in the middle of the GUI, serving in this way an overview which allows comparisons between them. Massive output of the main input decks is available through this interface, without the necessity to load them into the ANSA Preprocessing environment first. Of course, since the Configurator is part of ANSA, any configuration or separate include can be imported, in order to take advantage of the preprocessing functionality and to apply modifications or just simply check the FE-model quality.



Picture 5: The GUI of the Include Files Configurator within ANSA preprocessor

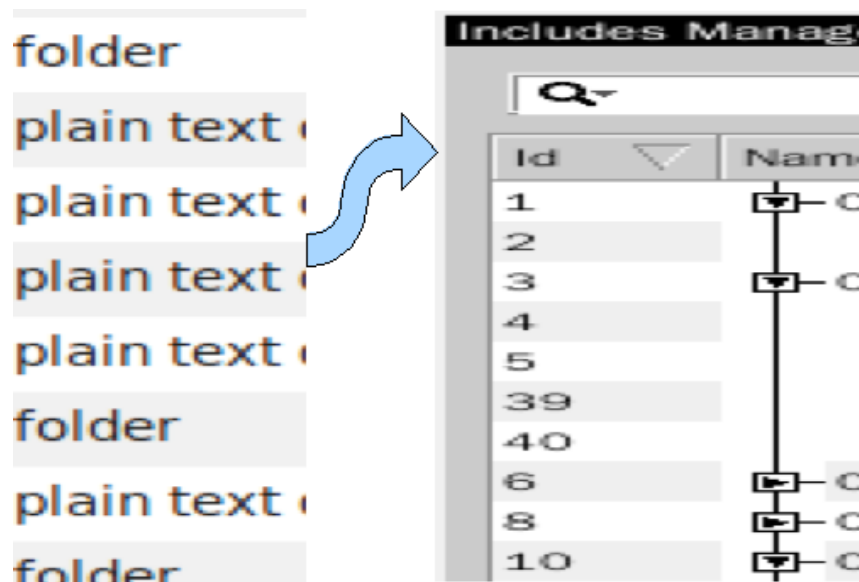
3 Application Example

The solutions given by these tools are depicted within the following paragraphs, showing an application example in various scenarios. Target is to demonstrate the capabilities that are available and their automatisms, as well as the scalability of the tools according to their level of usage among the engineering team.

3.1 Definition of the model tree

In order to work with the Configurator, the model tree needs to be defined first. This can be done in the following ways. First of all, by reading a main include file, that already contains the include file statements. But even by the absence of the main include file, import of the includes is possible by manually selecting them.

Even when choosing not to work with the ANSA DM capability, the include files might follow a simple data structure suitable for the users needs, as it can be seen in Picture 6. In this case, the support of the Ildyna `*INCLUDE_PATH` keyword helps to adapt the include file structure quickly, being independent of the absolute location of the project data.

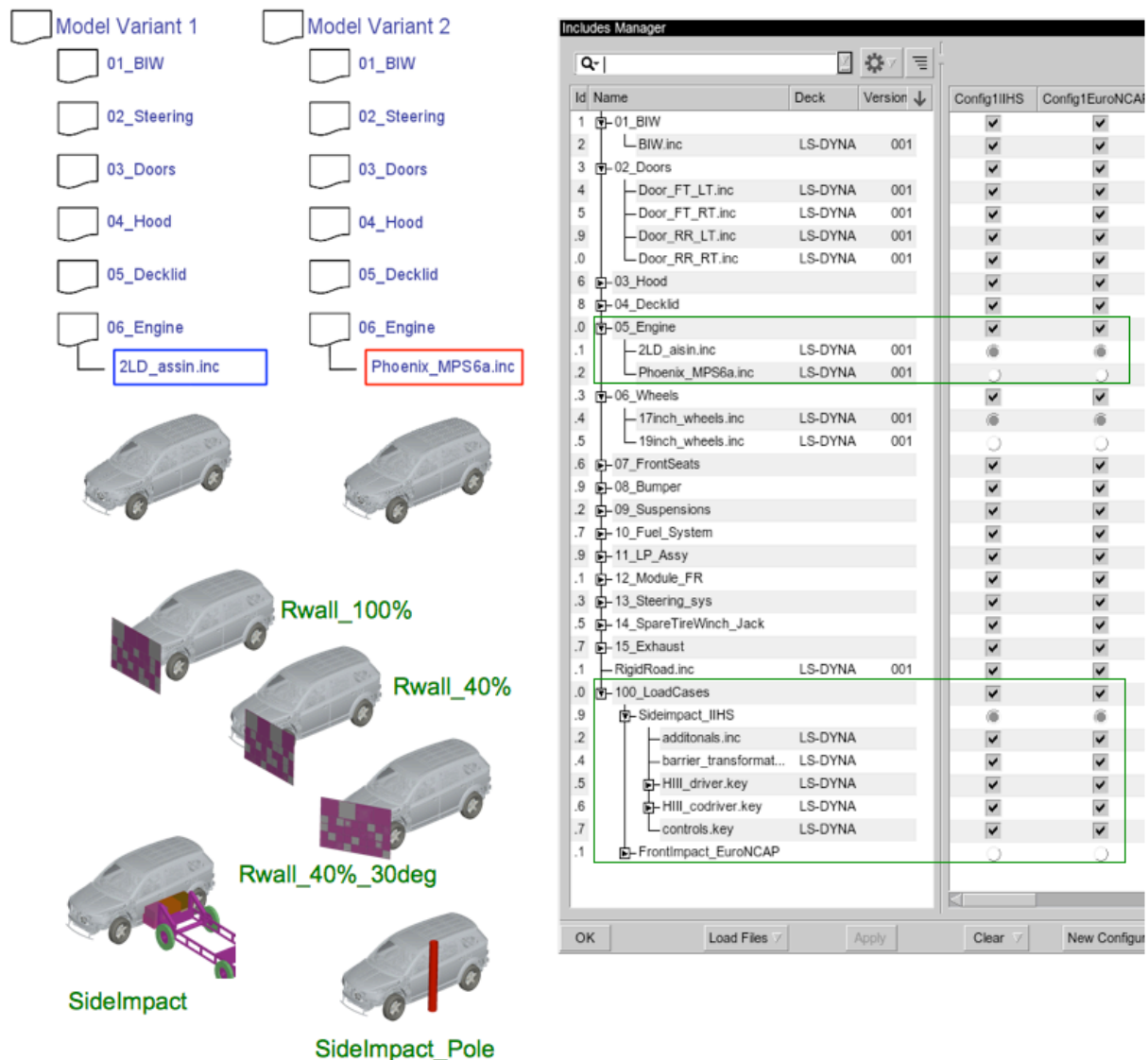


Picture 6: Even user defined include management structures can be handled with the Configurator

In case of working with the ANSA DM, the DM browser serves highly sophisticated filtering capabilities, in order to search for the include files to be used. Besides the version, the DM browser can look for various attributes, such as file creation and editing dates, user name, or user defined attributes.

3.2 Definition of model configurations

The basic concept of the model configuration represents a main include file, which after the application of the export activity, the include files being a part of it will be exported as include file statements. These configurations consists of different variants of sub-assemblies, that lead to a total different crush behavior. The example that is depicted in Picture 7 is focusing on this feature. Several variants of the module Engine exists and can be used, but only one of them at the time and eventually only in combination of a certain power-train assembly. During the definition of these configurations, the engineer builds up the tree and activates the includes that go along. The same exclusive dependence can be used, in order to apply different load-case scenarios.



Picture 7: Exclusive relationships between include files can be used in order to build different configurations in model and load-case level

3.3 Massive generation of main include files

The target is the generation of the main include file that contains all the include file statements. In order to facilitate the automated massive export of configurations, several settings are used:

- The full filename of the final main include file to be exported.
- Each configuration carries a comment section. This will be written within the main include file.
- User defined activities in form of a user script function, that will be executed every time the export is being done. This can be applied for the generation of keywords based on the FE-attributes of the sub-assemblies, without the necessity to load the model into ANSA to do this.
- The ls-dyna output deck version.
- In order to be able to package the main include file together with all the involved includes, the option to copy all includes to the output directory can be used.
- All files generated can be exported UNIX-formatted, in order to work with the Configurator even through a Windows operating system without any troubles.

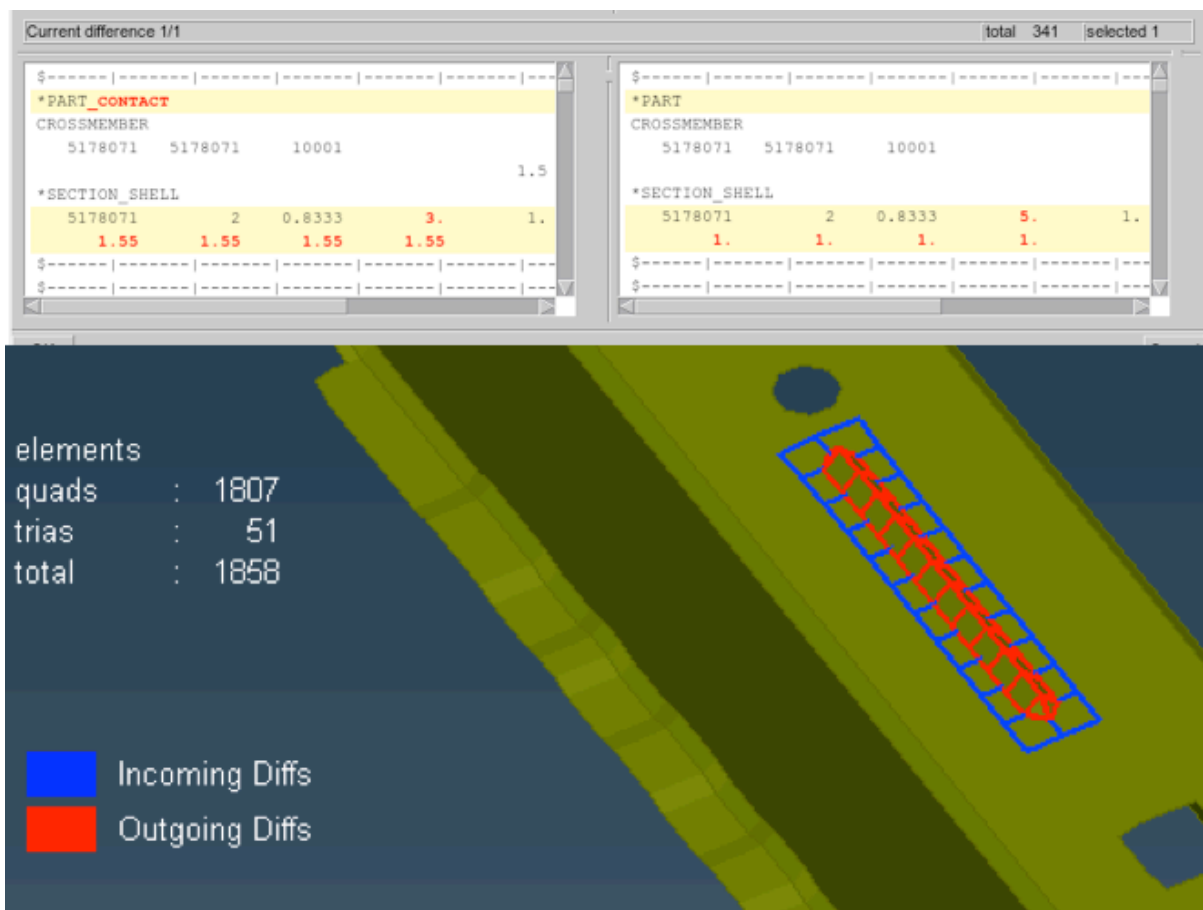
3.4 Performing design changes, updates and comparisons

In order to perform design changes, the engineer has the option to use a build-in text editor within the Configurator or to use the full preprocessing powers of ANSA, by simply loading the complete

configuration or just a part of it. ANSA script functions can be optionally set per configuration, that will be executed every time before and/or after the configuration is imported into ANSA.

After performing the change, the new version of the include file needs to be populated in the ANSA DM, as a new version or study version, according to the excessiveness of the modifications. In order to update the configurations and to use the new version of the include file, a simple query within the ANSA DM facilitates the model update in one click, an important feature in order to share changes within or across engineering teams.

In case, various design proposals of different includes file versions needs to be combined, the Compare tool is the solution. All Isdyna keywords are compared. Especially for parts, in order to find the correspondence of them from the one assembly and the other to compare them, the Compare tool is independent of *PART id's. The center of gravity, the area and the weight of the parts are calculated and if these values satisfy a certain threshold controlled by the user, the parts are compared. The Compare report shows differences in geometry level as well as in the level of the FE-properties such as thicknesses, number of integration points or material settings. On top, combinations can be made, in order to keep those characteristics from both of the model, that changed during the optimization process and that will build the new CAE version, for which a new cycle begins with the verification of the improvements.



Picture 8: Comparison of model changes made in geometry level as well as in the FE-properties, shown in a diff mode following to the Is-dyna syntax

4 Summary

It has been shown that working with include files, in order to build up several configurations of a car crash simulation model, can be very well assisted by the use of the Include Files Configurator, a tool that is part of the ANSA preprocessor. It serves the capabilities that are necessary for the main include files generation and enables the management of variations in model as well as in load-case level. Linked with the Data Management system, overview is given over the huge amount of data. Tracking of include file versions has been made possible, as well as to do queries about model updates.

Being fully integrated within ANSA, a complete preprocessing environment is served for the simulation engineer, contributing into major time and cost savings during the CAE process work-flow, by producing high quality solver input models and by ensuring confidence to the Isdyna simulation results.

5 Literature

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