

LATEST DEVELOPMENTS AND ADVANCEMENTS IN ANSA AND META FOR CRASH AND OCCUPANT SAFETY SIMULATION AND MODEL CREATION

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ABSTRACT –

The increasingly demanding and complex requirements in Crash Analysis, require continues and innovative software development. In an effort to meet and exceed the demands of the industry, BETA CAE Systems is introducing new cutting edge technologies. Both in the pre processing area with ANSA, and in post processing with μETA. This paper presents these new technologies.

Support for all the explicit solvers used for crash analysis is extended and always updated, keeping in line with the current releases of the solvers in terms of keyword support. More importantly, model checks, that are needed to make sure that the model quality is the highest possible, are continuously added and customized to meet each different solver's unique requirements.

With the introduction of a new version of ANSA in 2009 a new user interface was presented. New data browsing and model handling tools have been developed to simplify the handling of complex crash models. The new interface is a long-term effort that allows the CAE engineer to work in a modern software interface environment leading in increased productivity and "ease of use".

On the same time, the development of highly specialized tools can greatly reduce the time of pre processing by automating various difficult operations. Examples are, a kinematic solver that allows the manipulation of complex kinematic mechanisms of crash, tools to automate positioning of the various impactors and barriers, automate assembly, connector, mass trim and load creation for load case generation. In the field of occupant and pedestrian safety new tools were introduced that automate the procedure of implementing the various test protocols in all stages, from target identification to impactor positioning.

The existence of single, isolated functionality with high degree of automation does not suffice for improving the overall CAE workflow. This is why the above ANSA functionality can seamlessly work with and exploit the integral tools of ANSA DM for data organization and streamlining, and ANSA Task Manager for capturing, executing and safeguarding all model build up actions.

In the area of post processing the advances are equally impressive in the latest μETA versions. Better system resources utilization such as smaller memory footprint and a huge speedup in graphics performance, guarantee that even the biggest models won't compromise the responsiveness and feel of the software environment. Additionally advanced functionality, like the direct calculation of section forces, provides the tools that are needed for the evaluation of the results. Recently process automation tools are introduced which together with advanced report generation functionalities makes the automation of post processes easy.

TECHNICAL PAPER -

1. INTRODUCTION

The crash simulation model creation process is getting increasingly complex. Crash CAE needs to deliver analysis results for increasing number of loading conditions and test protocols. In addition automobile companies offer more variants of the same vehicle (sedan, station wagon etc.), which makes the certification process even more complicated.

Internally the CAE departments have to deal with their own process burdens such as having to use a lot of different software tools in order to build the models. Various pre-processors are used and each one is used to create a certain portion of the models. Different departments and disciplines within an organization use a different solver, which makes the interoperability of their data a hard task. Additionally custom solutions (scripts etc.) and in-house software increase the operational complexity.

In the last years with the rapid increase in computational power, there is a trend for the simulation models to become larger, in terms of number of elements / degrees of freedom, and more complex in the modelling of physics. This results into a huge amount of information that the CAE user needs to manage and to verify its correctness.

In this paper the role of ANSA and μETA is explored, in this demanding and complex CAE environment. Current tools and solutions are presented together with a glimpse of the future.

2. SOLVER SUPPORT

BETA 's software products have always been up to date, with respect to the needs of the CAE users for solver entities support. Building a strong relation with the users, the customer driven development philosophy has, as a goal, to deliver fast the new demands / requests for supporting the solvers. The crash solver support stands for all the popular industrial crash & safety solvers up to their latest versions, i.e. Abaqus Explicit, LS-DYNA, PAM-CRASH & PAM-SAFE and RADIOSS.

In recent years in order to meet these challenges BETA has engaged in alliances with all the major solver software companies, who have recognized BETA's position in the industry and a strong alliance is a natural occurrence.

3. MODEL CREATION TOOLS

In order for the model data to be usable by all disciplines the model needs to be constructed in a way that is discipline and solver independent. This is possible in ANSA with the concept of Common Model.

The Common Model is a state of the model where all the common engineering data are available in a solver neutral format (using ANSA entities). Such entities are the Connection Points, Connectors and General Entity Builders (GEB). These entities are created once and can be common to all solutions and to all CAE disciplines. At any point they can be realized and create automatically the desired solver entities directly from the engineering data and the customization data such as library items.

The advantages of this approach of having solver independent data is:

- The interoperability between solver decks.
 - Easy to reproduce the FE entities during CAD and CAE part / model variations.
 - Carry over of data from one program generation to the next.
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3.1 Weldings

Connection Entities are ANSA entities that contain the engineering information of a weldment between two or more parts. Such information is the type of the connection (spotweld, seamweld etc), the geometrical information such as diameter, width or height and connectivity information (which parts participate in the connection). In order to support the various types of weldings (1D, 2D and 3D connections), ANSA supports the following type of welds:

- 1D connections: spot welds, gumdrops, bolts
- 2D connections: spot weld lines, seamlines, adhesive lines, hemmings
- 3D connections: adhesive surfaces

This information is maintained in the ANSA database and is managed by the Connections Manager. These connections can be realized into FE entities of any type, when the model becomes solver and discipline specific.

ANSA can read a variety of standard connection point formats such as MCF (xml), vip, vip2. In addition a custom connections reader can be developed with the ANSA scripting language. Also, numerous semi and full automatic tools are available for the creation of welding information. The welds are controllable by the user quality, since improper connection information is detected and improved.

3.2 Connectors

Connectors are ANSA entities that are used to connect two or more parts, sub-assemblies or includes, modelling the kinematic constraints that physically exist between them. Some characteristic features of the connector entities' realization are:

- The Connector Entities are defined using mesh density independent patterns for the identification of the connected entities. Thus, a connector can be applied on a hole, circular feature or a certain number of nodes or elements, in a pre-defined search domain.
- Connector Entities that connect a rigid with a deformable component, using a rigid interface, automatically detect the case and create the required keywords (for example in an LSDYNA case *CONSTRAINED_EXTRA_NODE instead of *CONSTRAINED_NODAL_RIGID_BODY entities).
- The Connector Entities can use the built-in representations (i.e. revolute and spherical joints) or custom made ones, retrieved as templates from ANSA DM libraries. Their keyword card values of the library items can also be parameterized, so that they can be editable during the set-up of the connector (such as dimensions of the FE-item or stiffness parameters required by its property entry)

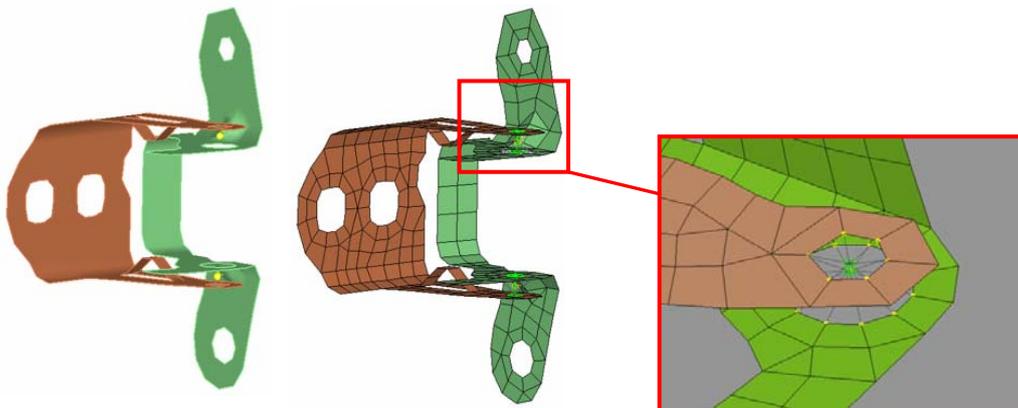


Figure 1 – Connector Entities before and after the realization of revolute joints.

3.3 General Entity Builder

The General Entity Builders (GEBs) are ANSA entities used to generate any kind of solver dependent FE entities. Their definition and behaviour is similar to the ones of the Connector entities described above. GEBs are used to create Boundary Conditions, Output requests and Mass Trimmings.

One example of GEB, is the GEB_OR (Output Request) for creating Cross Sections output request, so that the solver exports the cross sectional forces on specific locations. Using the Cross Section Assistant, the user can create a cross section plane. Options are provided to save the information used to create this plane as a GEB_OR entity. This GEB can be erased and re-applied, without losing the engineering information such as location, orientations and size of the plane. One important gain of using such entities is that they can be saved and imported to another model, in order to re-apply them. This allows the engineer to compare the crash behaviour of several model variants, by measuring exactly the same quantities.

4. AUTOMATION

Automation tools and methods exist within ANSA. The automation tools can be used to:

- Make processes faster
- Minimize user interaction
- Avoid user errors

4.1 Scripting

The BETA Scripting Language is a very powerful language based on the syntax of C (programming language). The BETA script gives users the ability to create custom made functionality and processes that cannot be provided by the hardcoded functionality. Access is given to the core functionality of ANSA and META through script functions library, which covers all available applications. In addition, a BETA script allows the users to create simple and advanced interface windows, thus providing a complete solution for the customization needs of the user.

4.2 Task Manager

The Task Manager is a tool within ANSA that allows the creation and execution of template driven processes. A Task is a hierarchical process comprising a series of distinct modelling actions that have to be followed in order to set-up a discipline specific model.

5. LOAD CASE TOOLS

5.1 Barrier Positioning

The Barrier Positioning tool is used to merge and properly position a Barrier to a crash model. During the execution of the function, the barrier is retrieved from the ANSA DM, or any other location in the file system, data pool and is automatically positioned and de-penetrated according to the load-case specifications.

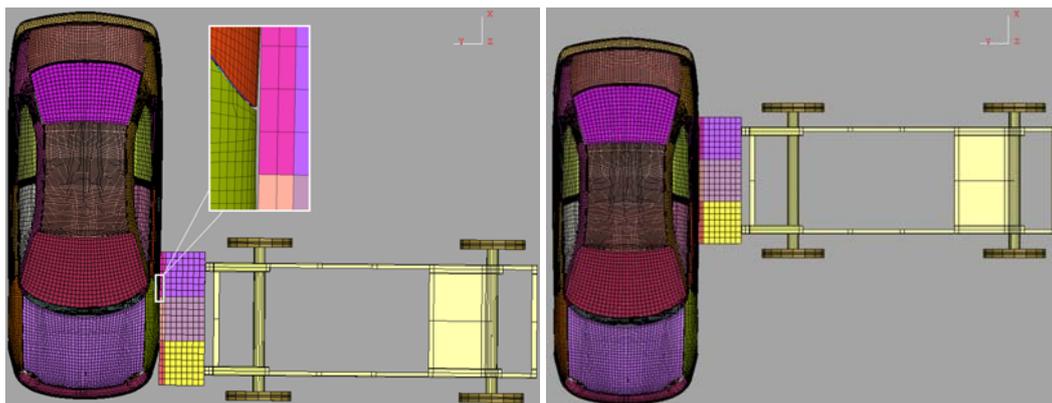


Figure 2 – Example of an application of the Impactor Positioning tool for a side impact

5.2 Dummy Positioning and Seatbelts

In alliance with the major suppliers of Crash-Test-Dummies FE-models, such as LSTC, Simulia, FTSS and Dynamore, these models along with the structure hierarchy and positioning information (stored for example in .pos or .tree files) are properly supported and validated. In case of absence of structure and positioning data, automatic tools are provided that include the necessary functionality for the creation of Dummies' structure, as well as for their user-friendly positioning and articulation, always respecting the high/low stop angle criteria of the joints' rotation.

Courtesy of CADFEM & LSTC



Seat model Courtesy of BMW AG

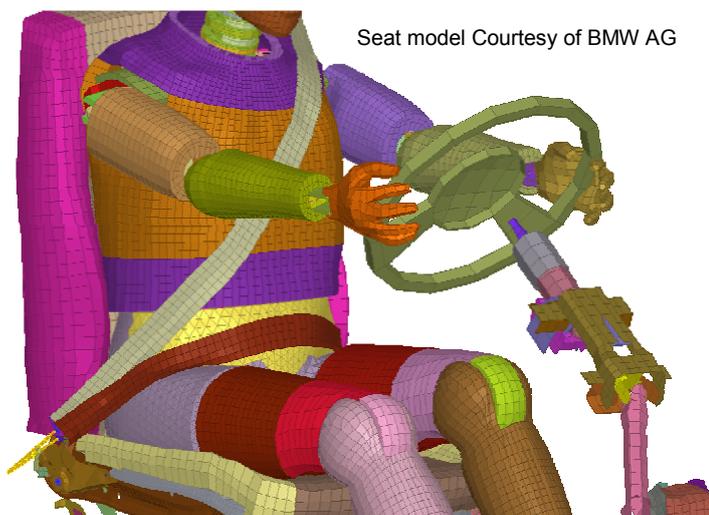


Figure 3-1 Example of a Dummy model read in ANSA together with its positioning information

Figure 3-2 Example of a Dummy model positioned, articulated & belted in ANSA

5.3 Dummy Positioning

The dummy positioning tools in ANSA allow for translation and rotation of a dummy and rotation of its parts. The movement can either be driven from a window interface or interactively from the screen.

5.4 Seatbelts

Seatbelt tools allow the creation of seatbelts. Advance fitting algorithms create seatbelts that have a natural fit around a dummy's torso.

5.5 Kinematics Tool

With the introduction of ANSA version 13.0 BETA CAE Systems has introduced a highly sophisticated set of tools that can handle any kind of positioning or articulation requirements of crash models. Taking into consideration the fact that in addition to dummies, suspensions, roofs and other subassemblies need to be repositioned, a multi body solver has been developed to be tightly integrated with the pre processor.

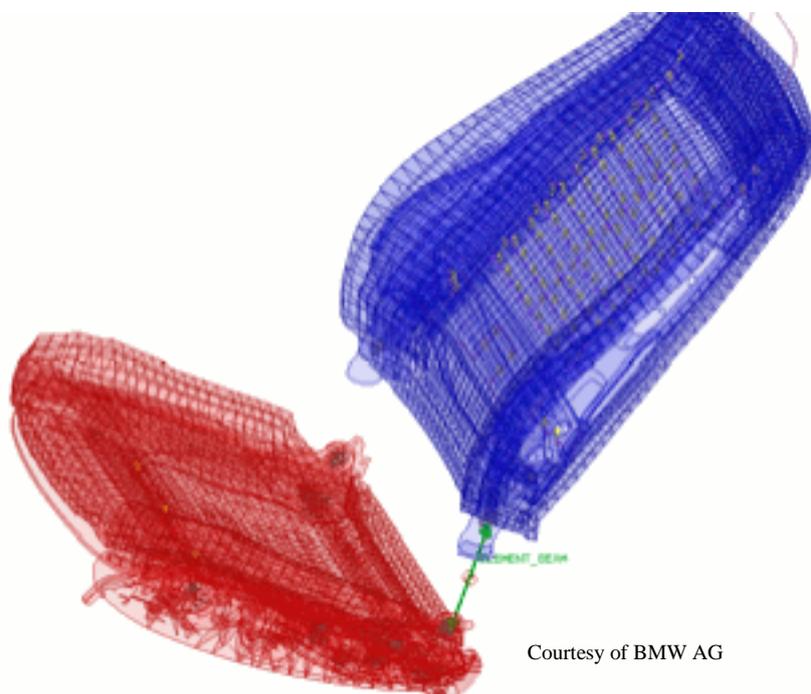
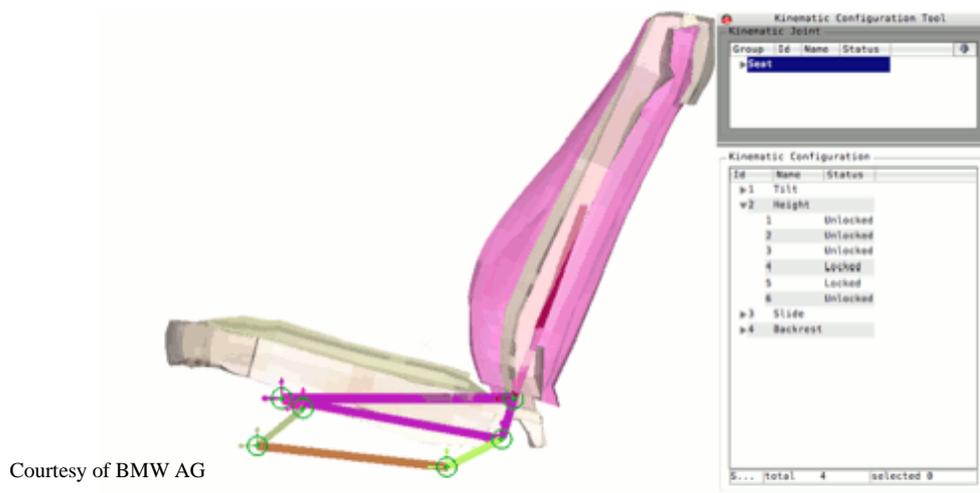


Figure 4 – Automatic detection of kinematic subassemblies and joint elements

Key features of the tool are:

- Functions that automatically, or semi automatically, helps the user to create the kinematic model from the existing FE model.
 - Information of the FE-joint elements like the high & low stop angles is transferred at the same time as constraints to the kinematic model.
 - The multi body solver HHT-I3 supports all the standard joint types (spherical, hinge, cylindrical etc).
 - Advanced joint types are available such as rack-pinion and coupler joints that can model advanced mechanical or electronic couplings.
 - The intuitive interface allows the organization of the kinematic components so, that different movement configurations can be predefined by the mechanism expert. Characteristic examples are the tilt and height adjustments of a seat model. This is important because not all users need to know all the details of the kinematic configuration but rather focus on positioning to them to the required position. For this job, the software provides an easy interface to move the model from these predefined configurations.
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Courtesy of BMW AG

Figure 5 – Example of a complete seat configuration setup using ANSA kinematic tool

5.6 Pedestrian Protection

In version 13.0.1 new functionality has been introduced that automatically applies the regulation directives to identify the target areas and target points. The EuroNCAP pedestrian testing protocol has been implemented in the Pedestrian Tool. Bumper and bonnet reference lines are automatically calculated on the FE-model, or on Geometry data, closely following the regulation procedure. The Adult and Child Head form zones are defined and divided into the twelve areas. Moreover, user created curves can overwrite the curves that represent the reference lines. Thus the user can intervene in the process if he wishes.

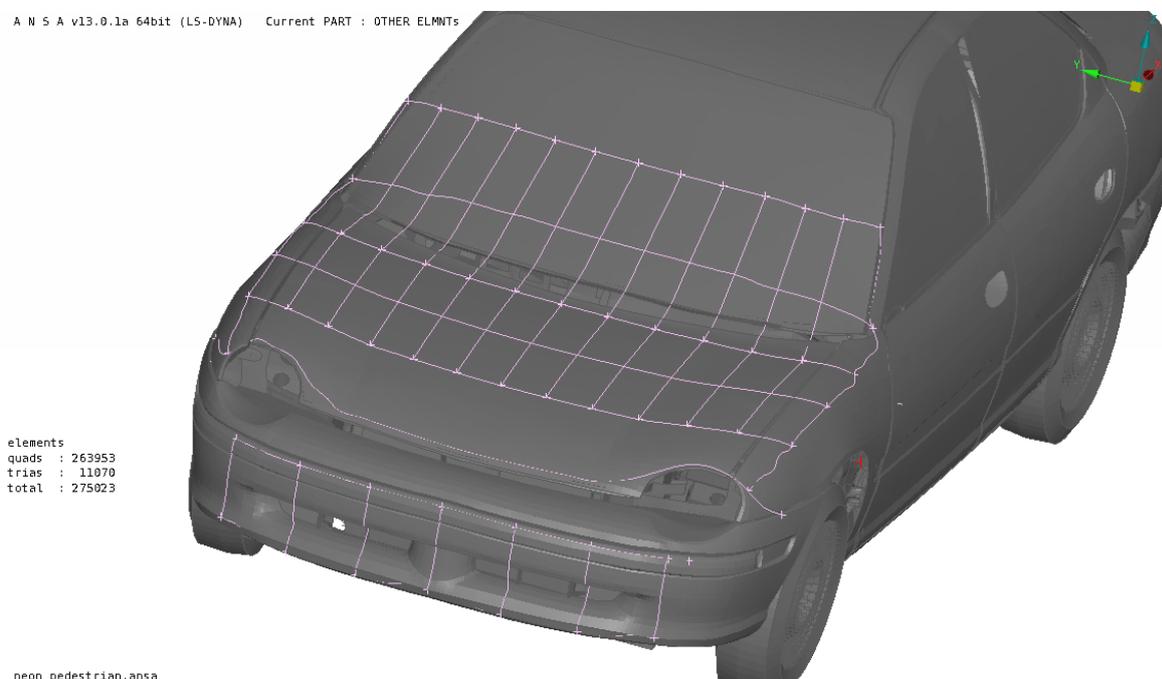


Figure 6 – Pedestrian Tool: EuroNCAP reference lines automatically created

For the identification of the target points the user has two options. Either create a uniform raster of user defined dimensions or detect a user defined number of the worst-case target points per area. This is achieved by scanning each area for the points with the least distance between the top bonnet surface and the underlying hard parts in the shot's direction.

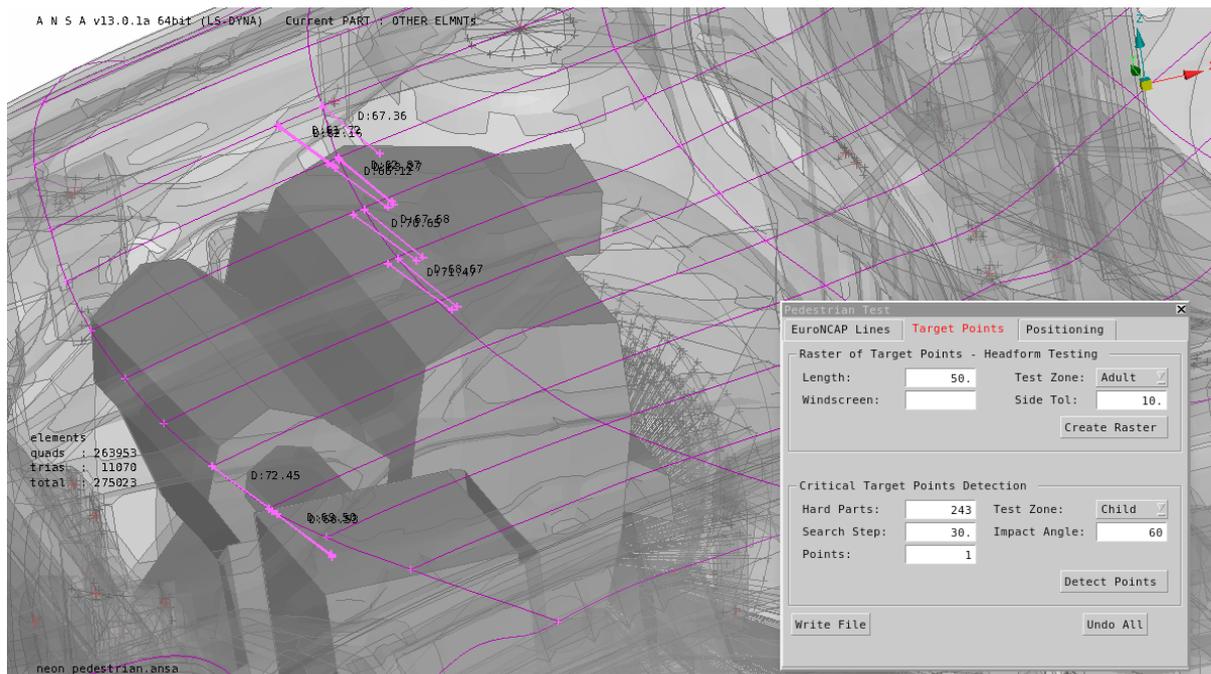


Figure 7 – Pedestrian Tool: Critical target point detection by taking hard parts into account

Following the definition of the target points, the positioning takes place and produces the respective solver dependant transformation keywords that define each load case.

5.7 Interior Protection

Positioning tools are provided in ANSA according to the FMVSS201u and FMVSS201 ECE R21 (Pendulum) protocols. Horizontal/vertical angle limits as well as the rebound angle of the free motion headform (FMH) are respected during positioning, following exactly the guidelines of the protocols. A user friendly interfacing that serves tools for easy and fast positioning of the impactors are provided.

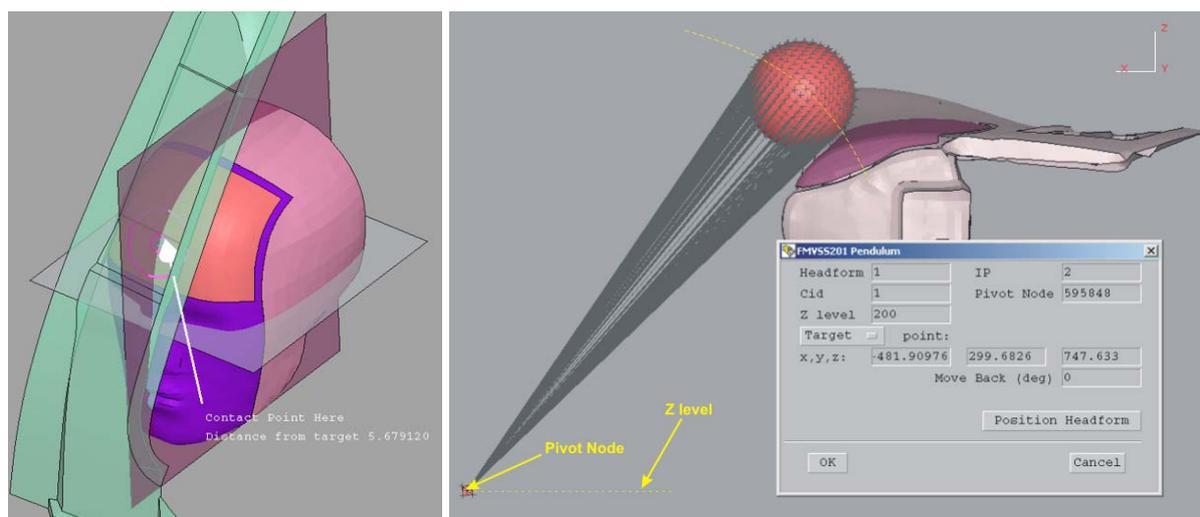


Figure 8 – Position tools for the FMVSS201 Occupant protection protocol

6. CHECKING MODEL INTEGRITY

It is very important that the user feels comfortable about the integrity of the model before he sends it to the solver. For this reason model checking functionality is of high priority in the development of ANSA. Whenever a checking activity is performed, a detailed error reports are served that allow an error management for a better identification of the problematic model areas, as well as a auto-correction algorithm according to the nature of the problem.

Since the Task Manager allows performing model check activities as well, the user can create custom-made model checking templates. These can be applied at sub-model or at full model level, in order to assure high model quality and ensure high accuracy of the simulation results.

7. INCLUDES

ANSA offers various navigation methods over an FE-model. One of these navigators, called the Includes Manager, is capable of handling, creating and managing include file definitions in a tree-like manner. It empowers the user to have a full control over the FE-keyword's id ranges, in order to satisfy numbering schemes of complete structures. Model modifications and changes can be performed so, that newly create FE-entities should be directly inserted to a certain include file definition.

8. GUI

The management of huge amount of data requires that the software have the right tools that are easy to use and can provide the user with relevant information fast. As of ANSA v13.0 a big effort has began for the overhaul of the ANSA user interface. The reason for this move was necessary in order to meet the current standards of Graphical User Interface design. Most of the advanced CAE pre processors, and other CAE software, have their design roots in the late 80s and early 90s. This is evident to anyone who is working in the CAE field. While through out these years a strong effort has been put in the development of powerful algorithms, which is the main field where big time savings can be achieved, the user interface has been neglected. This practice has started to show its shortcomings, as CAE becomes mainstream and more and more new engineers work in the field. Young engineers that have experience with other kinds of software like office productivity suites, the modern UIs of operating systems and web environments find it hard to learn and adapt to the archaic and outdated idioms of the CAE programmes. This results in great loss of productivity and inability to adapt to new tools and processes. Another fact that puts a lot of pressure on the interface design is the rapid rise of the model complexity. The CAE user faces a huge task which is to deal with this complexity. It's the goal of modern User Interface to relieve the user of this burden.

It is apparent that Modern User Interface alone cannot meet the challenges of the CAE pre processing. User Interface design, in order to be meaningful, always needs to be on top of smart and powerful algorithms which is the core of CAE. The new user interface allows for easier implementation of advanced functionality and gives the ability for fast learning for new users.

Having the above in mind, new tools have been designed and introduced in ANSA. These changes will be deployed progressively throughout the v13.x series of ANSA.

8.1 Model Browsing

Model browsing is done with the help of the Model browser, which is the central information centre of the programme. The model browser is a unified single browser for all the entities in

a model (including geometric entities). The user can control everything from the visibility of entities, to accessing the entities' cards, to creating new entities and many more. Its structure and look is that of a hierarchical tree list accompanied by the expanded list of the selected item. Various interface elements like history, search, context menus (right mouse click menus) etc have been implemented to add functionality. These are creating a familiar working environment to users since these concepts are widely used in today's software applications (file managers, mailers, web browsers, etc). This leads to uniformity and reduced training time for the users to become productive. Nevertheless various additions and extensions have been implemented to better handle CAE workflow.

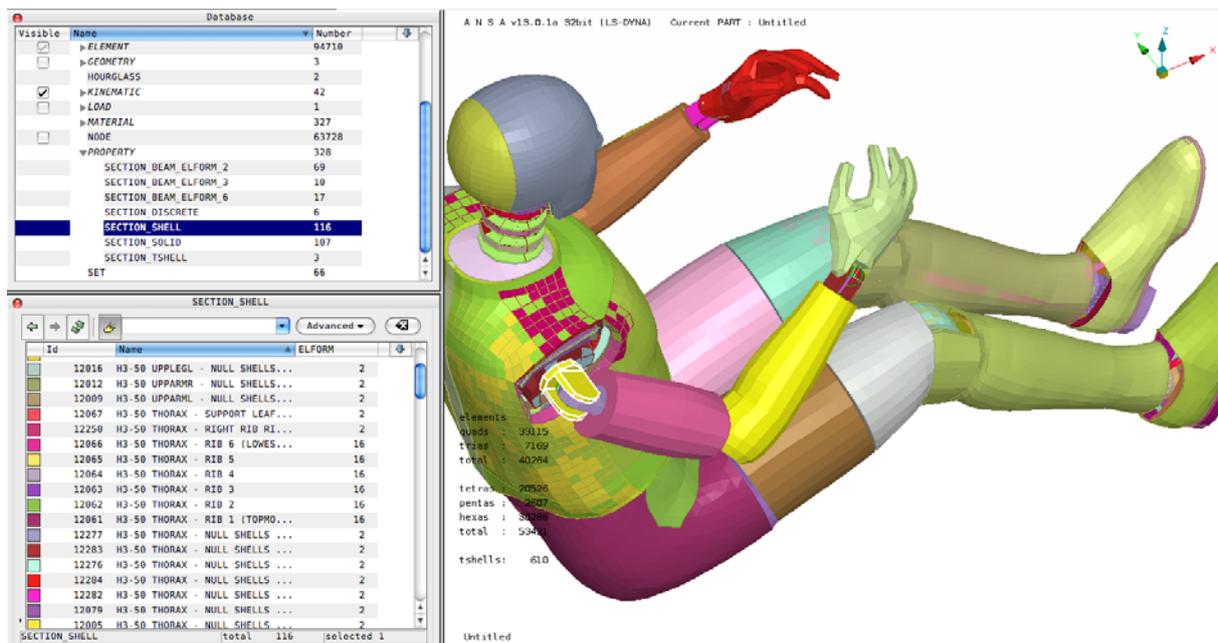


Figure 8 – Model Browser

8.2 Filters

As the user builds confidence using the tool the tool itself scales up nicely providing advanced functionality. One such functionality is the concept of filters. Filters are used to search easily and select model entities based on various attributes. More importantly filters can be saved and used as dynamical updated smart containers of entities.

8.3 Drag 'n' Drop

Another common idiom that has been imported is that of drag and drop. The user has the ability to select entities from the browser (or the screen) and drag and drop to other objects to create new entities such as includes, SETs etc. This functionality together with the advanced selection and filtering option give the ability to work in a very friendly and intuitive environment. This environment allows the set up of complex entities like *SET_GENERAL and *SET_*_ADD in ANSA v13.x to be a pleasant experience.

8.4 Dynamic Draw

Another area of great importance for the model comprehension and handling is the drawing of the various entities on the graphics screen. Through the graphics display the programme communicates with the user and helps him understand the model and interact with it. Unfortunately the complexity and size of modern models lead to graphics clutter, information overload along with programme unresponsiveness. Various new technologies have been designed and implemented to address these issues.

8.5 Detail on Demand

With the introduction of the “Detail on Demand” concept the graphic representation of the various model entities is dynamic and follows the user workflow. The most basic and notable change is that elements that are not in the user field of interest are drawn with reduced detail. The screen clutter is strongly reduced while at the same time more information is provided in the area of interest. The end result is a much clearer view of the model, more valuable information provided automatically and fewer user clicks.

8.6 Transparency on Pick

On the same line of thought a second concept was developed that helps the user when performing any action that requires selection from the screen. In order to unclutter the display only the elements that are relevant to that action being performed remain visible, while the rest become transparent and dimmed. So while they don't obscure the picking process at the same time the user remains well oriented in the model.

9. LATEST META DEVELOPMENTS

9.1 Performance improvements

μETA v6.3 contains significant performance improvements that are summarized in the following figure.

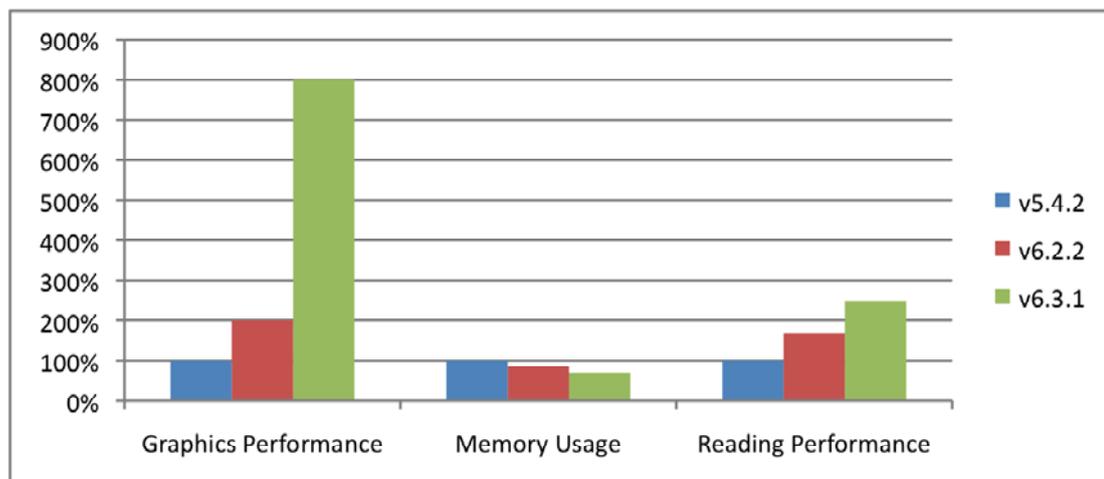


Figure 9: Performance improvements

In more detail:

9.1.1 Memory

In version 6.3.0 a 25% reduction in memory requirements compared to past version has been achieved. Also the 64 bit version has smaller memory footprint.

9.1.2 Graphics

A new algorithm has been introduced that improves drawing performance significantly. A speedup factor of 2 to 8 is expected depending on the graphics card of the machine. This speedup is even higher in contour plots and fringe plots.

9.1.3 Computation Speed

The latest versions includes optimization of the code for multi-core system. This reduces computation time for intensive operations like section forces calculation, reading geometry and results, evaluating user field functions, etc.

9.1.4 Reading results

The reading speed of the software is improved for all types of results. Additional method for reading femzip compressed d3plots on the fly, without decompressing first on the disk. This reduces also the maximum memory requirements during decompression and improves performance in case the user wants to load only a subset of d3plot states.

9.2 Section Forces Calculation

The calculation of section forces is an important aspect throughout the design cycle of a structure. However, section forces must be predefined in the input deck, thus making unavoidable a second run in case it turns out that it is needed to investigate the force distribution in arbitrary areas of the structure. The section forces tool in μETA is capable to compute forces and moments at any section defined by the user or predefined in the input deck, achieving very good correlation with the solver calculated results.

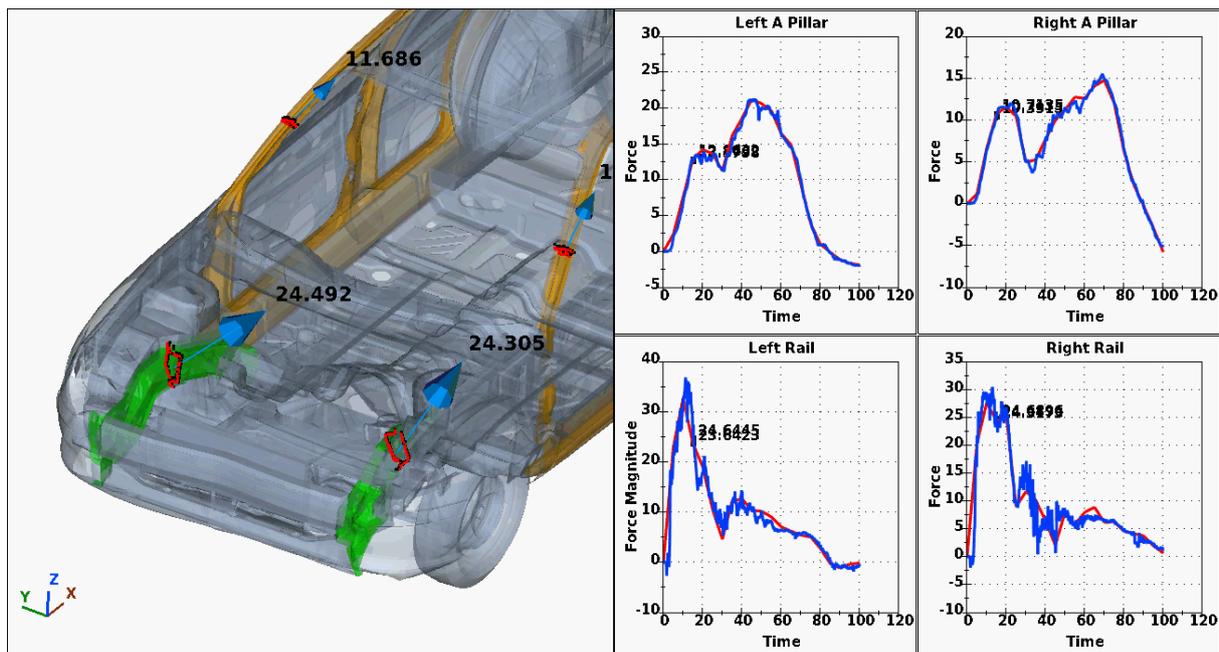
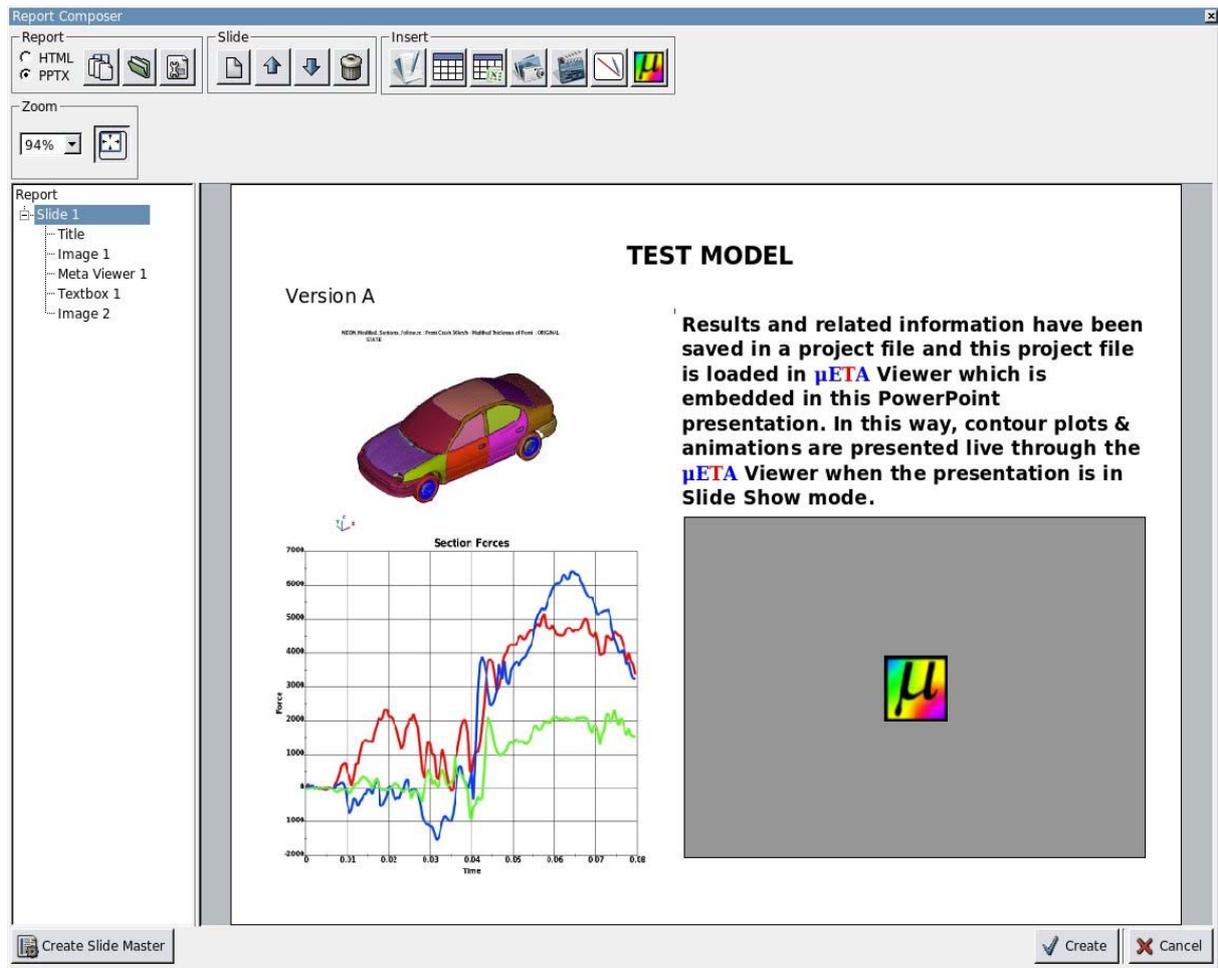


Figure 10: μETA calculated section forces compared to LS-DYNA

9.3 Report in powerpoint pptx

The new report composer tool allows the user to create a pptx report effortlessly, with powerpoint like functionality including Slide Master creation, Themes templates and drag & drop handling of objects. It is also possible to read and edit an existing pptx report, as well as to embed μETA viewer objects that include a 3d model or 2d plots that the user can handle interactively.

Additionally the Copy/Paste functionality to Clipboard helps users to easily transfer images and data from μETA to other software.

Figure 11. μ ETA report composer.

9.4 Automation

The automation toolset of μ ETA is enriched with the recent process automation tools. The session editor with the advanced session parameterization tools, the debugging capabilities, easy creation of toolbars and the compressed package creation manager, facilitates automation.

BETA scripting language and the embedded script editor offers enhanced flexibility and elevates the automation capabilities of μ ETA to a far greater extend.

9.5 Compression of Simulation results

A New capability will be added in v640 for data compression of simulation results. Apart from a standard gzip-like file compression, the size of result files is further decreased through the option to keep only necessary variables and up to the necessary level of accuracy, achieving high compression ratios (original/compressed size > 10). This technology will reduce storage requirements for huge models, but also will improve loading performance since smaller files needs to be transfer through network.

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