STANDARDIZATION OF X-ATTRIBUTE BODY ASSESSMENT BY COUPLING FEM AND MKS

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1. THE VISION

Although the build process of a CAE Trimmed Body model is well established and delivers completed models simultaneously for the Attributes Safety, NVH and Durability, the process to date was unable to provide a model suitable for those Attributes using MKS. The Flexible Body model needed for the MKS workflow is very dependent on weight, inertias and CoG data under different weight options and load conditions. Our challenge is to streamline the process of and reduce the time required to generate a Flexible Body from a Trimmed Body model and hence improve the delivery time to those Attributes working with MKS.

In this challenge, we recognized three main metrics:

- One model suitable for all Attributes

- Delivery Delay

- Flexible Body build process from Trimmed Body

We will go through each of these metrics to explain what we have done to optimize the delivery process.

<u>One model suitable for all Attributes</u>

Our first step was to understand, what our customers need to have represented in their models. To do this, we identified all of the requirements such as the mesh size and all the common contents for each and every attribute as well as particular singular needs. Also if and how these particular needs disturb or influence in any way the model behaviour for the other Attributes.

With this information, we were able to define Trimmed Body model settings that are common to all Attributes. From this common model, each of the Attributes can derive the model best suited to their particular requirements. In this way, complexity was eliminated and all

Attributes made their individual assessments on the same model content and assumptions. This also brought the benefit that only one master model needed to be stored in a central database, such as a location in TeamCenter.

Delivery Delay

Once the Trimmed Body has been delivered to the Attributes, a restricted amount of time is allowed in the virtual development phase to complete all CAE assessments and deliver proposals for design changes. The speed of this turnaround time is a common issue in the automotive industry. A "one-click solution" is a vision for all. Hence, we directed our work in this direction.

A full automation is difficult to achieve, as certain steps in the process cannot be made automatically or cannot be compressed: for example, the removal of some chassis parts because those parts already exist in the Adams model.

Another major issue to overcome is the sheer size of analysis result files. The job run times, the copying of files from server to server, and the creation of animation files. All of these and more take a long time and as such influence the delivery timing.

The last consideration is that we have to optimize the weight from our models in order to fit the reaction forces from the wheels. This optimisation usually requires more than one loop and as each loop means re-running almost the entire process again, time is used and this is counter-productive to keeping the process as short as possible in order to maintain the delivery timing.

To resolve these issues and considerations, we decided to use a display model and to automatically defined the model with the NVH Console.

Flexible Body build process from Trimmed Body

One definition of the Trimmed Body is that all the parts and components contributing to the structure and/or the mass are included in the model. This can be as FE representation or as a mass. This constitutes a huge quantity of information to consider and as such the model file is very large.

In the Flexible Body, we inspect the behaviour of the model for different modes. This is given in the MNF-file format. In these MNF-files, exists the information requested for global modes and for the 6 degrees of freedom of the interface nodes. For a commercial vehicle model, the MNF-file can have a size of 50 GB!

The animation does not need all the details represented in the Trimmed Body MNF-file, but if we use the huge file for all the computing and creating of the animation, at best, is would take several days for the processing to complete, at worst, it would not be possible. In our delivery time restrictions this is not acceptable.

For this reason, our effort will be concentrated on reducing the size of the MNF-file:
A run for creating a MNF-file with a display model was at this point not possible.

2. THE PROCESS

The definition of the models is a step which is not very time consuming. The next major step was for us to concentrate and act on the speed of the creation file and their size.

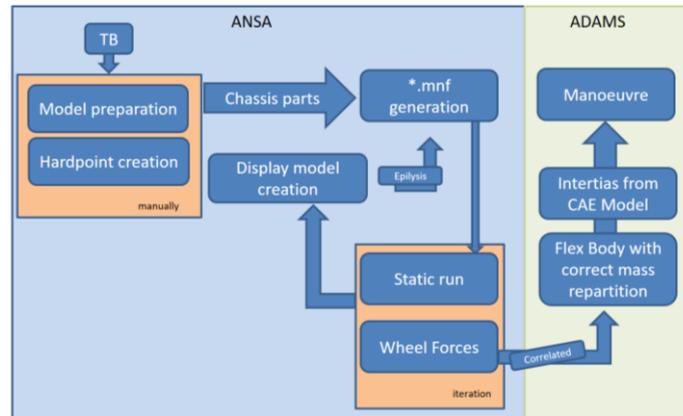The process could look like that shown in Figure 1.

Figure 1: CAE Workflow

Our first step is the preparation of the model:

- Deleted all the parts which are available in Adams or which be run separately as Flexible Body; such as Subframe, Steering Wheel, Trailing Arm, … etc.

- Determine the weight and inertias from the removed parts

- Creation of the hard points with Nastran Field 10 entry

After making this step we can start the creation on the display model.

Display model creation and job set-up in NVH-Console

Using a display model is a technique well known from NVH applications. A display model is an auxiliary FE model consisting of a much courser FE mesh than the original FE model. The crucial feature of a display model is that all its grids are contained in the original model as well. While the original FE model is used for the solving process, the results are output for the grids of the display model only. This leads to a drastically reduced output size for animations or the calculated Eigen modes of a structure.
We chose to work with NVH-Console because

(1) it facilitates creating a display model and

(2) it provides tools to set up an external super element run which is very similar to the run which calculates an MNF-file. The necessary changes from an external SE run to an MNF-file run have to be done manually but are quick, basic and not error-prone.

In the future, the MNF-file creation will be fully supported in ANSA either in Model Browser or/and in the Kinetic Environment.

	Subframe	Trimmed Body
# Grids full FE model	100.000	5.800.000
# Grids Display model	2.500	141.000
MNF w/ full FE model	430 MB	50 GB
MNF w/ Display model	10 MB	1.7 GB

Table 1: Properties of Display Models

Calculating the MNF-File with EPILYSIS

In the past, if you wanted to make a smaller MNF-file, you could choose to include just some parts in the output set and ignore the rest. The mesh size is always the same and you have an animation with reduced parts. Therefore, using a display model is an obvious way to reduce the file size without ignoring parts of the structure. However, FE solvers currently available on the market are not able to calculate MNF-files for such a display model.

In order to support the efficient creation of MNF-files BETA CAE has improved their FE solver EPILYSIS:

(1) Most importantly, EPILYSIS is now able to calculate an MNF-File using a display model. As the MNF-file contains the results and the geometry of the structure, the input file for such a FE calculation has to contain the original FE model as well as the display FE model. Both complete FE-files are included in the EPILYSIS input deck regardless of their coincident grids in order to keep the process simple and robust.

(2) The first internal step of the MNF-File calculations is a Craig-Bampton SE calculation. To speed up the calculation of the fixed-boundary normal modes of the structure EPILYSIS AMLS, which is an embedded feature in the EPILYSIS solver, can be used. This leads to a speed up of 10-20% in turn-around time of the complete MNF-File calculation compared to using the Lanczos solver for this step.

For example, a Subframe MNF-file can be reduced from 430 MB to 10 MB and for a Trimmed Body from over 50 GB to 2.5 GB (s. Table 1).

3. CONCLUSIONS

Although we have achieved significant progress within the last few months' work on the presented process improvement, work is still ongoing as further tuning potentials are identified.

To summarize there are two important improvements in the current process which could be introduced by deploying BETA CAE tools:

(1) The first is the automatic creation of the display model within ANSA

(2) The second and the most important is a new feature within EPILYSIS to create an MNF-file using a display model in order to reduce the file size of the MNF-file

Next steps planned to further improve the process and hence reduce time to delivery are:

- Creating MNF-file input deck in Ansa w/o any manual preparation

- Using ANSA to position different flex bodies

- Using the ANSA Kinetics solver to perform first evaluation runs for flex bodies

- Using META to display Adams results in order to deploy META capabilities for efficient post-processing, automation and reporting