
Usage of fully detailed CAE models for concept design with the ANSA Morphing Tool

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Summary:

During the concept phase of product development, simplified CAD and CAE models are used to retain model versatility and minimize the set up time and the analysis complexity. However, this process often leads to simplified calculations with inaccurate results diverting from a realistic solution. Additionally, considerable time is spent to convert the simplified CAE models to full detailed ones at a later stage.

This paper describes a recommended process for the usage of full detailed CAE models during the concept design phase. The resulting models are ready to run in LS-DYNA and their results are validated. This process is accomplished by the functionality of the ANSA Morphing Tool.

The engineer is able to use former versions of full detailed CAE models or even CAE models of similar product versions and transform them according to the new layout within a few work days. Using this process the engineer is able to run the first analysis without the need to add feature details and solver specific entities to the concept model.

Keywords:

Concept design, morphing, model shaping, parameterization.

1 Introduction

While a new product version is still at the concept design phase running a number of simulations can significantly help and guide the design process. A common technique is to use simplified CAE models for these simulations since the detailed CAE model is not available yet. Concept models are light and easy to handle and in most cases parameterized. However, the migration from concept models to detailed CAE models is time consuming. Many features like fillets, beads and holes should be added manually. Meshing, connections, boundary conditions and solver specific keywords should be re-applied. After the migration to the detailed CAE model, several tests should be run to verify that the results are error-free and realistic.

Instead of using simplified models full detailed CAE models could be used during the concept design phase. These are CAE models from former product versions which can be updated to the new shape. The ANSA Morphing Tool is used for the shaping process. Two case studies are presented in this paper to demonstrate the recommended practice for shaping full detailed models.

2 Fitting the BiW to new geometry

In this example a new outer shape is provided for a car model. The full detailed CAE model of the former version should be fitted to this new shape. The change of shape will affect the outer surface, the BiW and the doors. All other components should retain their shape and position but also retain their connectivity to the modified parts. Additionally, several constraints will be defined to fulfil model's geometrical specifications. Such constraints are the shape of the cross sections at the BiW members, distance between flanges and shape of parts that shouldn't be changed.

The FE model that is used in this example contains all model details and parts and it is ready to run for crash analysis in LS-DYNA. Boundary conditions for the crash analysis are already defined. Also any checks such as initial or property thickness penetration have been performed. The model is shown at figure 1. The new model version that will be used as the target shape contains only the outer surface of the parts that have been change (figure 2).

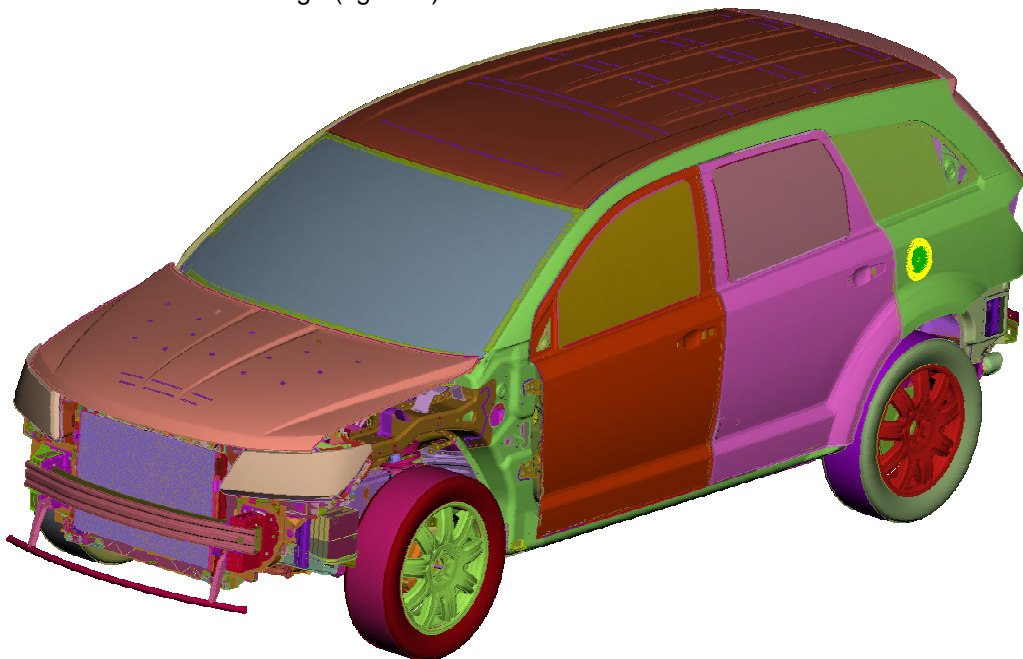


Figure 1: The full FE model

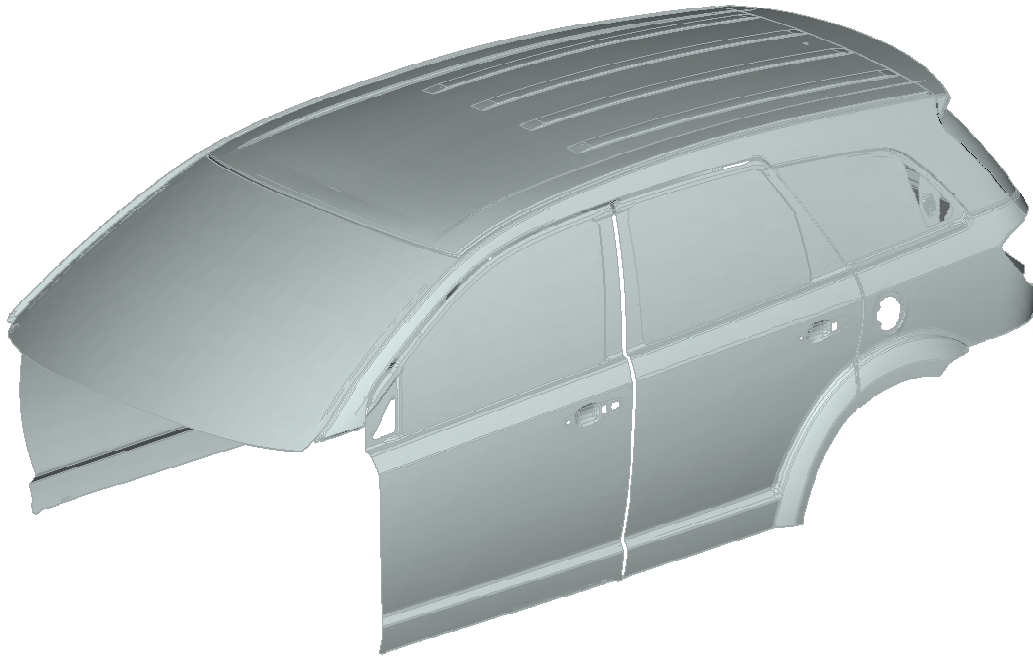


Figure 2: The target surface model

The new model is taller by 50 mm and the roof at the rear position narrower by 36 mm. Significant changes have been made at the doors shape both at surface and perimeter. B and C pillars have been moved backwards. A comparison of the two models reveals all differences that should be reached as shown at figure 3 and table 1. The fitting of the FE model to the target surface process that is followed to fit is described below.

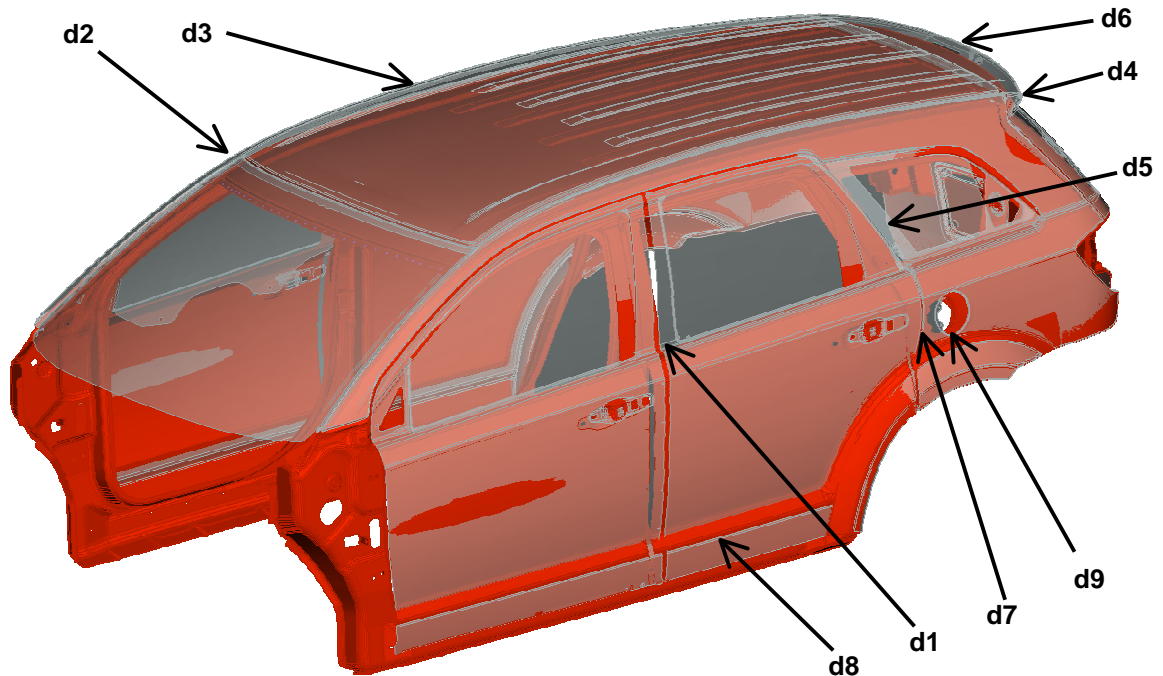


Figure 3: Model differences

<i>New style differences</i>	
d1	Movement of B-Pillar backwards by 100 mm (upper position) and 57 mm (lower position)
d2	Movement of roof member backwards by 85 mm
d3	Height incensement by 50 mm
d4	Shrinkage of the roof at rear position by 36 mm
d5	Movement of C-Pillar by 84 mm
d6	Movement of spoiler forward by 58 mm
d7	Modification of back door outline
d8	Modification of side surface shape
d9	Movement backwards of fuel cap

Table 2: Model differences

2.1 Constraining parts and Cross Sections

The first step for the fitting process is to define the constraints of the model shaping. The cross sections of the A, B and C pillars and the roof member should be kept intact even if these parts are moved or modified. In this case special entities, the *Morphing Boxes*, are created around the areas of interest. Even if the *Morphing Boxes* are used to modify the model shape, in this case they are used to facilitate the selection during the fitting process (figure 4). The parts inside the boxes can be controlled only in directions that do not affect their cross section shape.

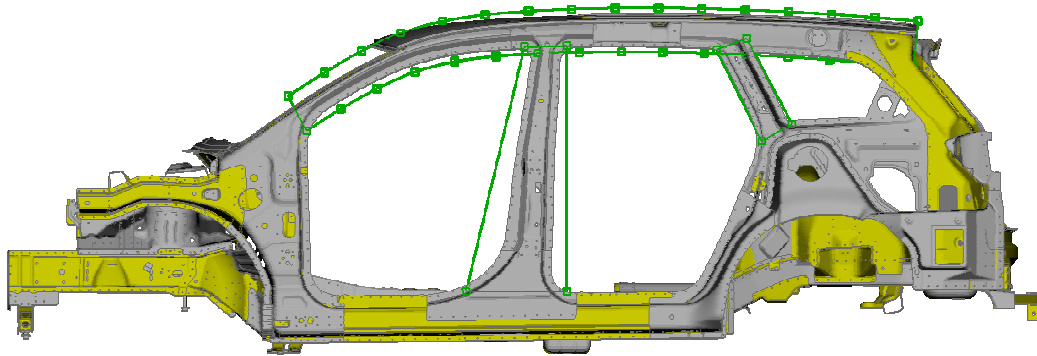


Figure 4: Cross sections constraints

Another kind of constraint is applied at the fuel cap in order to constrain its shape. A special entity of the Morphing Tool, the *Nested Element*, is applied on the fuel cap elements. Now, in case of any modification of the side part shape, the fuel cap will be moved as a rigid body and thus will retain its shape (figure 5). This kind of constraint is also applied to other parts like door hinges or features like beads and holes.

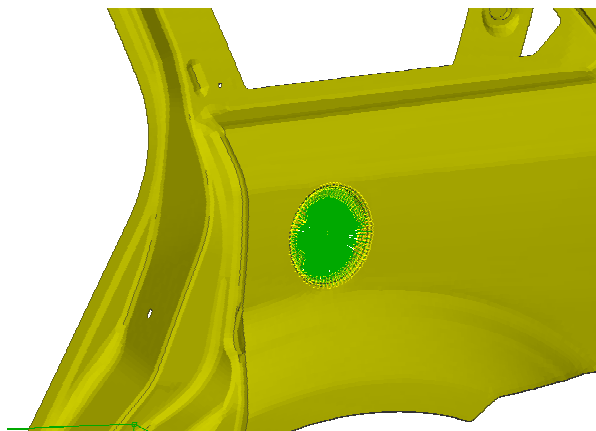


Figure 5: Nested Element constraint

2.2 Global modifications

The first step for the model shaping is consists of global modifications. These are the fitting of the roof, the movement of the B- pillar and the modification of the doors.

2.2.1 Roof fitting

By fitting the roof to the target surface, several modifications take place simultaneously. These are the modification of the height, the shortening of the rear roof member, the movement of the front roof member and the movement of the spoiler. Initial and target feature lines of the two models are used for this action. The parts that will be affected and the bounds that constrain the movement are selected here. A special function of the ANSA Morphing Tool performs the shape modification (figure 6).

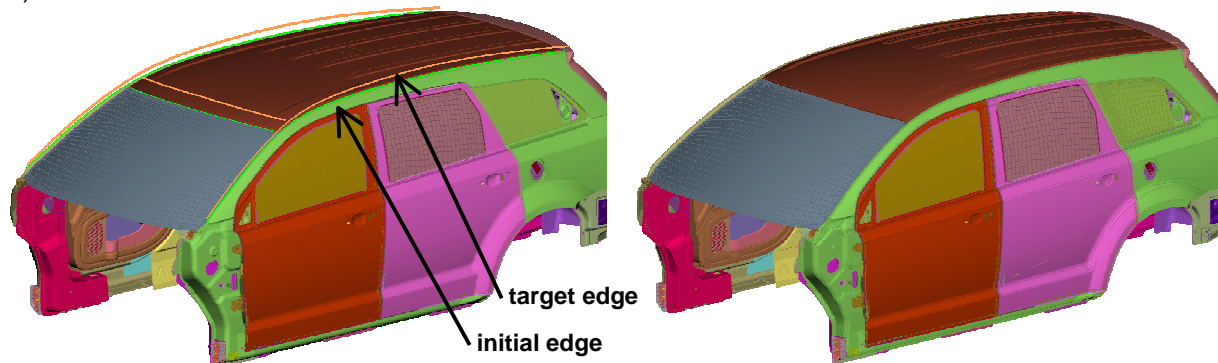


Figure 6: The fitting process

Within this process the cross section constraints are taken into account. Thus, the cross sections of the side members retain their shape during the shape modification (figure 7).

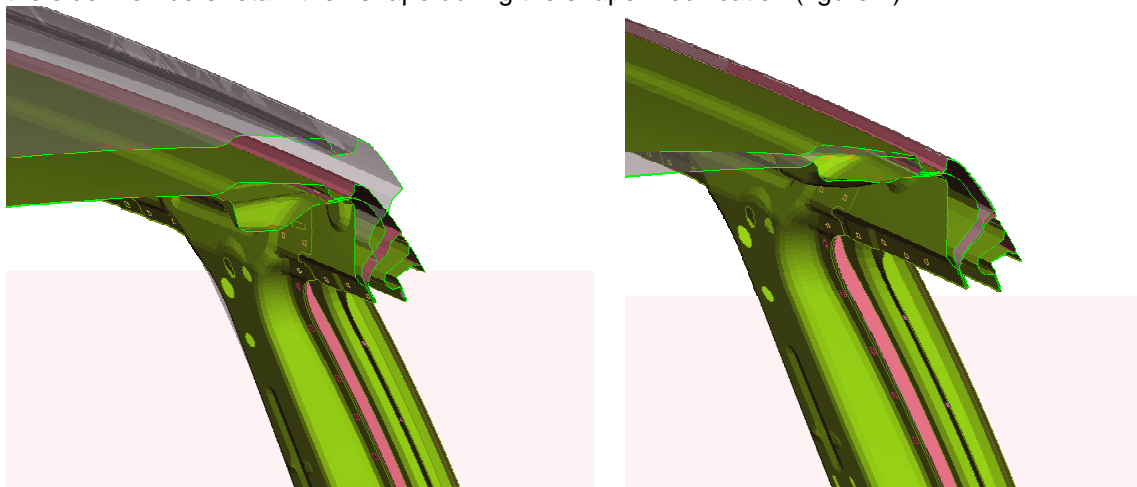


Figure 7: Cross section constraints

2.2.2 B-pillar movement

The target model doesn't prescribe the B-pillar position so the exact fitting by using initial and target curves is not possible. The only available information is the position of the doors on the target model. In that case, translation vectors are used to move the B-pillar backwards. To simulate a slight rotation of the pillar the upper and lower pillar parts are moved according to different translation vectors and values. The intermediate pillar elements follow smoothly the combined movement (figure 8).

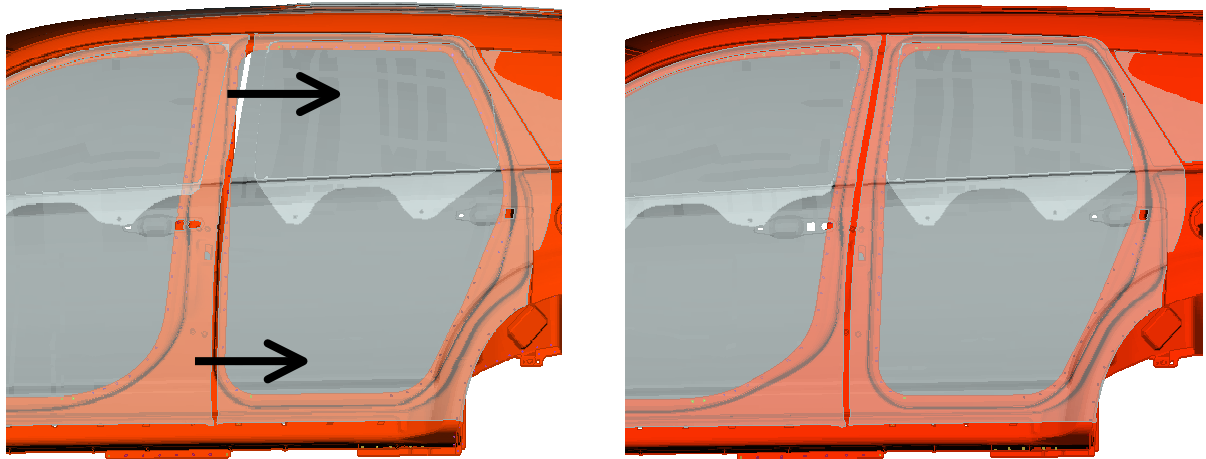


Figure 8: B-pillar movement

2.2.3 Doors modification

In this step doors are fitted to the target model by a combined movement; fitting of the door perimeters and door surface. The second stage which gives more accurate results is described later on. All parts of the door assemblies follow the fitting (figure 9).

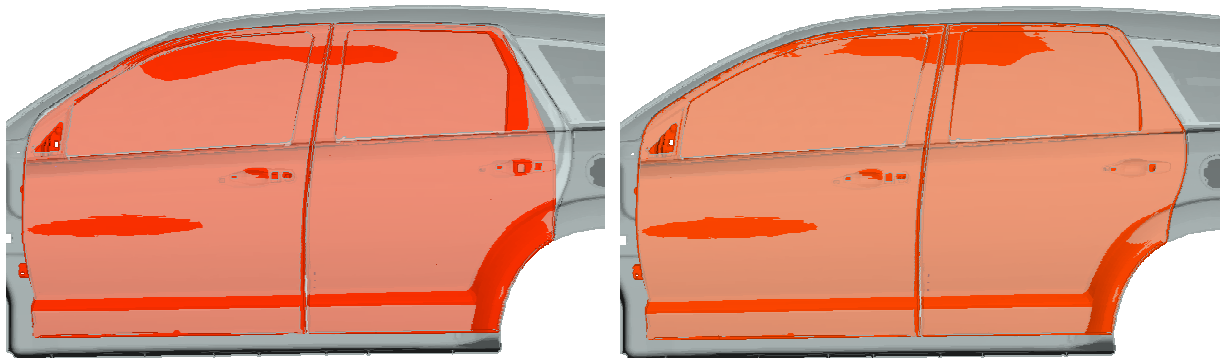


Figure 9: Doors fitting

2.3 Fitting the outer surfaces

After the global modification a detailed surface by surface fitting is applied among the initial and target parts. The outer surfaces of the doors are selected as initial surfaces which will be fitted to the relative surfaces of the target model (figure 10). The inner parts of the doors follow the movement. Performing a global modification prior to use the surface to surface fitting increases the result accuracy and eliminates the risk of unwanted distortions.

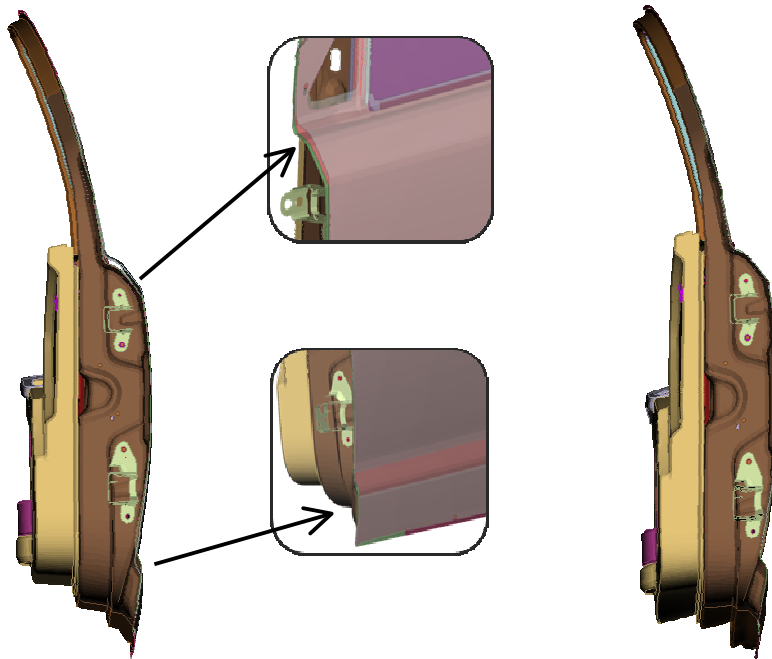


Figure 10: Surface to surface fitting

A final surface to surface fitting is applied on the BiW sides. In that case perimeter and surface to surface fitting is performed simultaneously. A function of the ANSA Morphing Tool is used which provides combined morphing actions in one step (figure 11).

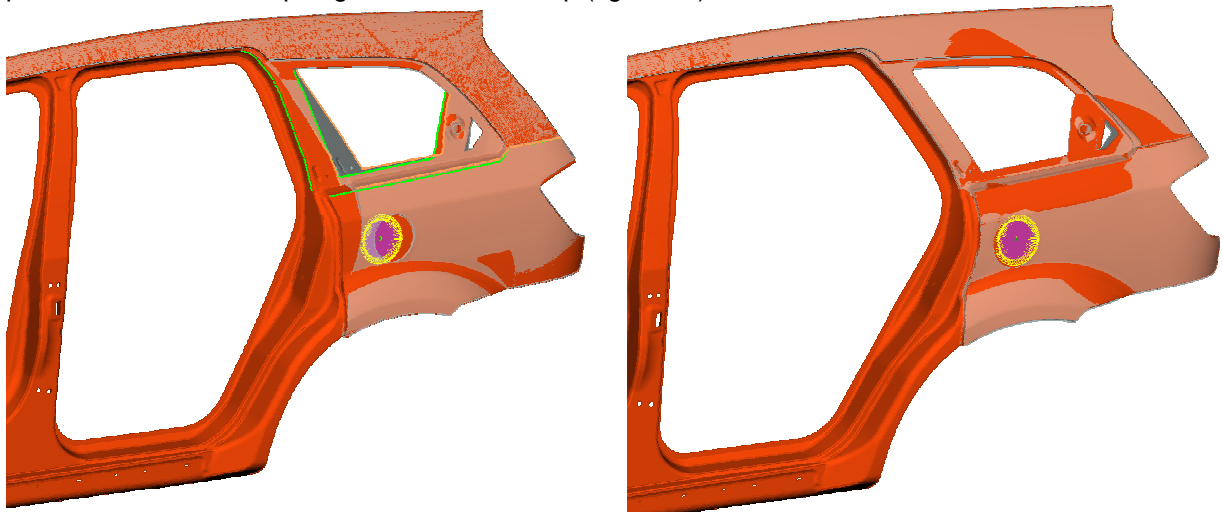


Figure 11: Fitting the BiW sides

2.4 Very important parts

Even if the above technique ensures smooth shape morphing, a special treatment can be applied for parts of great importance. These parts are excluded of any morphing action during the whole process. The engineer can treat them separately and modify their shape to fit to the new shape of the connecting parts. In this example the side bars have been excluded from the whole morphing process. After the morphing process finishes, new Morphing Boxes are created for each side bar. Using the morphing functionality the side bars are carefully placed to their new position and connected to the rest of the model (figure 12).

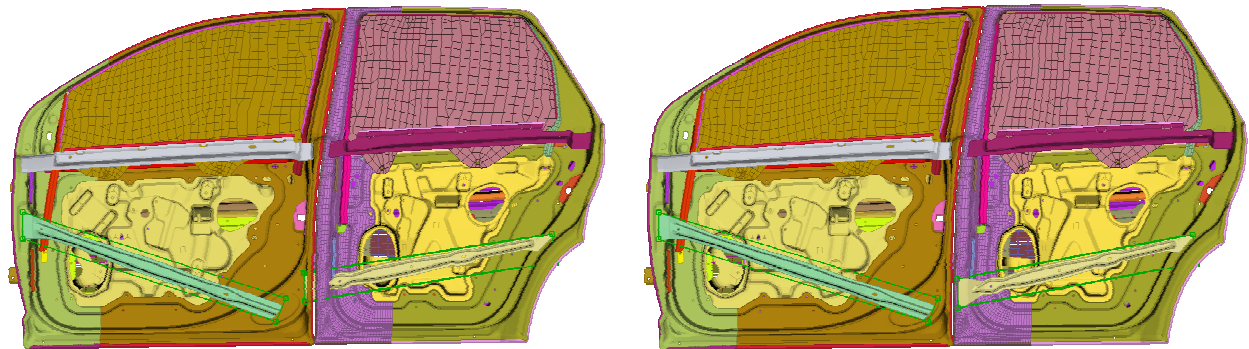


Figure 12: Modifying the side bars

2.5 Checking the model

Even if the initial model was ready to run in LS-DYNA, some checks should be performed again. These are the checks that are depended on the model shape. Intersections or property thickness penetration may occur after morphing in small amounts. Possibly, bad quality elements may appear in strongly deformed areas. Finally, distorted connection elements may occur. Penetration is automatically fixed after applying the relative check. Failed connection elements are isolated and re-applied if needed. Re- meshing is applied on failed elements according to specified quality criteria. After the above checks and fixes the model is ready to run in LS-DYNA (figure 13).

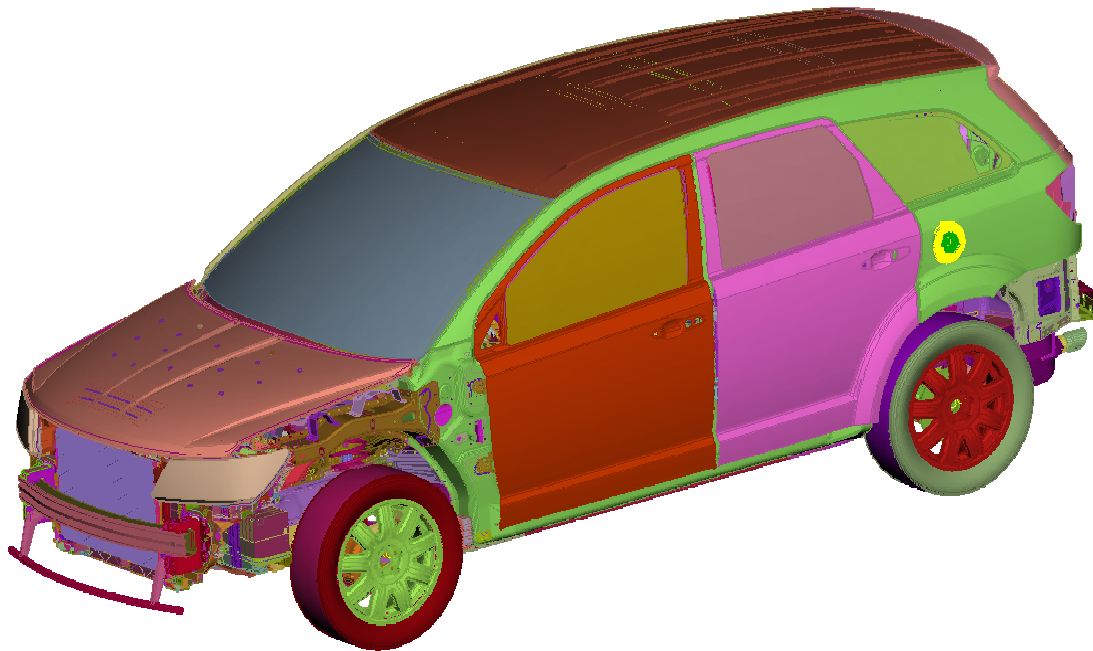


Figure 13: The final model

The time that is elapsed for the whole process is shown at table 1.

Action	Human hours [h]
Auxiliary entities definition (curves, sets)	4
Constraints definition	2
Global fitting	4
Surface to surface fitting	4
Handling excluded parts	3
Model check and fix	3
Total	20

Table 3: Process time

3 Merging two BiWs

A more extreme case is the combination of two models to produce a new one. Even if this is not the common practice to produce a new model this technique can give an estimation of an under development model. Different versions of the model (sedan, station wagon, hatch back, etc..) can be also defined very easily. The results of the tests that take place with such models can feedback the design department at any time of the design process.

In this example a sedan and an SUV models are used, to produce a new one (figure 14). Both models are BiW containing all details, realized connections and boundary conditions according to LS-DYNA format.

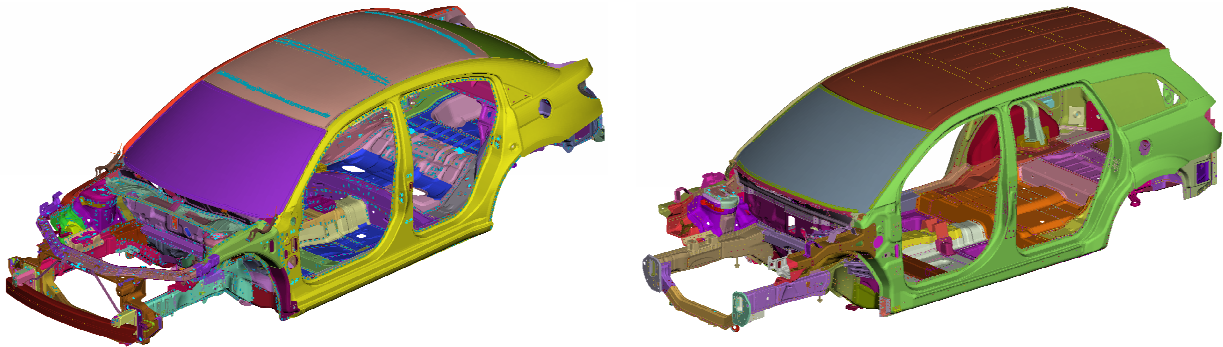


Figure 14: The sedan and SUV models

The first step is to cut the two models by planar cuts and remove the unneeded parts. The cutting position is identical for both models. Then the cut models are merged together where the sedan cutting section will be used as the fitting target (figure 15).

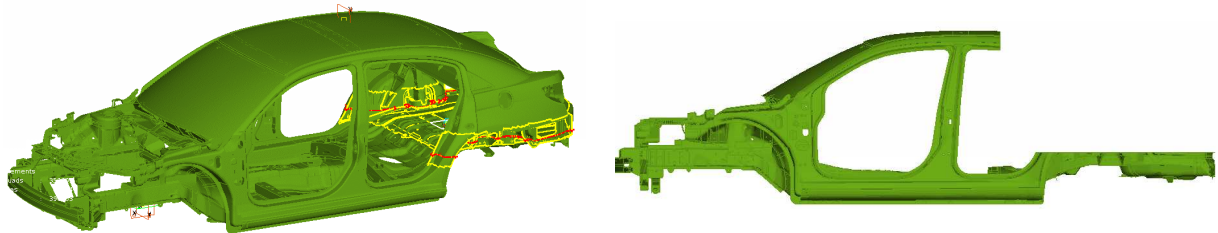


Figure 15: Cutting the sedan

3.1 Global morphing

The rear part of the SUV should be adjusted at the outfit of the sedan model. So, any modifications will be applied to the SUV. Global modifications are applied to the SUV part to come closer to the sedan. For this modification the ANSA Morphing Tool is used. Three dimensional Morphing Boxes are defined around the model to control its shape and several modifications take place. Firstly, the SUV height is reduced until fit the sedan height as shown at figure 16.

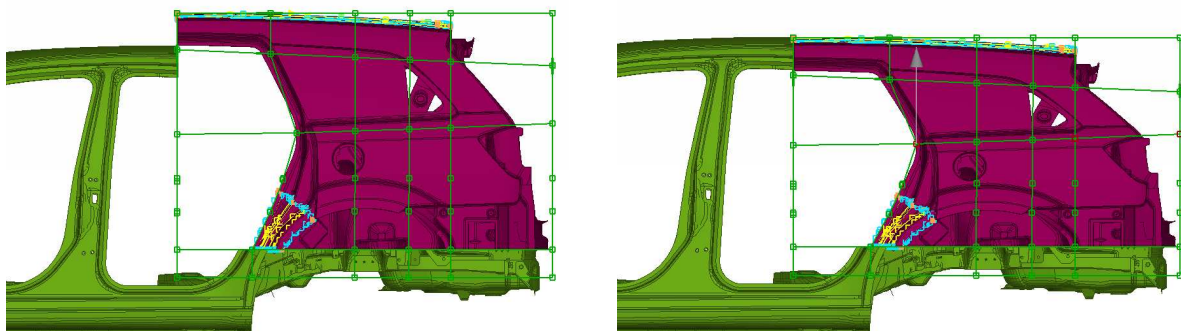


Figure 16: Global morphing to the SUV

Using the same Morphing Boxes the rear suspension dome is moved closer to the part that is going to be connected. At this step the movement is coarse. Exact fitting will be applied in a later step (figure 17). The same procedure is also used for other model parts.

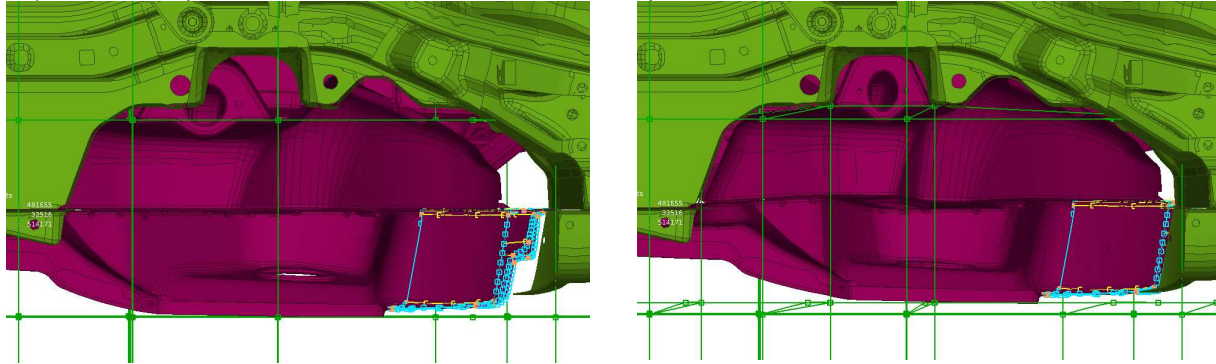


Figure 17: Coarse morphing on the suspension dome

3.2 Local morphing using 2D-Morphing Boxes

The cross sections of the two models side members are considerably different and a special treatment is needed. Two dimensional Morphing Boxes are applied at the moving part. The free edges of the SUV member are fitted on the respective edges of the sedan while the Morphing Boxes ensure smooth transition of the cross section shape (figure 18).

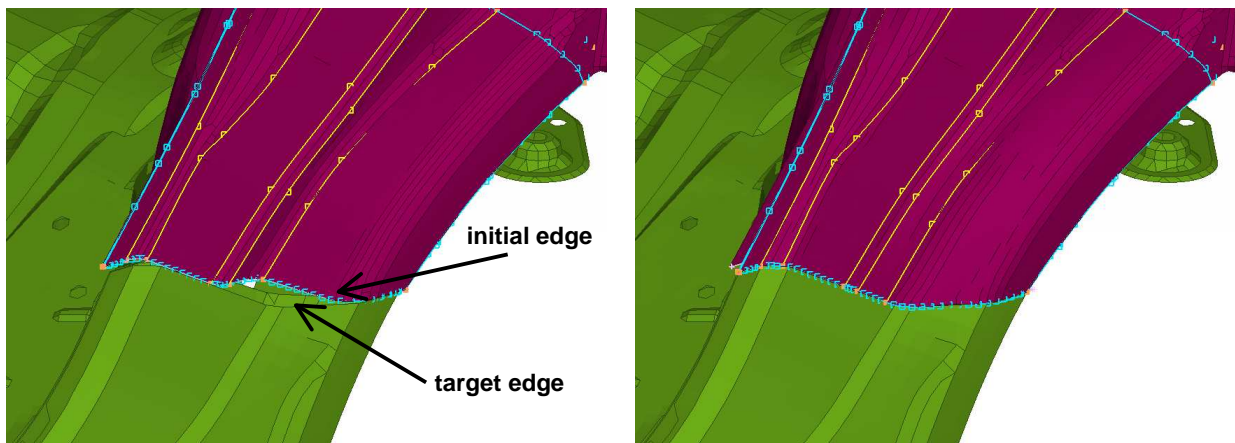


Figure 18: Fitting the side member edges

After the fitting process, the two parts should be connected together. Topology is applied on the parts which fills the cap between them by re-meshing and connecting the neighbouring elements. Setting up identical property and a final re-meshing completes the parts connection as shown at figure 19.

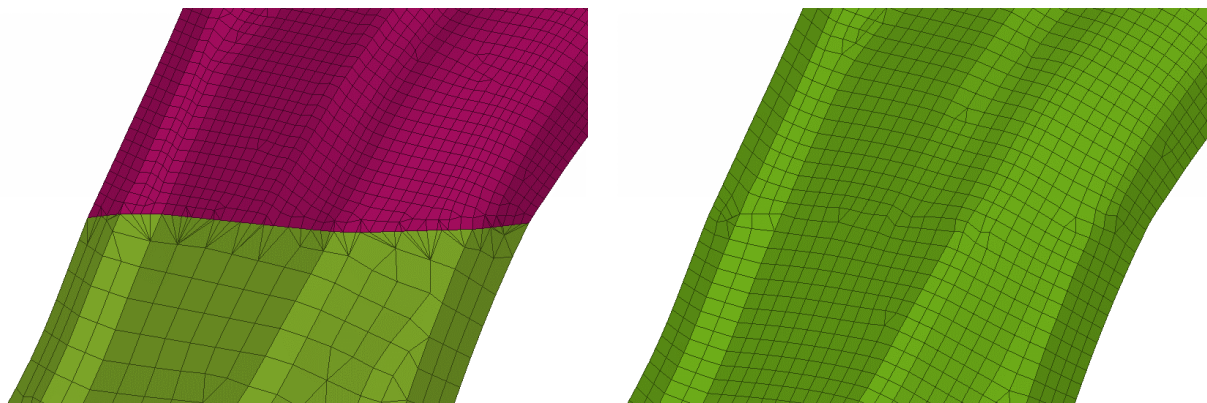


Figure 19: Parts connection

The same procedure is followed for the connection of the roof since the beads along the SUV roof should be flattened to connect successfully with the sedan relative roof part.

3.3 Connecting the parts

Several parts of the model should be connected one by one. The engineer should check if the adjacent parts are compatible and if the applied deformation can cause any problems to the model operation such as penetration or deformation of critical areas. The direct morphing approach is used for this task. Using this technique there is no need of defining any boxes but only the initial and target edges, the bounds and the affected elements. After the fitting action, the same process that used to the cross sections is used to connect the parts (figure 20).

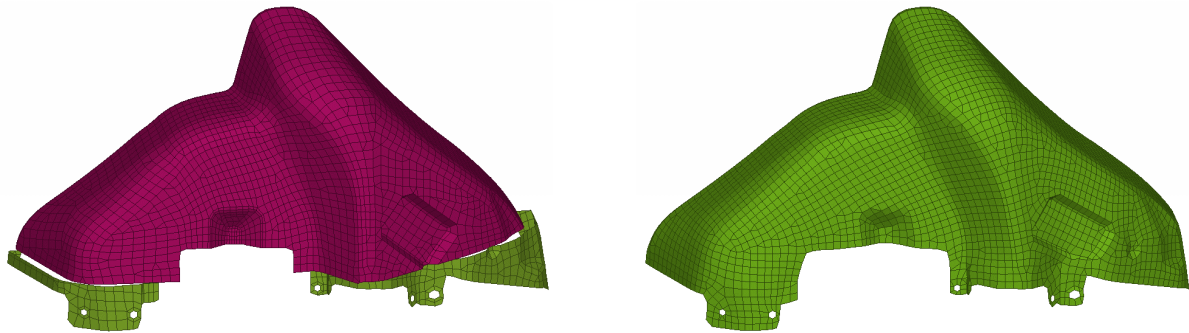


Figure 20: Connecting the rear suspension dome

3.4 Checking the model

The model is connected and the new shape is defined (figure 21). The model has all its detail and there is no need of adding any features like holes, fillets, etc., or redefine any boundary conditions and LS-DYNA keywords. However, in order to run correctly in LS-DYNA some checks should be performed. The whole model is subjected to intersection and property thickness penetration check. Few elements with property thickness penetration are fixed automatically by a special tool of ANSA. More checks are applied on the connections to ensure that the model shaping did not distort any of them. In that case distorted connections are reapplied to fulfil respective standards. The time that is elapsed for the whole process is shown at table 2.

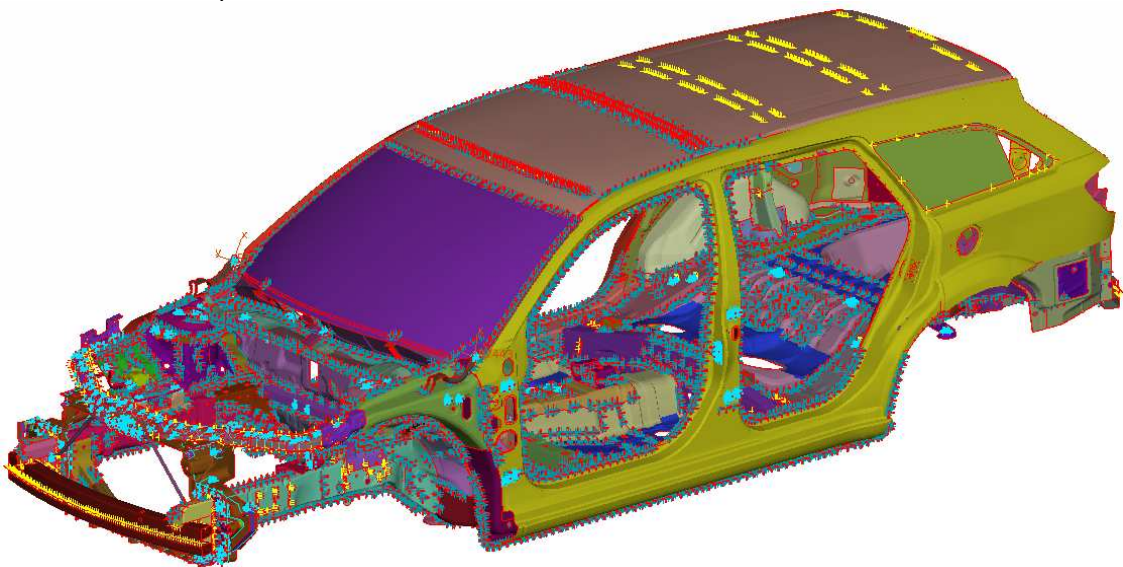


Figure 21: The final model

Action	Human hours [h]
Model cut and assembly	1 min
Morphing Boxes definition	5
Global morphing	1
Local morphing	1
Connecting the parts	6
Model check and fix	3
Total	17

Table 2: Process time

4 Conclusions

The use of detailed FE-models during the concept design offers great advantages. Validated models from former analyses can be updated within a couple of working days and fit the shape of under development models. The recommended process can be used for the fast extraction of results for model that is not yet completed and thus, help the design process. In that case some small deviations of the ideal geometry are not of great importance.

The CAE models are already meshed and after the fitting process, they are ready to run to solvers with only a few minor corrections. The engineer feels confident of using such models that have already been ran and tested for their results. Furthermore, the detailed CAE model contains all solver specific entities and keywords, like connections, boundary conditions and output requests and there is no need of redefining any of them.

Using this technique there is no need to create a new concept model every time a new model version arises. Additionally, there is no need to add model details like fillets, holes, beads, etc., as on the concept model since the detailed CAE models contain all the geometrical information. The time consuming migration from the concept to the detailed CAE model can be excluded.
