MPDB Pre- and Postprocessing in Generator4 and Animator4

Benito Cia, Leyre
Mospak, Christian
Kaulich, Christoph

GNS mbH

Abstract

While the development of modern cars reduces the risk of injuries for the occupants in a lot of different load cases which are well-defined for different scenarios, the risk to get injured when hitting another car with a partial overlap between the two vehicles is still high.
The structure of the two involved cars is not able to completely absorb the energy from the occupants. Around 2010, a new type of barrier and test procedures were developed in order to simulate this type of accident. A moving honeycomb barrier hitting a driving car with an offset, should help improving modern cars. This test is used as procedure for different NCAP organizations around the world from 2020.
Generator4 and Animator4, the FEA pre- and postprocessors from GNS mbH, can help the engineer to set up, start and evaluate simulations of MPDB barriers, calculating the loads on the occupants and the deformations in the barrier.

Mobile offset Progressive Deformable Barrier (MPDB)

Starting in 2020, the NCAP organization assesses vehicle safety for frontal impacts tests performing a frontal car to barrier crash, which is held with a new designed Movable Progressive Deformable Barrier (MPDB).
The test vehicle is equipped with a THOR 50th percentile male dummy (THOR50M) on the driver seat and a Hybrid III 50th percentile male dummy (H-III 50M) on the front passenger seat.
In the second row, a Q10 dummy is placed on the struck side while the Q6 dummy is seated on the non-struck side, the results of which are used for the Child Occupant Protection assessment in Euro NCAP.
The overlap is moderate at 50 percent of the total vehicle width. The moving trolley carries the progressive deformable barrier on the front outboard side and has a mass of 1400kg, as shown in next picture. [7]

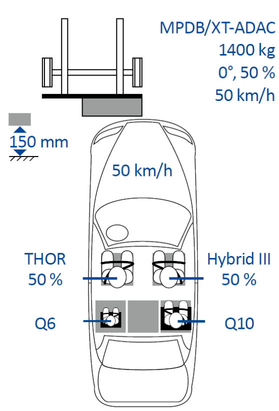

Figure 1: Front crash test assessment protocol according to NCAP [2]

According to the barrier specifications [3], the impactor consists of three stacked aluminum honeycomb blocks:

- The front block offers constant levels of force with deflection.
- The middle block has been processed to give a progressively increasing level of force with increasing deflection.
- The rear block offers again a constant level of force with deflection.

The rear block is then bonded to an aluminum back plate which is also used for mounting the impactor. The three blocks are bonded by three aluminum sheets and the entire impactor is covered by an aluminum skin (cladding) riveted to the front face.

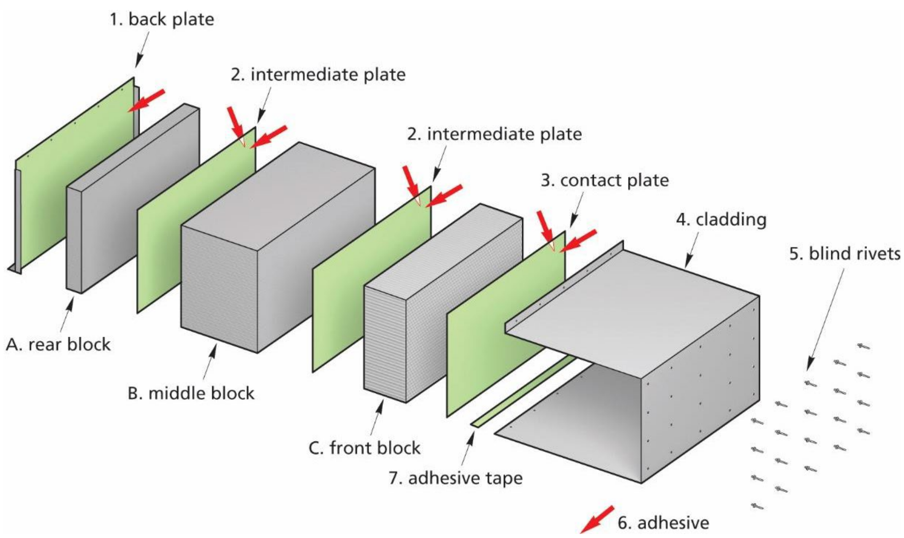

Figure 2:Exploded isometric view of MPDB [3]

This deformable impactor is then attached to the moveable trolley conforming to the specifications of Technical Bulletin TB022 [3], taking into consideration that the outboard edge of the MPDB must be 850 ± 10mm from the centerline of the trolley.

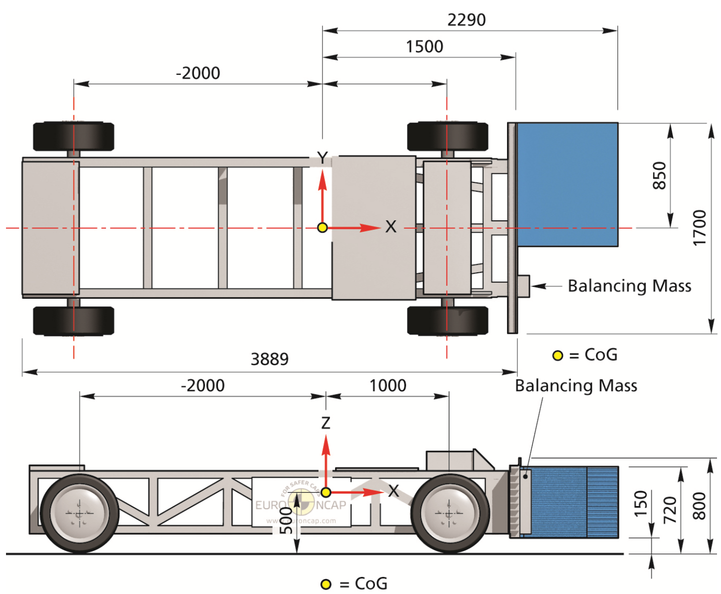

Figure 3: MPD Barrier and trolley specifications [1]

This new barrier model has to be tested both statically and dinamically in order to be validated and considered suitable for its usage at the NCAP test. For the static tests, the different honeycomb blocks are studied. On the one hand, the two external blocks (Designated by the letters A and C) are evaluated by statically crushing them with a strength from 1.540MPa to 1.711MPa and 0.308MPa to 0.342MPa respectively. On the other hand, the middle block (Designated as block B) is evaluated by taking test samples and compressing them between two parallel loading plates until the block compression reaches 355mm. For the dynamic tests, the deformable barrier is attached to a rigid wall in such a way that no relative displacement occurs during the test. Then, a non-deformable tubular impactor mounted on a trolley (presenting a total mass of 1300kg +/- 20kg) is driven against it at a velocity of 60km/h -0/+1km/h. The force deflection curves of the tested deformable barrier shall lie within the force corridors defined in Figure 4.

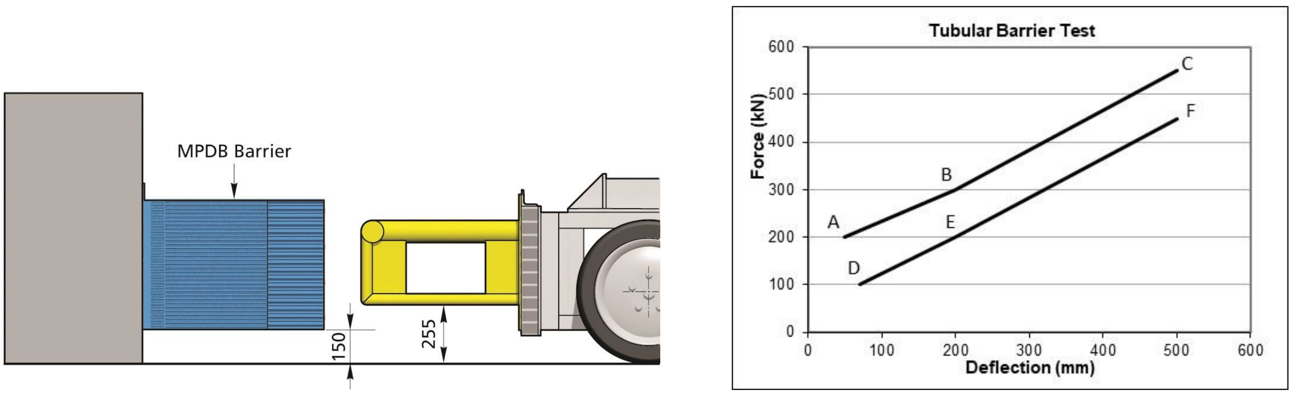

Figure 4: Dynamic validation tests and force deflection curve [3]

As it can be seen, the requirements necessary for the new barriers and their design have been greatly increased with the objective of representing as accurately as possible the reality of traffic accidents.
In the same way, the requirements and expectations for the virtual models of the used barriers are increased, which reach high levels of complexity in terms of modeling the materials (for example when it comes to the aluminum honeycomb blocks or the glue used between them) the geometries of the deformable honeycombs and the dynamic behavior of the contacts involved.

To meet the needs of the market in this regard, GNS mbH has developed an MPDB barrier model, making use of a great experience of more than 20 years in the field of numerical simulation. Providing accurate results and ensuring clean and reliable simulations, the model frees the engineer and allows him to focus on product design, thus achieving better results in terms of safety.

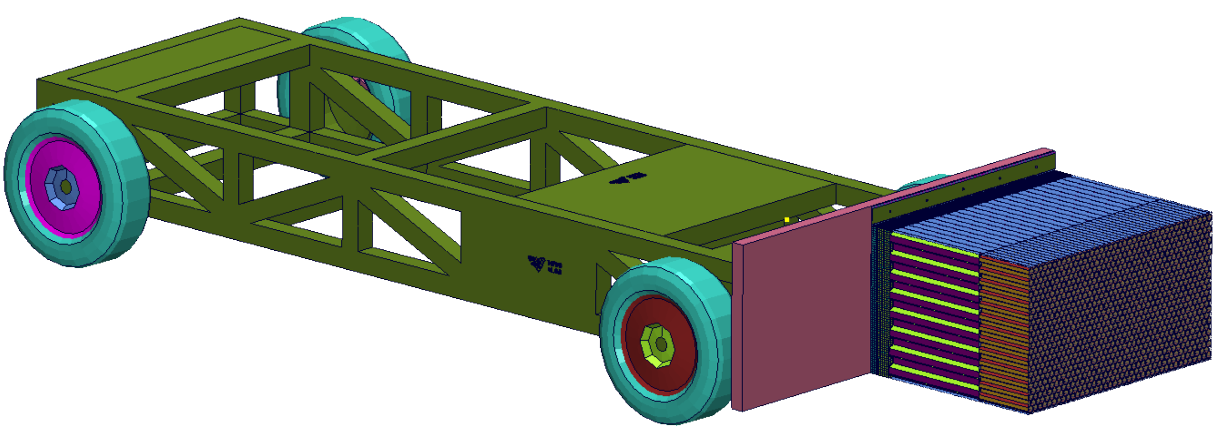

Figure 5: GNS mbH own F.E. MPDB model.

Testing protocols using the MPDB. Position requirements

In 2020 the European New Car Assessment Program (Euro NCAP) has updated its offset frontal impact test procedure. These updates are centered on the adoption of the Thor anthropometric test device and a new barrier face for the mobile progressive deformable barrier (MPDB). [4]

For the tests, the trolley is fitted with the Progressive Deformable Barrier (PDB) conforming to the specifications of Technical Bulletin TB022, as it can be seen at the next figure:

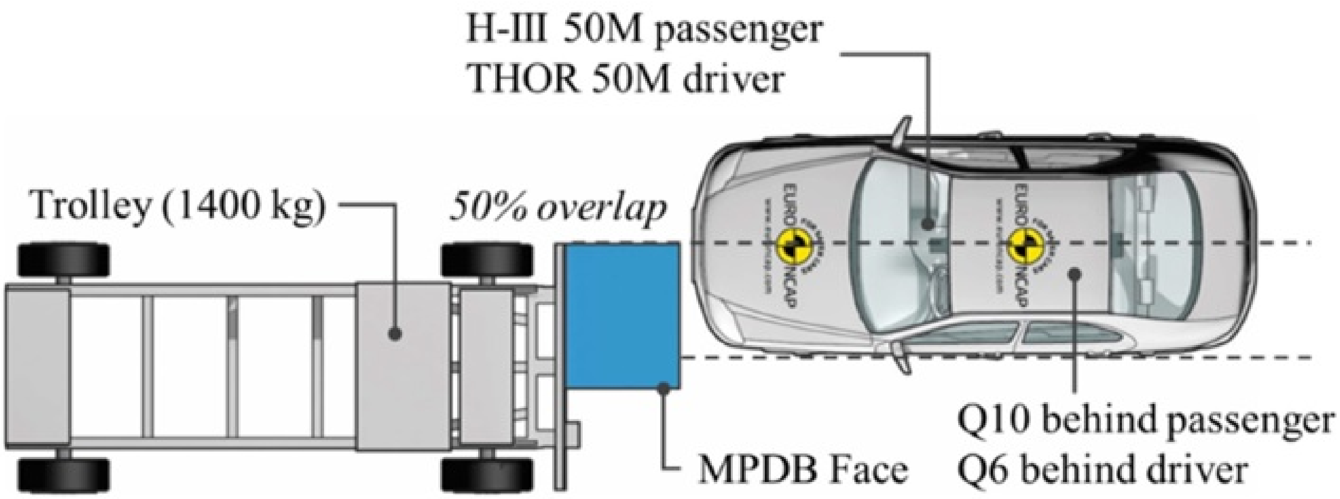

Figure 6: Front crash MPDB test Set-Up [7]

Among other specifications, the NCAP protocol lists a series of position requirements such as:

- The height of the barrier shall be such that the lowest part of the front face of the barrier is 150mm ± 5mm above ground level measured statically and prior to impact.
- The impact angle between the barrier and the vehicle to be tested must be 0 degrees.
  After the crash test, the impact angle of both the vehicle and the barrier trolley are to be measured as near as possible to the point of impact, being a deviation of only 2 degrees allowed.
- Target overlap is 50%. A maximal deviation of 25mm is allowed for the test.

In order to reproduce the accuracy required in real tests, specific tools can be used to handle the F.E. models used to represent the crash set-ups.

Generator4 solution for barrier positioning

Generator4 is a general-purpose preprocessor, combining the car safety functionality with geometry treatment and mesh generation under a friendly user interface, characterized by its flexibility and easiness.

Available for both, unix and windows platforms, allows the users to set-up LS-DYNA® models as well as those form other F.E. solvers.

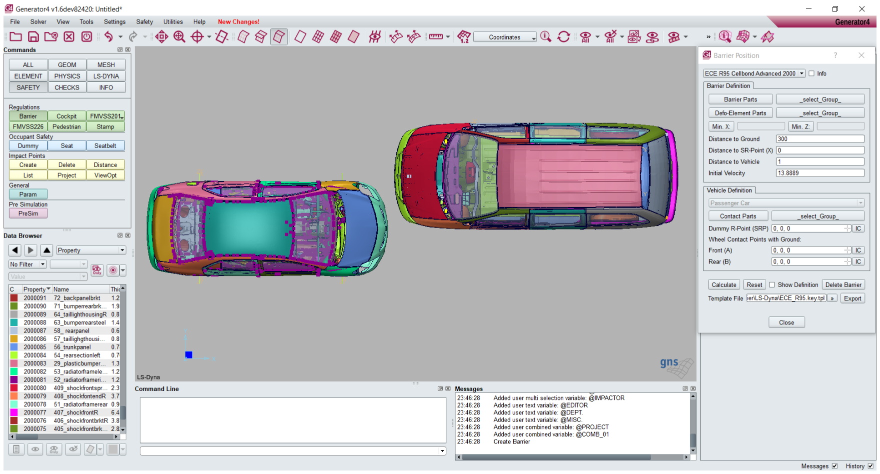

Figure 7: Generator4 GUI

Among the different GNS products, Generator4 stands out in the field of vehicle safety, taking impactor and barrier positioning as its very best. Good example of this, is the dedicated "Barrier Position" dialog, allowing the engineers to position all types of crash barriers in an intuitive, quick and accurate way.

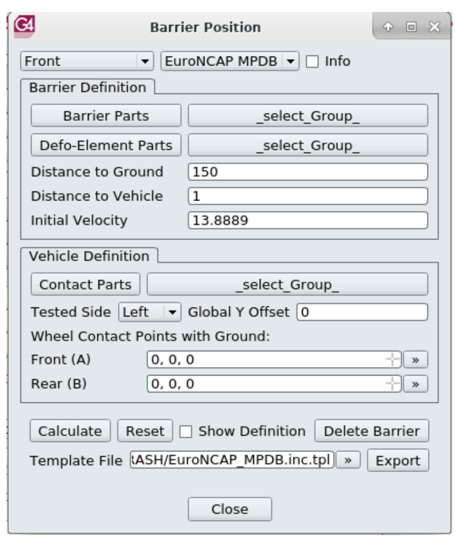

Figure 8: Generator4 customized dialog for MPD barrier positioning.

Graphically picking the used properties to model the barrier and the external parts of the vehicle in contact with it together with the vehicle center definition are enough for automatically positioning the new MPDB models according to the new test regulations.

As an addition, various options are also offered in the dialogue itself, which allow variations in the positioning of the barrier in order to easily set-up and carry out diverse robustness studies.
An example of this is the possibility of influencing the side to be evaluated in the vehicle, or the approach speed of the barrier and its height position.

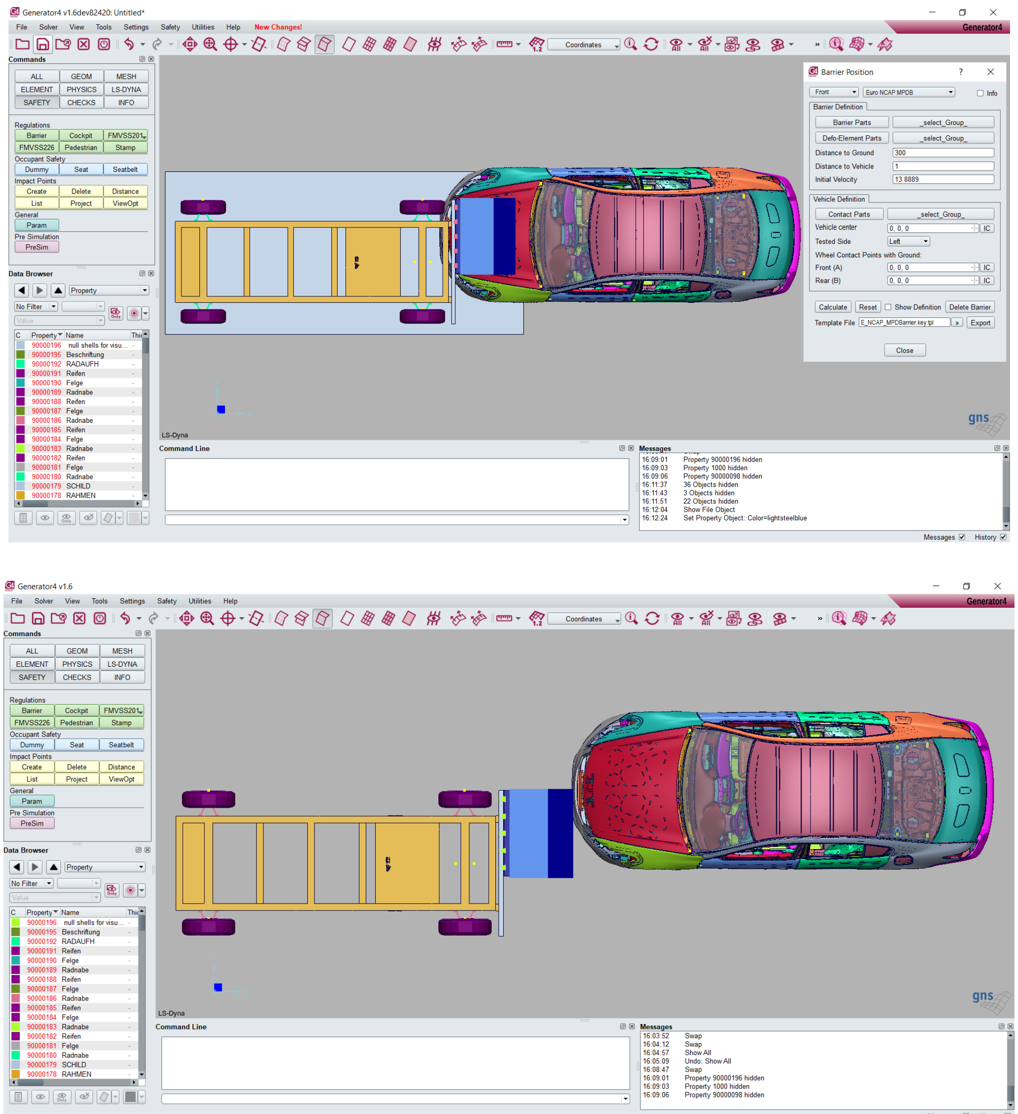

Figure 9: Generator4 barrier positioning process

Once the desired position is reached, Generator4 offers the possibility to store the position in an easy to handle solution based on customizable templates. By taking advantage of the template approach, the necessary definitions used by LS-DYNA are obtained.
This includes not only the *DEFINE_TRANSFORMATION keyword used for the positioning itself, but also the additional *SET and *CONTACT definitions that must be present between the barrier model and the tested vehicle.
Moreover, all these definitions are created and exported in an extra key-file that can be directly packed along with the rest of the model, without having to adapt any of the other key-files. This ensures a flexible and easy to handle model structure, while decreasing the human error factor.

Testing protocols using the MPDB. Evaluation requirements

According to the NCAP testing protocol, for measuring the deformation of the PDB barrier after a performed crash test, a 3D measuring system shall be used (e.g. 3D measurement arm with attachable scan module). This system must be capable of recording three dimensional co-ordinates of single points, as well as clouds of points (scanner). A tolerance of +/- 1mm is applicable to such a system. [1]

The evaluation of a MPDB test is based on a rating area which is located on the front side of the barrier. A grid of 1400 points is calculated on the barrier face. This grid is moved on the barrier in dependency from the car size. These grid points are projected on the deformed shape of the barrier, and the intrusion for every point is measured.

The measured values lead to a standard derivation of the intrusion, from which a homogeneity factor is derived.
Additionally, the acceleration of the barrier trolley is used to calculate an OLC (occupant load criteria) for a virtual occupant of the barrier.

Maximum intrusion is checked in the process and the result is modified in case an intrusion of more than 630mm on an area larger than 40mm x 40mm is found.
From these three single results, the compatibility modifier is calculated.

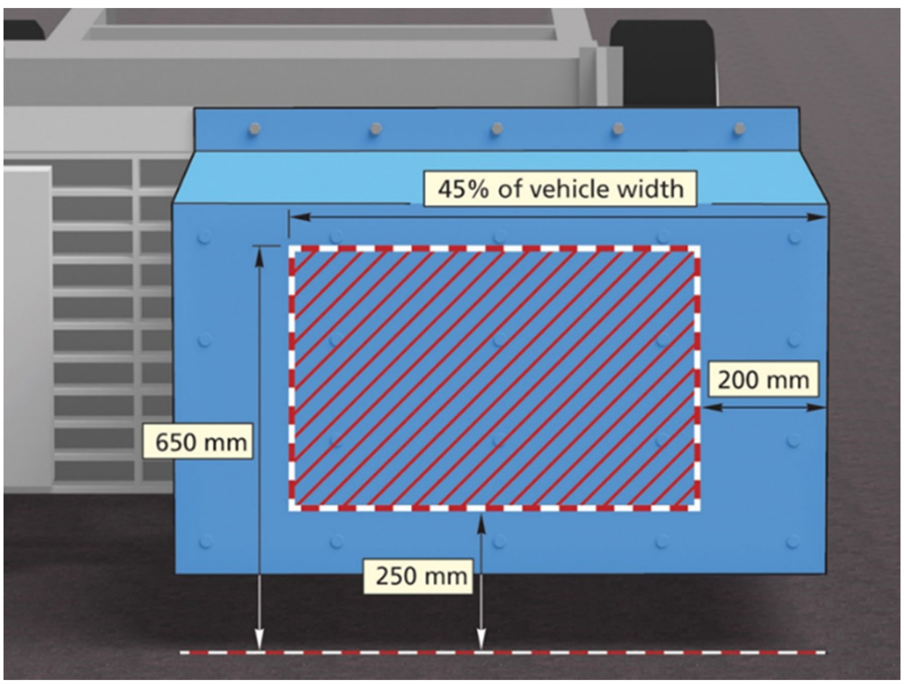

Figure 10: Compatibility assessment zone [7]

Animator4 solution for barrier evaluation

Animator4 gives the user the possibility to evaluate all needed signals and deformations of a EURO NCAP test setup in one session.

Available for both, unix and windows platforms, allows the users to read in LS-DYNA models as well as those form other F.E. solvers and hardware test results.

A simple and intuitive user interface helps the engineer to set up the needed definitions. The user is guided through the definition of barrier materials and orientation, acceleration signals and some definitions for more detailed inspection.

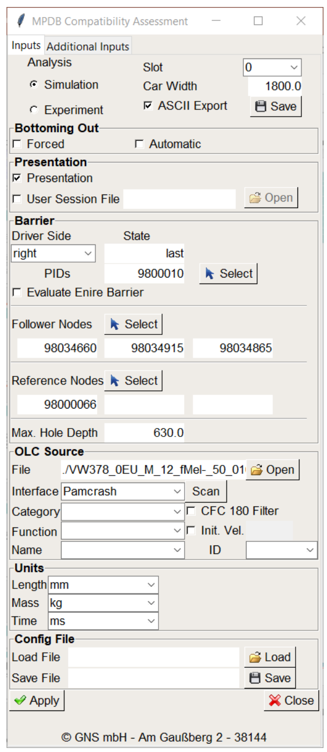

Figure 11: Animator4 MPDB GUI

After the initial setup of the needed parameters Animator4 first calculates the rating area on the barrier. Using this information, the gathering of the intrusion information is started. Using an improved distance measurement algorithm creates the field information plotted on the rating area. The standard derivation is also calculated and can be plotted as assistance for the engineer.

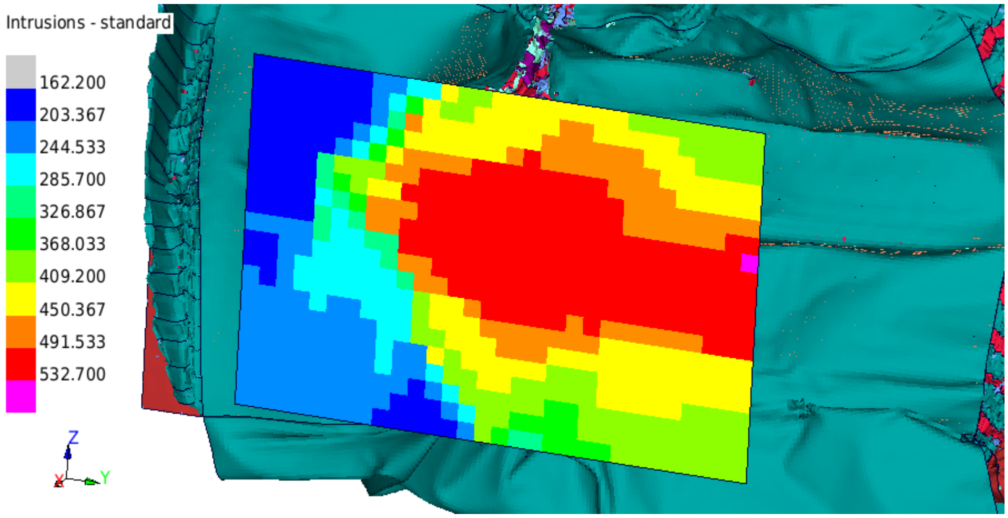

Figure 12: Animator intrusion plot

Based on the intrusion information the bottoming out decision is made. The intrusion field is searched for grid points with a value higher than 630 m, and the size of high value area is determined. If the size is larger than 40 mm x 40 mm, the modifier is adopted.
OLC calculation of the virtual trolley occupant can be started from acceleration or velocity signals, which both can be filtered while reading them in Animator4.

Using the results of these three parts a homogeneity factor is calculated and the results of the test are plotted on a prepared presentation slide.

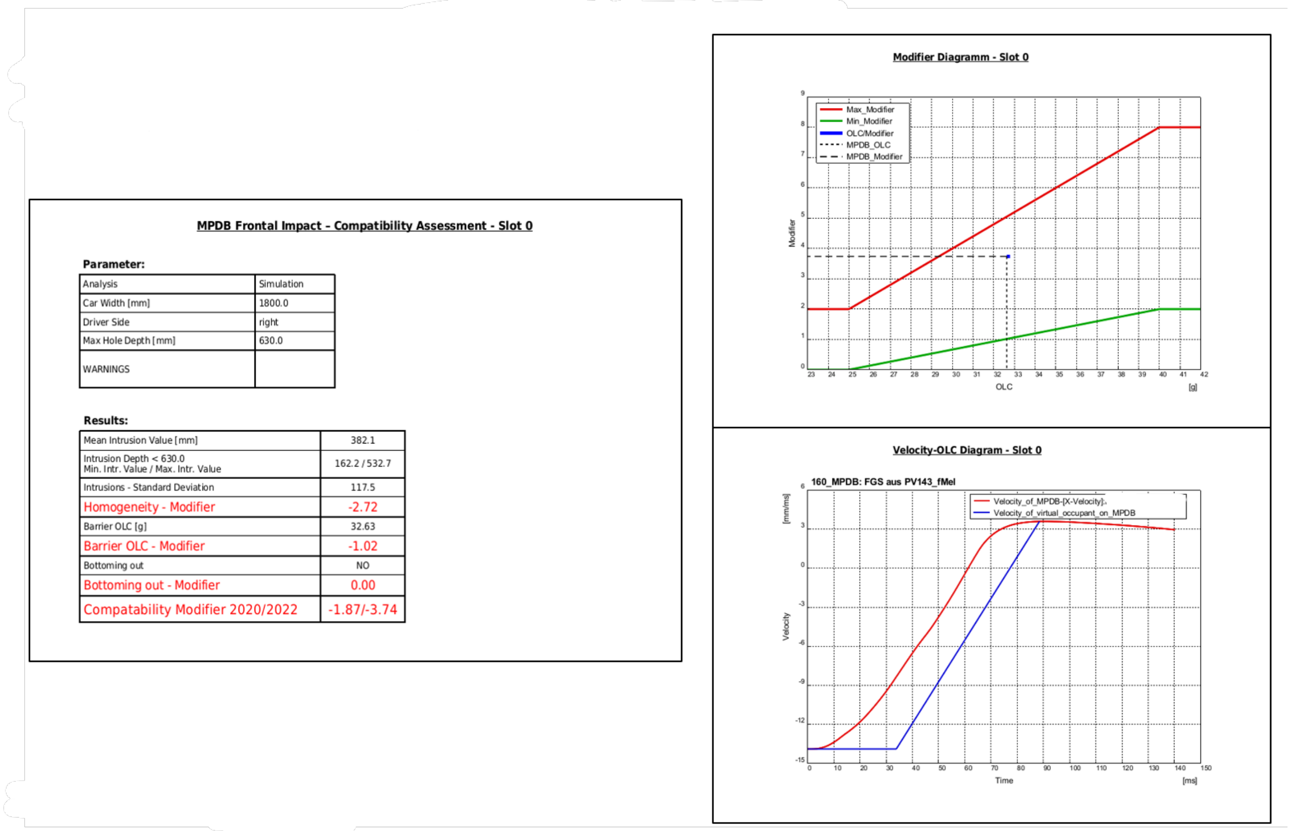

Figure 13: Animator4 result slides

As a single engineer seldom does only one simulation of one type, all definitions used for the described postprocessing can be stored as configuration file and can be loaded for repeated usage. Also, it is possible to include the whole process of calculation and data-handling in a batch job. In that way it can be integrated in automated job submission on a HPC cluster and the connected SDM system.

Summary

The further development of crash procedures in the direction of compatibility tests, will help the automotive industries to come closer to “Vision Zero”, no killed humans by cars.
The combination of Generator4 and Animator4 can improve the work of the engineers and speed up the development of new cars. Due to the high number of simulations needed to follow the regulations, the possibilities of automating the pre- and postprocessing steps and integrating it in various SDM systems are a great help.

References

[1] Euro NCAP, MPDB Frontal Impact. Testing Protocol, 2019.

[2] CAHRS, Safety Companion, 2020.

[3] J. Ellway, Euro NCAP MPDB Specification. Technical Bulletin TB022. v1.2, 2016.

[4] A. Ratzek and V. Sandner, "MPDB-Mobile offset progressive deformable barrier," in 24th Enhanced Safety of Vehicles Conference, Gothenburg, 2015.

[5] EuroNCAP, "Technical bulletin. Compatibility assesment. TB 027," 2018.

[6] J. Ellway, Euro NCAP Mobile Progressive Deformable Barrier Specification. TB022, NCAP, 2018.

[7] V. &. E. J. &. v. R. M. Sandner, " Euro NCAP -New Frontal Impact Test with Mobile Progressive Deformable Barrier (MPDB).," 2019.