RECONSTRUCTION OF A SIDE IMPACT ACCIDENT WITH FAR-SIDE OCCUPANT USING HBM – DISCUSSION OF POTENTIAL APPLICATION OF VIRTUAL HBM WITHIN A FAR-SIDE OCCUPANT PROTECTION ASSESSMENT

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ABSTRACT

Advanced Human Body FE models are now being used extensively in the development process of vehicle safety systems. This tool on one hand aids in the optimization of restraint systems and on the other hand also provides a detailed analysis of injury mechanisms when used within accident reconstruction.

A good documented (injury patterns & physical loading conditions) real world crash and its reconstruction not only ensure further development of vehicle safety, but also allows further improvement of these Human Body Models in terms of biomechanical validity and injury prediction capability. This is particularly important, as injury prediction should not only be based on physical thresholds or isolated tissue based injury parameters but should also allow a population based probabilistic estimation of injury risk.

Therefore the main objective of this study was the reconstruction and detailed analysis of a real world side crash using a numerical HBM. This real world side crash was chosen from the DBCars in-house accident database of Daimler. In the selected case, a medium sized Mercedes car was struck at approximately the front wheel on the passenger side and had a rollover subsequently. The driver sustained mainly abdominal injuries.

A THUMS V4 male model was used to represent the driver of the struck car and to reconstruct the injuries. The probabilistic injury criteria for pelvis fracture, recently published by J. Peres et al. and the probabilistic rib fracture criteria published by J. Forman et al. were implemented to the post-processing tool DYNASAUR. Further stress/strain based injury predictors for other body regions were also used within this study.

The real world crash and the injury patterns of the driver were compared and discussed with statistical data whether it can be considered as representative for a typical far-side load case. Finally the applicability of Virtual Testing and use of a HBM within an assessment protocol are discussed for this far-side load case.

INTRODUCTION

In March 2015, Euro NCAP published a Strategic Road Map, identifying major domains that are supposed to focus on key real life crash scenarios and that are supposed to be addressed by new and updated safety technology [1]. One of these domains are side impacts, since – according to Euro NCAP – far-side impacts have been overlooked in testing and seem equally important as casualties from near side impact. Suppliers of restraint systems aim to address these upcoming requirements with new restraint systems (“center bags”) [2].

On the other hand, data analysis based on NASS/CDS and CIREN done by Brumbelow et. al. [3] highlights the variety of impact conditions occurring in far-side impacts. This study analyzes impact direction of force, impact area, number of collisions, impact severity etc. in relevant cases, and investigates injured body regions. Given this detailed understanding, Brumbelow assigns a low priority to far-side scenarios contrary to Euro NCAP and conclude that they are difficult to address with a single test configuration.
Accident data analysis of GIDAS data [4] resulted in n=43 belted front row car driver or occupants of cars registered 2000 or later who were seated in the far-side position of a side collision by cars or other vehicles. Only 67% of the vehicles showed a compartment impact (Fig. 1, top left). Less than 30% of these had a perpendicular impact similar to side impact scenarios currently standard in laboratory tests (Fig. 1, top right). Injuries due to head-to-head contacts are not a major issue in the field, since head injuries in far-side cases with close occupant do not predominate. For both groups, thorax injuries are high. The share of abdominal injuries is also comparably high, many of them not further specified traumatic AIS2 injuries to liver or kidney (Fig. 1, bottom).

Several studies and researches have already shown, that human body finite element (FE) models are the method of choice to reconstruct real world crash injury outcome and demonstrated in the same way, that injury predictors and criteria used with these tools could be further validated and consolidated in comparison with real world crash scenarios.

Golman et al. [5] discussed the use of a HBM in detail within an accident reconstruction of a near-side crash selected from the CIREN (Crash Injury Research and Engineerin Network) database. He also comprehensively analysed the HBM response and injury prediction capability by applying several injury metrics from literature or recently developed and implemented to the human body model which has been used in his study.

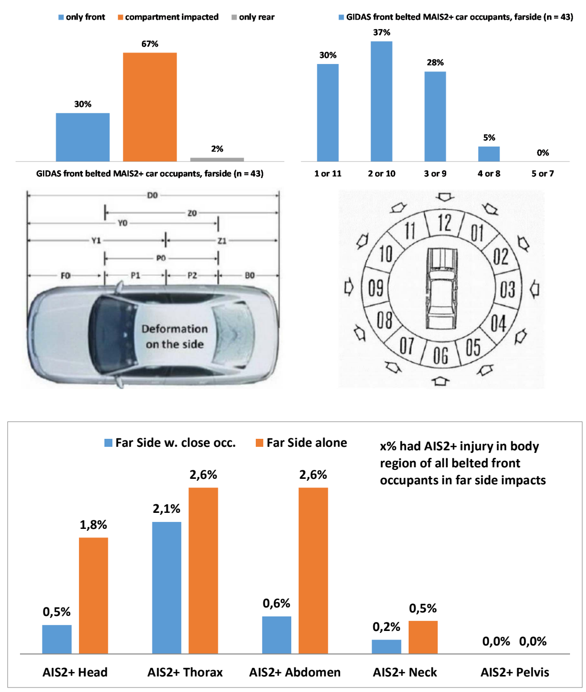

Figure 1. Accident statistics Far-side

This study now aims to:

1. Understand in more detail the injury mechanisms in far-side collisions and to show the capabilities and hurdles of human body simulations of these scenarios.
2. Apply a post-processing for evaluating injury risk.
3. Apply aspects of Virtual Testing in conducting accident reconstruction.

Therefore, similar to the study of Golman also the Total Human for Safety (THUMS) [6] [7] was used to represent the occupant, now in a far-side configuration, in this real case reconstruction. In addition, respectively in contrast to previous studies, a post processing tool was applied with THUMS to evaluate the HBM response and injury risk. This addresses mainly the aspect of standardization and harmonization of injury risk prediction and evaluation by virtual human body models and finally the applicability within assessment protocols.

This topic, respectively more general “Virtual Testing”, was extensively discussed within the European FP7 research project IMVITER [8]. The consortium comprised of 15 partners from Germany, France, Italy, Spain, Hungary and Greece and represented the main actors involved in EC motor vehicle type approval process. In the project, Virtual Testing was considered as use of simuation models in the assessment procedures of regulatory acts, replacing real tests or supporting real tests in terms of supplemental assessment procedure. Therefore, the following definition was formulated: “Virtual Testing (VT) can be defined as the assessment of any kind of requirement imposed on a physical part or system, which is conventionally accomplished through some kind of test, but performed using a numerical model instead. Thus, VT inherently replaces tests (also named Real Testing - RT) by simulation models and test results by simulation predictions.” Beside the demonstration of such a numerical assessment in four pilot cases, from which one focused on the application of HBM, also a generic VT type approval implementation process was developed. This process introduces the Verfification, Validation (V&V) and finally the type approval assessment in three consecutive phases (Fig. 2).

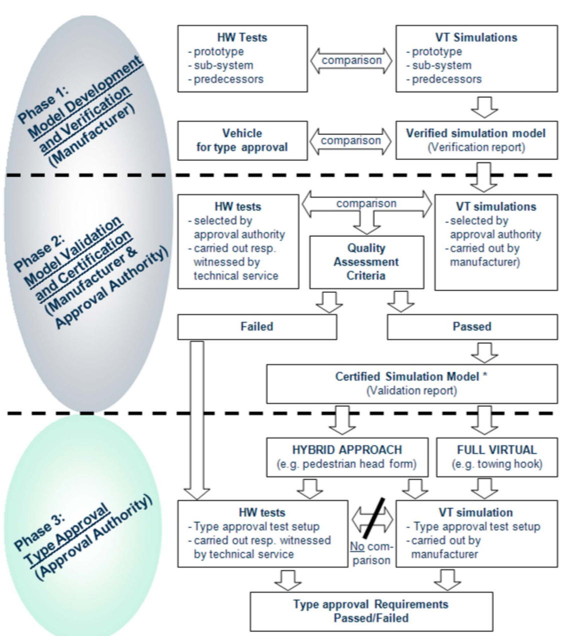

Figure 2. General IMVITER VT implementation flowchart

The European resarch project SafeEV (Safe Small Electric Vehicles through Advanced Simulation Methodologies) [9] was initated as follow-up project within the 7th European Framework Programme and consolidated the main findings from IMVITER. Mainly FE-HBM were implemented to a proposed assessment procedures and applied to evaluate advanced safety solutions for pedestrians and car occupants. Finally relevant and crucial processing steps within a projected tool chain were identified and discussed in the course of the project – e.g. V&V (Verification & Validation), recommendations for comparability of codes and especially harmonized and standardized post-processing methods including criteria definition were mainly identified as Best Practice respectively Key Building Blocks for VT and the implementation of HBM (Fig.3).

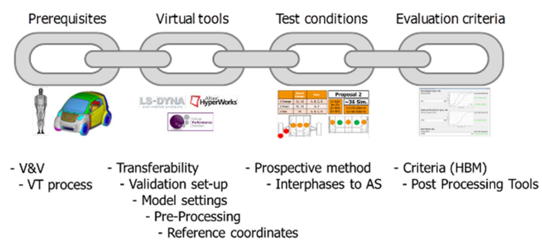

Figure 3. SafeEV tool chain of a virtual assessment including application of HBM and related Key Building Blocks

Therefore the purpose of this study was also to make use of some of the findings from these European projects and discuss e.g. the capability of a post-processing tool and recently published criteria for THUMS V4 to predict the injuries in a real world case on the one hand and to comment on their possible applicability within assessment procedures on the other hand.

METHOD

A real world side crash was chosen from the DBCars in-house accident database of Daimler. The Mercedes accident research unit investigates and reconstructs severe accidents of Mercedes-Benz cars since 1969.

The accident was reconstructed by PC-Crash [10]. The PC-Crash software is one of the leading tools for traffic accident reconstruction. Collisions up to 32 vehicles can be simulated in 2D and also in 3D. Car to car accidents, car to motorcycles, car to pedestrian accidents, occupant movement and also roll over can be calculated. Several databases of all common cars and motorcycles are included in PC-Crash.

The PC crash simulation was taken as a basis for the FE simulation analysis carried out in this study. THUMS V4.02 AM50 occupant Human Body Model was used as the driver of A-Class which was involved in the accident. This HBM was used to assess and predict the injuries happened in actual crash scenario.

The output data from the THUMS V4 simulations were mainly processed using the tool DYNASAUR V0.03 (PYTHON based - http://www.python.org/). DYNASAUR was developed by Graz University of Technology and a first application was demonstrated within the EU research project SafeEV [11] [12] [13]. With specified input concerning criteria and injury predictors, the tool runs automatically the complete assessment process and creates a standardized report. The tool is flexible in terms of possible adaption to different HBM and also additional implementation of criteria. The current version used within this study includes evaluation schemes for head injuries, rib fractures, organ damage, pelvis injuries, bone fractures and ligament ruptures.

Far-side Accident Reconstruction

Accident Scenario A 2015 Mercedes-Benz A-Class crossed a junction and was hit at the right side by a 2014 Mercedes E-Class station wagon. The impact was at approx. 80° angle at the right front wheel of the A-Class (see Fig. 4 & 6). The A-Class spun and rolled onto the passenger side where it came to the final position. There was an activation of the belt tensioner, driver and passenger front bag, knee bag, passenger side bag and right window bag.

Figure 4. Struck vehicle Mercedes A-Class: point of impact at the right front wheel

The driver of the A-Class was the only occupant (44years old, 178 cm, 125 kg). He was belted and suffered the following injuries: right kidney contusion, left shoulder contusion, left hip contusion, left hand laceration, right hand contusion, right lower leg contusion, whiplash of the cervical spine of the neck. The abdominal injury of the far-side driver results most likely from a contact with the center console during the impact from the E-Class. It is also very likely, that the whiplash and the right lower leg contusion occurred during this impact phase. In contrast it might be resonably assumed that the other injuries of the driver occurred during the rollover in the second phase of this accident.

Accident Reconstruction by PC-Crash Based on the accident investigation, different parameters like point of collision, speeds of the cars and friction were changed until the calculated final position corresponds as good as possible to the real final position. PC-Crash output provided results in terms of collision parameters and kinematics of the vehicles, which were now used in the FE reconstruction and simulation of the structural interaction of the vehicles**.** The final, reconstructed accident configuration and kinematics by PC-Crash is shown in figure 5-7.

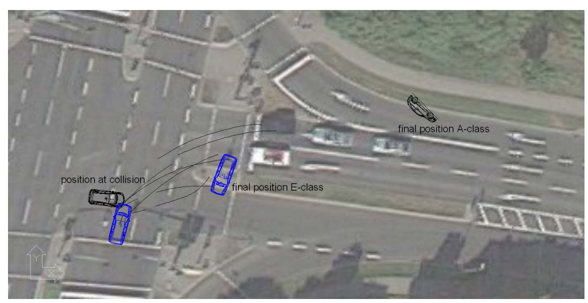

Figure 5. Sketch of accident scene
blue: impacting vehicle (E-Class), black: struck vehicle (A-Class)

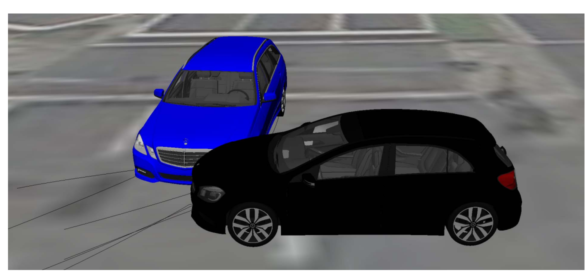

Figure 6. Impact configuration

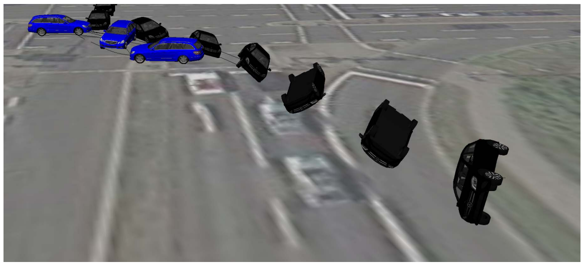

Figure 7. Movement of the cars from impact to the final position

FE Vehicle and Interior Models Accident reconstruction by PC-Crash gives a good visual impression of the accident. However, the amount of data that could be extracted from PC-Crash simulation is limited. Also, in the resultant velocity output from PC-Crash, as shown in Fig. 8, a sharp drop of velocity was observed, which would result in unrealistic acceleration levels in the next stage of the reconstruction. Thus, a need for full vehicle-to- vehicle FE crash simulation was identified.

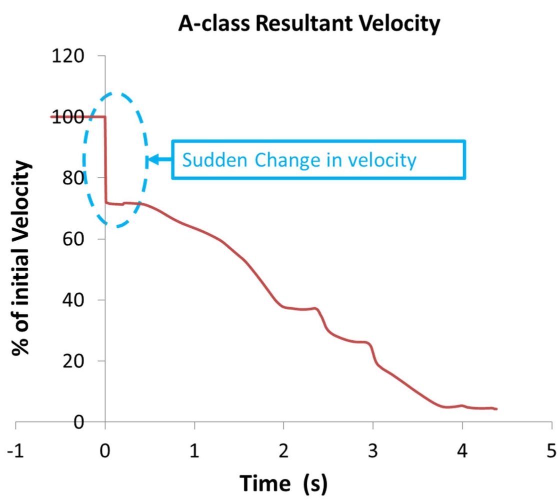

Figure 8. Resultant velocity v/s time output from PC-Crash

Explicit FE simulations with LS-DYNA are capable of providing realistic representation of the vehicle deformations as well as occupant kinematics under accident scenario.

Fig. 9 shows the full vehicle models used. The FE models include detailed BIW parts, engine compartment and the details of the components inside engine compartment, doors with trims, wheels and the suspension assembly etc. A detailed front fascia was absent in the A-Class model. The missing details primarily do not provide any structural strength, which is provided by front bumper cross member present in the model.

A vehicle-to-vehicle impact simulation was performed, with position and velocity inputs from PC-Crash and accident reconstruction data, to validate the FE model setup.

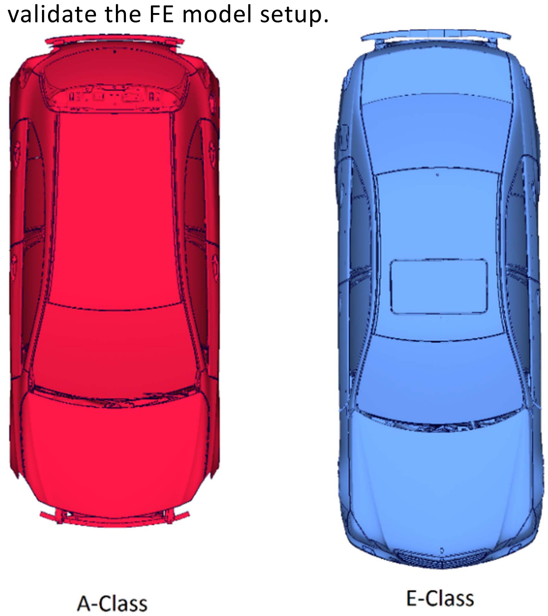

Figure 9. Full Vehicle FE models

The observed deformation pattern, however, was different from that in real crash. In addition, the second impact of the two vehicles was not achieved with the initial setup.

To validate the FE model setup, a parametric study was performed with impact locations (distance between center of front axle of the two vehicles), impact angles and friction between tire and road. Table 1 lists the parameters and their respective ranges studied.

Parameter	Value Range studied	Final value
Impact location	0 mm-1400 mm	1300 mm
Impact angle	90° - 76°	78°
Coefficient of friction	0.4 – 0.9	0.8

Table 1. Parameters of study

The setup shown in Fig. 10 was observed to match the deformation patterns on the vehicles. The second impact was also achieved as shown in Fig.11. The time difference between the two impacts was 239ms. A time difference of approximately 238ms was achieved in FE simulation. Fig. 12 shows photographs of vehicle taken after the accident with deformations in FE simulation overlaid on top of them.

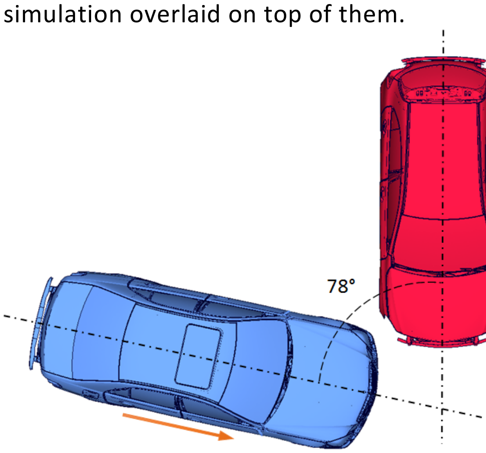

Figure 10. Final position of models for the full vehicle simulation

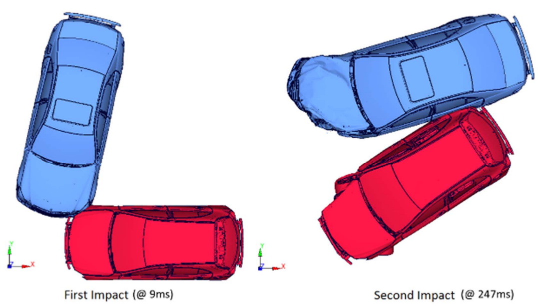

Figure 11. Impacts of the two cars in full vehicle simulation

Figure 12. Overlaid deformation patterns from simulation

The full vehicle simulation performed was observed to be computationally expensive. To reduce the computational time required and reduce the complexity of the study, a sled model of A-Class car was created from the full vehicle model. Fig.13 shows a so-called sled model, in which the components in vicinity of occupant e.g. seat, center console, door trims, steering wheel, and instrument panel were modelled as flexible and the rest including the structure were modelled as rigid.

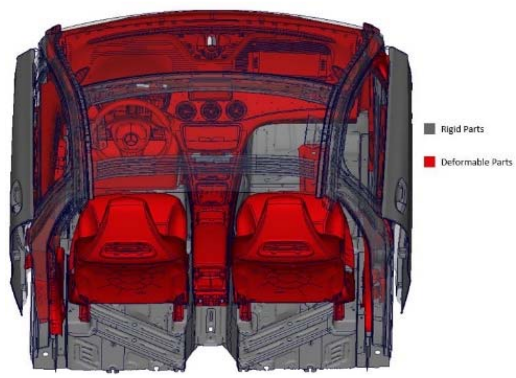

Figure 13. A-Class sled model

To transfer the motion from full vehicle crash simulation to the sled model, three nodes were identified where minimal deformation was observed. Displacement data from these three nodes were extracted and applied to the respective nodes in the sled to impart motion to the sled model. The sled simulation was overlaid over full vehicle simulation to verify transfer of displacement data (Fig. 14).

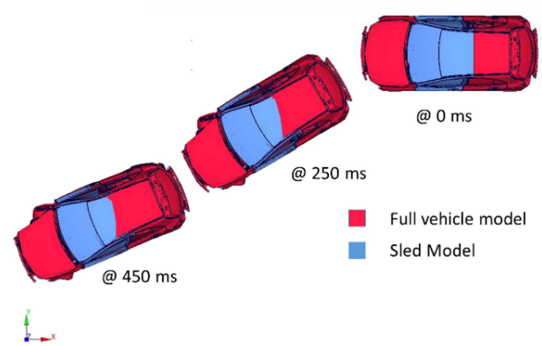

Figure 14. Sled model simulation overlaid over full vehicle simulation

Human Body Model The driver (far-side configuration) in this numerical study was represented by a THUMS Version 4.02 50%-ile male occupant model (AM50). THUMS was and is still developed by Toyota Motor Corporation and Toyota Central R&D Labs. Version 4.02 was released in 2015 [6] [7] with a total number of approximately 1.9 million elements and about 760000 nodes. In this version, the inner organs are modelled in detail. The model represents an average adult with a standing height of 178.6cm and a weight of 77.6kg.

It should be noted, that height of the driver matches well with 50th percentile male height, but the weight of the driver is much higher than that of THUMS V4. The possible obese body of the driver is currently not represented in this study. This fact is discussed in the FE result and discussion section.

THUMS V4 model was positioned in A-Class sled model on the driver side based on ergonomics posture calculations. Seat squashing was done to ensure proper contact between HBM and seat foam. A 3-point seatbelt was routed around the HBM using Primer 12.1 software. The seatbelt was equipped with pre-tensioner system. The positioned model is shown in Fig.15. It was observed during crashed vehicle inspection that the driver front airbag and knee airbag were deployed.

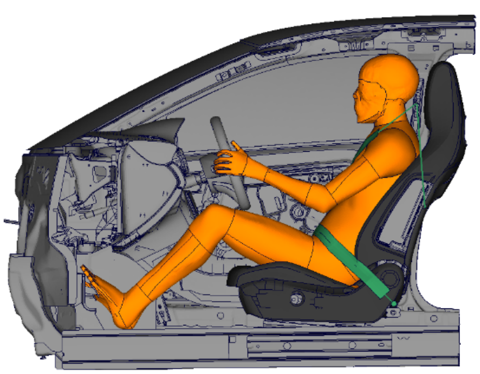

Figure 15. THUMS V4 positioned in A-Class sled model

Injury Metrics The THUMS V4 is a detailed human body model and has capability to predict injuries in complex loading conditions.

In this study, injuries in ribs, pelvis and kidney were analyzed and compared with those observed in the accident. From the injury data recorded in the actual accident, AIS 1 injuries i.e. whiplash, hand contusions and lacerations, shoulder contusion were not analyzed in this study. The injury criteria used to assess the injuries are shown in Table 2.

Body organ	Criteria developed by	Description of the criteria
Ribs	A.H. Burstein et. al.(1976) [17]	Deterministic criteria. 3% plastic strain in cortical bones as fracture limit
	J. Foreman et. al. (2012) [15]	Probabilistic criteria. Based upon maximum local strains
Pelvis	J. Peres et. al. (2016) [18]	Probabilistic criteria. Based upon maximum principal strain in pelvic bone.
Kidney	K. Shigeta et. al. (2009) [19]	Deterministic criteria based upon maximum principal strains in soft organs.
	J. Snedecker et al. (2005) [20]	Criteria based upon the local Strain Energy Density (SED) at time of rupture in kidney. Local SED of 43 kJ/mm^3 was set as limit.

Table 2. Injury prediction criteria

DYNASAUR tool, referred in the earlier section, was used to post-process the results. It is a PYTHON based post-processing tool developed to predict injuries based upon injury prediction criteria available in literature. The tool can be configured by the user to incorporate new injury criteria.

The injury criteria which are available in the tool and which were added as new are shown in Table 3.

Injury criteria available in DYNASAUR	Newly added injury criteria in DYNASAUR
CSDM SUFEHM Head injury Long bone fracture Ribs (Foreman) Internal organs - Heart - Interstine - Spleen - Lung - Liver	Internal organs - Kidney Neck (for SUFEHNM) Pelvis (Peres)

Table 3. Injury criteria in DYNASAUR

Additional criteria were evaluated using traditional post-processing tools such as LS-PrePost.

RESULTS

FE Simulations Occupant & Injury Prediction

The oblique nature of this far-side impact causes the HBM to have a predominant higher lateral component of movement than frontal. The first impact of the two vehicles was most severe resulting in the abdomen and pelvis of the HBM colliding with center console. The HBM was analyzed for resulting injuries based upon the injury metrics discussed in the previous section.

Ribs - **Burstein Criteria** Cortical part of 10th rib was observed to have more than 3% plastic strain, predicting fracture. Fig. 16 shows the plastic strain plot of the ribs.

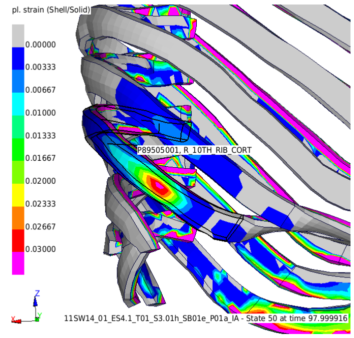

Figure 16. Fringe plot of plastic strains in ribs. 10th rib shows more than 3% plastic strain

Ribs - Forman Criteria Fig. 17 shows the probability of rib fracture as indicated by DYNASAUR tool. It was noted from the output that the right ribs have significantly higher probability of fracture than the left ribs, as right side of torso was coming in contact with center console. The 10th rib on the right side of THUMS V4 was showing almost 100% probability of fracture, similar to the prediction by Burstein criteria.

Part	Max. Strain	Element	Prob. age 25		Prob. age 45		Prob. age 75	
Left Ribs								
89003600	0.366588632774	89065560	100.0	%	100.0	%	100.0	%
89004101	0.00620840578133	89060440	0.0	%	0.0	%	0.0	%
89004201	0.00615574374454	89059824	0.0	%	0.0	%	0.0	%
89004301	0.00765847269325	89060229	0.0	%	0.0	%	0.0	%
89004401	0.00863407391196	89060306	0.0	%	0.0	%	0.0	%
89004501	0.00837533768893	89060502	0.0	%	0.0	%	0.0	%
89004601	0.0085898372437	89063314	0.0	%	0.0	%	0.0	%
89004701	0.0128756261142	89060909	0.0	%	0.0	%	8.6	%
89004801	0.00764044045865	89062486	0.0	%	0.0	%	0.0	%
89004901	0.00611427279304	89065205	0.0	%	0.0	%	0.0	%
89005001	0.00603118941948	89062943	0.0	%	0.0	%	0.0	%
89005101	0.00472901000064	89062449	0.0	%	0.0	%	0.0	%
89005201	0.00359445884732	89059618	0.0	%	0.0	%	0.0	%
Right Ribs								
89503600	0.338932013593	89566712	100.0	%	100.0	%	100.0	%
89504101	0.00484694932031	89560483	0.0	%	0.0	%	0.0	%
89504201	0.00520193765602	89561658	0.0	%	0.0	%	0.0	%
89504301	0.00716667408975	89563593	0.0	%	0.0	%	0.0	%
89504401	0.00498089712149	89560591	0.0	%	0.0	%	0.0	%
89504501	0.00516384863033	89560574	0.0	%	0.0	%	0.0	%
89504601	0.00543284785338	89565044	0.0	%	0.0	%	0.0	%
89504701	0.00713519776674	89560946	0.0	%	0.0	%	0.0	%
89504801	0.00824506162658	89565165	0.0	%	0.0	%	0.0	%
89504901	0.0234197562839	89560662	33.7	%	42.0	%	50.1	%
89505001	0.0731416579934	89562610	100.0	%	100.0	%	100.0	%
89505101	0.0234520839986	89560119	33.7	%	42.0	%	50.1	%
89505201	0.00298636518656	89564775	0.0	%	0.0	%	0.0	%

Figure 17. Probability of rib fracture from DYNASAUR tool (Forman Criteria)

Pelvis Fig. 18 shows the probability of injury in pelvic bone as per the criteria developed by J. Peres et al. The output, from DYNASAUR tool, showed more than 95% probability of AIS 2+ injury happening in pelvic bone.

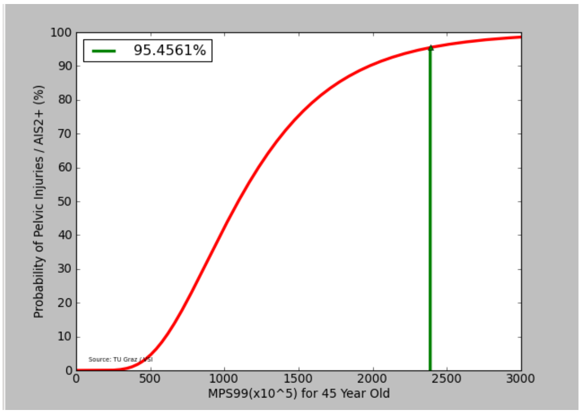

Figure 18. Probability of AIS2+ pelvic injury

Kidney - Shigeta criteria For analyzing the injury in kidney, maximum principal strain of 50% was maintained as a limit for injury. Out of 100% solid elements in right kidney, 63% of elements were observed to fall above the limit compared to 5% of elements out of 100% elements in the left kidney. Fig. 19 shows the number of elements in kidney plotted against the percentage of the Maximum Principal Strain limit at the time of HBM making contact with the center console.

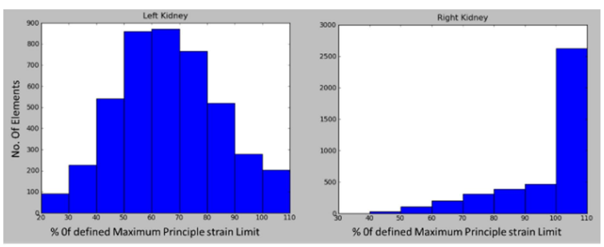

Figure 19. Distribution of number of elements in the kidneys with respect to the percentage of Maximum Principal Strain limit

Kidney - Snedecker criteria Strain Energy Density (SED) in the kidney was analyzed for injury prediction. It was noted, that the right kidney exceeded the minimum rupture limit, 43 kJ/m3, given by Snedecker. The maximum strain energy density observed in the kidney is 552.52 kJ/m3, indicating injury. The left kidney, however, did not exceed the minimum rupture limit. Fig. 20 shows the strain energy density fringe plot in the kidneys.

These observations establish the explanation of higher probability of rupture in right kidney.

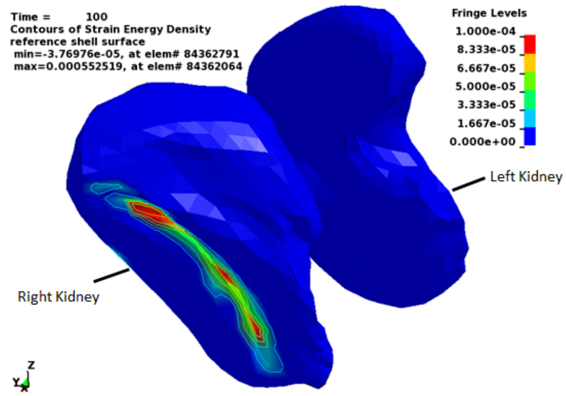

Figure 20. SED fringe plots for kidneys

DISCUSSION

Rib cage injury
Thorax injuries account for one of the highest number of AIS2+ injuries in far-side accident scenarios as discussed in the introduction section. It might be reasonably assumed that the main cause of the thoracic injuries is the contact with the center console of the car. As shown in Fig. 21, the contact between center console and thorax resulted in significant deformation of the ribcage, causing the lower ribcage to bend laterally at around 98ms. The rib injury prediction (Burstein and Forman criteria) showed high probability of fracture in the 10th rib. Whereas, the real occupant did not endure any injuries to ribcage. This difference could be attributed to the anthropometric difference (weight / obesity) between the THUMS V4 and the real occupant.

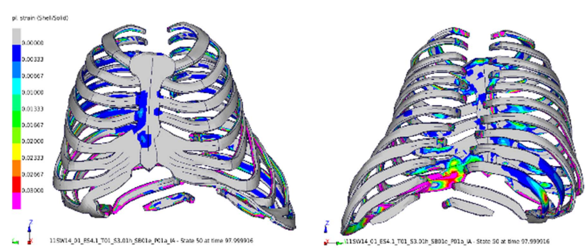

Figure 21. Deformation and plastic strain in ribcage @98ms.

Pelvic injury
The prediction by DYNASAUR tool showed a high risk of AIS 2+ pelvic injuries. The criteria, being

based upon local maximum principal strains, is sensitive towards the modelling related local strain concentrations, as reported by Peres et. al [18]. From the plastic strain plot in Fig. 22, it was observed that the high strains were only occurring at the hip joint area and the localized strains might over-predict the injuries in the pelvic bone.

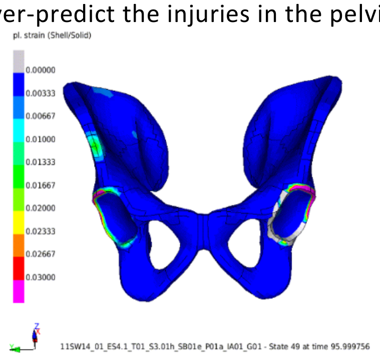

Figure 22. Plastic strains in pelvic bone

Kidney Injury

As mentioned in the result section, the right kidney was found to be more susceptible to injury than the left. The difference between the injury levels could be explained as the organs on the right (impact side) were subjected to direct loading from the vehicle interiors unlike the organs on the left (non-impact side).

Because of the difference in the loading, the right kidney was observed to have higher internal energy (Fig. 23). The right kidney attains maximum internal energy of 3.13 J at 100 ms whereas left kidney has maximum internal energy of 2.06 J at 96ms.

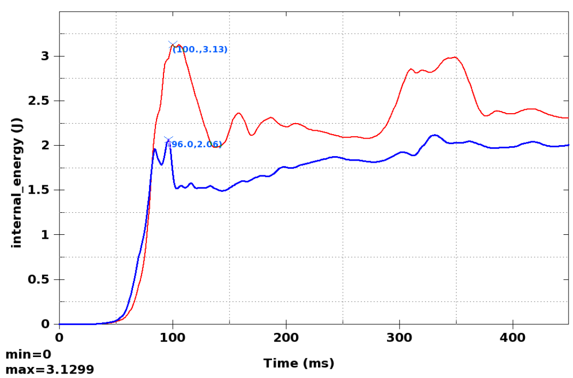

Figure 23. Kidney Internal energy v/s time (red: right kidney, blue: left kidney)

Subsequently, the elements in the right kidney also show high stress values as depicted in Fig. 24 and predicting higher probability for injury.

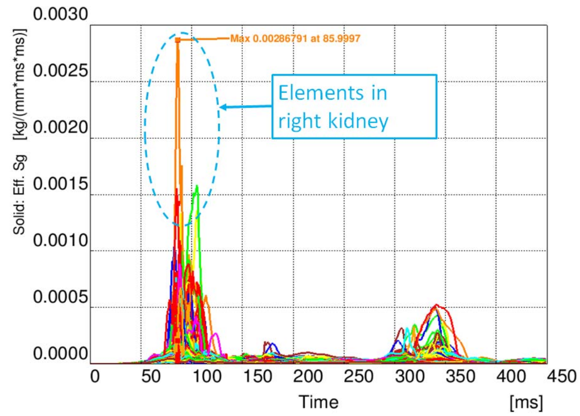

Figure 24. Effective stress v/s time in kidney solid elements.

LIMITATIONS OF THE STUDY

The deformations of the vehicles from photographs helped reconstruct the accident scenario. However, no data on the kinematics of occupant in real event is available. Therefore, the estimation of the contacts of occupant with vehicle interior with respect to accident event timeline and subsequent injuries is purely based on the FE Simulations. These predicted injuries are compared with the injury data from the accident data. The posture of the occupant inside the car as well as the seat position at the time of accident is also not known. The best possible occupant posture and seat position was computed using the ergonomics data and taken as input.

The THUMS V4 model used in this study is a western 50th percentile male model. The weight of HBM is around 77.6 kg and the model height is around 178.6cm. The body height of the driver of A-Class in accident scenario matches quite well with the model, whereas the weight (125kg) of the occupant differs significantly from the model weight. This difference could have led to different kinematics of the occupant and subsequently different injury risk. Therefore, the prediction of the rib fracture in the numerical study was interpreted as a first approximation to reality.

Finally the FE simulation just focused on the first phase of the accident scenario. The rollover was not taken into account for the injury risk estimation respectively occupant kinematics and further contacts with interior parts. For this, it was assumed that the rollover was less critical in terms of dynamics (acceleration) and consequences for the occupant.

In general, as the material properties of THUMS V4 have been validated, the injuries predicted could be related to actual scenario. Nevertheless, further study needs to be carried out with the THUMS V4 model scaled to occupant dimensions.

CONCLUSIONS

This study shows an in-depth reconstruction analysis of an accident between Mercedes-Benz A-Class and E-Class vehicles.

The first part of the study demonstrated successfully the combination of the two tools PC-Crash and LS-Dyna to reconstruct an accident, the structural interaction of the vehicles and related occupant kinematics and restraint interaction.
The second part of the study established a methodology of reconstruction of an accident using Human Body Model and proved their capability to predict and assess injuries in real life scenarios (like other studies also did). Beside the rib fracture the predicted injuries risk and injured body parts matched quite well with the real case. Considering the injury patterns the driver sustained during the impact, it can be stated, that this accident represents a typical far-side scenario. Nevertheless, limitations because of the subsequent rollover are already discussed.

Additionally, the use of probabilistic and deterministic injury criteria was demonstrated successfully within the effective application of the DYNASAUR tool. It is important to make a note of the fact that such a post-processing element is listed as a relevant Key Building Block on the way to "Virtual Testing" and especially with the use of HBM (findings and final recommendations of IMVITER and SafeEV).

More analyses of this type have to be performed to consolidate the methodical approach and to verify the applicability of the demonstrated tool chain in terms of Best Practice for "Virtual Testing" and the implementation of HBM to such procedures.

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