



White paper

Simulation
enabling technologies

The Occupant Injury Criteria tool

Using the Occupant Injury Criteria tool, combined with the rest of the available functionality of the META post-processor, simulation engineers can easily, extract occupant injuries from ATDs and HBMs along with their Restraint Systems' results, compare simulations with physical tests, and generate reports according to a wide range of regulations and consumer ratings.



Introduction



Figure 1: Front Impact simulation

The increasing number of legal regulations and consumer ratings for occupant safety, combined with the effort of manufactures to test additional crash scenarios, raise drastically the number of required simulations. Consequently, the time spent for post-processing, which includes the evaluation of both time history results and 3d animations, also grows.

Meanwhile, the comparison of simulation results to these of the physical tests (time histories and videos) makes post-processing more complicated and laborious. Moreover, engineers frequently must employ different software, depending to the type of results they are required to process. This creates further issues in their effort to streamline simulation post-processing.



Figure 2: Simulation vs Test video. (Courtesy of VOLVO Safety Cente)

Addressing these issues, BETA CAE Systems brings forth the Occupant Injury Criteria (OIC) tool in META, to facilitate the post-processing of occupant safety and the comparison between simulation and physical test results.



The Occupant Injury Criteria tool

The OIC tool offers all the required functionality for the post-processing of occupant injuries simulations.

It extracts and reports the most important injury results of the processed Anthropomorphic Test Devices (ATDs) and/or Human Body Models (HBMs), automating same time this process with the use of META sessions.

Employing the tool, the analyst can read results from contemporary solvers and physical tests.

Full PowerPoint reports can be generated with evaluations according to legal regulations or consumer ratings.

Apart from reporting the results, further evaluations within META can be performed with the aid of special functions provided by the tool.

For an even more thorough evaluation of the vehicle's safety, results of the vehicle and its restraint systems can be extracted and evaluated next to the occupant injuries.

When it comes to CAE and physical test results comparison, the OIC tool provides special functions that make the comparison simpler. As the tool is a part of the META post-processor, all the standard functionality for video post-processing can be combined with the results extracted from the OIC tool.

With ATDs and HBMs also supported in the same tool, their results can be easily compared. Finally, the OIC tool can define and extract results as responses and histories in DOE studies helping analysts to identify which parameters affect the occupant injury results.

“At PSA the META Occupant Injury Criteria (OIC) Toolbar has been introduced as the main tool for post-processing of dummy injury criteria.

The toolbar's approach to use a GUI in combination with predefined spreadsheets and configuration files, addresses perfectly the complexity involved to cover a big range of dummy types, various test data types and load cases for legal, consumer, as well in-house requirements”

Marcus Henkel, Technical Lead Engineer CAE Methods, Biomechanical Calculations STELLANTIS



Results Import

The most commonly used FE solvers are supported while for physical tests, results can be extracted from ISO-MME file format files, DIA-DEM files, ASCII files and ABF files.

Almost all ATDs are supported. By selecting the Impact type of the processed test, the analyst can read results for:

Front Impact ATDs: H3-05, H3-50, H3-95, THOR-05, THOR-50, THOR-50AV

Side Impact: ATDs: WS-50, ES-2, SID-IIs

Rear Impact ATDs: BioRID-II

And for the child ATDs: Q3, Q6, Q10, H3-3YO, H3-6YO, H3-10YO, CRABI-6, CRABI-12.

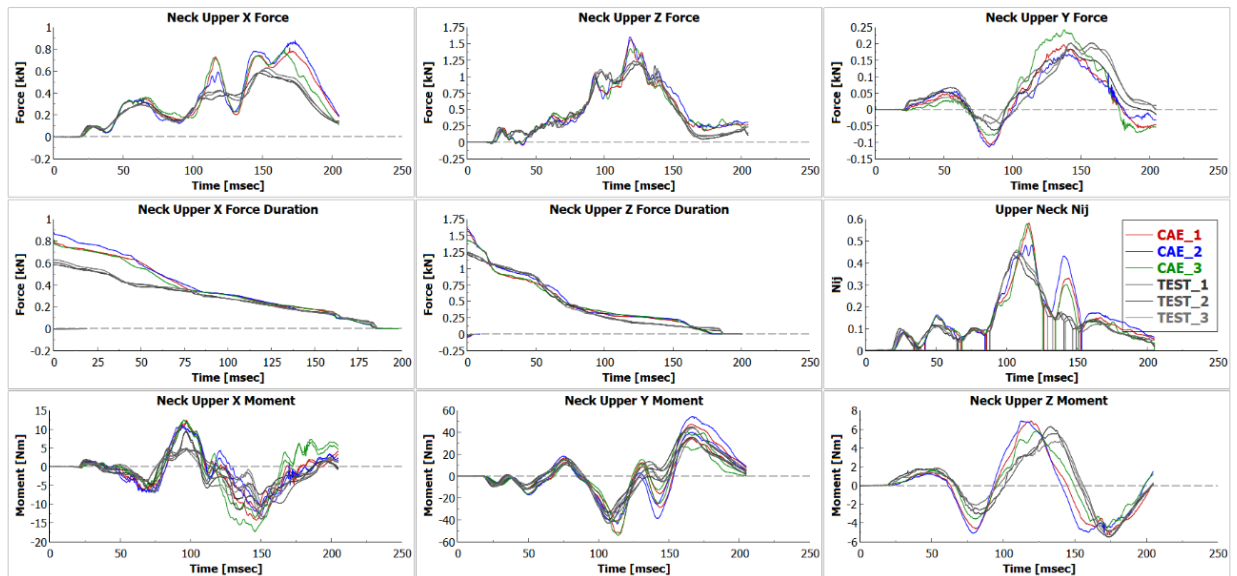


Figure 3: H3-50 Upper Neck results from 3 Simulations and 3 Tests



Calculations

The analysts have the option to extract and report the raw results, or filter the results according to SAE J211, according to legal/rating requirements, or even use their own selected filters for each channel. Raw and filtered results can be also overlaid.

All the needed Crash Injury Criteria, such as HIC, BrIC, Nij, NIC, 3ms clips, VC, and TI are calculated.

For THOR dummies, WS-50 and Q10 that use IR-TRACC devices (Infra-Red Telescoping Rod for the Assessment of Chest Compression) the OIC tool calculates automatically the Ribs compression using the output (2 angles and 1 displacement) of the IR-TRACC device.

For the WS-50 specifically, the OIC tool offers the option to the analyst to select how this calculation will be done according to different methods.

It also provides options for more calculations such as, the Chest Compression of the H3 ATDs linear or polynomial calculation, Viscous Criterion according to IIHS or ECE-R94, and more.

Vehicle's Structural results and Restraints systems

Along with occupant injuries, restraint systems' results can be extracted for a more comprehensive evaluation of each occupant's safety. This is further assisted with the support of user defined templates with which any kind of time history result can be added in the evaluation (simulation energies, vehicle's structural results, etc.).

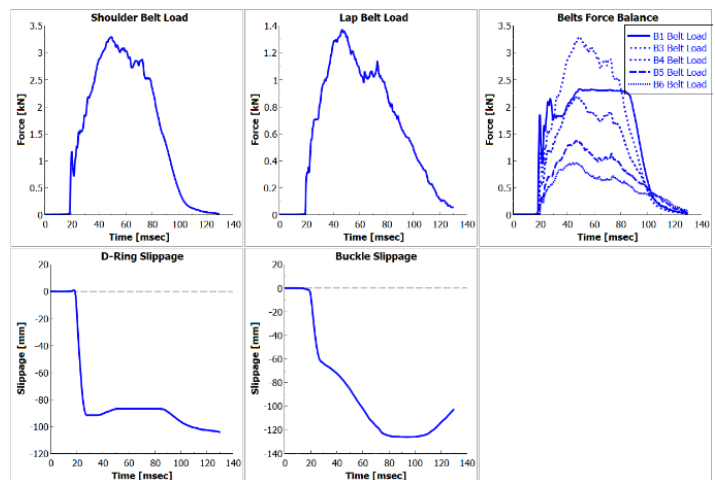


Figure 4: Seatbelt results



Legal Regulations and Consumer Ratings Reporting

OIC supports many loadcases of consumer ratings and legal regulations:

EU-NCAP, US-NCAP, C-NCAP, JNCAP, KNCAP, LATIN-NCAP, ASEAN-NCAP, IIHS, FMVSS 208, ECE R94, ECE R137, FMVSS 214, ECE R95, ECE R135, Japan Art.18 At-tachm.23

The analyst has the option to view the limits of these ratings and regulations on the time history plots and add them in the report.

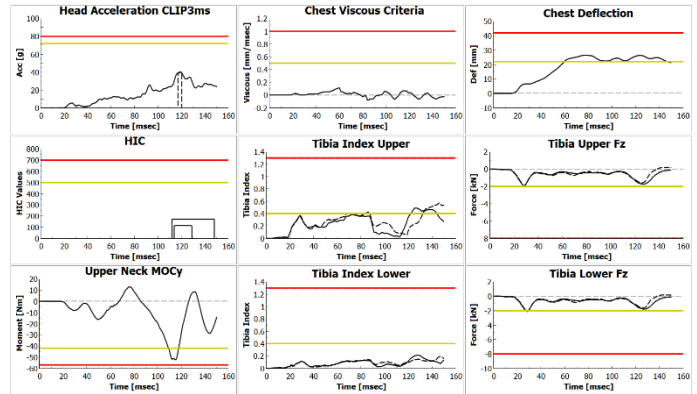


Figure 5: Euro NCAP limits for H3-50

“Leveraging META’s OIC tool has allowed my team to efficiently analyze injuries for numerous occupant types across consumer metrics. We’ve benefited greatly from the continuous improvement of the tool.”

Melissa Mack, *Safety CAE Integration Engineer*
General Motors

“The Occupant Injury Criteria tool facilitates a quick and convenient process for automating the plotting of useful ATD instrumentation data. This enables a more efficient and streamlined workflow, which allows for more time to effectively analyze our data.”

David Tes, *Safety CAE Integration Engineer*
General Motors



In the generated PowerPoint report, the Rating Points and Scores are calculated and presented.

EU-NCAP MPDB Rating of THOR-50 at position 1
Run: THOR-50_v1.6

Body Region	Points	NCAP Region	Points
Head	4	Head-Neck	4
Neck	4	Chest	1.18
Chest	1.18	Femur	4
Femur Right	4	Tibia	2.53
Femur Left	4	Total Points	11.71
Tibia Right	2.53	Final Points	5.855
Tibia Left	3.87		



EU-NCAP MPDB Rating of Q10 at position 6
Run: Q10_EUNCAP_v2020

NCAP Region	Points
Head	4
Neck	1.77
Chest	2
Total	7.77



US-NCAP Rating of H3-50 at position 3
Run: H3-50_passenger

Measurement	Value	Unit	Probability
Head	HIC15	167.0	-
Neck	Fz+	-0.297	kN
Neck	Fz+	0.094	kN
Neck	Nij	0.17	-
Chest	Deflection	2737	mm
Femur	Fz	-0.003	kN
Total			0.102
RR			1.08
Star Rating	stars		3



Figure 6: Driver (THOR-50) Euro NCAP rating in PPTX report

Figure 7: Child passenger (Q10) Euro NCAP rating in PPTX report

Figure 8: Passenger (H3-50) US NCAP rating in PPTX report

The analyst can add stricter limits for the legal regulation reports and apart from the pre-defined legal and consumer rating loadcases, also create reports with custom limits.

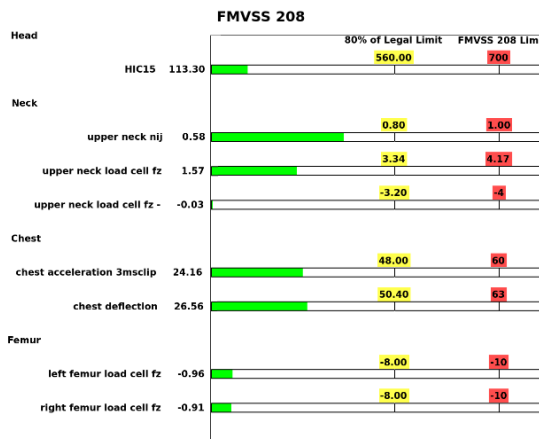


Figure 9: FMVSS 208 report with legal and stricter limits.

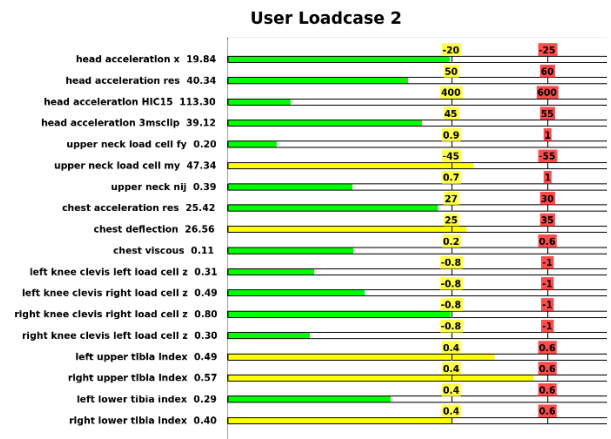


Figure 10: User defined loadcase with user limits.

Results Output and Automation

The extracted and calculated results can be exported in ASCII format (max injury values or complete time histories), in ISO-MME format, or as complete PPTX/PDF reports.

The generated reports can be easily customized with the help of simple META session files or Python scripts.

Results needed for Rating calculations can be exported separately in ASCII format while for Euro NCAP the results needed for the rating calculation can be added in the Euro NCAP's official spreadsheet.



The extraction of the results, the reporting and the output can be driven from a META session file and thus, the whole process can run automatically in batch mode.

Interactive Evaluation of Results

Apart from extracting results and automatically generating reports, functionality for efficient interactive evaluation of the results is provided. When many simulations or tests are processed, the analyst can easily isolate the results of specific runs. Max/min values of time histories can be identified on demand from within the tool.

For a better evaluation of the CAE results the time histories can be evaluated side by side with the 3d results. The time histories are related to the corresponding 3d entities. This way, the 3d entities (nodes, elements, etc.) of the selected time history results can be identified.

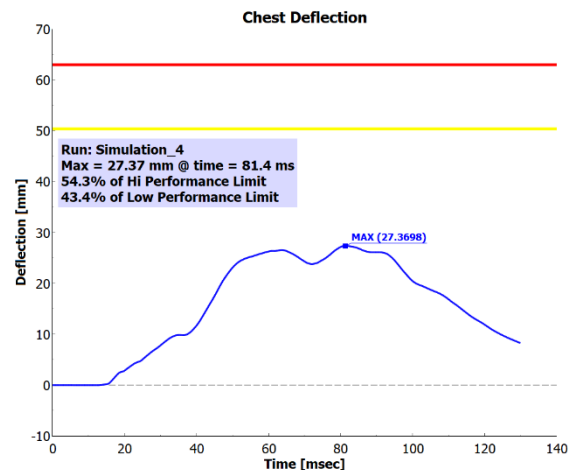


Figure 11: Automatic identification of Max/Min results

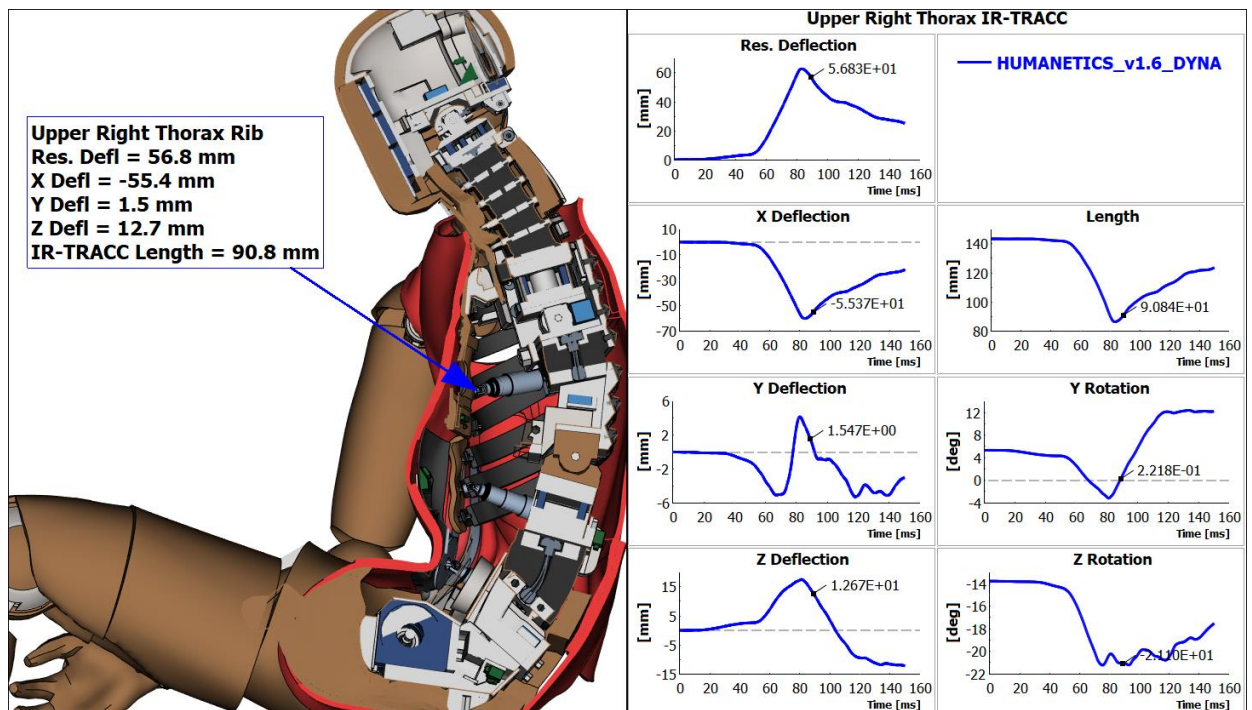


Figure 12: Animations and time history results parallel display. Identification of 3d entity related to the time history result



“The Occupant Injury Criteria tool enables the seamless ATD and HBM signal extraction, test-result correlation, and rating calculation, all in a single tool. This accelerates drastically our post-processing stage”.

*Stefan Schilling, Teamleader System & System Simulation
Autoliv, Germany*

Simulations vs Physical Tests

Since the OIC tool resides within META, all standard functionalities including annotations, cut planes, and video post-processing can be utilized. This way, apart from viewing CAE time history curves next to 3d animations, videos of tests can be loaded and presented next to the time history results from the test. Videos can be also correlated with the corresponding simulation animations and correlation analysis can be performed on the time history results.

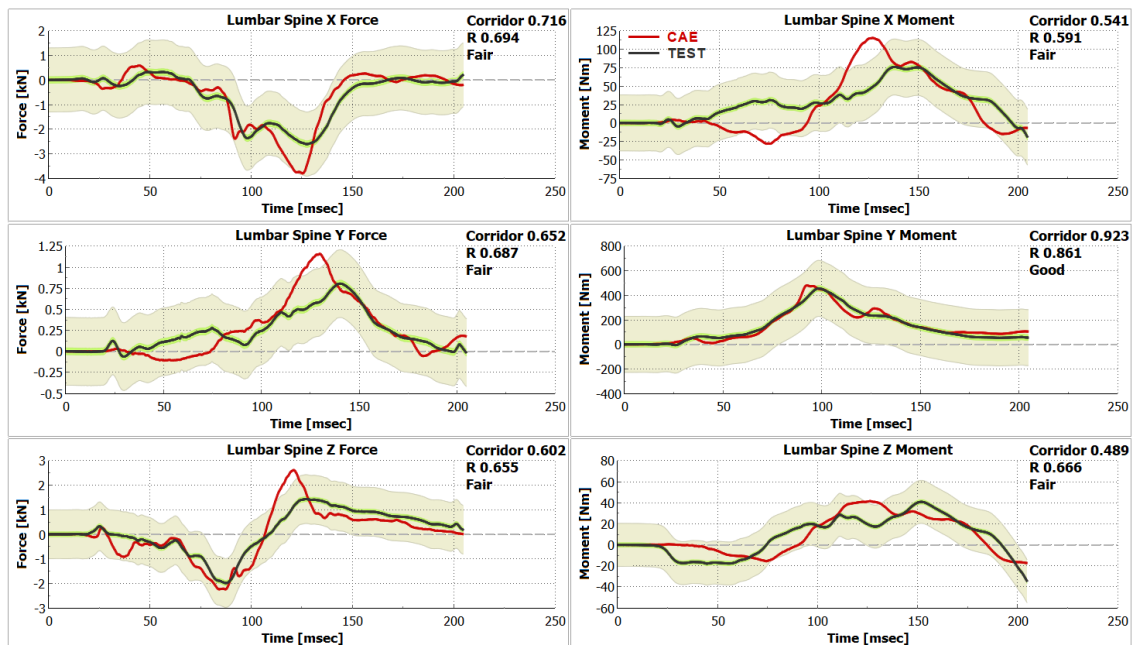


Figure 13: Correlation Analysis between Simulation and Test results



The tool itself provides some extra features for the comparison between simulation and physical test results. It is possible to automatically transform both results to the same unit system. Curves from Tests can be trimmed to be evaluated in the time range of the crash (same time range as the simulation).

Human Body Models

During the latest years, the use of Human Body Models (HBMs) in safety tests has been increased, especially for autonomous vehicles. Although more results can be extracted from a HBM than from an ATD, it is common to compare and match the results between them.

The Occupant Injury Criteria tool can extract time history results from GHBM models matching ATD results. This way, apart from comparing HBMs to ATDs, different simulation runs of HBMs, even from different solvers, can be compared.

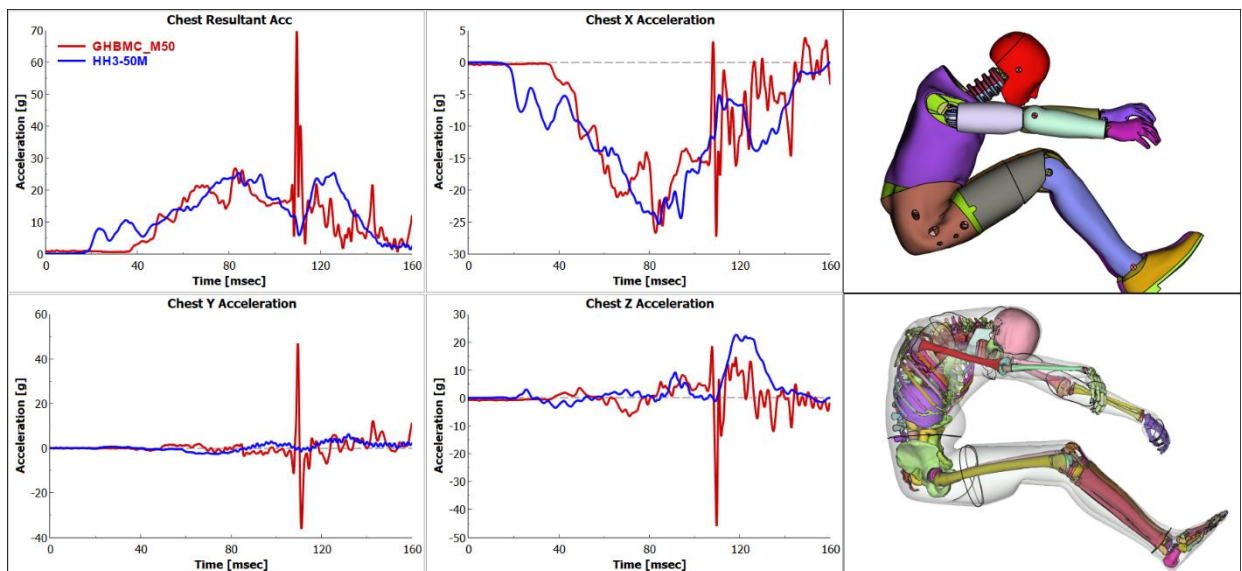


Figure 14: Overlaying ATD with Human Body Model results



DOEs and Optimization

Design Of Experiment studies (DOEs) are the state of the art in identifying all the different parameters affecting the occupant's injury results and they are increasingly used.

The Occupant Injury Criteria tool offers the capability to define and extract occupant injury results as responses and histories in DOE studies and optimizations. It extracts the responses in a format that is supported from optimizers such as, LS-OPT and modeFRONTIER. Upon running a base simulation, the analyst can select from a list that contains all the extracted results which ones will be used as responses and histories. Same time, a session file is automatically created to be used by the optimizers to call META to extract the same responses again after each experiment's solution, or in the optimization loop.

“The Occupant Injury Criteria tool has made it so much easier and faster to process simulation data. The time saved on preparing the data is now spent on analyzing it and therefore we can make better decisions for our clients”.

*Irmantas Burba, CAE Project Engineer
Applus IDIADA*

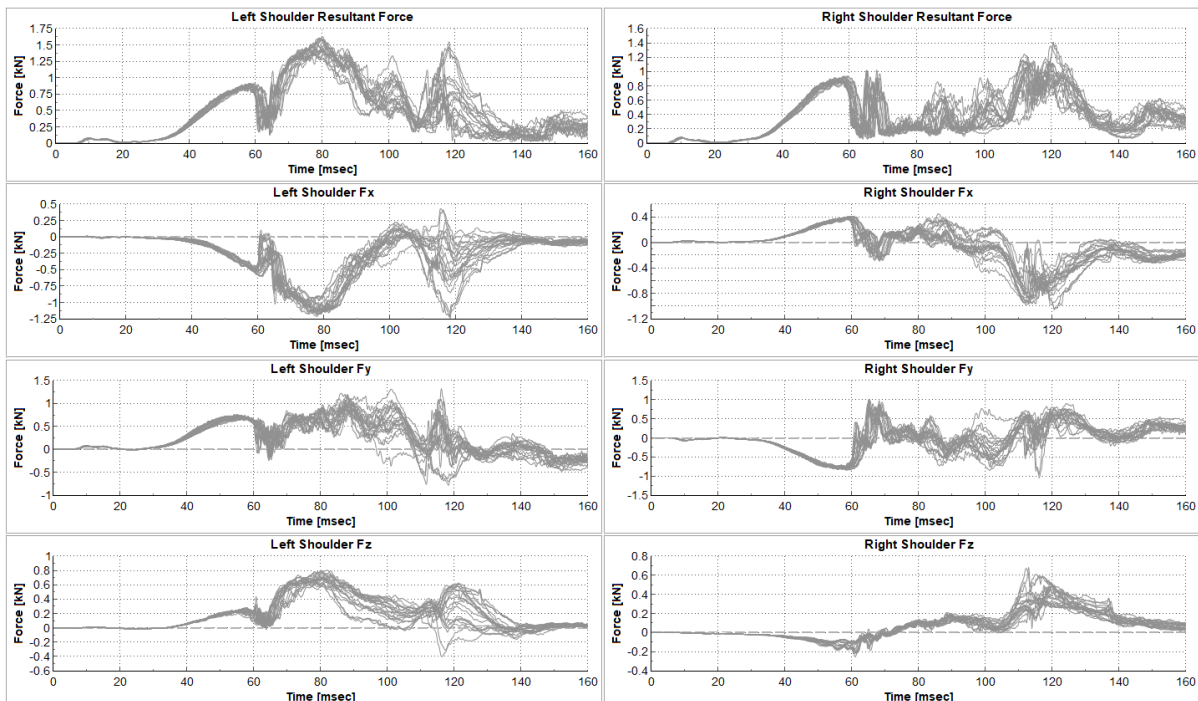


Image 14: History results of DOE



Conclusion

Using the Occupant Injury Criteria tool combined with the rest of the available functionality of the META post-processor, engineers can easily, extract occupant injuries from ATDs and HBMs along with their Restraint Systems' results, compare simulations with physical tests, and generate reports according to a wide range of legal regulations and consumer ratings.

The use of the same tool for the analysis of Simulation and Test results, time histories – animations – videos, apart from being cost effective, is less complex and makes the work of simulation engineers easier and faster.

The Occupant Injury Criteria tool is constantly updated in order to support new ATDs and new versions of existing ATDs, to support any updates in consumer ratings and legal regulations and to offer new functionality for even more efficient post-processing and interactive evaluation of the results.

We simulate frontal loadcases (ECE and EUNCAP) and by using the tool we get a decent overview of the dummy values avoiding manual work or extra evaluation set up. The tool is easy to handle and when we have questions the BETA support, always respond within a day.

*Andreas Erb, CAE Engineer
EDAG Engineering GmbH*

About BETA CAE Systems International AG

BETA is a simulation solutions provider, dedicated to the development of state-of-the-art software systems for CAE. For almost 30 years, we have been developing tools and delivering services for the front-runners in numerous sectors by listening to their needs and taking up even the most demanding challenges. For more information on BETA CAE systems, our products, and our services, visit www.beta-cae.com

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