

Occupant Injury Criteria, a Complete Solution for the Evaluation of Occupant and Structural, Simulation and Physical Test Results in META

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Abstract

For any type of simulation and after each solver run, the vast majority of the post processing actions for the evaluation of results and report generation are always the same. Particularly for Occupant Safety tests the increasing number of regulations, the use of different dummy types per regulation-test as well as the different vehicle variants that may exist and have to be tested, significantly increase the number of simulations and corresponding post-processing actions. Apart from this repetition, proven to be time consuming, cumbersome and prone to errors, another laborious issue is the comparison of the simulation with the physical test results.

Volvo Car Corporation (VCC) found the answer to the above problems in META, the Post Processor of BETA CAE Systems International. Using the Occupant Injury Criteria tool and the rest of the available functionality in META, VCC CAE engineers are able to automatically post process LS-DYNA® results and create reports for the occupant injury and structural results of the vehicle while, at the same time, easily compare simulations with physical tests.

The use of the same tool for analysis of curves and animations, automatic report creation and comparison between simulations and physical tests (both time history results comparison and animation with video correlation) makes the job of the engineer easier and allows more time for productive work. VCC test engineers use the same tool to process the physical test results so the collaboration between them and the CAE test engineers becomes easier.

This paper presents the capabilities of the Occupant Injury Criteria tool of META and how VCC engineers use it to save time in order to focus on the creation of better and safer cars.

Introduction

Comparison of simulation with physical test results can be laborious and time consuming. Particularly for vehicle Crash Tests, for which engineers have to evaluate occupant injury results along with structural results of the vehicle, using time history results and 3d animations of simulations overlaid with videos of the physical test, this job becomes quite complicated too. One more thing that contributes to this complication is that usually engineers have to use different software depending the type of results they have to process. On top of all the above, the fact that the vast majority of the post processing actions for the evaluation of results and the report generation are always the same, makes a part of this job even unpleasant.

BETA CAE Systems International developed a tool, the Occupant Injury Criteria in META, its Post Processor, to make the post processing of Occupant Safety and the comparison between simulation and physical test results easier.

Occupant Injury Criteria tool

The Occupant Injury Criteria tool streamlines the extraction of occupant injury results. Results from many simulations and physical tests can be processed simultaneously or separately. For each processed simulation – test, results for up to 4 occupants can be created. The results of the same occupant that come from different simulations - tests are overlaid in order to be compared. The tool provides an efficient and easy manipulation of the created results for better inspection and comparison of them.

Supported File Formats and Dummies

The tool can extract results from LS-DYNA and other solvers. Results that come from physical tests can be read from ISO data files or DIADEM files.

The Crash Test Dummies that can be processed are:

Front Impact:	Side Impact:	Rear Impact:	Child Dummies:
- H3-05	- ES-2	- BioRID-II	- Q6
- H3-50	- SID-IIs		- Q10
- H3-95	- WS-50		
- THOR-50			

The user has to select an Impact type in the interface of the tool. According to the selected Impact type a list with Regulations – Tests is populated from which the user can select one. The list with the available dummies is created according to the selected Impact type and Regulation – Test.

Results

When running in GUI mode the tool searches the given results directory and lists all the found results. The user can select from these lists all the different simulation and physical test runs for which results will be created.

For each selected simulation or test, results for up to 4 dummies can be created. One collection of windows (Page) is created for each processed dummy with results calculated by the Solver or results coming from the Physical test and Crash Analysis Criteria calculated by META.

The first window of the Page is a Summary window which includes the most important occupant injury results according to the dummy type. The peaks of these results are also presented as a bar chart.

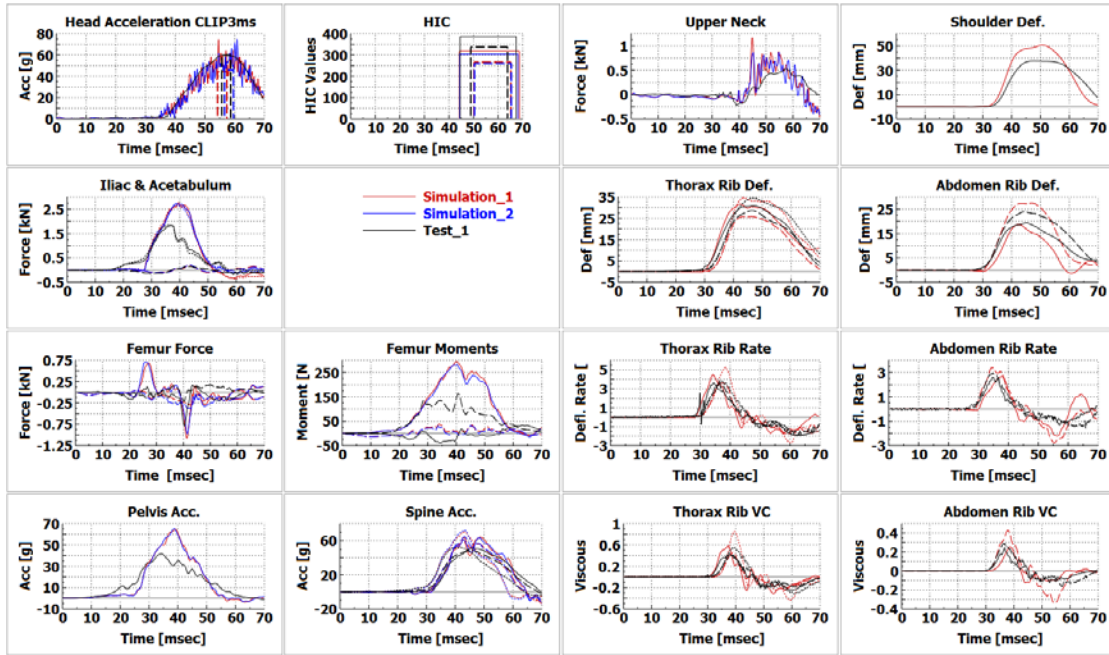


Fig. 1: Summary of Results of comparison of two simulations and one physical test of a SID-II's dummy

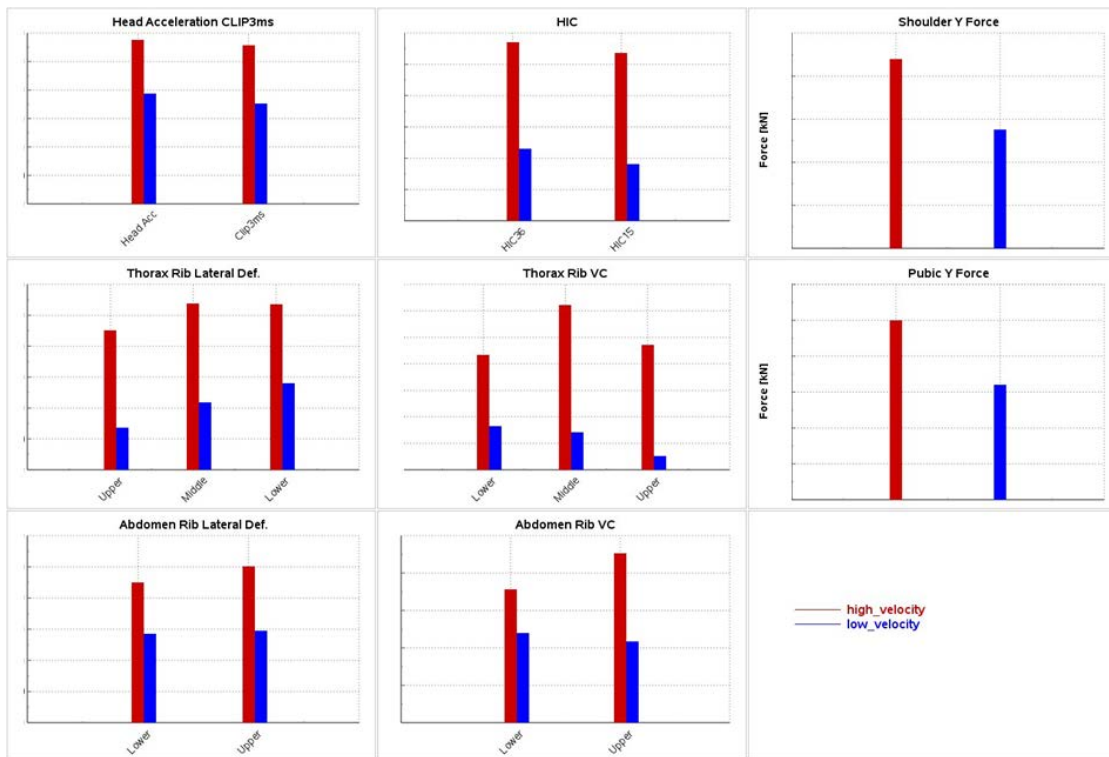


Fig. 2: Comparison of two simulations of a WorldSID (50th Male) dummy as bar-chart of peak values, courtesy of Volvo Car Corporation

Apart from the window with the Summary of results, one window for each component / sub-assembly of the dummy is also created in order to view these results in more details.

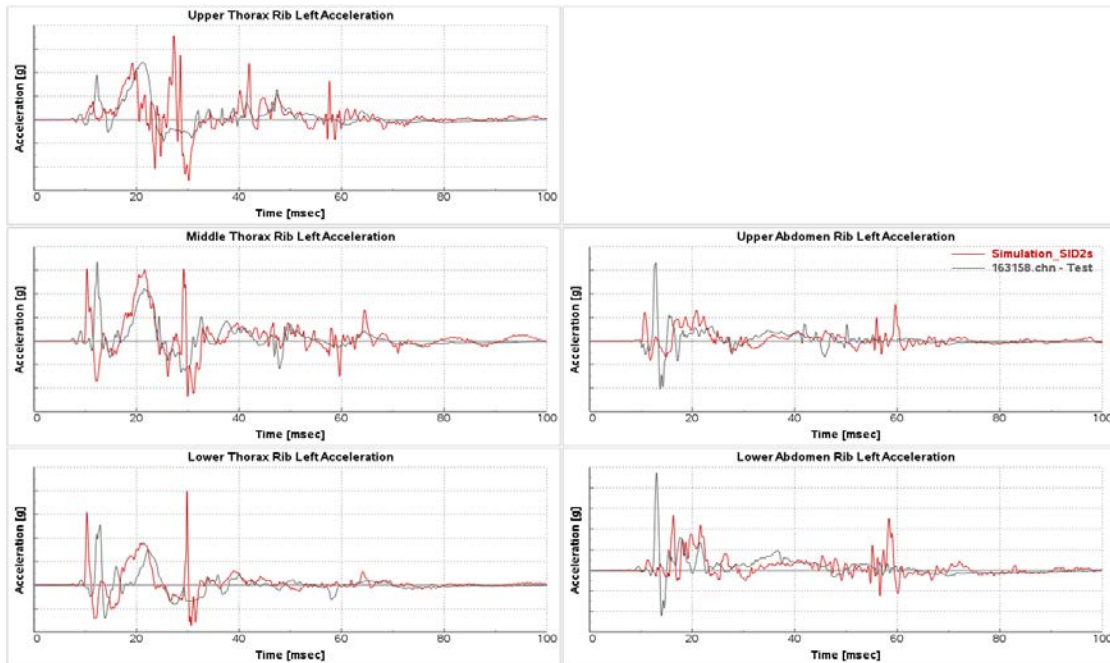


Fig. 3: Rib Acceleration results comparison of one simulation and one physical test of a SID-IIs dummy, courtesy of Volvo Car Corporation

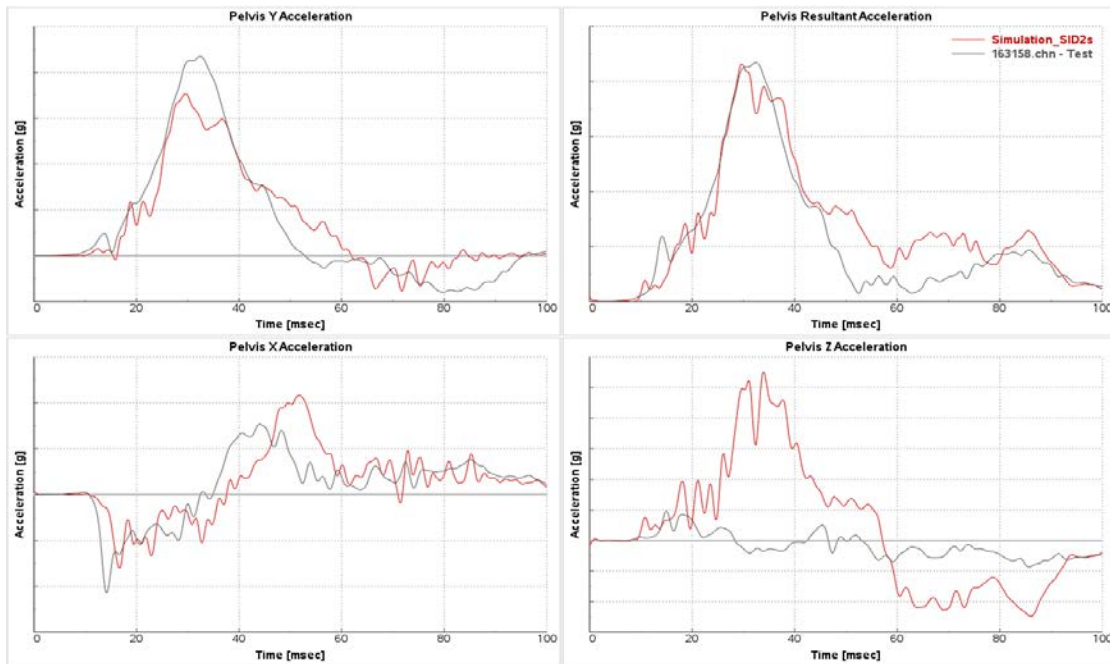


Fig. 4: Pelvis Acceleration results comparison of one simulation and one physical test of a SID-IIs dummy, courtesy of Volvo Car Corporation

If a Regulation – Test has been selected then one more window is created. In this window all the results that are required from the selected Regulation – Test for the calculation of vehicle’s rating are presented as a bar chart.

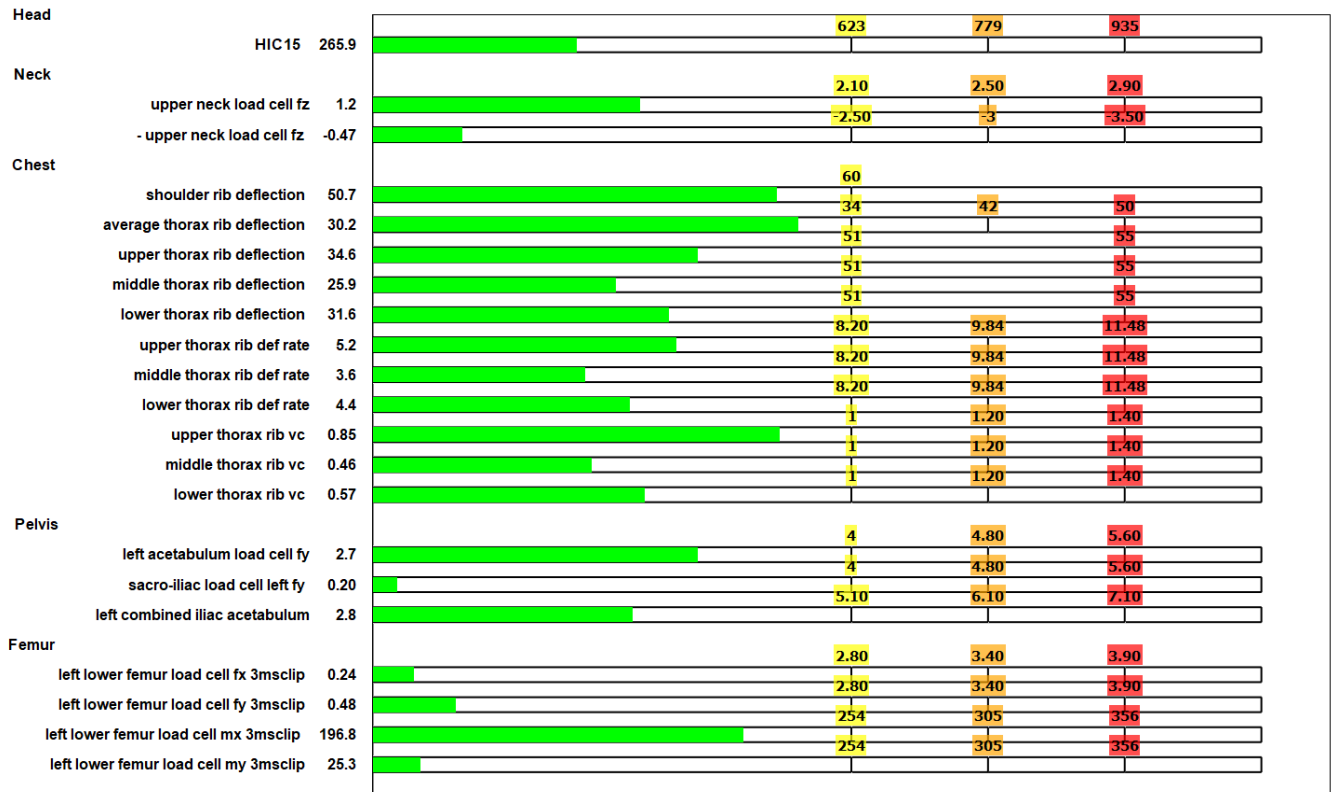


Fig. 5: SID-II's dummy results according to IHHS

Curves can be created to show the limits of the selected Regulation – Test. “User Limits” stricter than the Regulation – Test can be also defined.

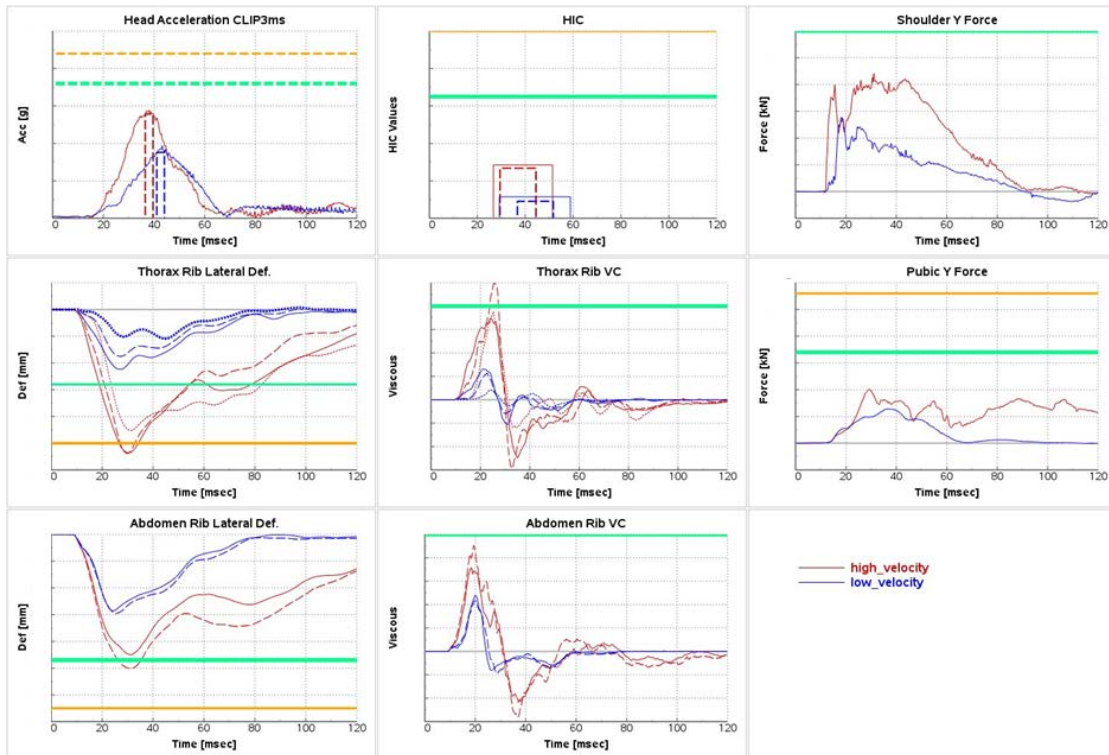


Fig. 6: Summary of Results of comparison of two simulations of a WorldSID (50th Male) dummy with EU-NCAP and User Limit curves, courtesy of Volvo Car Corporation

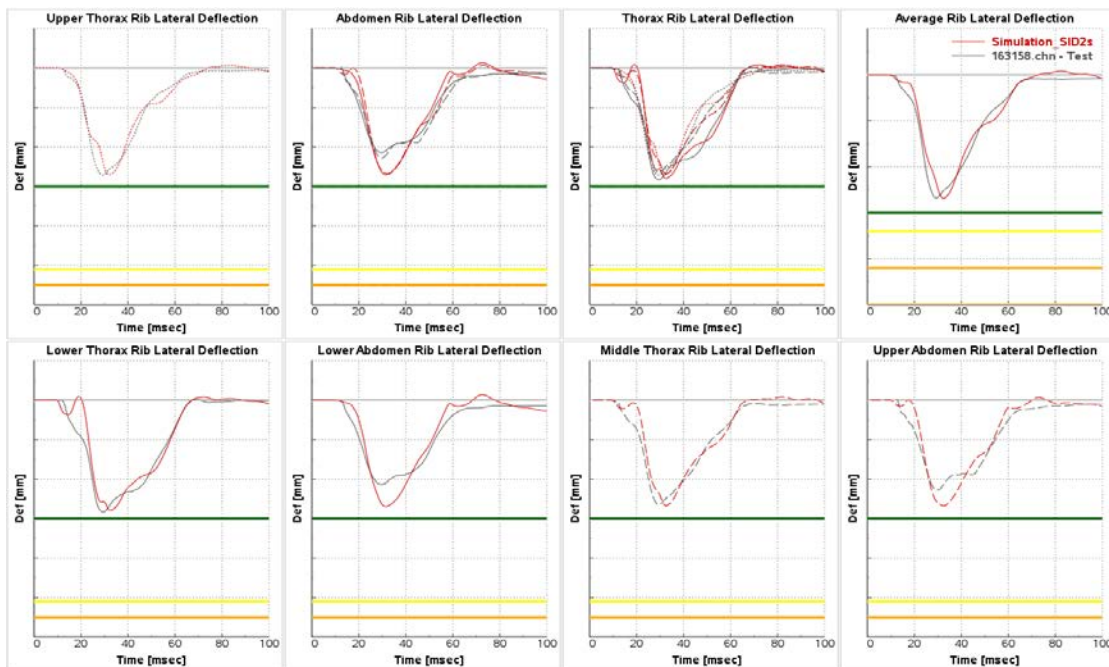


Fig. 7: Comparison of Rib Deflection results of one simulation and one physical test of a SID-IIs dummy with IHS and User Limit curves, courtesy of Volvo Car Corporation

The tool by default extracts some standard results, the most important results, which are required for the evaluation of each dummy type. There is also the possibility to extract additional results either for each dummy or results of the vehicle in order to perform a complete analysis. The user through the tool can create templates that can be used for the creation of the extra results and these templates support both simulation and physical test results. If additional results are added for a specific dummy then extra windows will be created in the Page of that dummy. If a template with “Non-dummy” related user defined results is provided to the tool then a new page will be created.

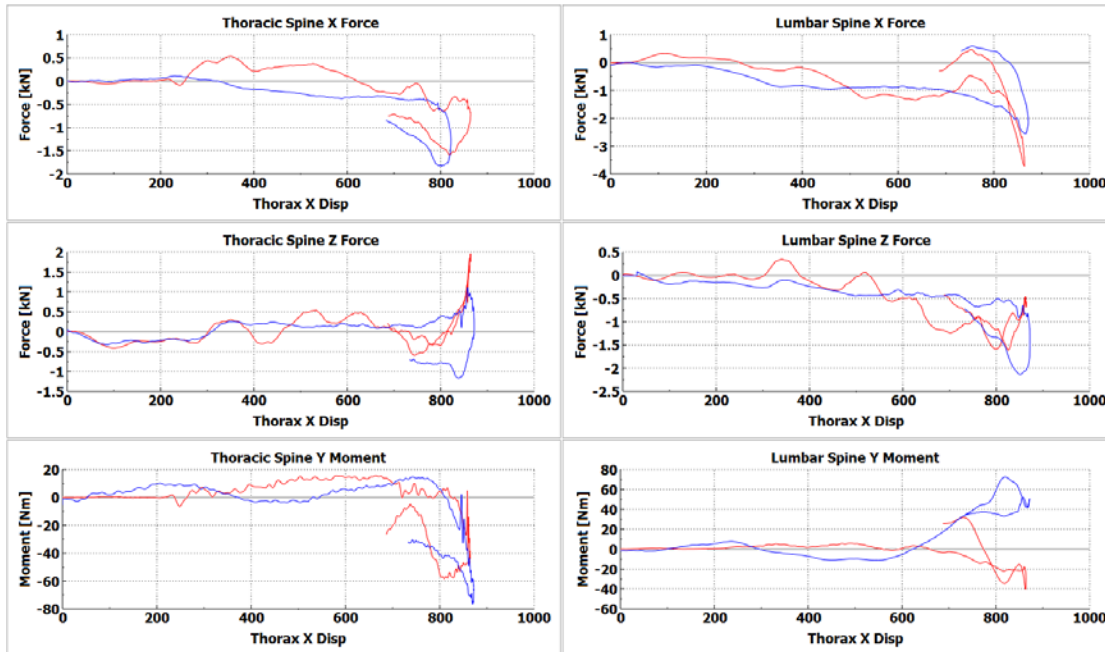


Fig. 8: Comparison of Spine Force over Displacement results of two simulations

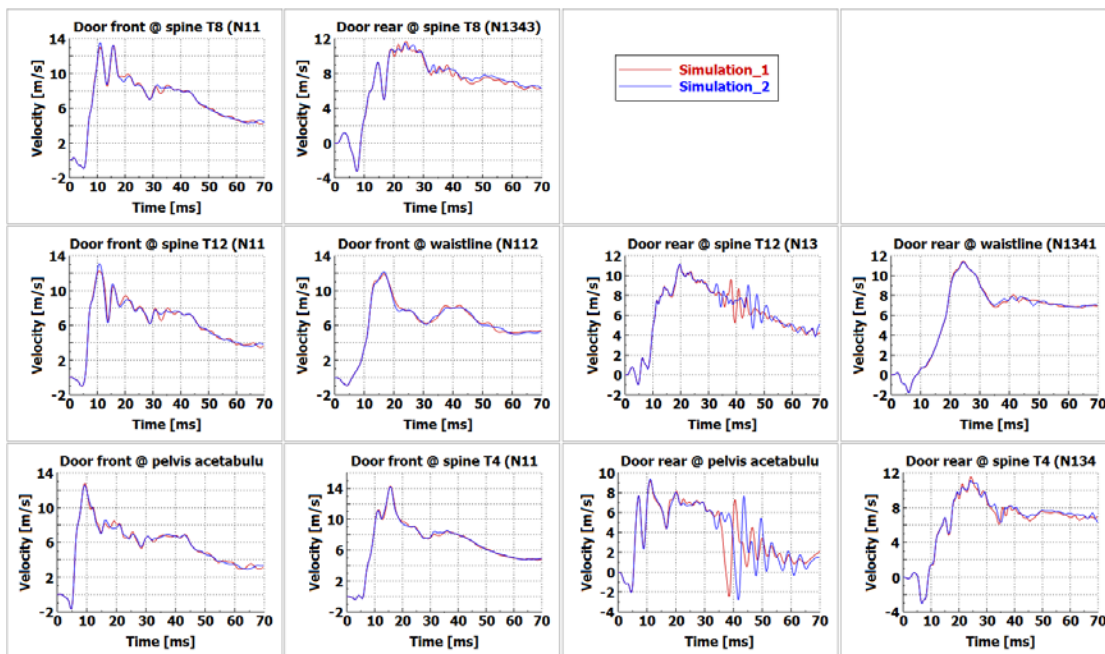


Fig. 9: Comparison of structural user defined results

It is also possible to customize the standard results. Results of different components / sub-assemblies of the dummy that are created in different windows can be added in new windows totally customizable (window layout, titles, etc.) by the user.

Handling of results

The tool provides efficient and easy manipulation of the created results. Results of specific simulation or test runs can be isolated for better inspection when many runs are processed simultaneously. The curves of specific runs can be also edited after their creation (coloring, styles, trimming of time, etc.)

Identification of results

The user can select a plot of results and the tool will automatically focus on those results and identify the Max and Min values of each simulation and physical test.

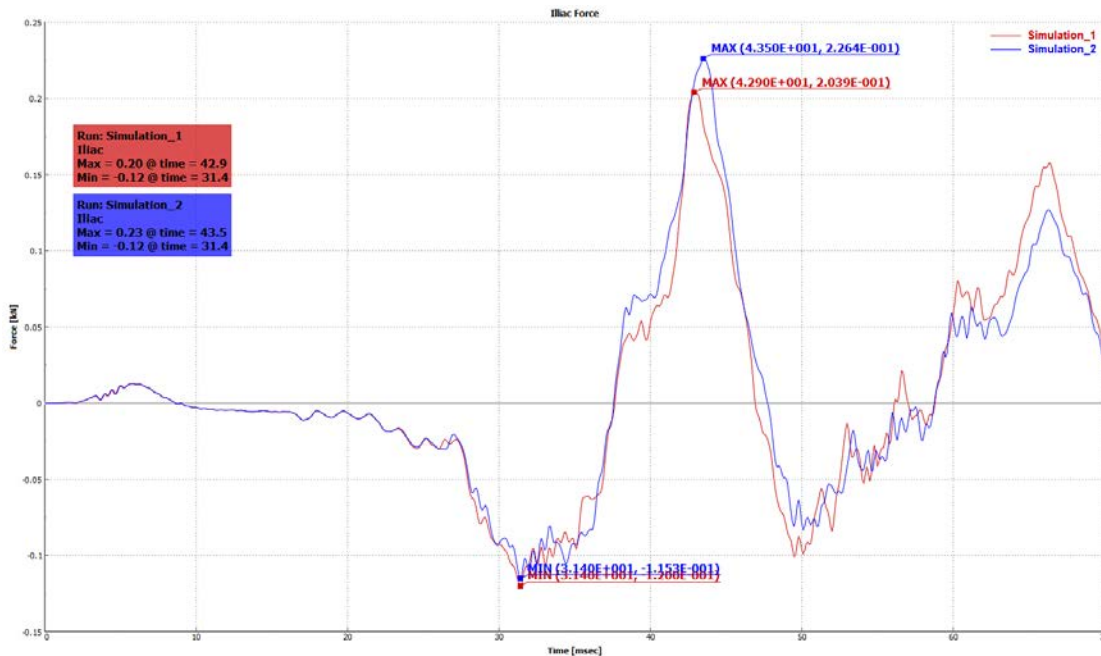


Fig. 10: Identification of Max/Min results

Reporting

A PowerPoint report can be created for each processed Dummy. This report, apart from images of all the results, will contain also tables with the Max values of each result and in case a Regulation – Test has been selected, the rating value (without taking into account modifiers) will be calculated and added in the report.

Results Overview: IIHS, SID-IIIs, 1: Simulation_1

Measuring Point	Max/Min	Units	Value
HIC36	Max	-	318
HIC15	Max	-	266
Head Acceleration Res.	Max	g	74.7
Head Acceleration Res. Clip3ms	Max	g	44.4
Head Acceleration X	Abs(Min)	g	31.0
Head Acceleration Y	Max	g	69.9
Head Acceleration Z	Max	g	30.9
BrIC		-	
Head Rot. Vel. X		deg/msec	
Head Rot. Vel. Y		deg/msec	
Head Rot. Vel. Z		deg/msec	
Upper Neck Fx	Abs(Min)	kN	0.338
Upper Neck Fy	Max	kN	0.237
Upper Neck Fz	Max	kN	1.17
Upper Neck Fz -	Abs(Min)	kN	-0.468
Upper Neck Mx	Abs(Min)	Nm	24.3
Upper Neck My	Abs(Min)	Nm	24.0
Upper Neck Mz	Max	Nm	13.9
Shoulder Fx	Max	kN	0.658
Shoulder Fy	Abs(Min)	kN	2.25

Measuring Point	Max/Min	Units	Value
Shoulder Fz	Max	kN	0.526
Shoulder Y Defl.	Max	mm	50.7
Shoulder Y Accel.	Max	g	2.18
Thorax T1 Y Acc.	Max	g	64.2
Thorax T4 Y Acc.	Max	g	63.8
Abdomen T12 X Acc.	Abs(Min)	g	17.6
Abdomen T12 Y Acc.	Max	g	70.3
Abdomen T12 Z Acc.	Max	g	21.9
Abdomen T12 Res. Acc.	Max	g	71.2
Thorax Upper Rib Left Acc.	Max	g	199
Thorax Middle Rib Left Acc.	Max	g	177
Thorax Lower Rib Left Acc.	Max	g	146
Abdomen Upper Rib Left Acc.	Max	g	150
Abdomen Lower Rib Left Acc.	Max	g	126
Upper Thorax Rib Def.	Max	mm	34.6
Middle Thorax Rib Def.	Max	mm	25.9
Lower Thorax Rib Def.	Max	mm	31.6
Average Thorax Rib Def.	Max	mm	30.2
Upper Thorax Rib Def. Rate	Max	mm/msec	5.20
Middle Thorax Rib Def. Rate	Max	mm/msec	3.64

Fig. 11: Example of Max results in Report

Apart from the PowerPoint report results the tool can output images in specified by the user directories and save the maximum and minimum values of all created results in text files.

Collaboration of Occupant Injury Criteria with standard META functionality

Occupant Injury Criteria is a tool that runs in META and can be used by engineers in combination with the standard functionality of META.

Animations & Graphs (3d & 2d) Interoperability

Prior, during or after the creation of the time history results from the tool, the 3d results of the simulations can be loaded and processed.

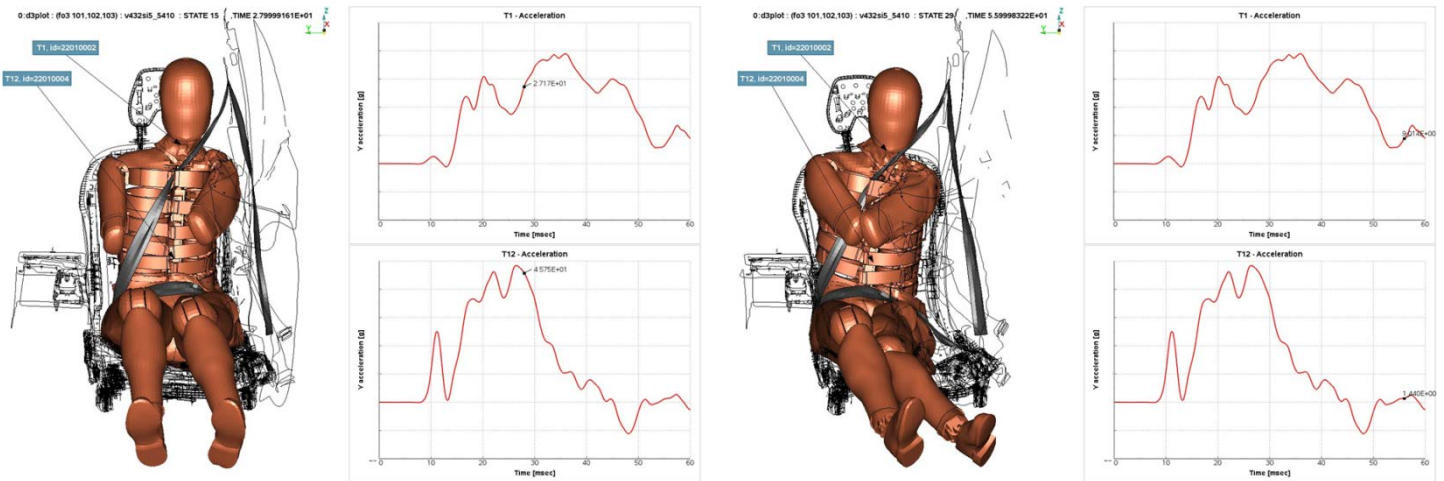


Fig. 12 & 13: Example of a 3d model animation along with time history results from Occupant Injury tool, courtesy of Volvo Car Corporation

Video overlay with Animations & Graphs

META apart from being a powerful software for post processing finite element simulation results also facilitates importing videos. META provides all the necessary tools for visualization, comparison and processing test videos and simulation models.

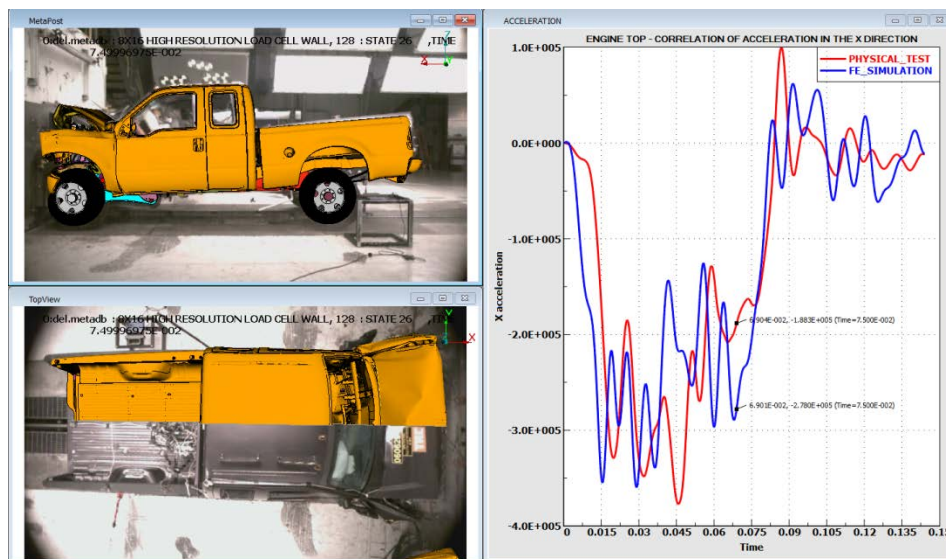


Fig. 14: Example of a simulation model and test video animation along with time history results from the Occupant Injury tool

Saving results in compressed META native format for future post processing

The Occupant Injury Criteria tool can run in no-GUI mode through a session file. This way it can be executed automatically after LS-DYNA is finished in order to create all the desired results, a PowerPoint report, save Max and Min results in text files and as images, load and process 3d animation results and finally save all these in a META native format database.

The compression capabilities of META, specially designed for simulation results, far exceed the conventional compression solutions reducing storage requirements and more importantly bringing database downloading times to affordable levels. META offers full control of the data accuracy stored and advanced parameterization per model/component/part and per result.

These databases can be used either for visualization of the current simulation results or can be overlaid and compared, through the Project Overlay functionality of META, with other similar databases that can contain simulation or physical test results.

Optimization of Occupant Injury results

The direct coupling of ANSA and META with LS-OPT[®] and LS-DYNA give the engineers the capability to use occupant injury results created from the Occupant Injury Criteria tool as responses in their optimization jobs.

This can be achieved through the cooperation of the OptimizerSetup, a special tool of META for the extraction of responses and the coupling with LS-OPT, with the Occupant Injury Criteria.

Conclusions

Using the Occupant Injury Criteria tool and the rest of the available functionality in META, Volvo Car Corporation (VCC) CAE engineers are able to automatically post process results and create reports for the occupant injury and structural results of the vehicle while, at the same time, easily compare simulations with physical tests. The use of this tool has significantly reduced the time they need for the aforementioned tasks completion.

The use of the same tool for analysis of curves and animations, automatic report creation and comparison between simulations and physical tests (both time history results comparison and animation with video correlation) makes the job of the engineer easier and allows more time for productive work. VCC test engineers use the same tool to process the physical test results so the collaboration between them and the CAE test engineers becomes easier.

References

- [1] META Post Processor version 18.1.x. User's Guide, BETA CAE Systems International, December 2017
- [2] Kleidarias S., Pavlidis V.: "A Unified Environment For Processing Test Videos And Simulation Models", 11th European LS-DYNA Conference 2017
- [3] Korbetis G., Siskos D.: Multi-Disciplinary Design Optimization exploiting the efficiency of ANSA-LSOPT-META coupling", 7th European LS-DYNA Conference 2009