

Automated Extraction of Occupant Injury Results

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1 Introduction

There are an increasing number of standardized tests, for which a vehicle should comply with and all these tests, usually, require the generation of a standardized report.

For the generation of reports for simulated tests, after each solver run, the followed post-processing actions are always the same. In addition, for Occupant Safety tests the use of different dummies per test, adds more similar post-processing actions.

This repetition is proven cumbersome, time-consuming and prone to errors. Therefore, the automation of the execution of those actions and the subsequent report generation is required.

Apart from automating the repeated post-processing actions another problem is to compare the results of the simulated tests with the physical tests results.

This paper presents a software tool developed in μ ETA (mETA), the Post-Processor of BETA CAE Systems S.A., that automatically processes and creates reports for Occupant Protection in Interior Impact.

2 μ ETA Tools for Automation

The automation requirements are facilitated by three different tools in μ ETA:

- the user toolbars
- the session files
- the scripts

Each of these can be used alone as well as in combination with the others so as to deliver the maximum level of automation in each case. Added to this, the effortless creation of automated procedures is greatly assisted through respective editors for each of these tools.

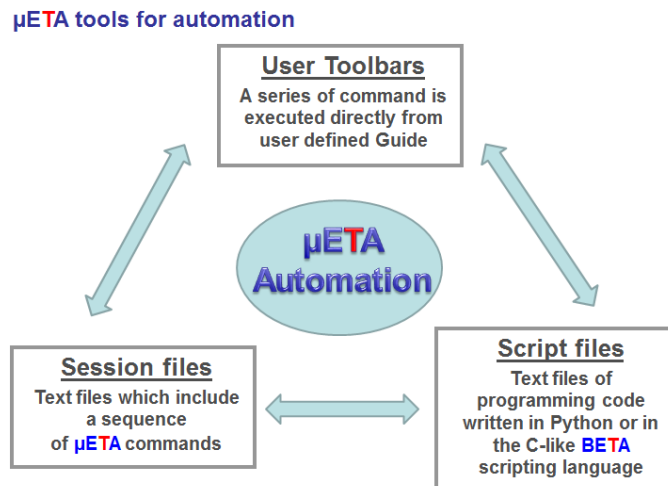


Fig. 1: Tools for Automation in μ ETA

What can be achieved with these tools:

- Combination of 3d and 2d tasks
- Custom GUI: User Toolbars, GUI Library functions for scripting
- Direct access to all analysis' results through respective commands
- Fully automated reporting (html, pptx, pdf, ps)
- Automated processes can be executed before, after or between manual processes
- Created processes can be shared among different levels (company, group or user level)

Based on these automation capabilities BETA CAE systems has developed a suite of standard tools to automate the post processing and the creation of reports for Pedestrian Safety analysis, Occupant Protection in Interior Impact (FMVSS 201U), IIHS structural ratings, Bus Rollover (ECE R66) and recently Occupant Injury results. These are included within the standard installation of mETA.

These tools streamline the extraction of the results for the respective tests. They lead directly to reports and create overview models for supervisory evaluation in cases of a large number of simulation runs.

3 Occupant Injury Criteria tool

The last addition in this suite of tools is the Occupant Injury Criteria tool which automates the extraction of occupant injury results.

Different dummy types can be processed simultaneously from many simulations and physical tests and the results 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.

Apart from extracting the standard required results for each dummy the analyst can easily add more results for each dummy or more results of the vehicle in order to perform a full analysis.

3.1 Supported file formats and dummies

The tool can extract results from LS-DYNA and other solvers. For physical test results ISO data files are supported. The dummies which can be processed are:

Front / Rear Impact:	Side Impact:
- H3-05	- ES-2
- H3-50	- SID-IIIs
- H3-95	- WS-50
- Q6	- Q6
- Q10	

3.2 Interface

The tool is mainly divided in three tabs. In the first tab, the Read Results tab, all the input that is needed from the tool in order to create the results must be added. For example if the tool will run Simulation or Physical Test results or both, file formats and unit systems for Simulation and Physical Test, Impact Type, Regulation, how many dummies exist in the car during the test and then for each dummy it's type, version, if limit curves will be created, etc.

In the second tab, the Settings tab, there are options for the output unit system, trimming of curves time, curves coloring, etc. From the third tab, the Results handling tab, it is possible to apply focus commands on curves on processed variant level, edit the curves after they are created etc.

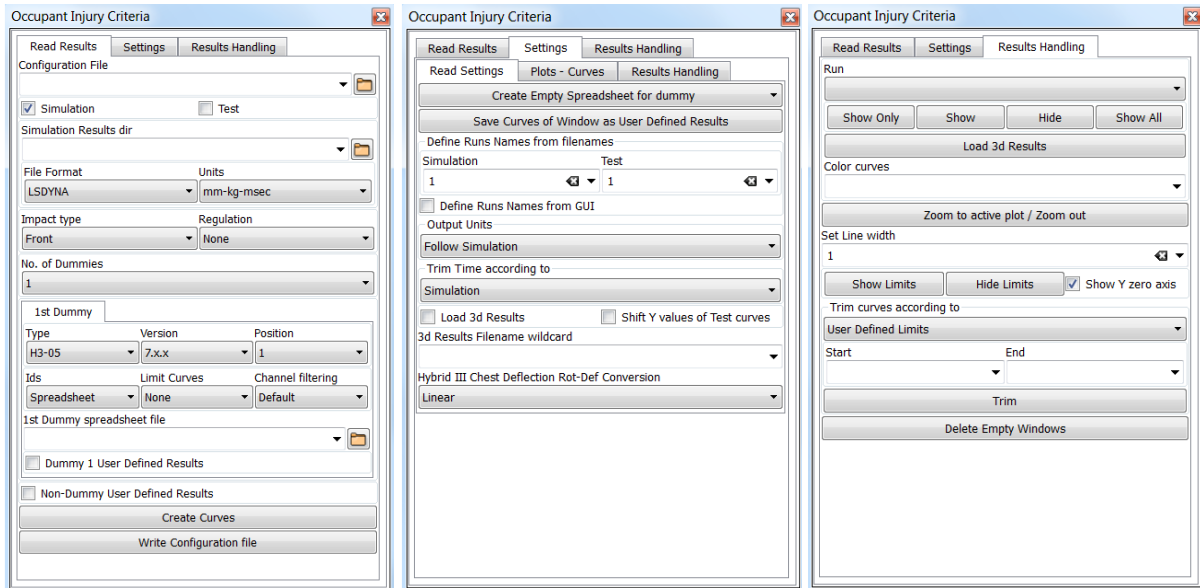


Fig. 2,3,4: Interface of the tool. Read Results tab, Settings tab, Results Handling tab

3.3 Extracted Results

The tool searches the given results directory and lists all the found results (first for simulation and then for physical test results). The user can select from these lists the Simulation variants and Physical test runs for which results will be created.

From each selected Simulation or Test run, results for up to 4 dummies can be created. One 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 μ ETA.

In this page one Summary window exists with all the results that are needed to evaluate this dummy.

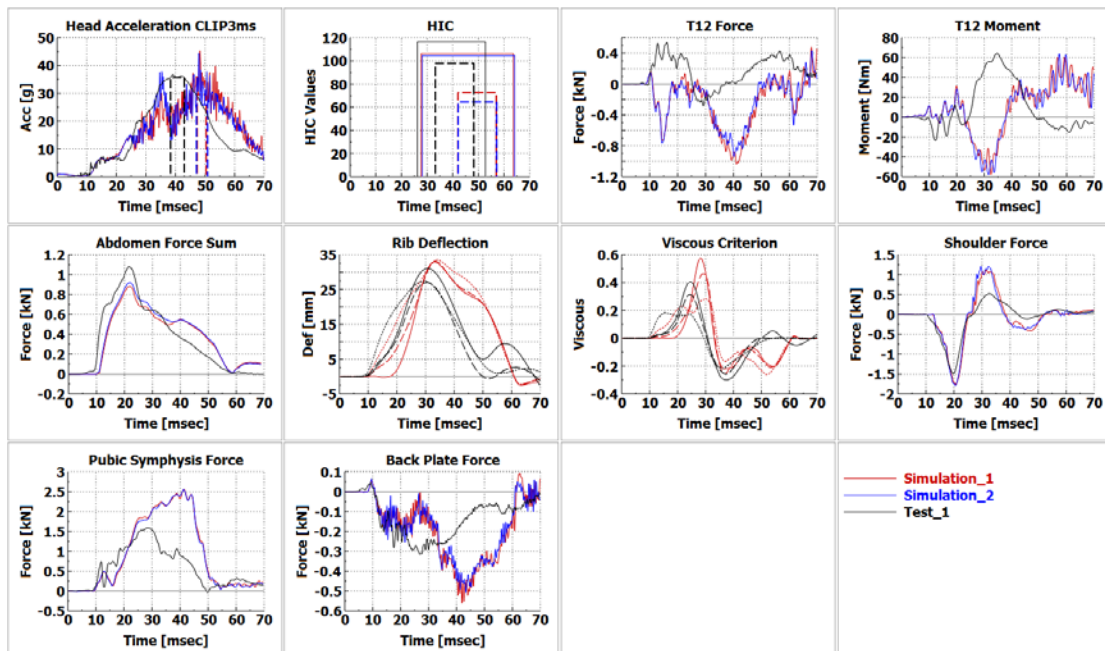


Fig. 5: Summary of Results for ES-2 dummy

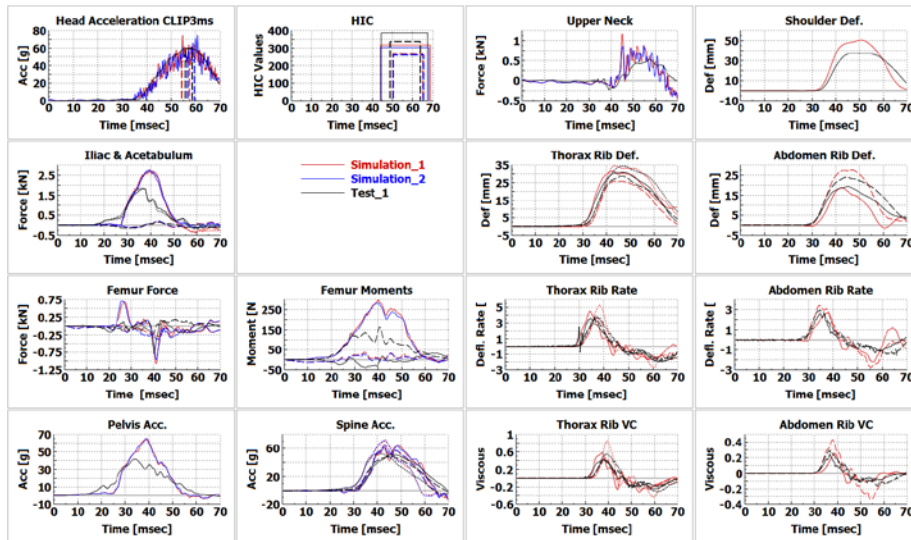


Fig. 6: Summary of Results for SID-III dummy

Apart from the window with summary of results one window for each type of results is also created in order to view these results in more details.

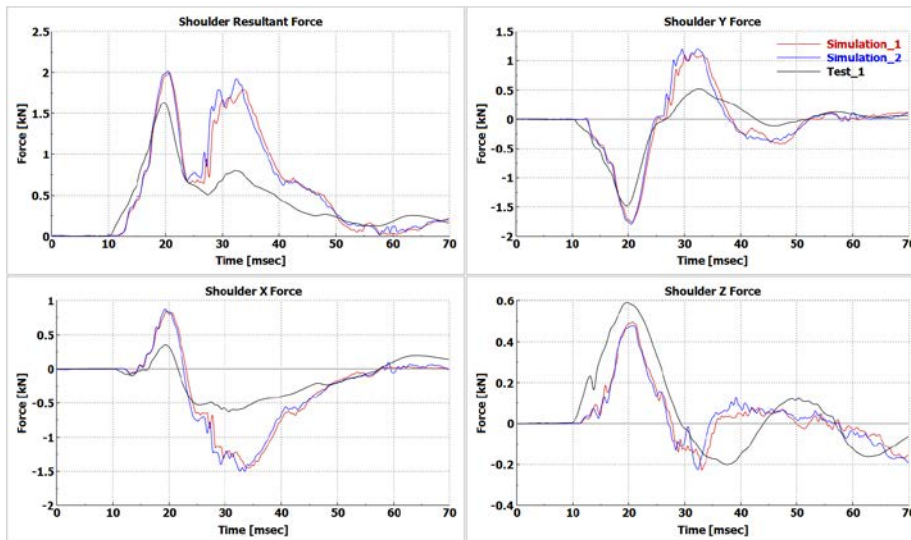


Fig. 7: Window with Shoulder results for ES-2 dummy

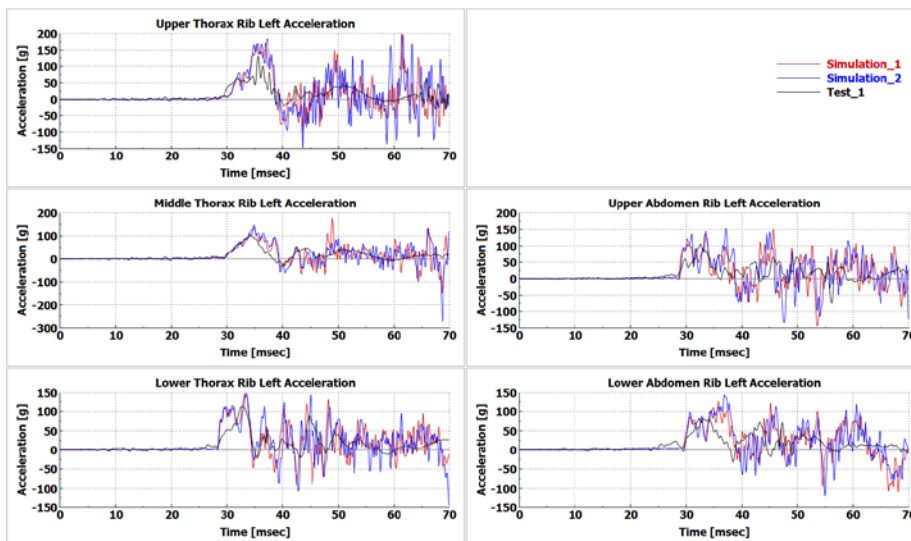


Fig. 8: Window with Rib results for SID-III dummy

The tool extracts the standard results that are required for the evaluation of each dummy but it is also possible to extract additional results either for each dummy or results of the vehicle in order to perform a complete analysis. These are completely user defined results.

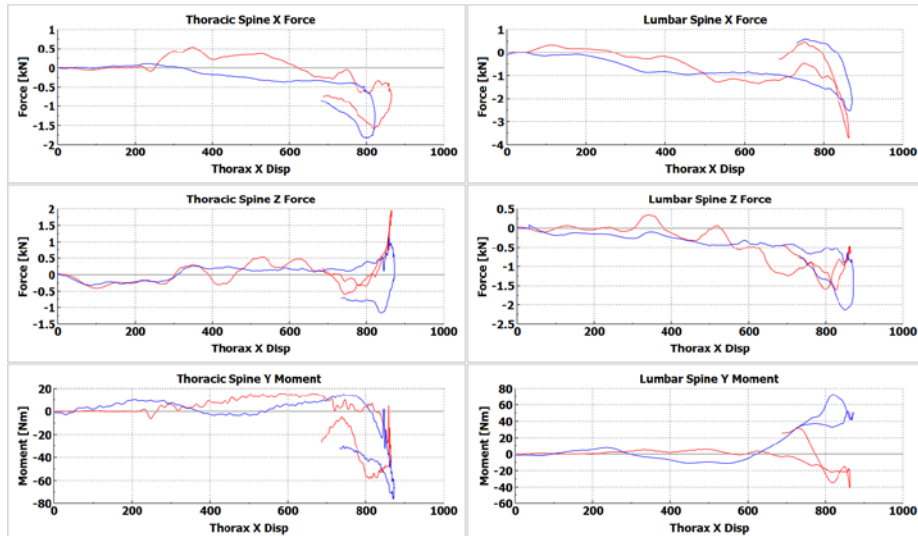


Fig. 9: Extra results for H3-50, Spine Forces and Moments over Displacement

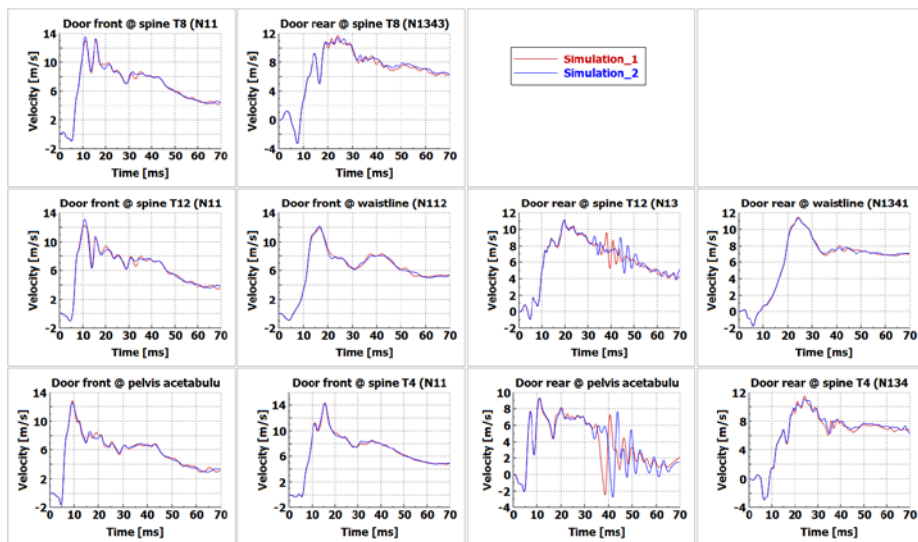


Fig. 10: Non-dummy User Defined results

3.4 Results Handling

After the results are created, each processed variant (Simulation and Physical Test) is added in the Run drop-down menu of the Results Handling tab of the tool. By selecting a Run from this drop-down menu the user can apply focus commands (show only, hide, show) to the curves of this Run. This way when many Simulations and Physical Tests are processed the comparison between them becomes easier.

It is also possible to load the 3d results (geometry of the model and displacements) of a selected simulation Run in order to see what exactly happened in this simulation. This way all the capabilities of μ ETA for 3d Post-Processing can be used, such as having the same views like in the physical test, creation of cut-planes for better visualization of results, easy identification of critical results, importing videos of the physical test and correlating these videos with the simulation.

3.5 Future Developments

3.5.1 Reports

The tool currently extracts the Occupant Injury results and from its next version it will be able to create automatically reports. Standard Power Point reports will be created, according to the selected Regulation, which will contain tables with all the needed results and images of the results (curves). Apart from adding the results to Power Point reports, the results will be added in spreadsheet files, such as the Euro-NCAP-Spreadsheet.

\$ label	US-NCAP limits	User defined limits	Simulation_1	Simulation_2	Test_1
\$ Additional limits for acceleration results					
limit_head_acceleration_res		75	44.9	44.5	36.6
limit_head_acceleration_HIC36	1000	700	106.2	104.6	116.5
limit_head_acceleration_3msclip		65	29.5	25.9	35.6
\$ Deflections					
intrusion_upper_rib_def	44	32	32.9		31.1
intrusion_middle_rib_def	44	32	33.1		27.0
intrusion_lower_rib_def	44	32	33.5		27.4
\$ Additional limits for deflection results					
limit_intrusion_upper_rib_vc		0.5	0.6		0.4
limit_intrusion_middle_rib_vc		0.5	0.5		0.3
limit_intrusion_lower_rib_vc		0.5	0.3		0.2
\$ Forces and moments					
pubic_load_cell_fy	6.0	2.5	2.6	2.6	1.6
back_plate_load_cell_fy		0.8	0.6	0.5	0.3
t12_load_cell_fy		1.3	1.0	0.9	0.5
t12_load_cell_mx		120	109.5	103.7	63
\$ Additional limits for force results					
limit_abdomen_load_cell_sum	2.5	0.9	0.9	0.9	1.1

Side MDB Test		Driver	
0		Value	Points
HEAD			
Peak resultant acceleration - g		45.1413	
HIC ₁₅		106.2	4.000
Resultant Acc. 3 msec exceedance - g		29.54	4.000
Incorrect airbag deployment modifier (-1)			0.000
Head assessment		4.000	
CHEST			
Top Compression - mm		32.19	1.962
Viscous criterion - m/s		0.57	2.529
Top rib assessment			1.962
Middle Compression - mm		33.10	1.780
Viscous criterion - m/s		0.46	2.176
Middle rib assessment			1.780
Bottom Compression - mm		33.52	1.696
Viscous criterion - m/s		0.28	4.000
Bottom rib assessment			1.696
Incorrect airbag deployment modifier (-1)			0.000
T12 Modifier (-2)			0.000
T12 Fy - kN		0	
T12 Mx - Nm		0	
Backplate Load Modifier (-2)			0.000
Backplate Fy - kN			
Chest assessment		1.696	

Fig. 11, 12: Examples of Power Point table and spreadsheet reports(Euro-NCAP-Spreadsheet)

3.5.2 Dummies, Solvers, Results

In the future the tool will support more dummy types, such as BioRID-II, Q10 for Side Impact, THOR. More Solvers and file formats for Physical Test results will be supported too. Finally the calculation of more Crash Analysis Criteria will be added in μ ETA, such as Nkm, NIC, Time At Level, BRIC, etc.

4 Summary - Benefits from using the Occupant Injury Criteria tool

The Occupant Injury Criteria tool streamlines the Post-Processing and the report generation with a few clicks assuring an error free outcome. It provides efficient and easy manipulation of the created results for better inspection and comparison of them. It is designed according to the respective regulations but it can be customized according to the engineer's needs.

Using μ ETA and the Occupant Injury Criteria tool an engineer can post-process the 3d animations of simulation results, extract the Occupant Injury results (curves) from simulations and physical tests and compare them and correlate also the 3d animations of simulations with the videos of physical tests, using only one software. This software (μ ETA) can be easily coupled with LS-OPT (along with ANSA, the Pre-Processor of BETA CAE Systems S.A.) in order for the engineer to optimize the results.

5 Literature

- [1] Pavlidis V., Siskos D., "Current Trends in Post-Processing of FEA Results in the Automotive Industry"
- [2] μ ETA version 15.1.0 Occupant Injury Criteria Toolbar, BETA CAE Systems S.A