Post-processing of the 2020 Euro NCAP Frontal Impact test in META

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1 Abstract

New cars are continuously becoming safer thanks to improvements in crash test regulations and standards. Currently crash test regulations and standards assess the safety performance of vehicles in frontal impacts under the precondition that the vehicle's supporting structure is hit in such a way that the crumple zone absorbs energy during the crash.

The General German Automobile Club (ADAC) accident research data shows, however, that in a car-to-car impact, the vehicle's supporting structures might not hit in the same way as in the standard frontal impact tests. In these cases, the crumble zone of the vehicle cannot be fully utilized and this can lead to severe injuries.

In 2010, the ADAC introduced a new test to assess the compatibility of vehicles in a car-to-car impact. In this test, a special honeycomb-shaped barrier is used, and its surface is scanned for evaluation after the test. This test with a progressive deformable barrier was named ADAC compatibility test or MPDB test.

In 2020, the European New Car Assessment Programme (Euro NCAP) will update its offset frontal impact test procedure. These updates will be centred on the adoption of the Thor anthropometric test device and of the Mobile Progressive Deformable Barrier (MPDB).

META, the post processor of BETA CAE Systems, offers tools for the complete evaluation of occupant injury results of the 2020 Euro NCAP test and for the compatibility assessment of the MPDB to car impact.

The Occupant Injury Criteria tool automatically processes LS-DYNA and physical test results of THOR 50th (2020 Euro NCAP offset frontal impact test driver), Hybrid III 50th (passenger), Q10 and Q6 (back seats) dummies. Reports can be created with the Adult and Child Occupant Protection Scores.

The EU-NCAP MPDB tool of META automatically calculates the Occupant Load Criterion (OLC), the Standard Deviation of the MPDB's front face intrusions and finally the penalty points of the compatibility assessment.

2 Euro NCAP 2020 Frontal Impact test

In 2020 Euro NCAP will implement the last point of Roadmap 2020. The classic ODB crash test is replaced by the new MPDB test against a mobile barrier. The two major updates in this test are the use of THOR-50 dummy as driver, instead of H3-50 and the compatibility assessment between the car and the barrier.

META, the post processor of BETA CAE Systems, offers tools for the complete evaluation of occupant injury results of the 2020 Euro NCAP test and for the compatibility assessment of the MPDB to car impact.

3 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. 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.

3.1 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, DIADEM files, ASCII files, etc.

The Crash Test Dummies that can be processed are:

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

Table 1: Supported dummies

3.2 THOR-50 Post-processing

By selecting to post-process a THOR-50 dummy and create a report for Euro NCAP, the Occupant Injury Criteria tool v19.1.2 calculates and adds in the report the occupant protection score according to AOP v9.0.0.
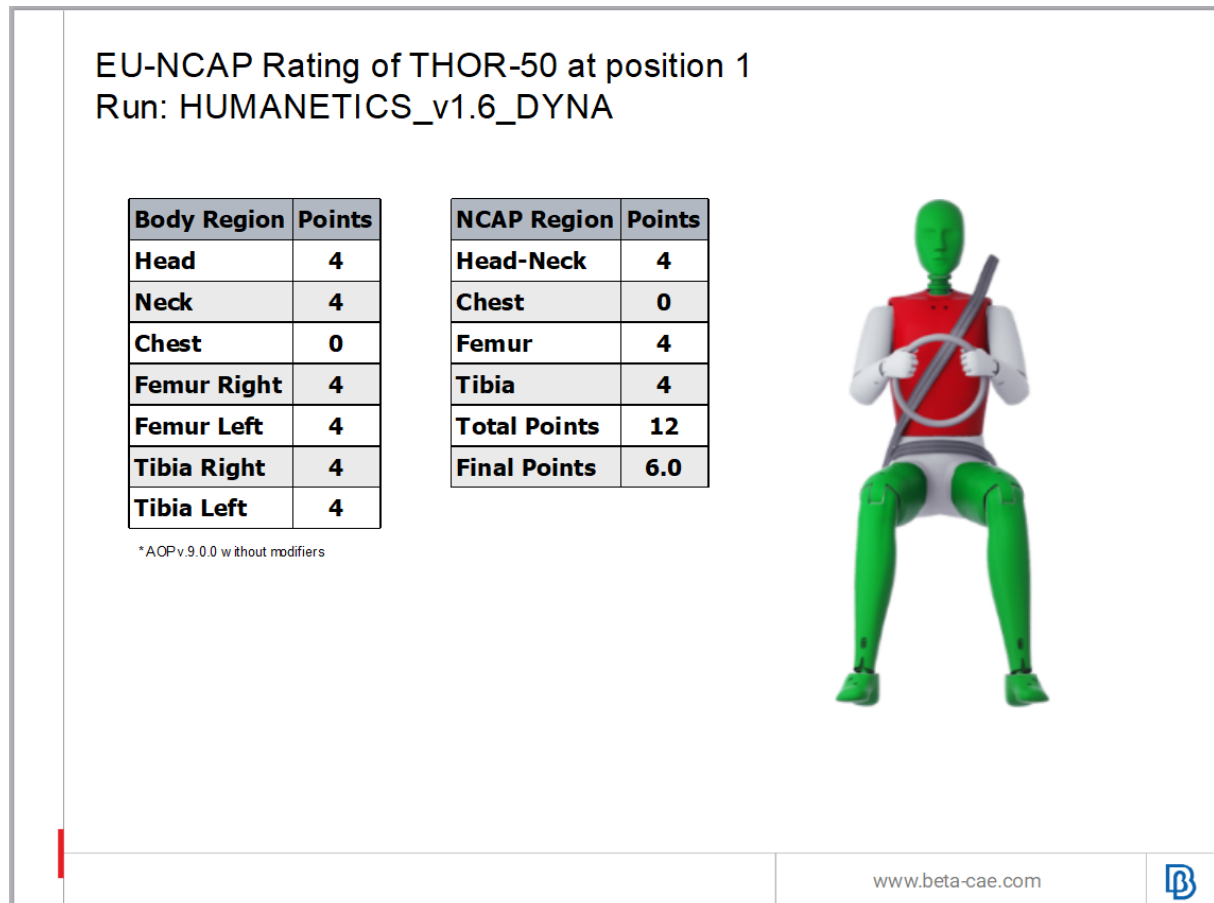
EU-NCAP Rating of THOR-50 at position 1
Run: HUMANETICS_v1.6_DYNA

Body Region	Points
Head	4
Neck	4
Chest	0
Femur Right	4
Femur Left	4
Tibia Right	4
Tibia Left	4

NCAP Region	Points
Head-Neck	4
Chest	0
Femur	4
Tibia	4
Total Points	12
Final Points	6.0

*AOP v.9.0.0 without modifiers

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Fig.1: Occupant protection score for THOR-50 driver according to AOP v9.0.0.
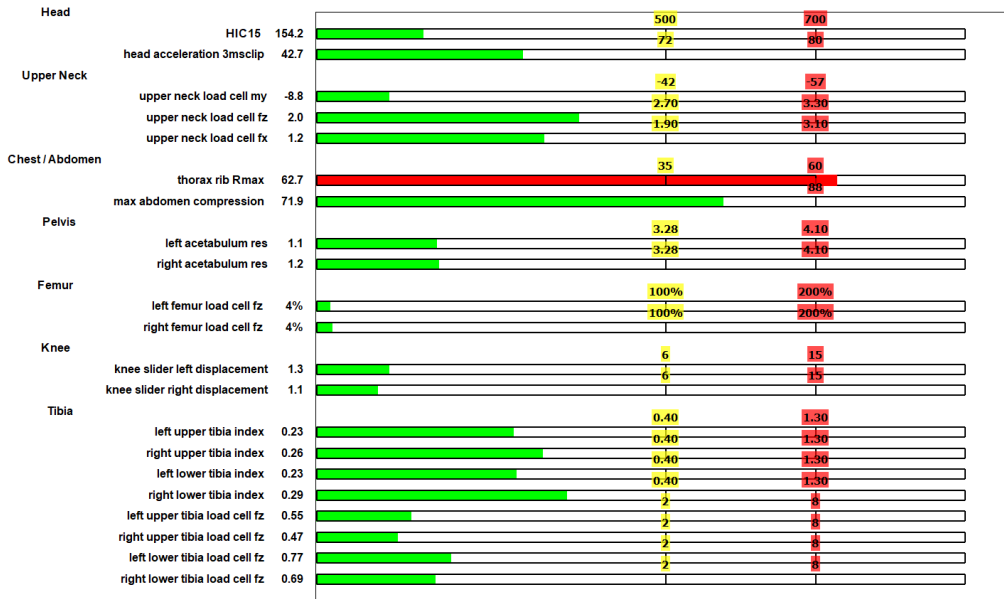
Fig.2: Results used for the Euro NCAP protection score calculation as bar-chart show how close the results came to the Euro NCAP limits

Results for each component of the dummy are created as graphs over time and one slide is added in the report for each component. The Euro NCAP limits are also presented as curves in the respective windows.
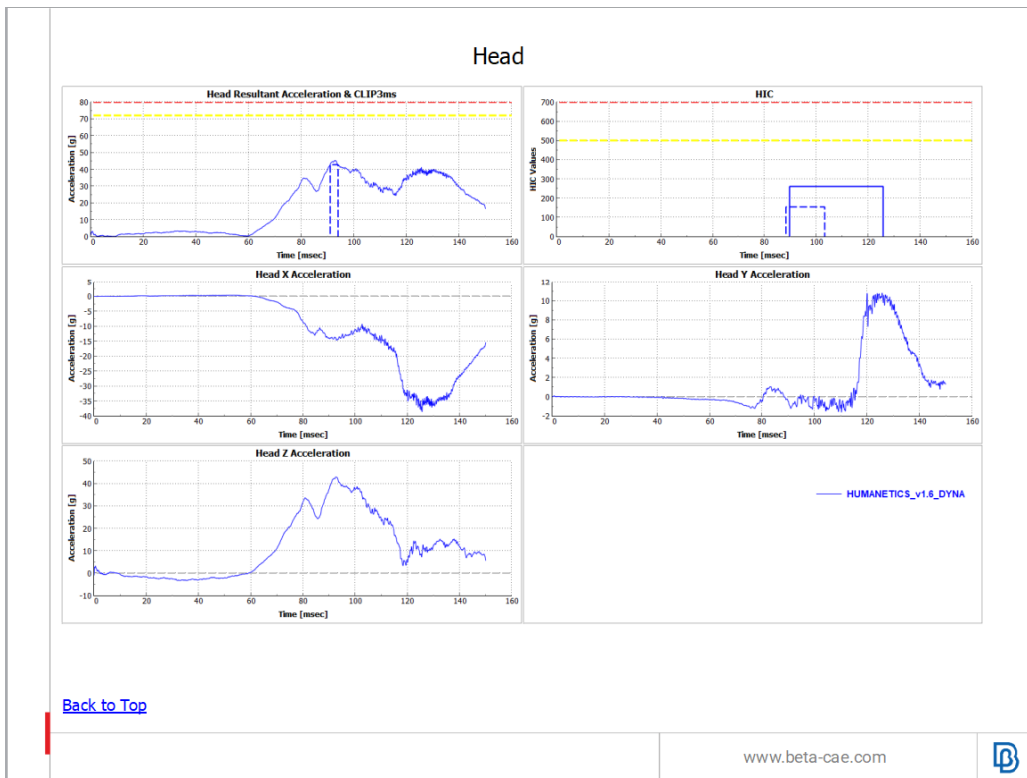

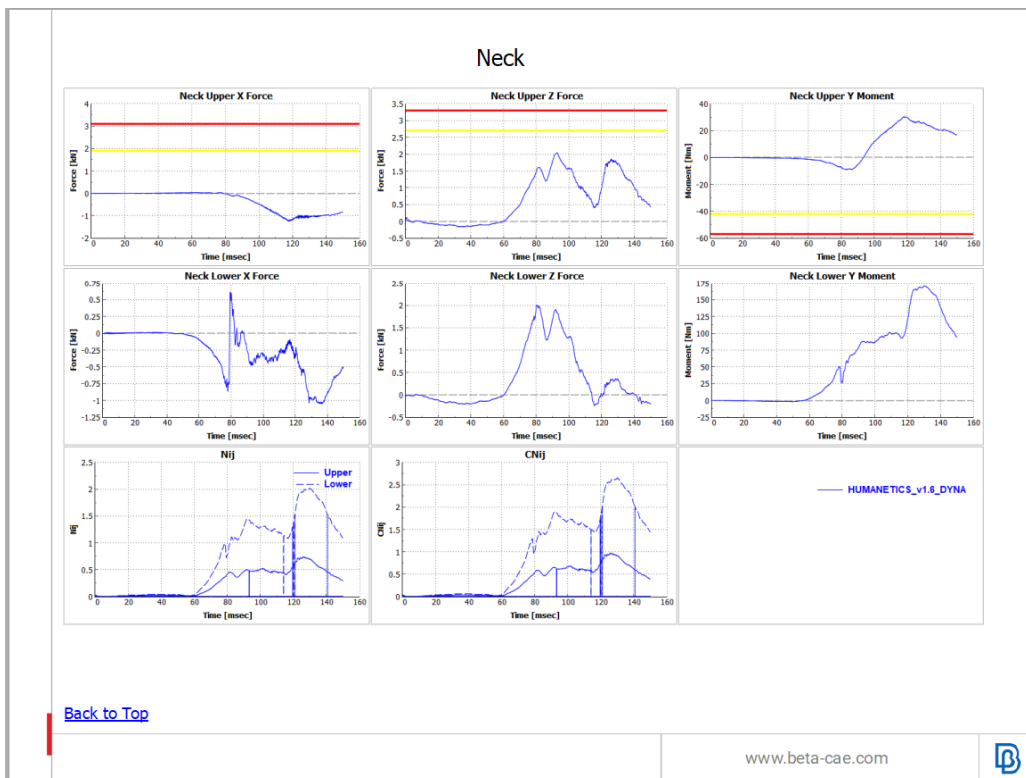*Fig.3: Head results in report. THOR-50 results courtesy of Humanetics.*

Fig.4:   Neck results in report. THOR-50 results courtesy of Humanetics.
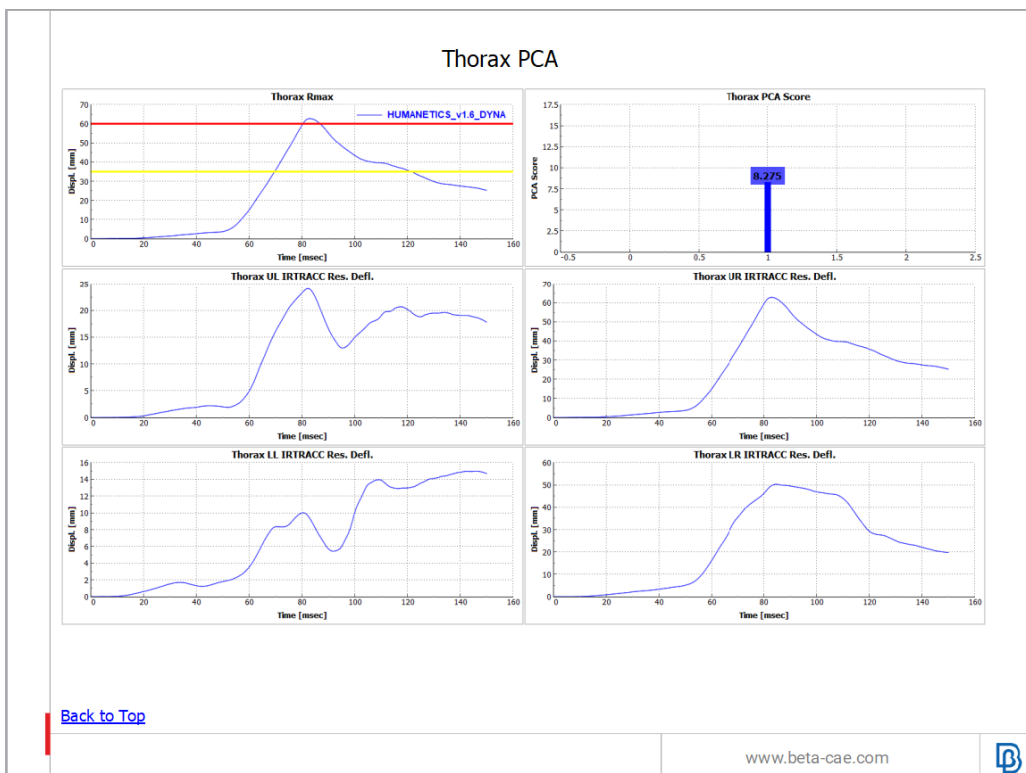

Fig.5:   Thorax rib deflection results in report. THOR-50 results courtesy of Humanetics.

The following results are created for THOR-50: Head Accelerations, BrIC, Neck Forces and Moments, NIJ, Shoulder Forces, T1 Accelerations, T4 Accelerations, T4 Angular Velocities, T12 Accelerations, Sternum Acceleration, Thorax Upper Left deflections, Thorax Upper Right deflections, Thorax Lower Left Rib deflections, Thorax Lower Right rib deflections, Thorax PCA, Abdomen Left deflections,

Abdomen Right deflections, Abdomen Compression, Abdomen Accelerations, Pelvis Accelerations, Pelvis Angular Velocities, Left Pelvis ASIS Forces and Moments, Right Pelvis ASIS Forces and Moments, Acetabulum Forces, Left Femur Forces and Moments, Right Femur Forces and Moments, Knee Displacements, Tibia Upper Forces and Moments and Index, Tibia Lower Forces and Moments and Index, Left Foot Accelerations, Right Foot Accelerations.

The maximum values of all created results are added in tables in the report.

Measuring Point	Max/Min	Units	HUMANETICS_v1.6_DYNA
HIC36	Max	-	261
HIC15	Max	-	154
Head Acceleration Res.	Max	g	45.3
Head Acceleration Res. Clip3ms	Max	g	42.7
Head Acceleration X	Abs(Min)	g	38.6
Head Acceleration Y	Max	g	10.8
Head Acceleration Z	Max	g	42.9
BrIC	Max	-	0.925
Head Rot. Vel. X	Abs(Min)	deg/msec	0.011
Head Rot. Vel. Y	Abs(Min)	deg/msec	0.049
Head Rot. Vel. Z	Max	deg/msec	0.013
Upper Neck Fx	Abs(Min)	kN	1.24
Upper Neck Fz	Max	kN	2.04
Upper Neck My	Abs(Min)	Nm	-8.83
Lower Neck Fx	Abs(Min)	kN	1.05
Lower Neck Fz	Max	kN	2.01
Lower Neck My	Max	Nm	170
Upper Nij	Max	-	0.743
Lower Nij	Max	-	2.02
Upper CNij	Max	-	0.974

Measuring Point	Max/Min	Units	HUMANETICS_v1.6_DYNA
T1 Acceleration Res.	Max	g	54.8
T4 Acceleration X	Abs(Min)	g	53.0
T4 Acceleration Y	Max	g	17.9
T4 Acceleration Z	Abs(Min)	g	16.0
T4 Acceleration Res.	Max	g	56.6
T4 Ang. Vel. X	Abs(Min)	deg/msec	0.285
T4 Ang. Vel. Y	Abs(Min)	deg/msec	0.435
T4 Ang. Vel. Z	Abs(Min)	deg/msec	0.542
T4 Ang. Vel. Res.	Max	deg/msec	0.606
T12 Acceleration X	Abs(Min)	g	43.4
T12 Acceleration Y	Max	g	19.6
T12 Acceleration Z	Abs(Min)	g	18.5
T12 Acceleration Res.	Max	g	47.3
Max Abdomen Compression	Max	-	71.9
Normalized Abdomen Compression	Max	-	0.302
Upper Abdomen Acc. X	Abs(Min)	g	59.2
Mid Sternum Acceleration	Abs(Min)	g	62.7
Thorax PCA Score	Max	-	8.27
Thorax Rmax	Max	mm	62.7
Upper Left Thorax Defl. X	Abs(Min)	mm	22.6

Fig.6:   Max values of all created results in report tables

The interoperability of the 2d plot tool (graphs tool) of META with the 3d offers the ability to load the geometry and the 3d results of the simulation and synchronize their animation with the graphs.
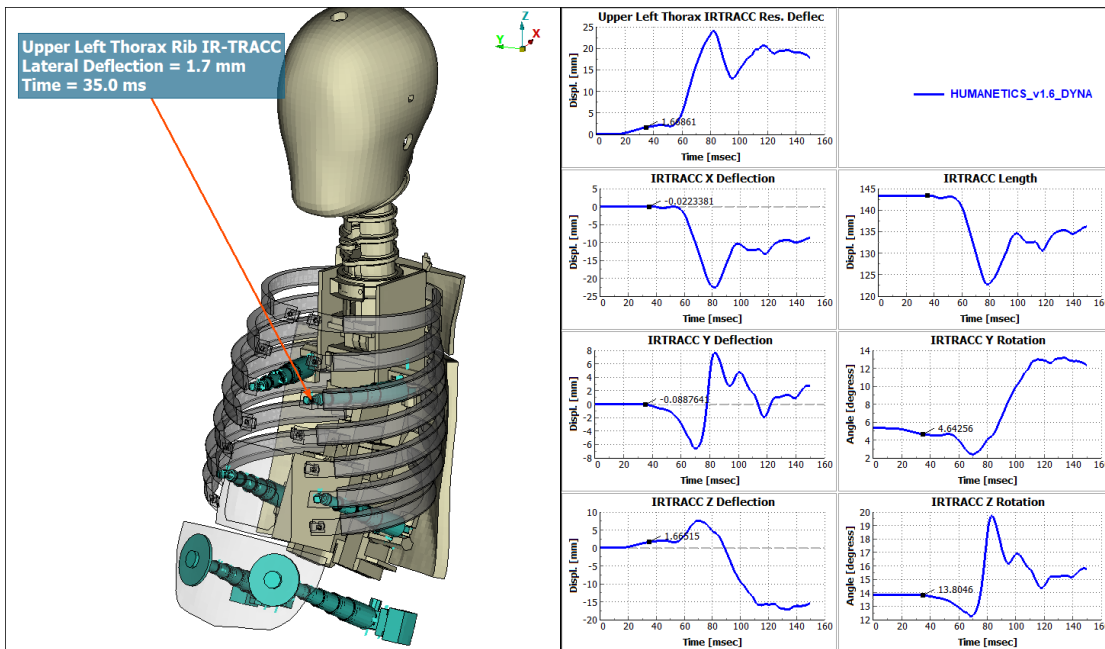

Fig.7:   Upper Left Thorax IR-TRACC Deflection graphs synchronized Graphs
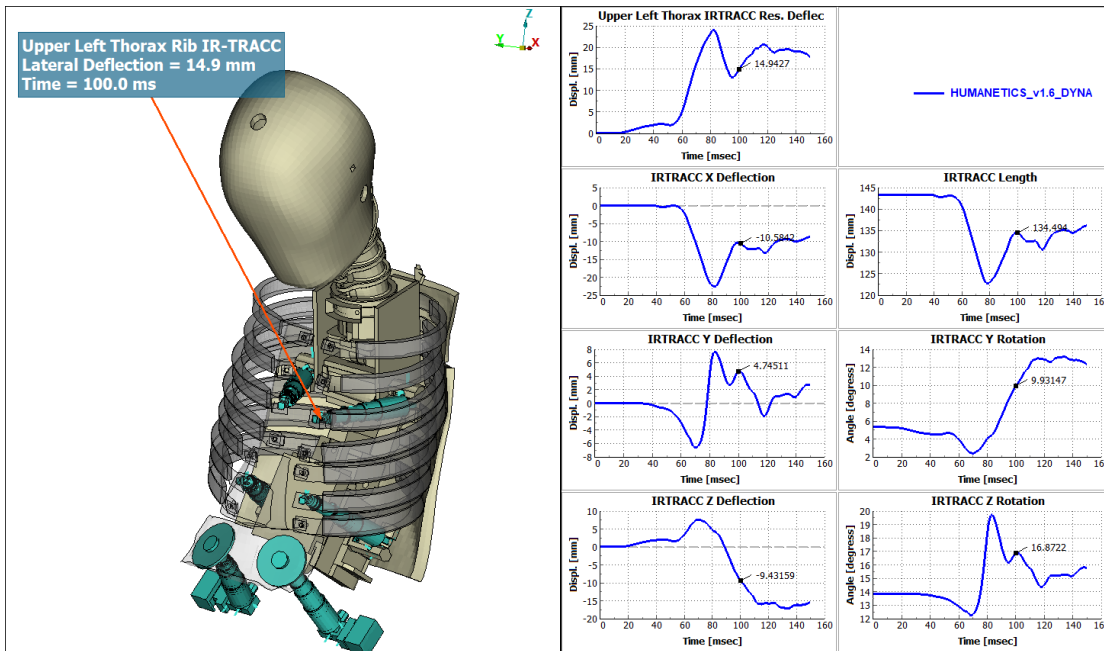
Fig.8:   Upper Left Thorax IR-TRACC Deflection graphs synchronized Graphs

3.3   H3-50 Post-processing

In the new MPDB test of Euro NCAP the Hybrid III 50th dummy is used as passenger. META apart from processing each dummy separately can also post-process and create the report for both driver and passenger simultaneously. Two separate reports will be created in this case.

The report of the H3-50 dummy includes again the occupant protection score and the following results: Head Accelerations, Neck Forces and Moments and NIJ, Chest Defection, Chest Accelerations, Pelvis Accelerations, Thoracic Spine Forces and Moments, Lumbar Spine Forces and Moments, Femur Forces, Knee Displacements and Forces, Upper Tibia Forces and Moments and Index, Lower Tibia Forces and Moments and Index, Foot Accelerations.
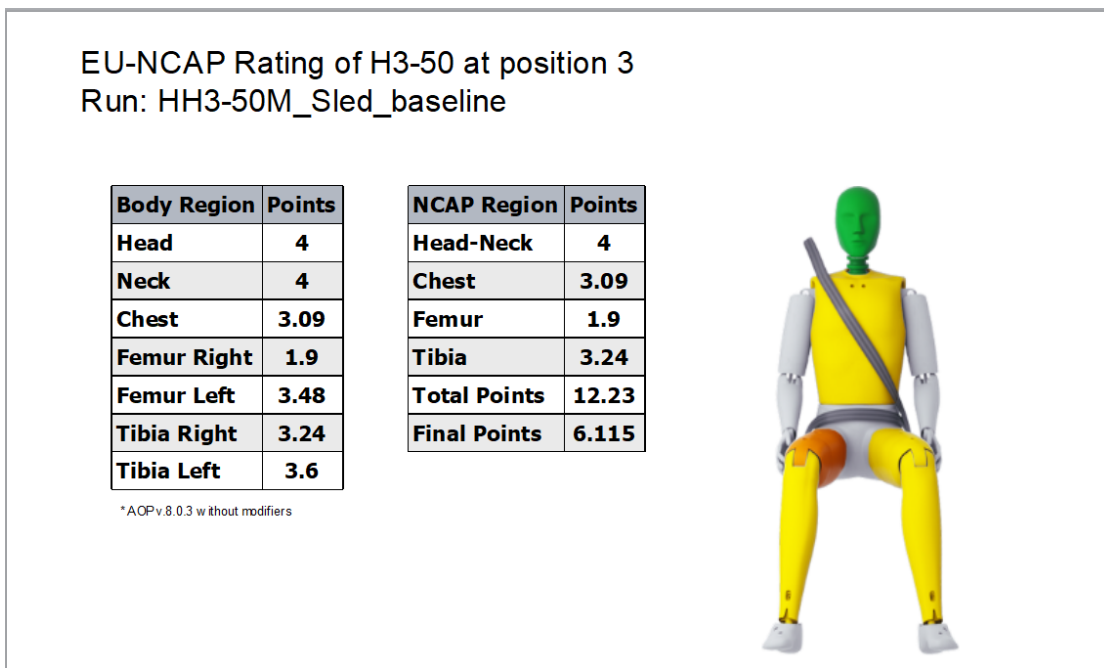

Fig.9:   Occupant protection score for H3-50 passenger according to AOP v8.0.3.

EU-NCAP

Measuring Point	HH3-50M_Sled_baseline	HH3-50M_Sled_variation1	HH3-50M_Sled_variation2	121258-9	121258-10	121258-11
Head						
HIC15	113.2	107.6	110.0	63.9	68.9	67.3
head acceleration 3msclip	39.1	38.2	36.1	29.3	30.2	29.5
Upper Neck						
upper neck load cell my -	-41.5	-33.8	-41.9	-33.3	-36.0	-36.5
upper neck load cell fz	0.67	0.73	0.59	0.61	0.66	0.66
upper neck load cell fx	-0.00	-0.00	-0.00	0.00	0.00	0.00
upper neck load cell fx -	-0.81	-0.88	-0.81	-0.58	-0.60	-0.63
Chest						
chest deflection	26.6	22.8	32.4	29.1	30.0	32.2
chest viscous	0.11	0.07	0.14	0.07	0.09	0.08
Femur						
left femur load cell fz	-0.96	-0.99	-0.96	-0.56	-0.56	-0.56
right femur load cell fz	-0.91	-1.1	-0.91	-0.60	-0.56	-0.63
Knee						
knee slider left displacement	7.2	9.2	6.9	0.19	0.22	0.24
knee slider right displacement	10.7	10.8	10.6	0.00	0.00	0.00
Tibia						
left upper tibia index	0.49	0.49	0.47	0.39	0.35	0.38
right upper tibia index	0.57	0.55	0.64	0.36	0.36	0.34
left lower tibia index	0.29	0.44	0.20	0.15	0.14	0.15
right lower tibia index	0.40	0.52	0.38	0.12	0.12	0.11
left upper tibia load cell fz	1.9	1.9	1.9	1.2	1.2	1.3
right upper tibia load cell fz	1.9	2.0	1.9	1.2	1.3	1.3
left lower tibia load cell fz	2.1	2.1	2.1	1.6	1.5	1.5
right lower tibia load cell fz	2.1	2.1	2.1	0.23	0.23	0.21

Fig.10: Results monitored by Euro NCAP in report table. Comparison of 3 simulations and 3 physical tests
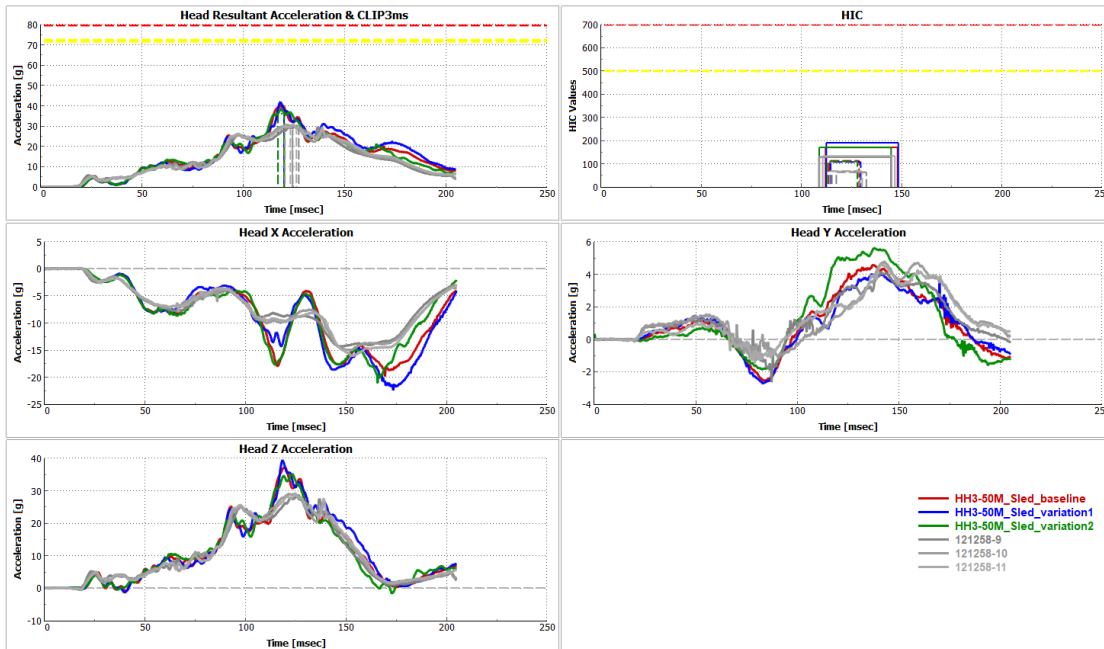

Fig.11: H3-50 Head results in report. Comparison of 3 simulations and 3 physical test results courtesy of Humanetics
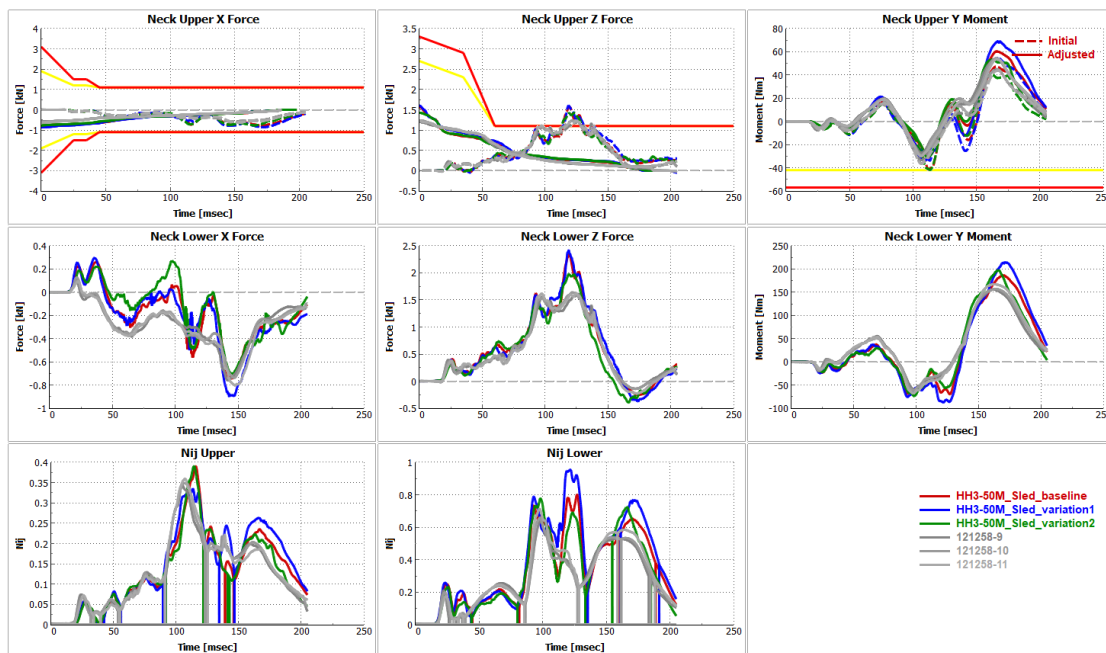
Fig.12: H3-50 Neck results in report. Comparison of 3 simulations and 3 physical test results courtesy of Humanetics

3.4 Q6 and Q10 child dummies in back seat Post-processing

At the back seat the new Euro NCAP test will use again Q6 and Q10 child dummies. The report of the child dummies includes the child occupant protection score according to COP v.7.2.2 and the following results: Head Accelerations, Upper and Lower Neck Forces and Moments, Spine Accelerations, Pelvis Forces and Moments, Pelvis Accelerations, Lumbar Forces and Moments, Chest Deflection, Sacro-Iliac Forces and Moments, Pubic Forces and Moments, Femur Forces and Moments.
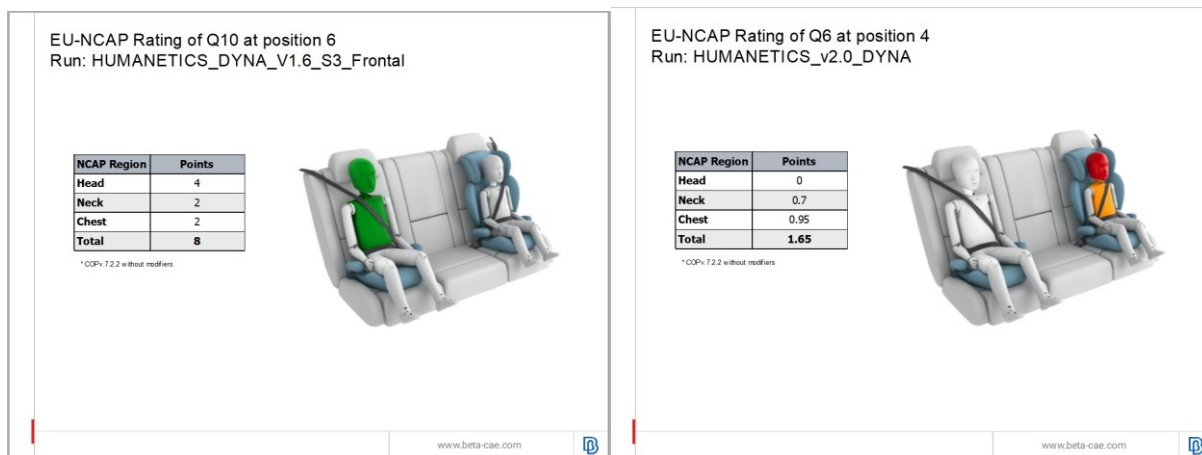

Fig.13: Child occupant protection scores for Q10 and Q6 at the back seat according to COP v.7.2.2.

4 EU-NCAP MPDB tool

The EU-NCAP MPDB tool of META automatically calculates the Occupant Load Criterion (OLC), the Standard Deviation of the MPDB's front face intrusions and finally the penalty points of the compatibility assessment.

It is possible to calculate penalty points of the compatibility assessment either for the last time step of the simulation or to automatically find at which time step there is the maximum Standard Deviation of the MPDB's front face intrusions and calculate the points for that time step

Fig.14: Deformations of the front face of the barrier.

Fig.15: Front face of the barrier intrusion values in spreadsheet and calculation of the Standard Deviation of the intrusion values in the evaluation area.

Fig.16: Calculation of OLC, Bottoming Out and Final Penalty Points.

5 Summary

Using the Occupant Injury Criteria and the EU-NCAP MPDB tools along with the rest of the available functionality in META, engineers are able to automatically post process results and create reports for the occupant injury and structural results of the new Euro NCAP 2020 MPDB frontal impact test and 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.

6 Literature

[1]   Euro NCAP Technical Bulletin 027 Compatibility Assessment, Version 1.0, November 2018
[2]   Volker Sandner, Andreas Ratzek, MPDB-Mobile offset progressive deformable barrier, a new approach to cover compatibility and offset testing.
[3]   CARHS Safety Companion 2019