A holistic approach to post-processing of FEA results – Current trends

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In brief

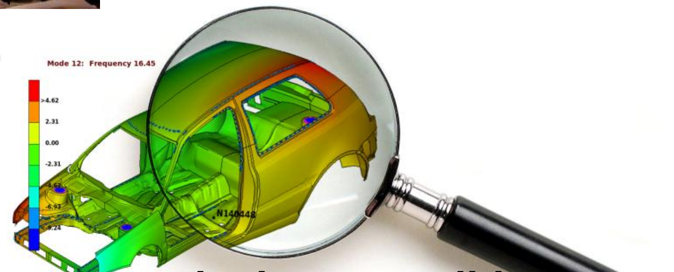
- Identification of post-processing challenges
- Post-processing challenges are analysed to related needs that should be met. These needs dictate the current post-processing trends
- Examples of addressing these needs with μETA

The evolution of post-processing

The post-processing challenges

Large models & data sets

Comparison studies



The best possible exploitation of results

Repeated post-procedures

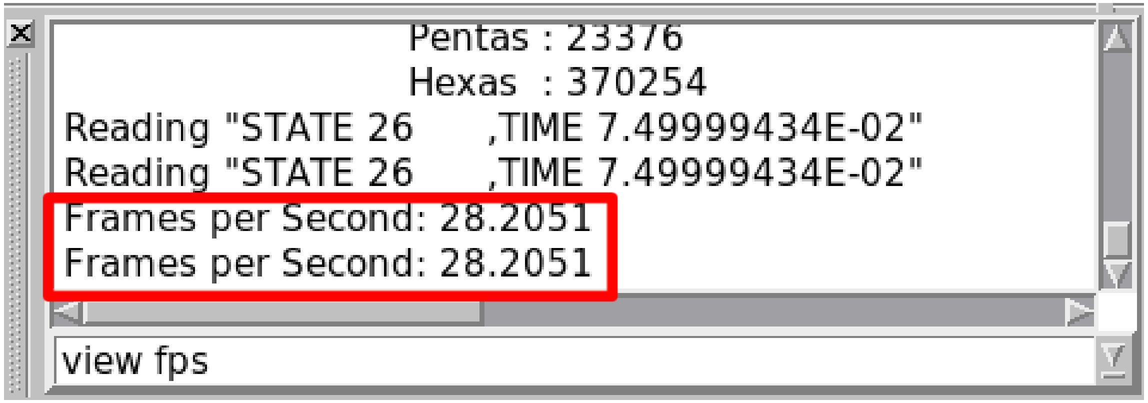
Communication of results

Large models & Data sets

The Challenge	**Large models & data sets**			
The Needs	**High graphics performance**	**Reduced memory usage**	**High reading performance**	**Reduced amount of stored data**
The Means	**New rendering algorithms optimized to match platform's graphical resources**	**Improved memory management**	**Improved reading algorithms, optimised for different formats**	**A native binary format for storing selected data from the solver output**
The Benefits	**Easy & fast interactive handling of large models**	**Post-processing of larger models with limited resources**	**Reduced idle time due to reading large files (>80 GB) and data sets**	**1. Reduced storage needs 2. Significant reduction of loading time**

Graphics performance

Platform configuration	Model size
CPU: Intel(R) Core(TM)2 Duo CPU T9400 @ 2.53GHz RAM: 3.8 GB Graphics Renderer: NVIDIA, Quadro FX 3700M OS: Linux FedoraCore 11 64bit	Nodes: 5,293,254 Shells: 4,705,975 Solids: 399,138



Up to 8X performance improvement using the new rendering algorithms

Best possible exploitation of results

The Challenge

The best possible exploitation of results

The Needs

Dig into results in detail	3D & 2D post-processing	Calculation of new results by the post-processor

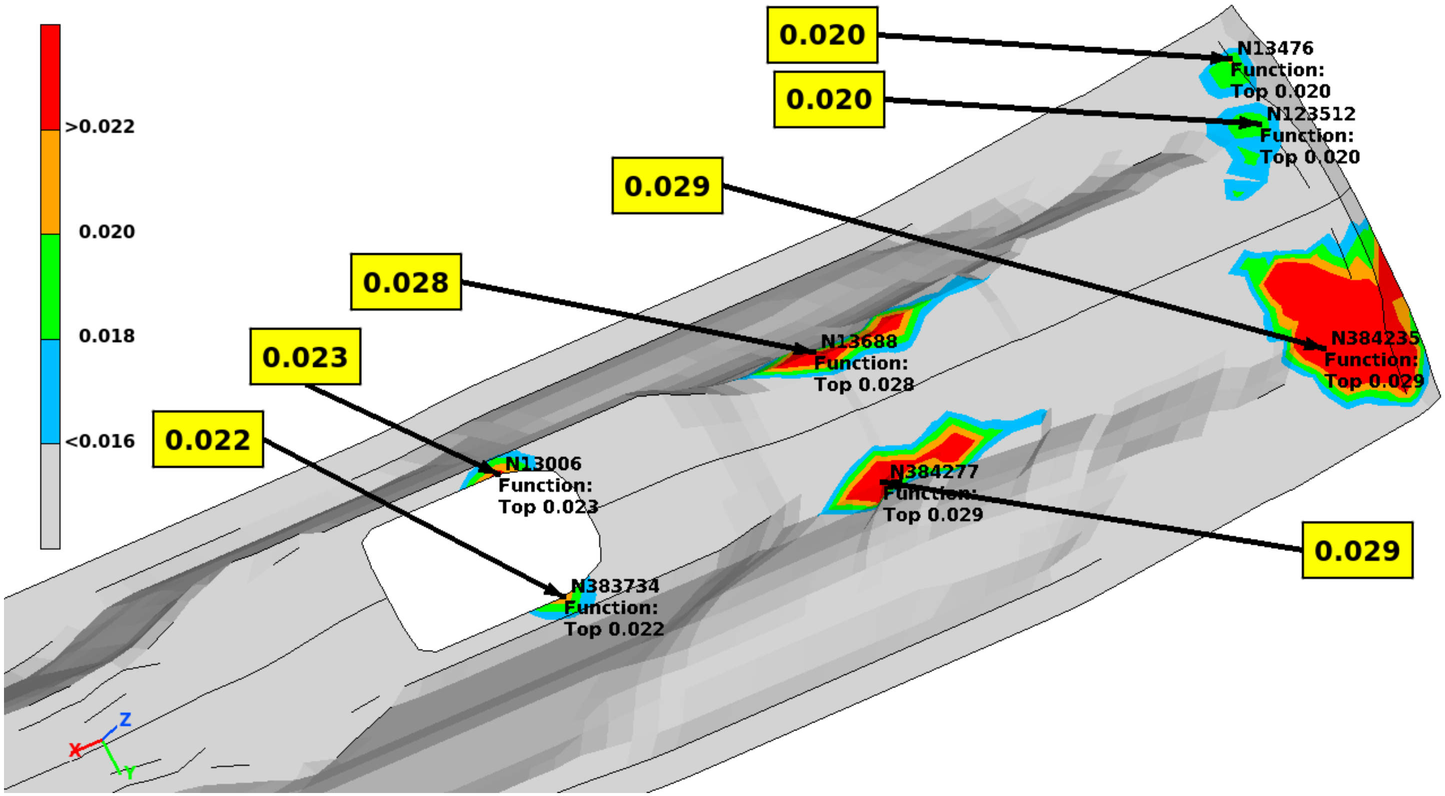
The Means

Advanced filtering capabilities (eg: identification of hot-spots)	1. 3D & 2D modules embedded within the same software 2. Interoperability between modules	Calculation tools for: 1. Section forces 2. Linear combination of solver's results 3. Calculation of discretisation errors 4. Tools for calculation of NVH results ….Other tools …..

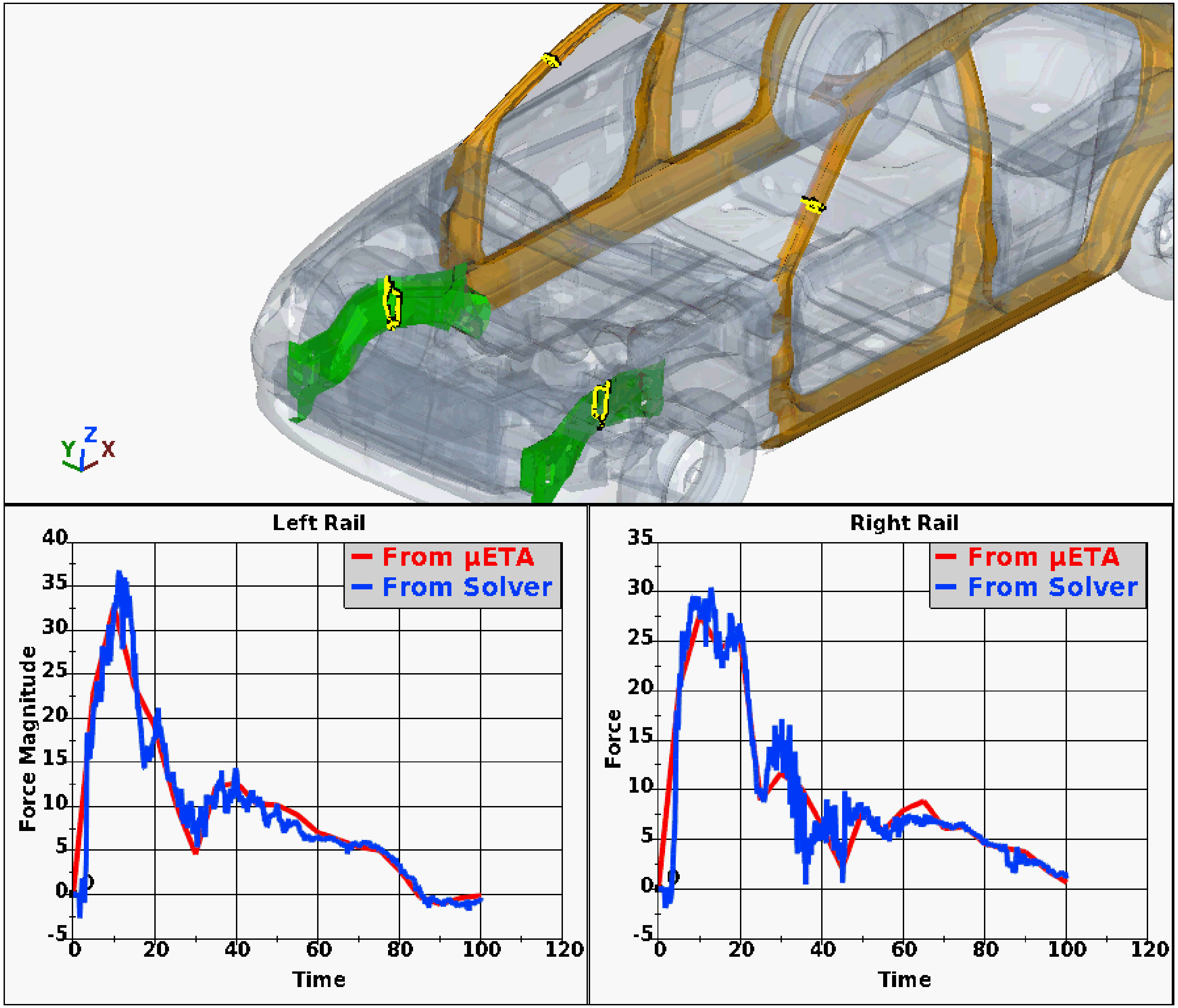
The Benefits

1. Time saving 2. Better insight of results 3. No important information is missed	1. Faster & easier post-processing 2. Information is passed from one module to the other in real time	1. Time saving 2. More "what-if" studies conducted faster & easier without re-running the solver 3. Verification of results

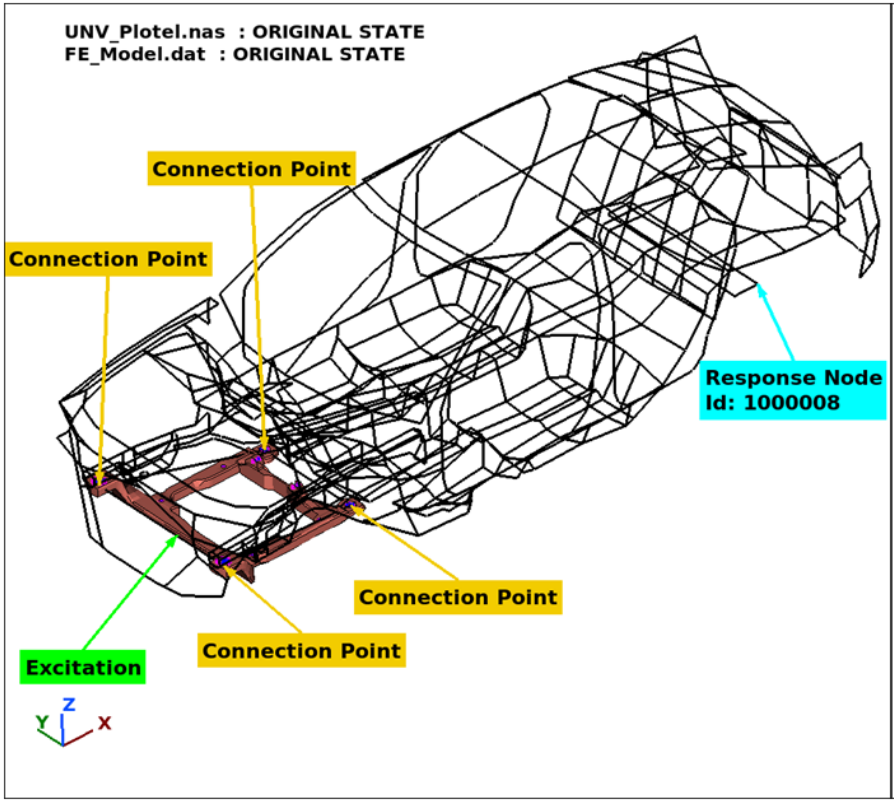
Advanced filtering

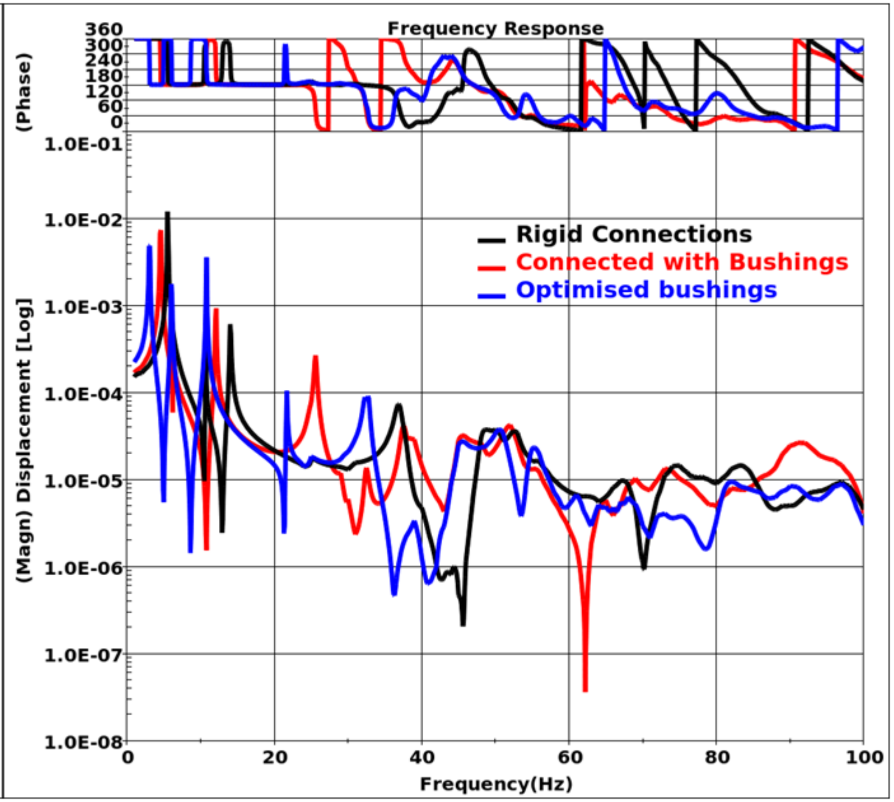


Section Forces calculator



FRF assembly





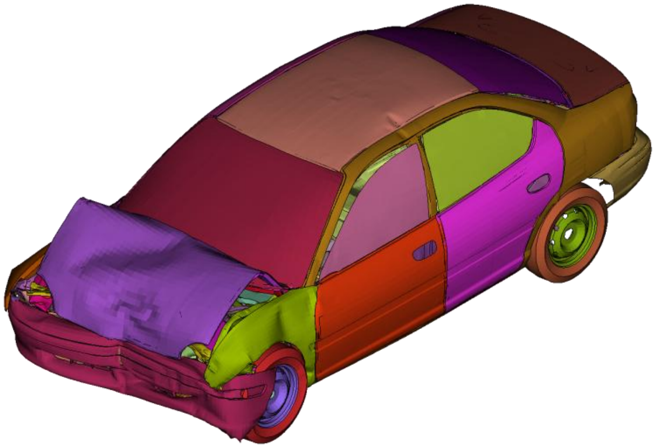
Comparison studies

The Challenge: Comparison studies

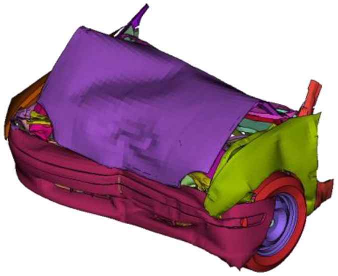
The Needs	Reduced memory requirements	Evaluation of design changes	Reduced repeated actions for all models	Integrate test data
The Means	Smart loading of results only for the area of interest	1. Calculation & graphical display of differences 2. Spreadsheet based comparison of results 3. Synchronised models' animation	Smart tools for transferring attributes between models	1. Image/Video matched to model's view 2. Video synchronised with model's animation 3. Video tracking 4. 3D & 2D display of test results
The Benefits	More models can be compared with the same memory resources	Well justified conclusions on design changes	1. Time saving 2. Easy & smooth processing	1. Check validity of FE model & testing 2. Exploit test results that are not available from FE

Reduced memory requirements

How many models can be compared with 4GB of RAM ?



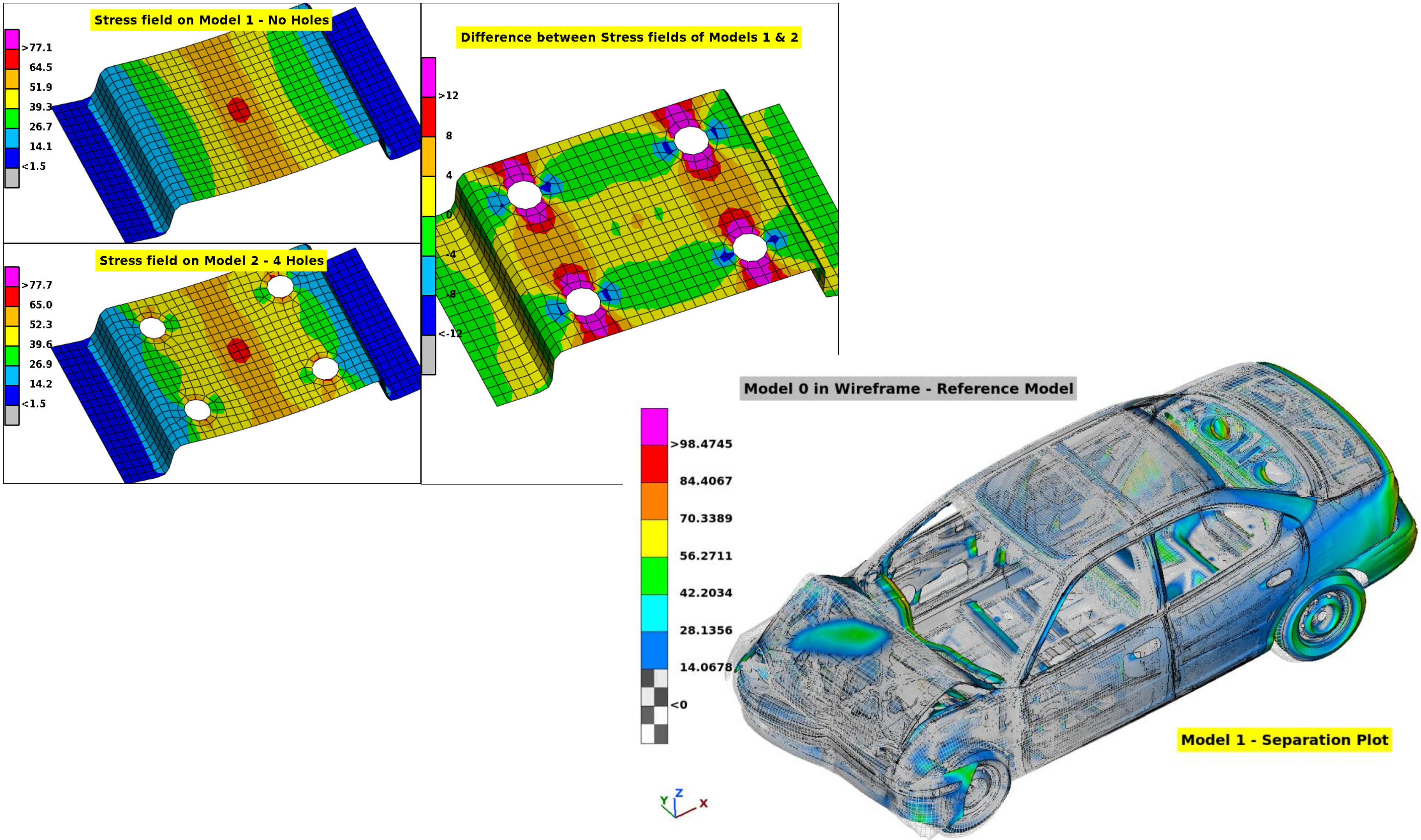
Whole model:
5M elements
10 states
≈ 2 models



Parts of interest:
2M elements
10 states
≈ 4 models

Evaluation of design changes

Results comparison between models with non-compatible mesh



Evaluation of design changes

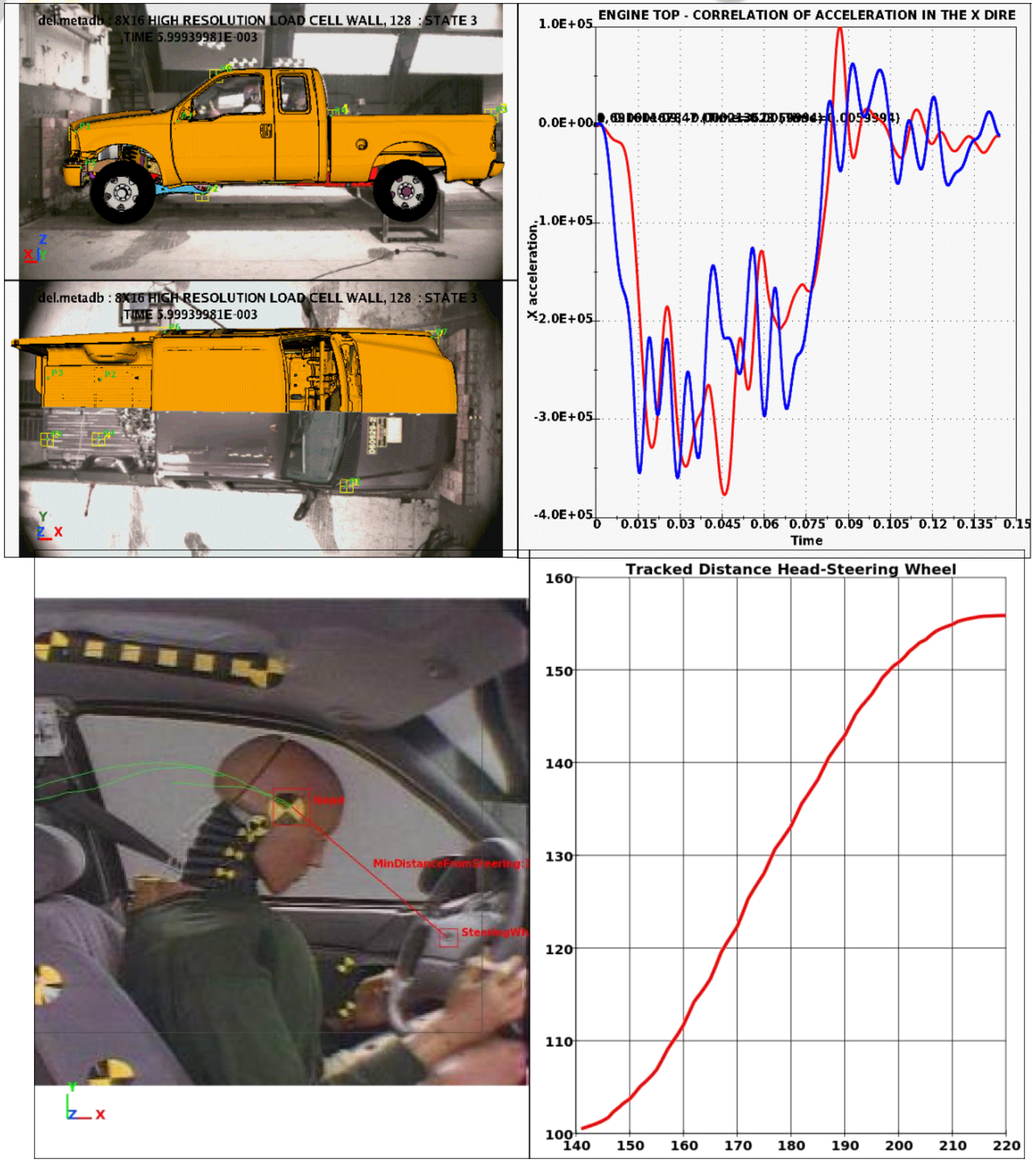
Multi Model,State Statistics

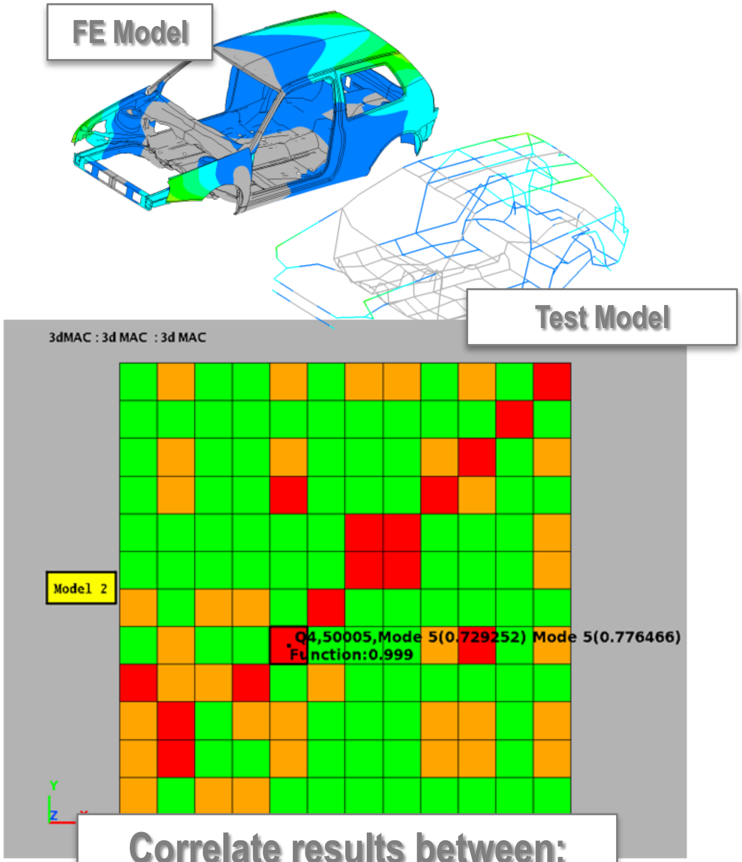
Id	State 1			State 2			State 3			State 4			Max	Max at	Min	Min at
	Model 0	Model 1	%	Model 0	Model 1	%	Model 0	Model 1	%	Model 0	Model 1	%				
31	475	484	1.81	445	489	9.79	475	496	4.31	475	496	4.31	495.916	Model 1,State 3	445.056	Model 0
44	477	601	26.1	501	592	18.1	502	492	-1.97	502	492	-1.97	601.148	Model 1,State 1	476.743	Model 0
45	424	456	7.5	376	436	16	437	382	-12.5	437	382	-12.5	455.595	Model 1,State 1	375.803	Model 0
48	793	651	-17.9	945	669	-29.2	749	603	-19.4	749	603	-19.4	945.093	Model 0,State 2	603.182	Model 1
51	330	296	-10.4	316	282	-10.8	320	285	-10.9	320	285	-10.9	330.273	Model 0,State 1	281.888	Model 1
52	249	272	9.48	255	262	3.04	250	277	11.1	250	277	11.1	277.466	Model 1,State 4	248.54	Model 0
59	947	950	0.304	910	858	-5.74	914	759	-16.9	914	759	-16.9	949.689	Model 1,State 1	759.071	Model 1
60	947	902	-4.77	832	834	0.213	714	919	28.7	714	919	28.7	946.93	Model 0,State 1	713.583	Model 0
65	336	333	-0.927	314	291	-7.08	301	290	-3.44	301	290	-3.44	335.68	Model 0,State 1	290.444	Model 1
66	360	301	-16.5	292	298	2.27	281	310	10.2	281	310	10.2	359.991	Model 0,State 1	281.45	Model 0
71	405	435	7.45	410	499	21.7	423	544	28.7	423	544	28.7	543.808	Model 1,State 4	405.037	Model 0
72	478	570	19.3	456	596	30.7	458	587	28.2	458	587	28.2	595.673	Model 1,State 2	455.742	Model 0
73	454	466	2.62	510	480	-5.91	599	503	-15.9	599	503	-15.9	598.667	Model 0,State 3	453.837	Model 0
76	419	491	17.3	423	508	20.1	418	512	22.7	418	512	22.7	512.417	Model 1,State 3	417.648	Model 0
77	405	563	39	370	470	26.9	449	533	18.8	449	533	18.8	562.557	Model 1,State 1	370.02	Model 0
122	683	886	29.8	632	753	19.1	786	808	2.82	786	808	2.82	885.919	Model 1,State 1	631.891	Model 0
123	421	640	52.2	750	724	-3.42	547	803	46.8	547	803	46.8	803.142	Model 1,State 4	420.761	Model 0
149	769	744	-3.24	692	735	6.28	646	539	-16.7	646	539	-16.7	768.669	Model 0,State 1	538.82	Model 1
150	358	367	2.57	390	372	-4.67	391	406	3.83	391	406	3.83	406.077	Model 1,State 3	357.971	Model 0
183	336	343	2.01	340	359	5.62	352	370	4.95	352	370	4.95	369.534	Model 1,State 4	336.404	Model 0
1000	0	499	0	0	508	0	0	501	0	0	501	0	508.29	Model 1,State 2	0	Model 0
Min	0	272.112	-17.9265	0	262.248	-29.1833	0	277.466	-19.422	0	277.466	-19.422				
Min at Id	1000	52	48	1000	52	48	1000	52	48	1000	52	48				
Max	946.93	949.689	52.198	945.093	857.897	30.7039	913.572	918.502	46.7661	913.572	918.502	46.7661				
Max at Id	60	59	123	48	59	72	59	60	123	59	60	123				
Sum	1.01E+04	1.12E+04	164	1.02E+04	1.1E+04	113	1E+04	1.09E+04	113	1E+04	1.09E+04	113				

All | Invert | Visible | Pick | Filtering:

Models: all | Show: Visible | All Entities | Stat: Max Function | States: Selected | Cycles: All

Validation & integration of test data





Correlate results between:

FE ⟷ FE

Test ⟷ FE

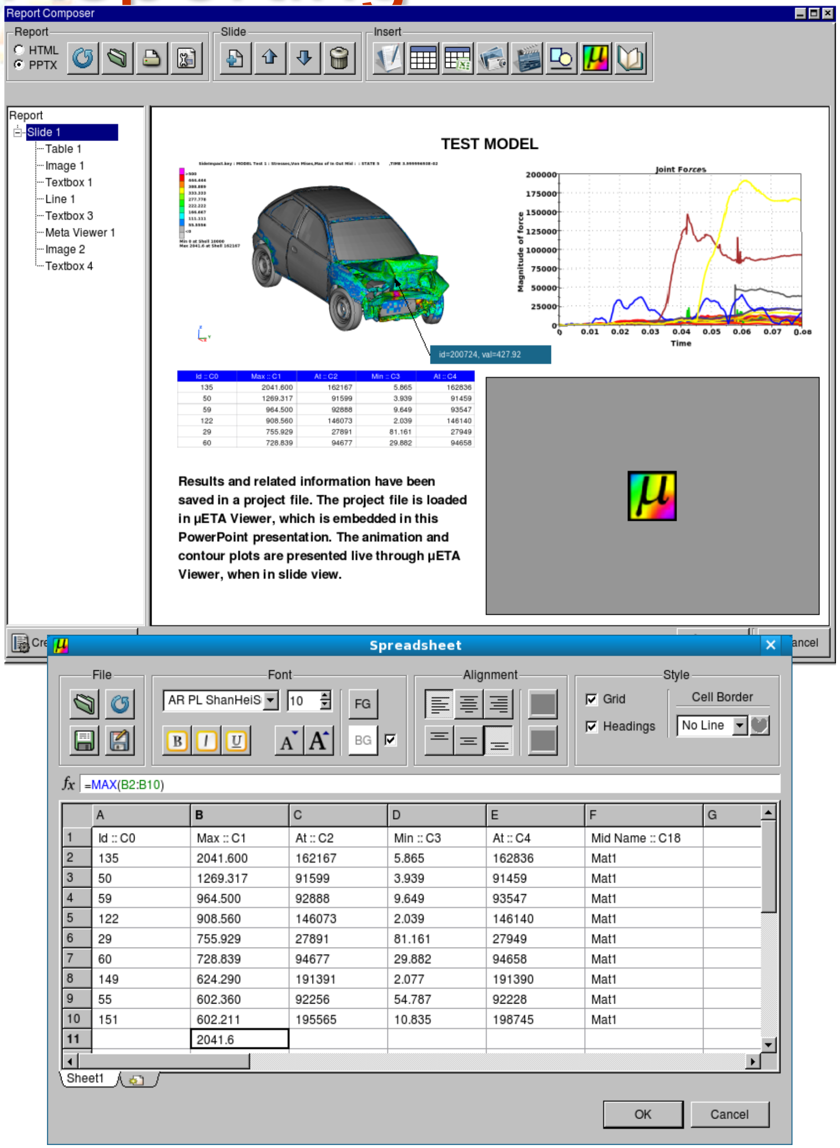
Test ⟷ Test

Communication of results

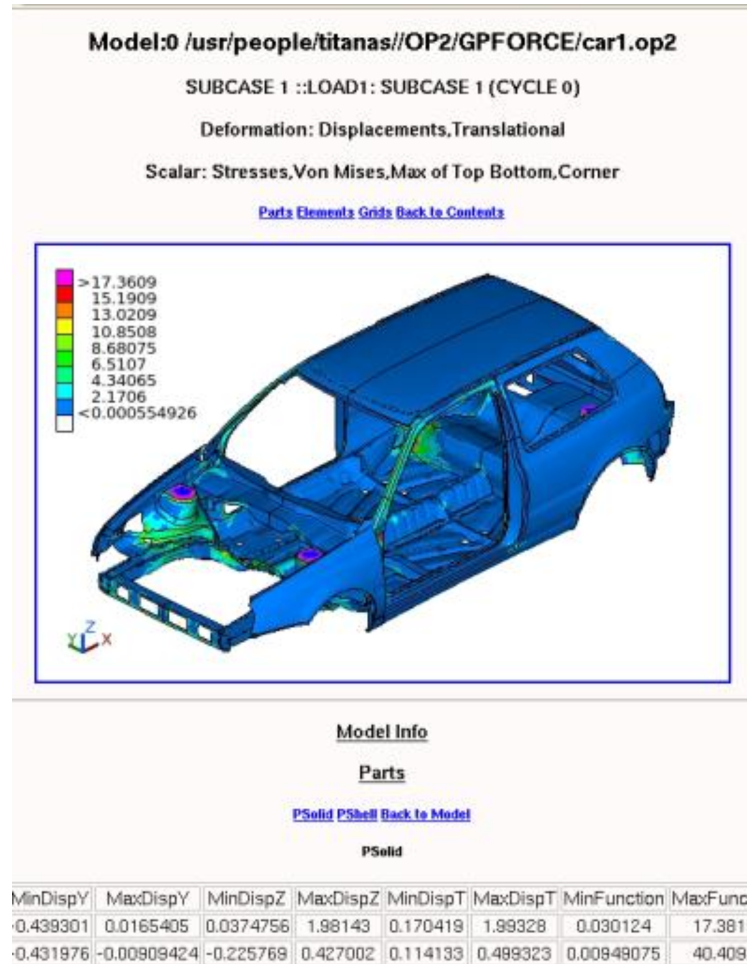
Communication of results

The Challenge	Communication of results			
The Needs	Real time information in clear form	Reporting	Exchange information with the pre-processor	Collaboration with other users
The Means	1. Real time annotations 2. Results in spreadsheets 3. Various options for results identification	1. Embedded report composer 2. Standard report	1. Input assembly information 2. Output of critical areas for pre-processing modifications	1. Free viewer for project files 2. Client-server scheme for the post-processor 3. Output in 3D-XML, VRML
The Benefits	1. Better insight of results 2. No missing information	1. Time saving 2. Easy & fast filling in of reports	1. Time saving 2. Error-free transfer of information	Fast, accurate & effective knowledge transfer

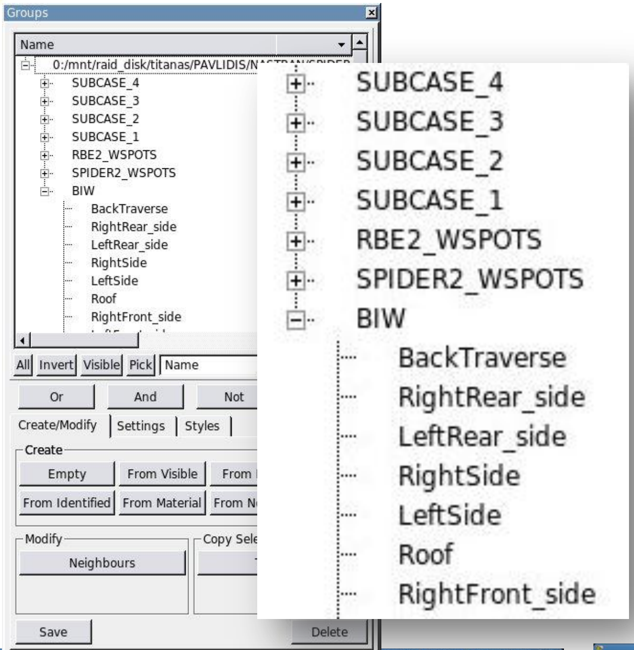
Reporting

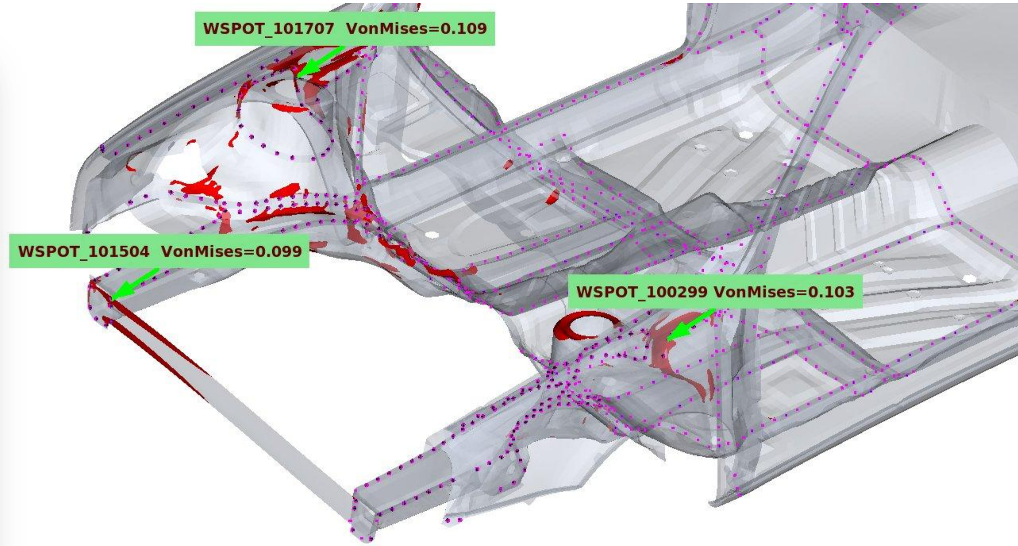


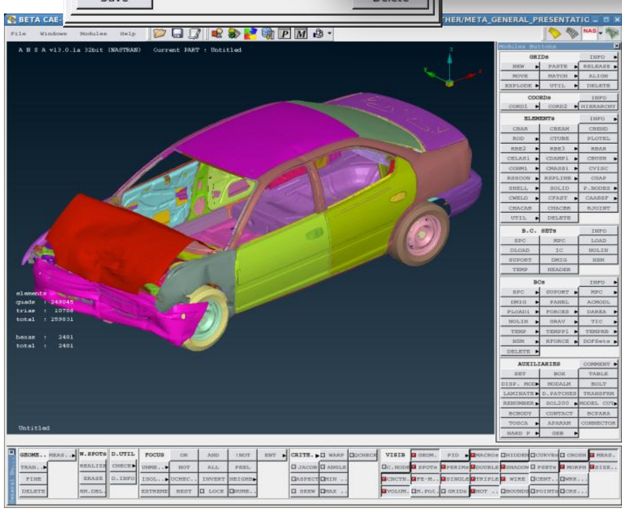
Standard Model Report summary with user selectable contents

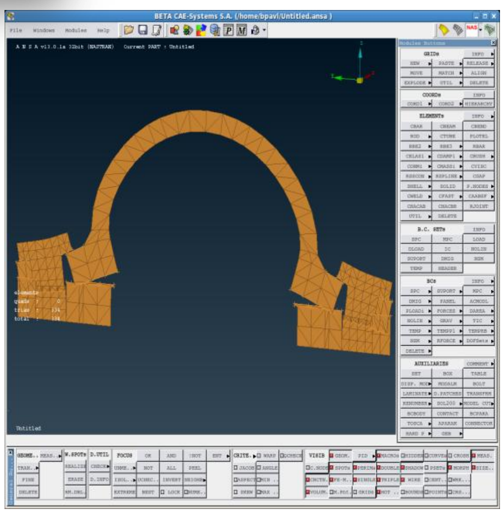


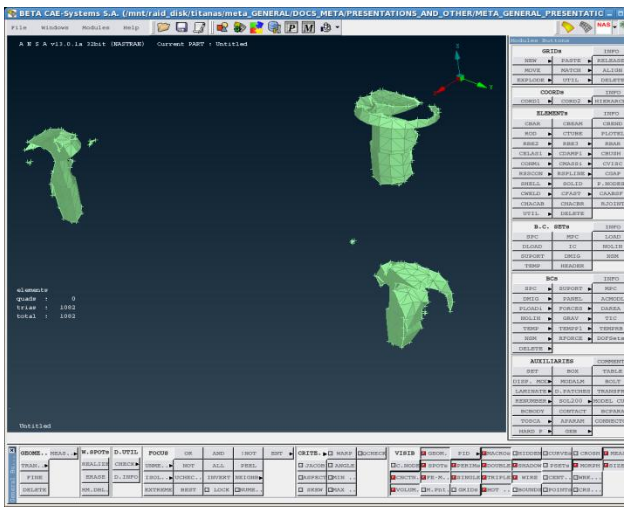
Communication with the pre-processor









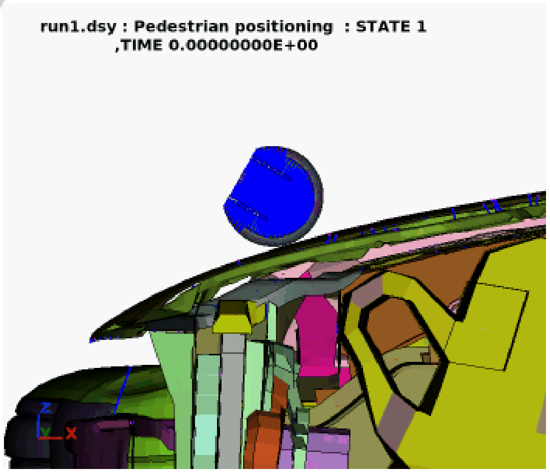


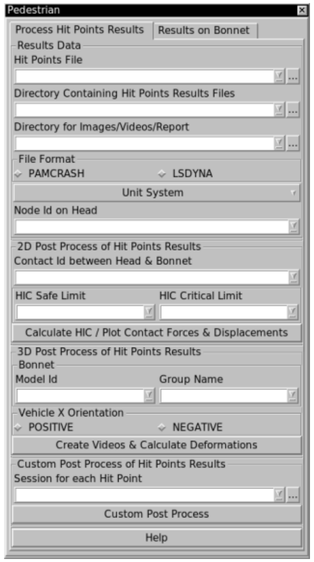
Repeated post-procedures

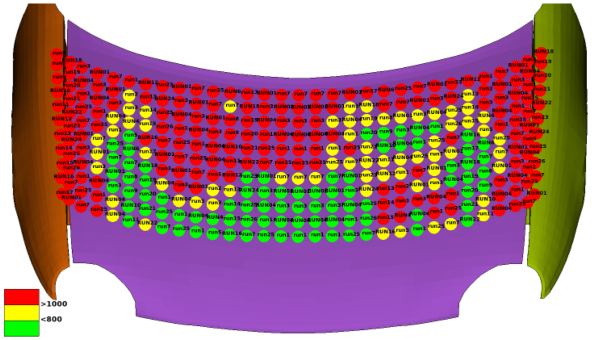
The Challenge: Repeated post-procedures

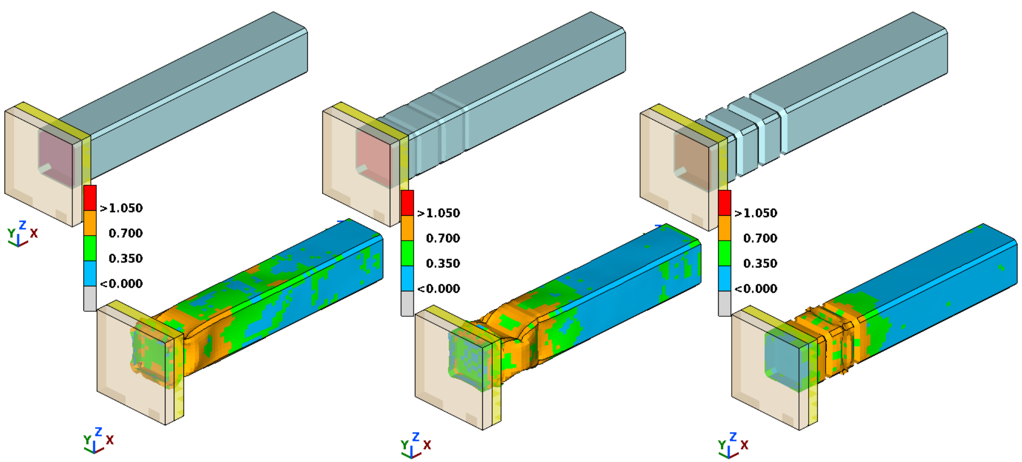
The Needs	Automation of repeated interactive actions	Automation of standard complicated procedures	Integration within optimisation cycles
The Means	1. Shortcuts & macros 2. User toolbars & Toolbar Designer 3. Actions synchronised with states	1. Sessions & session editor 2. Scripts & script editor 3. User toolbars & Toolbar Designer	1. Optimisation set-up 2. Standard ASCII format for exporting design responses
The Benefits	Fast & effortless interactive post-processing	1. Time saving 2. Avoid tedious interactive procedures 3. Error-free outcome 4. Allows easy & extensive verification of the post-processor	1. Fast & effortless coupling with optimisers 2. Integration within the optimisation cycle is independent from the optimiser

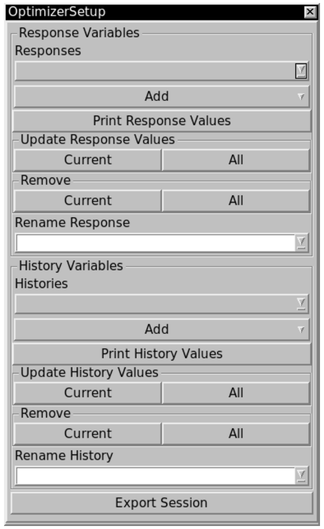
Automation of standard procedures











Conclusions

- General rule: “Get the most out of the available results in the fastest and easiest way”
- The post-processing requirements are diverse
- Performance will always be a challenge following the continuous increase of models size
- Everything that can be automated should be automated. Analysts should spend their time only to real engineering thinking
- Reporting capabilities of post-processors become more and more important