



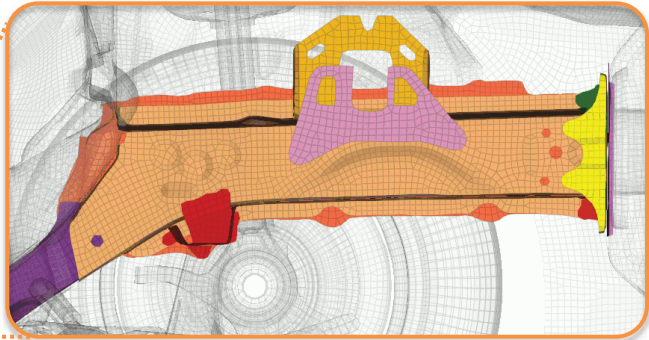
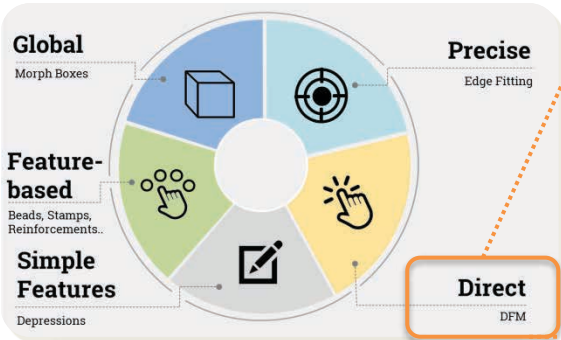
Next generation approach to Crash Simulation Optimization, incorporating CAD-Design parameters

Z.Kanellia, M.Tryfonidis, S.Tzamtzis
BETA CAE Systems, Thessaloniki

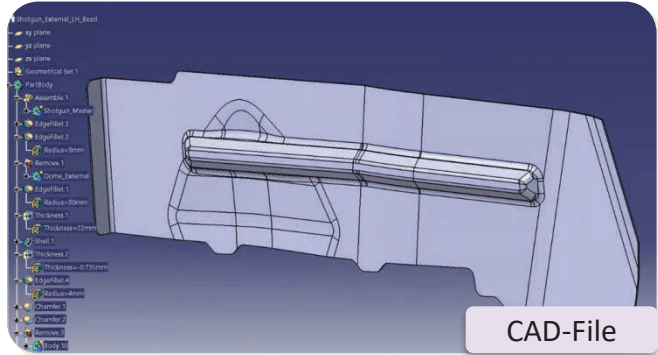
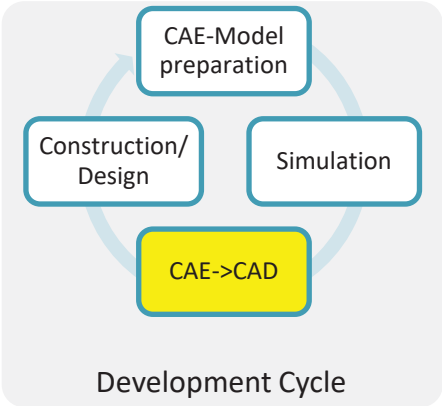
www.beta-cae.com

01 CAE back to CAD

Challenge:
Transfer Design Changes that improve the CAE-Function back to the CAD-Design



ANSA Morph & Design Toolbox



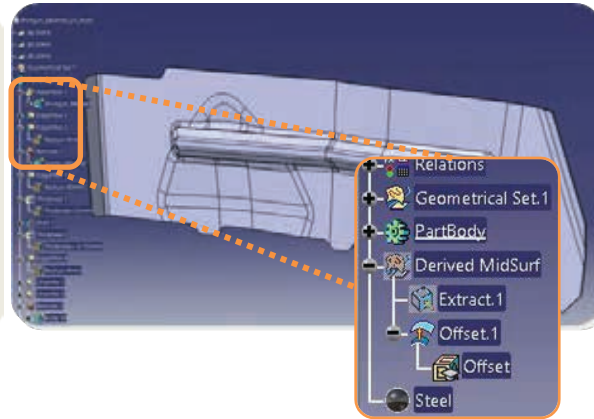
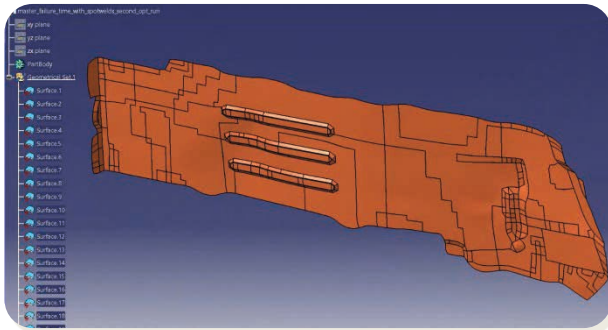
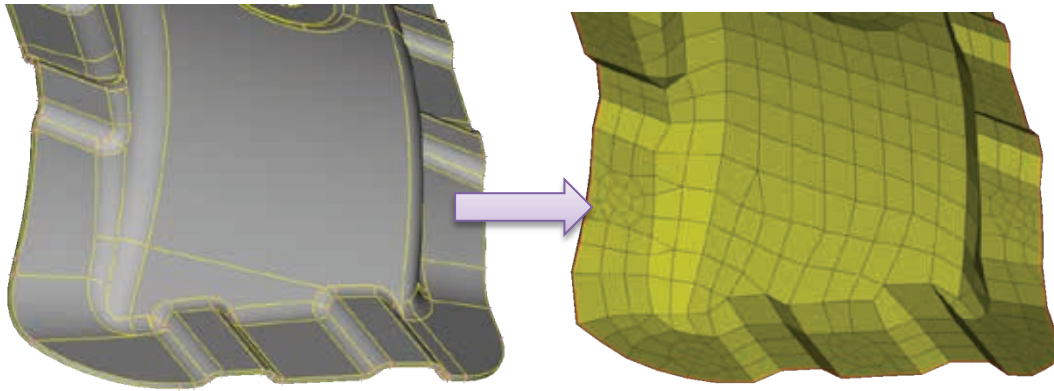
01 CAE back to CAD

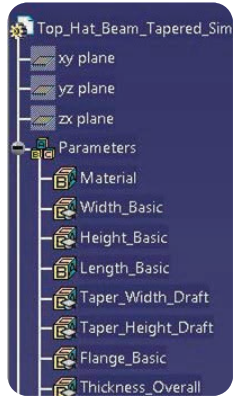
Challenge:

Transfer Design Changes that improve the CAE-Function back to the CAD-Design

Bottlenecks:

- FE-Model is a simplification from the original CAD-Design
- GEOM-export back to CAD results in “dead” geometry
- CAD-History, Constraints and other META-Data not included

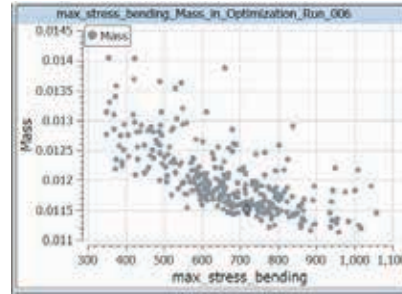




Design Parameters



Automation Service



2nd Optimization

02 Approach

Strategy:

- Design Parameters added in CAD-File
- Perform a 2nd Optimization Cycle

Innovation:

- Design Parameters affected directly during the Optimization Loop

Requirements:

- Low complexity
- High automation
- Traceability



Cross Platform



Scalable



Seamless integration



02 Approach

Strategy:

- Design Parameters added in CAD-File
- Perform a 2nd Optimization Cycle

Innovation:

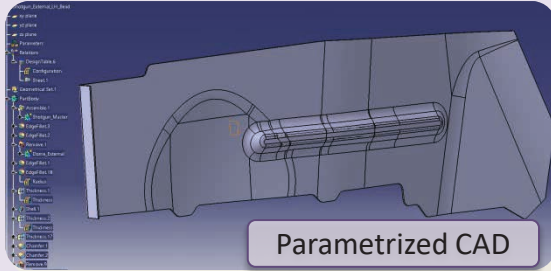
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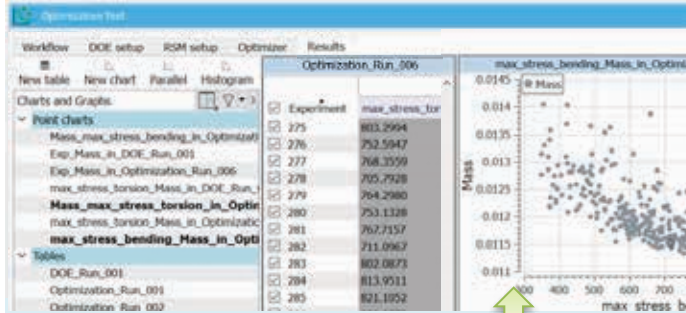
03 Implementation

Input

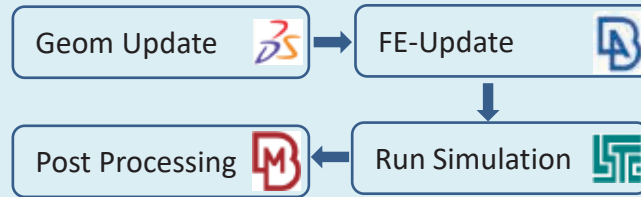


Simulation

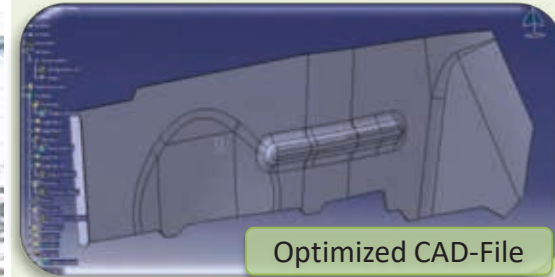
Optimization Process



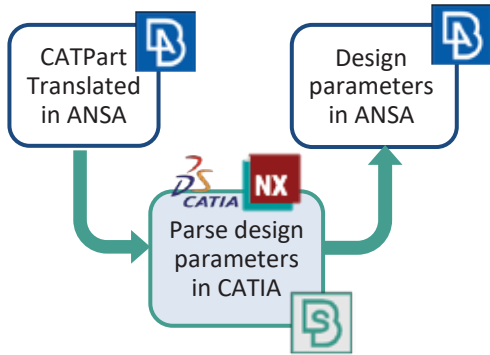
SPDRM Workflow Manager



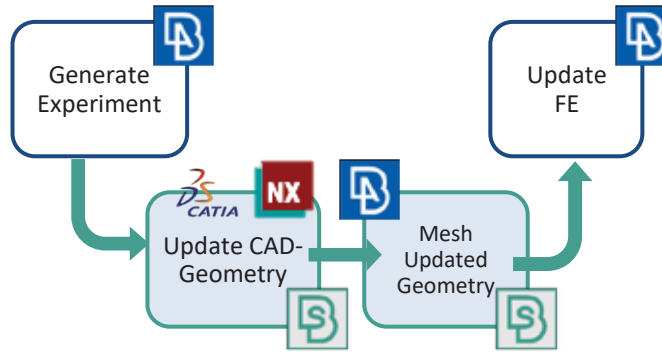
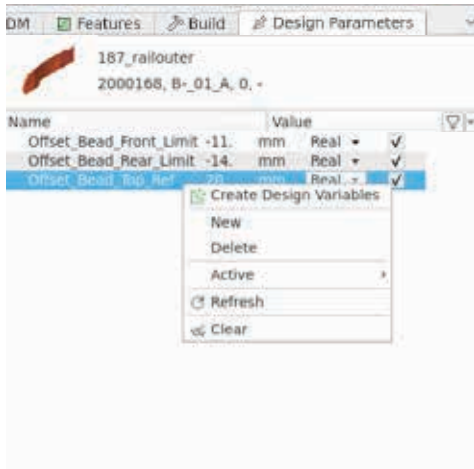
Result



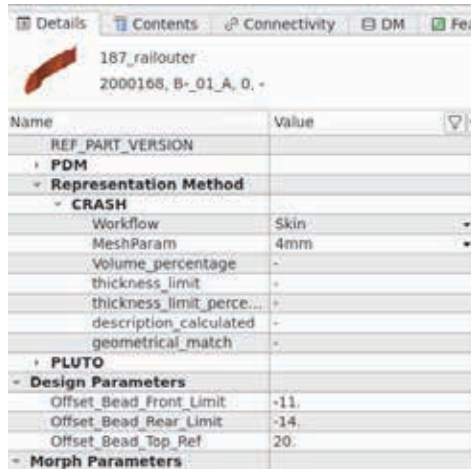
Optimized



Use Case 1: Parse CAD-Parameters



Use Case 2: Update FE



03 Implementation

Process Design

- Automation steps captured in Process templates
- Execute time and resource consuming Tasks on Beta Apps Launchers
- Design parameters overview and Process input Parameters are integrated within Model Browser

03 Implementation

The screenshot displays the KOMVOS SDM Console interface. On the left, a 'Process Instance List' table shows various process instances. On the right, a process flow diagram for 'Update CATPart (133061)*' is visible, featuring tasks like 'input collector', 'Update CATPart', and 'Prepare ANSA Part'.

Name	State	Application Path	Creation Date	Owner
Update CATPart	II	Update CATPart	03-Apr-2023...	CAPOS t...
Update CATPart	II	Update CATPart	31-Mar-2023...	CAPOS t...
Update CATPart	II	Update CATPart	13-Dec-2022...	CAPOS t...
Update CATPart	II	Update CATPart	19-Oct-2022...	CAPOS t...
Update CATPart d...	II	Update CATPart...	14-Oct-2022...	CAPOS t...
Update CATPart d...	II	Update CATPart...	14-Oct-2022...	CAPOS t...
Update CATPart d...	II	Update CATPart...	13-Oct-2022...	CAPOS t...
Update CATPart d...	II	Update CATPart...	13-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	13-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
Update CATPart	II	Update CATPart	12-Oct-2022...	CAPOS t...
Update CATPart	II	Update CATPart	11-Oct-2022...	CAPOS t...
Update CATPart	II	Update CATPart	11-Oct-2022...	CAPOS t...
Update CATPart	II	Update CATPart	27-May-202...	tryfon
Update CATPart	II	Update CATPart	27-May-202...	tryfon

DM : http://spdrm-dev-app2.localdomain:6080/

Process Design

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Execution

- Communication exchange about process status with main ansa
- Access to process statistics
- Traceability of process related data and meta-data

03 Implementation

The screenshot displays the KOMVOS SDM Console interface. On the left, a 'Process Instance List' table shows various process instances. The table has columns for Name, State, Application Path, Creation Date, and Owner. The right side of the screenshot shows a process design diagram for 'Update CATPart (133061)*'. The diagram includes a green 'input collector' box, a yellow 'Update CATPart' box, and a white 'Prepare ANSA Part' box. The 'KOMVOS SDM CONSOLE' logo is visible in the top right of the diagram area.

Name	State	Application Path	Creation Date	Owner
Update CATPart	II	Update CATPart	03-Apr-2023...	CAPOS t...
Update CATPart	II	Update CATPart	31-Mar-2023...	CAPOS t...
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Parse CATIA Para...	II	Parse CATIA Par...	13-Oct-2022...	CAPOS t...
Parse CATIA Para...	II	Parse CATIA Par...	12-Oct-2022...	CAPOS t...
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Update CATPart	II	Update CATPart	12-Oct-2022...	CAPOS t...
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03 Implementation

The screenshot displays the Optimization Tool interface. The top menu includes Workflow, DOE setup, RSM setup, Optimizer, and Results. The main window shows a tree view on the left with 'OPTIMIZATION_TASK_1' and its sub-tasks: Pre-Processing, Length_beads, Height_beads, Width_beads, Height_rail, Width_rail, and mass. The central 'Experiments' table lists various runs with columns for 'DOE Run', 'front_height', 'side_height', 'side_width', and 'rsm_1'. A blue box highlights the 11th row of the table, and an arrow points from this row to a detailed view of 'DOE Run_001' on the right. This detailed view shows the experiment's progress, a 'Show folder' and 'Show log' button, and a 'Monitor' section with a legend for Total (100), Active (4), Pending (89), Succeeded (7), and Failed (0).

DOE Run	front_height	side_height	side_width	rsm_1
1	1.291928	3.313131	2.929293	0.0444
2	1.277274	2.767677	1.383839	0.0468
3	1.494949	2.181818	4.242424	0.2021
4	0.888889	2.383838	0.252525	0.1911
5	0.888889	0.848485	4.090909	0.5696
6	2.020202	1.777774	4.040404	0.3233
7	0.444445	0.000000	0.808081	0.1
8	0.444445	1.888889	4.252525	0.1
9	0.444445	1.977798	4.787980	0.9793
10	0.444445	1.977798	4.252525	0.1
11	1.291928	3.313131	2.929293	0.0444
12	0.202020	1.777774	1.282828	0.9090
14	1.257525	1.111111	4.141414	0.2929
15	0.808080	0.383838	0.202020	0.8181
16	0.202020	0.565657	1.333333	0.9494
17	0.989897	1.535354	2.424242	0.5858

Process Design

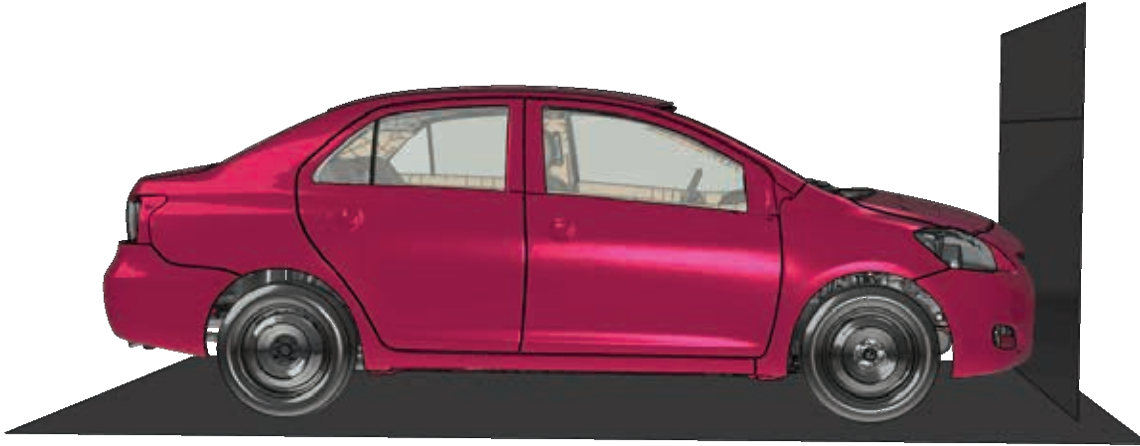
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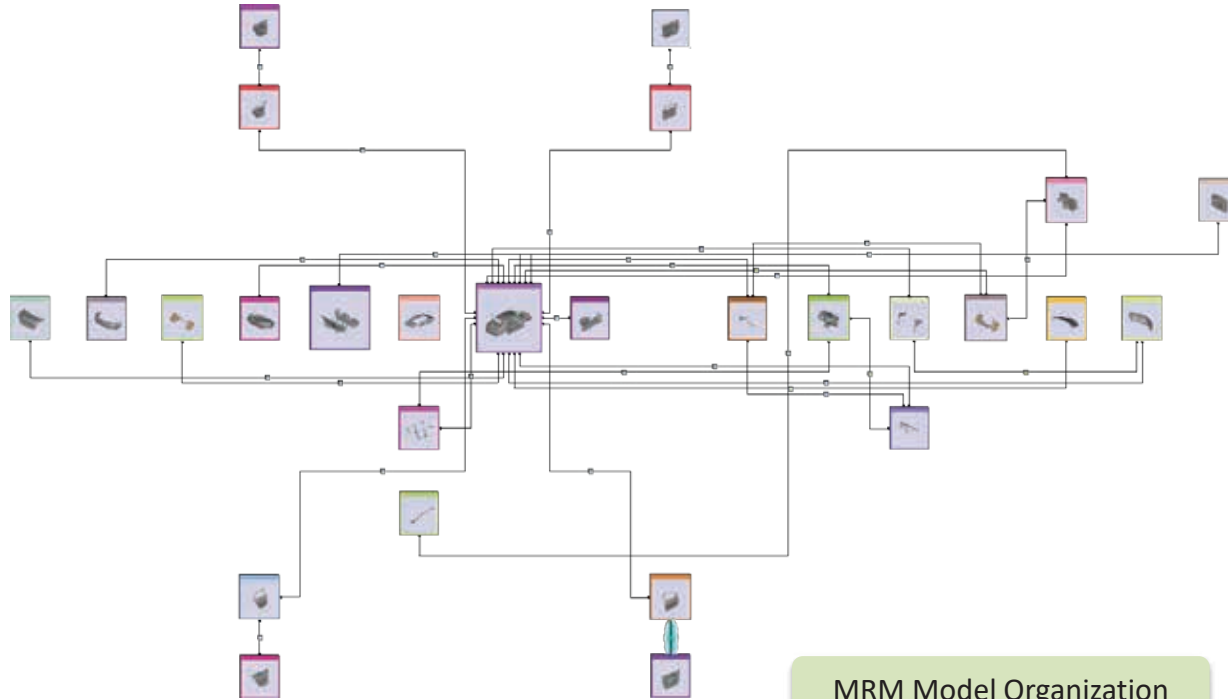
04 Example

Yaris Front Crash 56 km/h



04 Example

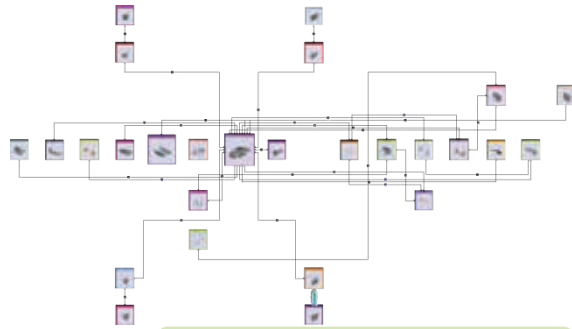
Yaris Front Crash 56 km/h



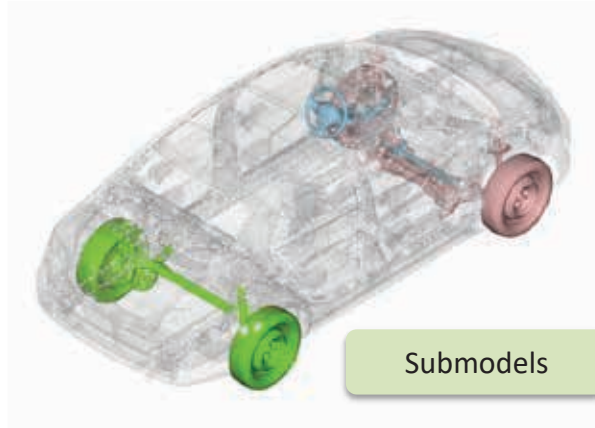
MRM Model Organization

- fmvss208_yaris_r01_sedan_001_01_01
 - Model Setup Entities
 - fmvss208_01
 - added_mass
 - contacts
 - controls
 - cross_sections
 - database
 - dummy_springs
 - gravity
 - ground
 - hourglass_cards
 - initial_velocity
 - materials
 - rigid_wall
 - rigid_wall_transformation
 - sensors
 - crash_assembly_yaris_r01_sedan_crash_001
 - 010_connections_yaris_r01__crash_fe_001
 - 100_biw_yaris_r01__crash_fe_001
 - 220_door_fl_yaris_r01__crash_fe_001
 - 230_door_fr_yaris_r01__crash_fe_001
 - 240_door_rl_yaris_r01__crash_fe_001
 - 250_door_rr_yaris_r01__crash_fe_001
 - 260_hood_yaris_r01__crash_fe_001
 - 270_trunk_yaris_r01__crash_fe_001
 - 280_windows_yaris_r01__crash_fe_001
 - 305_central_console_yaris_r01__crash_fe_001
 - 310_ip_yaris_r01__crash_fe_001
 - 315_ip_beam_yaris_r01__crash_fe_001

04 Example



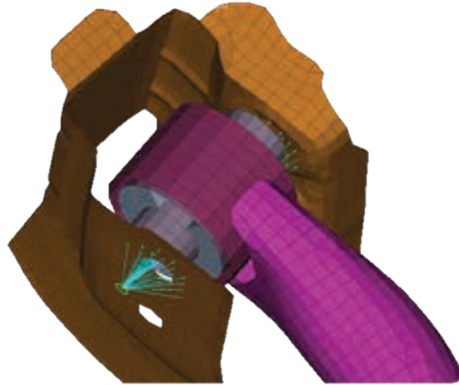
MRM Model Organization



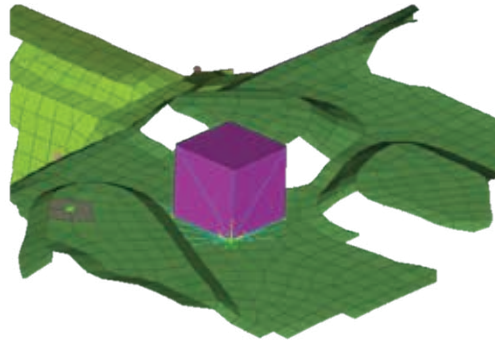
Submodels

Yaris Front Crash 56 km/h

- fmvss208_yaris_r01_sedan_001_01_01
 - Model Setup Entities
 - fmvss208_01
 - added_mass
 - contacts
 - controls
 - cross_sections
 - database
 - dummy_springs
 - gravity
 - ground
 - hourglass_cards
 - initial_velocity
 - materials
 - rigid_wall
 - rigid_wall_transformation
 - sensors
 - crash_assembly_yaris_r01_sedan_crash_001
 - 010_connections_yaris_r01__crash_fe_001
 - 100_biw_yaris_r01__crash_fe_001
 - 220_door_fl_yaris_r01__crash_fe_001
 - 230_door_fr_yaris_r01__crash_fe_001
 - 240_door_rl_yaris_r01__crash_fe_001
 - 250_door_rr_yaris_r01__crash_fe_001
 - 260_hood_yaris_r01__crash_fe_001
 - 270_trunk_yaris_r01__crash_fe_001
 - 280_windows_yaris_r01__crash_fe_001
 - 305_central_console_yaris_r01__crash_fe_001
 - 310_ip_yaris_r01__crash_fe_001
 - 315_ip_beam_yaris_r01__crash_fe_001



Connectors between Modules



Output Requests

05 Optimization 1



Yaris Front Crash 56 km/h

Design Space Exploration

- Addition of Beads
- Component's Cross Section

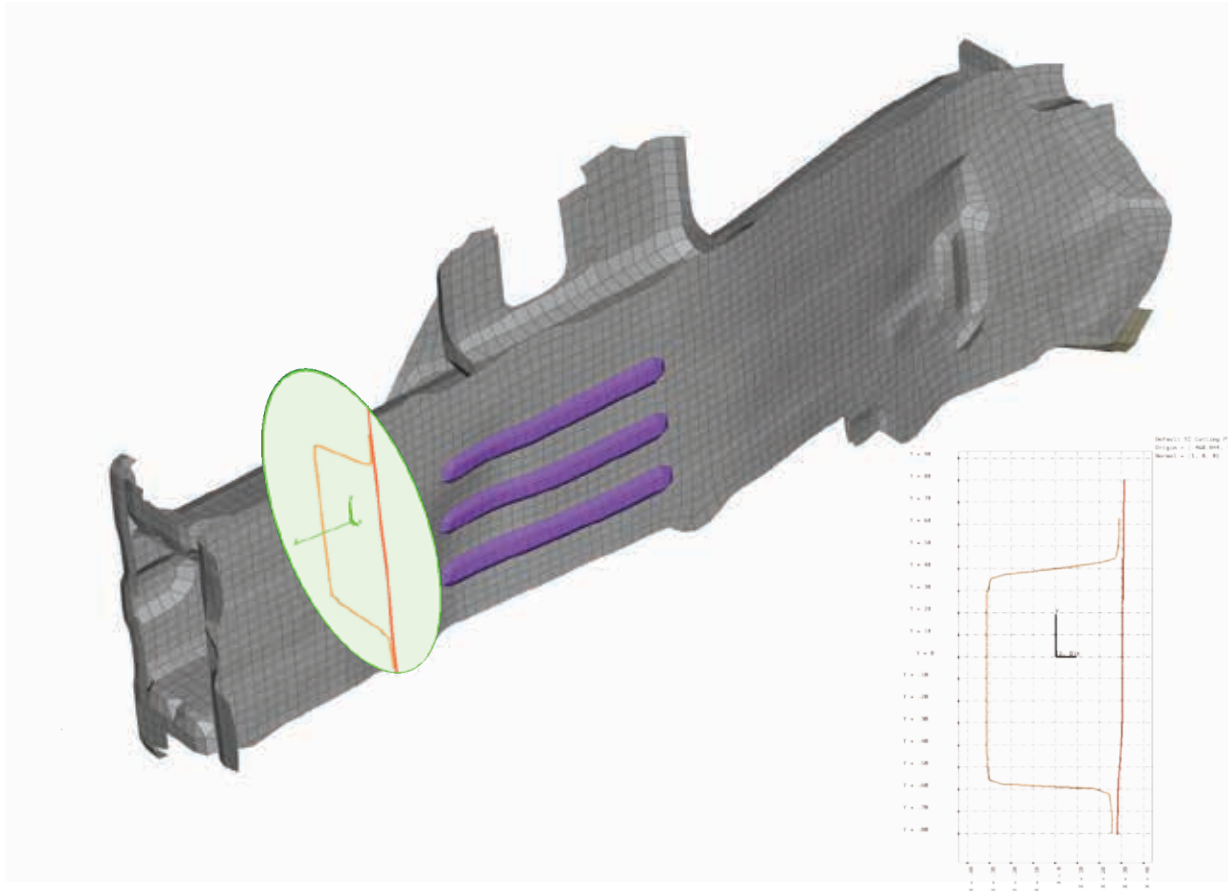


05 Optimization 1

Yaris Front Crash 56 km/h

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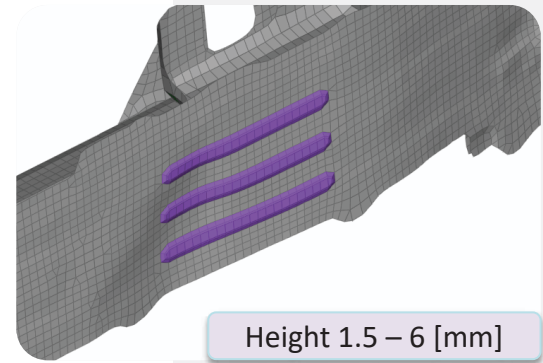
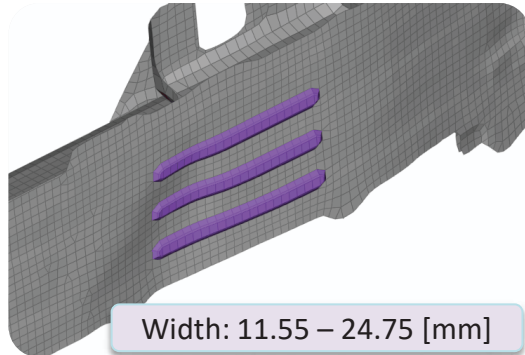
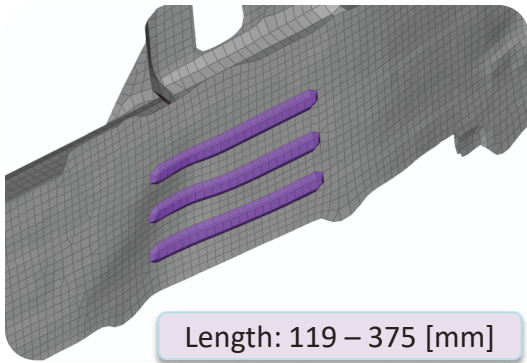
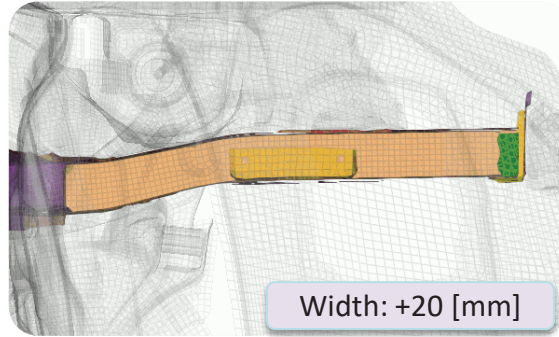
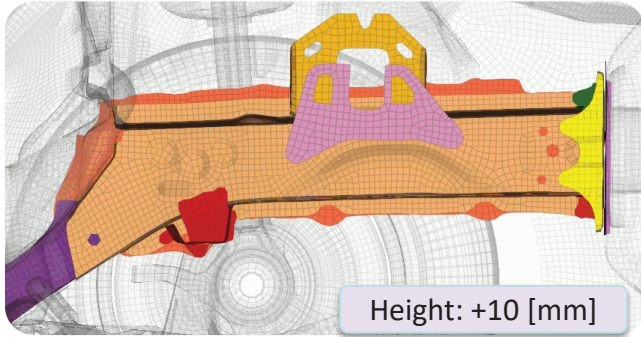
Yaris Front Crash 56 km/h

Design Space Exploration

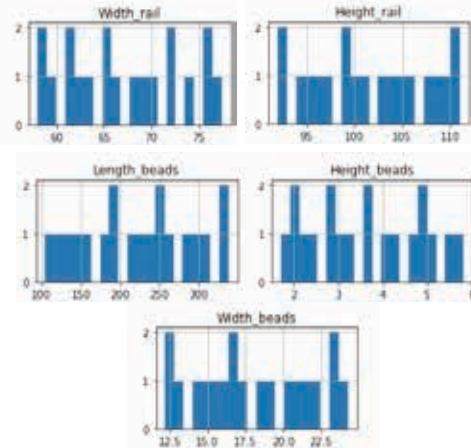
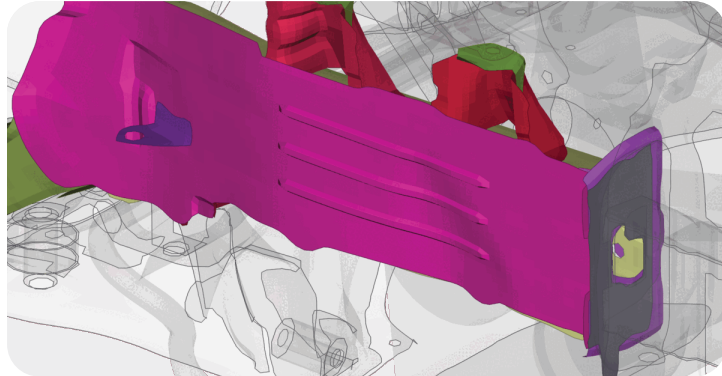
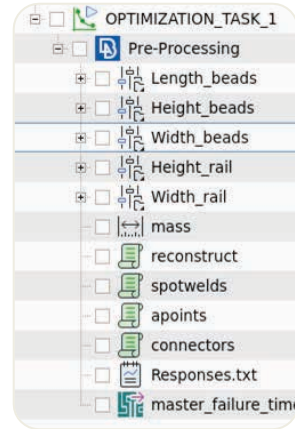
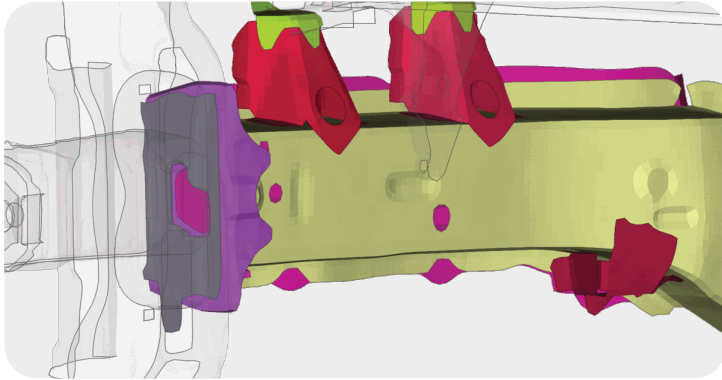
- Addition of Beads
- Component's Cross Section

Design Variables Overview

- Cross Section Width & Height
- Bead Length, Width & Height



05 Optimization 1



Yaris Front Crash 56 km/h

Design Space Exploration

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- Component's Cross Section

Design Variables Overview

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- Bead Length, Width & Height

Design of Experiments (DOE)

- 20 experiments

05 Optimization 1

Yaris Front Crash 56 km/h

Design Space Exploration

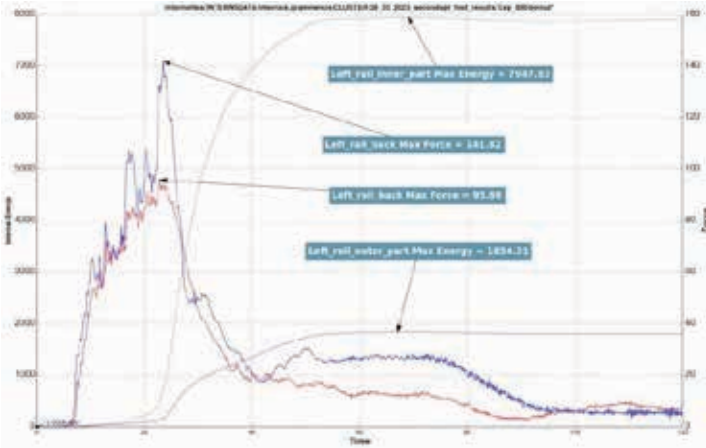
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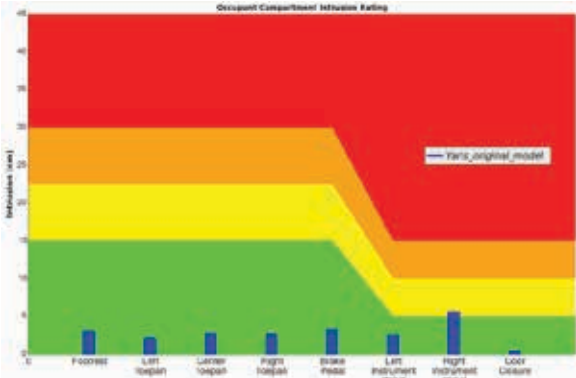
- Cross Section Width & Height
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Design of Experiments (DOE)

- 20 experiments
- Key results: Intrusions based on IIHS protocol and Cross Section force values



Key Results on Cross Sections



IIHS Structural Rating

05 Optimization 1

Yaris Front Crash 56 km/h

Design Space Exploration

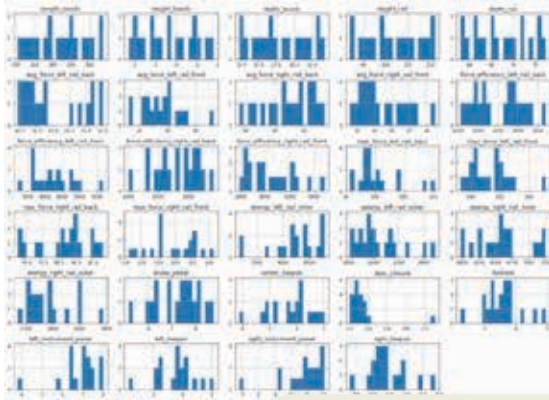
- Addition of Beads
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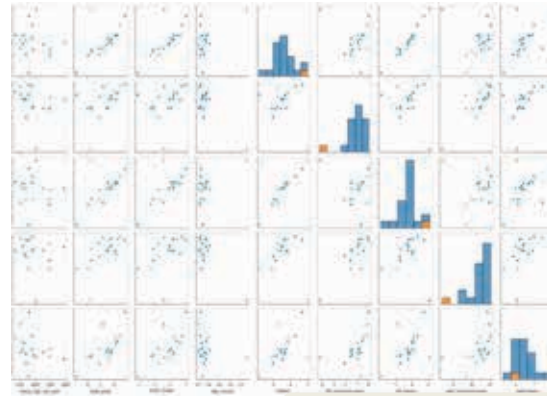
- Cross Section Width & Height
- Bead Length, Width & Height

Design of Experiments (DOE)

- 20 experiments
- Key results: Intrusions based on IIHS protocol and Cross Section force values
- Predictive Metrics



Distribution Plots



Scatter Plots



Correlation Matrix

	median	mean	std			
avg_force_left_rail_bead	0.75	0.81	0.09	0.94	0.99	0.96
avg_force_left_rail_bead_w	0.71	0.73	0.06	0.97	0.99	0.95
avg_force_right_rail_bead	0.98	0.99	0.21	0.76	0.73	0
avg_force_right_rail_bead_h	1.09	1.19	0.39	0.74	1.19	0
force_efficiency_left_rail_bead	117.11	108.89	104.71	0.166	101.38	0.22
force_efficiency_left_rail_bead_w	463.71	476.89	436.07	0.03	463.89	0.07
force_efficiency_right_rail_bead	61.22	61.85	60.21	0.19	62.81	0
force_efficiency_right_rail_bead_h	611.58	568.34	270.93	0.179	564.08	0
max_force_left_rail_bead	2.52	2.77	2.41	3.18	2.54	0.16
max_force_left_rail_bead_w	0.50	0.42	0.39	0.93	0.87	0.11
max_force_right_rail_bead	0.34	0.42	0.75	0.99	0.47	0.21
max_force_right_rail_bead_h	0.28	0.32	0.91	0.81	0.44	0
energy_left_rail_inver	343.69	354.19	369.04	0.03	350.39	0.12
energy_left_rail_inver_w	134.93	143.38	151.93	0.29	115.21	0.15
energy_right_rail_inver	282.32	294.39	292.83	0.04	300.95	0
energy_right_rail_inver_w	121.41	111.62	119.91	0.47	101.88	0.07
beads_padded	0.34	0.79	0.77	0.89	0.61	0
cross_section	0.87	0.83	0.80	0.71	0.68	0
door_slamark	0.09	0.09	0.14	0.71	0.71	0
doorstop	0.44	0.44	0.52	0.46	0.48	0
left_instrument_panel	0.99	0.94	0.91	0.71	0.62	0
left_keystone	0.46	0.46	0.37	0.48	0.49	0
right_instrument_panel	0.97	0.99	1.16	0.91	0.92	0
right_keystone	0.46	0.41	0.37	0.44	0.44	0.08

Predictive Power Score

05 Optimization 1

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- Bead Length, Width & Height

Design of Experiments (DOE)

- 20 experiments
- Key results: Intrusions based on IIHS protocol and Cross Section force values
- Predictive Metrics

Decision Making

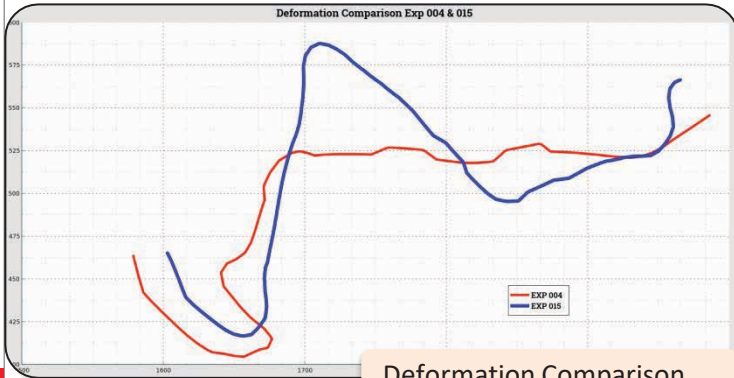
- ML-Based Predictive tools utilized



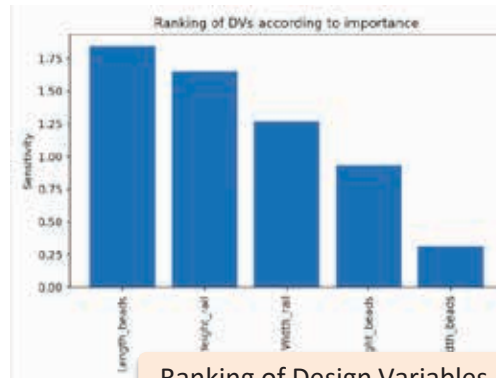
Exp 004



Exp 015



Deformation Comparison

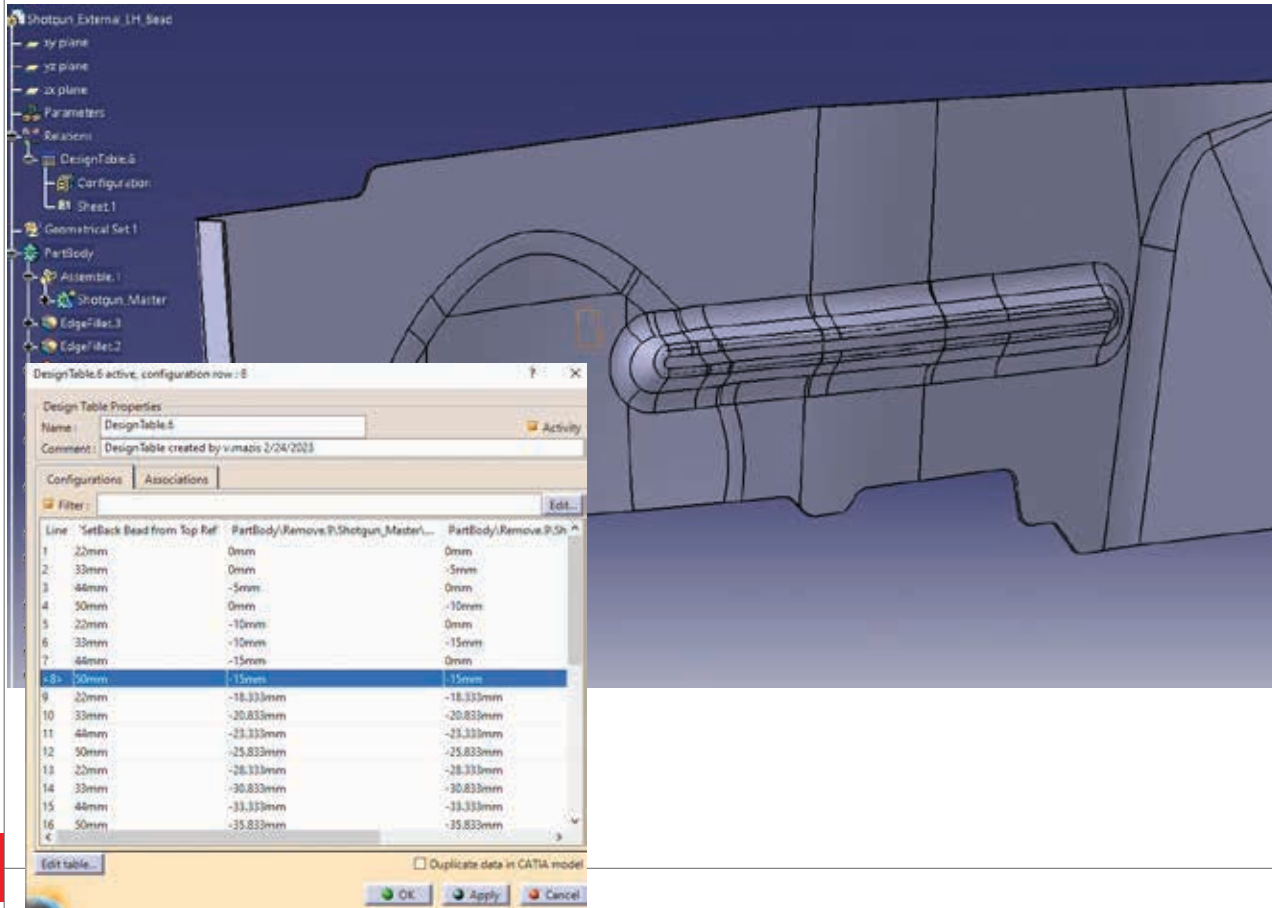


Ranking of Design Variables

06 New CAD Version

CAD Design Parameters

- In collaboration with CAD-Design team, Design Parameters are added
- The Final design deviates from the original CAE-Engineers proposal, due to various limitations



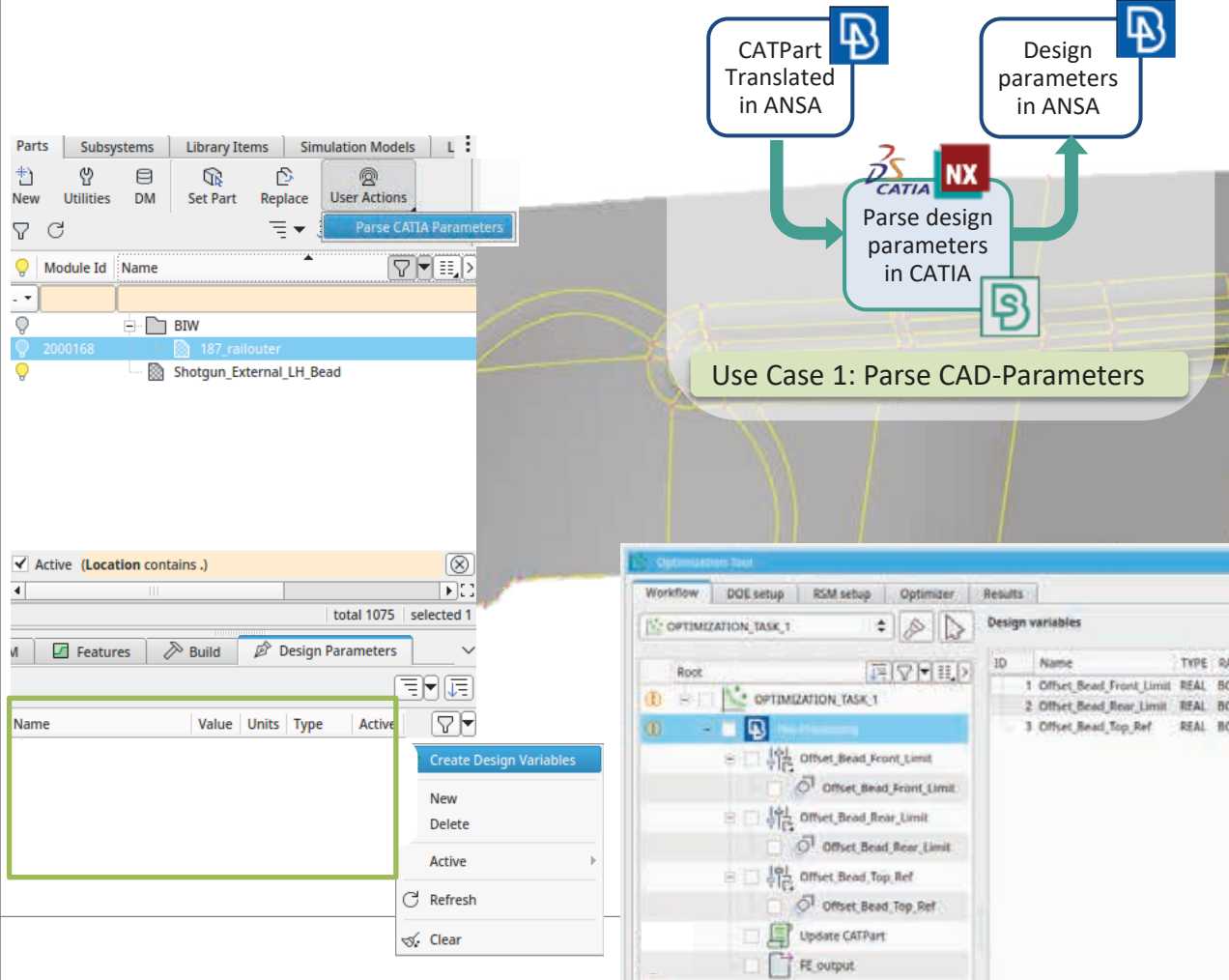
Performance CAE engineer



Performance design engineer

Parts design engineer

07 2nd Optimization

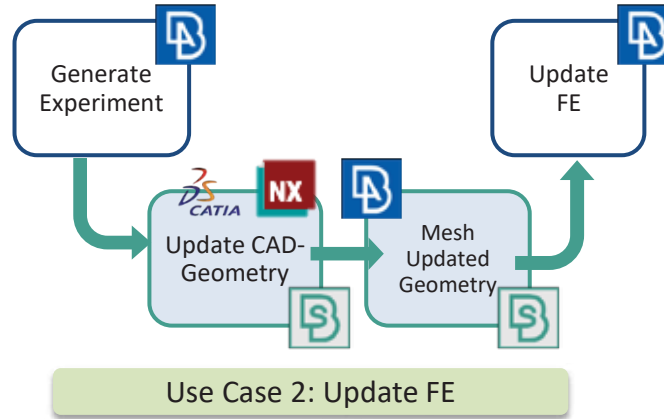


CAD Design Parameters

- In collaboration with CAD-Design team, Design Parameters are added
- The Final design deviates from the original CAE-Engineers proposal, due to limitations
- For a CATIA, a Design Table is prepared providing all parameters eligible for this optimization

Workflow Preparation

- Parse CAD-Parameters
- Create Design Variables
- Include the Update Catpart Call



07 2nd Optimization

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Workflow Preparation

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- Create Design Variables
- Include the Update Catpart Call

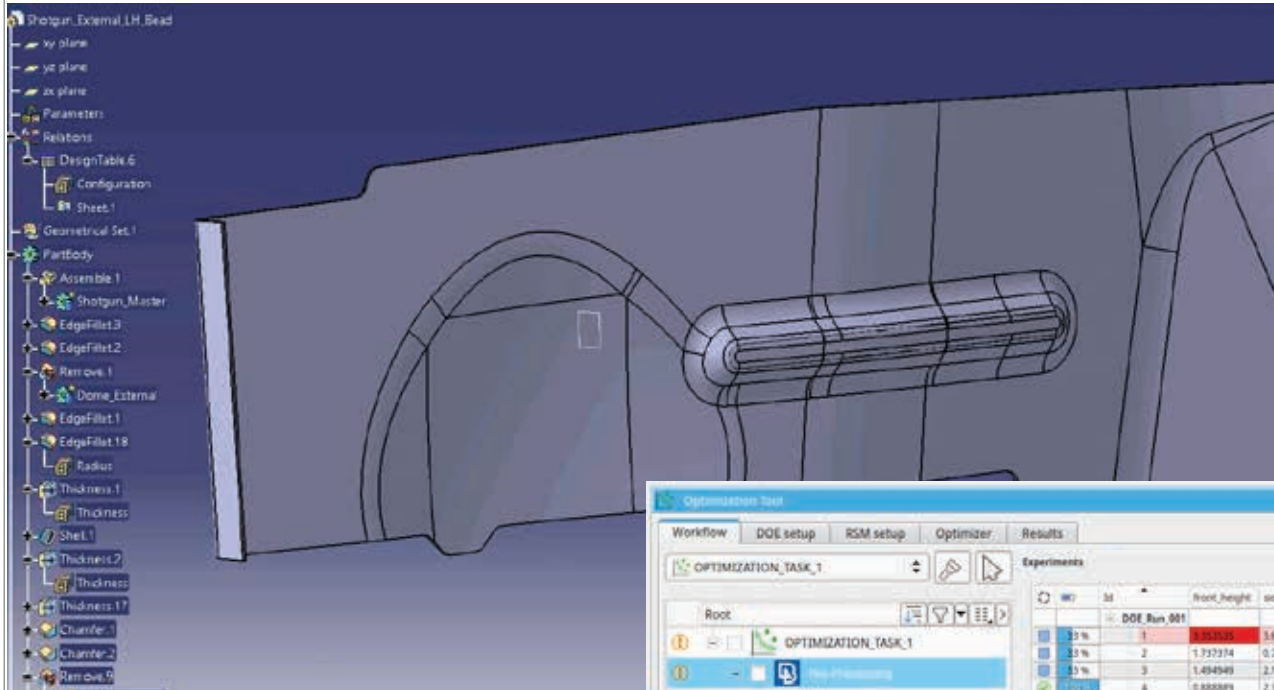
DOE Execution

- Update-FE action is run Per Experiment production

Optimization tool interface showing workflow and results.

DOE Run	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Front_height	1.353035	1.737374	1.494949	0.888889	0.680809	2.626262	0.646465	0.484848	0.303030	0.363636	1.292929	0.878788	0.939394	1.252525	4.000000	2.262626	0.969697
side.3	5.536	0.767	2.181	2.385	0.848	1.737	0.000	1.090	1.079	2.426	3.313	0.969	1.171	3.111	0.363	0.989	1.335

07 2nd Optimization

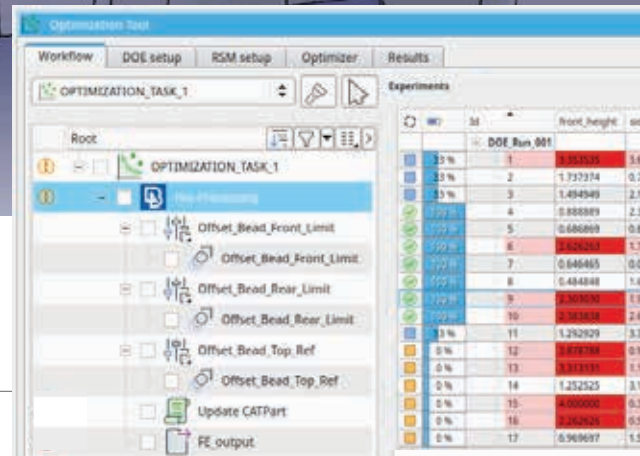


CAD Design Parameters

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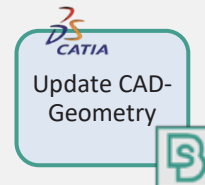
Workflow Preparation

- Parse CAD-Parameters
- Create Design Variables
- Include the Update Catpart Call

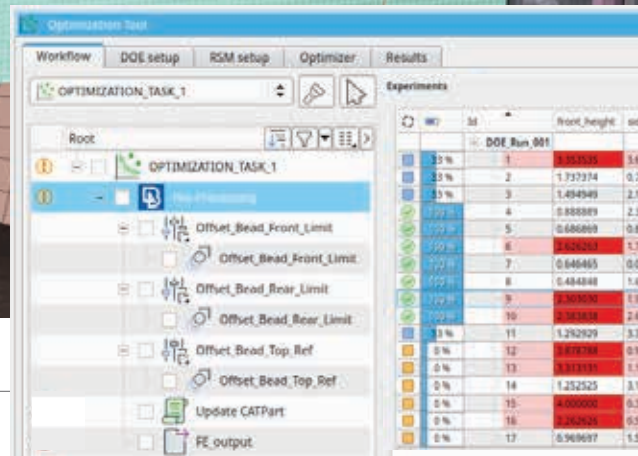
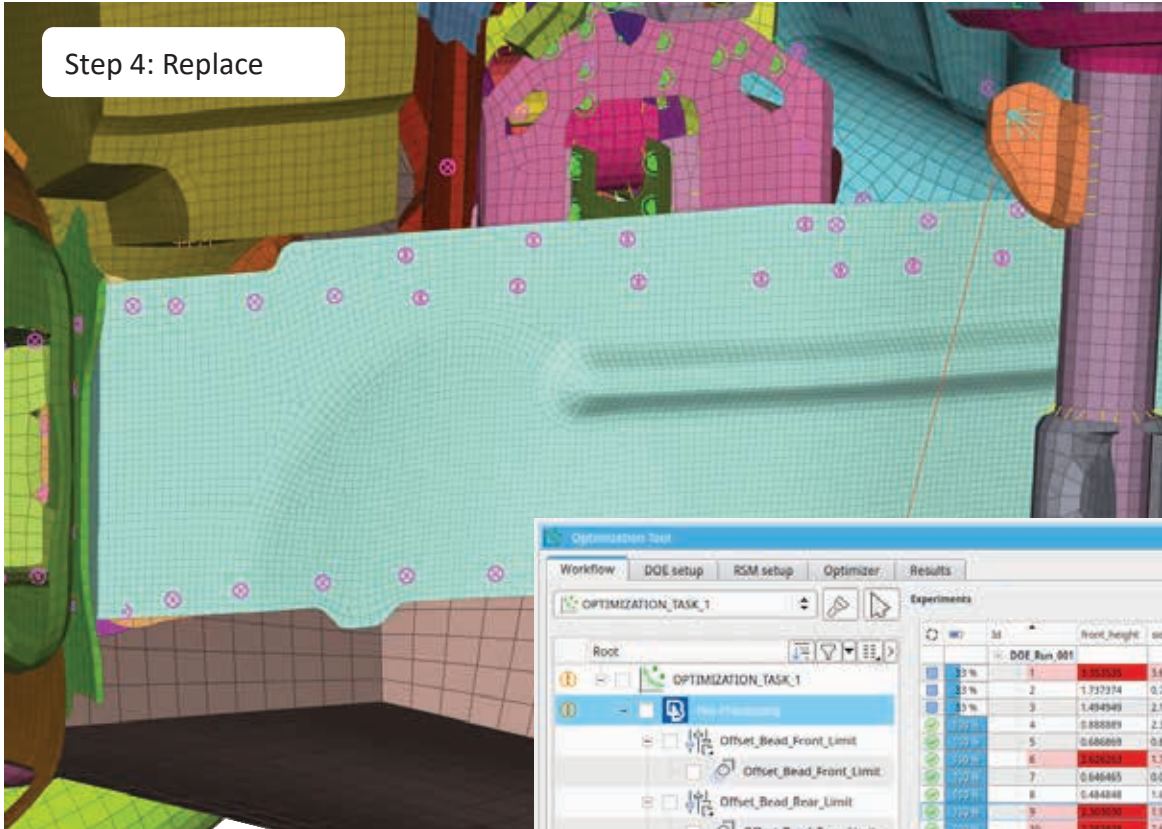


DOE Execution

- FE-Update action is run Per Experiment production



Step 4: Replace



07 2nd Optimization

CAD Design Parameters

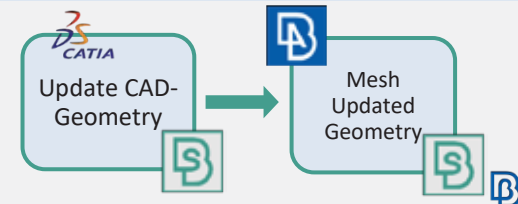
- In collaboration with CAD-Design team, Design Parameters are added
- The Final design deviates from the original CAE-Engineers proposal, due to limitations
- For a CATIA, a Design Table is prepared providing all parameters eligible for this optimization

Workflow Preparation

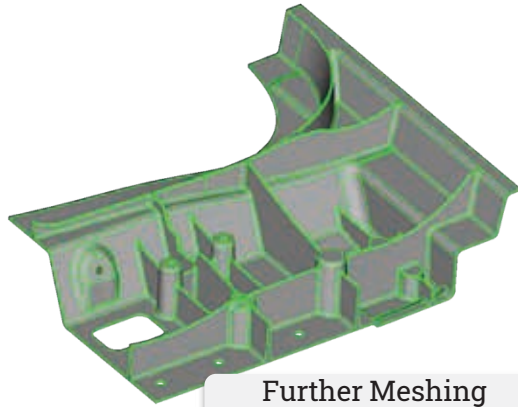
- Parse CAD-Parameters
- Create Design Variables
- Include the Update Catpart Call

DOE Execution

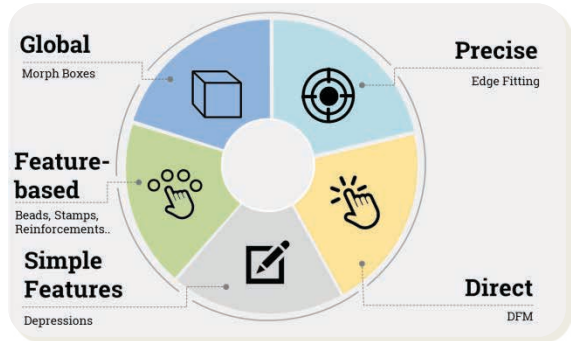
- FE-Update action is run Per Experiment production



08 Next Steps

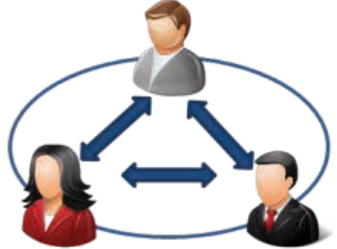


Further Meshing Strategies



ANSA Morph & Design Toolbox

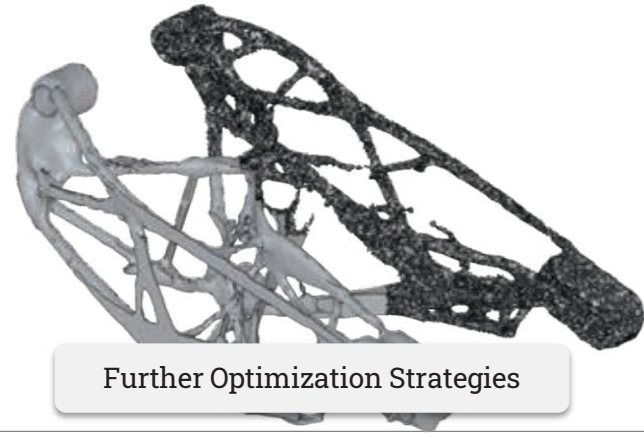
Performance CAE engineer



Performance design engineer

Parts design engineer

Improve CAD-CAE Communications



Further Optimization Strategies



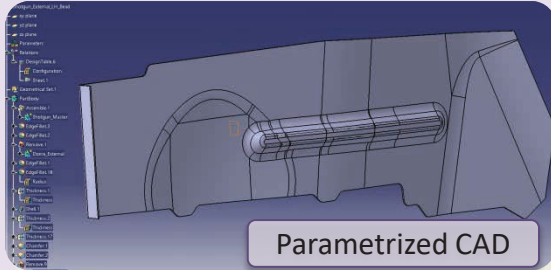
Stay connected



Thank you!

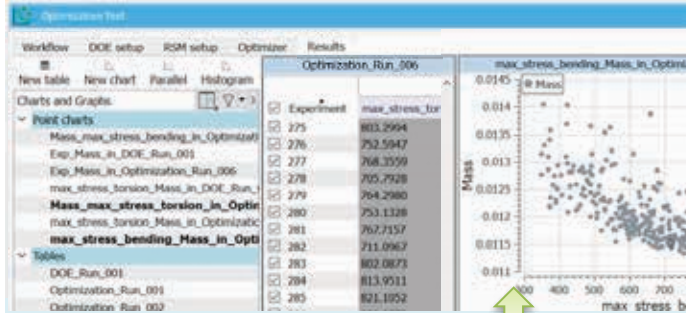
www.beta-cae.com

Input

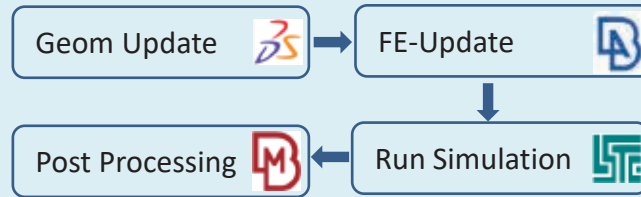


Simulation

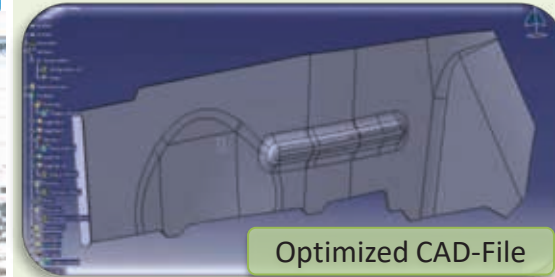
Optimization Process



SPDRM Workflow Manager



Result



Optimized