Parametric Design and Structural Optimization for Early Design Exploration



Landrover

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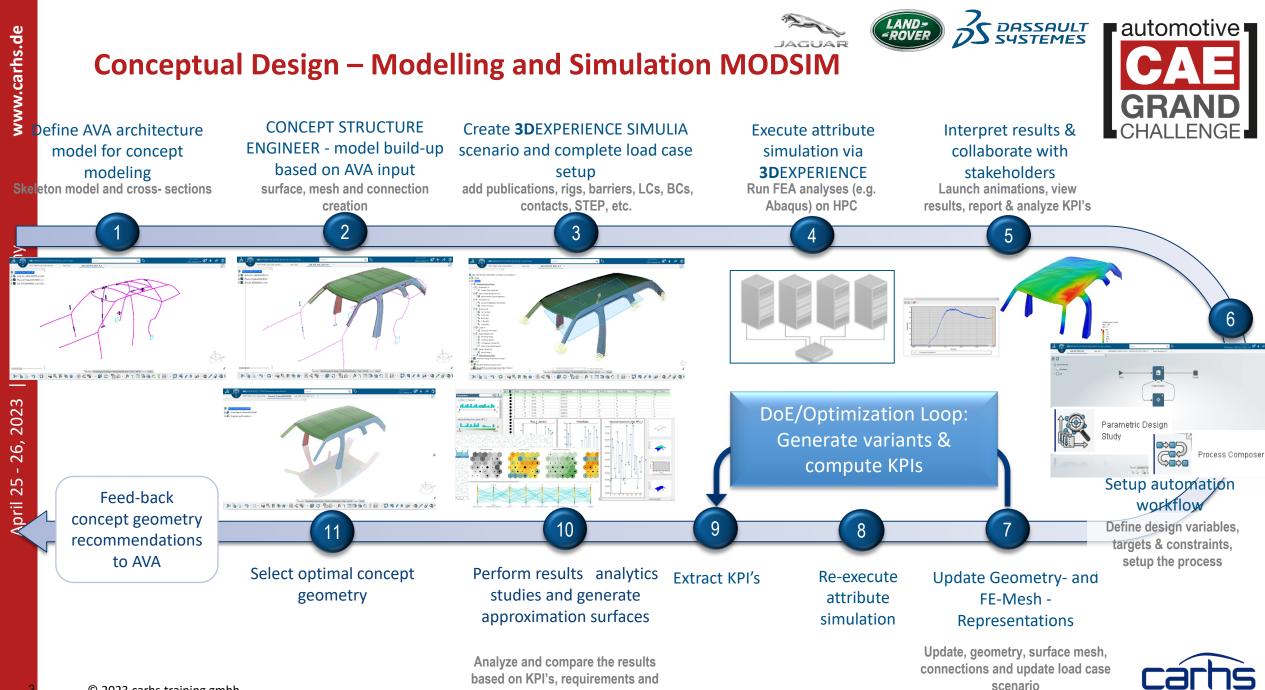






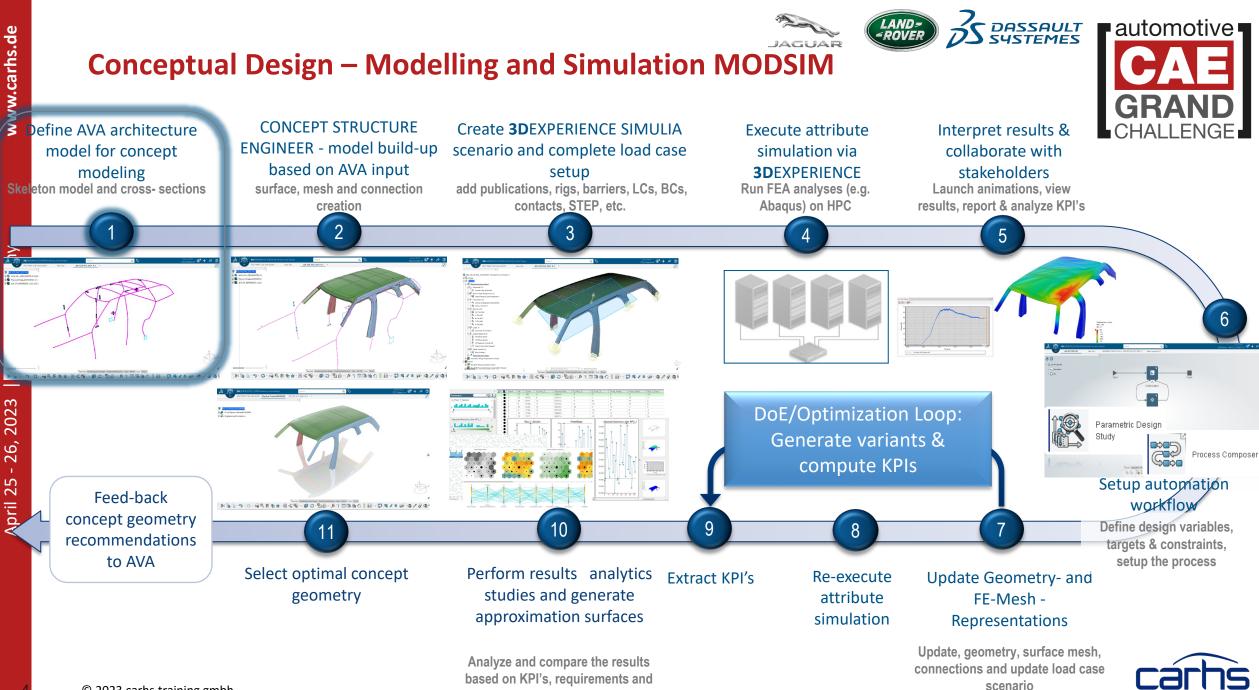






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DASSAULT SYSTEMES automotive **Conceptual Design – Modelling and Simulation MODSIM** CONCEPT STRUCTURE Create **3D**EXPERIENCE SIMULIA Define AVA architecture Execute attribute Interpret results & ENGINEER - model build-up model for concept scenario and complete load case simulation via collaborate with based on AVA input modeling **3D**EXPERIENCE stakeholders setup surface, mesh and connection Skeleton model and cross- sections add publications, rigs, barriers, LCs, BCs, Launch animations, view Run FEA analyses (e.q. creation contacts, STEP, etc. Abagus) on HPC results, report & analyze KPI's 2 3 5 6 **DoE/Optimization Loop:** added in the later Parametric Design Generate variants & Study 26, G Process Composer compute KPIs April 25 Setup automation

Feed-back concept geometry recommendations to AVA

Perform results analytics Select optimal concept geometry studies and generate

10

Analyze and compare the results

based on KPI's, requirements and

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Extract KPI's approximation surfaces

9

Re-execute attribute simulation

8

Update Geometry- and FE-Mesh -Representations

Update, geometry, surface mesh, connections and update load case scenario



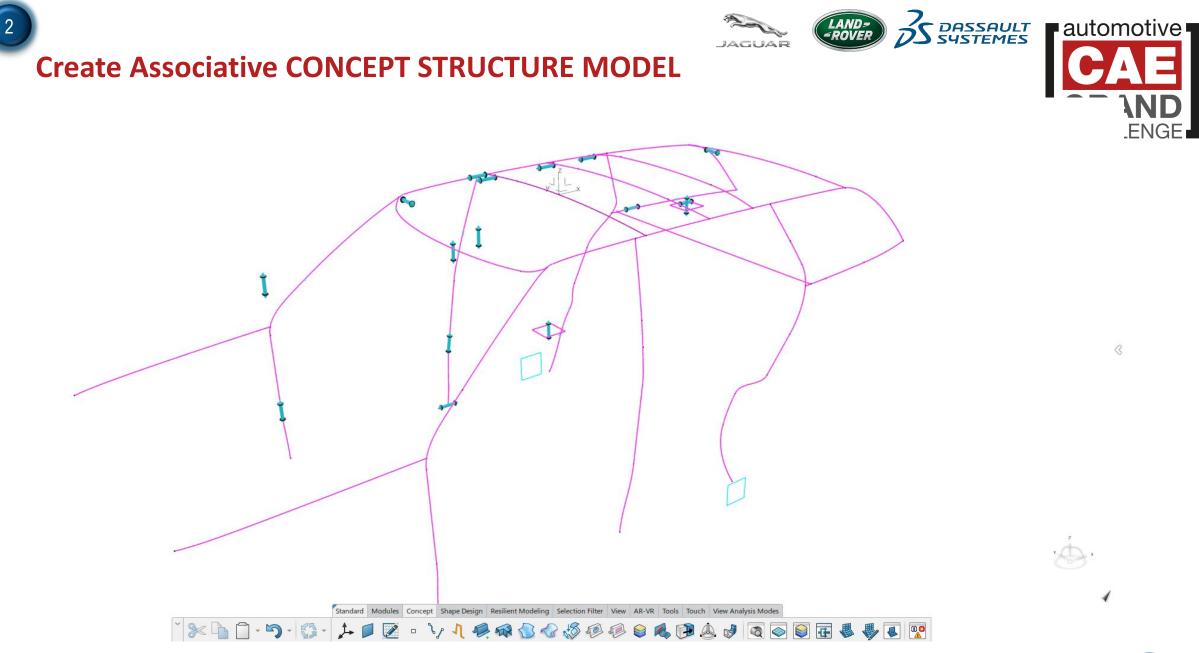
workflow

Define design variables.

targets & constraints,

setup the process

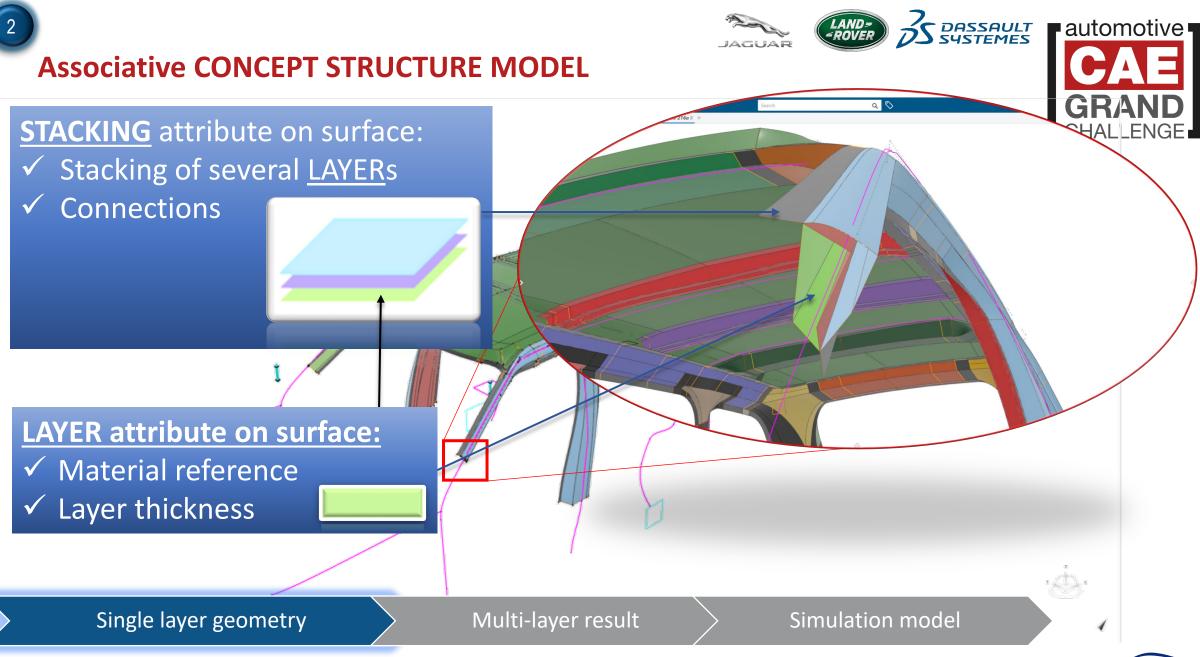






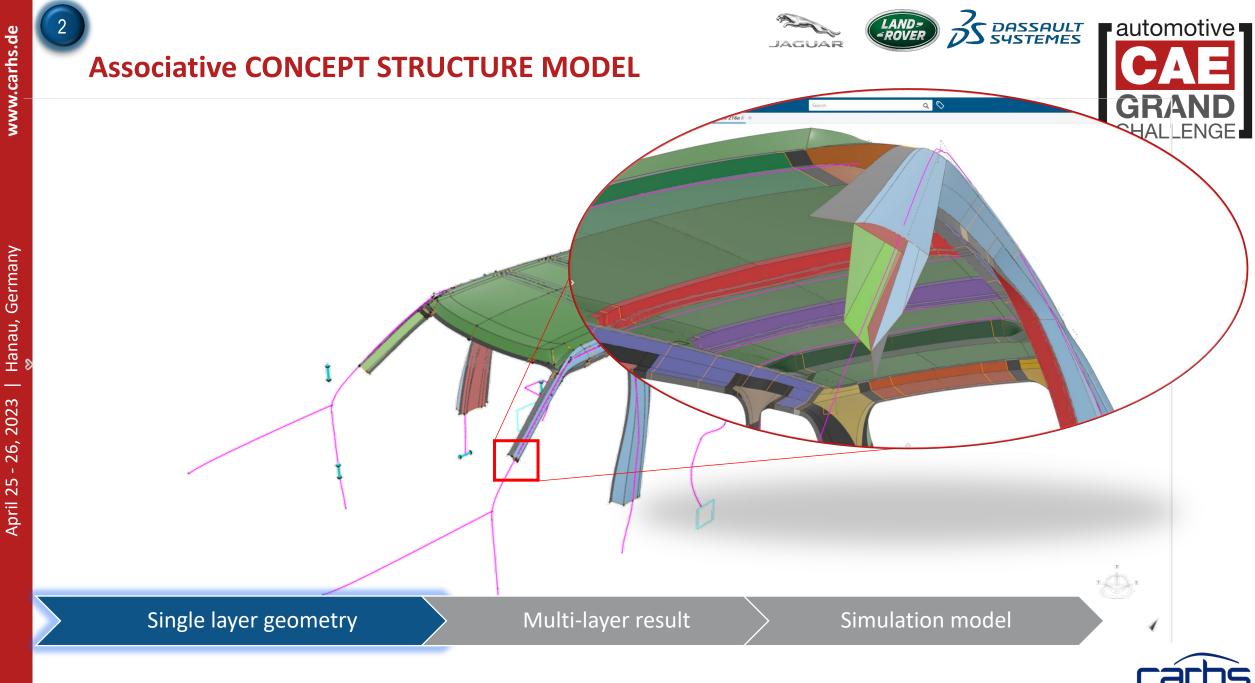
Hanau, Germany

April 25 - 26, 2023



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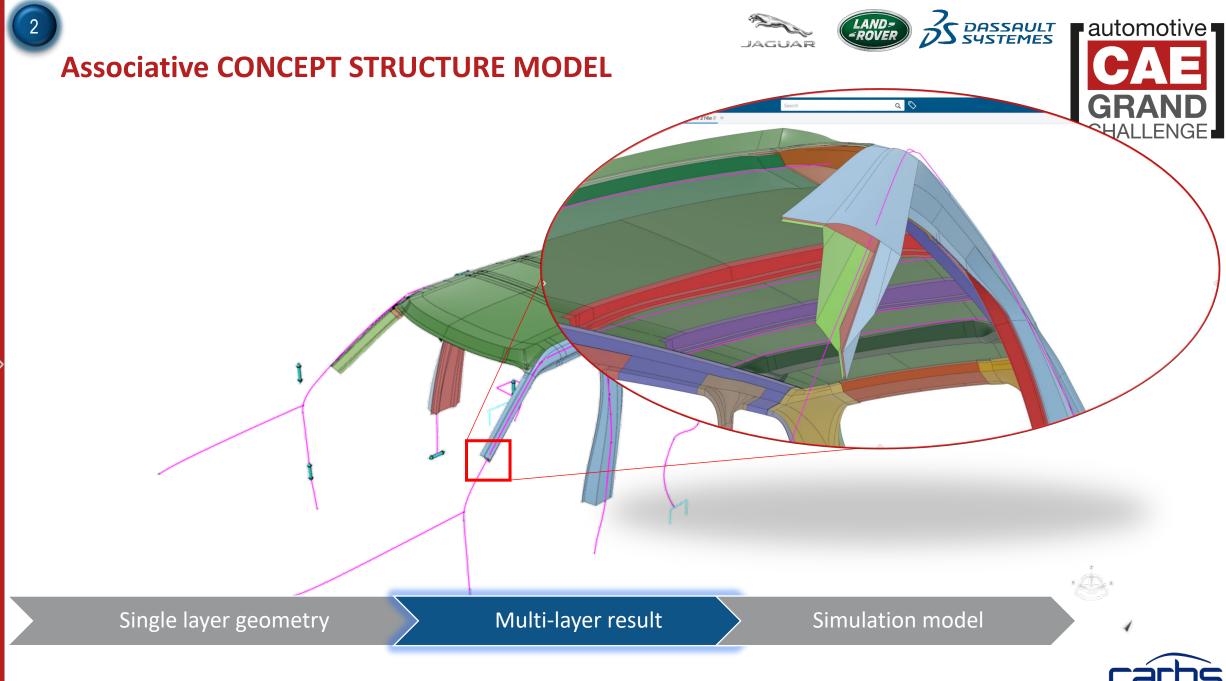
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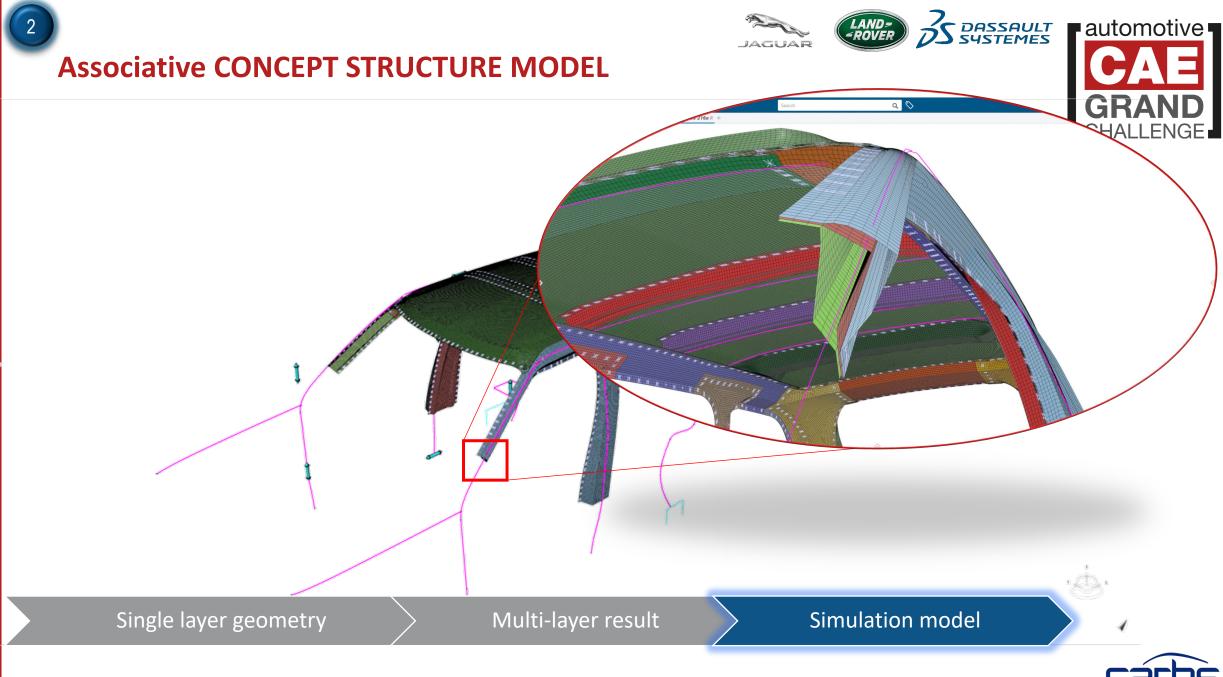
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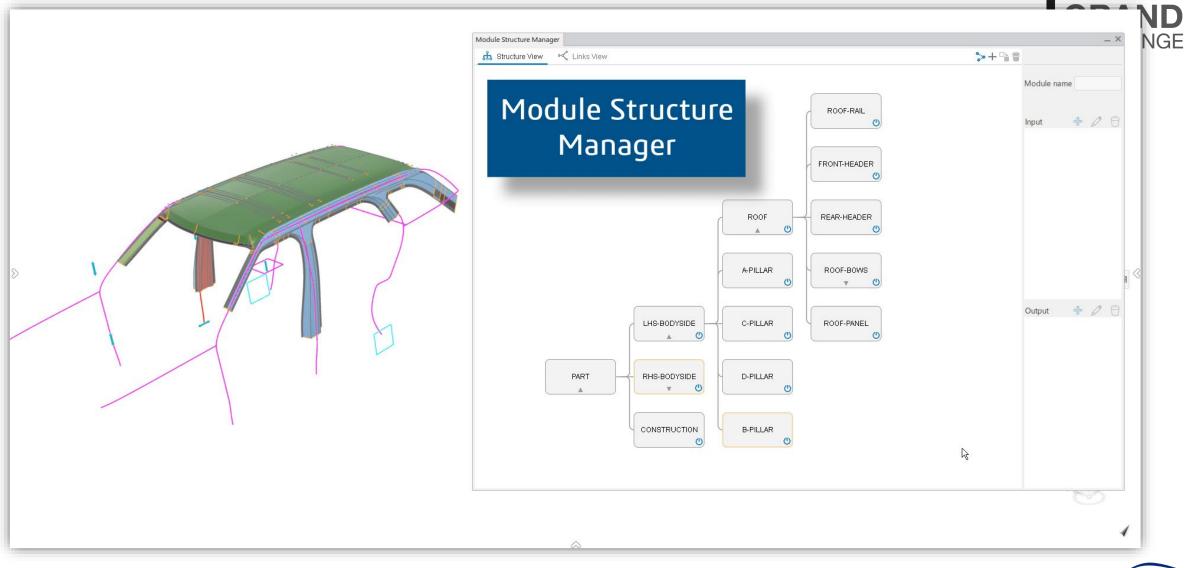
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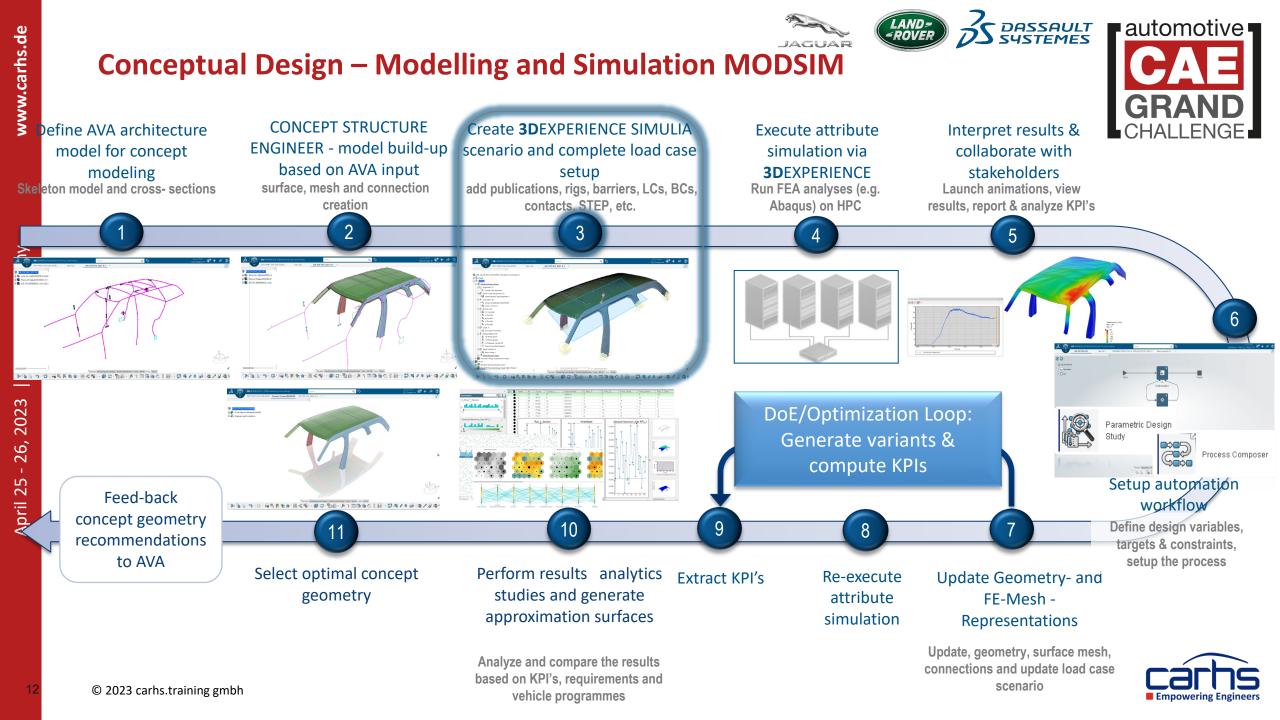
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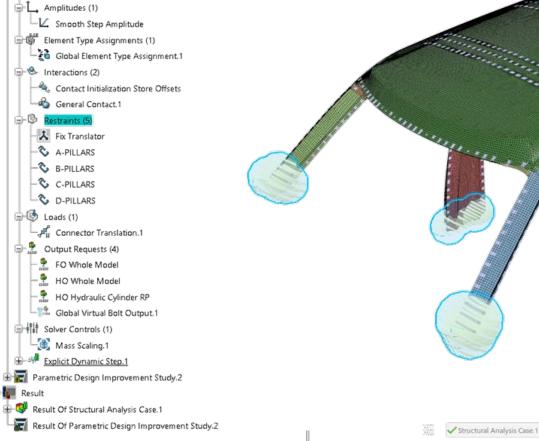
🗄 🌄 Model Scenario







Structural Analysis Case.1 Germany Hanau, 2023 26, April 25



Boundary Conditions: Fixed displacements of all Pillar ends



S8Z_JLR_CSE_POC_2022_FMVSS 216a Roof Crush Simple A.1

*

Explicit Dynamic Step 1

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FMVSS 216a Roof Crush scenario





Scenario Structural Analysis Case.1 Amplitudes (1) LA Smooth Step Amplitude Element Type Assignments (1) – 🗞 Global Element Type Assignment.1 \$ Global Virtual Bolt Output.1

🖶 🌄 Model

📄 🧐 Interactions (2) - Contact Initialization Store Offsets General Contact.1 Bestraints (5) 👗 Fix Translator - 🗞 A-PILLARS - & B-PILLARS - 🗞 C-PILLARS C D-PILLARS 🚽 🐼 Loads (1) - 🖧 Connector Translation 1 🕺 Output Requests (4) FO Whole Model 🔶 HO Whole Model - 🤔 HO Hydraulic Cylinder RP

S8Z_JLR_CSE_POC_2022_FMVSS 216a Roof Crush Simple A.1



Parametric Design Improvement Study.2

Result 🕬 Result Of Structural Analysis Case 1

Result Of Parametric Design Improvement Study.2

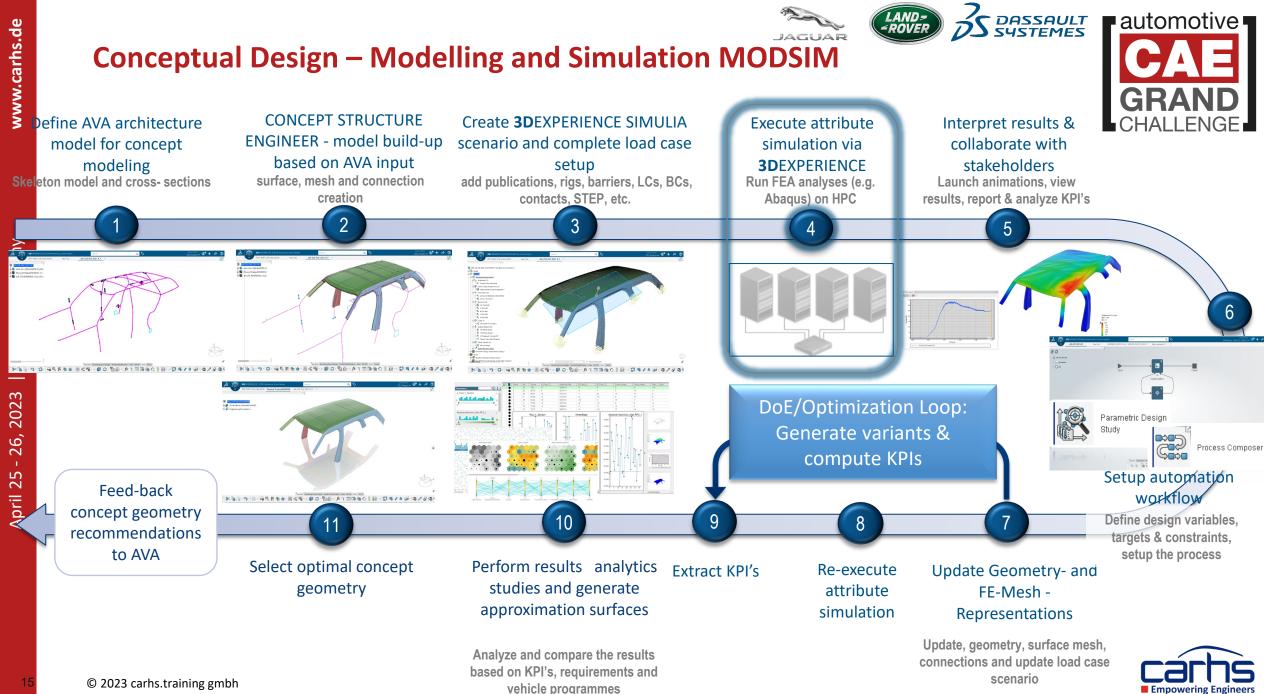
Structural Analysis Case.1 .

Explicit Dynamic Step 1

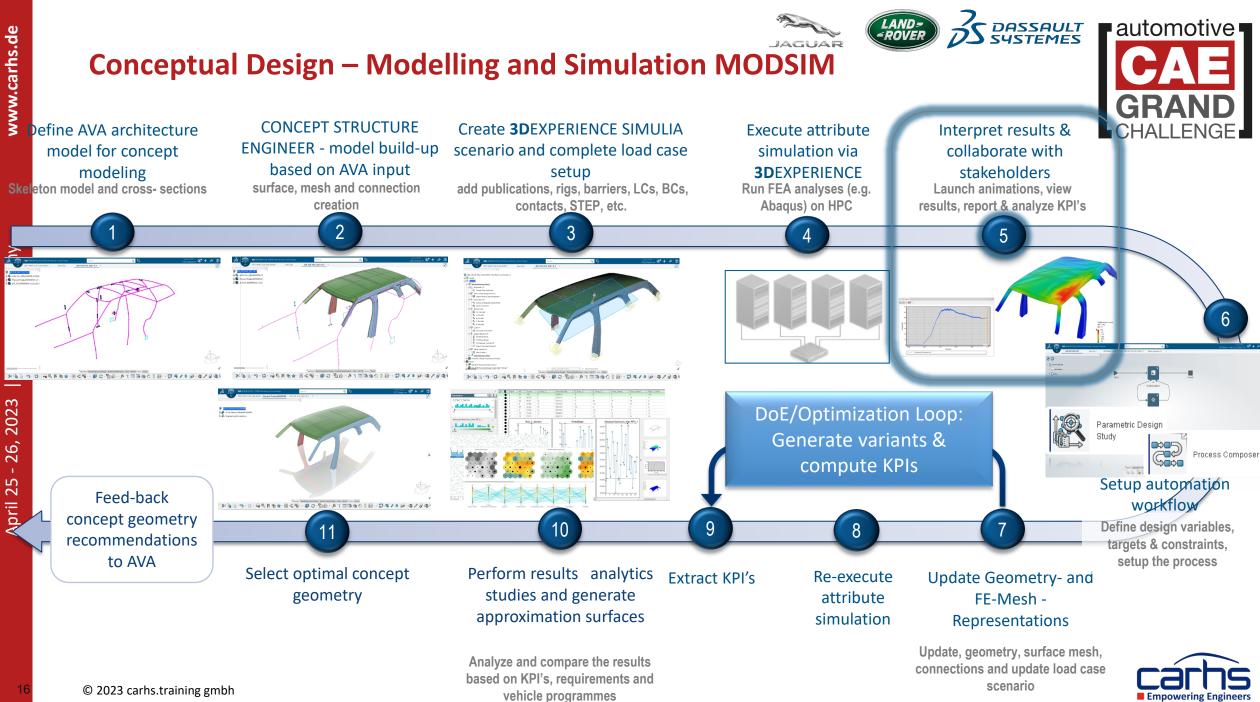
Load: **Enforced displacement** for rigid plate for 127 mm

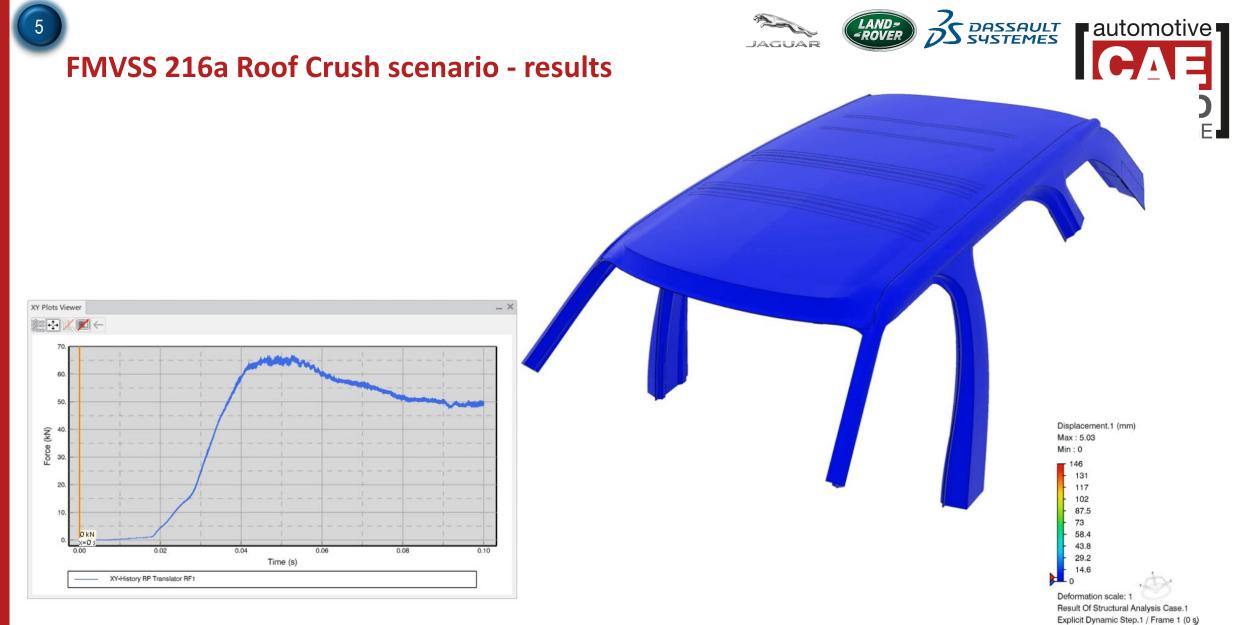
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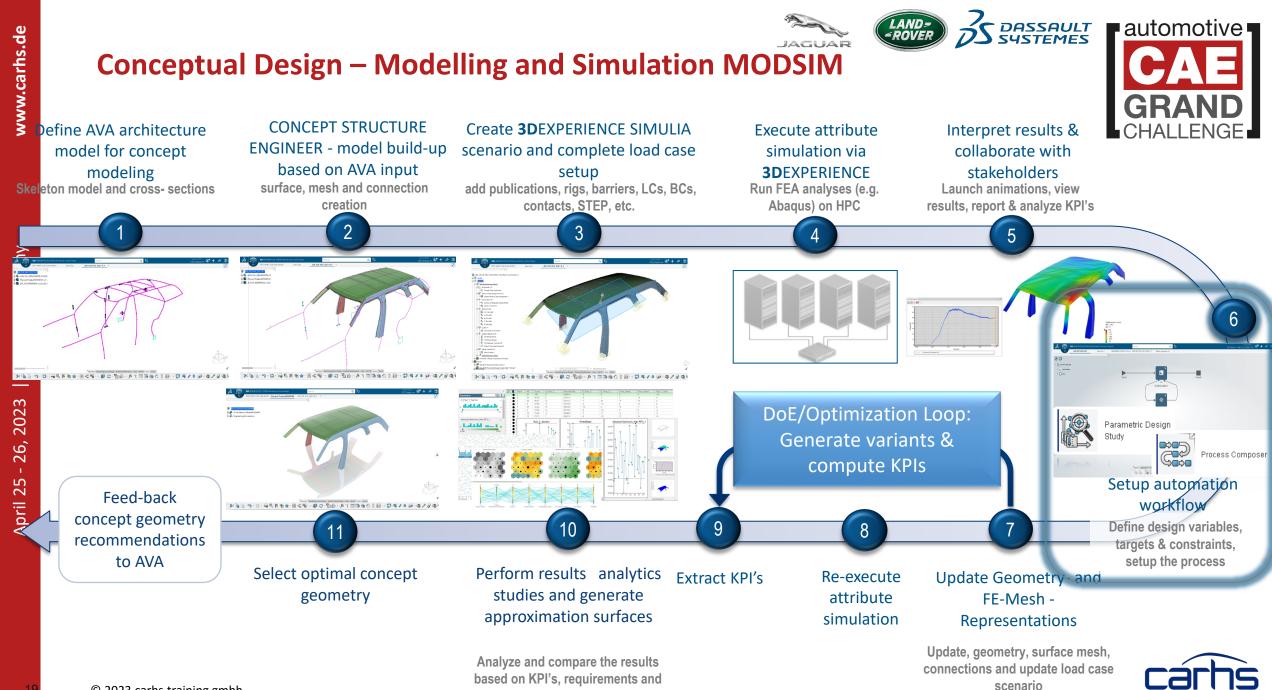
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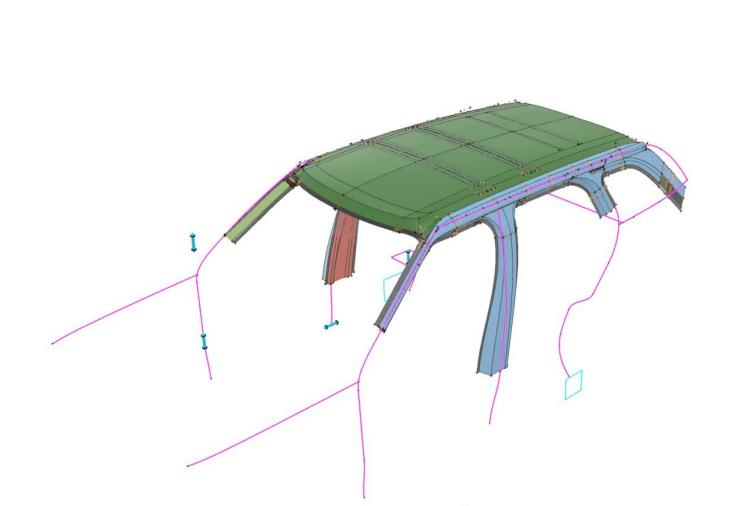
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Associativity - Structural Model and AVA Skeleton



CROSS MEMBER 1 OFFSET FROM FRONT HEADER CROSS MEMBER 2 OFFSET FROM FRONT HEADER CROSS MEMBER 3 OFFSET FROM FRONT HEADER DS_DEFINED_BPOST_POS_X_DELTA

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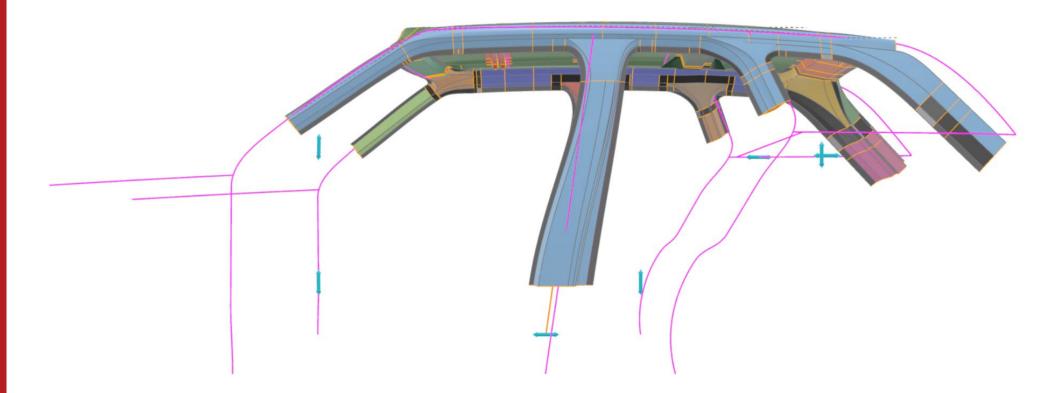


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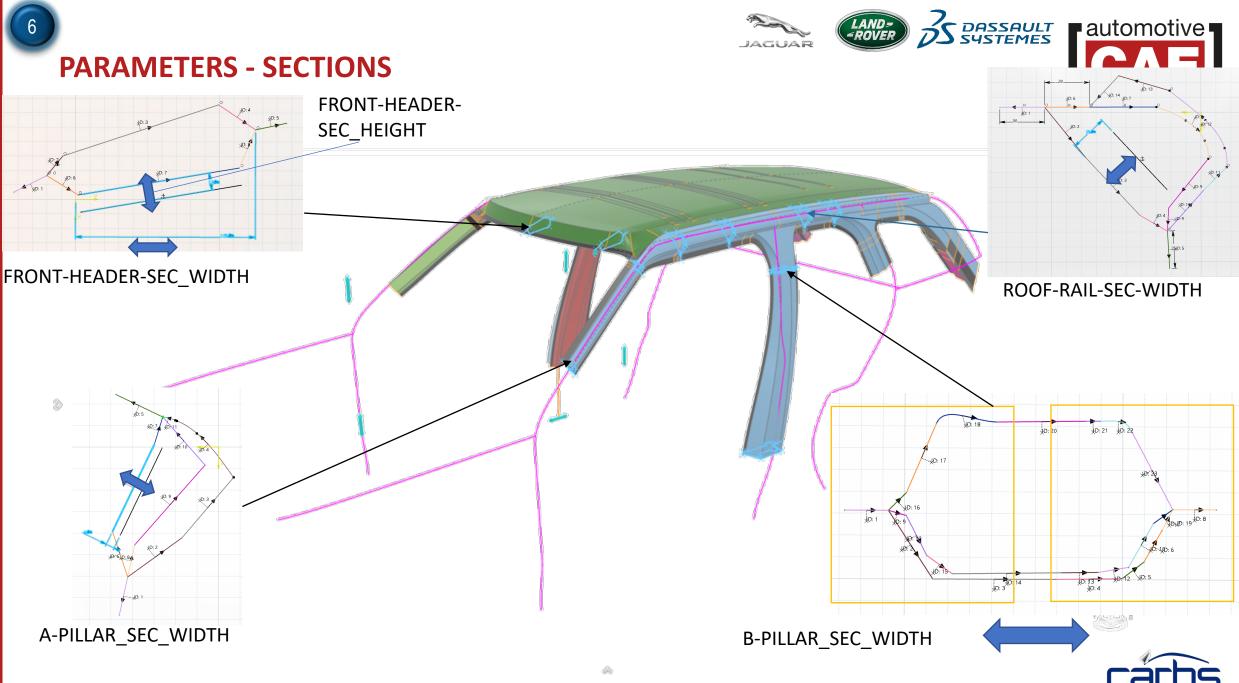
PARAMETERS - WHEELBASE









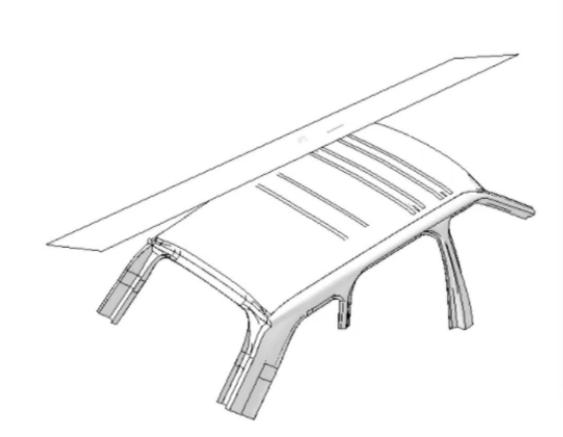


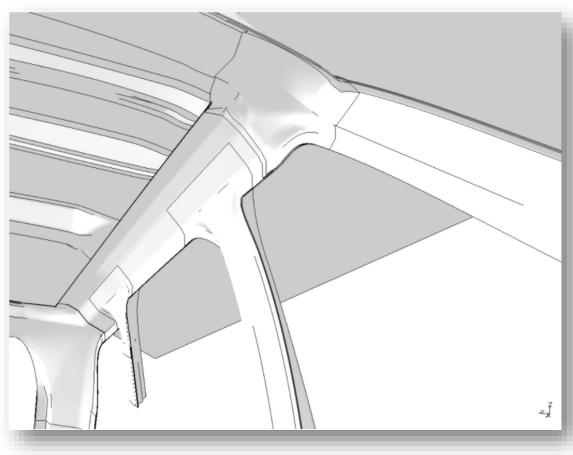
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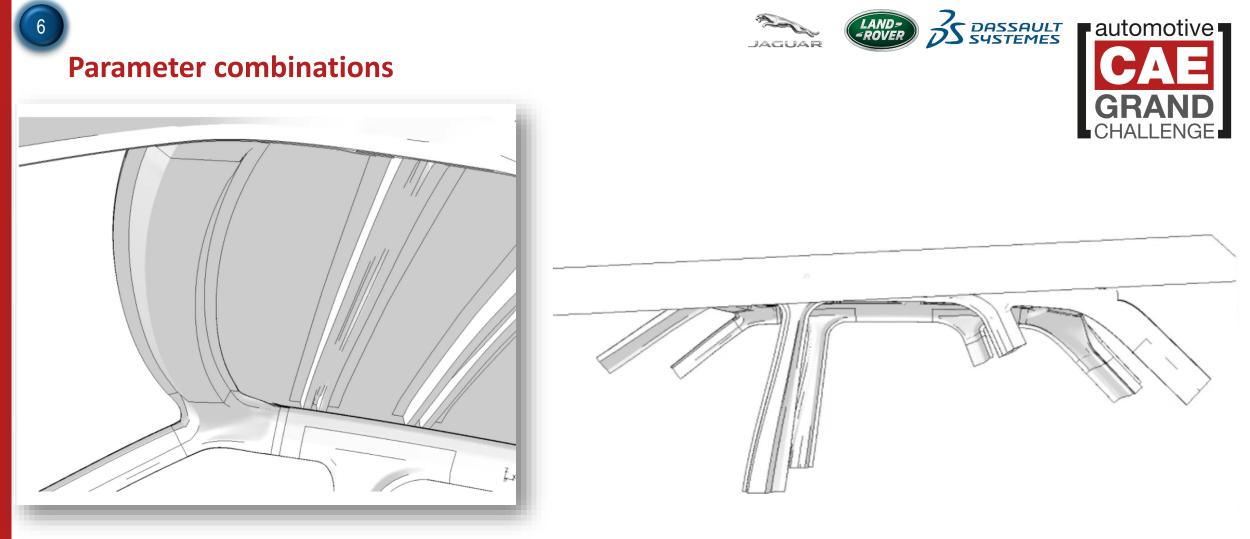


Parameter combinations











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parametric design study - setup

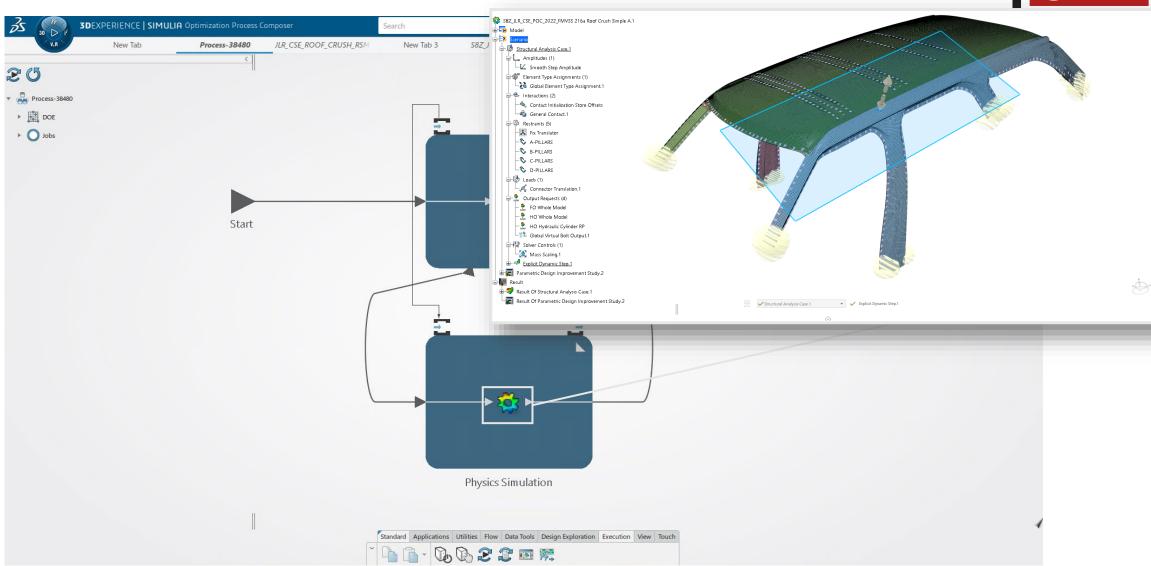
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S8Z_JLR_CSE_POC_2022_FMVSS 216a Roof Crush Simple A.1 B Model			Design var	iable	es			B LENG
Structural Analysis Case.1	Select	Name	T	Value	М	inimum	Maximum	
Amplitudes (1)	~	X CROSS MEMBER 1 OFFSET F	ROM FRONT HEADER	302.6mm	32	0mm	420mm	
🕞 🤴 Element Type Assignments (1)	Image: A second seco	X CROSS MEMBER 2 OFFSET F	ROM FRONT HEADER	835mm	70	0mm	800mm	
Global Element Type Assignment.1	Image: A start and a start	X CROSS MEMBER 3 OFFSET F	ROM FRONT HEADER	1257.8m	m 12	00mm	1300mm	
Contact Initialization Store Offsets	Image: A start and a start	X DS_DEFINED_BPOST_POS_X	DELTA\B-POST\USER	5.08mm	a	-50mm	🔒 50mm	
General Contact.1	Image: A start and a start	X WHEELBASE_delta		175.75m	m 🔒	0mm	🔒 300mm	1
Fix Translator	Image: A start of the start	X ROOF-RAIL-DEPTH_delta		-0.92mm	a	-10mm	🔒 15mm	
- C A-PILLARS	🖌 🔽 👘	X FRONT_HEADER_SEC_HEIGH	T_delta	-8.1mm	a	-10mm	🔒 10mm	
-S C-PILLARS		X FRONT_HEADER_SEC_WIDTH	I_delta	-0.84mm	a	-11mm	🔒 10mm	
D-PILLARS		X A-PILLAR_SEC_WIDTH_delta		0.2mm	a	-10mm	🔒 10mm	
Loads (1)		X B-PILLAR_SEC_WIDTH_delta		1.2mm	A	0mm	🔒 30mm	
Cutput Requests (4)			Press colored					
FO Whale Madel		Response	variables					
		response	variables					
Sel 🝸 Name				- T	Value	Minimum	Maximum	Objective
Mass\Mass Sensor.1\Result C	Of Structure	al Analysis Case. 1\Result Mana	jer		173.487kg			
		Structural Analysis Case. 1\Resul	-		7.57e+009N			🗡 Maximiz
			-					/ WIGATTIL
Maximum\Von Mises Stress.	I\Result O	f Structural Analysis Case.1\Res	ult Manager		1401.979N_mm2			
Maximum\Displacement Ma	anitude.1\	Result Of Structural Analysis Ca	se.1\Result Manager		138.218mm			

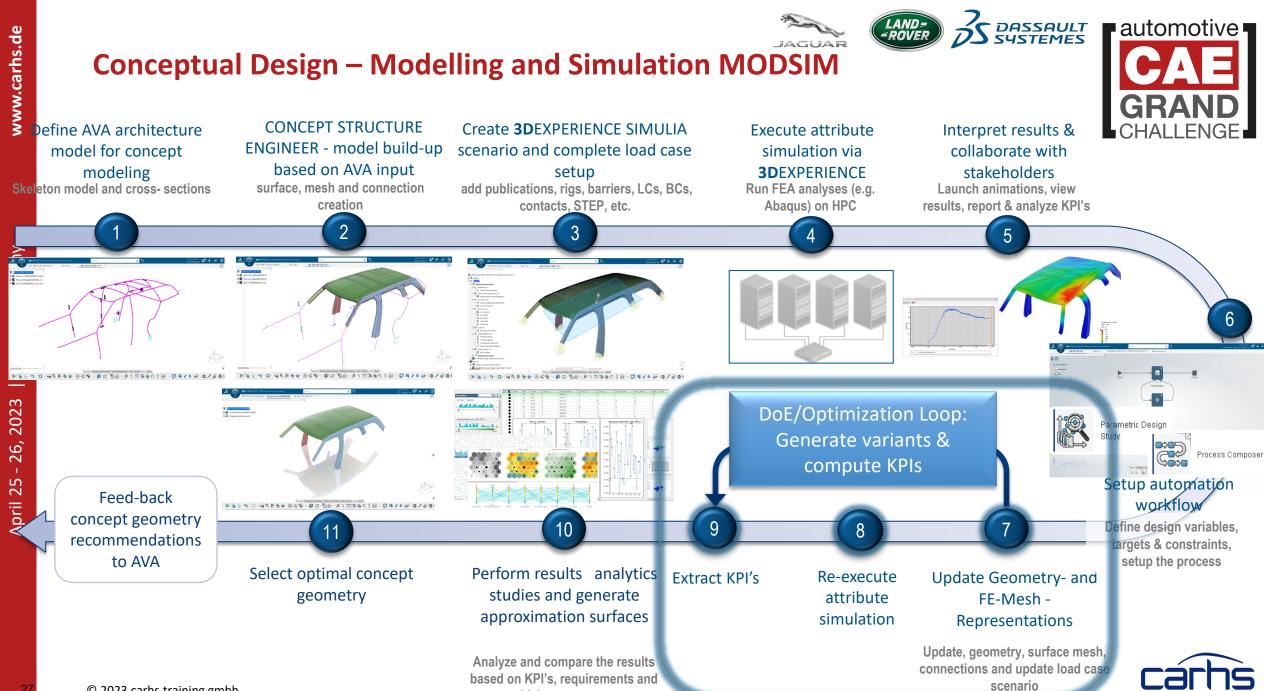
PROCESS COMPOSER workflow in 2022x



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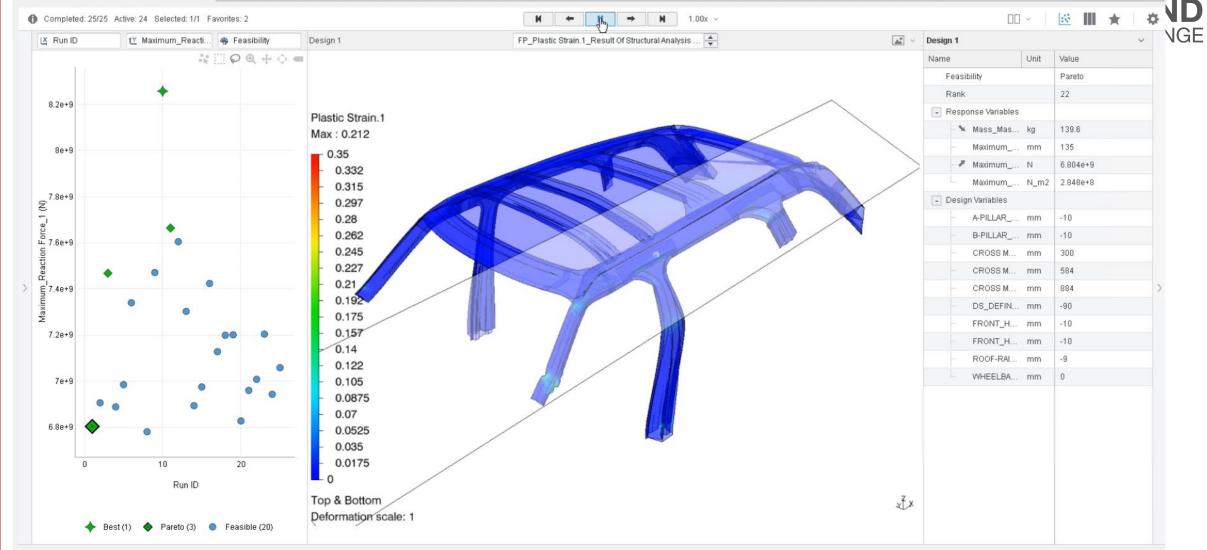
Parametric design study - Results





Study Results for Parametric Design Improvement Study.2

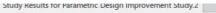
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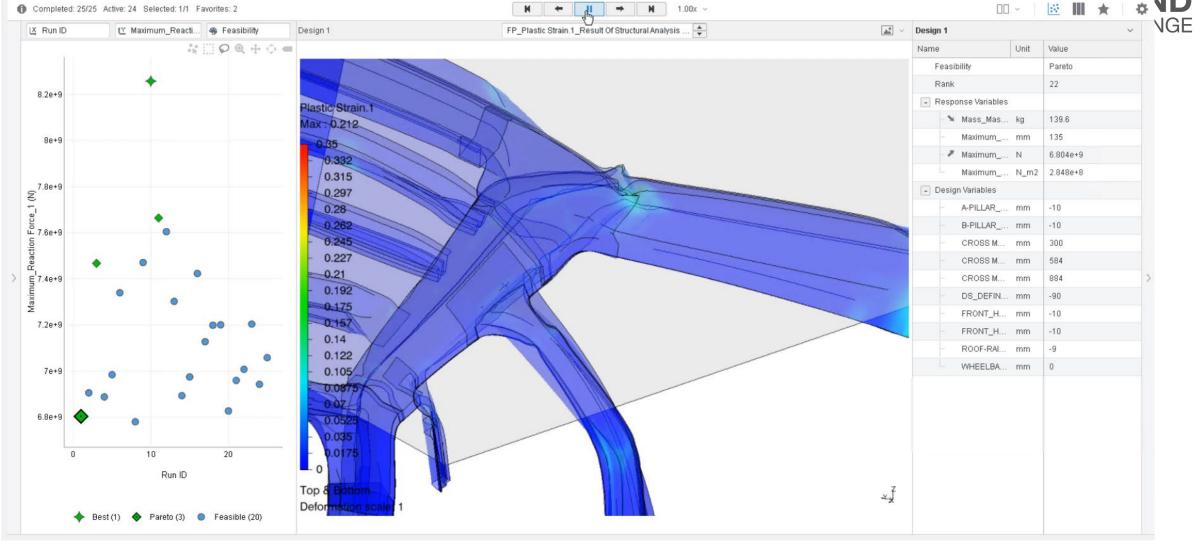
Parametric design study - Results





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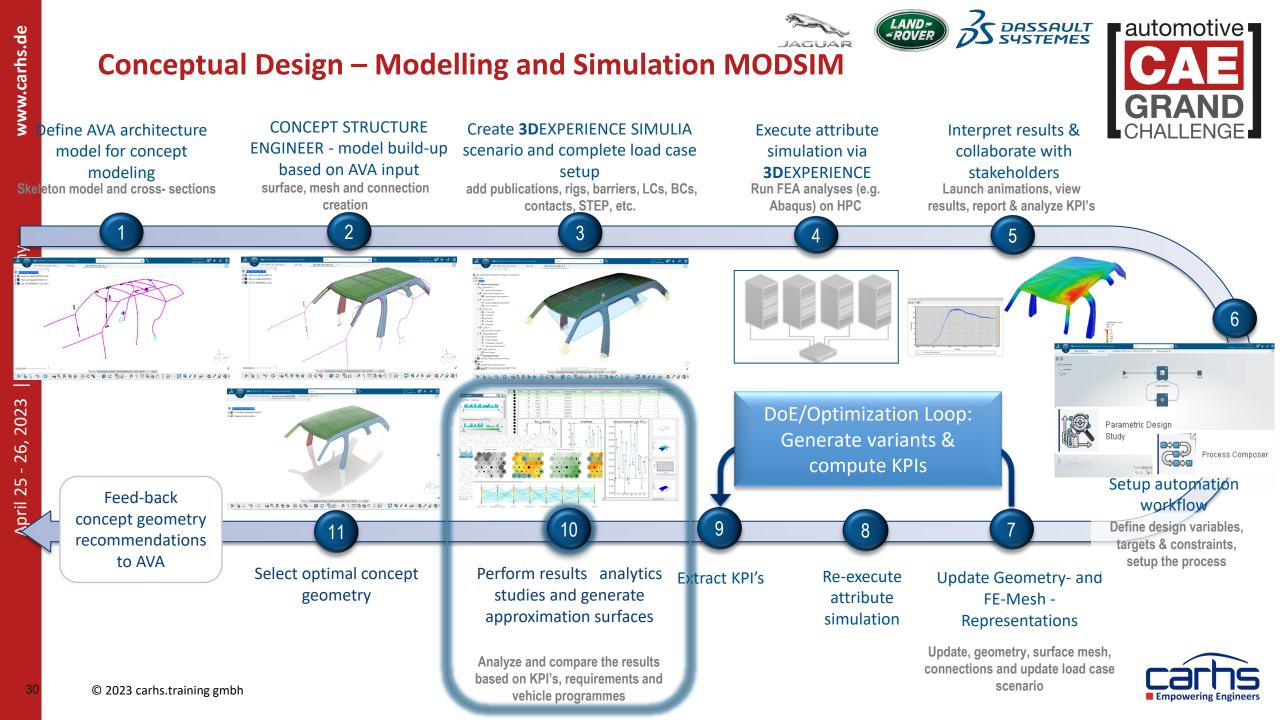
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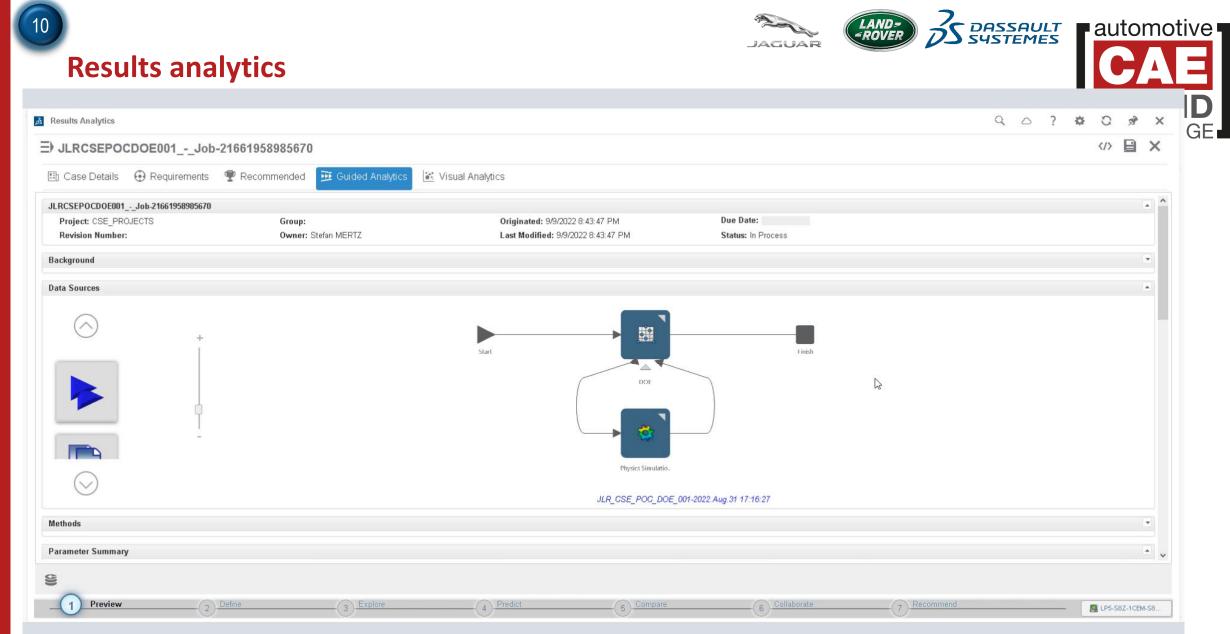




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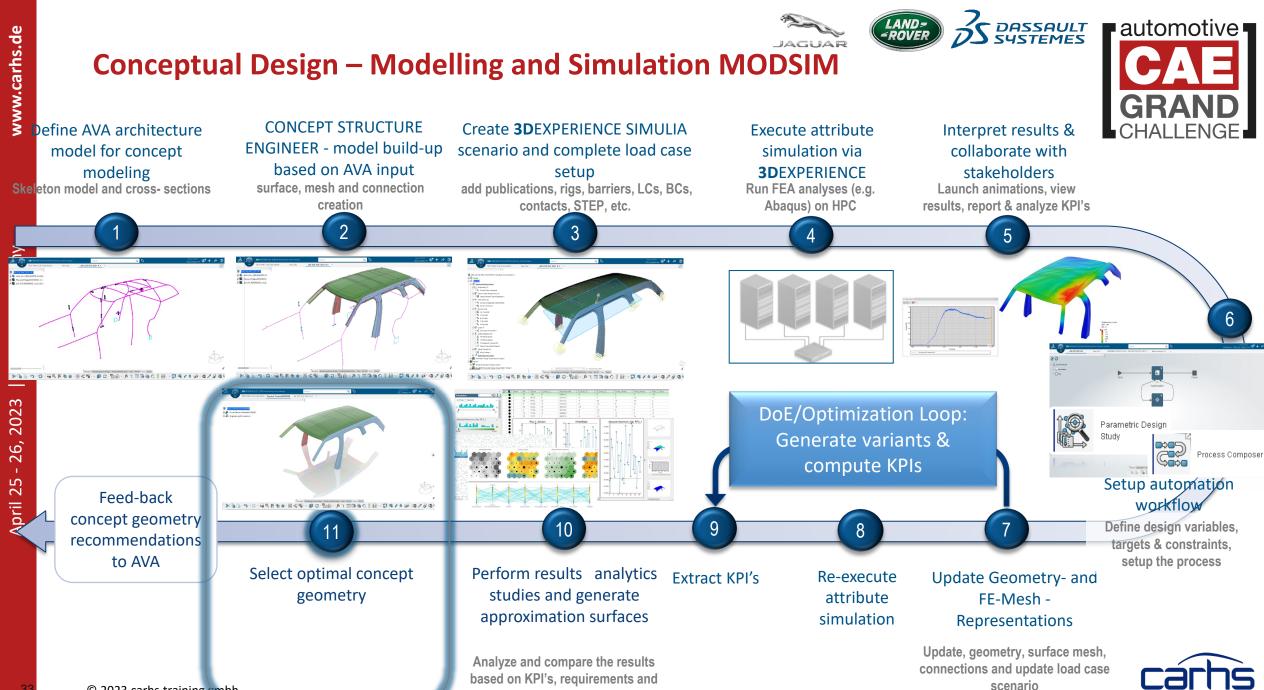
Optimization with approximation

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Stefan MERTZ EMEA Demo -- 796 | CSE_PROJECTS → 🔊 + 🄅 ② ۵ 🛇 3DEXPERIENCE | SIMULIA Optimization Process Composer Search JLR_CSE_ROOF_CRUSH_RS New Tab +<>> 🗎 🗙 ∃ JLRCSEPOCDOE001_-_Job-21661958985670 20 🗈 Case Details 🛛 🔂 Requirements 🛛 🖤 Recommended K Visual Analytics Validation Measures 🗸 Actual By Predicted Residual By Predicted Cross Validation % Error Fit + -V JLR_CSE_ROOF_CRUSH_RSM_OPT_S8Z Error Measures Response Surface Model 0.0493 Name Status Fit R-Squared 1.00 (>0.80) Response S... 🗸 😝 🛩 0.0153 0.0130 0.0107 0.00842 0.00613 0.00385 0.00157 Optimization_1 R-Squared Adjusted 1.00 (>0.80) 0.0332 Root Mean Square Error 0.00104 (<0.005) 0.0104 (<0.05) I Jobs Residual/Predicted 175 0.0172 0.00157 -7.192e-4 -0.00300 -0.00529 -0.00757 -0.00988 -0.0121 -0.0144 -0.0144 -0.01467 -0.0190 -0.0228 -0.0259 -0.0259 -0.0281 % Error Absolute Mean 0.00197 ual % Error Absolute Maximum 0.0281 0.00126 174 % Error Standard Deviation 0.00411 -0.0147 ÷---Parameters - Input -0.0307 171 A-PILLAR_SEC_WIDTH_delta 174 175 177 178 177 178 171 171 172 174 175 172 Predicted Predicted Error Measures Response Surface Model 1 8.259e+9 -8.206e+8 -9.59 R-Squared 0.834 (>0.80) N/A 6.47 5.54 4.60 3.67 2.74 0.824 (>0.80) R-Squared Adjusted 7.951e+9 5.487e+8 B-PILLAR_SEC_WIDTH_delta Root Mean Square Error 0.108 (<0.005) Start Residual/Predicted 0.915 (<0.05) 7.642c+9 2.767e+8 28.16 % Error Absolute Mean 0.973 -1.00 -1.93 -2.87 -3.80 -4.74 -5.87 -0.00 -7.54 -8.47 % Error Absolute Maximum 11.3 8 4.793e+6 · · · · · CROSS MEMBER 1 OFFSET FROM FRONT HEADER_ROOF 5 7.333e+9 _____ % Error Standard Deviation 2.07 7.024e+9 -2.671e+8 ۰. 361 2 295.6 CROSS MEMBER 2 OFFSET FROM FRONT HEADER_ROOF Profiler Measure Optimize 99 74 Approximation Status: Ready 4 Predict 7 Recommend B LP5-S8Z-1CEM-S8... Approximation

> Standard Applications Utilities Flow Data Tools Design Exploration Execution View Touch × 🔓 - 🚊 🍇 🛝 💖 🎇





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Verification run of best design



LAND= =ROVER

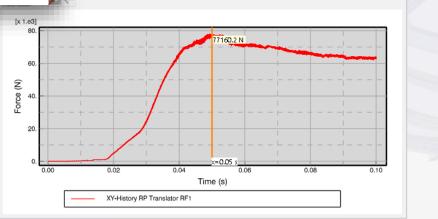
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Approximation Results

Run_Number 3	E	0
A-PILLAR_SEC_WIDTH_delta	3	-10
B-PILLAR_SEC_WIDTH_delta	3	4
CROSS MEMBER 1 OFFSET FROM FRONT HEADER_ROOF	3	320
CROSS MEMBER 2 OFFSET FROM FRONT HEADER_ROOF	3	744
CROSS MEMBER 3 OFFSET FROM FRONT HEADER_ROOF	3	964
DS_DEFINED_BPOST_POS_X_DELTA_B-POST	E	50
FRONT_HEADER_SEC_HEIGHT_delta	3	4
FRONT_HEADER_SEC_WIDTH_delta	3	-2
ROOF-RAIL-DEPTH_delta	Ŧ	9
WHEELBASE_delta	3	100
Mass_Mass_Sensor_1	Ξ	171.93352404180126
Maximum_Reaction_Force_1	Ξ	78359.416807



Plastic Strain.1 Max : 0.213	
Min : 0 0.35 - 0.332	

0.315 0.297 0.28

0.262

0.245 0.227

0.21

0.192 0.175

0.157

0.14

0.122 0.105 0.0875

0.07 0.0525 0.035 0.0175

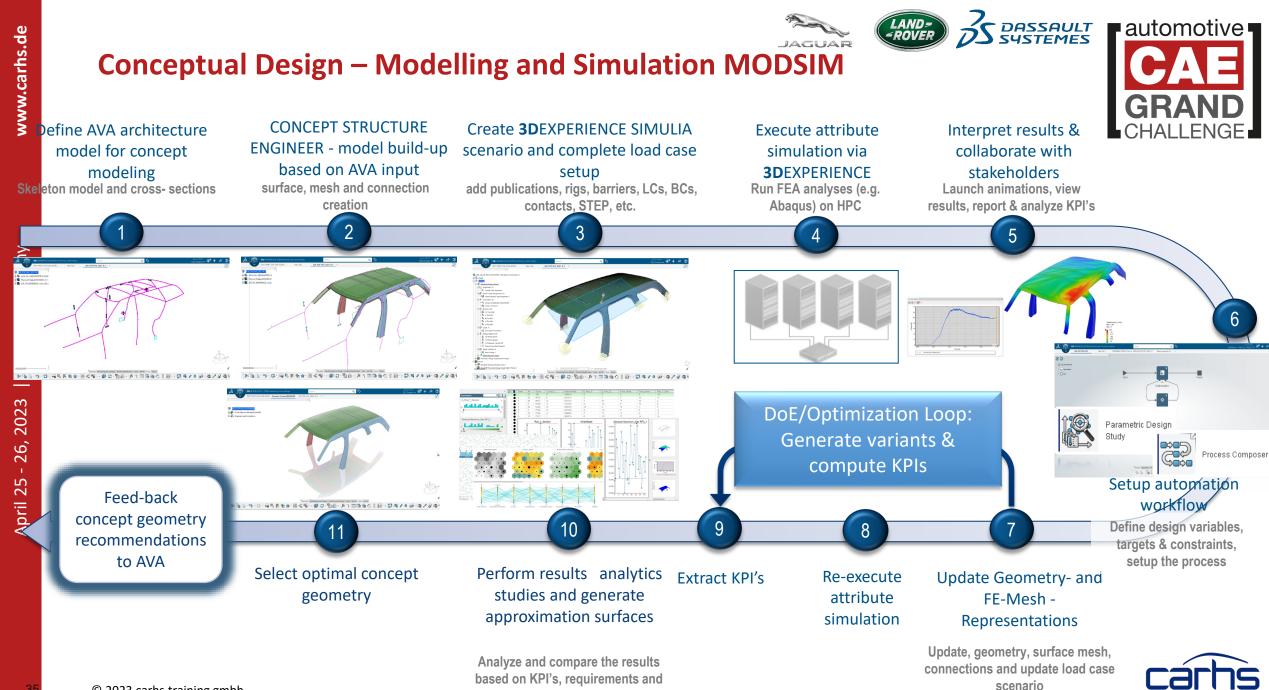
Top & Bottom Deformation scale: 1

Result Of Structural Analysis Case.1

Explicit Dynamic Step.1 / Frame 6 (0,05 s

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	Approximatio n	FEM
Reaction force [N]	78359	77160



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Add details to concept





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Conclusion

3D D

- End-to-end workflow ready to be used by everyone
- Saved time and reduced process complexity
- Enabler for optimization through simulation driven design
- The <u>flexibility</u> of the model, the <u>automation</u> of parametric variations and the <u>gapless access to simulation</u> enables a new level of evidence-based engineering driven by systematic design space exploration









Questions ?





