KIRCHHOFF AUTOMOTIVE

Optimization of typical Kirchhoff Automotive parts with Optistruct

3. European Hyperworks Technology Conference
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Abriged form of the ETHC 2009 presentation!

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Agenda

1. Overview of Kirchhoff Automotive

2. Optimization of an engine cradle – study of light weight designs with tailored rolled tubes and blanks

3. Conclusion

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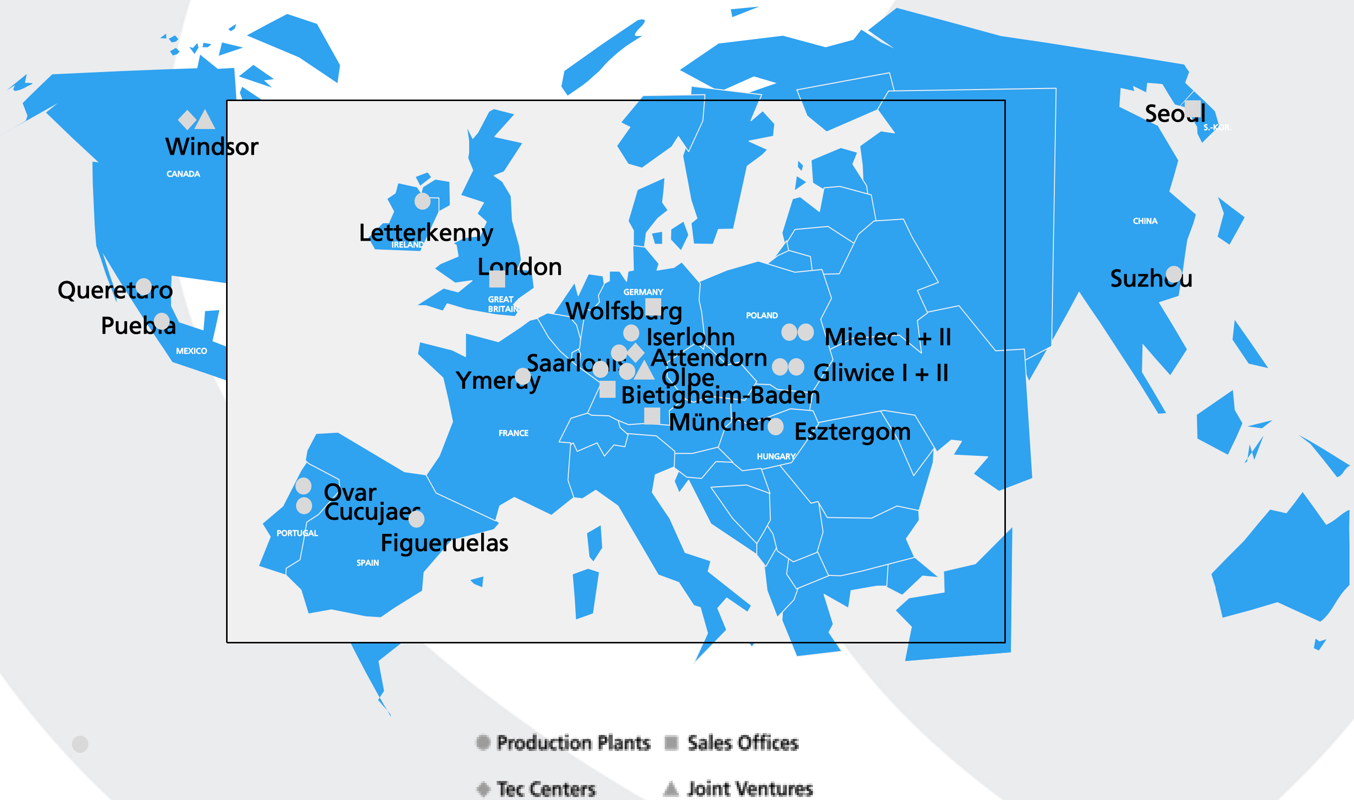
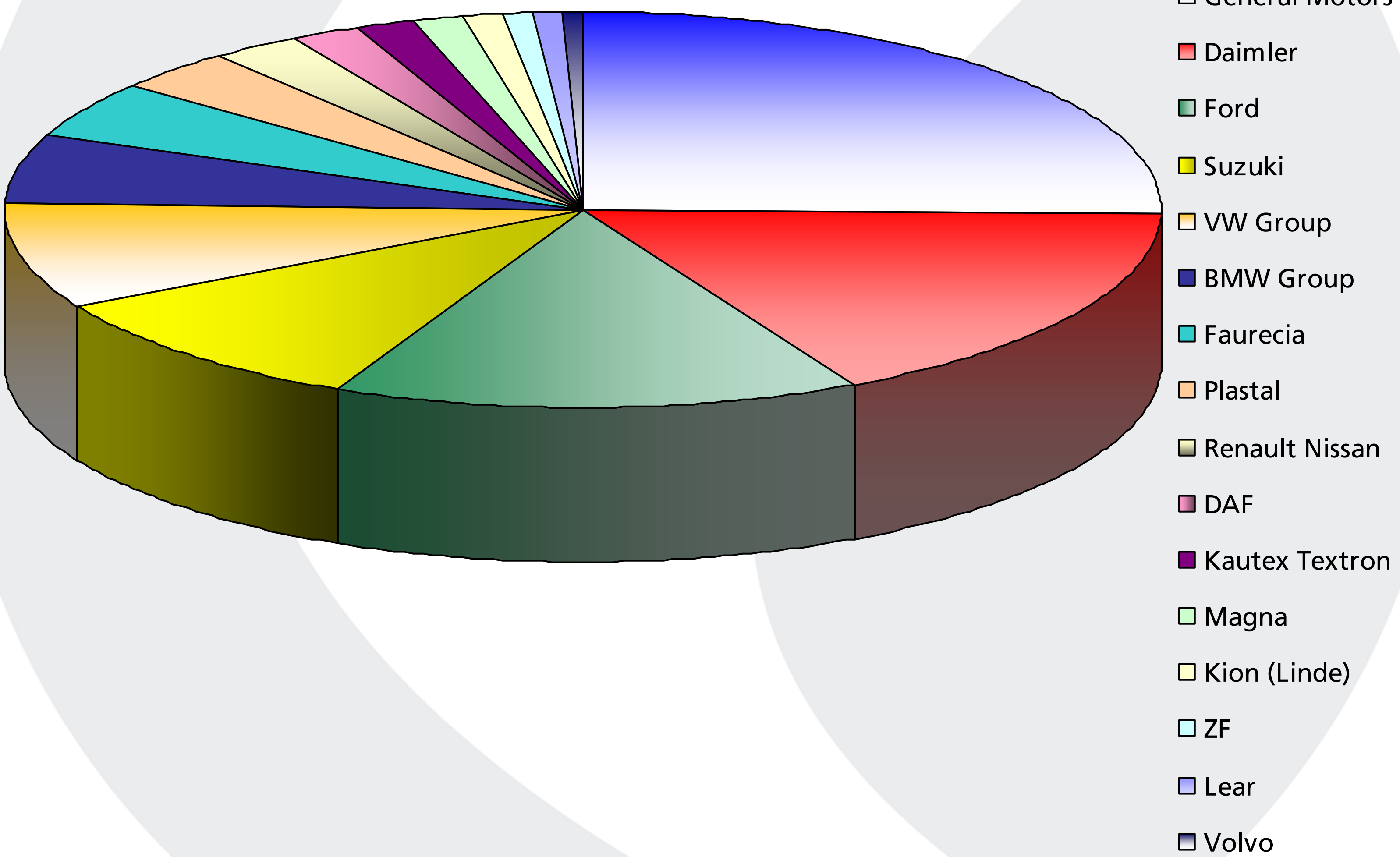
1. Overview of Kirchhoff Automotive - Locations

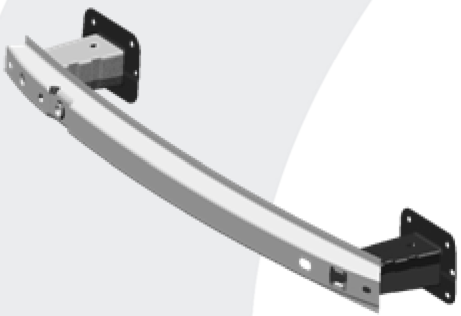
- 17 production plants in 9 countries
- more than 3.000 employees worldwide



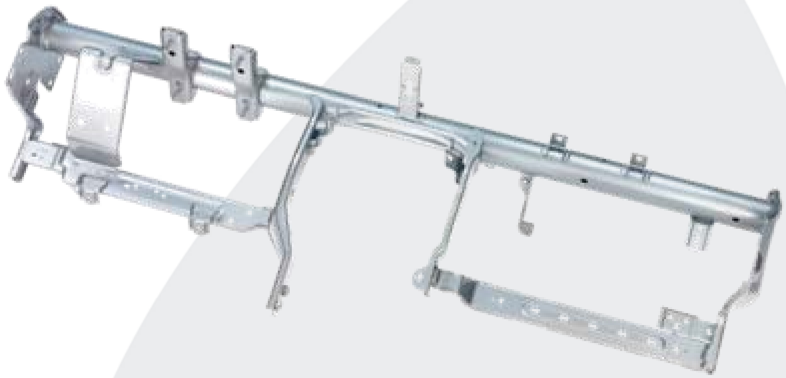
1. Overview of Kirchhoff Automotive - Our customers



1. Overview of Kirchhoff Automotive - Product portfolio passenger cars

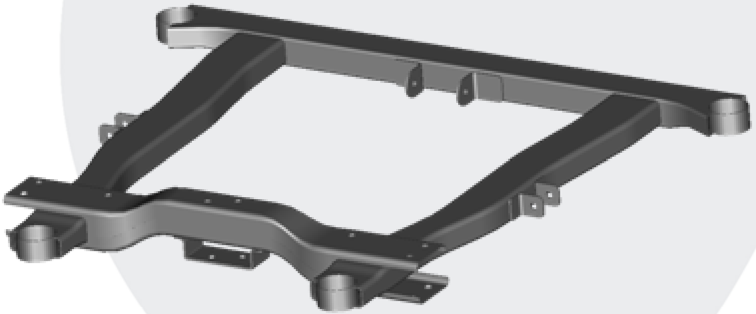


bumper systems



cross car beams

front ends



engine cradles

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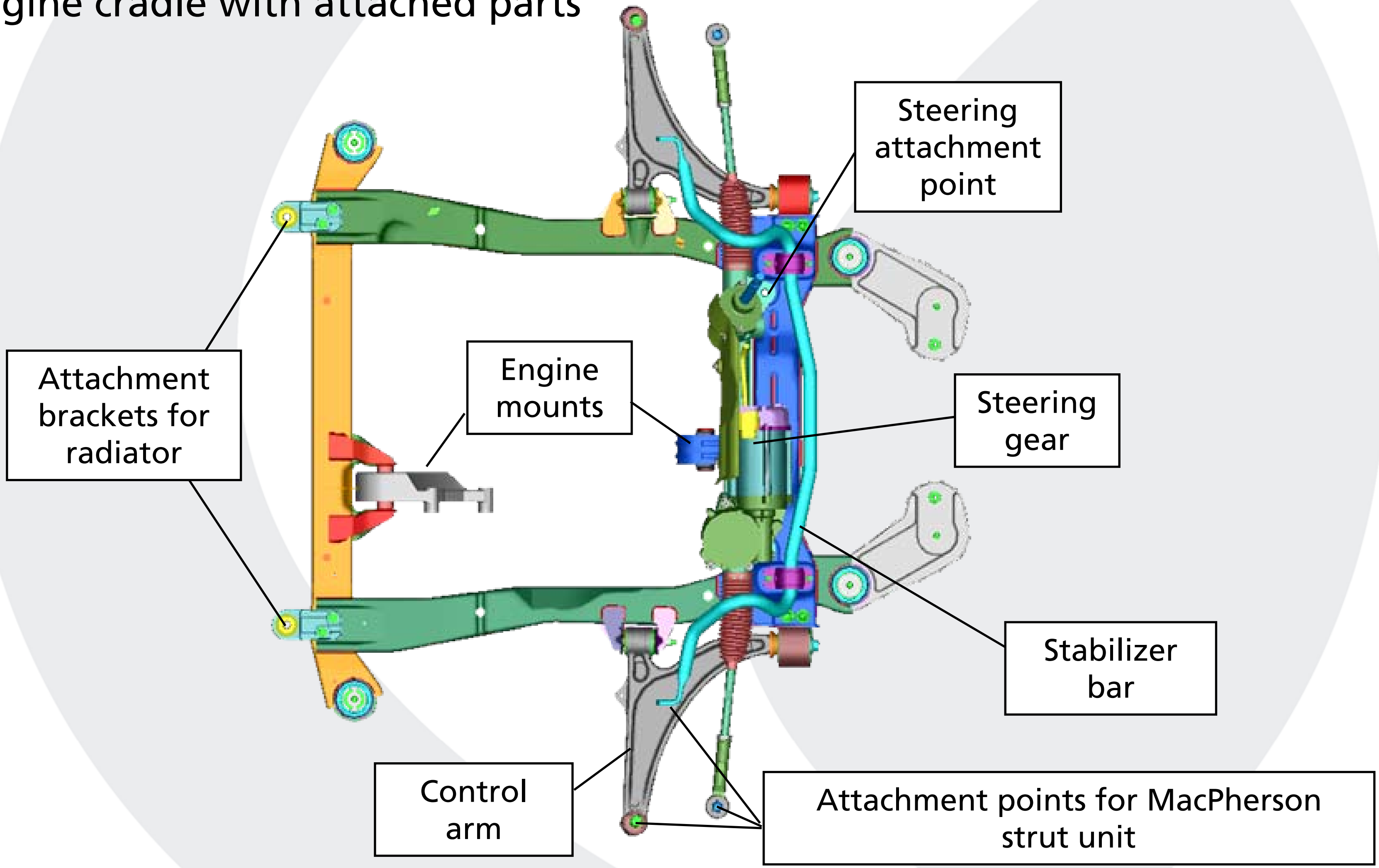
2. Optimization of an engine cradle

Engine cradle with attached parts



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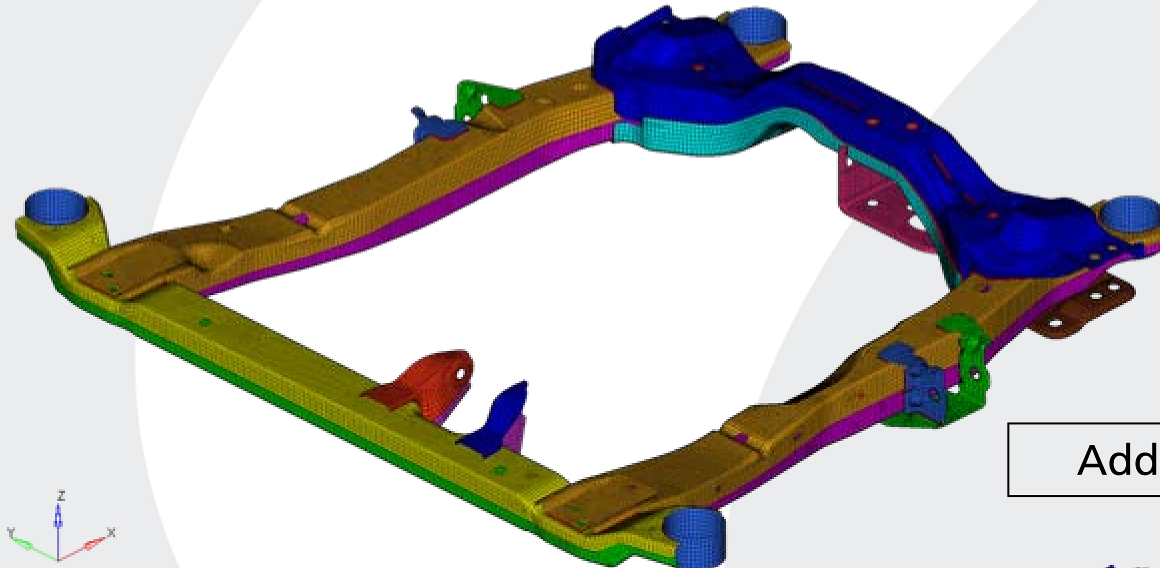
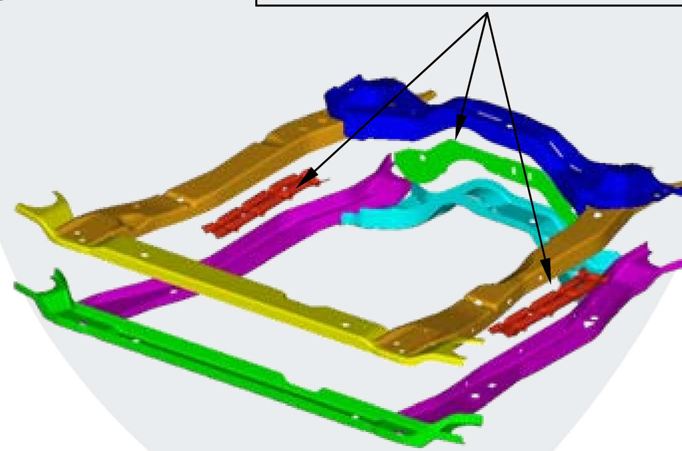
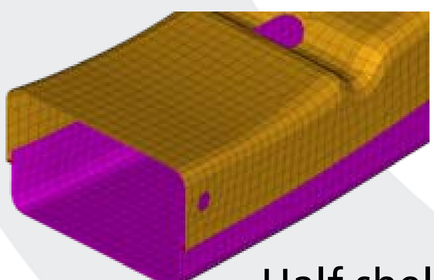
2. Optimization of an engine cradle - Base version

Current design for GM DELTA platform engine cradle:



Additional inlays





Half shell design

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2. Optimization of an engine cradle - Targets

Current design:

Part was developed for the highest requirements regarding engine power, weight & design of the car (high roof or low roof)

Task for new design:

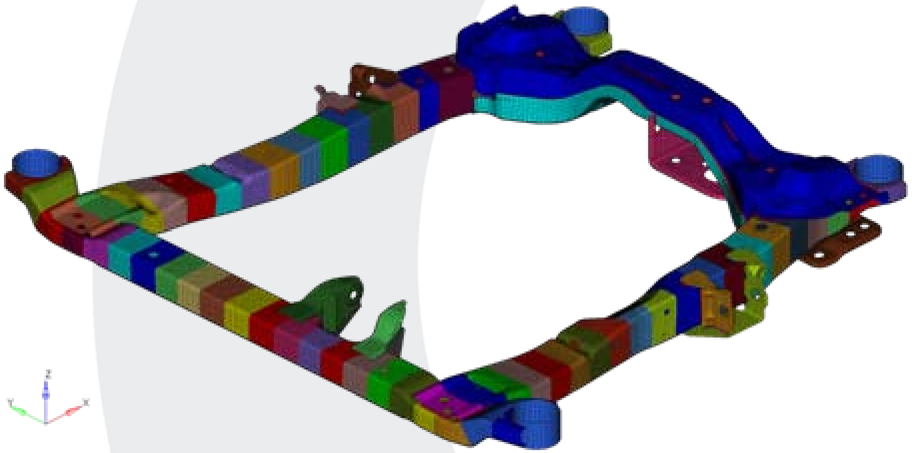
Find a lighter and cheaper version for 70-80% of the vehicle volume by reducing the requirements

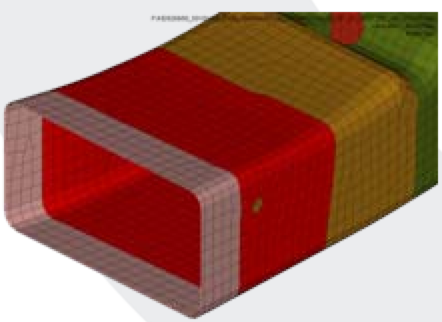
Version 1:	Version 2 & 3:
Base design with reduced sheet thickness	Tailor rolled designs

2. Optimization of an engine cradle - Alternative versions

Version 2:

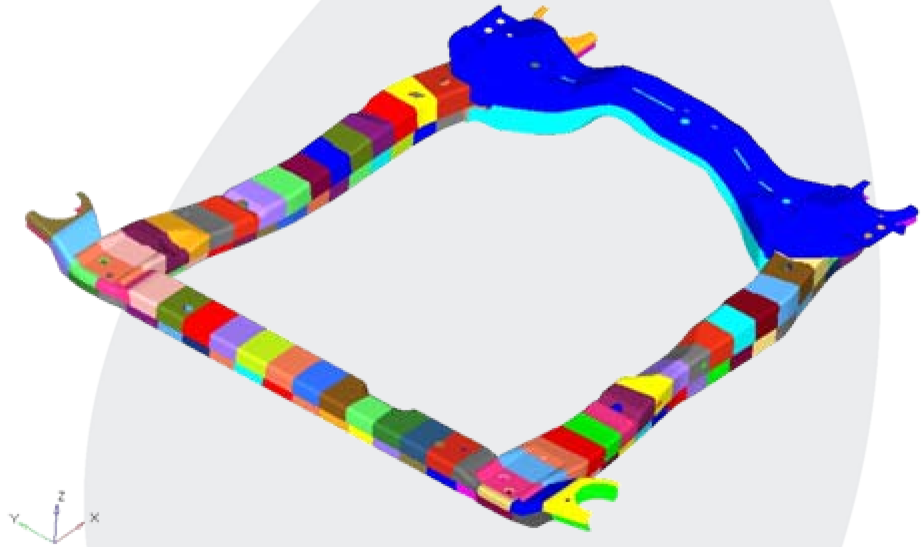
tailored rolled tubes (TRT)

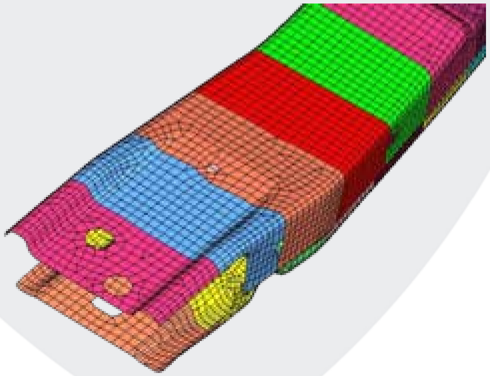




Version 3:

tailored rolled blanks (TRB)





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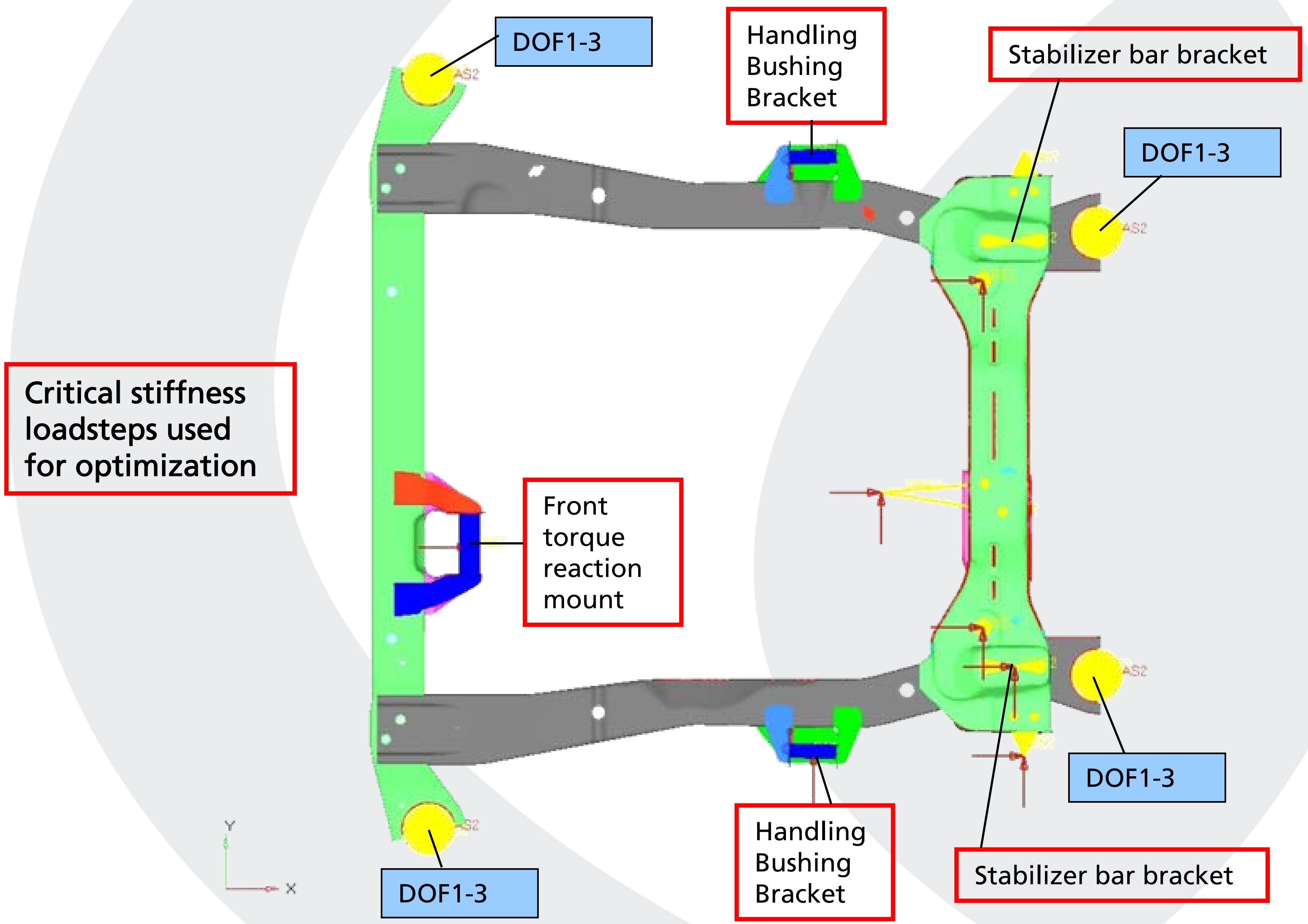
2. Optimization of an engine cradle - Stiffness loadsteps



2. Optimization of an engine cradle - Optimization setup

Responses:

- displacements
- mass

Constraints:

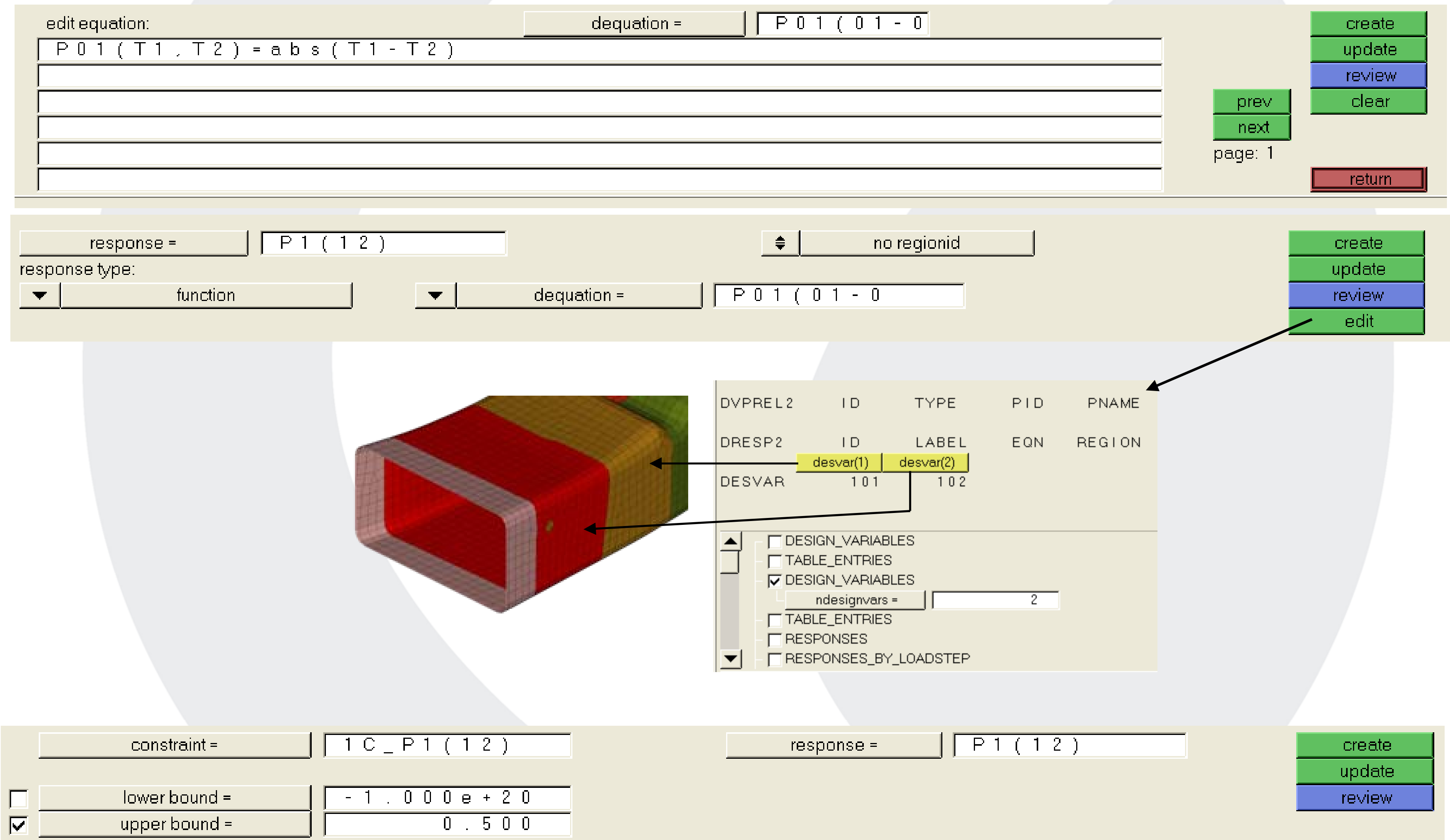
- upper bound of displacements for critical stiffness loadsteps

Objective: min. mass

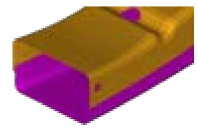
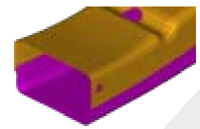
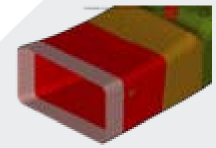
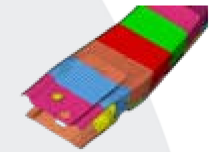
For TRT and TRB additionally:

Equations because of manufacturing constraints for sheet thickness variation (information from TR-manufacturer Mubea: 50mm → +/- 0.5mm)

2. Optimization of an engine cradle - Equations for TR-versions



2. Optimization of an engine cradle - Results

Lcase No.	Lcase Defn.	Dir	Target 100%	Targets reduced	Version 1 Base Design Target 100%	Version 1 Optimized design Targets reduced	Version 2 TRT Optimized Design Targets reduced	Version 3 Optimized design without reinforcements Targets reduced
					ASSY (kg) = 23.71	ASSY (kg) = 23.48	ASSY (kg) = 22.15	ASSY (kg) = 22.47
			KN/mm	KN/mm	KN/mm	KN/mm	KN/mm	KN/mm
F02Y	Handling Bushing Bracket (RH)	Y	16.0	14.3	14.6	14.8	15.1	14.7
F02Z		Z	5.0	4.1	4.1	4.3	4.3	4.3
F03 Y	Handling Bushing Bracket (LH)	Y	16.0	14.3	15.1	14.4	14.7	14.3
F03 Z		Z	5.0	4.1	4.1	4.3	4.3	4.3
F08Z	Stabilizer Bar Bracket (RH)	Z	16.0	15.4	15.4	15.6	16.2	15.9
F09 Z	Stabilizer Bar Bracket (LH)	Z	16.0	15.2	15.2	15.9	16.0	16.2
F11Z	Front Torque Reaction Mount	Z	2.5	2.2	2.2	2.2	2.2	2.3

→ All versions reach stiffness targets after optimization

→ TRT version has the best stiffness values

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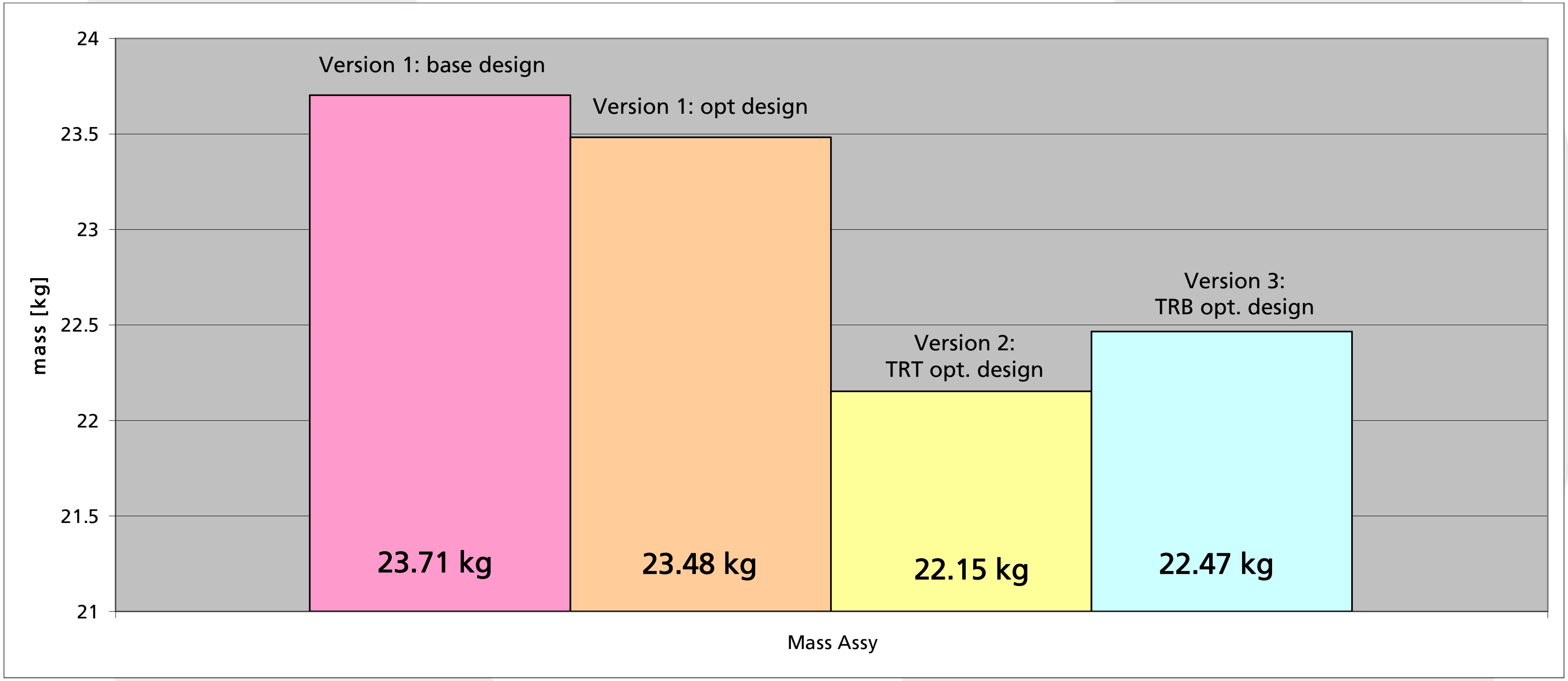
2. Optimization of an engine cradle - Mass overview



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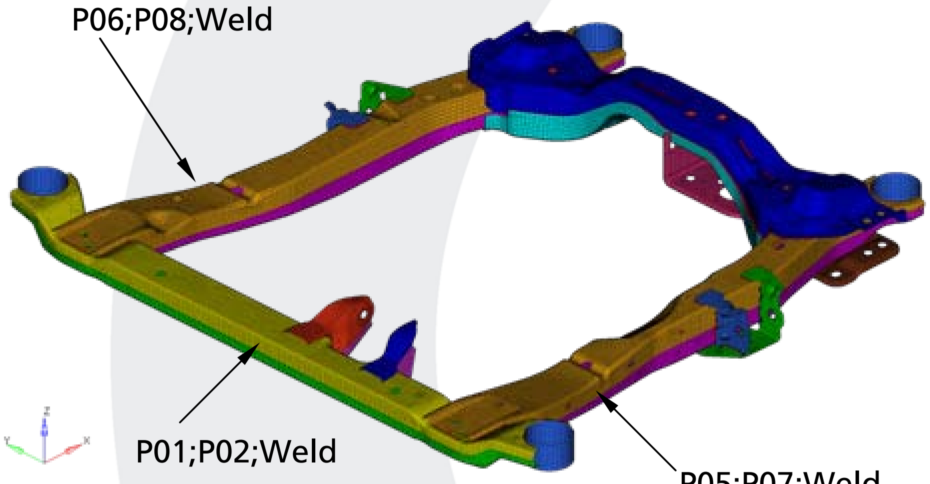
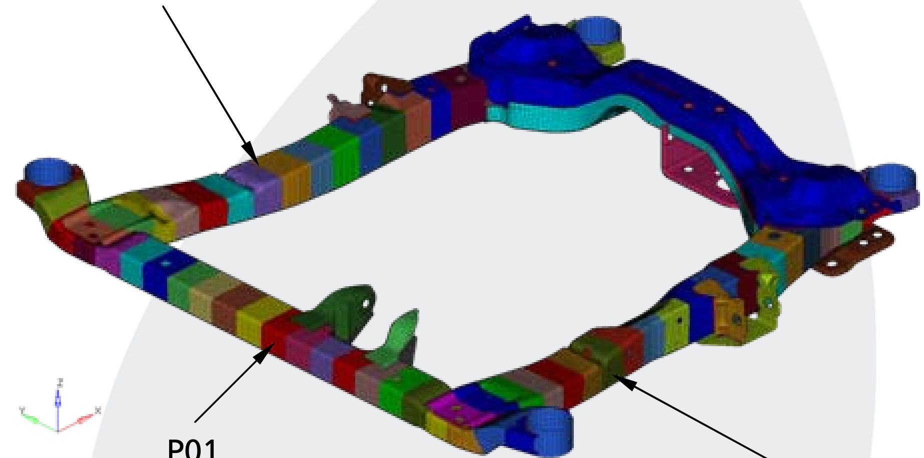
2. Optimization of an engine cradle - Mass Distribution V01 vs. V02+V03





Version 1 Base Design			Version 1 Size optimized			Version 2 TRT			Version 3 TRB		
Assy / Part	Mass (kg)	Mass Red. (%)	Assy / Part	Mass (kg)	Mass Red. (%)	Assy / Part	Mass (kg)	Mass Red. (%)	Assy / Part	Mass (kg)	Mass Red. (%)
ASSY	23.71	0.00%	ASSY	23.48	-0.97%	ASSY	22.15	-6.58%	ASSY	22.47	-5.23%
P01;P02; Weld	3.953	0.00%	P01;P02; Weld	3.789	-4.15%	P01	3.751	-5.11%	P01;P02; Weld	3.915	-0.96%
P05;P07; Weld	5.163	0.00%	P05;P07; Weld	5.208	0.87%	P03	4.372	-15.32%	P05;P07; Weld	4.822	-6.60%
P06;P08; Weld	5.173	0.00%	P06;P08; Weld	5.25	1.49%	P05	4.566	-11.73%	P06;P08; Weld	4.79	-7.40%

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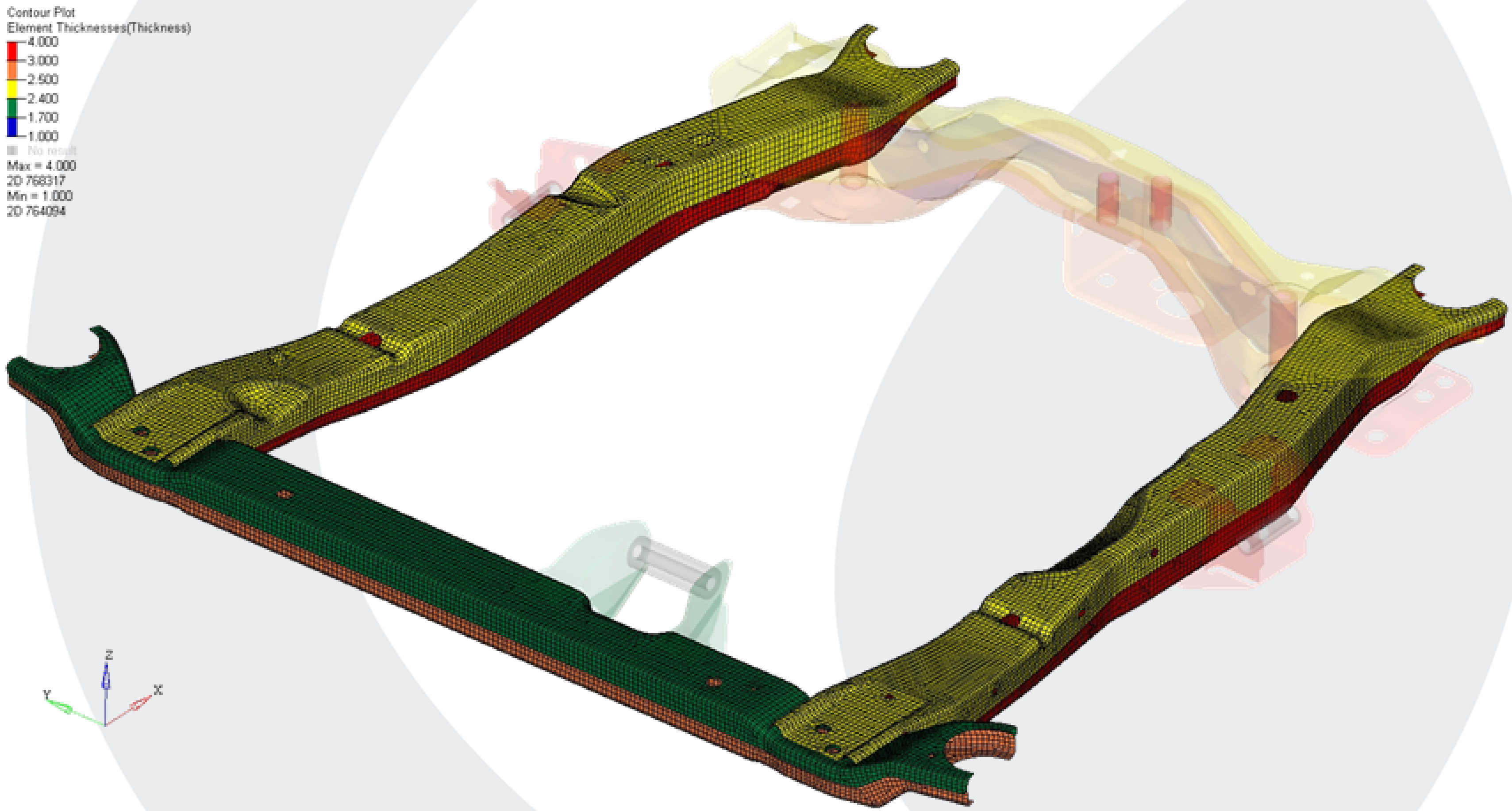
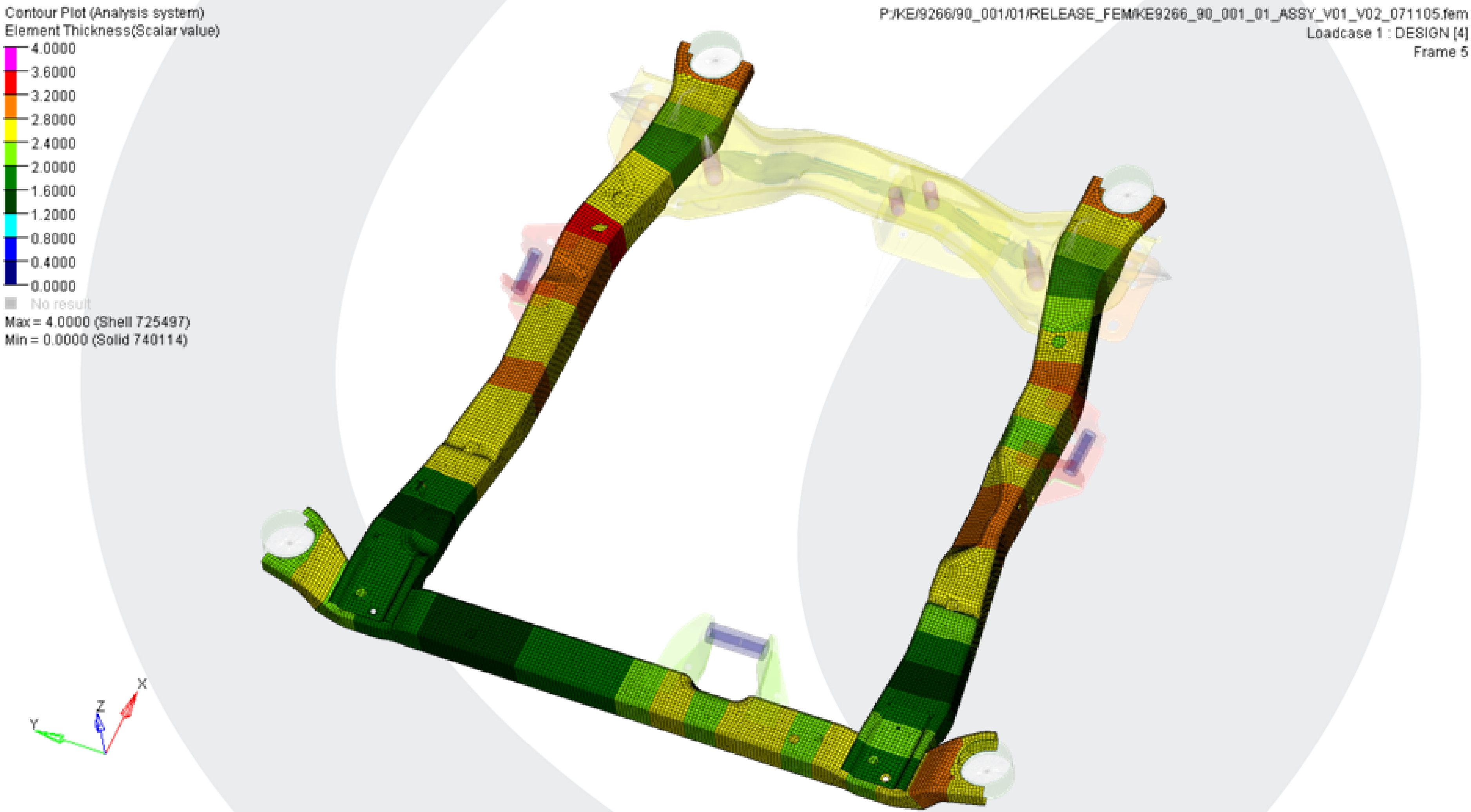
2. Optimization of an engine cradle - Element Thickness Base Design



Element thickness of optimized parts after optimization

2. Optimization of an engine cradle – Version 2: Element Thickness Optimized Design

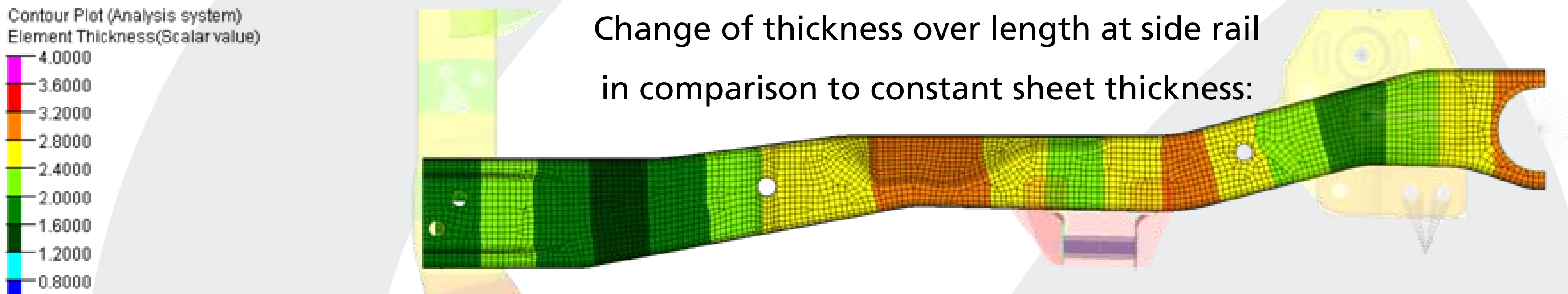


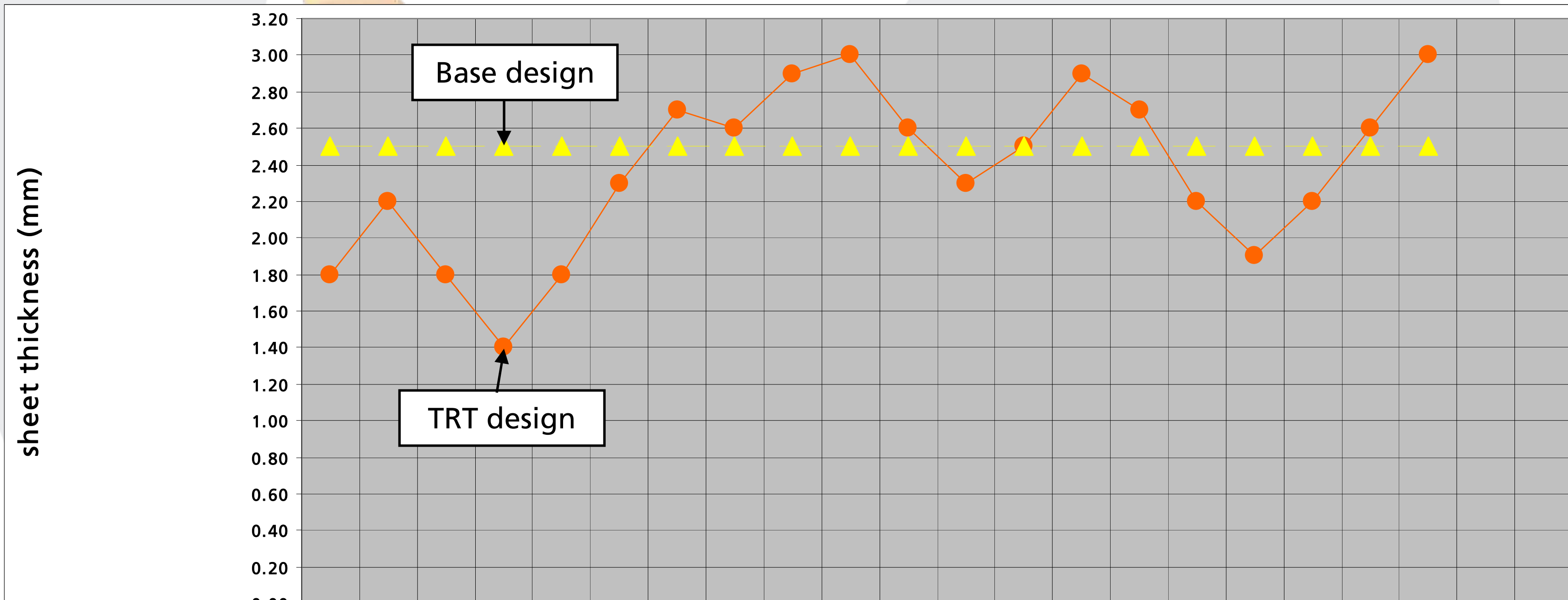
Change of thickness over length of optimized parts

2. Optimization of an engine cradle - Version 2: Element Thickness P03

Change of thickness over length at side rail

in comparison to constant sheet thickness:



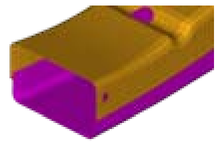


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
V02_01 - P03 TRT	1.80	2.20	1.80	1.40	1.80	2.30	2.70	2.60	2.90	3.00	2.60	2.30	2.50	2.90	2.70	2.20	1.90	2.20	2.60	3.00		
V02_00 - P03 Const.	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50		

2. Optimization of an engine cradle - Summary

- **Version 1:**

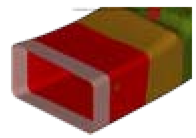
+ Low manufacturing costs



- Low mass reduction
- Additional inlays

- **Version 2:**

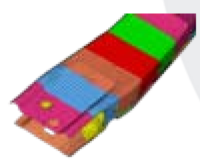
+ About 7% mass reduction with tailored rolled tubes
+ No additional inlays
+ Optimized strength / stiffness



- Highest manufacturing costs (TRT, Hydroforming)

- **Version 3:**

+ About 5% mass reduction with tailored rolled blanks
+ No additional inlays
+ Optimized strength / stiffness



- Heavier than version 2 because of overlapping shells and weldseam
- High manufacturing costs (TRB)

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2. Optimization of an engine cradle - Conclusion

- Version 2 (TRT) has the highest potential for mass reduction but high manufacturing costs and the need for new tools
- From 15-20% mass reduction on tailored solutions are profitable
- Less than 10% mass reduction for the engine cradle because of complex loadstep combinations

→ No change for series production part

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Agenda

1. Overview of Kirchhoff Automotive

2. Optimization of an engine cradle – study of light weight designs with tailored rolled tubes and blanks

3. **Conclusion**

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3. Conclusion

- Target is always to optimize performance and to reduce mass, time and costs at the same time
- Examples show that Kirchhoff Automotive uses all optimization disciplines to find the best solutions in a short time

  (e.g. steel or steel plastics version, best bead design, optimized topology,…)
- Size optimization is mainly used in the „fine-tuning phase“

Thank you for your attention