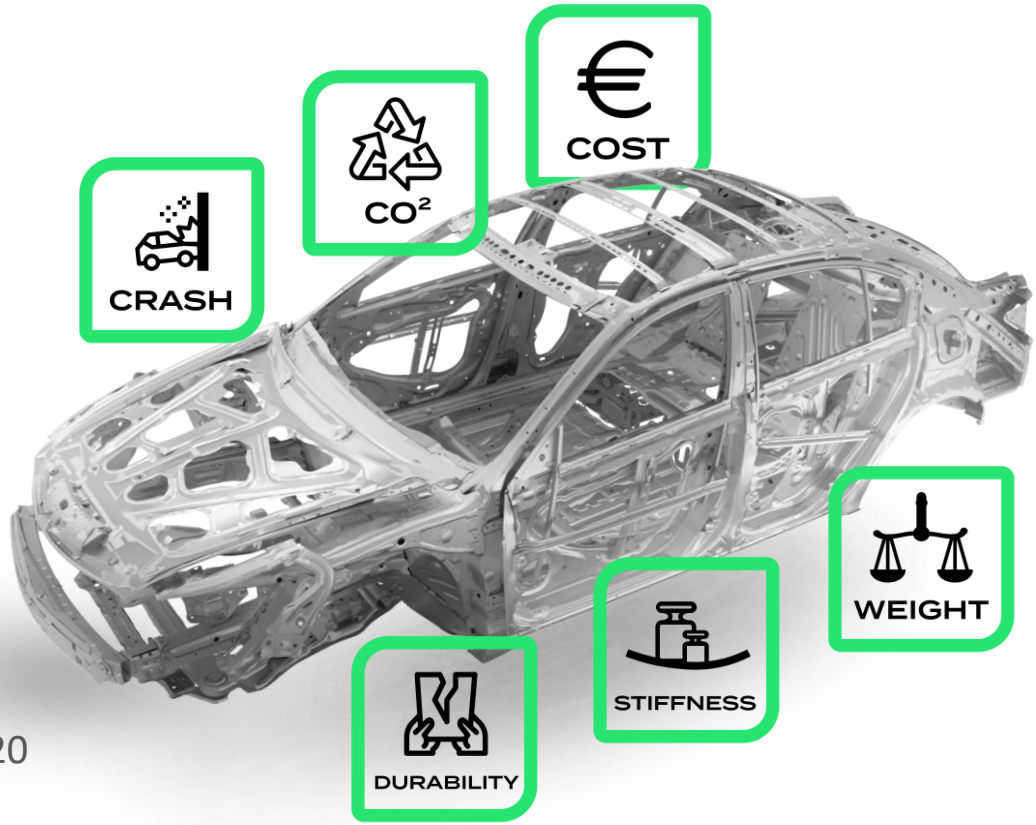
LWR – Lightweight Rating of Vehicle Body Structures

LWR-Soft
Lightweight Rating



Conference: Strategies in Car Body Engineering 2020
Location: Bad Nauheim
Date: 4th – 5th March 2020
Contact: Prof. Dr.-Ing. Thilo Röth
M.Sc. Sebastian Esser, MBA

Project-Background

The Project has been mainly performed with the research funding of the German Ministry BMWi (Bundesministerium für Wirtschaft und Energie) within the Research Subject „Light Weight Concepts for Vehicles on Roads and Rails“. The Project Execution Organization was the TÜVRheinland.

Project Name: „LeiRa“ – Leichtbau-Rating-System für Karosserie- und Fahrwerkstrukturen

Cooperation-Partner:

- Ford Werke GmbH
- Imperia GmbH / FEV Vehicle GmbH
- FH Aachen

Projektträger

TÜVRheinland®
Genau. Richtig.

Fördergeber

Bundesministerium
für Wirtschaft
und Energie

Programm: Leichtbaukonzepte für Straßen- und Schienenfahrzeuge

The shown results are mainly derived by the research activities of the FH Aachen (University of Applied Sciences)!

We are Living in a World of Rating Systems

Why do we use Rating Systems?

To get a quick and „objective“ judgment of the functional performance of a product!

Where do we use Rating Systems for Example?

Crash

Energy-Consumption

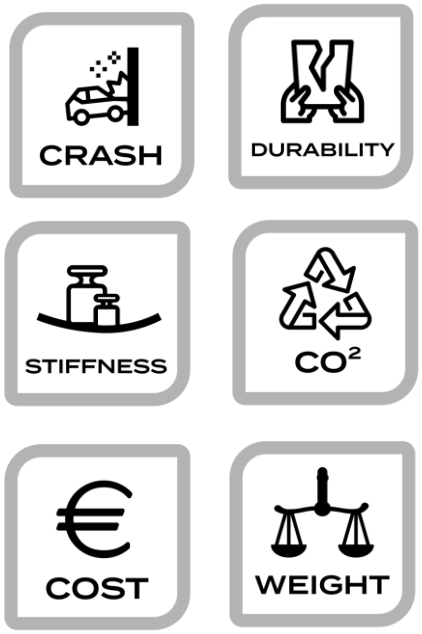
Tires

Food

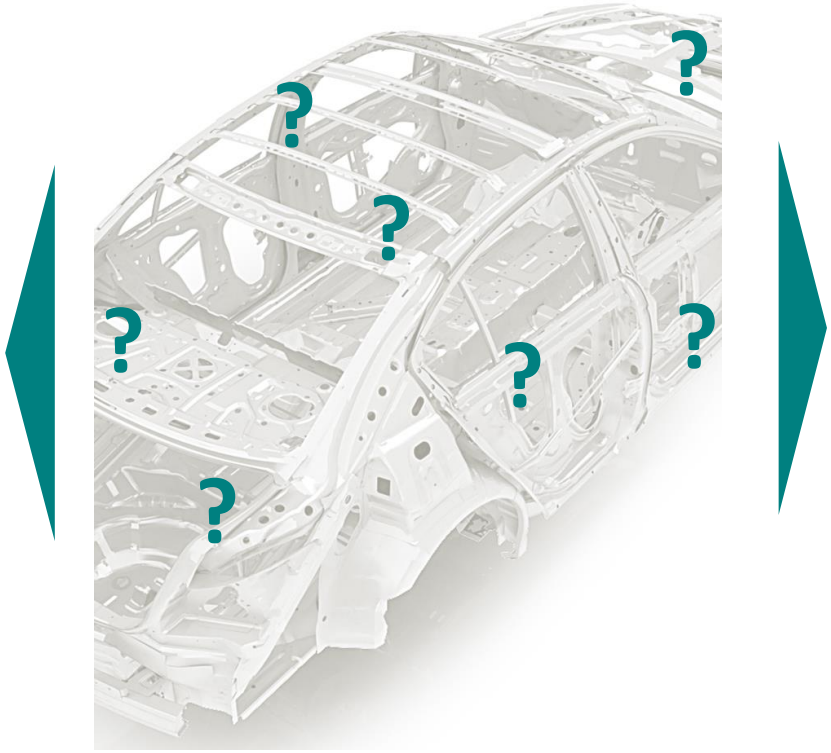
What is behind Rating Systems?

Detailed functional criteria or sub-criteria are getting judged on the bases of standardized tests. Typically the Weighting and the Balancing Method (or both together) are used to define a set of rating criteria.

To Judge Many Thousands of Different Body Structures a Light Weight Rating System need to Focus on the Objective Comparison of Vehicle Functions, resp. the Structural Functions



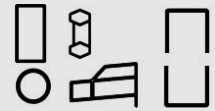
Rating Main Criteria



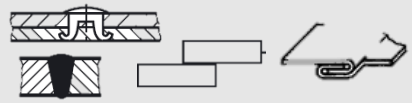
The Question is: What Lightweight Technology is at what location in a new BIW the best?

- **Materials**

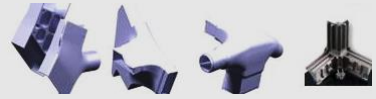
- **Design Principals**



- **Joining**



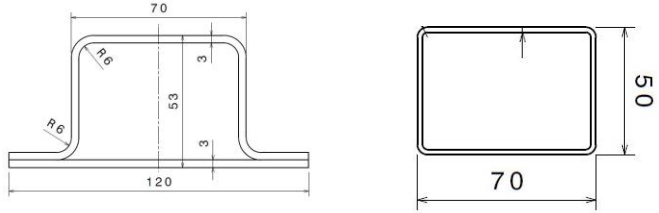
- **Manufacturing**



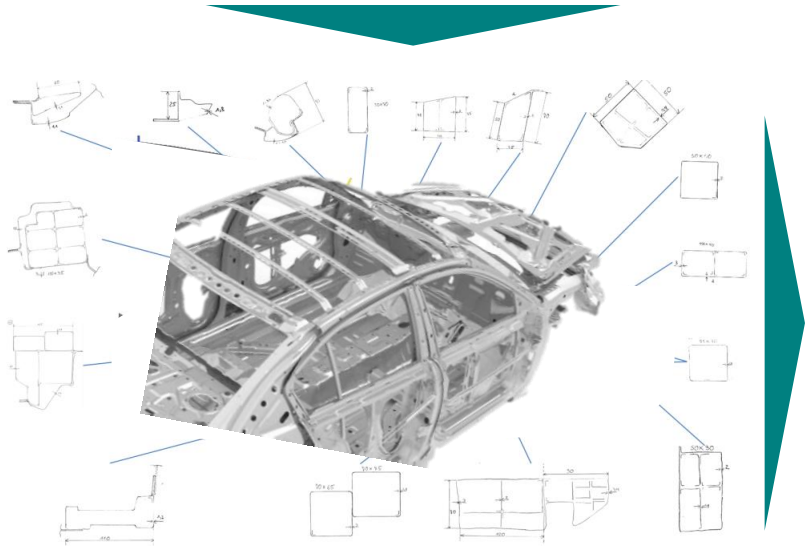
Thousands of Combinations to Design Body Structures!

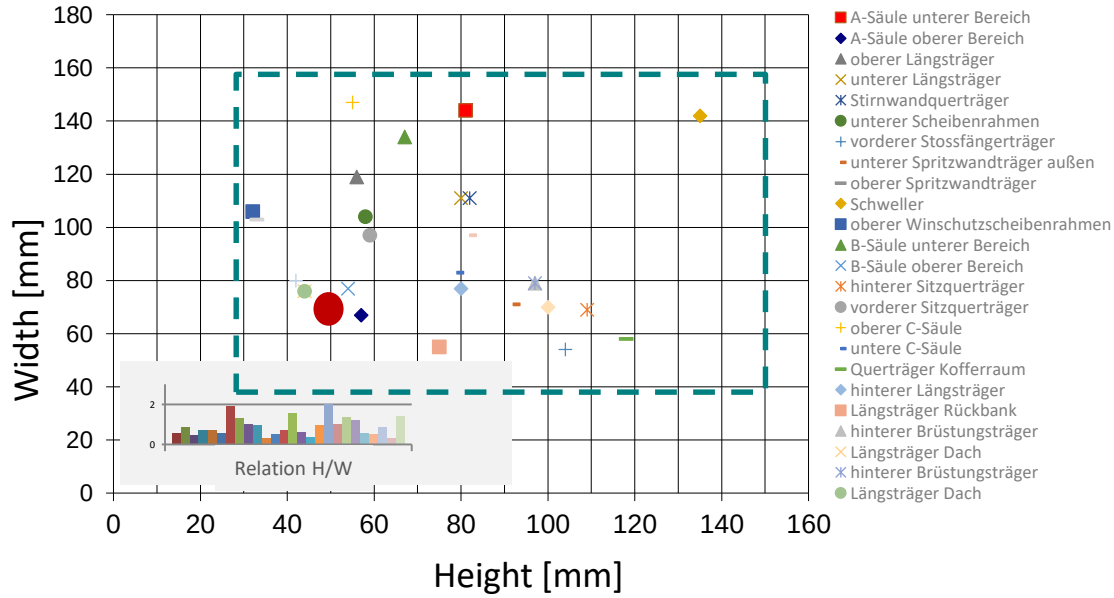
The Baseline of LWRating is a fixed defined Geometry of a Structure, which has been Derived from Vehicle Body Structures Benchmark

What is the right Space for the Reference Structure?

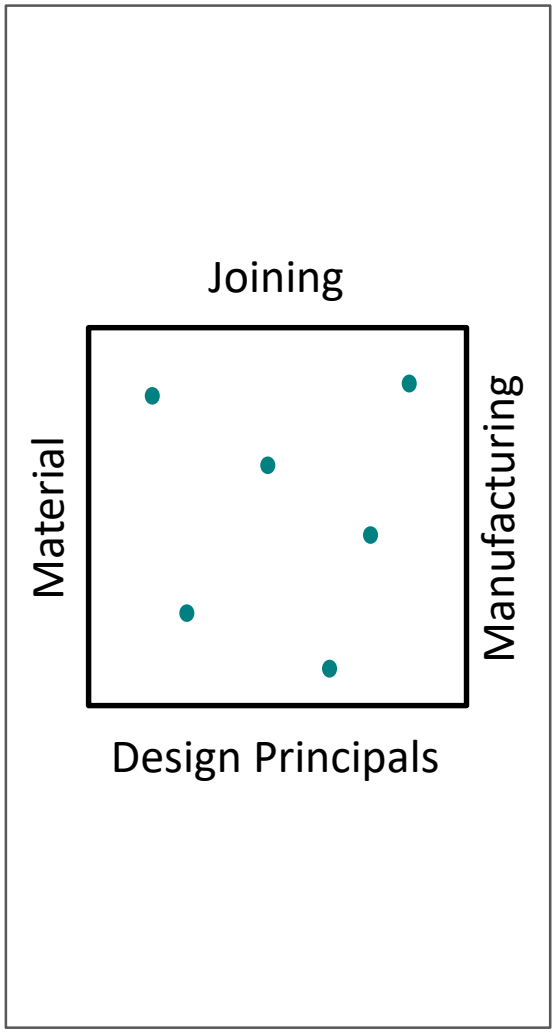


Length: 370mm





A Selection of State of the Art Structures and Future Structures have been used to validate the LWRating



	Stamping	Stamping	Rollform
Weight [kg]	0,98	0,95	1,27
Material	Steel (ZSTE 340)	Alu (AW 5083)	Steel (ST37-2)
Gauge [mm]	1,0	3,0	2,0
Joining	weld spots & Bond	Semi-tub. rivet & bond	-

	Extrusion	Vacuum Infusion	3D-Printing
Weight [kg]	0,88	0,48	0,90
Material	Alu (AW 6060)	CFK (KDK 8004)	Alu (AlSi10Mg)
Gauge [mm]	4,0	2,6	-
Joining	no	M5 Bolt & nut & bond	no

Based on the Weighting Method, LWRating assesses Lightweight Construction at 3 levels

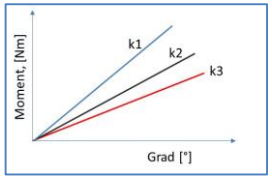
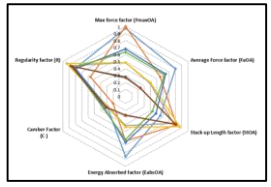
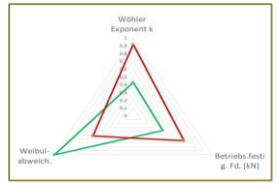
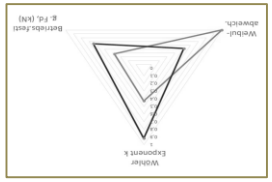
Level 1
Overall result

★★★★☆

Level 2
Per performance criterion

Stiffness / NVH	Crash	Durability	Sustainability/CO_2
★★★★☆	★★★☆☆	★★★★☆	★★★★☆

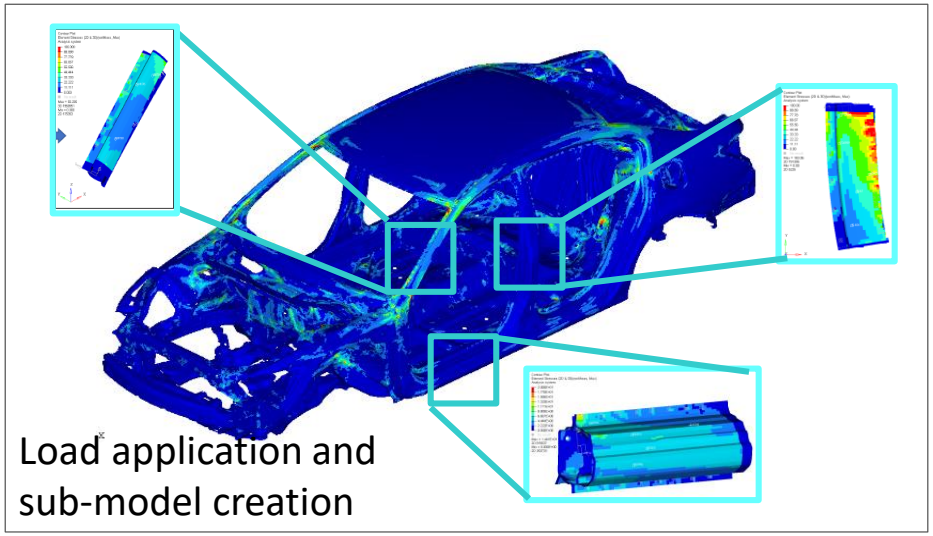
Level 3
Detailed review per load case

Stiffness (2 Factors)	**Crash** (11 Factors)	**Durability** (3 Factors)	**Sustainability** (3 Factors)
			
2 x 3 tests	4 x 3 tests	15-18 tests	3 Analysis

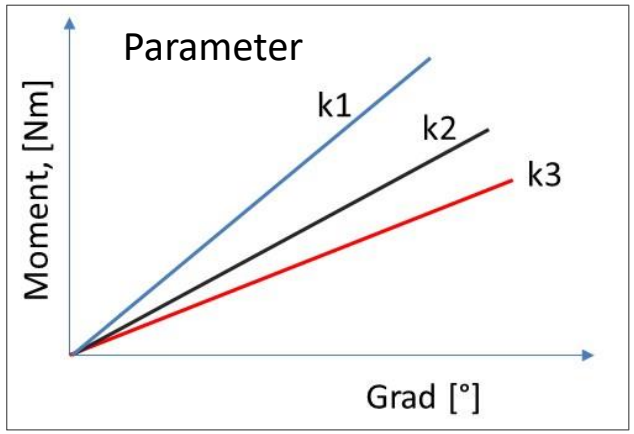
Like any other rating system, the LiRa rating scheme is evolutionary!

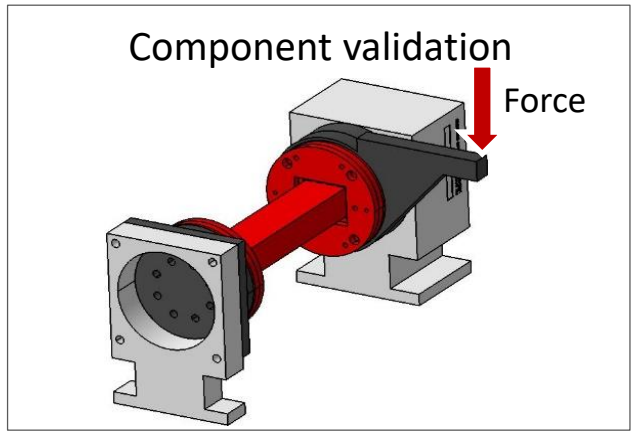
Based on the overall Vehicle Analysis the Stiffness Load Case and the Stiffness Parameter are derived

Determination of driving dynamics as input for body model



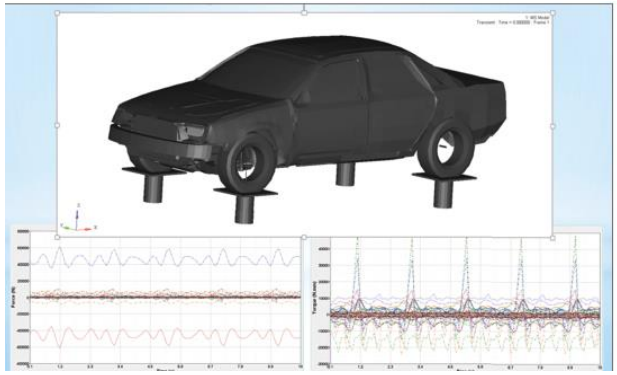
Load application and sub-model creation



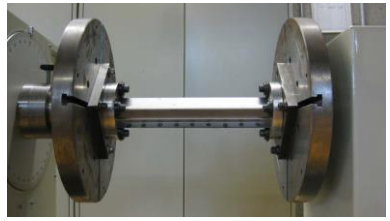


1 Loadcase
1 Parameter

Based on the overall Vehicle Analysis the Operational Strength Load Case and the Durability Parameter are derived

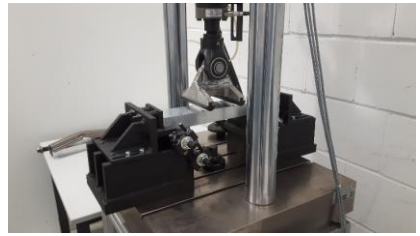


Analysis of real driving load conditions of structures



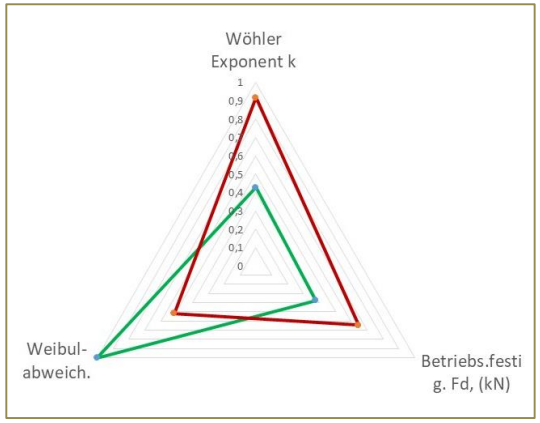
Torsion load

4-Point-Bend

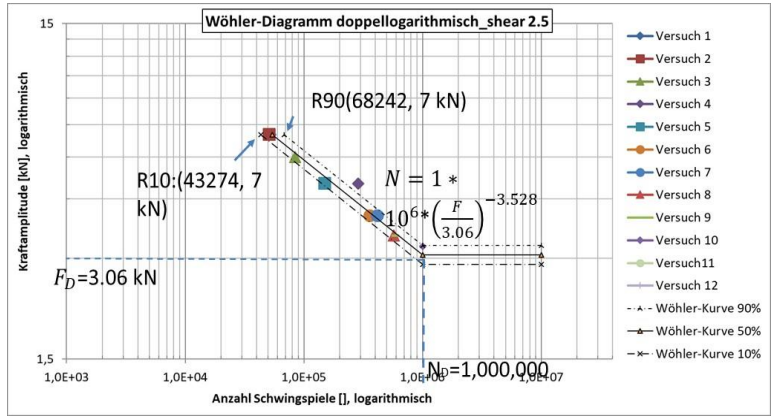


Load Cases - Definition

1 Load case
6 Force levels
3 Parameters



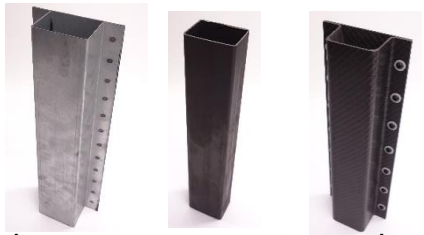
Parameters



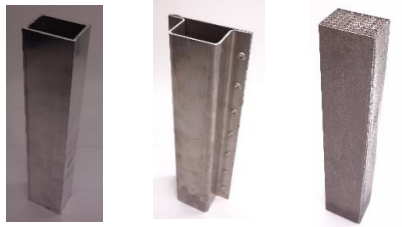
Component – Woehler – Curve

Process for determining the CO_2 Parameter on the basis of Reference Data and the help of a LWRating CO_2 evaluation Method

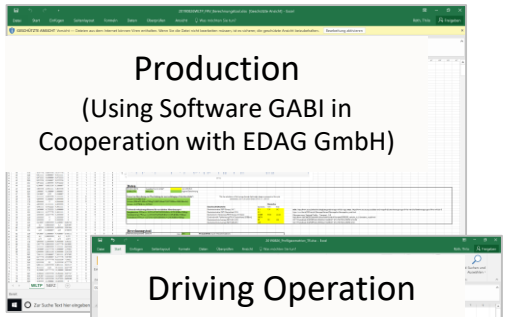
EU body and vehicle benchmark to define the reference base



Application on LWRating technologies



Data – Starting Base



Own LWRating-CO_2-Method

Gesamt-CO_2-Bilanz [kg]

	Herstellung	Betrieb	Recycling	Total	
P001	2,3	-0,80	-0,40	1,10	★
P002	7,19	23,39	2,25	32,83	★★★★★
P003	28,77	22,27	2,66	53,70	★★★
P004	8,79	30,47	2,95	42,21	★★★★
P005	21,34	21,08	2,46	44,88	★★★★

Legende (jew. Bestwert/Total)

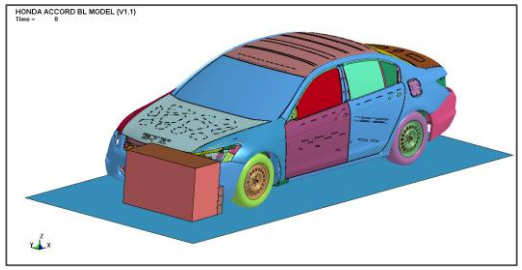
0-0,5	★
0,5-0,6	★★
0,6-0,7	★★★
0,7-0,8	★★★★
0,8-1	★★★★★

LWRating - CO_2-Parameter

3 Parameters

Based on the complete Vehicle Simulations and Deformation modes the LWRating Crash Tests are derived

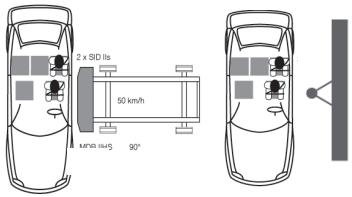
Full Vehicle Crash Load Cases



Frontal Impact

Rear Impact

Side Impact



Roof Crush

Deformation modes

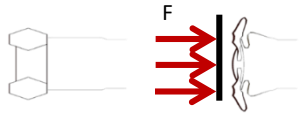
Fold bulge

Irregular Fold bulge

Bending through axial force

Fold bend

Bending through radial force

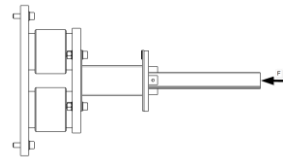


Crumpling

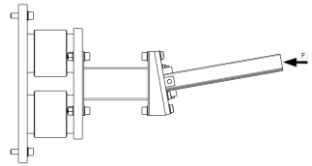
Derived tests

Crash (dynamic)
Crush (quasi-static)

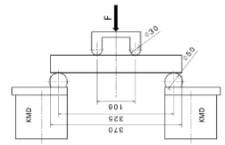
1.) Axial Load (0 degree angle)



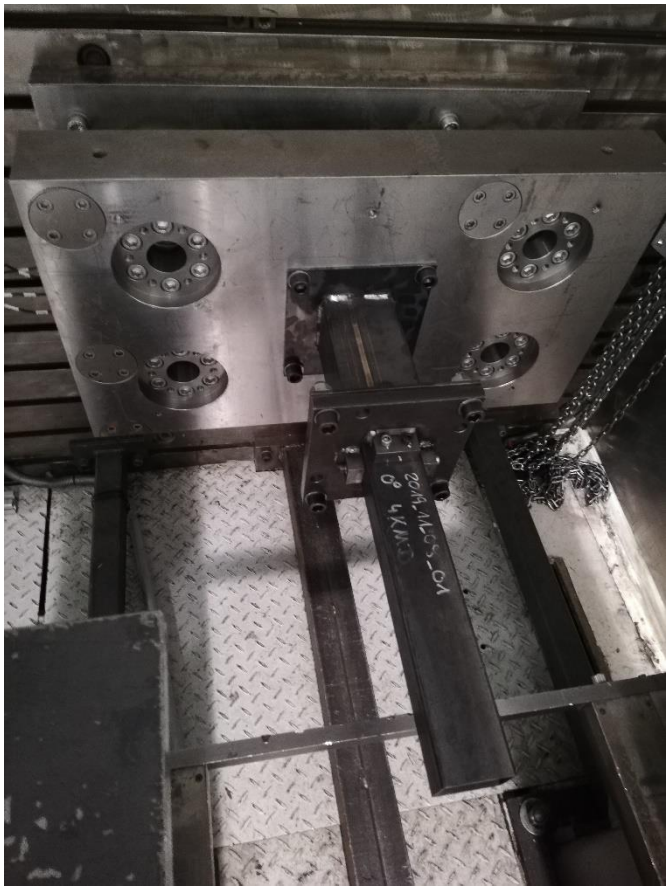
2.) Load at an angle (10 degree angle)

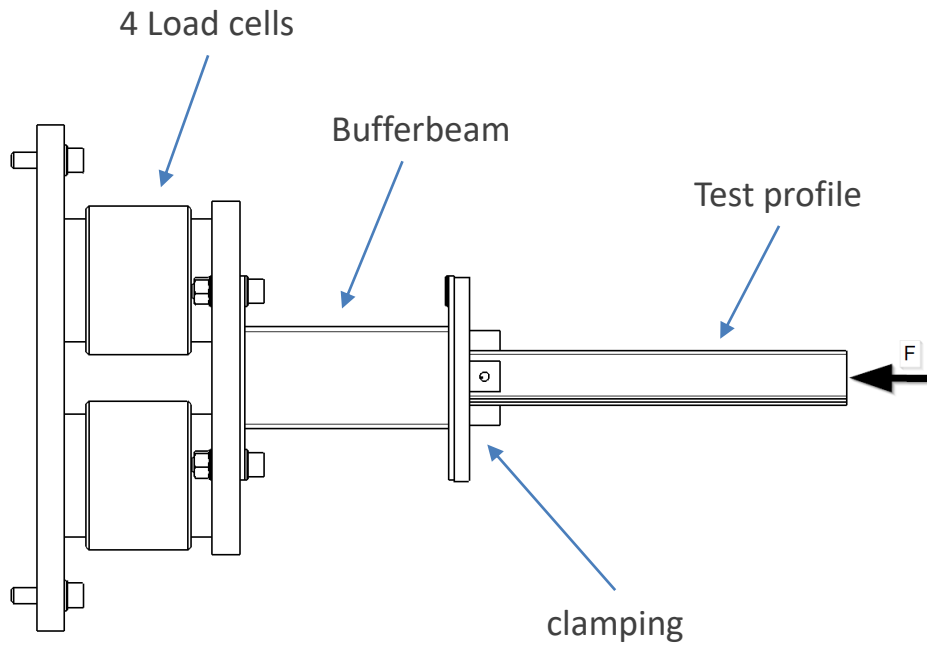


3.) 3-Point-Bending (3PB)



Final exemplary Test Setup for the High-Speed Crash Load Case under 0° and 60 kph





Speed:	60 kph
Mass sledge:	350 kg

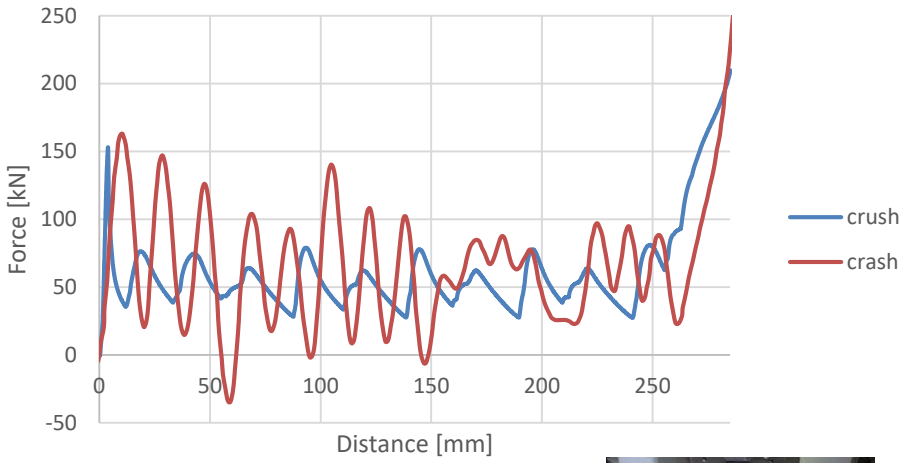
Comparison of High-Speed Crash and quasi-static Crush for an exemplary LWRating Profile

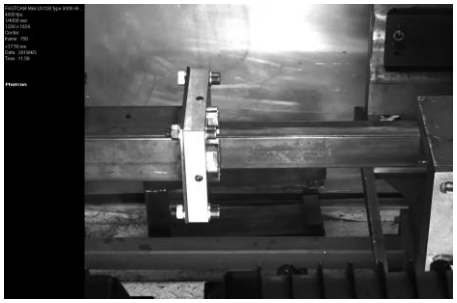
Steel Rectangle

Axial Load 0° Angle

Aluminum Rectangle

TP004 Comparison dynamic & quasi-static

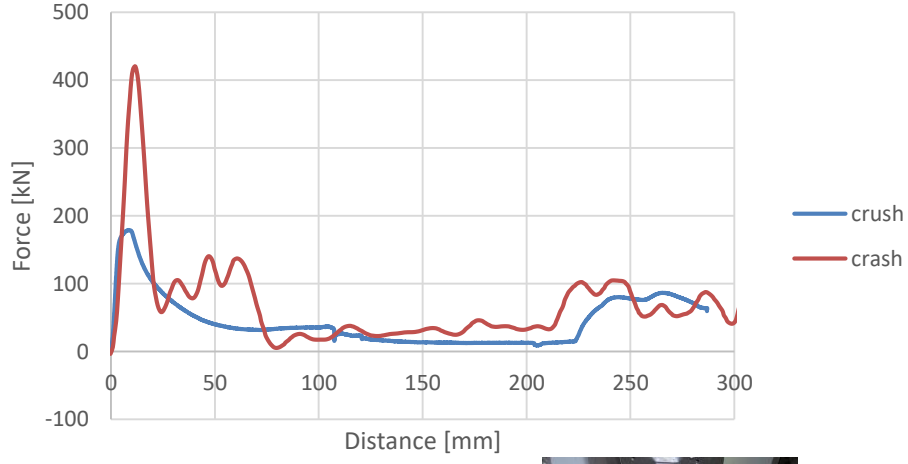


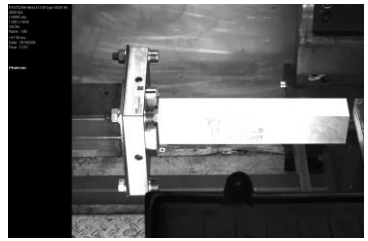


Crash / 60kph

Crush / 1mm/s

TP005 Comparison dynamic & quasi-static

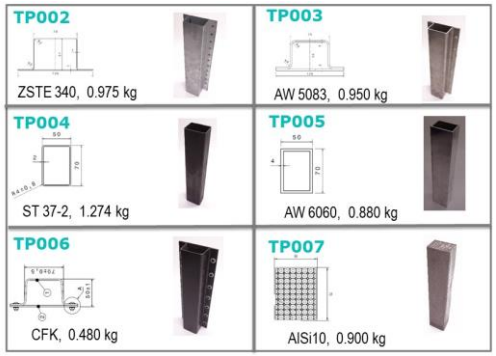




Crash / 60kph

Crush / 1mm/s

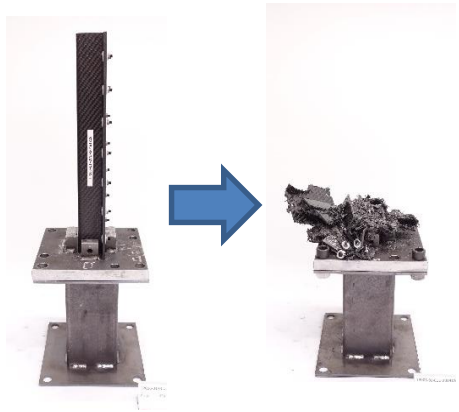
Test procedure for the Crash Load Case – From Test planning to Parameter Evaluation



Pos	Nr.	Funktion	Kurzbeschreibung	TP001	TP002	TP003	TP004	TP005	TP006	TP007	TP008
				D-U	St-Hut	Al-Hut	St-4K	Al-4K	CFK	3D-Druck	St-R
1	LiRa_01_CA	Crash	Axiale Stauchung bei 60km/h dynamisch		3	3	3	3	3	2	
2	LiRa_02_CA	Crash	Axiale Biege-Stauchung unter 10° bei 60 km/h dynamisch		3	3	3	3	3	2	
3	LiRa_03_CA	Crash	Biegung 3 Punkt (Fiansch ist auf den Auflagern) dynamisch bei 30 km/h ?		3	3	3	3	3		
4	LiRa_04_CA	Crash	Biegung 3 Punkt (Fiansch ist auf der Seite wo der Impakt statt findet) dynamisch bei 30 km/h ? Optional: wenn zeitlich möglich		3	3	3	3	3		
5	LiRa_05_CU	Crush	Axiale Stauchung quasistatisch		5	5	7	6	3	2	
6	LiRa_06_CU	Crush	Axiale Biege-Stauchung unter 10° quasistatisch		5	3	6	4	3	2	
7	LiRa_07_CU	Crush	Biegung 3 Punkt (Fiansch ist auf den Auflagern) quasistatisch		3	3	3	3	3		
8	LiRa_08_CU	Crush	Biegung 3 Punkt (Fiansch ist auf der Seite des Impaktors)		3	3	3	3	3		
9	LiRa_09_ST	Steifigkeit	Torsionssteifigkeit		2	2	2	2	2		
10	LiRa_10_ST	Steifigkeit	Biegung 3 Punkt (Fiansch ist auf den Auflagern)		2	2	2	2	2	1	
11	LiRa_11_ST	Steifigkeit	Biegung 3 Punkt (Fiansch ist auf der Seite des Impaktors)		2	2	2	2	2	0	
12	LiRa_12_BT	Betriebs-festigkeit	Torsion bei R=-1		15	15	15	15			10
13	LiRa_13_CO	CO2 / Anschauung			0	0	0	0	0		

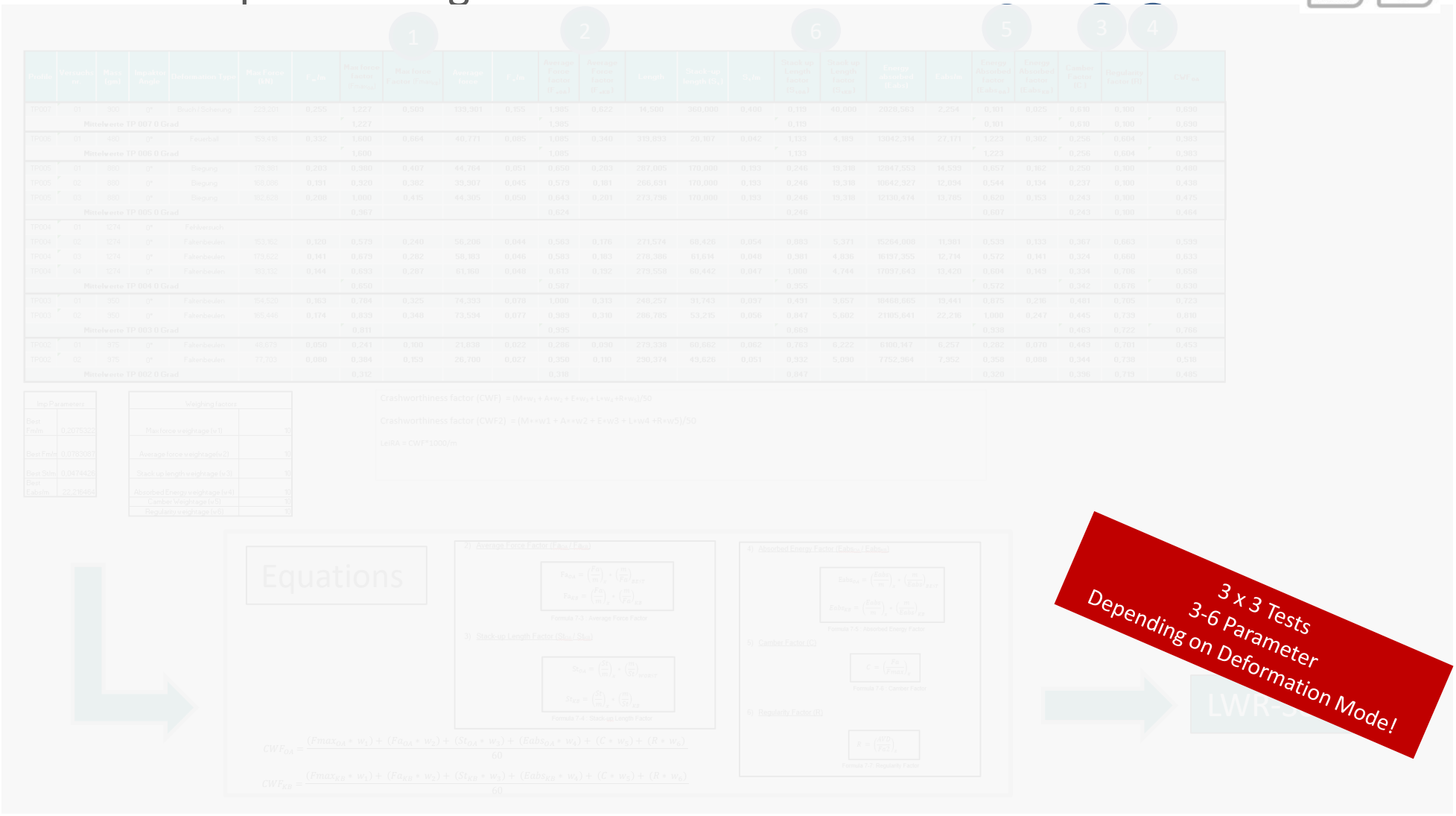
Trial program and test subjects TP2-7

- Force-displacement curves
- Standardized images
- Standardized films



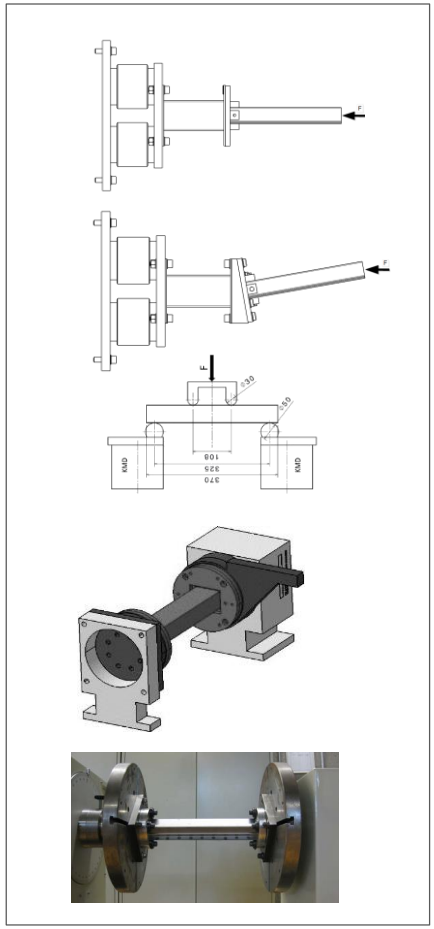
Creation of standard based test data

A look at the result Table, which is input for LWR-Software, serves as an example of a single Crash Load Case

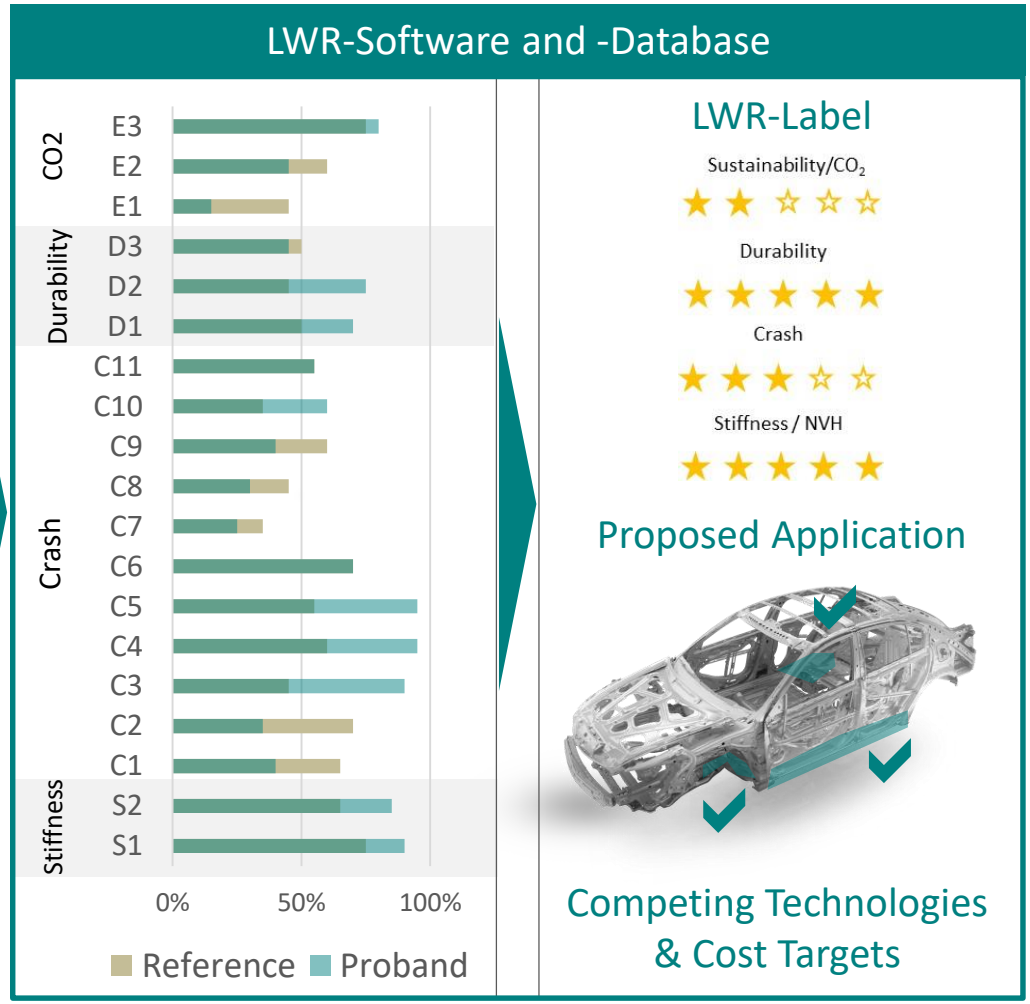


Scenario 1 - How to Use LWRating? A new Technology will be rated and according the rating results the best possible Areas will be proposed!

New Technology



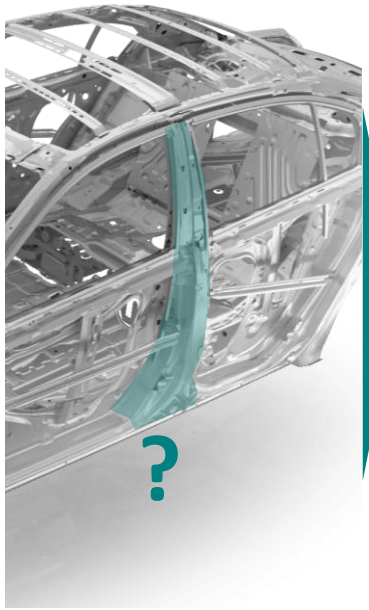
Testing & Analysis



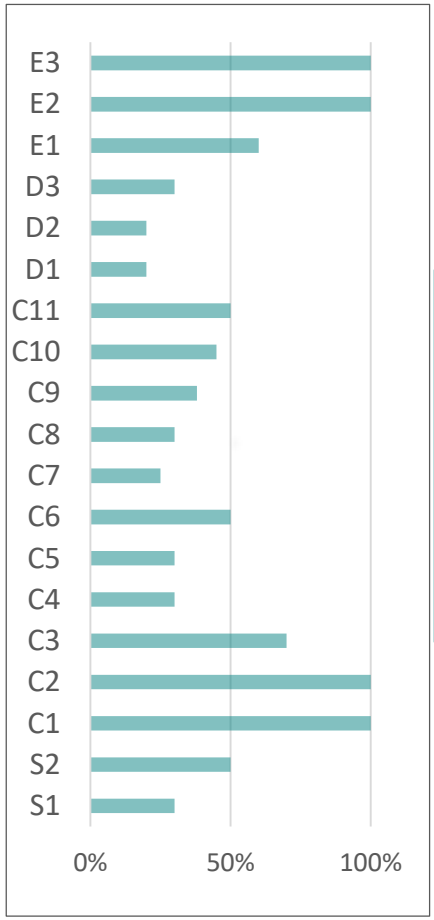
Functional Performance

Output-Data

Scenario 2 - How to Use LWRating? You are interested in an Area of a Body Structure and you want to know, which Technology is the best for it!

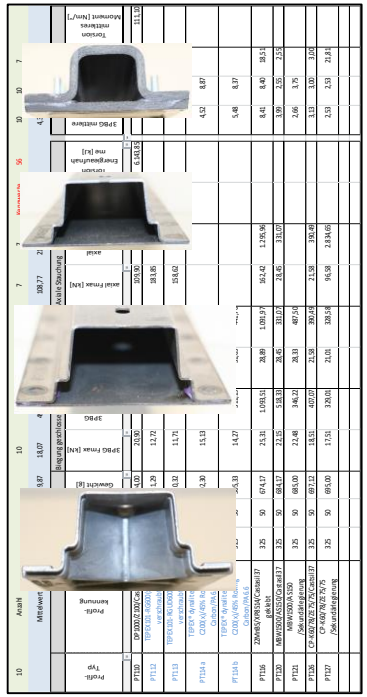


Application Area

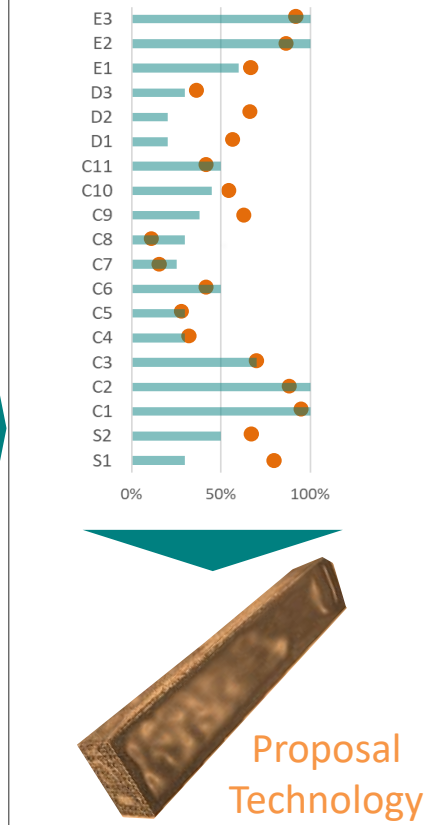


Functional Targets

LWR-Software and -Database

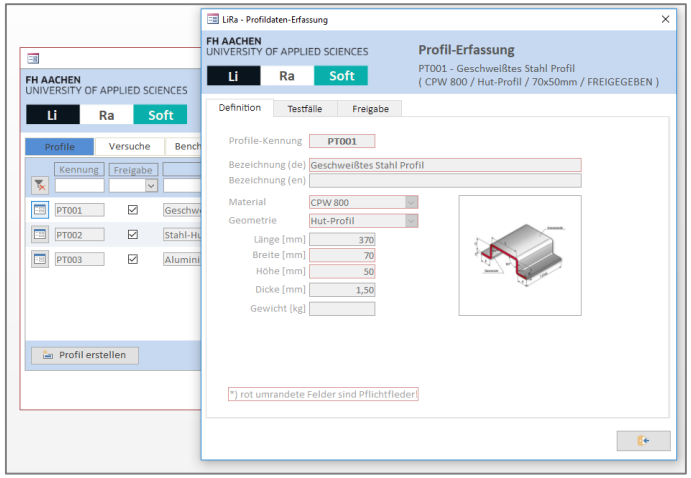


Technology Selection

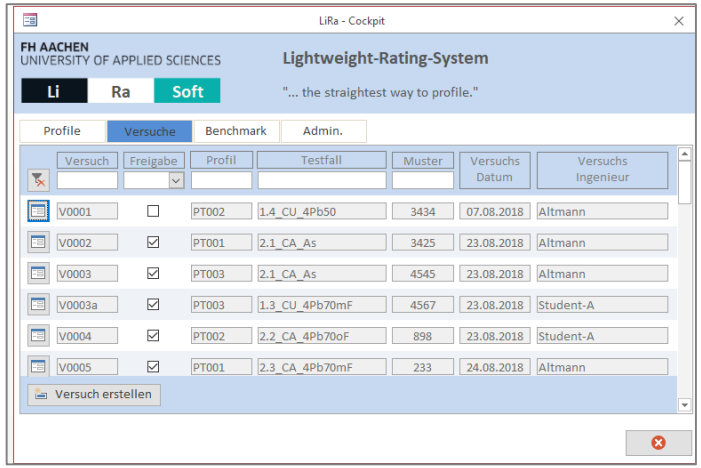


Analysis & Result

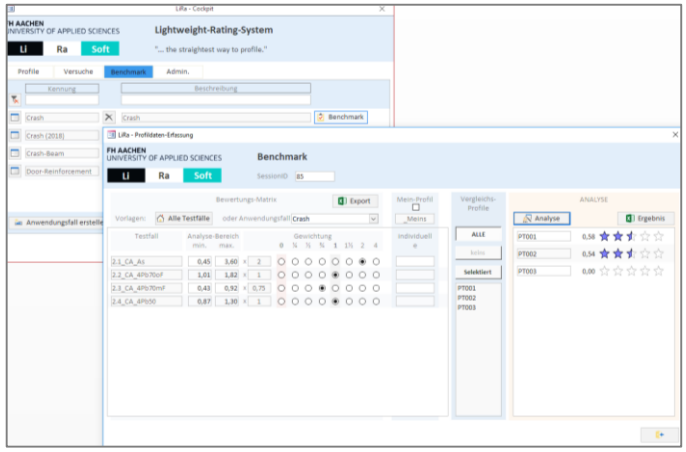
Having an Insight into the Software of LWR-Soft (Back End)



Geometrical Input-Data of Technology



Input of all Testing and Analysis-Data



Benchmark-Result & Rating &
(Proposal of Vehicle Area)

Analysis within Program Code

Summary

- With “LWR-Soft” a Light Weight Rating System for Body and Chassis-Structures has been introduced for the first time
- LWR-Soft is a Knowledge Based Tool for the Predevelopment of Vehicle Structures and it can be Used to Validate FEM-Models or the development of FEM-Methods
- Future Body Structures now can be rated with respect to an „objective“ State of the Art Standard of Vehicle Structures

Next Step

- Market Feedback to be gained
- Partner to be looked for to bring LWR-Soft to Industry-Standards

LWR-Soft
Lightweight Rating

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Thank You for Your Attention!

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