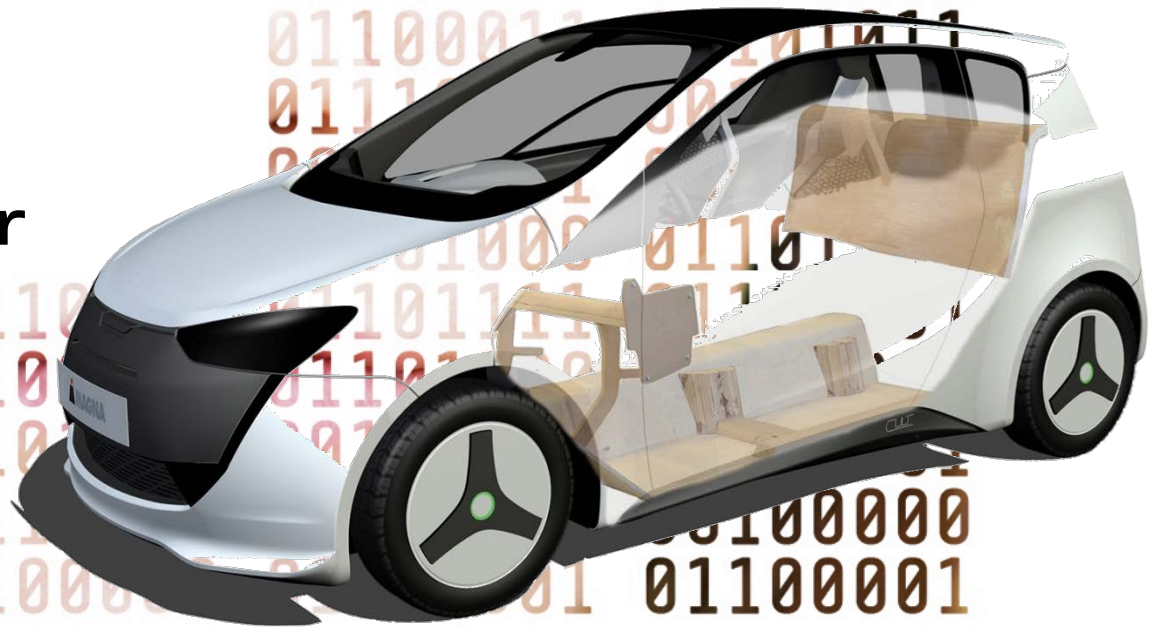
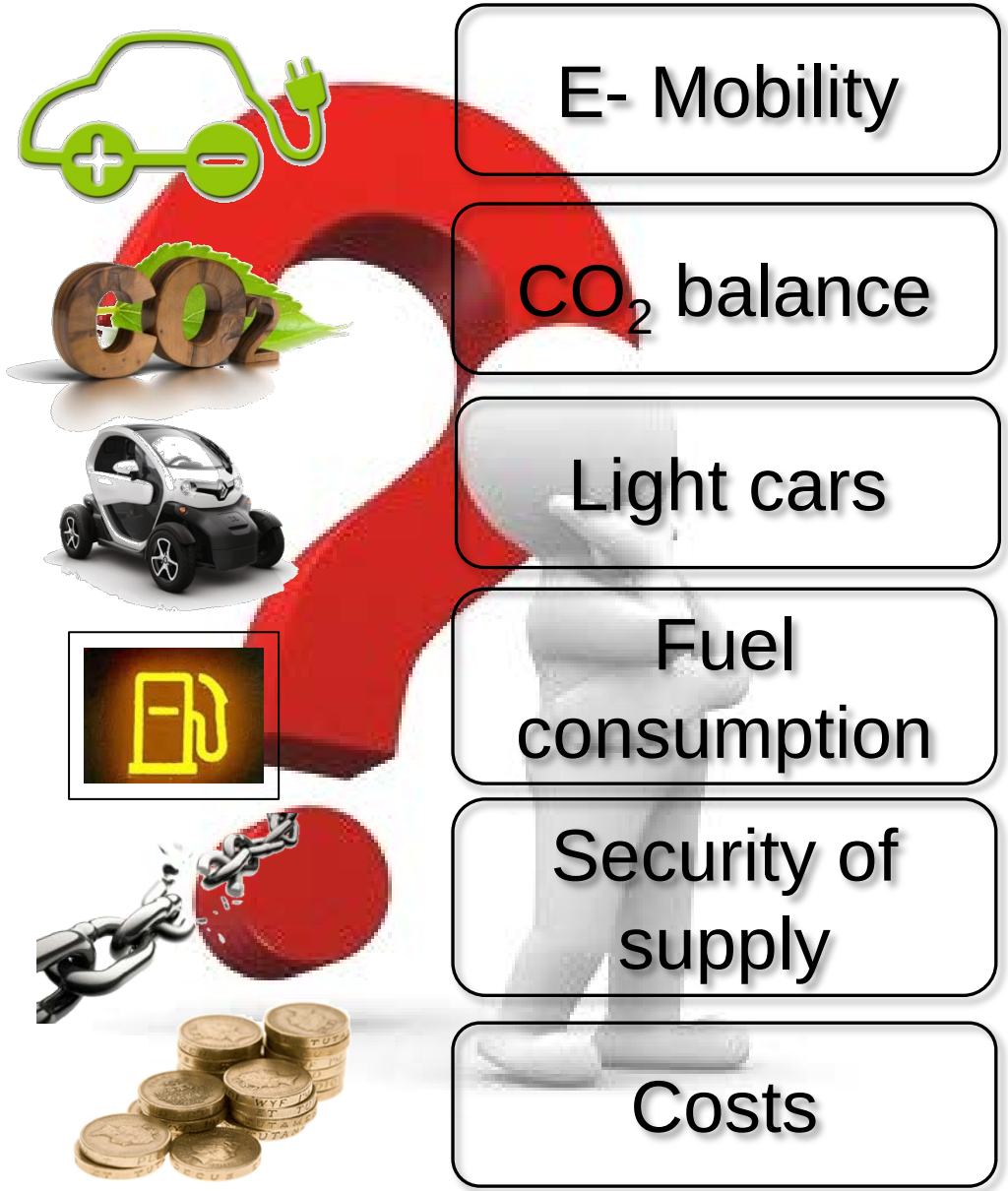
WoodCAR

wood computer aided research

Andreas Teibinger & Ulrich Müller



Motivation



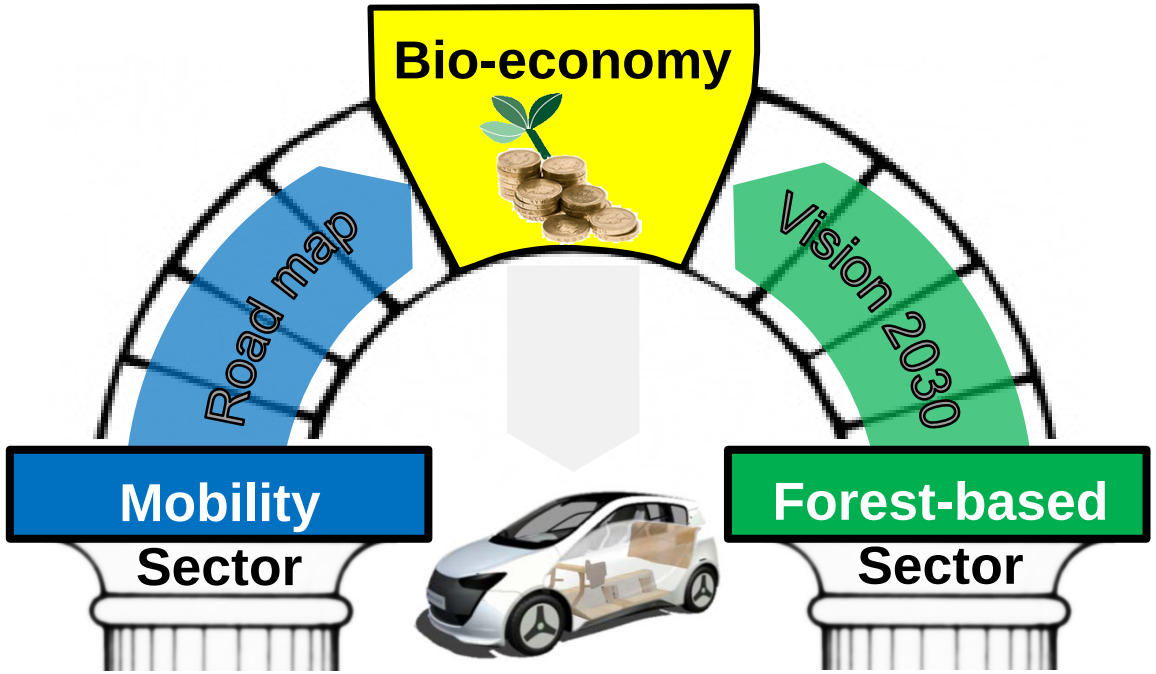
- E- Mobility
- CO_2 balance
- Light cars
- Fuel consumption
- Security of supply
- Costs

Wood-based Components

Feasibility study

WOOD for AUTOMOTIVE APPLICATIONS

Strategic Background



Electro Mobility
Weight Reduction
Fuel Consumption
Smart Materials
Cost Reduction

Cross Innovation

Functional products
New Products
Global Change
Improved Value Chain
Resource Efficiency

advanced wood-based components

WoodCAR

Bio-economy – a major trend to meet future challenges in:

- **Mobility Sector**
- **Forest-based Sector**

Actual Challenges & Boundary Conditions

- Comfort
- Safety
- Quality
- Regulations
- Interior
- Equipment

- Multi Material Mix
- New Materials
- Functional integration
- Component integration
- Cost and Weight Reduction

Motivation – Potential for New Wood-based Material Approach

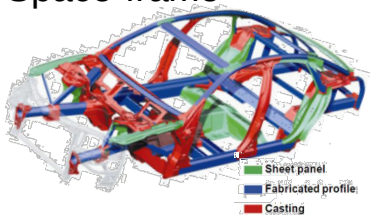
Multi-material mix for components and constructions

Engineer

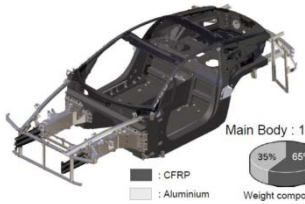
Optimal Design (lightweight, low costs, safety, ...)

Different concepts

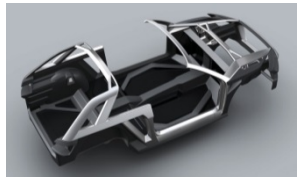
Space-frame



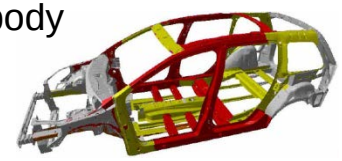
Monocoque

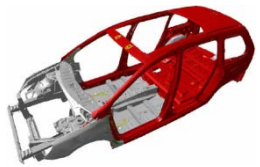


Innovative structure



Unibody





© Source: Daimler, AUDI, Toyota, PSA

Different materials

Steel

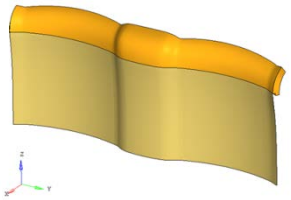
Aluminum

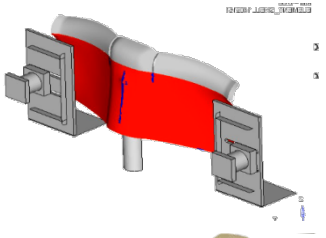
CFK

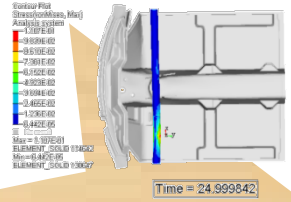
The right material on the right place with the right concept

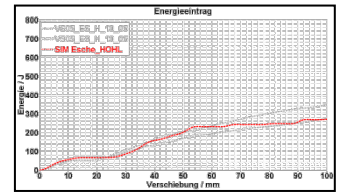
© Source: Voest Alpine, Porsche, BMW

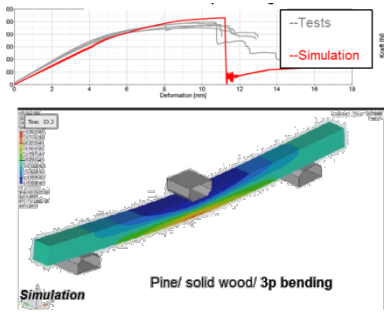
Development of a FE model for new Materials

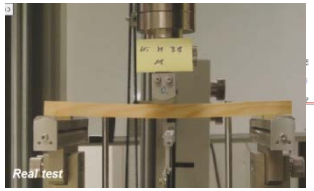


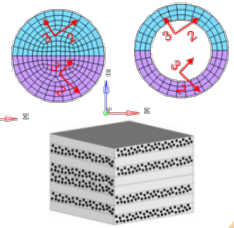












Source: Magna

CULT - Cars Ultralight Technologies

Component selection

Material testing
Material modelling

Simulation model

Component development & LCA

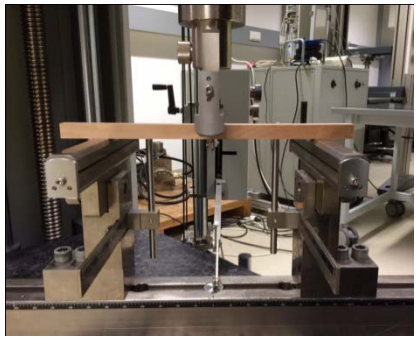
Component testing

Validation

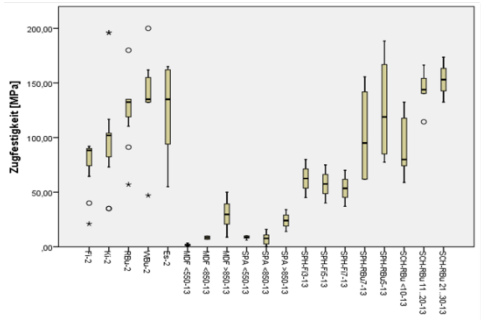
validated material model for several wood species and wood composites = basis for an iterative CAE process

Main tasks – technical part of the project

- material properties
- selection FE model
- Static loads simulation vs testing
- validation of the FE model
- engineering of wood components
- production of wood components
- material and crash tests



Material testing (N>500)

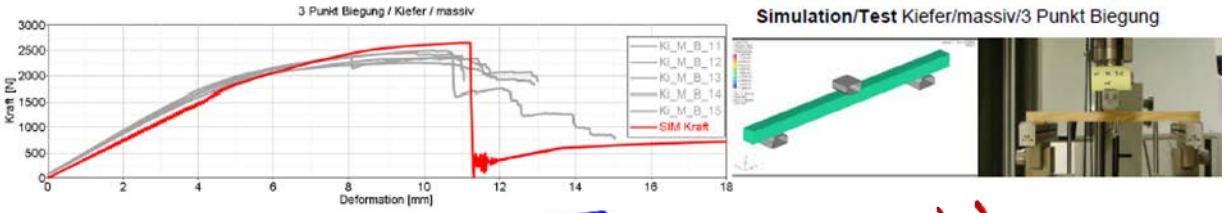


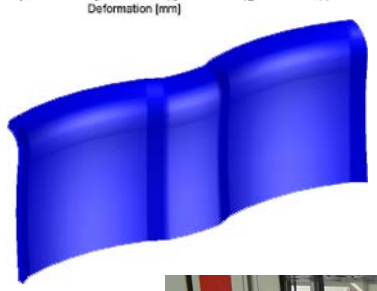
Analysing test results

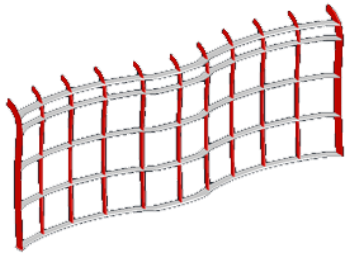
Literature research

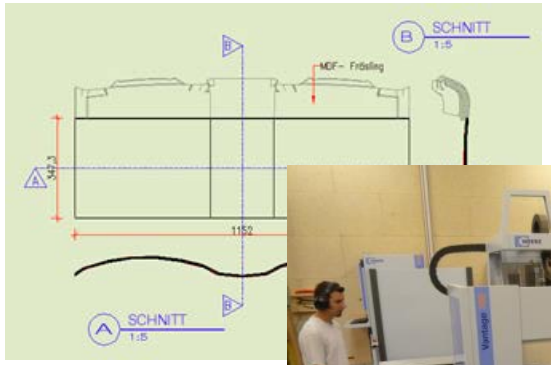
- σ_Z, $\sigma_{D,}$ σ_B
- ρ_0
- MOE
- τ
- $G_{12, 23, 31}$
- Poisson‘s ratio
- elongation
- strain rate

Data base









Development of the material model

Material cards (literature and test values)

```
*MAT_ENHANCED_COMPOSITE_DAMAGE
$
$ *MAT_054
$
$#################################################################
$#                          E       S       C       M       E    #
$#################################################################
$---+---1---+---2---+---3---+---4---+---5---+---6---+---7---+---8
$       MID        RO        EA        EB        EC      PRBA    (PRCA)    (PRCB)
$        54   0.71E-9
$       GAB       GBC       GCA      (KF)      AOPT
$                                       A1        A2        A3    MANGLE
$        V1        V2        V3        D1        D2        D3    DFAILM    DFAILS
$     TFAIL      ALPH      SOFT      FBRT     YCFAC    DFAILT    DFAILC       EFS
$        XC        XT        YC        YT        SC      CRIT      BETA
$=================================================================
```

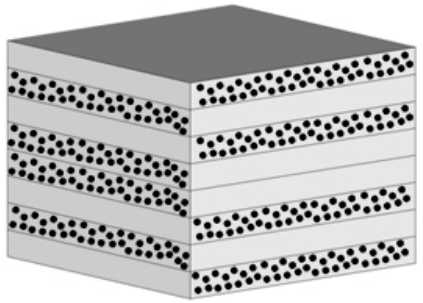
simulation of the material tests of solid wood for the validation of the material cards (Model)
→ Solid Models

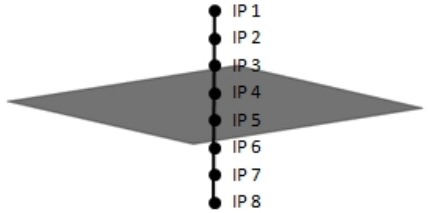
simulation of the material tests of laminated wood and plywood for the validation of the material cards (Model)
→ Solid Models

ONE validated material card for each wood species and all wood composites (solid / ply-/ laminated wood) and ALL models for solid and shell

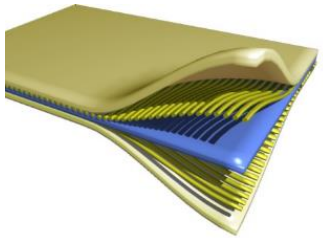
High number of characteristic values (N=600) and parameters and specific adaption of an existing material model necessary to simulate wood properly

- Data base
- Material tests
- Material cards
- Simulation
- Validation





- → modelling of shell structures (high relevance for crash simulation)
- → material properties were assigned to different layers and plies
- → virtual assembling of wood layers and plies

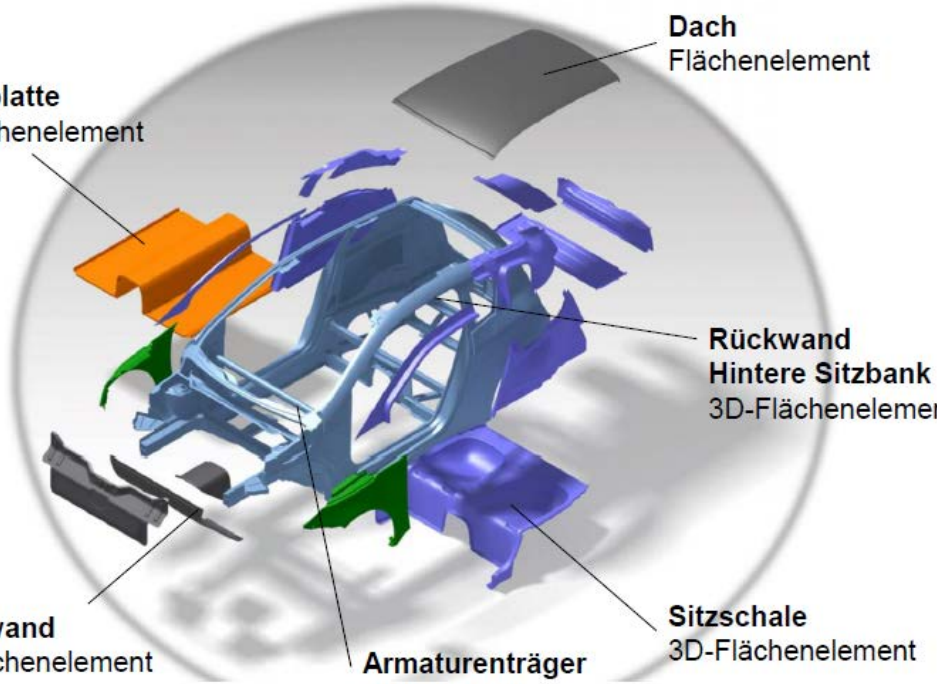


Knowledge based and tailor made wood composites

Selection of three components based on CULT

Subfloor

6 CULT components
+ 6 simplified components



Rear panel

6 CULT components
+ 9 simplified components

CULT – **C**ars **U**ltra**l**ight **T**echnologies

Source: Magna

Instrument carrier

60 CULT components

Crash tests performed

Crash tests @ VSI TU Graz

Impactor: 30kg

Impact speed: 9m/s ; ~32km/h

Kinetic energy : ~1200J

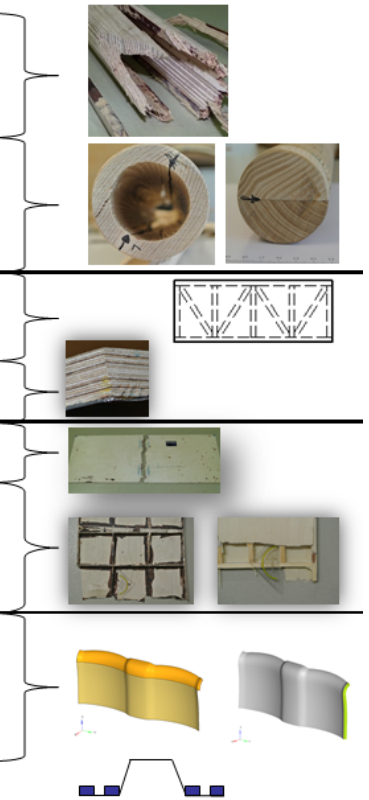
- 2 high precision 500 kN load cells
- Acceleration sensor
- 3 high speed cameras

Instrument carrier

Rear panel

Subfloor

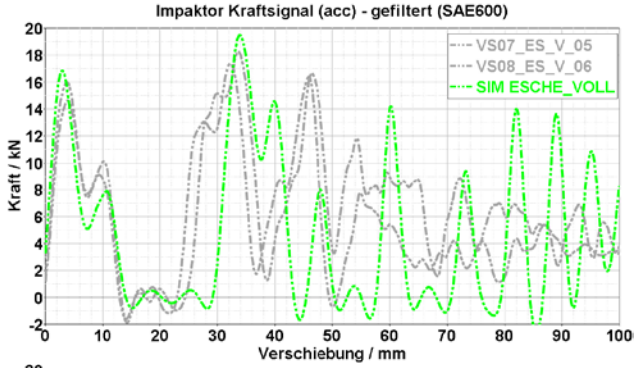
Test-ablauf	Benennung	Proben-bezeichnung
1	Schichtholz_Hohl (Birke)	Sch_H_07
2	Schichtholz_Hohl (Birke)	Sch_H_05
3	Schichtholz_Hohl (Birke)	Sch_H_06
4	Schichtholz_Hohl (Birke)	Sch_H_08
5	Esche_Hohl	ES_H_10_05
6	Esche_Hohl	ES_H_10_06
7	Esche_Vollholz	ES_V_05
8	Esche_Vollholz	ES_V_06
9	Prinzipbauteil_Unterboden_Rahmenkonstruktion (Birkenplatten 3 Schicht, Rahmen Esche)	PU_R_01
10	Prinzipbauteil_Unterboden_Rahmenkonstruktion	PU_R_02
11	Unterboden_Prinzipbauteil_Schichtholz_Aluschicht	UP_Sch_01
12	Unterboden_Prinzipbauteil_Schichtholz_Aluschicht	UP_Sch_02
13	Rückenlehne_Prinzipbauteil_Schichtholz	RP_Sch_01
14	Rückenlehne_Prinzipbauteil_Schichtholz	RP_Sch_02
15	Lehnen_Rippe_Prinzipbauteil (Rahmen dünn Esche)	LRP_01
16	Lehnen_Rippe_Prinzipbauteil (Rahmen dünn Esche)	LRP_02
17	Lehnen_Rippe_Prinzipbauteil_(Rahmen dick Kiefer)	LRP_K_01
18	Lehnen_Rippe_Prinzipbauteil_(Rahmen dick Kiefer)	LRP_K_01
19	Lehne_MDF	MDF_01
20	Realbauteil_Rippe	RR_01
21	Realbauteil_Rippe	RR_02
22	Lehne_MDF	MDF_02
-	Unterboden Realbauteil	nicht getestet

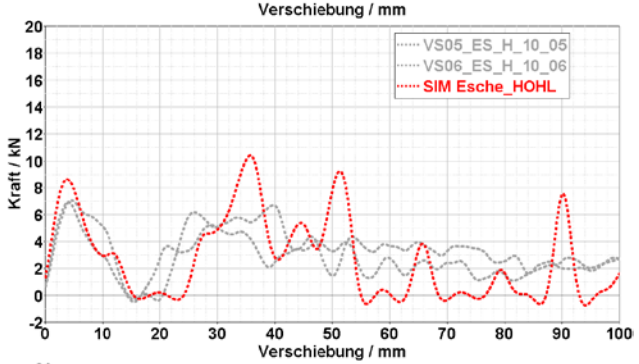


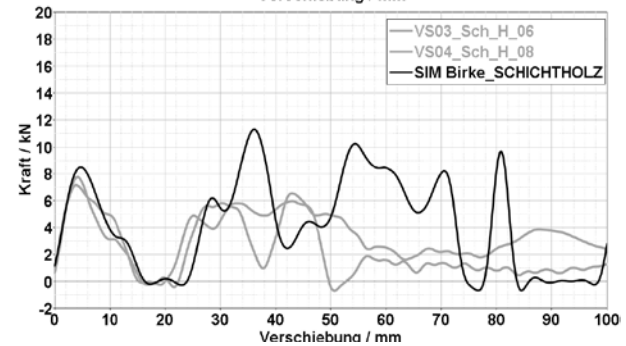
Validation - instrument panel carrier

-- tests -- ash solid wood, rod -- ash solid wood, tube -- birch laminate tube

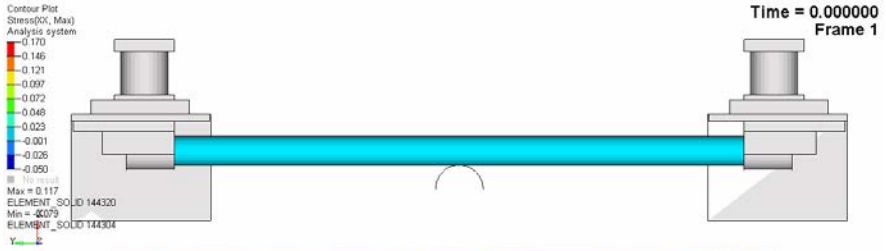
Force

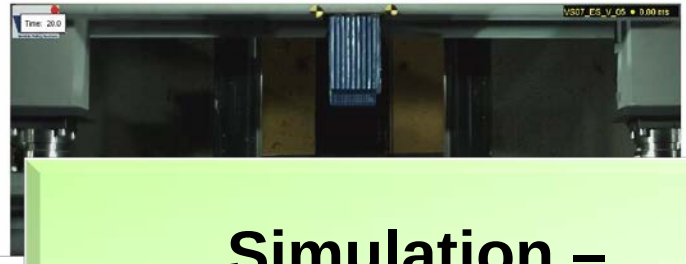




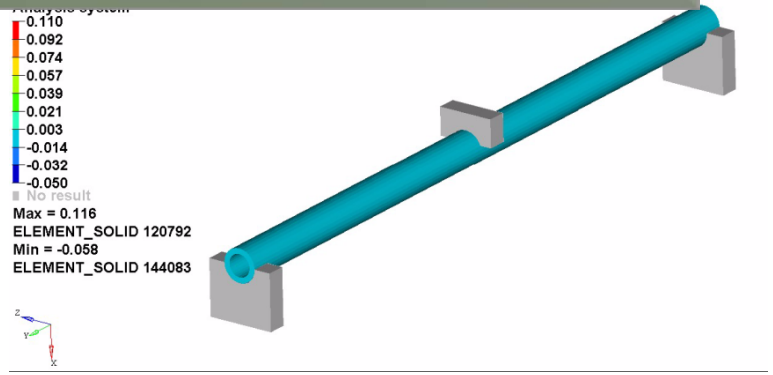


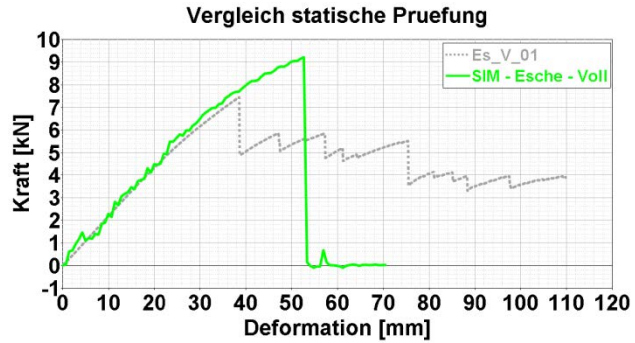
Displacement



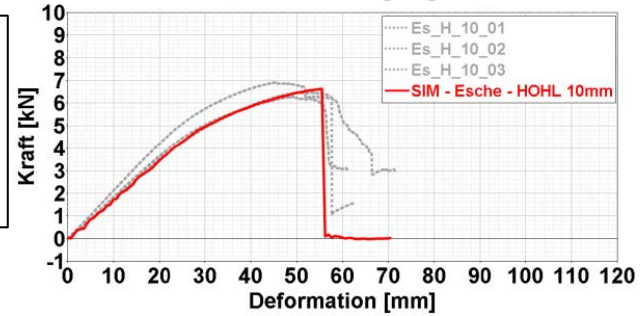


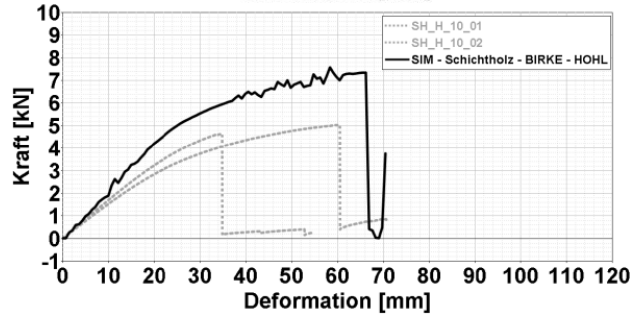
Simulation – sound prediction





Force



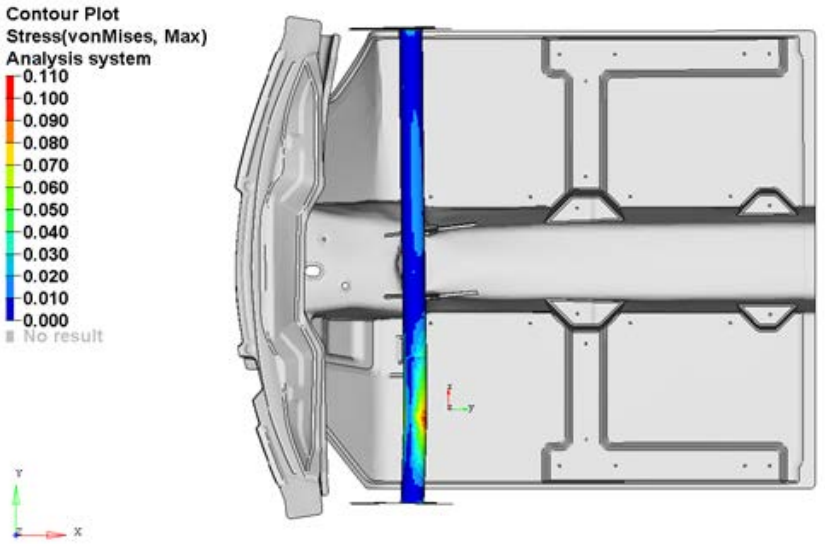


Displacement

Virtual Crash Tests of Wood Components

Simulation and demonstration within full vehicle simulation model

- Crashtest with 50 km/h against rigid wall
- LS Dyna full vehicle simulation model with ~ 2 Mio elements



Conclusio

- Applicable within full vehicle simulation
- Same simulation runtime
- Evaluation of component loads possible
- Design iteration within CAE process feasible

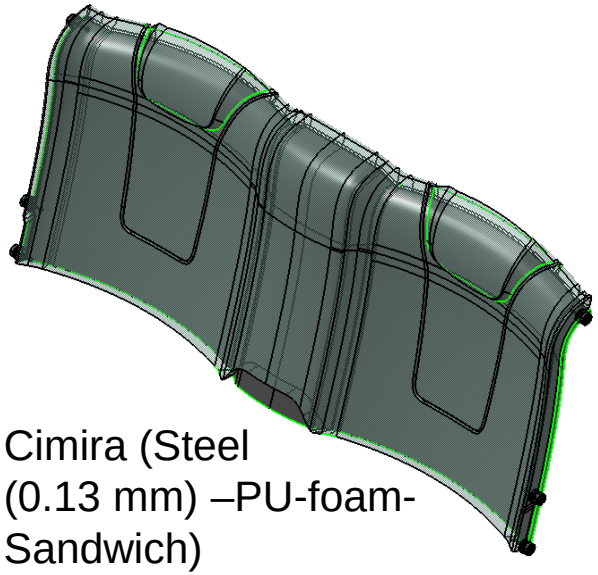
Costs and Weight backrest – wood vs CULT

CULT

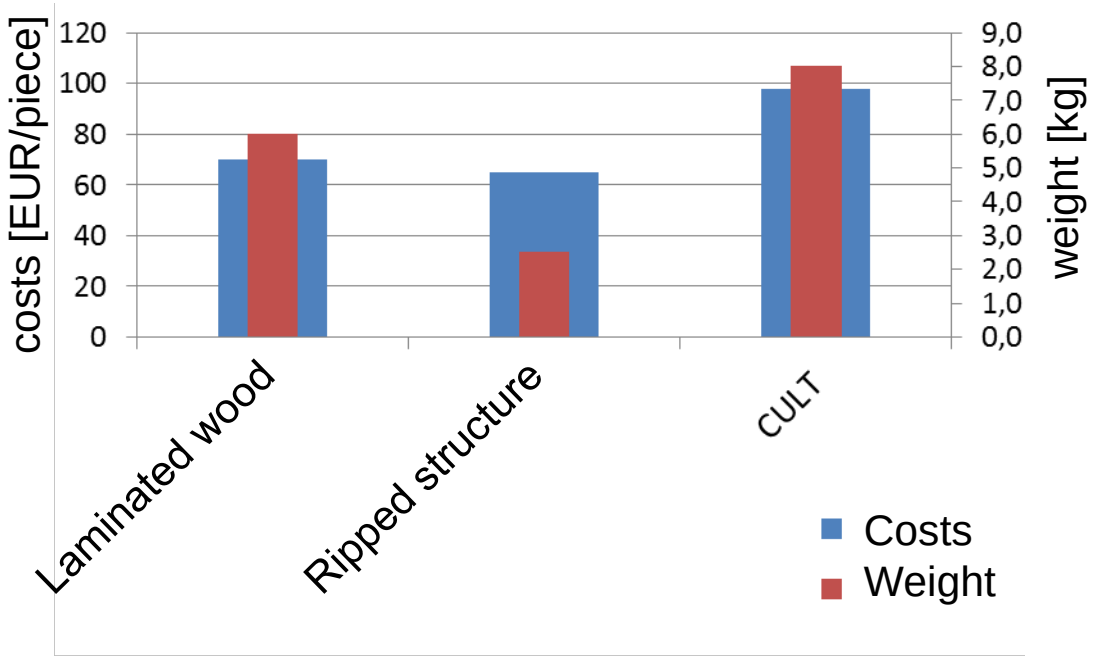
Cimira – backrest
weight ~8 kg
Price ~ 98 €
Invest: ~ 0.5 Mio. €

Wood-components

Laminated wood (plywood plies) with MDF headpart
Ripped structure covered with 3D-Danzer veneer
weight 2,5 and 6 kg, respectively
price ~ 70 €
Invest: ~ 70.000 €



Cimira (Steel (0.13 mm) –PU-foam-Sandwich)



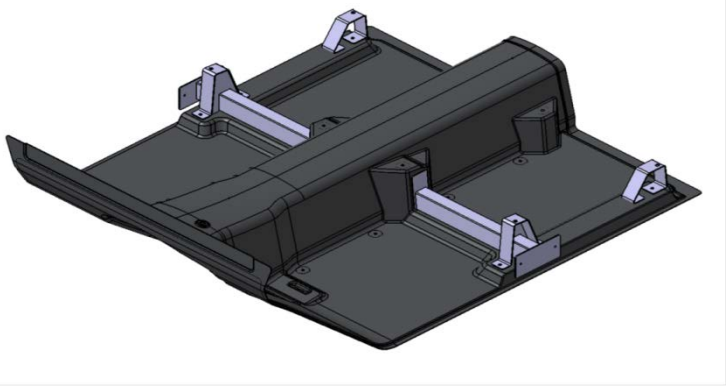
Costs and Weight subfloor – wood vs CULT

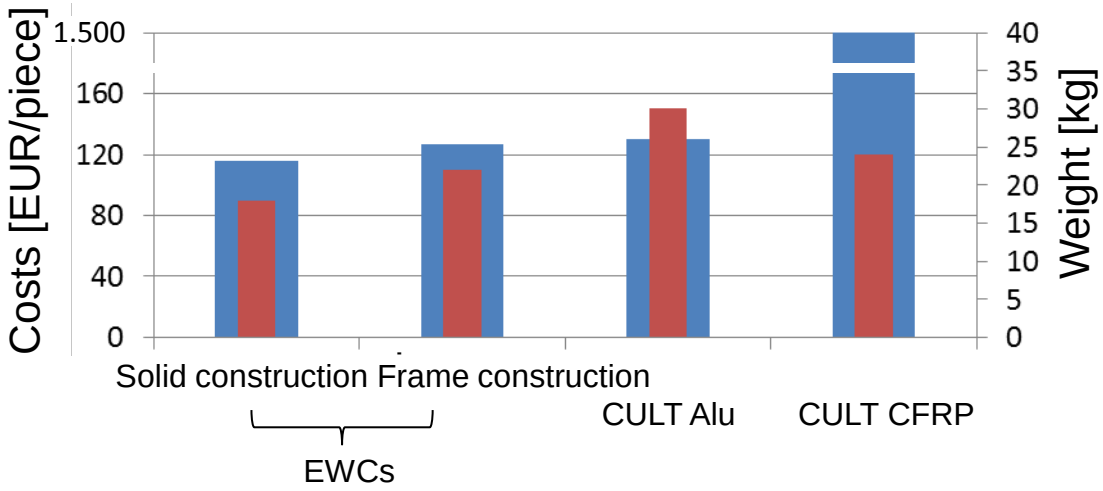
CULT

Alu-version
Weight ~ 30 kg
price ~ 130 €
Invest: ~ 1.4 Mio. €

Wood-components

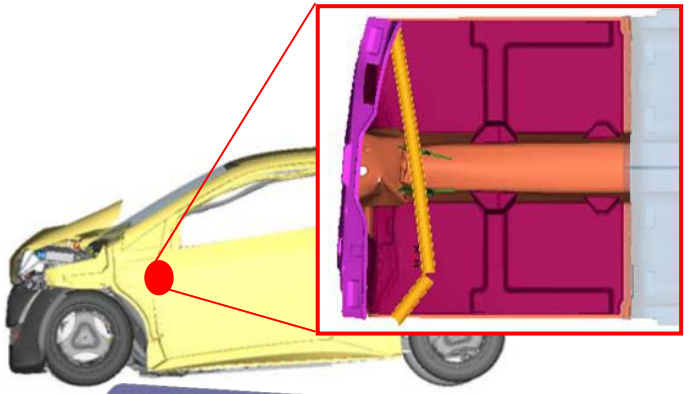
Subfloor: version 1: frame construction
version 2: laminated wood
Weight 18 to 22 kg
Price ~ 115 - 125 €
Invest: ~ 100.000 €



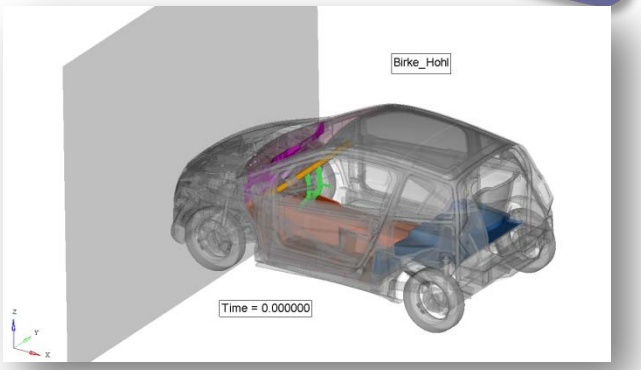


Summary of Results

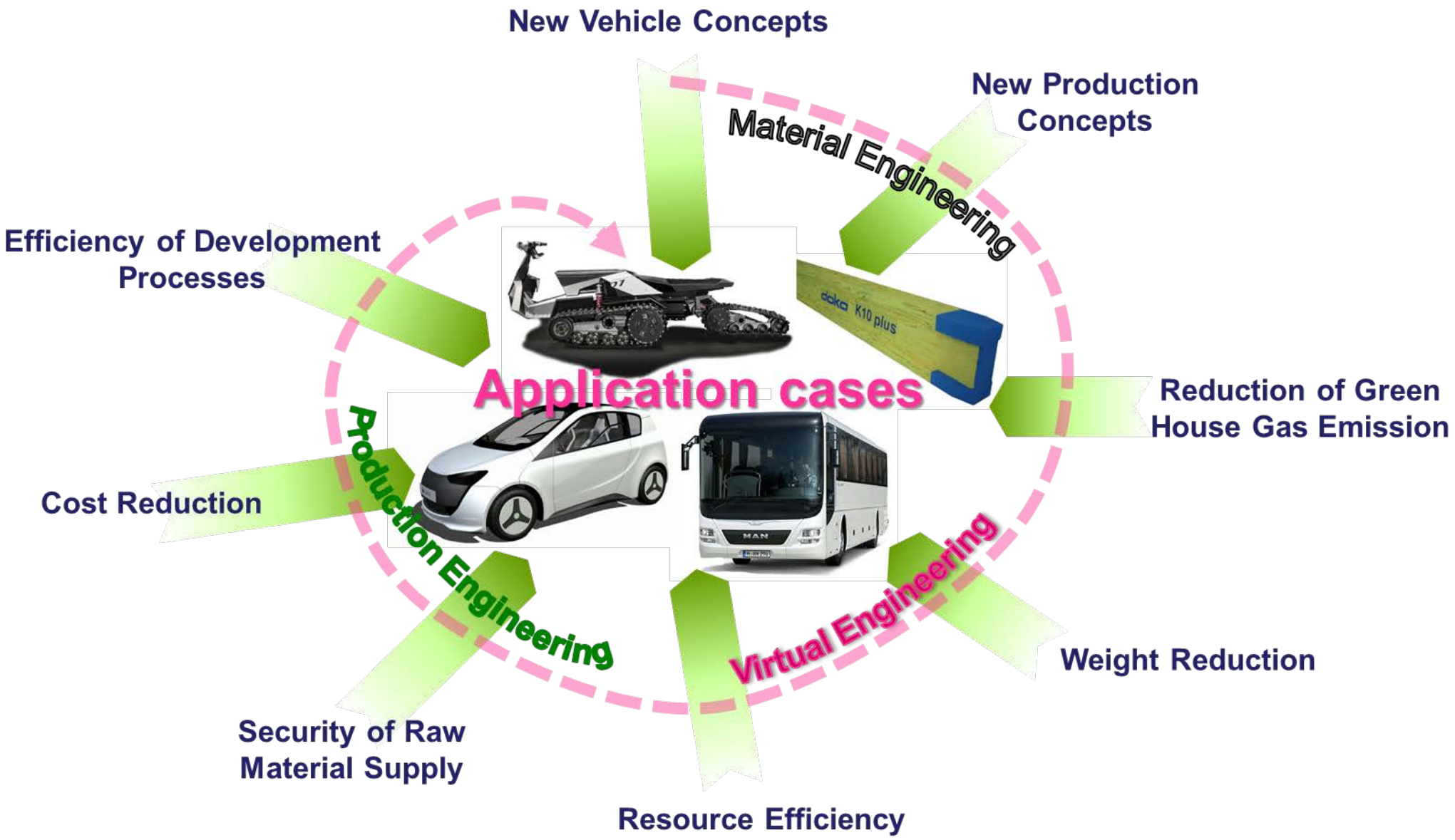
- **Simulation of wood and wood based composite is possible!**
- **Economic and technical potential for further use of the derived results is given!**
- **Design and adaption of components related to wood and wood based composites and production technologies is the key challenge for technical product implementation**
- **Basis for further research activities and discussions with OEMs / IPs is made**
- **Realistic time line for implementation of wood technology to automotive application → 2025 → scenarios for early use beside automotive sector are derived**
- **Project proposal including all relevant technical, economic and ecologic questions and potential for real implementation was submitted (2017 – 2020)**



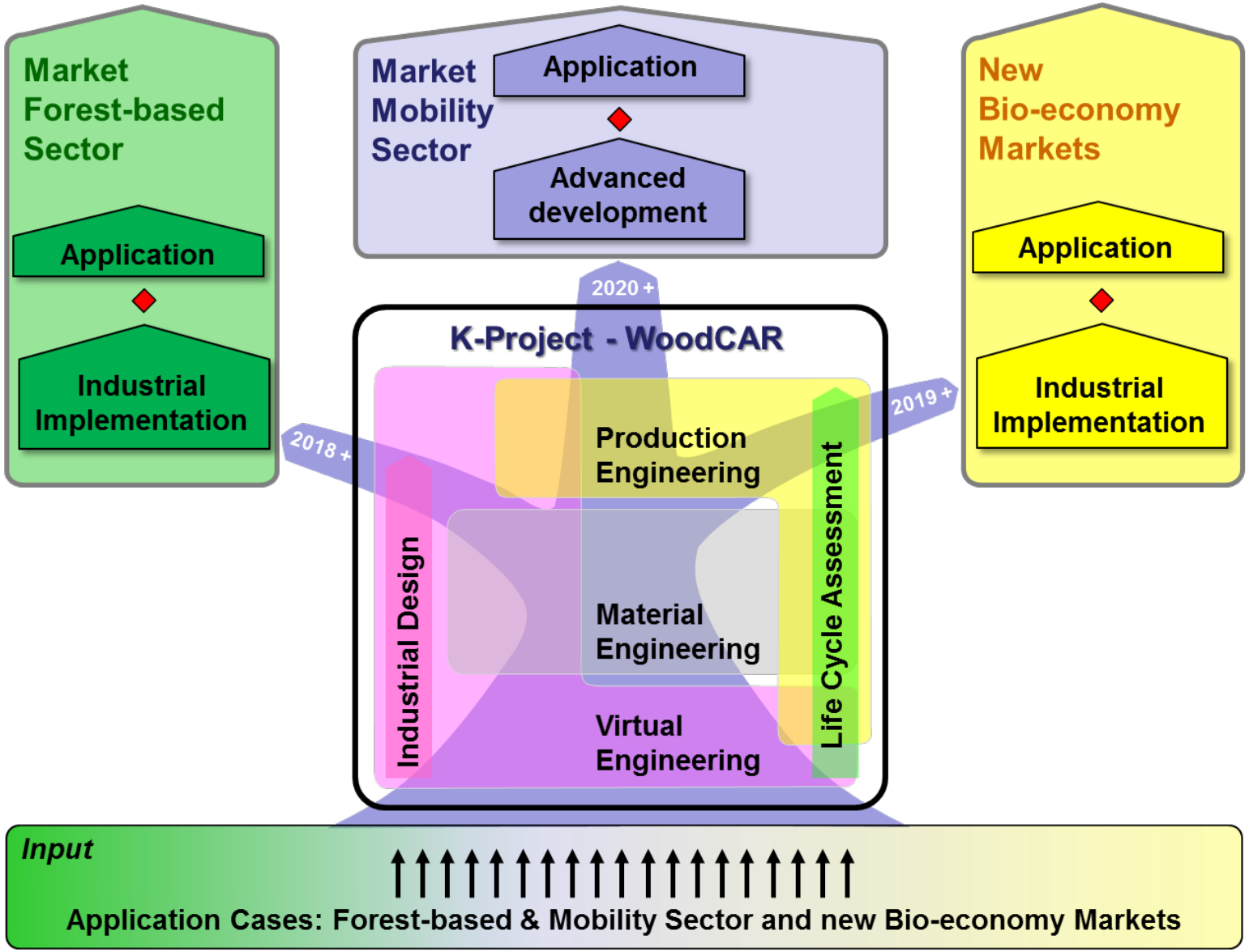
Assessment of failure behaviour within full vehicle crash based on derived results is possible!



Future Challenges & Boundary Conditions



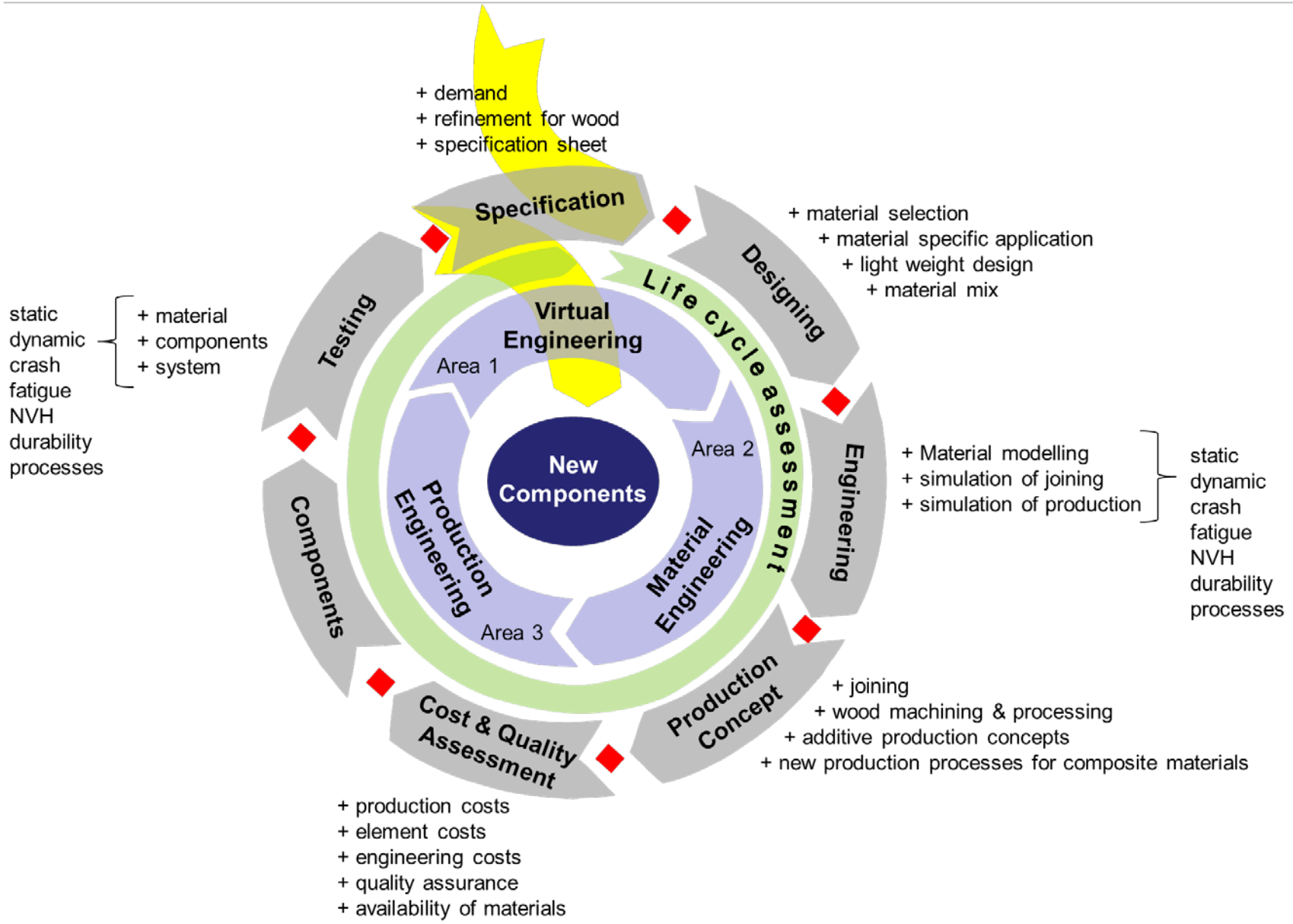
Exploitation Strategy – WoodCAR



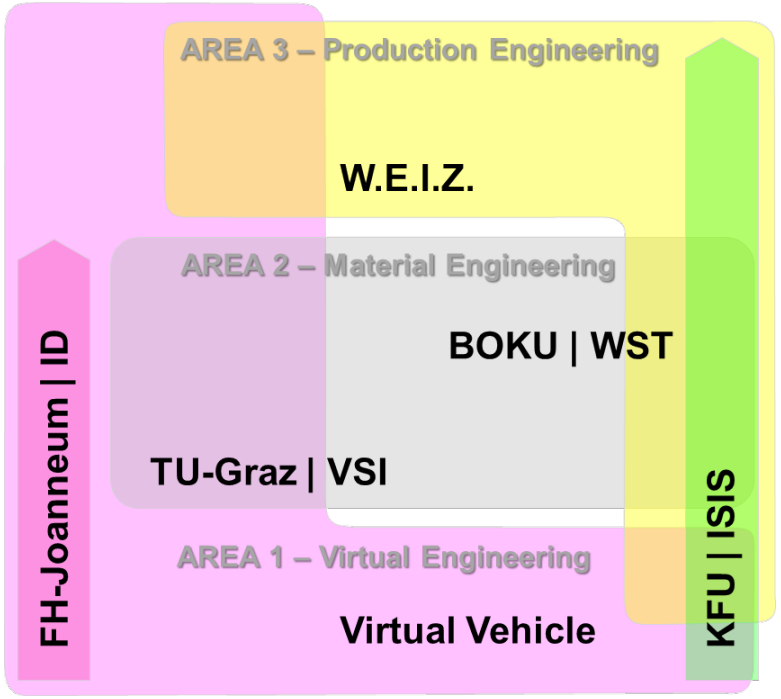
Staggered use of the derived know-how:

- **Main business forest based industry 2018+**
- **New business bio-economy markets +2019**
- **Mobility sector +2020**

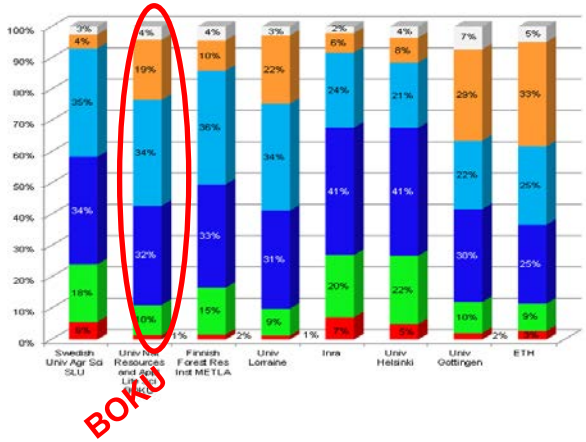
Idea and Implementation of the WoodCAR Project



Why was an wood based research initiative started in Austria?



Virtual Vehicle – internationally acting and acknowledged research centre



International evaluation based on amount and quality of scientific publications

Austrian wood based research Top 2 within Europe & Top 8 worldwide

FPS, 67TH International convention
June 9-11, 2013, Austin Texas

TU-Graz: VSI – Vehicle Safety Institute

FH JOANNEUM – Industrial Design

KFU Graz – Institute for Systems Science, Innovation and Sustainability Research

Innovationszentrum W.E.I.Z.

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Im Auftrag des Wirtschaftslandesrates

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