Battery Integration Workshop

SmartBatt: „Technical Slot 1" – Structural Integration

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Content

- Aim and targets of the Smartbatt project
- Structural related approach
- Battery related approach
- Crashworthy redesign
- Results

AIM & TARGETS

What´s the aim of the SmartBatt Project!

- Today different activities are going on for pure electric & hybrid electric vehicles
  - Batteries with high power and energy density are necessary for the electrification of the drive train of vehicles
  - Battery system is the heaviest part of an EV
  - This mass influences significantly the vehicle dynamics and crash behaviour

- Aim of the project is
  - To determine requirements for lightweight housings for lithium batteries in electric vehicles
  - To demonstrate a complete tool chain
  - Whole development process of housings and methods for safe and secure integration in the vehicle

What are the targets of the project?

- Battery for a class A BEV with 100km NEFZ Range
- 15% lighter than SotA (75% weight ratio between system and cell)
- Crash safety based on refrence SLC body
- Integrated BEV has same static and dynamic requirements as SLC
- Spend up to 6€/kg for weight reduction

STRUCTURAL RELATED APPROACH

Two ways in designing BEV´s

- Conversion or Purpose design
- Question to be answered
  - Loadcases
  - Boundaries
    - Mountings
    - Loadpaths
  - Requirements
  - Production platform – Changing?

Really hard to define so we focused on SLC with defined boundary conditions, 2 year project with focus on Battery

Source http://www.mitsubishi-motors.com

Source http://nissan-leaf.net

Task 2.2: Reference Project: „SuperLightCar“

Objective:
- weight reduction versus reference compact class body in white (BIW) at minimal additional costs
- weight reduction: ≥ 85kg (≥ 30%)
- lightweight costs (parts costs): ≤ 5€/kg

Motivation:
- economic demonstration of multi-material vehicle structures for high volume cars
- lightweight design as contribution for CO_2-emissions reduction

Realisation:
- complete CAD-design for BIW
- validation of structural performance (crash, static, etc.)
- description of joining technologies and production processes
- Life cycle analysis (LCA) for multi-material vehicle concepts
- assessment of different body concepts

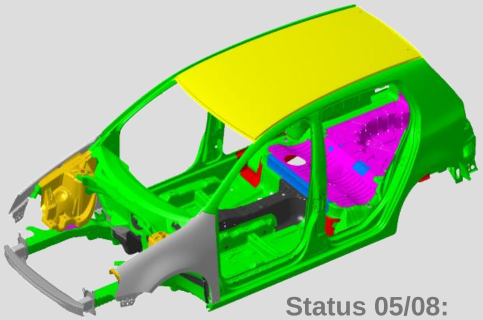
Milestones:
- design freeze (completion CAD/CAE) until 05/08
- assembly hardware prototyping until 12/2008

Coordination: Dr. Martin Goede

SuperLightCar

Materials

- Aluminium sheet
- Aluminium cast
- Aluminium extrusion
- Steel
- Hot-formed steel
- Magnesium sheet
- Magnesium diecasting
- Glasfibre thermoplastic



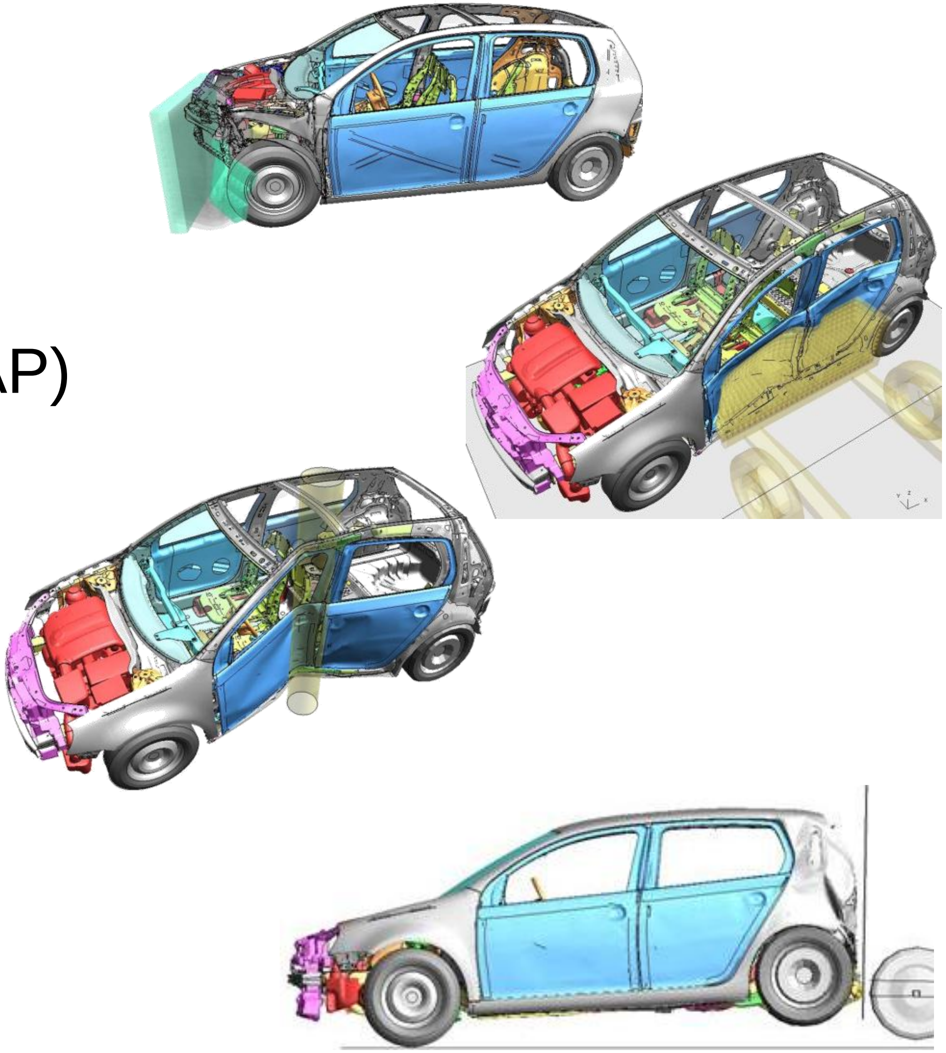
Status 05/08:
Δm -101kg (35%)

EUCAR
EUROPEAN COUNCIL FOR AUTOMOTIVE R&D

Body in White – from SLC-Project

SLC in different Crash scenarios – EU-Project

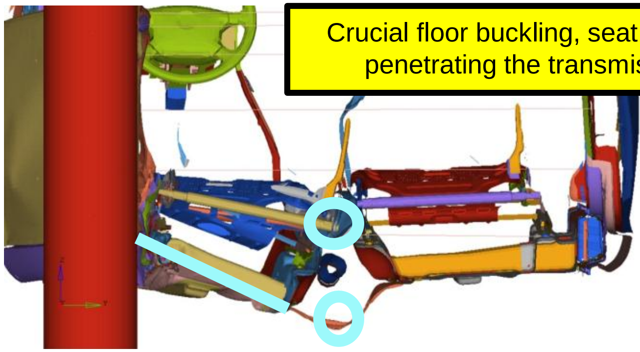
- Frontal Impact (EURO-NCAP)
- Side Impact (EURO-NCAP)
- Pole Test (EURO-NCAP)
- Rear Impact (FMVSS 301)



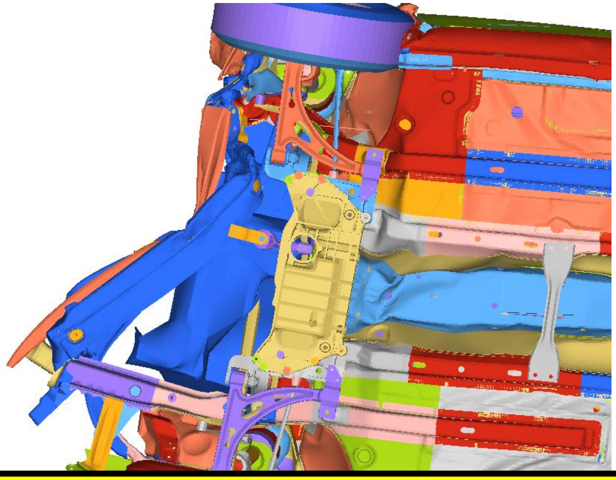
Source: http://www.superlightcar.com

Searching for a safe space that meets the requirements

- Critical deformation (Pole + Side MDB)

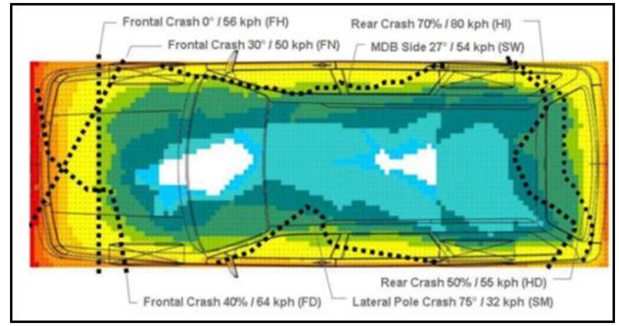


- Critical deformation (Rear and Front)

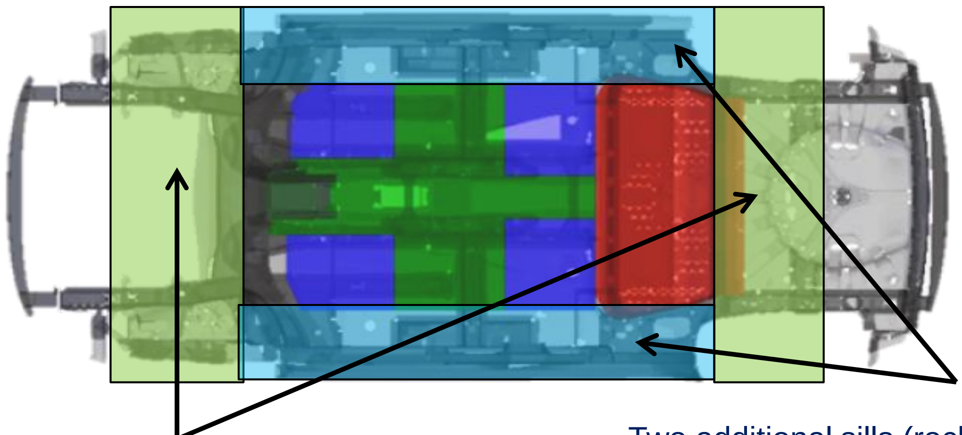


Searching for a safe space that meets the requirements

- Combining accident statistics with SLC-CAD
- Possible structural solution of EV body



Source: Justen R. and Schöneburg R.: Crash Safety of Hybrid- and Battery Electric Vehicles. 22th ESV-Conference, 2011



1

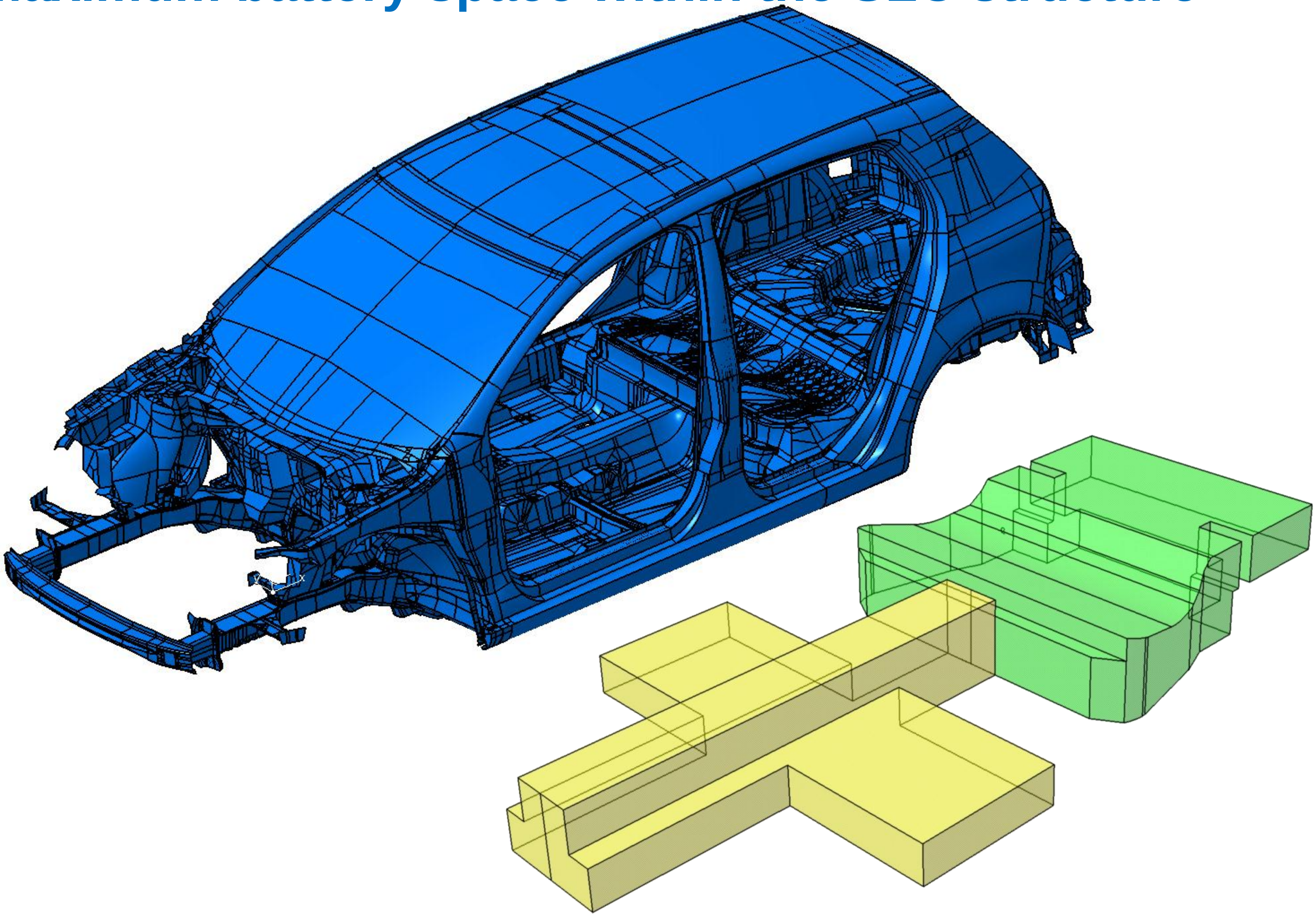
Given stiff front (conceptual block) we can justify similar design concept in the rear of vehicle. This gives us two stiff, crashworthy energy absorbing and anti-penetration limits of passengers cabin

2

Two additional sills (rocker panels) add additional stiffness (torsional stiffness in the first place). Like in current designs rocker panels work as important side impact energy absorbers. Side impact load transferring mechanism (to the non-stuck side) must be modified.

This opens a way to flexible platform design (sedan/coupe – substantial bending stiffness of floor panel).

Maximum battery space within the SLC structure



BATTERY RELATED APPROACH

Finding an optimal space ?

- From investigated cells:

Pouch

20Ah: 0,250kWh/l
100Ah: 0,347kWh/l
87Ah: 0,362kWh/l

Assuming 20kWh as target!

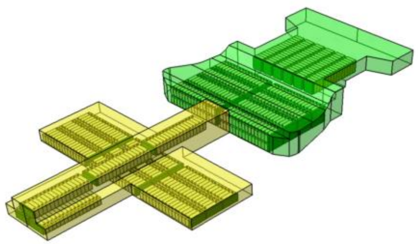
48 Liter – 85 Liter

Metall Case

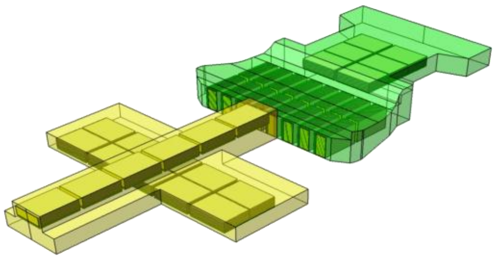
6,6Ah: 0,234kWh/l
4,4Ah: 0,366kWh/l
5,3Ah: 0,416kWh/l
2,5Ah: 0,220kWh/l

Concepts

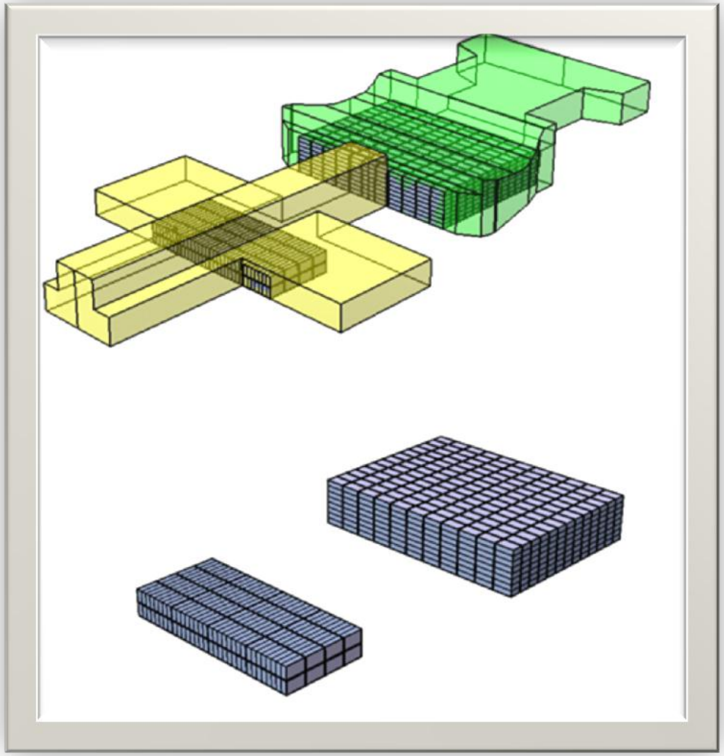
- Different investigated concepts within the maximum package



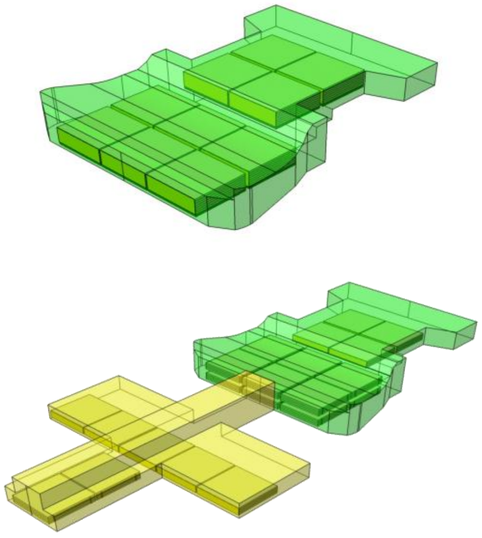
C3 battery system



C1 battery system



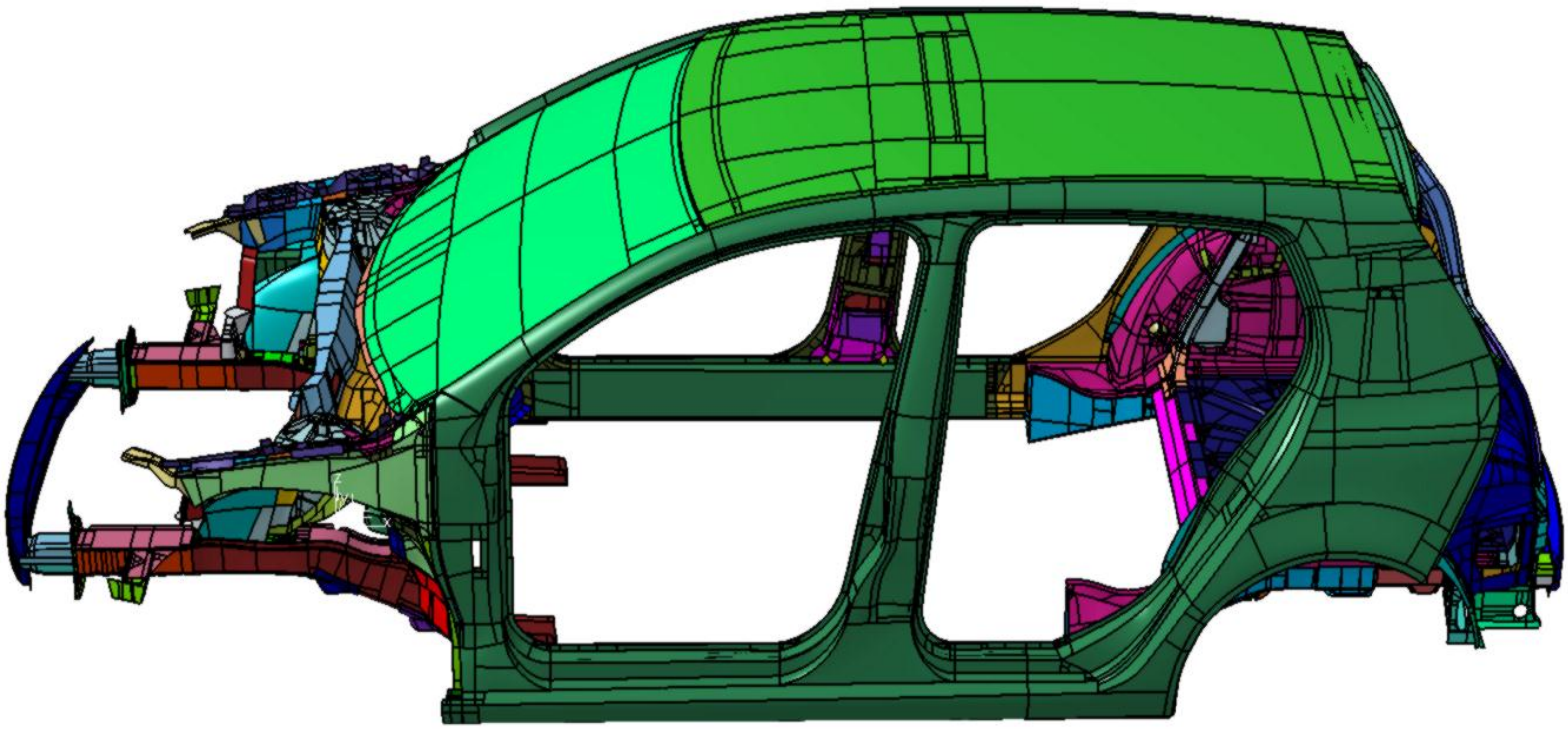
C4 battery system



C2 battery systems

CRASHWORTHY REDESIGN

SLC for Smartbatt - Starting Point



Battery integration approach

- Methodology

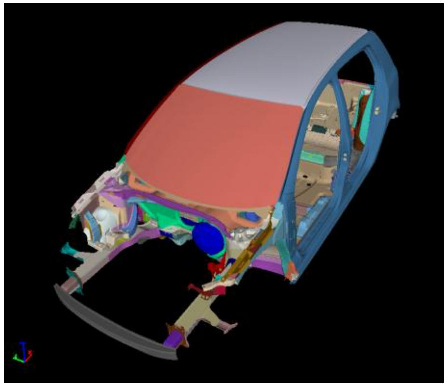
FEM → VCS → FEM

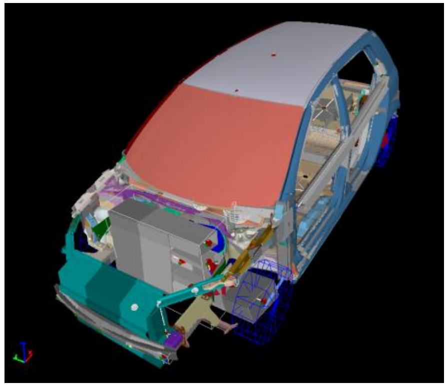
- **<u>Why using this chain?</u>**
- Reducing development time
  - By using the macro element method (VCS)
  - Extremely fast modelling
    - Thin walled structures (superbeam elements)
    - FE-SLC **~1million nodes** – ME-SLC **<200 nodes**
  - Extremely fast calculation
    - FE-SLC **8cores 14hours** – ME-SLC **1core 14seconds**

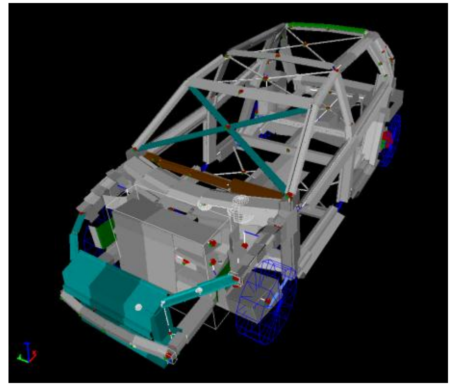
Battery integration approach

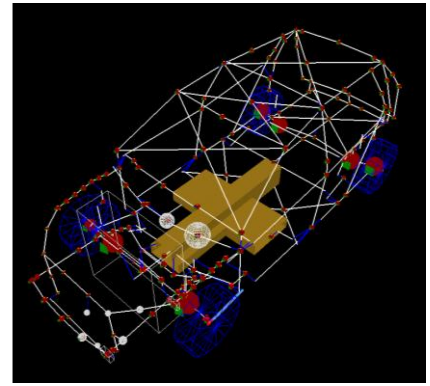
- FEM with SLC-BiW for validation data and focus on how changes will effect the structure
    - Generating input for Macro Element Methode (Visual Crash Studio - VCS)
- Validation of VCS model
    - Correlating: energy, accelerations, deformation patterns
- Defining an envelope for possible battery location (from CAD data)

Basic steps of the VCS Model Setup (FE – ME)





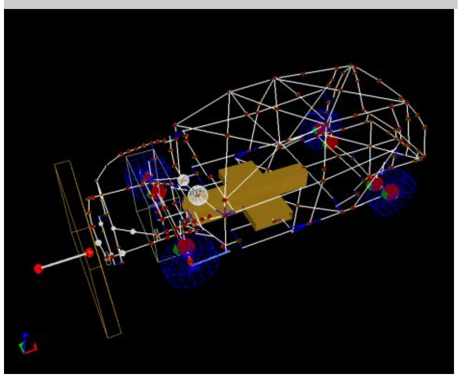




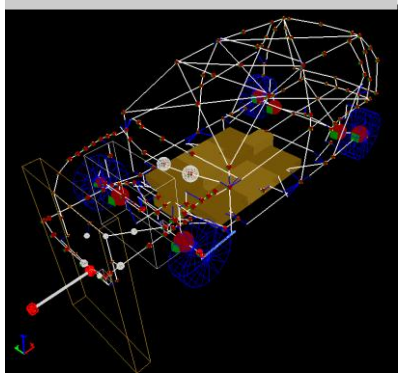
Concept Evaluation from a crashworthy view

- Feasibility study: family of 4 models **~10E3 simulations**

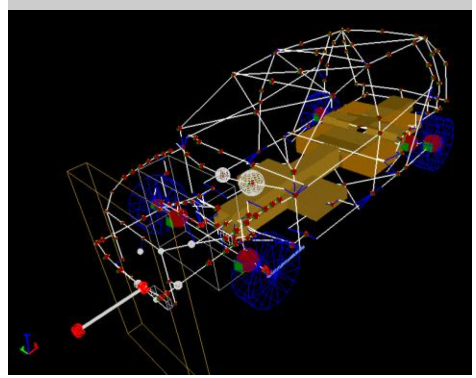
Central tunnel + side pockets



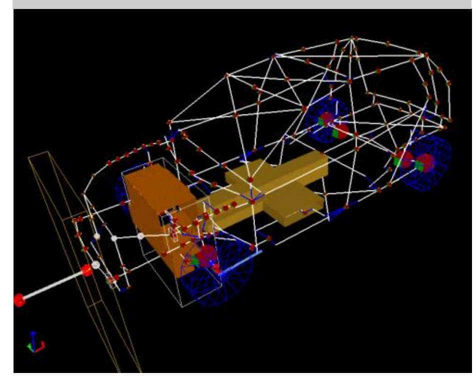
Floor panel



Central tunnel + side pockets + rear pack



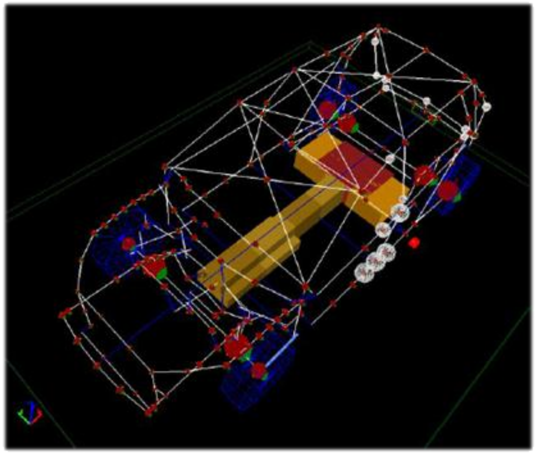
Front housing + central tunnel +side pockets



Checking the needs for battery integration against safety issues

- SOTA / Advanced / Innovative

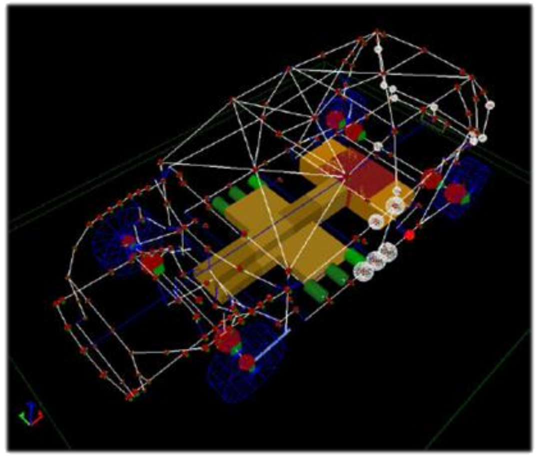
SOTA



Central tunnel and fuel–tank–replacement–housing is a must.

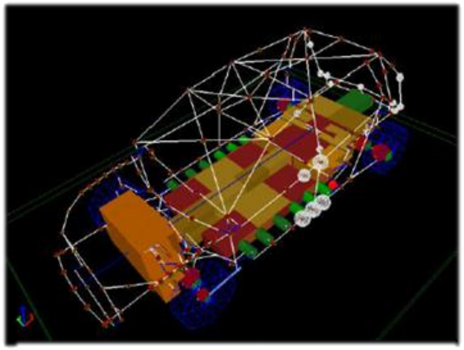
Crash integrity of the car does not exist without these components.
Perhaps the only reasonable solution for coupled mounting/integration concept.

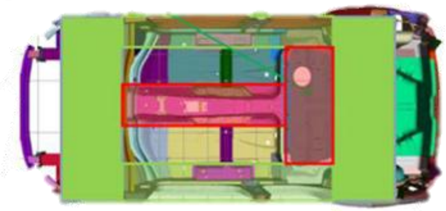
Advanced



Side pockets (at least central) are highly recommended (significant improvement of side collision response).

Innovative

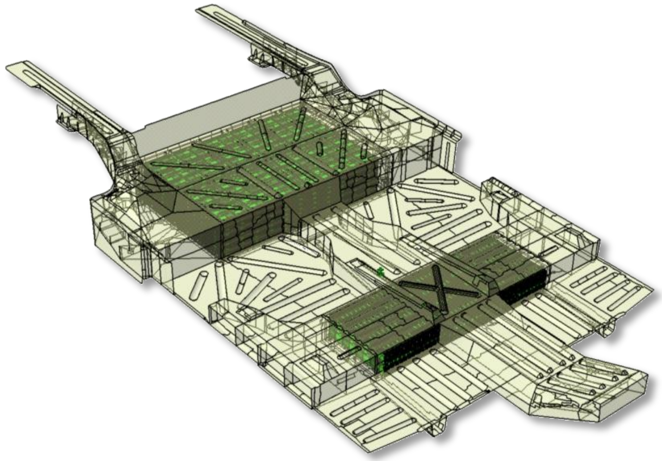




Innovative approach – integration with existing sheet–metal structure is a nightmare.
This concept clearly shows new trends in BiW design for EV.

RESULTS & CONCLUSION

Packaging of SmartBatt

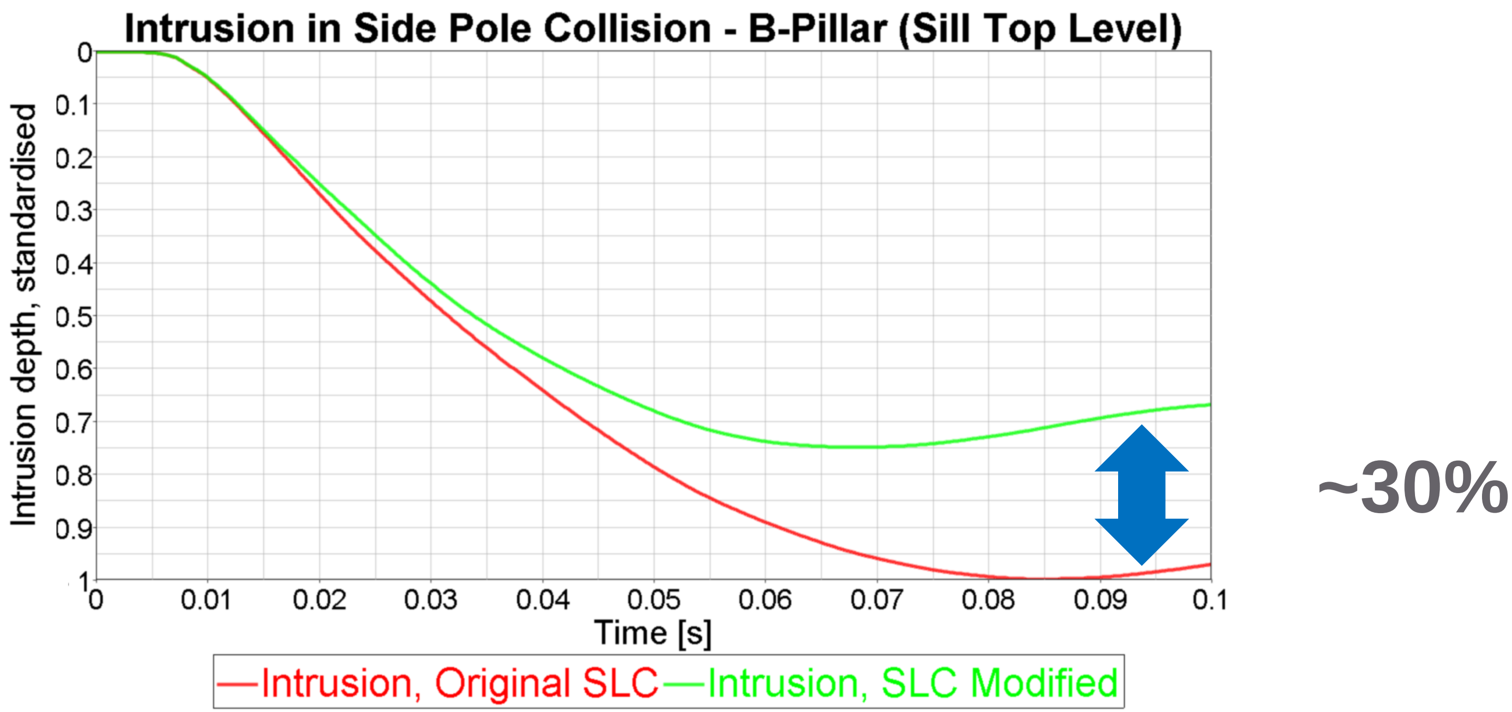


Detailed technical information of the SmartBatt system

system:	88s 16p
modules:	88
voltage:	325,6 V
capacity:	70,4 Ah
energy content:	22,92 kWh
weight:	160 kg
weight ratio:	13,3 %
grav. energy density:	157 Wh/kg

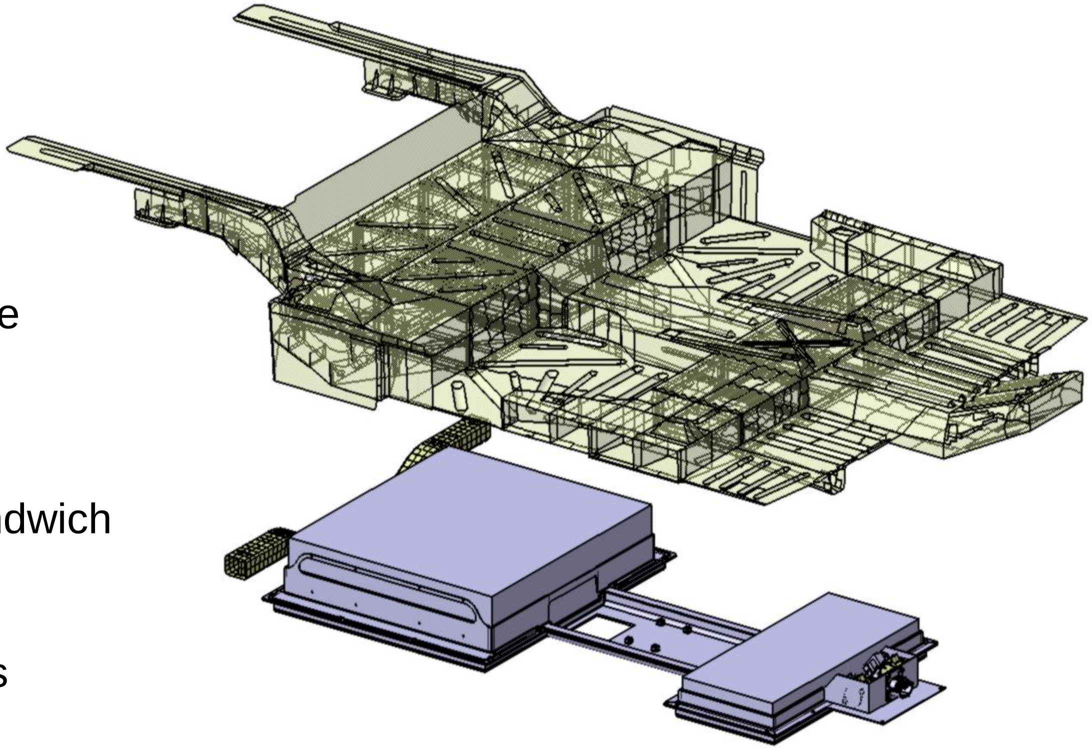
Improvements for side pole test

- Not only a safe battery housing → also improvements on vehicle level
- Example: intrusion depth



High integrated Battery housing

Facts:



- Meets the Smartbatt targets
- High grade of integration into the BiW structure
- Use of new materials like Al sandwich
- Crash protected battery modules
- Bolt-in system combines the advantages of structural integration and an easy and cost efficient assembly