AMAP Colloqium

Re-defining Driving Experience – Competences & Concepts Behind the Research Vehicle SpeedE

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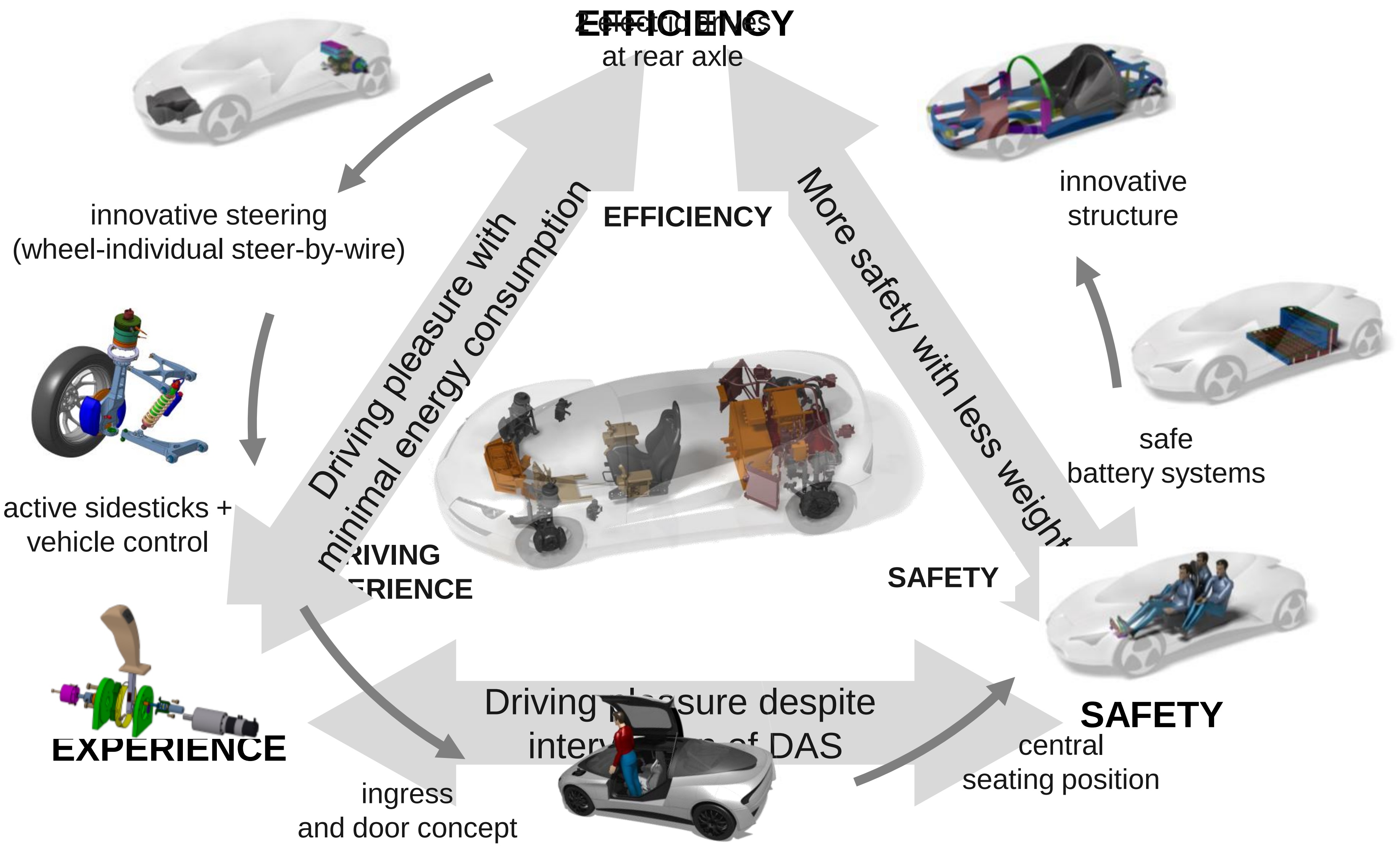
Agenda

- Introduction of the SpeedE Research Vehicle
- Functionally Adapted Physical Vehicle Architecture
- Body Structure
- Crash Deformable Battery System
- Electric Powertrain and Vehicle Electrical System
- Wheel-Individual Steer-by-Wire
- Sidesticks for Lateral Vehicle Guidance
- Synopsis and Outlook

Introduction of the SpeedE Research Vehicle
Open research and innovation platform



Introduction of the SpeedE Research Vehicle
Timeline

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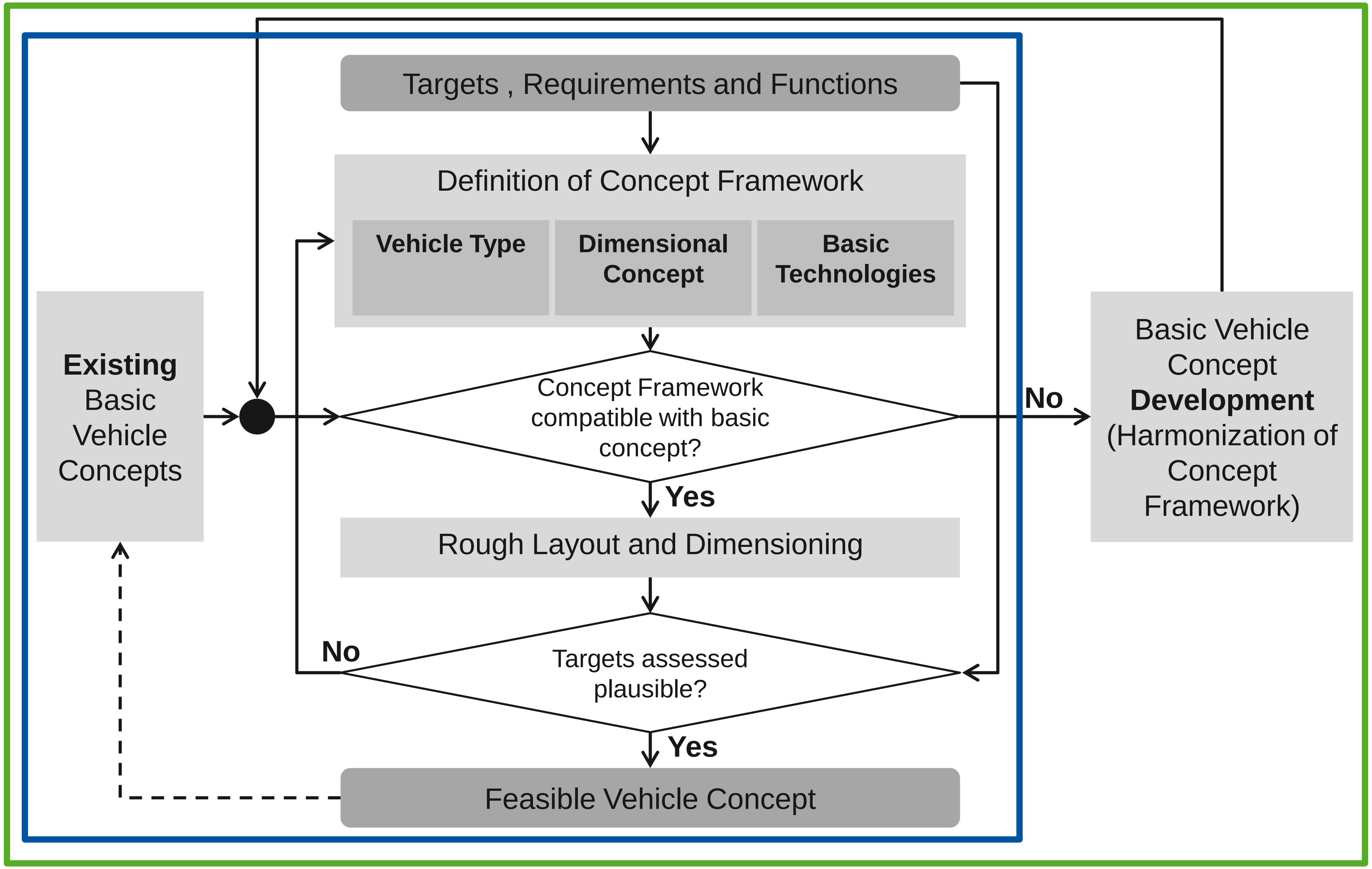
Functionally Adapted Physical Vehicle Architecture
Prospects of purpose design



Conversion Design

- Based on existing concept
- Efficient design approach
- Low risk regarding feasibility and invest
- Limited innovation potential for technical and creative design
- Evolutionary development

Purpose Design

- New Basic Vehicle Concept
- Comply with unique requirements and functions
- Innovative dimensional concepts possible
- Less compromises and improved setting of components
- Revolutionary development

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Functionally Adapted Physical Vehicle Architecture

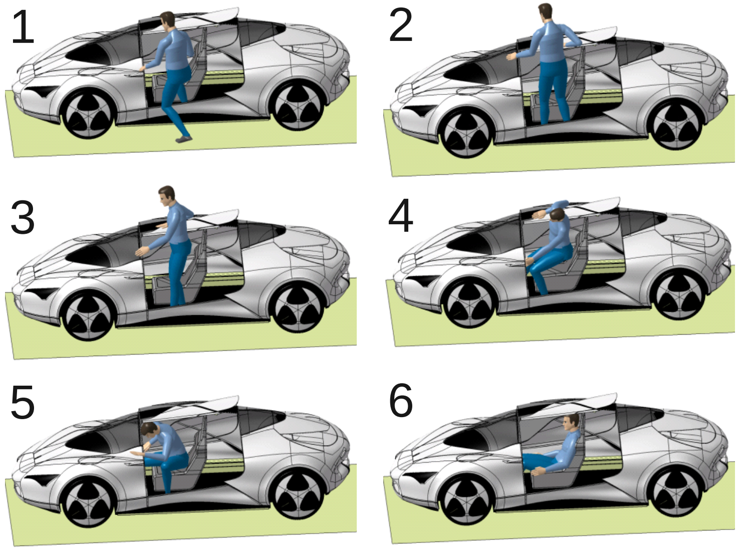
Ingress strategy for sportscar with central driver position

Challenges

[Source: Fifth Gear]

- Huge lateral distance from sill to seat
- No continuous seat row
- Torso movement limited by roofrail
- Leg movement limited by steering wheel

Concept Development



- Provide large lateral door opening
- Enter in upright body posture (1,2)
- Move next to the seat (3)
- Sit down compared to conventional seat ingress strategies (4,5,6)

Testing and Prototyping

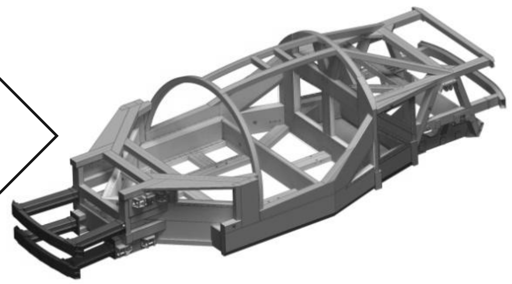
Body Structure
Development approach

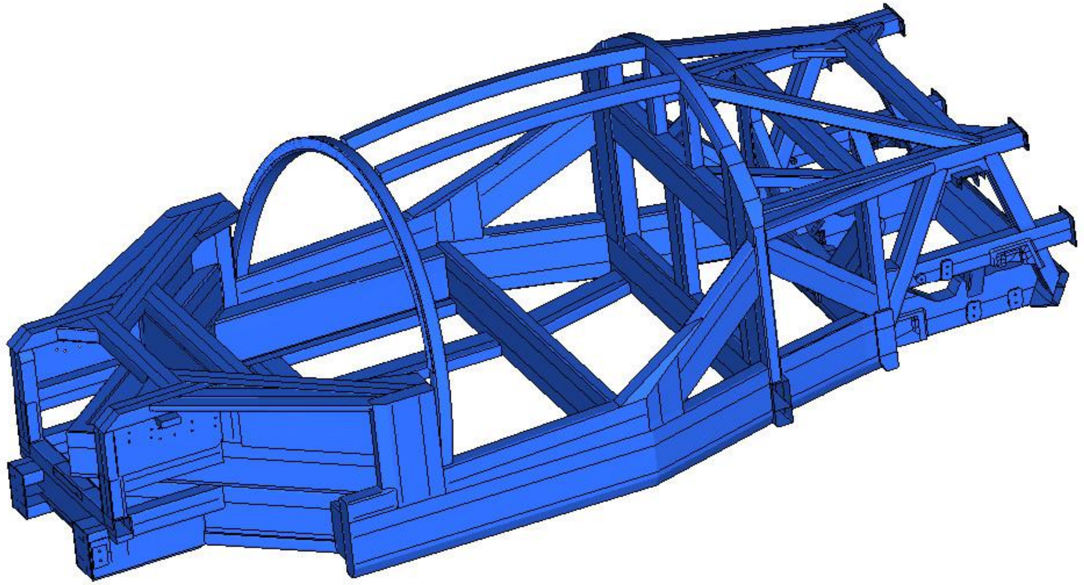
Component simulation
- Pre-dimensioning of components
- Determination of loads, section loads and load application

Global sucsessive topology optimisation
- Design space evaluation
- Design space determination
- Design inspiration

Simplified models
- Fast CAD and FEM modelling
- Assesment of alternatives
- Quasi static optimisation

Detailed design
- Transfer of simplified model to feasible design
- Detailed analysis and design iteration

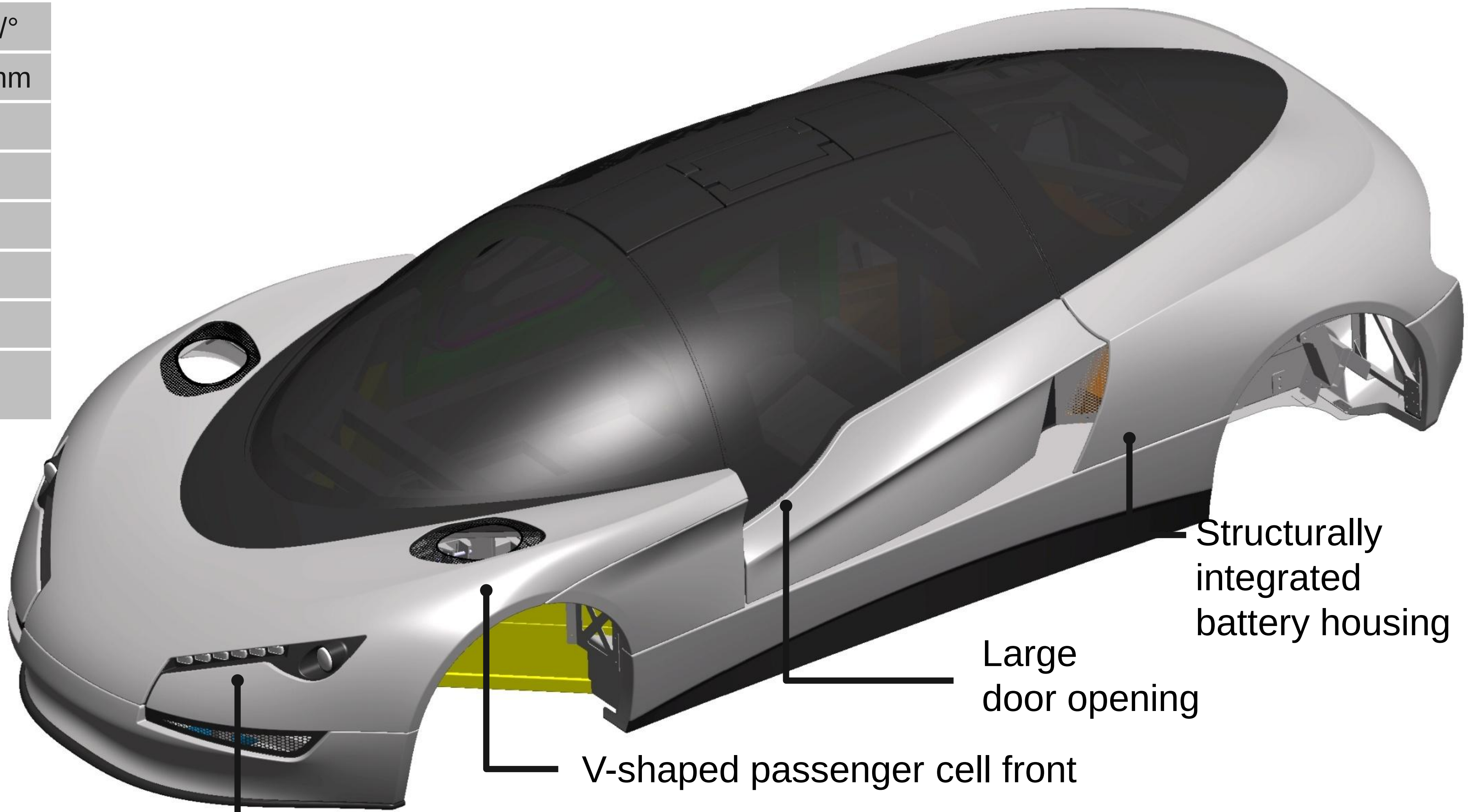




Body Structure

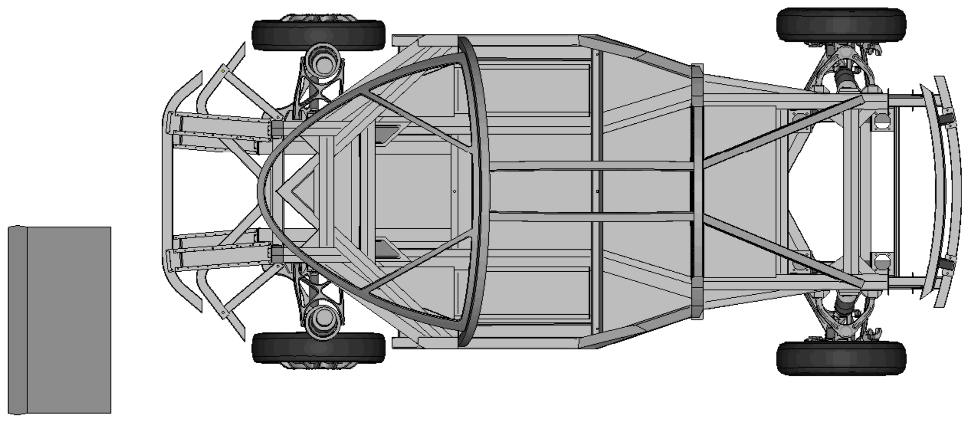
Unique Solutions Design Features of Functional Prototype

Torsional stiffness	49000 Nm/°
Bending stiffness	33700 N/mm
1st Eigenfrequency	70,3 Hz
2nd Eigenfrequency	71,4 Hz
Weight Body-in-white	256 kg
Material Mix	Al
	GFRP
	St-CFRP Sandwich

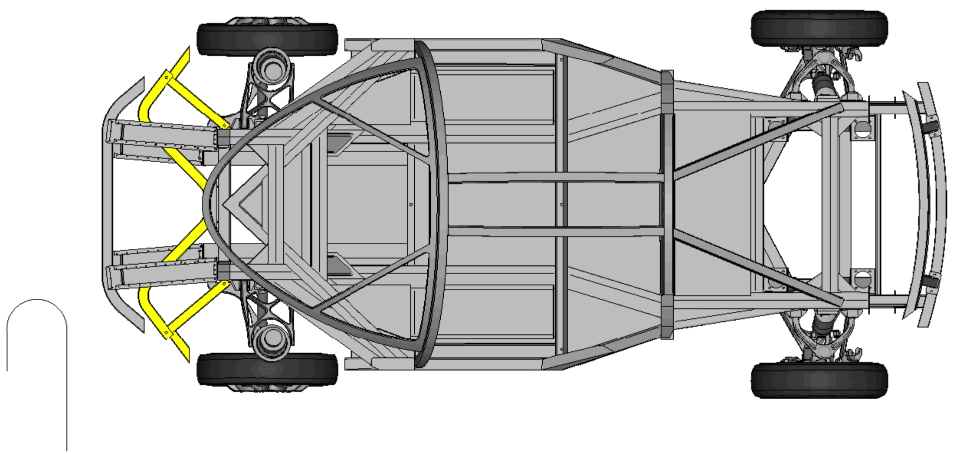


Body Structure
Numerical Analysis of Functional Prototype

Example: Front crash 40% offset deformable barrier



Example: Front crash small overlap 25% offset



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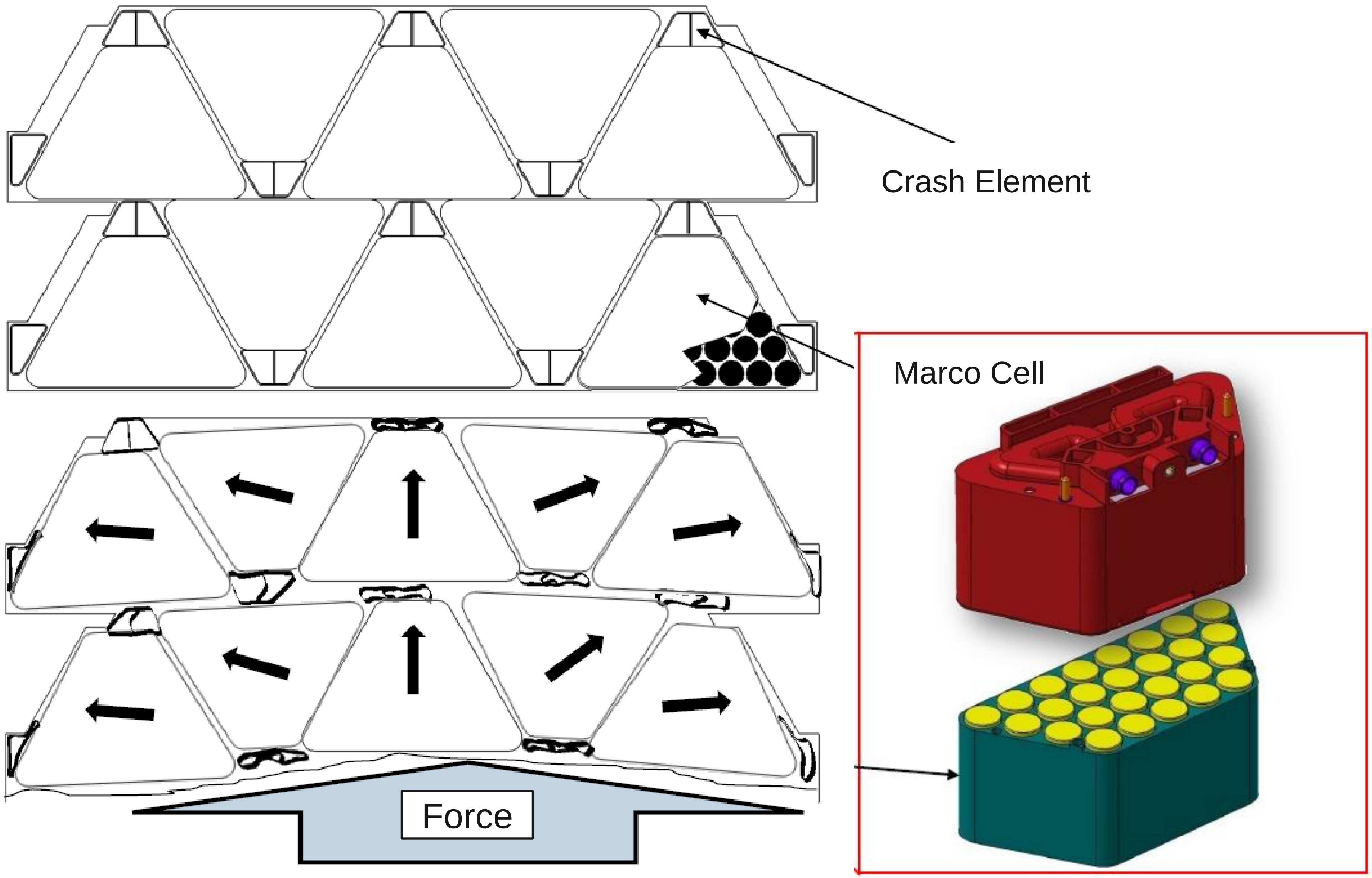
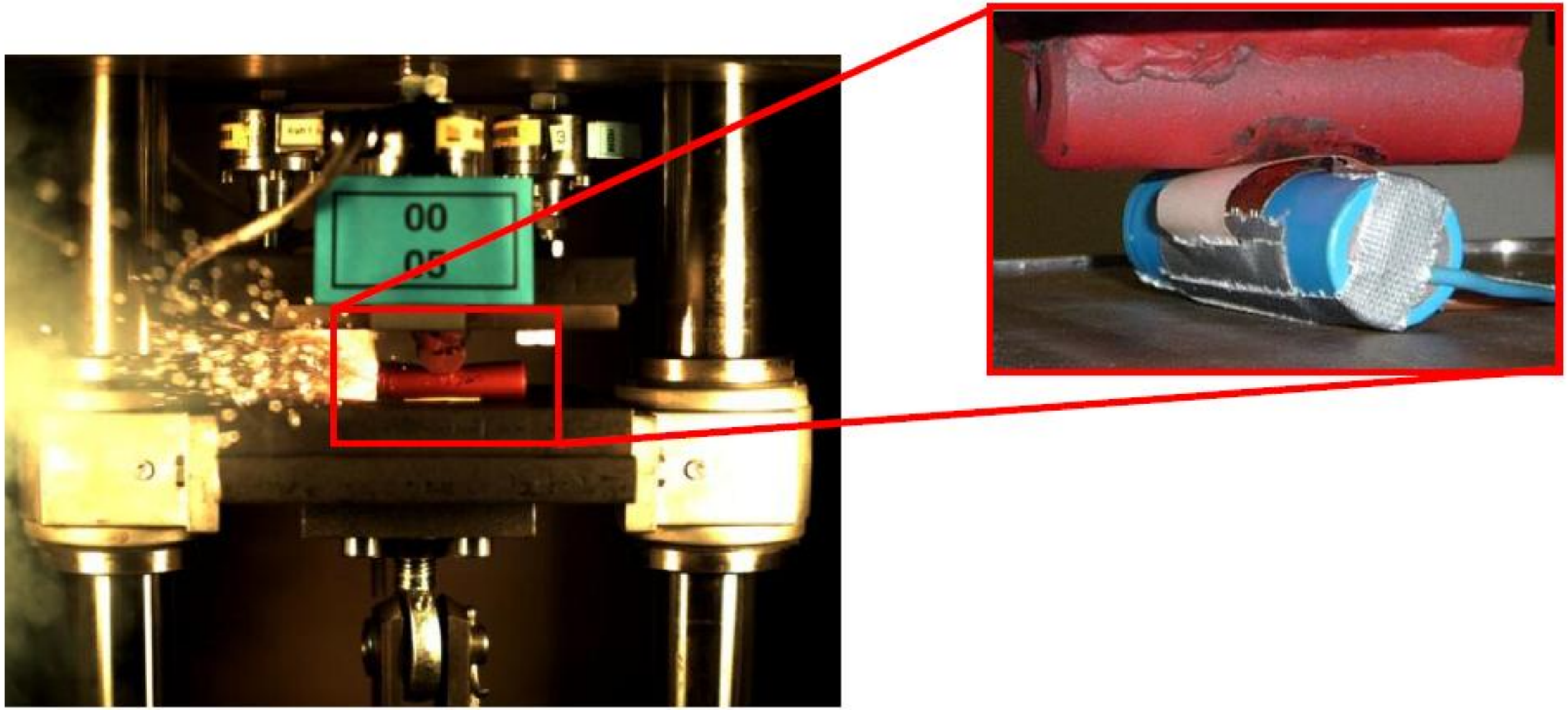
Crash Deformable Battery System
Approach



Crash Deformable Battery System

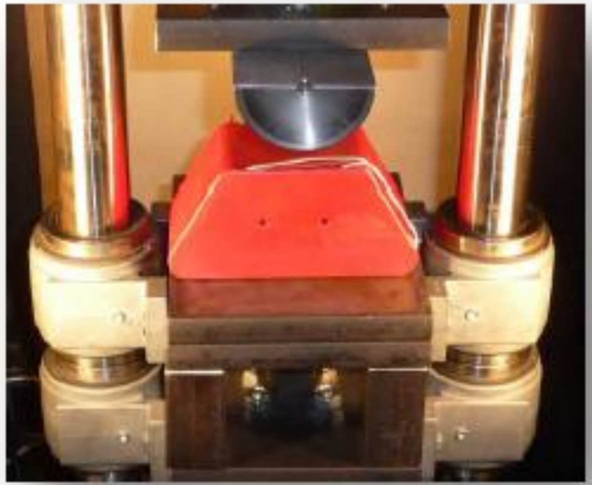
Behaviour of 18650 Battery Cell Under Mechanical Load



→ Battery cells have to be protected from high deformations to avoid thermal runaway

Crash Deformable Battery System
Physical Tests

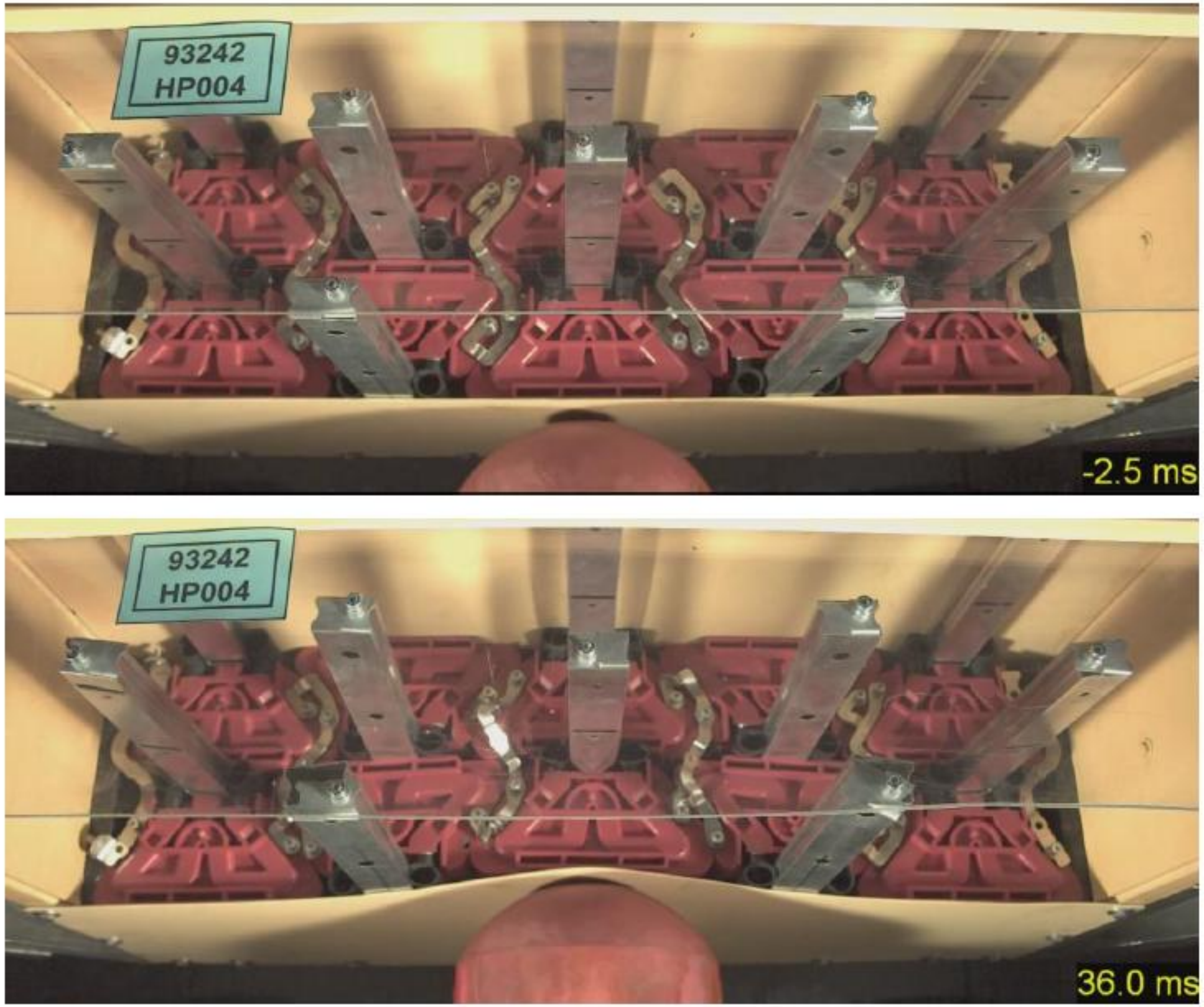
18650 Cell
Quasi-static



Macro Cell
Quasi-static

Battery System
Dynamic

Crash Deformable Battery System
Physical Tests



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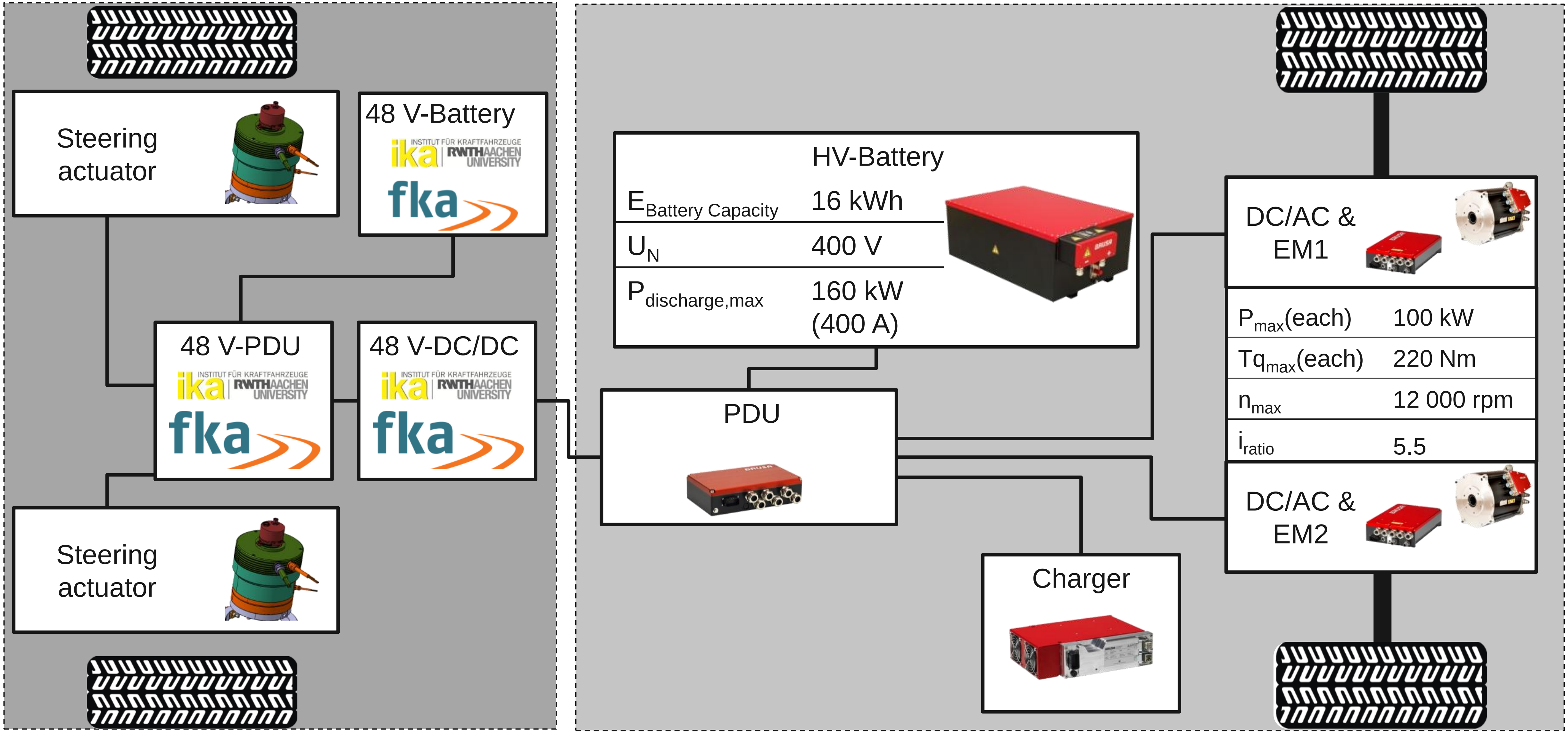
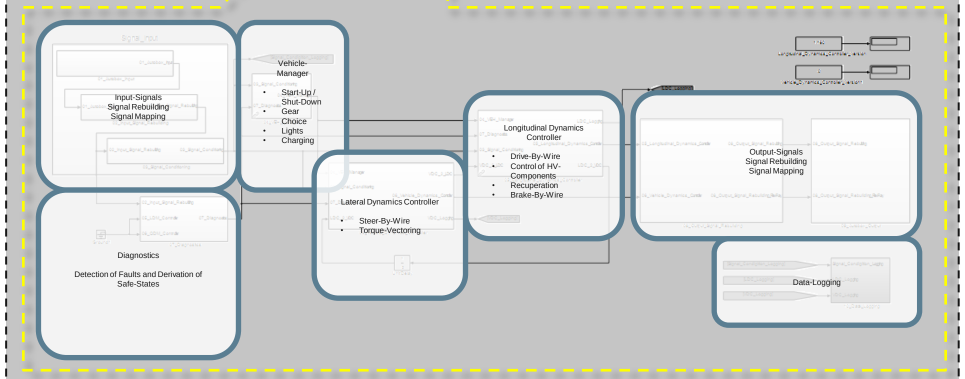
Electric Powertrain and Vehicle Electrical System
Topology



Electric Powertrain and Vehicle Electrical System
Drive-by-Wire & Brake-by-Wire

Driver Inputs

Functional Software



Component Outputs

two wheel-individual electric motors lead to high torque vectoring capability

four wheel-individual electro-hydraulic brake actuators allow for any wanted brake force distribution

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Historical Review

Steer-by-Wire system and large wheel steering angles

Steer-by-Wire System

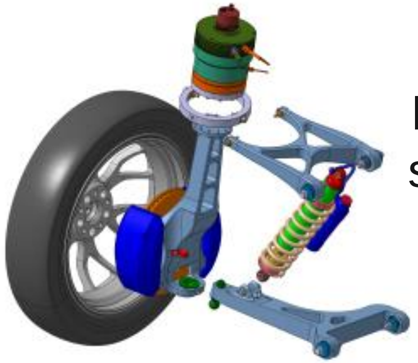
Research vehicle at ika 1991 with electro hydraulic Steer-by-wire system

Sidestick with potentiometer and rotary magnet

Large Wheel Steering Angles

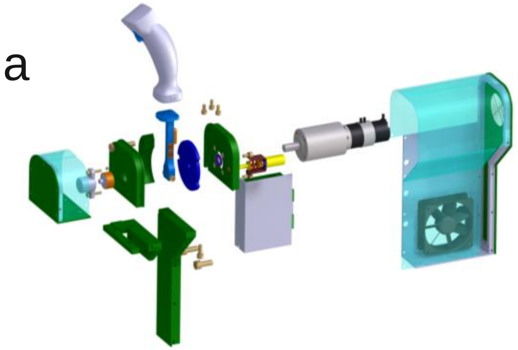
California United States. Date: 1933.

Steer-by-Wire System of the Research Vehicle SpeedE
Fields of research

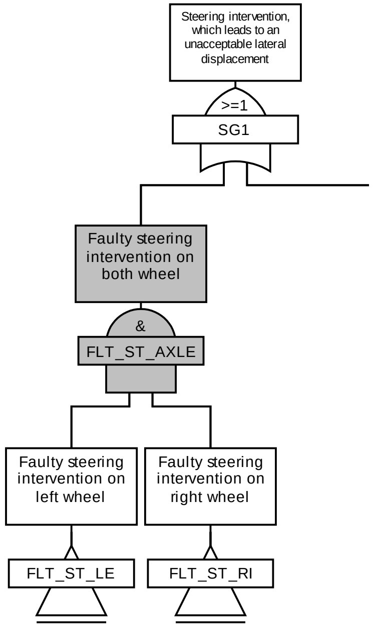


Innovative front axle suspension Concept

Vehicle guidance via active sidesticks

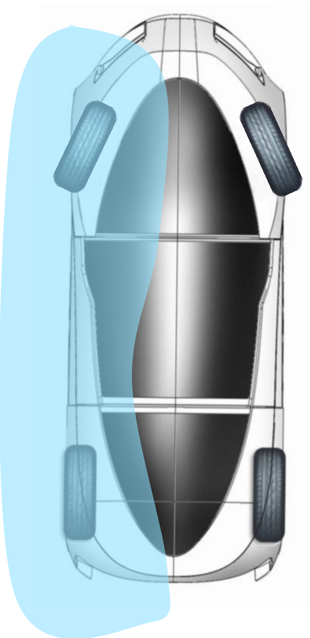


Steer-by-Wire System



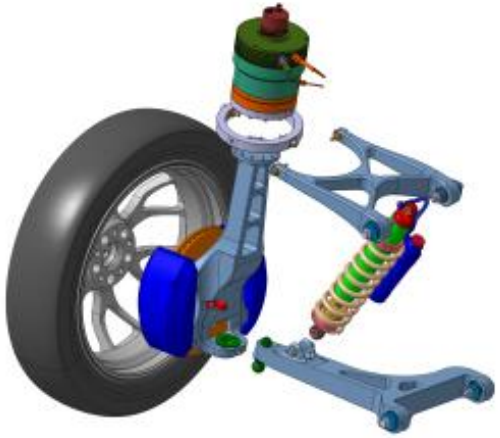
Functional safety concept

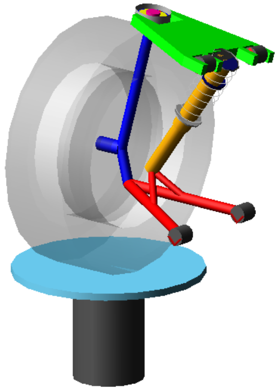
Innovative vehicle dynamics functionality

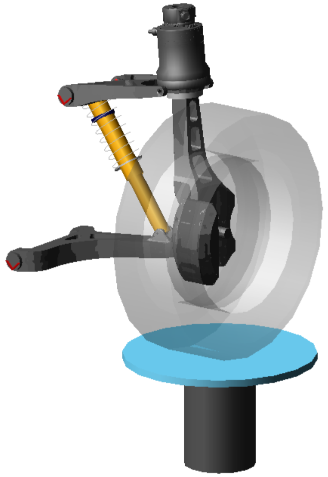


Steer-by-Wire System
Innovative front axle suspension concept

Design

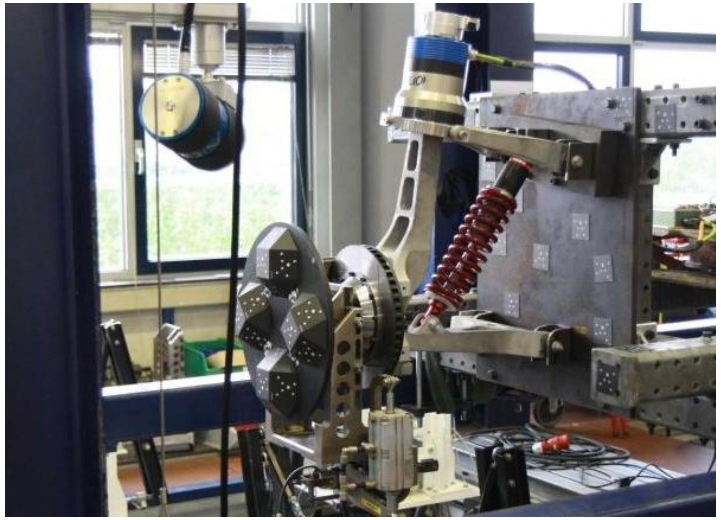


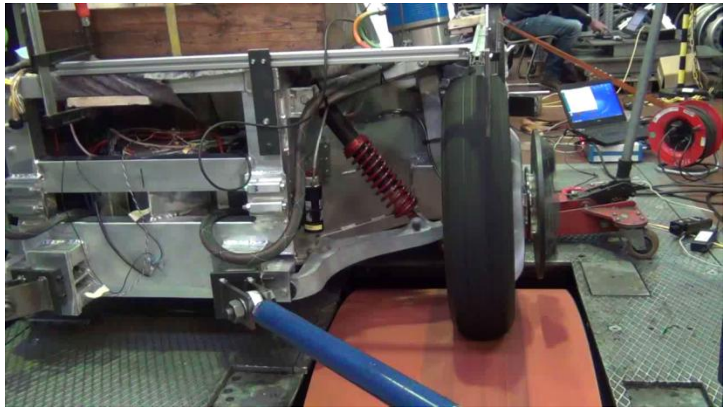




Implementation

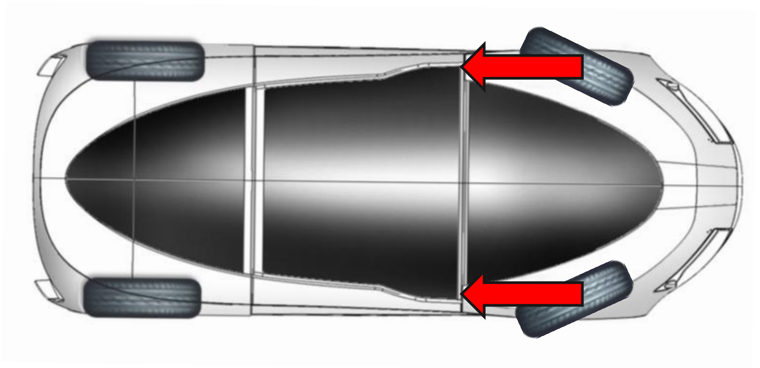
Validation



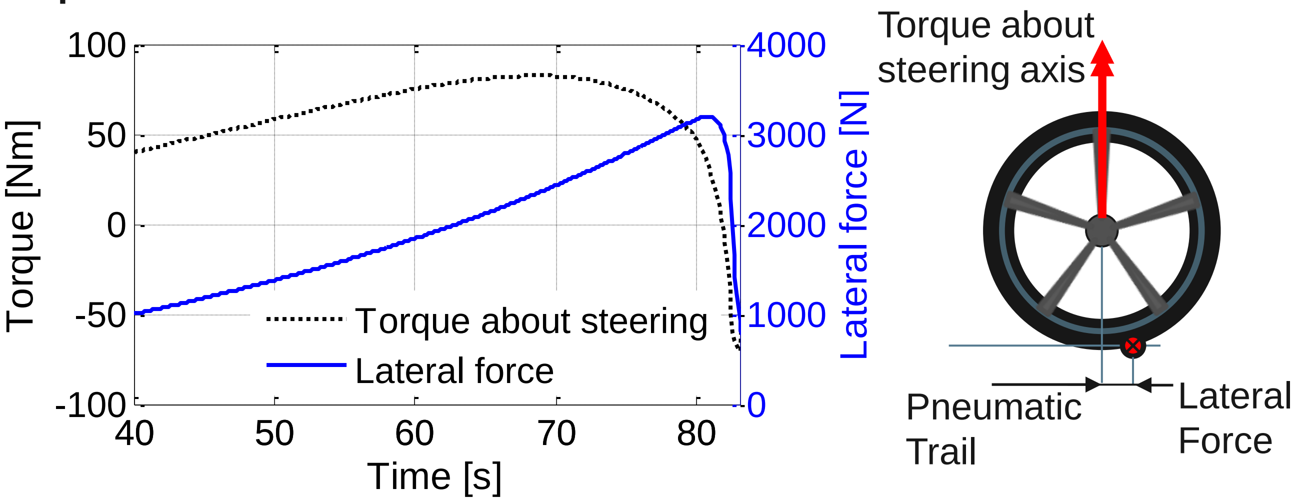


Steer-by-Wire System of the Research Vehicle SpeedE
Innovative vehicle dynamics functionality

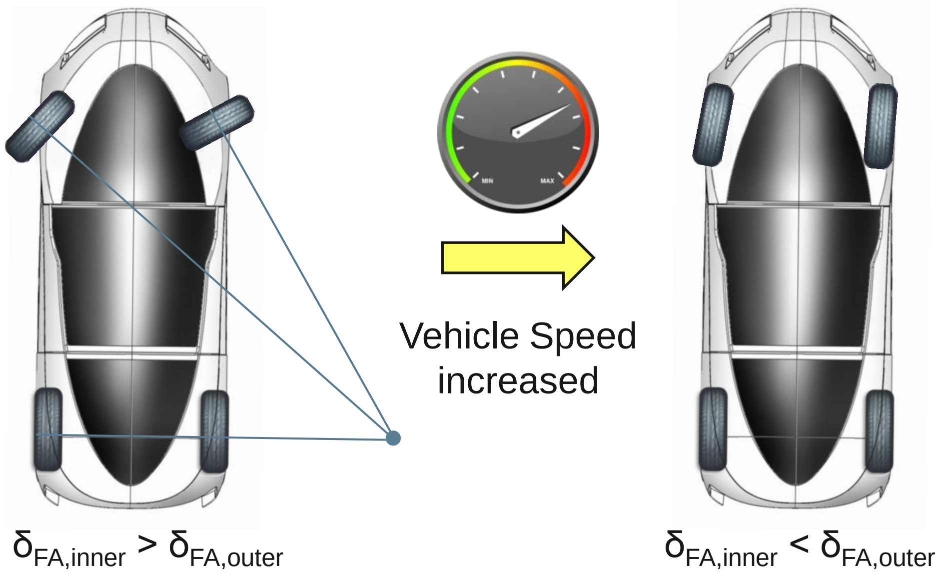
Parking brake/ Emergency brake



Optimization of lateral force



Modified ackermann design



Improvement of µ-split braking

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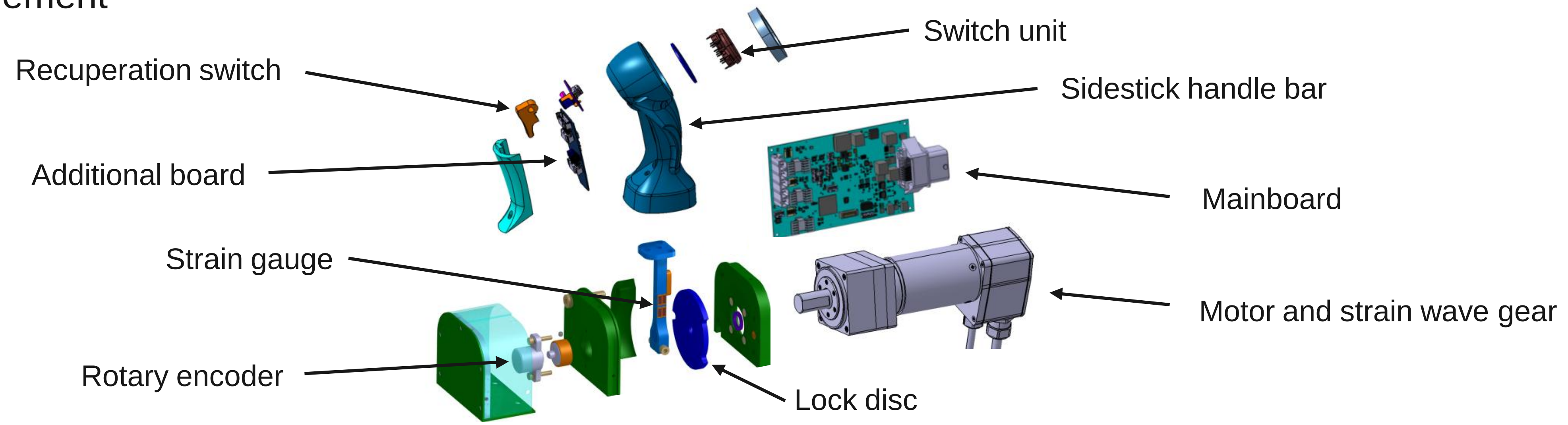
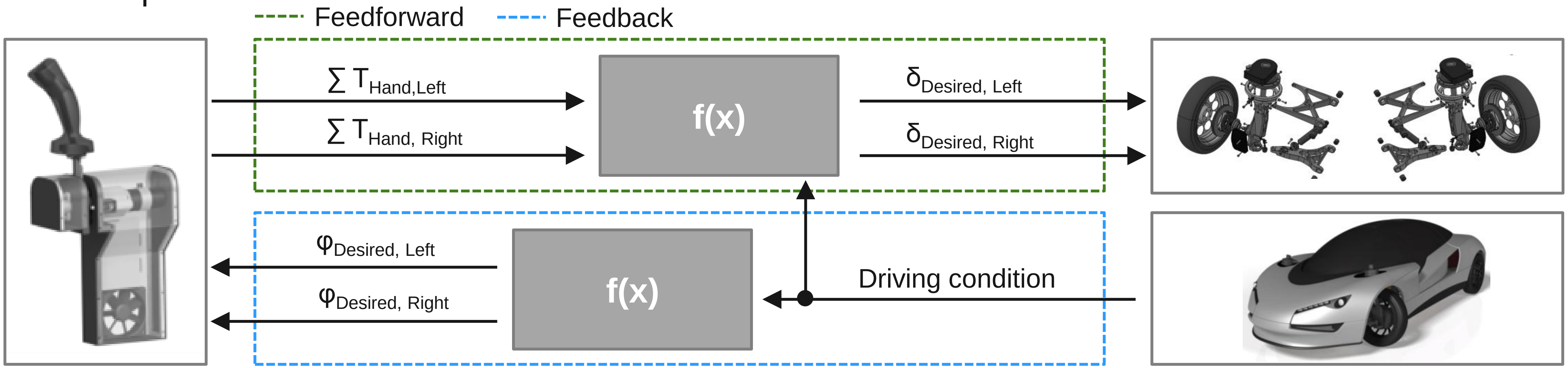
SpeedE
Vehicle Guidance

Control element



Control loop



Safety and reliability are the main concerns when it comes to Steer-By-Wire Systems

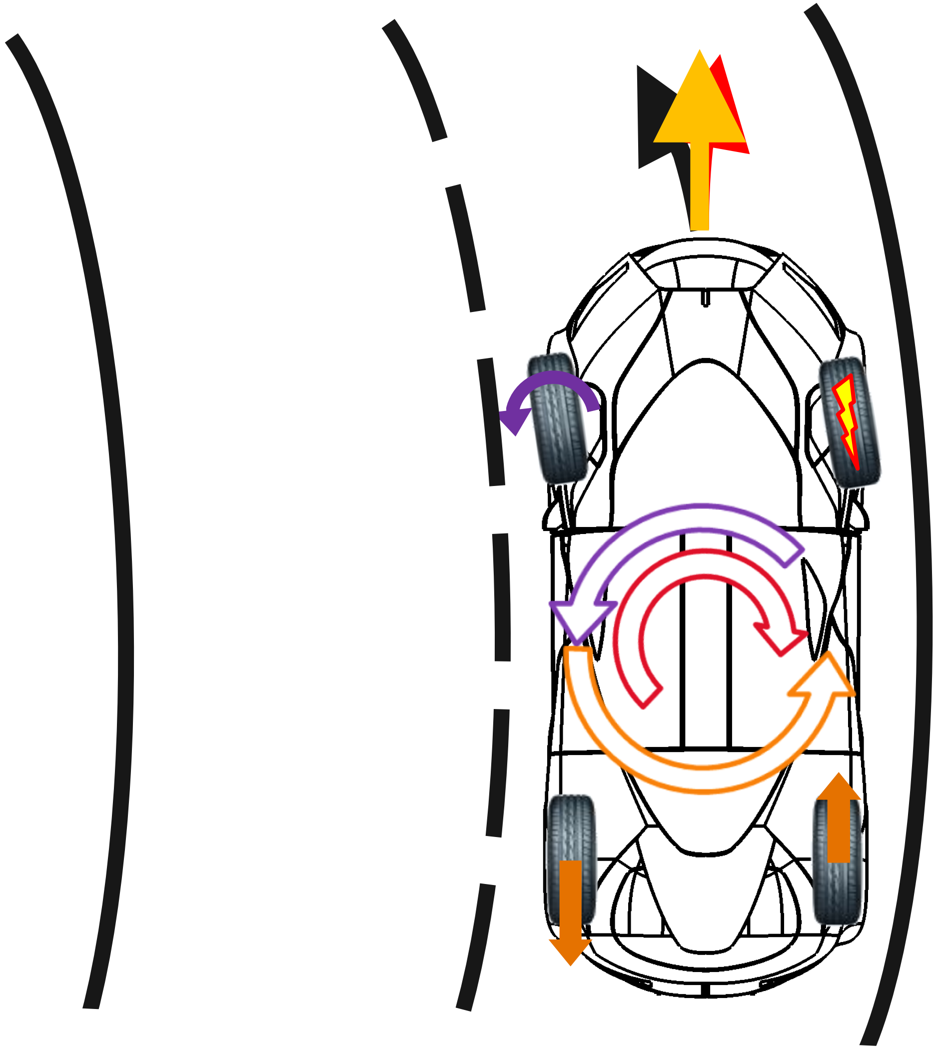
1. Solution

   Mechanical fallback layers or component redundancy
   “If one component fails, I need another one to replace it”

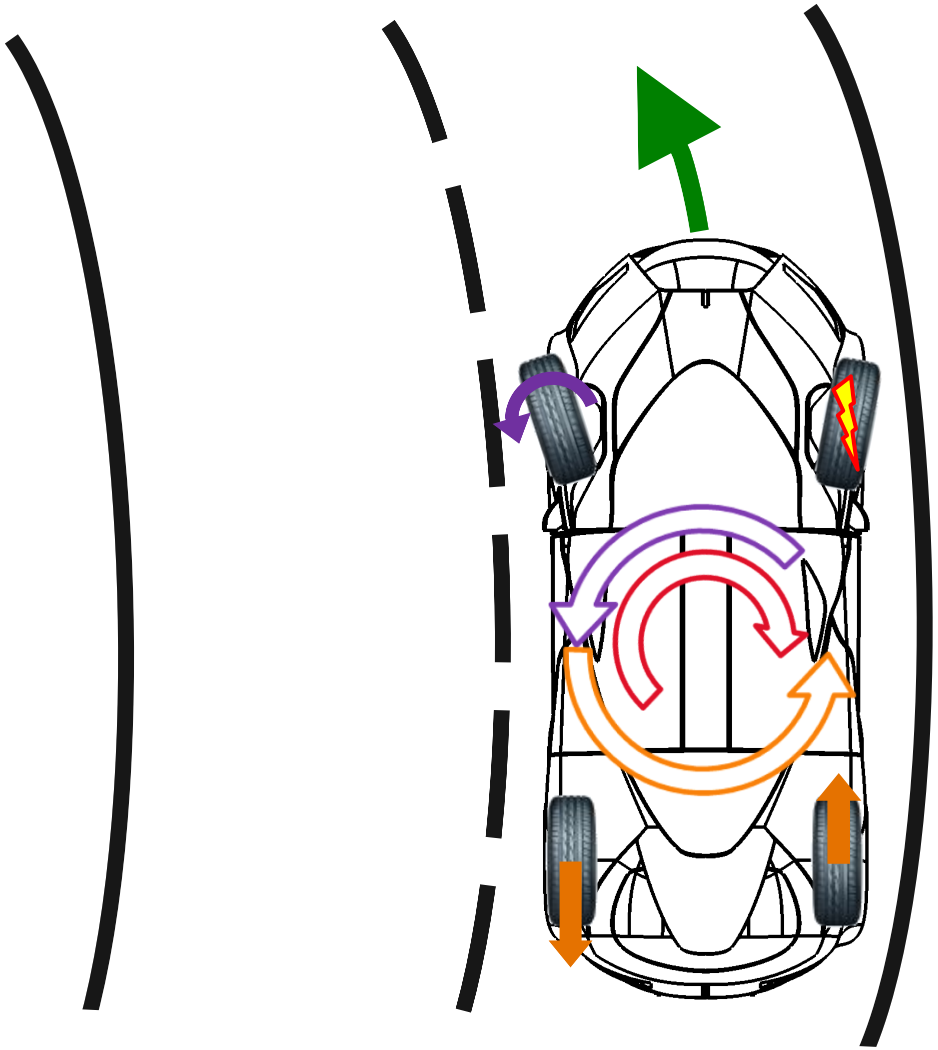
2. Solution

   Keep the solution space as wide as possible
   “If one component fails, I still have to be able to bring the vehicle to a safe standstill”

⇨ Steering angle failures are compensated by other vehicle systems (counter steering, torque-vectoring and braking)



SpeedE
Functional Safety



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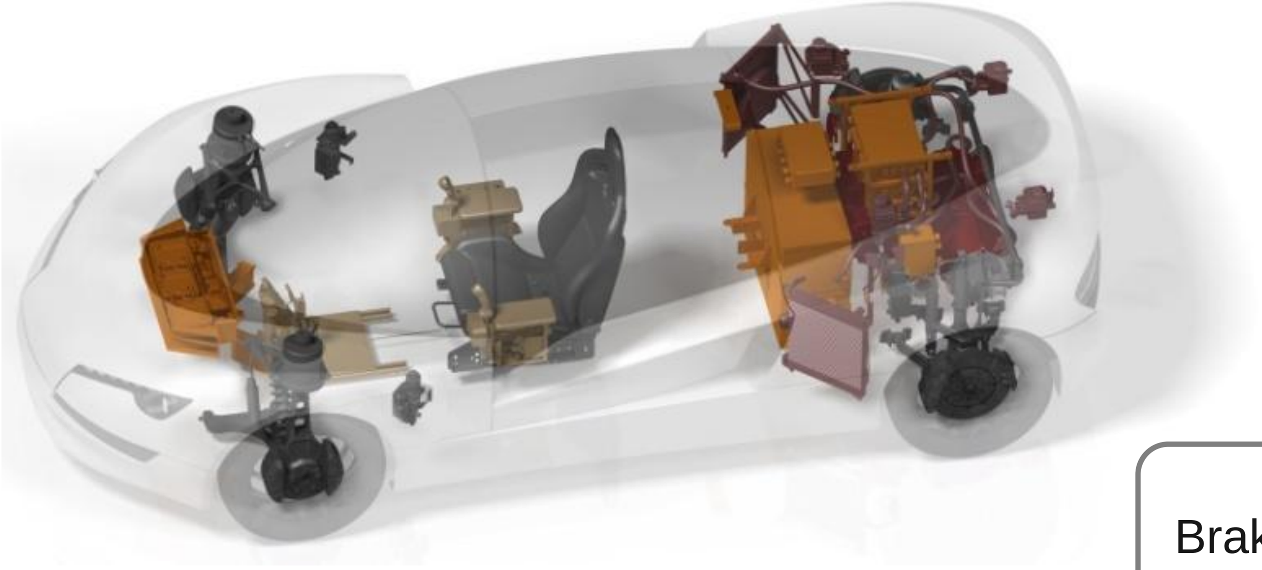
Synopsis and Outlook

- SpeedE resembles a unique and innovative research platform to investigate on future mobility
- Complete X-by-Wire platform



Drive-by-Wire

Steer-by-Wire

Brake-by-Wire

<u>Outlook:</u>

- Further refinement of vehicle functions – i.e. feed-forward and feed-back behaviour of the Steer-by-Wire system
- Development and implementation of a sensor concept for automated driving
- Implementation of functions for automated driving

Contact

Thank you for your attention

Thanks to the Hans Hermann Voss foundation
for their support in developing SpeedE

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