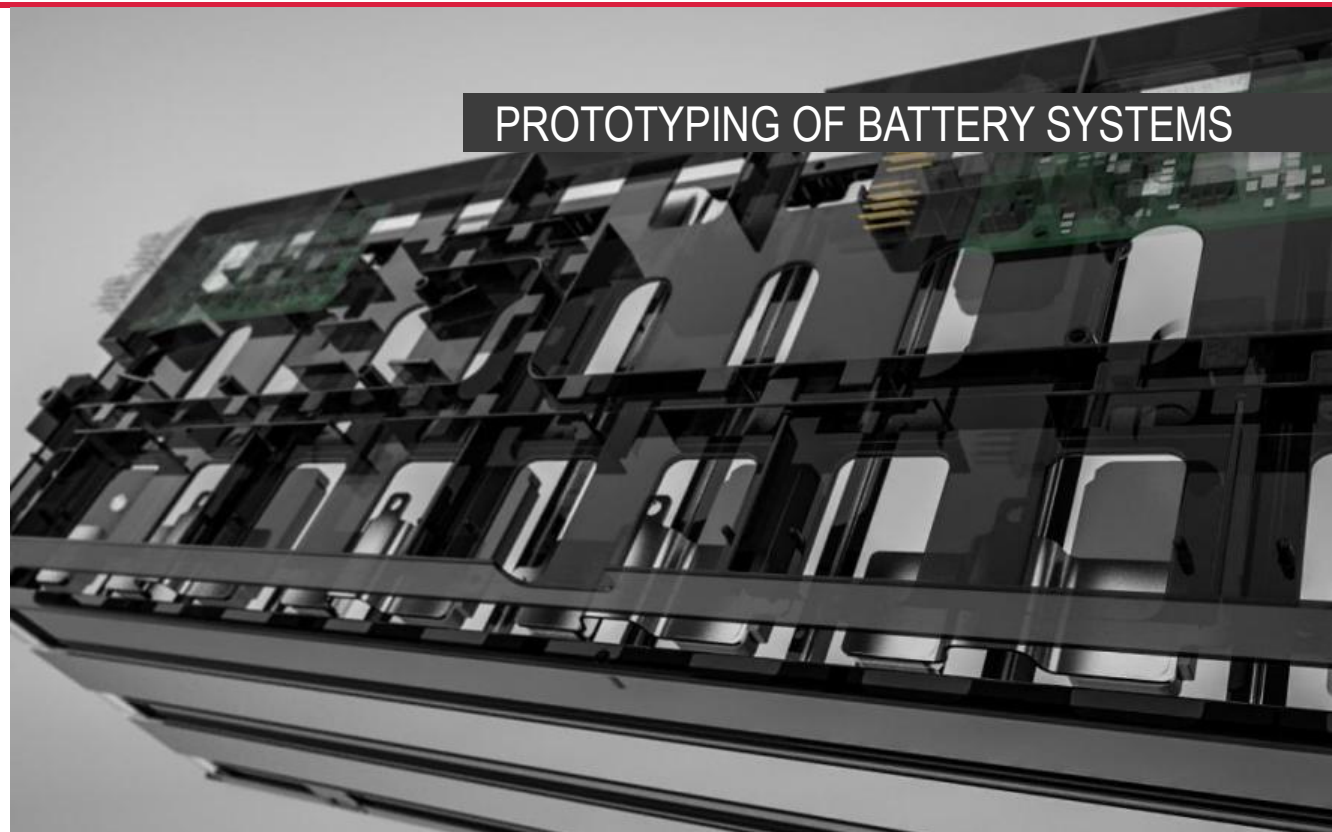


Presentation



Prepared for

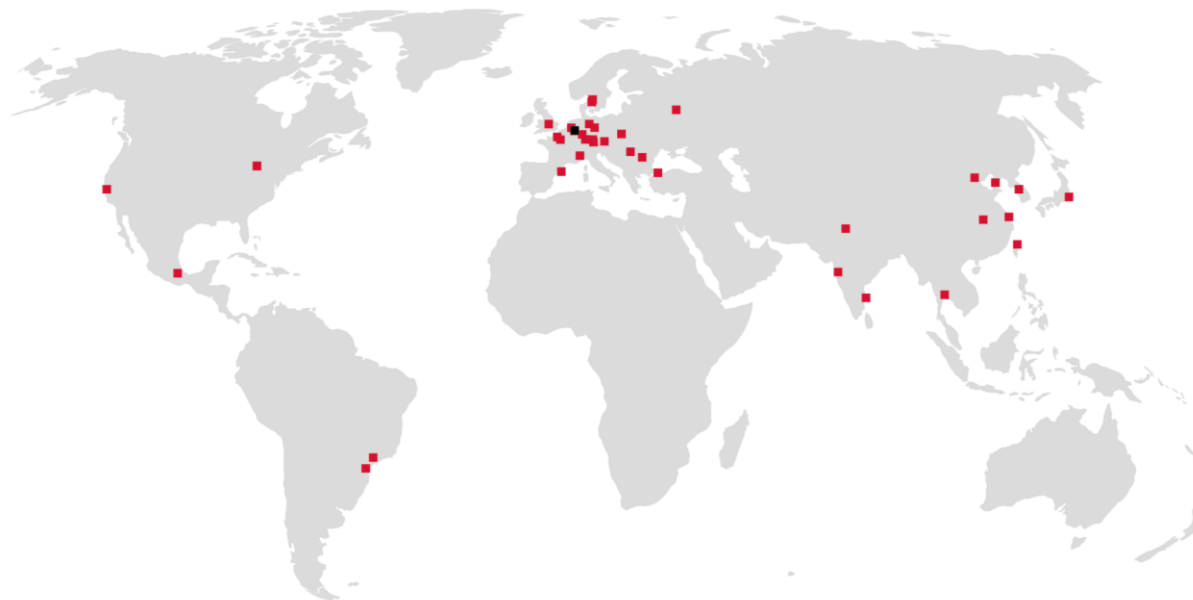
Lasersymposium
Elektromobilität 2019



Aachen, 20.02.2019
Dr. Michael Stapelbroek, Department Manager Battery Systems



Your engineering partner worldwide



■ Subsidiary ■ Headquarter

- Independent engineering company
- Supporting engineering developments from innovations up to SOP
- Optimizing customers products and processes
- ~630 M€ revenue expected in 2018
- Close to our customers:

40+

subsidiaries on four continents

200+

test cells for engines, transmissions, drivelines, e-machines, batteries

5900+

employees globally

Battery development is driven by energy content, lifetime, safety and fast charging



CURRENT BATTERY DEVELOPMENT CHALLENGES

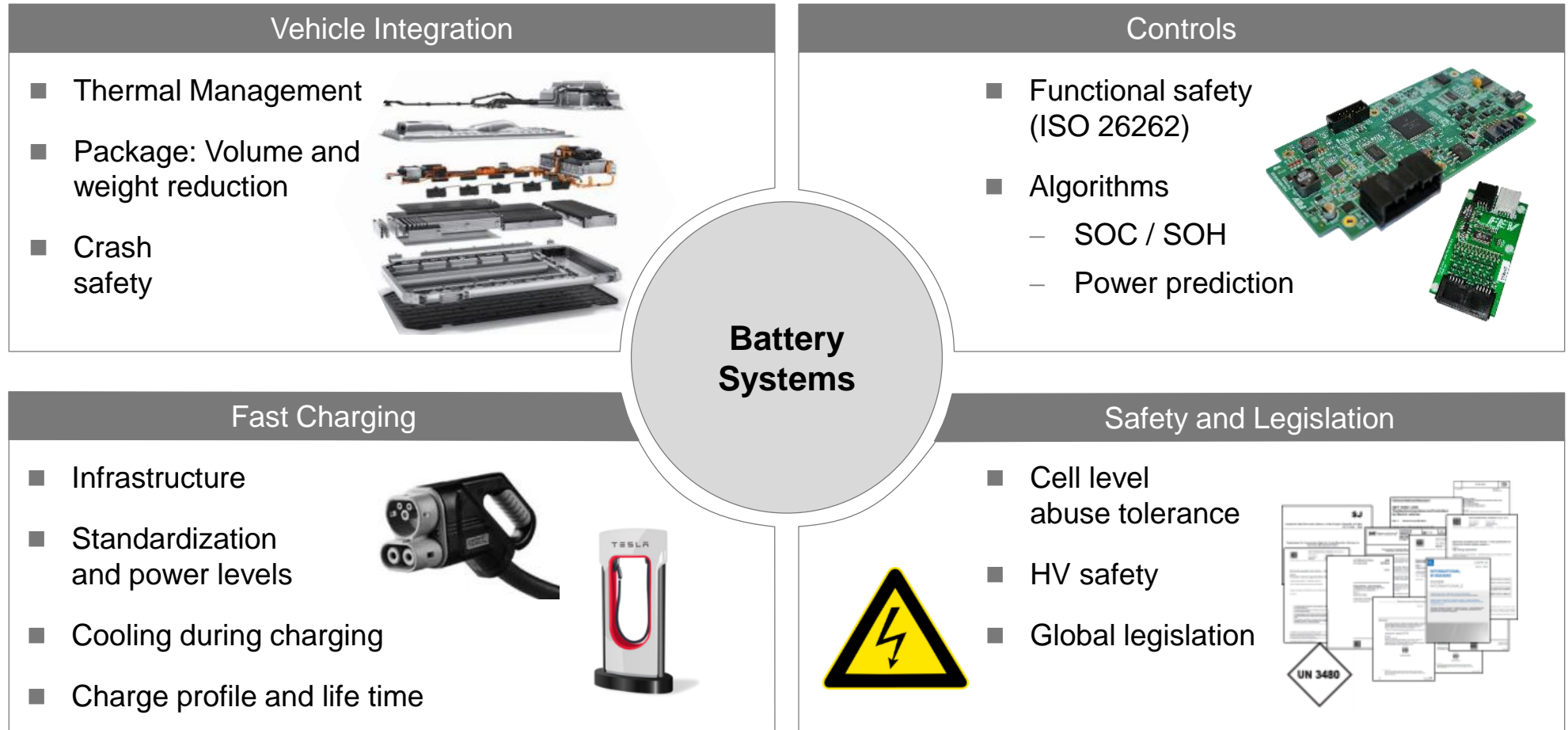


Image sources: Phoenix Contact, Tesla, insideevs.com

In 2008 FEV registered 12 pure electric vehicles and had a market share of 5% which means to be German market leader



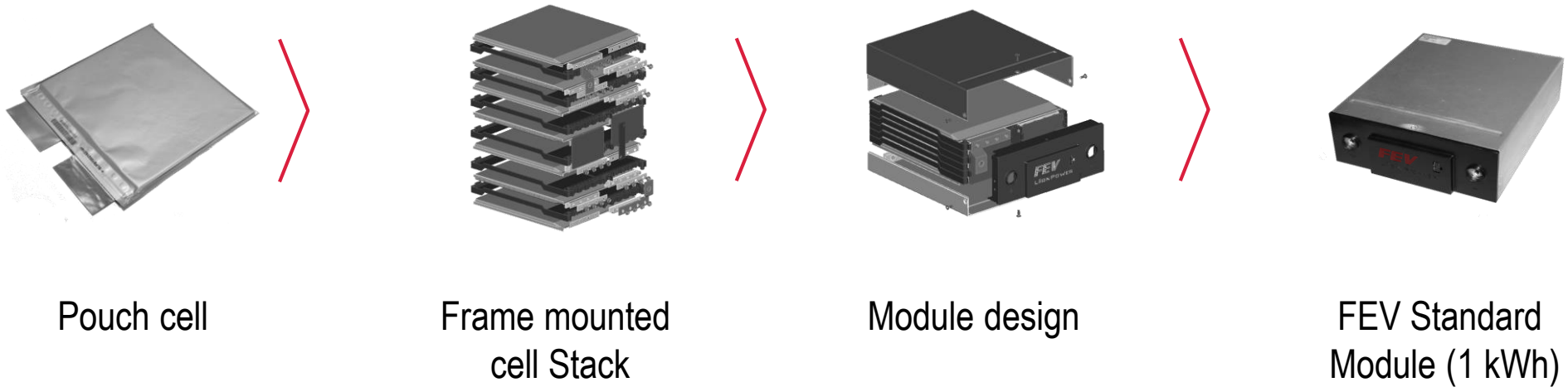
BATTERY DEVELOPMENT FOR SMARTWHEELS 2008



In 2008 the underfloor battery concept was innovative and new to the e-mobility community



BATTERY DEVELOPMENT FOR SMARTWHEELS 2008



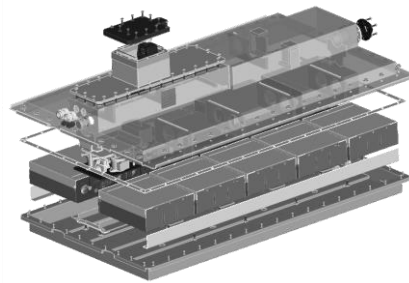
In 2008 the underfloor battery concept was innovative and new to the e-mobility community



BATTERY DEVELOPMENT FOR SMARTWHEELS 2008



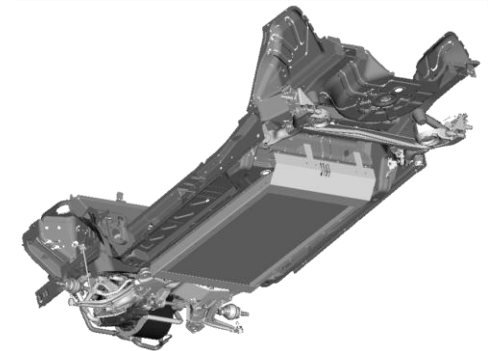
FEV Standard
Module (1 kWh)



Underfloor Vehicle
Integration



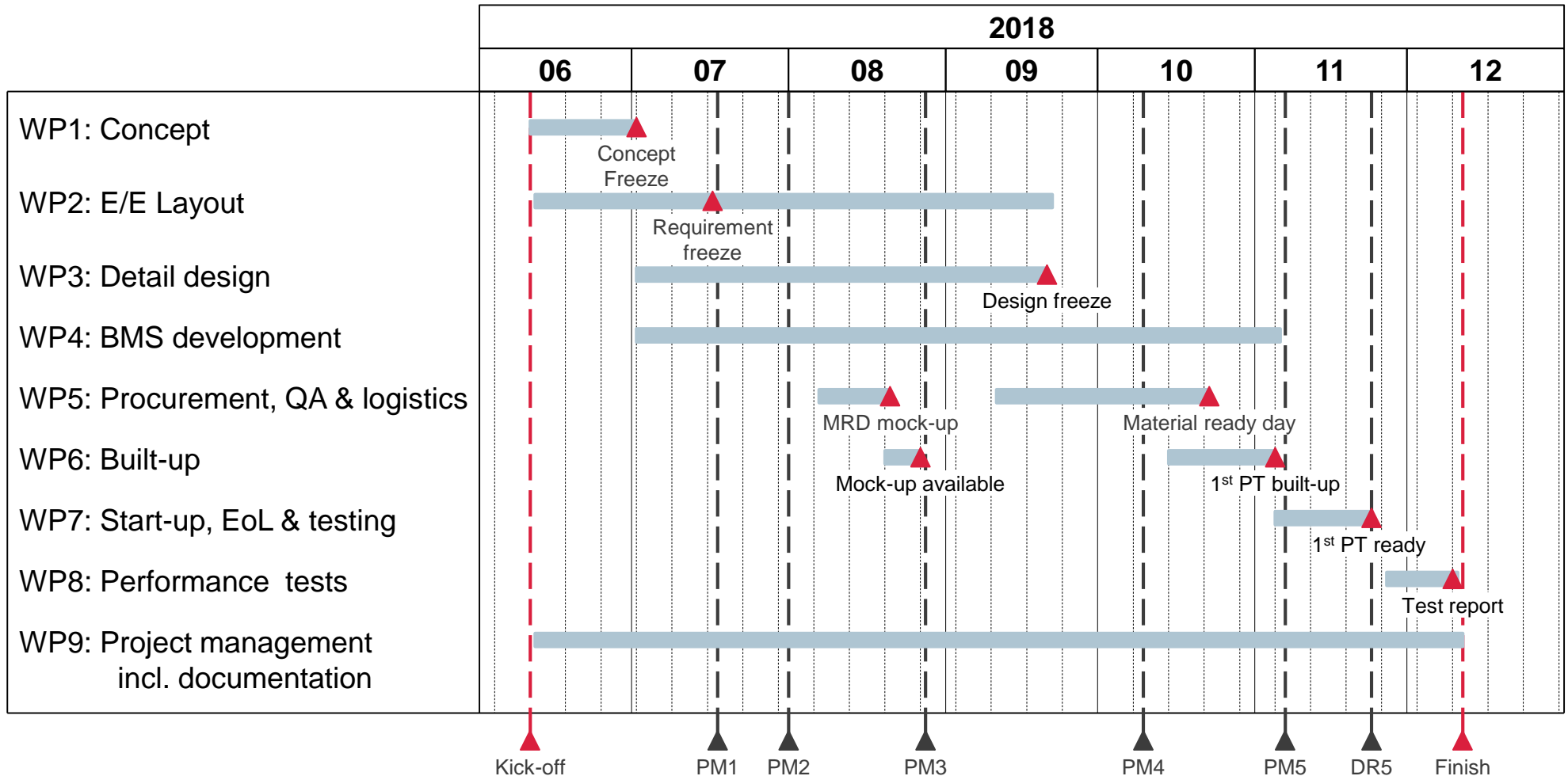
Pack design



Modular Battery Pack

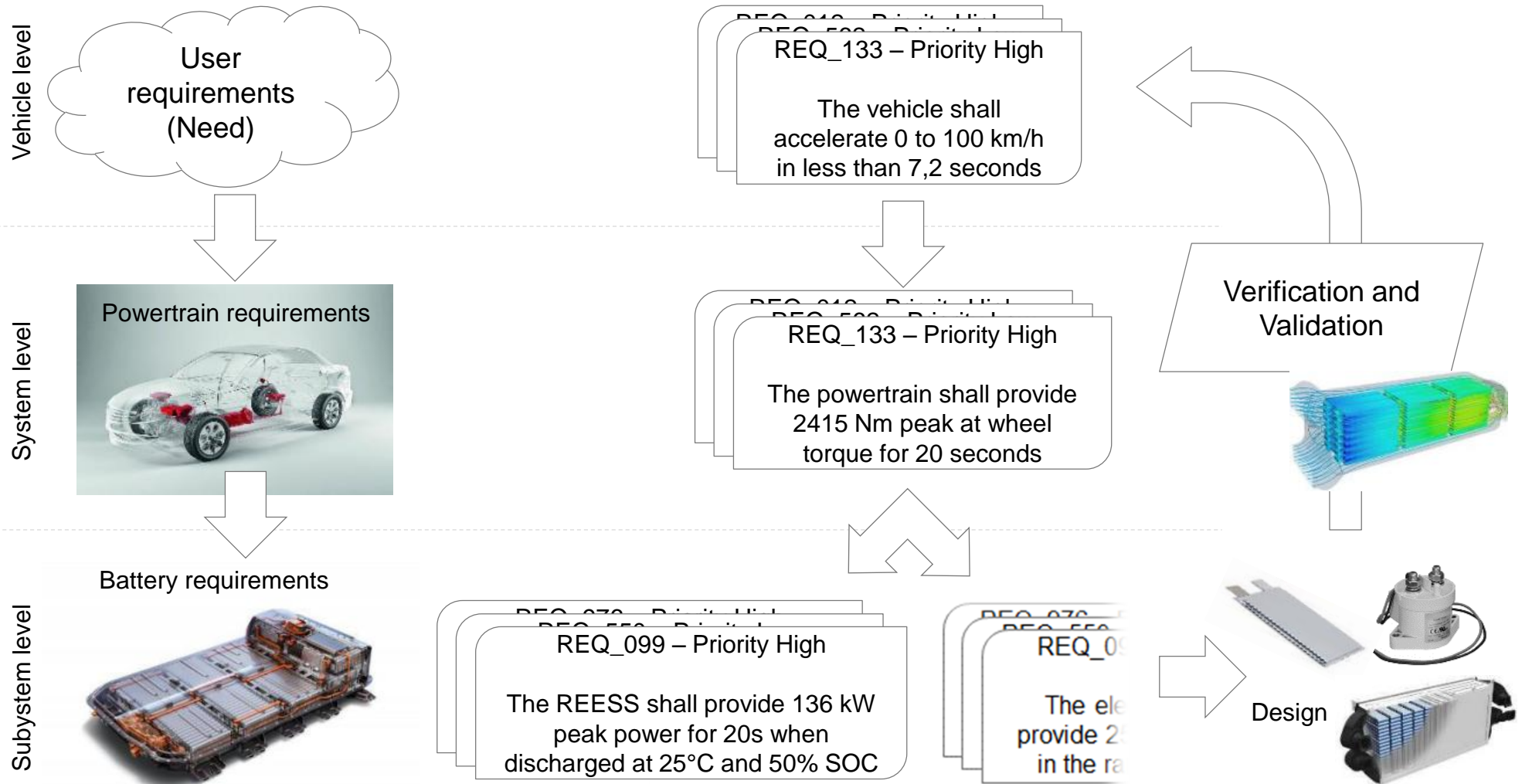
Requirements & Timing

Typical timeline of prototyping project



Requirements & Timing

Typical cyclic workflow for requirements engineering



Battery concept development is starting from the cell selection process

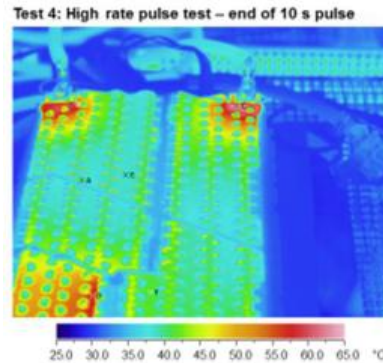


CELL CHARACTERIZATION CAPABILITIES

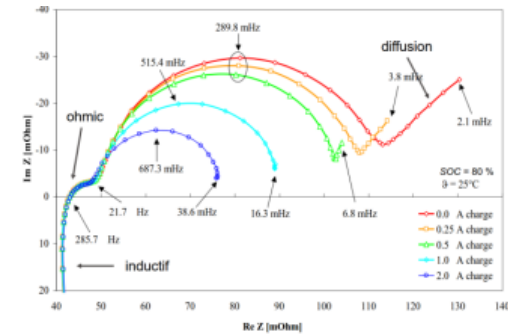
Electrical testing



Thermal testing



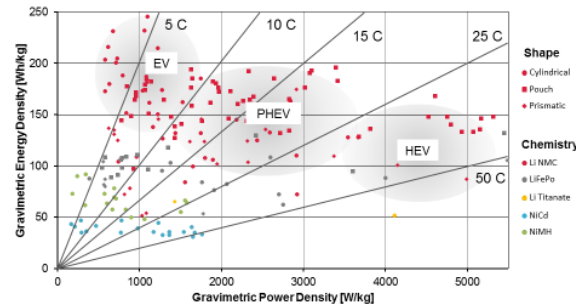
EIS testing



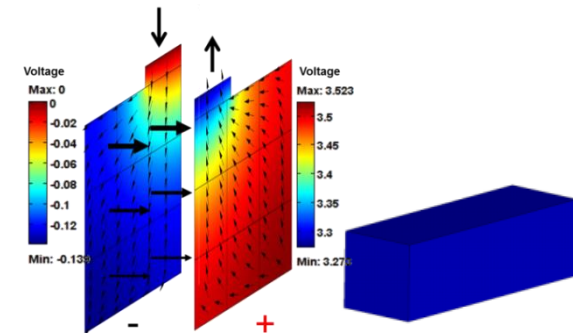
Aging



Database



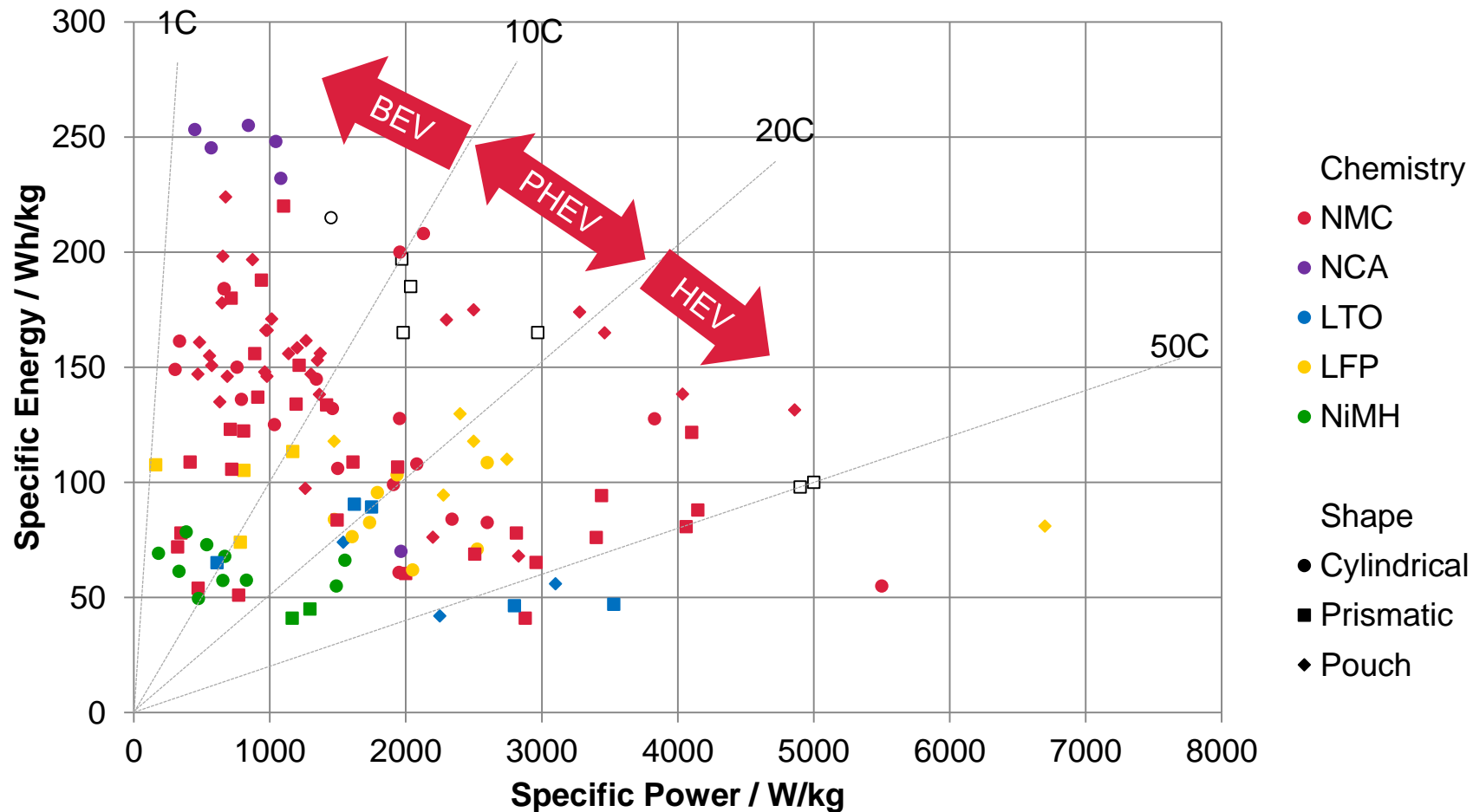
Spatially resolved sim.



FEV Database contains information from various sources and displays market trends and measurement results



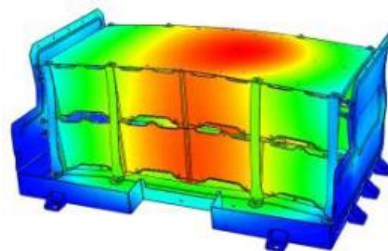
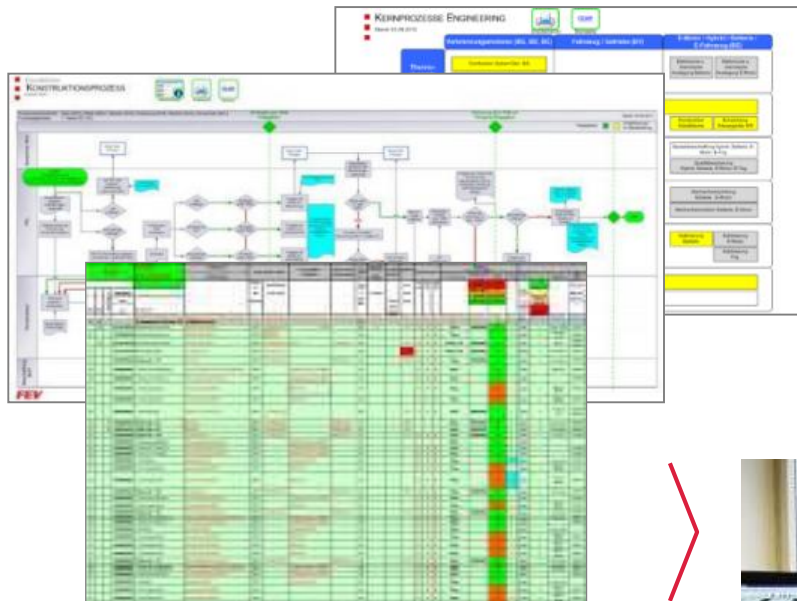
BENCHMARK & DATABASE RESULTS: RAGONE DIAGRAM (GRAVIMETRIC)



Key points for prototyping design are fast design processes, cell availability and project center



DESIGN - SIMULATION - PROCUREMENT



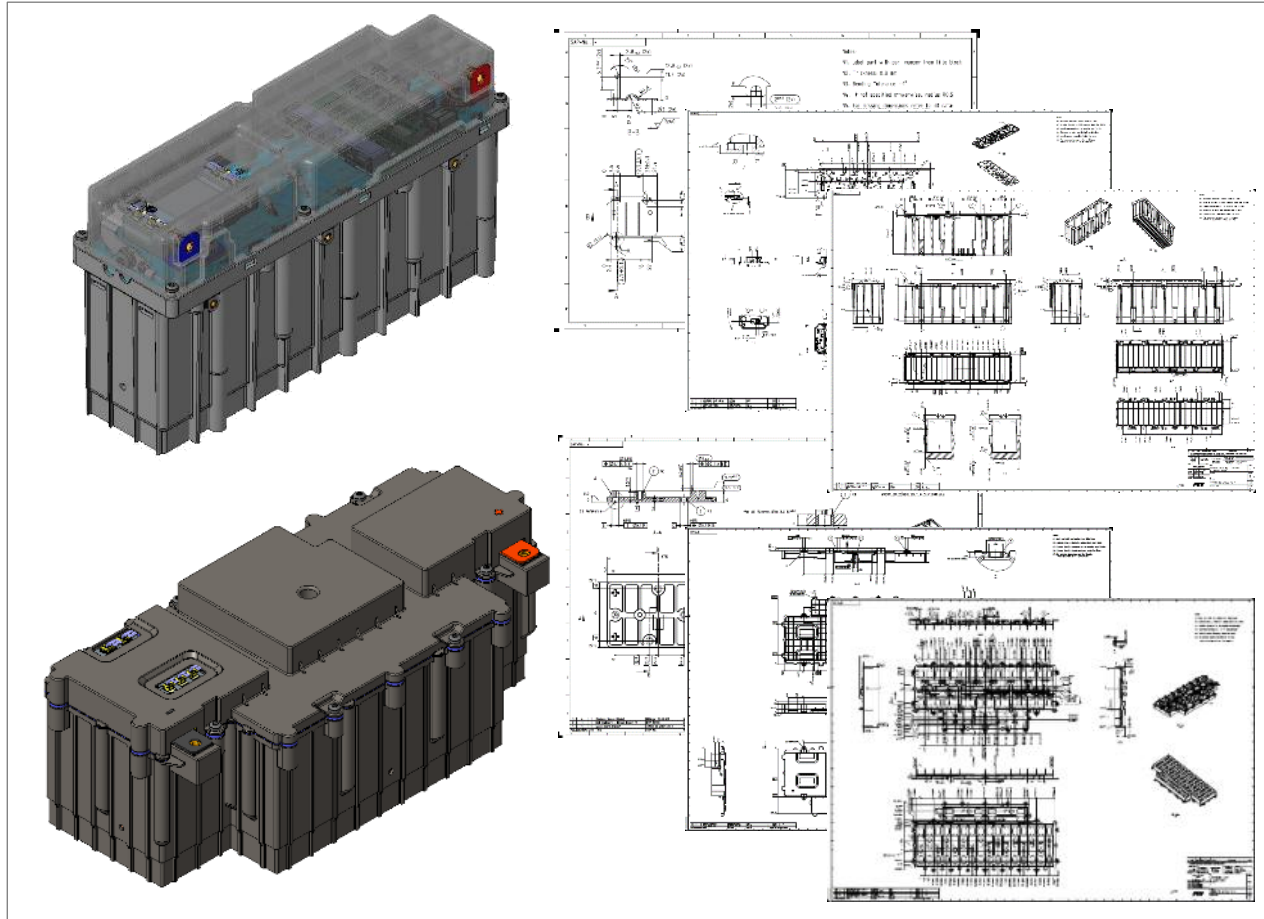
Key points

- Standard design processes and adaptable BOM
- Selection and availability of an appropriate cell
- Close interaction of design and simulation team (one room)
- Rapid prototyping manufacturing processes and prototype supplier network

Key points for prototyping design are fast design processes, cell availability and project center



EXAMPLE OF 48 V PROTOTYPE (FINAL 3D CAD & 2D DRAWINGS)



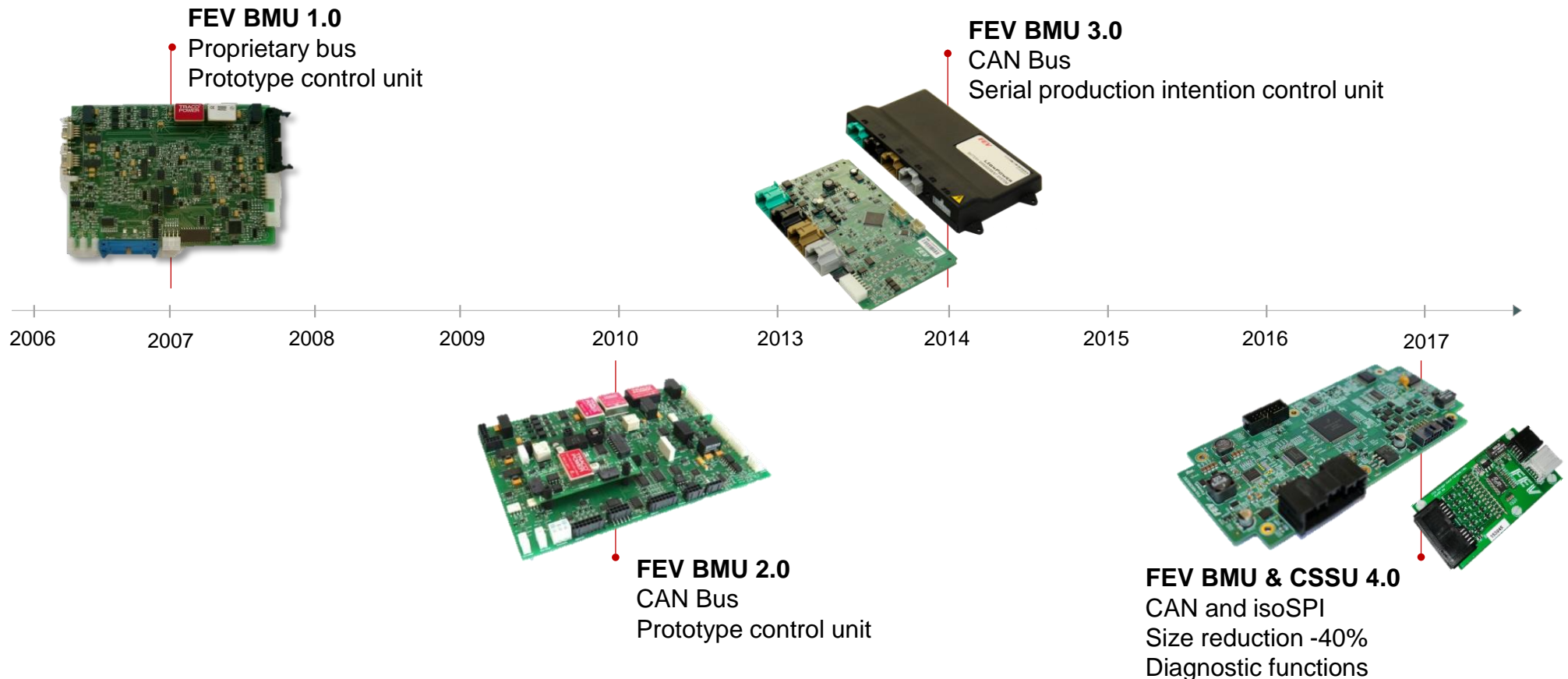
Capacity:	5 Ah
Energy content:	230 Wh
Nom. Voltage (Pack):	46 V
Max. Current (Nom.):	50 A
Peak Power (3s):	10 kW

Capacity:	20 Ah
Energy content:	920 Wh
Nom. Voltage (Pack):	46 V
Max. Current (Nom.):	100 A
Peak Power (3s):	20 kW

FEV uses an in-house BMS Hard- and Software for flexible and fast implementation in prototype projects



BATTERY MANAGEMENT SYSTEMS



Quality Management and Storage



FROM INTAKE TO WORKSHOP

Goods receiving from supplier



Quality inspection

Assembly workshop



Quality report & labeling



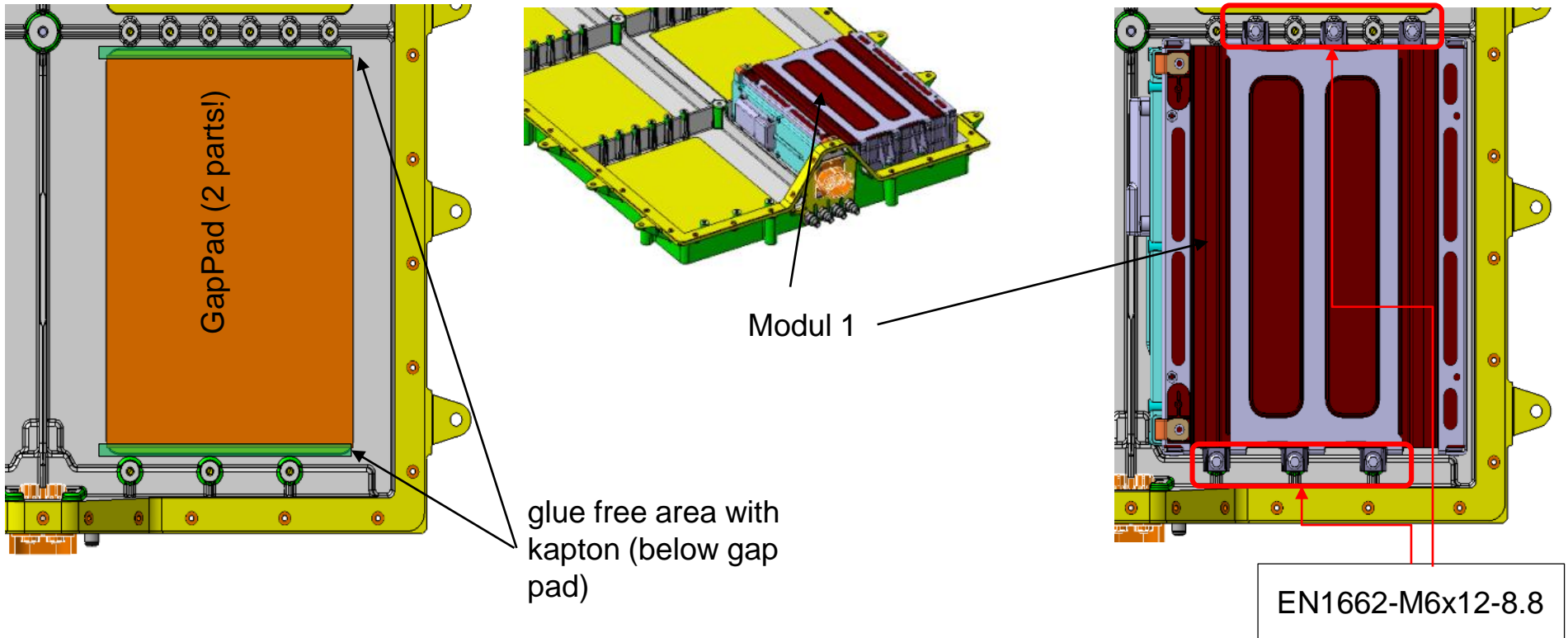
Hardware storage



Assembly and Build-up



EXAMPLE: ASSEMBLE MODULE ROW

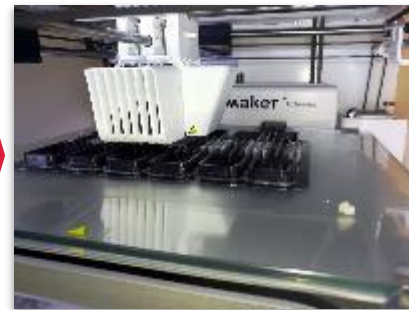
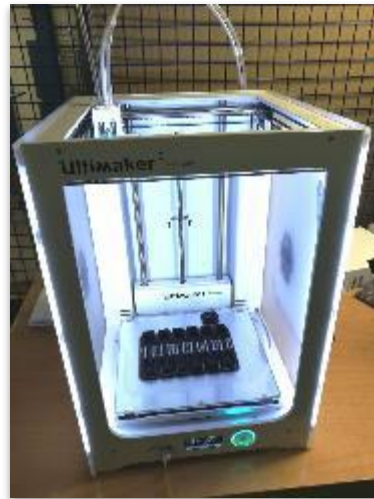
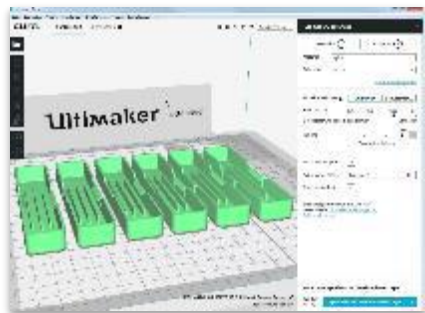


Tightening torque: max. 10 Nm + screw locking lacquer

ADVANCED PROTOTYPE METHODS

3D Printing – Support for small plastic prototype parts

- 3D in house printing for small plastic prototype parts, such as:
 - module cases
 - Brackets for prototype component and vehicle build
 - isolators for high voltage equipment



E/E Wiring Harness Development



FROM CONCEPT TO PROTOTYPE HARDWARE

Digital Wiring Harness Mock-Up

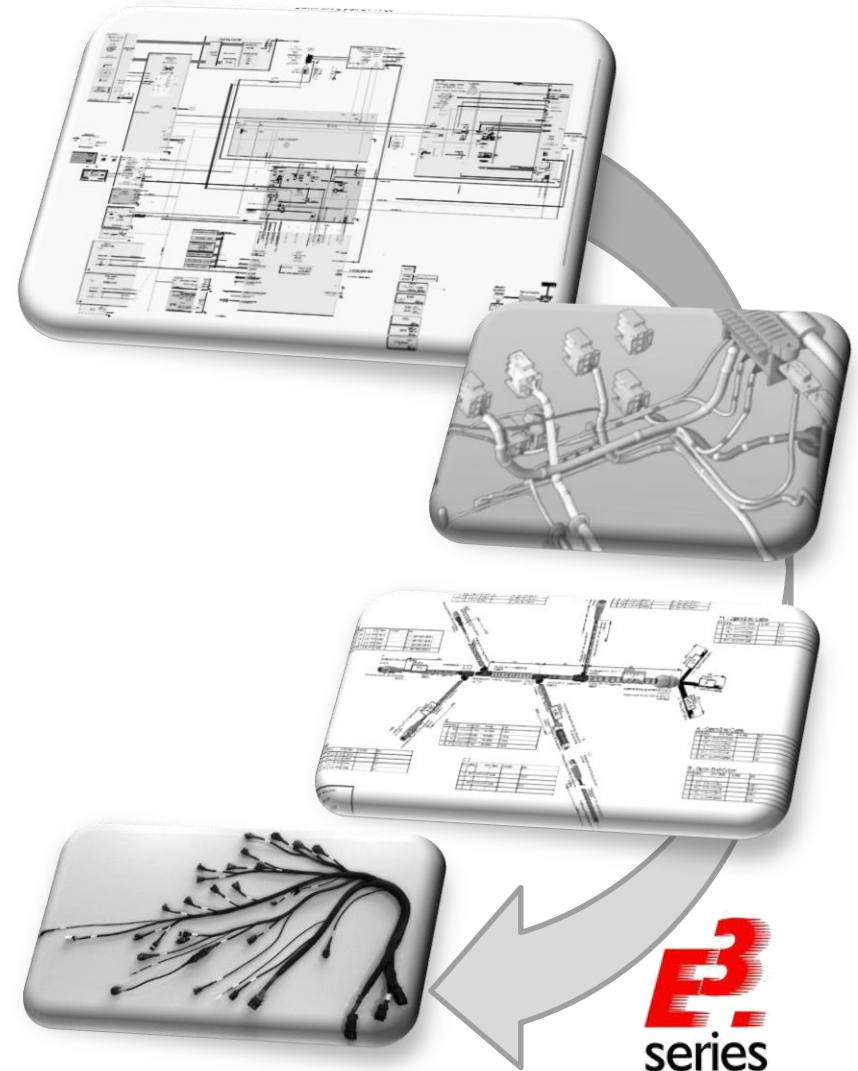
- Design of low and high voltage harness CAD - Modell
- Static and dynamic package investigation
- Harness length input for 2-D manufacturing boards

Physical Wiring Harness Mock-Up

- Assembly of Prototype Wiring Harness on Breadboard
- Testing at battery test bench (If needed)
- Battery Integration
- Testing of Wiring Harness in battery environment

Production Preparation

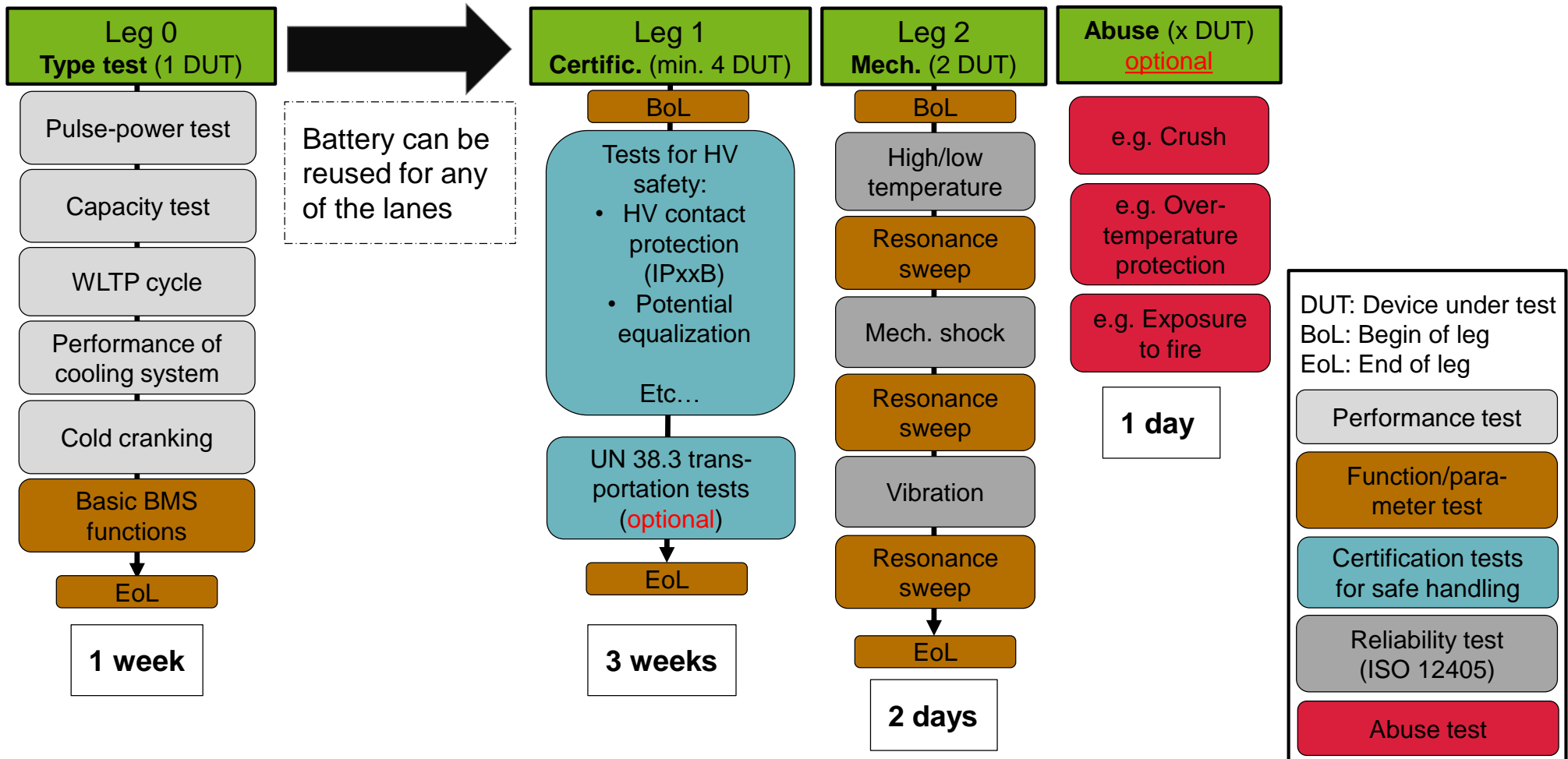
- Bill of Material
- Connections (Pin to Pin List)
- Cables (types, diameter, length, colors)
- Connectors



Prototype Battery Testing



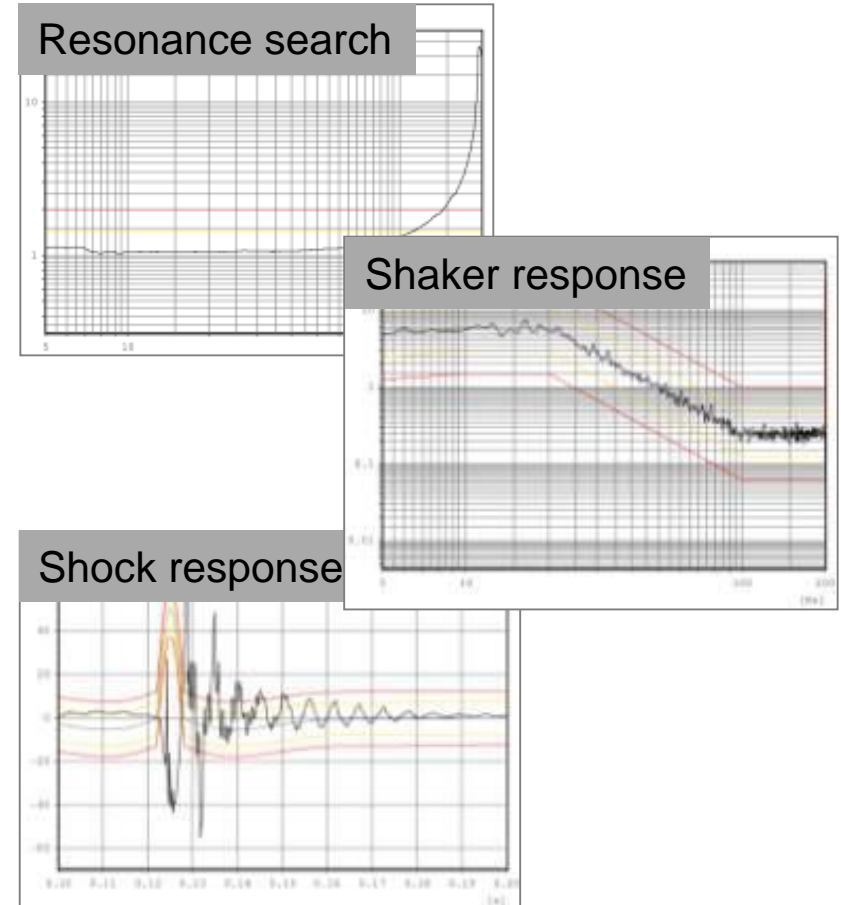
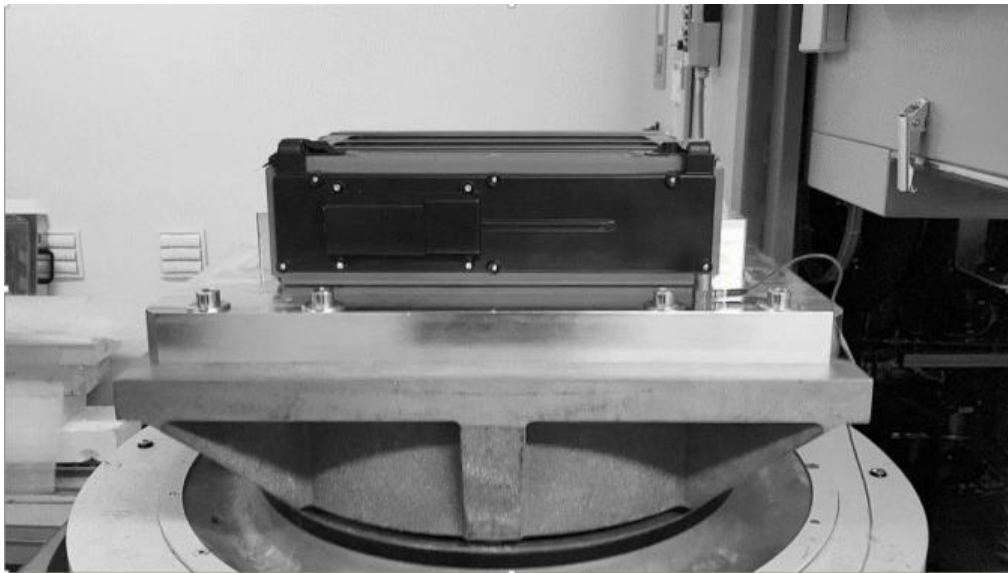
DV-TESTS TO ENSURE BASIC FUNCTIONALITY AND SAFE OPERATION



Prototype Battery Testing



EXAMPLE MECHANICAL TESTING ON MODULE LEVEL



Performance of Shock & Shaker tests in three dimensions, with and w/o climatic chamber

VARIOUS SOLUTIONS FOR PROTOTYPE STORAGE AND TRANSPORTATION



- Safety Data Sheet is needed
 - Identification of the substance
 - Hazards, Composition of Ingredients,
 - First aid, fire fighting information
 - Regulatory information
- Sea shipping: sealing and desiccant
- Prototypes only in transport boxes according to UN regulation.
- Country specific requirements on packaging and labels

Selected Battery Development Projects



UNDERFLOOR EV BATTERY DESIGN FOR TIER 1 SUPPLIER

Module design



Pack design



Scope of Work

- Cell selection on basis of FEVs Cell data-base
- Pack layout (design and E/E)
- Thermal and electrical simulation
- BMS hard- and software development
- Functional and HV safety
- Build-Up and Vehicle integration
- Verification & Validation on test bench and road

FEV has developed a HV prototype battery system for demonstration of TIER 1 battery production capabilities



MODULE FOR UNDERFLOOR EV BATTERY DESIGN FOR TIER 1 SUPPLIER



Module design

Specification

- 36 cells in 3p12s configuration
- Voltage: 44,4 V (nominal)
- Energy: 3,6 kWh
- Weight: ca. 18,5 kg
- Dimensions: 371,1 x 313 x 109 mm (L x B x H)

FEV involvement:

Development of prototype battery pack with BMS incl. design, simulation, build-up, testing

Rheinmetall Automotive involvement:
Design, Configuration

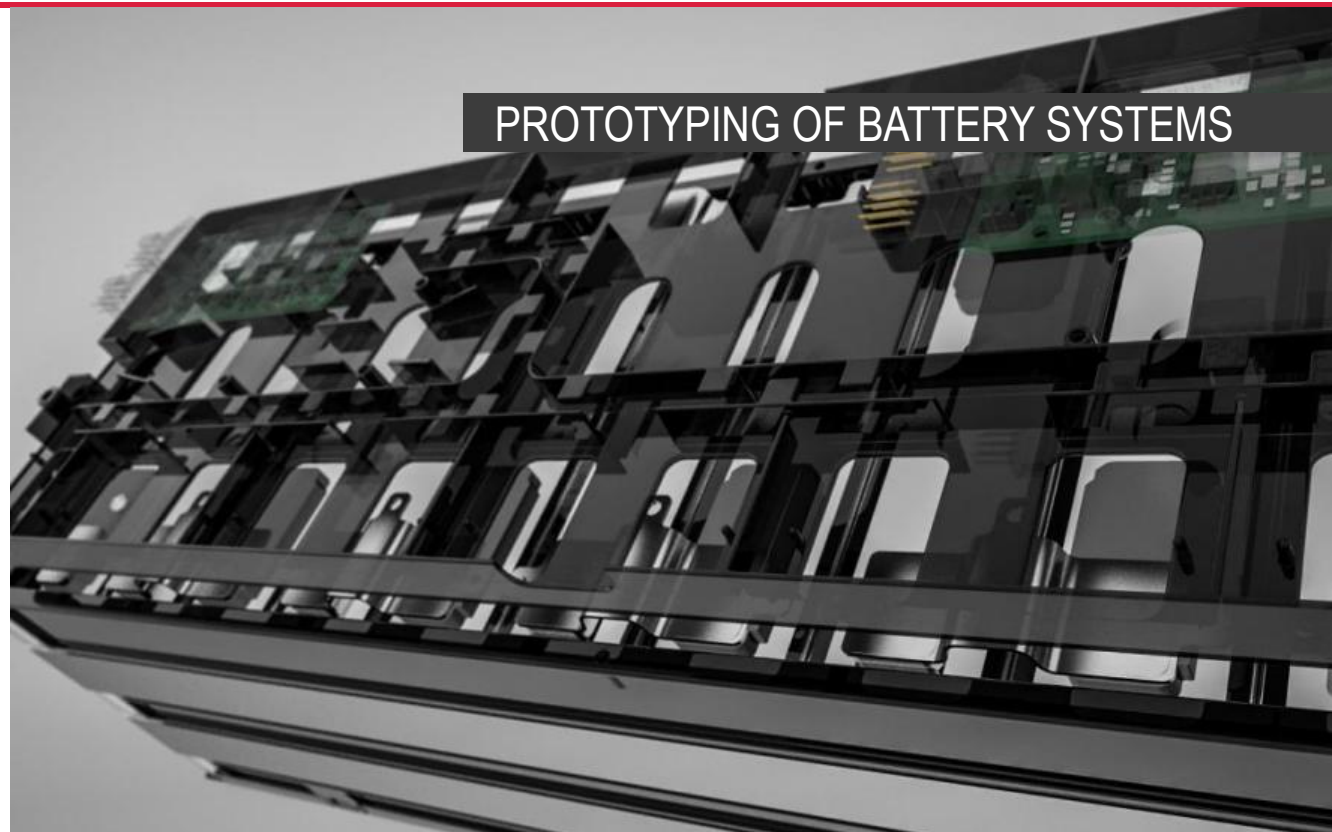
- Most important requirements of prototype battery systems are
 - Timing
 - Performance
 - Safety
 - Costs
- Availability of adequate battery cells is challenging and their procurement is time consuming
- A minimum of tests need to be performed due to safety reasons
- High quality is needed to fulfill customer needs

Presentation



Prepared for

Lasersymposium
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Aachen, 20.02.2019
Dr. Michael Stapelbroek, Department Manager Battery Systems

