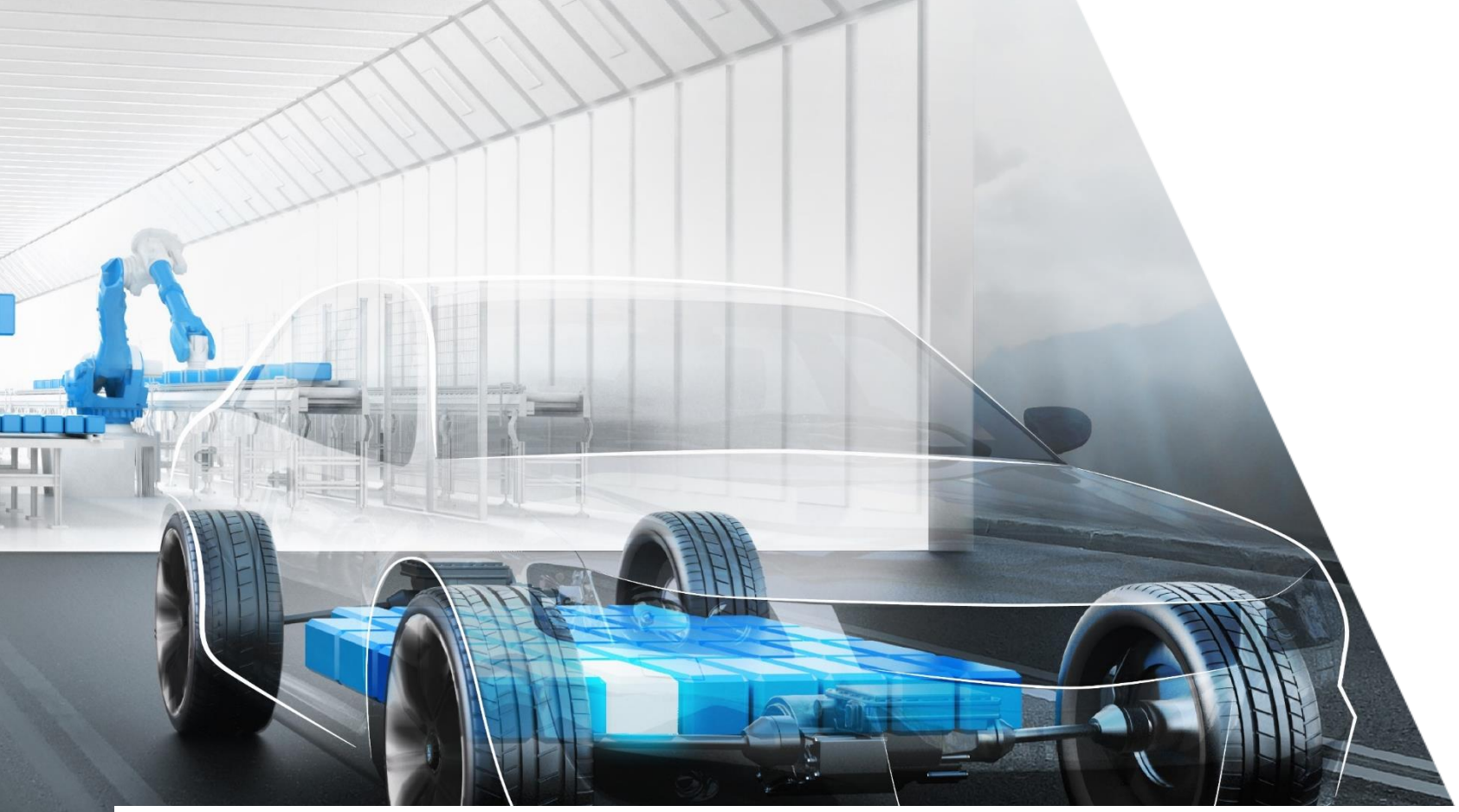
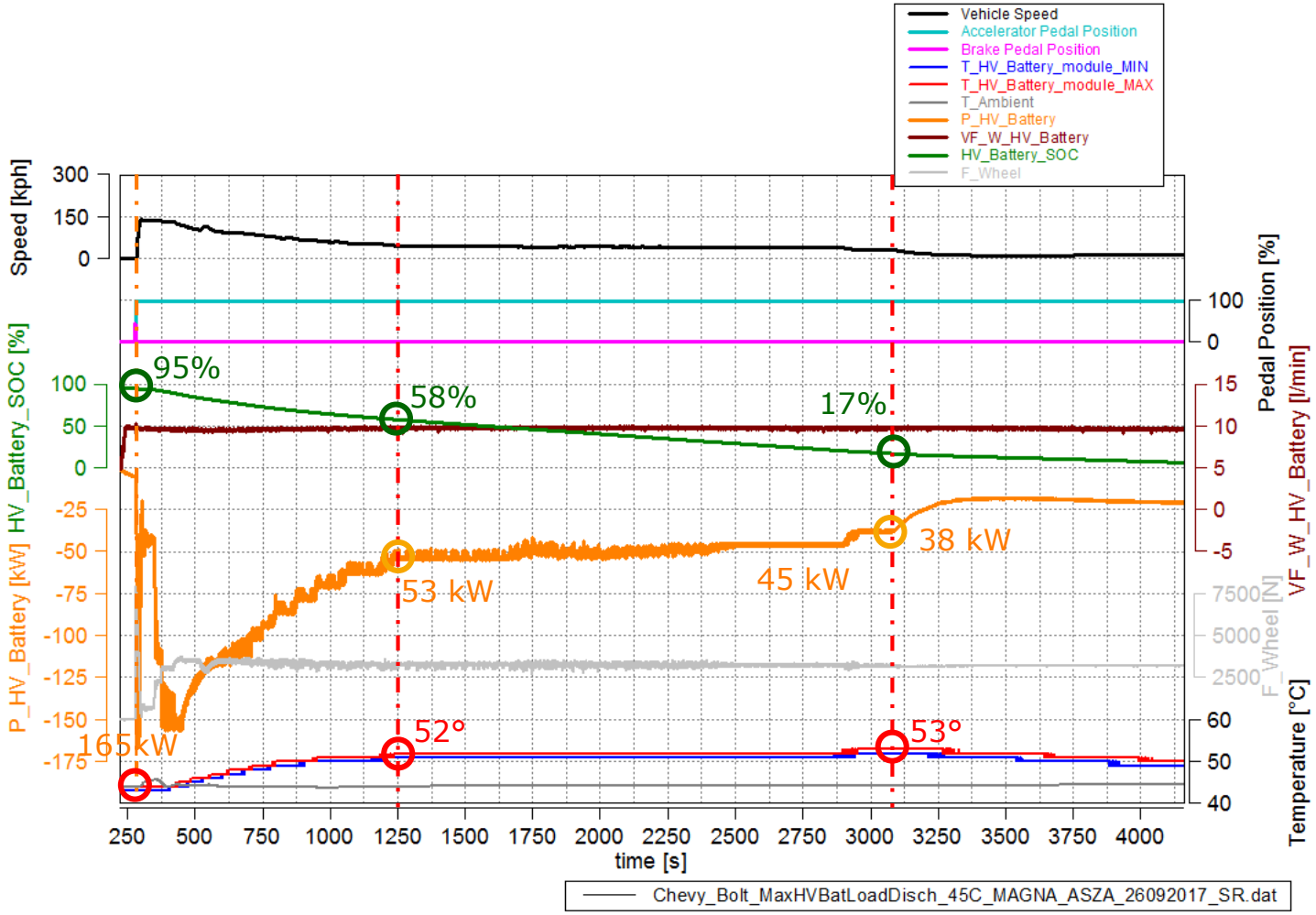


AVL SERIES BATTERY BENCHMARKING

From xEV to Battery Cell with AVL expert knowledge – Work package Examples

AVL List GmbH
(Headquarters)

EVALUATION OF PARAMETERS THROUGH HV-BATTERY TESTBENCH MEASUREMENTS



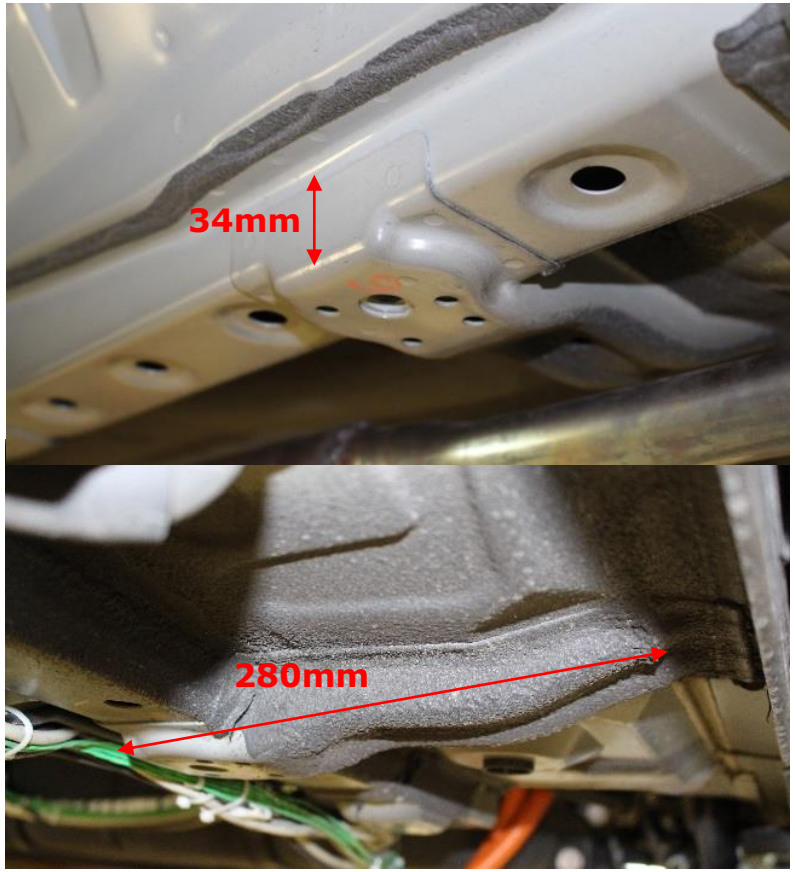
Chevrolet Bolt

→ Power Derating: 165 kW peak -> 52°C to 53 kW
→ 25 Minutes constant power of 50 kW
→ Volume Flow Rate battery coolant: 9.7 l/min

- High level of permanent power available
- Cooling power sufficient also in very high load situations
- Thermal spread between cells very well balanced

WP 1: Vehicle Benchmark	**WP 2: Powertrain Testing**	WP 3: Vehicle Environment	WP 4: Battery Interface	WP 5: Battery Testing	WP 6: Battery Teardown	WP 7: Module Testing	WP 8: Cell Testing	WP 9: Cost Analysis	WP 10: Abuse Testing

EVALUATION OF THE VEHICLE ENVIRONMENT WITH BATTERY INTEGRATION

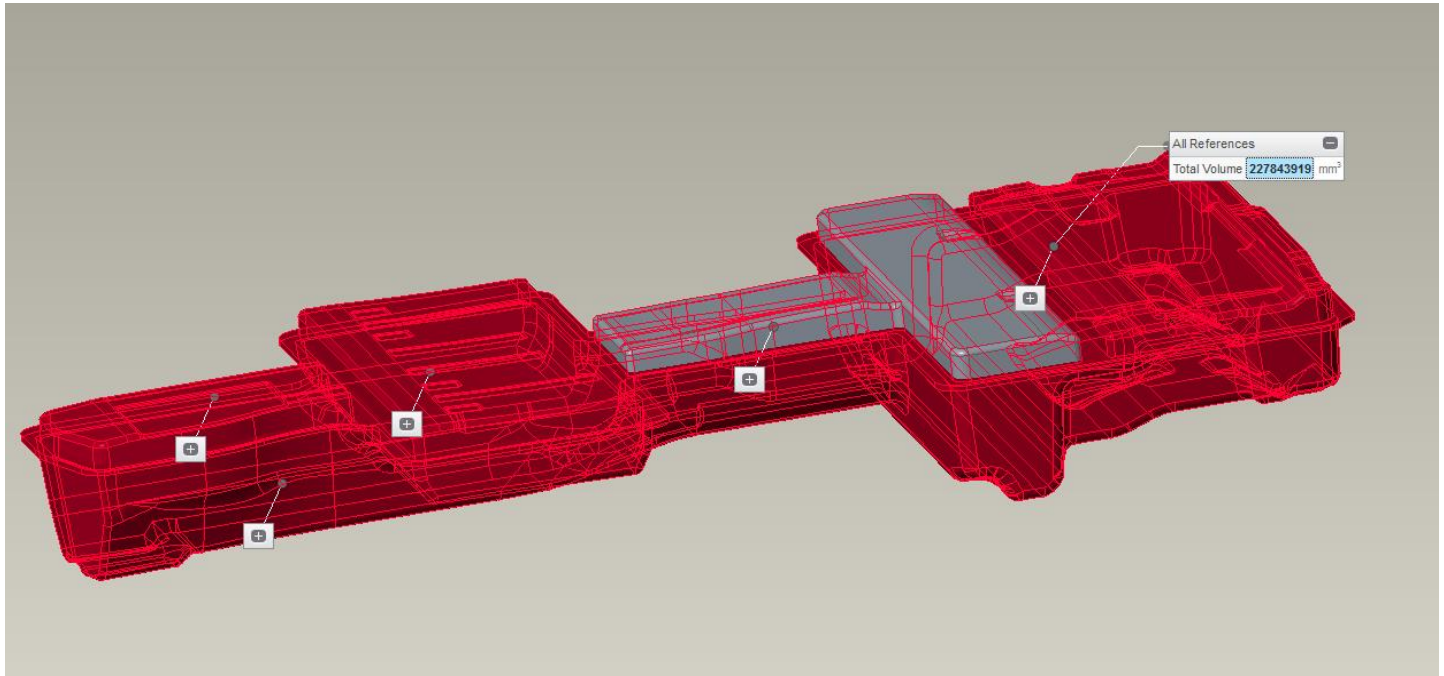


Parameter	Measured Distance / Weight
Distance side sill to module	407 mm
Side sill width	58 mm
Side reinforcement profile wall thickness	1.5 mm
Battery side reinforcement profile width	62 mm
Side reinforcement profile material	Steel
Battery Housing weight	42,5 kg

Mitsubishi Outlander

WP 1: Vehicle Benchmark	WP 2: Powertrain Testing	WP 3: Vehicle Environment	WP 4: Battery Interface	WP 5: Battery Testing	WP 6: Battery Teardown	WP 7: Module Testing	WP 8: Cell Testing	WP 9: Cost Analysis	WP 10: Abuse Testing

EVALUATION OF THE BATTERY INTERFACE PARAMETERS FROM 3D-SCAN



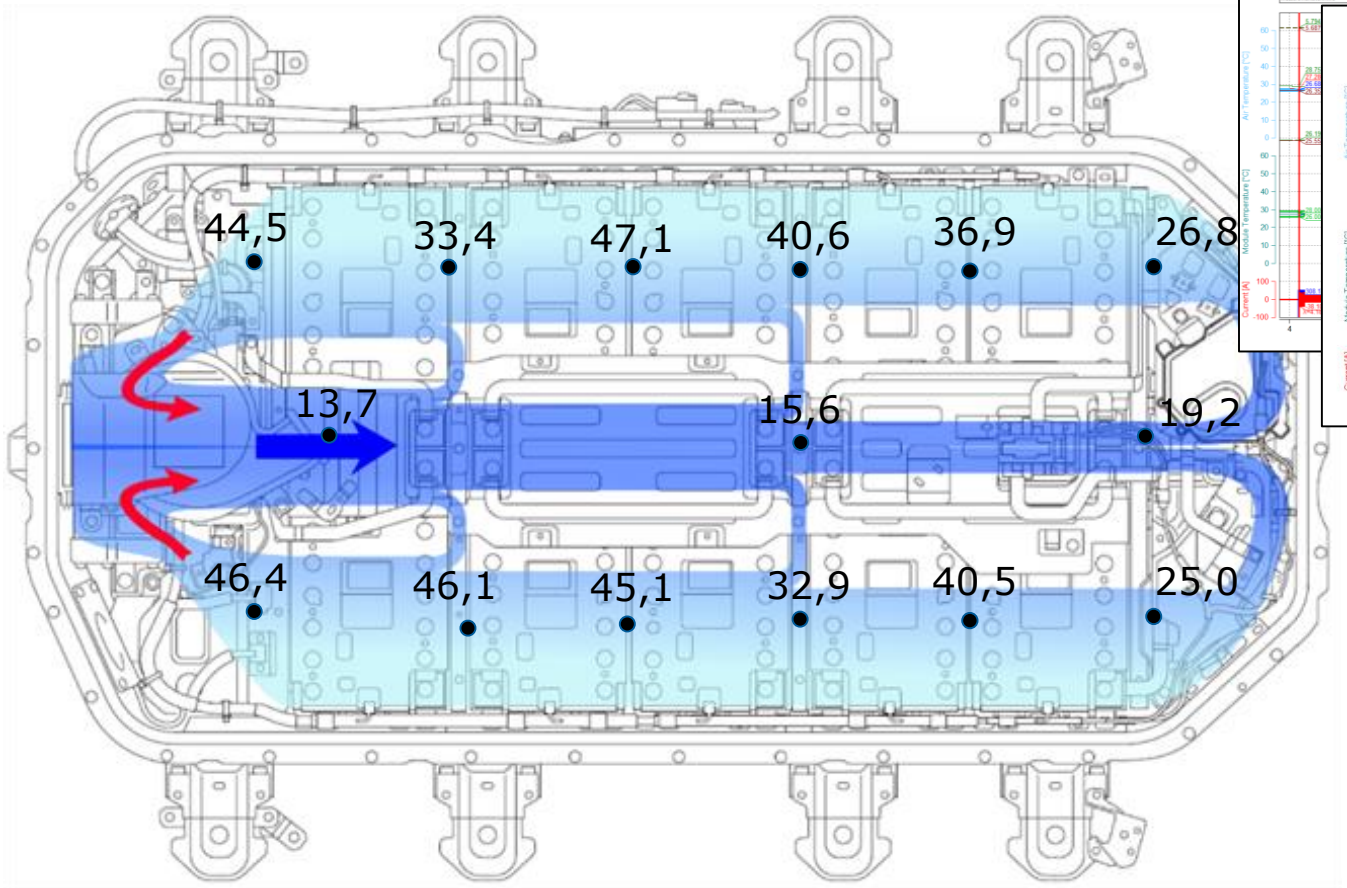
Parameter	Measured Distance / Weight
Volume [l]	**227,8**
Weight [kg]	**346,5**
Length [mm]	**2180**
Width [mm]	**1000**
Height [mm]	**280**

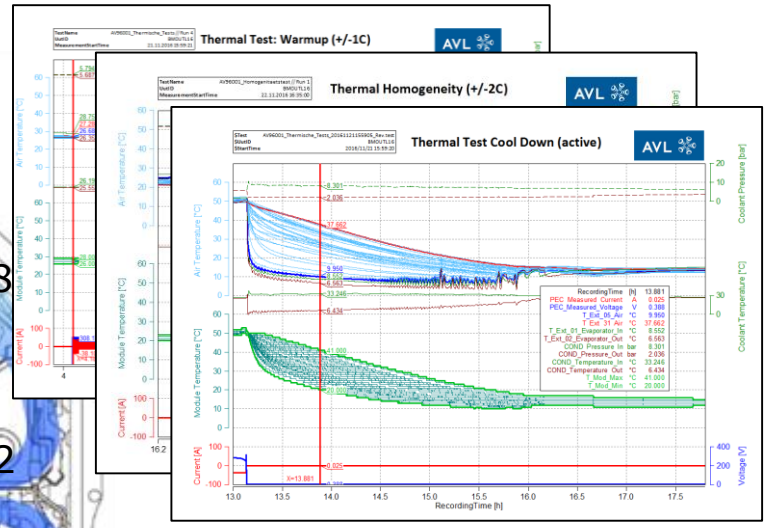
Volkswagen E-Golf

- No integration of cooling or contribution to vehicle stiffness
- Surprisingly efficient implementation in terms of volume and weight comparable to other packs that have above functions integrated

WP 1: Vehicle Benchmark	WP 2: Powertrain Testing	WP 3: Vehicle Environment	**WP 4: Battery Interface**	WP 5: Battery Testing	WP 6: Battery Teardown	WP 7: Module Testing	WP 8: Cell Testing	WP 9: Cost Analysis	WP 10: Abuse Testing

EVALUATION OF PARAMETERS THROUGH ACTIVE COOL-DOWN TEST MEASUREMENTS





Mitsubishi Outlander

- Maximum cell temperature spread in battery pack during cool down 22°C
- Cooling air differences within the inlet channel: 13,7°C to 19,2°C
- Cooling air temperature range at module inlet: 25°C to 47,1°C

WP 1: Vehicle Benchmark	WP 2: Powertrain Testing	WP 3: Vehicle Environment	WP 4: Battery Interface	**WP 5: Battery Testing**	WP 6: Battery Teardown	WP 7: Module Testing	WP 8: Cell Testing	WP 9: Cost Analysis	WP 10: Abuse Testing

EVALUATION OF CELL SAFETY WITH STATE OF THE ART ABUSE TESTS

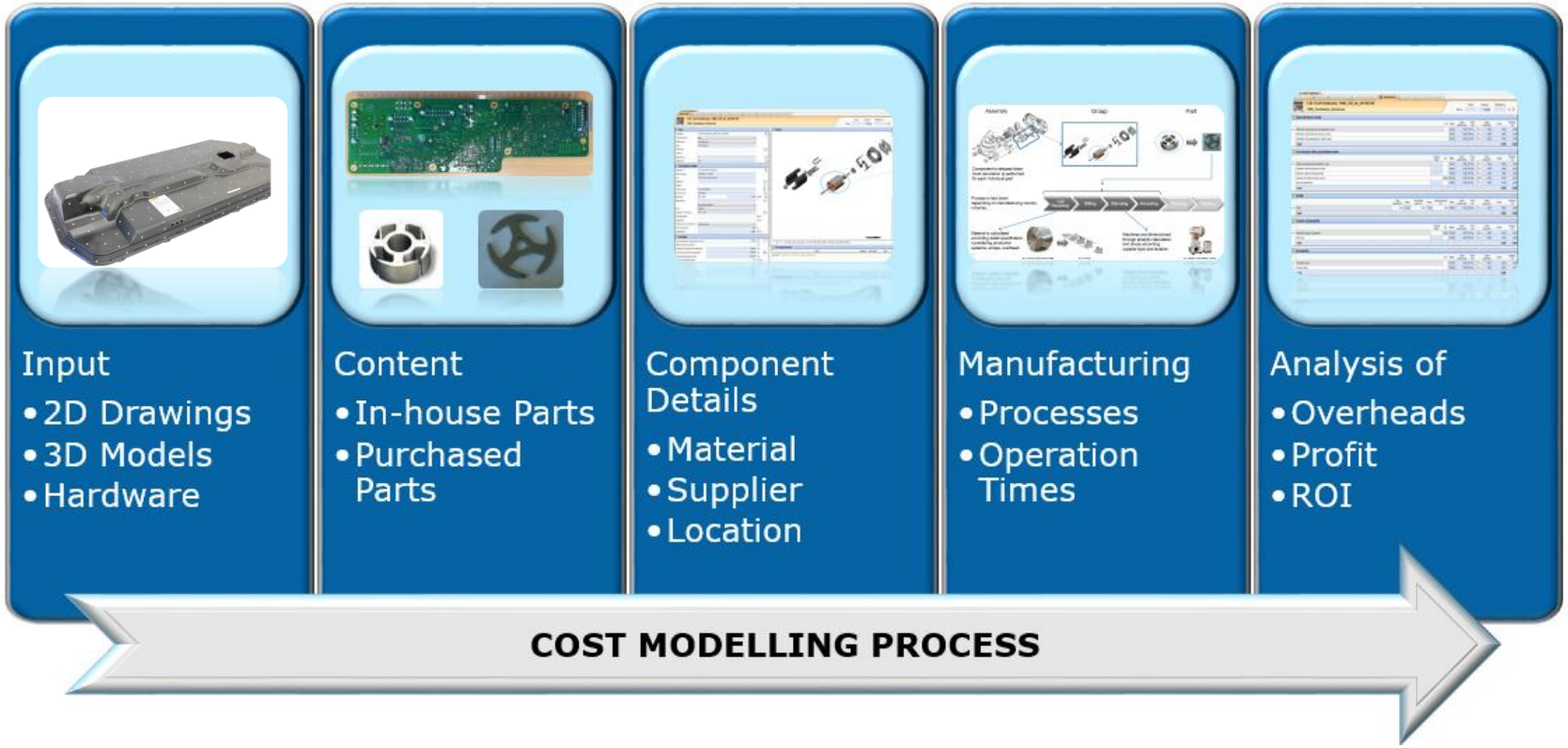
Tesla Model X

Nail Penetration according to **GB/T 31485-2015**

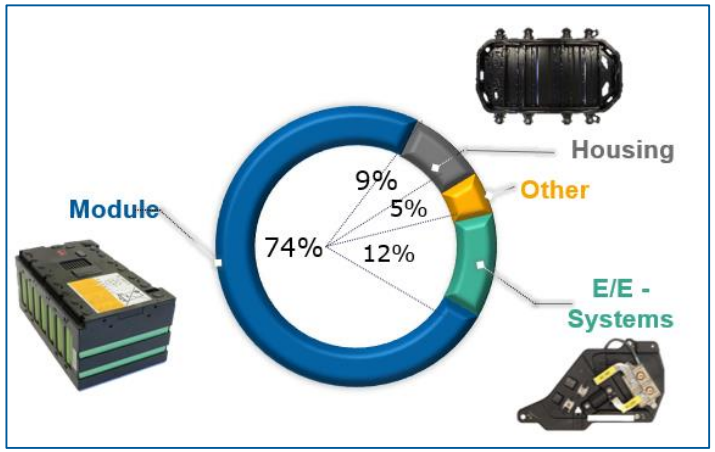
Thermal Stability according to **SAE J2462**

WP 1: Vehicle Benchmark	**WP 2:** Powertrain Testing	**WP 3:** Vehicle Environment	**WP 4:** Battery Interface	**WP 5:** Battery Testing	**WP 6:** Battery Teardown	**WP 7:** Module Testing	**WP 8:** Cell Testing	**WP 9:** Cost Analysis	**WP 10:** Abuse Testing

AVL COST ANALYSIS AND COST MODELLING PROCESS



Mitsubishi Outlander

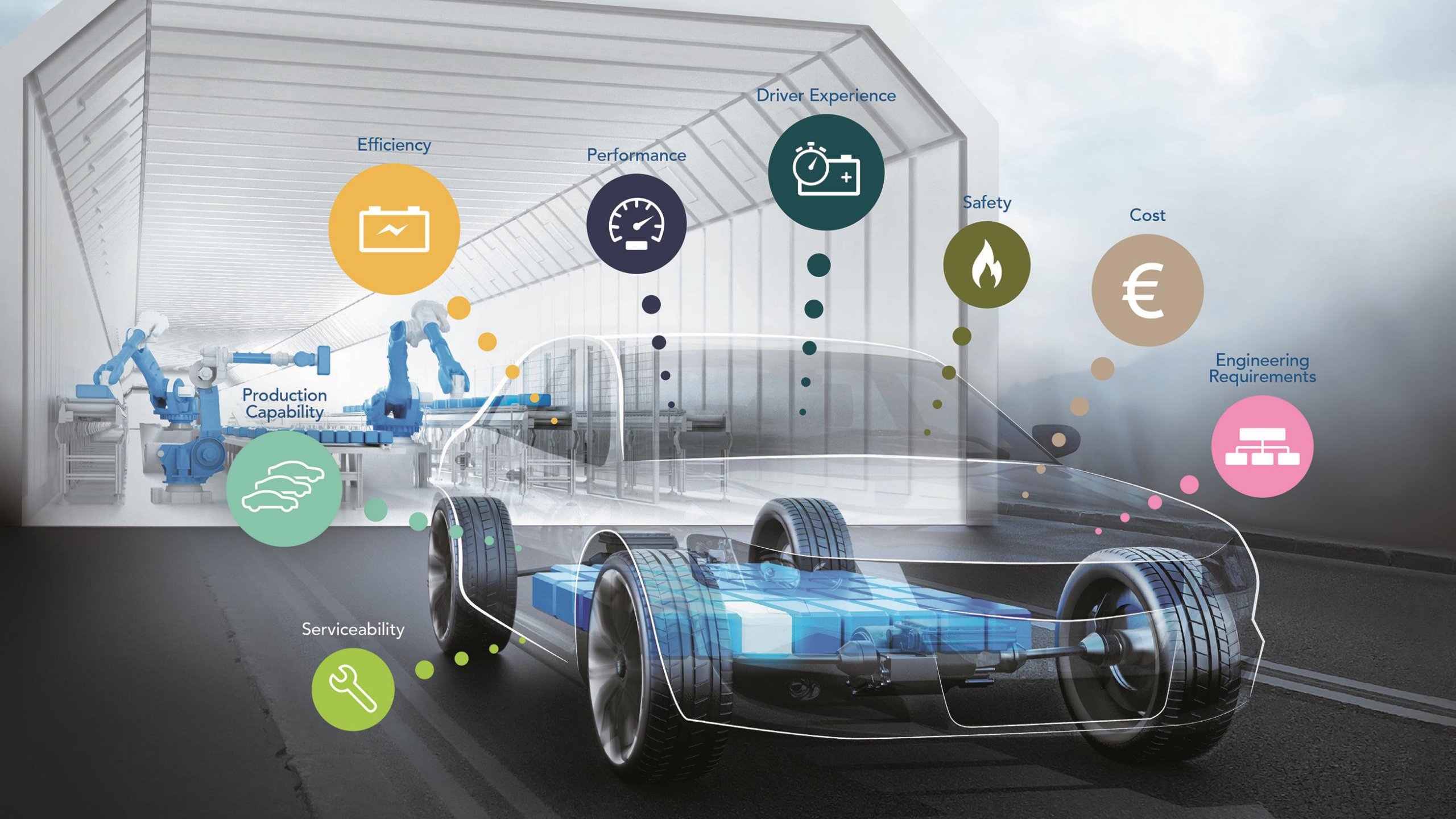


AVL Cost Modelling* allows the comparison of Technology, Design, Supplier and Location.

Enabling cost scenarios to be quickly developed.

*Cost calculation tool is Teamcenter product costing from Siemens

WP 1: Vehicle Benchmark	**WP 2:** Powertrain Testing	**WP 3:** Vehicle Environment	**WP 4:** Battery Interface	**WP 5:** Battery Testing	**WP 6:** Battery Teardown	**WP 7:** Module Testing	**WP 8:** Cell Testing	**WP 9:** Cost Analysis	**WP 10:** Abuse Testing


Efficiency
Performance
Driver Experience
Safety
Cost
Engineering Requirements
Production Capability
Serviceability