Battery Lifecycle Management
with the Concept of Digital Twins

Michael Baumann – Batteriestammtisch – 14.06.2018

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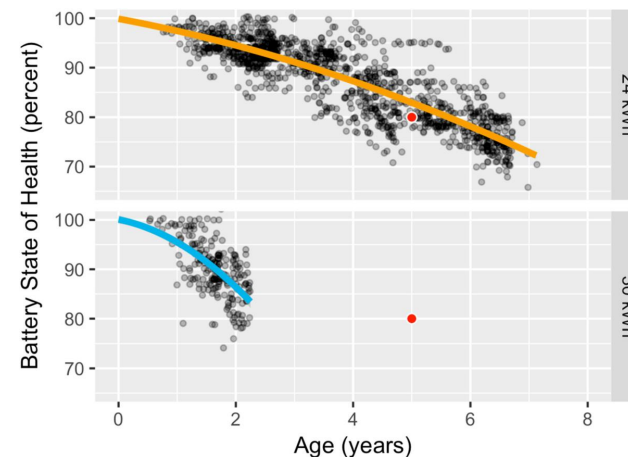80807 München

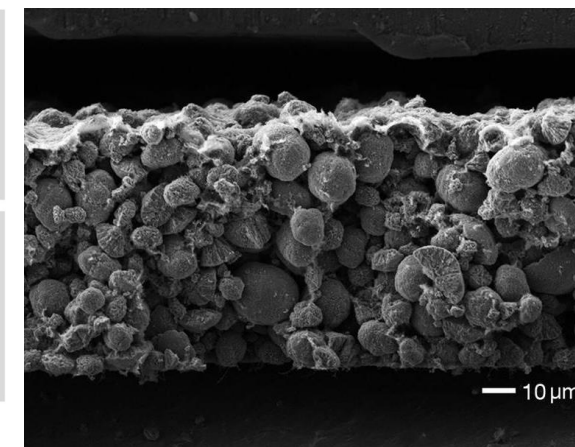# Problems with Lithium-Ion Batteries

Long battery development process

High testing effort
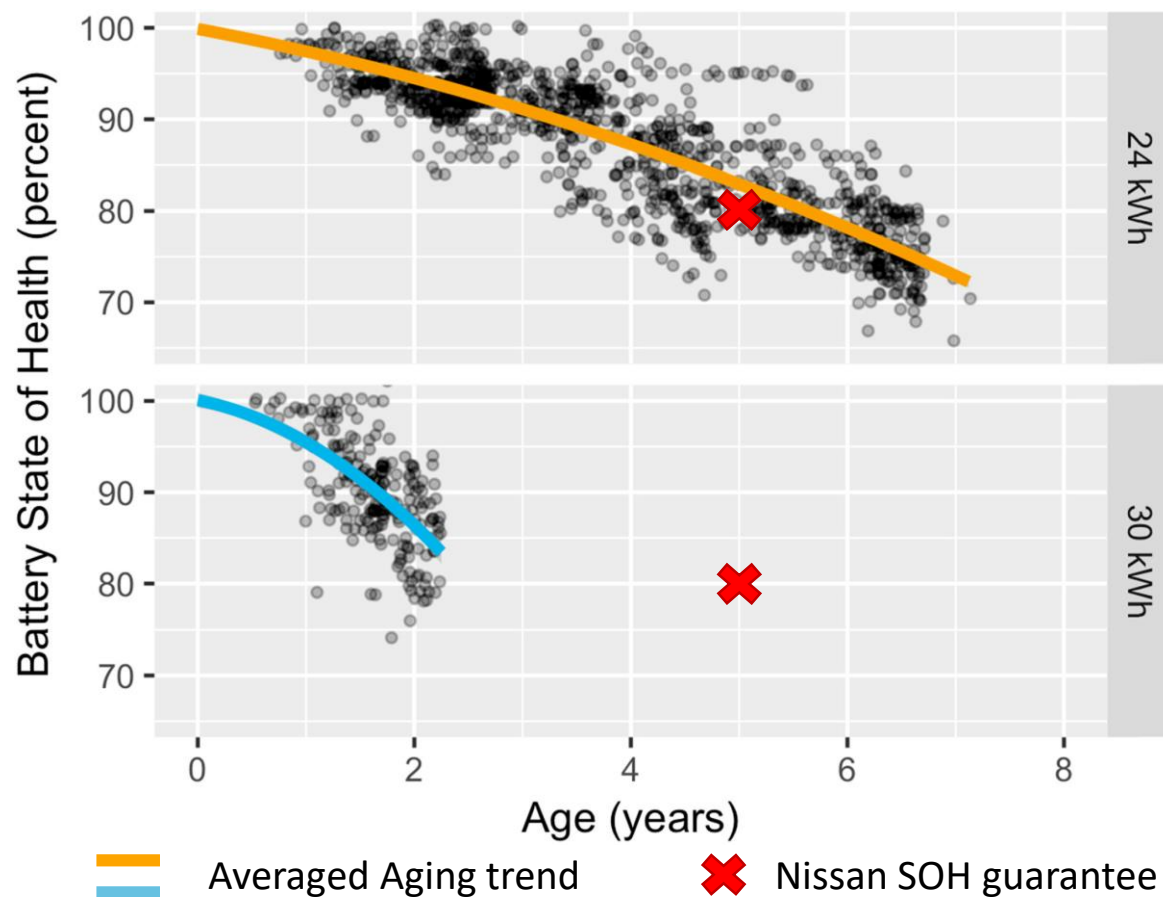

Unknown and short lifetime

Safety and reliability issues like lithium-plating

Picture: Nissan, Myall, TU Munich

Big players also make mistakes: Nissan Leaf aging behavior

Myall 2018 - Accelerated reported battery capacity loss in 30 kWh variants of the Nissan Leaf

Picture: Myall

„There was large variability between cars, but both battery models showed increasing decline with age.“

„The 30 kWh Leafs sourced from United Kingdom showed slower initial decline than those from Japan, …“

„If the high rate of decline in battery capacity that we observed in the first 2.3 years of a 30 kWh Leaf's lifetime were to continue, the financial and environmental benefits of this model may be significantly eroded.“

What might be a solution?

„Tesla often knows the problem before the driver does"*, because
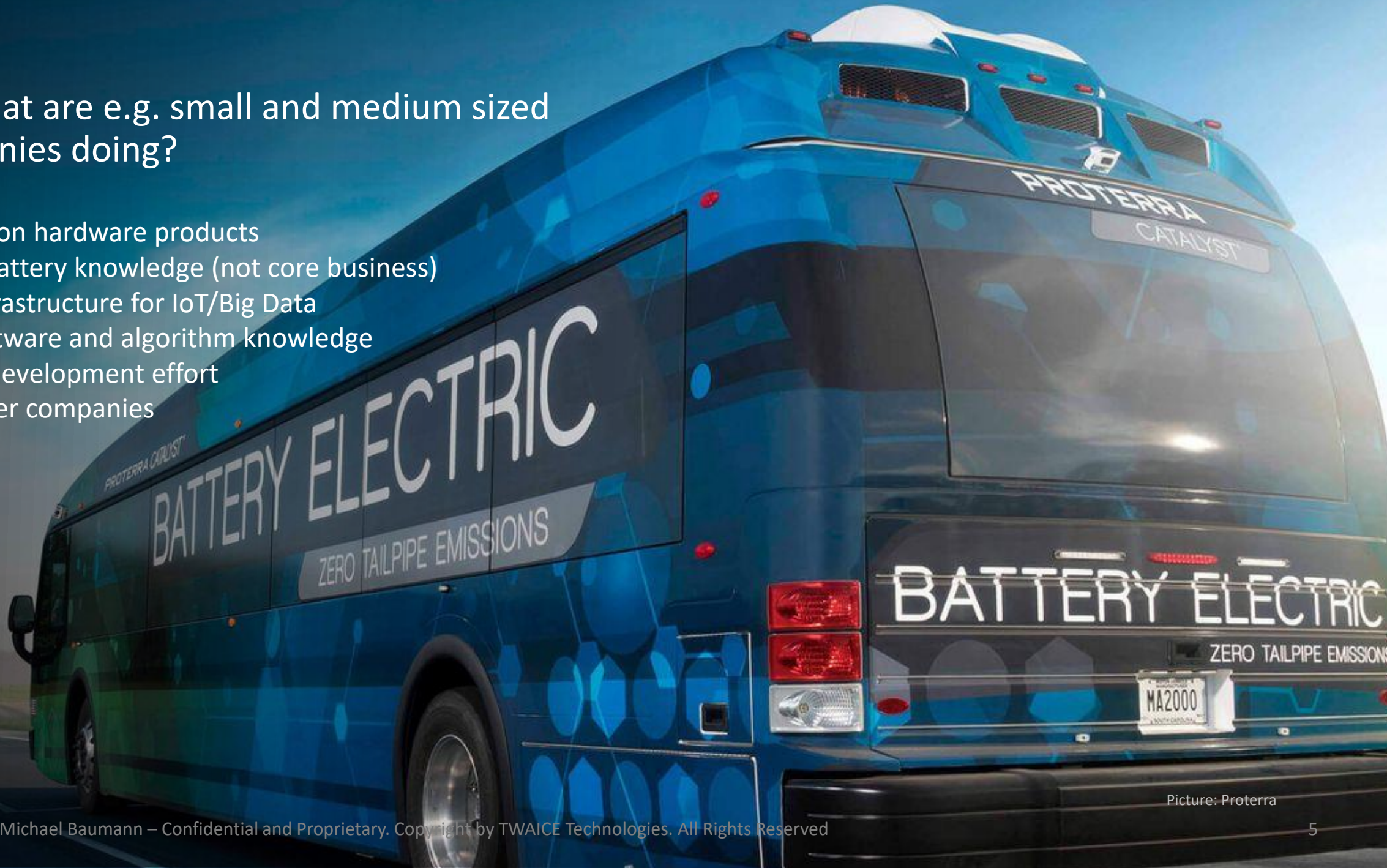Tesla uses onboard data and cloud analytics.
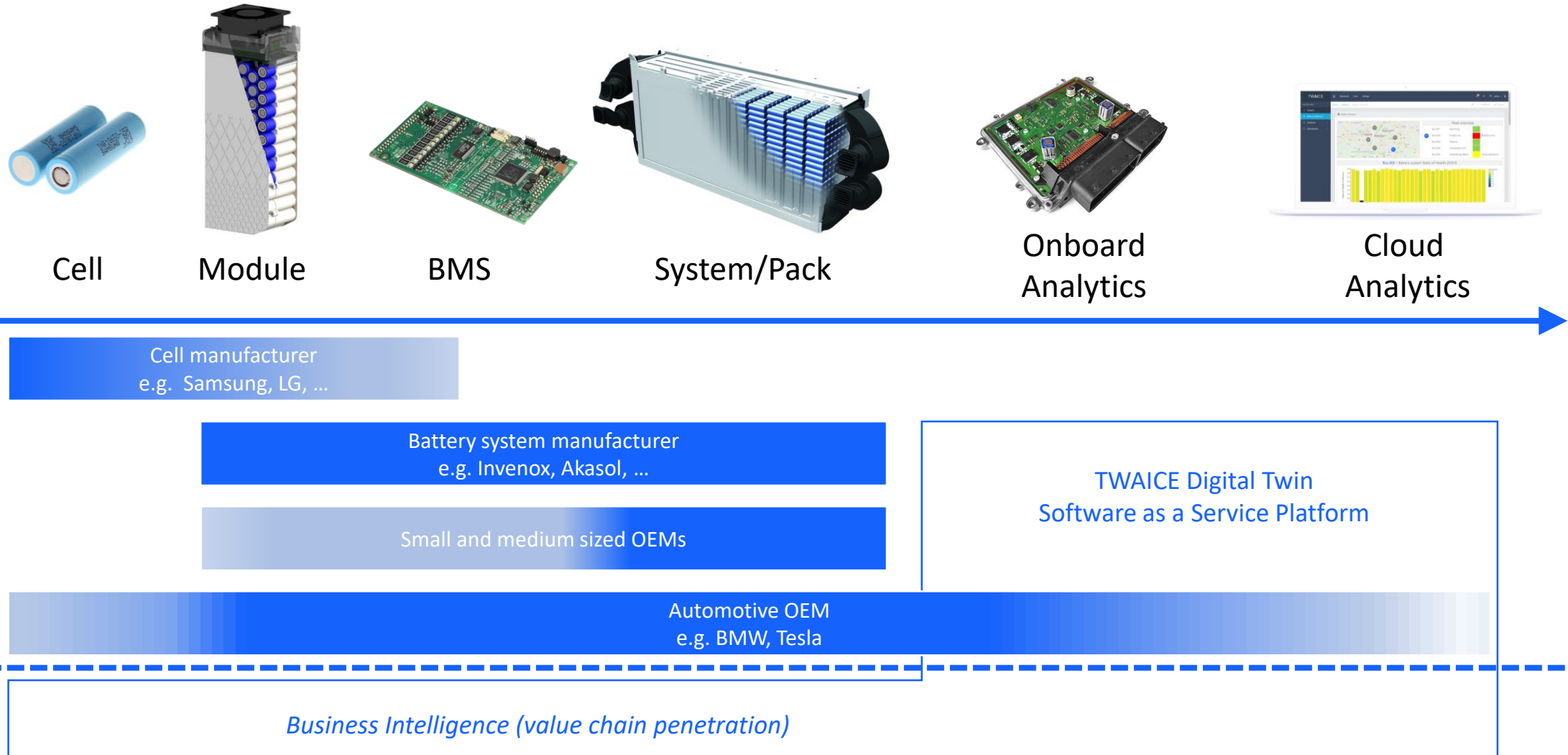
*thetaylorinstitute.org

Picture: Tesla

But what are e.g. small and medium sized companies doing?

Focused on hardware products
Lack of battery knowledge (not core business)
No IT infrastructure for IoT/Big Data
Little software and algorithm knowledge
→Huge development effort
for smaller companies

Picture: Proterra

Solution: TWAICE as the first *independent* battery analytic software provider

Cell — Module — BMS — System/Pack — Onboard Analytics — Cloud Analytics

Cell manufacturer
e.g. Samsung, LG, …

Battery system manufacturer
e.g. Invenox, Akasol, …

Small and medium sized OEMs

Automotive OEM
e.g. BMW, Tesla

TWAICE Digital Twin
Software as a Service Platform

Business Intelligence (value chain penetration)

# Solution: TWAICE Digital Twins (in the field) consist of …

Smart Control Unit (Onboard Analytics)

− Load data analysis (big data → smart data)
− Battery parameter update
− Secure transmission to central server
  e.g. TWAICE cloud
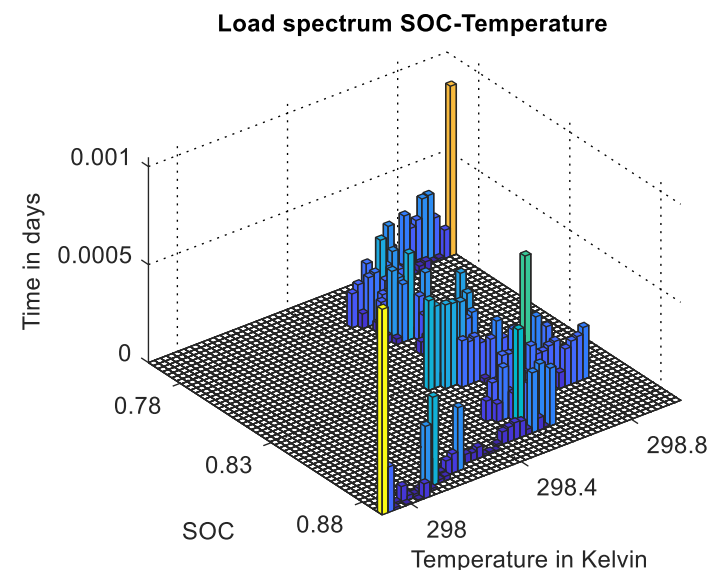
TWAICE Analytics (Cloud Analytics)

− Lifetime prediction and optimization
− Costumer specific dashboard (browser)
− Data base and machine learning unit
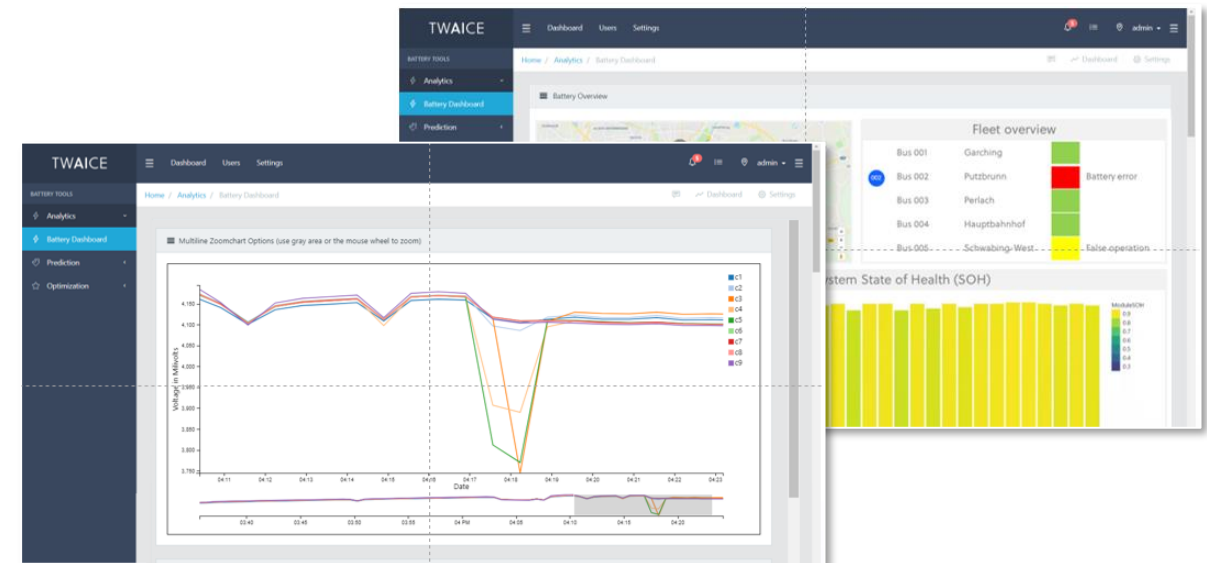
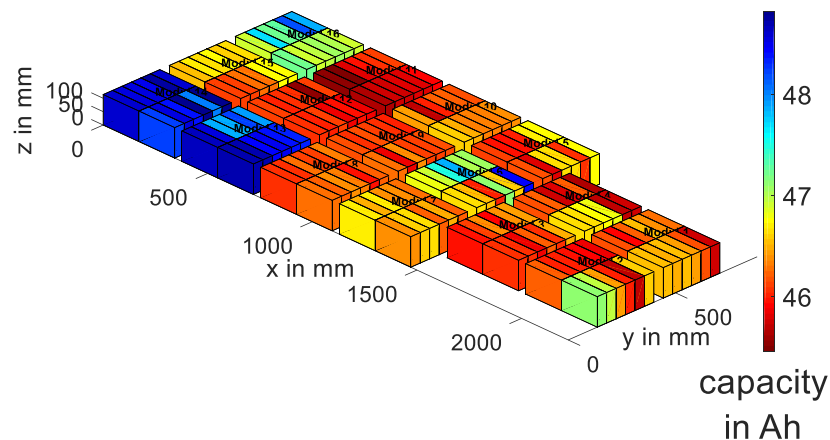# TWAICE's approach for digital battery twins in the field

**Load Data
Analysis**

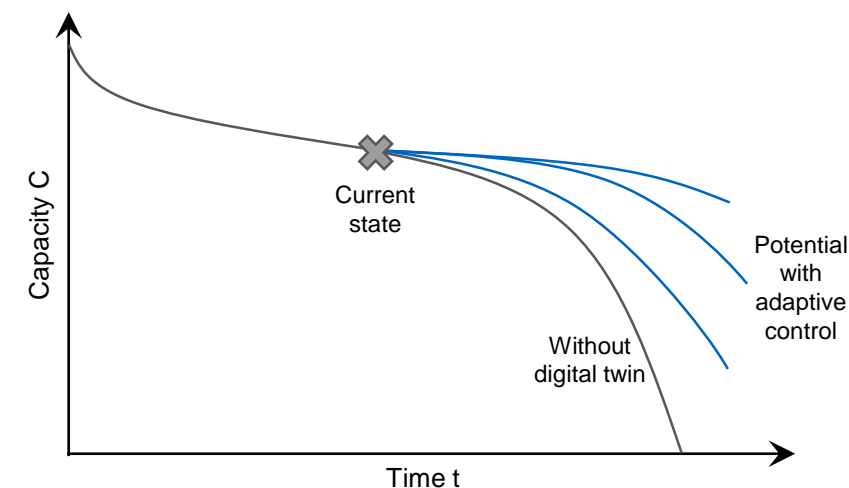Collection and aggregation of battery data (Big data → Smart data)

**Battery Parameter
Determination**

Continuous update of battery parameters along aging

**Lifetime Prediction &
Optimization**

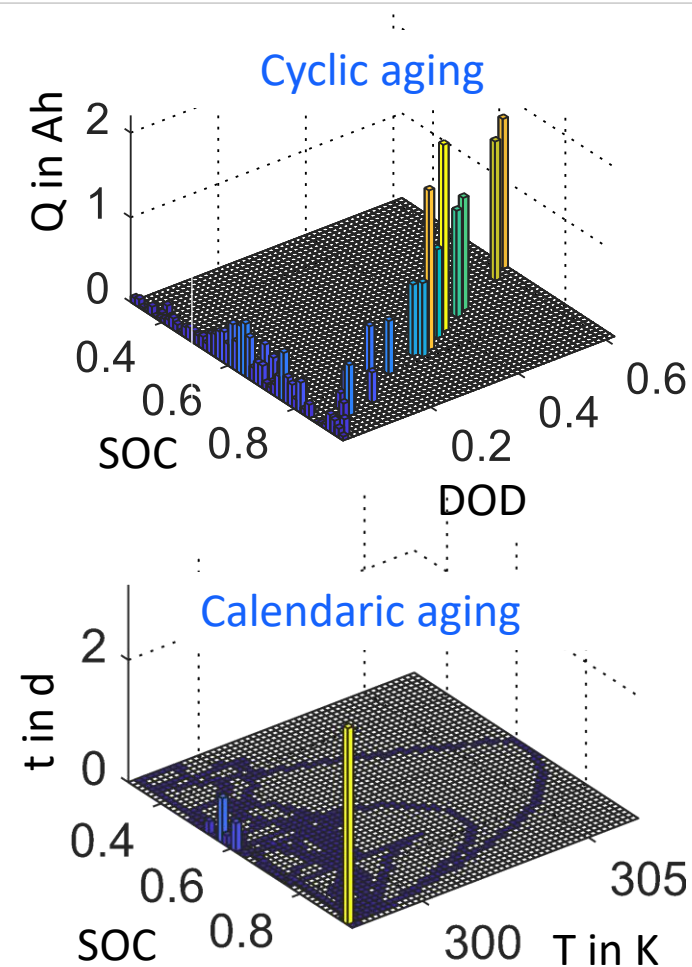Model-based aging prediction & optimization via adaptive control

Load spectrum SOC-Temperature

capacity in Ah

Load data analysis

Measurement data
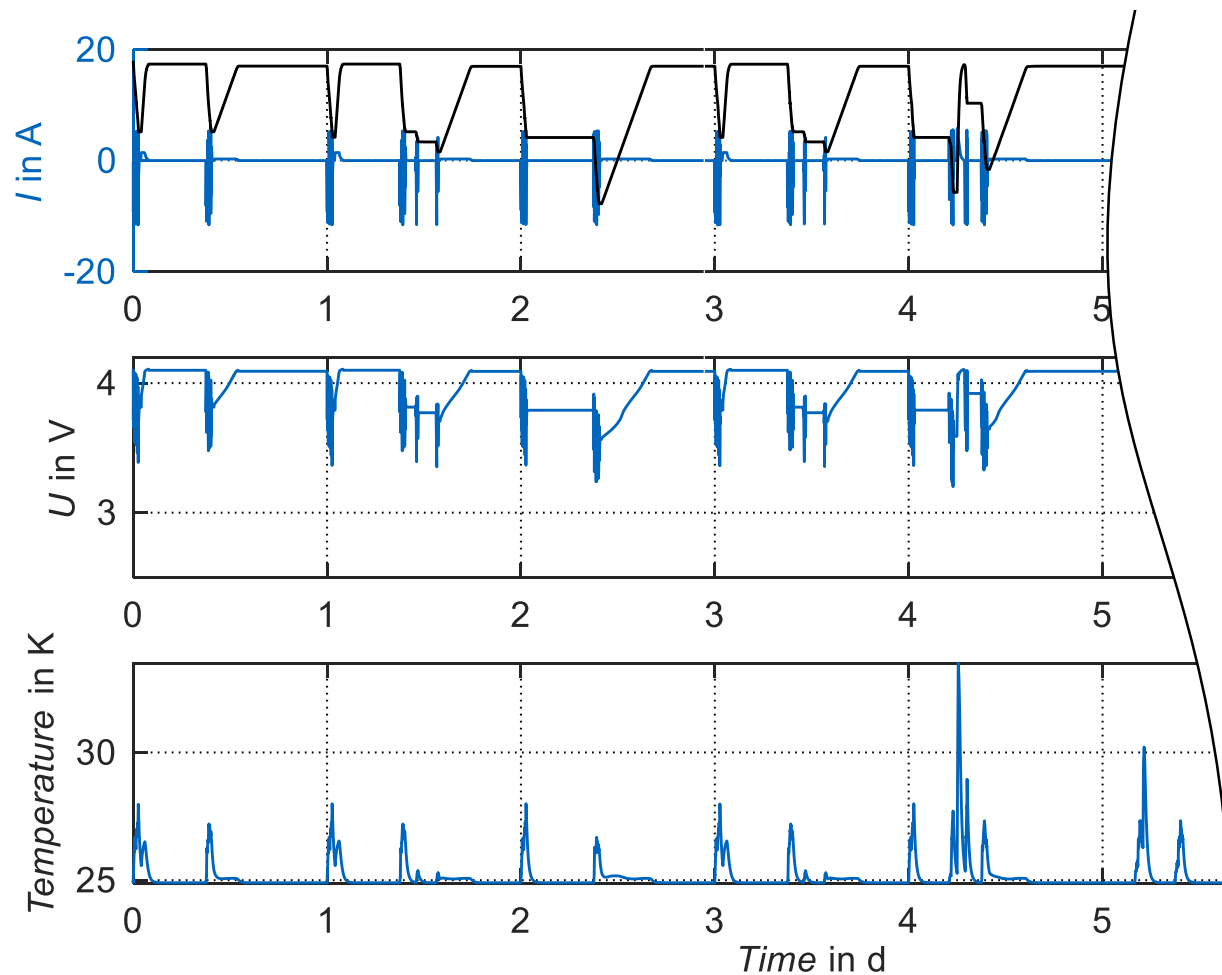
Load spectrum

Battery parameter determination

BMW i3 Battery Pack
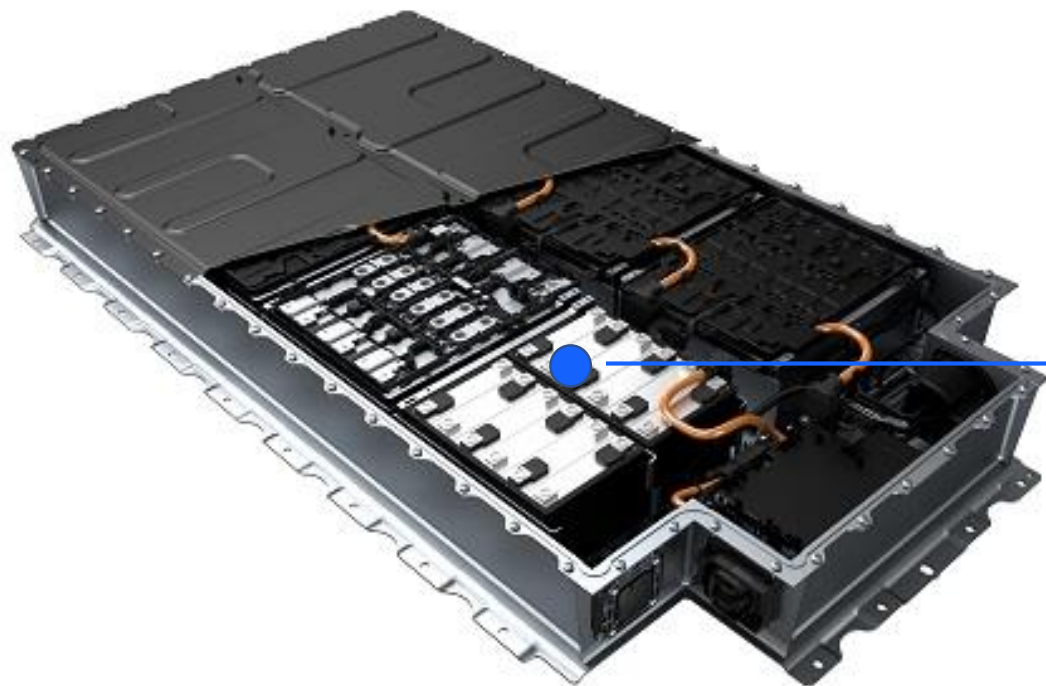
Capacity + Impedance Determination
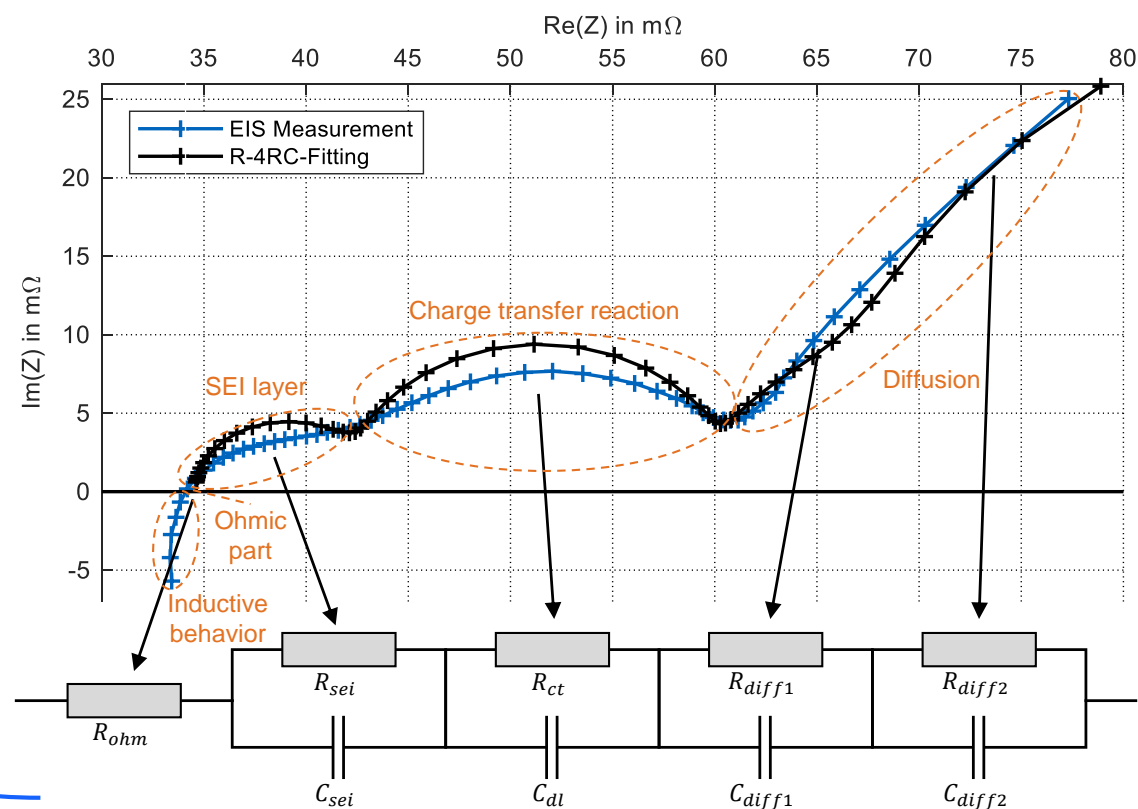
Lifetime prediction & optimization

Load input	Model-based prediction	Prediction & adaptive BMS

Load input
P(t)/I(t), T
for different
scenarios

| Electric-thermal |
| **+** |
| Aging (Empirical) |
| **+** |
| Aging (Machine Learning) |

Aging for different scenarios

Capacity C

Current state

Time t
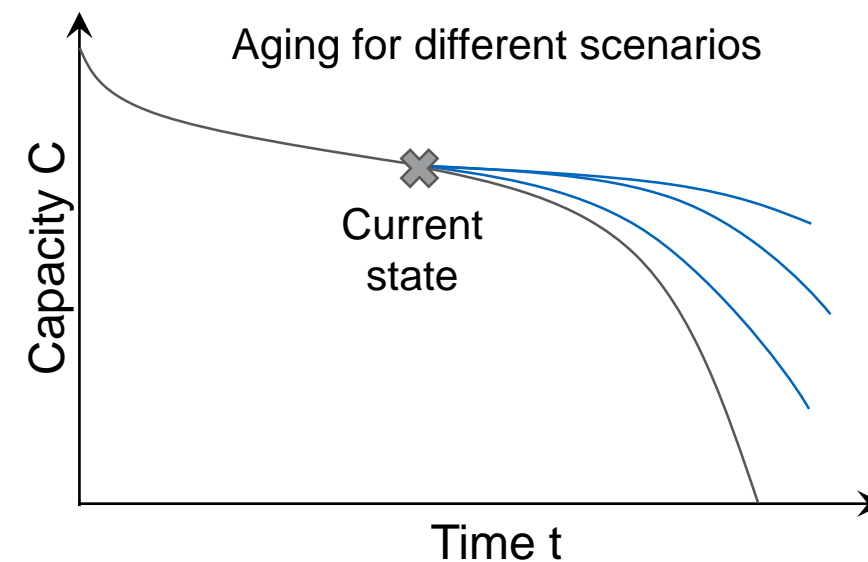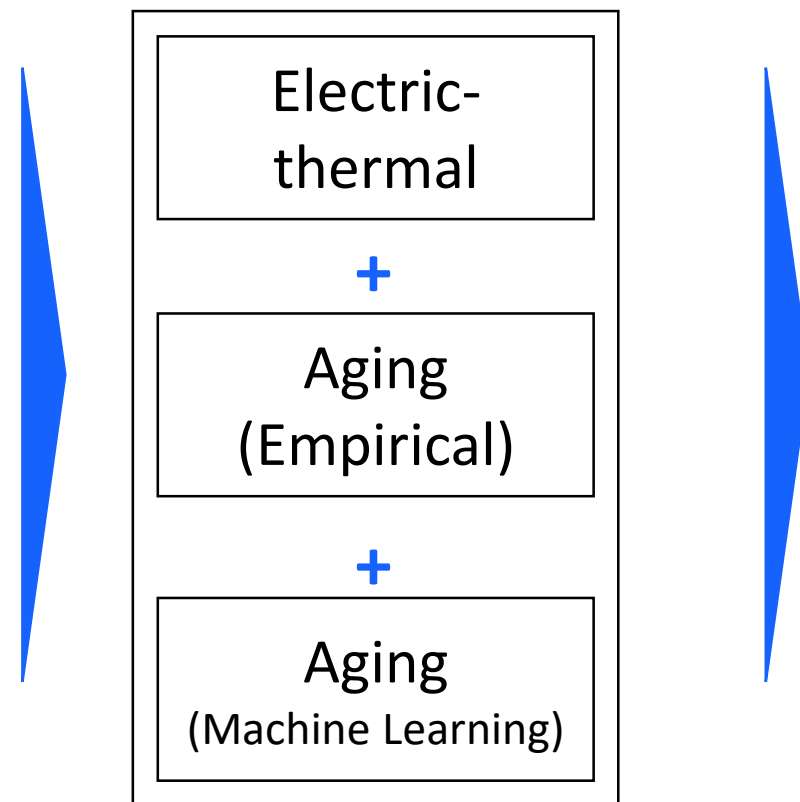
Example: SoH-determination
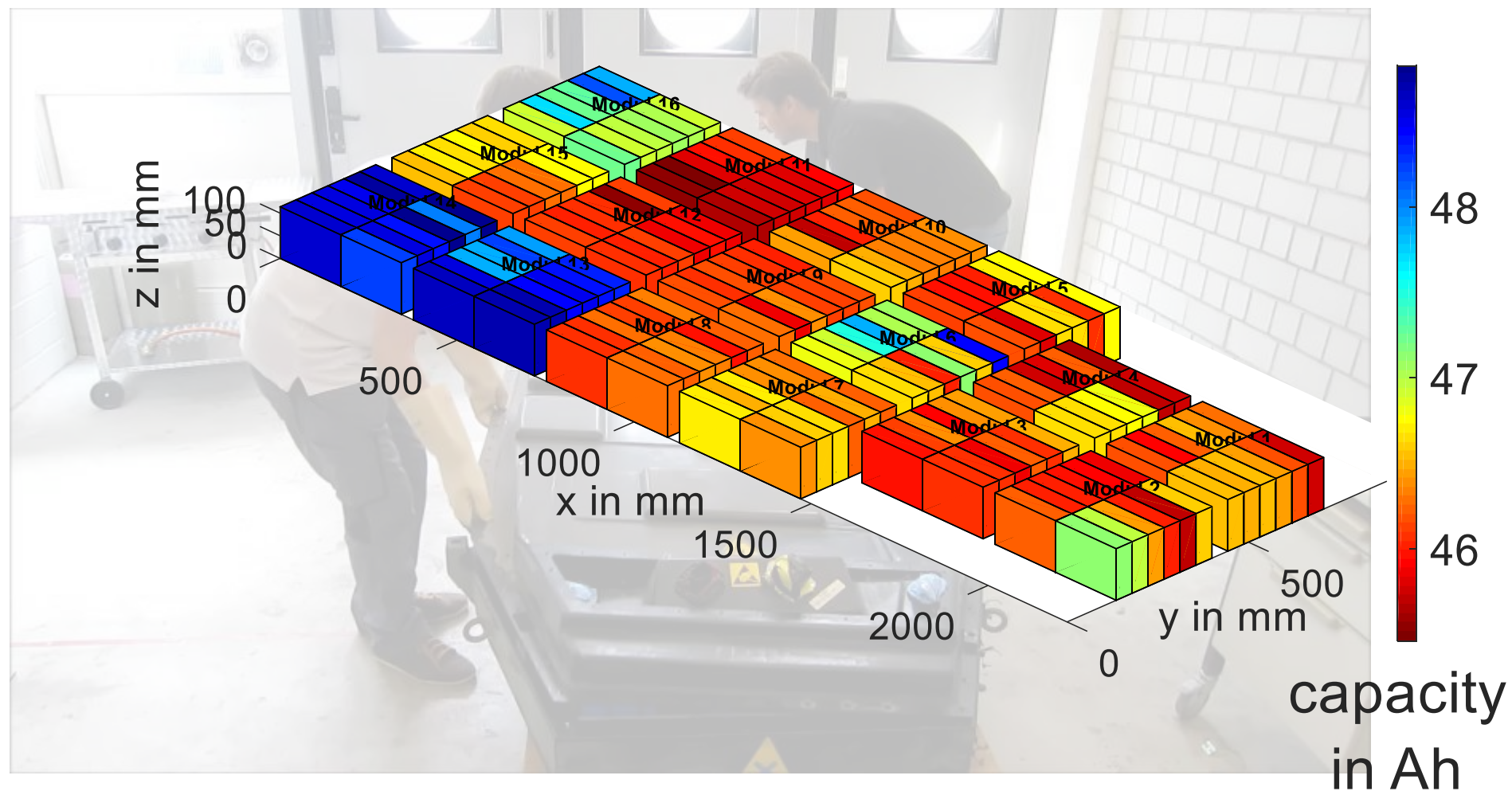
Customer segments

Battery Manufacturer

OEMs

Fleet Operators

Digital Twin platform enables benefits along the whole battery lifecycle

Development → **Production** → **Operation** → **Second-Life**

Development	Production	Operation	Second-Life
• Reliable prediction through 'fleet learning'	• Supplier qualification	• Reduction of TCO	• EoL Decision Making
• 'Closed loop' development	• Integrated quality management	• Evaluation of new possibilities e.g. bidirectional charging	• Enabling insurance contracts for Second-Life Storage
• Better performance of batteries	• Production process improvements	• Enabling of new business models like battery leasing	
		• Extended warranties	
		• Higher residual value	

Our business approach is partnering with industry leaders to build a digital twin software platform ultimately saving money, time and resources
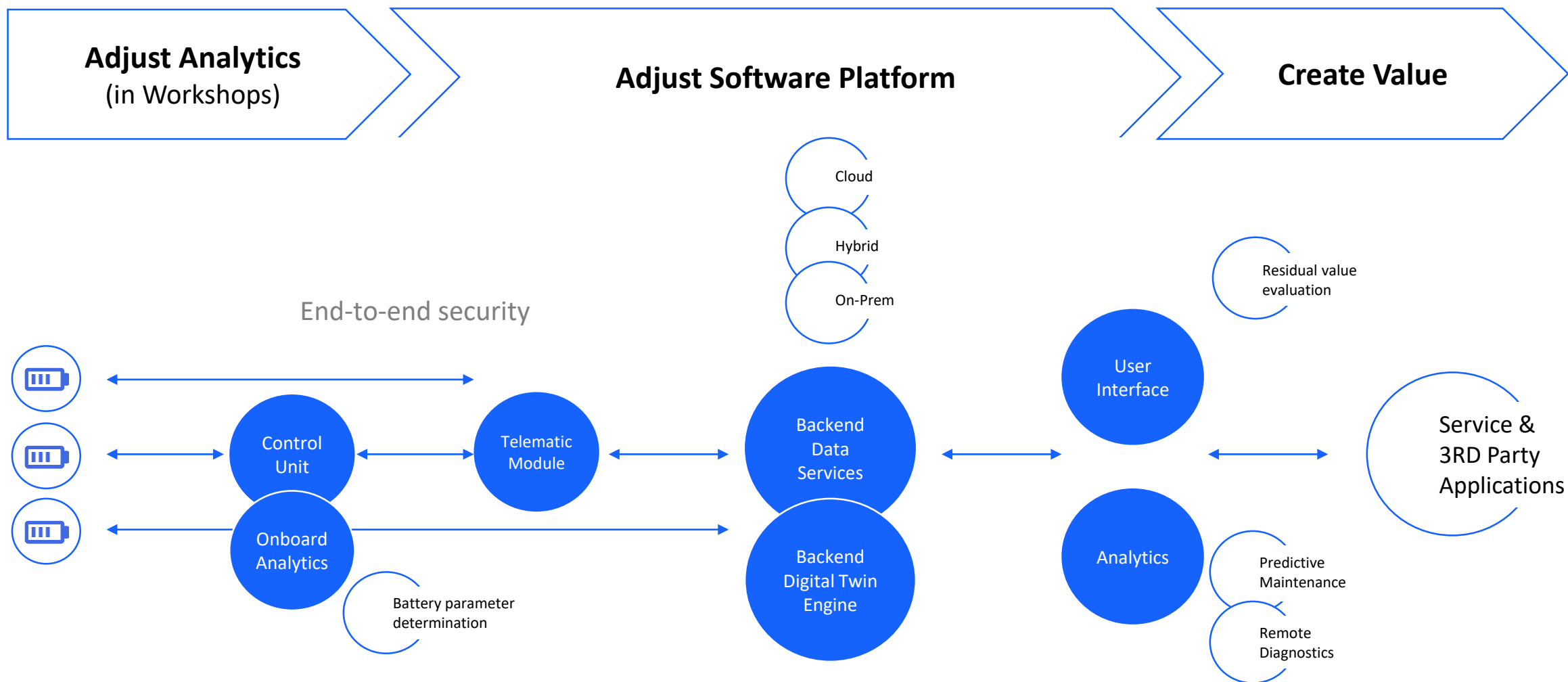
Adjust Analytics
(in Workshops)

Adjust Software Platform

Create Value

Cloud

Hybrid

On-Prem

End-to-end security

Control Unit

Telematic Module

Backend Data Services

User Interface

Residual value evaluation

Service & 3RD Party Applications

Onboard Analytics

Backend Digital Twin Engine

Analytics

Battery parameter determination

Predictive Maintenance

Remote Diagnostics

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