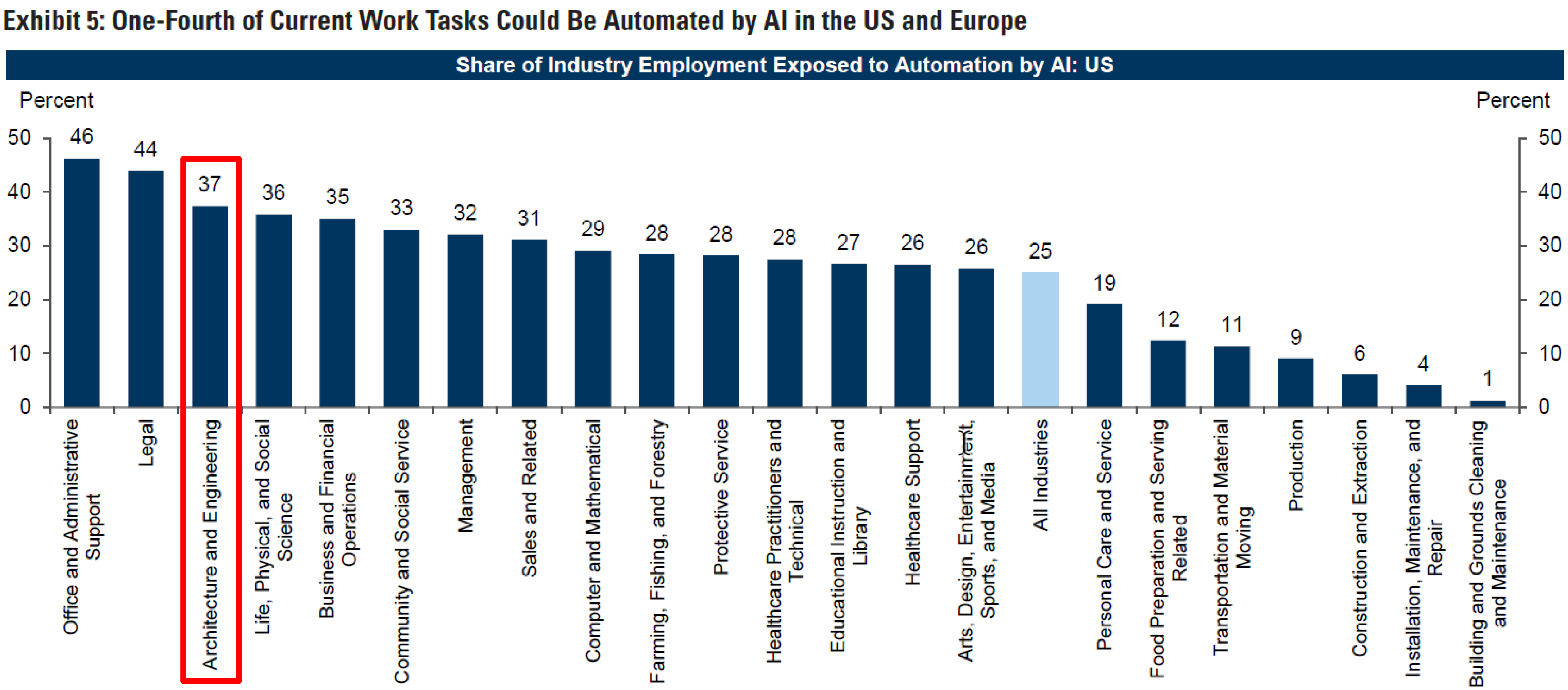
The Impact of AI on EV Battery Applications

Dr. Gerald Sammer

Impact of AI on Engineering



Source: Goldman & Sachs

Today’s Presenter

Dr. Gerald Sammer

Principal Business Field Owner, Battery & BEV.

M.Sc. in computer science and a Ph.D. in economics.

30+ years professional experience in computer science.

25+ years experience in automotive technologies.

AVL representative in the technical steering committee of the ASAM standardization group for automotive standards.

About Us

At AVL, we are one of the world's leading mobility technology companies for development, simulation and testing in the automotive industry, and in other sectors such as rail, marine, and energy.
Based on extensive in-house research activities, we deliver concepts, technology solutions, methodologies, and development tools for a greener, safer, better world of mobility and beyond.

AVL at a Glance

1948
Founded

75+
Years of Experience

29
Countries Represented

50+
Global Tech and Engineering Centers

12,200
Employees Worldwide

68 %
Engineers and Scientists

10 %
Of Turnover Invested in Inhouse R&D

2,200
Granted Patents in Force

AVL Software, AI and Data Intelligence

Application Know-How

Propulsion systems

Next generation vehicles

Automated and connected mobility

Electrification of functions

Embedded Software Development

- E/E platforms and integration
- Advanced Driver Assistance Systems (ADAS) and Automated Driving (AD)
- Functional safety and cybersecurity
- ASPICE compliant development

Cloud Software Development

- Customized data pipelines
- Scalable analytics
- Automated CI/CD pipelines

Simulation, Test Software and Methodology

- Design and simulation solutions
- Functional testing (MiL, HiL, SiL)
- Lab and process management
- Test automation and virtualization

Artificial Intelligence Solutions

- LLM utilization for Requirements
- Data analytics for development and fleet data
- Anomaly Detection
- Failure prediction
- Root Cause Analysis

All software solutions contain our innovation, engineering legacy and application insight.

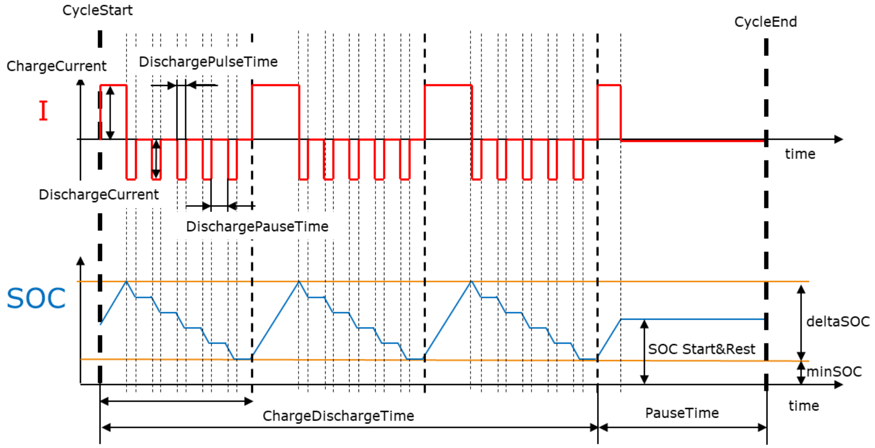
AGENDA

- AI Accelerated Cell Aging Tests
- Production Scrap Reduction
- BMS Optimization
- SOH Prediction and Analysis
- Reduction of Product Re-Calls

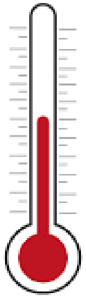
Dr. Gerald Sammer

AI Accelerated Cell Aging Tests

Influencing Factors on Cell Ageing



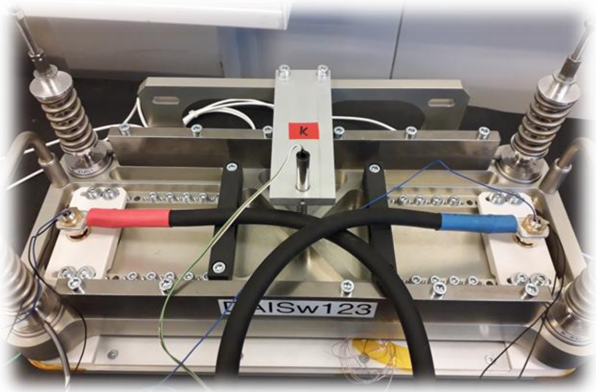
Discharge Current
Charge Current
DeltaSOC
SOC Min / Max
…



Temperature

Calendaric aging / resting
Resting time length
Resting time frequency
Resting SOC level

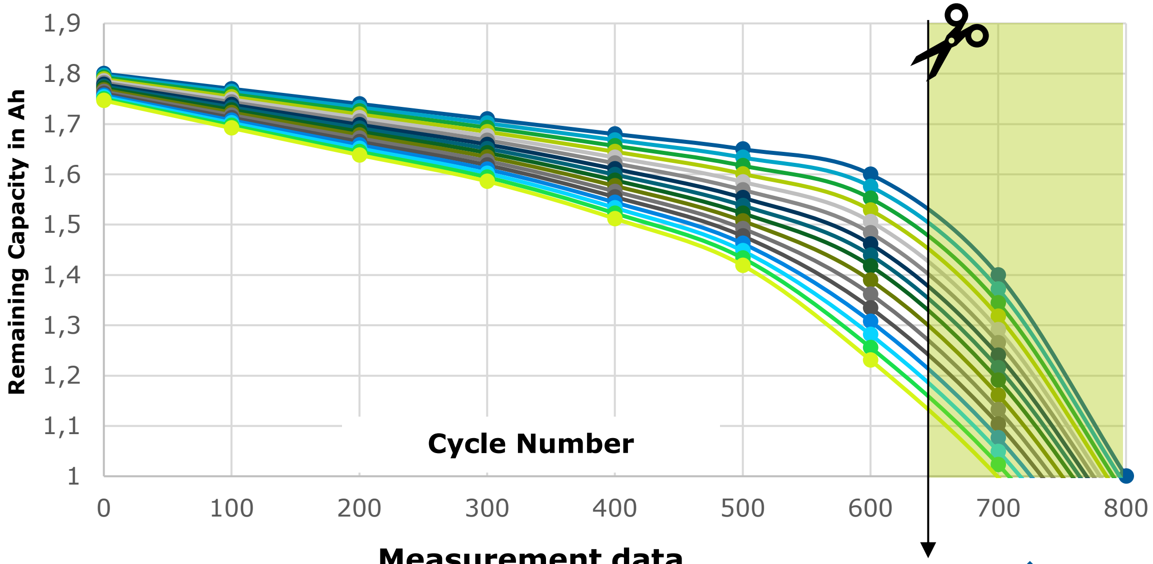
Mechanical Stress



And each parameter variation takes months to measure!

AI Accelerated Cell Aging Tests

Target: Capacity loss until EOL (e.g. 80% SOH)



Measurement data

Standard: 8-12 months cell cycling in the lab

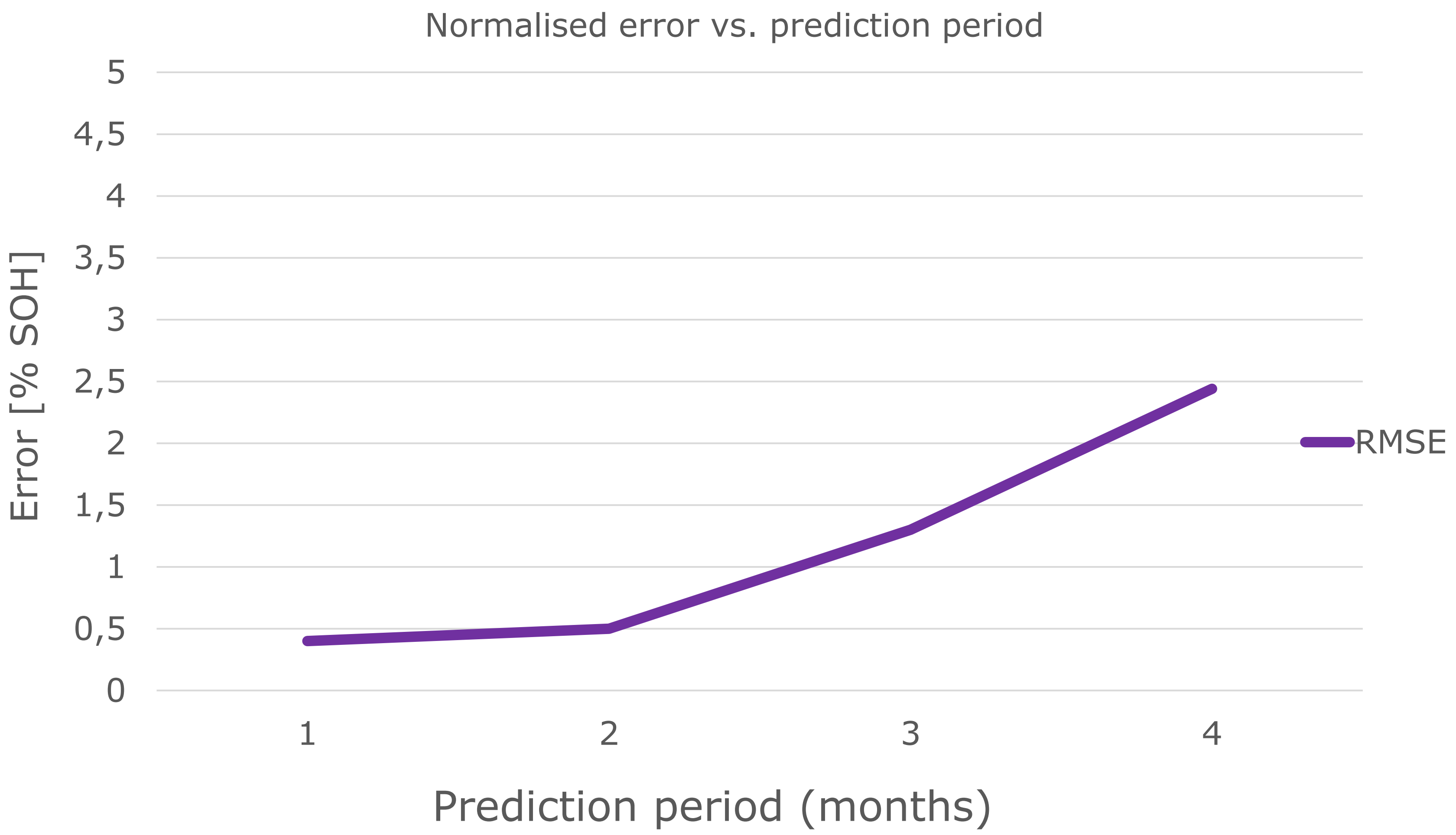
AI based method:

Use the recorded measurement data during testing to train a model that learns the correlation between fast aging cells and slow aging cells to predict the EOL behaviour of the slow aging cells.

20% - 40% reduction of test time

AI Accelerated Cell Aging Tests

Accuracy: 1-4 months reduction based on 12 months test campaign



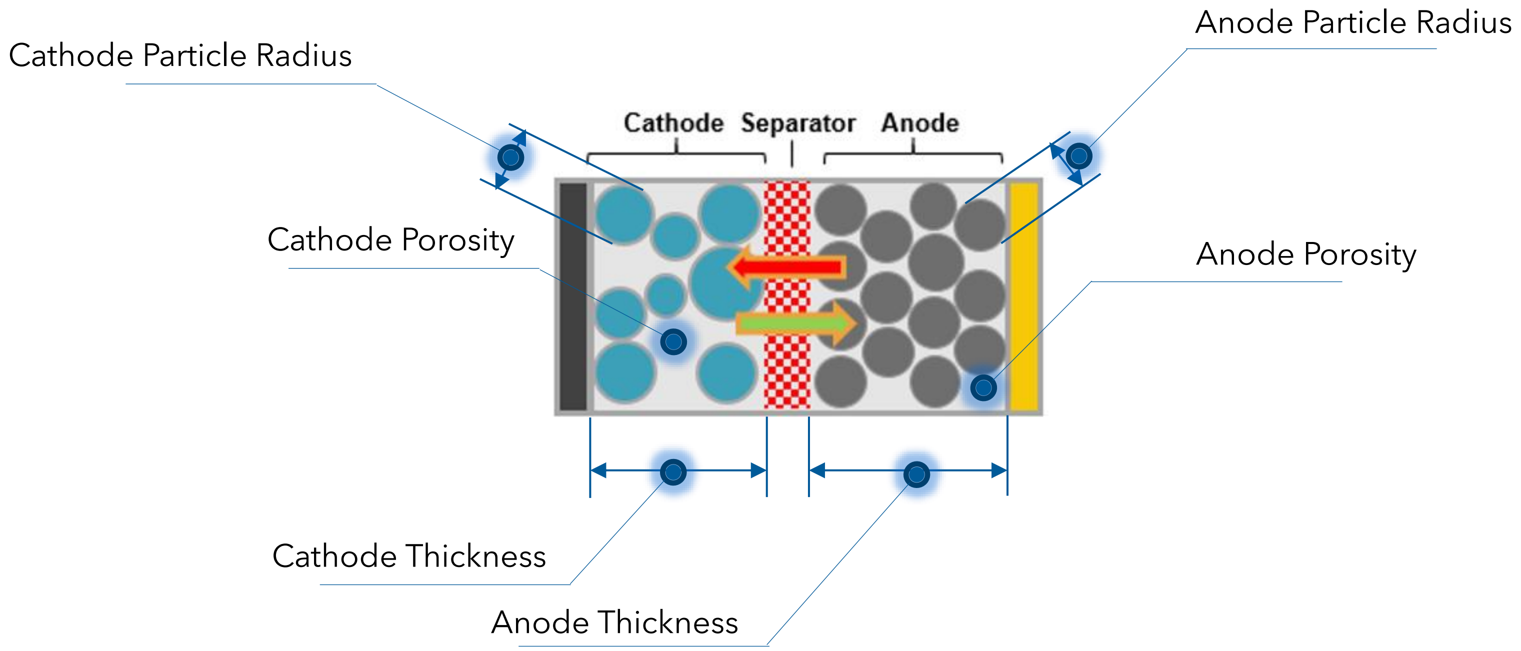
Error rate of predicted aging values with shortened test time

- 2 months cut (15%): 0.5% error rate
- 4 months cut (30%): 2.5% error rate
- Further optimization with *Active DoE* (AVL CAMEO™): 40% reduction

Production Scrap Reduction

Production Scrap Reduction

Battery cell factories are facing 30-50% scrap rate during production!

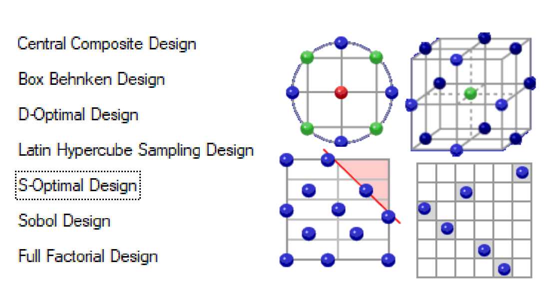


Goal: Reduction of production scrap from 50% to 5% with optimized cell performance

Production Scrap Reduction

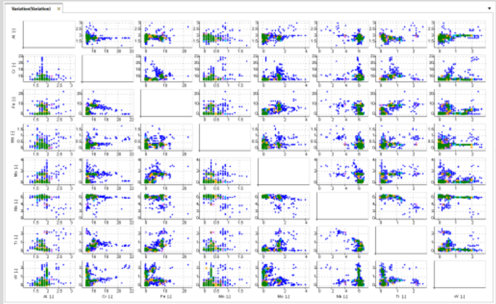
DoE Design

Mathematical design of the application



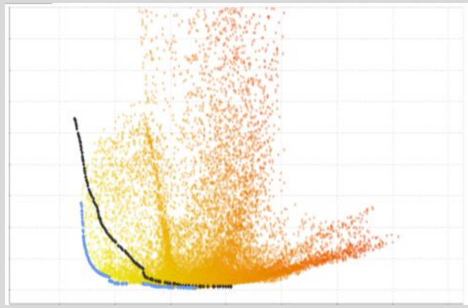
AI Modelling

Machine Learning



Optimizing

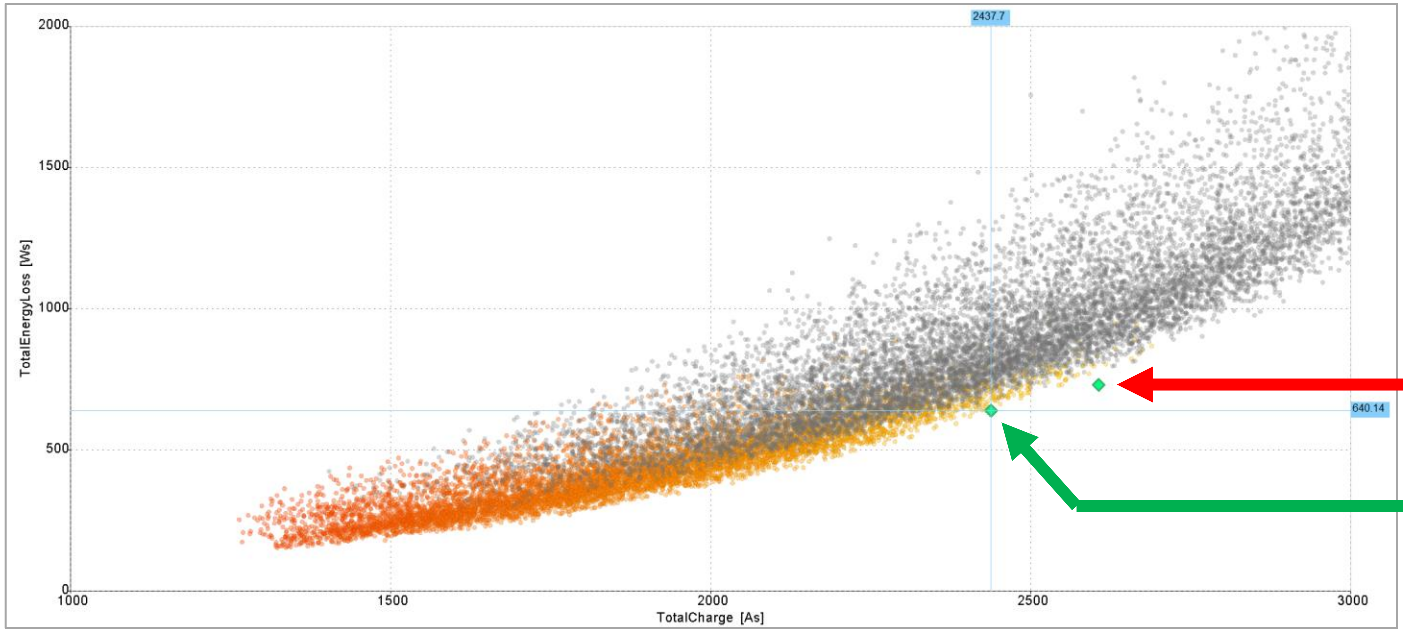
Optimization of performance versus scrap rate



*) DoE: Design of Experiments

Production Scrap Reduction

Parameter	Nominal	Optimized cell design	Production optimized
Capacity	2300 As	2606 As	2437 As
Losses	750 Ws	731 Ws	640 Ws
Scrap	-	50%	5%



The cell with 2437As capacity and 640Ws losses can be produced with 5% scrap considering given tolerances.

Optimized cell performance:
50% Scrap

Production optimized design:
5% Scrap

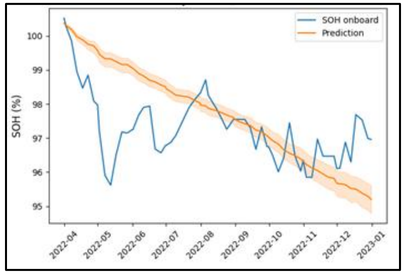
BMS Optimisation

AI & Cloud Optimised BMS

Battery health indicators

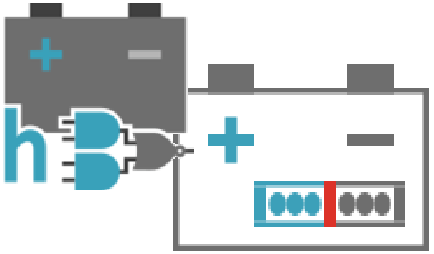
AI model in the cloud

Cloud-based SoH



Optimized control strategies

Vehicle Battery and BMS system



Challenges

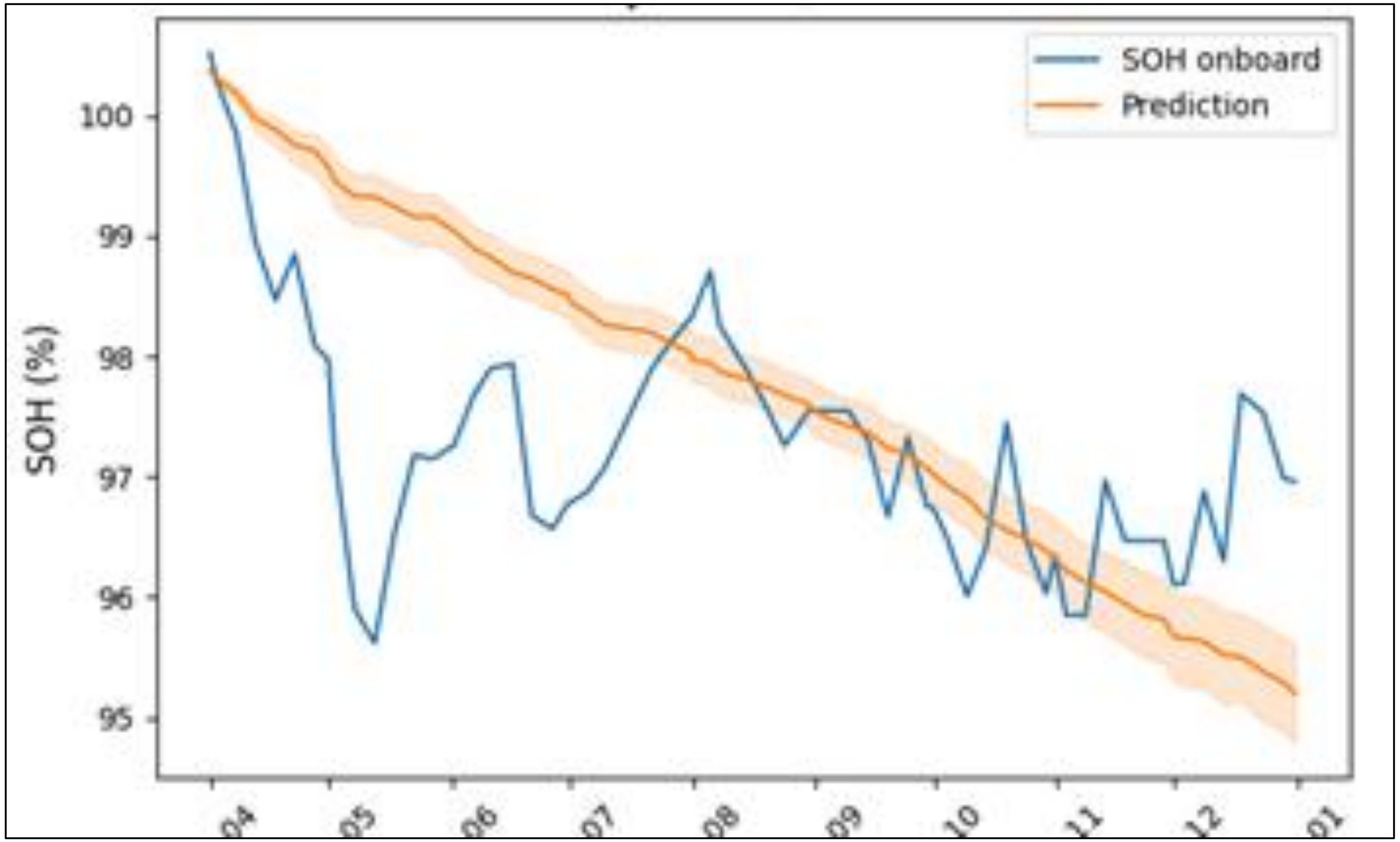
- Diverse operating conditions
- Detect warranty events
- Maintenance planning
- SoX prediction

Lifetime Prediction

Anomaly Detection

Exact SoX status

AI & Cloud Optimised BMS

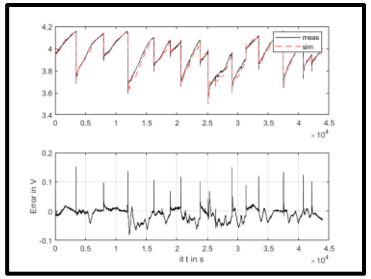


- Onboard BMS are limited in predicting SOH & SOC
- AI based cloud BMS systems provide robust trend predictions for SOH & SOH

SOH Prediction and Analysis

SOH Prediction and Analysis

SoH Estimation On Board
(RC modelling for single vehicle)

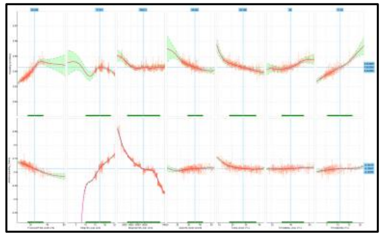


Current RC & SoH
for each vehicle

Estimation of battery health based on RC parameter identification for dynamic driving cycles for each vehicle.

Fleet Data Analytics and RUL Prediction in The Cloud

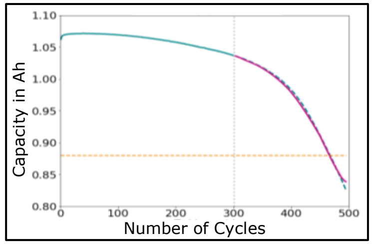
Range and SoH
(Meta modelling for complete fleet)



Influencing factors on
range & SoH for
complete fleet

Neural Network model training for range and SoH depending on driving and ambient conditions based on the complete fleet.

Lifetime Prediction
(Machine Learning incl. Federated Learning for model training)



Remaining
Useful Life
for each vehicle

Machine learning approach to predict the future behavior of the SoH based on the historic battery data. A Federated Learning approach is used to train the corresponding model over several fleets.

Reduction of Product Re-Calls

Reduction of Product Re-Calls

Recalls

Recalls avoided

VIN / Vehicle*)	Risk
1FAFP45X83F403461	87,6%
1C4NJPBA1CD661292	82,7%
1G8ZF5287XZ363384	79,3%
WMWRC33474TC49530	74,1%
WP0CA29924S650563	68,9%
WV2YB0257EH008533	64,1%
5TEWN72N63Z275910	60,7%
1GCFG25F6V1059733	54,1%
2G1WH55K5Y9322458	52,7%
SAJWA2GEXBMV00832	46,0%
5XYKT3A69DG353356	43,6%
2B3ED56F5RH142129	43,4%
4V4N99EH3CN554692	42,5%
1G4HP54KX24151104	42,2%
1FMCU14T6JU400773	36,2%
JHMSZ542XDC028494	30,8%
1GCHK23244F199207	28,1%
JH4DA9340LS003571	26,5%
1FAFP58S11A177991	23,5%
JM3TB2MA5A0235007	19,2%
JH4DC2380RS000036	16,2%
WBACB4324RFL14401	11,0%

*) Listed VINs are not real ones

Benefits:

- 92% less product recalls
- Hundreds of million $ saved in repair cost
- Safeguard brand reputation

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Thank you

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