

# SAFION

KNOW YOUR BATTERIES.

## How to find the fly in the ointment?

Why battery inspection is crucial for reliable products

# Same same, but different

## Batteries from the same batch ages in different trajectories

How it started



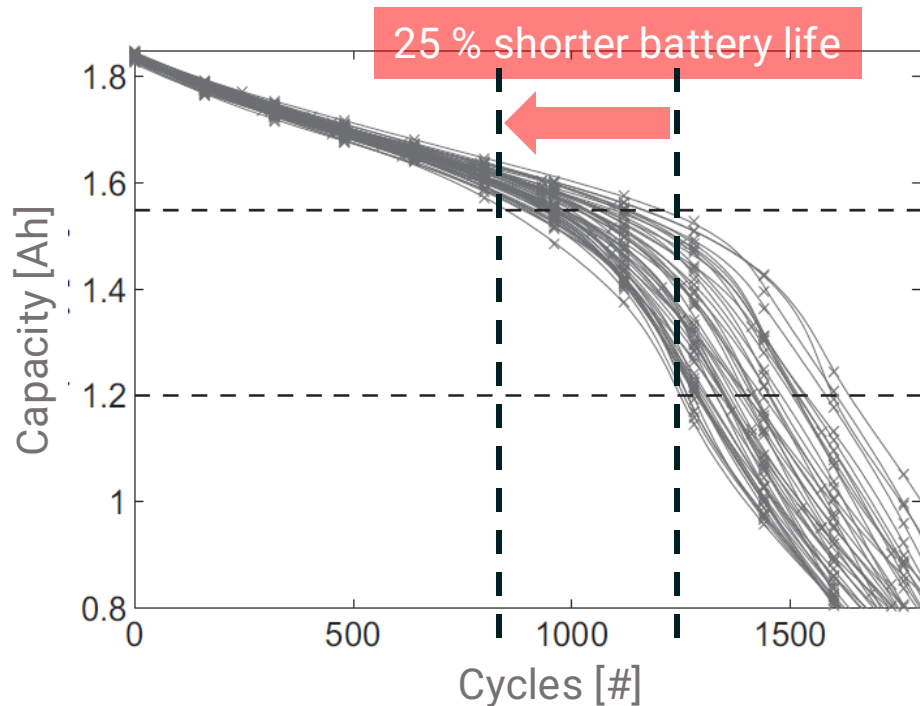
How it's going



# Battery Quality and Product Lifetime

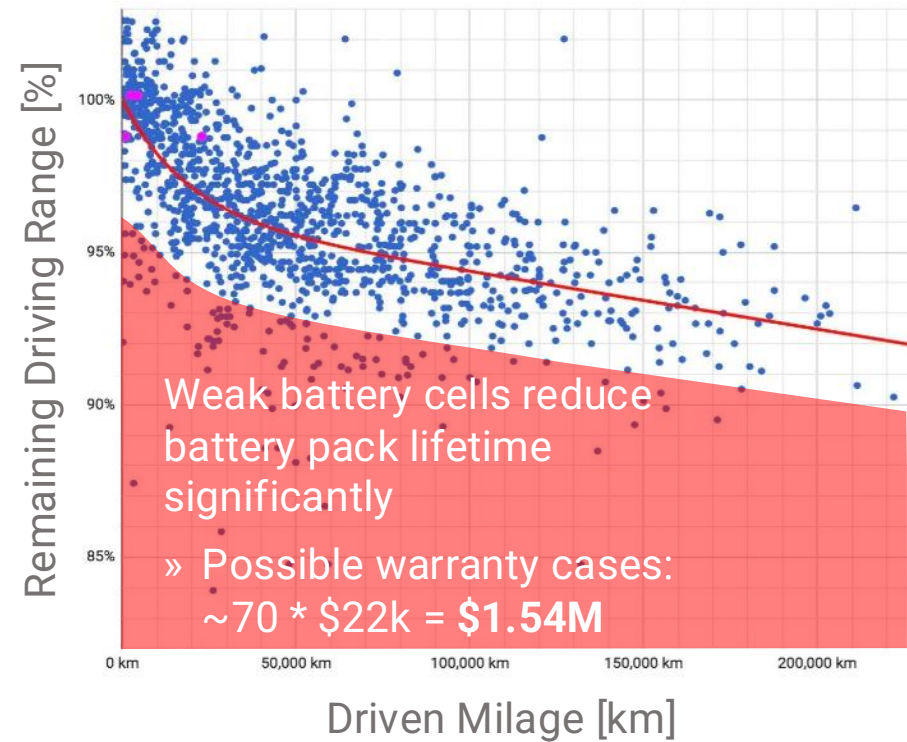
## Quality variations lead to safety and warranty cases

### Battery Quality Variations



Source: T. Baumhöfer et al. / Journal of Power Sources 247 (2014) 332e338

### Battery System Lifetime



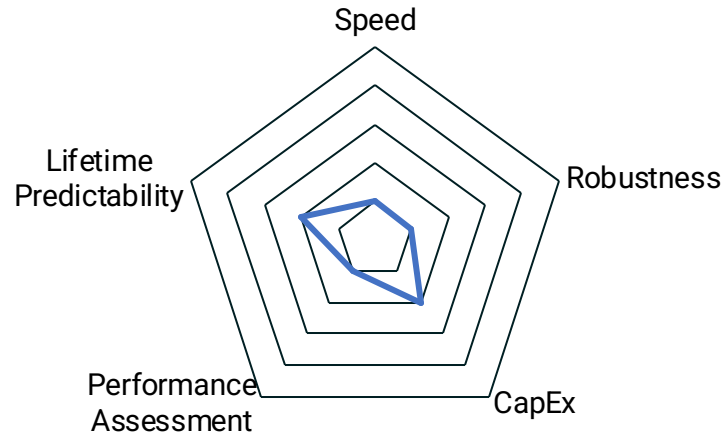
Source: <https://electrek.co/2018/04/14/tesla-battery-degradation-data/> and own modifications

# Present – End of Line / Incoming Goods Inspection

## Method comparison

### Self Discharge / OCV

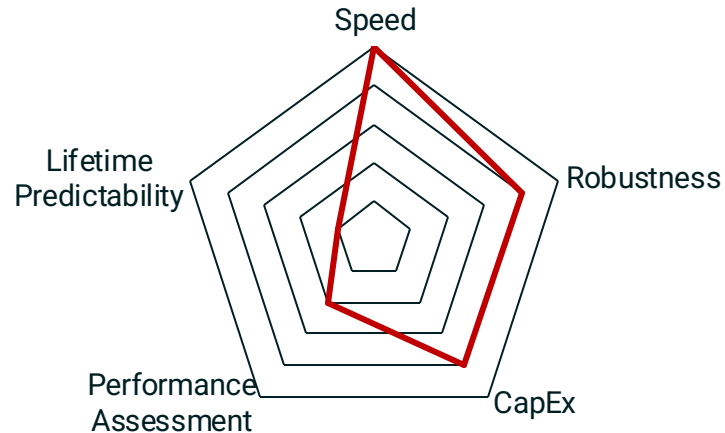
- Typically performed by cell manufacturer
- Weak quality correlation<sup>(1)</sup>



<sup>(1)</sup> Zilberman et al., <https://doi.org/10.1016/j.est.2019.100900>

### 1kHz Resistance / AC-IR

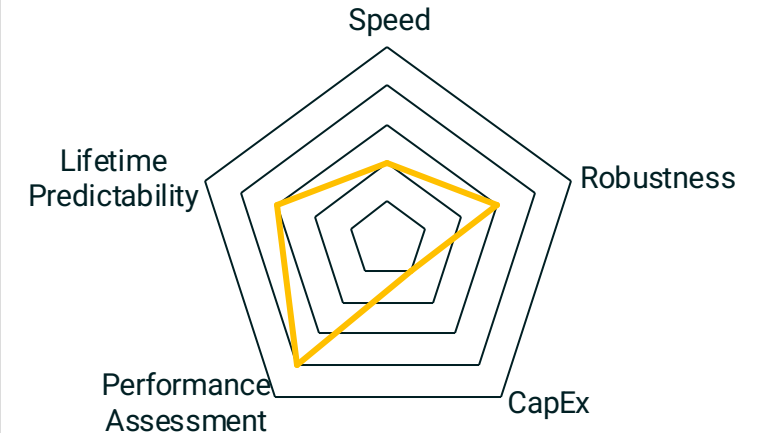
- Industry standard for a long time
- Weak quality correlation



<sup>(2)</sup> Hybrid pulse power profile characterization

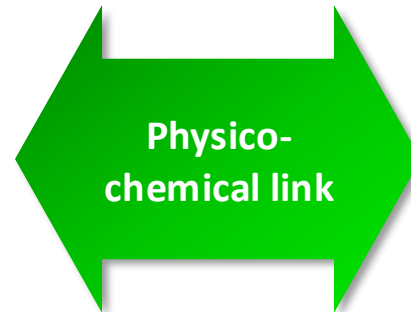
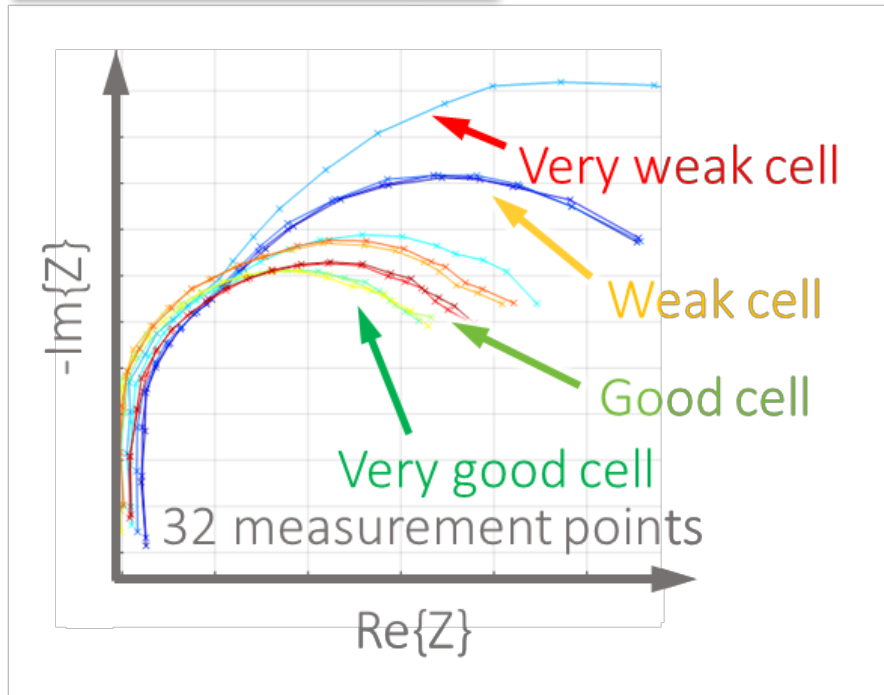
### Capacity / HPPC<sup>(2)</sup> Test

- Impractical in many applications
- Strong quality correlation

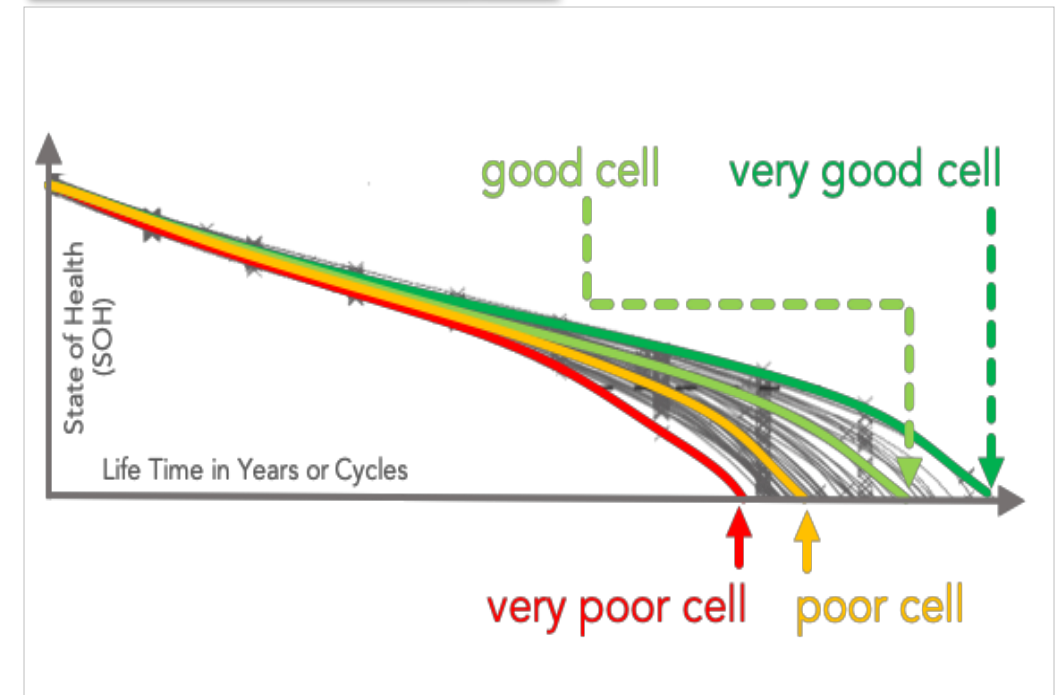


# EIS\* is Strongly Correlated with Battery Lifetime

## EIS\* Spectra



## Battery Lifetime

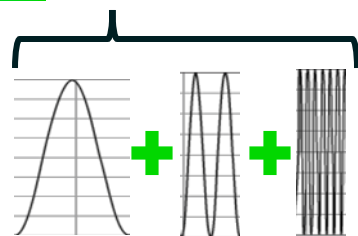
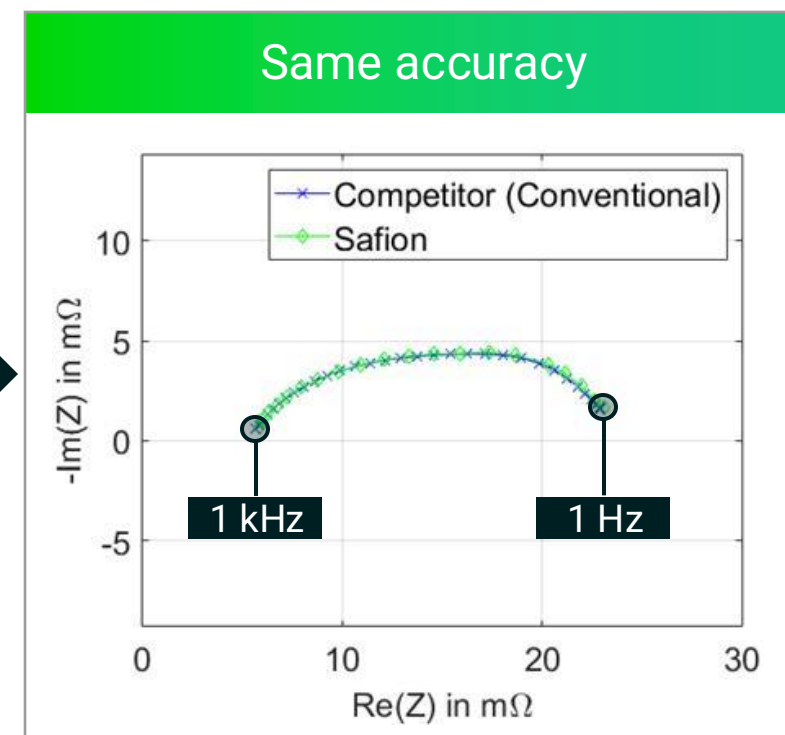
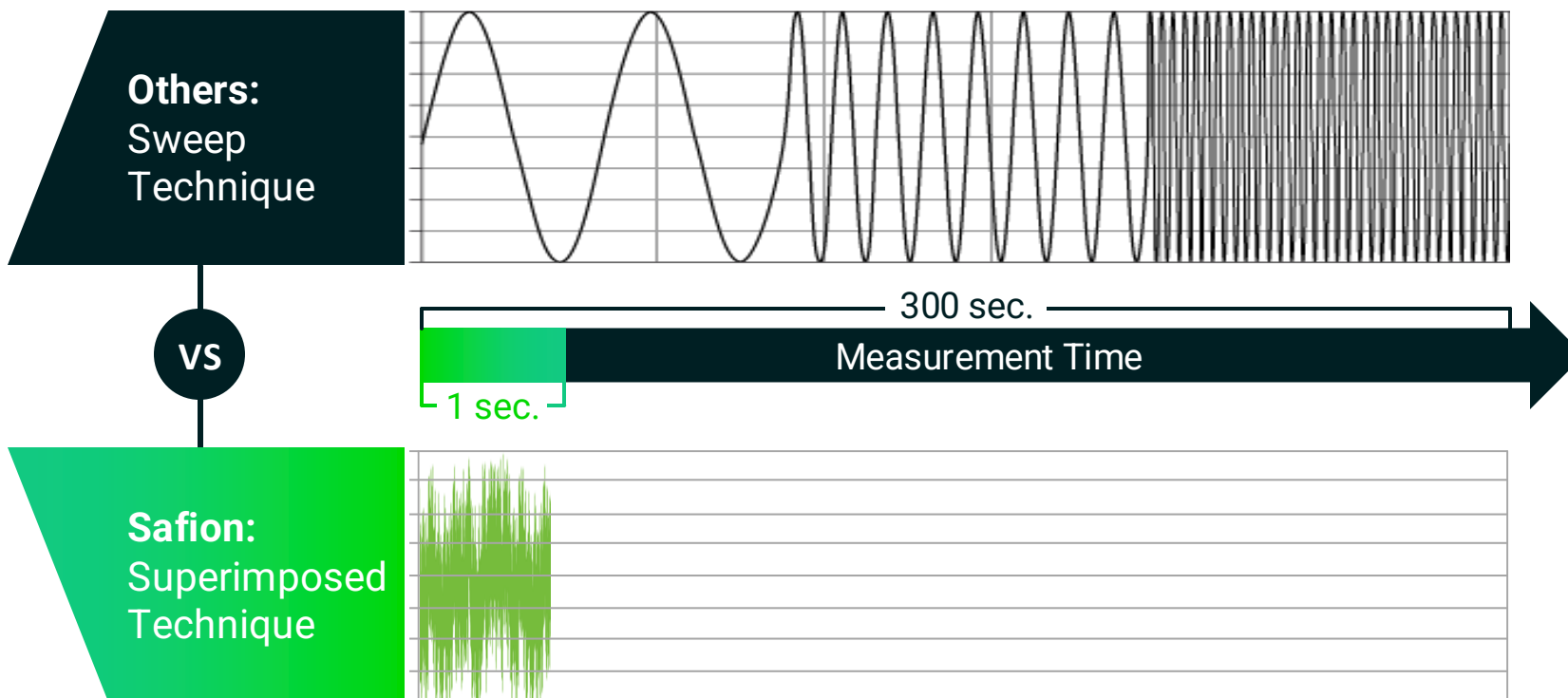


\*EIS: Electrochemical Impedance Spectroscopy



# Real-Time Electrochemical Impedance Spectroscopy

## Working Principle

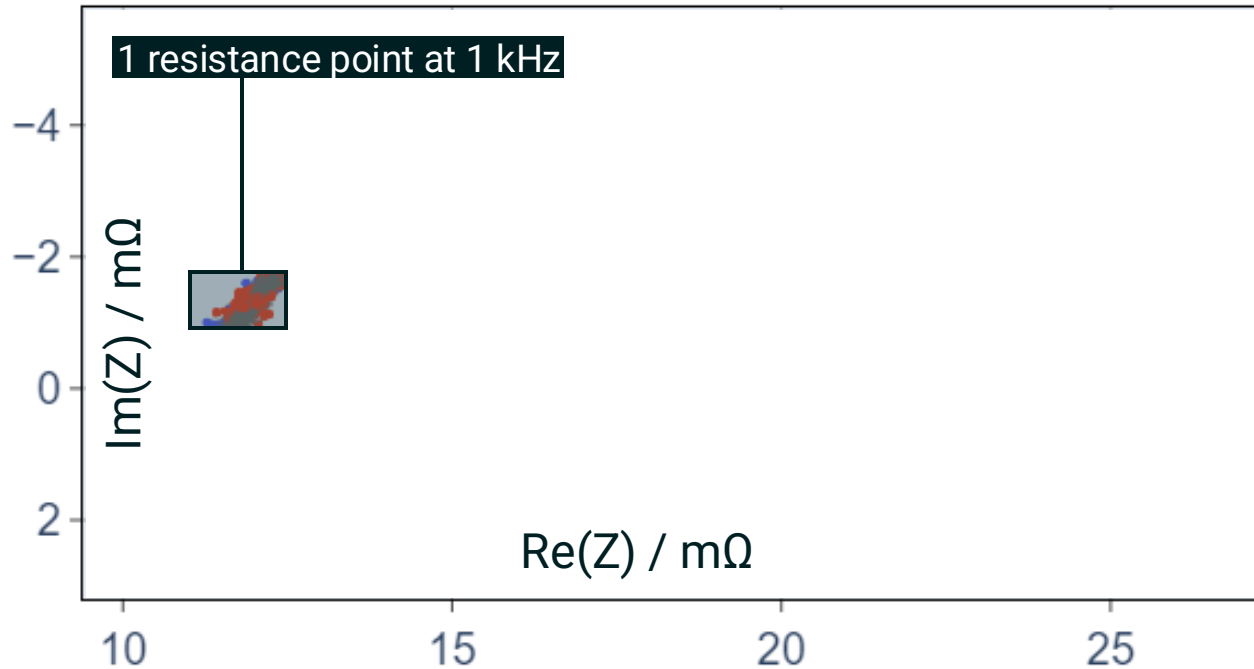


	Conventional EIS	Real-time EIS
Measurement Duration (1Hz – 10 kHz)	Minutes	Seconds
Measurement during dis-/charging	✗	✓
Measurement during temp. changes	✗	✓

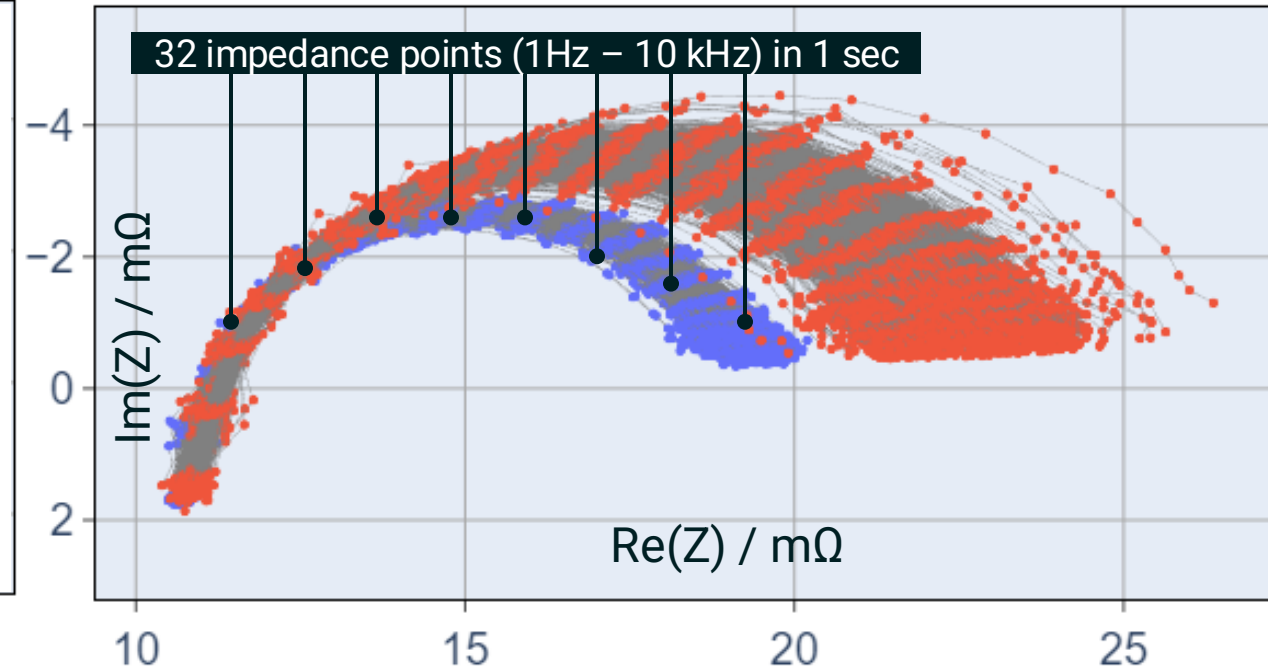
# EIS\*-based Battery Screening and Inspection

## Prediction of battery performance, safety and life

Others see a small part



We see the whole picture



\*EIS: Electrochemical Impedance Spectroscopy

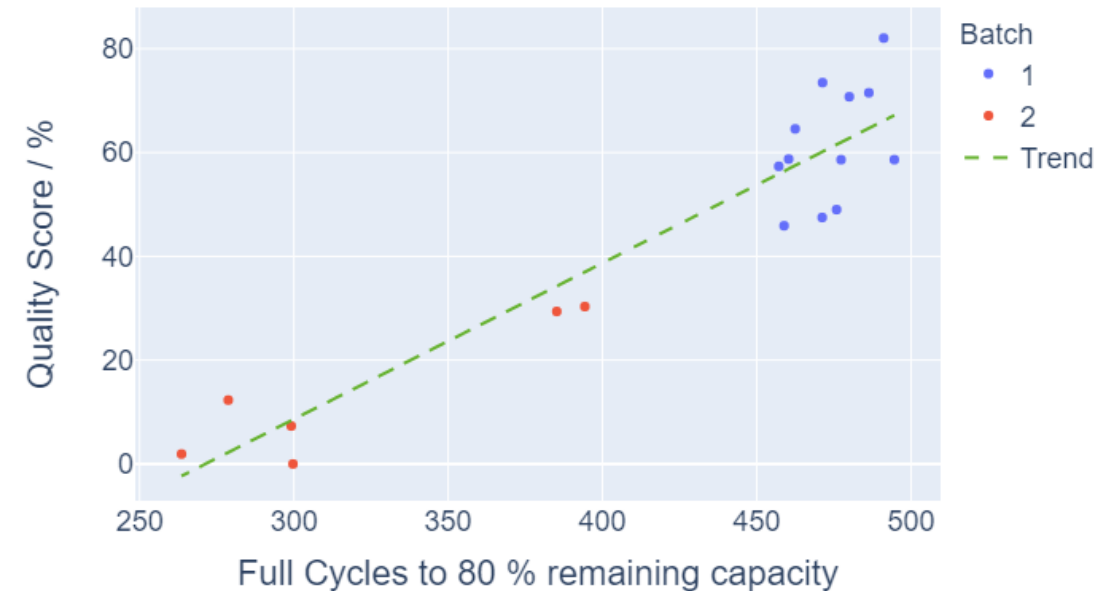
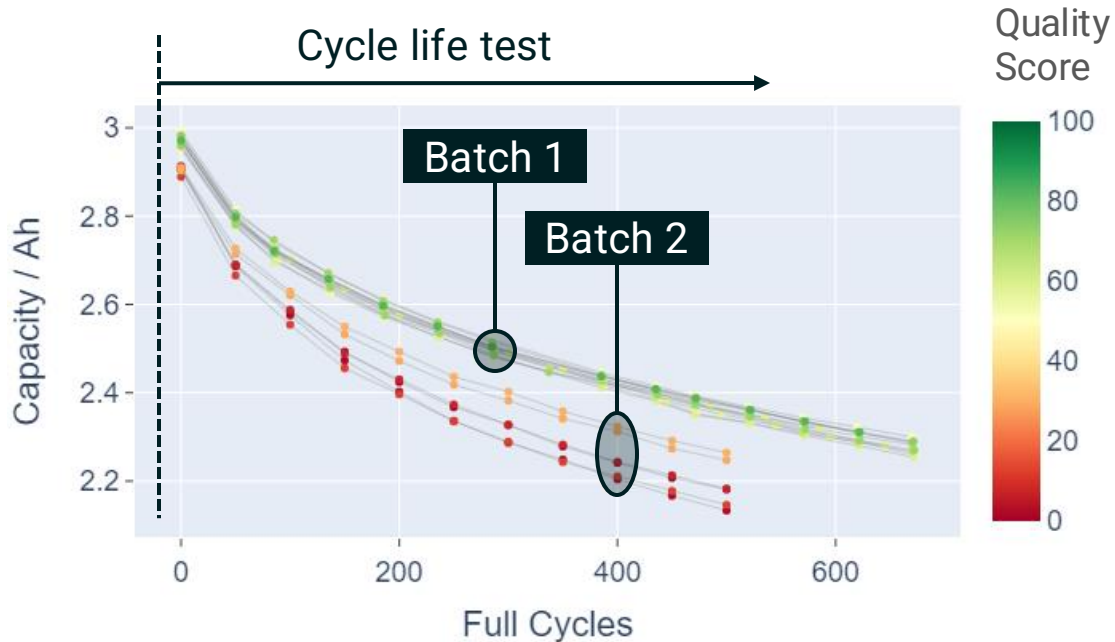
# EIS-based quality assessment and battery lifetime

## Scientifically proven high correlation

EIS assessment and grading at BOL <sup>(1)</sup>



Battery lifetime in operation



<sup>(1)</sup> Begin of Life





## Battery Quality Assurance



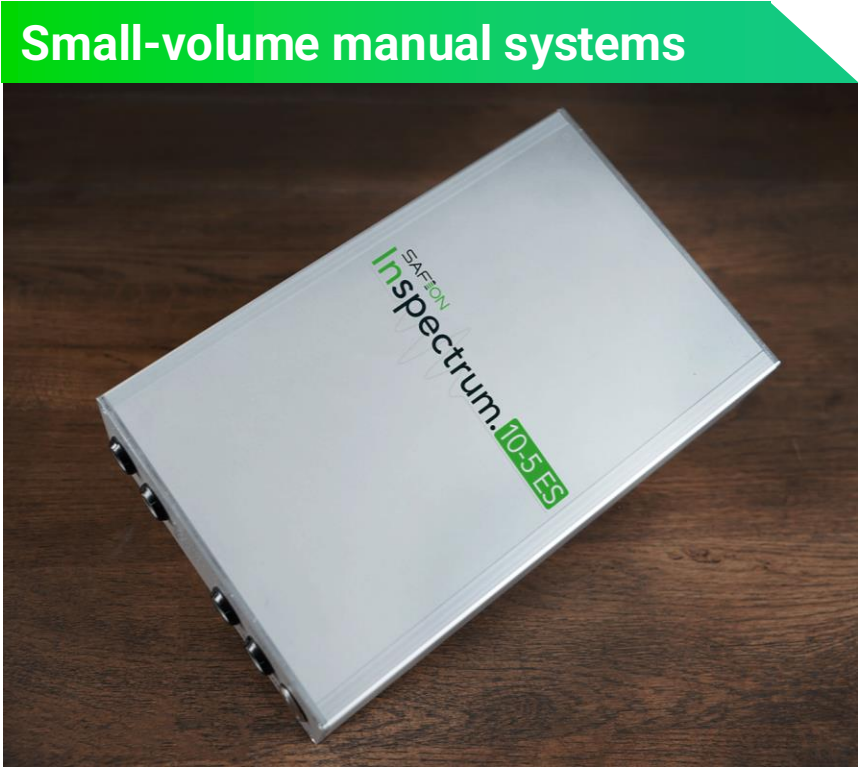
## Battery Characterization Automation



## Battery Management Systems

# Battery Cell Inspection – the End-to-end Ecosystem

## Hardware, Software, and Data Management platform



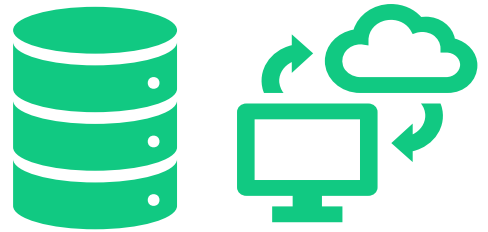
**Control Software**



**Automated inline systems**

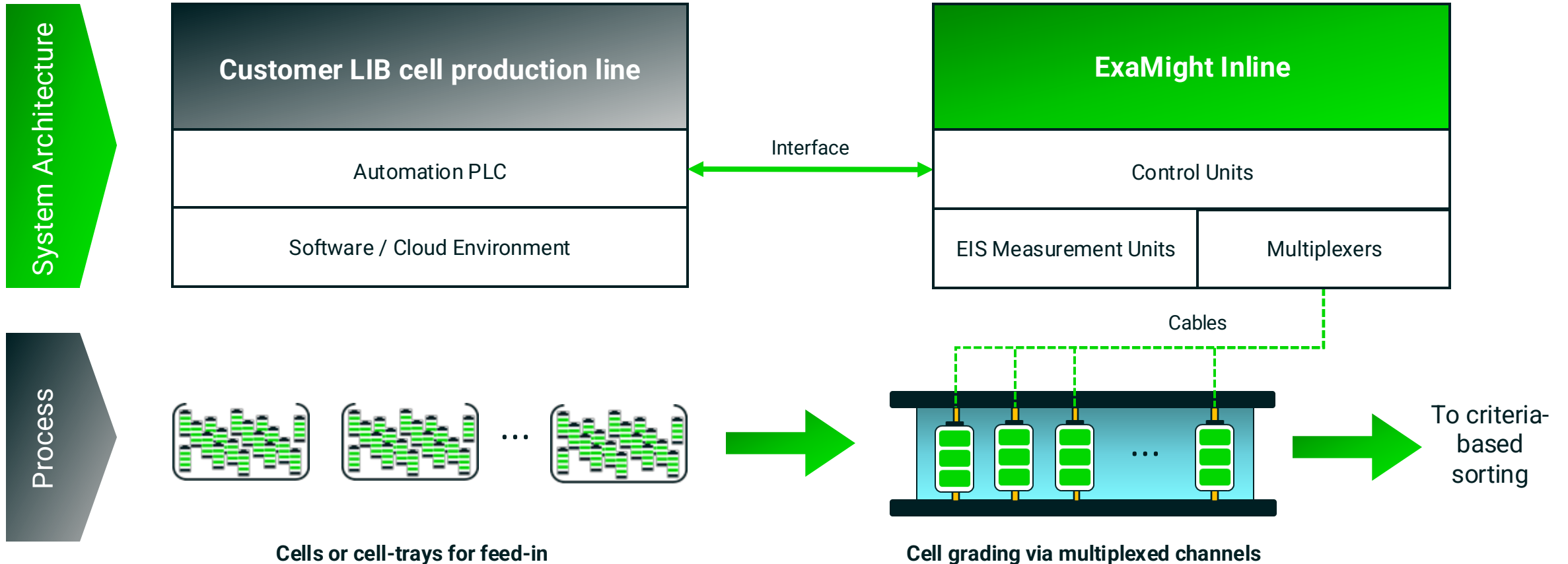


**Data Management**



# Solution Architecture for Automated Lines

## Seamless Integration to Test, Grade and Sort your Cells





## Battery Quality Assurance



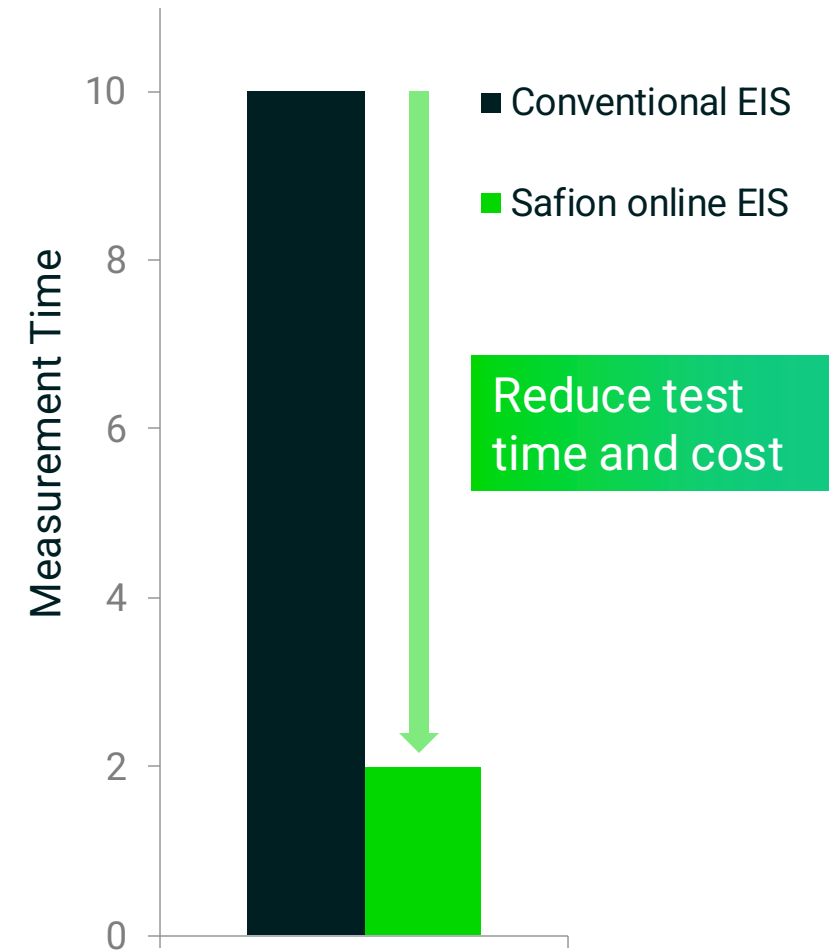
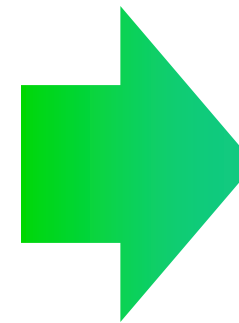
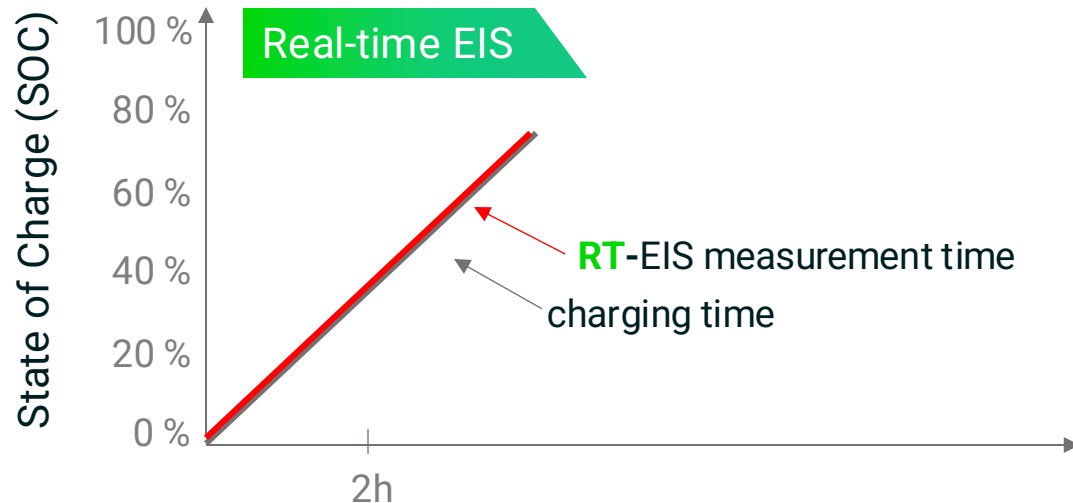
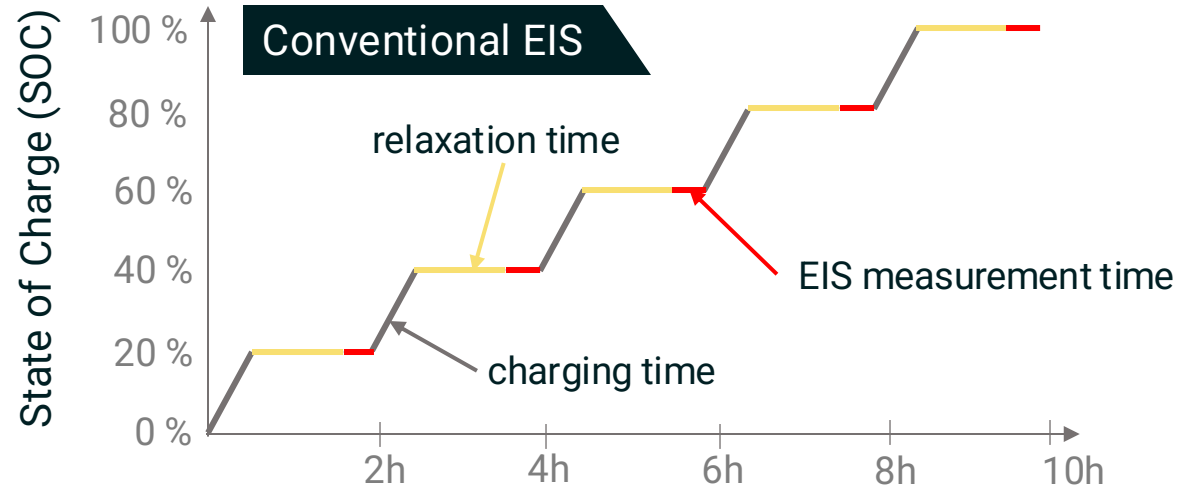
## Battery Characterization Automation



## Battery Management Systems

# Fast and Cost-Effective Battery Characterization

## Significant time and cost savings





# Inspectrum – ES and HD Series

## Your All-in-one Automated Solution for Battery Cell Characterization

### Inspectrum Essential (ES) Series

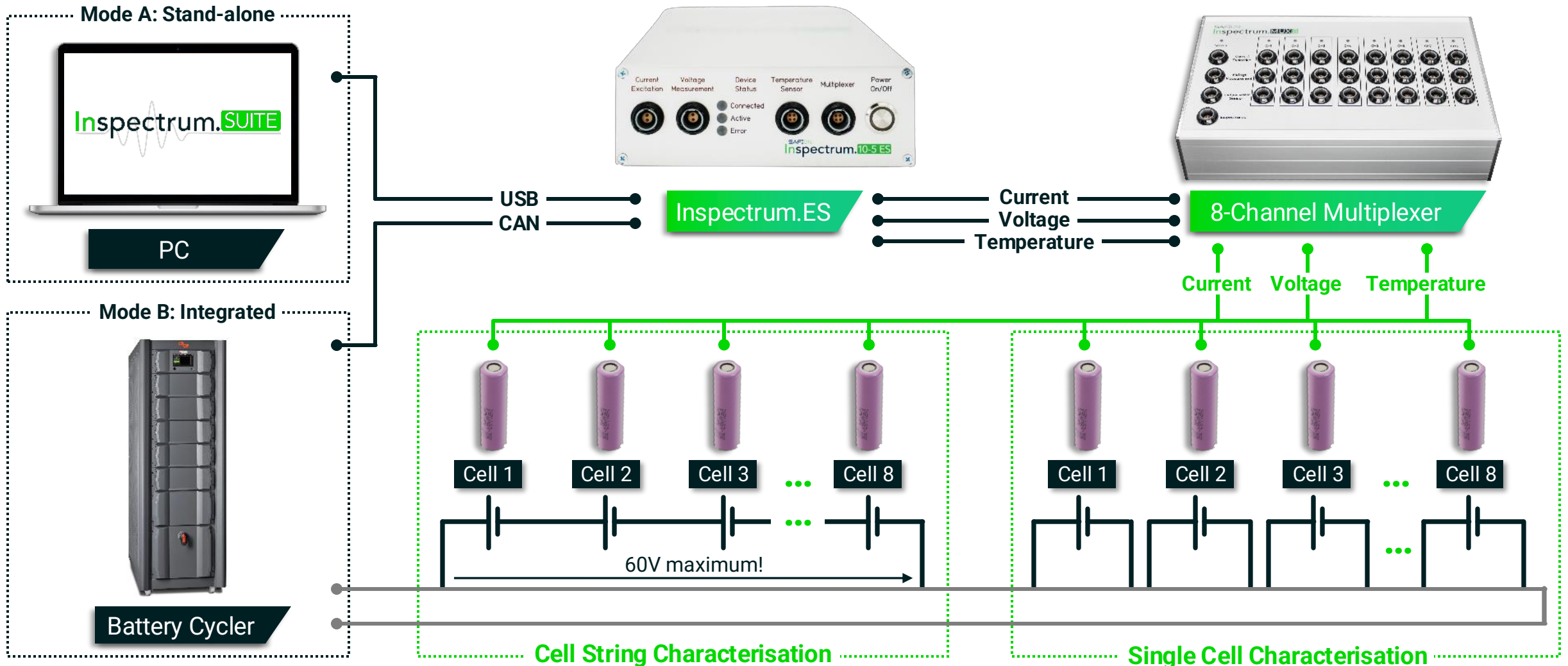


### Inspectrum High-Density (HD) Series



# Inspectrum.ES MEAS 10-5 with 8-CH Multiplexer

## Operation Modes





## Battery Quality Assurance



## Battery Characterization Automation

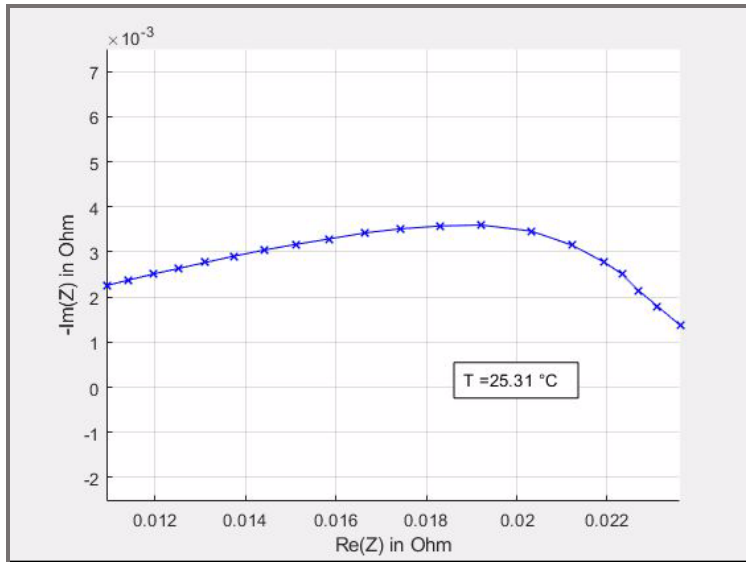


## Battery Management Systems

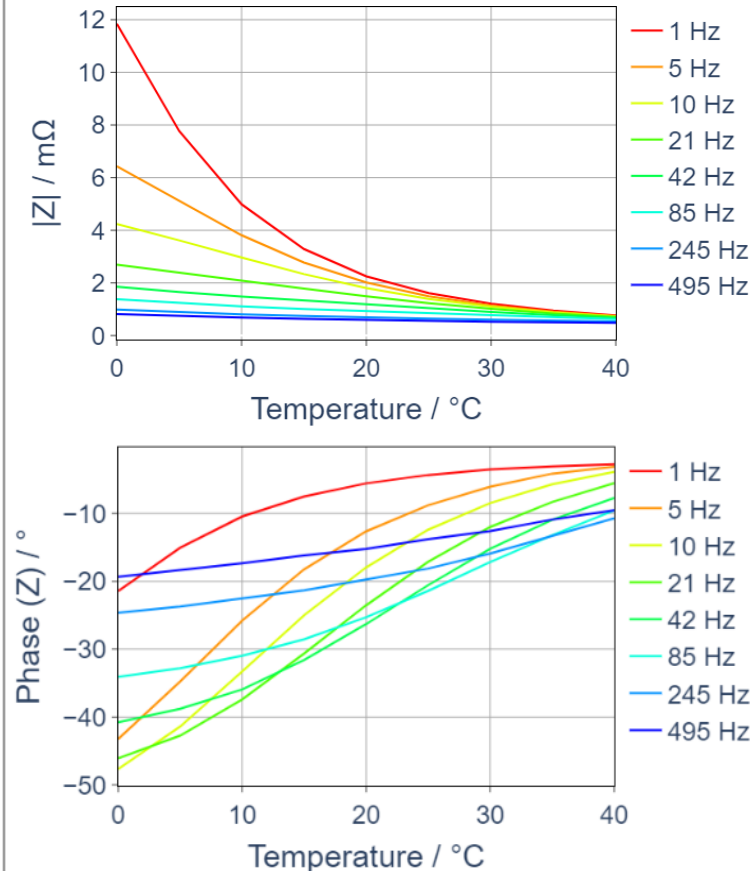
# Cell Core Temperature Estimation

## Simple algorithms with look-up tables

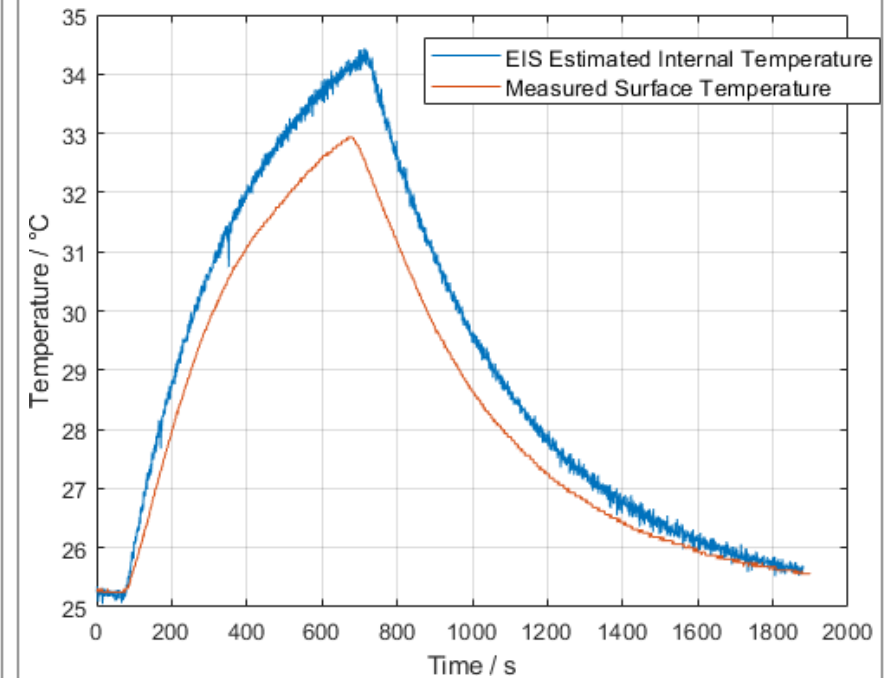
### Characterization: EIS vs. Temperature/SOC



### Parameter Selection



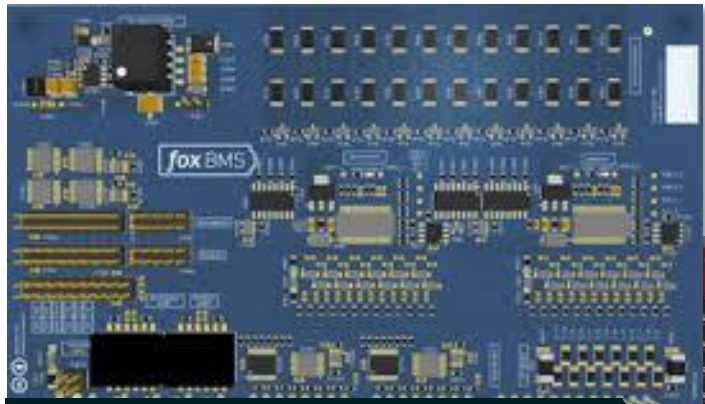
### Algorithm Implementation & Validation





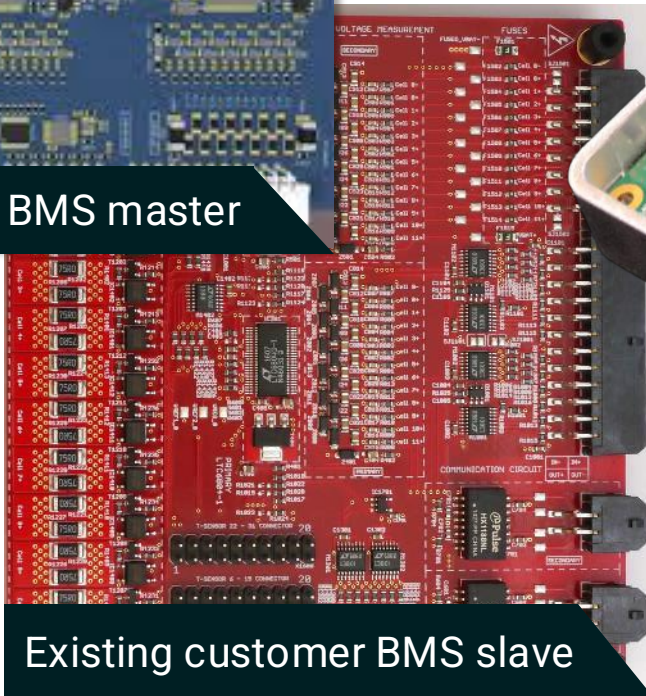
# BMS Integration of online Impedance Spectroscopy

## Only minor changes in the existing BMS architecture required



Existing customer BMS master

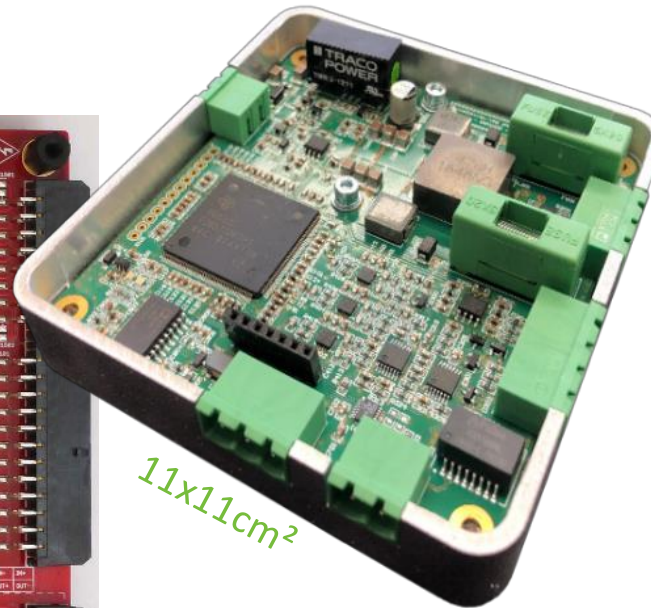
Source: <https://foxbms.org/>



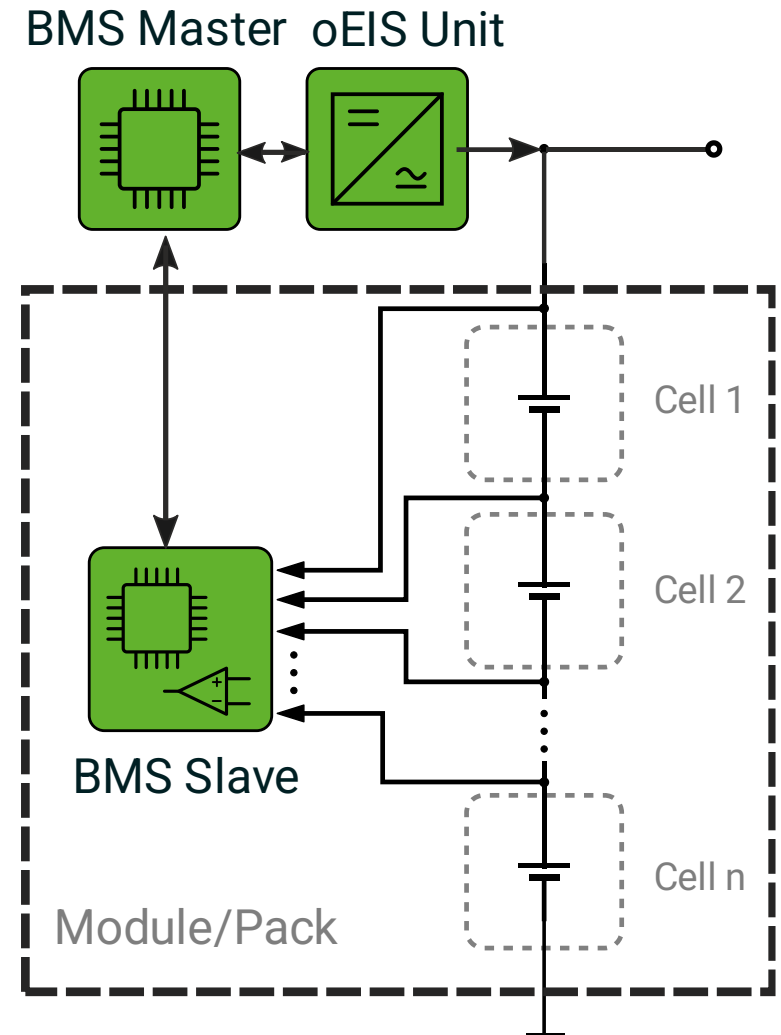
Existing customer BMS slave

Source: <https://foxbms.org/>

oEIS Unit



11x11cm<sup>2</sup>





# World's first online EIS (BMS)

The future is now!

Slave with  
standard Frontend

Online EIS  
Excitation  
and Master



Automotive OEM  
Cells

# Key Competences

## 10+ Years Experience In Lithium-ion Batteries



# Facts: Customers & Locations

## Based In Germany With Global Footprint

**Foundation:** February 2019

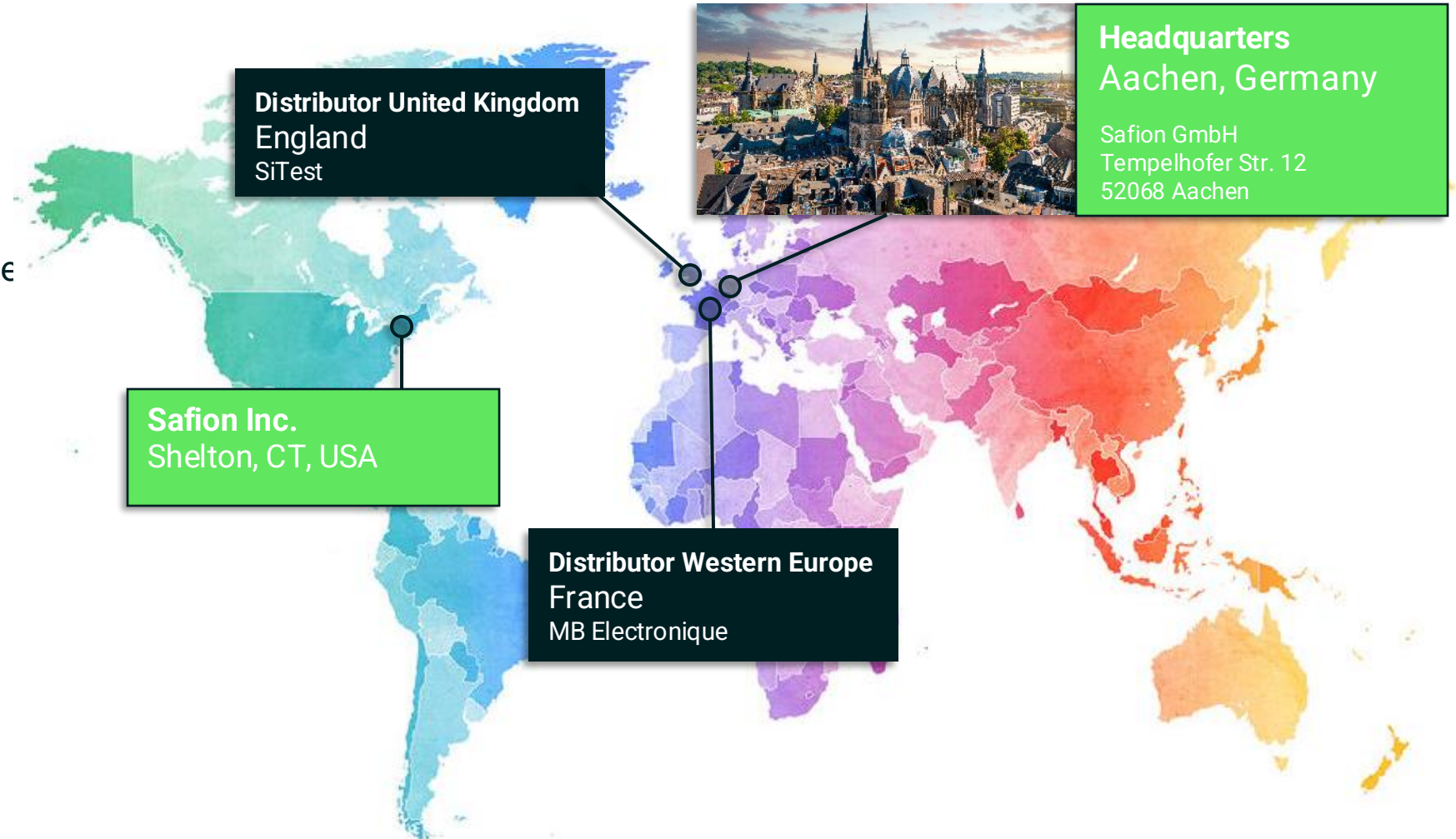
**Size:** 28 employees

**Diversity:** 10 nations / 30 % female

**Growth:** 300% / year

**Turnover:** €1.5 M / year

**Distribution:** Worldwide





The fast rely on us

SAFION



Mercedes AMG

The innovative rely on us

SAFION



Volocopter



The heavy rely on us

SAFION



EST-Floattech



# How we started





# How we are going





# And We Rely on Our Mannschaft. #WorkWithUs #ApplyNow

SAFION



# Thank you for your kind attention!

For more information, please reach out to us.



## Your Contact

**Harshvardhan Samsukha, M.Sc.**  
Sales Manager / Solution Engineer

✉ [Harsh.samsukha@safion.de](mailto:Harsh.samsukha@safion.de)

🌐 [www.safion.de](http://www.safion.de)

☎ +49 (0) 176 7589 4742