Predictive Safety — Preventing Battery Fires from Happening

April 2021

Battery Safety is an Absolute Necessity to Compete

Billions of dollars of costs associated with extensive recalls

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Auto Makers Grapple With Battery-Fire Risks in Electric Vehicles

Incidents involving electric vehicles made by GM, Ford and others highlight dangers of lithium batteries

A Chevy Bolt and its charging station during the 2020 Canadian International Autoshow in Toronto.

OCTOBER 12

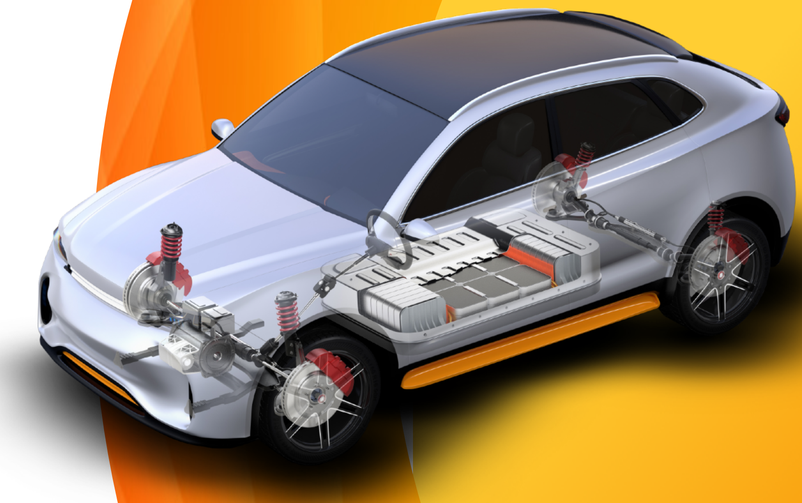
Hyundai to recall 77,000 Kona electric cars over risk of battery fire, fights LG Chem over cause

Fred Lambert - Oct. 12th 2020 6:08 am ET @FredericLambert

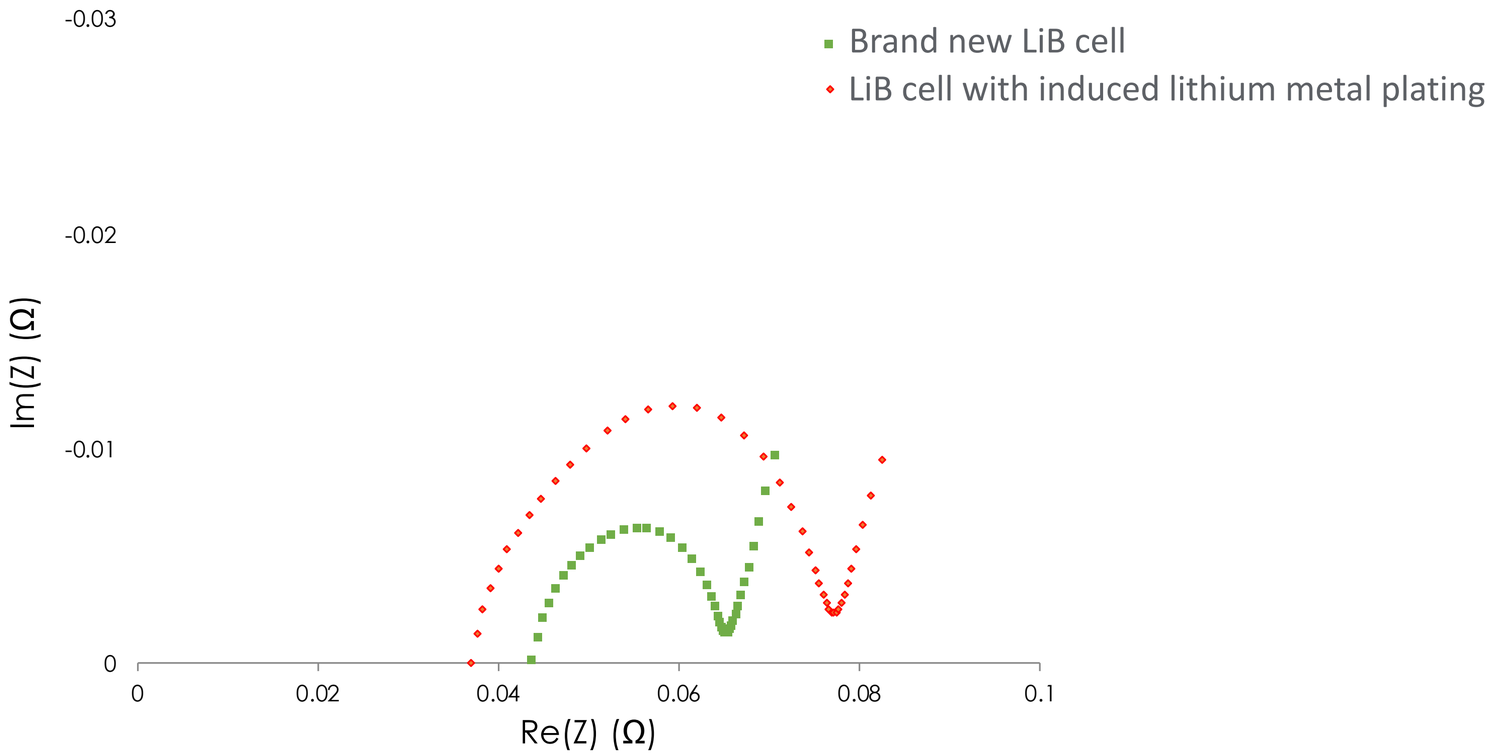
Battery Safety Must Be Predictive

We need to prevent fires BEFORE they happen

Safety is also a system requirement (not just battery)

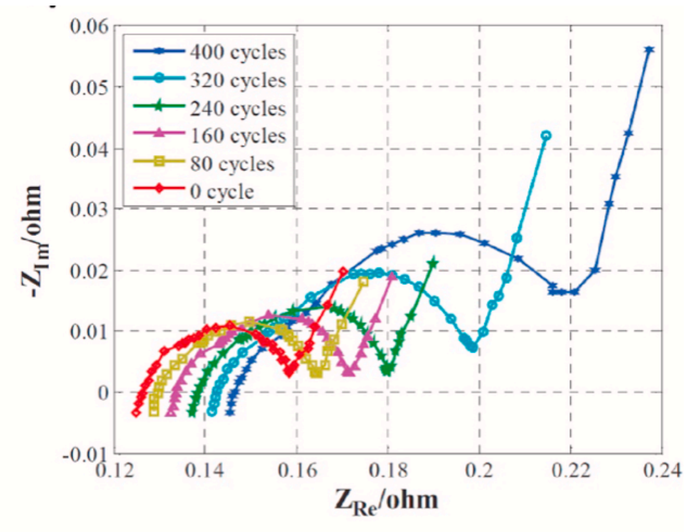


EIS is a Powerful Laboratory Tool for Early Diagnosis of Potential Battery Failures



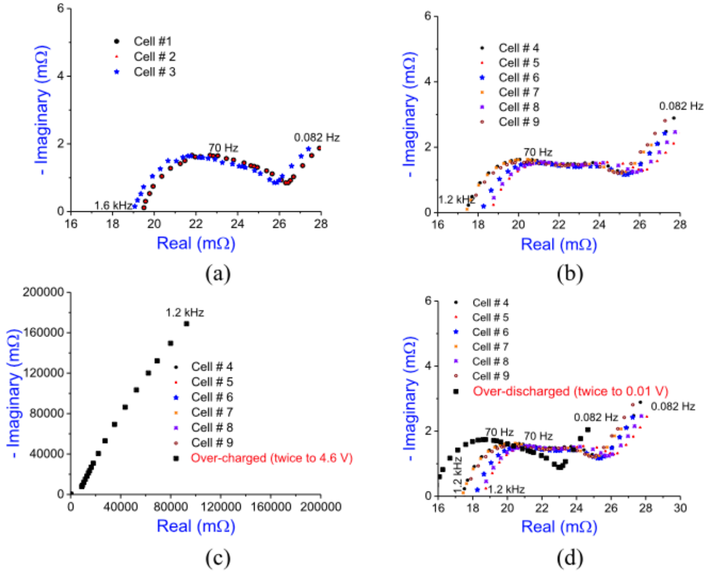
Several Research Efforts Demonstrate the Utility of EIS in Measuring Aging and Degradation

Two examples



Nina Meddings et al., National Physical Lab

"Application of Electrochemical Impedance Spectroscopy to Commercial Lithium-Ion Cells: A Review," *Journal of Power Sources, 480 (2020) 228742*



Bliss Cakhuff et al., Johns Hophins Univ.

"Impedance-Based Battery Management System for Safety Monitoring of Lithium-Ion Batteries," *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 65, NO. 8, AUGUST 2018*

What is Needed a Practical Implementation for In-the-field Diagnostics

EIS is only the “sensor” — it needs to be accompanied by intelligence capable of addressing the measurement’s limitations (e.g., repeatability, reproducibility, data interpretation, distinguishing between failure/aging modes…)

Models need to fuse relevant present and historical EIS data, operational and environment data (e.g., different SOCs, temperatures), extract appropriate metrics, and be “predictive”

Learning models benefit from data aggregation over large sets of batteries/cells in the field to increase confidence in prediction (statistical incidence of false positives & false negatives)

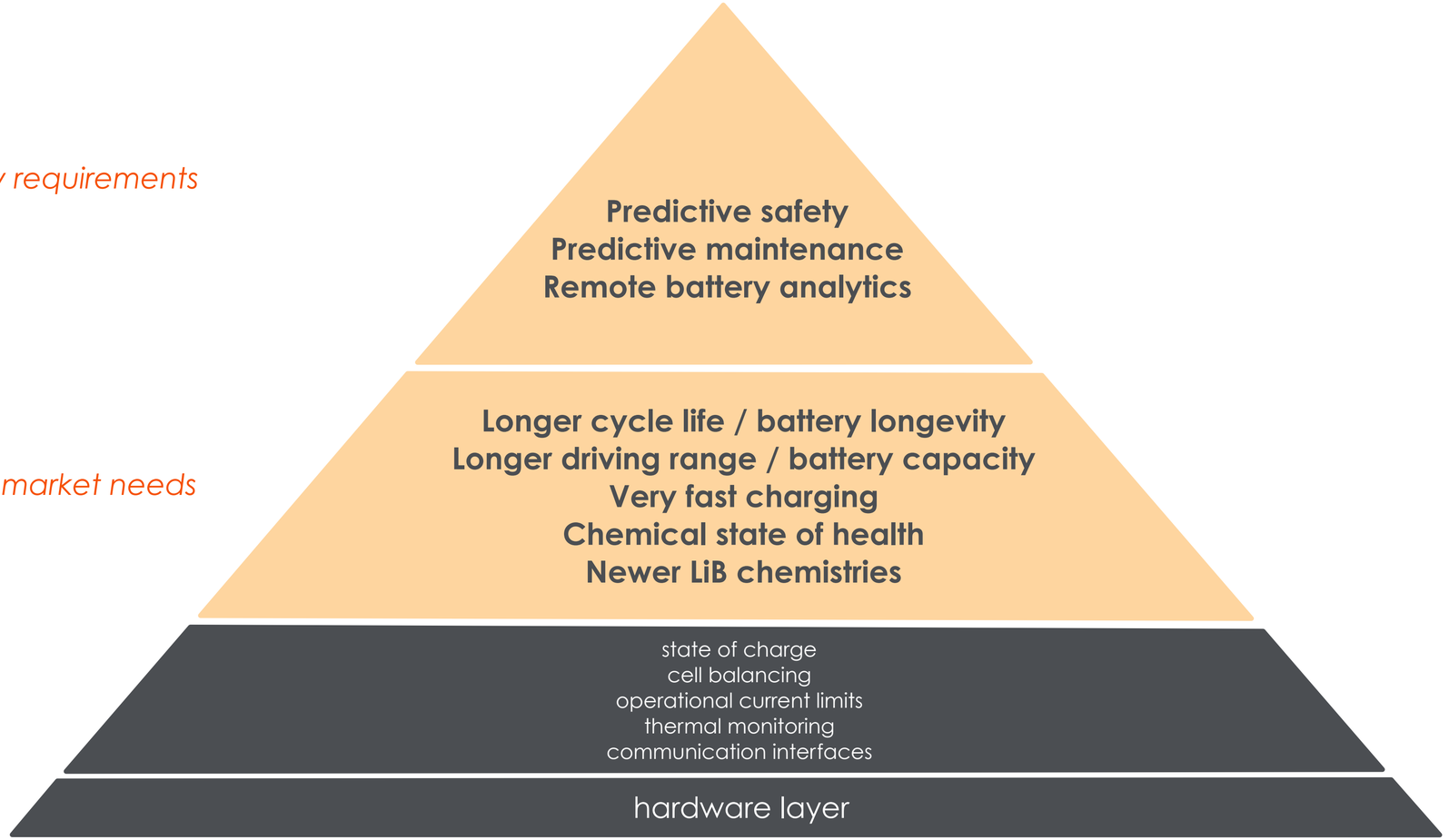
Solution must be “easy” to implement in a vehicle, preferably with no additional hardware to be cost-effective

An Expanded Role for the Battery Management System

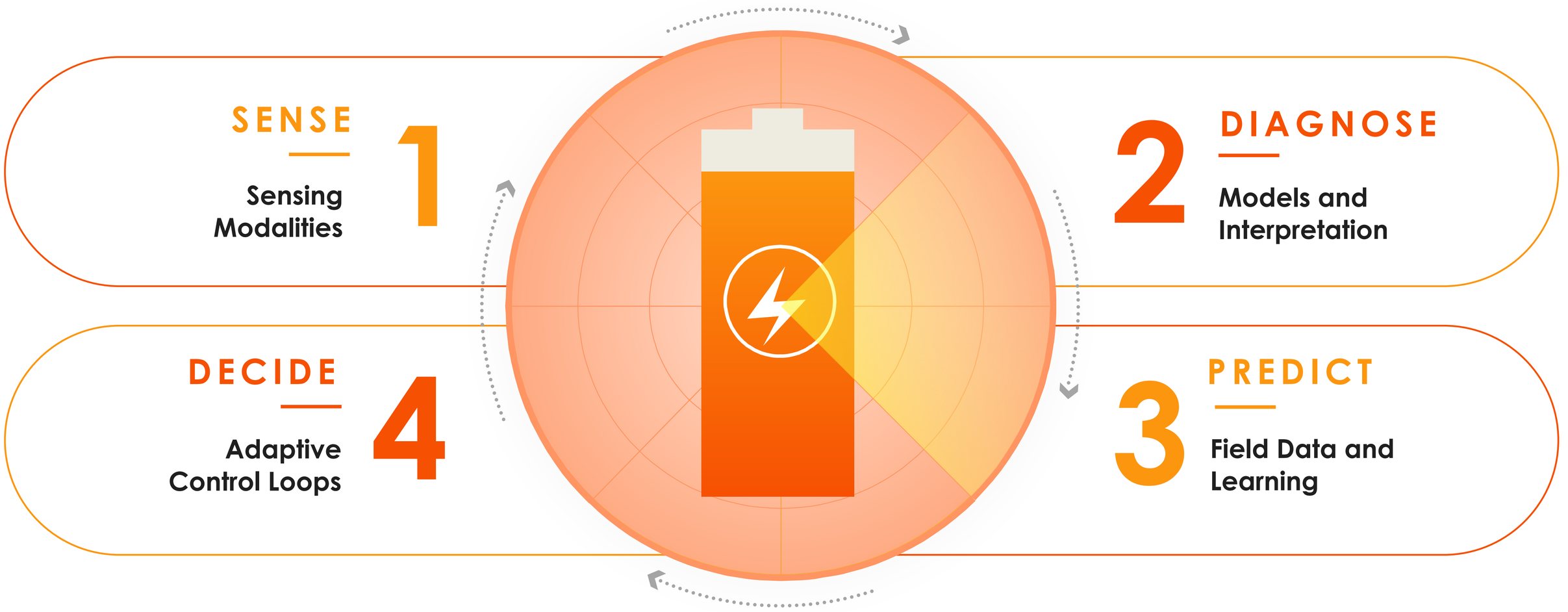
New safety industry requirements

New performance market needs

Conventional BMS



Intelligent and Predictive Algorithms are the Foundation of our BMS Software



Reimagining the battery experience….
with software only