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2024 AUSTIN

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DC Fundamentals of Testing Batteries

Martin Weiss

Chief Systems Architect, Transportation, NI

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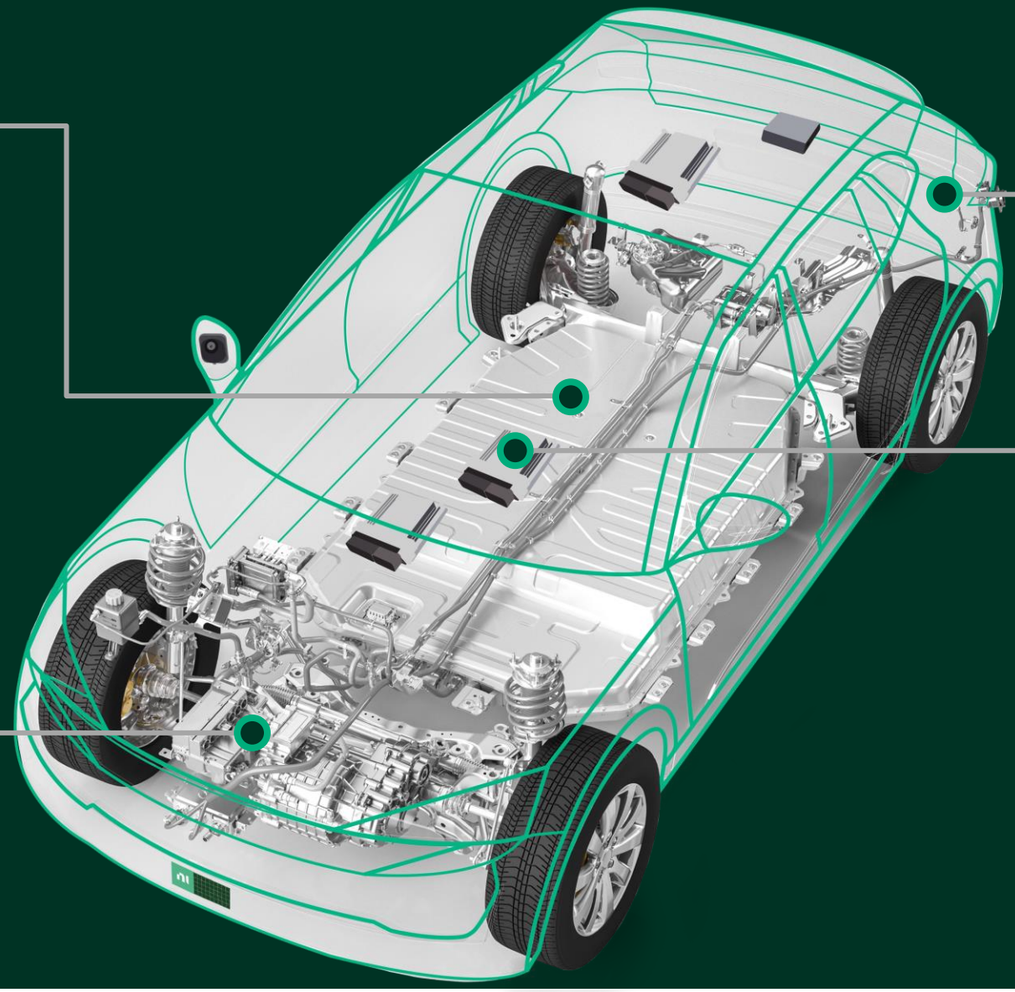
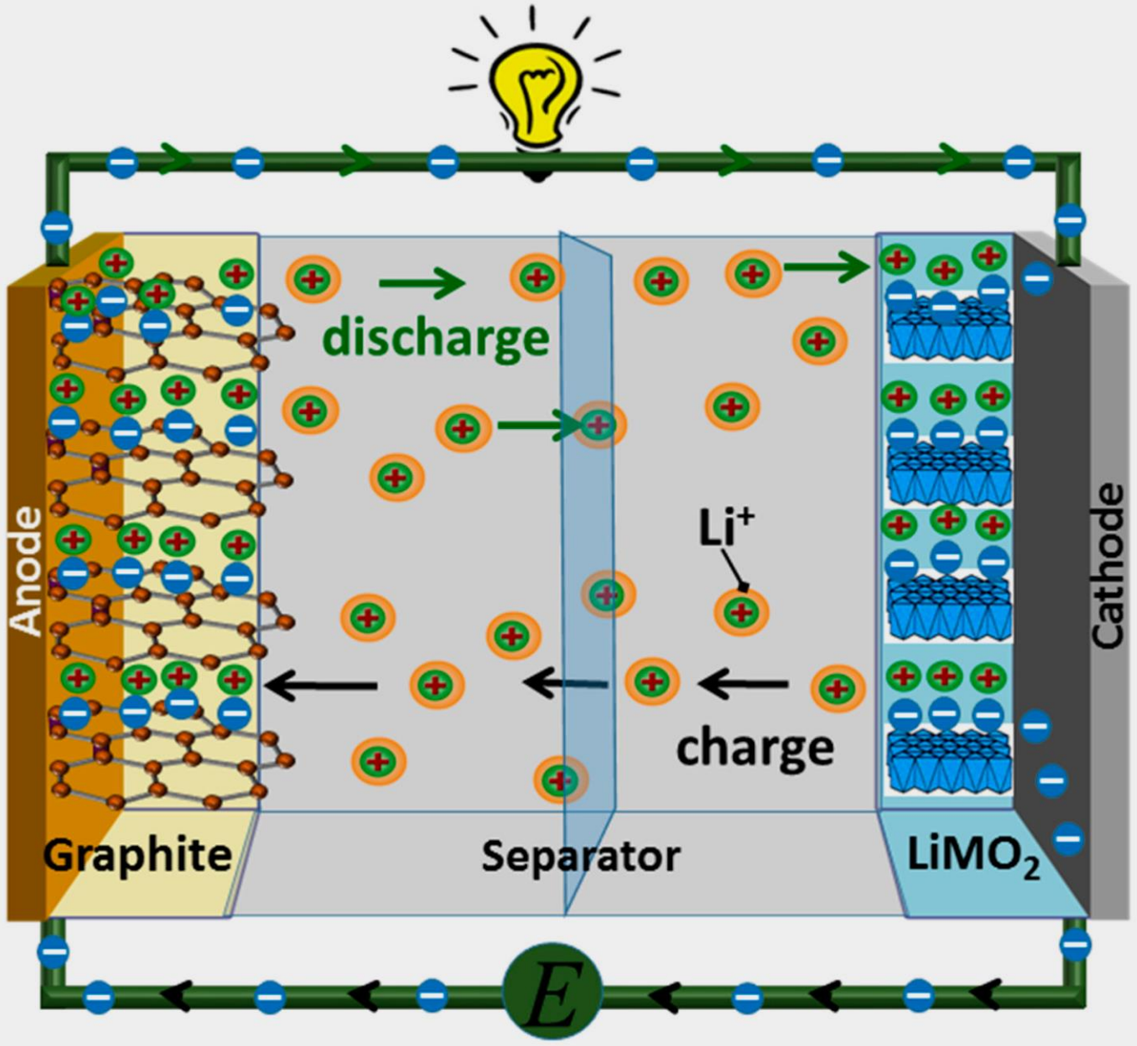
Presenter: Martin Weiss

Martin has over 30 years of experience developing automated test systems for evaluating power electronics and battery systems.

As the Chief Systems Architect at NI Transportation, Martin is responsible for the technical development and launch of new, industry-driven hardware and software test solutions. Previously, he worked as a Chief Product Director, Product Manger, Principal Design Engineer for high-tech companies including NH Research, Vocollect, Marconi Communications, and Telxon.

Accelerating EV Product Performance





Source: https://www.mdpi.com/2313-0105/4/1/7

Inside a Li-Ion Cell

Charging and Discharging (DC) plays a significant role in all forms of battery testing.

Batteries are **Electro-Chemical**

Battery testing can be:

Electro-Chemistry based

Electro-Physical based

Electro-Mechanical based
(and combinations of above)

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Inside a Battery Pack

Charging and Discharging (DC) plays a significant role in all forms of BMS testing.

BMS testing can be:

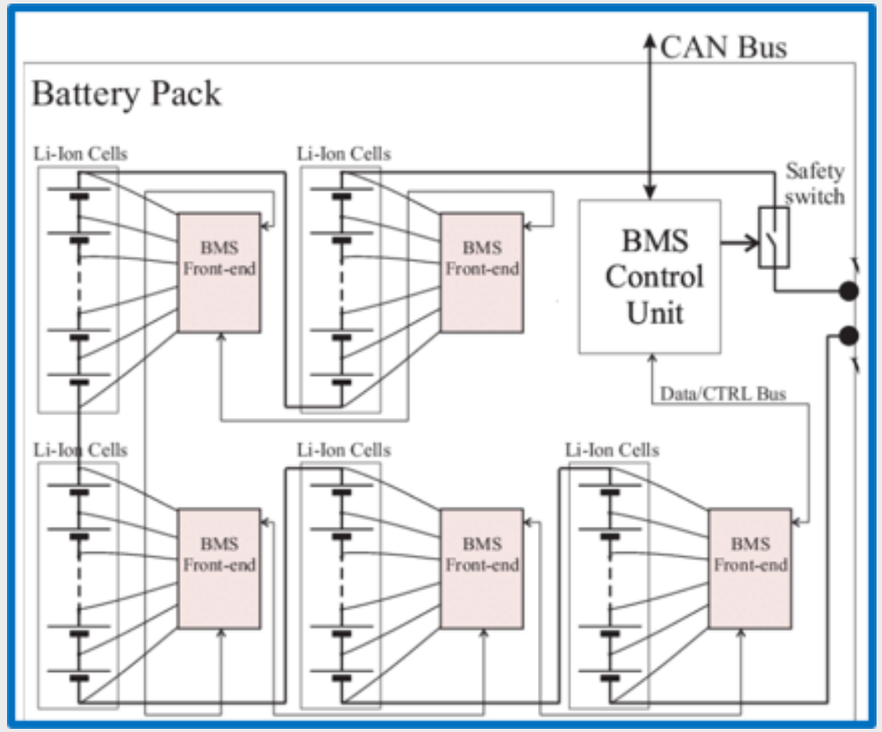
Controls-Theory based

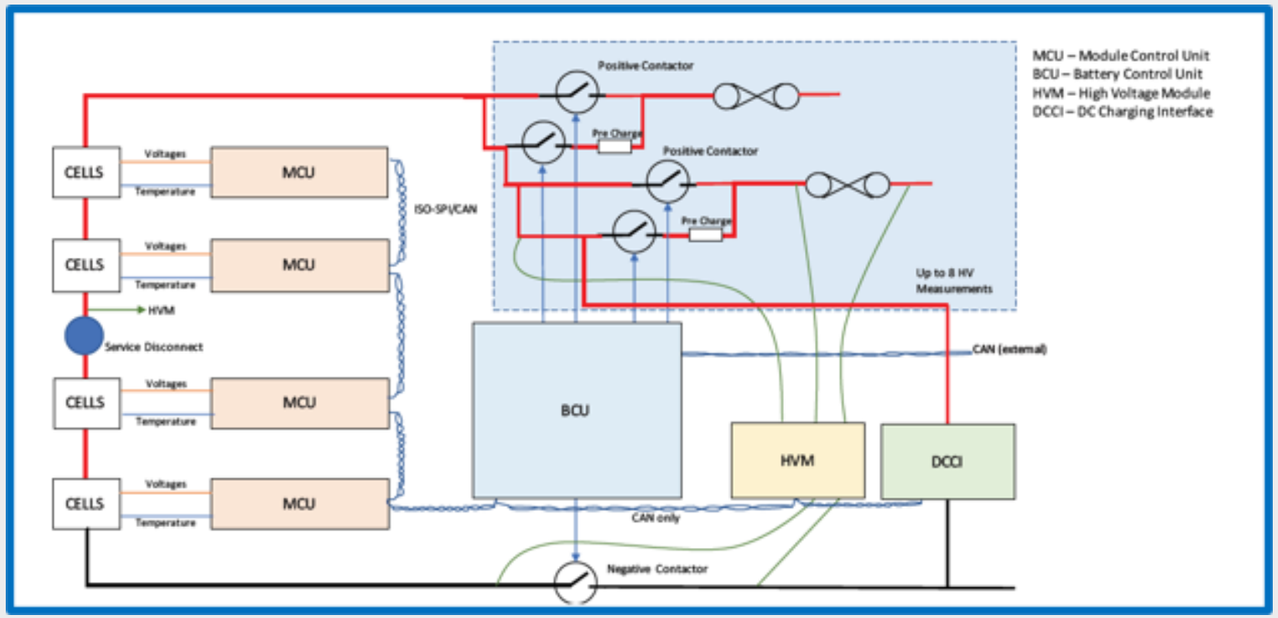
Safety Monitoring based

Systems Telemetry based

Battery State Algorithm based

Battery Cell Management based (and combinations of above)





DC is Fundamental in Most Battery Testing

ELECTRO-CHEMICAL TESTING

Chemistry Behaviors

- GITT
- PITT
- dQ/dV
- High Precision Coulometry

Cell Level Behaviors

- Capacity
- Temperature Effects
- Self-Heating
- Degradation
- Performance Dynamics

Module/Pack Behaviors

- Validation of multiple cells (with expected result)

ELECTRO-PHYSICAL TESTING

Cell

- Mechanical Dimensions
- Pressure (Needs / Exertions)
- Localized Phenomenon (Hot spots, thermal plate IF)

Module/Pack

- Thermal Management
- Electrical Interconnection
- Effect of BMS

Thermal Management Effects

Venting & Exothermic Management

ELECTRO-MECHANICAL TESTING

Cell Form Factor

- Swelling
- Mechanical Robustness

Mechanical Sealing

(Cell, Module or Pack)

Assembly Validation

Cooling System Validation

Abuse

- Crash Simulation
- Regulations
    - Shipping (UN)
    - EV (EU ECE R100)

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Fixed vs Flexible Solutions

Manual Methods | **Source & Load** | **Automated System** | **Next Gen System**

Fixed

Limited (or no) control of external systems

Embedded design – Highly task specific

Manufacturer or integrator dependency

Seemingly "small" changes may be impossible to make without redesign

Flexible

Easy third- party integration

Dynamic software controls

Modular and scalable power

Future-proofing

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Battery Test Challenges

Temperature Dependency

High Power Hazard

Long Test Times

Expensive

Constant Changes

Aggressive Program Schedule

Time-to-Market

Battery Performance

Total Cost of Test

The Right Approach to Control Your Test Strategy

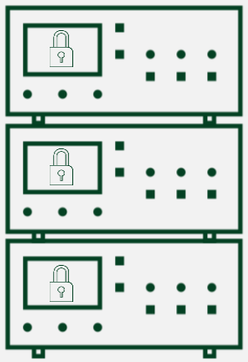
Closed System

"Vendor Knows Best"

Fixed Functionality

Closed Ecosystem

Customer Pays



Open Connected Approach

"Customer Knows Best"

Customizable Solution

Open, Vibrant Ecosystem

Customer Designs

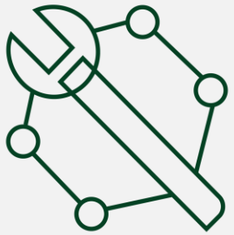
Fully Custom System

"Customer Does Everything"

Ground-Up System

No Ecosystem

Customer Maintains



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Power Electronics from Validation to Production

RESEARCH AND DEVELOPMENT → ← VALIDATION → ← PRODUCTION

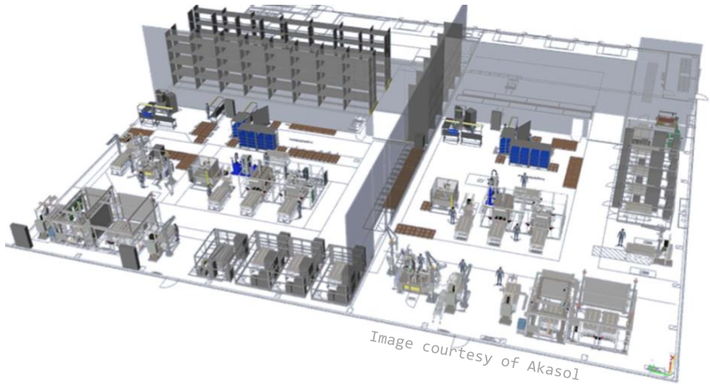
Software and Hardware Development | Virtual Test | Prototyping | Component Characterization | Durability | System Integration | Field Test | Process Tests | End of Line Test

Research and Validation Labs

Open and Flexible Solution Stack

- Data Analytics
- Data & Systems Management
- Test Software (Control/Sequencing)
- Control System (Comms, Measurements, Safety)
- Power Electronics
- Lab/Line Infrastructure
- Connectivity and Fixturing
- Commissioning, Operation, Maintenance

Battery Production Lines



Connected Workflow

← INCREASE PRODUCTIVITY DEEPEN SYSTEM INSIGHT LOWER TOTAL COST OF TEST →

NI Delivered | Integration Company

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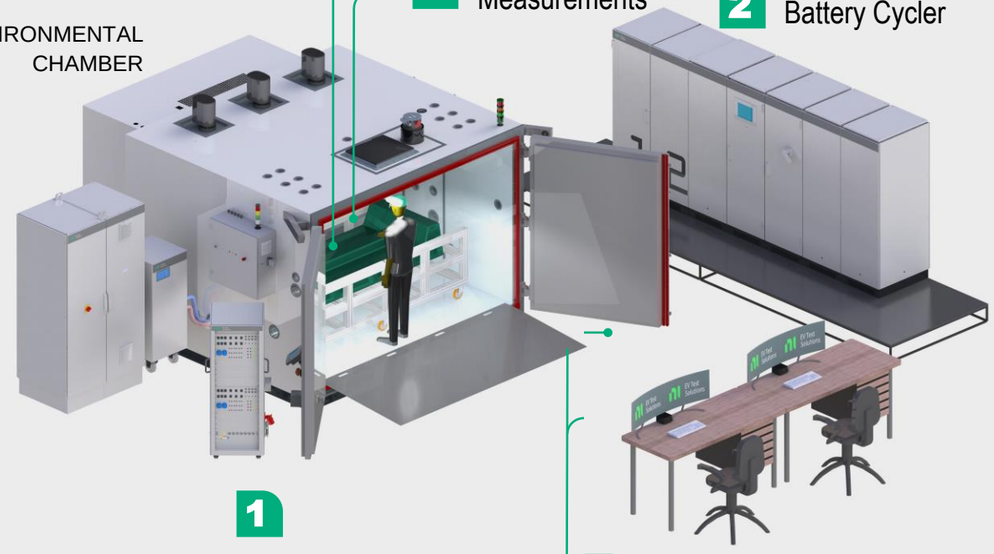
Modern Battery Lab Architecture

Software Connected Workflow

DESIGN — VALIDATION — PRODUCTION



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NI Software Suite

- Data Analytics
- Data & Systems Management
- Test Software
- Control System
- Power Electronics
- Lab/Line Infrastructure
- Connectivity and Fixturing
- Commissioning, Operation, Maintenance

6 HV Electronics Module And Battery EOL Testers

1. Scalable measurements at low cost per channel
2. Connection to power electronics, less rework
3. Rugged in-chamber measurements
4. Open, out-of-the-box or custom battery test software
5. Customized data dashboards for facility management
6. High voltage module and battery EOL quality in production facilities
7. NI's Software Suite

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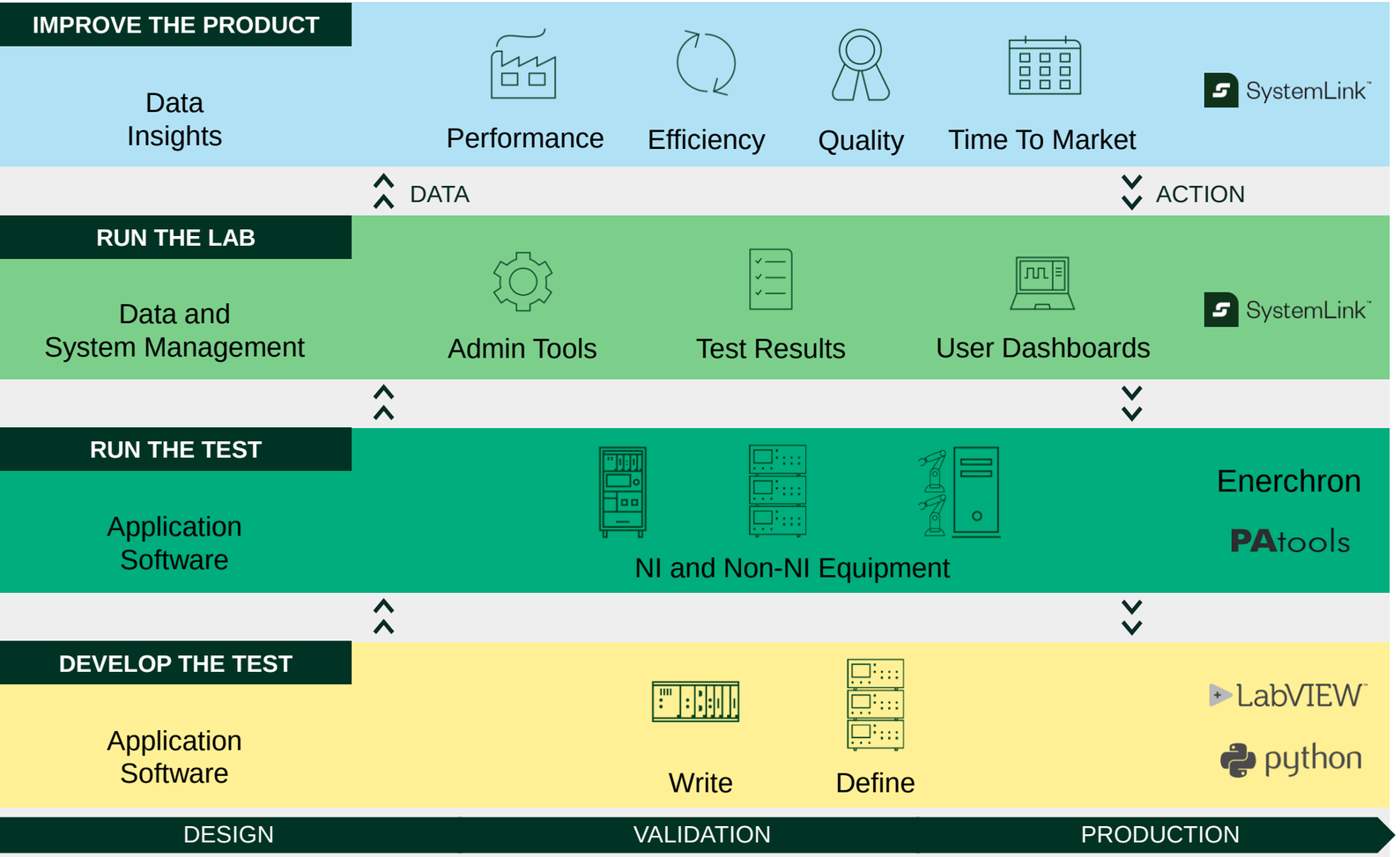
Battery Test System (BTS) Architecture

Open, Connected, Software-Defined Approach to Operating Modern Labs



Automate & Streamline Workflows

Connect & Increase Utilization of Test Systems

Enhance Data Management & Analysis

Automated Data Analytics

Integrated Suite with Complete Traceability

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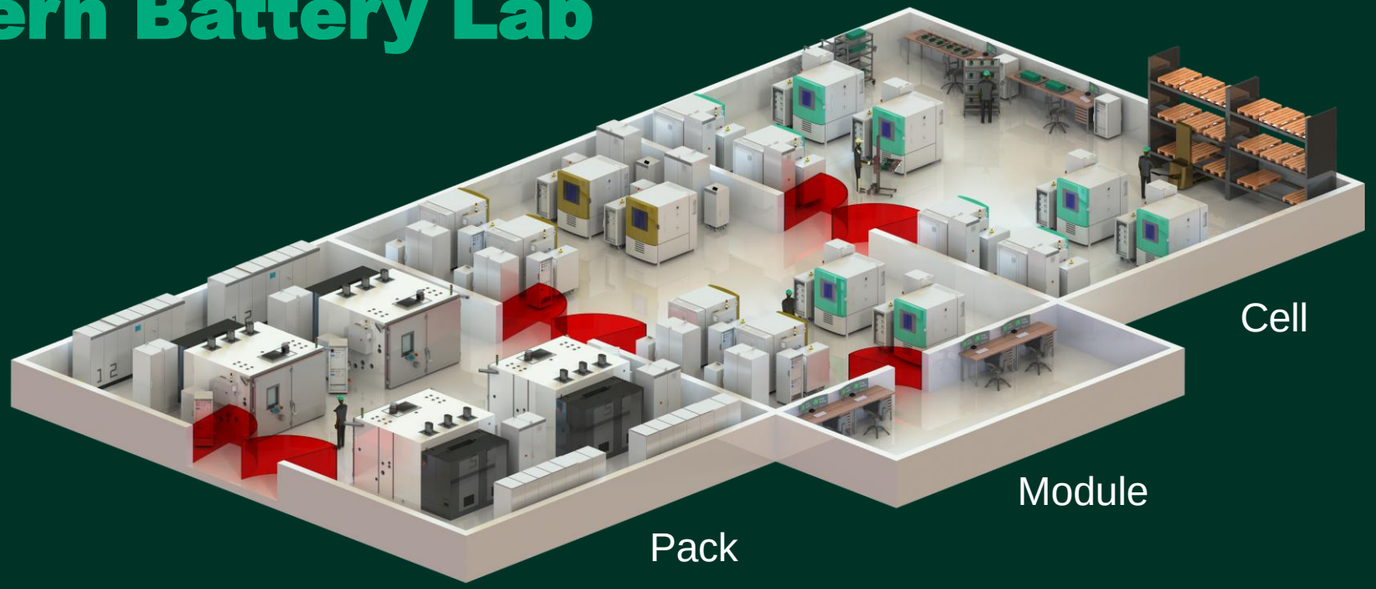
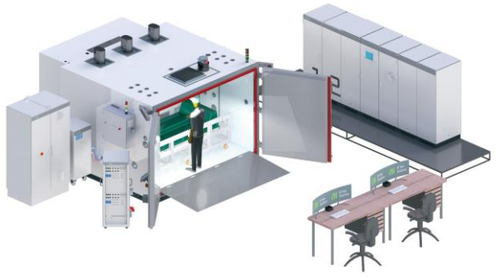
Modern Battery Lab





Pack

Module

Cell

Transformation of the Battery Validation Lab

OPEN AND FLEXIBLE SOLUTION STACK

Global Distributed Lab, Connected Lab
Product Performance

Multi-Test Bench, Connected
Lab Product Performance

Multi-Test Bench
Facility Management

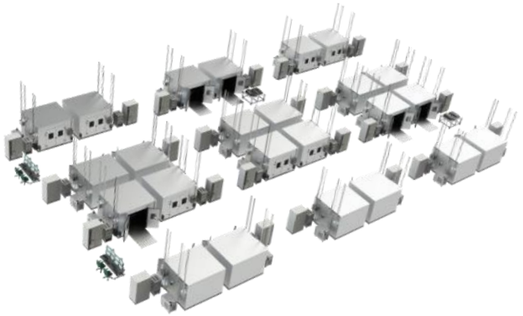
Single Validation Workbench
Customizable Test

Software

+

Data

Global Validation Labs



Scalability with
Software-defined Battery Lab

Battery Validation Workbench

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Mapping NI Battery Test Software Workflow to Your Needs

NI Battery Test Software Workflow

Configuration Management | Asset & Device Management | Test Performance Monitoring | Engineering Data Automation

Situational Awareness

APPLICATION VIEWS | USER DASHBOARDS | CONFIGURABLE REPORTS | ADMIN TOOLS

Systems Connectivity

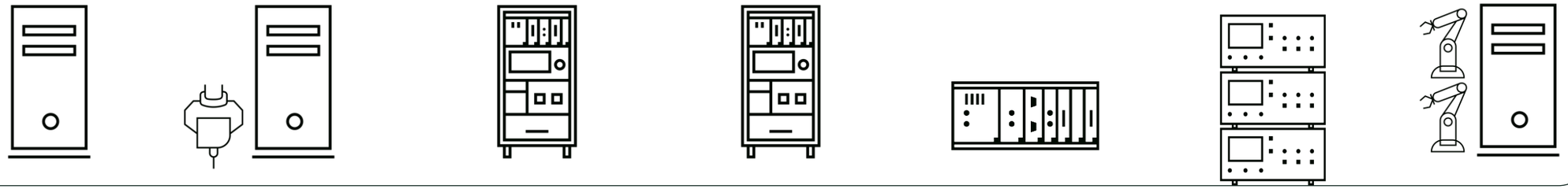
DEVICE DISCOVERY | REMOTE EXECUTION | MONITORING AND TAGS

Data Gateway

FILE INGESTION | TEST RESULTS

Battery Labs

Desktop PC/Servers | Test System Vendor A | Test System Vendor B | NI Battery Test System | NI Test Systems | Other Instrumentation | Automation systems



NI Battery Cyclers for Pack, Module, and ESS

Product	Feature Highlight	Dynamic Response	Technology	Cooling	Granularity	Cost/ Watt	Footprint/ Weight
ERS-BIC	Overload capability with fast recovery	Fast (ms)	IGBT	Water	Medium	● ○ ○	Large
NHR-9300	Mobility and power flexibility	Fast (ms)	SiC	Air	High	● ◐ ○	Small
HPS-17000	High frequency test signal production, High Serviceability	Very Fast (sub-ms)	SiC	Air	High	● ● ○	Medium

ERS-BIC

NHR-9300

NI HPS-17000

KEY FEATURES

ERS-BIC Solution Focus

Overload Capability

Dramatically increase peak loads without having to size the system for continuous power

Fast recovery capability

High Power / Lower Cost

Can make larger machines without linear cost increase

Multi-Channel Flexibility

Cell to be adjusted to the next pack design, ideal for validation

Rugged

IP 54 for protection near production areas

IMAGE COURTESY OF HEINZINGER

NI ERS-BIC | Use Cases

CUSTOMER: Battery Test Lab (SGS Group)

APPLICATION: Battery Pack Validation Test

SOLUTION: ERS-BIC

LAB SIZE: 30+ Stations (cycler channels and environmental chambers)

WHY NI

Extensive options for carrying out climatic and electrical tests along with overload capability with fast recovery

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KEY FEATURES

HPS-17000 Solution Focus

Battery Testing up to 1500V
for electric vehicle and energy storage applications

High Frequency Test Signal Production
for increased battery test coverage

Parallel Operation via time synchronization over Ethernet and **time-stamped setpoint** streaming for large, distributed deployments

High Serviceability and Modularity
Enhanced serviceability directly by customer

Swappable power bricks reduces downtime

System can run safely even if one power brick needs repair

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NI HPS-17000 | Use Cases

CUSTOMER: EV OEM

APPLICATION: EOL Test for Multi-Port Battery

SOLUTION: HPS-17000

LAB SIZE: 6 Cyclers Per Test Station

WHY NI

Units are dynamically reallocated to the different ports while stepping through the test procedure.

Tests include injection of high-frequency test patterns.

KEY FEATURES

9300 Solution Focus

Mobile-Friendly

Non-fixed installation / flexible configuration at different sizes

Easy serviceability by customer at the cabinet level

Future-Proofing: Modular and Scalable Power

Incremental increase at the cabinet level

Increase / split power at 100kW blocks

Software control dual range

High Power Density, Small Footprint, and Lightweight

Saves floorspace

Modular and scalable power 100kw up 2.4MW

NI Battery Cyclers | Use Cases

CUSTOMER: Government Research Lab

APPLICATION: Battery Pack Validation

SOLUTION: 9300

LAB SIZE: 30+ Reconfigurable Stations

WHY NI

Flexible: Lab was set-up with 9300 cyclers 1.1MW and 1.0MW configurations to reflect any power /voltage easily through a software command.

Future-proof: The flexible, and easy to use systems gives capability to test a wide range of power.

Mobile: Door-sized cabinets with wheels allow them to move hardware easily within their facility.

KEY ADVANTAGES

NI Battery Cyclers

1. **Future-proof design** with modular and scalable power up to 2.4MW and wide-operating envelope.
2. **Designed for Battery Test** with built in safety features: safety isolation contactor, polarity checker, pre-charge circuit, and more.
3. **Reliability & Serviceability** maximizes up-time through modular design.
4. **Flexible, Open Test Software Platform** to evolve with your future battery test requirements.
5. **Management & Analytics** to manage test stations, workflows and data efficiently and effectively.
6. **NI Extensive Partner Network** provides battery and system experts to solve your system test requirements.

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NI Integration | Use Cases

CUSTOMER: European OEM

APPLICATION: EV Battery Test for Cell/Module/Pack

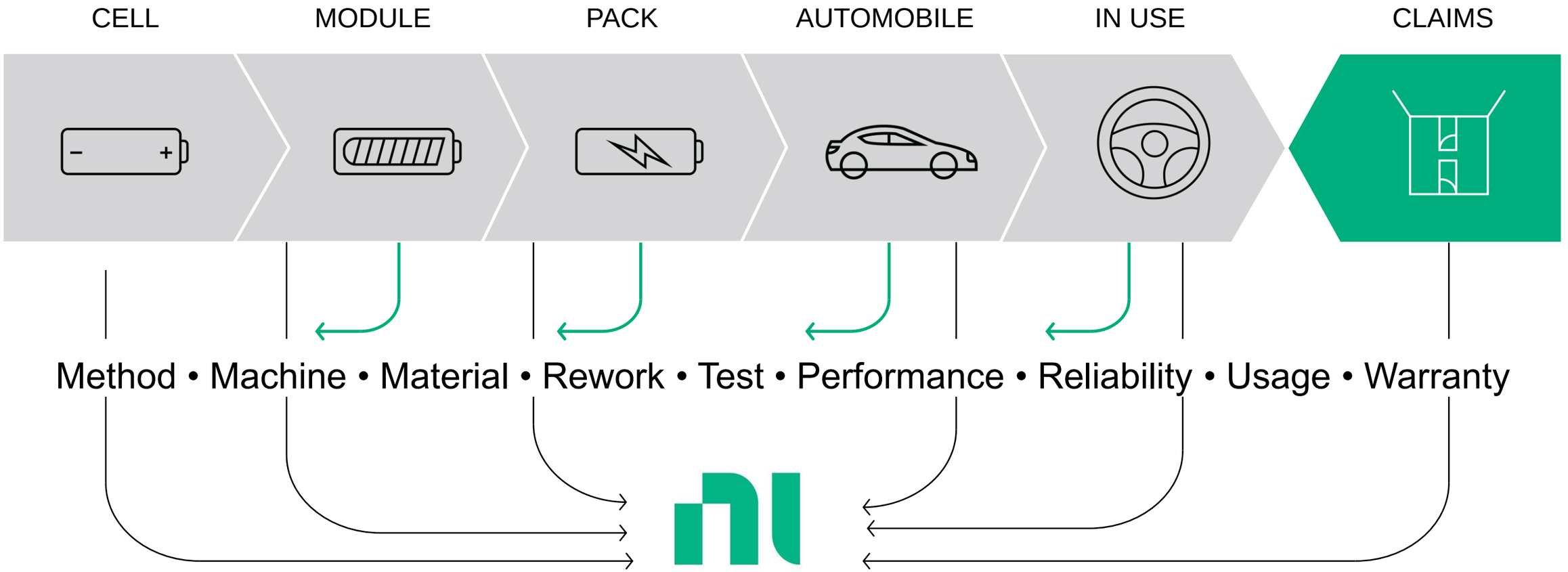
SOLUTION: Battery Test Field Integration

LAB SIZE: 30+ test station for cell, module and pack

WHY NI

- Parallel operation of 12 climate chambers for cell test in China and Sweden facilities
- 8 module testers for 400, 1000 and 1600 Amps
- 11 chambers for pack testing with various HVDC operation modes

End-to-End Visibility | EV Battery Process



Battery Test System (BTS) Architecture

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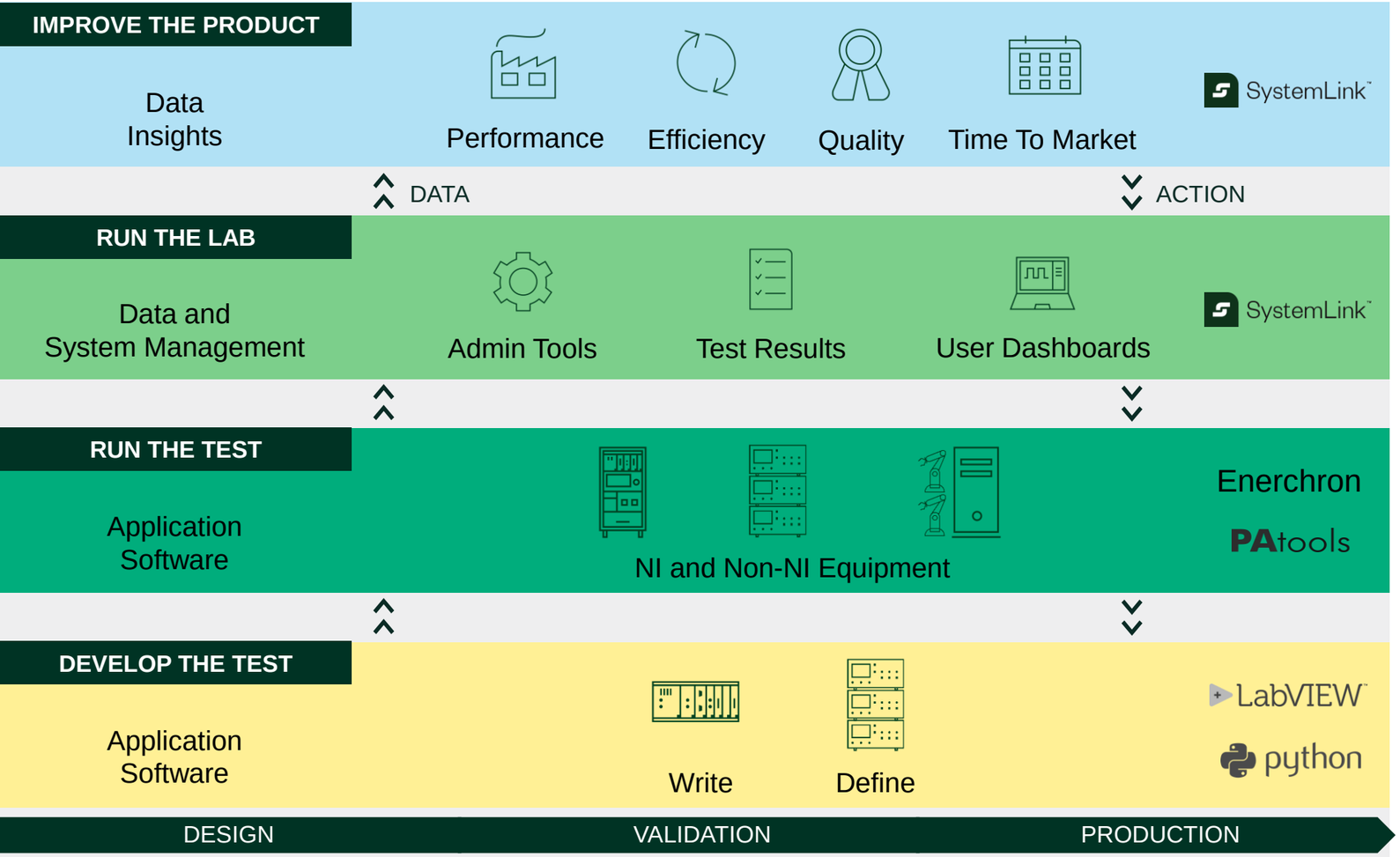

Automate & Streamline Workflows

Connect & Increase Utilization of Test Systems

Enhance Data Management & Analysis

Automated Data Analytics

Integrated Suite with Complete Traceability

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Using Data to Improve Batteries

1000’s Of Hours Saved Per Project

Maintain Vendor Independence

NI is helping us reduce risk, perform our engineering work more efficiently, and give us a **faster time to insights and decisions**.

Steve Tarnowsky

Retired Director, Global Battery Cell Engineering

General Motors

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