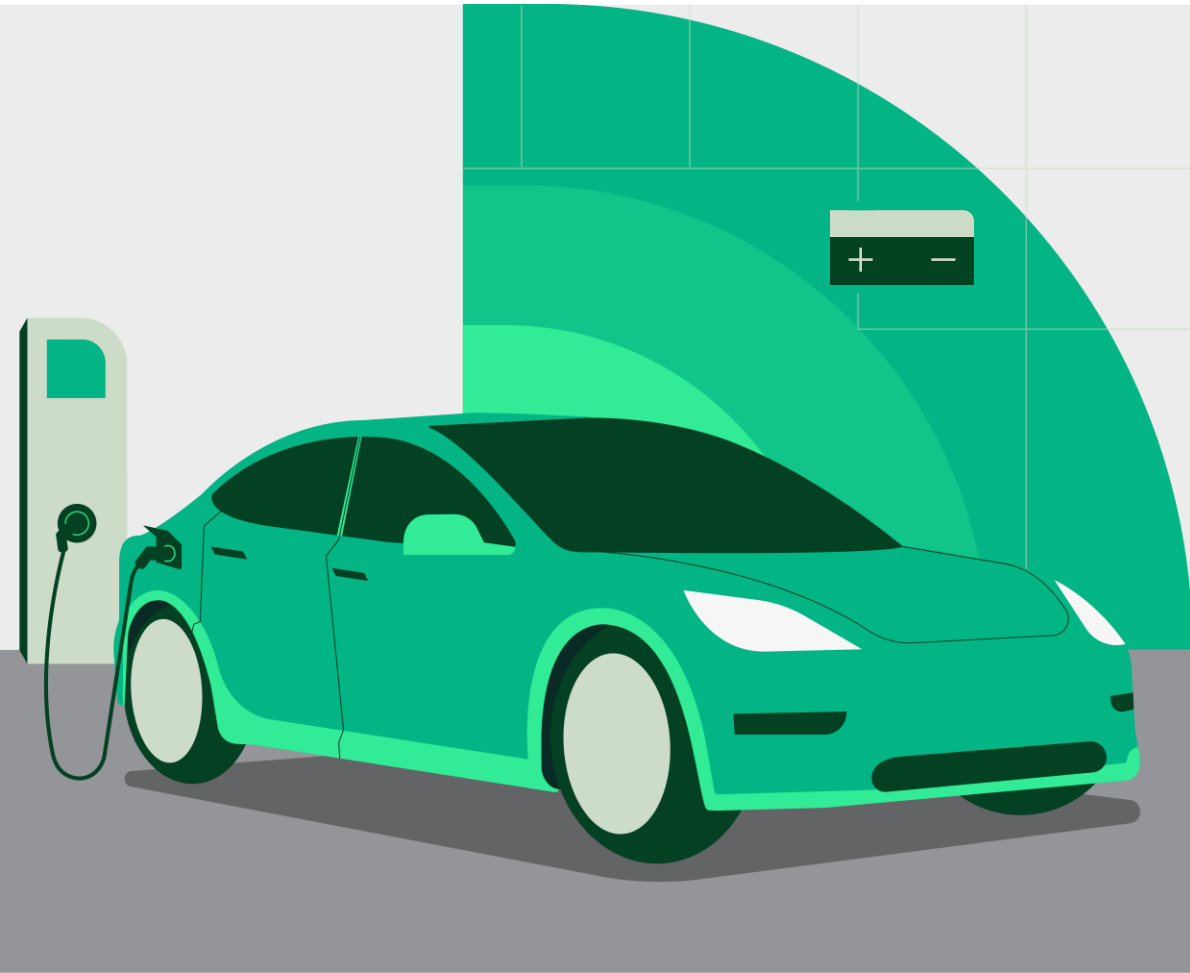WELCOME TO AUSTIN

CONNECT

2023 AUSTIN

Modern Battery Lab

Future Proof Battery Testing Through a Software-Defined Approach

Elijah Kerry

Chief Offering Manager, EV Energy Storage

Plan for Today

Software-Defined Battery Lab

Market Disruptions

Solution Overview

Hardware Roadmap

Software Roadmap

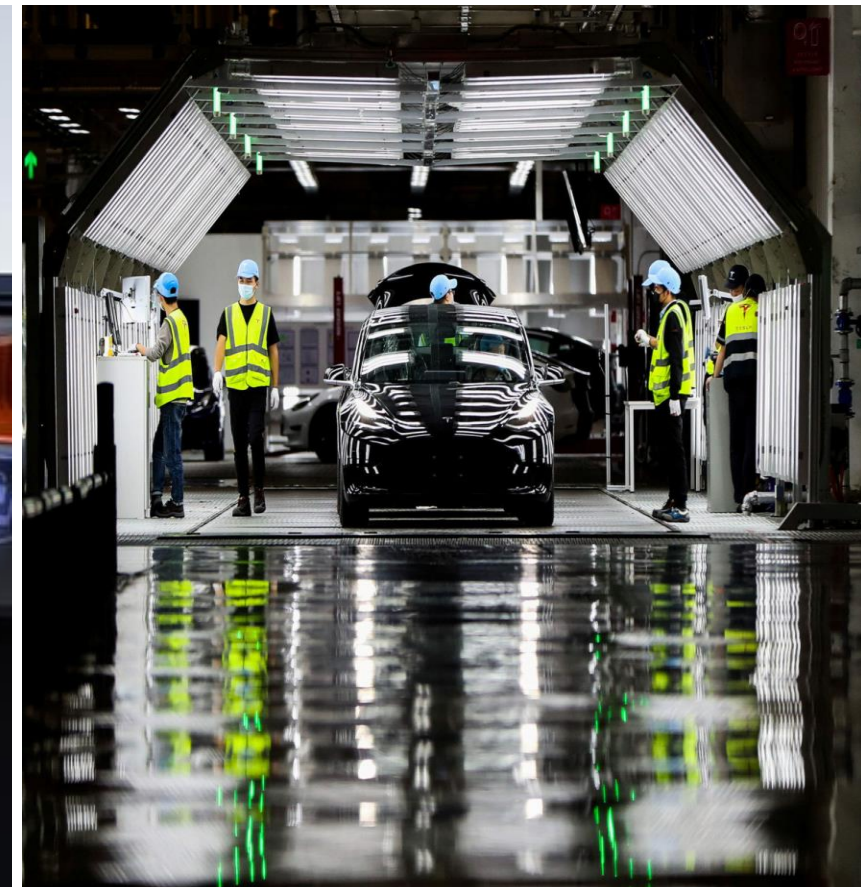# The Pace of Change Is Faster than Ever

Organizations Must Rethink Product Innovation or Risk Falling Behind

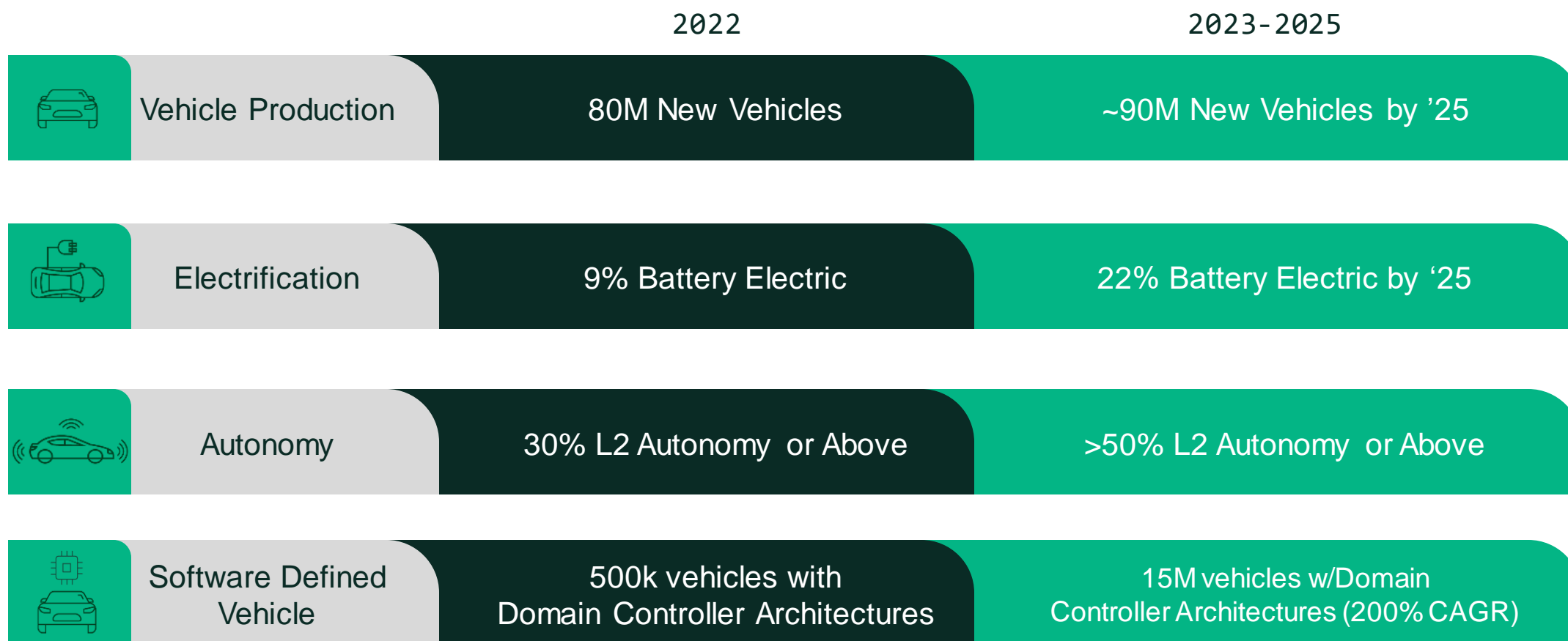**DRIVING TRAFFIC FATALITIES AND CARBON FOOTPRINT TOWARD ZERO**

SHIFTING PORTFOLIOS TO SOFTWARE-DEFINED BEVs

EVOLVING SUPPLY CHAINS AND COMMERCIALIZATION MODELS

The Road to the Future is Paved with Software

Acceleration of EV and ADAS Roadmaps will Require New Tools and Process to Meet Demand

		2022	2023-2025
	Vehicle Production	80M New Vehicles	~90M New Vehicles by '25
	Electrification	9% Battery Electric	22% Battery Electric by '25
	Autonomy	30% L2 Autonomy or Above	>50% L2 Autonomy or Above
	Software Defined Vehicle	500k vehicles with Domain Controller Architectures	15M vehicles w/Domain Controller Architectures (200% CAGR)

Overcome Battery Test Challenges

○ **Accelerate Time to Market**   ○ **Improve Battery Performance**   ○ **Reduce Total Cost of Test**

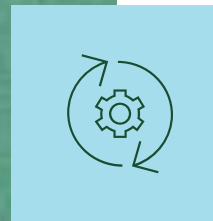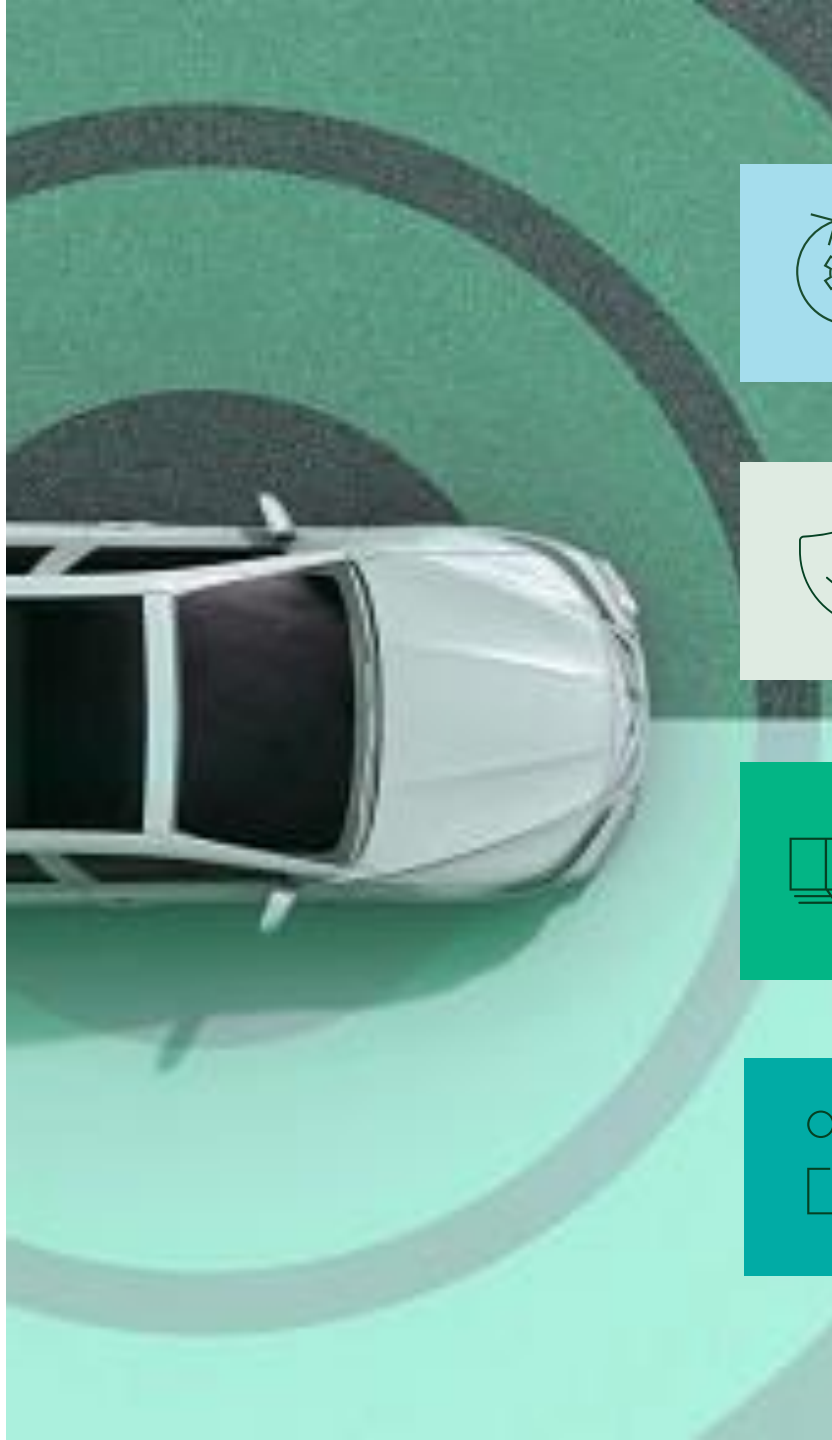|		
Temperature Dependency	**Long Test Times**	**Constant Changes**
High Power Hazard	**Expensive**	**Aggressive Program Schedule**

At NI, we're revolutionizing how enterprises use test systems and insights to drive product and business performance.
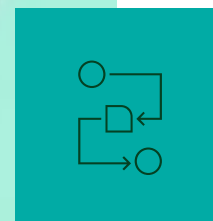
Reduce time to market by accelerating product development

Deliver customer satisfaction by improving functionality and reliability
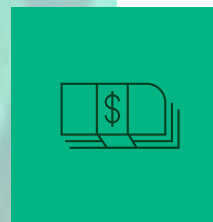
Improve the bottom line by reducing operational cost

Prepare for the future by adapting to evolving test needs

An Open, Software-Defined Approach to Transform the 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

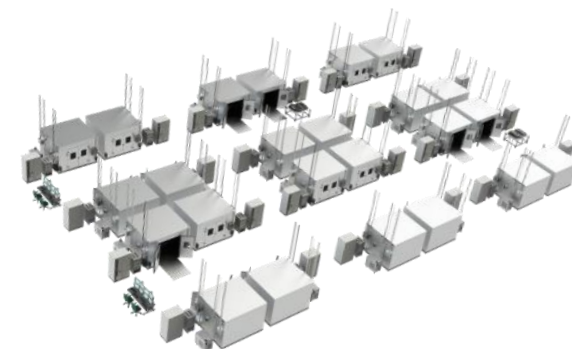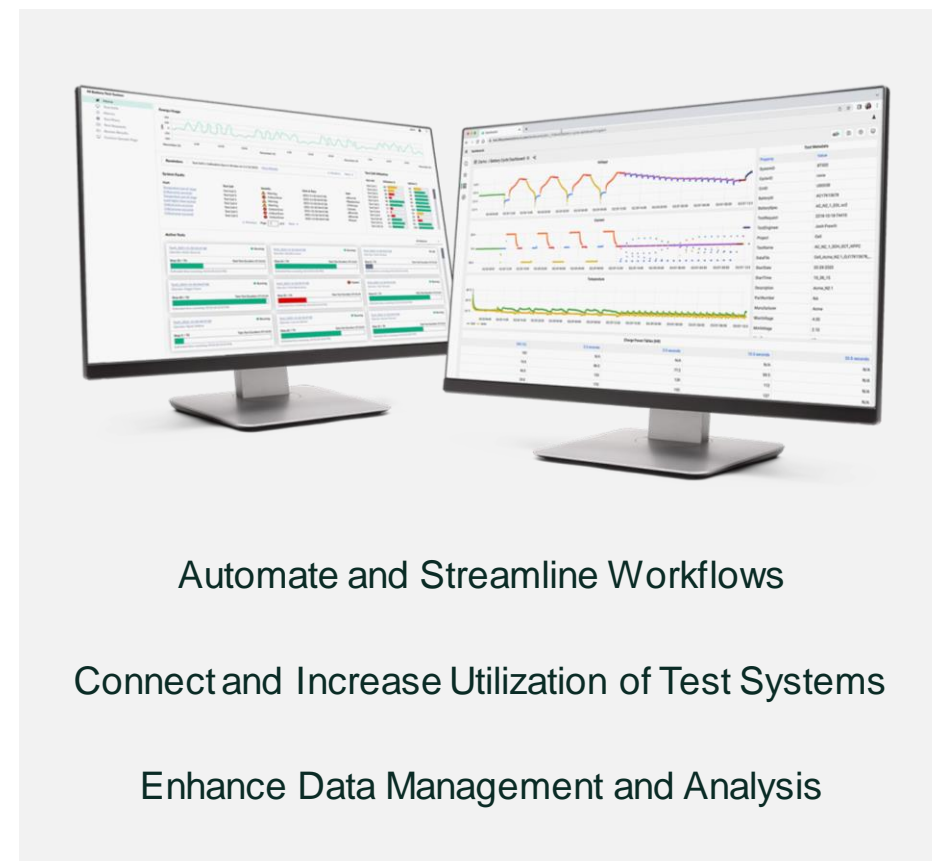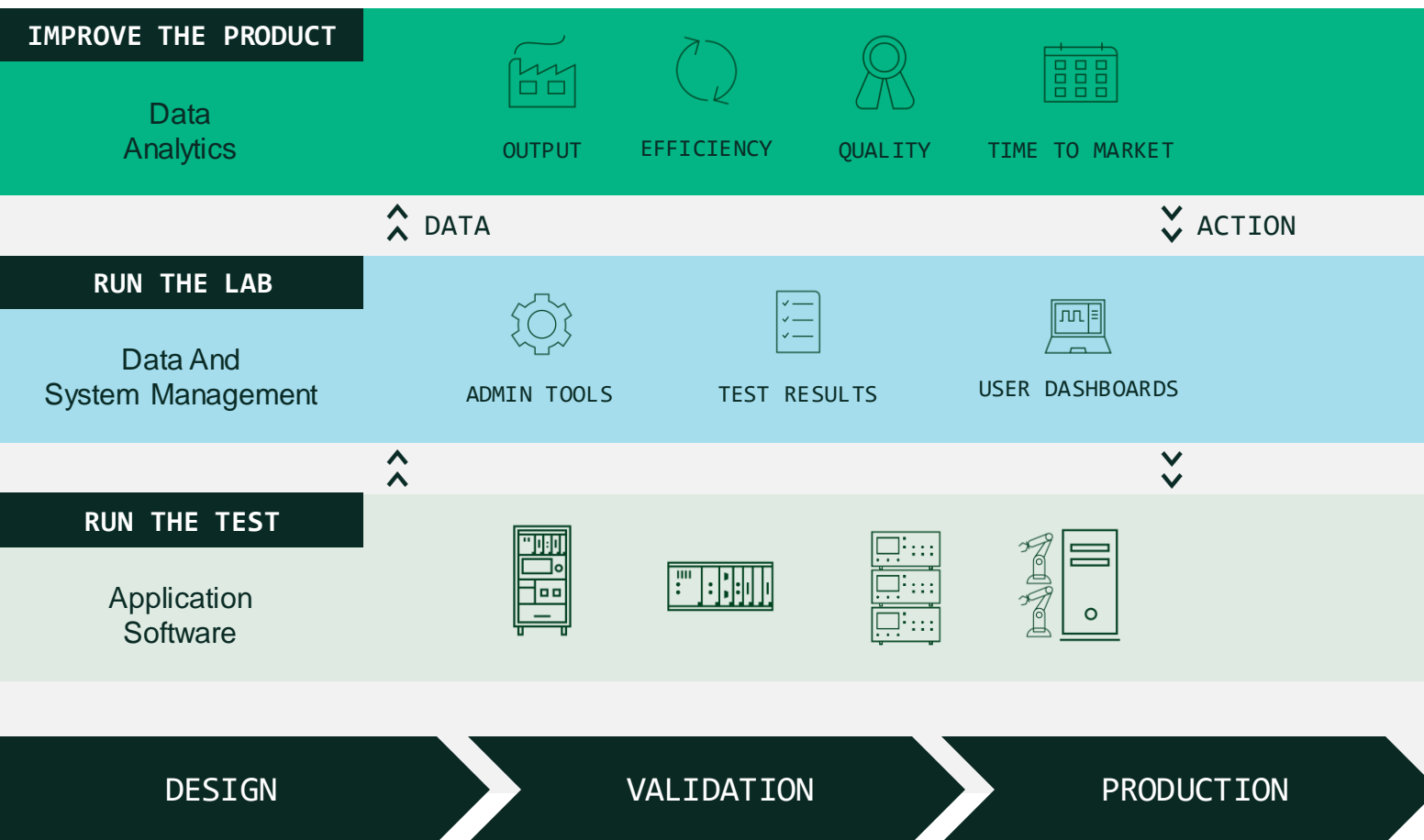**Single Validation Workbench Customizable Test**

SOFTWARE

+

DATA

Global Validation Labs

SCALABILITY WITH SOFTWARE-DEFINED BATTERY LAB

Battery Validation Workbench
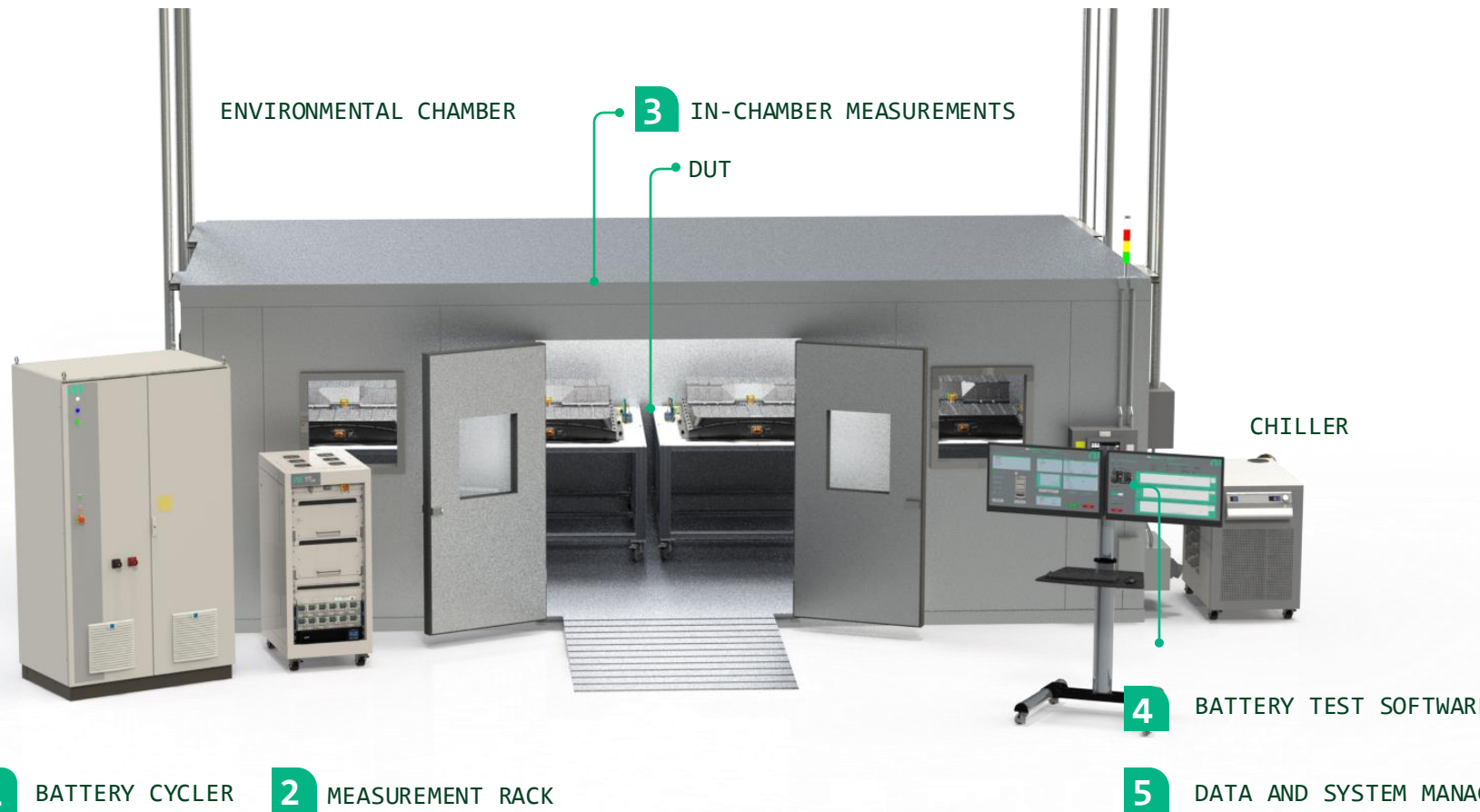
The Software-Defined Battery Lab

IMPROVE THE PRODUCT

Data Analytics

OUTPUT   EFFICIENCY   QUALITY   TIME TO MARKET

⌃⌃ DATA   ⌄⌄ ACTION

RUN THE LAB

Data And System Management

ADMIN TOOLS   TEST RESULTS   USER DASHBOARDS

⌃⌃   ⌄⌄

RUN THE TEST

Application Software

DESIGN ▶ VALIDATION ▶ PRODUCTION

Automate and Streamline Workflows

Connect and Increase Utilization of Test Systems

Enhance Data Management and Analysis

Battery Test System (BTS) powered by PAtools

ENVIRONMENTAL CHAMBER

3 IN-CHAMBER MEASUREMENTS

DUT

CHILLER

4 BATTERY TEST SOFTWARE

1 BATTERY CYCLER **2** MEASUREMENT RACK **5** DATA AND SYSTEM MANAGEMENT

1 Modular, flexible and scalable battery cycler portfolio

2 Expandable measurement rack with real-time controller

3 Rugged in-chamber measurements

4 Open, out-of-the-box or custom battery test software

5 Customized data dashboards for facility management
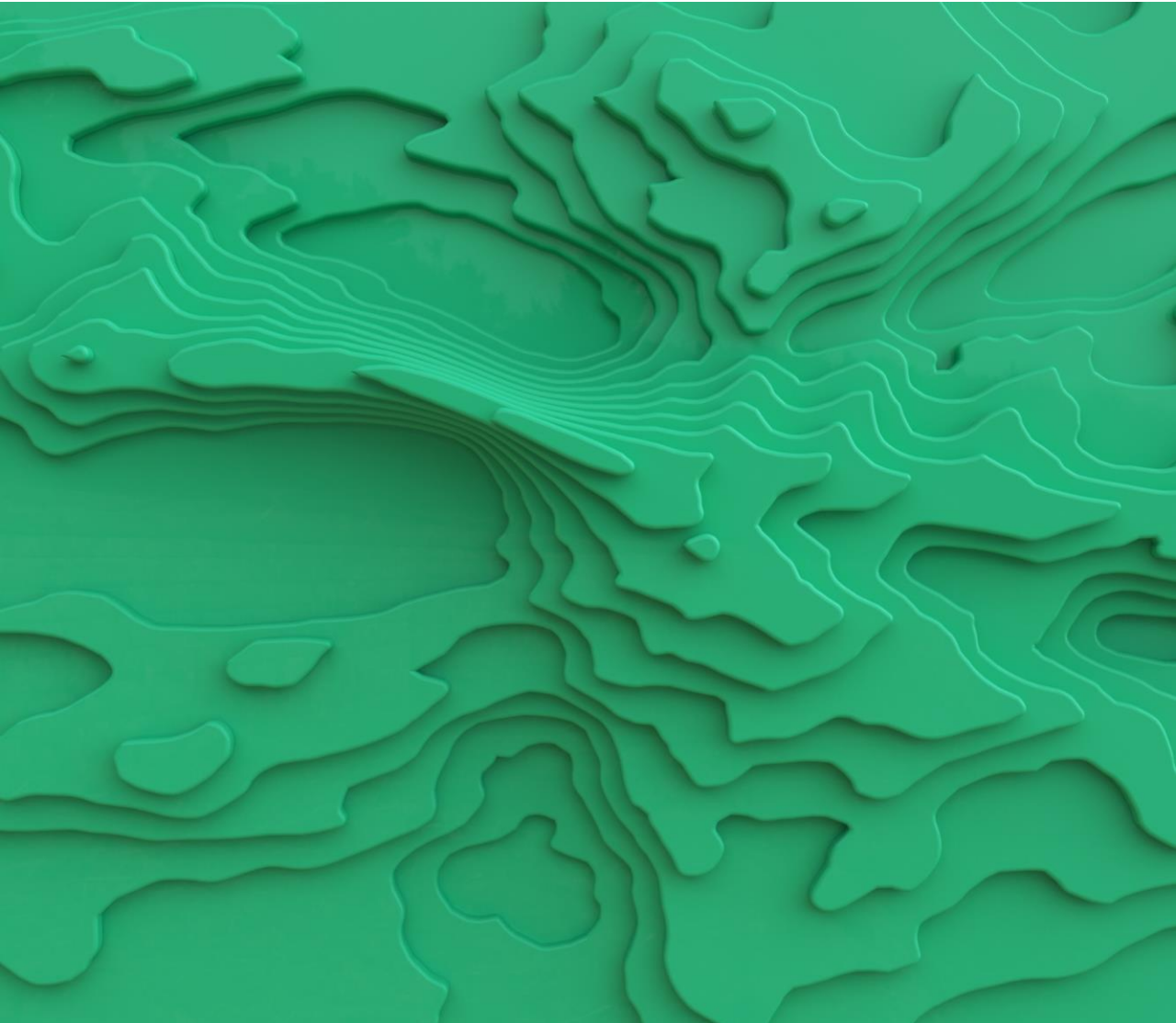
Hardware

Battery Cycler Integration in the NI Software Workflow

Seamless integration with NI cyclers, openness for third-party cyclers

Configuration-based interface for most existing Cyclers (CAN/Ethernet)

Interface with non-standard Cyclers through custom software plug-in

Increased development efficiency by standardizing software UI for customer battery cycler collection

HPS-17000

NHR-9300

NHR-4800

NHR-9200

ERS-BIC

NI Battery Cycler Portfolio – Highlights Pack Level

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

Increased Precision Power Measurement Capability

Network based high accuracy voltage, current and power measurement with warranted specifications for battery cyclers.

Key features

Up to 2000A Current Input (depending on current transducer)

0.05% Guaranteed Accuracy on Voltage and Current Typical

1.25MSPS Sample Rate

Continuous background calibration

Gain, offset, signal path interleaving

Thermally stabilized measurements

DSUB Interface to active Fluxgate current transducers

+/-10V Input, +/- 2A
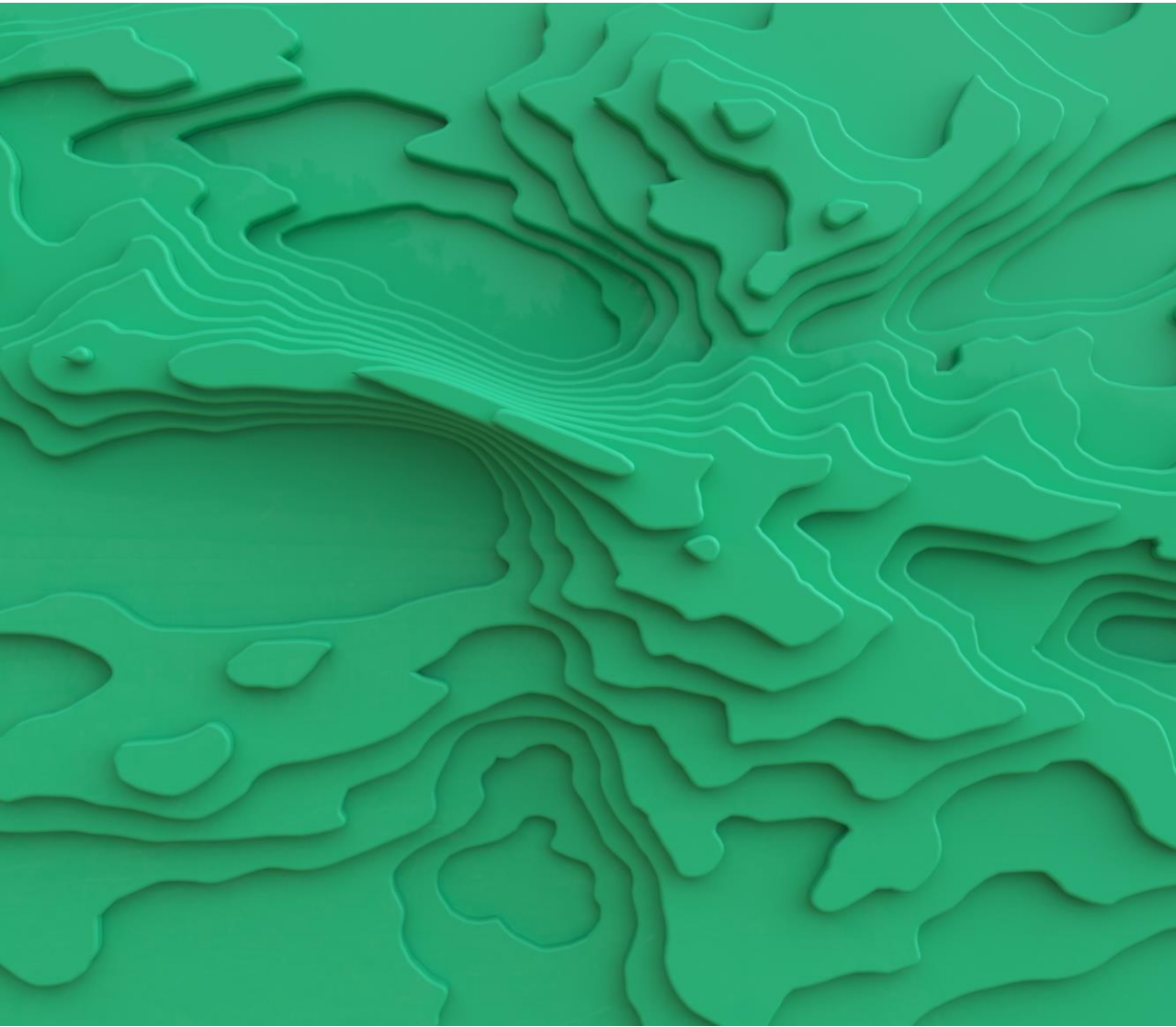
Software

Serving Large Labs Requires a Software-Centric Approach

"We provide world-class measurements and power electronics, combined with the tools and capabilities that are critical to ensure a safe and efficient lab at scale."
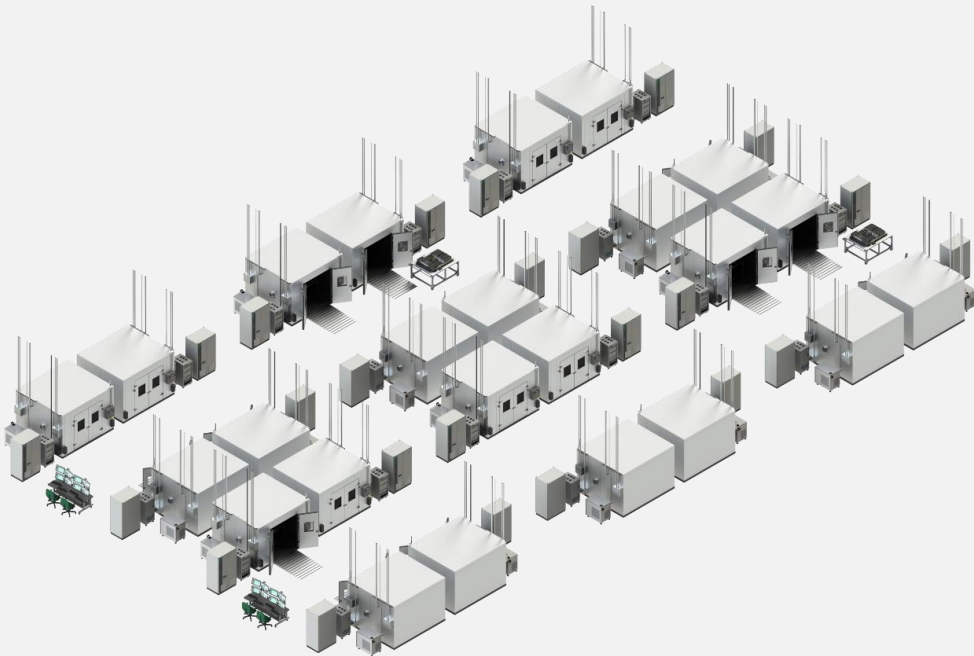
Customer Needs at Scale

Operational Efficiency
1. Test Planning and Allocation
2. Asset Tracking and Allocation
3. Service and Maintenance
4. Remote Monitoring
5. Cross-functional Communication

Power
1. Sub-division of Power
2. On-site Energy Storage
3. Regeneration
4. Load Balancing

Facilities
1. Floor Loading
2. Fire Resistance and Mitigation
3. Ventilation
4. Storage
5. Roof Infrastructure
6. Labor Requirements

Battery Test System - Software Architecture

LIMS COMPONENTS

Notifications	Data Aggregation	System / Asset Management	Test Scheduling	User Management	Analytics	Interactive Data Exploration	Power management
SL	SL	SL	SL + LIMS	SL	SL	SL	SL + LIMS

TESTSET DEVELOPMENT

Sequence Editor	Algorithms/ Subsequences	Operator Interfaces	DUT Interaction
PAtools	BTS, LV, VS, C, Python	BTS, SL	VCOM

TEST EXECUTION

Configuration/ Compilation	Execution Framework	Sequence Execution	Logging	Alarms and Reaction	Algorithms	Reporting
BTS	EVO	PAtools	BTS		BTS, LV, VS, C, Python	BTS / SL

HARDWARE INTERFACES

DUT Communication	Cycler Communication	Other Equipment Communication	Instrumentation Technology
VCOM	BTS	BTS	PXI / TSN / XC / ECAT

ni.com

FUTURE FUNCTIONALITY

NI BTS Web UI Example

NI Battery Test Software Workflow

HARDWARE-LEVEL

Define the Test Cell
Measurement and stimulus
Test cell abstraction

Add the DUT
CAN database
Safe operation limits
Lossless logging
DUT abstraction

APPLICATION-LEVEL

Write a Test
Sequencing
Time-dependent or critical sequencing
Test recovery

USER-LEVEL

Run a Test
Execute test script
Monitor test results (pass/fail)
Real-time measurements

FACILITY-LEVEL

Manage Facility
Plan and monitor test asset utilization
Monitor energy usage
Maintenance

Management Dashboards | Laboratory/Facility Level

Energy Usage

kWh

350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250

06/01 09/01 11/01 13/01 15/01 17/01 19/01 21/01 23/01 25/01 27/01 29/01

Test Cell Utilization

Test Cell	Utilization %	Uptime %
Test Cell 1	60	50
Test Cell 2	40	75
Test Cell 3	38	90
Test Cell 4	18	90
Test Cell 5	98	90
Test Cell 6	83	95
Test Cell 7	17	100
Test Cell 8	5	45

System log

Reminders   Test Cell 1: Calibration Due in 10 days on 11/12/2021   View Details

System Faults

Fault	Test Cell	Severity
Temperature out of range	Test Cell 2	⚠ Warning
Critical error occurred	Test Cell 3	✕ Critical Error
Temperature out of range	Test Cell 1	⚠ Warning
Load higher than normal	Test Cell 4	⚠ Warning
Critical error occurred	Test Cell 5	✕ Critical Error
Critical error occurred	Test Cell 5	✕ Critical Error
Critical error occurred	Test Cell 5	✕ Critical Error

Active Tests

Test1_2021-11-02 04:47:08   ● Running

Operator: Anton Rivernik

Step 30 / 70   Total Test Duration: 07:15:24

Estimated time remaining: 03:15:30 (5:03 PM)

NI Battery Test System

- Home
- Test Cells
- Alarms
- Test Plans
- Test Requests
- Review Results
- Custom Sample Page

admin

ni.com
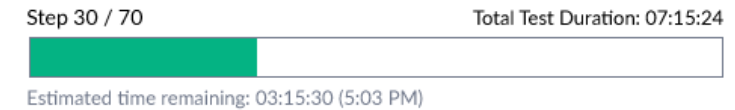
Management Dashboards | Test Cell Level

ni.com

Using Data to Improve Batteries

INSIGHTS FROM TEST DATA   PRODUCT LIFECYCLE
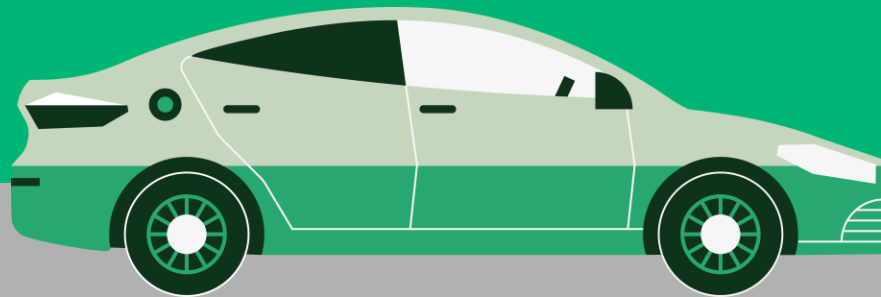
"The validation test data we get from NI systems enables our engineering teams learn more about our batteries and find ways to improve them even after they're on the field"
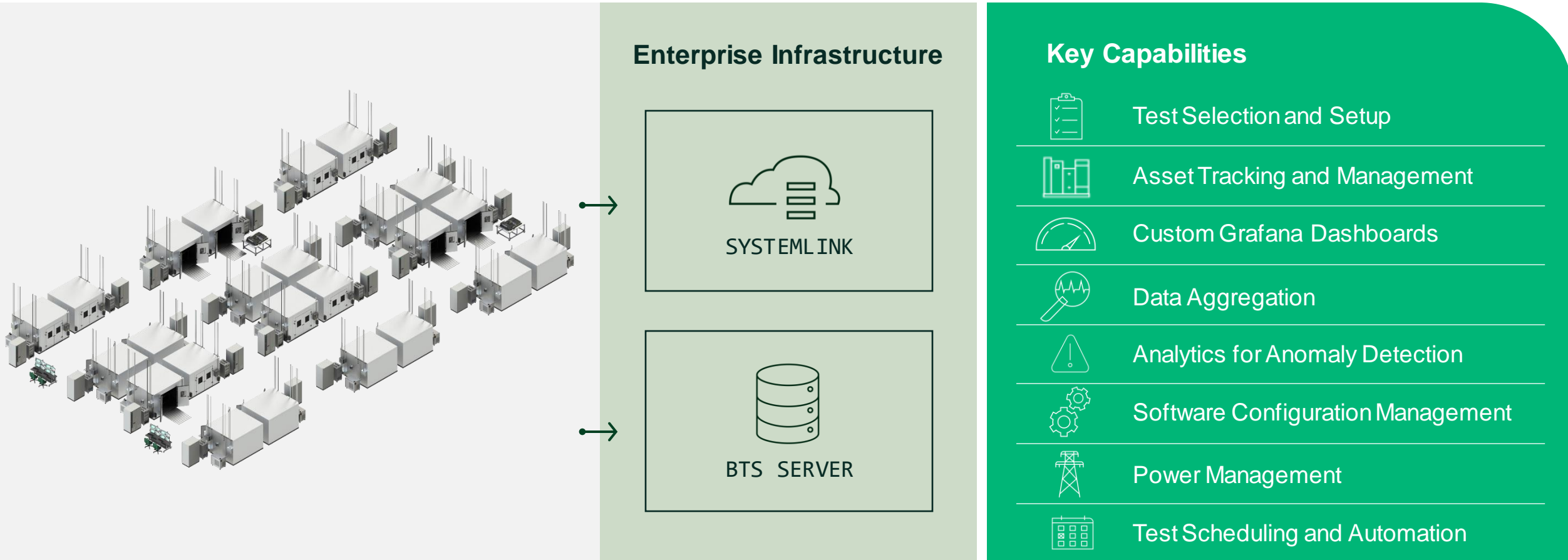
HENRIK RUDELIUS

DIRECTOR, VALIDATION AND SIMULATION
BATTERY SYSTEMS

NORTHVOLT

Solution for Large-Scale Lab Management Enabled by NI SystemLink Enterprise

Enterprise Infrastructure

SYSTEMLINK

BTS SERVER

Key Capabilities

Test Selection and Setup

Asset Tracking and Management

Custom Grafana Dashboards

Data Aggregation

Analytics for Anomaly Detection

Software Configuration Management

Power Management

Test Scheduling and Automation

BTS Laboratory Information Management System (LIMS)

- Workflow oriented across Test lifecycle from request through results

- Personalized queue tracks status of Test Requests and assigned work items

- Supports Test, Calibration and Maintenance workflows

- Comments functionality improves cross-team communication and collaboration

- Calendar shows operational visibility across entire Test Field

- Smart Scheduling shows Test Station availability based on Test Requirements
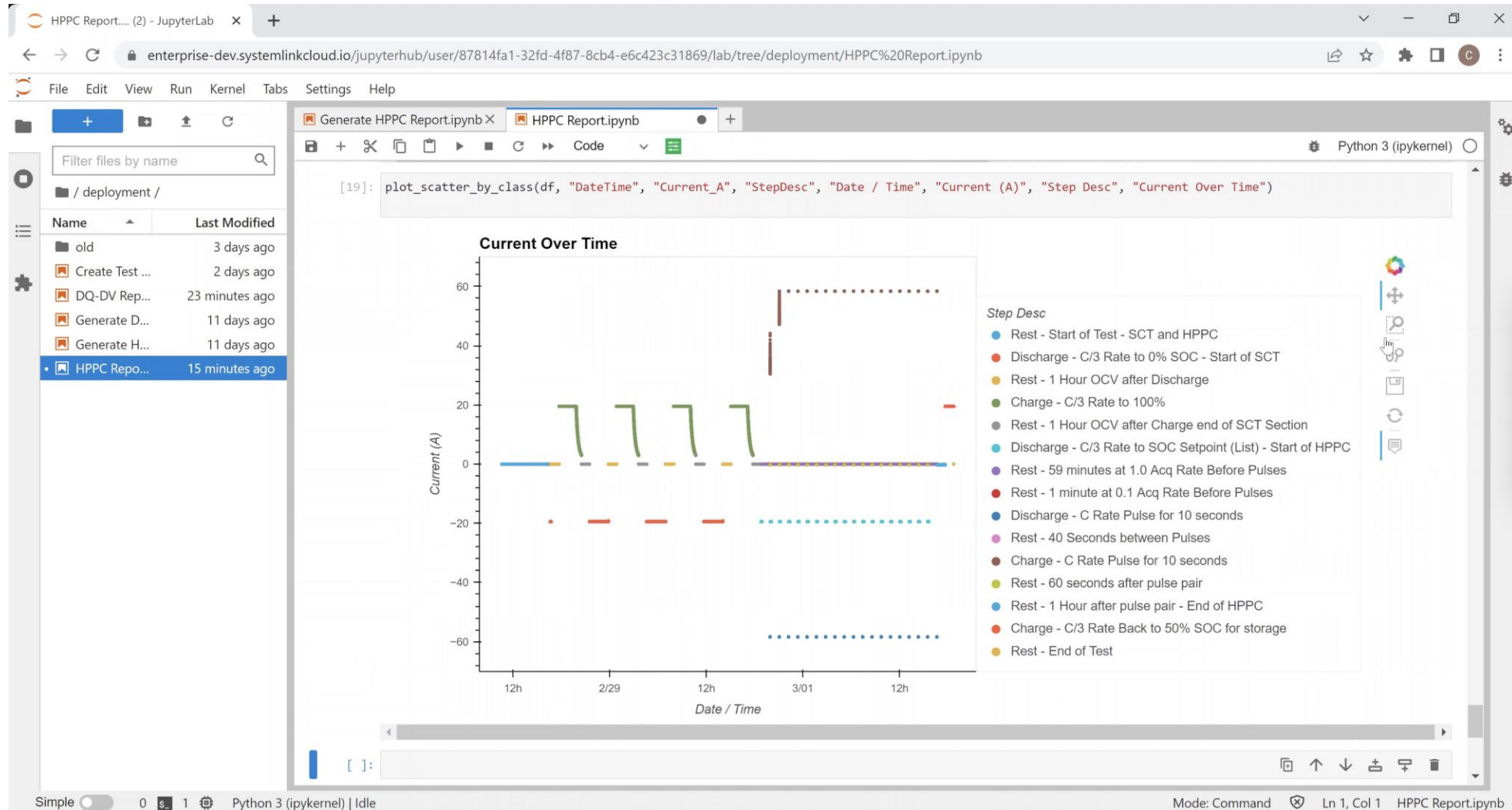
Link: **Battery Test Analysis Demo**

Battery Lab Management System Demonstration
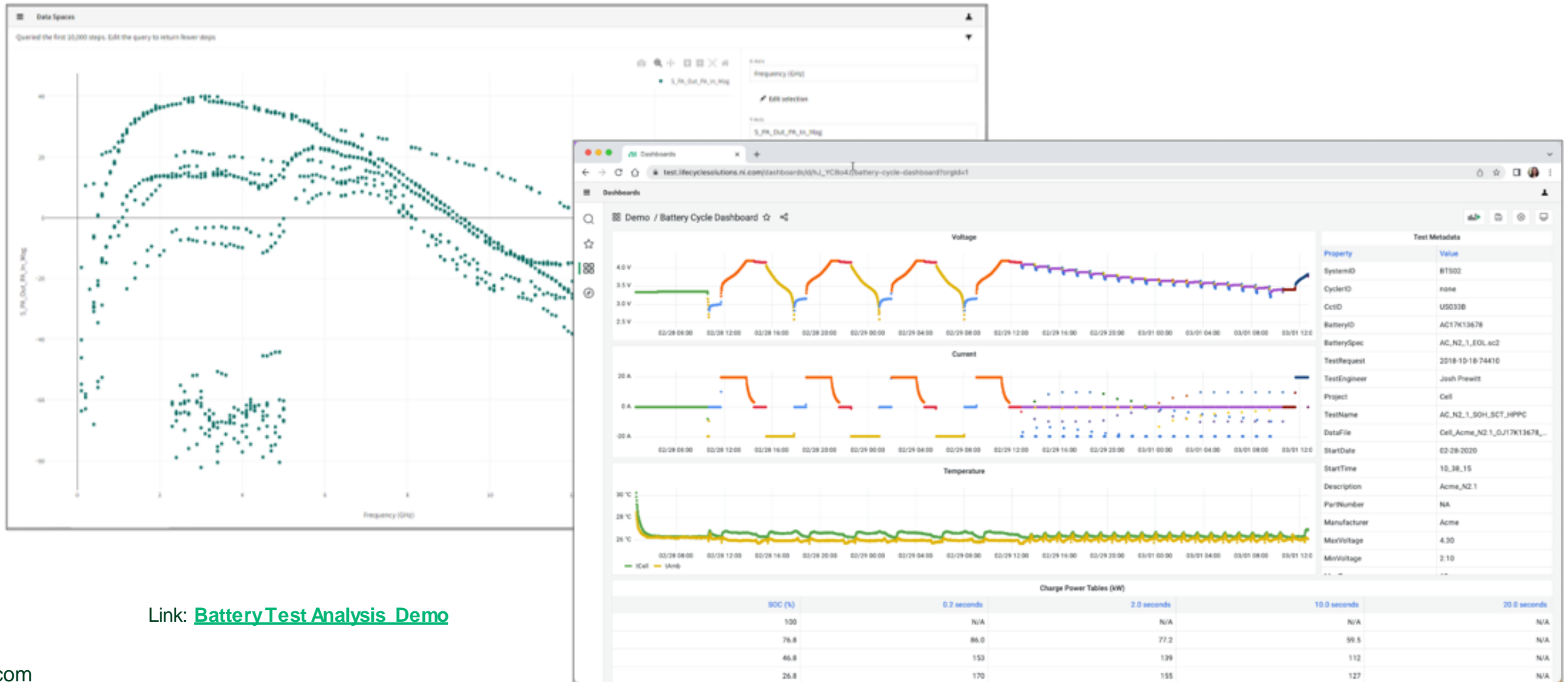
Link: **Battery Test Analysis Demo**

COMING Q3 2023

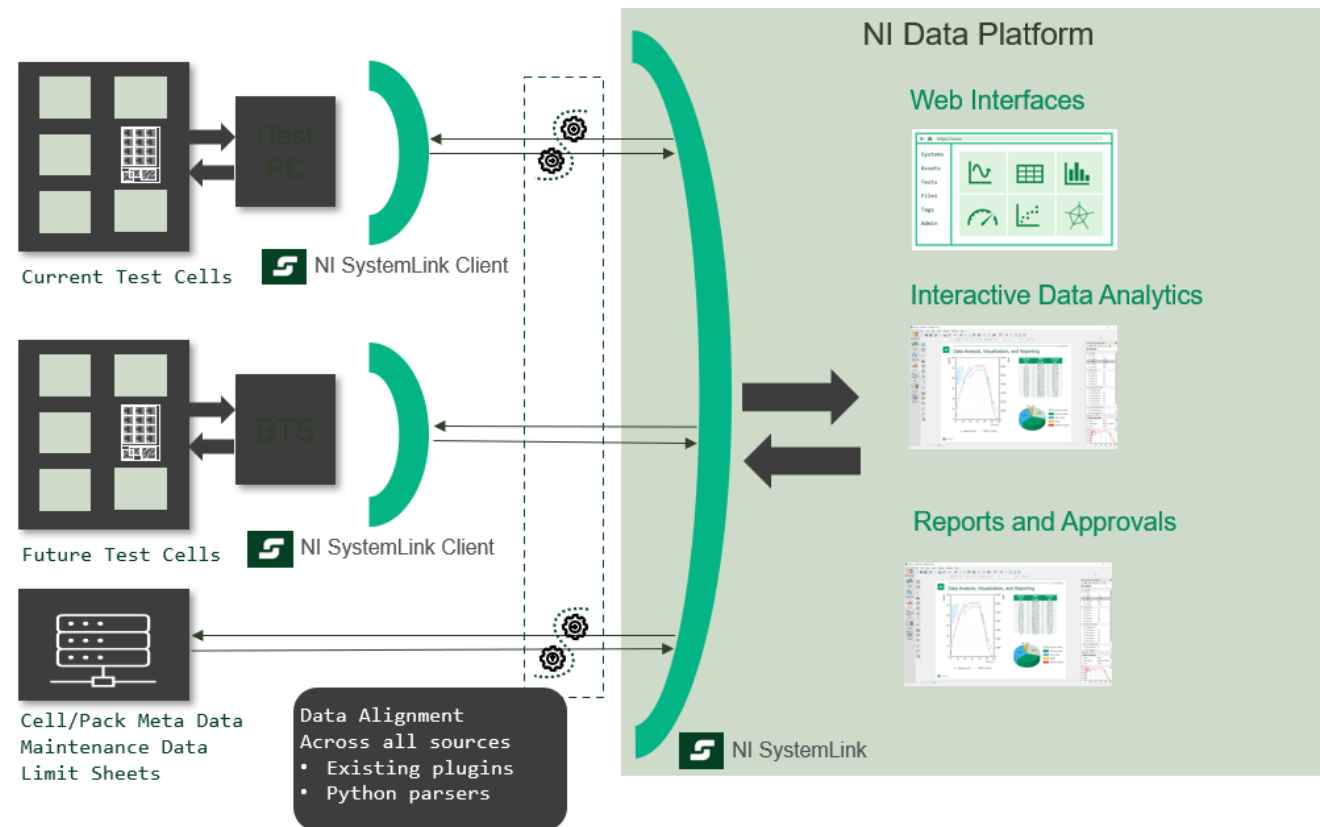# Charge/Discharge Current │ Visualization with Jupyter Notebooks

NI Product Analytics Services – Recent Engagement

EV Battery – Performance Data and Analytics for Top Automotive OEM

Project Scope:

- Deliver a battery analytics data solution that scales across all customer EV battery labs
- Complete solution includes hardware test systems + automation SW + integration services/IT support
- Built the complete data solution – architect and integrate into customer's existing IT systems
- Design for security, reliability, and performance – with enterprise requirements in mind

Current Test Cells

NI SystemLink Client

Future Test Cells

NI SystemLink Client

Cell/Pack Meta Data
Maintenance Data
Limit Sheets

Data Alignment
Across all sources
• Existing plugins
• Python parsers

NI Data Platform

Web Interfaces

Interactive Data Analytics

Reports and Approvals

NI SystemLink

Project Highlights

- Ingestion of >90TB of historical data and 750GB+ of weekly data and >500 active users

- Data transformation and visualization, plotting, statistical tools, signal generation, web access, data tagging, approval processes, and more

- Dynamic and static report generation

- Implementation of engineering workflows

- Integration of 3rd party tools like Jupyter Notebooks

- Automatic data ingestion from three existing battery labs with the ability to scale to more in the future
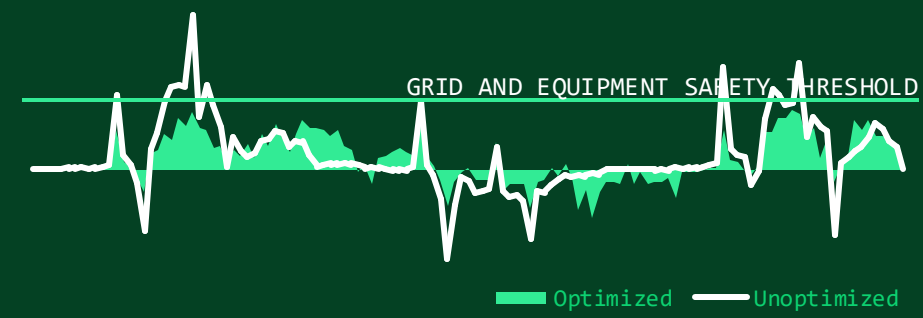
Power Management

TEST CELL 20 ENERGY USAGE

TEST CELL 19 ENERGY USAGE

TEST CELL 6 ENERGY USAGE
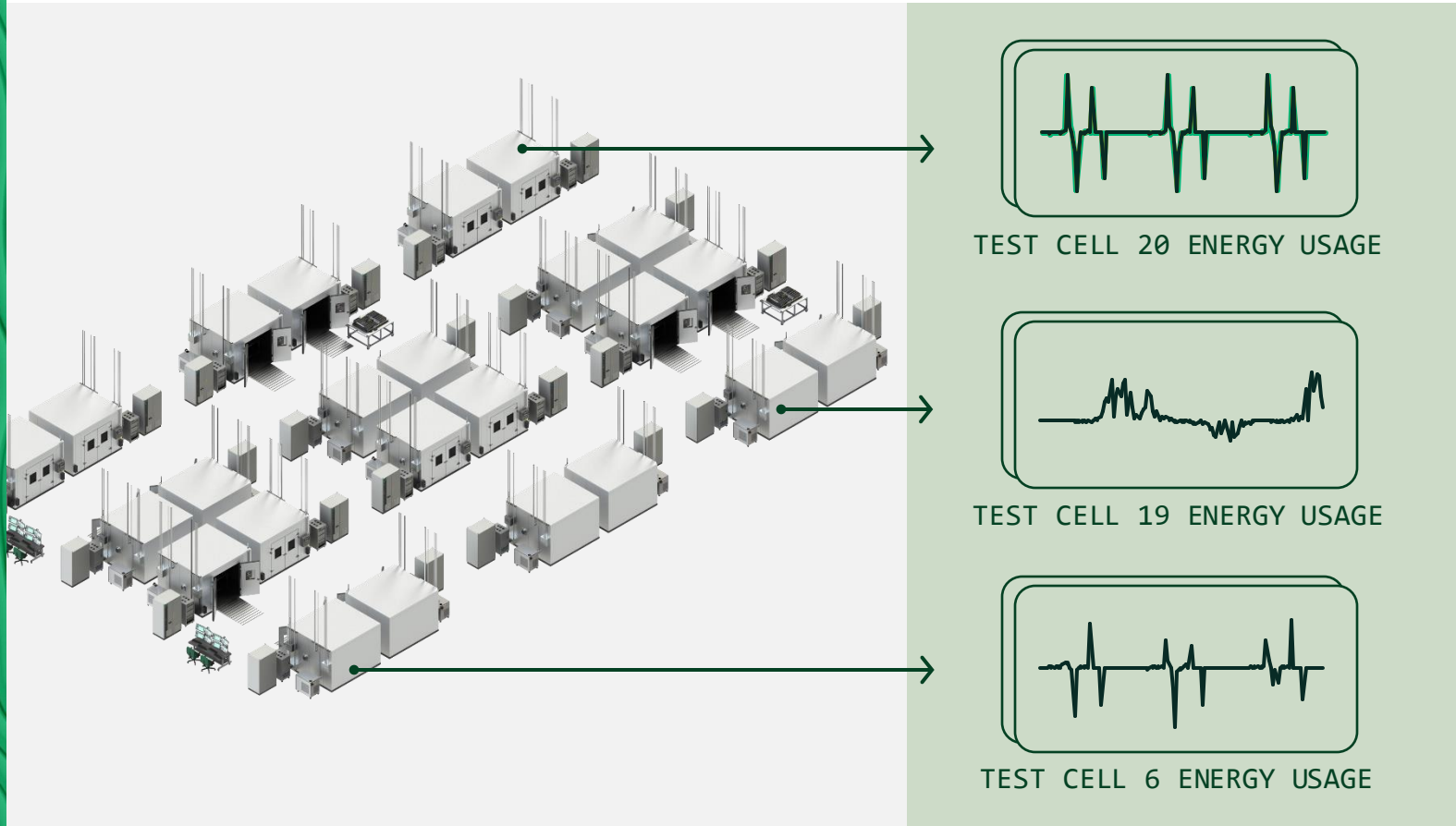
Operate Safely and Responsibly

Continuously monitor energy usage of all equipment

Promptly perform mitigation procedures and alarms

GRID AND EQUIPMENT SAFETY THRESHOLD

Optimized — Unoptimized

Optimize Energy Usage

Evaluate projected energy needs to recommend test scheduling

Minimize energy consumption and maximize asset utilization

Data Collection and Visualization

Securely Connect Systems and Transfer Data

- Manual upload via WebUI

- Automated data collection via APIs

Data Management

- Ingest file, test results and tabular data

- Metadata enrichment

- Quickly search, group and sort test results

- Ability to link test results to dashboards and report

Visualization

- View data tables in interactive view

- View and manage products
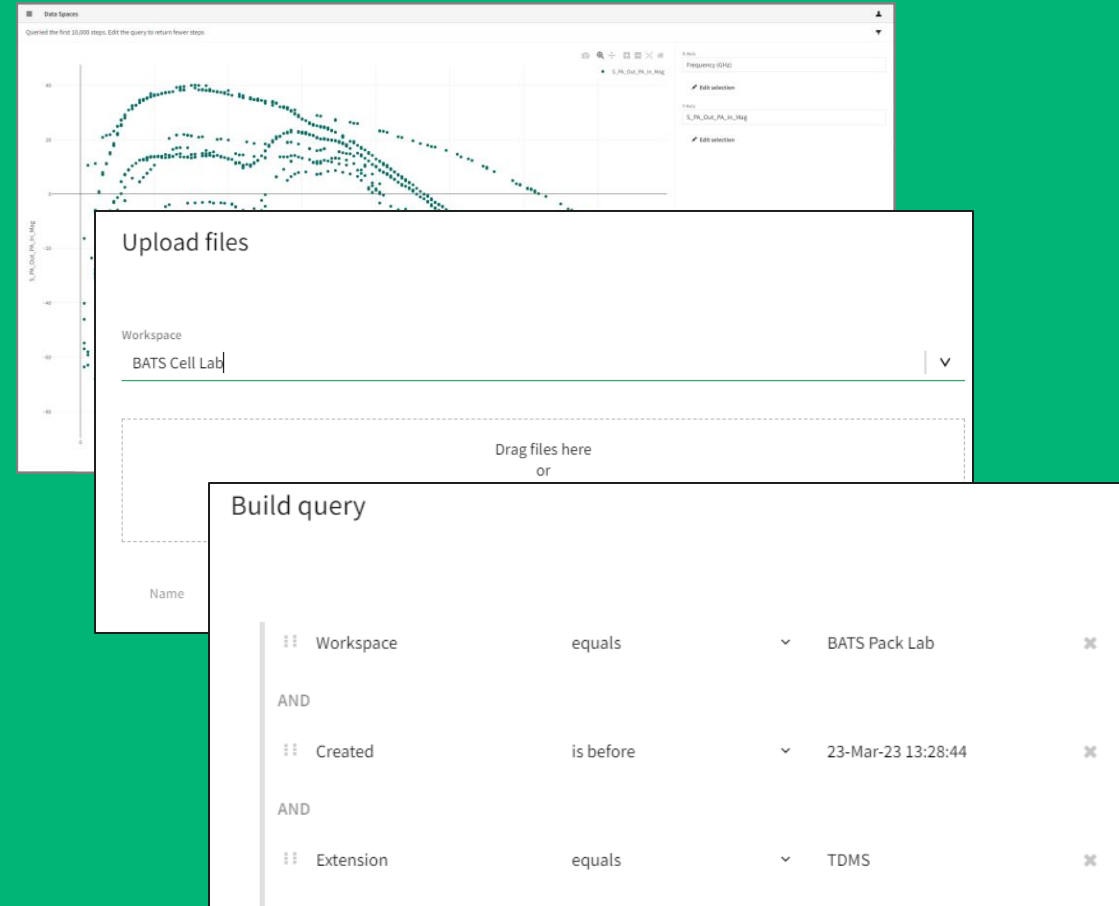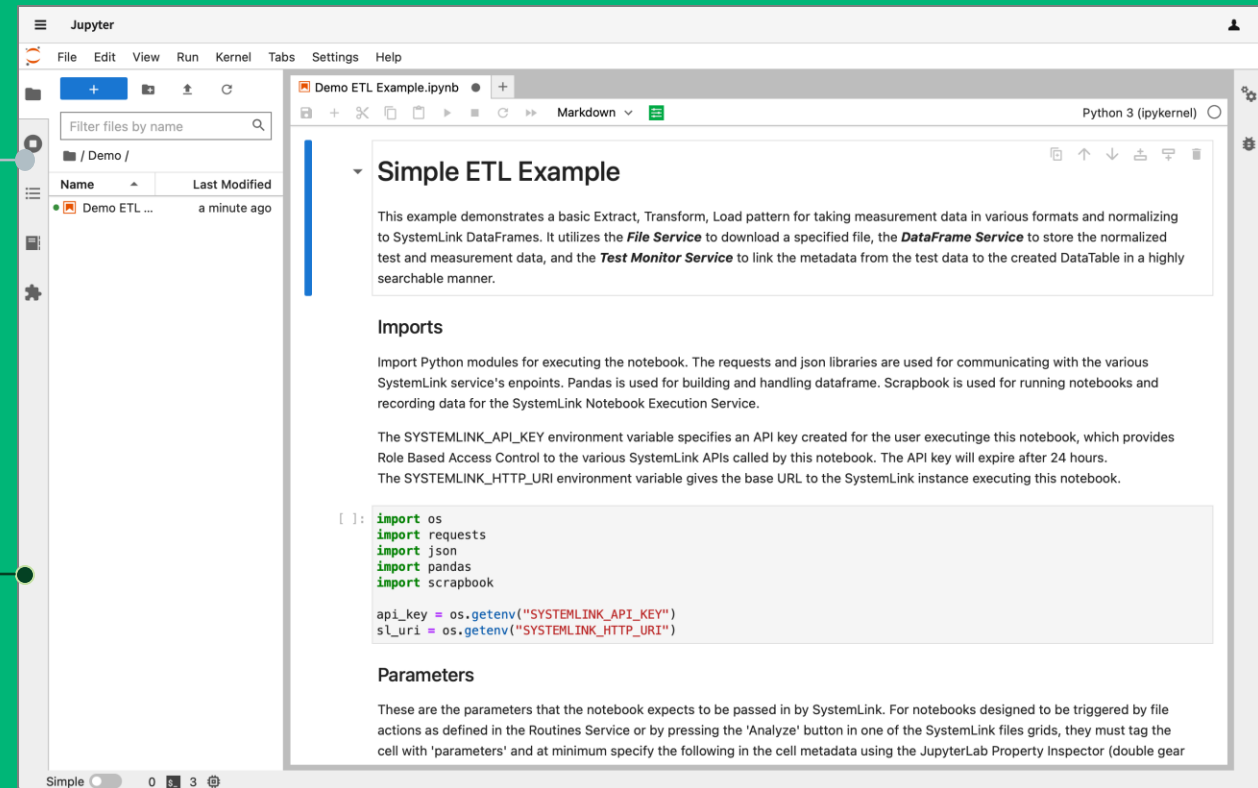
Test Data Analytics

Analysis Routines Development in JupyterHub

- Generate HTML and PDF reports
- Create ETL routines to transform data
- Create custom computation and metrics

Analysis automating, running, and monitoring

- Defined routines to run notebooks on file upload and update, on data table append, and on scheduled calendar time
- Run notebooks on the selected file and data tables on demand
- Integrate notebooks with dashboards to display high-level computed metrics and plots

Test Monitoring and Insights
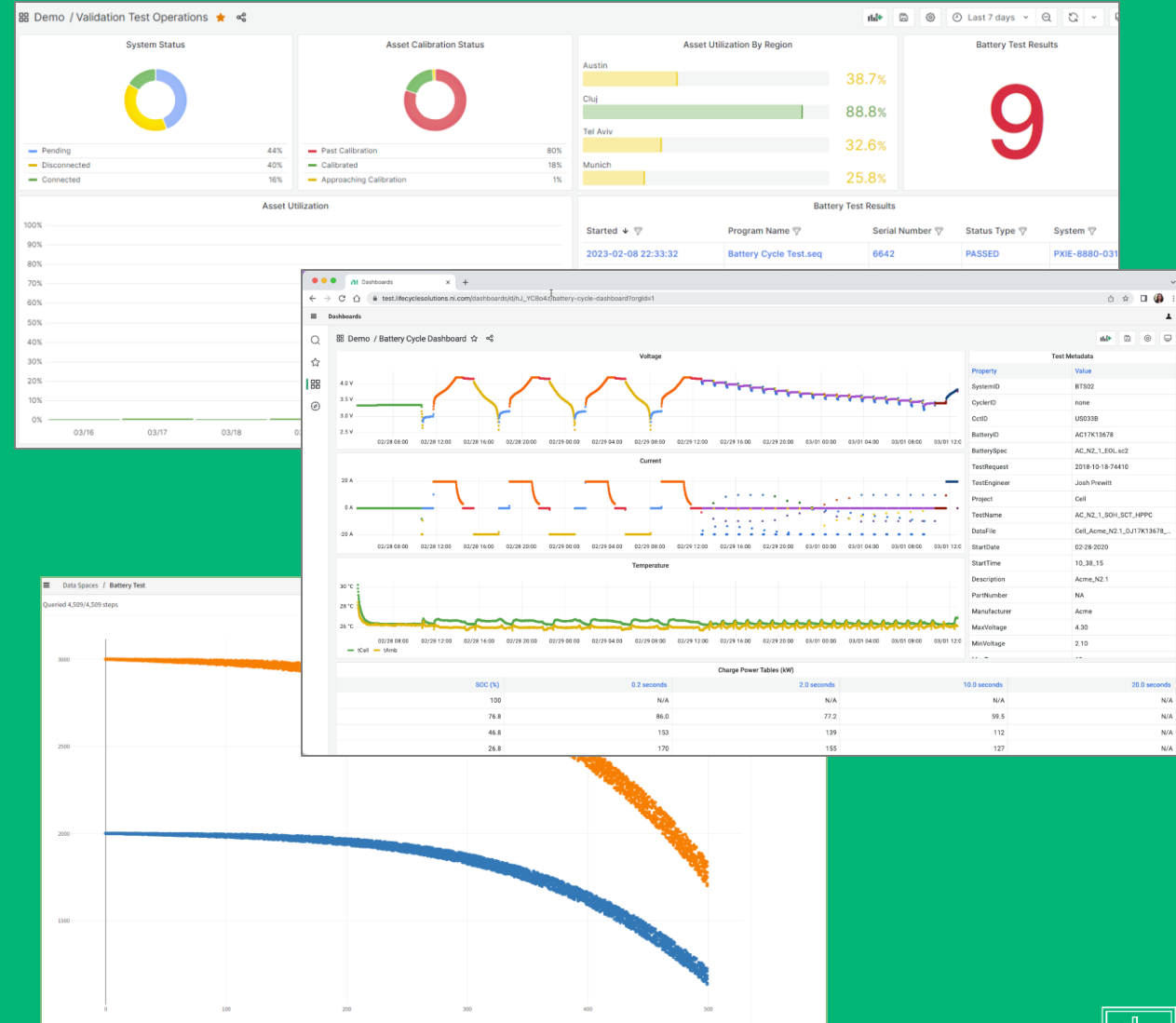
Viewing fleet wide test results
- View and query product and test results.
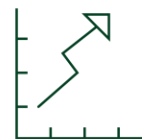- Drill into test steps and measurements.

Creating Test Module Dashboards
- Create dashboards to display test and KPI data.

Trending Test Data
- Visualize test performance over time.
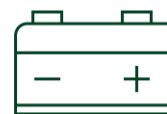- Plot test data against metadata associated with the test.

Accelerate test system development

Maximize reuse of battery testing investments

Connect battery data to improve performance through changes to software

Software-Defined Battery Lab

Open and Flexible Approach
to Automate the Validation Lab

Elijah Kerry

Question & Answers

Please submit your question through Q/A chat pod.