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Using Big Battery Data to Make Batteries that Work Better, Last Longer, and Function Reliably

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Outline

- Battery challenges across industries

- How are companies doing it today?

- Data-driven product development

- Data-driven product development in action

- Deeper analytics enabled by data-driven product development

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# Battery challenges across industries

Batteries are the bottleneck in nearly every application

- Resource intensive to test and develop

- Slow product development

- Incremental improvement

- Not enough time to test thoroughly for each application

- Inconsistent, unreliable in operation

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Longer warranties & expected battery lifetime

T. Baumhofer et. Al. / Journal of Power Sources 247 (2014) 332-338

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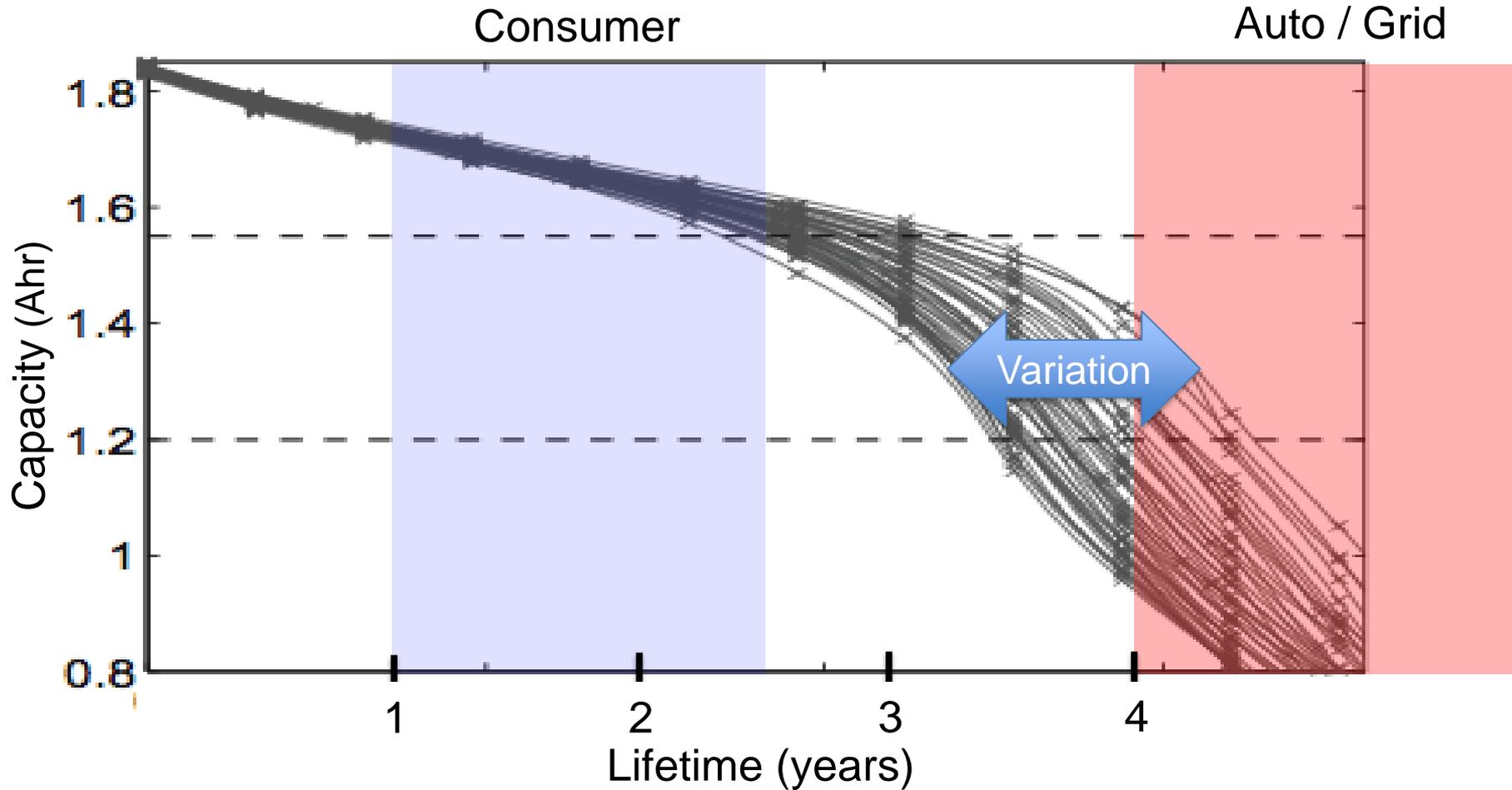
Batteries are no longer removable

- You used to be able swap a bad battery.

- Many applications now have embedded batteries.

- When a battery fails today, you need to ship the entire device. Warranty claims are much more expensive.

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Higher energy densities, smaller / thinner form factors and fast charging

- Higher voltages and current densities put more stress on the battery

- Increased risk of lithium plating

- Swelling has become an issue, especially in small form factors

- Batteries continue to catch fire

iPhone and Galaxy Note 7 fires

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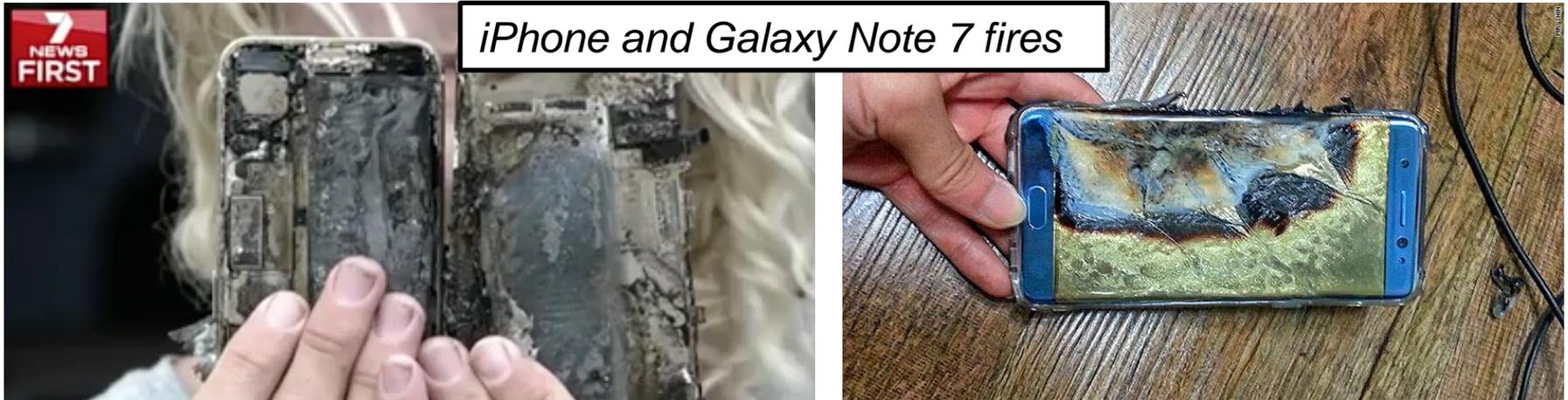
Consumer challenges

When asked: "What new or improved smartphone feature are you most excited about?"

*"**Improved battery life**" was the leading answer by a long shot.*

Fortune-SurveyMonkey study CES 2015

- Battery life is the single greatest source of consumer dissatisfaction

- User tastes are changing faster and faster

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Faster product development cycles
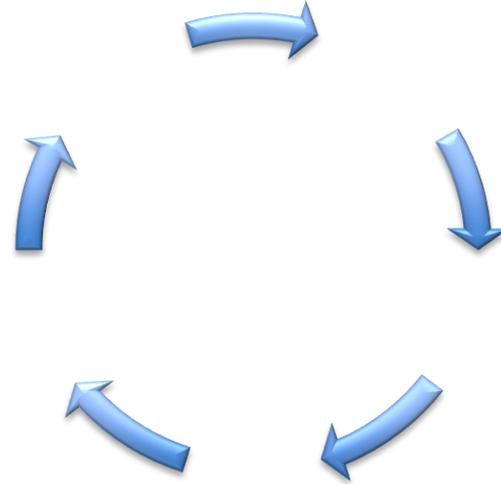
- Many industries are moving from biennial or yearly product cycles to 9 month or 6 month release cycles.

- This typically leaves only 2 to 4 months to evaluate batteries for an application.

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Choosing the right vendors

A   vs   **B**
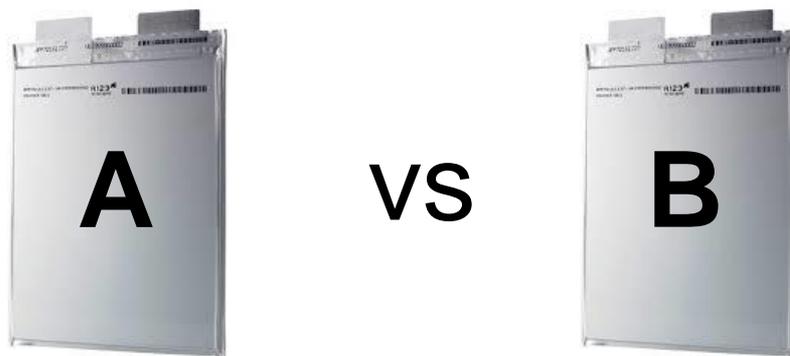
- It's almost impossible to compare vendors apples-to-apples using spec sheets alone.

- Reported 'cycle-life' uses a simplistic cycle that doesn't represent your application.

- Expected lifetime in application is impossible to determine without adequate testing, leading to warranty risks.

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Qualifying battery vendors better

- Many OEMs are sending people back and forth to Asia regularly to design and qualify custom batteries.

- QA data is being generated both in Asia at the battery vendors and in-house.

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How are companies doing it today?

All of these applications produce data

- In operation

- In research and development

- In integration testing

- In quality assurance

Manual analysis with makeshift tools

- Highly paid engineers spend hours per day doing basic analysis, relying on outdated desktop software, inadequate spreadsheet-based processes, and expensive custom IT systems.

- Companies employ full-time technicians to process data, which can introduce errors and create a disconnect between the engineers making decisions and the insights they need to make them.

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Basic automation

Static reports or back to Excel

- Some companies have taken steps to automate analysis, creating some basic scripting or Excel macros. These often produce static reports or require further analysis in Excel.

- Still can't dig into the data easily or compare across your tests. Often leads to complacence, guesswork, and even less data analysis.

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Can't analyze more than a handful of batteries at a time

Too many files, too many formats
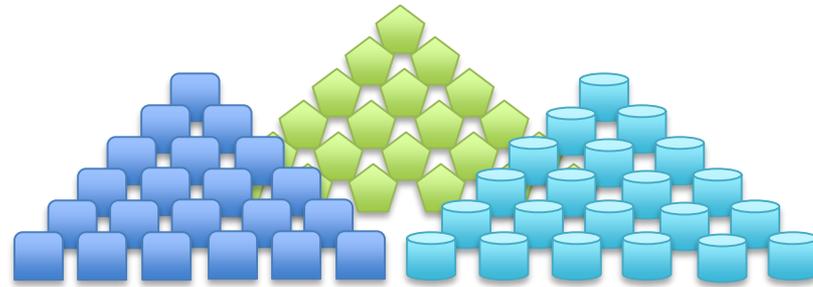
- Leads to empirical decisions made from small sub-segments of your body of data.

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Data isn't shared across the industry value chain

R&D   Manufacturing   Integration   Field
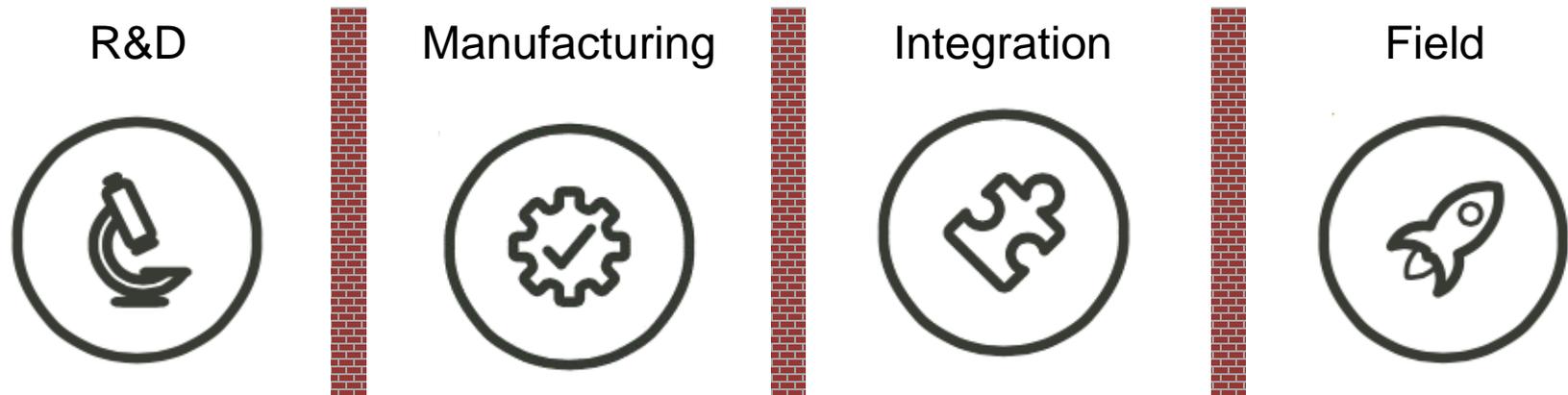
- Learning and the opportunity for improvement stops once it leaves your section of the organization.

- Data is starting to flow back, as warranty claims from long-life applications are sent back to battery vendors.

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Often just don't look at the data

*"Organizations **repeat up to 40%** of their experiments with resulting increased costs and longer development times."*

– IDC Insights

- Organizations are spending $$$ to generate this data, but are only scratching the surface of its value, typically running only pass fail analysis or looking at top-level statistics.

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Data-driven product development

Voltaiq is the enterprise platform for data-driven battery product development and optimization

R&D Manufacturing Integration Field
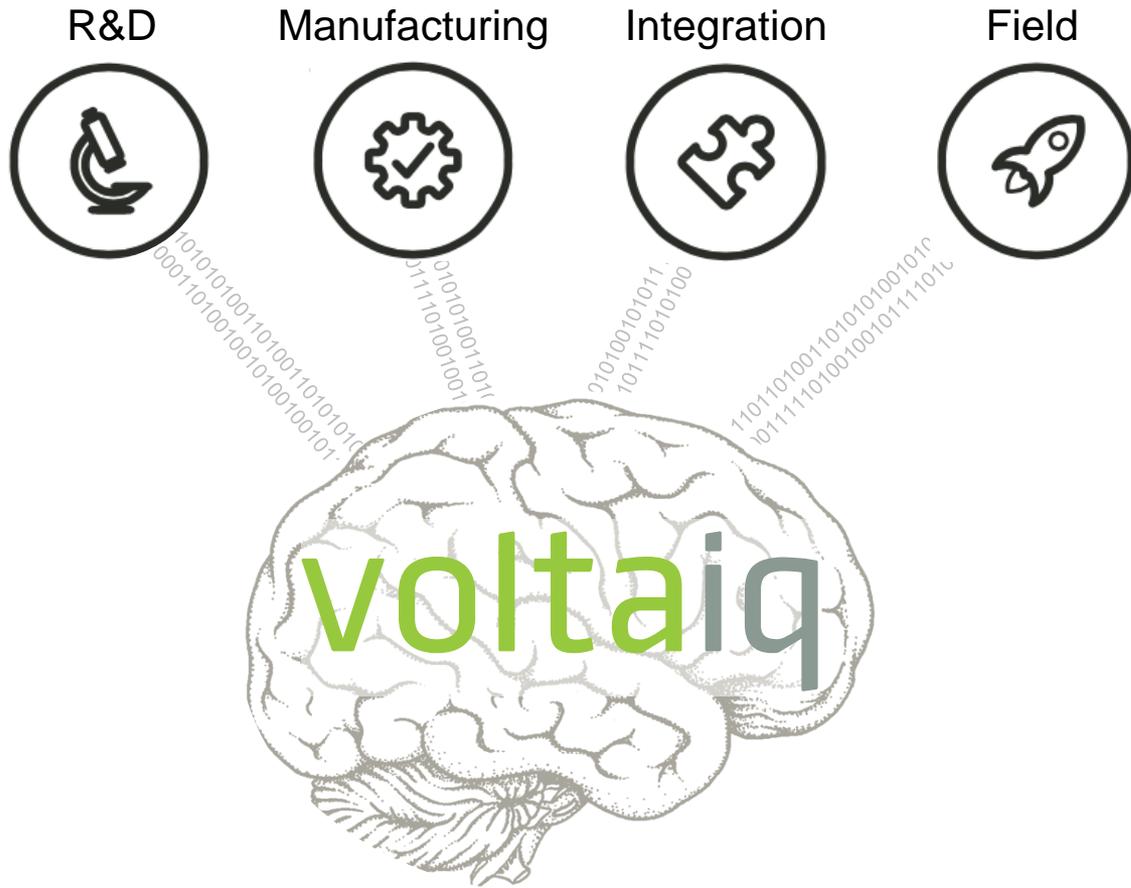
- Get products to market faster using resources efficiently.

- Ship with confidence, ensuring safety and reliability in the field

- **Turn battery performance into a competitive advantage**

Voltaiq: Access, Insight, Confidence

- ***Access***

  – One platform for all data, current and historical, across every facility

  – Search, analyze, and collaborate in real time

- ***Insight***

  – Industry-leading algorithms and powerful analytical tools uncover trends hidden in your data

  – Broad comparative analyses put results in context

- ***Confidence***

  – Data-driven decision making for faster iteration

  – Comprehensive analysis to mitigate battery product risks

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voltaiq Unified Data Pipeline

Data is instantly homogenized
and centralized in Voltaiq
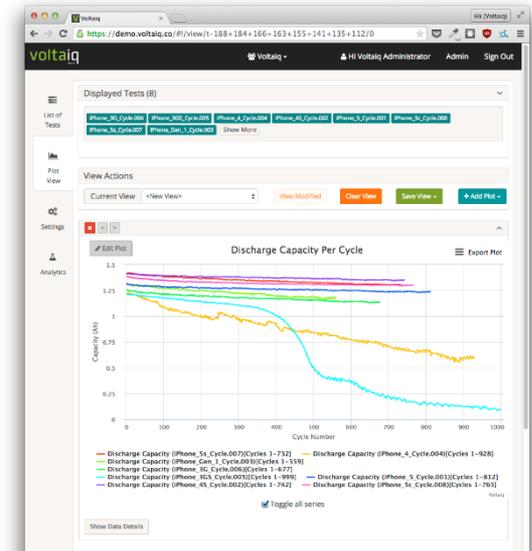
Any battery cycler or
external data stream

Quickly find, visualize
and analyze your data

Voltaiq gets battery powered products to market *faster*

Typical workflow for data analysis

Find the files you need, from among thousands
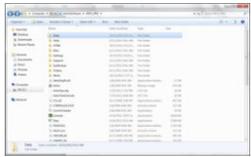
Transfer files to flash drive

Import the first data file into Excel
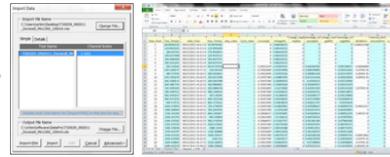
Plot the relevant data series, one by one
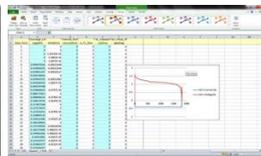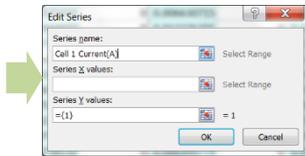
Repeat file import and plotting for each additional test

Modify plot options for each plot

Export plot for presentation or emailing to colleagues
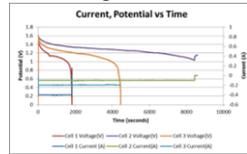
Repeat for each type of plot

Voltaiq workflow

Select tests to compare
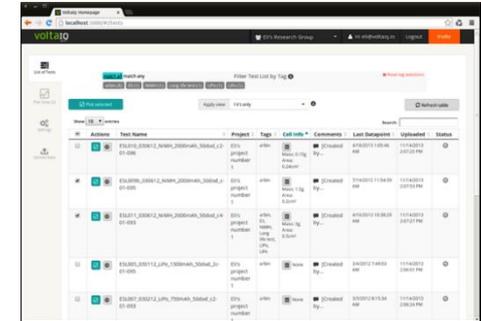
View plots in browser, share by URL
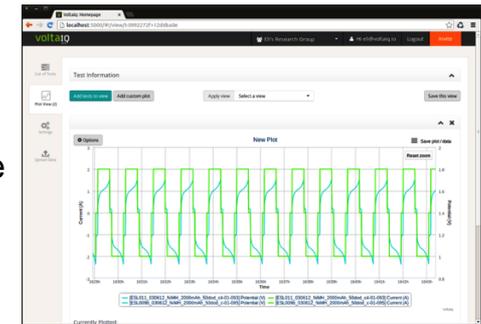
Up to 20 hours of an engineer's time is returned to Engineering every week!
Improve the pace of development and increase asset utilization - Saving $.

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Voltaiq uncovers actionable insights hidden in raw battery performance data

Find your data quickly

Advanced Filtering: 'full text', or on any specific field
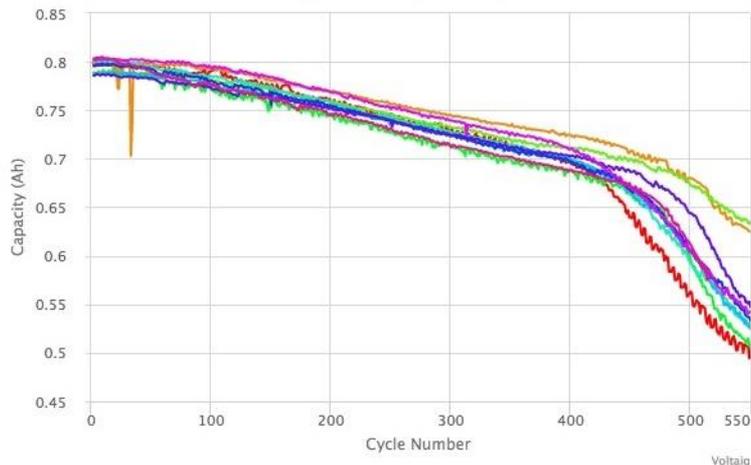
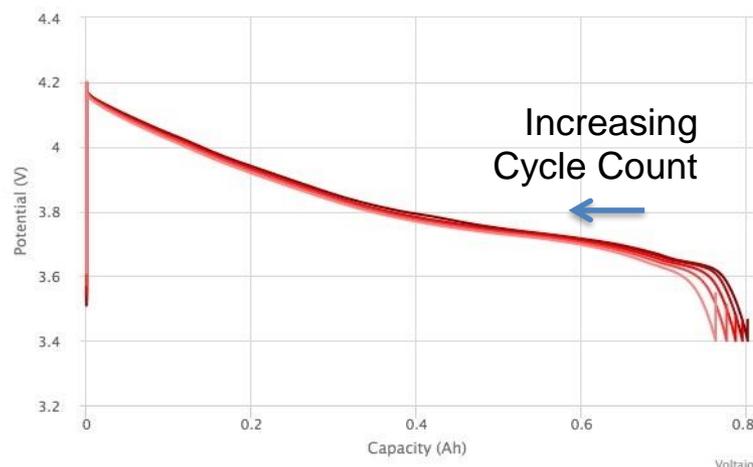Status Indicator

Store multiple tests

Projects

Meta-data

Custom Tags and Comments

Fully customizable, reusable data views with interactive plots

Batch analysis
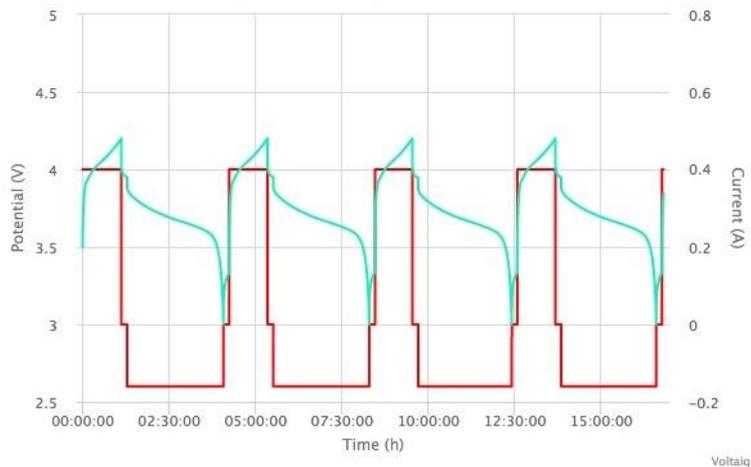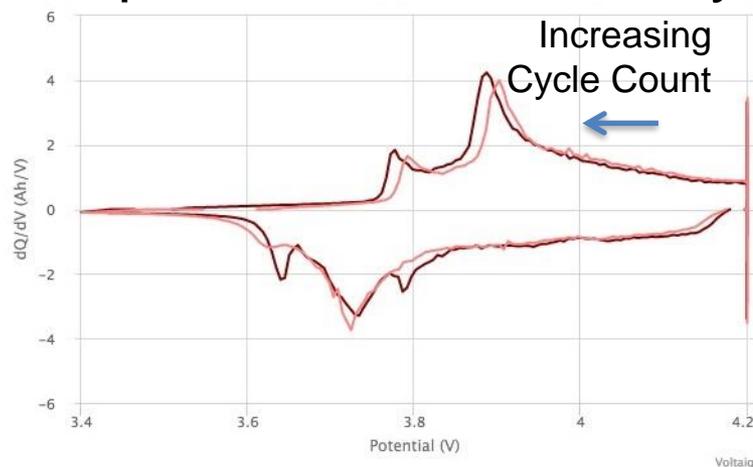

Overlay cycles over time

Increasing Cycle Count

Zoom in on areas of interest

Explore data in new ways

Increasing Cycle Count

Voltaiq configuration options

- Voltaiq Core
  - Automatically upload, process and normalize your data.
  - Quickly find and compare tests of interest.
  - Visualize, analyze and share your data in real-time.
- Voltaiq Analytics*
  - Perform custom and batch analysis using Python scientific and numerical computing libraries.
- Voltaiq Notebook*
  - Capture metadata around battery materials, processing, test conditions, and observations.
- Voltaiq Reports*
  - Design and schedule regular reports and event-based alerts.

* Optional

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Add-on Module: Voltaiq Analytics

- Python-based environment for advanced custom analysis, large-scale statistical studies and machine learning modeling

- Analyze any data in Voltaiq — live and historical

- Generate printed data, figures, and data files

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Example Voltaiq Analytics use cases

- Pass/fail automation
- Reporting automation
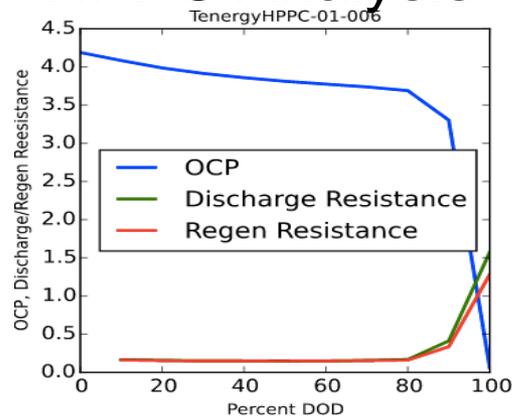- Specialty analysis (HPPC, Capacitor, etc.)
- Statistics for production, life prediction, etc.

Weibull Analysis

Alpha: 519.520,
Beta: 12.758
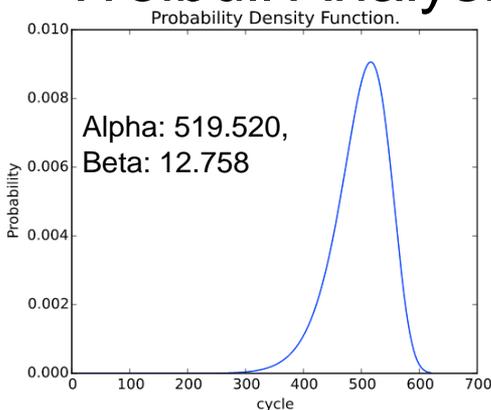
HPPC Analysis

SPC Control Charts
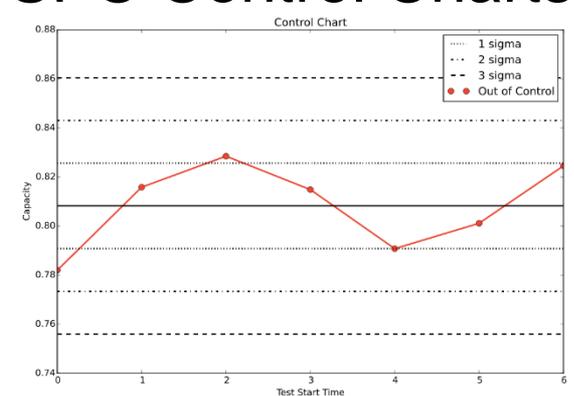
Add-on Module: Voltaiq Notebook

- Integrated data management with fully customizable notebook templates: Capture metadata around battery materials, processing, test conditions, and observations.

- Associate Notebook data directly with performance data, analyze in interactive plots in Voltaiq Core, custom analytics in Voltaiq Analytics.

- Full version control and traceability.

Full customization based on fields you need to track

Collect measurements over time

Example Voltaiq Notebook use cases

- In R&D to optimize device composition and build faster.

- Integrate with existing systems
  - Manufacturing execution system (MES)
  - Enterprise resource planning (ERP)

- Track measurements and observations over time.
  - Changes in weights and dimensions.

Add-on Module: Voltaiq Reports

- Schedule reports emailed directly to your inbox on a regular or event-driven basis.

- Full customizability.

- The Voltaiq 'virtual technician'
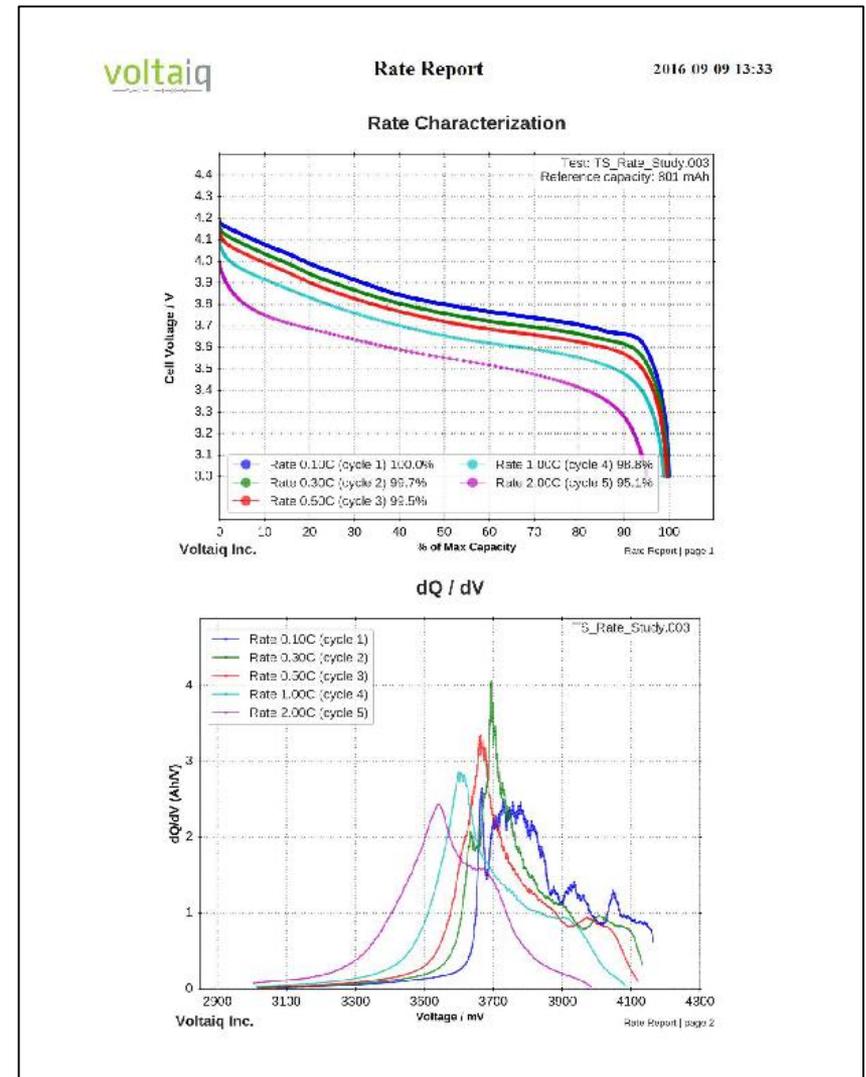
Data-driven product development in action

Research and Development

Voltaiq customer Blue Current testing batteries
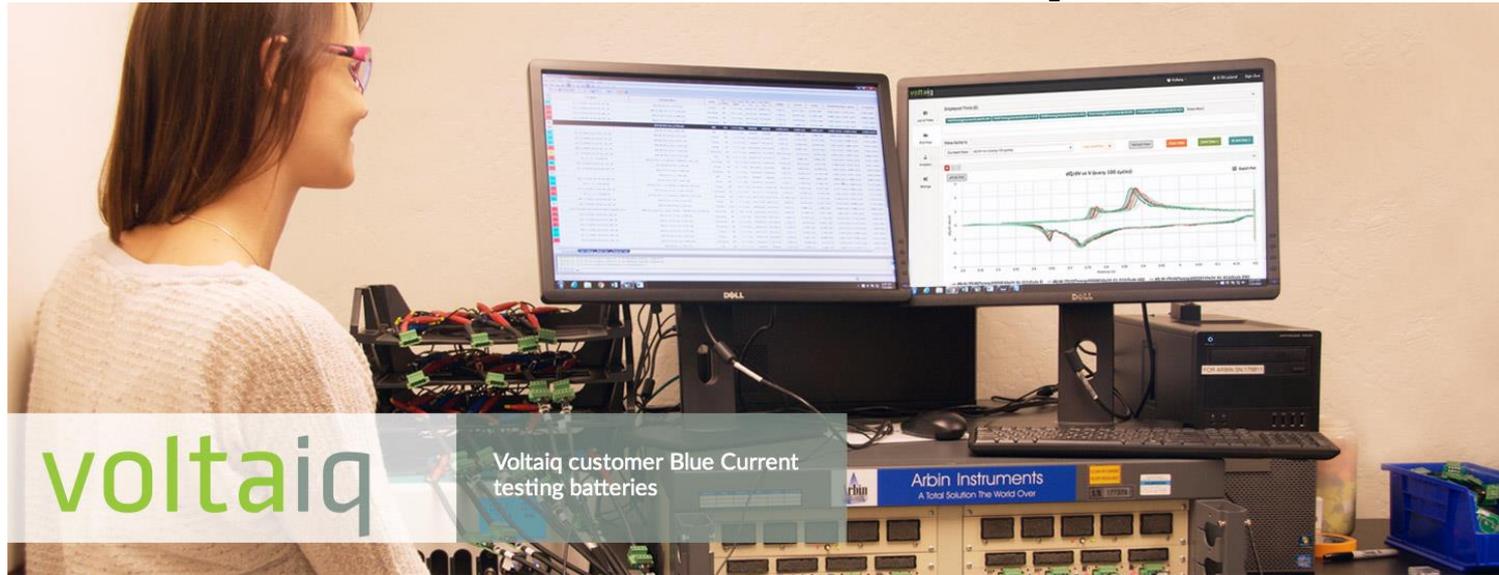
- Customers analyze new systems in real-time as tests are running, and learn much more about them.

- Engineering teams iterate faster and accelerate development cycles dramatically.

- Equipment utilization improves by spotting idle channels and channels that can be freed up.

Product integration and vendor selection
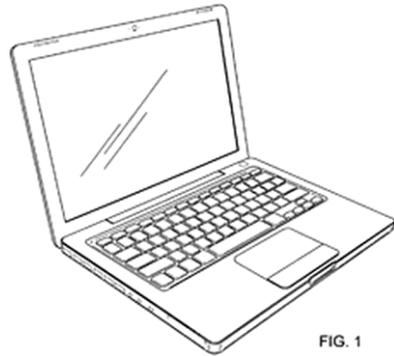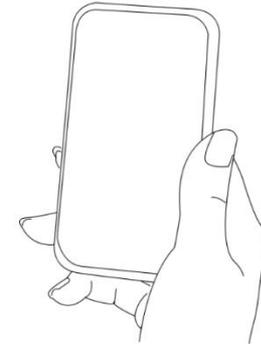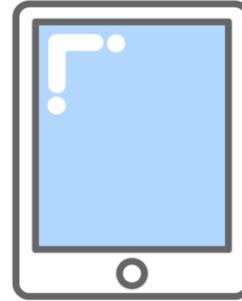
- Work with OEMs to better design and optimize batteries for each application.

- Ensure that batteries will last long enough in application, minimizing warranty risks.

- Directly tie vendor testing in Asia to testing performed in-house, ensuring reliability.

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Quality assurance

- Automate pass / fail reporting, including deeper analysis beyond basic statistics.

- More importantly, when something is amiss customers can quickly dig in and determine the root cause with real-time interactive analysis.

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Field Operations

- Compare system performance across market segments and applications.

- Identify and troubleshoot poorly performing systems.

- Predictive analytics for battery lifetime and failure: Assess SOH and remaining service life; schedule maintenance, replacement; estimate warranty liability.

Deeper analytics enabled by data-driven product development

Longer warranties have created new challenges

T. Baumhofer et. Al. / Journal of Power Sources 247 (2014) 332-338

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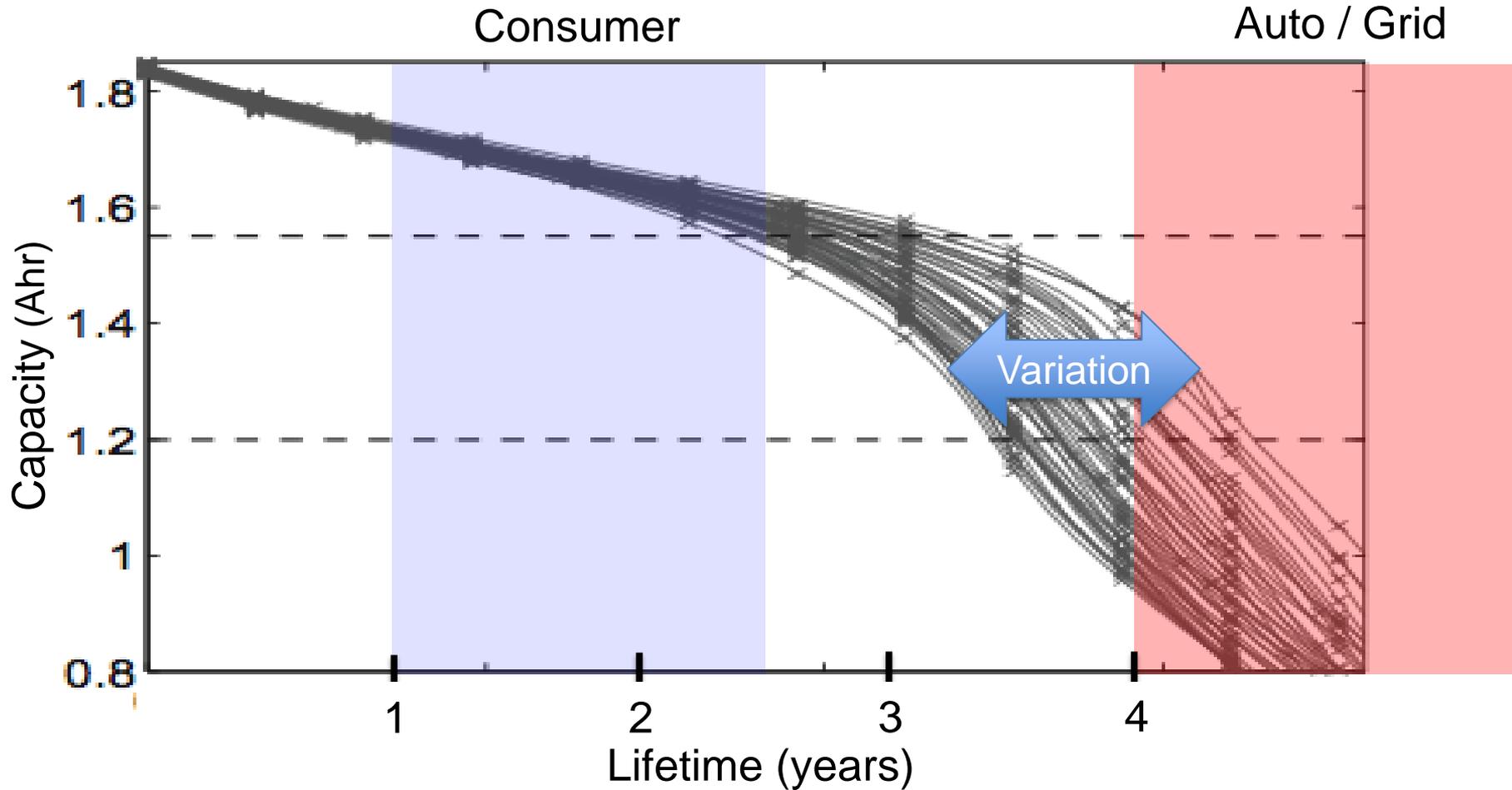
Getting more from your raw data: Capacity isn't enough

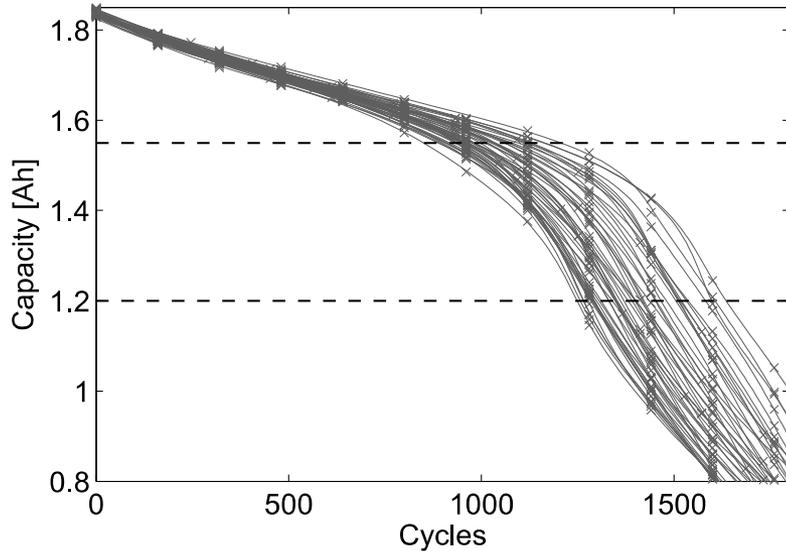**Fig. 6.** Different aging trends from 48 equal cells under same aging conditions and profiles.
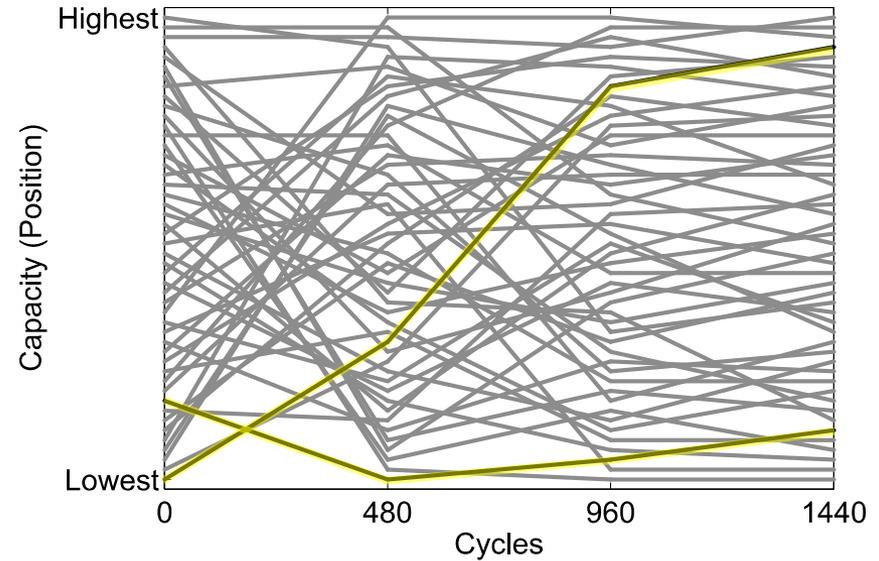

Fig. 7. Development of the position of the 48 cells within the sorted capacity at four cycle lifetimes.

Minimal correlation between capacity early and late in the life cycle

T. Baumhofer et. al. / Journal of Power Sources 247 (2014) 332-338

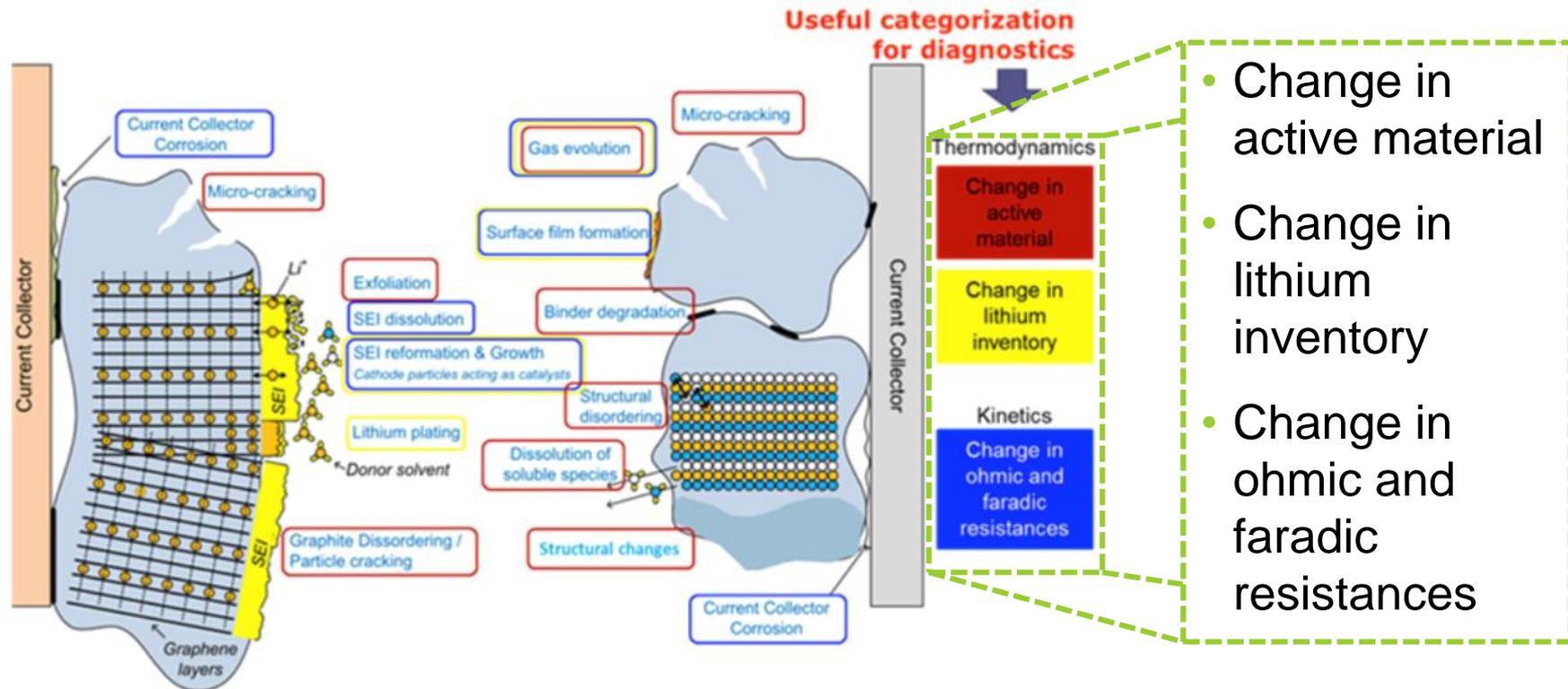# Need to probe deeper into the data

Identify signatures of primary degradation mechanisms

Fig. 1 Schematic of possible degradation processes in a Li-ion battery. Adapted with permission from [1].

- Change in active material
- Change in lithium inventory
- Change in ohmic and faradic resistances
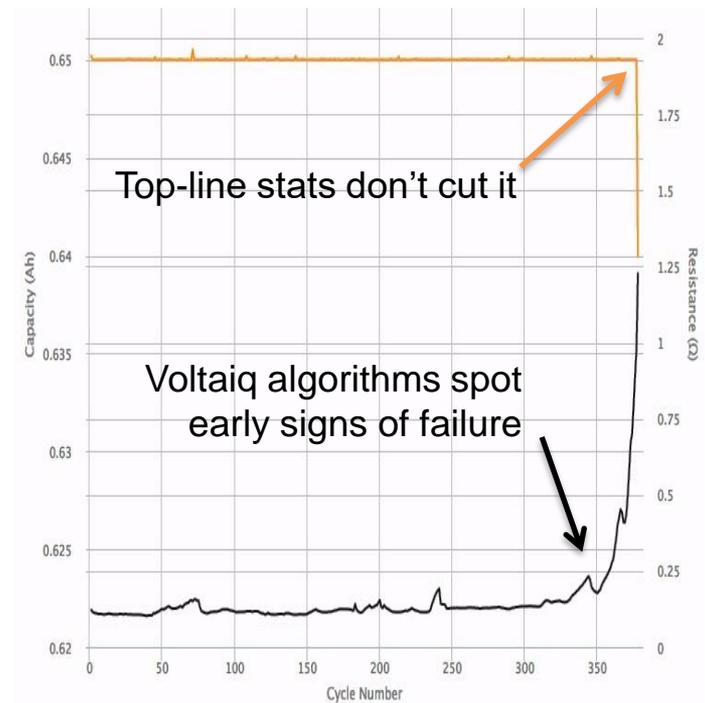
M. Dubarry et. al. / J. Energy Power Sources 1 (2014) 242-349

Dig deeper and extract key diagnostic information from raw time series data

From raw time-series current and voltage…

Predict failure

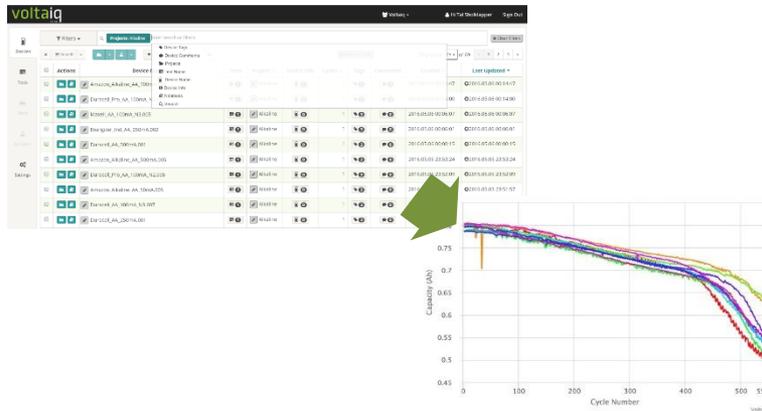Top-line stats don't cut it

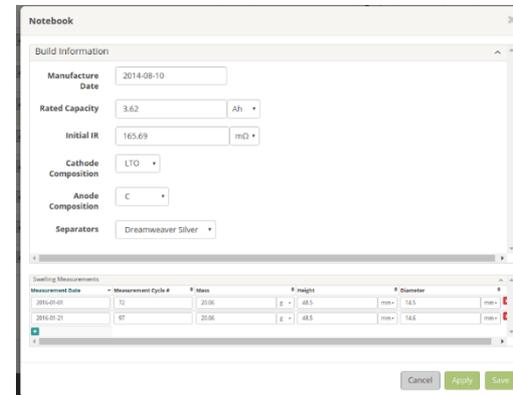Voltaiq algorithms spot early signs of failure
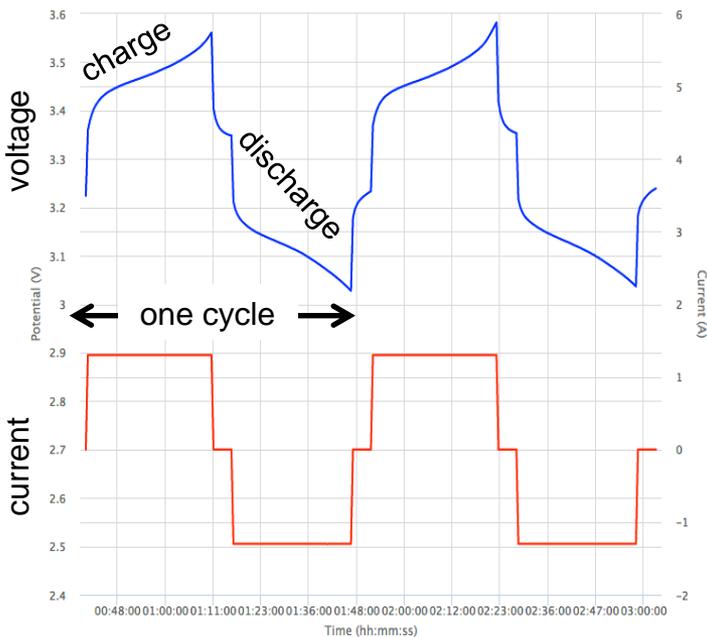
voltaiq
proprietary
analytics

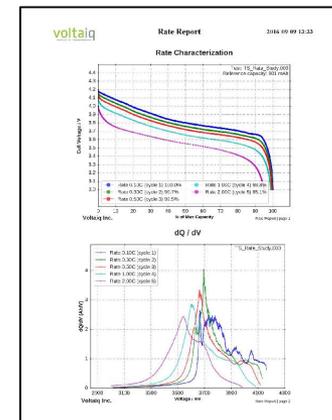# Use the Voltaiq Battery Intelligence Platform to drive product development

- ## Voltaiq Core

- ## Voltaiq Notebook

- ## Voltaiq Analytics

Alpha: 519.520,
Beta: 12.758
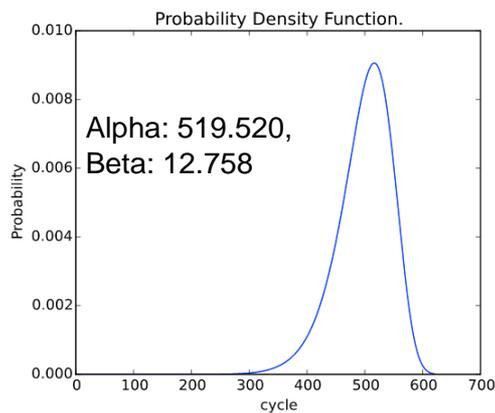
- ## Voltaiq Reports

Get Products to Market **Faster** at a **Lower Cost** and Ensure **Safety** and **Reliability**

- Complete projects significantly faster (10x or more) by leveraging existing research and IP, and automating routine data gathering and analysis.

- Uncover hidden knowledge by quickly aggregating and processing massive volumes of data from different operating units.

- Enable collaboration across employees, partners, departments and throughout the organization.

- Improve decision making with better, faster results through real-time, interactive reporting.

- Reduce the risk from product failure by 80%, potentially saving billions of dollars.

- Reduce total cost of ownership (TCO) through a common and consistent approach to IT services.

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Thank you!

To learn more please visit our website

www.voltaiq.com

or contact us at

info@voltaiq.com

(646) 586-3062

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