Thread eVTOL battery data, build digital twins and save lives

The eVTOL SHOW USA

Crowne Plaza, Palo Alto
October 24, 2023

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eVTOL batteries face three major data challenges

Peaxy provides a modular and scalable AI-based decision system for critical infrastructure within the industrial, energy, mobility, and defense domains.

The first-mile challenge

Capture edge data, transform it, and store it in a useable form.

The data fusion challenge

Manage diverse data sets, threaded by serial number, for the life of the asset.

The last-mile challenge

Ensure the operational relevance of the deployed analytics engines.

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Demanding use cases for premier customers

Battery R&D, manufacturing, monitoring, electrification

Industrial, life sciences and defense

Health monitoring, alerting	**R&D, Metrology, Mfg**	**R&D, Metrology**	**R&D, Metrology**	**CBM, digital twins, health monitoring**	**CBM, digital twins, health monitoring**	**Metrology**	**IIoT, CBM, Metrology and Mfg**
Grid batteries	Grid batteries	EV batteries	EV batteries	Submarine batteries and critical systems	Aircraft carrier electrification equipment	Spatial Proteomics	Munitions

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eVTOL Batteries Article - Aviation Week

How Do We Ensure eVTOL, UAM Batteries Are Fit To Fly?

Manuel Terranova October 13, 2022

When you do eventually step into an electric vertical takeoff and landing (eVTOL) vehicle, what assurances will you have that its batteries are reliable and safe for the next flight?

Aviation propulsion batteries present an extraordinary challenge because electrochemistry is fickle, making batteries harder to manage when compared to rotors, propellers, engines and airframes. This “fickleness” largely depends on two primary factors: (1) variability in battery manufacturing and (2) the dynamic nature of the eVTOL dispatch and operational environment.

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eVTOL Batteries Article - issues and challenges

Dynamic dispatch regimes with high C-rates.

Changing environmental variables … ambient temps, weather.

In-house Battery Management Systems.

SoC and SoH … the “fuel gauging problem.”

FAA oversight … competency set, lack of data standards (BMS, charging, data collection).

“Big Data” scale telemetry capture, computational data pipelines and tracking over the battery lifecycle.

Lack of threading to the atomic level - “tail number to cell number.”

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Battery failure headlines - incidents, public perception and regulation

Smoke Pours From Northern NY Solar Farm Battery Blaze; Governor Says It 'May Pose Health Risks'

Battery storage is a key piece of California's clean energy transition. But there's a problem with fires

Big Batteries Are Booming. So Are Fears They'll Catch Fire

An analysis by the California Public Utilities Commission estimated that 2 percent of grid storage facilities will experience "major safety-related" incidents, with the risk greatest during the first two years of operation.

Explosion fears lead San Diego to explore regulating lithium-ion batteries, storage facilities

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Battery failures headlines - fire risk, recalls, warranty exposure

Hyundai and Kia recall nearly 3.4 million vehicles due to fire risk and urge owners to park outdoors

At Least 100 New Ford F-150 Lightning Pickups Suffer Battery Pack Issue

Ford Adds Nearly 35,000 Mustang Mach-E EVs to Battery Recall

Multiple recalls spark Fed investigation of LG's electric car batteries

Five automakers have issued recalls linked to defective lithium-ion cells.

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Battery Failure Modes

Thermal Abuse – Thermal abuse occurs when batteries are subjective to extreme temperature ranges. Causes include extreme ambient temperatures, contact with burning or overheating adjacent cells, adjacent heat sources.

Electrical Abuse – Electrical abuse takes place when a battery is overcharged, charged too rapidly, or externally short-circuited. Dispatch regime that involve high C-rates are of specific concern, over-discharging beyond end voltage.

Mechanical Abuse – Mechanical abuse occurs if the battery is physically compromised when the battery is crushed, dropped, penetrated, or otherwise distorted to failure by mechanical force.

Internal Faults – Internal faults are generally tied to manufacturing defects, calibration errors, inadequate design, the use of low-quality materials, or deficiencies in the manufacturing process.

Environmental Impacts – Can be the result of extreme ambient temperatures, floods, ingress of debris or corrosive mists such as dust (deserts) or salt fog (marine locations), or rodent damage to wiring.

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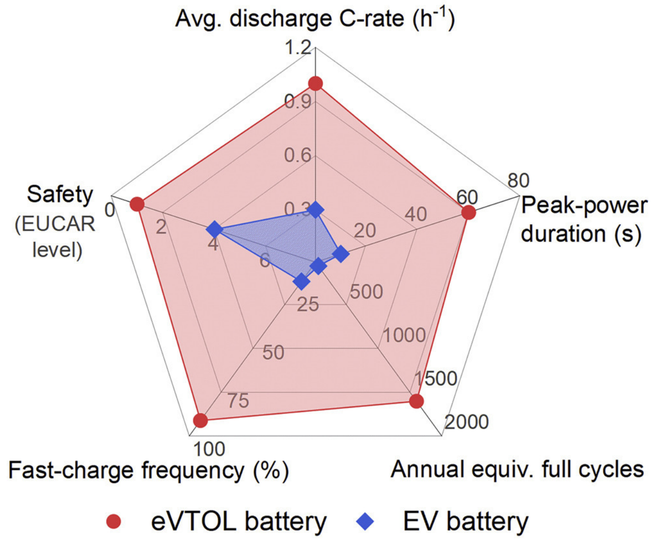
eVTOL Battery Testing Considerations

Battery, Airframe Tested In FAA, NASA eVTOL Crash Tests

December 20, 2022



https://doi.org/10.1016/j.joule.2021.05.001

Performance Metrics Required of Next-Generation Batteries to Electrify Vertical Takeoff and Landing (VTOL) Aircraft
William L. Fredericks, Shashank Sripad, Geoffrey C. Bower, and Venkatasubramanian Viswanathan

A review of safety considerations for batteries in aircraft with electric propulsion
Shashank Sripad, Alexander Bills, Venkatasubramanian Viswanathan

Challenges and key requirements of batteries for electric vertical takeoff and landing aircraft
Xiao-Guang Yang, Teng Liu, Shanhai Ge, Eric Rountree, Chao-Yang Wang

Effects of range requirements and battery technology on electric VTOL sizing and operational Performance.
Warren M., Garbo A., Kotwicz Herniczek M.T., Hamilton T., German B.

Lessons learned from the 787 dreamliner issue on lithium-ion battery reliability
N Williard, W He, C Hendricks, M Pecht

FAA is testing mechanical abuse...

...but the challenge is in the dispatch requirements...

...and the research community knows it!

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Battery lifecycle chain of custody

The battery lifecycle chain of custody

Battery OEM portion of the battery lifecycle chain of custody

- Lot Data
- Build Data
  QA Data
- Formation
  Charge Data

<1 year

Battery system integrator portion of the battery lifecycle chain of custody

- Battery System Commissioning Data
- BMS Telemetry Data
- PCS , Inverter, and Metering Telemetry Data
- Derived computations: RTE, Degradation, Capacity, other KPIs

10 - 15 - 20 years

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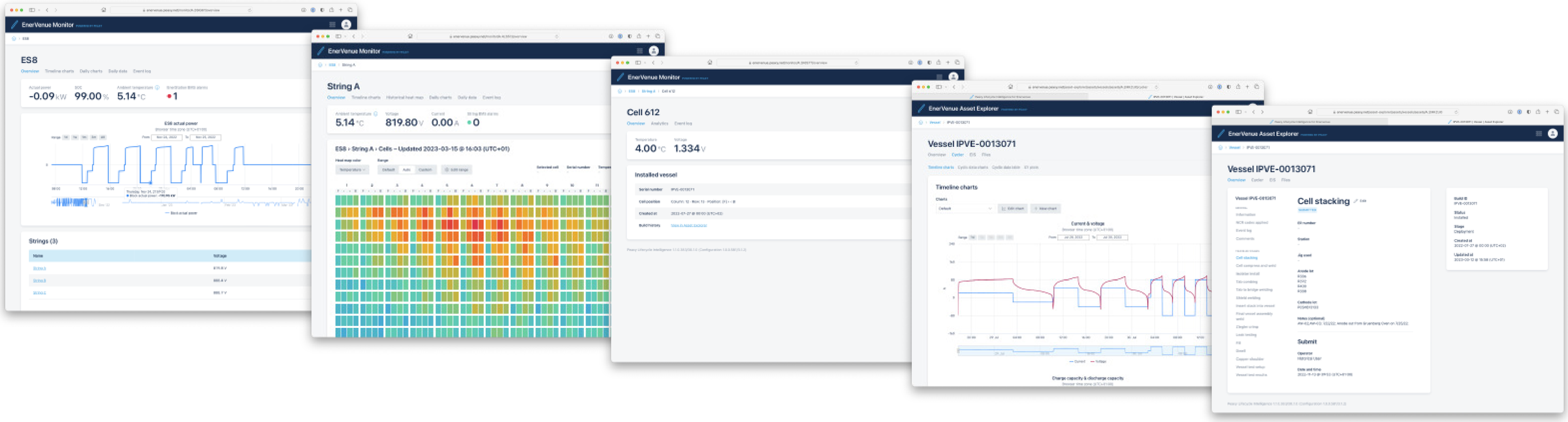
Comprehensive data threading is a must have capability for eVTOL batteries

Thread all the data, across the entire hierarchy of the fleet, from the site level to component lots … and make it queryable.



Site and energy block/array

KPIs and real-time performance information

String, battery and cell

Performance and warranty heat map

Individual battery and cell

Degradation, performance, configuration and service history

Individual battery/cell build and test

Build history, In-field telemetry, formation data, commissioning data

Individual battery/cell anode and cathode lot

Full BoM traceability

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Peaxy classification of digital twins

“Narrow Mission Twin”

Output Examples:

Degradation or SoH by serial number

Battery warranty compliance KPIs

Remaining Useful Life by serial number

Training visualizations

Inputs and processors:

Medium-res, real-time, telemetry

Usage profile-informed

Ambient conditions

Supervised and unsupervised ML

“Maintenance/Optimization Twin”

Output Examples:

CBM recommendation engine

Inventory optimization and staging

Health monitoring, predictive alerts

Forecasted A_o

Digital dossier, threaded information

AR/MR

Inputs and processors

Medium-res, real-time telemetry (1Hz)

Low-res geometry (5M+ polygons)

Tens of cores

Semi-empirical models

Fault mapping

Supervised and unsupervised ML

“Engineering/Design Twin”

Output Examples:

Design reviews, geometry validation

Design for manufacturability

Structural loading studies across operating regimes

Configuration recommendations

Electrochemistry physics model

VR/AR

Inputs and processors

High-res geometry (100M+ polygons)

High-res telemetry (10kHz)

Hundreds of processing cores

Physics-based models

Physics+costing+financial+lifing models

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Digital Twins for Batteries

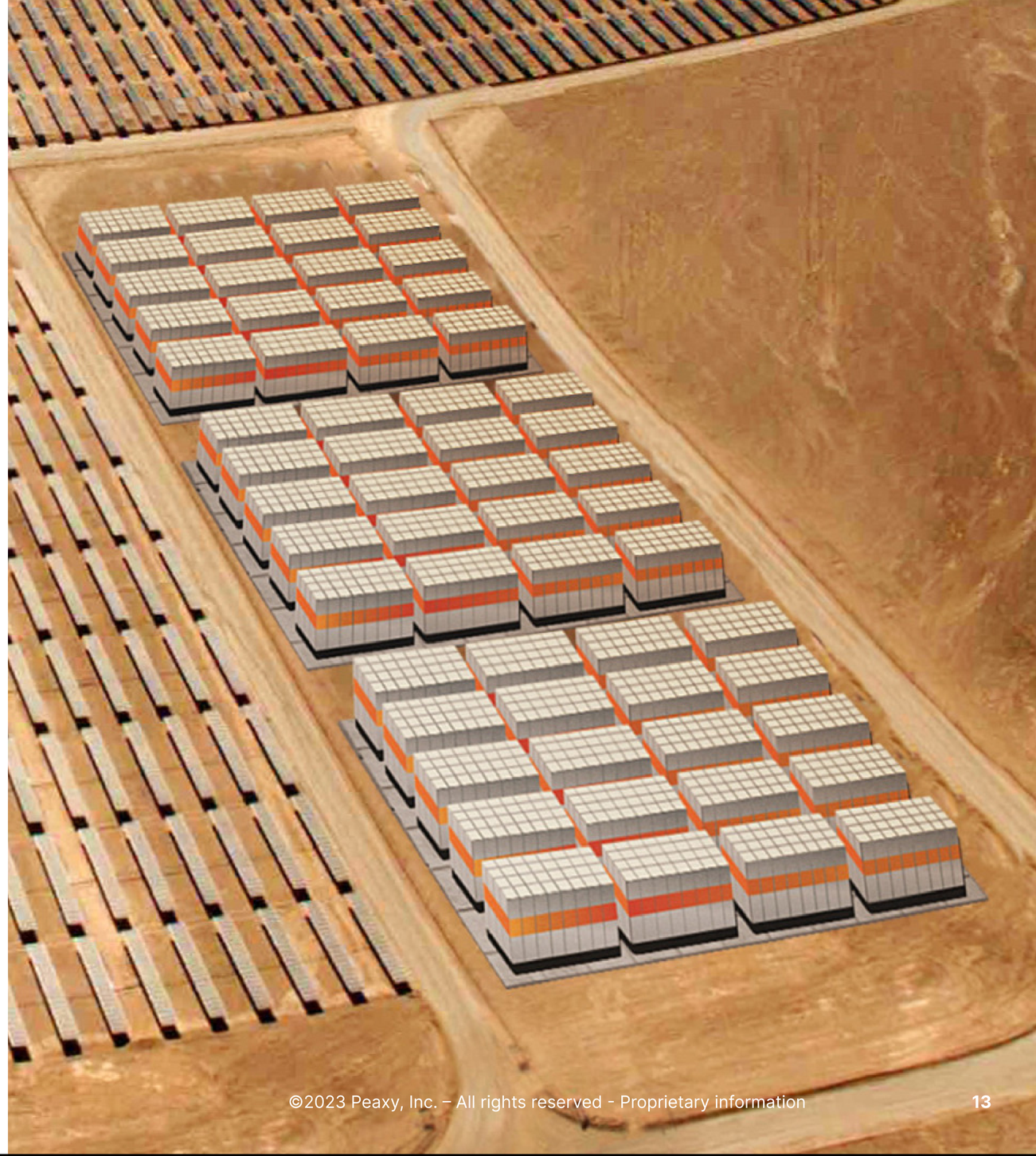
Performance Monitoring, Alerting, Anomaly Detection, Degradation, and Prediction

Component-level prediction (cell or module) … can be scaled and expanded.

Reports real-time status and provides prediction … but focused on a narrow mission.

Particularly useful in fleets that contain large number of similar -yet unique- asset types.

Useful for triggering CBM events / field service interventions.



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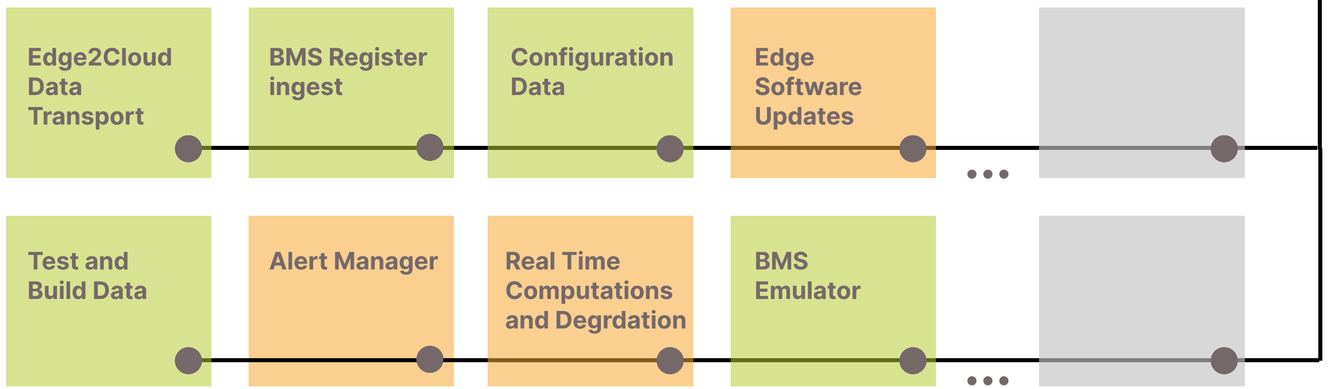
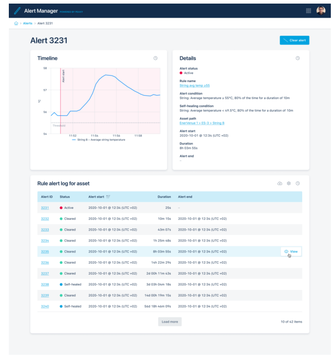
Battery Digital Twin - with full threading

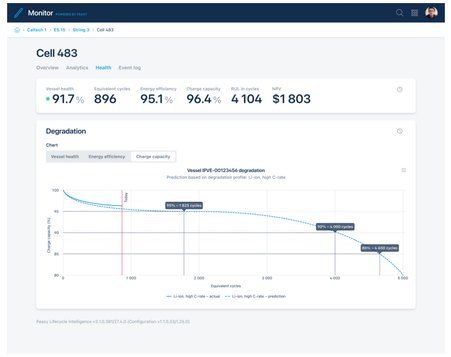


Threaded Digital Twin Components, Configuration Data, Telemetry and Computations

Primary Output: Anomalous Temperature, Voltage, and Degredation



Secondary Output: Alerting



Secondary Output: Degradation and SoH Details

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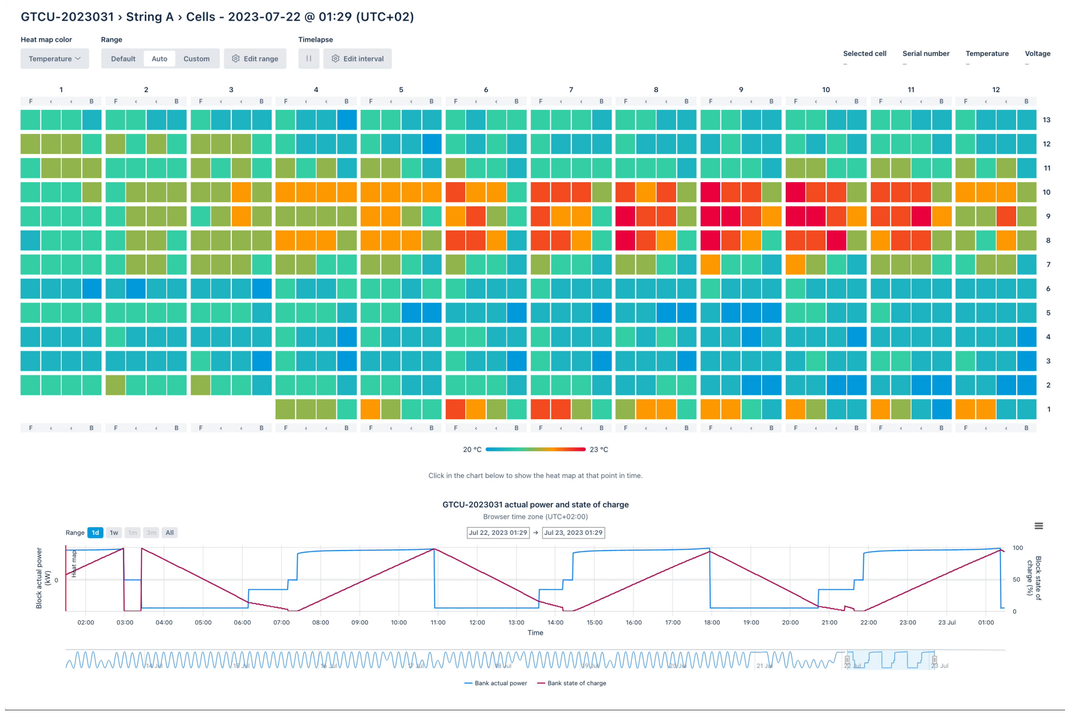
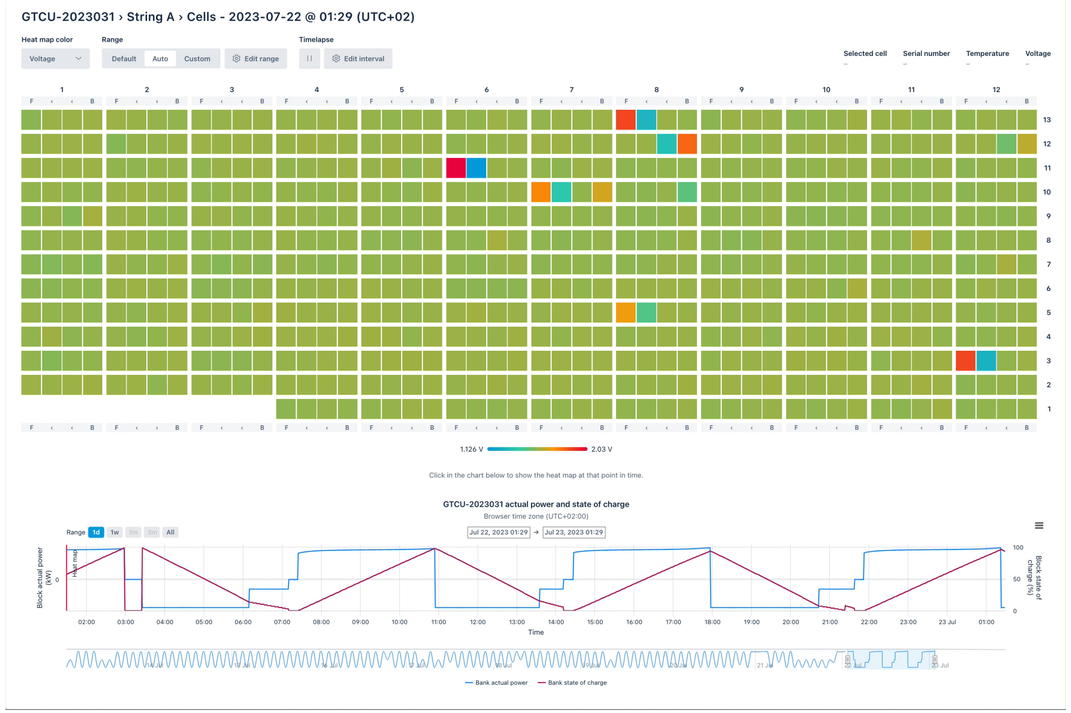
Battery Digital Twin





Actual Power and State of Charge with cell/battery module temperature-based heat map with playback capability.

System captures ambient data and weather forecast for complex alert rules.

Tuned algorithms can predict degradation or warranty impact.

Cell level performance KPIs and test history instantly available.

Actual Power and State of Charge with cell/battery voltage heat map with playback capability.

Alerts can include over and under voltage thresholds and degradation.

BMS Alarms at cell, string, block level instantly available.

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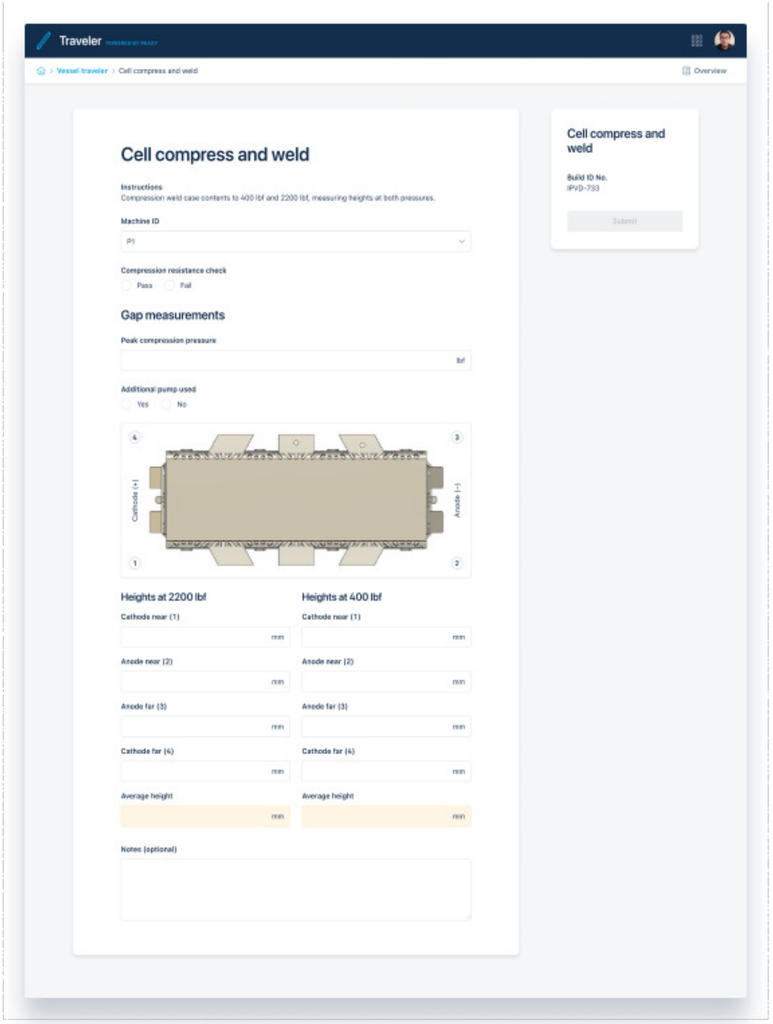
Battery Digital Twin - full threading including mfg, test and field telemetry

automated feature extraction for battery metrology and cyclers



digital travelers to capture all process steps on manufacturing line including fully automated stations

real-time, from-edge 1Hz data capture and analytics

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About Peaxy

Peaxy Lifecycle Intelligence software generates value from industrial data.

Core competencies

- Lifecycle data management and analytics subscription software for batteries, electrification and industrial equipment. Agile throughout … rapid deployment.
- First mile: Enterprise grade edge data capture and data pipelining for at-scale, unstructured and structured data. Repeatable SW and HW solutions for telemetry movement, parsing, processing, threading, edge capture, edge aggregation.
- Last mile: Application of CBM+, compound digital twins, machine learning algorithms and asset health scores to control, model, and predict industrial asset behavior.
- Extensive PLI integration track record with control and telemetry systems such as BMS and PLC systems. Experience includes batteries, ultra-capacitors, linear induction motors, compression, air handling, turbines, metrology, testing and other complex industrial and defense equipment.
- Our PLI software runs on AWS GovCloud, Azure, Google, and in fully standalone (air-gapped) configurations. PLI is SSO, OAuth2, Platform One (DoD), and ITAR compliant.
- Highly secure and DoD / DoE trusted: PLI listed with DoD Iron Bank, Impact Level 4/5 accredited. Audited by trusted DoD third party test suites. PLI inter-application communications run on hardened non-routable private network. All PLI managed data, both at edge and in the cloud is stored using encryption at rest. All data and control logic transmitted into or out of PLI is protected with authentication, authorization, and on the wire encryption.

Company

- Founded 2012 in Silicon Valley, California. Team is 42 people, most being software engineers/data scientists.
- We are an US headquartered company with European offices. The has an American Board of Directors, with a large majority of US investors and employees. Peaxy primarily serves private sector battery-focused companies, and complex electrification/metrology use cases for the US Navy and the DoE.
- SunSpec Alliance Contributing member, Maritime Technology and Innovation (MSTIC) member, National Security Technology Accelerator (NSTXL) member, NAATBat member.
- Active teaming agreements in defense sector with Delphinus Engineering, Booz Allen, Xsite, BeastCode and ECCOE.

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