How to Establish a Battery Health Transformation Program in 90 Days

DRIVING BOTH PROFITABILITY & SAFETY IN ELECTRIC ERA

Executive Summary

In electric vehicles, the battery has become the economic and performance core of the entire system. Metrics like State of Charge (SoC) accuracy and State of Health (SoH) tracking now directly shape range confidence, vehicle uptime, warranty costs, and brand trust. Even small errors can escalate quickly, creating range anxiety for customers, premature service calls, or unnecessary warranty swaps. Battery health is no longer just an engineering issue—it is a boardroom-level priority.

At the same time, regulations are raising the bar for transparency and software management. Europe's 2027 "battery passport" will require each EV battery to carry a digital record of its health and history, while UNECE R156 mandates that automakers establish secure, auditable Software Update Management Systems (SUMS) for over-the-air updates. These rules make it clear that OEMs must adopt data-driven, OTA-native approaches to managing batteries, with compliance, safety, and customer satisfaction on the line.

Industry leaders are responding by moving to data-first strategies built on precision telemetry, cloud data platforms, and AI/ML models for SoC/SoH estimation and degradation forecasting. When paired with SUMS-compliant OTA updates, these tools enable fleets to improve continuously over time.

The benefits are tangible: addressing SoC/SoH accuracy, degradation analytics, thermal risk management, and warranty integration helps OEMs cut warranty exposure, extend battery pack lifespan, and deliver a better customer experience. This eBook explores these pain points in detail, outlines practical solutions, and provides a 90-day action plan to help decision-makers take immediate, effective steps toward better battery health management—driving both profitability and safety in the electric era.

🔋 Pain Area 1: SoC / SoH Drift

> ⚠️ **The Problem:** BMS estimates for charge and health drift over time due to sensor errors, temperature effects, and chemistries like LFP with flat voltage curves. Small biases cause inaccurate range, false alerts, and customer mistrust.
>
> 🔎 **Warning Signs:** Unstable SoC readings, inconsistent range between vehicles, and mismatched capacity tests.

✅ **What Good Looks Like:** Cell-level telemetry, hysteresis-aware algorithms (e.g., adaptive Kalman filters), fleet-wide model personalization, and ongoing validation using “golden vehicles.”

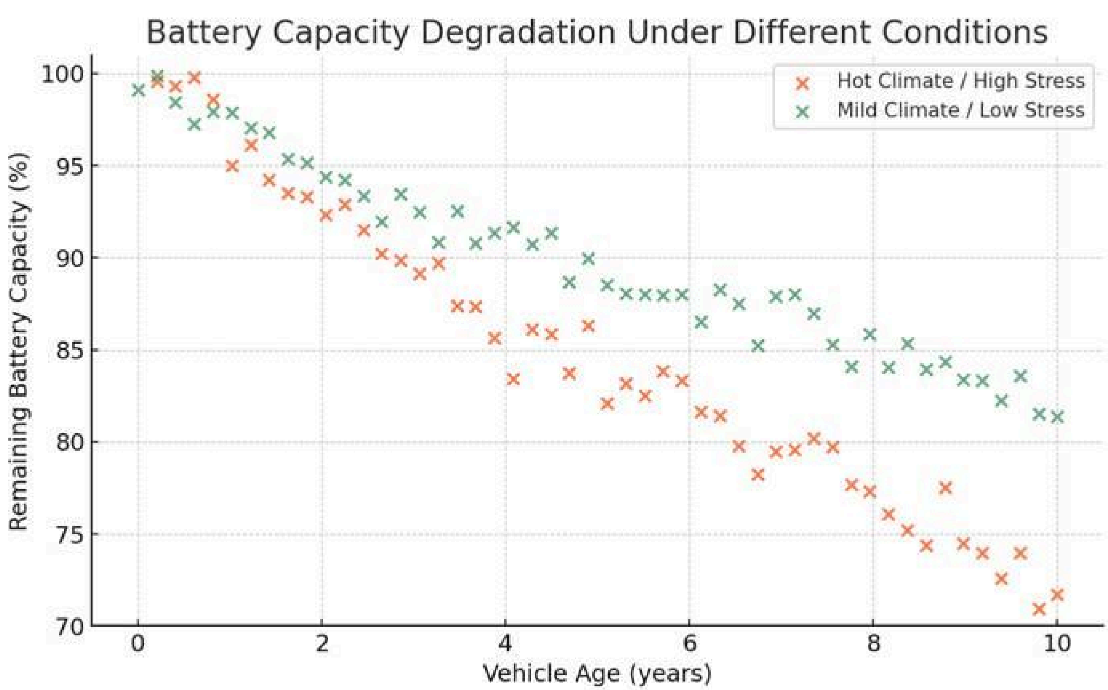
⚡ **Quick Wins:**

- Calibrate during rest windows (opportunistic OCV sampling).
- Deploy hysteresis-aware SoC algorithms.
- Report SoC/SoH with confidence intervals, not just a single number.

📉 Pain Area 2: Degradation Analytics

⚠️ **The Problem:** Calendar aging (time, temperature, SoC dwell) and cycle aging (DoD, C-rate) vary widely across fleets. Without analytics, OEMs can’t separate normal vs abnormal fade, leading to warranty surprises.

🔎 **Warning Signs:** Wide scatter in capacity at equal mileage, hidden power loss from impedance rise, early charging complaints.



Capacity Degradation: Batteries under stress (hot climates, high SOC, fast charging – red X's) fade faster than mild-use packs (green X's). After years, high-stress cells may drop to ~75% while low-stress remain ~85–90%. Analytics reveal these patterns, enabling OEMs to tailor maintenance and warranty policies.

✅ **What Good Looks Like:** A "degradation feature store" capturing SoC dwell, temperature exposure, throughput, and cycling profiles. Physics-informed ML forecasts RUL with confidence ranges, enabling proactive policies.

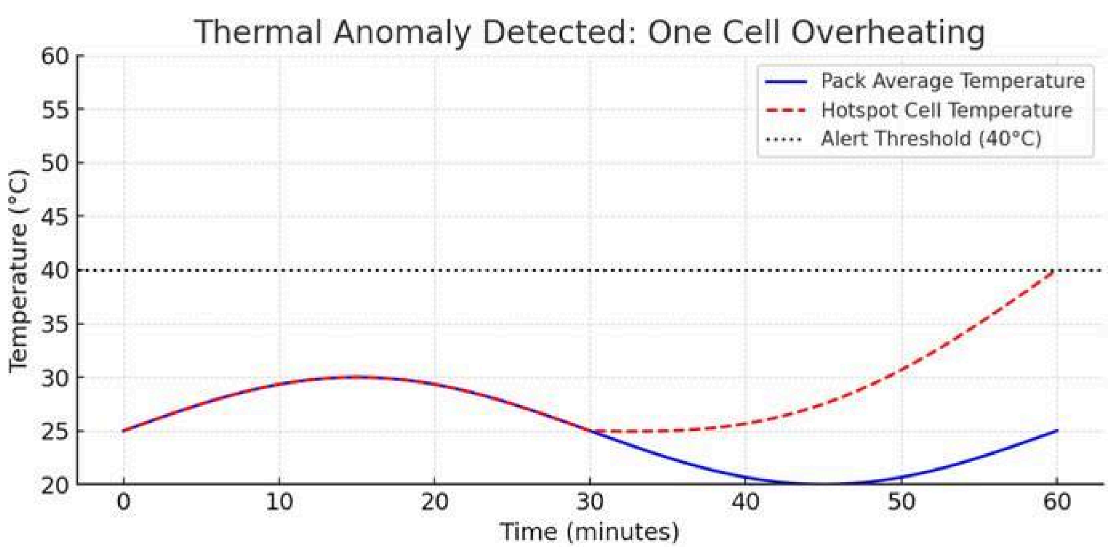
⚡ **Quick Wins:**

- Use existing SoC + temperature logs for calendar aging insights.
- Apply Incremental Capacity Analysis to identify aging modes.
- Push OTA updates to protect batteries (e.g., long parking mode, charging rate adjustments).

🔥 Pain Area 3: Thermal Events

⚠️ **The Problem:** Thermal runaway, though rare, is high-risk. Static thresholds cause false alarms or missed warnings; context-aware prediction is needed.

🔎 **Warning Signs:** Asymmetric heating across cells, frequent temperature alarms, and false positives in extreme weather.



Thermal Anomaly Detection: In the chart, the **red dashed line** shows one cell heating faster than the **blue pack average**. Rather than waiting for the 40°C limit, smart systems track rise rates and gaps, flagging issues early. Adaptive thresholds adjust for ambient conditions, reducing false alarms while still catching real risks.

✅ **What Good Looks Like:** Multi-sensor fusion, adaptive thresholds, gradient/rate-of-rise monitoring, and robust propagation control (cooling, venting, isolation). Fleet-wide event classifiers continuously improve detection.

⚡ **Quick Wins:**

- Fine-tune thermal limits via OTA by climate region.
- Add predictive cooldown cycles post-fast-charge.
- Track cell-to-cell gradient and rate-of-rise as KPIs.

💰 Pain Area 4: Warranty Exposure & Cost Gravity

⚠️ **The Problem:** Packs are the biggest warranty cost. Poor algorithms and blunt policies trigger costly "no fault found" swaps or missed real failures.

🔎 **Warning Signs:** High NFF swap rates, disputes over SoH measurements, volatile warranty reserves.

✅ **What Good Looks Like:** Standardized SoH test procedures across BMS, service, and customer tools; predictive, risk-based warranty thresholds; closed-loop learning from claims into analytics and OTA fixes.

⚡ **Quick Wins:**

- OTA-enabled standardized health test.
- Segment warranty by climate or usage cohorts.
- Educate customers via in-car software prompts.

Building a Battery Health Operating Model: What Leaders Need

To address battery health challenges at scale, OEM leaders must create an operating model that unites **data, technology, processes, and people**. Below is a framework outlining the critical components.

📊 Data Foundation

A strong data foundation is the bedrock of battery health management.

- **Cell-Level Logging:** Capture voltage, current, and temperature for each cell or module at high frequency with precise timestamps.
- **Contextual Data:** Include charger session details (duration, power, rate), ambient climate conditions, and location.
- **Fleet-Wide Feature Store:** Aggregate data into a centralized repository, producing usage profiles (e.g., SoC histograms, depth-of-discharge cycles, fast charge counts, thermal exposure patterns).

This comprehensive dataset ensures analytics are grounded in reality rather than assumptions.

🤖 Models & Validation

Deploy advanced models to extract actionable insights from the data.

- **Physics-Informed AI/ML:** Develop models that integrate battery science (e.g., effects of temperature on resistance, lithium plating behaviors) to improve SoC/SoH estimates and degradation predictions.
- **Uncertainty Quantification:** Ensure outputs include confidence ranges to guide decision-making.
- **Continuous Validation:** Maintain "golden vehicles" across climates and use cases to serve as reference benchmarks. Use A/B testing and cohort analysis to verify new model performance, ensuring algorithms remain accurate over time.

Treat the fleet as a living laboratory, continuously refining accuracy.

🌐 OTA-Native Control

Design your control and update strategy to be **OTA-first**.

- **SUMS-Compliant Pipeline:** Meet UNECE R156 standards with staged rollouts, rollback capabilities, and full audit trails.
- **Agile Policy Updates:** Enable remote tuning of charging profiles, derating thresholds, and test routines via configurable parameters.
- **Safe Deployment:** Start with 5% of the fleet, monitor results, then expand to 100% if successful, with rollback as a safeguard.

This agility allows OEMs to respond in weeks rather than years when new insights emerge.

🛡️ Risk & Compliance

Battery management must be treated as a **safety-critical system**.

- **Safety Case Documentation:** Record how thermal runaway risks, fail-safes, and software changes are managed.
- **Regulatory Alignment:** Build compliance reporting into processes, covering OTA regulations, emerging battery passport requirements, and cybersecurity mandates like ISO 21434.
- **Cybersecurity Integration:** Protect battery data and OTA controls against malicious interference.

Compliance not only avoids penalties but strengthens trust with regulators and customers.

🔧 Warranty & Service Integration

Break silos across engineering, warranty, and service functions.

- **Unified Tools:** Ensure technicians and engineers use the same SoH calculation methods and test procedures.
- **Shared Dashboards:** Create real-time KPI views accessible across teams.
- **Joint Cadence:** Schedule regular reviews where engineers present degradation trends and service managers provide field insights.

This alignment ensures warranty thresholds, repair policies, and updates are consistent, transparent, and data-driven.

👥 People & Process

Technology alone cannot drive change; culture and organization matter.

- **Cross-Functional Teams:** Form working groups that unite battery engineering, software, IT, service operations, quality, and legal.
- **MLOps Discipline:** Treat analytics models as products with version control, monitoring, and rollback procedures.
- **Operating Rhythm:** Define meeting cadences, goals, and KPIs to keep all stakeholders aligned.

A culture that treats **data and models with the rigor of hardware development** will build credibility, resilience, and long-term trust in the battery program.

The Future of Battery Health: AI, ML & OTA

A software-defined, battery-centric future is emerging. AI/ML and OTA will enable:

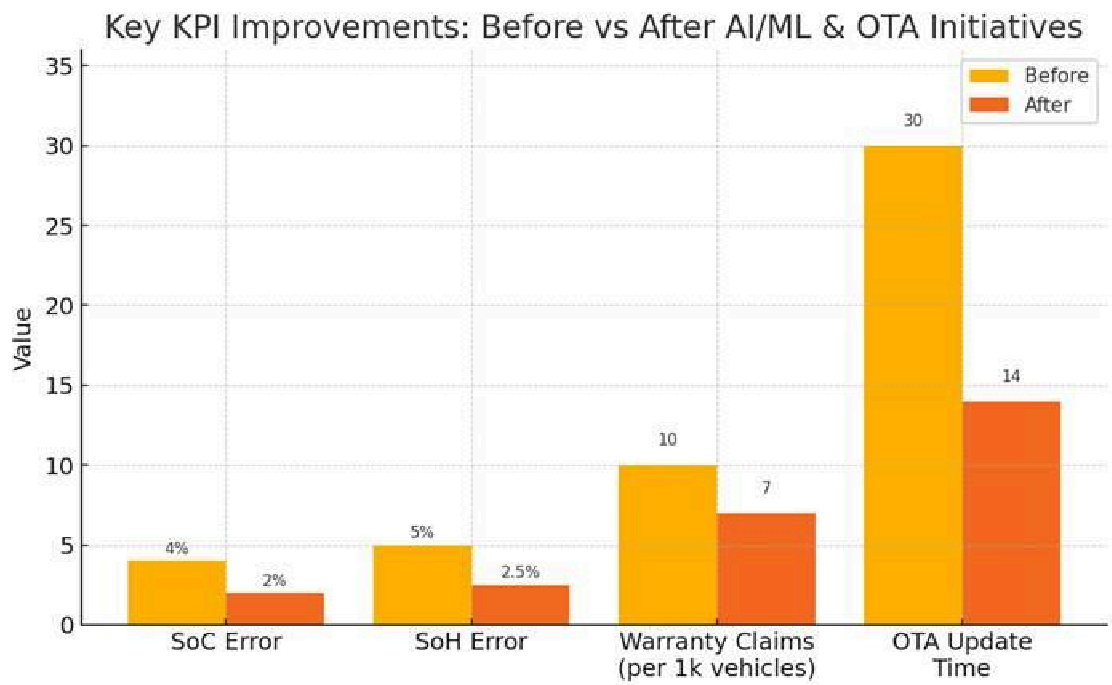
🧩 **Personalized Models** – Each battery develops its own digital twin, self-calibrating to usage patterns for highly accurate SoC/SoH estimates.
☁️ **Fleet Learning Loops** – Data from every vehicle trains central models, which are then redeployed OTA, creating a continuous improvement cycle.
🛡️ **Proactive Safety** – Early-warning AI detects subtle precursors of failures, coordinating with chargers to prevent issues before they escalate.
📑 **Built-In Compliance** – Automated reporting and real-time health data align with regulatory requirements, turning compliance into an advantage.
♻️ **Second-Life Value** – Verified SoH histories boost resale value and enable new business models for used EV batteries.

KPIs that Matter (and Target Bands)

To drive these improvements, it's crucial to define clear Key Performance Indicators (KPIs) for battery health management. Below are some of the most impactful KPIs that OEMs should track across Engineering, Service, and Warranty teams. We include target ranges to aim for (these will vary by chemistry and fleet maturity, but serve as general benchmarks). Each KPI should be tracked over time and segmented by relevant cohorts (e.g. climate, vehicle model, battery supplier) to glean insights:

🔋 Core Battery KPIs

- **SoC Accuracy (95% Confidence)**
  Measures accuracy of state-of-charge estimates vs. reference tests.
  Target: ±1.5–2.5% (current fleets); ±3–4% (older chemistries).
  Ensures driver trust in range display.
- **SoH Estimation Error (RMSE)**
  Gap between BMS-estimated vs. measured capacity.
  Target: <3% (ideally 1.5–2.5%).
  Critical for warranty and service decisions.
- **Thermal Gradient Rate (TGR)**
  Rate of temperature rise across cells during/after charging.
  Target: Alert if above 97th percentile of fleet baseline.
  Flags anomalies in thermal consistency.
- **Fast-Charge Exposure Index**
  Share of energy from fast charging at sub-optimal temperatures.
  Target: Keep in low single digits via smart charging controls.
  Reduces long-term degradation risk.
- **Warranty Claim Rate (per 1,000 vehicles)**
  Battery-related claims opened vs. fleet size.
  Target: Reduce by ~20% YoY.
  Direct link to cost savings and reliability.
- **OTA Safety Update SLA**
  Time to deliver critical safety updates fleet-wide.
  Target: 80% fleet coverage within 14–21 days.
  Demonstrates rapid response capability.



Impact of AI/ML + OTA on Battery Health KPIs

Adopting an AI/ML-driven OTA strategy delivers measurable gains:

- SoC / SoH Accuracy: Errors shrink from ~4–5% → ~2%, boosting range confidence and diagnostics.
- Warranty Claims: Drops from ~10 → ~7 per 1,000 vehicles, as analytics pinpoint true issues.
- Update Speed: Rollout time improves from ~30 → ~14 days, accelerating safety and performance fixes.

These improvements lower costs and strengthen customer trust in EV reliability.(See chart: orange = before, red = after).

OEM Readiness Checklist

For an OEM embarking on this battery health initiative, it's useful to assess readiness across key capabilities. Below is a checklist of enablers that should be in place (or actively being developed). An executive can use this to spark conversations with their teams on where gaps might exist:

- **Cell-Level Data Logging:** Do we record **detailed cell data** (voltage, temperature, current) and relevant context (timestamps, ambient conditions, charger info) from our vehicles? Without this granularity, our models will be flying blind. Ensure data is stored and accessible for analysis.
- **Hysteresis-Aware SoC Estimation:** For chemistries like LFP that have flat voltage curves, have we implemented an algorithm that accounts for **voltage hysteresis and flat regions**? If not, our SoC readings in those vehicles are likely off – we need that capability, ideally with a measure of confidence.
- **Physics-Informed Degradation Models:** Do we have models (or partnerships to develop models) that combine data science with electrochemical knowledge to predict battery aging? This includes handling both **calendar aging** and **cycle aging**, and being able to explain the predictions (e.g. "high temperature calendar aging dominant in Vehicle X").
- **SUMS-Compliant OTA Pipeline:** Is our OTA update system compliant with **software update management regulations** (staged rollout, rollback, auditable, and meets any type-approval rules in regions we sell)? If not, this could delay or derail our ability to push critical updates. Investing here has compliance and safety ROI.
- **Thermal Event Detection & Response:** Do we have **advanced thermal sensors or algorithms** in place to catch early signs of thermal issues? And is our battery pack designed with proper mitigation (venting, isolation) if one occurs? This includes having the right thresholds and logic in the BMS that can be tuned via software.
- **Standardized Capacity Test Routine:** Have we defined a **uniform battery capacity test** that can be run on demand? And is this implemented both in-vehicle (for self-diagnosis) and in service centers? This ensures everyone references the same "truth" when we say a battery is at X% health.
- **Warranty Analytics Pipeline:** Do we actively analyze battery warranty cases for trends and feed that back into design and policy? This means having a system where every battery claim is logged with data and root cause, and a process where that informs things like model updates or service bulletins. A high NFF rate should trigger an immediate investigation by engineering.
- **Regulatory Roadmap Mapping:** Are we tracking and prepared for incoming regulations around batteries (like EU battery passport data, recycling and second-life requirements, cybersecurity for OTAs, etc.)? This involves coordination between legal and engineering to ensure our data and processes will meet those needs when they hit (because they are coming, fast).

Think of the above as **hygiene factors** – if any of these are missing, they represent a risk to the success of a battery health program. Addressing them proactively will smooth the journey as you implement the improvements discussed.

Actionable Next Steps: 90-Day Transformation Plan

To kickstart the transformation, here's a structured 90-day plan broken into three focused phases. Each phase builds momentum with tangible, measurable steps that drive early wins while laying the groundwork for long-term scalability.

Phase 1: Day 0–30 — Lay the Data & Testing Groundwork

Objective: Establish reliable data pipelines, reference vehicles, and baseline metrics to enable accurate measurement and improvement.

- **Set Up a Fleet Data Pipeline**
  Begin building the feature store by defining what data to capture and ensuring consistent collection from vehicles. Start logging SoC dwell times, temperature histograms, and charge cycles. Even if it's just a subset of vehicles, get pipelines instrumented immediately.

- **Establish "Golden" Vehicles and Cycles**
  Identify a handful of reference vehicles across key climates and use-cases. Develop a repeatable drive/charge cycle (e.g., charge to 100%, discharge to 10% at a set load). Use these cycles to validate performance, detect drift, and track long-term capacity.

- **Baseline the KPIs**
  Calculate current baseline metrics (SoC error, SoH error, etc.) using available data. Publish results in an internal dashboard visible to all stakeholders. This shared baseline motivates improvement and provides a transparent benchmark.

Phase 2: Day 30–60 — Pilot New Algorithms & Thermal Controls

Objective: Validate new algorithms and control strategies in real-world conditions with pilot deployments.

- **SoC Model Pilot**

Roll out a hysteresis-aware SoC estimation update to a pilot group (500–5,000 vehicles). Start with fleets where SoC accuracy is known to be challenging (e.g., LFP chemistry). Enable uncertainty metrics alongside estimates. Monitor stability, accuracy, and impact on range confidence against a control group.

- **Thermal Observer Update**
  Deploy OTA updates introducing anomaly detection logic (gradient monitoring, adaptive thresholds). Prioritize vehicles in hot climates where thermal risks are greatest. Adjust post-fast-charge cooling policies to test improvements. Monitor results: fewer false alerts and reduced peak fast-charge temperatures.

Phase 3: Day 60–90 — Expand to SoH and Policy Integration

Objective: Move beyond pilots to scalable SoH routines, forecasting models, and compliance readiness.

- **Standard Capacity Test Rollout**
  Finalize the standardized capacity test routine. Deploy via OTA to the full fleet (or a major segment). Coordinate with service centers to guide customers and staff in using the new feature. Collect high-quality SoH data aligned across engineering and customer experience.
- **First Degradation Forecast Release**
  Launch an initial degradation forecasting model for internal or cloud analytics. Generate 8–10 year capacity projections per vehicle with error bars. Use forecasts to tune policies, e.g., apply OTA charge voltage limits for at-risk cohorts.
- **Compliance and Audit Preparation**
  Build governance muscles with the first SUMS audit artifact. Document process rigor (pilot, testing, monitoring). Establish a recurring release cadence meeting, treating battery improvements as productized updates.

The 90-Day Outcome

By the end of 90 days, you will have:

- Instrumentation in place to reliably capture fleet-level insights.
- Pilot data to showcase progress and demonstrate value to leadership.

- A standard capacity testing framework and initial degradation models in operation.
- A stronger organizational culture around continuous learning, updating, and compliance in battery management.

Conclusion and Call to Action

Battery health is fast becoming the differentiator for successful EV programs. OEM decision-makers who embrace a **data-centric, AI-powered approach with OTA agility** will not only reduce their costs (through fewer warranty failures and optimal maintenance) but also deliver a superior customer experience (through reliable range and safety). This executive guide has outlined the pain points and a roadmap to address them – now it comes down to execution.

The call to action: Partner with platforms and experts that can provide **end-to-end battery analytics and OTA solutions** – from precise data logging hardware to cloud-based machine learning models to secure OTA update pipelines. With the right technology stack (and team) in place, you can start cutting warranty exposure, extending pack life, and continuously shipping safety and performance improvements to the field. In an EV world, **battery health is never "set and forget"** – it's an ongoing commitment. But with the strategies in this eBook, it's a commitment that will drive enduring value for your customers and your company. Let's drive the future of battery health, together.

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[1] [3] Charged EVs | Europe's EV battery passport will bring transparency to the battery industry - Charged EVs

https://chargedevs.com/newswire/europes-ev-battery-passport-will-bring-transparency-to-the-battery-industry/

[2] Compliance with UN R156: Securing Vehicle Software Updates - AUTOCRYPT

https://autocrypt.io/unr156-securing-vehicle-software-updates/

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Sibros delivers connected vehicle solutions that help OEMs transform **battery health management** and fleet durability. Our platform empowers OEMs with:

- **Deep Logger**
  High-resolution cell and pack data logging to track SoC, SoH, and thermal trends, with analytics to reveal degradation patterns across climates and usage profiles.
- **Deep Updater**
  Secure, SUMS-compliant OTA updates to refine charging, deploy safety algorithms, and roll out fixes quickly with staged deployment and rollback safeguards.
- **Deep Commander**
  Remote commands for capacity checks, resets, and optimizations, enabling proactive maintenance and maximizing fleet uptime.
- **Battery Health Integration**
  Unified dashboards for engineering, warranty, and service teams to monitor KPIs, cut warranty exposure, and extend pack life.
- **Future-Ready Design**
  Scalable architecture built for EU Battery Passport and UNECE R156 compliance, with APIs to integrate seamlessly into OEM networks and analytics.

To learn how Sibros can accelerate your battery health strategy and unlock new connected vehicle value streams, visit sibros.tech or contact us at **info@sibros.tech**.