

Newsletter 12

From Black Box to Informed Decision

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How the R3-MYDAS battery demo case gives end-of-life EV batteries a well-founded next life

Over the coming decade, millions of electric-vehicle batteries will come off the road. Many of them still hold most of their original capacity. Yet today they usually reach the next owner as "black boxes": little is known about their chemistry, history, or remaining state of health. Opening a battery pack is still largely manual work that can take from half an hour to several hours. As a result, valuable batteries are recycled too early, while abnormal batteries are hard to spot.

The European Battery Regulation (EU) 2023/1542 is changing the rules by introducing a digital battery passport that includes information on the battery's state of health. For Europe, which depends on imported critical raw materials, keeping batteries in use for longer is a strategic goal as well as an environmental one. Over the past three years, the R3-MYDAS battery demo case, led by AVL together with SPIN Robotics, ITML and CSEM and in close collaboration with Netcompany-Intrasoft, has worked on one question: **what does it take to make a well-founded decision about the next life of a used battery?**

Understand, build, prove: three steps

Understand. The project started by mapping the battery value chain, from vehicle manufacturers and fleet operators to test labs, repurposers and recyclers, and by analysing what each of them needs to know about a battery. The finding was clear: the decisive information gaps lie at the hand-over points between these actors, and the state of health (SoH) is the piece of information that almost everyone needs. The team also developed a first concept for estimating SoH from a single measurement cycle and specified a robotic disassembly demonstrator.

Build. These requirements were then turned into technology: a factory concept in which the factory adapts to the battery instead of forcing every battery through the same process, force-controlled robotic disassembly, standardised data interfaces that make every disassembly step traceable, diagnostic methods for battery condition, and a data platform that brings all of this information together.

Prove. In the final project phase, the technologies are being validated on benchmark data and assessed against the key performance indicators of the demo case. The results will be documented in the final WP3 report at the end of 2026.

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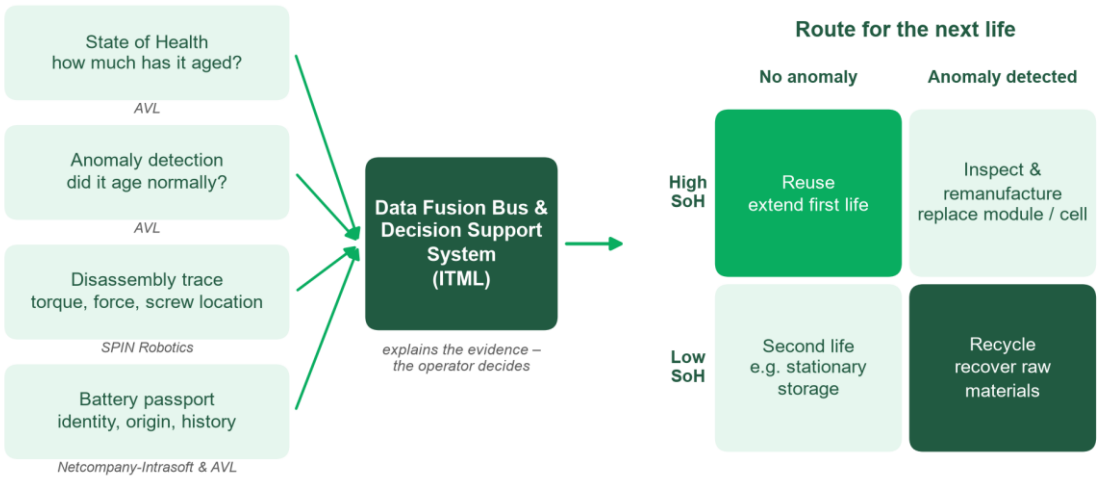
How much has it aged, and did it age normally?

At the heart of the demo case is the combination of two diagnostic views. **State-of-health estimation** tells us how much a battery has aged. AVL's method estimates it from a single charge–discharge cycle. It needs no complete usage history and no capacity test lasting several days, which makes it fast enough for triage at a disassembly line. In a benchmark covering about 50 cells and more than 13,000 cycles from public datasets and AVL laboratory measurements, the estimation error stayed on average below one percentage point of SoH.

Anomaly detection tells us whether the battery aged normally. The model learns the normal behaviour of voltage, current and temperature from healthy measurements only, so no catalogue of labelled faults is needed, and it flags where the measured signals depart from what it expects. Explainable-AI techniques (SHAP) show which signal and which operating condition are responsible, pointing engineers to the probable cause. In a benchmark with more than 2,500 artificially injected deviations, the method detected about one-third more events than a conventional baseline, meeting the project's target of a 30% improvement. The gain was largest for slow, gradual drifts, which are the hardest to spot by eye.

Why both? Because the same state of health does not mean the same risk. A battery with high remaining capacity and no anomalies is a candidate for direct reuse. The same capacity combined with abnormal behaviour calls for inspection and remanufacturing, for example by replacing a module. A battery with low capacity but normal behaviour can still serve for years in stationary storage, while a battery with low capacity and anomalies belongs in recycling. Together with the disassembly trace and the battery passport, the diagnostic results flow into a decision support system that explains the evidence. The decision stays with the human operator.



From battery health to the next-life decision: four sources of evidence, one decision support system, four routes.

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One demo case, many hands

SPIN Robotics developed force-controlled screw removal for collaborative robots, using its intelligent screwdriver. A model-based torque estimation in the tool firmware makes it possible to detect irregular screwing behaviour without additional sensors. Through an OPC-UA information model, every screw operation is recorded together with its location and linked to the identity of the battery pack. This turns the robot into a sensor-rich production asset and makes disassembly traceable down to the individual joint. SPIN also led the design of a future dismantling factory with separate areas for packs, modules and cells.

ITML built the Data Fusion Bus, the secure backbone that collects data from AVL, SPIN Robotics and CSEM. On top of it runs a web-based Decision Support System that brings battery information, diagnostic results and screwdriving data together in one view. An AI assistant answers questions based on a curated knowledge base of regulations, standards and battery manuals. It is deliberately designed to support human decisions, not to replace them.

CSEM set up the battery dismantling demonstrator in its testbed, working on the AVL-provided battery pack of a Jaguar I-PACE. CSEM developed vision-based screw detection that works across screw types, and it is now advancing towards adaptive unscrewing in which a neural network guides the robot while the SPIN screwdriver does the turning.

Netcompany-Intrasoft and AVL worked together on a digital battery passport for the Jaguar I-PACE battery. Netcompany-Intrasoft designed the passport schema based on AVL's feedback. Each value is stored together with its source, whether a measurement, a specification or third-party information, and a confidence level. AVL provided the battery data from its benchmarking. The passport is integrated into the R3-MYDAS marketplace.

The pieces are connected: AVL's diagnostic results and SPIN's process data flow through secure interfaces into ITML's Data Fusion Bus and are presented in the Decision Support System. Beyond WP3, AVL delivered two training courses on EV batteries, covering safety, diagnostics, the circular lifecycle and second-life applications, together with Deep Blue in October 2026. AVL also supplied battery and manufacturing-energy data for the project's life-cycle assessment led by AIMEN.

What remains

The next steps are already clear: validating the methods on new, previously unseen cells and on real battery faults, and moving from validated building blocks to a connected industrial disassembly line. The message of the battery demo case is simple. A used battery is not waste by default. With the right data, it can be given the life it is still fit for.

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