



Test protocols for Newman-based models calibration and validation (cell level)

Integrated approach to characterise, test and model lithium-ion batteries from cell materials to battery packs

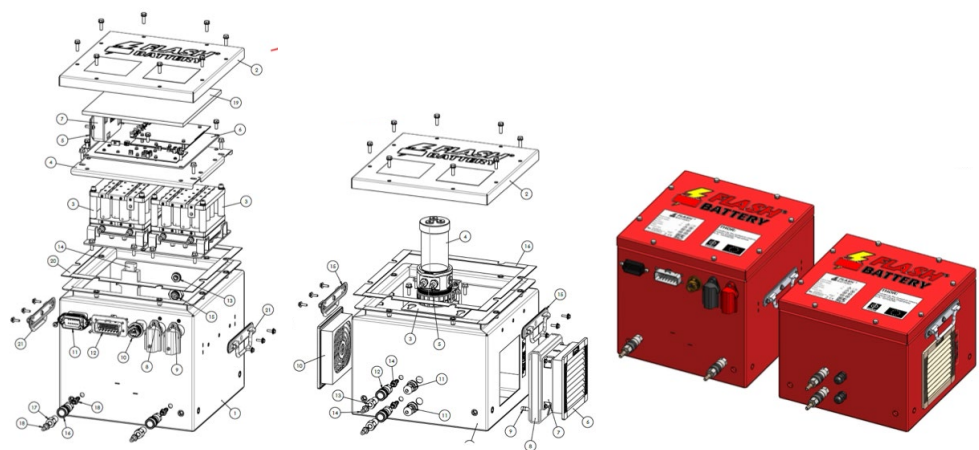
THOR develops a harmonised methodology to characterise and test lithium-ion batteries while enabling predictive modelling across multiple scales, from cell to module and pack. Using representative Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP) chemistries, the THOR team combined

controlled experiments, material-level analysis, and standardised procedures. The resulting datasets support simulation of performance, ageing, and safety. This approach improves comparability, reduces uncertainty in testing, and enables reliable scaling from laboratory cells to industrial batteries.

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■ Design of dedicated modules and packs



The context

Battery innovation is slowed by fragmented testing practices and long validation cycles. **THOR** addresses this by aligning requirements, measurement procedures, and data generation across a European research and industrial ecosystem.

The **initiative** involves coordination by a leading energy research organisation, with partners responsible for battery manufacturing, safety analysis, electrochemical testing, and modelling. Industrial contributors provided prototype and commercial cells, modules and packs, while research teams ensure consistency in testing and data interpretation. The **approach** is meant to serve all stakeholders across the battery value chain, including manufacturers and regulatory bodies.

Approach and Key Results

A common technical baseline for the THOR project has been established by defining lithium-ion **cell specifications** and aligned **testing procedures**. The work focuses on widely used 21700 lithium-ion cells, based on Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP) cathode chemistries with graphite anode, ensuring relevance for real industrial applications. **Clear requirements** were set for performance, safety, operating conditions, and expected

lifetime, so that all partners generate consistent and **comparable results**.

To support this, a **shared testing framework** was established, covering how batteries are measured and evaluated over time. This includes performance under different temperatures, charging speeds, and ageing conditions. The result is a set of reliable and comparable data that can be used across the entire value chain, from cell developers to system integrators.

In parallel, the internal structure of the batteries was analysed to understand what drives their electrochemical and thermal behaviour. **Key material properties** were identified and translated into inputs for **physics-based simulation models**. This creates a direct link between how a battery is built and how it performs in real use.

Building on these data, the consortium developed **Newman-based models** that replicate how batteries operate during charge and discharge with high fidelity. When combined with a thermal model, the evolution of the cell temperature during operation can also be simulated.

The models show high accuracy over 95% in predicting battery behaviour under real operating conditions ((dis)charging rate up to 1C), including performance and cell temperature at different testing temperatures (from 5 to



45°C). This demonstrates that combining standardised testing with physics-based modelling can reliably reproduce how batteries perform in practice.

Finally, the approach is extended to **battery ageing**. The models are able to simulate how batteries degrade over time by capturing key mechanisms such as internal layer growth and lithium deposition. Using the same conditions as real tests, they can predict how capacity, energy, and performance evolve during the battery's lifetime.

Impact

THOR contributes to a shift from purely experimental battery validation to integrated testing and simulation workflows. By standardising how batteries are characterised and measured, the project reduces variability between laboratories and improves the reliability of performance and lifetime assessments.

For **industry**, this enables faster design iterations and shorter testing campaigns. Battery developers and system integrators can evaluate performance and degradation under multiple conditions without extensive prototyping and testing.

Regulatory and certification bodies benefit from more consistent datasets, supporting the future integration of simulation into qualification processes. The approach also strengthens comparability between chemistries and formats, facilitating technology bench-marking and informed decision-making.

For **research and innovation actors**, THOR provides a structured foundation to develop scalable digital twins, bridging the gap between laboratory studies and real-world applications.

Partners and Roles

CEA-Liten

THOR project coordinator, battery ante/post-mortem characterization, performance testing and modelling

Vrije Universiteit Brussel

Lifetime testing and ageing modelling from cell level to module/pack level

Varta Innovation

Battery cells prototyping, initial testing and characterization

Flash Battery

Battery modules and packs prototyping and electrical testing

For further information about **THOR** and collaboration opportunities, please contact the **project coordination team** via the [official website](#) or the [project mail](#).

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Assumptions/limits:

Content derived from available project technical documentation; some stakeholder and contact details are generalised due to limited explicit information.