

# Advancing Battery Innovation: Insights from the twinBATT Cluster



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FASTEST

THOR



# THOR Project

## Innovative methodology for battery testing

TwinBATT Webinar  
May 5, 2025



Advancing Battery Innovation:  
**Insights from the twinBATT Cluster**

May 5, 2025  
9:00-10:30 AM (CET)  
Online Event



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# Context

**Battery physical tests are too expensive with a high environmental impact**



**Numerous** - needed for cells/modules/packs validation and for physics-based models development

**Long** - especially for aging investigation (several years)

**Destructive** - consume a lot of samples

**Complex** - require specific facilities, safety issues

**Not enough and not enough representative** to get precise predictions of performances, aging and safety of a battery

# About THOR project

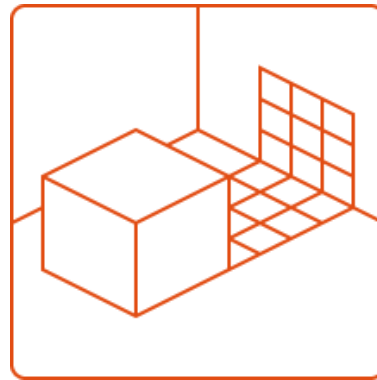
- Project number: 101103708
- Call: HORIZON-CL5-2022-D2-01
- Type of action: HORIZON Research and Innovation Actions
- Granting authority: European Climate, Infrastructure and Environment Executive Agency
- **Start Date: 01 June 2023**
- **Duration: 48 months**
- Scope: innovate battery design by developing a virtual tool able to reduce the number of physical tests
- TRL: from 2-3 to 5-6
- **9 European partners from 6 countries**

No.	Role	Legal name	Short name	Country
1	COO	Commissariat à l’Energie Atomique et Aux Energies Alternatives	CEA	FR
2	BEN	Institut National de l’Environnement Industriel et des Risques	INERIS	FR
3	BEN	Vrije Universiteit Brussel	VUB	BE
4	BEN	FEAC Engineering P.C.	FEAC	GR
5	BEN	Flash Battery	FLB	IT
6	BEN	Varta Innovation	VI	AT
7	BEN	ICONS	ICONS	IT
8	BEN	Asociación Española de Normalización	UNE	ES
9	BEN	ENGIE Laborelec	ENGIE-LABORELEC	BE



# Aim






**THOR aims to diminish the number of physical tests and nurture innovation in battery conception by developing a virtual tool - a Digital Twin that simulates battery behavior.**



Digital Twin is a **virtual representation** of a physical battery object

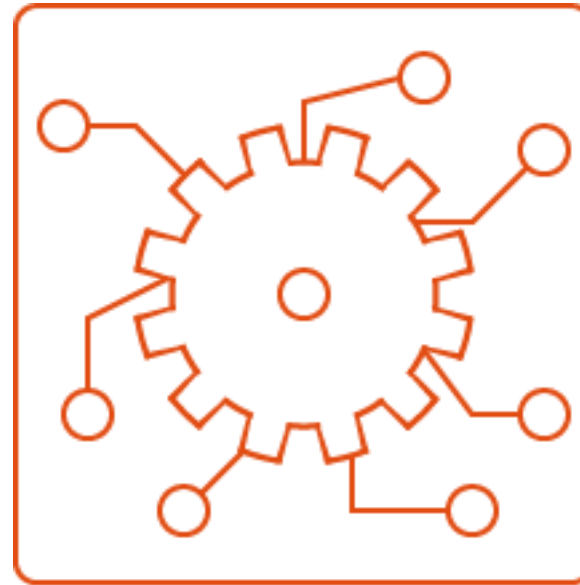
**The project targets mobility and stationary applications and focus on commonly used battery chemistries (representing 60% market share before 2030).**

# Expected impacts

With the Digital Twin	 Increasing the competitiveness of the European battery industry across the value chain.
	 Shorter time to market replacing many physical tests performed all along the battery development.
	 Reduced time and/or cost of battery development by at least 20% to 30%.
Additional metrics	 Improved battery design, for longer lifetime, and better reliability and safety.
	 Reduced investment and operational costs of battery systems.

# Outcomes

1. Closing of the loop with the possibility of **predicting the best set of parameters** for a given behaviour.
2. Performing **virtual tests** will become **more common**. In 10 years, 80% of industries will use a digital twin during the battery development phase.



# Outcomes

3. **New standards for battery data:** harmonisation of the data related to battery testing. The possibility to share data among projects will concur the development of open-source databases.



# Specific Objectives

Develop a highly predictive model for battery performance prediction

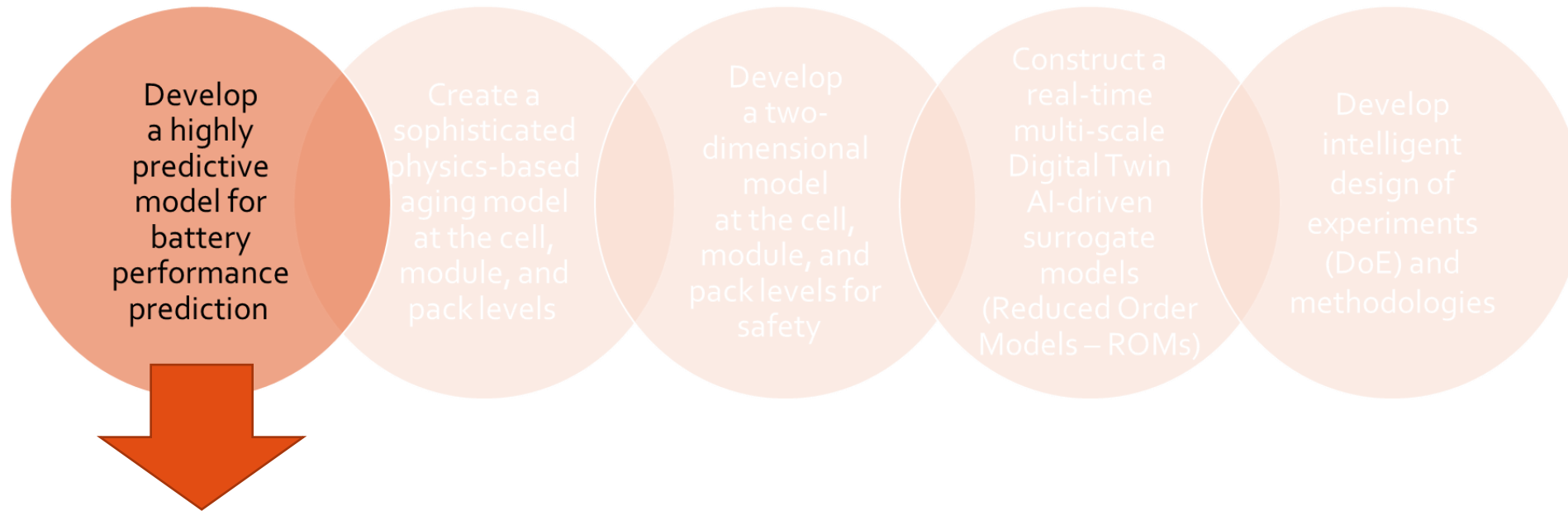
Create a sophisticated physics-based aging model at the cell, module, and pack levels

Develop a two-dimensional model at the cell, module, and pack levels for safety

Construct a real-time multi-scale Digital Twin AI-driven surrogate models (Reduced Order Models – ROMs)

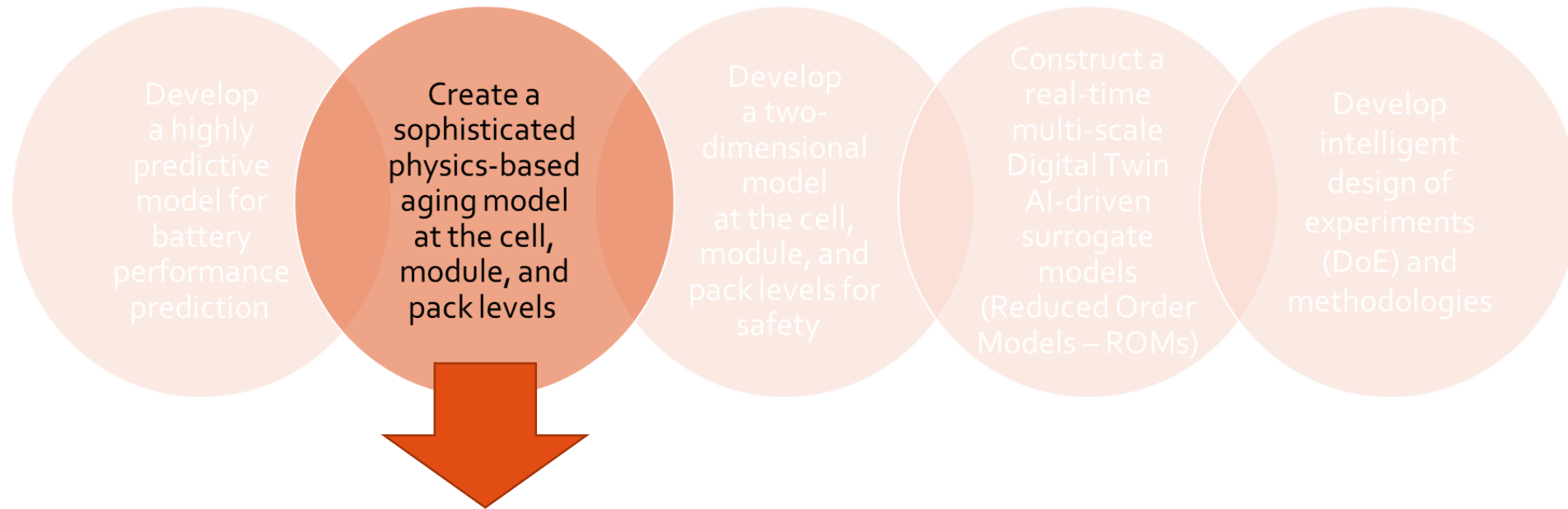
Develop intelligent design of experiments (DoE) and methodologies

# Objectives and associated KPIs



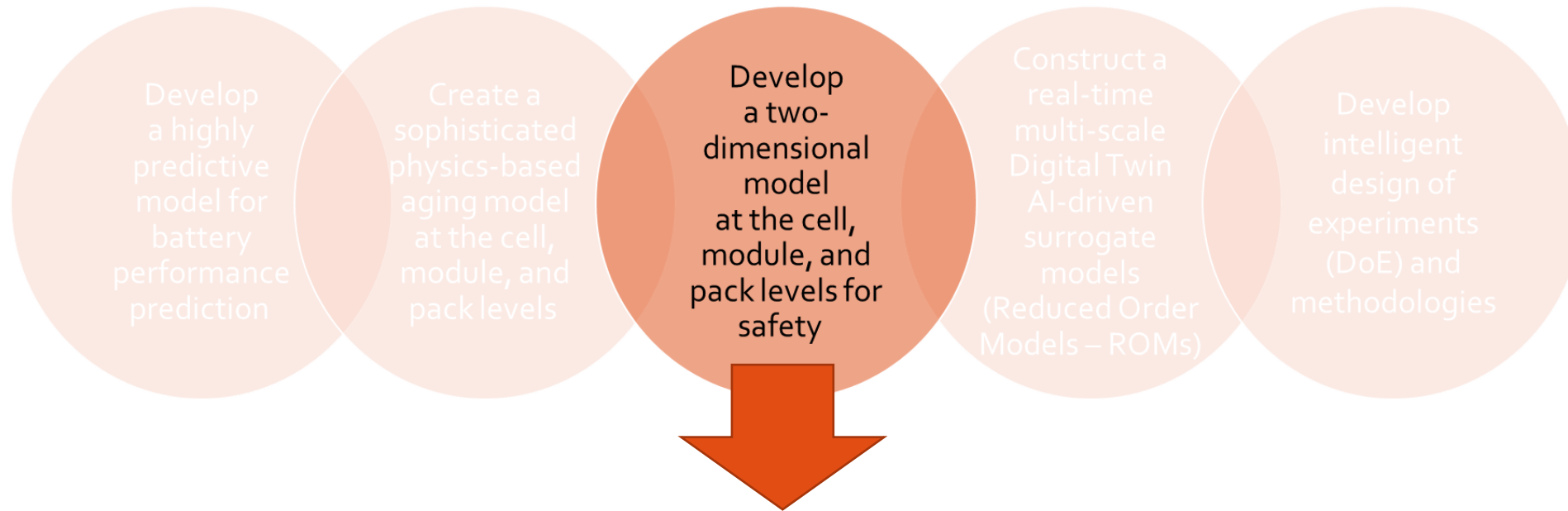
- ❑ **Min. 95% precision** on capacity prediction at 1C
- ❑ **Divide by 2 the number of input param.** to develop the P2D Newman model (currently up to 42)
- ❑ **Decrease by 2 the time needed to calibrate a model for a new chemistry**

# Objectives and associated KPIs



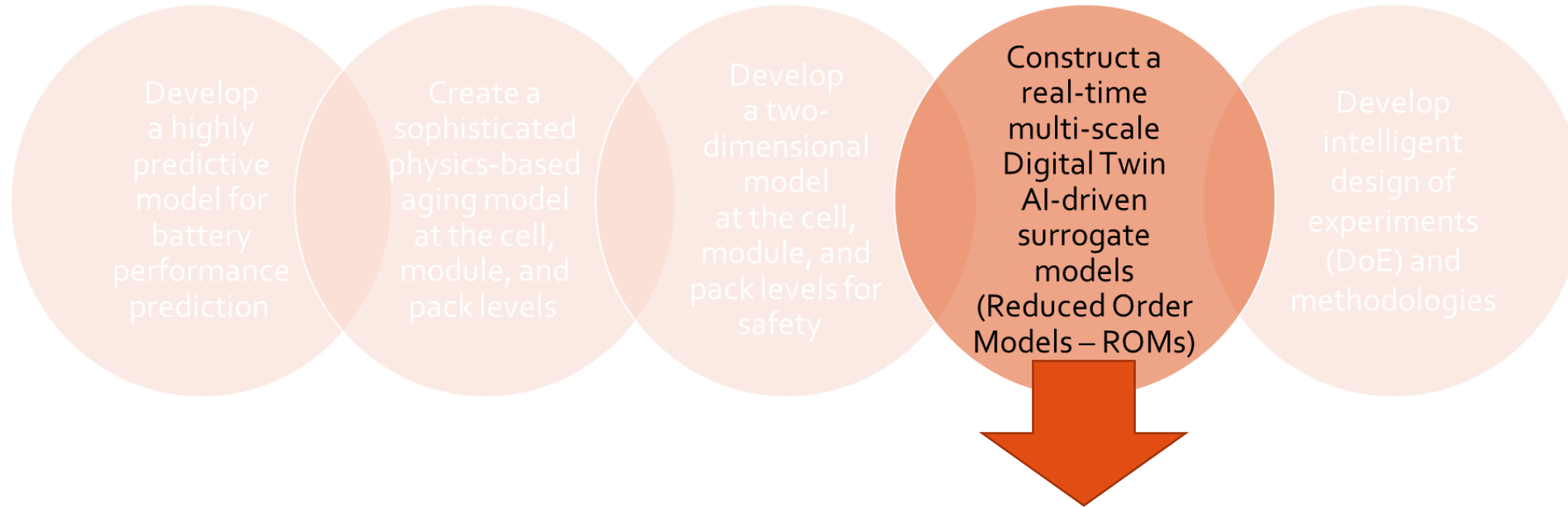
- Estimation error  $\leq 5\%$  at EoL on remaining capacity, voltage response, energy density, power capability
- Decrease the number of channel-month required to 200 (instead of 600 currently)
- Quick optimization and validation of the model for an optimized chemistry and/or battery design.

# Objectives and associated KPIs



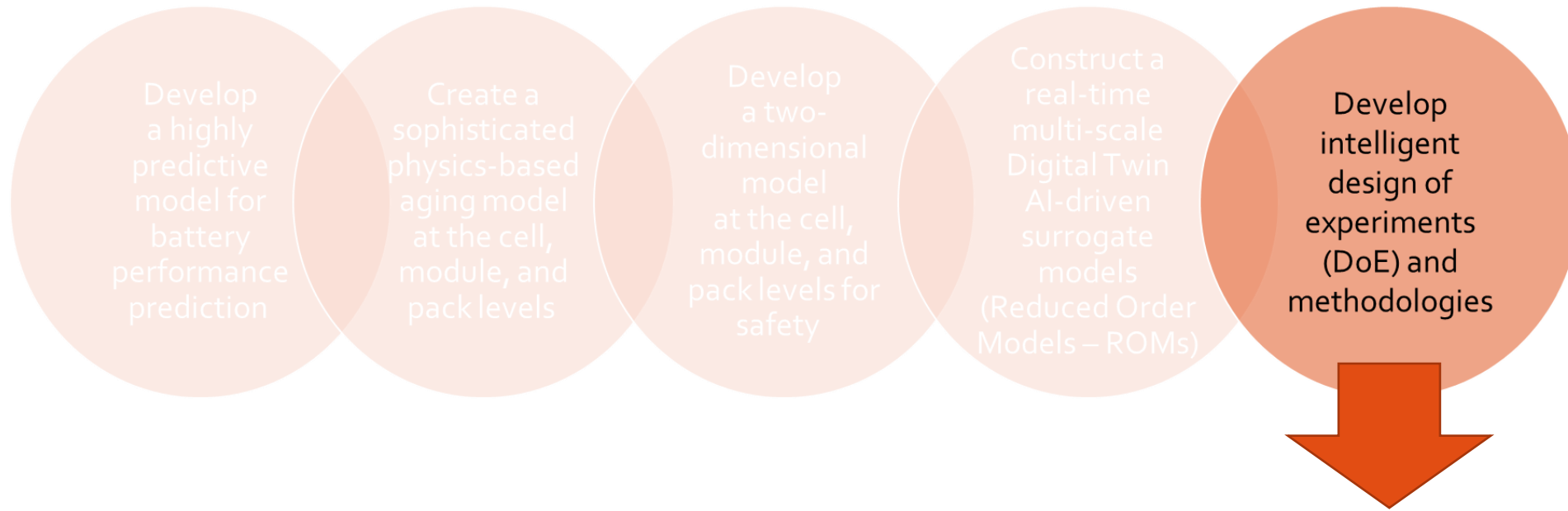
- Prediction of total heat released at cell, module and system level, and total amount of gas released at system level for at least 2 different scenarios (overcharge, overheating).
- Required inputs for the model limited to 5 experimental abuse tests at cell level and 2 at module level.
- Quick adaptation for other Li-ion alike chemistry and geometry (<2-3 months, ~87% reduction of time).

# Objectives and associated KPIs



- ❑ Amalgamation of performance, aging and safety prediction.
- ❑ Access to results in less than 1 second (almost real-time) instead of hours for high-fidelity models.
- ❑ Virtual testing with a user friendly Graphical User Interface enabling improvement of design and usage.

# Objectives and associated KPIs

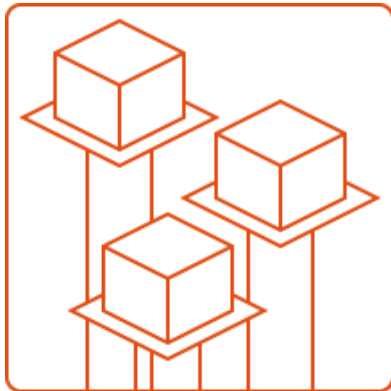


- ❑ **Fast user-friendly methodology using lab cells and facilities (<15 days) for perf. model parametrization.**
- ❑ **Smart test campaign for characterization of the aging parameters**
- ❑ **One experimental method to determine the total heat emissions at cell level,** reliable input for the model at module and pack levels.

# Innovations

## 3 physics-based models

Representing the performance, ageing and safety behaviour of a battery system at different scales.



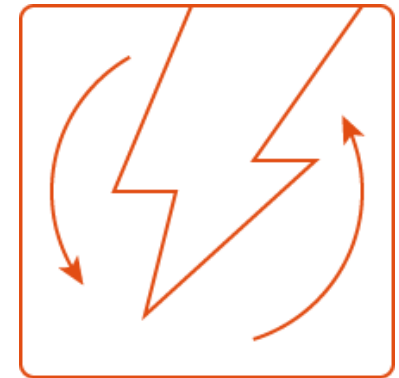
## Safety and risk reduction

Providing a better understanding of safety hazards and aging mechanisms.

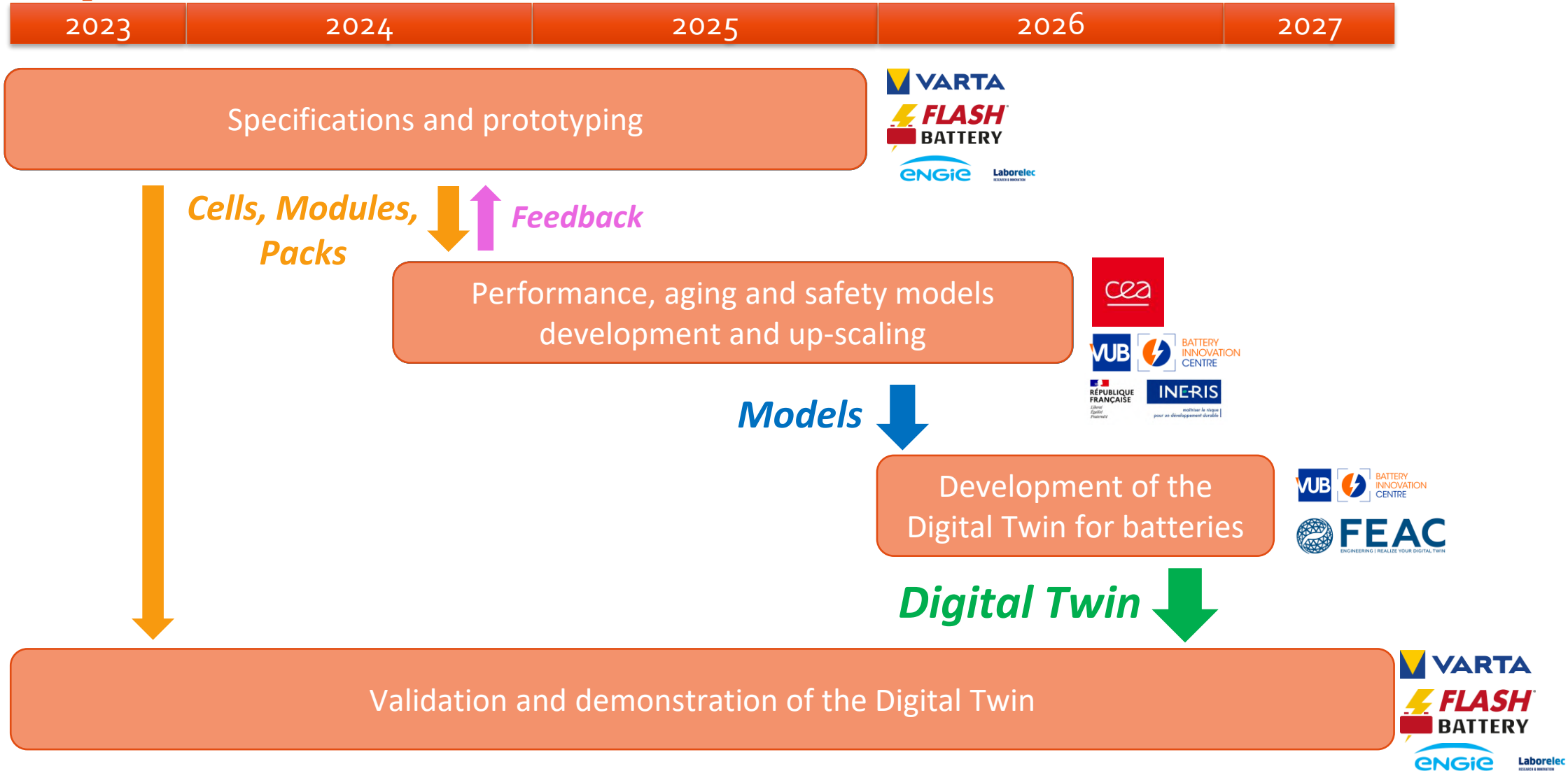


## Better energy management

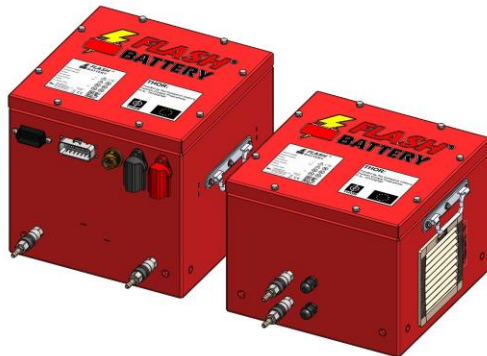
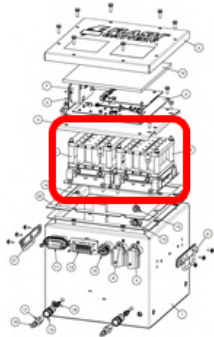
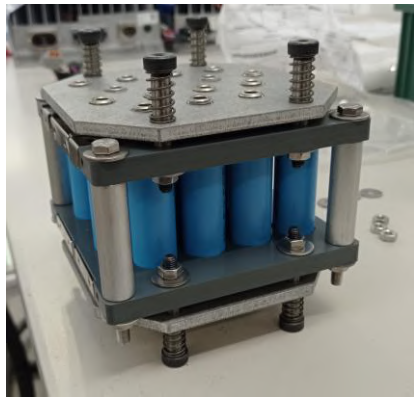
Further reducing operational costs and optimising recharging based on real usage profiles.



# Workplan



# Chemistry, samples



## Cells : 21700 cylindrical cells

- NMC/Gr prototype cells made by VI (2 batches with different specifications, tabless design)
- NMC/Gr commercial cells
- LFP/Gr commercial cells

Available

**Modules** : 16 NMC/Gr cells connected in 4s4P configuration, assembled by FLB

Under progress

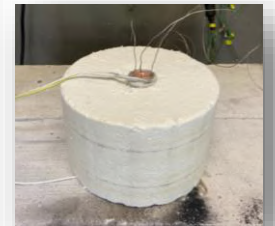
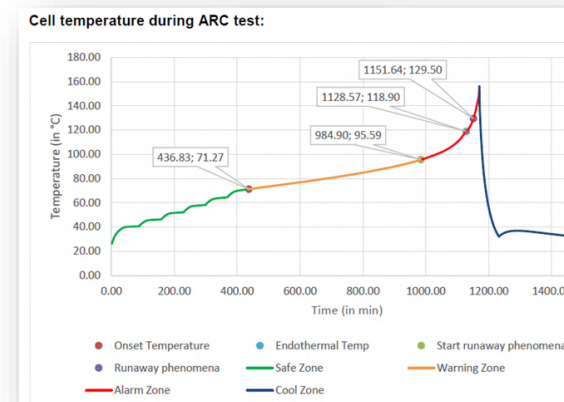
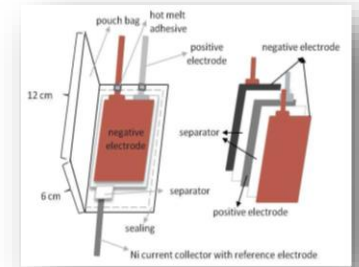
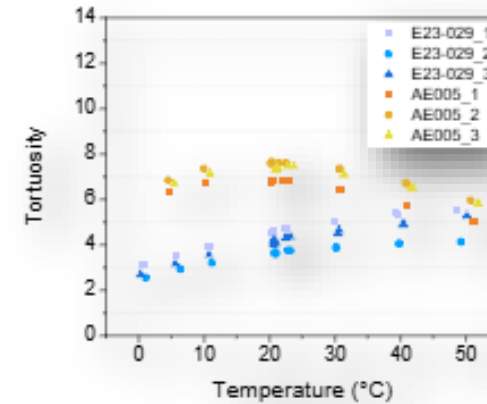
**Packs** : 2 NMC/Gr modules in series, assembled by FLB (sealed pack with additional box for thermal management components)

Q4/25-Q1/26

# Physical tests

Under progress

- **Performances, aging** (8 conditions: calendar, cycling and dynamic profiles)
- **Abuse tests (thermal, electrical)** to get input parameters for models development and for models validation at cell, module and pack level. Thermal and gas emissions measured.
- Few **post-mortem analyses**.



# Numerical tools developed for virtual tests



- **Database** gathering harmonized data and metadata on samples (components, cells, modules, packs) and tests results (electrical tests, abuse tests, post-mortem characterization)

Under progress

- **P2D Newman models** for performances and aging (improvement expected thanks to sensitivity analyses, smart parametrization methodology )

Under progress

- **2D model capable of predicting hazards consecutive to TR** of a battery (heat release and toxic gas emissions)

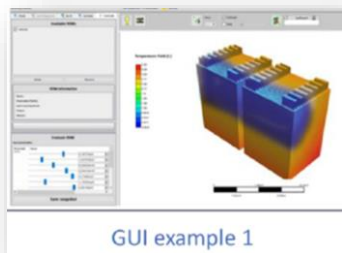
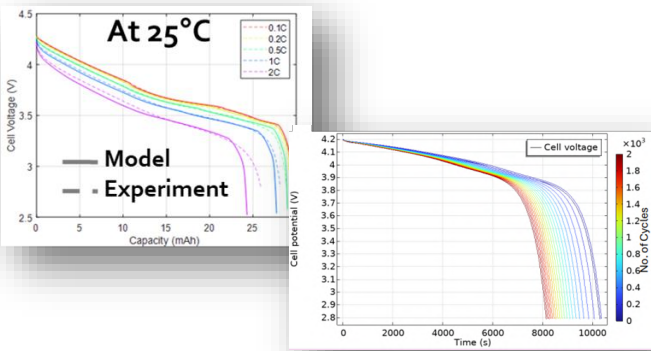
Starting

- Hybridized models using machine learning (Reduced Order Models: ROM), relying on performance, ageing and safety prediction capabilities at cell, module and pack scale

2026

- Multi-scale and almost real-time **Digital Twin** with a user-friendly graphical user interface (GUI)

2027





# Thank you for your attention!

## Get in touch

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Visit our website:

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# Consortium



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