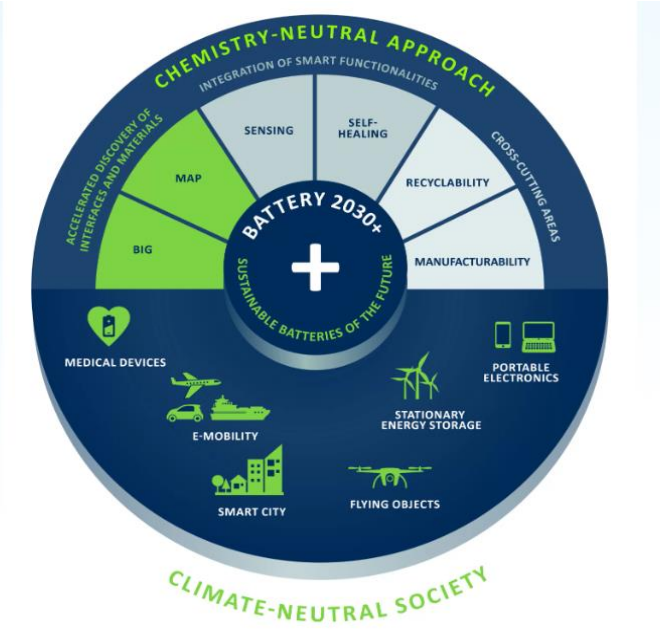
BATTERY 2030+

Contributing to
The European Batteries
R&I Community

Cross-linked goals



Roadmap update Oslo 27-6-2024

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Synergies among the research areas

- To foster effective collaboration between the research areas, specific goals were set: see Tables 4 pp 106 of the Roadmap. Cross linking for the short term (3yrs), medium term (6yrs) and the long term (10 yrs) between

    BIG-MAP & Sensing

    BIG-MAP & Self-Healing

    Sensing & Self-Healing

    BIG-MAP & Cross cutting areas

    Sensing & Cross cutting areas

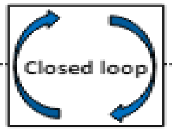
    Self-Healing & Cross cutting areas

    Cross cutting areas: Manufacturability & Recyclability

- **Purpose of this meeting is to update these synergies.**

Table 4 Roadmap

Table 4. Cross-linked short-, medium-, and long-term goals.

Cross-link	Short term (3 years)	Medium term (6 years)	Long term (10 years)
BIG-MAP & Sensing	Data from sensing and from operando characterization are correlated.	On-the-fly analysis of multimodal data from sensing on instrumentalized batteries.	The self-healing properties also include the healing of the sensors. Multiple self-healing properties can be detected with universal and unique models, thus autonomous procedures are in place for multimodal characterization and analysis of smart batteries.  Efficient feedback loop between BIG-MAP, Sensing, Self-Healing and the cross-cutting areas to efficiently manufacture and recycle next-generation battery cells incorporating new materials, engineered interfaces, sensors, and self-healing functionalities. Automated deployment of new advanced sensors in next-generation cells at pilot line level under recyclability constraints. Automated fabrication of easily recyclable self-healing components at pilot line level & POF of automated insertion of self-healing components into cells. Automation of integration and connection of internal wiring interfaces during cell assembly and possible transfer to the module level under recyclability constraints. The sorted materials are introduced in the beginning of the manufacturing chain for second life. Demonstration of manufacturing process for new battery technologies (SSBs, SIBs, etc.) by integrating recyclability criteria. Full POC of a manufacturing digital twin for LIBs by integrating recyclability criteria. Green & Large scale manufacturing with accelerated self-healing effect to be introduced. AI-based & high throughput manufacturability methodology for cells having accelerated self-healing mechanisms.
	Data of different sensor types regarding the output format is standardized and compatible.	Accelerate material characterization & discovery by on-the-fly utilization of sensing data in BIG-MAP.	
	An ontologized data management is in place.	Multisensor input is transferred to the BMS.	
	Data is efficiently transferred from sensing to modelling, and from modelling to sensing.	Preemptive & curative approaches are combined with an emphasis on interfaces and forwarding ontologies.	
BIG-MAP & Self-Healing	Monitoring and assessment of self-healing.	Preemptive & curative approaches are combined.	
	A predictive model is established to predict failures in self-healing and estimate the end of self-healing properties to work. Preventive self-healing is triggered.	Efficient feedback loop between sensing, the BMS, and/or AI modules to appropriately trigger the self-healing functions by external stimuli which are already implanted in the cell are established.	
	Development of electrolytes for self-healing and predictive modeling of how self-healing works in the cell (e.g., to suppress dendrite growth).		
	Self-healing data is transferred to the BMS.		
Sensing & Self-Healing	Self-healing is triggered based on sensor data.	Sensitivity and accuracy of sensors during long-term cycling and effects of sensor aging along with the sensor response to the cell.	
	The state of health and the self-healing functionalities are monitored with sensors to evaluate the long-term self-healing functionalities.	Efficient feedback loop between sensing, the BMS, and/or AI modules to appropriately trigger the self-healing functions by external stimuli which are already implanted in the cell are established.	
	Preemptive & curative approaches are combined.		
BIG-MAP & Cross-cutting areas	Exploration of new cell designs for the BIG-MAP disruptive materials, considering recyclability constraints.	A demonstration of the new and flexible manufacturing processes of the novel battery chemistries	
	New manufacturing routes of the BIG-MAP components, based on the AI data-driven models.		
Sensing & Cross-cutting areas	A procedure for the automatic insertion at pilot scale of the benchmark sensors inside the LIB cells.	A demonstration of the integration between manufacturability & recyclability criteria and the development of new advanced sensors.	
	Adaptation of internal interfaces and connections (communication pathways, electrical connections and power, etc.) to cell manufacturing tools and constraints under consideration of recyclability.	Integration of sensor fabrication process and their communication interfaces at cell level to the battery management system (BMS).	
Self-Healing & Cross-cutting areas	Exploration of self-healing functionalities that will enable manufacturability on the existing equipment.	Demonstration of spatial distribution of self-healing functionalities manufactured with roll to roll processes.	
	A procedure for adaptable manufacturing of the self-healing components (i.e., self-healing electrodes) in LIB cells.	New methodologies on multiscale modelling of manufacturing to be introduced and validated.	
	New cell design configurations including self-healing components to be explored.	Special cell design configurations to facilitate self-healing reactions	
	An energy-storage perspective for modelling of manufacturability to be introduced.		
	New manufacturing routes for self-healing components, considering recyclability constraints.		
	A demonstration of the integration between manufacturability & recyclability criteria and the development of new self-healing components.		
Cross-cutting areas: Manufacturability & Recyclability	Integrated design for sustainability and recyclability concepts in the manufacturing routes.	An initial POC of the integration between manufacturability criteria and the recyclability goals (easy to dismantle, sort and reuse).	
	Implement design for sustainability and recyclability concepts in the AI data-driven models.		
	Consider sustainability and recyclability concepts in the design of the cell.		

Some highlights (1)

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- Short & Medium term:

➢ Between BIG-MAP & Sensing the first steps are to correlate data from sensing and from operando characterization.

➢ Between BIG-MAP & Self-Healing the first steps involve detecting the effectiveness of self-healing mechanisms, accompanied by the development of predictive models.

➢ Between the smart functionalities Sensing & Self-Healing, data regarding the self-healing process need to be measured by sensors, giving feedback on self-healing efficiency.

➢ In the medium term, BIG-MAP, Sensing & Self-Healing will closely interact.

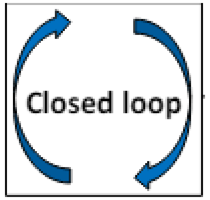
Some highlights (2)

- In the medium term, the implementation of new advanced sensors under manufacturability and recyclability criteria is to be demonstrated.
- Explore new manufacturing routes for new self-healing components.
- Concepts for the design for sustainability and recyclability will be integrated into the manufacturing routes: easy to dismantle, sort and reuse…
- To realize this vision, it is necessary to use consistent terminology throughout all research areas and creating a common ontology and standardized protocols.

Some highlights (3)

- Long term:

➢ A closed loop must develop between all research areas. This requires the research areas of BIG-MAP, Sensing and Self-Healing to closely interact in the first place. A continuous and efficient feedback loop must be established between sensor data, the BMS, and AI modules. The self-healing functions will be appropriately triggered in response to external stimuli detected by sensors or based on predictive models from BIG-MAP.



➢ Establishing a closed loop system will enable a feedback mechanism to efficiently manufacture and recycle next-generation battery cells.

Some highlights (4)

- One of the objectives is to ensure that, after their first life, the sorted materials will be given a second life and reintroduced at the beginning of the production chain. Direct recycling will be applied. This process includes preserving their full history and material information which will be obtained from sensor data. Self-Healing components are aimed to be automatedly fabricated with considering recycling constraints at pilot line level.