

Knowledge representation of battery manufacturing supported by an integrated ontology system



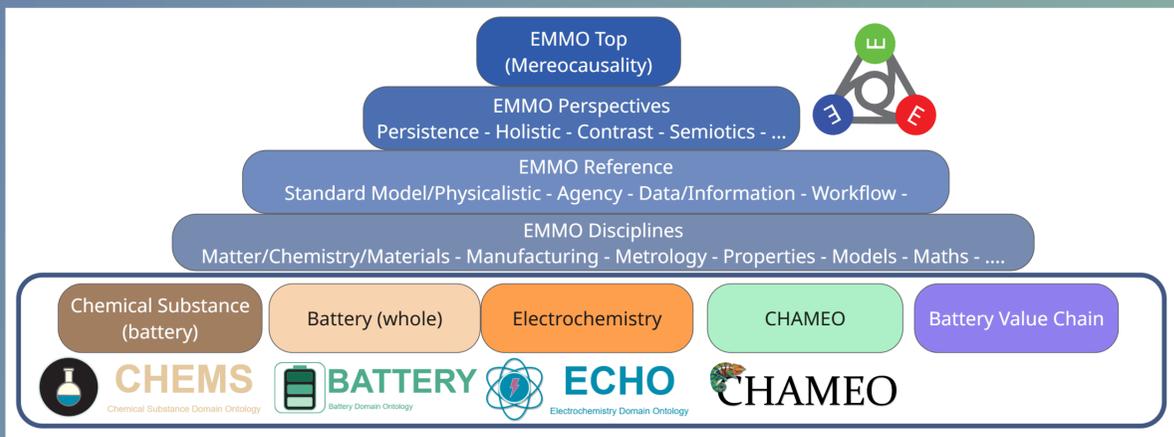
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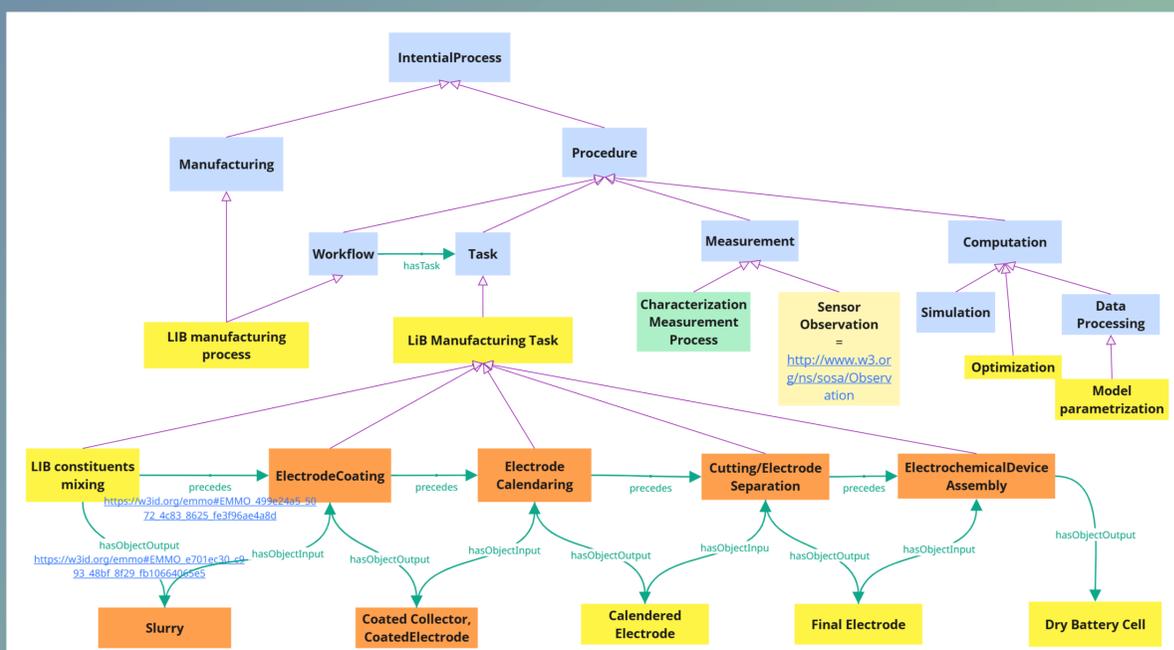
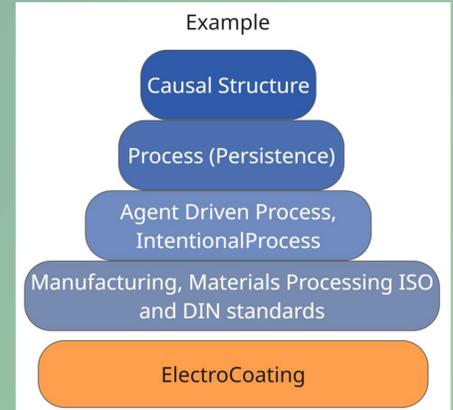


The fast-moving field of battery technologies including variations of materials and manufacturing processes requires decision support that is based on a knowledge base that represents and integrates the multiple chemistries, processes, data sources (e.g. sensors), characterisation methods etc. Moreover, a digital twin approach also needs to relate the virtual representation to “real” data. We present a single conceptual framework of all the diverse knowledge sources relevant to constructing a battery Digital Twin in the BatCAT project [1].

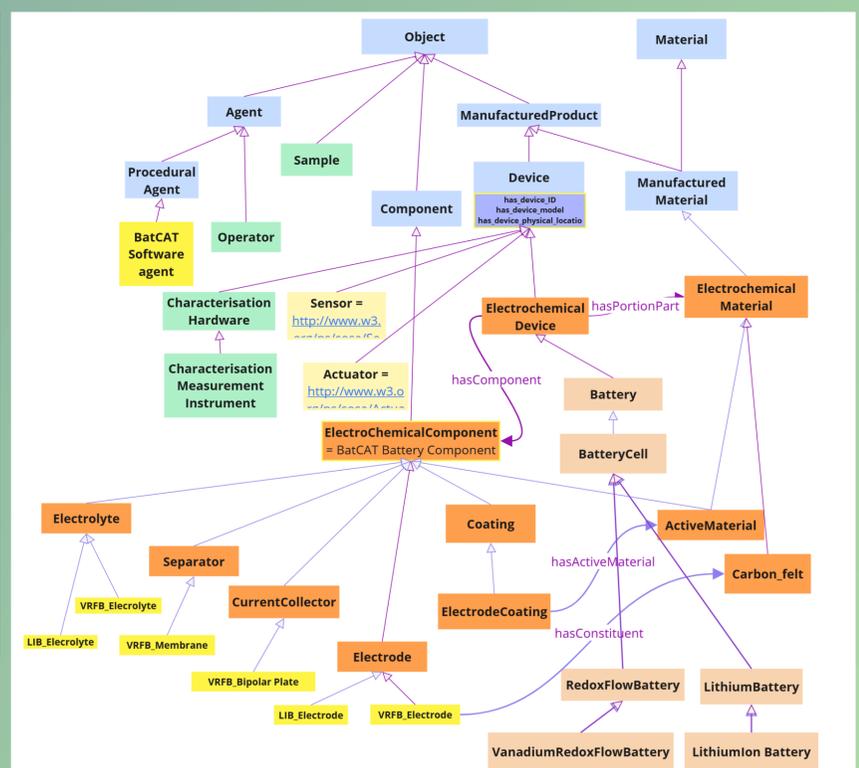
The project compiled an extensive set of competency questions and relevant metadata and mapped them to existing ontologies, in particular to the growing ecosystem of EMMO [2] and its domain ontologies, including CHAMEO [3], the Electrochemistry Ontology [4] and the Battery Domain Ontology [5]. In addition, it was found that the Sensor Network Ontology [6] can easily be aligned, based on conceptualisations of key classes and object properties that are similar to EMMO. Further ontologies that can be utilised going forward include the Chemical Substance ontology [7] and the Battery Value Chain Ontology [8]. As a result, the BatCAT ontology requires very few additional concepts, ensuring semantic interoperability in the battery domain. The Digital Twin is represented in EMMO by two interconnected semiotic triangles.



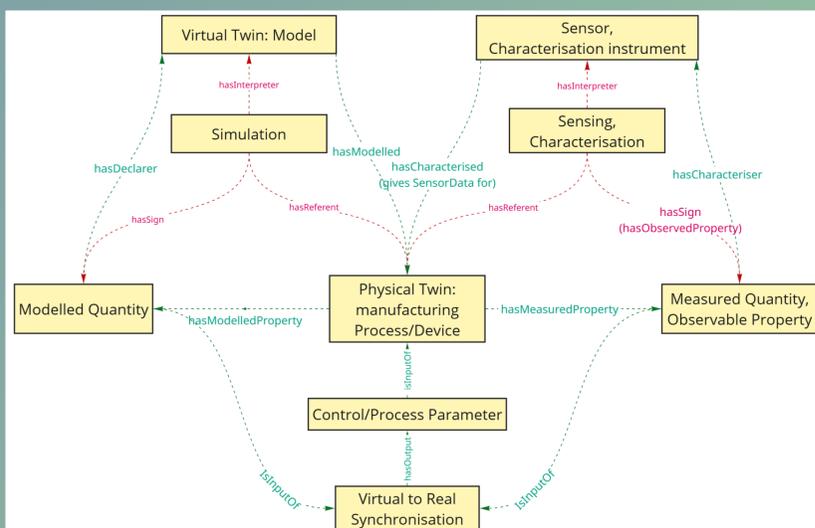
EMMO Levels from (a) the defined Mereocausal level, (b) Perspectives of the world, (c) Reference level, and (d) concepts based on broad disciplines. Below that are domain ontologies that build on these four levels. An example is given on the left.



Above: Processes and Procedures relevant for the BatCAT Lithium Ion Battery digital twin. Concepts are colour-coded as in the Domain-ontologies diagram. Additional BatCAT concepts are in yellow

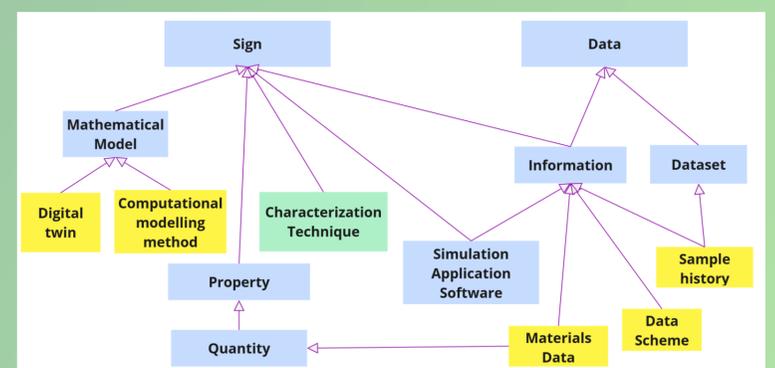


Above: Objects and Materials relevant for the BatCAT Battery digital twin. Concepts are colour-coded as in the domain-ontologies diagram. Additional BatCAT concepts are in yellow.



Left: Representation of a digital twin by means of two connected semiotic triangles. The physical process is both simulated and observed, and the respective quantities are used as input to a computation that aims to synchronise or optimize the process.

Below: Data and “Signs”, which are concepts that are a representation of something else, e.g. a model of a process.



References

- [1] Battery Cell Assembly Twin (BatCAT) <http://www.batcat.info/>
- [2] Elementary Multiperspective Material Ontology, <https://github.com/emmo-repo/emmo>
- [3] Characterisation Methodology Domain Ontology (CHAMEO), <https://github.com/emmo-repo/domain-characterisation-methodology>
- [4] Electrochemistry Ontology <https://github.com/emmo-repo/domain-electrochemistry>
- [5] Battery Domain Ontology, <https://emmo-repo.github.io/domain-battery/index.html>
- [6] Semantic Sensor Network Ontology, <https://www.w3.org/TR/vocab-ssn/>
- [7] Chemical Substance Ontology, <https://github.com/emmo-repo/domain-chemical-substance>
- [8] Battery Value Chain Ontology, <https://github.com/Battery-Value-Chain-Ontology/ontology>



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Innovate UK

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