



# Battery Modelling & Battery Management Systems

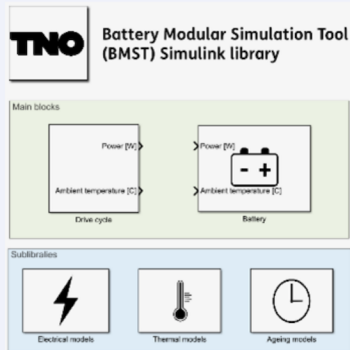
## Battery modelling and BMS

TNO's active topics of research for battery modelling and Battery Management Systems (BMS) consist of: BMS Topology Analysis Toolchain; SoX (State of Charge, Health, Function, etc.) estimation, including In-Situ Parameter Identification; Balancing Algorithm Development and Physics-model-based Control and Optimization; Thermal state estimation/prediction; Ageing models and mitigation via integrated powertrain control (incl. charging); Outline for architecture and algorithms to support the battery passport.

## Model-based development

TNO supports R&D activities by providing validated cell/module models for vehicle powertrain development. Models are developed and typically provided in MATLAB SIMULINK, but also in commercially available tools or standalone libraries like our in-house developed Battery Modular Simulation Tool (BMST). Our customers use these models for:

- Evaluating new battery chemistry technologies,
- Design and right-sizing for battery packs,
- Development of BMS & thermal management,
- Developing control and battery management strategies.



## BMS algorithm development toolchain

TNO's BMS algorithm development is part of a complete toolchain. The algorithm itself uses validated battery models to function, while extensive testing is employed to verify and validate algorithm performance under laboratory conditions before testing them in Real-World conditions by embedding them in the BMS of battery packs/prototypes.

## Design and optimization decisions for application specific development

TNO's tool is developed to understand the sensitivities and impacts of the accuracy of state estimation, balancing hardware design, battery chemistry/quality choice. This tool is supported by electrical and thermal characterization of the cells, as well as MIL and HIL testing environments for BMS algorithm development.

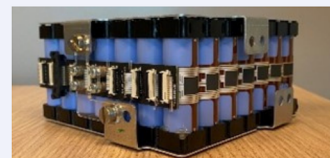
## Facilities

TNO Automotive is located on the Automotive Campus in Helmond, the Netherlands.



We offer state-of-the-art facilities and services for battery pack, development, design and testing. The climate chambers provide a means for real world testing under controlled conditions.

Other facilities are dedicated to testing safety, efficiency and performance of battery cells and complete packs including the MBS.



Testing can be performed from cells up to vehicle-level to emulate real-world conditions including charging.



**Unit Mobility & Built Environment**  
 Sr. Business Developer  
 Jan-Willem Sangers  
 jan-willem.sangers@tno.nl  
 +31 (0)6 4696 6129