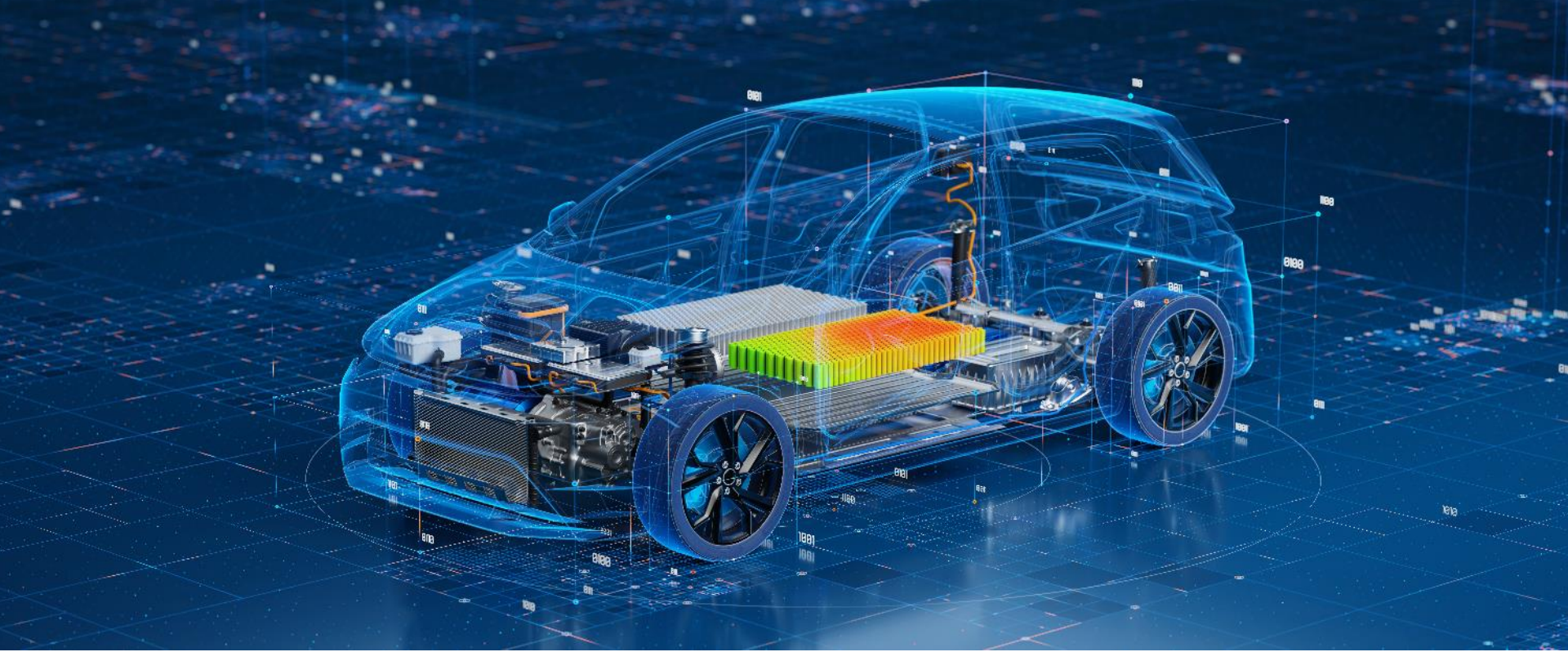


ALTAIR | danecca

DISRUPTING THE BATTERY DEVELOPMENT PROCESS WITH AN INTELLIGENT DIGITAL TWIN

Alex Gregory, Senior Project Engineer, Altair
David White, Battery Engineering Leader, Danecca
20th April 2023

Leading Convergence of Computational Science and AI in Engineering

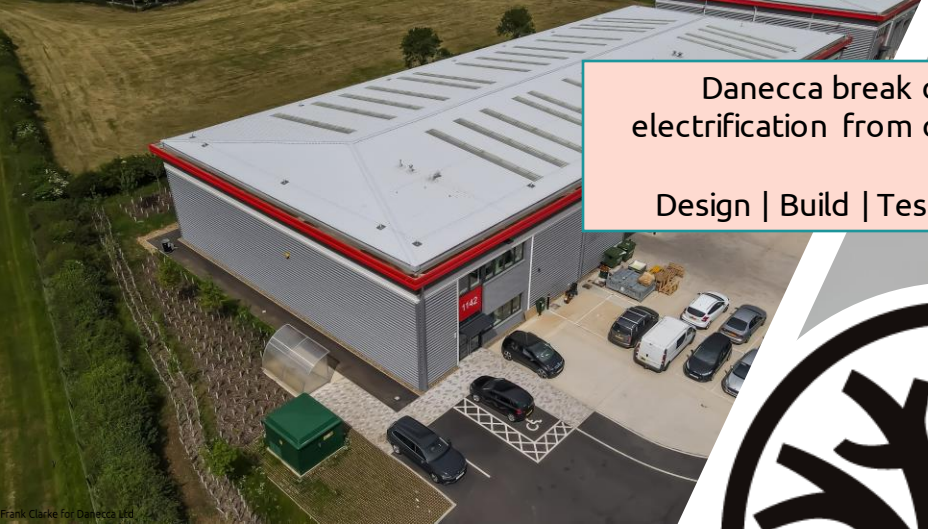
Altair is at the forefront of the evolution toward a smarter, more connected world.

Helping companies use digital twins, intelligent models, and the convergence of simulation, HPC, and AI to predict and optimize system outcomes.

ALTAIR

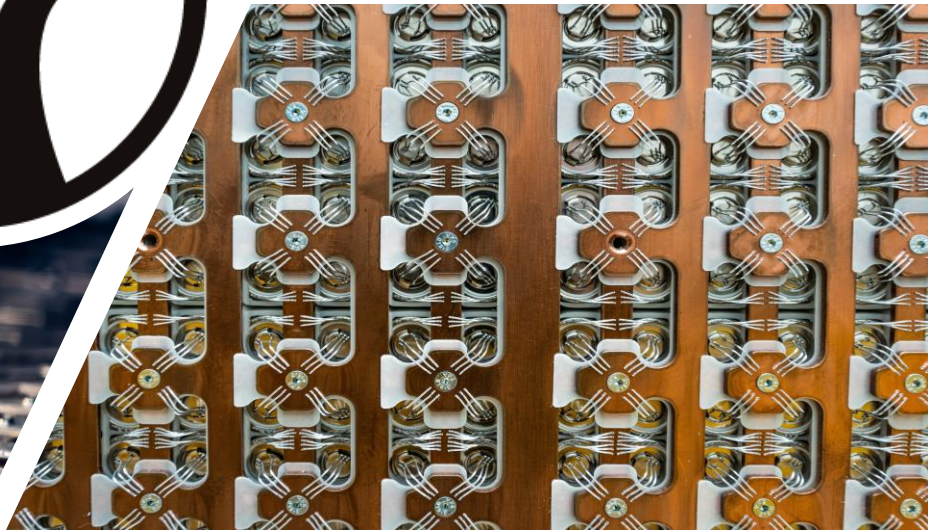
74 Offices in 27 Countries

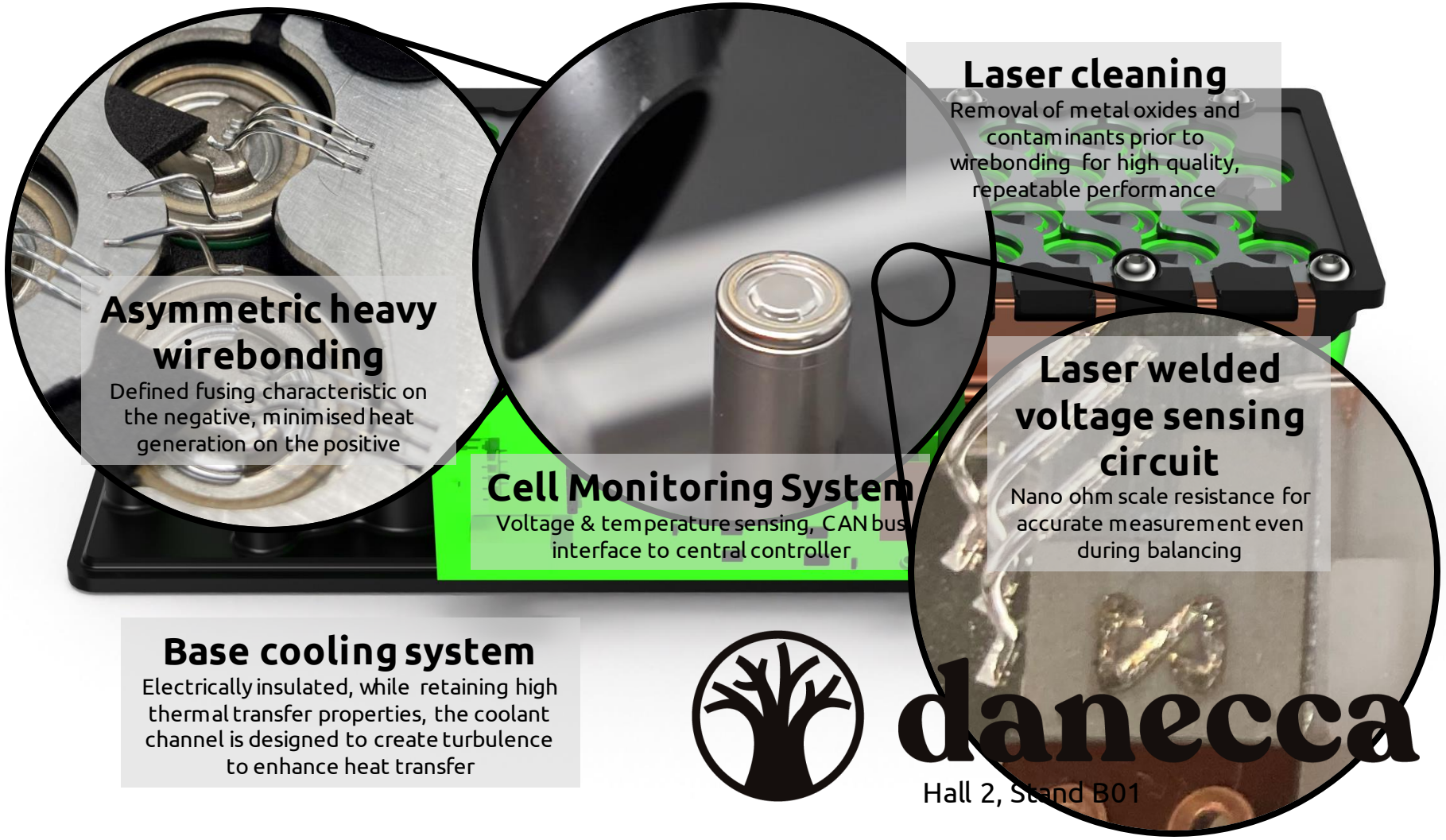
ALTAIR



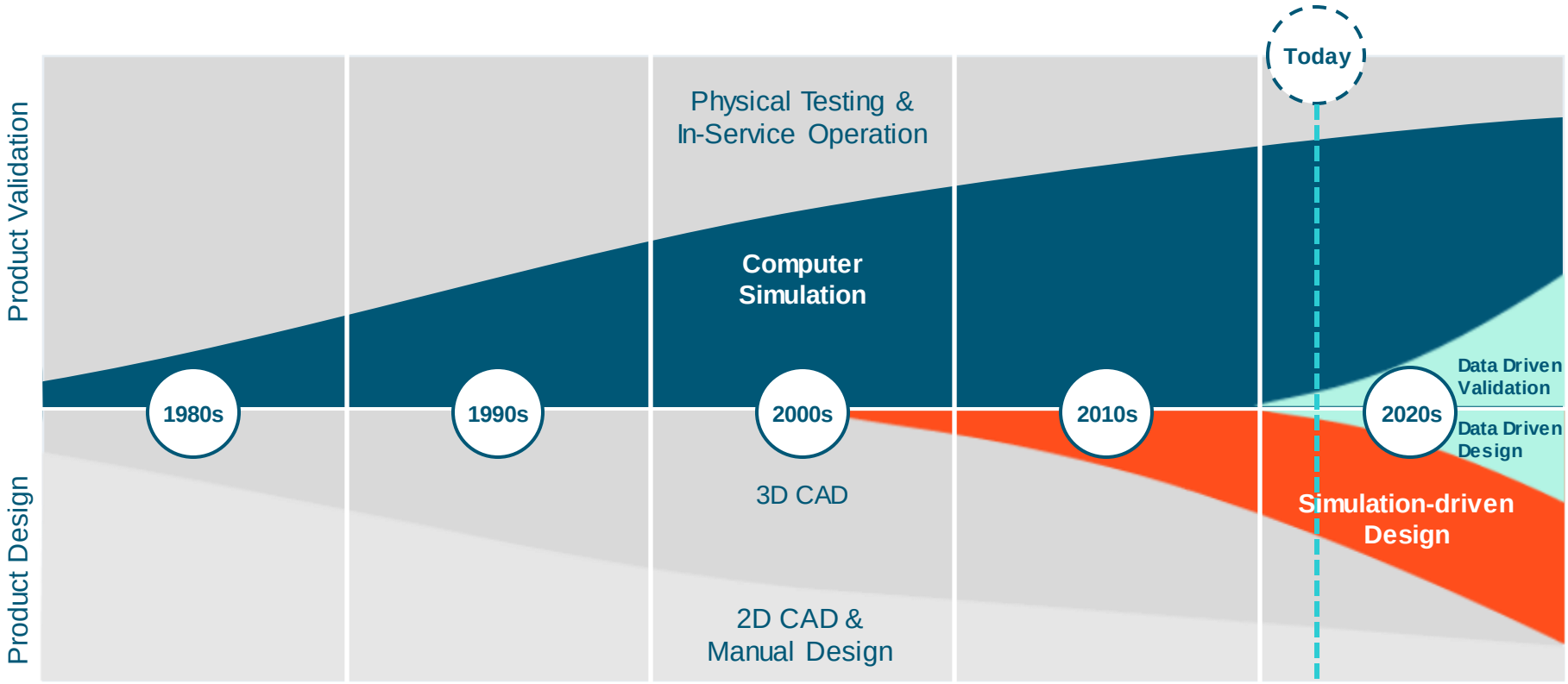
Danecca break down the barriers to electrification from our HQ at Silverstone, UK

Design | Build | Test | Intelligence | Factory




Laser cleaning
Removal of metal oxides and contaminants prior to wirebonding for high quality, repeatable performance
Asymmetric heavy wirebonding
Defined fusing characteristic on the negative, minimised heat generation on the positive
Cell Monitoring System
Voltage & temperature sensing, CAN bus interface to central controller
Laser welded voltage sensing circuit
Nano ohm scale resistance for accurate measurement even during balancing
Base cooling system
Electrically insulated, while retaining high thermal transfer properties, the coolant channel is designed to create turbulence to enhance heat transfer
danecca
Hall 2, Stand B01

The Digital Twin - Evolution of Simulation and Data



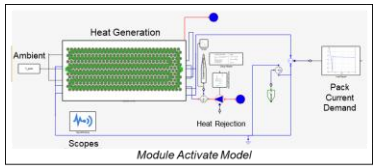
ALTAIR

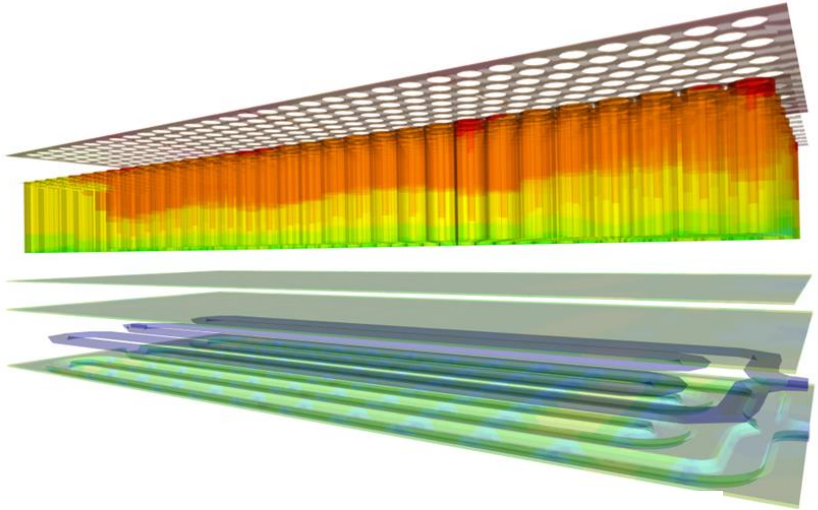
BATTERY SIMULATION TECHNOLOGY

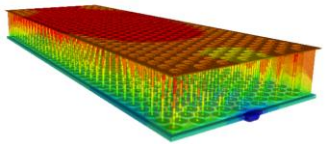
Battery Simulation Capabilities

Increased speed
Low fidelity OS model

Increased predictability
Improved physics of OS model







System Modelling Tools
Module / Pack Layout

Electro-Thermal-Fluid Optimization
Design & Verification

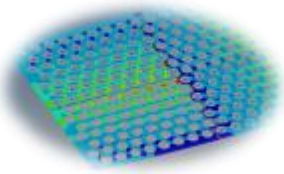
CFD
Verification

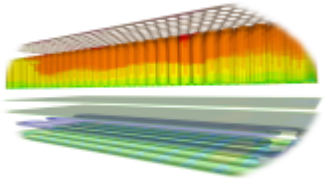
Altair OptiStruct®

ALTAIR

Predictive : Multi-Physics Capture

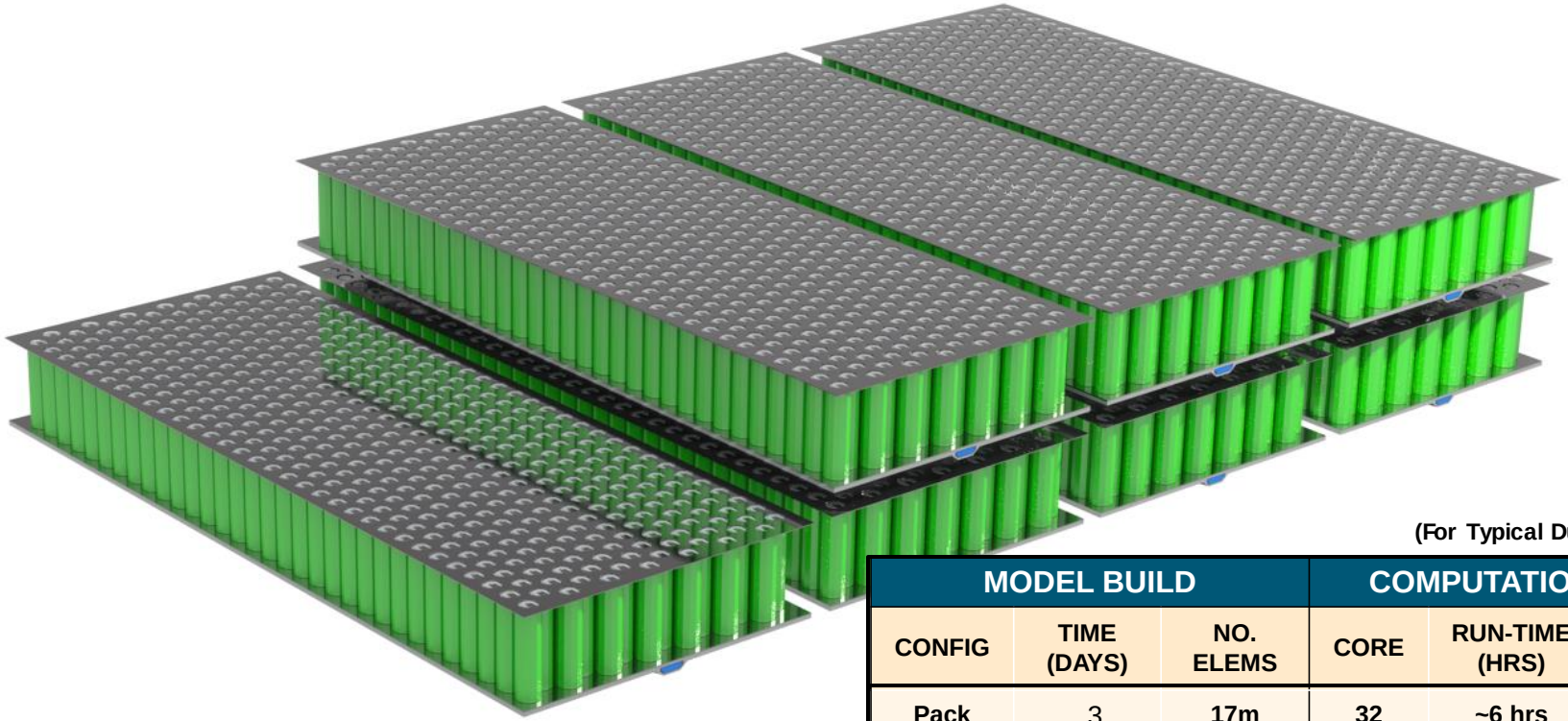
Electro-Thermal Analysis





ALTAIR

Productivity – Speed & Scale



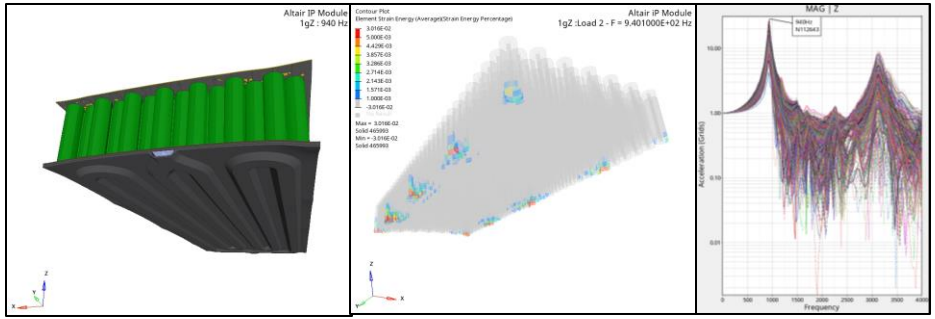
(For Typical Duty Cycle 600s)

MODEL BUILD			COMPUTATION COST		
CONFIG	TIME (DAYS)	NO. ELEMS	CORE	RUN-TIME (HRS)	MEMORY
Pack	3	17m	32	~6 hrs	~150Gb

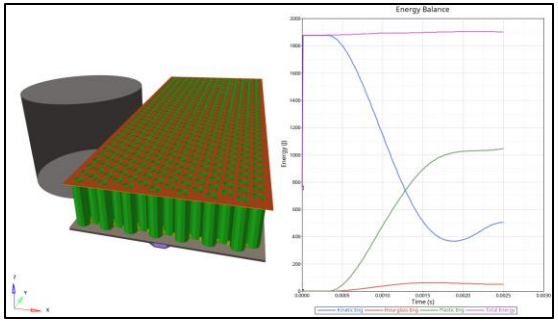
ALTAIR

Productivity- Single Finite Element Model

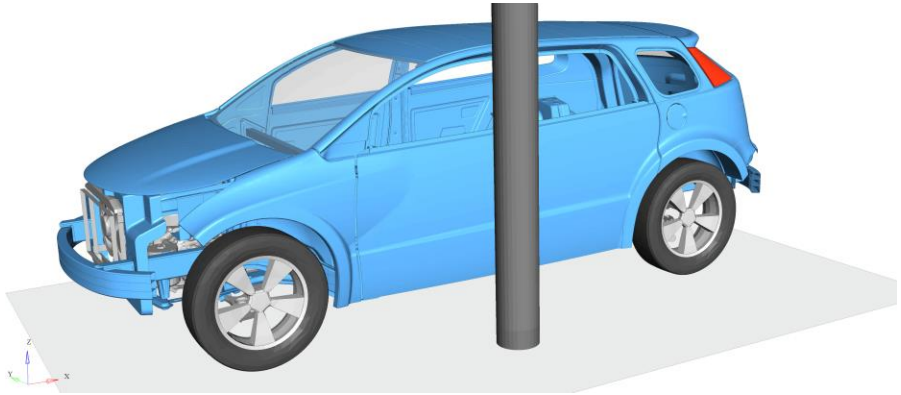
Multi Attribute Evaluation



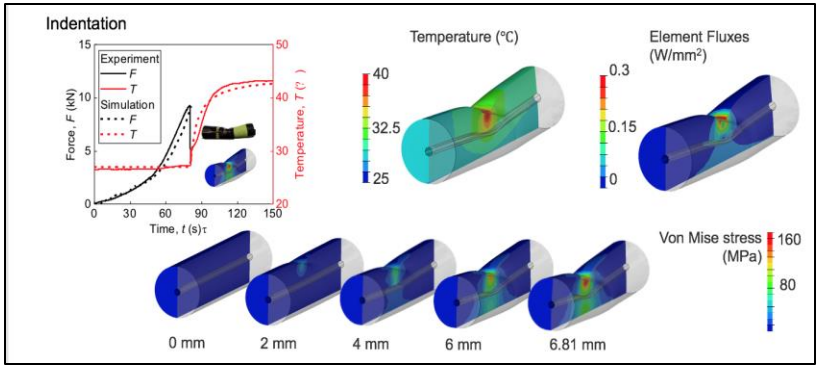
NVH, Durability



Impact



Thermal Runaway

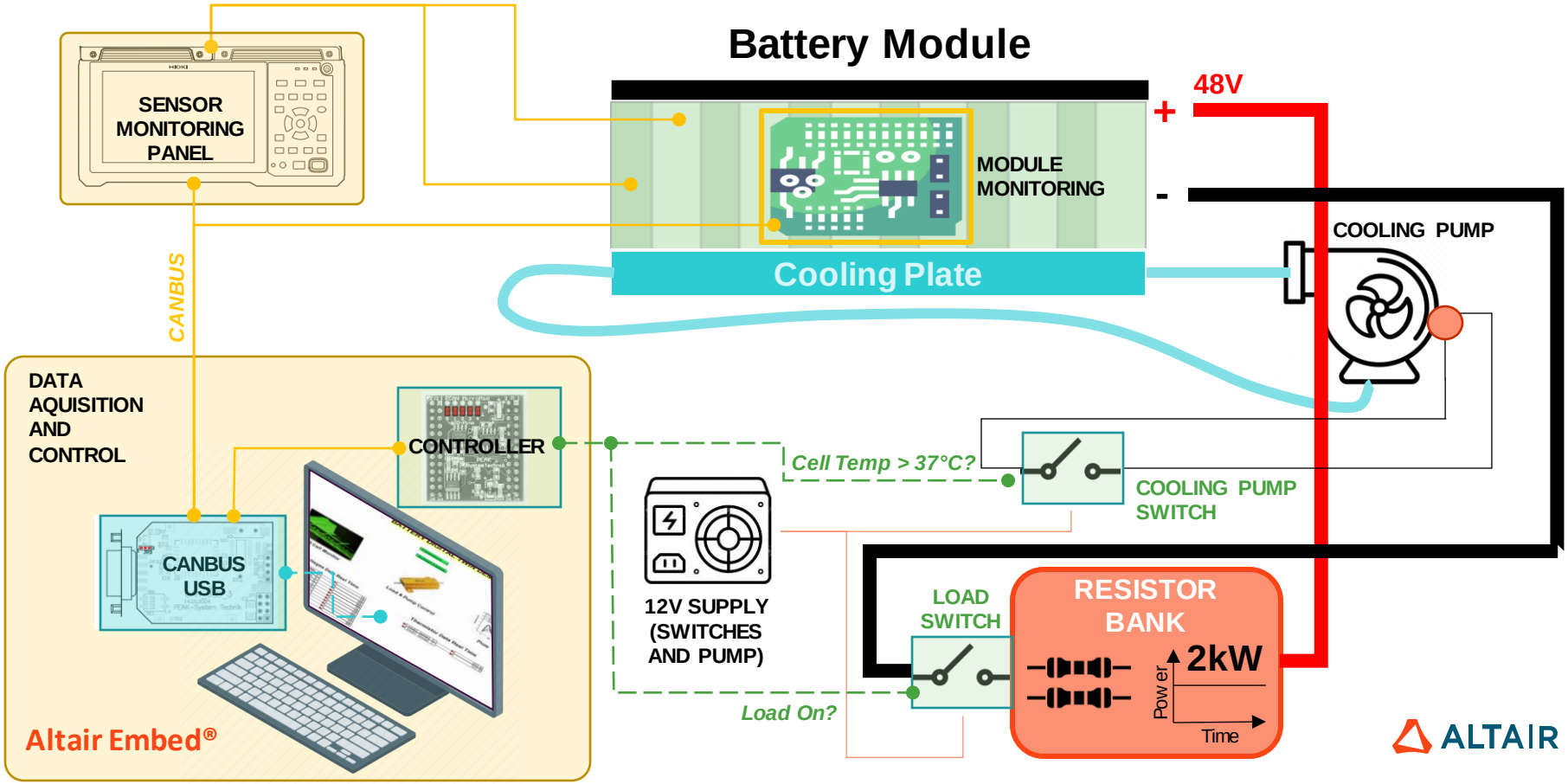


ALTAIR

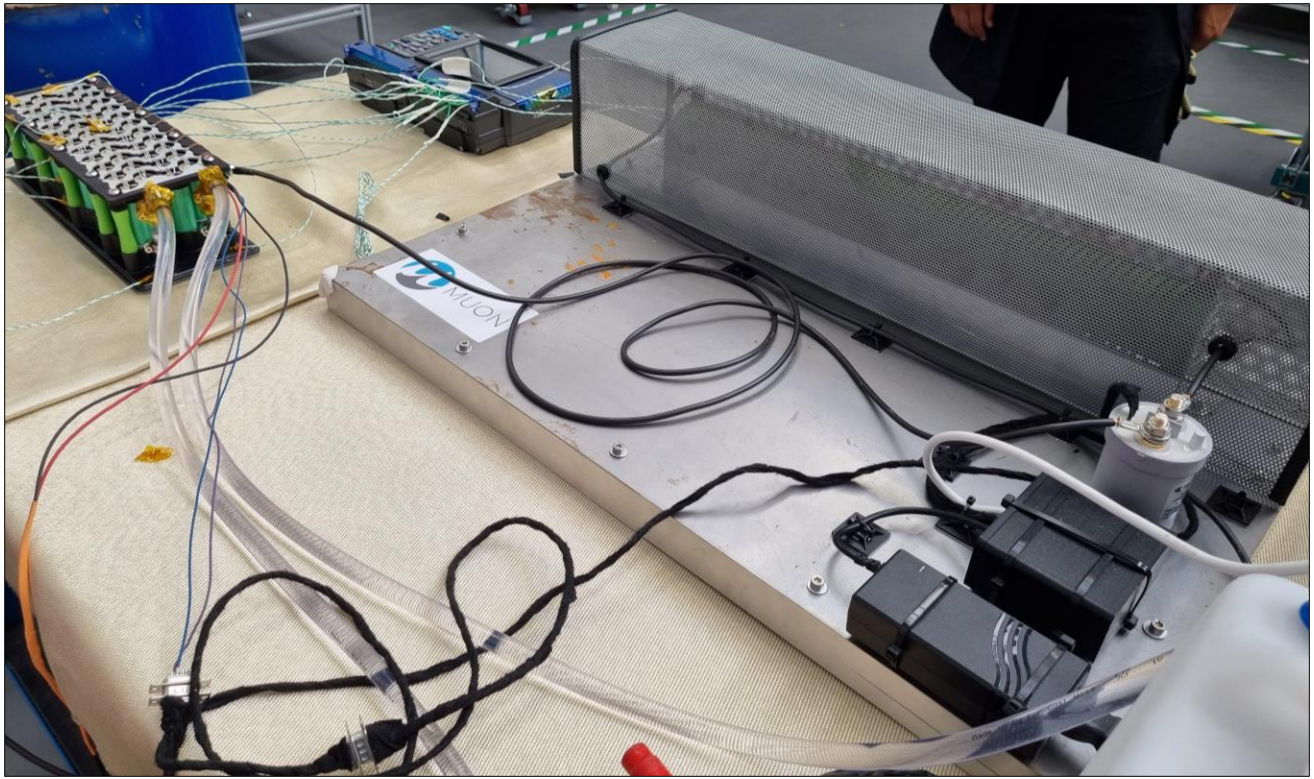
DIGITAL TWIN DEMONSTRATOR

danecca | ALTAIR

Demonstrator System Schematic

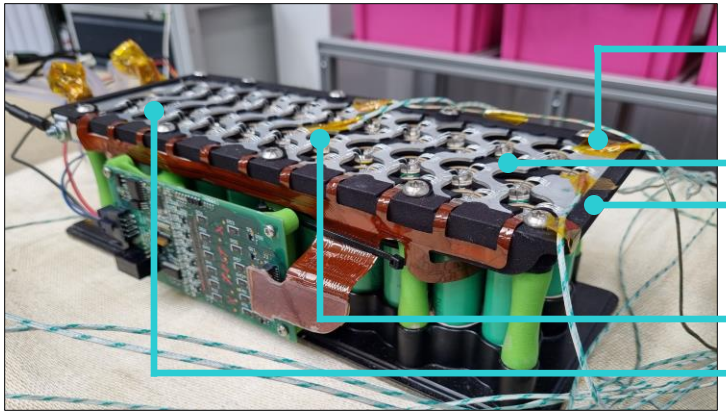


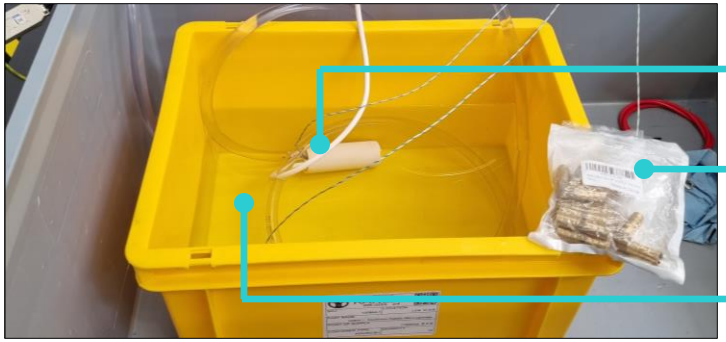
System

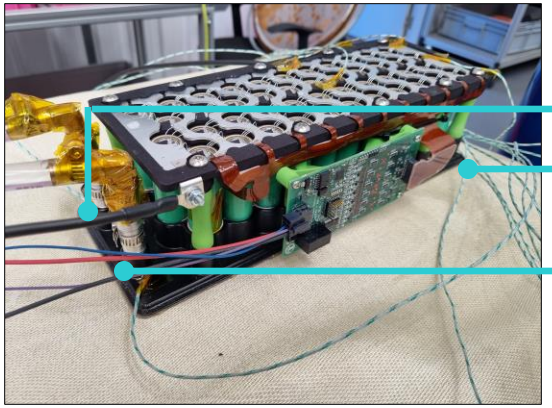


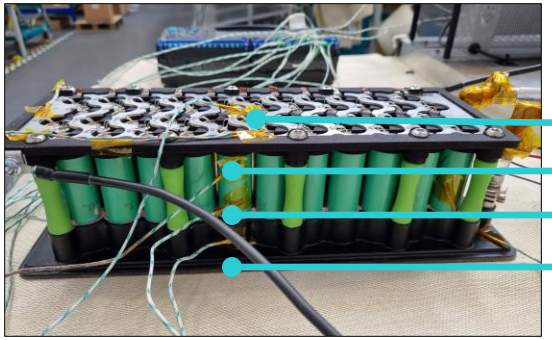
ALTAIR

Nervous System – Thermocouple Sensors (Sixteen Measurements)



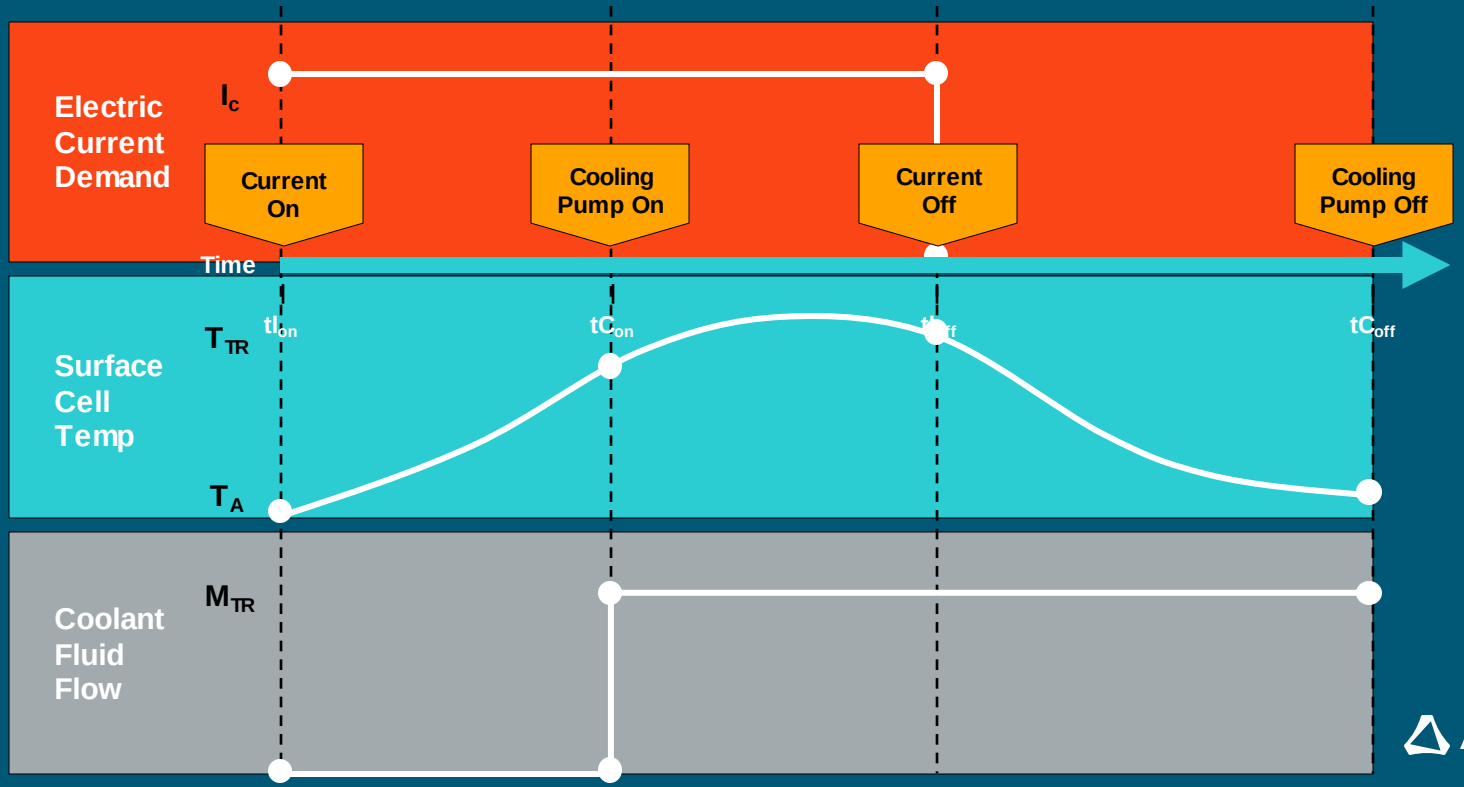






ALTAIR

The Brain - Event Modelling



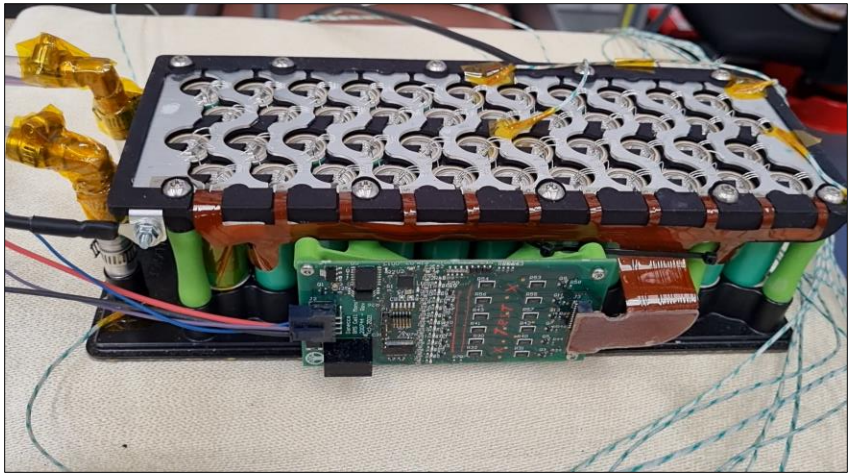
ALTAIR

INTRODUCING THE TWINS

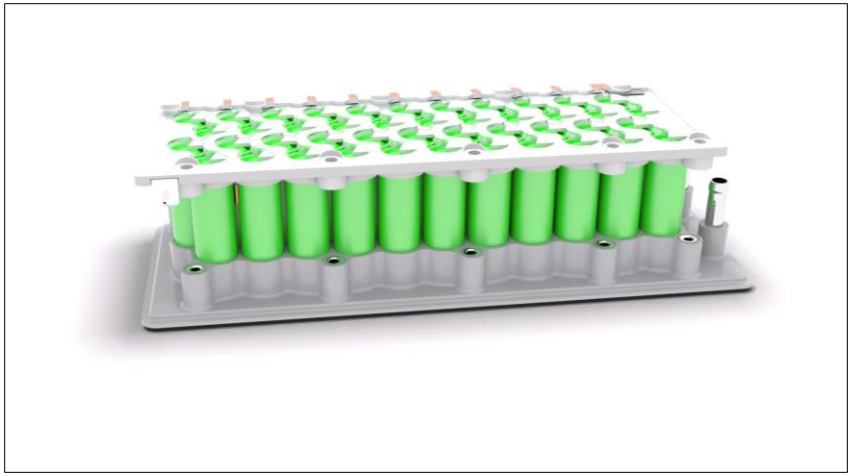
Battery Module

ALTAIR

Introducing the ‘Digital Twins’



Physical Twin



Digital Twin

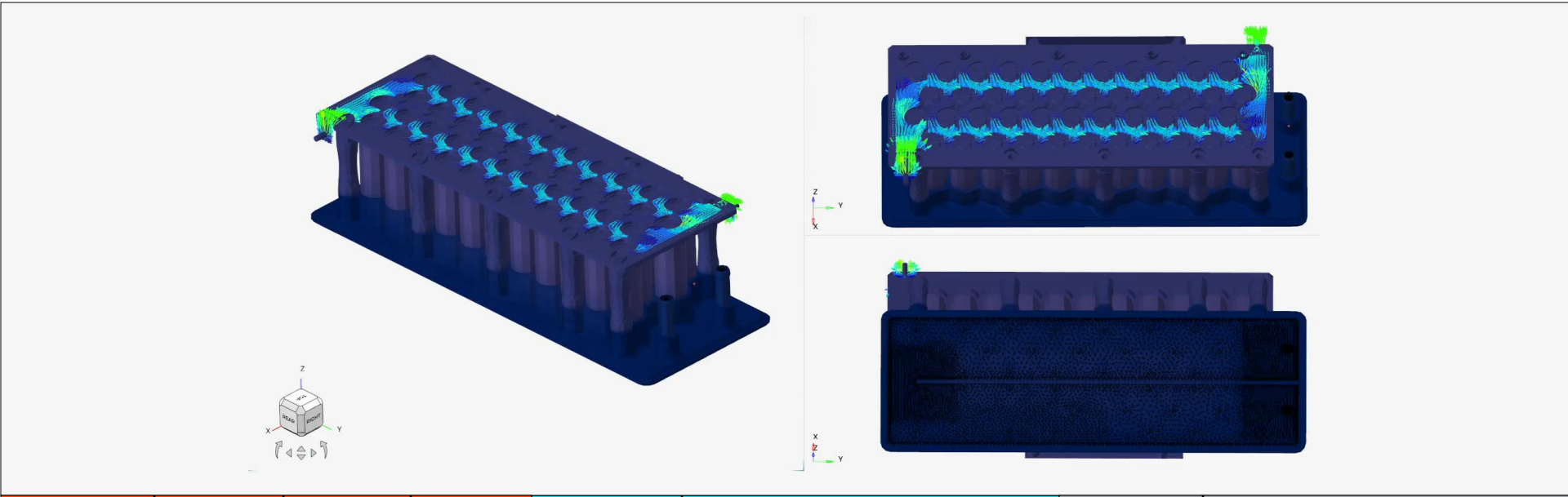
ALTAIR

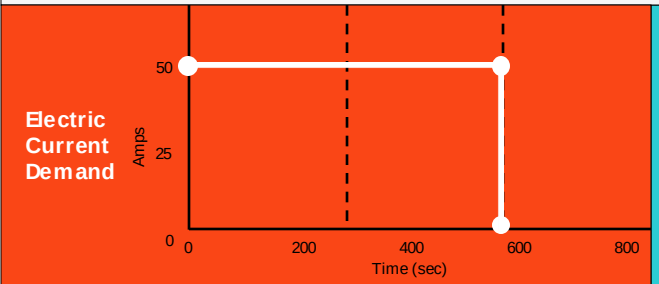
CORRELATION EXERCISE

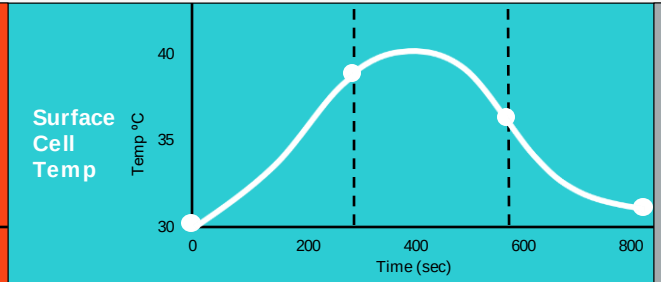
"The Twins Teach One Another"

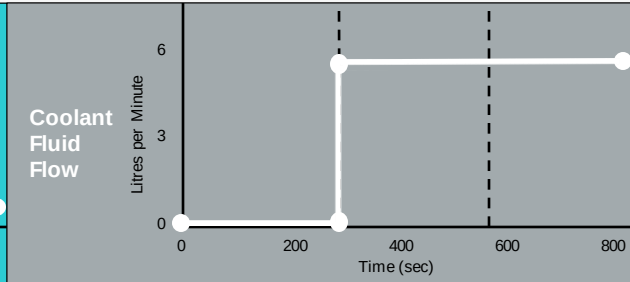
ALTAIR

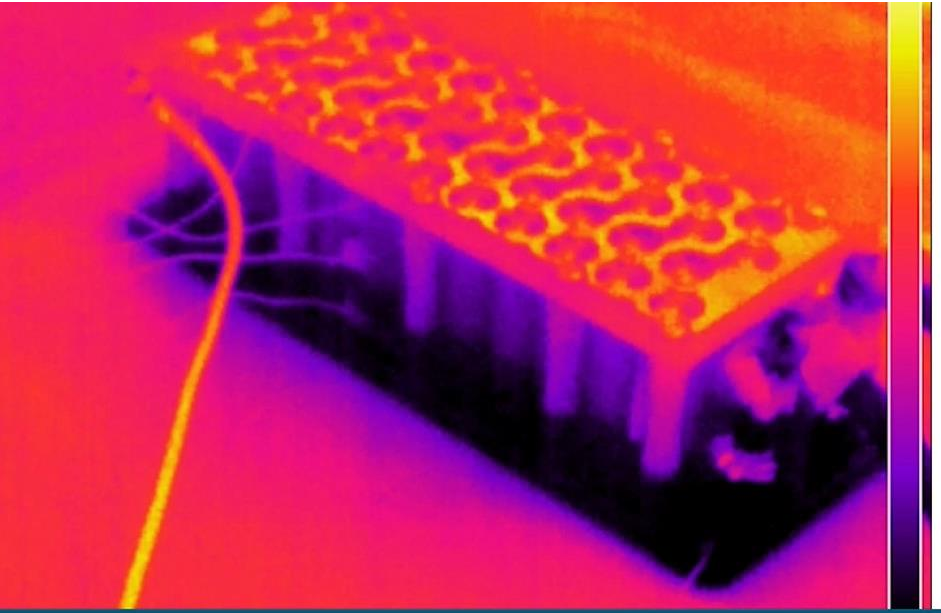
Digital Twin Multiphysics Results Display

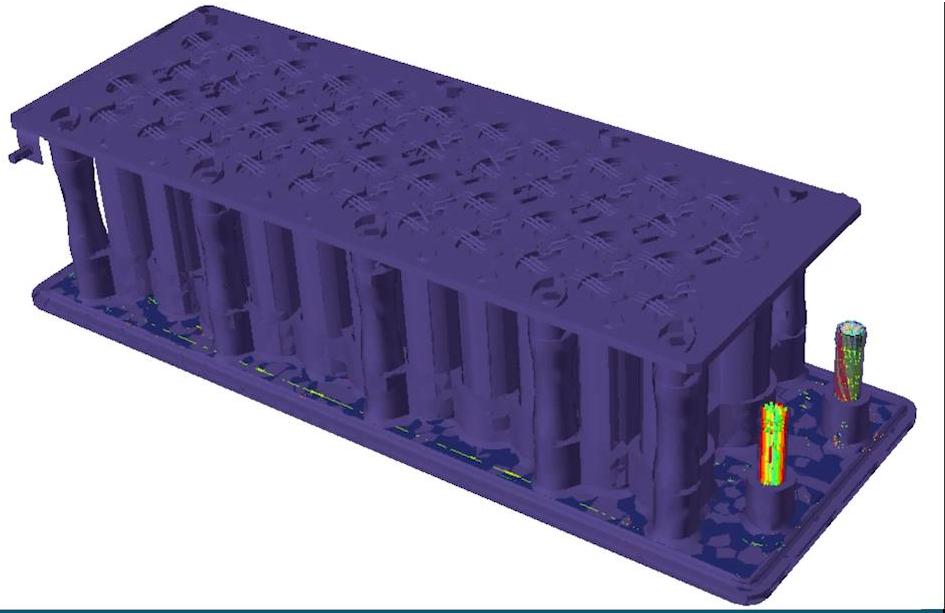


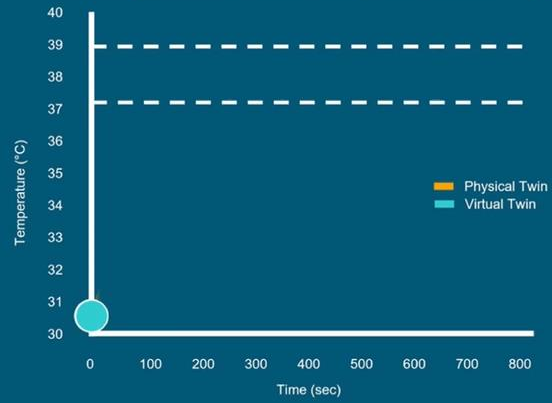


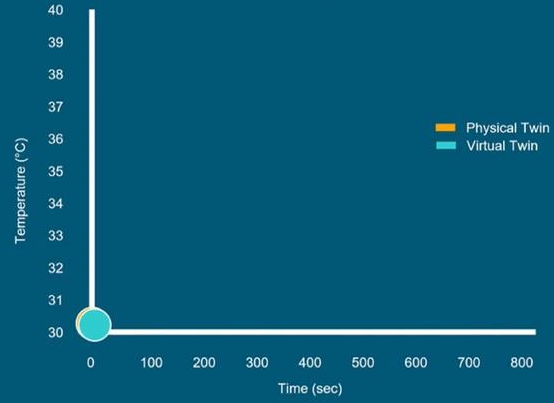









Battery Cell Surface Temperature S7P4(2)
Temperature (°C)
40
39
38
37
36
35
34
33
32
31
30
Physical Twin
Virtual Twin
0
100
200
300
400
500
600
700
800
Time (sec)


Busbar Temperature BB1
Temperature (°C)
40
39
38
37
36
35
34
33
32
31
30
Physical Twin
Virtual Twin
0
100
200
300
400
500
600
700
800
Time (sec)

DIGITAL TWIN

Unleash the Power with Optimization Technology

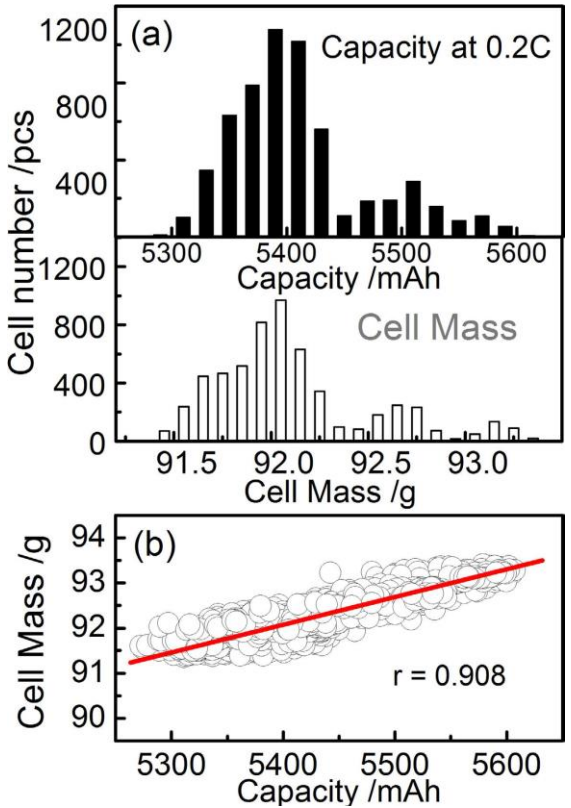
ALTAIR

Fast & Efficient Design Studies

- **'What-if'**
  - Tool is flexible and efficient
    - Component Thickness (e.g. Cooling Plate, Thermal Mats etc.)
    - Busbar Sizing – Busbar Joule Heating
    - Cooling Channel Profiles, Flow Rates, Chiller Temps, Pump Size
    - Cell Wiring Configurations – Current Imbalance

- **Optimization**
  - Understanding system sensitivity and optimization
    - Objective : Minimise Mass
    - Constraints : ≤ Battery Temp of Individual Cell or Cell Variation within a Group
    - Variables : Component Thickness, Cooling Profiles / Parameters

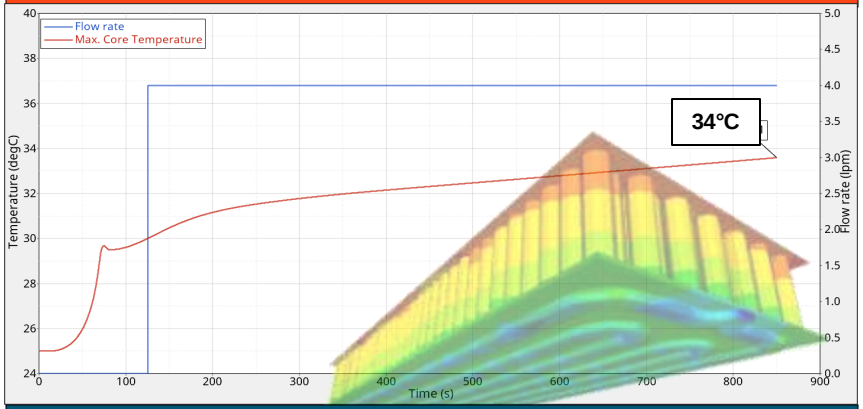
- **Robustness – Big Data**
  - Cell Variation (Mass, Geometry, internal resistance), Localised Busbar Connections



ALTAIR

Typical OptiStruct Range Optimization Study

Baseline

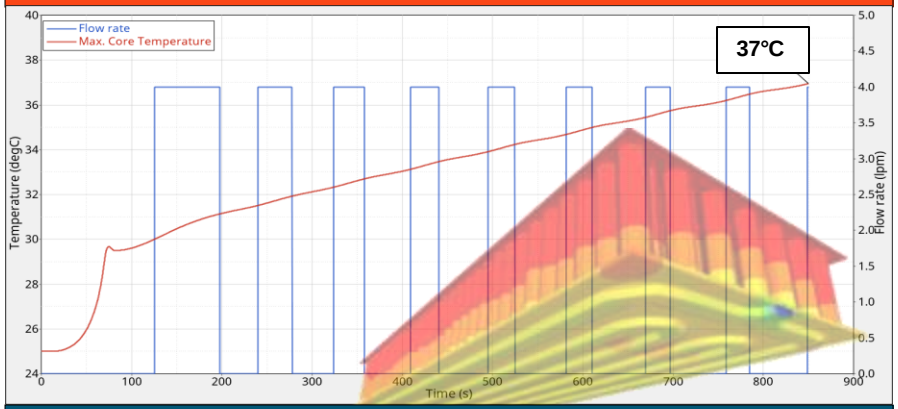


Cooling Pump Switched on at 30°C

Maximum Cell Temperature 34°C

Cooling Pump Duration 85% of the cycle

Optimised



Minimise Cooling Pump Duration

Switch Cooling Pump On/Off (Cell ΔT Gradient)

Maximum Allowable Cell Temperature 37°C

60% Reduction in Cooling Duration Time

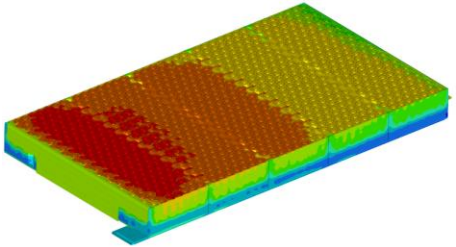
8 Pump On/Off Cycles Determined

5 Miles Range increase

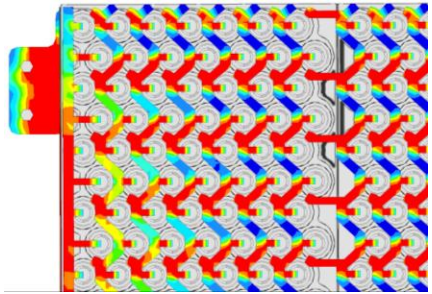
Typical Battery Pack Attribute Evaluation

THERMO-ELECTRICAL

Grid Temperature

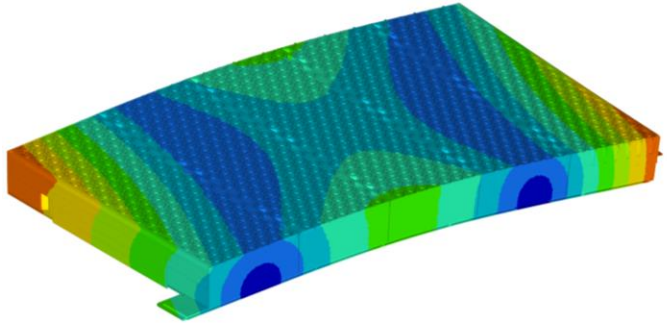


Current Density 2D



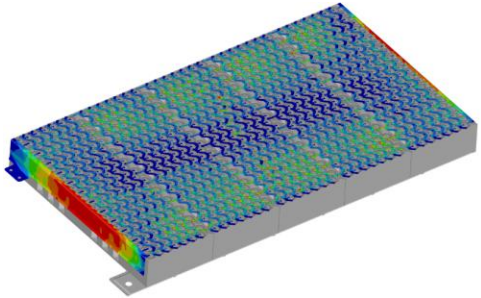
NORMAL MODES

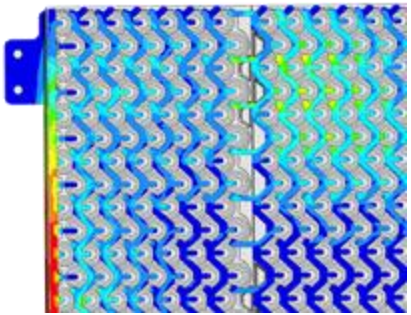
Eigen Modes



PSD

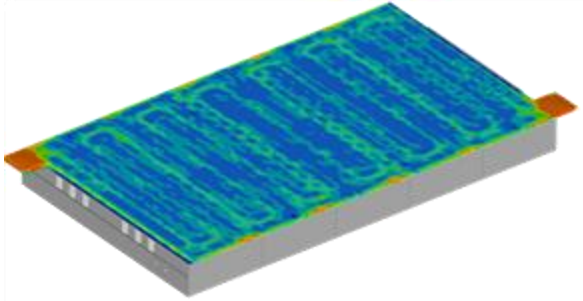
RMS Element Stresses (Segalman Von Mises Stress)



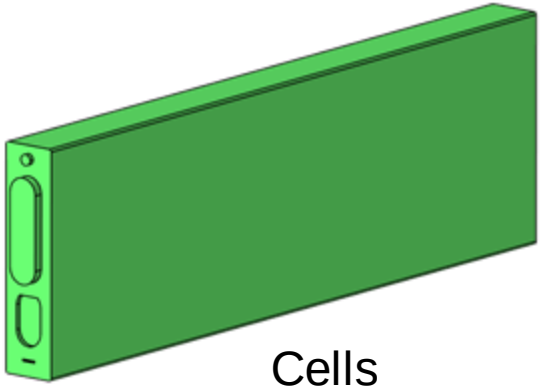


STRUCTURAL – Fluid Pressure

Element Stresses

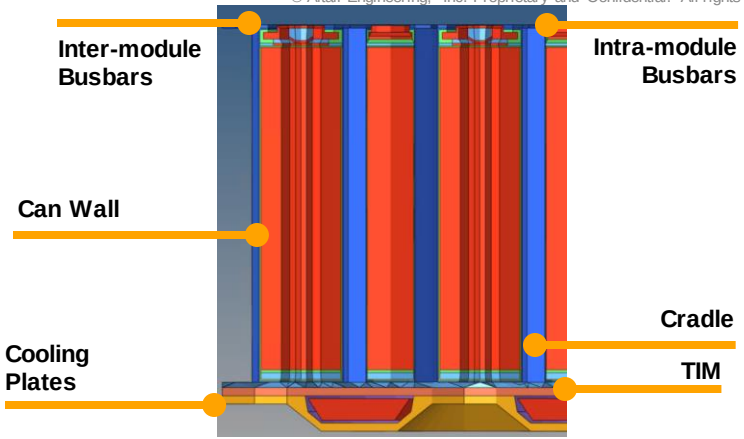


Typical Design Variables



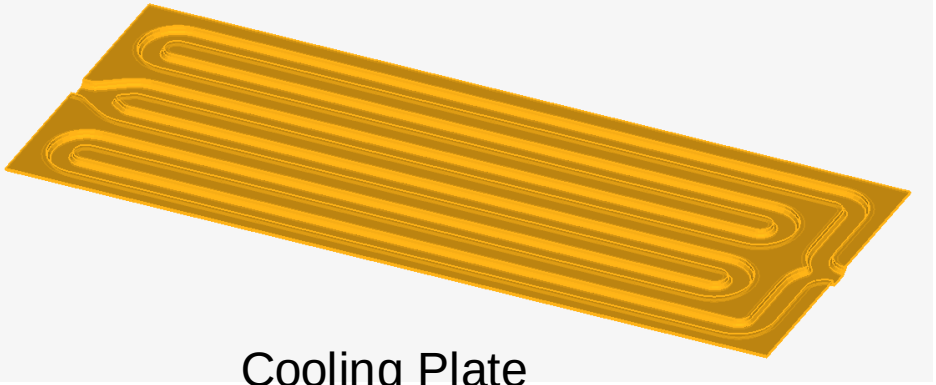
Cells

(Height, Casing Thickness, Internal Void, Orientation etc.)



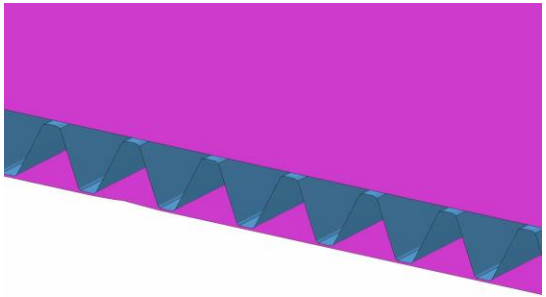
Module

Multiple Component Gauges



Cooling Plate

Structural Gauges

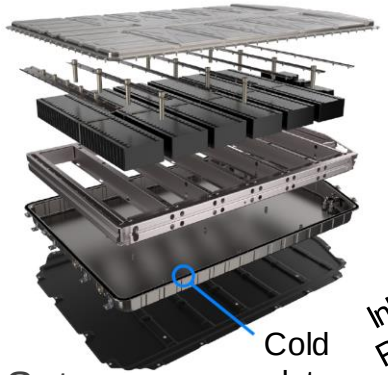


Cooling Plate Layout

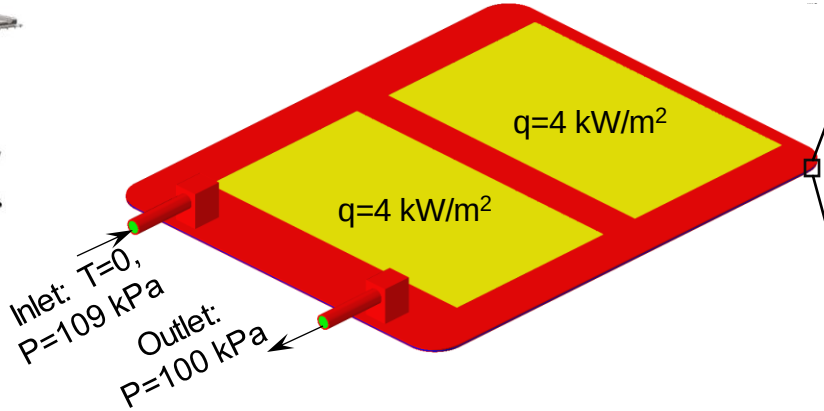
Height Variation (e.g. ±15%), Profile

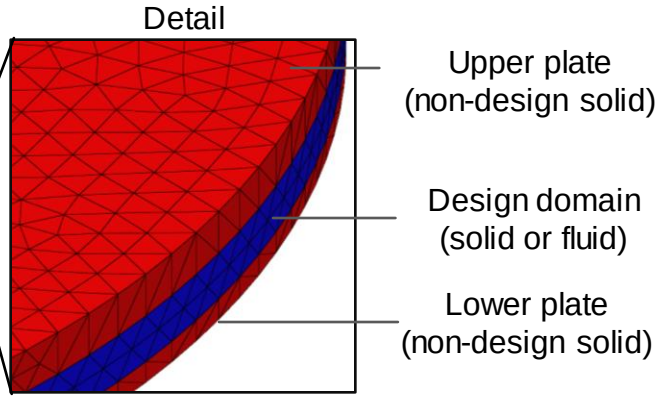
Battery Pack Cooling: Cold Plate Topology Optimization

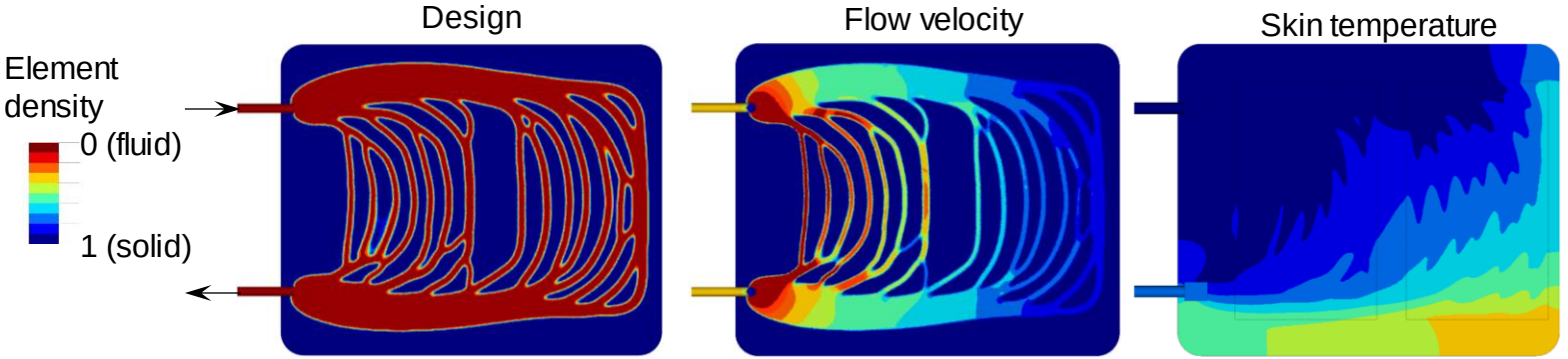
Cooling channel design by topology optimization to improve combination of conduction and forced convection based on design dependent flow.



Setup







Optimized design

ALTAIR

Project Gamma

- Faraday Battery Challenge UKRI funded project
- The project focuses on developing an integrated structural battery pack and wireless communicating battery cells to allow increased efficiency, reliability, and sustainability of automotive batteries.
- It aims to support the growth of UK manufacturers of automotive battery components and products.
- Consortia members:
  - Altair Engineering Limited
  - Jaguar Land Rover Limited
  - Danecca Ltd

ukri.org/news/delivering-the-future-of-battery-technology/

UK Research and Innovation

JAGUAR

LAND ROVER

danecca

ALTAIR

SUMMARY

Summary

- Agile Development – Physical & Virtual – ‘Pack Development in a Month’ Partner

- Rapid Simulation Tool
  - Verification – Complex Multi-Physics, Control logic Integration
  - Design – Productivity (Multi-Attribute Model Evaluation, Speed), Intelligence
  - Optimization – Control logic, multi-physics, multi-attribute

- Emergence of 3D Digital Twins to Impact Design

DISCOVER CONTINUOUSLY.
ADVANCE INFINITELY.

Visit altair.com to learn more.

#ONLYFORWARD

ALTAIR