WATERLOO BWC — EV BATTERY MODULE & COOLING INTEGRATION

SolidWorks CAD contributions to a competition EV battery module: cell layout, busbar geometry, cooling-plate clearances, and weekly cross-team design reviews.

SolidWorks CAD	Battery Module Design	Busbar Packaging	Coolant Routing	DFM Reviews	COMSOL (support)

14S4P	**4+**	**3**	**11**
Module configuration	CAD iterations	Subsystems integrated	Modules in full pack

CONTEXT

What the BWC project was

The Battery Workforce Challenge (BWC) is a student competition to design, prototype, and validate a complete EV battery pack to automotive standards, with Stellantis and Dana as industry partners. Waterloo's team organized the work into workstreams including Vehicle System Integration (VSI), which was responsible for ensuring that the module mechanics, busbar routing, thermal management, and enclosure geometry all fit together into a buildable 11-module pack.

I joined the VSI mechanical subteam as one of several engineering students working on the battery module design. The module itself is a 14S4P configuration — 14 cells in series, 4 in parallel — and forms the repeating building block of the full pack. My work ran from June to August 2025 and consisted of weekly SolidWorks contributions to a shared CAD environment, with findings and updates presented at weekly cross-team design reviews.

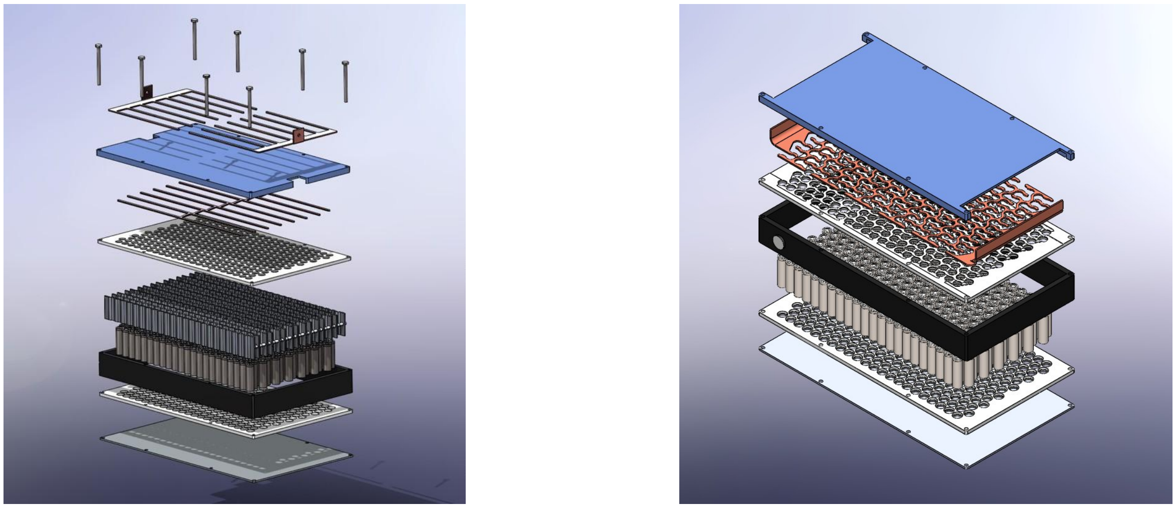

Fig. 1 — Left: full 11-module pack exploded view. Right: individual module showing cell array, busbar layer, cooling plate, and housing.

SCOPE OF WORK

What I contributed to the CAD

The module file I worked in had been started by earlier students and contained several geometry issues that needed to be resolved before the design could move toward manufacturing. Most of my contributions fell into three areas: fixing component conflicts, refining the busbar geometry, and checking clearances against the cooling plate.

> **Component conflict resolution**
>
> Several parts in the existing file had overlapping or interfering geometry — busbars clipping into cooling plate surfaces, cells positioned outside their holders, and brackets with dimensional mismatches that would have caused assembly problems. I worked through these iteratively, resolving interference checks and updating the affected components to produce a clean assembly. Each resolved version was uploaded to the shared SharePoint CAD repository for review at the weekly meeting.

> **Busbar geometry refinement**
>
> The busbars in the earlier design had features that were impractical to machine — tight internal radii, unrealistic wall thicknesses, and routing paths that conflicted with adjacent components. I modified the busbar profiles to geometries compatible with CNC machining, maintaining the required current-carrying cross-section while removing features that would have required additional fixturing or special tooling. Aluminum was selected as the busbar material based on its established use in competition EV packs at this scale: lighter than copper, lower cost, and adequate conductivity for the current loads involved.

Cooling plate clearance checks

The module uses a bottom-mounted cooling plate as its thermal management strategy. I validated that the cell holders, structural brackets, and fasteners all cleared the plate geometry with adequate tolerance for both assembly and thermal expansion. Where clearances were insufficient I updated the relevant features and flagged the changes in the weekly design review for sign-off from the thermal and electrical subteams.

Cell layout adjustments

Cell positions within the 14S4P array were adjusted in some iterations to resolve spacing conflicts and improve access for sensing harnesses. Changes were made with input from the electrical subteam to ensure that series/parallel groupings and tab orientation remained correct after any repositioning.

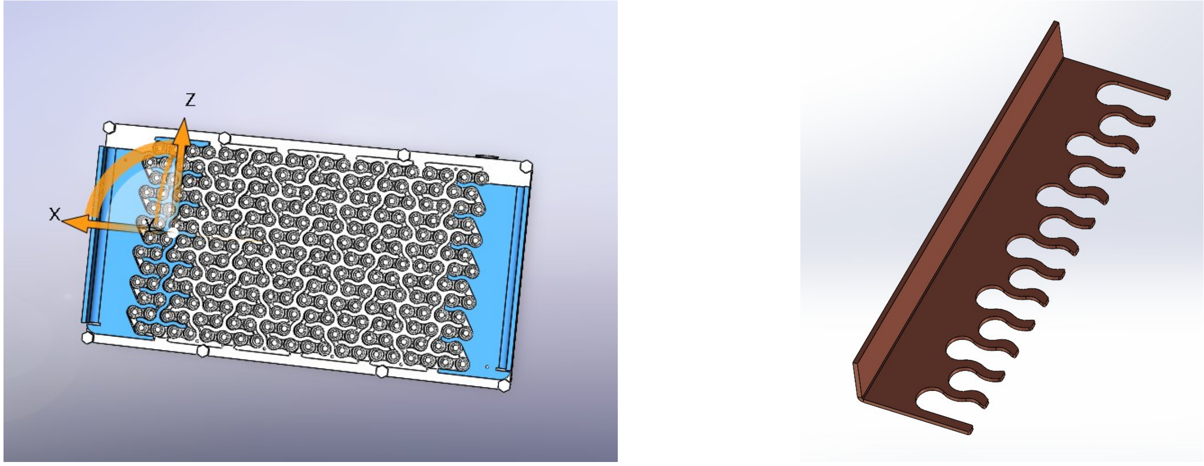

Fig. 2 — Left: busbar placement within the module assembly. Right: terminal busbar detail showing copper comb geometry with individual cell-tab contact fingers.

DESIGN TRADEOFFS

Decisions made during the work

Working inside an existing team design means most decisions are constrained by what's already been committed to upstream. The tradeoffs I navigated were practical ones: what to change, what to leave alone, and how to make changes that wouldn't break other subteams' work.

Machining compatibility vs. electrical performance in busbars

The original busbar geometry prioritized minimizing resistance by maximizing cross-sectional area, but some features were not realistically machinable. Reducing certain profiles to practical dimensions slightly increased resistance but kept the parts producible without specialized tooling. The net resistance increase was small relative to the overall pack impedance and was accepted by the team.

Clearance margins vs. pack density

Adding clearance between the cooling plate and the cell holders reduced interference risk but slightly increased the module footprint. In a tightly packaged 11-module pack, any growth in module size propagates to pack-level fit. Changes were kept to the minimum needed to achieve a clean assembly and were reviewed against the pack-level envelope at each weekly meeting.

Iterative weekly delivery vs. a single coordinated redesign

The team's workflow meant that design changes were delivered incrementally each week rather than in one coordinated redesign. This was practical given the number of people touching the shared file, but it also meant some iterations created downstream conflicts that needed to be resolved the following week. A more structured change-control process would have reduced that churn.

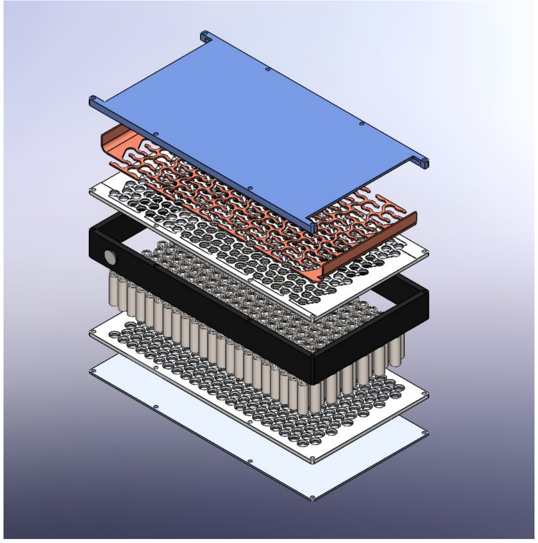

Fig. 3 — Top-down cell array view showing 14S4P arrangement within module housing and bottom cooling plate interface.

SIMULATION

COMSOL and ANSYS involvement

The VSI team used COMSOL and ANSYS to validate thermal and structural aspects of the module design. My involvement was supporting, not leading — I sat in on simulation runs and assisted with a small number of COMSOL setups, primarily thermal simulations examining heat distribution across cell groups and busbars. The simulation work was largely driven by other team members with more experience in those tools.

The main value for me was understanding how the CAD geometry I was modifying fed into the simulation inputs — specifically how cell spacing and busbar cross-section affected the thermal results. That feedback loop informed some of the clearance and geometry decisions I made in the CAD work.

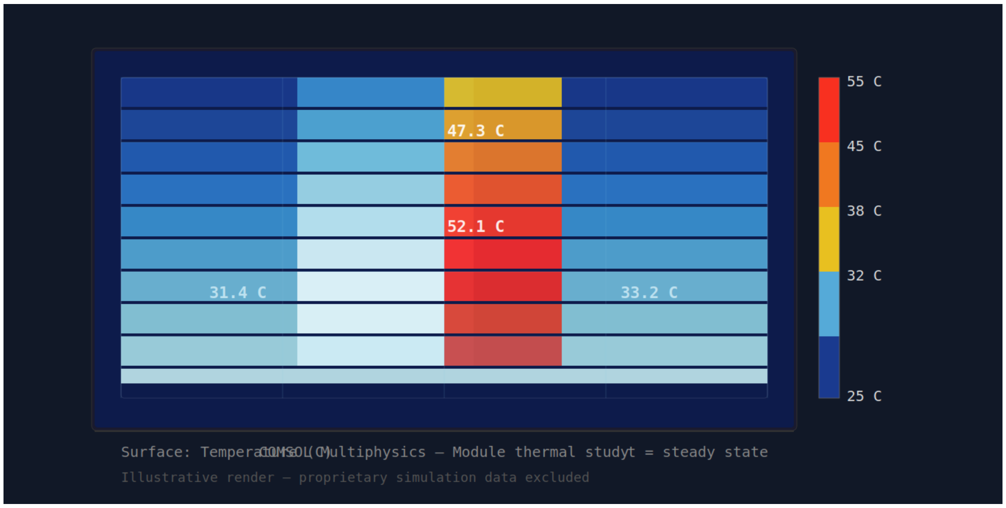

Fig. 4 — Illustrative COMSOL thermal render showing representative temperature distribution across module cell groups and busbars at steady state. Proprietary simulation data excluded.

PROCESS

How the work was delivered

Work was structured around weekly team meetings where each subteam presented updates, flagged conflicts, and received new task assignments. My contributions followed that rhythm: identify an issue or receive a task at Monday's meeting, work through the CAD changes during the week, upload the updated files to the shared SharePoint repository, and present the changes at the next meeting for feedback.

Presenting at these reviews meant communicating changes across subteams: explaining why a busbar profile changed, whether a clearance fix affected the thermal plate alignment, or why a cell reposition required a harness routing update from the electrical team. Working in that environment gave me a good read of how mechanical decisions propagate to other disciplines in a shared design.

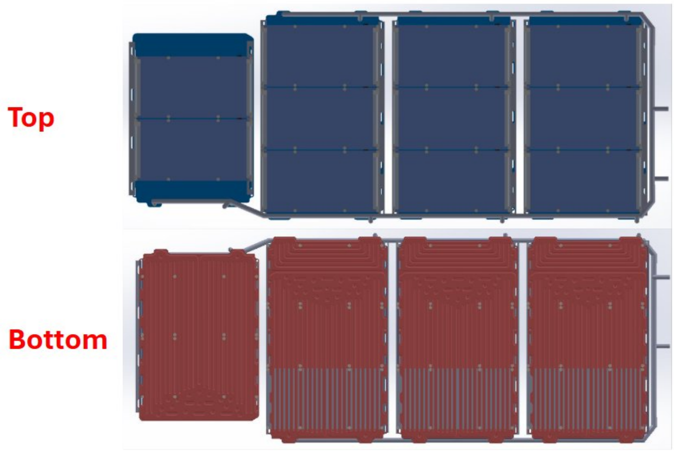

Fig. 5 — Full pack thermal management layout: top view showing module housings (blue), bottom view showing cooling plate channels (red) routed across all 11 modules.

RETROSPECTIVE

What I'd do differently

01 **Start with a clean conflict check before touching anything**

The most time-consuming part of the work was resolving geometry conflicts that accumulated from previous contributors. Running a full interference check at the start of each week before making any new changes would have separated inherited problems from ones I introduced, and made it easier to track what actually needed to be fixed.

02 **Build a personal change log alongside the shared files**

Because changes were delivered incrementally to a shared file, it was sometimes hard to trace which changes had been reviewed and accepted versus which were still pending. A simple change log per upload — what changed, why, and what review it was presented at — would have made the handoff cleaner and the history easier to read.

03 **Get deeper into the simulation tools earlier**

My COMSOL involvement was mostly observational. Getting more hands-on with the thermal simulations earlier would have let me make better-informed decisions about cell spacing and busbar geometry rather than relying on feedback from others after the fact.

REFERENCE

Technical specifications

Organization	Waterloo Battery Workforce Challenge (BWC)
Team	Vehicle System Integration (VSI) — Mechanical subteam
Role	Mechanical design contributor (one of several)
Duration	June 2025 to August 2025
Industry partners	Stellantis, Dana
CAD platform	SolidWorks (primary), AutoCAD (reference)
Simulation tools	COMSOL (thermal, support role), ANSYS (aware of, team-led)
Module config	14S4P — 14 cells in series, 4 in parallel
Pack size	11-module full pack
Thermal mgmt	Bottom-mounted cooling plate
Busbar material	Aluminum (CNC machined)

Key contributions	Interference resolution, busbar geometry refinement, cooling plate clearance checks, cell layout adjustments
Delivery method	Weekly SolidWorks file uploads to shared SharePoint; presented at weekly cross-team design reviews
Status	Competition EV — ongoing at time of contribution