TM-24 Design Review

TESLA

February 6th 2024

TORONTO METROPOLITAN
FORMULA RACING

Toronto Metropolitan University
Faculty of Engineering & Architectural Science

OUR DESIGN GOALS

1

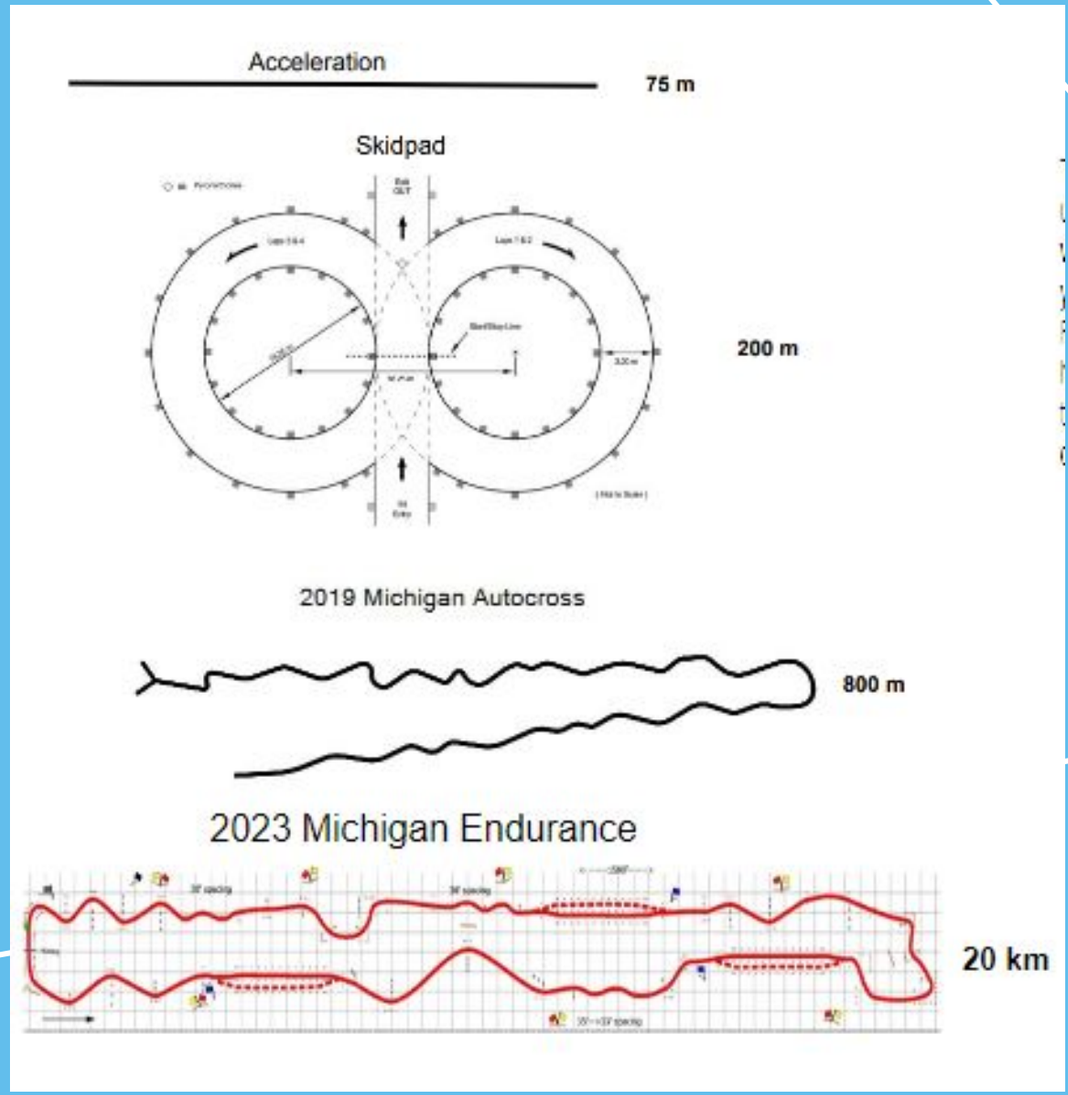
Pass all Technical Inspections

2

Be able to complete an endurance run

3

Manufacture a more competitive vehicle by reducing F.O.S and maintaining same weight with the addition of an aero package (336 kg)



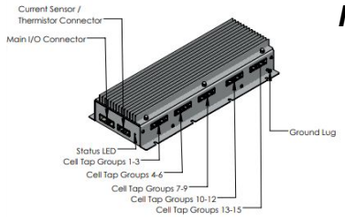
NEW ELECTRIC POWERTRAIN SYSTEM DESIGN

Battery Pack

- Sony Murata VTC6 cells
- Enepaq 1x7p module
- 7.4kWh, 84s7p (7 segments)
- Determined through OptimumLap sims
- Air cooled

BMS

- Orion BMS 2
- 84 cell taps
- 28 temperature sensors (4 per segment)



Reasons for Choice:

- Centralized topology
- Ease of use
- Reduces manufacturing time

Motor

- Emrax 228 Medium Voltage LC- 3 phase, synchronous AC
- Repackaged above differential/battery pack

Reasons for Choice:

- OptimumLap Performance
- Reliability - Popular product line among FSAE EV teams
- Rules Compliant - carries ingress IP65 rating
- Reduced manufacturing time

Vehicle Control Unit

- STM32 based VCU
- Updated electrical architecture to reduce CAN bus load

Motor Controller

- Drivetrain Innovation HV-500 Liquid Cooled
- 200-800VDC input range
- 6kW max. power

Reasons for Choice:

- Lighter than the Cascadia PM100DX
- Configurability/ease of use/reliability
- Cost is half that of many of the other brands compatible with Emrax motors
- Integrated support for regenerative braking
- Reduces manufacturing time

Drivetrain

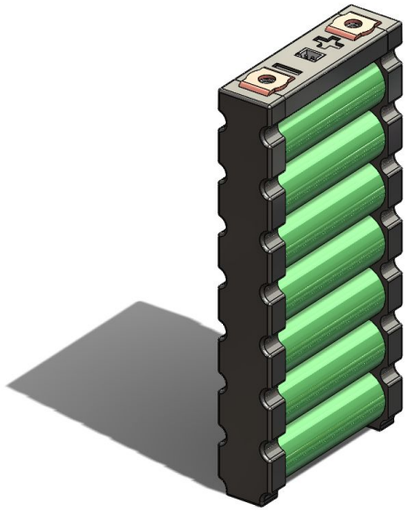
- Chain drive, fixed ratio
- Drexler FSAE clutch based limited slip differential
- Gear ratio: 3.5

Battery Pack

Battery

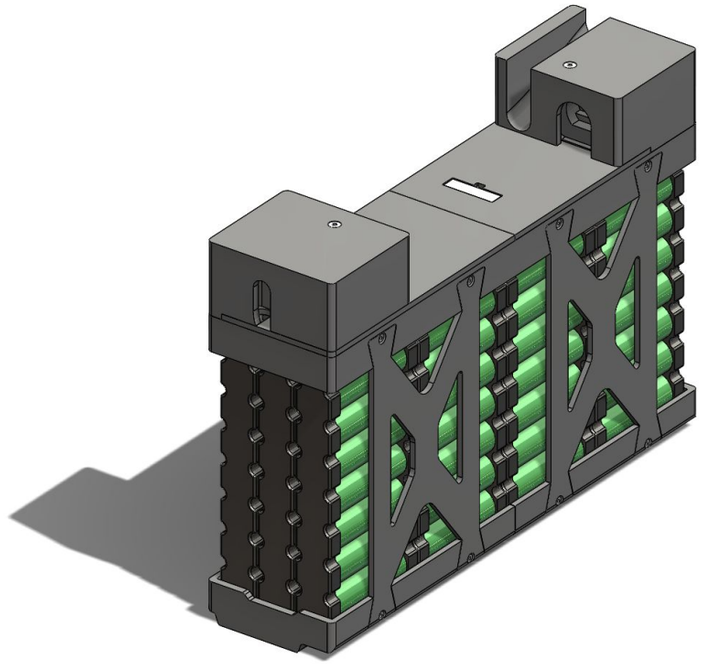
- Sony Murata VTC6 18650
- Max Cell Voltage: 4.2 V
- Rated Capacity: 3000 mAh

Module



- Enepaq battery module
- 7 cells in parallel
- 45 A fusible links

Segment

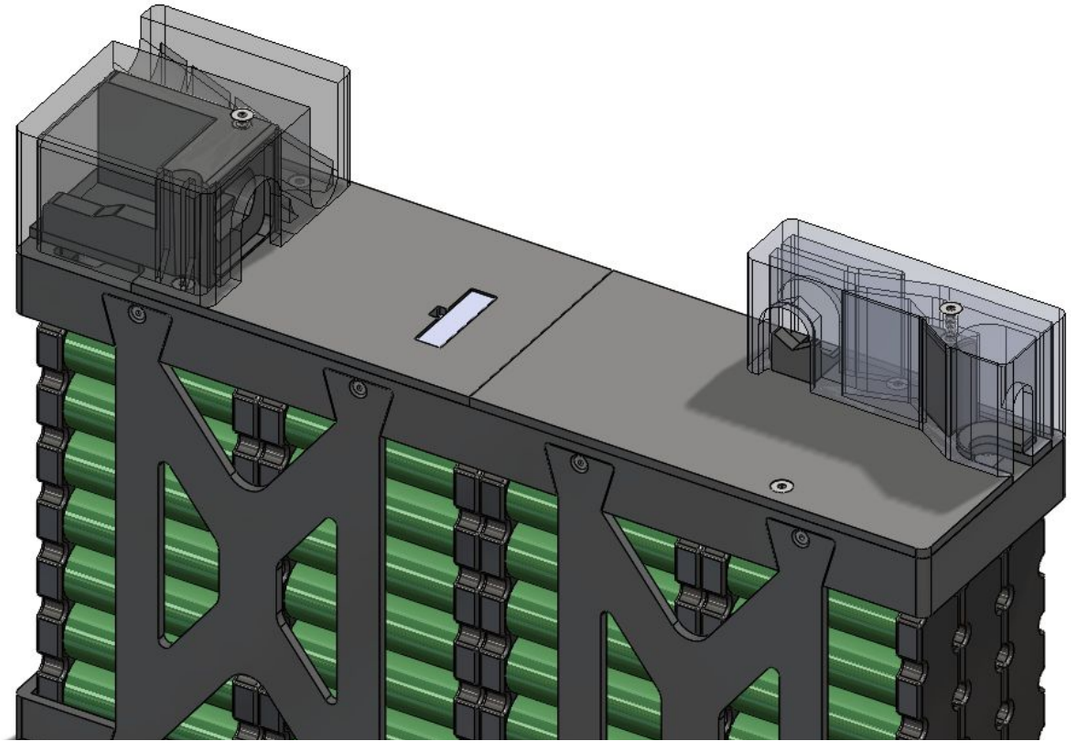


- 12 modules in series
- 3.27 MJ < 6MJ
- 50.4 V < 120 V
- 5.8 kg < 8 kg

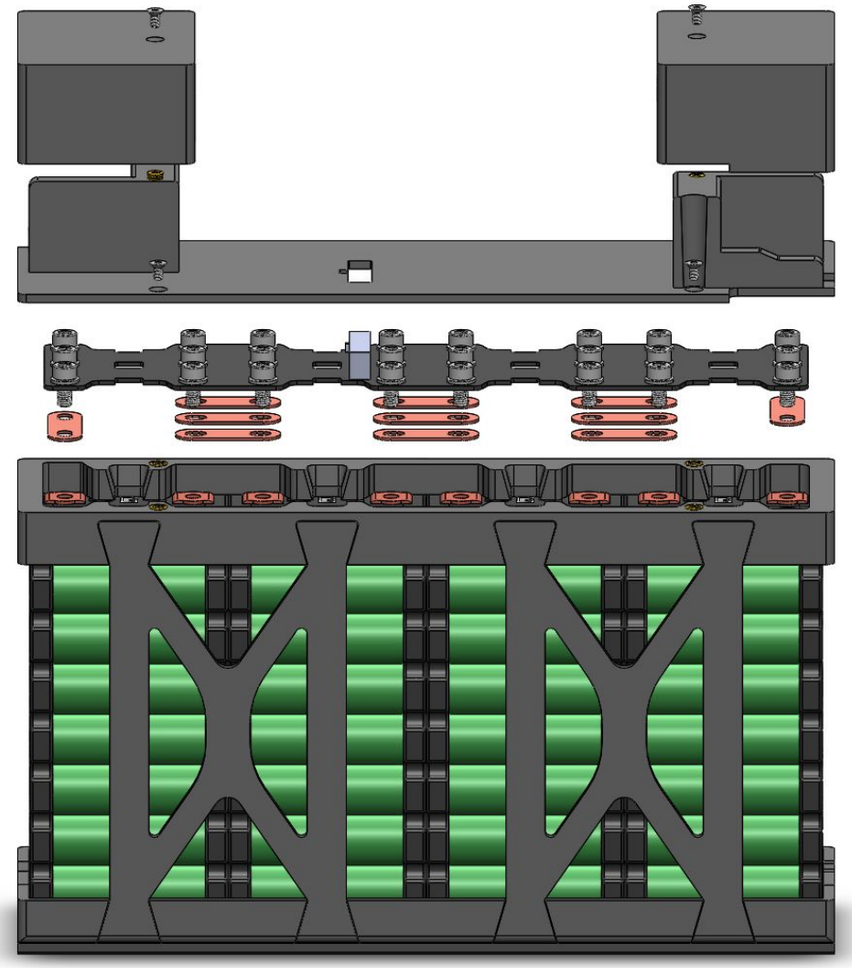
Battery Pack

Segments

New approach to segment assembly: to improve packaging & reduce manufacturing time of cell tap harnesses.



L: Harness passthrough, R: Connection to AIRs

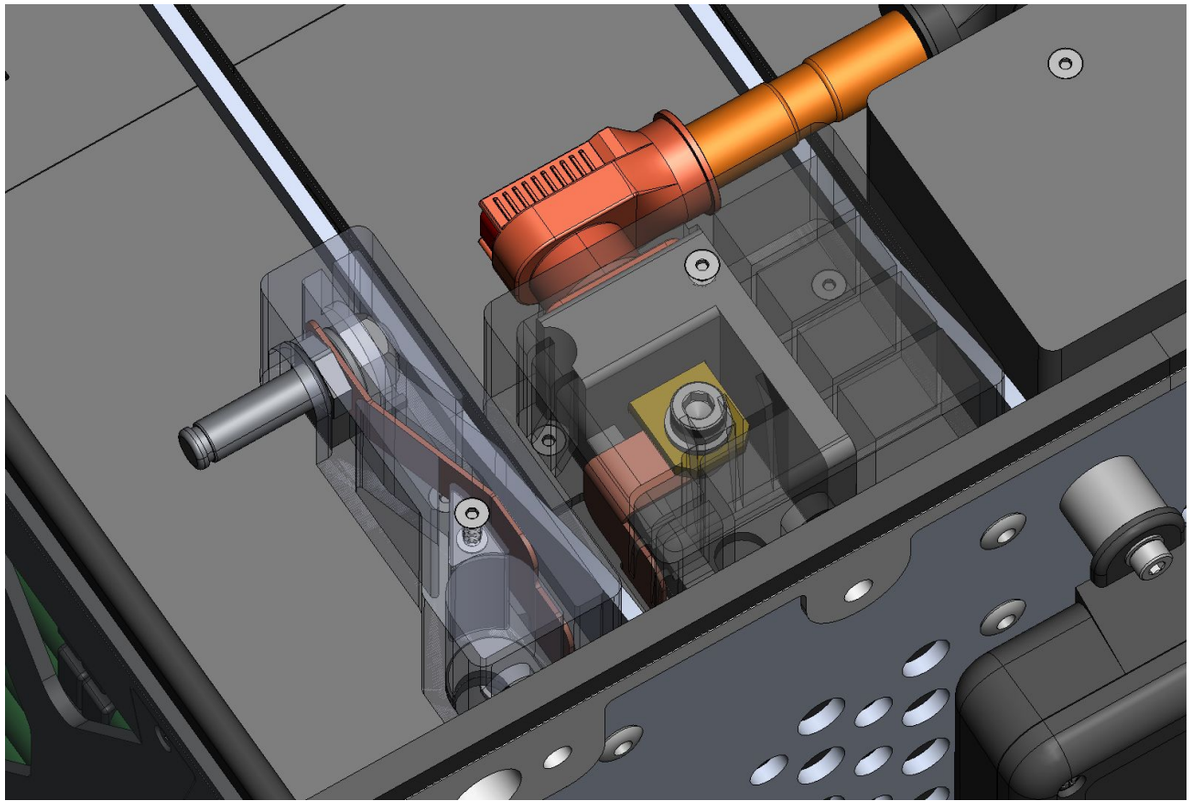


Exploded view of cover (default variant)

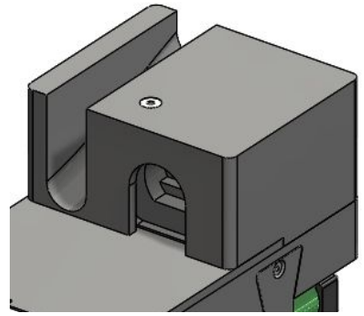
Battery Pack

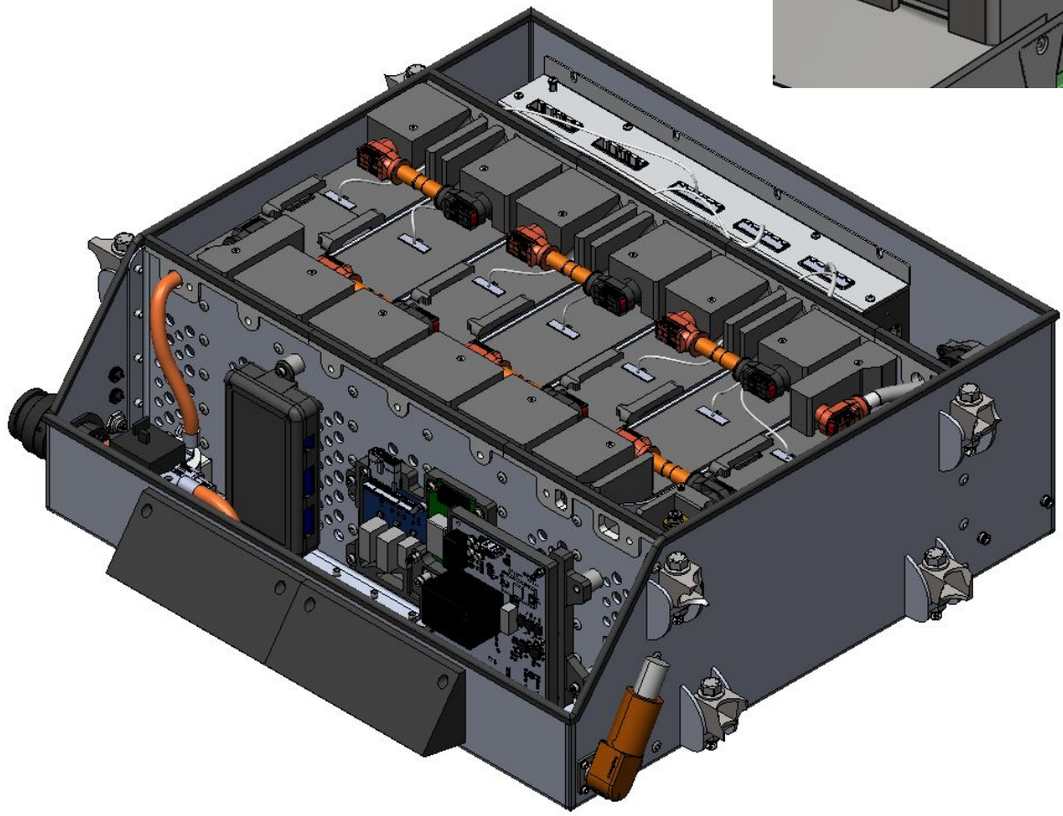
Segment Packaging

New Approach to maintenance plug connections: shorter wire paths, hardware supported and fixed by segment bracket geometry.



Amphenol Surlok Plus Stud & Lug

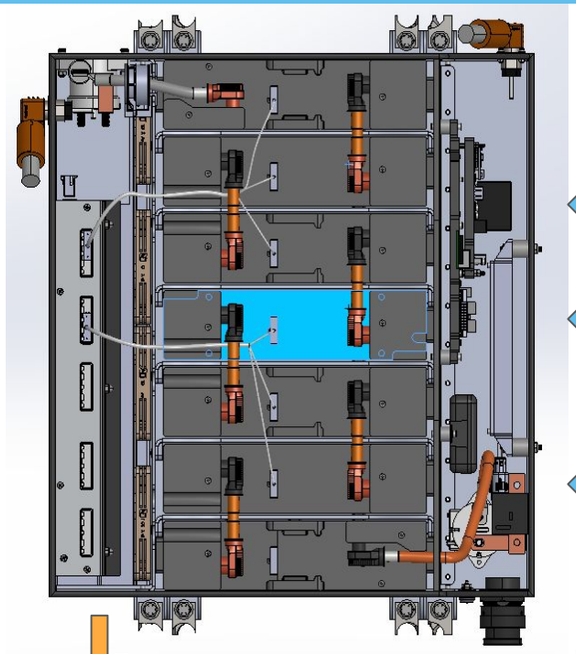


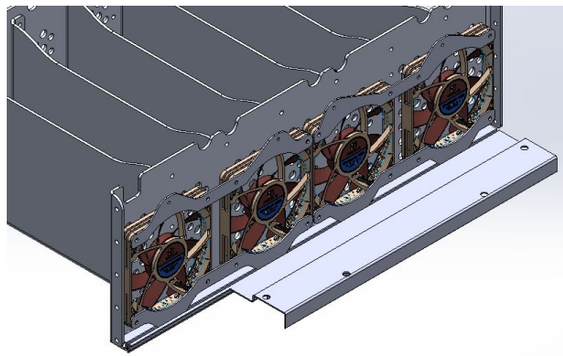


Battery Pack

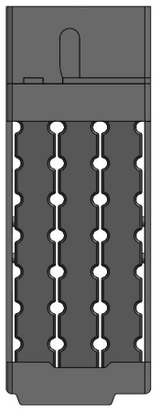
Cooling

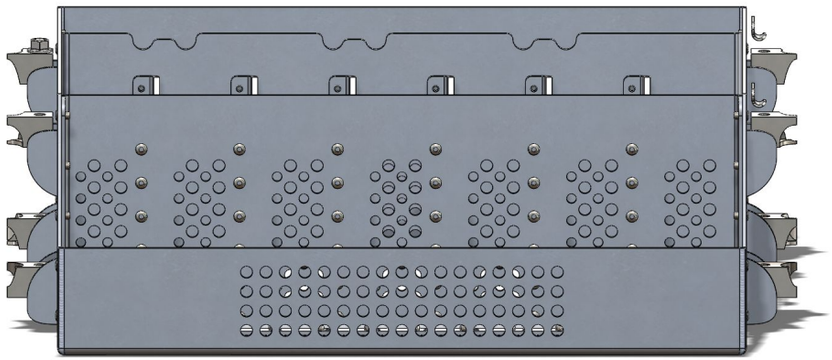
- Front intake, adjacent to firewall/roll hoop
- Rear exhaust, primarily through lid
- Array of 120x15mm fans pulls air through segments
- Combination of elastomer & foam based sealing between segment walls and container lid (to minimise recirculation)

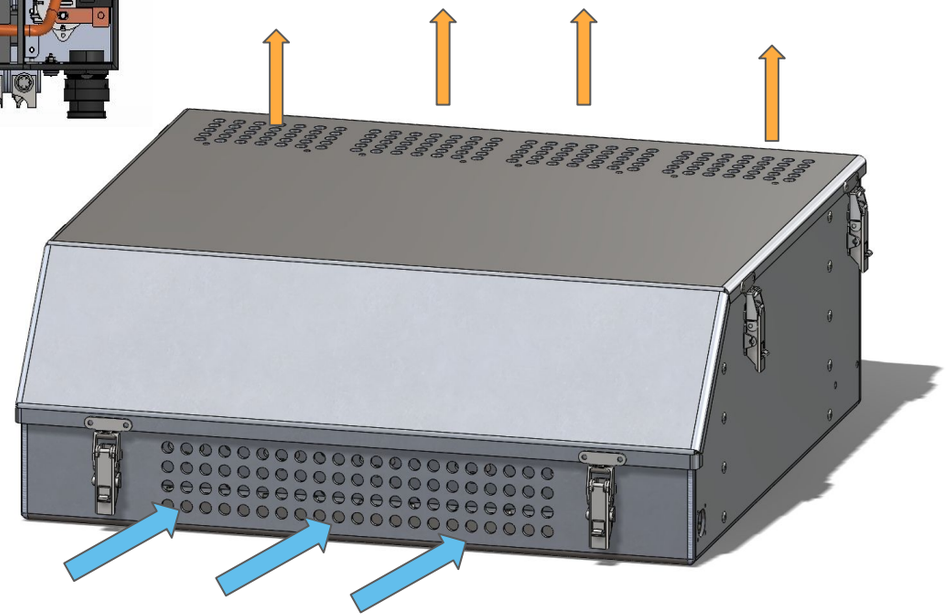




(Shrouds not pictured)



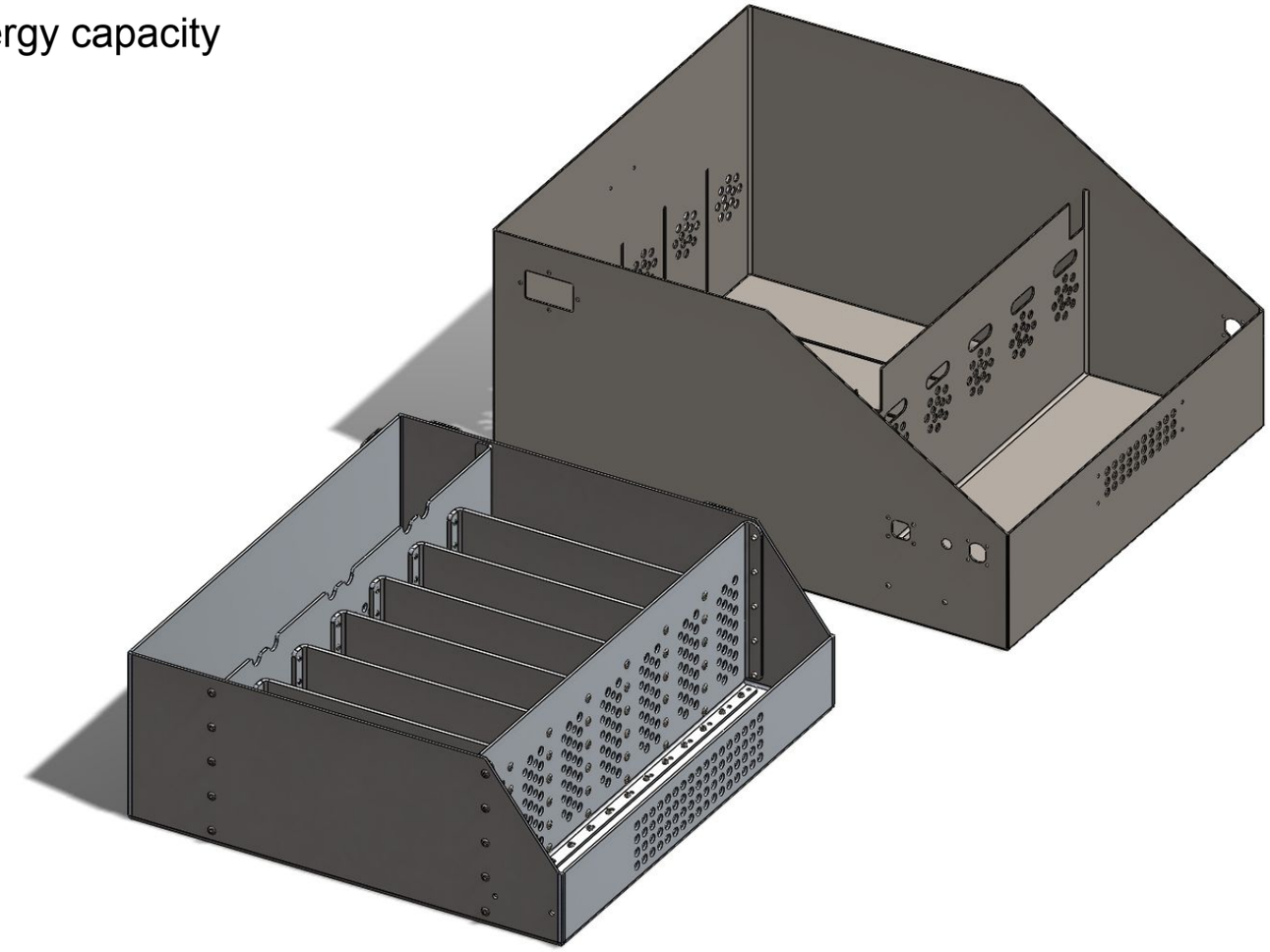




Container Re-packaging

40% reduction in overall container volume at same energy capacity achieved through improved component packaging.

Dimension	TM-23	TM-24	Change
Longitudinal	622 mm	525 mm	- 16%
Transverse	533 mm	567 mm	+ 6%
Vertical	330 mm	205 mm	- 38%



Container Construction & Manufacturing

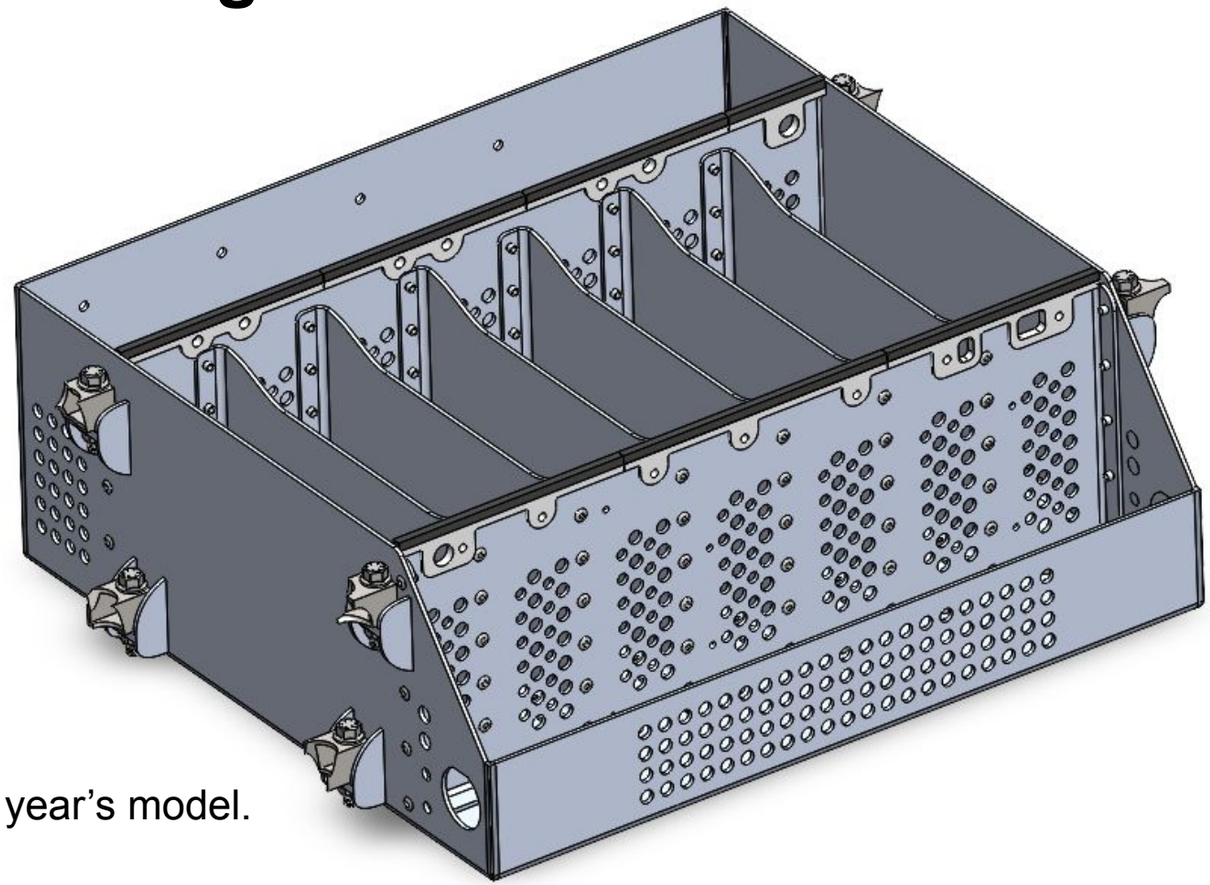
Material: 5052-H32 Aluminium
Advantages: Suitable for bending, good weldability, lightweight.

Construction:
Outer Wall: Single piece, four walls bent & corners welded.
Internal Walls: Bent with flanges, riveted to outer shell.

Mounting:
Location: Corners of the segment compartment.
Benefits: Reduced number of mounting points.

Objective:
Minimize welding to reduce warpage.
Speed up manufacturing with riveting.

Why Aluminium Over Steel?
Goal: Decrease container mass.
Result: Container weighs 15 kg, half the weight of the previous year's model.



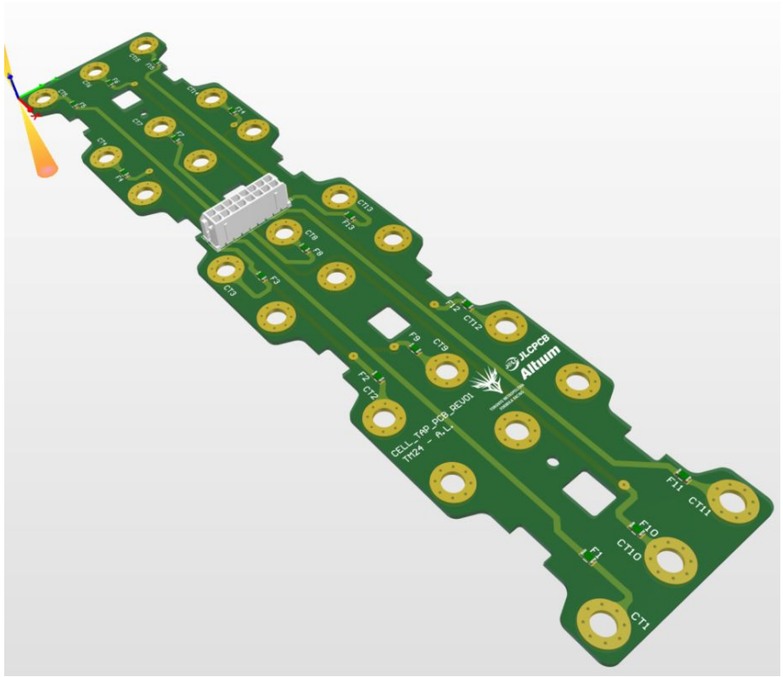
BMS (Battery Management System)

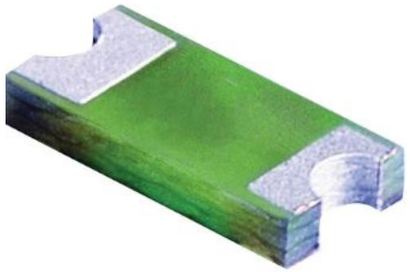
Cell Tap PCB Specs

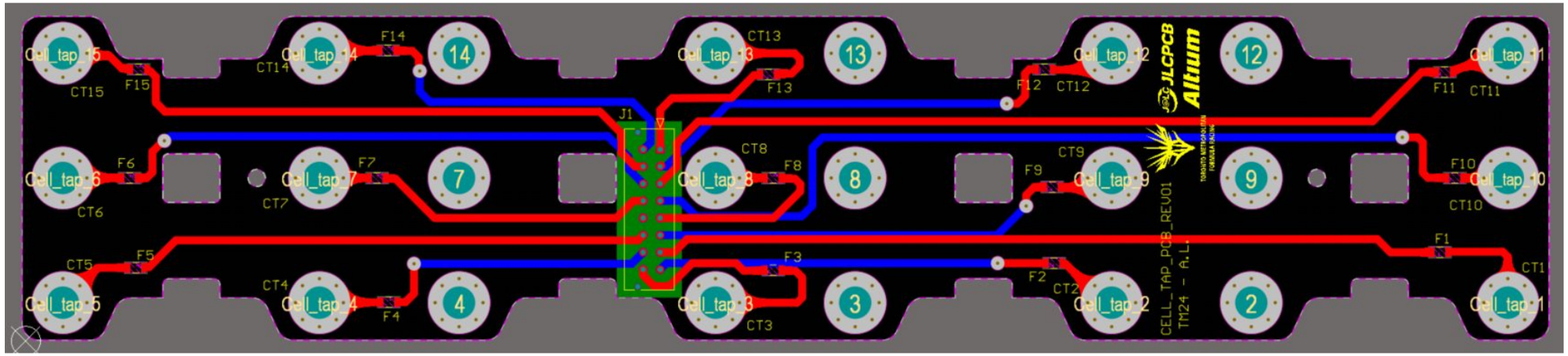
- Littelfuse SMD fuse per cell tap
  - 500 mA current rating (BMS internal fuse is 750 mA)
  - 63 VDC voltage rating
  - Fast acting
- Reinforced pads to tap each module
  - Fastened above busbars
- Clearance holes to connector thermistors
- 1 variant compatible with all segments by varying pinout at connector
- Molex Micro-fit 3.0 TPA header
  - UL94 V-0 flammability rating
  - 600V voltage rating
  - 8 A current rating per contact
  - Employs retainers for robust connection

Reasons

- Improves fuse integrity in TS
- Reduces wiring, cell tap wires all feed to one connector
- Stepping stone to future custom BMS design







VCU (Vehicle Control Unit)

2x APPS (Gill Blade360)

BSE (SSI P51)

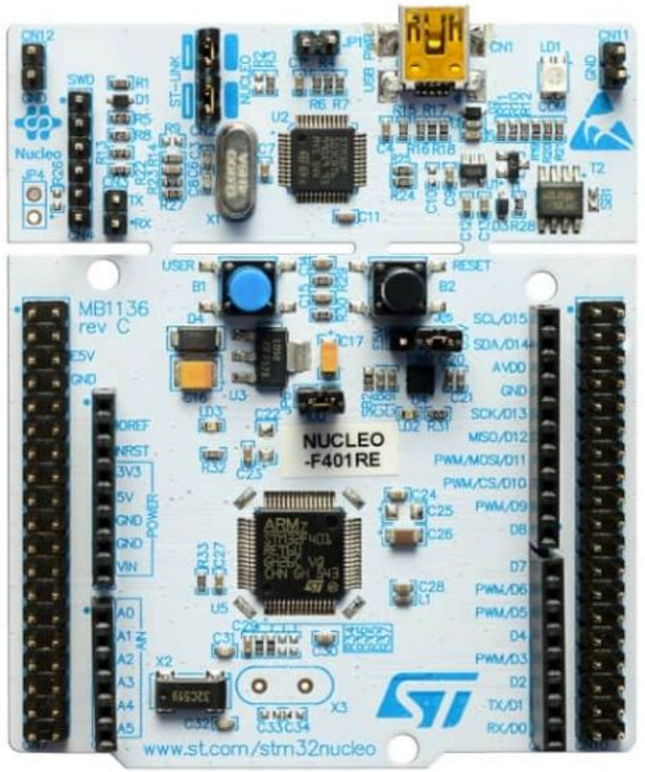
TSAL HV Active Output

BMS CAN DCL, Temps

VCU
Ready to Drive
APPS Out of Range
APPS Plausibility
Software BSPD
APPS Consolidation & Mapping

Inverter (DTI HV-500)
Torque Output Command Analog I/O

Inverter (DTI HV-500)
Drive Enable Digital I/O



Q&A