FORMULA SAE

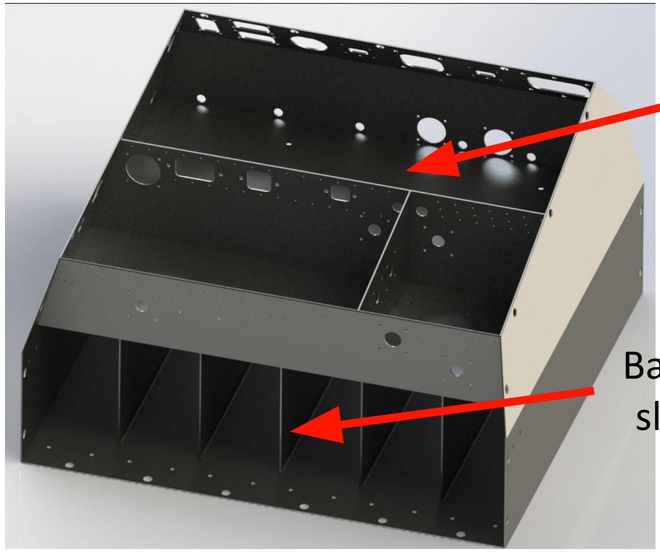
Powertrain

Accumulator, Power conversion, motor/controller selection/design, wiring considerations, transmission. Torque vectoring. Gearing. Regenerative braking. Selection/use of materials.

HV Enclosure: Design Goals and Highlights

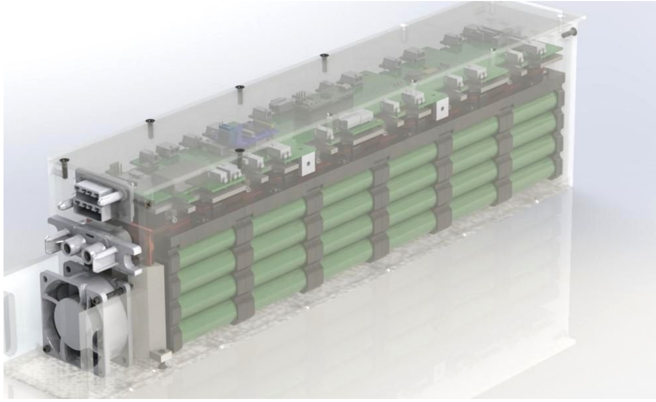
Design Goals:

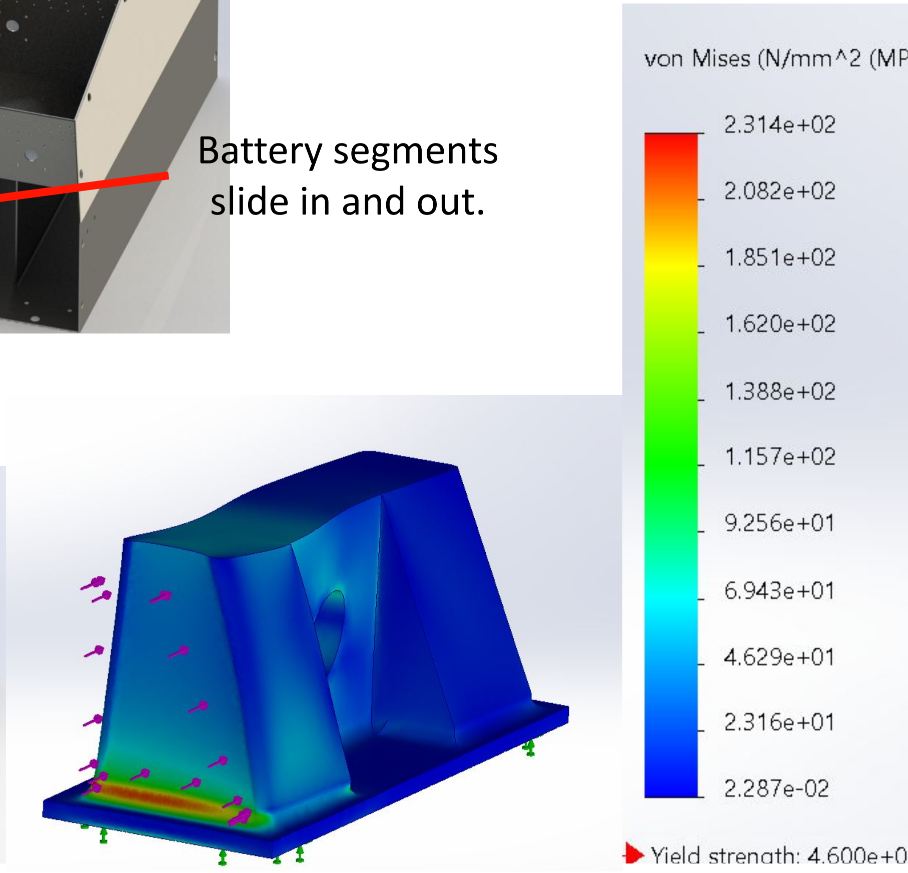
- **Accessibility**
  - Easy removal from car
  - Segments & peripherals
- **Packaging**
  - Reduce exterior HV wiring, consolidate electrical systems
- **Low CG goal**
  - Pack as many components as allowed by rules inside
  - Place low to the ground & near the COM
- **Safety**
  - Tab mount analysis
  - Secure battery casings



Separate electronics compartments.

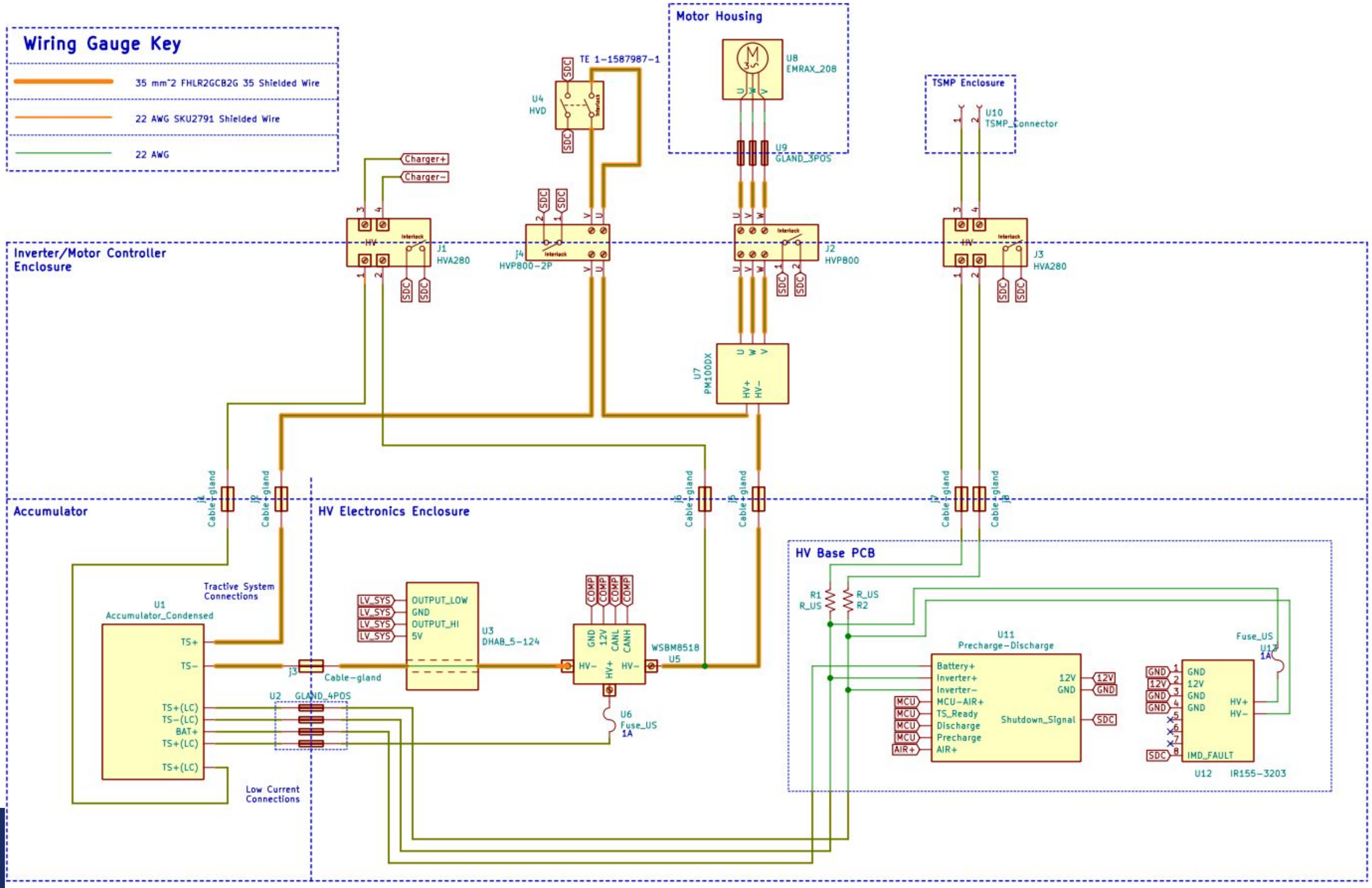
Battery segments slide in and out.





Tractive System

- 72s8p Li-Ion battery pack
  - **Max. Voltage: 302V**
  - **Nominal Voltage: 259V**
- Team-designed BMS
- 110A slow-blow fuse
- Cascadia PM100DX inverter
- Emrax 208 PMSM



COLUMBIA UNIVERSITY
FORMULA RACING

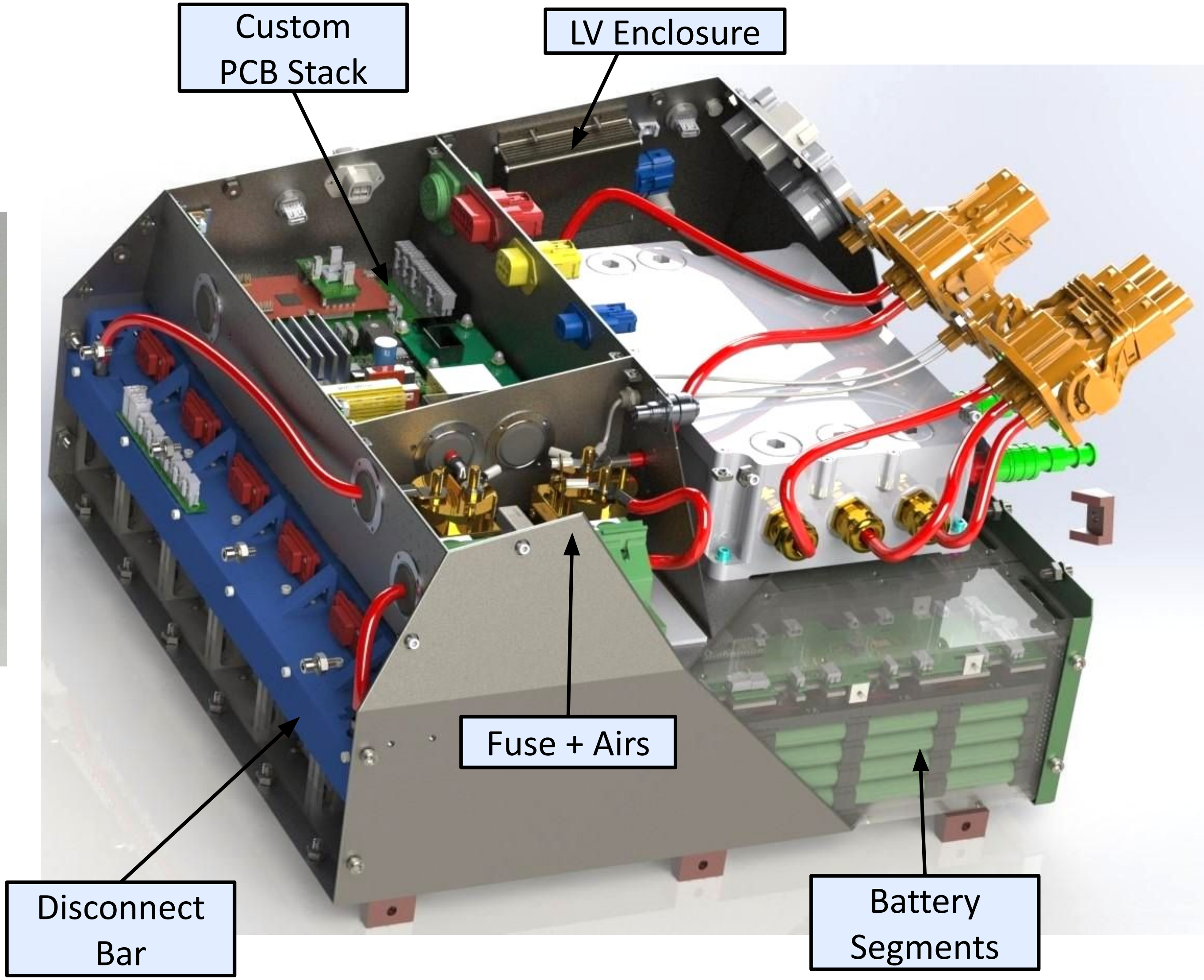
HV Electronics

Four distinct chambers

- Battery Pack
- AIRs + HV Fuse
- PCB Stack
- Inverter

Motor

- Emrax 208 Motor
- 302V Max, 259V Nominal Voltage
- 448 Nm Max Torque
- 350 A Current Rating



Energy Consumption Simulations

Simulation Goals:

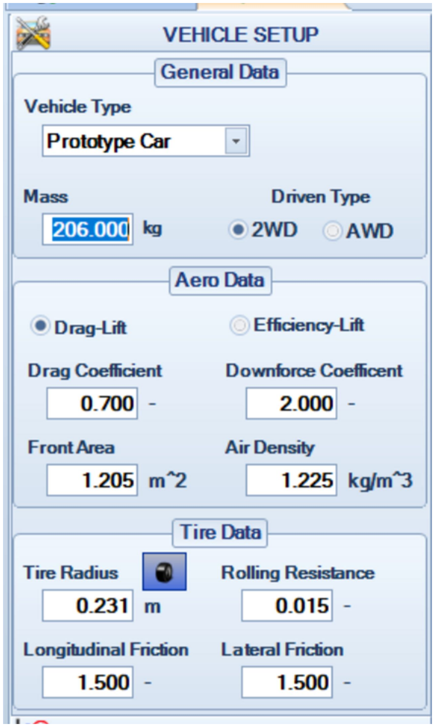
- Verify accumulator capacity
- Ideally enough power to last the endurance race (22km)
- Determine maximum speed to complete the race

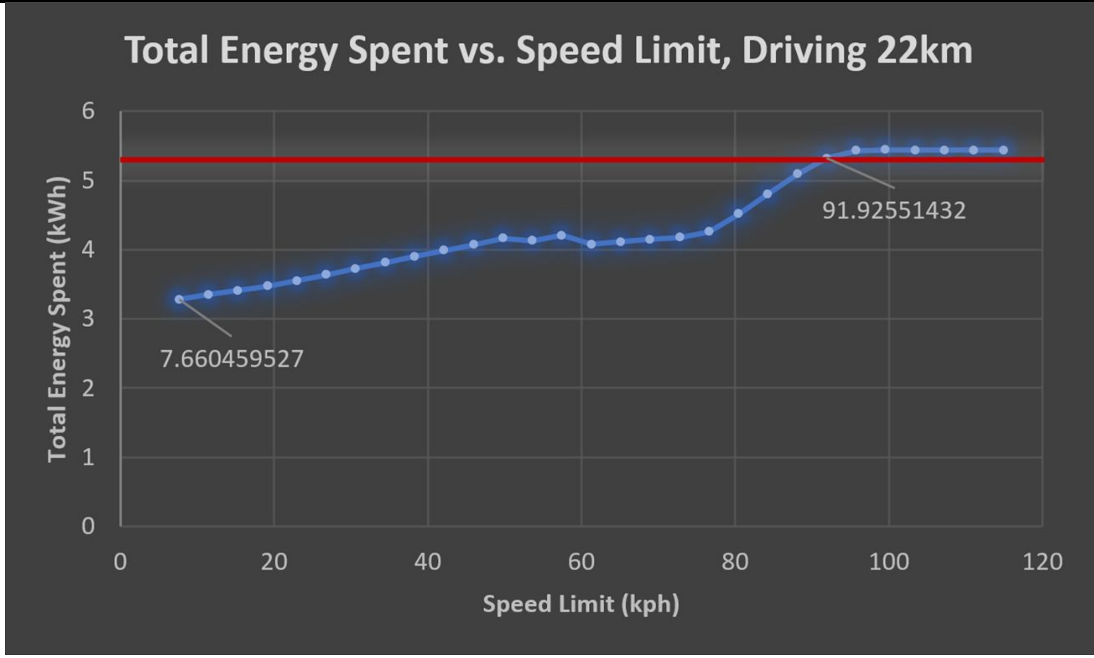
Process:

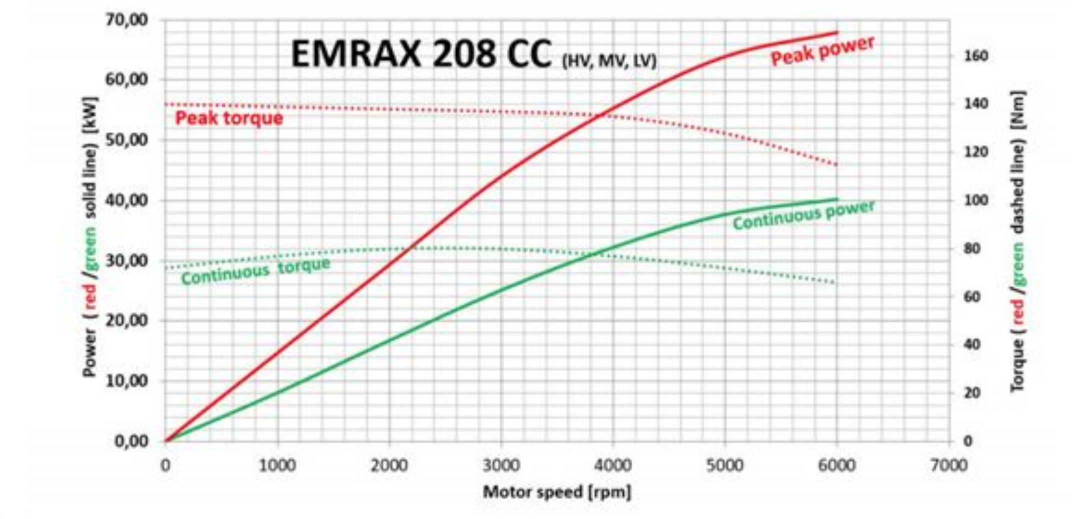
- Use OptimumLap software
- Input vehicle parameters
  - Mass, aero, motor curves
- Simulate energy consumption at different speeds

Result:

- Speed limit: 91 kph (ideal),
  76 kph (realistic)







Accumulator & Battery Management System

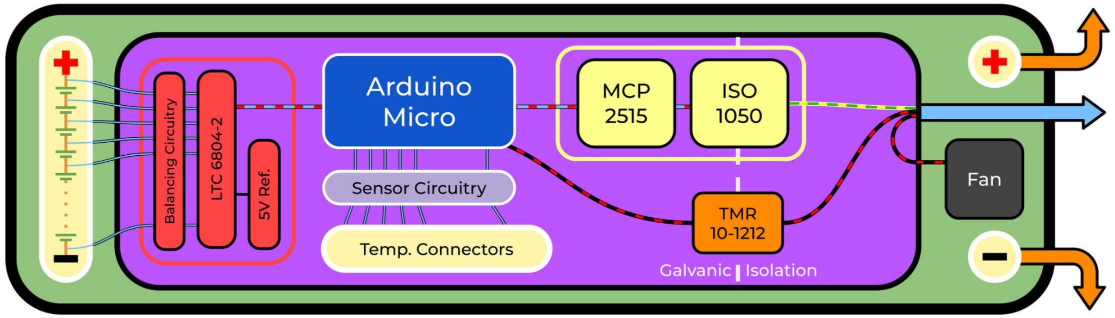
Design & Build:

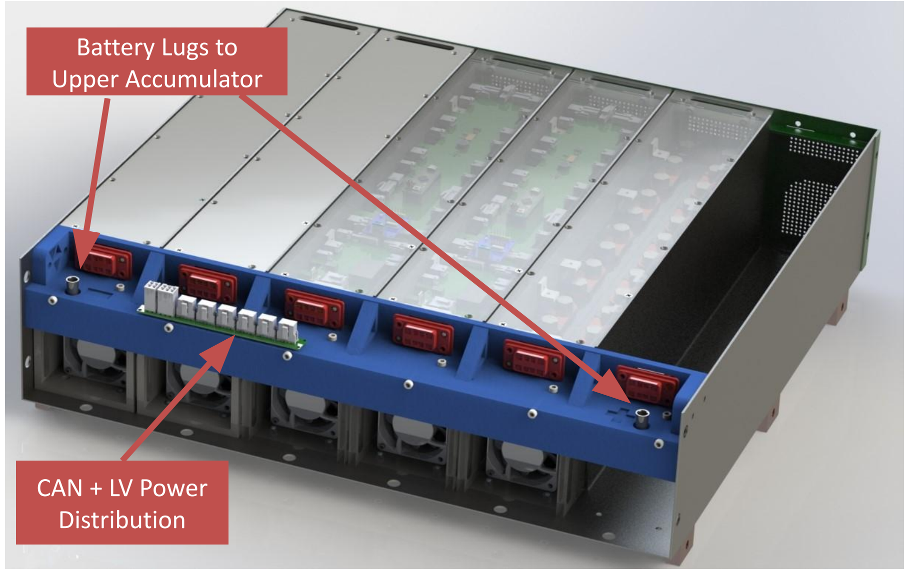
- 6 Segments, each < 60V
- Blind mate connectors on the back side (BMS and HV Path)
- Team-designed BMS with separate monitoring boards in each segment, on top of batteries

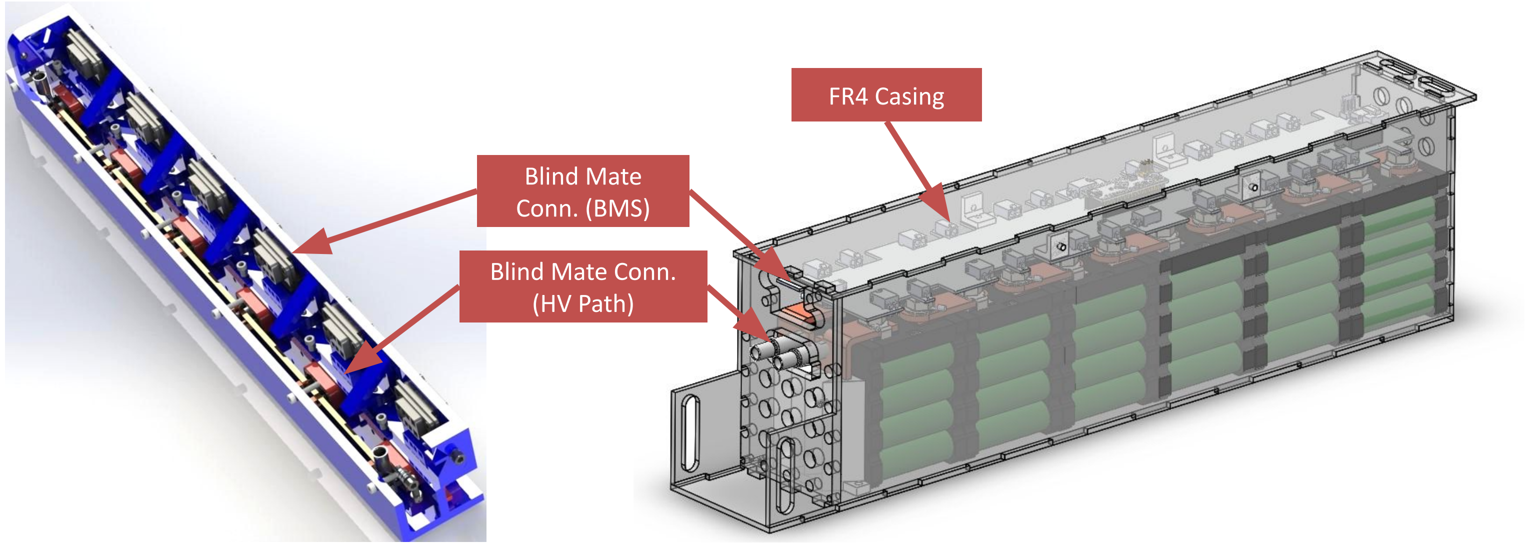
Integration & Testing:

- All data on the CAN bus, logged and analyzed
- Thermal experiments completed to justify no cooling

BMS Board Design:







Drivetrain Design Goals and Highlights

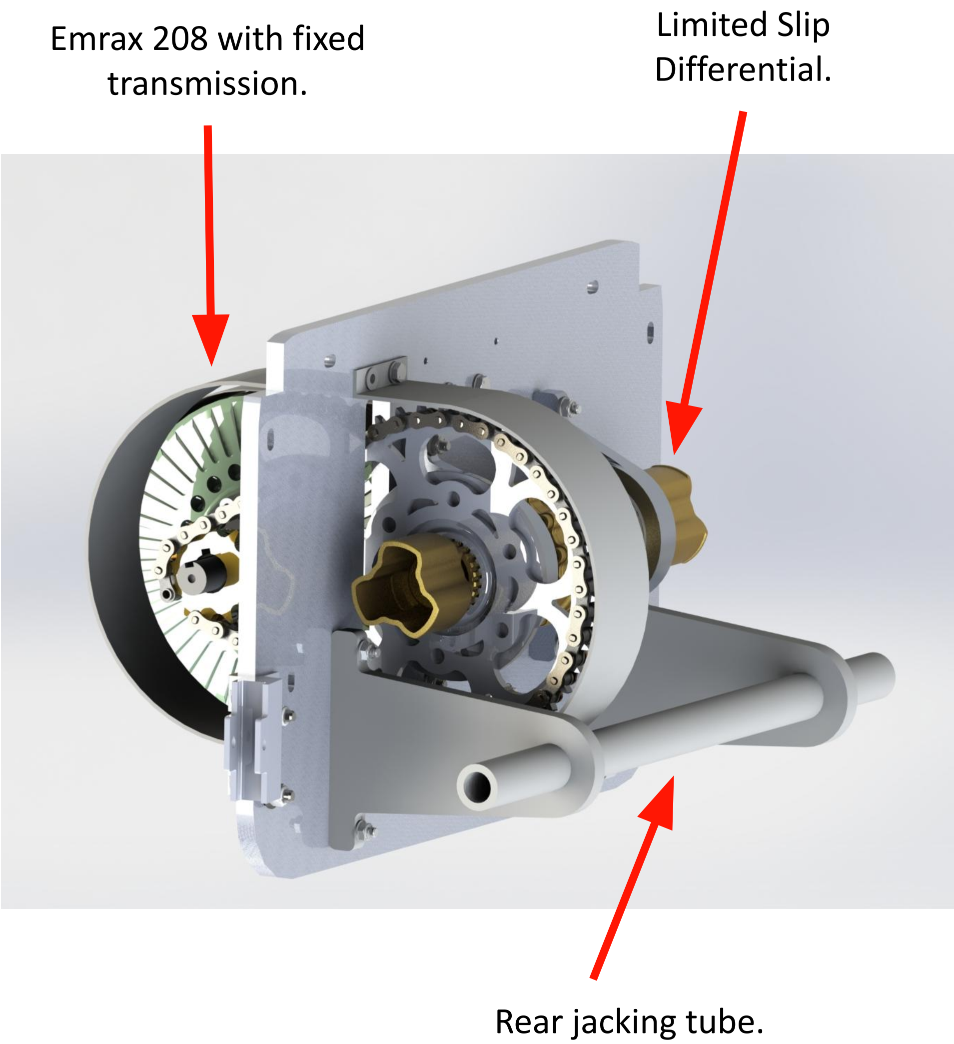
The drivetrain system includes an Emrax 208 motor, 2 fixed chain-driven gears, as well as a Drexler Salisbury differential.

Design Goals:

- Accessibility
- Manufacturability
  - In house production
  - Simplicity of mounting
- Structural Rigidity
  - Limit deflection of rotating components

Drivetrain Specs:

- 3.7 Drive Ratio
  (32t driven, 10t driving)
- 10.5° Max Half Shaft Angle
- 65 mph Max Velocity
- Drexler Salisbury Differential
- ¼” 7075 Aluminum Driven Sprocket
- 520 Motorcycle Chain
- 7075 Aluminum Chain Tensioning Guide



Cooling System

Loops Specifications:

- Operating Temp = **50 deg C** (122 deg F)
- Flow Rate = **6-8 LPM**
- Heat Input at peak power
  - Motor (95% efficiency) = 3.5kW
  - Inverter (97% efficiency) = 2kW
- Radiator -> Triple bypass for maximum cooling performance
- Sensor Data on Test Bench
  - Flow Rate = 6.34 - 7.29 LPM
  - Temp Increase while Spinning Motor (No load) = 26→31 deg C
  - Pressure = Pending data collection