Designing the battery packs that Customers want

Angus Lyon, Battery Tech Expo, April 2024

ROCKFORT ENGINEERING

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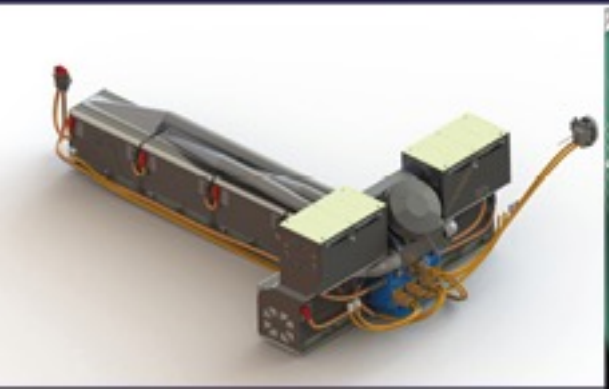
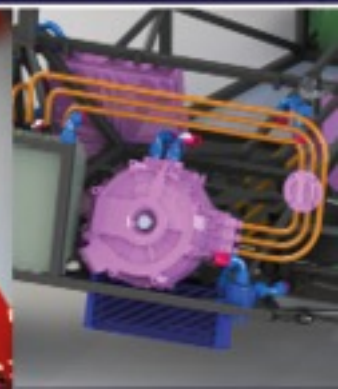




Rockfort Engineering Ltd

Summary

- Engineering consultancy supporting OEM, Tier 1, R&D, start-ups
- EV powertrain product design
- Road and race vehicles of all sizes
- Other industries including marine, rail and aviation

Technology Highlights

- F1 and Formula E systems
- Electric vehicle drivetrains
- Systems and control electronics
- Ancillary systems including brake-by-wire
- Vehicle torque & dynamic control
- Body and chassis electronics systems
- Functional safety (ISO 26262)

Vehicle Systems Engineering

Powertrain Systems

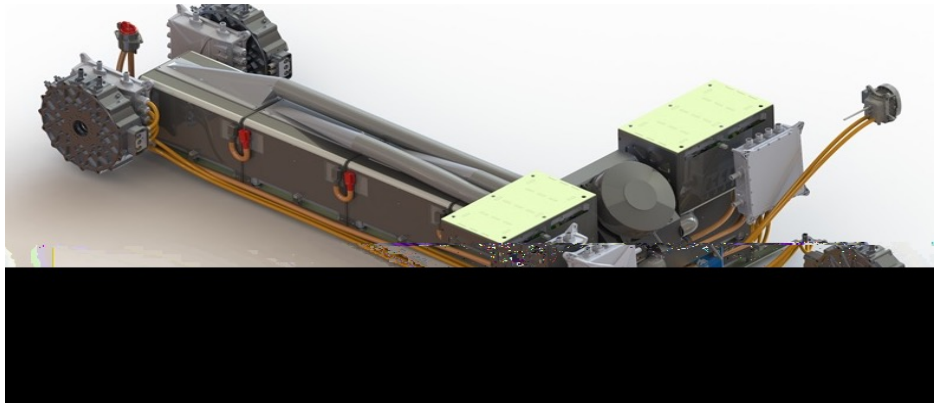
- Full electric or hybrid powertrains
- Sub system, ancillaries and control

Systems Design and Optimisation

- System modelling, simulation and analysis
- Sensing-to-actuation design
- Maximising safety, performance and efficiency

Electronics

- Software, control and integration
- Performance and dynamics management
- Industry compliant safety systems



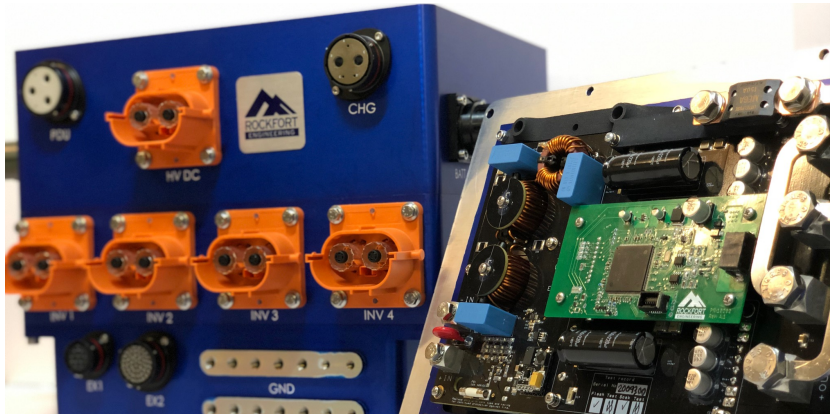
Battery and HV System Design

Battery Systems

- Modular or bespoke designs
- Performance or range optimised
- Integral BMS, sensing and control systems

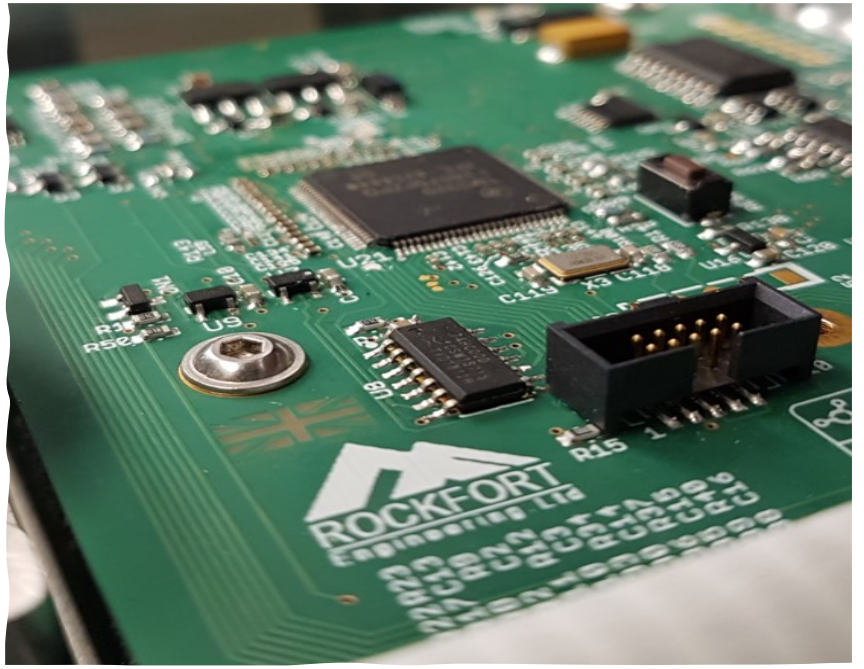
High Voltage and Control Systems

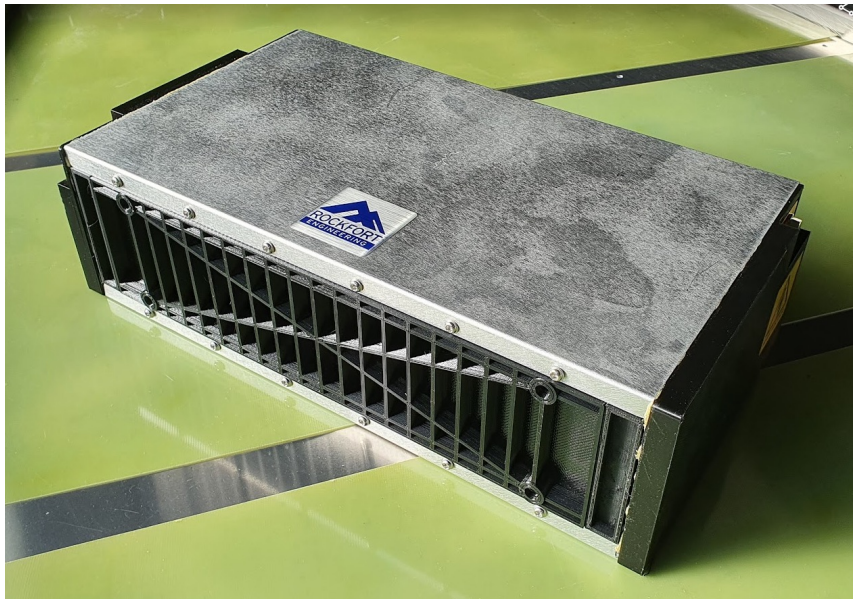
- Master or slave control
- Integrated safety and reliability systems
- Health and performance monitoring
- DCDC conversion
- Low voltage power, distribution
- Full vehicle control electronics



What is an EV Battery

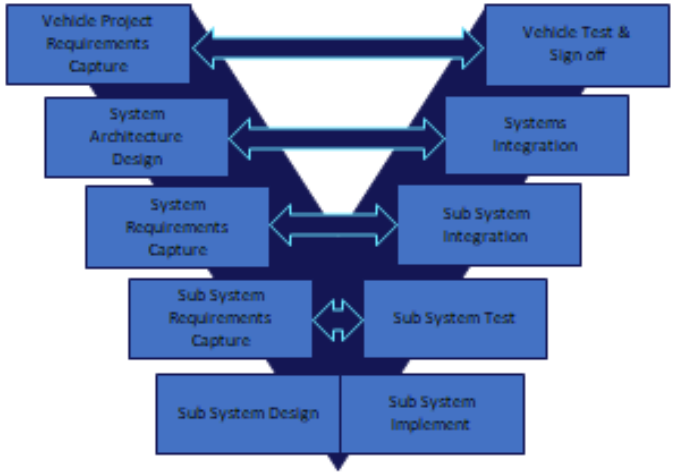
- A lot of cells
- Some electronics
- Quite a lot of wiring
- Some safety system
- Heating / cooling system (possibly!)
- Structure to hold it all together
- Box to stop it getting wet





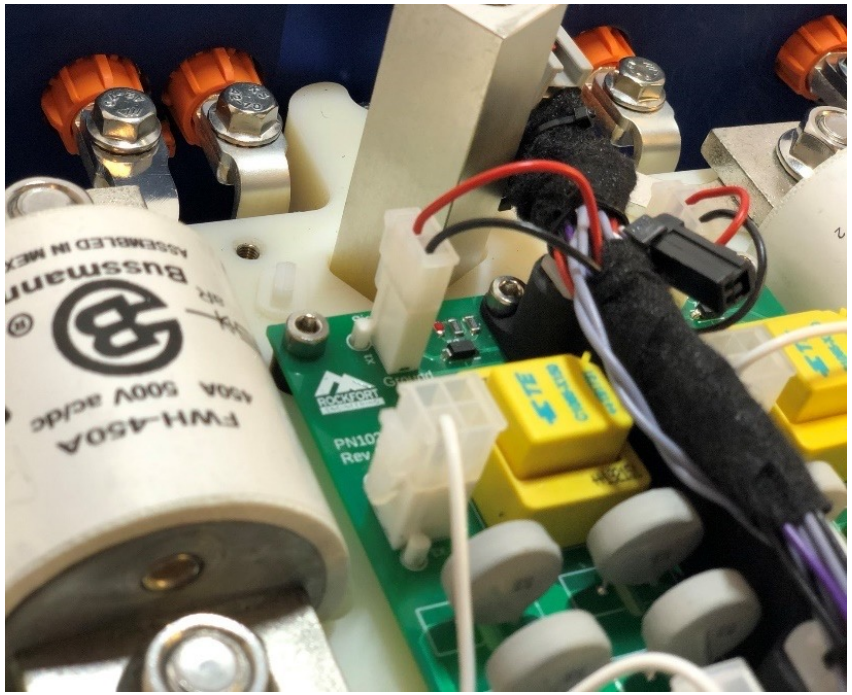
Step 1: Project Planning

- Ensure all interested parties are involved from the start
- Identify and agree clear milestones
- Use RASIC and project plan to ensure very clear definition of tasks, assignment of responsibility and timing
- Allow adequate time for requirements capture and specification.
- Focus on design & documentation, build will follow
- Commence supplier identification and management from the outset
- Keep customer in the loop throughout



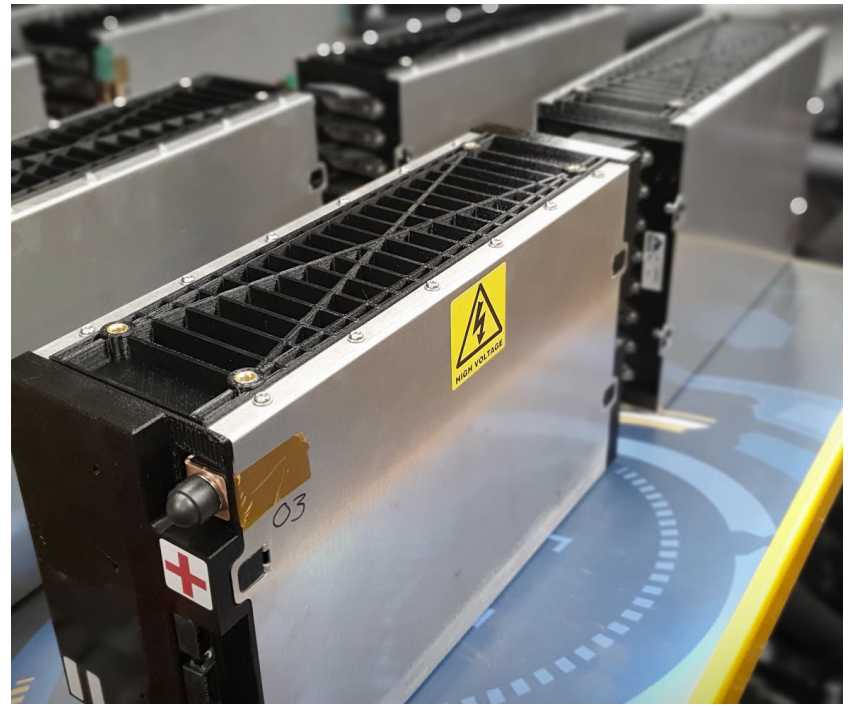
Step 2: Capture Customer Requiremen

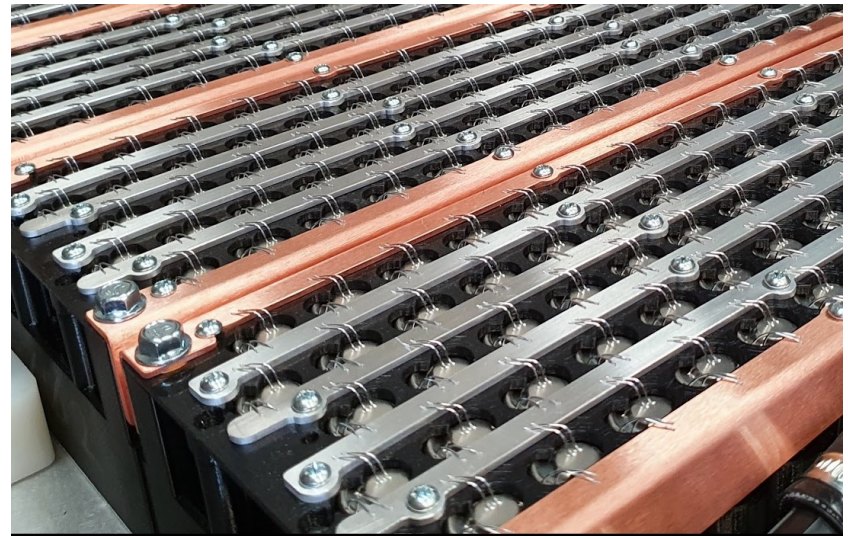
- Mechanical Format:
  - Must consider shape, installation and construction
- Energy and Power:
  - Often requires support and simulation support
- Structure and Weight
  - Niche, safety critical or commodity end product?
- Thermal Management:
  - Determined by performance and charging requirements
- Control
  - Communications and electrical interfaces
  - Functional requirements
- Safety
  - Compliance with standards required?



Step 3: Determine Compromises

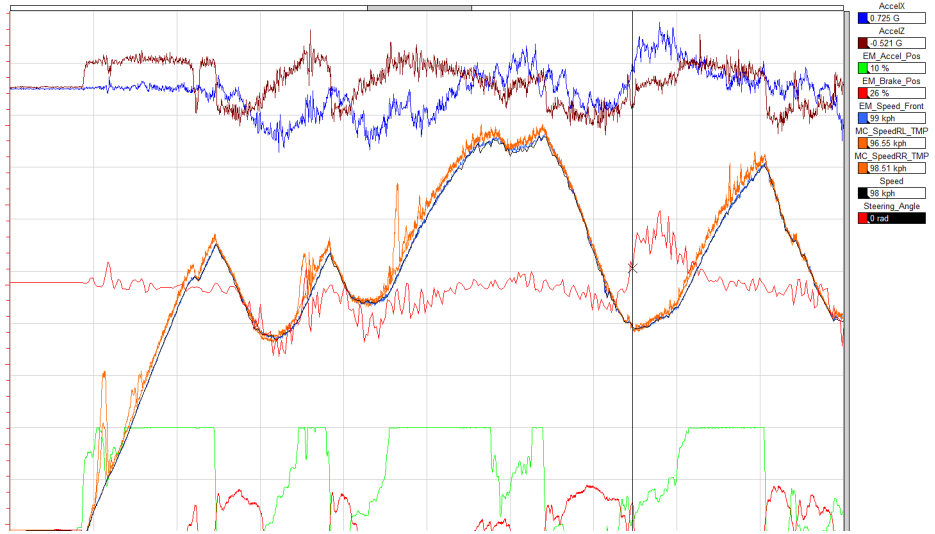
- Cell Selection
  - Always a compromise
  - Energy vs power is the key input
  - Cooling / heating requirements will affect decisions
- Module Format:
  - Affects thermal, power, energy and control behaviour
  - Mechanical format will often be the final deciding factor
- Safety:
  - Never compromised on
  - Actual levels depend upon application or regulatory requirements
- Mechanical Packaging
  - Structure to integrate with vehicle and support cell modules safely under potential high loads





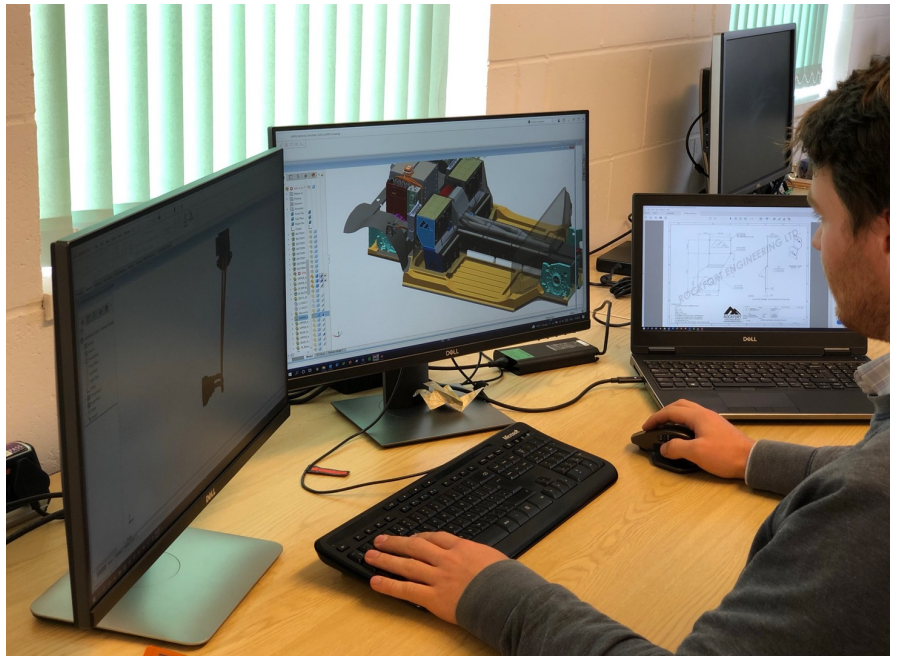
Step 4: Specification & Optimisation

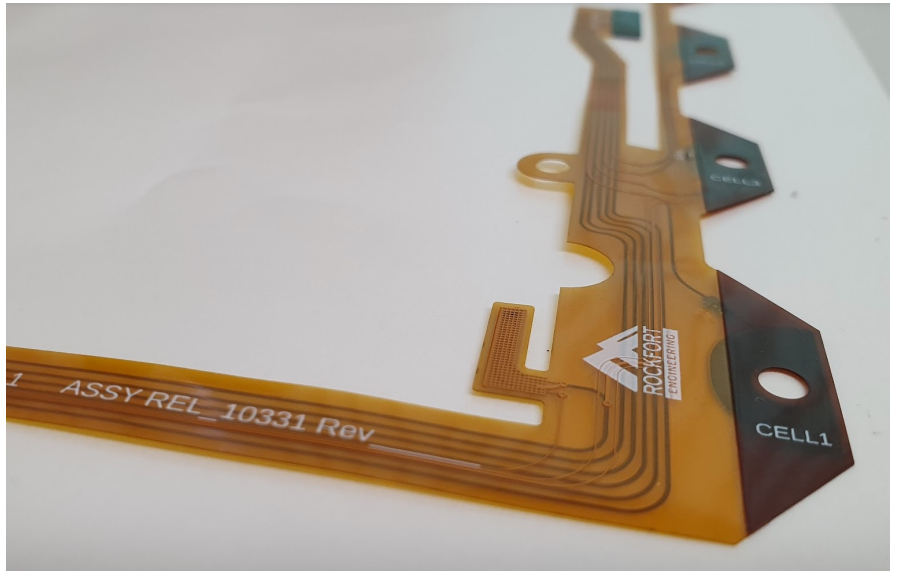
- Produce and validate simulation models
- Allow simulation to drive design
- Use representative drive cycles allows proper energy, range, performance and thermal predictions
- Complete this prior to design for maximum benefit
- Incorporate functional safety requirements
- Both should drive key specification and design decisions
- Avoid scope creep - limit optimisiation stage based on project requirements, budget and timing



Step 5: Design and Supply

- Design:
  - Prioritise based on complexity, supply and testing requirements
  - Include build tooling / jigs in design and manufacture process
- Coordinate:
  - All design disciplines must cooperate and coordinate
  - Respect all design interfaces
  - Minimise changes but admit defeat where appropriate
- Review:
  - Regular reviews and integration verification
  - Refer to requirements frequently
- Supply:
  - Suppliers to be selected before kick off or very early on
  - Close working essential to ensure material supply, timing and machine availability is anticipated
  - Local and overseas holidays must be accounted for



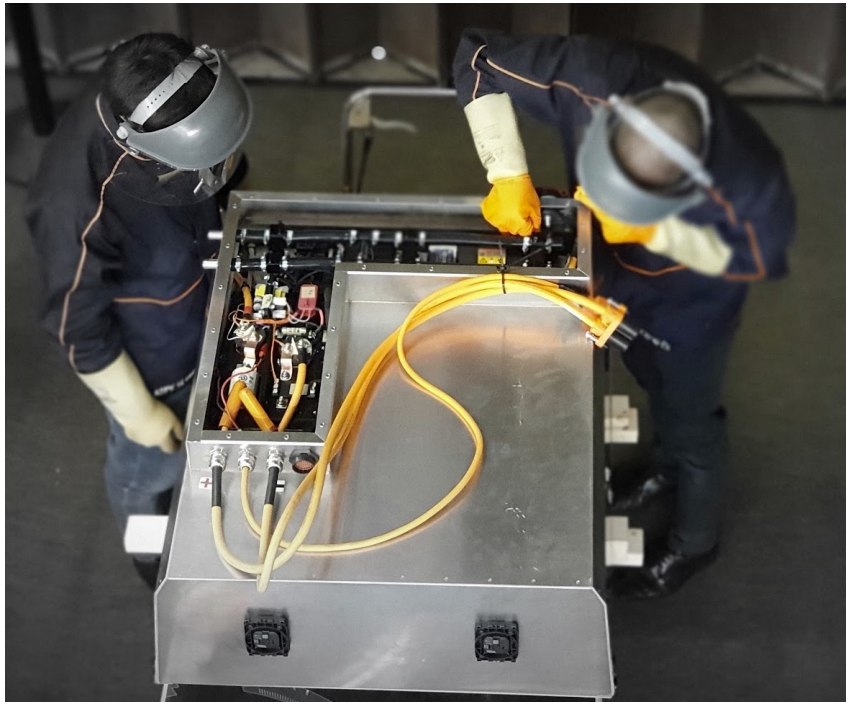


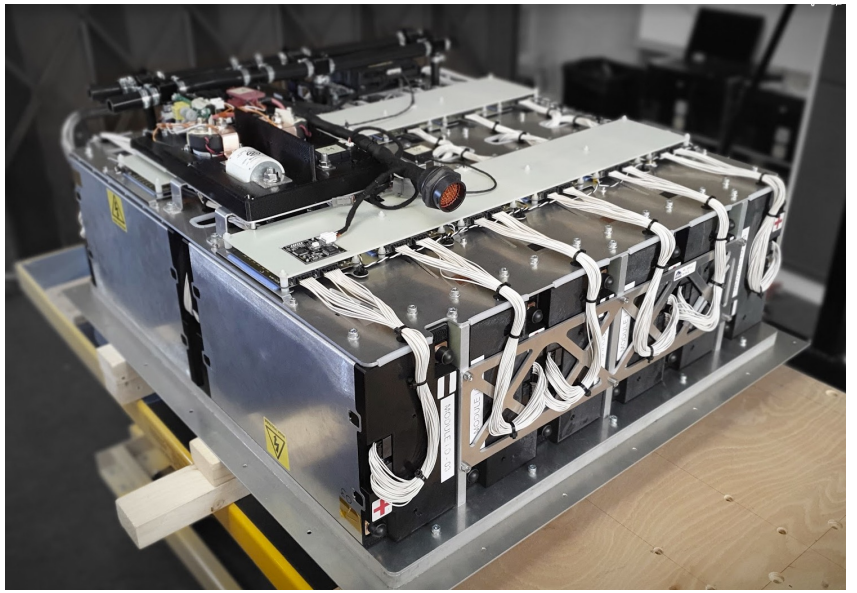
Step 6: Build Processes & Tooling

- Build process:
  - Consider from early on in design process
  - Compile build documentation during design phase
- Jigs and Fixtures:
  - Identify and prepare during the design process
  - Use modern manufacturing techniques for speed
- Testing:
  - Complete performance, mechanical and thermal testing prior to production part commitment
- Facilities and Equipment:
  - Plan and prepare facility use
  - Identify, source and prepare all equipment prior to build

Step 7: Build and Commission

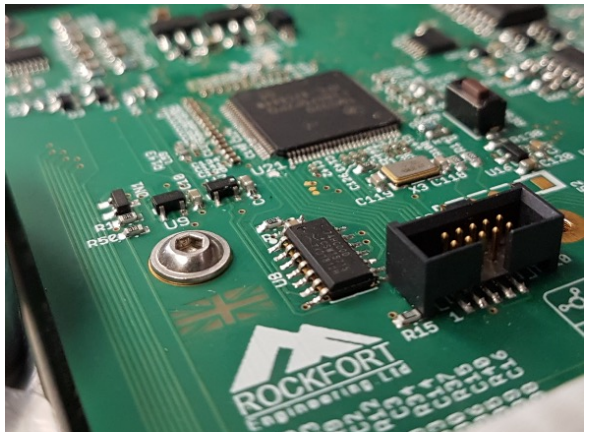
- Build:
  - Preparation work allows quick and problem free build process
- Validation:
  - Starts at cell level
  - Build confidence of each element
  - Post final build, validate pack for full functionality, capacity and performance
  - Think beyond electrical performance
- Customer Sign off:
  - Involve customer at all phases but particularly final sign off.
  - Plan and execute full vehicle level testing.
  - Ensure they get what they wanted!

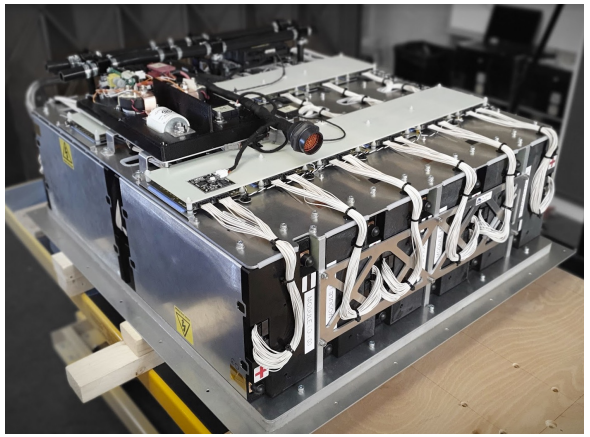


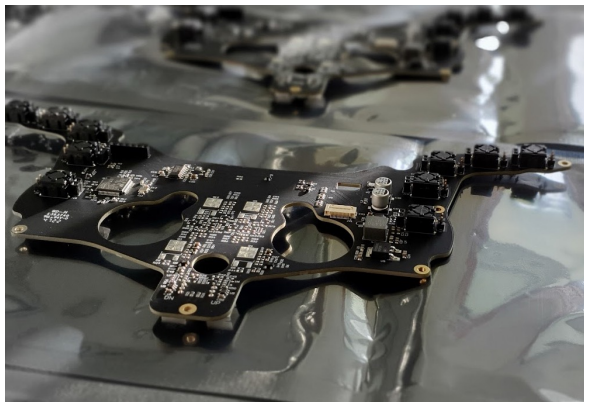


Key Messages

- Batteries are perceived as simple but are complex.
- Supplier is part of a team
- Detail requirements and responsibilities
- Use simulation to determine and validate requirements and lead design
- Deliver with structured project, design, build and validation program
- Strong team working and supplier management ensures on time and budget delivery
- With the above, a full battery delivery in under 6 months is easily achievable







Questions?

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