Rapid Battery Design

From clean sheet to completed pack in 5 months

Angus Lyon, Battery Tech Expo, April 2023

ROCKFORT ENGINEERING
info@rockfortengineering.com
rockfortengineering.com





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

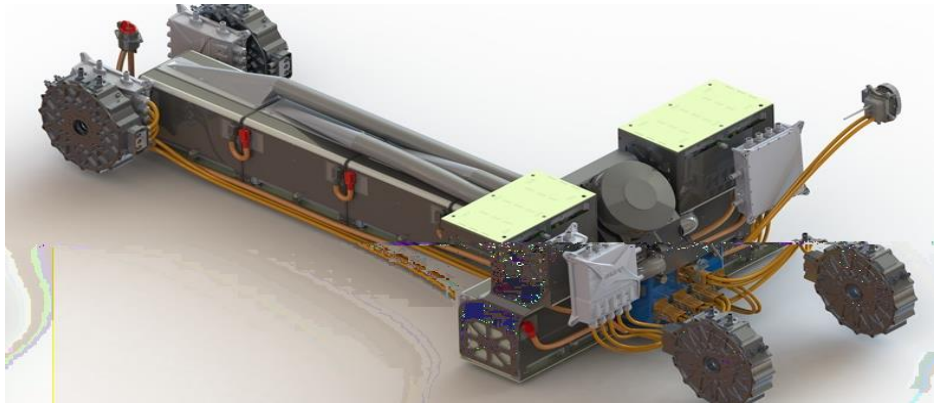
- Full electric or hybrid powertrains
- Sub system, ancillaries and control

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



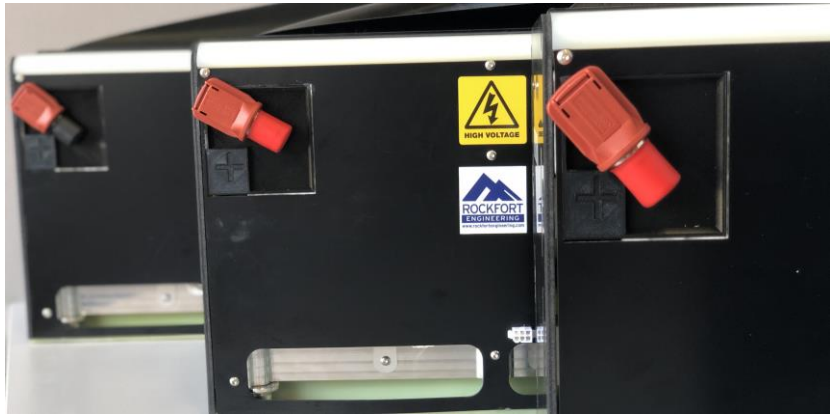
Battery and HV System Design

Battery Systems

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

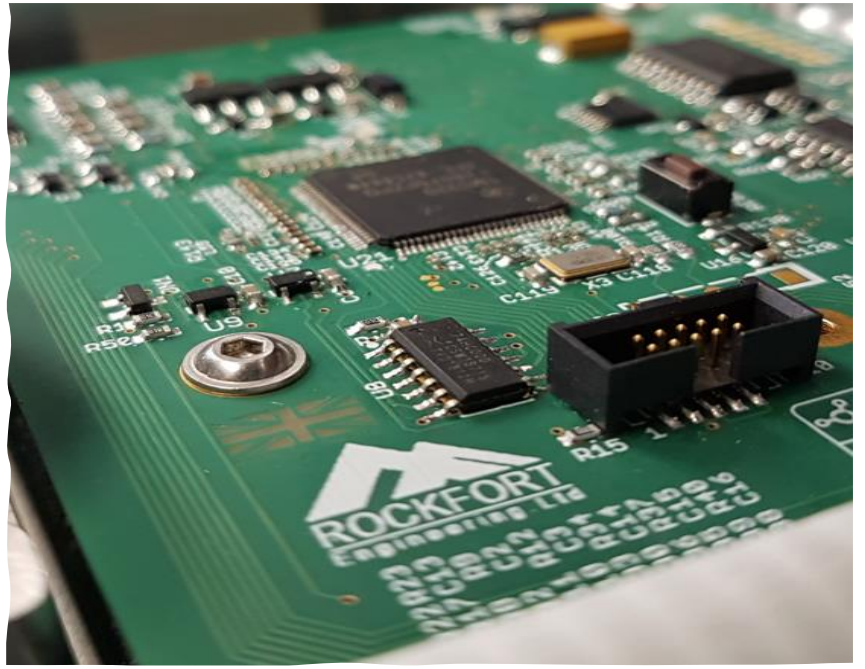
High Voltage and Control Systems

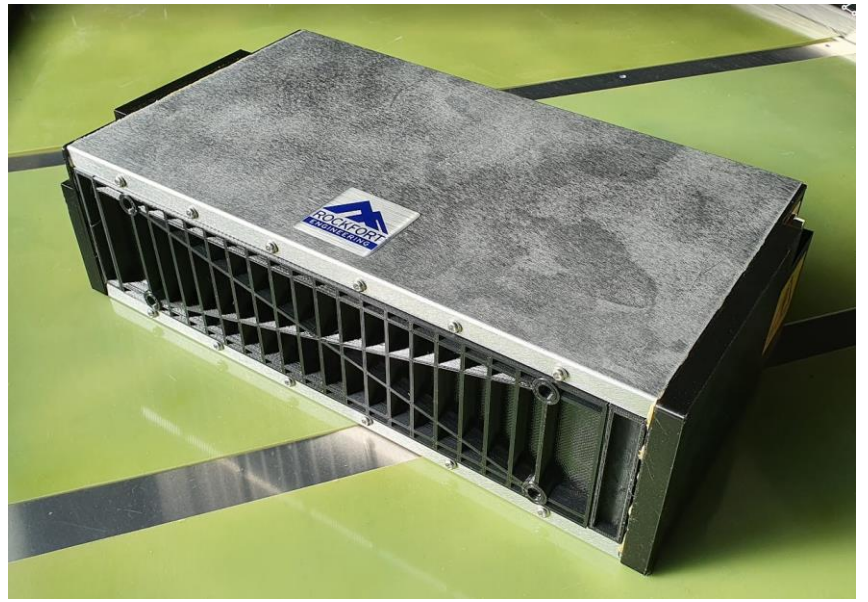
- Master or slave control
- Integrated safety and reliability systems
- Health and performance monitoring
- DCDC conversion
- Low voltage power, distribution
- Full vehicle control electronics



Five Months to Design an EV

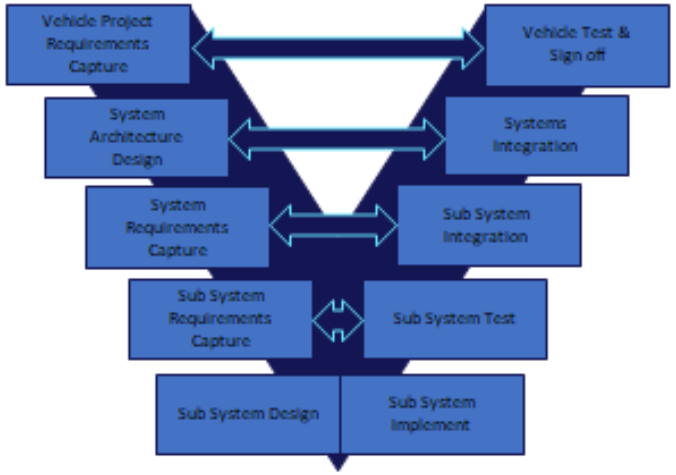
- Start Date: November 2022
- Completion Date: March 2023
- Starting Position:
  - Clean sheet pack design
  - Pack to be based on Rockfort “Pegasus” module
  - Chassis space required for pack, eAxle and ancillaries
- Requirements:
  - High performance
  - Battery module redesign required to optimise packaging and meet thermal requirements
  - High power and energy density required
  - Production basis target
  - Automotive safety compliance
- Project Objectives:
  - Design and build battery pack
  - Powertrain & cooling system installation
  - Design and install low/high voltage systems
  - Implement and integrate control system





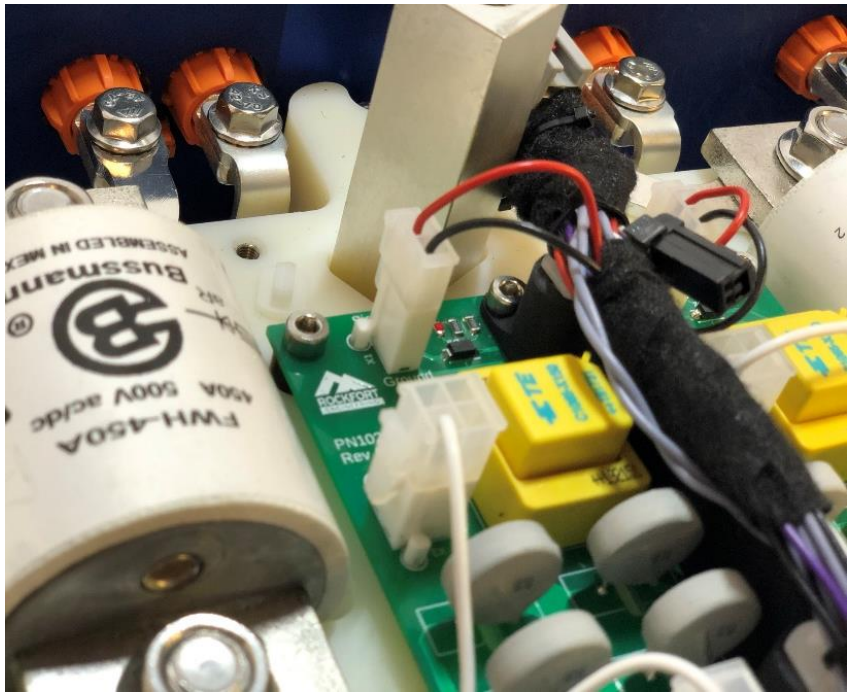
Step 1: Project Planning

- Ensure all interested parties are involved from the start
- Identify and agree clear milestones and stick to them
- 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
- Good and efficient communication with partners throughout



Step 2: Requirements

- Mechanical Format:
  - Irregular shape with chassis restrictions
- Energy and Power:
  - Targets 40kWh and 200kW
- Weight
  - Minimum on-weight compared to ICE
- Cooling:
  - Performance requirements mandated liquid cooling
- Structure
  - Weight reduction by utilising vehicle structure
- Control and Interfaces
  - System architecture with multiple ECUs
  - Control requirements
  - Mechanical, thermal, electrical and software interfaces
  - Sensing and control interfaces

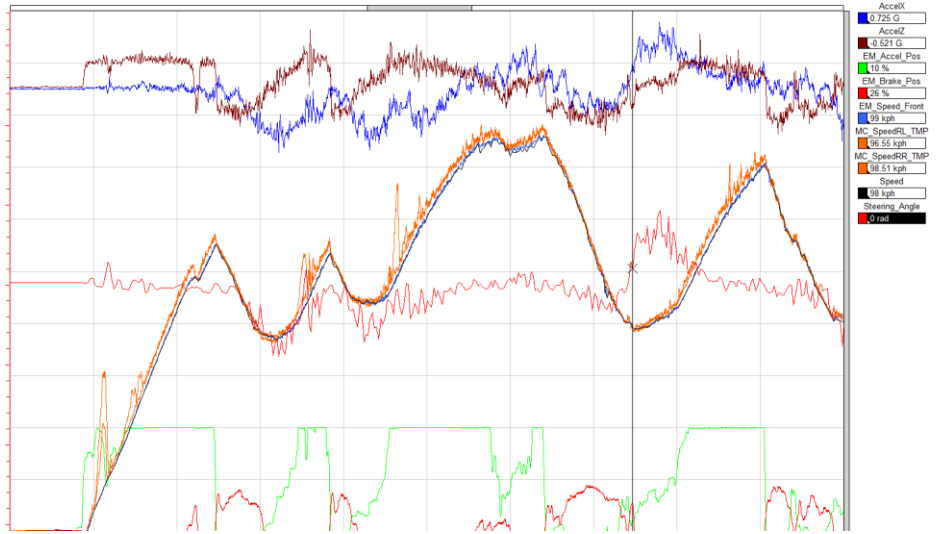


Step 3: Determine Compromises

- Cell Selection
  - Selection from family of cells to achieve best energy/power balance
  - Cooling / heating requirements
- Module Format:
  - Based on REL “Pegasus” module but modified to best suit available space
  - 3kWh / 33V, water cooled format selected
- Integrated Safety:
  - HV control & monitoring
  - Comprehensive battery management
  - Thermal runaway protection
  - Safety case generation regardless of how short project is
- Mechanical Packaging
  - Structure to integrate with vehicle and support cell modules safely under potential high loads

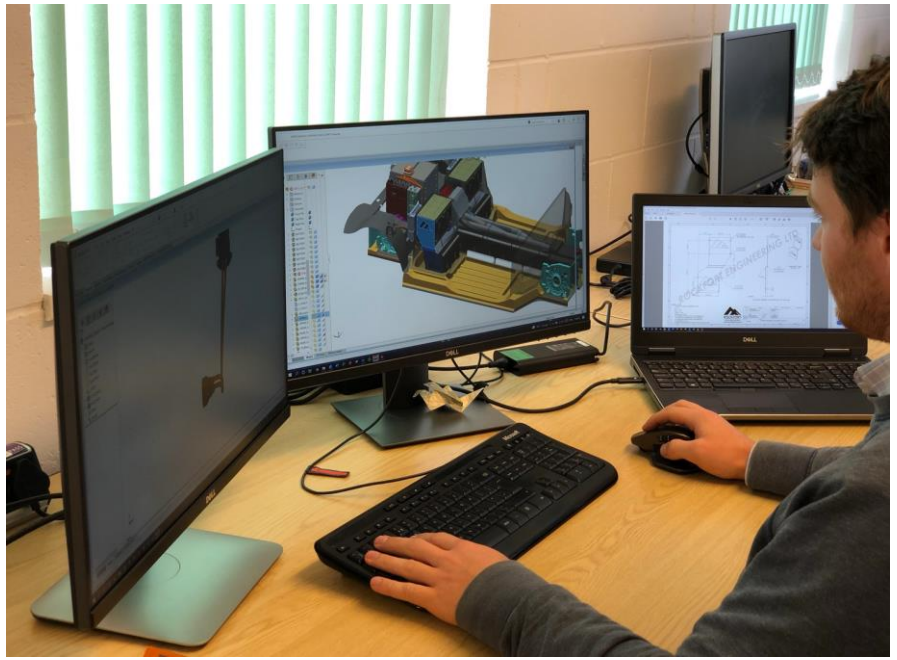
Step 4: Specification & Optimisation

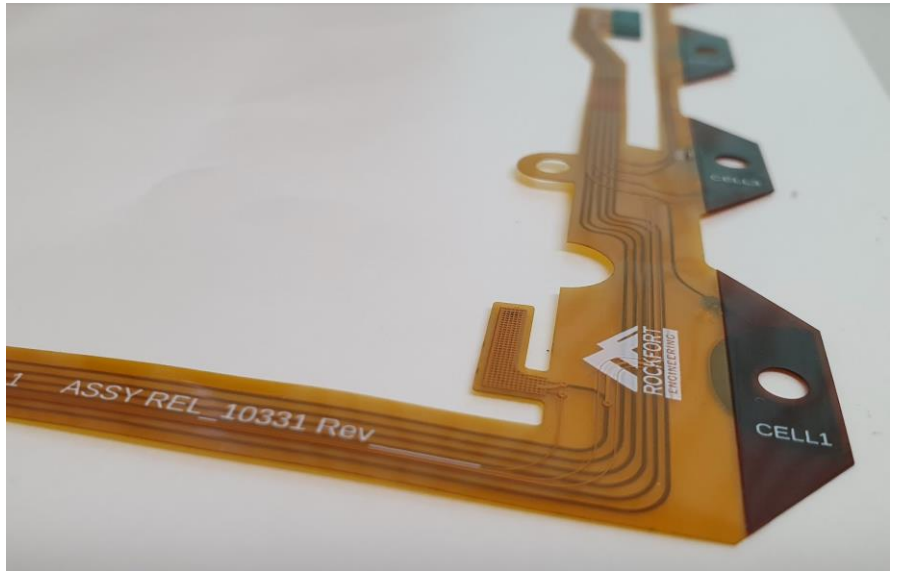
- Produce and validate simulation models
- Allow simulation to drive design
- Using representative drive cycles allows proper energy, range, performance and thermal predictions
- Complete this prior to design for maximum benefit
- Incorporating functional safety design brings further benefits
- Both should drive key specification and design decisions
- Don’t go too far, limit optimisiation stage based on project 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



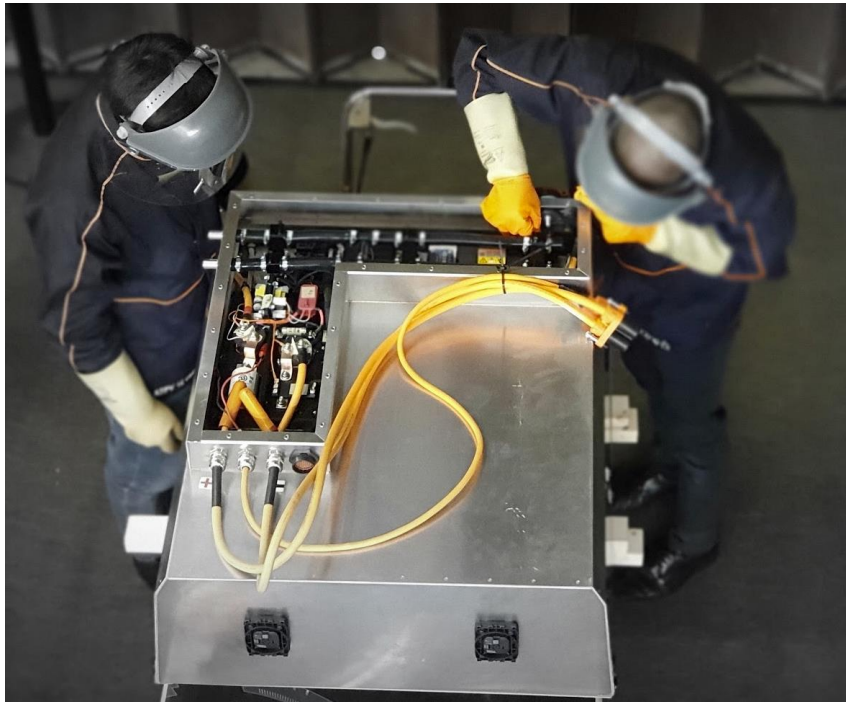


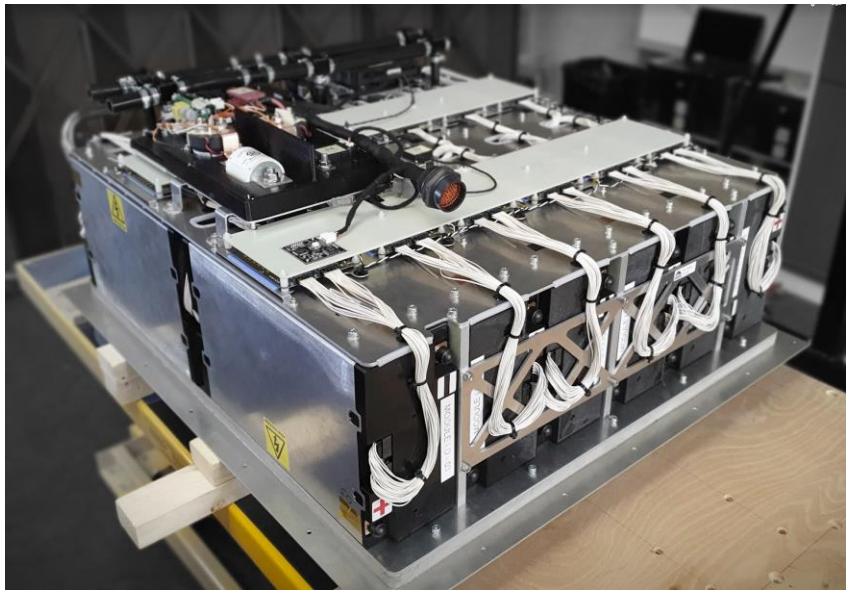
Step 6: Build Processes & Tooling

- Build process:
  - Considered from early on in design process
  - Build documentation compiled 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

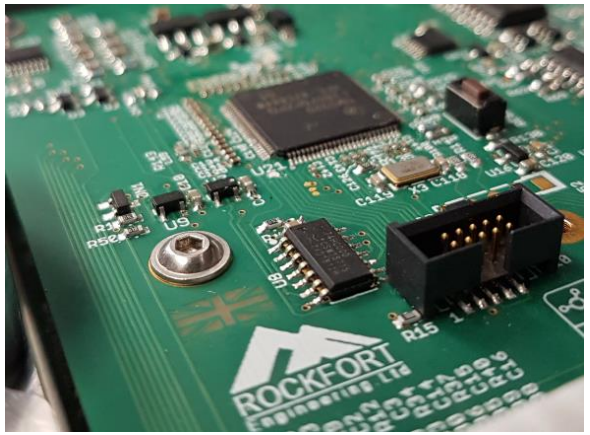
- Build:
  - Preparation work allowed quick and problem free build process
  - Test preparation allowed rapid pack commission and validation
- Results:
  - Pack delivers on performance and only minor compromise on capacity (36kWh)
  - On target for mass
  - Integrated full coverage safety
  - Durability up to 10g in all directions
  - Environmental protection validated
- Testing:
  - Car run successfully on first shakedown
  - Performance objectives achieved in under one hour of running
  - To date no mechanical, thermal or electrical problems

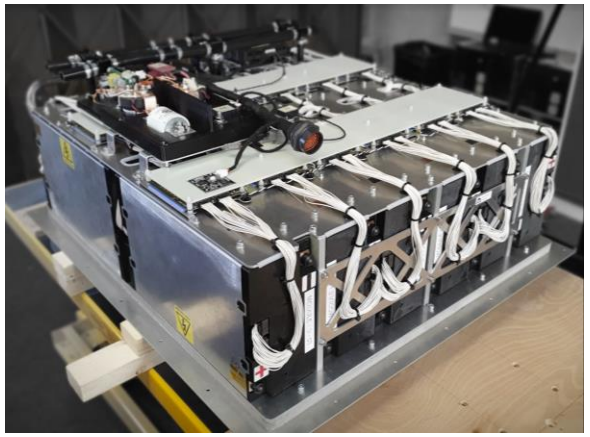


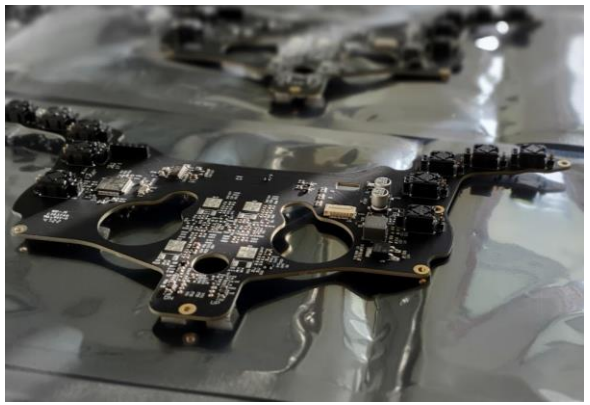


Key Messages

- Strong project planning and responsibility assignment avoids confusion
- Use of simulation to determine and validate requirements and lead design
- Detailed requirements avoid ambiguity
- Modular design allows rapid complete pack design
- Strong team working and supplier management ensures on time and budget delivery







Questions?

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info@rockfortengineering.com
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