

West Midlands Battery Ecosystem 2024

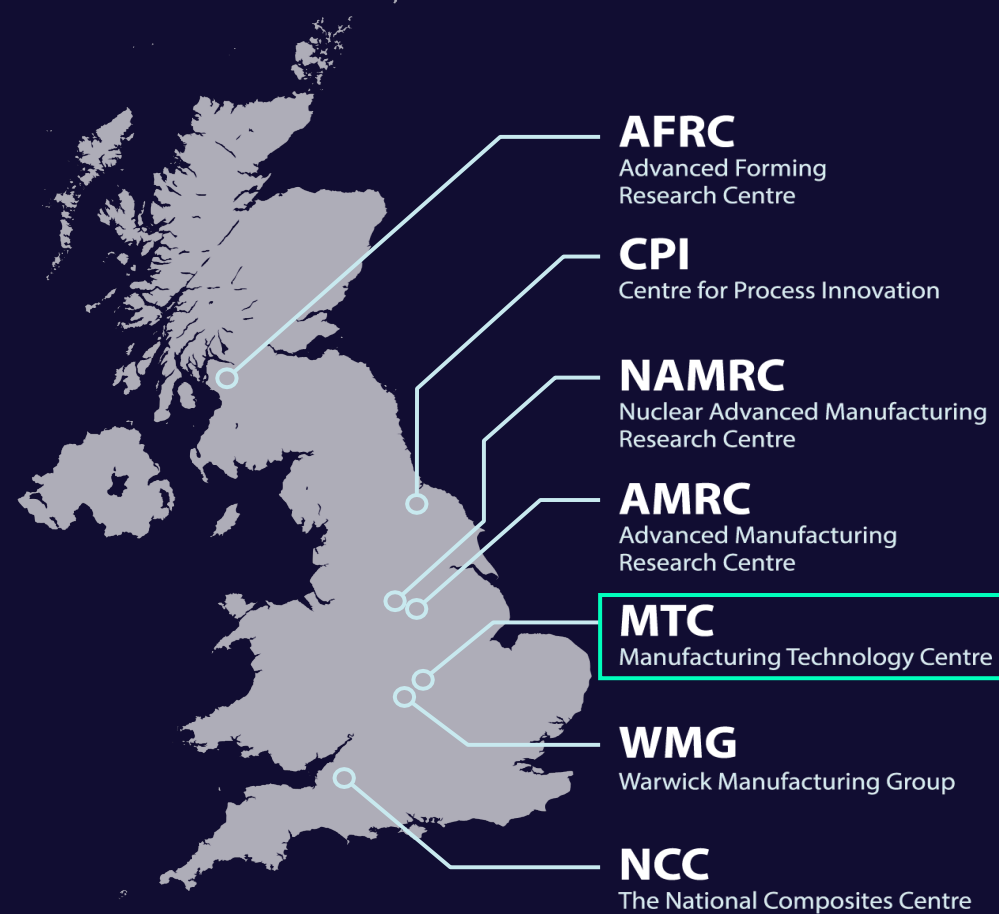
BATTERY MANUFACTURING RESEARCH AT MTC

Dr Mickey Crozier, Chief Engineer

4th November 2024

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THE HIGH VALUE MANUFACTURING CATAPULT



WHERE WE WORK



Aerospace



Defence & Security



Construction



Automotive

Infrastructure



AgriTech



Electrification



Power & Energy



OUR INDUSTRIAL MEMBERS

MTC OFFERINGS

Scale Up



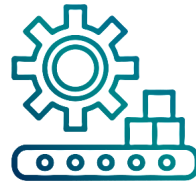
Design for X

Component and
product Design

Physics Modelling

Design for
Additive

Automated
Design



PROCESS DEVELOPMENT & QUALITY

Technology
down-selection

Additive
Manufacturing

Lasers
Automation and
Robotics

Electronics
Manufacturing



EQUIPMENT DESIGN

Special Purpose
Machines

Robotic
Workstations

End Effectors and
fixtures



FACTORY DESIGN

Scenario Mapping

Layout
Optioneering

DES

Virtual Build
Event

Visualisation



SKILLS & WORKFORCE DEVELOPMENT

Future Skills Fore-
sighting

National Apprentice
Standards Creation

Upskilling and
Reskilling

Training and
Apprenticeship
Delivery

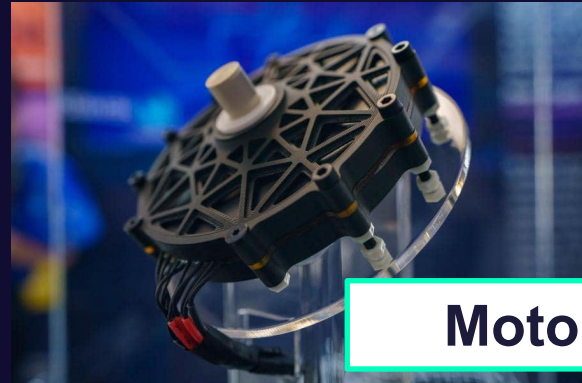


SUPPLY CHAIN DEVELOPMENT

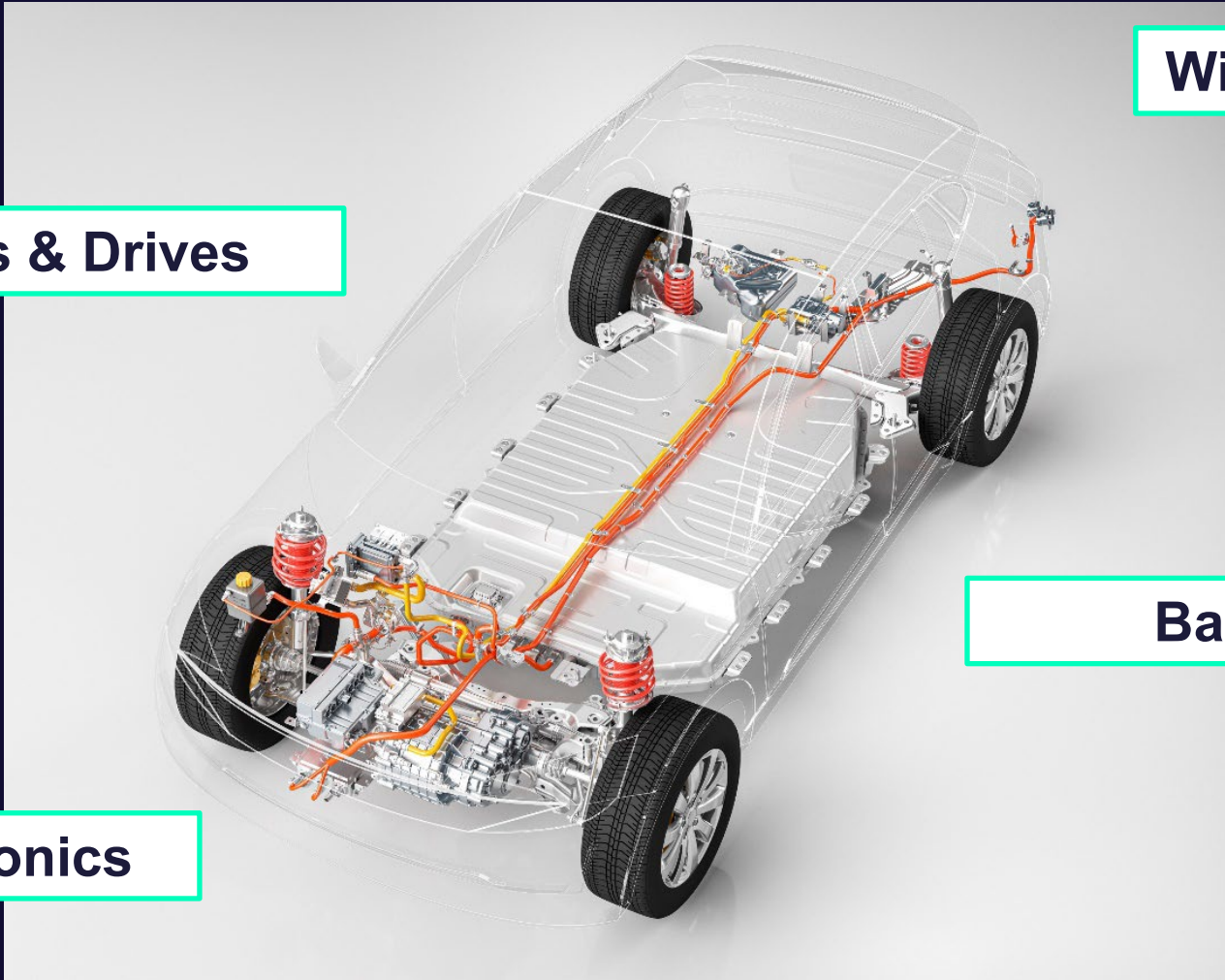
Assessment and
oversight of
supply chain

Targeted Supplier
Development
Programme

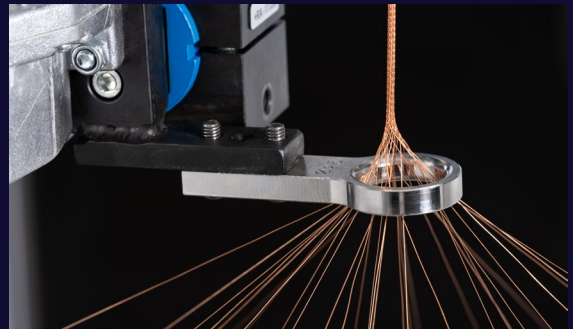
ELECTRIFICATION AT MTC



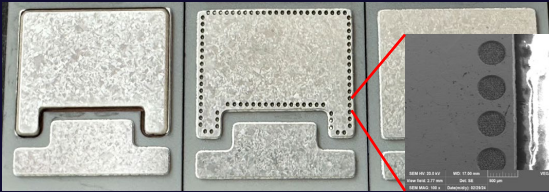
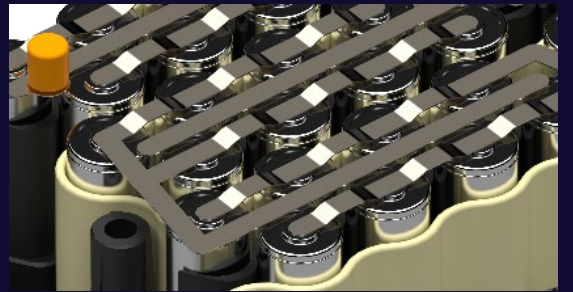
Motors & Drives



Wiring & Distribution



Batteries



Power Electronics

PARTNERS IN ELECTRIFICATION



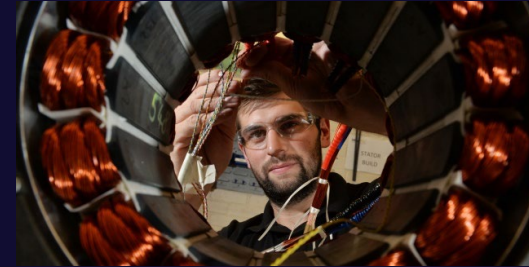
ELECTRIFICATION SCALE-UP PROGRAMMES



PERSEUS, £7.2m, JLR Lead Partner

Transitioning ICE to EDU Manufacture

- Manufacturability assessment of EDU
- Optimised component process flows / bill of sequence for factory planning and transition strategies from ICE to EV
- Exploration of repurposing current facility equipment from ICE to EV components.
- Supporting development of equipment and tooling through simulation, prototyping, physical trials and knowledge transfer
- EV supply chain analysis.
- Development of prototype automated solutions for specific steps within the manufacturing/assembly process



MAGTEC I.M.M.P.O.V.D, £5.5m, MAGTEC Lead Partner

- Technology and Manufacturing Readiness Level (TMRL) assessment and route to improvement
- Discovery – explore business and manufacturing current state to improve operational fundamentals
- Supply chain analysis and assessment of suitable suppliers
- Development of key assembly/manufacturing processes (near term quick wins and future fully automated solutions)
- Creation of optimised process flows and drive design for (and from) manufacture
- Development of prototype automated solutions for specific steps within the manufacturing/assembly process.



REE Corner, £41.2m, REE Automotive Lead Partner

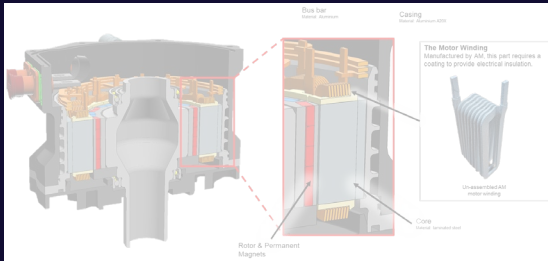
- Development of product designs utilising DfX principles.
- Technology and Manufacturing Readiness Level (TMRL) assessment and route to improvement.
- Supply chain analysis and assessment of suitable suppliers.
- Development of R&D facility in the UK – Assembly & Test process flows, process development, Virtual Factory Simulation and Automation studies.
- Development of pilot line facility to prove out scale production – enabling 'blue print' creation for global manufacturing.



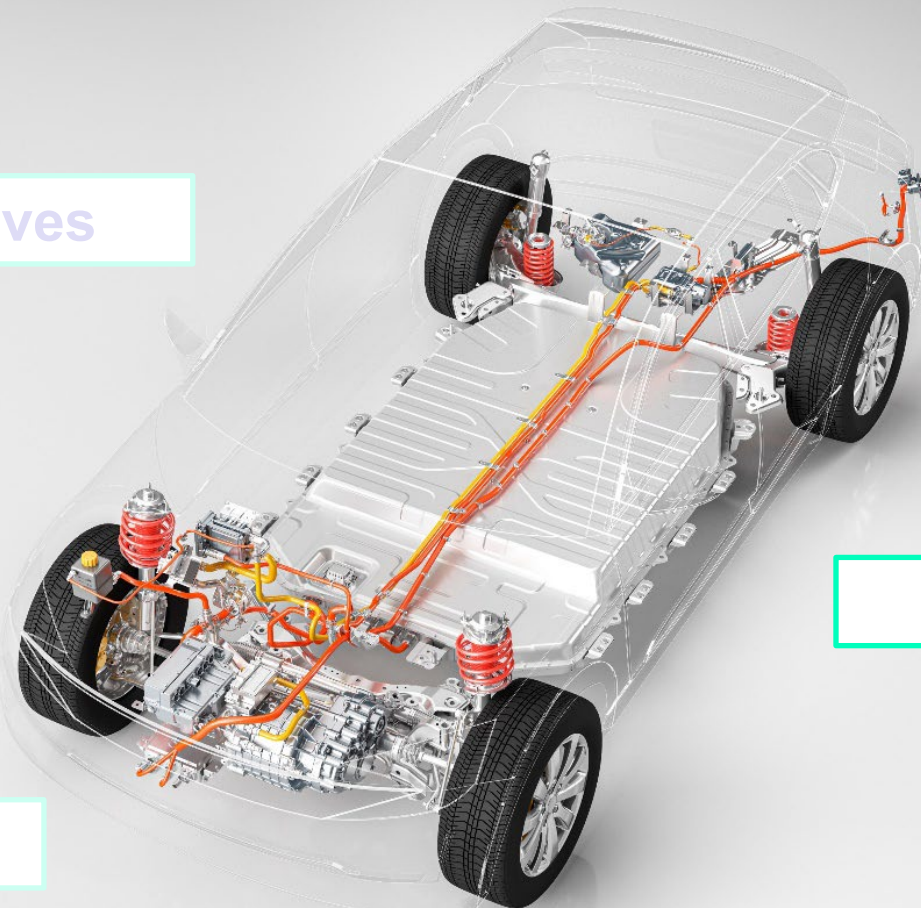
ELEVATION, £18m, Aston Martin Lagonda Lead partner

- Digital, connected tool-chain development
- Facility digital twins for UK assembly lines
- Net zero manufacturing and supply chain
- Life cycle assessments
- Supply chain readiness assessments

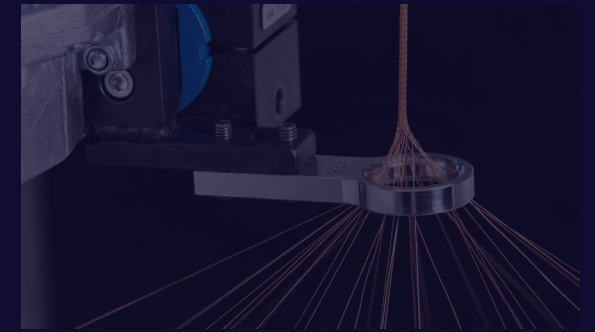
ELECTRIFICATION AT MTC



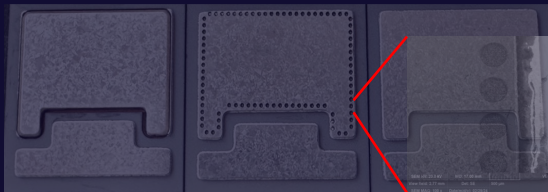
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Wiring & Distribution



Batteries



Power Electronics

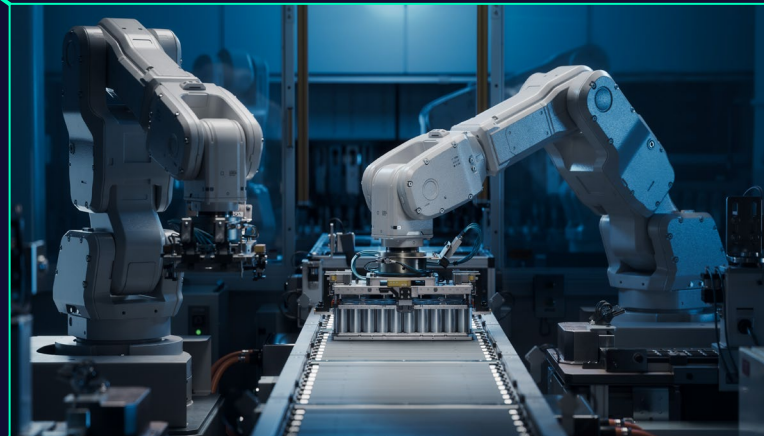
BATTERY OFFERING

SCALE-UP

- TRL/MRL assessments
- Design for Manufacture/Assembly (DfX)
- Virtual build
- Facility layout, modelling and visualisation, digital twin
- Supply chain assessment and improvement programmes

JOINING

- Technology/process/equipment selection.
- Joint design and material consultancy
- Preprocessing, including cleaning and surface treatments
- Process development and characterisation
- Prototype manufacture.
- Industrialisation.



CIRCULARITY

- Design for circularity (DfX)
- Reman strategies.
- Bespoke process development, including vision and in-process monitoring.
- Demonstration, validation and testing.
- Business case development.

AUTOMATION & ROBOTICS

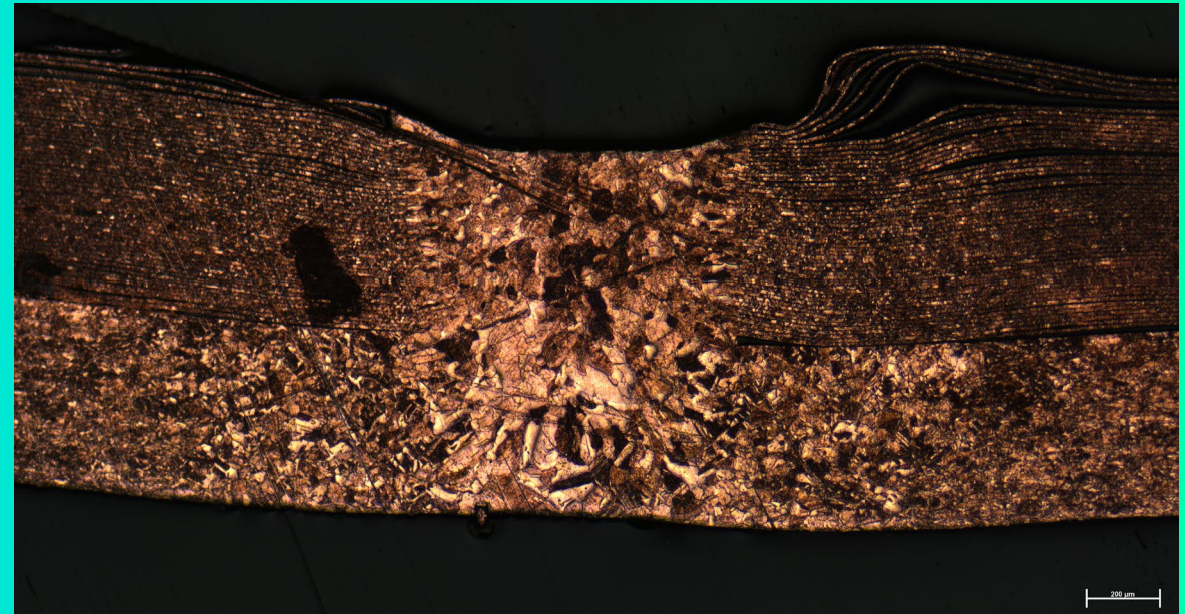
- End effector and special purpose machine design and build.
- Machine vision and in-process monitoring.
- Design of control systems.
- Programming, demonstration and validation.
- Industrialisation.

LASER JOINING

- Celltris are a start-up focussed on design and prototyping of high performance (light-weight, high-density) battery cells.
- The incumbent technology for electrode foil joining require close contact limiting the cell design. Laser welding can unlock that design freedom.
- The MTC conducted laser welding trials with multiple sources (IR, green, CW, pulsed) to optimise the weld performance.
- Fixtures, gas shielding and material preparation were all co-developed to enable a repeatable welding process.
- Robust and repeatable weld processes were developed for welding stacks of 50 copper foils either alone or to a 0.5mm copper busbar.
- Celltris now have confidence that laser welding can work and are now able to specify their production equipment requirements.

Celltris are delighted with the outcomes achieved in this project with the MTC. The results have significantly accelerated our development programme alongside gaining us the language to engage equipment suppliers and customers.

Sam Alexander, Co-founder, Celltris



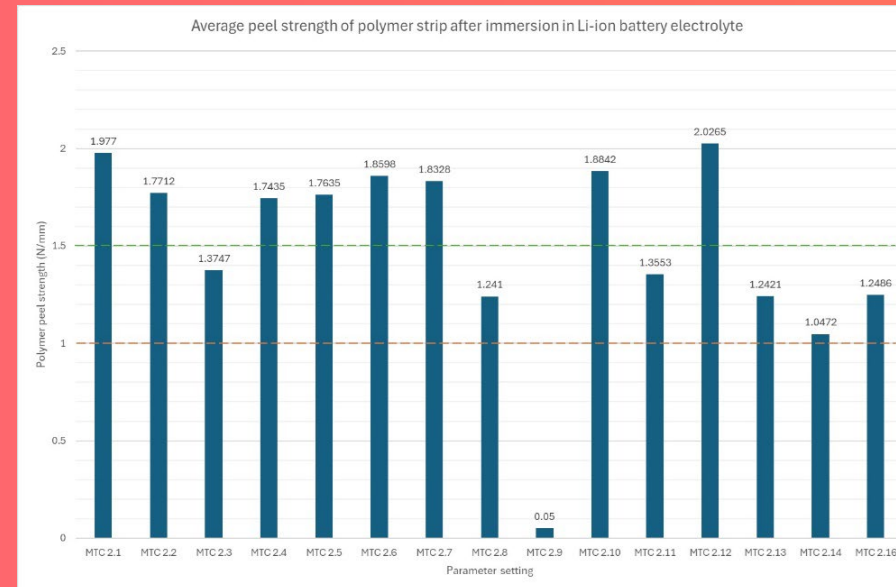
A laser welded stack of 50-off, 10µm thick copper foils to a 0.5mm copper busbar.

SURFACE PRE-TREATMENT

- Avocet Battery Materials are a UK producer of key components and technologies for battery components.
- Production of battery tabs involves bonding of polymer to the aluminium or nickel coated copper. Surface preparation is required for improved adhesion and corrosion resistance of the polymer/metal bond.
- The MTC developed a laser surface treatment as an alternative to chrome plating, banned in Europe under RoHS.
- Laser surface treatment has been shown to increase the peel strength of the polymer/metal bond after electrolyte bombing by up to 2x compared to chrome plating.
- ABM and MTC have recently won a £902k Faraday Battery Challenge project: Laser-Assisted Surface Enhancements for Roll-to-roll processing (LASER) to scale-up the process and embed it in ABMs production line.

Avocet have been working with the MTC for over 18 months developing our technology. Their expertise in the field of laser surface treatments has been instrumental to the project, and we have achieved greater results than we were hoping, surpassing performance results for current state-of-the-art components.

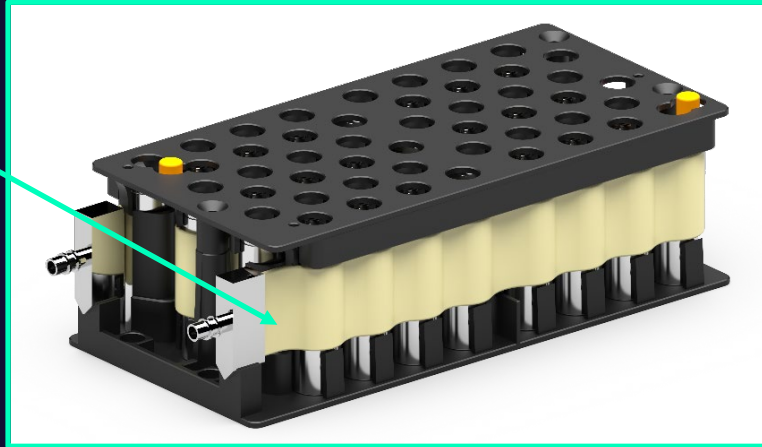
Martyn Brown, R&D Lead, Avocet Materials Group



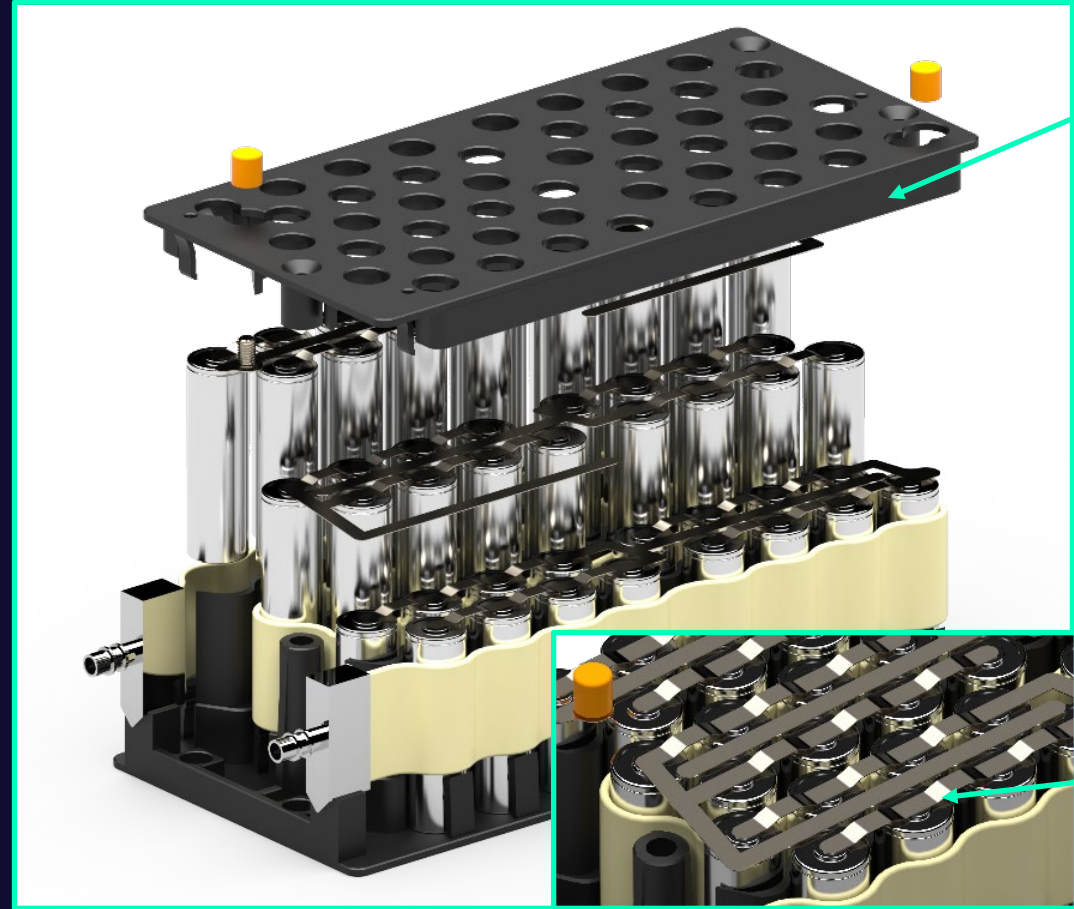
DESIGN FOR CIRCULARITY

Single-Sided Busbar connection to streamline assembly process

Aluminium micro-channel Liquid Cooling system for improved performance



Integral structural features in Fibre Reinforced Nylon to reduce part count



Stepped Busbar design to account for dimensional variance and add compliance

Improved Vibration-resistant Compliant cell mounting; no adhesives or foams



SUPPLY CHAIN ANALYSIS



BESS White Paper

- The UK currently has the highest installed base of battery energy storage systems in Europe, supported by high levels of renewables (solar, wind etc.)
- The supply chain for BESS will be competing with EV for scarce critical mineral resources (Co, Li, Ni, Cu etc.).
- Circularity can improve the UK's supply chain security in support of both BESS and EV.
- Likely to need dedicated manufacturing capacity for BESS in addition to EV.
- Read more in our UK Supply Chain Challenges for BESS White Paper.

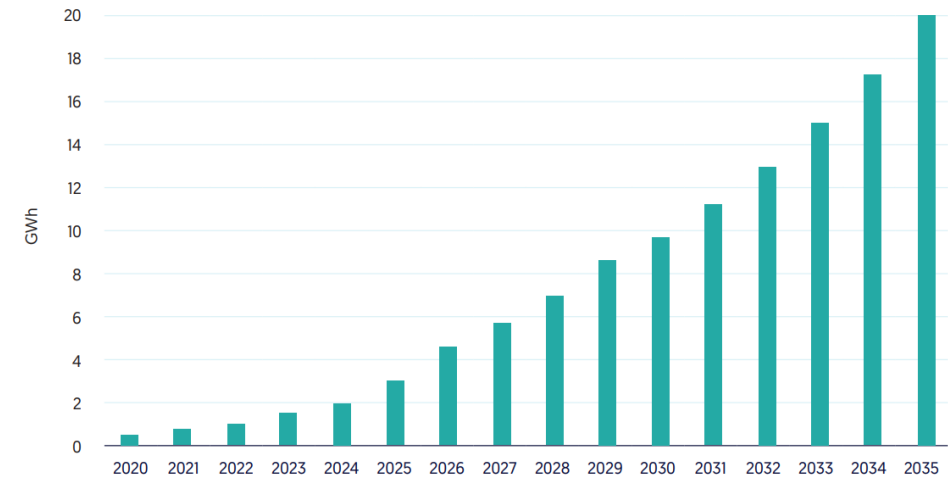


Figure 4: UK Annual demand forecast for stationary storage (GWh by Year) [Department for Business & Trade, 2023]

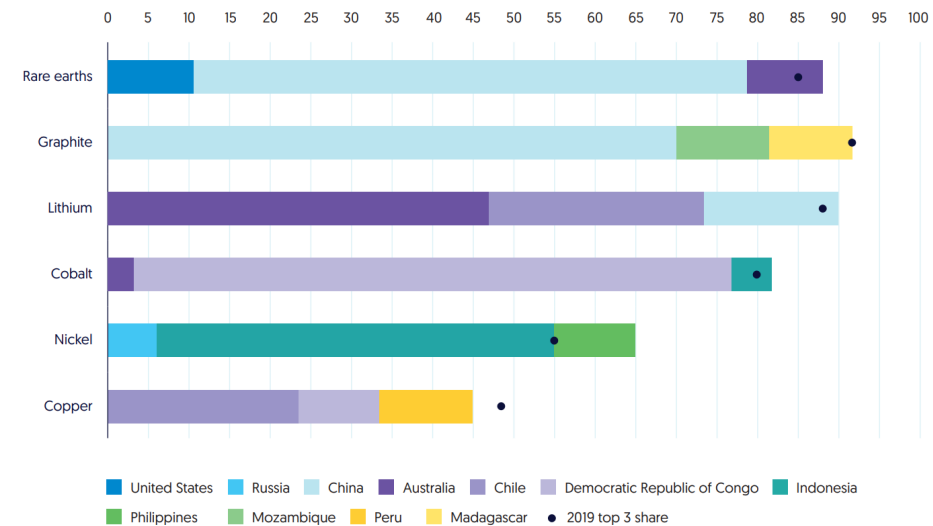
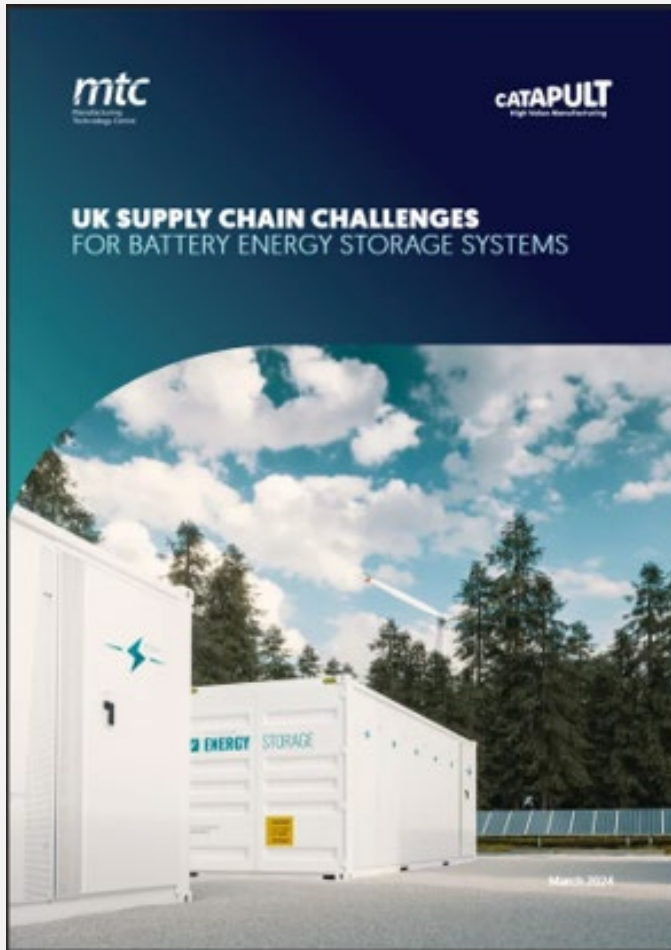


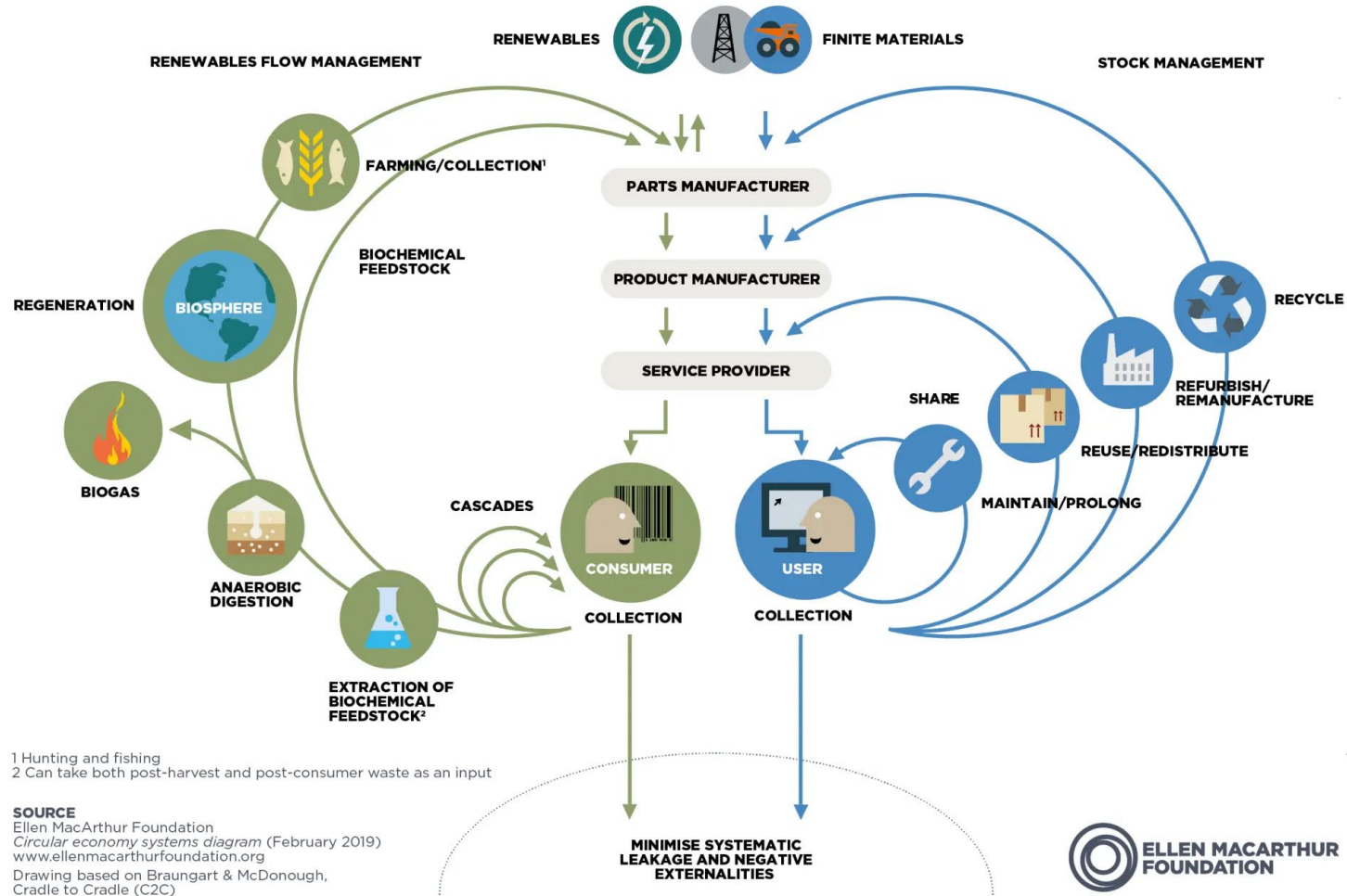
Figure 10: Share of top three producing countries in mining of selected minerals [IEA, 2022]

WHITE PAPER



Read more on 'UK Supply Chain Challenges for Battery Energy Storage Systems', www.the-mtc.org

CIRCULARITY



BATTERY CIRCULARITY OPPORTUNITIES AND CHALLENGES

- Batteries removed from EVs will either be **repaired/remanufactured** and put back into service, **reused** in second life applications, like stationary storage or **recycled** for material recovery.
- Remanufacture, Reuse or Recycling at scale requires fast processes to meet demand and economic viability on-shore in the UK.
- Full manual disassembly of a LIB pack in the UK costs roughly the same as the value of the materials within.

We need automation!

Challenges

- Variety in pack design (>450 different EV models globally, 2021)
- No design for disassembly
- Widespread use of adhesives and thermal pastes
- High voltage
- Chemical hazards
- Complex assemblies

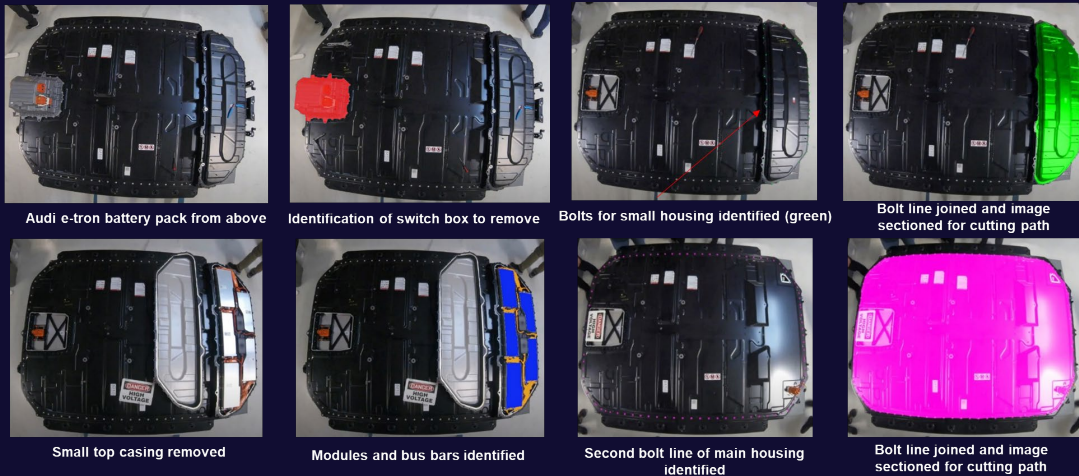


Image of adhesives used in a Tesla Model 3 battery pack
Image taken from TeslaOwnersOnline.com

MTC CONCEPT

Training

- AI driven robotic part identification and path planning speeds up learning of new packs
- Human in the loop ensures safety and validity of disassembly operations



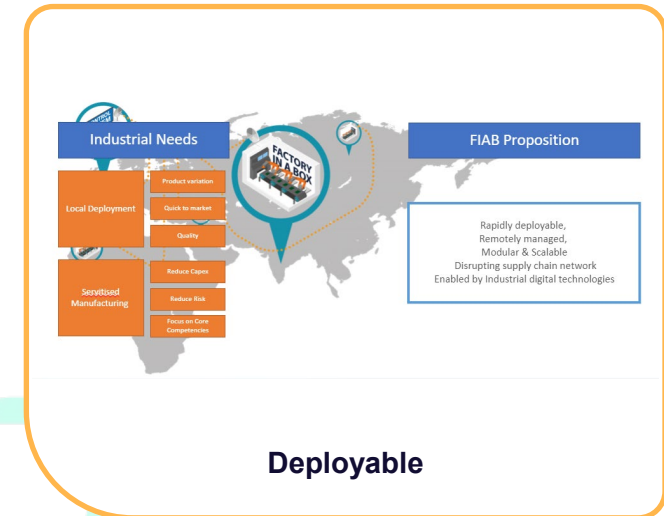
Operation

- A database of validated recipes enables rapid and safe operation.
- Machine vision used extensively to validate operations and flag any required human intervention.



MTC APPROACH

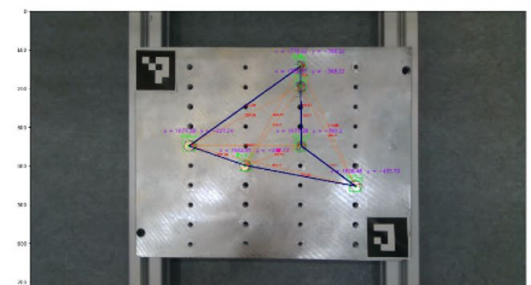
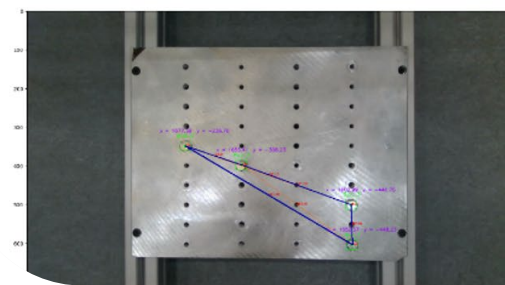
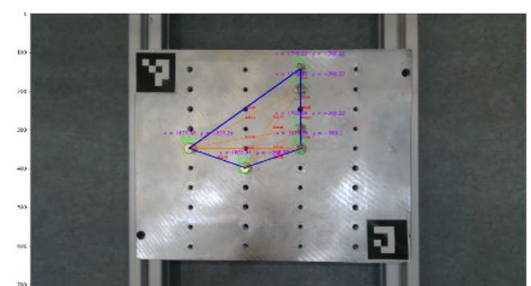
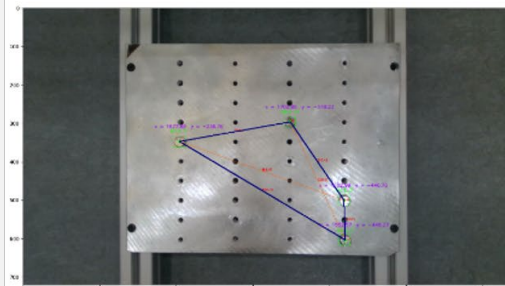
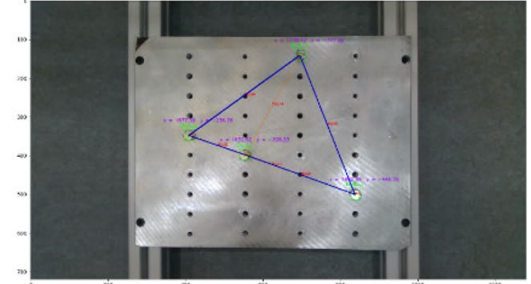
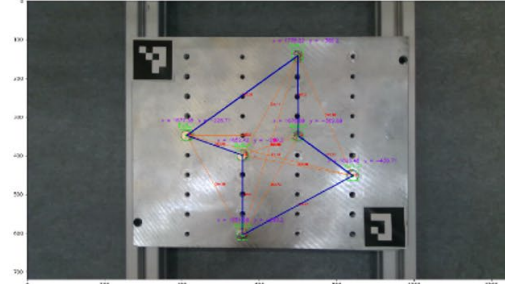
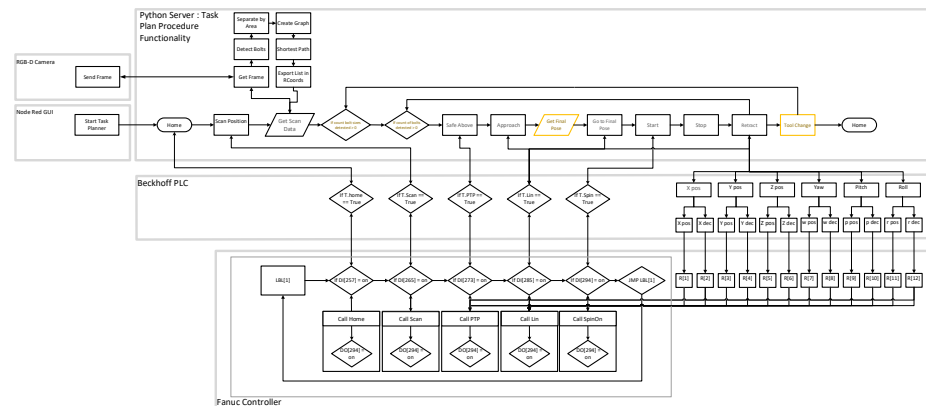
Development of an autonomous, pack design and robot agnostic disassembly system using industrial controls.



PROGRESS TO DATE

Bolt Detection and Path Planning

- Developed a systems and control architecture, machine vision, path optimisation algorithms and task planner for autonomous bolt detection and unfastening.
- Able to detect bolts and plan an optimised path in <100ms.
- Operating using an industrial robot and PLC based control system.
- Scalable to easily add in other disassembly operations (cutting, unclipping, removal)



BESPOKE AUTOMATION CELL

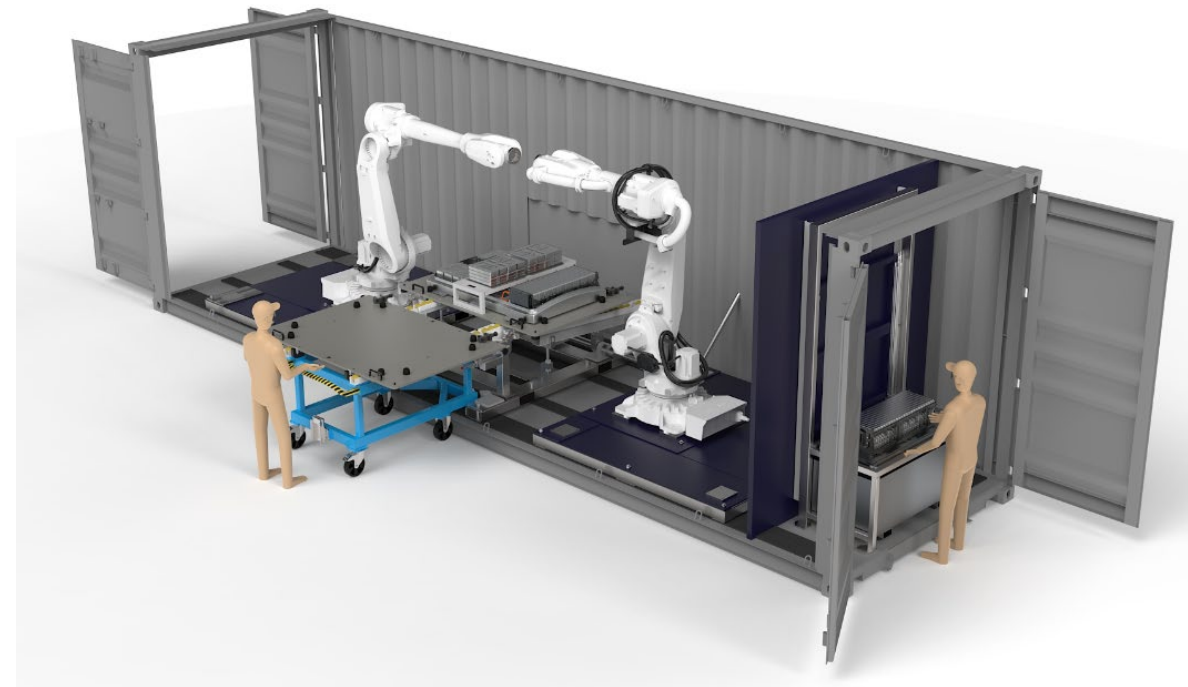
HazOps

- The Hazardous Operations and manufacturing cell (HazOps) is a flexible cell for battery pack assembly and disassembly/remanufacture.
- HazOps is based around the MTC's Factory in A Box (FIAB) concept. It is a transportable, remotely operated, flexible manufacturing cell.
- We have designed HazOps to incorporate the latest in robotics, machine vision, laser and battery safety technology.
- We will use HazOps to develop, demonstrate and validate automated AI driven rework of battery packs at rate.
- HazOps will be operational early Q2 2025.



Department for
Science, Innovation,
& Technology

£1.85M



Concept for the HazOps cell, currently being built for MTC by Prime Automation.

VIRTUAL TEARDOWNS

Tesla Model S



Hyundai ionic



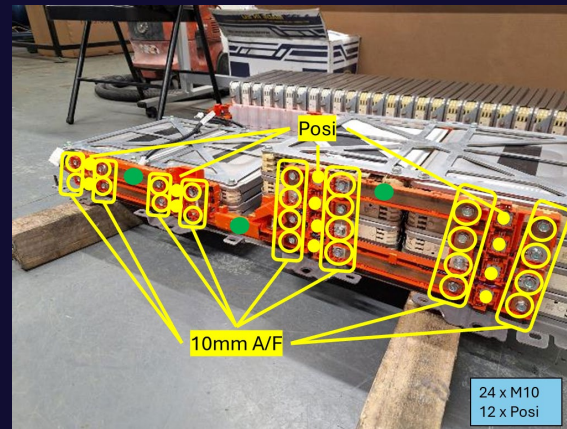
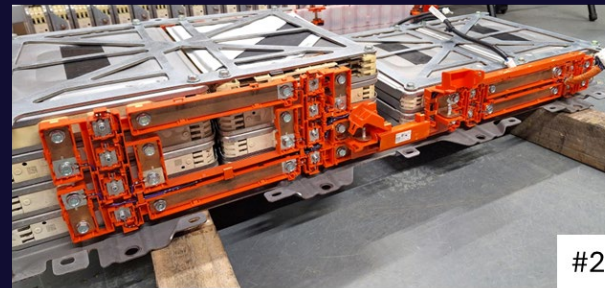
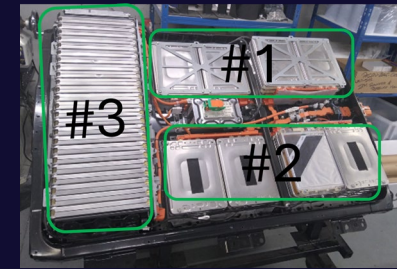
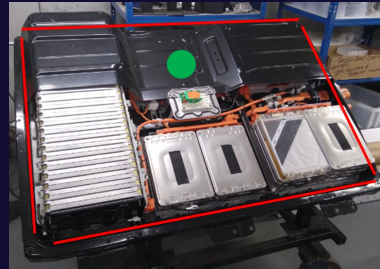
VW ID3



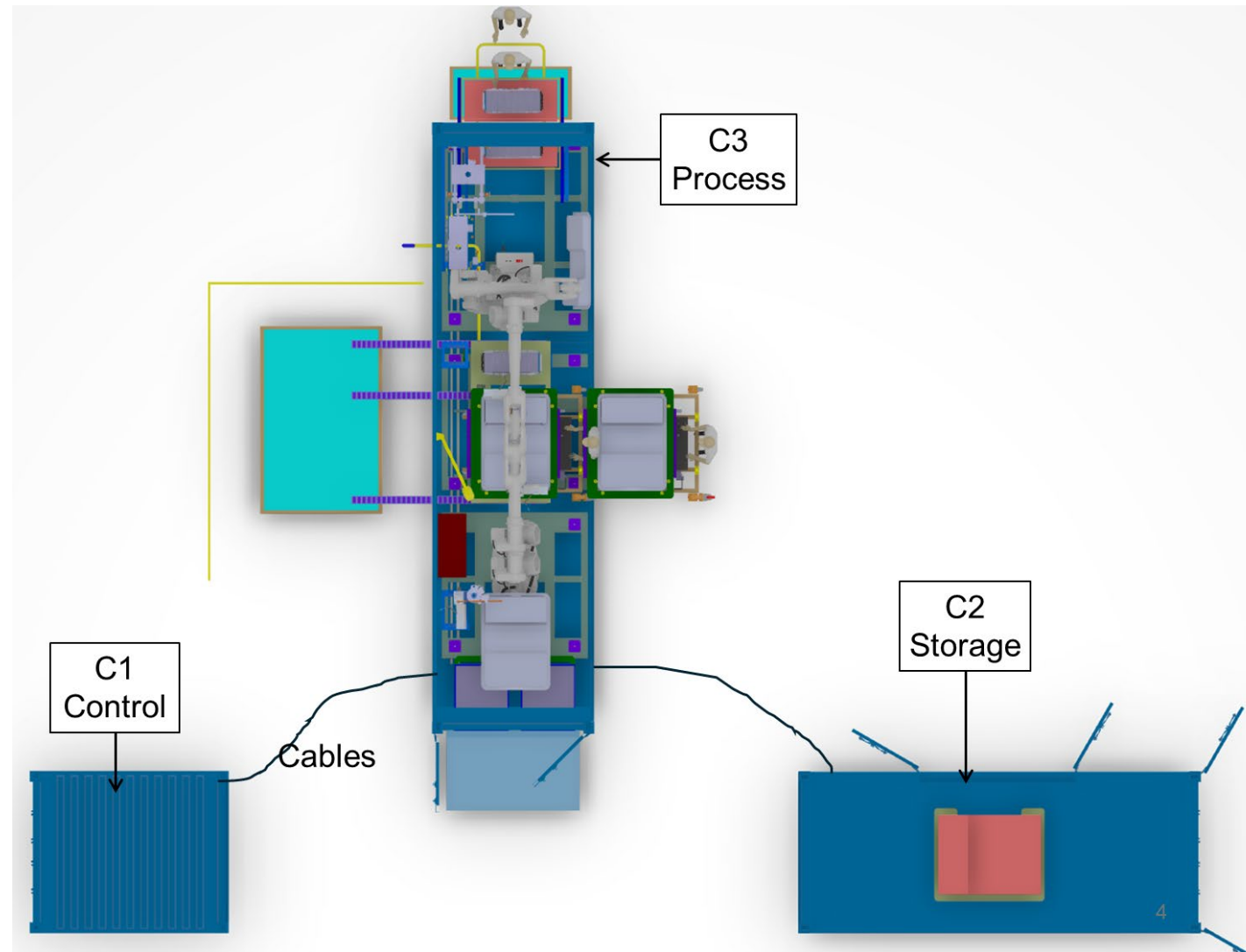
Nissan Leaf



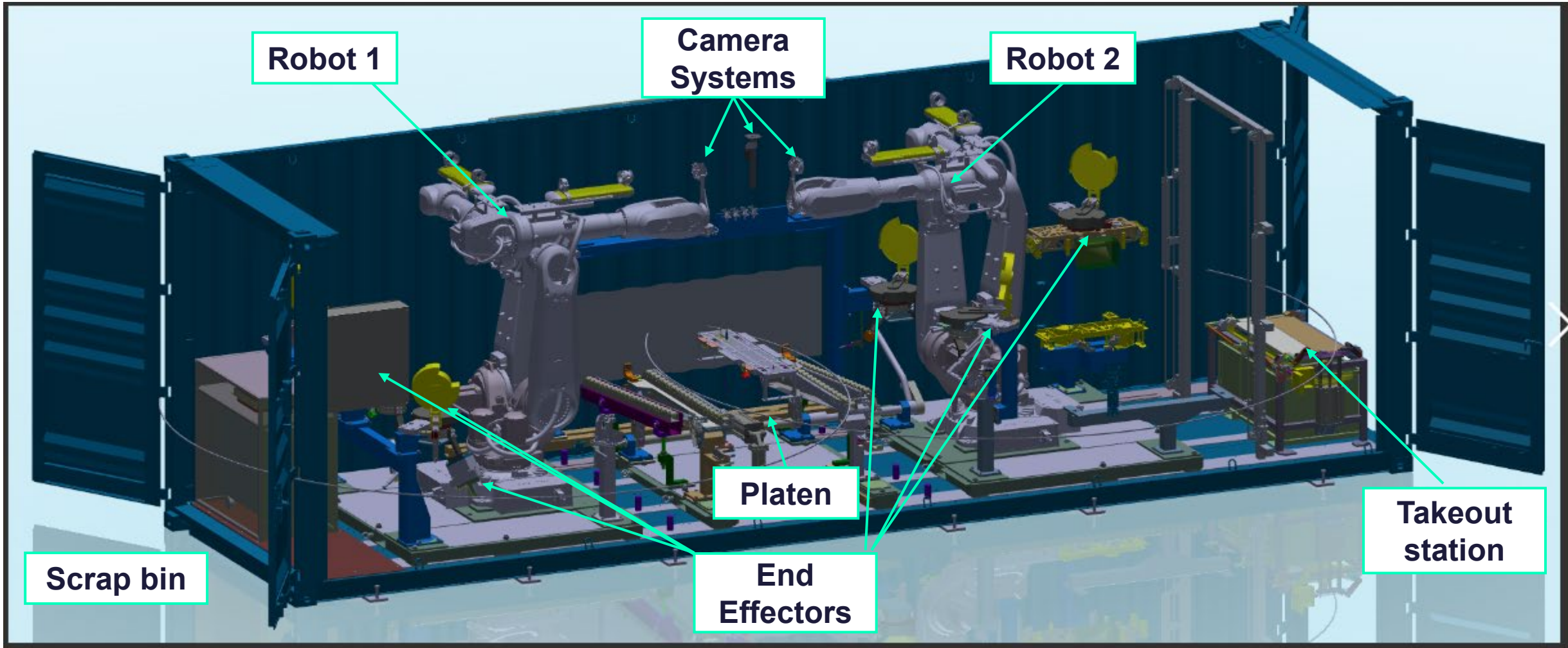
NISSAN LEAF TEARDOWN



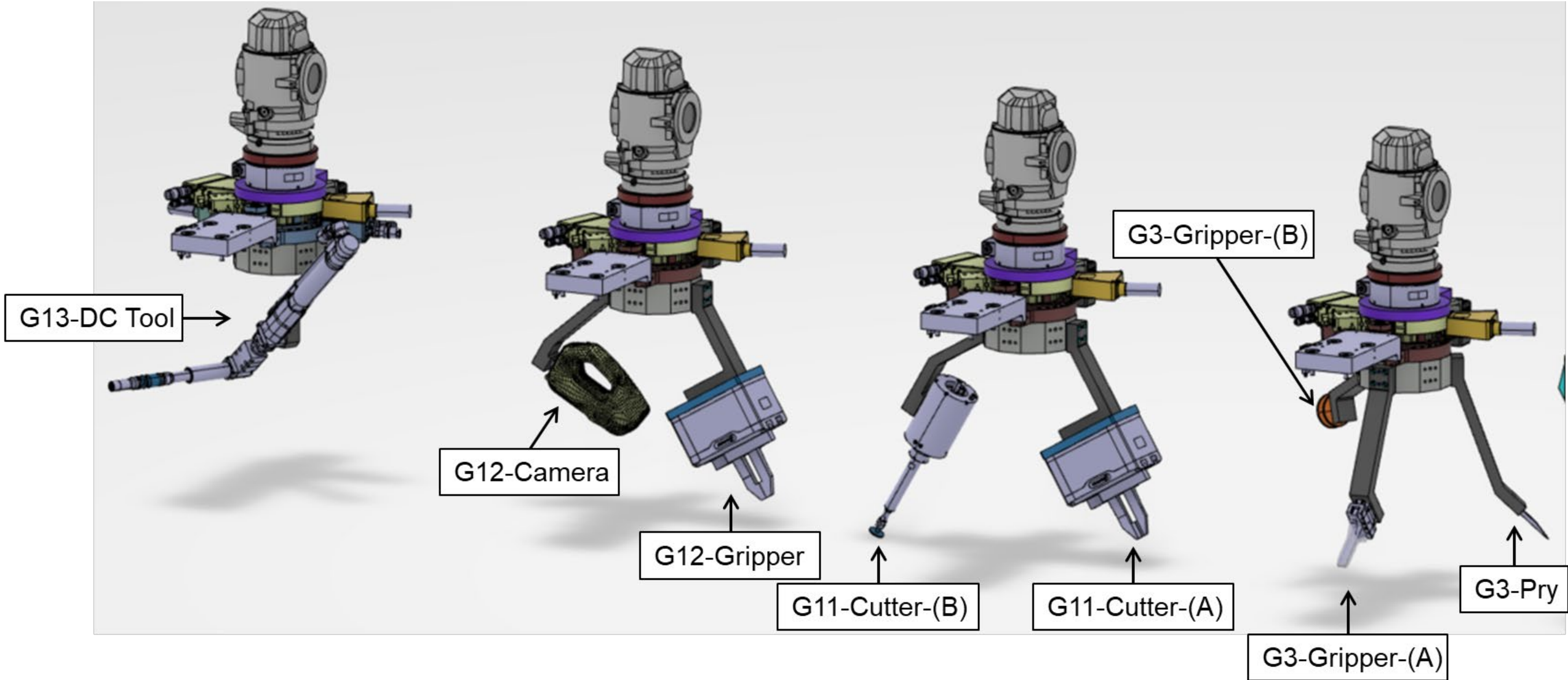
HazOps



HazOps



FLEXIBLE END EFFECTORS



SIMULATION



BUILD STATUS



CONCLUSION

Come and work with us

- HazOps will be a one-of-a-kind development cell, operational early next year and available for project work.
- MTC are actively looking for partners interested in prototyping, remanufacture or disassembly.
- If you'd like to find out more, please reach out.

Thanks for listening.

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