



INDUSTRIALISATION OF ELECTRIFICATION

**WORKING COLLABORATIVELY WITH
INDUSTRY AND ACADEMIA FOR A
MORE SUSTAINABLE FUTURE**

THE MTC IS
SUPPORTING
THE CREATION
OF INNOVATIVE,
WORLD LEADING
TECHNOLOGIES
THAT SUPPORT
ELECTRIFICATION

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INTRODUCING THE MTC

The MTC was established in 2010 as an independent Research and Technology Organisation (RTO) to help bridge the gap and create more meaningful and beneficial links between academia and industry to aid the growth of UK manufacturing.

Today, the MTC has over 800 employees, 100 industrial members, turns over around £100m and operates from sites in Warwickshire, Oxfordshire, South East London, Bristol and Liverpool.

Supported by the Government along with our partners in the Catapult, Innovate UK and our founding universities, we have been able to work alongside our members and industrial partners to deliver world leading innovation to the broadest range of UK based businesses from OEM's and large scale global manufacturers through to SMEs and new start-ups.

We have a unique environment, as we bring together the country's leading academics, engineers and industry professionals.

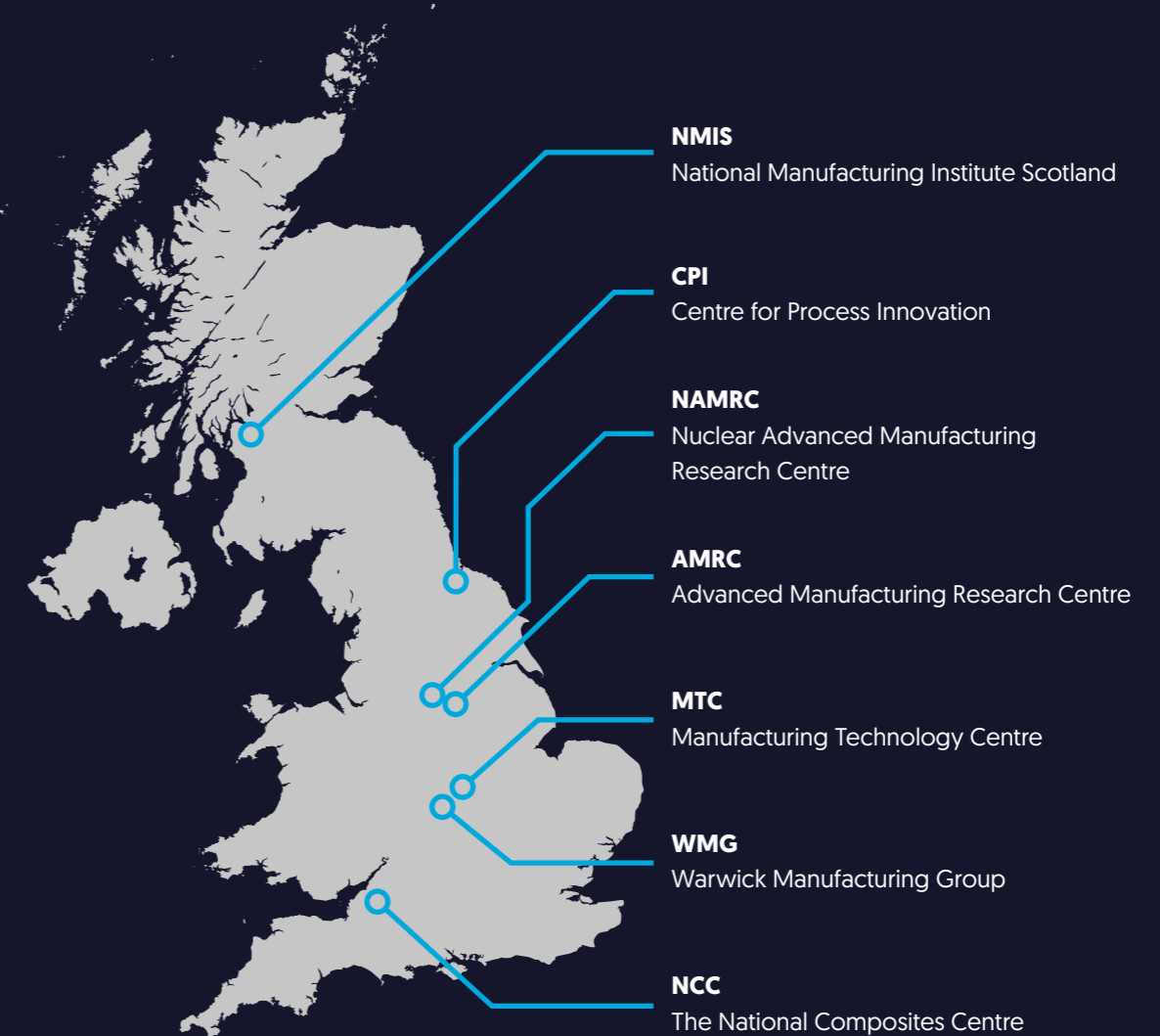
As our footprint has grown across the UK, we have been able to directly influence and support more and more advanced engineering businesses and manufacturers as we work collaboratively to drive the innovation and competitiveness of UK manufacturing.



THE CATAPULT NETWORK

The MTC is part of the High Value Manufacturing (HVM) Catapult, which is sponsored by Innovate UK.

The HVMC is the catalyst for the future growth and success of advanced manufacturing in the UK. It consists of seven Technology and Innovation centres across the UK and its vision is to work with companies of all sizes to bridge the gap from concept to commercialisation. All the centres offer access to leading edge equipment, expertise and an environment for industry collaboration.



THE FUTURE IS ELECTRIC

With a global drive towards net zero and wider use of sustainable energy, the UK is currently falling behind other nations. Whilst progress has been made in some areas, more needs to be done to meet the UK Government's target of achieving net zero by 2050.

Electrification, the movement to use sustainable energy sources to replace fossil fuels, has been identified as a key contributor to decarbonising industry and reducing the impact of climate change. As a result, there is huge industrial demand for high-performance power electronics, machines and drives (PEMD). These technologies are key to lower emissions and improved energy efficiency, resulting in lower energy costs in comparison to the use of fossil fuels.

Electrification presents exciting new opportunities for UK manufacturing on a grand scale. Businesses can reduce greenhouse gas emissions by introducing new technologies, leading to improved efficiency and productivity, resulting in significant economic, environmental and societal benefits.

The MTC has a full suite of capabilities, from supply chain mapping to product and process development, leading to the development of fully integrated production systems. These capabilities make use of the state-of-the-art technologies that have been at the MTC's core for over 10 years.

THE PRINCIPLES OF ELECTRIFICATION CAN BE APPLIED TO A WIDE RANGE OF INDUSTRIES.

At the MTC, our focus is on supporting - but not limited to - the following sectors:



AUTOMOTIVE



AEROSPACE



POWER AND ENERGY



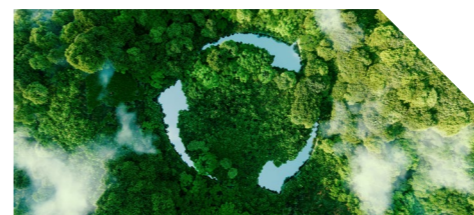
CONSTRUCTION AND INFRASTRUCTURE



SURFACE TRANSPORT



SPACE



SUSTAINABILITY



DEFENCE & SECURITY



TECHNOLOGY INNOVATION

Central to the work of the MTC is bridging the gap between academia and industry. By leveraging its network and capabilities, the MTC can bring ideas to life with the development of prototypes which could later lead to full-scale production solutions.



INDUSTRIALISATION AND SCALE-UP

The evolution from innovation to industrialisation is one of the biggest challenges faced by industry; often, businesses know what to do, but not how to get there. The MTC is adept in identifying skills and capabilities required and then integrating these to enable businesses to successfully implement new technologies or integrate existing manufacturing solutions.

SUSTAINABILITY

The MTC offers end-to-end capabilities to support businesses with implementing the principles of sustainability. Through people, processes and knowledge, the MTC seeks to challenge the status quo and support businesses with working towards more sustainable practices.



WE ARE LEADING
THE ROUTE TO NET
ZERO AND THE
DECARBONISATION OF
ENERGY IN THE UK
BY UTILISING SMART
DESIGN TOOLS AND
MODERN METHODS OF
MANUFACTURING

Danny McGee
Associate Director of Technology Strategy, MTC



DESIGN OPTIMISATION

We support our customers with the development of their products. Offering support with: the design of components and assemblies; modelling and simulation of the product or manufacturing process; and the adoption of high-value design techniques such as knowledge based engineering.

CASE STUDIES

- **Design for Additive Manufacturing (DFAM): Additive Manufactured Electric Motor** [Page 12](#)
- **Optimising the Performance of Heat Sinks Through the use of High-Value Design Tools** [Page 14](#)



FACTORY DESIGN

The MTC can take you from initial scenario mapping of your potential facility all the way to final build.. We can help with layout optioneering, discrete event simulation, visualisation and digital twins.

CASE STUDIES

- **Factory Optimisation & Visualisation for a Production Line** [Page 16](#)

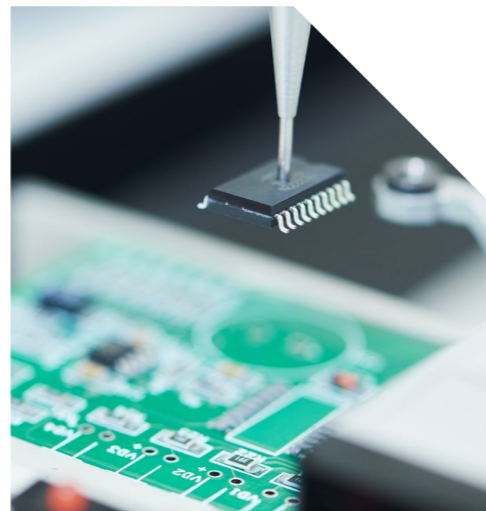


PROCESS DEVELOPMENT & QUALITY

The MTC has a wealth of expertise in process development and quality. From laser processing to electronics manufacturing, the MTC can help you develop effective and efficient manufacturing processes to support your electrification journey.

CASE STUDIES

- **Electroflight** [Page 20](#)
- **Addressing the Challenges Faced in the Design & Manufacture of Electric Motors** [Page 22](#)
- **Enhancing the Performance of Li-Ion Batteries in Harsh Environments** [Page 24](#)



EQUIPMENT DESIGN

We can help in the design of competent and capable equipment, tooling, and fixturing. All of which help you achieve the required rates of production.

CASE STUDIES

- **Utilising Automation Technologies to Establish Magtec as a Tier One Automotive Supplier** [Page 28](#)



SUPPLY CHAIN DEVELOPMENT

Looking to develop your electric supply chain? The MTC is well placed to help you with manufacturing support, assessment and oversight of your supply chain, and a targeted supplier development programme of all services on offer.

CASE STUDIES

- **Perseus – ICE to EDU** [Page 32](#)
- **UK Battery Manufacturing: Supply Chain Discovery and Mapping** [Page 36](#)



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BY WORKING WITH THE MTC,
WE HAVE MADE INTEGRAL
PROCESS IMPROVEMENTS AND
UPGRADES TO OUR MOTORS,
AS WELL AS MAXIMISING THE
FLOOR SPACE AT OUR NEW
FACILITY. THIS HAS HELPED US
TO SCALE UP OUR PRODUCTION
CAPABILITY AND PUT US AT THE
FOREFRONT OF THE HIGH-TECH
DESIGN AND MANUFACTURING OF
ELECTRIC DRIVE SYSTEMS AND
SPECIALIST HYBRID SOLUTIONS.

Andrew Gilligan
Managing Director, Magtec

*Case Study: Utilising Automation Technologies to
Establish Magtec as a Tier One Automotive Supplier*

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DESIGN FOR ADDITIVE MANUFACTURING (DFAM): ADDITIVE MANUFACTURED ELECTRIC MOTOR

THE CHALLENGE

Additive manufacturing (AM) has been identified as an enabling manufacturing technology to produce power-dense electric motors in a repeatable and short lead time. Whilst additive manufacturing isn't new, its application for end-use parts and tooling has become more prevalent only in recent years, and is demonstrating its potential to change the way that products are designed and manufactured.

In academia, there are a growing number of research papers that highlight the benefits associated with an additive manufactured motor, however there are limited examples of AM in commercially developed products. The MTC's technology experts initiated a project that considered the wider implications of additive manufacturing for electric motors. The aim was to provide recommendations, based on existing limitations, for creating the next generation of electric machines.

The development of electric motors has not seen this level of focus for nearly 100 years despite being high on the priority list for many industry sectors that are seeking significant improvements in cost, quality, reliability and performance, in both gravimetric and volumetric terms. Systems engineering and integration – doing more with key components and materials - are key to achieving this and so additive manufacturing is a key enabler for developing complex features and forms, essential to improving the functionality and performance of electric motors.

Steve Nesbitt
Chief Technologist, MTC

MTC'S SOLUTION

With support from the National Centre of Additive Manufacturing (NCAM) and the MTC's Electrification Steering Committee, the project team were able to identify the key challenges being faced by conventionally manufactured motors.

Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) assessments were conducted of additive manufacturing for key motor components. These assessments were combined with learnings from past projects and an analysis of present manufacturing techniques for each component. In doing so, the MTC was able to identify the current constraints and how, by, applying AM, these limitations may be resolved.

To demonstrate the potential benefits of leveraging the capabilities of AM, the cooling method of a commercial motor was reassessed, as a result of several iterations of a liquid-cooled motor casing.

THE OUTCOME

The benefits that AM can provide for each component of electric motors were identified, and a research and development roadmap was created to outline a route for progressing the implementation of AM in electric motors. Consequently, the MTC was able to propose new projects that can address the challenges and constraints of using additive manufacturing in electric motors.

The redesign of the casing allowed the motor to produce more power by the implementation of liquid cooling channels to prevent overheating. In addition, the design freedoms of additive manufacturing enabled for a weight saving of 10% and size reduction of 30% due to component integration. These design activities were supported by the software capabilities provided by Siemens Digital Industries, such as Siemens NX for CAD modelling, digital verification and technical product specification.

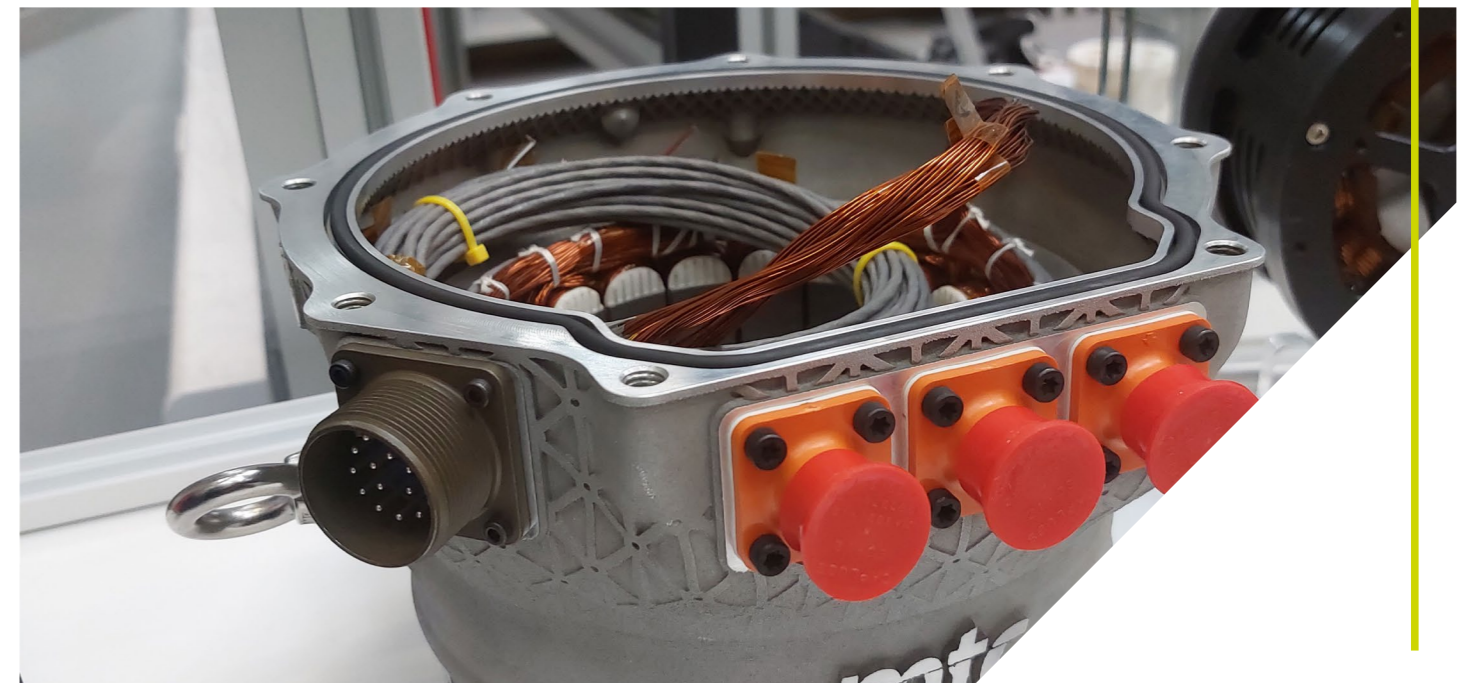
BENEFITS TO THE INDUSTRY

The process of manufacturing electric motors has a number of challenges to overcome; complex or manual assembly, materials that are difficult to process and can be rare and/or expensive, thermal management and lightweighting.

By leveraging the AM capabilities through the product redesign as demonstrated in the casing, key benefits were identified throughout the product and supply chain:

- Increased motor power density, resulting in a reduction in size and mass of key components
- Part count reduction, leading to simplified assembly and supply chains
- Increased manufacturing efficiency and reduced lead times
- Lower running costs
- Waste reduction
- Reduced assembly and inspection costs

The additive manufacturing motor roadmap provides a clear picture of the necessary developments required and potential challenges and constraints to introduce additive manufactured motors to industry.



OPTIMISING THE PERFORMANCE OF HEAT SINKS THROUGH THE USE OF HIGH-VALUE DESIGN TOOLS

THE CHALLENGE

There has been a seismic shift towards electrification and a significant increase in the use of power electronics as the UK looks to achieve the Government's net zero target by 2050.

Given the global transition from combustion engines to electric motor propulsion, industries such as automotive, aerospace and the rail sector are continually trying to find ways of improving the power density for their existing systems.

The challenge for the MTC was to use smart design tools such as topology optimisation to optimise an off-the-shelf heat sink, such as those found in a variable speed drive. The aim was to improve the heat transfer away from the electronic components, therefore allowing for enhanced thermal performance and a reduction in the overall weight.

MTC'S SOLUTION

To address the challenge, engineers at the MTC utilised high-value design tools that could achieve the desired performance benefits for the proof-of-concept demonstrator.

First, the team reverse engineered the initial design using traditional CAD software. COMSOL Multiphysics® topology optimisation was then used to remove the fins on the cross-sectional shape of the heat sink and optimised with a dendritic design to allow for a greater flow of air. Additional design work was conducted, applying a fractal approach to mimic the behaviour seen in nature and extend upon the output of the optimisation.

Further design changes were made to fully utilise the additive manufacturing design freedom. This included the addition of dimples to improve the surface texturing of the heat sink which further improved the heat transfer with a reduction in the pressure drop.

This project is a great example of the power of collaboration here at the MTC. By working together and utilising the expertise across technology themes, we've been able to deliver a demonstrator that could have a significant impact on UK manufacturing. More specifically, our industrial members in the motorsport and aerospace industries will benefit by using this novel design methodology and will see marked gains through the enhancement in the thermal performance of their power electronics systems.

Dan Walton
Technology Manager, Electrification, MTC

THE OUTCOME

The MTC has used thermal-fluid optimisation and additive manufacturing to produce a high-performance heat sink. These high-value design and manufacturing techniques have allowed for the proposed design to benefit from a 20% improvement in thermal performance with a 6% reduction in overall mass compared to the original design.

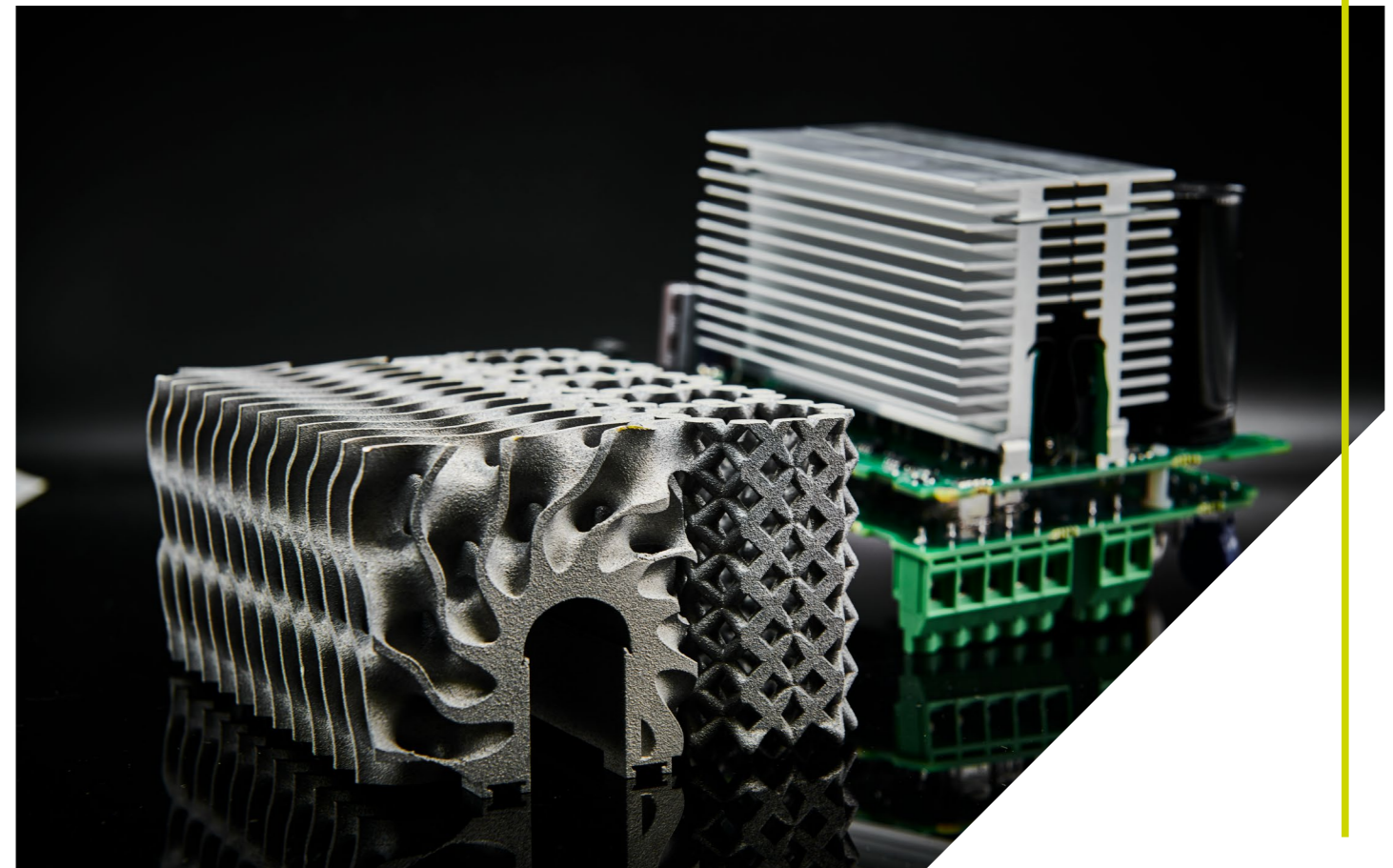
The result is a design workflow that could be applied to a variety of thermal management systems for numerous sectors where a cooling unit is significantly important for passive cooling.

BENEFITS TO THE CLIENT

Through being able to utilise state-of-the-art technologies, coupled with teams of experienced researchers and engineers, this project has shown how high-value design can positively impact UK manufacturing in industries where electrification is going to be essential to their future development.

It has also demonstrated that topology optimisation as a process can direct engineers to highly optimised designs that will reduce the time taken for the design process, save money in already costly processes, and provide lighter units with better performance and an increased power density.

This project demonstrates how the MTC can work with clients on novel design methodologies, to uncover the art of the possible, in sectors where thermal management is integral for improved performance and reliability.



FACTORY OPTIMISATION & VISUALISATION FOR A PRODUCTION LINE

THE CHALLENGE

Factory and production line optimisation can lead to significant improvements to the efficiency and cost effectiveness of manufacturing processes. But for many businesses, the challenge is in accessing key data and analysing it to support the decision making needed to realise these benefits.

As part of the organisation's expanding capabilities in electrification, the MTC identified a need to communicate the potential benefits of factory layout optimisation to its customers. In this example, the MTC selected the manufacturing and assembly sequence for an example electric motor. However, the same principles for Business and Factory Optimisation could be applied to a range of broader sector applications such as Batteries, Power Electronics, Hydrogen products, and more.

Areas that were identified for optimising the manufacture of electric motors included: the required number of workstations with a view to preventing supply bottlenecks, workstation placement to minimise footprint and time spent moving parts between workstations, and the number of operators necessary to run a production system to utilise its full capacity.

These factors are interdependent and multifaceted; consequently, a solution was required to address these complex challenges, and support engineers in making well informed decisions to improve manufacturing efficiency.

Simulation technology can provide significant benefits when optimising production processes, particularly when applied to emerging themes such as electrification. Its application spans across multiple sectors, and through the use of visualisation demonstrators and digital dashboards, raw data is transformed into a toolset that can inform key decision making whilst minimising risk.

Danny McGee
Associate Director of Technology Strategy, MTC

MTC'S SOLUTION

The MTC applied simulation technology and advanced data analysis methodologies to generate scenarios at different stages and levels of production of the example electric motor, in order to identify areas for optimisation.

Simulation techniques allowed analysis to be performed across multiple production factors (e.g. processes, material handling, storage and manual operations) at any one time. Solutions can then be tested for different scenarios (e.g. machinery, system reconfigurations, shift patterns and maintenance tasks) to help identify likely outcomes.

The data extracted from the simulation was analysed and configured into a dashboard to support users with better understanding the information. These interactive visualisations can display comparative solutions and help individuals from across the business to investigate and understand the data in a more accessible way.

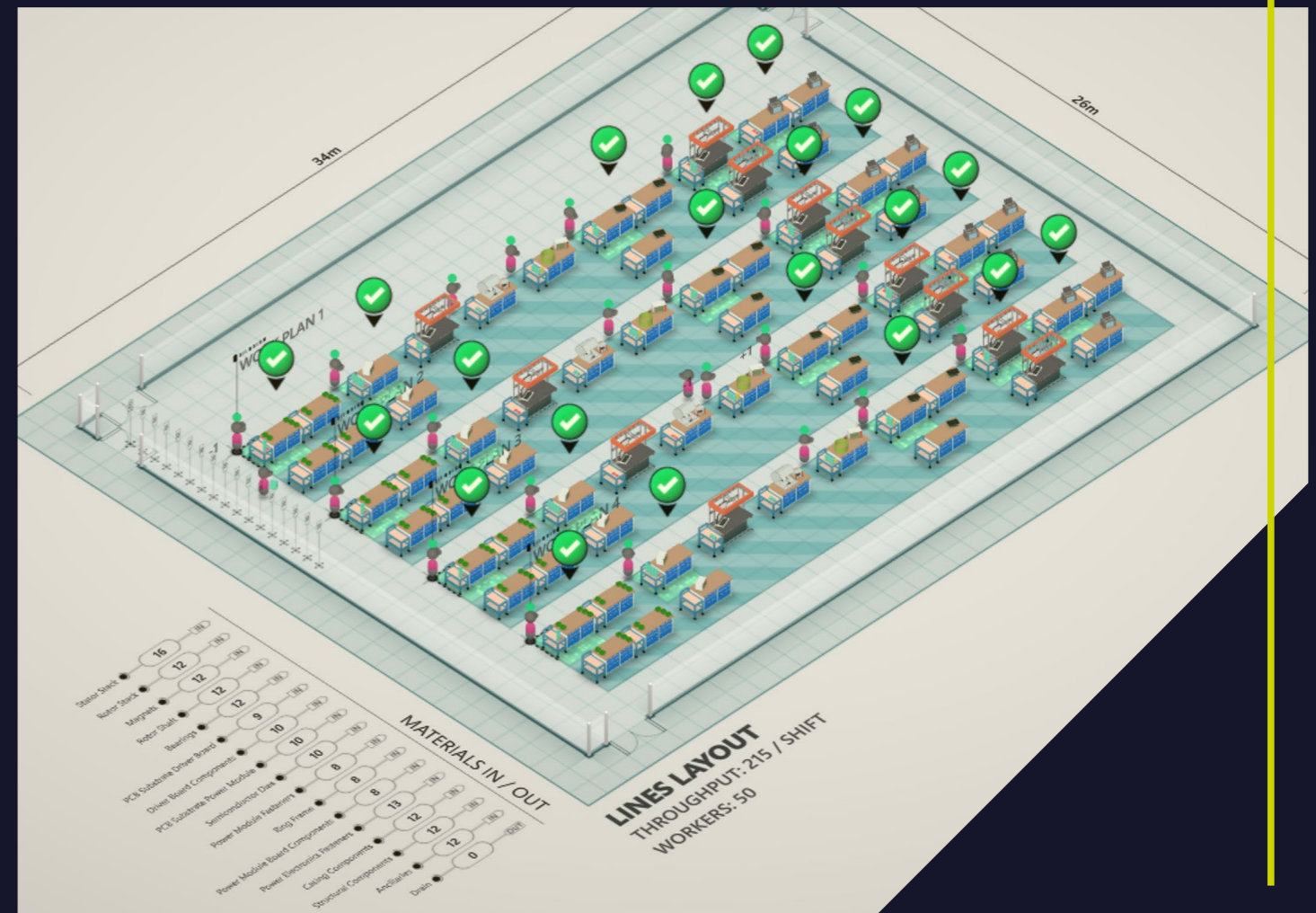
THE OUTCOME

The Factory Optimisation demonstration ultimately sought to identify challenges throughout the production process of an electric motor, and to provide meaningful insights to inform decision making. For example, the demonstration illustrated how a tenfold throughput increase (from 15 to 213 products per day) could be realised, whilst only requiring double the floor space (from 406 m² to 884 m²).

The advanced visualisation platform allowed these results to be presented in an interactive and accessible format - whereby individual workers and workstations could be analysed to understand the breakdown of value-added and non-value-added activities.

BENEFITS TO THE CLIENT

- Well informed decision making for factory and production optimisation to help minimise the investment risk in scale-up of products such as Electric Motors, Batteries, Power Electronics, and more.
- Intuitive interaction with simulation findings helps non-technical users to understand the analysis and gain meaningful insights into the behaviour of a production system.
- Visualisation of factory layout with accurate animations displays worker movements support further analysis into machinery and worker positioning.
- Virtual representation permits users to run different scenarios without impacting existing manufacturing output or costly prototyping.





ELECTROFLIGHT

THE CHALLENGE

Electroflight, a technology and engineering services organisation specialising in bespoke aerospace battery systems, approached the MTC's Manufacturing Support Services (MSS) team to conduct a project looking into improvements in battery cell cleaning.

The business, which operates in the aerospace and defence sectors, had recently conducted a study into wire bond reliability and strength following investment into new wire bonding processes. This research identified battery cell cleanliness as a major factor. Electroflight recognised that its existing manual methods of cleaning battery cells were labour intensive and caused issues with variability and challenges with scalability.

The MTC was tasked with identifying new cleaning methods and technologies to improve the cleaning process and subsequently enhance the wire bond weld strength and bonding strength consistency.

MTC'S SOLUTION

Laser cleaning was identified as the most suitable cleaning process, and in the first phase of the project, the MTC investigated the feasibility of laser cleaning of the battery cell to remove oxidation and contamination. A series of experimental trials were conducted and a total of 36 cells were laser programmed, cleaned and characterised, to assess the impact of the cleaning method on bond strength and variability.

Phase Two of the project focused on further optimising the cleaning process on both old and new cell batches. The results were compared against Electroflight's existing manual wet chemistry and mechanical cleaning methods, and optimum laser cleaning parameters were established.

THE OUTCOME

Following completion of the testing, the MTC identified an optimum laser power output to achieve targeted improvements in wire bond strength. This output resulted in a 130% increase in bond strength of the negative terminals and 40% increase for positive terminals, and a significant reduction in variability. The optimised cleaned cells also showed significant improvement on repeatability and pull testing performance of the cells during the wire bonding process.

Other factors that impacted wire bonding test results were also identified, such as variation in oxide layer thickness due to different batches of battery cells.

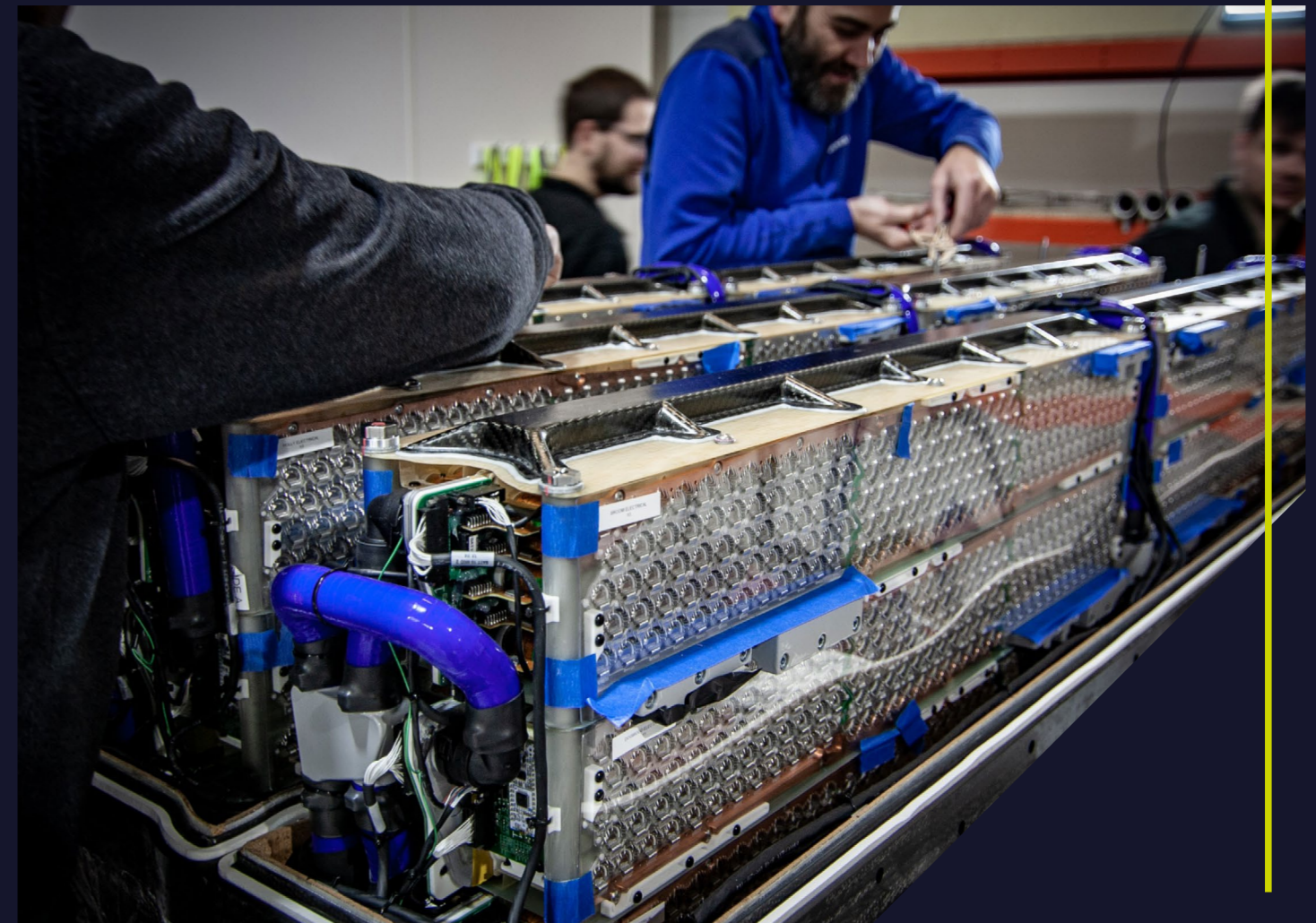
Following completion of the project, MSS introduced Electroflight to laser systems manufacturer IPG Photonics to support the adoption of onsite laser technology in-line with the findings from the MTC's study.

BENEFITS TO THE CLIENT

- Improved reliability and performance of battery modules.
- Enhanced wire bond strength and reduced variability, resulting in quality and safety improvements.
- Increased cleaning speed and subsequent productivity.
- Introduction to laser systems manufacturer to support on next stages of the project.

“The MTC have been excellent to work with. Everyone on the project was engaged from the start and incredibly proactive, and their passion and enthusiasm are reflected in what we've been able to achieve in a short space of time. The team also really understood the brief and identified a solution that not only met our technical objectives, but also our commercial and strategic objectives too.”

Douglas Campbell
Technical Director, Electroflight



ADDRESSING THE CHALLENGES FACED IN THE DESIGN & MANUFACTURE OF ELECTRIC MOTORS

THE CHALLENGE

Manufacturers are often seeking ways in which to evolve processes to improve the efficiency and effectiveness of both production techniques and solutions. Much of this is driven by the end user, and with electrical machines, there is a demand for greater mechanical power from more compact and lightweight devices.

In the world of electrification, mass is one of many critical performance parameters, and industry is seeing a drive towards customisation and bespoke components to deliver products sized for their specific application.

Through this project, the MTC sought to address these challenges by leveraging its own capabilities and that of its membership network and UK supply chain, to design, manufacture and assemble a high power-density electric motor prototype.

In order to best optimise the design and manufacture processes, the following areas of focus were identified:

- The use of smart design tools
- Component manufacturing technologies
- Automation and smart assembly workstations

“The scope of this project was such that it gave us the opportunity to explore new technologies within a real-world application, as well as the chance to utilise multiple tools and processes to deliver the end-to-end solution. We can now take our learnings from this work to support future R&D across UK industry.

Tom Cockerill
Chief Engineer, MTC

MTC'S SOLUTION

The MTC applied simulation toolsets provided by Siemens Digital Industries to generate and optimise the electro-magnetic, mechanical, and manufacturing design of the electric motor. The toolset allowed for rapid design iterations within a digital environment, so that designers could understand the influence of manufacturing process limitations on the expected performance of the motor.

The Computer-Aided Design [CAD] toolsets also allowed MTC designers to reduce the mass of the electric motor product and validate its structure for the calculated loading conditions. The same toolsets were then used to create engineering drawings to facilitate and communicate the design intent for manufacturing and assembly.

The electric motor was first manufactured using lowcost 3D printing to create a non-functional prototype, with a view to de-risking the manufacture of expensive metallic parts. This provided designers with the opportunity to experience the physical components and make an informed assessment as to whether design changes were required. In this case, a number of bespoke tooling or fixturing opportunities were identified and subsequently created to make the assembly process safer and more repeatable.

The MTC then used its in-house subtractive manufacturing and metrology inspection capabilities to create the first, fully-functional, electric motor prototype. Having access to state-of-the-art equipment, provided by DMG Mori and Hexagon Manufacturing Intelligence, gave the MTC an opportunity to critically assess all aspects of the design and manufacturing process. This has allowed further design and process recommendations to be made with a view to improving productivity, reducing costs, and de-risking the end-to-end process.

THE OUTCOME

In this demonstration, the digital toolsets from Siemens Digital Industries (e.g., Siemens NX and Simcenter Motorsolve) supported the MTC in developing a small, power-dense electric motor capable of 18kW mechanical output in a 7kg package.

The manufacturing and inspection capabilities of machinery provided by DMG Mori and Hexagon Manufacturing Intelligence allowed the MTC to rapidly manufacture, inspect, and then iterate the electric motor design.

The technologies provided by Bosch Rexroth AG also provided the MTC assembly process with intelligence and ensured 'Right First Time' production.

In addition, one of the key outcomes from this project is the successful demonstration of the local and UK supply chains in manufacturing high value electric machines. The programme's prototype has since become the foundation of future research and development activities across the MTC, with a view to showcasing the capabilities of the UK supply chain.

BENEFITS TO THE CLIENT

Having access to the state-of-the-art technologies, coupled with teams of researchers and manufacturing engineers, has provided a platform for the MTC to develop and prove manufacturing processes and technologies in a low-risk environment.



ENHANCING THE PERFORMANCE OF LI-ION BATTERIES IN HARSH ENVIRONMENTS

THE CHALLENGE

In recent years, there has been a growing demand for lithium-ion (Li-ion) batteries that have a longer lifetime and provide more consistent performance in harsh environment applications such as those found in the automotive, defence and oil exploration systems sectors.

Currently, in extreme atmospheric conditions, the expansion and contraction that the cell experiences cause a binder depletion between its current collector and its coated layer which results in delamination between the copper foil and its coated graphite, therefore causing significant reliability issues.

The challenge for the MTC was to exploit recent advancements in the laser processing of battery materials including the use of short, pulsed lasers to optimise Li-ion battery performance. The aim was to introduce different properties and restructure the surfaces inside Li-ion batteries to improve surface adhesion between the coated layer and the anode to ultimately reduce the possibility of failure.

“The reliability of Li-ion batteries in testing environments has long been under scrutiny and the question of how we can change the surface texture inside the cell to improve the performance has gone unanswered. However, through this project and the possibilities to alter the structure and characteristics of surfaces available through laser-based surface engineering technology, has shown that we can transform battery manufacturing and translate what we have learned across multiple sectors.

Reza Nekouie Esfahani
Senior Research Engineer, MTC

MTC'S SOLUTION

To address the challenge set out, engineers at the MTC utilised laser surface micro-texturing, a new, innovative process using ultra short, fast lasers that could achieve the desired performance benefits in the proof-of-concept demonstrator.

Firstly, the team completed a period of analysis on an off-the-shelf Li-ion battery to understand where the loss of performance was occurring and how this could be addressed.

Using laser surface micro-texturing, the team were able to create well defined and controlled structures on the surface of the anode to increase adhesion and improve bond strength which in doing so would better the quality of manufacturing in this high-energy anode material.

Through a series of further in-house tests to prove the validity of the solution, additional optimisations on the restructured surfaces were completed to enhance and prove the performance of the demonstrator battery in testing environments.

THE OUTCOME

The MTC used laser surface micro-texturing and an optimised laser setting to produce a new, micro-textured demonstrator battery that performs better under extreme conditions. The optimised battery showed a 32% improvement in the surface adhesion leading to a more robust and safer cell compared to the off-the-shelf Li-ion battery.

As a result of this project, the MTC has identified a high value manufacturing process that is a viable and scalable, alternative method to the current 'Roll-to-Roll' manufacturing process of the cells.

BENEFITS TO THE CLIENT

Through utilising an advanced laser-based surface engineering process, alongside the expertise of experienced researchers and engineers, the MTC has successfully demonstrated the positive impact that lasers can have on the performance of battery cells in extreme environments.

The integration of laser surface micro-texturing on the production line could also save time and make a vital performance change leading to the removal of calendaring from the current process and the use of more powerful lasers as surface texturing technology matures, improving the overall quality of Li-ion battery manufacturing.

Further to this, the MTC identified that this innovative process could be used to lengthen the life span of the battery and enhance how the cell manages heat by focusing on the texturing of the battery housing to allow the cell to charge under higher currents.

The project has also shown that laser surface microtexturing could provide wider benefits to other high value manufacturing industries. This process to improve the bond strength of adhesives could boost heat conduction in sectors where high-performance, thermal management units are used such as the aerospace, automotive and defence arenas. It could also support anti-fouling systems on propellers in the marine sector by creating surfaces with well-defined structures that are better for the environment and reduce pollution.

Overall, the creation of this new Li-ion battery demonstrator has shown that laser-based engineering processes could be vital to the development of Li-ion battery cells, and it has provided the MTC with an opportunity to work with its membership to explore how lasers could further influence UK manufacturing.



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THE TRANSFER OF KNOWLEDGE FROM THE TEAM AT THE MTC, AND OTHER PARTNERS, AND SPECIFIC DELIVERABLES OF THIS PROJECT HAVE BEEN VITAL CONTRIBUTIONS IN OUR PREPARATION FOR MANUFACTURE OF KEY BEV POWERTRAIN COMPONENTS. ULTIMATELY THIS WORK HAS GREATLY STRENGTHENED OUR POSITION AS WE SEEK TRANSITION TO EV POWERTRAIN PRODUCTION AND HELPED MOVE US TOWARDS THE ULTIMATE TARGET OF FULL ELECTRIFICATION.

Debora Mazzetta

Engines, Batteries and Drives Manager, Jaguar Land Rover

Case Study: Perseus – ICE to EDU

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UTILISING AUTOMATION TECHNOLOGIES TO ESTABLISH MAGTEC AS A TIER ONE AUTOMOTIVE SUPPLIER

THE CHALLENGE

Magtec, based in Rotherham, South Yorkshire, was founded in 1992 and develops, designs, manufactures, installs, repowers electric drive systems and components for a wide range of vehicle types. As a major force in the UK's electric vehicle (EV) supply chain, Magtec saw its new facility and the increasing requirements for its products as the ideal opportunity to take on the global market and become a tier one supplier.

Magtec identified that its current operation, including manual assembly and manufacturing processes, was not viable for international expansion. A £2.6 million grant from the Advanced Propulsion Centre enabled Magtec to work with the MTC, utilising experts in automation, power electronics and business transformation to advise on how the business could accelerate production to meet the growing demand for electric commercial vehicles.

“As the leading supplier in this country of electric drive systems and specialist hybrid solutions, we knew that we needed to engage industry specialists to increase our influence on the global sector. By working with MTC, we have made integral process improvements and upgrades to our motors as well as maximising the floor space at our new facility to help us to scale up our production capability and put us at the forefront of the high-tech design and manufacturing of electric drive systems and specialist hybrid solutions.

Andrew Gilligan
Managing Director, Magtec

MTC'S SOLUTION

Working in collaboration with Angel Trains, Dennis Eagle and the University of Sheffield Advanced Manufacturing Research Centre (AMRC), the MTC conducted the majority of the partner engagements using virtual conferencing due to the COVID-19 pandemic, utilising digital platforms to tour facilities, and conduct product and process workshops. This enabled up to 30 engineers at any one time to participate and advise, demonstrating the flexibility and cost effectiveness of digital solutions.

An important phase of the project was the discovery process with the MTC initially conducting a Technology and Manufacturing Readiness Level (TRL/MRL) assessment to gain an all-encompassing understanding of Magtec's current operation and to be able to identify what needed to be addressed to level up in the short and long term.

After identifying what could be done to automate current processes, the MTC also analysed the current motor and its assembly to advise on how to produce better quality and higher performing motors in a more automated fashion. This included upskilling stakeholders on more appropriate material choices and the assembly of the power electronics. This helped Magtec to recognise short term fixes as well as starting the business on its journey to a fully automated assembly and manufacturing solution that could produce more motors in an efficient manner.

To support with this and utilising its vendor agnostic approach, the MTC worked with Magtec on a thorough supply chain analysis to assess suitable, UK based suppliers of new materials and systems. This included vendor trials to analyse product effectiveness for a part of the new processes being implemented at the facility.

Aware that Magtec were in the process of moving to an all-new facility, the MTC also worked with partners to optimise process flows and drive design for manufacture to streamline the design and production solution.

The MTC created a digital factory environment which mapped the assembly process flows and visualised the full production line prior to transition from a manual to a fully automated facility. The digital factory environment also enabled the team to better maximise the floor space in Magtec's new facility and prepare for future production goals.



THE OUTCOME

- As a result of the ongoing project, Magtec now has the knowledge to produce over 2500 motors for electric and hybrid vehicles per year. This has the potential to scale up further towards the 5000 units per year target.
- Magtec successfully transitioned to its new 65,000sq ft facility with an improved factory floor layout that has also created a number of advanced manufacturing jobs as a result of the increased production requirements.
- MTC also supported Magtec to create a better performing and more easily manufactured power unit as a result of knowledge transfer work that encouraged Magtec to review some of its material choices and to implement new innovative automation technologies.
- The MTC worked closely with Magtec to upskill employees on the latest innovations in power electronics and automation to ensure they were ready to cope with the demand.

Our project with Magtec demonstrates the full breadth of the expertise that is available at the MTC for UK businesses, especially as we push towards a greener economy. In particular on this project, we have shown great flexibility in our approach and still been able to achieve the goals of the project and set another UK manufacturer on its way to a brighter future. Magtec are now better prepared to embrace future challenges from an operational and a skills perspective, while having products suitable for the international market.

Dr. Marc Henry
Business Development Manager, Electrification, MTC

BENEFITS TO THE CLIENT

- Magtec has increased its manufacturing productivity and is readying itself as a tier one supplier to the global automotive and transport industry. In doing so, it is levelling up the regional supply chain and strengthening the UK's position in the emerging global sector.
- For the wider UK electrification, transport and automotive sectors, projects like this are making a significant impact on the road to carbon neutral as UK manufacturing aims to meet the net zero goals set out by the UK government.
- Upgrading business operations and integrating new, innovative technologies throughout the wider supply chain also supports UK businesses to attract investment leading to improved employment opportunities and job development prospects for people living in the UK.



PERSEUS – ICE TO EDU

THE CHALLENGE

Jaguar Land Rover (JLR) are reimagining the future of modern luxury and it announced in 2017 its commitment that every Jaguar and Land Rover launched from 2020 would have electrified models available as part of its push towards 'Destination Zero.'

In November 2018, the successful JLR-led funding bid for project PERSEUS was announced, aimed at supporting the manufacturer and wider supply chain in transitioning to a flexible internal combustion engine (ICE) and electric drive unit (EDU) production line to address the variability in electric vehicle uptake in the UK. The successful bid was part of the Advanced Propulsion Centre (APC) 11 "Advancing the UK's Low Carbon Automotive Capability" competition.

The consortium JLR built with seven partners, including the MTC, aimed to prepare the existing ICE facility to become a flexible manufacturing line for ICE and electric vehicle (EV) production. Once complete, the adapted facility would allow JLR to ready for the changing product range and retain a customer demand focus.

To further our commitment towards Destination Zero, we wanted to use the PERSEUS project to continue to lead the way by advancing the electrification of one of our UK manufacturing facilities. The transfer of knowledge from the team at the MTC, and other partners, and specific deliverables of this project have been vital contributions in our preparation for manufacture of key BEV powertrain components. Ultimately this work has greatly strengthened our position as we seek transition to EV powertrain production and helped move us towards the ultimate target of full electrification.

Debora Mazzetta

Engines, Batteries and Drives Manager, Jaguar Land Rover

During the project in 2020, UK Government published its 10-point climate change plan, which announced that from 2030 new cars and vans powered by petrol and diesel will no longer be sold in the UK as part of the push towards net zero.

For the automotive industry, this seismic shift brings with it several obstacles that need to be overcome to integrate new, innovative powertrain technologies into existing production landscapes as well as levelling up the supply chains to meet the future demand from the mass market for electric vehicles.

MTC'S SOLUTION

The MTC working in collaboration with JW Froehlich, Mapel, HSSMI, Horizon Instruments, Fives Landis, Birmingham City University, all guided by JLR began the PERSEUS project with in-person meetings, facility tours and workshops. At the start of the pandemic the consortia successfully transitioned to virtual conferencing and increased the use of digital platforms; demonstrating the same flexibility needed to deliver a flexible ICE-EV production line.

The project aimed to break down every component of the electric drive unit (EDU) and MTC were able to advise on the manufacture and assembly processes including optimisation approaches. An important early phase of the project was the component-specific technology surveys focusing on the EDU.

These studies identified equipment, suppliers and enabled cross-consortia knowledge sharing, thereby upskilling all project team members involved. This would later be the starting point for the MTC's in-depth supply chain mapping study on the state of the UK, EU and international electric vehicle supply chain. The aim of the study was to look at the current capabilities as well as the knowledge gap to be able to build a greater understanding of the automotive sector and place MTC at the forefront to advise on its future.

This newly developed knowledge of the UK supply chain, in addition to existing strategic enablement expertise, was shared to create an all-encompassing strategy for JLR to transition to a fully flexible production line. Whilst also developing an understanding of the UK automotive supply chain capability, to increase the knowledge of the consortium.

This supported the significant undertaking by MTC project team, who provided knowledge transfer amongst the consortium, senior leadership teams and the wider workforce to build their understanding of power electronics and e-machines to ensure that they could then engage with the common language required to drive progress on the project.

To ensure a transition to EDU production was possible, consortium partners utilised the Advanced Propulsion Centre (APC) funding stream to develop their equipment and tooling through simulation, prototyping, physical trials, and knowledge transfer.

The JLR-led consortia collaboratively reviewed the existing EDU design, highlighted practical issues, identified ICE-EV cross-over points for existing equipment and created solutions for this complex challenge. Threaded throughout the project was an EV supply chain review conducted by the MTC, showing the huge UK manufacturing potential and existing growth opportunities to tap into.



THE OUTCOME

The PERSEUS project brought together teams of experts from multiple disciplines supporting to work across the multiple work packages. This JLR-led consortium successfully overcame the challenges presented over the course of the project, from pandemics to re-designs through to demonstrator manufacture delays.

A key aspect of the PERSEUS project involved the development of optimal component process flows to aid in factory floor planning; which were used to complement HSSMI's Production Line simulation models. This aimed to avoid costly investments in new equipment, the PERSEUS project team worked to establish which aspects of the existing manufacturing capability and equipment could be repurposed for EDU production, whilst also retaining the capability to manufacture ICEs.

Through the extensive technology surveys, not all the initial existing technology was found to be supportive of a flexible production line. This opened the door to other equipment and technologies including adaption of existing laser processing equipment for novel EDU applications. The MTC leaned on its internal Laser Processing team to join the project to assess concepts and conduct trials as part of the development work.

The MTC were able to support members of the consortium build custom machinery, alongside their own demonstrators, including a new special purpose conductor-forming machine. Designed to validate essential modelling and simulation, and further explore the unit's thermal and electrical conductivity capabilities that will ultimately lead to enhanced EDU performance. These demonstrator pieces can be seen in the electrification are of the MTC workshop.

Regular information sharing sessions amongst the consortium enhanced the knowledge transfer aspect of the project. As well as supported Birmingham City University in the development of Continuous Professional Development (CPD) courses for other staff within the partnering companies. These courses were created with the overall aim of targeting upskilling across the automotive industry with the rise of electric vehicle manufacture; the CPD courses are anticipated to launch to industry access in 2022.

The MTC also completed a thorough supply chain analysis and obtained a wider understanding of the capabilities within the supply chain for electric vehicles. Subsequently this exercise has given MTC a detailed understanding on the challenges faced and the next steps to prepare the UK automotive industry for a future powered by electric vehicles.

BENEFITS TO THE CLIENT

The work of the PERSEUS project has enabled the following to be achieved:

- The consortium and key stakeholders at these organisations have enhanced their knowledge of Electric Drive Units, enabling these organisations to better position themselves for the future.
- Road test a new set of Continuous Professional Development (CPD) courses alongside other consortia members, created by BCU. Expecting to be launched to the wider industry in 2022. [ref: The PERSEUS project - School of Engineering and the Built Environment | Birmingham City University [bcu.ac.uk]]
- JLR better understands what it needs to do to prepare for the transition into an EDU production line and fully flexible facility.

The project benefits were not limited to the consortia. The direct results of the UK Supply Chain Mapping Study have been shared with APC to create a heightened understanding of the current state of the electrification and electric vehicle supply chains. This should enable future funding to be targeted at the key areas for UK manufacturing. Key aspects of the study included:

- The current potential of the supply chain.
- Insight directly from industry on what needs to be addressed to be able to cope with the increasing mass demand for EDUs and electric vehicles.
- How to future-proof the supply chain by methods such as strategic enablement, knowledge transfer and upskilling.

The knowledge and expertise developed by the MTC is not only transferrable across the UK's Automotive Sector, but also to other sectors in the quest to minimise their carbon footprint by adopting electrification technologies. Involvement in this project has placed the MTC as a thought-leader for the manufacturing technologies required for industrialisation and scale-up of production of Power Electronics, Machines and Drives [PEMD] within the UK.



The APC is proud to have supported a project that prepares the UK's manufacturing capability for the net-zero future. The PERSEUS project has enabled Jaguar Land Rover and manufacturing equipment suppliers to investigate, develop, and prove out processes that allow engine facilities to convert to making electric drive units. The consortium of companies delivering the PERSEUS project have collaborated to build relationships, develop knowledge, and secure UK jobs.

Dan Fung
Head of Strategy and Planning, APC UK

UK BATTERY MANUFACTURING: SUPPLY CHAIN DISCOVERY AND MAPPING

THE CHALLENGE

The global demand for batteries is forecast to be worth \$310bn by 2027, covering the automotive, surface transport and power & energy sectors. With 84% of UK battery companies looking to move pieces of their supply chain closer to home, it's clear there are many opportunities within battery manufacturing in the UK. Development of both capability and capacity are key to ensure the UK's position in a global battery supply chain.

Research and development into all aspects of battery systems has grown to cover a wide range of topics, from electrolyte materials to improved chargers and novel vehicle-to-grid business models.

This project aimed to understand the current status of UK industry and research in the UK.

MTC'S SOLUTION

The MTC sought to take a fresh look at the battery landscape within the UK to understand the current players, geographic distribution of capacity and any gaps.

Following the process created in the original wide reaching EV Market review, conducted during the Perseus project in 2020. This latest review aimed to identify new entrants based within the UK and key components on the bill of materials, whilst highlighting the expansion in research and development activities.

THE OUTCOME

- A searchable database of organisation who are currently, or could be transitioned to, support the the battery manufacturing supply chain within the UK. From material suppliers to pack assemblers, including SMEs, large organisations, multinationals, Universities and RTOs.
- Identification of the most active areas of UK battery R&D from 2007 to 2027. The total R&D investment was found to be £846M over this period in TRL1-5 work.
- A heat map showing the geographic spread of the UK battery supply chain.

BENEFITS TO THE CLIENT

- An understanding of the current state of battery manufacturing in the UK which allows the MTC to signpost between organisations.
- Creation of a network of companies within the battery supply chain which can be leveraged for development of new products or to build consortia for collaborative R&D.
- Identification of quantifiable gaps in capability or capacity within UK battery manufacturing which supports the business justification for future R&D.

“Studies such as this are critical in understanding the UK and global market place. By completing landscape reviews the MTC has greater clarity around supply chain capabilities and is able to dig deeper into the untapped potential within that sector. Utilising this technical and commercial understanding greatly enhances the advice and steer we can provide to our customers and partners ensuring they come away with the best solutions.

Dr. Marc Henry
Business Development Manager, Electrification, MTC



Get in touch today to discover how the MTC can help your business.

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