Independently Powered Electrical Multiple Units (IPEMU) Proof of Concept

Full Business Case

Merseytravel Rolling Stock Programme

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Liverpool City Region Combined Authority – Strategic Investment Fund

Final Business Case for November 2019 Investment Panel

Project Summary Table

Name of Project	**Independently Powered Electrical Multiple Units (IPEMU) Proof of Concept**
Sponsor	Merseytravel
Nature of Applicant	Passenger Transport Executive
Economic Sector	Transport
Indicative Funding Sought	£3.5m
Indicative Funding Source/Fund	Transforming Cities Fund (TCF)
Location	LCR Wide
Call or Commission	Commission

Combined Authority and LEP Project Team

SIF Investment Team Lead	Paul Buntin
Investment Team Members	Sam Graham, Nick Green
Legal Lead	Jan Leong
CA Policy Input	Huw Jenkins – Lead Officer for Transport

1. Summary of Investment Team Considerations

The project, at concept stage, was endorsed by the external panel in October 2019. The panel discussions focussed on three key areas which have been addressed as follows:

- **How the trial will work in practice**: Merseytravel and Stadler, the supplier, have agreed a full delivery and monitoring plan. This will see the trial of 2 teams, running trains through the night to prove the concept and report on the benefits achieved.
- **External appraisal**: An independent appraisal of the proposed investment has been undertaken on behalf of the CA. The appraisal deemed the business case to be proportionate and adequate.
- **Ensuring regulatory consent for passenger operations**: Regulatory consent to operate the trial has been granted. At the end of the trial, Merseytravel will apply for consent to operate with passengers onboard. This is explored further in section 6.2

If the panel are satisfied with the above, then endorsement is sought to proceed to the CA for approval.

2. Project Overview

2.1 Background

The Merseyrail network is operated by Merseytravel under a concession contract. The network is electrified and powered by "third rail". Third rail systems are a means of providing electric traction power to trains. They use an additional rail (called a "conductor rail"). The new rolling stock trains are compatible with third rail.

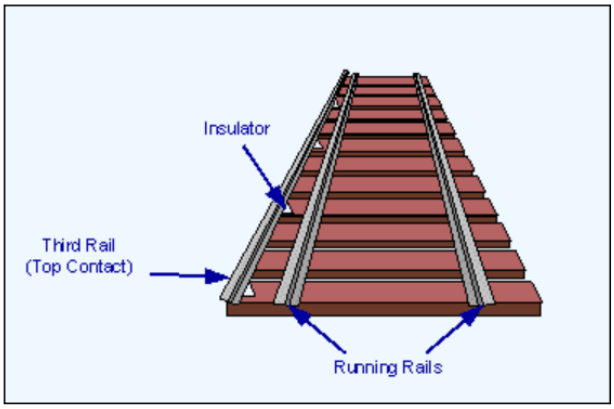

Figure 2.1 Third Rail

The Merseytravel Long Term Rail Strategy (LTRS) identifies several, mostly unelectrified routes, which link to the Merseyrail network. Due to Merseyrail being electrified travelling between these destinations requires passengers to change trains before they come into the Merseyrail network. The unelectrified routes would benefit from having direct Merseyrail services. To achieve this, the third rail would need to be installed along the full routes at substantial costs. These routes include for example:

- Ormskirk to Preston;
- Kirkby to Headbolt Lane/Skelmersdale/Wigan; and
- Hunts Cross to Warrington.

The concept of using battery technology, rather than third rail, on the lines has been identified as a cost effective, potential solution to extending the reach of Merseyrail trains. This technology is known as Independently Powered Electrical Multiple Units (IPEMU).

2.2 Project Description

Merseytravel wish to run a trial of IPEMU to:

a) test the concept of using battery power; and

b) assess the suitability of the technology to deliver the LTRS ambition of extending the geographic reach of the Merseyrail trains.

This is an opportunity to develop a new train fuel technology that could have major benefits for the LCR in terms of network expansion, efficiency and the potential for new rail stations.

Merseyrail own the current fleet of rolling stock which is now 40-years-old. This rolling stock is being replaced with a modern fleet of 52 Class 777 trains which will be owned by Merseytravel. The new fleet will be introduced over the course of 2020/21 and will be both third rail and overhead line compatible. There is also an option in the rolling stock contract for up to an additional 60 units to be purchased. The additional 60 units would permit the Class 777s to be deployed on any of the network expansion routes identified in the LTRS.

The new trains are lightweight (slightly over 100t) and have space in the underframe where the batteries can be fitted. The aim of the battery trial is to identify how much energy they will be able to store and how far this will allow the trains to travel. There are no current estimates on how far the battery can run, this is the purpose of the trial. When a train brakes, energy is created, and the battery technology allows this energy to be captured, stored and then used as the train accelerates. The challenge previously has been how to capture and then re-use the energy captured.

This is expected to lead to a significant reduction in the trains net energy consumption. Reduced energy consumption will deliver a financial saving and a reduction in the railway's carbon footprint.

2.3 Indicative Timescales

Assuming Investment panel endorsement, the timetable is as follows:

Final paper	November 2019
CA approval	December 2019
Grant funding agreement	January 2020
Commence testing	March 2020
Review outcomes of initial testing	December 2020
Complete trial	June 2021

3. Strategic Case

3.1 Case For Change

Without using battery technology on trains to expand the current network and run new services, third rail would have to be used. This is not only costly but also not encouraged from a policy point of view. The Office of Rail and Road (ORR) "considers that the weight of safety evidence creates a presumption against new-build or extended third rail being reasonably practical." The ORR do not discount expansion or new 3rd rail infrastructure but put the onus on the duty holder to continually review and seek improvements to 3rd rail infrastructure.

This would suggest that an alternative means of powering trains, such as IPEMU, on neighbouring networks would be needed but this would need to be compatible with Merseyrail trains to ensure seamless running in the future.

3.2 Fit with Investment Strategy

The project is closely aligned with the SIF Investment Strategy:

- Advanced manufacturing – the project will support research in a developing technology. The development of emerging technologies can help develop future skills for the workforce who are implementing the battery trial.
- Low Carbon – the trial of battery technology will aim to develop an alternative energy use to that currently used on the Merseyrail network.
- Place – the project will aim to improve access to the Merseyrail network by making the need to invest in the third rail redundant. This will also reduce the cost of any new stations that are built, if all trains operating in the region are IPEMU.

3.3 Fit with Other Priorities

The LCR was awarded £172m to fund innovative transport projects through the Transforming Cities Fund (TCF). The CA approved three key themes it wanted the money to deliver against. This project fits with Theme 1: Enhancing and expanding the public transport network to meet new areas of demand and Theme 3: Intervening for health and wellbeing.

3.3.1 Headbolt Lane Gateway

As part of the TCF, the CA commissioned the development of a new rail station at Headbolt Lane in Knowsley. The Headbolt Lane project is being developed to outline business case and it is anticipated that this will be presented to panel late 2020. The station will offer a regular 15-minute service for the Tower Hill and Northwood areas of Kirkby. Currently, there is no station servicing the area.

Figure 3.1 Location of proposed station at Headbolt Lane

The line that passes through the proposed Headbolt Lane Station is single track, meaning that for the 15-minute service to be maintained a double track section would needed. A new section of 750V d.c. third rail would need to be installed to support the new double track section, which is approximately 2 miles. Merseytravel aim to complete the battery trial before

the development of Headbolt Lane Station. If the trial is successful, then the technology can be used on trains using this section of the Northern Line. This would in turn lead to a saving of circa £10m on third rail infrastructure.

3.4 Objectives

The objective of the project is to demonstrate that using IPEMU is a technically and commercially viable option to facilitate the expansion of the Merseyrail network.

3.5 Outcomes of Options Analysis

Please refer to Appendix 1 for a summary of options considered.

3.6 Critical Success Factors

The success of the project in achieving this objective will be measured by the following criteria:

1. Confirmation of technical feasibility
2. Determination of IPEMU range (km)
3. Unit performance (acceleration, braking etc)
4. Battery life (years)
5. Securing regulatory authority to run in passenger service
6. Savings from reduced energy consumption (£, tonnes of CO_2)

3.7 Equality and Diversity and Inclusive Growth

The sponsor has completed the social value questionnaire and is committed to inclusive growth and sustainability through the following measures:

- All Merseytravel staff engaged in the delivery of the project earn more than the real living wage.
- Stadler, who are the key supplier in this regard, have signed the Project Collaboration Agreement, which adheres to Merseytravel's Responsible Procurement Plan.
- Stadler is committed to ensuring that small and medium sized enterprises (SMEs), black, Asian and minority ethnic (BAMEs) businesses, and suppliers from other under-represented groups or demonstrating a diverse workforce composition, have fair access to supply this programme.

4. Economic Case

4.1 Appraisal Results

An independent appraisal of the proposed investment has been undertaken on behalf of the CA. The appraisal deemed the business case to be proportionate and adequate.

The outcomes from the trial will determine whether battery technology can be deployed as a motive force for expansion of the Merseyrail network. From the cost model, savings of between £32.4 and £53.5m are estimated from the deployment of the IPEMU battery powered rolling stock over those where motive force is provided by A/C or D/C. Further details are provided in Annex 2.

5. Financial Case

5.1 Business Plan

The project involves working in partnership with Stadler, the rolling stock manufacturer to select and test battery technologies that can fulfill the objectives of the Merseytravel LTRS. The relevant contracts are already in place with Stadler as part of the Merseyrail Fleet Replacement Programme and the project would be added to the portfolio of projects within the Programme and managed by the team who are already in place. The table below sets out the timetable of the project against milestones.

Table 5.1 Project milestones table

	Milestone	Completion date
1	Identification of technologies and possible suppliers (via Stadler)	January 2020
2	Development of design concept including cooling and integration with the Class 777 propulsion/braking systems	March 2020
3	Completion of laboratory-based testing to select the most appropriate battery technology and supplier	September 2020
4	Fitment of at least one Class 777 unit with the selected technology and completion of a programme of trials	December 2020
5	Securing the necessary regulatory consent to be able to convert Class 777 to IPEMU operation and run in passenger operation	March 2021
6	Confirmation of the routes within the LTRS which could be realistically served by IPEMUs	June 2021
7	Confirmation of the key characteristics to allow motive power choices to be made when considering expansion of Merseyrail services. This will include: range, battery life, train performance, costs and energy/carbon savings	June 2021

This will see the trial of 2 teams, running trains through the night to prove the concept and report on the benefits achieved. The critical success factors identified above, will be tested with clear decision gateways to be passed. This will allow the project team to establish a set of technical and financial parameters for the implementation of the technology. If the trial is a success and all the new fleet are equipped with the battery technology, this will shape future decisions over the expansion of the network.

5.2 Funding Sought and Proposed Key Terms

Grant funding of £3.5m is sought. The project will be 100% grant funded by the CA through the Transforming Cities Fund. A draft Grant Funding Agreement has been created by legal using standard SIF Transport Schemes template. Claims will be quarterly in arrears and subject to delivering the agreed outputs from the business case. The Corporate PMO will provide Assurance Management of the contract and delivery of the outputs.

The table below shows the costs associated with the trial (provided by Stadler as part of the original procurement) and how they are broken down across the 18-month programme.

Table 5.2 Cost breakdown of trial

Elements of trial	**2020**	**2021**
Materials	£2,010,279	
Engineering Development Costs	£666,667	£333,333
Project Management – Merseytravel	£180,000	£90,000
Birmingham University – battery expertise	£10,000	
Path & Staff for Out of Service Tests		£150,000
Contingency		£100,000
Annual Total	£2,866,946	£673,333
Overall Total	**£3,540,279**	

5.3 Risks and Mitigation

In line with the arrangements within the Rolling Stock Programme, a full risk register has been created for this project. The most significant risks are summarised below.

Risks to CA

Risk	**Probability & Impact**	**Potential Mitigation**
Concept is unproven	Possible and would lead to IPEMU being discounted as a viable choice of motive power at this time	Rigorous project management and application of best engineering practice.

Delivery Risks

Risk	**Probability & Impact**	**Potential Mitigation**
Funding	Possible and would lead to inability to proceed	Approval of this business case and subsequent submissions
Safety	Unlikely but could lead to project being aborted	Careful choice of battery technology and associated cooling system
Regulatory Acceptance	Unlikely but could lead to permission to run in passenger service being denied	Build on existing dialogue with key stakeholders, particularly ORR
Resources	Possible and would cause delay	Stadler and supplier resources are critical. Committed plans will be required.

5.4 Diligence and Legal Commentary

We have scrutinised the IPEMU scheme and wider rolling stock delivery programme as per our assurance framework, we are confident that delivery is achievable in the timeline provided.

A funding agreement has been prepared by the CA's legal team. Project milestones have been included in the funding agreement, securing regulatory consent for IPEMU powered trains to run with passengers cannot be concluded until after the trial. Securing consent will not impact on the trial.

The project can be undertaken within the existing Manufacturing and Supply Agreement (MSA) between Merseytravel and Stadler. An option to undertake a trial of this nature has been included within the contract, which came into effect in February 2017.

6. Management Case

6.1 Deliverability and Leadership

The project naturally fits within the Rolling Stock Programme. The governance and project control processes for this programme are mature with a hierarchy of working groups, Operational Programme Board, Merseytravel Executive and Combined Authority.

The programme is led by a dedicated programme director, David Powell, Programme Director Rolling Stock. The responsible officer is John Fogarty, Director of Corporate Services for the CA, who chairs the Operational Programme Board.

Collaborative working arrangements have been a characteristic of the rolling stock programme which have led to the development of the rolling stock so far being successfully delivered within budget.

A detailed management case has been provided by the sponsor.

6.2 Regulatory consent

Consent has been granted for the IPEMU trial. Merseytravel will work with the Office of Road and Rail (ORR) to gain regulatory consent for using the IPEMU concept on passenger trains following the proof of concept. A positive dialogue has been maintained between the sponsor, the ORR, Network Rail (infrastructure manager) and Stadler throughout the seven-year development of the rolling stock programme.

This collaborative approach has shaped the development of the overall rolling stock programme, including IPEMU. Confidence is high that id the trial is successful consent can be gained to introduce batteries onto the passenger network.

7. Further Considerations

7.1 State Aid

There are no state aid implications for this project because it is a public sector transport investment.

Appendix 1 – Options Considered

Option	Description	Advantages	Disadvantages
Do nothing	Continue with the existing fleet		Fleet will eventually become redundant and have no technological improvements.
Do something	Continue to introduce new fleet but do not trial battery technology		Motive power choice for Merseyrail expansion is limited to 750V 3rd rail or 25kV overhead
Preferred Option	Undertake IPEMU proof of concept project	Enables fully informed decision making when selecting motive power. Potential for significant capital and operational cost savings Reduced delivery timescales for route expansion projects	None

Commentary: The choice of options is binary: either undertake the project or don't. No realistic delivery method, other than exercising the option within the Manufacturing and Supply Agreement (MSA) between Merseytravel and Stadler has been identified.

Appendix 2 – Economic Appraisal Results

Clearly, there is a 'value' to this information in the wider context of delivering the Long Term Rail Strategy (LTRS); however, it is not possible to monetise the direct study outcomes in a conventional manner.

For the purpose of the appraisal, the cost model prepared by the scheme sponsor has been used to estimate the costs (in terms of both capital and operating costs) of extension of the Merseyrail network by:

a) Electrification by A/C - i.e. trains powered via overhead power lines (such an option is available on the new trains);
b) Electrification by D/C - i.e. trains powered via third rail (the current method); and
c) Deployment of rolling stock equipped with IPEMU battery technology

Clearly, the outcome from the proposed trial would determine whether option c) was a viable alternative over A/C or D/C.

From the cost model savings between **£32.4-53.5M** are estimated from the deployment of the IPEMU battery powered rolling stock over those where motive force is provided by A/C or D/C.

After accounting for optimism bias and discounting the adjusted costs to 2019, the savings are **£60.7-86.9M (**see Annex 2).

Cost Savings of IPEMU over Electrification by A/C and D/C (appraised from 2019-2063)

Power Source	Cost Saving of IPEMU Battery	Discounted Cost Savings (adjusted for optimism bias)
A/C	£53.5 M	£86.9 M
D/C	£32.4 M	£60.7 M

It is evident that *should* the trial of the battery technology have a positive outcome and report that IPEMU is technically viable, then deployment of such technology to extend the Merseyrail network has the potential to deliver significant cost savings to the operator.

It is important to note that the estimated cost savings are many times greater than the cost of the trial itself (£3.5M). Hence, for a relatively small outlay there is a potential to leverage significant savings on the public purse (through reductions in subsidy).

Such savings would reduce the level of subsidy from the public purse.