TfEM:
EMR Regional Fleet Renewal

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SYSTRA

EMR Regional Fleet Renewal

East Midlands Railway (EMR) regional services are operated by two fleets. The first is a 26-strong two-car Class 158 fleet. These trains are approaching 35 years old and, as we will see, are starting to face issues around obsolescence. The remainder of the fleet is formed of 43 Class 170 units which are around 25 years old. These are a mixture of two- and three-car sets and have joined EMR over the last five years, replacing older Sprinter classes.

Both fleets are going through a process of refurbishment of passenger accommodation, which will provide an acceptable offer in the short to medium term. However, in the case of the Class 158s in particular, there is a need to consider longer term replacement with an objective of both addressing the need to decarbonise the fleet, whilst also providing sufficient capacity for a growing railway.

On the following slides we set out the rationale for replacement and the short- and long-term opportunities that exist.

Class 158		Class 170
1989-92	Years built	1998-2004
26*2-car	Fleet size	27*2-car 16*3-car
2-car: 146	Seating capacity	2-car: 122 3-car: 172
90	Max speed (mph)	100

The Fleet Challenge

The split fleet, which has two age profiles, adds to a wider challenge around its renewal as it creates a need for an earlier intervention to replace part of the fleet. The Class 158 fleet is reaching a point where there are challenges to its continued operation (as outlined in the table below), though some operators are refurbishing fleets to life extend them to the mid-2030s.

The Class 170 fleet could, in principle, continue in operation until 2040, by which point replacement with a decarbonised fleet would be necessary. The table below defines the specific issues with the current fleet and issues to be considered around its renewal.

Current fleet challenges

Class 158

- The trains will not be equipped with ETCS, precluding their use on the ECML between Grantham and Peterborough post-2030.
- Obsolescence around spares is becoming an issue as well as risk around aluminium fatigue.
- The units are likely to have to continue until the early 2030s given lead times for new trains, unless replacement by cascade can be achieved.
- The units were designed for long distance inter-urban work and are not well laid out for shorter urban services.
- It should be noted that, assuming sufficient spares can be sourced, there is no technical reason for the trains to continue on non-ETCS routes until the mid-2030s.

Class 170

- Class 170 could continue until 2040. Withdrawal in the early 2030s would leave the trains with some residual value that is unlikely to be recognised as further opportunities for cascade may be limited by that point.
- Class 170 will be equipped with ETCS but could potentially be suffering obsolescence issues by the late 2030s.
- This creates a need for a trade off between single fleet renewal or a staged approach where 158s are replaced first. Key to this will be the realistic point at which Class 158 could be replaced in any form.
- The fleet was designed for longer distance inter-urban work – this makes them suitable for Liverpool–Norwich and some other longer regional services, but their poor acceleration hampers the potential of routes with lots of stops (e.g. Robin Hood line).

Fleet Renewal Objectives

Whilst fleet renewal in some form is inevitable at some point, there are opportunities to address wider policy objectives as part of renewal, and addressing these can help form the basis for the decision on the most suitable approach. The key objectives are:

- **Decarbonisation** – Continuing with a 100% diesel fleet is not sustainable in the long run – the challenge is what approach to take to decarbonisation.
- **Connectivity** – There is a question whether journey times can be improved with more powerful trains capable of higher speeds or better acceleration. It is also an opportunity to review the fleet size required based on future services structures with higher frequency services or new links. The emergence of GBR may also produce opportunities for services to be remapped between different parts of GBR, further increasing the size of the current EMR Regional services
- **Capacity** – Providing a fleet that can meet future demand.
- **Accessibility** – Whilst all trains in use are compliant with PRM requirements there is a desire to push this further and provide level boarding for an improved passenger experience for all groups.
- **Reliability** – Are the trains currently in use reliable and would future fleets deliver an improved service? An aspect of this is the compatibility between the current fleets which provide operators with greater flexibility to manage the service.

We have included the above in a RAG assessment of options. An issue affecting all options assessed is the impact on net subsidy for the industry, with considerable pressure from the DfT to reduce cost and increase revenue. It is difficult to assess the impact on net subsidy in this context when comparing these options as whilst, for example, retention of Class 158 might be lower cost in the short term, full fleet replacement with, for example BEMUs, might generate more revenue due to reduced journey times and have lower operating costs but higher lease costs. We have therefore not provided commentary on net subsidy impacts.

Approaches to Renewal

There are several approaches to fleet renewal, the detail of which we explore in more detail in the following slides. These can be summarised as follows:

1. Cascade of existing DMUs from other routes, to replace Class 158 only. Long-term fleet replacement deferred until the late 2030s when Class 170 becomes life expired.
    - This could be achieved either via a direct cascade bringing in a new type of train or indirectly allowing more Class 170s to join the fleet.
2. Introduction of a new fleet in the short term, using diesel or diesel-electric bi-mode technology to replace a portion of the existing fleet, allowing the Class 158 fleet to be withdrawn. A variant of this would be to introduce new DMUs.
3. Retention of the current fleet until the early 2030s, followed by either of:
    - Delivery of a battery train fleet with discontinuous electrification/static chargers.
    - As above, but supported with electrification of Wigston–Sheffield/Nottingham, Derby–Birmingham and Nottingham–Clay Cross, reducing battery reliance and removing static chargers.
    - Full electrification.
4. Combination of points 1 and 3 with cascaded rolling stock being replaced comparatively quickly.

The approaches above work on an assumption that delivery of a fully decarbonised fleet does not occur until the early to mid-2030s. This assumption is driven both by procurement and production lead times (typically four years from order to deployment in service), but also an assumption that other Regional TOCs with older fleets (Northern/GWR) will be a priority for fleet renewal in the short-term at a time when funding is constrained.

Option 1A: Direct DMU Cascade (1)

The options for a direct cascade of DMUs to EMR are comparatively limited. Known fleet replacements that could release DMUs to EMR involve ScotRail, Northern, Great Western Railway and TransPennine Express (TPE). Of these, all but TPE would result in the scrapping of DMUs as the fleets released (primarily Class 150 and 156) would all be over 40 years old by the point of renewal.

However, TPE is planning to purchase new trains as part of the TransPennine Route Upgrade. Assuming Class 185s were retained on South TransPennine services, around 30 units would become available in the early 2030s. This would be sufficient to replace the entire Class 158 fleet at EMR.

The trains are currently equipped with First Class accommodation and are designed for longer inter-urban flows. This would make the trains suitable for longer distance services such as Liverpool–Norwich, which requires around 20 trains to operate. Were the units to operate this route, there would be the case to explore if operation of the service should move from EMR to TPE as this would allow the trains to be managed as a single fleet retained at their current base at Ardwick depot in Manchester.

Operating the units on a single discrete route would avoid having to mix Class 170 and Class 185 on the same routes as the two fleets are entirely incompatible, unlike the Class 158 and 170 fleets.

	Class 185
Years built	2006
Fleet size	~30*3-car available
Seating capacity	3 car: 169
Max speed (mph)	100

Option 1A: Direct DMU Cascade (2)

With 19 trains required for the Liverpool–Norwich route, work would have to be found for a number of additional units to replace all Class 158s. This could be achieved either by identifying another dedicated Class 185 route or by a cascade of units involving Northern.

The Nottingham–Skegness route might be suitable as a dedicated EMR route, with five units required in service across the year, but with a need to increase capacity in the summer where a pair of Class 185s could be operated.

An alternative approach would be for Class 185s to be utilised on some services that Northern currently operate with Class 170s. These Class 170s could then be cascaded to EMR. This would provide EMR with a fleet of Class 185s for Liverpool – Norwich, a route to which they would be well suited with Class 170s available for other routes.

Objective	Commentary	RAG
Decarbonisation	The units are heavy relative to Class 158/170 and will therefore increase fuel consumption relative to the current service.	
Connectivity	The trains operate at comparable speeds to Class 158/170. However, they are unable to operate under SP/MU speed differentials. Therefore, work would be required to explore if differentials could be removed or an HST differential applied.	
Capacity	The trains have similar capacity to a three-car Class 170 but would allow an overall increase in the number of vehicles operating services. They currently have First Class but this could be removed.	
Accessibility	The trains are PRM-compliant but do not provide level boarding.	
Reliability	The trains are known to be very reliable, achieving high mileages between failures.	

Option 1B: Indirect DMU Cascade

An alternative cascade would be to transfer the Class 185s released from TPE to CrossCountry. This would release 22 three-car and 7 two-car Class 170s, providing sufficient units to replace the Class 158s. The effect of this would be to boost capacity by increasing the number of three-car trains in the EMR fleet by 22, and also provide a standardised Regional fleet for EMR.

The limitation of this approach for CrossCountry would be the need to manage a fleet cascade that would not significantly increase its own fleet size. However, with GBR in place, this approach is more likely to be successful than it would have been under the previous more fragmented structure.

The objective assessment below is undertaken from an EMR perspective.

Objective	Commentary	RAG
Decarbonisation	Class 170s have comparable carbon emission to the Class 158s they would replace.	
Connectivity	Journey times would remain as now.	
Capacity	Transfer of XC Class 170s would increase the fleet size by at least 22 vehicles.	
Accessibility	The trains are PRM-compliant but do not provide level boarding.	
Reliability	The trains could be expected to be as reliable as the current EMR fleet, perhaps with a marginal increase in performance as fleet staff would only have to maintain a single fleet.	

Option 2A: New Build Diesel Bi-Mode

An alternative to a cascade would be an order for a new build bi-mode fleet targeted at the Norwich–Liverpool route. This would be designed to improve connectivity and passenger comfort on a long distance route, with potential for growth. The most operationally efficient approach would be to order additional Hitachi Class 810 units as a follow-on to those being delivered for EMR Intercity services, though the production line for these trains is now closed. However, other manufacturers – notably CAF who are building similar trains for LNER, Stadler who have a bi-mode currently used by Greater Anglia and TfW, and Siemens whose bi-mode fleet is now in service in Germany – could also supply such trains. This option would allow 20 Class 158s to be withdrawn, leaving a shortfall of six trains.

One challenge with this option is that it will significantly increase operating costs east of Nottingham, where typically two- or three-car trains operate, with four- or six-car trains west of Nottingham; this option would replace all services with five-car trains.

Objective	Commentary	RAG
Decarbonisation	Although bi-mode, the trains would consume greater volumes of fuel than Class 170s when running on diesel and there are only limited sections of the route that are currently electrified.	
Connectivity	Journey times would be reduced using trains with better acceleration and, on certain sections, higher maximum speeds.	
Capacity	Seating capacity would increase east of Nottingham.	
Accessibility	The trains are PRM-compliant but do not provide level boarding.	
Reliability	Fleet reliability should be as good as current trains but may not be exceeded due to the additional complexity of the trains.	

Option 2B: New Build DMU

An alternative option for the short- and medium-term would be to order new build DMUs, with the existing Class 170s cascaded elsewhere and the Class 158s withdrawn. The options would provide a single modern fleet for the region. However, there would be a number of drawbacks to this approach. Firstly, whilst the acceleration of the trains would be better than current DMUs, it would be worse than an electric alternative. Secondly, the trains would have a higher fuel consumption than the current units. Furthermore, and critically, by obtaining new DMUs at this juncture, full decarbonisation and the connectivity benefits of battery or electric traction would be deferred for a very long time, as there would be few, if any, opportunities to cascade the trains elsewhere. Therefore, the trains would likely continue in traffic well beyond 2040.

It is also worth noting that there is an uncertainty whether there would be appetite from manufacturers to supply such a fleet given the decarbonisation agenda, potentially leaving very limited routes in the supply chain to progress this option.

Objective	Commentary	RAG
Decarbonisation	Greater fuel consumption than existing trains, plus purchasing new DMUs at this point will extend the use of diesels for many years.	
Connectivity	Journey times would be very marginally reduced.	
Capacity	The fleet could be delivered to provide an all three-car operation.	
Accessibility	Level boarding has not been achieved with any contemporary UK designs; it is unlikely it would be provided for a new order with limited prospects for further units being delivered.	
Reliability	Fleet reliability should be as good as current trains but may not be exceeded due to the additional complexity of the trains.	

Option 3A: Battery Electric Multiple Unit (1)

A medium-term option would be to order a fleet of Battery Electric Multiple Units (BEMUs). Battery technology at the current time gives an operational range of 60 to 100 miles between charges, with this figure continuing to improve. Indeed, tests in Europe indicate ranges could be as high as 140 miles[1], although it should be noted that the larger loading gauge in Europe gives more space for batteries. Furthermore, more batteries add weight, increasing energy consumption and axle load, which can damage the track. Therefore, battery capacity provided should be tailored appropriately to a fleet depending on need.

The technology is relatively untested in the UK, bringing a certain level of uncertainty regarding its reliability for passenger services. However, the nature of the technology with fewer moving parts would indicate comparable reliability to diesel units as a minimum.

To introduce battery operation over the EMR network, charging infrastructure would be required. This could take two forms:

- Combination of static chargers at terminals and some intermediate stations (likely >2MW chargers to ensure suitable re-charge times), supported by discontinuous electrification on longer sections.
- Increased level of electrification on the core network for long distance services and freight. This would reduce the number of charging facilities required.

The use of battery trains would, relative to DMUs, reduce journey times due to better acceleration, fully decarbonise the fleet, allow an increase in capacity and provide a low floor option, helping to improve the platform train interface.

The second option described above would add further benefits to the case for electrification of the north end of the Midland Mainline, the Derby–Birmingham line, and would add value to freight electrification schemes such as the Joint Line between Peterborough and Doncaster.

It should be noted that the Liverpool-Norwich service may not currently be viable for BEMU operation due to the distances and potential need for discontinuous electrification in East Anglia. Therefore, this route may need to continue with Class 170s in the short to medium term.

[1]Tests of Stadler-built BEMUs in Germany

Option 3A: Battery Electric Multiple Unit (2)

Objective	Commentary	RAG
Decarbonisation	The trains would allow full decarbonisation of the network.	
Connectivity	Journey times would be reduced as a result of better acceleration.	
Capacity	The fleet size could be tailored to meet route requirements, including new routes such as the Maid Marion Line.	
Accessibility	With options for low floor trains, improvements could be made to the platform train interface.	
Reliability	Fleet reliability should be better than current trains as electric trains are typically more reliable than diesels.	

Option 3B: Full Electrification

A medium- to long-term option is to fully electrify all routes across the East Midlands. This would build on the electrification of the Midland Mainline to Nottingham and Sheffield and the Joint Line electrification for freight. A new fleet would be purchased to replace all DMUs. The benefits derived would be comparable to those for battery operation, perhaps with further improvements in journey times as the trains would have a lower mass as they would not be equipped with batteries. Other benefits relative to battery operation would be not having to equip stations and depots with static chargers, less pressure on turnaround times where charging would otherwise be required between journeys, and greater flexibility around improving connectivity and developing new timetables.

The risk with this approach, relative to battery operation, is the additional capital cost required for electrification, especially on routes with complex infrastructure. A further consideration related to this is that on some routes, such as Skegness where the route is long but frequency is relatively low, the capital cost will be disproportionately high for the benefits generated. These additional costs also risk the indefinite deferral of full electrification, especially where battery technology can be shown to generate the majority of the benefits of electrification for passenger services.

This does not mean that electrification should not take place for freight or long distance high speed services as the power requirements for these services are likely to exceed the practical capabilities of battery storage on-board trains.

The RAG assessment for this option is as per the battery train option.

Electrification as an Enabler
Journey time and operating cost reductions, associated with electrification, strengthen the case for improvements in service frequencies and the remapping of services to improve connectivity.
This increases demand and provides capacity to sustainably support housing and economic growth, whilst better utilising existing assets.

Wider Considerations

There are a number of wider considerations that need to be included around the fleet renewal process. Some of these have been alluded to in previous slides but are summarised below:

- **Impact of GBR** – the emergence of GBR could have the following impacts:
  - **Standardisation of fleet procurement** – a more coordinated plan may emerge on fleet renewal and efficiencies may be made in the fleet procurement process that will lower costs.
  - **Remapping of services** – previous boundaries between TOCs may become less relevant and it may become easier to alter service patterns and resourcing where a more efficient solution can be identified. In the EMR fleet renewal context this might involve the transfer of XC Nottingham/Leicester-Birmingham services to be resourced by EMR, or changes to the operation of Liverpool–Norwich services.
  - **Holistic business cases** – it should be easier to develop financial and economic business cases in a holistic way that benefit the railway as a whole rather than individual bodies.
- **Additional services –** longer-term fleet renewal options are better able to capture increases in fleet size required as the network grows. As we have shown, in the short-term cascade options are limited, which limits opportunities for growing the fleet.
- **Freight and long distance passenger** – both freight and long distance passenger services (especially CrossCountry) will need to address fleet renewal and decarbonisation in the coming years. These operators are more likely to justify full electrification of routes, this investment would be complementary to EMR Regional fleet renewal, and a combined business case could be developed for these interventions.
- Given that the current fleet is being refurbished and provides an acceptable passenger ambience, it may be better to avoid short-term fleet change if this ultimately increases the chances of a better long-term outcome.
- If the fleet size were to increase, including standardising on a three car fleet, additional depot and stabling capacity would be needed.

Summary

Below is a summary of the RAG assessment with three additional criteria added: operating, leasing and capital costs. Operating costs are a qualitative assessment and are relative to current costs, but exclude lease costs. Capital costs cover additional non-rolling stock items such as electrification or battery facilities.

Objective	Direct DMU Cascade	Indirect DMU Cascade	New build Bi-Mode	New build DMU	Battery Electric MU	Full electrification
Decarbonisation						
Connectivity						
Capacity						
Accessibility						
Reliability						
Operating cost						
Leasing cost						
Capital cost						

The RAG assessment is quite stark in its summary. Options involving cascade generally show neutral impacts, though with higher costs where Class 185s are introduced directly. New build DMUs and bi-modes generate slightly more benefits but incur additional costs. However, battery and electrification options show consistent benefits, including around operating costs, but higher leasing and capital costs.

Overall battery multiple units appear to have the strongest case with consistent benefits but lower capital costs than full electrification. If a short-term option were pursued, an indirect cascade would be the best outcome from an EMR perspective, though with the risk that this would defer a longer-term outcome.

SYSTRA