Department for Transport

SYSTRA

Great Western Route Modernisation

First Post-Opening Evaluation – Final Report

14th April 2022

with Addendum of 23rd September 2022

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Summary

Study objectives

The DfT commissioned SYSTRA, and subconsultants Tavistock Institute of Human Relations (Tavistock Institute or TIHR), to undertake a first post-opening evaluation for key elements of the Great Western Route Modernisation (GWRM) programme and related investments, primarily in respect of the long-distance service provision.

The specific objective of the study is to provide an assessment of the benefits delivered by the GWRM programme to date, including a value-for-money assessment of the long-distance service components in the form of a post-opening cost-benefit analysis. The evaluation also considers how the scope of works has changed within the programme lifecycle, and the effect this has had upon the achievement of intended objectives.

Great Western Route Modernisation programme

The GWRM is a complex programme of infrastructure works, new trains and major service changes affecting the services along the key rail corridor from London Paddington connecting the capital with west and south-west England and south Wales.

The full programme of works associated with the GWRM was made up of several interdependent elements:

- The Great Western Electrification Programme (GWEP) was the project to electrify the Great Western Main Line between Maidenhead and Oxford/Newbury/Bristol/ Swansea together with branch lines in the Thames Valley;

- The Western Capacity Enhancement Programme (WCEP) included infrastructure works to provide significant operating capacity improvements and to facilitate the introduction and cascading of new and existing fleets of trains both within the Great Western franchise and to or from other franchises; and

- The Intercity Express Programme (IEP) was an initiative to procure a new fleet of rolling stock for the Great Western Main Line to provide greater capacity, reduced journey times, increased passenger comfort and greater reliability.

In 2016, during the implementation phase, some elements of the full programme were de-scoped or deferred after the acceptance by the Secretary of State of the Hendy Review of late 2015. The deferrals and cancellations included a reduced scope of electrification, with some delayed delivery for a number of capacity-led engineering components. New rolling stock was, however, delivered, albeit with the long-distance fleet being procured as all bi-modal rather than as a mixed fleet of electric-only and bi-modal trains.

A summary of the GWEP electrification initially planned and delivered as part of the GWRM is shown in Figure 1.

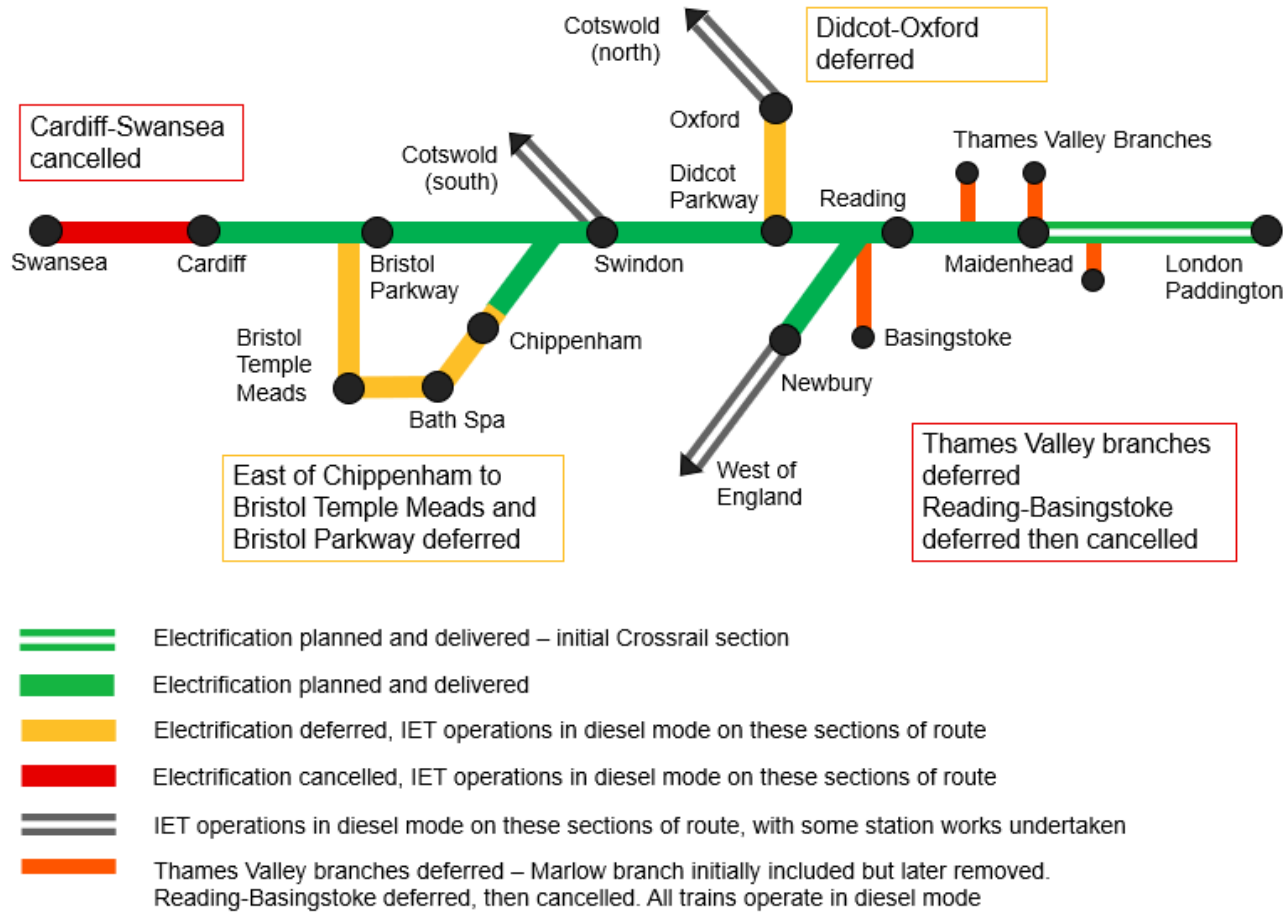

Figure 1: GWRM electrification – initially planned and delivered

Source: DfT data

Evaluation scope

The evaluation reported here considers the GWRM as delivered to the timetable change of December 2019, with a starting point for the analysis of the December 2011 timetable, effectively when early works on electrification started, the DfT instructed Network Rail to electrify the railway in its High Level Output Specification (HLOS) for Control Period 5 in July 2012 and orders for new trains were first placed.

This evaluation is focused on the initial performance of the InterCity-type long-distance service elements of the GWRM programme through an impact evaluation and supporting economic evaluation. This commission excludes any process evaluation, with process

issues having been considered extensively by others, including the National Audit Office (NAO) in its report on the Great Western electrification in November 2016.

The effects of the COVID-19 pandemic on passenger demand and related benefit delivery are of particular significance to GWRM, affecting the likely delivery and magnitude of the intended benefits arising from investments, particularly where these related to demand.

This report provides an assessment on the delivery to early 2020 of those aspects of the GWRM within scope of the evaluation. Some references and analysis cover the period from March 2020 when the pandemic started to have a key impact on demand patterns, but in general these areas are limited to baseline network and service operational issues rather than demand-based analysis.

In May 2022 a new timetable was introduced across many parts of the rail network. On the GWR long-distance network, and of relevance to this post-opening evaluation, was the change in the way Bedwyn services were operated. Therefore, service levels have changed since of the drafting of this report, with this affecting the references herein to service delivery at Bedwyn.

Logic mapping and Theory of Change

The development of a Theory of Change and associated logic map has been an important part of the evaluation of the GRWM, with the following steps taken in assessing the performance of the programme:

- Identification of key evaluation questions through a re-assessment and confirmation of earlier work on identifying programme objectives and expected benefits, including:
    - benefits mapping review and the development of a GWRM Theory of Change;
    - stakeholder engagement via a Theory of Change workshop and interviews with senior representatives; and
    - definition of a series of evaluation questions.
- Collation and analysis of baseline data and, where possible and meaningful (given the effects of the COVID-19 pandemic on travel patterns), post-opening data.
- Post-opening economic appraisal and cost benefit analysis to inform an out-turn ‘value for money’ assessment.

For the GWRM, the overarching rationale as set out in the simplified Theory of Change statement is:

If the GWRM programme adds train capacity and invests in electrification and bimodal trains, then the passenger experience will be improved, increasing rail usage and revenues due to a greater take-up of rail travel, and driving regional development and environmental benefits.

The three key themes identified for evaluation were: passengers, the environment, and costs:

- **Passenger experience** is improved by easier, quicker, better-connected, more reliable and more accessible train journeys. Better passenger experience is linked to longer-term benefits: higher demand for train journeys, reduced car use, more accessible job opportunities, and reduced social exclusion.

- The **environmental** performance of rail travel in the west and southwest is improved by the electrification of lines and purchase of bimodal trains. Environmental performance is linked to longer term benefits: increased rail usage, reduced car usage and reduced transport emissions from both rail and road.

- The **cost** performance of the rail network was affected by increased investment in rolling stock, line electrification, and infrastructure enhancements such as rail station improvements, which were potentially offset by the growth in revenue from increased passenger usage. Cost performance is linked to longer term benefits: improved franchise premiums, regional development, business opportunities for inward investment and greater tourism in the west and southwest.

This evaluation report is focused on the reporting performance against these key themes for InterCity type long-distance services, framed around a series of evaluation questions to direct the initial analysis. At a high-level there are three evaluation questions posed:

- How well did the programme meet the founding expectations regarding use of the railway network and its net costs?

- How has the programme contributed to reducing GWR's environmental impact?

- How has the programme contributed to wider social and economic vitality, and regional development?

Supporting these high-level questions, a number of more detailed questions were identified to focus on specific aspects of the impact evaluation and the next section outlines key impacts against those evaluation questions.

Key impacts

Passengers

How did the programme contribute to improved passenger experiences for long-distance journeys?

What improved for whom, what were the reasons for change, and in what context?

Did any intended beneficiaries fail to experience the intended benefits?

Service levels

- Significant improvements in **journey times** have been achieved for core long-distance routes from London to Bristol and south Wales, with services to Bristol on average 8 minutes or 8% faster in December 2019 compared to December 2011. Average journey times to south Wales are around 15 minutes or ~10% faster, with an average journey time of less than 2 hours to Cardiff and less than 3 hours to Swansea. Journey time benefits are also apparent on other long-distance routes including to Cheltenham with average savings of 15 minutes, and savings of up to 15 minutes on the fastest Cotswold (north) line services to Worcester.
- Average journey times between London and the south west of England have been reduced through the elimination of irregular stops at the smaller stations between Reading and Exeter on longer-distance train services to Devon and Cornwall. This has been enabled by the introduction of a new two-hourly semi-fast service between London and Exeter to serve those stations providing a better and more regular train service.
- The December 2019 timetable delivered significant **service frequency** improvements. The number of long-distance services increased by around 20% between the December 2011 and December 2019 timetables, with increases on all key long-distance routes, including into south Wales and the west of England. Principal increases in service levels have been to Bristol, moving to a three or four trains per hour service from two per hour, but with the introduction of some additional services not implemented due to the COVID-19 pandemic. Other key changes include providing an hourly through service from London to Gloucester and Cheltenham, doubling the number of direct services to the capital.
- The average age of the **rolling stock** operated by GWR fell from just under 30 years in 2011/12 to less than 12 years in 2019, with the new IET bi-modal trains deployed on long-distance routes and electric trains on key London and Reading commuter routes. In addition to the desire for new trains to provide greater capacity, increased passenger comfort and greater reliability, cascading of earlier rolling stock has included refurbishment to improve compliance with accessibility standards and increased capacity on other parts of the regional GWR network and elsewhere.
- The GWRM facilitated and funded a number of improvements to **station facilities, access and interchange** around the Great Western network. The principal anticipated benefits of platform extensions and associated improvements to station passenger information systems, particularly on long-distance routes, include:
    - improved distribution of passenger boarding at stations;
    - faster boarding and alighting times;
    - reduced anxiety for passengers alighting from the correct portion of the train and/or reduced number of missed stops, especially for passengers with luggage or mobility impairments;
    - reduced on-train crowding (and during COVID-19 in maintaining social distancing);
    - accessibility improvements such as additional tactile platform edging for sight impaired passengers; and
    - general improvement in passengers' experience.

Capacity

- Increases in **passenger capacity** for morning peak period passenger arrivals into Paddington associated with the delivery of some of the GWRM components are apparent to 2019, with a growth in seated capacity of 25% between 2011 and 2019 to just under 32,500. Growth in passenger demand of 30% was observed over the same period with just under 31,000 passenger arrivals during the peak period by 2019.
- The provision of IET services on long-distance routes has increased **train capacity** significantly over a standard configuration HST. The increase of 181-185 standard class seats is offset by a reduction of 46-47 first class seats, giving an overall increase in seating of over 25%. The number of long-distance passenger carriages available to the operator has increased by 24% from 2015 with the deployment of the IET trains, with overall passenger seat numbers increasing by around 33%.
- Indicative **passenger capacity** on long-distance services increased by around 40% between the December 2011 and December 2019 timetables. Passenger capacities increased on the key long-distance services to the Bristol area by 80%, to south Wales by 40%, and to the west of England by almost 45%. Modest increases in capacity have also been realised on services to Cheltenham through doubling the number of direct services, but with shorter IET trains normally deployed. Capacities have fallen slightly on the Cotswold (north) route as the mix of HSTs and Class 166 diesel trains used in 2011 have been replaced by a mix of 5-car and 9-car IETs trains.
- Overall capacity increases for the GWR regional services suggest an expansion in **seat miles** of around 75% between the December 2011 and December 2019 timetables, significantly more than the 20% increase in train mileage over the same period. The largest increases are apparent on the Cardiff/Bristol to Devon/Cornwall services, in particular enabled by the deployment of 4-coach modernised HSTs released from long-distance routes by the new IET trains in place of shorter diesel trains. The May and December 2019 timetable changes saw the weekday daytime service frequency on the Cornish Main Line between Plymouth and Penzance increase to two trains per hour enabled by signalling upgrades.

Performance

- Following the major dip in performance around 2017-18, especially affecting the long-distance group of services, driven by the infrastructure works and introduction of new rolling stock, there was a sustained improvement in performance heading towards culmination of the principal GWRM programme.
- **PPM measures** for the GWR long-distance network returned to just below 90% on key routes before the emergency COVID-19 measures were put in place in early 2020, a level slightly higher than at any time since 2010 and higher than the 83% average across all long-distance operators and the national average of 87%[1].

[1] Office for Road and Rail: Table 3114 - Public Performance Measure by operator and sector

- Despite these improvements and higher performance than many other operators, the PPM was lower than the 92.5% target identified in Network Rail's The Greater West programme[2]. The impacts of COVID-19 mean that a sustained period of operation with the new timetable has not yet been possible to better understand long-term performance.
- Shortly before the publication of this report, work led by Network Rail and all the train operators on the Western route, including GWR, identified a series of improvements necessary for the best performance of the new Elizabeth Line when it opens as a through operation east of Paddington to central London. It is expected that these measures will also be beneficial to GWR long-distance services.
- Resilience works to the network in the vicinity of Dawlish following the sea wall collapse in 2014 continue and these will contribute to performance being less affected by severe weather, rock falls, etc, in that area.

Passenger attitudes

National Rail Passenger Survey (NRPS) data has been used as a measure of **passengers' satisfaction** with their journey.

- For **overall satisfaction**, there has been a small overall improvement between 2010/11 and 2019/20. GWR is now one of the better performing long-distance franchises with higher satisfaction than both the West Coast Partnership (WCP) and East Midlands (EM) franchises in the Spring 2020.

- For the **trip indicators,** punctuality and reliability, there have been small but insignificant changes in satisfaction; this may reflect that the major changes to frequency and journey times were not realised until the December 2019 timetable change and therefore it may be too early to observe any significant impact on satisfaction for these indicators. GWR's long-distance routes have however performed relatively better than the other long-distance franchises in these indicators, which typically show falls in satisfaction for these indicators.

- For the **on-board indicators**, level of crowding, upkeep and repair of the train, there is evidence of increasing satisfaction across several of these indicators and GWR has typically outperformed other long-distance franchises, particularly those on which there has been no major change in rolling stock such as WCP and EM. The increasing trend is most notable from 2017/18 onwards which coincides with the start of the rollout of the new IEP rolling stock and so provides evidence that this has translated into increased passenger satisfaction.

[2] The Greater West programme was developed by Network Rail to manage the delivery of the various GWRM programme elements.

Environment

Has the electrification of lines and deployment of bimodal trains improved the environmental performance of the railway?

- Following **electrification** of the Great Western routes, over 40% of all GWR train mileage across the franchise is electrically operated. Around 60% of both long-distance and London and Reading commuter service mileage is electrically powered. 80% of train mileage on services to both Bristol and into south Wales runs under electric power. 25% of train miles on services to the west of England are electrically operated, with 40% on the Cotswold (north) route and 60% on the Cotswold (south) services to Cheltenham.
- The electrification delivered accounts for just under 95% of the initially planned electrified long-distance train mileage that would have operated were all route sections in the original GWRM to have been delivered. The loss of electric traction to Swansea, short sections to Bristol and from Didcot to Oxford, have been significantly offset by the use of bi-modal trains on services to the west of England that were not initially part of the GWRM. The IEP rolling stock programme did not cover the west of England routes and initial planning assumptions were that a pure diesel fleet would continue to be used, with modernised HSTs or Meridians released by the then planned Midland Main Line electrification being indicated as possibilities.
- Following delivery of the GWRM, total **emissions** on GWR routes fell by around 20% to 2019-20 despite an increase in train miles of 10%[3]. Annual savings in CO_2 equivalent of around 90 kilotonnes (=90 million kg) in emissions from diesel operation were partially offset by emissions from electricity usage at the source of generation of around 40 kilotonnes. With the move to a mixed diesel and electric operation, the average CO_2 equivalent emissions per train mile fell by around 25%.
- While there has been a large reduction in the **carbon emissions** per train mile across the rail industry from 2011, this has been driven by on-going improvements in the UK electricity generating mix and new electrification on selected routes. The GWRM electrification has contributed to this reduction of more than 25% in carbon emissions per passenger train mile over the last decade.
- Carbon emissions for generated electricity powering GWR's electric and bi-modal trains are expected to fall by over a half by 2030 and by 95% over the period to 2050. Diesel emissions are unlikely to change significantly, but traction technologies are likely to reduce the reliance on diesel, with battery and alternative fuel technologies expected to further reduce the emissions from rail use. Road vehicle emissions for each mile driven are also expected to reduce over time, in part due to increased electric car usage, with emissions per vehicle mile expected to fall by around 60% by 2050.

[3] Analysis based on outturn ORR energy consumption figures and train kilometres over the year during which the main GWRM timetable change took place. Adjusted to include Crossrail (GWR route).

Socio-Economic Outcomes and Impacts

There are a number of medium-term socio-economic outcomes and longer-term impacts that cannot be fully assessed at this early stage of evaluation, particularly due to the significant impact of COVID-19 on travel patterns during the period being evaluated. The following evaluation questions will therefore be considered in later evaluation reports:

Did improved passenger experience for long-distance journeys lead to higher rail demand, reduced car use, more accessible job opportunities, access to other facilities and reduced social exclusion?

Has the programme supported local communities, regional development, business opportunities for inward investment and greater tourism?

Has improved passenger experience lead to modal shift driving reductions in transport related emissions?

Economic evaluation

Implementation costs

Capital cost escalation in the early stages of the delivery of the GWRM led to a reconsideration of programme delivery. The expectation set out in the 2017 updated appraisal was that the full programme would be implemented but with a delayed delivery, with electrification costs increasing by around £1.4bn from the initial estimates of £2.7bn. In implementing the descoping set out in the Hendy plan, out-turn electrification costs were reduced by £0.90bn relative to the 2017 update appraisal, although still around £0.47bn higher than the initial business case estimates.

Operational Costs

Has the efficiency of long-distance train operations changed as a result of journey time improvements and performance impacts?

How have train operating costs for long-distance services changed following replacement of the HST fleet?

- Network Rail maintenance costs for the Western route, covering the substantive parts of the GWRM and much of the rest of the GWR franchise operating areas, have increased significantly from 2015-16, but only in line with wider spending on the rail network in England. Longer-term changes in operating costs may become apparent in future as maintenance efficiencies are expected due to infrastructure investments in track and other works delivered as part of the GWRM.
- Train operating costs for the GWR franchise have also increased significantly during the evaluation period, primarily following the substantial investment in new rolling stock. Overall operating costs per train mile have increased significantly and are now towards the upper end of the range of comparable operators. Excluding

rolling stock, other operating costs have increased only slightly in real terms across the GWR franchise[4].

- The GWR long-distance network is delivering a much greater level of service, an increase in the size of the fleet of just under 25% and an expansion in capacity/seat miles of 40%, and with an entirely new fleet of trains.
- A detailed assessment of how the efficiency of long-distance train operations has changed as a result of journey time improvements has not been possible in this evaluation. However, the move to fully bi-modal fleet, including expansion to cover all west of England services, points towards further efficiencies being possible, with some stakeholders at the Theory of Change workshop and during subsequent interviews identifying operating benefits of all long-distance services using a broadly common rolling stock fleet.

The significant impact of COVID-19 on travel patterns during the period being evaluated mean that following evaluation questions will be considered in later evaluation reports:

Did improved passenger experience lead to greater rail revenues?

Has the programme contributed to better franchise premiums?

In the interim, a qualitative review of the GWRM delivery against the earlier business case appraisals has been undertaken to consider following evaluation question:

Has the programme offered value for money, relative to expectations?

- The descoping of the electrification works has resulted in cost savings against assumptions in the updated appraisal of 2017, but still with some significant cost escalation compared to the earlier 2015 business case.
- Qualitatively, benefit delivery appears to be broadly similar to the earlier business case appraisals, driven by maintaining or improving service levels relative to expectations.
- While the out-turn scheme may have lower costs and similar benefits to the updated appraisal of 2017, potentially improving the monetised Benefit Cost Ratio (BCR), the changes are unlikely to be material enough to change the allocation of the GWRM programme from the 'Low Value for Money' assessment.

Based on current DfT guidance on handling short and long-term expectations of post-COVID travel demand growth, an indicative quantified economic evaluation of the long-distance components of the GWRM has been undertaken suggesting that:

- the out-turn long-distance components of the GWRM programme will deliver significant monetised transport benefits, including to rail users through the faster, more frequent, higher capacity and higher quality trains, and to road users through modal shift reducing traffic volumes and resulting in journey time savings;
- monetised environmental benefits are also generated, primarily through reduced emissions, including carbon savings;

[4] note that some maintenance and other operating costs are now included in the rolling stock costs

- based on the assumed growth rates, and current (but evolving) guidance, the streams of scheme benefits and costs over a 60-year appraisal period are expected to generate a net present value of around £560m (2010 prices) and a monetised benefit-cost ratio of 1.27; and
- conservatively assuming that there are no wider non-monetised benefits of the scheme, this BCR suggests that the long-distance scheme components offer 'Low Value for Money' using the DfT's Value for Money framework.

Summary of impacts

This first post-opening evaluation indicates that the GWRM programme has broadly met the founding expectations with regard to delivering passenger benefits.

The programme was descoped to control cost, but with little impact on the overall passenger benefits. It has delivered expected capacity increases, journey time and frequency improvements and, although it is not quite at the target set, reliability has improved significantly and is above the level achieved by most other long-distance operators.

The descoping of the programme has resulted in a slight reduction of environmental benefits compared to founding expectations but has still substantially contributed to reducing GWR's environmental impact. The environmental benefits from the programme have not been eroded as much as might have been expected as much of the impact of the descoping has been offset by other decisions made, particularly to procure all bi-modal trains for the long-distance fleet.

At this early stage of evaluation, it is not possible to assess how the programme has contributed to wider social and economic vitality and regional development. However, the expansion in capacity and reduction in journey times already delivered by the programme would point towards the potential to meet these wider objectives in the longer term.

The medium and longer-term performance of the train service delivery and management of revenues and operating costs will determine the ultimate value for money of the GWRM programme, how the investment has been affected by the COVID-19 pandemic and how it has contributed to the recovery from the pandemic.

Next steps

With this first post-opening evaluation report effectively limited to reporting on the key operational outputs from the investment in the GWRM, there may be merit in considering the development of a short-term outcome-focused evaluation report once post-pandemic travel behaviours have become established. A later report would then be able to address the longer-term social, economic and environmental impacts of the GWRM programme.

1. Introduction

1.1 Study profile

The DfT commissioned SYSTRA, and subconsultants Tavistock Institute of Human Relations (Tavistock Institute or TIHR), to undertake a first post-opening evaluation for key elements of the Great Western Route Modernisation (GWRM) and related investments, primarily in respect of the long-distance service provision.

The specific objective of the study is to provide an assessment of the benefits delivered by the GWRM programme to date, including a value-for-money assessment of the long-distance service components in the form of a post-opening cost-benefit analysis. The evaluation also considers how the scope of works has changed within the programme lifecycle, and the impact this has had upon the achievement of intended objectives.

Great Western Route Modernisation

The GWRM is a complex programme of infrastructure works, new trains and major service changes affecting the services along the key rail corridor from London Paddington connecting the capital with west and south-west England and south Wales.

The full programme is intrinsically linked with other major investments in the rail network, in particular Crossrail. Given the strong interactions between Crossrail and the Great Western franchised London commuter operations, the DfT asked SYSTRA to focus on the InterCity-type long-distance rail services impacted by the investment in the route and new trains.

The evaluation reported here considers the GWRM as delivered to the timetable change of December 2019. The starting point for the analysis is the December 2011 timetable, effectively when early works on electrification started, the DfT instructed Network Rail to electrify the railway in its High Level Output Specification (HLOS) and orders for new trains were first placed. The reporting of the evaluation considers performance against appropriate counterfactuals but also, where relevant, comments on performance against the original expectations of the programme before the 2015 descoping that delayed or cancelled a number of the electrification elements.

Impact and economic evaluation

This evaluation is focused on the initial performance of the InterCity type long-distance service elements of the GWRM programme through an impact evaluation and supporting economic evaluation. It provides an initial assessment of some of the short-term outcomes observed following the delivery of the key timetable changes in December 2019; however, given the effects of the COVID-19 pandemic, the evaluation report cannot offer a definitive assessment of the long-term performance of the programme.

This study and any subsequent phases of the evaluation will build on earlier work in assessing the post-opening impacts of investments in the rail network, in particular the evaluation case studies of economic impacts of new or improved rail lines undertaken in 2017/18[5] and the National Audit Office (NAO) through their November 2016 report 'Modernising the Great Western railway'[6].

This secondary purpose for the evaluation is to develop a greater understanding of some of the key issues and challenges involved in evaluation of complex rail projects and to expand on the current evidence base. This is considered in this report where appropriate. The outputs and lessons from this study will inform the DfT's approach to the post-opening evaluation of future rail schemes included in the Rail Network Enhancements Pipeline (RNEP).

This study excludes any process evaluation that would consider the development, management and delivery of the various interrelated programme elements. These issues have been considered extensively by others, including the NAO November 2016 report focusing on the GWRM.

COVID-19

The effects of the COVID-19 pandemic on passenger demand and related benefit delivery are of particular significance to projects in the RNEP in potentially affecting the likely delivery and magnitude of the intended benefits arising from investments, particularly where these relate to demand, for example reductions in crowding levels and increases in capacity. Short-term reductions in demand and benefit delivery, however, do not suggest that currently planned investments will necessarily offer lower value for money as future year demand and growth profiles may provide for different benefits to be realised.

The delay in benefits realisation points to the need for a further research phase for this evaluation as the wider economy returns to a 'new normal' position. This will provide an opportunity to review the new travel behaviours and undertake primary research with travellers, business and others to understand some of the medium- and longer-term impacts of the investment in the GWRM. The travel patterns and impacts of the

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[5] New or improved rail lines – Evaluation case studies of local economic impacts. Individual case studies including Corby, Falmouth, Leamington Spa, Oxford Parkway, Bromsgrove and Swindon and a collective Technical Report, January 2018, Steer Davies Gleave for DfT

[6] NAO Modernising the Great Western railway, NAO, November 2016. https://www.nao.org.uk/report/modernising-the-great-western-railway/

programme investment may, of course, be different from the trajectories that were emerging before the pandemic, as considered in this report.

It was recognised by the DfT that in due course such a secondary baseline analysis for GWRM, alongside other infrastructure programmes, may be required once travel patterns normalise, but also that this falls outside the scope of this current study.

This report therefore provides an assessment of the delivery of the GWRM to early 2020, rather than what would ordinarily be a fuller review of scheme performance broadly one year after implementation of the substantive timetable changes in late 2019. Some references and analysis cover the period from March 2020 when the pandemic started to have a key impact on demand patterns, but in general these areas are limited to baseline network and service operational issues rather than any analysis of early demand-based outcomes.

Evaluation approach

The approach adopted for the evaluation of the GWRM, in so far as it has affected the InterCity type long-distance service provision, has been focused around capturing the full range of outcomes and impacts likely to arise from the investment programme, using a Theory of Change based approach as the basis of the research, and drawing on comparators where relevant.

The development of a Theory of Change and associated logic map built on the earlier objectives setting and benefits mapping of the programme development stages. The following steps were taken in assessing the performance of the programme:

- Identification of key evaluation questions through a re-assessment and confirmation of earlier work on identifying programme benefits, including:
    - benefits mapping review and the development of a GWRM Theory of Change;
    - stakeholder engagement via a Theory of Change workshop and interviews with senior representatives; and
    - definition of a series of evaluation questions.
- Data collation and analysis of baseline data and, where possible and meaningful, post-opening data (given the effects of the COVID pandemic on travel patterns). This step included identifying the inputs and outputs of the programme, and an initial view of some of the early outcomes, focusing on the GWRM and services operated by Great Western Railway (GWR) (as franchise holder). The analysis also considers comparators where relevant.
- Counterfactual analysis was also undertaken to provide a basis for the modelling and forecasting required to deliver a post-opening economic appraisal and cost benefit analysis. This analysis can then be used, alongside other non-monetised or quantified assessments, to inform an out-turn ‘value for money’ assessment.

1.2 Structure

This first post-opening evaluation report outlines the evaluation process and initial findings through the following sections:

- Section 2: GWRM programme – focusing on components considered in this evaluation, primarily the long-distance InterCity-type services operated by the holder of the Great Western franchise, First Greater Western Limited (branded as Great Western Railway (GWR);
- Section 3: Theory of Change – identifying the impacts expected of the GWRM programme and the key questions arising for the evaluation;
- Section 4: Passenger Impacts – providing qualitative and quantitative assessment of performance to date;
- Section 5: Environmental Impacts – providing qualitative and quantitative assessment of performance to date; and
- Section 6: Economic Evaluation – setting out an initial post-opening value-for-money assessment of long-distance service elements of the GWRM programme; and
- Section 7: Summary and Next Steps – looking forward to requirements of any intermediate post-pandemic recovery evaluation and subsequent medium-term assessments for the performance of the investment programme.

1.3 Addendum

This report was prepared in the period to spring 2022 with train services at the time running to a modified timetable relative to the December 2019 timetable.

In May 2022 a new timetable was introduced across many parts of the rail network. On the GWR long-distance network, and of relevance to this post-opening evaluation, was the change in the way Bedwyn services were operated. Therefore, service levels have changed since of the drafting of this report, with this affecting the references herein to service delivery at Bedwyn.

More detail on the timetable change is provided in section 8.

1.4 Glossary of key programme terms

A full glossary of terms is provided in Appendix A to this report. However, given the complexities of the modernisation programme and its components, often using similar terminologies, a number of key programme terms are listed here:

GWRM – Great Western Route Modernisation – the programme under consideration in this evaluation. Note that Modernising the Great Western Railway has been a term used by the National Audit Office to mean the GWRM

GW – Great Western when referring to the Great Western franchise and currently operated by First Greater Western trading as Great Western Railway

GWR – Great Western Railway – the trading name for the holder of the Great Western franchise, First Greater Western Limited

GWML – Great Western Main Line – in this context, and for simplicity, the mainline railway routes from London Paddington handling InterCity-type long-distance services, including those to Bristol, Cardiff and Swansea, to the south west of England and to the north and south Cotswolds

GWEP – Great Western Electrification Programme – one of the components of the GWRM delivering electrification to the Great Western route

WCEP – Western Capacity Enhancement Programme – one of the components of the GWRM delivering upgraded infrastructure to the Great Western route

TGW – Network Rail's The Greater West Programme – developed to manage the delivery of the significant changes in infrastructure and rolling stock and train services set out in the GWRM and its constituent programmes

IEP – Intercity Express Programme – delivering new Intercity rolling stock to the Great Western franchise and the InterCity East Coast franchise through a Private Finance Initiative (PFI) style deal. These are the 'Class 800' trains

IET – Intercity Express Train – the name given to new trains delivered by the IEP to the Great Western franchise. The IET name also applies to the similar trains for the 'West of England' services, but procured outside of the IEP, These are the 'Class 802' trains and are virtually identical to the Class 800 trains delivered via the IEP

Crossrail – the construction project building the cross-London rail infrastructure from west of Paddington to Liverpool Street and beyond that will be served by TfL Rail services known as the Elizabeth Line

Elizabeth Line – rail services operated by TfL Rail on the new Crossrail infrastructure when this opens in 2022. GWR services transferred to TfL Rail in advance of the opening of Crossrail are referred to here, for convenience, as Elizabeth Line services although these services are not officially marketed as this by TfL

TOC – Train Operating Company – either franchised or non-franchised operators

HST, DMU, EMU – rolling stock types: High Speed Train as used by GWR on long-distance services from the 1970s to 2019. DMU – diesel multiple unit train. EMU – electric multiple unit train

2. Scheme Description

2.1 The Great Western Route Modernisation

The railway routes between London Paddington and the west and south-west of England and south Wales constitute one of the most important rail corridors in the UK. The core long-distance services offered by the Great Western franchise link London and Reading with the key centres of Swindon, Bristol, the communities in the south west peninsula and the Cotswolds. The route also provides the key link between the nations of Wales and England, serving Cardiff, Swansea and other key towns in south Wales to London.

In 2012, the government's High Level Output Specification 2014-19 (HLOS)[7] defined a vision and strategy for investment in the rail network, including the delivery of the GWRM. The full programme of works associated with the GWRM was made up of several interdependent elements:

- The Great Western Electrification Programme (GWEP) was the project to electrify the Great Western Main Line;
- The Western Capacity Enhancement Programme (WCEP) included infrastructure works to provide significant operating capacity improvements and to facilitate the introduction and cascading of new and existing fleets or trains[8]; and
- The Intercity Express Programme (IEP) procuring a new fleet of rolling stock to provide greater capacity, increased passenger comfort and greater reliability.

The GWRM programme was intended to exploit synergies between the earlier Reading Station modernisation and Crossrail, to support demand and economic growth and better environmental outcomes, and secure cost efficiencies.

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[7] High Level Output Specification (HLOS), 2012, https://www.gov.uk/government/publications/high-level-output-specification-2012

[8] Cascading is an industry term referring to the transfer of trains/rolling stock between lines and/or between operators

2.2 Evaluation scope

As this report focuses on the InterCity-type long-distance rail services, the assessment considers parts of GWEP and WCEP, and the IEP in so far as it delivered the new trains for the Great Western franchise. It but also includes the impacts of the new West of England fleet of trains procured outside of IEP that now form part of the interchangeable long-distance rolling stock fleet deployed on all long-distance services across the franchise.

Given the complexity of the interactions between different GWRM components, the staged delivery and deferrals/cancellation of some elements of the original programme, it has been challenging to neatly compartmentalise the evaluation of only the long-distance rail services. Where appropriate or where disaggregated data is not available, the assessments refer to the wider impacts of the GWRM as a whole.

Table 1 summarises the scope of the evaluation reported in this first post-opening report.

Evaluation element	Within scope	Not in scope
Theory of Change/ Logic mapping	GWRM, including the initial full programme and descoped delivery. The logic mapping exercise, while focusing on long-distance service provision, also considered GWR commuter routes and initial cascading of rolling stock elsewhere.	Investment in the Reading Station improvements and Crossrail. Detailed impacts of rolling stock cascades elsewhere, although the principles of capacity and improvements in rolling stock quality are considered in outline.
Impact evaluation	Focus on long-distance service provision with consideration of some headline messaging on TOC-level outcomes and impacts, including GWR commuter and regional routes.	Investment in the Reading Station improvements and Crossrail. Detailed outcomes and impacts on GWR commuter and regional routes.
Economic evaluation	Post-opening economic appraisal and cost benefit analysis for the GWR long-distance services, including: capital and operating costs benefits driven the improvements in long-distance service provision and (implicitly) the associated investment in station upgrades required to handle new trains.	Full assessment of costs and benefits across the GWRM programme as a whole, including impacts of the London/Reading commuter services and Crossrail. Assessment of the costs and benefits arising from the cascading of rolling stock to other parts of the GWR network or other TOCs.

Table 1: Summary of evaluation scope

For the evaluation, the core impact assessments that consider the early short-term outcomes of the GWRM are considered in absolute terms – what has happened since our base year of 2011. For the passenger focused impact evaluation, the key assessments, especially where the programme affects the GWR franchise as whole, have an implicit counterfactual of no change. For the core environmental assessments, driven by the electrification elements of the programme, performance is also considered against the expectations of the full GWRM programme delivery before its descoping beginning in 2015. A number of the assessments, including passenger satisfaction issues, consider an

analysis of performance of other predominantly long-distance train operating companies (TOCs)

For the economic evaluation there is a need to define a counterfactual for modelling purposes to test the monetised value of the benefit and cost streams. This is reported in more detail in section 6; in broad terms the counterfactual for the post-opening economic evaluation is an electrified commuter railway serving London, Reading, Didcot and Newbury but with the December 2011 timetable for long-distance services. This assumes no changes in long-distance rolling stock provision, no changes in journey times, train frequencies or wider provision, such as track capacities or station platform lengthening.

2.3 Summary of GWRM works

In broad passenger-facing terms, the full GWRM proposals comprised of electrification of the Great Western Main Line (GWML) between London Paddington, Reading and Newbury/ Oxford/ Swansea/ Bristol Temple Meads (via both Bath and Bristol Parkway) and electrification of some secondary and commuter routes in the Thames Valley area.

Major engineering enhancements were also part of the programme intended to support the delivery of a significantly enhanced timetable alongside replacement of virtually all long-distance and London/Reading commuter trains.

For a variety of reasons, considered in detail by the NAO[9] and other process assessments, some elements of the intended full GWRM programme were de-scoped or deferred. The Hendy review of late 2015 and early 2016[10], accepted by the Secretary of State in September 2016, recommended later delivery of some route sections and the deferral of the others into Control Period 6 (CP6, 2019/20 - 2024/25); deferrals and cancellations occurred over the period to March 2018. Table 2 provides an outline summary of the programme delivery versus planned, noting some deferrals and cancellations in infrastructure works, but the provision of new rolling stock as expected.

GWRM Component	Programme Delivery
GWEP - Electrification	Some parts of the GWEP electrification were deferred or cancelled, as set out in Figure 2
WCEP – Infrastructure works to increase capacity and facilitate new rolling stock	Some elements of the WCEP were deferred or delayed from their original programmes, with a number of components now delivered or scheduled for later delivery, including Bristol East Junction and the Reading Independent Feeder
IEP trains for the Great Western network	Delivery as planned, albeit with all trains being bi-modal rather than as a mixed fleet of electric-only and bi-modal trains. Additional trains were also delivered to cover west of England services, originally not in scope of the GWRM, and to respond to the descoping of electrification works

Table 2: Summary of GWRM programme delivery

[9] Modernising the Great Western railway, National Audit Office, November 2016
[10] Network Rail, Report from Sir Peter Hendy to the Secretary of State for Transport on the replanning of Network Rail's Investment Programme (Nov 2015) and Enhancements Delivery Plan Update (Jan 2016)

A summary of the GWEP electrification initially planned and delivered as part of the GWRM is shown in Figure 2.

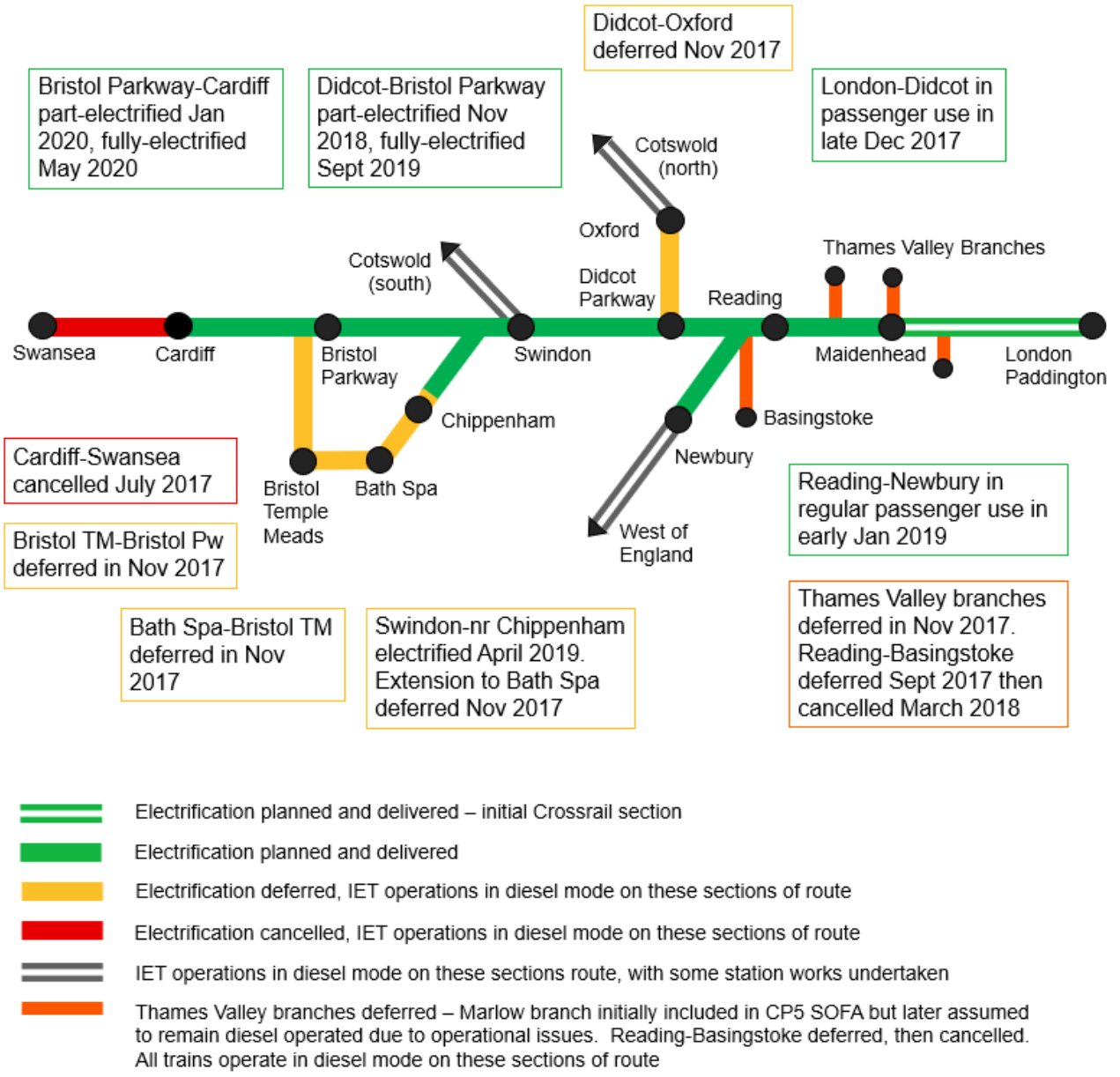

Figure 2: GWRM Electrification – Initially Planned and Delivered **Source: DfT data**

The 2012 IEP included both bi-mode and electric trains to provide long-distance services on the Great Western route. Trains to Bristol, Cardiff and Swansea were intended to operate largely using electric-only trains, with those extensions to non-electrified destinations and on the Cotswolds routes intended to operate using bi-mode trains. Services to the south west and west of England were expected to be operated by a residual HST fleet, with modernised HSTs or Meridian trains released by the then planned Midland Main Line electrification being indicated as possibilities.

In 2015, however, outside of the GWRM industry programme, approval was provided by DfT for a new West of England fleet of bi-mode trains very similar to those procured under the IEP.

Following the Hendy review of 2015, a Ministerial decision was made in spring 2016 to procure all IEP trains for the Great Western franchise as bi-modes, with an enlarged order to cover for the non-electrification to Oxford and through services to Bedwyn initially planned to be delivered as a shuttle connection from Newbury.

Cascading of some of the long-distance HSTs and most diesel trains operating on the London and Reading commuter services was a key part of the wider programme delivery.

The cascades are broadly similar to those initially planned in the full GWRM programme, summarised by the NAO in their 2016 report[11], with some delays having short-term impacts on secondary cascades elsewhere on the rail network and the timing of the withdrawal of the non-compliant Pacer train fleet. The opportunity was also taken to repurpose some former HSTs to increase capacity on some of the core regional routes in the GWR franchise, alongside other capacity gains through increasing the size of the rolling stock fleet.

Following the adoption of the Hendy plan in 2016 and the descoping of the full GWRM programme, Network Rail's The Greater West Programme (TGW) was developed to manage the various interfacing programmes. The TGW introduced a phased approach to delivery enabled by the gradual introduction of rolling stock and infrastructure, progressively extending the electric operation of both electric-only and bi-modal trains.

While there were some clear changes in the provision on the London and Reading commuter routes, apart from some small early timetable improvements to Cornwall and north and south Cotswolds routes in late 2014 and early 2015, ostensibly the long-distance timetable remained broadly unchanged until the major timetable change in December 2019, apart from transitioning to IET operation from largely HST operation.

Appendix B provides further details of the scope of works intended to be delivered through the GWRM, including some of the issues arising from the descoping and deferrals in programme delivery. This appendix also provides further details of the cascading of rolling stock, including recipient train operating companies (TOCs) and timings, and details of the staged introduction of the IEP fleet and other new and cascaded rolling stock leading up to the substantive December 2019 timetable change.

[11] Modernising the Great Western railway, NAO, November 2016

3. Logic Mapping and Theory of Change

3.1 Introduction

Underpinning this evaluation is a Theory of Change approach, seeking to build on the programme development phases in objectives setting and benefits mapping.

The Tavistock Institute (2010) produced a guide to logic mapping in the context of transport evaluations on behalf of the DfT[12]. Figure 3 identifies the main components of an 'intervention logic map'.

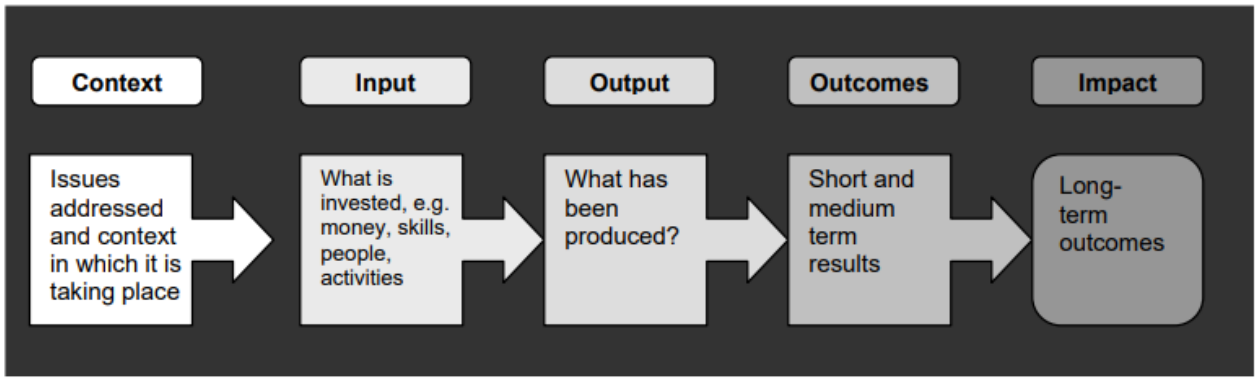

Figure 3: Components of a Logic Intervention Map
Source: Tavistock Institute, Logic mapping: hints and tips for better transport evaluations (2010)

The logic map generally reads from left to right, leading through a time sequence from the initial concept, through implementation to short- and longer-term results. This type of logic model, used widely in evaluations of this form, focuses on the underlying 'theory' of an intervention, seeking to gather evidence on the short-term outcomes and longer-term impacts where several different actions are taking place at the same time, and where the links between the actions and their anticipated outcomes are not necessarily straightforward.

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/3817/logicmapping.pdf

3.2 Theory of Change and benefits mapping

When the Secretary of State published the Network Rail CP5 Statement of Funds Available (SOFA) in 2012 it included the electrification and modernisation of the Great Western Main Line. The 'Electric Spine' scheme was also identified, including electrification of two sections of route relevant to the Great Western franchise between Reading and Basingstoke, and Oxford and Banbury.

The key electrification/ modernisation benefits set out in the SOFA were to:

- Reduce journey times on longer-distance services;
- Increase capacity, particularly on Thames Valley commuter services but also on the long-distance routes; and
- Increase capacity on routes not being electrified in the west and south west of England through a cascade of diesel trains from the Thames Valley.

These benefits to passengers were expected to translate into higher revenue, in particular on the InterCity long-distance services to be operated by the new IEP trains. As well as journey time improvements on existing routes and an increase in capacity, additional long-distance services were expected to be delivered, including new 'superfast' services to Bristol, hourly through services to Cheltenham and additional services to provide an hourly timetable to Worcester.

The full programme objectives identified were to:

- Deliver consistently high standards for passenger experience;
- Support economic growth through the provision of train services of appropriate frequency, journey time and capacity;
- Make best use of available route capacity to improve passenger and freight capacity;
- Deliver a consistently high level of train service performance for reliability and punctuality;
- Achieve whole industry benefits, including delivering value for money for taxpayers and fare payers through reduced costs and increased demand;
- Deliver an environmentally sustainable railway; and
- Ensure the safety and security of passengers and railway employees.

A 2019 benefits map for GWRM, illustrated in Figure 4, shows the key drivers of the programme as:

- modal shift to train;
- improve passenger experience; and
- commitment to carbon reduction.

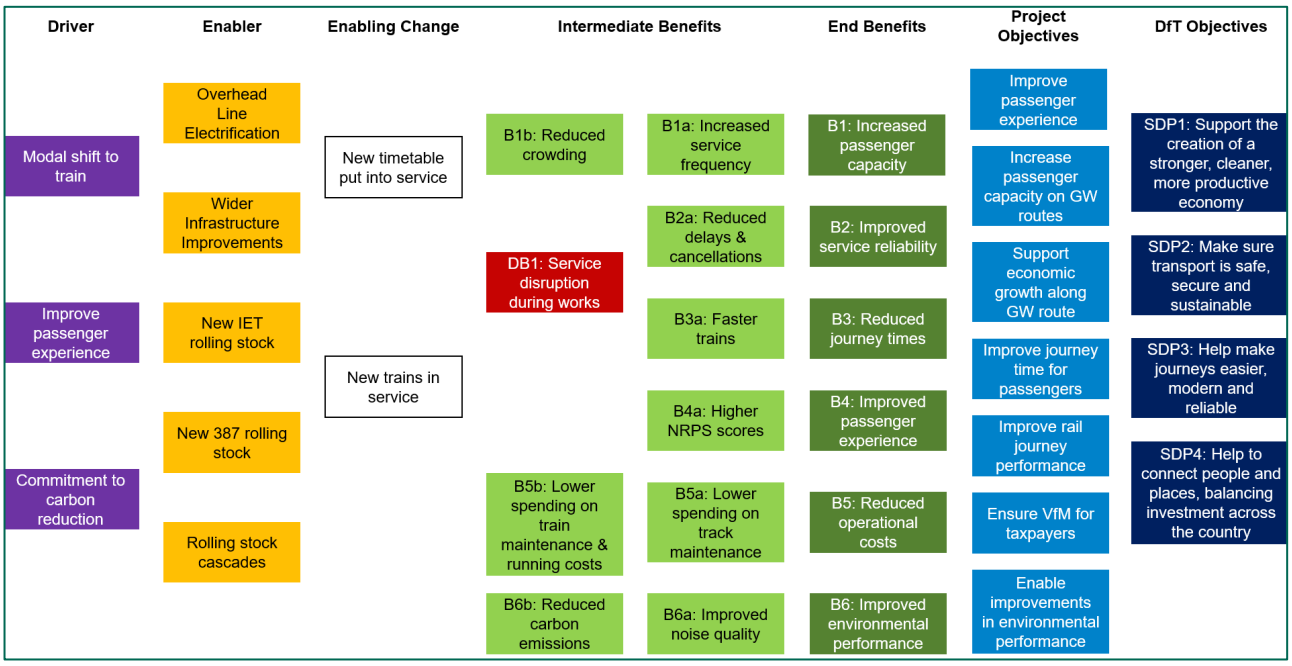

Figure 4: Benefits Mapping – 01/08/2019 GWRM

Source: DfT

Network Rail's The Greater West Programme (TGW) considered the 'benefits' of the programme from the introduction and cascading of rolling stock alongside the changes in the timetable structure for the Great Western franchise.

The benefits identified by Network Rail effectively comprised of direct impacts[13] of the HLOS investments and set out in the TGW Client Programme Requirements Document, and consequential impacts released by the planned service changes, primarily in terms of the passenger and operator experiences. The two benefits categories identified are:

Direct Impacts (specified or quantified benefits as defined by Network Rail):

- Capacity, and specifically increased peak capacity into London and Bristol;
- Journey time improvements, between London and Bristol Temple Meads, Cardiff, Swansea, Cheltenham and Worcester;
- Performance to meet national performance targets at a level of 92.5% PPM;

Consequential Impacts (non-quantified as defined by Network Rail)

- Improved environmental benefits, enabled through use of electrification;
- Improved passenger experience, enabled through the introduction of new trains, more seats and increased comfort; and
- Reduced operating costs, enabled by use of electric traction and new rolling stock.

[13] The Network Rail TGW refers to direct impacts as 'specified or quantified benefits' in that they can be measured against the requirements set out in the HLOS and TGW client Programme Requirements Document. The consequential impacts are referred to as 'non-quantified benefits' as these are seen as additional benefits to the HLOS. This definition of benefits differs, for example, from DfT definitions for economic appraisal where these Network Rail 'non-quantified' impacts are often in fact quantified

A 'Theory of Change' workshop and a series of subsequent stakeholder interviews were used to test the validity of the earlier benefits mapping and expected TGW programme benefits. During this exercise consultees were drawn from a range of senior staff from the DfT, Network Rail and the train operators who were engaged at various stages during the planning and delivery of the GWRM.

The focus for the workshop and interviews was to confirm the key drivers for the programme, by reviewing the enabling changes, understanding expected and, where possible, out-turn benefit delivery, and identifying any unexpected benefits or impacts.

The workshop and interviews confirmed that the key drivers identified previously remained valid for consideration in the evaluation, but with some suggested amendments made in developing three key themes:

- Combining earlier 'modal shift to train' and 'improve passenger experience' into a **passenger** theme – the emphasis on passenger service delivery will lead to increased rail usage and drive a modal shift from car, as well as generating wider social and economic benefits facilitated by accessibility and connectivity improvements.

- The commitment to carbon reduction could be widened to address both on-going railway and modal shift impacts and the environmental impacts of delivery under an **environment** theme.

- Given the importance of costs (alongside programming issues) as a key factor in de-scoping of the GWRM, the introduction of a **cost** theme appears to be appropriate, also allowing additional passenger revenues to be drawn into the assessment, as this will impact the future cost to government in letting a new or revised franchise or the equivalent delivery mechanism.

Through the Theory of Change workshop, it was possible to validate the earlier benefits map and ensure that no key elements were missing. This effectively maintains the process of developing scheme objectives and identifying benefit at the outset, and continuing to review and update these through to implementation and delivery.

The Theory of Change has distilled some of the complexities of the multiple drivers, enablers and expected benefits of the GWRM programme to a simpler narrative around which the evaluation has been framed.

For the GWRM, the overarching rationale as set out in the simplified Theory of Change statement is:

If the GWRM programme adds train capacity and invests in electrification and bimodal trains, then the passenger experience will be improved, increasing rail usage and revenues due to a greater take up of rail travel, and driving regional development and environmental benefits.

At a more detailed level, this can be used to frame the simplified Theory of Change map, shown in Figure 5. This does not aim to replicate or replace the earlier benefits mapping but provide an accessible framework around which the evaluation can be structured.

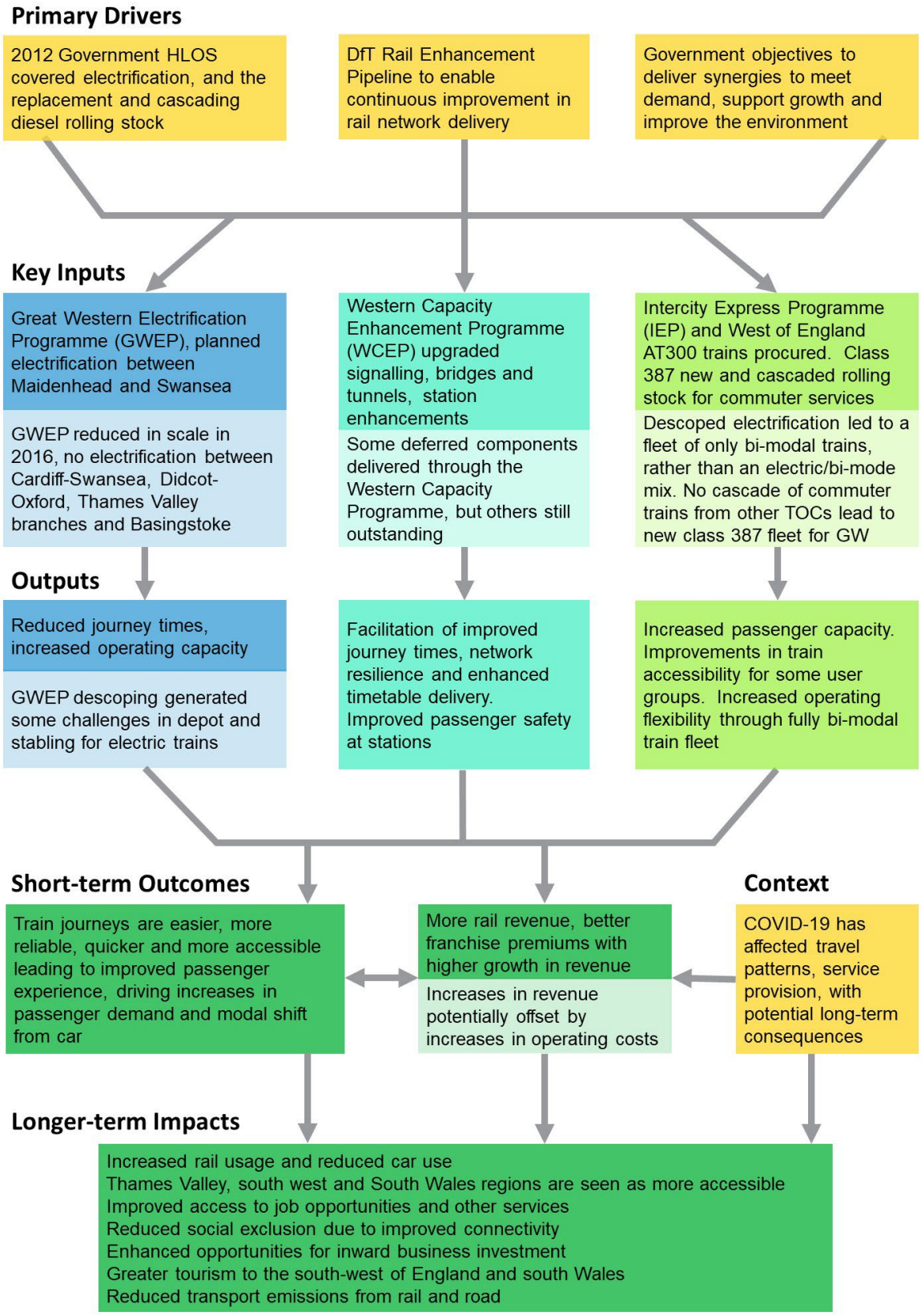

Figure 5: GWRM Theory of Change Map

The Theory of Change map presented in Figure 5 covers the three key themes developed from the original benefits mapping and the Theory of Change workshop and stakeholder interviews – passengers, the environment, and costs:

- **Passenger** experience is improved by easier, quicker, better connected, more reliable and more accessible train journeys. Better passenger experience is linked to longer term benefits: higher demand for train journeys, reduced car use, better access to job opportunities, and reduced social exclusion.

- The **environmental** performance of rail travel in the west and southwest is improved by the electrification of lines and purchase of bimodal trains. Environmental performance is linked to longer term benefits: increased rail usage, reduced car usage and reduced transport emissions from both rail and road.

- The **cost** performance of the rail network was affected by increased investment in rolling stock, line electrification, and infrastructure enhancements such as rail station improvements, which were potentially offset by the growth in revenue from increased passenger usage. Cost performance is linked to longer term benefits: improved franchise premiums, regional development, business opportunities for inward investment and greater tourism in the west and southwest.

The GWRM programme Theory of Change assumptions, grouped by the three key themes, include:

Passengers

- Additional route capacity will be translated into additional rail service provision and/or wider operational benefits;
- The programme will achieve higher standards of passenger experience, including shorter journey times, better reliability and punctuality, and increased capacity delivering reduced overcrowding and improving passenger comfort;
- Improved passenger journeys will drive increased use of the railway by existing passengers and modal shift from car, generating socio economic benefits for these passengers;
- Modal shift and transfer from car to rail will drive savings in car operating costs, make a net reduction to pollution and reduce accidents on the road network;
- Improved connectivity by rail can help drive local and regional economic growth, supporting improved access to employment and facilities for travellers and access to larger labour markets and catchments for employers and business;
- The safety and security of passengers and rail employees will be ensured; and
- Station upgrading and the design of the rolling stock will enable improved passenger access.

Environment

- Electrification of rail services will reduce the environmental impacts of operating the railway; and
- Based on a balance between costs, benefits and affordability, some local routes do not need to be electrified/ have electric trains.

Costs

- Assumptions of (any residual) capital spending and on-going operating costs based on the productivity of new infrastructure and technology are accurate;
- Passenger benefits are expected to drive long-term increases in revenues; and
- Increased passenger revenues will drive a reduced cost to government of supporting the railway.

The development of the Theory of Change should not be considered as a static one-off evaluation component, but part of a dynamic process, with the potential to review, refine and add nuance to the Theory of Change, logic mapping and the evaluation questions at any time during the evaluation lifecycle. Further insights developed from Theory of Change workshop and interviews are provided in Appendix C.

3.3 Evaluation questions

The initial GWRM benefits mapping, stakeholder engagement and Theory of Change narrative point to the key impact evaluation themes of:

- passengers;
- the environment; and
- costs.

This evaluation report is focused on reporting performance, where currently possible, against these key themes framed around a series of evaluation questions, focused on the InterCity type long-distance services. At a high-level there are three evaluation questions posed:

- How well did the programme meet the founding expectations regarding use of the railway network and its net costs?

- How has the programme contributed to reducing GWR's environmental impact?

- How has the programme contributed to wider social and economic prosperity activity and growth, and regional development?

Supporting these high-level questions, a number of more detailed questions can be identified to focus on more specific impacts:

Passengers

- How did the programme contribute to improved passenger experiences for long-distance journeys?

- What improved for whom, what were the reasons for change, and in what context?

- Did any intended beneficiaries fail to experience the intended benefits?

- Did improved passenger experience for long-distance journeys lead to higher rail demand, reduced car use, better access to job opportunities, access to other facilities and reduced social exclusion?

- Has the programme supported local communities, regional development, business opportunities for inward investment and greater tourism?

Environment

- Has the electrification of lines and deployment of bimodal trains improved the environmental performance of the railway?

- Has improved passenger experience lead to modal shift driving reductions in transport related emissions?

Costs

- Has the efficiency of long-distance train operations changed as a result of journey time improvements and performance impacts?

- How have train operating costs for long-distance services changed following replacement of the HST fleet?

- Did improved passenger experience lead to greater rail revenues?

- Has the programme contributed to better franchise premiums?

- Has the programme offered value for money, relative to expectations?

The evaluation questions identified here are likely to remain broadly valid for any future evaluation research. It is, however, possible that some may need to be revisited and amended to take account of any changes to the post-COVID train services and after there has been a demonstrable stabilisation of post-COVID travel patterns. This will ensure that any impacts of the programme can be assessed as a response to the endogenous drivers or established economic and other exogenous drivers, rather than pandemic recovery factors.

4. Passenger Impacts

This chapter addresses the following evaluation questions:

How did the programme contribute to improved passenger experiences for long-distance journeys?

What improved for whom, what were the reasons for change, and in what context?

Did any intended beneficiaries fail to experience the intended benefits?

Did improved passenger experience for long-distance journeys lead to higher rail demand, reduced car use, more accessible job opportunities, access to other facilities and reduced social exclusion?

It considers, in turn:

- **service levels**, primarily addressing the components of a rail journey, including journey times, service frequencies, rolling stock, but also addressing supporting elements around station facilities and access;
- **capacity**, drawing together train formations and frequencies in an assessment of changes in passenger capacities;
- **performance**, in considering changes in the measured performance of the network, primarily using the CASL (cancelled and significantly late) data; and
- **passenger attitudes** to changes in service provision, mainly drawing on time series data from the National Rail Passenger Survey.

4.1 Service levels

There are a number of components of rail travel that contribute to an overall level of service. These can include station access, waiting and travel times, changing trains as part of the journey and exiting the station. Passenger information can also play a key role in service delivery, including knowledge of service provision and the availability of real time and service planning information, especially at times of disruption.

The GWRM has focused on infrastructure and service provision, primarily in terms of electrification, capacity enhancements and new rolling stock. As part of the network-wide route improvements, some other aspects of rail travel have also been affected through works at stations to accommodate new rolling stock.

Most or all of the supporting infrastructure works around stations are geographically specific and affect individual stations and may address long-standing issues that could have a significant impact for individual travellers, especially in respect of mobility access. Whilst driven by the GWRM, these specific individual improvements are localised and better evaluated through focused local research rather than as part of a much wider programme evaluation.

Therefore, the delivery of specific works at stations associated with accommodating longer IET trains funded via the GWRM or linked initiatives such as Access for All improvements, for example at Chippenham and Cheltenham Spa, are not considered in this evaluation. The generalities of improvements in accessibility to and on trains are, however, considered qualitatively and through passenger satisfaction indicators, as examined in section 4.4.

Journey times – In vehicle time

Journey time improvements, in the sense of in-vehicle times, were identified as a key driver of the GWRM in the High Level Output Specification (HLOS). The HLOS used by Network Rail to drive The Greater West (TGW) programme of 2017 identified a series of journey time objectives for high speed services as part of the programme's benefits.

Table 3 uses an analysis of MOIRA data[14] to identify the changes in timetabled journey times and those identified in the HLOS. The table includes those routes identified in the Network Rail TGW, alongside key journey times to the west of England. The analysis illustrates journey times for trains departing from London Paddington terminating at the stations identified. The average figures shown are not demand weighted and represent weekday timetables.

In general, as shown below, the December 2019 timetable represents a shortening of long-distance service journey times on the main line from London Paddington. For all the core GWRM electrified or part-electrified routes, the fastest journey times are at least 10% shorter than in 2011.

All of the journey time objectives set out in the HLOS for the fastest trains have been met, except for small excesses against the HLOS objectives on the Cotswold (south) route to Gloucester (1 minute) and Cheltenham (5 minutes).

Journey times of trains from London to Bristol Temple Meads via Bath have improved, with a reduction in journey of 11 minutes for the fastest trains and the journey time of 87 minutes meeting the HLOS objective of 93 minutes. The introduction of fast limited stop services via Bristol Parkway, albeit curtailed due to the pandemic, provided a journey time of just over 80 minutes reducing the faster journey time to the centre of Bristol by 17 minutes. While the average journey times for all trains from London to Bristol Temple

[14] MOIRA 2.2.1 [August 2021], and licenced for GWR

Meads is 2 minutes longer than the HLOS objective, the 8 minutes saving represents an 8% saving relative to 2011 journey times.

The HLOS objectives for trains to Cardiff Central have been met for both the fastest trains and the average journey times. Reductions in the fastest weekday journey times to London are around 20 minutes from trains from both Cardiff and Swansea, with a reduction of around 15 minutes in the average weekday journey times.

	note A	Fastest Journey Time					Average Journey Time			
Service (train origin - terminal station)		Dec -11 (hh:mm)	Dec-19 (hh:mm)	change mins	change %	HLOS Target	Dec-11 (hh:mm)	Dec-19 (hh:mm)	change mins	change %
Paddington - Bristol Temple Meads		01:38	01:27	-11	-11%	01:33	01:43	01:35	-8	-8%
Paddington - Bristol TM via P'way	note B	n/a	01:21	-17	-17%	01:23	n/a	01:21	-23	-22%
Paddington - Cardiff Central		02:06	01:47	-19	-15%	01:55	02:07	01:53	-14	-11%
Paddington - Swansea		02:58	02:37	-21	-12%	02:39	03:03	02:48	-15	-8%
Paddington - Worcester SHilll	note C	02:13	01:57	-16	-12%	02:06	02:18	02:12	-6	-4%
Paddington - Gloucester	note D	n/a	01:41	n/a	n/a	01:40	n/a	01:46	n/a	n/a
Paddington - Oxford	note E	00:56	00:48	-8	-14%	00:49	*01:02*	00:56	n/a	n/a
Paddington - Cheltenham Spa		02:15	01:57	-18	-13%	01:52	02:16	02:01	-15	-11%
Paddington - Penzance		05:05	05:03	-2	-1%	n/a	05:19	05:10	-9	-3%
Paddington - Plymouth		03:16	03:08	-8	-4%	n/a	03:27	03:23	-4	-2%
Paddington - Exeter St. David's		02:38	02:23	-15	-9%	n/a	02:40	02:24	-16	-10%
Paddington - Bedwyn		01:13	01:03	-10	-14%	n/a	01:15	01:09	-6	-8%

Note A - Journey times derived from MORIA v2.2.1 [August 2021]. Secondary routeings are not included in the average journey times (eg south Wales/west of England to Paddington via Bristol, Bristol to Paddington via Westbury, Worcester to Paddington via Cheltenham).
Note B - change in journey time shown relative to routeings via Bath. Note Dec-19 introduced a limited number of services. More services were expected to be provided from May-20, although these were not introduced due to COVID-19 pandemic response timetables
Note C - the faster journey time in 2019 of 01:57 is achieved on a service running through to Hereford
Note D - no trains to/from London originate or terminate in Gloucester. 2019 figures are taken from the public timetable and cross-checked versus the Cheltenham figures. These timetabled journey times are presented to enable a comparison with the HLOS output journey times.
Note E - fast services considered only. In 2011 Oxford services consisted of a mix of fast, semi-fast and stopping services; an estimated average journey time for the fast trains is reported here. In 2019 all services were mostly fast trains stopping at Reading only, with slow trains offering connections at Didcot for intermediate stations.

Table 3: Journey time analysis for core long-distance routes

Source: MOIRA v2.2.1 [August 2021] SYSTRA

Average journey times between London and the south west of England have been reduced through the elimination of irregular stops at the smaller stations between Reading and Exeter on longer-distance train services to Devon and Cornwall. This has been enabled by the introduction of a new two-hourly semi-fast service between London and Exeter to serve those stations providing a better and more regular train service.

The changes in average journey times for terminating trains from London Paddington are illustrated graphically in Figure 6.

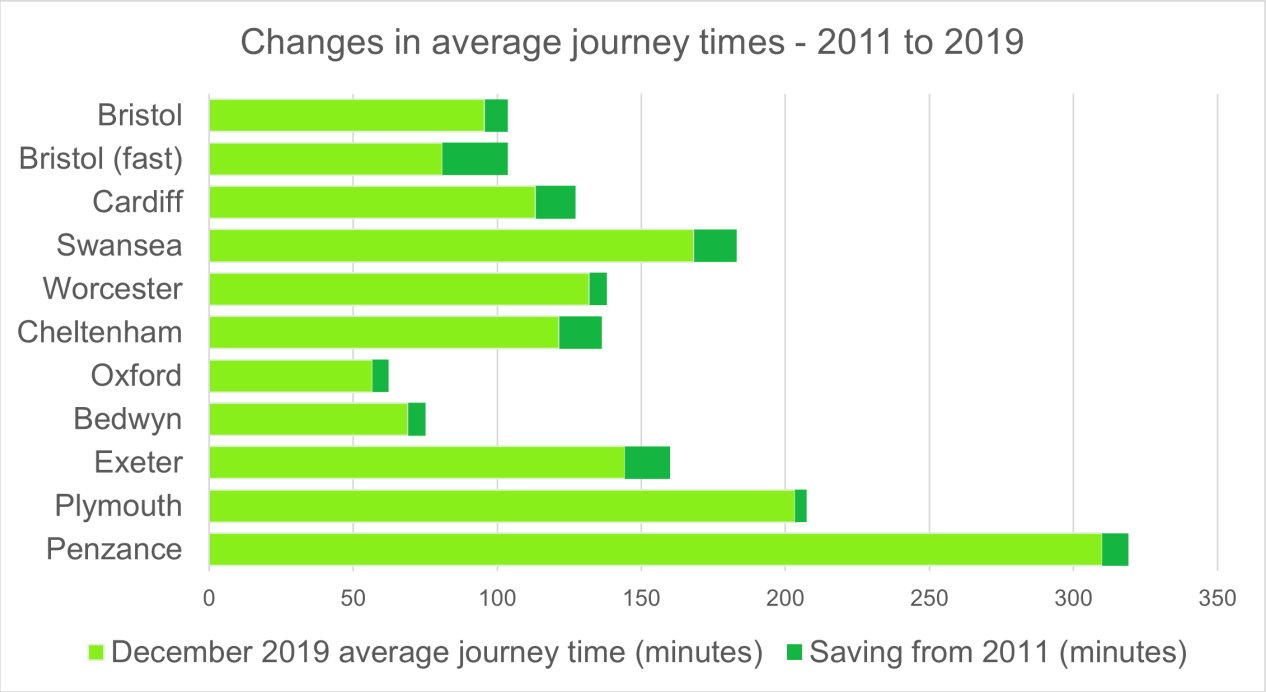

Figure 6: Changes in average journey times for core long-distance routes

Source: MOIRA v2.2.1 [August 2021], SYSTRA

There are similar journey time changes for eastbound trains arriving into the capital, albeit with the journey time savings for the fastest services generally being a little lower than those in the westbound direction. The reasons for these non-symmetric changes between 2011 and 2019 timetables have not been considered in any detail but may reflect underlying differences in the directional symmetry of stopping patterns and timetable rules, including recovery and pathing allowances.

Significant improvements in journey times have been achieved for core long-distance routes from London to Bristol and south Wales, with services to Bristol on average 8 minutes or 8% faster in December 2019 compared to December 2011. Average journey times to south Wales are around 15 minutes or ~10% faster, with an average journey time of less than 2 hours to Cardiff and less than 3 hours to Swansea. Journey time benefits are also apparent on other long-distance routes; to Cheltenham with savings of 15 minutes (and an improved frequency as noted below), and on the Cotswold (north) line to Worcester.

While it is clear that journey times have been reduced in general, some of the time savings have been driven in part by changes in stopping patterns with an increased number of 'existing' peak period services not stopping at Reading, Didcot or Swindon, potentially saving around 4-6 minutes in journey time. It is apparent that these changes may have affected some travellers and businesses in reducing connectivity, particularly at Reading.

Other potential drivers of faster timetable changes, such as any changes in the way recovery and pathing times were handled between the timetables in 2011 and 2019, have not been considered but are unlikely to materially affect the changes identified in Table 3.

In their review of the GWRM, the NAO[15] identified a risk that the top speeds of the new bi-modes when operating under diesel power would be lower than the existing high-speed diesel trains and that this could affect journey times.

The analysis above suggests that for end-to-end journeys on the core GWR routes journey times have not been significantly impacted by operating under diesel power on short non-electrified sections of route, with significant benefits delivered for core services to Bristol and Cardiff, and on both Cotswold routes.

There are also significant journey time benefits for services to Swansea. Sensitivity testing undertaken for the 2015 GWRM appraisal suggested that bi-mode trains running under diesel power for the 45 miles between Cardiff and Swansea would be three minutes slower than operating under electric power. This differential cannot be tested in practice, but an indicative analysis of out-turn timetables suggests that the post December 2019 timetable delivers journey times that are only slightly longer than expected under electric operation but less than the earlier expected diesel timings.

Journey time savings on the west of England services are apparent to Exeter but are much lower for the longer routes into Devon and Cornwall, potentially reflecting differences in performance for the bi-mode trains on the steeply graded routes south of Newton Abbot.

A more detailed analysis of train performance would be required to confirm any potential journey time deficits arising from operating bi-mode trains in diesel mode, including the impacts of unmuzzling the Class 800 diesel engines and delivering the West of England Class 802 trains higher rated engines[16].

Service frequencies

In general, the InterCity type long-distance routes operated by GWR have been focused on offering direct through trains to/from London. Services have traditionally served a core network of the major centres of Bristol, Cardiff, Swansea, Exeter and Plymouth, ordinarily with at least hourly services. Smaller centres and routes have also retained through services, generally at lower frequencies, including extended services to Weston-Super-Mare, Carmarthen/West Wales and Penzance and on the Cotswold (north) route to Worcester/Great Malvern and Hereford.

Services on the Cotswold (south) route until completion of the GWRM were provided by a mix of through services running every two hours from London to Cheltenham, and a timetabled interchange at Swindon in the hours between. The post-GWRM timetable of December 2019 has moved to an hourly through service model, providing enhanced connectivity on the route.

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[15] Modernising the Great Western railway, NAO, November 2016

[16] The original specification for the Class 800 trains included a ‘muzzling’ of the diesel engines to reduce power usage, in part as this additional power would not been needed in normal operations with full electrification. With deferred or cancelled electrification, and IET use on all West of England services, additional diesel power would ordinarily be needed and the Class 800 trains were ‘unmuzzled’ and Class 802 trains provided with higher powered engines.

Table 4 provides a summary of the GWR weekday timetables for those from December 2011 and following the major timetable recasting in December 2019. Apart from the delayed introduction of some additional superfast services to Bristol and Cardiff, the 2019 timetable represents the delivery of the GWRM-driven frequency improvements, drawing together the electrification programme (GWEP), the capacity enhancement programme (WCEP) and the rolling stock replacement programme (IEP for long-distance services).

A set of service groupings has been used to simplify the analysis of frequency changes. The relatively small number of short-workings (primarily at the start or end of services) are included in the respective groupings.

In general, the December 2019 timetable represents a major increase in service levels. This was one of the key objectives of the GWRM and the marketing messaging accompanying the timetable change focused on the increase in high-speed services.

The commentary following the table provides details of key changes in service provision, focusing primarily on the long-distance service changes driven by the GWRM.

	Trains/day				Train Miles/day
Grouping	**Dec-11**	**Dec-19**	Change		Change 2011-19
GWR Main Line - Bristol group (note A)	57	82	25	44%	42%
GWR Main Line - Wales group	61	69	8	13%	11%
GWR West of England group (note A)	46	52	6	13%	13%
Cotswolds North	41	45	4	10%	17%
Cotswolds South (direct and connections)	33	36	3	9%	46%
Long Distance Total	**238**	**284**	**46**	**19%**	**21%**
London - Reading GWR/Crossrail (note B) inc Thames Valley, Basingstoke, Gatwick	530	688	158	30%	19%
London - Newbury/Bedwyn, Oxford and Banbury fast services (note C)	109	139	30	28%	25%
London - Didcot and Oxford slow services	93	102	9	10%	6%
Didcot to Oxford/Banbury (local connections)	*0*	*60*	*60*		included above
London and Reading Commuter Total	**732**	**989**	**257**	**35%**	**17%**
Other GWR routes - Cardiff/Worcestershire to Bristol, South Coast, South West & branches	507	571	64	13%	21%
Other GWR Routes	**507**	**571**	**64**	**13%**	**21%**
GWR plus Crossrail (excluding Heathrow services, Sleeper and bus/coach services)	**1477**	**1844**	**367**	**25%**	**20%**

Notes: A - The limited number of Taunton trains routed via Bristol are included in the Weston-Super-Mare figures. The limited number of Exeter services routed via Bristol are considered in the Somerset and Exeter figures
B - Does not include Heathrow Express or Heathrow Connect services
C - Calls on long-distance services at Oxford and Newbury/ Bedwyn are not considered in the table, but terminating trains are

Table 4: GWR Weekday Timetables – Trains per Day, 2011 and 2019

Source: MOIRA 2.2.1 [August 2021], SYSTRA

The number of long-distance services increased by around 20% between the December 2011 and December 2019 timetables, with increases on all key long-distance routes, including into south Wales and the west of England. Principal increases in service levels have been to Bristol, moving to a three or four trains per hour service from two per hour, but with the introduction of some additional services not implemented due to the COVID-19 pandemic. Other key changes include providing an hourly through service from London to Gloucester and Cheltenham, doubling the number of direct services to the capital.

Based on the December 2019 timetable[17], key changes for long-distance services arising from GWRM include:

- Bristol services, with some extensions to Weston-Super-Mare:
    - the December 2011 timetable and general pre-GWRM service pattern offered two trains per hour;
    - the December 2019 timetable introduced additional peak period services increasing the frequency of service from two to three trains per hour, with some stops removed east of Chippenham delivering the faster journey times noted above. The introduction of additional off-peak services from Bristol Temple Meads to London Paddington, via Bristol Parkway, planned from spring 2020 was deferred due to the COVID-19 pandemic.
- Cardiff and Swansea, with some extensions to West Wales:
    - the general pre-GWRM service pattern offered two trains per hour to Cardiff and running through to Swansea. One train per day in the December 2019 timetable was extended to Carmarthen, with other extensions into West Wales generally offered in the summer timetables;
    - the December 2019 timetable introduced two additional eastbound AM peak and three additional westbound PM peak period services and three extra evening services. The removal of some stops east of Bristol Parkway delivered the faster journey times noted above.
- West of England services to Somerset, Devon and Cornwall:
    - the general pre-GWRM service pattern offered a mix of one or two trains per hour to Exeter and Plymouth with extensions to Penzance and Paignton;

[17] The December 2019 timetable was suspended during 2020 due to the COVID-19 pandemic with a temporary reduced timetable introduced under the Emergency Measures Agreement between GWR and DfT. The long-term timetable will be determined in due course through other new arrangements and this may not provide the same levels of service as the December 2019 timetable.

  - the December 2019 timetable introduced some additional services at times to fill in some, but not all, of the hourly intervals with a second departure.

- Cotswold (south) to Gloucester and Cheltenham

  - the general pre-GWRM service pattern offered through services from London every two hours, with the intermediate hours served by a connecting service at Swindon to/from Gloucester and Cheltenham;

  - the December 2019 timetable moved to a through train model, eliminating all weekday daytime interchanges at Swindon, except early mornings and late evenings and at weekends.

- Cotswold (north) to Worcester, Great Malvern and Hereford

  - the general pre-GWRM service pattern offered a broadly hourly service to Worcester, with some gaps in service and short-workings east of Worcester, and some extensions to Great Malvern and Hereford;

  - the December 2019 timetable consolidated the timetable with the earlier gaps filled and standard hourly service provided and a modest increase in services extended west of Worcester to Great Malvern and Hereford.

In general, train miles (the numbers of trains and the distances they travel) broadly follow the number of trains operated. Key differences on the long-distance routes are apparent on the Cotswold (north) route where there are 17% more train miles compared to 10% more train services; the 2019 services have extended some of the short workings in 2011 to serve Worcester and more services are extended to Great Malvern.

Fast commuter services have been retained from Oxford and Newbury/Bedwyn, with both served by IETs. Oxford trains are provided by hourly services on the Cotswold (north) route interspersed by hourly dedicated services running between London and Oxford only broadly maintaining the earlier half-hourly service levels. Significant improvements have been delivered on fast services to Newbury and Bedwyn, with more through services to London, longer trains and increases in seat mileage.

On the London-Reading commuter routes, there are more significant differences between increases in numbers of trains and train miles. This includes the introduction of local connecting diesel services between Didcot and Oxford following the deferral of electrification to Oxford and the removal of slow commuter services from Oxford to Reading and London. Some additional train miles are also operated on other regional GWR routes, including, for example, additional Cardiff to Penzance services.

While the number of trains operating on long-distance routes had increased across all service groupings, individual stations may have seen some changes in levels of service due to stopping patterns and other nuances of the delivery timetables.

The increased number of non-stopping services, particularly at Reading, linked to the faster journey times noted above, have resulted in some reductions in service frequencies for selected journeys, with both individual and wider business concerns being raised

through railway stakeholder engagement processes and in the public domain, and particularly via local press outlets. These issues are considered below alongside some other elements of stakeholder engagement and the knowledge of service changes.

In their Western Route Study of August 2015, Network Rail identified an anticipated Indicative Train Service Specification (ITSS) for 2019 to the section of route from London Paddington to Reading assuming the delivery of the GWRM (including, at the time, electrification of the Thames Valley branches (except Greenford), the transfer of Crossrail services from Reading and Western Rail Line to Heathrow).

Table 5 shows the ITSS noting that all expected service levels not dependant on other investment have been delivered or have a capability to be delivered.

Anticipated 2019 Indicative Train Service Specification off-peak trains per hour (tph) direction	Delivered	Notes
Main Line trains:		
• 4tph Paddington – Heathrow Terminal 5	yes	-
• 1tph Paddington – Oxford	yes	-
• 1tph Paddington – Newbury	yes	generally extended to Bedwyn
• 1tph Paddington – Cheltenham Spa	yes	-
• 1tph Paddington – Worcester via Oxford	yes	some extended to Malvern/Hereford
• 4tph Paddington – Bristol Temple Meads (2tph via Bath, 2tph via Bristol Parkway)	capability	some extended to Weston/Taunton. Parkway services not implemented
• 2tph Paddington – south Wales	yes	some extended to Exeter
• 1tph Paddington – Westbury	yes	-
• 1tph Paddington – Exeter or beyond	yes	-
Relief Line trains:		
• 4tph Paddington Crossrail – Heathrow T4	)	) can operate to specified
• 2tph Paddington Crossrail – Maidenhead	) capability	) frequencies and to be
• 2tph Paddington Crossrail – Reading	)	) extended eastwards via Crossrail
• 2tph London Paddington – Reading or beyond (residual outer suburban service)	yes	extended to Didcot
• 4tph Freight	capability	not examined
Services dependent on other investments: • 4tph Heathrow Terminal 5 – Reading	no	anticipated implementation during CP6 not delivered

Note: 'Capability' refers to the ability to operate to the ITSS even if the post-December 2019 and/or COVID-19 adjusted timetables have not been fully delivered. Services may be included in working timetables but not operate

Table 5: Delivery of Network Rail 2019 Anticipated Indicative Train Service Specification

Source: Network Rail and SYSTRA

Rolling stock

An integral part of the GWRM programme was the provision of new rolling stock, seeking to modernise the train fleet and enhance passengers' experiences. In addition, new rolling stock was seen as a key driver to permitting a step change in the capacity of the network.

In general, the vast majority of long-distance services were formed of GWR HSTs in 2011, with a limited number of services on the Cotswolds routes handled by other trains primarily on local or connecting services. As of December 2019 virtually all services on both routes are now handled by GWR IETs.

The average age of the rolling stock operated by GWR fell from just under 30 years in 2011/12 to less than 12 years in 2019[18], with the new IET trains deployed on long-distance routes and electric trains on key London and Reading commuter routes. In addition to the desire for new trains to provide greater capacity, increased passenger comfort and greater reliability, cascading of earlier rolling stock has included refurbishment to improve compliance with accessibility standards and increase capacity on other parts of the regional GWR network and elsewhere.

Table 6 and Table 7 identify the outputs arising from changes in rolling stock deployment, considering key features of the new rolling stock and the resulting rolling stock cascades respectively, with an assessment of the benefits delivered, primarily noting the changes in capacity and passenger experience. These tables exclude the forthcoming deployment of Class 769 tri-modal trains (electric overhead, third-rail, diesel) intended to operate on some Thames Valley routes, releasing further 3-car 165/166 trains for deployment elsewhere.

Outputs: new rolling stock deployment	Benefits delivered
Long-Distance Routes GWR IET (IEP and AT300s West of England and additional trains) 58 x 5-car, 35 x 9-car trains	Bi-mode operation retains capability to serve non-electrified route extensions and engineering diversions, including into Wales via Gloucester and Bristol via Newbury/Trowbridge Additional passenger capacity offered by 9/10-car units over earlier HSTs Improved accessibility and safety standards and meeting current requirements Changes in quality and ambience - including quality of ride, boarding/alighting, seating lighting, passenger information, cycle storage - to be tested via passenger feedback and satisfaction ratings
London/Reading Commuter GWR Class 387 33 x 4-car trains (+ 9 on hire)	Additional capacity offered over earlier 3-car or 2x3-car Class 165/166 trains Improved accessibility and safety standards, fully meeting current legislative requirements Changes in quality and ambience could be tested via passenger feedback and satisfaction ratings

Table 6: Summary of outputs from deploying new rolling stock – key features

Source: GWR Facilities Guide 2021, SYSTRA

[18] Office of Road and Rail data, Table 6313 - Average age of rolling stock by operator

Outputs of rolling stock cascades	Benefits delivered
Long-Distance Routes GWR IET (IEP, AT300s West of England and additional trains) Cascades - GWR HST fleet reformed to GWR Castle Class 4-car trains - GWR HSTs to Scotrail franchise to strengthen provision and provide a secondary cascade of trains to Northern - GWR Class 180 fleet to Grand Central	Replaces GWR long-distance HST and Class 180 trains and GWR 2/3-car trains on Cotswolds local and connecting services Offers improved capacity, accessibility and safety compliance, allowing 'less-non-compliant' HSTs to be withdrawn. Changes in quality and ambience Improvements in capacity and passenger experience expected for the TOCs using cascaded rolling stock
London/Reading Commuter GWR Class 387 Cascades - cascaded GWR Class 165/166 fleet to GWR regional routes - secondary cascades to other GWR routes and TOCs, withdrawal of GWR Pacer trains - Class 345 Crossrail rolling stock allows Heathrow Express to be operated by GWR Class 387 trains released from stopping train duties on the GWML	Replaces GWR Class 165/166 offering improved capacity, accessibility and safety compliance. Changes in quality and ambience Improvements in capacity and passenger experience for TOCs using cascaded rolling stock (Northern, East Midlands, Scotrail, Transport for Wales) Replacement of the non-standard Class 332 trains on the Heathrow Express simplifying train operations and maintenance
Other GWR Routes GWR Class 165/166 fleet from Thames Valley Cascades - GWR Classes 150/153/158 elsewhere on the GWR network and to other TOCs	Improvements in capacity and passenger experience (Northern, East Midlands, Scotrail, Transport for Wales) and withdrawal of GWR Pacer trains Changes in quality and ambience

Table 7: Summary of outputs from deploying new rolling stock – cascades

Source: SYSTRA

The cascading of rolling stock arising from the GWRM, primarily driven by the new IET fleet and the Class 387s for London and Reading commuter routes, has provided enhanced capacity and changed passenger experiences elsewhere on the GWR network. Wider network benefits have been delivered to other train operators receiving cascaded rolling stock, and allowed the withdrawal of the non-compliant Pacer trains.

Most or all cascaded trains have been, or will be, refurbished to some extent before re-entering service with either GWR or other operators, potentially driving a range of passenger experience benefits. For example, the cascaded fleet of Class 165/166 trains, comprising of 57 units/151 vehicles for the GWR services around the Bristol area are being refurbished via a £5.5m contract intended to update the vehicle interiors and make these trains more suitable for the mid-distance journeys common of the routes to be served.

Station facilities, access and interchange

The GWRM facilitated and funded a number of improvements to stations around the Great Western network, primarily linked to accommodating the new rolling stock. While not explicitly considering specific improvements at individual stations, it is valuable to consider the outcomes from the investment in improving accessibility to and on trains arising from new rolling stock provision.

In general, access to and within railway stations throughout the UK has been improving over time with investment throughout the network, funded through a range of sources, including established investment streams, Access for All[19] funding and local authority/stakeholder mechanisms.

Major early pre-GWRM investments at stations on the Great Western network included operational and passenger focused schemes delivered at the key interchanges of Reading, Bristol Parkway and Newport, with smaller scale more recent improvements in passenger accessibility, for example at Chippenham and Cheltenham Spa. The accessibility improvements delivered by these schemes included new passenger lifts, improved pedestrian access and safety, more accessible bus-rail interchange and additional cycle storage.

Other on-going improvements at stations have included forecourt schemes, for example expanded car parking provision at Tiverton Parkway, Gloucester, Westbury and a new 400-space multi-storey car park at Taunton opened in May 2021 as part of the multi-million-pound station regeneration project.

These investments in station facilities are therefore not part of the GWRM but help support the investment in infrastructure and rolling stock delivered through the programme.

More specifically linked to the GWRM were platform extensions provided at stations served by the new IET trains, principally at stations along the north and south Cotswold routes, with some accompanying improvements in wider facilities, such as improvements to station passenger information systems and new waiting and associated rooms, for example at Moreton in Marsh.

A similar programme of platform extension took place at many stations on the London commuter network, including at all stations west of Maidenhead to Reading, to Didcot and Newbury that were shorter than the standard 8-car train length.

The principal benefits of platform extensions particularly on long-distance routes include:

- improved distribution of passenger boarding at stations;
- faster boarding and alighting times;

[19] Network Rail's Access for All Programme provides an obstacle free, accessible route to and between platforms as part of the Government's Inclusive Transport Strategy https://www.networkrail.co.uk/communities/passengers/station-improvements/access-for-all-improving-accessibility-at-railway-stations-nationwide/

- reduced anxiety for passengers alighting from the correct portion of the train and/or reduced number of missed stops, especially for passengers with luggage or mobility impairments;
- reduced on-train crowding (and during COVID-19 in maintaining social distancing);
- accessibility improvements such as additional tactile platform edging on new platform (and existing platforms) for sight impaired passengers and
- general improvement in passengers' experience.

At stations where platform extensions have not been feasible, mitigation through the use of selective door opening has maintained safety for passengers, but with less flexibility in boarding and alighting and continued passenger anxiety and/or missed stops.

The GWRM itself has no direct impact on station access and interchange provision per se, although the provision of enhanced through train services between London and Gloucester and Cheltenham has significantly reduced the need for interchange at Swindon. The removal of the need to interchange on weekdays and for most of Saturday daytime periods will have reduced the extent of crowding that could occur in the confined waiting areas on platforms 1 and 2 at Swindon, improving the experience for passengers originating and waiting at Swindon as well as improving the journey experience for passengers for Cheltenham and intermediate stations.

Public awareness of service changes

With the GWRM investment being implemented to a fully operational railway, it was inevitable that there would be some disruption to existing operations at selected times and changes to service provision that would impact on existing travellers.

The key timetable change in December 2019 when the substantive journey time and frequency changes were implemented was accompanied by an extensive communications and promotion programme. This included a public and stakeholder engagement communication campaign, building on some of the communication lessons learnt from the industry's implementation of major timetable changes in 2018.

Transport Focus, in their October 2019 report[20] into the timetable changes, were keen to understand levels of awareness and understanding about the changes among GWR passengers.

In December 2019 Transport Focus used their Transport User Panel, inviting over 1,100 members who had indicated that they used GWR services, to report on their pre-opening understanding of the forthcoming service changes; over 440 panellists took part in the survey. Following the implementation of the timetable changes, Transport Focus hosted a survey on their website and re-contacted their earlier panellists. Around 200 passengers using GWR services between the end of December 2019 and the end of February 2020 provided feedback on their experiences. Due care should be taken in interpreting and using the survey findings, given that the panel is not representative of all rail users by demographics or geography.

[20] Great Western Railway December 2019 Timetable Change Survey, Transport Focus, October 2019

The survey covered the timetable changes across the GWR network, with the analysis reported in aggregate. Therefore, the commentary developed below will include responses from long-distance travellers on the IET network, those travelling in the London and Reading commuter areas and those using the west and south west regional networks.

The baseline survey identified a very high level of awareness that some major timetable changes were forthcoming, suggesting that the information campaign had been effective and a high level of understanding of the rationale for the changes. Key quantified findings included:

- over 80% of business and leisure travellers were aware of the forthcoming timetable changes to some degree;
- over 95% of commuters were aware of timetable changes and over 75% reported they had a good idea of what the changes would be;
- the majority of people had heard about the changes through information provided at stations (89% of commuters, 76% of business travellers and 70% of leisure travellers);
- among those aware of the changes, 60% thought that they would impact on the journeys that they make at least to some extent, with 15% thinking that they would be affected 'a great deal'; and
- 47% of those with at least some awareness of the changes said that they understood the thinking behind the changes and a similar proportion said that they support the changes.

The headline findings from the Transport Focus report noted that the *"overwhelming majority of people were aware of the timetable change…"* with references to "*a range of information channels, including station and on-board announcements, websites, apps, emails and pocket timetables"*.

The report noted that "*many perceived GWR to be coping well with the timetable change and commented on* the additional staff support at stations…" and that *"the advance warning of the changes had been good.*" It was noted, however, that "*some would have liked to have seen greater consultation and more detail on specific services (sic) changes in addition to the high level warnings.*"

4.2 Capacity

Forecast capacity requirements

The NAO noted[21] that there was a good case for increasing capacity on the Great Western route, given that, in autumn 2013, three of the ten most overcrowded train services in England and Wales were Great Western services into London Paddington. It was also recognised that DfT forecasts suggested passenger demand on the route would grow by 81% between 2013-14 and 2018-19, with an extra 21,200 passengers arriving at London Paddington during the peak period.

Network Rail's Market Studies of October 2013, of which three focused on the passenger market (the fourth looking at freight markets), also identified expectations of significant background growth and demand from committed schemes on the routes from Paddington.

As shown in Table 8, the London and South East Market Study[22] forecast an increase of just under 200% in Paddington 'inner suburban'/'relief line' commuter demand between 2012 and 2023 with further growth to 2043, primarily as a result of both an abstraction of passengers from other rail and London Underground services to Crossrail, and a stimulation of new journeys.

Of key relevance for this assessment is the identified projected growth in peak demand on 'outer suburban'/'main line' services into Paddington from an outer suburban and longer distance market of just under 30% to 2023 and almost 100% over the longer-term to 2043.

Service Group	2011 total passengers	Forecast passengers in 2023	Increase 2011 to 2023	Forecast passengers in 2043	Increase 2011 to 2043
Inner Suburban - Crossrail and relief lines	4,100	12,200	198%	14,200-16,500	243-298%
Outer Suburban Mainline and other fast services	8,500	9,500-11,000	11-29%	12,700-17,000	49-99%

Table 8: Network Rail London and South East peak hour passenger demand projections
Source: Network Rail: South East Market Study, October 2013

The projected growth rates were used in Network Rail's long-term planning processes set out in their Western Route Study[23] of August 2015 to develop capacity-based conditional outputs *'to provide sufficient capacity for passengers travelling into central London during peak hours, taking into account anticipated growth over the period to 2043'* for inner suburban services (conditional output CO1) and main line services (conditional output CO2). The Western Route Study also identified a number of additional capacity-based conditional outputs, including similar issues at Reading, Bristol and elsewhere.

[21] Modernising the Great Western railway, NAO, November 2016
[22] London and South East Market Study, Network Rail, October 2013
[23] Western Route Study, Network Rail, August 2015

Overall capacity delivery

With a staged delivery of key components of the GWRM, there has been a gradual increase in capacity offered on the network over the past 10 years.

Figure 7 illustrates the passenger capacity and passenger demand for the three-hour morning peak period for 2010 to 2019 taken from estimates of London terminals passenger arrivals[24]. This period includes nuanced changes in timetables in the early years, before the more substantive introduction of new commuter and long-distance rolling stock fleets. Combined, both of the drivers generate an increase in morning peak period capacity of 25%, broadly similar to demand growth over the period. Note that post-December 2019 timetable changes impacts are not included in this figure.

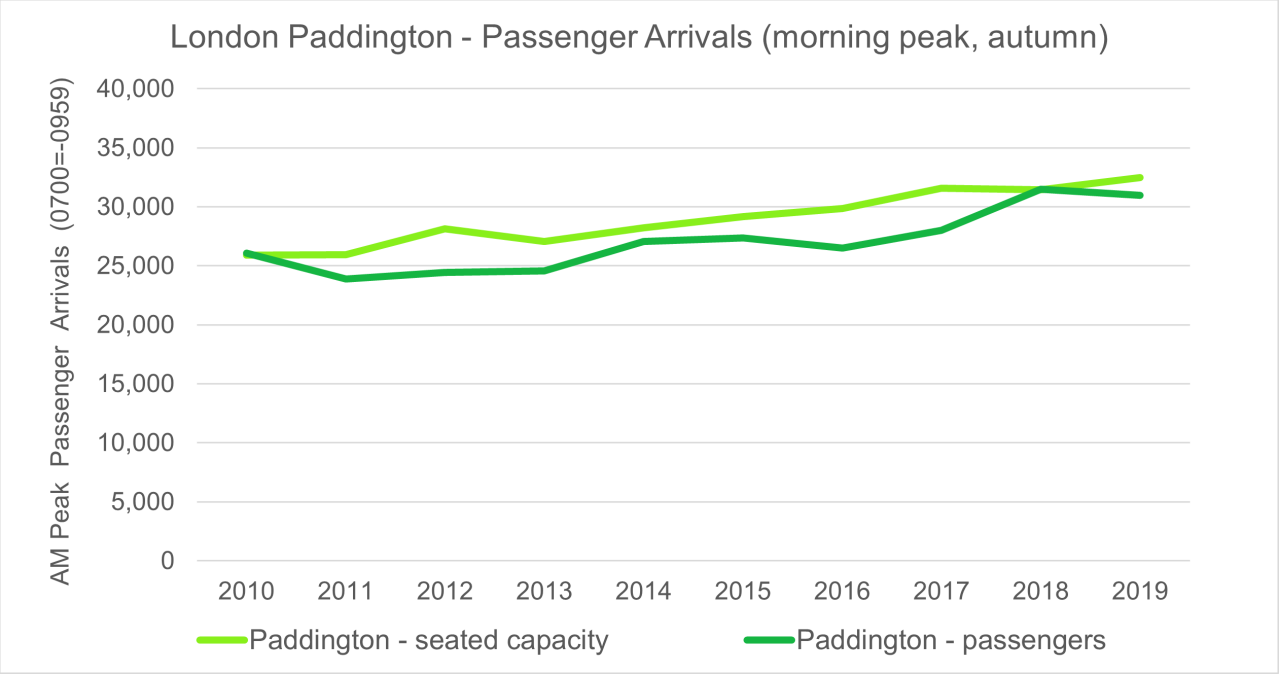

Figure 7: London Paddington rail passenger arrivals (autumn counts, first and standard class)

Source: DfT rail statistics, table RAI0201, SYSTRA

Figure 7 identifies a peak passenger demand for journeys to Paddington of 26,000 in 2011, slightly above seated capacity, giving an average occupancy of 101% across all trains and all three peak hours; this figure fell back to 92% in 2011 before maintaining an average seated occupancy of 93% across all subsequent years to 2019.

The average seated occupancies for arrivals at Paddington are shown in Figure 8 alongside a summary of other London terminal arrivals. In 2010, Paddington had the highest seated occupancy factors of any of the north London mainline terminal stations and maintained an above average occupancy across north London terminals thereafter. However, those terminal stations in the south (London Bridge, Blackfriars, Waterloo and Victoria) consistently have much higher occupancy factors.

[24] DfT rail statistics RAI0201 provides estimates of station arrivals for a typical autumn weekday

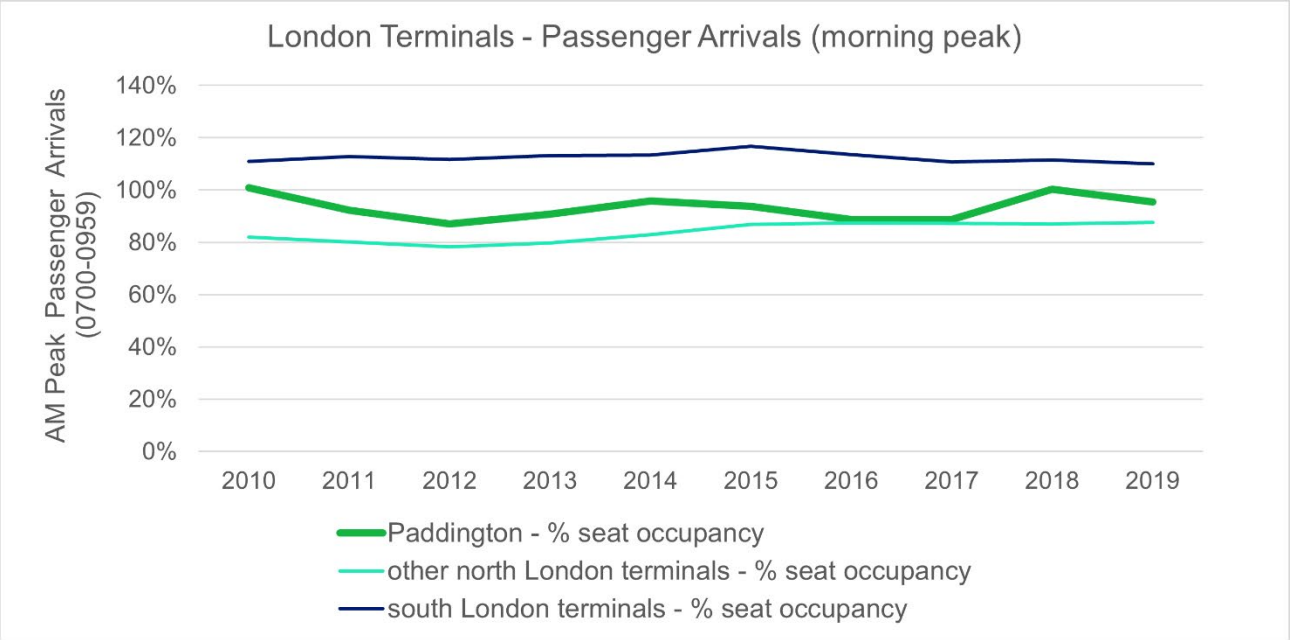

Figure 8: London terminals rail passenger arrivals (autumn counts, first and standard class)
Source: DfT rail statistics, table RAI0201, SYSTRA

Increases in passenger capacity for morning peak period passenger arrivals into Paddington associated with the delivery of some of the GWRM components are apparent to 2019, with a growth in seated capacity of 25% between 2011 and 2019 to just under 32,500. Growth in passenger demand of 30% was observed over the same period with just under 31,000 passenger arrivals during the peak period by 2019.

Within the peak period, average occupancy factors can be observed to be higher for the peak hours within the period. At a train-by-train level, individual train formations can also become important; some of the earlier overcrowding issues noted by the NAO in their 2016 report may have arisen from peak period trains often using 3-car formations.

It is apparent that from 2011 to 2019 some 'peak spreading' has occurred primarily since 2016, with additional demand handled by the less busy periods in the peak period. For arrivals at Paddington, there has been a general move to earlier arrivals with greater increases in occupancy factors occurring in the two-hour period before 0800 despite increases in capacity. These changes are illustrated in Table 9, showing the growth in capacity in the period from 0600-0659 of over 50% and demand of over 100%, resulting in occupancy rates increasing from 37% in 2011 to around 50% by 2019. This is in contrast to the period between 0800-0859 where the growth in passenger arrivals largely matched capacity growth.

Paddington Station Arrivals – peak period	2011	2013	2015	2017	2018	2019	Change 2011-19
0600-0659							
- Capacity	4,126	3,938	4,460	5,096	5,934	6,398	+55%
- Passenger arrivals	1,525	1,680	1,975	2,288	3,013	3,159	+107%
- Occupancy	37%	43%	44%	45%	51%	49%	
0700-0759							
- Capacity	7,765	8,175	8,687	10,005	10,448	9,784	+26%
- Passenger arrivals	7,096	7,646	8,515	8,996	10,942	9,973	+41%
- Occupancy	91%	94%	98%	90%	105%	102%	
0800-0859							
- Capacity	10,503	10,846	11,711	12,339	12,023	13,142	+25%
- Passenger arrivals	11,046	11,212	12,642	12,385	13,941	14,011	+27%
- Occupancy	105%	103%	108%	100%	116%	107%	

Table 9: Paddington peak hour passenger capacity, arrivals and occupancies (autumn counts, first and standard class)
Source: DfT rail statistics, table RAI0201, SYSTRA

Over the peak period as a whole, observed growth rates to 2019 are significant, annualised from 2011 at 3.3% per annum. This rate of increase is lower than forecast in the Network Rail Market Study for the inner suburban/relief line services that have now been taken over by Crossrail. However, Elizabeth Line services are not yet running through to central London, with the new connectivity to central London expected to be a key driver of demand growth. Overall growth of GWR services of 30% between 2011 and 2019 is, however, a little ahead of the expected growth for the outer suburban/main line services set out in the Market Study.

With AM peak capacity growth annualised from 2011 to 2019 at 2.9% per annum lagging behind demand growth, it is possible that observed demand growth could have been constrained by capacity limitations, especially if the more recent GWRM-led capacity increases had not been delivered.

Capacity enhancements

Capacity changes on individual Great Western routes have been delivered through a combination of the number of services operating and the use of new or cascaded rolling stock that generally offer increases in seated and standing capacities.

Table 4 above provided details of the number of train services operating, noting an increase in the number of long-distance services of around 20%, increases of around 35% in London-Reading commuter services (including Crossrail) and a 13% increase in the numbers of trains per day operating on other GWR routes, principally regional and local routes around Bristol and the west and south west.

Table 10 below provides details of the numbers of vehicles in the fleet and train capacities showing both standard and first class seating capacities for the long-distance routes. The other train capacities shown have changed a little over time for some vehicle types as seating was removed to improve accessibility and/or in downgrading first class seating.

Overall, the numbers of vehicles in the operating fleet has increased significantly, with further provision for the Elizabeth Line services that, in due course, will run cross-London using Crossrail infrastructure.

Class of Train	2015 GWR fleet (vehicles)[A]	2021 GWR fleet (vehicles)[A]	Passenger capacity standard+ first[A]
Long-distance routes			
Class 253 HST – 8-car	464	-	395+119
Class 180 – 5-car	25	-	242+42
Class 800/2 – 5-car	-	290	290+36
Class 800/2 – 9-car	-	315	576+71
Approx total vehicles	485	605	
Change in passenger vehicles 2011-19		+24%	
Change in approx. seat numbers 2011-19		+33%	
Other GWR routes			
Class 143 – 2-car	16	-	104
Class 150 – 2-car	80	40	122-136
Class 153 – 1 car	14	-	75
Class 158 – 2 or 3-car	43	43	130-198
Class 255 HST – 4-car	-	56	303
Class 165 – 2 or 3-car	88	88	186-286
Class 166 – 3-car[B]	63	63	244
Class 387 – 4-car[B]	-	168	224
Class 769 – 4 car	-	note[C]	276
Class 345 Elizabeth Line	-	note[D]	450
Approx total vehicles	304	458	
Change in passenger vehicles 2011-19		+51%	
Change in approx. seat numbers 2011-19		+35% (exc Elizabeth Line)	

Table 10: GWR rolling stock fleet numbers and seating capacities
Source: MOIRA v2.2.1 [August 2021], DfT Rolling Stock Perspectives (2015-18), GWR Facilities Guide 2021, SYSTRA

Note A – sourced from established industry sources, but with some inconsistencies that are not material to this analysis
Note B - some commuter services in 2015 were operated by 2x3-car Class 165/166 formations, with most Class 387 formations consisting of 2x4-car trains with some 3x4-car trains
Note C – Class 769 trains are yet to be introduced but will result in a further cascade of Class 166 trains
Note D – Elizabeth Line services currently operating from Paddington to Reading are part of a large fleet of 70 9-car trains that will be deployed on cross-London service from 2022

The provision of IET services on long-distance routes has increased train capacity significantly over a standard configuration HST where trains are operated as either 9-car units or 2x5-car units. The increase of 181-185 standard class seats is offset by a reduction of 46-57 first-class seats giving an overall increase in seating of over 25%. The number of long-distance passenger carriages available to the operator has increased by 24% from 2015 with the deployment of the IET trains, with overall passenger seat numbers increasing by around 33%.

Table 11 presents a summary of the changes in capacity between 2011 and 2019 arising from the changes in the numbers of service operating and rolling stock deployed. This uses a seat miles metric (that is the number of seats available multiplied by the distance that seat travels) and provides a useful measure of the capacity changes in considering the number of seated passengers who can be carried and how far they can travel.

Table 11 shows the overall significant increase in long-distance seat miles, driven by both increases in train miles and train capacities. This was one of the key objectives of the GWRM in supporting capacity growth on both long-distance and London-Reading commuter services, and in helping to address constraints around other key centres identified in Network Rail's long-term planning processes.

	Seat Miles/day (000s) (note A)			Train Miles/day
Grouping	**Dec-11**	**Dec-19**	Change	Change 2011-19
GWR Main Line - Bristol group (note B)	3,641	6,553	80%	42%
GWR Main Line - Wales group	5,588	7,831	40%	11%
GWR West of England group (note B)	5,586	8,069	44%	13%
Cotswolds North	2,367	2,224	-6%	17%
Cotswolds South (direct and connections)	1,260	1,379	9%	46%
Long Distance Total	**18,442**	**26,056**	**41%**	**21%**
London - Reading GWR/Crossrail (note C) inc Thames Valley, Basingstoke,Gatwick	2,493	4,076	63%	19%
London - Newbury/Bedwyn, Oxford and Banbury fast services (note D)	1,956	2,304	18%	25%
London - Didcot and Oxford slow services	1,654	2,052	35%	6%
Didcot to Oxford/Banbury (local connections)	*0*	*184*	inc above	inc above
London and Reading Commuter Total	**6,103**	**8,616**	**41%**	**17%**
Other GWR routes - Cardiff/Worcestershire to Bristol, South Coast, South West & branches	3,195	5,631	76%	21%
Other GWR Routes	**3,195**	**5,631**	**76%**	**21%**
GWR plus Crossrail (excluding Heathrow services, Sleeper and bus/coach services)	**27,740**	**40,303**	**45%**	**20%**

Notes: A - Seat miles derived from train miles and MOIRA capacities, adjusted to improve representation of train capacities but not through a comprehensive or train-by-train review of rolling stock formations, as provided in Appendix B.
B - The limited number of Taunton trains routed via Bristol are included in the Weston-Super-Mare figures. The limited number of Exeter services routed via Bristol are considered in the Somerset and Exeter figures
C - Does not include Heathrow Express or Heathrow Connect services
D - Calls on long-distance services at Oxford and Newbury/ Bedwyn are not considered in the table, but terminating trains are

Table 11: GWR weekday indicative seat miles per day, 2011 and 2019

Source: MOIRA v2.2.1 [August 2021] data, SYSTRA

Indicative passenger capacity on long-distance services increased by around 40% between the December 2011 and December 2019 timetables. Passenger capacities increased on the key long-distance services to the Bristol area by 80%, to south Wales by 40% and to the west of England by almost 45%. Modest increases in capacity have been realised on services to Cheltenham through doubling the number of direct services, but with shorter IET trains normally deployed. Capacities have fallen slightly on the Cotswold (north) route as the HSTs used in 2011 have been replaced by a mix of 5-car and 9-car IETs trains.

The introduction of new Class 387 electric trains, Class 345 electric trains for the Crossrail services, and IETs on services to Newbury/Bedwyn has increased overall capacities significantly on the London-Reading commuter routes, with seat miles around 40% higher in the December 2019 timetable than in the December 2011 equivalent.

As a result of the cancellation of electrification to Oxford, fast services from London to Oxford are reliant on the hourly Cotswold (north) service supplemented by hourly dedicated services running between London and Oxford only. These services use IET trains operating in diesel mode from Oxford to Didcot, with the deployment of a mix of 5-car and 9-car trains varying by service and day-to-day. It is possible that variations in capacity may have an impact on passenger crowding on service to and from Oxford. This may in due course be seen in formal passenger satisfaction or stakeholder responses.

The extensive cascading of rolling stock as a result of the GWRM has resulted in a significant expansion in capacity on other regional and local GWR routes. These changes include cascaded high density Class 165/166 trains and the reconfiguration of some of the former long-distance HSTs to form the Castle Class trains deployed on some regional routes from Cardiff and Bristol to Devon and Cornwall. The deployment of 4-coach modernised HSTs released from long-distance routes by the new IET trains in place of shorter DMUs provided an increase in capacity. This improvement was accompanied by an increase in service levels to two trains per hour on the Cornish Main Line between Plymouth and Penzance, enabled by signalling upgrades.

Overall capacity increases for the GWR regional services suggest an expansion in seat miles of around 75% between the December 2011 and December 2019 timetables, significantly more than the 20% increase in train mileage over the same period.

The capacity expansion on the regional and local GWR services provides some or all of the responses to the capacity growth requirements set out in the Network Rail Western Route Study.

The way capacity increases have manifested themselves in reduced levels of crowding and increases in passenger satisfaction is considered in the following sections, in so far as it can be given the constraints on demand arising from the COVID-19 pandemic.

4.3 Train performance

Rail network performance can be a key driver of passenger satisfaction, with this demonstrated by earlier research, including reporting for the DfT that examined, and confirmed, a correlation between performance and passenger satisfaction[25]. Specifically in the context of the GWRM, this link is also demonstrated in section 4.4 of this report.

A range of established performance metrics are available to assess performance, with the following two key metrics in general use and assessed in relation to the GWR network as a whole and at a more focused level on InterCity-type long-distance service groups:

[25] Service Quality Incentives in Rail Franchising, SYSTRA, 2016

- PPM – Public Performance Measure of train punctuality – including all trains running to or ahead of time and those with delays of up to 10 minutes for long-distance services or of up to 5 minutes for other GWR service groups, including the London and Reading commuter and regional services; and

- CASL – Cancelled and Significantly Late – including trains that are more than 30 minutes late and/or cancelled in full or in part in either terminating earlier than their final destination or skipping some scheduled stops to reach their destination earlier.

Both of these metrics are based on planned service delivery which includes planned engineering work and blockades. This means that whilst services may be disrupted during engineering possessions, including longer journey times, reduced frequencies and potential replacement road transport, the PPM and CASL measures are in relation to the planned works and not measured against normal timetables.

Therefore, it is possible that while engineering works will disrupt passenger journeys, and generally at weekends and less-busy travel times, the PPM and CASL performance metrics will not show any impacts unless further disruption occurs or works overrun. However, engineering work disruption whether planned or not may impact on customer satisfaction, with passenger perceptions generally being considered against passenger expectations which may or may not include perceived allowances for engineering works.

During the delivery of the GWRM, extensive engineering works were required associated with both electrification of parts of the route through the GWEP and the infrastructure works driven by the WCEP. The period covered by the performance analysis includes a number of engineering blockades of various degrees of coverage and duration. Table 12 outlines the number of blockades over the period from 2016 to 2021. While the table provides some indication of the extent of works on the railway, it does not consider the intensity of disruption arising; for example there was a six-week closure of the Severn Tunnel linking Bristol to Newport for electrification works over the late summer in 2016.

GWRM Blockades	2016	2017	2018	2019	2020	2021
Category 1 - 3 days of more	6	13	27	8	11	11
Category 2 - between 1 and 3 days	3	44	55	142	208	140
Bristol east junction blockade						28
Commercial Development (tbc)					27	27

Table 12: Approximate numbers of GWRM blockades during GWRM and linked works

Source: Network Rail

Network Rail's The Greater West (TGW) Programme introduced a national performance target as a key quantified benefit of the GWRM. The TGW noted that 'Network Rail is targeted to deliver performance at a level of 92.5% PPM for the Western Route by the end of CP5' (Control Period 5 (2015-2019)).

Figure 9 provides the industry standard moving annual average (MAA) PPM metrics for the Great Western franchise 'sectors' split by long-distance routes, London and Reading commuter routes and the rest of the regional network of GWR routes.

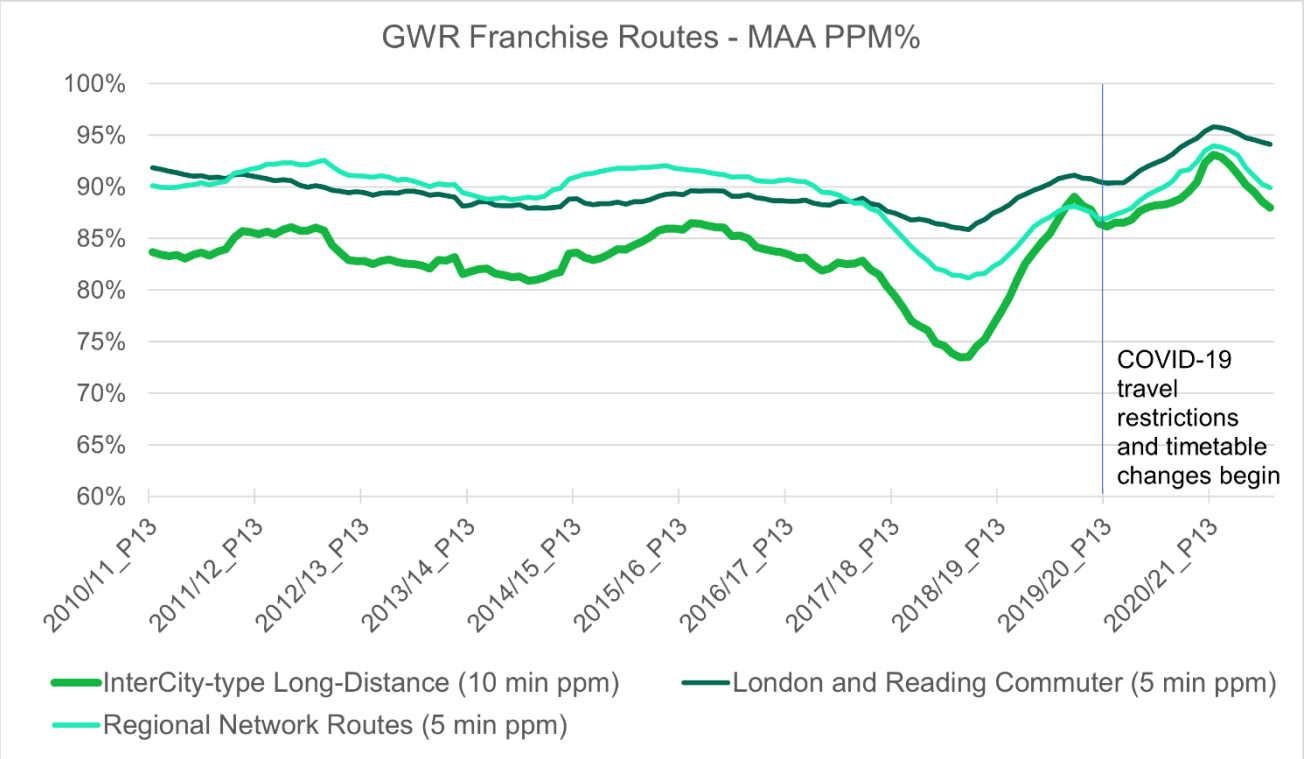

Figure 9: GWR franchise sectors - moving annual average (MAA) Public Performance Measure (PPM)
Source: Network Rail via DfT, SYSTRA

From around 2010-11 to 2013-14 there was a small but gradual decline in performance followed by some modest improvements, especially in long-distance performance. From this peak around late 2015 and early 2016, performance began to fall with the franchise holder noting in the GWR 2016/17 Annual Stakeholder Report[26] that on-going improvement works and preparation for electrifying the network had begun to impact on performance. Key issues at the time were concentrated in the Thames Valley, but there were also other key points across the GWR network, with extensive track lowering works around Bath, closure of the Severn Tunnel and a number of signalling renewal schemes.

Performance across the franchise as a whole fell further in 2017 and 2018, with further extensive works on electrification likely to have contributed to this decline, compounded by signalling works including upgrades in Paddington, Cornwall and Bristol, and major drainage works at Hinksey and Chipping Sodbury.

The introduction of the IET trains appears to have had an impact on performance. Early operational issues with the IET fleet included air filter and radiator problems leading to cancellations and short-formation of trains. The GWR 2018/19 GWR Annual Stakeholder report[27] noted that "*performance was not good enough and we had too many cancellations and too many delays. In the main this was caused by the combination of moving from our old rolling stock to brand new and refreshed trains at the same time as Network Rail undertook the largest programme of track improvements ever made in a single year*".

[26] GWR Annual Stakeholder Report 2016-17, GWR 2017
[27] GWR Annual Stakeholder Report 2018-19, GWR 2019

As works progressed towards completion and the new rolling stock settled in regular operation, the overall performance of all franchise sectors improved significantly through towards implementation of the December 2019 timetable. A small reduction in PPM scores followed across all sectors through to the spring of 2020, with this likely to have been driven, at least in part, by the additional number of services offered by the new timetable and the need for operating patterns supporting the timetable to settle down.

A sustained view of the timetable implementation on performance was not possible before the COVID-19 travel restrictions and timetable changes impacted on passenger numbers, rail operations and the resulting variations in operating performance.

Following the major dip in performance around 2017-18 especially affecting the long-distance group of services driven by the infrastructure works and introduction of new rolling stock, there was a sustained improvement in performance heading towards culmination of the principal GWRM programme. This may have been expected as infrastructure improvements were completed, initial teething troubles with the IET fleet were addressed and the long-distance operations moved from a mixed operation of new and old rolling to a solely IET network.

During the period before the pandemic, PPM measures for the GWR long-distance network returned to a level slightly higher than at any time since 2010. At just below 90%, this was higher than the 83% average across all long-distance operators and the national average of 87%[28]. Despite these improvements and higher performance than many other operators, the PPM was lower than the 92.5% target identified Network Rail's TGW.

Figure 10 considers long-distance service performance at a more disaggregate level showing broadly similar patterns, with the Bristol services having consistently the best PPM performance, and the West of England services the worst. The performance differentials have not been considered in detail in this evaluation but may in part be due to the relative complexity of operation and on-going issues with the resilience of the south-west network despite on-going delivery of the South West Rail Resilience Programme[29].

The sustained increases in performance through to the implementation of the major timetable change in December 2019 saw PPM for the Bristol group of services in excess of 90% for four consecutive 4-week periods (2019/20 periods 7-10), the highest scores for more than a decade. Performance on the routes to south Wales also improved significantly, with PPM scores all higher than the earlier peak performances in 2011-12 and 2015-16.

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[28] Office for Road and Rail: Table 3114 - Public Performance Measure by operator and sector

[29] South West Rail Resilience Programme was established by Network Rail to identify and implement the options to improve rail resilience between Dawlish and Teignmouth following the sea wall collapse in 2014

Performance on the historically poorer performing west of England routes recovered from the very low PPM scoring of around 65% in 2017-18 to around 83% by late 2019, a level last observed in 2011-12.

There was a small dip across all long-distance service following delivery of the timetable change through to the spring of 2020. From spring 2020 performance was impacted by the COVID-19 demand and timetable changes reducing service levels and passenger demand. A number of specific issues also affected performance, including in early 2021 when safety checks were made on the IET fleet.

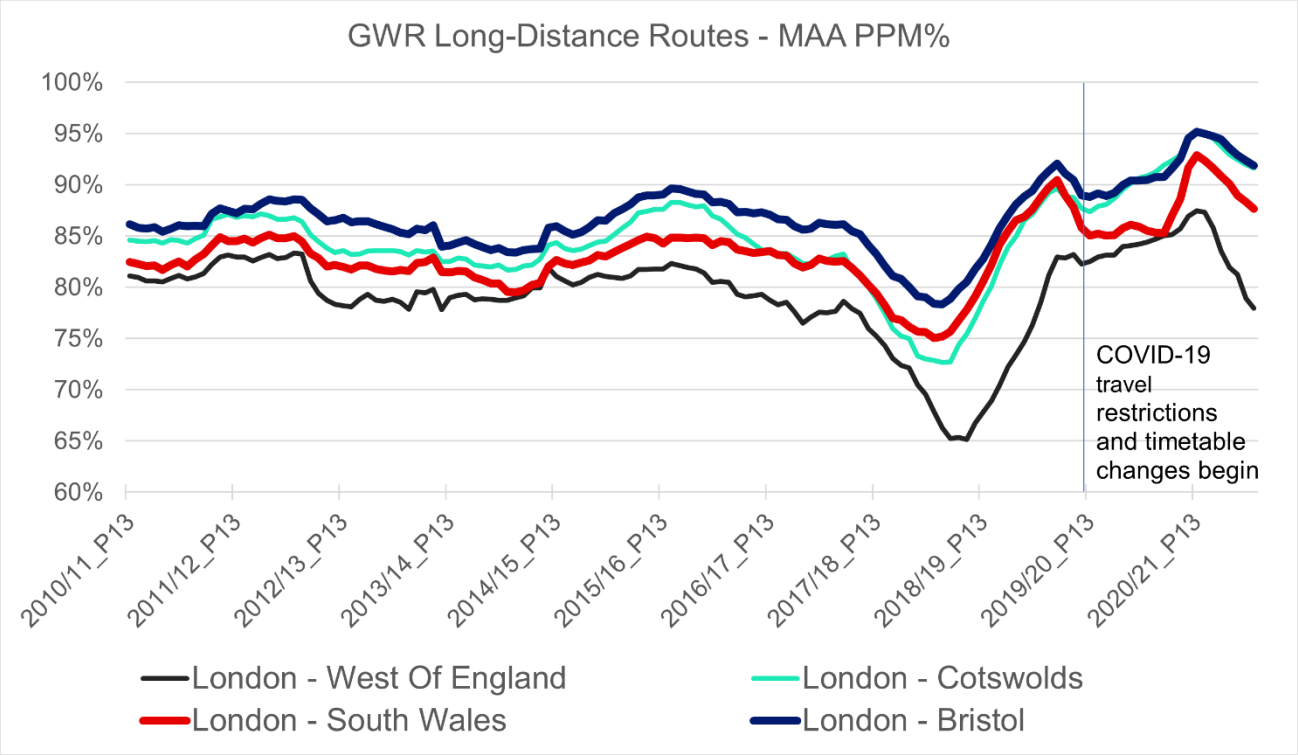

Figure 10: GWR long-distance services – moving annual average (MAA) Public Performance Measure (PPM)
Source: Network Rail via DfT, SYSTRA

Performance in respect to cancelled and significantly late services (those delayed by over 30 minutes) follows broadly similar patterns to the PPM measure, albeit inverted. Figure 11 shows the CASL performance for the GWR franchise 'sectors' with Figure 12 providing the equivalent data for the long-distance service groups.

As with PPM, the long-distance services have a generally poorer performance than the London and Reading commuter services and the regional networks with a higher number of CASL services. By service group there are also some differences, with the Bristol and South Wales service groups having the lower CASL score, and the West of England and Cotswold service groups consistently higher between 2012 and 2019.

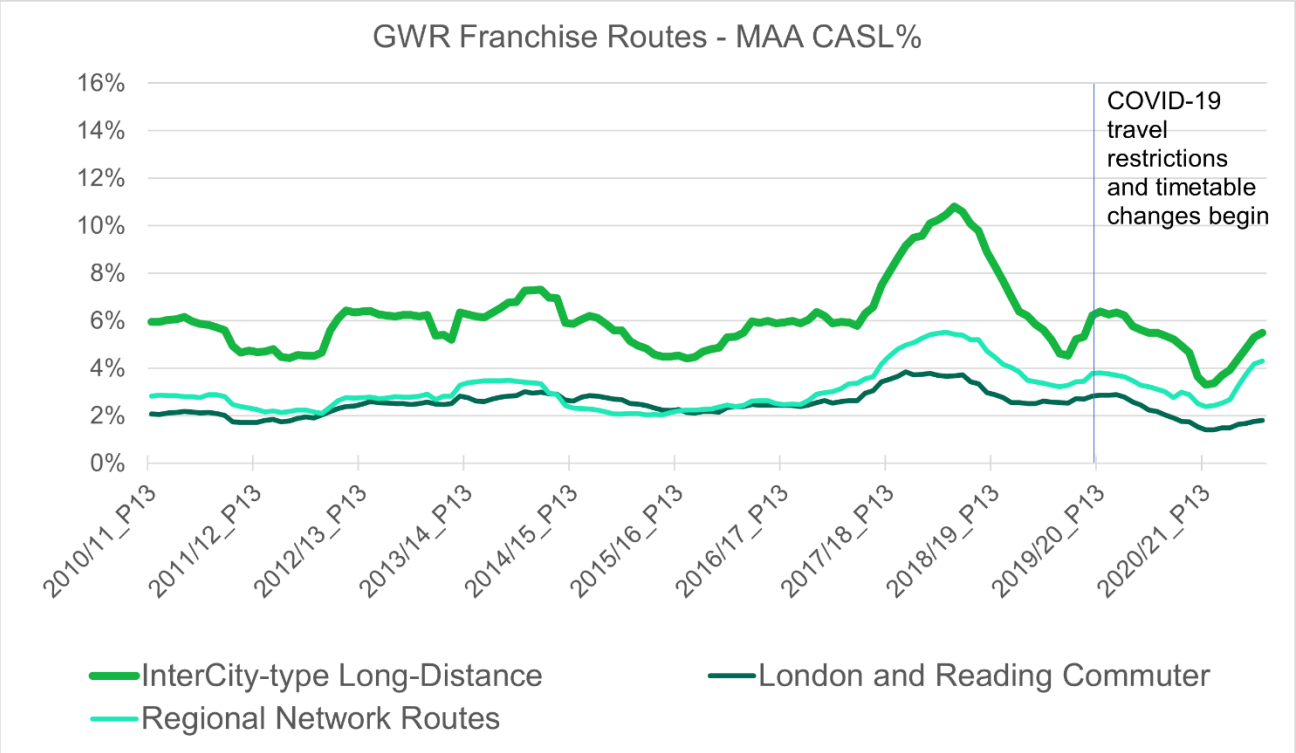

Figure 11: GWR franchise sectors – moving annual average (MAA) Cancellation and Significantly Late trains (CASL)
Source: Network Rail via DfT, SYSTRA

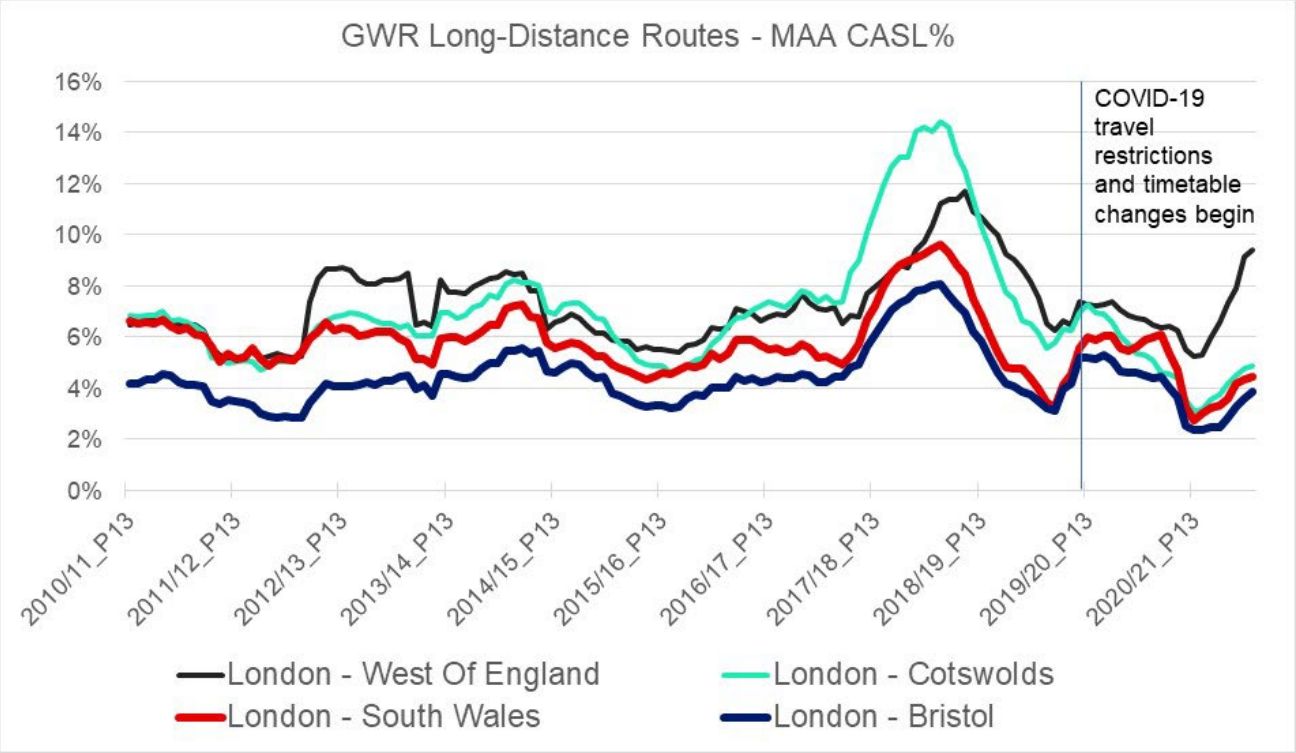

Figure 12: GWR long-distance services - moving annual average (MAA) Cancellation and Significantly Late trains (CASL)
Source: Network Rail via DfT, SYSTRA

A further breakdown of the CASL incidences identifies specific service group issues; west of England services have a much greater proportion of their CASL scores linked to

significantly late services reflecting route lengths, service complexity and interactions with other local routes, while the Cotswold routes have a much greater proportion in part-cancelled services with this potentially reflecting the operating challenges with a part-single-track railway (between Oxford and Charlbury, Evesham and Norton Junction south of Worcester and between Malvern and Hereford).

Future performance changes

Shortly before the publication of this report, work led by Network Rail and all the train operators on the Western route, including GWR, identified a series of improvements necessary for the best performance of the new Elizabeth Line when it opens as a through operation and it is expected that these will also be beneficial to GWR long-distance services.

Resilience works to the network in the vicinity of Dawlish following the sea wall collapse in 2014 also continue to be delivered, and these will contribute to performance being less affected by severe weather, rock falls, etc, in that area.

4.4 Passenger attitudes

Analysis of the National Rail Passenger Survey[30] (NRPS) will assist in assessing whether the GWRM has achieved one of its ultimate objectives i.e. to improve the passenger experience through an increase in passenger satisfaction.

For this evaluation study:

- The analysis focusses on change in satisfaction in relation to aspects of service provision that have been impacted by the GWRM i.e. the infrastructure / capacity upgrades, timetable improvements and introduction of new rolling stock.

- NRPS data has been analysed from autumn 2010 (before the GWRM began) to spring 2020 (the first NRPS survey conducted after the December 2019 timetable change which represents completion of the GWRM). This period therefore includes the time before, during and after the GWRM and so allows assessment of the full impact on satisfaction of the GWRM. It is noted that there is no data available beyond spring 2020 as the survey has since been paused due to the Covid-19 pandemic.

- The autumn and following spring survey scores have been averaged e.g. autumn 2010 and spring 2011. This is because there can be significant differences between the autumn and spring survey waves as the latter are conducted between January and March when train reliability and therefore satisfaction tends to be lower due to poorer weather conditions; comparison between autumn and spring survey data could therefore be misleading.

[30] See Appendix D for more details on the NRPS

- The results presented are for GWR long-distance routes only rather than at the whole TOC level, which is in line with the focus of this study. The excluded GWR routes are:
    - London Thames Valley – journeys on the short-distance services in and around the Thames Valley; and
    - West – journeys on the regional network of services in the west of England.

It is noted that any conclusions from the analysis of the NRPS indicators may be limited at this stage: to date only one survey (spring 2020) has been conducted *after* the full completion of the GWRM. Furthermore, the satisfaction scores from spring 2020 must be treated with caution as these are based on a lower sample size than normal due to the premature termination of the survey due to the onset of Covid-19; this results in a larger margin of error. More definitive conclusions will only be possible once more passenger satisfaction data is available which will reflect the full impact of the GWRM.

Whilst it is not possible to definitively link any change in passenger satisfaction to the GWRM, the causal link can be strengthened by also assessing the change in satisfaction on comparator TOCs. This indicates what may have happened to satisfaction in the absence of the GWRM i.e. the counterfactual, and so allows measurement of the programme's impact. Comparators selected should be similar in nature to GWR and, crucially, should have had a relatively stable service over the period analysed e.g. rolling stock, service frequency, network coverage which would not have led to potential changes in satisfaction.

Identifying a suitable comparator over the period in question is challenging as nearly all TOCs will have implemented changes that could have affected passenger satisfaction. Whilst GWR is categorised as a London and South East (LSE) type operator for the purposes of the NRPS reporting, given the focus of this study is on the GWR long-distance routes, it would seem appropriate for the comparator(s) to be a long-distance TOC with the majority of services to/from London. Non-London long-distance operators (CrossCountry and TransPennine Express) have therefore not been considered, nor have open access operators (Grand Central, Hull Trains) owing to their different governance arrangements and incentive regimes. This leaves Avanti West Coast, London North Eastern Railway and East Midlands Railway (the current operators). Their suitability as a comparator for GWR together with any notable events that could have impacted satisfaction is shown in Table 13.

Franchise	Current TOC	Suitability as comparator	Notable events
InterCity East Coast (ICEC)	London North Eastern Railway (all routes)	• Long-distance operator with majority of services to/from London • No major timetable changes or route upgrades over study period • However, fleet was upgraded and the London terminal enhanced, which reduces suitability	• Major reconstruction, modernisation and enhancement of London Kings Cross completed 2012 • Several changes of operator (East Coast 2009 to 2015, Virgin Trains East Coast 2015 to 2018 and London North Eastern Railway 2018 to date). • New rolling stock (Class 800/801) introduced in 2019
West Coast Partnership (WCP)	Avanti West Coast (all routes)	• Long-distance operator with majority of services to/from London • No major route upgrades over study period • No major rolling stock replacement over study period	• New direct services introduced in 2014/15 e.g. to Shrewsbury • Spring 2020 NRPS could be impacted by change in operator from Virgin Trains to Avanti West Coast
East Midlands (EM)	East Midlands Railway (London routes only)	• Long-distance operator with majority of services to/from London. Like GW serves a significant commuter market. • No major route upgrades over study period • No major rolling stock replacement over study period	• Change of operator (East Midlands Trains to 2019, East Midlands Railway 2019 to date) • Electrification from Bedford and Corby with Class 360 trains (built in 2002-05) used for commuter services from May 2021

Table 13: Comparator TOCs and notable events from 2011 to 2021

All have differences with GW long-distance in terms of their service offer, with the West and East Coast services serving relatively fewer commuters and East Midlands rather more, in line with its rather shorter distance orientation. Also, for our purposes, the comparators should focus on where we might expect GW to have been in the absence of the modernisation programme. This makes ICEC less suitable as by mid-2012 major terminal station improvements and enhancements were completed at Kings Cross, while new rolling stock was introduced in 2018. These changes make it a more appropriate comparator for GW with enhancements (or Do Something), while for a Do Minimum comparator (no significant investment) WCP and EM are more suitable.

A further consideration in the analysis is the impact of performance on satisfaction. Previous work undertaken by SYSTRA for the DfT[31] established that there is a strong positive correlation with the NRPS overall satisfaction indicator and performance (as measured by the public performance measure, PPM); this relationship was found to be universal across all TOCs included in the analysis, one of which was GWR. Furthermore, there was also a strong positive correlation with PPM and other NRPS indicators including those related to station and train. There was also evidence of rolling stock improvements

[31] Service Quality Incentives in Rail Franchising, SYSTRA, 2016

and station upgrades having a positive impact on satisfaction, but this was more limited compared to the influence of PPM. The study therefore highlighted the dominance and importance of PPM in driving passenger satisfaction. The finding is significant for this evaluation as any changes in GWR's passenger satisfaction as measured by NRPS could in fact be being driven by changes in the TOC's PPM rather than or in addition to the improvements associated with the GWRM. Assessment of PPM is therefore also included in the analysis to identify the extent to which performance could be driving changes in passenger satisfaction.

Overall satisfaction

Figure 13 shows the trend in overall satisfaction with the journey between 2010/11 (the average of the autumn 2010 and spring 2011 surveys) and 2019/20 (the average of the autumn 2019 and spring 2020 surveys). This shows an overall increase in satisfaction[32] of 6 percentage points from 84% to 90%; however the increase is not statistically[33].

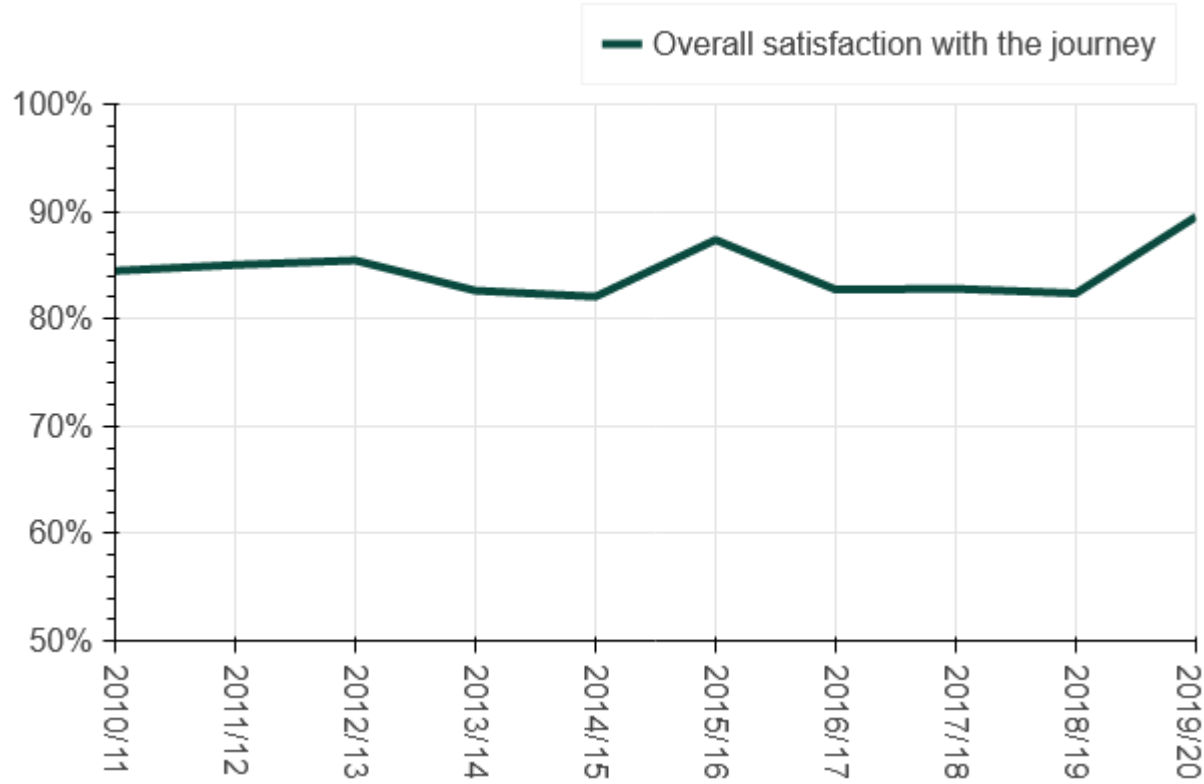

Figure 13: NRPS Overall Satisfaction with Journey, 2010/11 to 2019/20 (GW Long-Distance)

Overall satisfaction remained constant at 82% between 2016/17 and 2018/19. Any increases in satisfaction due to the GWRM during this period may have been offset by dissatisfaction with performance which showed a steady decline between 2016/17 and 2018/19 as measured by the PPM moving annual average, MAA (Figure 14). Due to the

[32] satisfaction is defined as passengers who are 'satisfied' or 'very satisfied'

[33] a relationship is statistically significant if the odds of such a relationship appearing by chance or coincidence are small (< 5% when the confidence level is 95%, as used in this analysis)

strong correlation between PPM and passenger satisfaction, this will likely have adversely impacted passenger satisfaction. The fall in PPM on GW could in part be linked to the blockades associated with the GWRM; whilst PPM excludes planned blockades and is only based on services scheduled to run, the blockades could have impacted performance on the rest of the network. Furthermore, if the blockades resulted in services not running or a less frequent service, then passenger satisfaction is likely to have fallen.

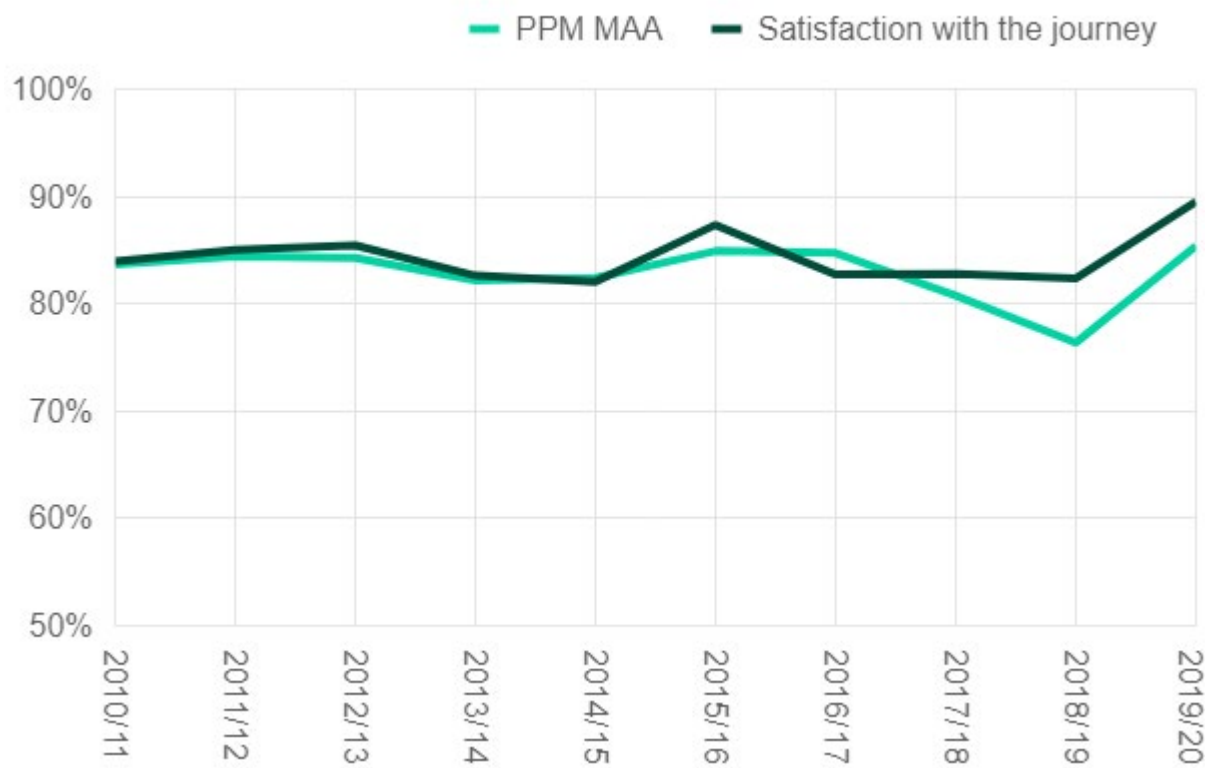

Figure 14: NRPS Overall Satisfaction with Journey and PPM MAA, 2010/11 to 2019/20 (GW Long-Distance)

Figure 15 and Table 14 show the change in overall satisfaction with journey from 2010/11 to 2019/20 for GW and other long-distance franchises. This shows a mixed picture: whilst none show a statistically significant change[33], WCP and EM show an overall decline in satisfaction and GW and ICEC show an overall increase.

The recent decline in satisfaction on WCP is possibly linked to a decline in PPM since 2016/17. The increase in satisfaction on ICEC could be attributable in part to the operator moving into the public sector in 2018, the introduction of the new Azuma rolling stock in 2019 and improving performance since 2018/19.

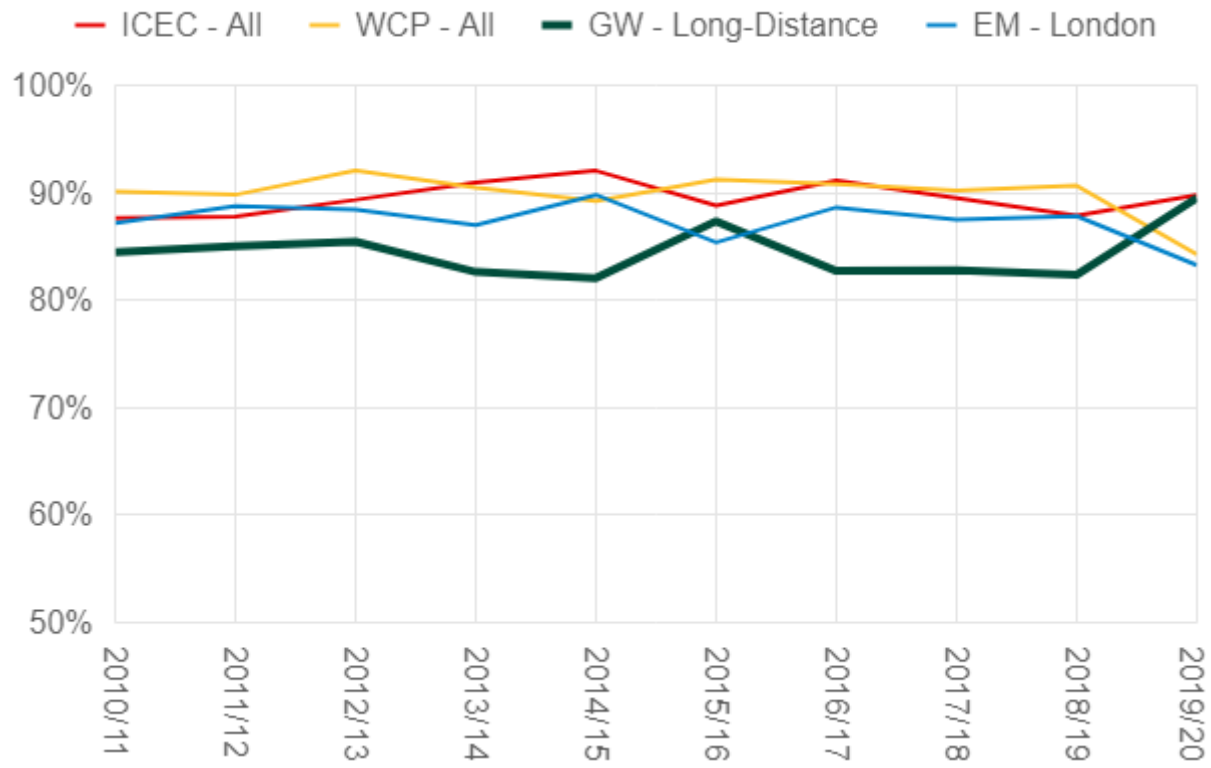

Figure 15: NRPS Overall Satisfaction with Journey by Franchise – GW and Comparators, 2010/11 to 2019/2020

Franchise	Overall Satisfaction 2010/11	Overall Satisfaction 2019/20	% Change	Statistical Significance
GW	**84%**	**87%**	**+3%**	**No**
WCP	90%	84%	-6%	**No**
ICEC	88%	90%	+2%	**No**
EM	87%	83%	-4%	**No**

Table 14: Change in Overall Satisfaction with Journey by Franchise – GW and Comparators, 2010/11 to 2019/2020

If the average of the WCP (-6%) and EM (-4%) positions is taken as a crude representation of where GW long-distance might have been without investment (a Do Minimum comparator), a decline of 5% is observed compared to a 3% improvement that GW achieved with the GWRM: this represents a relative improvement to GW of 8%. There was also improvement on ICEC (+2%); this is broadly in line with expectations given that ICEC had like GW new rolling stock; whilst it had more modest timetable improvements than GW, it also had very major enhancements to its London terminal which will have positively impacted many of its passengers. It can therefore be concluded that relative to long-distance franchises on which no major improvements were implemented, passenger satisfaction on GW increased.

Trip indicators

Figure 16 shows the trend in satisfaction with punctuality and reliability against the PPM MAA from 2010/11 to 2019/20. This shows some correlation between the two, as expected. The satisfaction indicator is in line with the overall satisfaction indicator (Figure 13). There is an overall increase of 4% in satisfaction with punctuality and reliability from 2010/11 to 2019/20. The trend shows various peaks and troughs over the period with a low of 73% in 2018/19 followed by a recovery with satisfaction peaking at 82% in 2019/20.

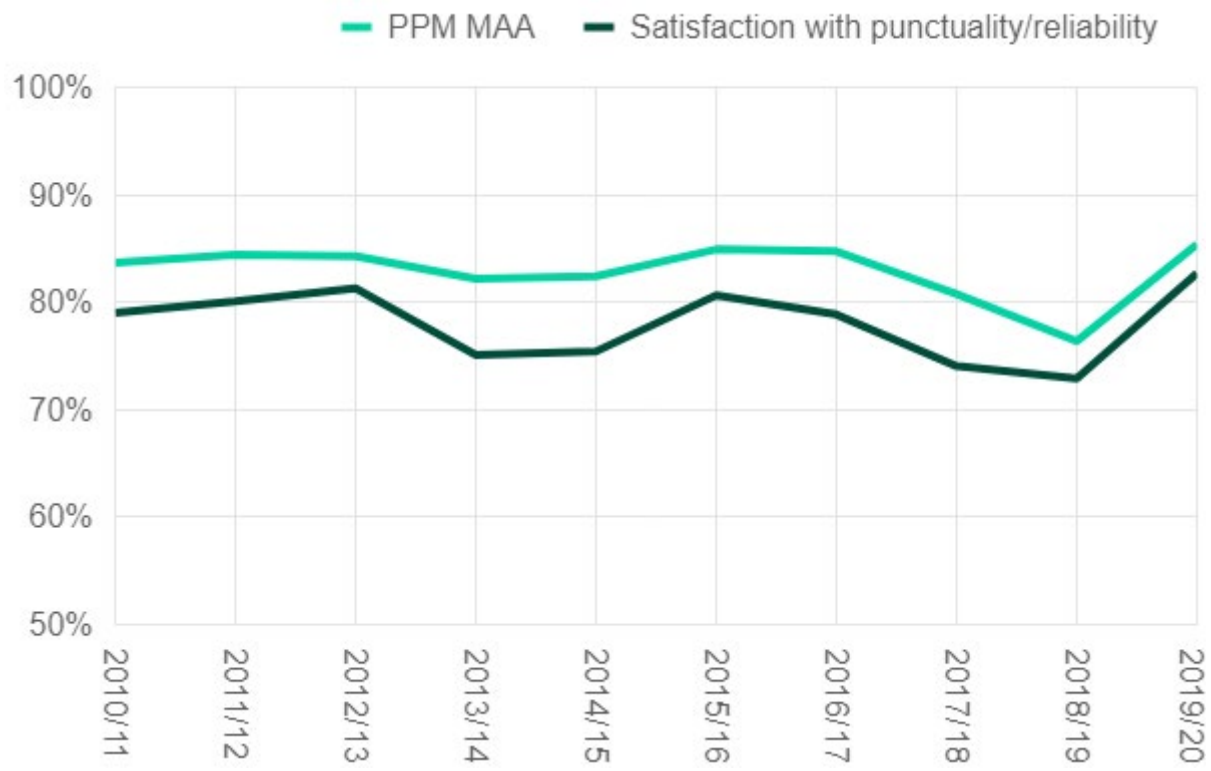

Figure 16: NRPS Punctuality & Reliability and PPM MAA, 2010/11 to 2019/20 (GW Long-Distance)

The trend in satisfaction with frequency of trains is shown in Figure 17. Between 2010/11 and 2019/20, satisfaction is broadly flat with minor variations around an average of 84%. This may reflect that the frequency of long-distance services did not change materially until the December 2019 timetable and therefore any change in satisfaction has not yet been captured.

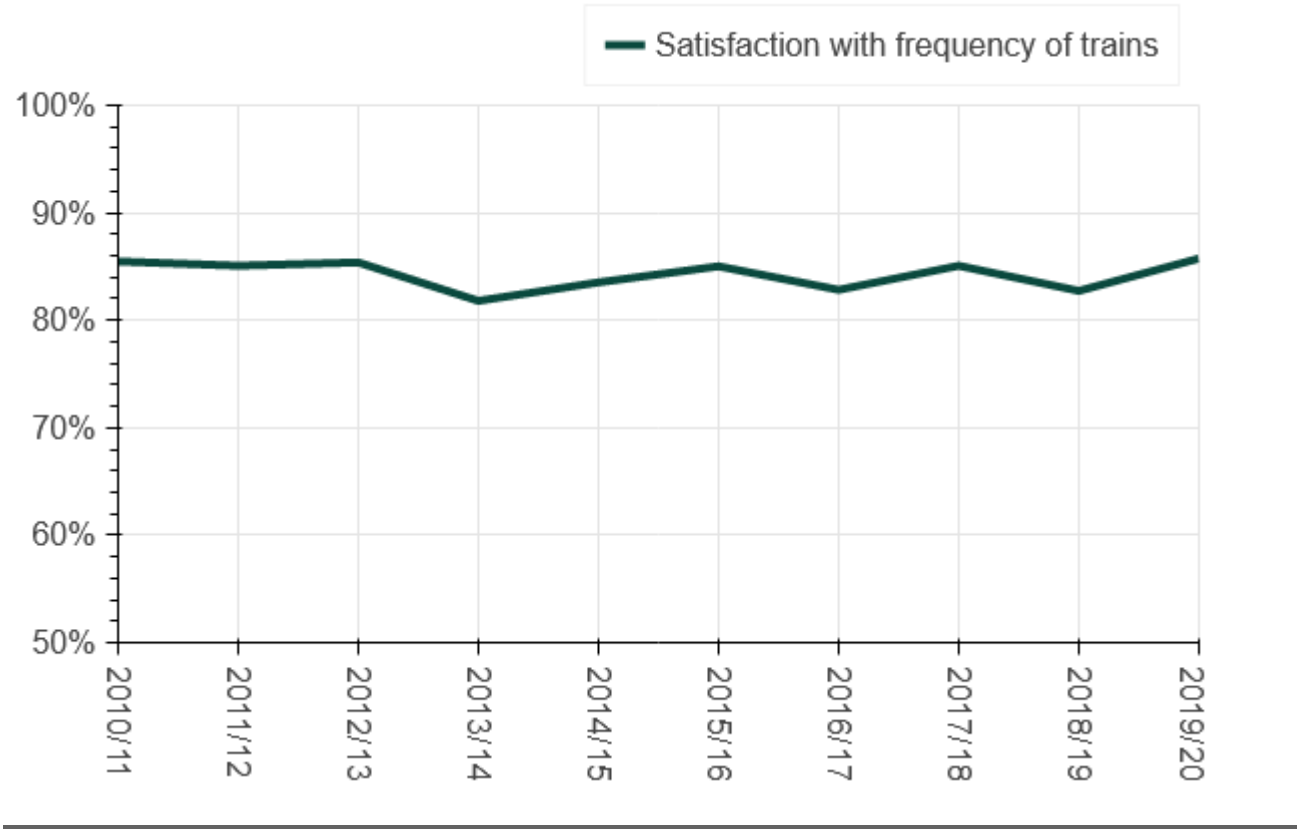

Figure 17: NRPS Frequency of Trains, 2010/11 to 2019/20 (GW Long-Distance)

Figure 18 shows the trend in satisfaction with length of journey time. Whilst there is an overall increase of 4% between 2010/11 and 2019/20, the increase is not statistically significant33. Similar to frequency, this may reflect that the main journey time savings were not realised until the December 2019 timetable change.

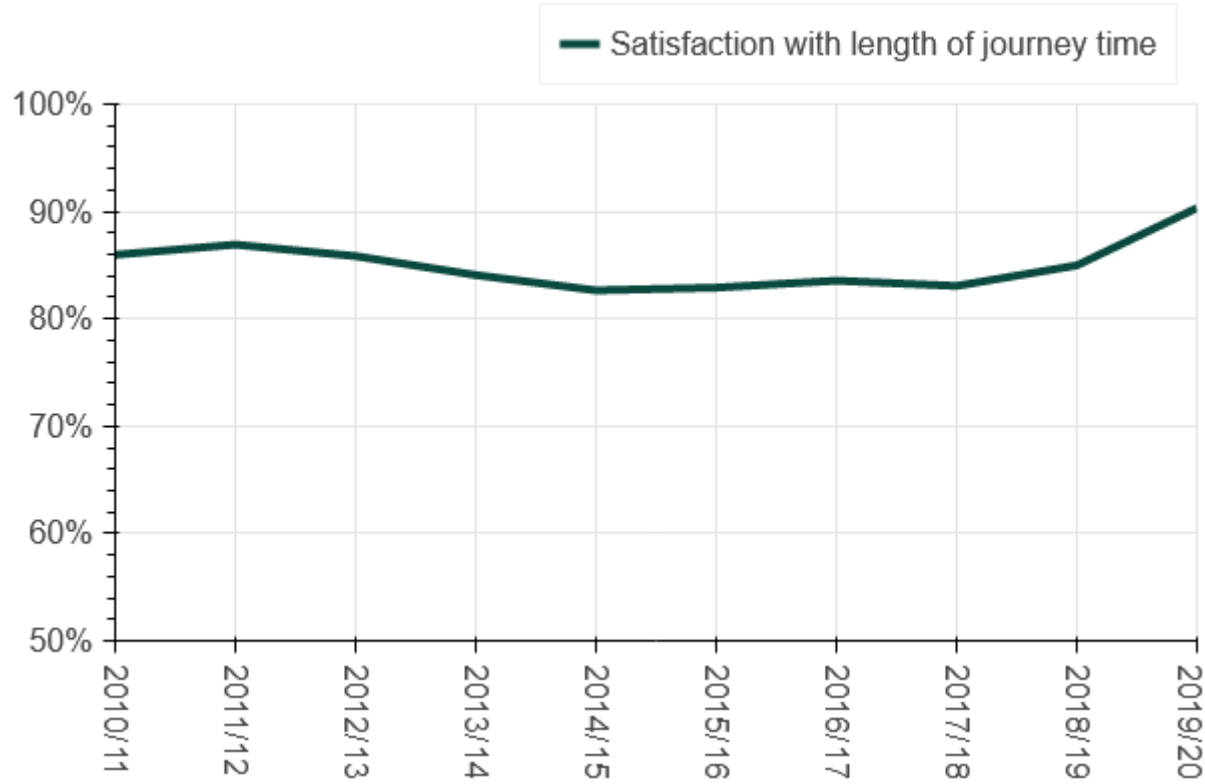

Figure 18: NRPS Length of Time Journey Scheduled to Take, 2010/11 to 2019/20 (GW Long-Distance)

Table 15 shows the change in satisfaction for the three trip indicators assessed for GW and the three comparator franchises between 2010/11 and 2019/20. This shows that GW has performed relatively better than the other franchises assessed on the punctuality and reliability, and length of journey time indicators.

Franchise	Satisfaction 2010/11	Satisfaction 2019/20	% Change	Statistical Significance
Punctuality & Reliability				
Great Western	**79%**	**83%**	**+4%**	**No**
West Coast Partnership	90%	78%	-13%	No
InterCity East Coast	84%	82%	-2%	No
East Midlands	88%	78%	-10%	Yes
Frequency of Trains				
Great Western	**85%**	**86%**	**+1%**	**No**
West Coast Partnership	89%	86%	-3%	No
InterCity East Coast	90%	88%	-2%	No
East Midlands	85%	79%	-6%	No
Length of Time Journey Scheduled to Take				
Great Western	**86%**	**90%**	**+4%**	**No**
West Coast Partnership	93%	90%	-4%	No
InterCity East Coast	90%	90%	0%	No
East Midlands	89%	88%	-1%	No

Table 15: Change in Trip Indicators Satisfaction by Franchise – GW and Comparators, 2010/11 to 2019/2020

On-board indicators

The trend in overall satisfaction with the train is shown in Figure 19 (note that this indicator was only introduced in the autumn 2012 survey). Whilst there is an overall increase in satisfaction since 2012/13, it is not statistically significant[33]. The fall in satisfaction in 2018/19 is possibly linked to deterioration in performance as previously mentioned.

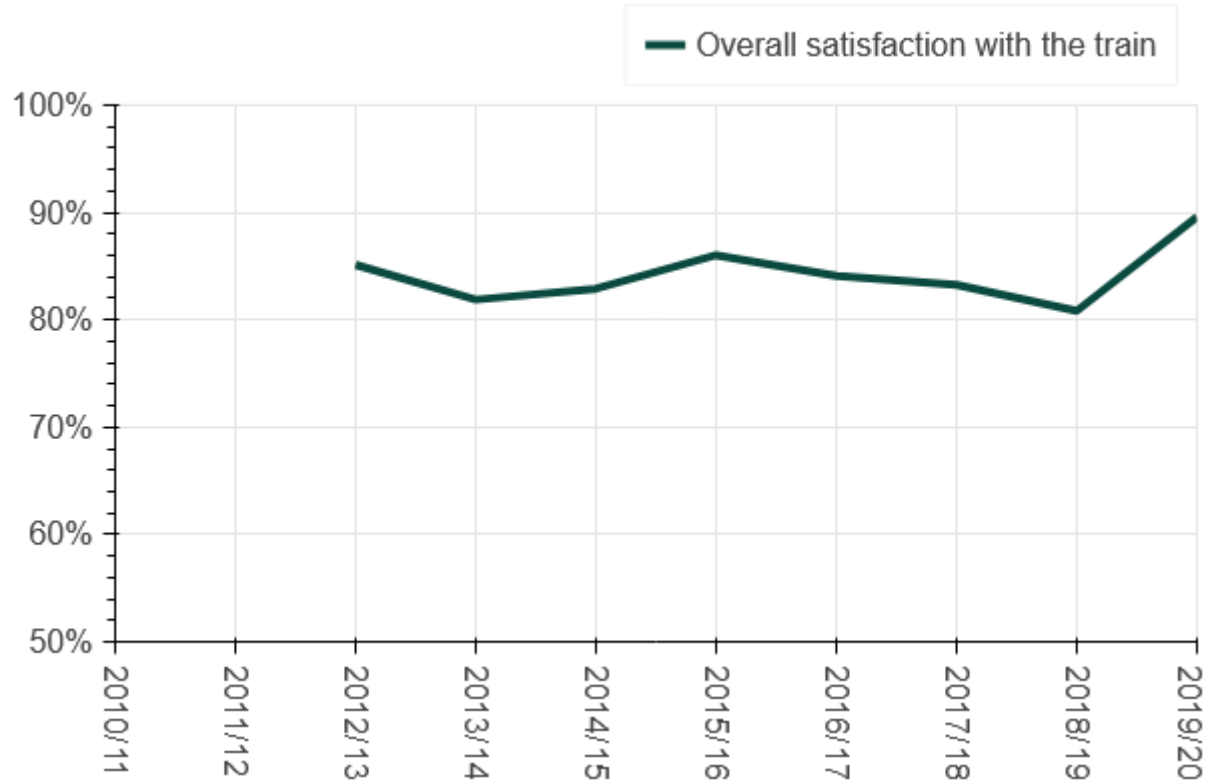

Figure 19: NRPS Overall Satisfaction with Train, 2012/13 to 2019/20 (GW Long-Distance)

For satisfaction with the level of crowding, there has been an overall increase of 8% between 2016/17 (when the indicator was introduced into NRPS) and 2019/20 (Figure 20). The trend is statistically significant[33] which may provide an early indication that the increase in capacity following the introduction of the new IEP rolling stock from 2017 has translated in increased satisfaction with level of crowding.

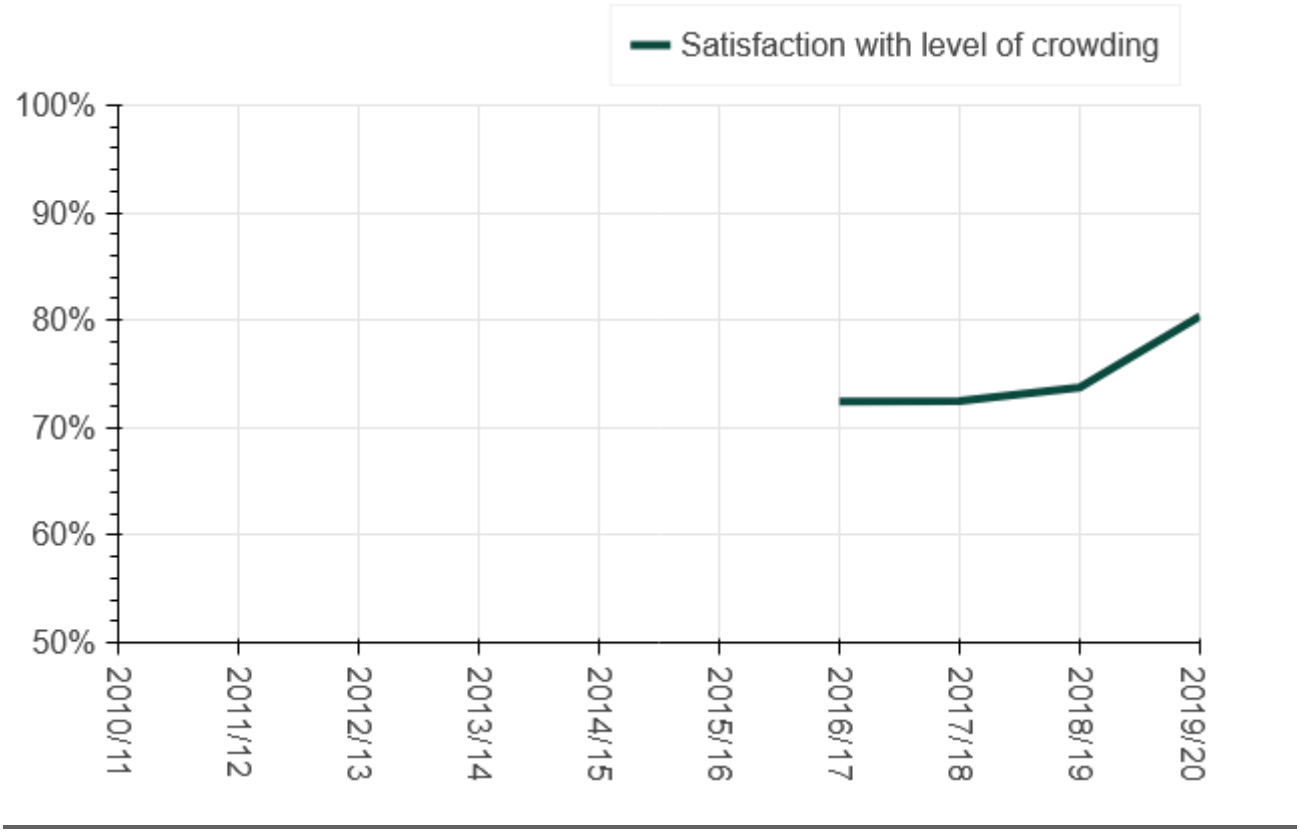

Figure 20: NRPS Level of Crowding, 2016/17 to 2019/20 (GW Long-Distance)

Figure 21 shows the trend in satisfaction with the upkeep and repair of the train. This shows a statistically significant increase[33], with satisfaction increasing by 8% between 2010/11 and 2019/20, and with a consistent increase since 2016/17. Given the latter coincides with the period during which the new IEP rolling stock was introduced, this provides strong evidence that the GWRM has resulted in increased passenger satisfaction with the condition of the trains.

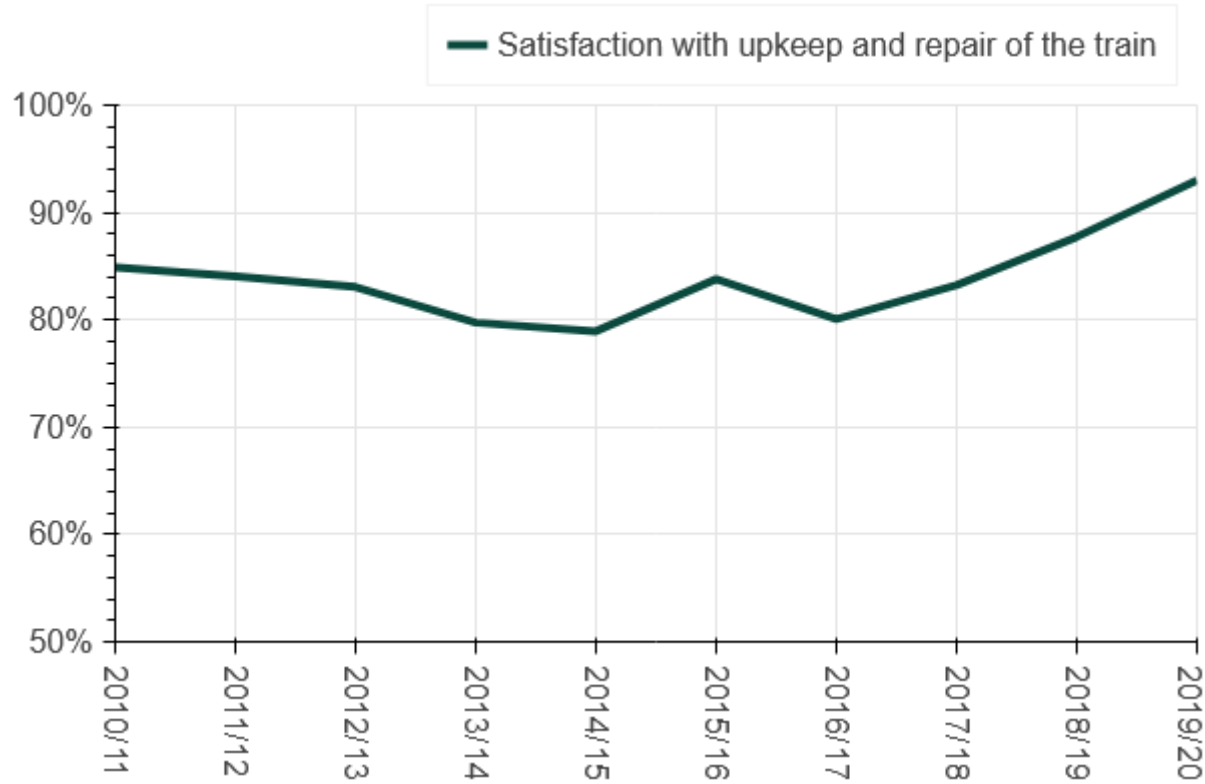

Figure 21: NRPS Upkeep and Repair of the Train, 2010/11 to 2019/20 (GW Long-Distance)

For satisfaction with the comfort of the seat, whilst there is only data from spring 2017 onwards, there was a 3% increase between 2018/19 and 2019/20 (Figure 22). This may provide an early indication of increasing satisfaction with the seats on the new IEP trains.

Figure 22: NRPS Comfort of the Seats, 2010/11 to 2019/20 (GW Long-Distance)

Figure 23 shows the trend in satisfaction with connections with other train services. This is broadly flat with minor variations around an average satisfaction of 79%. There was however a drop of 3% between 2018/19 and 2019/20; this could reflect a reaction to the changes to interchanges associated with the December 2019 timetable e.g. removal of almost all interchange requirements between London and Cheltenham and Gloucester. However, such changes may take a while for passengers to adapt to and it may be too early to draw any conclusions.

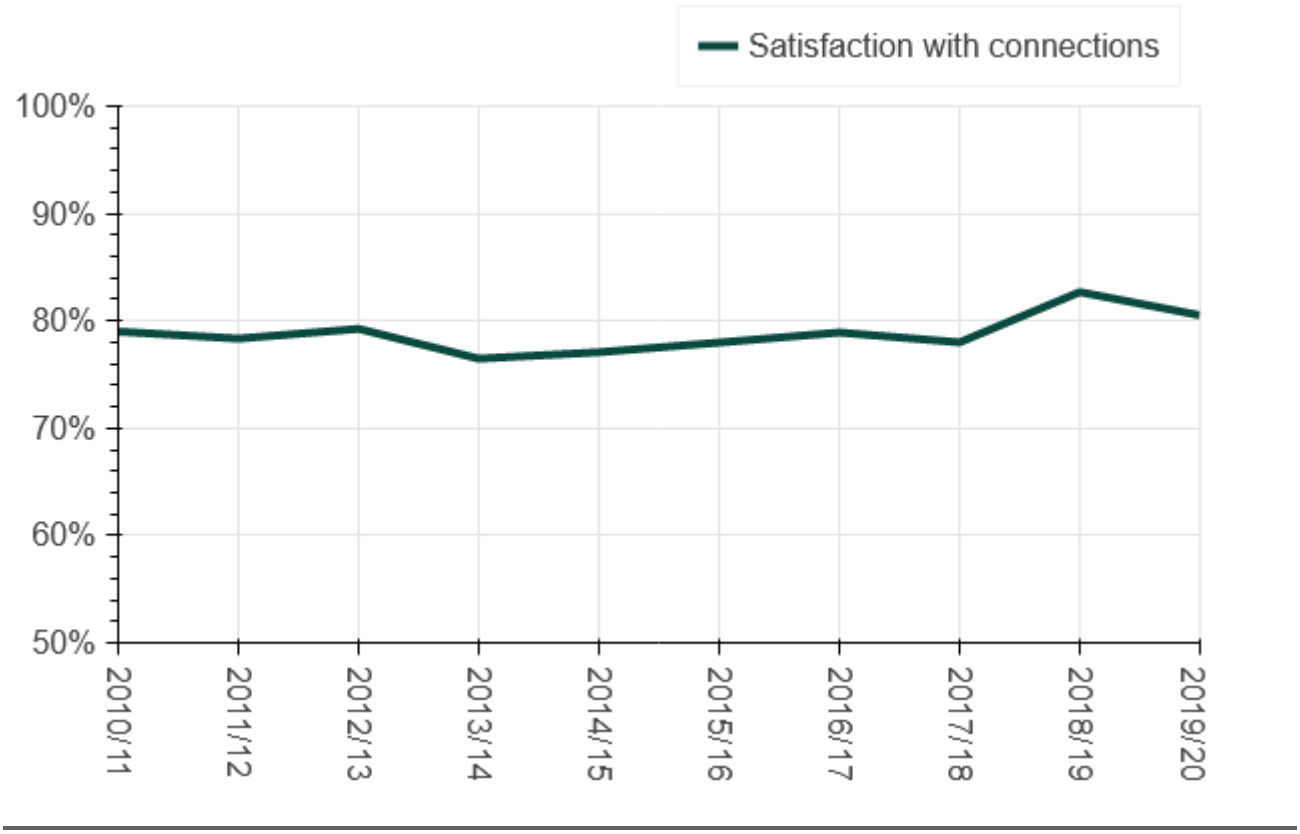

Figure 23: NRPS Connections with Other Train Services, 2010/11 to 2019/20 (GW Long-Distance)

Table 16 shows the change in satisfaction for the five on-board indicators assessed for GWR and the three comparator franchises between 2010/11 (or when the indicator was introduced to the NRPS if later) and 2019/20. This shows that for overall satisfaction with train, level of crowding, upkeep and repair of the train and comfort of seats, GW has performed relatively better than the other long-distance franchises. This provides evidence that the introduction of the new IEP rolling stock from 2017 onwards has translated into improving satisfaction relative to other franchises. The only other comparator franchise on which there has been a major change in rolling stock is InterCity East Coast with the introduction of their Azuma trains from mid-2019 onwards, which may not yet be fully reflected in its satisfaction scores.

Franchise	Satisfaction 2010/11[34]	Satisfaction 2019/20	% Change	Statistical Significance
Overall Satisfaction with the Train				
Great Western	**85%**	**90%**	**+4%**	**No**
West Coast Partnership	92%	83%	-9%	Yes
InterCity East Coast	88%	88%	0%	No
East Midlands	87%	80%	-7%	Yes
Level of Crowding				
Great Western	**72%**	**80%**	**+8%**	**Yes**
West Coast Partnership	81%	77%	-4%	No
InterCity East Coast	81%	80%	-1%	No
East Midlands	74%	74%	+0%	No
Upkeep and Repair of the Train				
Great Western	**85%**	**93%**	**+8%**	**Yes**
West Coast Partnership	89%	80%	-9%	Yes
InterCity East Coast	81%	85%	+4%	No
East Midlands	78%	65%	-13%	Yes
Comfort of the Seats				
Great Western	**71%**	**72%**	**+1%**	**No**
West Coast Partnership	81%	77%	-3%	No
InterCity East Coast	81%	78%	-4%	Yes
East Midlands	77%	70%	-7%	Yes
Connections with Other Train Services				
Great Western	**79%**	**81%**	**+2%**	**No**
West Coast Partnership	81%	87%	+7%	No
InterCity East Coast	81%	83%	+3%	Yes
East Midlands	74%	78%	+4%	Yes

Table 16: Change in On-Board Indicators Satisfaction by Franchise – GW and Comparators, 2010/11 to 2019/20

[34] 2012/13 for Overall Satisfaction with Train; 2016/17 for Level of Crowding and Comfort of Seats

4.5 Demand and economic responses

One of the key drivers for the GWRM programme identified in the benefits mapping presented in Figure 4 was that of modal shift to train, with this expected to be delivered through a demand response to the improvement in rail service provision.

Figure 24 provides a summary of the annual passenger demand for the Great Western franchise as reported via the Office of Road and Rail (ORR), sourced from the LENNON ticketing and revenue database[35] and TOC information. The GWR figures do not include the non-franchised Heathrow services or demand on services transferred from GWR to Crossrail/TfL Rail. This includes services those running from Paddington to Hayes & Harlington from May 2018, and then further transfer of the stopping services from Paddington to Reading from December 2019.

The figure also shows the demand changes for Great Western and the comparator franchises indexed to 2011-12 and covering the period from mid-2016 when the first new electric rolling stock was deployed on GWR services. As the analysis covers all service groups for the Great Western franchise, the South Western franchise has been included to provide a comparator to a TOC that also operates London commuter routes.

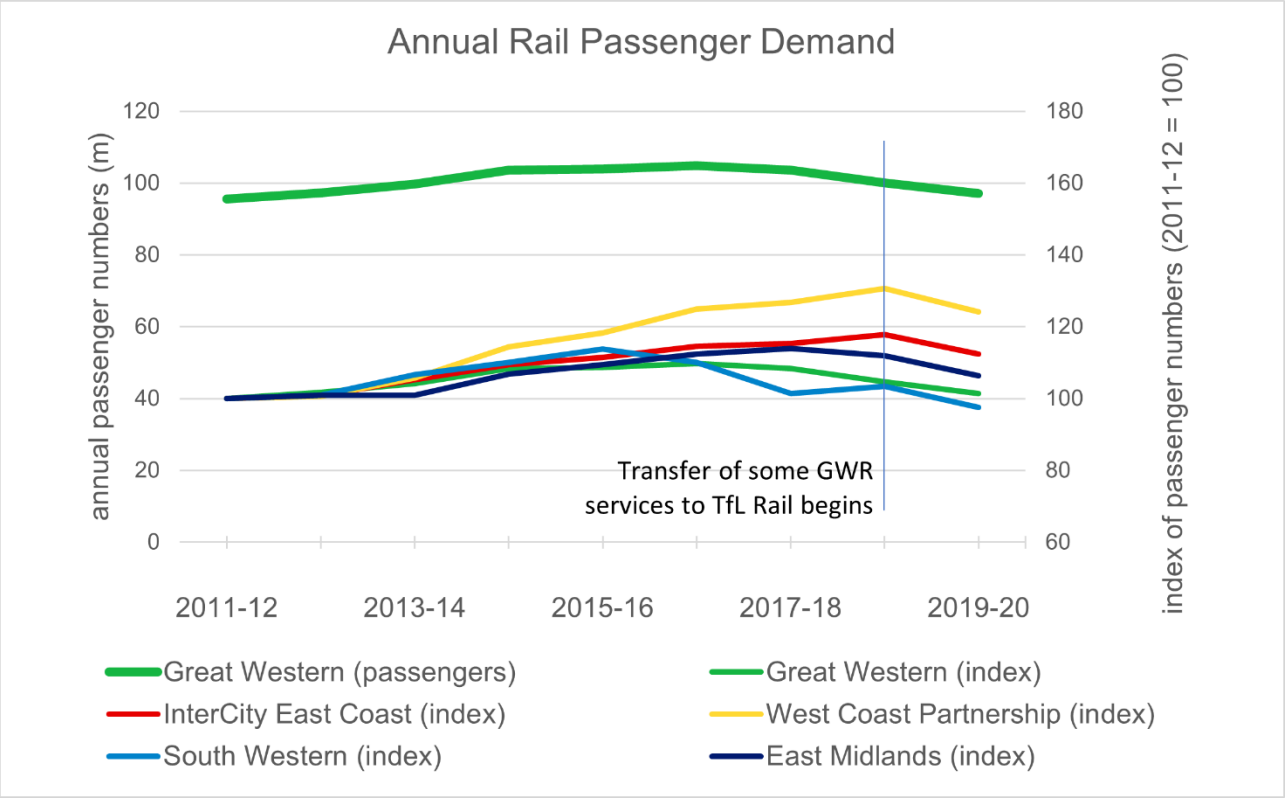

Figure 24: Rail franchise operator annual demand, 2011-12 to 2019-20

Sources: ORR, SYSTRA

[35] LENNON is the industry's ticketing and revenue system (Latest Earnings Networked Nationally Over Night)

A detailed analysis of the drivers underpinning the demand changes identified in Figure 24 has not been undertaken. Relative to the comparator TOCs, indexed demand growth for the Great Western franchise from 2011-12 was broadly similar through to around 2016-17, apart from the long-distance only West Coast Partnership franchise which had a markedly higher growth. In 2017-18, further growth was apparent on both the long-distance only franchises of InterCity East Coast and the West Coast Partnership and the mixed East Midlands operation, whilst the London-commuter dominated South Western franchise demand fell by around 8%. GWR's demand however fell slightly by a little over 1% to 2017/18, before falling further as some of the inner-London and then outer-London commuter services were transferred to Crossrail, with the vertical line on the figure indicating the start of the transfer of services from GWR.

It was suggested by some involved in the Theory of Change stakeholder engagement that there was an early positive demand response for the long-distance service groups to the major timetable change in December 2019. However, the emergence of the COVID-19 pandemic and associated travel restrictions around two to three months after the change in timetables means that a fuller demand response has not occurred. Analysis of out-turn demand during 2020 and 2021 will not provide any meaningful indicator of the medium to long-term demand-related outcomes and impacts of the GWRM.

Ordinarily a number of the further key social and economic responses to transport investments would be expected to emerge following scheme delivery through some early outcomes, and then in the longer term some years after, once individual and business behaviours adjust to the changes in connectivity. These outcomes may include modal shift to rail resulting in reduced road congestion, improved access to employment and health facilities helping in reducing social exclusion, and improvements in connectivity driving new development and inward investment.

Given that the COVID-19 pandemic has effectively stalled and set back the realisation of the initial short-term outcomes of the GWRM programme even further, these medium-term outcomes and longer-term impacts cannot be assessed at present.

5. Environmental Impacts

This chapter addresses the following evaluation questions:

Has the electrification of lines and deployment of bimodal trains improved the environmental performance of the railway?

Has improved passenger experience lead to modal shift driving reductions in transport related emissions?

Enhanced environmental sustainability was identified by the NAO in their summary of the expected benefits of the GWRM industry programme[36], primarily being driven by new and newly deployed trains.

The GWRM benefits mapping shown in Figure 4 identified two key environmental-related drivers:

- modal shift to train; and
- the commitment to carbon reductions.

The enablers of change identified in the benefits mapping were overhead line electrification and new IET and Class 387 rolling stock, with the expected benefits being identified as reduced carbon emissions and improved noise quality.

Although some of the participants in the Theory of Change stakeholder engagement sessions considered that environmental issues were a secondary consideration in the development of the GWRM, environmental issues appear to have remained important as the programme was delivered. 'Day-to-day' environmental delivery issues, particularly in respect of ecology, were identified by the Network Rail participants as critical in some sensitive locations during construction works. Network Rail's expectations, set out in their TGW programme, also included the delivery of 'improved environmental benefits'. The TGW noted these benefits as a non-quantified (i.e. a benefit not identified as a quantifiable target in the HLOS).

[36] Modernising the Great Western railway, NAO, November 2016

The changing political context on environmental issues, in part reflecting increasing public awareness and concerns over decarbonisation, could now be seen as more important in the context of the decarbonisation agenda.

This chapter focuses on the GWRM electrification:

- setting out the expected extent of electrification and the actual outputs following the descoping of the GWRM programme; and
- the initial outcomes in terms of changes in carbon emissions arising from train operations.

The demand driven environmental benefits arising from modal shift to rail from car will emerge through either retaining existing rail travellers on the rail network and/or attracting new patronage that would otherwise travel by car for the same journey or for journeys to different destinations. However, as there was only a limited period between the key December 2019 timetable change and the onset of the COVID-19 restrictions significantly affecting travel behaviours, any modal shift outcomes will need to be considered when post-pandemic timetables and associated passenger behaviours are established.

This evaluation does not consider the wider environmental issues around scheme construction, such as ecology and noise associated with the electrification and capacity enhancement works that ordinarily would be considered through the formal scheme planning and delivery processes.

Similarly, this evaluation does not consider lifecycle carbon issues, such as embedded carbon emissions during construction works (e.g. the use of concrete in piling for electrification masts) or in producing new rolling stock. These issues are beyond the scope of the current report, are extremely complicated and potentially very wide ranging.

5.1 Electrification outputs

In 2012 the DfT identified rail electrification as a strategic priority. Network Rail had set out the case for electrification in 2009 for some parts of the UK network, highlighting the role that electrification could play in delivering environmental benefits, alongside a range of other benefits. In 2012, the DfT announced a large volume of electrification works to be delivered by Network Rail in the 2014–2019 rail investment period.

Of the £34.3 billion budget for operating, maintaining, renewing and enhancing the railway in England and Wales for the period, £3 billion was for electrification schemes, including, but not limited to the Midland Main Line from Bedford to Nottingham and Sheffield, and the Great Western Main Line from London to Swansea.

The de-scoping of the GWML proposals, described in section 2.2, recommended later delivery of some sections of electrification, the deferral of the others into CP6 and ultimately some cancellation of parts of the initial proposals.

The original GWRM proposals were to procure a mixed fleet of electric-only and bi-mode IET trains; the bi-mode trains proving an effective way of allowing direct links to be maintained to towns and cities off the electrified network. The Great Western network had a long history of providing extensions to the core routes to Weston-Super-Mare and into

west Wales including Carmarthen, and Tenby/Pembroke in the summer months, as well as through trains to Cheltenham and Gloucester.

Under an 'electric-only' model, similar to that used after the electrification of the West Coast and East Coast Main Lines, these towns and cities would just have been served by diesel trains, potentially running for a long-distance 'under the wires', or the passengers forced to change trains.

Following the descoping of the electrification proposals and the broadly parallel decision to move to a fully bi-modal fleet, all InterCity type long-distance services are now handled by bi-mode IET trains, either of the original IEP Class 800 order or the later AT300 Class 802 order.

Table 18 identifies the route sections and lengths covered by the original electrification proposals and those delivered, deferred or cancelled. In summary, the GWRM electrification was expected to electrify just under 300 route miles, but to date has delivered around 60% of this though electrifying 180 route miles

Most of the planned electrification was on double track routes, with some quadruple track sections between London and Didcot, around Bristol and between Severn Tunnel Junction and Cardiff,. The single track Thames Valley branches were also included in the programme. Overall the programme:

- was expected to electrify around 730 primary track miles; but to date
- has delivered around 70% of this through electrifying over 510 primary track miles.

GWRM Electrified Sections Route: Planned and Delivered	Route Length[A]	Status
Paddington to Maidenhead	24.1 miles (39 km), quadruple track	Delivered
Maidenhead to Reading	11.7 miles (19 km), quadruple track	Delivered
Thames Valley Branches[B]	14.5 miles (23km), single track	Deferred
Reading to Didcot	17.2 miles (28km), quadruple track	Delivered
Reading to Newbury	17.1 miles (28km), double track	Delivered
Reading to Basingstoke	13.7 miles (22km)[C], double track	Cancelled
Didcot to Swindon	24.2 miles (39km), double track	Delivered
Didcot to Oxford	10.4 miles (17km), double track	Deferred
Swindon to Bristol Parkway	34.5 miles (55km), double track	Delivered
Swindon to east of Chippenham	18.8 miles (30km), double track	Delivered
East of Chippenham to Bristol T.Meads	22.3 miles (36km), double track	Deferred
Filton Bank (Parkway area – T.Meads)[D]	7.2 miles (11km), quadruple track[E]	Deferred
Bristol Parkway to Severn Tunnel Jnt	11.8 miles (19km), double track	Delivered
Severn Tunnel Jnt to Cardiff Central	21.6 miles (35km), quadruple track	Delivered
Cardiff Central to Swansea	45.5 miles (73km), double track	Cancelled

Table 17: GWRM Planned and Delivered Electrification **Source: DfT, SYSTRA**

Notes: A – route lengths do not include junction spurs at Reading, Didcot Parkway and Bristol East Junction.
B – Marlow, Windsor and Henley branches. While Marlow was originally included in the SOFA electrification scheme it was omitted later due to potential operational issues with the reversal at Bourne End.
C – distance reported to Southcote Junction where the line from Reading to Newbury diverges.
D – route length provided between Parkway and Temple Meads and Filton Abbey Wood and Patchway.
E – Filton Bank was double track until late 2018 when re-quadrupling of the route was completed.

In practice, the absolute number of electrified track miles planned and delivered may be a little higher when accounting for junction spurs and passing loops on double track sections of route, but overall the proportions delivered will remain around 60% and 70% respectively.

Table 18 expands on the route-based assessment of electrification to draw in train services by considering the extent of train miles that are operated under electric traction. This assumes that for the bi-mode IET trains, diesel is not ordinarily used on electrified sections of the route.

The table provides a proportion of electrified train miles operated in the December 2019 timetable, identifying that over three quarters of train miles on routes to Bristol and south Wales operate on electrified sections of route, with lower proportions on the other GWR long-distance routes that serve the Cotswolds and west of England.

The table also identifies the proportion of electrified train miles delivered relative to the original GWRM electrification plans. This shows that the deferrals and cancellation of electrification have resulted in over 80% of initially planned electrified train miles being delivered on services to Bristol, South Wales and on Cotswold (north) routes. All of the expected electrified train miles have been delivered on the Cotswold (south) routes with full electrification to Swindon for these services.

The move to an all bi-modal fleet has allowed the west of England routes to contribute to the electrified train miles; the original GWRM did not intend to use any electric or bi-modal trains on these routes. Including the west of England services, almost 95% of expected electrified long-distance train miles are now operated under electric traction.

	Electrified Train Miles			Relative to full GWRM
Grouping	**Dec-11**	**Dec-19**	% of total train miles	out-turn % of full programme
GWR Main Line - Bristol group (note A)	0	7,700	76%	80%
GWR Main Line - Wales group	0	9,900	82%	83%
GWR West of England group (note A)	0	2,900	24%	new electric
Cotswolds North	0	2,200	39%	83%
Cotswolds South (direct and connections)	0	2,600	62%	100%
Long Distance Total	**0**	**25,300**	**57%**	**94%**
London - Reading GWR/Crossrail (note B) inc Thames Valley, Basingstoke, Gatwick	0	5,300	46%	67%
London - Newbury/Bedwyn, Oxford and Banbury fast services (inc connections)	0	5,000	81%	93%
London - Didcot and Oxford slow services	0	4,000	85%	91%
Didcot to Oxford/Banbury (local connections)	*0*	*0*	0%	0%
London and Reading Commuter Total	**0**	**14,300**	**61%**	**79%**
Other GWR routes - Cardiff/Worcestershire to Bristol, South Coast, South West & branches	0	0	0%	0%
Other GWR Routes	**0**	**0**	**0%**	**0%**
GWR plus Crossrail (excluding Heathrow services, Sleeper and bus/coach services)	**0**	**39,600**	**42%**	**88%**

Notes: A - Seat miles derived from train miles and adjusted MOIRA capacity coding, adjusted to improve representation of train formations
B - The limited number of Taunton trains routed via Bristol are included in the Bristol group figures. The limited number of Exeter services routed via Bristol are considered in the West of England group figures
C - Does not include Heathrow Express or Heathrow Connect services

Table 18: GWR Weekday Electrification Train Miles, 2011 and 2019 **Source: MOIRA v2.2.1 [August 2021] data, SYSTRA**

This comparator analysis against the 'full' GWRM assumes that all the planned electrification was delivered and that route 'extensions' to Weston-Super-Mare, west Wales and both Cotswold routes would operate with bi-modal trains under diesel power when working beyond the electrified network. For the services to the west of England, it was originally envisaged that these would be maintained using diesel powered HSTs, at least until the decision in mid-2015 to procure the initial AT300 Class 802 IET fleet.

For the services to the west of England, the ability to run under electric power to Newbury (or to just east of Chippenham for those limited number of services routeing via Bristol) provides benefits in reducing the extent of diesel operation. These include environmental benefits of reduced use of diesel power and providing an extended operating range for trains, increasing service resilience compared to operating only under diesel power.

Following electrification of the Great Western routes, well over 40% of all GWR train mileage across the franchise is electrically operated. Around 60% of long-distance and London and Reading commuter service mileage is electrically powered. 80% of train mileage on services to both Bristol and into south Wales runs under electric power. 25% of train miles on services to the west of England are electrically operated and between 40% and 60% on the two Cotswold routes.

The electrification delivered accounts for just under 95% of the initially planned electrified long-distance train mileage that would have operated were all route sections in the original GWRM to have been delivered. The loss of electric traction to Swansea, short sections to Bristol and from Didcot to Oxford, have been significantly offset by the use of bi-modal trains on services to the west of England that were not initially part of the GWRM.

For the London and Reading commuter market, key mainline operations are provided by fully electric services or by IETs on fast services to Oxford and Bedwyn, running under diesel power for the last 10 miles between Didcot to Oxford or the last 13 miles between Newbury and Bedwyn. Overall, just under 80% of the electrified train mileage has been delivered compared to the initial full GWRM electrification programme.

In seat mileage terms, that is the number of train miles factored by the number of seats per train, the proportion of the initial full GWRM electrification programme that has been delivered remains at broadly 95% for the long-distance services, but increases by 8 percentage points reflecting that the electrification has been delivered on the primary routes and that deferred or cancelled electrification schemes were mainly on secondary routes or Thames Valley branch lines.

5.2 Carbon emissions

With the delivery of a substantive electrification programme, even if a little smaller than initially planned, the GWRM has led to a significant reduction in the use of diesel traction across the franchise, with replacement of the HST fleet on long-distance routes and the Class 165/166 Turbo trains on most of the London and Reading commuter routes.

While the electrification in full or part of many long-distance services and commuter routes has directly replaced the use of diesel trains, the cascading of rolling stock around the network has also altered the diesel traction usage for passenger services elsewhere on the GWR (and wider) rail network.

Traction power requirements

The net outcome of these traction power changes is shown in Table 19 for the Great Western network. The figures include an uplift in the electric power consumption to account for the transfer of former GWR commuter routes to Crossrail that were included in the declared estimates until 2017-18.

The table also provides a synthesised 2020-21 estimate for power consumption assuming a full year of the December 2019 timetable and has been developed to illustrate the further increase in electric traction power that would have been likely, had the COVID-19 pandemic not interrupted service delivery.

The table also shows the broad GWR traction power share of all UK passenger rail services (excluding the heritage sector and freight operations) and the power-to-carbon

conversion rates, as derived from the Office of Road and Rail (ORR) reporting of rail power usage and carbon emissions.

	Great Western Railway and Crossrail (note A)		Approximate GWR share of all UK passenger rail		Carbon conversion rates (note B)	
	Traction electricity usage (kWh)	Traction diesel usage (litres)	Traction electricity	Traction diesel	Traction electricity kg CO_2e/kWh	Traction diesel kg CO_2e/l
2011-12	0	96,592,000	0%	20%	0.46	*3.02*
2012-13	0	101,045,000	0%	21%	0.47	3.02
2013-14	0	101,015,000	0%	21%	0.45	2.93
2014-15	0	102,787,000	0%	21%	0.50	2.93
2015-16	0	103,995,000	0%	21%	0.47	2.91
2016-17	2,824,000	106,825,000	0%	21%	0.42	2.97
2017-18	31,469,000	101,705,000	1%	21%	0.36	2.95
2018-19	128,648,000	86,945,000	3%	19%	0.29	2.97
2019-20	154,472,000	75,734,000	4%	16%	0.26	2.76
Synthesised 2020-21 (note C)	*173,379,000*	*79,969,000*	*n/a*	*n/a*	0.24	2.76
COVID-19 impacted 2020-21	128,794,000	59,405,000	4%	17%	0.24	2.76

Notes: A - Power data is observed for GWR, with an estimate of the electric power requirement for the GWR services transferred to Crossrail from 2018. All analysis excludes Heathrow services. B - implied conversion rates for all passenger trains across the UK rail network from ORR (table 6105, energy consumption and CO2e emissions). Alternative conversion factors are available from TAG guidance, but these would not be consistent with the ORR analysis. The conversion rate for diesel in 2011 has been adjusted by SYSTRA to provide a smoother profile of implied conversion rates and emissions across the UK rail network. C - synthesised values estimated assuming a full year of the post-December 2019 timetable with no-COVID timetable impacts, primarily driven by estimated electrified and diesel train miles

Table 19: GWR Traction Power and Carbon Conversion Rates **Sources: GWR, ORR, SYSTRA**

As a major franchise, which was until the delivery of the GWRM reliant entirely on diesel traction, the Great Western routes used around 20% of all diesel traction power across the UK passenger railway network as a whole. While the new rolling stock on GWR routes has reduced diesel power consumption by around 25-30%, the share of national diesel usage remains relatively high, falling to only 16% of the national total. The newly electrified GWR services account for around 4% of the national electric passenger traction power usage.

Also apparent from the ORR data shown in the table is the strong decline in implied CO_2e emissions per kilowatt hour of electric power consumed, especially in the period from 2014-15 as the UK's power generation mix changed. Diesel emissions remained largely unchanged over time but fell in 2019-20.

It should be noted that these declared out-turn rates include some degree of estimation by ORR in handling returns from the franchise operators regarding fuel consumption and train miles. While some care needs to be taken in using these estimates, similar trends of reducing emissions are apparent for the carbon conversion rates set out in the DfT Transport Appraisal Guidance (TAG), although at a detailed level there are some differences in historical emissions rates between the two sources.

GWR carbon emission changes

Figure 25 illustrates the combined carbon impacts of the changes in emissions for diesel and generated electricity used to power trains alongside train service changes for the GWR operation as a whole.

The figure also shows the changes in CO_2 equivalent emissions per train mile (using the train kilometre metric as reported by ORR) as the GWR network transitioned from a fully diesel operation to mixed diesel and electric. As in Table 19, the figures include estimates for the operation of the Crossrail services transferred to GWR.

The emission estimates for 2019-20 are based predominantly on the pre-December 2019 timetable, but with electrification works largely completed and operation of long-distance services using the bi-modal IET trains and the London and Reading commuter routes operated by electric trains. This move to electric operation can be seen to significantly reduce overall emissions and emissions per train mile.

Synthesised figures for full operations in 2020-21 are provided to confirm the reduction in emissions per train mile and the small impact of the increased service levels offered by the December 2019 timetable. The actual 2020-21 emissions arising from the reduced emergency timetable that operated during the COVID-19 pandemic are shown as a dotted line in the figure.

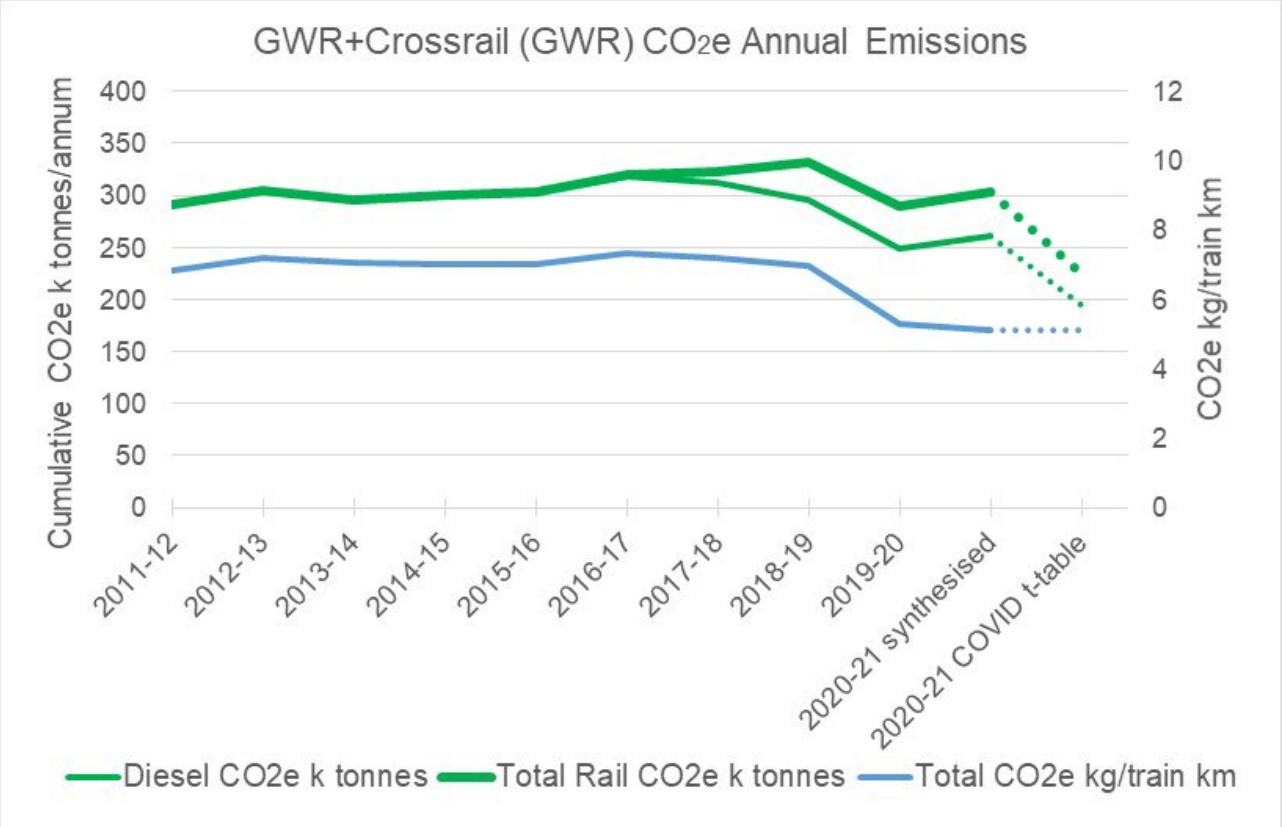

Figure 25: GWR total carbon emissions and emissions per train km
Note: the figures use a train kilometre distance metric as reported by ORR **Sources: GWR, ORR, SYSTRA**

Following delivery of the GWRM, total emissions on GWR routes fell by around 20% to 2019-20 despite an increase in train miles of 10%. Annual saving in CO_2 equivalent of around 90 kilotonnes (=90 million kg) in emissions from diesel operation were partially offset by emissions from electricity usage at the source of generation of around 40 kilotonnes. With the move to a mixed diesel and electric operation, the average CO_2 equivalent emissions per train mile fell by around 25%.

Figure 25 shows the large decline in total emissions arising from the temporary COVID-19 timetables. The reduced emissions per train mile of 25% has been maintained and provides the basis for locking in the benefits of the move to electric traction in the longer-term. Future year changes can be expected to be largely driven by further reductions in emission rates as the UK electricity power generation mix changes alongside any changes in train service provision.

It has not been possible to disaggregate the GWR emissions based on specific rolling stock emission rates to consider the overall impacts of only the InterCity-type long-distance services. At a broad level, long-distance electric train miles account for around 65% of all electric train miles and 35% of all diesel mileage, although the differences in fleet composition and power requirements suggest train miles may not be a robust metric to use in precisely estimating the long-distance share of total emissions.

National changes in carbon

In common with all rail and wider public transport operators, actual emissions in 2020-21 have fallen compared to earlier years, in line with the reductions in services levels arising from the pandemic. However, as identified in Figure 25 there have also been reductions in the underlying emissions per kilowatt hour or litre of diesel fuel over time, especially in relation to the electric power generation mix.

Figure 26 considers the average changes in CO_2 equivalent emissions per train mile across the rail network as a whole from 2011-12 and from 2015-16 for the comparators of the West Coast Partnership and East Midlands franchises, as well as West Midlands franchise for which data was available.

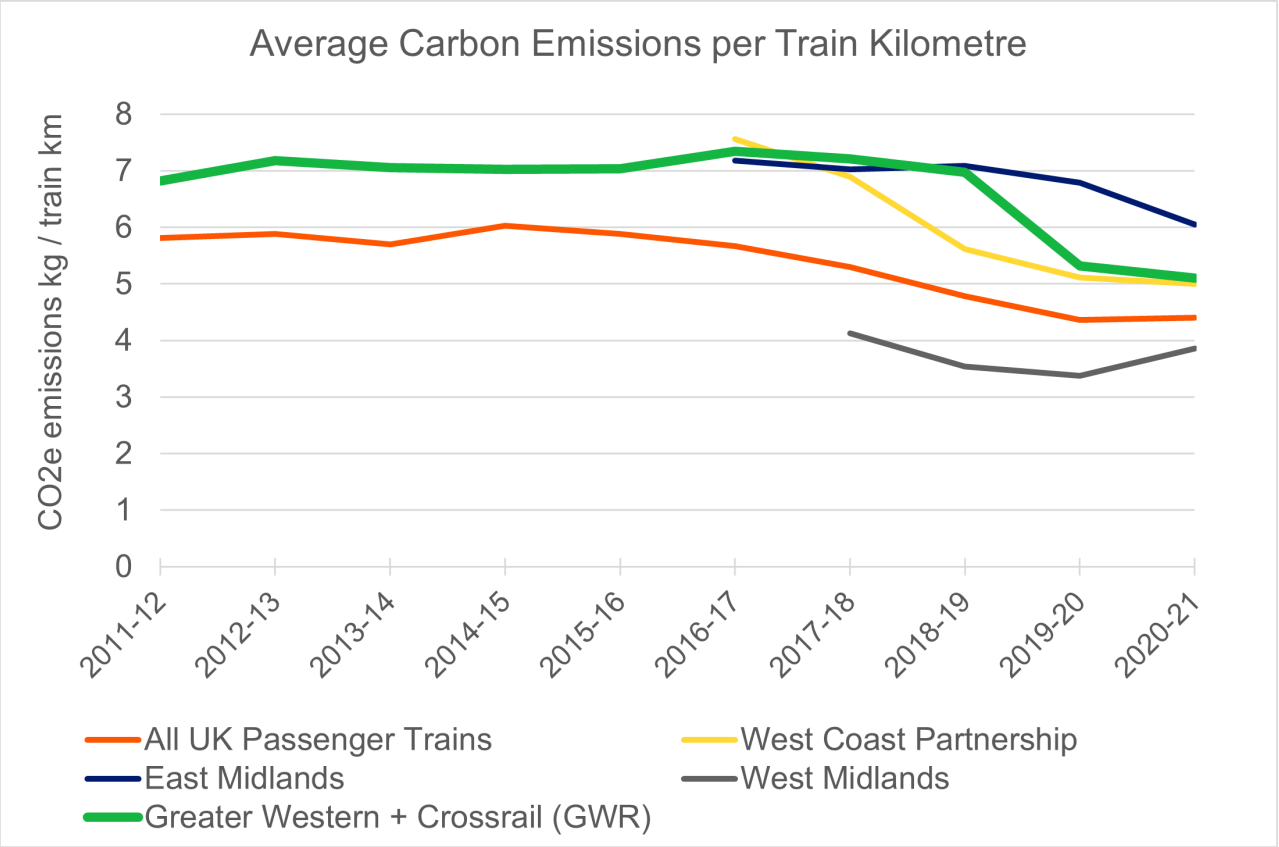

Figure 26: GWR and comparator TOC emissions per train km
Note: the figures use train kilometre distance metric as reported by ORR **Sources: GWR, ORR, SYSTRA**

Figure 26 repeats the GWR emissions profile from the earlier figure, but within the context of changes in the wider rail industry. The figure for all UK passenger trains includes the impacts of GWR itself, but also other changes in the emissions drivers. These drivers included:

- the falls in electric power emissions noted in Table 19 – this being the key reason for the reduction in emissions per train mile apparent for the already largely electrified West Coast Partnership franchise;
- electrification elsewhere on the network, including Edinburgh to Glasgow (and wider links to Stirling and Alloa), in the north-west around Manchester, Liverpool, Wigan and Preston, fill-in schemes in the West Midlands and London – the observed decline in emissions rates in 2020-21 on the East Midlands franchise is driven by the recent electrification between Bedford and Corby; and
- the mix of services operated on any one network – for example on the West Midlands franchise, where emission rates have increased slightly as the COVID-19 influenced timetable has altered the mix of diesel and electric services, with diesel operated mileage disproportionately driving the average emission rates.

The GWRM electrification has contributed to the more than 25% reduction in carbon emissions per passenger train mile across the UK rail network over the last decade. This large reduction in the carbon emissions per train mile across the rail industry from 2011 has been driven by on-going improvements in the UK electricity generating mix and new electrification on the Great Western route and elsewhere on the rail network.

Were the electrification of the Great Western route to have not taken place, but the capacity improvements to have been delivered by diesel trains, then it is likely that the emissions from GWR services would have increased with additional train mileage offsetting any small reductions in the underlying emissions arising from each litre of diesel used.

The focus for the analysis above has been on traction power. In practice, there are a number of additional power requirements or other potential sources of carbon emissions, including:

- transmission or distribution losses (for GWR the equivalent of around 2% of traction power);
- regenerative energy produced;
- non-traction based power usage such as those arising from depot, ancillary or other building and road vehicle power requirements;
- any additional maintenance trains and use of road vehicles linked to electrification over and above the requirements for a non-electrified line; and
- any reductions in track maintenance trains and use of road vehicles due to upgrading of the operational infrastructure.

No analysis has been undertaken of this power usage or emissions associated with changes, if any, in the railway infrastructure maintenance requirements arising from the modernisation programme; these changes would be expected to be relatively small when set against normal passenger operations.

Bi-modal train emissions

In their review of the GWRM, the NAO[37] suggest that 'the decision to procure all the trains as bi-modes means that the Great Western Route Modernisation industry programme will not achieve all the benefits that the Department expected in the short-term'. In respect of the environment, in addition to the reduced extent of electrification, the NAO noted that the bi-mode trains cause more damage to the track and incur higher energy costs than electric-only trains, as they weigh more, implicitly suggesting they bring lower

[37] Modernising the Great Western railway, NAO, November 2016

environmental benefits than electric-only trains. Similarly, it was noted that the bi-mode trains used in diesel mode are also noisier and emit more pollution than electric trains.

It has not been possible to determine the extent of any premium in electricity use in operating bi-mode trains in electric mode relative to similar electric only trains. In due course, data may become available to test this premise and consider the additional power requirements in effectively carrying a diesel engine when working in electric mode.

The NAO also note that for the DfT to deliver the benefits originally expected from electrification, some of the bi-mode trains would need to be modified to remove diesel engines once the line has been electrified. With around 95% of expected electrified train mileage for long-distance services delivered, the trade-offs between the marginal environmental benefits and the substantial loss in operating flexibility in developing a small sub-fleet of electric-only trains to serve Newbury and Cardiff, would need to be considered in further detail.

Further monitoring of out-turn data concerning the environmental performance of bi-mode and electric-only IEP/AT300 series trains could be used to support both an enhanced evaluation of the GWRM and a wider assessment of the relative benefits of bi-mode trains. To do so, data will need to be made available from the more sustained operations of Class 800/802 bi-mode trains operated by GWR, London and North Eastern Railway, TransPennine Express and Hull Trains, and the Class 801/803 electric-only trains operated by London and North Eastern Railway and First's Lumo service.

Future year carbon emissions

As noted in Table 19, there have been reductions in carbon emissions across the rail industry over the past decade, primarily through improvements in electric power generation mix and through some electrification of the rail network.

Based on the DfT's TAG Databook of November 2021, CO_2e emissions for rail transport electric power usage are forecast to fall significantly, with a 95% reduction in emissions per kWh used on the rail network by 2040. This change will mean that electricity for rail traction will be associated with extremely low carbon emissions.

Table 20 summarises the underlying 2021 emissions forecasts for electricity used in the rail network in TAG, with these forecasts now having a more rapid move towards very low emissions for electric powered rail in the longer-term than those applicable during summer 2021.

Year	Carbon dioxide emissions per kWh: rail electricity
2010	363g
2015	324g
2020	274g
2030	*120g*
2040	*14g*
2050	*6g*

Table 20: Out-turn and forecast rail transport electric power emissions

Source: TAG Table 3.3

Table 20 suggests that over time there will be further sustained and significant reductions in emissions from the electrified rail network, with carbon emissions for generated electricity powering GWR's electric and bi-modal trains expected to fall by over a half by 2030 and by 95% over the period to 2050. Although there have been some reductions in emissions arising from diesel power usage on the rail network, TAG suggests that emissions from diesel power are not forecast to change significantly in the future. There are initiatives underway on the rail network that are considering supplementing diesel power with batteries, including on the IEP fleet. Other initiatives for non-electric trains include the use of bio-fuels and other new fuels to directly reduce emissions. These approaches may result in reduced rail emissions, effectively through further reducing the proportion of rail operations that are diesel powered.

In terms of modal shift impacts, the trajectory in CO_2e emissions from travellers on the road network is also a reduction in emissions on a per vehicle mile basis. The average emission rates noted in the TAG Databook for fossil fuel cars are expected to decline by around 30-33% by the early 2040s. The increasing use of electric vehicles will also impact on car emissions as the fleet transitions from virtually all fossil fuels in 2020 (99% of vehicle miles) to a more mixed fleet by 2040 and 2050 (67% and 56% fossil fuels respectively). Based on these fleet mixes, by 2040 emissions from cars per vehicle mile are expected to fall by a little over 50% from 2020 levels and by just over 60% by 2050.

Therefore, while emissions per vehicle mile from the road network are expected to fall, including through increased use of electric vehicles, there will remain significant emissions benefits to be gained through modal shift to rail. These medium and longer-term outcomes can only be considered properly following the establishment of stable post-pandemic travel patterns and will need to be assessed in later evaluation phases.

6. Economic Evaluation

6.1 Introduction

This chapter addresses the following evaluation questions:

Has the efficiency of long-distance train operations changed as a result of journey time improvements and performance impacts?

How have train operating costs for long-distance services changed following replacement of the HST fleet?

Did improved passenger experience lead to greater rail revenues?

Has the programme contributed to better franchise premiums?

Has the programme offered value for money, relative to expectations?

It considers, in turn:

- **scheme costs and revenues**, assessing the out-turn capital costs of the programme, operating costs and revenues associated with the long-distance service provision to support an out-turn economic evaluation of this component of the wider GWRM programme;

- the **pre-opening economic appraisal** for the GWRM programme setting out the value of the costs and benefits underpinning the original 2015 and updated 2017 scheme appraisals;

- **a high-level qualitative assessment** outlining the key changes between the earlier appraisals and out-turn for each of the appraisal components that contribute to the monetised benefit-cost ratios used to inform a value for money assessment; and

- the **detailed economic evaluation** of the long-distance components of the GWRM programme, drawing in the out-turn costs identified and monetising some of the key transport demand, revenue and benefit streams identified in the impact evaluations in the earlier section 4 and 5 of this report.

6.2 GWRM scheme costs and revenues

Capital costs

Capital cost streams for the ex-post economic evaluation have been developed from the out-turn costs sourced from Network Rail's Oracle system, collated quarterly. Out-turn costs are available for the period from the start of CP3 (2004) to mid-way through CP6 2020/21, representing 97.8% of total spend.

As of autumn 2021 virtually all GWRM work had been completed, with the equivalent of around 2.2% of spending still to be accounted for. Therefore, forecast costs for this remaining spend beyond 2020/21 were included in total out-turn costs, assuming appropriate cost inflations based on CPI / RPI and any specific commodity indices.

Evolution of capital cost estimates

Table 21 below provides a summary of the movement in costs from the initial capital cost estimates underpinning the business case of 2015, through the updated appraisal undertaken in 2017 to the DfT/NR 2021 out-turn costs provided for this evaluation.

At a headline level, the 2017 updated appraisal cost estimates increased significantly from those set out in the original 2015 business case, from around £3.0bn to £5.5bn. Of this increase of £2.5bn, additional electrification costs accounted for £1.4bn. Of the remaining headline increase of around £1.1bn, a large majority are related to other works that were not included in the earlier appraisal, such as the Reading Independent Feeder, Oxford station area capacity works, passenger capacity enhancements at Bristol Temple Meads and re-signalling in Cornwall.

The descoping of the GWRM that followed the Hendy reviews of late 2015 and early 2016 was intended to manage delivery following initial cost escalation with the early implementation of elements of the GWRM programme. The updated appraisal of 2017 considered the delivery of the full electrification programme, but to a delayed delivery timescale. In out-turn, cancellation and the (implicit) further deferral of electrification works has meant that out-turn costs have also fallen significantly compared to those set out in the 2017 updated appraisal, with electrification costs £0.9bn lower.

Fuller details of the line items included in each of the core cost estimates are provided in Appendix A.

GWRM component costs £m nominal/out-turn	2015 business case	2017 updated appraisal	2020/21 DfT/NR out-turn estimates
Electrification works	2,659	4,021	3,124
Key infrastructure works	308	793	548
Other works		680	115
Additional IEP costs			28
Scheme appraisal estimates	**2,967**	**5,494**	
Out-turn costs			**3,813**

Table 21: GWRM capital cost estimates and appraisal cost estimates, 2015 and 2017 appraisals, out-turn
Source: Updated appraisal 2017, DfT/NR 2020/21 analysis, additional IEP costs via DfT

Cost escalation in the early stages of the delivery of the GWRM led to a reconsideration of programme delivery. The expectation set out in the 2017 updated appraisal was that the full programme would be implemented, but with a delayed delivery, with electrification costs increasing by around £1.4bn from the initial estimates of £2.7bn included in the 2015 appraisal. In implementing the descoping set out in the Hendy plan, out-turn electrification costs were reduced by £0.90bn relative to the 2017 update appraisal, although still around £0.47bn higher than the initial business case estimates.

Figure 27 illustrates the evolution in electrification cost estimates and the out-turn by section of route. This shows that the expected increase in costs for the main electrification works was around £1.0bn from the 2015 business case to the 2017 updated appraisal. In out-turn, these costs were effectively controlled through deferring electrification from Didcot to Oxford, and from east of Chippenham to Bath, Bristol Temple Meads and the Filton area (representing 80% of the planned delivery). The cancellation or deferrals of the electrification from Cardiff to Swansea and on the Thames Valley branches limited out-turn spending on electrification to £3.1bn.

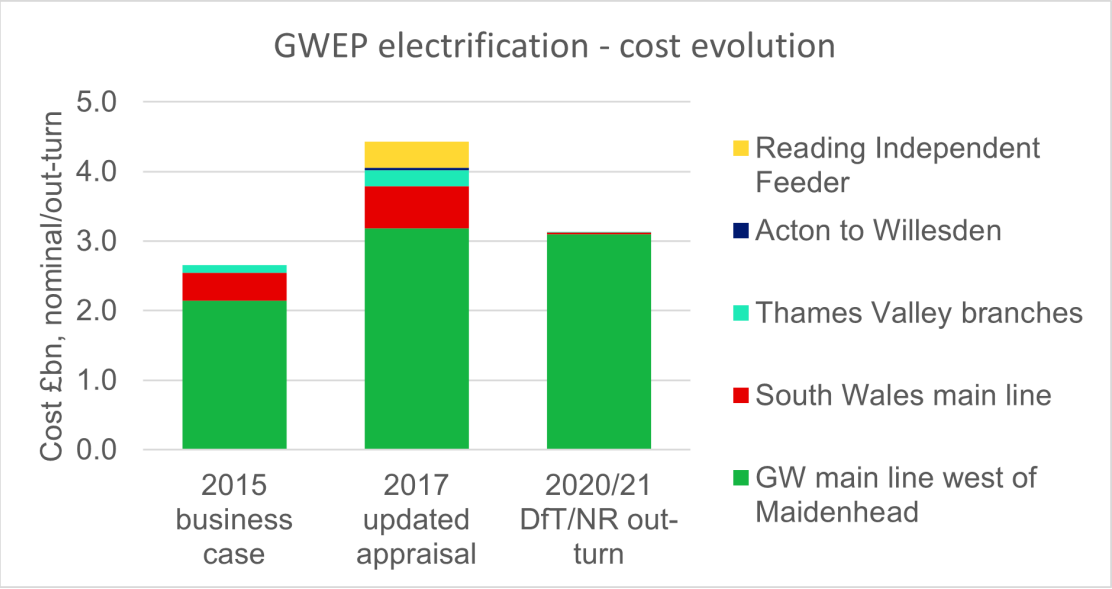

Figure 27: GWRM electrification – estimated and out-turn costs
Source: Great Western electrification project business case: Phase 1 report, CH2M, June 2017, DfT/NR 2020/21 analysis

The Reading Independent Feeder proposal (to enhance power supplies, improve reliability and provide greater flexibility for maintenance regimes) was included in the 2017 updated appraisal, though was then deferred and is now scheduled for delivery from 2023 via Network Rail's Enhancements Delivery Plan England and Wales. These costs were not covered in the DfT/NR out-turn estimates and have not been included in the GWRM economic evaluation that follows.

Capital costs for the economic evaluation of GWRM long-distance components

For this evaluation of the GWRM long-distance services, cost items have been allocated to provide an approximate out-turn capital cost for long-distance service improvements.

Table 22 provides a summary of the cost allocations used in the economic evaluation for the long-distance components of GWRM programme. These costs are based on:

- the counterfactual of electrification extended from Maidenhead to Reading (for Crossrail) and to Didcot and Newbury; and
- allocations of line items made by SYSTRA.

Fuller details of the inclusion and exclusions in estimating the long-distance cost components are provided in Appendix B, alongside a 'prime user' sensitivity developed drawing on advice provided by the DfT on which costs could be allocated to the long-distance services, even if the focus for investment was on other service improvements.

GWRM long-distance costs £m	2020/21 DfT/NR out-turn estimates	Assumed out-turn long-distance costs
Total costs	3,813	2,322 (64% of full costs)

Table 22: Indicative GWRM cost estimates for long-distance economic evaluation
Source: Updated appraisal 2017, DfT/NR 2020/21 analysis, SYSTRA

Operating costs

The benefits mapping presented earlier explicitly identified reducing operational costs as a target benefit for the GWRM, including lower spending on track and train maintenance and running costs (intermediate benefit B5b). Both of these benefits were expected to contribute to reduced operational costs (end benefit B5 in the benefits mapping).

Network Rail's published and audited Regulatory Financial Statements provide data on track maintenance and operating costs for the Western route (effectively covering much of the GWR train operational area, except in Wales). For the industry CP6 (including 2019-20 and 2020-21) the region was combined with Wales, with Network Rail's own analysis being used to derive the Western element of the now combined Wales & Western costs.

Table 23 provides a summary of Network Rail's operations, support and maintenance costs for the Western Route as a whole for 2011-12, 2015-16 and 2019-20. These overall area costs implicitly include elements of the GWRM and spending on route infrastructure support, including the regional networks in the south west. Further intermediate year costs and a fuller description of the cost line items are included in Appendix C.

Significant increases in operations and support costs on the Western route are apparent, including between 2015-16 and 2019-20. In their financial overview of the rail system in England[38] the NAO noted that these costs relating to running the rail network had increased between 2015-16 and 2019-20 largely due to accounting adjustments that moved some capital expenditures to operational costs.

Maintenance cost changes between 2015-16 and 2019-20 are also large with overall increases of 40% in cash terms. Costs of signalling and telecommunications and additional spending on electric power and overhead line equipment were apparent. However, overall expenditure on maintaining the condition and capability of the existing rail infrastructure across England also increased by a similar rate; the NAO noting that the England-wide increases were partly due to planned work in preparation for CP6 and partly due to the impact on assets of hot weather in 2018.

Out-turn spending cash prices (£m)	Operations support	Maintenance (trackwork, signals, civils, power etc)	Total
NR Western Route 2011-12 2015-16 2019-20	 75 69 117	 102 122 171	 177 191 288
Change 2015 to 19	+70%	+40%	+51%
Change in NR spend on all routes in England 2015 to 19	+36%	+41%	+38%

Table 23: Network Rail operations, support and maintenance costs for Western Route, 2011-12 to 2019-20
Source: Network Rail, NAO's Financial overview of the rail system in England

[38] Financial overview of the rail system in England, NAO, April 2021

Network Rail maintenance costs for the Western route, covering the substantive parts of the GWRM and much of the rest of the GWR franchise operating areas, have increased significantly from 2015-16, but only in line with wider spending on the rail network in England. Longer-term changes in operating costs may become apparent in due course as maintenance efficiencies are expected due to infrastructure investments in track and other works delivered as part of the GWRM.

In the economic appraisals that follow in this section the operating costs include the access charges levied on the GWR franchise to reflect the Network Rail maintenance costs noted above. This follows the approach adopted in the business case of 2015 and the updated appraisal of 2017.

Figure 28 outlines the changes in the GWR franchise operating costs reported by ORR from 2015-16 to 2019-20. Operating expenditure is broken down by a number of key cost types, including staff, access charges, rolling stock, diesel power and other operating expenditure that includes electric power used by electric trains. Total operating expenditure is shown by the uppermost green line on the graph.

While spending in real terms fell slightly between 2015-16 and 2016-17, total expenditure increased significantly thereafter, including in 2018-19 and 2019-20 when a number of GWR London and Reading commuter services were transferred to Crossrail/TfL Rail.

The major change in operational costs across the GWR franchise has been in rolling stock costs, with these costs accounting for over 33% of all operational costs in 2019/20 as opposed to only 7% in 2015/16. These increases reflect the significant changes made to the GWR train fleet, with significant numbers of new trains and increasing capacity, and in cascading trains to other parts of the GWR network to replace life expired rolling stock.

Of the non-rolling stock costs, over the period 2015-16 to 2018-19 GWR staffing costs remained largely unchanged, increasing by 5% from 2018-19 to 2019-20. Diesel costs began to fall following early electrification and in 2019-20 were over 30% lower than in 2015-16, but with increases in electric power costs (implicitly) included in the other operating expenditure' category. With some variations in access charge (potentially linked to the increases in rolling stock carriage miles and the transition in Control Period 6) and 'other operating expenditure' category, all non-rolling stock costs increased by 9% overall between 2015-16 and 2019-20.

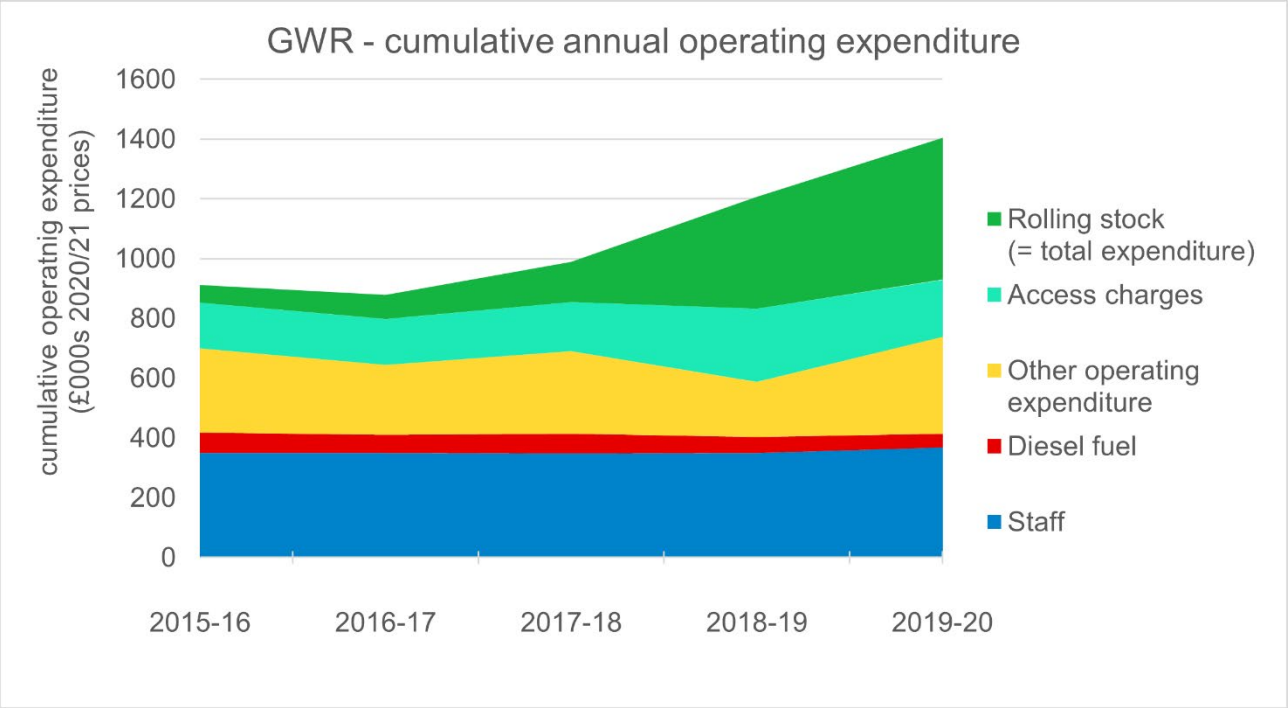

Figure 28: Great Western Rail franchise operational costs, 2015-16 to 2019-20

Sources: ORR, SYSTRA

Rolling stock costs

Rolling stock costs have risen due to a number of drivers, primarily linked to age of the rolling stock, rolling stock quality and the number of trains now in service across the GWR franchise.

It should also be noted that ORR's definition of rolling stock leasing costs includes both capital and non-capital rentals associated with the maintenance of rolling stock. New trains generally do not have the same maintenance arrangements as the older trains they replace and are often supported by full Train Service Agreements from the train manufacturer who takes responsibility for some maintenance expenditures rather than these residing with the train operating company. In these cases, maintenance costs may be handled through an increase in the non-capital charges.

The issue of industry-wide increases in rolling stock costs has been examined by the NAO[39] and in the subsequent Public Accounts Committee investigation into costs. The ORR costs and the NAO's adjusted estimates both point to overall increases in rolling stock costs of over 90% across all franchised operators, with significant cost increases for all operators with new and enlarged fleets. These cost increases are clear for GWR, but large increases in rolling stock costs are apparent for other TOCs with new train fleets, including InterCity East Coast, Thameslink, Northern, TransPennine and West Midlands.

The drivers for these rolling stock cost increases are identified by the NAO as being largely related to the new trains, including maintenance arrangements wrapped up on the train

[39] Financial overview of the rail system in England, NAO, April 2021

leasing charges, but also because of the need to lease more rolling stock to run more services.

The key changes on GWR routes have seen a reduction in the average age of the rolling stock, increased quality and a significant increase in fleet size. With the costs of the new IET trains significantly higher than the HST fleet built in mid to late 1970s, rolling stock costs for the long-distance routes have increased significantly.

An outline analysis, based on the reported ORR costs[40], points to total rolling stock costs for the long-distance fleet increasing from around £35m per annum in 2015-16 to around £415m in 2020-21 (in 2020-21 prices). This increase covers the provision of new trains and the associated capacity expansion of just under 25% in numbers of passenger vehicles and a 33% increase in numbers of seats (and a 40% increase in passenger seat miles). These costs have also wrapped up some of the maintenance and other expenditures associated with the new IET fleet and especially those procured under the IEP PFI-style deal that cover capital, maintenance, servicing and associated 'risk and adjustment' costs for these trains.

For the other GWR routes, while the leasing costs for the new Class 387 trains are greater than for the Class 165/166 diesel trains they replace, unit maintenance costs per train mile appear to be lower. The cascades of trains and service/capacity improvements around the rest of the GWR network driven by the release of the HST and Class 165/166 fleets result in a number of changes in rolling stock costs. With the very low lease cost of Pacer trains being withdrawn and the numbers of relatively low-cost Class 150/153s being reduced, inevitably rolling stock costs increased on the regional routes with further cost increases being driven by the expansion of the train fleet.

The outline analysis of the ORR costs also points to total rolling stock costs for the London and Reading commuter and regional train fleets increasing from around £25m per annum in 2015 to around £60m in 2020-21 (in 2020-21 prices). This increase covers the provision of new trains, some refurbishments and the associated capacity expansion. Some maintenance costs associated with the new Class 387 train services agreement will have also been wrapped up in these headline cost increases.

Figure 29 builds on the ORR analysis, combining this with the train miles operated to identify changes in the overall operating costs per miles across a set of comparator TOCs. The two figures show the overall operating costs, including rolling stock costs, and operating costs excluding rolling stock.

The first of these figures shows the clear increases in costs as the train fleet is updated, with costs per mile increasing from a mid-position of the comparator TOCs considered to the upper range and similar to InterCity East Coast (but with further cost increases on East Coast apparent in the later 2020-21 figures as more IEP trains are brought into service).

The second of these figures removes the rolling stock costs showing a different set of cost trajectories, especially for GWR and for InterCity East Coast. The interpretation of costs excluding rolling stock costs can be difficult given the complications noted above, whereby more of the maintenance of new trains can be wrapped up in non-capital lease charges,

[40] ORR Data Portal Table 7226 report on operating costs by franchise

and with different coverage for different classes of train and between the IET rolling stock procured via the IEP PFI-style deal or direct procurement.

In relation to other TOCs, the GWR costs franchise remained consistently a little lower than InterCity East Coast but moved to be somewhat higher than the West Coast Partnership where non-rolling stock costs per train mile have fallen slightly over time. East Midlands Trains operating costs per train mile have gradually increased over time due to changes in access charges and other expenditure, but also significant increases in staffing costs. At a headline level, Great Western franchise staffing costs have remained broadly unchanged per train mile, with the increase in absolute costs of £18m or 5% between 2015-16 and 2019-20 reflecting the 5% increase in train miles, although some staff costs may now be accounted for in the rolling stock categories as noted above.

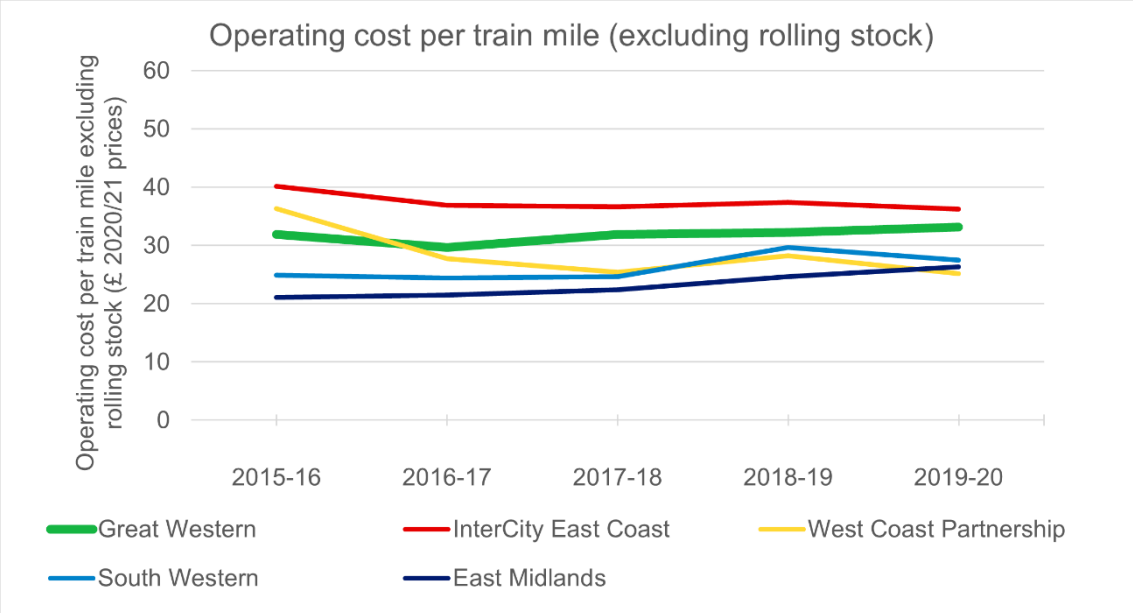

Figure 29: Operating costs per train mile, GWR and comparator TOCs, 2015-16 to 2019-20

Sources: ORR, SYSTRA

Train operating costs for the GWR franchise have increased significantly following the substantial investment in new rolling stock. Driven by rolling stock costs, overall operating costs per train mile have increased significantly, and are now towards the upper end of the range of comparable operators. Excluding rolling stock, costs have increased only slightly in real terms across the GWR franchise, although some of the maintenance and other operating costs associated with the new IET fleet and Class 387 trains are wrapped up in rolling stock costs.

Evolution of operating cost estimates

The treatment of operating costs in the underlying business case appraisals is very complex, with detailed operating cost models being used to assess both the Do Minimum and Do Something scenarios. It is understood that these costs were modified, rather than fully revised in the appraisal update of 2017.

A detailed assessment of the movement of the expected operating costs set out in the business case appraisals and through to out-turn has not been possible as part of this evaluation. This is in part due to treatment of costs in the original business case and the handling of the Do Minimum in the appraisal and the counterfactual in this evaluation. Furthermore, the availability of only aggregated out-turn costs for the GWR franchise as a whole has led to challenges in unpicking the allocation of some operating cost components, especially relating to maintenance and servicing for new rolling stock.

In contrast to the changes in capital costs, the operating costs reported in the 2015 business case and updated appraisal of 2017 are more broadly aligned. This is perhaps to be expected as the main change in industry operating costs as reported above relates to rolling stock, and the GWRM-driven changes were anticipated in this area.

Relative to the earlier business case expectation, the out-turn scheme has been delivered as a fully bi-modal solution, but otherwise the service provision is broadly as expected, albeit with some changes likely to affect out-turn operating costs, including:

- Set Availability Payments (SAP) and associated 'risk and adjustment' (R&A) costs for the bi-modal trains procured through the IEP PFI-style deal;
- the move to bi-modal trains procured outside of the IEP PFI-style deal (through a leasing arrangement with Eversholt) for west of England services and services to Newbury/ Bedwyn and Oxford, with changes in leasing costs, diesel and electric traction costs and other operating costs;
- the potential for improved operational scheduling and lower energy costs from the use of a more interoperable 5- and 9-car long-distance fleet. The expanded single train type operating all long-distance services reduces operating constraints across the network and for working services beyond Bristol to Weston-Super-Mare and the west of England, and from Swansea to west Wales;
- delays in cascades of electric commuter trains to the GWR, and consequentially within GWR and to other TOCs resulting in some changes in costs due to different train leasing and other operating costs, for example the leasing costs for a full Class

387 commuter fleet are higher than the initially planned mixed Class 365 and Class 387 fleet;

- other delays and changes in fleet deployments, including, for example, later withdrawal of Pacer trains and the reconfiguring of some HSTs to form the Castle Class of train used on some key GWR regional routes; and
- deferral of electrification changed the expected stabling arrangements for the electric commuter trains and may have increased operational costs in needing to use stabling facilities in Swindon, resulting in increased out-of-service train mileage and requirement for trains paths.

Operating costs for the economic evaluation of GWRM long-distance components

Operating costs relating to the long-distance routes were sought from DfT and the GWR franchise holder. While it may be feasible to generate detailed costs for key service groups using 'bottom-up' data or through a detailed breakdown of line items between service types, this was not possible within timescale and resource constraints in the industry. Similarly, it has not been possible as part of this study to develop a detailed but proportionate operating cost model of the type used to develop the cost estimates of the 2015 business case.

However, a simplified approach has been used to develop an indicative allocation of the total operating costs for the GWR franchise set out in Figure 28, primarily driven by train miles for the three key service types, with a series of weightings applied to the staff costs, diesel fuel, access charges, and other operating costs. Rolling stock costs have been informed by leasing costs provided by the DfT and the SAP cost estimates and out-turn values.

Therefore, the estimated allocation of costs to the long-distance components of the GWRM shown in Table 24 should be treated with some caution and only used as an indicative cost for the purposes of the economic evaluation of the GWRM long-distance routes. Given the approach used and challenges in reconciling some other reported cost streams, a range of sensitivity tests for the economic evaluation are reported in section 6.5 below.

The streaming of operating cost growth over time for the economic evaluation of the GWRM long-distance components and the associated counterfactual is also dealt with in section 6.5.

The indicative allocation of costs for long-distance services identifies an approximate share of 67% of the total GWR franchise operating costs identified in the ORR reporting. The allocation suggests that at an aggregate level of the remaining franchise costs could be allocated broadly evenly between the London and Reading commuter services and the GWR regional routes.

Of the long-distance costs, around 44% are associated with rolling stock following modernisation of the whole of the long-distance fleet. Long-distance costs represent a disproportionately high proportion of total rolling stock costs across the franchise. Similarly, access charges are incurred disproportionately on the long-distance services and are likely to represent over 80% of all total access charges incurred by the franchise.

GWR operating costs £m 2019-20 (2020-21 prices)	2019-20 operating costs	Indicative 2019-20 long-distance costs	Approximate long-distance share of costs
Staff	368	178	48%
Diesel fuel	47	28	59%
Rolling stock	475	415	87%
Access charges	190	160	84%
Other operating expenditure	324	163	50%
Total operating costs	**1,404**	**944**	**67%**
Weekday train miles	77,600	36,500	48%
Weekday seat miles (000s)	40.300	26,100	65%

Table 24: Indicative GWRM operating cost estimates for long-distance components

Source: SYSTRA estimates using ORR data

An allocation of the 2015 costs for the franchise suggest the long-distance share of total operating costs has increased over time from around 57% to the 67% identified above, primarily driven by the cost of the deployment of new rolling stock. Diesel fuel costs allocated to long-distance routes fell from around 65% in 2015-16 to 60% in 2019-20 as many of the London and Reading commuter routes also moved to electric traction and the IETs appear to have a higher diesel consumption rates than the (re-engined) HST fleet that they replaced.

The proportion of access charges associated with long-distance services may have also fallen slightly as, while more long-distance services were operated in the December 2019 timetable, the IETs incur lower variable track access charges than the HST fleet.

At a headline level operating costs of the long-distance services operated by GWR have increased significantly, but the network is delivering a much greater level of service, significantly increased capacity and with an entirely new fleet of trains. Rolling stock cascades have also provided capacity increases to other part of the GWR and national rail network.

Two evaluation questions were specifically focused on operating cost changes and the efficiency of the long-distance services. Given the changes in operations arising from the COVID-19 timetable changes, these questions cannot be answered in full. In due course, a stable timetable and sustained operating costs data will become available to respond to the questions.

In the interim, however, it is clear that the replacement of the GWR HST fleet has significantly increased the costs of long-distance service provision. Overall real terms operating costs are estimated to have increased by 80% from 2011-12 to 2019-20 against a backdrop of a 30% real terms increase across all franchised operations. However, the GWRM programme has delivered an increase in the size of the fleet of just under 25% and provided an expansion in seat miles of over 40% during the same period. With all services handled by new IET trains, further substantive work on the rolling stock is not expected until any mid-life refurbishment and ultimate replacement in 2052-53 when the IEP PFI-style deal concludes.

At a detailed level the substantive increase in operating cost is related to the provision of the new IET trains, initially procured through the IEP PFI-style deal and then through the leasing of the West of England and additional Class 802 trains. Track access charges appear to be lower for the new IET fleet that the HSTs. Specifically tracking IET maintenance costs and relating these to the earlier HST fleet may be more challenging given the contractual arrangements on service and train availability for the IET fleet. The treatment of maintenance and other operating costs makes it difficult to conclude how other costs have changed, although these may become apparent in due course or if specific cost data becomes available from the GWR operator and/or other railway reporting sources covering a more sustained period of use of the new IET fleet.

In developing the earlier business case sensitivities around a fully bi-modal fleet, a detailed re-diagramming exercise identified opportunities for slightly more efficient utilisation of rolling stock, including the use of 5-car and 9-car train sets. In expanding the fleet to cover all west of England services, further efficiencies appear possible, with some stakeholders at the Theory of Change workshop and during subsequent interviews pointing towards operating benefits of all long-distance services using a broadly common fleet.

Revenues

The benefits mapping presented in section 3.2 did not explicitly identify increased revenue as a key deliverable of the GWRM programme, but rather focused on seeking modal shift to rail and improved passenger experience, alongside ensuring value for money for tax-payers. Implicitly these drivers point to the delivery of increased revenues to the rail industry and through this to potentially improved financial performance that could reduce the cost of service delivery to Government.

Figure 30 provides a summary of the indexed annual passenger fare and other operator incomes for the GWR franchise as reported in the ORR franchised passenger train operator finance reports and covering the period from 2015-16[41].

Against a backdrop of reduced incomes to 2017-18 and transfers of all GWR Reading commuter stopping trains to London to Crossrail/TfL Rail, GWR revenues increased slightly in real terms in 2018-19 and more significantly to 2019-20. The increase in GWR passenger-related income from 2018-19 is higher than the comparator TOCs presented and higher than the total revenue across all franchised operators as a whole. However, a significant part of this reported increase was due to higher incomes from other sources, with fare incomes increasing by 1.3% in real terms from 2018-19 to 2019-20 while all other comparator TOCs and franchised operators as a whole reported reduced real income.

The figure includes long-distance comparator TOCs and the South Western franchise to provide a comparator to a TOC that also operates London commuter routes.

[41] ORR Data Portal Table 7226, report on fares income and other income (includes car parking, catering etc). For comparability between franchises, this also includes fares income that is passed directly to franchising authorities

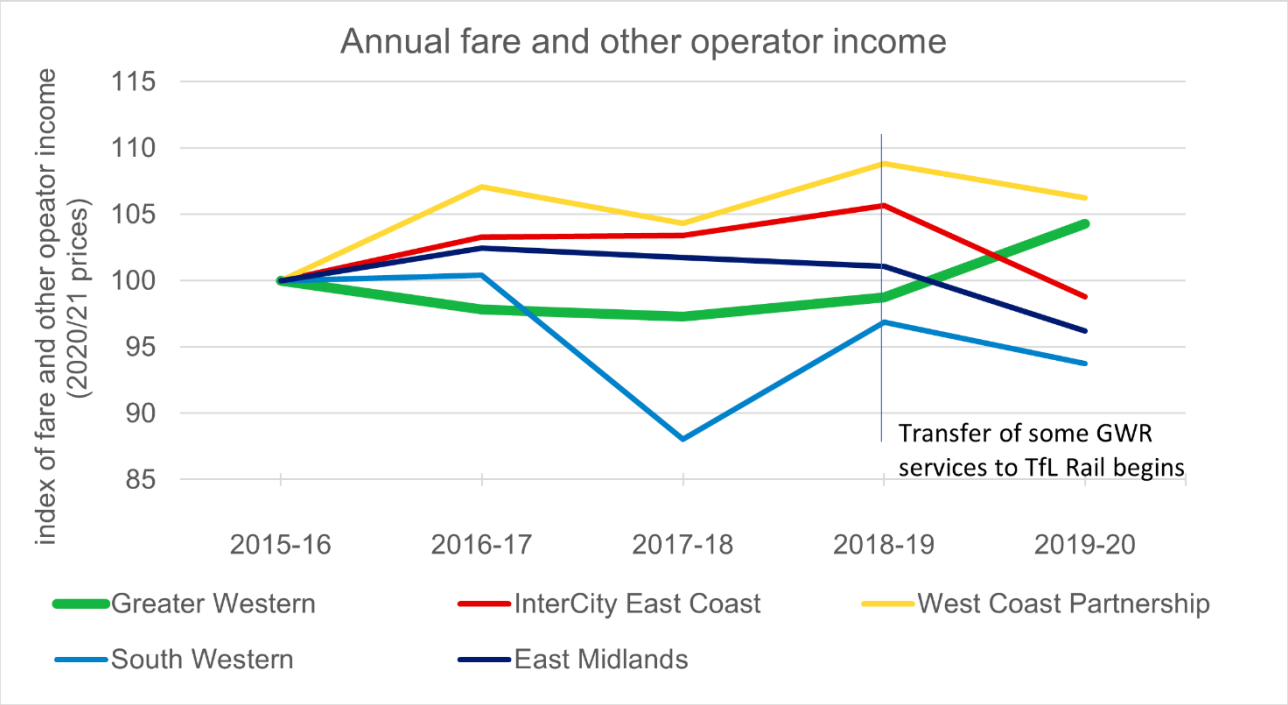

Figure 30: Rail franchise operator fare and other operator income, 2015-16 to 2019-20

Source: ORR, SYSTRA

A detailed analysis of the drivers underpinning the revenue changes identified in Figure 24 has not been undertaken. However, it is apparent that while GWR demand fell slightly from 2017-18 to 2018-19 and 2019-20 (as illustrated in Figure 24) overall passenger miles remained virtually unchanged. These changes may have been driven by increased long-distance demand driven by changes in long-distance service provision and changes in commuter travel into London and Reading resulting in the loss of shorter-distance journeys, as some services were progressively transferred to Crossrail/TfL Rail.

The implied average yield across the GWR franchise as a whole increased by 3.0% in real terms per passenger mile from 2017-18 to 2019-20 at a rate higher than some of the comparator TOCs but lower than others. However, trip lengths across the GWR franchise, indexed to average in 2015-16, have increased significantly over this same period, as illustrated in Figure 31. This reflects the significant changes in the franchise services, including the smaller proportion of shorter distance commuter demand flows into London and Reading following the transfer of services to Crossrail/TfL Rail.

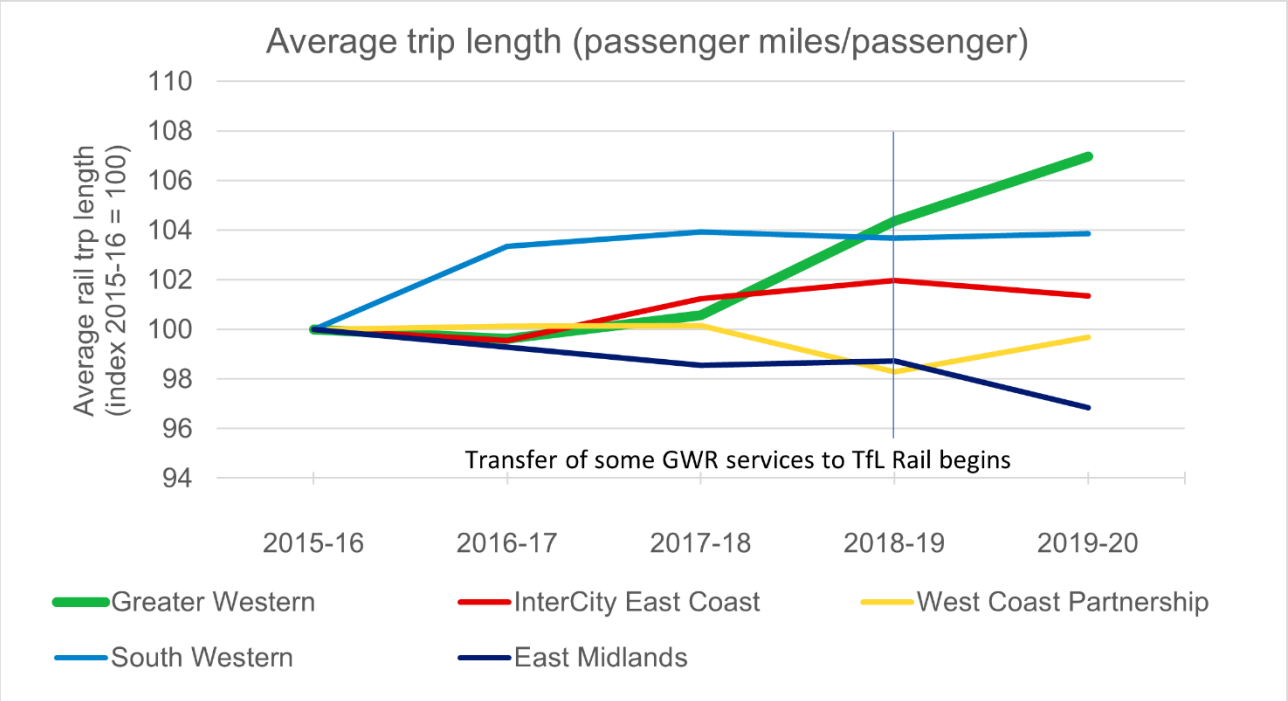

Figure 31: Rail franchise operator, implied trip lengths, indexed change 2015-16 to 2019-20

Sources: ORR, SYSTRA

As with the demand responses, the revenue figures point to some early positive responses to provision of new rolling stock and service enhancements in advance of the more substantive timetable changes of December 2019. It was also suggested by some stakeholders at the Theory of Change workshop and during subsequent interviews that there was an early positive revenue response for the long-distance service groups to the improvements offered by the major timetable change.

The COVID-19 travel restrictions put in place in March 2020 mean that the expected full revenue responses have not occurred beyond those of the first few months of operation of the new timetable. Therefore, testing whether the improved passenger experiences identified in section 4 have led to greater rail revenues, and whether any revenue changes can be translated into better franchise premiums will need to be questions to be addressed in subsequent evaluations as the medium-term post-pandemic outcomes and longer-term impacts become apparent.

6.3 Pre-opening GWRM economic appraisals

The 2015 business case set out the investment case for the GWRM summarising what the programme of electrification and capacity works could achieve and how the new trains serving both London and Reading commuter routes and long-distance routes would impact on passengers. The business case assessed the value-for-money using a monetised benefit-cost ratio (BCR), although other non-monetised appraisal elements may also have been expected to contribute to decision making at the time[42]. In general, high BCR are seen as beneficial delivering a greater value of monetised benefits relative to the scheme cost.

The 2015 appraisal assessed the GWRM programme as 'High Value for Money' with a monetised BCR of 2.36:1, as illustrated in Table 25. An updated appraisal was developed for the DfT in 2017 as infrastructure works and the IEP were being delivered.

The 2017 appraisal took account of changes in scheme specification, including the move to bi-mode trains, and a number of additional scheme components. With the changes in economic parameters, reduced benefits and revenues, and increases in cost, the 2017 updated appraisal suggested the GWRM would provide 'Low Value for Money' with a monetised BCR of 1.07:1.

Table 25 provides a summary of the 2015 business case appraisal and the updated appraisal of 2017, with additional detail provided in Appendix D. This identifies an erosion in the present value (PV) of benefits of over £400m, substantial increases in capital costs of over £1,800m PV, and a reduction in revenues (of around £250m PV, which is largely driven by the changes in economic parameters between the appraisals undertaken in 2015 and 2017).

GWRM pre-opening economic appraisal - key metrics	2015 economic case for the GRWM Value (£m present value, 2010 prices)	2017 updated appraisal (scenario A) Value (£m present value, 2010 prices)
Present value of benefits Present value of costs	5,137 -2,173	4,726 -4,432
Net present value (NPV) Benefit-cost ratio (BCR)	2,964 2.36:1	293 1.07:1
Value for Money allocation	High	Low

Table 25: GWRM 2015 business case and 2017 updated appraisal results (scenario A)
Source: Great Western electrification project business case: Phase 1 report, CH2M, June 2017

[42] The DfT Value for Money framework (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/918479/value-for-money-framework.pdf) and earlier guidance notes applicable in 2015 provide a holistic, transparent view of a proposal's value for money using an assessment that includes consideration of monetised impacts, non-monetised impacts, and uncertainty.

6.4 Economic evaluation - high level assessment

With the long-distance components of the GWRM being the focus of this evaluation, a detailed economic evaluation of the whole programme was not developed.

However, with much of the earlier impact evaluation considering programme-wide delivery, a high-level assessment of delivery performance has been considered in this section 4.

Table 26 provides a review of the key changes in benefits between the business case forecast and out-turn for the key components of the business case appraisals. This suggests the passenger-focused delivery has been broadly similar or better than intended, but with some losses in environmental benefits arising from descoping of electrification, though offset by the wider use of bi-mode IET trains.

Table 27 provides a review of the key changes in scheme costs drawn from the analysis above, with a significant increase in capital costs relative to the initial scheme specification and costs later controlled by descoping parts of the electrification programme. Operating costs have increased, as anticipated in the earlier business case, principally due to the costs of introducing the new IET rolling stock. Revenue performance is likely to be broadly similar to the earlier expectations offsetting, to some extent, the increased operating costs.

GWRM economic appraisal benefit components	Commentary – out-turn vs business case forecast
Rail user benefits - Faster journey times - Reduced crowding - Enhanced journey quality	- Rail journey times for all GWRM long-distance routes have met or exceeded the HLOS targets, except for marginally longer journey times between London and Gloucester and Cheltenham; - cancellation of electrification between Cardiff and Swansea appears to have had only a marginal impact on journey times, with bi-modal trains delivering the target journey time improvements; - the introduction of IETs has delivered journey time improvements for west of England services, particularly to Exeter; - frequency improvements have been delivered as expected, with marked increases in service levels which have contributed to reduced generalised journey time and user benefits; - capacity improvements have been delivered largely as planned through new trains, rolling stock cascades and service improvements - journey quality and reliability benefits have been realised, providing reliability towards the top level of all similar operations, albeit not quite to the high aspirations set out in the HLOS; and - service delivery as expected or better, suggesting unit benefit rates may be similar or above expectations, but with out-turn user benefit volumes dependent on post-COVID recovery profiles. Performance broadly similar or exceeding the business case expectations.

GWRM economic appraisal benefit components	Commentary – out-turn vs business case forecast
Non-user benefits - road user benefits - accident benefits	- Service delivery has been broadly similar or exceeded expected provision, suggesting that the attractiveness of the enhanced rail services may be similar to the earlier business cases. Volumes of road user time and accident benefits will be dependent on post-COVID modal shift recovery volumes. Performance broadly similar or exceeding the business case expectations.
Environmental benefits - emissions due to rail operations - emissions due to modal shift	- Emissions from rail operations have decreased through electrification. Descoping has resulted in some increases in diesel usage relative to earlier expectations, but these changes have been significantly offset by bi-modal trains using electric power on west of England services; - future year reductions in emissions from rail service delivery will be larger than expected due to decarbonisation of the underlying electricity generation, permitting an increase in service levels whilst still delivering significant reductions in emissions; and - modal shift from car to rail will drive a change in vehicle mileage and reductions in emissions, with benefit levels dependent on post-COVID recovery volumes. The absolute changes in future road-based emissions may be smaller than expected due to the recent more ambitious decarbonisation plans for the road network. Performance slightly worse than expected due to scheme descoping, with additional diesel emissions being offset by bi-modal trains maximising the use of electric power on west of England services. Modal shift emissions benefits will be dependent on post-COVID modal shift recovery volumes. arising from improved rail service delivery.
Government tax changes	- Modal shift from car to rail will drive a change in motoring taxation revenues. Changes in taxation will be driven by the post-COVID modal shift recovery profiles. Performance likely to broadly similar to business case given service delivery driving modal shift is broadly similar to the business case.

Table 26: GWRM out-turn versus forecast – high level benefit appraisal commentary

GWRM economic appraisal benefit components	Commentary – out-turn vs business case forecast
Capital costs	- Descoping of the GWRM resulted in cost savings of £0.9bn relative to the costs assumed in the 2017 updated appraisal (assuming deferred components of the GWRM will be delivered through other funding mechanisms), and - deferral of electrification to Oxford may have resulted in changes in the costs of depot and stabling works elsewhere to accommodate electric trains intended to be stabled in Oxford. Capital costs are lower than the 2017 updated appraisal, but still higher than the earlier business case and with less electrification delivered.
Rail operating costs	- It has not been possible at this stage to determine how the move to a fully bi-modal fleet for long-distance routes has affected SAP and wider maintenance costs, but it is likely that diesel costs will have increased relative to the business case, but with improved operational scheduling from using a more interchangeable fleet; - the move to bi-modal for all long-distance services to the west of England (and Newbury to Bedwyn) may have impacted on costs relative to the 2015 expectation of maintaining the use of HSTs; - delays in cascades of commuter trains to GWR, within GWR and to other TOCs may have resulted in some short-term changes in costs and benefit delivery, with some longer-term impacts due to changes in fleet deployment and quality and capacity changes; and - descoping of electrification may have increased costs of stabling some commuter trains in Swindon, resulting in increased out-of-service train mileage and requirement for trains paths. Operating costs have increased significantly, driven by rolling stock costs, but while there are some uncertainties over precise costing, the direction of and scale of costs was anticipated.
Rail revenues	- Revenue responses to the December 2019 timetable change would have been expected, albeit with some lag. Some early responses to new rolling stock were apparent, with some stakeholders suggesting a very positive revenue response in early 2020; and - rail journey times for all GWRM long-distance routes have largely met or exceeded the HLOS targets potentially driving increased demand and revenues, but with out-turn user benefit volumes dependent on post-COVID recovery profiles. Performance broadly similar to business case.
Other operating costs and revenues	- Road vehicle operating costs savings due to modal shift to rail are considered as a transport user benefit (as noted above); and - changes in other public transport operator and/or parking operator costs and revenues would be expected to be marginal relative to other cost and benefit line items. Performance expected to be broadly similar to business case.

Table 27: GWRM out-turn versus forecast – high level cost and revenue appraisal commentary

At a high level, the descoping of the electrification works has resulted in savings in costs against assumptions in the updated appraisal of 2017, but still with some significant cost escalation compared to the earlier 2015 business case. However, qualitatively, benefit delivery appears to be broadly similar to the earlier business case appraisals, driven by maintaining or improving service levels relative to expectations.

While the out-turn scheme may have lower costs and similar benefits to the updated appraisal of 2017, potentially improving the monetised BCR, the changes are unlikely to be material enough to change the allocation of the GWRM programme from the 'Low Value for Money' assessment.

Post-pandemic cost and benefit delivery profiles

The COVID-19 pandemic has clearly interrupted the expected demand and benefit profiles for the GWRM. Demand and revenues reduced significantly during the periods of travel restrictions with annual demand across the GWR franchise in 2020-21 falling to only 19% of the 2019-20 figures, and only 16% in revenue terms. A significant recovery has taken place across the industry, but with potentially longer-term consequences as travel behaviours respond to changes in working practices, shopping patterns and access to other social activities.

How these demand changes impact on the long-term benefit streams is also uncertain, but at a detailed level, they can be considered in the formal economic evaluation using the relevant DfT TAG and rail industry specific guidance, as reported in the detailed economic evaluation of the long-distance services that follows in section 6.5.

At a strategic level, however, it is clear that the GWRM will continue to deliver a stream of benefits in a post-pandemic environment, with the benefits of modal shift driven by the GWRM delivering travel time and environmental benefits

In respect of the wider social, community, economic and environmental impacts of the GWRM, these benefits would generally take longer to emerge and the pandemic will have further set back the benefit delivery and complicated any assessment of the initial outcomes and longer-term impacts. However, the increased capacity and quality of the service delivered by the GWRM are clear, as is the contribution to reducing carbon emissions through the substantive electrification of the network.

The DfT (and the GWR franchise holder) have the opportunity to use various monitoring and feedback mechanisms to manage revenues, operating costs and wider benefit delivery streams. The way the DfT choose to trade-off these three components across franchise renewals will determine the actual value of the stream of benefits and costs delivered by the GWRM.

Further time will be required for any long-term impacts to be assessed, over and above the short-term changes arising from the pandemic itself that has constrained passenger demand and revenues. Isolating the impacts of the GWRM from any wider post-pandemic recovery measures will be very challenging, but it is clear that the GWRM investment

provides the transport capacity to support that recovery and to do so in a sustainable and low carbon way.

6.5 Economic evaluation – GWRM long-distance components

A detailed economic evaluation has been developed to assess the benefits of the delivery of the long-distance components of the GWRM based on the rail industry MOIRA forecasting model and drawing on the capital costs and operating costs identified in section 6.2 above. By necessity this is a different assessment to the pre-opening economic appraisal for the wider GWRM programme that was considered in the business case of 2015 and the updated appraisal of 2017.

The qualitative programme-wide assessment enables a placement of the detailed long-distance evaluation against the programme as a whole.

Figure 32 illustrates how the qualitative programme-wide assessment and the economic evaluation of the long-distance components of the GWRM sit in relation to the earlier pre-opening appraisal.

Direct comparisons between the BCRs are not valid given the different scope of services and counterfactual being considered in the long-distance post-opening economic evaluation. Additionally, changes have been made in the underlying appraisal parameters between the updated appraisal of 2017 and the current 2022 assessment of long-distance routes, including general updating of TAG and rail forecasting guidance and specific handling of COVID-19 impacts.

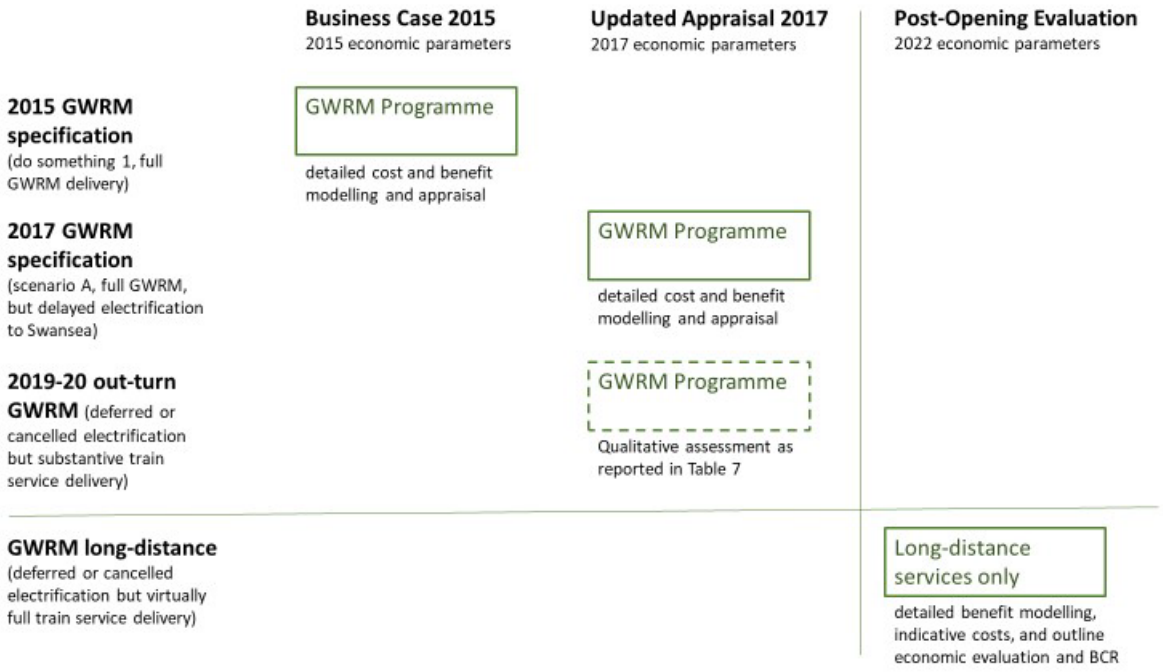

Figure 32: GWRM pre-opening scheme appraisal and post-opening economic evaluation

Evaluation approach

The evaluation has been conducted in line with the TAG, with standard parameters and evaluation assumptions taken from the associated TAG Databook[43]. The evaluation has involved calculating the Present Value of Benefits (PVB) and Present Value of Costs (PVC) over a 60-year evaluation period. The difference between the PVB and PVC is the Net Present Value (NPV), and the ratio of the PVB to the PVC is the scheme's initial Benefit-to-Cost Ratio (BCR).

The evaluation has involved assessing the incremental benefits and costs related to the long-distance elements of the GWRM programme relative to the scenario without these improvements i.e. the counterfactual. In broad terms the counterfactual for the post-opening economic evaluation is an electrified commuter railway serving London and Reading/Didcot and Newbury, but with the December 2011 timetable for long-distance services. This assumes no changes in rolling stock provision from the pre-GWRM long-distance rolling stock fleet, no changes in journey times, frequencies or wider provision, such as station platform lengths, facilities and quality. The counterfactual assumptions for each component of the GWRM programme are shown in Table 28.

Component	Counterfactual assumptions
Electrification	Assumes electrification from Paddington to Maidenhead and Reading, but also extended to Newbury and Didcot to avoid complications of mixing long-distance benefits with those arising from the major changes offered by the electrification for commuter services west of Reading.
Capacity and other infrastructure	Assumes additional capacity is to be delivered only in the GWRM-facilitated 2019 long-distance timetable. Wider infrastructure provision, such as station improvements and platform lengthening, also assumed to be delivered with the GWRM-facilitated 2019 long-distance timetable.
Rolling stock	Long-distance services - the counterfactual assumes the retention of the HST fleet for the provision of the long-distance services. Following the 2015 business case it was assumed that the HST fleet would be replaced by a new 125mph diesel fleet in 2034/35 after modernisation to improve PRM accessibility and environmental compliance during the early 2020s. London/Reading commuter services – the counterfactual assumes that services are provided by EMU trains as per 2019, including Class 345 trains on Crossrail/Elizabeth Line services and Class 387 trains on GWR services. GWR regional services - the counterfactual assumes that rolling stock as 2019 with DMU cascades to regional GWR services driven by electrification to Didcot and Newbury. However, in practice other rolling stock would need to be provided for the Cardiff/Bristol to Devon/Cornwall services as the Castle Class HST sets may not have been available to cascade.

[43] TAG Databook, latest version published November 2021 https://www.gov.uk/government/publications/tag-data-book

Component	Counterfactual assumptions
Service provision	Long-distance services – the counterfactual assumes that service levels are those of December 2011 timetable with journey times, frequencies and train capacities in place before any GWRM investments were made. London/Reading commuter services – the counterfactual assumes services are as operating in the December 2019 timetable, with electrified services provided by GWR and Crossrail, and diesel services on the Thames Valley branches but with no through services to London Paddington. This has assumed that electrification to Newbury and Didcot would be delivered. GWR local and West Country services - assumed as per the December 2019 timetable.

Table 28: Counterfactual assumptions

Benefits

The evaluation of the benefits of the long-distance components of the GWRM programme has been undertaken over a 60-year period following the substantive delivery in December 2019 of the passenger timetable improvements arising from the GWRM.

Firstly, to allow the calculation of benefits, the total GWR passenger demand, revenue and miles for the GWRM programme and the counterfactual scenarios have been modelled over the 60-years. This has been achieved using the GWR version of MOIRA[44] which has provided the base demand in 2019 which has then been grown in line with:

- exogenous drivers e.g. economic and population growth;
- December 2019 timetable impact; and
- rolling stock impact.

The modelling methodology to derive the passenger demand, revenue and miles over the evaluation period is documented in Appendix E.

The incremental benefits of the GWRM programme scenario on long-distance services relative to the counterfactual have then been estimated over the 60-year evaluation period. In line with the pre-opening GWRM economic appraisals, the following benefits have been quantified:

- journey time benefits;
- crowding benefits;
- quality benefits;
- non-user benefits; and
- indirect tax.

The rationale and methodology for quantifying each of the benefits above is summarised in Table 29. For the journey time, crowding and quality benefits, existing users derive the full benefit but new users i.e. the additional demand in the GWRM programme scenario only

[44] Rail appraisal tool used to estimate demand and revenue, and specifically issuing MOIRA 2.2.1 [August 2021] licenced for GWR

derive half of the benefit compared to existing users in line with the 'rule of a half' economic theory[45].

Benefit	Rationale	Methodology
Journey time	The December 2019 timetable changes have resulted in journey time savings for passengers on long-distance services.	Generalised journey times (GJT) for individual flows in the modelled scenarios are extracted from MOIRA; the difference between the two represents the journey time saving resulting from the December 2019 timetable change. The journey time savings are monetised using values of time (VoT) by journey purpose taken from the TAG Databook.
Crowding	New rolling stock has increased capacity on almost all long-distance routes resulting in reduced crowding for passengers.	In the absence of a crowding model or any post-December 2019 load factor data (due to COVID-19), crowding benefits are assumed to be 5% of the total realised PVB. This has been benchmarked against the pre-opening GWRM economic appraisals which indicated crowding benefits were ~11% of the total PVB. However, crowding benefits for long-distance routes would be expected to be lower than this given load factors are typically lower and crowding limited to specific sections of route at peak periods.
Quality	New rolling stock is of superior quality e.g. improved comfort, condition, accessibility, ride quality which is valued by passengers.	A value of 1.5% of in-vehicle time (IVT) has been assumed for rolling stock improvements. This is based on research[46] which values rolling stock improvements at between 1 and 2% IVT. This is applied to a demand-weighted average IVT for long-distance flows for each journey purpose and then monetised using VoT.
Non-user benefits	The increase in rail demand resulting from the GWRM programme will have resulted in mode shift from car to rail resulting in benefits to remaining highway users e.g. decongestion, accident reduction, improved air quality, noise reduction.	A car diversion factor of 26% from the TAG Databook has been applied to calculate the changes in car kms resulting from increase in rail demand. Marginal external cost parameters are used to monetise the following impacts: • highway congestion, infrastructure and accidents; • local air quality and noise; • greenhouse gas emissions; and • indirect tax effects (car fuel duty only). For highway congestion, it has been assumed that the proportion of traffic in each congestion band is as per the England and Wales average in the TAG Databook to represent the geographical coverage of the GWR network.

[45] Economic theory suggests that when users change their travel in response to a change in cost (from C0 to C1), the benefit derived (or net consumer surplus) averages half the change in cost (the 'rule of a half'). This is because some users will shift with only the smallest change in cost (so small the cost can still be assumed to be C0) whereas others will only shift when the cost is C1. The average benefit across all users is therefore ½ x (C1 - C0).

[46] The demand for public transport: the effects of fares, quality of service, income and car ownership, Paulley et al, 2006

Benefit	Rationale	Methodology
Indirect tax	As rail fares do not attract indirect taxation, increased expenditure on rail fares reduces the amount of indirect tax paid to the Treasury. This effect only applies to consumer spending.	The change in total rail revenue between the modelled scenarios for long-distance services only is multiplied by the average indirect tax rate (19%) to give the total change in indirect tax.

Table 29: Summary of methodology to quantify benefits

Costs

Capital costs used in the economic evaluation are drawn from the allocation of the full GWRM capital costs to the long-distance routes reported in Table 22. In the absence of detailed spend profiles by section of route, the streaming of these long-distance costs is based on the profile of overall out-turn spending from Network Rail's Oracle system, but with some backloading to reflect the later delivery of electrification works west of Didcot.

Operating costs used in the economic evaluation are drawn from the allocation of the full GWR franchise operating costs to the long-distance routes reported in Table 24. A similar allocation exercise for the counterfactual for 2019-20 has been undertaken assuming that long-distance service delivery remained in the hands of the HST fleet.

The stream of costs for the counterfactual and long-distance routes builds on these underlying costs, but then draws in assumptions on the increases in cost components over time and spending to maintain service provision throughout the appraisal period. Key considerations here include the assumed need for early spending on the HST fleet in the counterfactual to extend their front-line service life and improve accessibility compliance and the more substantive later replacement of the HST and IET fleets. The streaming mirrors the approach used in the earlier more detailed business case appraisal of 2015 in considering differential cost growths and the replacement of rolling stock at appropriate times as the trains become life-expired (HST fleet in 2034-35 and the IET fleet around 2052-53 as the IEP contract terminates).

	Long-distance service provision	
GWRM investment costs		Share of capital cost
- Counterfactual capital costs	£1.392 bn	36%
- Long-distance costs	£2.422 bn	64%
GWR franchise operating costs – 2019-20		Share of franchise cost
- Counterfactual operating costs	£0.640 bn/annum	58%
- Long-distance costs	£0.944 bn/annum	67%

Table 30: GWRM and GWR franchise – indicative costs of long-distance service provision **Source: SYSTRA analysis**

Rail revenues are considered as part of the present value of costs in the economic evaluation. There is potential for any revenue surplus to theoretically offset the capital

costs in the appraisal, thus enhancing the scheme BCR, and likewise any revenue shortfall will require additional support from government and reduce the scheme BCR.

The revenues used in the long-distance appraisal are driven by demand forecasts, as described above. The implied growth in long-term revenue forecasts have been compared to the assumptions of operating cost growth to ensure the appraisal reflects a realistic long-term profile to ensure revenue surpluses or premiums are not artificially influencing the out-turn NPV or BCR.

Benefit-cost analysis

The streams of annual monetised benefits and costs over the 60-year appraisal period have been converted to 2010 prices where necessary using the GDP deflator values in the TAG Databook. They have then been converted into 2010 present values with a discount rate of 3.5% applied for the first 30 years from the present day and 3.0% thereafter and then summed over the 60 years. This gives the PVB, PVC, NPV and BCR as shown in Table 31. This suggests that the long-distance components of the GWRM programme could be placed in the 'Low Value for Money' category.

GWRM economic evaluation components	Long-distance out-turn evaluation PV £m 2010	Notes
Benefits - Faster journey times - Reduced crowding - Journey quality - Non-user benefits Indirect taxation	 1,966 132 133 729 -316	GWRM rail journey times meet or exceed the HLOS targets. User benefit estimates include the impact of COVID on demand in the first years of the evaluation period. Full details of the earlier appraisal are not available to confirm any other differentials in user benefits streams. Non-user benefits are much lower than the earlier appraisals driven by reductions in the TAG parameters
Present value of benefits	**2,644**	
Costs - Operating costs - Capital costs Revenue	 -2,479 -2,057 2,452	Rail operating cost changes and revenue changes broadly net out to zero, similar to the updated appraisal of 2017. Capital costs are lower than 2017 business case due to descoping of works, but still higher than expected in the earlier 2015 business case
Present value of costs	**-2,084**	
Net present value (NPV)	560	
Benefit-cost ratio (BCR)	1.27	
Value for Money category	Low	While not directly comparable to the updated appraisal of 2017, the allocation of the long-distance components of GRWM as 'Low' remains similar to the earlier appraisal

Table 31: GWRM long-distance components – detailed out-turn economic evaluation

Source: SYSTRA analysis

A detailed economic evaluation for the out-turn long-distance components of the GWRM programme identifies the delivery of significant monetised transport benefits, including to rail users through the faster, more frequent, higher capacity and high quality trains and to road users through modal shift reducing traffic volumes and resulting in time savings. Monetised environmental benefits are also generated, primarily through reduced emissions, including carbon savings.

Based on the assumed growth rates, and current (but evolving) guidance, the streams of scheme benefits and costs over a 60-year appraisal period are expected to generate a net present value of around £560m (PV 2010 in 2010 prices) and a monetised benefit-cost ratio of 1.27. Conservatively assuming that there are no wider non-monetised benefits of the scheme, this benefit-cost ratio suggests that the long-distance scheme components offer 'Low Value for Money' using the DfT's Value for Money framework.

COVID scenarios

In addition to the definition of the train service provision for the counterfactual, there is currently the additional challenge of determining a suitable post-COVID-19 economic growth scenario to be used in the economic evaluation.

Across the transport sector various agencies are considering how to handle post-pandemic forecasts. With an increasing volume of data available to understand potential responses, a range of post-COVID scenarios have begun to be developed and set out in TAG and through specific rail industry guidance, including the demand driver generator (DDG) and Exogenous Demand Growth Estimator (EDGE) forecasts.

These emerging forecasts acknowledge the uncertainties through a range of different post-COVID scenarios that can be applied at an analytical level in developing the economic evaluation.

Based on data supplied by the DfT in February 2022, long-term post-COVID reduction factors for the Great Western franchise are as reported in Table 32. While strictly designed for longer term forecasts, and applied as a blanket reduction from 2024 onwards, it was suggested by the DfT that these factors could also be used in the short-term to cover the first couple of years through to 2024. In applying these demand factors throughout the appraisal period, it has also been assumed that some more modest operating costs savings would be made in the Low and Medium Demand Cases to manage any significant revenue deficits. The resulting NPV and BCRs from these sensitivities are also reported in Table 32.

Franchise	Low Demand Case	Medium Demand Case	High Demand Case
DfT long-term COVID reduction factors Great Western franchise	70%	85%	98%
Net present value (NPV) Benefit-cost ratio (BCR)	-£411m PV 0.82	£74m PV 1.03	£458m PV 1.21

Table 32: Long-term COVID reduction factors and GWRM long-distance economic evaluation sensitivities
Source: DfT (22-2-22) and SYSTRA analysis

Outline sensitivities

With the scheme delivered, the GWRM capital costs are certain. Key uncertainties in the evaluation are focused around the future year streaming over the 60-year appraisal period, with demand and benefit streams influencing the PVB and revenues and operating costs affecting the PVC.

The remaining sensitivities shown in Table 32 examine uncertainties that the evaluation team consider as key to understanding the robustness of the core economic evaluation.

In the core economic evaluation, the operating cost changes and revenue changes broadly net out to zero, similar to the updated appraisal of 2017. In the sensitivities below changes in cost and revenue stream have been made independent of each other. However, in practice, the DfT, operator and local stakeholders are all incentivised through various mechanisms to seek to manage out-turn demand and revenue profiles, and hence if revenues fall, costs are likely to be managed to avoid significant revenue shortfalls.

Sensitivity test	Detail of sensitivity test	Net present value and benefit to cost ratio
Core economic evaluation	Economic evaluation as reported in Table 31	NPV £560m PV BCR 1.27
Increased capital costs allocated as long-distance costs	Additional capital cost items allocated to long-distance costs, including Oxford capacity remodelling, Swindon-Kemble redoubling and resignalling in Cornwall	NPV £438 PV BCR 1.20
Increased user and non-user benefits	increased benefits delivery arising from out-turn journey time shorter than the HLOS targets and benefits to the west of England services. Range - all benefits assumed +5% or +10%	Range NPV £814 – 1069m PV BCR 1.42 – 1.58
Increased crowding benefits	increased benefits from reduced crowding on long-distance trains moving from 5% of benefit totals to 10%, broadly as per the initial business case appraisals	NPV £704m PV BCR 1.34
Variations in rolling stock costs	some uncertainties in SAP and maintenance for the IEP procured fleet. 10% increase in estimated SAP costs. No change in revenues to reduce any revenue shortfalls.	NPV £67m PV BCR 1.03

Sensitivity test	Detail of sensitivity test	Net present value and benefit to cost ratio
Maintenance costs for IET fleet	some uncertainties in the underlying maintenance cost allocations and how these will change with new rolling stock. Increase costs compared to core evaluation during the IEP contract of 20%. No change in revenues to reduce any revenue shortfalls	NPV £189m PV BCR 1.08
Maintenance costs for counterfactual HST fleet	Representation of increased counterfactual costs of maintaining the full HST fleet equivalent to a +2% points pa premium on other operating costs up to a maximum of +20% in 2029-30	NPV £761m PV BCR 1.40
Increased diesel fuel costs	diesel fuel cost inflations assumed at 3.3% pa throughout the appraisal rather than 2.3% pa	NVP £732m PV BCR 1.38

Table 33: GWRM long-distance economic evaluation sensitivities

Source: SYSTRA analysis

For the indicative out-turn BCR presented in the core economic evaluation in Table 31 to fall to below 1.00, and therefore allocated to the 'Poor' Value for Money category, the value of revenue and benefit streams identified above would need to fall throughout the 60-year appraisal period by 11%. This allocation assumes that there would be no response from the DfT or the franchise holder in seeking to address any revenue or benefit shortfalls, or to further manage operating costs in response to demand shortfall.

With this risk coverage and potentially a range of wider economic benefits not included in the assessment, the allocation of the out-turn GWRM programme within 'Low Value for Money' category appears to be reasonably robust.

7. Summary and Next Steps

7.1 Summary

This first post-opening evaluation indicates that the GWRM programme has broadly met the founding expectations with regard to delivering passenger benefits.

The programme was descoped to control costs, but with little impact on the overall passenger benefits. It has delivered expected capacity increases, journey time and frequency improvements and, although it is not quite at the target set, reliability has improved significantly and is above the level achieved by most other long-distance operators.

The descoping of the programme has resulted in a slight reduction of environmental benefits compared to founding expectations but has still substantially contributed to reducing GWR's environmental impact. The environmental benefits from the programme have not been eroded as much as might have been expected as much of the impact of the descoping has been offset by other decisions made, particularly to procure all bi-modal trains for the long-distance fleet.

At this early stage of evaluation, it is not possible to assess how the programme has contributed to wider social and economic vitality and regional development. However, the expansion in capacity and reduction in journey times already delivered by the programme would point towards the potential to meet these wider objectives in the longer term.

In the 2015 Business Case, driven by a monetised economic appraisal, the GWRM programme was initially expected to deliver a 'High Value for Money' as categorised by the DfT in their Value for Money guidance. Following the cost increases observed in the early delivery stages, the updated appraisal of 2017 reassessed this allocation and suggested the programme would delivery 'Low Value for Money'. The assessment in this evaluation suggests that while the long-distance components of the programme may be expected to generate a higher monetised benefit to cost ratio, the value for money allocation would remain as 'Low'.

7.2 Next steps

With this first post-opening evaluation report effectively limited to reporting on the key operational outputs from the investment in the GWRM, there may be merit in considering the development of a short-term outcome-focused evaluation report once post-pandemic travel behaviours have become established. A further later report would then be able to address the longer-term social, economic and environmental impacts of the GWRM programme.

The key new analysis for a post-pandemic short-term outcome-focused evaluation report could include some or all of the following components:

- update of the supply-side analysis concerning train service outputs including journey times, capacities, reliability, punctuality, operating cost and other operating outcomes from a more sustained delivery of the key post-pandemic timetable;
- consider performance influences and wider drivers on customer satisfaction;
- update of the environmental assessments, drawing on actual out-turn power and emissions data for the new IET rolling stock;
- where possible, make use of the demand assessment to inform an initial environmental assessment of outcomes driven by modal shift, primarily in terms of carbon emissions, but also other factors such as local air quality and noise;
- build on other rail evaluations, and in particular any baseline and evaluation of Crossrail;
- build on some elements other localised ex-post evaluations linked to the GWRM to examine any early local economic impacts of investments in the rail network, for example in respect of station improvement works;
- consider on-going operator monitoring and feedback, including through the established GWR stakeholder engagement processes; and
- include on-going and additional research to draw together a wider view of the initial supply-side, demand-driven and environmental outcomes and how these will drive the longer-term impacts of the programme delivery.

8. Addendum

This report was prepared in the period to spring 2022, referring in the main to the timetables operating from December 2019. It is recognised that train services were running to a modified timetables during the COVID-19 period and subsequently following the easing of travel restrictions. However, in general, the service delivered in early 2022 broadly followed the December 2019 service configuration.

In May 2022 a new timetable was introduced across many parts of the rail network. There were a number of changes affecting the GWR network, including curtailing GWR services east of Portsmouth. On the GWR long-distance network, and of relevance to this post-opening evaluation, was the change in the way Bedwyn services were operated.

Following the December 2019 timetable change, services to Bedwyn were generally provided by hourly services from London to Newbury and terminating in Bedwyn and vice versa. During the COVID-19 period, some services were withdrawn, but retaining through services throughout the day. In May 2022 the timetable was recast, with all through services starting or terminating in Bedwyn withdrawn. These services were replaced by electric trains operating between London and Newbury and a diesel shuttle running between Newbury and Bedwyn. Some stops on longer-distance services at Bedwyn on peak period trains were retained.

The revised timetable of May 2022 provides a similar strategy to that initially envisaged for the GWRM before the expansion of the IET fleet to directly serve Bedwyn, using electric trains to Newbury and diesel shuttle to Bedwyn. The remainder of this report, however, refers to service commencing in December 2019. Therefore service levels have changed since of the drafting of this report, with this affecting the references herein to service delivery at Bedwyn.

The medium and long-term train capacity and environmental outcomes and impacts of this change, if retained as a permanent timetable feature, can be tested in due course, including the impacts on other routes to which the rolling stock has been redeployed.

Appendices

Appendix A – Glossary

Appendix B – GWRM scope

Appendix C – Theory of Change – workshop insights

Appendix D – National Rail Passenger Survey

Appendix E – GWRM capital costs estimates and out-turn costs

Appendix F – Indicative allocation of long-distance capital costs

Appendix G – Network Rail operations, support and maintenance costs

Appendix H – Evolution of the business cases from 2015 to 2017

Appendix I – Modelling methodology

Appendix A. Glossary

BCR – Benefit to Cost ratio

BEIS – Department for Business, Energy & Industrial Strategy

Bi-Modal/bi-modes – rolling stock types: trains which can operate using electric power on electrified routes and under diesel power on non-electrified routes, including the GWR IET long-distance fleet. Battery power may also be used, and the Class 769 trains intended to be deployed by GWR on part/non-electrified routes will offer capabilities of running on two types of electrified routes (overhead and third rail) as well as diesel mode

CH2M – consultants to the DfT in developing the updated appraisal of the GWRM in 2017

CP5, CP6 etc – rail industry regulatory control period. CP5 2014-2019, CP6 2019-2024

Crossrail – the construction project building the cross-London rail infrastructure from west of Paddington to Liverpool Street and beyond that will be served by TfL Rail services known as the Elizabeth Line

DDG – demand driver generator - rail industry demand future year forecasting tool (see also EDGE)

DfT – Department for Transport

DMU – rolling stock types: diesel multiple units as used on non-electrified routes, primarily on the commuter services to London and Reading (until electrification), residual non-electrified routes on the Thames Valley and on GWR regional routes

EDGE – Exogenous Demand Growth Estimator - rail industry future year demand forecasting tool (see also DDG)

Elizabeth Line – rail services operated by TfL Rail on the new Crossrail infrastructure when this opens in 2022. GWR services transferred to TfL Rail in advance the opening of Crossrail are referred to here, for convenience, as Elizabeth Line services although these services are not officially marketed as this by TfL

EMU – rolling stock types: electric multiple units as used on electrified routes from 2017 on the route from London Paddington to Reading, Didcot and Newbury (and for a limited number of planned services and event services to Cardiff)

GDP – Gross Domestic Product (as used in deflating cost streams)

GW – Great Western when referring to the Great Western franchise and currently operated by First Greater Western trading as Great Western Railway

GWRM – Great Western Route Modernisation – the programme under consideration in this evaluation. Note that Modernising the Great Western railway has been a term used by the National Audit Office to mean the GWRM

GWR – Great Western Railway – the trading name for the holder of the Great Western franchise, First Greater Western Limited

GWML – Great Western Main Line – in this context, and for simplicity, the mainline railway routes from London Paddington handling InterCity-type long-distance services, including those to Bristol, Cardiff and Swansea, to the south west of England and to the north and south Cotswolds

GWEP – Great Western Electrification Programme – one of the components of the GWRM delivering electrification to the Great Western route

HLOS – government's High Level Output Specification for the rail industry (in this case for the period 2014-19)

HST - rolling stock types: High Speed Train as used by GWR on long-distance services from the 1970s to 2019

IEP – Intercity Express Programme – delivering new Intercity rolling stock to the Great Western franchise and the InterCity East Coast franchise through a Private Finance Initiative (PFI) deal. These are the 'Class 800' trains

IET – Intercity Express Train – the name given to new trains delivered by the IEP to the Great Western franchise. The IET name also applies to the similar trains for the 'West of England' services, but procured outside of the IEP, These are the 'Class 802' trains and are virtually identical to the Class 800 trains delivered via the IEP

MOIRA – rail industry forecasting tool used to generate demand and revenue forecasts

NAO – National Audit Office

NPV – net present value

NR – Network Rail

NRPS – National Rail Passenger Survey

PFI – Private Finance Initiative

PVB – present value of benefits

PVC – present value of costs

SAP – Standard Availability Payments stream used as the key payment mechanism for the provision of the GWR IET trains procured under IEP PFI-style deal

SDG – consultants to the DfT in developing the GWRM business case in 2015

SOFA – Network Rail's Statement of Funds Available

TAG – Transport Appraisal Guidance setting out the processes and parameters to be used in transport scheme appraisal

TGW – Network Rail's The Greater West Programme – developed to manage the delivery of the significant changes in infrastructure and rolling stock and train services set out in the GWRM and its constituent programmes

TOC – Train Operating Company – either franchised or non-franchised operators. Specific TOCs referred to in this evaluation include ICEC (InterCity East Coast), WCP (West Coast Partnership), EM (East Midlands)

WCEP – Western Capacity Enhancement Programme – one of the components of the GWRM delivering upgraded infrastructure to the Great Western route

Appendix B. GWRM scope

In broad passenger-facing terms, the full GWRM proposals comprised of electrification of the Great Western Main Line (GWML) between London Paddington, Reading and Newbury/ Oxford/ Swansea/ Bristol Temple Meads (via both Bath and Bristol Parkway) and electrification of some secondary and commuter in the Thames Valley area.

Major engineering enhancements were also part of the programme intended to support the delivery a significantly enhanced timetable alongside replacement of virtually all long-distance and London/Reading commuter trains.

The intended full GWRM programme has three key components:

- GWEP - Electrification - some parts of the GWEP electrification were deferred or cancelled, as set out in Figure 2 in the main text;

- WCEP – Infrastructure works to increase capacity and facilitate new rolling stock - some elements of the WCEP were deferred or delayed from their original programmes, with a number of components now delivered or scheduled for later delivery, including Bristol East Junction and the Reading Independent Feeder; and

- IEP trains for the Great Western network – these new trains were delivered as planned, albeit with all trains being bi-modal rather than as a mixed fleet of electric-only and bi-modal trains. Additional trains were also delivered to cover west of England services, originally not in scope of the GWRM, and to respond to the descoping of electrification works

Infrastructure

As initially planned the GWRM included the following electrification works:

- Electrification of the Great Western Main Line (GWML) between London Paddington, Reading and Newbury/ Oxford/ Swansea/ Bristol Temple Meads;
- Electrification of the Thames Valley branches - Slough-Windsor, Maidenhead-Marlow, Twyford-Henley, and
- Electrification of the Reading to Basingstoke (originally part of the ‘Electric Spine’, but later moved to GWEP).

Some elements of the intended full GWRM programme were de-scoped or deferred following the Hendy Reviews of late 2015 and early 2016, which was accepted by the Secretary of State in September 2016,

Four parts of the GWEP project were deferred to CP6::

- electrification from Didcot Parkway to Oxford;
- electrification of Filton Bank, which links Bristol Temple Meads to Bristol Parkway;
- electrification from a point around one mile east of Chippenham station, to Thingley Junction and on to Bath Spa and Bristol Temple Meads; and
- electrification of the Thames Valley branch lines to Marlow, Henley and Windsor.

The following supporting projects were descoped from the GWRM:

- Reading Independent Feeder, to provide alternative power to London to Didcot on the Western mainline and feeding Reading depot;
- Bristol East Junction, remodelling of the junction to the east of Bristol Temple Meads;
- Oxford Corridor Phase 2 – to unlock physical and timetabling constraints both at Oxford station and along the rail corridor both north and south towards Banbury and Didcot respectively; and
- Acton Bank, linking the GWML and the North London Line (primarily for freight).

Additionally:

- Electrification of the route Cardiff and Swansea was cancelled; and
- Electrification of the route between Reading and Basingstoke was cancelled.

The Reading Independent Feeder project has been identified in NR's Enhancements Delivery Plan [47] with a target completion date of April 2023.

The Bristol East Junction scheme was moved into the RNEP, completed in Autumn 2021 and is expected to increase reliability of operations on the eastern approaches to Bristol Temple Meads

One of the key areas of infrastructure issues arising from the infrastructure de-scoping was on the depot and stabling strategy. This had some impact on InterCity type long-distance operations, requiring some additional works at Laira depot (Swansea), St Phillips Marsh dept (Bristol) and Long Rock (Penzance) to handle the new IEP trains and the short Castle Class High Speed Trains (HST) retained to cover the smaller than planned diesel multiple unit (DMU) cascade. These changes in the programme specification are implicitly considered in the assessments that follow.

The more significant impacts of the infrastructure de-scoping on depot and stabling has been on London and Reading commuter services. The loss of Oxford as a stabling location for electric multiple unit (EMU) trains had a significant follow-on operational impact, including the need to develop alternative stabling locations and increasing extent of empty rolling stock movements around the network. As these impacts fall primarily on the commuter services they have not been addressed in this evaluation.

The wider package of GWRM infrastructure measures also includes passenger-facing elements such as platform extensions to handle longer trains, including on stations on the Cotswold (north) route, and operational improvements and requirements, such as an extension to the turnback siding at Bedwyn to handle longer terminating trains, and gauging works to accommodate cascaded trains from the London and Reading commuter services transferred to local services in the west of England These supporting measures to the headline electrification schemes are implicitly considered in the evaluation.

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[47] Enhancements Delivery Plan, England and Wales Entry Into Service schedule, Network Rail, March 2021

A summary of the electrification initially planned and delivered as part of the GWRM is shown in Figure 2 in the main text to this report.

Rolling stock

In respect of rolling stock, the primary elements of the GWRM are the replacement of all long-distance rolling stock and much of the diesel powered rolling stock used in the London and Reading commuter services.

The new IET rolling was built to replace the earlier HSTs that had provided the mainstay of long-distance service provision since first introduced in 1976/77. Some intermediate re-engineering and refurbishment of the passenger accommodation had taken place, but ostensibly the trains were around 40 years old at the time they began to be superseded by the new rolling stock.

The initial planning for the replacement of the diesel HST fleet on Great Western route in late 2007 was focused around the procurement of diesel Intercity Express Programme trains after electrification plans were initially rejected. With the later announcement of London to Swansea electrification and the entry into the market of bi-mode train capability, the 2012 IEP included both bi-mode and electric trains for the GW route; the 2015 business case identifying 32 x 5-car bi-mode trains (Class 800) and 18 x 9-car electric trains (Class 801). IEP options were exercised in early 2014 to increase the number of electric trains.

Effectively the IEP order was for the first large scale bi-mode passenger train fleet in the UK. Current environmental and other drivers point to further, more widespread use of bi-mode trains, with technology development into forthcoming rolling stock including tri-mode options. A programme initiated in 2020 to replace one under-floor diesel engine on some of the GWR Intercity Express Trains with a battery may, if agreed, convert the units to tri-mode operation, offering the potential for additional future year environmental benefits of the programme.

Services on the Great Western mainline to Bristol and Cardiff and the Cotswolds routes were intended to be operated by a mix of bi-mode and electric trains. The Great Western Mainline Enhancement business case of 2015 noted that services to the south west and west of England running via the ‘Berks and Hants’ line were to be operated by a residual HST fleet in the December 2019 timetable. The initial planning assumptions for the GWRM and IEP programmes were that a pure diesel fleet would continue to be used on west of England services, with modernised HSTs or Meridian trains released by the then planned Midland Main Line electrification being indicated as possibilities.

Later in 2015, however, outside of the GWRM industry programme, approval was provided by DfT for a new West of England fleet of bi-mode trains, consisting of 22 x 5-car and 7 x 9-car bi-modes (AT300, Class 802).

Following the Hendy re-plan of late 2015, a Ministerial decision was made in spring 2016 to procure all IEP trains for the Great Western franchise as bi-modes, with an enlarged order of 7 AT300/Class 802 trains following in mid-2016 to cover for the non-electrification to Oxford and through services to Bedwyn initially planned to be delivered as a shuttle connection from Newbury.

A number of technical changes have been made to the rolling stock, including 'unmuzzling' of the diesel engines on the Class 800 series of trains seeking to replicate timetable performance of the Class 802 trains intended to be used on more challenging gradients in Devon and Cornwall and the potential battery provision of the 5-car AT300/Class 802 fleet.

The IEP and West of England trains were progressively introduced into passenger service across the Great Western network from autumn 2017. As of the December 2019 timetable, the Great Western franchisee, GWR, has available 35 x 9-car trains and 58 x 5 car-trains, with these being referred to as Intercity Express Trains by GWR.

For the London and Reading commuter services, the 2015 business case envisaged new and cascaded EMU trains being deployed on non-IEP operated services on the electrified lines, including services from London to Reading, Didcot and Newbury routes, and on fast services from London to Oxford.

Originally intended to be operated by cascades units from the Thameslink, Southern and Great Northern (TSGN) franchise operated by Govia Thameslink Railway (GTR), delays with the Thameslink project led to a smaller fleet of new Class 387 trains being procured for the Great Western franchise, with other new Class 345 trains coming into service for the Crossrail services operating on the route from Reading to Paddington.

The delays in the potential EMU cascades and ultimate replacement with new rolling stock had some follow-on impacts on cascades of the diesel multiple unit rolling stock it displaced elsewhere on the GWR network, and in the subsequent secondary cascade to other parts of the country.

Figure 33 illustrates the cascades arising from the deployment of new rolling stock for operating long-distance and commuter routes on the Great Western network. In the figure the first column sets out the new trains delivered as part of the GWRM or in linked investments, with the second column identifying the trains that this new rolling stock has replaced, with third column showing where this roiling stock has been cascade to. The figure does not show further secondary cascades, for example those arising from the transfers of ex-GWR rolling stock to Grand Central and Scotrail.

It should be noted that while the majority of the intended cascades have taken place, some further movement in fleet deployments will arise when the bi-mode Class 769 trains become available for use on services from Reading to Gatwick Airport and other Thames Valley routes releasing further Class 165/166 trains.

The cascades are broadly similar to those initially planned in the full GWRM programme, summarised by the NAO in their 2016 report, albeit with some delays to the transfers to other TOCs, delays in decommissioning the fleet of GWR Pacer trains and the Heathrow Express Class 332 rolling stock that was replaced by new Class 387 rolling stock.

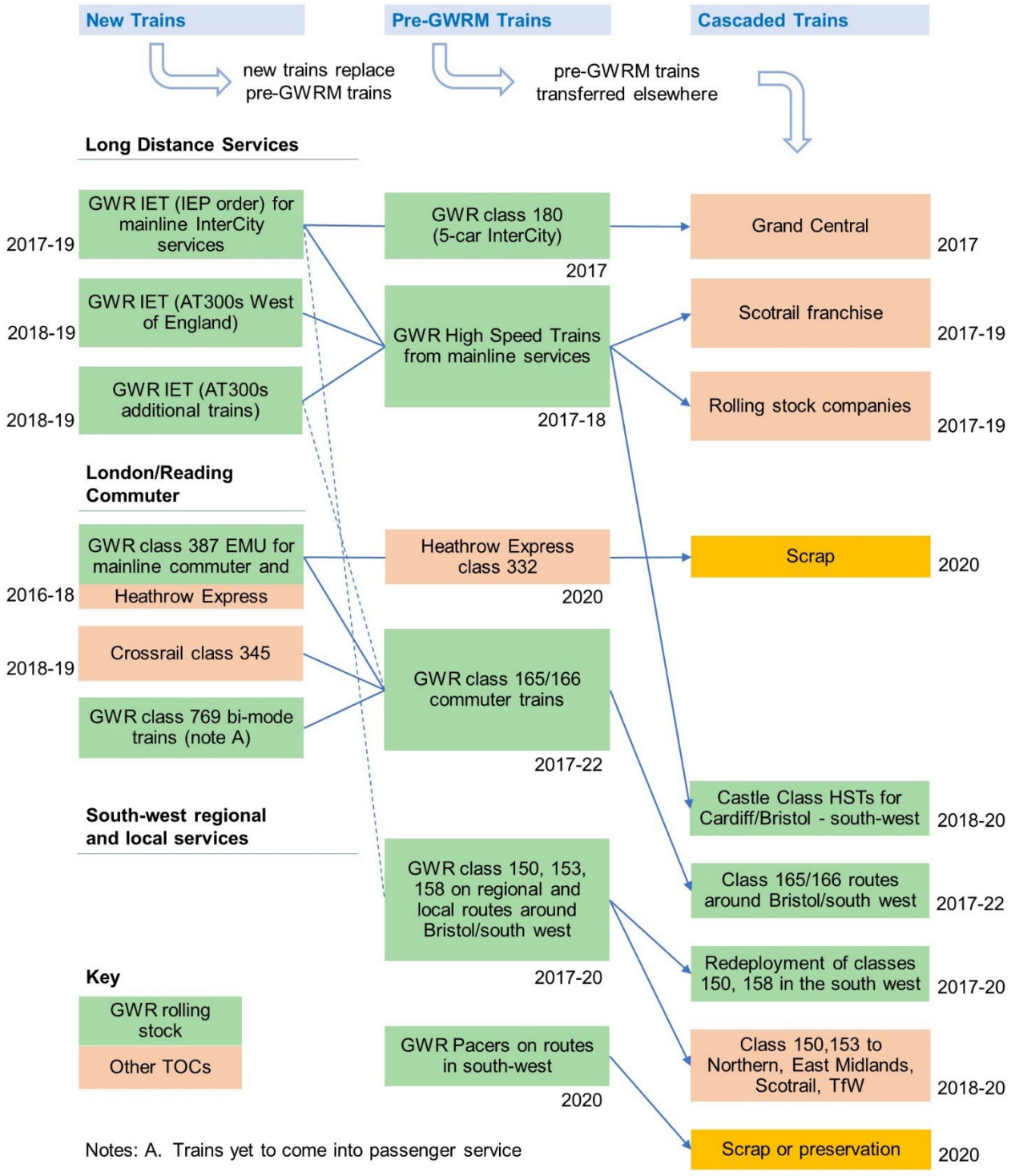

Figure 33: GWRM-Facilitated Rolling Stock Cascades **Source: DfT data, SYSTRA updating**

Service provision

Following the adoption of the Hendy plan in 2016 and the descoping of the full GWRM programme, Network Rail's The Greater West Programme (TGW) was developed to manage the various interfacing programmes required to deliver new and cascaded rolling stock and new services around the Great Western franchise. The TGW introduced a phased approach to delivery, enabled by the gradual introduction of rolling stock and

infrastructure, progressively extending the electric operation of both electric-only and bi-modal trains.

The TGW programme Benefits Release Overview of 2017 acknowledged some programme elements were essential for the service to be delivered, but others could be mitigated at the cost of an impact on expected benefit delivery. As part of the TGW programme a number some delivery components were re-profiled, with NR recognising that the deferments would delay benefit delivery, with the primary GWRM-driven timetable change taking place in December 2019 and that full benefits would not expected to be delivered until CP6 (2019-24). Benefit delivery may now be delayed further by the effects of the COVID-19 pandemic.

Table 34 provides a summary of principal changes in the rolling stock deployment and timetable changes arising from the GWRM. While there were some clear changes in the provision on the London and Reading commuter routes, apart from some small early timetable improvements to Cornwall and north and south Cotswolds routes in late 2014 and early 2015, ostensibly the long-distance services remained broadly unchanged until the major timetable change in December 2019, apart from transitioning to IET operation from largely HST operation.

Date	Rolling stock and timetable changes – Great Western Franchise. December 2011 to December 2019
December 2014 and May 2015	Some early timetable improvements to Cornwall and north and south Cotswolds routes
September 2016	Initial electrified London commuter services from London Paddington to Hayes & Harlington and in spring 2017 to Maidenhead
October 2017	First new IET services to Bristol and south Wales, running to HST timings, with new trains progressively introduced on other long-distance routes, resulting in a mixed fleet of HSTs, Class 180 and IETs
Jan-May 2018	Electrified commuter service start running to Didcot, with long-distance IETs services using electric power to Didcot. TfL Rail services replace GWR commuter trains to Hayes & Harlington in the first stage of the transfers of services to the Elizabeth Line
August 2018	First IETs operating to the south west (GWR AT300 Class 802)
Jan-May 2019	The last IET enters service (excluding the initial test train) in January and by May all HSTs and Class 180 are replaced by the new IETs
December 2019	Key timetable change – all electric services retimed with faster journey times, new limited-stop super-fast services to Bristol and south Wales, north and south Cotswold services increased or consolidated to hourly, south-west service frequency and journey time changes. Substantive changes London and Reading commuter routes and regional services
May 2020	Full electric services to Cardiff. Additional off-peak super-fast services to Bristol planned to be introduced but deferred due to effects of the COVID-pandemic on passenger demand

Table 34: Summary of Principal Rolling Stock and Timetable Changes

Source: DfT data

Appendix C. Theory of Change – workshop insights

The Theory of Change workshop and interview process discussed in section 3.2 of the main report identified several key insights from participants relating to aspects of the impact evaluation that have been developed further in the impact evaluation where appropriate. Several process considerations were also raised; these issues appear to have been, in the main, examined and articulated elsewhere and are therefore not considered in further detail.

These supplementary points, structured around our key three themes, included:

Passengers

- The need for clarity at project outset of a specific set of expectations as to how modernisation programmes will deliver passenger-focused benefits, and specifically the desire to better understand and articulate impact issues such as passenger satisfaction, reliability, building resilience into the timetable and broadening the customer base.

- The early delivery of benefits realised during the staged implementation of the programme was being consolidated and expanded in the period between the infrastructure works being completed and the beginning of the COVID-19 pandemic in March 2020. Increases in passenger numbers (particularly those travelling for leisure) and revenue were becoming apparent as a result of improved passenger experience due to factors such as increased capacity and improved reliability.

- The need to consider the impact of the on-going evolution of working practices during the scheme planning and development phases (further exacerbated by COVID-19), when shaping of this type of modernisation programme.

- The value of an explicit assessment of how modernisation would lead to improved access for people with mobility impairment.

- The unexpected benefits during the pandemic of increased capacity for social distancing and for increases in leisure travel volumes, with some lessons learnt for managing the network in the future.

- The impacts of deferred or cancelled elements of the programme generated some adverse feedback from some stakeholders, largely due to the perceptions that the anticipated public relations and economic benefits of electrification per se would be eroded, although passengers would, broadly, still receive the same or similar benefits.

Environment

- The secondary importance given at the time, more than 10 years ago, to emissions-focused environmental impacts of electrified operation of the railway during the planning and re-scoping of the GWRM. The focus of the programme was on the delivery of passenger and operational benefits in moving from a diesel operated railway to one primarily focused around electric power.

- In contrast, a strong environmental focus in preparing and delivery of earthworks for electrification of the railway and the impacts these works could have on ecological, habitat and wider environmental issues along the alignment.

Cost

- The importance of programme management and delivery cost as drivers for the re-scoping of the GWRM programme, with the impact on benefit delivery being a secondary consideration. However, the anticipated total cost of the programme has been broadly as anticipated in 2015, albeit delivering fewer infrastructure improvements and with some consequential impacts on benefit delivery, including delayed realisation of benefits and a slightly different packaging of benefits.

- The expectation that some significant works would have been required regardless of GWRM taking place, with life-expired rolling stock, signalling renewals, platform extensions required in the relatively short to medium-term. With no investment, costs would otherwise have increased dramatically and the railway would become increasingly unreliable and extremely overcrowded, with worsening passenger experiences potentially driving modal shift away from rail, and ultimately threatening economic development and growth across the Great Western area.

Appendix D. National Rail Passenger Survey

Transport Focus surveys more than 50,000 rail passengers per annum to produce the National Rail Passenger Survey (NRPS), which measures passengers' satisfaction with their journey. The survey asks passengers' overall satisfaction as well as satisfaction with thirty different aspects of service provision which can be tracked over time.

Pre-COVID-19, the survey was undertaken twice a year, in spring and autumn, from a representative sample of journeys. The NRPS data is weighted to ensure it is representative of passenger journeys on each train operating company (TOC), both passenger numbers and the profile of these journeys e.g. journey purpose.

Appendix E. GWRM capital costs estimates and out-turn costs

Table 35 provides a capital cost table and notes expanding on the summary provided in Table 21. The table reports the 2015 business case Do Something 1 costs, the updated appraisal of 2017 for Scenario A, and the out-turn costs provided by DfT/Network Rail in Autumn 2021 including estimates of spending to complete in 2021-22 and 2022-23.

GWRM component costs £m nominal/out-turn	2015 business case	2017 updated appraisal	2020/21 DfT/NR out-turn	Out-turn status, see notes below
Electrification works[A]				
- core electrification	2,143	3,180	3,101	descoped
- Cardiff-Swansea	405	610	19	cancelled
- Thames Valley branches	111	231	4	def'd/cancelled
Key infrastructure works				
- IEP Western capability	163	162	180	delivered
- IEP GWML capacity	-	45	48	delivered
- Thames Valley EMU capability	52	43	45	delivered
- West of England DMU capability[B]	-	48	29	delivered
- Bristol-Abbey Wood capacity	93	105	137	delivered
- Oxford station area capacity/enhancement[C]	-	273	104	part delivered
- Bristol TM pax capacity[B]	-	117	5	note B
Other works				
- Westerleigh-Barnt Green[B]	-	6	-	note B
- Swindon-Kemble doubling	-	-	23	delivered
- Access to Assets[BE]	-	64	57	delivered
- DNO clearance works[F]	-	94	5	note F
- Cornwall resignalling[B]	-	54	14	note B
- Cotswold (north) plaforms[G]	-	0	11	delivered
- West of England platforms[G]	-	0	5	delivered
- Reading independent feeder[H]	-	371	-	2023 delivery
- Depot and stabling[I]	-	66	-	note I
- Western resilience[B]	-	25	-	note B
Additional IEP costs				
- Depot 'fuel farm' costs			23	delivered
- Swansea station shore supply			5	delivered
Scheme appraisal or out-turn costs	**2,967**	**5,494**	**3,813**	
Estimates reported in the 2017 but not used in the scheme BCR				
- Reading station redvelopment[K]		812	550	
- Acton-Willesden electrification		31	0	
- Heathrow western link		1,298	-	
Headline reported cost estimates	2,967	7,635	4,363	
Key: new cost items introduced compared to previous appraisal				

Table 35: GWRM capital cost estimates and appraisal cost estimates, 2015 and 2017 appraisals, out-turn
Source: Updated appraisal 2017, DfT/NR 2020/21 analysis, additional IEP costs via DfT

Note A - electrification - full programme electrification west of Maidenhead included in both the 2015 and 2017 appraisals, with the out-turn DfT/NR 2021 costs being based largely on the descoped Hendy plan specification. SWML electrification to Swansea – now cancelled – with sunk costs included in DfT/NR 2021. Thames Valley branches – now cancelled/deferred – with sunk costs included in DfT/NR 2021.

Note B - Bristol Temple Meads passenger capacity works and a range other works were included in the 2017 headline cost estimates and associated 2017 update appraisal, but not in the 2015 business case. Some of these investments have progressed in part or full with costs incurred to date included in the DfT/NR 2021 out-turn costs

Note C - Oxford station area capacity – was examined as part of the 2015 appraisal, but while in 2015 NR considered that some of these costs should be attributable to GWRM, DfT agreed that the 2015 appraisal would not include these costs, in part due to either being driven by, or offering wider benefits, to other projects (including the delivery of Chiltern line improvements). However, the 2017 appraisal did consider the full costs of the Oxford station area capacity works. The costs spent to date on Oxford station area capacity (just under 40% of the original budget) are included in the headline out-turn DfT/NR 2021 costs.

Note D - Swindon Kemble redoubling – costs were not included in either of the 2015 or 2017 appraisal, but have been identified in the headline DfT/NR 2021 costs.

Note E - Access to Assets: a programme to a) Improve physical access to the railway for Maintenance and Renewals activities b) Maximise the productive use of the available Maintenance and Renewals access periods and c) Improve the reliability of key asset types. Costs were not included in either of the 2015 appraisal, but were in the 2017 appraisal and in out-turn DfT/NR 2021 costs.

Note F - GWEP DNOs – funding for NR to move electric infrastructure, then seek costs back from the distribution network operators

Note G - North Cotswold and West of England platform lengthening – these line items were not identified in the 2015 appraisal, but were in the 2017 appraisal but with a zero cost. Platform lengthening on both routes was identified in the out-turn DfT/NR 2021 costs.

Note H - Reading independent feeder - not included in 2015 appraisal costs, but it was in the 2017 updated appraisal. The scheme was deferred and not included in DfT/NR 2021 costs, but was identified in the Network Rail's Enhancements Delivery Plan England and Wales Entry Into Service (EIS) schedule as being on schedule for delivery in 2023.

Note I - Depot costs – this these line item was not identified in the 2015 appraisal, but was for the 2017 appraisal, noting costs at Oxford, Didcot and West Ealing. The out-turn DfT/NR 2021 costs did not include any London/Reading commuter depot costs or other costs that may be associated with the West of England IEP fleet not covered by the IEP PFI-style deal or with any depot works associated with the GWR regional services (such as at Exeter)

Note J – Additional costs associated with the IEP arising from the move to a fully bi-modal fleet involved additional diesel fuelling facilities at North Pole and Stoke Gifford depots, works at Swansea depot and shore supply works at Swansea station

Note K - Reading station redevelopment – included in the 2017 headline cost estimates and out-turn DfT/NR 2021 costs, but not included in the 2015 estimates and (as part of the do minimum throughout) not used any of the scheme appraisal

Appendix F. Indicative allocation of long-distance capital costs

Table 35Table 36 expanded table and notes setting out the allocation of long-distance capital cost initially provided in Table 22.

GWRM long-distance costs £m out-turn	2020/21 DfT/NR out-turn estimates	Assumed out-turn long-distance costs	Inclusions/exclusions for the long-distance components
Electrification works	3,124	2,003	excludes electrification works east of Reading, Didcot and Newbury[A] assumed in the counterfactual
Key infrastructure works	547	303	excludes Thames Valley EMU and West of England DMU capability, Oxford station capacity[B]
Other works	114	21	excludes 'access to assets', Swindon-Kemple redoubling[C] and Cornwall resignalling[D]
Additional IEP costs	28	28	depot 'fuel farm' and additional shore supply at Swansea station
Total costs	**3,813**	**2,322** 64% of full costs	
Alternative 'prime user' long-distance cost sensitivity		2,563 67% of full costs	includes all Oxford station capacity costs, Swindon-Kemble redoubling and Cornwall resignalling

Table 36: Indicative GWRM cost estimates for long-distance economic evaluation
Source: Updated appraisal 2017, DfT/NR 2020/21 analysis, SYSTRA

Note A – Long-distance electrification costs are assumed to be directly proportional to the electrified track miles west of Didcot vs all electrified track miles. It is accepted unit costs will vary by section of route and that the long-distance sections of route do include the Seven, Chipping Sodbury and Newport tunnels.

Note B – Oxford station works were explicitly excluded from the 2015, in part due to either being driven by, or offering wider benefits, for others schemes. These costs were included in the 2017 updated appraisal in full. The out-turn costs incurred on the part delivered of these have not been allocated to the core GWRM long-distance costs reflecting the wider benefits of this scheme to others services; the full costs are considered in the 'prime user' sensitivity estimate.

Note C - Swindon Kemble redoubling costs were excluded from the copper long-distance costs as while, an enabler for electrification, hourly through or connecting services were operating before GWRM and so these costs may not have been essential to operate the enhanced through service timetable from December 2019; the full costs are considered in the 'prime user' sensitivity estimate.

Note D – Resignalling in Cornwall was not considered as GWRM long-distance cost as this scheme was deemed to be not essential for the delivery of the long-distance December 2019 timetable, although in practice it has delivered an enhanced train service on the Cornish Mainline delivered by both long-distance and regional routes; the full costs are considered in the 'prime user' sensitivity estimate.

Appendix G. Network Rail operations, support and maintenance costs

Table 37 expands the summary of Network Rail's operations, support and maintenance costs for the Western Route initially provided in Table 23.

Operations and support costs refers to locally-managed costs for the Western route along with a portion of the central costs which have been allocated in line with the Regulatory Accounting Guidelines. Note that these costs do not include TEICR costs (Traction Electricity, Industry Costs & Rates) that are passed onto the train operators.

Network Rail's maintenance expenditure covers track, signalling and communication, electric power and fixed plant (including overhead line equipment) and other maintenance costs. These line items are managed at route level, with teams working on multiple different train lines based on geographic location and mix of skills. Maintenance refers to locally-managed costs in Western along with a portion of the central costs which have been allocated in line with the Regulatory Accounting Guidelines.

£m cash prices	Operat'n	Support	Track	Signals Telecom	Civils & B'dings	Electric Power & Plant, OLE	Other	Total
2011-12	*75*		45	19	16	2	20	*164*
2012-13	*73*		48	19	14	1	16	*160*
2013-14	*84*		46	19	20	1	17	*169*
2014-15	*39*	*40*	39	20	22	4	31	*195*
2015-16	***41***	***28***	**39**	**22**	**25**	**4**	**32**	***191***
2016-17	*44*	*26*	43	22	30	4	32	*201*
2017-18	*46*	*51*	49	26	28	10	23	*233*
2018-19	*57*	*49*	51	28	30	10	29	*254*
2019-20	***55***	***62***	**50**	**31**	**28**	**12**	**50**	***288***
2020-21	*60*	*93*	50	34	32	12	49	*339*
Change 2015 to 19	70%		40%					51%
NR spend in England 2015 to 19 (note A)	36%		41%					38%

Table 37: Network Rail Operations, Support and Maintenance Costs, 2011-12 to 2020-21

Source: Network Rail

Note A – changes in Network Rail's spending taken from the NAO's Financial overview of the rail system in England with costs the 2019-20 prices converted to cash using the GDP deflator

Appendix H. Evolution of the business cases from 2015 to 2017

The 2015 appraisal assessed the GWRM programme as 'High Value for Money'. The updated appraisal developed in 2017 as infrastructure works and the IEP was being delivered, assessed the programme as offer 'Low Value Money' taking account of:

- the Ministerial decision in spring 2016 to procure all IEP trains for the Great Western franchise as bi-modes (the previous appraisal assumed that the new IEP trains operating to Swansea would only operate in electric mode);
- the inclusion of updated economic parameters;
- updated scheme costs; and
- a change to the definition of the 'Do Something' electrification option being appraised to account for the installation of electrification infrastructure to Cardiff by December 2019 and the use of the new bi-mode trains operating under diesel traction on other route sections, until full electrification was completed in 2024. This scheme was referred to as Scenario A.

Type of benefit/cost	2015 economic case for the GRWM Value (£m present value, 2010 prices)[A]	2017 updated appraisal (scenario A) Value (£m present value, 2010 prices)[A]
Benefits		
- Faster journey times	3,417	3,241
- Reduced crowding	510	507
- Enhanced journey quality	149	142
- Non-user benefits	2,003	1,657
- Indirect taxation	-942	-821
Present value of benefits	**5,137**	**4,726**
Costs		
- Operating costs[B]	-4,221	-4,145
- Capital costs[C]	-2,636	-4,470
Revenue	4,684	4,183
Present value of costs	**-2,173**	**-4,432**
Net present value	2,964	293
Benefit-cost ratio	2.36:1	1.07:1
Value for Money allocation	High	Low

Table 38: GWRM 2015 business case and 2017 updated appraisal results (scenario A)
Source: Great Western electrification project business case: Phase 1 report, CH2M, June 2017

Note A – all costs and benefits shown as present values discounted to a 2010 base and expressed in 2010 prices as applicable to appraisals undertaken at the time

Note B – costs do not include the full costs for maintaining the infrastructure

Note C – capital costs estimates of early 2015 before any cost escalation was apparent. The 2017 updated appraisal included some additional works that were not considered in the earlier 2015 business case

Appendix I. Modelling methodology

To allow the calculation of benefits, the total GWR passenger demand, revenue and miles in the GWRM programme and counterfactual scenarios have been modelled over the 60-year evaluation period, disaggregated by origin-destination flow and journey purpose as follows.

Base demand

The GWR version of MOIRA has provided the observed demand and revenue for the year ending September 2019 i.e. before the substantive timetable change in December 2019. This represents an appropriate base year for the GWRM programme scenario. For the counterfactual scenario, as this base year will contain the demand uplift due to the modest pre-2019 scheme improvements i.e. minor timetable changes, introduction of new rolling stock, adjustments have been made to strip out these demand impacts as shown in Table 39.

Scenario	Base MOIRA Demand & Revenue Matrix	Adjustments
Counterfactual	For year ending Sept 2019 (observed)	Impact of 2011 – 2019 long-distance timetable changes (see Table 41)
GWRM programme	For year ending Sept 2019 (observed)	N/A

Table 39: Base demand by scenario

Ticket type to journey purpose mapping

MOIRA demand and revenue outputs are disaggregated by ticket type i.e. Full, Reduced, Season. To facilitate the application of TAG parameters which are typically given at a journey purpose level i.e. commute, business and leisure, a simple ticket type to journey purpose mapping has been assumed as follows:

- Full → Business
- Reduced → Leisure
- Season → Commute

Exogenous growth

Post-2019, demand has been grown in line with the DfT's Exogenous Demand Growth Estimator (EDGE) model factors which uses the Demand Driver Generator (DDG) dataset of forecasted variables to grow rail demand in line with TAG demand elasticity parameters based on the Rail Demand Forecasting Estimation (RDFE) study. The DDG dataset includes the following exogenous factors which are assumed to be outside the direct control of the rail industry:

- GDP;
- Employment;
- Population;

- Car Costs;
- Car Journey Time;
- Bus Cost;
- Bus Journey Time;
- Bus Headway;
- Underground Cost; and
- Air Passengers

In line with TAG, the EDGE factors are used to provide growth for the 20 years from the date of the evaluation study i.e. 2042. Beyond this date and for the remainder of the evaluation period, demand has been grown in line with projected population growth only[48]. This approach assumes that there will be no future capacity constraints.

The EDGE factors include the inherent economic impacts of COVID-19 (GDP, employment etc) but do not account for the behavioural impacts (working from home, social distancing etc). To reflect these impacts, the DfT's Rail COVID Forecasting Tool has been used to provide COVID demand growth factors for application to the EDGE. The COVID low and medium scenarios have been used as sensitivity tests which pivot from the core EDGE forecast.

The same growth factors have been applied to demand, revenue and passenger miles. This therefore assumes that there is no change in average yield over the evaluation period.

Timetable impact

MOIRA has been used to assess the demand uplift associated with the December 2019 timetable change (Table 40) in the modelled scenarios. This allows the impact of the substantive changes to the long-distance routes in the December 2019 to be isolated when assessing the incremental benefits of the GWRM programme relative to the counterfactual.

[48] Principal projection - UK summary - Office for National Statistics (ons.gov.uk)

Scenario	Route	Timetable	Demand Impact
MOIRA base year	Long – distance	May 2019	N/A
MOIRA base year	Other	May 2019	N/A
Counterfactual	Long – distance	May 2019	Counterfactual – Base (no demand impact for long-distance routes)
Counterfactual	Other	December 2019	Counterfactual – Base (no demand impact for long-distance routes)
GWRM programme	Long – distance	December 2019	GWRM programme – Base
GWRM programme	Other	December 2019	GWRM programme – Base

Table 40: MOIRA Runs – December 2019 Timetable Change

Additionally, to isolate the timetable-only demand impact of timetable changes to long-distance services pre-2019, the MOIRA timetables shown in Table 41 have also been run. The difference between the two demand matrices has been used to strip out the demand impact of the modest pre-2019 long-distance timetable changes from the counterfactual demand.

Scenario	Route	Timetable	Demand Impact
MOIRA base year	Long – distance	May 2019	N/A
MOIRA base year	Other	May 2019	N/A
Counterfactual	Long – distance	May 2011	Base – Counterfactual
Counterfactual	Other	May 2019	Base – Counterfactual

Table 41: MORIA Runs – Pre-December 2019 Timetable Change

SYSTRA APPROVALS					
Version	**Name**		**Position**	**Date**	**Notes**
v1.0d	Authors	David Carter Ian Bruce	Director Associate	17/03/2023	Accessibility updated for figures and charts
	Checked	Toby Cuthbertson Katie Hall	Director Director		
	Approved	David Carter	Director		