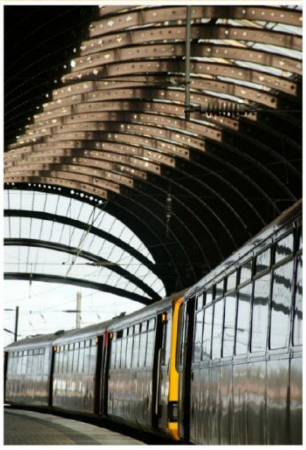

Assessment of capacity allocation and utilisation on capacity constrained parts of the GB rail network

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1. Introduction

1.1 Purpose of this study

The McNulty Rail Value for Money (RVfM) report on the value for money of the GB rail network examined the overall cost structure of the railway sector to identify options for improving value for money to passengers and the taxpayer. This included a 'top-down' benchmarking assessment of GB rail, comparing output metrics such as costs, passenger kilometres, track kilometres and train kilometres to other rail networks across Europe. The RVfM assessment highlighted inefficient allocation of capacity on the network, measured as passenger kilometres per train-kilometre (train capacity) or train kilometres per track kilometre (track capacity), as a constraint on the industry's ability to accommodate extra traffic and concluded that these inefficiencies may lead to infrastructure-based solutions to the problem being preferred when other means are available which would represent better value for money. This study is an attempt to understand what the nature of any inefficiency might be from a 'bottom-up' perspective.

SKM Colin Buchanan, along with its partners GHD and Winder Phillips Associates, was commissioned by Office of Rail Regulation (ORR) to gain better insight into the nature and the scale of any inefficiencies in the allocation and utilisation of capacity on the GB rail network through consideration of a small number of case studies.

It is intended that this study will inform ORR's policy towards incentivising the improved efficiency of capacity utilisation in CP5 and beyond, especially given that the demand for capacity is forecast to grow significantly in the coming years[1]. Part of the current policy debate in this area is whether or not the incorporation of a Capacity Utilisation Charge into the track access charging framework is likely to be beneficial. The purpose of this study is to take one step back and identify, through the use of case studies, what the scale of the problem is, and whether the industry (including train operators, the Department for Transport (DfT) or Transport Scotland (TS) which procure the passenger franchises, Network Rail and the ORR) could improve the efficiency with which capacity is allocated. This study sits alongside another study undertaken by NERA which considered the options for a Capacity Utilisation Charge as an incentive to improve capacity.

1.2 Capacity utilisation

Efficient utilisation of capacity is defined as the most advantageous scenario when considering the potential economic impacts of alternative uses. An efficient position is therefore considered to be where it is not possible to derive an alternative use which has a positive Benefit Cost Ratio (BCR) compared to the status quo. Inefficiencies may come from a variety of sources such as:

- Network Rail – to what extent is NR incentivised to produce an economically efficient timetable? Are incentives for carrying additional trains outweighed by incentives to maintain and improve performance or by pressures to carry out maintenance efficiently?

---

[1] The Initial Industry Plan (September 2011) proposes measures to deliver, by 2019, an additional 170,000 seats at peak times for commuters on key urban networks and provide capacity to accommodate a 30% increase in rail freight traffic

- DfT / TS – to what extent do political requirements for services and the inertia created by the existing franchising model make changes to the timetable difficult? Does the degree to which funders prioritise performance within the HLOS process incentivise against efficient use of capacity?
- ORR – how do the ORR's track access policies drive the efficient allocation of capacity, including the 'not primarily abstractive' test which new open access services, as well as some services by franchise operators, are required to pass?
- Freight operators – how frequently are timetabled freight paths used?
- Rolling stock – are there trains of the right type, length and performance characteristics to maximise the use of available infrastructure capacity?

1.3 Report structure

This report considers the context of capacity allocation and utilisation, provides a short discussion on the theoretical issues to be addressed including details of the methodology we have applied (including the rationale for selecting the case study locations), and examines four case studies which illustrate different parts of the network with differing geographic, service and infrastructure attributes.

- Section 2 provides some background and context for the study;
- Section 3 presents a theoretical discussion on the factors which affect capacity allocation and utilisation;
- Section 4 summarises the case study methodology;
- Sections 5-8 provide a summary of the case studies;
- Section 9 presents our findings;
- Appendix A discusses the selection of the routes for the case studies;
- Appendix B gives more detail on the operational characteristics of the case study routes;
- Appendix C provides an analysis of freight path utilisation; and
- Appendix D is a glossary of terms.

This report is not intended to be a Route Utilisation Strategy (RUS) for the case study routes. Instead it takes a high level view, using the case study areas to highlight the issues and principles which may affect efficient use of capacity.

2. Background and context

2.1 Background

Until recently, there has been broadly enough capacity on the rail network to accommodate most of the demand for rail services. Since privatisation, passenger demand has increased significantly (see Figure 1) and during this period improvements to capacity have been made (e.g. West Coast Main Line upgrade) and major capacity enhancements begun (e.g. Crossrail, Thameslink). Despite the recent recession, passenger demand has held up and is predicted to grow further in the coming years[2] and therefore management of the existing infrastructure, through considering demand-side changes or trading off different types of service, has become more important. When paths are allocated, the opportunity cost of the path is not always considered (except when franchises are let or when ORR considers track applications), so therefore the structure of the industry may prevent the efficient allocation of capacity. Given this context, ORR is considering whether the introduction of a Capacity Utilisation Charge for operators running services in capacity constrained parts of the network would improve efficiency, as the charge may encourage operators to change when and where they choose to operate some of their services.

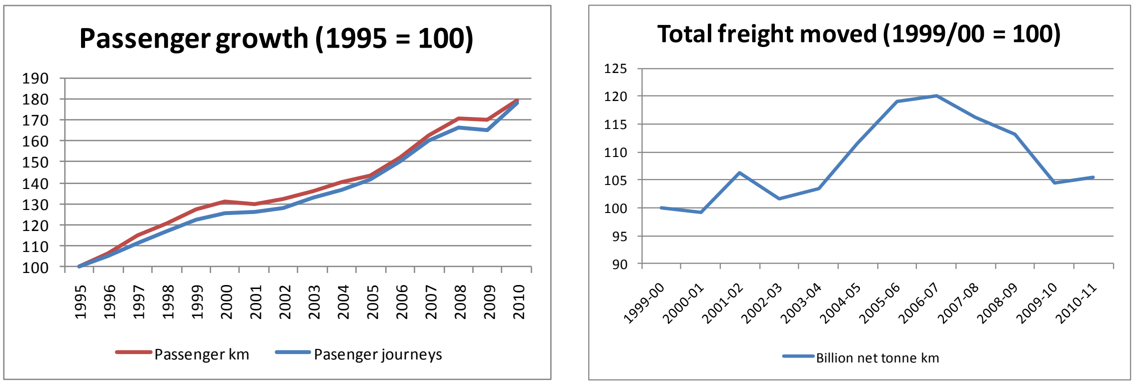
As part of this study we examine efficiency in three different ways, which are described in more detail in section 3.2:

- Efficient for the network owner – providing maximum utilisation of the infrastructure;
- Efficient for the rail industry as a whole – taking into account passenger revenues and operating costs; and
- Efficient for society as a whole – taking into account the economic benefits that services generate.

There has been significant growth in passenger traffic on the GB rail network since privatisation. Figure 1 shows that both passenger kilometres and passenger journeys have increased by approximately 80% since 1995/96. Freight traffic has proved to be more sensitive to the recent macroeconomic instability than passenger traffic, but the network still carries approximately 5% more freight traffic (as measured in net tonne kilometres) in 2010/11 than in 1999/00 despite the recession.

[2] The IIP forecasts annual growth in passenger km between 2013 and 2034 of 1.9% to 2.4% on London and South East services, 2.1% to 2.9% on Long Distance services, and 2.8% to 3.7% on Regional services

Figure 1: Index of passenger and freight growth



Source: ORR National Rail Trends, passenger kilometres in calendar years and passenger journeys in financial years commencing in the year shown

This growth in passenger traffic has been accommodated on a network the size of which has remained largely static – total GB track kilometres was 31,766 in 2003 and 31,108 in 2011[3]. Whilst the overall size of the network has remained relatively constant, during this period there has been significant capital investment in new rail infrastructure (e.g. double tracking Oxford – Worcester, reinstatement of the Airdrie – Bathgate route) as well as the significant enhancement of capacity on existing routes, e.g. the upgrade to the West Coast Main Line.

Despite the enhancements that have taken place in recent years, on certain parts of the network – in particular London and the South East – capacity is becoming increasingly constrained (i.e. there is a greater demand for paths than can be accommodated in the timetable), and as a result large capital investments such as Crossrail and Thameslink are under construction to provide additional capacity for more paths, in part by removing the constraint on capacity that terminating stations in city centres can create[4]. Such large-scale improvements generate a step-change in the provision of capacity, but may not provide value for money if growth in demand is lower than forecast. In this case, the constraint requires more of an incremental solution to capacity such as lengthening platforms to enable longer trains to operate. Understanding the nature of the capacity constraint and how the constraint manifests itself, e.g. inability to find additional paths or increased delay minutes, is crucial so that it can be addressed in an efficient way – i.e. are there ways of incentivising the industry to use the existing capacity more efficiently prior to any large-scale infrastructure enhancement?

The problem of capacity constraints is a function of three factors: capacity allocation, train utilisation and infrastructure utilisation:

- Capacity allocation is defined as the process by which a train journey (or ‘path’) is allocated to the passenger or freight operator. This is facilitated through access rights and timetable planning, either as part of the agreed timetable changes or through short-term planning.

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[3] Source: Network Rail Annual Returns (2007 and 2011)

[4] A terminating station in a city centre will be able to handle fewer services than a through-station because the turnaround of trains and number of platforms become constraints on the number of services that can arrive. For example the introduction of Crossrail at Paddington and Liverpool Street means the number of services that will be able to serve both stations will be much greater than at present.

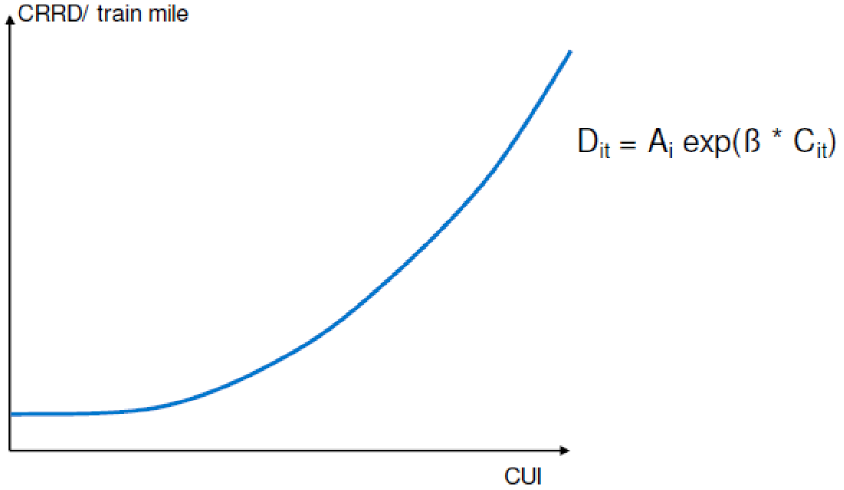
- Train utilisation is the measure by which a path is used to its maximum potential. For passenger services, this is a function of the number of passengers on a train and whether the service is operating at its maximum length. For freight services, this is a function of the amount of cargo that is being carried on the train relative to its maximum capacity. However because freight trains are commercial operations, if there is insufficient cargo then generally the service will cease to operate and therefore this particular aspect of train utilisation is not considered further in this study.
- Infrastructure utilisation measures how well the infrastructure (track, platforms, etc.) is being used through the number of paths operated compared to the maximum number of paths the infrastructure allows. It is a function of the mix of service types and train types as well as the infrastructure, and in addition for freight services what proportion of the paths reserved in the timetable is being used.

This study investigates allocation and utilisation on capacity constrained parts of the network. A part of the network is defined to be capacity constrained if there is a greater demand for paths than can be accommodated within the timetable. However, even if the route is not capacity constrained at present, given the forecast growth in demand for passenger and freight we may assume some routes will become so in the future. Accordingly we have tested options for dealing with constraints in our case studies even where a capacity problem does not appear to exist currently.

The decision as to whether a train can be accommodated has been subject to a number of tests including a view on whether the additional train might add to the risk of poor performance to the extent that it becomes unacceptable. The trade-off between capacity and performance is an important one, as utilising more paths exacerbates any knock-on effects of delays. There is a linear increase in the levels of primary delay (e.g. an increase in the number of trains means that delays caused by fleet failures will go up simply because there are more trains). There will also be a larger increase in reactionary delays – known as Congestion Related Reactionary Delay (CRRD) – as the number of trains operated increases and there is less time available for services to recover. This relationship[5] is shown in Figure 2, with delay increasing exponentially as capacity usage increases, measured by the Capacity Utilisation Index (CUI). Increased CRRD may also manifest itself in more cancellations as the operational controllers attempt to recover the service by creating space for recovery.

[5] Source: Recalculating the Capacity Charge Tariff for PR2008 (Faber Maunsell, October 2007)

Figure 2: Relationship between capacity utilisation and reactionary delay



CUI is a measure of the amount of free space in a given timetable and provides an indication of how that timetable may perform. As part of its work on updating the Capacity Charge for CP5, Network Rail is planning to review and recalibrate the CUI. There is no definitive rule which states that a particular level of CUI will lead to poor performance, but a value in excess of 80% is generally predicted to lead to poorer levels of performance, particularly during disruption where the scope for recovering the service is limited. In reality, many of the London commuter routes operate at higher levels, in particular during the peak periods. The East Coast RUS, for example, states that the 'Down' lines (northbound out of Kings Cross) operate at 100% during the evening peak.

The trade-off between capacity and performance is demonstrated by incentives on Network Rail which are intended to encourage improved performance through a targeted Public Performance Measure (PPM) value. As we describe later, there are also incentives on NR to accommodate additional services so capacity and performance must be traded off against each other.

2.2 Allocation of available capacity

The process by which network capacity is allocated is complex. Broadly it is based on the track access rights contained in access agreements as agreed between Network Rail and the Train Operating Company (TOC) or Freight Operating Company (FOC) concerned and approved by the ORR. Rights of access for a defined period of time reduce commercial uncertainty for franchising and for investment in trains, staff, stations, freight facilities and services. There are no charges for the track access rights, charges only apply where the rights are used. Even before issues surrounding the prescriptive nature of franchising policy in recent times – where bidders have been asked to submit timetables to meet detailed Service Level Commitments – are taken into account, there are some deliberate rigidities in the system for allocating capacity in places where there is more than one operator, based on fair and reasonable access across different operators and even handed treatment by the network owner.

Inevitably, new rights must be capable of being accommodated alongside existing rights in track access contracts (Network Code Part D[6]), but those existing rights may be based on historical arrangements rather than current demand. Part J of the Network Code does contain a “use it or lose it” mechanism whereby unused rights can be removed (J4) and a freight transfer mechanism (J7), where access rights are transferred between operators, for instance if haulage contracts change. As we discuss below, in relation to new timetables on the East Coast route, major change is complex and difficult to negotiate because of the multiple operators, particularly freight and open access passenger operators, which have access rights that must be accommodated. Except as a result of a major timetable re-cast, there is little substitution of services, i.e. one train usurping another’s path when there is no spare capacity.

2.3 Track access rights

Each operator of train services is required to obtain the appropriate rights to operate its services. These rights are approved by the ORR and applied in the creation of a timetable by Network Rail.

Along with licence requirements needed to ensure safe and appropriate operation of the network, the ORR takes into account the impact that any changes to services might have on the operation of the network as a whole when considering track access applications, as well as considering the impact on Network Rail and other operators. In the case of Open Access Operators (OAOs), this includes the potential financial impact of new services on the costs and revenues of the industry as a whole.

The granting of rights to operate services is thus an important element in how capacity is used and allocated between different operators.

2.4 Development of the timetable

In procuring recent passenger franchises, DfT/TS specified the services to be operated in a detailed way (i.e. frequency, maximum journey time, stopping patterns). The rationale behind this approach was to make sure that TOCs provide an appropriate level of service in return for the subsidy, or reduced premium payment, for including socially desirable services that would not otherwise be commercially viable.

As a result of this policy, the recent franchise agreements are still quite prescriptive with regard to service patterns[7], with TOCs’ ability to vary service patterns in response to demand often being quite limited in practice. Therefore much of the timetable development is driven by the work that was carried out by DfT/TS as part of the renewal of the franchise. Franchise requirements are evolving and in future TOCs may have more freedom to make changes to the timetable. The degree to which TOCs are free to vary the service will be of critical importance in determining whether a Capacity Utilisation Charge is likely to be effective or influence behaviour in practice.

[6] “Part D” is a timetable development process based on bids made under access contracts.

[7] The Intercity West Coast franchise, let during 2012, was the first to allow operators more flexibility in specifying the timetable by requiring a weekly number of stops at each station.

Network Rail, rather than the TOCs themselves, is responsible for the development of a Working Timetable (WTT) that accommodates the access rights approved by the ORR. The TOCs may provide their proposed timetables to DfT during franchise bidding. Development of the WTT is a lengthy process (see Figure 3) and, for the December 2012 timetable change, work began in September 2011 with NR consulting on proposed rule changes[8]. Operators' requests for access had to be provided by March 2012 and the timetable is published 26 weeks before it comes into effect, subject to dispute resolution.

Figure 3: Timeline for development of the WTT[9]

	Months before timetable go-live															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NR begins consultation on rule changes	♦															
NR begins to develop draft timetable			♦													
NR publishes Timetable Planning Rules and Engineering Access Statement						♦										
TOC request for access deadline							♦									
Timetable published										♦						
Timteable go-live																♦

In the freight market much can change in the nine months between the request for access and the timetable coming into operation. The fluidity of the market means that there is a risk that some freight paths in the WTT may be no longer required by the commencement date and new ones may be needed.

Although most paths are allocated as part of a timetable change, there is a degree of flexibility in the system to allow paths to be run at short notice. When an additional or altered path is required at short notice, operators place a bid with Network Rail for the changes to the timetable. For TOCs most of these changes are a result of engineering work or special events (e.g. sporting fixtures), whilst for freight operators the requirement is driven by short-term traffic requirements. The bids for these changes can be made at various stages up to and including Very Short-Term Planning (VSTP) on the day. This process can vary by traffic type. For example, with regard to coal flows in the North East of England, a weekly programme has traditionally been produced showing which services are planned to operate in the week ahead. The bidding process set out in the Network Code is commonly known as "Day A for C", that is an amended bid will be received on Monday for a train to operate on Wednesday.

In order to simplify this process, Network Rail will include in the timetable a number of "Q" paths. These are paths in the timetable based on the timing of the standard freight path for the route in question, or may be supported by specific rights in a freight operator's track access agreement. These paths are intended for services which are anticipated will run during the period for which the timetable is valid, but where there is a degree of uncertainty about their regularity. They are most used by the coal sector where the market is extremely fluid in terms of demand and the origins and destinations of flows. Often Q paths have multiple origins or destinations, for example coal trains may have paths to three separate power stations and will

[8] Network Rail Network Statement 2013

[9] Produced from information within the Network Statement 2013

run to one of these three on a given day as required (these options are known as "Y-paths"). If the path requested is a new path that is not already in the timetable then it must be shown to be ‘conflict-free’ in relation to existing timetabled services.

2.5 Current track access charging regime

This section summarises the current use of charges and other incentives in relation to track access. The ORR is in the process of consulting on the incentives for Control Period 5 (CP5) as part of its periodic review process (PR13).

2.5.1 Charges

The following charges are levied on operators by Network Rail:

- A variable track access charge (VTAC), covering track maintenance costs, reflecting the type, speed and weight of trains as they pass across the network.
- A Capacity Charge, which is intended to compensate Network Rail for the expected increase in Schedule 8 performance regime payments (see section 2.5.4) because of the impact additional services have on CRRD. The Capacity Charge aims to neutralise the incentive that Network Rail would otherwise have to reject proposals for additional services on the grounds that they would lead to an increase in costs associated with increases in reactionary delays. The Capacity Charge is set at the ‘service group’ level, which generally groups together similar types of services and separates peak and off-peak passenger traffic, and a single rate applies for freight services. Weekend rates for the Capacity Charge are set at 50% of the corresponding weekday rate.
- A fixed track access charge is paid by franchised train operators to fund the long-term costs of the network, such as renewals.

2.5.2 Incentives

Network Rail is incentivised to accept extra traffic onto the network by way of the Volume Incentive. The running of an extra train results in additional revenues for Network Rail equal to the relevant VTAC. Where actual ‘wear and tear’ cost is above the efficient cost reflected in the VTAC, there may be a financial disincentive for Network Rail to accommodate additional demand. The Volume Incentive provides additional revenue for Network Rail dependent on its ability to accommodate more passenger and freight trains on its network.

2.5.3 Administrative measures

As discussed in section 2.2 above, Part J of the Network Code relates to changes in access rights and allows for “use it or lose it” access right reviews. ORR is investigating whether freight operators not using their paths is a significant problem, and two of the case studies in this report will inform this process.

2.5.4 Performance regime

A performance regime exists to insulate both Network Rail and train operators from disruptions (both planned and unplanned) caused by the other party.

The Schedule 8 regime is in place to compensate operators for (unplanned) delays caused by other operators or problems with the network. When Network Rail is responsible for the cause of delay it compensates the operators, but it is also rewarded for better than expected performance. In addition to the financial incentive regime, poor performance on delays can have licence implications, reputational and political risks for Network Rail, the operators, DfT/TS and the ORR. These financial and other risks are a disincentive to risking performance for the sake of increasing capacity.

Compensation for operators' services disrupted by (planned) infrastructure maintenance or renewal is covered by the Schedule 4 regime. This is based upon the values derived for Schedule 8 but 'discounted' to reflect the expectation that advance notice of delays reduces the impact on revenues. There is a charge on operators (known as the access charge supplement) in order to fund the Schedule 4 regime.

2.6 Review of the evidence base

2.6.1 Summary of the RVfM report

The RVfM report was commissioned jointly by the DfT and ORR and the final report, 'Realising the potential of GB rail' was published in May 2011[10].

The study examined two key elements of capacity management and utilisation. Firstly train capacity, reflecting the overall passenger-carrying capacity of the train, and secondly infrastructure capacity, incorporating the constraints of the infrastructure to run trains e.g. line speed, conflicting train routing, stopping patterns, signalling.

The report notes that from a network perspective, the "British network is intensively used, although not as densely utilised as the Netherlands or Swiss networks". There are some geographic factors such as the distances between major centres and the mix of traffic type that account for this. The population distribution in Great Britain is uneven – rural parts such as Wales, the Scottish Highlands and some parts of northern England contrast with densely populated areas in London and the South East. This may also contribute to a less densely utilised network on average when compared to the Netherlands, which has a higher population density[11] and a more even distribution of population than in Great Britain.

It also noted an increasing tendency in mainland Europe to separate infrastructure for long-distance passenger, freight and regional/commuter services thereby increasing the theoretical infrastructure capacity.

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[10] http://www.rail-reg.gov.uk/server/show/ConWebDoc.10401

[11] Netherlands - 489 inhabitants per square mile, compared with 254 per square mile for United Kingdom in 2009 (source: Eurostat)

The RVfM report has based these conclusions on a top-down analysis of output metrics such as passenger kilometres and train kilometres. Whilst this enables comparisons to be made with other networks at a global level, it does not allow for different characteristics at an operational level or look at the specific reasons for why this might be the case on different parts of the network. The RVfM methodology contrasts with this study which approaches the question of capacity allocation and utilisation through a bottom-up analysis.

In terms of train capacity, the RVfM report found that Great Britain’s train utilisation (measured as passenger kilometres per train-kilometre) was “at the low end of the sample” of European countries. This implies that, given the high level of crowding on some trains, there must be a large number of services that have very few passengers or, in the case of radial commuter routes, high levels of crowding are experienced only for part of the journey as it nears the terminal station. The benchmarking found “substantial variations” in train capacity utilisation within the GB rail network, with East Coast and Virgin Trains showing the highest utilisation – in part through the use of discounted advance fares – with Arriva Trains Wales and Northern showing the lowest utilisation.

The report highlighted the following reasons for under-utilisation of capacity:

- Commuter and rural passenger services experience heavily-peaked and seasonal demand meaning that off-peak trains are invariably not fully-loaded;
- The fares structure is not designed to manage demand out of the peak into the ‘shoulders’ of the peak;
- Frequent, short trains drive higher revenues but are not an efficient use of capacity; and
- The prevalence of through-services to minimise the number of interchanges for passengers, which have shorter or not fully-loaded trains operating in capacity constrained parts of the network.

It also highlighted the trade-off between running more services and the potential detrimental effect that may have on performance, citing the example of the Wessex Main Line timetable in 2004 as improving performance at the expense of operating a lower-density service[12].

In summary, the RVfM report highlighted the following opportunities for improving value for money:

- Using price and yield management to spread peak loads;
- Longer-term integration with land use planning to optimise demand for travel (e.g. better matching future housing developments with employment centres based on existing infrastructure or train capacity);
- Reviewing the structure of track access charges to ensure that the full marginal cost of train movements, including the opportunity cost, is paid by operators;

[12] Realising the potential of GB rail – Detailed report (page 259)

- Changing the industry's mindset to consider total ridership capacity before commissioning capacity enhancement schemes as currently "nobody within the industry is focused on the productivity of the overall system approach to total ridership" and "the IM (Infrastructure Manager) has a tendency to promote large capital-intensive construction solutions... when other solutions may be more important," the implication of this being that infrastructure spending should be a last resort solution to capacity constraints;
- Nominating an individual or body who is solely responsible for improving train and network utilisation;
- Examining whether segregation of service types (e.g. physical separation of fast and slow services) or homogenisation of train speeds (e.g. all services on one line having the same speed and stopping pattern) would provide operating, economic and social benefits; and
- The greater use of older rolling stock during peak periods.

2.6.2 Using incentives to improve capacity utilisation

ORR commissioned NERA to consider the scope for using track access charges to provide incentives that will help improve infrastructure capacity allocation and therefore more efficient capacity utilisation. NERA considered a simple option for changes to access charges – a fixed additional charge per train-kilometre applied to a small number of network categories by location and time of day – as well as a model-based, bespoke approach. The study highlighted a risk that such a charge may lead to off-peak services being withdrawn (due to higher costs of operating the service) or freight operators switching to alternative routes that contribute to an increase in industry costs. NERA concluded it was doubtful about the scope to improve capacity utilisation by changing TOCs' decisions through the introduction of charges alone or similar incentives.

The report did, however, suggest that charges might provide stronger incentives for Network Rail to be pro-active in improving capacity utilisation, e.g. by identifying timetable changes to free up additional train paths. Currently Network Rail has strong incentives to improve performance that may outweigh the volume incentive which is designed to encourage it to accommodate services. Because track access bids are more likely to reflect the financial impact of the change (and hence the utilisation), the effectiveness of a Capacity Utilisation Charge is likely to be correlated to the amount of flexibility that TOCs are given as part of the franchising process.

2.6.3 Periodic Review 2013 – Consultation on incentives

In December 2011, ORR published its consultation document on incentives for the PR13 process[13]. This document draws on the RVfM report and the NERA study to formulate the ORR's emerging views on the use of incentives during the next Control Period (2014-19), including in relation to capacity utilisation.

[13] http://rail-reg.gov.uk/pr13/PDF/pr13-first-consultation-incentives_141211.pdf

The document summarises the following key messages with regard to the incentive regimes:

- Network capacity is a sometimes scarce resource and it is important that ORR incentivises its efficient allocation and usage (where 'efficient' is defined as the most advantageous scenario when considering the potential economic impacts of alternative uses), particularly given the forecasts for significant increases in rail demand;
- ORR will review the volume incentive, which encourages Network Rail to accept extra traffic onto the network, disaggregating by Network Rail route – disaggregation is considered to increase the effectiveness of the volume incentive;
- ORR supports the principle underpinning the Capacity Charge, which reflects costs associated with reactive delay – the Capacity Charge recovers the Schedule 8 payments caused by additional traffic that are directly incurred by Network Rail;
- ORR does not intend to consider sharing of TOC and Network Rail revenues in PR13 – whilst this might have incentivised Network Rail to support growth in industry revenue (and therefore additional capacity) it may dampen TOC incentives to maximise revenue;
- ORR is not minded to proceed with a reservation charge (where operators pay for paths that are in the timetable but are not used) but further research on path utilisation will confirm this view;
- ORR will research the extent to which infrastructure capacity is under-utilised before deciding whether to act to develop indicators to monitor capacity utilisation. Publishing indicators of capacity utilisation may improve capacity utilisation by providing stakeholders the opportunity to challenge operators or Network Rail. However low utilisation is only an issue if it prevents other services from operating, so this study will inform ORR of the levels of track capacity utilisation across the case studies;
- ORR welcomes views on levying a charge to incentivise better use of capacity (Capacity Utilisation Charge) – this study supports the evidence around whether such a charge would encourage more efficient use of the network.

The case studies investigated as part of this study therefore provide a direct input to ORR's work on incentives to promote efficient capacity allocation and utilisation, by giving direct examples of whether or not problems exist on the network today.

2.7 Summary

The RVfM report concluded that the British network is intensively used (although not as much as Switzerland or Netherlands), but that the average train loadings (i.e. train utilisation) are low compared with most European railways.

The study acknowledges that in terms of track capacity, the maximum utilisation can only be achieved when services have the same characteristics and that the technical efficiency falls when anything other than a uniform service is operated. The British network has a variety of different uses – local metro, suburban, Inter-city, regional, rural, freight – with different stopping patterns and rolling stock types that share the same track, therefore it is not surprising that maximum levels of utilisation are not achieved.

The radial nature of the network surrounding London, and to some extent Manchester, means that there is limited potential to extend track or terminal capacity, as land is not readily available. This leads to the need for high cost capital projects such as Crossrail, Thameslink and Northern Hub in order to overcome these terminal constraints.

It may also be the case that track capacity is not efficiently allocated because of the structure of the industry:

- Network Rail has to balance competing sets of incentives, on the one hand to improve performance of the network whilst on the other hand encouraging more services which increase the risk of reactionary delays. The performance and capacity targets are specified by the funder (DfT/TS) as part of the HLOS process and the ORR provides the regulatory incentives and funding to meet the targets. It may be that the recent drive to improve performance has led to Network Rail making trade-offs in favour of performance by not allowing increases in the number of trains on constrained parts of the network in response to increased demand. However, if train operating companies were to be denied access for this reason, they could seek access by approaching ORR under Sections 17 or 22a of the Railways Act.
- The existing franchise agreements are also often prescriptive in terms of the services that must be operated. Changing service levels is often non-trivial and inevitably involves revisiting the financial models produced during the bidding process. This makes it difficult for operators to increase services to respond to changes in demand unless planned for in the franchise agreement. It is understood that the new franchise agreements which are developed under the new franchise policy may give operators more freedom to run services that respond to changes in demand, which could lead to changes in demand for paths or the characteristics of those paths.
- The opportunity cost of using a path for another purpose is not always considered when allocating capacity, although it is considered when franchises are let, or when ORR assesses competing claims for access.

In terms of train capacity, the RVfM report suggests a number of reasons why Britain has a lower utilisation than other European railways, including lightly used off-peak services, peak services with very high loadings as they near the terminal stations and lower loadings for the rest of the journey, through-services to destinations (which are desirable to passengers, reducing the need to interchange) running short formation trains, and the lack of double-deck trains in the UK which are common across Europe.

The report suggests that by improving average loadings of existing, lightly loaded services there is an opportunity to improve industry unit costs. It is worth noting however that the marginal cost of operating off-peak services where there is a high demand for peak services is usually low because the rolling stock and staff tend to be available. Therefore an off-peak service does not usually need to attract large volumes of passengers for it to be commercially viable. The opportunity cost of whether another service of greater economic value could operate instead of the lightly loaded off-peak service may not always be assessed, however, and so could lead to an inefficient allocation of capacity. As a financial incentive, however, a Capacity Utilisation Charge would only reflect the potential financial value of a service. The possible divergence between the financial and economic value of train paths could potentially distort incentives for funders and the industry, leading to the withdrawal of low-financial/high-economic yield services.

3. Theoretical discussion of capacity allocation and utilisation

3.1 Network capacity

Total network capacity is largely a function of the following constraints:

- Infrastructure – the number and layout of tracks, line speed, signalling equipment, frequency and type of junctions, crossovers (where trains move from one line to another) and intermediate stations;
- Termini– how long it takes to unload/load passengers and freight, how many platforms or reception sidings a terminal has, how long it takes to prepare a train for the next journey;
- Rolling Stock – the method of propulsion (diesel or electric traction), its acceleration, braking and top speed, passenger or freight load capacity, length and which routes it has clearance to operate over;
- Operating Rules – minimum time between services (planning headways) on plain line sections, at junctions (junction margins) or at stations, how long it takes to load or unload passengers (station dwell times), and allowances for Temporary Speed Restrictions or other engineering work, performance requirements or complicated train movements (pathing); and
- Differing service patterns – which stations are called at, which lines are used and how often trains transfer from one line to another.

We deal in more detail with each of these areas of constraint below. For each study area our judgement on whether the route is capacity constrained at present is time bound, there may be only parts of the day when there is demand to run more trains. Each constraint reacts and impinges on the other. For example it may be possible to run 20 trains per hour (tph) on plain line sections of the route, but the combination of junction capacity and turnaround time at the terminus makes only 18 tph possible.

Our report is necessarily high level and we have neither undertaken the depth of work contained in Route Utilisation Studies nor have we carried out any simulations to test the operability of our possible approaches to easing constraints. Similarly, we have not tested the effect on punctuality and reliability other than qualitatively or considered whether there is capacity for additional services beyond the boundaries of the case study areas. Our report is intended to provide examples of possible approaches, not recommended solutions, to assist the ORR in making decisions about the use of incentives or direction on the use of capacity.

3.1.1 Infrastructure

The basis from which all discussions about capacity begin is the signalling system and the associated track configuration at junctions and termini. The signalling system itself is designed around the types of services which are planned to operate at the time it is introduced, the technology available and what cost can be afforded. Signalling system capability can be optimised by operating a single class of rolling stock and a standard service pattern. For example, metros tend to have a uniform service pattern, providing high frequency services using a standard type and length of train that is designed for rapid boarding and disembarking of passengers, and some use moving block signalling and automatic operation.

On a mixed traffic railway like most of the GB network, which has some trains at high speed with limited stops, some with lower speed but better acceleration, and some with lower speed and lower acceleration, signalled capacity tends to be a compromise between these different uses, especially with the existing fixed-position lineside signalling.

A theoretical maximum capacity can be calculated by assuming uniformity of stopping pattern and rolling stock, but in practice this is unachievable on a mixed traffic railway and in any case ignores whether there is sufficient demand to justify such a level of service.

A further complication is the location and type of junctions and crossovers, whether they are for diverging routes or for changing from one line to another on the same route. The design of these is important (e.g. flat junction vs. grade separated junction), capacity being reduced with every conflicting move and for every junction requiring a speed which is lower than the normal line speed. On high capacity railways like metros, there might only be cross overs at the terminus at either end – although there are cross overs which are not in everyday use, for engineering work or emergencies – whereas mixed traffic railways generally require more junctions and crossing capabilities.

Any piece of infrastructure that requires a change of speed will eat into capacity, whether that is a junction, station or a curved piece of track requiring a speed restriction. A recent example is station calls at West Ham on the Southend/Tilbury/Fenchurch Street route which could not be timetabled until the signalling system was adapted to accommodate them without a reduction in train throughput.

If there is insufficient space to allow a faster train to overtake a slower train, e.g. a long-distance passenger train to overtake a freight train or stopping train, that can also affect capacity, though it would be possible to increase the throughput of trains if everything ran at the speed of the train which most closely matched the signalling capability.

These infrastructure constraints are fixed for relatively long periods (e.g. mechanical signal boxes have an extended/indefinite asset life whilst most relay-based signalling installations experienced more than 30 years of working life[14]), generally only being altered at the time of renewals or when there is a business case for upgrade. Whilst infrastructure with a shorter asset life has a higher whole life cost, it does enable modern technology to be implemented sooner than if the asset life was longer. For the purposes of this study, we have excluded infrastructure changes, as our focus is on what might be done without such changes, though we recognise that in some circumstances infrastructure change may provide better value for money.

[14] Signalling Review: final conclusions of the medium-term review (ORR, December 2005)

3.1.2 Termini

The ability to accommodate trains at the beginning and end of their journey is often one of the key limiting factors in the number of services that can be operated. This is not just an issue at 'dead end' termini such as London Charing Cross but also at otherwise through locations where following trains need to overtake, requiring bay platforms or turnback facilities, such as at Reading.

Platforms at terminal stations have different characteristics and not all platforms are suitable for all trains due to their length, the servicing required at them (e.g. water or catering supplies), loading gauge and traction type (electric or diesel). This places an additional constraint on the ability to accommodate services.

Termini combine the capacity issues arising from the junctions immediately outside – which are required to access the platforms – with whether there are sufficient platforms of the right type. The layout and signalling of these junctions can be critical to the capacity of the terminus.

As with infrastructure, this study does not address physical issues which can only be changed infrequently. We use the case studies of East Coast Main Line and Bristol Temple Meads (which in effect is treated partly as a terminus) to assess possible forms of terminal capacity improvement.

3.1.3 Rolling stock

The theoretical maximum number of paths assumes that all services are operating with the same rolling stock. In practice, along a line of route there is commonly a mix of types of trains with different top speeds, acceleration/braking characteristics, train length and speed of the door opening mechanism. For example, longer trains take more time to clear sections to allow the signal to be cleared for the next train.

Furthermore the passenger-carrying and freight load capacity of a route may be limited by the available rolling stock. There may be infrastructure capability to have more trains or longer trains but insufficient rolling stock (or types of rolling stock with the relevant performance characteristics) available to make use of it.

3.1.4 Operating rules and practices

Network Rail's Timetable Planning Rules (TPR, formerly known as the Rules of the Plan) provide the framework within which a timetable is developed. The TPR include the planning headway, junction margins, station dwell times, minimum turnaround times, platform re-occupation times, platform lengths, timing allowances and point-to-point timings.

Network Rail's Engineering Access Statement (EAS, formerly known as the Rules of the Route) provides the arrangements for Network Rail to obtain engineering access to the network.

The TPR could be considered a constraint on using available infrastructure. Some rules are essential to prevent conflicts, whilst others provide time to enable perturbations to be coped with more easily. One way to squeeze more capacity out of the existing infrastructure is by reducing these allowances and sharpening operating practices to reduce perturbations through training and pro-active management. The degree to which there is scope for flexibility within the TPR can vary route by route: there are high frequency routes, for example on the ‘third rail’ electrified network[15], which appear to work with smaller timetable planning constraints (e.g. junction margins) than elsewhere, possibly because high demand has already driven improvements in operating practices.

As an example, turnaround times tend to include an operational allowance to ensure on time departure of the return service. In some locations (e.g. Moorgate) the turnaround time has been reduced by one minute by having a different driver for the return service, who should be at the rear of the inbound train (or waiting on the platform) to offset the time taken for a driver to walk from one end of the train to the other. There also seems to be great variability in turnaround times for inter-city trains. If infrastructure capacity is constrained, then taking up platform time with replenishing a catering facility may not be the most efficient use of that capacity.

We refer in our study areas therefore to these TPR allowances. If there is a capacity constraint then it may be worth reducing the allowances whilst at the same time mitigating the detrimental impact on performance by retraining staff and accepting any residual performance risk as being outweighed by the benefit of the increase in capacity. Although the structure of the industry – where TOCs bear the performance risk (for TOC-caused delays) and Network Rail benefits through the volume incentive – means incentives are not aligned. Areas to investigate would be likely to include management of dwell times at stations, turnaround times and driving technique – particularly in maximising acceleration and braking capability and reversing some of the losses engendered by “defensive driving”. Again though, there are trade-offs here, as efficient use of capacity delivered through the highest performance of the rolling stock (i.e. fast acceleration and maximum braking) may not be the most efficient in terms of energy usage. It is worth noting that defensive driving has been introduced for safety reasons, although the rules vary across operators and so reviewing these may result in opportunities to increase capacity by standardising defensive driving rules.

We use the case study of the East Coast Main Line to assess a reduction in turnaround times at a terminal station, London Kings Cross.

3.1.5 Service patterns

As explained earlier, the greatest infrastructure capacity is achieved where all services have a common service pattern and rolling stock.

On the GB network, a common service pattern with all trains calling at the same stations is more usual in the off-peak. In the peak periods however, compromises are made to maximise revenue whilst still providing a service to lower demand stations and also to try and spread train loadings so that more passengers can be accommodated. This leads to an irregular ‘skip stopping’ service pattern and a mix of origins/destinations.

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[15] Where power is distributed via an electrified rail (the third rail) instead of through overhead line equipment

Where there is a four-track railway, with fast lines and slow lines, there is an easier separation of different service types. However there remain train movements across junctions (to access alternate routes) and weaving from slow to fast lines and back again either to access platforms or to overtake slower traffic. These movements across lines further eat into the theoretical maximum capacity that can be achieved.

Freight loops are a way of holding freight trains from entering congested parts of the network during busy periods, potentially improving the efficient use of the infrastructure. However this has the effect of increasing the freight train journey time, which has associated cost implications and potential logistical difficulties. Also, the increasing length of container trains that operate on the network (and therefore improving train utilisation) means that some freight loops are now not long enough to accommodate them.

In practice, services tend to evolve gradually over time and it is rarely possible to undertake a 'first principles' approach to capacity utilisation because the historic structure of services will itself have created a certain level of demand, in terms of the decisions that people make about where to live and work. This includes a degree of expectation surrounding the origin and destination of services, speed and frequency.

Operators will have been set up to meet this demand and will often be obliged to serve particular markets through their franchise agreements, and to obtain the appropriate track access rights to meet these obligations.

Development of services is therefore generally incremental in nature, retaining existing services with only a limited degree of 'flex' available to accommodate new services. In some cases this has exacerbated the tendency to increase the overall frequency of services, since operators may be reluctant to significantly reduce their existing services to accommodate new ones. For example, when the fast London to Cambridge services were introduced the slow and semi-fast services serving intermediate stations were retained. Also, when more than one operator is involved, one operator's benefit may only be achievable at the expense of other operators irrespective of whether the total size of the rail market increases.

Changes to the mix of service (e.g. a shorter distance service with more stops vs. a longer-distance service with fewer stops, or passenger vs. freight) may lead to a more efficient use of capacity, although the existing franchise agreements do not make adjustments to the current mix straightforward.

This also goes some way to explain and support Network Rail's approach to capacity which is, as described in the RVfM report[16], "a tendency to promote large capital-intensive construction solutions to capacity issues, when other solutions may be more efficient". However, a report by Ofwat into capex bias across the regulated utilities[17] noted "capex bias appears to be less of an issue in the postal and rail sectors."

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[16] Realising the potential of GB rail – Detailed report (page 260)

[17] Capex bias in the water and sewerage sectors in England and Wales – substance, perception or myth? A discussion paper (Ofwat, 2011)

Having said that, increasing service frequency drives up demand, potentially at the expense of performance[18]. Increased frequency may be inefficient, in terms of train capacity, in the short-term but in the longer-term can lead to greater efficiency in terms of train utilisation. That is, two 5-car trains rather than one 10-car train per hour may initially seem inefficient, in terms of train capacity and the economy, requiring a separate crew and using another path. However, if it stimulates growth and more revenue and if, eventually, it leads to the requirement for two trains which are in total longer than the alternative use then that is potentially efficient in terms of train capacity and the economy.

We use the case studies of the Great Eastern and the East Coast Main Line to assess the possibilities of recasting services to maximise use of network capacity. To test the effect of substituting a more valuable service for another lower value one we use the South Humberside study.

3.2 Efficient allocation and use of capacity

In this study we have defined efficiency in three ways to capture the differing effects of actions on different parts of the industry and the wider society:

- Efficient for the network owner: By considering the notional objectives of a network owner, this means maximising the return on capital by achieving the maximum utilisation that the infrastructure allows. This focus is relevant in the context of the periodic review.
- Efficient for the rail industry (profit maximisation): By this we mean taking into account all the industry's costs and revenues including TOCs, FOCs, rolling stock leasing companies (ROSCOs) and Network Rail. This is the focus of the RVfM report and recognises that what is efficient for Network Rail may not be efficient for everyone. It is also possible that, given the industry structure and the flow of payments, efficiency for the industry as a whole may be costly for one particular company within it. This measure also recognises that unless the services are attractive, industry efficiency may be reduced by changes to increase capacity.
- Efficient for society and the economy: By this we mean taking into account the wider impact of the changes proposed on the economy and society and recognising that the Government and others contribute to subsidise the industry because of these wider benefits (such as journey time benefits, modal shift, crowding relief, agglomeration). So what might not be efficient for Network Rail or the industry might still be efficient in these broader terms, i.e. can the change to the service generate a positive BCR compared to the status quo? However, there is a caveat in relation to this efficiency as to whether it is affordable, as is implicit in the Statement of Funds Available (SoFA) approach.

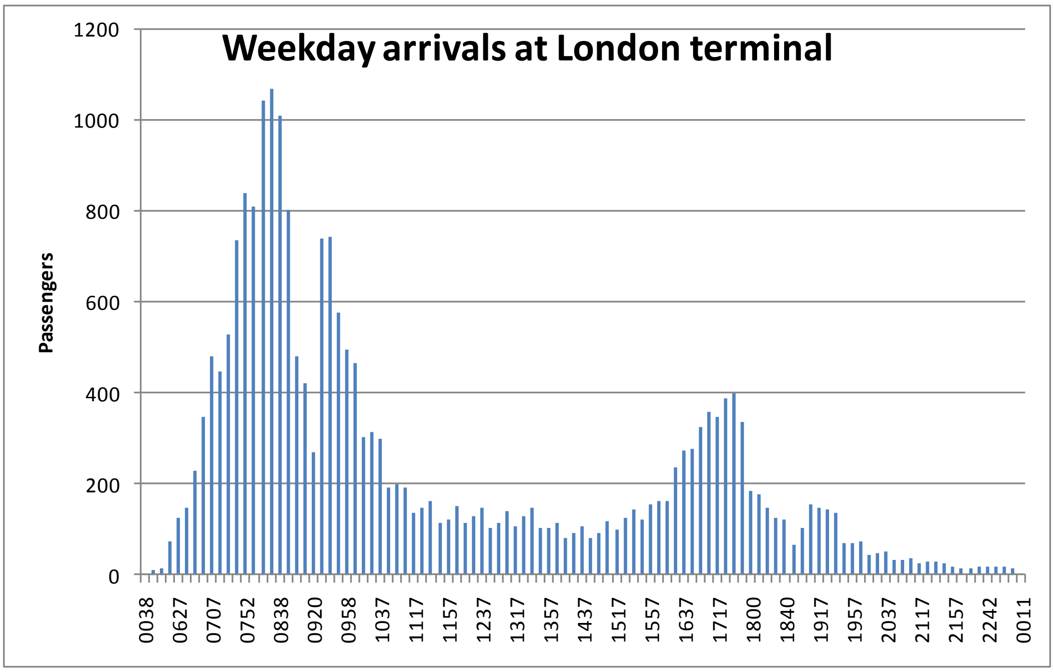
We use these efficiency tests to establish, largely qualitatively for this study, whether the studied changes are likely to be more or less efficient than the present situation.

[18] For example, on a South East flow towards London with three trains per hour and a station to station journey time of 30 minutes, increasing frequency to four trains per hour would increase demand by around 9% however if this change also increased average lateness by one minute demand would be reduced by 5% (source: PDFH analysis)

3.3 Demand

Passenger demand for services varies across the time of day, with train utilisation (load factor) also varying considerably. Figure 4 shows the modelled number of passengers by time of arrival into a London terminal on a weekday[19]. This shows the surge in demand after the commencement of the off-peak period at 0930, creating a second peak. A tapered fares structure might help to smooth demand, and some operators including South West Trains have introduced super off-peak tickets to try and address this by offering a reduction in price compared with off-peak tickets for travel during the quietest times of the day.

Figure 4: Profile of weekday arrivals at a London terminal by time of day



The attractiveness of the service, in terms of its journey time and arrival time at key locations, is the key determinant of individual train loading. Services that are less attractive will be more lightly used even in the peak although, purely in terms of train capacity, even these services can be heavily loaded if the train formation is shorter. Each route will be most efficiently used from a network perspective when the longest possible trains are run at the closest frequency. From the industry (financial) perspective, however, those trains need to be attracting greater revenue than the cost of operating them otherwise the cost of rolling stock, staff and fuel might make them inefficient. In practice it is not possible to completely match train length to demand because trains are procured as fleets and multi-carriage units (which can be coupled together to form longer services) and because of rolling stock diagramming constraints where the available fleet of trains must be matched to the timetabled services.

Whilst load factors in the off-peak can be low, the marginal cost of operating the service is also often low: firstly, because the rolling stock is available and would otherwise be stabled at a depot or in a siding, and secondly because the crews would also be idle if the operator could

[19] Source: MOIRA, terminal identity redacted on commercial confidentiality grounds

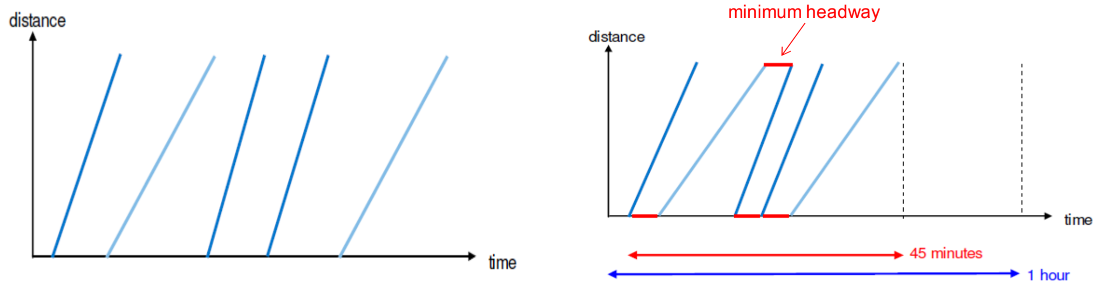
not employ on-train staff on a part-time basis. It is therefore, from an industry perspective, better to run a service in the off-peak if revenues are greater than the marginal cost, subject to there being no competing demand for the path by a train which might have a higher net revenue.

3.4 Capacity and congestion

The GB rail network is generally congested for relatively short periods of the day, at specific locations (in particular around London and other conurbations). Congestion occurs mainly in the peak direction, but there is also some congestion in the contra-peak direction[20] for example as trains arriving into London in the morning peak depart the termini to enable other peak direction services to arrive.

The CUI is one measure of the amount of space that exists in an existing timetable and sequence of services. It is calculated by taking an hour's worth of trains across a section of route and compressing them (moving each service as close to the preceding one as the signalling headway allows, without re-ordering services). The CUI is then the proportion of the hour that is taken up by the timetabled services. A CUI of 75% therefore means that 25% of the hour (15 minutes) is 'headway' between the services – see Figure 5[21]. The CUI measure infers how well a timetable could absorb delays, although it does not consider whether there is the possibility of developing a more efficient timetable.

Figure 5: Calculation of Capacity Utilisation Index



Whilst London commuter services will generally have a high train utilisation (efficient use of rolling stock) and high load factors during the peak (in the peak direction at least), during the off-peak train utilisation and load factors are much lower but, as explained above, the marginal cost of running off-peak services is also low and so operating more off-peak services could be more efficient than leaving trains in sidings. There may not be any other demand for paths at these times, if so the opportunity cost of the capacity would be zero. Additional trains during the peak are difficult to accommodate, and where paths can be found the marginal cost of operating the service tends to be high, due to the cost of additional rolling stock, train crew and increased Schedule 8 costs.

[20] During peak periods, travelling in the opposite direction to the peak flow of passengers
[21] Taken from "Recalculating the Capacity Charge Tariff for PR2008" (Network Rail, 2007)

In that sense inserting additional paths could:

a) make network use more efficient, but
b) reduce efficiency for the industry as a whole due to high operating costs, but
c) for society as a whole, improve efficiency by adding frequency that a funder was prepared to pay for (e.g. for crowding relief, to accommodate growth or agglomeration benefits).

4. Methodology

4.1 Overview

We have used case studies to provide specific examples of the issues surrounding capacity allocation and utilisation. ORR requested that we consider four route types to represent issues across the network as a whole, with at least two of the case studies having significant amounts of freight traffic:

- Long-distance, high value (i.e. high revenue yield);
- London and South East commuter;
- Route into a non-London conurbation; and
- Rural.

The RVfM report suggested that the industry examine whether segregation of service types or homogenisation of train speed, would provide operating, economic and social benefits. In selecting our case studies, we have identified routes where there is a known capacity constraint (ECML south, GE Mainline), where operational requirements constrain capacity (Bristol Temple Meads station) and where high volumes of timetabled freight paths mix with local and inter-urban passenger services (South Humberside). We have examined scenarios where changes could theoretically be made to the existing timetable in order to increase the number of services that can be operated, and tested some of the revenue and economic impacts of making such changes to see whether a positive BCR could be achieved.

4.2 Rationale for selecting the case studies

Table 1 summarises our route case study selection including routes which have significant freight traffic. Note that our routes cover different types of freight including inter-modal container traffic and coal traffic. Inter-modal cargo consists of containers which have been transported by sea to UK ports and are then transferred to rail for onward journeys (or vice versa). These services tend to have a higher path utilisation as port operators are keen to move freight on as additional containers arrive continually. Coal traffic however is less predictable as the power station it is being transported to, and the port from which it arrives, can vary. Power stations also tend to have good stores of coal so there is less time pressure in terms of delivery. Coal traffic therefore has a lower utilisation of paths (and higher levels of short notice trains).

Table 1: Case studies summary

Route type	Route description	Freight traffic
Long-distance high value	East Coast Main Line (South) – Kings Cross to Peterborough	Limited, but has open access passenger operators
London and South East commuter	Great Eastern – Stratford to Colchester	Significant – inter-modal container
Non-London conurbation	Bristol Temple Meads area	Some – mixture of aggregates, coal and metals
Rural	Doncaster (ex station) to Cleethorpes	Significant – coal, inter-modal container, metals, petroleum

More details of the options considered for these case studies are set out in Appendix A.

4.3 Case study methodology

We have identified four case studies which illustrate different parts of the network with differing geographic, service and infrastructure attributes. Using these case studies we examine, illustrate and comment upon how more services could be accommodated, including the potential re-allocation of track capacity as well as comment on issues surrounding the potential impact upon performance, engineering access or rolling stock diagramming, and the value of each service considered. For each of the case studies, we applied the following process.

(1) Summarise the existing position:

- Produce a 'pen portrait' of each case study, assessing the route against the capacity determinants described in section 3;
- Describe the existing services and how they are used (i.e. what is the demand for existing services) – MOIRA[22] forecasts of individual train loads have been used to understand the demand for existing services, but it should be noted that these are modelled and do not include re-distribution as a result of crowding or the impact of differential fares including open access/advance purchase; and
- Review the RUS documents for the study area to understand the current situation vis-à-vis capacity utilisation (not considering future changes unless specifically mentioned).

This provides the context for the study area and highlights which constraints are tested in the particular case study. To illustrate this we use the industry forecasting model MOIRA to analyse the impacts of two timetable changes which set out to increase capacity, the 'Eureka' timetable on the ECML and a timetable re-cast on Great Eastern in December 2004 following the franchise re-mapping. This provided 'before' and 'after' numbers of trains and type of trains, as well as the revenue impacts.

[22] MOIRA is the rail industry's standard demand and revenue forecasting model.

(2) Future potential changes – consider whether improvements can be made to efficiency as a result of changes to:

a) terminal usage;
b) rolling stock usage;
c) operating rules and practices, including engineering access time; and
d) service patterns.

The purpose of this is to understand whether infrastructure or train capacity could be more efficiently allocated within the study area using the method chosen. The scenarios modelled show what changes could be made in order to accommodate additional paths. We then examine whether the intervention to improve allocation and utilisation of capacity (e.g. introducing additional paths) would be efficient. It should be noted that we have not considered whether there is an over-provision of capacity at any time of day.

Using the case studies, where a capacity constraint is identified, we test the following questions, including those points raised in the RVfM report with reference to capacity:

- Is it possible to add additional paths by flexing the current service?
- Are there lightly used trains that prevent higher value paths?
- What would be the effect of a homogenised service?
- Are there shorter or lightly loaded through-services that prevent higher value paths?

(3) Valuation of potential changes – we assess whether changes to any of these would be more or less efficient in the three categories identified (network owner, rail industry and society). For passenger services, demand and revenue impacts have been modelled in MOIRA alongside a cost assessment based on the change in mileage. Forecasting revenues for freight services is complex so freight services are assumed to generate sufficient revenue to cover their costs, otherwise they would not operate.

The economic value of paths was measured by applying the change in Generalised Journey Time (GJT)[23] from MOIRA to the appropriate values of time for passenger trips in WebTAG. In the time available we have not been able to quantify all economic benefits such as changes to crowding levels, modal shift or agglomeration benefits, therefore these have been considered qualitatively. For freight the economic value of additional paths are modelled using the DfT's Mode Shift Benefit (MSB) values, which have replaced Sensitive Lorry Miles (SLM) as a means of capturing the impact of transferring freight from road to rail. The combined revenue and economic values are then put in the context of estimates of train operating costs. We have not been able to calculate a BCR at this stage, however the estimate of the magnitudes of potential costs and benefits imply whether a positive BCR could be achieved given more detailed analysis.

[23] Generalised Journey Time (GJT) is a function of in vehicle time, waiting time, frequency, interchange, access and egress times

There is therefore a three-stage process – assessing first the impacts on Network Rail, then the financial impacts on the rail industry and finally the economic benefits.

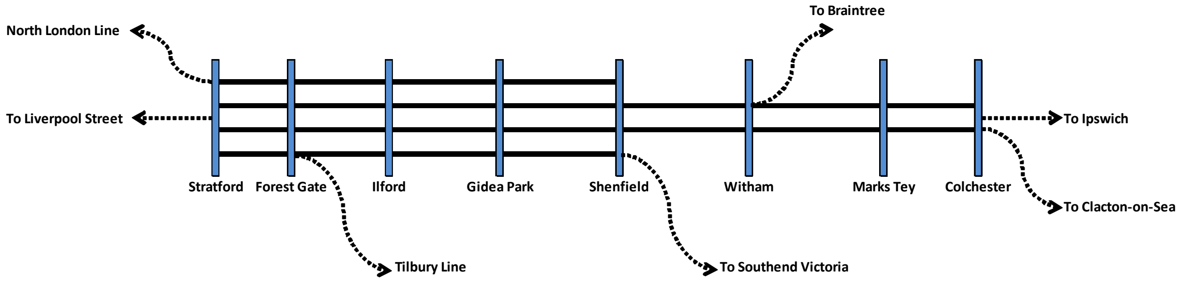
It is important to note that the scenarios modelled in the case studies are theoretical and have not been subject to a detailed operational assessment or modelling. The scenarios are intended to illustrate what changes could be made in theory, however we are not recommending any course of action for any specific route. This study is not intended to reproduce the level of detailed analysis which is carried out as part of the RUS process or for specific timetable changes.

5. Case Study 1 – Great Eastern Main Line

5.1 Route overview

The London and South East commuter case study covers the section of the Great Eastern Main Line (GEML) between Stratford and Colchester. The GEML is a four-track railway with two fast lines (Main Lines, MLs) and two slow lines (Electric Lines, ELs) between Stratford and Shenfield and then two tracks between Shenfield and Colchester. Figure 6 gives an overview of the track layout and more details about the infrastructure and rolling stock along the route can be found in Appendix B.

Figure 6: Track layout for GE Main Line case study



5.1.1 Service patterns

All regular passenger services are currently run by a single operator, Greater Anglia (Abellio). On the ELs, passenger trains are predominantly local, stopping services operating between Liverpool Street and Shenfield, also known as the 'GE Inners'. These will become part of the Crossrail operating concession from 2015. Passenger trains on the MLs are predominantly longer-distance fast services, to Southend, Braintree, Colchester, Clacton, Ipswich and Norwich, with limited but varying stopping patterns.

The GEML is a major freight route, in particular for international, inter-modal container traffic travelling between Felixstowe port and the North London Line for onward travel to the midlands and the north. Freight trains currently operate outside of the peak periods for passenger traffic. The Felixstowe/Nuneaton upgrade project is intended to support increased freight demand from Felixstowe to the midlands, avoiding the GEML and London.

5.1.2 Planned use of train paths

The Greater Anglia RUS in 2007 showed the peak CUI between Shenfield and Liverpool Street as being 90% or higher, and for Colchester to Shenfield it was 70-90%.

Figure 7 shows the number of train paths in the morning and evening peak hours between Stratford and Colchester. There are no freight trains during the peak hour, and the maximum number of paths achieved is 38 tph between Ilford and Stratford in the morning. Beyond Shenfield there are fewer paths as the route goes from four-track to two-track. Some services terminate at Shenfield and some go on to the Southend route.

Figure 7: Timetabled paths between Stratford and Colchester during peak periods

Looking at the mix of services on the fast (ML) and slow (EL) lines as shown in Figure 8, the ML lines get closer to their theoretical maximum than the ELs. This could be because services have limited stops within our case study area and are relatively homogeneous. In the morning peak between Chelmsford and Shenfield there are 16 paths out of a maximum possible of 20. The services on the EL lines have a range of origins/destinations (Ilford, Gidea Park and Shenfield) and do not all stop at the same stations. This variation in service pattern uses up track capacity.

Figure 8: Split of train paths on EL and ML lines during peak hours

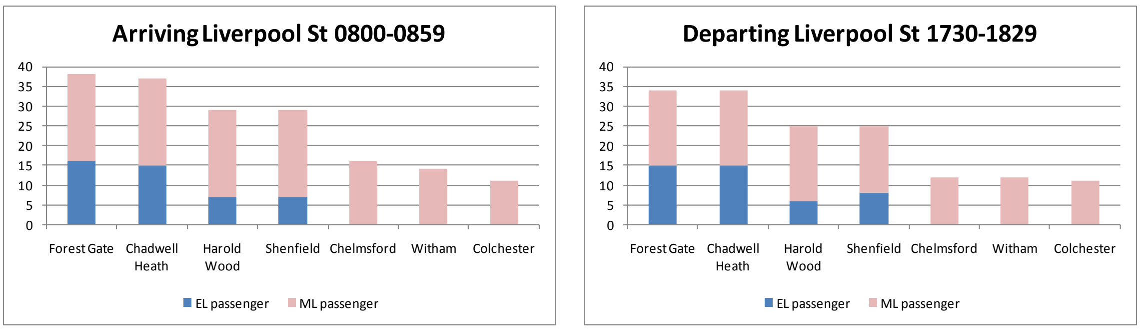


Figure 9 shows the number of train paths during an off-peak hour (1200-1259 in the 'Down' direction, i.e. departing London). The levels of freight vary by time of day, day of the week and time of year but are on average two or three paths per hour.

Figure 9: Timetabled paths from Stratford to Colchester during off-peak

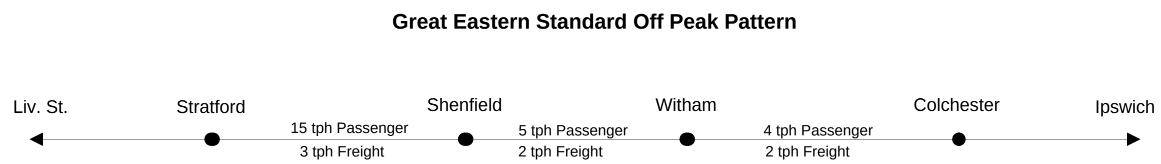
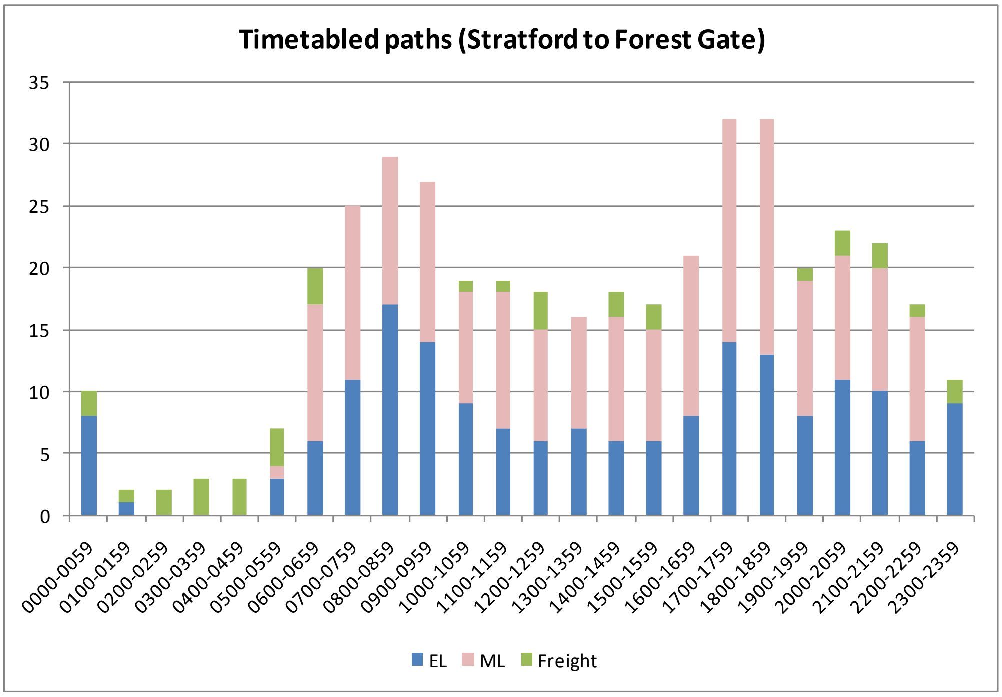


Figure 10 considers one small section of the route from Forest Gate to Stratford. This was chosen because it is the section within the case study area that has the highest levels of traffic. The chart below shows the number and type of trains, by hour of day, for a Wednesday during the winter 2011/12 timetable in the Down direction (departing London). It shows the increase in train movements during the peak periods, with higher utilisation during the evening peak to match commuting demand out of London.

Figure 10: Timetabled paths from Stratford to Forest Gate (Down direction) by time of day



The Public Performance Measure (PPM Moving Annual Average, Period 1 2012/13) shows the proportion of trains which arrive 'on time'[24] and was 92.1% for "Southend and Metro" services (including ELs to Shenfield) and 86.7% for Mainline services (Main Lines to Chelmsford, Colchester, Ipswich and Norwich)[25].

5.2 Freight path usage

The ORR requested that we look specifically at the usage of timetabled freight paths. The majority of trains on the route are inter-modal flows to/from Felixstowe. The take up of train paths on these services was in the region of 90% over the 11 week period from 2 January 2012. There are, however, variations within the inter-modal traffic. Some paths are not used at all, for example the 4L27 Wembley to Harwich path, and we understood this flow has now ceased. Other inter-modal flows, e.g. 4L74 Birch Coppice (near Tamworth) to Ipswich, ran on only one occasion whereas 4L77 Lawley Street (Birmingham) to Felixstowe is in the working timetable (WTT) as a "Fridays Only" service but ran twice as many services. This demonstrates that, whilst the levels of path take up by inter-modal trains is generally higher than other flows, there

[24] Within 5 minutes of arrival time for London & South East or Regional services and within 10 minutes for Long Distance

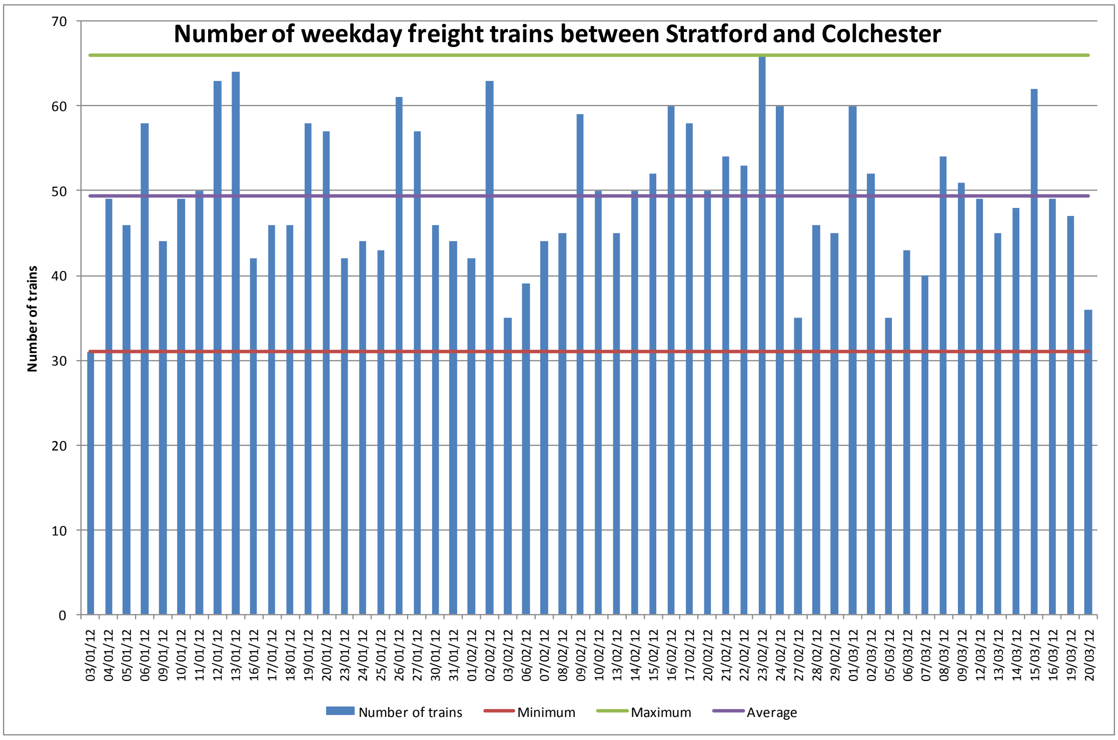
[25] http://www.networkrail.co.uk/aspx/742.aspx (sub-operator performance, accessed 12 June 2012)

is still a degree of variation managed through the short-term planning process to deal with customer requirements.

Other services such as the nuclear traffic between Sizewell, Southminster and Sellafield run very infrequently, in the case of the former around 20% of the planned services and the latter no occasions at all. The Marks Tey Tarmac trains have a low utilisation despite being in the WTT as Monday to Friday (SX) paths. See Appendix C for a detailed breakdown of utilisation by train headcode and train type.

Figure 11 shows the number of freight trains operated by day along the route (in both directions) over the 11 week period. Note the day with the lowest traffic was the first day after the Christmas holidays. The number of freight trains timetabled varies by day and by time of year, but for a Wednesday in the winter 2011 timetable, there are 70 timetabled freight paths per day – 35 in each direction. Some of these timetabled paths will not be taken, and in addition to the timetable there will be short-term planned freight with the net utilised position (on average over the period) 49 paths per day, with a standard deviation of 8.3. We understand that some of this variation was due to an overnight diversionary route being in place three days per week for part of this period.

Figure 11: Number of weekday freight trains run between Stratford and Colchester



Weekday actual freight movements – an average of 49 trains per day – contrasts with weekend freight movements where, on the days when freight trains do operate, there is an average of 12 trains per day (Figure 12). Network Rail possessions are widespread at the weekend for infrastructure maintenance which restricts freight train operations. Demand for freight paths is much lower at weekends, although it is not clear whether the reduced rail access opportunities contribute to this lower demand. Possessions elsewhere on the network are also likely to have a significant impact on freight as compared to passenger traffic on this route.

Figure 12: Number of weekend freight trains run between Stratford and Colchester

One market that has been growing over the last few years is freight traffic for the retail sector. The key requirement for this sector is 'just in time delivery' of perishable goods to key locations throughout the UK. The modal shift of this business to rail has been as a result of increases in the cost of oil and the impact of various working time directives affecting lorry driver hours. The advent of double-deck trailers and the campaign for longer, heavier lorries is a continuing threat to this traffic and the need for rail to have access to the network on a 24/7 basis is seen by all of the freight operators as essential to the long-term security of this business.

Freight customers have told ORR they would value a railway available for freight traffic seven days a week[26]. As part of this study we asked rail freight operators for their views[27]:

- "[name of the freight operator] definitely needs to increase, even further, its number of Saturday and Sunday services to satisfy the market, however, the lack of regular and predictable weekend railway access is what's stopping us from committing to some of this new business."
- "7 day railway availability would enable rail to increase its market share versus road and therefore overall would not reduce the requirement for paths Monday to Friday, as it would generate the need for additional paths."
- "7 day railway is an absolute prerequisite in order for rail to win new business and compete effectively with road. The major retailers – Tesco, Asda, J Sainsbury, Morrisons and M&S all use rail as part of their supply chain to some extent but the inability to offer a 7 day service is restricting growth."

[26] For example GB Railfreight response to ORR PR13 consultation on incentives (http://rail-reg.gov.uk/pr13/PDF/pr13-incentives-response-gb-rail-freight.pdf)

[27] Source: emails to SKM Colin Buchanan from DB Schenker, Freightliner, GBRf

- "Given that the UK road network is open 24/7, in order to compete, rail freight operators also need to be able to offer delivery schedules at weekends where required by the customer. This would include long-distance traffic requiring delivery early Monday morning or despatch late Friday night. A major barrier faced by rail freight operators in this respect relates to Network Rail's weekend engineering possessions and the limited availability of suitable diversionary routes."

5.3 Trains and loadings

Table 2 shows train services and loadings for this route as modelled by MOIRA. Liverpool Street has been chosen as a location for loading data because not all services stop at Stratford, and all GE services to Liverpool Street will pass through our study area. GE Metro is defined as the 'Inner' services which terminate or begin at Shenfield, Gidea Park or Ilford. GE Mainline is defined as all services operating beyond Shenfield. The values shown in the table are the number of people arriving or departing on the services as appropriate.

Table 2: Weekday modelled train loadings at London Liverpool Street (GE only)

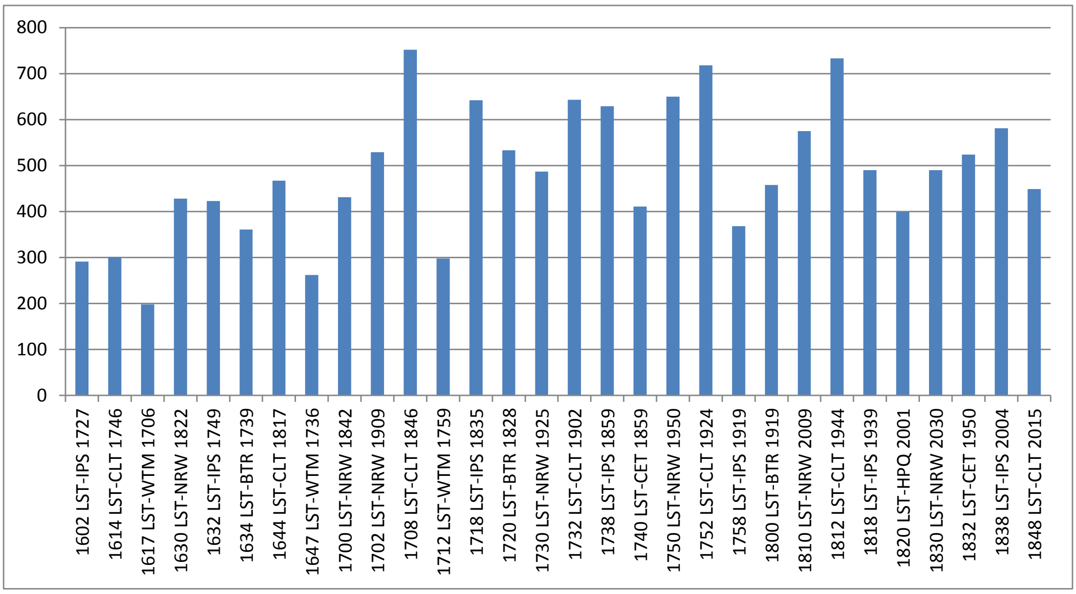
	All Day	AM Peak	PM Peak	Off-Peak/ Contra-Peak
Number of services	**637**	**89**	**86**	**462**
GE Mainline	377	53	50	274
GE Metro	260	36	36	188
Number of passengers	**122,321**	**43,210**	**37,397**	**41,714**
GE Mainline	74,830	24,809	21,719	28,302
GE Metro	47,491	18,401	15,678	13,412
Average loadings	**192**	**486**	**435**	**90**
GE Mainline	198	468	434	103
GE Metro	183	511	436	71

Source: MOIRA, AM peak defined as 0700-1000, PM peak defined as 1600-1900 (peak direction only).

Peak period loadings are particularly high, although an 8-car Electric Multiple Unit (EMU) has 600-640 seats depending on rolling stock type (see Appendix B). Off-peak and contra-peak loadings are light, particularly on the GE Metro services where the average modelled load is 71 per train.

Within the average loadings there is considerable variability even during the peak, as shown in Figure 13. The 1708 Clacton service has a very high loading – over 700 passengers – it runs fast from Stratford to Chelmsford, followed by a stop at Witham. This service is followed by the 1712 Witham service which has the same stopping pattern (with an additional stop at Hatfield Peverel), but has less than half of the number of passengers of the 1708 service. While there are two paths being used here, the train utilisation as a result of the stopping pattern is not efficient, with the bulk of the demand on the 1708.

Figure 13: Average modelled passenger loadings departing Liverpool Street during the PM peak



Source: MOIRA

Table 3 below shows the number of trains by time period with different levels of loading. This highlights the variability of loadings and reinforces the RVfM conclusion that demand during the peak is heavily concentrated during a high-peak hour and there is more scope for accommodating demand outside of this period.

Table 3: Modelled train loadings at Liverpool Street during PM peak period

Number of services	1600-1659	1700-1759	1800-1859
700+ passengers	0	2	1
600-699 passengers	0	4	0
500-599 passengers	0	2	3
400-499 passengers	3	3	4
<400 passengers	4	2	1
Average load (3hr peak)			**435**

Source: MOIRA

5.4 Demand for more paths

Following the implementation of Crossrail there will be a significant increase in capacity on the GE Metro services. The London & South East RUS forecasts passenger growth of nearly 50% on Main Line services by 2031 and proposed the use of the two additional lines between Stratford and Liverpool Street that will be released as a result of trains currently using the ELs operating through the Crossrail tunnels. This could deliver 28tph on the Up Main Line from Shenfield to Stratford according to the RUS.

Inter-modal freight demand continues to grow and, in particular, traffic from the Port of Felixstowe where work started in March 2012 to construct a new North Rail Terminal. The Greater Anglia RUS forecasts 30 deep sea inter-modal trains per day from Felixstowe to Stratford and the North London Line by 2023, even with the introduction of the Felixstowe-Nuneaton line upgrade. This compares to an average of around 14 paths per day from Felixstowe towards London in our freight data sample. The opening of the London Gateway port in late 2013[28] will lead to an increase in freight traffic through Forest Gate Junction and Stratford unless the line between Tottenham & Hampstead is electrified.

5.5 Possible capacity and congestion relief measures

This section considers a number of scenarios where additional track capacity (train paths) can be provided, and the potential impacts of the timetable changes that are required to achieve these. Note that, apart from the historical example, these are theoretical and have not been subject to detailed operational feasibility assessments.

5.5.1 Historical analysis of a change of service pattern

In December 2004, the Greater Anglia operator at the time, National Express, introduced a new timetable following the franchise re-mapping which combined the West Anglia, Great Eastern and Anglia Railways franchises in April 2004.

Before the timetable change (September 2003), there were 22 paths on the Main Lines into Liverpool Street in the morning high-peak hour from 0800-0859. Following the change, this reduced to 20 paths. The concept was to operate fewer services that were longer and faster. The result was that the number of trains which were operated reduced, the number of station stops reduced from 182 to 171 and, although the revenue generated per path increased from £4,367 to £4,779 (source: MOIRA), the total revenue was essentially unchanged.

Using our three efficiency tests this:

a) reduced the efficiency of the network (fewer trains on a network that could take more),
b) increased the efficiency of the industry (cost of labour, fuel and rolling stock reduced outweighing reduction in revenue), and
c) probably had no impact on societal efficiency.

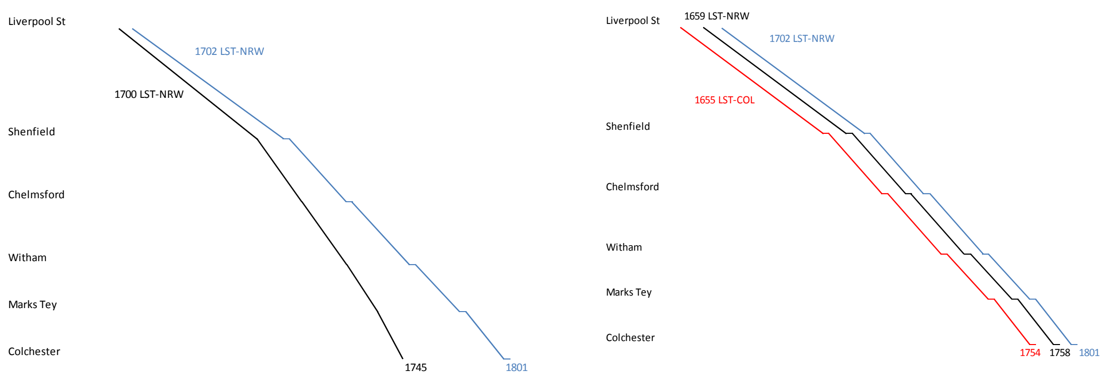
However, in the longer-term, this provided room to enable additional paths to be added back in the future (there are 22 paths in the current timetable) which is more efficient for the network and probably also for society.

[28] http://www.londongateway.com/ (accessed 12 June 2012)

5.5.2 Additional ML service during the evening peak

Examination of the timetable for the evening peak showed a fast Liverpool Street to Norwich service occupying multiple paths. By changing the 1700 Liverpool Street to Norwich service to run one minute earlier and call at Shenfield, Chelmsford, Witham, Marks Tey and Colchester, it is possible to insert an additional service to Colchester departing Liverpool Street at 1655 and calling at the same stations. Figure 14 shows these trains before and after the change. The black line shows the fast 1700 service and the red line shows the new 1655 service.

Figure 14: Train graph for Stratford to Colchester in the evening peak



These changes to the timetable were run through the MOIRA model to estimate the overall impact on passenger demand and revenue. The analysis showed that there would be an increase in passengers (1,486 on the three services compared to 1,125 on the original two) however there was a slight overall reduction in revenue of £23k per year. This was due to an increase in short-distance, low-yield flows whilst deterring passengers on long-distance, high-yield flows. The operating cost for the service is in the region of £100k per year[29], compounding the impact of the reduction in revenue.

Using our three efficiency tests:

a) network capacity is being more efficiently utilised as there are more trains operating on the network, but
b) there is a reduction in revenues as a result of fewer people travelling to Norwich, Ipswich and Diss, and train operating costs are higher (additional rolling stock and train crew) so it is not efficient from an industry perspective, but
c) what this scenario does achieve is an increase in the number of passengers (360 per day) that can travel from Central London during the peak period which could lead to agglomeration benefits assuming capacity is available in the morning peak to accommodate these additional passengers. However, the loss of revenue and additional operating costs will likely outweigh these additional benefits.

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[29] Using £7.50 per mile for an 8-car EMU, SKM/GHD estimate based on experience.

5.5.3 Homogenisation of service patterns to increase peak services

More efficient use of the network could be achieved by providing services at regular intervals that have the same calling pattern. We have investigated the potential impacts of a homogenised service on the ELs and MLs during the evening high-peak hour.

In order to contain the number of variables we have done this on the basis of the TPR time allowances. Although the planned signalling headway is 2 minutes, because of platform re-occupation times we have investigated a 3 minute service frequency, providing 20 tph on both the ELs and MLs. However this could only be achieved if crossing moves were prevented, which would mean the removal of direct services along the Southend Victoria branch (as this requires conflicting moves at Shenfield). A shuttle service was therefore included for the Southend Victoria branch to connect at Shenfield.

Because more trains are operated, it is more efficient for the network. For the industry, because demand falls on the long-distance, high-yield flows, there is an overall revenue loss. Some stations do benefit from the change (Chelmsford, Shenfield, Ingatestone and Forest Gate in particular) but the overall impact is substantially negative, losing £1.2m per year. If services on the main line stopped at one of Ingatestone, Hatfield Peverel and Kelvedon – instead of all three – the negative impact is reduced but it is still significant, losing £0.8m per year. Operating costs are also increased because more trains are required, therefore this is not efficient for the industry.

Alternatively, if the ML services are kept as in the current timetable and the EL services are homogenised to achieve 20tph, the overall revenue impact is positive – an increase of £171k per year – because the impact on journey times is smaller and some poorly served locations are being served more regularly.

Table 4 below shows the revenue impact as a result of an all-stations peak hour stopping service on the EL lines, whilst keeping ML services as they are today.

Table 4: Revenue impact of 20tph all-stations EL service

Location	Revenue impact (£k pa)
Forest Gate	51
Brentwood	48
Harold Wood	29
Manor Park	22
Goodmayes	14
Seven Kings	11
Ilford	-20
Romford	-27
Other flows	43
Total	**171**

However, this is before the additional cost of providing the service has been considered, which is estimated as £740k per year due to extra rolling stock and crews required, or whether the additional services could be accommodated at Liverpool Street or Shenfield terminal stations.

Analysis of the GJT impacts of the change shows that there would be an economic disbenefit of £1.1m per annum, therefore significant crowding relief or agglomeration benefits (not quantified) would need to be generated in order for it to outweigh these benefits and be efficient for society.

So under our efficiency categories this would:

a) be more efficient for network as more services could be operated;
b) less efficient for the industry due to operating costs exceeding revenue increases; and
c) is unlikely to be efficient for society due to the large GJT disbenefits.

Nevertheless, over time it could become efficient for the industry as demand grows. Current load factors probably do not require a 20tph service, however as demand is forecast to grow significantly on the EL services (63% to 2031 according to the London & South East RUS) enabling extra trains to run during the peak is likely to become more important in terms of accommodating additional demand. Table 5 below shows the top four EL services in terms of forecast demand in 2031 with the existing and homogenised timetable although note that MOIRA is not able to crowd passengers off of services in the current timetable.

Table 5: Impact of 20tph all-stations EL service on demand in 2031

Service (current timetable)	Forecast Load (2031)		Service (homogenised timetable)	Forecast load (2031)
1717 LST – SNF 1759	1437		1730 LST – SNF 1813	870
1707 LST – SNF 1749	1201		1745 LST – SNF 1828	853
1727 LST – SNF 1809	1197		1700 LST – SNF 1743	843
1746 LST – SNF 1829	1046		1715 LST – SNF 1758	841

An 8-car EMU has around 600-640 seats so 12-car EMUs (900-960 seats) would be required in 2031 with the current timetable to accommodate additional demand (which may require infrastructure enhancements such as platform lengthening) and even then load factors could be up to 150%. With a homogenous timetable, 8-car EMUs would operate at a similar load factor (150%) to 12-car services on the current timetable potentially saving infrastructure costs, as well as lease costs of additional vehicles.

5.5.4 Additional freight path during the off-peak

Analysis of the WTT has shown that an additional freight path can be provided in the off-peak. The additional path is exactly half an hour earlier than the 4M93 Felixstowe to Lawley St path. No changes were made to surrounding services as there were no obvious conflicts present from analysis of the train graph printout provided to us by Network Rail. There are potentially some minor timing changes that would be required to a passenger service terminating at Colchester.

We have identified this path within the study area and we have not examined whether it can be accommodated elsewhere on the network.

Utilisation of container paths on the GE Main Line is high (90%) and there is continued growth in container traffic from Felixstowe, so it is assumed that if a path can be found then it would be taken even with the availability of paths on Felixstowe/Nuneaton. Using an exemplar freight path of Felixstowe to Lawley Street[30] we have estimated the economic value of containers travelling by rail instead of road. One freight path is equivalent to 60 lorry trips[31] and this has been valued using freight MSB values as being worth around £6,500 in 2010 prices. Over the course of a year, one path running five days per week operating at 90% utilisation, the path could be worth in the region of £1.5m of economic benefits, excluding revenues for transporting freight which are assumed to cover the costs of operating the service plus the profits for the FOC. Under this analysis under all our efficiency scenarios it is always efficient to run an additional freight train where there is demand for it (unless long run track costs become excessive).

5.5.5 Trade-off between off-peak passenger services and freight services

We investigated the potential trade-off between off-peak passenger services and freight within the study area. If freight demand reached a point in the future where there were no additional paths available in the off-peak, we tested the impact of removing the 1252 Ipswich to London Liverpool Street service and replacing it with a freight path as a theoretical assessment of what the trade-off might be. We have assumed that timetable adjustments would be possible to even out the passenger off-peak service, and have applied a factor to reduce the revenue impacts accordingly, however we have not attempted to re-cast the timetable.

Using MOIRA, we estimate that the revenue impact of removing this one service would be a loss of £54k per year. The economic disbenefits associated with increasing passenger journey times (forcing some passengers to wait longer for a train) would be -£130k per year. As off-peak services are provided using spare rolling stock and train crew, we have not assumed there would be a cost saving from withdrawing this service.

As shown above, a container freight path on this route could deliver economic benefits of £1.5m per year if it can operate at 90% utilisation. Even if the path was 50% utilised, the economic benefits would be worth around £0.8m per year. This is significantly more than the revenue and GJT disbenefits associated with the removal of the off-peak passenger service, although we have not assessed any disbenefits associated with passenger services outside of our case study area.

This suggests that, for this case study, it is more efficient for society to operate freight services than off-peak passenger services if demand for freight reached a level where there were no more freight paths available.

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[30] Freight path 4M93 (Monday to Friday), was used 55 days out of 56 over the 11-week period

[31] Source: Value and Importance of Freight, Network Rail (July 2010)

5.6 Summary

The capacity on this route is heavily utilised by passenger and freight services in both peak and inter-peak periods. Peak period passenger demand justifies an intensive train service which has been developed to provide both frequent and fast services to a wide range of destinations. While economically efficient (in terms of time savings to passengers) this is inefficient in terms of capacity utilisation. An intensive peak period service in turn leads to a fairly intensive off-peak service as the marginal cost of running these services using existing rolling stock and train crew (given the very limited use of part-time working for these staff) is low. The intensive off-peak service then reduces the availability of paths for freight services.

Capacity on this corridor could be increased for passenger services in the peak by greater homogeneity of services, that is trains having similar stopping patterns, and in the off-peak for freight by either flexing a passenger service slightly so it no longer runs in a standard pattern or by replacing a passenger path with a freight path.

The result of our analysis shows that considerable additional passenger capacity can be provided by running a more homogeneous service but at present the economic benefits of doing so are outweighed by the disbenefits of longer journey times for some users. However, as demand increases these disbenefits are far lower than the capital cost of new infrastructure that would be required to accommodate more trains.

The additional freight path that could be achieved by slightly flexing a passenger service brings considerable economic benefits which outweigh the marginal disbenefits from re-timing the passenger service. In terms of replacing a passenger path with a freight path in the off-peak there is a clear economic benefit of doing so if, as in this case, we are assuming the freight path will be taken up with a high value, well utilised inter-modal container service.

In summary, therefore, this case study supports McNulty's comments that more capacity can be obtained from the existing infrastructure, negating the need for expensive capital projects but this will be at the cost of slower journeys for some passengers. It also supports the case for removing less heavily used passenger services in the off-peak if they are constraining the growth of freight services on this corridor, albeit we have not assessed whether suitable paths are available along the full route for freight traffic outside of the study area.

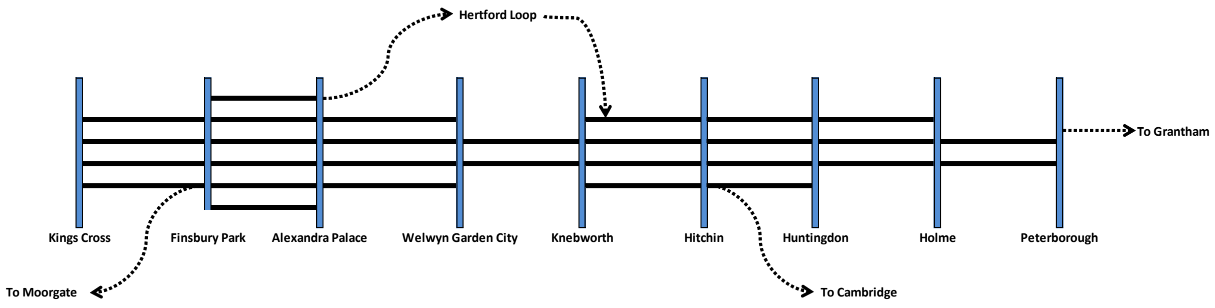
6. Case Study 2 – East Coast Main Line (South)

6.1 Route overview

For the long-distance, high value case study we examined East Coast Main Line (South). The study area is defined as the route between Kings Cross and Peterborough. In this study our main focus is on the long-distance, high value services. We are not explicitly looking at local and commuter services, for example, on the Hertford Loop between Alexandra Palace and Stevenage via Hertford North, or the branch to Moorgate from Finsbury Park or to Cambridge, although this case study does make reference to services which operate over these routes.

The route is predominantly four-track between Kings Cross and Huntingdon with a two-track section between Welwyn Garden City and Knebworth over the Welwyn Viaduct. After Huntingdon, there are two tracks in the northbound (Down) direction but only one track in the southbound (Up) direction for approximately ten miles, after which it becomes two-track. Figure 15 shows a simple track layout for the route and more details about the infrastructure and rolling stock along the route can be found in Appendix B.

Figure 15: East Coast Main Line (South) track layout



6.1.1 Service patterns

There are two franchised operators – East Coast and First Capital Connect (FCC) – as well as open access operators Hull Trains and Grand Central running services out of Kings Cross station. East Coast operates long-distance services, some of which call at Stevenage and Peterborough, using a mix of electric and diesel rolling stock. FCC operates a mixture of fast services (to Peterborough, Kings Lynn, Cambridge) and stopping services (to Welwyn Garden City, Letchworth) through the case study area using electric rolling stock. Hull Trains operates diesel trains from Kings Cross to Hull, calling at Stevenage to pick up or set down only. Grand Central operates diesel trains from Kings Cross to Bradford and Sunderland, not calling at stations in this study area.

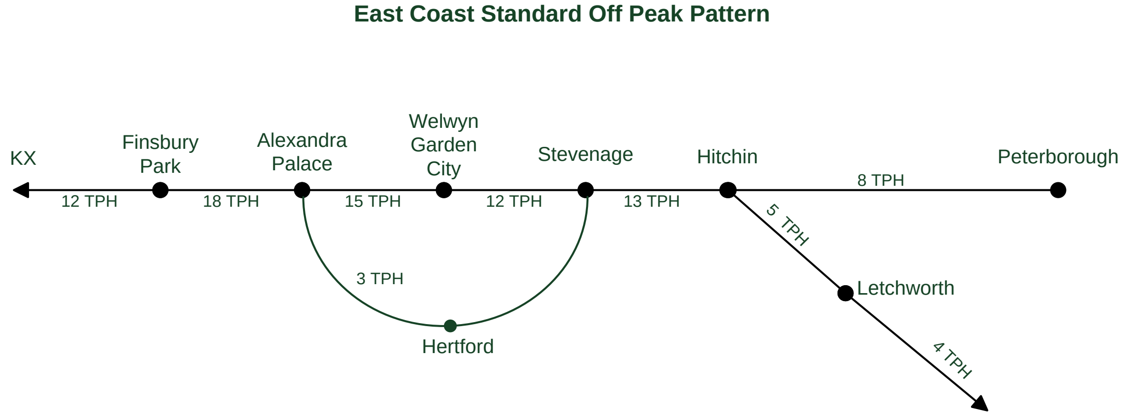
In the morning peak, there are relatively few East Coast services and the peak period is dominated by FCC commuter services, with the East Coast 'peak' being slightly later. In the evening peak however, both FCC and East Coast peaks overlap and there is great demand for paths.


A limited number of freight services operate from the junction with the North London Line, via the Hertford Loop and on to destinations in the North and North East. Analysis of the freight WTT shows in the region of 10-15 paths timetabled depending on the day of operation.

6.1.2 Planned use of train paths

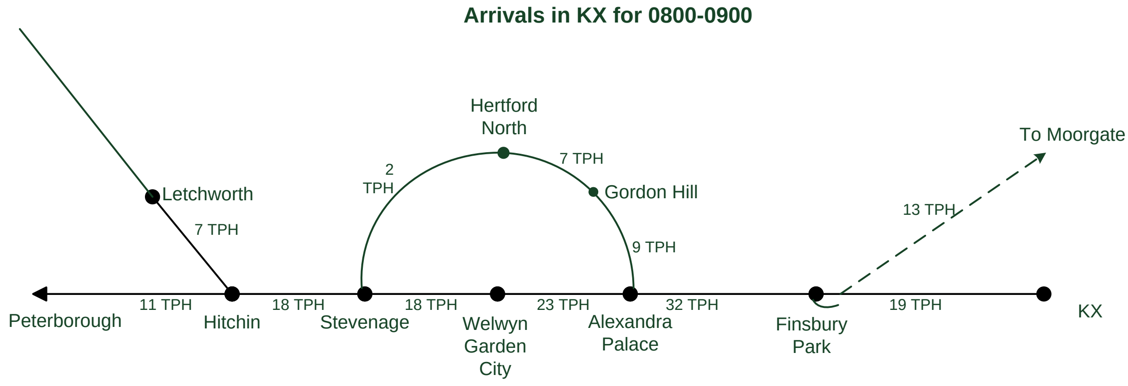
Figure 16 shows the standard off-peak pattern in both directions. The highest overall utilisation is between Finsbury Park and Alexandra Palace before trains join/leave the mainline to serve Moorgate and the Hertford Loop.

Figure 16: Timetabled paths between Kings Cross and Peterborough during off-peak



The utilisation rises considerably during the peaks. Figure 17 shows the capacity usage in the Up direction (southbound) for arrivals at Kings Cross between 0800 and 0900, the busiest hour of the day. It is worth noting that during this period only five East Coast services arrive at Kings Cross. The vast majority of services are FCC which reflects the fact that most of East Coast's business trains arrive after 0900. This staggering of the morning peak allows FCC to run more commuter services in the high-peak hour.

Figure 17: Timetabled paths from Peterborough to Kings Cross during morning peak



The maximum usage is 32 tph on the Alexandra Palace to Finsbury park section, just eight paths less than the overall theoretical maximum. Peterborough to Hitchin is 11 paths out of a maximum 15. The arrivals at Kings Cross are limited by platform capacity, with the minimum turnaround times a particular constraint.

Figure 18 shows the timetabled paths departing Kings Cross in the evening peak. During this period, 34 tph is possible between Finsbury Park and Alexandra Palace.

Figure 18: Timetabled paths departing Kings Cross during evening peak

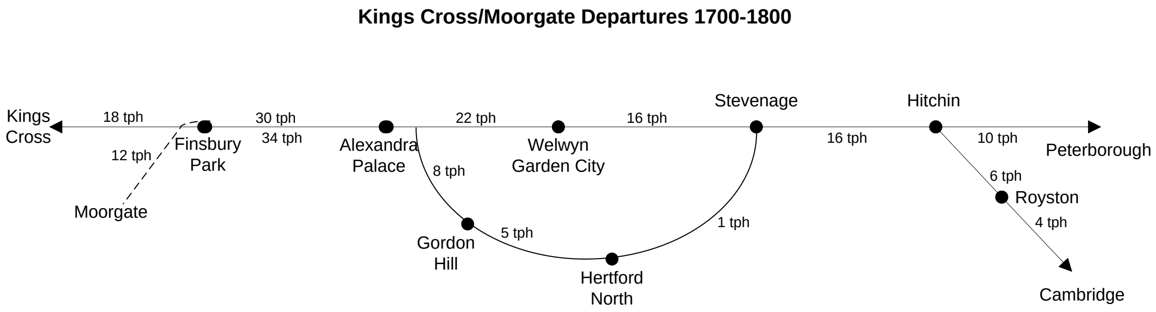
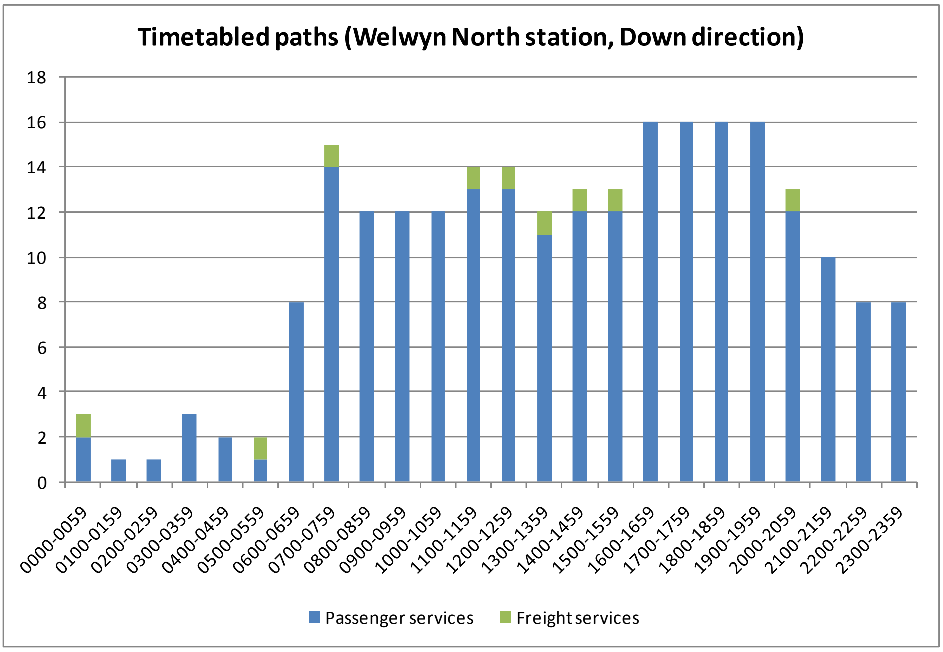


Figure 19 shows the number of trains through Welwyn North station in the Down direction (i.e. heading north), on the two-track section of the route, by time of day. This shows a maximum of 16 tph achieved during the evening peak. As shown in the GEML case study earlier, freight services avoid the peak periods and the largest number of services is during the evening peak period.

Figure 19: Timetabled paths at Welwyn North station by time of day (Down)



Performance on the route is below that of other inter-city routes, with the PPM for East Coast for the 12 months up to 5 February 2012 being 86.0%[32], the lowest of all franchised passenger operators, although this had improved to 86.6% by 26 May 2012.

6.2 Trains and loadings

Table 6 shows modelled train services and loadings at Kings Cross broken down by operator and time of day. Average loadings are high during the peak periods, although open access operators' loadings are significantly lower with no more than one service in any peak period. East Coast services have fairly high loadings even in the off-peak/contra-peak and on Sundays, where loadings are higher than the all day average for a weekday. During the off-peak or contra-peak direction, open access loadings are low compared with the franchised TOCs, at least in part reflecting restrictions on their service patterns imposed by ORR's access policy[33].

One option to make better use of capacity might be to use splitting and joining of services (e.g. at Doncaster) so only one path is used through the congested southern section of the ECML but two paths are effectively available to northern destinations. An alternative means of improving the use of capacity could be the relaxation of the 'not primarily abstractive' test, which ORR is considering as part of the periodic review.

Table 6: Modelled train loadings at London Kings Cross

	All Day	AM Peak	PM Peak	Off-Peak/ Contra-Peak	Sunday (All Day)
Number of services	**465**	**49**	**52**	**364**	**406**
FCC	286	34	34	218	289
East Coast	151	14	16	121	93
Grand Central	14	0	1	13	14
Hull Trains	14	1	1	12	10
Number of passengers	**89,777**	**19,092**	**21,862**	**48,823**	**49,916**
FCC	51,458	14,288	14,833	22,337	21,565
East Coast	35,608	4,665	6,669	24,274	25,315
Grand Central	1,046	-	116	930	1,597
Hull Trains	1,665	139	244	1,282	1,439
Average loadings	**193**	**390**	**420**	**134**	**123**

[32] http://www.networkrail.co.uk/aspx/699.aspx accessed 11 April 2012 and 11 July 2012

[33] ORR's policy for allocating capacity is such that, provided services are not primarily abstractive, capacity is allocated to the service which delivers the greatest net economic value; ordinarily the implication of this is that the loading on the open access service is in excess of that which would be achieved by replacing these services with franchise services – netting off transfers from one service to another and accounting for crowding impacts. ORR has stated its intention to consider changes to its access policy so that open access services may in future be able to stop at a wider range of stations, thereby increasing their load factors – see "01/05/2012 Periodic review 2013: setting the financial and incentive framework for Network Rail in CP5" chapter 7.

	All Day	AM Peak	PM Peak	Off-Peak/ Contra-Peak	Sunday (All Day)
FCC	180	420	436	102	75
East Coast	236	333	417	200	272
Grand Central	75	-	116	71	114
Hull Trains	119	139	244	106	144

Source: MOIRA, AM peak defined as 0700-1000, PM peak defined as 1600-1900 (peak direction only).

6.3 Demand for more paths

The ECML has been the subject of a number of capacity studies in recent years. In December 2010, Network Rail published its East Coast Main Line 2016 Capacity Review to form an addendum to the ECML RUS, investigating the demand for train paths in a December 2016 timetable. This focused on the capacity of the route in 2016 and how that capacity could be allocated. It highlighted the key constraint on the ECML as "the section between Peterborough and Huntingdon, particularly in the southbound direction where the extended section of two-track railway is a capacity constraint."

Network Rail is carrying out infrastructure enhancements on the route in order to increase capacity. At Finsbury Park, a new platform in the Up (southbound) direction and enabling passenger trains to use two more lines will enable some Moorgate Inner suburban services to operate independently of outer suburban and Long-Distance High Speed services, removing the need for some crossing moves. Grade separation of the junction at Hitchin will remove crossing moves for trains heading towards Cambridge.

The 2016 Capacity Review concluded that demand for paths exceeds the capacity available and that trade-offs in journey times or service specifications would be needed to accommodate additional services after the completion of the committed infrastructure enhancements. It noted that the value of paths can be maximised by reducing journey times on key flows to London (i.e. Edinburgh, Newcastle and Leeds) and that the most valuable additional passenger services are between London and well served towns and cities at the southern end of the ECML (e.g. Stevenage and Peterborough). Additional inter-modal freight paths were estimated to have a relatively high value per path compared to the alternatives and container traffic one of the highest economic value of all options. It recommended "the industry develop a holistically planned timetable which will generate a higher level of socio-economic benefits and revenues than a series of new services introduced as increments to the existing ECML timetable."

6.4 Possible capacity and congestion relief measures

6.4.1.1 Historical analysis

A new timetable was introduced on the East Coast Main Line in May 2011, called the 'Eureka' timetable, which provided an increase of 19 services per weekday, particularly in the number of paths into and out of Kings Cross.

Analysis using MOIRA shows that whilst revenues to London increased by around £7m per annum, non-London flows suffered a revenue decrease of around £7m per annum, with a net positive impact of just under £0.5m. A significant amount of the revenue increase was abstracted from the open access operator Grand Central. The rest of the gain is through generated trips. Passengers also perceive benefits of a standard pattern timetable, which is easier to remember, and not reflected in the MOIRA results.

Our MOIRA analysis suggests that the main flows which increased revenue as a result of Eureka were London to Newcastle, York, Leeds, Stevenage and Edinburgh. The main flows which saw reduced revenues were Newcastle-Glasgow, Glasgow-York, Darlington-Glasgow, Edinburgh-Newcastle and Newcastle-Stevenage.

This change, under our three efficiency tests is:

a) more efficient for the network as more services were accommodated;
b) probably less efficient for the industry with substantially different impacts for East Coast and Grand Central and with the costs of the extra services outweighing the revenue gain; and
c) has different economic benefits for different areas. Positive for the London flows with the exception of Peterborough, but losses for the north of England, Scotland and provincial flows.

6.4.2 Additional evening peak Main Line services

By changing the service pattern, it was possible to find an additional two paths on the fast line out of Kings Cross in the evening peak. We have not tested whether these paths are available north of Peterborough, as this is outside our study area, but we have considered what changes are needed to existing services within the study area in order to accommodate more Long-Distance High Speed services. Two new paths (assumed to be to Edinburgh and Leeds) were accommodated by making the following alterations:

- East Coast services no longer stop at Stevenage in the peak direction during the peak
- FCC services no longer stop at Welwyn North[34] in the peak direction during the peak
- FCC services no longer terminate at Peterborough but at Huntingdon
- Any FCC service stopping at Stevenage uses the slow line

The aim of these changes was to homogenise the service pattern and rolling stock capabilities. Using MOIRA to test the revenue impact of these changes, we forecast a net revenue increase of £77k per year. The revenue lost from removing the stop at Welwyn North is negligible. Operating costs however are estimated to be £2.1m per annum for an additional service to each of Leeds and Edinburgh[35]. In terms of the economic impacts due to changes in journey time, there is a marginal disbenefit of -£50k per year when considering all of the changes.

[34] Welwyn North is a station located on the two-track section of the ECML between Welwyn Garden City and Knebworth

[35] Based on £14 per mile for an 11-car 125mph long-distance service, value taken from the East Coast Main Line 2016 Capacity Review (Network Rail, 2010)

Stopping services at Welwyn North effectively uses up an additional path so each additional stop here would use up one of the new paths.

Using our efficiency tests this case is:

a) Efficient for the network, as more trains can operate over the infrastructure;
b) Not efficient for the industry in the short-term with insufficient new revenue to justify the extra operating costs; and
c) Not efficient for society and the economy as there are GJT disbenefits and other economic benefits such as crowding relief and agglomeration are unlikely to outweigh the very high operating costs.

6.4.3 Reduction in turnaround time at Kings Cross

Part of the rationale for selecting this route as our long-distance high value case study was the opportunity to investigate the impact of reducing the turnaround time in the platforms at Kings Cross.

Currently platforms are occupied for, on average, 83% of the available time, increasing to 96% when platform re-occupation times[36] are taken into account. This appears to be efficient utilisation of infrastructure at the terminal, but does not consider the efficiency of the turnarounds themselves.

Two scenarios have been examined, to see how the utilisation changes:

- Option 1 – reducing all services to their minimum turnaround time in the TPR
- Option 2 – removing an additional 5 minutes from the TPR time for each turnaround.

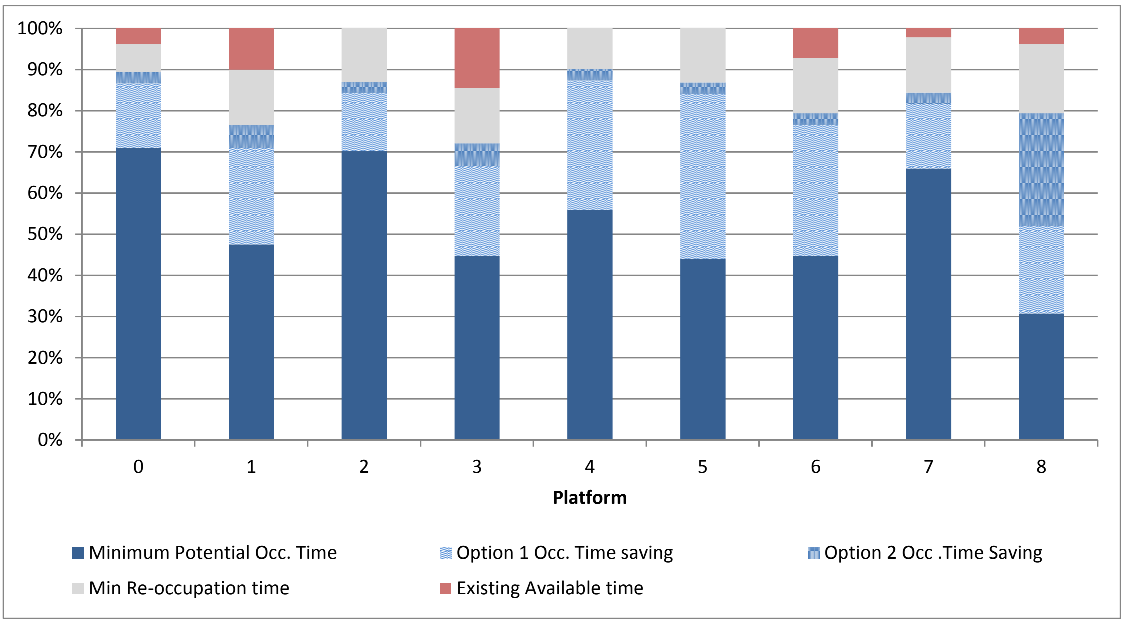
The results show that the average utilisation falls to 72% in option 1, and to 66% in option 2. The amount of available time in each platform exceeds 40mins in six out of the nine platforms in each case study, providing sufficient room for additional paths.

Figure 20 shows the occupation of Kings Cross platforms. The current occupation time is the total of the minimum potential time, option 1 saving and option 2 saving (i.e. all the blue segments). For platform 0 this is just below 90%. The grey segment corresponds to the platform re-occupation time, i.e. the time taken for a train to leave the platform and the next train to occupy it. The red segment shows the unoccupied time for the platform, note that platforms 2, 4 and 5 are fully utilised.

The option 1 and option 2 occupation time savings are shown in the lighter shades of blue. These are the potential time savings that could be realised under each scenario. On platform 8 for example there are significant potential efficiency gains. Under option 1, there would be the potential for additional services in particular to platforms 4, 5 and 6. Option 2 generally gives a slight additional benefit over option 1, except at platform 8 where it has a greater impact.

[36] This is the minimum time between one service departing a platform and the subsequent service being able to arrive.

Figure 20: Illustration of platform occupancy at Kings Cross under modelled scenarios



The analysis shows that additional platform capacity for extra services can be created at Kings Cross by reducing turnaround times to the minimum TPR times. It should be noted that additional capacity at Kings Cross is unlikely to be sufficient *by itself* to create an additional path, it would need to be considered alongside other measures. We have not investigated whether a full timetable re-cast based on reduced turnaround times could yield additional track paths along the route, or assessed the additional operating costs, or what services might use the space created, but using our efficiency typology, any additional path created is likely to show increased efficiency for the network as more services could operate from the terminal infrastructure.

Note also that the Thameslink Programme, once completed, will remove some of the FCC trains from Kings Cross – these will go through the Thameslink core[37] instead – releasing additional platform capacity. On what is already the worst performing inter-city service it may be felt that this reduction in the recovery available from turnaround times creates unacceptable additional performance risk, and clearly mitigation measures would be required to deal with this.

6.5 Summary

This corridor is heavily utilised by a mixture of inter-city and commuter service types, the majority of which terminate at Kings Cross. The main capacity constraint occurs in the evening peak, as the morning peak demand for commuter and inter-city services do not fully coincide. Kings Cross station also acts as a constraint.

In the evening peak, additional paths can be obtained by removing or changing stopping patterns and bring greater homogeneity to services. Whilst these changes are presently not economically efficient – in that additional revenues and time savings do not offset operating

[37] The section of the Thameslink route between St Pancras and London Blackfriars

costs – as demand increases they will be more cost effective than very expensive infrastructure enhancements such as four tracking throughout between Huntingdon and Peterborough and increasing capacity at Welwyn Viaduct. There would also be the potential for political difficulties, as there would be some clear losers from reductions in service to a small number of stations.

Additional paths along this corridor would require greater capacity at Kings Cross which has already seen the introduction of an additional platform recently (Platform 0). In examining turn round times at the station it is possible, if these were reduced to the minimum levels laid out in the train planning rules, to increase the number of trains that the station could handle, again negating the need for expensive new infrastructure. There may however be implications for service performance if potential recovery time from reducing turnaround times was reduced.

The case study also highlighted a number of lightly loaded trains using the corridor at peak periods. Whilst it appears that paths could be freed up by joining such trains and splitting them further north, in practice this is complicated by having different operators and the need for different rolling stock, albeit with similar performance characteristics as that used at present, which is not presently available.

This case study has identified that capacity can be increased through the operation of a homogenised service and tighter operational performance in train turnarounds at Kings Cross. However, these changes would have a negative impact on some passengers who will see a reduction in service and increase risks in relation to operational performance. It has also identified an alternative to one of McNulty's proposals, that is, instead of reducing the number of through-services there may be potential for greater use of splitting and joining trains to maintain direct services while reducing the number of paths used on constrained parts of the network.

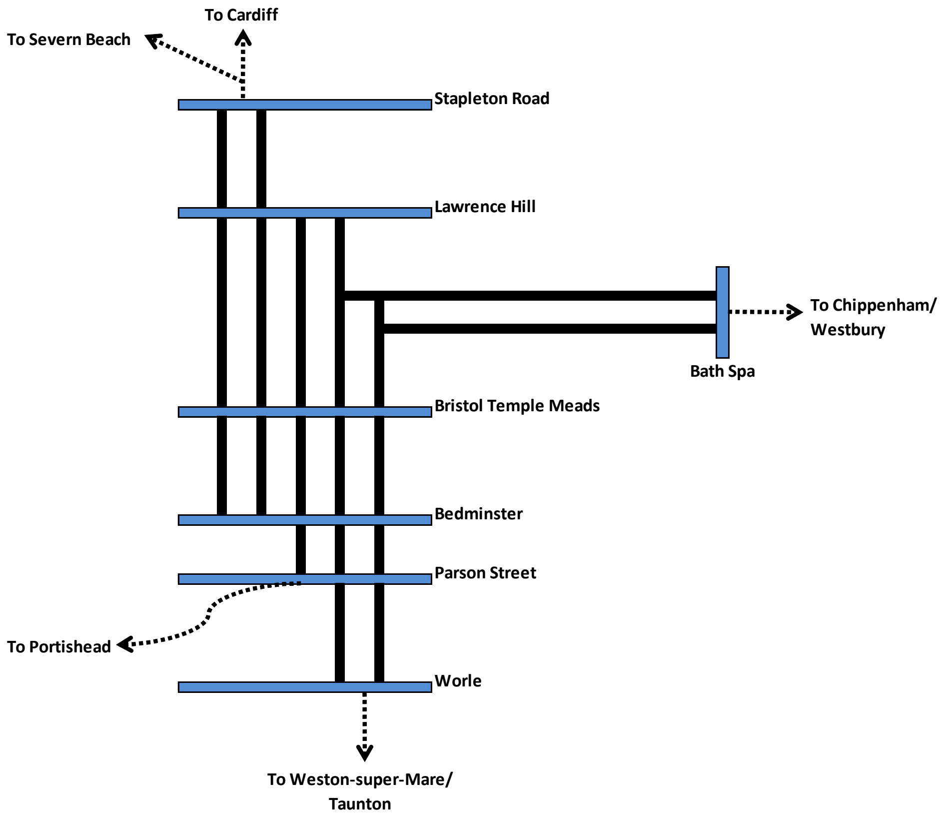
7. Case Study 3 – Bristol Temple Meads

7.1 Route overview

For the route into a non-London conurbation case study, we have examined Bristol. This case study covers the three lines of route feeding into Bristol Temple Meads, with an area bounded by Bath Spa (to the east), Stapleton Road (north) and Worle (south) as shown in Figure 21. More details about the infrastructure and rolling stock along the route can be found in Appendix B.

The station is served by mixture of long-distance inter-city, regional and local services all of which operate both as through-services and terminating services. Our focus is on exploring one of McNulty's proposals of improving efficiency by reducing the number of through-services. A significant proportion of trains serving Bristol Temple Meads are through trains which are required to not only reverse direction but also to cross the station throat in entering and leaving the station.

Figure 21: Bristol Temple Meads area track layout



7.1.1 Service patterns

Passenger services are operated by First Great Western (FGW), CrossCountry and South West Trains (SWT).

FGW operates a structured cross-Bristol local network. The commuter/regional cross-Bristol services link locations to the north (Bristol Parkway/Cardiff/Severn Beach/Cheltenham/ Gloucester) with locations to the east, via Bath (Portsmouth/Weymouth/Westbury) and to the south (Taunton/Weston-super-Mare). The Long-Distance High Speed (LDHS) cross-Bristol services link London to the south west of England (Plymouth/Penzance).

CrossCountry operates LDHS services between Bristol Temple Meads and Manchester Piccadilly, and through-services from Penzance to Aberdeen.

SWT operates only a handful of regional services between Bristol Temple Meads and London Waterloo, although, due to the long route and high number of station stops, they would not realistically be used to travel from London to Bristol.

Freight services also operate through the station to and from locations including Portbury Coal Terminal, Portbury Automotive Terminal and Freightliner's depot at Stoke Gifford.

7.1.1.1 Planned use of train paths

There are 528 passenger train movements each day (with an arrival and a departure classified as two movements), 164 (31%) of these services terminate or start at the station, 152 (29%) to/from the north or east and 12 (2%) to/from the south. Furthermore, of the 364 'through' train movements, 142 (27%) reverse in the station, departing northwards from the station, the same way they entered. In effect Bristol Temple Meads acts as a terminus for over 50% of train movements.

Table 7: Platform occupation times at Bristol Temple Meads during PM peak

Movement	GW	XC	SWT	Total	Train movements
Depart/Terminate North/East	123	21	8	152	152
Depart/Terminate South	11	1	0	12	12
Through Service	72	39	0	111	222
Reversing Service	68	3	0	71	142
Total	274	64	8	346	528
Movement by direction					
North	331	66	8	405	77%
South	83	40	0	123	23%

7.2 Trains and loadings

Table 8 shows modelled weekday train loadings at Bristol Temple Meads by operator. CrossCountry trains are shown as having the highest loadings all day and in the PM peak, with SWT average loadings highest in the AM peak albeit that they only operate one service.

Table 8: Modelled weekday train loadings at Bristol Temple Meads (by TOC)

	All Day	AM Peak	PM Peak	Off-Peak/ Contra-Peak
Number of services	**528**	**52**	**52**	**424**
FGW	414	42	42	330
CrossCountry	106	9	10	87
SWT	8	1	0	7
Number of passengers	**50,195**	**7,541**	**8,441**	**34,213**
FGW	37,250	6,052	6,495	24,703
CrossCountry	12,424	1,306	1,946	9,172
SWT	521	183	-	338
Average loadings	**95**	**145**	**162**	**80**
FGW	90	144	155	74
CrossCountry	117	145	195	105
SWT	65	183	-	48

Source: MOIRA, AM peak defined as 0700-1000, PM peak defined as 1600-1900 (peak direction only).

Great Western operates both long-distance and local services so Table 9 shows the breakdown of all services by service type, both “long-distance” and “local”. Local services are more lightly loaded, even during the peak periods.

Table 9: Weekday train loadings at Bristol Temple Meads (service type)

	All Day	AM Peak	PM Peak	Off-Peak/ Contra-Peak
Number of services	**528**	**52**	**52**	**424**
Long-distance	340	29	31	280
Local	188	23	21	144
Number of passengers	**50,195**	**7,541**	**8,441**	**34,213**
Long-distance	41,065	5,409	6,762	28,894
Local	9,130	2,132	1,679	5,319
Average loadings	**95**	**145**	**162**	**80**
Long-distance	121	186	218	103
Local	48	93	79	37

Source: MOIRA, AM peak defined as 0700-1000, PM peak defined as 1600-1900 (peak direction only). Long-distance defined as Scotland, Manchester, Leeds, Brighton/ Southampton/Portsmouth, Penzance/Plymouth/Paignton, Exeter/Weymouth, Cardiff/Swansea, London)

The Great Western RUS shows that average passenger loadings across the morning peak period (0700-1000) are less than 80% of train capacity offered. The ORR's National Rail Trends for 2010 shows Passengers in Excess of Capacity in the morning peak of 7.4% and 21.2% of trains have some standing passengers.

7.3 Demand for more paths

The CUI levels for the 2007 timetable morning high-peak hour presented in the RUS show the approaches to Bristol Temple Meads from the north and south west as being in excess of 75% and the approach from the east as being medium (50-75%). The RUS identifies Bristol Temple Meads as a significant source of delay minutes with 220,000 minutes per year.

According to the latest Station Usage data for 2010/11 published by ORR, Bristol Temple Meads has 8.4m entries and exits per year and a further 1.1m interchanges. This makes it the 32nd busiest station in Great Britain (and the 13th busiest outside of London) in terms of entries and exits. The RUS makes the following comment about passenger demand to Bristol:

"Bristol is the largest urban centre in the South West Government region, providing employment, education opportunities and leisure activities. In 2007, approximately seven million passenger rail journeys started or ended at Bristol Temple Meads, a 75% increase from four million in 1998. Trips to Bristol by rail, particularly for commuting purposes, have become increasingly more attractive in recent years as a result of an improved train service and increased road congestion, and car parking costs, into and around the city centre.

"The level of rail demand varies considerably by time of day with demand at its highest level in the high-peak hour (0800-0859)."

Crowding levels on local services have previously been a cause for concern, and the GW RUS predicts overcrowding will occur by 2019, with train loads expected to be in excess of 130% in the high-peak hour on the Cardiff corridor.

The RUS highlighted 'Bristol peak capacity' and 'Bristol performance' as two of the gaps to be addressed. It recommended train lengthening on 11 services during the morning and evening peaks to increase capacity on Bristol services. An additional hourly cross-Bristol (Temple Meads to Yate) service and an additional hourly Bristol Temple Meads to Bath Spa shuttle service were also recommended.

A capacity upgrade at Bath Spa is in development (GRIP4 – single option development) to provide reduced platform re-occupation times, reduced headways and improved performance. Four infrastructure options to improve capacity and performance to Bristol Temple Meads from the north, east and south west approaches were considered. The RUS recommends the provision of four tracks between Bristol Temple Meads and Parson Street through the extension and conversion to passenger use of the carriage line from Bristol Temple Meads to Bedminster rejoining the main line just beyond Parson Street; plus a three or four-track section between Dr Days Junction and Filton Abbey Wood. In addition, increasing the line speed to 125 mph between Bristol Temple Meads and Bridgewater was recommended.

7.4 Possible capacity and congestion relief measures

7.4.1 Splitting a through service

In this scenario we have assessed the impact of splitting a through service into two separate services, in order to test the RVfM report conclusion that shorter, through-services are an inefficient use of both train and infrastructure capacity.

Analysis of the current wide mix of services also sees a wide mix of train types, train lengths (which impacts on junction clearances) and train loads as shown in Figure 22.

Figure 22: Train loads departing Bristol Temple Meads during PM peak

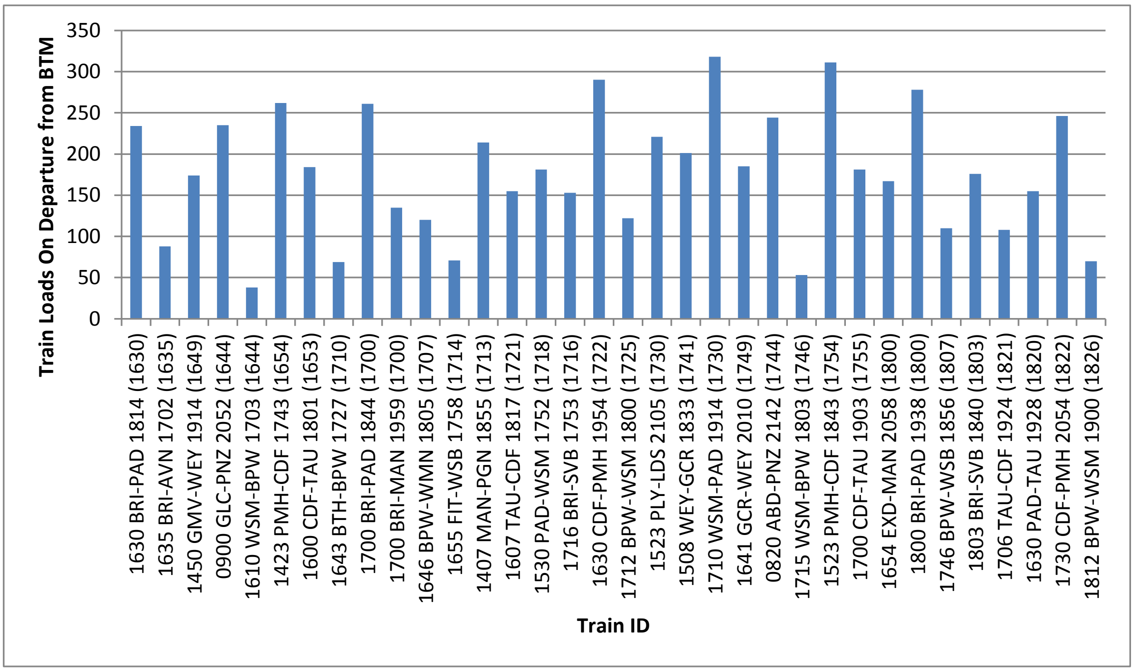


Table 10 below shows there are six trains during the PM peak period (1630-1829) with less than 100 passengers. When considering the smallest units operating through Bristol Temple Meads are a 1-car Class 153 with 72 seats and a 2-car Class 150 with 150 seats (see Appendix B), this implies that train loadings for these services are light.

Table 10: Train loadings at Bristol Temple Meads during PM peak period

Number of services	1630-1729	1730-1829
300+ passengers	0	2
200-299 passengers	6	4
100-199 passengers	8	8
<100 passengers	4	2
Average load (3hr peak)		**162**

This is similarly evident when considering revenue by service. In the peak, the MOIRA estimated value of some example services are:

- Bristol Temple Meads to Avonmouth; £182
- Taunton to Cardiff Central; £1,260
- Bristol Temple Meads to London Paddington; £5,950
- Aberdeen to Penzance; £17,514

We tested a scenario in the PM high-peak (1700-1759), where three services perform east to north reversing moves, using up capacity by a minimum of 12 minutes additional junction margins. By splitting such services at Bristol Temple Meads, and having services start and end in more appropriate platforms, these junction margins could be removed entirely, potentially freeing up three additional paths, depending on the stock used to run these additional services. The reversing trains that have been split are:

- 1508 Weymouth – Gloucester 1833
- 1523 Portsmouth Harbour – Cardiff Central 1843
- 1643 Bath Spa – Bristol Parkway 1727

In order to see if the loss from splitting a through service could be compensated for by increasing frequency, additional services were been added from Bristol Temple Meads to Gloucester (departing BTM at 1711), Cardiff (departing 1739) and Avonmouth (departing 1746).

While the through-Bristol demand is forecast to fall by £63k annually, the additional services generate £65k, resulting in a net £2k improvement in revenue. This is without filling the additional paths with the highest value long-distance services. Appraising the impact on journey time, there is a small economic benefit of £40k per annum resulting from the changes, therefore this scenario does not have a material impact.

An alternative scenario considered substituting the additional Avonmouth local service with a long-distance to Manchester, also departing at 1746. Note that we have not examined whether this service could be accommodated at Birmingham New Street, as this is outside our study area. The revenue impact of this scenario was an increase of £256k per year, resulting in a net increase of £193k. Appraising the impact on journey time, there is an economic benefit of £340k per year. Operating costs are estimated at £1m per year[38], outweighing the revenue and economic benefits.

In our three efficiency scenarios this case is:

a) more efficient for the network as additional services can be operated;
b) not more efficient for the industry because the revenue increases do not outweigh the increased operating costs; and
c) not more efficient for society as a whole as economic benefits from journey time savings and increased revenues do not outweigh the operating costs.

7.5 Summary

At present Bristol Temple Meads does not appear to be capacity constrained but certain services are overloaded and demand is projected to increase significantly. A clear difference between the Bristol case study and the London ones is the large variation in train loadings. At Bristol the highest loaded train in the evening peak carries around ten times more passengers than the least. This has implications in how capacity is allocated in future with pressure to displace relatively lightly loaded local services with better loaded long-distance ones.

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[38] Based on £5 per mile for a 3-car inter-regional service, taken from the ECML 2016 Capacity Review (Network Rail, December 2010) – using a longer train would further increase the operating costs

We tested the implication of replacing through trains that have to reverse at Temple Meads with services that terminate at Bristol. In the evening peak we removed three through trains which released three additional paths – for example, a through Weymouth to Gloucester service was replaced by separate Weymouth to Bristol and Bristol to Gloucester services plus in this case an additional train to Gloucester. The revenue and economic benefits of undertaking this split is positive as well as providing more capacity for future growth. The increase in benefits was even higher if one of the additional paths was allocated to a long-distance rather than a local service, however operating costs currently outweigh the benefits.

In the longer-term it is clear that additional capacity can be provided when needed by recasting train services to remove through-services at far lower cost than providing new infrastructure.

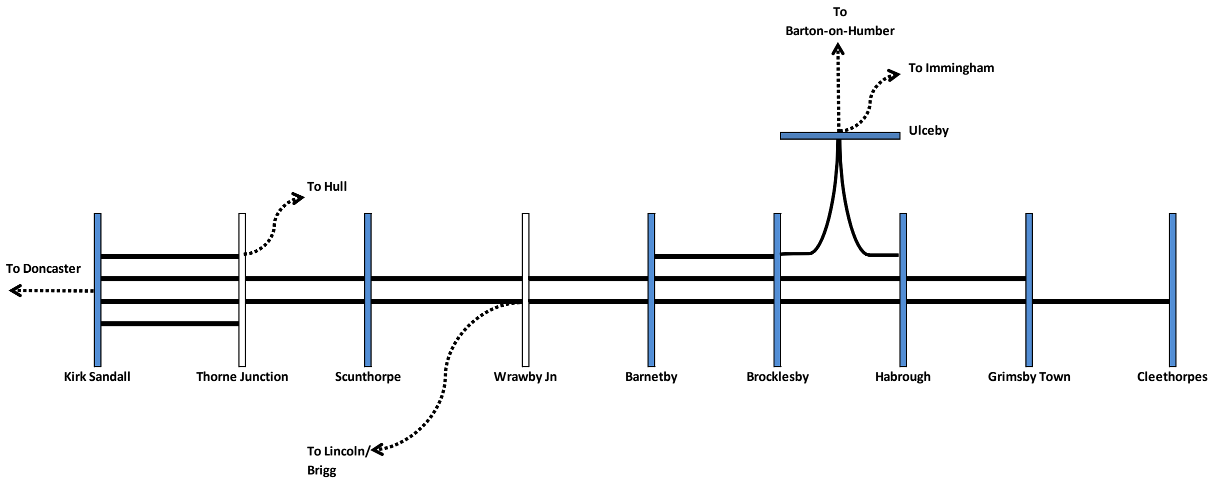
8. Case Study 4 – South Humberside

8.1 Route overview

This case study of a rural route covers the line of route between Cleethorpes and Kirk Sandall Junction to the east of Doncaster station as shown in Figure 23. More details about the infrastructure and rolling stock along the route can be found in Appendix B. The section between Cleethorpes and Grimsby Town is single line and used only for passenger services. Grimsby Town to Brocklesby Junction is also only for passengers but it is a double line section. The final section between Brocklesby Junction and Kirk Sandall Junction is mostly two tracks and used by both passenger services and a large number of freight services.

The main focus of the analysis has been to examine a route where freight traffic dominates, in order to ascertain whether freight paths that are not utilised are a constraining factor and to better understand the trade-off between passenger and freight services.

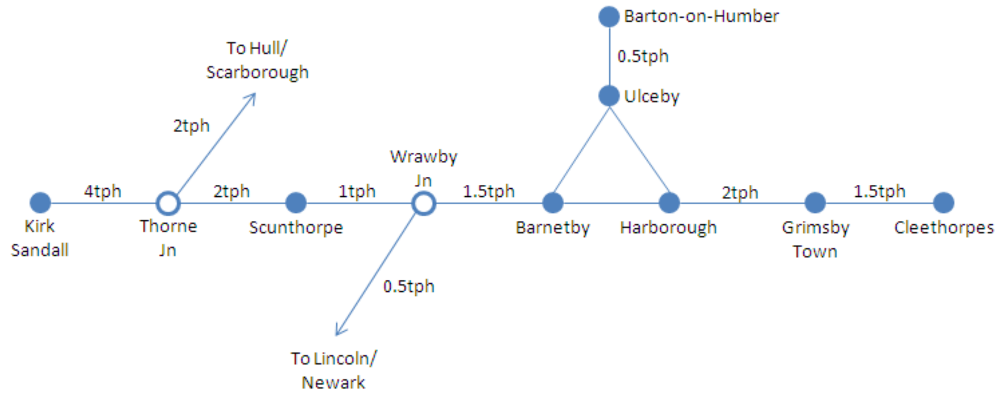
Figure 23: South Humberside route layout



8.1.1 Service patterns

Passenger services are run by Northern (between Cleethorpes and Barton-on-Humber and between Scunthorpe and Sheffield/Lincoln), Transpennine Express (between Cleethorpes and Manchester Airport via Doncaster), and East Midlands Trains (between Grimsby and Newark). In addition, there are Northern services between Sheffield and Bridlington/Scarborough, which run through the study area briefly between Kirk Sandall and Thorne Junction. Figure 24 shows the current passenger service levels in the study area (off-peak).

Figure 24: Passenger service between Cleethorpes and Doncaster



There are a large number of freight flows along the case study route to and from Immingham port. The freight traffic on the route is a mixture of different types of heavy bulk traffic. The main flows are coal from Immingham to various Yorkshire, Lincolnshire and Nottinghamshire power stations, fuel from the Immingham refineries, steel traffic from Scunthorpe, bulk iron ore and refuse traffic to Roxby Gullet. Important freight flows are:

- Coal imported via Immingham to power stations across the country
- Metals flows (imported ore and finished steel) to and from Immingham and Scunthorpe
- Petroleum flows from Lindsey Oil Refinery
- Inter-modal container traffic from Immingham

Each working timetable freight path was analysed using 11 weeks of data to see how frequently it operated. Some paths for coal traffic have multiple origin and destination points depending on the power station being supplied, and trains from Immingham have different headcodes sharing the same path depending on the power station (this also applies to fuel oil trains from Humber and Lindsey refineries). These cases were treated as one path in the analysis, although on occasions two trains ran as Short-Term Plan (STP) changes.

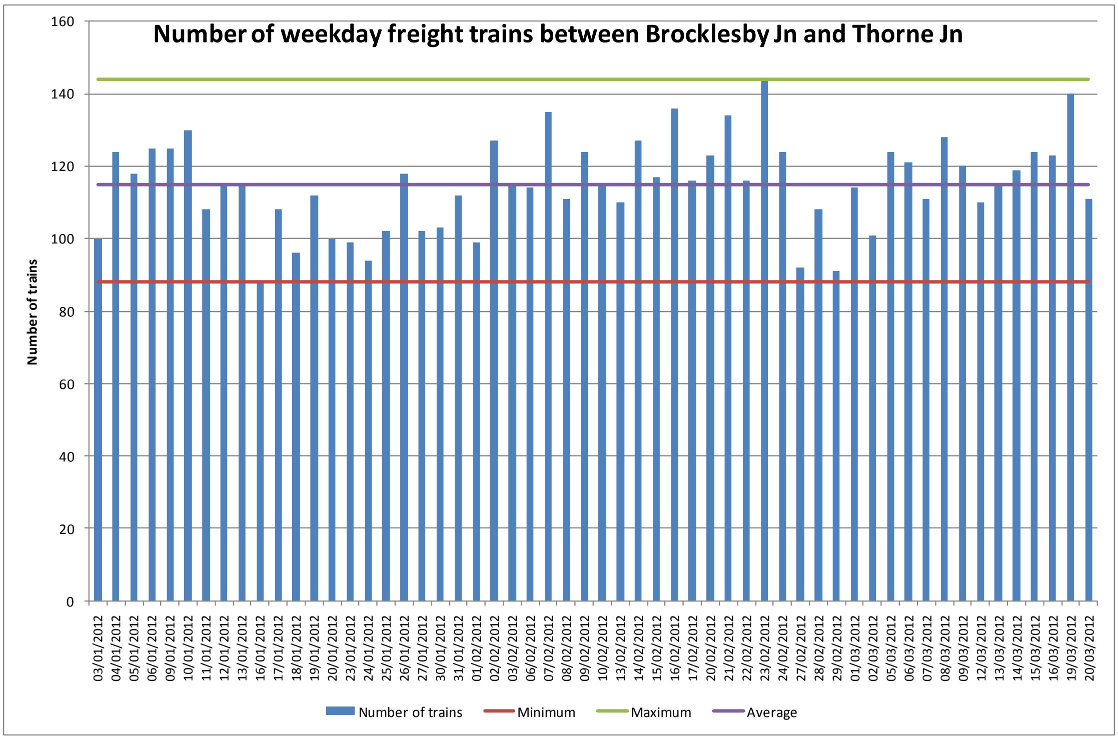
8.2 Use of freight paths

There are a number of Monday to Friday (SX) paths that were not used at all (see Appendix C) and only the refuse trains to Roxby Gullet ran every day. There are around 100 to 110 paths in each direction every day which vary by day of the week. It is difficult to be precise as some of the paths clash in theory but will be adjusted by the STP plan.

The average number of freight trains each day over the 11 week sample period was 115 in both directions as shown in Figure 25, with a standard deviation of 12.6 – larger than for the Great Eastern case study. There is also a wide variation in the number of trains operating over any 24 hour period. Whilst some flows such as the iron ore trains from Immingham to Santon (Scunthorpe steel works ore terminal) or the refuse trains to Roxby Gullet operate most of the days they are planned to, other traffics are more variable. This is particularly the case with import coal flows which are subject to frequent volume changes based on power station needs and shipping schedules at the docks. There are also variations in the fuel flows into the Immingham refineries. Some flows have ceased although paths are still in the WTT. For example, there are still paths from Redcar to Scunthorpe which were not used during the sample period. The route is dominated by bulk flows and these are subject to greater levels of variation and the STP planning requirement will always be much higher than the flows on the Great Eastern route.

The overall volumes suggest that capacity is not a major constraint for freight on the route, but there may be issues with the operational times at key freight terminals. Even on the busiest day, overall there was easily sufficient capacity to operate services.

Figure 25: Number of weekday freight trains run from Brocklesby Junction to Thorne Junction



The finding of the case study is that there is not a capacity constraint along this route and that any under-utilisation of freight paths (the average utilisation is estimated at 34%) is not currently preventing further utilisation of the route by others.

8.3 Trains and loading

Table 11 shows passenger trains and modelled loadings at Grimsby Town all day on a weekday. Transpennine Express (TPE) runs the longer-distance inter-urban services, and Northern/East Midlands Trains (EMT) the local services. Average loadings of local services at Grimsby Town are very low.

Table 11: Weekday modelled train loadings at Grimsby Town

	All Day
Number of services	**47**
TPE	32
Local	15
Number of passengers	**1,532**
TPE	1,325
Local	207
Average loadings	**33**
TPE	41
Local	14

Source: MOIRA.

8.4 Demand for more paths

The Yorkshire & Humber RUS plans for continued growth in freight traffic to Immingham, particularly inter-modal. It also recommended further development of line speed improvements between Doncaster and Cleethorpes to address the ‘regional links’ gap.

8.5 Possible capacity and congestion relief measures

Even though we did not find that there was a capacity constraint on this route, we tested a scenario whereby freight demand increased to the level where there was a constraint. In order to accommodate this, rather than try and squeeze capacity, we looked at substituting one type of train for another i.e. replacing a passenger train by a freight train. We considered that in the event that efficiency of the industry moved higher up the policy agenda, this was something that might be considered elsewhere.

There is moderate passenger demand on this route (600,000 journeys per annum, worth £7.9m). Should freight continue to grow, the track section approaching Barnetby is likely to be the constraint. We tested how valuable freight paths would have to be from an economic benefit perspective for it to be more efficient to substitute a freight path for a passenger service on this track section.

Four scenarios were tested, the results of which are shown in Table 12:

- Halve frequency of TPE services between Scunthorpe and Cleethorpes (creating 16 paths)
- Remove all TPE services between Scunthorpe and Cleethorpes (creating 32 paths)
- Halve frequency of EMT services between Market Rasen and Grimsby Town (creating 7 paths)
- Remove all EMT services between Market Rasen and Grimsby Town (creating 15 paths)

Table 12: Summary of scenarios tested

Operator	Route	Change	Paths saved	Revenue impact	Economic impact (journey time)	Operating cost saving[39]	Required benefit per freight path per day[40]
TPE	Scunthorpe – Cleethorpes	Halve frequency (2hrly service)	16	-£379k	-£1,277k	£608k	£1,047
TPE	Scunthorpe – Cleethorpes	Remove service	32	-£1,914k	-£8,275k	£1,216k	£4,487
EMT	Market Rasen – Grimsby Town	Halve frequency (4hrly service)	7	-£71k	-£390k	£269k	£439
EMT	Market Rasen – Grimsby Town	Remove service	15	-£150k	-£841k	£581k	£437

It is assumed that the revenue collected by freight operators would be sufficient to offset their operating costs. By comparison, the economic benefits of a container train travelling from Felixstowe to the West Midlands was in the region of £6,500 per path implying these scenarios would be economically beneficial if appropriate paths could be identified. Considering an iron ore train from Immingham to Scunthorpe steel works using the same methodology, the economic value of the path is estimated as £1,200 which is sufficient benefits, assuming an average path utilisation of 25%, to outweigh the revenue loss and journey time disbenefits for all scenarios except for the complete removal of TPE services.

Using the three efficiency tests, this was:

a) Neutral for the network as one train substituted for another;
b) More efficient for the industry as the operating cost saving is greater than the revenue disbenefit for all scenarios except complete removal of TPE. This assumes that better use can be made of the rolling stock and staff saved elsewhere; and
c) Positive for society in terms of lorry miles avoided, saving of subsidy and relative value of passenger benefit losses.

8.6 Summary

The utilisation of freight paths along this route was not found to be a constraint on capacity. Passenger train loadings are low, particularly on the local services, and it is likely that, should capacity be constrained in the future by growth in freight traffic, it would be more economically efficient to replace some passenger paths with freight paths.

[39] Assuming £5 per train mile (source: ECML 2016 Capacity Review, Network Rail – inter-regional service)
[40] Assumes 25% utilisation

9. Findings and conclusion

9.1 Introduction

The rail network has seen a substantial increase in train services over the last decade to meet record passenger and freight demand. This has led to substantial investment in increasing capacity across the network to tackle capacity constraints. However, at present rail services are heavily subsidised by the taxpayer and increasing investment in expensive capacity enhancements may lead to further demands on taxpayers rather than reducing the burden.

In looking at calls to increase capacity on the network it is therefore important to understand the nature of the constraint; a desire to run more trains when existing trains or track capacity are not well utilised is unlikely to be economically efficient.

This study has therefore used four case studies of corridors or locations where there was a perceived capacity constraint in an attempt to answer the following questions:

a) Is there an actual capacity constraint?
b) If yes, can additional capacity be obtained by re-timetabling services in an economically efficient manner?
c) Or can capacity be reallocated in an economically efficient manner?

Our analysis and tests are theoretical in the sense we have not been able to assess the operational impacts of any changes tested on the rest of the rail network. Rather they attempt to illustrate the types of changes that could be made and the possible impacts of them.

9.2 Summary of case studies

In three of the four case study areas we found that there were capacity constraints, but that these were limited to certain times of day. These related principally to the traditional morning and evening peak periods. Where there were capacity constraints we identified possible changes to services that would provide additional capacity on the network. These changes to services ranged from minor flexing of passenger services, faster turnaround of services at termini, taking out through-services where they require reversal at a station, reducing station stops to major recasting of timetables. In the latter two cases the aim was to bring greater homogeneity to services.

The benefits of such changes in terms of capacity enhancement varied from a single additional path an hour to a homogenised service pattern with an extra 11 services an hour. As with all timetable changes there are winners and losers and in many cases the disbenefits are greater than the benefits. However, the capital costs of alternative infrastructure enhancements are generally well in excess of any loss in benefits that arises from the timetable recastings that we modelled.

The other change we tested was reallocating paths from passenger to freight in the off-peak. In the examples we tested there was a clear economic benefit from this re-allocation of capacity although we did not test whether other passenger services would be impacted by the additional freight paths outside the corridor we studied.

On two corridors where there was a significant volume of freight traffic we reviewed the utilisation of freight paths to ascertain whether a low take up of timetabled paths acted as a capacity constraint. Our analysis suggested that while freight path utilisation varied considerably depending on the nature of the freight being moved, it was not presently acting a constraint for other uses.

In assessing the impacts of our proposed changes we have used a tri-partite assessment of efficiency: for the rail network owner, for the rail industry and for the wider economy and society. This has demonstrated even at the qualitative level, that changes have very different impacts on those efficiency elements and indeed on individual companies.

In reviewing these high level findings account needs to be taken of the following:

a) Capacity is not just about finding paths but satisfying demand. Building a market for rail is a long-term process, so a capacity allocation that is deemed to be inefficient in the short-run may become more efficient as the market for rail develops and the frequency of the service can be an important contributor to building this demand. Initially running shorter trains at a higher frequency may be less efficient but if that builds demand those shorter trains may eventually need to become longer to satisfy demand and thereby increase efficiency for the network, industry and society. There is therefore a distinction to be made between satisfying demand that already exists and growing demand where it does not yet exist.
b) Some tested changes require additional resources which may not be readily available, in particular rolling stock. Homogeneity of rolling stock performance is difficult in a mixed traffic railway with rolling stock of different ages and long life.
c) Running more trains risks PPM performance levels because the flexibility to deal with perturbations is reduced and consequential delays affect more trains. However, some of these risks can be mitigated by more training and supervision and it may also be worthwhile having a lower PPM in order to gain capacity.
d) None of the studied changes has been operationally tested by simulation and no assessment has been made about whether service changes in the study areas could be accommodated in the network outside the study area.
e) Most of the studied changes would result in significant loss to some passengers. Even where there are overall benefits such losses may be politically unacceptable.

9.3 Implications for the wider network

The four case studies have highlighted that capacity issues tend to be location specific and complex. Freeing up capacity on one section of route may bring few benefits if elsewhere on the route a constraint cannot be resolved. A mixed-use ‘turn up and go’ railway with local and long-distance passenger services coupled with freight services is never going to achieve maximum throughput in terms of capacity allocation. Any changes to service patterns will throw up winners and losers leading to capacity allocation being as much a political issue as an economic or operational one. However, the study has identified a number of points that would benefit from further consideration.

Even within peak periods on very heavily utilised corridors, the number of passengers carried per available path varies greatly. Changes to station calling patterns, fares and the use of behavioural techniques could all be utilised to achieve more even loadings and increase the efficient use of capacity (matching better demand to supply) without any additional investment or significant economic impacts. Note that the effectiveness of fares to influence travel behaviour is dependent upon the flexibility and choice available to passengers, as well as their acceptance and understanding of more complex fares structures. At the extreme, every service would have a different price depending on its loading, however that would be too complicated for passengers to understand and also go against the principles of ticket simplification. A balance therefore needs to be made to encourage sufficient behavioural change to make a difference to capacity utilisation.

Changes in the supply of capacity take a long time to be realised – additional rolling stock or infrastructure enhancements require detailed feasibility, procurement and implementation activities – whereas changes in demand can be realised much faster given the right incentives. Using fares to encourage passengers to shift their behaviour from the busiest services to those with more capacity could deliver efficiency gains by smoothing out demand. Funders can use fares as a means to manipulate demand. For example, technology such as smart ticketing is an enabler to be able to capture what time a passenger made a journey and charge that passenger the appropriate amount.

Linked to the above, whilst incompatible rolling stock and a variety of operators makes splitting and joining of trains difficult on certain routes, there would appear to be the potential for increasing capacity and maintaining the range of destinations served by such measures. In this way, only one path is required into a constrained terminal but two destinations still maintain a direct service. A time penalty would apply to these passengers but would be outweighed by the benefit of additional paths. This may benefit the ECML (south) route.

In some locations, notably on the Bristol Temple Meads case study, while capacity appears to be constrained, the number of passengers per path appears low suggesting short trains that could be lengthened instead of operating additional services, although this may have an infrastructure cost (due to platform lengthening) as well as a rolling stock cost.

Certain services are poor users of capacity, these include those that have to reverse at stations and cross the whole station throat on their way in or out. While loss of through journeys often leads to a significant financial and societal disbenefit, the splitting of such services could free up a significant number of paths (as shown in the Bristol Temple Meads study) which in some locations could generate significant economic benefits over the longer-term as demand continues to grow.

Turnaround times of up to 40 minutes seem overgenerous at some stations (notably Kings Cross) and if they could be reduced this would diminish the need for additional platforms and possibly free up rolling stock. Even for local services, turnaround times can be reduced if the next turn is taken by another driver.

Homogenisation of services provides significant capacity benefits. Whilst there are often clear losers from such a change it is a way of achieving marked increases in capacity – as shown in the GEML case study – usually without the need for major infrastructure investment capacity.

Outside the peak periods and major conurbations there is a need to reconsider the value of freight services as shown in both the GE and South Humberside case studies where freight paths are shown to have a greater economic benefit than some off-peak services. The evidence suggests that it makes no economic sense to constrain freight traffic at the expense of off-peak passenger services, even if this is often a politically difficult argument to sell.

Appendix A – Selection of the route case studies

Four case studies have been selected to cover the various types and mixes of traffic and forms of capacity constraint experienced across the GB rail network. This Appendix describes the short-list of options identified and the rationale for selecting each case study route.

Long-distance, high value

East Coast Main Line – South

The southern end of the ECML – defined as Kings Cross to Peterborough – is well known for being capacity constrained and has a history of operators, including open access operators, bidding to ORR to run competing services.

There are two franchised operators – East Coast and FCC – as well as open access operators Hull Trains and Grand Central running services out of Kings Cross station. East Coast operates long-distance services, some of which call at Stevenage and Peterborough, using a mix of electric and diesel rolling stock. FCC operates a mixture of long and short-distance services between Peterborough and Kings Cross using electric rolling stock. Hull Trains operates diesel trains from Kings Cross to Hull, calling at Stevenage to pick up or set down only. Grand Central operates diesel trains from Kings Cross to Bradford and Sunderland, not calling at stations in this study area.

There is a limited amount of freight operating on this section of the ECML, in the region of 5-10 paths per day according to the East Coast RUS.

The route is characterised by capacity constraints, the NR ECML 2016 capacity review found the key constraint on the whole line is the section between Huntingdon and Peterborough, particularly southbound because the morning peak southbound into London is more concentrated than the northbound evening peak away from London, and there is only one track southbound between Holme and Huntingdon, whereas there are two tracks northbound. The two-track section over the Welwyn Viaduct is also a constraint. Network Rail has delivered an additional platform at Kings Cross (platform 0), and is in the process of delivering a new grade separated junction near Hitchin and a reinstated platform at Finsbury Park to provide increased capacity.

East Coast Main Line – North

The section of the ECML north of Doncaster is being analysed by Network Rail for freight path utilisation. Depending on the study area, this will include East Coast, Transpennine Express, CrossCountry and Northern franchised services as well as Hull Trains and Grand Central. This provides a mix of diesel and electric rolling stock (only East Coast operates electric trains) and different stopping patterns.

This section has much more freight than the southern end, up to 50 paths per day between York and Darlington according to the RUS.

This section also has significant capacity constraints, in particular the two-track section between Northallerton and Newcastle, which is approaching full capacity.

West Coast Main Line

The section between Crewe and Carstairs was suggested as a potential case study. On this route, passenger services are operated by Virgin Trains, Transpennine Express, London Midland, Northern and EMT with a mix of long-distance and stopping services, as well as electric and diesel rolling stock. The London-Scotland sleeper service is also included.

There is significant freight along this route, particularly coal and container traffic around Carlisle.

This route has some capacity for growth according to the RUS, although there are some sections with minimal or no capacity for growth (e.g. Carlisle).

Great Western Main Line

The section between London Paddington and Didcot provides a mixture of long-distance and stopping services, although it is dominated by one operator (FGW) and apart from Heathrow Express and Heathrow Connect, all services are operated by diesel rolling stock. CrossCountry services run through the section between Reading and Didcot. An overnight sleeper from London to Penzance is operated by FGW.

There is a significant amount of freight on this route, in particular between Reading and Didcot.

Services into London Paddington in the peak periods are particularly crowded although Crossrail will provide additional capacity on the slow lines. In addition, electrification and new high speed rolling stock will further change the characteristics of this route.

Midland Main Line

The section between St Pancras and Leicester was proposed. On this route, high speed passenger services are operated by EMT and FCC provides local stopping services. This gives a mix of stopping patterns and traction type with electric FCC rolling stock and diesel EMT rolling stock.

There is a reasonable amount of freight on the Midland Main Line, with a high number of paths near Leicester station where coal and inter-modal traffic travelling east-west interacts. Aggregates, metals and petroleum traffic travel along the whole of the route.

The implementation of the Thameslink Programme will increase train lengths in the medium term.

Summary

Our preferred route for the long-distance, high value case study is ECML (South). We recommend this because it has the interaction with commuter services, with particular issues at Kings Cross regarding platform occupancy, and has significant infrastructure constraints. The

services operating along this section are highly loaded and high value, in contrast to the northern end of ECML.

We were unable to review the ECML (North) work being undertaken by Network Rail ahead of making the decision about which case study to choose. It was therefore not possible to see if there are any synergies with our study, because it had not been completed. Our second choice for this case study was therefore Midland Main Line (St Pancras to Leicester), should data for ECML (south) be difficult to obtain.

London and South East commuter

Brighton Main Line

The Brighton Main Line provides Southern passenger services (including the Gatwick Express) into London Victoria and London Bridge, two of the busiest commuter stations in London. It also includes FCC services which go on through the centre of London and beyond to the Midland Main Line. This gives a mix of fast and stopping services with more than one franchise operator.

There is a limited amount of freight operating on this line, some aggregates traffic in the Purley area and between Earlswood and Haywoods Heath.

The route between Brighton and East Croydon has some capacity constraints, including the two-track section south from Balcombe Tunnel Junction to Brighton.

London, Tilbury and Southend

The LTS line has a good mixture of passenger and freight traffic between Barking, Grays and Tilbury. The current levels of freight are reasonably low, however freight traffic is expected to increase significantly following the opening of London Gateway port in late 2013. There is just one passenger operator (c2c) using one type of rolling stock so passenger services are too similar and therefore not representative of other commuter routes.

Whilst capacity utilisation is fairly high, there does remain scope for additional capacity.

Great Eastern

The route between Stratford and Colchester has just one operator (Greater Anglia) however it provides a mixture of short, medium and long-distance services and a mixture of different electric rolling stock types (EMUs and locomotive-hauled) with a small number of diesel units.

There is significant freight along the route, mainly container traffic from Felixstowe travelling to Stratford where it joins the North London Line.

The London & South East RUS notes that the GEML faces a major challenge for further increasing peak capacity once 12-car operation has been implemented, with infrastructure enhancements (remodelling Bow Junction area and upgrading the Temple Mills lines for passenger use) recommended.

Summary

Our preferred route for the London and South East commuter case study is Great Eastern (Stratford to Colchester) as this provides a mixture of service types and stopping patterns along with significant container freight. Our second choice, in the event of data not being available for Great Eastern, was Brighton Main Line (East Croydon to Brighton).

Route into a non-London conurbation

Leeds

We considered the route between Leeds and Manchester from Leeds West to Ardwick. This covered a mixture of fast (Transpennine Express) and local (Northern) passenger services with different rolling stock and stopping patterns. Leeds station is constrained with a mixture of local and long-distance services.

This cross-Pennine route also includes freight which is significant towards Leeds station (in the region of 10-19 trains per day).

Manchester

The Manchester stations have a mix of passenger train operators with Virgin and CrossCountry long-distance services plus Transpennine Express, EMT and Arriva Trains Wales regional services at Piccadilly, along with Northern local services. There is also a significant amount of container freight through the conurbation.

Routes into Manchester are capacity constrained and the Ordsall curve plus proposals for the Northern Hub are likely to alleviate much of the constraints through re-routing services to avoid conflicting movements.

Birmingham

Birmingham New Street is a complex station that is in the process of being remodelled. One possible route for this conurbation would be Moor Street to Snow Hill. Passenger services are provided by Chiltern Railways and London Midland. All trains are Diesel Multiple Units and have similar stopping patterns. There is a limited amount of metal freight carried through the route according to the RUS.

The route does have a capacity constraint with eight trains per hour during the off-peak (six London Midlands and two Chiltern) combined with low line speeds (less than 35mph) and freight traffic. However it is relatively straightforward and probably not very representative of non-London conurbation services.

Glasgow

Like Birmingham, Glasgow is also a complex conurbation in terms of rail access. One option would be Queen Street high level. Passenger services are operated by Scotrail and the high


level station is the terminus for the Edinburgh shuttle services and all routes north of the 'Central Belt'. Services are operated by diesel rolling stock. There is little freight on this route.

Most non-London conurbation stations are through-stations, whereas Queen Street is a terminal station therefore it is not representative of this route type.

Bristol Temple Meads

Passenger services at Bristol Temple Meads are provided by FGW (long-distance, non-London inter-urban and local services), SWT (local services) and CrossCountry (inter-urban services). There is in the region of 13-24 freight paths per day through the station according to the RUS, including aggregates, coal and metals.

Bristol station would provide a mix of train lengths and a complex operating layout. During the peak, capacity utilisation is high on all routes into Bristol Temple Meads, complicated by reversing of trains in the station, making this a capacity constrained part of the network.

The study area was defined as Stapleton Road to the north, Bath Spa to the east and Worle to the south.

Summary

Our preferred choice for the non-London commuter route is Bristol Temple Meads because it is multi-operator, a mixture of long and short train formations, has a complex layout and includes a variety of freight. Our second choice would be Birmingham Moor Street to Snow Hill.

Rural route

Settle – Carlisle

The Settle to Carlisle route has long headways which reduce capacity but there is not currently a capacity constraint. Passenger services are operated by Northern using diesel rolling stock and there is a significant amount of freight traffic, particularly gypsum and short-term coal, although coal traffic is forecast to decline.

South Humberside

The section from Doncaster to Cleethorpes provides a mix of passenger services – local services provided by Northern and regional Transpennine Express services – with significant levels of freight from Immingham including coal, inter-modal, metals and petroleum.

It is described in the Network Rail route plan as one of the main capacity constraints, as a result of Absolute Block Signalling and a single line section between Cleethorpes and Grimsby Town.

Highland Main Line

The Highland Main Line between Perth and Inverness is an option for the rural case study. Passenger services are provided by Scotrail and a small number of East Coast and sleeper services also operate. There is a limited amount of freight on the route.

The line is predominantly single track with some double track between Blair Atholl and Dalwhinnie and on the approach to Inverness.

Swansea to West Wales

This section is characterised by several single line sections – Swansea to Llanelli, Whitland to Pembroke Dock and Clarbeston Road to Fishguard Harbour. Arriva Trains Wales provide local services and Great Western provides long-distance services from Swansea to Camarthen (and Pembroke during the summer). There is little freight along the route.

Summary

Our recommendation for the rural route is the Doncaster to Cleethorpes section because it has lots of freight, including short-term coal traffic, is capacity constrained and has a mix of two operators and service types. Our second choice would be the Highland Main Line.


Appendix B – Case study route profiles

This Appendix includes more detail of the infrastructure, rolling stock and operational constraints for each of the route case studies.

Great Eastern Main Line (Shenfield – Colchester)

Infrastructure

The route has four tracks as far as Shenfield – two fast lines (Main Lines, MLs) and two slow lines (Electric Lines, ELs) in each direction – reducing to two tracks thereafter. There are lines branching off to Southend Victoria from Shenfield, to Braintree from Witham, to West Anglia and the North London Line from Stratford and from Forest Gate to the Tilbury line. All lines are electrified with 25kV AC overhead equipment.

Signalling is track circuit block along the whole case study route. The route from Liverpool Street to Marks Tey was resignalled in the mid-1990s whilst Marks Tey to Colchester was resignalled in 2009[41] which implies that the type of signalling should not be a limiting factor on the potential capacity.

Termini

The main terminus for Great Eastern, London Liverpool Street, lies outside of our study area. Within the study area, passenger trains terminate at Ilford, Gidea Park, Shenfield, Chelmsford, Witham, Braintree and Colchester. A freight train terminal is located at Marks Tey.

Rolling Stock

GE 'Inner' services on the ELs are generally operated by Class 315 EMUs. These have a maximum speed of 75 mph and a 4-car unit has 318 seats[42]. They can operate in formations of four or eight coaches, being limited to this by platform lengths. Class 321 EMUs operate to Braintree, Southend Victoria and Ipswich and sometimes operate the Inner services. These trains have a maximum speed of 100 mph and a 4-car unit has 307 seats. On the Main Lines, Class 90 locomotive-hauled stock operates to Norwich with its speed limited by the maximum line speed of 100 mph. Class 360 EMUs operate to Clacton-on-Sea, Colchester and Ipswich. These trains have a maximum speed of 100 mph and a 4-car unit has 288 seats. Class 321 and 360 EMUs can operate in formations of up to 12 coaches.

There are examples of passenger train timings that relate to the slowest train capability to allow for substitutions so that a less capable train can run in the path of a more capable one, e.g. Class 360 and Class 321 timings are the same in the WTT. Locomotive-hauled trains call at few stations within the study area (hourly at Stratford and Chelmsford) so despite their poorer acceleration they tend to catch up with stopping trains.

41 Greater Anglia RUS (Network Rail, December 2007) and http://www.signallingsolutions.com/CaseHistory/ColchesterClacton.aspx (accessed 12 June 2012)

42 Source: Greater Anglia Franchise Consultation (DfT, January 2010)

Operating rules and practices

Passenger train signalling headways for planning purposes are 2 minutes on all lines between Stratford and Shenfield, and 3 minutes between Shenfield and Colchester. Freight train signalling headways are 2 minutes on all lines between Stratford and Seven Kings except between Stratford and Forest Gate which is 3 minutes on all lines.

The GE Mainline Train Planning Rules therefore allow up to 30 passenger trains per hour (tph) between Shenfield and Stratford running at a 2 minute headway for trains on each of the MLs and ELs, and 20tph at a 3 minute headway for passenger trains between Shenfield and Colchester and for freight services across the route.

This is the theoretical maximum capacity before considering the impact of station dwell times (typically half a minute for EMUs and one minute for locomotive-hauled stock), platform re-occupation times (typically 3 minutes), margins for ‘crossing moves’ at junctions (typically 2 minutes) and changes to sectional running times for trains making crossing moves (this varies by location between half a minute to two and a half minutes depending upon the type of train, e.g. a long/heavy freight train will require longer to make a junction manoeuvre than a light/shorter EMU). In addition to the above there are a range of location and time specific allowances, for example dwell time at Chelmsford is generally one minute and is increased to one and a half minutes during the evening peak due to passenger volumes.

Further allowances are required for engineering (Temporary Speed Restrictions) and Performance, typically 2 minutes from Bow Junction to Shenfield and 2-3 minutes from Shenfield to Colchester, with different values at weekends.

Maintenance of the network generally occurs between Saturday evening and Monday morning when at least two lines are blocked to traffic. This enables freight traffic to operate through the night during the week.

East Coast Main Line (Kings Cross – Peterborough)

Infrastructure

The route is four-track from the station ‘throat’ at Kings Cross (consisting of Up and Down, Fast and Slow lines) and opens out to six tracks at Holloway with the addition of Up and Down Goods Lines. This continues through Finsbury Park where there is a connection to the North London Line and Moorgate until Alexandra Palace where there is a branch off to the Hertford Loop. From here it remains four-track until Digswell (one mile north of Welwyn Garden City) where it becomes two-track across the Welwyn Viaduct to Woolmer Green (two and a half miles later) where it reverts to four-track. At Hitchin is the junction with the lines to Cambridge. At Huntingdon, there are two tracks in the northbound (Down) direction but only one track in the southbound direction. This continues for ten miles to Holme where it becomes one track in each direction until Peterborough.

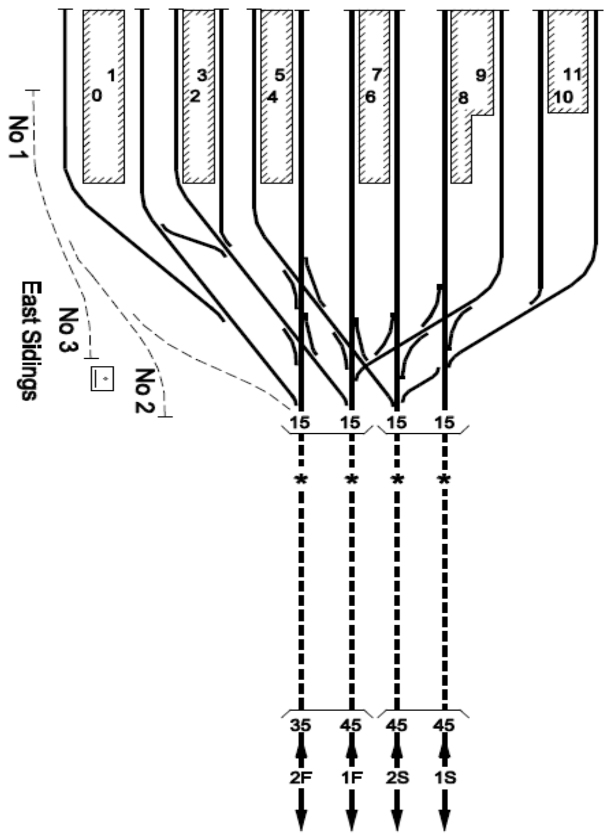
The standard planning signal headway is four minutes except for Kings Cross to Hitchin which is three minutes (fast and slow lines). Signalling is track circuit block between Kings Cross and

Peterborough, but is not modern and is due to be upgraded to ERTMS cab-based signalling in 2019 which is expected to increase capacity.

Termini

Kings Cross is the terminus of the route. It has 12 platforms, of which nine can accommodate long-distance high-speed trains and suburban services, with a further three platforms accommodating suburban trains only[43].

Figure B1: Kings Cross station layout



Source: Network Rail Sectional Appendix

The fast, long-distance services covered under this study generally go beyond the study area before terminating.

Rolling Stock

East Coast services are operated by locomotive-hauled trains, either Class 43 High Speed Trains (HSTs) – diesel trains for destinations which are not electrified – or Class 91 IC225s which are electric. Both locomotives have similar top speeds (125mph), however the Class 43s have lower acceleration characteristics than the Class 91s.

[43] Route Specifications 2011 London North Eastern, Network Rail

Hull Trains operates 5-car Class 180 DMUs with a top speed of 125mph. These trains have a capacity of 268 seats. Grand Central operates a mixture of HSTs and Class 180s.

FCC commuter trains are either 4-car Class 317 EMUs with a top speed of 100mph and 269 seats[44], 3-car Class 313 EMUs with a top speed of 75mph and 232 seats or 4-car Class 365 EMUs with a top speed of 100mph and 243 seats. EMUs operate in multiple formations during peak periods.

Operating rules and practices

Dwell times at stations range from half a minute for EMUs to one minute for DMUs (open access operators) and one and a half minutes for HSTs/loco-hauled stock. At Peterborough, dwell times are two minutes for all trains. Platform re-occupation times are as follows:

- EMU/DMU (same direction) = 3 minutes
- EMU/DMU (opposite direction) = 5 minutes
- HST/Loco-Hauled (same direction) = 4 minutes
- HST/Loco-Hauled (opposite direction) = 6 minutes

Turnaround times are 6 minutes for EMUs during the peak (this can be reduced to 5 minutes if a different driver is used for the second journey) and ten minutes for EMUs during the off-peak. Times for HST/Loco-Hauled stock vary depending on where they have arrived from and are as follows:

- 35 minutes from Newcastle
- 30 minutes from Yorkshire
- 40 minutes from Scotland
- 30 minutes from Hull (20 minutes Monday to Friday 0700-1000 and 1600-1900, Saturday all day and Sunday 1700-2100)
- 35 minutes Grand Central from Sunderland (20 minutes at weekends)

These times compare to minimum turnaround times at Paddington of 30 minutes for HSTs from Penzance and 20 minutes for HSTs from Cardiff or Bristol, and at Euston of 30 minutes for services from Liverpool/Manchester and 40 minutes for services originating north of Carlisle.

There is a complex series of junction margins for crossing manoeuvres. The most significant of these occurs when trains make crossing moves at Kings Cross – platforms 1 to 8 require 5 minutes, and platforms 9 to 11 requires 4 minutes[45].

Based on the planning headways the following theoretical maximum paths per hour (under a standardised stopping pattern and rolling stock) are:

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[44] Consultation on the combined Thameslink, Southern and Great Northern franchise (DfT, May 2012)

[45] London North East Train Planning Rules, April 2012 (Network Rail) – does not reference Platform 0

- Kings Cross to Hitchin – 20 paths per hour fast lines + 20 paths per hour slow lines = 40 maximum paths where four-track
- Hitchin to Huntingdon – 15 paths on the fast lines + 12 paths on the slow lines = 37 maximum paths where four-track
- Huntingdon to Peterborough – 15 paths per hour on Fast lines

Engineering access generally requires the closure of either the fast or slow lines each night.

Bristol Temple Meads

Infrastructure

Services from the north and the east all enter the station via the same five-track section, with northbound/eastbound services diverging at Bristol East junction which is situated just to the northeast of the station. Southbound services operate over a three-track section of route to Parson Street, and a two-track section onwards to Worle after which services to Taunton and Weston-super-Mare diverge at Worle junction.

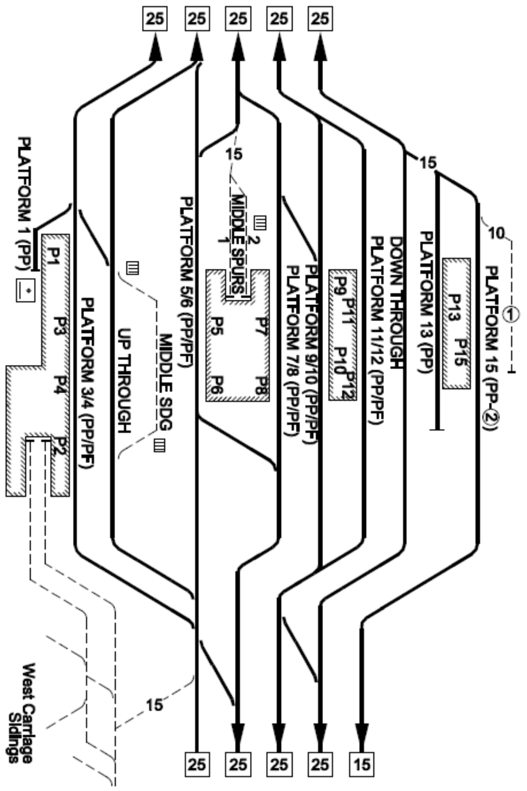
Passenger service signalling headways for planning purposes are generally 4 minutes, whilst the Severn Beach branch works on “one train working”. The route to Worle has track circuit block signalling and is due for resignalling around 2015-19.

Termini

Bristol Temple Meads has nine platform faces some of which are divided in two along their length to make nominally 14 platforms, 13 of which are currently in operational use with platform 2 not currently used. Several platforms are shared due to the long curvature of platform areas. Platforms 13 and 15 are mainly used by Long-Distance High Speed services and platforms 5 and 6 used by long-distance inter-urban services. The remaining platforms are used by local services[46].

[46] Network Rail Route Specification 2011 - Western

Figure B2: Bristol Temple Meads station



Source: Network Rail Sectional Appendix

Rolling Stock

A variety of rolling stock uses Bristol Temple Meads station. Class 43 HSTs provide services to the west of England and London. CrossCountry Class 220/221 DMUs run to Plymouth, Glasgow and Manchester, etc. These are mostly 4- or 5-car units with 200-260 seats whilst Class 43 HSTs with extra seats operate selected services. Class 158 DMUs operate the Cardiff to Portsmouth service, these are 3-car units with around 200 seats. Local services, including the Severn Beach branch, are formed by a mixture of Class 150 (2- or 3-car) and Class 153 (1-car) DMUs[47]. Class 150s have around 150-200 seats, whereas Class 153s have 72 seats.

Operating rules and practices

Platform dwell times are 2 minutes for DMU’s and 3 minutes for HST’s, with 4 minutes allowed for platform re-occupation. For reversing trains, dwell time increases to 5 minutes with a further 5 minutes needed for platform re-occupation.

In addition, allowances for conflicting moves across the junctions are typically 2.5 to 3 minutes, and a train entering the station from the east (e.g. from Portsmouth) and leaving the station towards Cardiff will need to cross all the tracks.

[47] Source: Bristol Temple Meads station working book (December 2011 – May 2012)

South Humberside (Doncaster – Cleethorpes)

Infrastructure

The route can be split into the following sections:

- Cleethorpes to Grimsby Town – single line section for passenger traffic only. Headways are four minutes although a non-stop service can leave three minutes in front of an all-stations service.
- Grimsby Town to Brocklesby Junction – double line section for passenger traffic only. Absolute Block Signalling is in operation on much of this section.
- Brocklesby Junction to Kirk Sandall Junction – mostly two tracks with some three/four-track sections, dominated by freight traffic to/from Immingham with some passenger services.

Signalling systems on this line vary. The line from Doncaster to Scunthorpe is track circuit block controlled from Doncaster and Scunthorpe power signal boxes. From just east of Scunthorpe at Appleby the line reverts to Absolute Block with a series of signal boxes controlling the section to Grimsby, including the key junctions at Wrawby, Barnetby and Brocklesby. The final single line section between Grimsby and Cleethorpes is track circuit block is controlled by Pasture Street box.

Termini

There are no significant terminus issues in this study area.

Rolling Stock

Transpennine Express services from Cleethorpes are operated by Class 185 DMUs which have a top speed of 100mph, and are 3-cars in length with 169 seats. Northern services are operated by Class 153 DMUs which are 1-car units with 72 seats and a top speed of 75 mph. East Midlands Trains operates services from Grimsby to Newark also using Class 153 DMUs.

The majority of freight traffic is “Class 6” with return empty flows of coal traffic able to run as Class 4 due to the lower axle load.

Operating rules and practices

The standard planning headway on the route from Doncaster to Scunthorpe is 4 minutes. Beyond Scunthorpe most of the railway is Absolute Block and the TPR does not give headways. NR supplied a breakdown of the planned SRTs between the relevant blockposts on the route.

This means that the maximum number of paths will vary by section of the route but the core section between Barnetby and Brocklesby has the longest running time. For Class 6 trains (the slowest services) that time is 6 minutes in the Up direction. This means that if all traffic was Class 6, the commonest class on this section, a maximum of 10 freight paths could be accommodated on the Up line. On the Down line the TPR quotes that there is a headway of 5 minutes on the main line and 8 minutes on the Down goods line. This means that there is a maximum of seven freight paths per hour on the goods line.

Engineering access is generally Saturday and Sunday evenings with single line working in some instances.

Appendix C – Analysis of freight path utilisation

- Great Eastern
- Bristol Temple Meads
- Doncaster – Cleethorpes

Freight train overview on the GE Mainline

The following tables show the usage of freight paths in the WTT for the 11 week period from 03 January 2012. It shows utilisation on weekdays, out of a total of 56 days.

(a) Forest Gate to Colchester:

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
4L74	Birch Coppice Sdg to Ipswich	1	ThFO	22	5%
4L71	To Felixstowe	22	FO	11	200%
4L60	To Felixstowe	22	MSX	29	76%
4L23	To Felixstowe	24	MSX	29	83%
4L00	Hams Hall to Ipswich	11	FO	11	100%
4L24	Birch Coppice to Felixstowe	0	MSX	44	0%
6L58	Mountsorrel	9	WThFO	33	27%
4L77	to Felixstowe	22	FO	11	200%
6L68	Willesden to Southminster CEGB	0	TThO	22	0%
6L30	Acton – Parkston	4	Varies		
4L82	To Felixstowe	55	MSX	44	125%
4L69	Lawley St. to Felixstowe	44	MSX	44	100%
4L58	Lawley St. to Ipswich	0	MSX	44	0%
6Y35	Ripple Lane to Ipswich	9	WO	11	82%
6L70	Crewe to Sizewell BNFL	13	MSX	44	30%
4L41	Crewe to Ipswich	55	SX	56	98%
4L95	To Felixstowe	54	MSX	44	123%
6L57	Acton to Ipswich	8	TThO	22	36%
4R98	Felixstowe	43	SX	56	77%
4L02	To Felixstowe	2	MSX	44	5%
4L89	To Felixstowe	52	SX	56	93%
4L37	To Felixstowe	10	MO	11	91%
4L41	To Felixstowe	55	MSX	44	125%
6L27	Wembley to Parkston	0	MSX	44	0%
6L38	Hayes to Parkston	5	SX	56	9%
4L30	To Felixstowe	11	MO	11	100%
4L27	Wembley to Parkston	0	MThO	23	0%
6L95	Cliffe Hill to Marks Tey Tarmac	0	W/ThO	22	0%
6L50	Crawley to Marks Tey Tarmac	1	TWFO	33	3%
4L93	To Felixstowe	51	SX	56	91%
4Y88	Wheel Lathe Ilford to Ipswich	9	MO	11	82%

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
4L70	Rugby to Ipswich	48	SX	56	86%
4L75	To Felixstowe	50	SX	56	89%
4L90	To Felixstowe	0	SX	56	0%
4L22	To Felixstowe	55	SX	56	98%
6L78	Acton Marks Tey Tarmac	0	SX	56	0%
4L92	To Felixstowe	54	SX	56	96%
4L30	To Felixstowe (All Mondays)	11	WThO	22	50%
4L68	To Felixstowe	54	SX	56	96%
4L96	To Felixstowe	21	SX	56	38%
4L73	To Felixstowe	19	ThFO	22	86%
4L97	Trafford Park to Felixstowe	54	SX	56	96%

(b) Colchester to Forest Gate

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
6M75	Southminster to Crewe	0	TThO	22	0%
6V55	Marks Tey Tarmac to Hayes	0	MSX	44	0%
6O50	Marks Tey Tarmac to Crawley	4	TO	11	36%
4M75	Ex Felixstowe	21	FO	11	191%
4M52	Ex Felixstowe	0	MSX	44	0%
6L58	Mountsorrel to Chelmsford	9	WThFO	33	27%
4M45	Ex Felixstowe	43	MSX	44	98%
4M21	Ex Felixstowe	0	MSX	44	0%
4M74	Ipswich to Birch Coppice	41	MSX	44	93%
4M86	Ex Felixstowe	46	SX	56	82%
6R34	Ipswich to Ripple Lane	9	WO	11	82%
4M00	Ipswich to Hans Hall	56	SX	56	100%
6V79	Marks Tey Tarmac to Hayes	1	TWFO	33	3%
4C88	Ipswich to Ilford Wheel lathe	9	MO	11	82%
6M53	Chelmsford to Mount Sorrell (aggregates)	11	WThFO	33	33%
4R97	Ex Felixstowe	44	SX	56	79%
4M81	Ex Felixstowe	54	SX	56	96%
4M88	Ex Felixstowe	51	SX	56	91%
4M23	Ex Felixstowe	55	SX	56	98%

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
4M87	Ex Felixstowe	54	SX	56	96%
6V17	Parkston to Acton (Refuse)	4	SX	56	7%
4M08	Ex Felixstowe	0	SX	56	0%
6M57	Ipswich – Watford Concrete (aggregates)	7	ThO	11	64%
4M93	Ex Felixstowe	55	SX	56	98%
4M02	Ex Felixstowe	55	SX	56	98%
6M69	Sizewell BNFL to Willesden	13	SX	56	23%
4S88	Ex Felixstowe	53	SX	56	95%
4M89	Ex Felixstowe	54	SX	56	96%
4M92	Ex Felixstowe	55	SX	56	98%
6O65	Snailwell Sdg to Sheerness Steel Works (scrap metal)	0	FO	11	0%
4V32	Ex Felixstowe	0	TWO	22	0%
4M85	Ipswich to Rugby	47	SX	56	84%
4M53	Ex Felixstowe	55	SX	56	98%
6V61	Marks Tey Tarmac to Hayes	0	ThO	11	0%
4M59	Ex Felixstowe	21	ThFO	22	95%
4M73	Ex Felixstowe	22	ThFO	22	100%
4M42	Ex Felixstowe	22	ThFO	22	100%
4M94	Felixstowe to Lawley St	49	SX	56	88%

Freight train overview for Bristol Temple Meads station

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
4C07	Stoke Gifford to Portbury Coal Terminal	42	FSX	45	93%
6V99	Bescot to St Blazey	0	TO	12	0%
4V07	Rugby to Portbury CT	3	MSX	45	7%
4V69	Chaddesden to Portbury CT	0	SX	56	0%
4C05	Stoke Gifford to Portbury CT	27	SX	56	48%
4V32	Felixstowe to Bristol FLT	0	WThO	22	0%
4V55	Rugby to Portbury CT	4	MSX	45	9%
4C56	Stoke Gifford to Portbury CT	26	SX	56	46%
4V30	Tilbury to Bristol FLT	45	MSX	45	100%
4V26	Grain to Bristol FLT	10	MSX	45	22%
4C59	Stoke Gifford to Portbury CT	10	SX	56	18%
4V59	Basford Hall to Portbury CT	23	MSX	45	51%
6V74	Crewe Coal Yard to Bridgewater (Nuclear Flask)	10	SX	56	18%
6V21	Hope to Moorswater (cement)	0	MSX	45	0%
4V04	Basford Hall to Portbury CT	47	MSX	45	104%
4C04	Stoke Gifford to Portbury CT	7	SX	56	13%
6V51	Arpley to Portbury Automotive	20	SX	56	36%
4L30	Bristol FLT to Felixstowe	11	MO	11	100%
4F23	Avonmouth to Portbury CT (all Tuesdays)	3	MO	11	27%
4F83	Aberthaw to Portbury CT	6	SX	56	11%
4L32	Bristol FLT to Tilbury	44	SX	56	79%
4O24	Bristol FLT to Grain	11	SX	56	20%
4C70	Aberthaw to Portbury CT	1	SX	56	2%
4F27	East Usk to Portbury CT	5	SX	56	9%
4D98	Avonmouth to Bristol Barton Hill	0	ThO	11	0%
4V13	Chaddesden to Portbury CT	0	SX	56	0%
4V46	Rugeley to Portbury CT	0	SX	56	0%
4C09	Stoke Gifford to Portbury CT	52	SX	56	93%
6V77	Cliffe Vale to St Blazey (Clay)	0	ThO	11	0%
6M13	Portbury CT to Ratcliffe	0	SX	56	0%
4V58	Basford Hall to Portbury CT	0	SX	56	0%
4V56	Rugeley to Portbury CT	0	SX	56	0%
4C66	Stoke Gifford to Portbury CT	20	SX	56	36%
6C99	Alexandra Dock to St Blazey (Clay)	11	MTO	23	48%

Headcode	Train Type	Days Operated	Planned	Max days	Utilisation
4C03	Stoke Gifford to Portbury CT	1	FSX	45	2%
6M07	Portbury CT to Rugeley	37	MSX	45	82%
6F65	Portbury CT to Uskmouth	32	MSX	45	71%
6M55	Portbury CT to Rugeley	30	SX	56	54%
6M61	Portbury CT to Rugeley	33	SX	56	59%
6F90	Portbury CT to Fifoots Power Stn	14	SX	56	25%
6M04	Portbury CT to Rugeley	39	SX	56	70%
6V62	Fawley to St Phillips Marsh (Fuel)	12	TO	12	100%
6B86	Portbury CT to Aberthaw	6	SX	56	11%
6C62	St Phillips Marsh to Tavistock Jn	12	TO	12	100%
6B69	Portbury CT to Aberthaw	1	SX	56	2%
6X52	Portbury Automotive to Mossend	19	SX	56	34%
6C51	Parkandillac - Alexandra Dock	0	ThO	11	0%
6C41	Burngullows to Alexandra Dock	0	ThO	11	0%
6C39	St Blazey to Alexandra Dock	14	ThO	11	127%
6M02	Portbury CT to Fiddlers Ferry	52	SX	56	93%
6M37	Moorswater to Hope (cement)	0	MSX	45	0%
6M12	Portbury CT to Fiddlers Ferry	20	SX	56	36%

Freight train overview for South Humberside

The following tables review the weekday train operation on the route between Thorne Junction and Brocklesby. Each WTT path was analysed to understand how frequently it operated. Note that some paths for coal traffic have multiple start and destination points depending on which power station is being supplied. Trains from Immingham have different headcodes sharing the same path depending on the power station (this also applies to fuel oil trains from Humber and Lindsey refineries). These were treated as one path in the analysis, although on occasions two trains ran as STP changes and are noted in the table.

(a) Doncaster to South Humberside

Head Code	Train	No of Days (out of 56)
6E81	Oil to Humber R	0
6E27	Oil to Humber R	0
6K30	Iron Ore	18
4R02	Import Coal	28
4R31	Import Coal	17
4R03	Import Coal	30
6E58	Oil to Humber R	0
4R42	Import Coal	21
6E11	Oil to Imm Texaco	9
6E38	Oil to Lindsey R	25
4R05	Import Coal	40
4R04	Import Coal	40
6E98	Ayshire Coal to Imm	22
4D44	Belmont to Scunthorpe	0
6D45	Steel (Redcar – Scunthorpe)	0
6D77	Oil to Lindsey R	1
6D46	Oil to Humber R	0
4R32	Import Coal	18
6E09	Swansea Burrows (Coal) to Imm	12
4E48	Coal from Hatfield Colliery	1
6E15	Eastleigh to Scunthorpe	0
4E54	Coal from Hatfield Colliery	0
6K18	Iron Ore Santon – Imm	30
4R06	Import Coal	44
6D45	Steel (Redcar – Scunthorpe)	0
6T48	Iron Ore (Redcar – Santon)	0
6E39	Steel	10
4R07	Import Coal	28
4R08	Import Coal	42
6K19	Iron Ore – Santon Imm	38
4R33	Import Coal	15
6D97	Steel – Lackenby – Scunthorpe	51
6E29	Only Runs Round at Barnetby	0
4R29	Import Coal	3
4D22	Import Coal	7
6D48	Coal to BSC Scunthorpe	37
6E01	Refuse (Scunthorpe – Northenden)	56
4R90	Import Coal	14

Head Code	Train	No of Days (out of 56)
6E07	Refuse	45
6E76	Toton to Hedon Rd (Hull)	5
4R09	Import Coal	50
6D27	Steel to Goole	0
6K20	Iron Ore (Santon – Imm)	34
4D61	Import Coal	3
6D95	Steel (Scunthorpe – Goole)	3
4R10	Import Coal	38
4D23	Import Coal	19
6D94	Steel to Goole/Hedon Road	31
6H92	Belmont to Goole Glassworks	0
6D54	Coal to BSC Scunthorpe	33
6D74	Belmont to Scunthorpe	0
4C71	Scunthorpe to Immingham	30
6K21	Iron Ore (Santon – Imm)	40
4R11	Import Coal	38
6E20	Margam to Immingham	29
4R78	Import Coal	13
4R34	Import Coal	3
4E59	Coal – Hatfield Colliery	0
6E44	Coal to Scunthorpe BSC	12
6D63	Coal to Scunthorpe BSC	23
6E46	Oil to Lindsey R	39
4R12	Import Coal	45
6K22	Iron Ore (Santon – Imm)	35
4C72	Scunthorpe – Immingham	48
4R13	Import Coal	29
6D04	Steel (Masborough – Scunthorpe)	12
4C73	Scunthorpe – Immingham	42
4R35	Import Coal	10
4R14	Import Coal	28
6K23	Iron Ore (Santon – Imm)	43
4R15	Import Coal	31
4R41	Import Coal	13
4D37	Coal to Hull CT	2
6K24	Iron Ore (Santon – Imm)	36
6D42	Oil Eggbank – Lindsey R	6
4R16	Import Coal	23
4C75	Scunthorpe – Immingham	16
6E06	Refuse	56
6E32	Oil to Lindsey R	24
6E02	Crewe to Scunthorpe	0
4R17	Import Coal	39
6E84	Rockware Glass	0
6E37	Oil to Lindsey R	0
6E54	Oil to Humber R	41
4R36	Import Coal	10
6D57	Steel	1
4R18	Import Coal	37
6K25	Iron Ore (Santon – Imm)	37
4D24	Import Coal	1

Head Code	Train	No of Days (out of 56)
6E82	Oil to Lindsey	36
6D49	Oil to Lindsey R	12
6D13	Oil to Lindsey R	7
4R19	Import Coal	24
4C76	Scunthorpe – Immingham	8
4E63	Coal to Hatfield Colliery	0
6D80	Oil to Lindsey	0
4E10	Steel	0
6D34	Oil to Lindsey R	2
6K26	Iron Ore (Santon – Imm)	43
4R37	Import Coal	22
4R20	Import Coal	32
6E41	Oil to Lindsey R	27
4R21	Import Coal	49
6D88	Steel (Goole – Scunthorpe)	3
6D11	Steel (Lackenby – Scunthorpe)	49
4D65	Import Coal	13
6K27	Iron Ore (Santon to Immingham)	26
6E27	Oil to Imm Texaco	0
4R94	Import Coal	11
6E31	Oil to Lindsey	0
6E48	Oil to Lindsey	7
4R22	Import Coal	50
6D43	Oil to Lindsey	52
6E59	Oil to Lindsey	14
4R23	Import Coal	35
6E08	Steel to Immingham	49
6E88	Goole Glassworks	24
4R30	Import Coal	15
6K28	Iron Ore (Santon – Imm)	23
6E55	Oil to Lindsey R	26
4E23	Barrow Hill to Immingham	1
4R24	Import Coal	46
4C79	Scunthorpe – Immingham	3
6E38	Oil to Lindsey	25
6E48	Oil to Lindsey	7
6D03	Tinsley – Immingham Nordic – Chemicals	33
6E72	Stalybride – Immingham – Chemicals	15
6E79	Steel (Wolves to Scunthorpe)	0
6E83	Ketton to Immingham – Cement	0
4R01	Imported Coal	19
4C80	Scunthorpe – Immingham	7
6E07	Refuse	45
4E32	Dollands Moor – Scunthorpe	35

(b) South Humberside to Doncaster

Head Code	Train Type	No. of Days (out of 56)
6N03	Oil from Lindsey R	43
6B23 6H41	Import Coal (on 15 occasions both trains ran)	45
6C20	Import coal	3
6H09	Import coal	6
6M47	Steel	0
6J62	Import coal	29
6R24	Import coal	13
6V98	Oil from Lindsey R	27
6M76	Oil from Lindsey R	0
6R24	Import coal	13
6T31	Iron Ore - (Imm- Santon)	19
6C81	Immingham to Scunthorpe	2
6C22	Import coal	0
6H40	Import coal	21
6M62	Import coal	5
6H09	Import coal	6
6F23	Immingham to Worksop	20
6T18	Iron ore - (Imm – Santon)	32
6M33	Imm – Stalybridge – Chemicals	15
6R02	Import coal	22
6C12	Import coal	0
6F49	Import coal	12
6Y05	Import coal	3
6M35	Oil from Humber R	15
6R41	Import coal	2
6M11	Oil from Lindsey R	36
6T19	Iron ore (Imm – Santon)	33
6R41	Import coal	2
6V40	Steel	4
6M32	Oil from Lindsey	22
6B23	Import coal	21
6D03/6R03	Import coal	5
6T19	Iron Ore (Imm – Santon)	33
6M61	Oil from Humber	0
6R31	Import coal	9
6D95	Ex Goole Docks	3
6C41	Import coal	13
6Y08	Import coal	0
6R04	Import coal	4
6M66	Import coal	41
6B23	Import coal	21
6J03	Immingham Nordic – Chemicals	38
6B05	Import coal	2
4L87	Scunthorpe – Ipswich (MD)	3
6A49	Hatfield Colliery Coal	0
6H16	Import coal	30
6T48	Ore train to Redcar	0
6H93	Goole Glassworks	16
6C71	Immingham – Scunthorpe	0

Head Code	Train Type	No. of Days (out of 56)
6D50 6D73 6D39	Oil ex Lyndsey	25
6R06 6C01 6D39	Import coal	13
6C72	Immingham – Scunthorpe	0
6H43	Import coal	17
6T21	Iron Ore (Imm – Santon)	35
6H85 6R07	Import coal	19
6D89	Immingham to Decoy Yard	1
6M57	Oil from Lindsey R	14
6C73	Immingham to Scunthorpe	6
6J65	Immingham to Barrow Hill	18
6R08 6M49	Import coal	13
6D75	Scunthorpe to Doncaster	0
6T22	Iron Ore (Imm – Santon)	36
6N04	Oil from Lindsey R	0
6N10	Oil from Humber R	0
6R33	Import coal	15
6D79	Oil ex Lindsey R	0
6D90	Ex Goole Docks to Doncaster	0
6C09	Import coal	50
6X01	Imm – Eastleigh	0
6M05	Refuse	56
6M55	Oil from Lindsey R	0
6D31	Oil from Lindsey R	2
6R60	Import coal	12
6D31 6M55	Oil from Lindsey R	2
6Y13 6R10	Import coal	39
6T23	Iron Ore (Imm – Santon)	41
4M10	Scunthorpe – Wellingborough	0
6Y15	Import coal	9
6C75	Immingham – Scunthorpe	42
6B11 6F11 6H60	Import coal (on 9 days 2 trains ran)	57
6M07	Refuse	54
6J27	Ex Goole Docks	5
6A60	Coal ex Hatfield Colliery	0
6F92	Import coal ex Hull	0
7D10	Scunthorpe to Doncaster	0
6R71	Import coal	15
6M00	Oil from Humber R	30
6T24	Iron Ore (Imm – Santon)	36
6M51 6R12 6C59	Import coal (all but 1 path was taken by 6M51)	49
6C76	Immingham to Scunthorpe	46

Head Code	Train Type	No. of Days (out of 56)
6J94	Hedon (Hull) to Masborough	22
6R34 6H44 6H33 6R32	Import coal (6H44 only ran on 3 occasions, 2 on the same day as 6R34, 6H33 ran twice, 6R32 did not run)	25
6R62	Import coal	6
6T25	Iron ore (Imm – Santon)	37
6M51	Coal (Hull to Rugby)	48
6D05	Steel	0
6R14 6Y17 6F72	Import coal (on 7 occasions 2 trains ran)	36
6N45	Redcar BSC Ore	0
4D30	Immingham Workshop	0
6D57	Steel (Scunthorpe local trip)	1
6T26	Iron Ore (Imm – Santon)	42
6H15	Import coal	8
6M02	Scunthorpe – Crewe	0
6R35	Import coal	9
6R16	Import coal	18
6C42	Import coal	21
6C79	Coal (Scunthorpe BSC)	15
6F17 6H07	Import Coal	43
6H94	Goole Glassworks	1
6T27	Iron Ore (Imm – Santon)	39
6M24	Oil from Lindsey R	49
6M06	Refuse	56
6019	Scunthorpe – Dollands Moor	46
6A65	Coal ex Hatfield Colliery	0
6V19	Immingham to Margham	26
6H17	Import coal	0
6R18 6F98	Import coal	3
6R46	Import coal	4
6D20	Rockware Glass – Doncaster	0
6F75	Import coal (Hullo)	0
6N73	Steel to Lackenby	38
6H31	Rockware Glass	7
6H04	Import coal	3
6T28	Iron ore (Imm – Santon)	30
6B19	Import coal	22
6C80	Import coal	7
6R20	Import coal	5
4N85	Redcar BSC	40
6F46	Import coal	21
6M99	Imm – Bescot/Wolves, Steel	54
6T29	Iron ore (Imm – Santon)	19
6R25 6B21	Import coal	1
6C21	Import coal	48
6M47	Steel	0
6D24	Scunthorpe – Belmont	0

Head Code	Train Type	No. of Days (out of 56)
6R73	Import coal	20
6V96	Import coal	1
4N86	Redcar BSC	27
6R37	Coal to Gascome Wood	3
6V70	Oil from Lindsey R	24
6V84 6V96	Oil from Lindsey R	19
6V11	Oil from Imm Texaco	8
6R22	Import coal	48
6T30	Iron ore (Imm – Santon)	22
6V98 6V70	Oil from Humber (on 9 occasions both trains ran)	51
6R64	Import coal	13
6F23	Import coal	20

There are a number of SX paths that were not used at all and only the refuse trains to Roxby Gullet ran every day.

There are around 100 to 110 paths in each direction each day which vary by day of the week. It is difficult to be precise as some of the paths clash in theory but will be adjusted by the STP plan.

Appendix D – Glossary of terms

Term	Description
BCR	Benefit to Cost Ratio
Bottom-up Assessment	Detailed assessment of the inputs and relationships between factors that cause system outputs
Capacity Allocation	The process by which paths are allocated as part of timetable development
Capacity Charge	Compensates NR for increased Schedule 8 performance regime payments resulting from additional services causing CRRD
Capacity Constraint	Occurs when no additional capacity is possible with the current infrastructure
Capacity Utilisation	Overall assessment of the level to which train and infrastructure capacity are being used along a route
Capacity Utilisation Charge	A potential charge to operators for running services through congested parts of the network
Contra-Peak	During peak periods, contra-peak services are travelling in the opposite direction (e.g. away from London in the morning peak)
Control Period	Funding period for Network Rail, CP5 is the subject of the periodic review and runs from April 2014 to March 2019
CRRD	Congestion Related Reactionary Delay, these are delays that result as a knock-on effect from other services causing problems. As capacity utilisation increases, CRRD increases exponentially
CUI	Capacity Utilisation Index, a measure of the amount of free space in a given timetable – as utilisation increases, free space reduces
DfT	Department for Transport
DMU	Diesel Multiple Unit, a diesel powered train which is capable of being coupled to other similar units
Down Direction	Trains travel in the 'Down' direction away from London and other main urban centres
Dwell Time	Time spent by a train at a station to allow passengers to board and alight
ECML	East Coast Main Line
Efficient use of Capacity	When it is not possible to derive an alternative use which has a positive BCR when compared to the status quo
EMT	East Midlands Trains
EMU	Electric Multiple Unit, an electric powered train which is capable of being coupled to other similar units

Term	Description
FCC	First Capital Connect
FGW	First Great Western
Flow	Combination of origin, destination and route for rail services (e.g. London to Leeds via Peterborough)
FOC	Freight Operating Company
GEML	Great Eastern Main Line
GJT	Generalised Journey Time, includes in vehicle time as well as station access/ egress, wait time, frequency and a penalty for interchanging trains
Grade Separated Junction	A junction where one line rises up and over other lines to avoid conflicting moves
GRIP	Governance for Railway Investment Projects, a NR process that divides a project into eight stages from output definition to project closeout
Headcode	An identification code for services within the timetable
Headway	The minimum space between following trains that the infrastructure allows. The Planning Headway is the minimum timetabled separation between trains
High-peak Hour	The hour during the day which has the highest number of passengers
HLOS	High Level Output Specification, set by DfT to specify the outputs it wishes Network Rail to deliver in the upcoming 5-year Control Period
IIP	Initial Industry Plan, joint industry proposals for CP5
Infrastructure utilisation	A measure of how well the rail infrastructure is being used relative to its maximum capacity
Inter-modal	Container traffic which is transported by sea to UK ports and onward by rail or road
Junction Margin	The minimum separation between two trains crossing the same junction that the infrastructure allows
LDHS	Long-Distance High Speed
Locomotive-Hauled	A train which consists of a locomotive and carriages instead of an EMU or DMU. A freight train is also locomotive-hauled
MOIRA	Rail industry model for forecasting demand and revenue impacts of timetable changes
Moving Block Signalling	A cab-based signalling system whereby 'blocks' – which in traditional signalling are the distance between the signals – are continually moved to define the safety zone around a train thus increasing the throughput of services along a route
MSB	Mode Shift Benefits, DfT methodology for valuing the economic benefits of transporting freight by rail compared with road
Network Capacity	The capacity of the network, in terms of paths and train utilisation, considering the infrastructure, rolling stock, service patterns and operating rules

Term	Description
Not Primarily Abstractive	The test which ORR uses when considering new open access operators. If an application for open access takes the majority of its passengers from other existing operators (rather than generating new passenger journeys) this is known as 'primarily abstractive' and the application would be rejected
NR	Network Rail
Open Access Operator (OAO)	Train company which is not franchised but operates services on an 'open access' basis e.g. Grand Central, Hull Trains
ORR	Office of Rail Regulation
Path	A train journey from its origin to its destination including the route it takes to get there
Plain Line	Section of a route which is free of junctions, crossovers, platforms, etc.
Platform Re-occupation Time	The minimum time between a departing service leaving the platform and the subsequent service arriving
PPM	Public Performance Measure, the percentage of trains arriving within 5 or 10 minutes of their arrival time (depending on the type of service)
Q-Path	A freight path in the timetable that is anticipated to be run at some point, but there is uncertainty about whether it will run on a given day
Rolling stock diagramming	The process by which rolling stock units are matched to services where each unit starts at a depot (or stabling location), forms one service after another before returning back again
ROSCO	ROlling Stock leasing COmpanies
RUS	Route Utilisation Study, planning document produced by Network Rail to prioritise future operational and infrastructure improvements for a route
RVfM	The Rail Value for Money study, commissioned jointly by DfT and ORR which recommended changes to the industry to encourage cost reduction and efficiencies
Service Group	Grouping of similar services (e.g. SWT Windsor Lines (inner) – peak) used in the rail industry as the basis for various parameters including the Capacity Charge
Schedule 4 and Schedule 8	Performance regime for planned (Schedule 4) and unplanned (Schedule 8) delays to services which compensate operators for revenue lost when performance is worse than benchmark. If performance is better than the benchmark, operators make a payment to NR, sharing increased revenues
SoFA	Statement of Funds Available to deliver the HLOS as provided by DfT
STP	Short-Term Plan, services that are added to the timetable at short notice
SWT	South West Trains
SX	Saturday eXcepted, trains that run Mondays to Fridays only in a Monday to Saturday timetable
TOC	Train Operating Company (franchised)

Term	Description
Top-down Assessment	Based on system outputs (e.g. passenger miles) without analysis of the inputs or relationships between factors causing the outputs
TPE	Trans Pennine Express
tph	Trains per hour
TPR	Timetable Planning Rules, produced by NR
Train Utilisation	A measure of whether a train is being used to its maximum capacity – for passenger services it is number of passengers, for freight it is the amount of goods moved
TRUST	A train running and punctuality monitoring system, mainly fed by automatic inputs from signalling systems
TS	Transport Scotland
Turnaround Time	Minimum time required for a terminating service to turn around and form the following service
Up Direction	Trains travel in the 'Up' direction towards London and other main urban centres
Value for Money (VfM)	The benefits of a change outweigh the costs of implementing the change sufficiently for it to be worthwhile to make the change. DfT has categories of VfM based on the BCR, for example high value for money has a BCR in excess of 2.0, i.e. the benefits are double the costs
Volume incentive	Payment to NR over and above the Capacity Charge and VTAC to give an added incentive to accommodate additional paths
VSTP	Very Short-Term Planning, where paths are allocated at a two days' notice usually for freight or special events (e.g. sporting)
VTAC	Variable Track Access Charge, paid by operators to cover infrastructure maintenance costs
WebTAG	DfT's transport appraisal guidance
WTT	Working timetable, the operating train timetable for the given period
Y-Path	A type of Q-Path which has multiple destinations, i.e. the destination may vary by day or week