RailKonsult

Office of Rail Regulation

Efficient Expenditure Benchmarking of Network Rail against North American Railroads

Summary Report

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Executive Summary

As part of their preparation for the next periodic review (PR13), the Office of Rail Regulation are considering the international benchmarking opportunities available from review of infrastructure management operations outside Europe. This report provides an initial analysis of the North American operators.

The analysis was based solely on a review of information that is available within the public domain. Three generic groups of railroads were considered and compared with Network Rail. These were:

- Class I Railroads (BNSF, CSX-T, Canadian National and Norfolk Southern);
- Amtrak; and
- Selected passenger operators (Metra, Metrolink, BART and Caltrain).

The analysis was based on reported infrastructure expenditure for 2010. Both capital (renewals and enhancements) and maintenance expenditure was included in order to achieve better compatibility between definitions. No central overheads have been apportioned for Network Rail or any of the comparator organisations. The costs were harmonised in terms of purchasing power parity.

Direct values were not obtainable for all the organisations due to the limitations of the publically available information. A sensitivity analysis was undertaken to understand the impact of using very conservative assumptions.

The table below provides a summary comparison between the different comparator groups for each of the metrics. The table quotes both pessimistic (using conservative assumptions) and most likely values for each comparator, as assessed in the sensitivity analysis.

Network Rail's total infrastructure costs per mile (i.e. maintenance and capital investment expenditure) have been taken as the baseline for each of the metrics. For simplicity, this value has been converted to an arbitrary value of 100 in the table below. The values of the other comparator groups are calculated relative to this baseline.

For example, the cost per route mile of Class I railroads has been assessed as being within a range of 28% to 32% of Network Rail's cost per route mile. However, Network Rail's costs per route mile are reduced to 48% if infrastructure enhancement costs are removed, as considered in the sensitivity analysis.

		Class I Railroads		Amtrak		Passenger Operators		Network Rail	
Route Length		28	32	151	181	76	341	48	100
Track Length		42	48	108	130	66	316	48	100
Train Miles		227	285	108	144	216	303	47	100
Gross Ton Mile		9	10	43	66	136	196	48	100

Considering the basket of four metrics provides a rounded view of the relative performance of each generic group. For example, Amtrak's figures are affected by its high proportion of multiple-track railway.

The report evaluates the relative impact of thirty other factors on the relative costs per mile. These are:

- Traffic Characteristics;

  The three generic groups have different traffic characteristics, from high axle load freight trains, through high-speed passenger trains to local regional commuter services.

- Operational Methodology;

  The three generic groups also have different operating methodologies. The Class I railroads operate long trains over long distances. Amtrak operates a regular service over the North East Corridor and long distance infrequent trains over host railroads. The passenger operators are focused on the movement of commuters into and out of city centres.

- Geography and geology;

  Distances between centres are much greater in North America than Britain. Similarly, the extent of changes in geography is greater, although the frequency of changes is less. This harmonisation factor will increase the Network Rail costs per mile relative to the Class I railroads.

- Climate;

  North America experiences extreme climatic events, including floods, tornados, hurricanes and heavy snow fall. This harmonisation factor will increase the Network Rail costs per mile relative to the Class I railroads.

- Environment and legislation;

  No specific items of environmental legislation were identified within the study that would assist in explaining the differences in costs per mile.

- Engineering standards;

  No specific engineering standards were identified within the study that would assist in explaining the differences in costs per mile.

- Safety;

  The frequency of incidents on North American railroads, particularly derailments, is higher than in Britain. This may be a factor in explaining the differences in costs per mile.

- Unionisation;

  No specific union related issues were identified within the study that would assist in explaining the differences in costs per mile.

- Complexity (multiple track, density of S&C and operational property);

  The networks of the Class I railroads are less complex than found on Network Rail's system. This is a factor that assists in understanding the difference in costs per mile. From the available information, this is not a factor that significantly affects the comparison between Network Rail and Amtrak or the other passenger operators.

- Complexity (importance of switching yards);

  Switching yards are a critical part of the Class I railroads' networks as a consequence of their operational methodology. This means that there is a greater proportion of investment and operation expenditure spent on them. This harmonisation factor will increase the Network Rail costs per mile relative to the Class I railroads.

- Train control systems;

  In general, the train control systems in use currently in North America are simpler than those deployed by Network Rail. This is primarily driven by the differences in traffic characteristics. This is a factor in explaining the differences in costs per mile.

- Engineering access to the network;

  Engineering track access is constrained on the freight railroads as they are focussed on earning money by moving freight. As a consequence they focus on clustering work and completing within short time periods. This is seen as good practice.

- Structures;

  Although there are more tunnels and bridges on the British system, there appear to be a number of major North American structures (such as bridges with moveable spans) that require renewal. It has not been possible to determine the influence of this factor within the current study.

- Traction power;

  Amtrak apart, very little of the North American railroad network includes a traction power system. This is a factor in explaining the differences in costs per mile.

- Switches and crossings;

  No specific switch and crossing related issues were identified within the study that would assist in explaining the differences in costs per mile.

- Rail management;

  Larger rail sections and harder steel are used in North America. There appears to be a good rail management process in place using both lubrication and grinding techniques. This is seen as good practice.

- Cascaded materials;

  A strategy of cascading rail from high to lower category lines is evident from the statistics. This is seen as good practice.

- Renewal of sleepers;

  Timber sleepers are still the predominant type in use in North America. The railroads deploy “spot resleepering” programmes. This is seen as good practice.

- Ballast management and tamping;

  In general, different approaches are used in Britain and North America to the management of ballast. Although areas of good practice have been identified, it has not been possible to determine the influence of this factor within the current study.

- Level crossings;

  There is a higher frequency of level crossings in North America, but there is less complex control systems associated with them. It has not been possible to determine the overall influence of this factor within the current study.

- Relative quality of infrastructure;

  Consideration of the proportion of the network affected by speed restrictions was used as a proxy to gain an insight into the relative quality of the infrastructure. However, it was still not possible to determine the influence of this factor within the current study.

- Mechanisation;

  Indications from the data reviewed are that there is a higher degree of mechanisation in North America, with consequential reduction of labour on site. This is seen as good practice.

- Skill levels of workforce;

  No specific skill level related issues were identified within the study that would assist in explaining the differences in costs per mile.

- Degree of standardisation;

  No significant level of standardisation was identified across any of the generic groups. However, the Class I railroads are large enough to gain economies of scale from internal standardisation. This is not seen as a factor in explaining the differences in costs per mile.

- Vertical integration;

  The North American railroads are all vertically integrated. This provides a clear focus when making investment decisions. This is seen as good practice.

- Industry structure;

  North America has an integrated industry with railroads agreeing rights to use each others facilities. For the purposes of this study it has been assumed that the prices paid are closely related to the costs incurred.

- Sources of funding;

  Addition funding, such as ARRA (American Recovery and Reinvestment Act) has been made available that may have resulted in artificially high investment expenditure in 2010. This does not appear to be the case following review of the figures.

- Relative labour costs (cost of benefits);

  A study undertaken on behalf of the Amtrak Office of Inspector General identified that the cost associated with North American staff is more than that of European railway employees.

- Asset management approaches;

  Examples have been identified of North American railroads making best use of technology, implementing improved approaches from information acquisition through intervention delivery. This is seen as good practice.

- Outsourcing.

  Activities are outsourced where the provision of specialist knowledge and/or resources is value-adding. This is seen as good practice.

The impact of these different factors can be grouped under five generic headings:

- Factors that have been identified as “harmonisation” issues that would decrease Network Rail’s apparent costs per mile;
- Factors that have been identified as “harmonisation” issues that would increase Network Rail’s apparent costs per mile;
- Factors that have been identified as likely to have no significant impact on the relative apparent costs per mile;
- Factors that have currently been identified as having an uncertain impact on the relative apparent costs per mile (from the available information reviewed as part of this study); and
- Factors that have been identified as North American “good practice” and help explain the relative differences in the costs per mile.

The table below also categorises the factors in terms of:

- Country, i.e. factors that are the result of the general environment and outside the control of the different railway organisation;
- Industry, i.e. factors that are the result of the way that the local railway industry operates and, as such, the different railway organisations can influence or partially control these factors; and
- Company, i.e. factors that are the result of the way the different railway organisations decide to manage their business.

Factor Categorisation	Harmonisation: Decrease NR Relative Unit Costs	Harmonisation: Increase NR Relative Unit Costs	"Minimal Impact" Factors	"Uncertain Impact" Factors	North American "Good Practice"
Country Related (No control)		Geography and geology Climate	Environment and legislation Traffic characteristics	Structures Sources of funding (Amtrak in particular)	
Industry Related (Limited control)	Train control systems	Relative labour costs (cost of benefits)	Operational methodology Engineering standards Unionisation Degree of standardisation Industry structure	Level crossings	Vertical integration
Company Related (Controllable)	Safety (with respect to frequency of derailments) Complexity (multiple track, density of S&C and operational property) Traction power	Complexity (importance of switching yards)	Switches and crossings	Ballast management and tamping Relative quality of infrastructure Skill levels of workforce	Engineering access to the network Rail management Cascaded materials Renewal of sleepers Mechanisation Asset management approaches Outsourcing

It is concluded that, although there are significant environmental differences between the railway industry in North America and that in Britain, there would be value obtained in understanding the benefits gained from specific elements. In particular, the report identifies different approaches to rail management and the business focus achieved through vertical integration.

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1.0 BACKGROUND

1.1 Previous Work

The Office of Rail Regulation (ORR) has started undertaking its initial reviews as part of the next periodic review process (PR13). These are intended to provide the ORR with insight into the scope for Network Rail to achieve further efficiencies during the next Control Period (CP5).

As Network Rail is the only railway infrastructure manager in Britain, the ORR has developed a methodology based on international benchmarking in order to assess Network Rail's capability to improve efficiency. During CP4, the primary focus was in comparing their performance with those of other European Infrastructure Managers.

From initial benchmarking work undertaken by the ORR and others (such as the UIC), it is apparent that the North American Railroads achieve significantly better efficiencies than other Infrastructure Managers. However, the nature of their rail networks is different to those found in Europe. They are predominately freight operators with a much simpler infrastructure, such as less junctions and no traction power system. As such, it has been difficult to undertake direct comparisons.

The purpose of this study is to produce a set of comparable high-level metrics that enable comparisons to be made through better understanding of the reasons for the apparent differences in cost structures. This will enable any potentially transferable lessons to be identified. In particular, the intent is to focus on those parts of the North American railroad system that carry mixed traffic (passenger and freight). These may be more likely to provide transferable lessons.

1.2 Methodology

The methodology adopted consisted of a staged approach based on gathering information that is already in the public domain and applying technical understanding to interpret the results. The study included the following stages:

- Desktop Review;
- Calculation of high-level metrics and initial adjustments;
- Analysis;
- Assessment of reasons for gap; and
- Consolidation of findings.

This approach was adopted in order to provide the required deliverables within the available timescale. There was insufficient time available to put in place confidentiality agreements with the relevant North American railroads and robustly assess any information supplied. However, there is a significant level of reported information available and a number of previous reports on the subject. These were used as the basis for the study.

2.0 COMPARATOR RAILROADS

2.1 Basis of Selection

As already noted, due to the time constraints under which this study was undertaken it was not possible to engage directly with any of the North American Railroads. The data was collected using previously published research and from documents in the public domain.

The railroads were selected on the basis of:

- Readily available data;
- Ensuring that the sample provided a representative view of North American industry;
- Particular focus on mixed traffic operations, i.e. operation of passenger services.

The study reviewed three generic types of North American Railroad:

- Class I Railroads;
- Amtrak;
- Passenger Railroads.

This approach proved successful in generating a high quantity of data. However, there were some gaps in the available data, particularly with respect to the passenger operations. Difficulties were also encountered in identifying suitable data sources for Canadian passenger operations.

2.2 Class I Railroads

The main operators in the United States are the Class I Railroads. The Association of American Railroads offers the following definition:

> *"U.S. Class I Railroads are line haul freight railroads with 2006 operating revenue in excess of $346.8 million. Two Canadian railroads, Canadian National Railway (CN) and Canadian Pacific Railway, have enough revenue that they would be U.S. Class I railroads if they were U.S. companies. Both companies also own railroads in the United States that, by themselves, qualify to be Class I railroads. Two Mexican railroads, Ferrocarril Mexicano and Kansas City Southern de México, would also be Class I railroads if they were U.S. railroads. The U.S. Class I railroads in 2006 are: BNSF Railway, CSX Transportation, Grand Trunk Corporation, Kansas City Southern Railway, Norfolk Southern Combined Railroad Subsidiaries, Soo Line Railroad, and Union Pacific Railroad."*

Previous international benchmarking studies have concluded that the Class I Railroads are amongst the most efficient operators. Additionally, as well as being the largest operators in North America, there is also a high level of information available on these organisations as a consequence of the overall regulatory environment.

Assessment of these organisations provides a baseline against which the performance of the other groups can be measured. Subsequent analysis of the gap between them and other generic groups of railways must include consideration of the fact that their routes are predominately freight only lines.

The Class I Railroads selected for inclusion within the study are:

- BNSF Railway;
- CSX Transportation;
- Canadian National (CN), including Grand Trunk Corporation (GTC); and
- Norfolk Southern (NS).

BNSF was chosen as representative of a large operation. CSX-T and NS provide examples of typical medium size operation. CN provides a Canadian perspective.

Appendix A contains pen-pictures of these railroads. In the main, these pen-pictures have been produced using information available from relevant websites.

2.3 Amtrak

Amtrak is the primary passenger service operator in the United States. Its website states that:

> *"Amtrak was created by Congress in 1970 to take over the passenger rail services previously required to be operated by private freight railroad companies in the United States. Those companies showed they had operated the services at a net loss of millions of dollars for many years."*
>
> *"Amtrak operates a nationwide rail network, serving more than 500 destinations in 46 states and three Canadian provinces on more than 21,200 miles of routes, with more than 20,000 employees. It is the nation's only high speed intercity passenger rail provider, operating nearly 60% of its trains at top speeds in excess of 90mph/145kph"*

Amtrak has been the subject of several previous benchmarking studies, assessing its performance with that of Network Rail and other European Infrastructure Managers. This includes the dataset used by the ORR for regional international top-down benchmarking.

As with the Class I Railroads, there is an extensive range of information in the public domain detailing Amtrak's performance, particularly in relation to the North East Corridor (NEC) where it acts as a vertically integrated operator.

2.4 Passenger Railroads

Across both the United States and Canada there are a number of other local passenger operations. These generally provide a commuter service into the larger cities. They usually operate over a mix of their own infrastructure plus that of other railroads. Operational delivery is also regularly outsourced.

Following a review of the main passenger operators across North America, most were excluded from the study as a result of one of the following criteria:

- Small network mileage;
- Complexity of network (operating rights or different forms of rail system); and/or
- Lack of sufficient information readily available.

Appendix B contains details of the passenger operators considered for review in this study.

Following completion of the review, the following passenger operations have been included within this study:

- Metra (Chicago);
- Metrolink (Los Angles);
- BART (San Francisco); and
- Caltrain (San Francisco).

Appendix C contains pen-pictures of these operators. As with the Class I railroads pen-pictures, these have been primarily produced using information available from relevant websites.

Although BART is a mass transit system, it has been included within the study as it is:

- Heavy rail construction;
- Self contained; and
- Third-rail traction power system.

As such, it maybe appropriate to undertake a more detailed future comparison between BART and either the Merseyrail network or a subsection of the southeast network.

3.0 HIGH-LEVEL METRICS

3.1 Data Collection

The key sources of information used for this assessment have been:

- Surface Transportation Board R-1 Reports;
- Surface Transportation Board Employment Reports;
- FRA Safety Database;
- National Transit Database;
- Railroad Annual Reports and Budget Submissions;
- Amtrak OIG Reports;
- Railroad Websites and other relevant websites;
- Professional Presentations given by Senior Railroad Engineers;
- Railroad In-House Magazines; and
- Trade Journals.

The list is in prioritised order, with information being sought first from the sources at the top of the list.

The base year used for comparison purposes was 2010. This represents the calendar year for the Class I Railroads and variations on a 2010/11 financial year for the other operations. It is not believed that this variation will have had a significant impact on the assessment as only a small number of high-level metrics have been generated.

A representative review of 2008 and 2009 data has been undertaken in order to ascertain whether there are any significant “spikes” in the 2010 values. Nothing significant was identified in the figures used to calculate the metrics, other than the on-going global financial downturn. This has been assumed to affect all the organisations equally.

Network Rail data has been extracted from:

- 2010/11 Annual Report;
- 2010/11 Annual Return;
- 2007 (CP4) Asset Policies; and
- RSSB Annual Safety Report 2010/11.

3.2 Assumptions

Within the study constraints it has not been possible to derive a full set of data for all the selected organisations. In particular:

- BNSF become a subsidiary of Berkshire Hathaway Inc in February 2010, which has resulted in a restricted ability to understand the level of capital investment;
- Individual details gathered for both Canadian National and Amtrak cover either part or the complete network, but not both in all cases;
- Incomplete data has been identified with respect to the physical configuration of the infrastructure, particularly for the passenger operating organisations.

Where gaps existed in the dataset, conservative assumptions have been made. The basis of calculating these assumptions has been through using all available information. For example, the gross ton miles for the Metra system has been calculated using the reported revenue train miles and the stated average weight of a train. A sensitivity analysis has been undertaken to determine the impact of these assumptions.

One key assumption that has been made relates to the fully integrated nature of the network, with each organisation generally having operating rights over infrastructure owned by others. This assumption is discussed further below and in Section 4.26.

3.3 High-Level Harmonisation

The initial harmonisation factor applied was for Purchase Power Parity. As the majority of financial figures used are quoted in US Dollars, this has been used as the basis for comparison, i.e. Canadian Dollars and Stirling have been converted into US Dollars.

In addition to harmonisation of the financial units of measure, all the units of length have been converted to miles and those of weight to tons.

3.4 High-Level Metrics

In order to simplify the assessment, the railway organisations considered during this study have been consolidated into four generic groups:

- US Class I Railroads (BNSF, CSX, CN/GTC, and NS);
- Amtrak (both as a single entity and the North East Corridor);
- US Passenger Operations (Metra, Metrolink, BART and Caltrain); and
- Network Rail.

An unweighted average value has been used in the tables below to represent each of the generic groups. Any significant differences in the values obtained have been noted and commented on in the following sections.

Four high-level metrics have been calculated as indicators of the relative efficiency of each type of railway operation. These are:

- Cost per route mile;
- Cost per track mile;
- Cost per train mile; and
- Cost per gross ton mile.

The use of this “basket of metrics” to understand the differences in costs per mile between the generic groups enables consideration to be taken of the different approaches to operating their train services.

The North American passenger operations generally operate over both their own infrastructure and that of other railroads, typically Class I railroads. The accounts include within the expenses the costs paid out to these “host” railroads. For the purposes of this review it has been assumed that the price charged by the host railroad is representative of the costs incurred. It is believed that this is a reasonable assumption on the basis of the high-level nature of the metrics being considered.

The table below summarises the cost per mile for each metric using data derived from the total infrastructure related operating expenditure declared by of each of the railway organisations.

		Class I Railroads	Amtrak	Passenger Operators	Network Rail
Route Length	$k/mile	388	5,714	2,332	624
Track Length	$k/mile	296	2,051	1,092	317
Train Miles	$/mile	95	135	77	19
Gross Ton Mile	$/mile	15	214	197	76

Table 1: Operating Cost per Mile

This indicates that Network Rail's costs per mile are less than those of the North American passenger operators, but that there are no clear conclusions to be drawn when comparing their performance with those of the Class I Railroads.

3.5 Funding – Capitalisation of Activities

Capital investment activities in the United States include many activities that would be classified as maintenance expenditure in Britain. In general, any activity that improves the asset, or extends it operational life, is capitalised[1]. This means that activities such as tamping that would be considered as maintenance expenditure in Britain are part of the capital investment in the accounts of US railway organisations. However, in reviewing the accounts of the various organisations it has been identified that there are inconsistencies, e.g. grinding appears to have been included as either maintenance expenditure or capitalised investment by different organisations.

As an example of this issue, Caltrain's track capital investment proposed for FY2010[2] is quoted as including the following activities:

1. *Replacement of stock rails and points at ends of #20 passing tracks on an as-needed basis.*
2. *Replacement of rail joints - approximately 100 locations.*
3. *Removal of old or bonded over insulated (Allegheny) joints – about 50 locations (100 welds).*
4. *Production ties and surfacing - 30 miles surfacing, 25 turnouts and 1500 ties, various locations.*
5. *Purchase and installation of rail lubricators for six locations.*
6. *Purchase of small tools and equipment required for track maintenance activities.*
7. *Relay of approximately five track miles of rail at approximately MP 9, MP 17 and MP 48.5.*
8. *Procurement of approximately 8,000 tons (two trains) of ballast for FY2011.*
9. *Rebuilding grade crossings at Fair Oaks Lane (Atherton), Peninsula Avenue (Burlingame), Villa Terrace Avenue and E. Bellevue Avenue (San Mateo) and shift approximately two track miles of mainline track.*
10. *Surfacing through grade crossings at 4th Avenue, 9th Avenue and Mary Avenue (San Mateo), Oak Grove Avenue (Burlingame) and pedestrian crossing at Lawrence Avenue (Sunnyvale).*

[1] Railroad Industry Overview document, published on the Internal Revenue, US Department of Treasury website

[2] Details taken from Caltrain Quarterly Capital Program Status Report: 4th Quarter FY10

In Britain almost all these items would be considered to be maintenance expenditure. A high-level analysis of Amtrak's proposed infrastructure investment projects for FY10 indicated the following split in terms of British activity definitions:

Maintenance:	4%
Renewal:	64%
Enhancement:	32%

A revised set of metrics are included below. These are based on the total annual expenditure by each organisation.

		Class I Railroads	Amtrak	Passenger Operators	Network Rail
Route Length	$k/mile	479	6,775	3,560	1,238
Track Length	$k/mile	365	2,433	1,672	630
Train Miles	$/mile	118	159	125	38
Gross Ton Mile	$/mile	18	253	319	150

Table 2: Total Cost per Mile

This alternative view of the metrics has not significantly altered the overall position, although in general it indicates that Network Rail's figures are higher than those of the Class I Railroads.

3.6 Vertical Integration

A further difference between Network Rail and the North American comparator railway operations is that the latter are all vertically integrated. That is, they undertake both the role of infrastructure manager and train operator.

A third calculation of the metrics was undertaken with the figures amended to include consideration of both infrastructure maintenance and capital expenditure (including both renewals and enhancements). The figures used to calculate these metrics were taken from either the Annual Reports or, for the Class I Railroads, the Form R-1 documents.

They include all infrastructure related cost categories, but do not apportion any of the central overheads. That is, there is no reflection in the figures of relative size of overheads, nor has any evaluation been undertaken on whether the definition of what is included as overheads is consistent. It is not believed that this will have a significant impact on these high-level metrics. The same approach has been adopted for all the comparator organisations and Network Rail.

The revised figures are indicated in the table below.

		Class I Railroads	Amtrak	Passenger Operators	Network Rail
Route Length	$k/mile	144	781	1,758	516
Track Length	$k/mile	110	283	829	262
Train Miles	$/mile	36	17	48	16
Gross Ton Mile	$/mile	6	27	123	63

Table 3: Total Infrastructure Cost per Mile

Considering these results:

- Cost per route and track mile (infrastructure driven metrics)

  For both of these metrics, the Class I Railroads are indicating significantly lower costs per mile.

  A significant proportion of Amtrak's North East Corridor is multi-tracked railway. It is believed that it is this factor that is driving the high cost/mile figure for route length. The costs per track mile are broadly equivalent to those of Network Rail.

  The passenger operators have higher costs/mile for both metrics. This maybe as a result of the relatively small network sizes operated.

- Cost per train mile and gross ton mile (operations driven metrics)

  The Class I Railroads are indicating significantly lower costs per gross ton mile, but not per train mile. This is indicative of these organisations operating fewer, but heavier trains.

  Whilst Amtrak's costs per train mile are broadly equivalent to those of Network Rail, their costs per gross ton mile are significantly less. This indicates that the average weight of an Amtrak train is more than that of British trains.

  The passenger operators have significantly higher costs/mile for both metrics. Again, this maybe as a result of the relatively small network sizes operated.

3.7 Sensitivity Analysis

One of the potential sensitivities that have been identified is the scalability of the organisations' metrics. That is, the ability to make meaningful comparisons between relatively small (passenger) operations and very large railway operations.

Two of the four passenger operations included in the analysis (BART and Caltrain) operate over 100 route miles or less. Their metrics are between two and ten times larger than the larger passenger operators (see Appendix D). If their figures are removed from the analysis the revised "infrastructure" results are as indicated in the revised table below.

		Class I Railroads	Amtrak	Passenger Operators	Network Rail
Route Length	$k/mile	144	781	390	516
Track Length	$k/mile	110	283	174	262
Train Miles	$/mile	36	17	34	16
Gross Ton Mile	$/mile	6	27	85	63

Table 4: Sensitivity Analysis – Impact of Small Railroads

The remaining two passenger operators (Metra and Metrolink) both operate networks with 400 to 500 route miles. It can be seen from the table above that restricting the analysis to these two organisations results in the metrics for the passenger operations moving closer to Network Rail's figures.

Within the constraints of the current study it has been necessary to base the analysis on figures that are in the public domain. As a consequence, some of the values used in the metrics have been estimated on the basis of best available information. Although in general these calculated figures have adopted a conservative approach, a sensitivity analysis has been undertaken to understand the impact of their use.

The revised assumptions are:

- Canadian National's investment is 50% in the United States rather than proportioned on the basis of route miles;
- Capital expenditure for BNSF and US operations of Canadian National are both100% infrastructure related i.e. no investment in rolling stock. The assumption used in calculating the metrics for Table 3 was based on the published budgeted CAPEX investment in rolling stock;
- Metrolink is a single track railway rather than the dual track railway assumed to calculate previous metrics;
- Calculated train miles for Canadian National and Amtrak have resulted in 25% over-estimate (both calculated indirectly in previous analysis);
- Estimated gross ton miles for Amtrak, Metra and Metrolink have been over-estimated by 25% (previous calculations used average train weights); and
- Network Rail's enhancement expenditure should be excluded (previous analysis made no distinction between renewal and enhancement as it has not been possible to ensure common definitions between all the comparator organisations).

These revised assumptions are all pessimistic. For example, all the non-Network Rail metrics include an element of enhancement expenditure within the capitalised spend. Excluding all Network Rail's enhancement spend, whilst retaining that element in the other calculations, provides a worst-case comparison. Similarly, considering Metrolink to be a completely single-track railway is also known to be very pessimistic.

These revised assumptions have been included within the adjusted "infrastructure" metrics table below (which also continues to exclude Caltrain and BART from the passenger operators).

		Class I Railroads	Amtrak	Passenger Operators	Network Rail
Route Length	$k/mile	163	935	390	246
Track Length	$k/mile	125	341	232	125
Train Miles	$/mile	45	23	34	8
Gross Ton Mile	$/mile	7	41	114	30

Table 5: Sensitivity Analysis – Impact of Assumptions

Table 6 below provides a summary comparison between the different comparator groups for each of the metrics. The table quotes both the pessimistic and most likely values for each comparator as assessed in this section. The source of the base data is noted in the table.

Network Rail's total infrastructure costs per mile (i.e. the values quoted in Table 3, Section 3.6 above) have been taken as the baseline for each of the metrics. For simplicity, this value has been converted to an arbitrary value of 100 in the table below. The values of the other comparator groups are then calculated relative to the baseline.

For example, the cost per route mile of Class I railroads has been assessed as being within a range of 28% to 32% of Network Rail's cost per route mile. However, Network Rail's costs per route mile are reduced to 48% if infrastructure enhancement costs are removed, as detailed in the sensitivity analysis above.

		Class I Railroads		Amtrak		Passenger Operators		Network Rail	
		Table 3	Table 5	Table 3	Table 5	Table 3	Table 5	Table 5	Table 3
Route Length		28	32	151	181	76	341	48	100
Track Length		42	48	108	130	66	316	48	100
Train Miles		227	285	108	144	216	303	47	100
Gross Ton Mile		9	10	43	66	136	196	48	100

Table 6: Sensitivity Analysis – Relative Range

The following observations are made from this high-level review:

- The reported range in Network rail's figures is driven by the exclusion of investment in system enhancement, which is not reflected in the comparators;
- In general, the Class I Railroads are indicated to be operating at significantly lower costs per mile. The exception, the cost per train mile, is probably primarily a result of the different type of operations (intensive frequency of passenger services versus a lower number of much longer and heavier freight services);
- In general Amtrak's metrics indicate higher costs per mile, with the significant disparity in the route length metric generated as a consequence of much of their infrastructure being multi-track routes;
- North American passenger operators show a large range of values which is believed to be indicative of the wide variation in the nature of their operations.

4.0 GAP ANALYSIS

4.1 Basis of Assessment

Further details of performance and approach were gathered as part of the study in addition to that required to calculate the high-level metrics. This information has also been gained from the public domain.

An understanding of the drivers behind the variations in the metrics calculated in section 3 has been undertaken using this base information supplemented with a high-level understanding of North American Railroad operations in comparison with the British environment and current approach.

The details in this section are intended to provide an insight into the potential to compare Network Rail with North American Railroads. Much of this section will require further validation to ensure that the full details are correctly understood and that appropriate figures are being used to compare the different organisations.

The following sections each consider a particular topic to determine the extent of the differences between North America and Britain and the impact that those differences are likely to have on the relative costs per mile.

In this section, the term “cost per mile” is deemed to include the basket of all four metrics used in Section 3 unless otherwise specifically indicated. Factors that change the infrastructure costs of an organisation affect all four metrics, e.g. consideration of the quantity of operating property. Factors that harmonise differences in the nature of the infrastructure will only affect the infrastructure driven metrics (costs per route mile and costs per track mile), e.g. extent of traction power system.

4.2 Traffic Characteristics

The four generic groupings used for the metrics have different traffic characteristics:

Class I Railroads typically operate slow-speed, long length trains over large distances. Typically, the trains will carry 15,000 tons and travel over 1,000 miles at average speeds of around 30mph.

The trend is towards operating heavier trains with higher axle weights resulting in increased dynamic loading requiring larger components. The number of train movements per day is relatively low, but the tonnage carried is high. It is understood that although typically current axle loads are of the order of 35 ton, there is a movement towards the development of 39 ton axle loads.

Amtrak operates two types of traffic. The first is long distance passenger services that predominately run over host railroads, generally the Class I railroads. The passenger traffic is a very small proportion of the Class I traffic levels and has negligible impact on their costs per mile. Amtrak paid $137m in FY2010 to the host railroads (less than 5% of annual expenditure).

However, the passenger traffic can cause pathing problems due to its different characteristics in comparison with the prevailing freight traffic. Freight traffic is regularly given priority over passenger trains on non-Amtrak infrastructure. In order to mitigate the consequence of this, Amtrak has negotiated “punctuality bonus payment clauses” with host railroads to improve their train performance.

The main part of Amtrak’s operations is on the North East Corridor where it is responsible for both infrastructure management and train operations. This is the only route with trains operating at speeds of over 100mph. In addition to Amtrak’s passenger service, the infrastructure also carries some freight traffic plus intensive commuter services operated by local metros in the main suburban areas. From previous studies, it is known that the high speeds, in combination with the relatively high weight of the trains, causes infrastructure maintenance problems particularly at junctions.

Amtrak is reliant on central government funding, with revenue covering 85% of operating expenses in 2010. Funding is allocated on an annual basis with final agreement not always being received until after the financial year has already started. One result of this is that Amtrak's asset policy has been based on maintaining its infrastructure for longer, with the average age of components being greater than seen elsewhere.

Overall, Amtrak's system-wide punctuality in 2010 was 80%, with the flagship Acela Express punctuality achieving 79%. A train is considered "late" if it arrives at its endpoint terminal more than 10 minutes after its scheduled arrival time for trips up to 250 miles plus all Acela trips, regardless of run length (i.e. majority of trains operating on North East Corridor). The tolerance is increased as the journey length increases; up to 30 minutes for trips of 551 or more miles. Network Rail's PPM for the Long Distance sector was 87.7% in 2010/11 (defined as arriving at the planned destination station within 10 minutes of the planned arrival time).

Amtrak's service reliability is adversely affected by the host freight railroads frequently giving priority to their own services when operating off Amtrak controlled infrastructure. However, the documents reviewed indicate that, historically, this is the level of punctuality that has been achieved.

A potential hypothesis is that there is a linkage between the relative punctuality levels being achieved and the differences in the cost per mile metrics. However, more analysis is required on the underlying issues in order to understand this linkage.

The selected passenger operators provide commuter services in Chicago, San Francisco and Los Angles. The main traffic flows are the morning and evening rush-hours. The networks are small in comparison with the other groupings, ranging from almost 500 route miles down to less than 100 miles. They are reliant on subsidy from local governments as fare-box receipts do not cover costs.

In most cases they operate over a mixture of their own infrastructure and that of other railroads. They have generally invested heavily to upgrade the infrastructure in order to increase the operating speeds. Typically, the average speed is 35mph as a consequence of the number of intermediate stations.

The Bay Area Rapid Transit (BART) operates on its own, self-contained system. It has a 5'6" gauge track and uses a third-rail traction power system at maximum speeds of up to 80mph. The network includes high proportions of tunnels and elevated track. Although a relatively small network (104 route miles), it does include characteristics that are similar to a number of Network Rail's inner-urban commuter operations. A particular issue that BART is currently facing is the need to reinforce the strength of its infrastructure to provide adequate earthquake protection.

The punctuality on the selected passenger operations is stated as almost 95% on average. On time is understood to be defined as trains arriving at their last station stop within five minutes of the schedule. Network Rail's PPM for the London & South East sector was 91.1% in 2010/11 (defined as arriving at the planned destination station within 5 minutes of the planned arrival time).

From the above descriptions it can be seen that there are greater differences between the type of railway in Britain and those of the comparator organisations in North America than is the case with previous comparisons with European railways. The impact of these differences is reviewed below.

4.3 Operational Methodology

Class I railroads operate much larger trains over longer distances than is the norm within Britain. From the understanding gained, their operation also involves more use being made of switching yards. Other than specific commodity trains that operate to and from customer depots, the majority of their train consists will be re-marshalled several times along the main trunk routes. This maximises the load per train and minimises operational costs. This approach means that the networks have a number of very large switching yards at key locations.

Class I freight trains travel long distances (typically 1,300 miles over 2 to 4 days) and the logistics revolve primarily around availability of passing facilities, remarshalling requirements, loco crewing and fuelling, and feeder services. Regulating is carried out from a few main hubs, with some functions devolved to local control. Yards and maintenance depots are generally self-regulating in support of the overall traffic plan. Mobile maintenance crews cover in-transit train exams and carry out running maintenance and repairs.

There is a mix of infrastructure required to manage different types of traffic. For example:

- Merchandise trains conveying mixed commodities require extensive yard and depot facilities along a route;
- Coal trains are generally an end-to-end operation, travelling between client owned loading and unloading facilities; and
- Intermodal trains that require transfer facilities at strategic locations along a route.

The passenger operations are similar to aspects of passenger operations within Britain. Amtrak operates a series of passenger services across the country. None operate as intensive a timetable as is generally the case in Britain.

The passenger operators vary from high-intensity regular urban services (similar to those seen in southeast England) through to peak-time services with very few trains timetabled outside the peaks.

4.4 Geography and Geology

The distances between major areas of population in North America are much larger than those in Britain. This has an impact on some of the operating methods as described elsewhere. It also means that the density of infrastructure for the Class I railroads is much lower than in Britain. The larger distances increase the cost of managing the infrastructure, either due to the additional time taken for teams to travel to site or the need for additional teams (that are responsible for less infrastructure) in order to manage the travelling time.

North America also has a vast range of types of geography that the railroads encounter, from crossing the Rockies, through running across the mid-west plains through to the large river deltas. These provide some extreme infrastructure challenges that have to be overcome, particularly with respect to the mountainous terrain and crossing large navigable water courses.

Except in the urban areas, the routes generally follow the local terrain. Hence gradients are frequently steep, and of considerable length and at or near the ruling gradient. For example, the Tehachapi Loop in Southern California is one of the biggest maintenance challenges in terms of logistics and costs to its owner Union Pacific. A considerable amount of traffic uses this route everyday with both UP and BNSF running trains over the infrastructure.

As with the issue of the overall size of the country, the type of geography is only a potential factor in explaining the differences in cost/mile between Network Rail and the Class I Railroads. Whereas Britain doesn't have the extreme challenges faced by the Class I Railroads, it does face more frequent changes in the type of geography and geology.

The North American passenger operations plus Amtrak's North East Corridor services primarily operate in urbanised environments. Network Rail's environment is similarly urbanised in comparison to these operations, but the Class I operations primarily run through rural areas. Urban environments are more likely to generate third-party problems, such as trespass and vandalism, and require more work to be undertaken in possessions due to space constraints.

Overall, the differences in geography are unlikely to explain the difference in costs between Network Rail and both the passenger operators and Amtrak. However, they are likely to lead to an increased cost to the Class I railroads, i.e. a reason for increasing the gap for all four metrics rather than decreasing it.

4.5 Climate

North American experiences some extreme weather conditions, which vary considerably between the Rockies, Mid-West, Eastern Seaboard and the Southern States. At its simplest, the wide differences in air and rail temperature between the seasons (as well as between day and night) provide challenges to the infrastructure engineers in managing the consequential thermal stresses in rails.

The wide range of rail temperatures makes it difficult to determine a suitable neutral temperature (i.e. the temperature at which thermal stress in the rail is zero). Neutral temperatures in North America can typically be more than 10°C higher than in Britain.

One result of these thermal issues is that there is a high risk of track buckles, leading to potential derailments. Approximately 3% of all derailments were due to track buckles in 2009 (noted as causing over $8m damage). There will also be an increase in maintenance costs to mitigate this risk.

As well as these seasonal changes, there are also severe weather events such as floods and tornados. The FRA Safety Statistics indicate that the following derailments were caused by climatic conditions during 2009:

- 19 due to snow, mud, ice, etc on tracks;
- 2 due to tornados;
- 4 due to floods; and
- 10 due to high intensity winds.

To a degree, the climatic problems are anticipated, being treated as "normal" occurrences and dealt with as a matter of course. However, ad hoc natural disasters such as Hurricane Katrina can cause huge damage to infrastructure which cannot be anticipated. Rehabilitation costs can be immense, both in terms of the cost of rebuilding the infrastructure plus the loss of revenue until routes are reopened. CSX-T lost over 100 miles of complete railway (track and formation) to Hurricane Katrina, although it was all replaced within 3 months.

Flooding is also a significant problem faced by the Class I railroads. In 2011, BNSF was faced with significant flooding of the Mississippi River. It lifted 8 miles of track by 8 feet and constructed 7 miles of six-foot high berms to protect its routes. The overall impact of the flooding was quoted as being $300m on their website. This was not a one-off incident as 166 miles of track were flooded during 2008 causing damage to track, ballast and substructures.

Snow and ice storms cause particular problems in the northern parts of the country. In February 2011, between 12 and 24 inches of snow fell during a single storm, affecting most of the Northern States.

The costs of snow clearance are identified as a separate line item in the Form R-1 returns, with the 2010 figures being:

- BNSF $12.6m;
- CSX-T $5.0m;
- GTC $4.3m; and
- NS $7.6m.

In terms of explaining the gap, the impact of the extreme weather conditions primarily only affects the Class I railroads, although Amtrak are also affected by these issues. On the basis of the quoted additional investment requirements, this could represent approximately 5% of infrastructure costs. The costs associated with the snow storms relate to all railways operating through the northeast of the United States. In both cases, however, the net result is to increase the size of the gap between Network Rail and the Class I railroads for all four metrics rather than explain the initially identified gap.

4.6 Environment & Legislation

Differences in environmental and legislative requirements could be a driver behind the variations in cost per mile. For example, Network Rail has previously commented on the costs it incurs complying with wildlife protection requirements (badgers, crested newts, etc.)[3].

No specific information has been gathered on this subject in the course of this study. However it has been noted that environmental legislation is becoming more rigorous on both sides of the Atlantic. This is leading to more restrictive requirements for the disposal of spent ballast.

One piece of United States legislation that has a significant financial impact that has been identified is the requirement to introduce Positive Train Control (PTC) by 2015. This is considered further below (Section 4.11).

At this stage, no variations in environmental or legislative compliance requirements have been identified that will have a significant impact on the high-level costs per mile.

4.7 Engineering Standards

Minimum engineering standards are set at a national level in North America, but each individual railroad then adapts then to meet their own requirements. From the brief overview gained in the course of this study, it appears that in general the Class I railroads in particular exceed these requirements in order to achieve the necessary performance levels.

As noted above, the North American infrastructure carries a different type of traffic. The focus is on moving large freight volumes long distances at lower speeds, whereas the largely passenger railway in Britain operates with lower axle loadings at higher average speeds. From an infrastructure manager's perspective it is probable that a service involving the operation of 15,000 ton freight trains will cause more degradation than the equivalent (in tonnage terms) passage of 200 "Sprinter" style trains.

As a consequence of these different characteristics, the North American engineering standards have developed rail sizes and sleeper spacing that accommodate these higher axle loads.

[3] Network Rail reported estimated annual expenditure of £10m ($15.3m) complying with legislation to protect rare species (HM Treasury: Infrastructure UK Cost Review Main Report December 2010)

4.8 Safety

The table below provides a comparison of some of the high-level annual safety statics.

		Class I Railroads	Amtrak	Passenger Operators	GB (Network Rail)
Workforce Fatalities	Number	2	0	0	1
Train Accidents	Number	245	89	2	18
Derailments	Number	177	21	1	8
Mainline Collisions	Number	4	3	0	2
Fatalities per Million Employees	p.a.	58	0	0	28
Train Accidents per Million Train Miles	p.a.	3.5	2.2	749	56
Derailments per Million Train Miles	p.a.	2.45	0.52	0.46	0.02
Mainline Collisions per Million Track Miles	p.a.	0.05	0.07	0.00	0.01

Table 7: Safety Performance Indicators (2010)

As such incidents occur at a low frequency, an average statistics using the last five years' reported level of incidents is also included. In general, all the organisations included in the study have shown an overall improvement during the five-year period.

		Class I Railroads	Amtrak	Passenger Operators	GB (Network Rail)
Workforce Fatalities	Number	2	0	0	2
Train Accidents	Number	299	91	3	40
Derailments	Number	219	34	2	18
Mainline Collisions	Number	6	2	0	4
Fatalities per million employees	p.a.	71	20	122	62
Train Accidents per million Train Miles	p.a.	4.3	2.3	0.9	0.1
Derailments per million Train Miles	p.a.	3.0	0.8	0.5	0.1
Mainline Collisions per million Track Miles	p.a.	0.09	0.04	0.04	0.01

Table 8: Safety Performance Indicators (2006 - 2010)

Train accidents include incidents such as collisions between trains and road vehicles as well as derailments. Although the "fatalities per million employees" provides a good relative indicator, it does not take into consideration any significant differences in number of contractors used.

The North American and British definitions have not been fully compared to ensure total compatibility. However, using the PHRTA[4] definition for British incidents, the sub-categories broadly cover the same types of incidents. Note that the Network Rail figures are actually for the rail industry in Britain, but this provides a more representative figure when comparing with the vertically integrated operations found in North America.

The low incident numbers for the passenger operators mean that comparisons using their statistics are probably less valid. Within the constraints of the low actual numbers, the employee fatality rates are broadly similar. Both the North American and British railway organisations have high-profile safety campaigns.

There are significant differences in performance levels when considering the relative rates at which derailments and collisions occur. The North American figures include all train accidents and derailments, i.e. including those that occur within yards. The latest FRA Safety Statistics[5] indicate that, nationally, 35% of all train accidents occur on the mainline. If these proportions are representative of the railroads being reviewed, then the apparent gap between the North American figures and those of Network Rail will reduce.

As noted below (Section 4.10), the method of operation in North America results in much greater activity in their switching yards. As such, it is likely that, relative to Britain's experience, there will be a higher proportion of derailments and staff accidents in these locations.

The problems associated with trespasser fatalities are greater in North America. The FRA report indicates that there were 417 fatalities in 2009, whilst the RSSB Annual Safety Performance Report for 2010/11 records 27 fatalities and 208 suicides.

Issues related to accidents at level crossings are considered below (Section 4.20).

The top infrastructure causes of train accidents on the mainline are reported by the FRA as:

- 26 number due to catenary system defects
- 24 number due to wide gauge following a sleeper failure;
- 18 number due to transverse fissure in the rail;
- 16 number due to a track twist fault; and
- 16 number due to a track buckle.

Although the headline figures appear to indicate significant safety performance differences between North America and Britain in terms of the frequency of train accidents, the factors discussed above mean that there maybe little value to be gained at this stage in exploring this issue further as a reason for the gaps in the cost per mile at this stage.

The remaining statistic from the above table is the frequency at which derailments and collisions occur. The figures indicate a significantly worse performance in North America.

Assessment of the more detailed breakdown given in the FRA Safety Statistics indicates that a maximum of 1 out of 11 infrastructure caused collisions could have occurred on the mainline (defect noted as separation of railhead from web).

There is no breakdown provided in the FRA Statistics between derailments that occur on the mainline and those that occur in yards. The Network Rail figure is based on mainline derailments.

Anecdotally, there has been a view that this is one of the drivers behind the lower cost per mile achieved in North America. That is, the higher number of derailments is indicative of lower maintenance standards and an acceptance of the consequences. However, the focus

[4] Potentially Higher-Risk Train Accidents (PHRTA)
[5] FRA Railroad Safety Statistics 2009 Annual Report – 229 train accidents on mainline, 293 in yards and 141 at other locations.

on keeping traffic moving in order to earn revenue, particularly on the trunk routes that operate at capacity, would tend to negate this view.

For example, BNSF-hauled coal is used to generate more than 10% of the electricity produced in the United States. The impact of high numbers of derailments would soon be felt at a national level.

The national train accident statistics from the FRA for 2009 indicate that:

- 66% of train accidents resulted in derailments;
- 38% of train accidents occurred on the mainlines; and
- 34% of train accidents were caused by infrastructure faults.

There is a higher frequency of derailments and train accidents in North America, based on consideration of higher-risk incidents. It may also be an indicator of differences in the broader society of acceptance of risk. For example, the frequency per head of population of fatalities in road accidents is three times higher in the United States than in Britain.

This is an issue that requires more detailed investigation and is probably best addressed by British track engineers assessing the general state of the North American infrastructure. It is possible that there is a particular type of infrastructure that is causing the high frequency rates, such that a suitable adjustment in value can be determined.

4.9 Unionisation

There are a number of Union organisations representing staff groups in North America. The unions are particularly strong in California and the North East part of the United States. Negotiation of collective salary agreements occurs in similar manner to Britain.

There are also strong agreements in place with the individual railroads in terms of the type of work that is out-sourced rather than being undertaken by the in-house employees.

The review undertaken to date has indicated that it is unlikely that there are any significant differences in the level of unionisation of employees in the four groups that would help to explain the differences in costs per mile.

4.10 Complexity of Network

A large proportion of the Class I North American Railroad routes are single line with long passing loops (that can be up to 6 miles in length) to accommodate train regulation. They are long, thin lines that provide coast-to-coast routes.

Headways between trains are much greater than is the norm in Europe. Sections of line in North America can reach capacity with only 50 – 70 trains per day. This is partly as a result of the lower average line speeds (generally around 30mph) and length of the trains (up to 2 miles). However, the nature of the train control systems is much simpler than seen in Britain. The issues around the signalling system are considered below (Section 4.11).

This is in contrast to the nature of the railway network in Britain which is predominately two-track with a high degree of complexity in terms of switches and crossings (S&C). As a comparison, approximately 26% of Network Rail's system is single track whereas the average of the Class I Railroads reviewed was 77%. Previous analysis undertaken by RailKonsult has suggested that the cost of maintaining single track railway is 14% less than that for a double track railway per route mile, for the same level of traffic (annual tonnage carried)[6].

[6] Relative Infrastructure Managers' Efficiency, September 2010 RailKonsult for Office of Rail Regulation

Limited data was identified as to the number of S&C units installed in the main lines of the Class I Railroads. From the available information, it appears that whilst, Network Rail has an average of 1 unit per track mile, the ratio in North America is 1 unit per 6.5 miles. The UIC LICB benchmarking model is based on the maintenance and renewal cost of a unit of S&C being equivalent to 330m of plain line. Using this, there is no significant difference to the equivalent length of The Class I track miles, but Network Rail's equivalent track miles are increased by 20%. This will affect the infrastructure driven metrics.

As already noted, the Class I Railroads place greater emphasis on the use of switching yards and intermodal depots. From the details provided in the Form R-1 reports, the selected organisations spend 3.5% of their maintenance expenditure on these facilities. From press releases, it is also clear that they are investing heavily in new intermodal yards. For example, Norfolk Southern is developing three new yards, with an average size of 275 acres, each of which represents an investment of approximately $100m.

There is also significant investment in providing additional passing facilities and sidings to increase capacity and/or operate longer trains. Again, full details of the level of expenditure are not available.

In Britain, investment in new freight facilities is generally undertaken by third parties. Consideration of this factor will increase the size of the cost/mile gap for all metrics.

None of the Class I Railroads are electrified. The impact of this is considered below (Section 4.14).

Other than additional expenditure on switching yards and depots, the Class I Railroads do not manage the same volume and diversity of operational property that has to be maintained in Britain. For example there are no passenger stations to maintain, with or without complex heritage and protected status. Nor is there the same density of buildings associated with traffic control, signal-boxes etc. Network Rail's 2009/10 Annual Return indicated that 10% of their capital expenditure was spent on operational property. This will affect all the metrics.

Amtrak's system has a similar complexity as Network Rail's in terms of S&C and proportion of single track. On the same basis as calculated above, Amtrak's equivalent track miles would increase by 25% to take cognisance of the number of S&C units.

On its own infrastructure, only 16% of the network is single track. A significant proportion of the network is multiple-track, i.e. more than two-tracks. Whereas this would normally attract a premium when harmonising the costs per mile, this is not believed to be appropriate in this case. The premium is based on the difficulties in accessing the centre line(s) for maintenance and renewal. From previous discussions, this is not to be understood to be an issue for Amtrak.

As a high-speed passenger operator, Amtrak's train control system is of a similar complexity to those seen in Europe. Amtrak also has a similar level of operational property to maintain, including iconic buildings in locations such as Philadelphia.

Amtrak's North East Corridor has an electrified traction power system covering approximately 90% of their network.

The complexity of the passenger networks is seen as being similar to passenger branches in Britain. From the limited information available on their physical configuration they are generally two-track, un-electrified railways, although some lines do have traction power systems. From very limited available information, it appears that the density of S&C is similar to Network Rail. As with Amtrak, they appear to have a broadly similar level of operational property to maintain.

4.11 Train Control Systems

As already noted, the current signalling arrangements in North America are much simpler than those found in Britain. This is due to the low level of passenger operations (with consequential complex timetabling), less complex infrastructure, lack of tight headways and a simpler approach to signalling principles. As space constraints are often less onerous than in Britain, a much larger use can be made of repetitive layouts, reducing design costs and allowing more consistency in application of the signalling.

Historically, each railway company developed its own approach to signalling, although there are only two broad approaches. The emphasis is on controlling the speed of trains rather than informing the driver how far in front of them the track is clear and exactly where he is being routed. This is known as speed signalling as opposed to the route signalling system used in Britain.

The railways in North America also have areas known as 'Dark Territory'. These are sections of route with no signals. Train control is achieved by radio communication between the train crew and dispatchers who are based in central control rooms. Once a train enters a 'Dark Territory', its exact location is not known until it emerges at the opposite end of the section.

In 2008 legislation was enacted that requires all lines over which either passenger trains, or trains carrying Toxic Inhalation Hazard (TIH) materials, must have Positive Train Control (PTC) fitted by 2015. The Federal Railroad Authority (FRA) factsheet on PTC notes that there are 11 different PTC projects in varying stages of development involving 9 different railroads and over 4,000 miles of track. As with other aspects of the North American railway industry, this indicates a lack of standardisation. However, the size of many of the railroads means that they are able to achieve economies of scale on their own.

It is believed that this capital investment will be included in the figures used to calculate the metrics. However, generally most railroads are still in the early stages of their compliance programmes and expenditure levels remain low.

At this stage, it is believed that the differences in train control systems are unlikely to impact on the relative costs per mile of Network Rail, Amtrak or the passenger operators. However, the current cost of train control for the Class I Railroads is likely to be significantly lower. Using engineering judgement on the basis of the limited available information they maybe ⅓ the cost of Network Rail's costs due to the simplified approach.

From the 2010 Annual Return, Network Rail's signalling maintenance costs were 16% of the overall maintenance cost. Signalling renewal accounted for 15% of the total renewals expenditure.

4.12 Engineering Access to Network

Revenue and customer delivery is the priority for all Class 1 Railroads as they are run with a tight focus on operating trains in order to generate revenue. This means that the networks utilise as much operational capacity as possible and the windows for engineering work are short, maybe only 2 hours. The average length on Canadian National's infrastructure is between 6 and 8 hours.

In a recent magazine interview[7], Kansas City Southern Chief Engineer John Jacobson is quoted as saying:

> *"We work with tight work windows that require extensive, ongoing planning and close coordination between engineering, transportation and purchasing. A ten to twelve hour window is huge for us".*

[7] Source: http://www.progressiverailroading.com/pr/article/Maintenance-of-Way-Managing-tracktime-windows--26255

Class 1 railroads are tackling the problem of ensuring disruption is kept to a minimum and maximum productivity is achieved, in a number of ways. Clustering of work enables targeting of all types of work to be undertaken in an area or "segment" so as to minimise disruption. This is an approach that BNSF are understood to have adopted.

Canadian National has increased production by employing "mega gangs" staffed by more than 40 crew members working in the same area. These gangs can install several thousand ties per day in the six-to-eight hour windows. They also employ "super surfacing gangs" comprising of seven workers together with two high-production tampers (with dynamic stabilisers) and maintenance tampers for crossings. A super surfacing gang will complete work on five to ten miles of track per day and eliminate the need for spot surfacing.

As already noted, the Class I Railroads contain significant proportions of single line track. This negates the opportunity of undertaking maintenance of way with traffic passing on the adjacent line. Working on single track railways also increases the logistical complexity of maintenance and renewal work.

From previous work undertaken, it is understood that Amtrak undertake a significant proportion of their work through short blockades of track sections whilst traffic is routed along adjacent tracks.

With respect to the passenger operators, little detail has been obtained from most on their engineering operations. Caltrain's website does give details of their working practices. This indicates that they are able to undertake work between 1900 and 0430. They also have some opportunities to work 24 hours with single line operations around their worksite.

From the limited evidence gathered it appears that the Class I Railroads make more efficient use of their possessions. This is partly as a result of their vertical integration providing a clear link to actual revenue flows (see below for further consideration of the benefits from vertical integration).

It appears that Amtrak and the other passenger operators are able to obtain possessions to undertake their work. However, any consideration of the potential impact of their possession utilisation on the relative cost per mile would require further bottom-up review.

4.13 Infrastructure Characteristics - Structures

From the data available, Network Rail appears to have considerably more bridges and tunnels on their system than the North American organisations. The data sources each use different methods of measuring structures, e.g. number, number of spans, length of lined tunnel bore. However it appears as though there ratio of Network Rail bridges to those of the Class I Railroads is around twenty to one. The same ratio in terms of tunnels is around ten to one. Many of the North American structures carry much higher tonnages per annum than their British equivalents.

The proportion of significant structures on the North American railroads appears to be higher due to the number of bridges along the eastern seaboard that have moveable spans. As an example, there is a 103 year old, 890-foot-long structure on Union Pacific's railroad that spans the Mississippi River on the Overland Route in Clinton, Iowa. The double-track, steel through-truss swing span bridge accommodates up to 65 freight trains daily and is used to haul about 140 million gross-tons of cargo annually. During a typical 24-hour period, the swing span might be open a cumulative total of five hours to accommodate barge traffic during the peak river shipping season (barge traffic has priority over rail traffic). Reliability of the moveable spans is a key factor in the need for renewal. A new design for this bridge has been completed and the total cost of renewal is expected to around $400 million.

Additionally, there are numerous structures to consider that were built many years ago and are diverse in nature. Timber bridges are coming to the end of their life and are gradually being replaced. A number of timber bridges are being replaced as there is uncertainty over their ability to safely carry the ever-increasing axle weights.

Over half the structures on the BNSF system were built before 1960, with the oldest being constructed in 1878. BNSF has 13,100 bridges on its network. It employs 70 dedicated bridge inspectors with an annual budget of $110m.

The nature of Amtrak's structures is similar to those of the Class I railroads, but with a higher proportion of tunnels. These are through the major urban areas, such as Baltimore.

The passenger operators appear to have a similar type and ratio of structures to Network Rail, except the BART system. This system is broadly ⅓ in tunnels and ⅓ on bridges.

Network Rail's 2010 Annual Return indicates that expenditure on structures accounted for 8% of maintenance expenditure and 12% of the renewals budget. Due to the nature of the specific challenges faced in maintaining and renewing the structures in North America it is difficult to ascertain whether the large discrepancy in numbers feeds through to being a key driver of the differences in the costs per mile.

4.14 Infrastructure Characteristics – Traction Power

As already noted, the Class I Railroads have no traction power systems. The passenger operations are also primarily diesel operated. The main exception to this is Amtrak, which operates an electrified system on the North East Corridor. Additionally, approximately 15% of the passenger operators' track miles have a traction power system.

As an aside it is probably worth noting that the extreme climatic conditions experienced by the North American Railroads do not lend themselves to the use of traction power systems.

From Network Rail's Annual Return 2010, the proportion of maintenance expenditure on traction power systems was 4%, with a 4% of the renewals budget also spent on the traction power system. This will affect the infrastructure driven metrics.

4.15 Infrastructure Characteristics – Switches and Crossings

The impacts on the relative costs per mile of variations in S&C density have been considered previously when discussing the relative complexity of the networks (Section 4.10).

Traditionally, heavy (136 lb/yd) rail with built-up bolted switch and stock rails, common crossings, on hardwood timbers, with a mixture of screw and spike fastenings are used. Hardened rail and cast crossings are now common, particularly for areas with heavy use. However, hardwood timbers with screw fastenings are still favoured due to their availability, flexibility and ease of handling compared to concrete bearers. It is understood that larger turnouts are now standard on heavy railroads using 141lb rail.

Heavy maintenance, rather than complete renewal, is the common policy, with much emphasis on weld repairs at common crossings.

Switch actuation systems vary from sophisticated electrical and mechanical interlocking in urban, complex, and yard areas through to hand and spring operation released locally at loops and refuge sidings.

There is a move towards movable point frogs (swing nose crossings) in order to provide a smoother transition and reduce the impact loads compared with traditional crossings. It should be noted that the previously noted issues of track stresses due to the wide temperature variations (Section 4.5) will cause enhanced problems when swing nose crossings are installed. This means that the locations of these need to be carefully considered.

A recent innovation is a jump frog. The jump frog is effectively a ramp that allows the flange of a wagon to climb up and raises the wagons wheels over the stock rail and ramp down the other side. This means that the stock rail can remain continuous for through traffic on both sides of the track. The main benefit is that train travelling through the lead do not see the crossing. Reducing the discontinuities improves maintenance costs, but it is only suitable for specific locations. They are only used where low volumes of traffic need to traverse the tracks at slow speed.

4.16 Infrastructure Characteristics - Rails

Since 1869, the standard rail section has risen from 50lb to 141lb and even higher to as much as 155lb in some locations. It has been found that curve wear life of 141lb head hardened rail is 22% greater than that of 136lb or 133lb rail sections.

One consequence of this development is that there is a large variety of rail shapes with little standardisation. Even the width of the rail feet varies. The Form R-1 Reports include details of the rail weights installed on each rail network. This indicates that there are 28 different rail weights in use, another example of a lack of standardisation.

The main types in use are:

132lb/yard:	27%
136lb/yard:	25%
115lb/yard:	12%
Other 25 types:	36%

To accommodate the ever increasing capacity issues on North American railroads, axle loads on freight cars have increased and trains have got longer. The general maximum axle load on freight cars is currently 36 tons which require heavier, harder and cleaner steel in order to extend the life of the rail. American railroads have been working with rail manufacturers over the years to produce cleaner steels. These cleaner steels are of a much higher quality with few imperfections, reducing the number of inherent rail defects.

Rail head hardness is also a key factor. The surface hardness of premium141lb rail is 415 Brinell (BHN) with a hardness of 385 BHN at one inch below the surface. The BHN of normal grade CEN60 rail now being used by Network Rail on primary routes is in the range of 260 BHN.

Rail management is an important aspect of infrastructure management. In addition to the type of steel used, the other key components are lubrication and grinding.

In order to reduce rail wear on curves, gauge face lubricators are widely fitted across all networks. These can be solar powered which enables them to be fitted in remote locations where it would otherwise be difficult to obtain a suitable power source. Significant improvements have been made in the quality of lubricant used and the application processes.

The stresses caused by wheel rail interfaces are continually being addressed by North American railroad companies in order to extend the life of the rail. The recent development of a “top of rail friction modifier” has helped to further reduce the stresses at the wheel rail interface. The intent is to keep the coefficient of friction just above the point where wheel spin of the locomotive will occur, but allow the contact stresses to be reduced as much as possible. BNSF has installed a number of these devices across its system already.

The use of this equipment has resulted in smoother running and provides a payback in better fuel efficiency. Investing in the infrastructure and taking the improvement from train operations is another benefit of vertical integration.

Rail grinding is seen as an important activity on North American railroads in order to control contact stresses and mitigate the risks of rolling contact fatigue. Canadian National ground approximately 13,664 miles in 2009 (45% of the network) and BNSF treated 16,043 miles of rail in 2010 (51%). In comparison, Network Rail ground 64% of their track mileage. In addition to maintaining the rail profile and controlling defects, grinding rail also provides more reliable information to the ultrasonic rail flaw detection cars while they are testing.

The rail life extension strategies are producing favourable trends for BNSF. Rail life on curves is much shorter than on tangent, so improved rail life is evident on curves first. Between 1997 and 2002 the length of new rail necessary to replace worn-out rail on curves was reduced by 405 kilometres, a 48% decrease. A reduction of 992 (22%) in the number rail defects on curves was achieved[8] between 1997 and 2001.

PR08 funded Network Rail's rail renewals at an average of 2.7% of the network per annum in CP4. Review of the figures quoted in the Form R-1 documents enables an analysis to be undertaken of the rate at which the Class I Railroads are renewing their rail across the different categories of lines. The forms detail the proportion of track in each track category, which is defined according to the annual tonnage carried. Categories A and B include all tracks carrying more than 5 MGT per annum. For the comparator railroads, this represents 61% of the networks, but accounts for 78% of the rail replacement activity.

Category E contains "Way and Yard Switching" tracks. As already explained in Section 4.10 above, these areas are seen as a more critical element of the network than in Britain. Analysis of the figures indicates that 10% of rail renewal activity is undertaken on Category E tracks. If this category is removed from the distribution of rail renewal activity analysis, the revised conclusion is that 87% of rail renewal is undertaken on 80% of the network that forms the higher category tracks.

Review of the figures quoted in the Form R-1 documents also enables an analysis to be undertaken of the rate at which the Class I Railroads are renewing their rail in comparison with Network Rail. A normalised renewal rate for Network Rail is included in the table below to take cognisance of the difference in traffic levels. This has been assessed by considering the gross ton miles carried per track mile at a network level across the comparator organisations. The factor has been calculated as a multiplier of 5 times Class I traffic levels.

Rails	Rate of Renewal
NR	1.9%
NR normalised	9.5%
Average Class I	2.7%

Table 9: Rail Renewal Rate

Using this normalised figure, it appears that the rail management regimes implemented in North America are increasing the average rail life by more than three times. At a simplistic level, this would appear to indicate that Network Rail could reduce its expenditure on rail renewal by approximately ⅓ through introduction of a coordinated rail management programme.

4.17 Infrastructure Characteristics – Cascaded Materials

From the various documents reviewed it is obvious that a large proportion of the rail is cascaded to lower tonnage routes to further extend the life of the rail. In North America, this is known as "relay rail". For example, in 2010, Canadian National replaced 273 miles of continuous welded rail in the United States, of which 152 miles was relay rail (56%). CSX-T policy appears to be that a high proportion of rail recovered from Category A and B routes is re-used on the lower category routes and in yards. Some relay rail is also bought in from other sources, mainly rail rehabilitation firms, for use on Track Category B routes.

[8] Presentation by Craig Hill to OVG Eisenstadt, May 2002.

The Form R-1 data includes details of both the quantity of relay rail used, plus the relative costs of supplying both new and relay rail to site. The details for 2010 are tabulated below.

		BNSF	CSX-T	GTC	NS
Relay Rails	%age	18	22	56	24
Savings Over New	%age	5	17	29	20

Table 10: Savings from Cascaded Rail

The GTC (Canadian National) figures are significantly different to those of the other railroads. It is possible that this is as a result of their recent strategy of increasing capacity by acquiring smaller companies and then upgrading their tracks. Ignoring their figures, this still indicates an average saving of 14% through an extensive cascading programme.

4.18 Infrastructure Characteristics - Sleepers

Timber sleepers still tend to be the type predominately used in North American. Norfolk Southern remains a “100% timber sleeper” railroad. It is believed that this is as a consequence of them being locally sourced and cheaper when considered in terms of the combined cost of supply and installation. The widespread practice of spot sleeper renewal rather than complete renewal makes it more cost effective to retain timber sleepers (see below). Timber sleepers are rarely used in Britain.

Concrete sleepers are generally used when renewing (or new build) on the main trunk routes. It is worth noting that Amtrak is prematurely replacing a batch of faulty concrete sleepers supplied between 10 and 20 years ago.

Sleepers are spaced at between 34 and 38 per length (60 foot), compared to 26 to 30 per length in Britain.

Replacement on a cyclic basis using plain timber ties is still the predominant heavy maintenance activity. Complete renewal of track and ballast is only carried out where engineering and economic criteria indicate it is beneficial. Where timber sleepers are specified, the work is carried out by specialist teams with mechanised equipment on a “moving factory” principle. Shoulder or total ballast cleaning is often carried out in conjunction with the work. In all cases comprehensive tamping completes the process.

PR08 funded Network Rail’s sleeper renewals at an average of 2.2% of the network per annum in CP4

An analysis of the spread of sleeper renewal activity undertaken across the different line categories (as undertaken for rail renewal activity) indicates a significant variation in activity on the higher category tracks, i.e. those carrying more than 5MGT across the comparator railroads. This wide variation requires further investigation to understand the differences.

Again review of the figures quoted in the Form R-1 documents enables an analysis to be undertaken of the rate at the Class I Railroads are renewing their sleepers. As per the previous rail replacement analysis, a factor has been applied to take into consideration the differences in annual traffic carried.

Sleepers	Rate of Renewal
NR	1.4%
NR normalised	7.0%
Average Class I	3.0%

Table 11: Sleeper Renewal Rate

However, at a simplistic level, this would appear to indicate that Network Rail could reduce its expenditure on sleeper renewal by approximately ½ by adopting a spot resleepering programme.

4.19 Infrastructure Characteristics – Ballast and Tamping

Ballast depths and configurations on North American railroads are similar to those used on Network Rail's infrastructure. However, the policy of component renewal on North American railroads means that ballast is usually renewed separately to rails and sleepers. This means that the track needs to stay insitu whilst the ballast is cleaned or renewed

There are a number of different types of undercutting machines that are used to undertake this operation. These vary from large scale machines, such as a Plasser American Corp. RM80 ballast under cutters, through to under cutters that are mounted on excavator dipper arms.

Ballast shoulder cleaning is also a common activity undertaken to improve drainage. This is not common practice in Britain, but could be adopted and provide reduced costs through not having to replace the whole of the track cross section with new ballast.

Majority of these ballast cleaning operations are on single line and spoil is placed on the line side by conveyor belts from the machines and then graded. This used to be a common practice in Britain up until the early nineties. It saved costs on engineer's trains and post work spoil management.

A similar analysis to that undertaken with the sleeper and rail renewal rates has been completed to consider the relative tamping rates (including application of the annual traffic factor). These are shown in the table below.

Tamping	Proportion of Network Treated
NR	1.7%
NR normalised	8.5%
Average Class I	26.6%

Table 12: Annual Tamping Activity

These figures appear to indicate that Network Rail is more efficient in using their tamping machines. However, this would need to be verified through more detailed review as other explanations could be that the North American railroads are much less reliant on manual intervention to maintain alignment or that the figures are not comparable. For example, it is not clear whether tamping associated with renewals is included in both set of figures. The North America rates are likely to include a high proportion associated with spot resleepering, an activity seldom undertaken in Britain.

Little or no stoneblowing is undertaken in North America.

4.20 Infrastructure Characteristics – Level Crossings

The table below indicates the numbers of level crossings on the various types of railway being compared in this study.

	Class I	Amtrak	Passenger Operators	Network Rail
Number per Route Mile	1.7	0.3	1.2	0.9

Table 13: Frequency of Level Crossings

Although, other than Amtrak, it appears as though there is a higher frequency of level crossings in North America, this may not necessarily lead to an increase in costs. The unit costs are likely to be lower than in Britain as, generally, there is much less associated control infrastructure in the US. Many crossings are only fitted with signs, warning lights and/or bells.

Level crossings are a major safety issue in the United States. The FRA Safety Report for 2009 indicates that there are 219,495 crossings, of which 2,016 pedestrian only. For comparison there are 6,500 in use on Britain's main lines. The FRA recorded 1,640 incidents on US public crossings in 2009 resulting in 247 fatalities. In Britain, RSSB recorded 4 pedestrian fatalities at crossings plus 5 vehicle collisions, none of which resulted in a fatality.

From a human factors perspective it is likely that there is a greater temptation to try and beat the train if you know it can be 2-mile long and travelling at 40mph.

As in Britain, there is an on-going campaign to remove grade crossing, by either closing them or installing bridges instead.

It is not possible to determine if the differences in level crossings will have a negative or positive impact on the relative costs per mile.

4.21 Relative Quality of Infrastructure

No information has been identified that enables a direct comparison of track quality to be made. As a proxy, the relative proportion of the network affecting by a temporary speed restriction has been considered. In order to undertake this analysis engineering judgement has been used and the average length of a speed restriction in Britain is considered to be 100 yards.

	Class I	Amtrak	Passenger Operators	Network Rail
Proportion of track restricted	4.9%	0.2%	-	0.4%

Table 14: Frequency of Speed Restrictions

It is believed that this analysis still provides an incomplete picture.

- The spread of values for each of the Class I Railroads is from 9.4% to 0.5%, which appears to indicate different strategies have been adopted. For example, the use of a speed restriction instead of investing in a renewal if there are no capacity constraints. This would appear to be the case with CSX-T where most of the renewal expenditure is on the higher category lines.
- The absolute number of speed restrictions also fails to consider the severity of the restriction (with their business approach, it is believed that a Class I Railroad would not tolerate the adverse impact on fuel consumption of a severe restriction).

4.22 Degree of Mechanisation

Although no quantitative data has been identified, all the documents reviewed indicate that there is a high degree of mechanisation across all categories of North American Railroads. As an example, an explanation of engineering activities on Caltrain's website details the use of three crews, each with between 2 and 7 personnel: tie gang; surfacing gang; and welding gang. The reviews above of sleepers (Section 4.18) and ballast management (Section 4.19) are also indicative of a high degree of mechanisation.

It is our understanding that, in general, the average age of the machines in North America is older than in Britain. However, they are operated by dedicated operator/maintainer crews who have a personal interest in ensuring that output is maintained.

There is a movement by railroads towards longer five year contracts with the supply chain, rather than the current annual contract model. This is to encourage investment in new (higher productivity) machines. As such it provides a “win-win” position.

4.23 Skill Levels of Workforce

No data has been identified from this study that enables a comparison to be made with respect to the relative skill levels of the workforce and the potential impact this might have on the cost gaps.

It might not be unreasonable to suggest that, as the North American rail industry has not experienced the same degree of organisational change and upheaval in recent years as Britain, it has a more experienced workforce. A more experienced workforce would be better placed to make more ‘judgment’ based decisions rather than applying a conservative “fits all” general rule.

However, from previous study visits to the United States it is clear that there are genuine concerns about the age profile of the existing workforce. This is a consequence of the greater continuity and depth of experience. It is understood that, in order to address this concern, there are a number of initiatives in place to incentivise skilled staff to remain working for the railroads beyond the point at which they have earned their pension entitlement.

At this stage, there is no information with respect to this factor that assists in understanding the variations in the cost per mile metrics.

4.24 Degree of Standardisation

As already noted, little evidence has been found in any of the North American railroads of a standardised industry approach. Examples referred to above are the wide variety of rail profiles in use (Section 4.16) and numerous different PTC systems (Section 4.11). Although many components are based on standard AREMA (American Railway Engineering and Maintenance of Way Association) standards, each railroad tends to adapt them to their own particular requirements.

The only example of standardisation identified during the review was a reference to potential savings as a result of BNSF and Union Pacific agreeing to adopt the same ballast specifications.

It appears as though standardisation is a potential area of further opportunity for all the groups being compared. However, the Class I railroads are able to achieve significant economies of scale as a result of their own large demands for specific components.

4.25 Vertical Integration

It is believed that the vertical integration of the railway structure in North America with the consequential direct linkage between investment decisions and the impact on revenue streams is one of the key drivers behind the differences in performance levels. This direct linkage helps to direct investment into the correct areas of the overall business and also enables spending to occur in one area whilst savings are taken in another. For example, the previously quoted example of a business case for installing rail head lubrication (Section 4.16) with part of the benefit being taken through improved fuel consumption would be difficult to implement in the current British industry structure.

As virtually all expenditure is tied to revenue generated, management is focussed on maintaining a competitive edge by adding value to the company’s asset life-cycle. The condition of the asset is well understood, enabling accurate intervention decisions to be made. Additionally, all disciplines contribute to the decision making process to ensure that resources are put into the routes that offer the best returns for the outlay. This may be, for example, to improve infrastructure reliability, route enhancement, capacity and flow improvements or efficiency gains through better methodology and innovative equipment.

As the Class I railroads are complete transport companies totally dependent on their own earnings and resources to maintain assets so as to provide a competitive and acceptable service to customers, their decision-making is focussed on adding value to the business. It appears that their strategies are clearly linked to the prevailing economic and environmental conditions. This belief is borne out by the fact that, although there has been a reduction in the volume of freight in each of the past 3 years, revenue and profits have been increased. This has been accomplished by measures such as devising revised purchasing policies and re-scheduling of services. Large savings have been made without losing the focus on the service to the customer.

Being vertically integrated, it means that the infrastructure engineers have to compete hard with other departments for allocation of investment funding, e.g. considering expenditure on new locomotives and wagon fleet rather than additional track. It is expected that the discipline of determining justified expenditure on infrastructure to be very tough as a consequence. It would be interesting to compare the investment planning processes, including the expectation on engineers to identify and deliver real business benefits from their activities. It is assumed that they are held to account for their delivery of the benefits.

On 3rd January 2012 Canadian National announced the merger of three of its operating subsidiaries. The driver for the merger was the operational efficiencies and service improvements obtainable from integration of the workforces into a unified group. This is another example of the benefits derived from vertical integration and clarity of view on providing an efficient and reliable rail service.

Although not an aspect of infrastructure management, it is worth noting the policies being adopted by several railroads for fuelling locomotives. For example, BNSF have changed their schedules so that the locomotives fully fill their fuel tanks at Kansas instead of Chicago. This will save BNSF $1m p.a. This is indicative of the attention to detail and the size of the organisations.

At this stage, the impact of this factor on evaluating the gap is difficult to determine.

4.26 Industry Structure

As already noted, almost every North American organisation reviewed as part of this study has operating rights over those of other organisations. The policy of negotiating operating rights is expanding with increasing cooperation as large regional intermodal hubs are being developed.

The railroads are also all vertically integrated with both train operations and infrastructure management undertaken by the same entity. As noted below (Section 4.30), the Class I railroads and Amtrak tend to undertake the majority of work using in-house resources. However the passenger operators outsource delivery of parts of their operations to third parties. In some cases, all delivery operations are outsourced.

As a consequence of this type of industry structure it is difficult to disentangle the various costs to arrive at clear costs allocated to specific sections of infrastructure. It is not possible to undertake such analysis using public domain information.

For the purposes of this study it has been assumed that the prices paid for services provided by others are closely related to the costs incurred. It is believed that this approach to determining the metrics provides a reasonable high-level view of the different costs per mile, particularly in terms of the granularity provided between the different generic groups of organisations.

4.27 Funding Sources (ADA, ARRA, SOGR)

Amtrak in particular is recipient of funds from several sources and for several different programmes. These include:

- ADA (Americans with Disabilities Act)
- ARRA (The American Recovery and Reinvestment Act)
- SOGR (State of Good Repair)

One hypothesis that was identified was that the availability of this additional funding would artificially increase Amtrak's (and the other passenger operators) capital investment. However Amtrak's 2010 capital investment levels do not reflect this hypothesis when considered with that of other years:

2009 (actual)	$769m
2010 (actual)	$689m
2011 (budgeted)	$1039m

4.28 Cost of Labour

An Amtrak Office of Inspector General Report was published in 2009[9] comparing the cost of North American railroad labour with that of European railway employees. It concluded that the cost per Amtrak employee was:

- 1.3 times as much due to differences in base wages;
- 3.5 times as much due to the average level of overtime; and
- 4.2 times as much due to the benefits per employee provided to employees.

The latter factor has an impact on all North American comparator organisations in the study, but it will effectively increase the gap rather than assisting in explaining the reasons for the gap.

4.29 Improvements in Asset Management Approaches

A number of examples of good asset management practice have been identified in the course of researching this study. Several have been mentioned previously. These include:

- Rail management;
- Cascading materials;
- Spot resleepering; and
- Mechanisation.

In particular, it was noted that Canadian National have an initiative called "Precision Engineering" which is using integrated resource planning software (SAP-based) to collect inspection data and help plan the correct interventions. The software also provides compliance assurance. It appears to be similar to the asset and work management system that RailKonsult saw being implemented within Amtrak during a study visit in 2010.

BNSF have had several improvement campaigns. They started with "World Class Maintenance", moved to "Maintenance Excellence" and now have "Best Way Engineering".

[9] Evaluation Report E-09-01 Comparison of Amtrak Infrastructure Labor Costs to European Railroad Averages March 24 2009

Again, this makes use of SAP to gather data and provide information. It also includes the use of 6-Sigma techniques and latest technology to help make right decision at right time.

These programmes are indicative of the type of activity being undertaken by the North American Railroads to ensure that there is a process of continual improvement and cost reduction.

4.30 Outsourcing

There are agreements in place with the unions that control the degree to which outsourcing occurs in North America. Anecdotally, this is understood to be the main barrier to outsourcing. For example, Norfolk Southern is understood to undertake all its work in-house. As with Britain, all the Class I Railroads undertake maintenance in-house.

There are railroad specific rules on what can be offered to supply chain, usually based on minimum values. BNSF involves the supply chain where specialist plant and/or specialist knowledge and skills are required. The service is focused on the supply of the expertise. For example, the supply chain provides the crew and specialist plant for ballast cleaning operations, but BNSF haul the machine from site to site, provide new ballast and tamp the track.

The supply chain concentrates on providing efficient volume delivery of a few key tasks, e.g. tie replacement. This means that the contractor has the advantage of deep knowledge and can maintain a pool of specifically skilled labour and plant. The substantial geographical distances covered by the Class I railroad networks provide a focus such that the plan produced is the most efficient and cost effective. This planning is likely to mean that there is much less unnecessary and costly moving between different distant worksites. The outcome is competitive unit rates.

As already noted, some of the passenger operations out-source all operational and maintenance activities, acting solely as managing agents.

5.0 CONCLUSIONS

5.1 Insight from Metrics

Four different high-level metrics have been evaluated:

- Cost per mile on the basis of route length;
- Cost per mile on the basis of track length;
- Cost per mile on the basis of train miles; and
- Cost per mile on the basis of gross ton miles.

For each of these four metrics, Network Rail's 2010 performance has been compared with:

- A representative group of Class I Railroads;
- Amtrak; and
- A varied group of passenger operators from the United States.

Several iterations of the metrics were calculated that represent different "slices" of each organisations cost stack. The version that provides the best insight is the view that attempts to extract comparable spending on infrastructure.

In comparison with the Class I Railroads, Network Rail's costs per mile are generally significantly higher. The exception to this is the cost per train mile. This is to be expected as the Class I Railroads operate fewer trains that are significantly longer than seen in Britain. A typical North American train would haul in excess of five times the weight of a British freight train, with passenger trains being significantly lower. Whilst the results of the sensitivity analysis indicate that the gap maybe over estimated, it still indicates a similar picture.

The calculated metrics indicate that Amtrak's costs per mile are broadly equivalent to those of Network Rail, with the extreme sensitivity analysis indicating that Network Rail's costs might be lower. This is different to the outcome from previous studies. Further work is required in order to understand the underlying reasons behind this, although one hypothesis is that the "State of Good Repair" programme is a contributory factor.

In comparison with the passenger operators, Network Rail's costs per mile are significantly lower. Two hypotheses that may explain this gap are:

- Even the largest passenger system is a factor of 15 times smaller than Network Rail. The high-level metrics may not be sufficiently scalable to be representative over this range. As each is a self-standing unit, it is possible that there are fixed cost elements that are required regardless of the size of network being managed This is exacerbated as they are commuter routes that maintain a peak-time capability which is under utilised throughout the rest of the day.
- In general, the passenger operations run services using previously run-down freight railroad infrastructure. Their capital investment programmes appear to contain a significant element of "backlog renewals" to improve train speeds and reliability.

5.2 Initial Gap Analysis

The nature of the railway industry in North America is very different to that found in Britain. In particular, the organisations are generally vertically integrated with infrastructure management and train operations under the direction and control of the same entity.

Thirty different factors have been considered that may have an impact on the relative costs per mile. These can be grouped under five different generic headings:

- Factors that have been identified as “harmonisation” issues that would decrease Network Rail’s apparent costs per mile;
- Factors that have been identified as “harmonisation” issues that would increase Network Rail’s apparent costs per mile;
- Factors that have been identified as likely to have no significant impact on the relative apparent costs per mile;
- Factors that have currently been identified as having an uncertain impact on the relative apparent costs per mile (from the available information reviewed as part of this study); and
- Factors that have been identified as North American “good practice” and help explain the relative differences in the costs per mile.

The generic groups are tabulated below. This also categorises the factors in terms of whether they are a consequence of the:

- Country, i.e. factors that are the result of the general environment and outside the control of the different railway organisation;
- Industry, i.e. factors that are the result of the way that the local railway industry operates and, as such, the different railway organisations can influence or partially control these factors; and
- Company, i.e. factors that are the result of the way the different railway organisations decide to manage their business.

Factor Categorisation	Harmonisation: Decrease NR Relative Unit Costs	Harmonisation: Increase NR Relative Unit Costs	"Minimal Impact" Factors	"Uncertain Impact" Factors	North American "Good Practice"
Country Related (No control)		Geography and geology Climate	Environment and legislation Traffic characteristics	Structures Sources of funding (Amtrak in particular)	
Industry Related (Limited control)	Train control systems	Relative labour costs (cost of benefits)	Operational methodology Engineering standards Unionisation Degree of standardisation Industry structure	Level crossings	Vertical integration
Company Related (Controllable)	Safety (with respect to frequency of derailments) Complexity (multiple track, density of S&C and operational property) Traction power	Complexity (importance of switching yards)	Switches and crossings	Ballast management and tamping Relative quality of infrastructure Skill levels of workforce	Engineering access to the network Rail management Cascaded materials Renewal of sleepers Mechanisation Asset management approaches Outsourcing

Table 15: Summary of Identified Factors

5.3 Recommendations for Further Work

Not withstanding the difficulties in understanding the high-level metrics, it is believed that valuable insight could be gained by the ORR through undertaking a more detailed "bottom-up" benchmarking exercise to better understand the cost benefits achieved by aspects of the Class I Railroad operations.

In particular, the following areas have been identified:

- Benefits derived from vertically integrated operations through a "clear line of sight" between investment expenditure and revenue impact; and
- Asset management policies, such as the approach to rail management.

The gap analysis review of various factors reveals a number of significant areas of difference between North American Class I Railroads and Britain. However, there are sections of track on the main trunk routes that have similar infrastructure to that found in Britain. Although there maybe some commercial issues to resolve, it is recommended that one of these sections of route is chosen for review. This would include both calculation of the relative costs per mile and the asset management strategies deployed to deliver them.

In terms of gaining a better understanding of the high-level metrics reported in this study, it is recommended that further work is undertaken in the following areas:

- Review the overall quality of the infrastructure through on-site inspection in order to better understand the differences in derailment frequency and evaluate the degree to which the lower unit costs are driven by acceptance of lower standards;
- Undertake a joint exercise with Amtrak to understand the drivers behind the relative movements in costs per mile (noting that Amtrak is already included within the dataset used by the ORR for regional international top-down benchmarking); and
- Develop a suitable methodology to enable a comparable set of metrics to be developed that enables Network Rail (or sections of their system) to be benchmarked against the passenger operations.

APPENDIX A: PEN-PICTURES OF SELECTED CLASS I COMPARATOR RAILROADS

BNSF

BNSF Railway (http://www.bnsf.com) operates one of the largest railroad networks in North America with approximately 32,000 route miles (including operating rights) in 28 states and two Canadian provinces. BNSF has a centralised operations centre at Fort Worth that dispatches trains and monitors the network. The system is divided into thirteen divisions, grouped into three regions (south, central and north).

On February 12, 2010, Berkshire Hathaway Inc. acquired 100% of the outstanding shares of Burlington Northern Santa Fe Corporation common stock that it did not already own.

It transports a wide range of products and commodities:

- Consumer Products (31% 2010 revenue);
- Coal (27%);
- Industrial Products (20%); and
- Agricultural Products (22%).

The main routes are:

- Northern Transcon from Seattle to Chicago;
- Southern Transcon from Los Angeles to Chicago; and
- Powder River Basin.

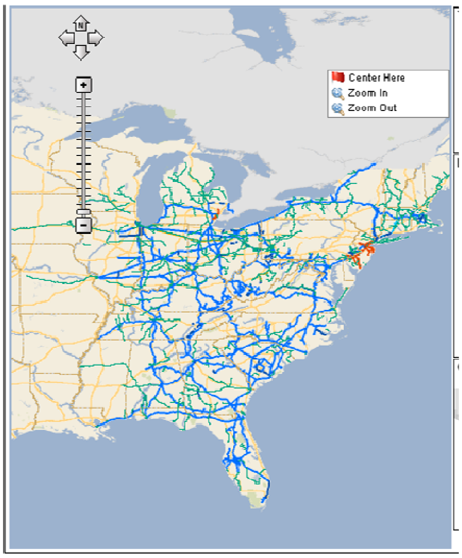
The two main east/west routes cross the Rockies and have been the subject of recent investment to increase capacity by adding additional tracks to remove “pinch points”. Such major projects include the completion of seven miles of double track in New Mexico's Abo Canyon in early June 2011.

Network Map from BNSF Website

BNSF operates across a full range of climate differences. The varying climate and terrain, as well as different traffic densities, result in a variety of infrastructure issues that must be managed.

CSX Transportation

CSX-T (http://www.csx.com) operates through 23 States to the East of the Mississippi river, the District of Columbia, and the Canadian Provinces of Ontario and Quebec. Its 21,000-mile network (including operating rights) serves major population centres, and over 70 ocean, river and lake ports from the St.Lawrence Seaway and the Great Lakes to the Atlantic and Gulf coasts and the Mississippi River.



Network Map from CSX Website

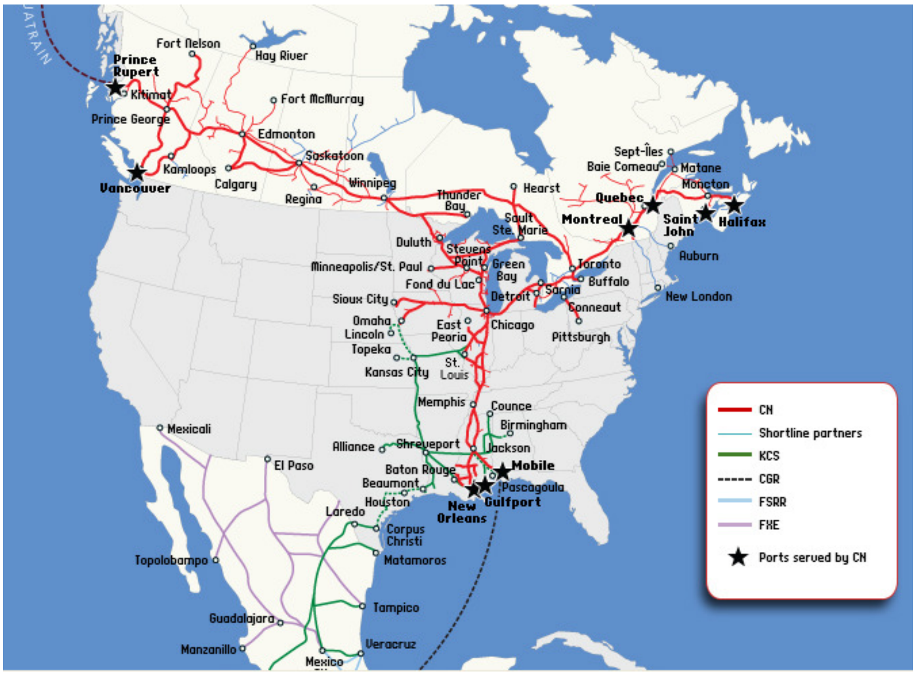
Rail shipments fall into 3 main service groups which generate the following revenue:-

Merchandise	57%
Coal	32%
Intermodal	9%

Canadian National Railway (CN)

The Canadian National Railway Company (http://www.cn.ca/en/index.htm) spans Canada and mid America from the Atlantic and Pacific Oceans to the Gulf of Mexico. The network covers approximately 20,600 route miles of track (including operating rights) and serves key ports along its tri-coastal gateway network

Following CN's privatisation in 1995, the company embarked on a series of major acquisitions intended to strengthen its position in the North American market place and enhance it's routing and distribution capabilities.



Network Map from CN Website

Norfolk Southern (NS)

Norfolk Southern (http://www.nscorp.com/nscportal/nscorp/) is based in Norfolk, Virginia. It operates approximately 20,000 route miles (including operating rights) in 22 states and the District of Columbia. It serves the south east, east and mid-west regions of the US. Its major railroad competitor, which operates in very much the same area, is CSX-T.

NS handles freight traffic in all the major market sectors i.e. raw materials, intermediate products and finished goods. Overseas freight is significant, transporting via several Atlantic and Gulf Coast ports. In addition, it also claims to operate the most extensive intermodal network in the eastern US. Key freight statistics are:

- Coal, coke and iron ore: 170.8 million tons moved in 2010, contributing $2.7 million to total operating revenue (28%). The largest commodity group;
- General merchandise traffic: 123 million tons moved in 2010, contributing $5.0 million to total operating revenue (53%). The business is divided into the following five main commodities, with % contribution shown in each case: automotive (7%); chemicals (14%); metals and construction (10%); agriculture, consumer products and government (14%); paper, clay and forestry (8%)
- 66% of the general merchandise volume originated as direct NS generated business, with the remainder being generated by connecting carriers;
- Intermodal traffic: 2.9 million intermodal units were moved in 2010 (comprising trailers, US and international container traffic and road-rail equipment). This sector provided 19% of total operating revenues.

There are several key freight corridors:

- New York City area to Chicago via Allentown and Pittsburgh
- Chicago to Macon via Cincinnati, Chattanooga and Atlanta
- Appalachian coalfields to Norfolk and Sandusky, Ohio
- Cleveland to Kansas City
- Birmingham to Meridian
- Memphis to Chattanooga

Network Map from NS Website

APPENDIX B: POTENTIAL COMPARATOR PASSENGER OPERATORS

Location	Railroad	Route Miles	Operating Cost $m	Capital Cost $m	Type of System	Comments
			Costs cover mechanical & infrastructure			
National (US)	Amtrak	21,000	3700	1300	Heavy	Own infrastructure NE Corridor, but freight operating rights
Alaska	Alaska Railroad Corp (ARRC)	467	140	73	Heavy	Class II, state-owned, mixed traffic RR -broadly standalone. However, unable to find any financial details
Arizona	Valley Metro	20	33	45	LRT	Operates in the Phoenix area
California	Bay Area Rapid Transit (BART)	104	634	585	Heavy	Operates rail service in San Francisco Bay area. Self contained, wide gauge, third rail system
California	Los Angles County Metropolitan Transportation Authority (LACMTA)	17	89	10	Heavy	Mileage and costs are predominately LRT (Heavy figures only quoted)
California	Penisula Corridor Joint Powers	77	97	82	Heavy	Oversees Caltrain - San Francisco to Gilroy. UP and own infrastructure and trains (plus Amtrak).
California	Sacramento Regional Transit District	38	125	38	LRT/Bus	Figures quoted are for LRT and bus routes
California	San Joaquin Regional Rail Commission	86	15	61	Heavy	Overseas Altamont Commuter Express - San Joaquin-Santa Clara. Only operates 3 trains each way daily
California	Southern California Regional Rail Authority (SCRRA)	512	180	563	Heavy	Operates Metrolink commuter-rail services in southern California
Colorado	Regional Transportation District	35	30	?	LRT	Operates transit services in Denver
Connecticut	Shore Line East				Heavy	Operates within Metro North and Amtrak territory
Florida	South Florida Regional Transportation Authority	71	68	30	Heavy	Operates Tri-Rail in South Florida. Accounts not separated from other transport services
Florida	SunRail	61			Heavy	Construction yet to start - FDOT buying CSX right of way
Georgia	Metroplitan Atlanta Rapid Transit Authority (MARTA)	48			Heavy	Atlanta area - MARTA being upgraded & maintained by Alstom?
Illinois	Chicago Transit Authority (CTA)	224	1340	653	Bus/LRT Heavy	Chicago and surrounding suburbs.
Illinois	Commuter Rail Division of the Regional Transportation Authority (Metra)	488	220	212.1	Heavy	Chicago and surrounding suburbs - operates on BNSF, UP, CSX etc infrastructure plus its own
Maryland	Maryland Transit Administration (MTA)	16 / 187		50 / 75	Metro, LRT, Heavy	Heavy and commuter figures quoted
Massachusetts	Massachusetts Bay Transportation Authority (MBTA)				Various	Operates in Boston area.
Minnesota	Metro Transit	40	17		LRT. Commuter	Operates in Minneapolis / St Pauls area. Commuter figures quoted

Location	Railroad	Route Miles	Operating Cost $m	Capital Cost $m	Type of System	Comments
			Costs cover mechanical & infrastructure			
New Jersey	New Jersey Transit	997	1809	1350	LRT, Bus, Commuter	Complex linkage of tracks and operations covering Amtrak, Metro North, NS and ConRail, CSX.
New York	MTA Long Island Railroad (LIRR)	701	1700	179	Commuter	
New York	MTA Metro-North Railroad	385	1300	224	Commuter	Operates to NYC's northern suburbs
New York	MTA New York City Transit (NYCT)	227	6300		Heavy	Operates subway in NYC (OPEX includes other transit systems?)
North Carolina	Charlotte Area Transit System (CATS)	9	12	3	LRT	Operates in Charlotte area
Oregon	Tri-County Metropolitan Transportation District of Oregon (TriMet)	15	6	0.02	LRT, Commuter	Operates in Portland area. Figures quoted for commuter rail only
Pennsylvania	Southeastern Pennsylvania Transit Authority (SEPTA)	280	1147	400	Various	Operates in Philidelphia area, using own/CSX/Amtrak infrastructure
Texas	Dallas Area Rapid Transit (DART)	72	16	619	LRT	Operates in Dallas/Fort Worth area
Texas	Metropolitan Transit Authority of Harris County (METRO)	8	15		LRT	Operates in the Houston area
Texas	Forth Worth Transportation Authority (The T)	37				Funding being sought - would operate over DART infrastructure
Texas	Trinity Railway Express (TRE)	34	20	4.5	Commuter	Operated by DART & Fort Worth Transportation Authority
Utah	Utah Transit Authority (UTA)	45	15	5	LRT, Bus, Commuter	Figures quoted for commuter only (except CAPEX).
Virginia	Virginia Railway Express	55	64	30	Commuter	Operates in Northern Virginia suburbs to downtown Washington, D.C over MARC and Amtrak infrastructure
Washington	Sound Transit	74	36	125	LRT, Commuter	Operates in central Puget Sound area. Figures quoted for commuter only.
Canada	GO Transit	243	664	1300	Commuter (bus/trains)	A division of Metrolinx, operating in Toronto & Hamilton areas. Own 54% of infrastructure. Accounts not separate
Canada	VIA Rail	223				VIA Rail operates over 12,500 route miles, but doesn't publish figures indicating cost of its own infrastructure
Canada	South Coast British Columbia Transportation Authority (TransLink)	43	18	16	Various	Planning, funding and admin for various systems in Vancouver area. Commuter rail figures quoted

Included in study

Excluded due to complexity (figures include other passenger systems or interlinked infrastructure)

Small network (less than 50 miles at first pass)

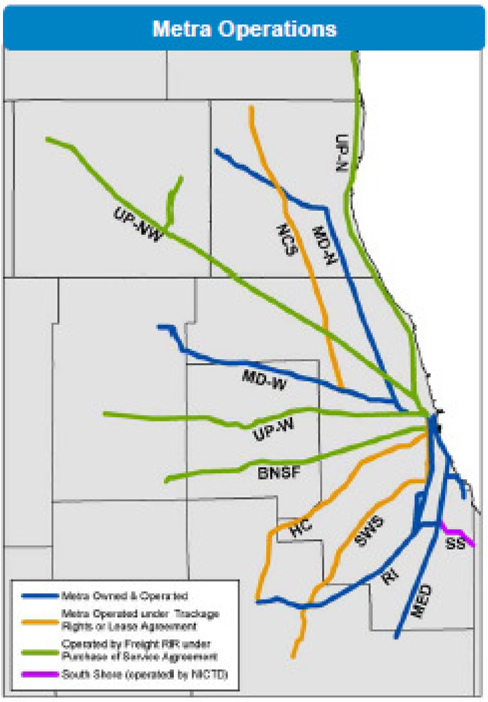
APPENDIX C: PEN-PICTURES OF SELECTED PASSENGER COMPARATOR OPERATORS

Metra

Company

Metra (http://metrarail.com/metra/en/home.html) operates a commuter system in the Chicago area. On a typical weekday it will run 700 trains from the suburbs into downtown Chicago. It provides a vital transportation link for more than 300,000 people each weekday.

It was formed in 1983. Since 1985, it has rebuilt the region's commuter rail network virtually from the ground up, investing nearly $6 billion to maintain its capital assets, improve the system and expanded the services. Metra owns 36% of its own routes, with the remainder owned by either Class I Railroads or Amtrak.



Network Map from Metra Website

Metrolink

Company

The Metrolink (http://www.metrolinktrains.com/) system is managed by the Southern California Regional Rail Authority (SCRRA). It purchased 175 miles of track, plus associated infrastructure from Southern Pacific in 1990, plus the rights to use Los Angeles Union Station from Union Pacific.

It is a commuter rail system serving Los Angeles and the surrounding area of Southern California. It provides service over 500 route miles, primarily during the morning and evening peak times.

Network Map from Metrolink Website

BART

BART (http://www.bart.gov/) is heavy-rail public rapid transit system connects San Francisco with cities in the East Bay and suburbs in northern San Mateo County. Track gauge is 5'6" wide with ballast-less track and third rail propulsion power using 1000-volt DC electricity. The system began operation in September 1972.

Network Map from BART Website

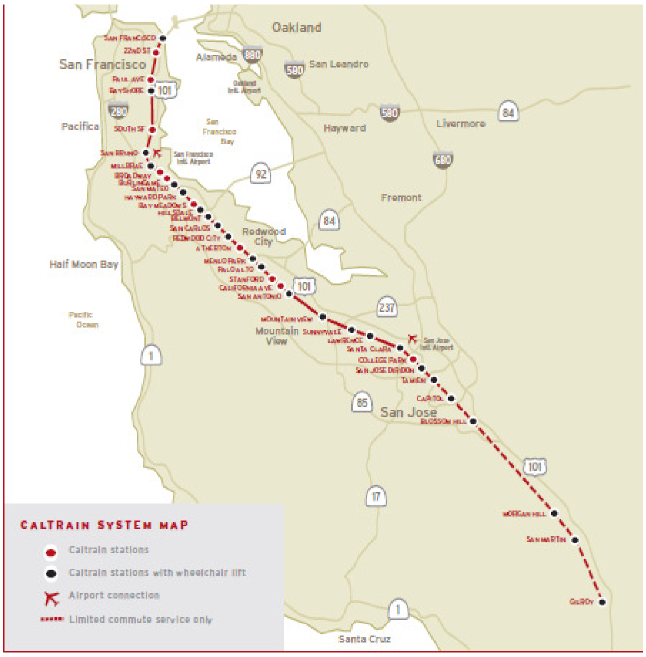
BART is operated by the San Francisco Bay Area Rapid Transit District, a special-purpose transit district that was formed in 1957 to cover San Francisco, Alameda County, and Contra Costa County. The system is being expanded to San Jose with the Silicon Valley BART extension.

Caltrain.

Caltrain, (http://www.caltrain.com/) is a California commuter rail line on the San Francisco Peninsula through to the Santa Clara Valley (Silicon Valley). It runs from Gilroy via San Jose to San Francisco, with 34 stations and 77 route-miles of track.

The maximum line speed is 79mph, with some trains operating a limited stop pattern to reduce end-to-end timings.

Caltrain is governed by the Peninsula Corridor Joint Powers Board (PCJPB), which consists of three member agencies from the three counties in which Caltrain line serves. On August 19, 2011, Caltrain announced a staff recommendation to sign a five-year, $62.5 million contract with Missouri based TransitAmerica Services, a subsidiary of Herzog Transit Systems. TransitAmerica Services will take over not only the conductor and engineer jobs on the trains, but dispatching and maintenance of both equipment and trackage/right-of-way.



Network Map from Caltrain Website

APPENDIX D: METRICS FOR PASSENGER COMPARATOR RAILROADS

The table below contains the metrics for the individual passenger operators reviewed as part of this study. This is based on consideration of expenditure on infrastructure and the same set of assumptions as used to calculate the metrics included in Table 3 of Section 3.

		Metra	Metrolink	BART	CalTrain
Route Length	$k/mile	547	232	4,960	1,292
Track Length	$k/mile	231	116	2,324	646
Train Miles	$/mile	30	38	49	74
Gross Ton Mile	$/mile	76	95	136	185

Table 15: Total Infrastructure Cost per Mile for Passenger Operators

Table 16 below provides a summary comparison between the different comparator groups for each of the metrics. Network Rail's total infrastructure costs per mile (i.e. the previously quoted values in Table 3, Section 3.6) have been taken as the baseline for each of the metrics. For simplicity, this value has been converted to an arbitrary value of 100 in the table below. The values of the other comparator groups are then calculated relative to the baseline. For example, the cost per route mile of Metra has been assessed as being 106% of Network Rail's cost per route mile.

		Metra	Metrolink	BART	CalTrain
Route Length	$k/mile	106	45	962	251
Track Length	$k/mile	88	44	886	246
Train Miles	$/mile	191	241	309	468
Gross Ton Mile	$/mile	121	152	217	295

Table 16: Relative Infrastructure Cost per Mile for Passenger Operators

From the figures above it can be deduced that:

- Infrastructure measures (cost per mile based on route and track length) are similar to Network Rail for the larger passenger operators;
- Traffic measures (cost per mile based on train miles and tonnage) are more than Network Rail for the larger passenger operators, indicative of a less intensive service pattern;
- All cost per mile metrics for the smaller passenger operators (BART and CalTrain) are greater than those for Network Rail.

It is believed that more insight would be obtained if the above comparison was relative to parts of Network Rail, rather than the complete system. For example, comparing BART with Merseyrail or Metra with the Birmingham commuter routes would probably be more meaningful.

Balfour Beatty
Rail

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