RailKonsult

Office of Rail Regulation

Relative Infrastructure Managers' Efficiency

Evaluation of UIC LICB Approach

Summary Report

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Executive Summary

RailKonsult were commissioned by the Office of Rail Regulation to review the methodology used by the International Union of Railways (UIC) in constructing the Lasting Infrastructure Cost Benchmark (LICB) model. Both the mechanics of the model and the harmonisation factors used have been reviewed.

This document reports on the conclusion of these reviews. It also considers whether current processes and technology have resulted in other technical factors being more appropriate.

In conjunction with these reviews a series of Study Visits were undertaken in order to gain a better understanding of the specific issues faced by particular Infrastructure Managers.

The insight gained from these activities has been used to look at the relative gaps in unit costs between the different Infrastructure Managers. Potential explanations have been provided for a proportion of each gap.

Finally, areas of further study are recommended in order to improve the interpretation of the output from international benchmarking exercises in preparation for PR13.

Acknowledgements

RailKonsult wish to acknowledge the support and assistance received from other organisations in compiling this report.

In particular, we are extremely grateful for the input received from all the Infrastructure Managers and their open attitude to participating in the work, despite the day-to-day pressure.

Contents

1.0 BACKGROUND

1.1 Introduction

As part of the recently completed CP4 review, the Office of Rail Regulation (ORR) commissioned a number of work packages related to international benchmarking and comparative reviews of methodologies used in Europe.

The work undertaken during the review led to the development of a process that involved both a "top-down" econometric-led analysis and a "bottom-up" engineering-led review. This combination provided a good overall perspective of the relative efficiencies and opportunities for improvement.

The recently published independent evaluation of Periodic Review (PR08) highlighted the importance of benchmarking, recommending that the ORR continue to develop the process in preparation for PR13.

As such, the ORR wish to develop this approach further in order to gain a better insight into the drivers affecting the relative efficiency of different Infrastructure Managers.

2.0 METHODOLOGY

2.1 Background

One of the principal data sources used to undertake the international benchmarking exercise during PR08 was the UIC LICB study.

Between 1995 and 2005 an international benchmarking project was carried out that included fourteen Western European railways plus six North American and four East Asian railways. The International Union of Railways (UIC) "Lasting Infrastructure Cost Benchmarking (LICB)" project has continued this work since 1996.[1]

There are currently fourteen Infrastructure Managers who are part of the UIC LICB group. The purpose of the group is to benchmark maintenance and renewal expenditures. The base data is harmonised in order to compare the performance of each Infrastructure Manager using the following parameters:

- Purchasing Power Parities;
- Degree of Electrification;
- Single versus Multiple Tracks;
- Switch Densities; and
- Track Utilisation.

This study has reviewed the approach adopted by the UIC LICB model, including the harmonisation factors, from both an econometric and engineering perspective. An improved understanding of the drivers behind the apparent differences in unit costs has been obtained through gaining an insight into the issues and approaches adopted by other Infrastructure Managers to asset management.

[1] UIC Project – Lasting Infrastructure Cost Benchmark (LICB) 10 Years of Benchmarking 1996 – 2005.

3.0 REVIEW OF FACTORS

3.1 Harmonisation Process

Each railway has its own characteristics that affect the annual cost of maintaining and renewing the infrastructure. These characteristics are the result of the specific geographical and political environments as well as the utilisation and technical aspects of the network.

In order to undertake international comparisons it is necessary to apply harmonisation factors that account for these differences. However, it is important to select the correct harmonisation factors. The purpose of benchmarking is to identify the underlying differences in approach, so that transferable lessons and best practice can be identified and learnt. If all the variables are harmonised there will be no variation in unit costs.

3.2 Industry Changes

The power of having a consistent dataset using the same set of definitions and factors is that long term trends can be identified for investigation and understanding. However, over the last 15 years there have been a number of changes affecting the manner in which railways are managed. These include:

- Political
    - On-going movement towards open access, with train operation and infrastructure management split;
    - Reduced public acceptance of safety risks;
    - Increasing environmental pressure;
    - Increasing societal requirement for on-time arrival; and
    - Continued need to provide value for money during a global recession.
- New Technology
    - Head hardening of rails;
    - Deployment of IT to extend potential condition monitoring capability; and
    - Introduction of new signalling systems based on ERTMS[2] philosophy.
- Plant Development
    - Increased productivity from machines such as tampers;
    - Improved high-output equipment; and
    - Cost effective bespoke items to solve specific issues.
- Process Improvement
    - Use of grinding to control RCF[3];
    - Use of Decision Support Systems to provide guidance to engineers; and
    - Increased consideration of systems rather than individual engineering discipline's assets.

With all these changes it is possible that there is an alternative set of harmonisation factors that are now more appropriate for use when undertaking international benchmarking.

[2] European Railway Traffic Management System – European train control and command system.
[3] Rolling Contact Fatigue – a type of rail defect.

4.0 REVIEW OF UIC LICB MODEL

4.1 Background

A review was undertaken of the harmonisation factors that underpin the UIC LICB harmonisation factors. This review has been undertaken using both documentation available within the public domain and analysis of the UIC spreadsheet containing the base data.

4.2 Mechanics of Model

The macro-economic harmonisation is achieved by applying a Purchasing Power Parity (PPP) adjustment to the dataset. There is no labour cost adjustment.

Four cost elements are harmonised individually (maintenance and renewal costs for both electrification and other assets). The most recent maintenance expenditure figures are used, but the renewals figure is an average. This does remove the impact of any volatility in year-on-year renewals activity.

Electrification harmonisation is based on proportional extrapolation of electrification cost from the actual proportion of a network electrified to a reference case of a network that is 70% electrified. It is stated that this relationship is informed by regression analysis.

Single/multiple track harmonisation factor is based on single track being more expensive to maintain (per track-km) than multiple track.

The switch density harmonisation factor is based on the cost of a switch being equivalent to the cost of 330m of plain line. The factor is only applied to non-electrification costs, i.e. no account is taken of any additional wire runs required where the switches form a cross-over.

The track utilisation harmonisation factor for maintenance is based on train frequency. This is based on the assumption that the largest impact of traffic on maintenance activity is track access. The track utilisation harmonisation factor for renewals is based on tonnage, calculated as the average density across the whole network.

For several of the harmonisation factors cost variation is assumed to be a linear function for each of the railways, but with a railway-specific unit cost factor used. It is also assumed that the marginal cost remains constant. As such, it is a linear relationship that is specific to each railway. This may create comparison problems if there are major differences between the reference cases and the actual levels of each harmonisation element in a particular country.

4.3 Sensitivity Analysis - PPP versus Market Exchange Rates

Taking due cognisance of the uncertainty of the harmonisation models identified above, the understanding gained has been applied to a sensitivity analysis.

The conclusion of this analysis is that choice of exchange rate can make a difference, but in recent years use of PPP versus market exchange rate has not had a significant impact on Network Rail's relative position as compared to the average. In general, PPP rates are the preferred way of doing international comparisons, though it is acknowledged that they are far from perfect.

4.4 Sensitivity Analysis – Harmonisation Factors

A second sensitivity analysis reviewed the impact of the harmonisation factor values that have been used in the UIC LICB dataset.

In summary, it was found that this initial set of sensitivities indicates that the set of assumptions made were favourable to Network Rail. Varying the parameter values does not improve Network Rail's ranking, it only keeps them the same or makes them worse.

5.0 PRIORITISATION OF TECHNICAL FACTORS

5.1 Background

There are numerous structural factors other than the UIC LICB harmonisation factors that may have an impact on cost when undertaking inspection, maintenance, refurbishment and renewal of the railway infrastructure.

An analysis of a wide range of individual technical structural factors was carried out from an engineering perspective in order to determine if the factors currently in use remain the most appropriate, or whether there are any others that should be considered.

The engineering factors were split into eight generic areas:

- Track configuration;
- Traffic;
- Permanent way;
- Formation and drainage;
- Signalling;
- Traction power system;
- Structures; and
- Asset age.

5.2 Baseline Scenario

A baseline scenario was derived and used as a datum or starting point to which structural factors could be added to in order to determine how the model would change. The baseline scenario represented 1 route kilometre of a typical track configuration.

The analysis was undertaken by assessing the impact of introducing each of the identified technical structural factors in turn into the baseline so that an overall score could be calculated. This analysis took into account all the different disciplines of track, signalling, electrification and structures. It also considered each of the relative activities that would be undertaken with respect to inspection, maintenance, refurbishment and renewal of the infrastructure.

The engineering views were based on good practice and not constrained by the need to comply with any local Standards. This was to avoid the need normalise across other European countries that could have different standards and interpretations from those used in Great Britain.

5.3 Conclusion

The six structural factors with the most impact on the base model from an engineering point of view were found to be:

- Switch and crossings;
- Asset beyond design life;
- Level crossings;
- Removal of electrification as traction power system;
- High utilisation (≥20 MGT per year); and
- Multiple track (> 2 tracks – assumed to be 4-track for this analysis).

Four of the top six structural factors, from an engineering perspective, are those used by the UIC LICB for their harmonisation of costs. The additional factors are the impact of level crossings and asset beyond design life.

5.4 Peer Review Feedback

The output was peer reviewed as part of the Study Visits to other Infrastructure Managers.

One noted that the two largest factors that they had to manage were assets beyond design life and possession availability. Their other major issue is dealing with formation issues caused by either insufficient ballast depth or poor drainage.

Possession availability was also a major issue for a second infrastructure manager in their drive to optimise their asset management process. The ratio of day versus night working (including the ineffective work periods) has a major effect on maintenance costs.

The third infrastructure manager explained one of their biggest problems was with steep gradients combined with sharp radii curvature. In combination with large differences in the speed of trains this causes side wear on the high rail from passenger traffic and the low rail from freight traffic. The rail must be replaced regularly, together with pads and fastenings. If this is not done the life of the concrete sleepers will be significantly reduced due to excessive wear, resulting in damaged and broken sleepers.

This is an example of multiple factors being applied to a specific environment. The analysis that has been undertaken in this part of this project has been on the basis of single changes to the baseline. The unusual nature of this particular operating environment (in pan-European terms) is indicative that this should not be a harmonisation factor, but seen as a reason for differences in benchmark values.

6.0 HIGH IMPACT TECHNICAL FACTORS

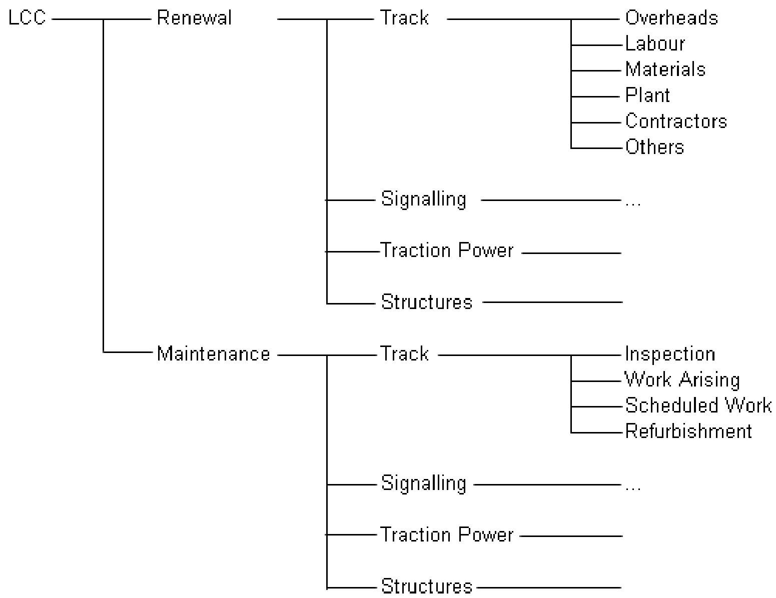
6.1 Background

The second part of the modelling exercise was to review the potential impact of the top six factors identified in the previous section. A cost model was developed to enable the changes to be evaluated.

The purpose of this simple model is to provide indicative harmonisation factors from an engineering perspective. It is not intended to form the basis of a life cycle costing model, although it does use similar concepts. It has been used to form a reference framework from which to evaluate the engineering input. The framework is intended to be generic as it is used to evaluate asset management strategies that range from “sweating the asset” through to “renewal to minimise maintenance intervention”.

6.2 Construction of Framework

The reference framework that has been used to evaluate the impact of the changes is based on the high-level structure depicted in summary form in the diagram below.



The output from the analysis is summarised in the table below.

Structural Factor	Value
Single Track	0.86
Switch Density	1.17
Beyond Design Life	1.34
Level Crossing	1.01
No Electrification	0.74
High Utilisation	1.63
Multiple Track	2.08

The values in the table represent the impact of adding each specific structural factor to the same baseline scenario used in the previously described analysis of the technical structural factors, with the other factors unchanged. For example, a single track section of track is 86% of the cost of the baseline scenario of a two-track section, with all other factors (such as level of traffic carried by the route) unaltered.

An interesting item to note is the relatively low impact of level crossings, despite the high impact attributed to this factor in the initial analysis. This is because the second analysis not only considers the impact of the factor but also the extent of the railway that is affected by the factor. An average level crossing will only affect 20m of the 1,000m long base model, resulting in the overall impact being significantly diluted.

6.3 Sensitivity Analysis

A sensitivity analysis was undertaken on those factors that appear in both the above list and the UIC LICB list of harmonisation factors, i.e.

- Degree of Electrification;
- Single versus Multiple Track
- Switch density; and
- Track Utilisation.

The sensitivity analysis was based on consideration of two different (extreme) scenarios. For example, the two scenarios considered for electrification were that:

- Degree of electrification impacted solely on the electrification activities only; and
- Consequential impact of electrification on track and signalling activities had been under-estimated by a factor of 2.

The output is shown in the table below.

Structural Factor	Value		
	Lower	Calculated	Upper
Single Track	0.64	0.86	0.92
Switch Density	1.10	1.17	1.28
No Electrification	0.64	0.74	0.89
High Utilisation	1.56	1.63	1.99

6.4 Application of Output

The value for each structural factor as calculated above (other than “Beyond Design Life”) has been applied to the unit costs of Network Rail plus the four other Infrastructure Managers that were part of this study. That is, the technical harmonisation factors derived from this study have been applied to unit cost rates reported by previous reviews.

The output from this harmonisation analysis is tabulated below.

Structural Factor		Network Rail (GB)	A1	B1	C1	D1
Harmonised Spend	€k/km	121.2	58.2	58.5	82.5	69.7

The reason “Beyond Design Life” has not been included is that there is no simple method of assessing the degree to which the infrastructure is globally beyond its design life. Asset age measured in years since installation is not an accurate indicator. This factor can be represented by the use that the asset has received, which is generally in terms of traffic carried, compared to its design use.

At this stage it is suggested that this factor is more suited to being an interpretation criteria to understand differences when benchmarking rather than a harmonisation factor in its own right.

6.5 Application of Linear Extrapolation

In deriving the above conclusions, there is an implicit assumption that the harmonisation values can be linearly extrapolated. Consideration has been given as to whether there are economies of scale/scope that can be generated. For example, if all switches are in a limited geographical area, then the unit cost of maintaining each unit is reduced as there is less downtime travelling to/from different locations. On the other hand, if there is a short 10km of electrification this would have a significantly higher unit cost as there is a minimum level of resources required to maintain any length of electrified line, i.e. resources are under-utilised because there is insufficient asset to fully occupy them.

From the perspective of the analysis undertaken in this report, the focus has been primarily on the impact on front-line delivery. Hence, economies of scale/scope are only generated in the first example if the switches in a particular area need attention from the same team at the same time. This would be the case if maintenance is undertaken on the basis of periodic intervention.

There are economies available in renewal terms where a longer site provides an opportunity for extended use of high-output equipment whilst minimising the impact of repeated mobilisation and demobilisation.

The analysis has been undertaken on the basis of good engineering practice, which would be that intervention is made on the basis of need. As such, the adoption of a linear relationship would not appear to be unwarranted for such a high-level review.

It is worth noting that it is understood that the UIC LICB harmonisation model applies similar linear extrapolation techniques.

7.0 STUDY VISITS

7.1 General

Four Study Visits to other Infrastructure Managers were arranged as part of the project. The participants were selected on the basis of those that it was believed would provide good comparative information in relation to the approach adopted in Britain and that were likely to be interested in participating in the review.

The British participants in these visits included representatives from ORR, Network Rail and AMCL (who were delivering a parallel project) as well as RailKonsult. The itineraries were arranged to accommodate as many of the interests of each party as possible.

7.2 Infrastructure Manager A1

Background

The Infrastructure Manager manages train paths and track access agreements. All maintenance work is undertaken by the main train operating company, which is responsible for day-to-day maintenance and for delivering renewal contracts. Renewals work is undertaken by either in-house teams or by contractors.

Specific Infrastructure Characteristics

The railway system includes a modern high-speed network, a comprehensive conventional system, and an ageing rural network. In general, rural tracks are only receiving sufficient attention to keep them open, except those for which additional funding is received from regional governments.

Asset strategies have been developed suitable for these low use rural lines including:

- Varying either ballast depth or sleeper spacing to achieve required formation stiffness;
- Avoiding formation rehabilitation by decreasing sleeper spacing; and
- Using cascaded materials, especially concrete sleepers.

Possession Strategy

Short daytime blocks of an hour are taken on high speed lines for inspection. These one hour blocks can be doubled up along the route. However, there is pressure to give up these midday possessions to earn extra revenue from running trains. Currently 70% of work is undertaken during daytime, but it is anticipated that this will switch to only 30% in daytime over next few years.

Night-time possessions are generally 4½-6hrs duration for maintenance and 9hrs for renewals on higher traffic density lines. On the high-speed network, the renewal possessions are generally no longer than 7hrs. High utilisation of possession time is achieved as it only takes 1hr to mobilise and demobilise.

On lower utilised routes, renewal possessions will generally be blockades lasting for several weeks. Trains are replaced by buses, with a mix of stopping and express buses to provide service flexibility.

Possessions are difficult to obtain on lines around the capital. Generally work in this area is “between trains”.

Workforce Protection

It is estimated that 12½% of maintenance staff are employed as look-outs. The staff culture is to trust in lookout chain rather than radio systems. Train warning systems are available at strategic locations such as junctions. Portable safety equipment is also used.

Local safety rules allow a train to pass a work site on the adjacent line at a maximum speed of 160km/h, whilst other infrastructure managers have rules allowing trains to pass at speeds of up to 300km/h.

Engineering Support & Development

There is an asset database that is populated by the maintenance operator. It starts with a map of the network and enables the user to drill down to discrete parts of the network with only a few clicks. Once a particular track section was found, the track geometry and other track recording information was only a click away.

The infrastructure manager intends to introduce Route Managers, but not until they have the correct decision support tools to work with to enable them to balance the pressure of maintenance costs and increasing train services. The existing tools facilitate management at a macro level, but are not able to delve into the detail. The new tools are being developed internally with consultancy support to convert them into production tools suitable for wider use.

Workforce

One of the key issues being faced is that the maintenance operator is a monopoly organisation with strong unions. The workforce was described as resembling a somewhat “military” organisation in that they have a single objective and, if this is frustrated, they are not easily able to flex and change objectives. It is recognised that it is difficult to change this culture.

Regulatory Environment

It was noted that a major cost has been the requirements introduced by various regulations and laws such as:

- GSM-R;
- Asbestos;
- PCB in transformers;
- Bridge paints;
- Working at Height.

These all increase costs. For example, it was estimated that achieving compliance with the working at height requirements has cost €10-15m.

The infrastructure manager carries the risk of the environmental conditions and is obliged to pay the maintenance operator additional money for any extra work caused by climate damage.

Performance Requirements

A performance contract has been put in place and the infrastructure manager has started to develop the next delivery contract with the maintenance operator based on:

- Quality of service;
- Indicative level of renewals (or other activities); and
- Development of a set of unit costs.

Currently, the maintenance operator reports against a number of maintenance objectives including:

- Reliability;
- Punctuality;
- Mean time to repair; and
- Track geometry.

7.3 Infrastructure Manager B1

Background

The infrastructure manager is vertically integrated. Work is predominately undertaken by an in-house workforce, exceptions being specialist tasks or major projects.

Specific Infrastructure Characteristics

Both high-speed passenger trains and heavy axle load freight trains operate over its infrastructure. This means that the assets see high impact loading. In addition, there are a number of intensive metro operations that track-share in the major conurbations.

Currently, the track renewal activity is being driven by concrete sleeper failures. There is a major ASR[4] problem with those manufactured between 1990 and 2000. Other than renewal, the only remedies are inspection and speed restrictions.

[4] Alkali silica reaction, causing aggregate to expand and the concrete to spall.

Possession Strategy

Majority of the main line is four-track with junctions consisting of a series of crossovers provided every five to ten miles. Blockade access can be obtained on one of the four lines through pre-planning (it appeared that the train service is recast to facilitate this). High-output track renewal trains can work alongside open lines, even when operating on the middle lines.

Workforce Protection

Working on a live road is not permitted, unless the workers can move well clear before the arrival of a train. It was stated that chains of up to 5 advanced lookouts can be used to provide protection in some areas.

Inspection and maintenance staff are allowed to walk on their own between junctions. They can “shunt” the track circuit to provide red signal protection. Every junction has a local panel and the maintainer can take control to obtain signal protection whilst working in and around that location.

Engineering Support & Development

It was noted that there is a shortage of backroom engineering staff to analyse root causes of problems in support of the delivery teams. As such, full use was not always made of the available technology.

An asset and work-bank management tool is being rolled out. The critical success factor is in solving the people issues, not the coding. First step was to use system for timesheets (time worked and time allocation). The incentive for the staff was to ensure that their payroll information is right. The Infrastructure Manager benefits as they are now able to collect cost information, which underpins the asset and work management modules. This step required agreements with all the relevant unions.

The next step (which is in-progress) is to introduce basic inspections to enable compliance to be monitored. Work orders are generated for foot inspections and recorded as complete to close inspections.

All defects are entered into the management system, i.e. making it a defect management system, whereas the British approach is to only enter actionable defects into the equivalent system, i.e. making it a work management system. There is a judgement call to be made between full visibility and information overload.

Workforce

All disciplines appear to have a well developed training package to bring new entrants into the industry and give them the correct competence. The first stage is an aptitude test to ensure that the right person has been recruited.

The training is modular, consisting of classroom periods followed by time back with their allocated teams being mentored on the specific task. Each test must be completed before moving on to the next one.

The Infrastructure Manager is suffering from the consequences of having an ageing workforce, many of whom are now retiring and being replaced. For example, the average length of experience of electrification staff is 7 years. They have recognised the need to manage the experience/apprentice ratio.

Industrial engineering training is provided to local teams to improve understanding of the issues. Exercises have been developed that require students to think about how best to use the available resources to maximise output, particularly where output rates vary.

Regulatory Environment

The infrastructure manager has to comply with a rigorous set of regulations. These are inflexible, for example requiring the same maintenance and inspection regime for relays and micro-processors. All inspections are based on periodicity, not on use. Inspections are still required even if the asset is not in use (e.g. a switch that is plated out of use)

On the other hand, there are no vehicle acceptance issues encountered when improving a vehicle. For example, one of the track renewal trains seen was new in the mid-1970s, but has been significantly altered following feedback from the field. This was achieved without the need for extended approval processes.

Alterations undertaken include:

- Upgraded engine fitted (requiring fuel tank to be moved);
- Lights added;
- Cranes added; and
- Turntable installed to eject broken sleepers.

Performance Requirements

The Infrastructure Manager operates a simple set of performance indicators that measure the main things that the business needs to worry about:

- Safety;
- Financial;
- Customer Service; and
- Management.

The performance indicators are regularly reported and reviewed using a simple pack that is standard across all functions with Pareto graphs, worst performing asset and trends identified. The figures cascade from top to bottom, with appropriate scores based against improvement on last year's performance (40%) and success in achieving this year's target (60%).

7.4 Infrastructure Manager C1

Background

The Infrastructure Manager is a public enterprise that is owned by the government. It was established following the outsourcing of all major and minor maintenance activities as well as all renewal activities. Operation of trains is undertaken by others.

Specific Infrastructure Characteristics

The network is one of the most densely used rail networks in Europe, with a mix of passenger and freight traffic.

Possession Strategy

Changes were made to safety rules due to employee fatalities and now an employee on the track is treated the same as a train. This total separation of workforce and traffic has led to more night time work in complete possessions, initially raising costs.

Workforce Protection

As noted above, all work has to be undertaken within a possession.

Engineering Support & Development

The asset management tools in place include:

- An integrated and shared information system providing real data on key asset management requirements (i.e. costs, asset performance, utilisation, work outputs, quality);
- Reliable asset deterioration information supplied by an external supplier to both the infrastructure manager and the maintenance contractors;
- Effective decision support tools are used by all parts of the industry to support good asset management;
- Life cycle modelling used to optimise the life of the track; and
- Trend analysis used to determine optimal maintenance intervention times.

Workforce

No particular issues were raised.

Regulatory Environment

No particular issues were raised.

Performance Requirements

There is a performance contract in place with the maintenance contractors. This has been developed and improved with experience. The performance contracts have both incentives and penalties for the contractor. The Infrastructure Manager specifies the outputs required with respect to performance and quality. The inputs (work activities) are determined by the contractor in order to meet the required outputs.

7.5 Infrastructure Manager D1

The Infrastructure Manager has an asset strategy process that is based on:

- A detailed plan for the current year;
- Conceptual plans to meet network targets over the following 2 years; and
- Plans for strategic project work over a longer time horizon.

It is understood that a six-year rolling budget is submitted, although only the first year is funded. The longer strategic view is developed by a central team, with regional organisations delivering the current year's work programme.

The planning process makes use of the life cycle models produced by a local university.

Different models are used depending on gross tonnage, radii, rail weight and track sub-soil or formation type. A combined maintenance and renewal strategy for the duration of the service life has been devised for each of the 60 standard track sections.

The models primarily consider the track assets. They provide the basis of maintenance and renewal policies. From the modelling it is possible to determine work volumes and these are used to set budgets for the regions in line with government funding.

The asset management approach that has historically been adopted is to undertake high-quality renewals of the complete track system in order to minimise expenditure on maintenance intervention. Analysis using the life cycle models has indicated that this is the most cost effective method.

The configuration of the infrastructure enables access to be gained for maintenance and renewal. Standard features include:

- Bi-directional signalling installed;
- Separate power supplies for each track;
- Wide track separation; and
- Cross-over facilities that have been retained.

These features enable track access to be gained whilst allowing a train service to continue to be operated. This has been found to be more effective than obtaining maintenance savings from reducing the complexity of the infrastructure, incurring greater cost maintaining traffic flows whilst work is undertaken.

8.0 BOTTOM-UP BENCHMARKING

8.1 Background

In order to gain a better understanding of the drivers behind the differences in unit rates and identify best practice, three areas were the subject of further investigation during the Study Visits. These were:

- Management of Renewals;
- Use of Condition Monitoring Information; and
- Efficient Delivery.

8.2 Renewals Process

Infrastructure Manager A1's main line renewal programme is based on an optimised macro LCC model. Macro plans are developed by the Infrastructure Manager, who is currently working on the latest 5-year macro plan. A longer term approach has also been taken, with a 50 year plan being produced to examine the sustainability of their policies. Track renewals are planned on the assumption that the line will remain open for at least another 40-50 years. Application of this criteria means that only half the network is being renewed at the moment.

In response to past Government budget cuts, the Infrastructure Manager has previously deferred renewal requirements by undertaking additional maintenance. Audit and economical modelling has subsequently showed that it was actually costing more to manage the asset in this manner.

The track renewals work-bank is planned for a five-year period with minimum changes expected. The intent is to develop a programme that provides a level workload for the track renewal machines over the five-year timeframe.

There is a greater focus on renewing longer sections of track in order to gain efficiency benefits and a reduction in maintenance costs. Renewals are of generally 5-10 kilometres in length.

A micro level renewals plan is proposed by the maintenance operator for 1-2 years ahead. This is reviewed by the Infrastructure Manager and the work agreed depending on the budget available. Prioritisation is based on safety, quality of service, actual deterioration and life cycle (gross tonne km, speed and knowledge of any particular problems).

Traditionally, total track renewal has been undertaken as ballast, rail and timber sleepers have had the same life. However, with concrete sleepers having a longer life, mid-life ballast cleaning has now been introduced.

Renewal of Control and Command assets is not entirely LCC driven, but by technology becoming obsolete. The life cycle for the signalling system is generally based on manufacturers' design life.

Annual viaduct and bridge replacement budgets are very variable, with spending levels being "all or nothing" depending on activity levels.

The oldest traction power system is less than 70yrs old and no problems have been encountered to date. There is no renewal policy currently for these assets, with individual components and wire replacement being considered as part of the maintenance activity. Their condition is in the process of being audited in order to confirm whether there are any issues.

Infrastructure manager C1 has a database of all track assets. All the assets have been given a theoretical renewal year based on their asset age and track utilisation. This means that it is possible to produce a theoretical forecast of renewals well into the future.

When an asset is due for renewal, it is peer reviewed by independent external engineers using a standard scoring system that was developed by the Infrastructure Manager. The scoring system takes into account the condition of the asset and its individual components, with the calculated score providing a technical renewal date. As this system is an easy to follow standard way of reviewing assets, it takes away any individual perception and preferential engineering views of the inspecting engineer to ensure that a consistent approach is applied to each inspection.

The maintenance contractors can also put forward renewal proposals. Both the Infrastructure Manager and the contractors are constantly monitoring trends and degradation through RCM and other tools. This trend analysis can identify potential early renewals on assets that have been given a longer life.

Once an asset is proposed for renewal, it is inspected by independent engineers and the scoring system is used once again to give the asset a technical score and date for renewal. The contractor must propose a renewal at least 24 months before the proposed renewal date otherwise they will have to pay to maintain or renew the asset themselves.

It was noted that the current renewal forecast shows a large increase in costs for signalling and energy supply. This is because a heavy programme of signalling and catenary wire renewal is about to start.

High productivity equipment is utilised wherever practical in order to keep costs down. The Infrastructure Manager is in a position whereby they can use the pan-European market for renewal contractors. This means that there is a competitive market with a number of experienced contractors with high-output plant available. It has kept renewal costs down, with a reduction in costs of around 20% being realised over the past few years.

For Infrastructure Manager B1, track renewals activity is being driven by concrete sleeper failures. The programme is being prioritised by the number of speed restrictions, amongst other appraisal criteria. This has been successful as train delays have been reduced by 50%.

In general, the policy adopted for all types of asset is to defer renewal for as long as possible. For example, sections of the traction power system were installed between 1913 and 1918. The asset was built to last and although some components have been renewed (such as contact wire) others are still the original items (for example OLE masts and insulators).

Infrastructure manager D1 determines renewals on the basis of asset condition, considering both safety and performance (reliability). Budget availability is part of the decision making process. Decisions and prioritisation are made by a group of experts.

The decision process includes consideration of alternative approaches, such as additional work (maintenance or refurbishment) or imposition of speed restrictions.

It is understood that decision making, planning and design is undertaken in-house. This makes management of the interfaces simpler and costs are reduced. Work is carried out by either in-house teams or experienced contractors, with dedicated railway plant and personnel, who have to deliver to specification and on time.

On all primary routes the track is totally renewed. Piecemeal component replacement has been assessed and found to be more expensive. The track policy that has historically been applied can be summarised as:

- Renew to highest quality, then maintain with the objective to maximising asset life, before finally renewing and cascading material.
- Most financial benefit is to ensure longest ballast life, by treating formation and fixing drainage.

8.3 Condition Monitoring

Current policy of infrastructure manager A1 is to only fit condition monitoring when building new high speed lines. It is fitted at interlocking level, not at component level. There are no plans to retro fit RCM as this is not seen as cost effective

One area of innovation mentioned was the use of flying drones and helicopters for the inspection of bridges, particularly in difficult to reach locations.

Remote condition monitoring equipment is extensively used on the network of infrastructure manager C1. Various systems are in place to give “intelligence” on how their asset is performing.

One of the systems is a preventative maintenance and fault diagnosis system that was developed in 1999 to address the problem of point failures that were becoming a major issue on the network. It is used as a performance monitoring and enhancement tool by the Infrastructure Manager. The contractors use it as a means for planning preventative maintenance and reducing costs. This is achieved by means of less frequent maintenance regimes and lower train delay penalties.

Another system detects every wheel of every train passing over the infrastructure by means of optical sensors and accurately measures the quality of each wheel. As well as identifying wheels in need of attention, it also has the benefit of ensuring defective wheels are repaired before they do extensive damage to the track infrastructure, thus saving on maintenance and renewal costs.

Many of the level crossings are fitted with remote condition monitoring equipment reducing unnecessary maintenance intervention of the signalling infrastructure.

The data collected from both the trackside condition monitoring equipment and the train borne track recording vehicles can be analysed using a standard software package. The deterioration rates of both track and overhead line systems are monitored. It is extensively used for asset management tasks, including developing plans for maintenance delivery such as tamping and grinding programmes. It has the ability to display multiple levels of information and is easily configured by its end users to display individual end user requirements.

Condition monitoring equipment is not widely used by infrastructure manager B1. However, one interesting item of equipment used by the track engineers is a train to monitor gauge restraint. This imposes a lateral force onto the track to check the condition of sleepers and insulators. It also checks rail rotation as there have been several derailments from rails rotating in concrete sleeper track.

Event monitoring is fitted to lifting bridges with remote dial-up facility. These are used to diagnose problems.

The only use of condition monitoring for signalling assets that was identified was that the fibre communications network has a good diagnostic system that can identify the offending board when there is a malfunction. Infra-red surveys are undertaken of the electric traction asset, with hot-spots classified as either:

A Immediate reaction;

B Scheduled intervention; or

C Monitor deterioration.

Infrastructure manager D1 uses condition monitoring across all engineering functions to provide indications of potential failures. It has been stated during previous visits that one reason for the efficiency gains between 1996 and 2005 was the move from largely fixed interval maintenance to condition based intervention. This required a major investment to better understand the condition of the track assets via investment in new technology for the track recording coach. The infrastructure manager believes that they have moved on from “front-line opinion” towards more measurable criteria for renewal decisions.

8.4 Efficient Delivery

No significant quantitative information was gathered on the processes that may specifically be used to ensure efficient delivery programmes was generated during the visits to Infrastructure Managers A1 and B1.

It is apparent that both infrastructure manager C1 and its contractors use condition monitoring and other systems to ensure that work is delivered as efficiently and affectively as possible. By knowing the assets trends and degradation then applying the measurements of reliability, availability, maintainability and safety (RAMS), maintenance and renewal on the network can be scheduled to be done at the correct time.

It was also noted that the Infrastructure Manager defers renewals until a package can be constructed on a route and let to tender to a suitable contractor with high output equipment. This may involve additional maintenance to enable sections to be suitably deferred. In this manner, the renewals programme can be efficiently delivered.

Infrastructure manager D1 reviews work programmes using relevant experts in order to optimise output from both an engineering and productivity perspective.

9.0 COST OF DELIVERY GAP

9.1 Country Specific Environment

In order to fully understand the variations that the international benchmarking exercise indicates it is necessary to have an insight into the approach taken by each Infrastructure Manager and the issues that they are facing at the time that the exercise is being undertaken. Examples that have been highlighted during this review include:

- Network Characteristics

  The Study Visits gave an improved understanding into the nature of the networks being managed and the particular issues. For example, a significant rural network might be retained despite low traffic utilisation, or the country may act as a significant freight corridor with traffic flows that must be maintained. The local geography also has an impact on asset management, varying from deep valleys and high mountain passes through to large conurbations with many wide navigable waterways that must be crossed.

- Asset Management Philosophy

  Two extreme approaches to asset management were found within the group of organisations reviewed. Two make renewal decisions based on the need to minimise maintenance intervention whilst a third applies “tender loving care” to extend the asset life as long as possible.

- Time Specific Issues

  Several asset specific issues were noted during discussions with engineers. For example, an Infrastructure Manager noted that their costs had increased significantly in order to manage an RCF problem several years ago, whilst another is currently dealing with a major problem with concrete sleepers failing due to ASR problems.

  The impact of local legal and regulatory orders can also have a major impact. Examples noted during the Study Visits included prohibition of working on a “live” railway, restrictions on working at height, and the impending need to introduce Positive Train Control.

  Whilst the impact of these (or similar issues) will be felt by most railways at some stage, the timing will not be identical. Hence, taking a snap shot comparison may not provide a true comparison unless these types of cost drivers are identified and understood.

- Unions

  In conversations with two of the infrastructure managers it was apparent that a significant constraint to improving operational efficiency was the power of the unions in combination with an external political environment that did not encourage conflict with the unions. One of the Infrastructure Managers noted that there was a current funding shortfall of 5% (€100m per annum) due to the failure to achieve the target productivity improvements, with union opposition to change assumed as being a significant reason for this shortfall.

9.2 Differences in Approach

There were a number of different approaches to asset management that have been observed during this review. They have a significant impact on unit costs, as calculated in the various published benchmarking studies. These are:

- Effective size of network;

  The network managed by infrastructure manager A1 includes a significant section of rural routes that are only being maintained to allow safe operation of trains at slow speeds, and a relatively new high-speed network that currently requires minimal renewal and maintenance intervention. As a consequence, it is estimated that the average infrastructure unit rate is understated by 30%.

- Contracting strategy;

  The European countries benefit from access to track renewals contractors based in each country, but able to operate in any other. From the Infrastructure Manager's perspective, this provides a competitive market. From the contractor's perspective, it provides a larger potential client base. This gives the confidence required to invest in high-output plant, providing benefits to everybody. Further confidence is provided through many Infrastructure Managers working with the supply chain to give a stable long-term work-bank. Infrastructure manager C1 noted that, as a consequence, they have seen a 20% reduction in unit rates.

- Possession strategy;

  Discussions with other infrastructure managers indicated that several are able to provide long blockades to enable renewals to be efficiently delivered. This approach is supported by having the railway infrastructure support this strategy, such as bi-directional signalling and crossovers. Infrastructure Manager A1 noted that their unit rates in blockades are reduced by 20-30% whilst a higher figure of up to 50% has been quoted in other European reviews[5].

  Additionally, two infrastructure managers are able to gain daytime access to the tracks. This eliminates premium payments for working unsociable hours and higher productivity rates are achievable from avoiding the need to work in the dark.

  Note that the above savings may only relate to engineering costs rather than whole railway costs (i.e. including cost of train service alterations). However, these consequential costs are likely to be reduced (in comparison with Britain) as the infrastructure is available to maintain services.

- Proactive use of condition monitoring technology;

  From the organisations reviewed, only one is making use of the information from widespread adoption of condition monitoring to drive maintenance activity. Their experience has indicated that a 10% saving can be gained from adopting condition based maintenance intervention.

- System renewal;

  As already noted, there is a wide range of renewal strategies adopted, from negligible renewal through to an aspiration of almost negligible maintenance.

[5] International Benchmarking of Track Cost, O. Stadler.

Associated with this is a variation in strategy from complete renewal to renewal by component. Further work is required to understand the implications of these approaches and the impact on asset life, but a crude estimation indicates that renewal costs are increased by 10% through the component approach.

- Renewals backlog;

  As already noted, it is difficult to measure a renewals backlog as asset design life is not readily convertible into an age. However, one of the Infrastructure Managers has undertaken a review that indicates that overall 30% of the assets are beyond their design life. Their plan is to recover this backlog over a ten-year period.

  A second Infrastructure Manager stated that an extra €100m per annum was being requested to deal with their backlog. It is understood there is also a ten year strategy to eliminate this backlog.

- Efficient delivery;

  It has not been possible to gather any significant quantitative data indicating potential efficiencies available from planning to undertake several activities as an overall programme. However, there is probably an element of this in the savings achieved by some of the Infrastructure Managers in their renewal unit rates.

- Workforce Protection

  The final common factor identified during the Study Visits was the provision of lookout protection for work undertaken whilst trains are still operating. Despite the availability of suitable advanced warning technology on the market, there is a preference amongst the workforce to deploy chains of advanced lookouts.

  Anecdotal figures provided during the Study Visits indicated that between 12½% and 35% of staff were involved in this activity.

9.3 Baseline Figures

In order to consider how the above elements explain the gap between the different Infrastructure Managers' unit rates, it is necessary to have a comparable baseline. From the data available to RailKonsult at this stage, it has not been possible to construct a single baseline. Hence, several baselines have been used that are from similar time periods. As a consequence, the unit rate used as the starting point is not the same for all the graphs.

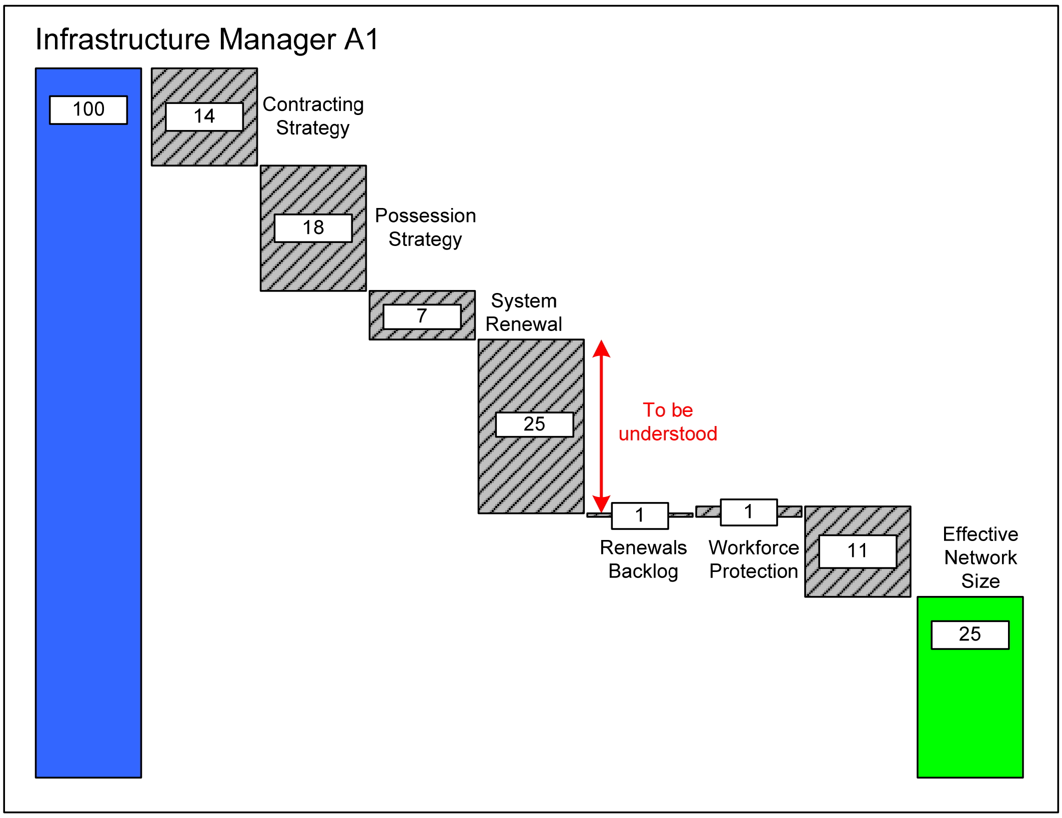
9.4 Gap Analysis

The information in the above sections has been used to explain the gap between Network Rail's unit costs and those of the other Infrastructure Managers. This is a first pass analysis and further work could be undertaken to refine the calculations. The output is represented graphically in the cascade diagrams below.

In each case there is an unexplained residual gap. This might consist of:

- Other technical factors (such as differences in asset inspection processes as previously reported by RailKonsult);
- Macro-economic factors such as industry-specific staff costs;
- Regulatory and union pressures as previously noted, but not quantified; and

- Variations in input/output relationships, due for instance to scope economies or – more doubtfully – scale economies (but note that scale economies tend to be exhausted quite quickly in this industry, i.e. at modest output levels).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Possession Strategy
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System Renewal
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To be understood
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Renewals Backlog
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Workforce Protection
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Effective Network Size
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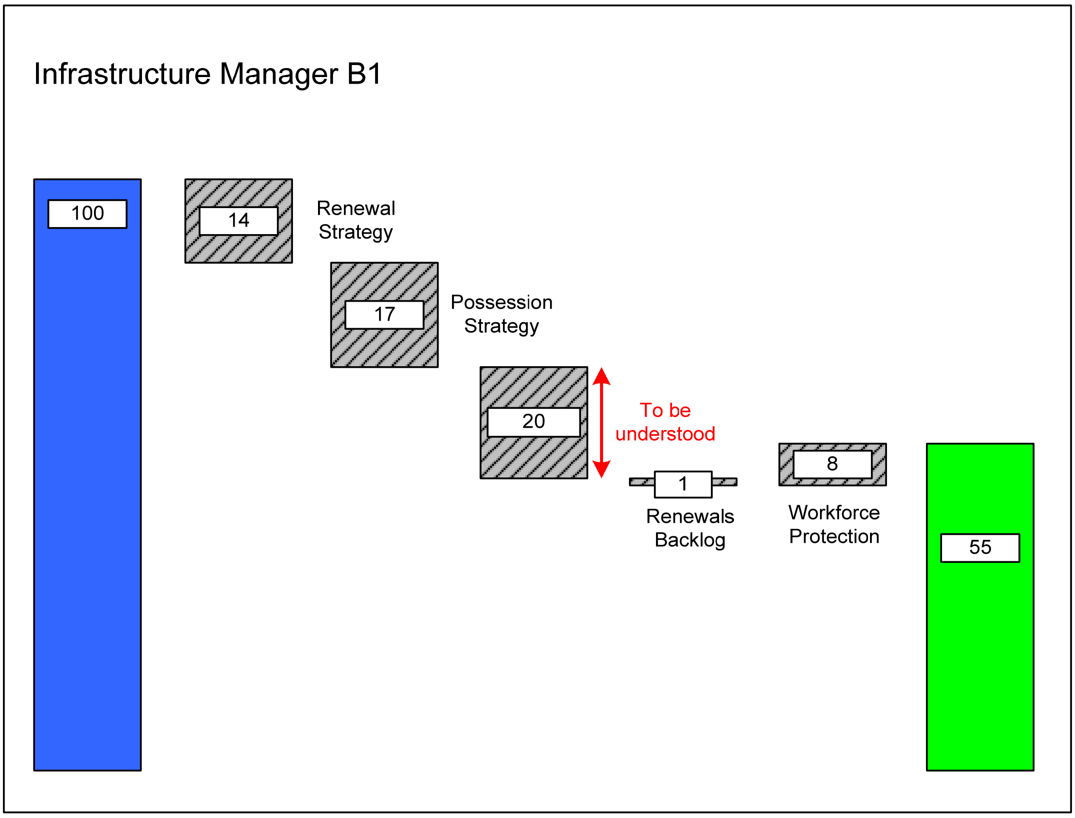
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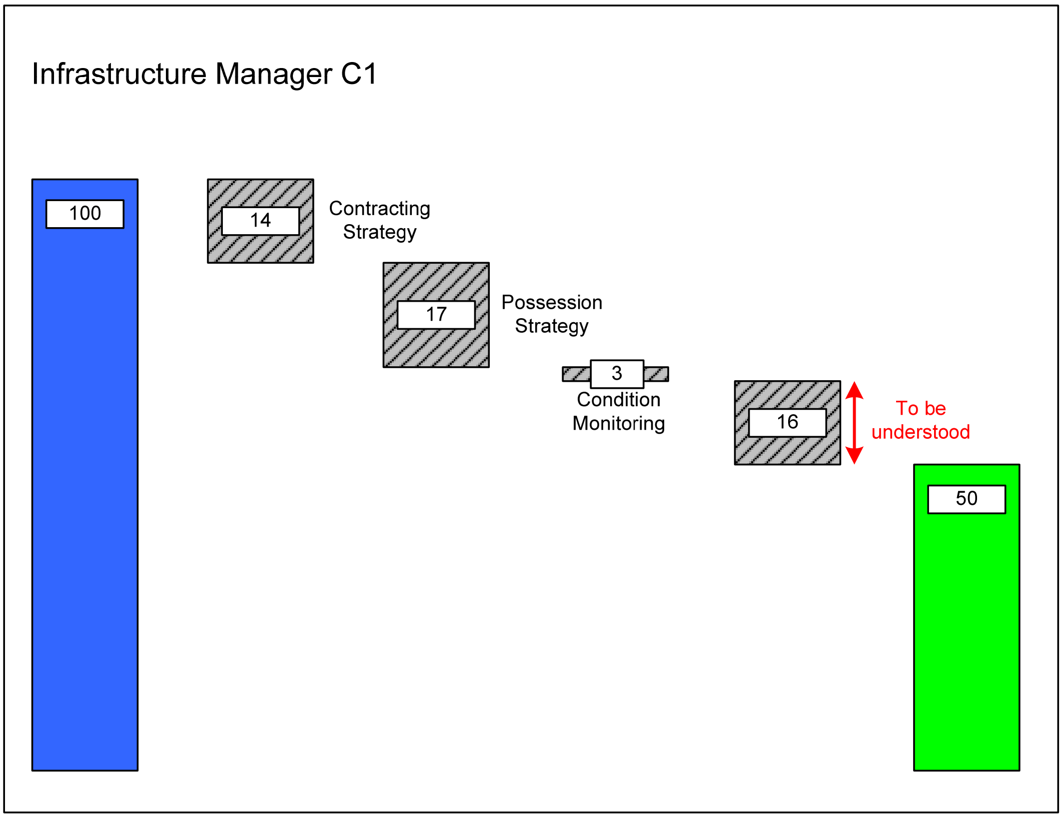
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Condition Monitoring
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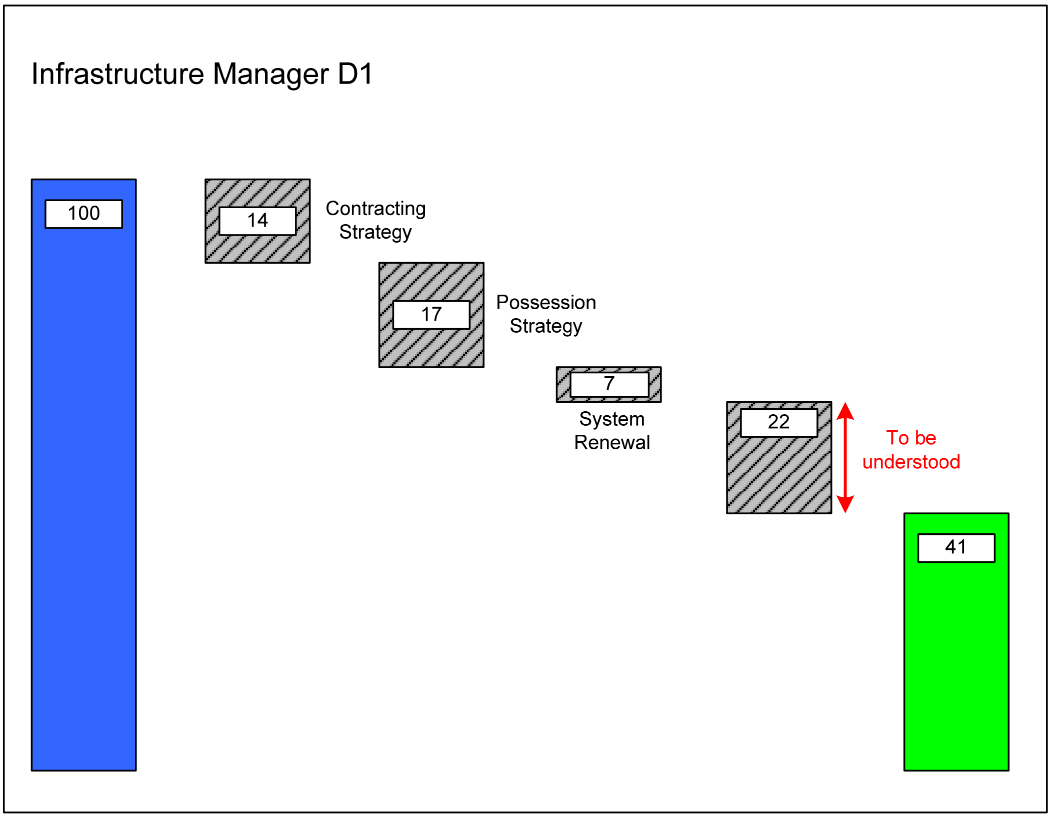
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10.0 RECOMMENDED FURTHER WORK

10.1 Background

It is anticipated that this report will form part of the initial output in a programme building-up to the planned PR13 regulatory review. The review has identified several areas that it is believed would provide a better understanding of the relative performance of different Infrastructure Managers. These are detailed below.

10.2 Possession Strategy

There is pressure on Network Rail to move towards the provision of a 7-day railway. This requires the development of a different possession strategy plus the associated strategies for delivery of maintenance and renewal work.

Similar pressures to change possession strategies have been identified elsewhere. For example, the drive to increase freight traffic is likely to lead to the elimination of day-time possessions. There are also safety related pressures requiring all work to be undertaken in a possession, resulting in the transfer of activity to nights.

The total possession costs to the railway also vary. Other networks have been designed to continue operating whilst engineering work is undertaken. Some have identified opportunities to provide buses for the last and first trains at little extra costs, but significant benefit to productivity. They also appear able to utilise a greater proportion of their possession time through quicker mobilisation.

The feedback received from several sources indicated that possession availability was a major impact on the delivery of maintenance and renewal work.

It is recommended that a more detailed review is undertaken into the impact of various possession strategies to both the Infrastructure Manager and the railway as an overall undertaking.

10.3 Renewal Strategies

The various benchmark studies all indicate that Network Rail's renewal expenditure is significantly greater than that of other Infrastructure Managers, both in terms of volume and unit costs. There are a number of potential reasons for this being so:

- Recovery of renewal backlog;
- Premature renewal of assets;
- Use of sub-optimal life cycle cost models to support decisions;
- Not deploying most efficient processes;
- Timing issue related to rollout of next generation of technology;
- Increased level of rolling stock imparted damage; or
- Combination of above factors.

It is recommended that further work is undertaken to fully understand the drivers behind Network Rail's apparent higher renewals unit costs.

In particular, it is recommended that a mechanism is developed whereby a measure of the renewal backlog can be derived. Maintaining an asset beyond its design life was one of the high impact factors identified in the analysis. However, as already noted, asset age is not a reliable indicator of whether design life has been exceeded or not.

10.4 Asset Management of High and Low Use Routes

It has been identified that the there are at least three different generic types of network:

- High-speed networks that are relatively modern;
- Rural networks that are being maintained on a day-by-day basis; and
- Core networks that have a life cycle asset management approach deployed.

It is believed that there is a significant difference in the overall unit costs as a result of the different strategies deployed on these types of routes.

Deductions from examination of the UIC/LICB general data on railway networks lead to the conclusion that Network Rail operates a network with below average tonnage and is predominantly used by passenger traffic. In reality, many parts of the network have a significantly different operating environment from that portrayed at the global level. Network Rail has identified this issue itself and it is developing route specific asset strategies that are appropriate for the different environments.

From the above, it is recommended that further research is undertaken to understand the variation in operating routes maintained by each Infrastructure Manager plus the impact of the environments on maintenance and renewal costs. The purpose of this study would be to enable identification of any Infrastructure Manager whose unit rates are either under- or over-stated as a consequence of the range of types of route included in their networks.

10.5 Detailed Gap Analysis

It is recommended that a detailed bottom-up “gap analysis” is undertaken between Network Rail and another Infrastructure Manager to identify all the significant elements that drive the variation in unit costs. Such an analysis would:

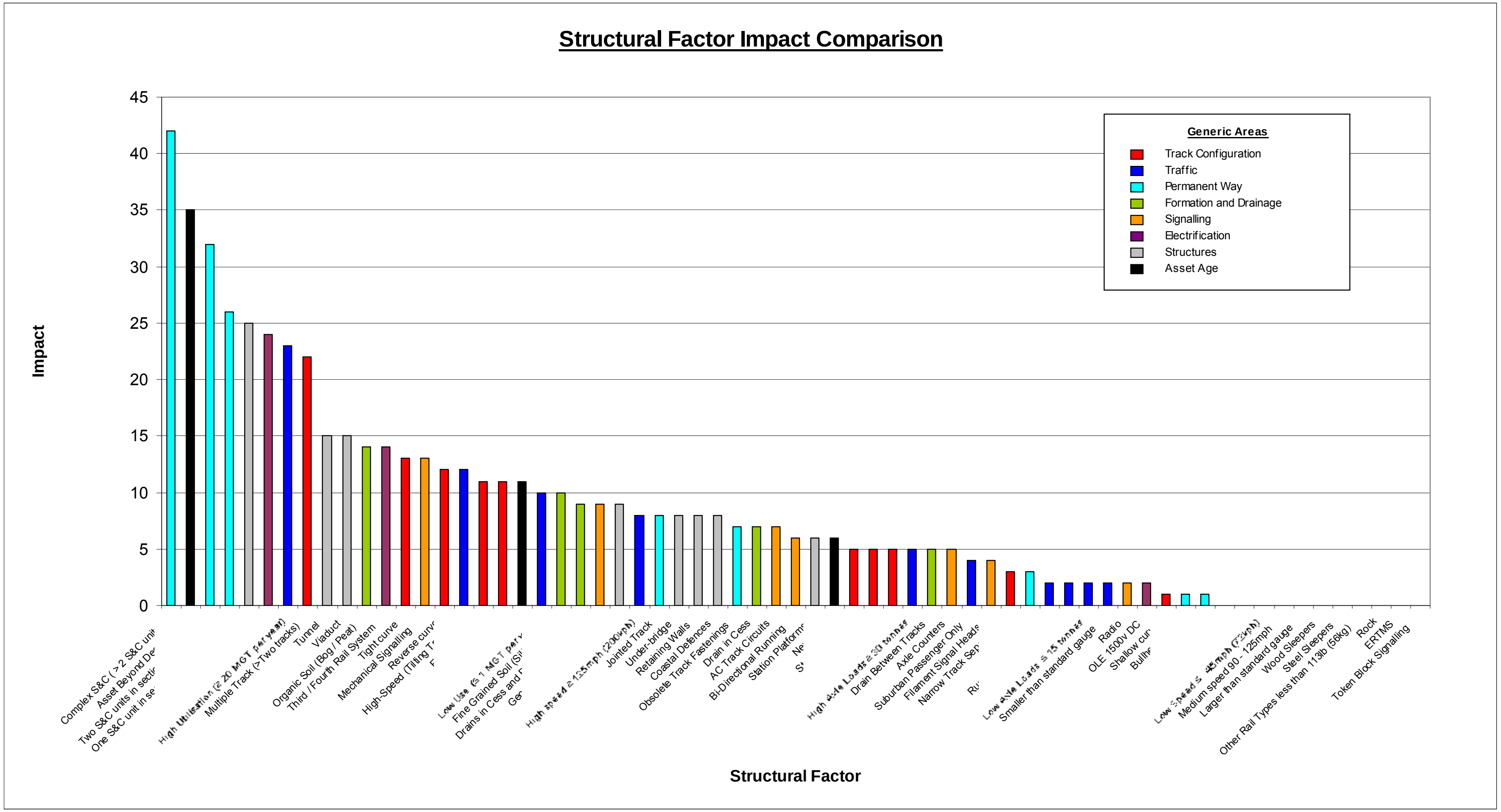
- Validate the generic assumptions applied in explaining gaps;
- Validate the harmonisation process;
- Confirm the cost drivers noted previously;
- Identify any further major cost drivers; and
- Identify best practice processes.

10.6 Multiple Structural Factors

This review process considered the impact of each technical factor separately on the base model. As identified in the feedback, particular combinations of two or more of these factors can result in a significantly larger impact than each in isolation. In this case, the combination of steep gradients, sharp track curvature, and high speed differentials between types of traffic cause rapid track wear.

It is recommended that a review of the technical factors is undertaken to identify any other combinations that may have a significant impact, particularly when the additional variable of rolling stock is added (rail/wheel interface).

The following Figure provides a bar chart view (and relative importance) of all structural factors considered in the bottom-up engineering model.


Structural Factor Impact Comparison
Impact
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Generic Areas
Track Configuration
Traffic
Permanent Way
Formation and Drainage
Signalling
Electrification
Structures
Asset Age
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