RailKonsult

**Office of Rail Regulation**

# Relative Infrastructure Managers' Efficiency

**Evaluation of Gap Analysis Factors**

**Redacted Summary Report**

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The authors of this report are employed by Balfour Beatty Rail Technologies. The work reported herein was carried out under a Contract placed in December 2010 by the Office of Rail Regulation. Any views expressed are not necessarily those of that Office.

## Executive Summary

During 2010, RailKonsult were commissioned by the Office of Rail Regulation to undertake a series of Study Visits in order to gain a better understanding of the specific issues faced by particular Infrastructure Managers. The insight gained was used to look at the relative gaps reported in maintenance and renewal costs between the different Infrastructure Managers.

In this follow-up study, RailKonsult have been requested to undertake further investigations into the reasons for the relative gaps. Using a generic asset management model, a number of potential factors have been identified that could explain the gap based on the approach expected from a good asset manager.

Each factor was prioritised and a short list selected for further consideration in more depth. This consisted of a bottom-up review with good practice being identified for each of the prioritised factors through consideration of a series of case studies.

An underlying theme is the improvement in confidence of predicted activity levels:

- Use technology to collect the correct **asset information** to feed into …
- Degradation models as part of **Decision Support System** tools, enabling …
- **Sustainable** asset policy decisions to be made, with robust plans that …
- Facilitate work clustering that improves utilisation of **possession** time, …
- Working with suppliers to invest in **developing** better solutions that are ...
- Effectively implemented with good **change management**.

The case studies have been sourced from a number of different countries. This is indicative of the fact that no Infrastructure Manager has been identified as having a monopoly on good practice, i.e. nobody has adopted all the identified areas of good practice.

Although specific local constraints may exist that prevent complete adoption of the identified areas of good practice by particular Infrastructure Managers, they will not prevent adoption of the general philosophies. In many cases, Network Rail has already identified the areas of opportunity and started an implementation process.

An initial estimate has been made of the potential opportunities from each of the prioritised factors. This has been calculated on the basis of public domain information and does not include any estimate of the required investment. The size of the potential opportunities is expressed in terms of a range, taking cognisance of the methodology constraints. These are indicated in the table below.

| | | | | |
|---|---|---|---|---|
| 1. | Efficient Collection of Asset Information | £30m - | £50m | |
| 2. | Use of Decision Support Tools | £30m - | £60m | |
| 3. | Possession Strategy | £50m - | £100m | Per annum |
| 4. | Sustainability of Strategy | £75m - | £405m | |
| 5. | Development Strategies | £30m - | £60m | |
| | **TOTAL** | **£215m -** | **£675m** | |
| 6. | Management of Change | £210m - | £475m | Lump sum |

All the opportunities indicated above are expressed as annual savings, except for item 6 which is a “one-off” saving. The approach used to calculate this potential saving is based on an acceleration of the change programme. Although there maybe other opportunities to provide improvements through alternative change management methodologies, these have not been considered in this study.

Within the constraints of the current study, it has not been possible to eliminate all areas of potential duplicated savings. The two primary sources are:

- Existing change programmes already addressing the issue in part; and
- Interdependencies between the factors identified in the above table.

A more detailed investigation into these factors, plus the existing initiatives, is required in order to determine the extent of the duplication. It is likely that the level of duplication will be between 10% and 25%. This reduces the potential annual savings as indicated below.

| | Lower | Upper | |
|---|---|---|---|
| Estimated potential opportunity | £215m | £675m | p.a. |
| Revised estimate – 10% duplication | £195m | £610m | p.a. |
| Revised estimate – 25% duplication | £160m | £505m | p.a. |

Although not reviewed in depth within this study, an initial consideration has been given to the precursor activities required to obtain the savings identified above. From this it has been concluded that it is unlikely that these savings will be available until CP5, particularly when considering the extent of the change programme already underway for CP4.

The study was undertaken independently of the recent Value for Money review and completed prior to the publication of these findings. However, the conclusions are complimentary with those in the recently published final report.

It is recommended that more detailed consideration is given to the following areas:

- Benefits from increased effectiveness of collecting asset condition information, using technology that is readily available;
- Development of suitable possession strategies that provide whole industry savings, making better use of predicted intervention requirements;
- With regard to the variation in reported asset renewal rates, determine the appropriate levels of life extension, renewal and enhancement activity;
- Review best practice in change management processes from other industries and determine how these benefits can be realised in the rail industry.

It is also recommended that further analysis is undertaken of the available savings in order to validate the initial work undertaken as part of this review.

**Acknowledgements**
RailKonsult wish to acknowledge the support and assistance received from all the other organisations in compiling this report.
In particular, we are extremely grateful for the input previously received from the Infrastructure Managers and suppliers contacted in the course of these studies, particularly their open attitude to participating in the work, despite the day-to-day pressure.

## Contents

# 1.0 BACKGROUND

## 1.1 Previous Work

RailKonsult have undertaken a number of studies that require consideration of the benefits that can be derived from different approaches to the maintenance and renewal of railway infrastructure. This work has included both the comparison of different approaches and the provision of support for the implementation of these changes in approach.

As part of the recently completed periodic review of funding for Britain's railway infrastructure, the Office of Rail Regulation (ORR) commissioned a number of studies related to international benchmarking and comparative reviews of methodologies in Europe. RailKonsult undertook work as part of this programme.

Earlier this year, RailKonsult undertook further work on behalf of the ORR. This included a review of the relative efficiency of five Infrastructure Managers[1], including Network Rail. A more detailed study into the harmonisation process that is required to undertake international benchmarking studies formed part of this work. Both economic and engineering factors need to be included within the harmonisation process. An output of the study was an initial high-level, top down gap analysis of the relative infrastructure maintenance and renewal unit costs[2]. This provided insight into the cost drivers affecting the relative efficiency of different Infrastructure Managers.

[1] Redacted version of document can be found at http://www.rail-reg.gov.uk/upload/pdf/econometric_update_2010_railkonsult_paper.pdf.

[2] In this process the term unit cost is defined as the total harmonised maintenance and renewal cost per km, as typically calculated in the UIC LICB studies.

# 2.0 METHODOLOGY

## 2.1 Introduction

As part of the preparation for PR13, the ORR wish to further develop their comparative review work in order to gain a better insight into the principal drivers affecting the relative efficiency of different Infrastructure Managers. In particular, they wish to gain a better insight into:

- Different approaches to asset management; and
- Opportunities available for improvement in the unit rate for maintenance and renewal in Britain.

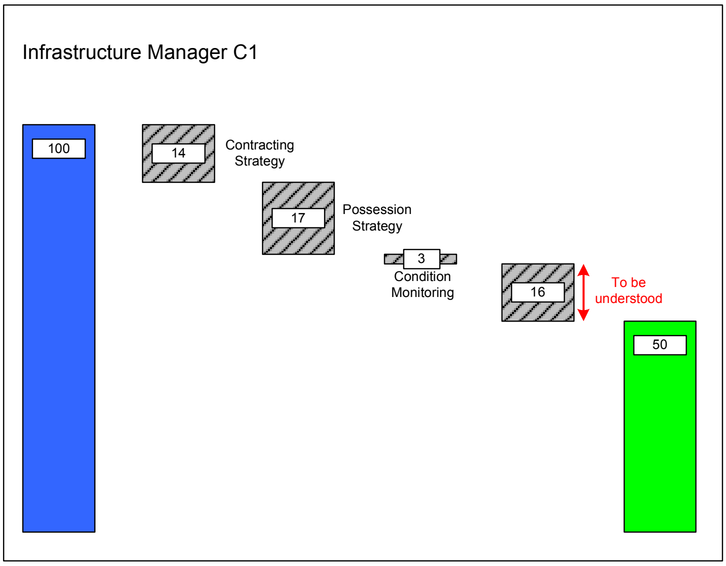
The recently completed review of “Relative Infrastructure Managers’ Efficiency” identified a number of areas that contributed to the difference in unit rates. These were:

- Contracting Strategy;
- Possession Strategy;
- Proactive Use of Condition Monitoring Information;
- System Renewal;
- Efficient Delivery;
- Renewals Backlog;
- Effective Network Size; and
- Workforce Protection.

In addition to the specific areas identified, other related factors may help to explain the gap, such as:

- Efficiency of taking and giving-up possessions;
- Utilisation of possessions; and
- Management of asset information, including the technology used.

This analysis resulted in the development of four cascade diagrams that provided an initial indication of the reasons behind the gap in costs between Network Rail and each of the other Infrastructure Managers. An example is shown below.



This review was a top-down exercise that looked at the apparent gap. A complementary "bottom-up" review has now been undertaken that enhances the understanding of the relative positions. A "bottom-up" approach provides identification of good asset management practice through an engineering and process review.

## 2.2 Outline Methodology

The approach used for delivery of this work was to undertake a staged desk-top review, making full use of the information and knowledge gained from work undertaken previously. This was supplemented with some additional research to complete the assessments.

The first stage included the following activities:

- Review each of the specific issues from 2010 gap analysis report;
- Identify other issues that are likely to be part of the explanation of the gap;
- Prioritise the issues; and
- Select six issues for further consideration.

Each of the prioritised issues has been considered in more detail, with the scope of this detailed review including consideration of:

- Identified good practice;
- Current British practice, including any reasons or constraints as to why the current British approach is different;
- Potential improvement opportunities; and
- Changes needed to implement best practice into Britain.

## 2.3 Analysis Approach

The approach taken has been to identify good practice as used by Infrastructure Managers across Europe and elsewhere in the world. Current British practice has also been identified. These reviews include consideration of any applicable constraints. The document uses this information to determine potential opportunities for improvement.

The desk-top reviews have been updated to take into consideration recently published work. In particular the output from the Infrastructure UK study and the conclusions from the Innotrack studies have been considered.

It should be noted that:

- No Infrastructure Manager has been identified that has a monopoly on good practice, i.e. nobody has adopted all the identified areas of good practice;
- There are local constraints that will prevent complete adoption of the identified areas of good practice by all Infrastructure Managers, although this may not prevent adoption of the general philosophy;
- In many cases, Network Rail has already identified the areas of improvement and started an implementation process.

These case studies of good practice to illustrate potential hypotheses are used to explain the differences seen between Britain and Infrastructure Managers in other countries.

## 2.4 Financial Assessment

The report includes outline estimates of the size of each of the potential opportunities, although this is not necessarily the size of the available savings.

These estimates have been made on the basis of a preliminary review. Calculation of these estimates has been constrained by the limits of information available in the public domain. As such, it has been necessary to use engineering judgement to estimate some of the values. In many cases, these judgements have been informed by experience gained by other Infrastructure Managers.

No assessment has been included at this stage of:

- Improvements achieved since 2009/10 (baseline for the main sources of financial data);
- Additional investment requirements; or
- Potential duplication of savings identified from different factors.

Due to lack of information in the public domain, the estimates have not been able to take into account any consideration of the changes in the cost base already achieved by Network Rail during the current financial year, or assumed to be achieved as a consequence of the CP4 driven Transformation Programme.

As already noted, Network Rail are already aware of many of the initiatives. However, it is not clear to what extent these initiatives have already been implemented or investment committed. As such, any estimate of further required investment is not possible. For the same reason, neither has consideration been given to the implementation programme timescales at this stage.

The structure of the study has been to consider various aspects of asset management. As such, it is likely that some of the financial savings may have been over-estimated through double-counting. For example, improvements to the planning process will have been accrued whilst considering the benefits from better knowledge of the asset condition, better degradation modelling, improved possession utilisation, improved clustering of activities and the quicker deployment of new technology. There has been no overall consolidated functional assessment included as part of this review.

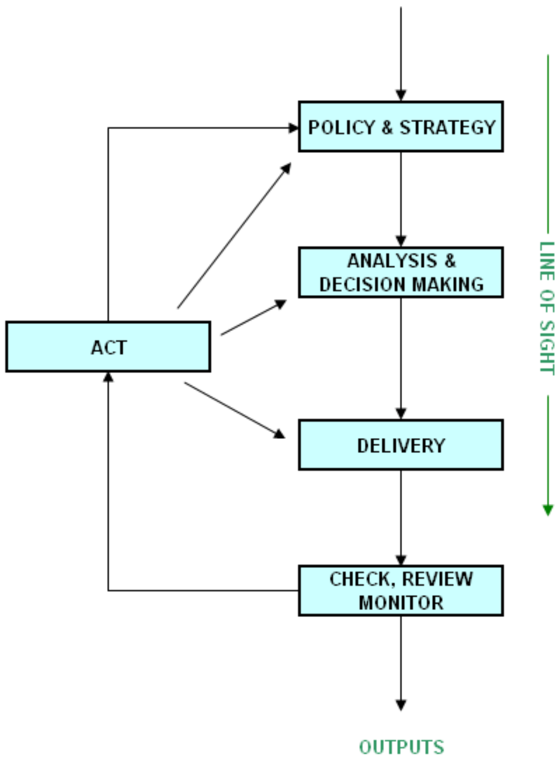
The quoted savings are indicative of the relative opportunities and contribute to the increased understanding of the key drivers.

This work has been undertaken in parallel with the Rail Value for Money (R-VfM) review being undertaken by Sir Roy McNulty. At the time of writing, only the Interim Report was available for review. As such, it has not been possible to consider the degree of overlap with any recommendations emerging from the R-VfM study.

# 3.0 ASSET MANAGEMENT

## 3.1 Stage 1 Summary

There are a number of asset management models available for consideration, including those developed for general use plus others developed for railway specific applications. These models have been reviewed and the diagram below indicates the high-level approach, developed as a framework to guide the analysis undertaken for this assignment.




Using this framework as a basis, almost forty critical asset management factors have been identified that influence the efficiency and effectiveness of an Infrastructure Manager's performance. These are listed in Appendix A to this document.

## 3.2 Selection of "Top Six"

Within the constraints of the current study it was not possible to fully investigate all the factors identified. The prioritisation criteria used to select the factors to take forward into the second stage of the study were:

- Initial view on the likely size of the impact of the factor in explaining the gap in unit costs; and
- Ease by which any identified good practice could be transferred to Britain.

Any factors over which the Infrastructure Manager has limited control were given a low prioritisation as a consequence of the second chosen criteria.

Many of the factors are inter-related. This makes the prioritisation process more difficult. The approach adopted has been to consider the specific aspect of each factor in isolation, to the greatest degree possible.

This high-level prioritisation exercise was based on previous work and the team's insight and understanding of the issues. A copy of the prioritisation diagram is included as Appendix B to this report. The top six factors identified were:

- Change Management
- Possession Strategy;
- Use of Decision Support Systems;
- Efficient Collection of Changed Asset Information;
- Sustainability of Strategy; and
- Development Strategies (Innovation).

As already noted, RailKonsult undertook a "top-down" gap analysis in 2010. Eight factors were identified as contributing to the gap as a consequence of the discussions held with the other the other Infrastructure Managers.

The further work that has now been undertaken to gain a better insight into the drivers behind the identified gaps has resulted in some clarifications to the view taken in the previous report. These views have now been validated using a bottom-up perspective through this assignment. A comparison of the list of issues is provided in Appendix C of this document.

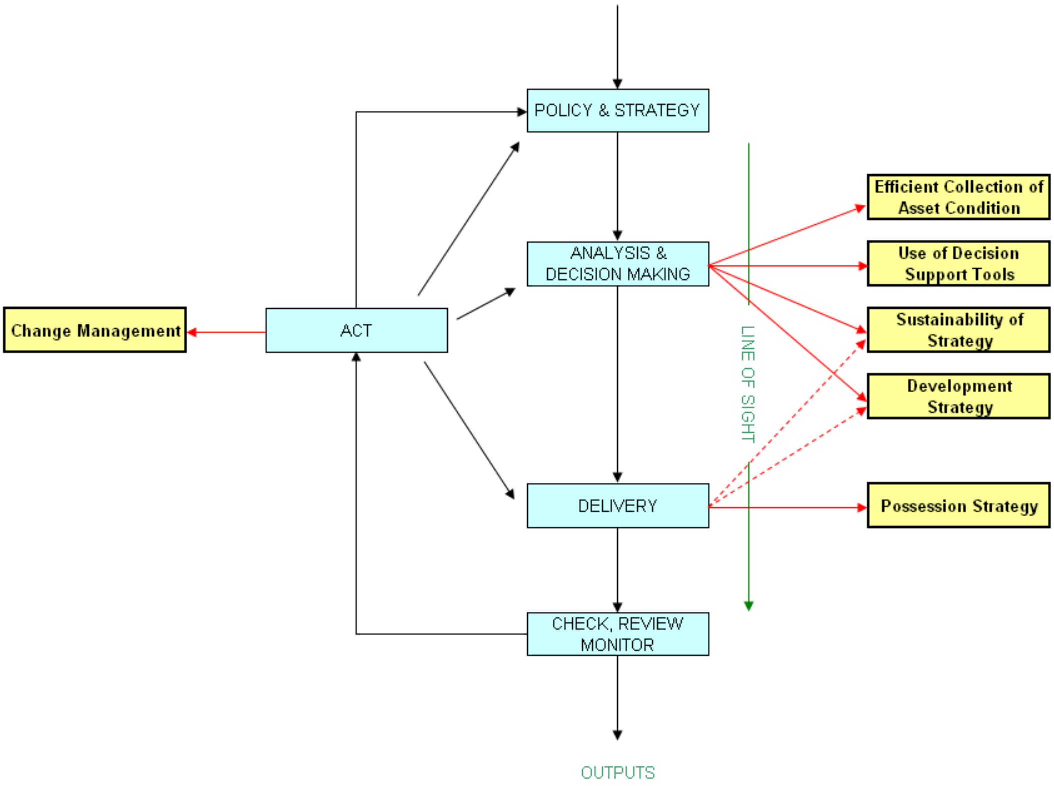
A number of the previously identified factors are closely related to the factors prioritised as part of this study. For example:

- Understanding the use made of asset information is a key driver in determining the asset information that most be efficiently collected;
- Selection and use of the appropriate Decision Support Tools requires an understanding of the whole life cost models plus the use of route or asset based criticality;
- Both the possession strategy and consideration of the sustainability of the chosen asset management strategy (i.e. is work being deferred such that a future backlog is being created) require use of an appropriate long-term planning horizons;
- Identification of the criticality of different assets on delivering system performance has an impact on the optimum level of both inspection and renewal; and
- Organisation strategy influences all the factors, but particularly the ability to manage change.

### 3.3 Interlinking of Elements

All parts of the asset management cycle indicated in the diagram above in Section 3.1 should be considered in order to improve the effectiveness of an Infrastructure Manager's performance. Each of the factors identified during Stage 1 of this study are interlinked, providing support to other factors elsewhere in the cycle.

The diagram below indicates how the six prioritised factors fit into the overall asset management cycle and, as such, underpin the tactical delivery element of the cycle. As the diagram shows, the prioritised factors are primarily related to the analysis and decision making part of the asset management cycle.


POLICY & STRATEGY
ANALYSIS & DECISION MAKING
DELIVERY
CHECK, REVIEW MONITOR
OUTPUTS
ACT
Change Management
LINE OF SIGHT
Efficient Collection of Asset Condition
Use of Decision Support Tools
Sustainability of Strategy
Development Strategy
Possession Strategy

# 4.0 EFFICIENT COLLECTION OF ASSET INFORMATION

## 4.1 Summary of Issue

Having first determined the information inputs that need to be measured, the next step is to select the most efficient and effective way of gathering that information. An important aspect of achieving this aim is that those involved in the collection of the data must respect the integrity of the process and the data.

The information used to assess the work to be undertaken must be up to date and accurate. Accuracy of location is a key element of this equation. The cost of the collection process can be minimised by automating the processes and selecting an inspection frequency appropriate to the risks and deterioration mechanisms.

## 4.2 Good Practice

Good practice in efficient collection of asset information is based on:

- Selection of the assets to monitor and their characteristics;
- Use of appropriate technology to reliably and consistently collect the identified condition information.

Application of asset management principles enables the required condition information to be identified. This also requires an understanding of the critical assets.

**Identification of Critical Assets**

A methodology has been developed to categorise all switch and crossing units, which is based on speed, tonnage, number of axles and switch passage configuration (trailing or facing, through or turnout). This is then used to determine inspection and maintenance regimes.

**Route Criticality**

The maintenance and renewal policies for regional lines use a ‘patch and mend’ approach, with components being cascaded from main lines. Rural lines only receive minor maintenance with speed restrictions used to ensure safety, unless additional funding is received from local sources.

Understanding the degradation mechanisms also enables the Infrastructure Manager to determine the optimum frequency of inspections. The selected frequency should ensure that safety levels are not breached and that an appropriate intervention can be planned to occur at the optimum time.

There are constraints to the scope of information that can be collected manually. For example, the prediction of degradation rates usually requires an understanding of an asset’s use. The number of trains using a particular asset is not easy to accurately determine using manual methods, but this data can be collected as a result of installing monitoring equipment.

**Use of Technology to Capture Additional Data**

A system has been developed to monitor traffic levels by measuring train weights. These are then used to calculate track access charges for the train operators. It has also been used to determine the level of traffic travelling over the network, which has been found to be up to 16% higher than the level previously calculated based on information from the timetable.

The information has been used to help classify switches into categories so that maintenance regimes could be altered accordingly. Switches that handle the majority of traffic are Class A switches and switches that contribute very little to the traffic process are classed as C switches. A further category contains the hand operated switches. As a consequence of this categorisation, Minor switch maintenance costs have dropped by 10%.

There are four main generic approaches available for the collection of asset condition information:

- Use of dedicated inspection vehicles;
- Installation of monitoring equipment onto service trains;
- Use of fixed equipment to monitor condition of assets; or
- Undertaking manual inspections.

Maximum benefit is derived from using an integrated approach that utilises each of the above methods as best suited to the specific requirements of each particular circumstance.

**Integrated Approach to Inspection**

The Infrastructure Manager and their maintenance contractors use an independent operator to collect track and traction power system condition information, which is then made readily available across the industry.

This information is supplemented by additional input collected through condition monitoring installed on critical signalling equipment. This is then used by centrally based teams for (long-term predictions), contract management centres and local staff.

This approach, together with other initiatives, provides the basis from which it is possible to significantly reduce the frequency at which foot patrols are undertaken.

**Development of Condition Monitoring Equipment**

A monitoring system has been fitted to approximately 20% of points, reducing the number of failures and consequential train delays. The identification of parameters to be measured is based on an understanding of the degradation mechanisms that determine when maintenance intervention is required.

In addition to determining when intervention is required, the systems are also used to confirm that the maintenance intervention has been effective.

Work continues to develop technological solutions that eliminate the need for manual inspections.

**Switch Blade Wear Monitoring**

The S&C measurement and inspection system records laser line and video data to enable switch and nose profiles to be compared against a library of standard drawings. The software compares the measured and theoretical profiles enabling the required parameters to be consistently reported as defined in the relevant standard. It is currently still in the development phase and an initial system has been fitted to an old tamper. It has proved able to achieve an accuracy of 0.2mm and can inspect up to 200 switches per day without the requirement for any possessions.

The fourth option in the list above, undertaking manual inspection, requires more detailed controls in order to minimise both safety risks and the risk of poor quality information. Automated collection of asset condition information reduces the potential for errors. The use of hand-held devices also reduces labour cost, both in terms of the time required to input the data and the level of wasted effort due to entry errors, leading to problems such as repair teams being sent to wrong location.

**Introduction of PDA-Based Technology**

An Infrastructure Manager has started implementing PDA technology for use by their inspection teams. These provide the inspectors with prompts as to which assets to inspect and the details required. The information is automatically downloaded onto the management system, reducing the likelihood of errors. It also provides a record of the inspection having been undertaken.

In conjunction with Credo, Invensys produced a white paper on the total cost of ownership of signalling systems[3]. One of the case studies within the paper describes the impact achieved on reducing train delays by implementing a strategy that was based around condition monitoring of the asset.

**Condition Monitoring**

A metro route that was under five years old and had failed to attract the passenger ridership that it was designed to take. This had not been helped by the poor reputation that the route had developed for being unreliable. The solution was led by engineering and involved three steps. The first step was to improve resilience and iron out teething problems with the original implementation. The second step was to make more of their engineers available during peak hours to resolve failures. The final step was to introduce asset condition monitoring to alert field engineers to potential failures before they occurred, an early warning system.

The condition monitoring sensors were retro-fitted to existing components. The engineers focused on the most critical components for the trial: those that were hard to reach, exposed to lightning strikes or intensely used. This allowed them to limit the scope of the trial and take maximum advantage of the benefits. Early indications are positive; with failures having declined dramatically by 95% between 2005 and 2008.

[3] White paper produced by Credo on behalf of Invensys “Total Cost of Ownership of Rail Signalling Systems”, dated April 2010.

## 4.3 Current British Practice

Network Rail have been developing both train-based inspection systems (track geometry, NDT inspection of rails and condition of traction power systems) and fixed condition monitoring systems (points, track circuits and interlockings) as part of the Intelligent Infrastructure programme.

However, generally in Britain there remains more reliance on manual inspection methods with the collected data then manually entered into the appropriate system then elsewhere. This is both less efficient and less effective, as it increases the number of individuals involved, each of whom are providing their own interpretation of asset condition and location. Development and implementation programmes are in place to automate the collection of many types of asset information.

In many cases data is held on local databases, preventing value being leveraged by easily viewing the information across the complete network. This can, for example, help to identify trends of under-performing components that require re-engineering.

**Rail Asset Management System**

A survey was undertaken of systems used to recording and monitoring rail defects. The results of the survey found enormous differences between maintenance depots with respect to the quality of data captured and the type of systems being used.

A rail asset management system was developed. This was designed with not only the data capture user in mind, but also the engineering functions that require the data to make proactive decisions on rail management strategies. The system proved that it was an ideal engineering tool for rail asset management and decision making.

The use of inspection vehicles in the automated collection of information relies on the accuracy of the system used to ensure the information can be used for run-on-run comparisons. This means that the data must be well managed and that the systems on the inspection trains are regularly calibrated, preferably using a standard test track.

**Calibration of Inspection Trains**

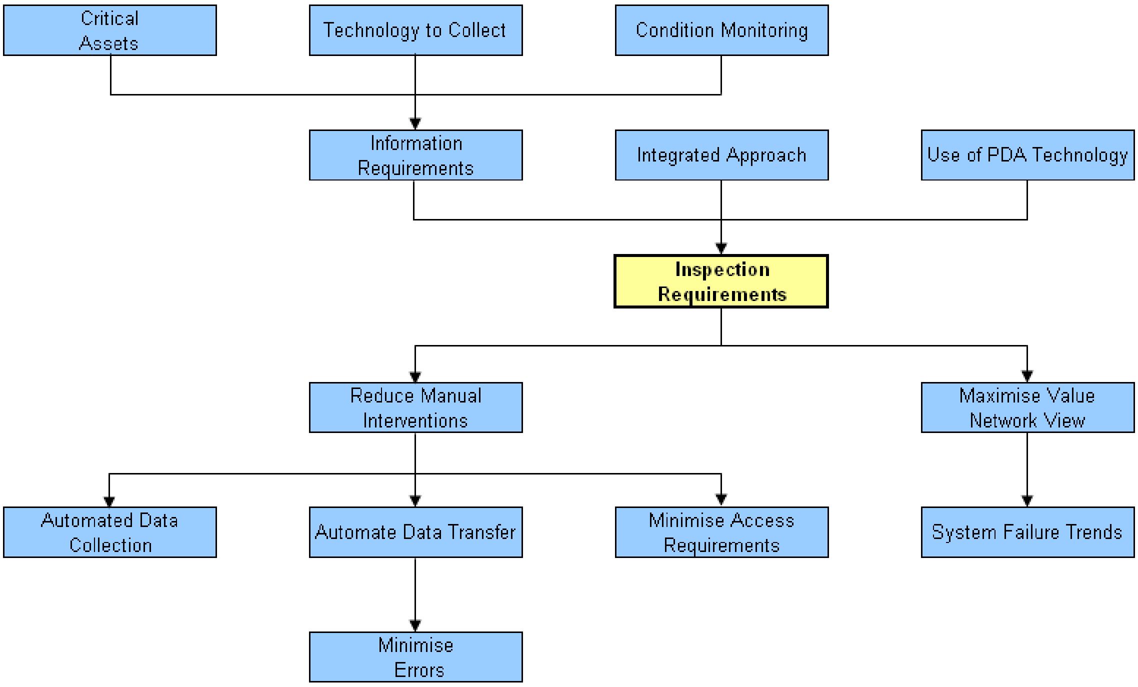
Inspection vehicles are sent to a test track following any significant refit work for calibration. The test track includes specific sized defects that can be consistently used for calibration purposes.

There are several different methods of collecting track geometry data. Different types of filters are also used to produce useful outputs. As a consequence, each type of recording vehicle will produce slightly different outputs. Infrastructure Managers need to have intervention standards based on the track recording technology in use on their system.

Identification of the critical assets enables an inspection regime to be developed that prioritises collection of information from these assets. The process of assessing asset criticality has been an area focussed on recently for track assets in Britain.

## 4.4 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




From the case studies it can be seen that:

- Information requirements need to be identified, which requires consideration of;
    - Asset criticality and appropriate parameters to monitor condition;
    - Deployment of suitable technology to meet these needs;
    - Use of automated condition monitoring to provide trending information.
- An integrated approach is required that monitors from the system level down to functional component level; and
- Further automation through the use of PDA technology should be used to as far as practicable to minimise inconsistency and data entry errors.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Automated data collection

  Currently, Network Rail maintenance personnel of all functions still spend a considerable proportion of their time undertaking inspections. Automation of these inspections will reduce costs (through less manual intervention) and provide more consistent and comparable measurements.

  This requires identification of the required measurements and deployment of suitable monitoring equipment (static or train-borne) to collect this data. Many systems are already available and in use by other organisations.

  Estimated size of opportunity is in the range £20m to £27m.

- Automated data entry

  Network Rail has a large group of staff managing the Ellipse work planning system. A significant element of their work is entering details of inspection reports and work done. Transfer to the use of PDA devices for data collection will automate the process. This reduces the level of support staff required and will also eliminate data entry errors.

  This requires the deployment of suitable PDA devices. Such devices are already being used by other Infrastructure Managers.

  Estimated size of opportunity is in the range £5m to £10m.

- Minimise access requirements

  Automation of the inspection process will reduce, or eliminate, the requirement for possessions solely in order to undertake infrastructure asset inspections.

  This requires the implementation of suitable virtual inspection strategies to automate asset data collection as referred to above.

  Estimated size of opportunity is in the range £3m to £8m.

- System failure trends

  Provision of a visualisation tool, together with consolidation of all the data into a single system, will provide engineers with the capability to view national trends. This will enable poorly performing components to be identified more quickly and the requirement for revised maintenance regimes to be determined.

  This requires all the data to be made available through a suitable visualisation tool and ensuring that those collecting the data have the necessary respect for the integrity of the data.

  Estimated size of opportunity is in the range £1m to £2m.

Another, intangible, benefit is provided through the intrinsic value that can be developed from the collected data. Obtaining a clear understanding of the asset condition and its degradation rate is of value to the Infrastructure Manager. It will provide the input into Decision Support Systems as described later (including enabling the degradation rules to be refined) and it will enable work to be better specified and planned.

It is understood that experience from an Infrastructure Manager indicates that the introduction of a system to monitor wheel condition has given a 5-10% reduction in infrastructure costs. However, the business case for installation of the condition monitoring equipment was predominately based on reductions in train delays.

Similarly for improved train performance, experience from an Infrastructure Manager[4] indicates that a reduction of overhead line failures of 60% has been achieved through combining automated inspection information with an FMEA analysis to determine optimum maintenance interventions.

[4] Proceedings of the Institution of Mechanical Engineers, Volume 222, Part F: J. Rail and Rapid Transit pp399 – 412.

## 4.5 Implementation Issues

The primary ***safety*** issue will be to ensure that sufficient, accurate information is collected to mitigate the risks of infrastructure failures in service. This requires consideration of both the frequency of information collection and the type of parameters to be measured in order to ensure a full understanding of the condition is obtained. The tolerances on the measurement methods must be considered as part of this analysis.

The ***implementation*** factors to be considered revolve around both hard and soft issues. The acquisition of reliable technology is important. These risks can be mitigated by implementing a pilot scheme before rolling-out nationally. Tackling the softer issues require a change in culture so that the information is treated with the respect required and that the benefits of automation are properly understood.

# 5.0 USE OF DECISION SUPPORT TOOLS

## 5.1 Summary of Issue

Decision Support System (DSS) tools use whole life cycle models to determine optimum future intervention requirements, enabling these models to be applied by engineers to the specific circumstances under review. Whereas visualisation systems enable engineers to gain an easy overview of asset performance, DSS tools take the next step and provide modelling capability, i.e. the ability to answer "what if" questions.

Specialist systems engineers are generally used rather than functional engineers. The DSS tool might be operating at either network or site level, depending on the type of analysis being undertaken (predicting future system activity levels or determining the optimum intervention time for a particular location).

Other types of analysis that an asset manager would use a DSS tool to provide assistance include:

- "What If" scenario assessments to evaluate the impact of different traffic levels;
- Assessments of the overall impact of combinations of degradation mechanisms; and
- Determining the impact of trade-off decisions (for example moving funds from maintenance to renewal budget)

It has recently been noted that "maintenance used to be highly based on individual, subjective experience from local track supervisors" but now life is more complicated[5]. From the study visits undertaken it appears that all the Infrastructure Managers are experiencing issues of loss of experience. This becomes a "double whammy" as the demands to increase capacity whilst reducing unit costs results in a requirement for an improved understanding of asset performance.

Although such tools support the decision-making process, skilled and competent engineers must make the final decisions, not the tools.

## 5.2 Good Practice

The quality of the data (both in terms of accuracy and breadth) is critical if DSS tools are to be used as the basis for planning intervention work. Without the requisite quality, the wrong decisions will be made and/or the plans will not be implemented as there will be no credibility that they are correct.

**Quality of Data**

A management centre has access to information that includes up to date details of the condition of track and traction power systems from the inspection processes and for critical signalling systems from condition monitoring equipment. This information can be evaluated to determine the required maintenance regimes and also undertake specialist system level analysis such as determining the best route for additional freight flows.

5 Paper by Arjen Zoeteman: "Life cycle cost analysis for managing rail infrastructure" [Nov 2001], European Journal of Transport and Infrastructure Research

**Quality of Data**

An Infrastructure Manager has an integrated DSS to manage their maintenance activities. At a recent presentation, the supplier who supported the development of this tool noted that one of the key success criteria was that all those involved in collection of the data had to have full respect of the data and a clear understanding of the consequence if inaccurate data is fed into the system.

Implementation of the system in itself has helped to improve the quality of the information. It is the visualisation tool that provides the user-interface and enables anomalies to be identified and corrected. Typical anomalies include missing information or obviously incorrect location synchronisation between recordings.

These systems can be used as both a data visualisation system and a DSS tool. An example of the use made of the system is that it enables their engineers to model the impact of changing the tamping frequency on a particular route.

**Integrated Planning**

Introduction of a network-wide decision support tool has enabled the quantity of tamping undertaken to be reduced by 20% through better decision on when and where to intervene.

A DSS system containing details of track, signalling and traction power assets can provide the necessary input information to enable engineers to plan the optimum intervention treatment.

**Integrated Planning**

An Infrastructure Manager has developed an integrated maintenance tool. It has the combined capabilities of both asset management and work management systems. It contains details of the work required (cyclic and arising from inspections) and resource availability (machines, men and possessions) enabling initial work programmes to be formulated two years out based on algorithms, which are successively refined until they become work schedules containing specific jobs a week out. The asset management information is being used to develop standard activities based on reliability studies.

From review of several European models, it is evident that the key success criteria are:

- Asset databases that are complete, trusted and used by everyone;
- Retention of expertise at all levels that enables consistent network-wide decisions to be made on asset life and renewal programmes.

There is a need for good tools to help make the decision, and then good experienced engineering analysts are required to consider the options and intervene wisely.

**Long-Term Modelling**

Decisions on maintenance and renewal strategies can be supported by DSS tools that assist in selecting optimum renewal dates. Although the under-lying strategies differ, engineers from several different Infrastructure Managers use long-term modelling to optimise their renewal programmes. The DSS tools make use of WLC models to enable these analyses to be undertaken.

Another approach is to use the tools to provide a theoretical life for each asset. Central oversight of plans enables the technical lives of adjacent assets to be ‘managed’ to minimise operational impact through clustering work into the same blockade.

**Long-Term Modelling**

The Infrastructure Manager’s approach is to use centrally developed long-range models to verify the proposed bottom-up locally proposed work plans. The availability of information centrally has led to more planning at the centre using experienced and competent engineers.

It is noted that most work on whole life cycle (WLC) modelling has occurred within the track area. There maybe several reasons for this:

- Track represents a large proportion of M&R expenditure;
- Decisions on when to intervene are dependent on a number of variables and potential methods when considering track assets;
- Other assets such as signalling and traction power systems are renewed due to issues other than purely condition, such as technology obsolescence, with components being replaced under maintenance between system renewals.

Adoption of a WLC approach enables optimisation of the life of each component. It requires knowledge of the cumulative use of the asset (such as cumulative tonnage of traffic running over them or the number actuations of a switch) and the deterioration rates at each location. A good DSS tool provides the capability to pull this information into suitable WLC models for analysis.

With good asset information and deterioration trending, engineers are able to establish where components are beginning to deteriorate and prioritise the required intervention. This whole life approach to maintenance intervention will extend the asset life.

**Whole-Life Maintenance Interventions**

Whole life based maintenance track interventions include:

- Repadding;
- Preventative maintenance regimes on S&C;
- Targeted grinding and lubrication regimes to optimise rail wear;
- Preventative replacement of poor ballast sections; and
- Rail defect grinding before need to change rail sections.

The Infrastructure Manager undertakes cyclic interventions throughout the life of the asset, for example replacing pads on a regular basis when the track is restressed. Their modelling has shown that sleeper life is extended by ensuring pads are regularly replaced, thus retaining track-form elasticity.

They have also undertaken trials that indicate that the use of under-sleeper pad reduces ballast deterioration by a factor of three. This equates to a 30% reduction in ballast whole life cycle costs.

## 5.3 Current British Practice

Currently, it is understood that Network Rail has limited DSS tools available for use by delivery engineers that have sufficiently detailed local information and appropriate WLC models to understand the impact of alternative planned interventions.

**Reactive or Proactive Interventions**

It is understood that there are limited tools available to engineers planning delivery of maintenance enabling them to determine the optimum whole life intervention. Work schedules are consequently driven by defined inspections and reactive interventions based on the minimum safety levels specified in Standards.

Systems such as V-TISM enable them to understand the impact of changes at a network level. However these are not readily available to support the production of local asset management plans. There is a reliance on engineering knowledge, skill and experience at a local level with limited national oversight. This leads to a short-term planning horizon being taken on the basis of a specific engineering function rather than whole system.

**Work Management System**

The main system used by the delivery units is Ellipse, which is primarily a work management system rather than a DSS tool to support asset management. Ellipse also has asset register and asset condition recording capabilities.

It is a cross-functional tool, i.e. it is used by all the engineering maintenance functions. It provides the ability to understand the type and quantity of maintenance interventions being undertaken.

Ellipse is used to build work delivery programmes, with prioritisation determined on the basis of minimum actions, not an assessment of optimum intervention based on whole life cycle costs. The planners who build-up the work programmes are not required to have good engineering knowledge. This effectively results in the outputs being optimised activity schedules, not optimised asset management plans.

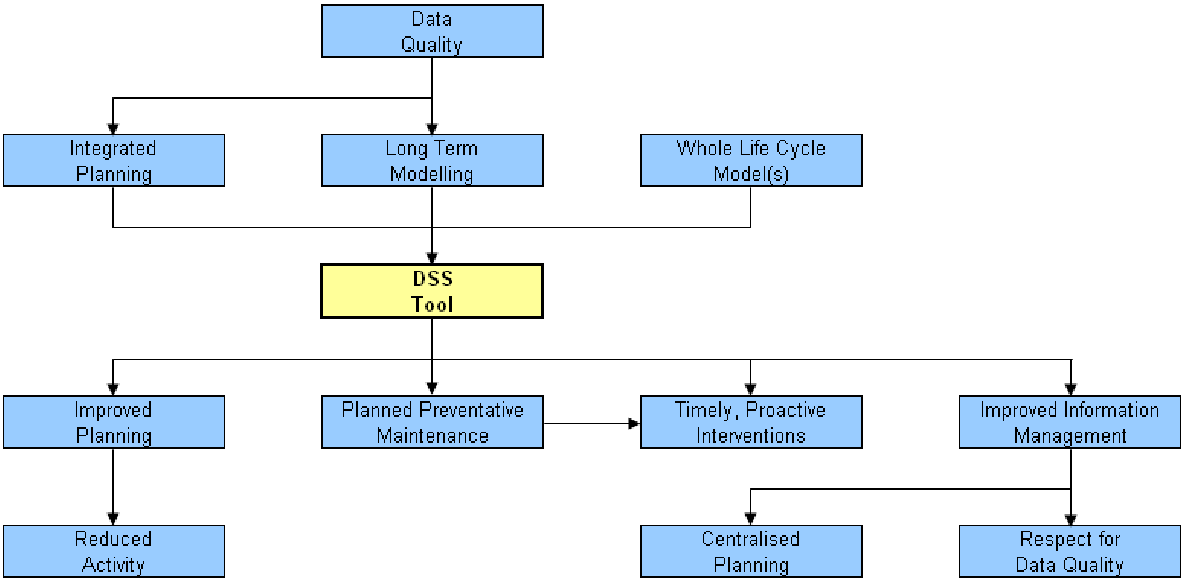
Good asset information is required in order to understand the type, age and condition of track infrastructure. However its life depends on traffic tonnages and types, its construction, geology and the quality of intervention applied to it through its life. Network Rail calculates the residual life remaining in a track component on the basis of cumulative tonnage.

As noted in Section 5.2, the quality of the information is critical to enable the correct decisions to be made. Optimised “just-in-time” renewals cannot be part of the asset management strategy if there are concerns over the accuracy of the information being used.

It is understood that GEOGIS has been cleansed again for the CP5 modelling despite it being cleansed within the last two years for CP4 work. Infrastructure Managers elsewhere seem to have a much better quality of information within their systems. One of the issues in ensuring good quality information is contained in the British systems maybe that those collecting the information can perceive little value to themselves.

## 5.4 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




From the case studies it can be seen that:

- An integrated approach to planning is required, with the requirements of all functions considered in the same process;
- Quality of data collected and entered must be high, with those managing the data having respect and understanding of the need for accuracy;
- Improvements are generated through the capability to undertake long-term modelling;
- Robust output is obtained from good data quality feeding into whole life cycle models that have realistic degradation models.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Improved planning

  The availability of good DSS tools with reliable degradation modelling enables better long-term planning. This improves efficiency by facilitating increased plant utilisation and ensuring the necessary preparatory work is completed.

  This requires DSS tools with the right degradation models to be available for use by appropriately trained engineering analysts. It also requires reliable and accurate data to be available.

  Estimated size of opportunity is in the range £5m to £11m.

- Planned preventative maintenance

  Using the DSS tools, suitably competent analysts are able to determine the correct preventative maintenance interventions based on whole life cycle benefits, e.g. replacing rail pads in order to extend the life of rails and sleepers. This will reduce overall activity levels and possession requirements.

Network Rail is already rolling out a reliability centre maintenance initiative for their signalling assets (ROSE). The availability of a DSS tool would enable the engineers to make the required decisions more quickly and accurately.

This requires DSS tools with the right life cycle models to be available for use by appropriately trained business analysts. It also requires reliable and accurate data to be available.

Estimated size of opportunity is in the range £4m to £8m. However, the experience of other industries has shown that the introduction of reliability centred maintenance strategies produces significantly greater efficiencies.

- Timely proactive intervention

  Intervening with the correct treatment at the correct time eliminates the need for extra work, e.g. if a slurry spot is treated early it is possible to eradicate it with a single visit, whereas delayed intervention can result in the need to treat multiple beds.

  This requires DSS tools with the right degradation models to be available for use by appropriately trained analysts. It also requires reliable and accurate data to be available.

  Estimated size of opportunity is in the range £18m to £37m.

- Centralised planning

  A centralised system containing the required data and supporting models enables more planning to be done centrally, using suitably competent engineering analysts.

  This requires both an integrated Asset Information strategy plus availability of reliable and accurate data.

  Estimated size of opportunity is in the range £1m to £2m.

- Better data quality

  Regular use of the data will identify areas of poor quality data and/or missing data. Currently, there are regular “data cleansing” activities undertaken to improve the quality of asset information.

  This requires a cultural change such that the need for good quality data upon which to base decisions is understood throughout the industry.

  Estimated size of opportunity is in the range £1m to £2m.

  Note that this only relates to direct savings. Further savings are generated by correcting the existing data errors. For example, the inspection and maintenance costs of a section of line will be significantly reduced if it is correctly identified that track is continuously welded rather than jointed (through consequential reduced frequency of inspections, no need to plan to lift, pack or grease joints or pull back rails, etc.).

  Data quality also has an impact on the outcome of regulatory discussions about the future level of funding. For example, in respect of funding levels for structures, the ORR noted in their final determination for the CP4 settlement[6] that:

[6] Determination of Network Rail’s outputs and funding for 2009-14 (p79) http://www.rail-reg.gov.uk/upload/pdf/383.pdf

*"… we do not accept that CECASE[7] analysis yet gives reliable estimates of the activity and expenditure levels necessary to achieve this."*

This comment was made as a consequence of the limited data available for use in the analysis. The result of this lack of confidence in the modelled data was a reduction of approximately £300m between Network Rail's Strategic Business Plan and the ORR's Final Determination.

## 5.5 Implementation Issues

The primary ***safety*** issue will be to ensure that the information used is correct, particularly positional information where the tools are using historic trends to predict when future failures are likely to occur. This will also require a clear understanding by the engineers using the tools of any constraints in the models being employed.

The ***implementation*** factors to be considered revolve around both hard and softer cultural issues, as well as the need for having robust processes in place.

The acquisition of reliable technology is important. The associated risks can be mitigated by implementing pilot schemes before rolling-out nationally to ensure that the initial rules used are appropriate. Tackling the softer issues requires a change in culture so that the information produced is correctly understood and that the output is respected, resulting in the appropriate actions being taken.

There is a need for a robust feedback processes to ensure that up to date information is used to analyse the impact of different potential solutions.

[7] CECASE (Civil Engineering Cost and Strategy Evaluation) is a structures modelling tool used by Network Rail.

# 6.0 POSSESSION STRATEGY

## 6.1 Summary of Issue

Although some work is undertaken between trains, most infrastructure expenditure is increasingly incurred in possessions. During previous work it has been noted that there is a wide range of generic possession strategies that are pursued by various Infrastructure Managers. These typically include:

- Multi-day/week blockades;
- Long weekend possessions;
- Short midweek possessions;
- Combinations of the above.

Generally, the unit costs of infrastructure maintenance and renewal activities are reduced as possession length increases (provided the quantity of work required to be undertaken occupies the full possession time). However, increasingly the main driver is consideration of the impact on rail users, with the financial impact on train operations being balanced against the improved efficiency achieved for delivery of infrastructure work. Opinions as to the best solution differ, with some operators preferring a single long interruption with the certainty of no further disruptions for several years, whilst others chose multiple shorter possessions.

An option on multiple track railways is to keep at least one line open throughout the duration of the works. This requires:

- Suitable infrastructure (bi-directional signalling and crossovers);
- Ability to manage railway operations with reduced infrastructure; and
- Ability to work with an adjacent line open to traffic (protection arrangements, type of plant and separation of tracks).

Whilst other European countries regular adopt this approach, it is not such an easy solution in Britain due to the historic characteristics of the network.

A further consideration in terms of possessions is the utilisation made of the available access. This includes issues such as the time to take and give up a possession plus the number of activities planned to occur within the possession. As noted during the ORR Best Practice Study[8], possessions can be taken in 10 minutes, including isolations. This can significantly increase the output from short possessions.

Lloyds Register Rail undertook a more detailed review of possession utilisation on behalf of the ORR in 2006. This study considered the approaches adopted by a number of different Infrastructure Managers.

## 6.2 Good Practice

The approach to possessions varies considerably from regular short midweek possessions through to multi-day blockades. A balance is required between disruption to service operations and providing efficient infrastructure maintenance and renewal activities.

An approach used by European Infrastructure Managers is to minimise the access requirements by adopting intervention techniques that reduce the number of visits required through the life cycle, whilst also optimising the time between asset renewals.

[8] ORR Best Practice Study Visit to Denmark, 17 September to 21 September 2007, Mervyn Carter, Andrew Wallace and Frank Zschoche

**Reduced Operational Impact: Use of High-Output Plant**

A strategy of using high-output equipment has been developed. In conjunction with their ability to operate on one track whilst working on the adjacent line, maximum output is obtained from short blockades.

**Reduced Operational Impact: Use of Protection Systems**

Mobile barrier systems have been developed that enable staff to operate safely within an enclosed space, without the risk of being struck by a train on an adjacent line. This enables traffic to continue operating normally on one track whilst minor maintenance is undertaken on the adjacent line.

A typical system is effectively a rail vehicle without a floor, providing protection from the elements and allowing appropriate power feeds for tools.

It is understood that the enclosed barriers have now been further developed into a production support system. Materials are fed in from an adjacent vehicle and the power tools used in the vehicle have been customised to undertake the task in hand. This has resulted in productivity improvements of up 40%.

**Reduced Operational Impact: Purpose Designed Equipment**

Most European Infrastructure Managers rely on plant specifically designed for a particular task. These machines are generally produced by one of the main suppliers, such as Plasser & Theurer or Matisa, who provide their equipment to clients across Europe.

One benefit from using purpose design equipment, as opposed to multi-purpose road-rail excavator based machines, is that they can be developed such that they can operate with only a single line under possession and/or without a need for the overhead traction power system to be isolated. These characteristics, plus designs that are effectively a single production unit or mobile factory, mean that mobilisation from “last train to start of operations” is minimised.

Consequently, there is increased opportunity for their deployment.

**Reduced Operational Impact: Mechanised Inspection**

A process has been developed that enables mechanised inspection systems to be used wherever possible, be they train-borne or fixed. The train-borne systems are able to operate between service trains and have no impact on the timetable.

**Reduced Operational Impact: Infrastructure Configuration**

The Infrastructure Manager has progressively relocated line side equipment (such as relay cabinets) further from the track during renewal activities[9]. This is so that they can be maintained without the need for staff to be protected from operational lines by possessions or other means.

Whether high-output or not, the benefits from efficient use of specialist equipment is achieved through the quality of the logistical support operations. Both the equipment and any supporting materials trains need to be managed so that they are ready for each work shift. This includes being in the right place, at the right time and facing in the right direction.

**Support Tools to Minimise Operational Impact**

National capacity meetings were introduced in order to reduce the impact of possessions on train operations (particularly short-notice requirements). The process was supported by use of DSS tools that enabled decisions to be made that balanced work objectives and network availability. Adopting this approach has reduced the number of train paths affected by over 50%[10].

In discussions with several Infrastructure Managers, it has been noted that overall coordination becomes more difficult as the number of different train operators using the network increases.

The overall number of possessions required on a particular route section can be minimised by undertaking as much work as possible within each opportunity. This requires good visibility of the required work over an extended period and the ability to look at the requirements of each of the different functions. Detailed planning is then required to ensure that there are no conflicts at the interfaces between each activity.

This process, known as activity clustering, can be undertaken in one of more of three different dimensions:

- Clustering activities into the same timeframe (by delaying or doing work early);
- Clustering activities along a route (extending possession block points); and/or
- Clustering activities across disciplines (e.g. track renewal whilst replacing a bridge).

Successful clustering relies on good management of interfaces (activity and logistical flows) plus availability of sufficient specialist resources.

**Activity Clustering**

Track renewals are planned to avoid a “patchwork quilt” of different short sections requiring renewal in different years. This policy supports maximising utilisation of their high-output plant.

[9] International Review of Railway Safety Practices (for the Independent Transport Safety and Reliability Regulator) by Lloyd’s Register, 2009.
[10] RFF Annual Report for 2009

**Activity Clustering**

The management of track renewals is arranged so that the minimum section treated is in the range 5 – 10km. This optimises the use of the high-output equipment, thus providing more output per possession hour. It also provides improved maintenance benefit as there are longer sections of new asset.

The Infrastructure Manager has a target of achieving a stable work-bank with minimal variation (short-term programme changes or movement in demand requirements). This is in order to maximise the productivity of the high-output equipment.

**Activity Clustering**

The use of DSS tools enables the Infrastructure Manager to obtain a long-term view of the future work requirements. With these extended work planning timeframes (up to three years), it is possible to plan to either defer or accelerate major intervention work in order to maximise the quantum of activity in each possession This allows extended possessions to be negotiated with the train operators as there is a clear understanding that a route will not require blocking again for several years.

**Activity Clustering**

It was noted in the report on the ORR Best Practice Study Visit[11] that a Possession Controller for a 48-hour possession had 89 worksites, with 1,100 personnel delivering work valued at Aus$4.8m.

One method of activity clustering, as practised by parts of Network Rail, is to include within the programme of work both items that are generated on the basis of condition plus those that are identified on the basis of service sustainability. The latter are items that are not a condition-based priority, but can be undertaken efficiently whilst the opportunity is available and help to reduce the average life of an asset.

Another way of reducing the number of possessions required is to ensure that the maximum number of hours is used to deliver work whenever a possession is taken.

**Possession Mobilisation – Various**

The ORR Best Practice Report on the study visit[12] notes that possessions are taken in 20 minutes.

In a previous study undertaken on behalf of the ORR by Lloyds Register Rail it was noted that it taking a possession in various countries can take 15 minutes, 30 minutes, or 30-45 minutes.

[11] ORR Best Practice Study Visit to Australia - 20 August to 05 September 2007, David Brace and Paul Dawkins (CDL Group)

[12] ORR Best Practice Study Visit to Denmark 17 September to 21 September 2007, Mervyn Carter, Andrew Wallace and Frank Zschoche

As well as time spent taking possession of the track, there is also the time spent mobilising the work site ready to commence the activity. Typical approaches to preparing prior to the possession in order to minimise this mobilisation time include moving trains into position prior and taking the possession around them or using nearby stabling sidings. In general, most European countries have more sidings closer to their work sites.

Other preparatory activities include improving road/pedestrian site access and undertaking work prior to the possession, such as laying out new materials where possible. In Britain, bridge reconstructions are generally a good example of the benefits of prior preparation.

Another factor for consideration is the length of possessions used.

**Possession Length**

Along with many other European countries, one Infrastructure Manager has moved towards short possessions in order to minimise timetable disruption. However, they are also making use of longer possession in order to improve efficiency. This is on the basis of not returning to undertake further traffic-disruptive work for several years. Long-term possession plans (typically 5 years) are the subject of analysis to determine the best option. Long-term planning also enables the impact of longer possessions to be included within published timetables.

Another Infrastructure Manager uses longer possessions, but a combination of single line working and availability of diversionary routes enables them to manage the consequential impact on the timetable. The ability to do this is restricted where the network is operating at full capacity.

**Possession Optimisation**

An Infrastructure Manager explained that a regular strategy used is to substitute buses for the lightly loaded last and first trains. This is in order to improve possession output by extending the working time.

**Multi-Functional Possessions**

It was noted in the report on the ORR Best Practice Study Visit that a Possession Controller for a 48-hour possession had 89 different worksites across the full range of functions.

A European Infrastructure Manager generally operates in short mid-week possessions. They are able to deliver significant work volumes in short possessions through detailed planning and the use of innovative plant and processes.

**Detailed Delivery Planning**

Possessions are generally six to eight hours long. A specific methodology has been developed that enables a turnout to be replaced within a single possession. This involves maximised mechanisation of the activities, specially developed plant and small dedicated teams who know exactly what is required from them.

**Reduced Operational Impact: Use of Technology**

Routine use is made of Dynamic Track Stabilisers (DTS) elsewhere in Europe. Although generally used in Britain to enable reopening of the track at higher speeds following engineering work, the technology also provides better interlocking of the ballast. This means that the benefits obtained from tamping last longer, extending the interval between tamping interventions.

A similar approach was described by another Infrastructure Manager who deploys “surfacing teams” that consist of a tamper, a DTS and a Ballast Distribution System, so that all the required work is completed in a single visit.

**Reduced Operational Impact: Maintain Quality**

Having gained confidence in a policy of high quality track renewal to minimise maintenance intervention, an Infrastructure Manager has reduced the fleet of tampers used to maintain their complete network to just 9 machines. These are centrally programmed based on the identified need for intervention, as determined by the inspection regimes and decision support systems.

Conditions on some sections of the main routes are now such that very high working rates are being achieved by these machines (1800m/hour). This enables, in some cases, operation in the daytime between scheduled services. DTS machines are routinely used to follow up both maintenance and renewal tamping to achieve rapid ballast consolidation and thus lateral stability. This is particularly beneficial during the summer months to mitigate the risk of track buckles.

The exact scope of work required can be minimised by undertaking more detailed surveys prior to planning the works.

**Technology to Improve Work Specification**

With the support of the supply chain, an Infrastructure Manager is using GPR technology to better define the scope of ballast renewals. Undertaking site surveys of proposed ballast shoulder renewal areas enables them to determine the ballast fouling and identify exactly the areas requiring treatment.

This ensures that the possession lengths are minimised through constraining the work scope to only include the required work. An additional benefit is that they are also able to better calculate the amount of new ballast required.

It is understood that the use of GPR has reduced the cost of shoulder cleaning by 20-25%.

## 6.3 Current British Practice

Access requirements by the Infrastructure Manager are minimised elsewhere by making use of opportunities to undertake engineering work on one line whilst operating service trains on the adjacent lines. There are a number of reasons, some historic and others due to infrastructure configuration, that make this more difficult to adopt in the short-term in Britain.

**Network Configuration**

The configuration of the rail network in Britain has a number of characteristics that constrain the widespread use of "adjacent line open" possession strategies such as:

- Lack of bi-directional signalling;
- Inability to isolate traction power on a single line only (due to nature of installation);
- Inability to isolate traction power close to junctions without isolating the junction as well;
- Lack of crossover facilities (particularly facing crossovers);
- Tight clearances between tracks; and
- Cross-track cables feeding adjacent lines (signalling and/or traction power).

There is continued removal of these facilities across the network as the cost of on-going maintenance provision is more easily understood than calculating the value provided from the increased operational flexibility.

There appears to be little incentive to planning staff to look at creative solutions where the location and activity offers alternative approaches. This includes previous practices of mixing full line and single line periods within a possession. The number of stakeholders that would be involved, together with the move to a dedicated national planning unit, makes it more difficult to identify when and where the normal rules can be altered to advantage without sacrificing safety.

It is understood that the Network Rail high-output teams' output is constrained as they are only able to accommodate two cable disconnections per work shift. This constraint would be exacerbated where traction power is supplied via a conductor rail as a consequence of the additional cables that would require managing.

One potential solution to this issue would be to prepare the route in advance of the work. For example cross-track signalling and power cables could to be accommodated in under-track crossings and traction current bonding reconfigured to maintain electrical safety and integrity both on the line to be worked on and on line(s) which will remain open to traffic. Doing this presents no insurmountable technical problems and is of permanent future benefit in protecting the integrity of the infrastructure whenever work is carried out. It would require investment and possessions in order to undertake these preparatory works.

Despite these issues, it is understood that the Network Rail's machines are consistently meeting European levels of productivity and output quality. However, unit costs are not being achieved due to logistical problems such as the ease at which the extra-length trains can be moved from their depots to the worksites. The extended transit times also impact on activities such as the time available to undertake preventative maintenance on the vehicles.

Strategies adopted in Europe to maximise utilisation of the machines include operating from A to B along one track of a route and back to A on the other track. This simplifies the logistics of feeding trains into the worksites as well as the need to comply with any operating constraints relating to the number and extent of temporary speed restrictions.

Use of single line possessions with adjacent lines open to traffic requires competencies that are becoming rarer in Britain. The age profile of staff means that this level of retained expertise continues to reduce, as experienced people retire.

**Reduced Competence**

From an operational perspective, the lack of widespread signalled bi-directional operation means that single line working requires a pilot man. From an infrastructure operations perspective, work has to be managed so that nothing fouls the open line.

The RIAB recently published a report on an incident at Washwood Heath where a passing service train was struck by a rail[13]. Reference is made to the fact that there were 12 different procedures, 4 different manuals / books and at least 1 Standard that were directly relevant to the incident. This approach of work being governed by standards does not encourage safe behaviours to be naturally demonstrated.

The incident will further increase the reluctance of others to use this approach in future. Efficient operations require a judgement to be taken on the appropriate balance of cost required to mitigate risks. Understanding levels of available staff competence is an input to that decision making process.

Although there is a strong imperative on all Infrastructure Managers to reopen routes to operational traffic on time, the industry-wide consequences of giving-up a possession late in Britain seem more severe. This leads to a more conservative approach being adopted for possession utilisation than seen used by other Infrastructure Managers, with additional contingencies included in the plan. With increasing pressure being applied in Britain to shorten possession time due to the demands to operate more trains, this will have growing impact on the cost of delivery.

**Reduced Optimisation**

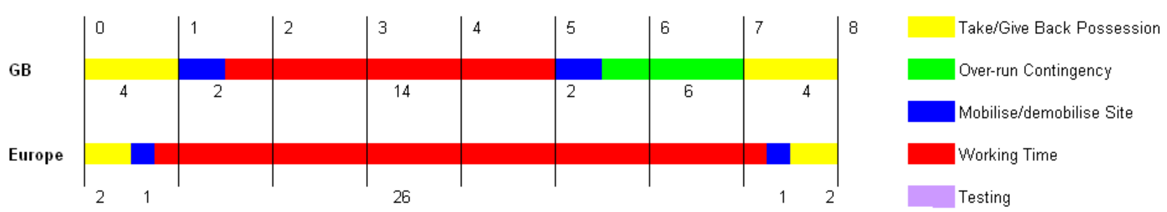
The risk-adverse approach to mitigating the likelihood of a possession over-run is driven by external forces/stakeholders as well as the financial pressure from train performance schemes.

It can lead to there being only a single work site within a possession to avoid issues at the interfaces. The work plan will generally be developed with an aim of handing back the possession before the planned team.

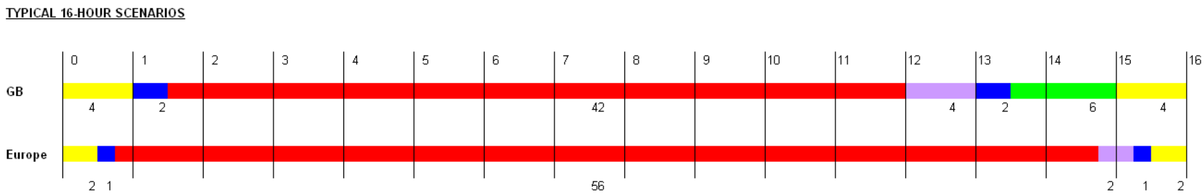
Both of these drivers result in sub-optimal use of the available possession time.

The diagrams below indicate the proportion of working time typically available within British and European possessions. Both typical 8 and 16 hour possessions are depicted.

TYPICAL 8-HOUR SCENARIOS




[13] Rail Accident Report Passenger train struck by object at Washwood Heath on 6 March 2010, January 2011, RAIB Depratment of Transport




**Reduced Optimisation**

The introduction of a dedicated planning unit has provided increased professional expertise. However, it has also introduced a new interface between those specifying the work and those planning it. There needs to be close cooperation to ensure that plans are optimised and that the time constraint tolerances are used effectively by the planners.

As an example of the result of this approach, it is understood that tamping and grinding machines are now doing far higher transit miles between working shifts because each machine is being scheduled to the next highest priority site. With an engineering overview, productivity could be increased and transit running decreased by reviewing sites and clustering jobs with suitable manual remedial intervention for delayed priority sites.

The additional transit miles being travelled will decrease the life of the machines as this is not a task that they are primarily deigned to undertake.

The regime adopted in Britain to compensate train operators for the cost of service disruptions as a result of engineering work (possessions or loss of facilities) is more sophisticated than that seen elsewhere. The regulatory framework includes mechanisms for both possession disruption (Schedule 4) and train delay (Schedule 8). A performance indicator to measure possession disruption to both passenger and freight trains has also been introduced recently.

**Potential Perverse Incentives – Minimise Disruption**

Review of Network Rail's Annual Report for 2009 plus the ORR publication "NR Monitor" for the same period indicates that:

- Financially, cost of train delay minutes (Schedule 8) was broadly on target;
- Possession disruption costs (Schedule 4) are less than planned; and
- Possession disruption KPIs for both passenger and freight is better than target.

Although these figures appear to be telling a "good news story", there is no visibility of the potential costs and impact on productivity associated with achieving these targets.

**Potential Perverse Incentives – Sophisticated Process**

The incentive scheme that is incorporated into the regulatory framework is the result of significant consultation and development work that has been undertaken to consider the needs of all the stakeholders.

However, it is believed that the complexity of the scheme has led to it being too difficult to routinely undertake business case reviews of whether it is more cost beneficial to spend additional money on Schedule 4 costs in return for increased productivity within a possession. As a consequence of this hypothesis, it is believed that possession planning is generally undertaken on the premise of using standard block times.

**Potential Perverse Incentives – Christmas Working**

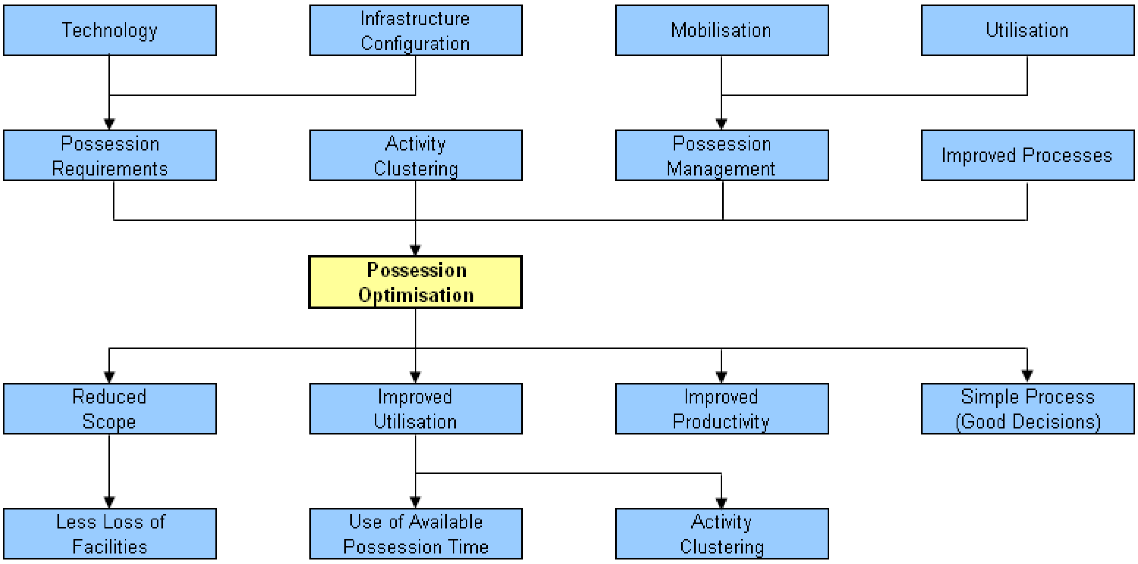
As a result of the pressure to minimise the impact on train operations, Britain's railway industry now has significant peaks of activity over Bank Holidays, particularly during the Christmas/New Year period. The use of resources at this time usually attracts significant premium payments.

Elsewhere in Europe, there is very limited (if any) activity over Christmas. The main reasons for this are:

- Risk of adverse weather conditions, particularly low temperatures;
- High cost of mobilisation, particularly when any facilities required can usually be provided at more suitable times of the year, at normal cost;
- This period is traditionally utilised for workshop-based refurbishment of plant and equipment; for the rest of the year maintenance is carried out in the field; and
- Machine crews are nomadic and very often multi-national, with home leave over Christmas being both expected and provided.

## 6.4 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




From the case studies it can be seen that:

- Possession requirements can be reduced by the appropriate use of technology, such as the use of high-output equipment or the use of equipment that only requires a single line block without isolations;
- Possession requirements can be reduced by progressive improvements to infrastructure configurations, such as by moving location cabinets so that they can be accessed without the need to be on the track;
- Activity clustering improves utilisation of possessions, with clustering possible either across functions, by careful selection of possession limits or by delaying/bringing forward work items ;
- Better management of the possession processes can also reduce lost possession hours through improved hand-over/hand-back processes and contingency management; and
- Alternative processes are available that reduce the need for possessions, such as virtual inspection techniques.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Reduction in loss of operational facilities

  There are techniques available that enable work to be undertaken without the need for isolations or the requirement to block all lines throughout the possession. This means that trains can continue to operate around the worksite.

  This requires the requisite operational and planning competencies to be available, plus investment in the necessary equipment. There would also need to be a campaign to gradually change the infrastructure configuration in order to facilitate this approach.

Estimated size of opportunity is in the range £2m to £11m.

- Improved utilisation of possession time

  Currently, the process used to take and give back possessions in Britain is noticeably longer than those used by other Infrastructure Managers. Also, due to the pressure applied by many stakeholders, there is a risk-adverse approach to mitigating possession overruns. This usually includes adding contingency time within the work plan. For possessions of 8 to 16 hours duration, it is estimated that this reduces utilisable possession time by approximately 30%.

  Removing this lost time requires introduction of an improved method of taking possessions and a different approach to mitigating the risk of possession over-runs.

  Estimated size of opportunity is in the range £9m to £18m.

- Improved utilisation from activity clustering

  As noted in the case studies, many Infrastructure Managers use activity clustering as a tool to improve utilisation of possession hours. Whether by time, geography or function, it is possible through better long range planning to successfully cluster more work into each possession. This requires detailed planning and delivery management.

  Activity clustering requires good long-range modelling and detailed planning. It also requires DSS tools to be available that enable easy financial analysis of different possession strategies to be undertaken.

  Estimated size of opportunity is in the range £16m to £21m.

- Improved productivity from better planning

  The need to undertake work in shorter possessions provides a focus for the industry to develop smarter methods of undertaking work. Efficiencies can be gained from reducing the number of shifts planned for each resource (plant and manpower).

  Improving productivity through better planning requires a culture to be in place that encourages innovative approaches and rewards teams who find ways of reducing the required possession time.

  Estimated size of opportunity is in the range £6m to £11m.

- Improved productivity from processes and technology

  A number of the case studies identified opportunities for improved productivity through adoption of different approaches, such as:

  - Reduced tamping intervention from higher installed quality;
  - Remote capture of asset condition;
  - Higher output from plant by avoiding “patchwork quilt” intervention patterns; and
  - Using better inspection techniques to determine the exact assets that need treatment.

  No associated generic precursors have been identified, other than the need for investment to implement each of the specific solutions.

Estimated size of opportunity is in the range £6m to £24m. Some of these savings are already included in other sections, e.g. reduced possession requirements from remote capture of asset condition.

- Improved decision making from simple process

  It is believed that the current process for calculating compensation for train delays does not easily facilitate a cost benefit analysis comparing the extra costs versus cost reduction from productivity improvements. This would identify occasions were it is more beneficial to cancel trains to provide a suitable possession window. Other benefits include the potential for less Bank Holiday working (with consequential reduction in the payment of premium resource rates) and less people required to manage the compensation process.

  The principal precursor is the development of a suitable DSS tool.

  Estimated size of opportunity is in the range £11m to £17m.

## 6.5 Implementation Issues

The primary ***safety*** issue will be to ensure that sufficient possession time is made available to maintain the railway, particularly during the transition period from the current approach to one that reduces the engineering access requirements. There are also risks associated with the introduction of a new methodology for taking possessions that must be mitigated.

Particular risk mitigation will be required to ensure that the communications processes are sufficiently robust to confirm that the correct sections of infrastructure are blocked before work commences. Any changes would need to be supported by an appropriate launch plan.

The ***implementation*** factors to be considered include the need for changes to the Rule Book. The implementation programme would be extended by factors such as the planning lead time for existing work-bank driven possessions.

# 7.0 SUSTAINABILITY OF STRATEGY

## 7.1 Summary of Issue

Any strategy must be sustainable, in that it considers the whole life cycle and does not result in an increasingly unreliable network. The life of an asset maybe determined on the basis of time (age), tonnage or number of operations. A sustainable strategy means that decisions are not made on the basis of short term imperatives, producing a plan that results in renewals being deferred beyond the optimum point. This does not mean that a good asset strategy cannot include life extension of assets to achieve a more optimal programme of asset renewals.

In terms of understanding the relative unit costs of different Infrastructure Managers, the question of apparent renewal backlog is a critical factor. The underlying assumption used in the benchmarking process is that, in general, there will be a steady level of assets reaching the end of their life. The use by the UIC LICB dataset of average renewal expenditures over a number of years in their assessment process further smoothes any peaks and troughs.

A factor in considering the sustainability of the chosen strategy is the ability to fully implement any changes. For example, a strategy of refurbishment requires the implementation of a culture and capability that proactively extends the life of the assets.

The adoption of different intervention strategies can have an impact on the overall unit costs. A strategy that has been adopted elsewhere is one of minimal capital expenditure as a consequence of the economic and political environment that they operate within. They have an excellent understanding of their asset condition and through appropriate levels of component exchange, are broadly able to deliver the required levels of train performance. The question of the sustainability of this strategy has been questioned by others.

An analysis of the whole life benefits of renewing either earlier or later in the life cycle of an asset has been reviewed by others. This indicated it that maybe less economically beneficial to significantly extend an asset's life and defer the renewal, whereas analysis by a different Infrastructure Manager has led to the opposite conclusion. This disagreement on the best approach is indicative of the fact that there is no simple answer and suitable strategies are required.

In Britain, a legacy of the Railtrack era as Infrastructure Manager was perceived to be a renewals backlog, which Network Rail has been addressing since its formation.

## 7.2 Background

The UIC LICB benchmarking analysis is based on the assumption that the level of maintenance and renewals activity being undertaken by each Infrastructure Manager is appropriate to sustain the long term future of the infrastructure. Enhancement expenditure is excluded from the analysis.

The approach introduces several issues that could be relevant in understanding some of the differences in harmonised costs of the various Infrastructure Managers. These issues include:

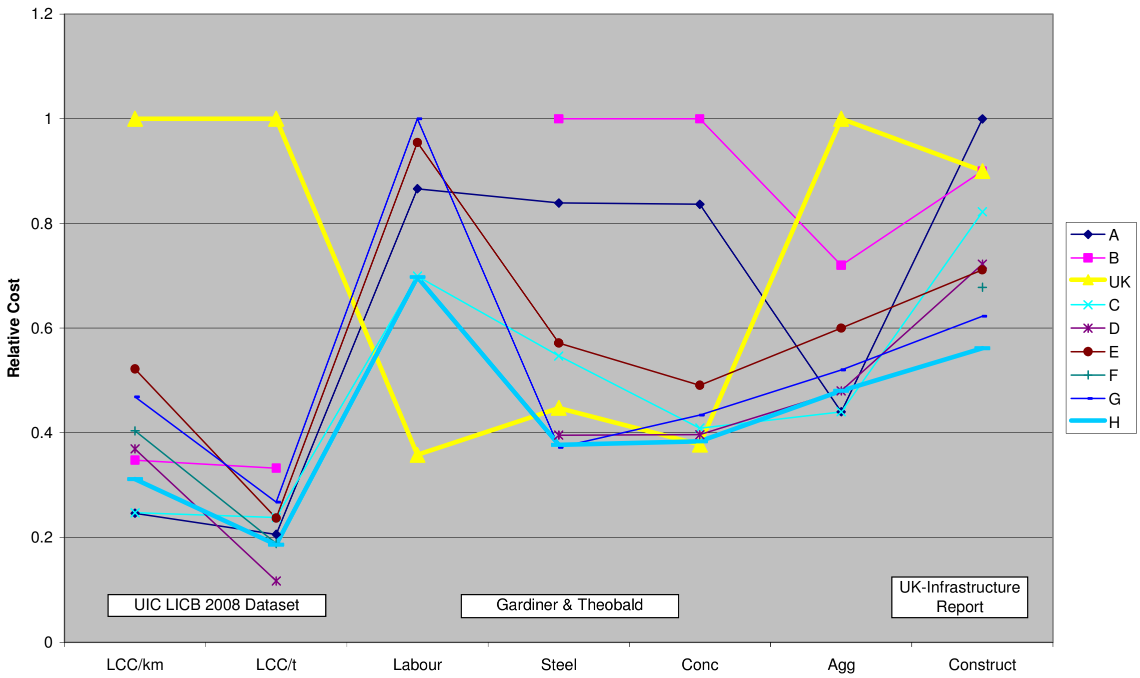
- Unsustainable deferment of work that will need a future recovery programme;
- Consistently defining the boundary between renewal and enhancement work; and
- Consideration of renewal activity superseded by enhancement projects.

A review of the relative renewal strategies and some financial comparisons has been undertaken. The conclusions drawn are as follows:

- Overall, quality of rail infrastructure is not perceived to be significantly different across the main European Infrastructure Managers;
- Independent reviews that have assessed the backlog of work are based on the balance of renewal and maintenance intervention, not safety;
- Analysis of UIC LICB data[14] (based on traffic carried) would appear to indicate that track (particularly rail) in Britain is replaced at an earlier age (see graph below);


- Signalling renewal strategies can be managed through component replacement, so renewal decisions are generally made on the benefits achieved from transferring to the latest technology;
- Most traction systems are generally yet to reach the end of their useful life and, to date, the primary strategy adopted has been component replacement;
- Renewal of structures is based on a life cycle significantly in excess of any benchmarking period;
- Relative levels of enhancement expenditure varies significantly across Infrastructure Managers, potentially impacting on the reported renewal activity;
- A review of the Infrastructure UK results with those from UIC-LICB would appear to indicate that, whilst Britain's input costs are generally low, the output costs are high[15] (see graph below);

[14] This is a high-level analysis based on the reported proportion of the asset reported as being renewed and the network-level average traffic carried. Input data is from 2008 UIC LICB dataset, using average traffic and asset renewal data. Term "Ballast+" includes proportion of ballast recorded as being either replaced or cleaned.




- There is some evidence to suggest that Britain has adopted a more conservative approach to innovation and the adoption of new technology than other countries.

From the evidence, a potential hypothesis appears to be that any "backlog" of work is caused by a change in the desired maintenance/renewal mix. This is usually either as a consequence of:

- Need to reduce Opex expenditure through increased investment;
- An increase in rate of degradation as a result of increased or changed traffic levels; or
- Need to renew long life assets that do not become life-expired uniformly over time.

If the hypothesis is correct, other than the latter case, the causes of "backlog" are more influenced by the decisions of stakeholders (primarily maintenance intervention levels and available funds) than by technical factors.

## 7.3 Good Practice

A method of managing the renewals programme is to use life extension techniques on specific components. As noted previously, this approach can also be used to cluster renewals in order to efficiently utilise possession opportunities.

**Development of Life Extension Techniques**

Specialised teams undertake life extension of switch and crossing units at a set periodicity. These techniques include the Second Life System (SLS) that enables gauge issues to be rectified. This approach has led to the required skill sets and competences being developed.

[15] This is only a high-level analysis, with no harmonisation undertaken. It compares the average cost for each category for each country with the highest reported rate for that category, providing a simple visual comparison.

**Deployment of Life Extension Techniques**

Long-term modelling provides a theoretical life, which is converted into a technical life following inspection. Central oversight of plans enables the technical lives of adjacent assets to be extended such that renewal items can be “clustered” into the same possessions.

**Life Extend or Renewal Decisions**

The decision on whether to renew or life extend through heavy maintenance and/or component replacement is undertaken by cost benefit analysis (DCF). The analysis makes use of life cycle models to predict the maintenance input required. Other factors considered include likely train delays and any potential safety impact.

As well as enabling possessions to be better utilised, other advantages from clustering work (both geographically and chronologically) are:

- Enables high-output equipment to be efficiently utilised; and
- Enables signalling, traction power and track to be renewed at the same time.

**High Output Renewals – Various**

Good ballast conditions are considered by most European administrations to be essential for economic maintenance and realising the life expectancy of other components. They consider it better to ballast clean and maintain by tamping, rather than the British approach of maximising ballast life by use of stoneblower technology.

**High Quality Renewals**

For main routes a policy of complete renewal is adopted, including in many cases formation rehabilitation and drainage. The availability of Formation Rehabilitation Machines capable of carrying out this complex process in single line possessions has influenced this decision. This approach is considered to be justified where it is necessary to ensure highly reliable performance from the asset at minimum cost and intervention. Where the recovered track from these renewals has a residual life expectancy, it is cascaded directly to subsidiary routes.

Sections subjected to “fence to fence” total upgrade then revert to a “reballasting and rerailing” strategy, with maintenance replacement of pads, insulators and fastenings, at appropriate intervals over the long term. Sleeper renewal will occur no more frequently than every 40 years.

**Maintain High Quality**

An Infrastructure Manager has reduced the fleet of tampers used to maintain their network to just 9 machines. These are centrally programmed based on the identified need for intervention, as indicated by the inspection regimes and decision support systems.

Conditions on some sections of the main routes are now such that very high working rates are being achieved by these machines (1800m/hour). This enables, in some cases, operation in the daytime between scheduled services. DTSs are routinely used to follow up both maintenance and renewal tamping to achieve rapid ballast consolidation and thus lateral stability. This is particularly beneficial during the summer months to mitigate the risk of track buckles.

The case studies are indicative of the benefits that can be derived from a long-term strategy of targeting renewals, sometimes at a higher level than is necessary from condition assessment, on selected routes. However, as explained below, this can provide benefits at a network-level through cascading material to less critical routes.

It appears that several Infrastructure Managers are developing their asset renewal programmes around the availability of the next generation of technology (particularly signalling control systems), in order to maximise the available benefits.

**Monitoring Technology Development**

An Infrastructure Manager has started a programme that will see the entire network switch to an ERTMS signalling system by 2021. This will not only improve reliability, but also provide enhanced safety and capacity benefits. By adopting a programme of complete conversion to the new system, they will obtain additional benefits through avoiding the need to deliver multiple staff training programmes or hold stocks of different spares.

The experience from across Europe of deploying ERTMS has not been totally positive. Difficulties have been experienced in managing the transition from a classical signalling system to an ERTMS based solution. Technology continues to evolve and this has caused problems of system integration between infrastructure and rolling stock elements.

One strategy that can be used to achieve an affordable and sustainable renewal policy is to cascade components, usually involving the movement of components from high use lines to lower category routes. Many Infrastructure Managers recover signalling components to a central location for refurbishment and testing prior to reissue.

**Component Cascade Strategy**

The track renewal programme includes cascading material to lower category lines as an integral element. It is understood that this whole life cycle approach maximises the asset life, although it may result in higher renewal activity on the primary routes. The benefits from this higher level of renewal are seen through lower levels of maintenance intervention being required, such as less frequent tamping.

An alternative approach is to replace at component level rather than system level. Depending on the extent of the component replacement, this may be undertaken within a general maintenance programme.

**Component or System Renewal**

The traction power system is almost 100 years old and has not been renewed. However, many components have been replaced during the intervening period including the contact wire. This is an approach adopted by several Infrastructure Managers.

**Route Criticality**

Maintenance and renewal policies for regional lines use a 'patch and mend' approach, with components being cascaded from main lines. Rural lines only receive minor maintenance with speed restrictions used to ensure safety, unless additional funding is received from local sources

## 7.4 Current British Practice

In Britain, future renewal levels are forecast using models that include predicted operational requirements. The specific site proposals are based on condition inspections undertaken by local staff.

**Development of Track Renewal Programme**

Network Rail use V-TISM to centrally determine the renewal requirements, based on age and deterioration. A track policy, based on route criticality, is then applied to determine the future activity levels.

The specific site proposals are based on condition inspections that are undertaken by local staff. These proposals are then peer reviewed to ensure national consistency and application of engineering rules. The nature of the track assets means that there is a low level of variation in the quantity of renewals required each year, unless there is a significant change in engineering policy.

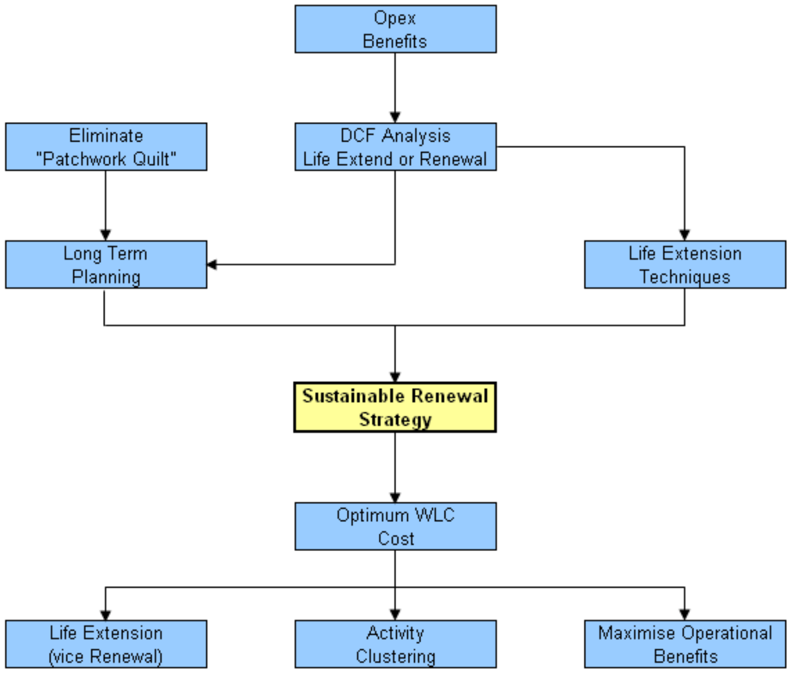
**Development of Signalling Renewal Programme**

In addition to those proposed as a result of asset condition, signalling renewals can be proposed as a result of track renewals, remodelling schemes or capacity increases. The need for a renewal may be avoided by component replacement under maintenance until obsolescence issues are encountered.

As with several other asset types, the quantum of signalling renewals included in each year's programme can vary significantly. As signalling renewals are driven by factors other than the condition of the asset (such as major electrification schemes) both historic and future life cycles tend to have clustered asset life expiry dates.

## 7.5 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




From the case studies it can be seen that:

- Renewal strategies can be managed through long-term modelling to determine the best time to renew based on whole life and system perspectives;
- Life extension techniques enable renewals to be postponed until the determined optimal time; and
- Avoiding “patchwork quilt” renewals provides operational benefits.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Life extension

  Through understanding the available methods and being able to predict the future maintenance workloads, it is possible to determine whether it is more beneficial to defer renewal activities or undertake them prematurely.

  This approach requires the right data (asset details, asset condition and unit costs) entered into good models, with the benefits and costs being considered at a system level.

  The overall benefits are difficult to calculate. From a signalling perspective, the adoption of an approach of complete replacement of all the complete train control system with an ERTMS solution is based on a number of benefits[16]:

  - Improved safety from automatic train protection facilities;
  - Increased operational performance providing additional capacity;

[16] “The Signalling Programme: A total renewal of the Danish signalling infrastructure” published by Banedanmark, 2010.

- Improved train performance from reduced asset failures;
- Reduced maintenance from removal of trackside equipment;
- Single system reducing the need for multiple spares and training programmes; and
- Procurement efficiencies from large contract awards.

It has not been possible to easily identify the potential financial implications of this strategy in terms of Britain's network.

Review of the track assets indicates that Britain replaces it's assets at an earlier stage than other Infrastructure Managers. Extending the average asset life by 30% with an increase in maintenance costs of 30% would provide a potential saving of £370m.

However, the potential opportunity may be reduced in the short-term due to the position in the renewal cycle of several large systems. For example, many British signalling systems were replaced during the Modernisation and Electrification Programmes (late 1950s to early 1970s). These large one-off signalling renewals are not evenly spread and are starting to become required again. Long-term forward planning would enable this issue to be understood and the potential of a network-wide rollout strategy evaluated.

However, even a 5% reduction in renewal levels would provide an opportunity benefit of £62m.

- Avoid "patchwork quilt" renewal patterns

  Through long-term planning, it is possible to cluster renewals so that the opportunity is taken to efficiently renew more assets at the same time.

  This approach requires the right data (asset details, asset condition and unit costs) entered into good models, with the benefits and costs being considered at a system level.

  The potential savings from this approach are already included elsewhere.

- Maximise operational benefits

  Targeted asset renewal can provide additional operational benefits. For example, one signalling renewal strategy is supporting a policy of significantly reducing the number of control centres required across the network. Another example would be the elimination of jointed track to reduce maintenance requirements.

  Adoption of this approach requires a clear understanding of the greater benefits that can be realised from a "renewal campaign".

  Estimated size of opportunity, based on the two examples quoted, is in the range £13m to £37m.

## 7.6 Implementation Issues

The primary ***safety*** issue will be to ensure that any change in asset policies and renewal programmes does not result in an overall reduction in asset condition such that safety levels are breached, ultimately increasing the risk of derailment or collision.

The ***implementation*** factors to be considered include the need for a coordinated change programme such that the changes are well communicated, as well as the provision of training and support tools.

# 8.0 DEVELOPMENT STRATEGIES

## 8.1 Summary of Issue

Innovation is required to meet the on-going demands for the railway systems to carry more trains, running more reliably whilst costing less to operate. Meeting these demands requires continual development of people, processes and plant. In terms of good asset management, these developments must be generally targeted at solving the identified problems, rather than pure “blue sky” thinking.

An Infrastructure Manager can encourage the supply chain to innovate and develop new solutions by:

- Clearly communicating the asset policies that it has adopted; and
- Providing sufficient detail to enable the supply chain to assess the potential benefits and risks from any development investment.

They can also influence the development strategy both directly through the provision of funding and indirectly through ease of product approval process and speed of adopting innovative solutions.

A good example of supply chain encouragement was the development of formation renewal trains. A proposal was made to the Infrastructure Manager by a supplier indicating that they had a concept that they could develop to help reduce the cost of formation rehabilitation. A partnership was formed that has proved successful for both parties.

Early evidence gathered by R-VfM team indicated that innovation in the industry is lower than anticipated[17]. An industry must maintain a critical mass of innovative activity flowing through into the delivery teams in order to achieve the necessary level of continuous improvement. In Britain this does not appear to be the case in the rail infrastructure industry.

It is perceived that Britain has a culture where fear of failure is too great to encourage innovation. Project managers select proven solutions rather than risk time and/or cost overruns on their project. Additionally, the need to consult with many stakeholders before change can be implemented acts as a further disincentive.

## 8.2 Good Practice

The approach adopted to risk management is key to the successful introduction of innovative solutions. In general, the supply chain will tend to have more incentive to develop new and improved ways of managing the asset than an Infrastructure Manager. The reason for this is that the supplier will be trying to enter the market or increase their market share. As such, they are likely to make more proactive decisions on the likelihood of success during the development phase. The culture of most Infrastructure Managers is one of being conservative towards change in order to minimise any safety risks.

A suite of three models has been developed by a European contractor that is used when working with Infrastructure Managers. These provide the necessary incentives for both parties to invest in developments, with the most appropriate being selected for the specific circumstances.

[17] Presentation given by Sir Roy McNulty to Infrastructure Maintenance, Renewals and Upgrades Conference, London November 2010

**Partnership Models**

Three different models have been used when working with the Infrastructure Manager[18]:

- Win-Win Model

  This involves a profit sharing agreement, with each party focused on its core capabilities but an aim to improve the end-to-end process. An example of this is the deployment of High-Output OHLE plant.

- Total Service Package Model

  A second model is the provision of a total service. Efficiency is driven into the process by through long-term work-banks and dedicated teams. Delivery of S&C renewal is an example of this approach. The client defines where, when as well as determining possession availability, leaving the supplier with responsibility to deliver.

- Joint Venture Model

  The third model involves the formation of a commercial partnership. This approach was used in supply of modular S&C units to site, which required development and procurement of new equipment.

**Encouragement of Innovation in Tender Responses**

When responding to ITTs issued by a particular Infrastructure Manager, contractors are free to offer any methodology that will achieve the overall specification. Acceptance of an offer will usually be on the basis of the least number of possessions, the maximum output in each possession and the lowest cost.

Mobilisation can be expensive for some sites, especially where the safety systems are necessarily extensive and innovative ways of implementation at least cost can be instrumental to winning the work.

Infrastructure Managers need to understand the market in order to ensure that short-term gain does not result in long-term pain. The following case study is an indication of the potential implications of short-term focus.

**Highly Competitive Market Conditions**

Competition between European track contractors is intense currently as they all need to maximise utilisation of their high output equipment. In these market conditions, it is understood that at least one Infrastructure Manager has adopted a “least cost” approach that has been reinforced by inviting new players into the market and delaying the issue of ITT documents. This has reduced the unit price by over 50%. However, this is now at a level where investment in new machinery is unsustainable and there will be long-term productivity impacts.

[18] Co-operation and Innovation Cut Life-cycle Costs by Martin Benkler, Railway Gazette International, November 2010

A number of case studies have been identified across Europe that demonstrate the benefits that can be gained by using the specialist knowledge in the supply chain to develop ideas in partnership with an Infrastructure Manager.

**Development of Switch Monitoring System**

An Infrastructure Manager is working with their supply chain to develop a method of measuring switch blade wear without the need for a track possession.

**Development of Defect Measurement System**

An Infrastructure Manager worked with a specialist supplier to develop a system to monitor defect density and damage depth during grinding operations. The solution has now also been deployed in Austria, France, Netherlands and Poland[19]

**Development of a Formation Train**

A supplier developed the concept of formation rehabilitation plant and then discussed this with an Infrastructure Manager. This resulted in them gaining agreement for support to be provided for the development of an initial machine and undertake the necessary trials. A machine was ordered (with the plant manufacturer and supplier sharing the risk of failure). The trials proved the concept viable and the supplier now operates a fleet of 6 machines that are used all over Europe.

A key benefit of using the supply chain is the potential introduction of innovative thinking. This is based on bringing clarity of focus on achieving a solution, rather than using a team that attempts to find a solution whilst also still delivering their day job. This approach works best when there is a clear specification of the required outputs, including a clear definition of the main drivers for innovation – time, quality, or cost.

**Modular Switch**

A need was identified for the capability to be able to renew a lead within a short midweek possession. The time constraint was the prime driver.

As already noted, another strategy used in Europe is continuous development of the initial concept to further improve performance.

[19] Rail Milling and Grinding, James Abbott, European Railway Review (Digital), 2009

**Continued Development of a Formation Train**

A supplier developed the mechanised formation renewal process. The concept continues to be developed and the latest version acts as a ballast cleaner, converting to a formation rehabilitation machine (by dropping an additional cutter chain) to treat specific short intermediate lengths that require attention

**Continued Development of Enclosed Barrier Vehicle**

The concept of enclosed barrier vehicles was developed in order to enable staff to safely work on a track whilst the adjacent line is open. The initial concept has continued to be developed with power feeds for tools and methods of supplying material to the required area now added. These additions have further improved productivity.

**Encouraging Continual Innovation**

In order to consistently win work, contractors have to offer on-going development of methodology and equipment. This is entirely at their own risk, but where the Infrastructure Manager can see that efficiencies and cost reductions can be gained, it can result in work being awarded. The contractor can then implement the innovation in real conditions, with the incentive to make it succeed and gain a competitive advantage.

Although Infrastructure Manager does not directly financially support such development, because it is an informed client it will recognise the potential benefits that could accrue from the initial proposal. The contractor can develop the proposal for inclusion in future tender responses safe in the knowledge that the Infrastructure Manager will not attempt to take ownership or divulge details to the contractor's competitors.

The view taken by Infrastructure Manager is that, when the contractor successfully implements the proposal and gains a competitive edge, its other suppliers will have to follow and they will reap the broader benefits at that stage.

Development projects do not need to be solely confined to the introduction of either new technology or equipment. Changes in process through the robust application of production engineering principles can be equally effective at reducing costs through the removal of waste.

**Industrial Engineering**

An Infrastructure Manager employs an industrial engineer to improve their productivity. It was noted that a third of improvements come from plant, a third from processes and the final third from people.

**Industrial Engineering**

A European Infrastructure Manager noted in their recent Annual Report that the cost of UIC 7-9 track renewal has been reduced to €668k/km as a result of the use of industrial engineering to improve productivity.

Approval processes need to be clearly defined and effective, whilst ensuring that risks are suitably controlled.

**Approval Process**

All requests for new products or processes have to go through a two stage process. Firstly an application is made to the Rail Regulation Office for type approval. Once this has been approved, the application then goes to the Infrastructure Manager for technical approval.

The whole process takes approximately 6 months. However, if trials are required, then this timescale could extend to 12 months but very rarely beyond.

Interoperability approval certificates are accepted by a number of European organisations. For example, when mobile flash butt welding was introduced approval certificates from its introduction elsewhere were accepted as proof that the system is safe and technically competent to undertake the work.

**Approval Process**

When a contractor develops new methodology which involves the introduction of new plant and equipment, there will be confidential advice and encouragement offered by the Infrastructure Manager. There is an approval process to be gone through, and although this is onerous, particularly for OTP which will transit on the open network, it is well-defined and designed to proactively support progress towards acceptance.

With approvals in place, the contractor will want to trial the new methodology. The Infrastructure Manager will sometimes provide a trial site, but usually the contractor will have to implement the system alongside the existing system at a site where he has already been awarded the contract to carry out the work. The Infrastructure Manager will support and facilitate the trial, but this has to take place without detriment to the completion of the contracted work.

## 8.3 Current British Practice

RSSB recently undertook research on behalf of TSAG to review the issues surrounding introduction of innovation into the rail industry in Britain[20].

**Constraints to Introduction of Technical Innovation**

Identified barriers included:

- Lack of systems view
- Limited timescales
- Weak innovation processes
- Weak innovation culture
- Implementation risks (testing, standards, acceptance)
- “You offer an idea and next you know its out as an ITT to cheapest bidder”
- Unique GB constraints – small specialist market
- Long asset life (impact on business case of remaining asset life)
- Risk adverse (“known as person who bought failure”)
- Standards syndrome

Proposed solutions included:

- Industry leadership to sponsor
- Industry capability
- Reduced commercial risk (assess on basis of safety and fitness for purpose)

One of the issues observed in Britain is that any development initiative will involve a number of specialist groups. This results in the need for a higher level of stakeholder consultation (not necessarily with any clear identification of responsibilities) slowing down progress towards implementation. The number of stakeholders can also lead to a lack of clear leadership and decision-making process.

**Stakeholder Consultations**

Development of new solutions may require involvement of delivery teams, technology teams, NDS, procurement teams plus the product approval group. The product approval process is not well granulated to be suitable for both items of large plant and those processes that are relatively small in scope (and risk), but potentially provide significant benefits.

[20] RSSB Report T934 Enabling Technical Innovation in GB Rail Industry, April 2010, produced by A. D. Little.

Some of the difficulties faced by the supply chain in Britain are clearly set out in a recent quote[21]:

> *"There is a keenness within the supply chain to work together, but opportunities for planning, specification and innovation have to be driven by the client. The difficulty is that we don't know the work stream, or the timescales get changed on rail projects, or the specifications change."*

The dual pressure of these constraints and the need for ever increasing cost reductions is removing organisations from the supply chain. These issues are recognised and much work has been done to improve the visibility of future work streams.

There does need to be discussions and guidelines issued by the Infrastructure Manager in order to ensure that the developments provide system level efficiencies.

**New S&C Designs**

A new suite of S&C designs (RT60) using 60 kg/m rail was developed by the supply industry to an outline specification that required a common footprint to be used by each manufacturer. The solutions that were developed were sufficiently different that there was no inter-changeability between the different manufacturers' solutions. The way forward has been to move to a standard design (NR60) based on the best aspects of the individual RT60 designs.

It has been noted that other Infrastructure Managers provide the opportunity to develop and implement good ideas. The route often taken in Britain is that, following development, the implementation phase is the subject of competitive tendering. This adds risk to the developer in that they may not necessarily have the opportunity to obtain a return on their investment. It is not clear whether this is an issue of interpretation of EU Procurement legislation or one of corporate governance.

Factors beyond the control of the stakeholders, such as local legislative requirements, can prevent the simple introduction of proven European solutions.

**Modular Switch and Legislative Compliance**

The British modular switch concept is based on a proven process that has been operating in Europe for several years. Several existing wagon designs exist. However, the existing designs were not used as they did not comply with Working at Height Regulations.

In order to comply with this legislation a series of cross beams and deck beams have been introduced to remove the need for staff to climb onto the wagons. As a result:

- It takes longer to load the new switch panels to the tilting wagons at the depot;
- Different system configurations are needed for each type of layout; and
- The system does not easily allow for old panels to be recovered using the wagons.

[21] Janet Strzebrakowski, Interim Head of Procurement, Colas Rail. Quoted on Supply Management website (www.supplymanagement.com) on behalf of Chartered Institute of Purchasing & Supply

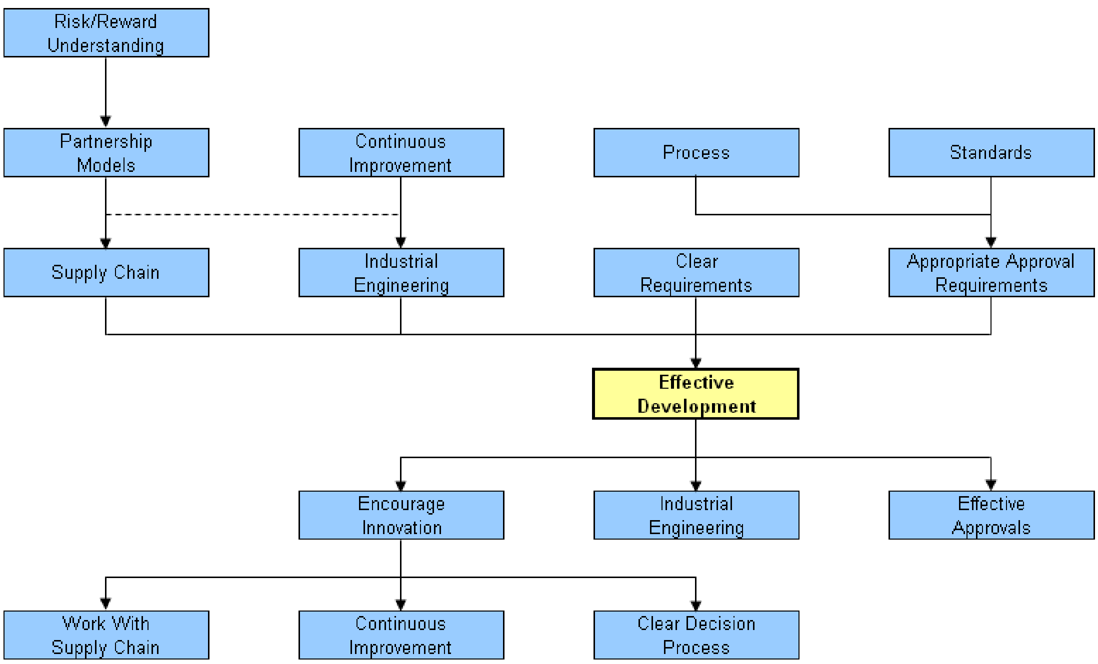
The cost of complying with legislation and Standards is an issue raised within the recent Infrastructure-UK report[22]. Two relevant examples noted in the report are that:

- Network Rail estimates that it spends in excess of £10m per annum complying with legislation to protect rare species such as newts, badgers and bats; and
- Impact of industry-specific standards is that a passenger lift for the rail industry costs £59k per unit more than the equivalent lift for other environments.

This is further exacerbated by the general increase in requirement to demonstrate compliance, which is a more general issue rather than just a British one. European plant manufacturers estimate that this has added 5% to the cost of their equipment over recent years.

## 8.4 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




[22] HM Treasury: Infrastructure UK Infrastructure Cost Review: Main Report December 2010

From the case studies it can be seen that:

- Both supply chain and Infrastructure Managers contribute to new developments;
- Different models have been used to provide an equitable risk/reward relationship;
- Further performance benefits are gained from continuous improvement;
- Process improvement through application of industrial engineering concepts provide benefits as well as those initiatives that involve technological advances;
- Clear requirements from the Infrastructure Manage help the supply chain to develop relevant solutions; and
- Appropriate processes and standards facilitate effective approvals.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Working with the supply chain

  A number of the case studies identify scenarios where the supply chain has developed ideas that have provided benefits to both parties.

  Both parties need to come to an arrangement that provides sufficient potential reward relative to the risks and the required investment. The balancing point can be shifted by the Infrastructure Manager providing comfort through provision of testing facilities and/or indicating potential future work if the development is successful.

  Estimating the size of this opportunity is difficult. Two case studies have been evaluated (loss of investment in new plant due to changes in circumstances and savings from implementing a new process). These provide an estimated £12m reduction in costs.

- Continuous improvement

  Further benefits can be obtained from continual improvement and refinement of developments rather than freezing the process once a working solution has been achieved.

  Key to successful implementation of this is a culture of change and development throughout the industry, with an acceptance that not every idea will be a success.

  The potential savings from this approach are already included elsewhere.

- Clear decision processes

  A clear decision making process is key to the successful involvement of the supply chain. It is noted that, due to corporate governance issues, the supply chain is quite often able to make quicker investment decisions than the Infrastructure Manager.

  Decisions have to be timely and correct.

  The potential savings from a single case study of delayed decision making has identified potential savings of £2m.

- Industrial engineering

  Manufacturing and other industries have adopted methodologies that identify and eliminate waste. This is particularly applicable to repeatable activities, such as those used in maintenance and core renewals.

  A culture of accepting the need for change is required. It also requires widespread introduction (and acceptance) of industrial production engineering skills into the industry.

  Estimated size of opportunity is in the range £16m to £39m.

- Effective approvals

  Approval costs are driven by the criteria stipulated in the relevant standards that must be met and the validation effort required to prove compliance. European plant manufacturers have recently noted that increased requirements have added 5% to the cost of new machines.

  These costs can be removed if it is possible to set criteria based on reducing the risks to a practicable level. Such an approach requires a good understanding of the basic engineering concepts, plus the likelihood and consequences of failure.

  Based on the plant example only, the estimated size of opportunity is in the range £0m to £5m.

As noted above, it is difficult to estimate the improvements that will be derived from improving the effectiveness of the development process, although it is a key enabler for delivery of many other benefits.

However, the EU funded Innotrack programme of research[23] concluded that savings in the range 10-30% could be achieved through improved working relations between Infrastructure Managers and the supply chain. It is believed that under-pinning this improvement will be the implementation of an effective development process in order to put in place the changes required to reduce costs.

## 8.5 Implementation Issues

The primary ***safety*** issue will be to ensure that any change to the approach used to introduce innovation does not introduce increased safety risks. In particular, the approval processes need to be lean, but remain robust and appropriate to the idea under consideration.

The ***implementation*** factors to be considered include the need for an industry level cultural change in the way that innovation is approached. There also needs to be a balance between encouraging innovation and a situation whereby efforts to solve problems are duplicated through an uncoordinated approach.

[23] INNOTRACK Concluding Technical Report, edited by Anders Ekberg and Bjorn Paulsson, UIC 2010

# 9.0 MANAGEMENT OF CHANGE

## 9.1 Summary of Issue

The final factor to be reviewed is consideration of how new processes or technologies are implemented. In particular, the rate at which they are rolled out and incorporated into the "business as usual" scenario.

Management of change should be part of every organisation's normal operations. Both the environment and the demands placed on railway Infrastructure Managers are continually changing. Opportunities from the development of new processes, plant and equipment also result in the requirement for changes to be continually managed into ongoing operations.

The management process must follow a logical sequence and consider all aspects of the change. For example, introducing new asset policies will have minimal impact if the requirements of the revised approach are not communicated throughout the organisation and the industry. The changes in asset policy must also be supported by appropriate revisions to Standards.

The speed at which these changes are made will have an impact on how quickly the benefits are realised. Other countries introduced the modular switch concept within four years, whereas the speed of change in Britain for the same concept has been slower.

As noted in the preceding sections, Britain has, as a minimum, at least started consideration of adopting many of the good practices identified from elsewhere. However, it is the ability to complete the change process that is generally an area of weakness. The speed at which change occurs is slowed down by the:

- Cultural resistance to change and general conservative nature, both as a nation and specifically within the rail industry;
- Complexity of industry structure, with the high number of stakeholders that are involved and must be consulted; and
- General risk-adverse approach, with the fear of failure being predominant.

Effective change management is a process that the rail industry in general is poor at doing. It has been noted that the industry has a risk-adverse attitude to changing rules. The safety critical nature of most asset management activities is one of the key drivers of the conservative nature of the industry.

## 9.2 Good Practice

Successful change management requires a complete programme of activities to be undertaken. The availability of a new piece of plant is not in itself sufficient to deliver performance improvements.

When the supply chain is involved in the change, the process is regularly driven by the commercial pressure of competition and the need to achieve a reduction in unit costs.

**Rerailing Process**

A supplier developed a lean rail replacement process that involved the use of small items of plant and dedicated high-performance teams. This approach has provided higher output levels at lower cost.

Contractors are encouraged to introduce innovative ideas and they readily receive backing from the client. Timely feedback is provided by the client if the idea is accepted as a way forward for the industry. The view taken is that if the approvals process was slow it would stifle any innovation.

## 9.3 Current British Practice

As previously noted in this document, current British development practice leads to the involvement of a high number of stakeholders. When it comes to the change management phase, the lack of decision making can result in inertia and existing practices being maintained by a traditionally conservative industry.

**Introduction of RailVac**

RailVac has been introduced in many countries across Europe and the range of activities has been developed to over 40, covering most engineering functions. This development of activities has been encouraged by all levels of Infrastructure Managers' organisations.

There has been limited use made of this technology in Britain over the last 5 years. To date, the machine used has been a UIC gauged machine, limiting the potential benefits available. The supply chain has been reticent to invest in a British-gauged version of the machine (that would be much cheaper to operate) due to a lack of clear strategy.

The involvement of multiple stakeholders, across different functions and different levels, has resulted in a lack of focus for development of the technology in Britain. Only limited benefits have been gained to date. These have been in areas where there are 'hot-spots' of local staff who have understood the opportunities offered by the technology.

The complexity of the industry also creates inertia. As identified in the initial RVfM study report from the review being led by Sir Roy McNulty, this is exacerbated by the lack of common objectives through the industry.

**Track Renewal with Kirow Cranes**

A supplier has developed an improved track renewal process that makes use of their Kirow 250 cranes incorporating specially-designed beams and equipment. The process has been proven and accepted for use in their operational area. However, no mechanism exists for this process to be taken forward nationally.

This also manifests itself in terms of extended implantation programmes, effectively delaying rollout of new products and processes.

**ERTMS Compliant Technology**

A supplier has been developing an interlocking system over the last seven years. It is a modern solution that will support future transfer to ERTMS technology. In six years working in Britain a single interlocking system has been installed. Approximately 100 interlockings are being installed in one European country, with work having commenced two years ago and programmed to be completed in 2012.

**Modular Switch**

The initial modular switch development process took approximately four years from concept through to incorporation into normal operations, including an initial pilot operation using two wagons. The rollout of the similar modular switch process in Britain has taken approximately six years to date.

Gaining agreement with all the relevant stakeholders adds to the length of implementation programmes.

**Stakeholder Consultation**

Network Rail have recognised that there is a need for better asset information systems in order to produce robust asset management plans with work efficiently clustered. However, there have been several years of consultation with all the internal stakeholders so far in order to draft an agreed system specification.

A similar example is the plan to migrate to 14 control centres. This is already planned to take between 25 and 30 years to implement and two years of discussion has only moved the industry to PQQ stage.

However, failing to communicate with stakeholders correctly also leads to implementation problems.

**Stakeholder Consultation**

In 2010, Network Rail was fined by the ORR following failures in the implementation of a new Integrated Train Planning Systems (ITPS) that were deemed to be breaches of its licence[24].

The investigation undertaken by the ORR into the problems caused by the implementation of the ITPS found that the problems were caused by a “failure to consider properly, mitigate and communicate the risks of initial problems affecting operators and passengers.”

However, where there is an alignment of objectives, then it has been shown that it is possible to achieve change quickly.

[24] ORR Press Release ORR/27/10.

**Use of RailVac at Foxhall Junction, Didcot**

There was a high risk of an emergency speed restriction being applied due to very poor and deteriorating ballast conditions under S&C at Didcot. This would have had a significant impact on operation of the Great Western Main Line.

The only identified technical solution that could resolve the problem within the available time (and possessions) was to use the RailVac to remove the life expired ballast without the need to remove the S&C or disconnect the signalling.

The alignment of objectives by all parties meant that it only took 18 days from placing the order to the first possession. In this time the following was undertaken:

- Obtained VAB certification, safety approval and product acceptance for the UIC version of the machine;
- Audit of supplier to satisfy Safety Case;
- Medical and PTS training of operators in Sweden; and
- Transported machine from Sweden to Didcot.

The job was a complete success.

British Rail evolved a change model that was able to counter the inertia generated from the size of a national Infrastructure Manager.

**BR Change Management**

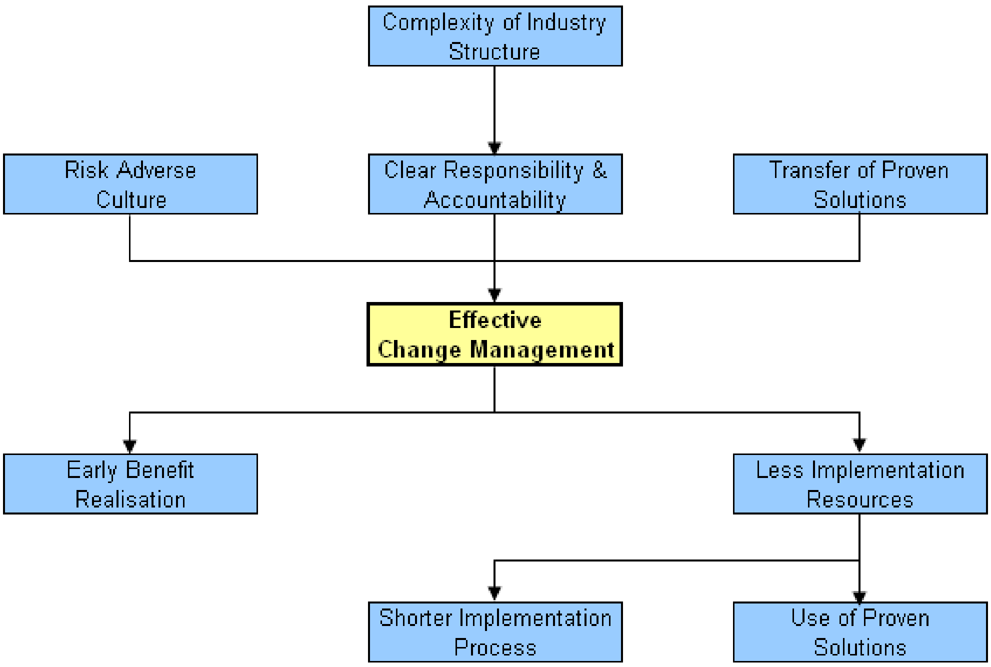
The change management structure included a Development Engineer in each region. They had a remit to develop new processes and products at their local level, including liaising with the supply chain. Additionally, there were between 2 and 5 Development Engineers at the centre to drive strategic initiatives.

Many successful projects were supported by this team working together with local engineering teams. These included the introduction of more efficient processes using laser levelling and Dynamic Track Stabilisers (DTS).

In some ways, the environment within which the railway industry operates in Britain is different to that found elsewhere. However, the basic requirements remain the same and the differences are regularly used as reasons to constrain implementation of proven European solutions.

### 9.4 Improvement Opportunities

The diagram below summarises the good practice that has been identified both in Britain and elsewhere.




From the case studies it can be seen that:

- A risk-adverse culture exists within the industry that does not encourage change;
- Lack of clarity in the accountability and responsibilities within the complex industry structure provides a disincentive to effective change; and
- Proven solutions are not quickly transferred into the rail industry in Britain.

From the diagram, it can be seen that consideration of the case studies has identified the following areas for improvement:

- Early benefit realisation

  A more effective change process would enable implementation periods to be significantly shortened, reducing the time from concept to completion of rollout. This would mean that the benefit streams would start earlier.

  Achieving this would require a desire within the industry to change and improve. It would also require clear leadership with allocation of responsibility and accountability for delivery of initiatives.

  The size of this opportunity has been estimated by considering the efficiencies set by the ORR for CP4. If it is assumed that the implementation programmes developed to meet the efficiency profile could be accelerated by between 10% and 20%, then the potential benefit range is £210m to £473m.

- Shorter implementation process

  A shorter change programme would require less man-days of management support, unless additional resource is required to enable the programme to be accelerated.

  Achieving these savings will require an effective change process.

  Estimated size of opportunity is in the range £0m to £2m.

- Use of proven solutions

  Use of proven solutions would also facilitate shorter change programmes, again reducing the management support requirements.

  Achieving these savings will require an effective change process plus an understanding of actual differences between Britain and other countries.

  Estimated size of opportunity is in the range £0m to £1m.

## 9.5 Implementation Issues

The primary ***safety*** issue will be to ensure that there are no unexpected impacts at system level from changes made at sub-system level.

The ***implementation*** factors to be considered include resolving the organisational issues that include insufficiently clear leadership and the involvement of numerous stakeholders. There are also more general issues to tackle, such as a risk adverse culture with a high resistance to change. This is encouraged through both the media and unions exerting pressure to resist change.

# 10.0 CONCLUSIONS

## 10.1 Summary

A meeting of Infrastructure Managers was held at Network Rail's Westwood facilities in June 2010. This was organised by The Community of European Railway and Infrastructure Companies (CER) and EIM, the European Rail Infrastructure Managers. A paper presented by Anthonie Bauer and Ted Luiten indicated that:

- "A structural approach based on an asset management framework shows 20-25% potential in cost reduction"
- "A clear strategy on track possessions and maintenance, adapted to the local possibilities, reduces unavailability significantly"
- "A clear focus on life-cycle effects of decisions reduces life cycle costs potentially by 15-20%"

The analysis undertaken in connection with this review supports these comments. The specific factors discussed in this document give the comments a British context and indicate some of the particular areas where benefits could be gained. It is recognised that progress is being made in many of these areas, but the critical factor is change management – the effective timely implementation of the revised way of doing things.

Each of the factors is inter-linked to the others. An underlying theme is the improvement in confidence of predicted future activity levels:

- Collect the correct **asset information** to feed into …
- Models forming part of **Decision Support System** tools that enables …
- **Sustainable** asset policy decisions to be made, with robust long-term plans that …
- Facilitating work clustering that improves utilisation of **possession** time and…
- Gives confidence to suppliers to invest in **developing** better solutions that are **...**
- Effectively implemented with good **change management**.

Considering each of the factors in turn, the following areas for focus have been identified:

- Inspection

  Maximising use of available technology to obtain consistent monitoring of infrastructure at least cost. However, to avoid abortive investment, it is necessary to first determine the information requirements for effective asset management, i.e. information collected must be based on need not technology availability.

- Decision Support Systems

  An Asset Information strategy is required that supports both front-line decision making and strategic planning/prediction activities, providing more certainty to the short, medium and long term plans. In conjunction with the use of experienced engineering analysts, this will leverage maximum benefit from the information collected, enabling optimum interventions to be properly planned. This will result in the ability to deliver more efficiently with robust long-term plans.

- Possessions

  Improved detailed planning (based on the output from DSS tools) will facilitate increased possession utilisation. The possession strategy needs to balance efficiency and operational benefits; increased costs on one side can provide benefits that are delivered to the other side. So, achieving a suitable balancing mechanism is not simple. Although the 7-day railway may not be fully affordable in the short-term, many of the concepts will provide benefits.

- Sustainability

  Integrated long-term asset policies are required that ensure renewal intervention is undertaken at the correct time and the benefits are fully realised. These strategies should consist of a mix of maintenance, life extension (component replacement) and system renewal, based on route and asset criticality. Benefits will arise from ensuring that asset renewal is properly timed from a whole-life and whole-system perspective.

- Development

  An appropriate risk/reward balance can provide an environment that encourages the supply chain to work in partnership, investing in innovation to both their and the Infrastructure Manager's mutual benefit. This is supported by confidence that work-bank predictions are a robust indicator of future demand.

- Change Management

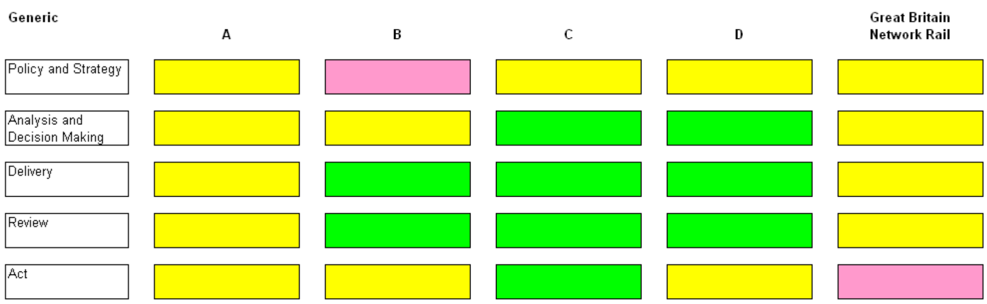
  Many of the "good practice" ideas are already known about and being investigated in Britain. What the industry is failing to achieve is effective implementation of these ideas. This requires clear responsibilities and a sense of urgency.

## 10.2 Relative Performance of infrastructure Managers

A comparative analysis has been undertaken of the asset management performance of the five Infrastructure Managers visited during the 2010 study visits[25]. The methodology adopted was to apply the generic asset management model developed as part of this study as the framework for the comparative review. The relevant good practice case studies identified have then been used to compare the performance of each of the selected Infrastructure Managers.

The details have been entered into a set of tables and a qualitative view taken of the relative performance for each generic area using a simple red / yellow / green coding system. The colour coding used is as follows:

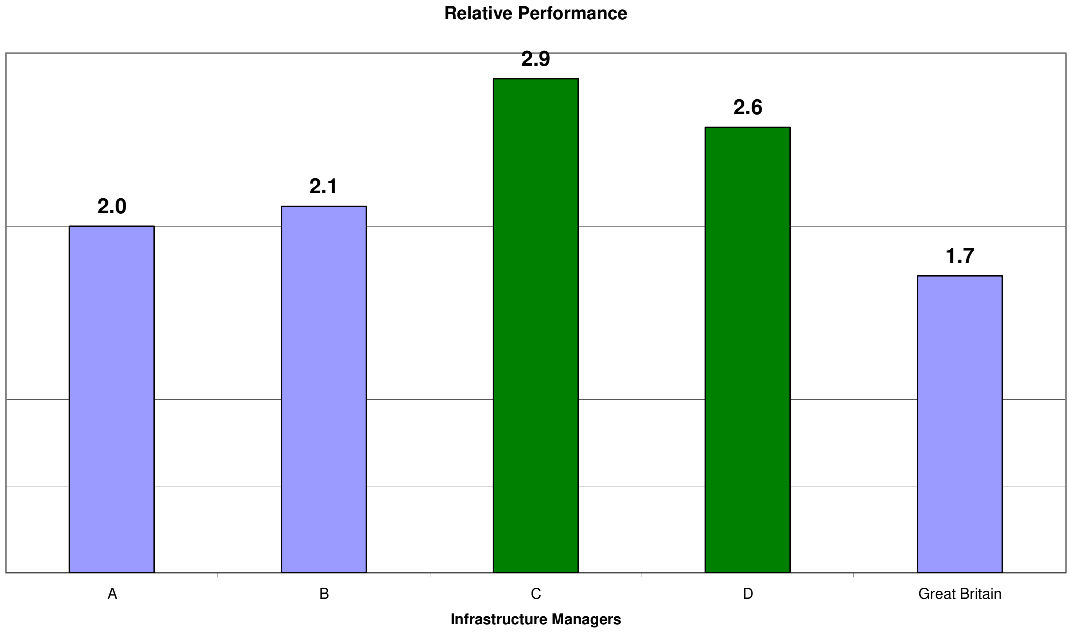
| | |
|---|---|
| Green | Example of good practice |
| Yellow | General industry maturity level |
| Red | Opportunities for improvement |




[25] Redacted version of the final report can be found at http://www.rail-reg.gov.uk/upload/pdf/econometric_update_2010_railkonsult_paper.pdf.

The details have not been peer reviewed by the respective Infrastructure Managers, but represent the status of each as determined from the information gained during the study visits undertaken during the 2010 work and subsequent analysis. No site visits were undertaken to validate any of the information provided. In some cases, little information was gathered for a particular subject for each of the Infrastructure Managers involved.

The conclusions are depicted graphically below.




## 10.3 Table of Potential Opportunities

The table on the following pages summarises the potential opportunities. This includes outline estimates of the size of each of the potential opportunities and an indication of the primary precursors that would need to be put in place to achieve these performance improvements.

Section 2.3 describes the methodology adopted to calculate the size of the potential opportunities and identifies the potential constraints in the methodology used.

The opportunities indicated in the following table are annual savings, except for item 6 which is a “one-off” saving. The approach used to calculate this potential saving is based on an acceleration of the change programme. Although there maybe other opportunities to provide improvements through alternative change management methodologies, these have not been considered in this study.

Within the constraints of this study it has not been possible to eliminate all areas of potential duplicated savings. The two primary sources are:

- Existing change programmes are already addressing the issue in part; and
- Interdependencies between the factors identified.

An example of the potential duplication of savings is the planning process. As part of their CP4 change programme Network Rail are already revising the way in which planning is undertaken. From the factors identified in this report, improvements in the planning process could be obtained from better:

- Understanding of asset condition;
- Degradation analysis;
- Technology; and
- Clustering of work.

The target savings from the existing Network Rail change programme were not available as part of this review. The current review did not include a detailed study into what a revised planning process may look like if all the identified opportunities were incorporated.

It is not possible to determine the extent of the duplication without undertaking detailed investigations into all the factors and existing initiatives. It is likely that the level of duplication will be between 10% and 25%

Although not reviewed in depth within this study, an initial consideration has been given to the precursor activities required to obtain the savings identified above. From this it has been concluded that it is unlikely that these savings will be available until CP5, particularly when considering the extent of the change programme already underway for CP4.

This study was undertaken independently of the recent Value for Money review led by Sir Roy McNulty[26] and was completed prior to the publication of his findings. However, the conclusions are broadly complimentary with those in the recently published final report.

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

| Factor | Potential Benefit | Potential Size of Opportunity | Precursor Activity |
|---|---|---|---|
| Collection of Asset Information | | | |
| 1.1 | Automated data collection – consistent measurements with reduced manual intervention | £20m to £27m | Identification of all critical measurements required and deployment of fixed or train borne systems to monitor these parameters. Use of hand-held devices for remaining manual inspections. |
| 1.2 | Automated data entry – reduced manual intervention and correction of errors | £5m to £10m | Deployment of hand-held devices. |
| 1.3 | System level analysis – identify failure trends | £1m to £3m | Collection of asset information and use of data visualisation tool to enable easy assessment of information. |
| 1.4 | Minimise access requirements – less requirement for access for manual inspections | £3m to £8m | Introduction of virtual inspection strategy for plain line and S&C. |
| DSS Tools | | | |
| 2.1 | Improved planning – improved productivity by integrated modelling and planning system | £5m to £11m | DSS tools with suitable degradation models to be available for use by appropriately trained business analysts. Also requires reliable and accurate data to be available. |
| 2.2 | Planned preventative maintenance based on WLC modelling (less work required and reduced number of possessions) | £4m to £8m | DSS tools with suitable degradation models to be available for use by appropriately trained business analysts. Also requires reliable and accurate data to be available. |

| Factor | Potential Benefit | Potential Size of Opportunity | Precursor Activity |
|---|---|---|---|
| 2.3 | Timely intervention - proactive "what if" modelling so that intervene once, at optimum time | £18m to £37m | DSS tools with suitable degradation models to be available for use by appropriately trained business analysts. Also requires reliable and accurate data to be available. |
| 2.4 | Centralised planning - reduced number of planners | £1m to £2m | Asset Information strategy implemented with reliable and accurate data available. |
| 2.5 | Better data quality – errors and missing data identified and remedied | £1m to £2m | Cultural change so that all users respect requirement for quality data. |
| Possession Strategy | | | |
| 3.1 | Reduced loss of operational facilities (use of single line working, no isolation etc.) | £2m to £11m | Competency to undertake detailed planning and investment in suitable equipment.<br>Some infrastructure configuration changes required. |
| 3.2 | Improved utilisation of possession time (increased working time) | £9m to £18m | Improved method of taking possessions. Different method of mitigating risk of possession over-runs. |
| 3.3 | Improved utilisation from activity clustering | £16m-£28m | Requires good long-range modelling and detailed planning. Also requires DSS tools to enable simple CBA of possession time flexibility to be calculated. |
| 3.4 | Improved productivity from better planning | £6m to £11m | A culture that encourages innovative approaches and rewards teams who reduce required possession time. |
| 3.5 | Improved productivity from process and technology | £6m to £24m | Investment to implement each of the specific solutions. |
| 3.6 | Improved decision making from simpler process | £11m to £17m | Development of a suitable DSS tool. |

| Factor | Potential Benefit | Potential Size of Opportunity | Precursor Activity |
|---|---|---|---|
| Sustainable (Renewals) Strategy | | | |
| 4.1 | Life extension - reduced renewal activity from life extension based on life cycle assessment | Estimate – up to £370m | Right data entered into good models, with benefits and costs considered at a system level. |
| 4.2 | Avoid “patchwork quilt” renewals – renewal clustering to increase renewal output levels | Benefits included elsewhere | Right data entered into good models, with benefits and costs considered at a system level. |
| 4.3 | Maximise operational benefits | £13m to £37m | Clear understanding of greater benefits obtained from “renewal campaign”. |
| Development Strategy | | | |
| 5.1 | Work in partnership with supply chain | £0m-£12m | Balance potential reward relative to risks and required investment |
| 5.2 | Continuous innovation – develop existing solutions further | Included above in 5.1 | Culture of change and development throughout the industry |
| 5.3 | Clear decision making process Speedy and effective | £0m to £2m | |
| 5.4 | Industrial engineering - improved productivity by deploying techniques | £16m-£39m | Culture of accepting need for change is required plus widespread introduction (and acceptance) of industrial engineering skills into industry |
| 5.5 | Effective approvals | £0m - £5m | Approval process based on appropriate controls and standards |
| Management of Change | | | |
| 6.1 | Early benefit realisation – quicker implementation process | £210 - £473m | A desire within the industry to change and improve. Clear leadership with allocation of responsibility and accountability for delivery of initiatives |
| 6.2 | Shorter implementation process - reduced management resource | £0m to £2m | An effective change process |

| Factor | Potential Benefit | Potential Size of Opportunity | Precursor Activity |
|---|---|---|---|
| 6.3 | Use of proven solution - reduced management resource by easier acceptance of solutions already proven elsewhere | £0m to £1m | An effective change process with a clear understanding of actual differences between Britain and other countries |

## 10.4 Recommendations

It is recommended that further work is undertaken during the forthcoming periodic review in the following areas:

- Consider full benefits realisable from improved processes that increase the effectiveness of collecting asset condition information, through the use of technology that is already available;
- Develop suitable possession strategies that provide whole industry savings, making better use of predicted intervention requirements;
- Based on the wide variation in asset renewal rates from the analysis of the activity levels reported in the UIC LICB database, determine the appropriate levels of life extension, renewal and enhancement activity that efficiently provide the required safety and reliability performance;
- Review best practice in change management processes from other industries and determine how these benefits can be realised in the rail industry.

As part of these studies, more detailed consideration of the available savings should be undertaken to validate the initial work undertaken as part of this review.

# APPENDIX A: IDENTIFIED FACTORS

## Objectives (Inputs)

1.a Effective Network Size and Route Criticality

1.b Legislation

1.c Macro-Economic Factors

1.d Power of Unions

1.e Power of Government

1.f Development of Technology

1.g Industry Structure

1.h Supply Chain Structure

1.i Network Characteristics

## Policy and Strategy

2.a Planning Horizon

2.b Organisational Culture

2.c Standards

## Analysis and Decision Making

3.a Asset Information

3.b Collection of Correct Information

3.c Efficient Collection of Changed Asset Information

3.d Management of Information/Data

3.e Use of Asset Information

3.f Asset/Component Criticality

3.g Sustainability of Strategy

3.h Whole Life Cycle Modelling

3.i Use of Decision Support Systems

3.j Calibre, Competence and Authority of Decision Makers

3.k Selection of Intervention Strategies

3.l Development Strategies

**Delivery**

4.a In-house or Out-Source
4.b Clear Specification
4.c Detailed Planning
4.d Possession Strategy
4.e Resource Productivity and Utilisation
4.f Efficient Delivery
4.g Production Methodologies
4.h Safety Regime

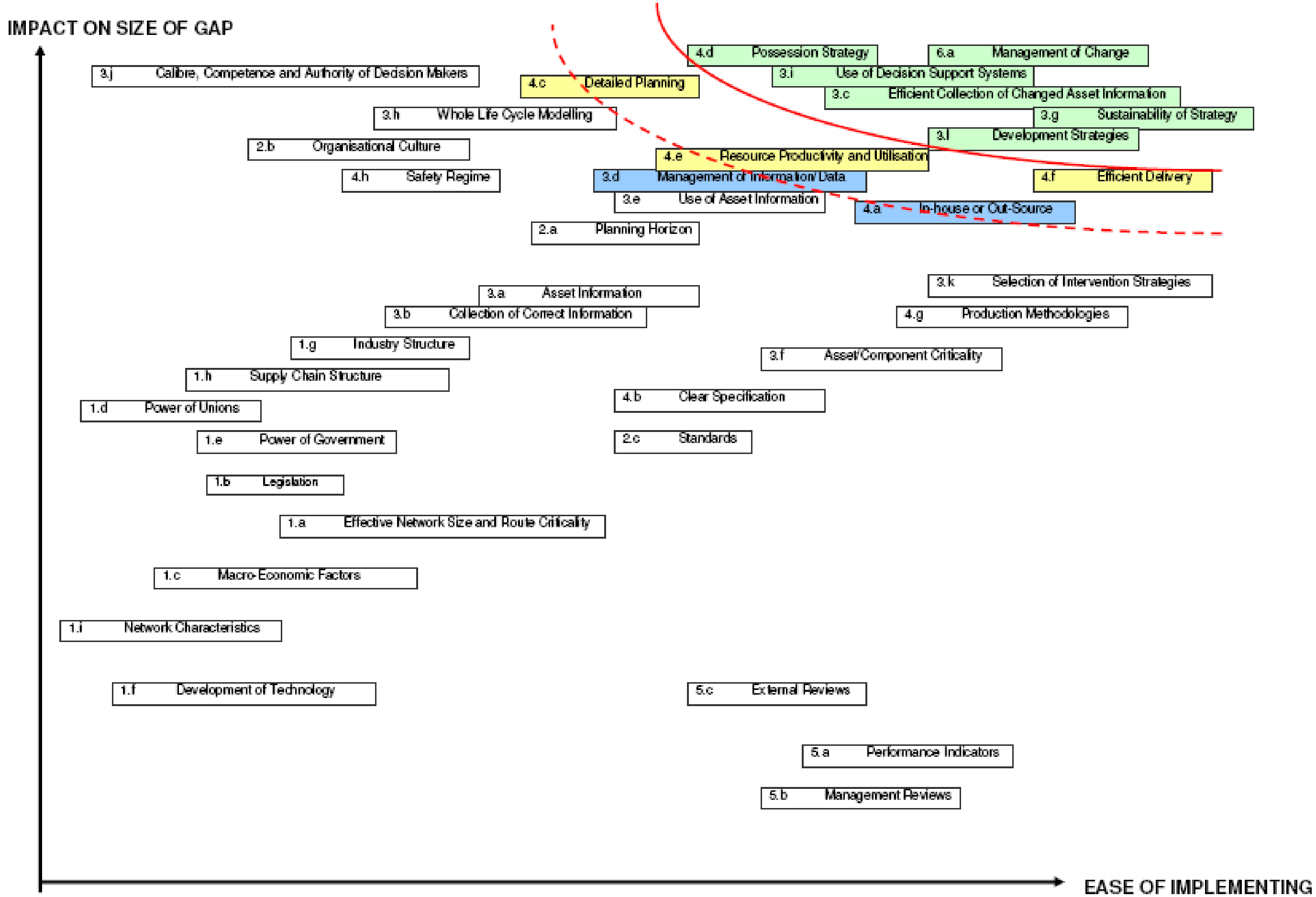
**Check, Review, Monitor**

5.a Performance Indicators
5.b Management Reviews
5.c External Reviews

**Act**

6.a Management of Change

## APPENDIX B: PRIORITISATION OF FACTORS



## APPENDIX C: COMPARISON OF FACTORS RESULTING IN EFFICIENCY GAP

| Factors from "Relative Infrastructure Managers' Efficiency" Report | Equivalent factor from Asset Management Cycle Review | Comments |
|---|---|---|
| Effective Size of Network | - | Seen as a harmonisation correction, not a factor to explain gap |
| Contracting Strategy | 1.h: Supply Chain Structure<br>4.a: In-House or out-Source<br>4.f: Efficient Delivery | Topic included in several factors, none of which were in top-six priority group.<br>NOTE: It is understood that the R-VfM team are examining this area in some detail. |
| Possession Strategy | 4.d: Possession Strategy | Included |
| Proactive Use of Condition Monitoring Technology | 3.c: Efficient Collection of Changed Asset Information<br>3.i: Use of Decision Support Systems | Included |
| System Renewal | 3.g: Sustainability of Strategy | Included |
| Renewals Backlog | | |
| Efficient Delivery | 4.f: Efficient Delivery | Assessment placed this factor just outside top-six priority group. |
| Workforce Protection | 4.h: Safety Regime | Part of this factor has been included within the review of the possession strategies. |
| - | 6.a: Change Management | Included |
| - | 3.l: Development Strategies (Innovation) | Included |

Balfour Beatty
Rail