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Annex P

(Confidential) Worley Parsons and Transportation Technology Centre – UT3 Parallel Comparison Exercise – Consultant's Report, 18 August 2008

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QR NETWORK

Transportation Technology Center, Inc.

UT3 Parallel Comparison Exercise

Consultant's Report

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QR NETWORK
UT3 PARALLEL COMPARISON EXERCISE
CONSULTANT'S REPORT

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EXECUTIVE SUMMARY

The Queensland Rail Network (QR) 2005 Access Undertaking (referred to as UT2) is effective for the four year period up to 30th June 2009. In order to conform to the Queensland Competition Authority's (QCA) requirements, QR is to submit to the QCA, a Draft Access Undertaking for the period commencing 1 July 2009 (referred to as UT3).

To authenticate the submission QR established a UT3 Taskforce. The primary objective of this Taskforce was to compile a robust and tenable justification for the UT3 forecast through;

- The detailed quantification of assets currently maintained;
- Clear specifications of objectives of the maintenance standards and processes;
- Explanations of the activities which are required to achieve these objectives and details of the management processes controlling these activities;
- The reasoning and justification behind the methodology and approach behind the activities;
- Transparent analysis of the forecasting approach in relation to scope of work and derivation of cost estimated; and
- Quantification of key risk factors.

To validate the works supporting the submission QR further engaged WorleyParsons, with their associates, Transportation Technology Center, Inc., Aitken & Partners and Lazuri Enterprises Pty Ltd (the Consultant) to conduct an analytical review of the maintenance plan as detailed in the points above.

In order to provide maximum value in the review the Consultant set up a team of skilled professionals to address the issues put forward in QR's draft UT3 submission. The team consisted of discipline specific specialists who met regularly from February 2008 with representatives from:

- The WorleyParsons group;
- Transportation Technology Center Inc. (TTCI);
- Aitken & Partners; and
- Lazuri Enterprises Pty Ltd.

The findings of the Consultant, their comments and recommendations are included in detail in the set of supporting documents (listed in Appendix 1). This report includes a summary of the major findings and conclusions derived from the supporting documents.

The Consultant reviewed the current Service Level Specifications and Key Performance Indicators (KPIs) for Rail Infrastructure Maintenance. The Consultant confirmed the appropriateness of the majority of existing KPIs but highlighted the following:

- The lack of robust methods for measuring the quality achieved. If the only KPI being monitored is production against program then the maintainer is incentivised only to complete the work, even if the quality of work is poor;
- Where KPIs are concerned with rare events such as trespass, it is better to analyse the time between incidents rather than the number of incidents in a period;
- Further statistical work is required on KPIs that necessitate noteworthy changes in performance;
- Where passenger trains or other traffic require different sets of parameters which may be significantly increasing or impacting on maintenance requirements of a section, the Consultant recommends reviewing whether a consensus based approach may be adopted in order to provide specific 'fit-for-purpose' infrastructure and maintenance requirements.

The Consultant is confident that the comprehensive review of the KPI structure that is currently being undertaken for the commencement of the UT3 will eliminate most of the above concerns and answer the issues as detailed in the Consultant's review.

The Consultant undertook a field asset condition audit and found in general that the condition of assets was good, except for the extent of fouling of ballast. Engineering methods and processes were considered appropriate and in line with international and national industry practices.

The Consultant was concerned at the level of coal fouling on the network and through observations in the field concluded that much of this was due to poor loading and unloading practices and faulty closing mechanisms on rolling stock.

The Consultant concluded that it would be beneficial to supply chain operations to introduce financial mechanisms which provide incentives to all parties to introduce innovative mitigation solutions or procedures which will minimise the coal fouling issues on the network.

The Consultant observed that within the field engineering practices, such as rail management (monitoring of rail wear for example) the systems currently adopted by QR can be considered world leading, achieving relatively long periods of rail life in comparison with similar operations. QR can also be considered a world leader in the use of regular measurements of percentage void contamination to plan ballast cleaning and in its innovative trialing of the use of stone-blowers for heavy haul operations. Previous research would indicate that these trials have proven successful and beneficial for the relevant users.

The Consultant was impressed with the current plans for the implementation of a new GIS based asset register which will be integrated with planning management decision support tools. The implementation of this system will facilitate the seamless flow of information between planning and recording systems and enable greater efficiencies in programming and planning maintenance works in the 24/7 peak conditions under which the coal system operates.

The Consultant conducted an international benchmark on engineering processes and methodologies and concluded that in comparison to other heavy haul railway operations, QR performs better in some aspects of infrastructure maintenance, and in others performs on average. The Consultant did not find any method or process where it could give a definite result that QR performed badly or was using processes or justifications that did not conform to the latest research or trends.

The Consultant conducted an international benchmark on engineering maintenance costs and found that QR costs were neither the highest nor the lowest. The Consultant acknowledges that QR does not differentiate activity costs and Major Programmed Maintenance (MPM) and Routine Maintenance (RM). The Consultant confirms that this approach allows QR greater efficiency to switch resources between MPM and RM activities, which, in today's current resource market may be a more efficient option. However this choice in planning cost activities is a significant impediment when trying to draw conclusions from national comparisons.

The Consultant notes that historically many of QR's decisions were taken on a sustainable approach, implementing solutions to maximise the efficiency of existing assets rather than expending capital investments on renewing infrastructure which still had a significant period of calculated residual life. The Consultant highlights that there comes a point in time where the benefits of sustainability are outweighed by the costs of inefficiency through the use of assets which are no longer suited to today's demands. The Consultant acknowledges that QR may be currently reviewing this situation in regards to some of its assets.

The Consultant concluded that the underlying logic of charging for short term increases in GTK, or giving discounts for running fewer trains is flawed for many reasons. It either assumes the coal railways are part of a much bigger network, all maintained by a monopolistic infrastructure maintenance provider that is able to efficiently move resources at short notice anywhere on the larger network in an efficient manner. Alternatively it assumes a maintenance contractor with a significant reserve capacity of skilled labour and specialised machinery that can be efficiently moved to or from a site at short notice. Or it assumes that a prime maintenance contractor is able to draw on a supply of casual skilled labour and specialised equipment held by small firms and available for hire at short notice at day rates. This reasoning disregards the reality of the Central Queensland labour market and geography, and fails to comprehend the business environment due to the specialist nature of rail infrastructure resources.

Overall the Consultant concludes that:

- The achievability and realism of existing KPI's is reasonable although some work is required to refine the data obtained in order to enhance the decision making process and provide greater incentives for quality improvement at a holistic supply chain operation level. This work is currently under progress for the UT3 undertaking;

- In general asset condition was found to be good, and existing strategies, standards and processes in line with international trends. Engineering judgment and reasoning was found to be sound, and the scope and volume of work appropriate for the existing site conditions. Some strategies and processes were judged as being innovative and to be commended;

- In general costs were calculated as being comparative in international benchmarking, with allowances in some items for specific North Queensland conditions. A critical requirement was identified for specific studies which address the reality of the Central Queensland geography.

1. INTRODUCTION

1.1 Queensland Rail Network (QR) 2005 Access Undertaking (referred to as UT2) is effective for the four year period up to 30th June 2009. In order to conform to the Queensland Competition Authority's (QCA) requirements, QR is to submit to the QCA, a Draft Access Undertaking for the period commencing 1 July 2009 (referred to as UT3).

1.2 In July 2005 the QCA issued a draft decision on QR's UT2, rejecting the report and recommending that the following be implemented in order for the Authority be able to approve it:

- An independent review of the appropriateness of UT3 strategy and measures

1.3 In January 2008 QR commissioned the Consultant (WorleyParsons) to conduct a review of its UT3 submission.

1.4 This review was to include:

- A desktop review of submission documents and commentary on the appropriateness, suitability and competitiveness of:
  - Key Performance Indicators (KPIs);
  - accepted engineering processes, maintenance methodologies and adopted practices;
- Site audits of randomly selected assets and confirmation of the condition of assets;
- Benchmarking of methodologies, outputs and assumptions against similar international railways; and
- A commentary on costs and competitiveness.

Purpose and structure of this paper

1.5 Based on the work undertaken over the last four months, this document represents the final conclusions drawn from the review undertaken by the Consultant and submitted to QR, for use as a reference in its submission to the QCA.

1.6 The remainder of this paper is structured as follows:

- Part 2 contains an overview of the approach that the Consultant adopted when formulating its final conclusions;

- Part 3 deals with KPIs and provides comment and conclusions on the incentives and drivers of value for money proposed for UT3;
- Part 4 provides conclusions from asset condition audits which were undertaken as part of this remit;
- Part 5 focuses on QR engineering and processes, inspection, analysis and decision making methods in relation to maintenance activity;
- Part 6 provides summary conclusions from the international benchmarking report;
- Part 7 deals with costs and summarises each of the building blocks of the financial framework, as well as calculations of access charges; and
- Part 8 focuses on recommendations based on the findings of this review.

2. OVERVIEW AND METHOD

Background

2.1 The Queensland Competition Authority Act (the Act) 1997 established a State based regime to allocate third party access to specific types of infrastructure. In 1998 Queensland Rail's below rail infrastructure was identified by the Queensland Competition Authority (QCA) Amendment Regulation as being subject to the provisions of the Act.

2.2 The QCA has previously approved two access undertakings (UT1 and UT2). These undertakings are the basis on which the tariffs that apply to trains operating on the commercial coal network are defined. The latest undertaking (UT2) is defined for the four years up to 30 June 2009.

2.3 The tariff is made up off:

- Asset related charges (which combine the Return On Assets (ROA) and net depreciation as valued using Depreciated Optimised Replacement Costs (DORC)) analysis undertaken in 2000 ;
- Operating costs;
- Maintenance costs

2.4 Maintenance costs included in the UT1 undertaken were agreed by the QCA after a detailed review process as summarised in the paper "The Cost Effectiveness of Queensland Rail's Infrastructure Maintenance, Central Queensland Coal Systems, November 2000"

2.5 That review was undertaken over a twelve month period and 'utilised extensive QR staff interview information and data supplied by QR, maintenance contractors and other railway administrations'[1]. As a result of the review a 15% efficiency factor was accepted by QR, despite "a number of concerns with the QCA's analysis"[2]

2.6 During the UT1 period it was found that maintenance costs were higher than the calculated allowance. However, the difference between the two over the period was less than 10% and was "offset to some extent by higher tonnage throughput and associated AT1 payments"[2]

[1] Queensland Rail (2000) "The Cost Effectiveness of Queensland Rail's Infrastructure Maintenance, Central Queensland Coal Systems" November 2000, pg i.

[2] QR Network (2008) UT3 Submission 2008 "Chapter 2 Purpose, Context and Objectives" pp 1

2.7 For the UT2 period the QCA approved maintenance costs that were on average 1% higher than those proposed by QR. The costs proposed were "developed using average target cost levels which reflected expected efficiencies for specific maintenance activities". However detailed analysis at the end of 2006/2007 showed that these costs were fundamentally flawed as they:

- Did not anticipate the current mineral boom and consequent increase in coal traffic;
- Did not sufficiently take into account the impact of increased activity on unit rates for key activities;
- Did not anticipate changes in maintenance practices required to maintain the track in fit for purpose condition in view of increased throughput and capacity expansions;
- Did not truly reflect the cost of delivering maintenance activities.

2.8 Estimates highlighted that if the UT2 revenues were not increased, by the end of 2006/2007 "QR would have already incurred maintenance costs estimated to be approximately $52 million higher than its maintenance allowance in the first two years of UT2 and QR expected to incur similar losses in the last two years of UT2"[3]

2.9 Subsequently QR proposed that UT2 maintenance forecasts would not be used for the remainder of UT2, and a proposal was put forward to base the maintenance forecasts for the final two years of the undertaking on the maintenance forecasts approved in the UT1 decision. This proposed an increase in the maintenance allowance in the final two years of the undertaking.

2.10 To substantiate the proposal QR established a UT3 taskforce which was given the objective of developing a robust and tenable justification for the UT3 forecast through the development of a comprehensive maintenance plan which comprised[3]:

- Detailed quantification of assets currently maintained;
- Specification of objectives of maintenance standards;
- An explanation of activities which are required to achieve these objectives and how these activities are managed;
- Discussion on the methodology and approach behind the activities and justification;
- An analysis of the forecasting approach in relation to scope of work and derivation of cost estimated; and

[3] QR Network (2008) UT3 Submission 2008 "Chapter 2 Purpose, Context and Objectives" pp 1

- Quantification of key risk factors.

2.11 In addition, to further substantiate the proposal QR engaged the Consultant (WorleyParsons, Transportation Technology Center, Inc., Aitken & Partners and Lazuri Enterprises Pty Ltd) to conduct an analytical review of the maintenance plan as detailed in 2.10.

Method of work

2.12 WorleyParsons set up a team of skilled professionals to address the issues put forward in QR's draft UT3 Submission. The team consisted of discipline specific specialists who met regularly from February 2008 with representatives from:

- The WorleyParsons group;
- Transportation Technology Center Inc. (TTCI);
- Aitken & Partners; and
- Lazuri Enterprises Pty Ltd.

Each specialist added maximum value by conducting an analytical review of their area of technical skill.

2.13 This specialist group defined and specified the work it considered necessary to support this review, engaging additional support where appropriate.

2.14 Distinct disciplines were defined as:

- Track and structures;
- Signals;
- Traction;
- Telecommunications;
- Asset Maintenance processes; and
- Economics and Business processes.

2.15 On completion of the preliminary draft of each section of QR's UT3, the group reviewed the section and submitted preliminary comments and recommendations to QR. QR met with group representatives regularly to raise and clarify any issues that were found. On completion of this review, where appropriate and agreed in principle between QR and the Consultant, such recommendations were included in the subsequent submission of the draft.

2.16 A final review was conducted by the Consultant on submission of the completed QR document. Any outstanding issues, omissions or recommendations which the Consultant still considered relevant, are the basis of this summary and are compiled in this report.

2.17 Based on professional experience and knowledge of the railway industry internationally, the Consultant selected a number of 'similar' railways from which to benchmark engineering and management processes, assumptions and costs of undertaking the works. Relevant personnel were contacted from these railways and invited to participate in the benchmark exercise.

2.18 Questionnaires were sent out to all agreeing participants and results were analysed in two reports. A preliminary 'summary' of the results, which is an abridged version of the final report, and the final report itself, are included as annexures to this document. Summary and conclusions from this benchmark study are included in this report.

2.19 To substantiate and confirm the reasonableness of QR's assumptions of asset condition and remaining life assessments, each specialist conducted a site asset audit on the asset appropriate to the discipline. This audit was conducted through a random selection of appropriate assets, an analysis of condition and QR assertions.

2.20 The Consultant considered all findings from the work that was undertaken, as described above. It has initiated its own internal debates and sought advice from industry contacts and individuals where appropriate. Each following section of this report sets out how the key issues identified have been taken into consideration. The final section (Section 8) of this report summarises the main conclusions and recommendations as either to be addressed or taken into consideration in future consultations.

3. COMMERCIAL ARRANGEMENTS & KEY PERFORMANCE INDICATORS

Introduction

3.1 This section provides comments on Key Performance Indicators (KPI's) as submitted for UT3.

Commercial Arrangements

3.2 It is noted that QR "cannot impose obligations on Ports to clean portions of their track or change their coal un-loading activity to minimise impact on QR Networks rail infrastructure"[4]. Both these factors have a significant effect on the transport function through increased maintenance costs and increased requirements for maintenance possessions. In a true equitable commercial arrangement it would be expected that any increases to costs caused by the 'inefficiencies' of one party in the supply chain would be recoverable by the party who is compromised through these inefficiencies.

QR would be within its rights if it refused to accept a train delivered from a private siding (i.e. the Port) in a fouled condition. Similarly, the Department of Main Roads would not allow trucks to enter the State controlled road system from a worksite in a fouled condition. Deposits of clay and gravel over road surfaces would force clean-up costs onto the taxpayer.

3.3 It is noted that QR has a contractual obligation "to provide a known cap on the number, location and time interval between track possessions"[5]. Similarly, it is expected that relevant system users will have a contractual obligation to maintain that cap and not infringe on the number, location and time agreed. If components within the supply chain are to perform within a systematic commercial arrangement it would be expected that mechanisms that promote innovations that extend beyond individual boundaries and provide increases in efficiencies for whole supply chain operations would be in place.

Currently it appears that the supply chain is operating as single components, with the business objectives of some stakeholders having precedence over the objectives of another.

3.4 Cooperative coal chain planning is essential to optimise the efficiency of the supply chain. It should be operated as an entire system rather than a series of components driven by individual profit.

3.5 The practice of booking additional capacity is not efficient in relation to optimised usage of the transport component. It indicates a lack of planning at input and output ends of the supply chain.

[4] QR Network (2008) UT3 Submission 2008 "Chapter 3 Commercial Arrangements" Section 3.1

[5] QR Network (2008) UT3 Submission 2008 "Chapter 3 Commercial Arrangements" Section 3.2

3.6 It is noted that QR has a contractual obligation to provide the "best possible response time[6]" to any network disruption (even force majeure events). It is felt that the expectation of "best" is inappropriate and would not be agreed to in a 'normal' competitive commercial agreement. The words "reasonable response time" should be used instead.

3.7 It is noted that QR has a contractual obligation to provide "some[7]" spare capacity. The word 'some' needs to be defined and written into the contractual agreement if it is to have any relevance. In order to effectively plan the total number of days unavailable for train traffic there must be guidance within the agreement of the actual traffic requirements and the "additional spare capacity" required. An example of this would be surge capacity at around 10% sustainable over time period of X, where X is the duration required.

Reliability and Efficiency Rating

3.8 Failure to perform preventative maintenance has the potential to significantly impact the operation of the supply chain in the future. Figure 1[8] shows a probabilistic maintenance model based on eight random variables. These variables include:

- The initial reliability index β;
- The time of damage initiation Tt;
- The reliability index deterioration rate A;
- The time of first application of preventative maintenance Tpt;
- The time of reapplication of preventative maintenance Tp;
- The effect the duration of preventative maintenance has on reliability TpD;
- The deterioration rate of the reliability index during preventive maintenance effect θ; and
- The improvement in the reliability index immediately after the application of preventative maintenance γ9.

[6] QR Network (2008) UT3 Submission 2008 "Chapter 3 Commercial Arrangements" Section 3.2
[7] QR Network (2008) UT3 Submission 2008 "Chapter 3 Commercial Arrangements" Section 3.2
[8] Van Noortwijk & Frangopol et al (2003) " Life-Cycle cost and performnce of Civil Infrastructure"
[9] Frongopol, DM et al (2007) "Reliability and Optimisation of Structural Systems, Assessment, Design and Life-Cycle Performance".

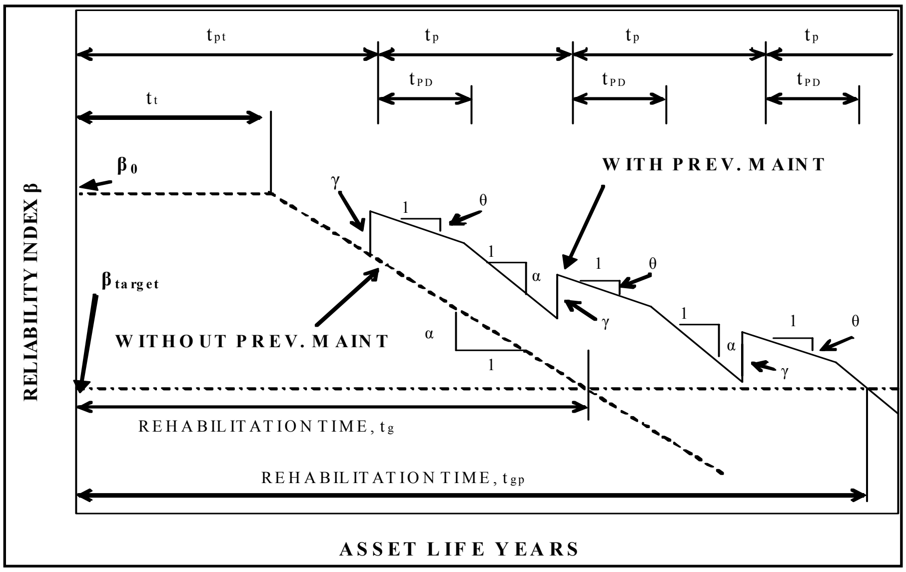

Figure 1 Reliability profiles for options with or without preventative maintenance

Using a Monte Carlo simulation to generate the probability density functions of the variables, the computational procedure for evaluating the total expected cumulative cost of maintenance during interval (0, t_h) is[10]:

$$E\left[C_{t,cumul}\left(t \le t_H\right)\right] = \sum \left|\sum \left\{P_{\tau,i}\left[t\right] \times C^T_{x,i}\left(t_H\right)\right\}\right| \quad \text{Eq. 1}$$

Where $E[\ ]$ is the expected value operator, $C_{t,cumul}(t \le t_H)$ = the present value (discounted) of the cumulative cost at time t_H, $P_{\tau,i}$ = the probability of maintenance action i being applied at time t, $C^T_{x,i}$ = the discounted cost of maintenance action i, and t_H = the time horizon.

Figure 1 and Equation 1 are included to demonstrate the relationship between increasing costs and the impact on the asset (through the reliability index) when preventative maintenance is not carried out. The optimum reliability index and the focus put on preventative maintenance (in addition to essential maintenance required to keep the structure safe) should be negotiated ab initio by all parties of the supply chain taking into account sanctioned future capacity requirements. The outcome of these decisions should form the basis of the contract. Any variations on this should be considered as such.

[10] Kong & Frangopol (2003) "Life-cycle Reliability based maintenance Optimisation of Deteriorating Structures", Journal of Structural Engineering 2003

Parties must be made aware that increases in usage will require increases to maintenance procedures in order to maintain the current reliability index. Where maintenance is not carried out a maintenance deficit will occur. This will necessitate increased maintenance activity and costs to 'jump' back to the required reliability index curve (as indicated by γ in Figure 1). This is not a case of 'paying twice' but a necessary preventative measure to maintain reliability. An alternative is to forego this 'jump' and reduce the reliability index with the subsequent increased risk of failure. If this alternative is taken users must accept the risk that failures may result in major incidents involving significant costs and delays to the operation of the supply chain.

3.9 In previous submissions it is noted that QCA analysis appears to be aimed at extracting value from infrastructure assets by implementing condition based maintenance, or what might be called maintenance to life expiry. This ignores the reality that assets have a half life, beyond which the maintenance required to keep them in an acceptable condition steadily climbs (please refer to the impact on reliability index as shown in Figure 1).

This analysis is considered adequate and cost effective if and when there is not a high expectation on reliability. On a system that is highly dependent on the constant running of traffic, taking risks with reliability to save minor costs on preventative actions may not be of financial benefit to supply chain operations in the long term.

3.10 The QCA initiated studies into QR maintenance practices some eight years ago. A study of the cost-effectiveness of renewal-based maintenance strategies revealed that strategies that place more weight on renewal result in lower unit maintenance costs[11] but also impact on the reliability index[12]. Such practices may also increase risks of infrastructure failure (as reliability of the asset fit-for-function decreases), potentially resulting in long shutdowns or delays to operations.

The authors of Ref. 11 noted that U.S. Class I railways maintain their infrastructure through a mix of ordinary maintenance and periodic renewal of infrastructure components. Different railways use different proportions of ordinary maintenance and periodic renewal with little consensus as to the best combination.

Furthermore, the cost-effectiveness of emphasizing one method over the other has not been analysed using empirical data.

3.11 The objective of previous QCA research was to investigate the cost-effectiveness of renewal-based maintenance strategies using high-level financial data from industry sources. The results indicate that

[11] Cost-Effectiveness of Railway Infrastructure Renewal Maintenance, George A Grimes, and Christopher P. L. Barkan, Journal of Transportation Engineering. August 2006. http://cee.uiuc.edu/railroad/CEE/pdf/Grimes%20&%20Barkan%202006.pdf

[12] Frongopol, DM et al (2007) "Reliability and Optimisation of Structural Systems, Assessment, Design and Life-Cycle Performance".

maintenance strategies that place more weight on renewal result in lower unit maintenance costs, at least within a specified observable range. The results imply that if railroads constrain renewal maintenance to reduce overall capital expenditures, increasing maintenance expenses will more than offset temporary reductions in capital spending.

3.12 The Consultants believe that without establishing KPI's for acceptable asset condition, it is not possible to determine if premature asset replacement is occurring. Further, KPI's should include provision for renewals-based maintenance where financial analysis shows that such practice is warranted. Any expectation that an extensive heavy haul rail network can be effectively managed on a few KPI's is simplistic. KPI's should be an aid to management but should not override common sense engineering assessments made by observations at site.

Service Delivery

3.13 Expansions in service deliveries will aggravate issues in regards to availability of possessions. It is considered important for clear price signals to be provided that reflect the disruption associated with maintenance operations through disruption of possessions as well as supply chain operations through possessions.

3.14 QR's preference to spend on new infrastructure in order to reduce future maintenance costs raises the argument as to which way to take such renewals-based maintenance. It is definitely CAPEX if it raises the standard of the asset. If it maintains or raises the asset to existing 'fit-for-purpose' however, it is arguably 'required maintenance' and as such should be picked up in the Access Charge.

Key Performance Indicators: Service Level Measures

3.15 There are 41 existing KPI's. It is intended that these will continue to be monitored in UT3.

3.16 The Track Condition Index (TCI) is a measure of the quality of the very worst track locations. It is calculated from the mean plus three standard deviation point of the distribution of each Parameter Index over a track section. While this can be used to ensure no section of track exceeds an allowable maximum roughness, it is not a good indicator of overall track condition.

Monitoring the condition of only the very worst track locations can cause problems. It may lead the track maintainer to focus all effort on a small number of difficult locations. A lack of attention to other locations could cause the overall track condition to deteriorate.

The Consultant recommends that track condition indices are also calculated for the mean and mean plus two standard deviation points on the distribution, with the engineer to supply a timeframe between track condition measures and works. This would introduce two new KPI's.

3.17 TCI is calculated by summing the Parameter Condition Indices (PCIs) for top, twist, gauge and alignment without weighting. This implies that each parameter has the same order of magnitude and a similar weighting. It may be possible that PCIs for alignment, for example, may be large and those for twist, for example, small. This should be investigated and, if found to be true, KPI's should be used for each track parameter.

Asset Condition

3.18 Table 1from QR's submission claims to cover asset condition, however the TCI is the only direct measure of asset condition. The other KPI's measure the results of poor asset condition (e.g. delays and buckles). The Consultant recommends that additional measurements be included that confirm the actual condition of the asset.

Table 1 Existing Alliance Agreement KPI's – Asset Reliability and Maintenance Performance

Asset Reliability / Condition	Maintenance Performance
Transit Time Delay	**Fault Response**
Track and Structures	Traction Power (High Priority)
Trackside Systems (Signal)	Signal (High Priority)
Trackside Systems (OHL)	**Production Against Program - Infrastructure**
Track	Resleepering
Derailments (due to Infra.)	Resurfacing
Track Condition Index	Rail Grinding
Buckles/Pull Aparts	Ballast Undercutting
Rail Defects	Track Recording
Trackside Systems - signals	Non Destructive Testing
Faults	*Trackside (traction)*
Wrong side Failure	Routine Maintenance
Restored in face of train (RIFOTS)	Major Maintenance
Signals passed at danger (SPADS)	*Trackside (signal)*
Trackside Systems – Traction Power	Routine Maintenance
Dewirements (due to Infra. Equip.)	Major Maintenance
Transformers	
Faults (non-resetable trips)	

For example, consider the stress free temperature in rails. At the start of an access undertaking there will be a distribution of stress free temperature across the network as shown in Figure 2. At the end of the access undertaking the distribution may have changed as shown in Figure 3. This could be caused by track maintenance and rail repairs without adequate restressing. Rail on the network is still within the tolerances of stress free temperature, and there may have been no buckles. However the track asset is clearly in a worse condition than it was at the start of the access undertaking.

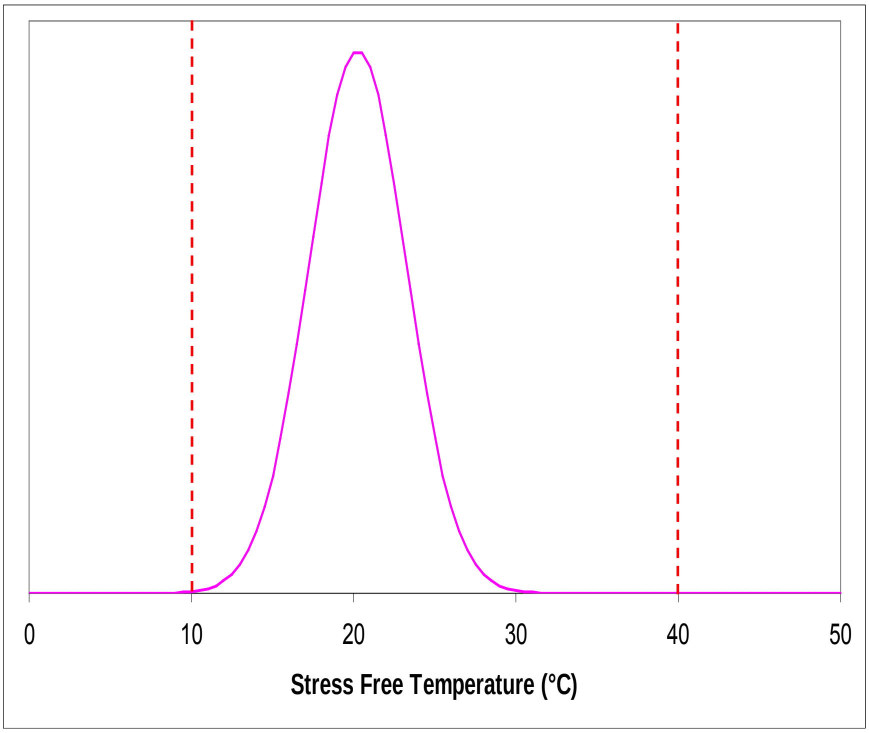

Figure 2 Stress Free Temperature Distribution – Start of Undertaking

3.19 The Consultant recommends that a ballast fouling index also be implemented. Data would need to be gathered through a planned robust testing regime, using accepted investigative procedures such as Percentage Voids Contamination (PVC). In some North American railways a system integrating modelled radar testing with dielectric parameters compares data to field confirmed gradation levels. This measure identifies threshold areas which are then integrated through GIS systems for maintenance planning and prioritisation. It is understood that QR is currently investigating the use of such procedures.

3.20 The Consultant recommends that KPI's also be implemented for drainage and sleeper condition. Poor drainage has been identified as a maintenance driver as a general principle in the operations of railways.

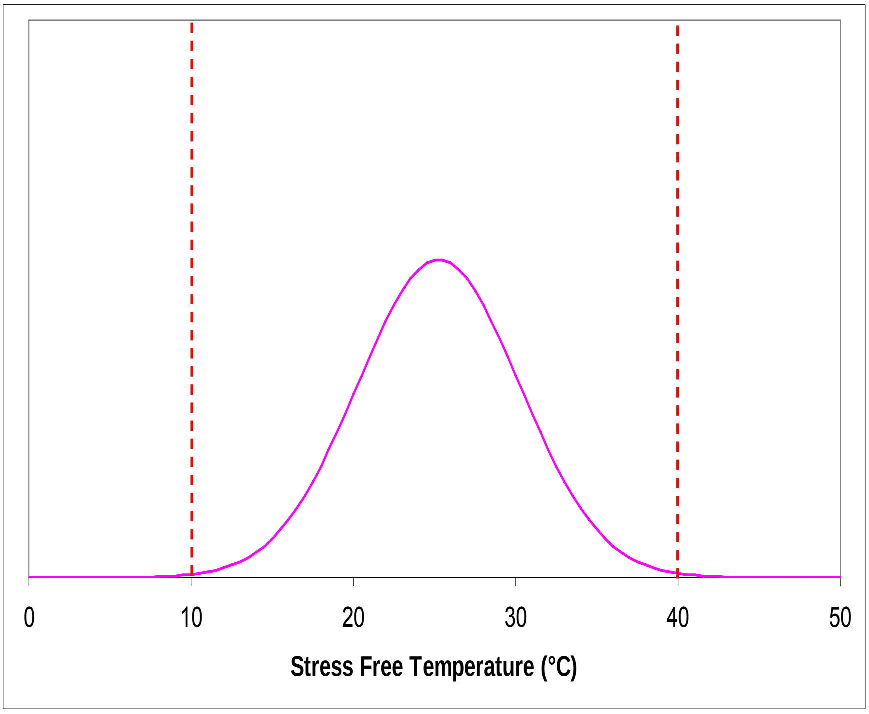

Figure 3 Stress Free Temperature Distribution – End of Undertaking

3.21 Similar arguments could be made for other aspects of asset condition. Another example is rail wear. Rail wear may be within the limits over the whole network, however it could be much closer to the limit at the end of the access undertaking than it was at the beginning. This means the track manager and maintainer are going to have to renew additional rail during the next access undertaking.

The Consultant recommends including more KPI's on general asset condition. These could be based on information regarding the asset's condition that is already being recorded.

3.22 It is important to ascertain the fit-for-purpose standard at the beginning of the undertaking, and identify those parts of the network which fall short (i.e. the maintenance deficit). The asset should be fit-for-purpose at the end of the undertaking, and if not, the deficit should be calculated and taken into account when establishing the next undertaking. Similarly where a maintenance deficit is identified, the additional costs required to get the asset to fit-for-purpose should be calculated when establishing the undertaking costs.

The Consultant believes that KPI's should be implemented for this. A maintenance deficit has as real an effect on the bottom line as a financial deficit.

Production Quality

3.23 For the items in Table 1 under the heading "Production Against Program" there should be some measure of the quality achieved. Track possessions for maintenance work have a direct effect on the movements of "revenue" trains. Therefore it is not sufficient to only record that the planned work was completed. In addition, there should be a measure of the benefits of the work undertaken.

For example, the programmed kilometres of tamping may have been completed but the quality of the work may have been poor. This may result in additional track possessions being required later to achieve the desired track quality.

If the only KPI being monitored is production against the program, then the maintainer may be motivated to just complete the work and not give sufficient focus to the quality of the work being undertaken.

KPI Targets

3.24 To date, KPI data has been reviewed at monthly Alliance Team management meetings. Throughout the submission document QR refers to an existing "service level specification". It is not clear to the Consultant where this service level is specified. It does not appear that targets exist for the current KPI's. Thus, the Consultant concluded that KPI's are currently not used to correctly judge whether a desired service level has been achieved or not.

It is anticipated that KPI targets may be introduced for UT3. Historical KPI data has been provided for the period from July 2001 to December 2007. The Consultant has analysed this information to determine whether sensible targets could be set for UT3. Several examples of this analysis follow.

Analysis

3.25 Figure 4 shows the history of resurfacing (tamping) production against program. The horizontal line through 166 indicates the average production against program. Clearly production has varied about this average for the last six years without any indication of reason for increase or decrease.

The horizontal dashed lines in Figure 1.4 at 280 and 52 respectively are at plus and minus two standard deviations from the average. Over the last six years resurfacing production against program has varied between these limits.

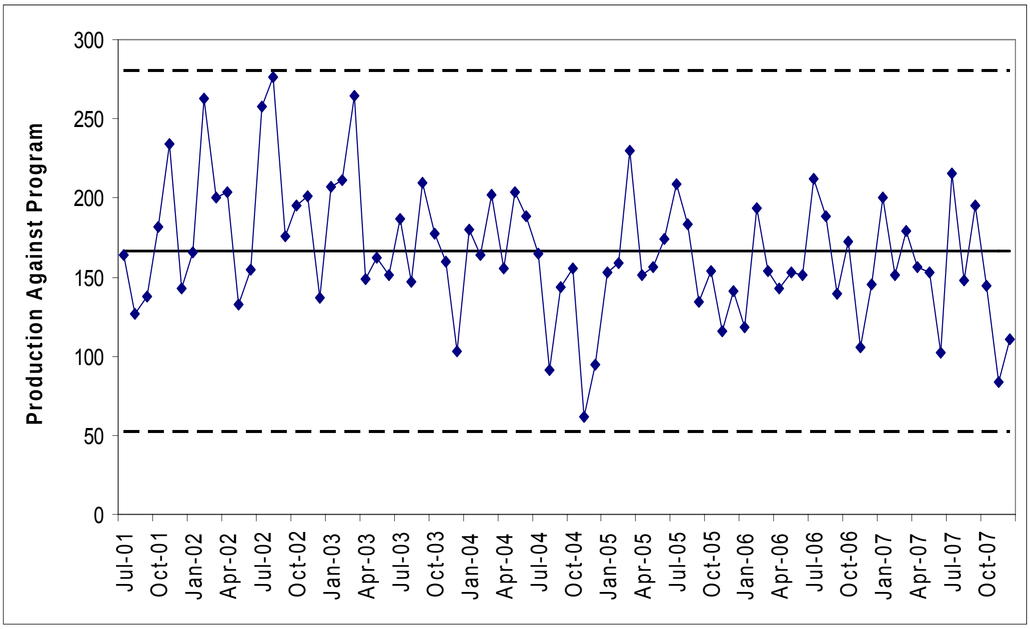

Figure 4 History of Resurfacing Against Program

In the terminology of Statistical Process Control one would say resurfacing production is in control with large variation. One can expect future production to vary between 52 and 280 around a mean of 166 unless a change is made to the process. With this amount of variation it will be difficult to determine if any change has made a difference to production. If, for example, next month's production is 250 there will be no definitive answer as to whether this is just part of the typical variation or if it is due to some change that was made.

3.26 Figure 4 demonstrates how difficult it would be to set a meaningful performance target for resurfacing production. Performance would have to change by at least 70% from its current average in order to be noticed. It is unlikely that any asset manager would accept such a target.

One solution is to set a target for a reduction in variation. If the month-to-month performance has less variation then changes will be easier to detect and targets can then be set. Another option is to derive KPI's that have less variation.

3.27 When KPI's are concerned with rare events such as trespass it is better to analyse the time between incidents rather than the number of incidents in a given period. Figure 5 shows the results of this type of analysis on the trespass data from July 2001 to December 2007. There were four trespass incidents in this period.

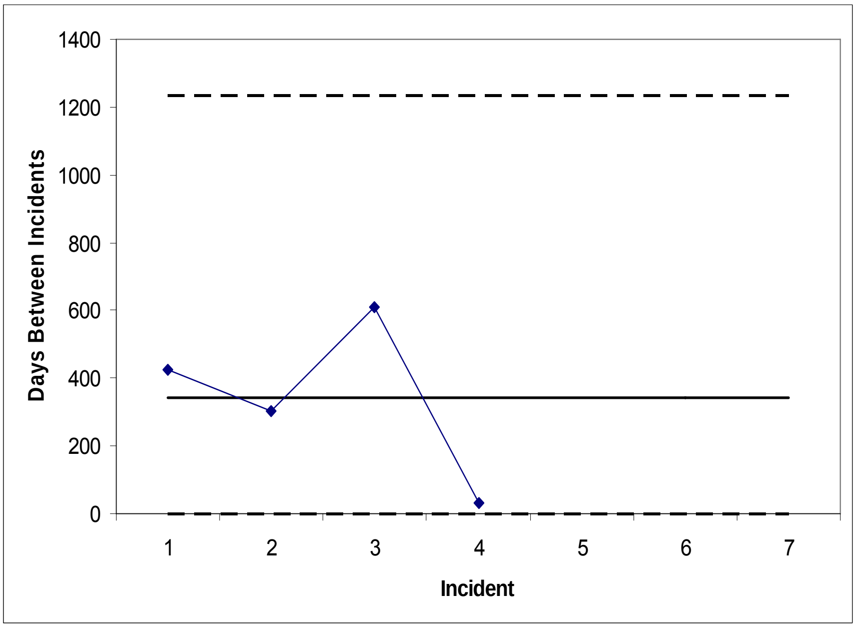

Figure 5 History of Time Between Trespass Incidents

Figure 5 shows that the mean time between trespass incidents is 340 days. There is a large variation in the time between these incidents. Unless something is done to affect trespass incidents one could expect the next incident to occur any time up to 1230 days from the last incident.

3.28 These statements may seem very general, but they are all that can be legitimately derived from the historical data. They illustrate the difficulty in setting targets for KPI's such as reductions in trespass incidents. Even if there were no further trespass incidents for three years one could not be sure if this was just part of the normal variation or a definite sign of improvement.

Safety & Cost

3.29 Safety and Cost Control measures are included in the existing 41 KPI's used in UT2. Care has to be taken when mixing safety and cost measures. Safety is measured in fatalities, injuries, lost time, etc. These cannot be compared with dollars unless a value has been placed on them.

3.30 Costs and safety clearly interact. For example, maintenance costs may be reduced by including more than one job in the same possession. As a result there will be more interfaces between different teams at the worksite and a greater chance of incidents.

3.31 The Consultant understands that QR requires risk assessments to be carried out on certain activities. It is not clear, however, how the trade-off between cost and safety is made in day-to-day decisions. The Consultant recommends that some thought be given to avoiding a focus on reducing costs that may lead to a negative impact on safety.

Passenger Rail Requirements

3.32 A small number of passenger trains operate on some of the lines included in the undertaking. High speed passenger trains require higher standards of track geometry and signalling than heavy haul freight trains. These requirements have to be met if a passenger train operation is intended for a line, regardless of how many such trains actually run. Passenger trains may also have different requirements for punctuality compared to freight trains.

3.33 The higher standards required for passenger trains may potentially drive costs on freight rail lines. In instances where only a small portion of the network is beholden to these requirements, a consensus based approached may be adopted. If a certain standard is developed to provide a 'fit-for-purpose' asset, these requirements may ultimately provide business benefits. Further work would be required to ascertain the feasibility of such an approach.

The Consultant recommends that the impact of passenger train requirements upon QR's Network Access's infrastructure management be recognised in some way.

Proposed New Service Level Measures

Train paths

3.34 Numerous references are made in QR's submission to paths not being available to revenue trains. Keeping record of an unavailable path when it isn't required for a revenue train will yield distorted results. A better measure would be identifying paths not available when a revenue train is ready to be dispatched.

3.35 Further, not all coal train paths are of the same value. When there is surge due to shipping requirements at the port, paths will have a naturally higher value. The railway operator is caught between the coal company (which does not want to stock pile), and the shipping company (which does not want its ship delayed at port). Just-in-Time (JIT) logistics place an additional burden on the transport link, one it should be compensated for.

Above Rail Operator

3.36 Several important issues are not included in the analysis of the impact of infrastructure maintenance on the performance of the above rail operator. Table 2 gives some examples. The Consultant recommends that these should also be considered for possible use as KPI's in UT3.

Table 2 Additional Impacts of Infrastructure Maintenance on the Above Rail Operator

Impact	Effect	Measure
Single line working	Reduces the impact of possessions. Not appropriate for all types of maintenance work. Some safety risk issues	
Quality of track maintenance	Poor quality of work performed requires follow-on work sooner than would otherwise be required.	Comparison between track quality index before and after work.
Choice of the type of maintenance	The wrong choice of maintenance (e.g. continued tamping rather than ballast cleaning) means more possessions are required in the long run.	Can be measured over simple LCC (Life-cycle cost) by comparing the effect of the measure in expanding life of the component/ system
Balance between "interval tamping" and "chase tamping".	The correct balance will result in the minimum possession requirement while delivering the required track standards.	Can be measured through availability and LCC.
Efficient use of possession time	Too much time spent setting up and shutting down the work site will leave insufficient time to get the work done and require a further possession.	% of possession time spent actually working.

Supply Chain Impact

Table 3 Further Supply Chain Impacts on the Track Maintainer

Impact	Effect	Measure
Inflexibility in the possession plan	Greater flexibility would allow campaign maintenance to be performed and ultimately increase track availability.	
Train failures and derailments	These prevent access for planned possessions and may divert resources.	Number of incidents – type of incident (minor/major) and length of delays
Train speed restrictions due to train condition	Trains having wheels with flats, for example, may be required to complete their journey at reduced speed. This puts pressure on the timetable and may lead to possessions being cancelled.	Number of faulty cars not detected and running at full speed, or number of detected wheel flats. Penalties for faulty rolling stock as implemented in Austria and USA.

3.37 Table 3 shows three further impacts of the supply chain on the track maintainer's ability to perform the required maintenance tasks. The Consultant recommends that these are also considered for possible use as KPI's in UT3.

Proposed Service Specification

3.38 A modest increase of three KPI's to the existing 41 is proposed. The Consultant considers it better to have more KPI's that are specific than a few KPI's that are general. When a specific KPI shows a significant change it will be relatively easy to discover the reason. KPI's should also be specific to the targeted business unit and level of management responsible.

3.39 The Consultant anticipates that the existing and new KPI's will be reviewed at the monthly Alliance Team management meetings. KPI's that show no significant change from previous values would not be discussed. Time would only be spent on KPI's that showed a significant change in value. Therefore it should not matter if the total set of KPI's used is large, as the focus would only be on KPI's with significant variations.

3.40 The Consultant recommends that the new KPI's discussed and those additional KPI's listed above be reconsidered. All those that are readily measurable should be included in UT3.

3.41 Defining the KPI's is a step towards defining a service level specification. The specification should set targets for each KPI and describe the actions that will be taken if the targets are not met or are exceeded.

If historical data is available for the proposed new KPI's it should be analysed to determine if meaningful targets can be set. Targets, penalties and rewards should not be set for KPI's that historically have a large variance.

Conclusions

3.42 QR Network Access is proposing to add three more KPI's to the service level agreement for UT3. These new KPI's address the availability and management of possessions and the impact of speed restrictions.

The Consultant recommends three further changes to the service level specification:

a) Improved definitions of all KPI's.

b) An addition of at least three new, but possibly more, KPI's

c) Changes to KPI monitoring methods

3.43 This report gives examples of KPI's that need to be defined more clearly. The Consultant recommends that clear and unambiguous definitions of all KPI's be included in an appendix to the service level specification or published in a separate document.

3.44 Some of the existing KPI's are combinations of several, more specific performance indicators. Overall Track Condition Index, for example, combines track top, twist, gauge and alignment parameters. The Consultant recommends that KPI's for the detailed parameters be included in the service level specification.

3.45 An attempt has been made to condense the proposed new service level measures into just three new KPI's. The Consultant recommends that all the new KPI's that are readily measurable should be included.

3.46 KPI's are essential if it is required to follow the principle "you can't manage what you don't measure". However, care must be taken when using KPI measurements to make management decisions. Considerable care is also necessary when setting KPI targets and incentives. The Consultant recommends the following principles:

- Monitor the required number of KPI's that each cover specific details of the undertaking.
- Use statistical methods to focus attention on KPI's that exhibit noteworthy changes.
- Understand and act on the causes of noteworthy changes in performance.
- Do not spend time and effort looking at KPI's that continue to follow historical behaviour.
- Do not set targets for KPI's that have large variances.
- View a reduction in variance as a performance improvement.

3.47 QR Network has advised the Consultant that currently a comprehensive review of the KPI structure is being undertaken in readiness for the commencement of the UT3 undertaking. Where considered appropriate, the previous recommendations will be considered as part of this review.

4. ASSET CONDITION

Site Audits: Asset Condition

Introduction

4.1 This section provides findings from the asset condition audits conducted by Consultant discipline specialists conducted in the period March to June 2008.

Method of Work

4.2 Site audits of asset condition were conducted during the period from March to June 2008.

4.3 The Condition of relevant assets to each specific workstream were audited individually by specialists in the particular discipline.

4.4 Auditors were accompanied by relevant QR site staff that assisted the auditor in obtaining any relevant information pertinent to the audit. They also assisted by answering technical and process questions in regards to the asset and the maintenance of the asset.

4.5 Each specialist produced a brief report on their findings and subsequent discussions were held with QR representatives to clarify any issues or further questions.

4.6 Following discussions and preliminary comments, a review of Section 5 Description of Assets of the UT3 submission was conducted, and a comparison made between what was indicated and what was found on site.

4.7 A final summary of findings was compiled by each specialist. The summary and conclusions from these findings are included in this section.

4.8 The discussion is broken down into the relevant workstream disciplines.

Ancillaries

Wagons

4.9 Three types of coal wagons operate on the Blackwater, Goonyella, Moira and Newlands systems. These are:

- VAZQ (20.0to axle load, gross 80t)
- VSHL/VSAS (26.0to axle load, gross 104t)
- VCAS/VCAL (26.5to axle load, gross 106t)

All these wagons have bottom discharge doors.

4.10 The wagons were found to be in fair condition, although gaps were commonly seen around the doors. Figure 6 shows an example of this on an empty wagon. Daylight can be seen shining through the gap between the door and the wagon body. Some of these gaps were quite large with a significant amount of dust seen spilling from them on loaded wagons.

Figure 6 Gaps on wagon bottom doors allow spillage in transit

Loading Facilities

4.11 Loading was controlled manually from a hopper depositing the coal directly into each wagon. In some cases the loading was not uniform.

4.12 Figure 7shows a wagon with more coal at the near end compared to the far end. At the near end the coal is spilling over the top sill of the wagon.

4.13 Figure 8 shows that the far end of the wagon is not fully loaded.

Figure 7 Overloading of wagons

Figure 8 Uneven loading of wagons

Overloading or poor loading of cars at loading facilities is known to cause spillage of coal along the route. This is more noticeable when the train gathers sufficient speed and/or passes over crossings, points or areas where slight jolting to the wagon may occur. The chemistry of coal is such that it is an extremely corrosive material and relative to other bulk minerals (for example iron ore) can significantly increase deterioration of track assets.

4.14 Significant spillage was also apparent on wagon platforms, couplings and other surfaces (Figure 9). This could be caused by poor loading or spillage from the top of the wagon in transit. Figure 10 shows coal caught on the bogie side-frame during improper unloading. Spillage such as shown in Figure 9 and Figure 10 can fall off in transit, causing deterioration and damage to assets.

Figure 9 Spillage on wagon surfaces

Figure 10 Coal on bogie side-frame

Civil (Track and Structures)

4.15 Site visits were made from 30 March to 1 April 2008 on the Goonyella and Blackwater systems. In general, the auditors gained the impression of a well maintained railway. The rail, turnouts, sleepers and fastenings were, with a few exceptions noted below, in good condition. The most noticeable defect was the poor condition of the ballast, which is also discussed below.

Rail and rail furniture

4.16 The surface condition and transverse profile of the rail was visually inspected at several curved and straight track locations. No rail was found close to its wear limits. Short (less than 10 mm long) rolling contact fatigue cracks were seen on the gauge corner of some curved rails. Grinding stone marks were also observed on the rails. This is consistent with a grinding program that is being used preventively to control rail surface damage and maintain rail profile.

4.17 At the regional office in Mackay the auditors talked to the QR staff responsible for planning rail renewal. The process of making regular rail profile measurements was discussed. The auditors were satisfied with the knowledge and experience of the QR staff and their understanding of the need for multiple and frequent measurements.

4.18 Figure 11 shows fishplate and rail fastening corrosion exacerbated by coal spillage along the track. Corrosion of the Fist type rail fasteners was also observed. Galvanised Pandrol clips were being installed at a renewal site.

Figure 11 Corrosion to rail furniture

Ballast

4.19 The ballast was found to be fouled with coal in loading and unloading facilities, yards and the main line. Contamination within areas after loading zones was also very noticeable (Figure 12)

Figure 12 Contamination was severe within loading zones

Figure 13 shows a site on the Blackwater main line where the ballast under both tracks is completely fouled with coal dust.

Figure 13 Blackwater main line contamination away from unloading and loading zones

In some locations the ballast appeared to be relatively clean (see Figure 14). However, when a few stones were moved the extent of the coal fouling could be seen as shown in Figure 15.

Figure 14 Apparently clean ballast

Figure 15 Contamination beneath the surface

Several examples were seen of coal being washed from the ballast into the cess by rain (see Figure 16).

Figure 16 Coal being washed from ballast into cess

The effect of coal pollution in the ballast was discussed with QR staff. It was agreed that coal falling onto the surface of the ballast finds its way to the bottom of the ballast layer by vibration and being washed down by rain. The coal pollution builds up from the bottom of the ballast, reaches the bottom of the sleepers, and finally fills all the available voids. Coal pollution is pushed under the sleepers by the vibrating and squeezing action of tamping tines. Coal pollution can cause track geometry problems in two ways. Firstly, it holds moisture in the formation. Where the formation has high clay content (common for QR), the wet clay cannot support the traffic loads and squeezes out sideways, allowing local track settlement. Secondly, the clogged ballast has different strength properties, particularly when wet, compared to clean ballast. It loses its shear strength and can deform in a similar way to wet clay under traffic loads.

QR staff produced records of speed restrictions caused by track geometry problems after periods of heavy rainfall. This evidence supports the common understanding of the behaviour of polluted ballast described above.

4.20 The auditors were told about a process QR uses for measuring the Percentage Void Contamination (PVC) of the ballast. These measurements provide a scientific basis for prioritisation of ballast undercutting. The measurement frequencies and sampling methods were discussed and found to be satisfactory. It was not possible in the time available for the auditors to witness samples being taken or analysed.

4.21 A location on the Goonyella system was visited where stone-blowing had been performed. Track geometry faults had arisen at this location due to coal pollution. Frequent tamping had been required to treat the problem. Since stone-blowing, the site has not required further tamping. The auditors' visual inspection showed the track geometry to be satisfactory. The local track engineer said he was pleased with the stone-blowing results at this site.

Turnouts

4.22 The auditors inspected several turnouts. All the turnouts inspected in the main lines had swing-nose crossings as shown in Figure 17. The condition of the turnouts on the main lines was very good. All the components were in place and the fastenings were tight. Although there was coal pollution in the ballast, the points, nose and operating rods were clear of coal.

Figure 17 Swing nose turnouts

Coal pollution was observed at a turnout in an unloading facility. This was being cleaned with a special vacuum system as shown in Figure 18.

Figure 18 Cleaning of coal contaminates with vacuum system

Formation and drainage

4.23 The auditors visited a location on the Goonyella system where a formation failure had been repaired. The failure had occurred in an area with poor drainage where "black clay" is present. The repair had been made by lifting the track, excavating the ballast and treating the formation with a blanketing layer. At one location on the network some pooling of water was noted on the cess indicating sub-optimal drainage in other areas.

However it is noted that QR are commencing the first stage of a formation strengthening capital works program to address the formation issues on a priority basis.

4.24 Figure 19 shows a location where there had been a rock slide caused by heavy rainfall. QR had previously installed an instrumented fence at this location. The system sent a signal to the control centre when the rocks broke the fence and blocked the track. Trains were stopped before a serious accident could occur.

Figure 19 Monitoring rock fall on unstable embankment

Bridges and Culverts

4.25 Cracks were observed in some bridge abutments. These were being monitored by QR. Bridges and culverts were generally in reasonable condition. Some concern was expressed at the condition of some of the older culverts where structures had not been strengthened to carry the increasing axle loads.

Figure 20 Typical RC bridge. Debris seen consists of roadway washed out in recent flooding

Figure 20 shows a bridge over a river that had experienced an exceptionally high flow after a period of heavy rain. The bridge was being inspected for movement and scour. The access road that forded the river had been washed away.

Traction

4.26 The age of the power supply assets on the QR systems of Blackwater and Goonyella is in most cases measured from the age of the respective systems i.e. ~ 2008 – 1987 = ~ 21 - 22 years.

4.27 This implies, assuming that the asset condition is typical of similar power assets of the same age, that for each major class of asset:

- Traction power transformers – should be serviceable for a least a further decade but the units must be carefully monitored. Also new transformers should be added to the system so that a transformer failure does not result in a significant loss of traction power.
- Auto transformers – are nearing the end of their serviceable life and a regime of continuous replacement should be considered.
- Circuit breakers and switchgear – are technically obsolete and should be replaced with modern designs to ensure an adequate supply of spares. Cannibalization of old switchgear can be undertaken in order to maintain spares for older equipment that remains on the system. Obsolescence not withstanding, the switchgear should be capable of operation for a least another decade.
- Protection relays – are technically obsolete and a regime of continuous replacement should be considered.
- Fault locators - are technically obsolete and a regime of continuous replacement should be considered. It should also be noted that many modern protection relays include fault locators. Therefore replacing protection relays may also resolve the fault locator issue.
- Batteries and battery chargers should be replaced at a frequency of no more than approximately 15 year intervals depending on the service conditions they experience (e.g. higher temperatures will result in a shorter service life for batteries). If the age of the units is approximately 21 -22 years (which the Consultant has been unable to confirm) then all battery systems should be replaced.
- Harmonic filters – should be serviceable for a least a further decade, with capacitor cans replaced if failures occur.

4.28 The original auto transformers are of rudimentary design which has caused some service issues. Many units have experienced partial discharge issues and there have also been some failures.

Discharges in gas-filled cavities in insulation, resulting from incomplete impregnation, high moisture in paper, gas in oil supersaturation or cavitation, (gas bubbles in oil) leads to X wax formation on paper. X wax formation comes from Paraffinic oils.

The design of the units, a basic sealed construction without conservator, has probably led to moisture ingress and may have contributed to the partial discharge issue.

Many units have been vapour phase cleaned in order to remove X wax deposits.

QR has replaced approximately 10 with a more expensive (i.e. with traditional conservator installed) design which is expected to perform better.

4.29 Due to increases in traction load the existing power transformers (28 off at 30 MVA rating each) are being utilized to their full capacity. Capital projects are planned to increase the number of substations which will subsequently reduce the overall load. At the moment the failure of any one of the 30 MVA transformers will lead to an overload of the remaining units, which is clearly an undesirable state of affairs.

The pH of the transformer oil is acidic requiring about 0.1 mg of KOH per g of oil to neutralize the pH. The graph (Figure 21) below gives typical expectations for the acidity of transformer oil with regards to service life assuming no oil replacements are made.

The age of the units is approximately 21 - 22 (2008 – 1987) years so an acid number of 0.1 is relatively good compared to an expected acid number of approximately 0.8 for units of this age. This is assumed to be due to regular maintenance and oil replacement. The 0.1 figure is the point at which deterioration starts becoming more pronounced.

Oil should be reclaimed when levels reach 0.2 mg/g, this should be planned for in future maintenance budgets.

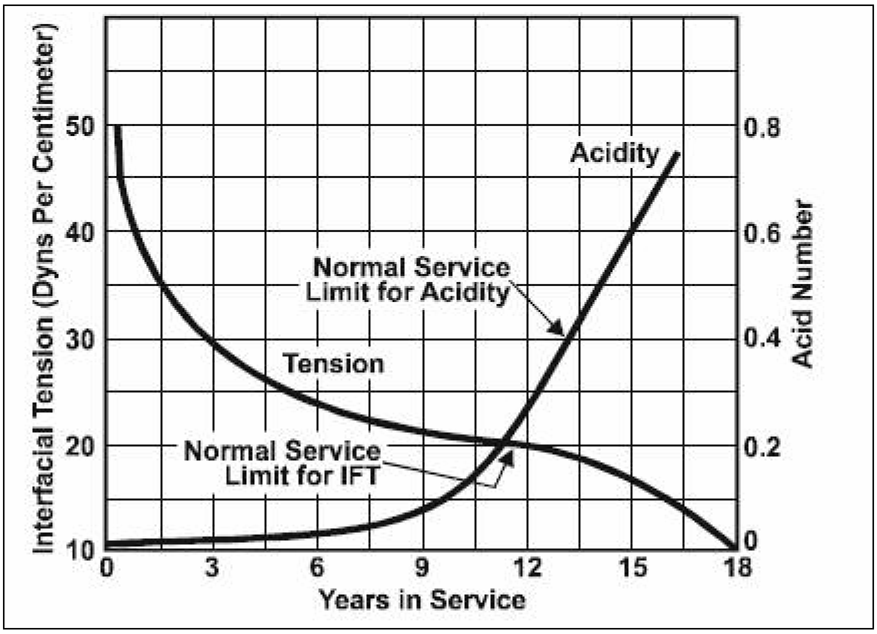

Figure 21 Interfacial Tension, Acid Number, Years in Service

4.30 Ongoing maintenance of the BICC neutral section is required to ensure that these devices do not contribute to system faults. In particular it is critical that the magnetic switching arrangements should always be carefully maintained as incorrect assembly after maintenance potentially can cause electrical faults.

4.31 The Consultant was unable to establish the in-service reliability of the existing assets in quantitative detail due in part to the minimal recording of service statistics since 2004. However, it is expected that this situation will improve as monitoring asset management systems being currently developed are put in place.

In particular it is not known what proportion of assets have been replaced in response to failures. Accordingly the comments given above draw upon the understanding that the Consultant has obtained from QR personnel of the condition of assets. It also takes into account the Consultant's general operational experience of power supply equipment in the rail industry and in the wider power transmission and distribution industries.

Signals and Telecommunications

4.32 The telecommunications assets are generally combined under "backbone" in the cost details. The main element of the telecommunications assets is certainly the backbone communications link along the railway line. The backbone system is a combination of optical fibre and microwave equipment designed for high reliability and very high availability.

4.33 All of the equipment used is of carrier grade (as used by major telecommunications carriers) and is designed and built for very high reliability. Failures of this class of equipment are very rare and it is generally designed to operate for around twenty years with minimal maintenance.

4.34 The distinction between reliability and availability is made at a system level. Faults and damage to the equipment and cables can occur so backbone systems use one or more methods of duplicated connection. Failure of any one item is a reliability problem, requiring a repair, but the overall system availability will not be affected as the equipment will automatically switch around the faulty section.

4.35 Microwave backbone systems only have equipment at the microwave sites so the reliability of the systems is only dependent on the equipment at the sites. Optical fibre systems have the same characteristics at the site but of course have a cable between locations which can be vulnerable to damage.

4.36 There is inevitably a trade-off between the backbone technologies. Microwave sites are generally on hill tops or mountain tops to maximise the line-of-sight distance between the locations. The microwave sites are usually chosen to also give good mobile radio coverage of the railway line. A site distant from the railway line is not useful for railway signalling. Associated systems located there require either a further spur link from the microwave site to the track side or a cable connection from the site to the line. It is normal practice to use the microwave system as a back-up connection, providing a highly reliable link to key points along the railway. Being away from the railway easement any incident along the track is unlikely to affect the microwave equipment so communication can be maintained after serious incidents (eg flooding, major derailment involving several kilometres of track).

4.37 Optical fibre cable is the modern method of interconnection of many trackside sites. The cable is not affected by electrification, is very reliable, has low loss and generally will work until it is physically damaged. The life of the cable can be affected by the installation methods and by soil movement around the cable (if it is directly buried).

4.38 QR has chosen to use a combination of optical fibre and microwave systems to create the backbone along the coal routes. The optical fibre connects the trackside equipment and the microwave links into the optical fibre at key locations. Mobile radio base stations are generally located at the microwave sites. The transmission network is shown in overview in Figure 22.

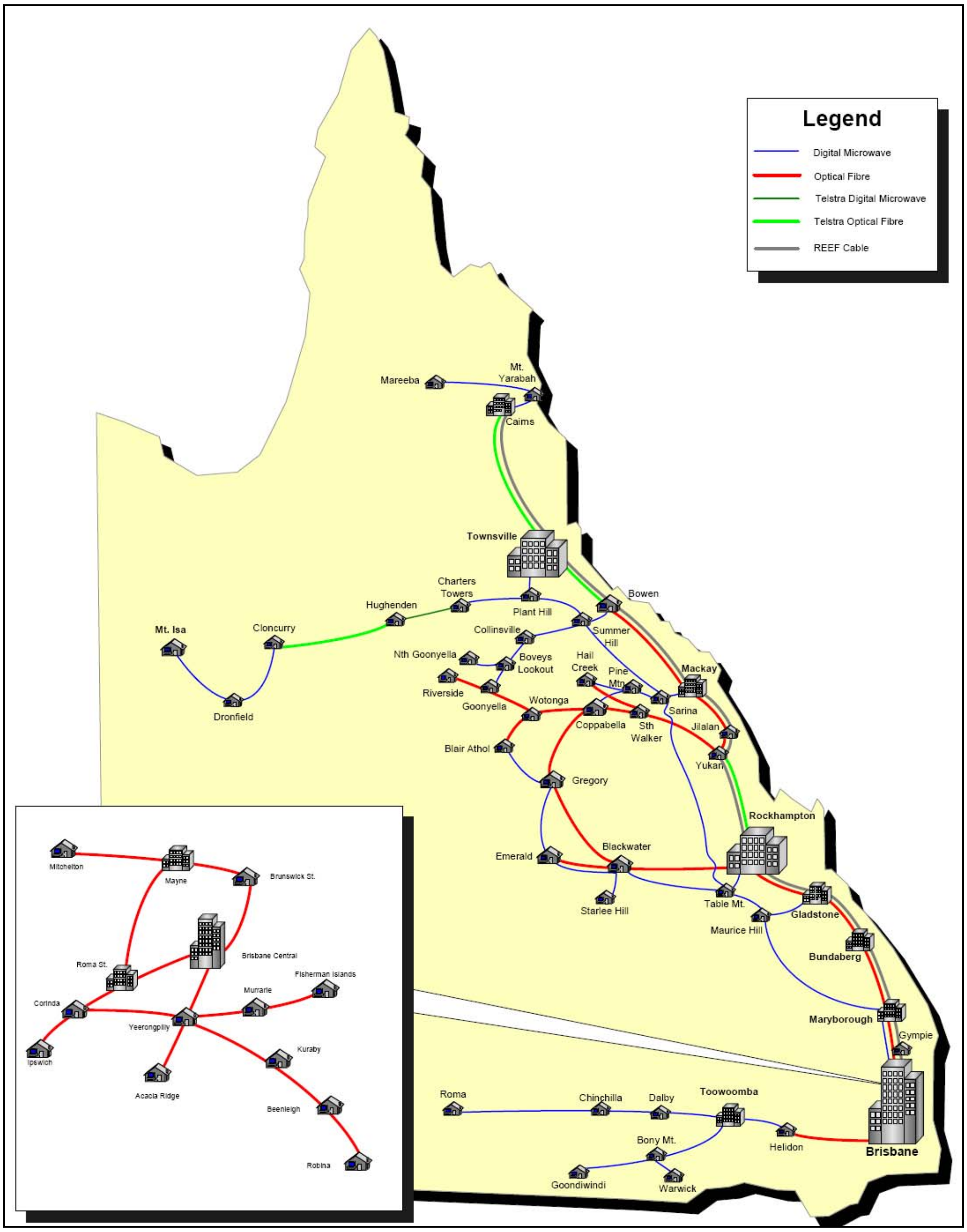

Figure 22 QR Transmission Network

4.39 The optical fibre cables were installed during the electrification of the lines. QR was an early adopter of fibre optic technology and has had some problems as a consequence of the early implementation. The optical fibre cable was directly buried or ploughed in some areas, as was the practice for copper cables at the time. This has turned out to be a problem in areas with reactive soil as the cable has been stressed by soil movements. The optical fibre cable in these areas should be replaced before it fails completely. The Consultant understands that there is provision for this replacement in the QR capital works program.

4.40 Apart from the mechanical problems with the cable installation mentioned above, the optical fibre systems are working reliably.

4.41 It was impractical to achieve a full audit of telecommunications sites and equipment so a sample of sites in the vicinity of Rockhampton was inspected. The sites were chosen to include each of the technologies in use in the region. The control and maintenance centres at Rockhampton were also visited.

4.42 The various technologies and systems are described in the following paragraphs. Each system is discussed in relation to the sites at which it was inspected.

4.43 Gogango Microwave Site. Gogango is a microwave and mobile radio repeater site on a hill top some distance from the railway line. The site was established at the time of electrification and was built to last. Over twenty years later the building is in excellent condition and the tower appears to be in an equally good state. The building design has a concrete floor and roof, double brick walls and a steel roof deck for rain water runoff. There is a water tank and a separate diesel generator power room.

Figure 23 Gogango Microwave Site

4.44 This site is tidy and well maintained. The equipment is checked routinely at six monthly intervals and the tower is checked annually. Power for the equipment is derived from the mains supply, with a substation at the site. Backup power is provided by a diesel generator and the equipment operates from a 510 Ah battery. The load on the battery at the time of inspection was around 25 A but this varies considerably with mobile radio traffic. The dimensioning of the battery and power supply seems appropriate.

Figure 24 Battery power supply

4.45 The battery is currently the most maintenance intensive aspect of the site as there have been problems with the battery terminals leaking. This issue has occurred at most of the sites where this brand and model of battery is in use and is the subject of a dispute with the manufacturer. The Consultant would recommend that the battery problems be assessed and if found to be justified, that all of the affected batteries be replaced by a different brand. A three monthly visit is currently required to check the batteries for leakage.

4.46 Mobile radio equipment is provided for three functions. The primary service is Train Control Radio (TCR), carrying traffic only between train controllers, drivers and track staff. This is an open channel system on which all participants can hear all calls. There is a tone based selective calling system and GPS data transmission is possible to ascertain train location. A Maintenance Service Radio (MSR) system is used by track staff and is also available as a back up train radio system. These two systems use similar technologies and are of similar age. The third system is a Trunked Radio that is available for general communication and PABX access. The trunked radio system is now life expired but is maintained because it provides communication where there has been no alternative.

4.47 The equipment for both the TCR and MSR is now about twelve years old. The equipment can still be maintained and spare parts are available. It would be wise to plan for replacement of at least the hardware on these systems after this UT3 period.

4.48 There is very limited mobile radio coverage along much of the railway. The trunked radio service satisfies a need that might otherwise not be met. The trunked system currently carries around 300 calls each day. The question for QR is whether to replace the outdated trunked radio equipment with a modern system or to abandon the service altogether. There are several candidate technologies for a replacement system that would offer good service and could potentially be integrated with both the

TSR and MSR systems. The trunked radio system can probably be maintained in its current form for the duration of UT3. A decision on its replacement will be needed by the start of the following agreement.

4.49 The microwave equipment on this route is Siemens digital radio, installed in 2002. This equipment has a notional life of fifteen years. It could last for longer but will probably be considered inadequate for its required communication tasks well before the end of its operational life. The rate of change of technology is very rapid.

4.50 Wallaroo Microwave and Optical Fibre Site. Wallaroo is a trackside site at a signal interlocking location. There is a guyed mast for the microwave and mobile radio systems, linking this site into the overall microwave network. The trackside optical fibre cable is brought into the site and the transmission equipment is interconnected here. The building is constructed in a similar style to Gogango and is in excellent condition. The building has been kept clean and tidy and should not require substantial work for many years.

Figure 25 Wallaroo Microwave and Optical Fibre Site

4.51 The microwave equipment is the same variety and age as that at Gogango. It should give reliable service for ten or more years.

4.52 The SDH optical fibre equipment is about three years old and could be expected to be useful for at least another fifteen years.

4.53 The optical fibre cable is around 20 years old and is affected by movement of the black soil in which it was laid. Replacement of this cable should be planned for the next few years, preferably in conjunction with some major civil works so that the cost of access and installation is minimised.

Figure 26 Optical Fibre Multiplex Equipment

4.54 The mobile radio systems at this site are of the same vintage as those at Gogango and the same comments apply.

4.55 **Bluff Station Optical Fibre Site.** This is a new site and has a completely different approach from the previous sites. A portable building has been used, rather than the previous brick and concrete style. The building has sheet metal and foam sandwich construction with a flat steel roof. Air conditioning is used to remove heat from the building, supplemented by vent panels on the sides of the building. The building is obviously much cheaper to install than the other style. The long term costs of maintenance, protection from vandalism and security have yet to be determined.

Figure 27 Bluff Station Optical Fibre Site

Figure 28 Generator Bluff Station

4.56 The generator at this site is a packaged unit, remote situated from the building. This approach is widely used for modern installations and removes a number of problems related to vibration and fuel storage in a communications building.

4.57 The same style of optical fibre equipment is used in this building. The optical fibre cable termination has been brought into the building.

4.58 There is a small Siemens PABX unit in this building to accommodate the needs of Bluff Station and the surrounding sites. The PABX is new and is expected to be useful for between seven to ten years. After that period the manufacturer will probably have forced obsolescence of the equipment. One could debate the relevance of providing a PABX at this location to below rail operations. Since the PABX is already in place and the operating costs minimal; this is not really an issue of any significance for UT3. In the long term there will need to be a clear definition of whether such facilities should be provided.

4.59 **Tryphinia Dragging Equipment Detector.** The dragging equipment detector is a simple bar arrangement between and beside the rails. It is connected to a monitoring unit which generates a message if any bar is disturbed. The hardware for the analysis and message generation is contained in a pole mounted location case beside the track. This communicates with the Tryphinia interlocking equipment room through a UHF radio link. A mobile radio in the location case broadcasts a message to the train on the train control channel to advise the status of the dragging equipment detector. The equipment is all in good condition and requires minimal maintenance. The life expectancy of the equipment is difficult to gauge but it should give at least five more years of reliable service.

Figure 29 Tryphinia Dragging Equipment Detector

4.60 **Mt Archer Level Crossing Monitor.** Level crossing equipment is supplied and maintained as a signalling system. At each site there is a monitoring unit that provides status and alarm information to the control centre at Rockhampton. The monitoring units have been developed within QR over a number of years and are becoming a maintenance issue. This is a problem for QR, rather than for UT3 and is not likely to become an issue in this UT3 period. It should be reviewed for the next period because if QR does not have a replacement unit by then, the coal lines may have to be equipped with commercial, off-the-shelf devices. Integration of these devices will be expensive and time consuming. It should be noted that the monitoring units are very versatile and have been used for many sites and functions.

4.61 **Marmor Hot Box Detector.** The Hot Box Detector is a wheel bearing temperature measurement device which generates a warning message to the train driver and control if any of the axle boxes are at elevated temperatures. The communications operation follows similar concepts to the dragging equipment detector. The communications equipment is in good condition and should give five or more years of reliable operation.

Figure 30 Batteries showing leakage from terminals

4.62 **Marmor Traction Power Site**. Some older optical fibre interface and multiplex equipment is still in service at Marmor. This equipment is scheduled for replacement under the current works program. Apart from this aspect, the site is in good condition. The batteries are of the same type as those discussed previously and should be replaced when an appropriate solution is found.

4.63 **Network Monitoring & Management.** QR has network monitoring and management tools for many of the systems that have been installed.

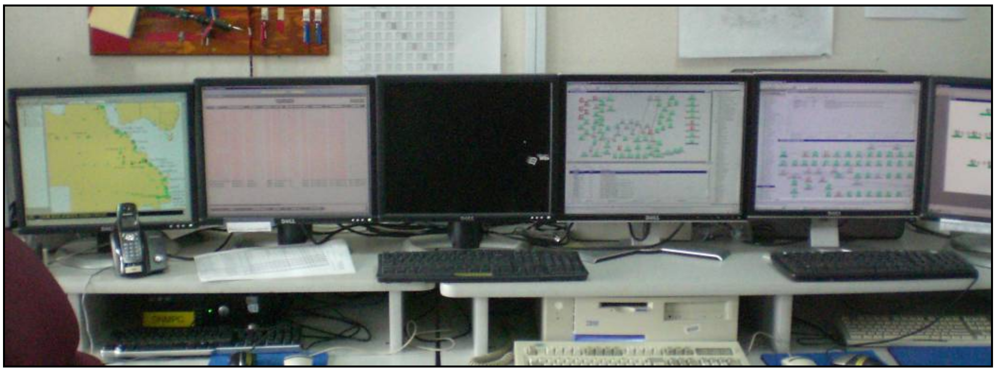

Figure 31 Network Monitoring systems

At present, the monitoring systems are not integrated. It was evident from some tests performed on site that the tools are not used for any maintenance requirement analysis or prediction. This is an area where some expenditure on integration and configuration of the monitoring tools would be wise. The Consultant would recommend that funds and resources be allocated to network monitoring and management of the coal lines specifically. The network management system could feed into the asset management system discussed below. However, it is more important to have some reliable fault and monitoring data for the entire UT3 communication system.

Asset Maintenance System

4.64 A lack of a centralised one-stop maintenance, asset based system was noted. Instead a variety of registers and systems (some propriety) are used. These are currently not integrated and information is required to be manually transferred and imputed from one register to another. This is an ineffective use of a database register and often results in redundancies at many levels.

4.65 QR is currently developing an integrated GIS based asset register, monitoring and asset management planning tool. Although the development of this system may be costly and the changeover period and training may take considerable time, it is believed that the benefits of a robust and integrated asset maintenance planning system far outweigh the concerns. The consultant believes that the implementation of such a system will alleviate some of the current concerns as detailed in 4.64.

5. MAINTENANCE ACTIVITIES TO MAINTAIN THE ASSET

Introduction

5.1 This section provides conclusions and comments on QR adopted processes and methodologies implemented to maintain the asset.

5.2 The objective of this section is to comment on the appropriateness of the adopted engineering processes and methods. The Consultant considered that through observation, and international comparison with solutions and practices worldwide, a professional opinion on the fundamental engineering reasoning and efficiency, could be formulated. From this assessment a reasonable justification of the volume and scope of work could be given.

5.3 Subsequently, the costs as a line item product of the work proven to be necessary can be partly justified, provided that rates are within optimised limits of possession, manpower, equipment, and the like. (Figure 32).

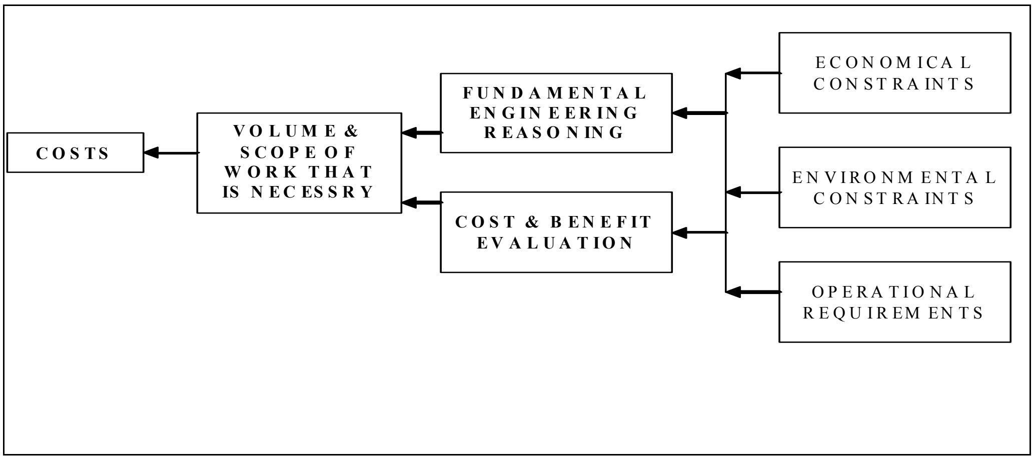

Figure 32 – Logical justification of cost build up

5.4 As there are numerous work line items, the Consultant estimated that the time restrictions of the study period did not allow for every line item to be justified in detail. Instead, a focus was put only on the major cost items. Engineering analysis, experience and judgment was used to calculate and justify the volumes of work in these major items and the reasoning behind the processes.

Method of Work

5.5 The Consultant primarily conducted a desktop review and assessment based on professional engineering experience and knowledge of:

- QR accepted maintenance Engineering Standards;

- Relevant papers and documents covering adopted procedures and previous analysis; and
- QR's preliminary draft of Section 5 Description of Assets and Section 7 Infrastructure Maintenance Provision of the UT3 Draft Access submission.

5.6 During the review process, discussions were held between the Consultant and QR to discuss and clarify any issues arising from the review.

5.7 Site visits and audits (as detailed in Section 4) were conducted concurrently to the desktop review. These substantiated the engineering desktop assessment of relevant papers and standards as detailed in 5.2 through supporting field data and anecdotal evidence.

5.8 Constraints were identified under which operations must be continued regardless. These include:

- Standards, as mentioned in 5.2;
- Safety regulations, as reviewed and discussed on site; and
- Labour/Resources constraints

These were defined by QR and validated for 'reasonableness' by the Consultant in this review. The assessment was based on the Consultant's previous experience, knowledge of the industry and information on current trends.

5.9 To facilitate this 'focus' on high expenditure line items the Consultant grouped major line items into distinct "sectors". These were defined as:

- Rail Management – includes all the tasks which fundamentally manage the rail (grinding, rail renewal, ultra-sonic testing, etc; and
- Geometry Management – includes all tasks which fundamentally manage track geometry (under-cutting, stone blowing, formation treatment, inspection, etc)

It was felt that together these two cover a significant portion of the budget

5.10 The Consultant developed the following model to logically review and assess each of the defined major items

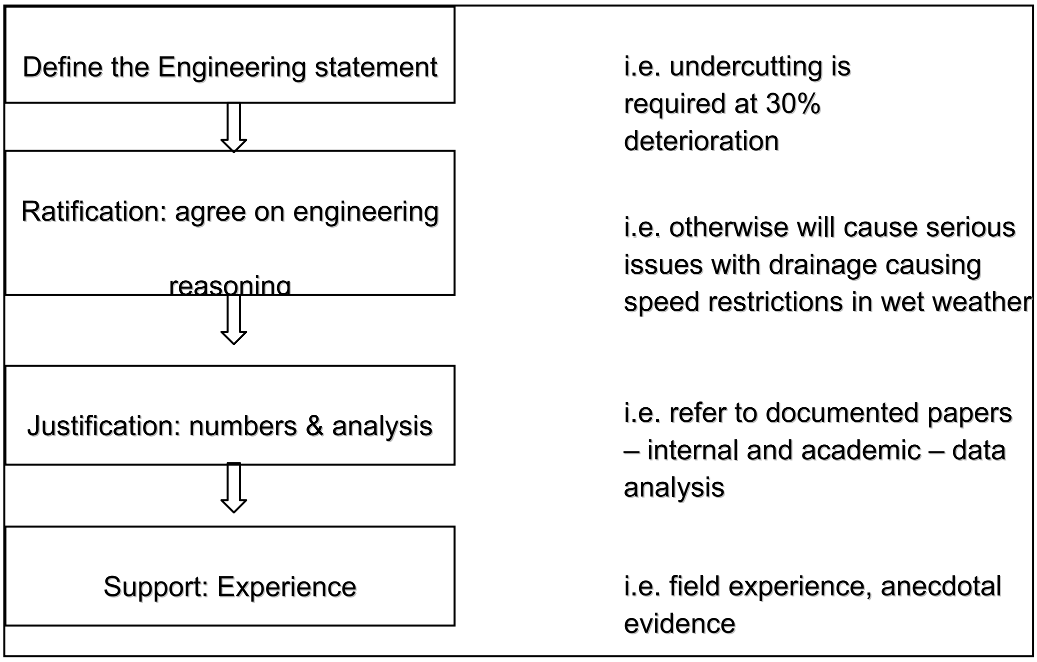

Figure 33 – Model for logical engineering reasoning review

The site visits, as detailed in Chapter 4, were a necessary item to support the definitions and agree on the ratification.

5.11 A final commentary of the processes and methodologies adopted within each of the focus sectors (as described in 5.7 was compiled by the relevant discipline specialist. The summary and conclusions from these are included in this section.

5.12 The discussion will proceed in the sectors of the major items as defined above. A brief discussion on other line items will conclude this section.

Rail Management

5.13 Rail Management involves:

- Grinding to promote optimum wheel-rail contact and prolong life;
- Renewal when wear limits have been reached; and
- Regular wear measurements

5.14 The Consultant felt that processes in this area were supported by sound engineering and conformed to international best practices.

5.15 Regular wear measurements and monitoring provides robust data that can be used to calculate rail renewal volumes for UT3.

5.16 Rail wear rates and failures compare favourably to international comparisons for similar operations, with the rail failure rate on QR significantly lower than on most other railways.

5.17 The Consultant concluded that QR has excellent processes for monitoring wear. Regular measurements of rail wear and information from monitoring provides robust data from which sound decisions can be made on rail renewal requirements. This knowledge has allowed QR to increase the amount of permissible rail wear, thereby extending rail life. It has also allowed the amount of rail renewal required in UT3 to be estimated accurately.

Geometry Management

5.18 Geometry Management involves:

- Resurfacing based on TRC output and hi-Rail inspections;
- Stone blowing to extend life;
- Under-cutting when the ballast is too dirty; and
- Formation repairs

5.19 Ballast cleaning is a critical activity of track maintenance. It is noted that previous assertions have claimed that QR is using excessive amounts of ballast, due to its extensive ballast cleaning operation. Ballast undercutting has been held to be warranted only to half depth, based on desktop comparisons with railways elsewhere. Ballast savings, however, were predicated on the recovery of a significant proportion of the ballast undercut from the track. In practice it was confirmed that very small amounts are reusable due to heavy contamination. It is recommended that such desktop analysis be reviewed using actual results from tests and recovery data from undercutting works.

5.20 Reductions in the surfacing programs and prolonged life for sleepers and ballast were predicated on coal contamination measures currently being implemented. The coal spillage problem, however, has been exacerbated by overloading wagons and careless unloading procedures, driven by a calculated policy of maximising coal throughput regardless of medium to long term infrastructure costs.

5.21 Normal ballast degradation rates combined with coal fouling of ballast are reasons for the current level of work. There are a range of mitigation measures which can be implemented, ranging in cost and effectiveness. Predicting the return on such investments to the supply chain operations is complex, especially when the high price and current continuation in demand for coal is unpredictable (historically many mineral booms have ceased suddenly with costly repercussions to investors and infrastructure owners).

5.22 Historic data from the coal network shows a correlation between rainfall and temporary speed restrictions. Previous studies and assessments on ballast cleaning requirements have been conducted from results taken in the UK and Germany. These are not sub-tropical climates and do not suffer from the combinations of wet weather and extreme temperature ranges which will put different pressures on track infrastructure in substandard condition.

5.23 As utilisation of Percentage Void Contamination (PVC) testing increases it is indicated that the ability to assess ballast cleaning requirements will improve. This should empower engineers and managers to increase the effectiveness of ballast cleaning programs through greater ability to prioritise, especially in conditions where availability for ballast undercutting maintenance paths becomes scarce. This ability has the potential to significantly improve this service delivery and should be monitored in order to implement improvements in UT4.

5.24 It is anticipated that the introduction of mitigation measures derived from the results of the Coal Loss Management project will decrease the amount of contamination. To ensure that these mitigation measures are actually reducing the need to clean ballast at the current rate, extensive monitoring will need to take place over the next period to verify both the calculations of coal loss reductions and the effect of the mitigation processes on deterioration rates and consequent maintenance activities.

5.25 The introduction of stone-blowing predominantly to heavily coal fouled ballast profiles is a new application of this technology. Stone-blowing has been shown to be two to five times more durable than tamping on mixed passenger and freight lines in the UK[13]. Careful testing and evaluation should be performed on QR to determine both the increase in durability and the type of track condition that would benefit most from stone-blowing.

5.26 Significant differences were noted between planned and actual tamping, specifically on the Blackwater system. The differences were, however, considered within planning tolerances of +/- 20%. It is noted that QR is increasing the Track Recording Car (TRC) runs to four per year. This should see a subsequent improvement in planning of the resurfacing task. These improvements will have an effect on the UT4 submission.

5.27 It is noted that the majority of track machine fleet is around 11-13 years of age. Currently QR is formulating a business plan for replacements of the fleet over the next five years.

5.28 With predicted increases in traffic it is expected that spillage will increase. This highlights the necessity of implementing some mitigation measures to decrease spillage rates and attempt to slow down the resulting damage to the infrastructure.

5.29 With predicted increases in traffic the need for ballast undercutting will increase. Whilst mitigation methods may be being implemented to minimise spillage levels, it will take some years for

13 www.harscotrack.com (June 2008)

maintenance levels to 'catch up' and for the benefits of these mitigation methods to be reflected in levels of maintenance costs.

5.30 Geometry vehicle data recorded using Track Recording systems is the key element in track maintenance. QR is implementing next generation systems which are currently on schedule for delivery in late 2008. It is anticipated that the use of these new systems will empower the engineer to make better maintenance decisions in the future. It is recommended that improvements are monitored closely so that reduced costs can be accurately incorporated in UT4.

Other Items

5.31 Some of the Consultant team surmised that the walking inspection conducted by the Track Patrolman (TP) of concrete sleepered mainline track every four years is not adding value to what has already been covered in other inspections. However, this opinion was debated amongst the Consultants. It is recommended that a review of the benefits of this inspection be undertaken. This review may include listing the types of defects recorded by the patrolmen.

5.32 Currently inspection results are mainly entered into the Rail Infrastructure Maintenance System (RIMS) manually. Checks and audit of works including the results from scheduled patrol inspections are also manually entered into the RIMS as are results from the TRC. Manual entering of data at different levels is time consuming and prone to error in interpretation of written descriptors and site notes, errors in typing and delays and redundancies caused by one level of inspections being entered before another. Effective inspection and reporting is critical if it is to be used as a basis for efficient maintenance planning and control. There is no indication that alternatives such as the use of PDAs and laptops for immediate data updates are currently being considered.

5.33 With predicted increases in traffic the availability of possessions for maintenance will decrease, or alternatively, the availability for capacity for the allocation of maintenance windows will logically decrease. As volumes increase, further emphasis will be placed on QR's ability to prioritise and plan maintenance works effectively. QR is addressing some of these issues through:

- the acquisition of new maintenance plant such as the Loram C21 plainline grinder and the Loram MPC Plainline grinder; and
- the development and implementation of advanced asset management tools

Asset management was an area where the Consultant felt that significant improvements could be made which would empower QR to make better use of maintenance path capacity and cost savings in maintenance planning activities.

Asset Management

5.34 A summary of current engineering maintenance information flows is shown in Figure 34

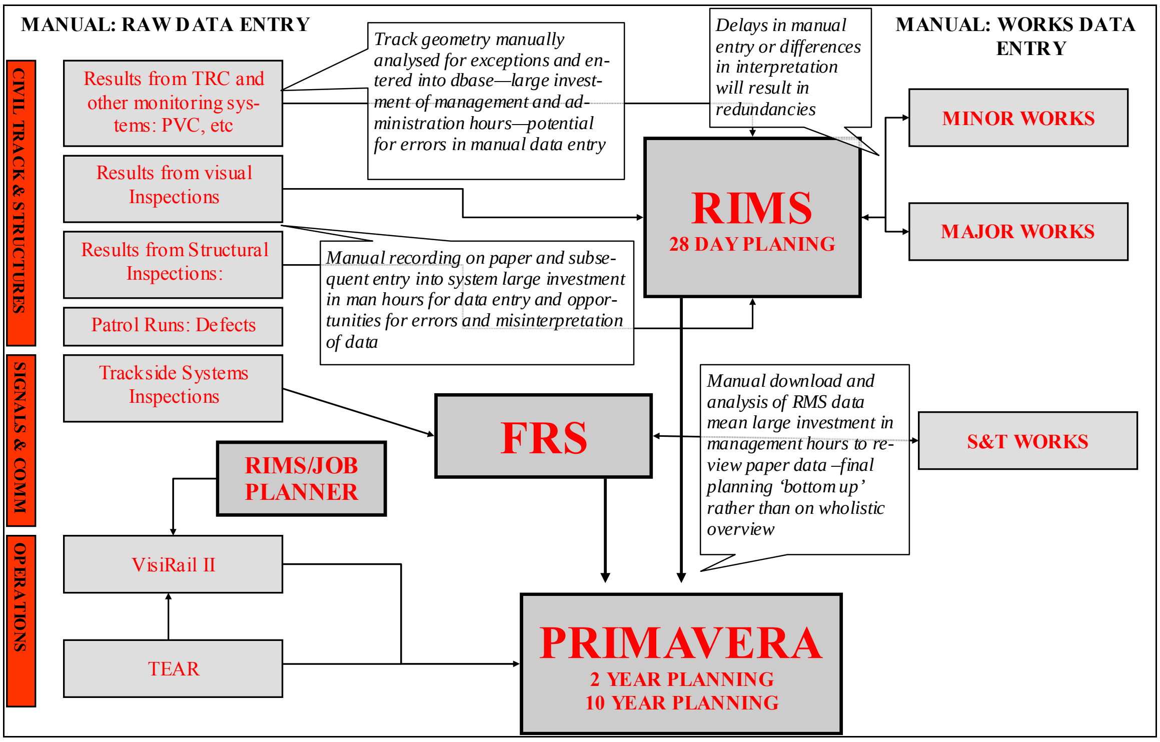

Figure 34 Information flows

5.35 The main issue with this system is the large investment in man hours required to review data, analyse and format it for manual input into databases and planning tools such as Primavera.

5.36 The lack of integration of the data at the real time level makes it difficult to address multi-problems during a single shutdown, especially if the shutdown is 'impromptu' or has had a minimum period of notice. The potential backlog of data from minor works and patrol entries can cause costly redundancies and possible critical 'omissions'. The Consultant notes that these issues will be alleviated in the future as proposed GIS based asset management database and decision support systems are developed and implemented.

5.37 The database does not interoperate with the planning tool creating an information 'gap'. This means that planning can only take place when all manual data records are up to date. This can be difficult in practice as the relevant paperwork from out-based offices may need to be relayed to central offices, where those not involved in the original inspections and works are entering the data. This also increases the risk of misinterpretation of the data.

5.38 The current information flow means that the final 'planning' and subsequent budget is derived from a 'bottom up' approach. This indicates that final decisions are based from the various districts and disciplines and priorities are made without seeing the 'big' picture and then fed into the big picture in retrospect. Contemporary research indicates that a system based on an initial overview of the total situation, and centrally managed processes, i.e. 'top down', will deliver more efficient results and significant cost savings.

5.39 It is felt that significant improvements could be made through the adoption of technology such as:

- The use of hand held devices to record inspection data and provide auto uploads into real time databases;
- Adaptation of databases to provide visual references as to where work is scheduled and been performed. Such data can be transferred real time to hand held or portable devices;
- Interface with track geometry data allowing automatic analysis to identify exceptions; and
- Seamless information flows between planning and recording systems.

5.40 During site visits QR advised the Consultant about the current development of a new GIS based maintenance planning tool which will ultimately be integrated with planning management decision support tools. It is intended that this system will allow visual reference (graphical displays) of all rail lines and assets, as well as being able to insert layers representing activities such as scheduled works, works recently completed, defects detected or rail telemetry data. With many databases already in place the transmission of this data into GIS layers is mainly a matter of time and resources rather than complexity. It is felt that the implementation of such a system will add significant value to the maintenance process, resulting in greater efficiencies and cost savings.

5.41 It is well documented in the maintenance literature that proactive maintenance is 2-4 times more beneficial than reactive maintenance. 'Reactive maintenance' is considered as often the result of a failure or downtime whereas 'planned maintenance' is ideally performed in the off peak hours and hence minimises the impact on customers. This is the rule as applicable to both rail and road operations where peak (usually during commuter hours) and off peak (usually during night or other 'unsociable' periods') are clearly defined. However, little research has been conducted as to the optimum reactions when considering operations that do not have clearly defined peak and off peak times, that is, when all periods have the same high cost implications and impact on customers. In these situations traditional long planned proactive maintenance may not always be optimum or even possible. Potentially, a flexible system which provides interoperability between equipment and labour resources , to maximize effectiveness of reactive maintenance when shut-downs occur may be of greater efficiency in these 24/7 operations, and perhaps there is a growing need for research to examine the traditional model for optimization of engineering maintenance under these conditions (consider the Japanese solutions). Additional costs associated with the quick transfer of equipment and resources, or maintaining such resources 'on hand to enable efficient 'unplanned' activity may be insignificant when compared to long planned shut downs of operations at 'peak' periods. The ability to view the big picture in real time will increase efficiencies through enabling organised 'reactive' (in effect proactive with minimal planning lag) maintenance even at short notice.

5.42 The planned implementation of the system will begin in the UT3 period. It is believed that the operation of this system will enable the provision of greater detailed information for the analysis of maintenance performance for the UT4 period assessment.

Telecommunications

System Monitoring

5.43 QR has a number of network monitoring and management systems for the telecommunications equipment. As discussed in the Site Audits section, the Consultant recommends that some expenditure on integration and configuration of the monitoring tools is required, if optimum potential is to be gained from monitoring equipment.

5.44 There are two reasons for improving the network monitoring processes. The primary reason is to be aware of network faults and the second is to provide statistics for more effective routine maintenance.

5.45 The Consultant has highlighted the redundancy and diversity that has been provided in the QR network to ensure that a single fault does not interrupt communication. This means that failures are not immediately obvious unless they generate an alarm at a control location and unless that alarm is monitored. If faults go undetected and unrepaired the next failure of equipment will result in a network outage. Timely information about faults permits efficient utilisation of maintenance staff, particularly when the telecommunications site is distant from the maintenance depot.

5.46 Routine maintenance is discussed in the next section. With a more comprehensive data base of fault rates, types and locations, the routine maintenance schedules could be optimised.

Scheduled Maintenance

5.47 The telecommunications assets benefit from a preventive maintenance plan that ensures that each site is visited at regular intervals. Failures in modern electronic equipment are rare and generally cannot be predicted so the preventive maintenance consists of:

- Battery checks – for corrosion and state of charge
- Diesel generator checks
- Performance verification of installed electronic equipment.

5.48 The routine service schedule is appropriate and the excellent condition of the sites visited demonstrates that the maintenance is being performed appropriately.

5.49 The period between maintenance visits has been chosen somewhat arbitrarily. In an environment where physical damage to antennas, masts, fencing or buildings can have serious consequences, the interval between visits to site is a risk management issue. It is difficult to recommend any change in site visit interval on other than an arbitrary basis.

5.50 The maintenance that is performed on the equipment varies with the type of visit. More detailed checks are made on the equipment at less frequent intervals. Probably the ageing mobile radio equipment requires the most time on site for routine checks. When this is replaced with more modern equipment the servicing requirement will be reduced. Remote monitoring will almost certainly be provided with the new equipment and the work on site will be reduced to physical inspection.

Emergency Power Supplies

5.51 Telecommunication systems are required to work in times when other services have been disrupted. Virtually every backbone system has battery backup, usually designed for at least ten hours of operation. In addition, critical sites have diesel generator backup for prolonged power outages.

5.52 The most unreliable components of most telecommunications sites are the diesel generators. Even with regular maintenance they often fail to start when required. The fuel for the generators has a limited life and is often not used within that period, necessitating replacement of the tank full of fuel.

5.53 Solar power supply is widely used for telecommunications equipment but is still relatively expensive and is vulnerable to vandal attack. It is not normally used as an emergency backup power source but as a primary supply.

5.54 A new approach to emergency power supplies is to use fuel cells with hydrogen fuel. QR coal are early adopters of this technology and are planning to install fuel cells as backup power sources in a number of locations. The QR approach is to connect sufficient gas bottles to the system to provide at least 48 hours of backup power, with more bottles stored on site but not connected. The reserve bottles on site can be easily connected as the active bottles are exhausted, avoiding the need to get trucks or heavy equipment to sites that may be isolated due to flooding or washouts.

5.55 The use of fuel cells is an innovative approach that should reduce the maintenance costs for the telecommunications sites and increase the availability of the telecommunications network.

Depot Facilities and Repairs

5.56 The telecommunications technicians are based at Rockhampton, where there is a well equipped workshop. The location is appropriate and the facilities are generally suitable.

5.57 The majority of the workshop task at present is repair and testing mobile radio equipment. The equipment in use is discussed elsewhere in this report. As this equipment is now at the end of its life cycle the maintenance load is increasing and some components are becoming more difficult to obtain.

5.58 The workshop has suitable test equipment and facilities for efficient maintenance of analogue mobile radio equipment. Digital test equipment and more sophisticated diagnostic tools will be required for the next generation of mobile radio equipment but that is beyond the term of UT3.

5.59 We were not able to assess the training that is being given to maintenance staff. There is the continuing problem of attracting and retaining skilled technicians with so many employment opportunities available at the mines. The Consultant recommends that continuing training and development programs be provided for maintenance staff to develop their skills and improve the attractiveness of QR as an employer. This will come at a cost but the cost should be much less than that experienced with rapid turnover of staff.

Cost of Maintenance

5.60 From field discussions the Consultant concluded that there are very few cost codes relevant to the coal lines and that detailed information required for benchmarking comparisons is not available. However the Consultant understands the within QR Telcoms is described s a statewide asset, and subsequently its costs are allocated on a predefined user ratio. Hence unit details of costs, for any one system, i.e. coal are not appropriate.

5.61 The Consultant advocates that it would be helpful to be able to further identify the costs of direct field staff, engineering supervision and ineffective time. As the same technicians work on locomotives, backbone systems and communications associated with signaling and wayside monitoring.

6. SUMMARY OF INTERNATIONAL BENCHMARKING EXERCISE

Introduction

6.1 This section provides a summary of the results of the international benchmark that was undertaken by the Consultant as part of this review.

The focus of the benchmark exercise was too enable a robust comparison on strategies, methods and policies used in similar railways, comment on identified inefficiencies and recommend possible efficiency improvements.

Caution in Benchmarking

6.2 Caution must be exercised when interpreting the results from benchmarking exercises as there are numerous factors which will impact the result. Elements such as inherent environmental factors like underlying foundations or topography need to be considered and their impact upon the final result assessed.

This is especially critical when comparing costs and management processes. Different accounting treatments, cultures and history all will have a significant impact on how results from benchmarking are interpreted and presented.

6.3 Northern Queensland conditions are fairly unique, which makes finding comparable operations difficult. This is due to a combination of 'local' factors, including:

- Relatively high annual tonnages;
- High temperature ranges;
- High concentrated rainfall periods;
- Significant contamination of the corridor from spillage of coal; and
- Narrow gauge.

Notwithstanding 8.2 and 8.3, the following organisations were invited to participate in a benchmark comparison of maintenance engineering and costs. When choosing railways to participate, a specific focus was given to finding operations which shared similar freight tasks and construction to the QR system.

Railways within Australia:

- QR Network, two different lines (Goonyella and Blackwater);
- BHP Billiton;
- Rio Tinto;
- FMG; and
- ARTC Hunter Valley.

International railways invited were:

- Brazil, VALE;
  EFVM; Estrada de Ferro Vitória a Minhas;
  EFC; Estrada de Ferro Carajás;
- Brazil, MRS;
- South Africa, Transnet (formerly Spoornet);
- Sweden, Banverket;
- Canada, CN;
- USA, CSX;
- USA, BNSF;
- USA, UP;
- USA, NS;
- USA, Amtrak;
- UK, Network Rail; and
- Germany, DB.

In addition, a questionnaire was completed for TTCI's Facility for Accelerated Service Testing (FAST). This is a short, high tonnage, heavy axle load test track. The results from the FAST questionnaire were only used where the length of track had no significant effect on the answer.

Methodology

6.4 In order to facilitate the required responses, two questionnaires were formulated. Each focused on one of two main topics relating to maintenance of heavy haul railways:

- Track and structures
- Costs and processes

6.5 It was considered inappropriate to undertake a similar benchmarking exercise for signals and communications and power due to the variety of configurations and equipment together with the differing life cycles of the various components. For these disciplines a national comparison was undertaken based on the Consultant's experience in similar projects for other authorities.

6.6 Each railway organisation involved in the study was sent the two questionnaires. It was felt that different personnel from different departments, and possibly different levels of management of a railway organisation would complete each questionnaire. The quality, accuracy and timing of the responses were expected to be higher if this approach was adopted.

All the railways were sent a letter introducing the questionnaires. This letter detailed the conditions under which the survey was being conducted and assured complete confidentially of the participants.

Normalisation

6.7 To enable a comparison of indicators relating to track, it is generally necessary to take into account the variables which contribute to such a comparison. The data is then normalised with a "normalising factor".

The normalising factor is derived from a formula compiled from experience that basically assigns "average" track with a factor of one (1) and increases or decreases according to the characteristics assumed to affect the maintenance needs. The assumptions can be argued and adjusted following further consultation if this is found justifiable. However the use of a standard approach enables comparison and also the ability to understand the components included in the normalising factor. Sensitivity analysis can then be applied to the track factor by altering the constants and weightings within the formula.

It should be emphasised that the track factor is a reflection of the track component standard and does not consider maintenance requirements resulting from the types of traffic usage.

Table 4; Normalising Factors for Participating Railways shows the normalising factors based on the normalisation formula with its negative and positive factors for the participating railways.

Costs and Structures Questionnaire	A	B	C	D	E	F	G	H	J	K	M
Factor A	0.88	0.80	0.88	0.97	0.95	0.86	0.75	1.03	0.80	0.79	0.75
Factor B	0.07	0.19	0.07	0.68	0.02	0.04	-	0.28	0.20	0.05	0.45
Factor C	0.01	0.00	0.00	0.01	0.00	0.00	-	-	0.00	-	0.01
Factor D	1.03	1.03	1.03	1.00	1.03	0.97	1.00	1.00	0.97	1.03	1.00
Harmonisation factor (A+B-C)xD	0.97	1.02	0.97	1.64	0.99	0.86	0.75	1.31	0.97	0.87	1.20

Table 4: Normalising Factors for Participating Railways

Further information in relation to the normalisation formulae used for this analysis is included in the full Benchmarking report, included as a supporting document.

Normalising Process

6.8 Hypothetically, if considering the costs of railways X & Y, where the costs of X are double the costs of Y and after applying a calculated normalisation factor of 2 (i.e. A/B =2) the conclusion is that both the railways have the same normalised costs. This means they are equally efficient or cost effective. If, however, the calculation of the normalisation formula is challenged and it is said that the factor should be 1.5, the results now indicate that railway X is less efficient than Y. If the factor is challenged again and it is decided the factor should be 2.5 the results now indicate that railway X is more efficient than Y. The argument begins to revolve around the normalisation factors and not about the cost data.

Where there is a paucity of data, the above process becomes particularly relevant as the minor differences between the railways being assessed are the basis for most of the discussion.

In these cases a discussion based on the raw data was included with the data from the analysis. These discussions examine the reasons why railway X costs may be double to that of Y, to try and rationalise the results. It is felt that these discussions substantiated the outputs from the normalisation process where the normalisation process alone could be seen as being misleading.

Response

6.9 In general the response was disappointing with only nine of the total number of railways invited having responded. The reasons given are summarised as follows;

- Members of the organisation not authorised to participate in questionnaires and surveys;
- Members of the organisation too busy to allocate time and resources to respond; or
- Lack of trust or fears of commercial sensitivity in divulging the required information.

The latter was particularly apt to the cost and processes questionnaire however the responses that were received do allow some meaningful observations to be made.

6.10 The following provides a detailed summary with commentary on the answers to the questionnaires that were distributed for the QR UT3 benchmarking study. The initial paragraphs give a summary of the results from the track and structures questionnaire. This is followed by analysis from the cost and processes questionnaire. The section describes the results of the questionnaires and compares QR with the other participating railroads. Subsections have the same headings as the major maintenance products defined by QR in Part 6 of its submission to the QCA.

Results: Track and Structures

6.11 Complete track and structures questionnaires were returned from five international railroads. Incomplete questionnaires were received from three international railroads. The questionnaire was completed by QR for the Blackwater and Goonyella systems. Table 5 gives some general information about the participating railroads.

Table 5 General Railroad characteristics

Railroad	Max. Speed (km/hour)	Max. Axleload (tonne)	Freight % of MGT	Track Layout
Blackwater	160	26.5	98	Double in parts
Goonyella	80	26.5	100	Double in parts
S	110	30	99	Double
T	96	32.4	> 90	Double
U	70	30	98	Single
V	64	35.4	100	Single loop
W	100	32	100	Double
X	50	32.5	100	Single
Y	70	31.5	100	Single
Z	65	27.5	100	Double

Table 5 shows that the participating railroads are almost entirely for freight traffic with only a few carrying passenger trains. QR has the highest operating speed (for passenger trains) and the lowest axleloads.

6.12 Table 6 lists the details of the construction of the track in both QR's network and other railroads that responded to the questionnaire.

Table 6 Track Construction

Railroad	Track Gauge (mm)	Rail Section (kg/m)	Fastening Type	Sleeper Type	Sleeper Spacing
Blackwater	1067	47, 53, 60	Fist, e-clip and Fastclip	Steel, timber and concrete	685
Goonyella	1067	53, 60	Fist, e-clip and Fastclip	Concrete	685
S	1435	60	e-clip	Concrete	600
T	1435	68		Concrete and timber	
U	1435	60	Pandrol	Concrete	600
V	1435	68, 70	Elastic and cut-spike	Concrete and timber	610 and 490
W	1435	68, 70	Safelok	Concrete	600
X	1600	57, 68	e-clip	Timber	540
Y	1600	68	e-clip and Deenik	Timber	540
Z	1067	68	Deenik	Timber and steel	540

Table 6 shows that railroads with broad, standard and narrow track gauge are represented. QR uses concrete sleepers on its main coal routes, whereas some other railroads use timber and steel sleepers. It is noteworthy that QR uses concrete sleepers when its axleloads are lower than other railroads using timber sleepers. This was initiated in 1982 by an economic study which demonstrated the cost benefits of concrete sleepers, particularly in light of reducing availability of timber which itself, was reducing in average periodic life. QR's sleeper spacing is wider than other railroads, which is consistent with its use of concrete sleepers.

Figure 35 shows how rail section varies with axleload on the railroads that responded to the questionnaire. For railroads with more than one axleload or rail section the maximum is plotted.

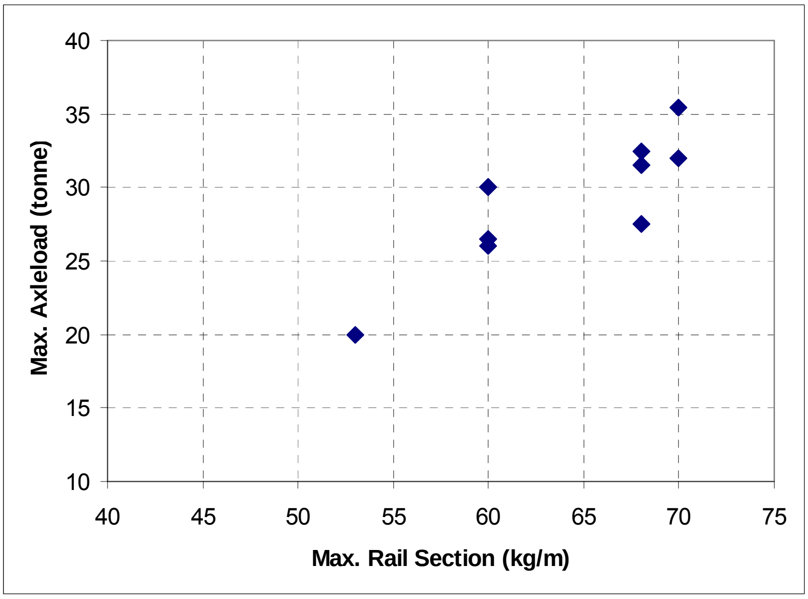

Figure 35 Variation of Rail Section with Axleload

Figure 35shows that railroads tend to increase rail section for heavier axleloads. QR, by using 60 kg/m rail for 26.5 tonne axleload, is consistent with the general trend.

Track Structure Management

6.13 Table 3 compares several items relevant to track structure maintenance on the various railroads.

Table 7 Track Structure Management Data

Railroad	Tamping Interval (MGT)	Ballast Cleaning Interval (MGT)	Geometry Recording Interval (MGT)	Stone blowing
Blackwater	30 to 150	> 1500	26	Under evaluation
Goonyella	50 to 150	720 to 3600	90	
S	78	750 to 1000	35	Not used
U		375 to 500	12.5	Not used
V		1250	42	Not used
W	110	> 1500	56	Not used

X	100	1400	35	Not used
Y	93	> 2200		Not used

The tamping interval in Table 7is calculated from the length of track tamped each year, the length of the line and the gross tonnage of traffic. This allows comparison of railroads that tamp with regular intervals to those that tamp on an as required basis.

Table 7 shows that QR's tamping interval is similar to that on other railroads. QR is adding new tamping machines and regulators to its fleet and phasing out some of the older machines. This is a good plan and necessary to achieve the volume of maintenance tamping that will be required in UT3.

6.14 QR plans tamping using the regular measurements made by its track recording car. This is common practice in freight and passenger railroads. The process could be improved by making it easy to overlay several recent track recordings in order to determine any deterioration trends.

Table 7 shows that QR's track geometry recording interval on the Goonyella system is longer than on other railroads. QR supplements its track geometry recordings with frequent hi-rail inspections. If track access restrictions reduce the frequency of these inspections in the future, then consideration should be given to increasing the track geometry recording frequency.

6.15 In some places QR is achieving ballast life that exceeds that of other railroads. In many places QR is experiencing ballast lives that are considerably less than other railroads. Railroad Y has experienced approximately 2,200 MGT since it was built and the ballast has not needed to be cleaned. Such discrepancies in benchmarking highlight why caution should be undertaken when making comparisons.

6.16 Reduced ballast life on QR is assumed to be due to the amount of ballast pollution from the coal trains on QR. Coal is known to escape from the doors under the wagons, be blown from the top of wagons, fall from overloaded wagons and fall from the bogies where it sometimes collects during unloading. Other coal railroads have experienced the same problems. British Rail, for example, reduced coal spillage by adding wind protection to the top of the wagons and reducing the overloading of wagons.

Iron ore railroads experience ballast pollution from service trains. One is starting to use a spray over the iron ore during loading to avoid spillage in transit. Controlled loading and filters in the wagon drainage holes are also used.

6.17 Ballast cleaning is recognized by railroads to be a very expensive activity. It is a slow process that causes significant disruption to service traffic. In general, railroads faced with ballast pollution from spillage have identified and adopted solutions to the problem. Progress on identifying and adopting solutions for coal spillage on QR has been slow. The recommendations from the Coal Loss Management Project should be adopted as soon as they are available.

Railroad X claims to clean ballast when the level of pollution in the ballast reaches 60 to 70 % of the available voids. No reasons were qualified for this; however it is assumed that any of the following could apply:

- Conditions are not aggravated by heavy rainfall;
- Lack of maintenance possessions or capacity to conduct maintenance requirements; or
- Standard required is less.

This is significantly different to the value of 30% adopted by QR. By the time the ballast cleaning takes place on QR the percentage of void contamination may have reached 40 to 50%, but this is still less than the level used as a guideline by railroad X.

6.18 QR uses ballast cleaning as a preventive measure. Ballast with 30 to 50 percent void contamination may perform reasonably well when it is dry; however after heavy rainfall numerous track geometry faults may arise requiring speed restrictions to be imposed. By using a relatively conservative value of percent void contamination to trigger ballast cleaning, QR is minimizing the disruption to service trains during the rainy seasons.

6.19 QR is a world leader in the use of regular measurements of percent void contamination to plan ballast cleaning. The sampling method and interval is suitable for its operations. The results allow ballast cleaning to be planned only when and where it is required.

6.20 None of the participating railroads except QR uses mechanized stone-blowing for track geometry maintenance. Stone-blowing was pioneered on British Rail where today it is used very successfully to treat sections of track that do not respond to tamping. It is used on lines that carry mainly passenger trains. QR is praised for taking the initiative in using stone-blowing to extend ballast life on predominantly freight lines. Some success has already been noted. It is not clear if the potential benefits of stone-blowing have been taken into account in estimating the ballast-cleaning and tamping requirements for UT3.

6.21 None of the participating railroads reported using regular ground probing radar measurements to access ballast or formation condition. Ground probing radar has been trialled by North American railroads. One North American railroad is known to be planning to use it to prioritise ballast cleaning and is developing the measurement process and frequency. The use of ground probing radar is being investigated by QR, but no benefits from this technology have been included in the track maintenance requirements for UT3.

Rail Management

6.22 Table 8 shows some data from the questionnaire that is relevant to rail management.

Table 8 Rail Management Data

Railroad	Ultrasonic Inspection Interval (MGT)	Rail MTBD (MGT km)	Rail Defect Type	Rail MTBF (MGT km)	Rail Failure Type	Grinding Interval MGT)		Rail Life (MGT)	
						Tangent	Curves	Tangent	Curves
Blackwater	35	525	TD, IBJ	2100	Vertical, IBJ	40	10 to 20		
Goonyella	52	905	TD	3620	Vertical, IBJ	40 to 50	10 to 15	1500 to 3000	500 to 600
S	35	764	TD	1680		40	10 to 40	1250	
T	17								
U	13		RCF	2133	Vertical	60 to 80	20 to 25	478	245 to 410
V	6				Vertical			1250	625
W	15		TD	113	Welds, Vertical	113	28	2250	1100
X	15	700	RCF	519	Vertical	35	35	1400	490 to 1120
Y			RCF	1246		31	31	700	700

Table 8 shows the Mean Time Between Defects (MTBD) and Mean Time Between Failures (MTBF) for the rail. This is the gross tonnage of traffic between defects or failures per kilometre of track.

Table 8 shows QR's hi-rail ultrasonic inspection interval is longer than most other participating railroads. However the MTBD is similar on QR to other railroads. This shows that the longer inspection interval is acceptable.

6.23 The main types of rail defects on QR are Transverse Defects (TDs) and Insulated Block Joint (IBJ) failures. On railroads U, X and Y the main type of rail defect is Rolling Contact Fatigue (RCF). The MTBF for railroads X and Y is shorter than for QR. This may be due to the shorter grinding interval used by QR on curves. The rail life on QR's tangent track appears to be longer than on other railroads. This is another indication that QR's grinding and ultrasonic testing intervals are appropriate. QR's rail life on curves is comparable with other railroads.

6.24 QR has an excellent process in place for monitoring rail wear. The regular measurements of rail wear coupled with the information obtained from monitoring sites on curves enables good decisions to be made on rail renewal requirements. This knowledge has allowed QR to increase the amount of permissible rail wear, thereby extending rail life.

6.25 QR is modernising its fleet of rail grinding machines. The Consultant believes this to be the best course of action considering the age of the existing fleet and the increased levels of service traffic planned for the UT3 period. A key improvement from the new plain line grinding machine is its ability to achieve in one pass the same result that would require several passes using the existing machines. This will allow increased production and reduced disruption to service trains.

Off Track Maintenance Management

6.26 The questionnaire contained no questions specific to off-track maintenance activities. The periods of heavy rainfall experienced on the QR network can be expected to cause more off-track work compared to railroads operating in drier climates. Heavy rainfall requires cess drains to be clean. It can also cause bank slips. QR has developed detectors that notify the control centre when a bank slip occurs. These detectors have been installed at locations with a high risk of bank slip.

6.27 Much of QR's coal system runs through areas of verdant vegetation. The high temperatures and heavy rainfall cause more vegetation control work than on railroads with drier and less tropical climates.

6.28 The high level of pollution from coal spillage on the QR network gives rise to significant work cleaning the area around turnouts. QR uses a special vacuum for this purpose.

Structures Management

6.29 Most of the cost of structures management involves bridge inspection and maintenance. Table 9 shows some data relevant to bridge maintenance.

Table 9 Bridge Management Data

Railroad	Steel	Timber	Concrete	Masonry	Total Bridges	Bridges per Track km	Bridge Cost (% of Budget)
Blackwater			62		62	0.10	4%
Goonyella			70		76	0.13	3%
S	3		29	1	33	0.44	1%
U	12				12	0.04	
V	1		2		3	0.70	
W	10		25		35	0.27	
X	249		345		594	0.35	25%
Z	43		110		153	0.34	29%

Table 9 shows that QR has greater overall percentage (i.e. 100%) concrete bridges to timber and steel than other railroads. The costs of maintaining steel bridges are generally higher than those for concrete bridges. Thus, QR's unit cost of bridge maintenance is expected to be lower than the other participating railroads.

6.30 Figure 36 shows how the percentage of the maintenance budget spent on bridges varies with the number of bridges per kilometre of track on the railroads that provided this data.

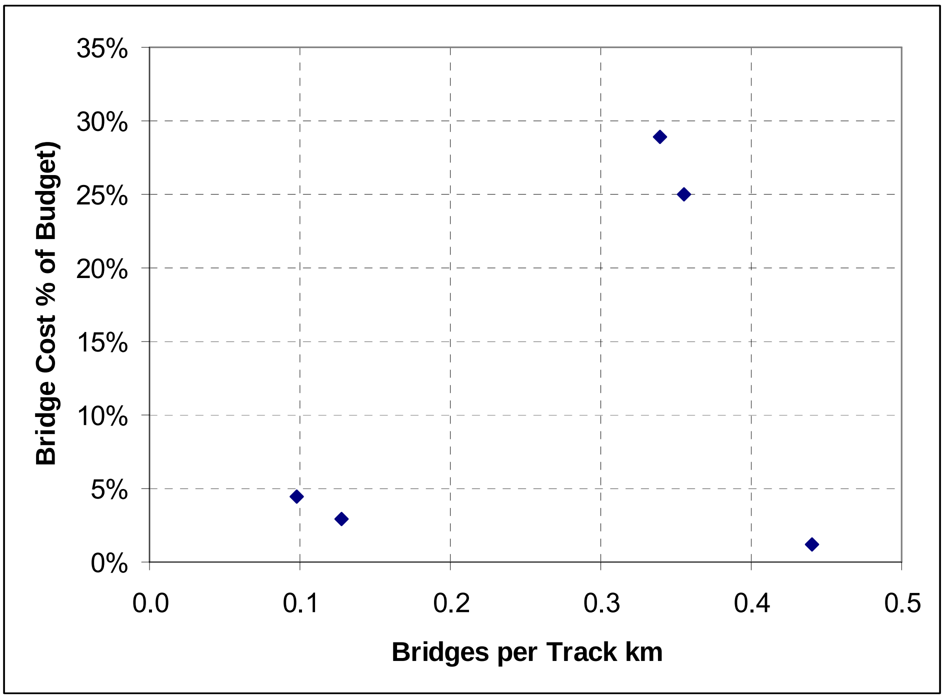

Figure 36 Variation of Bridge Cost with Bridge Density

Figure 36and Table 9 shows that railroad S has the lowest bridge maintenance budget while having the highest number of bridges per kilometre of track. This is assumed to be due to a difference in the way bridge costs are budgeted on this railroad compared to the others.

6.31 Apart from the data point for railroad S, Figure 36 shows a trend of increasing bridge cost with the number of bridges. QR's bridge maintenance costs, which are lower than most other railroads that provided data, are consistent with the general trend.

Research

6.32 In the early 1990's extensive research was carried out be the Office of Research (ORE)[14] that evaluated the factors that influence damage to track and hence the total life cost of the track. A particular focus was given to the effects of an increase of axle load on the European network. For track deterioration the committee focused on track geometry. Relevant findings were[15]:

14 Part of the International Union of Railway (UIC) Action Program

15 Shenton MJ (1990), "Track Maintenance Planning and the Estimation of the Effect of Increased Axle Loads" Proceedings of Workshop on Heavy Axle Loads, October 14-17 Pueblo, Colorado, Association of American Railroads

- Tamping could improve the quality of a section of track to more or less a constant value, which was not affected by the quality before maintenance;
- Grinding could improve track geometry as well as reduce cracking of concrete sleepers; and
- Correcting level by stone blowing could obtain a higher durability of geometry than by tamping.

The ORE committee failed to quantify the changes in track costs due to changes in axle loads, because the diversity of practices among networks made it impossible to define absolute values for changes in maintenance costs. However the findings above additionally confirm that QR is implementing best known practices for maintaining asset life in heavy haul conditions.

Responses: Costs and Processes

6.33 The response to the cost and processes questionnaire was poorer than the response to track and structures with only five incomplete questionnaires being returned. Additionally, many of the responses were found to be vague and gave a wide range of indicative costs and expenditures. However some comparisons and interesting factors were able to be analysed from the data and these are summarised in the following paragraphs.

6.34 In general, despite some expectations to the contrary, when compared with railways carrying similar freight in similar conditions, it was found that on average QR costs were not excessive. Figure 37 compares data from the questionnaires with data taken from a 2007 report produced previously by WorleyParsons and now available from an open public internet resource[16]. Current cost data was indexed to account for inflationary factors:

[16] http://www.accc.gov.au/content/20practice.htm (July 2008)

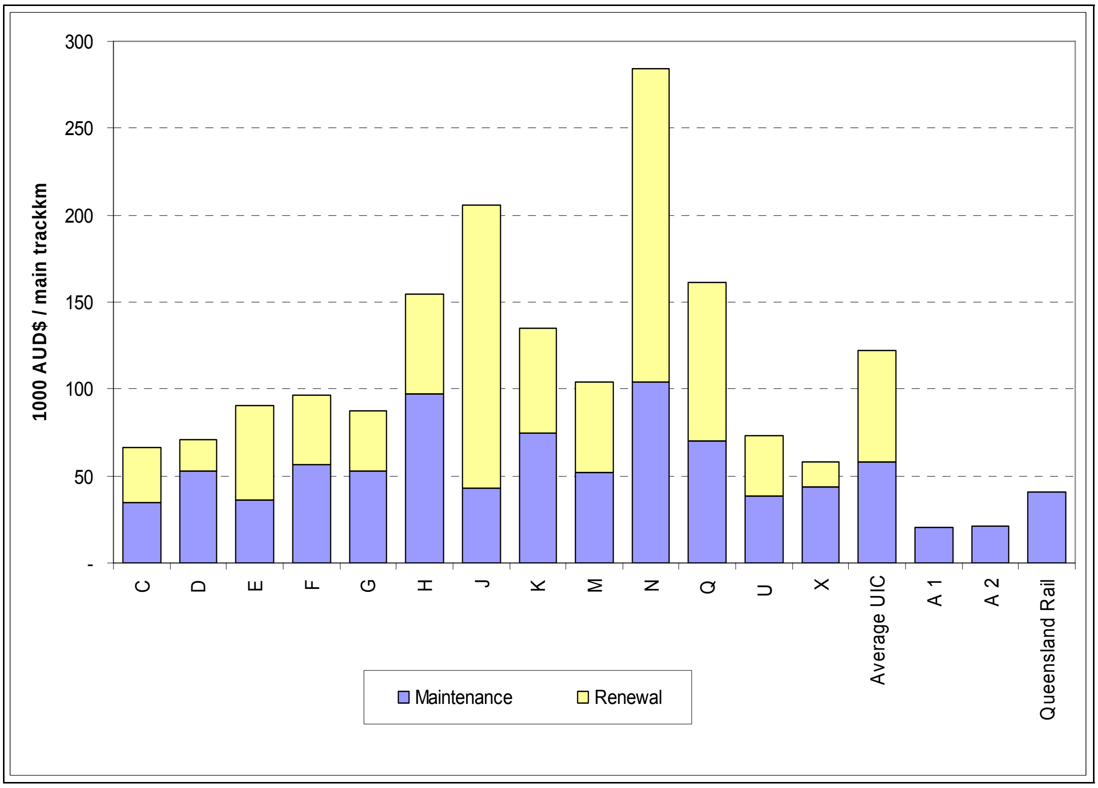

Figure 37 Annual expenditure per main track km.

Major expenditure items

6.35 Respondents were asked to list their five major expenditure items and give the percentages of these items in their total maintenance budget. Although not all respondents gave a percentage they all listed the five major items. These are shown in Table 10.

No clear trend is distinguishable from Table 10. This highlights the diversity in practices, requirements and operating cost allocations of different railways and confirms the difficulties in attempting to interpret results gained from benchmarking cost activities. As can be seen railway A spends significant funds on 'clearing' indicating specific issues which may be inherent to the environment or prior history of accepted maintenance practices. The table above highlights that if a specific maintenance process is required for operations to continue then the cost is a product of that requirement and is generally unavoidable. A preferable and more appropriate approach is to examine the processes and methodologies for reasonableness and appropriateness and then examine the costs. If the process is efficient and necessary then it can be assumed that the cost is a necessary product.

Table 10 Major expenditure items and percentage of total maintenance budget

No	Item & Percentage					
	QR	A	B	C	D	E
1	Ballast Undercutting – 15%	Grinding program – 20.7%	Track maintenance – 50%	Track maintenance – 46%	Rail replace	Ballast undercutting – 44%
2	PW Corridor maintenance – 8%	Clearing (specific) – 20.5%	Bridge maintenance – 21%	Railway machine maintenance – 23%	Turnout replace	Tamping – 6.3%
3	Mechanised Resurfacing – 6%	Immediate maintenance – 14.7%	Infrastructure maintenance – 8%	Wagons Maintenance – 10%	Sleeper replace	Rail Grinding – 5.7%
4	Rail Grinding – 6%	Repair after inspection – 12.9%	Rolling stock maintenance – traction – 4%	Infrastructure maintenance – 7%	Ballast Cleaning	Turnout steel replacement – 3.0%
5	Preventative Signals maintenance Yards – 4%	Schedule based maintenance – 9.1%	Wagons maintenance – 4%	Bridges maintenance – 4%	Formation rehab.	Drainage and cutting works – 4.3%
	39%	77.9%	87%	90%		63.3%

6.36 QR's highest maintenance cost item is ballast undercutting, the demand for which is aggravated by extensive coal spillage on the network. However, on benchmarked railways it was interesting to note that despite mitigation measures being implemented, the percentage cost of this item still remained higher than other regular maintenance items.

It is also to be noted that some coal fouling mitigation measures, such as the replacement of all bottom discharge wagons on the network with tipplers, and the installation of strict monitoring systems at loading and unloading sites, would involve substantial capital investment by operators and users. These have to be assessed in relation to the current cost of ballast undercutting, bearing in mind that even with these improved logistics ballast undercutting would potentially remain a major cost item due to the very large tonnages being moved. This would indicate that perhaps no system has found the optimum solution to this problem.

6.37 Prior to the resource boom of the last decade QR undertook a comparative assessment weighing up the costs to supply chain efficiency by creating longer journey cycle times through the use of tippler wagons versus the shorter unloading times provided by the use of bottom dump wagons. The result of this assessment formed the justification from which QR made the decision to use bottom-dump wagons on its coal network. To date the supply chain has had the advantage of shorter cycle times.

6.38 In response to this problem QR has commissioned the Coal Loss Management Project. On completion of the project, and on substantiation of any benefit cost analysis required to implement solutions, it is anticipated that QR will ensure that recommendations from the Coal Loss Management Project will be adopted as soon as they are available. This will help to reduce the impact of the short term maintenance programme as well as achieve long term objectives. In the interim, QR is trialling accepted innovative technologies, like the use of stone-blowing machines, in an effort to reduce costs in the future.

6.39 Despite coal fouling causing a significant problem for ballast cleaning, rust and deterioration on the asset caused by the abrasive chemical constitution of coal does not appear to have caused other major problems to rail or ancillaries. This indicates that other programs implemented by QR can be considered adequate and efficient in maintaining the asset as fit for purpose.

6.40 Despite relatively low axle loads, which in part are related to limitations posed by existing infrastructure and rolling stock, QR maintained one of the highest annual tonnages. This indicates that the network is operating under relatively harsher conditions in regards to opportunities to conduct routine maintenance procedures and pounding on the assets.

Possessions

6.41 Possessions or “gaps” in operations are essential to conduct these procedures and it is considered that for each task there is an optimum time when these works can be carried out to the greatest efficiency. If the required slots are minimal or perhaps rarely available, then regardless of the planning effort for each task, it will remain fundamentally inefficient as it will not be possible to make optimum usage of mobilised resources.

6.42 In comparison with other railways, QR has a high rate of cancellations for planned possessions (10%, compared with 0.5% for other national railways). A primary reason for this may be the nature of operations on the QR Network, where operations are carried out on a 24/7 basis with no differential between ‘off-peak’ and peak periods. By not having ‘off-peak’ periods in which to plan maintenance, engineering operations must always take place in ‘peak’ periods’ or during mine shutdowns. When shutdowns are cancelled and operations can continue or when other issues arise the cancellation of ‘maintenance’ will naturally tend to take precedence over the cancellation of ‘operational traffic’ as stopping supply chain operations in critical peak periods is costly. However, such cancellation and postponing of planned maintenance possessions may lead to a backlog of maintenance work and subsequent increased requirements and costs in the following year.If coal prices increase before this period the costs of operation cancellations during the following year will become even more critical putting greater pressures on cancellations of maintenance and potentially creating a greater percentage of cancellations.

Key Performance Indicators and Management Processes

6.43 The main performance indicators were given as:

- Train delays due to infrastructure
- Hours of coal train delays due to infrastructure
- Number of delayed coal trains due to infrastructure
- Number of train disruptions due to infrastructure
- Total number of functional disruptions

Just two railways have penalties for non-performance. For these railways one would assume there is a higher pressure to ensure a reliable service.

6.44 The overall conclusion is that the majority of respondents are not recording the required data for detailed computer modelling and maintenance planning, with QR being no exception. Data recording is often a casualty of cost reduction pressure, as it is not perceived as having a direct bottom line benefit. Some of the railways stated that there are evaluations and implementation processes for such tools in progress or planned in the near future. It is felt that QR is potentially a leader in this trend with its ongoing development of a GIS based comprehensive track maintenance monitoring and planning system.

6.45 Only two respondents record track condition or maintenance data directly to a maintenance model. It was not clear whether this recording included both condition monitoring data and maintenance activity details. Just a few railways use modern predictive modelling tools to predict future requirements, infrastructure maintenance and renewal. Models reported were diverse and included rail replacement, track surfacing, risk assessment, switch condition, rail grinding and defect management. Only one respondent recorded using an overall predictive tool however it was not indicated whether this included a GIS component. The overall opinion is that such a tool would maximise the efficiency of planning and potentially decrease wastage of resources, subsequently decreasing costs.

6.46 In critiquing costs it must be noted that QR experiences enduring circumstances such as:

- Significant spillage problems due to bottom-discharge doors, faulty doors or poor unsupervised loading and unloading practices;
- Comparatively less available paths for possessions and routine maintenance procedures; and
- Cancellation of planned possessions with no system in place for penalties and / or additional costs to be distributed to relevant third parties in relation to these cancellations.

Sustainability

6.47 QR has historically taken the sustainable approach, that is, decisions to improve operations through enhancements and effective maintenance of existing assets rather than through major capital renewal expenditures. During the period that whole of life costs are significantly lower than replacement costs, this approach imposes minimal cost penalties to system users and owners. However, there may be a point in time where such short term savings become costs through inefficient practices (it is considered that advances in engineering and technology can advance this moment immaturely). At this point in time one must decide whether replacement or improvement is the most sustainable option for the future, giving due consideration of predictions for future requirements of the asset when assessing the benefits such investments,

Signals

6.48 Benchmarking a signalling system is difficult because of the variety of configurations and equipment together with the differing life cycles of the various components. An example is relay based interlocking that has been in use for in excess of 30 years and may continue in the future without needing replacement. In comparison is the point machine, which has an average service life of 10 to 15 years. Each asset in a signalling system has its own life cycle. All assets of a signalling system however are generally renewed when a signalling system is replaced even if some assets are relatively new.

6.49 To benchmark a signalling system as an asset, the components of the signalling system would need to be identical or of a similar type so as to not distort the results and render the comparison ineffective.

6.50 The QR signalling systems and assets are generally life expired. They are of an age that any benchmarking of these assets may not provide effective comparisons to other railways. The life cycle of the various components benchmarked may be so different that the value of receiving a benchmark on overall costs is not considered as having an impact on the outcome.

6.51 QR has indicated they are embarking on a replacement signalling system program that may involve technology improvements. This approach will significantly improve the railway assets and depending on the technology chosen, may provide benefits for benchmarking in the future.

6.52 Hence no benchmarking was able to be undertaken due to insufficient asset management information made available in order to perform an effective comparison. In addition, the signalling assets were at or near their end of their life and due for replacement in the near future. The age of the life expired assets makes it difficult to compare against more recent technology.

Telecommunications

6.53 The communication requirements for railways have changed in recent years. The traditional vertically integrated railways placed the emphasis on providing communication systems for the operations staff, for business applications and for client liaison. A modern below-rail operator still requires communications for operations activities, primarily for train control, but has fewer requirements for PABX systems, computer terminals and the like.

6.54 Modern communication systems are based on open standards and (with a few notable exceptions) equipment from different manufacturers can be used interchangeably. Systems can therefore be built and interconnected or extended without being locked into a particular supplier. High quality communications equipment, installed and maintained correctly, is highly reliable. Although faults are rare, the remote location of most equipment makes access time consuming so it is normal practice to put in duplicated or redundant systems. The systems are normally designed to automatically bypass faulty equipment.

6.55 Extensive fault monitoring and remote configuration capability is built into the equipment so that a remotely located control centre will receive alarms and act on them as soon as a failure is identified. The redundant design means that failure of a part of the system does not stop communication: train operations continue.

6.56 The biggest problem for communication network designers and managers is the rate of change of technology. This affects the networks in three ways:

- The demand from users for more capacity, speed or flexibility is always increasing, so that a system that was designed with what appeared to be ample spare capacity is soon at the limits of its capacity.
- The equipment manufacturers respond to these demands and to the continual improvements in device technology by releasing new models of equipment and ceasing manufacture of older equipment. The new models are generally more capable and cheaper than their predecessors but they are definitely different and are not plug-in replacements.
- Whole generations of technology are going through their life cycles in periods of ten years or less. Most technologies have backwards compatibility but some are incompatible with previous technologies or require gateway devices for interconnection.

6.57 The technology used in any particular railway will depend very much on when the equipment was installed and far less on any virtue of the technology of that equipment compared with the technology chosen by another railway. If one were to compare the technology choices of ten railway networks with construction projects active today, they would probably be very similar. Those ten railways would have made completely different choices five years ago and will doubtless make different choices in another five years. Within ten years the systems they have installed today will be obsolete and will probably be being replaced.

6.58 To benchmark maintenance and equipment costs one must therefore compare systems of similar age. There are so many differences in technology, reliability and maintenance requirements that other comparisons are generally not helpful.

6.59 Hence, for communication network designers and managers the biggest issue is the rate of change of technology. Benchmarking technology choices and the maintenance costs associated can therefore only be achieved for systems of the same age. Thus international comparison was felt to be inappropriate. In regards to national comparison, from previous experience in undertaking similar exercises, the Consultants confirmed that other major national railways have similar approaches, technology and systems age to that of QR[17].

Power

6.60 Benchmarking QR against other rail systems with respect to power assets is problematic because most other rail systems in Australia use different electrical arrangements. The QR system, being a more modern AC based network, compares favourably with the earlier systems (e.g. of Sydney and Melbourne) which rely on DC traction supplies. This effectively constrains these systems to operate only as Metro – passenger systems. The coal carrying QR system would not have been achievable without the relatively higher voltage 50/25 kV AC design.

6.61 It is possible to directly compare QR assets with similar assets used by electricity transmission and distribution companies over a similar time period. Where assets can be directly compared, (e.g. substation transformers and switchgear) the maintenance and asset condition conform to typical expectations for an electrical transmission or distribution company of similar extent and asset age. The one proviso to this observation is that cycling traction loads expose electrical equipment to more onerous operational conditions than the steady loads experienced by electrical utilities. Accordingly, the asset condition of the major equipment within QR is reasonably good.

6.62 The main departure of the railway electrical system compared to an electricity company is the prevalence of auto-transformers on the railway system. On utility systems these units are rare. These are expected to be a significant maintenance cost in the years to come and will require careful maintenance and replacement planning.

[17] Further details in supporting document "Benchmarking of Heavy Haul Railways, International and National Comparison" Section 3 Signals & Telecommunications

Asset Life National Benchmark

6.63 In addition to the international benchmarking on engineering maintenance processes and costs, a national comparative assessment on industry accepted asset lives in relationship to QR asset life figures and QCA adjusted values, was undertaken. This benchmarking was based on WorleyParsons professional engineering and commercial experience of Australian industry accepted norms.

6.64 In order to make this comparison WorleyParsons were given the following assumptions of asset lives by QR and the QCA (Table 11).

Table 11 Asset Lives as registered by QR and QCA benchmark assessment

Asset Class Description	Adjusted Life (QCA	QR's Fixed Asset	Benchmark Assessment
Railway Track - Heavy[18] : Goonyella / Blackwater	35	30	20-30
Railway Track - Medium[19] : Goonyella / Blackwater	35	45	25-35
Railway Track - Light[20] : Goonyella / Blackwater	35	45	
Track Turnouts - Heavy : Goonyella / Blackwater	35	20	15-20
Track Turnouts - Medium & Light : Goonyella / Blackwater	35	25	15-20
Railway Track - Heavy : Moura	40	30	20-30
Railway Track - Medium: Moura	40	45	25-35
Railway Track - Light : Moura	40	45	
Track Turnouts - Heavy : Moura	40	20	15-20
Track Turnouts - Medium & Light : Moura	40	25	15-20
Railway Track - Heavy : Newlands	44	30	20-30
Railway Track - Medium : Newlands	44	45	25-35
Railway Track - Light : Newlands	44	45	
Track Turnouts - Heavy : Newlands	44	20	15-20
Track Turnouts - Medium & Light : Newlands	44	25	15-20
Timber Sleepers			5 - 15
Bridges: Concrete Rail Bridges - heavy	50	100	50
Concrete Culverts & Pipes – Heavy	50	100	20-30
Concrete Culverts & Pipes – Medium	50	100	40-50
Steel Pipe Culverts - Heavy	50	50	20-30
Steel Pipe Culverts - Medium	50	50	40-50
Earthworks: Cuttings	50	100	100

18 Assumed to be 26tal and over
19 Assumed to be 20tal – 26tal
20 Assumed to be under 20tal

Earthworks: Embankments	50	100	100
Administration Buildings	38	40	10-20
Building Facilities	38	20	10
Computer Systems	38	3	3
Training Equipment	38	10	
Fences	38	20	20
Floodlighting	38	20	20
Unsealed Roads	38	99	10
Control Systems (Signal – Non vital)	38	15	10-20
Train/Track/Environment Monitoring Systems	38	25	10-20
Control Systems (Signals)	30	10	
Level Crossing Protection	30	25	
Train Protection Systems	30	15	
Signal Interlockings - Relay	30	30	
Signal Interlockings - Mechanical	30	40	
Signal Interlockings - Processor	30	15	
Field Equipment & Cables	30	25	
AWS Magnet			
Signal Signage			
Electric Points			
Telecommunications: Data Network Equipment	30	15	10-20
Telecommunications: Linking Network Equipment	30	15	10-20
Telephone Exchange Equipment	30	20	10-20
Electrical System Equipment: Traction Supply Transformers	35	20	20
Electrical System Equipment: Traction Power System Equipment	35	20	20
Power Distribution: Traction Power Distribution	35	50	20-30

Limitations to Data Analysis

6.65 The figures given in Table 11 were considered quite general. They don't factor for the different variables which have significant effect on asset life, but also have often 'bunched' the various components together. An example is 'track', where a calculation for the life for track has been assessed when the ballast is renewed, which is at different intervals to the rail and sleepers.

6.66 The Consultant did not consider that the figures proposed by QR, or the adjusted figures given by the QCA, accurately reflect the variations that need to be considered. Little modification is given even under the usage (tonnage) variable. It is recommended that if these figures are to truly reflect the potential asset life, which is an essential factor to ascertain when planning maintenance programs and/or budgets, a more comprehensive analysis needs to be undertaken where these variables are taken into account. This type of analysis would provide a more robust and valuable assessment of asset life.

6.67 It appears that the QCA figures neither attempt to reflect the traffic differences on the different systems, nor do they effectively differentiate between heavy, medium and light services. Further, they do not differentiate between components such as plain track and turnouts, or between design differences such as under 800 m radius curvatures and straight track. It is recommended that in future these variables be taken into account when calculating average life figures.

6.68 It is recommended that some assets are better expressed in Million Gross Tonnes (MGT) rather than years. This would be considered the case for rail, sleepers (concrete or steel, not timber), switches and crossings, and ballast.

6.69 It was felt that some assets' 'life definition' also requires further clarification. For example does ballast undercutting after 8 years mean that the ballast life is only 8 years. At what percentage return does ballast undercutting become renewals (and life is determined) or maintenance (life is rehabilitated)? Or is ballast life only expired when the whole of the ballast is discarded and replaced with new?

6.70 As a similar definition problem as above, the replacement of Signal and Telecommunication equipment is rarely replaced as a whole. Mostly the replacement involves components only (i.e. switch rail, stock rails, crossings, etc). Again, at what point of component replacement is life expiry officially termed?

6.71 Notwithstanding the observations above the Consultant established some 'average figures' based on a 'best fit' comparison to the methodology used to obtain the figures shown in Table 11. It is highly advocated that in future the above recommendations be considered in the calculation of asset life.

Track and Structures

6.72 It is the professional opinion of the Consultant that the lives given by QR for heavy track are reasonable. If these lives are accepted it seems logical that a greater asset life would be given to the "medium" track in view that it should be carrying less tonnages and traffic. Hence the Consultant concluded that a life of 30-40 years would not be unreasonable for the type of track on the network. This is consistent with the QCA adjusted life figure of 35 -40years.

The Consultant reiterates that at this level of analysis, a difference of 5-10years is difficult to dispute and qualify without further detailed assessment of the asset.

6.73 Turnouts of 50 kg rail do not exist on QR. Therefore QR would not have any medium weight turnouts and would be using 60 kg turnouts throughout "heavy" and "medium" track sections. Industry acceptance for turnout life under the conditions in the coal systems would be expected to be in the order of 15-20 years, or a figure less than the equivalent rail.

The swing-nose turnouts used by QR should have a longer life than fixed crossing turnouts, thus the 20 years given by QR is not unreasonable. Similarly a difference of 5-10 years is difficult to dispute and qualify without further data; therefore one would assume that a figure in-between the 20yrs given by QR and the 35yrs given by QCA (i.e. 25-30yrs) would be considered appropriate.

In general, turnout life is hard to define. Typically, individual turnout components are replaced when they wear out and it is difficult to say what the life of a turnout as a single entity is. Without replacement of key components its life as a unit is only the life of the component which is replaced first.

6.74 Strengthening bridges upgrades the capacity to allow for original design life to be maintained with the increased loading. The original Blackwater PSC bridges (50% of the original bridges before duplication) are known to have been strengthened to allow loading increases from 20 tal to 26 tal. It is anticipated that for these bridges and others that have been similarly strengthened, a 50 year design life would be reasonable. This is consistent with the QCA endorsed adjusted life figure.

6.75 As with bridges, concrete culvert design life can be expected to be around 100 years. However culverts are generally not strengthened when track axle loads are increased, so it is reasonable to assume that some of these structures may be under stressed conditions. Professional opinion suggests that in these circumstances a high percentage - say approximately thirty percent - of culverts can be expected to fail within the next 10 - 20 years. Culverts constructed at 20 tal may have a residual life of 30 – 50 years. On heavy track a conservative figure of between 20-30 years is considered reasonable, and both the 50 year QCA endorsed figure and the 100 year figure given on the QR asset register are considered optimistic.

6.76 The residual life of steel pipe culverts is significantly influenced by other factors such as corrosion[21] and abrasion, but the implementation of concrete inverts may prevent premature rusting and deterioration. In addition, steel pipe culverts can be severely affected by piping or leakage deteriorating the structure behind the steel interface. As a general rule 50 years life is applied to a new structure. However, as with bridges, if extreme loading and adverse conditions are being applied, then the structure needs to be assessed individually. Applying a broad assessment is considered a risk, considering the relatively high risk of failure of these structures if conditions deteriorate.

6.77 The life of civil works such as cuttings and embankments, roads, etc. is heavily dependent on due maintenance being carried out and environmental and geographical factors inherent in the area. (i.e. type of rock/soil/slope gradients etc). If correct maintenance is carried out and effective drainage and optimum environmental conditions are present, these should have indefinite life. It is considered inappropriate to put a definite generic 'life' on these assets. For embankments in particular if the

[21] For example, a culvert on the Sydney Newcastle freeway rusted out in 25-30 years

geographical foundation is stable, such an asset could last indefinitely without any maintenance other than vegetation clearance.

6.78 The life of unsealed roads is heavily dependent on construction and usage as well as the environmental factors mentioned above.

Telecommunication systems

6.79 Experience has indicated that the life of telecommunication systems is usually driven by technology and/or operational redundancy[22] of the systems rather than perceivable "life expectancy" of the individual components. Experience to date has indicated that various telecommunication systems are likely to be technologically redundant in 10 - 20 years.

Electrical Systems

6.80 Experience has indicated that similar to the above, the life of electrical systems is also usually driven by technology and/or operational redundancy of the systems rather than perceivable "life expectancy" of the individual components. Although it is expected that these systems should have a longer technical life than telecommunications systems, experience to date has indicated that it is unlikely to be much beyond 20 years.

Power Systems

6.81 Experience has indicated that similar to the above, the life of power systems is also usually driven by technology and/or operational redundancy of the systems rather than perceivable "life expectancy" of the individual components. Although it is expected that these systems should have a longer technical life than either of the previously discussed systems, experience to date has indicated that it is unlikely to be up to 50 years and a technological redundancy of around 20 – 30 years is considered more reasonable.

Summary

6.82 In summary, other than for specific components such as turnouts, the QR given life appears "generally reasonable" and greater uniformity was found between these figures and figures obtained from the independent professional review. Disparities between QR and QCA adjusted figures were generally minor. In consideration of the range of asset life calculations where variables are used to assess residual life, it is difficult to argue the differential without a more in depth analysis of the asset geographical conditions and design criteria, current/historical/future usage and maintenance lag/history.

[22] Where technologically redundant implies that the system is no longer supported by the manufacturer/ software/hardware supplier and operational redundancy implies a change in operational limits (i.e. increases in axle load, changes in train types, etc) which no longer are able to be supported by the system.

6.83 The biggest differences between figures from QCA and QR for Railway Track occur in the heavy category. The Consultants assessment concluded that most of QR's lives could be realistic depending on the confirmation of the definition of heavy rail category.

7. COSTS

Introduction

7.1 Part 7 examines costs and summaries each of the components of the financial framework as well as the calculation of access charges. It is also, in part, a summary of all the comments the Consultant has provided to date.

The Development of Costs and Assumptions

7.2 A "bottom up" approach to estimating maintenance costs for the Central Queensland coal network was conducted. Each of the four subsidiary systems was evaluated separately and then combined as a total business. The major cost elements included were:

- Track and structures maintenance (recurring maintenance – track, bridges etc)
- Mechanised resurfacing (MPM - tamping, ballasting and stone-blowing)
- Ballast cleaning (MPM)
- Rail grinding (MPM - rail rectification)
- Traction system maintenance (electric traction overhead and substations)
- Trackside systems ,maintenance (signals and communications)
- Track inspection (ultrasonic, geometry)

7.3 An allowance was added to the direct costs for each of these elements to account for corporate overhead (finance, human resources, information technology and payroll), together with an operator's margin.

7.4 Direct costs include wages, overtime and allowances, employee related on-costs, maintenance consumables (ballast, etc), operating and maintenance, equipment leasing and facilities.

7.5 As QR infrastructure services the whole Queensland railway system, corporate overheads have been apportioned against the Central Queensland coal network on the basis of similar sized companies. A loading of 5% was allowed.

7.6 With regard to commercial practice, a 9% loading has been allowed to reflect the operating margin payable in a maintenance contract. This is a low figure, but is warranted by the security of the implicit Alliance Agreement with QR.

Appropriateness of Cost Build-up

7.7 The bottom up estimation of costs aggregates unit rates across each coal system. This is appropriate as the lines in each sector vary in complexity and asset count of specifics such as bridges, turnouts, crossovers, signals, level crossings, etc. They also vary significantly in terms of gross tonnes of traffic carried.

7.8 QR does not differentiate between activity and costs as either Major Programmed Maintenance (MPM) or Routine Maintenance (RM). This is not to imply that programmed maintenance does not occur, but rather that QR finds it convenient to switch resources between MPM and RM activities as required by planning contingencies. It does, however, make unit cost comparisons with other Australian railways somewhat difficult, as the MPM/RM categorisation is becoming widespread, probably due to outsourcing of maintenance activities.

7.9 Heavy haul railways suffer great wear and short asset lives. This tends to result in rail, sleepers and ballast appearing more like consumables rather than assets which can be expected to have lives of 50 years or more, and therefore more properly capitalised.

7.10 Factors such as the marked variability of maintenance due to traffic volume as well as the short asset life of track components in this service, lead the Consultant to believe that there is a strong argument to include all track related costs in access charges on heavy haul lines. This is especially significant if the railway is likely to be an ongoing concern in the very long term. Mr Ken Talbot of McArthur Coal recently stated that coal demand would remain strong for at least the next twenty years.[23] The QR network, however, is likely to be functioning long beyond that.

Efficient Costs

7.11 QR operates in a cost environment where manning levels, remuneration and working conditions are dictated by industrial agreements and Government policy. Efficiency must be assessed within these constraints. A desktop comparison with other heavy haul operations working under less constrained conditions is therefore not a valid measure of relative efficiency.

7.12 The Consultant has undertaken a “bottom up” assessment of QR efficiency by assessing manning levels, remuneration, skills, labour productivity, maintenance planning, use of consumables and the adequacy, availability and productivity of equipment. It was found that within those constraints, the maintenance efficiency of QR is reasonable.

7.13 In any organisation it would be possible to identify certain practices that might be called inefficient. As such, it would be fair to say that there are some details of QR maintenance that are not at the standard of world's best practice. Labour demarcation is one such issue. Progress in that area,

[23] Andrew Fraser. (2008) “Queensland coal bottlenecks to cost billions” The Australian. 17th June 2008.

however, would require the reformation of Industrial Relations arrangements, which is unlikely in the present environment. Nevertheless, the overall conduct of QR as a maintenance provider was found to be efficient.

7.14 The determination of a practice being 'efficient' can only occur over a short period and therefore efficiency can only be defined within the parameters of the existing infrastructure and methods of operation. UT3 will apply for four years, which is the short term merging into the medium term. Given that it could take two to three years just to identify the need for, order and commission a large item of track machinery, the value of the current term 'efficiency' over the longer term could be misleading. This is evidenced by Pacific National who has argued for the longer term to be considered when making access decisions.[24]

7.15 There is evidence to suggest that QCA efficiency targets have actually militated against the provision of efficient infrastructure. There have been no penalties imposed to minimise coal fouling, no provision for estimating the maintenance deficit at the beginning of an undertaking period and no allowance for the extra resources to overcome it. Coal contamination and maintenance deficits have therefore increased.

7.16 In the UK, in order to meet demand, rail industries are attempting to double their traffic volumes. The Office of Rail Regulation (ORR) recently acknowledged that periodic reviews of access charges, service delivery and efficiency were not facilitating long term decisions. Its Executives and Senior Management have sought extra powers to identify long term issues, particularly those that are investment related. In the Queensland context, this would address the issues of track gauge, axle load, wagon type and traction power, and place access charging in a long term efficiency context.

7.17 If a company today was considering constructing a 100 million tonne per annum heavy haul railway in Australia, it is unlikely they would adopt the specifications of the QR network. They would not adopt a 1067mm (3ft 6in) track gauge, would not contemplate an axle load less than 35 tonnes (the new FMG railway in the Pilbara is engineered for 40 tal), In this regard the assertion that Queensland coal railways are at or near world best practice is therefore unsustainable. This is not because their maintenance regime is inefficient, but because the basic infrastructure, in some parts, may not be best contemporary solution suited to today's task.[25]

7.18 This in itself locks in inefficiency, as it presumes the infrastructure, rolling-stock and handling facilities are efficient, when some or parts of some may be potentially sub-optimal.

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[24] Pacific National Network & Access (2005). "Victorian Rail Access Regime Rail Access Pricing Consultation Paper: Submission To The Essential Services Commission". November 2005. Para 14.

[25] Laird, Dr Philip (2004) "Submission to the Productivity Commission Re Review of National Competition Policy Arrangements". University of Wollongong, October 2004. p3.

7.19 Average costs will be ascertained for the four coal systems in QR, and aggregated into the whole Central Queensland coal network.

7.20 In 2007/08 approximately $20 million of consumables were used in maintaining the coal system. About 75% of this expenditure was for items directly related to maintenance, such as new rail, sleepers and ballast, turnouts, plant hire and trade services. Indirect consumables accounted for the remainder, such as fuel, vehicle operating and maintenance, training, communications, accommodation and office supplies.

7.21 Major equipment, such as the Plasser & Theurer Ballast Cleaner (Figure 38), the Loram 80 stone main line Rail Grinder, and the smaller 24 stone turnout grinder, ballast tampers and ballast regulators (Figure 39), are utilised across the entire QR network. Their costs, however, are apportioned to the coal network on a kilometre basis. Procurement of machines such as these is a significant capital expense (the two grinders are valued at $30 million), with long lead times due to their specialised nature as well as the requirement for them to be adapted to narrow gauge.

Figure 38 Plasser RM900 Ballast Cleaner

Figure 39 QR Ballast Tamper and Ballast Regulator

7.22 The Infrastructure Services Group (ISG) uses the same staff, at the same marginal cost, to undertake both planned and unplanned work. This provides network access with an efficient means to react to changes in circumstance throughout the year. This is particularly so for changes in traffic volume and extreme rainfall, which interfere with the planned commitment of resources. Rapid response to these occurrences and flexibility is one of the fundamental reasons why QR has chosen to have an Alliance agreement rather than a hard contractual relationship with ISG or an external contractor.

The Calculation of Access Charges

7.23 The traditional organisation of railways in Queensland, including the coal lines, was as one large, single network, maintained by a substantial Infrastructure Division. Resources could, to a degree, be relocated around the whole network in response to traffic variation, weather events and accidents. This meant resources could be balanced to achieve overall efficiency. Therefore, a traffic downturn on the coal lines would enable resources to be moved to productive work in other areas. This would reduce the costs of maintenance on those coal lines without compromising overall QR network maintenance efficiency. With the move to Open Access and outsourcing, this approach is no longer possible.

7.24 Queensland has adopted a model which provides limited private access to the State owned railway infrastructure, in competition with the State owned train operator. Most other Australian railways have a hybrid State owned / private access regime with infrastructure maintenance contracted to a specialist provider. Queensland has chosen to contract in-house to its own ISG. This is intended to preserve the flexibility of the monopoly model, where resources can, to a degree, be optimised for overall efficiency. Nevertheless, the QR / ISG Alliance is still a form of "contract" and is treated as such by the QCA, which expects forward estimates of maintenance costs to be presented for UT3.

Variability

7.25 The QCA UT1 assumed a direct variability between infrastructure maintenance and the volume of traffic, measured by Gross Tonne Kilometres (GTK). It further imposed cost penalties and discounts for train operators if tonnage exceeded or fell short of agreed annual volumes.

7.26 QCA's logic behind this position is two-fold. Firstly, it assumes that maintenance is indeed variable with GTK over the short term. This fact is disputed and is currently the focus of a WorleyParsons Queensland Railway Network engineering study. Secondly, it assumes that a maintenance regime could efficiently be adapted to traffic variability in the short term. The Consultant would argue that this is unsustainable.

7.27 The high variability of track maintenance costs with traffic volume on heavy haul railways has been established by a number of international studies. It may be taken as a given that track deteriorates significantly with high volumes of traffic. Equated mileage parameters developed by the American Railway Engineering and Maintenance-of-Way Association (AREMA) are based on studies of major North American railways, although warnings are given that there could be significant cost differentials between railways in different areas. The AREMA study went on to state that at tonnages over 35Mgta the effect of additional volume is non-linear and unquantifiable.[26] Similarly, the ORR in the UK has made several studies, recently summarised by Dick Bullock. The ORR findings in 2000, 2005 and 2007 for the variability of track renewal with tonnage have fluctuated from 36% to 44% back to 22%. Mr Bullock noted that variability would be much higher for the QR heavy haul lines.[27]

7.28 The actual factors affecting track maintenance variability with GTK while likely to be high cannot be ascertained from desktop studies of other railways. The influence of track gauge, terrain, climate, wagon type, axle loading and train speeds are sufficient to warrant Queensland based studies. While insufficient time appears to be available to accomplish this study prior to the commencement of UT3, a provision for a review of these factors during the course of the undertaking could be made in order to incorporate evidence from field studies.

7.29 There is very little literature available to define exactly what short term variability is. No study of this issue has been found. "Short-term" is generally left undefined in the context of railway track maintenance, but in economics the short term is defined as that period when output may only be varied by making more intensive use of available resources.

[26] American Railway Engineering and Maintenance-of-Way Association, (1999). "Manual for Railway Engineering" p16-11-2

[27] Bullock, D (2007) "Variability of Infrastructure Costs – Recent Developments in UK"

7.30 The resources of maintenance contractors must be geared to the contracted tasks. If not, their businesses will be inefficient and unprofitable. Spare capacity is minimised which means that a short term increase in task can only be met by buying in resources from other providers at short term hire rates. Conversely, a traffic downturn or other event that reduces the maintenance task will not reduce the cost of the contract in the short term. If the provision of track maintenance is assumed to be on a contract basis, it follows that it must be for an agreed traffic task, with the railway being maintained "fit for purpose" to set axle loads, speeds and maximum number of train paths. The number and length of track possessions needs agreement, as do the cumulative delays from speed restrictions.

7.31 Under a contracted maintenance regime, the railway must be "fit for purpose" at the end of the review period as it was at the beginning. The major inhibitors to a contractor fulfilling this objective would be:

- Traffic congestion reducing track possessions;
- Weather damage; and
- Accident damage.

Major flood damage, or a major derailment, would generally be beyond the resources of a maintenance contractor to repair. This makes it necessary to bring in skilled labour and equipment from other railway districts, or short term hires from other contractors at very high rates. It is not uncommon for resources to be sourced from many hundreds of kilometres, and for infrastructure work elsewhere to come to a virtual standstill while the emergency persists. This is the reason why QR prefers to retain some otherwise redundant track machinery, however accessing skilled labour still remains a problem.

7.32 The peculiar nature of railway infrastructure demands specialised training processes, both in safety and maintenance methods and techniques. This, unfortunately, militates against the quick up-take of skilled labour. The problem is exacerbated by the remote location of most railway infrastructure worksites, coupled with the short supply of labour in an economy with very low unemployment.

7.33 The railway industry has a number of small infrastructure maintenance providers. Often they are ex-employees of the larger State railway systems, who have set up as independent companies and purchased some smaller items of equipment. These resources are available for hire at high daily rates, and are used to "fill the gaps" in the large maintenance contracting companies when an unforeseen workload occurs. There are few such small firms located in the Central Queensland coal network.

7.34 The short term for a maintenance contact is therefore the period in which its output can only be increased by hiring in resources at daily rates, temporarily relocating resources from other areas, and buying such material (sleepers, rail and ballast) as is available. None of these options are attractive, and tend to be reserved for emergencies.

7.35 Maintenance providers therefore gear for an agreed output and cannot quickly alter their resources or use them elsewhere should a downturn in traffic occur. In the short term a maintenance contract is virtually 'take or pay[28]', so it is difficult to argue that an access seeker should either pay a penalty or receive a discount merely for traffic fluctuations outside of an agreed volume. The length of this period is between one and three years, reflecting that resources become gradually less fixed, not suddenly.

7.36 In the short term, however, it is also unreasonable to increase charges on access seekers if they increase volume, provided they do not interfere with the agreed track occupations or otherwise inhibit the maintenance contractor.

Coal Contamination

7.37 Although it is unlikely that there will be observable deterioration of track caused by short term variations in GTK, the Consultant would argue that coal contamination is occurring in direct proportion to wagonloads of coal shipped, even in the short term, and this is not being reflected in access charges. A maintenance contractor could not be expected to maintain "fit for purpose" over the period of a contract if coal throughput increases, and with it, ballast contamination. A maintenance deficit will occur.

7.38 This assumes coal loading and unloading practices remain unchanged, with wagons being overloaded resulting in side spillage and wind loss, and coal ploughing at unloaders resulting in spillage from wagon bogies and under-gear.

7.39 The maximisation of coal throughput is recognised as a positive for the Australian economy, especially when prices are at record levels. Coking coal prices have increased by approximately $100 per tonne in 12 months. Given the current cost of these commodities, maximising wagon loading and equipment turnaround is good business, even at the expense of increasing track damage. Suppose an additional 10 million tonnes of coal was shipped at a price of $300/tonne. The ballast undercutting task would have to be doubled as a result. Even at an additional cost of $25 million, the extra track maintenance would still only account for less than a cent per tonne of the price of the total coal shipped.

7.40 In circumstances such as these, it would be more than justified to recompense the maintenance provider with funds from access charges in order to rectify damage to a State asset, both in the short

[28] "take or pay" contract can also be defined s a throughput or tolling contract whereby one party has the obligation of either taking delivery of goods or paying a specified amount, for example where in an agreement between a 'buyer' and a 'seller' the 'buyer' will still be obligated to pay some amount even if the 'service' or 'product' is not delivered.

and longer term. Bearing in mind that a privately owned railway would refuse to permit the operation of overloaded or contaminated trains without compensation, it would be reasonable to expect the implementation of price mechanisms which reward parties in the supply chain to invest, innovate, or otherwise, in solutions which will lead to minimization of the problem and improvements to overall supply chain operations as well as benefits to all parties.

Weather and Accident Damage

7.41 Storms may result in washouts and other infrastructure damage, or merely leave a waterlogged terrain that inhibits access. More serious storm damage could even result in train wrecks. In such circumstances the MPM programs are interrupted, as resources must be devoted to restoration of service and clean-up. Clearing the back up of traffic will subsequently reduce track occupation windows, and a maintenance deficit will build.

7.42 To avoid the notion of "pay twice", a maintenance deficit following weather or accident damage could possibly be financed by a special surcharge. A process for ascertaining such a deficit and the resulting surcharge would need negotiation, with understanding by all parties that the costs involved were an unforeseen and unavoidable consequence of moving coal long distances in the tropics.

Train Density and Lost Track Possessions

7.43 If the number of trains increases to the point that occupation windows are infringed, this will either reduce the amount and effectiveness of work by the maintenance provider, or force higher costs onto that provider to achieve the "fit for purpose" standard. It is noteworthy that train density does not necessarily imply an increase in GTK. More trains may operate with fewer wagons, or more likely, trains may be scheduled at times otherwise set aside for track occupations. These types of events could be triggered by port related demands. The cost of lost track possessions should rightly be a penalty levied at appropriate system users.

7.44 Some estimate of forward maintenance needs seems unavoidable, but a portion of past estimates has been proven to be unreliable when compared with actual performance. Ideally, forward estimates should be based on a maintenance contract for the line section in question. This should include an assessment of track condition and residual life, as well as an estimate of any maintenance deficit.

7.45 If the contract period is lengthy, frequent reviews of KPIs and traffic levels would be necessary, with a provision for adjusting access charges to reflect significant variations in committed resources.

7.46 Maintenance deficit should be clearly identified both before the beginning of the undertaking period, and at the end. The tender could then indicate the items needing correction to start with, specify the standard required at the end of the contract, and fix the guaranteed track occupation regimes during the contract period. Access charges could then be fixed accordingly.

7.47 The issue of what constitutes "maintenance" also needs clarification. Some criticism has been levelled at QR for undertaking "renewals" in lieu of "maintenance". This issue in general has been studied, and the findings support the need for renewals as a means of ensuring overall maintenance costs are minimised.[29] The authors of the study noted that major U.S. railways maintain infrastructure through a mix of ordinary maintenance and periodic renewal of infrastructure components. The proportions of ordinary maintenance to periodic renewal varied, with little consensus as to the best combination. Furthermore, the cost-effectiveness of emphasising one method over the other had not been analysed using empirical data. The study investigated the cost-effectiveness of renewal-based maintenance strategies using high-level financial data from industry sources. It found that maintenance strategies placing more weight on renewal generally result in lower unit maintenance costs. The results imply that if railroads constrain renewal maintenance to reduce overall capital expenditures, increasing maintenance expenses will more than offset temporary reductions in capital spending.

7.48 The results are consistent with the hypothesis that an emphasis on renewal programs for track maintenance is cost-effective from an engineering viewpoint. It also provides an explanation for why railroads have consistently increased their use of renewal maintenance in relation to ordinary maintenance. Further, apparent differences in unit maintenance costs can be largely explained by the degree to which individual firms apply renewal strategies.

7.49 Capital expenditure on renewals comprises the largest portion of overall capital spending in railways. If railways unduly constrain renewal maintenance in an effort to conserve capital resources, it is likely they will find that ordinary maintenance expenses will rise disproportionately in relation to the reductions in capital expenditures. Making such trade-offs may improve free cash flow temporarily, but the effect will only be short lived as overall maintenance cost will eventually increase.

7.50 The issue is a live one, as rail replacement is recognised as the key item of variability with traffic volume. One would expect that given the degree of ballast fouling on the coal network, undercutting and ballast renewal would nearly be of the same importance. Given the acknowledged high variability of track maintenance with GTK, it is reasonable to treat these items as maintenance in a heavy haul context.

Increased GTK and Maintenance Variability

7.51 Over the long term railway infrastructure, above rail assets and port facilities, can be augmented through capital investment. Maintenance providers can alter their inventories of equipment and skilled labour to adapt to changes both in line capacity and throughput somewhat more quickly, probably between two to three years.

[29] Cost-Effectiveness of Railway Infrastructure Renewal Maintenance, G.A. Grimes & C.P. L. Barkan http://cee.uiuc.edu/railroad/CEE/pdf/

7.52 A substantial increase in GTK would be necessary to create a measurable deterioration of infrastructure. A given category of track is suitable for a wide range of tonnage. For example, the UK Railtrack Co (UKR) specified its Category 2 track as being suitable for 16 to 38 million tonnes gross at an operating speed of 50 kph. Its Category 1 track is suitable for approximately twice the range of gross tonnage (see below Figure 40).

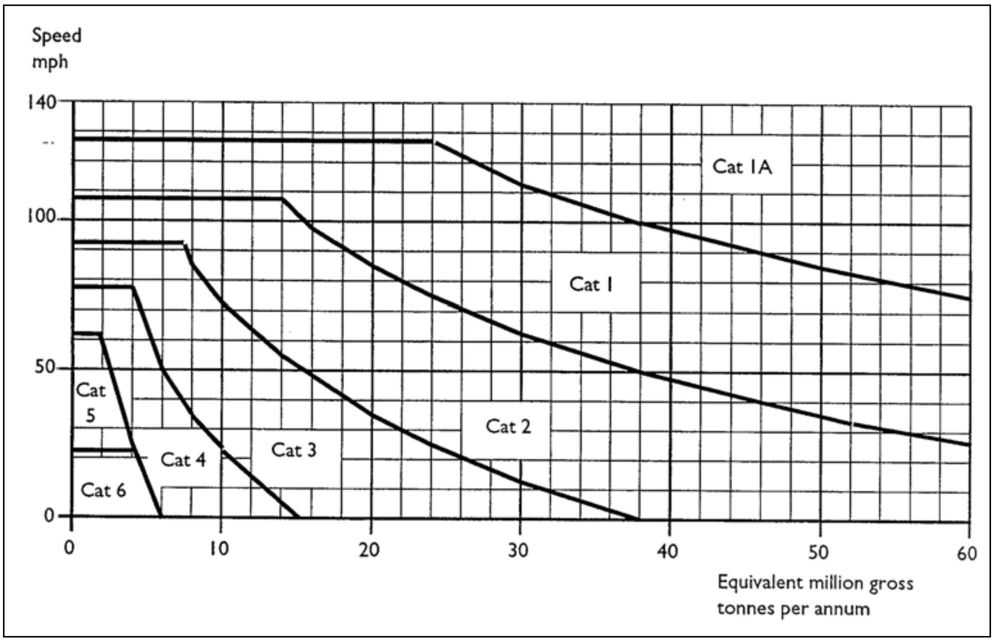

Figure 40 Track Categories in relation to speed and MGT

7.53 Much of the QR coal system has gross tonnage in the range covered by UKR Category 2, which is a similar standard track. The inner main line sections of the QR coal system operate at Category 1 standards and gross tonnages. This resilience to volume changes is indicative of the difficulty of measuring track deterioration due to short term changes in GTK on a given track section.

7.54 Given the lead times and expense of obtaining more track maintenance capacity, maintenance providers will need assurance of efficient operation of the system.

7.55 As noted above, on heavy haul railways maintenance varies more or less directly with volume in the long term. These effects may not necessarily be measurable in the short term, or produce a short term change in maintenance costs. In the long term, however, the effects will be evident and maintenance will have to ramp up to meet requirements.

7.56 This will produce a discontinuous short run marginal cost curve, as capital investment is necessarily uneven. In Figure 41, the original scale of output gives the short run average cost curve SAC' whereas the next possible scale gives SAC" and so on. There is no possible short run curve between SAC' and SAC". This has long been recognised as typical of railways.[30] As explained above, the short run curves for railway maintenance are steeper than notionally drawn in Figure 1.

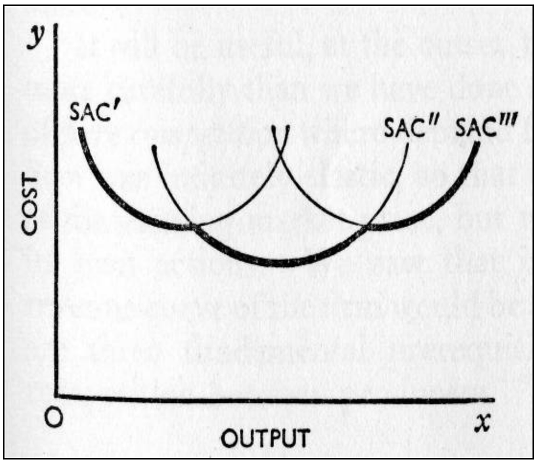

Figure 41 Railway Long Run Marginal Cost

7.57 Reviews of maintenance contracts should be frequent enough for long term variations in volume to be met by suitable increases of maintenance capacity.

7.58 A measurable decline in the "fit for purpose" standard constitutes a maintenance deficit. This is just as real as a financial deficit in an ongoing heavy haul railway, as the deferred expenditure will have to be committed in a subsequent period.

7.59 This would not include slow deterioration of assets such as rail, provided the asset condition did not restrict the load or speed of trains. Eventual replacement of basic components, such as rail, sleepers and ballast, would be undertaken as a renewals program, which would be separately contracted and is definitely not short term GTK variable.

7.60 Coal companies have protested at the notion of having to "pay twice", by which it is implied they are paying twice for the same service. It is evident that railway infrastructure maintenance on a heavy haul network cannot be fine tuned to the point that at the end of each maintenance contract there is no maintenance deficit.

7.61 If access charges are established sufficient to maintain track "fit for purpose" for the duration of a maintenance contract, which in turn will be based on traffic projections from the miners, the charges will be fair. If significant increases of traffic produce a maintenance deficit at the end of the period,

[30] Stonier, A.W & Hague, D.C.. (1964) "ATextbook of Economic Theory". London. 1964. p123-4.

the next maintenance contract must include restoration of track to "fit-for-purpose" standard, together with the extra resources to maintain the asset at the higher traffic level. Access charges would be based on the new maintenance contract. Paying for the deficit in this manner would not be a second payment for the maintenance services from the first contract, but instead a deferred payment for additional wear and tear not foreseen by any party.

7.62 Wear and tear induced by short term increases in aggregate train mass is unlikely to be measurable. The most likely causes of maintenance deficits would be through ballast contamination, floods and train wrecks. As discussed above, restoration to "fit-for-purpose" should be financed by penalties and surcharges.

Conclusion

7.63 The underlying logic of charging for short term increases in GTK, or giving discounts for running fewer trains is flawed for many reasons. It either assumes the coal railways are part of a much bigger network, all maintained by a monopolistic infrastructure maintenance provider that is able to efficiently move resources at short notice anywhere on the larger network in an efficient manner. Alternatively it assumes a maintenance contractor with a significant reserve capacity of skilled labour and specialised machinery can be efficiently moved to or from a site at short notice. Or it assumes that a prime maintenance contractor is able to draw on a supply of casual skilled labour and specialised equipment held by small firms and available for hire at short notice at day rates. This reasoning disregards the reality of the Central Queensland labour market and geography, and fails to comprehend the business environment due to the specialist nature of rail infrastructure resources.

7.64 In the short term a maintenance contract is 'take or pay', so it is difficult to argue that an access seeker should pay either a penalty or receive a discount merely for traffic fluctuations outside of an agreed volume.

7.65 Maintenance deficits happen. It is just as unreasonable to expect maintenance providers to precisely estimate the resources for a maintenance contract, as it is to expect miners to precisely estimate their forward output. Including restoration of the track standard as "fit-for-purpose" in a subsequent access charge does not constitute a second payment for the same service, but rather a deferred payment for unforeseen wear and tear.

7.66 Most maintenance deficits are due to ballast contamination, flood damage and wrecks. Ballast contamination is occurring in direct proportion to wagonloads, and until loading and unloading practices are reformed, the rectification of this problem should be financed by penalties on relevant system users. Flood and accident damage induced maintenance deficits should be covered by special surcharges, as it is not possible to factor them into normal access charges.

7.67 The access regime needs to be cognisant of long term efficiency issues relating to the outdated infrastructure standards applying in Central Queensland.

8. RECOMMENDATIONS AND CONCLUSIONS

Introduction

8.1 The following section summarises the recommendations of this report.

Commercial Arrangements & Key Performance Indicators

8.2 The Consultant believes that it is important for QR to be provided with clearer contractual definitions and boundaries to reflect the level of requirements. For example "additional spare capacity" should be defined as the extent of surge capacity required for the specific time duration.

8.3 The Consultant believes that the implementation of cost mechanisms for rewarding investments, innovations, or otherwise, for improvements to whole of supply chain operations and minimization of issues such as coal fouling and possessions cancellations will facilitate the understanding by all parties of the costs of individual actions and inefficiencies on the whole of the supply chain operation.

8.4 The Consultant confirms that both theoretically and in practice, failure to perform preventative and necessary maintenance will result in a maintenance deficit. This deficiency will in turn increase the levels of asset deterioration. Force majeure events such as flooding will only serve to aggravate this problem and create greater maintenance deficits. The Consultant notes that requirements for resources and possessions to conduct the work may not be available in the short term, especially in situations where track volumes are increasing. This may further exacerbate the problem.

The Consultant recommends that a mechanism for compensation of costs be developed to account for these deficits so the impacts are clear to all supply chain users.. It is therefore recommended that KPIs be implemented to quantify these maintenance deficits as a maintenance deficit is as real to the bottom line as is a financial deficit.

8.5 The Consultant recommends that a mechanism for agreement on the reliability index is made during the contractual period, in order to define 'fit for purpose' in the circumstances. A suggested consensus section by section approach to standards may ultimately provide business benefits.

8.6 The Consultant assessed that without establishing robust KPIs for asset condition, it is not possible to determine if premature asset replacement is occurring. KPIs should also include provision for renewals-based maintenance where financial analysis shows that such practice is warranted.

8.7 The Consultant recommends that a ballast fouling index be implemented and linked to a compensatory mechanism to calculate the additional costs incurred through inefficient loading and unloading practices. This can then be used to develop a reward system to facilitate the implementation of solutions to minimize the affects of these costs and increase efficiencies within these practices. The Consultant believes that such mechanisms serve to clarify the impact of such practices on all supply chain operations.

8.8 The Consultant recommends additional changes to the service level specifications. These include:

- Improved definition of all KPIs;
- An addition of at least three new, but possibly more KPIs (as detailed in Section 3); and
- Changes to KPI monitoring methods.

Asset Condition

8.9 In general the Consultant found that, except for polluted ballast, the condition of the assets is very good. The only recommendation is that mechanisms for mitigation of ballast fouling be implemented as soon as possible.

Asset Maintenance

8.10 The Consultant concluded that QR has excellent processes for rail management, achieving increased rail life, in comparison to similar operations world wide.

8.11 The Consultant noted that although ballast undercutting amounts were significant, the amount of work was warranted, due to extensive coal fouling of the track. The Consultant recommends that financial cost and benefit assessments to the supply chain operations be carried out to predict the return of investments in mitigation measures to this problem. The Consultant notes that many mineral booms have ceased suddenly with costly repercussions to investors and infrastructure owners.

8.12 The introduction of stone-blowing predominantly to heavily coal fouled ballast profiles is a new application of this technology. However research has shown that stone-blowing can be two to five times more durable than tamping on mixed lines and the Consultant commends QR on its approach. However, the Consultant highlights the need to conduct careful monitoring and assessment of site data to determine the increases in durability and type of track condition that would benefit most from this technology.

8.13 The Consultant recommends that integration and co-operability of the current asset planning tools is undertaken as soon as possible. It is believed that the implementation of the GIS based system currently being developed will provide major cost benefits. It will also empower greater efficiencies in planning possessions and in addressing multi-problems during single shut-downs.

Benchmarking

8.14 In general the track and structures international benchmarking concluded that QR Network practices and engineering methods followed current international best practice and trends.

8.15 QR was confirmed as a world leader in number of innovative practices, including:

- Regular measurements of percent void contamination (PVC) to plan ballast cleaning;
- Mechanised stone-blowing for track geometry maintenance;
- Research into using regular ground probing radar measurements for ground and ballast condition; and
- Rail wear monitoring programs.

8.16 On the whole QR costs were not found to be the highest when compared with railways carrying similar freight in similar conditions. A breakdown of specific unit rates confirmed that on average QR costs were not excessive, even when compared with national respondents.

8.17 QR has a relatively high rate of possession cancellations, the Consultant concurs that this is potentially due to user supply chain demand and 24/7 peak operations. The Consultant highlights that cancellations of planned work will lead to maintenance deficits which increase deterioration rates whilst decreasing the reliability index in the long term. The Consultant would recommend pricing mechanisms be implemented for possession planning which clarify the costs of disruptions of possessions at certain points in the operations as well as the potential future costs to supply chain operations of cancellations of the maintenance.

8.18 The Consultant recommends that certain asset lives be assessed in MGT rather than years, and that additional factors (as detailed in Section 6) be included in the assessment analysis.

Costs

8.19 The Consultant has noted that QR does not differentiate activity and costs and Major Programmed Maintenance (MPM) and Routine Maintenance (RM). As expanded in Section 7 the Consultant is not criticising this approach and acknowledges that this does not mean that programmed maintenance does not occur, but rather that QR finds it more efficient to switch resources between MPM and RM activities as required by planning contingencies. However, the Consultant highlights the fact that the lack of this distinct differentiation in the activity costs does make it difficult to make unit cost comparisons with other Australian railways and the Consultant points this out as a significant impediment when benchmarking costs and attempting to draw robust conclusions from such comparisons.

8.20 The Consultant acknowledges that it is always possible to identify inefficient practices in any organisation, and it can be fairly stated that in any organisation one will find practices that cannot be defined as the world's best. For QR, labour demarcation is one such issue, but radical progress in that area would require a reform to Industrial Relations arrangements that are unlikely in the present environment. Research has shown, however, that working environments that have such arrangements in place are often rewarded by greater loyalty and constancy by employees. It must be noted that in the current resource environment this factor could perhaps be considered of benefit.

8.21 Criticism has been directed at practices within QR which are a product of the basic infrastructure and foundation on which the network is built. The Consultant agrees that today's best practice for the construction of 100MGT heavy haul railway would not adopt:

- A 1067mm track gauge;
- Would not contemplate an axle load of less than 35 tonnes;
- Would not use bottom discharge wagons; and
- Potentially would use off-the-shelf high powered diesel electrics rather than electric traction.

Changing the current infrastructure to contemporary best practice would involve substantial financial investment which would need to be recuperated from users. Instead the current infrastructure has been adapted to provide a sustainable solution. As with any aging and perhaps not 'best suited infrastructure', the compromise on this solution is the additional requirements for maintenance. Maintenance is a 'whole of life-cycle activity' if existing infrastructure is 'fit for purpose'. The period for replacement is calculated when the whole of life cost of the existing asset exceeds the cost of replacement.

8.22 The underlying logic of charging access users for short term increases in GTK, or giving them discounts for running fewer trains, is flawed. It assumes the coal railways are part of a much bigger network, all maintained by a monopolistic infrastructure maintenance provider that is able to efficiently move resources at short notice anywhere on the larger network in an efficient manner. Alternatively it assumes a maintenance contractor has a significant reserve capacity of skilled labour and specialised machinery that can be efficiently moved to or from a site at short notice. Or it assumes that a prime maintenance contractor is able to draw on a supply of casual skilled labour and specialised equipment held by small firms and available for hire at short notice at day rates. It disregards the reality of the Central Queensland labour market and geography, and fails to comprehend the business environment for the specialist nature of rail infrastructure resources.

8.23 In the short term a maintenance contract is 'take or pay', so it is difficult to argue that an access seeker should either pay a penalty or receive a discount merely for traffic fluctuations outside of an agreed volume.

8.24 Maintenance deficits happen. It is unreasonable to expect maintenance providers to precisely estimate the resources required for a maintenance contract, just as it is unreasonable to expect miners to precisely estimate their forward output. Including restoration of track standards as "fit-for-purpose" in a subsequent access charge does not constitute a second payment for the same service, but rather a deferred payment for unforeseen wear and tear.

8.25 Most maintenance deficits are due to ballast contamination, flood damage and wrecks. Ballast contamination is occurring in direct proportion to wagonloads, and until loading and unloading practices are reformed, the rectification of this problem could be encouraged through the implementation of cost mechanisms to award improvements in processes or development of innovations which mitigate the problem. Flood and accident damage induced maintenance deficits should be covered by special surcharges, as it is not possible to factor them into normal access charges.

8.26 The terms of maintenance contracts are critical in determining the short term variability of maintenance cost with GTK. Further study of typical rail infrastructure maintenance contracts is therefore warranted.

8.27 The issue of maintenance variability with GTK needs to be studied in the context of Central Queensland, including track condition monitoring. It is important that "normal" maintenance variability be separated from the special issue of coal contamination, as there is strong evidence to suggest that coal contamination is directly proportional to wagonloads, and further, constitutes a disproportionate burden on maintenance resources. Such a study would also be useful in ascertaining the build up of maintenance deficits.

8.28 The access regime needs to be cognisant of long term efficiency issues relating to the outdated infrastructure standards applying in Central Queensland.

9. QUALIFICATION

9.1 In preparing this report WorleyParsons has exercised the degree of skill and care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering design principles.

9.2 WorleyParsons has used all reasonable endeavors to inform itself of the parameters and requirements of the project and has taken all reasonable steps to ensure that the report estimate is as accurate and comprehensive as possible given the information upon which it is based.

9.3 It is not intended that this report represent a final assessment of the feasibility of the project.

9.4 WorleyParsons reserves the right to review and amend all calculations, cost estimates and/or opinions included or referred to in the report if:

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10. SUPPORTING DOCUMENTS

The summaries and conclusion in this report are detailed in full in the consultants supporting documents which include;

- Life Asset Register Benchmark;
- Marginal Costs: Fixed and Dynamic Variables;
- Queensland Railways Maintenance Variability;
- Optimising Locations of Maintenance Depots;
- Comments on Service Level Specification for Rail Infrastructure Maintenance;
- Benchmark Heavy Haul Line;
- Northern Queensland Coal Network Systems; and
- QR Maintenance Margins.