# Independent Reporter A

Track Service Life Project

Final Report

Review of Network Rail's Further Work on Track Service Life Predictions – April 2007

**Halcrow Group Limited**

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### Contents Amendment Record

This report has been issued and amended as follows:

| Issue | Revision | Description | Date | Initial |
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| 1 | 0 | Draft Final for comments | 13/04/07 | PRE/RS |
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| 1 | 3 | Final with ORR further comments added | 23/05/07 | PRE/RS |

# Content

# 1 Introduction

## 1.1 Background to the Project

1.1.1 As part of its role as Independent Reporter, Halcrow has been appointed by ORR (and endorsed by Network Rail) to assist in it's undertaking to review and assess Network Rail's track renewals forecast for Control Period 4 (CP4 – 2009 to 2014).

1.1.2 Track service lives have been used to calculate track renewals volumes within the modelling computed by Network Rail's Infrastructure Cost Model (ICM). The renewals volumes were then costed and integrated into Network Rail's Initial Strategic Business Plan (ISBP), submitted to ORR on the 3rd July 2006.

1.1.3 As Network Rail's required track renewals expenditure for CP4 will be determined by this process it will be largely driven by Network Rail's track service life assumptions. Halcrow have been commissioned to advise on the appropriateness of these assumptions.

1.1.4 Network Rail have developed their own Track Service Life table which is stated in the most recent version of Network Rail's Track Asset Policy and reproduced in Table 1 below.

| Track Cat. | CWR | Jointed Rail | Hardwood Sleepers | Concrete Sleepers | Softwood Sleepers | Steel Sleepers | Slab track | Ballast | S&C |
|---|---|---|---|---|---|---|---|---|---|
| 1A | 30 | 40 | 30 | 35 | 35 | 30 | 35 | 25 | 25 |
| 1 | 30 | 40 | 30 | 35 | 35 | 30 | 35 | 25 | 30 |
| 2 | 40 | 40 | 40 | 40 | 35 | 40 | 40 | 40 | 35 |
| 3 | 45 | 40 | 45 | 45 | 35 | 45 | 45 | 45 | 40 |
| 4 | 50 | 45 | 50 | 50 | 40 | 50 | 50 | 50 | 45 |
| 5 | 70 | 60 | 50 | 55 | 40 | 50 | 55 | 60 | 50 |
| 6 | 70 | 60 | 50 | 65 | 40 | 50 | 65 | 65 | 60 |

*Table 1 Extract from Track Asset Policy 30 June 2006*

1.1.5 These expected service life figures have been arrived at through a detailed review of track types against track category by a number of experienced Network Rail Track Engineers, then collectively developed and ratified at a summit meeting in Leiden, Netherlands in 2005.

## 1.2 Network Rail's CP4 Development Work

1.2.1 Network Rail are currently undertaking a detailed 'bottom-up' review of the CP4 forecasts by locally assessing routes to estimate renewal levels in CP4 and beyond. The output of the review will be used to refine the ICM generated volumes referred to above and compare them to the newer service life table generated volumes to ensure they adequately represent the network.

1.2.2 The service life table described above which was developed and ratified in Leiden, Netherlands has become colloquially known as the 'Leiden' Model. Unlike Network Rail's Infrastructure Cost Model (ICM), the 'Leiden' approach is a table of average asset lives for particular track categories. Once an asset type has achieved its life it is assumed to be renewed, and If GEOGIS says this has not happened, 'Leiden' creates a backlog volume.

1.2.3 Following the ratification of the ‘Leiden’ service life tables, Territory Track Engineers were authorised to modify the tables for their Territory to suit their routes. These modifications are known as ‘Leiden Plus’. Three Territories, namely LNE, Southern and Western chose to adjust the tables in this way and both Scotland and LNW chose to keep the table as it was agreed in Leiden, as they regarded the table as being representative of the majority of their lines.

1.2.4 The detailed ‘bottom up’ review for the CP4 forecasts involves a review of the service lives shown in this model (or ‘Leiden Plus’) and ICM against locally known variations which have an impact on track service lives.

1.2.5 This work is being done by the Territory Track Engineers and reviewed by the Head of Track Engineering for every Strategic Route Section (SRS) of which there are approximately 300 across the network. The output of Network Rail’s exercise will be to inform a review of the current average service life assumptions to supplement or change the output from ICM.

1.2.6 Network Rail aim to complete the Territory based work by March 2007, and then to consolidate the output into a revised set of service life assumptions, producing a first draft for input into the development of ICM version 2.

## 1.3 Remit for the Project

1.3.1 The remit given to Halcrow for the project is to assess the validity of Network Rail’s assumed service lives by undertaking two exercises as follows:

*Task A – An audit of the Territory Bottom Up reviews*

1.3.2 A desk top review of Network Rail’s process and logic regarding their territory-based review of the 300 SRSs and how they have used the information to amend the service lives used in ICM. This is carried out as follows:

(a) To review a sample of Territory Route Strategy Templates and supporting documentation to form an assessment of the sufficiency of the data used and the validity of the assumptions made.

(b) To review Network Rail’s subsequent process of consolidating the 300 templates into a refined set of service lives. This shall also be reviewed with particular comment on the logic and process used and the conclusions reached.

(c) To recommend any further work that Network Rail could do to improve the refinement of service lives.

*Task B – Sample Route Studies*

1.3.3 A detailed study of a sample of SRSs to provide an independent assessment of typical service lives on particular route types. This will be based on a detailed study of a representative sample of strategic route sections across a range of different track categories.

1.3.4 This will be achieved through site visits and sample saloon rides backed up with supporting information provided by the Territory Engineers (GEOGIS data, track renewal proposals, track geometry data etc.).

1.3.5 For each sampled SRS, a view is to be formed on the average economic service life that is typical to each sample. In order to reach an objective view, comment is required on whether the sampled route is skewed by any factors that could result in longer or shorter service lives than other comparable routes.

1.3.6 Consideration is also required on the assumed maintenance / renewal balance for each SRS and comment on whether it appears to be the optimum for that route.

1.3.7 It is required by ORR that assessing service lives, it is assumed that track asset management of the route (inspection, maintenance and renewal) is improving towards best industry practice. This is to ensure that recommended service lives are not constrained by any sub-optimal practices continuing into CP4, and benefit from optimum maintenance input.

1.3.8 Also, as required by ORR, it shall be assumed that traffic flows remain at current levels throughout CP4, unless there are committed changes already planned.

### *ORR Guidance on Sampling*

1.3.9 ORR have given guidance on the Task B sampling of sites as follows:

It is important that a representative sample of SRS's are chosen.

Track categories 1A and 6 are unlikely to be representative samples due to their low population. Therefore it is suggested that samples are chosen from each of the track categories 1 to 5 (inclusive).

The sample from each track category should also be based on the most common stewardship class, therefore representing typical performance requirements, i.e. the sample in each track category should align as best as possible with the dominant route class, as suggested in the table below:

| *Track Category* | *Dominant Route Class* |
|---|---|
| 1 | Primary |
| 2 | Primary |
| 3 | Secondary, LSE |
| 4 | Secondary, LSE |
| 5 | Rural, Freight |

Further refinement of the samples has also been necessary within the range of track component types. Steel Sleepers, Slab Track and S&C have been excluded from the samples in order that the predominant plain line track component types can be given more of a focus.

## 1.4 Project Deliverables

1.4.1 The project is to be deliberately run in parallel with Network Rail's Territory based review and aims to allow time for Network Rail to revisit and address any shortcomings that are revealed by the project prior to the end of April 2007. Therefore an ORR approved programme is a requirement to ensure that the project can be delivered on time.

### *Programme*

1.4.2 The programme includes the following milestones:

(a) An initial briefing by Network Rail to understand the process used and progress made.

(b) An approved proposal of the route samples to be used in the study.

(c) An interim report by 30th March 2007 summarising findings and conclusions to date, covering both Tasks A and Task B.

(d) Completion of the audit of 'Leiden Plus' Territory based review work (pending completion by Network Rail due by Easter 2007) (Task A).

(e) Completion of the route study work and submit report (Task B).

(f) Fortnightly progress meetings varied, as agreed to accommodate site visits and meetings, with ORR throughout.

*Reports*

1.4.3 The project output is reported as follows:

(a) An interim report on the 30 March 2007 with sufficient analysis to allow ORR to finalise its initial thinking on the effect of the exercise on the ISBP figures.

(b) A final report (in draft form by 13 April 2007) with the conclusions for both tasks A and B as follows:

(i) Task A concluding with an assessment of how effective Network Rail's process has been in refining service lives for track assets throughout the network and suggestions of any recommended further work.

(ii) Task B concluding with the estimated service lives for each sub-asset for each sampled route in each track category, and suggested network averages with commentary explaining how the sampled SRS were extrapolated into Network averages, the assumptions made and the tolerances that apply.

*Presentation of Project*

1.4.4 A presentation of the issues contained in the above reports to both ORR and Network Rail.

# 2 Findings for Task A – Audit of Territory based reviews

## 2.1 Background

2.1.1 The desk top review of Network Rail's process and logic regarding their territory-based review of the 300 SRSs was initiated with a meeting with Network Rail's HQ CP4 team lead by the Strategy Engineer (Track).

2.1.2 It was explained that Network Rail are carrying out a Territory based review of the track renewal volumes being generated by the Infrastructure Cost Model (ICM). This review involves two streams of activity as follows to examine each SRS:

(a) To calculate track renewal volumes using GEOGIS (Network Rail's Track Asset register) data and the 'Leiden' service life table with local variations to the table where appropriate (known as 'Leiden Plus')

(b) To carry out a 'bottom up' review to consider the age, track condition and other local characteristics of the routes together with the track asset policy and deterime renewals volumes against both the ICM generated volumes and the 'Leiden or Leiden Plus' generated volumes.

2.1.3 The HQ CP4 team have developed a spreadsheet for the Territories to complete in order to gather a consistent range of information about the local characteristics of different SRS's. The results were then populated onto a master spreadsheet so that locally adjusted volumes for track renewals can be developed and compared to the ICM generated track renewal volumes and the volumes generated by the Leiden process.

2.1.4 As part of the audit process, meetings were convened with the CP4 Territory representatives at Swindon (Western), York (LNE), Glasgow (Scotland), Birmingham (LNW) and London Waterloo (SE). These meetings were to discuss and understand the process used by each Territory and to review the logic used and the information submitted on spreadsheets and sent to HQ. These meetings were also used to discuss arrangements for Task B sample route studies.

2.1.5 Network Rail's process considered the following infrastructure characteristics to review the type of local variation:

(a) Average number of tracks, number of S&C units and route KMs for each SRS

(b) Local variations of component mix (Jointed Track versus CWR) and route specific component characteristics such as percentage of pre-1975 rail, softwood sleepers, pre-1979 concrete sleepers and sleepers with obsolete fastenings.

(c) Historical maintenance issues relating to track geometry and rail failures

(d) Route specific predominance of sharp curvature (% of route)

(e) Special Features such as Tunnels, Weak Embankments, Bridges with Longitudinal Timbers etc.

(f) Electrified lines with Third Rail (DC) or Overhead Line Equipment.

2.1.6 The rail traffic characteristics of each route were also considered as follows:

(a) Equivalent Gross Million Tonnes per annum (EGMTPA), both the maximum value and the average.

(b) The line speed (mph), both the maximum value and the average.

(c) Dominant Track Category

(d) Anticipated traffic growth

2.1.7 Planned volumes of renewal for the remaining part of CP3 (to 2009) for each route were also considered, so that they could be taken out of the equation for CP4. The following component renewals were considered for CP3:

(a) Rail

(b) Sleepers

(c) Ballast

(d) Switches and Crossings (S&C)

2.1.8 For each SRS, the perceived accuracy of the 'Leiden' service life table was then considered in terms of:

(a) Route specific infrastructure characteristics (as described in 2.1.5 above)

(b) Route specific rail traffic characteristics (as described in 2.1.6 above)

(c) Any strategic renewal influences specific to the SRS (such as some accelerated high output renewals)

2.1.9 Because neither service life curves nor the Leiden modelling process on it's own takes fully into account Network Rail's Track Asset Policy or the classification of Route types (Primary. Secondary, LS&E, Rural and Freight), it was necessary to consider track renewal volumes with an element of engineering judgement taking these factors into account.

## 2.2 Findings at the Territory Meetings

2.2.1 Each Territory has an appointed CP4 representative who has been dedicating time and resources to developing this exercise. Each representative has involved their respective Area Track Engineers (ATE's) who have in turn consulted their Track Maintenance Engineers (TME's) to develop the route specific information to populate the spreadsheet for each SRS.

2.2.2 The Territories were asked to consider the Leiden Service Life table and to carry out a sense check on the service lives and their relevance to the actual service life experienced in practice.

2.2.3 Although each Territory was tasked with the same exercise, there was a degree of flexibility allowed for, to develop the logic used to carry out a sense check on the track service lives where necessary. For example on Scotland and LNW Territories they made a conscious decision not to change the Leiden model whereas on LNE, Western and South East some small adjustments were made where applicable. Route specific knowledge was used to justify any variations to service life and this information was gathered and populated on the spreadsheets provided by HQ.

2.2.4 Each Territory also carried out a 'bottom up' review of each SRS against it's anticipated need for renewal in CP4 having taken into account outstanding renewal items planned for the remainder of CP3. This was a review based on track condition and a lookahead based on track service life expectations for the components on each route.

2.2.5 This exercise was necessary as some Territories believed that on some of their routes the Leiden model on it's own was not the most appropriate method of forecasting the replacement of components where traffic volumes where small and component life was long and varied. Scotland Territory particularly believed that some of their rural routes were particular cases where the track could not easily be modelled based on network wide component specific rules.

2.2.6 An important part of the modelling process has been to use and validate GEOGIS. Each Territory was asked about the reliability of GEOGIS at the audit meetings and each Territory gave a different estimate of their confidence in the accuracy of GEOGIS data. This is due to the historical changes in organisation where areas have been restructured and the varying degree of focus in maintaining the records undertaken by the different responsible organisations over the years. The reliability of the data (both age and component type) was estimated as 80% to 100%, but this was mainly based on perception rather than known figures.

2.2.7 Each Territory has developed their 'bottom up' judgemental volumes taking into account some measured clearance of renewal backlog generated by the Leiden model and the age profile from GEOGIS. However, the ICM approach using service life curves, calculates renewal volumes based also on GEOGIS data, but includes a backlog volume which is smoothed over future years. Therefore both the Leiden generated backlog and the ICM approach resulted in two very different ways of applying backlog, and both approaches have been important to inform the Territories, so that a considered conclusion for each route can be developed for CP4.

2.2.8 Regarding Backlog, because GEOGIS cannot be totally relied upon, and the track service life table (or curves) used are not route specific, it is justified that a measure of backlog clearance is considered separately by the Territories for each route. Furthermore, there is the need to consider an allowance for planned renewals that won't be done in CP3 because of the difficulties of getting possession access. However, this assessment of backlog has been more subjective and is based on individual assessments and engineering judgement. Furthermore, these individual assessments of backlog were not based on any clear definitions for determining whether a section of track was in backlog or not.

2.2.9 However, having developed appropriate renewal volumes in the 'bottom up' process for each of their routes, this could then be used as a direct comparator to the ICM and Leiden (or Leiden Plus) generated volumes.

2.2.10 LNW in particular, have taken an extended approach to the whole exercise. As well as gathering the data for CP3 and CP4, they have decided to look ahead at a 60 year life cycle from the start of CP3 and have considered a renewals profile to 2064. This of course relies heavily on the accuracy of age of asset data in GEOGIS being correct, and to this end LNW have validated GEOGIS by checking track assets at local level and using OMNICOM video footage to further check the component types.

2.2.11 The LNW approach has allowed the backlog volumes to be considered against a renewals profile in one complete life cycle which reduces in volume as the percentage of CWR and concrete sleepered track grows as jointed track and softwood sleepers are replaced.

## 2.3 Conclusion of Territory Meetings

2.3.1 Each Territory has applied good logic and a high level of commitment to this process, which has been an exercise involving both fact finding and engineering judgement. The assessment of CP4 renewal volumes was based on the 'bottom up' condition driven requirements for each route and the appropriate application of the track asset policies with a view on the relevance of the track service life table (used in the 'Leiden' and ICM models) to each specific route.

2.3.2 The route specific characteristics were gathered so that HQ could take a network wide view and examine opportunities to use these characteristics to modify the track asset service lives in the ICM model. This would bring the ICM nominal service lives closer in line with those resulting from application of the Track Asset Policies.

2.3.3 The extensive work carried out by LNW supplemented their bottom up exercise with the modelling of track renewal volumes over 12 control periods (60 years). This served as a strategic life cycle check against the local engineer's bottom up review of the condition driven requirements for each route.

## 2.4 Network Rail's Co-ordination of Territory Submissions

2.4.1 Although each Territory completed their reviews as requested, the co-ordination process including pulling the data together for the 300 SRS's was still 'work in progress' at HQ level and not expected in draft form until the end of April 2007.

2.4.2 Part of the HQ co-ordination process involves a peer review of the Territory's 'bottom up' volumes using the network wide Saloon inspections, reviewing Problem Statements and plans for specific renewals proposals. The Saloon inspections enable HQ to get a feel for the main routes, their component mix, ride quality and the opportunity for consultations with 'guest' Track Maintenance Engineers and Track Section Managers as they travel over their respective routes.

2.4.3 Halcrow witnessed this process on Saloon runs over the Scotland and South East Territories (see map in Appendix C). Although a peer review of renewal volumes using the Saloon inspections is limited to what can be seen and felt from a 'driver's perspective' of the track, it was a good opportunity to check the Territory assumptions with the respective Track Engineers and Managers at Section, Depot, Area and Territory levels.

2.4.4 The Saloon Inspection peer review process is not absolute as the coach only covers a selection of routes, however it does cover enough to get a representative sample of all route classifications and track categories. Having received the Territories 'bottom up' data, HQ then plan to use a Saloon run on each Territory to confirm their view on the volumes submitted..This is on-going and will add to, but not prevent the peer review process from being completed.within the timescale they have allowed.

2.4.5 On 5th April 2007, a meeting was convened with ORR, Network Rail and Halcrow as a meeting for Network Rail to report progress on the Territory based 'bottom up' review process and for Halcrow to provide some feedback following their Task 'A' Territory visits and Task 'B' Track Inspections.

2.4.6 Network Rail presented summary information for the 300 SRS's which compared ICM volumes, Leiden volumes and Territory 'bottom up' volumes. This analysis revealed that there were some inconsistencies between Territories in the 'bottom up' volumes which required a further review.

2.4.7 Furthermore the volumes considered thus far have been based on both modelling in ICM and using the Leiden Plus process which considers component service lives individually as composite volumes and not together as 'total track' volumes. The Territory 'bottom up' exercise has been based on composite volumes, whereas the track renewal programme for each year is based on 'total track' volumes, except where a case exists for reballasting, resleepering or rerailing only. Therefore, where the ICM or Leiden model for a particular SRS will give rail renewal at 30 years, sleeper renewal at 35 years and ballast renewal at 25 years, in a renewal programme this track will most likely be renewed as a total track renewal at, say, 25 years. Therefore the full service lives of the rail and sleepers has not been realised. To allow for this the modelled Leiden volumes should be adjusted upwards. This was demonstrated by Network Rail when they presented a chart showing CP4 renewal volumes with 'maximum coherence' at SRS level.

2.4.8 Therefore, the business engineering decision taken each year on the renewal of 'total track' rather than individual components of the track system, will build in some marginally early renewal of individual components when compared to the modelled composite volumes. However, this is balanced out in practice by an individual component service life being exceeded because it has legitimately out-lived it's expected average service life.

2.4.9 Network Rail has considered ways of presenting the track renewal volumes as a mix of total track volumes and composite volumes. The coherence process is still very much 'work in progress' and is being used to further validate the 'bottom up' volumes.

## 2.5 Conclusion of Territory based reviews

2.5.1 In summary this has been an exercise to compare the ICM generated volumes of track renewal with those generated using the Leiden service life tables. This comparison has been used to produce further volumes for each SRS based on the local characteristics and condition driven need for each route determined by the Territory and Area Engineers.

2.5.2 In producing three sets of volumes, the backlog (defined as theoretical life expired components) is dealt with in three different ways. ICM calculates the backlog by using track service life based on established service life curves and spreads it in a way that attempts to make the overall volumes of renewal distributed more evenly over the CP3 and CP4. The Leiden Plus process keeps the calculated theoretical backlog separate which enables an informed view to be taken when the Territories produced there 'bottom up' analysis.

2.5.3 The conclusion of this is that Network Rail are able to make an informed engineering judgement on what is the most appropriate way of dealing with theoretical backlog. This is wholly appropriate as there is a need to consider theoretical backlog against what is real backlog given that the track service life approaches (both ICM and Leiden) cannot take into account the true life expectancy variations on every SRS.

2.5.4 The Scotland Territory findings in particular demonstrate that there are significant variations within some track categories that influence track service life. Therefore without a more sophisticated modelling technique than what is currently being achieved within ICM, there is a need to review and adjust the volumes outside of ICM and so that theoretical backlog can be assessed and validated using engineering judgement.

2.5.5 The Territory based reviews have been necessary to sense check both the modelled service lives being considered and the way in which theoretical backlog is dealt with in CP4. The approach by the Territories and the CP4 teams so far, as witnessed, has been logical and with a high level of commitment. Furthermore, Halcrow have been able to develop a high degree of confidence in Network Rail's process from the meetings, Saloon inspections and Track inspections.

2.5.6 However, the process is still incomplete and relies on further validation by HQ of the Territory volumes, further development of how the final renewal volumes are arrived at by refinement of the ICM and a demonstration that any real and not just modelled backlog of renewal has been dealt with in an appropriate way for CP4.

# 3 Task B – Sample Route Studies

## 3.1 Background

3.1.1 As stated in the introduction, Task B involved a detailed study of a sample of SRSs to provide an independent assessment of typical service lives on particular route types. This was based on a detailed study of a representative sample of strategic route sections across a range of different track categories.

3.1.2 The logic used to select the locations where samples were to be inspected is shown in Appendix B. The aim was, having taken sufficient samples within each chosen track category, parallels can then be drawn to make informed conclusions about commonality across the route classifications where possible.

3.1.3 A cross-section of Strategic Route Sections (SRS's) across the network was chosen that gave an even distribution of locations in Track Categories 1 to 5 within each Route Classification (Primary, Secondary, London South East, Rural and Freight). There were 30 No. SRS's chosen on the basis that using two mandays per Territory i.e. 10 mandays, and that three SRS's could be covered on each day of inspections.

3.1.4 Further to this, Network Rail informed Halcrow that they wish to rationalise the Route Classifications to split London South East into LSE (Key) and LSE (Other) and to integrate LSE (Key) into Primary routes and LSE (Other) into Secondary routes.

3.1.5 The following is the summarised list of sites sampled:

*Primary & LSE (Key) Routes*

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Holgate | Up | LNE | 2 |
| Crewe Coal Yard | Up | LNW | 1 |
| Madeley | Down Slow | LNW | 2 |
| Wedgwood | Up | LNW | 2 |
| Ipswich | Up | SEA | 2 |
| Milford | Up | SEA | 2 |
| Great Bedwyn | Up | WES | 1 |
| Lawrence Hill | Up | WES | 3 |
| Pilning | Up | WES | 2 |

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Holgate | Down | LNE | 2 |
| Crewe Coal Yard | Up Slow | LNW | 3 |
| | | | |
| Wedgwood | Down | LNW | 2 |
| Ipswich | Down | SEA | 2 |
| Milford | Down | SEA | 2 |
| Great Bedwyn | Down | WES | 1 |
| Lawrence Hill | Down | WES | 3 |
| Pilning | Down | WES | 2 |

## *Secondary & LSE (Other) Routes*

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Radford | Up | LNE | 3 |
| Thurgurton | Up | LNE | 4 |
| Worksop | Up | LNE | 2 |
| Atherton | Up | LNW | 4 |
| Allanfearn | Single | SCO | 4 |
| Bogside | Up | SCO | 2 |
| Cardross | Up | SCO | 3 |
| Craddlehall | Up | SCO | 3 |
| Ewell West | Up | SEA | 3 |
| Farnham | Up | SEA | 3 |
| Kirby Cross (LSE) | Single | SEA | 4 |
| Carmarthan | Down | WES | 4 |
| Fairwater | Up | WES | 5 |

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Radford | Down | LNE | 3 |
| Thurgurton | Down | LNE | 4 |
| Worksop | Down | LNE | 2 |
| Atherton | Down | LNW | 4 |
| | | | |
| Bogside | Down | SCO | 2 |
| Cardross | Down | SCO | 3 |
| Craddlehall | Down | SCO | 3 |
| Ewell West | Down | SEA | 3 |
| Farnham | Down | SEA | 3 |
| Thorpe Le Soken | Down | SEA | 4 |
| Carmarthan | Down | WES | 4 |
| Fairwater | Down | WES | 5 |

## *Rural Routes*

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Bingham | Up | LNE | 4 |
| Bottesbud | Up | LNE | 4 |
| Saxondale | Up | LNE | 4 |
| Burscough Bridge | Up | LNW | 5 |
| Achanalt | Single | SCO | 5 |
| Strathcarron | Single | SCO | 5 |
| Kilkerran | Single | SCO | 5 |

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Bingham | Down | LNE | 4 |
| Bottesbud | Down | LNE | 4 |
| Saxondale | Down | LNE | 4 |
| Burscough Bridge | Down | LNW | 5 |
| Clunes | Single | SCO | 4 |
| | | | |
| Beccles | Single | SEA | 5 |

## *Freight Routes*

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Crynant | Single | WES | 5 |
| Leverton | Down | LNE | 5 |

| Location | Line | Territory | Track Category |
|---|---|---|---|
| Crynant | Single | WES | 5 |
| | | | |

3.1.6 As stated above, Halcrow selected the 30 SRS's which were then given to the Territories to pick sites for inspection. Because sections of track proposed for renewal offer the best opportunity to get a snapshot of the track components nearing the end of their service lives, selected Renewal Proposal sites were chosen by the Territories for each SRS. It was also decided that adjacent sections of track which weren't proposed for renewal could also be easily visited and assessed to increase the sample volume. The added benefit of this would be that newer track forms could also be included in the study.

3.1.7 There were 66 No. sites visited (58 No. Plain Line and 8 No. S&C). It was later agreed that because the S&C sites were few and covered a wide range of Track Categories and Route Classifications that this wouldn't be a big enough sample to draw any conclusions. Therefore, the S&C sites have been excluded from the study and are not shown in the above listings.

## 3.2 Findings on the Site Inspections

3.2.1 Regarding the track characteristics at each site, as well as a wide range of speeds, tonnages and locations, there was a wide variety of track component types sampled. The following are examples of this:

*Rail*

Flat Bottom Jointed, Flat Bottom CWR, Bullhead Jointed and Bullhead CWR

*Fastenings*

Flat Bottom: Pandrol (Both Lock Spikes and Screws on Wood sleepers), Heyback Clips, Mills Clips, BJB Clips, SHC Clips, Elastic Spikes, Macbeth Spikes and AD Clips
Bullhead: Panlock Keys, Wood Keys and Steel Spring Keys

*Sleepers*

Flat Bottom: Concrete, Hardwood, Softwood and Steel
Bullhead: Concrete, Hardwood and Softwood

3.2.2 As previously stated, a primary driver of service life variations is the impact of vehicle speeds, aggregate tonnages, axle loads, vehicle/wheel maintenance and bogie stiffness. The variety of traffic vehicle types and their respective characteristics which have an impact on the track components is covered by a wide spectrum of vehicles. Therefore some of this impact was witnessed first hand at various sites and each route had its own traffic profile which was described by the Network Rail Engineers based on their local knowledge. This gave Halcrow a feel for some of the relevant issues relating to the traffic profile on the routes visited.

3.2.3 The pre-privitisation built passenger rolling stock such as the Sprinter Class 150, 156 and 158's are generally track friendly. However, the post-1997 built passenger rolling stock such as the Class 170 (used on the Rural Lines) is less track friendly due to the bogie stiffness particularly on curved track. As far as Freight locos are concerned, the Class 67 Locos have been generating high P2 wheel profile forces which have been causing a higher degree of track damage.

3.2.4 Another primary driver of service life variation is the environment which surrounds the track system. Halcrow witnessed a broad range of geological and topographical characteristics which had an impact on natural drainage conditions and sub-grade stiffness both of which determined the quality of the track levels and alignment and the potential for bottom-up ballast congestion (due to formation failure).

3.2.5 Also noted was how lineside vegetation and tree cover can heavily influence rates of deterioration particularly with wood sleepered track. In fact there was a noticeable variation in track condition depending on how much the track was exposed to natural light and ventilation. For example, there were some large variances on similar routes, between track which was out in the open and exposed compared to track which stayed continually in the shade and rarely dried out. In poor damp conditions such as this, ballast becomes quickly congested (top-down) and rail and fastenings can corrode quickly.

3.2.6 The impact of maintenance on track service life was also varied and there was a range of care and attention evident that was not always appropriate to the Track Category (or Route Classification). Other maintenance issues observed were where rail pads were past their serviceable life and were starting to have an impact on shortening the life of rails, sleepers and ballast. Track Drainage was another issue where examples of lack of maintenance were contributing to the shortening of rail, ballast and sleeper life. These were two maintenance issues that appeared to be a widespread problem when we discussed this with Network Rail based on our observations. Although other examples of maintenance neglect were observed, they were on a small and manageable scale and none were issues affecting safety of the line.

3.2.7 However, there were also many examples of good maintenance having a very positive impact on track service life. Where joints have been consistently maintained and sleepers spot replaced, there were many sections of Bullhead Jointed track for example exceeding their service life greatly. On some Territories, the extensive use of Stoneblower had been used on track that was not responding to tamping with some very positive results.

3.2.8 There are also well known problems with the range of fastenings experimented with between the mid fifties and mid seventies. Rail creep problems associated with these fastenings which have a poor ‘toe hold’ are particularly challenging and the AD and BJB fastenings which have lost their ‘toe hold’ are in need of constant care and attention. Halcrow witnessed many sites where there was evidence of the local Track Section Manager having the challenge of managing these difficult sites and achieving successes by extending the service life and avoiding early renewal.

3.2.9 There was also an issue related to the service life of wood sleepers. For each site, one of the objectives was to determine the age of the components on the ground and confirm this with the age recorded in GEOGIS. The actual age could then be compared with the Track Service Life (Leiden) Table used by Network Rail for the respective track category.

3.2.10 However, for wood sleeper sites recorded in GEOGIS, the age would often be determined by the ballast age or the age stamped on the chair or baseplate fixed to it. As Softwood Sleepers in particular have a shorter lifespan than the rail and ballast, they are regularly spot replaced until complete renewal of rail, sleepers and ballast takes place. Therefore this will lower the average age profile of a section of wood sleepers so that it can continue to co-exist with the rail, chairs and ballast. Therefore using the GEOGIS age for wood sleepers for comparison against the service life table gives a false picture if much of the sleepers have been spot replaced.

3.2.11 In terms of the factors described above that influence longevity of track service life, Halcrow found that there is a stark difference in the Rural Track Category 5 track in the Scotland Territory between the Kyle of Lochalsh and Far North lines and other Rural Track Category 5 lines sampled.

3.2.12 This contrast makes the Kyle of Lochalsh and Far North lines stand out from other examples of routes inspected within this category. When you have all the right environmental conditions, exceptionally light traffic volumes and light axle loads, a dedicated, skilled and experienced maintenance workforce, easy track access and adequate possession time combined with a suitable supply of sleepers and rail for spot replacement, the service life can be extended far beyond that on the regular Rural Cat.5 lines.

3.2.13 Furthermore, these lines are predominately Bullhead jointed track systems from one end to the other. In these circumstances, this is an optimum light rail track system that lends itself to spot replacement and is resilient and forgiving enough to easily withstand the horizontal and vertical forces as applied on these routes. Provided that traffic conditions remain unchanged (i.e. without heavier and less track friendly vehicles), the Bullhead Jointed track system can exist as a perfectly satisfactory component system on lines such as these.

3.2.14 As this is an exceptional case, and at the request of the Office of Rail Regulator, it is dealt with in greater detail in a dedicated section in Item No.4.

## 3.3 Analysis of the sample route studies

3.3.1 For each of the 58 Plain Line sites, the current Rail, Sleeper and Ballast life has been considered. This has been compared to the Track Service Life (Leiden) Table to determine how it compares in terms of whether it has outlived the table or fallen short.

3.3.2 A further assessment has been made by Halcrow to determine the expended life and make a judgement of the remaining life if any. This further assessment is then compared to the Leiden table and expressed in terms of a Percentage. For example, a component type assessed at 100% is an endorsement of the Leiden service life table, whereas a 90% suggests that Leiden might be too high for that component in that location.

3.3.3 Having considered the summary of these results, it was decided to remove 8 No. sites which were distorting the figures to give some clarity to the findings.

3.3.4 Firstly the 3 No. sites on the Kyle of Lochalsh lines have been removed for the reasons given above. These will be analysed separately and compared to the main results.

3.3.5 Secondly, 5 further sites were removed from the analysis for various reasons due to exceptional circumstances. The 5 sites are shown as follows:

(a) Crewe Coal Yard (Up Fast): Rail life had been extended by spot re-railing in a number of places thus making the original rail appear to have a longer life than it was able to be serviceable for.

(b) Carmathan (Down): There was uncertainty of the expended rail life as rail markings said 1953 but it was strongly suggested that the rail had been cascaded and/or laid dormant out of service for a number of years before installation.

(c) Thurgurton (Up Line): Had severe formation problems which had significantly reduced ballast life.

(d) Great Bedwyn (Down Line): Appeared to have had a mid life ballast clean at some point therefore ballast life was difficult to determine.

(e) Bottesford (Down): Sleeper life was judged to have been life expired many years ago but had been kept going through spot resleepering.

This leaves 50 sites in the main analysis.

3.3.6 The following summarises Halcrow's findings based on a service life prediction for each site compared to the Leiden table.

*Average Service Life Predictions*

| Average (%) | | | |
|---|---|---|---|
| | **Rail** | **Sleepers** | **Ballast** |
| **Primary** | 104 | 107 | 104 |
| **Secondary** | 114 | 107 | 106 |
| **Rural** | 118 | 124 | 105 |
| **Freight** | 116 | 126 | 99 |

*Maximum Service Life Predictions*

| Maximum (%) | | | |
|---|---|---|---|
| | **Rail** | **Sleepers** | **Ballast** |
| **Primary** | 119 | 143 | 140 |
| **Secondary** | 157 | 153 | 136 |
| **Rural** | 133 | 163 | 120 |
| **Freight** | 128 | 168 | 112 |

*Minimum Service Life Predictions*

| Minimum (%) | | | |
|---|---|---|---|
| | **Rail** | **Sleepers** | **Ballast** |
| **Primary** | 88 | 89 | 56 |
| **Secondary** | 82 | 69 | 76 |
| **Rural** | 100 | 100 | 90 |
| **Freight** | 96 | 93 | 92 |

*Range of Service Life Predictions*

| Range (%) | | | |
|---|---|---|---|
| | **Rail** | **Sleepers** | **Ballast** |
| **Primary** | 31 | 54 | 84 |
| **Secondary** | 75 | 84 | 60 |
| **Rural** | 33 | 63 | 30 |
| **Freight** | 32 | 75 | 20 |

3.3.7 The conclusions from this can be sub-divided as follows:

*Rail*

3.3.8 On the Primary routes Halcrow have found a close correlation with the Leiden table. The range is small which also suggests that the accuracy of the sample is representative. However, there is a 14 to 16 per cent increase on the Secondary, Rural and Freight routes and a particularly large range on the Secondary routes.

*Sleepers*

3.3.9 On the Primary and Secondary routes, Halcrow have found a close correlation with the Leiden table. However, the range for the Secondary routes is again very large due to the wide range of sleeper types (and fastenings) on these routes. The Rural and Freight lines however cannot be relied upon because of the softwood sleeper issue described in 3.2.8 and 3.2.9 above.

*Ballast*

3.3.10 For all route classifications, Halcrow found a close correlation with the Leiden table. The large range found on the Primary routes reflects the wide rate of deterioration due to variances in environmental conditions as described in 3.2.3. and 3.2.4. above. These conditions are not specific to the route classification but because of the high priority of Primary Routes will result in sites where early renewal of ballast is required.

## 3.4 Other Observations

*Opportunities for extending service life*

3.4.1 A re-occurring theme was a disconnect between Engineering and Maintenance with respect to sections of track proposed for renewal receiving levels of component upgrade or enhancement without involving the Territory Track Renewals Engineer. The consequence of this is that renewal proposals which are well advanced in the planning stage were occasionally receiving an upgrade or enhancement that would legitimately extend the life expectancy, particularly if the correct specification was applied.

3.4.2 However, because there is not a network wide process which allows component upgrade or enhancement work to be proposed and funded according to an Engineering led general specification, the opportunity to extend life in a structured way against the cost benefit of a delayed renewal cannot be easily achieved.

### *Maintenance practice observed*

3.4.3 The challenges for Maintenance are many. Good industry maintenance practice tailored to meet the needs of the route, balanced against a renewals strategy and life extension strategy are essential to achieve longevity of the components. The challenge of doing this is magnified on routes where the constraints are greater due to limited access opportunities, limited funds and scarce resources.

3.4.4 There were examples of this witnessed at both ends of the spectrum. On some Primary and Secondary routes where access was limited, the quality of the rail, sleepers and ballast was affected more by dipped SMW welds, broken fastenings and worn rail pads. Whereas on some Rural and Freight only lines where access was less of a problem, dipped joints and poor drainage were witnessed in places because the resources were regularly re-directed onto other lines with a 'higher profile'.

### *Renewals backlog*

3.4.5 The Office of Rail Regulator have asked Halcrow to consider whether there is a real renewals backlog or not having had the benefit of seeing renewal proposal sites at close quarters.

3.4.6 Before this can be addressed there are 3 points to consider regarding the selection of track for renewal. In paragraph 2.4.7 the difference between modelled composite track renewal volumes was compared to total track renewal volumes. Here total track renewal volumes are considered further as follows:

(a) Total renewal (i.e. renewal of rail, sleepers and ballast) is an approach to ensure that component design is systematically upgraded and is considered to be the most cost effective approach taken over the life cycle to renew the track asset for some routes. Network Rail wish to take a route by route approach to whether total renewal is appropriate or not.

(b) Given that total renewal is a strategy for renewal of the track asset, it is always likely that where this is applied, inevitably some individual components will be renewed early when rails, sleepers and ballast are renewed together.

(c) A theoretical renewals backlog will arise if the age of the sub-component type exceeds the selected track service life before it is renewed. As the service life determines this, then the track service life table used will determine the theoretical backlog. As the Track Service Life tables/curves are an average for the network there will be inconsistencies unless a route specific service life table is used.

3.4.7 To consider whether a section of track is in backlog or not, we need a definition of what constitutes a total renewal backlog site. For Halcrow to give a view on real backlog, a definition must be found. There has been no clear definition stated thus far which has been agreed between Network Rail and ORR. Therefore the following is a suggestion based on Halcrow's findings.

3.4.8 For Primary, Secondary and Rural Routes:

A section of track is considered a renewals backlog item, if the rail, sleepers and/or ballast have exceeded their service life, and;

(a) The condition is such that some form of mitigation is, or will be necessary (speed restriction, temporary non-compliance, tie bars fitted etc.) within 18 months., or

(b) The fastenings system between the rail and sleeper is of an obsolete type and is subject to high levels of maintenance activity in order to prevent a condition of track speed restriction being imposed.

3.4.9 For Freight Routes:

A section of track is considered a renewals backlog item if the rail, sleepers and/or ballast have exceeded their service life, and;

The condition is such that some form of mitigation is, or will be necessary (speed restriction, temporary non-compliance, tie bars fitted etc.) within 18 months, and

Network Rail's strategy for the particular Freight Route is to apply composite renewal of the track asset as the means to maintain the condition and age profile of the track generally.

3.4.10 Using the above as a definition, backlog sites were witnessed on Primary, Secondary and Rural routes where the service life had been exceeded and the track system had obsolete fastenings. However, very few sites were witnessed where track service life had been exceeded and poor track condition could not be dealt with by maintenance, except on the obsolete fastening sites.

3.4.11 On Freight routes, backlog sites were witnessed where the service life had been exceeded and poor track condition was not being successfully dealt with.

3.4.12 This was our conclusion using the current track service life tables. However, our sampling gave us the view that for Rail and Sleepers particularly on Secondary, Rural and Freight lines, had a longer average service life than the Leiden Service Life Tables showed. Therefore in Halcrow's view, although a real backlog exists, it much smaller than the Leiden generated backlog suggests.

## 3.5 Conclusions of the sample route studies

3.5.1 For the sites sampled on the Primary Routes, the average service life found was very close to the Leiden Service Life table. There were examples of early renewal justifiably being proposed particularly where the ballast had become congested. For the rail and sleepers, the range of service lives found was very small on the Primary routes compared to other routes.

3.5.2 For the sites sampled on the Secondary Routes, the average service life found for sleepers and ballast was close to the Leiden Service Life table. However, for rail there were examples found were the rail could last a lot longer on these routes. The range for sleepers was also very large because of the variation of sleeper types and fastening types sampled.

3.5.3 For the sites sampled on the Rural and Freight Routes, the average service life found for ballast was close to the Leiden Service Life table. However, the average rail life found was as much as 16% to 18% longer even with the Kyle Line and Far North removed from the calculation. The sleeper life was heavily influenced by the age taken from the markings on the chairs and baseplates. Because there had been a large volume of spot resleepering which lowered the age profile of the sleepers, the percentages calculated for the sleepers are unreliable, as it suggests that the Leiden Service Life value for Softwood sleepers could be potentially increased by over 20%, which is a false conclusion to draw.

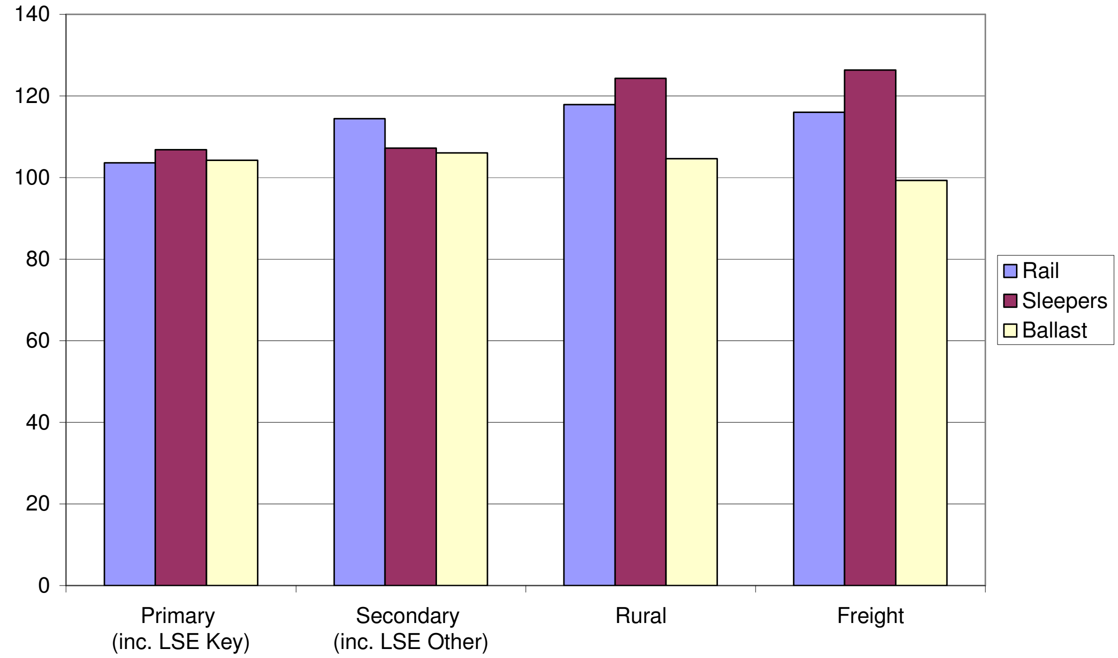



*Table 3: Showing the Average Service Life of the Sampled Sites*

3.5.4 For the Kyle Line and Far North lines the three sites sampled are summarised as follows:

| Location | Rail | Sleeper | Ballast |
|---|---|---|---|
| Achanalt | 128 | 100 | 128 |
| Clunes | 136 | 100 | 123 |
| Strathcarron | 130 | 100 | 130 |
| | | | |
| Average | 131 | 100 | 127 |
| Maximum | 136 | 100 | 130 |
| Minimum | 128 | 100 | 123 |
| Range | 8 | 0 | 7 |

3.5.5 The average rail life sampled was 31% longer than the Leiden service life table and the ballast 27% longer life. The sleeper life was kept at 100% of it's life by perpetual spot replacement of the sleepers. In other words the sleepers with expended life would be balanced by those that had been replaced in between. Therefore provided that this process of sleeper replacement continued the average service life of the sleepers would be kept at 100% and not become life expired.

3.5.6 Halcrow did not witness any other lines with track age and characteristics such as the Kyle Line and Far North lines but were informed of other lines on the network that may have similarities. The East Suffolk line and Cumbrian Coast line were other lines with similarities.

# 4 Scotland Territory sample route studies

## 4.1 Background

4.1.1 As stated above, a dedicated assessment is given of the findings from the Scotland Territory route studies sampled.

4.1.2 As well as the sample route studies at the locations previously mentioned, a Network Rail Inspection Saloon ride in Scotland was also used by Halcrow (see map in Appendix C) to get an overview of the following routes:

(a) Glasgow (Springburn) to Stirling

(b) Stirling to Perth

(c) Perth to Inverness

(d) Inverness to Kyle of Lochalsh

(e) Inverness to Aberdeen

(f) Aberdeen to Dundee

4.1.3 The two days of sample track inspections were spent with one day on the Glasgow electric suburban lines and one day in the Inverness area.

4.1.4 The objective of the inspections was to consider the age profile of the track components observed and to consider the expended life and life expectancy of the components and the reasons why asset life is either shorter or longer than that shown in Network Rail's 'Leiden' service life table.

4.1.5 Where sufficient samples can be taken within each chosen track category, parallels can be drawn to make informed conclusions about commonality across the route classifications (Primary, Secondary, Rural and Freight) where possible.

4.1.6 To this end, samples were chosen to give a broad range of sampling across the route classifications for Track Categories 1 to 5 (where applicable).

4.1.7 For the Scotland sampling, the following routes/locations were chosen:

| Route Location | Sample Location | Line | Component Type | Track Cat. | Route Class. |
|---|---|---|---|---|---|
| Far North plus Kyle Line | Clunes | Single | Bullhead Jtd (Softwood) | 4 | Rural |
| | Achanalt | Single | Bullhead Jtd (Softwood) | 5 | |
| | Strathcarron | Single | Bullhead Jtd (Softwood) | 5 | |
| Perth - Inverness | Craddlehall | Up | Bullhead Jtd (Softwood) | 3 | Secondary |
| | Craddlehall | Down | FB CWR Concrete | 3 | |
| Aberdeen - Inverness | Allanfearn | Single | Bullhead Jtd (Softwood) | 4 | |
| Ayr lines, Wemyss Bay and Gourock | Bogside | Up | FB CWR Concrete | 2 | |
| | Bogside | Down | FB CWR Concrete | 2 | |
| Glasgow North electric routes | Cardross | Up | FB CWR Concrete | 3 | |
| | Cardross | Down | FB CWR Concrete | 3 | |
| Stranraer - Ayr | Kilkerran | Single | FB Jointed Softwood | 5 | Rural |

## 4.2 Observations

4.2.1 The sampled track sections enabled Halcrow to see the evidence of Network Rail's Track Asset Policy on route strategy for track renewals put into practice. Most of the sites chosen were proposals for renewal in either CP3 or CP4 and during discussions with the Territory Track and Renewals Engineers the strategy for each of the routes visited was explained.

4.2.2 Additionally, the Saloon ride described in 3.1.3 above also provided Halcrow with an overview for each route travelled which revealed the predominance of CWR track over Jointed Track (or vica versa), the various route strategies for component specifications, areas of obsolete components, and the level of maintenance & recent renewals (particularly ride quality).

4.2.3 The Far North and Kyle Lines are both predominately Bullhead Jointed track lines. In fact the Kyle Line as seen from the Saloon was approx. 64 route miles of continuous Bullhead Jointed track from one end to the other. These lines have been dealt with by 'component specific renewal' over many years making use of bullhead rail cascaded from other routes and sleepers spot renewed as and when required. The ballast is generally well drained and not prone to either top down or bottom up congestion as there is very little Freight (no spillage) and mostly founded on a Rock sub-base that is free draining and not prone to pumping or formation failure. The track geometry has been maintained to a good standard and the joints have not been allowed to cripple over the years because of the light traffic and the appropriate level of maintenance.

4.2.4 The Far North and Kyle Line also benefits from a maintenance regime that includes a dedicated workforce which results in a high level of care and attention. It also has an RETB Electronic Token Block system which allows for easy track access and a train service that allows the line to be blocked up to 12 hours every night without disrupting the normal passenger service.

4.2.5 These features make Far North and Kyle Line, particularly the Cat.5 tracks, an interesting and perhaps exceptional case when compared with many other Rural lines on the network. Furthermore, these lines have all the characteristics which contribute to component life longevity.

4.2.6 In contrast, the Ayr to Stranraer line sample, also on a Rural line (Cat.5), was more typical of Rural lines elsewhere on the network. It has a mix of Jointed track types (both Flat Bottom and Bullhead) with a proportion of CWR. This profile of track components and the level of traffic means that the life expectation is much more in line with the Leiden service life table and the strategy includes a deliberate policy to gradually replace jointed track with CWR (unlike the Cat. 5 lines in Far North and Kyle).

4.2.7 The remaining samples were all taken on Secondary lines. It was interesting to observe the broad range within the traffic profile on these lines i.e. Track Categories 2, 3 and 4, and compare this to the Track Construction Standard specification which separates Track Categories 3, 4 and 5 from Cat.2. This creates a two tier strategy for component specification within Secondary lines which can result in specifications for CEN60 Concrete sleepered CWR on Cat 2 lines and CEN56 (113A) Steel Sleepered CWR on Cats. 3 and 4. This variance in specification is wholly appropriate for the respective track categories but appears to be another example where it is not easy to simplify the route strategy without sub-dividing the route classifications.

## 4.3 Findings

4.3.1 In the Inverness area in particular the examples were showing much longer life spans for rail and ballast (compared to the Leiden service lives). Many sections of Bullhead Jointed track laid in the 1930's and 1940's have been kept going beyond their life expectancy by the component specific renewal of sleepers and an appropriate level of maintenance.

4.3.2 At Achanalt on the Kyle line a section of 1924 85lb Bullhead track was sampled and the rail life was still not approaching it's head loss wear limit. This was the exception rather than the rule but demonstrates how slowly the wear rate develops on this line if the appropriate level of maintenance can be applied and the traffic remains light. Also, in this scenario, it is unlikely that there will be other faults (other than rail wear) driving early renewal of the rail. This is not typical when compared to other Rural routes.

4.3.3 On most sites, GEOGIS showed the sleeper age to be the same as the rail age. However it was noted that many sleepers had been replaced and probably been completely renewed by spot resleepering over the years since the original rail was installed.

4.3.4 The rail wear records were available for scrutiny on each site and this made the assessment of expended life a mixture of calculated logic and engineering judgement. However as expected for rail of this age, the knowledge of the historical usage of the rail was limited and it is likely that the rail in many places had been cascaded from higher category lines at some point in the past. Nevertheless, from this an assessment of the remaining life of the components was estimated.

4.3.5 The following tables summarise the results of these findings for the Inverness area:

**Secondary Routes:**

The Leiden Table service lives are shown in brackets.

| **Adjusted life expectancy following assessment (years)** | | | | | |
|---|---|---|---|---|---|
| Cat | CWR | Jointed Rail | Concrete Sleepers | Softwood Sleepers | Ballast |
| 3 | 60 (45) | 61 (40) | 60 (45) | 35 (35) | 61 (45) |
| 4 | | 64 (45) | | 40 (40) | 64 (50) |

| **Percentage Change to Leiden Table** | | | | | |
|---|---|---|---|---|---|
| Cat | CWR | Jointed Rail | Concrete Sleepers | Softwood Sleepers | Ballast |
| 3 | 133% | 153% | 133% | 100% | 135% |
| 4 | | 143% | | 100% | 128% |

**Rural Routes:**

| **Adjusted life expectancy following assessment (years)** | | | | | |
|---|---|---|---|---|---|
| Cat | CWR | Jointed Rail | Concrete Sleepers | Softwood Sleepers | Ballast |
| 4 | | 61 (45) | | 40 (40) | 61 (50) |
| 5 | | 77 (60) | | 40 (40) | 77 (60) |

| **Percentage Change to Leiden Table** | | | | | |
|---|---|---|---|---|---|
| Cat | CWR | Jointed Rail | Concrete Sleepers | Softwood Sleepers | Ballast |
| 4 | | 136% | | 100% | 123% |
| 5 | | 129% | | 100% | 129% |

4.3.6 As can be seen from the above tables, rail and ballast life expectancy is much higher than the Leiden service life tables for these samples. It is also worth noting that the Flat Bottom CWR concrete sleepered track is also expected to last much longer on the Cat. 3 secondary route sample.

## 4.4 Conclusions of the Scotland Territory Review

4.4.1 As stated previously, Far North and Kyle Lines are possibly an unusual case when compared with many other Rural lines on the network and has the characteristics which contribute to component life longevity.

4.4.2 Particularly on lightly used rural lines, well maintained Bullhead Jointed track has a high life expectancy and can exceed the Leiden service life greatly provided that component specific renewal keeps the average age profile of sleepers down to co-exist with the service life of the rail and ballast.

4.4.3 Conversely, on most other lines, Jointed Bullhead track can often be in discrete sections within a predominately CWR railway and subject to moderate to high tonnages and speeds. In this scenario it is appropriate to have a strategy to replace it with CWR. However, as a predominate light rail track system in an area with skilled and dedicated resources geared up to maintain it, there is a strong case for perpetuating this component type and keeping the bullhead jointed track system unless there is a business case to change it.

4.4.4 The Bullhead track system is a proven system on well maintained light rail rural routes such as those found in Scotland and therefore perpetuating the Bullhead track component system is wholly appropriate as part of a low cost maintenance and renewal strategy. Provided that traffic conditions remain unchanged (i.e. without heavier and less track friendly vehicles), the Bullhead Jointed track system can exist as a perfectly satisfactory component system on lines such as these.

4.4.5 The consequence of component specific renewal is that the age profile is not easily captured on GEOGIS particularly where sleeper age can vary greatly from one sleeper to the next. Therefore a service life model, which uses GEOGIS for age of road data cannot be relied upon for sleeper age on a line maintained by component specific renewal.

4.4.6 Furthermore, if the sleeper age is recorded in GEOGIS as the same as the rail age, then a false theoretical backlog of sleeper renewal volumes will be generated.

4.4.7 For the Far North and Kyle lines, theoretical renewal backlog volumes generated by ICM will need to be reviewed otherwise inappropriate service lives will skew the output and distort the volumes for CP4. This will be further distorted by the inaccurate age profile of the sleepers captured on GEOGIS. Network Rail are of course aware of the need to deal with these issues within their bottom up review of all 300 plus SRS's and are already being addressed in ICM version 2.

4.4.8 The ICM figures for Far North and Kyle are showing twice as much rail and ballast renewal for CP4 is required as compared to Network Rail's bottom up exercise. This is due to the large theoretical backlog being created within the model. Network Rail's 'bottom up' exercise takes into account a volume of backlog based on the Territory's own assessment of real backlog. Therefore for this SRS at least there will be a significant and valid adjustment to the ICM volumes.

4.4.9 Provided Network Rail can find a way to deal with all the routes with similar characteristics such as this without loosing sight of the need for low cost 'component specific renewal' (such as patch resleepering and spot re-railing) to keep the age profile down, their review will successfully deal with this concern and prevent a theoretical backlog from turning into a real backlog of component renewal.

# 5 Recommendations

## 5.1 Task A

5.1.1 That ORR notes that this report is currently based on Network rail's current position which is still inconclusive in it's review of the final figures for CP4 track renewals.

5.1.2 That ORR accept the work of the Head of Track Engineering and his Territory Engineers as thorough and professional in developing new track asset service lives and renewals volumes in preparation for Network rail's CP4 submission subject to the following further work.

5.1.3 Halcrow recommends that CP4 track renewal volumes (including an allowance for backlog) are considered for each Route Classification and that a further review is carried out to consider splitting both Secondary and Rural routes to reflect the variances within each of these route classifications.

5.1.4 Halcrow recommends that the measured clearance of backlog built into the 'bottom up' volumes produced by the Territories for CP4, is reviewed to check that there is no over-estimation in their assumed backlog volumes.

## 5.2 Task B

5.2.1 That ORR accepts the findings from Halcrow's field work in that it generally reinforces the view taken in task A that the Head of Track Engineering and his Territory Engineers' are thorough and professional in developing new track asset service lives and renewals volumes in preparation for Network rail's CP4 submission.

5.2.2 That ORR consider further work to review Network Rail's predicted track asset service lives for Switches and Crossings.

# 6 Appendices

## Appendix A: Meeting schedule

| Date | Venue | Attendees |
|---|---|---|
| 17/01/07 | ORR Office, One Kemble St., Holborn – First Meeting | • Andrew Wallace, ORR<br>• Mervyn Carter, ORR<br>• Colin Brading, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 02/02/07 | Network Rail Office, 40 Melton St., Euston | • Andy Jones, Network Rail<br>• Peter Lander, Network Rail<br>• Phil Edwards, Halcrow |
| 20/02/07 | NR Western Territory, 125 House, Swindon | • Peter Bridges<br>• Phil Edwards<br>• Richard Spoors |
| 23/02/07 | ORR Office, One Kemble St., Holborn – Progress Meeting | • Andrew Wallace, ORR<br>• Colin Brading, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 26/02/07 | NR LNE Territory, George Stephenson House, York | • Kevin Boyle, NR<br>• Peter Cushing, NR<br>• John Adams, NR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 27/02/07 | NR Scotland Territory, Buchanan House, Glasgow | • Bob Gardiner, NR<br>• Mike Tomlinson, NR<br>• Martin Batty, NR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 02/03/03 | NR LNW Territory, The Mailbox, Birmingham | • Bob Massingham, NR<br>• Jonathan Pegg, NR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 05/03/07 | NR SE Territory, Main Offices, Waterloo | • Paul Meads, NR<br>• David Mansfield, NR<br>• Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 05/03/07 | Waterloo – Progress Meeting | • Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |
| 22/03/07 | ORR Office, One Kemble St., Holborn – Progress Meeting | • Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Mervyn Carter, ORR |
| 02/04/07 | Milford to Clapham Jct – Progress Meeting | • Andrew Wallace, ORR<br>• Phil Edwards, Halcrow |
| 05/04/07 | One Eversholt St., Euston | • Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow<br>• Andy Jones, Network Rail<br>• Peter Lander, Network Rail<br>• Dan Boyde, Network Rail |

| | | |
|---|---|---|
| 17/04/07 | Network Rail Office, 40 Melton St., Euston – Presentation by Halcrow | • Mervyn Carter, ORR<br>• Colin Brading, ORR<br>• Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow<br>• Andy Jones, Network Rail<br>• Peter Lander, Network Rail<br>• Dan Boyde, Network Rail |
| 22/05/07 | ORR Office, One Kemble St., Holborn –Close Out Meeting | • Mervyn Carter, ORR<br>• Colin Brading, ORR<br>• Andrew Wallace, ORR<br>• Phil Edwards, Halcrow<br>• Richard Spoors, Halcrow |

# Appendix B: Logic used to select sampled sites

**Beakdown within each Cat-Class**

| Class/Cat: | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 886 | 4329 | 3067 | 1010 | 372 | 391 | 243 | 10298 |
| LSE | 0 | 54 | 830 | 1799 | 1040 | 295 | 130 | 4148 |
| Secondary | 0 | 131 | 1415 | 3451 | 3487 | 1946 | 285 | 10715 |
| Rural | 0 | 0 | 0 | 225 | 769 | 2710 | 145 | 3849 |
| Freight | 0 | 3 | 109 | 387 | 386 | 583 | 623 | 2091 |
| Total | 886 | 4517 | 5421 | 6872 | 6054 | 5925 | 1426 | 31101 |
| % | 3% | 15% | 17% | 22% | 19% | 19% | 5% | |

**Percentage Distribution (See Note 1 Below)**

| | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 3% | 14% | 10% | 3% | 1% | 1% | 1% | 33% |
| LSE | 0% | 0% | 3% | 6% | 3% | 1% | 0% | 13% |
| Secondary | 0% | 0% | 5% | 11% | 11% | 6% | 1% | 34% |
| Rural | 0% | 0% | 0% | 1% | 2% | 9% | 0% | 12% |
| Freight | 0% | 0% | 0% | 1% | 1% | 2% | 2% | 7% |
| Total | 3% | 15% | 17% | 22% | 19% | 19% | 5% | 100% |

| | |
|---|---|
| Sampled Cat.Class | 85% |
| Other Cat.Class (Cat 1A & 6) | 7% |
| Non-Sampled Cat.Class Routes | 8% |

Notes

| | |
|---|---|
| 1 | Exclude the Cat 1A & 6 Cat-Classes and all the Cat-Classes of 1% or less, then 13 No. Cat-Classes remain (as highlighted in yellow above). |
| 2 | This means that 85% of the network is represented by the 13 No. Cat-Classes chosen. |
| 3 | For the inspections we have assumed that 6 sites per Territory can be visited based on two days of site visits per Territory. |
| 4 | We have assumed that each of these sites will have more than one section of track/renewal proposal available for inspection in the Cat-Class chosen. This to be further discussed at Territory level meetings. |
| 5 | Therefore we have aimed to cover between 2 to 3 sites of each of the 13 Cat-Classes highlighted (summary as shown above). The percentage volume in each Cat-Class dictates whether it is 2 sites or 3 e.g. If a Cat-Class represents 10-15% of the network, then there are 3 sites chosen, below 10% there are generally 2 sites. |
| 6 | To get a broad selection of geographical locations across the network, we have chosen the centres to be representative of the Territories, however in order to cover the three LSE Cat-Classes sufficiently, we have had to select a high number of LSE Cat-Classes on the SE Territory as for most of the centres visited on the other Territories, the LSE routes are out of range. |

**Number of SRS's for Site Visits**

| **South East Territory** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| LSE | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 5 |
| Secondary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Freight | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 2 | 2 | 2 | 1 | 0 | 7 |

| **London North East Territory** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| LSE | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Secondary | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 3 |
| Rural | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Freight | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | 0 | 1 | 1 | 1 | 1 | 2 | 0 | 6 |

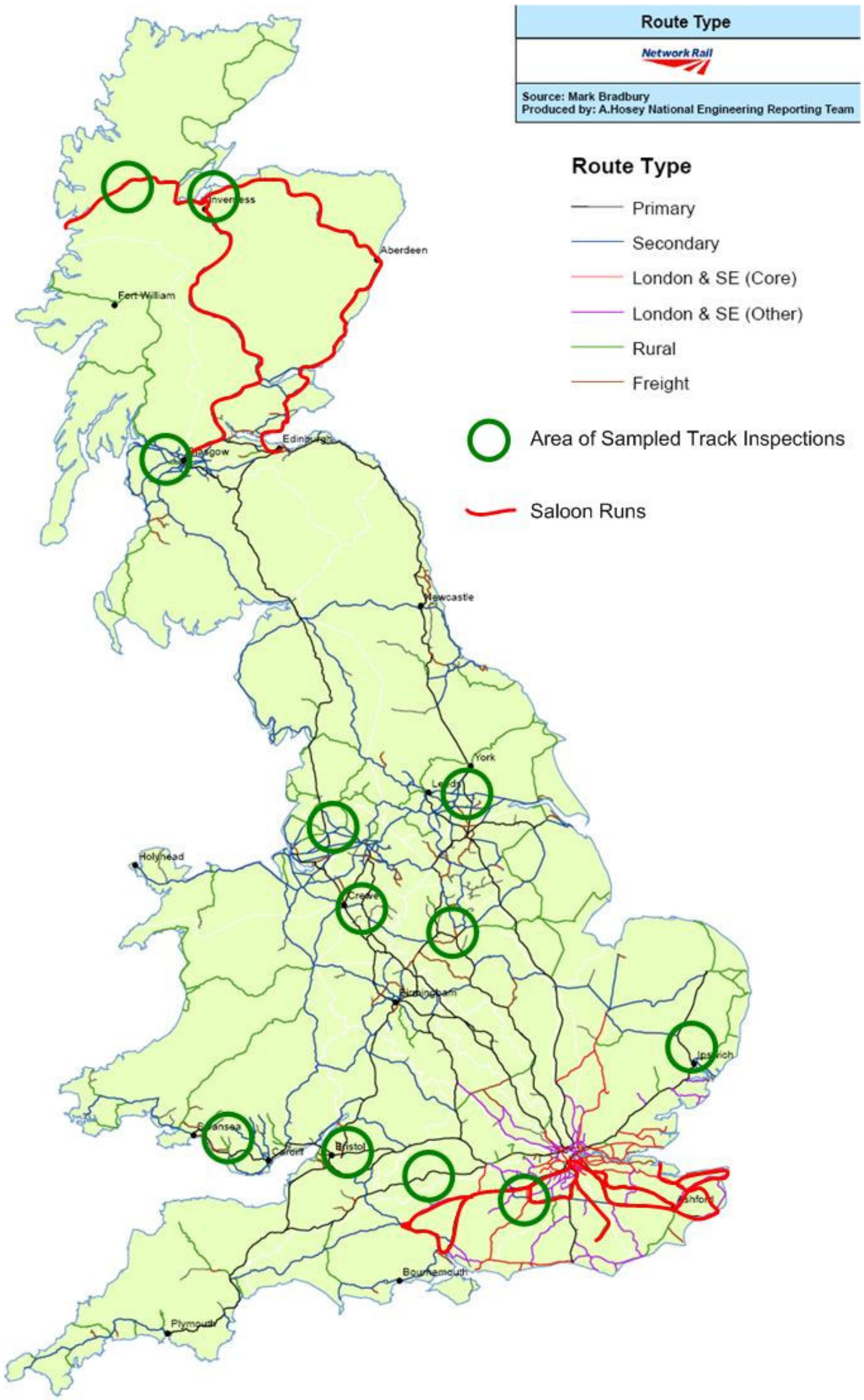
| **Western Territory** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 3 |
| LSE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Secondary | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Rural | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Freight | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | 0 | 1 | 1 | 1 | 1 | 2 | 0 | 6 |

| **London North West Territory** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 3 |
| LSE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Secondary | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| Rural | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Freight | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 6 |

| **Scotland Territory** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LSE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Secondary | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 4 |
| Rural | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Freight | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 6 |

| **All Territories** | 1A | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 3 | 3 | 2 | 0 | 0 | 0 | 8 |
| LSE | 0 | 0 | 2 | 2 | 2 | 0 | 0 | 6 |
| Secondary | 0 | 0 | 2 | 3 | 3 | 3 | 0 | 11 |
| Rural | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| Freight | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Total | 0 | 3 | 7 | 7 | 7 | 7 | 0 | 31 |

# Appendix C: Map of Inspections and Saloon Runs



# Appendix D: Sample Route Studies – Track Inspections

The Track Inspection Reports are detailed on individual sheets for the 58 No. sites. These are contained in a separate electronic document as an appendix to this report.