Independent Reporter A

Switches & Crossings Service Life Project
Final Report

Review of Network Rail's S&C Service Life Predictions – May to July 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
1	0	Draft Final for comments	26/06/07	PRE/RS
1	1	Draft Final with ORR comments	05/07/07	PRE/RS
2	1	Final with NR comments	18/07/07	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 In April 2007, Halcrow produced a report as part of this commission on the appropriateness of Network Rail's assumptions with respect to Plain Line track. This further report is a continuation of this but to focus on Switches and Crossings (S&C) renewals particularly for CP4.

1.1.5 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

1.1.6 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.

1.1.7 Network rail are currently reviewing the suitability of these service lives and how they should be best used in the next version of the ICM.

1.2 Network Rail's CP4 Development Work

1.2.1 Network Rail are currently undertaking a detailed 'bottom-up' review of the plain line CP4 forecasts by locally assessing routes to estimate renewal levels in CP4 and beyond. This exercise did not include S&C.

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 a detailed study of a representative sample of S&C proposal sites to be considered for renewal in CP3 and into CP4.

This will be achieved through choosing sites to be visited which align track category with the dominant route type. This will be backed up with supporting information provided by the Territory Engineers (GEOGIS data, track renewal proposals, track geometry data etc.).

1.3.2 The remit required comment on:

a) How closely the observed service lives at which layouts are being put forward for replacement, align with the requirements for S&C performance and service lives stated in Network Rail's Track Asset Policy document, applied to each Route Type (Primary, Secondary, Rural & Freight).

b) The variability of service lives taking account of duty speed and tonnage (and track category), and possible reasons for service lives being significantly different to the average

c) The effectiveness and accuracy of how S&C renewals are prioritised and targeted, taking account of the interrelationship with re-signalling schemes, and impact upon overall route operational (train delays etc) and technical (track geometry quality) performance

d) The suitability of each sampled S&C unit for timely heavy maintenance or refurbishment in order to extend asset life and optimise the whole life cost of the asset.

e) The sufficiency of observed historic maintenance input to the S&C for each route-type, taking into account performance requirements and access.

f) Identification of any best practice that could optimise the S&C work volumes in CP4 using whole-life cost measures

g) The likelihood of an approaching bow-wave of S&C renewals that would justify a higher renewal rate in CP4.

h) The assumed maintenance / renewal balance for each SRS and comment on whether it appears to be the optimum for that route.

1.3.3 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.

1.3.4 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.

1.4 Project Deliverables

1.4.1 This project is to be run during May, June & July 2007. The review aims to allow time for Network Rail to consider any findings of this work prior to finalising their Strategic Business Plan for CP4 due to be submitted in October 2007.

Programme

1.4.2 The programme includes the following milestones:

(a) An initial briefing by Network Rail to understand process used within the ICM and its development (May 2007)

(b) Propose and agree with ORR and Network Rail the route samples to be used in the study, likely to be between 5 and 10 SRS's (May 2007).

(c) Submit project plan, with key milestones (8 June 2007).

(d) Complete the route study work and submit report (29 June).

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

Deliverables

1.4.3 The project deliverables are summarised as follows:

(f) A summary of routes to be sampled and the reasons for their selection.

(g) A programme of activity.

(h) A draft report for review by ORR.

(i) A presentation of the issues contained in the report to ORR and Network Rail.

(j) Final report incorporating Network Rail and ORR's comments.

2 Studies of sampled S&C Layouts

2.1 Background

2.1.1 As stated in the introduction, a detailed study of sample S&C layouts was carried out choosing sites to be visited which align track category with their dominant route type.

2.1.2 Each Territory was asked to select a sample of S&C proposal sites for CP3 or CP4 (or other 20 years old plus sites) from the Route Classes (Primary, Secondary and Rural/Freight). We also introduced a further sub-division on the Primary and Secondary Routes, as these are the routes with the majority of S&C renewals, of a) Slow Turnout Speed S&C and b) High Turnout Speed S&C layouts i.e. S&C with Switches A to E and S&C with Switches F to H.

2.1.3 In summary, Halcrow asked for samples from the following five categories:

1. Primary – Switches A to E

2. Primary - Switches F to H

3. Secondary - Switches A to E

4. Secondary - Switches F to H

5. Rural/Freight

2.1.4 Whereas last time Halcrow chose the general locations to carry out the inspections, each Territory was given the flexibility to choose sites that would be practical for the purpose of carrying out daytime inspections within a safe system of work.

2.1.5 The following is the summarised list of sites sampled:

Primary & LSE (Key) Routes

Location	Pts.	Territory	Track Category
Colton Nth Jct	2297	LNE	1A
Colton Nth Jct	2298	LNE	1A
Sth Kirkby Jct	2244	LNE	1
Sth Kirkby Jct	2245	LNE	1
Birmingham International	695	LNW	5
Birmingham International	698	LNW	1
Berkswell	2A	LNW	1
Victoria Park	299	SE	2
Lea Jct	300	SE	2
Lea Jct	301/302	SE	2
High Meads Jct Stratford	303/305	SE	4
Grantshouse North Jct	11A/B	Scotland	1

Location	Pts.	Territory	Track Category
North Lincs Jct	1078A	LNE	2
North Lincs Jct	1079	LNE	2
Shaftholme	2511	LNE	1A
Weaver Jct	1746	LNW	1A/2
Weaver Jct	1423B	LNW	1A
Hartford	1724	LNW	1A/2
Hartford	1725	LNW	1A
Slough	330A	Western	1A
Slough	342	Western	2
Slough	343	Western	2

Secondary & LSE (Other) Routes

Location	Pts.	Territory	Track Category
Church Fenton	1365	LNE	2
Coventry Nth	141	LNW	4
Sutton Br. Jct	20	Western	3
Abbey Foregate (Shrewsbury)	53	Western	3
English Bridge Jct (Shrewsbury)	174/175	Western	3
Nantwich	GF	Western	3
Whitchurch	GF	Western	3
Crewe Jct (Shrewsbury)	23	Western	3
	29	Western	3
Ladybank	379	Scotland	2
Ladybank	381A	Scotland	4
Ladybank	382	Scotland	4
Ladybank	377	Scotland	2
Halbeath	422	Scotland	2
Epsom	840 &Dias	SE	3
Epsom	841	SE	3
Epsom	844	SE	3

Location	Pts.	Territory	Track Category
Epsom	845	SE	3
Epsom	846	SE	3
Epsom	847	SE	3
Epsom	848	SE	3
Epsom	849	SE	3
Lincoln	35	LNE	4
Lincoln	63	LNE	3
Lincoln	Dia	LNE	4
Thorne Jct	2021	LNE	2
Thorne Jct	2022	LNE	2
Saltney Jct	717	LNW	3
Saltney Jct	718	LNW	3
Falkland	113	Scotland	2
Falkland	114	Scotland	2
New Cumnock	19	Scotland	2
	21A	Scotland	2
New Cumnock	6A	Scotland	5
	6B	Scotland	2

Rural Routes

Location	Pts.	Territory	Track Category
West Parade Jct (Hull)	94/95	LNE	5
Bearly West Jct (Coventry)	12/14 13Dia	LNW	4

Location	Pts.	Territory	Track Category
Slough	331	Western	4
Slough	330B	Western	4

Freight Routes

Location	Pts.	Territory	Track Category
Longannet Power Station	24	Scotland	3 (Prev. 5)

Location	Pts.	Territory	Track Category
Annbank	GF	Scotland	2

2.1.6 The range of sampled sites across the various track categories within the route classifications is shown below. There are 80 S&C units sampled (between 15 and 17 S&C Units per Territory).

	Primary (& LSE Key)					Secondary (& LSE Other)		
	Cat. 1A	Cat. 1	Cat. 2	Cat. 4	Cat. 5	Cat. 2	Cat. 3	Cat. 4
Scotland		1				10		3
LNE	2	1	3			4	2	2
LNW	5	2	2		1		3	1
Western	4		4				7	
South East			3	1			13	
Totals	11	4	12	1	1	14	25	6

	Rural				Freight Only			
	Cat. 3	Cat. 4	Cat. 5	Cat. 6	Cat. 3	Cat. 4	Cat. 5	Cat. 6
Scotland					2			
LNE			1					
LNW		1						
Western		2						
South East								
Totals		3	1		2			

2.2 Analysis of sampled sites against Route Type

2.2.1 The following summarises Halcrow's findings based on the S&C service life predictions for each site compared to Network Rail's service life table (see 1.1.5 Table 1). This has been summarised against each route type and shows the variation between the Halcrow view when compared to the Network Rail average service life table and the range of variation within each route type.

Percentage of Halcrow view against Service Life Table				
	Min	**Average**	**Max**	**Range**
Primary	80%	104%	167%	87%
Secondary	70%	104%	130%	60%
Rural	90%	99%	107%	17%
Freight	100%	111%	123%	23%

Primary

2.2.2 On the Primary routes we have found a close correlation of average service lives with the Network Rail table. However, the range is large and demonstrates that by replacing much of the component parts of the layout, the life in some circumstances can be extended by as much as two thirds, particularly if the ballast condition remains good.

2.2.3 On Primary routes there is a wide variation because of the variability factors (explained further in section 2.3) but additionally because of the range of Track Categories. We sampled S&C layouts in each of the Track Categories 1A, 1, 2, 3, 4 & 5 within the Primary routes which added to the variability of speeds and tonnages within this route classification.

2.2.4 For example, the Primary route class included the 100mph Birmingham/Berkswell layouts and the 100mph South Kirkby Jct layouts (East Coast Main Line). It also included the North London Line layouts and London suburban lines such as Slough which have shorter service lives because of the historical problems associated with limited possession access and the relative differences maintaining the slower speed lines at different thresholds and intervention levels to the higher speed lines.

Secondary

2.2.5 On the Secondary routes, again we have found a close correlation of average service lives with the Network Rail table. However, the range for the Secondary routes is again quite large because of the variability factors (explained further in section 2.3) but additionally because there were examples of early renewal as an inescapable consequence of having to renew crossover layouts which connect two different Track Category lines.

2.2.6 An example of this is at New Cumnock where we sampled a crossover from the Up Goods to the Up Main. The renewal of this layout was being driven by the service life of the Up Main whereas the Up Goods half of the crossover would theoretically be renewed early.

2.2.7 At the other end of the range we found that possession access was generally easier on Secondary routes compared to Primary routes. Therefore, although the range of track categories within Secondary was much narrower than that for Primary (i.e. only track categories 2, 3 & 4), the opportunities for changing components and therefore extending the life of the layout were greater.

Rural

2.2.8 On the Rural routes, the sample was much smaller because we believe the overall volume of S&C renewal proposals is much less, compared with the Primary and Secondary routes. We believe this is more of a conscious effort to propose the higher route classes because the Rural and Freight routes can be more easily life extended and therefore it is more important to give a greater priority to Primary and Secondary routes.

2.2.9 However, for the sample we had, we have found a close correlation with the Network Rail table and a small range within plus or minus 10%.

Freight

2.2.10 Only two sites were sampled on Freight only routes. We found a close correlation with the Network Rail table except that on one site the service life had been extended by the replacement of components as and when required. There is a general feeling that on track categories 4, 5 & 6 that provided the S&C layout is 113A Vertical design, it is perfectly acceptable to perpetuate the layout by replacing components as and when required in most circumstances. However, where spillage has contaminated the ballast or where heavy volumes of freight are causing high levels of damage and wear, Network Rail will often need to consider complete renewal of the layout.

2.3 Variability of S&C Service Lives

2.3.1 From the sites sampled the expended life of the S&C layouts observed have been considered and a judgement made on the remaining life expectancy. These were then compared to the Track Service Life table to test the average service lives for each track category. As the majority of the sites sampled were proposed for renewal in the current control period or in CP4 (2009-2014), the Territory Renewals Engineers were able to explain their rationale for proposing the S&C layout for renewal.

2.3.2 The following summarises Halcrow's findings based on the S&C service life predictions for each site compared to Network Rail's service life table (see 1.1.5 Table 1).

Percentage of Halcrow view against Service Life Table				
Track Cat.	**Min**	**Average**	**Max**	**Range**
1A	112%	120%	156%	44%
1	93%	123%	167%	73%
2	83%	103%	129%	46%
3	63%	102%	115%	53%
4	98%	102%	109%	11%
5	70%	87%	102%	32%

Table showing percentage variation of track service lives

2.3.3 The average service lives for Track Cat. 1A and 1 are higher because of the heavy maintenance (timber and ironwork replacement) that has been necessary to maintain standards on these higher speed lines. We would not necessarily recommend that the average service life for these lines is extended as it is important to maintain the quality which cannot always be achieved through life extension by heavy maintenance. Therefore, although the average was high we could well have agreed with a proposal for renewal at the 25 and 30 year points respectively at which point, much less heavy maintenance would have been completed.

2.3.4 The average service lives for Track Cat. 2, 3 and 4 are similar to those in the Network Rail table. We have found that the full range of variability factors (see below) applies within this range of Track Categories and in the main they are balanced out by an even spread of positive and negative variations.

2.3.5 For Category 5 the sample is very small and influenced by severe ballast congestion caused by spillage and heavy volumes of freight which are causing high levels of damage and wear. However, the sample is too small to draw reliable conclusions.

Variability Factors

2.3.6 There were many variability factors found when comparing the age of the S&C layout at proposed renewal date with the Track Service Life table. The main reasons for this were as follows

(k) S&C component design variations

(l) The influence of maintenance constraints

(m) The strategic renewal factor

(n) Remodelling and rationalisation schemes.

(o) Enhancements to improve the performance and reliability of the points

(p) Track Geometry variations (due to poor underlying ground conditions, poor installation, poor design etc.)

(q) Traffic influences (spillage, RCF, track un-friendly vehicles etc.).

S&C Component Design

2.3.7 There has been a wide range of S&C components witnessed on the site visits. These were mainly due to changes over the years as the designs for standard layouts have developed. The predominant S&C designs are shown as follows:

- 95lb Bullhead Rail with Under Cut or Straight Cut Switches (Joggled) and Built Up Crossings fixed to softwood timbers (Pre-Nationalisation design standard)
- 109lb Flat Bottom Inclined Rail with Straight Cut Switches & Chamfered Switches and Built Up Crossings on ST Baseplates (with Spring Clip fastenings) on softwood timbers (Post-Nationalisation design standard introduced in the early 1950's)
- 113A Flat Bottom Vertical rail with Chamfered Switches and either Built-Up, Part Welded or later Cast Manganese Monoblock Crossings with Pandrol fastenings laid on hardwood timbers (developed in the late 1960's)
- 113A Flat Bottom Vertical rail with Full Depth and later Shallow Depth Switches and either Part Welded, Cast Manganese Monoblock Crossings or later Cast Centre Block Crossings with weldable legs, with Pandrol fastenings laid on Concrete Bearers suitable for use in Continuously Welded Rail locations. (developed in the 1980's)
- RT60/NR60 Flat Bottom Inclined rail with Shallow Depth Switches and Cast Crossings with weldable legs with Pandrol fastenings laid on Concrete Bearers suitable for use in Continuously Welded Rail locations. (developed in the late 1990's/early 2000's)

These changes in design have generally improved the durability of the components and increased the life expectancy of S&C layouts.

2.3.8 Many of the improvements have been made to improve the reliability of moveable components thus reducing points failures, reactive maintenance and wear & tear on assemblies. Improvements such as shallow depth switches (eliminating stud bolts) and the standard provision of low friction slide systems and roller baseplate mechanisms under the switches have also improved the traditional switch assemblies.

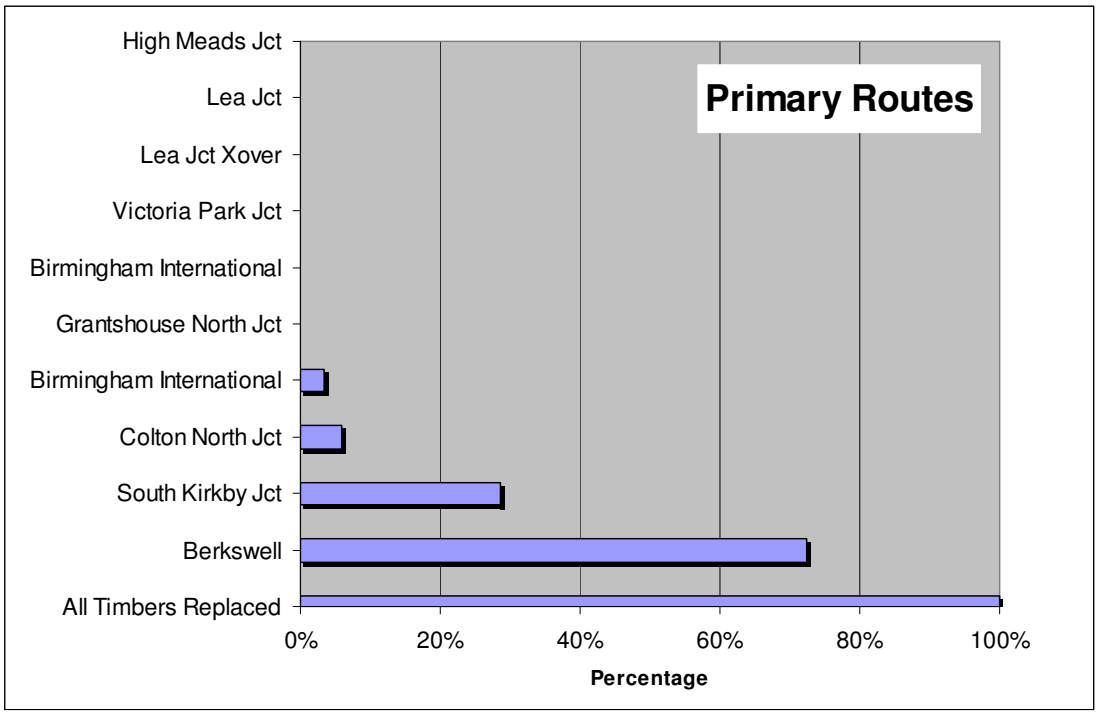
2.3.9 Changes to the inclination of the rail and the reduction in bolted rail joints have been taken to improve the quality of the ride through the layout which also reduces wear and tear and improves the durability of components. This has been facilitated by the design improvements necessary to make S&C layouts with sufficient strength to be an integral part of continuously welded track.

2.3.10 The use of concrete bearers instead of hardwood timbers should improve service life of the newer layouts. The early concrete bearer layouts on Cat. 1A and 1 will soon be reaching the average service life and although we didn't observe any on our visits, it will be interesting to compare how they have performed compared to hardwood timber layouts. The comparisons between hardwood and softwood timbers have been interesting as although this was an important improvement it appears to have not been as successful as was previously expected.

Maintenance Constraints

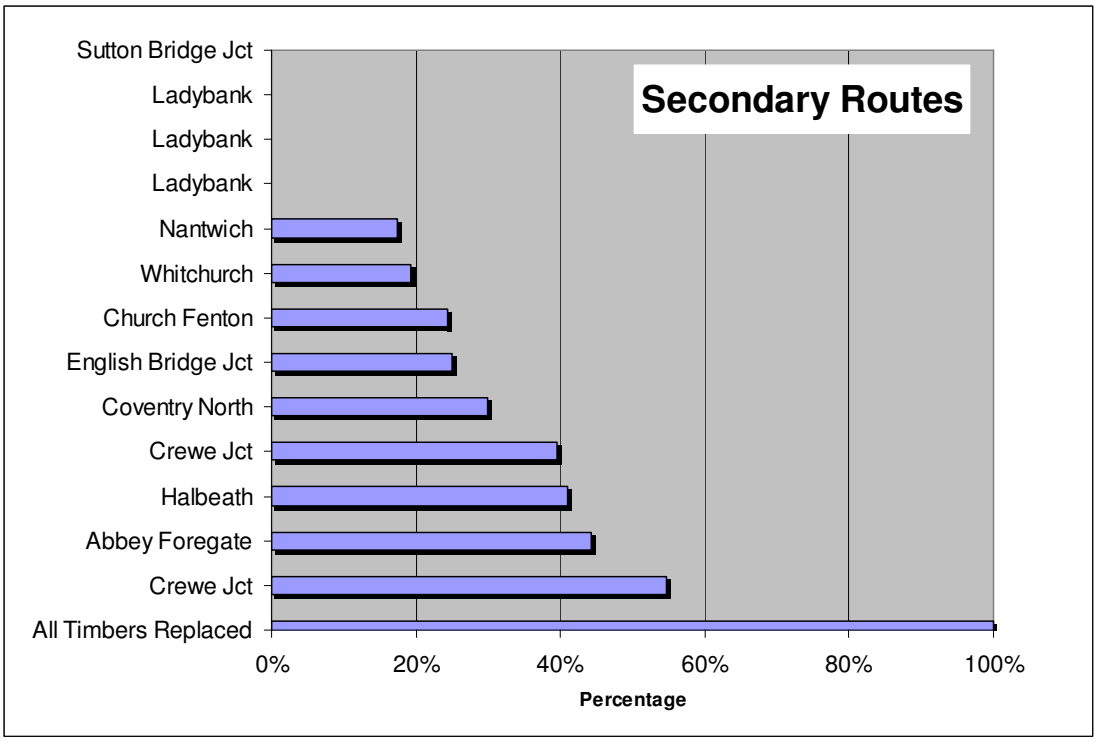
2.3.11 One of the significant findings from this study has been the wide variation in component replacement carried out when comparing similar layouts of a similar age on the same track category and route type. One example was on the Rugby to Birmingham line where two sites (only 5½ miles apart); one a crossover (698 pts) had only 3% of the timbers replaced whereas the turnout at Berkswell had 72% of the timbers replaced during its lifetime. The Berkswell turnout was 5 years older and not being considered for renewal in CP4 (for good reason) whereas 698 pts was planned for renewal in 2010/11 (again for good reason). One explanation for this was the difference between the two layouts when it comes to changing timbers. The longer timbers and the lack of sufficient room to easily pull them out seemed to be the main reason why the timber replacement on 698 pts was so low.

2.3.12 To demonstrate the wide variation in the volume of timbers replaced in each turnout, crossover or double junction, the following graph shows samples taken from the sites visited on each Territory for the Primary and Secondary Routes.



Graph showing percentage of timbers replaced on sampled Primary Routes

2.3.13 It is interesting to note from the graph above that the layouts with no timbers replaced are almost exclusively those which are below Track Category 1A and 1. They are all sites which are 75mph or less (on the through lines) and are therefore slower speed layouts and considered lower priority than the higher speed route layouts, albeit that they are on Primary Routes.



Graph showing percentage of timbers replaced on sampled Secondary Routes

2.3.14 There were several sites where timber condition was poor and the timber replacement was low or zero, even on the higher category routes. The explanation given for these was that possession access was poor or that it was a low priority and therefore maintenance resources were often deployed on the lines with easier access or higher priority routes. Provided that there were no safety risks, train performance implications or issues of non-compliance with the standards, it could be accepted as a practical approach that would suit the route strategy. Therefore, Primary and Secondary route sites like this,,would be dealt with earlier by total renewal driven by timber (and/or ballast) condition.

2.3.15 The North London Line is a good example of this where possession access has been extremely limited for many years and the local engineers are regularly reassessing priorities in order to optimise possession time with the limited resources available. The crossover at Victoria Park has particularly suffered as it is one of the lesser used crossovers but with a track category 2 rating, so the through tracks are heavily used but the connection between the Up and the Down is of low strategic importance.

2.3.16 Another factor that influences the service life is the requirement to change S&C units because of rail defects and damage. There were a number of examples where recent replacement of S&C units had been necessary that would change the business case for renewal of the layout in terms of its suitability. On some low category routes there were layouts that would be suitable for re-assessment and refurbishment to extend their life given that the S&C units had been replaced with new ironwork since the decision to renew had been taken.

Strategic Renewal Factor

2.3.17 The strategic renewal factor becomes a major influence on S&C service lives when an area of S&C layouts which are closely linked in one general location are renewed all together as part of an integrated proposal. This often includes layouts of different ages or different Track Categories (i.e. different speeds and tonnages) where a diverging route has a different Track Category to the main route.

2.3.18 There was an example of this found at Ladybank where the layout consisted of three turnouts (and a set of traps) on the junction. There was only one turnout on the Cat. 2 lines and the remainder on the Cat. 4 lines (see diagram below). The renewal proposal was for the whole layout and being driven by the age and condition of the Cat 2 turnout. In theory, if the Cat 2 turnout can be extended for approx. 10 years than there would more service life gained from the Cat. 4 S&C which would last its expected life span without significant heavy maintenance. Such life extension appeared to be possible.

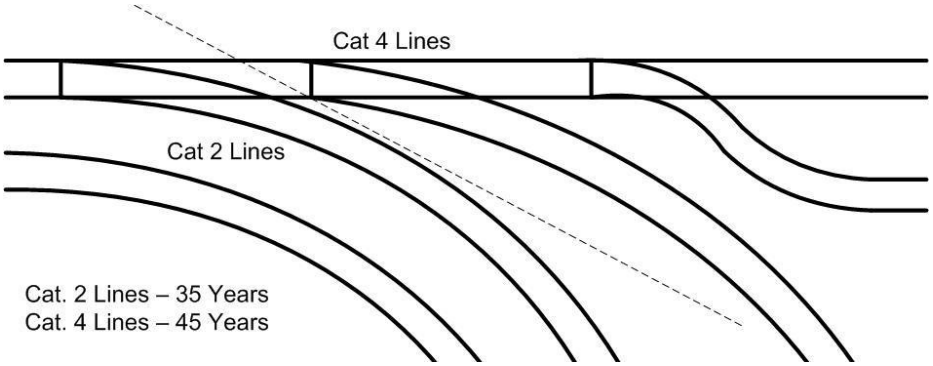


Table 2 Ladybank Jct showing Cat. 4 lines branching off Cat. 2 lines

Remodelling and Rationalisation Schemes

2.3.19 There were a few sites visited that were subject to remodelling or rationalisation. Inevitably S&C layouts will be removed before the end of their expected life in these circumstances. The unfortunate aspect of this was the uncertainty of whether any good materials would be recovered. The potential for cascading S&C components for spares or for S&C refurbishment elsewhere appears to be restricted to the immediate area otherwise it disappears as part of the S&C renewal process and sometimes recovered by external contractors.

Performance Enhancements

2.3.20 The life of S&C layouts can be extended by default when performance enhancement works are carried out to improve the reliability of the points. This is a positive approach to strategically important points and very often there is a beneficial cost saving in doing this. However there have been examples witnessed where Renewals Engineers have been unaware of the enhancement works being carried out by Maintenance and have not had an opportunity to reassess the site and its planned date for renewal (which may be too late to do so).

2.3.21 Exceptions to this it seems is when an enhancement is part of a special project such as recent examples where the Sersa Second Life System has been used on S&C layouts. We are aware of a project at Rochester (Kent) to extend the life and reliability of the S&C there by using restoration techniques to extend the life of timbers to eliminate baseplate shuffle and restore the integrity of the fixings.

Track Geometry Variations

2.3.22 Clearly track geometry variations and deviations through S&C layouts have a direct impact on vehicle ride quality which in turn influences the service life of the S&C components. The quality of pre-fabrication and installation has played and will play a major part in the degree of success that maintenance will achieve year on year as they aim to keep the quality of top and line within the specified limits.

2.3.23 Track geometry designs have improved over the years and the shift from timbered layouts to concrete bearers has enabled the prefabrication quality control process to be improved. However many of the timbered S&C layouts observed had top and alignment faults due to the poor quality finish of the original formation level and bottom ballast layer at installation. Since the widespread introduction of Laser controlled formation and ballast levels in the late 1980's the situation has improved. However, the 'ballast memory' on the pre-Laser controlled sites continues to pose a significant challenge to the Maintenance organisations as they S&C tamp to restore the top.

2.3.24 Some timbered S&C layouts suffered from misalignments which were inherent in the layout, spiked in a position that couldn't be corrected properly without a major re-gauging exercise. The 'alignment memory' would be perpetuated regardless of the number of times that the layout was S&C tamped. This was compounded by discrete top faults that were inherent in the rails/S&C especially in the stretcher bar area around the tips where timbers cannot be accessed by the tamping tines. Dipped welds and joints were evident particularly on the layouts with first generation welds and the jointed layouts that pre-date the strengthened S&C continuously welded into CWR.

2.3.25 One example of the influence which limited possessions has on track geometry was observed at Slough. The track layout is four tracks with the Main lines to the south and the Relief lines to the north. Possessions are therefore taken of either the Main lines or Relief lines. Following recent tamping of the three running crossovers from the Down Main to the Up Relief, poor top was observed in the crossover from Up Main to Down Relief where it had been tamped in the normal direction only as no possession of Up Main and Down Relief together could be arranged. Such geometry variations can only reduce the service life and cause higher overall maintenance costs.

Traffic Influences

2.3.26 Much has been written elsewhere about Rolling Contact Fatigue (RCF) and the effect of track unfriendly Rolling Stock particularly the heavier, bogie stiff passenger rolling stock introduced post privatisation. Whereas RCF has no respect for track whether it is plain line or S&C and therefore examples of RCF were found on a small number of sites.

2.3.27 However the majority of S&C layouts observed were RCF free. This may be partly because it had been treated by rail grinding which was evident on some sites.

2.3.28 Freight traffic has a different influence on track components particularly switch damage, worn crossing noses and wheelburns, all of which were observed. Coal spillage was also a significant factor and contributed to the shortening of ballast life where there was significant congestion.

2.4 Other Observations

Appropriateness of S&C renewal proposals

2.4.1 Our inspections have broadly supported Network Rail's track renewal decisions. Whilst we do not consider S&C is being renewed early, we do believe there is more work to be done to align the precise date of renewal with the necessary maintenance work required towards the end of its service life.

2.4.2 This is particularly relevant on the track category 1A and 1 lines where the average service life is theoretically at it's shortest. There is often a need to extend the service life with heavy maintenance to maintain the top, line and gauge to the tighter tolerances required on these lines. However, as already stated, the level of heavy maintenance that is practical varies greatly and cannot be applied consistently as an approach to extending average service lives.

2.4.3 Furthermore, the renewal of switches and crossings units can be an expected maintenance intervention in the life of a switches and crossing layout. This is usually due to wear/damage of the switch blade or crossing nose beyond acceptable tolerances. When this work is carried out, replacement or repositioning of the timber bearers is also considered to give added life to the unit. This intervention may marginally extend the modelled service life, and the renewal date is then determined by the overall condition of the ballast and the ability to maintain acceptable track geometry through the unit.

Opportunities for extending service life and optimising the whole life cost of S&C

2.4.4 On Category 1A and 1 lines, heavy maintenance will be necessary as and when required but complete renewal when the appropriate time comes seems a sensible strategy rather than a policy of life extension works which may not maintain the high quality that complete renewal would achieve. In the London suburban areas there may be a case as they are generally slower lines with difficult possession access and very little heavy maintenance maybe the reality unless a major refurbishment is planned.

2.4.5 On Track Category 2 and 3 lines (as with Track Cat. 1A and 1) a gradual conversion to NR60 layouts will be taking place over the coming years. Therefore major life extension works on Cat. 2 and 3 lines may not be the favoured strategy by Network Rail as it seeks to improve performance. However, it is the moveable areas of the S&C layouts (i.e. the switches and switch diamonds) that suffer on the timbered layouts. Therefore, partial renewal of the switch panel or switch diamonds associated with reballasting seems a sensible option to extend the life and improve the performance of the layout.

2.4.6 There are opportunities to perpetuate the 113A Vertical S&C layouts on the Track Category 4, 5 and 6 lines. This fits with the Track Construction Standards (NR/SP/TRK/102) and would be particularly applicable on layouts that have already received significant refurbishment and are not limited by site constraints. Provided that the ballast condition was acceptable (or could be easily renewed) and there were no problems with the formation and drainage this would be a way of extending the service life and reduce the whole life cost.

Historical Maintenance practices observed

2.4.7 Maintenance of track drainage systems has been lacking in many areas for a number of years. On a small number of layouts, ballast congestion, weeds and poor drainage was observed.

2.4.8 There were also examples of short rails, wide block joints with damaged end posts, tight block joints with lipped rail ends, the odd fishbolt missing due to poor drilling and examples of poor top and alignment.

2.4.9 The observed geometry of top and line through many of the S&C layouts was fair to poor. The track geometry recording traces produced at some inspections showed track in the poor or very poor bands for 70 metre chord lengths. This suggests that service life will be shortened unless improvements can be made. If poor quality ballast or ballast memory is the root cause, early renewal is inevitable. If this is known not to be the case, service life should be extended by a planned approach to survey the layout, including 200 metres of plain line either side of the units, and design a new top and line. Implementation should be undertaken after good practice preparation of renewing ferrules, tightening fastenings and filling ballast beds.

Best Practice observed

2.4.10 There was a number of best practice initiatives observed as follows:

- Renewing jointed Crossings with weldable leg Crossings in strengthened S&C.
- Replacing 4 hole IBJs with welded 6 hole glued joints.
- Fitting lateral restraint plates to mitigate the risk of buckles in switches.
- Fitting roller baseplate systems to switches and switch diamonds

S&C Renewals backlog

2.4.11 In our analysis we found that 27% of the sites sampled were already exceeding the service life shown in Network Rail's service life table. However, only 4 sites (5% of all the sites) had exceeded the service life by 5 years or more. As explained earlier, we have considered it to be appropriate that service life is extended by heavy component replacement and refurbishment where applicable. For these four sites, the following summarises the level of re-timbering and S&C unit replacement so far.

- Berkswell, 72% of timbers replaced and all S&C units replaced.
- Crewe Jct. 23pts, 39% of timbers replaced plus all switches and 2 out of 6 crossings replaced.
- Shaftholme 2511 pts., some spotting and timbers pulled through.
- Slough 330 pts., some component renewal but will become redundant soon.

2.4.12 Therefore taking condition as well as service life into account, we don't consider to have seen any S&C layouts which are in backlog.

3 Conclusions and Recommendations

3.1 Conclusions

Primary Routes

3.1.1 For the sites sampled on the Primary Routes, the average service life found was very close to the Service Life table. There were examples of early renewal justifiably being proposed particularly on the Track Cat. 2 lines. However, when considering the high category Primary lines (Cat. 1A and 1), because possession access was limited, most of the sites sampled had already exceeded their expected service life and although heavy maintenance had extended the life, the desirable solution was complete renewal at the 25 years (Cat 1A) and 30 years (Cat 1) to maintain the quality needed.

3.1.2 The notable issue on the Cat.2 (and below) Primary routes was the much lower level of heavy maintenance carried out compared to the Cat 1A and 1 Primary lines. This was due to a combination of limited possession access and the lower priority being given to these lines in favour of the Cat 1A and 1 lines. This resulted in a shortening of the service life compared to the average service lives for these lines.

Secondary Routes

3.1.3 For the sites sampled on the Secondary Routes, the noticeable aspect was that the level of maintenance replacement of components was generally higher than the other route types. As these routes are generally away from the bigger cities and busier inter-city lines, possession access is easier and dedicated resources are not so much redirected onto higher priority routes. They are also generally given a higher priority than the Rural and Freight routes and in many places they are regarded as the rural area's 'main line'.

3.1.4 Furthermore, the track category range within the Secondary routes is generally Track Cat. 2, 3 & 4. so the speed and tonnage and therefore service life is in the mid range. Therefore the combination of easier possession access, dedicated resources and slower speed S&C makes these layouts suitable for extending track service life by heavy maintenance and refurbishment.

3.1.5 The number of years that can be added to the life expectancy of an S&C layout through refurbishment and heavy maintenance is not well understood. However an analysis of the 113A Vertical S&C layouts on Secondary routes has shown that typically a year of service life can be added for a 5% increase the number of timbers changed. This is dependant on the ballast conditions allowing this and rail/S&C wear and tear being dealt with by the replacement of the ironwork as and when required.

Rural Routes

3.1.6 On the small sample taken on the Rural routes we have found that there is a close match with the Network Rail Service Life table and the range of variations to this is also small. However, the potential for heavy maintenance and refurbishment to extend service life is there but not often taken.

3.1.7 On the Rural Routes the possession access for maintenance is usually not an issue, but heavy maintenance is often focussed elsewhere on the Secondary and Primary routes and to this extent the Rural Routes suffer.

3.1.8 However, where these routes do have an advantage is in the day to day maintenance attention. Because it is possible to carry out minor lifting and packing and refurbishment of fastenings/fixings during daylight hours (using lookout or T2 protection), we believe this to some extent offsets the smaller volume of heavy maintenance received. This approach keeps service life expectations consistent with the track service life table and therefore limited examples of extended or shortened service life were found in this route type.

Freight Routes

3.1.9 Again, the sample of Freight Routes was small because very few S&C layouts by comparison with the other routes were proposed for renewal. However, because some layouts were subject to high levels of damage to obsolete fastening systems and ballast was being contaminated by spillage, it was not possible to maintain these S&C layouts perpetually by spot replacing individual components. Therefore we believe a level of S&C renewal on Freight routes is necessary albeit small by comparison with the other route types.

Cascading Materials

3.1.10 At the precise date of renewal many units have switches and crossings with further asset lives. We would like to recommend that renewal contractors safely retain these units in the locality for reuse or that they are returned to a central recycling point by Network Rail.

Renewal Decisions

3.1.11 From the observations made during our inspections we found decisions to include particular units for renewal in future annual programmes were based on sound engineering judgement at the time of inspection. However, we did find that the decision making timescales to include a particular unit in a future annual renewal programme did not give confidence to the maintenance organisation, who found it necessary to renew switches or crossings between the time of an engineer's renewal inspection and the date of renewal. This has lead to units being renewed with one or two year old replacement switches or crossings insitu.

Track geometry through S&C

3.1.12 Generally the track geometry presented on inspections, observed by eye, measured by track gauge and seen in the New Measurement Train outputs, was poor. We consider this to be an important factor in service life and believe more needs to be done to raise the importance of good track geometry through switches and crossings, to the maintenance organisation.

3.2 Recommendations

3.2.1 There is a need for a closer relationship and understanding between the Engineering function, who are the decision makers to renew S&C in a particular year, and those who have the day to day responsibility for maintenance and performance of the units, in order to maximise service life or minimise whole life costs.

3.2.2 On the Primary routes there is currently a significant difference in the range of S&C service lives between the higher speed main lines and the 'City Suburban' lines within this route type. If Network Rail is considering a route strategy based approach to S&C maintenance and renewals, we would recommend that these strategies acknowledge this difference.

3.2.3 On the Secondary Routes, Rural and light Freight routes there is the potential for a structured whole life cost analysis that will determine the scope of heavy maintenance and refurbishment necessary to extend S&C service life. This may not be relevant on the early S&C designed layouts (such as Bullhead and Flat Bottom Inclined layouts) but we think there is much potential for extending service lives on 113A Vertical S&C layouts within this route type.

3.2.4 We recommend that more work should be done to return, store and recycle good condition or nearly new switches and crossings from renewal sites.

3.2.5 We have noted above how the quality of the track geometry has an impact on the track service life of Switch and Crossing layouts. We are aware of considerable advances in the development of strengthened layouts, their pre-fabrication and the use of modern installation techniques over recent years. However, we remain concerned that the result of these benefits is not being translated into the geometric quality and hence the longer service lives of the finished product.

This, we believe, is mainly because there is no absolute requirement for renewals contractors to measure their installed S&C layouts and demonstrate that they have met the track geometry tolerances as set out in NR/SP/TRK/102. Therefore we recommend that action is taken by Network Rail to enforce this basic engineering requirement on its track renewal contractors.

3.2.6 For S&C layouts with difficult physical constraints and/or possession access, we recommend a review of maintenance techniques available to optimise S&C life in such locations.

4 Appendices

Appendix A: Meeting schedule

Date	Venue	Attendees
22/05/07	ORR Office, One Kemble St., Holborn – First Meeting	• Andrew Wallace, ORR • Mervyn Carter, ORR • Colin Brading, ORR • Phil Edwards, Halcrow • Richard Spoors, Halcrow
20/06/07	Progress Meeting	• Andrew Wallace, ORR • Phil Edwards, Halcrow • Richard Spoors, Halcrow
29/06/07	Network Rail Office, 40 Melton St., Euston – Presentation by Halcrow	• Mervyn Carter, ORR • Andrew Wallace, ORR • Phil Edwards, Halcrow • Richard Spoors, Halcrow • Andy Jones, Network Rail • Peter Lander, Network Rail • Dan Boyde, Network Rail

Appendix B: Sampled Sites – S&C Inspection Sheets

The S&C Inspection Sheets are detailed on individual sheets for each site. These are contained in a separate electronic document as an appendix to this report.