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INNOTRACK

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D5.4.2 – Final Report on the Logistics of S&C

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Glossary

Abbreviation/acronym	Description
BV	Banverket
CSS	Corus Steel Slab
IM	Infrastructure Maintainer
LCC	Life cycle costs
M&R	Maintenance and renewal
MTBSAF	Mean time between service affecting failures
NR	Network Rail
S&C	Switch(es) and Crossing(s)
SNCF	Société Nationale des Chemins de fer Français
TSR	Temporary Speed restriction

1. Executive Summary

The present deliverable is the final report on the logistics of S&C which includes consideration of the innovative S&C solutions developed within SP3 Switches & Crossings. The report builds on the first report on the logistics of S&C by going deeper into the details of the logistics of S&C and assesses the contribution of novel S&C technologies to reduction in life cycle costs (LCC).

The overall objective of the work, from a track construction point of view, is to improve the installation time of each innovative solution and thus provide an additional lever in LCC reduction.

This report details the methodology undertaken, the results, and concludes by recommending strategies for S&C renewal logistics that will contribute to the goal of reducing LCC by 30%.

The methodology followed quantifies the LCC benefits that are achievable following application of the recommendations made in the first report for the optimisation of S&C logistics strategy to minimise costs of installation, whilst maintaining the quality of installation both initially and in terms of subsequent deterioration under traffic.

The novel S&C technologies considered were adoption of modular S&C technologies, and the use of pre-assembled slab S&C technologies such as Corus Steel Slab (CSS), whilst the criteria against which potential LCC reductions were quantified against were:

- Potential for improvement in the initial quality of installation, and the subsequent benefits from reduction in track geometry and component degradation.
- Potential manpower savings.
- Potential for reduction in possession times.
- Potential for restoration of immediate full linespeeds.
- Potential for modal shift from road to rail (or vice versa) for delivery of components and S&C units.
- Shortening of delivery timescales.

The analysis detailed in this report has quantified the LCC savings that may be realised from these criteria, and has shown that implementation of modular S&C renewal techniques has significant potential to contribute to the goal of reducing LCC by 30%. For a renewal of a single standard switch of type UIC60-EW-500-1:12, it has been shown that significant LCC savings may be achieved as follows:

- 51% reduction in labour hours required;
- 62.5% reduction in possession times
- 30% reduction in plant costs.

Additionally, IMs that are implementing modular renewal of S&C are anticipating that the improved installed quality achievable can reduce the rate of service affecting failures by nearly 30%.

2. Introduction

The purpose of INNOTRACK work package 5.4 has been to develop switch and crossing (S&C) construction and logistics methods for several innovative solutions that have been identified by work package (WP) 5.1 and sub-project (SP) 3 in coordination with the related SP/WP teams. These methods have been developed in order to improve installation rate, quality of installation and to reduce the subsequent need for maintenance, thereby contributing to life cycle cost (LCC) reduction. Each step of the installation process has been analysed and particular focus has been put on the supply chain from production point to final installation point in order to identify possibilities to achieve higher quality and for optimisation and simplification.

In addition, maintenance aspects have been addressed in close cooperation with the SP3 team. This includes an analysis of the frequency of needed maintenance operations and development of maintenance and renewal (M&R) methods. The feasibility of predictive maintenance based on pre-determined parameters has been assessed. It is a known fact that quality of installation has a big impact on LCC.

The overall objective of the work, from a track construction point of view, is to improve the installation quality and reduce the installation time by employing the appropriate innovative solution and thus provide an additional lever in LCC reduction.

The present deliverable is the final report on the logistics of S&C which builds on the first report on the logistics of S&C by going deeper into the details of the logistics of S&C, and assesses the contribution of novel S&C technologies to reduction in LCC.

This report details the methodology undertaken, the results, and concludes by recommending strategies for S&C renewal logistics that will contribute to the goal of reducing LCC by 30%.

The methodology followed quantifies the LCC benefits that are achievable following application of the recommendations made in the first report for the optimisation of S&C logistics strategy to minimise costs of installation, whilst maintaining the quality of installation both initially and in terms of subsequent deterioration under traffic.

The novel S&C technologies considered were adoption of modular S&C technologies, whilst the criteria against which potential LCC reductions quantified for personnel, plant and possession logistics requirements were assessed fell into the following categories:

- Pre-renewal and preparation activities
- Removal of old S&C and site preparation
- Installation of replacement S&C
- Post-renewal activities
- Time penalties from possession requirements

3. Method

This work package was undertaken initially in four phases, the methodology and the results for which have been detailed more fully in the First Report on the logistics of S&C (deliverable D5.4.1):

1. Review of current practice by European IMs for S&C maintenance and renewal logistics, with identification of best practice and logistics work volume base-lining;
2. Determination of logistics requirements for novel S&C renewal and predictive S&C maintenance methodologies including consideration of outputs from INNOTRACK SP3;
3. Comparison of logistics work volumes for novel S&C maintenance and renewal solutions with baseline (i.e. conventional maintenance and renewals);
4. Production of recommendations for optimisation of S&C logistics strategy to minimise costs of installation, whilst maintaining the quality of installation both initially and in terms of subsequent deterioration under traffic.

The conclusions from D5.4.1 showed that implementation of a renewal strategy based on the use of either of the modular S&C technologies studied would have the potential to reduce S&C logistics costs through:

- Improvement in the initial quality of installation, and the subsequent benefits from reduction in track geometry and component degradation.
- Reduction of life cycle costs.
- Manpower savings.
- Reduction in possession times.
- Restoration of immediate full linespeeds.
- Modal shift from road to rail for delivery of components and S&C units.
- Shortening of delivery timescales.

The final phase of the work, which is detailed in this report, sought to provide strong quantification of the LCC savings that were achievable from implementation of the modular S&C renewal technologies recommended in D5.4.1, and their contribution to the INNOTRACK goal of reducing LCC by 30%. This was achieved through LCC analysis in conjunction with the work being undertaken within SP6. Also undertaken was extension of the work carried out in the first part of the WP whereby direct comparisons were made between the novel S&C logistics technologies and the base-lined current best practice S&C logistics requirements. A more detailed comparison between manpower requirements and plant costs was undertaken for a typical S&C renewal of a single standard switch of type UIC60-EW-500-1:12 to determine the magnitude of the potential savings resulting from adoption of novel S&C logistics activities. This type of S&C is considered to be representative of much of the S&C used by European IMs, with the costs for a crossing renewal being typically 15% higher than for the equivalent half set (source: Network Rail). It was assumed that the route on which the renewal was being undertaken was a mixed traffic railway with a linespeed of 160km/h and moderately frequent traffic. It was also assumed that trackside access roads were present. The breakdown of logistics activities included those associated with site preparation, transport of materials to site, removal of scrap materials and logistics associated with post-installation follow up work.

The costs determined for each of the sub-activities were not absolute, but they are considered typical at current rates for a European infrastructure manager, and were determined from a number of sources involved in the sub-project.

Not considered in the LCC analysis were the costs of the raw materials such as the new ballast and the S&C panel itself, nor the activities and costs associated with design and pre-planning for S&C renewal not directly linked to logistics. Although some design of S&C layouts would need to be specific to accommodate the logistics method used, it is not anticipated that the costs associated with these would vary significantly between S&C installations using traditional or novel logistics methods.

Also not considered to be within the remit of this report is quantification of the LCC savings that are attributable to the retention of S&C geometry under traffic that is possible following handover to traffic

of the S&C installed using the novel logistics methods. These savings are being calculated and reported as part of SP3. Table 1 shows the work activity breakdowns that were analysed for the conventional S&C renewal and the modular S&C renewal. Section 4.1 gives further information on how the manpower volumes and plant costs were calculated for each work activity, and the assumptions used.

As an illustration of the potential LCC savings achievable when applied to an actual route, a case study analysis was produced for the exemplar route in Great Britain from Woking Junction to Portsmouth Harbour, which is representative of the route type on which the work breakdown analysis was based.

4. Results

This section details the findings from the work activities undertaken that were defined in Section 3.

The detailed results from the S&C renewal comparison undertaken are shown in Annex 1. The costs determined for each of the sub-activities are not absolute, but they are considered typical at current rates for a European infrastructure manager, and were determined from a number of sources involved in the sub-project.

4.1 Derivation of labour resources and plant costs for S&C renewal work elements

For each of the work activities given in Table 1, the labour resources and plant costs required to complete the activity for were derived using information supplied by the infrastructure managers, and where sufficient detail had not been given, approximations were made. The time and resources required are consistent with those quoted by the IMs and which have been summarised in D5.4.1. The following sub-sections give further information on the manpower volumes and plant costs that were calculated for each work activity, and the assumptions used, including where there are significant differences between the work undertaken for conventional and modular renewals and the impact of these on LCC.

Activity	Sub-activity	Applicability	
Pre-renewal and preparation activities		**Conventional**	**Modular**
	Selection and clearance of lineside component storage areas	✓	✓
	Transport of replacement components to site	✓	✓
Removal of old S&C and site preparation			
	Movement of plant and personnel to site	✓	✓
	Dismantling and removal of S&C panel	✓	✓
Installation of replacement S&C			
	Installation and assembly of panel	✓	✓
	Welding	✓	✓
	Initial track geometry restoration	✓	✓
	Control system commissioning	✓	✓
	Final commissioning and testing	✓	✓
	Removal of plant and personnel from site	✓	✓
Post-renewal activities			
	Final track geometry restoration	✓	✓
	Final inspection and acceptance	✓	✓
Time penalties			
	Time lost as a result of possessions	✓	✓
	Temporary Speed Restrictions	✓	✓

Table 1 – Breakdown of work elements for conventional and novel S&C renewals

4.1.1 General assumptions – productive shift length and labour

Most IMs have shift lengths for maintenance and renewal activities of approximately 8 hours, and hence this was taken as the standard shift length for the analysis. Weekend and overnight

possessions can generally be considered to be of a similar length, although it must be acknowledged that weekday overnight possessions can often be shorter as a result of service demands.

The productive length of each 8 hour shift, however, is invariably much shorter as a result of the time needed to travel to site, set up and take down and withdraw from site. Actual productive working time per shift can be significantly lower than the shift length, and one European IM quotes an average productive working time of 4.5 hours calculated as follows:

Average shift length	**8**	**hours**
Less:		
Travel to site	0.5	hours
Set up site	0.5	hours
Other interruptions	1.5	hours
Take down site	0.5	hours
Travel from site	0.5	hours
Total working time	**4.5**	**hours**

For this analysis, with some exceptions, it is assumed that labour cannot be deployed usefully outside the productive working time for other significant work activities, and therefore must be charged on the basis of a full shift for the work activity concerned. Labour requirements for all work activities also acknowledge the fact that staff will be required for unproductive but essential activities such as safety provision, and the resources allocated for this are noted for each work activity.

Hourly rates for labour varies widely across member states and staff grades, so absolute labour costs accurate for all member states cannot be derived, therefore labour volumes are shown in hours throughout.

4.1.2 General assumptions - plant

Plant costs have been estimated on the basis that the equipment attracts hire/lease charges for a full 8 hour shift, but down time either side of the renewal activity whilst awaiting deployment having been transported to site and prior to collection after the renewal activity have not been included. Charge out rates for plant vary widely across member states, and according to the terms of individual leasing contracts and hire periods, so absolute plant costs accurate for all member states cannot be derived.

This analysis has assumed the following unit rates, which have been derived from actual rates used by a European IM in estimating costs when planning renewals, but these must be revised according to local circumstances:

Specialist road/rail plant e.g. excavator or material/spoil train	€2,000	per shift
Conventional excavator or similar, or medium weight commercial vehicle	€1,000	per shift
Tamper, regulator or stoneblower plus crew	€4,000	per shift
Small plant or specialist tools	€500	per shift

4.1.3 Pre-renewal and preparation activities

Pre-renewal activities and preparation work will be required prior to the S&C renewal taking place to ensure that site access is facilitated and the materials needed for the renewal are on site and located as conveniently as possible at the time they are needed. Approximately one shift is required in total for these activities, which is in line with the time of 5-10 hours that has been quoted by DB (reference D5.4.1 Section 4.1.2).

Selection and clearance of line-side component storage areas

This work activity covers the work undertaken whereby a site adjacent or near to the S&C is selected and prepared for the storage of plant and materials needed for the renewal. On the assumption for this study that an access road is present adjacent to the railway, no access is required to the track to

complete this work activity and thus there is no need for disruption to traffic, hence this phase of the renewal is taken to be carried out outside of possession conditions.

Plant and labour requirements are assumed to be a single conventional excavator and crew of two for half of one shift, plus two members of safety staff to act as lookout and site warden. There may also be a requirement for small plant such as vegetation clearance equipment, and materials such as temporary fencing and gravel, but these are considered to be insignificant compared with the hire cost of the excavator.

Although modular S&C renewal requires fewer materials to be stored on site prior to the renewal taking place, some preparation work will be required so it is assumed that labour and costs will be identical to conventional S&C renewal.

Transport of replacement components to site

This work activity is the transport of materials to site that will be needed for the renewal, including the S&C components and drive, small plant such as generators, temporary lighting and welding equipment. Again, it is assumed that this work activity will be undertaken outside possession conditions with no interruption to traffic. Components are assumed to be delivered wholly by road in half of one shift, probably the second half of the same shift as that in which the site preparation work is undertaken. Plant and labour requirements are taken as being two medium weight commercial vehicles and crew of two, plus two members of safety staff.

For modular S&C renewals, since the S&C panels will arrive on site pre-assembled, the only materials that will need to be transported to site in advance will be the small plant, and so it is assumed that only one medium weight commercial vehicle will be needed. No reduction in labour requirements is anticipated however.

4.1.4 Removal of old S&C and site preparation

This phase of S&C renewal covers the work activities needed to remove the life expired S&C panel and prepare the substrate for the new S&C panel. These work activities need to be undertaken under track possession conditions, and for this analysis it is taken that the total duration of this phase will be two shifts.

This phase of renewal is required to be undertaken to the same scope and standard for both conventional and modular S&C renewal techniques, however in parallel with the introduction of the modular S&C renewal technique, Network Rail has introduced automated ballast collection, which has the potential to reduce the time for old S&C removal and site preparation to a single shift, which is assumed in the modular S&C renewal analysis.

Movement of plant and personnel to site

This work activity covers the provision of plant and personnel needed for the old S&C removal activities, and it is assumed that these facilities are retained for the second phase of the renewal. However, these resources are not included in this part of the assessment as they are accounted for later.

Labour resources are shown as being null for this work activity, as these would be accounted for as part of the unproductive time per shift quoted in Section 4.1.1 and thus included in the estimate given under the resources needed for the dismantling and removal of the S&C panel.

Plant costs are restricted to the transport needed for materials needed on the day (mainly ballast for a conventional S&C renewal) and removal of spoil at the end of the renewal. D5.4.1 states that most IMs use rail transport for these activities and it is assumed that one train is capable of being used for both activities. The cost of provision of this for the two shifts required for removal of the old S&C and site preparation is included in the estimate for this work activity.

Dismantling and removal of S&C panel

This work activity covers the disconnection of the S&C panel from the adjacent plain line sections and its interface with the signalling system, disconnection of power to its drive, and removal of the panel. Following removal of the spoil, this work activity also includes removal of life-expired components plus spoil, and the scarification of the ballast.

Labour requirements for this work activity, based on information supplied by an IM, is taken as being a total of 16 persons for two shifts, consisting of ten track workers, four safety personnel and two signalling interface engineers.

Plant requirements are taken as being one specialist road/rail excavator, with two additional tools, plus two items of small plant such as a dumper truck for removal of spoil.

For the modular S&C renewal analysis, the use of automated ballast collection significantly reduces the shift length needed to one shift, with the specialised plant needed being a direct replacement for the road/rail excavator. With increased mechanisation the labour needed is also reduced and this has been accounted for by reducing the number of track workers required from ten to six.

4.1.5 Installation of replacement S&C

This third phase of S&C renewal covers the extensive work activities needed to install and commission the replacement S&C panel, including installation of:

- Geotextiles and ballast
- Bearers
- Fastenings, rails and frogs, plus:
- Welding and grinding
- Initial track geometry restoration
- Control system commissioning
- Final commissioning and testing
- Removal of plant and personnel from site

The total duration of this phase is taken to be two shifts, which together with the removal of the old S&C work activities gives a total time of 32 hours needed on site for the major renewals work, which is consistent with the 30 hours quoted by Banverket and 37 hours quoted by Network Rail in D5.4.1. The following sections define the resources needed for the major work activities to be undertaken during this phase of the renewal.

There is again significant potential for savings in time, labour and plant to be accrued through the use of modular S&C renewal techniques during this phase, and the nature and potential of these are described where appropriate in the following sections.

Installation and assembly of panel

The bulk of the labour and plant requirements for conventional renewals are accounted for in this work activity, and it is acknowledged that these resources will also be used to some extent to deliver the other work activities. The installation and assembly phase of the S&C renewal also utilises the same resources used for removal of the old S&C panel, and hence labour requirements are taken as being a total of 16 persons for two shifts, consisting of 10 track workers, four safety personnel and two signalling interface engineers, and plant requirements are taken as being one specialist road/rail excavator, with two additional tools, plus two items of small plant such as a dumper truck for removal of spoil.

The work undertaken during this work activity covers installation of the new ballast sub layer, laying down of bearers, installation of chairs and sliders followed by the crossing itself and the stock, switch and check rails and tie bars. Also included is installation of the additional ballast needed in the sleeper cribs and shoulders.

There are significant savings that may be made in this work activity through the adoption of the modular S&C renewal technique, mainly through the ability to install the S&C panel much more quickly than for conventional renewals. All of the work that would otherwise be needed to lay the bearers, slide chairs, rails, fastenings and drive mechanism can be achieved in one operation, and the information given by the IMs shows that there is the potential for the whole renewal to be achieved in 8 hours. There are also significant potential for a reduction in the labour needed, as much of the renewal is mechanised using specialised rail wagons with tilting beds.

The analysis assumes therefore that modular renewal can be completed in one shift, with a reduction in the number of track workers to six. It also assumes that the road/rail excavator which would be used for the conventional renewal would not be required, although there is an equivalent cost associated with provision of the train of specialised wagons.

Welding

This work activity covers the welding activity required to connect the S&C panel to the adjacent plain line including rail re-stressing and rail grinding once the panel has been installed, with resources taken as being four welders for one shift, plus four items of specialist welding equipment.

Initial track geometry restoration

Restoration of the track geometry to allow safe resumption of services following installation requires one tamper plus crew for one shift.

Even with geometry restoration, conventional renewals usually require application of significant temporary speed restrictions (TSRs) to reduce the impact of settlement of the ballast and panel under traffic conditions. Modular S&C renewals can drastically reduce this as a result of the higher installed quality and integrity of the panel, even to the point where immediate restoration of line-speed operation is possible.

Control system commissioning

This work activity covers the commissioning of the S&C drive and its reconnection and interfacing with the signalling system. Lubrication of the slide chairs and rollers and adjustment of the switch rail throw and locking mechanisms will be undertaken during this work activity. It is assumed that the bulk of the labour and plant needed for this will be supplied from the resource already accounted for in the work activity covering installation and assembly of the S&C panel, however there will also be a requirement for the services of specialist signalling engineers. This work activity therefore covers the resource needed for these, this being two signalling engineers for two shifts.

Final commissioning and testing

Upon completion of the S&C panel renewal and commissioning, this work activity covers the testing, inspection and acceptance required. The additional resource needed for this work activity is assumed to be two permanent way engineers for one half shift.

Removal of plant and personnel from site

This work activity covers the removal of plant and personnel that were needed for the S&C removal activities upon acceptance and hand back. Labour resources are shown as being null for this work activity, as these would be accounted for as part of the unproductive time per shift quoted in Section 4.1.1 and thus included in the estimate given under the resources needed for the installation and assembly of the S&C panel.

The plant cost included in this work activity covers provision of train used for the component, ballast and spoil removal for the two shifts required for the installation and assembly of the S&C panel. This is assumed to be the same train used in the phase where the old S&C panel is dismantled and removed.

4.1.6 Post-renewal activities

After a period of ballast and panel settlement under traffic following handback, it is usual for track geometry to be restored and the S&C panel to be inspected and maintained to ensure correct operation of the switch rail throw and locking mechanisms. This phase covers the resource and labour needed for these activities, which are assumed to occur overnight or outside track possessions without disruption to train operations.

Final track geometry restoration

The resources needed for this work package to restore the track geometry to allow safe resumption of linespeed operation requires one tamper plus crew for one shift.

Final inspection and acceptance

This work activity covers the drive adjustment, testing, inspection and acceptance required following final track geometry restoration. The additional resource needed for this work activity is assumed to be two permanent way engineers for one half shift.

4.1.7 Time penalties

An additional element of the LCC analysis of S&C logistics is the need to account for the value of time lost as a result of the track being unavailable for use by scheduled train services during the possession time needed for the S&C renewal, and also the degraded performance as a result of temporary speed restrictions (TSRs) being imposed in advance of full commissioning. The monetary value of these time penalties will vary widely according to the traffic levels that would otherwise be using the railway and the terms of the national access charging regimes.

As described in D5.4.2, significant penalties can also be imposed under the terms of the national operator or regulator policies governing access to the railway infrastructure, with such penalties resulting from S&C renewal accounting for 26% of the total in 2008/9 for Network Rail.

It is thus difficult to quantify such time penalties in the analysis in terms of monetary values, or in a manner whereby their impact is appropriately proportioned in comparison with the labour, materials and plant costs of the renewal.

Therefore, the potential reduction in possession time needed for S&C renewal using the modular technique has been calculated as an index against that for conventional S&C renewal. For imposed TSRs, the appendices give an average speed limit and duration which has been based on the information given by IMs for D5.4.1.

4.1.8 Contribution of novel S&C to reduction of LCC

The analysis described in Section 4.1 has shown that the adoption of the modular technique for S&C renewal has significant potential to reduce the volume of labour, plant costs and possession time required for a typical S&C renewal.

In terms of labour savings, modular S&C renewal has the potential to reduce the total manpower required by 51%, and possession time reduced by 62.5% from 32 hours to 12 hours.

Indicative plant costs may be reduced by 30%, although this is highly dependant on individual lease/hire agreements, and does not consider the capital cost and impact of residual value of the specialised tilting bed wagons required for modular S&C renewal.

No quantification has been made for the potentially significant savings from the reduction of the time and magnitude of TSRs imposed following reopening to traffic, as these are dependant on the track access charging and penalty regimes imposed by member states and the traffic and track characteristics of the specific renewal sites.

In addition to the LCC savings that may be achieved from the labour, plant costs and possession time factors analysed as part of the work to produce this report, D5.4.1 has also shown that IMs anticipate that the improved installed quality achievable using modular S&C renewal techniques can reduce the rate of service affecting failures by nearly 30% (reference D5.4.1 Section 4.2.2).

4.2 Exemplar route case study

To illustrate the magnitude of some of the potential LCC savings that can be accrued from implementation of modular S&C renewals, and the impacts of the higher installed quality on subsequent S&C reliability, this section applies the findings of WP4.5 to one of the INNOTRACK case study routes.

Woking Junction to Portsmouth Harbour is an 80km mixed traffic route in the United Kingdom of mainly twin track with a ruling line speed of up to 160km/h, and is therefore representative of the type of route for which the S&C logistics work breakdown analysis is applicable.

A database of the instances of S&C located along the route was sourced, which was filtered to include only the S&C located on the main lines. Low speed S&C at stations and loop lines were not considered to be representative. The result was that 55 instances of S&C were found.

An age of road analysis was then undertaken which showed that there was a wide range of installation dates for the 55 instances of S&C, so the median year of installation was calculated to determine an average age for the S&C located on the route. This average age was approximately 25 years which also accounted for more recent S&C renewals that were not included in the data, which in turn enabled the S&C renewal frequency of 2.2 S&C units per year to be calculated.

At the labour and plant logistics savings determined as part of this study, if all subsequent renewals on the route were undertaken using the modular S&C renewal technique, time savings per year for renewals on this 80km route section could amount to over 700 hours for labour, and 44 hours for possession requirements.

These annual savings could ultimately be increased to over 900 hours for labour and nearly 60 hours for possession requirements, if the 30% increase in reliability resulting from the higher installed quality can be translated to S&C life, once replacement of all of the S&C units on the route had been completed using the modular S&C renewal technique.

Significant in service reliability improvements are also possible if all of the S&C units on the route are replaced using an optimised modular S&C renewal technique. Network Rail's aspiration to raise the mean time between service affecting failures (MTBSAF) from 1 in 2.5 years to 1 in 3.5 years through the introduction of optimised modular S&C renewal (reference D5.4.1 Section 4.2.2) equates to a potential reduction in failures associated with S&C from 22 per year to 15 per year for the Woking to Portsmouth Harbour route.

5. Conclusions

The initial analysis detailed in deliverable D5.4.1 showed that implementation of a renewal strategy based on the use of either of the modular S&C technologies studied would have the potential to reduce S&C logistics costs through:

- Improvement in the initial quality of installation, and the subsequent benefits from reduction in track geometry and component degradation.
- Reduction of life cycle costs.
- Manpower savings.
- Reduction in possession times.
- Restoration of immediate full linespeeds.
- Modal shift from road to rail for delivery of components and S&C units.
- Shortening of delivery timescales.

The subsequent analysis detailed in this report has further quantified the LCC savings that may be realised from implementation of modular S&C renewal techniques, and has shown that these can contribute to the INNOTRACK goal of reducing whole system LCC by 30%. For a renewal of a single standard switch of type UIC60-EW-500-1:12, it has been shown that significant LCC savings may be achieved as follows:

- 51% reduction in labour hours required;
- 62.5% reduction in possession times
- 30% reduction in plant costs.

Additionally, IMs that are implementing modular renewal of S&C are anticipating that the improved installed quality achievable can reduce the rate of service affecting failures by nearly 30%.

6. Annexes

6.1 Single standard switch (UIC60-EW-500-1:12), conventional renewal

6.2 Single standard switch (UIC60-EW-500-1:12), modular renewal