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INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

Deliverable D5.2.3 - Improved logistics from INNOTRACK solutions

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

Abbreviation / acronym	**Description**
AT	Alumino-Thermic
CER	Community of European Railway
EFRTC	European Federation of Trackworks Contractors
EIM	European Infrastructure Managers
ERPC	European Railway Procurement Committee
FB	Flash Butt
FFBW	Factory Flash Butt Welding
HLOS	High Level Output Strategy
IM	Infrastructure Manager
IM	Infrastructure Manager
ITS	Integrated Technology Strategy
KPI	Key Performance Indicators
LCC	Life cycle costs
LICB	Lasting Infrastructure Cost Benchmarking a UIC project since 1996
LWR	Long Welded Rail
M & R	Maintenance and renewal
MFBW	Mobile Flash Butt Welding
PPP	Public Private Partnership
S&C	Switches & Crossings
SP	Sub-Project
TRIS	Track Information System
TSI	Technical Specification for Interoperability
WP	Work-Package

1. Executive Summary

Logistics is the management of the flow of goods and other resources between the point of origin and the point of consumption in order to meet the requirements of the user. It involves the effective integration of activities such as information flow, transportation, inventory, warehousing, and material-handling that together realise the value of time, space capacity utilisation resulting in a cost effective supply chain. Although the origin of logistics lie within military, the modern business world recognises the importance of effective logistics and has fully embraced the important principles through detailed analysis, discrete event modelling, and computer simulation of the various stages.

The results from Sub-Project 5 constitute a big step forward in handling logistics and procurement in the railway sector in an efficient manner. The result is maybe not the same step forward that was foreseen in the INNOTRACK Description of Work at the beginning of the project. The reality was much more complex and above all more long-term than expected. But for the first time a lot of important issues have been identified and handled.

It has been showed that the logistic aspects have to be considered in the development of innovative solutions especially when the LCC arguments are taken into account.

Sub-Project 5 in INNOTRACK has identified the need for a better dialogue between the IMs and the contractors. At the same time, due to procurement regulations and procedures, this dialogue is today much stricter than earlier.

The reports in Sub-Project 5 also show that some of the questions raised by the contractors are already considered by the IMs. The problem is too often that it takes time to change procedures, a well-known Achilles' heel of the railways. Some problems, like increased possession times, are already in the focus for the majority of the IMs but the situation with increased traffic (many European countries had an all time high in operations during 2008) has in reality meant a decrease in possession times.

The present document provides a synthesis of the impact which could be obtained by implementing enhanced logistics procedures.

In relation with the Sub-Projects 2, 3 and 4 which were oriented to the development of technical solutions, Sub-Project 5 has studied the logistics of solutions related to Support, Switches & Crossings and Rail. These subjects are detailed one after the other in the present document.

Concerning the logistics of track support structure the content of the report can to be seen as an attempt to put Sub-Project 2 output in the context of the relation between Infrastructure Managers and Contractors.

The findings of WP5.1 (see D5.1.7) have identified seven areas which are critical to success, mostly linked to management issues. But among these, some may also have a direct technical repercussion which effect could be felt on worksite, and these are : Work programming; Project management and logistics; Rules and regulations; Plant.

With these elements in hands, the logistics view on Sub-Project 2 new products can be built.

In the Sub-Project 2 many investigation and innovative developments were carried out pertaining to the assessment, monitoring and reinforcement of track sub-grade as well as the evaluation and test of superstructure innovations.

The implementation of the innovative solutions developed by Sub-Project 2 will involve some logistics and possibly new processes which may bring about changes compared to the current way of working. For example new equipment or tools, which are not commonly used at the moment on trackwork site, may be required. Planning of the work and possession may have to be more anticipated, traffic disruption is not required or no speed restriction is necessary at handover to operation, etc.

The proposed study will be limited to some selected output of Sub-Project 2 related to :

- sub-grade improvement by implementing inclined Lime/Cement columns from trackside
- new ballast less trackform consisting of embedded slab track developed by Balfour Beatty, and of Corus steel slab track.

The report on the logistics of Switches & Crossings includes consideration of the innovative S&C solutions developed within Sub-Project 3 – Switches & Crossings. It 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%.

Finally regarding Logistics and Rail, the importance of effective management of the supply chain and logistics for the maintenance of renewal is widely recognised and has driven the following three key developments that have made a step change difference in the optimisation of logistics of rail:

1. 120m long as-rolled rails
2. Rail delivery systems

3. Mobile solid phase flash butt welding process

Nevertheless, logistics of rails remains complex as it is affected by a very wide variety of factors such as the intended use of the rails (track renewal, track maintenance, S&C manufacture) and access to the location of use. Consequently, it was recognised that the development of a definitive directive for the logistics of rails should not be the prime objective of the Innotrack Project. Instead, critical analysis of the various factors influencing logistics of rail was considered to be more beneficial as it would enable a clearer adoption of the principles involved for the variety of circumstances encountered on different European networks. Several conclusions have been drawn from the analysis and the key aspects related to the financial impact of rail logistics are:

1. It has been concluded that logistics is an enabling technology for the introduction of innovations such as long length rails and mobile FB welding. Consequently the resulting benefits are already accounted for against the respective innovations.
2. The second area of financial impact should be covered by the contractual agreements between the rail supplier and IMs but availability of unit cost (Euro per tonne-km) could yield savings by comparison.
3. The final area of financial impact is likely to result from the choice made from the selection of logistic solutions discussed in Section 3. However, the optimum choice is not universally applicable to all networks and all circumstances and consequently it is not possible to derive a numerical first cost or LCC saving for each of the choices. Instead, the discussions presented in Section 3 could be converted into a “decision-tree” software programme to facilitate the choice of the optimum logistic solution. However, this was outside the scope of the current project.

2. Introduction

The innovative technical products were developed in the Sub-Project 2 (Support); Sub-Project 3 (Switches & Crossings); and Sub-Project 4 (Rail & Welds) with the challenging objective of a 30% gain in LCC.

The subject of Sub-Project 5 (Logistics & Services) is rather about processes and methods related to new track construction and maintenance & renewal :

- How to bring to the site track components, equipment & tools ?
- How to maintain these components ?
- How to manage the access to the track and the track possession ?

And the main question was: “How to improve the logistics ?”

Keeping in mind that the 30% gain in LCC provided by a technical solution could be wasted through bad logistics solutions.

From the results of the Work-Package 5.1 it has appeared that the interaction between contractors and infrastructure managers bears significant potential for savings (see deliverable D5.1.7).

And this could be reached by addressing the following (but non exhaustive) matters :

- A preparation in advance of the works related to planning, track access and possession, supply.
- An optimisation of the means and resources.
- The possibility of crossing borders (setup of common rules & regulation throughout EU)

The structure of Sub-Project 5 was setup to address the logistics issues in relation with the output of Sub-Projects 2, 3, and 4 :

In the continuation of Work-Package 5.1 dealing with the review of existing, the conduct of interfaces between contractors and infrastructure managers and identifying ways of improvements…

The validation of improvements was carried out in Work-Package 5.2.

And the application to :

- Support, S&C, and Rail

were led respectively in Work-Packages 5.3, 5.4, and 5.5.

A synthesis of this work is presented in this deliverable in the sections below.

3. Design of validation procedures

3.1 Introduction and approach of validation procedures

As stated in D5.1.7 the interface between contractors and infrastructure managers bears significant potential for increasing efficiency of track maintenance and renewal works. It is also stated that the performance of the contractors' works can be improved by more collaborative partnership-based approach with infrastructure managers aimed at optimising the use of the possession times available, reducing the costs and/or delivering more for available budget and thus increase the efficiency of providing railway infrastructure for operators in general. The problem was to find the right organisation within the IMs where the question is dealt with. Since the question is wide there are often several different parties who are handling parts of the question. The consequence of this is that INNOTRACK has met difficulties in SP5 to find the people in charge of these questions.

The following activities have been carried out to meet these difficulties.

3.1.1 Information exchange with European Railway Procurement Committee - ERPC

ERPC is an informal group that was created within UIC among the heads of procurement in different railways. They have annual meetings and the main idea is information exchange. There are no working groups with an allocated budget reporting to ERPC.

INNOTRACK has been reporting to, and discussing with the ERPC. In Saltsjöbaden on the 6th of March 2007 INNOTRACK was on the agenda. Several members of ERPC were afraid that INNOTRACK would give participating industry preferential treatment. Of course this is the case since the participating industries works close to the IMs and gets information about problems that the IMs have and also needs for specific innovations. At the same time it is important to point out that there is no preferential treatment in specific purchase situations, which is the important item from a legislative point of view. There is no alternative to working in projects like INNOTRACK if the railways shall have a competitive and well functioning railway industry.

In October 2009 INNOTRACK results were presented to the ERPC in Germany.

3.1.2 Starting up long term work in organisations within and outside INNOTRACK

Since INNOTRACK is a project limited in time and resources it is important that existing organisations within and outside of the INNOTRACK consortium takes over the responsibility of the result from INNOTRACK. This is especially the case since most implementation is done when INNOTRACK is ended. One initiative in SP5 is described in the above section. Another initiative was to hand over some of the result to working groups in existing bodies. This has been very successful and is described in chapter 3.

3.1.3 Open questions after INNOTRACK

The biggest problem is that European practices vary considerably between different countries. The situation is also very complex within most countries. A lot of national practices and laws regulate the situation in every individual country. This means that the transformation process will be much longer than expected. The intention from INNOTRACK was to address these questions to IMs and industry so that the results of SP5 will become a basis for future work and not some interesting “shelf warmers”.

One must have in mind that benchmarking of unit costs indicates that there is considerable room for improvement. Only in adopting the currently best practice there is a significant potential in reducing costs and increasing performance of track maintenance and renewal.

3.2 EIM, EFRTC and CER Working groups

3.2.1 Market strategies

Remit for market strategies

Michael Robson EIM is responsible for this Working Group. The group is lead by Martin Arter NR.

The purpose is to propose methodology/criteria for IM’s to assess the benefits/disbenefits of contracting in or contracting out maintenance and/or renewal of their network. These methodology/criteria should be based on current best practices, whilst also exploring the scope for new processes.

It is also to identify any points of principle which should be followed e.g. the client must not loose its knowledge of the assets.

The scope should detail the main areas where the methodology can be used encompassing an understanding of the long term costs and benefits of either contracting in or out or a mix of

strategies. It should also propose the type of data which should be shared between IM/Contractors to ensure that a balanced view is reached. The work started by looking at the areas of major costs track work, signalling, electrification before moving onto other areas e.g. telecommunications. The scope does not include actual procurement of the services. In order to ensure no bias from either side it is proposed to have the sessions run by a facilitator.

Planned deliverables:

- A document which lists measurable criteria under different headings, separating maintenance and renewal by track work, signalling and, electrification
- Identification of categories of information which can be shared between IM/Contractors and a proposed format for this together with how this information would be used in evaluating contracting strategies.

Result so far

A questionnaire on in/outsourcing maintenance & renewals has been sent out and answered. The questionnaire covered two aspects:

- What criteria do IMs use to make decisions on in/outsourcing M&R works?
- How do IMs measure the performance of contractors and/or in-house teams in charge with M&R works?

Network Rail prepared the questionnaire. Below you can see some result from these questionnaires.

There are also several case studies.

Please rate the following criteria according to their importance in taking decisions to in/outsource maintenance & renewal works	*1 = not important, 5 = essential*					Average score	Rank
	1	2	3	4	5		
➢ There is a rigid, constraining framework (national law, political context, pre-defined policy…) that limits in/outsourcing decisions by the IM	3	2	2	2	2	2,8	12
➢ Competence available in-house vs. competence available on the market	1	0	3	4	3	3,7	7
➢ How critical the activity is, desire to maintain a certain level of control	0	1	0	4	5	4,3	1
➢ Keeping knowledge and know-how inside the company	0	1	1	3	6	4,3	2
➢ Large vs. smaller volumes of work	1	0	6	1	3	3,5	9
➢ Level of competition on the contractors' market	1	0	1	5	4	4,0	4
➢ Access to technology / innovation / knowledge	1	1	1	4	2	3,6	8
➢ Cost optimisation	0	1	0	5	5	4,3	2
➢ Own resource optimisation	1	1	0	3	5	4,0	4
➢ Peak period leading to an overload of work	1	2	2	2	3	3,4	10
➢ A positive risk analysis has been carried out	2	2	3	2	1	2,8	13
➢ Contractor's track record of successful projects	2	1	3	0	4	3,3	11
➢ Evidence that the contractor has appropriate resources and the capability to deliver the activity to the agreed specifications and schedule	0	2	3	1	5	3,8	6

Part 1: decision-making criteria from 11 Infrastructure Managers.

Value Adding Behaviours	*Please state whether you agree or disagree that the following behaviours **add** value*			Agree	
	Agree	Partly agree	Disagree	*IMs*	*Contractors*
➢ Openness on the work scheduled to be done over the medium-term (five years)	87%	7%	7%	57%	100%
➢ Clarity and simplicity of technical, legislative and safety standards required to be met in delivering the work	94%	6%	0%	100%	89%
➢ Long term partnerships between client and contractor	63%	19%	19%	43%	78%
➢ Single point of contact with contractors	50%	36%	14%	43%	44%
➢ Development of industry wide training schemes that contractors are able to get involved in if they wish	67%	27%	7%	86%	44%
➢ Behaviours of mutual respect – treating each other with honesty, courtesy, openness and respect – agreed via a partnership charter or equivalent	88%	13%	0%	86%	89%
➢ Joint development of whole life best value solutions	87%	7%	7%	71%	89%
➢ Collaboration and concise, clear, timely communication	88%	13%	0%	100%	78%
➢ Good Safety and Environmental culture at all levels	100%	0%	0%	100%	100%
➢ Openness about Financial issues	69%	25%	6%	71%	67%
➢ Work is delivered to the agreed quality first time	94%	6%	0%	86%	100%

Part 2: value-adding vs. value-destructing behaviours form 7 IMs, 10 contractors in 10 countries.

Value Destroying Behaviours	*Please state whether you agree or disagree that the following behaviours **destroy** value*			Agree	
	Agree	Partly agree	Disagree	*IMs*	*Contractors*
➢Lack of clarity in scope of work to be done, frequent uncontrolled and late changes by client, specifications, standards and capacity	100%	0%	0%	100%	100%
➢ Short-term late-notice contract award	88%	6%	6%	86%	89%
➢ Poor scope definition at both the future workbank level and individual project level as well as late changes to scope	88%	13%	0%	71%	100%
➢Switching between in-sourcing and out-sourcing for any particular activity	63%	31%	6%	43%	78%
➢ Lack of focus by client on activities that could make the contractors more successful	75%	19%	6%	71%	78%
➢ **Poor site management or pressure to take "short cuts"**	94%	0%	6%	100%	89%
➢ **Poor quality work impacting passengers and requiring corrective action**	88%	13%	0%	86%	89%
➢ **Poor change management process**	81%	6%	13%	71%	89%
➢ **Short notice change to track access requirements or availability**	93%	7%	0%	71%	89%

Part 2: value-adding vs. value-destructing behaviours form 7 IMs, 10 contractors in 10 countries.

Today a structure for the Market Strategy draft report is ready. In the background the INNOTRACK report is an important input to this work**.** The report will have two parts. The first is "Decision making criteria used by Infrastructure Managers" where identifying types/categories of relevant criteria, measuring performance of maintenance & renewal works and refining and weighing range of criteria identified is reported. The second is "Understanding the importance of behaviour". Finally there will be and Catalogue of best practice examples and also General conclusions and recommendations

This work is a good example who other bodies have taken over an done a good job

3.2.2 Long term Funding and Strategic Planning

Remit Long term Funding and Strategic Planning

Michael Robson EIM is responsible for this Working Group.

The purpose is to deliver proposals on how to empirically measure the benefits of Long Term Funding and Strategic Planning in the railway industry in respect of maintenance and renewal. The ability to measure the benefits will enable more effective lobbying for long term funding.

The scope is limited to maintenance and renewal work. The group should look at all factors including investment in people, process, research and machinery.

A careful study should be made of the UIC ongoing work Lasting Infrastructure Cost Benchmarking (LICB), Regulatory Bodies and IM/Contractors KPIs to see what already exists and how they could be built upon.

Planned deliverables:

- A set of performance indicators showing projected performance, asset condition, safety and price across a number of key activities over periods of between 1 and 10 years as a benefit of long term financing. This information will be used by IMs to lobby Member States for long term funding of infrastructure investment
- A table showing the reducing costs/increased output for the same level of investment over varying periods of time from 1 to 10 years. This information will be used by IMs to lobby Member States for long term funding of infrastructure investment
- A set of common KPIs to be used by IM/Contractors showing outputs in key areas to support EIM/CER in discussions with member states in terms of Multi Annual Contracts. These KPIs should cover the main activities in track work signalling and electrification.

Result so far

The lack of IM resources has made today's result poor.

3.2.3 Safety issues hindering harmonisation of rules and regulations for cross-acceptance of machinery, staff and working processes

EFRTC is responsible for this Working Group. The work is planned to end in 2010.

The objective of this task is to facilitate the cross-acceptance of contractors work by harmonizing safety rules and regulations related to contractors' plant, staff and works based on true willingness to find a consensus with added value for both national and pan-European level.

The Tasks are.

- Completion of the overview of the application of the Safety Directive 2004/49/EC with full European coverage with regard to
  - Safety authorities
  - Investigating bodies
  - Role of IM
  - Impact on the contractors
- Review of the safety requirements as applied by IMs and legislation per country – identification of differences and problems for cross acceptance aiming at harmonisation of the safety rules for work-site protection and logistics
- Cost implication of the safety requirements for contractors – benchmarking and best practices
- Means of the protection of the staff working in the track – review of the existing systems and proposal for harmonisation
- Contractors involvement in the process of the revision of TSIs related to safety
- EIM and EFRTC cooperation with regard to the elaboration of CEN standards related to safety
- Agreement on the calendar for the implementation of harmonized rules and regulations

Planned deliverables:

- Review of the application of Safety Directive – identification of potential impacts on contractors and commitments to implement by all stakeholders – report (lobbying document) at M6, responsible: Mr Naggar
- Review of current equipments and practices for the protection of the staff working in the track, report (benchmarking/code of practice) at M12, responsible; Mr Guyot
- Identification of major obstacles in application of the various safety requirements for cross-acceptance of contractors work – report (lobbying document/code of practice) at M12, responsible: Secretary General
- Proposal for harmonisation of the safety rules for work-site protection and logistics report (code of practice/proposal for rules/regulations) at M18, responsible:
- Cost implication of the safety requirements for contractors – report (lobbying document) at M 24, responsible:
- proposal for the European project on individual warning installations/systems complying with ERTMS/ETCS, proposal at M24, responsible: Secretary General
- Periodical reporting on contractors' involvement in the process of the revision of STI related to safety, reporting every 6 months, responsible: Secretary General
- Periodical reporting on EFRTC involvement in CEN activities, reporting every 6 months, responsible: Mr Guyot
- Periodical review of the agreed calendar for the implementation, reporting every 6 months, responsible Chairman

Lean and efficient working teams for each item with the appointment of the association's experts who shall be competent, committed and contributing to the fulfilment of remit. For this purpose it is essential to define the profile of experts and to select those accordingly.

3.2.4 Rules and Regulations – Harmonisation of Procurement Procedures

The remit of Rules and Regulations – Harmonisation of Procurement Procedures

This remit was based on the re-initiation of the tasks proposed by the former EIM/EFRTC Working Group on Harmonisation of Procurement (HoP). It forms a part of the overall remit for harmonisation of rules and regulations for cross-acceptance of contractors following the proposals of the joint infrastructure managers – contractors' workshop (Paris, 18.06.2008) as outcome of the INNOTRACK project.

The tasks is carried out by the newly set-up joint Working Group with strengthening the participation of infrastructure managers from EIM, enhancing them by infrastructure managers - members of CER, and contractors – members of EFRTC.

The appointments of the members for the new joint CER/EFRTC/EIM Working Group is made on the basis of the circulation of this remit by EFRTC, EIM and CER secretariats to its members calling for the experts of their members having capability and expertise to work on this remit.

The Chairmanship of the joint Working Group will be assured jointly by appointed infrastructure manager and contractor. Eric Maatjes from ProRail on behalf of infrastructure managers and Nick van den Hurk from VolkerRail on behalf of contractors are proposed to act as the joint Working Group Chairmanship.

Planned deliverables:

- Remit – "Lobby" document as a call for experts to "man-up" the working group. Circulation of call by CER/EFRTC/EIM secretariats ends 2008.
- The start of the work by current core team, appointment of participants was the 7th October 2009. Produce a draft document on decision making process.
- Draft documents (in a matrix format) per EIM / CER member on:
  - Technical requirements ;
  - Organizational set up ;
  - Administrative and economical thresholds ;
  - Staff build up and competences ;
  - Plant & Equipment including the operational process & admittance ;
  - Current blockades preventing quick wins.
- Set of documents with analysis of the differences, proposals for solutions to overcome them based on consensus building.
- The sequence of the documents will be decided at the joint CER/EFRTC/EIM meeting.
- Draft document on the implementation of the recommendations; i.e. via cross acceptance of audit results.
- Draft document on the procedure to resolve differences of opinion on proposed solutions.

The objective is to set up lean and efficient working structure with the appointment of the association's experts who shall be competent, committed and contributing to produce deliverables as set up above.

Result so far

Also here there have been problem with engagement from IMs.
A new start up meeting was held in Amserdam on 7th October 2009. It was a breakthrough with nine contactors, ten IMs and three organisations. All participants agreed that the work was important and to carry on with the task according to the remit.
On the meeting the "DIRECTIVE 2004/17/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 March 2004 was one of the working documents. Coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors" was discussed and a will be a basic document for future work.

3.3 Validation of result

3.3.1 Validation criteria ratings

	WP 5.3 – Support		WP 5.4 – S&C		WP 5.5 – Rail	
Seven Success Critical Areas	Financial Impact	Difficulty of Implementation	Financial Impact	Difficulty of Implementation	Financial Impact	Difficulty of Implementation
A – Market Strategies	M	L	H	M	H	M
B – Long Term Funding and Strategic Planning	H	M	H	M	H	M
C – Work Programming	H	M	H	M	H	M
D – Management and Logistics	M	L	M	M	M	M
E – Contracting Strategies	M	L	M	M	M	M
F – Rules and Regulations	H	M	H	H	H	H
G – Plant	M	L	H	H	H	H

Financial Impact – High (H), Medium (M), Low (L) – High is worst case.

Difficulty of Implementation – High (H), Medium (M), Low (L) – High is worst case.

The separate validation above was not possible to do within INNOTRACK. Therefore it is based on earlier interviews and questionnaires from D5.1.5, D5.1.6 and background material.

1. H-L – 0 Cases
2. H-M – 9 Cases (Blue)
3. H-H – 4 Cases (Red)
4. M-L – 4 Cases (Yellow)
5. M-M – 4 Cases (Green)

It was suggested to regroup the seven success critical areas (A to G) since they have a different aspect.

Some are political like A, B and F. Some are commercial while others are logistics and engineering aspects together.

3.3.2 Findings

Market strategies have successfully been tackled. See chapter 3.1.

Long term funding, planning and contracting has also been tacked. It has not been so successful mainly due difficulties to find suitable and engaged resources from the IMs. See chapter 3.2.

Work programming and Project management and logistics have been worked with in WP5.3 – WP5.5.

Contracting strategies and rules and regulations have been worked with by EFRTC, EIM and CER. See chapter 3.3 and 3.4. It is also been a part of WP5.3-WP5.5.

Finally Plant has been worked with in WP5.3-WP5.5.

This means that all findings from D5.1.5 and D5.1.6 have been addressed.

4. Logistics and Support

4.1 Introduction to Logistics and Support

Following the review of existing methods and the analysis of the relation between Infrastructure Managers and Contractors, which was achieved during the development of the WP5.1, the current study could be presented as an application of WP5.1 results and conclusions to the logistic of SP2 output. Alternatively it could be presented as a logistics assessment of SP2 output analysed through the grid of the results and conclusions of WP5.1.

WP5.1 was aiming at identifying best practices and making proposals for promoting good management and logistic practices in track maintenance and renewal work. The development of the work, implemented through interviews and analysis, demonstrated that there is large potential for savings through the improvement of the overall process of track maintenance and renewal. Figures of savings between 10 to 30 % were set forth.

These figures are matching the INNOTRACK overall objective of 30% reduction in LCC and are showing that logistics aspects have to be considered in the development of innovative solutions. The other side of the coin is that a 30% gain in LCC provided by a technical solution could be wasted through bad logistics solutions.

It is thus vital to carry out a logistics assessment of the SP2 output. Those elements of WP5.1 with immediate application on site have to be first identified and then crossed with the logistics requirement of the SP2 innovations.

As an example, either Infrastructure Managers or Contractors, predominantly requested a better track possession policy, a better planning enabling for example the implementation of high output methods, the industrialisation of processes, common rules & regulations, and an optimised utilisation of the fleet.

- Elements of conclusions and recommendations from WP5.1 that can have a direct application for the development of WP5.3 are detailed below:
  - Contracting strategies of infrastructure managers e.g. long term planning, dependability, economies of scope and scale, output orientation (innovation, LCC-aspects), terms of employment/build-up and continuity of skills
  - Track possession policy: vast potential for process-innovation to make better use of operational windows
  - Industrial engineering of processes and worksites (good-practice knowledge management)
  - Rules and regulations, particularly in safety and logistics (worksite protection and material supply) have a massive impact on productivity and LCC.
  - Fleet utilisation for heavy equipment is often too low. This results in the fleet size of some very expensive machinery to often be far above real needs. The consequence is a high capital cost and an immediate consequence for initial direct costs of track maintenance and renewal. However, this situation is sometimes justified by few and short disposal times on high-density lines.

- Infrastructure Managers identified the following constraints affecting logistics:

- Fluctuating levels of funding from governments, adversely affecting the ability to plan long-term
- The loss of skilled staff through retirement and a shortage of suitable new people willing to come to the industry
- The variability of track condition resulting in relatively small and inefficient packages of work unsuitable for high-output methods of working
- A limited number of component suppliers resulting in resource shortages and poor competition

The output of SP2 that have been considered for the current study concern:

- sub-grade improvement by implementing inclined Lime/Cement columns from trackside
- new ballast less trackform consisting of embedded slab track developed by Balfour Beatty, and of Corus steel slab track.

The study should be seen as an attempt to put SP2 output in the context of the relation between Infrastructure Managers and Contractors.

4.2 Logistics analysis

4.2.1 Input and Benchmark from WP5.1

Different approaches have been followed to encompass the existing methods that have been developed throughout Europe: on one hand face-to-face interviews were carried out and on the other hand an online questionnaire was filled in.

Two aims of these investigations were: primarily to collect quantitative data with the help of questionnaires and interviews and secondly to collect qualitative information during face-to-face interviews. Quantitative information collection was about procedures relating to: rail; sleepers; ballast; switches and crossings; machinery; and maintenance and renewal planning.

Two deliverables summarise the studies:

- D5.1.5 “Final Report on Existing States-of-the-Art for Construction, Maintenance and Renewal Activities and Assessment of Logistic Constraints”
- D5.1.6 “Final Report on conduct of interfaces between contractors and infrastructure managers"

The logistics & support analyses in this report will be guided by these two reference documents.

From the conclusions and recommendations of WP5.1, two ways forward have emerged:

- one is focusing on the management and strategic level. It was taken over by the Infrastructure managers, members of EIM and CER and EFRTC contractors which are the most suited bodies to carry out this work;
- the second approach is focusing on the technical level and is developed inside INNOTRACK.

Figure 1 below shows the split of the work between the management and technical levels. This report deals with the technical level.

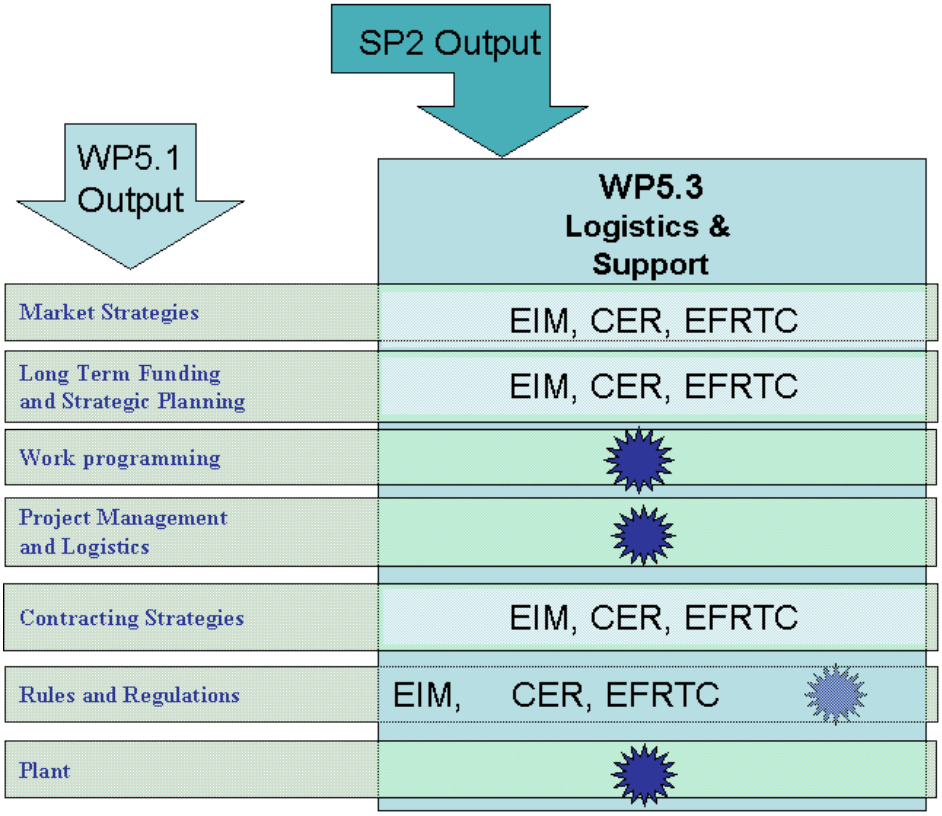


Figure 1: Split of logistics priorities between technical and management levels

Further, D5.1.6 has classified the key findings of WP5.1 pertaining to the conduct of interface between Infrastructure Managers and contractors into seven clusters detailed below:

A – Market strategy

B – Long-term funding, planning and contracting

C – Work programming

D – Project management and logistics

E – Contracting strategies

F – Rules and regulations

G – Plant

Among these areas those that have a direct application on logistics at a worksite level include:

- Work programming
- Project management and logistics
- Rules and regulations
- Plant

These areas thus have a direct application to the logistics of support.

Work programming

From a logistics point of view the fundamental building blocks for good economics of resource deployment with a substantial impact on unit cost are:

- plant and staff deployment during track possessions
- well programmed project pipeline and sequencing of plant and staff deployment (logistics from work-site to work-site)
- minimum disturbance strategies and procedures for assessing the overall costs of the intervention into the track

Work Programming to ensure the proper planning and programming is at the heart of all efficiency of contractors works and should include:

- consistent sequencing of all work over time and geographically
- coordination of activities, bundling
- a “clockwork” approach to worksite logistics and work execution (mutual programme management)
- a well programmed pipeline of major projects leading to such a “clockwork” approach to worksite logistics and work execution
- avoiding large programme changes resulting in increase of costs both for supply-side and regarding the execution of work
- careful attention to all details in the planning process and work programming

The infrastructure managers’ approach in this regard is a key to create a cost efficient framework, for the execution of works by contractors primarily by

- mid-term planning and work programming
- consistent sequencing of work
- logistics and execution dependability
- an even distribution of workload over the year

Project management and logistics

Multiple interfaces on site between IM, and the IM’s suppliers and contractors introduce cost and undermine responsibility to deliver efficiency. Maintenance and renewal works are often carried out by various parties (e.g. staff of the infrastructure manager for worksite protection, contractor's staff for work execution). This increases the number of the interfaces and the effort required for coordinating the work (elimination of synergies, process perturbations, etc.). There is also often a great variability in working time per possession – output can be improved by step change both in processes and technology. Substantial gains can be made (double digit %) if good-practice at the supply-interface is ensured.

Due to the fragmentation of work without clearly defined responsibilities for project management, the contractors cannot sufficiently influence the overall efficiency of the project. Moreover, they often have to take the risk for delay in the execution of the work and thus cost due to the disturbances in the logistics, which are beyond their potential intervention. It is therefore vital that project management is clearly defined and assured by a body/person authorised by client and agreed with contractor. The logistic process also has to be carefully designed in the overall programming of the work jointly with contractors at a very early stage. All changes in project management and logistics have to be agreed with contractors and risk properly allocated.

Rules and regulation

The differing rules and regulations are a key barrier to entry into national markets. This includes border issues: "it takes months sometimes to transfer equipment to another country". It also concerns cross-country acceptance of certifications for machinery (technical and process) and for innovations. Such an acceptance

would enhance competition and ensure that efficiency gains are rolled-out more easily. In general, a more open market would result in lower prices, more efficient sizing of capacity and better utilisation.

Sometimes very rigid rules for worksite protection and logistics can have a very substantial impact on productivity and costs. They can be also onerous in proportion to benefits. So there is a need for harmonisation based on good practices. This includes a certification process that encourages innovation rather than obstructing it

Plant

The cost for moving equipment (logistics) is often very high; it consumes considerable time, often as a consequence of improper planning Coordination between infrastructure managers and contractors in purchasing and specifications of heavy equipment is essential for "avoidance of over-sized, over-specified fleets".

Plant utilisation (e.g. measured by productive shifts per year) varies between less than 50% in some countries and up to 90% in others

Benchmark of logistics constraints

From the quantitative inquiry reported in D5.1.5, it is interesting to notice the benchmark of logistics constraints identified by the Infrastructure Managers (abstract of D5.1.5 hereafter).

Infrastructure Managers identified the following constraints affecting logistics:

- Fluctuating levels of funding from governments, adversely affecting the ability to plan long-term
- The loss of skilled staff through retirement and a shortage of suitable new people willing to come into the industry
- The variability of track condition resulting in relatively small and inefficient packages of work unsuitable for high-output methods of working
- A limited number of component suppliers resulting in resource shortages and poor competition

The input and benchmark that can be drawn from WP5.1 as presented above constitutes a helpful reading grid that will be the basis for the analysis of the logistic aspects and for the taking account of suggested ways of improvement.

4.2.2 Output from SP2 “Substructure”

SP2 has carried out many investigation and innovative developments on the assessment, monitoring and reinforcement of track sub-grade as well as evaluation and test of superstructure innovations.

The implementation of the innovative solutions developed by SP2 will involve some logistics and possibly new processes, which may bring about changes compared to the current way of working. For example new equipment or tools, which are not commonly used at the moment on trackwork sites, may be required. Planning of the work and possession may have to improve, etc.

Below, each “critical-to-success” area identified in section 4.2.1 will be considered and checked towards the logistics demands introduced by the SP2 innovations. A reference for comparison will be defined.

In this section logistics related to sub-grade improvements using inclined columns and related to superstructure improvements will be the analysed. This covers track work activities from the construction of a new track to maintenance and renewal.

The analysis will be developed following the framework below:

Field of implementation and reference

Is the solution applicable to maintenance, renewal or new track construction.

Reference to the traditional technique the innovation is aiming at replacing.

Work programming

Plant and staff deployment during track possessions.

Sequencing of work over time and geographically.

Coordination of activities: interfaces with other activities.

Logistics and execution dependability.

In case of maintenance or renewal: is traffic disruption, re-routing or other measure required .

Project management and logistics

Interfaces with other parties on site.

Possession and access to the track:

- worksite area required by the innovative solution, time from reception of worksite until handing-over for operation including preparation of worksite, convey of equipment & tools, etc.
- does the solution requires rail or road access (large or small; reinforced or not), which make not applicable in some configurations;

Rules and regulation

Are the equipment & tools used able to overcome borders hindrance?

Is there any certification required.

Plant

Description of equipment & tools required :

- does the innovative solution requires heavy or light equipment,
- with high or low output rate

Taking account of the logistics constraints

Does the installation of the innovative solution require skilled labour or not.

Are the track conditions suitable for high-output methods of working?

Does it require new components? How is the supply situation?

Sub grade improvement: inclined columns

Field of implementation and reference

This solution is essentially applicable to the maintenance of ballasted track when the reinforcement of the sub grade is required to avoid significant settlements. It is suitable when the track is laid on soft soils.

It is to be compared with a more classical solution, which would consist in removing the track, reinforcing the sub grade and reinstall the track.

Work programming

Plant and staff deployment during track possessions:

- A special machine for injection of lime/cement columns has to be brought on site with associated staff to operate it.

Coordination of activities: interfaces with others:

- No specific interface with other activities.

Logistics and execution dependability:

- Site has to be prepared for columns injection i.e. removal of stones if they are present.

Traffic:

- Work can be done without traffic interruption.

Project management and logistics

Possession and access to the track

- The worksite area is of a limited length: it is a punctual site, at the moment not foreseen to be implemented lengthwise over larger distances.
- Preparation of the worksite: stones have to be removed.
- Access to the track: access from side, which is able to support the load and dimension of heavy equipment.

Rules and regulation

Equipment & tools machine used, able to overcome borders hindrance:

- The type of equipment used should have no particular problems in crossing borders.

Required certification:

- A QA system for contractors is required.

Plant

- Heavy equipment is required (crane, specific cement columns machine).
- The total schedule is decreased by 30% with subsequent consequence on output rate. It can be increased by increasing the number of equipment.

Logistics constraints

- Skilled labour is required for operating the lime/cement columns injection.
- The market for lime/cement columns is functioning with good competition between competent contractors.

Superstructure innovations: steel–concrete–steel trackform

Field of implementation and reference

This solution is applicable to new track installation or renewal.

It should preferably be implemented in case of the renewal of a switch and crossing.

The reference for comparison is the classic ballasted track.

Work programming

Plant and staff deployment during track possessions:

- Heavy cranes have to be brought on the worksite to handle steel beams.
- Workers are required for mounting the steel structure and concreting.

Sequencing all works over time and geographically:

- It is similar to a classical ballasted track.

Coordination of activities: interfaces with others:

- In case of new track construction, interface with others is the same as with ballasted track construction.
- In case of renewal, there is an interface with the catenary system

Logistics and execution dependability

- Whether this innovative solution is implemented in renewal or new track construction, there is no specific dependability compared with ballasted track.

Traffic

- In case of renewal, traffic disruption is required on the concerned track. Work has to be done during night or a re-routing has to be implemented to minimize delay. Work programming in advance is then a major issue. However, the disruption will be less than for the traditional solution.
- When the track is handed over to operation no speed restriction is applied.

Project management and logistics

Interfaces with others on site

Possession and access to the track:

- road access which is able to support the load and dimension of heavy equipment
- possible rail access
- low track possession which could be justified by the modular aspect of the design and the use .of steel beams as structural support.

Rules and regulation

Equipment & tools machine used, able to overcome borders hindrance:

- the required equipment & tools consist of cranes and concreting truck which can easily cross borders.

Required certification:

- no specific certification

Plant

- Heavy equipment may be required in order to handle steel beams.
- Specific installation equipment could be developed in the view of a mechanised installation, which would increase the output rate.

Logistics constraints

- No skilled labour is required for the installation of this innovative solution.
- This innovative solution is developed by Corus.

Superstructure innovations: Embedded Rail Slab Track

Field of implementation and reference

- This solution is applicable to new track installation or renewal.
- The reference for comparison is the classic ballasted track.

Work programming

Plant and staff deployment during track possessions:

- A slipform paver has to be brought on site including a competent operator.
- Topographer for implementing the guiding of the slipform paver.
- Workers for the installation of the steel reinforcement, the rails, etc.

Sequencing all works over time and geographically:

- This type of installation method requires a significant length per day to be efficient.
- The formation has to be prepared and the guiding of the slipform paver has to be implemented.

Coordination of activities: interfaces with others:

- Whether it is a new track construction or a renewal, interface with others is the same as with ballasted track construction.

Logistics and execution dependability:

- The formation has to be prepared over a significant length
- Concrete supply has to be ensured to feed the slipform paver.

Traffic

- In case of renewal, traffic disruption is required on the concerned track. A re-routing has to be implemented to minimize delay.
- Work programming in advance is then a major issue.
- On handover to operation, a speed restriction has to be applied.

Project management and logistics

Possession and access to the track:

Depending on the type of installation the possession time will vary: it will decrease when using slip-form process and increase when using pre-cast elements and cast in-situ method.

The access to the track has to be adapted to the chosen installation method. Access of heavy equipment has to be considered when implementing pre-cast elements installation or slip-form process

Rules and regulation

Equipment & tools machine used able to overcome borders hindrance:

- the required equipment & tools, especially the slipform paver and the concreting truck should have no particular problem in crossing borders.

Required certification:

- no specific certifications

Plant

It is possible to use a slip-form paving machine, which will provide a high output rate and a good quality. Then a minimum length handed over from the civil works is required so that high output level can be reached.

Alternative solutions are :

- installation of pre-cast elements: requires heavy cranes
- cast in-situ installation: lower output rate.

Taking account of the logistics constraints

- The installation of this innovative solution requires a quite skilled labour for the operation and guiding of the machine.
- The track conditions and the use of a slipform paver can be suitable for high-output methods of working
- This innovative solution is developed by Balfour Beatty.

5. Logistics and S&C

5.1 Introduction to Logistics and S&C

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

5.2 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 baselining;

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 baselined 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.

5.3 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.

5.3.1 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

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.

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

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 lineside 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.

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.

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 linespeed 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.

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.

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.

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.

Not 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).

5.3.2 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 linespeed 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.

6. Logistics and Rail

6.1 Introduction to the Logistics and Rail

Logistics is the management of the flow of goods and other resources between the point of origin and the point of consumption in order to meet the requirements of the user. It involves the effective integration of activities such as information flow, transportation, inventory, warehousing, and material-handling that together realise the value of time, space capacity utilisation resulting in a cost effective supply chain. Although the origin of logistics lie within military, the modern business world recognises the importance of effective logistics and has fully embraced the important principles through detailed analysis, discrete event modelling, and computer simulation of the various stages.

The importance of effective management of the supply chain and logistics for the maintenance of renewal is widely recognised and has driven the following three key developments that have made a step change difference in the optimisation of logistics of rail:

1. 120m long as-rolled rails
2. Rail delivery systems
3. Mobile solid phase flash butt welding process

Nevertheless, logistics of rails remains complex as it is affected by a very wide variety of factors such as the intended use of the rails (track renewal, track maintenance, S&C manufacture) and access to the location of use. Furthermore, consideration of logistics of rails needs to be expanded to a wider perspective to include those aspects of renewal and maintenance that ensure optimum longevity of rail and the track as a system. Thus logistics of rails also needs to consider the influence of:

- Improved safety of track renewal and maintenance
- Improved quality of construction
- Reduced first time and life cycle costs of track renewal and maintenance

Achievement of the above targets requires a very significant technical input and these aspects, amongst other influencing factors, are discussed in this report.

6.2 Logistics of Rail – The Process

A schematic summary of the logistics of rails and associated activities is shown in Figure 1. Each of the 4 identified subsets are examined and discussed in more detail in the subsequent sections.

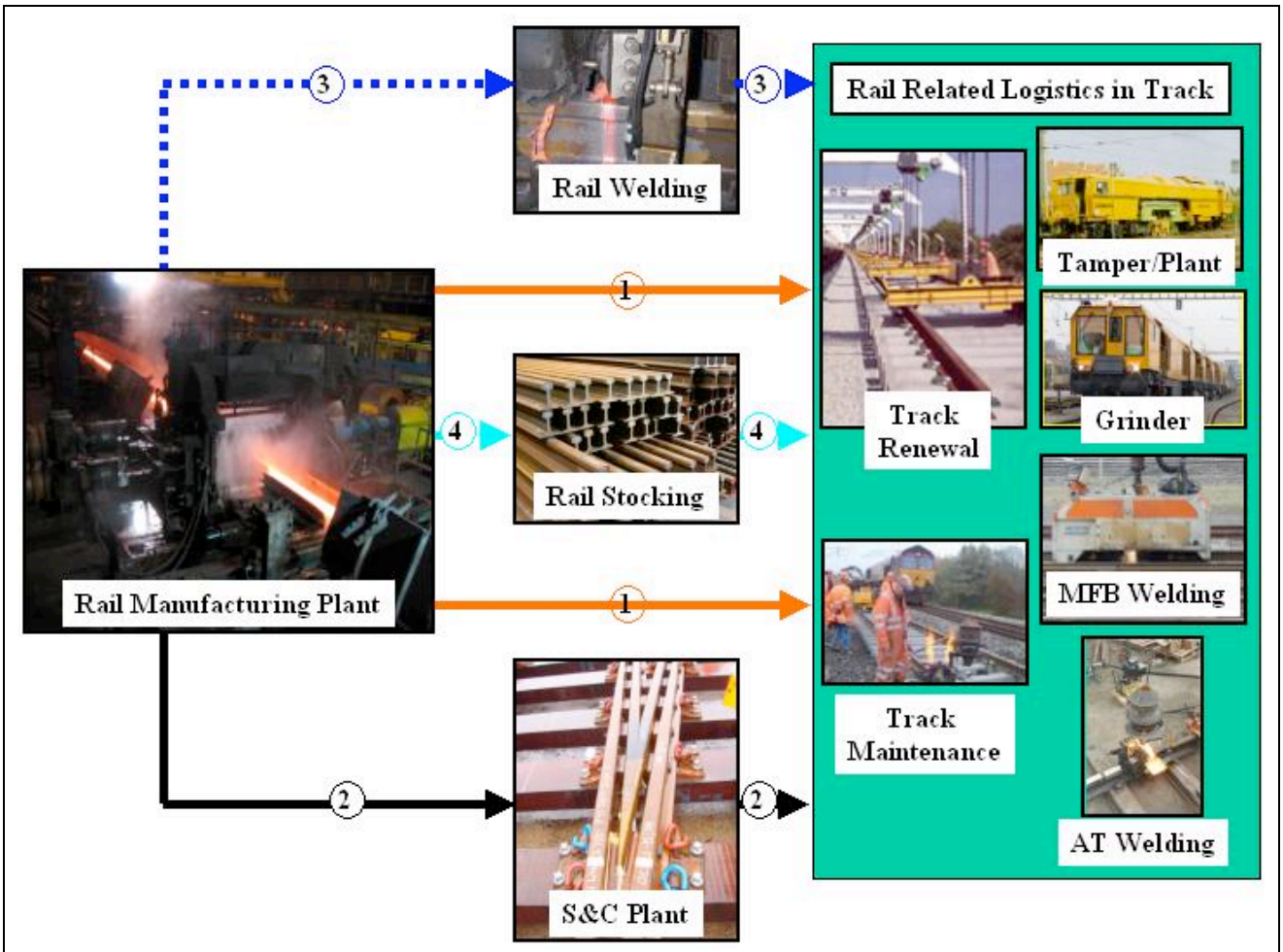


Figure 1 Various aspects of rail related logistics

Although a primary objective of logistics of rail is a reduction in initial and life cycle costs of track renewal and maintenance, which involves a number of different options and steps, it should be emphasized that optimisation of individual steps is not necessarily the optimum for the whole process.

It is apparent that Options 1, 3, and 4 in Figure 1 are different alternatives available for the supply of rails to track side; hence the need to examine their technical and logistical pros and cons. This is covered in Section 3.1 below.

In contrast, the manufacture of S&C requires the supply of rail lengths to specialist manufacturing plant for which the optimum logistics requirements are likely to be different to those of direct supply of rails to track side. However, one further aspect of logistics that needs to be considered in this case is the supply of the manufactured S&C unit to track side. This is covered in Section 3.2.

6.2.1 Rail Supply to Track Side

The total length of track within the EU 27 countries is approximately 300,000 km[1]. Assuming an annual replacement rate of just 2.5% of track, the length of rail requirement is 15,000 km per annum. However, a

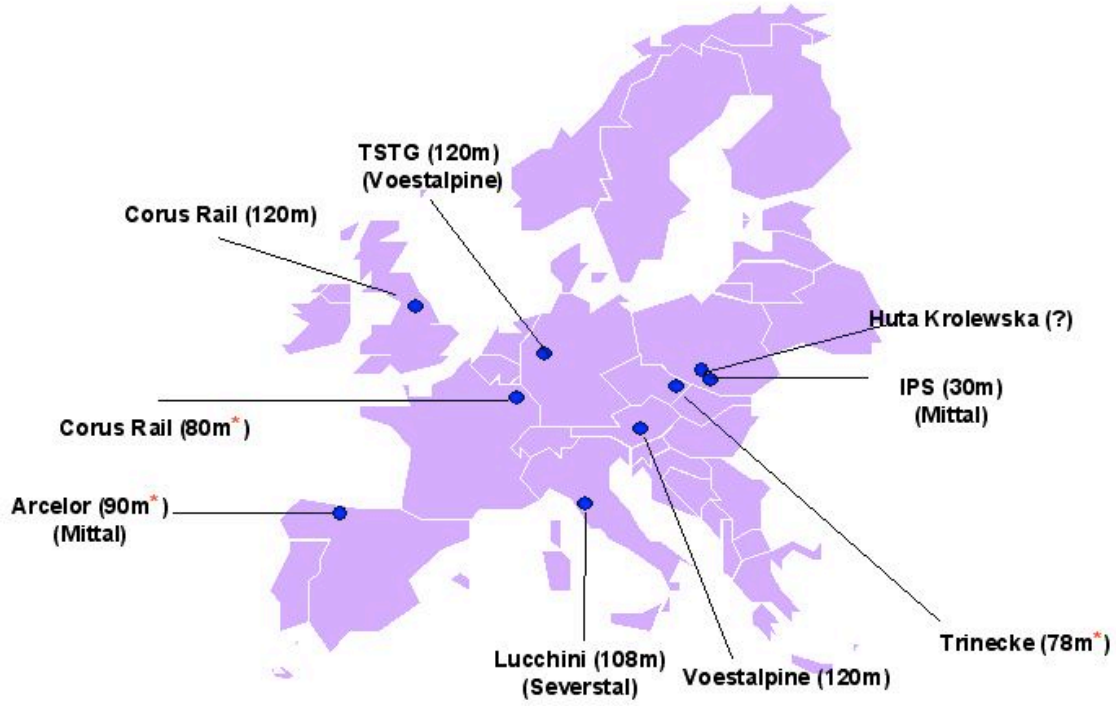
key requirement for the optimisation of logistics is the breakdown of the rail requirement by the intended use. Thus, as indicated in Figure 1, rail supply to track side serves the following 4 distinctly different usage operations for which the optimum rail logistics solutions also differ.

1. Full track renewal or new construction
2. Renewal – rail replacement only
3. Renewal of specialist track
4. Track maintenance – replacement of short lengths associated with defect removal

Full Track Renewal or New Construction

The very nature of the full track renewal or any new track construction process requires longer possession times and the delivery of many other materials and plants to the construction site. Hence there is a clear need for coordination of the flow of the various materials to and from the site. Furthermore, in support of the objective of minimising the LCC of track, the cost effectiveness of the logistics of rail supply needs to be balanced against the key technical desirables for longevity of the track.

Breaks at aluminothermic welds account for well over a third of all rail breaks in most modern railways[2] although there is a belief that introduction of improved process control and better welder training has made modern AT welds more robust. Furthermore, particularly in higher speed lines, longitudinal geometry and the crown profile at AT welds is also considered to be a key cause of rail degradation as it can lead to the formation of squat type defects at the welds themselves or lead to higher dynamic forces following the weld that in turn can give rise to rolling contact fatigue and increased rate of degradation of track geometry. Hence there is a clear need to minimise the incorporation of AT welds through the use of longer length rails. The location of the major long rail manufacturers within the EU and the longest length produced is shown in Figure 2. It is apparent that 7 out of the 9 rail rolling mills have, or soon will be, capable of producing rail lengths in excess of 100m and rail length cannot be a discriminating factor. However, the rail mills are widely dispersed and, at least some, remote from the major rail consuming areas. Although the distance between the point of manufacture and that of use has a significant bearing on the total cost of delivered rail, this can be addressed through the tender process by making sure that the rail price is inclusive of delivery to site. Hence, shorter delivery distances will be reflected in lower total cost of delivered rail.



*= >100m capability under development

Figure 2 Rail Manufacturing Plants Within the EU

However, railways are long linear assets and although the availability of rails up to 120m long straight from the manufacturer has been a significant development, there remains a need for cost effective and technically robust technique for joining long hot rolled rails in track. The options available are discussed below.

(a) >100m Hot Rolled Rails Welded Using AT Welds in Track:

This option offers a reduction in the number of both AT and flash-butt welds compared to the use of up to 36m length rails that was considered the norm not many years ago. Although transportation of up to 120m long hot rolled rails is more expensive than shorter lengths of around 36m, they can be transported using standard flat wagons with several alternative discharge systems. However, as indicated earlier, the longevity and the robustness of profile of aluminothermic welds is widely questioned and although the use of up 120m long rails has reduced the number of such welds in track, the presence of an AT weld at 120m intervals remains the weak link in this option. Hence the option of constructing track with 108/120m as rolled lengths of rail joined together with AT welds is not the optimum choice for the construction of new track and is also unlikely to be the option of choice for the majority of long length full track renewals. Thus the alternative option available is to combine the benefits of long hot rolled lengths of rails (>100m) with the greater internal

integrity of solid phase flash-butt welds. The adoption of this welding process leads to three further options for delivery of higher integrity welded lengths of rail to track.

(b) Mobile FB welding (MFBW) of >100m rails delivered directly to renewal / rail replacement site

This option uses a mobile flash butt welding (MFBW) plant to join >100m long hot rolled rail lengths into the length required at a new track construction or full renewal site. The closure weld can be made using either the MFBW unit or using an AT weld.

Again, the >100m rails can be delivered to site on standard flat bed wagons. The option has the advantages of reducing the number of AT welds in track compared to Option (a). However, site conditions necessitate more careful control of weld alignment and stripping to ensure the desirable level of longitudinal and transverse profiles around the weld. A further logistical restriction that needs to be considered is that a cost effective deployment of MFBW requires a minimum number of ~15 welds per shift.

Hence this option is suitable for full track renewal or rail replacement for all lengths of track where adequate possession time is made available and there are a sufficient number of welds for cost effective deployment of a MFBW unit.

(c) Use of **Mobile Factory FB Welding Unit at Location Close to Construction/Renewal Site**

This option is a slight variation on the use of MFBW with the added advantage that welding can be undertaken in more controlled environment to better support the rail lengths using roller tables. It should be noted that the larger number of welds made using a MFFBW unit make it more economical than similar number of AT welds or even MFBW made directly in track. It also offers the opportunity to form longer lengths of LWR that can then be joined in track using an AT closure weld. The plant facilities required to transfer the LWR needs to taken into account in the planning of logistics for this option. Furthermore, the use of this option is restricted by the availability of suitable locations close to the construction/renewal site and the availability of MFFBW plants that are not as readily available as standard MFBW units.

Hence this option is best suited for longer construction or renewal sites where a MFFBW unit can be located nearby.

(d) Use of **Factory FB Welding (FFBW) Unit**

This is a well established option in which hot rolled rail lengths can be welded into LWR strings. The move to the use of >100m hot rolled rail lengths reduces the number of welds and thereby contributes to a reduction in the installation costs and LCC of track renewal and maintenance.

Traditionally, all major railways have owned and operated welding plants although a few of the larger rail manufacturers have installed welding plants close to the rail rolling mill. The latter option involves internal transfer within the manufacturing plant followed by delivery of a standard length of LWR to the construction/renewal site.

Such factory FB welding plants are designed with the necessary processing stages and controls to ensure consistency of weld integrity. In particular, the use of semi-automatic profile grinding followed by laser

alignment checks ensures that longitudinal profile is maintained within close tolerance. Furthermore, since in general, rails from individual rollings are used in the manufacture of LWR strings, they offer a closer match of dimensional tolerance to ensure better control of geometry around the weld.

Although dedicated LWR train units are required to transport such welded rails, good control of logistics ensures fuller payloads on such trains to deliver the necessary number of lengths to individual construction/renewal sites.

The choice of the length of the LWR string is governed by various factors including the longest lengths that could be transported through the network and the availability of a suitable LWR train unit. In the UK, 2 x 108m hot rolled rails are welded at a FFBW and the 216m LWR transported to site using specialised delivery trains owned by the Infrastructure Manager. In comparison, the longest LWR lengths in France and Germany are 400m and 300m respectively while 800m LWR strings are common in the Baltic States.

Thus this option is suitable for full track renewal or rail replacement for all lengths of track where MFBW or AT welding can be used to join the LWR strings into the lengths required for the sites with preference given to MFBW for longer sites.

Renewal - Rail Replacement Only

It is necessary to consider the logistics of rail for those sites that require only the replacement of rail rather than full track renewal. The work undertaken in Innotrack SP1 has demonstrated that railway networks are not a single linear asset but comprise of a multitude of curved and tangent track segments with different rates of rail degradation. Consequently the life span of rails in tight and moderate curves is shorter than those in tangent track. Furthermore, rail life curtailment because of the occurrence of rolling contact fatigue (RCF) in some curves has necessitated rail replacement at an early stage before ballast or sleeper life is exhausted. In contrast, rail life in tangent track is much longer and hence is likely to be a closer match to the life expected from sleepers and ballast. The segmentation exercise revealed that the length of many of the tighter and moderate curves lies in the range 200m to 600m. Hence, the options for rail logistics that need to be evaluated are:

(a) >100m Hot Rolled Rails Welded Using AT or Mobile FB Welds in Track

As discussed in respect of the new construction and full track renewal sites, although this option offers a reduction in the number of both AT or flash-butt welds compared to the use of up to 36m length rails, preference needs to be given to the use of solid phase welds delivered either by mobile or factory FB welding units. Consequently, the use of AT welds to join the long hot rolled lengths is not considered optimum for the renewal of rail in a large majority of curves. However, a further logistical consideration is access to some rail renewal sites – at times, access restrictions at some sites may not permit delivery of LWR strings and hence it may be necessary to deploy the longest hot rolled lengths that could be delivered and welded on site. In such circumstances, the use of MFBW or AT welding to join the rails will be dictated by factors such as economics of MFBW and the traffic density carried on the track.

(b) Use of Factory FB Welding (FFBW) Unit

The use of LWR strings manufactured using >100m long hot rolled rail lengths is considered to offer the optimum solution because:

1. It offers the longest available LWR string comprising high integrity factory FB welds.
2. Multiples of such LWR string can be used to span the full length of the rail renewal site
3. It reduces the time required to install the rails on site as significantly fewer site welds are required

The installation contractor of a recent installation in a UK network preferred the option of 216m LWR string compared to 2 x 108m hot rolled rail lengths welded in track using mobile FB welds.

Although the deployment of this option requires investment in LWR train units, such units are available in most major railway networks. A maintenance program of such train units is also essential to ensure that rails are not damaged in transit.

Delivery of Rail for Specialist Track

Supply of rail for the renewal of level crossings is an example of rail delivery for specialist track. Corrosion of rails from the salt treatment of the passing road is a major rail degradation mechanism at such locations. This is further exacerbated in third rail environments that promotes stray current corrosion. Consequently, there is a growing demand for the use of rails coated with corrosion protective coatings. Such rails are generally available in shorter lengths sufficient to span the width of crossings and need to be handled carefully.

The logistics solution to satisfy such requirements is a specialised rear steer flat beds complete with HIAB discharge facilities. This solution is employed for all remote locations or sites where there are no discharge facilities. Short length rails, up to 27m long, can also be delivered using standard flatbed trailers.

Delivery of Rail for Track Maintenance

The term “track maintenance” can have widely different scope in different railways. The logistics requirements discussed in this section are with respect to the delivery of shorter length rails as replacement of track with identified discrete defect. There is stipulation of a minimum distance of around 4.5m between two adjacent joints or welds in track in most railways and consequently removal of defects requires a length of rail generally ~9m long. There is an appreciably large proportion of rail supply that is required in shorter lengths as is apparent from over 20,000 defects taken out of a 32,000km network. However since defects could occur in any part of the network, the replacement short length rails are best stocked at discrete locations such as maintenance depots.

Hence, the most flexible logistical solution for the delivery of short length rails (up to 27m) is by road using flatbed trailers.

6.2.2 Delivery of Rail for S&C Manufacture

S&C are specialist track system components that are manufactured at supplier premises and generally require shorter length rails. Again, the most flexible logistical solution for satisfying the requirements of S&C manufacturers is by road using flatbed trailers. However, the innovation in logistics with respect to S&C units lies in the supply of the manufactured unit to site. The growth in passenger and freight traffic necessitates a reduction in the time window for maintenance and renewal and any temporary speed restriction following renewal and/or maintenance. In this context, there are initiatives in some railways for a modular construction approach to the installation of S&C. This system requires significant pre-assembly of the S&C units so as to minimise the assembly time required during the installation possession. A system to transport to a modular S&C is shown in Figure 3 below. This is a good example of the important role of logistics in introducing innovations to reduce the cost of track renewal and maintenance.

Figure 3 Transport of pre-assembled S&C panel – Network Rail modular S&C initiative[4]

6.2.3 Delivery of Rail to Stockholding Locations

Figure 4 below shows the location of the rail rolling mills and those of the major rail welding plants. It is apparent that there will be significant distances between the point of manufacture and the point of use for many railway network locations throughout Europe. Consequently consideration needs to be given to stockholding at strategic locations to permit shorter delivery time to the point of use. Clearly, the use of stockholding suffers from the disadvantages of double handling and deterioration of quality through corrosion when stored for long periods. Although these disadvantages could be overcome through careful handling and controlled stock rotation, it is essential to assess the balance of economic impact of stock holding and

the savings from full payload deliveries at lower costs to the stockholding location. Some of the existing welding plants (e.g. Eastleigh in the UK network) may already be strategically located close to the area of greatest usage and hence serve as ideal stockholding locations for both LWR strings as well as long hot rolled lengths.

Figure 4 Location of rail rolling mills and rail welding plant within the EU

Not on the map: Kaipianinen Finland, Sannahed Sweden, Entrocamento Portugal and Schaerbeek Belgium

It should be noted that a survey undertaken by Innotrack SP5 indicated that the IMs carry a maximum of 10% of annual requirement in stock; the magnitude of this is governed by several factors including the distance from and the nature of the supply contract with the primary supplier and the magnitude of unplanned maintenance and renewal that is undertaken within the network.

6.2.4 Transport by Sea Vessel

Rail transportation can also be executed using sea vessels, where appropriate. This type of transportation is beneficial for larger tonnages to be shipped to the same final destination over long-distances. The salient points of note in undertaking this mode of transportation of rails are:

1. Rails need to be transported under deck to protect them from saline corrosion. On deck transportation of rails is not recommended
2. Careful stacking plan, even under deck, is required to prevent corrosion damage from “sweating of rails”
3. Availability of suitable vessels restricts the rail lengths that can be transported in this manner to a maximum of 80m, although more commonly to 60m.
4. The loading and unloading systems need to be carefully engineered to prevent distortion and permanent bending of the long length rails.
5. The pre loading and post unloading stocking conditions need to be assessed carefully to prevent corrosion damage

6.3 Financial Impact of Choice for Logistics of Rail

The preceding sections have demonstrated the technical merits of the use of longer lengths of hot rolled rails and solid phase flash butt welding to join such rails. It has also been shown that railway operations are complex and the “one size fits all” approach is not pragmatic. The innovation required from logistic operations related to rail was to enable the deployment of the specific innovations. In this context, rail logistics has developed the systems to deliver up to 120m long hot rolled rails on standards flat bed wagons and the delivery of up to 400m long welded strings on specialist LWR trains. Mechanisms to hold the rails in position during transit, to maximise the payloads, and to assure a safe discharge have also been delivered. Equally, innovation has been introduced in the transport of pre-assembled S&C panels to facilitate rapid installation of modular units. It is, therefore, apparent that the key financial impact comes from logistics of rail acting as the enabler for the introduction of rail innovations that are key to the realisation of LCC savings in track renewal and maintenance.

The second area of financial impact lies within the contractual agreements between the rail supplier and IMs and although availability of unit cost (Euro per tonne-km) may yield savings by comparison, it was not feasible because of commercial confidentiality. More detailed consideration of the contribution of logistics and the contractual interfaces are presented earlier deliverables from the project[5-6].

The final area of financial impact is likely to result from the choice made from the selection of logistic solutions discussed in Section 3. However, the optimum choice is not universally applicable to all networks and all circumstances and consequently it is not possible to derive a numerical first cost or LCC saving for each of the choices. Instead, the discussions presented in Section 3 could be converted into a “decision-

tree" software programme to facilitate the choice of the optimum logistic solution. However, this was outside the scope of the current project.

7. Conclusions

As said in the executive summary and looking in the mirror on the objectives of SP5 in INNOTRACK it is clear that they were a bit optimistic. The European situation was much more complex than expected and could not be correctly encompassed without an international overview of the European situation. This means that the outcome of SP5 was not the expected.

However if we look at the results from WP5.1, described in D5.1.7, it is a big step forward. For the first time the real problems have been identified on a European level. Earlier reports and findings have too often been top level and not gone into enough technical details. The result from WP5.1 could be defined as good and first State-of-the-art reports in this area.

The work carried out in INNOTRACK has also improved the understanding for the Track Contractors of the IMs situation and vice versa. This is probably the most important outcome of SP5 in INNOTRACK.

Another conclusion already said in the executive summary is that a follow up project of SP5 is well motivated and needed if different European Union directives like “DIRECTIVE 2004/17/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 March 2004 shall have a chance to become a reality in the future.

One of the key objectives of INNOTRACK was a reduction of life cycle costs with 30%. And the present document illustrates the beneficial impact brought by the implementation of enhanced logistics. The potential of cost reduction is clearly shown in the sections 4, 5, and 6 respectively pertaining to Support, S&C, and Rail.

The main idea of the Logistics and Support could be presented as an application of WP5.1 to the logistic of SP2 output.

Four areas identified as "critical to success" in WP5.1 were guiding the current study of Logistics and Support : Work programming, Project management and logistics, Rules and regulation, and Plant. And they were crossed with the logistics involved by the implementation on site of the innovative solutions resulting from SP2.

Three innovative solutions output of SP2 were selected and these are related to sub-grade improvement and superstructure innovations.

Finally it can be drawn that it is an additional asset to consider the relation between Infrastructure Managers and Contractors in the development of innovative track solutions.

Concerning the Logistics and S&C the analysis detailed in this document 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%.

Finally, from Logistics and Rails it can be drawn that this subject remains complex as it is affected by a very wide variety of factors such as the intended use of rail (track renewal, track maintenance, S&C manufacture)

and access to the location of use. Consequently, it was recognised that the development of a definitive directive for the logistics of rail should not be the prime objective of the INNOTRACK project. Instead, critical analysis of the various factors influencing logistics of rail was considered to be more beneficial as it would enable a clearer adoption of the principles involved for the variety of circumstances encountered on different European networks. This approach could also be translated into a “decision –tree” software to facilitate the choice of the optimum logistic solution. The key conclusions from the analysis of the different influencing factors undertaken are:

1. The supply of rails to track side needs to be examined with respect to its intend use and the associated resources available.
2. The supply of rails to S&C manufacturers is also best undertaken by road using flat bed trailers. However, the innovation in logistics of S&C has been in the use of inclined wagons to transport pre-assembled S&C panels to facilitate significantly more rapid and accurate installation.
3. Three distinct areas of financial impact of rail logistics have been examined.

8. Bibliography (optional)

Level of confidentiality and dissemination

By default, each document created within INNOTRACK is © INNOTRACK Consortium Members and should be considered confidential. Corresponding legal mentions are included in the document templates and should not be removed, unless a more restricted copyright applies (e.g. at subproject level, organisation level etc.).

In the INNOTRACK Description of Work (DoW), and in the future yearly updates of the 18-months implementation plan, all deliverables listed in section 8.5 have a specific dissemination level. This dissemination level shall be mentioned in the document (a specific section for this is included in the template, both on the cover page and in the footer of each page).

The dissemination level can be defined for each document using one of the following codes:

PU = Public

PP = Restricted to other programme participants (including the EC services);

RE = Restricted to a group specified by the Consortium (including the EC services);

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This level typically applies to internal working documents, meeting minutes etc., and cannot be used for contractual project deliverables.

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