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Deliverable Update

The "Delivery update" gives brief overviews of INNOTRACK deliverables that have been submitted or are ready for submission to the European Commission. The current issue includes deliverables submitted from the start of the project until end of December 2008 and some until February 2009.

The full deliverables are available at the INNOTRACK KMS (www.uic-online.com) under Documents > Official Documents > Deliverables.

Public reports are also available at www.innotrack.eu under the heading "Results".

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D0.1 Project management plans and quality assurance

Lead contractor..ARTTIC
Submitted 2007-01-15
Size...31 pp

Executive summary

Management of an integrated project must take into account the requirements that are inherent to inter-organisational collaboration. These include sharing of knowledge, organisation and management of work in a result-driven way, decision-making by consensus in governance bodies and effectiveness in the exchanges among partners.

This document presents guidelines and procedures for the persons in charge of the management tasks in INNOTRACK and is divided in two sections, presenting:

- the project organisation and the decision-making bodies.
- the management procedures to be applied.

This document should be considered as a complement to other official documents including the EC contract and its annexes, the Consortium Agreement and the various EC guidelines.

Research and innovation-related tasks are organised in 7 sub-projects corresponding to the main research domains, each with its own set of Work Packages (WPs)

The management at the global (Integrated Project) level ensures governance and coordination of the whole project and its relations with the EC. The corresponding management tasks are grouped in SP0.

INNOTRACK will be coordinated by UIC and supported by a project office.

INNOTRACK management is structured in two levels: Strategic, with the Steering Committee (SC) and Technical with the Technical Coordination Group (CG), composed of the leaders of the 8 sub-projects. The Steering Committee is the highest decision and strategy making body of INNOTRACK. Specific rules for this decision making bodies are stipulated in sections 3.2.1 and 3.2.2 respectively.

The Project Coordinator UIC is acting as the unique interface between the project and the EC. The Coordinator is the focal point for all technical and administrative content of the project. They have appointed a Project Manager, Björn Paulsson from BV, who will represent the Coordinator and is in charge of the overall contractual and scientific supervision of the project.

Each sub-project is led by one partner, the SP leader, who chairs the SP Coordination Board. The SP Coordination Boards consists of all partners involved in the sub-project. The SP Coordination Boards are responsible for the execution of the overall technical objectives and work programme for each sub-project and reports to the INNOTRACK Coordinator and Technical Coordination Group.

The SP leader appoints WP leaders, responsible for the coordination of the work carried out within that work package and the achievement of the objectives. The WP leaders report to the SP Coordination Boards and are responsible for the production of their deliverables.

The Project Management Office (or the Project Office) is staffed by a Management Team, reporting directly to the Project Coordinator. The Project Management Office is led by ARTTIC.

The project will use electronic means to facilitate communication, including a collaborative website administered by UIC, and mailing lists for the different intervening groups (see section 4.1).

Concerning publications, a contractor cannot publish Knowledge or Pre Existing Know-how generated by another contractor without that partner's written approval. A 30-day prior written notice to all the contractors and the commission is needed for any planned publication (see 4.2.1 for details).

A list of project meetings is available and maintained on the internal web site. Rules and recommendations for meetings are given in section 4.3.1 to 4.3.3.

Each document has a single "Owner", regardless of how many contributors it has. The owner leads the production of the document, makes proposals for content and required contributions and consolidates drafts. Templates for INNOTRACK documents are available on the Intranet. Each document is filed with a unique filing code, detailed in section 4.4. A

project archive administered by the Project Office stores copies of final deliverables, periodic reports and minutes.

The deliverable development process is presented in section 4.5. All important deliverables will be peer-reviewed to verify the technical, scientific and formal quality before submission to the EC. The Project Office will provide a tool for planning and follow-up of deliverables.

Annual reports and reviews are required by the Commission. The Project Manager and the SP leaders with the support of the Project Office will coordinate the preparation of these reports. A list of required reports is given in section 4.6. The reports are due 45 days after the end of the reporting period.

Annual EC reviews are organised by the Commission with external reviewers. After the review, the reviewers will provide their evaluation in a review report issuing recommendations.

As the EC contractual reporting covers one year, internal reporting is necessary to monitor project progress and detect problems and risks at earlier stages. In months 3, 9, 15, 21, 27 and 33, all partners fill out a one-page questionnaire, covering the previous 3-months-period. In months 6, 18 and 30, all partners provide a mid-year report including a description of activities and results, status of deliverables and milestones, and an estimation of the resource consumption (budget and efforts).

The financial management includes procedures for financial statements, payment handling and project accounting. The financial provisions for INNOTRACK project are described in Annex 2 (Part B) to the

INNOTRACK contract and further detailed in the EC document “Guide to Financial Issues relating to Indirect Actions of the Sixth Framework Programmes”.

Financial Statements (form C) completed by each contractor are submitted to the Commission by the Coordinator together with the management report within 45 calendar days after the end of each 12 months reporting period. Financial Statements must be accompanied by an audit certificate from an independent auditor (or for public bodies from a competent public officer) if the cumulated requested Community financial contribution is equal to or exceeds 150000 EUR. The Project Office will be responsible for collecting, formally checking and compiling the partners’ Financial Statements. A procedure for the preparation of Financial Statements is provided in section 4.8.1.

The first Pre-financing paid by the EC consists of 85 % of the requested EC contribution for the first 18 months. For the subsequent periods, payments consist of the balance between the validated Financial Statements of the previous reporting period and the pre-financing for the last 18 months-period plus the pre-financing for the next 18 months period. As stated in the EC contract and following the rules set out in the Consortium Agreement, the Coordinator must distribute the EC financial contribution to the contractors without unjustified delay. For Contractors not providing deliverables on time or providing non-compliant deliverables, the contribution allocation can be retained until the situation is remedied.

All payments of the EC financial contribution are made to the Coordinator with the Project Office monitoring the payment process.

The nature of collaborative projects like INNOTRACK makes the partner's work highly interdependent.

All partners therefore need to agree on mechanisms to identify and assess possible and potential risks. A risk management procedure has been established and is detailed in section 4.9.

The good implementation of procedures and guidelines described here, together with a good knowledge about the EC contract and its annexes, the Consortium Agreement and the various EC guidelines, will facilitate the collaboration between partners and ensure a high quality of project deliverables and reporting towards the EC.

D1.1.1 Database of representative vehicles and characteristics from participant countries

Lead contractor...Rail Safety and Standards Board
Submitted... 2007-02-21
Size ....10 pp

Executive summary

One of the key objectives of SP1 is to verify that the technical solutions developed in INNOTRACK to reduce infrastructure costs have successfully addressed the root causes within the railway system and are suitable for a wide range of present and future traffic conditions across Europe focusing particularly on mixed traffic railways. Such a study has not been previously carried out on a European level.

WP 1.1 is to gather the vehicle characteristic information that would enable INNOTRACK to ensure that any technical solutions are suitable for present and future traffic with the wide range of vehicle characteristics possible in Europe.

To help achieve this objective, this report provides the deliverable D1.1.1: "Database of representative vehicle types and characteristics from participant countries." The collection of European railways vehicle data from the countries of partner organisations was planned in two stages using two forms which were designed in consultation with representatives from the other INNOTRACK work packages.

The first form, which was to be completed for this report, was for recording summary data on the range of representative vehicles that are used in the participant countries that should be taken into account in INNOTRACK's assessment of track deterioration. This included vehicles which are representative of vehicles most commonly used in service, key new vehicle designs proposed for use in service in the next 5 -20 years and vehicles or vehicle defects which produce most damage of the infrastructure. The second form, which was not for completion at this stage, is for gathering far more detailed data for selected representative European vehicles.

A database of summary vehicle data has been developed which should help to enable the vehicles team to select representative European vehicles. It is clear, however, that the gathering of the more detailed data and vehicles models required is not going to be easy either due to commercial sensitivities or just a lack of adequate data in some instances. It is proposed that, where commercial sensitivities exist, some manufacturers could carry out track degradation modelling themselves and provide the output data to the INNOTRACK team. The INNOTRACK team could then develop and tune generic models which give the same output data as the commercial modelling has predicted.

D1.1.2 Database of European generic vehicle characteristics

Lead contractor...Rail Safety and Standards Board
Submitted... 2008-04-17
Size ....22 pp

Executive summary

Infrastructure Managers have traditionally been cautious regarding the introduction of new technology into the railway system, as unproven innovation may introduce unexpected and serious risks. Product acceptance procedures may further inhibit or prevent the adoption of new ideas as the benefits may be considered insufficient to justify the risks. The result of this caution is that some regard the railway as unreceptive to new ideas, and lagging behind other transport modes. INNOTRACK should correct this view as the IMs seek to reduce whole life costs by the introduction of new technology. However the need to ensure that the innovative solutions resolve the issues and do not import new problems to the railway remains.

SP1 seeks to address this need within INNOTRACK by modelling the vehicle track interaction for the problem conditions identified by the IMs to ensure that the root cause of the problem is fully understood and that the solution proposed successfully addresses this cause without introducing new risks.

The simulations must ensure that solutions are suitable for a wide range of present conditions across Europe, focusing particularly on mixed traffic railways. Such a study has not previously been carried out on a European level.

The function of WP 1.1 is to gather the vehicle characteristic information to enable INNOTRACK to ensure that most technical solutions are suitable for the wide range of vehicle characteristics possible in Europe not only now but also in the future.

As a first step deliverable D1.1.1, "Database of representative vehicle types and characteristics from participant countries", identified the representative vehicles and their characteristics for the European partners. A database of summary vehicle data was developed to enable the selection of representative European vehicles which would form the basis for generic vehicle models.

Although the amount of detailed vehicle information provided was limited, Manchester Metropolitan University (MMU) already has a range of vehicle dynamics models which not only represent UK vehicles but are also representative of a number of European vehicles. Data provided by Banverket (BV) has helped to identify with greater certainty a more complete range of detailed European vehicle characteristics.

This paper proposes that for each of seven European vehicle types, three models will be produced representing a low impact vehicle, a high impact vehicle and what may be considered as close to a typical vehicle.

MMU have already developed the generic model for the Multiple Unit case which can be used for the basis of the three Multiple Unit generic models.

Although the database includes some wheel and rail profiles, there continues to be an urgent need for partners to provide libraries of profiles for moderately worn and fully worn wheels and rails under a range of operational conditions. This is important as the forces generated by new wheels on new track are frequently

very different to the interaction of worn profiles and it is essential to ensure that the range of conditions and load spectra that track is subjected to can be accurately characterised when verifying the solutions developed by the INNOTRACK project.

D1.2.1 Standardised method for converting measured track data into segments for "virtual tracks"

Lead contractor .... DB
Submitted 2008-04-17 (rev2)
Size .... 20 pp

Executive summary

This report outlines the approach to track geometry segmentation and generation of representative track sections required by deliverable D1.2.1. In particular it considers the method by which 'representative' track sections (alternatively termed 'virtual test tracks') may be generated from large quantities of track recording coach geometry data.

A toolkit has been developed in Matlab with the aim of generating a range of representative track segments from large volumes (entire routes of several hundred kilometres or more if required) of input data. By this means a short track segment, say 20 km long, can be generated that may be considered representative in one form or another of the entire route. A number of options are available in this respect as different analysis tasks may require track segments that represent different aspects of the route in question.

The toolkit is currently configured to use data from the UK track recording vehicles and will require some modification to use data from other administrations. This is not expected to present any significant difficulties.

At present the toolkit only addresses the track geometry aspects of segmentation. This only partially fulfils the requirements of 'segmentation' as it does not consider the duty conditions (tonnage, traffic type etc.) of the route in question.

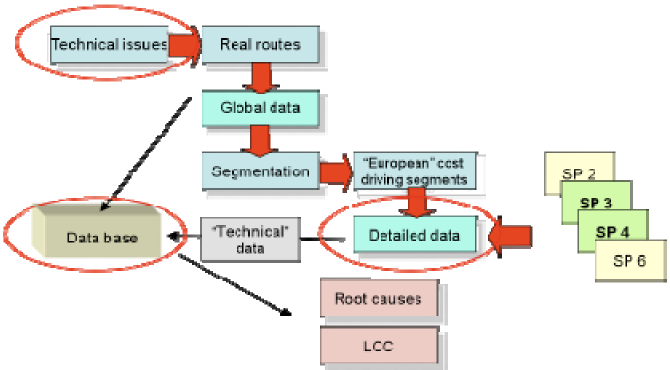
D1.2.2 Track sections and track irregularities – Analysis of DB sites

Lead contractor .... DB
Submitted... 2008-06-20
Size .... 45 pp

Executive summary

Track segments or track sections with major impact on life cycle costs are the basis for the work in INNOTRACK. The following diagram shows schematically the accepted workflow for gathering data in the project. Start point of the analysis were the technical issues worked out during the IM's workshops of the different railways involved in the project.

During the workshops the IM's should select up to 3 sites, which should relate to the technical issues. From a "global view" taking into account the track layout, track design and operational parameters segmentation should be carried out for those routes and the cost driving segments should be identified. The comparison between all IM's lead either to "European cost driving segments" or to the question of best practice.



For the identified cost driving segments detailed data should be gathered and provided to the technical subprojects for further analysis and technical optimisation. The workflow is described on the next page.

The most important result of the detailed track analysis at DB is that a general segmentation failed. The reason for this is that the track behaviour and required maintenance does not only depend on the place (track parameters and operationally parameters) but on the time (history of maintenance and maintenance strategies). Due to the unknown history of maintenance a sufficient accurate identification of segments is quite more complicated or impossible. A general decision for products or processes for existing lines on the basis of segments does not ensure an optimum regarding LCC.

The following report presents the results of the detailed technical and economical analysis of DB sites, selected during the IM workshop. For technical issues with economical impact related track sections were identified and all available and validated data are collected and provided to the common data base.

This version includes only results of the track. Results of the analysis for the switches and crossings, which were carried out in cooperation with subproject 6 LCC assessment are presented in the report D3.1.2.

Note: Due to the close relationship between the cost driving track segments and the track irregularities promoting failures and degradation the reports D1.2.2 and D1.2.3 are merged.

D1.2.4 Populated data base of track section characteristics for general modelling for design and LCC and specific problem segments

Lead contractor .... DB
Submitted 2008-07-04
Size .... 30 pp

Executive summary

This document summarises the results of compilation of track sections characteristics to be used for simulation and LCC calculation. The detailed data were included in the database of INNOTRACK and contained among the technical data of the track also track geometry measurements.

The following tables will give an overview over the existing data and data files and included information.

In this version data from DB site 1 are included.

D1.2.5 Track segmentation

Lead contractor .... DB
Submitted 2009-02-13
Size .... 36 pp

Executive summary

Railway track is an asset that is many thousands of kilometres long that require continuous maintenance to remain fit for purpose. This asset does not degrade at a continuous rate but is variable due to the difference in geometry, track structure and the loading conditions that different parts of the network are subjected to. Therefore to understand degradation and plan maintenance of the track it has to be broken down into smaller sections. Within the Innotrack project this has been carried out so that the sections are defined by their geometrical and loading characteristics; this is called Track Segmentation. Primary segmentation has been carried out using data provide by each IM from their track recording coach. This report details the analysis of the track recording coach data that has been carried out and the next steps to allow secondary segmentation to be carried out to understand the degradation of different segments of track.

D1.3.3 The root causes of problem conditions and priorities for innovation

Lead contractor... NR
Submitted 2009-03-04
Size.. 18 pp

Executive summary

The stated objective of the INNOTRACK project is to reduce the whole life cost of track maintenance and renewal while increasing annual tonnage and speed by the introduction of innovative products and processes. The process for defining the requirements for innovation was;

1. Determine the European track problems responsible for the problem conditions from national workshops
2. Confirm that these problems result in the highest costs
3. Explain the root causes of these problem conditions
4. Suggest how innovation may be able reduce or eliminate these problems

The national workshops produced results that, once differences due to climate extremes were eliminated, were broadly similar. The cost data provided by the participating IMs confirmed that generally the high cost issues were the same across Europe with only differences in ranking.

The root causes of these problems are generally well known at a high level although for specific instances detailed investigation would be necessary to confirm that the cause was the same as the general case. A number of track experts have added their opinions to the root causes and contributed to the bibliography.

Having defined the root causes of the problems, innovation should be focused on:

• Removing the cause

This may be outside the scope of this project. E.g. high vehicle track interaction forces may be the root cause of certain track degradation conditions. This may be reduced by improved track quality but the great benefits of different vehicle characteristics is not within the scope of INNOTRACK

• Reducing the whole life cost implications by

o Reducing the damage
o Reducing the time and cost to repair or replace
o Reducing the cost of components and processes
o Avoiding the cost of train delays by predicting incipient failure
o Improving availability through designs that operate in degraded mode until a suitable opportunity to repair or replace

Two causes of high degradation and failure predominate. These are the energy at the wheel rail interface and secondly the inability of track support to sustain the applied loading.

Priorities for innovation should be based on the root causes of the problems. The suggestions for innovation offered in this report are not exhaustive and will be overtaken in time by new technology. The range of possible innovative solutions is great, and as technology advances ideas that have previously failed may become realistic. An open mind is therefore essential to the process for evaluating innovation.

D1.4.1 Publication of detailed framework for information and data collection

Lead contractor............ University of Birmingham
Submitted... 2007-07-01
Size ....25 pp

Executive summary

INNOTRACK Sub-project 1 (SP1) has the task of delivering the detailed framework for information and data collection. This is intended to facilitate precise and efficient communication between project partners, through provision of a framework to support collection, storage and analysis of project data. This report explains the methodology employed to develop the framework, and provides an overview of the framework itself. It concludes by describing future work that will be required in this area as INNOTRACK progresses.

To address this task SP1 broadly followed the process described in the INNOTRACK Schedule of Work. The first step involved working with the infrastructure managers (IMs) and railway industry suppliers in a number of national workshops to identify the combinations of track and vehicle characteristics/conditions responsible for a high proportion of maintenance and renewal expenditure. This was followed by work to standardise the output from the workshops, through the adoption of an information management framework that will ensure it is presented in an unambiguous manner.

Not all of the workshops have yet been held, but enough data has been collected to allow the principal track faults to be identified (see Figure 3 in Appendix A). The ranking of faults was found to correlate well with the priorities identified by each national IM. It has proved difficult, however, to establish a similar degree of correlation between the ranking and corresponding maintenance costs. More work therefore, needs to be done in this area. Plans are being made to hold in the near future, a workshop attended by all IMs. It is hoped that this will review and validate the consolidated findings of the national workshops.

In parallel with the workshops, SP1 has developed a web-based questionnaire and SQL relational database for the collection, standardisation and analysis of project data. The questionnaire covers the principal parameters used to describe track faults. Work is currently underway to incorporate questions covering aspects of logistics. In order to support efficient searching of the database, care has been taken to develop questions that keep 'free-text' answers to a minimum by offering users menus of pre-determined answers. The database structure is shown in Figure 7 of Appendix A

The questionnaire and database are still undergoing tests among members of SP1. Once these are complete the questionnaire will be launched and database population will start.

D1.4.2 Database of models and list of potential model gaps

Lead contractor............ University of Birmingham
Submitted... 2007-07-01
Size .... 7 pp

Executive summary

This report outlines the work that was undertaken in order to produce an online database of models and data analysis tools within SP1 of the Innotrack project.

A database of over 230 models and data analysis tools has been compiled and made available to the Innotrack project via the database website (http://www.innotrackdataentry.co.uk/DefaultQuestions.aspx). For each entry in the database the following fields are populated:

- Tool name
- Description – a description of the tool's purpose
- General inputs – high level description of input data required
- Specific inputs – a more detailed description of input data
- Exact inputs – where available, a description of the specific input data requirement
- General outputs – high level description of output data generated
- Specific outputs – a more detailed description of output data generated
- Exact outputs – where available, a description of the specific output data generated
- Division in railway system – classification of which subsystem the tool applies

The database forms the first phase of a task aimed at identifying methods for linking existing modelling tools and finding gaps in modelling technology. Later in the project, research will focus on understanding the potential benefits of using methods such as the eXtensible Markup Language (XML) for interchange of data and models between modelling tools. It is hoped that this work will lead the way to more efficient data handling and potential allow semi-automatic or automatic interchanges between tools.

D1.4.3 Process for the linking of modelling tools

Lead contractor............University of Birmingham
Submitted 2008-12-16
Size .... 32 pp

Executive summary

The assessment and reduction of Life Cycle Cost (LCC) in the railway domain depends on a number of component characteristics. One of the key features of any design of rolling stock or infrastructure component is the effect that it has on the LCC of the system. In the area of design and development there are many software tools that are implemented by the engineers and designers to asses these effects. In general these tools were developed independently of each other and, while some of them contain common features and concepts, they are named and represented in different ways.

The work outlined in this deliverable proposes a method for integrating different tools where the output of one tool could provide the input to another tool. In principle, any exchange of data between geographically remote systems and applications would use current Web standards for information interchange. This deliverable outlines a demonstration of the required Web standards and illustrates by example how this standard can be used to represent railway modelling data.

D1.4.4 Completed knowledge repository available online and data mining routines for system wide analysis

Lead contractor............University of Birmingham
Submitted 2009-01-28
Size .... 11 pp

Executive summary

The University of Birmingham hosts a bank of servers available to support industrial research and development projects. These are Windows based and are available to be configured to suit individual project requirements for Web applications, databases, etc. For the INNOTRACK project some of these servers have been configured to hold industrial railway data such as Wheel Impact Load Measurement (WILM), Unmanned Geometry Measurement System (UGMS), track recording car data, as well as data produced as outputs of tools such as Clementine.
The servers are provisioned to support small industrial 'experiments', such as data processing, data integration and data mining. However, they can be configured for additional large scale data storage if required.
To date in the INNOTRACK project, some of the data used has been stored on the servers, and simple data processing routines have been developed. In the final stages of SP1 it is planned that more comprehensive data processing and data mining routines will be developed.
The servers are being used predominantly by researchers at the University of Birmingham, but access can be granted to external clients.
It should be noted, that the main content of D1.4.4 is the presence of the servers and associated data itself, and not the content of this report.

D1.4.6 A report providing detailed analysis of the key railway infrastructure problems and recommendation as to how appropriate existing cost categories are for future data collection

Lead contractor............ University of Birmingham
Submitted.. 2008-09-19
Size ....20 pp + 20 appendices

Executive summary

The European Commission-sponsored INNOTRACK project is aimed at reducing the life cycle cost of track maintenance by 30%. It will achieve this by developing innovative maintenance methods and technologies, targeted on those aspects of track maintenance that cause the most problems and lead to the highest costs. It will also use life cycle costing (LCC) methods to assess the cost impact of the new technologies and decide whether they provide value for money.

This report describes two studies carried out in support of these aims. The first was a study to identify the principal track problems facing Europe's IMs. The report explains the methodology used to do this and the results obtained.

The second was a study to identify whether there is a common maintenance cost structure among INNOTRACK IMs, capable of supporting LCC analysis. The report describes the analysis of existing cost structures and identification of a set of principal European maintenance cost categories.

Principal Track Problems

The study involved close working with, and substantial input from, the INNOTRACK partner IMs, namely:

- ADIF Administrador de Infraestructuras
- OeBB Oesterreichische Bundesbahnen
- CD České Dráhy a.s
- RFF Reseau Ferre de France
- DB Deutsche Bahn
- BV Banverket
- NR Network Rail
- PR ProRail

In essence, the methodology adopted for the study involved asking each INNOTRACK partner IM to hold two internal workshops designed to try and identify the main track problems and rank them in order of importance. In outline, the methodology had eight basic steps as follows:

1. Create a template to guide discussion in the Phase 1 IM Workshops;
2. Hold the Phase 1 Workshops to identify the main track problems, their underlying causes, possible solutions and methods of evaluating performance;
3. Consolidate the results of the Phase 1 Workshops based on the reported problems (ignore underlying causes at this stage;
4. Rank the problems based on the frequency with which they were reported and omit from the ranking those problems reported by less than two IMs;
5. Create a template to guide the discussion in the Phase 2 IM Workshops, based on the ranked list of problems from Phase 1 and include associated underlying causes;
6. Hold the Phase 2 IM Workshops to rank problems and underlying causes from the point-of-view of cost;
7. Consolidate the results of the Phase 2 IM Workshops, and finally;
8. Create a list of track problems and underlying causes prioritised on the basis of cost impact.

Analysis of the results from the Phase 1 Workshops identified the following track problems to be the most important based, on the number of IMs experiencing that particular type of problem. The problems are listed in descending order of importance:

- Track: bad track geometry
- Rail: cracks and fatigue
- S+C: switch wear
- Substructure; unstable ground
- Joints: insulating joint failure
- Rail: corrugations
- Rail: wear
- Structures: major line closures
- Fasteners: worn/missing pads
- Sleepers: renewal optimisation
- Culverts/pipes: flooding
- Ballast: stone spray
- Ballast: ballast wear
- Rail: low friction/adhesion
- Joints: weld quality
- S+C: common crossings
- S+C: Manganese crossings
- S+C: geometry maintenance
- S+C: loss of detection

Analysis of the results from the Phase 2 Workshops identified the following track problems and underlying causes to be the most important based on their cost impact, again listed in descending order of importance:

area	problem	cause
Rail	cracks and fatigue	creep forces;
Rail	cracks and fatigue	bad wheel/rail interface
Track	bad track geometry	soft sub-structure/bad drainage
S+C	wear in switches	sub-structure
Rail	corrugations	vehicle/track interaction
S+C	cracked manganese crossings	weld quality
S+C	geometry maintenance	optimal maintenance regime?
Sub-structure	unstable	soft sub-structure/wet bed
Track	bad track geometry	sub-optimal maintenance
Track	bad track geometry	wrong/unknown stress free temperature

Further analysis of the Phase 2 results showed there to be a positive correlation between the importance of a track problem as measured by frequency of reporting, and the importance as measured by cost impact.

Maintenance Cost Categories

IMs were asked to list the cost categories they currently use and state the percentage of their maintenance budget allocated to each one. An analysis of this data was then carried out to determine whether a set of cost categories existed, common to all of the INNOTRACK IMs.

Analysis of the initial data found some commonality between the cost categories, but also a degree of variability. Further work was carried out therefore, to remove cost headings used by only to one or two IMs (for example, snow clearance), and to consolidate some detailed costs into higher-level cost categories (for example, consolidating the detailed category of 'ultrasonic inspection' into the higher level category of 'inspection'). As a result, the following existing principal cost categories were identified for use in LCC analysis:

- Welding;
- Grinding;
- Inspection;
- Rail Lubrication;
- Track renewal;
- Sub-grade;
- Geometry;
- Drainage, and;
- Minor periodic maintenance.

D2.1.1 In-situ measurement preliminary database, based on information management framework

Lead contractor................University of Karlsruhe
Submitted..2008-04-17
Size ....16 pp

Executive summary

This report reflects the state of the in-situ database in SP2.1. Showing different examples of data and data set gathered for the use in a smart database with continuous improvements. Within SP2.1 a big variety of scales have to be combined. The database should give the possibility to recognize the evolution of track irregularities using different methods of investigations of track and subsoil.

Data from conventional and improved soil investigations as well as dynamic measurement methods with vehicles (e.g. OMWE) are gathered therefore.

This report, including structures and methods presented, will be used as a basis for collecting and migrating data within WP2.1 and the other subprojects. The examples shown are provided by the partners. They include data from track lines with significant track irregularities.

D2.1.2 In-situ measurement preliminary database, based on information management framework

Lead contractor............................LCPC & CETE
Submitted 2008-05-06
Size..25 pp + 4 app

Executive summary

The CETE NC, associated partner to LCPC, is involved in the design of a demonstrator for continuous track stiffness assessment. From an existing method called “Portancemetre” for platform modulus assessment, a technology transfer has been studied for application on rail tracks.

Technical characteristics have been defined from a feasibility study on a re-created track. Per rail, a minimal static force of 5000 daN and a dynamic one between 1500 daN and 4500 daN is a correct dimensioning to obtain the stiffness of the track, influenced by ballast and subgrade properties.

A validation test on a real shunt track near Paris with a vibrating roller having parameters approaching those expected for the demonstrator, and equipped with an innovative device for continuous variation of amplitude and calculation of stiffness, on this site 85 kN/mm, has shown that a vibration amplitude in the range 0.2 to 0.4 mm is able to perform the specifications in dynamic forces.

A version 1 demonstrator has been designed as an active axle with vibrator boxes in phase over the two rails, with separate treatment of measures. Logistics consists in transporting by road the demonstrator in kit elements and assembling them near each test site.

However, some difficulties more important than expected have occurred: the safety regulations to obtain railways agreement before doing the tests on real tracks are not easy to integrate in the demonstrator. A towed axle couldn’t be authorized to roll, even just for demonstration. Consequently, different contacts with railway establishments and manufacturers have been taken to design a demonstrator version 2 with a specific frame enclosing the active axle. This stage is in progress as well as the study of incidence on costs, which may raise of 10 to 30% for the equipment, and on logistics to reach and to assemble the demonstrator on the tests sites.

The deliverable describes the activity done between September 2006 and July 2007.

D2.1.3 First phase report on the modelling of poor quality sites

Lead contractor..............Czech Tech Univ Prague
Submitted.. 2008-07-04
Size ....68 pp

Executive summary

In agreement with the content of partial Task 2.1.8 Physical modelling of poor quality sites of the integrated INNOTRACK project, the objective was to perform the physical modelling of substructure with a low bearing capacity of the subgrade and variable thickness of the ballast bed. The substructure was modelled in laboratory conditions in a 1:1 scale. Model constructions were loaded with forces corresponding to static axle loads of 22.5 t; 25.0 t and 27.5 t. The research objective was to determine the deflection values of the ballast layer of gravel under the sleeper and the sub-ballast layer of crushed stone mixture, to measure the values of the moduli of deformation and the impact moduli of deformation, to assess the effect of the thickness of gravel on the sleeper and sub-ballast layer deflection values and the effect of a resilient under-sleeper pad on changes in the gravel and sub-ballast layer deformations.

This Deliverable also comprises the particular results of Task 2.1.10 Numerical modelling of poor quality sites.

D2.2.1 State of the art report on soil improvement methods and experience

Lead contractor............................ Czech Railways
Submitted 2008-02-13
Size .... 53 pp

Executive summary

This report presents the state of the art of soil improvement methods with knowledge and

practical experience to solve problems of insufficient subgrade and railway embankment conditions at the railway networks of the INNOTRACK consortium members, representatives of 6 European railway companies (ADIF, BV, CD, DB, ÖBB, SNCF).

The range of methods introduced in the chapter 3 “Summary of investigated methods” is wide and they were used at a very different volume, from several metres up to tens of kilometres, with experience from test sites up to routine use. Application of particular methods depends on geotechnical conditions, economic possibilities, tradition and experience of every railway company too. The range of methods, their volume and experience with them is presented at the chapter 4 “Conclusion” at its particular sections:

4.1 “Overview of methods by routine use”,

4.2 “Overview of methods by standard covering”,

4.3 “Overview of methods by range of application.

These overviews are completed by the section 4.4 “Examples of practical application of some investigated methods”, where several realisations of a subgrade improvement are introduced by photos or charts and basic information. Some of the railway consortium members sent specific documents from practical realizations of particular methods for this section.

For the elaboration of this report, a questionnaire was made, where experts from railway companies filled in information about their experience with each improving method which was used in their railway network. Filled questionnaires can be found in annex to this report (see chapter 6).

This document will be used as a basis for coming work of WP2.2 - Track subgrade improvement.

D2.2.4 Description of measurement sites and LCC reference sites

Lead contractor... SNCF
Submitted... 2009-02-13
Size .... 57 pp

Executive summary

Since improvements of track subgrade are extremely expensive (maintenance of track support, and especially the ballast, has always been a major cost driver) and require intrusive maintenance, there is a need for research to develop new cost effective track systems and maintenance procedure.
So far, track monitoring has mainly been focussed on the visible or directly accessible part of the track surface: geometry, rail surface corrugation, rail defects, state of fastening system, ballast profiles, etc.
SP2 aims to develop new tools and methods for the investigation of a set of subgrade characteristics and to propose an innovative substructure assessment method, based on a comprehensive analysis of the different parameters.
The development of investigative tools and methodologies for the subgrade layers (non destructive and possible to use in a systematic and economic way on long track sections) as well as a methodology for the estimation of the global track potential from a comprehensive analysis of monitoring data, would allow the infrastructure manager (IM) to avoid non-adapted inefficient maintenance operations.
In this way, the WP2.1 is focussed on track bed quality assessment. Therefore, objectives are:
• Set out relevant parameters to be measured,
• Identify the most relevant measurement techniques for each physical parameter
The major questions can be summarised as:
• How does subgrade/subsoil Influence the long and short time behaviour of track?
• How does the operated track interact with the subgrade/subsoil?
• Which external influences have be taken into account additionally?
In order to give answers to these questions, methods based on measurements of subgrade parameters and track behaviour were applied. The measurements concerned stiffness and its variability and track behaviour as well as the characterisation of the area below the rails by means of geophysical

methods, penetrometer, endoscopy, sampling and lab testing.
The results of the in-situ measurements have been gathered in a database, which is one of the deliverables of the SP2.
In order to make easy the future handling of such a database, the first part of this report proposes to give information on the sites which have been investigated, detailing the characteristics of these sites (location, information on traffic, geometry, information on soil composition, encountered problems on the site…).
With the same purpose of developing new cost effective track systems and efficient maintenance procedures, the SP6 focuses on LCC assessment. LCC is an appropriate method to identify cost drivers and to gather the costs of a system, a module or a component over its whole lifetime including development, investment, maintenance and recycling costs.
Different views and evaluations allow the comparison of different systems and deliver necessary information for technical and economical decisions. In the field of railways, LCC is as widely implemented as it could be and will provide a definite advantage to the IMs in helping them to calculate costs for the implementation of innovative technologies.
In the frame of INNOTRACK, LCC will be defined at a European level and will be used to identify cost drivers and assess the track components, modules or methods developed in SP2 to SP5 to fit the European problems defined in SP1.
The SP2 contribution to LCC consists of giving information on some investigated sites. These sites were selected through the maintenance problems which already existed there and through the different results obtained in the frame of the SP2 work. These selected sites are called “Reference sites”. They will then be used as a reference system for LCC calculations.
From the description of these sites, SP6 will establish reference models. The evaluation of optimised systems will be based on these reference models. In order to make easy the handling the SP2 data related to the selected sites, the second part of this report gives information on the selected sites and details the characteristics of these sites (location, information on traffic, geometry, information on soil composition, encountered problems on the site…). In this part, the template proposed by the SP6 is also filled in.
This will help the SP6 to establish the LCC models.

D2.3.1 Validation methodology and criteria for the evaluation of frame type, unballasted or slab-track based superstructure innovations

Lead contractor .... Corus
Submitted 2008-09-15
Size .... 12 pp

Executive summary

NNOTRACK Sub Project 2 aims to investigate new track support concepts, which can improve on the effectiveness of conventional ballasted track to support railway traffic. A number of such concepts have been proposed and range from small changes to conventional systems through to slab – track and beyond using radical alternative designs incorporating novel materials. Development of innovative tools to optimise the design of these track forms are also being explored and techniques for adapting maintenance procedures to meet increasing traffic demands and reduced access times. WP2.3 focuses on the superstructure and on optimisation of its design and/or components on the basis of numerical simulations, laboratory experiments and full size tests.

In order to assess modifications to conventional ballasted track or to evaluate the effectiveness of the novel track forms studied, a clear definition of the requirements of the supporting superstructure must be established

The purpose of this deliverable is to provide quantifiable criteria that can be used to assess and compare the precise benefits of each potential solution. In this way the design and optimisation processes can proceed against a scientific background and any benefits of the novel solutions can de demonstrated and quantified. As the effects of changes in the support structure can be wide reaching and can influence the performance of other parts of the system, the engineering criteria that make up this defined methodology are divided into the areas where these effects can be measured and quantified.

A common parameter to combine these competing criteria is that of cost. Optimisation for cost using universal rules is difficult – this has been the subject of other studies outside the project, which will be brought to bear if appropriate.

D2.3.2 Optimised design of steel–concrete–steel track form

Lead contractor... Corus
Submitted 2008-03-14
Size ....55 pp + 6 Annexes

Executive summary

The primary objective of WP 2.3.6 is to develop and validate a consistently supported track system using steel based composite structural systems while ensuring that the installed cost of such a system is maintained as close as possible to that for conventional ballasted track.

Subsidiary objectives include:

- Low maintenance tracks (less activities, easier/automatic/self-inspection, diagnosis and monitoring)
- Changes in track-structure to provide better load distributions and/or higher load carrying capabilities
- Cheaper materials (e.g. in new build formation)
- Cheaper construction (see also the Logistics Sub Project)
- Shorter construction time
- Reduced renewal possession time.
- Maintenance with minimal traffic interruptions

These have all been tackled in the designing of this new track form.

This deliverable report includes the results of work to optimise the design of the WP 2.3 (Superstructure Developments) Corus steel slab track system through parametric studies in relation to slab overall stiffness and strength, with differing track conditions, including detailed stress analysis, fatigue evaluation, environmental impact studies and testing.

The principal elements of the Conceptual Design are

- Pressure on the formation is reduced by the stiffened slab design which distributes the load over a larger area.
- There is a base or support slab consisting of steel beams of low height encased in concrete for protection against corrosion
- The upper steel frame can transmit loads directly to the formation independently of the base slab during the period of concrete curing.

Future work is proposed to include implementation in a switch and crossing renewal, which will be used to verify the LCC impact as well as allowing verification measurements.

D2.3.3 Design and manufacture of embedded rail slab track components

Lead contractor.............................. Balfour Beatty
Submitted... 2008-06-12
Size .... 39 pp

Executive summary

We consider that our fundamental task is to support INNOTRACK in their endeavours to deliver to the Commission, proof that track infrastructure can be both manufactured and installed at a cost 30% less than currently available in the marketplace.

We believe we have demonstrated that the essential elements of such a solution exist. In the first phase of this project, we have analysed and designed a product. It has been developed from proven engineering principles to be simpler, easier, quicker and cheaper both to manufacture and to install.

In addition, we have identified where operational cost can be reduced to meet a potential LCC reduction of 30%. This applies, not just to some components, but to the overall track system. Indeed savings may be extended further into the operational cost of vehicles using such a system e.g. elimination of tamping fleet.

This report documents the design for manufacture and installation of components for the Balfour Beatty Embedded Rail System. The main design modifications between MkI and MkII systems are examined, along with details of the further optimisation of components. In addition, a description of the manufacturing method for each component is summarised.

To prove the design of the MkII system, a series of static tests were undertaken. The tests were based upon existing British and European Standards for railway track applications. The sub-system was subjected to three tests; longitudinal rail restraint, vertical rail restraint and vertical stiffness. The performance of the embedded rail system was found to meet or exceed the requirements as defined by the trans-European high-speed rail system.

The key installation techniques for a cost effective installation of an embedded rail system have been considered, including a pre-cast slab, slip-formed slab and a cast in-situ slab. The new 'clipped lid' installation device, which facilitates the setting of both the embedded rail sub-system components and final track alignment, has also been illustrated.

For the next phase of the project, we need to test the components to confirm the track quality retention, robustness and to validate the LCC assumptions. We also anticipate, one of the Infrastructure Managers to provide an opportunity to deliver for the Commission, a real in track demonstration to prove the LCC saving are a reality. The project will then have been visibly successful to the credit of all its participants.

D3.1.1 Definition of key parameters & Report on cost drivers for goal-directed innovation

Lead contractor .... DB
Submitted 2008-07-03
Size .... 36 pp

Executive summary

The aim of the Innotrack project is to reduce Life Cycle Costs of about 30%. Therefore the purpose of this deliverable is to identify the key parameters for optimizing the track related performance of S&C.

This is be done by embedding the analysis of real cost factors into the identification of track related components and the general cost factors of a S&C. Key parameters for optimization are then identified by combining the results of cost factor analysis with the identified components and cost factors.

Because of insufficient infrastructure data bases for getting data of costs for maintenance activities as far as possible representative lines have been selected for the cost factor analysis.

The analysis of the selected high speed line from DB (with UIC 60 S&C, mixed traffic with about 17.5 MGT/year (average) and 458 chosen S&C) has identified the following key parameters:

a. **50%** of the overall costs are for **inspection, service and test measures**. These are thus the main cost drivers overall at the selected DB line.

b. **excluding inspection/service/test** the main cost drivers with 65% are renewal of half set of switch (35%), large elements[1] (17%) and frog renewal (13%).
The other activities like welding, corrective maintenance (e.g. minimal repair), tamping etc. sum up "only" to 35% on the selected line.

c. First results from another DB analysis confirm this conclusions in general but show that the **costs for renewal of switch rails are roughly equal to the costs for renewal of frogs**.

The analysis of the maintenance costs of the selected line from BV (with mixed traffic (about 25% passenger and 75% freight traffic) with assumed 18 MGT/year) has identified the following key parameters:

The main cost drivers (without inspection/service/test) are

- Short-range planned actions after inspections with 30% (mainly including adjustment, build up welding and minimal repairs as actions after inspection)
- Long-range planned actions after inspection with 26% (including replacement of frogs, switch rails and check rails as part of the condition based maintenance)
- Costs for inspections & predetermined maintenance with 17%.

The costs for these measures sum up to 73% while the amount for the other activities inspection, grinding and tamping are of 27%.

Because the distribution of the maintenance costs to the detailed activities for short- and long-range planned actions and for failure costs is not yet available further analysis is required to break down the costs to types of S&Cs and to the associated maintenance activities and components of a S&C. As well as to investigate is the difference between the costs for DB and BV.

Follow-up analyses for other routes with different characteristics are under way. It will be reported in later deliverables which will also include data analysis from other railways.

[1] The data bases do not include detailed specifications of the category 'large elements', but this category includes large components like frogs, switch rails, check rails etc.

D3.1.3 Draft specification of the S&C demonstrators

Lead contractor ... DB
Submitted ... 2008-12-10
Size ... 17 pp

Executive summary

This document contains the proceeding and the draft demonstrator specifications for the WP 3.1 track related improvements.

In the following chapters the overall proceeding and the simulation steps are described. This is followed by a description of preliminary works: identifying the main cost factors as a motivation for optimizing frogs and switch blades via simulation. In the end the demonstrators are presented.

It should be pointed out that this approach is a premiere: to develop optimized track related components of a switch with scientific methods and simulation tools in a European wide collaboration of suppliers, infrastructures and Universities instead of a time consuming 'learning by doing'.

D3.1.4 Summary of results from simulations and optimisation of switches

Lead contractor ... Chalmers
Submitted ... 2009-02-13
Size ... 38 pp

Executive summary

The work in INNOTRACK SP3.1 (tasks 3.1.5 Materials and 3.1.6 Optimisation) aims at the development of innovative S&C (Switches & Crossings) designs that allow for increased axle loads and speeds and lead to decreased need for maintenance. INNOTRACK deliverable 3.1.4 provides an extended summary of the work performed up to December 2008. It contains three parts:
1. The optimisation of S&C is mainly based on numerical simulations. Since simulation work is shared between different partners (Chalmers, DB, MMU and VCSA), it was necessary to *develop a common simulation platform*. To ensure that the results of the simulations are comparable and represent reality correctly, it was decided to perform a *validation* of the different software used on the basis of results from *field measurements* in Härad (Sweden). The first part of the report describes the field test in Härad and presents a comparison of measured and calculated wheel–rail contact forces.
2. *Optimisation of dynamic track gauge in the switch panel*
Railway vehicles often experience significant lateral displacements, sometimes leading to wheel flange contact, when running in the through route of the switch panel. This often creates increased wheel and rail wear and sometimes rolling contact fatigue problems on the rails, requiring increased supervision and maintenance and reducing the life of the components.
The geometry of the gauge variation in the switch panel is in the study represented in a parametric way. Based on a parametric study, two possible optimal solutions were found and validated by evaluating a wider set of simulation cases. The main benefits obtained by the new designs proposed are (i) a significant *reduction of wear*, represented by *Tg*, in all locations analysed along the switch, and (ii) a significant *reduction of traction coefficient*, and therefore improved behaviour in terms of *rolling contact fatigue*.
3. *Optimisation of geometry and support stiffness in the crossing panel*
Severe impact loads may be generated when the wheels are transferred between wing rail and crossing nose in the crossing panel. The objective of this study was to optimise the crossing geometry and the support stiffness of the superstructure in order to reduce the contact stresses induced by the

wheels. Different modifications of crossing nose and wing rail profiles are proposed and compared based on numerical simulations.

The comparison of standard support stiffness with reduced support stiffness (by means of elastic rail pads) shows that the *impact loads can be reduced* considerably especially for crossing negotiation at high speed. Investigations of different crossing geometries show that it is difficult to find a solution which leads to a force reduction for all wheel profiles occurring in service.

Nevertheless, the MaKüDe crossing design showed the best performance especially for mean worn wheel profiles for both running directions (facing and trailing moves). In connection with reduced support stiffness (e.g. elastic rail pads), this crossing design will lead to a significant reduction of the impact loads and consequently a high *potential for LCC reduction*.

Full details on the work summarised here are given in separate reports appended to this deliverable:

• E Kassa and J C O Nielsen, Dynamic interaction between train and railway turnout – full-scale field test and validation of simulation models. *Vehicle System Dynamics* Vol 46, Issue S1 & 2, 2008, 521-534 (Appendix A in D3.1.4)

• D Nicklisch, Validation of a SIMPACK model for simulation of turnout passing, INNOTRACK Technical report, April 2008, 13 pp (Appendix B in D3.1.4)

• J Perez, Optimisation of the dynamic gauge for railway switches, INNOTRACK Technical report, December 2008, 25 pp (Appendix C in D3.1.4)

• D Nicklisch, SIMPACK-simulations of passing switches and crossings, INNOTRACK Technical report, December 2008, 11 pp and two appendices (Appendix D in D3.1.4)

D3.2.1 Definition of acceptable RAMS and LCC for DLDs

Lead contractor..Contraffic
Submitted 2008-11-15
Size..28 pp

Executive summary

The report starts with an overview of the devices currently used on UIC 60 switches given by railway companies. The report continues with an overview of DLD equipment investigated in this study and RAMS and LCC for current applications. From this analysis RAMS requirements for innovative solutions are deduced.

In conclusion the LCC calculation based on the data of two Network companies shows differences between the two.

A LCC calculation for a target configuration including all DLD components with a much higher MTBF and also a higher initial investment show a LCC cost reduction of 41 % exceeding the Innotrack project goal of 30 % reduction.

The LCC target can be archived by investing into more reliable and less maintenance intensive equipment.

D3.2.2 Functional requirements for hollow sleepers for UIC 60 and similar type switches

Lead contractor....................................... Contraffic
Submitted... 2007-12-19
Size ....22 pp

Executive summary

The present specification is based on the requirements of European railway operators to applications of integral switch setting and monitoring systems. This specification is to be declared a European standard.

In specifying the geometrical requirements maximum importance was attached to small dimensions (compact components) so that especially for the switch setting systems no restrictions shall apply with regard to mounting, layout and transport. Nevertheless the mounting space should be determined in such a way that the majority of the existing solutions for setting system components can be integrated into the hollow sleeper without difficulty. Preferably UIC 60 stockrail and switchers are to be used which is the scope of the Innotrack project. The proposed hollow sleeper can be used or adapted to other profiles also.

The specification covers in detail:

- Geometric specifications for the hollow sleeper
- Functional requirements

- Requirements in terms of availability and reliability
- Description of the tests required.

D3.3.1 List of key parameters for switch and crossing monitoring

Lead contractor............University of Birmingham
Submitted 2008-11-04
Size .... 42 pp

Executive summary

The purpose of the report is to identify the key parameters for optimising the performance of switch and crossing systems. The key parameters are those which, when altered, have the largest impact on the resulting performance of a switch and crossing system and hence provide indication of incipient failure.

This document first outlines the process followed for the identification of the key parameters. Further details are then presented on particular switch systems, the results of the identification process and the conclusions about what parameters are fundamental for optimisation. The focus has been on switch systems rather than crossings, because automated monitoring, which forms the basis of a realistic optimization effort, is most easily installed in the switch actuator system. The key parameters for optimization are therefore the parameters measured within this system.

D3.3.2 Available sensors for railway environments for condition monitoring

Lead contractor............University of Birmingham
Submitted 2009-02-13
Size .... 36 pp

Executive summary

European infrastructure managers currently use a number of different condition monitoring systems to assess the health of point machines on their networks. The aim of these systems is to both detect failures before they occur (fault detection) and to aid with diagnostics (failure diagnosis).

This report outlines the initial findings from phase one of a research project undertaken by the University of Birmingham's Centre for Railway Research and Education, on behalf of Network Rail. The work aimed to assess the potential for point condition monitoring to predict and diagnose incipient failures. This report focuses on the groups of failure modes which can be detected and diagnosed using condition monitoring.
In the context of the INNOTRACK project, this work demonstrates effectively how sensors, measuring the key parameters identified in D3.3.1, can detect the changes in switch performance which appear when incipient faults are developing. The work is support by failure data from Network Rail's failure management system, a priori knowledge in the form of failure mode effects analyses and experimental data collected during the research at a Network Rail training facility (Escrick, York).
Further work, which will be reported separately, will concentrate on generic data acquisition hardware systems and algorithms for automatic detection of point machine faults.

D3.3.3 Requirements and functional description for S&C monitoring

Lead contractor..................................... Contraffic
Submitted... 2009-03-06
Size .... 27 pp

Executive summary

The objective of the Innotrack project is to find new technologies for S&C which can contribute to an overall 30% reduction in their life-cycle cost. Around 50% of the LCC for a S&C system comes from routine maintenance, which is generally organised according to fixed periods which are determined using a conservative estimate of the amount of time it is safe to leave parts of the S&C unmaintained. This means that more money is spent than necessary, in periodic maintenance. Technical staff are also exposed to lineside hazards more than is necessary, because of the extra time they spend on site.
Additionally, these maintenance and inspection periods are not always sufficient to mitigate the risk of rightside failures. Inspection by humans often

only has a superficial insight into the operation of a switch.

A more efficient approach to maintenance would be to have accurate automatic condition monitoring systems which can direct maintenance activities more efficiently by only specifying and scheduling tasks which are needed.

The requirements for automatic monitoring systems will be different depending on what equipment is to be monitored and where the system is operating. However, it has been possible to create a generalised set of requirements which can be applied globally and these are presented in section 4.

The functionality and physical architecture of the higher levels of monitoring systems have also been specified in this document. The functional architecture in section 5 shows how the system is expected to interact with its environment, and includes a description of the inputs and outputs. The possible physical architecture is described in section 6.

D3.3.5 Requirement specification for the DLD and monitoring demonstrator

Lead contractor......................................Contraffic
Submitted 2008-10-25
Size .... 14 pp

Executive summary

Includes also D3.2.4.

The report contains the requirements for the SP3.2/SP3.3 switch control and monitoring demonstrator system. These have been agreed by the working party for SP3.2/SP3.3 and mandate the development of two separate demonstrators, one by VAE (in collaboration with Contraffic), and the other by Vossloh Cogifer.

The requirements have been formed into statements, each with a unique number. In some cases, requirements with a broad scope have been decomposed so that each can be tested separately. Decomposed requirements carry the number of their parent plus their unique child number. Parent and child numbers are separated by decimal points.

Not all the requirements are mandatory. Those which are mandatory are marked with an ‘M’ beside the requirement title.

Following functional analysis of the system, the requirements should be decomposed so that all are single, testable statements, each of which applies to a different function or component. This will make it easier to determine whether the requirements have been fulfilled and therefore whether the demonstrator has achieved what was needed.

Background information on the DLD components used in the two planned demonstrators is provided in section 3.

D4.1.1 Interim database for actual and new, innovative rail/joints

Lead contractor.....................voestalpine Schienen
Submitted.. 2008-03-14
Size ....16 pp

Executive summary

This report describes degradation data from test sites that have been monitored by both rail producers and the Infrastructure Managers (IM’s). The parameters that have been monitored and reported are those which have a major influence on rail and joint degradation, including wear and rolling contact fatigue (RCF). This report gives details on the methodology of data collection along with an explanation of what data has been collected; the data is collated in an accompanying spreadsheet. The data reported include information on the track characteristics, loading characteristics and the degradation which has been observed.

Analysis of the data has been and continues to be carried out in parallel with this collation exercise with the initial results on rail degradation mechanisms being reported in the accompanying deliverable D4.1.2.

D4.1.2 Interim rail degradation algorithms

Lead contractor................................Corus & VAS
Submitted.. 2008-05-02
Size ....32 pp

Executive summary

In Railways and rail manufacturers have collected large amounts of data on the degradation of rail over the years. This has given invaluable information on the performance of different rail grades in service. This data is being collected together in a database with the results reported in D4.1.1. This deliverable, reports on an initial analysis of this data aimed at deriving algorithms for the degradation of rails as a function of track geometry, rail grade and loading conditions. The derived algorithms will then be used to establish definitive guidelines for the selection of rail grades to maximise the expected life for the various duty conditions.

The analysis has shown that wear is the key degradationmechanism of rail for tight curves of less than 700m while rolling contact fatigue is a major problem for curves of intermediate radii. However, since maintenance of rail profile is also a key requirement for the management of RCF, understanding of wear behaviour for other track characteristics is also considered to be important. The initial analysis has demonstrated that this is a non-trivial problem because of the wide range of variables that are present within the collected data. Further problems also include the lack of information on certain parameters that are important to the performance of rail in track. Although some clear trends have become apparent from the initial analysis, it has also revealed where further analysis is required and this will be reported in a further deliverable.

D4.1.3 Interim database for actual and new, innovative rail/joints

Lead contractor .... voestalpine & Corus
Submitted 2008-06-03
Size .... 14 pp

Executive summary

This interim report describes the work carried out within work package WP4.1 on rail grade selection. It should be emphasised that this is an interim report and is the basis for further work within Innotrack. Comments and supplementary information from other partners or expert groups are most welcome and will be considered for the final deliverable.

The development of the interim guidelines on rail grade selection is based on the analysis of data from the monitored sites (Deliverable D4.1.1 and D4.1.2). However, material properties determined under closely controlled tests on specialist equipment in WP4.3 will be used to assess the efficacy of available wear and RCF models and when combined with the observed in-service performance data will form the basis of establishing definitive guidelines for the selection of rail grades.

D4.2.1 The impact of vertical train-track interaction on rail and joint degradation

Lead contractor .... Banverket
Submitted... 2007-11-15
Size ....20 pp + 10 app

Executive summary

In this tentative report we present a summary of the work carried out during approximately the first nine months of the INNOTRACK project regarding the influence of rail/joint degradation on operational loads and subsequent deterioration. The focus is here on the vertical train–track interaction and related deterioration.

The work within this field can be divided in two categories. The first concerns the collection of input and validation data. In this category the current deliverable includes measurements of in-field axle loads, in-field monitoring of squats and compilation of material data.

The second category is the actual numerical simulation and resulting quantifications of increased operational loads and deteriorations. Here the deliverable includes a state-of-the-art study of the effect of material characteristics on material deterioration and the practical implications. Further, the deliverable contains reports of parametric studies of the influence of rail corrugation, the growth of larger rail cracks, the influence of the design of insulated joints and the influence of rail squats.

D4.2.2 Interim report on "minimum action" rules for selected defect types

Lead contractor.. Corus
Submitted 2008-01-21
Size... 35 pp

Executive summary

This report sets out a scientific approach to the determination of 'minimum action' timescales i.e. the timeframe within which the engineer must take action when a defect has been discovered.

For the purpose of this report, 'Minimum Actions' are defined as 'the actions that the engineer with responsibility for the safety of the line must take in the event that a defective or broken rail is discovered'. Thus the report is not about preventative maintenance strategies such as rail grinding. It is about the actions required and the timescale for action when preventative measures have failed to stop the development of a crack that threatens the integrity of the rail.

Within Europe, practices, in particular minimum action timescales, vary widely. This is not surprising since so do inspection regimes, and the two are closely connected. The longer the period between inspections, the greater the time available for defect growth and hence the shorter the time available (on average) to take action when a defect is discovered. Axle loads and traffic density would also be expected to have a major effect.

As a generality, it is not possible to predict, with confidence, the residual life of a specific rail containing a crack. There is too much scatter in material properties, support conditions, vehicle loadings, residual stresses etc. to enable this to be done. However a considerable amount of information is available on the range of properties, support conditions etc. that are experienced. Using these data and the process of Monte Carlo simulation, it is possible to predict, on a system wide or track category basis, what the effect of changes in minimum action time scales, inspection method or inspection period, traffic pattern or track construction will be on the proportion of defects that will result in rail breakage.

This is the essence of the approach proposed in this report. It combines fracture mechanics based residual life prediction with Monte Carlo simulation.

The method described will provide a tool for the evaluation and optimisation of inspection procedures and action timescales, a means of predicting what effects changes in traffic pattern will have on breakage rates and a means of assessing the benefits of different forms of track construction.

The method is necessarily limited by the boundaries of current scientific knowledge. In particular the rate of growth of rolling contact fatigue cracks is still an active area of research. Hence, whilst there is no conceptual problem in applying the method to head checks and squats, in practice, our fundamental understanding of the phenomenon may need to be to be advanced before the approach can be applied.

In the form presented here, the model also assumes that the initial defect is small. Thus the model will not deal with the major defects that occasionally occur in alumino-thermic welds as a function of process faults. Arguably this is more a process control problem than one that should be contained by routine inspection.

In the next phase of the project, the methodology described will be implemented as a software package. This will be available to Infrastructure Managers under a separate agreement.

D4.3.1 Initial definition of conditions for testing matrix of rail steels and welds

Lead contractor.. DB
Submitted... 2007-08-21
Size ....24 pp

Executive summary

This paper has been written in order to define and reconcile the test matrix of the INNOTRACK work-package 4.3 'Innovative laboratory tests of rail steels and joints'.

The tests shall be performed due to data obtained from site observations of railway operators. On the basis of these data a programme for specific laboratory tests will be established in order to validate the site observation results under different service conditions such as speed, axle loads, angle of attack etc.

Service conditions for laboratory tests (i.e. wheel-rail test rig or twin disk tests) will be derived from the above mentioned experiences and will be compared to the experimental capabilities of the project partners. The conduction of the tests is based on the experience of each project partner from other projects. Their transferability to rail material testing is a known risk of the work package.

The testing capabilities of the project partners are described as Annexes 1 to 4

Annex	Originator	Objective
1	UoN	Description of twin disk rail material testing
2	VAS	Description of test rig rail material testing
3	DB	Description of rail on roller tests
4	Chalmers, TUD	Subsequent numerical calculations, regarding rail degradation

The tests will be performed with original rail and wheel material. The grades, forces and other parameters of the tests have been reconciled within the workgroup. It is intended that the test conditions of the different partner's tests should have common effects at RCF.

For proving this, numerical simulations provided by the other project partners will be used in the progression of the WP 4.3.

The combination 'operational demands vs. experimental capabilities' form the WP 4.3 test matrix as the main result of this deliverable.

D4.3.2 Characterisation of Microstructural Changes in Surface & Subsurface Layers of Rails with Traffic

Lead contractor........................... Corus Group plc
Submitted 200-10-11
Size.. 21 pp

Executive summary

Rolling Contact Fatigue (RCF) of rails, whether manifested as head checking, gauge corner cracking or squats, continues to be one of the key rail degradation mechanisms reducing the life span of rails with a significant adverse impact on the Life Cycle Cost of the track infrastructure. Not surprisingly, this issue and, more generally, the rail-wheel interface and its implications for track maintenance have been the most prominent topic of railway research. However, although plastic deformation and resulting work hardening of the surface and sub-surface layers of the rail are universally acknowledged, a quantitative assessment of this microstructural damage and property change has been restricted to measurement of micro hardness.

The work reported in this document has provided an alternative way of assessing the misorientation of grains as a result of the passage of traffic through the use of Electron Back Scatter Diffraction techniques. Although based on a relatively small number of samples, the work has demonstrated that the thickness of the damaged layer reduces with increasing hardness of the rail. Implications of this finding on the magnitude of metal removal during grinding have been briefly discussed and this document is expected to serve as a discussion document to formulate a programme of work to answer the questions and hypothesis presented.

The work has also demonstrated that Scanning Electron Microscopy provides a useful way of examining RCF affected running surfaces and has shown that RCF cracks are a consequence of plastic deformation of very thin layers of material to create ledges. It has been found that replicas can be used to study this surface deformation phenomenon and could be used to look at both RCF-free and RCF affected track.

In view of the very encouraging results, the scope of the original work programme and the deliverable 4.3.2 has been significantly increased to examine a larger number of samples and consequently, this document should be treated as an interim deliverable with the final document to be delivered later.

D4.3.3 Results of first test rig measurements

Lead contractor... DB
Submitted 2008-05-23
Size....................................24 pp + 3 appendices

Executive summary

This paper and its attachments report on the results of first test rig tests being performed by the WP4.3 partners UoN, VAS and DB. The seven tests were based on the test conditions described in the deliverable 'D4.3.1-F2-Testing_Matrix_Definition'.

These first tests aimed

- to demonstrate the applicability of the test conditions to the test rigs
- to achieve first results of material tests
- to provide input data for numerical calculations.

The detailed reports are attached to this document as a set of separate pdf-files.

The table below gives an overview on the results.

Name of test	Per-former	Test rig	Test conditions	Results
5000 Dry	UoN	SUROS	5,000 cycles dry Corus 400 vs. R7	wear only no crack detection
5000 Dry + 5000 Wet	UoN	SUROS	5,000 cycles dry + 5 000 cycles wet Corus 400 vs. R7	wear cracks detected at 4000 'wet' cycles, i.e. at 9000 total cycles.
15000 Dry	UoN	SUROS	15,000 cycles, dry Corus 400 vs. R7	wear only no crack detection used
260-20-wet #1	VAS	VAS test rig	100,000 passes wet, R260 vs. R7 water supply temporarily interrupted	Wear RCF/HC after 10 – 50 k passes
260-20-wet #2	VAS	VAS test rig	100,000 passes wet, R260 vs. R7 continuous water supply	Wear No HC
DB A01	DB	test rig A	680,000 load cycles mixed (1/3 wet, 2/3 dry) R260 vs. R7	Wear RCF/HC at test end (no intermediate testing)
DB C01	DB	test rig C	1.2 mio load cycles wet (continuous) R260 vs. R7	Wear No HC

The first tests of UoN performed at SUROS test rig generated wear under dry contact conditions and wear/RCF under mixed wet and dry conditions. The tests were performed for one pair of rail/wear materials only.

The first tests of VAS and DB at their full scale wheel-rail test rigs provided profile data for subsequent numerical calculations. Profile data will be exchanged between the WP4.3 partners directly on request. The tests were performed for one pair of rail/wear materials too.

The tests give cause for the assumption that water is of great importance for the formation of head checks if it is applied non-continuously.

- The SUROS-tests did produce cracks only in case of wet after dry conditions.
- HC appeared at gauge corner during VAS' test 'wet#1' when the water supply had accidentally been interrupted. A second test 'wet#2' under the same conditions but with continuous water supply ended without formation of HC.
- The DB results are similar. The test 'DB C01' at a roller rig with continuous water application did not produce HC even over 20 MGT or 1.2m load cycles. By contrast, usual tests at DB's roller rig A (e.g. 'DB A01') using intermittent water dust do generate HC at less than 10 MGT or 0.6m load cycles.

Unfortunately parts of DB's test rig C have been destroyed during test 'DB C01'. DB therefore reflects on another test assembly.

The consequences for the next full scale tests are still under discussion within the work group.

D4.3.4 Calculation of contact stresses and wear

Lead contractor....................................... TU Delft
Submitted 2009-02-15
Size......................................23 pp + 5 appendices

In this report a methodology for the simulation and analyses of wheel-rail rolling contact is presented. It is applied to the determination of the contact stress, micro-slip and the location of maximal contact stress of the first laboratory tests conducted in the frame of WP4.3. Subsequently the locations of RCF initiation are predicted. The predictions are compared with the test results, and the validity of the methodology is established. It is also shown that with the presented methodology deviation of rolling contact conditions from their nominal ones can be identified, so that accurate predictions can be made.
The methodology can be employed for analysis of rolling contact under operational conditions and lab conditions. The results of the analyses can further be used for wear and rolling contact fatigue analyses etc.
The report D4.3.4 was undertaken to support comparison of contact conditions between the machines used for testing within WP 4.3

D4.4.1 Rail inspection technologies

Lead contractor.............University of Birmingham
Submitted 2008-11-04
Size...42 pp

Executive summary

Nowadays, rails are systematically inspected for internal and surface defects using various non-destructive evaluation (NDE) techniques. During the manufacturing process rails are examined visually for any surface damage, while the presence of any internal defects is assessed mainly through ultrasonic inspection.

Similarly, ultrasonic wheel probes have been extensively used by the rail industry for the inspection of rails in-service. Unfortunately, conventional ultrasonic wheel probes cannot reliably detect small (<4 mm) surface defects - particularly Rolling Contact Fatigue (RCF) cracks – in rails.

Despite the fact that several maintenance procedure models have been developed based on the rail damage present, their accuracy is not sufficient to eliminate the need for inspection. For that reason, the rail industry has invested considerably in the research and development of alternative NDE methodologies. The current international practice is to combine non-destructive evaluation of the rail network with preventative maintenance procedures, such as rail head grinding, in order to optimise the trade-off between maintenance cost and reliability.

Recently, hybrid systems based on the simultaneous use of pulsed eddy current probes and conventional ultrasonic probes have been introduced in Germany and elsewhere for the high-speed inspection of rail tracks. Pulsed eddy current probes are capable of accurately detecting RCF cracks of moderate size (~4 mm) and can operate at speeds of up to 72 km/h without significant variation in their performance. Nonetheless, eddy current probe performance is largely affected by lift-off variations, which means that certain surface defects can still be missed during inspection. For that reason extensive research is currently under way for the development of novel high-speed NDE equipment, involving high speed cameras, Alternating Current Field Measurement (ACFM) probes, Electromagnetic Acoustic Transducers (EMATs), Field Gradient Imaging (FGI), ultrasonic phased arrays, laser ultrasonics, and multi-frequency eddy current sensors. Some of the aforementioned methods, such as the ACFM, are already available for use by the rail industry but the inspection speeds currently achieved (~2 km/h) permit the quantitative inspection of only small rail segments, where damage is already known to exist. This report comprehensively reviews non-destructive evaluation methodologies in use around the world for rail defect detection. This includes a detailed overview of non-destructive evaluation theory and the techniques used to incorporate condition data into maintenance procedures. It also presents a comprehensive overview of the current state-of-the-art in non-destructive evaluation of railways coupled with an extensive discussion of future developments and novel inspection methodologies in the field.

D4.4.2 Operational evaluation of an inspection demonstrator (phase 1 : laboratory and static tests)

Lead contractor.. SNCF
Submitted 2008-06-27
Size .... 124 pp

Executive summary

Rails are periodically surveyed by non-destructive manual or train-borne inspections in order to detect crack initiation and to ensure that crack expansion remains within a preset threshold. These periodic surveys are mandatory to maintain the required level of railway safety. As they tend to be more frequent on high standard infrastructure (higher loads or speed), rail inspection techniques and strategies are a challenging issue for future infrastructure maintenance.

The cost of these routine control operations is fairly high for various reasons:

- many manual operations are required (either because no inspection train is available, or because post inspection crack characterisation and periodic control are carried out manually);
- many hand operations are necessary to transfer the results from site inspection to remote databases and vice-versa, resulting in commonly observed inaccuracies in defect positioning;
- track availability is reduced because train-borne inspections can only be performed at reduced speeds, causing limitations to track availability.

The objective of improving rail inspection methods thus strongly contributes to the overall aim of reducing infrastructure maintenance costs.

Future inspection processes should also guarantee the highest level of security for operators and, if possible, improve operating conditions (exposure to weather, communication with remote databases, defect positioning) as well as improving environmental aspects (use of fluid coupling products).

To better respond to these objectives, it is necessary to evaluate and use the best relevant techniques currently available on an inspection demonstrator, which will be tested in the last phase of this work package.

D4.5.1 Overview of existing rail grinding strategies and new and optimised approaches for Europe

Lead contractor....................................... SPENO
Submitted.. 2007-08-31
Size .... 7 pp +3 app

Executive summary

The work package 4.5 studied the present situation with rail maintenance in order to find out potentials for development of strategies aiming at reduced life-cycle-costs for the rails.

D4.5.2 Target profiles

Lead contractor....................................... SPENO
Submitted.. 2008-05-31
Size .... 10 pp

Executive summary

WP4.5 summarized first the present grinding strategies and specifications of the represented IMs (see deliverable D4.5.1). The second step was to collect all the target profiles for grinding work used by them and to compare their shape and application in order to prepare guidelines for an optimized use.

Besides the standard target profiles for grinding, which are usually the as-rolled profiles, specific profiles to combat gauge corner fatigue are applied. They are described in this document.

D4.5.3 Input for LCC calculations

Lead contractor....................................... SPENO
Submitted.. 2009-02-06
Size .... 17 pp + 2 annexes

Executive summary

The work package 4.5 summarized the present grinding strategies and target profiles used in order to identify potential for improvements aiming at reducing LCC.

This document describes fields of improvement such as specifications and logistics, to maintain rails more economically and how to change towards a preventive cyclic grinding strategy.

D4.6.1 Report on the influence of the working procedures on the formation and shape of the HAZ

Lead contractor................................ Goldschmidt
Submitted 2007-08-21
Size .... 18 pp

Executive summary

One of the degradation mechanisms of welds is the differential wear between the bulk metal and the heat affected zone (HAZ) arising from the difference in hardness and wear resistance in the two regions. Consequently, welds exhibiting softened critical heat affected zones (HAZ's) wear away preferentially during service in track, leading to the development of localized wear dips or 'weld batter' on the running surface of the welded rail.

In the case of Flash Butt Welds, this degradation mechanism has been countered by reducing the width of the HAZ, particularly, the thickness of the band of lower hardness so that the weld is no longer visible to the wheel. The development of the Narrow HAZ welding procedure, patented by Corus, and the resulting properties are described in this document.

The process parameters of flash butt welding that contribute towards the formation of the heat affected zone have been critically examined and optimised with the aim of significantly reducing the HAZ width towards the narrower end of that specified in EN 14587-1. The process has been applied to all the commonly used rail steel grades and a number of rail sections. The success of the new process has been demonstrated through the results obtained for Grade 350 HT, 60E1 rail. Data for bend strength, hardness profile, and bending fatigue strength all demonstrate full compliance with EN 14587-1.

In the aluminothermic welding process the HAZ is produced by the heat input during preheating and by the superheated molten steel. By modification of the preheating parameters and the pouring system the width of the HAZ can be influenced. An additional possibility to influence the HAZ is a post heat treatment of the weld after the final grinding process.

The influencing process parameters to alter the width of the HAZ have been discussed. SkV-Elite is the welding process that provides the narrowest HAZ compared to the other welding processes. Nevertheless, the width of the weld and the width of the HAZ need to be considered with regard to the properties of the complete welding joint. The change of properties along the complete weld has to be controlled to optimize the performance.

Within this project HPW has been chosen as welding process because of its innovative welding procedure, that a selective alloying technique allows decoupling the properties of head and base of the weld. The high wear resistance of a hard head can be combined with the higher ductility of a base with lower hardness.

D4.6.2 Report on the influence of the working procedures and post treatment on static and dynamic fatigue behaviour of wluminothermic welds

Lead contractor................................. Goldschmidt
Submitted... 2008-11-03
Size .... 13 pp

Executive summary

In the present report two post treatments of aluminothermic welds are described that can successfully be applied to improve the weld properties.

One of the influencing factors on the static as well as on the dynamic fatigue behaviour of aluminothermic welds is the quality of weld surface and design of the weld collar. Especially the transition from rail to weld collar needs to be taken into account. The presence of any kind of weld defects and notches at this transition can be the cause for fracture initiation and failure of the weld. A mechanical post treatment of the weld (ultrasonic impact treatment) is available and it can be shown that the fatigue life of aluminothermic welds can clearly be improved. The mechanical deformation of the surface layers has a beneficial influence, but also a

further effect on the microstructure in greater depths under the surface improves the fatigue life.

Changing selectively the microstructure of a component to effectuate a better performance of the weld is the purpose of the second method described in this report. A post heat treatment of the base of weld and rail can be applied to improve the bending properties of high strength rails. In the example given in the report it could be shown that the deflection during the slow bend test of full-hardened rails could noticeably be increased.

D5.1.1 Preliminary report on the existing state of the art for construction and maintenance activities of logistic constraints and definition document on logistics needs and constraints and definitions of benchmarks

Lead contractor..EFRTC
Submitted 2008-04-17
Size...7 pp + 3 app

Executive summary

The technical annexe of the EC contract - Description of Work (DoW) is a legally binding document describing tasks to be performed, milestones and deadlines, allocation of resources and responsibilities of INNOTRACK project partners for deliverables. EFRTC is one of the contractual partners in the INNOTRACK project that was formally launched on 1st September October 2006 and to be completed on 31st August 2009. INNOTRACK is a major, joint effort by European railways and their industrial partners focussed on a coordinated innovation for track systems and the associated asset management practices, both under cost and performance aspects. The project is sponsored by the European Commission with a 10 Mio Euro budget.

INNOTRACK will last for 3 years. EFRTC - members will take an active role in providing their expertise in high performance and cost efficient track work management practices.

BSL and the University of Birmingham shall support EFRTC in delivering tangible results contributing to the optimisation of the supply chain interface between infrastructure managers and track work contractors (WP 5.1). It will identify best practices and make proposal for promoting good management and logistical practice in track maintenance and renewal work.

BSL and the University of Birmingham support EFRTC in setting-up a structured questionnaire that is discussed jointly and completed with both, contractors and infrastructure managers. It is evaluated systematically regarding advanced practices in the field and disseminated in peer group conferences. With regard to tangible output for EFRTC members it is envisaged to optimise contracting strategies and management practice in the cooperation between infrastructure managers and contractors, demonstrate the impact on cost of maintenance and renewal activities as a result of optimised practices (e.g. higher capacity utilisation of heavy machinery, better work-site logistic, contractual room for innovative work processes under LCC-criteria) and to give indications in broad, but quantitative terms about value-added ("lower unit costs") to infrastructure managers on one hand and enhance financial performance of contractors on the other.

Work package 5.1 (WP 5.1) focuses on the interface between infrastructure managers and contractors/suppliers. Especially:

- Identification of best technical and commercial logistics practices used on European Railway Networks and collation of experiences accumulated by all IMs
- Definition of innovative and cost effective methodologies taking into account the constraints of Railway Networks (possessions) in order to reduce LCC

Maintenance activities, related logistics and processes are in the focus of the project as they are a major driver of infrastructure's LCC.

The interviews shall give the IM/suppliers/contractors the opportunity to give their view on any areas for improvement in the current supply chain. The information gathered in the interviews is analysed e.g. in terms of the international transferability and the LCC impact.

The results of the analysis will be made available to the participants so that a mutual learning process can be commenced and participants can share innovative ideas and practices.

This interim report gives an overview of the achievements so far.

D5.1.4 Preliminary report on conduct of interfaces between contractors and IM's and means of improvement

Lead contractor..EFRTC
Submitted 2007-09-15
Size.. 16 pp

Executive summary

The deliverable D5.1.4 is a preliminary report on interfaces between contractors presenting the outcome of interviews with four contractors.
The interviews have been conducted by EFRTC subcontractor – BSL management consultant who is reporting to EFRTC Steering group set up for managing the EFRTC contribution to INNOTRACK project.

The Group is led by Jeremy Candfield, Honorary President of EFRTC and Director General of UK Railway Industry Association with participation of Dieter Schreck from Schreck-Mieves representing the contractors' view and Imrich Korpanec, EFRTC Secretary General.

The following approach was taken for interviews:

- in the first stage the selected companies for interviews have been asked to respond to the structured web-site questionnaire agreed by SP5 members and managed by University Birmingham
- in the second stage they have received additional questions focused on quantitative evaluation of their interface to Infrastructure Managers as a further preparation for interviews
- Finally the interviews have been conducted by EFRTC consultant (and SP5 team dedicated for interviews in the future).

In spite of time pressure and difficulties in planning and performing interviews within the period of months July and August 2007 the reports from interviews present valuable initial input to WP 5.1 deliverables outlining the ways for improvements and potential for costs reduction.

The major findings are presented in the conclusion of the report.

Other 2 to 3 interviews are envisaged in order to get a good coverage of various aspects of interfaces taking into account geographical location, size, structure and performance of contractors and their position in European market.

The findings will be analysed and processed in the final report making the proposals for the overall improvement for interface between Infrastructure Managers and Contractors aiming at significant further cost reduction.

D5.1.5 Final report on existing states-of-the-art for construction, maintenance and renewal activities and assessment of logistic constraints

Lead contractor............ University of Birmingham
Submitted.. 2008-11-04
Size ....100 pp

Executive summary

Adopting best practice in the field of track maintenance and renewal is crucial to achieving low costs for Europe's railway. European practices vary considerably between countries. Initial Life Cycle Cost (LCC) benchmarking of unit costs indicates there is considerable room for improvement when compared to costs achieved in the United States. The variation in maintenance and renewal costs has been related to outsourcing, yet this is only one of many factors. One of the aims of Sub-Project 5 (SP5) is to see if standardisation and the use of a more collaborative approach to logistics can help achieve lower costs, among a very heterogeneous set of European railways. To assist with this, Work Package 5.1 (WP5.1) produced two questionnaires to identify the current logistics practices of INNOTRACK Infrastructure Manager (IM) partners and contractors, relating to maintenance and renewal. This report studies the responses received from IMs. The responses from contractors are dealt with in a separate report.

The first questionnaire was web-based (referred to in this report as the 'web questionnaire') and asked questions that were quantitative in nature. The second was designed for use in face-to-face interview situations (referred to in this report as the interview questionnaire) to gather qualitative data. The data collected was then analysed to identify the current state-of-the-art (benchmark) for maintenance and renewal logistics activities, and the constraints that apply.

The search for IM logistic experts started in earnest at the beginning of August 2007 and was not an easy task. The topic of logistics is very wide and it was difficult to find one expert from each IM with sufficient knowledge to answer all the questions. By November 2007, however, experts had been found from all eight INNOTRACK IM partners.

The opportunity to contribute to the questionnaires was not restricted to INNOTRACK partners, but the efforts of WP5.1 were primarily focused on getting them to respond. One non-INNOTRACK IM participated:

The results of the interviews have been summarised as follows:

- The majority of IMs purchase centrally the rails, sleepers, ballast and S&C they require
- Most materials are supplied by rail
- The majority of IMs make use of call-off contracts for supply of rails, sleepers and S&C. In some countries where crushed stone is widely available, ballast is bought on the 'spot' market from the supplier nearest the work site
- The majority of IMs use 'just-in-time' supply techniques and hold low levels of component stocks as a result
- The majority of IMs try to balance planned work against available resources
- The majority of IMs recover used track components and use them again, but with differing degrees of enthusiasm. It can be difficult to make the financial case for recovery
- All IMs have responsibility for identifying and specifying the maintenance and renewal work required
- The great majority of maintenance and renewal work is done in 'white periods', when there is no train service. Long blockades of the line do not seem to be common
- After work has been completed the normal practice seems to be to open the line to traffic with a temporary speed restriction
- The majority of IMs work with their contractors to decide what method of work should be used
- The majority of IMs will use a track renewal possession to carry out maintenance work as well
- The majority of IMs use programmes of rail grinding and rail lubrication to extend track life
- The majority of IMs carry out maintenance in-house
- The majority of IMs use private contractors for renewal work
- The majority of IMs use training courses and examinations to improve and test the competence of their staff

The results of the web questionnaire are shown in Appendix K of this report and summarised below. Three IMs responded to the questionnaire: two were INNOTRACK partners, while the other was a non-INNOTRACK IM. A small number of contractors also responded to the questionnaire, but the results below refer only to responses received from IMs.

It is important to remember when reading the questionnaire results that, not only was the response low, but also those IMs that did respond did not answer all of the questions. The summary of results below does not state how many IMs answered each question. It is important to be aware therefore, that, where a result states all respondents carry out a particular logistics practice, this may be based on the answer from only one IM. This is not an ideal foundation from which to identify the common logistics practices on Europe's railways, however, the study had no option but to proceed on this basis.

Rails

- 60% of IMs place orders for rail more than three months in advance of required delivery date.

- 60% of the IMs use framework contracts for rail supply: contract duration is between one and two years.
- 60% of the rail supply call-off contracts do not have volume guarantees.
- IMs use an average of three rail suppliers each.
- Bulk distribution of rail is generally carried out by the IMs, perhaps because the rail distribution market is seen as not very competitive. Delivery of rail to site is 100% by train
- The stock of rail held by IMs at any one time is no more than 10% of the annual tonnage used
- The market for rail welding seems under-developed, with approximately 80% being carried out by the IMs
- Recovery of rail from renewal sites is greater than 50% of available tonnage. Of this, 100% is re-used

Sleepers

- All IMs use framework contracts for sleeper supply, with 60% having duration of five years.
- All of the framework contracts have a volume guarantee
- IMs use an average of three suppliers each.
- Sleepers are ordered between three and twelve months in advance of required delivery date.
- The stock of sleepers held varies between IMs: DB hold less than 10% of annual requirement at any one time, while REFER hold between 30% and 40%.
- The cost of sleeper distribution is up to 10% of the cost of the sleepers themselves. 80% of distribution is by rail.

Ballast

- All IMs use framework contracts for supply of ballast. Contract duration is generally one year and the contracts do not have volume guarantees
- IMs order ballast between one and three months in advance of required delivery date
- The number of suppliers used is high: One IM use up to fifty
- Less than 10% of annual ballast requirement is held as stock at any one time
- The cost of ballast distribution is high at up to 100% of the cost of the ballast itself
- 70% of ballast is distributed by rail
- Recovered ballast is either reused, sold for other purposes, or disposed of. The cost of disposal varies
- Approximately 20% of re-ballasting is carried out using high-output machinery. 50% is done using standard equipment and 30% is done using mechanical excavators

Switches and Crossings

- All IMs use framework contracts for the supply of S&C. Contract duration varies from one to five years and the contracts do not carry volume guarantees
- S&C for renewals is generally ordered between six and twelve months in advance.
- S&C for maintenance is generally ordered between three and six months in advance
- IMs use on average two S&C suppliers
- S&C is not held in stock by IMs
- 95% of S+C for renewals is distributed by rail
- Less than 15% of S+C renewal is of the modular type. 70% is assembled by the side of the line, while a further 15% is renewed piecemeal

Track Machinery

There were no responses from IMs to these questions

Renewal and Maintenance

There were no responses from IMs to these questions

Logistics constraints

IMs 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 along any given route, 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

D5.1.6 Final report on conduct of interfaces between contractors and IM's and means of improvement

Lead contractor..EFRTC
Submitted 2009-03-06
Size ....34 pp

Executive summary

The report presents the results of the studies on interface between contractors and infrastructure managers based on extensive and structured interviews targeting the project objectives for the improvement in cost efficiency and performance of track maintenance and renewal works. In total, representatives of twelve

Track works contractors and seven infrastructure managers were interviewed. To assure the openness and critical approach the interviews have been carried out by an independent consultant with significant experience on the topic. The interviews have been analysed, findings discussed at workshop seminars both with contractors and infrastructure managers and finally processed in order to provide a consistent set of findings and recommendations. The main section of the report briefly presents the approach and methodology and provides summary records of interviews with each contractor and infrastructure manager. The interviews were conducted bearing in mind that the records will be presented in an anonymous way in order to preserve an open-minded and critical approach and to get a truly objective and representative picture regarding current practices and potential improvements.

At the final stage a joint workshop was held with the involvement of all stakeholders concerned i.e. also all European infrastructure managers outside the project and in particular decision-makers in order to build up consensus with European coverage and to identify the most promising areas for the improvement. Key conclusion were tested and double checked during this workshop with representatives from both sides. The numerous findings as resulting from the processing of interviews were finally grouped in the following seven clusters:

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

There was a high degree of consensus on these conclusions which is a good starting ground for joint efforts to pursue the implementation

These areas as identified in the report and the approach as taken by BSL Consulting as an independent adviser gives an impulse for the future joint work of IM and contractors to achieve the objective of optimising the supply chain with project target of achieving 30 % LCC reduction.

Infrastructure managers, members of EIM and CER and EFRTC contractors have agreed on the follow up of the INNOTRACK conclusions and recommendations. The following priority areas from the report findings were put forward for the future work:

• Market, long term funding, strategic planning
• Contracting strategy including harmonisation of procurement
• Review of current rules and regulations for cross acceptance of machinery, staff and works, proposal for harmonisation including qualification of contractors
• Review of the existing safety rules and regulation, current practices, proposal for harmonisation in particular with the focus of the protection of the staff working on the track

D5.1.7 Public report on construction, maintenance & renewal activities – conduct of interface between infra managers and contractors and suggested improvements

Lead contractor.. EFRTC
Submitted.. 2009-02-17
Size ....14 pp

Executive summary

The interaction between contractors and infrastructure managers bears significant potential for increasing of the efficiency of track maintenance and renewal works. The performance of the contractors' works can be improved by a 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 increasing the efficiency of providing railway infrastructure for operators in general.

European practices vary considerably between countries and benchmarking of unit costs (UIC project on
'Long Lasting Infrastructure Cost Benchmarking' – LLICB) indicates that there is considerable room for improvement. Adopting best practice is therefore crucial for reducing costs and increasing performance of track maintenance and renewal.

Maintenance and renewal activities, related logistics and processes are the focus of the presented studies, as they seem to be a major driver of railway infrastructure's life cycle costs (LCC). The variation in maintenance and renewal costs has been related to outsourcing, yet this is only one of many factors. One of the aims of Sub-Project 5 (SP5) was to see if standardisation and the use of a more collaborative approach to logistics can help achieve lower costs, among a very heterogeneous set of European railways.

To assist with this, WP5.1 produced two questionnaires to identify the current logistics practices of INNOTRACK Infrastructure Manager (IM) partners relating to maintenance and renewal. The first questionnaire was web-based (referred to in this report as the 'web questionnaire') and asked questions that were quantitative in nature. The second was designed for use in face-to-face interview situations (referred to in this report as the interview questionnaire) to gather qualitative data. The data collected was then analysed to identify the current state-of-the-art (benchmark) for maintenance and renewal logistics activities, and the constraints that apply.

In addition to the questionnaires this report presents the results of the EFRTC / BSL study on the interface between contractors and infrastructure managers based on a further set of structured interviews. In total, representatives of twelve track works contractors and seven infrastructure managers were interviewed. To ensure an open and critical approach, the interviews were carried out by BSL, an independent consultant with significant experience on the topic. The interviews have been analysed the findings discussed at workshop seminars both with contractors and infrastructure managers and finally processed in order to provide a consistent set of findings and recommendations.

The interviews were conducted bearing in mind that the records will be presented in an anonymous way in order to preserve an open-minded and critical approach and to get a truly objective and representative picture regarding current practices and potential improvements. The full records of interviews with each contractor and infrastructure manager are provided in the report D 5.1.6.

At the final stage a joint workshop was held with the involvement of all stakeholders concerned i.e. also all European infrastructure managers outside the project and in particular decision-makers. This action was taken in order to build up consensus with European coverage and to identify the most promising areas for the improvement. Key conclusions were tested and double checked during this workshop with representatives from both sides. The numerous findings resulting from the processing of interviews were finally grouped in the following seven clusters:

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

There was a high degree of consensus that these clusters are success-critical areas for both Infrastructure managers and contractors. It should, however, be pointed out that there are various degree of commonality due to some country specific aspects which may affect the efficiency of potential transfer/implementation of best practices and innovative proposals.

Among the many aspects that were consistently raised in the interviews and underlined by empirical evidence, the major areas for the improvements can be summarized as follows

• Contracting strategies of infrastructure managers are vital for efficiency, 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 is an *“efficiency-critical”* issue; re-orientation is necessary to better use of possession windows by exploring vast potential for process-innovation
- Industrial engineering of processes and worksites to be a prime area of management attention (good practice knowledge management),
- Fleet utilisation for heavy plant is often too low i.e. high capital cost with resulting immediate consequence on initial direct costs of track maintenance and renewal; as a consequence fleet size of some very expensive machinery is often far above real needs
- Rules and regulations, particularly in safety and logistics (worksite protection and material supply), have a massive impact on productivity and LCC. In a number of cases there is already much room for the improvement on the national level.
- Process efficient friendly European harmonization will add further value for the opening of the market and true standardization resulting in cross acceptance of equipment and works.

With regard to LCC and in the situation where more and more railway networks get squeezed with capacity requirements it is important to emphasize that not only the direct cost of maintenance intervention can be reduced, but also the opportunity costs to train operation can be decreased. Through better utilization of track possessions, some capacity can be released for train operation through the higher process efficiency and performance of the contractors.

Results of interviews and workshops as presented in key findings clearly demonstrated that there is enormous potential for savings in the improvement of the overall process of track maintenance and renewal.

The examples from the comparison of the current practices in the various countries proved that savings between 10 to 30 % are realistic and in some cases these savings may be even higher.

D6.1.1 Incorporated rules and standards

Lead contractor....................................Banverket
Submitted 2007-05-10
Size.. 58 pp

Executive summary

INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty. In the field of railways, RAMS technology and LCC are as widely implemented as they could be and will provide a definite advantage to the Infrastructure Managers (IMs) in helping calculate costs for the implementation of innovative technologies. In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The sub-project SP6 deals with RAMS and LCC.

Banverket (BV) had the responsibility to conduct a survey on different rules and standards used by different IMs and related industries as a part of work of WP1 (Work Package 1) within SP6. Eleven questionnaires have been received, out of 24 sent out (answering rate 46%). However, the input from the IMs and related industries is not sufficient to enable a fully comprehensive picture of RAMS and LCC to be reported. Based on this limited information, the following conclusions can be drawn. For ease of comparison BV divided the participants into 4 categories i.e. Infrastructure Manager, Contractors, Manufacturers and SAO (SME, Academia, and Organisation).

General understanding about RAMS and LCC

- IMs have a slightly better understanding of RAMS and LCC than the manufactures and contractors. RAMS and LCC analysis don’t seem to be exhaustive as not many factors are being considered.
- Tools and models are mostly self-developed.

RAMS standards, database and tools

- Not many RAMS standards are being used. It concludes participants don’t consider RAMS issues in all phases of system life cycle.
- Most of the participants use their self-developed software for RAMS analysis.
- Only IMs define reliability target for their systems. One reason may be that there is not sufficient feed back from the IMs to the manufacturers. Reliability analysis is mostly done by ex-

pert estimation not by the tools. Most of the participants have failure databases.

- All IMs define availability targets. Very few do spare parts planning in accordance with target availability. Availability analysis is also done mostly by expert estimation.
- Maintainability targets are considered by only very few participants. Analysis is mostly done by experts.
- 50 % of IMs have safety target for their systems and 35 % of the participants do prepare hazard log for their system.

Life Cycle Cost

- Less than 50% of the participants do have a LCC standard/ guideline.
- LCC is used evaluate investment alternatives.
- Very few participants consider penalty cost, traffic disruption cost, cost due to unavailability / downtime in their LCC calculations.
- Participants reported service life time both as technical life time and economical life time.
- LCC calculation is considered in investment phase, operation and maintenance phase and disposal phase

Synergy

- Synergy effects with LICB were reported and the areas were identified where it will provide useful information to INNOTRACK.

This report identified different tools and standards that are used by different participants. The following report will look more into the models that were used to develop these tools also models used by different other industries will be considered which will help in providing useful information in the field of RAMS and LCC analysis. The subsequent report will also look into how different data are collected for the LCC calculation especially for the operation and maintenance phase. Finally, it can be concluded that the low amount of answers Is due to LCC and RAMS being in its infancy stage among most of the participants, This means that INNOTRACK can support the use of LCC thinking and RAMS technology within the railway sector.

D6.1.2 Models and tools

Lead contractor .... Banverket
Submitted.. 2007-05-10
Size ....33 pp

Executive summary

INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty. In the field of railways, RAMS technology and LCC are widely implemented and will provide a definite advantage to the IM:s (Infrastructure Manager) in helping calculate costs for the implementation of innovative technologies. In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The sub-project SP6 deals with RAMS and LCC.

Banverket had the responsibility to conduct a survey on various models and tools used by different IMs and related industries as a part of the work of WP1 within SP6. The input from IMs and related industries is not sufficient to draw a fully comprehensive picture of RAMS and LCC to be reported. Based on the limited information following conclusions can be drawn.

Conclusions

- RAMS programmes and analysis are in a very initial stage within IMs and the manufacturers.
- Data quality and data availability are the major problems in meeting RAMS and LCC targets.
- TRAIL, RailSys, Optimizer+ are some of the tools used by IMs for availability simulation.
- Manufactures and contractors depend on the information provided by IMs to carry out their RAMS and LCC analysis.
- LCM, D-LCC, T-SPA are the LCC tools used by IMs as per the survey. These tools in general used for enhancement projects not explicitly for LCC calculation for the whole track system.
- Catloc, UNILIFE/UNIDATA, PriFo are some of the additional tools found out during the survey which can be used for benchmarking.

- Safety Risk Model (SRM) is a tool which models a wide range of safety hazards in railway systems.
- Major benefits of RAMS and LCC analysis are found out to be optimising maintenance strategy and taking decision on maintenance/renewal with the regulators.

Areas of improvement:

- Environmental costs needs to be considered while modelling LCC.
- Risk analysis has to be considered in LCC calculation.
- Spare part planning needs to be done as per availability targets.
- IMs have to clearly define RAMS and LCC specifications in the contracts with manufacturers and contractors; this will be done in work-package 6.4 (RAMS and LCC in contracts/wordings/policies).
- IMs should define achievable RAMS targets and lay out a procedure to attain those targets.
- Unforeseen costs like reduction of passengers, loss of good will due to train delays should be modelled.

D6.2.1 Unique boundary conditions

Lead contractor..ADIF
Submitted 2008-05-03
Size... 34 pp

Executive summary

INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty. In the field of railways, RAMS technology and LCC are widely implemented and will provide a definite advantage to the IM:s (Infrastructure Manager) in helping calculate costs for the implementation of innovative technologies. In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The sub-project SP6 deals with RAMS and LCC. Task 6.2 deals with Life Cycle Cost Methodology and a first step within this task is to address the required economical boundary conditions.

Life cycle cost analysis can be more or less detailed or ingenuous but it cannot deliver a fair decision support process without coherent rules. This deliverable addresses the need to agree on unique economical boundary conditions, specifically the capital budgeting techniques, the choice of proper discount rate and the choice of time horizon for LCC analysis.

Concerning capital budgeting techniques it was shown that Net Present Value (NPV i.e. Total Present Value in Life Cycle Costing) is the most accurate procedure for decision support. A combination of techniques and indicators can also be advisable as a complement to NPV results: particularly estimation of Annuity factor, break-even or in some cases Internal Rate of Return (IRR) can bring useful indications.

Economical boundary conditions are key factors on the results provided through LCCA. An in-depth evaluation of current practices concerning the discount rate and the time horizon on infrastructure project appraisal was performed. Most recent bibliography on the subject shows that, among the diversity of criteria and values adopted, there is a tendency to use reduced values for discounting combined with large periods of consideration.

A detailed theoretic analysis performed towards the definition of an unique criterion for discounting and the time horizon of LCCA has driven to the following first suggestions:

- To consider a variation of 3% to 5% for the discount rate, with a reference value of 4%
- To consider a range of 30 to 40 years as time horizon, with 40 years as recommended upper bound for large investments on ballasted tracks assessed through LCCA (closely linked with an accurate estimation of the alternatives residual value as discussed)

Both results are in accordance with most recent research and guidelines in project appraisal and life cycle costing practices.

These first findings will need to be further analysed and agreed within WP6.2 before adopting a final criterion for the on-going work within SP6.

D6.2.2 Benchmark of LCC tools

Lead contractor...ADIF
Submitted 2008-01-25
Size..39 pp + 4 app

Executive summary

Optimisation of track constructions or track components regarding technical and economic requirements is essential for railway companies to fit the market and to compete against other means of transport. Due to the long lifetime of the track and track components – ranging between 20 to 60 years – pre installation technical and economic assessments are necessary to optimise the track construction and get the return on investment (ROI) in a manageable timeframe. LCC and RAMS technology are two acknowledged methods for assisting the optimisation process.

The original purpose of deliverables D6.2.2 and D6.2.3 was to assess and improve the existing models and tools within each Infrastructure Manager. However, according to WP6.1 results, few IM's have established standards and models for LCC analysis. Furthermore, when LCC is in use, information available on current practices and models is still too scarce to be able to compare and analyse: it is extremely difficult to gather information on the precise LCC methodology applied, boundary conditions (technical and economical), cost categories and cost matrix, levels of detail etc. On the other hand, tools are not available for testing making impossible the task of producing a comparison and improvements in the few existing tools.

Therefore, the WP6.2 workgroup has decided to focus on available commercial tools to use on the future steps of the project. The use of commercial LCC application software will make easier the accomplishment of common analysis within different Infrastructure Managers and Suppliers, allowing the comparison of similar evaluations, with similar models, although with different (and confidential) inputs.

This report (D6.2.2/3) performed an analysis of the existing LCC commercial tools, assessing various aspects of each program. The goal was to evaluate the best features of each tool and identify which tool fits best the requirements for LCC modelling of railway infrastructure within SP6, as well as to recommend improvements to be performed within the project.

With the purpose of benchmarking LCC commercial tools, relevant information like software manuals and demo versions were requested to LCC software suppliers and additionally, a questionnaire was performed. A wide variety of tools, ranging from simple ones to sophisticated software packages were analysed. It was not achievable to have answers to the questionnaires from the suppliers, but it was possible to complete the study through the analysis of the manuals and demo versions provided.

From the analysis performed it was found that almost all software's addresses the basic features required for LCC modelling of railway infrastructure. Furthermore, based on a specific evaluation of the capability of each software regarding more than thirty criteria (answering more than 50 questions) it was possible to decide on two tools for further analysis in detail, in order to select the best-suited tool to use in INNOTRACK WP6.5.

Some key features to assess were defined and two identical models were built on the two selected tools to assess their capabilities on each key feature. A quantitative approach and scoring was defined and the results obtained made it possible to identify the best "performer" tool. Finally, a list of improvements were suggested to meet the interest of INNOTRACK LCC modelling: to improve the "Importability" of (all) variables from a database; to allow functions changing over time as input; to improve comparability and "check process" of inputs and detection of errors and to incorporate a Monte Carlo Simulation toolbox to perform a probabilistic analysis.

D6.2.4 Database and requirements as input for WP6.5

Lead contractor..ADIF
Submitted 2008-11-18
Size .... 28 pp

Executive summary

INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty. In the field of railways, RAMS technology and LCC are starting to be implemented and will provide a definite advantage to the IM:s (Infrastructure Manager) in helping calculate costs for the implementation of innovative technologies.

In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The sub-project SP6 deals with RAMS and LCC. Work Package 6.2 deals with Life Cycle Cost Methodology and this last deliverable presents guidelines on the requirements to address LCC analysis within Work Package 6.5.

D6.3.1 Boundary conditions for RAM(S) analysis of railway infrastructure

Lead contractor...ÖBB
Submitted 2009-01-26
Size .... 38 pp

Executive summary

Aim of this deliverable is to point out the potential of using RAMS technology for the infrastructure and to implement a demonstration of RAMS technology for track systems or track components and to get a clear view about RAMS.
The first step for the description of the boundary conditions for RAMS analysis of railway infrastructure is to study the literature and find out which standard methods are useful for application in railway infrastructure.
At beginning of the deliverable we give a short overview about methods of RAMS and then we are sharpening the focus to the possible use of these methods for the railway infrastructure.
In the second part we sketch the boundary conditions of railway infrastructure to the parameters of RAMS.
In our opinion “RAMS” is in a very early state of development for the railways. Every partner has his own doings, but not concrete applications for publish it in a deliverable. So as coordinator we tried to give an overview about the situation at some partners and we hope that the partners in the project Innotrack have similar national problems and can pick useful information out and give additional input as response.
It is also very useful for the railways to identify the needs of their clients and customers to define the relevant categories and criteria for the RAMS analysis.

D6.3.2 Requirements for RAMS-analysis of railway infrastructure regarding deterioration rates, influence functions, statistical methods, monitoring method, etc.

Lead contractor...ÖBB
Submitted.. 2009-01-26
Size .... 22 pp

Executive summary

By means of three examples, described of the three organisations DB, VAS and ÖBB, this report deal with the potential of RAMS analysis of railway infrastructure.
The examples show the current use of methods using the existing data to calculate the RAMS factors. The DB analyses are based in most cases on SAP R/3 Net. As Innotrack decision, chapter 2.2 in this deliverable is based on a specific chosen high speed line, here determined to track (here without S&C). It means that the switches and crossings (S&C) have not been taken into consideration by the following analysis. The database containing the representative panels (selection of technical places) for track (and S&C) serves as input parameter for LCC analysis and identification of cost driver.

Chapter 2.3 shows the RAMS spreadsheets used by partner VAS to determine values. They are based on the leaflet UIC 712E "rail defects". Not all defects are listed, because some will no longer occur in state-of-the- art rail manufactured today. There are some information inside which should demonstrate how to fill it.
ÖBB shows in chapter 2.4 the different points of view on availability in railway infrastructure with example on a simple line. At our today point of view we have some difficult problems to solve, they are discussed in the chapter.

D6.3.3 Necessary developments of RAMS technologies

Lead contractor..ÖBB
Submitted 2009-01-30
Size...21 pp

Executive summary

By the work carried out on RAMS analysis so far within INNOTRACK several facts become apparent and should be appreciated as a background for this study.
Firstly, the use of RAMS analysis in the railway infrastructure is limited and where it occurs it is in an early stage, especially in the track and civil engineering sector This is in contrast e.g. to the signalling sector where the use of RAMS is more used. The reason is the complexity of the railway system and the tradition of the track and civil engineering system. The complexity stems from several sources. One is the interaction of several railway areas (track, s&c, catenary and signalling, etc.). A second complication is the vast need of data for RAMS analysis. This data is often hard to define and scattered between different databases and organisations. In other words, there are a lot of measured data in the track sector, but these are seldom easy
to obtain and often difficult to compare between railways since they are defined/measured in different manners.
In contrast to parts of the infrastructure like the signalling equipment, where the RAM-parameters are defined in relation to the operation time, the technical performance of the track has to refer at least to the load of the track. For a complete analysis other boundary conditions like distribution of speed or vehicle types are necessary. But these important conditions that may change over the years are rarely monitored and therefore not available in detail.
Additionally the geographical distribution of assets and the various influences of the environment increase the complexity. A final, and very important factor, is the current high proportion of human intervention in track operations (e.g. in maintenance operations). This results in a large and currently largely unquantifiable scatter in RAMS input parameters.
Secondly, where RAMS is beginning to be adopted it shows promising results. By an operational RAMS assessment the problems described above become visible and can be addressed. Furthermore there is a strong link between RAMS and LCC analysis and many of the obstacles faced are similar.
Due to the reasons above it was realised that more basic development is necessary before RAMS analysis can become fully functional in the railway community.
Consequently, it was decided to focus on the identification of necessary developments in the current deliverable. The objective is to highlight, by examples, how RAMS analysis is currently adopted by the participating IMs ÖBB, ADIF, DB, BV and NR. Furthermore complications and challenges are communicated and needs for future developments are identified.
Some conclusions of the current study are:
• Railway organisations currently use RAMS technologies as a tool for the decision in specific cases. For the complete railway system it is currently not possible to combine the different requirements of the various product fields in a general RAMS analysis.
• It is necessary to find common definitions of RAMS-related terms in the railway sector. As an example we can pose some questions regarding the term “availability”, e.g.:
- is it function of the capacity of utilisation of the line;
- what data can we collect in order to describe this;
- do we need a common definition for train delays? Definitions currently employed differ between the infrastructure managers.

The problem of different definitions is further enhanced by the different maintenance strategies of the European railway organisations.
New products pose a problem in that key data for RAMS analysis are normally not available.
Areas identified as priorities for future developments are:
1. More extensive data collection and analysis
2. More extensive databases
3. Better definitions of failures and general RAMS terminology
4. Improvements in verification of data employed for reliability analyses
5. More data collection through load detectors and intelligent infrastructure
6. Use of reliability data in planning of predictive maintenance

Due to the above reasons the work in INNOTRACK with RAMS is not fully what was planned in the DoW. The work is more an important step forward in using RAMS for track and civil engineering purposes. The work in WP6.3 is therefore probably more important than expected.

D7.1.1 Set up of private and public project websites

Lead contractor .... UIC
Submitted 2006-11-04
Size .... 46 pp

Executive summary

This document describes and specifies the installation and operation of a web portal dedicated to the INNOTRACK Project.

The web-portal has been described in the DoW (Description of Work) as below:

"A dedicated project website and e-dissemination tools will be provided by the UIC team responsible for hosting and managing the UIC website, including Knowledge Management tools."

The web-portal includes two components:

- a public website, which will be the "project window" towards a large audience;
- a Knowledge Management System (also called private website) which is provided as an online-tool to support the collaborative work of the consortium members.

The definition of a coherent "project image", graphical profile, and logo was the first step required to develop the websites. Consequently, this document also includes information on these topics.

D7.1.2 Set up of dissemination platform

Lead contractor .... UIC
Submitted 2006-12-05
Size .... 12 pp

Table of contents

D7.1.3 Planning report: set up of network of industries and infrastructure managers

Lead contractor .... UIC
Submitted 2007-05-23
Size .... 6 pp

Table of contents

D7.1.4 Report on the dissemination activities and proposal for further actions/update

Lead contractor................................ UIC / UNIFE
Submitted 2008-06-30
Size.. 17 pp

Executive summary

A dissemination platform was established at the start of the project to ensure the effective exploitation of project results by partners and implementation and technologies within infrastructures. The platform functions continuously as an essential tool for the implementation of products and methods developed. While the majority of dissemination takes place towards the end of the INNOTRACK project, a number of activities have already taken place. Past, current and future activities are reported and described.

A number of mediums of dissemination have been and are continually being employed:

- Public website and INNOTRACK Extranet & KMS
- Newsletters and press releases
- Events and conferences
  - Project rresentation in related conferences & events
  - Preparation of internal conferences and workshops
    The yearly GA & Workshop is one of the most important forums for disseminating information inside and outside the INNOTRACK project.
- Technical leaflets & publications
  - UIC-leaflets and guidelines incorporate the results and form the basis for European standards and Technical Standards for Interoperability (TSIs).
- Links with past and current EU-funded projects
- Guidelines
  - A proportion of the deliverables are assigned as guidelines and will be instructional manuals prepared in a form suitable for direct implementation of the results.
- Databases
  - Several of the deliverables are databases. It is the goal of the project that the databases can be used outside of INNOTRACK. Therefore a special review has taken place.
- Preparation of Summary Reports
  - In order to make the progress of INNOTRACK easier to grasp, a summary report containing all Executive Summaries has been brought forward. This document is a living document that is enlarged throughout the project. The report is available from the public website.
- Training materials
  - Training is an essential tool for implementation of project results and there is a link between dissemination activities and training activities. A special activity has been undertaken to contact several training centres in different European countries.
- Industry-meets-SP6
  - Joint Industry-Railways collaboration on Life Cycle Costing to achieve sector-wide confidence in LCC modelling and develop a 'systems approach' to Life Cycle Costing with broad participation.
- Current contact with IMs outside of INNOTRACK
  - The Track Expert Group in UIC plays an important role to review, disseminate and also implement the results of INNOTRACK. A special subgroup has been established. This subgroup consists mainly of IMs outside of INNOTRACK. The group has a special folder on the KMS.

A dissemination timetable sets out past, current and future activities. UNIFE has been working actively

with its experts committees and UIC with its Track Experts Group in providing periodic work progress updates and results.

D7.2.1 Establishment of training platform

Lead contractor .... DB
Submitted 2008-10-30
Size .... 60 pp

Executive summary

The report includes former D7.2.2 - *Report on current practices for training/education of track staff.*

The subproject SP7 is vital for the overall project. Widespread dissemination of the project results assures sector acceptance and implementation of these results. It is also vital to promote the project involving the various recipients, the project's partners to exchange knowledge, the experts to assure sector acceptance, the Commission to furnish deliverables and general public to be informed.

This subproject is organised and managed to assure awareness and implementation of results to all stakeholders inside and outside the consortium and liaise with the IP for light rail. Implementation of results is the ultimate goal. Dissemination and implementation is often a weak part in railway R&D projects. Dissemination is the most crucial part of the project and therefore the results need to be implemented.

The prime objective of WP 7.2 Training Platform is to provide coherent training programmes in order to assure the long term availability of skilled and trained workforce for implementation of INNOTRACK results.

Objectives

- Mapping of current training practices
- Establishment of training platform
- Training on LCC methodology

Description of work

The work will start with mapping the present state of art and benchmarking of current practices with identification of gaps and needs. This work will be initiated by professional staff of UIC with support of its members based on experience and achievements made so far with e.g. dedicated courses on high speed operation and technology, e-learning and commerce, etc.

In order to assure wide coverage of the needs of all stakeholders including those not involved in the project it is proposed to set up Training Platform, complementary to the Networks of IMs and Industry, which will follow up the development and implementation of training programmes in European dimension.

The staff for training platform will be provided from experienced Infrastructure Managers and Industry, supported by academia and other professionals. The project accompanying Training Platform will also serve to prepare the necessary strategy for further staff education in close interaction with the industry experts responsible for the technical development within INNOTRACK.

Among the above principle tasks the Training platform will periodically update training programmes including

- Definition of the training scope for dedicated/targeted groups
- Specification of training methodologies to be drafted and tested in order to prepare wider application for future implementation, in particular appropriate e-learning implementations
- Preparation of the schedule for training events

The interactive e-learning seems to be an appropriate attempt to train the huge number of involved staff in the course of the physical system/service implementation in particular after project's end.

The project will establish synergies between its training and dissemination activities to share as much as possible tools, materials and methodologies.

A specific tool for the training of the generic LCC methodology will be developed and the resulting training seminar will be held.

In this regard a basic training workshop LCC has taken place on 26-27 February 2008 in Paris (s. 3.1). The training contained the LCC methodology with theoretical background, results of the software benchmark, and exercises of test cases in LCC analysis with the software D-LCC. As a result of the software benchmark in WP 6.2 D-LCC was evaluated as most suitable tool for INNOTRACK purposes.

Concerning the tool a specific software training will taken place on 17th September 2008 in Paris. This is a part of the contract closed between ALD (as the producer of the tool) and INNOTRACK purchasing the software (s. section 3.3). The software tool, import/export of data, modeling etc. will be some of the contents of the specific software training.

LCC is performed in order to evaluate investment alternative. The specific software D-LCC is designed to compare different solutions with respect to LCC optimisation, i. e. there will be the chance to compare all the calculation, to sum up and finally to extend the model as we have to calculate the full system. To achieve this aim a template has been sent out to the SP leaders to be filled in to develop the LCC model based on each SP. This contains the definition of relevant data and parameters requirements (to be delivered by SP1-5) in the field of LCC and RAMS as input to the LCC model to be developed in WP 6.5. On the basis of the provided results the design of a proper LCC model with the essential key issues can be carried out (in D-LCC), that will meet all requirements of each SP and any particular project respectively.

Furthermore there is a demand for an additional training in Life Cycle Cost Assessment. As a result from the questionnaires regarding current training/education and future training needs, all IMs consider Life Cycle Cost Assessment an area where knowledge is scarce and in need of training. Therefore the Life Cycle Cost Assessment area is given special attention in the training platform.

As referred to the current status of the responses of the questionnaires there are no technical training needs with the exception of Logistics. Therefore on this basis it is not possible to implement a technical training. It is possible that further completed questionnaires will be received from IMs. If a technical training is required it will be implemented in WP 7.2 ‘*Identification of needs and specifications for coherent training programmes*’.

D7.3.1 Set up the technical review & standardization platform

Lead contractor.................................UIC/UNIFE
Submitted...2007-08-21
Size ....13 pp

Table of contents

D7.3.2 Technical review platform

Lead contractor...UIC
Submitted.....................................2008-04-1704
Size ....11 pp

Executive summary

The deliverable process is divided into three main parts:

- The preparation of the first version: under the responsibility of the SP leaders
- The peer review: under the responsibility of the S&T coordinator
- Approval and delivery to EC: under the responsibility of the Project Manager

The aim of the peer review is to

- Ensure a firm scientific basis
- Ensure high quality of content and presentation
- Ensure “implementability”
- Pave the way for dissemination
- Ensure traceability of corrections and validations
- Be a streamlined process with limited additional efforts

To this end INNOTRACK uses

- Internal and external reviewers
- Reviewers from academia, railway infrastructure managers and railway industry

- Written external review reports and responses

This report outlines the entire process of deliverable preparation and submission. In particular the information flow and the use of the INNOTRACK knowledge management system (KMS) is described in detail.

A crucial area in the quality assurance of deliverables is internal and external reviewing. Depending on the scope of the report an external review can focus on the scientific content, on the industrial relevance and/or on the relevance of the results to the railway sector. In the latter two cases the INNOTRACK consortium is cooperating with UNIFE and by the Track Expert Group of the UIC to get relevant and high-quality reviewing. The detailed description of how the reviewing is handled, how review comments are accounted for etc is described in detail in the report.

To provide a practical aid for lead participants responsible for the preparation of deliverables, the report contains check-lists both regarding the preparation of the deliverable and regarding document handling.