INNOTRACK

Innovative Track Systems

Summary and highlights

Edited by Anders Ekberg & Björn Paulsson

Executive summary of the concluding technical report

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INNOTRACK Objectives

The INNOTRACK project has been a joint response of the major stakeholders in the rail sector – infrastructure managers (IM), railway supply industry and research bodies – to further develop a cost effective high performance track infrastructure by providing innovative solutions towards significant reduction of both investments and maintenance related infrastructure costs.

INNOTRACK has been a unique opportunity to bring together rail IM's and industry suppliers and to concentrate on the research issues that has a strong influence on the reduction of rail infrastructure life cycle cost (LCC). INNOTRACK has been founded by the EC commission under the 6th Framework Programme, contract no TIP5-CT-2006-031415.

The philosophy of INNOTRACK

The future importance of the railways can increase if the new demands on the railway can be met – tools to meet many of these demands are handled in INNOTRACK

Today the railways are facing new demands. Examples are higher speeds and higher axle loads (often in combination), higher availability, fewer disturbances and reduced LCC. At the same time environmental demands and safety requirements must be fulfilled. Most railways have also many bottlenecks where there are very small margins for disturbances. If these new demands can be met, the future importance of the railways can increase. The results from INNOTRACK will help the railways tackle these issues in the important area of track and substructure. This part represents 50–60% of the maintenance and renewal costs of a typical railway. This means that the results from INNOTRACK have a significant impact on the overall cost reduction for the railways.

These challenges are described more in detail in chapter 2 of the INNOTRACK Concluding Technical Report. It is important to understand that all these demands and challenges are not only empty phrases, but a reality in the everyday operations of the railways.

The result from INNOTRACK is like a toolbox with many innovative solutions. Some selected solutions are presented as "highlights" in this chapter in order to give an overview of the contents of INNOTRACK. Some of these highlights are very technically oriented, while some are of a more overall nature. In addition there is a full list of implementable results from INNOTRACK presented in Appendix VI of the INNOTRACK Concluding Technical Report.

The railway system is very complex

The main reason for the complexity of the railway system is that it often is a mixture of components of different age and status that have to work together in a system. Replacement of components is also a continuous and ongoing process. Today the railway infrastructure is therefore like a patchwork that has to perform to higher demands. For this reason changes have to be carefully executed.

Another important factor is that a significant part of the knowledge regarding railways in general, and track structures in particular, is empirical. This means that we know what will happen if the situation is static, but if we have to meet new demands there will often be a radical change in the system response. For this reason we must not only know "how" (as is currently the comment case), but also "why" in order to predict the effect of changes. In INNOTRACK a lot of new knowledge is brought forward to understand exactly "why" phenomena occur to make it possible to predict the future response of the track structure.

To change (or rather to upgrade) parts of the system with new, better performing components means that the new components must fit in the complex railway system. To introduce new components is a necessity since many old components need replacement and/or cannot meet new demands. However, in order to avoid a situation of trial-and-error, there is a need to make this introduction in an ordered fashion where it is ascertained that technical, LCC and logistics demands are met. This process has also been a focus of INNOTRACK.

To further complicate the situation, there is a trend (generally positive) that the components are becoming more and more international. Further, the role of the industry in developing new products has changed and is changing even further, see chapter 7 of the INNOTRACK Concluding Technical Report. This means that new components are to less extent tailored for specific national needs. Further, the IM has less control of the development of the products, but must set their specifications based on functional requirements. This puts new demands on both IM and industry in assuring that components have a correct quality and can perform in the railway system in an expected way. INNOTRACK has scrutinized this issue from both a technical and an LCC point of view.

Most cost drivers are international

Investigations in INNOTRACK have shown that the most important cost drivers are international. Therefore several proposed implementation projects would be more efficient if they were carried out in an international cooperation. If it is possible to create active international working groups, the implementation of new solutions will go faster and require fewer resources. INNOTRACK has for the first time identified the European track related cost drivers and their root causes in the areas of substructure, track and switches & crossings. Further, INNOTRACK has been and is actively engaged in aiding and coordinating implementation on a European level.

Research and development is a necessity and an efficient way of progressing, especially in the railway area. Today research and development (R&D) in the railway area is a necessity to achieve cost reduction and better performance. It is also a good way to cooperate between IM's and the industry so that the needs of the IM can be matched to the product development in the industry, and to ensure that the developed products/services/processes fit in the system and perform in the intended manner. This is still more important since a larger part of r&d today is done in different environments where the industry's part is successively increasing and today is considered to have passed the IM's in volume.

Implementation of new knowledge is difficult but a necessity

It has traditionally been difficult to implement new knowledge in the railways. It is today the Achilles heal of R&D. Here the IM's must become more efficient and assure that if a new product is introduced this introduction is carried out in an ordered fashion (see above) and that also the knowledge related to this product is incorporated in the organisation. In INNOTRACK considerable resources have been allocated from UIC and UNIFE to support implementation in a more professional manner.

INNOTRACK —a brief summary of highlights

Subsoil assessment

Cost driver

Variability in soil conditions leads to unstable track geometry and high needs for maintenance.

Solution

INNOTRACK has carried out a comparison between several assessment methods for subsoil conditions to evaluate their capabilities and accuracy. In addition, a database for storing, finding and visualizing data on subsoil conditions has been developed.

Benefits

Possibility to optimize reinforcement efforts, which reduces track geometry degradation and need for tamping.

Next steps

Optimized use of national assessment methods internationally "with the definition of assessment methology". Wider use and addition of further data to the developed track condition database. Evaluation of time dependence of track conditions.

Track stiffness

Cost driver

Track stiffness is an important factor in the interaction between train and track. In simplistic terms the track stiffness governs the track's impact on the vehicle. This is especially crucial for high-speed and heavy-freight operations. It should here be noted that it is normally not the specific stiffness that is of most importance, but rather the variation of the stiffness. Further, the track stiffness has a natural variation due to climate. Varying too low or too high track stiffness leads to higher dynamic loads, which is an important cost driver.

Solution

INNOTRACK has taken a significant step forward in concluding the question. Techniques have been developed for measuring and evaluating track stiffness. Through this the understanding of the influence of track stiffness has been increased, which has made it possible to optimize the track stiffness distribution. INNOTRACK has further, for the first time, carried out international comparisons of variations of track stiffness in switches. The results clearly show the significant potential for reducing dynamic forces. The measurements demonstrated in INNOTRACK give a tool for monitoring and maintaining proper stiffness distributions in switches, but also e.g. in transition zones.

Development and evaluation/ comparison of several track stiffness measurement methods has been performed in INNOTRACK. To assess the influence of varying subsoil conditions, INNOTRACK has further developed and evaluated a number of numerical and experimental techniques and methods.

Benefits

Better knowledge of the track stiffness gives the potential to lower dynamic forces and reduce degradation of track and switches & crossings.

Next steps

Track stiffness has a strong influence on the loading of the track and rolling stock. Track stiffness is still an open question in the Technical Specification for Interoperability (TSI) Infrastructure. The result from INNOTRACK can be a good input to enhance the TSI.

The results from INNOTRACK will further be used to optimise switches & crossings.

Four methods for subgrade improvements

Cost driver

Improving subgrade conditions is very costly. These costs relate not only to manpower and materials etc, but also to costs for traffic disturbances, speed regulations etc.

Solution

INNOTRACK has developed, implemented and evaluated four different methods for subgrade improvements. These include an optimized use of geo-grids and geotextiles, the use of vertical soil–cement columns, and the use of inclined lime-cement columns. The latter method has been applied without the need to close down the track, which leads to significant cost savings and minimal traffic disruptions. All these methods have been verified by numerical simulations/ calculations and/or experimental tests.

Benefits

The improved and optimised methods will, as have been demonstrated, decrease LCC significantly. It will further decrease operational disturbances.

Next steps

The developed solutions need now be integrated in national and international regulations.

Two innovative track-forms

Cost driver

Variation in the support stiffness of track is a key contributor to more rapid degradation of track quality and rail integrity. Consequently, the track requires more frequent tamping to correct the line and level, rail grinding to remove surface defects such as rolling contact fatigue, and non-destructive testing of the rail to prevent rail breaks and ensure safe operations. The situation is further exacerbated for switch & crossing units because of the complexity of layouts and the associated higher dynamic forces.

Consequently, the key driver for the development of new track forms was to reduce life cycle cost of track by engineering out variability through design and installation techniques.

Solution

Two innovative track forms have been developed in INNOTRACK:

The Embedded Rail System

The system features high productivity construction with sequential high output concreting, alignment and railing. Up to 1.5 metres per minute for a high speed railway. No tamping or ballast costs. An innovative rail shape that allows 25% more rail wear and a full use of harder rail steels. A vehicle interactive design to minimize rolling stock costs. The continuously supported simple low component system provides support for fully automated vehicle-borne inspection including video, ultrasonic and geometry. There is also a potential for full fibre optic sensing in the slab for settlement.

The Two-Layer Steel Track

This system has been specifically designed for switch & crossing layouts that consume a highly disproportionate amount of the track maintenance budget. The steel – concrete 2 layer track is a novel track design that has been taken from concept to prototype installation within the project. It features a consistent support through design to minimise maintenance requirements. It is a modular construction that facilitates rapid installation, which leads to reduced installation time and costs.

Benefits

The Embedded Rail System

High productivity construction with 30% reduced construction time, reduced construction cost – competitive with ballast, Low cost construction equipment from road industry. The solution also features increased tunnel clearances with a low construction depth. Maintenance is reduced with improved vehicle interaction, no ballast maintenance, increased rail life (fatigue and wear) and 60 years plus life of track. Facilitates automated inspection with full ultrasonic inspection. It also allows for fully automated video/geometry inspection by design. In addition several failure modes have been eliminated.

The Two-Layer Steel Track

The two-layer design ensures consistency of support and adjustability. The modular construction with a panel-based design enables rapid and cost effective installation and logistics. It provides the ability to open at line speed at handover after each possession. The degradation of support is significantly reduced resulting in minimum maintenance (no tamping) and increased track availability. Further, the more consistent support and rail – wheel contact conditions leads to an increased rail life. Installation costs are comparable to ballasted track switches & crossings when train delay costs are taken into account.

Next steps

The solutions are now being implemented in operations.

A guideline for optimum selection of rail grades

Cost driver

The undifferentiated use of conventional (non-heat treated standard carbon) rail steels in curves up to 5.000 m results in avoidable excessive maintenance cost and/ or premature re-investment cost for exchanging the rails.

Solution

Based on a multitude of long-term track measurements INNOTRACK has been able to develop and calibrate predictive models for overall rail degradation in terms of wear and rolling contact fatigue (RCF). Compared to standard rail grades, heat-treated rails show a superior wear and RCF resistance. Two different rail grade selection recommendations – a "radii based" recommendation and a "deterioration based" approach – were worked out. Both methods have led to consistent results that confirm the technical and economic advantages of the extensive utilisation of heat treated premium steel grades.

Benefits

The improved rail durability by a shift towards heat treated premium steel leads to a significantly extended service life, substantially reduced life-cycle cost and, at the same time, to an increased operational availability of the track. Also the payback of the incremental investment can be achieved in a very short time. Respective cost-savings can be specifically calculated by using the LCC model developed in INNOTRACK, as has been shown in the project.

Next steps

The guideline developed in INNOTRACK is now employed by the UIC Track Expert Group and is proposed to form the basis for a UIC/ UNIFE TecRec (replacing the UIC leaflet 721).

Squat formation

Cost driver

Squats are becoming increasingly more common on the European network. Remedial maintenance actions of grinding, weld restoration, or replacement of a short length of rail containing the defect have a significant impact on the maintenance budget.

Solution

The knowledge of causes of squat formation and the factors affecting growth need to be enhanced so that optimized mitigating actions can be applied. The work in INNOTRACK has been a significant step in this direction by the use of field measurements and numerical simulations. In particular, the question of which initial defects that will propagate to form full-scale squats has been thoroughly investigated.

Benefits

The work in INNOTRACK provides means in optimizing maintenance actions and will facilitate a move to planned maintenance. The magnitude of maintenance cost reduction will be influenced by track and traffic characteristics but is expected to be significant.

Next steps

The gained knowledge needs to be incorporated into operational codes and "minimum action" handbooks. The conclusions are mainly based on observations on the Dutch network. The study needs to be expanded to examine if the findings are equally applicable in other European networks. There is still a major need for further knowledge, e.g. regarding growth rates under general operating conditions.

Corrugation

Cost driver

Corrugation increases noise emission levels and wheel–rail contact forces. The standard mitigating action is grinding, which is costly and causes traffic disturbances. There is also some evidence for increased susceptibility of corrugated track to squat defects.

Solution

INNOTRACK has developed a method to determine allowable corrugation magnitudes with respect to noise pollution and risks for the formation of wheel and rail cracks.

Benefits

The numerical toolbox that has been developed can be employed to determine grinding intervals etc.

Next steps

The derived knowledge needs to be established in operational codes, "minimum action" handbooks and practices. To further optimize maintenance actions, deeper knowledge on corrugation growth and the relationship between operational loading conditions and crack formation would be valuable.

Insulated joints

Cost driver

Insulated joints impose a discontinuity in the rail. Due to this they will be subjected to high operational loads that may cause joint dips (leading to even higher loads) and material rollout (causing short-circuiting of the signalling system). The remedial actions, unless detected at early stages of deterioration, often result in replacement and hence add significantly to maintenance costs and causes traffic disturbance.

Solution

INNOTRACK has carried out an extensive simulation campaign on the mechanical deterioration of insulated joints. In addition, field measurements have been made in order to verify simulations. The result is a significantly improved understanding of the influence of various operational parameters and the associated deterioration mechanisms.

Benefits

The work in INNOTRACK lays the foundation for prescribing joint geometry and allowable tolerances for different operational conditions. Furthermore, the improved understanding of deterioration mechanisms are also expected to contribute to improved designs of insulated joints.

Next steps

The derived knowledge needs to be established in operational codes, "minimum action" handbooks and practices. Further increased knowledge is needed, e.g. regarding the influence of traffic situation, support conditions, material characteristics etc.

Rail cracks

Cost driver

Cracks in rails are ultimately a safety problem. In order to prevent cracks to grow to failure, they need to be detected and mitigated in the early stages of growth. Further excessive overloads need to be avoided. Lack of accuracy in preventive measures, including the permissible passing loads, lead to increased costs and/or decreased levels of safety.

Solution

The growth of rail cracks has been studied in INNOTRACK with the aim of quantifying the influence of operational parameters and in predicting inspection and maintenance needs. An example of use is the identification of allowable load magnitudes induced by wheel flats.

Benefits

With the work in INNOTRACK, the accuracy of operational decisions and mitigating actions has increased. A particular benefit is that existing "minimum actions" can be examined and verified/revised using scientifically proven techniques.

Next steps

The results from INNOTRACK have already been employed for better regulations regarding operational loads. Harmonization on a European scale is needed. Furthermore, the work related to inspection intervals needs to be implemented in "minimum action" handbooks and codes and the technique extended to other key defects encountered on European networks.

Rail tests

Cost driver

Good tests of rail grades promote the development of suitable rail grades and pertinent maintenance strategies. This will decrease maintenance costs. Field tests are very costly and hard to carry out under controlled conditions. If laboratory tests can replace these significant cost savings will be obtained. However, the current European rail standard (prEN 13674: 2009) does not include any direct measure of the various rail grades to the two key rail degradation mechanisms of wear and rolling contact fatigue (RCF). Instead, the standard and the railways rely on the indirect measures of surface hardness and tensile strength. Furthermore, the current tests for wear and RCF undertaken by various organisations (IM's, rail manufacturers, and academia) are not comparable and only provide an indication of the operational performance of the various rail grades. All of these factors lead to less efficient and more costly tests than needed and can contribute to the non-optimum selection of rail grades.

Solution

INNOTRACK has carried out work on harmonizing laboratory tests of rail grades (scaled and full-scale) and relating these to in-field operational conditions by the use of numerical simulations and laboratory investigations of micro-structural deformation/damage. The systematic approach adopted is unique in the railway world and the results have provided further scientific evidence of the benefits of premium steel grades.

Benefits

The work in INNOTRACK has provided a methodology of comparison of rail grades and the guideline produced is expected to be included in future Euronorm rail specifications.

Next steps

The work carries on both in formalizing and standardizing reporting of tests (also field tests) and in improving the methods of comparing test and operational conditions through numerical simulations and microstructural deformation / damage investigations. An initiative will be taken to have this as an important input to a new CEN standard.

Inspection methods and equipment to detect rail cracks

Cost driver

Inability to detect rail cracks at an early stage of growth hinders the planning of mitigating actions such as grinding. It may also lead to that cracks are allowed to grow too long before removal, which leads to higher grinding costs and more operational disturbances, and also to a shorter rail life. In severe cases this may even be a safety issue.

Solution

A significant number of inspection methods and equipment to detect rail cracks have been tested in INNOTRACK. The different methods have been compared with respect to accuracy for different types of cracks. The equipment has been evaluated in laboratory conditions, as well as in field.

Benefits

The work in INNOTRACK provides an IM with a good basis to select suitable equipment to detect rail cracks.

Next steps

The work is continuing in the European projects INTERAIL and PM'n'IDEA.

Grinding procedures

Cost driver

Grinding is a necessary maintenance method used to increase rail life and reduce costs. Grinding costs are today high. Two reasons for this are poor logistics planning and lack of network grinding strategies.

Solution

INNOTRACK has delivered a guideline on optimized grinding procedures. This guideline includes not only technical specifications (e.g. profile tolerances), but also logistical and strategic considerations.

Benefits

The INNOTRACK guideline gives support in deciding target profiles. It also aids an IM in optimising grinding from a logistics perspective and to impose a clear grinding strategy for the whole network.

Next steps

The work is continued in a group that will make a TecRec based on the INNOTRACK guideline. The new TecRec shall be expanded as compared to the guideline in the following areas: How a strategy shall be implemented, logistics aspects, economical aspects, coordination with other maintenance activities, and harmonisation of target profiles.

Welds with a narrow heat affected zone

Cost driver
The welds form a disturbance in the track properties. This may lead to increased loads, which promote rail degradation. Further, welding consumes significant amounts of energy, which is relevant both from an LCC and an environmental perspective.

Solution
INNOTRACK has developed and evaluated the benefits of welds with a narrow heat affected zone.

Benefits
The narrow heat affected zone welds are superior from an energy management perspective. In addition, INNOTRACK has evaluated the beneficial mechanical properties of the narrow heat affected zones.

Next steps
The narrow heat affected zone welds need now be wider deployed in operational services and national and international regulations adopted to account for the findings from INNOTRACK.

Charting of cost distributions

Cost driver
Lack of a standardized way of keeping track of costs and relating them to components, work tasks etc, prevents an identification of cost drivers and an LCC optimization of the network.

Solution
INNOTRACK has carried out a charting of main cost drivers on a European scale and detailed charting of the distribution of costs related to track, switches and crossings. This charting has showed where the potentials for cost savings are. Further INNOTRACK has proposed a framework for a unified cost breakdown structure.

Benefits
Based on the identified cost drivers in INNOTRACK, the work on decreasing LCC can be carried out in an efficient manner. Further, unifying cost structures promote international cooperation and exchange of information and knowledge.

Next steps
The work in INNOTRACK is a first step. To gain general acceptance there is a need to bring the work forward in standardization bodies.

Optimizations of switches & crossings

Cost driver
Switches & crossings (S&C) are discontinuities in the track systems. They impose dynamic loads on track and rolling stock and are prone to mechanical failures.

Solution
Through numerical simulations calibrated from in-field measurements, INNOTRACK has been able to propose several measures to optimize the mechanical characteristics of s&cs and thereby decrease their detrimental influence. These measures include gauge widening, optimized track stiffness and component geometries.

Benefits
The innovative solutions promote a decrease in operational loads that will decrease the deterioration of the S&C as well as the detrimental influence on passing vehicles.

Next steps
The proposed measures are now under full-scale validation. Results so far indicate a significantly increased performance of the optimized switches & crossings.

Numerical damage prediction and optimization of switch components

Cost driver
Switch components are highly dynamically loaded components in the track system and therefore prone to damage, which requires costly maintenance and/or replacement, often involving significant traffic disruptions.

Solution
INNOTRACK has for the first time ever demonstrated a methodology to numerically predict the detailed deterioration in terms of plastic deformations, wear and rolling contact fatigue of an operational crossing nose. To carry out this, a multitude of advanced simulation packages had to be combined together with a determination of relevant material properties. Validations towards operational components show a very good accuracy. INNOTRACK has also tested innovative S&C materials in laboratory tests with very interesting results. The framework to implement the mechanical characteristics of these innovative materials in numerical simulations is developed.

Benefits
The result of INNOTRACK is a toolbox that can be used to optimize switch components already in the design stage. This will save significant costs in premature track tests and will lead to optimum choice of both materials and design of switches & crossings. Furthermore, definition of the required material properties and testing techniques has provided a much needed technique to aid metallurgical design and development of new steels used for the crossing nose and other rail components.

Next steps
Currently the work continues with the analysis of the effect of altered materials. Further full-scale tests including some innovative materials are being carried out to further validate the simulations. The work now needs to continue with the development of optimized solutions and the operational integration of these in switch systems.

Open standard for electronic interlocking and hollow sleepers

Cost driver
The lack of a standardized interlocking interface is currently a hinder for obtaining production scale effects and increase competition within Europe. The same is true for hollow sleepers, where a

standard geometry would also promote the adaptation of tamping machines.

Solution
INNOTRACK has proposed an open standard for electronic interlocking. In addition INNOTRACK has proposed a standardized hollow sleeper to house driving mechanisms for switches.

Benefits
As mentioned above, the derived solutions will promote benefits of scale etc. In addition the standardization will facilitate sourcing. For these reasons the standardizations proposed by INNOTRACK are likely to lead to significant costs reductions.

Next steps
The proposed standard on hollow sleeper is now being processed by the CEN. The standardized interlocking interface needs some further development before being forwarded to standardization bodies.

Key parameters for switch monitoring systems

Cost driver
Unplanned maintenance of switches is costly and leads to traffic disruptions. The problem is further aggravated if there is little information to aid the maintenance staff in locating the error.

Solution
Key parameters for switch monitoring systems have been identified in INNOTRACK. Algorithms for fault detection have been developed. To validate the monitoring systems, laboratory and in-field tests have been carried out.

Benefits
The work carried out in INNOTRACK will aid in the development of switch monitoring systems that can indicate malfunctioning components and thus decrease time needed for repair. They can also be used to identify evolving faults so that maintenance can be carried out before these become critical and cause a malfunction of the switch.

Next steps
The solutions in INNOTRACK need now be further developed and included in commercial products.

LCC evaluation methodology

Cost driver
One of the most significant complications in the introduction of innovative solutions in the track sector is the assessment of their LCC impact. This may lead to incorrect decisions and related increases in costs.

Solution
INNOTRACK has developed a stringent, unified methodology for LCC evaluations on a European level. The method provides the ability to evaluate the LCC impact of different scenarios. It further results in well-defined analyses that clearly define which factors that have been taken into account.

Benefits
Apart from providing an objective tool for decision making, the LCC model developed in INNOTRACK will be used for comparisons between different scenarios. Further it can highlight parametric influences such as the effect of adopting different discount rates or delaying interventions.

Next steps
The methodology is currently in operational use e.g. at the DB. The further European use is foreseen to lead to improvements such as a more extensive analysis of the influence of statistical scatter and the inclusion of improved models to predict deterioration.

Logistics solutions

Cost driver
The logistics cost drivers comprise management/organisational, strategic and technical issues, such as:

- full or partial lack of track possession policy with a clear plant and staff deployment, and identified minimum disturbance strategies and procedures
- insufficient long-term planning and funding with commitments from governments
- deficiencies in work programming and project management

Further, local rules and regulations are often key barriers to the opening of national markets.

Within INNOTRACK however only technical cost drivers were dealt with.

Solution
INNOTRACK has derived solutions which minimise track possession times, allow for maintenance without traffic disruption, provide a high output rates, minimise the impact of rules & regulations by the use of standard machinery. Examples of these are:

- From Track Support and Superstructure: inclined cement columns, embedded slab track, and two layer steel slab track.
- From Switches & Crossing: implementation of a modular S&C, “plug-and-play” solutions, and steel slab track.
- From Rails & Welding: use of ultra-long rails (up to 120m weld-free), less welding, “just-in-time” direct transportation to construction site, reduced manipulation and stock keeping.

Benefits
Estimated savings in LCC is 30%. This includes qualitative estimations, which are however based on a tangible reality and thus considered reasonable.

Next steps
Key issues often relate to processes, people and culture. A key to success is to build a closer and more open relationship between infrastructure managers, industrial companies and contractors. Important next steps are the joint work groups that have formed between EIM/CER/EFRTC and other associations.

Evaluating the effects of INNOTRACK

Evaluation of logistics benefits

In chapter 7 of the INNOTRACK Concluding Technical Report an overview of currently on-going changes due to a more international approach in the European railway landscape is described. Also a picture of the present situation is given as background to identify possible ways of improvements related to the identification of logistics constraints and ways to overcome these. The interviews with both contractors and IM's have indicated significant possible cost reductions solely from mitigating these logistics related issues. Possible improvements include more collaborative, partnership-based approaches aimed at optimizing the use of available possession times, reducing costs and/or delivering more for the available budget and thus increasing the efficiency of providing a railway infrastructure for operators in general.

Technical and economical assessment

Evaluating Life Cycle Cost (LCC) of the asset is an important tool in the decision process. In INNOTRACK this has been addressed in a dedicated subproject. The work is summarized in chapter 8 of the INNOTRACK Concluding Technical Report.

An important result from INNOTRACK is that a harmonized LCC calculation method at a European level has been established. This method enables to identify cost drivers, assess the costs of track components/ modules and to make cross-country comparison. In the evaluations it is found that the discount rate has a significant impact on LCC as described and quantified for different situations.

Several complications in carrying out LCC-calculations are clarified. Examples are the relation between technical and economical aspects and how service life is dependent on failure rates for different components in the railway system. Other factors like availability and influence of repair rate are also considered.

Since the significant part of LCC is fixed before the installation phase it is here the largest parts of the savings can be made. This also means that it is very important that IM's give feedback to the suppliers in order to reduce LCC.

RAMS (Reliability, Availability, Maintain- ability and Safety) evaluations have also been addressed in INNOTRACK. Use of RAMS in the area of track and structures was found to be in an early stage. Therefore some basic considerations were done and proposals for future development presented.

Overall cost reduction

The objectives of overall cost reductions from INNOTRACK are explained in detail in Chapter 2 of the INNOTRACK Concluding Technical Report. The work in INNOTRACK has demonstrated that it is not possible to present a common international figure of the total cost reduction related to the solutions developed in INNOTRACK. The reason for this is mainly that every IM has a different maintenance policy and that the costs for maintenance and renewal vary a lot.

Of more interest is perhaps which reduction that can be achieved for a specific railway. This is an important question since the full implementation of result from INNOTRACK is a process that will take many years. Which parts and areas shall a specific railway prioritise in this process? Chapter 9 of the INNOTRACK Concluding Technical Report presents a summary of the evaluation of the potential overall reduction in LCC obtained by implementation of a range of INNOTRACK innovations at four IM's. These evaluations show that the potential LCC reductions are on the order of the set objective. This result is also backed by detailed analyses of some innovative solutions using a standardised LCC process that has been developed within INNOTRACK.

Dissemination and implementation

Many EU-projects end when the project is formally finalised. The reason is simply that there are no economical benefits for many participating members to carry on with the implementation work. For this reason too many EU-projects produce "shelf warmers" that are not operationally implemented. In INNOTRACK it has been an ambition from the beginning to have a focus on implementation. This is the reason for the engagement and contribution with extra resources from the UIC.

During and after the formal end of the project, an extensive work has been carried out to prepare and support implementation of the INNOTRACK results. This work has engaged many railways both within and outside the INNOTRACK consortium as well as several organisations and regulatory bodies. This is described more in detail in chapter 10 of the INNOTRACK Concluding Technical Report.

In addition an Implementation Group has been established based on INNOTRACK Steering Committee and Coordination Group. The aim of this group is to promote and coordinate the Europe-wide implementation of INNOTRACK results. This makes INNOTRACK a unique project in the way implementation is organised.