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INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

Deliverable 7.1.5
Identification of relevant codes and correlation to INNOTRACK results

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Glossary

Abbreviation/acronym	**Description**
CEN	Comité Européen de Normalisation (European Committee for Standardization)
FMEA	Failure Modes, Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
HAZ	Heat Affected Zone
IM	Infrastructure Manager
LCC	Life Cycle Costing
RAMS	Reliability Availability Maintainability Safety
RCF	Rolling Contact Fatigue
TSI	Technical Standard for Interoperability
UIC	Union of International Railways

1. Executive Summary

The result from INNOTRACK will to a large extent be implemented into different national European Codes. Motivated by this, the current report sets out to describe the (theoretical) hierarchy of regulations in Europe. This is done both at a European and a national level. The conclusion of this investigation is that the hierarchy is far from clear-cut. Further, there are major differences both geographically (different practices in different countries) and in how well the regulations on a certain hierarchy level contains specifications suitable for that level. The latter is a common problem when too detailed high-level regulations hinder development of efficient (from a RAMS and LCC perspective) solutions adapted to local conditions.

To make the description more concrete, the report also focuses on some selected examples of research in INNOTRACK. These are:

- Rail grade selection
- Squats
- Rail grinding profiles
- RAMS analysis
- Hollow sleepers
- Ground reinforcement through piling

The regulatory frameworks in these areas are described. Further, a description is given on how the regulations influence the work in INNOTRACK and how INNOTRACK's research findings influences the regulatory framework.

2. Introduction

2.1 The INNOTRACK dissemination platform

The INNOTRACK dissemination platform is a key component of the broader area of dissemination and training. It involves communicating the INNOTRACK project's progress and results to its target groups. Dissemination activities are crucial to achieving implementation of the products and technologies developed in the project and demonstrating genuine LCC reductions. The work in establishing and utilizing the dissemination platform is schematically shown in Figure 1.

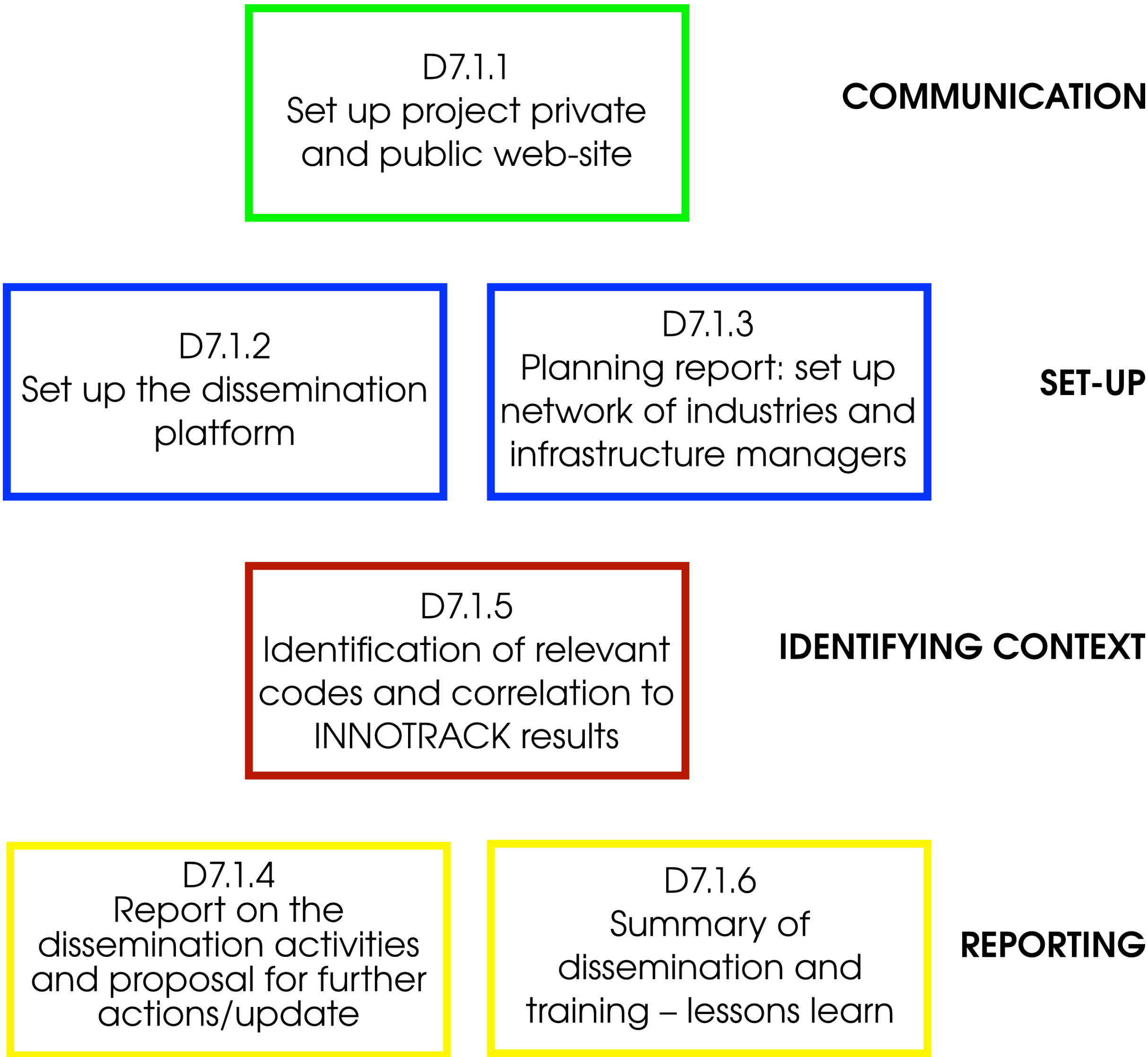

Figure 1 Organisation of the dissemination platform

Actors both inside and outside of the project will implement the INNOTRACK results. The target groups for the results and how they are addressed are described in detail in Deliverable *D7.1.6: Summary of dissemination and training – lessons learnt*.

2.2 Interaction between the regulatory framework and INNOTRACK

The current deliverable describes the regulatory framework consisting of codes and standards. This framework has influenced the work in INNOTRACK. One example is the development of slab track solutions as described in *D2.3.1: Validation methodology and criteria for evaluations of superstructure innovations*, *D2.3.2: Optimised design of a steel-concrete-steel track form to provide consistent support for low maintenance operation based on modelling and laboratory testing*, *D2.3.3: Design and Manufacture of BBEST slab track components*, *D2.3.4: Testing of the innovative BB ERS trackform*, *D2.3.5: Applications and benefits of a new 2-layers track form for existing tracks*, *D2.3.6: Slab track benefits and best value analysis for selection of a track system*. Here, the derived innovative solutions must comply with the regulatory framework in order to gain approval for field testing and operational implementation. As is evident from the above reports, much of the work has been addressing these demands.

It could be noted that for innovative solutions, it may well be that the current framework is not suited to an assessment. This can be manifested in two ways: either the solution fulfils the requirements, but nevertheless fails to operate in a satisfactory manner. One well-known example is here the Tacoma bridge outside Washington that collapsed due to extensive dynamic vibrations that were not captured by the codes applicable at the time of construction.

The second form of complication is that the regulation raises demands that are not applicable for the innovative solution. An example of this is gas pressure welding as described in the INNOTRACK deliverable *D4.6.5: Gas Pressure Welding – Quality of Test Welds*. Here the current regulations regarding the heat affected zone (HAZ) are derived for flash butt welds or aluminothermic welds. Due to the difference in production processes neither of these are directly applicable since there are significant differences in *e g* HAZ hardness profiles stemming from differences in metallurgical transformations during manufacturing.

Another example of this case is the embedded rail solution developed in INNOTRACK. This case has been taken as a pilot study for a systematic way of assessing solutions where there current regulations are insufficient. The study is presented in INNOTRACK deliverable *D1.3.4: Report on the most appropriate tools for evaluation of the issues raised within INNOTRACK where no proven method already exists*.

The main focus of this report is however not how INNOTRACK is affected by the current regulations, but the opposite: How the INNOTRACK results will and should affect current regulations. In this context it is important to remember that INNOTRACK in principle deals with three kinds of innovations:

- **Innovative products**
  Typical examples are the slab track solutions, optimised switches, monitoring equipment *etc* developed in INNOTRACK.
- **Innovative processes**
  Examples here are improved logistic solutions, welding techniques, inspection techniques *etc*
- **Innovative methodologies**
  This includes for example improved classification methods for tracks and vehicles, maintenance limits, life-cycle cost (LCC) and RAMS assessments.

In all these areas the research in INNOTRACK should and will have an effect of existing regulations.

In the case of innovative products, the main influence will be in modifying existing classifications (as discussed above) and in defining new standards. An example of the latter is the development of a standardized hollow sleeper (as described in *D3.2.2: Functional requirements for hollow sleepers for UIC 60 switches*), which is now considered for a European standard (by the CEN TC 256/SC 1 Track applications group).

In the case of innovative processes and methodologies, there may also be potential areas where standards (on a European or a national scale) may be addressed. One such example is the definition of Common European cost and maintenance structures (see *D1.4.6: A report providing detailed analysis of the key railway infrastructure problems and recommendation as to how appropriate cost categories for future data collection*). However, the main influence on regulations is expected in the field of codes and handbooks.

An identification of which Deliverables that may affect existing (or pave the way for new) standards, codes and handbooks and which areas these address has been carried out. The result is included in the Excel spreadsheet of Deliverables and Milestones (under the tab *Implementation*). The list will also be included as an appendix to the INNOTRACK Concluding Technical Report.

2.3 Contents of the report

As discussed above, the identification of which INNOTRACK results that may (and should) influence the regulatory framework is ongoing and will be reported in full when the project has been concluded and such an assessment can be made. The current report does not focus on this task. Instead it aims at giving an overview of the regulatory framework in Europe. This is done partly from a theoretical perspective of how the regulation hierarchy is supposed to be organized. In addition, some examples are given to show how the actual regulatory framework is in some areas relevant for the INNOTRACK research. These examples also show how INNOTRACK is influenced by and influences the regulations in these areas.

The final chapter gives some examples of the (theoretical) hierarchy of regulations in some selected countries.

3. The regulatory framework in Europe

3.1 The theoretical hierarchy

The hierarchy of the regulatory framework in Europe could theoretically be described with a pyramid as in *Figure 2*.

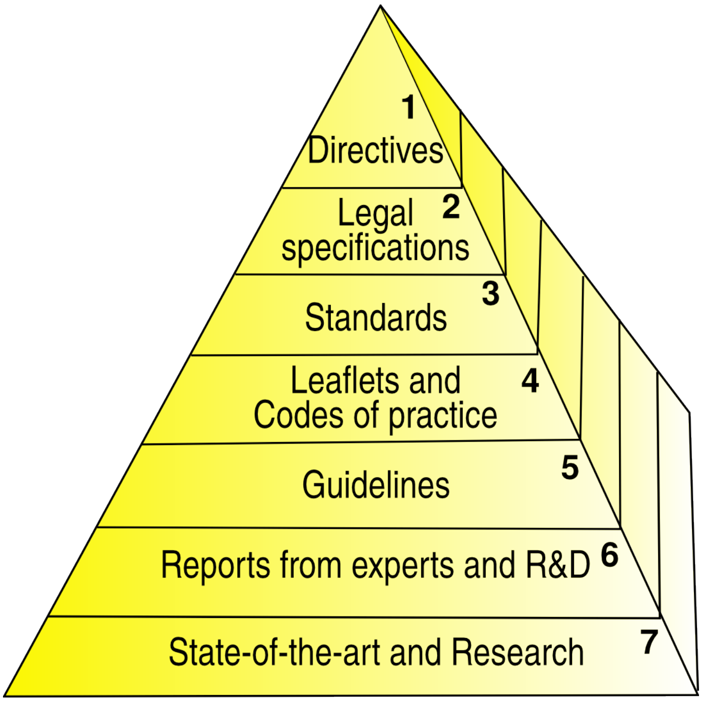

Figure 2 Theoretical hierarchy of regulations in the European rail sector

The top level consists of directives. Today the quality of the directives is in general very good and on a suitable level.

The second level includes the legal specifications. For the railways the most important ones are the Technical Specifications for Interoperability (TSI). Sadly the qualities of these are in many cases poor in the track sector, especially regarding the translated TSIs. The TSIs are also often not as stringent as would be desired. It is far too common with a mixture of functional demands and detailed demands. In the pyramid this corresponds to the legal specifications trying to regulate topics that are below its intended level of responsibility. This makes the task of translating the TSIs to coordinated regulations very cumbersome. The general opinion among IMs and the industry is that ERA has not lived up to its responsibilities and created applicable specifications. This has led to significant criticism. Hopefully the situation will improve as the drafting process of the TSIs mature.

The third level consists of codes, norms and standards. Here CEN is doing a good job in *TC 256 Railway applications*. The problem here is that the mandate the CEN has limits their work. In INNOTRACK we have therefore taken initiative to serve *TC 256 Railway applications* with information in areas of relevance to them. The cooperation with *TC 265 Railway applications* is today good.

It should be noted that the levels 1 to 3 exist also on a national scale. The harmonization between national and European regulations vary between countries both in terms of how much of the European framework that is fully adopted and the amount of additional national regulations. Also the organisation of authorities responsible for this regulatory framework differs between countries. This makes it difficult to make any general remarks.

At levels 4 to 7 the situation is more diffuse and the actual situation may vary even more between countries. Here we have tried to define some typical levels.

In our categorization, level 4 consists of Leaflets and equivalent documents. The Leaflets (where UIC leaflets, and the upcoming UIC/UNIFE TecRecs are typical examples) represent the common opinion of several organisations (typically infrastructure managers).

At level 5 are Guidelines. These are a way to express more precise statements on implementation recommendations than ordinary reports. They are in this sense generally more “hands-on” than leaflets.

At level 6 you have technical reports from research, development and investigations. These are the outcome of R&D activities. Generally they focus on a rather narrow topic and do not constitute generally accepted conclusions, opinions and knowledge to the same extent as Leaflets and Guidelines.

Finally at level 7 State-of-the-art reports. These summarize the current knowledge in a certain field, but generally do not introduce any additional research findings.

Note that the higher up you are in the pyramid, the more time it has generally taken to establish the regulatory documents. The time it takes to produce a standard or a TSI (in the order of a decade from initiation to final code) means a considerable amount of the content is old and out of date. If this is not mitigated, the railways will never benefit from R&D in an efficient way. As mentioned above, INNOTRACK is trying to help in this aspect by a rapid communication of research results through the established dissemination platform.

In section 5, a brief description of selected national codes in some European countries is given with an analysis of how INNOTRACK results can be merged into these.

4. An overview of some current regulations and practices in Europe

Section 3 outlined how the regulatory framework is organised in theory. In this section some examples of regulations related INNOTRACK research are presented.

4.1 Rail grade selection

Rail grade selection has been dealt with in the INNOTRACK deliverables *D4.1.3: Interim guidelines on the selection of rail grades* and *D4.1.5: Definitive guidelines on the use of different rail grades*.

Today the main regulations regarding rail grade selection are:

- The European standard EN13674-1:2008-01, which specifies different qualities of pearlitic rail steels in terms of chemical composition, material strength *etc*. This standard is generally followed throughout Europe and will not be discussed in the following.
- The UIC Leaflet 721, which gives recommendations for rail grade selection under different operational conditions.

The recommendations of UIC Leaflet 721 are summarized in Figure 3. The selection is based on curve radius and annual tonnage of the line.

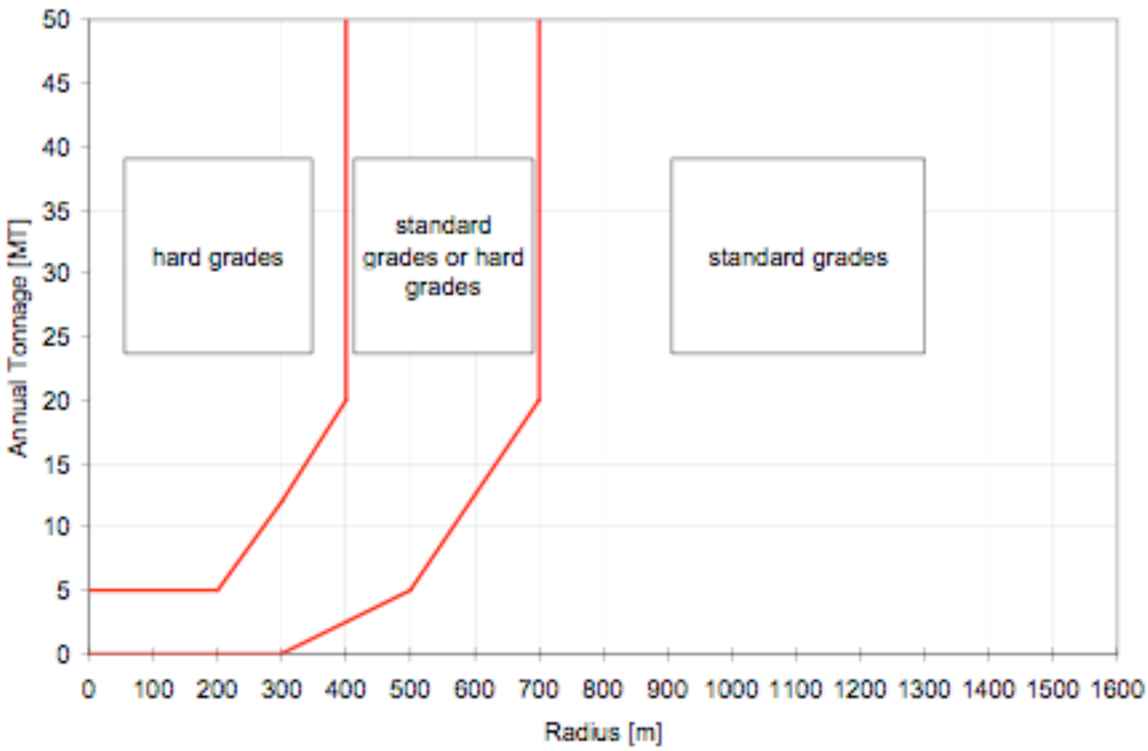

Figure 3 Selection of rail grades according to UIC Leaflet 721.

The actual national practices for rail grade selection are indicated in *Figure 4*. In the comparison between Figure 3 and *Figure 4* all grades with a number larger than 260 can be considered as "hard grades". It is sufficient to conclude that the differences in national practices are significant and the adherence to Leaflet 721 rather poor.

This is not surprising. The reasons for rail selection may be very local. It should perhaps be more of a surprise if for instance the rail grade selection in northern Sweden and in southern Spain coincided.

Further, the general trend towards harder steel grades as compared to Leaflet 721 that can be seen in *Figure 4* has a simple explanation. Since Leaflet 721 was drafted the trends in operations has been towards heavier and faster vehicles, often with stiffer bogies. Naturally this puts higher demands on the rail and a natural counter-action is the adoption of harder rail grades. Further, advances in research and development have made harder steel grades both better and more economical.

<table>
<tr><th>Radius [m]</th><th>≤ 300</th><th>≤ 400</th><th>≤ 500</th><th>≤ 600</th><th>≤ 700</th><th>≤ 800</th><th>≤ 1500</th><th>≤ 3000</th><th>> 3000</th></tr>
<tr><td>UIC</td><td colspan="2">R350HT</td><td colspan="3">R350HT/R260</td><td colspan="4">R260</td></tr>
<tr><td>DB</td><td colspan="5">R350HT (≥ 30.000 t/d)</td><td colspan="4">R260</td></tr>
<tr><td>DB new</td><td colspan="7">R350HT (≥ 50.000 t/d)</td><td colspan="2">R260</td></tr>
<tr><td>CH</td><td colspan="2">R350LHT</td><td colspan="3">R350LHT/R320Cr</td><td>R320Cr
R350LHT</td><td colspan="3">R260</td></tr>
<tr><td>CH (pro-posal)</td><td colspan="2">R370CrHT</td><td colspan="2">R350LHT</td><td colspan="3">Bainite up to 1200 m</td><td colspan="2">R260</td></tr>
<tr><td>AT</td><td>R350HT</td><td colspan="8">R260</td></tr>
<tr><td>SWE</td><td>R350HT</td><td colspan="8">R260</td></tr>
<tr><td>SWE (HH)</td><td colspan="8">R350HT</td><td>R260</td></tr>
<tr><td>NOR</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
<tr><td>UK</td><td colspan="9">R260</td></tr>
<tr><td>IT</td><td colspan="9">R260</td></tr>
<tr><td>BE
LUX</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
<tr><td>NL</td><td>R350HT
R370CrHT</td><td colspan="5">R370CrHT</td><td colspan="2">R370CrHT</td><td>R260</td></tr>
<tr><td>DK</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
<tr><td>PL</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
<tr><td>H</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
<tr><td>RO</td><td colspan="5">R350HT</td><td colspan="4">R260</td></tr>
</table>

Figure 4 National practices for rail grade selection

The INNOTRACK deliverable *D4.1.5: Definitive guidelines on the use of different rail grades* presents an updated recommendation for rail grade selection that better reflects today's practices and operational conditions.

The regulations on rail grade selection illustrate two important facts:

- The operational conditions as well as the knowledge level increases with time. Regulations should therefore not remain static.
- It is very important to distinguish between which regulations that should be recommendations and which should be requirements. In the current case, it is obvious that the national practices on rail grade selection have been adopted to optimize the selection under the national conditions. If the selection criterion promoted by Leaflet 721 had been mandatory (as in specified by a TSI) it is therefore reasonable to presume that the corresponding economical losses had been enormous.

The research findings and recommendations for INNOTRACK have now been disseminated to the railway community through the release of the report and through in-depth presentation at a seminar in Brussels 2009-10-14 where large parts of the rail experts in Europe participated. In addition, a course on rail grade selection and its implementation organized by the UIC is planned for 2010. Further, the UIC-Track Expert Group has brought up the revision of Leaflet 721 on the agenda.

4.2 Squats

Squats are a form of rolling contact fatigue (RCF) that appears as a discrete defect often with a localised widening of the running band. In INNOTRACK they have been treated in deliverables *D4.21: Estimations of the influence of rail/joint degradation on operational loads and subsequent deterioration. Tentative report. D4.2.4: Improved model for loading and subsequent deterioration due to squats and corrugation* and *D4.2.6: Recommendation of, and scientific basis for minimum action rules and maintenance limits.*

Current maintenance limits regarding squats are given in Table 1. It is seen that the immediate action upon detection of a squat varies from nothing to fitting of clamps or repair welds, and speed reductions. Mitigating actions depend on the size of the detected squat (measured as crack depth or by relative ultrasonic response). It is seen that the regulations vary greatly between different IMs.

Table 1 Maintenance regulations regarding squats

IM	Length	Depth	Emergency action	Timescale
UIC	L>200mm	or >25mm		2 weeks
			Fit clamps	6 weeks
	50<L<=200mm	or 10<D<25mm		12 months
	<=50mm	or <10mm	Re-inspect	Normal inspection interval
ProRail		>50% (>25mm) head height	40km/h	As soon as possible
			or fit clamps	3 months
		20% (10mm) < D< 50% (25mm) head height		4 Weeks
		<20% (10mm) head height		3 months
		No ultrasonic response	Re-inspect visually	6 months
DB	L > 30mm	or: > 20mm	single squat: 120km/h (160km/h) with clamp (different kind) multiple squats or squat in conjunction with Head Checks: 20km/h	Immediately
	10mm< L ≤ 30mm	or 10mm< Depth ≤ 20mm	Repair weld	Before next inspection
	<10mm	all	Repair weld	
NR	SCL >50mm	>15mm Deep	20mph [32km/h] & Clamps	Rectify within 7 Days
		≤15mm Deep	Clamps	13 Weeks

		No depth	Clamps	13 Weeks
	SCL ≤50mm	>15mm Deep	Clamps	7 Days
		≤15mm Deep	Clamps	13 Weeks
		No depth		13 Weeks
ÖBB	>50mm	>10mm	Block Line	Immediately
			10km/h with clamps or under packed	
			60km/h with clamps and under packed	
	Mid Sleeper bay			
	<50mm	<10mm	30km/h	
			100km/h with clamps and under packed	
	Over sleeper			
	<50mm	<10mm	30km/h	
			100km/h with clamps	
BV	≥ 100mm			1 Month
	L≥ 500mm	≥5mm ϕ FBH depth ≥ 10 mm		1 Month

The definition of squats is given in UIC leaflet 712 (code 227). In relation to the current research within INNOTRACK an interesting finding was made: The classification in UIC leaflet 712 is mainly based on research on squats in UK and Japan carried out in the 70's. The research in INNOTRACK has been carried out at ProRail in the Netherlands. In-depth discussions were had with the external scientific reviewer. These also continued during the *8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems* in Florence, September 15–18, 2009. From the discussions it became clear that although the characteristics of the squats studied in the Netherlands were very similar (if not identical) to the descriptions in the UIC leaflet and thus the squats studied in the UK, the root causes for squat initiation seem to differ substantially. This is of interest in many aspects: Firstly, if the root causes differs, the most efficient mean of mitigating squats is likely to differ for different operational conditions. Secondly, the limits for squat growth (basically the size of a squat that will continue to grow) as established in INNOTRACK should be very depending on the operational conditions. The latter was naturally a suspicion already in the INNOTRACK research, but the discussions made this even clearer.

The discussion above on the regulations on squats further highlights the first observation made in connection to the selection of rail grades, i.e. the operational conditions as well as the knowledge level increases with time and regulations therefore should not remain static. Further three other important facts are highlighted:

- Classifications (in this case of damages) are often made based on appearance. Actions (in this case mitigating) however must be based on root causes. There is an inherent conflict here in that two root causes may lead to phenomena with the same appearance.

And related to this:

- If a nomenclature is introduced, it is very important that it is as clear and unambiguous as possible. A flawed nomenclature may often be worse than no nomenclature at all (the latter case forces a detailed explanation of the phenomenon in question).
- The background to regulations must be documented and accessible so that the engineer can make a qualified assessment on whether current phenomena falls within the scope of the regulation.

The last point is especially important in cases where exceptions to the regulations need to be granted.

The work carried out in INNOTRACK gives indications of which squats that should be considered as prone to propagate. It further outlines how such an assessment can be carried out for generic operational conditions. This is likely to pave the way for an update of Leaflet 712 and National maintenance regulations.

4.3 Rail grinding profiles

An overview of different rail profiles adopted in Europe is presented in INNOTRACK deliverable *D4.5.2: Target Profiles* and in *D4.5.5: Concluding grinding recommendations*.

Regulations for rail grinding can be found in *EN 13231-3: Railway applications – Track – Acceptance of works – Part 3: Acceptance of rail grinding, milling and planing work in track*.

Rail profiles standardized on a European scale are specified in *EN 13674-1: Railway applications – Track – Rail – Vignole railway rails 46 kg/m and above*. A summary of some profiles (EN standardized and not) is given in *Figure 5*. This summary includes profile 54E5 (= 54E1 AHC in *Figure 5*), which is at present the only anti-head check profile to be incorporated in EN 13674-1.

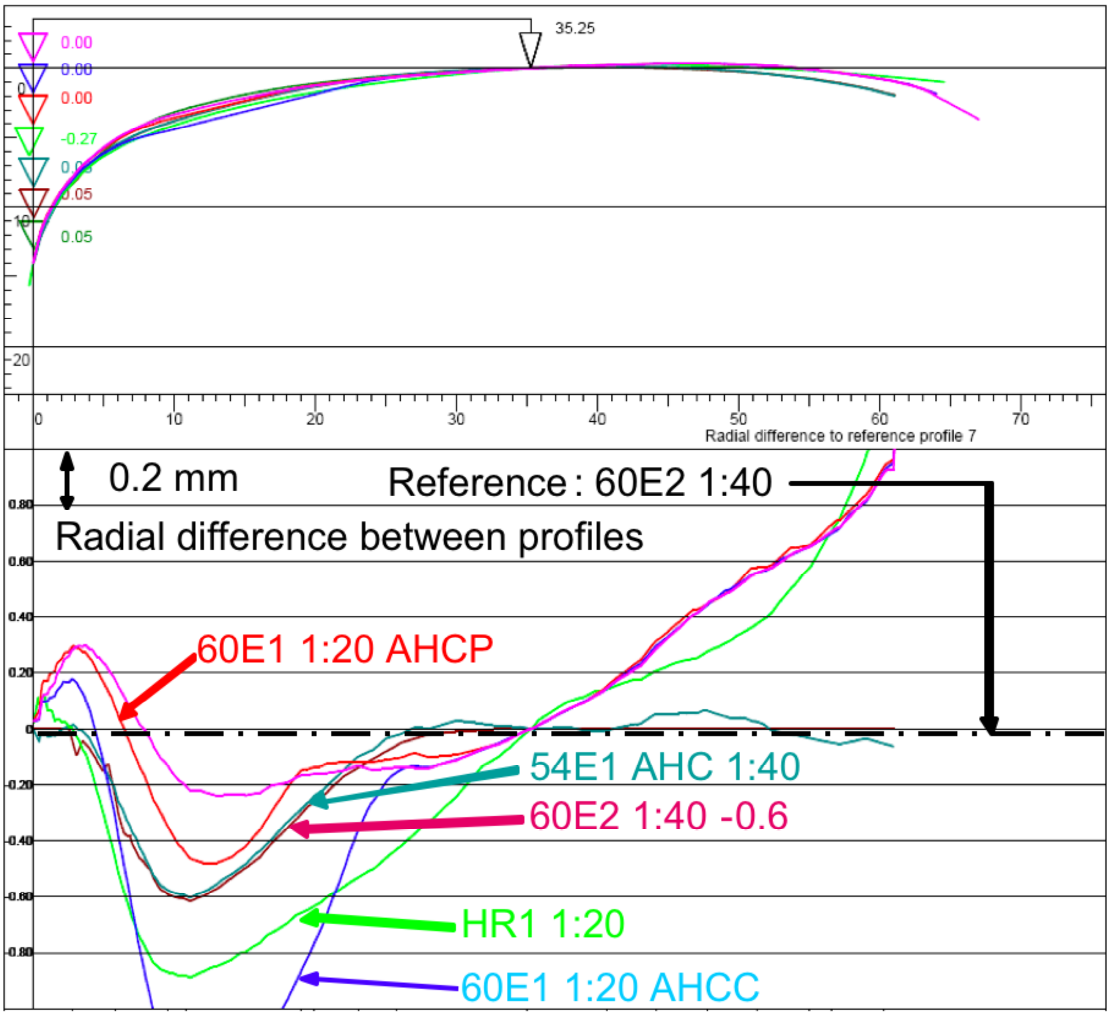

Figure 5 Rail grinding profiles

When examining *Figure 5*, it should be kept in mind that production tolerances are in the order of at minimum +/- 0.3 mm. This means that several of the presented profiles match within the allowed tolerances. One of the important results from the INNOTRACK research in the field is to point out that there should therefore be significant room for further standardizations. This is likely to result in significant cost savings.

The research findings and recommendations for INNOTRACK have been disseminated through in-depth presentation at a seminar in Brussels 2009-10-14 where large parts of the rail experts in Europe participated. It will further be disseminated through the release of the INNOTRACK guideline *D4.5.5: Concluding grinding recommendations*, which has been reviewed at several IMs. In addition, the work on improving grinding practices continues between the members of the INNOTRACK work package group.

4.4 RAMS analysis

In INNOTRACK deliverable *D6.1.1: Incorporated rules and standards* an extensive review was carried out regarding standards of relevance for RAMS (Reliability, Availability, Maintainability and Safety) analysis in the railway sector.

These standards are:

- EN 50126: Railway applications – the specification and demonstration of RAMS
- IEC 61160: Formal design review (amendment 1)

- IEC 60300-3-1: Dependability management- part 3, application guide – section 1: Analysis techniques for dependability, guide on methodology
- IEC 60706: Guide on maintainability of equipment (part 1 – 6)
- IEC 60812: Analysis technique for system reliability – procedures for FMEA
- IEC 60863: Presentation of reliability, maintainability and availability predictions
- IEC 61025: Fault tree analysis
- IEC 61078: Analysis techniques for dependability – reliability block diagram method
- IEC 61165: Application of Markov techniques
- IEC 61709: Reliability of electronic components
- IEC 61508: Functional safety of electrical/electronic safety related systems (parts 1-7)
- IEC 60605: Equipment reliability testing
- IEC 61014: Programmes for reliability growth
- IEC 61070: Compliance test procedure for steady-state availability
- IEC 61123: Reliability testing – compliance test plan for success ratio
- IEC 60319: Presentation of reliability data on electronic components
- MIL STD 471a: Military standard maintainability verification/ demonstration/evaluation
- MIL STD 2173: Reliability centred maintenance
- IEC 60571: Electronic equipment used on rail vehicles, components, programmable electronic equipment and electronic system reliability (part 3)
- MIL STD 785B: Reliability program for systems and equipment development and production
- MIL STD 756: Reliability modelling and prediction
- MIL STD 1629: FMECA
- IEC 812: Analysis techniques for system reliability - procedure for FMECA

The categorization of these standards with respect to the RAMS topics is given in *Table 2*.

The enquiry of the actual application of these standards revealed that among the five IMs questioned, all employed *EN 50126: Railway applications – the specification and demonstration of RAMS*. Further. One IM had adopted *IEC 60300-3-1: Dependability management- part 3, application guide – section 1: Analysis techniques for dependability, guide on methodology*.

The poor adoption can perhaps partly be accredited to a poor knowledge on RAMS. However also in organizations where the RAMS knowledge is high RAMS adoption is still in its infancy. The likely main reason for this is the complications in obtaining suitable input data for the analyses.

The lesson learned in INNOTRACK is that standards in themselves are not sufficient to ensure the adoption of a new technology. Two additional key requirements are education and knowledge, and also the required infrastructure (in this case in the form of databases with input data, and analysis software).

The work in INNOTRACK will forward the adoption of RAMS analysis since it tackles both the level of knowledge, the input data (a major topic in INNOTRACK's subproject 1 – Duty) and the software for RAMS analysis (by sharing knowledge on available and employed tools).

Table 2 Standards applicable to RAMS analysis in the railway sector

Reliability	**Availability**	**Maintainability**	**Safety**
EN 50126	EN 50126	EN 50126	EN 50126
IEC 61160	IEC 61160	IEC 61160	IEC 61160
IEC 60300-3-1	IEC 60300-3-1	IEC 60300-3-1	IEC 60300-3-1
IEC 60812	IEC 60863	IEC 60706	IEC 61025
IEC 60863	IEC 61165	IEC 60863	IEC 61508
IEC 61025	IEC 61070	MIL STD 471A	MIL STD 1629
IEC 61078		MIL STD 2173	IEC 812
IEC 61709			
IEC 60605			
IEC 61014			
IEC 61123			
IEC 60319			
IEC 60571			
MIL STD 785B			
MIL STD 756			
MIL STD 1629			
IEC 812			

4.5 Hollow sleepers

Hollow sleepers are used to enable the passage of driving and locking devises equipment and other installation equipment below the switch. Currently there are no standard for hollow sleepers. This means that every switch manufacturer use their own geometry *etc*. There are some complications with this. Two examples are: The infra-manager is “locked in” to one delivery channel. Further, there are problems in designing switch tamping machines, since the available space depends on the dimension of the hollow sleeper.

Early on in INNOTRACK, the benefits of a common standard were identified. In INNOTRACK deliverable *D3.2.2: Functional requirements for hollow sleepers for UIC 60 switches*, a draft standard for hollow sleepers was derived. This draft has been delivered to the CEN sub committee *TC 256/SC 1 Track applications*.

This example illustrates some important items:

- If there is a need to derive a standard, a European project is a very good forum to create a draft since it allows for an early consensus among major actors on the European railway market.
- The drafting of the final standard is a long and more “political” process. This is not suitable for a European project.

- The CEN committees are dependent on input in the form of scientifically based drafts. The reason is that the committees themselves do not have the resources to prepare such drafts. Cooperation between European projects and the CEN is therefore a win–win relationship: The project can forward their needs and suggestions and the CEN gets a high quality working material that significantly eases the standard authoring.

For the specific case of hollow sleepers, the work in INNOTRACK can now be considered as closed. There are other areas where European standards are a possible implementation channel. An evaluation of these has started and will continue.

4.6 Ground reinforcement through piling

Two form of piling as a soil reinforcement method are investigated in INNOTRACK: Relatively short vertical piling and inclined piling. Both piling techniques are based on deep mixing methods. The research is documented in deliverables *D2.2.5: Subgrade reinforcement with columns Part 1: vertical columns Part 2: inclined columns* and in the guideline *D2.2.8: Guidelines for subgrade reinforcement with columns. Part 1; vertical columns and Part 2; inclined columns*.

In D2.2.8, the following applicable codes have been identified

- EN 1990: Eurocode: Basic of Structural Deign
- EN 1991: Eurocode 1: Actions on Structures
- EN 1997-1: Eurocode 7: Geotechnical Design – Part 1: General Rules
- EN 196-1 to 8, EN 196-21, EN 197-1 and 2 that deal with cement.
- EN 459-1 and 2 that deal with building lime
- EN 10080: Steel for the Reinforcement of Concrete
- EN 12716: Execution of special geotechnical works. Jet grouting
- EN 791: Drill rigs
- EN ISO 14688-1: Geotechnical investigation and testing. Identification and classification of soil. Identification and description
- EN 14679: Execution of special geotechnical works. Deep mixing

In addition, some handbooks have been identified.

This example illustrates a rather common case where new methods are to be adopted: Codes, norms and standards exist, but they are general and leave major areas open. In this case there is thus a need for practical handbooks and not general standards. Due to their specific nature, these need to contain a large proportion of regional/national content and also account for the varying conditions that may occur in different cases.

In INNOTRACK a guideline that gives general guidance to the different types of piling has been authored. This guideline then has to be complemented by national/regional handbooks that give advice on an even more detailed level. This work has already begun at *e g* Banverket.

5. Examples of different codes

In INNOTRACK we had an ambition to compare different national codes in order to se how easy or difficult it was to implement result from R&D projects like INNOTRACK. This was a more difficult exercise than expected. Our ambition was to look at codes from BV, DB, NR and SNCF. Sadly the codes from SNCF were confidential so the comparison could only be carried out for three different codes. The whole idea was to see if the codes are hinders that make implementation more difficult or if INNOTRACK results can easily be merged in to the national codes.

These topics have also been discussed at the visits to IMs where implementation has been discussed.

The conclusion is that for many technical codes it is quite easy to implement result from INNOTRACK. When national considerations based on national empiric knowledge are involved, the difficulties to implement increases.

5.1 DB

The code looked at in this study is “Schienen erneuern oder auswechseln; Schienen in Gleisen erneuern oder auswechseln“ with number 824.2510 from 2003. The code regulates renewing of rail. Its target group is a senior track engineer. This means that it can be short and precise. It is modern and very easy to read and understand.

Since the statements are technical and clear it ought not to be to difficult to implement result in an updated version. If this is the case with other German codes the possibility to implement result from INNOTRACK would be easy.

5.2 NR

The code looked at in the study is “Inspection and Maintenance of Permanent Way” with number NR/L2/TRK/001 and issued 28 August 2008. This code has a target group out in the field. This means that a lot of descriptions have to be added in order to make the Code possible to use. The code is also a modern code.

Since the technical values are closely linked to describing text how to measure and maintain. Here the implementation is much more difficult especially since many of described values are empiric. The empiric values are in most cases based on the national situation. This means that international recommended result from INNOTRACK has to be adjusted according to this.

5.3 BV

The BV experience is based on the authors many years' personal experience. The quality of Swedish codes vary. Some are modern and some old. For examples the code concerning maintenance of isolated joints BVH 522-210 issued 2001-08-01 can easily be updated with INNOTRACK result. This is also the case for many other codes that are technical and describe a specific item. Codes for routines like inspection need more work to apply. One problem for BV is that the code structure has been changed too often.

Generally most result can be implemented. A concrete proposal for implementation has now been produced together with project proposals for 2010 and 2011.

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6. Conclusions

The current report has described the theoretical hierarchy at a European level and in some European countries. This description shows that the hierarchy is far from clear-cut. Further, the problem that results when high-level regulations impose detailed regulations is highlighted.

The report then turns to some specific examples of INNOTRACK research and discusses regulations in the area in relation to the INNOTRACK research. Several lessons can be learnt from this investigation. Some examples are:

- Operational conditions as well as the knowledge level increases with time. Regulations should therefore not remain static.
- It is very important to distinguish between which regulations that should be recommendations and which should be requirements.
- If a nomenclature is introduced, it is very important that it is as clear and unambiguous as possible.
- The background to regulations must be documented and accessible so that the engineer can make a qualified assessment on whether current phenomena falls within the scope of the regulation.
- If there is a need to derive a standard, a European project is a very good forum to create a draft since it allows for an early consensus among major actors on the European railway market.
- The drafting of the final standard is a long and more “political” process. This is not suitable for a European project.

This may seem like self-evident statements, but when put in context (as in this report) it is clear that they in fact are not.

In addition the examples how the results in INNOTRACK will be implemented on different level in the (theoretical) hierarchy of regulations from standards to state-of-the-art reports.

The conclusion is that for many technical codes it is quite easy to implement result from INNOTRACK. When national considerations based on national empiric knowledge are involved the difficulties to implement increases. Another remark is that the more modern a code is it seems easier to implement new result.

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