



Project no. TIP5-CT-2006-031415

## INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

### **D7.2.1 Establishment of training platform (including former D7.2.2 - Report on current practices for training/education of track staff**

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

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## Glossary

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Abbreviation/acronym	Description
ADIF	Administrador de Infraestructuras Ferroviarias
ALD	Advanced Logistics Developments
BV	Banverket
CZ	Czech Railways
DB	Deutsche Bahn
D-LCC	Decision by Life Cycle Cost
IM	Infrastructure Manager
LCC	Life Cycle Costing
LCCA	Life Cycle Costing Assessment
RAMS	Reliability Availability Maintainability Safety
SP	Sub Project
WP	Work Package

# 1. Executive Summary

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## Participants and Description of work

Workpackage	7.2 – Training Platform			Start date or starting event:			T0
Participant id	UIC	UNIFE	BV	NR	RFF	DB	
Person-months per participant	3	3	2	2	1	3	

The Subproject 7 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 WP7.2 **Training Platform** is to provide coherent training programmes in order to assure the long term availability of skilled and trained workforce for implementation of INNTRACK 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 INNTRACK.

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 WP6.2 D-LCC was evaluated as most suitable tool for INNOTRACK purposes.

Concerning the tool a specific software training will taken place on 17<sup>th</sup> 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 WP6.5. 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 WP7.2 'Identification of needs and specifications for coherent training programmes'.

## 2. Introduction

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The efficient introduction of new products, technologies and procedures in the railway sector cannot be achieved without having skilled and trained personnel.

At present railway sector is characterised by aging of skilled personnel and shortage of qualified staff in particular in field and operation. Therefore the establishment of training programmes along with the achievements of INNTRACK project will be vital for the implementation of the results in long term.

There is some scarce experience at some Infrastructure Managers and Academia with training/education short courses but a coherent training programme starting from staff working in the field and ending by Engineering for track design and technology does not exist. For establishing and implementing of such a programme it is proposed to set up a dedicated **Training Platform** within INNTRACK project.

The content of D7.2.2 (Report on current practices for training/education of track staff) is contained in this document and involves an evaluation of the current training/education and future training needs of IMs. It is drawn from a questionnaire which asks IMs to rate the level of current knowledge and training practises against the different technical components of track infrastructure that the project addresses. IMs are also asked to indicate the future training needs and rate the level of importance of the different areas. This task enables the training platform to focus its efforts in current known deficient areas. This coupled with the future task of identifying the needs and specifications for coherent training programmes provides for a complete training programme that addresses current and future needs in all the key areas of track infrastructure – those areas covered by INNTRACK.

INNTRACK will also set up a training programme for the training of IMs on the use and implementation of the generic LCC calculation methodology that the project will devise. This will ensure that the methodology is implemented European wide and can serve as a comparison for IMs across Europe.

### Note:

The 'original' deliverables D7.2.1 (Establishment of Training Platform) and D7.2.2 (Report on current practices for training/education of track staff) had been merged into a single 'new' D7.2.1 (Establishment of Training Platform and report on current practices for training/education of track staff). This "combined" deliverable covers both 'original' deliverables and follows the progression of work in the training platform extending from the establishment of the training platform, through to identification of current practices and training needs to current and future training activities.

The 'old' D7.2.3 has become the 'new' D7.2.2 (Identification of needs and specifications for coherent training programmes), which is covered in another document.

### 3. Training platform

The deliverables of WP7.1 are available and in a good shape. The internal project website is running quite smoothly and improvements are discussed regularly.

All sub projects should be covered by the dissemination activities. It is perceived that basic knowledge on LCC methodology is not clear among project partners and basic training should address this first. Therefore the training within the content of SP 6 – Life Cycle Cost Assessment would be the focus of actions within WP7.2. Thus technical training in LCC forms an important part of this work package.

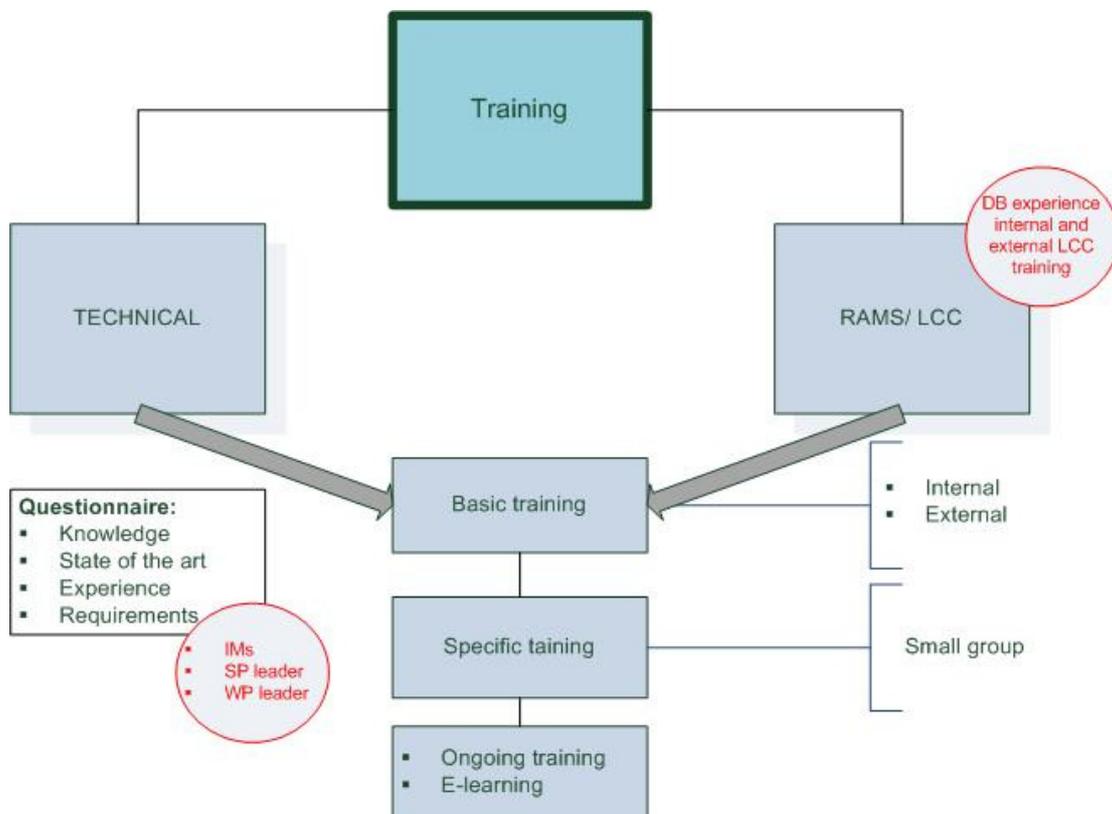
Life cycle costing is the process of economic analysis and assessment of acquisition and ownership of a product. LCC is a supporting method for professional decision making in all phases (especially in early phases) of a product's life cycle.

#### 3.1 Activities

The structure of WP7.2 in the combined deliverable D7.2.1 & D7.2.2 separates the Training Platform into two streams:

- Technical
- LCC / RAMS

Both streams follow the same process, starting with general training and then moving into specific training (content to be determined via outcome of questionnaires and discussion with IM's and SP/WPLEaders).



**Figure 1: Scheme training platform**

As Figure 1 shows, training activities have to be planned and developed.

### **Stream RAMS/LCC Training:**

#### **1. General Training Workshop with a basic training**

This training workshop with basic training in LCC has taken place 26-27 February 2008 at UIC offices in Paris.

- Target Groups
  - INNTRACK internal target group: SP leaders and WPLEaders
  - External Infrastructure Managers (UIC members): IMs that are interested in LCC and RAMS methodology
- Content
  - Theoretical Background
  - LCC and RAMS definitions
  - Methodology approach of INNTRACK
  - Economic boundary conditions for LCC and RAMS
  - Results of Software Benchmark
  - Test cases of LCC analysis
- Venue
  - UIC Paris
- Time
  - 2 days
- Date
  - 26-27 February 2008

As a result of the evaluation it could be stated that the regularity of use of RAMS and LCC is low and tools and models are mostly self-developed.

The results of the evaluation highlight the improvement areas followed up:

- Use of LCC analysis
- Maintenance and tools analysis
- Research and development phase, investment phase, operation and maintenance phase, disposal phase
- RAMS standards (not many standards in use; EN 50126 is the most used railway standard), RAMS database, RAMS software
- RAMS tools

Unawareness of different RAMS and LCC terms confirms the need of common typology, definitions of methods which will be defined in the frame of INNTRACK. The dissemination and training are therefore vital for INNTRACK and crucial for the success of the post project phase – implementation of new innovative products which must be inter-operable, safe and cost efficient in migration with existing infrastructure.

The basic training was on the basis for LCC, how it can be used in INNTRACK and on the tool that is used in SP6. Tool used in training was the commercial specialised software D-LCC. LCC software (D-LCC) helps in consideration between variants respecting the whole life cycle. The benchmark and evaluation of existing LCC tools are completed, which results in D-LCC as the most suitable tool for INNTRACK purposes (solutions asked in WP6.2). D-LCC is not company specific software and could be used within INNTRACK.

Test cases of LCC analysis were practised in the training by using the software D-LCC.

Further information of the LCC basic training see attached slides in the annex (s. 5.2).

Important to highlight that with the software come the model, which means that the work of building it and thinking through the model is proceeding in the Work Package WP6.5. The software is not an asset management system, it is designed to compare different solutions with respect to LCC optimization.

#### **2. Specific Software Training**

Referred to the closed contract between INNTRACK and ALD regarding the D-LCC tool a specific software training will take place in Paris conducted by ALD.

**a. Software Training Workshop 1**

- Target Groups
  - Experts for LCC software
- Content
  - Software tools
  - Import/export data
  - Modelling
- Venue
  - UIC Paris
- Time
  - 1 day
- Date
  - 17<sup>th</sup> September 2008

**b. Software Training Workshop 2**

- Target Groups
  - Experts for LCC software
- Content
  - Software / Revision after the optimization of the software by implementing the integrated improvements by ALD
- Venue
  - UIC Paris
- Time
  - 1 day
- Date
  - To be defined

Regarding the Technical stream the following training activities have to be planned and developed:

**Stream Technical Training:**

**3. Basic Training**

- Target Groups
  - INNTRACK internal target group: SP leaders and WPLEaders
  - Technical Specialists of IMs
- Content
  - Specific questions of respective railways
  - In depth training of specialist
  - Demonstration and use of model and tool chosen by INNTRACK
- Venue
  - At the premises of the respective railway company
- Time
  - 1 day
- Date
  - To be defined between training team and railway companies

**4. Specific Training Workshops:**

**a. Specific WS 1**

- Target Groups
  - Technical Specialists of IMs
- Content

- Specific questions of respective railways
  - In depth training of specialists
  - Demonstration and use of model and tool chosen by INNOTRACK
  - Venue
    - At the premises of the respective railway company
  - Time
    - 2 days
  - Date
    - To be defined between training team and railway companies
- E-learning

#### **b. Specific WS 2**

- Target Groups
  - All INNOTRACK members
- Content
  - Demonstration and use of model and tool chosen by INNOTRACK via presentation
  - Open forum for discussion
- Venue
  - At the premises of the respective railway company
- Time
  - 1 – 2 hours
- Date
  - To be defined between training team and railway companies

As far as concerning the responses from the questionnaire up to now there are no needs for technical training with the exception of Logistics. Mainly all IMs agree training in Life Cycle Cost Assessment and at times Logistics is necessary. On the basis of the current responses a technical training is not possible. But the assessment of technical training needs is not finished yet, so if a technical training is required it will be implemented in WP7.2 'Identification of needs and specifications for coherent training programmes'.

## **3.2 Current practices for training/education of track staff & needs**

### **3.2.1 Questionnaire**

To identify the training necessities and the already existing knowledge, a questionnaire has been prepared. LCC and RAMS is well known as result of SP6, but the requirements of SP2 – 5 are open. The questionnaire is prepared and is to be discussed with SP leaders. The revised questionnaire has to be sent out to the IMs.

Important to know is level of practical experience, is the training already be offered internal or external of the company, is there a training program and is there need for more training. The weighting of the answers have to be done to derive the importance of activities.

Skill area / Competency	What is the level of practical experience? 1 - 5 (1=Low; 5=High) Other relevant details?	Is there currently a training program? (Yes / No) What is the frequency & duration?	Is there a need for more training? (Yes / No) Proposed frequency & duration?	Rate importance of additional training: 1 - 5 (1=Low; 5=High)
<b>SP2 – Support</b>				
Monitoring of track bed / support (track geometry, ballast profiles, etc)				
Maintenance of ballast				
<i>Other (specify):</i>				
<b>SP3 – Switches and crossings</b>				
Monitoring of switches & crossings (including Driving & Locking devices)				
Maintenance of switches & crossings				
<i>Other (specify):</i>				
<b>SP4 – Rails</b>				
Rail and joint degradation monitoring				
Welding and rail replacement				
Rail maintenance (incl. grinding)				
<i>Other (specify):</i>				
<b>SP5 – Logistics</b>				
Interface with contractors				
Advanced / State-of-the-Art installation and renewal techniques				
<i>Other (specify):</i>				
<b>For Infrastructure Managers:</b>				
LCC (Life-cycle-costing)				
RAMS				
Cost-benefit analysis				
<i>Other (specify):</i>				

**Figure 2 - Questionnaire**

Responses were received from the following Railways:

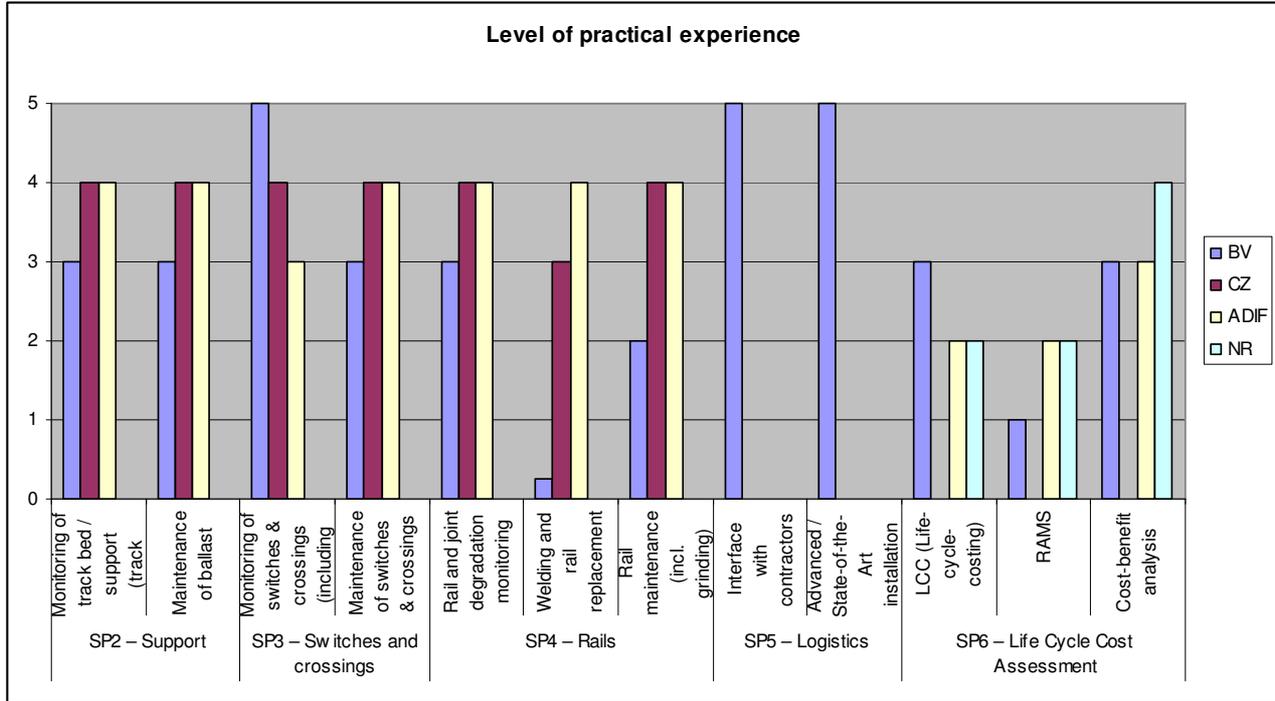
- Banverket
- Czech Railways
- ADIF
- Network Rail (Life Cycle Cost Assessment only)

The completed questionnaires are included in Annex A & 5.1 an evaluation follows.

It is possible that further completed questionnaires will be received from IMs. The results and analysis of further questionnaires will be incorporated into this report, which will be reissued as a new version. The evaluation is broken up into segments related to the questionnaire.

### 3.2.2 Analysis of questionnaires & conclusions

#### Current levels of practical experience & existing training programmes



**Figure 3 - Current levels of practical experience**

Current training programme - Frequency & Duration					
Skill area / Competency	BV	CZ	ADIF	Network Rail	
SP2 – Support					
Monitoring of track bed / support	✓ 1 time / 3 yr	✓	x*	Not regular basis	
Maintenance of ballast	✓ 1 time / 3 yr	✓		just conferences	
SP3 – Switches and Crossings					
Monitoring of switches & crossings	✓ Every 2nd year	✓	x		
Maintenance of switches & crossings	✓ Not regulated	✓	x*	Some in welding	
SP4 – Rails					
Rail and joint degradation monitoring		✓	✓	8 hr / yr	
Welding and rail replacement	✓/x	✓	✓	16 hr / yr	
Rail maintenance (incl. grinding)	x	✓	✓	16 hr / yr	
Ultrasonic testing			✓	40 hr / yr	
Stress measurement			✓	16 hr / yr	
SP5 – Logistics					
Interface with contractors	✓ 1 time / 1 yr				
Advanced installation and renewal	✓				
SP6 - Life Cycle Cost Assessment					
LCC (Life-cycle-costing)	x		x*	Not reg, just conf	✓* Frequency matches demand
RAMS	x		x*	Not reg, just conf	✓* Frequency matches demand
Cost-benefit analysis	✓/x On request		x*	Not reg, just conf	✓* 2 days per every few months

**Figure 4 - Current training programmes – frequency and duration**

\*For Network Rail, training is provided in support of the Yellow Book, directed at preparing safety cases for projects; RAMS and LCC are a component of the training, but not the main theme.

Looking at the graph above, the level of practical experience is relatively high in each of the surveyed IMs for all the track component areas (Support, Switches & Crossings, Rails) but low for logistics. This indicates that the classic track components are generally well understood whereas the more complex but less well-defined area of logistics lacks knowledge (with the exception of BV which has evidently improved knowledge in this area).

This fact is reflected in the table of current training programmes, which shows existing training programmes of low-medium (but often unspecified) frequency and duration for track component areas (SP2 - 4) but a lack of training in Logistics (with the exception of BV which also recorded a high level of knowledge).

In terms of training priorities, BV generally gives training precedence to Support, Switches & Crossings and Logistics and less to Rail; conversely ADIF gives more training to Rail and less to other areas; CZ provides similar levels of training to all areas, except Logistics and Life cycle cost assessment.

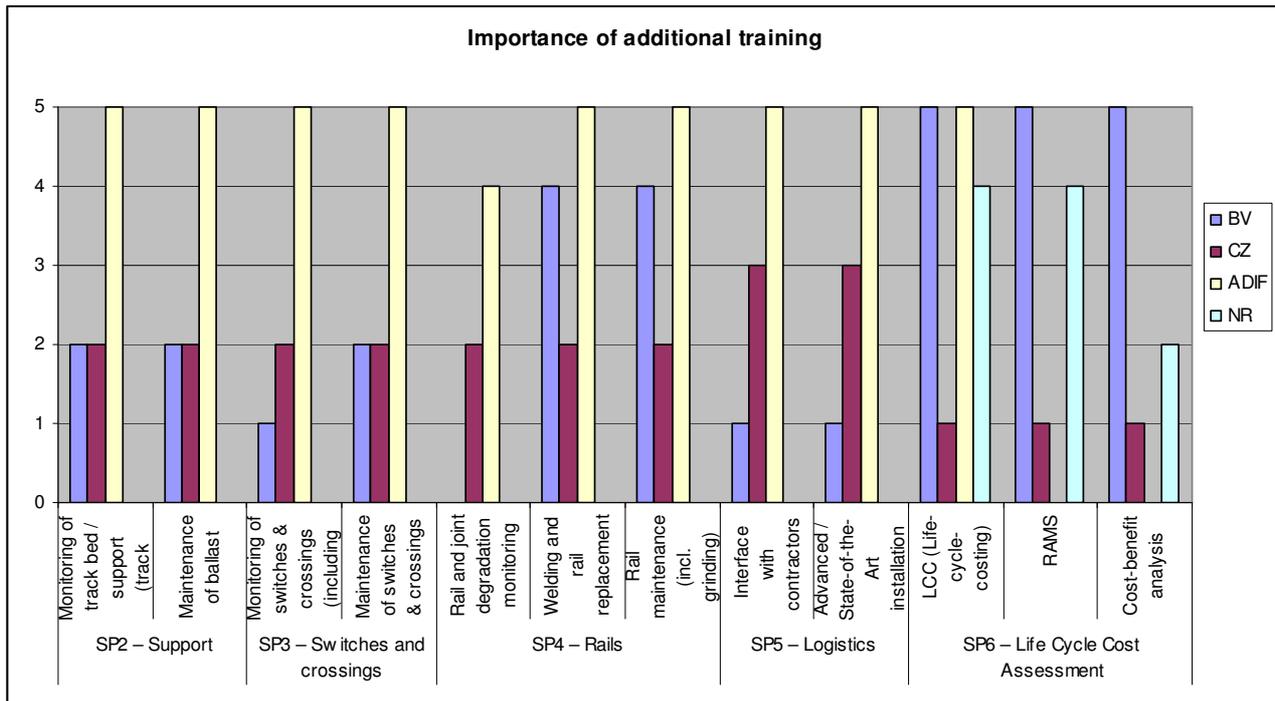
Life cycle cost assessment records a low-medium level of practical experience (with the exception of CZ where information wasn't available) with similar counts in each area for each recorded IM. Current training programmes either don't exist or are scheduled on request or when conferences take place. Knowledge and training in this area is clearly at a lower level than for (technical) track component areas.

In the case of Network Rail, training is provided in the support of the Yellow Book (it used to be given solely by Praxis, but other organisations now have the competence and approval to provide the training). The Yellow Book is directed at preparing safety cases for projects – RAMS and LCC are a component of the training, but not the main theme). The frequency is generally matched to demand e.g. a lot of training was provided during the West Coast Modernisation. Training on safety related cost benefit analysis features prominently in Network rail's risk assessment training. This is a course given regularly (every few months) with a duration 2 days. There isn't any formal training on more general cost benefit analysis. However, the approach is well embedded in a number of processes e.g. investment submissions, standard setting, etc.

**Needs for further training and level of importance**

Need for more training - Frequency & Duration				
Skill area / Competency	BV	CZ	ADIF	
<b>SP2 – Support</b>				
Monitoring of track bed / support	N Current regs	N	Y Every 4 years	
Maintenance of ballast	N Current regs	N	Y Every 2 years	
<b>SP3 – Switches and Crossings</b>				
Monitoring of switches & crossings	N	N	Y Monthly / 2-5 days	
Maintenance of switches & crossings	Y* May be need	N	Y Monthly / 2-5 days	
<b>SP4 – Rails</b>				
Rail and joint degradation monitoring	Y	N	Y	
Welding and rail replacement	Y	N	Y New procedures	
Rail maintenance (incl. grinding)	Y	N	Y New system	
Ultrasonic testing			Y If necessary	
Stress measurement			Y New methods	
<b>SP5 – Logistics</b>				
Interface with contractors	N Current regs	Y		
Advanced installation and renewal	N Current regs	Y		
<b>SP6 - Life Cycle Cost Assessment</b>				
LCC (Life-cycle-costing)	Y		Y	Network Rail Y Few days / 6 months
RAMS	Y		Y	Y Few days / 6 months
Cost-benefit analysis	Y		Y	N Current training adequate

**Figure 5 - Needs for further training – frequency and duration**



**Figure 6 - Needs for further training and level of importance**

The table above shows a somewhat mixed impression for the need for further training in the different areas. While the need for further training in track component areas (Support, Switches & Crossings, Rails) is varied but generally low (except perhaps in the case of ADIF who deems training in these ‘core’ areas necessary), all IMs agree training in Life Cycle Cost Assessment and (at times) Logistics is necessary. The trend follows from the previous section of existing training programmes for which IMs have indicated existing knowledge and training is more or less adequate in track component areas (SP2 – SP4) but falls short in Logistics and Life Cycle Cost Assessment.

In detail, BV indicates further training is not necessary in Support and Logistics (where current regulations confirm) and in Switches & Crossings except for Maintenance where there might be a need (for welding there is a clear programme for other maintenance). Further training in Rails and Life Cycle Cost Assessment is considered necessary. Czech Railways considers existing knowledge & training in component areas SP2 – SP4 as adequate with no further training required but sees further training in Logistics as necessary. ADIF considers further training in all areas necessary (except for Logistics where no comments were made on current knowledge and further training needs) even though current training programmes in Rails are already established. Occasional training (once every 2 – 4 years) is preferred for Support while more rigorous training for Switches & Crossings is deemed necessary. Training in Rails warrants training only where new products/methods are employed.

Network Rail, who only commented on Life Cycle Cost Assessment, considers further training in LCC & RAMS as necessary but Cost-benefit analysis adequate. As follows from the previous section on current knowledge/training, all IMs surveyed consider Life Cycle Cost Assessment an area where knowledge is scarce and in need of training. As a result, the Life Cycle Cost Assessment area is given special attention in the training platform for the project.

In terms of the importance of further training, the results are varied with all IMs giving differing degrees of importance on track component areas – ADIF’s level is constantly high whereas BV & CZ’s count is medium-low. IMs give training in Life Cycle Cost Analysis elevated importance, which follows from previous results (except for Czech Railways which gives the area lower importance). The specific area of LCC rates as the highest in overall importance of further training.

### 3.3 Software Tool D-LCC

As Figure 1 shows, training activities have to be planned and developed. In this course a Training Workshop LCC was taken place 26-27 February 2008 at UIC offices in Paris.

The basic training was on the basis for LCC, how it can be used in INNOTRACK and on the tool that is used in SP6. As a result of the benchmark and evaluation of existing LCC tools in WP6.2 D-LCC is the most suitable tool for INNOTRACK purposes. Therefore D-LCC was the tool used in training and a the test cases of LCC analysis were practised in the training by using the software D-LCC.

The process of purchasing the software is coming to the end. The negotiation of contract regarding D-LCC as common LCC tool for this project is finished and the contract is already closed. The contract based on the quotation of ALD contains following points:

- the costs for D-LCC licenses and improvements are 50.000 €. Max. 10 single licenses for companies contracted by UIC.
- additional licenses cost is 5.700 € per license.
- the name of contracted company to use D-LCC must be forwarded to ALD.
- furthermore one day software training to be conducted (in Paris).

The contract will be signed between INNOTRACK and ALD. The UIC will take the license for all INNOTRACK partners. The following partners will buy a license for D-LCC:

1. ADIF,
2. BV,
3. DB,
4. NR,
5. UIC,
6. Corus and
7. Voest Alpine Schiene

The following partners are interested to use the program:

1. Alstom,
2. CD and
3. University of Birmingham

They have to decide as soon as possible to buy a license.

Nicole Kumpfmüller will contact Alstom and CD and John Amooore will contact Clive Roberts from University of Birmingham.

The following partners will not buy a license:

1. ÖBB and
2. ProRail

ProRail has already a management system including LCC, but supports the project by data.

ALD as the producer of the software D-LCC is going to implement the agreed list of improvements and to optimize the tool for INNOTRACK purposes. After the optimization of the software there will be necessary to conduct a second specific software training because of the revision part.

## 4. Conclusions

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The training platform of WP7.2 is planned partly as E-learning (web-based) and as personnel training at UIC Paris.

DB is very skilled in the fundamental LCC training, which is also being done as internal training at DB. DB also offered another form of this training external for other railway industries. As part of result of SP6, DB is the only one partner with a specific LCC training.

The working package focused, as agreed, on LCC.

All sub projects should be covered by the dissemination activities. The identification of the needs and specifications for coherent training programmes ensure a complete training programme that addresses current and future needs in all the key areas of track infrastructure, those areas covered by INNOTRACK. It is important to focus the efforts of the training platform in current known deficient areas. The evaluation drawn from a questionnaire shows the level of current knowledge and training practises and the future training needs with the level of importance of the different areas.

The classic track components are generally well understood whereas the more complex but less well-defined area of logistics lacks knowledge. Thus the level of practical experience is relatively high in each of the surveyed IMs for all the track component areas (Support, Switches & Crossings, Rails) but low for logistics.

This fact is reflected in the evaluation of current training programmes, which shows existing training programmes of low-medium (but often unspecified) frequency and duration for track component areas (SP2 - 4) but a lack of training in Logistics (with the exception of BV which also recorded a high level of knowledge).

While the need for further training in track component areas (Support, Switches & Crossings, Rails) is varied but generally low, all IMs agree training in Life Cycle Cost Assessment and Logistics is necessary. Life cycle cost assessment records a low-medium level of practical experience and so current training programmes either don't exist. In terms of the importance of further training, the results are varied with all IMs giving differing degrees of importance on track component areas. The specific area of LCC rates as the highest in overall importance of further training.

In terms of the assessment of technical training needs the Life Cycle Cost Assessment area is given special attention in the training platform for the project.

As mentioned in the previous section one training activity was the LCC training workshop on 26-27 February 2008 in Paris. The content of the basic training contained in the LCC methodology and exercises of test cases regarding LCC analysis with the software D-LCC. In connection with this action a specific software training will be taken place due to the closed contract between ALD and INNOTRACK. The date for the software training is fixed on 17<sup>th</sup> September 2008 in Paris and will be conducted by ALD.

Up to now there are no technical training needs with the exception of Logistics. On the basis of the current responses from the questionnaire a technical training is not possible. But the assessment of technical training needs is not completed yet, because it is possible that further completed questionnaires will be received from IMs. So if a technical training is required it will be implemented in WP7.2 'Identification of needs and specifications for coherent training programmes'.

Important to know is a potential cooperation with the Rail Training Centres Europe-wide. Information of different training centres (they have regular meetings) can probably help with input on the questionnaires. This point should be followed up strongly and integrated in the training platform for the project.

## 5. Annexes

### 5.1 Annex 1 – Completed questionnaires on current practices for training/education and the need for further training

#### Banverket

Skill area / Competency	What is the level of practical experience? 1 - 5 (1=Low; 5=High) Other relevant details?	Is there currently a training program? (Yes / No) What is the frequency & duration?	Is there a need for more training? (Yes / No) Proposed frequency & duration?	Rate importance of additional training: 1 - 5 (1=Low; 5=High)
<i>SP2 – Support</i>				
Monitoring of track bed / support (track geometry, ballast profiles, etc)	Varying from no experience to very high	Yes / 3 years	No (according to current regulations)	2
Maintenance of ballast	Varying from no experience to very high	Yes / 3 years	No (according to current regulations)	2
<i>Other (specify):</i>	There is a need for more condition monitoring besides safety inspections (which is what we have today), as for example track stiffness, gpr etc (which is part of SP2)			
<i>SP3 – Switches and crossings</i>				
Monitoring of switches & crossings (including Driving & Locking devices)	5	Yes (Tested every 2 <sup>nd</sup> year)	No	1
Maintenance of switches & crossings	3	Yes (Not regulated)	Might be a need For welding there is a clear programme for other maintenance this topic can be discussed	2 To achieve better maintenance the mangament is more important than the skill of track staff, which we believe is sufficient in most cases
<i>SP4 – Rails</i>				
Rail and joint degradation monitoring	3	no	yes	3-4
Welding and rail replacement	1/4	Yes/no	yes	4
Rail maintenance (incl. grinding)	2	no	yes	4

## Czech Railways

Skill area / Competency	What is the level of practical experience? 1 - 5 (1=Low; 5=High) Other relevant details?	Is there currently a training program? (Yes / No) What is the frequency & duration?	Is there a need for more training? (Yes / No) Proposed frequency & duration?	Rate importance of additional training: 1 - 5 (1=Low; 5=High)
<i>SP2 – Support</i>				
Monitoring of track bed / support (track geometry, ballast profiles, etc)	4	yes	No	2
Maintenance of ballast	4	Yes	No	2
<i>SP3 – Switches and crossings</i>				
Monitoring of switches & crossings (including Driving & Locking devices)	4	Yes	No	2
Maintenance of switches & crossings	4	Yes	No	2
<i>SP4 – Rails</i>				
Rail and joint degradation monitoring	4	Yes	No	2
Welding and rail replacement	3	Yes	No	2
Rail maintenance (incl. grinding)	4	Yes	No	2
<i>SP5 – Logistics</i>				
Interface with contractors	N/A	N/A	Yes	3
Advanced / State-of-the-Art installation and renewal techniques	N/A	N/A	Yes	3
<b>For Infrastructure Managers:</b>				
LCC (Life-cycle-costing)	N/A	N/A	No	1
RAMS	N/A	N/A	No	1

## ADIF

Skill area / Competency	What is the level of practical experience? 1 - 5 (1=Low; 5=High) Other relevant details?	Is there currently a training program? (Yes / No) What is the frequency & duration?	Is there a need for more training? (Yes / No) Proposed frequency & duration?	Rate importance of additional training: 1 - 5 (1=Low; 5=High)
<i>SP2 – Support</i>				
Monitoring of track bed / support (track geometry, ballast profiles, etc)	4	Not on a regular basis, just conferences	Yes, every four years	5
Maintenance of ballast	4		Yes, every two years	5
<i>SP3 – Switches and crossings</i>				
Monitoring of switches & crossings (including Driving & Locking devices)	3	No	Yes Monthly / 2 to 5 days	5
Maintenance of switches & crossings	4	No (However, basic knowledge dealing with switches & crossings is included in welding courses)	Yes Monthly / 2 to 5 days	5
<i>SP4 – Rails</i>				
Rail and joint degradation monitoring	4	Yes, 8 Hours per Year		4
Welding and rail replacement	4	Yes, 16 Hours per Year	Yes, because of new existing procedures	5
Rail maintenance (incl. grinding)	4	Yes, 16 Hours per Year	Yes, because of the use of a new system	5
<i>Other (specify):</i>				
Ultrasonic Inspection	4	Yes, 40 Hours per Year	Yes, If it were necessary	5
Stress Measurement	3	Yes, 16 Hours per Year	Yes, because of introduction of new methods	5
<i>SP5 – Logistics</i>				
Interface with contractors				
Advanced / State-of-the-Art installation and renewal techniques				
<b>For Infrastructure Managers:</b>				

## Network Rail

Skill area / Competency	What is the level of practical experience? 1 - 5 (1=Low; 5=High) Other relevant details?	Is there currently a training program? (Yes / No) What is the frequency & duration?	Is there a need for more training? (Yes / No) Proposed frequency & duration?	Rate importance of additional training: 1 - 5 (1=Low; 5=High)
<b>For Infrastructure Managers:</b>				
LCC (Life-cycle-costing)	2	Training is provided in support of the Yellow Book (it used to be given solely by Praxis, but other organisations now have the competence and approval to provide the training). The Yellow Book is directed at preparing safety cases for projects – RAMS and LCC are a component of the training, but not the main theme). The frequency is generally matched to demand e.g. a lot of training was being provide during West Coast Modernisation.	There is a case for providing more training in the areas of LCC and RAMS.  The lack of training is a key contributor to the lack of deployment of the methods.  The training should be targeted at practitioners or potential practitioners at various levels c.f. six sigma training. An appreciation of the methods is also required by asset management policy and strategy decision makers.  A course of a few days at six monthly intervals would probably suffice.	4
RAMS	2	As above (LCC)	As above (LCC)	4
Cost-benefit analysis	4	Training on safety related cost benefit analysis features prominently in Network rail's risk assessment training. This	Current level of training is probably adequate.	2

## 5.2 Annex 2 - Material of Training Workshop LCC taken place 26-27 February 2008 at UIC offices in Paris



### Life Cycle Costing

Training Workshop at UIC Headquarter 26. – 27. Feb. 2008

ADIF, Banverket, Deutsche Bahn AG, ProRail  
 UNIFE, UIC



INNTRACK LCC TRAINING  
 Nicole Kumpfmüller (DB), Ulla Essling (Banverket)  
 Paris, 26. – 27.02.2008




### LCC - Cost Matrix

From IEC 60600-3-3 the shown cost matrix is known.  
 Basis: means of production.

Technical structure

Cost categories

Cost category: material costs

Life Cycle Phases

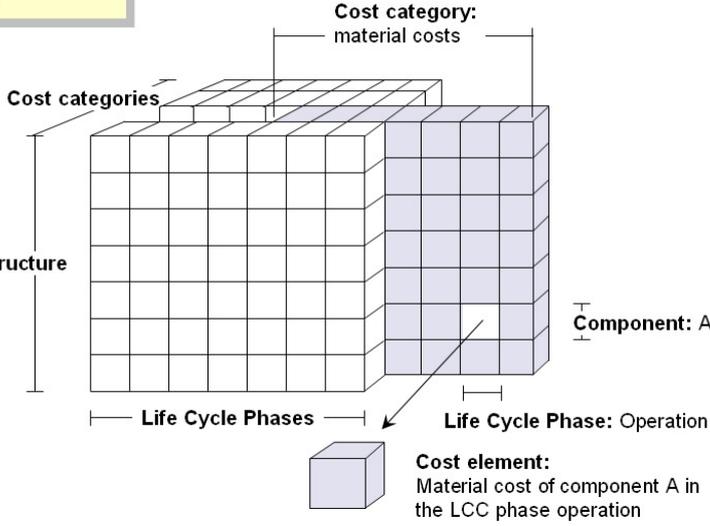
Life Cycle Phase: Operation

Component: A

Cost element: Material cost of component A in the LCC phase operation

This view separates the life cycle phases and the categories in two dimensions

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### What means LCC?

**LCC** (Life Cycle Costing) means

- collection,
- systematical analyzing and
- goal oriented reporting

of **all product related costs** from the first phase to the last one of its life span - development to disposal of a product

### Objective of the training workshop?

- Why LCC
- Method LCC-A within Innotrack (basics, theory)
- Actual state of SP6 (discussions ongoing SP and industry)
- Software benchmark result SP6.2: using the software D-LCC

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### Program 1. day (26.02.2008)

- 10:00 Welcome at UIC headquarter (UIC)
- 10:15 Introduction, objective and content
- 10:30 LCC Innotrack basics
- 12:00 Software D-LCC (introduction) 
- 13:00 Lunch 
- 14:00 Exercise (E1) – group training
- 15.30 Result presentation/ discussion 
- 16:00 End of first day 

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### Program 2. day (27.02.2008)

- 09:00 Start  
Summary and recapitulation of 1. day
- 09:15 D-LCC step-by-step  
» Result presentation/ discussion
-  • 12:30 Lunch
- 13:30 Exercise (E2) – group work
- 14:30 Result presentation/ discussion
- 14:45 Feedback/ Discussion
-  • 15:00 End training workshop

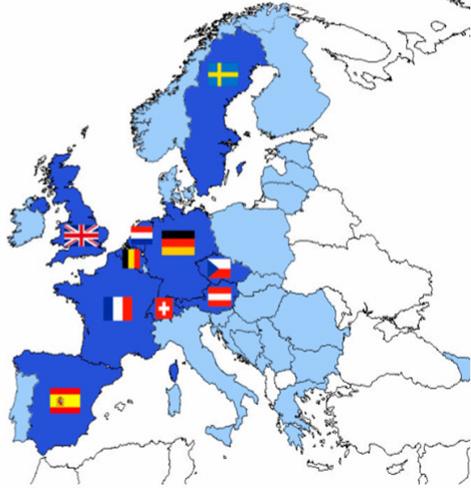


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### EU Project Inntrack with the task of 30% reduction of LCC

- **First European project with comprehensive cooperation between Infrastructure Managers and Industry regarding the complete track construction**
- **Most innovative project to deliver new products, processes and methodologies in order to achieve the ERRAC objectives**
- **Significant LCC reductions and RAMS improvements in order to strengthen the competitiveness of railway sector in a persistent manner**
- **Reduction of time to market of innovative solutions European wide (market driven interoperability)**



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### Tasks for IM now and in the future

ERRAC: traffic increases about 30%

- 50 – 60% of mtn. costs are track related
- a dominating part of track disturbance is related to track
- more money for maintenance is not possible → rather a reduction
- new demands:
  - higher speeds
  - higher axle loads
  - better availability
  - reduced traffic disturbance
- How much money is needed to maintain the infrastructure assets without long-term loss of value?
- How and where to spend this money with maximum benefit?

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### Innovation - the translation of research and development into added value, reduced LCC and improved RAMS

**PRODUCTS**

- new rail steel materials
- optimised track components (sleepers, resilient elements etc.)
- innovative switch designs
- improved driving and locking devices (DLDs)
- new subgrade treatments
- new rail steel materials
- new cost effective track forms

**PROCESSES**

- logistics processes (construction, inspection, maintenance)
  - sensor technologies & signal processing
  - soil improvement methods
  - innovative grinding methods
- improved welding techniques
  - preventive and planned maintenance
  - inspection techniques

**INNOVATION**

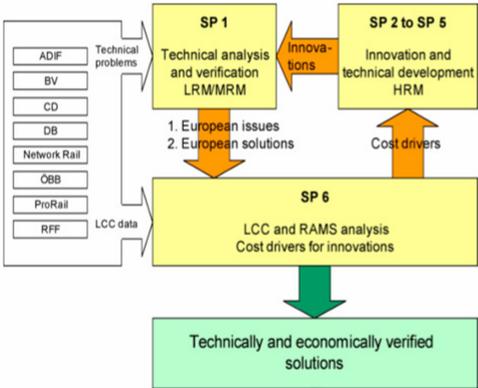
**METHODOLOGIES**

- classification methods for track and vehicle characteristics
- defining duty conditions from vehicle track interaction
- assessment of technical and economical problems
- Europe-wide accepted LCC and RAMS evaluations

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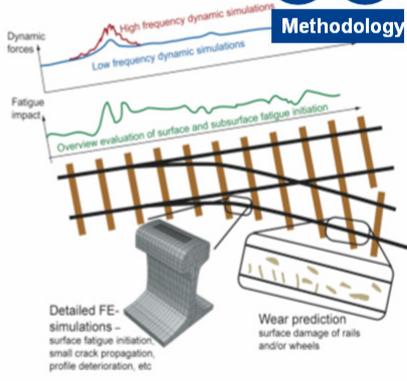
### Combination practical approval, simulation, RAMS(S) and LCC for the technical and economical optimal solution



SP 1

SP 6

**Methodology**



utilize developed models to optimize components

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Titel durch Klicken hinzufügen

- **Basics of LCC**
  - **Innotrack WP 6.1**
  - **Theory**
  - **LICB**
  - **Innotrack WP 6.2**

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**What means LCC?**

**LCC** (Life Cycle Costing) means

- collection,
- systematical analyzing and
- goal oriented reporting

of **all product related costs** from the first phase to the last one of its life span - development to disposal of a product

Even if the abbreviation „LCC“ suggests a consideration of only costs, both costs and revenues could be taken into account. Hence LCC is a complete variant of cost effective analysis.

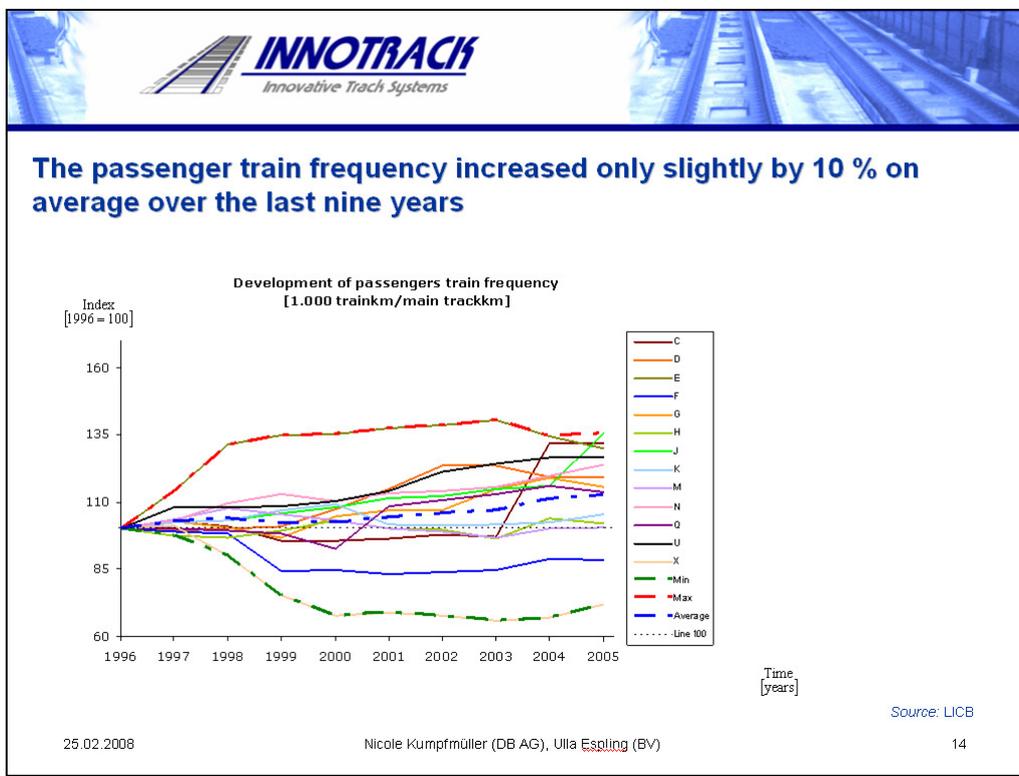
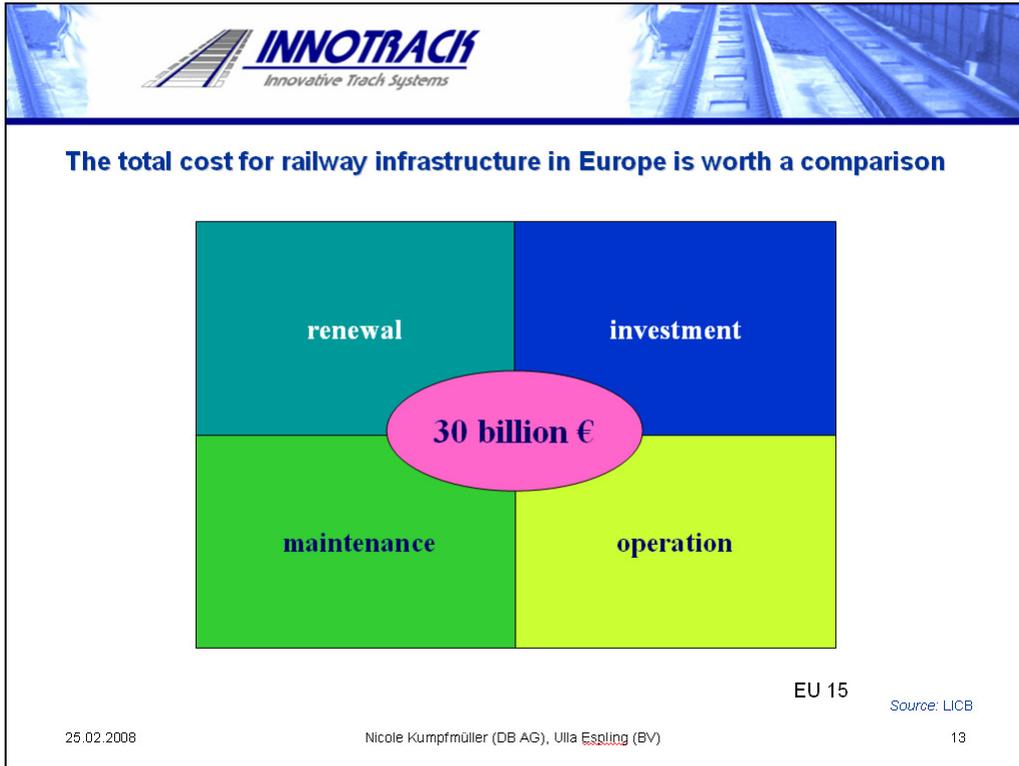
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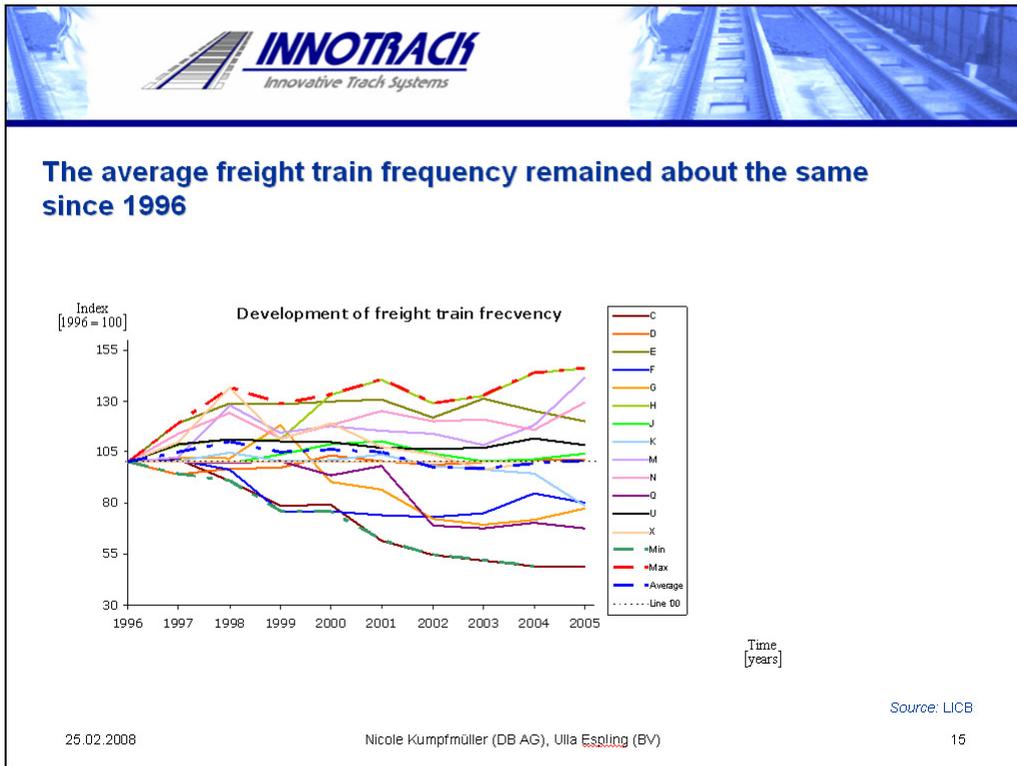


**Why LCC?**

- Best price-performance ratio
- supporting method for professional decision making
- decisions now have effects over centuries in railway sectors
- LCC software (D-LCC) helps in consideration between variants respecting the whole life cycle

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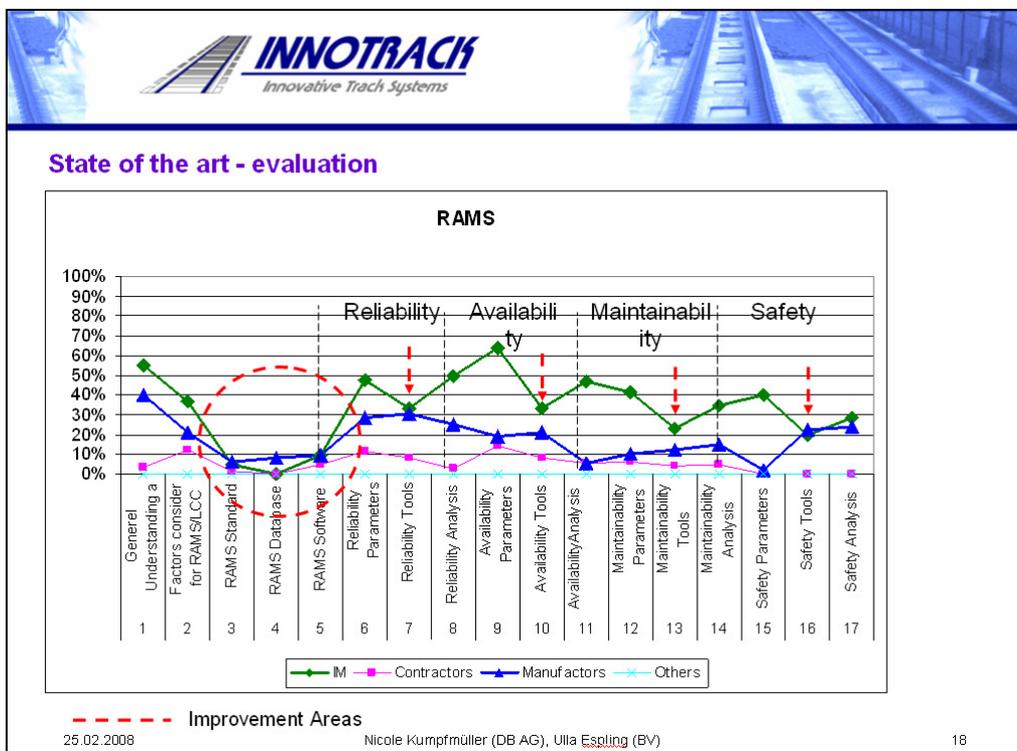
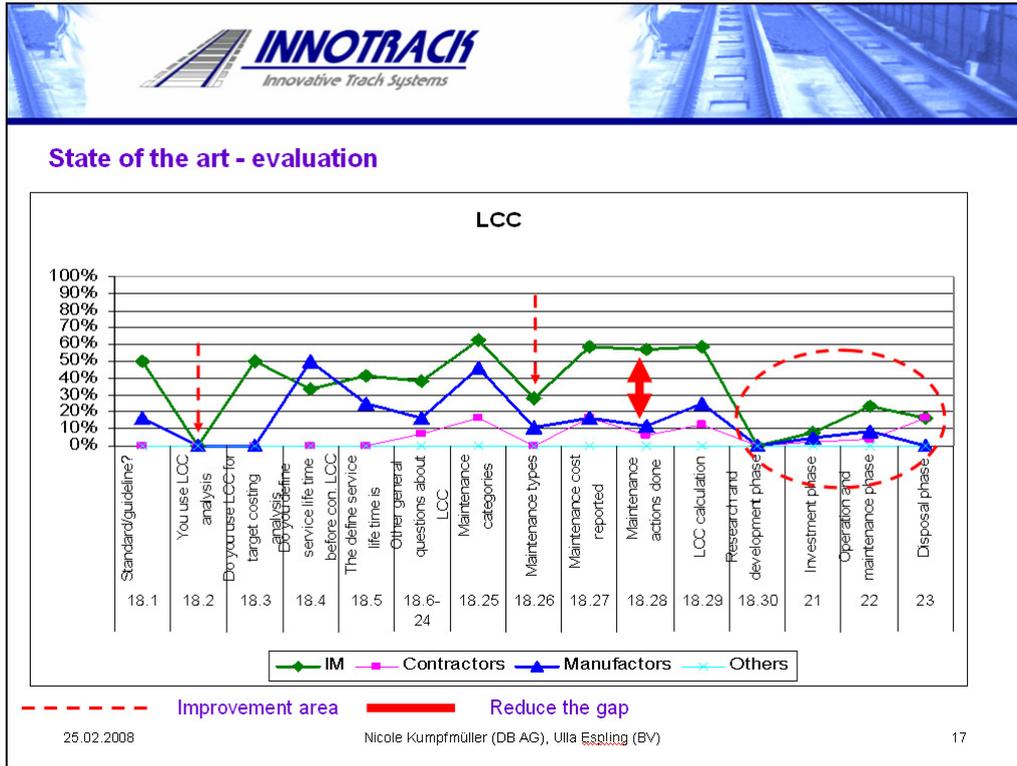




**State of the art: general understanding (D6.1)**

- Regularity of use of RAMS and LCC is low
- Tools and models are mostly self-developed
- Most considered factors
  - Traffic Volume
  - Average axle load
  - Type of superstructure (track, sub grade, sleeper, rail)
  - Maintenance strategy/policy

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### State of the art - evaluation

Factors considered for			
RAMS/LCC analysis	by	Reliability	by
Traffic volume	73%	N.r of failures/month or year	82%
Type of rail	73%	MTBF	73%
Type of maintenance strategy/polic	73%	Failure rate ( $\lambda$ )	64%
Type of track	64%	MTTF	45%
Type of sleeper	64%	MDBF D=Distance	36%
Type of traffic	45%		
Axle load	45%		
Type of sub grade	45%		
		Maintainability	by
		MTTR	82%
		MTTM	36%
		N.r of maint. Shortcoming/m	36%
		MTBM	27%
		MDT D=Down	27%
		MTTRec (recover)	27%
		Availability	by
		Total train delay	64%
		Train delay caused by infrastructure	64%
		Technical availability	55%
		Operational availability	55%
		Inherent availability	45%
		Train delay (hours)	45%
		Train delay caused by specified infrastructure asset	45%

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### RAMS standards

- Not many standards in use
- EN 50126 is the most used railway standard

R	A	M	S
<b>EN 50126</b>	<b>EN 50126</b>	<b>EN 50126</b>	<b>EN 50126</b>
IEC 61160	IEC 60300-3-1	IEC 61160	IEC 61160
IEC 60300-3-1	IEC 60863	IEC 60300-3-1	IEC 60300-3-1
<b>IEC 60812</b>	IEC 61165	IEC 60706	<b>IEC 61025</b>
IEC 60863	IEC 61070	IEC 60863	IEC 61508
<b>IEC 61025</b>		MIL STD 471A	MIL STD 1629
<b>IEC 61078</b>		MIL STD 2173	<b>IEC 812</b>
IEC 61709			
IEC 60605			
IEC 61014			
IEC 61123			
IEC 60319			
IEC 60571			
MIL STD 785B			
MIL STD 756			
MIL STD 1629			
<b>IEC 812</b>			

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**Summary LCC knowledge (state of the art)**

- Less than 40 % of those who answered have a LCC standard/ guideline
- LCC is performed in order to evaluate investment alternative
- Discounting rate and inflation are considered by most. They are usually constant over the life cycle period
- Down time and disruption costs are considered by few
- Few consider penalty cost
- LCC calculations are mostly considered in investment, O&M and disposal phase

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**Problems**

- Insufficient data collected
- No adequate involvement of IMs as well as suppliers
- Unawareness of different RAMS and LCC terms. Not common understanding of different terms
- Not common definitions concerning investment, operation and renewal
- Time keeping
- Inadequate answers

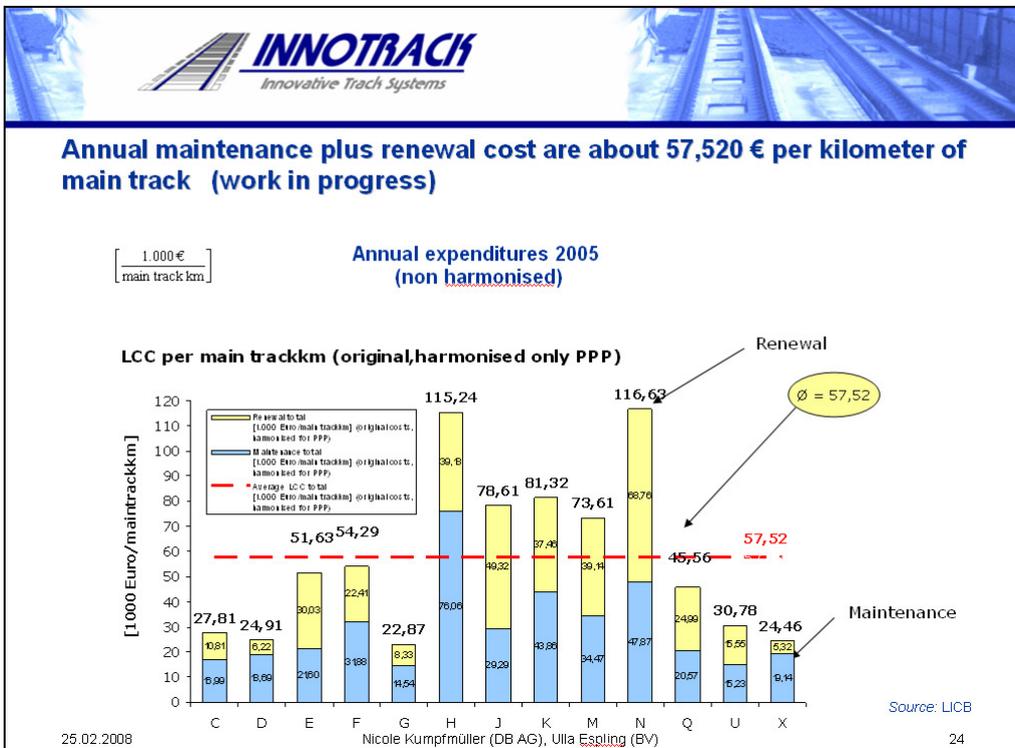
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**Titel durch Klicken hinzufügen**

- Existing project results (LICB)**

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## Factors influencing expenditure

1. Asset Quality : annual expenditure as % of replacement value
2. Maintenance /Renewal decisions ( see following slide)
3. Quality indicators (e.g.)
  - Rail Breakages
  - Train Delays
4. Inspection Frequency (and % staff involved )
5. Monitoring / « Asset-based » decision information
6. Wear limitation/ acceptable tolerances
7. Vehicle /Infrastructure interaction
8. Contracting (in-house or out-sourcing)
9. Standards – UIC, EN , TSIs
10. Operational hindrance issues

Source: LICB

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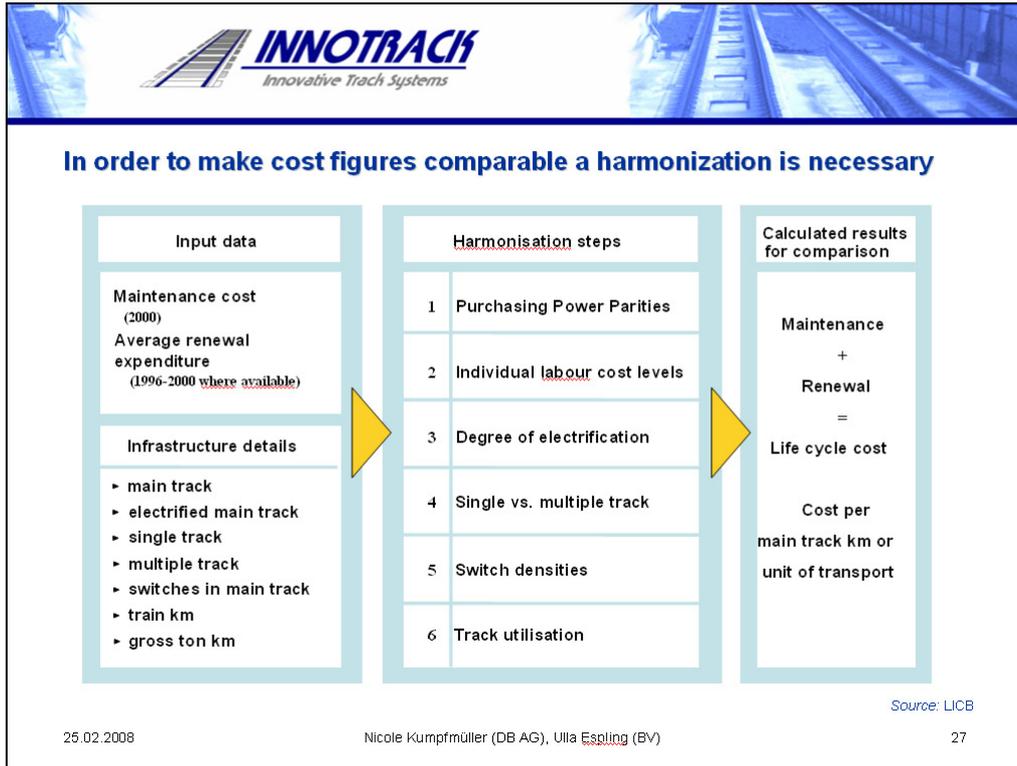


## Other General Observations on benchmarking and consequent policy (1)

- It is important to clearly understand the specific characteristics of the network ( asset age, frequency and mix of traffic, quality objectives)
- Planning based on optimising life cycle costs should ensure the most stable expenditure flow and performance of the network
- Under-expenditure in previous years leads to increased expenditure in both maintenance and renewals in following years (generally maintenance expenditure become less productive in such situations but is necessary simply to maintain standards within tolerable limits)
- The appropriate level of annual expenditure need to be set having regard to the quality aspiration for the future and the real value of retained assets.
- The ability to maintain infrastructure quality is directly related to initial quality at installation

Source: LICB

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**Titel durch Klicken hinzufügen**

- **Software benchmark SP6.2**

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### Benchmark of LCC tools

✓ **Analysis of available LCC tools\***

Relex-Lcc

LCC-ware

**D-LCC**

**CATLOC**

UNIFE-UNILIFE

↓

→ **Analysis/ description of main features of each tool**  
(User's manuals, Evaluation/demo licences, tutorials, Web seminars, email...)

\* only software that could be used within Innotrack (not company specific)

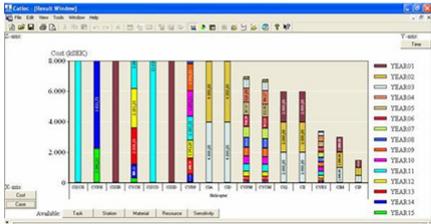
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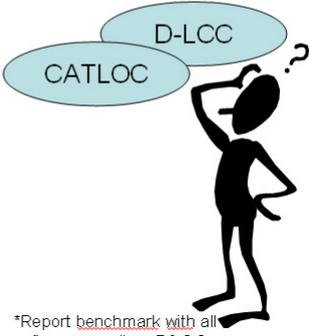


### Benchmark of LCC tools

✓ **Evaluation and testing of D-LCC and CATLOC\***

- a. Definition of the **most relevant factors** to test / model
- b. **Weighting** of the factors
- c. **Scoring** of tools





\*Report benchmark with all software suppliers D6.2.2

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### a. Definition of relevant evaluation factors

- ✓ Input (from excel/database) –“Importability”
- ✓ Failure detection (import, input, calculation)
- ✓ Alternatives (within and comparisons)
- ✓ Multiple projects (copy/paste/comparison)
- ✓ Distribution functions over time
- ✓ Output (to excel/database)- “exportability”
- ✓ Export of Results to excel (post-process)
- ✓ Sensitivity analysis over time period
- ✓ User-friendliness
- ✓ Capability of introducing improvements / support
- ✓ Licence and support Cost

- Variables (to be able to import from Innotrack database)
- Formulas
- PBS
- CBS
- Distribution functions

- Cost aggregation
- Breakdown possibility
- Results allocated to periods
- Check of the input data

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### b. Weighting of the factors – weighting table (1)

	+	++	+++
<b>Input (from excel/database) –“Importability”</b>			
• Variables (all) → <u>Innotrack</u> database			✓
• Formulas	✓		
• PBS	✓		
• CBS	✓		
• <u>Distribution functions</u>			✓
<b>Failure detection (import, input, calculation)</b>	✓		
<b>Alternatives (within and comparisons)</b>		✓	
<b>Multiple projects (copy/paste/comparison)</b>		✓	
<b>Distribution functions over time</b>			✓

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### b. Weighting of the factors – weighting table (2)

	+	++	+++
<b>Output (to excel/database)- "exportability"</b>			
• Export of Results to excel (post-process)			✓✓ (most important)
• Cost aggregation	✓		
• Breakdown possibility	✓		
• Results allocated to periods		✓	
• Check of the input data			✓
<b>Sensitivity analysis over time period</b>			✓✓ (most important)
<b>User-friendliness</b>		✓	
<b>Capability of introducing improvements / support</b>			✓✓ (most important)
<b>Licence and support Cost</b>			✓✓

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### c. Scoring of tools

① – Poor

② – Good

③ – Very good

X

}

**SCORE**

weight

+ → ①

++ → ②

+++ → ③

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### c. Scoring of tools (1)

	D-LCC	CATLOC
<b>Input (from excel/database) –“Importability”</b>		
• Variables (all) → Inntrack database	2(*)	1
• Formulas	1	1
• PBS	3	2
• CBS	3	1
• <u>Distribution functions</u>	1(*)	1 (*)
<b>Failure detection (import, input, calculation)</b>	2	3
<b>Alternatives (within and comparisons)</b>	3	1
<b>Multiple projects (copy/paste/comparison)</b>	1	2
<b>Distribution functions over time</b>	2	2

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### c. Scoring of tools (2)

	D-LCC	CATLOC
<b>Output (to excel/database)- “exportability”</b>		
• Export of Results to excel (post-process)	3	1
• Cost aggregation	3	2
• Breakdown possibility	3	3
• Check of the input data	3	3
• Results allocated to periods	3	2
<b>Sensitivity analysis over time period</b>	2	2
<b>User-friendliness</b>	2	1
<b>Capability of introducing improvements / support</b>	...?	...?
<b>Licence and support Cost</b>	...?	...?

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**(6.2.4) Database – definition as input to SP1**

- ✓ Definition of relevant data and parameters requirements (to be delivered by SP1-5) as input to the LCC model to develop in WP6.5
  - **Key aspects of LCCA for railway track**, Track components features, Maintenance & renewal actions, prediction / degradation processes / life cycles
  - Technical boundary conditions, renewal definition, Maintenance strategies, Traffic categories, Track design categories, **discussion on the set of rules and links required between components**
  - **Data requirements (including format) as input from SP 1 to SP5**
  - **Unit Cost Database features as input from each partner in WP6.5** (for LCC calculation)

**ADIF → First draft in progress**

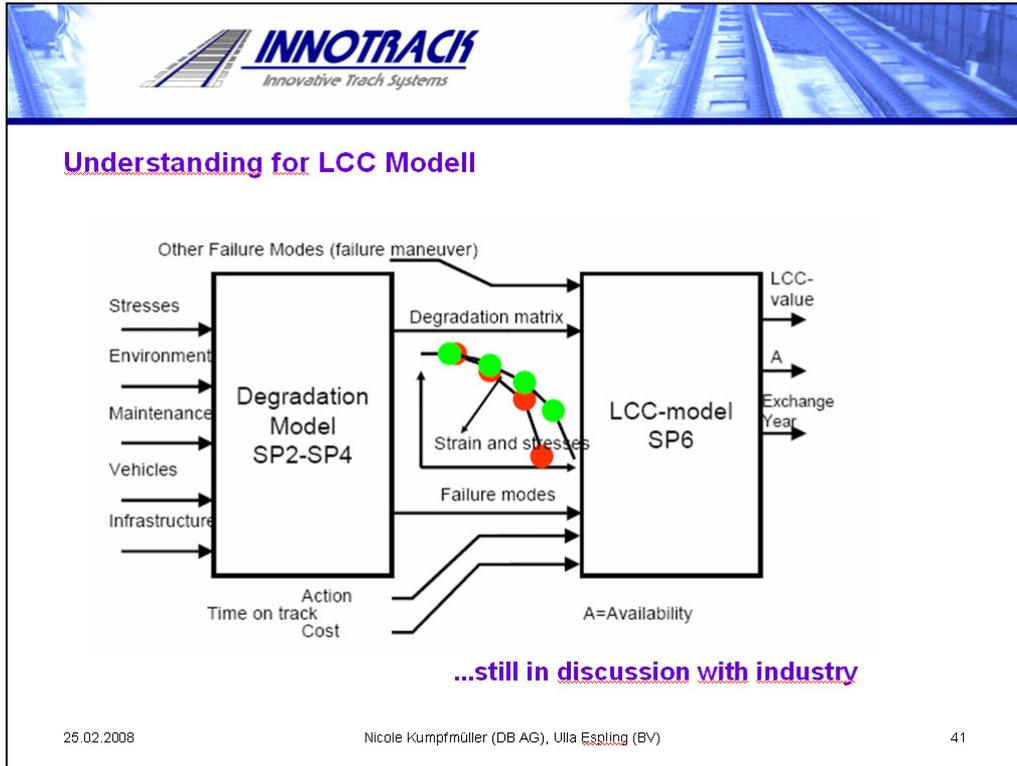
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**Titel durch Klicken hinzufügen**

- **LCC theory/ basics**

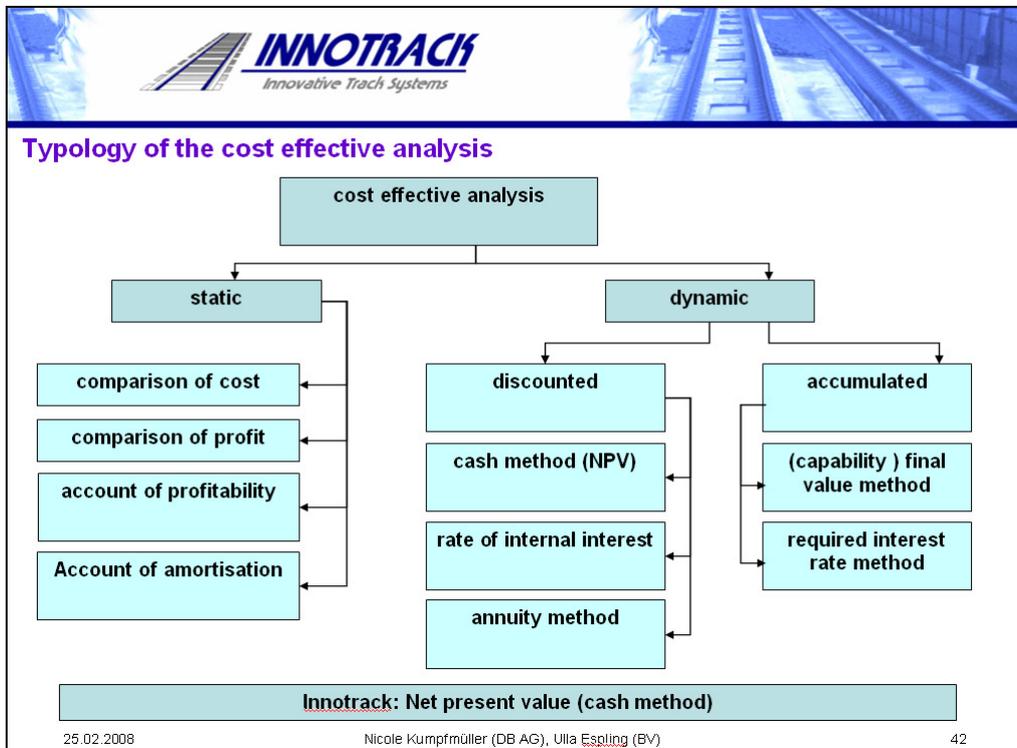
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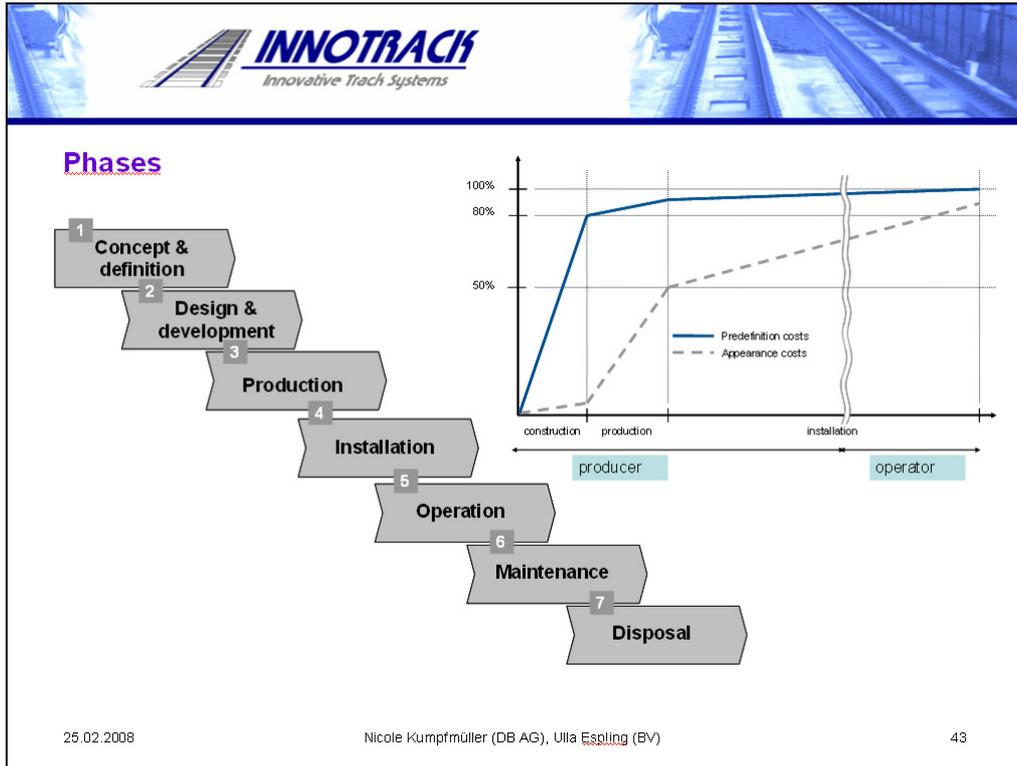
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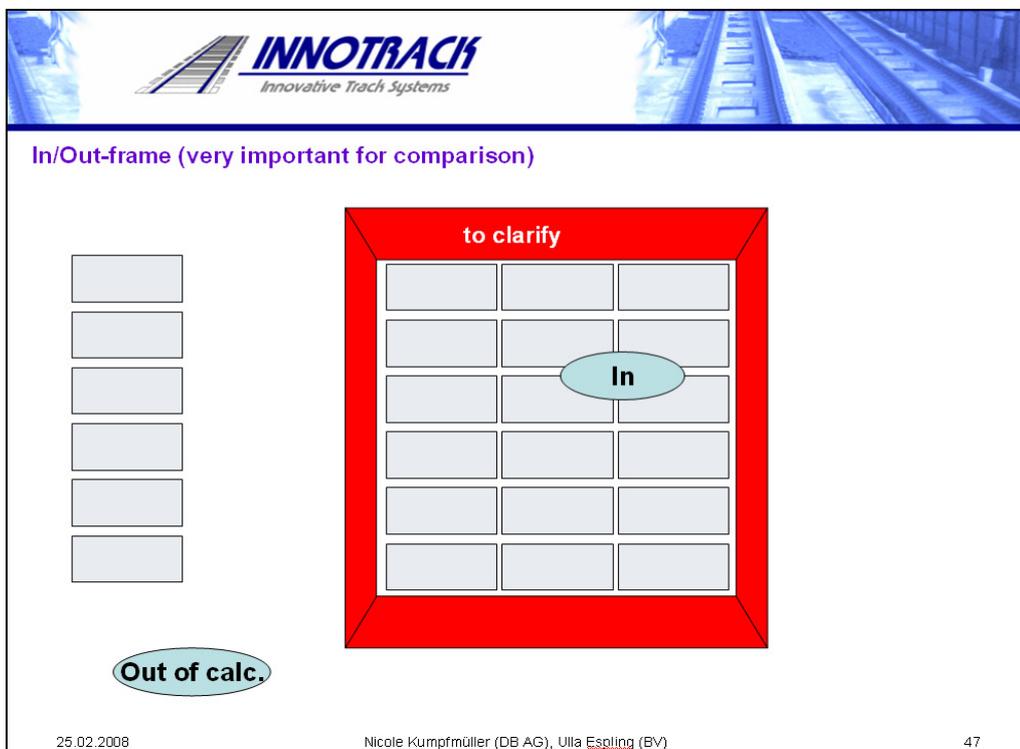
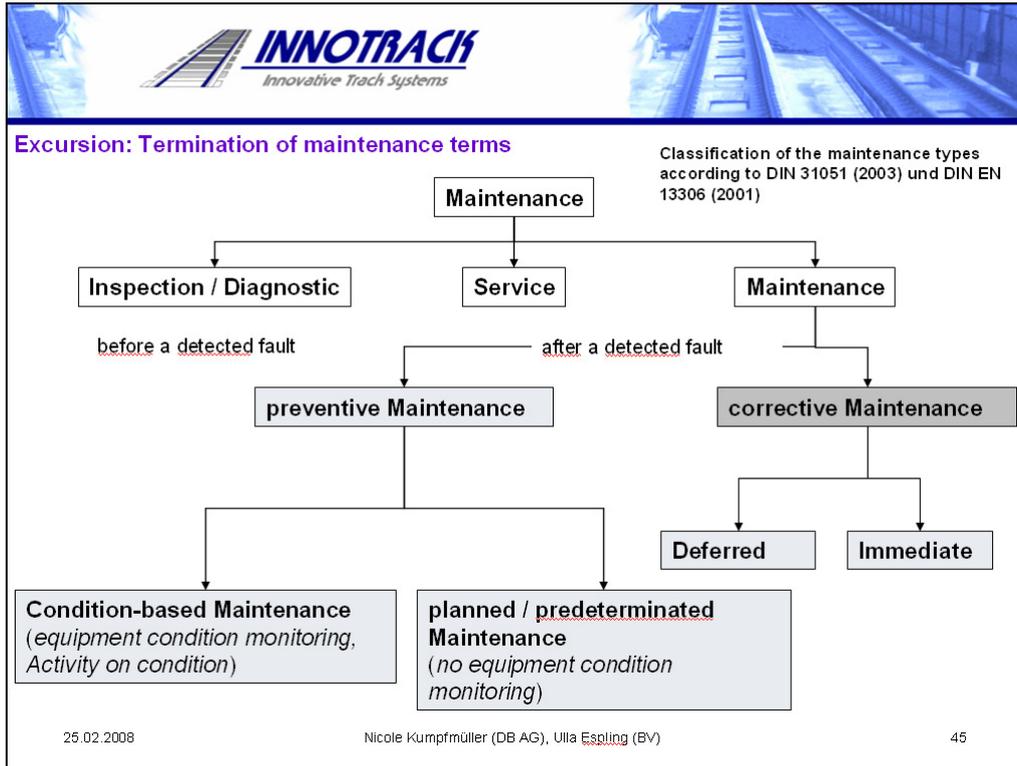
42

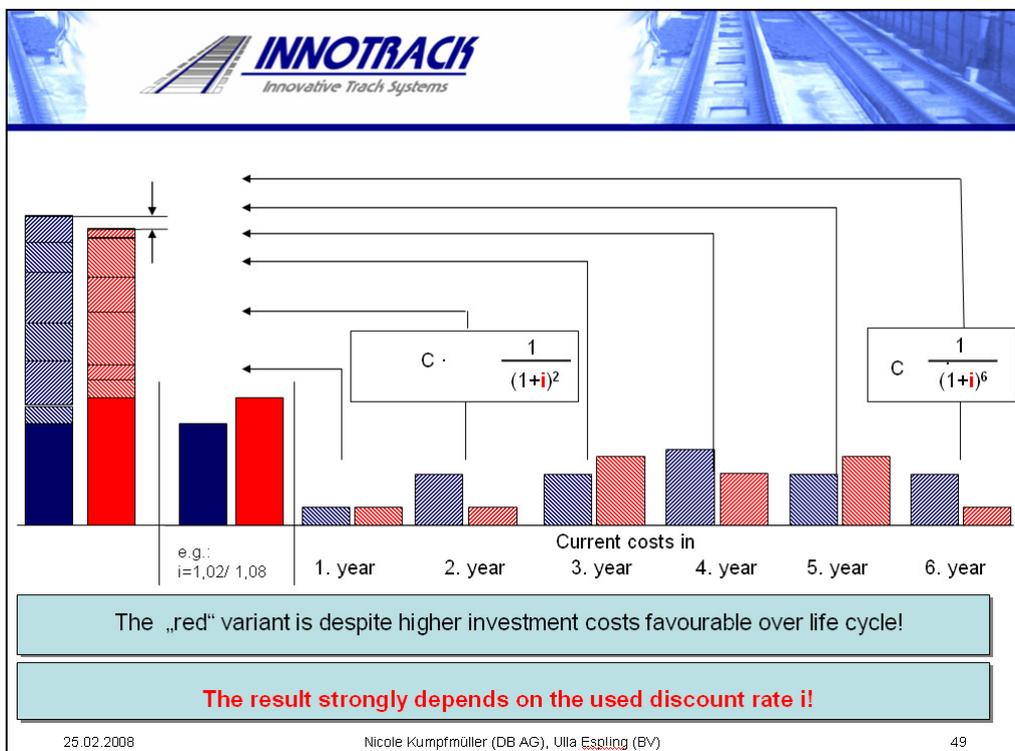
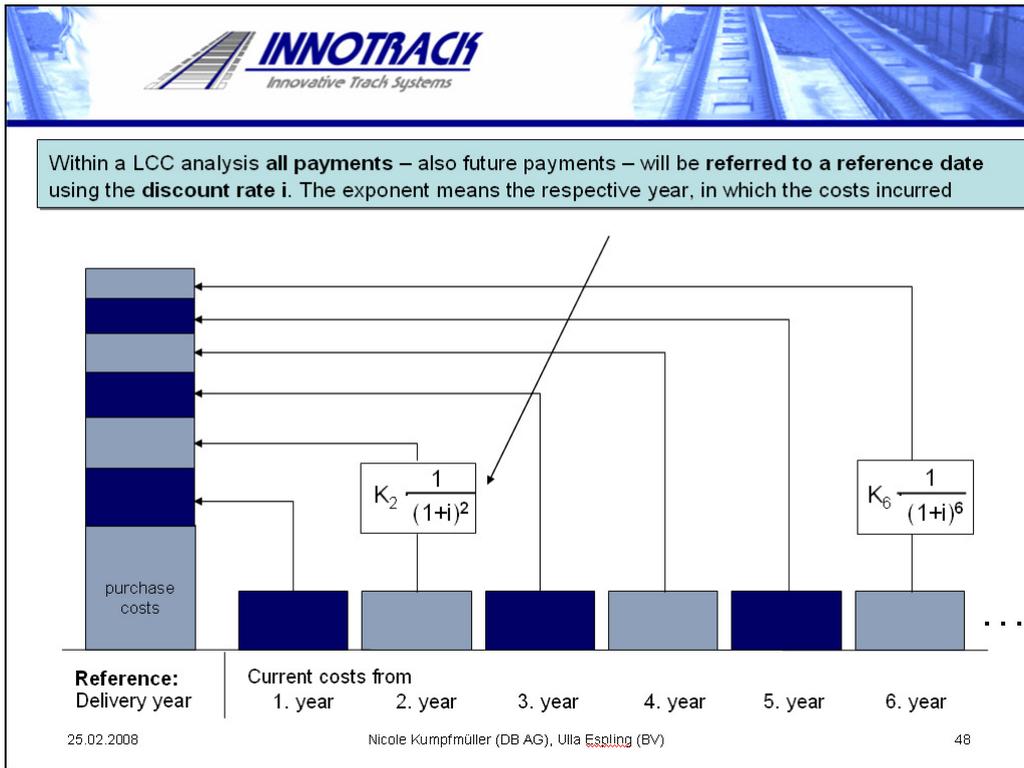


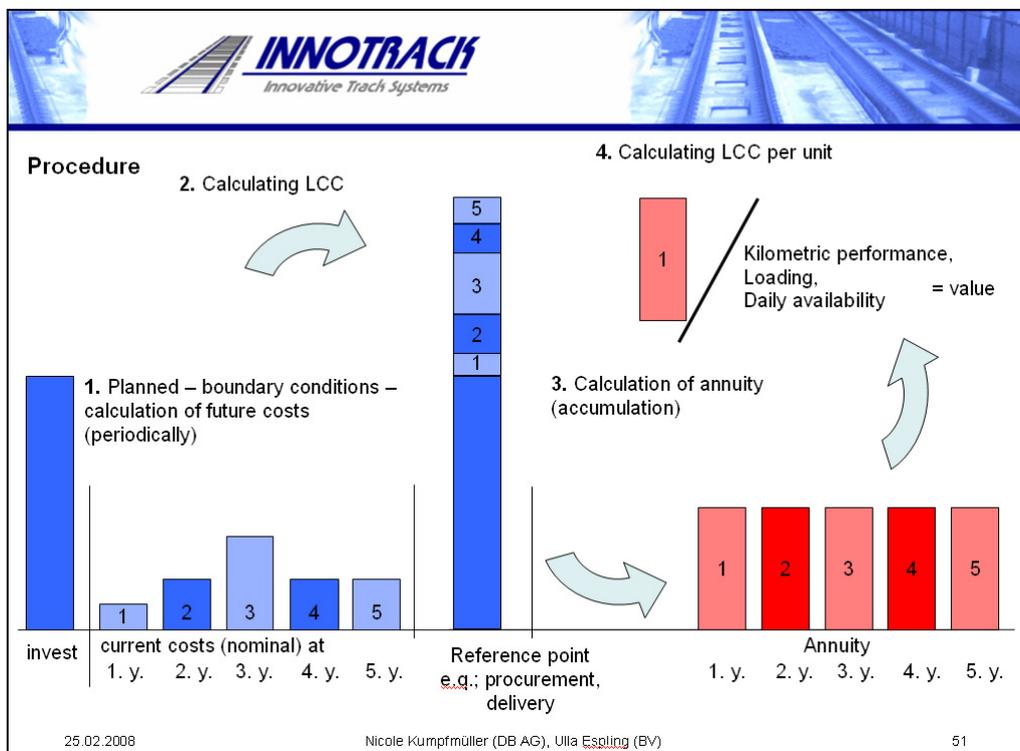
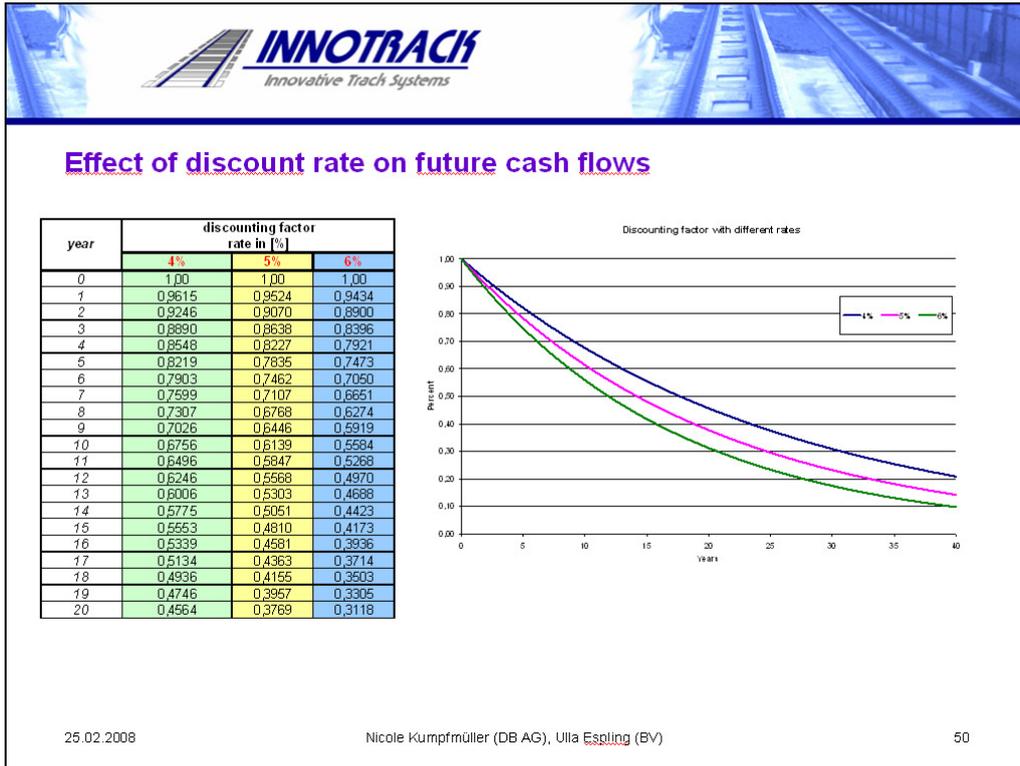
I. Procurement	II. Operation	III. Maintenance	IV. Non Availability
I.1 Preparation one-time / generic/ product-specific (product family) I.2 Preparation recurrent / project-specific (single product) I.3 Investment I.4 Imputed residual value I.5 Decommissioning / retraction / sale / removal (tasks) I.6 Disposal / recycling (material) I.7 Others	II.1 Service II.1.1 Personal costs II.1.2 Energy II.1.3 Cleaning II.1.5 Provision II.1.6 Insurance II.1.7 Fees II.1.8 Communication II.1.9 Other costs	III.1 Preparation one-time III.2 Inspection/ Diagnostic III.3 Service III.4 Maintenance preventive (condition based/ pre-determined) III.5 Mtn. corrective (Deferred/ immediate) III.6 Residual value III.7 Disposal/ Recycling (material) III.8 Design and system support III.9 Others	IV.1 Planned IV.1.1 Malfunctions IV.1.2 Delays IV.1.3 Less Serviceability IV.2 Unplanned IV.2.1 Malfunctions IV.2.2 Delays IV.2.3 Less Serviceability

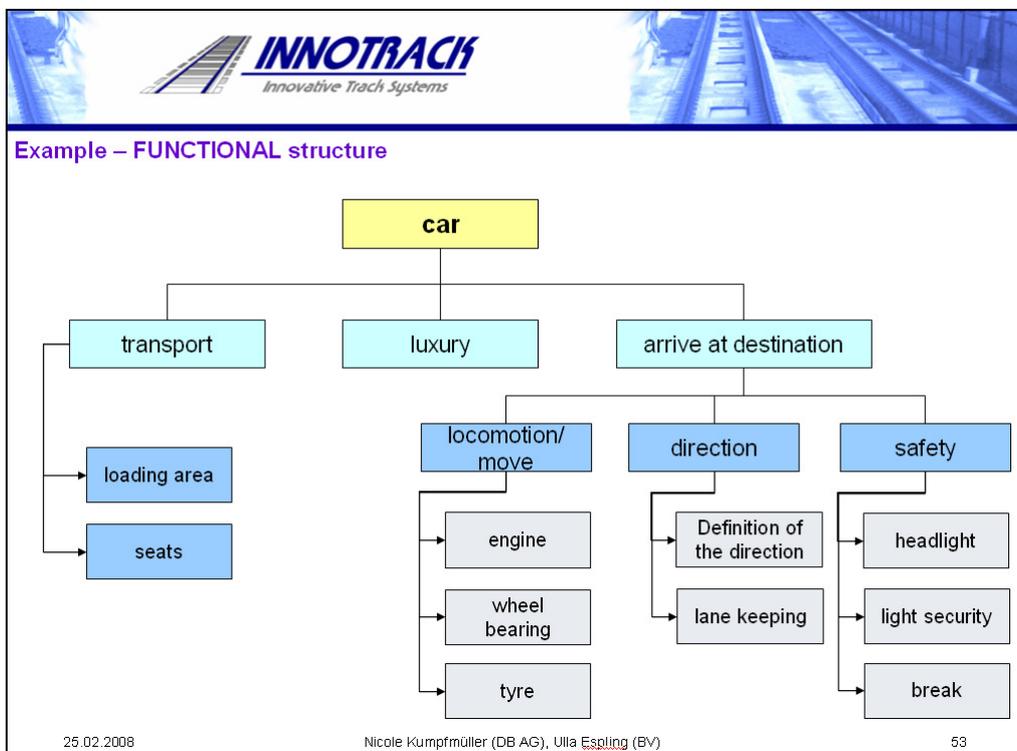
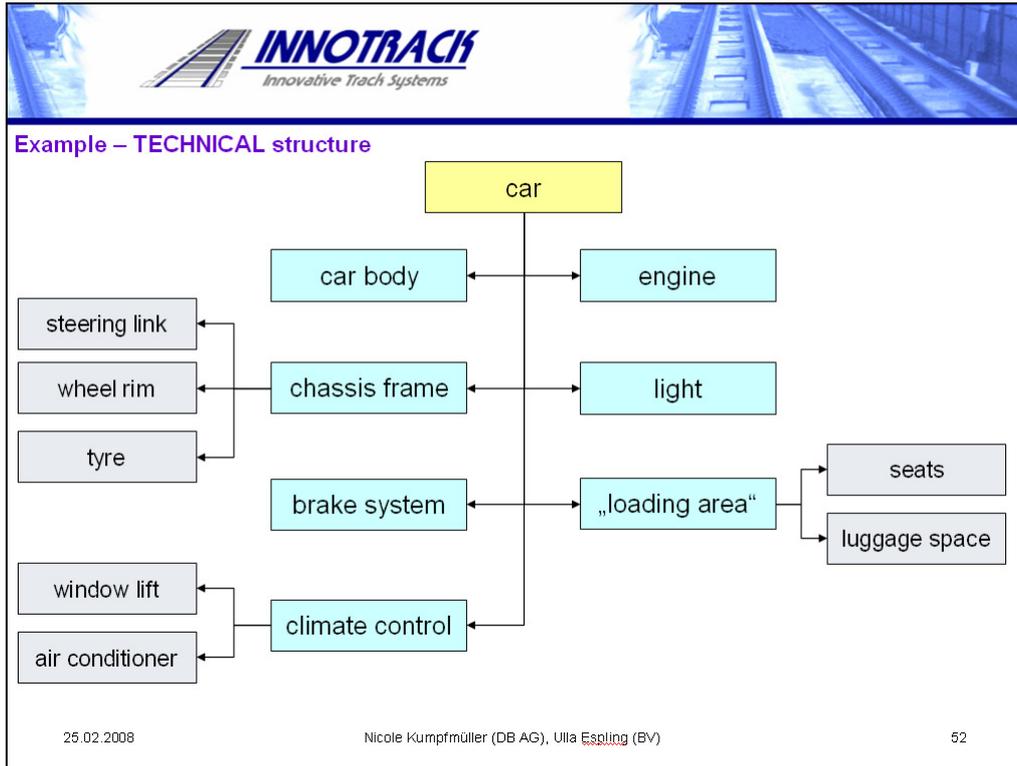
= LCC

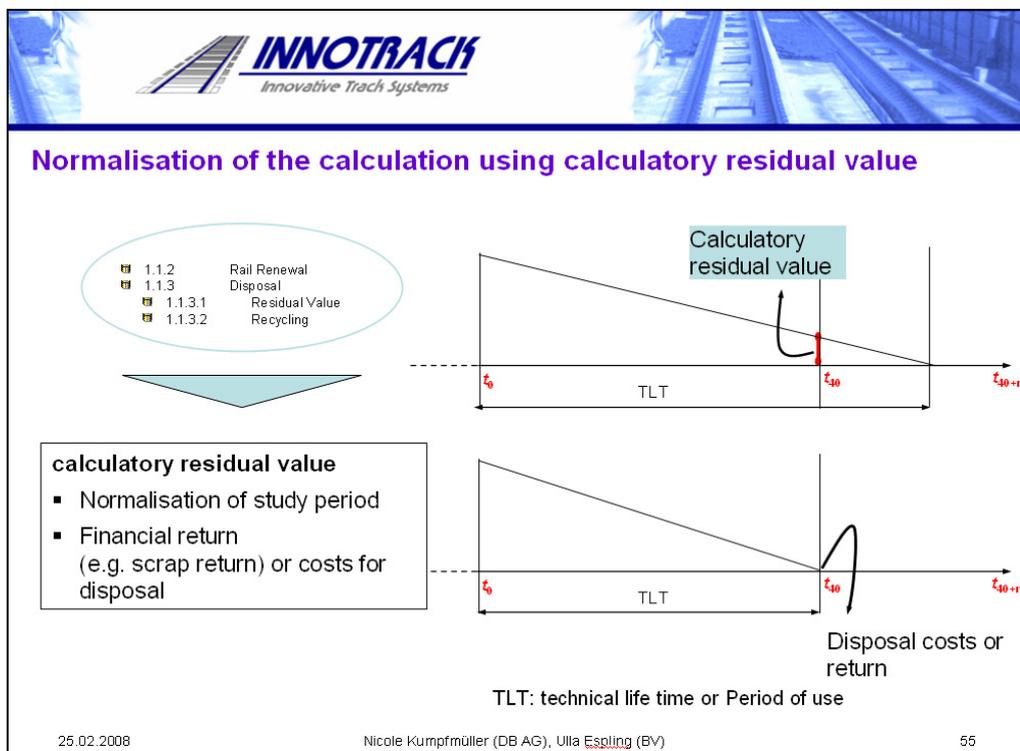
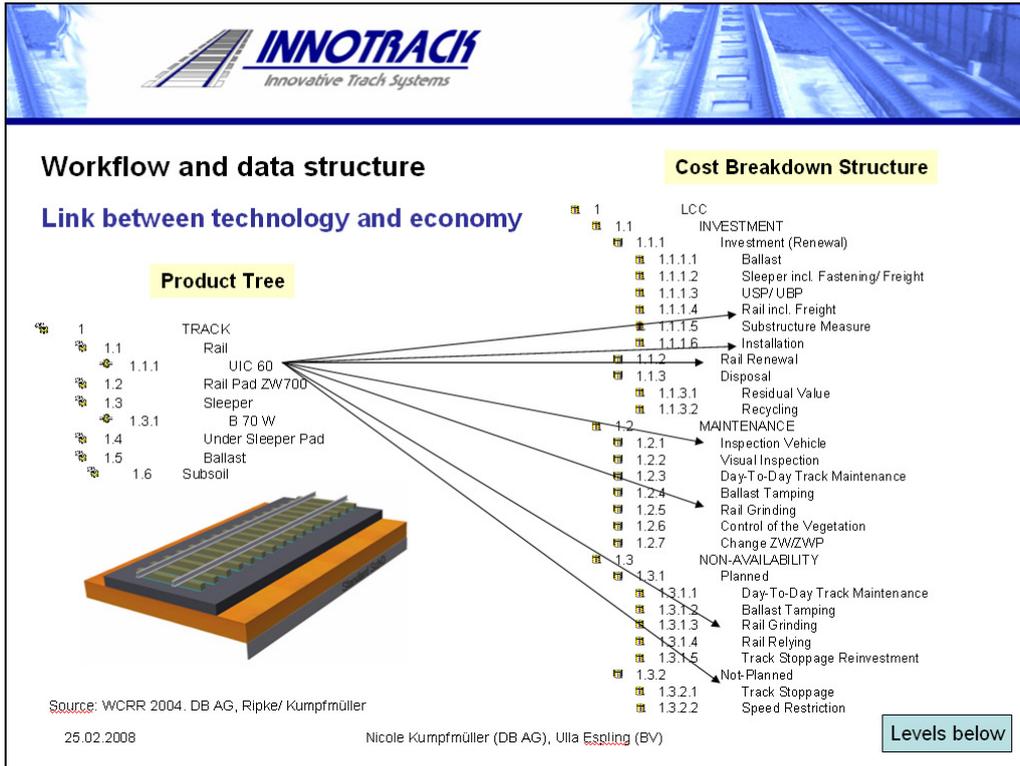
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### FAQ LCC

- How does the rate of interest or discount rate influence the LCC?
- Key values for lower LCC?
- Key Phases for LCC?
- Which discount rate has to be taken into account?
- LCC for increasing or decreasing traffic?
- How to handle depreciation in life cycle costing?

LCC guidance in process till end of project (WP6.5)

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### Which discount rate has to be taken into account ?

NR	6.5 %		
DB	5.9 %	←	For infrastructure
Public investor	≅ 4.0 %		
Private investor	5.0 % ++	←	Depending on risk
InnoTrack	≅ 4-5 %	←	For comparison

**InnoTrack**  
 ✓ real discount rate 3 – 6 %  
 ✓ study period track 40 years

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### Task of SP 2, 3, 4 and 5

- Define reference system
- define boundary conditions
- explain improvement/ innovation

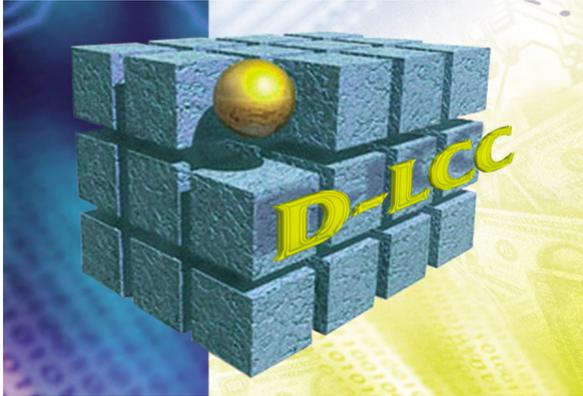
→ for each SP

→ system approach next step (SP1) to ensure the consistent improvement

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### SOFTWARE D-LCC



**contact (license) & download demo:**  
<http://ald.co.il/>  
[support@ald.co.il](mailto:support@ald.co.il)

**contact (before license)**  
[paulo.teixeira@upc.edu](mailto:paulo.teixeira@upc.edu)  
[nicole.kumpfmuller@bahn.de](mailto:nicole.kumpfmuller@bahn.de)

**manual:**  
uploaded KMS – SP6

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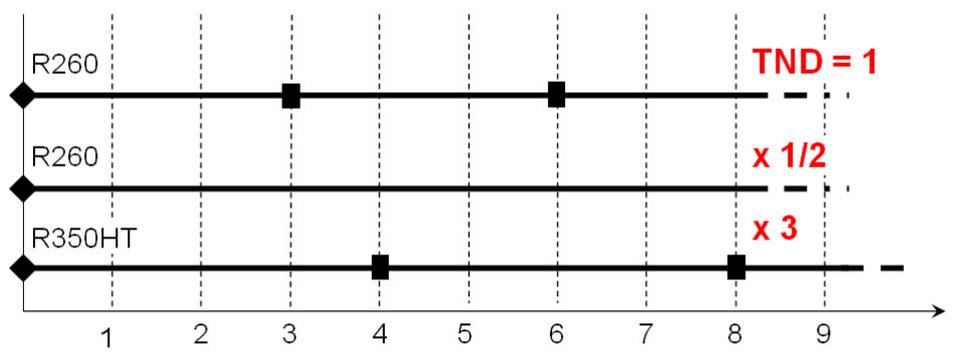
### TEST CASE 1

- RAIL Steel grade and maintenance
- CASE description

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### Comparison of lifecycle due to steel grade & maintenance



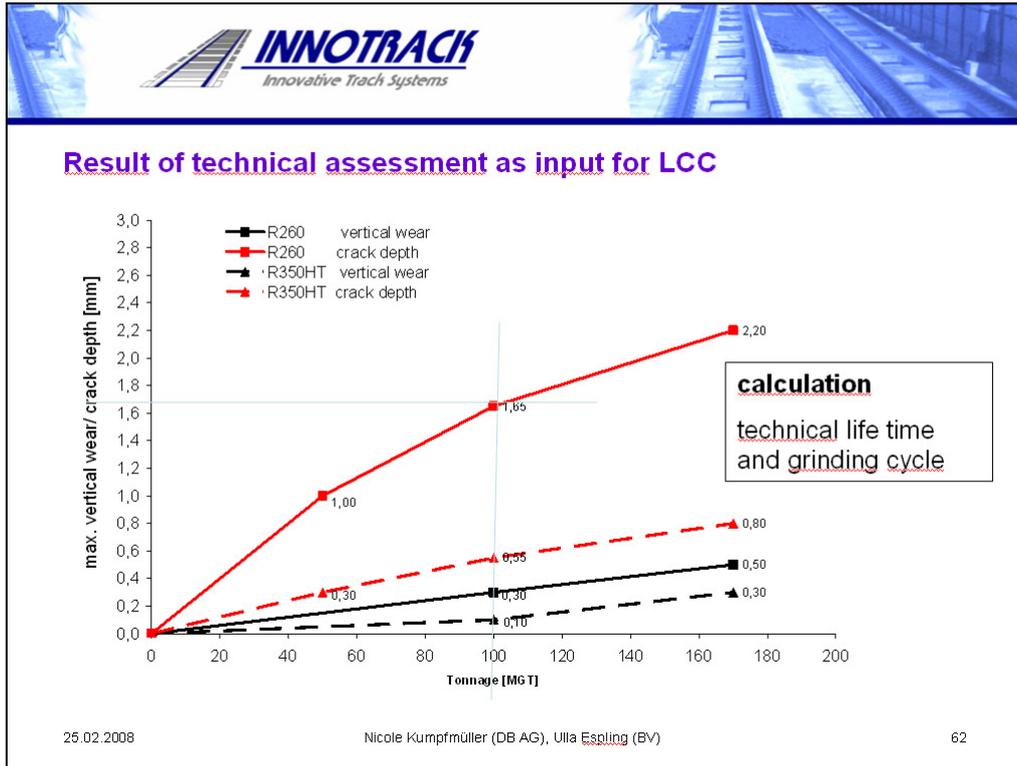
Installation

- Rail 60 E1
- 90.000 Gt/d

■ MTN

study period

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**First task**

- technical or functional structure
- build PBS ↔ CBS
- which information do you need for your LCC model (both PBS/ CBS)

**Second task**

- ask for information required (or assume own data)
- start with your LCC model within D-LCC (think about the model incl. units before!)

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**TEST CASE 1**

- RAIL Steel grade and maintenance
- SOLUTION**

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**Test case 1 – (one possible) solution with assumed values**

	Technology 1	Technology 1	Technology 2
<b>Rail type</b>	60 E1	60 E1	60 E1
<b>Steel grade</b>	R260	R260	R350HT
<b>Loading</b>			
GT/d	100.000	100.000	100.000
MGT/a	36,5	36,5	36,5
<b>Tangent track</b>	1 unit	1 unit	1 unit
<b>Curve/ 1500 meter</b>	1 unit	1 unit	1 unit
<b>TLT</b>			
•Tangent	....	....	....
•Curve	590 → 16 (16,2)	290 → 8	1752 → 40 (48)
<b>MTN</b>			
•Tangent	-	-	-
•Curve [a]	3	-	4 (solution factor 3)
<b>Invest incl. logistic etc [€/m]</b>	200	200	1 +20% → 220
<b>MTN costs [€/m]</b>	20	20	20
<b>Scrap [€/m]</b>	20	20	20

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### Test case 1 – solution (one possible)

I. Procurement	II. Operation	III. Maintenance	IV. Non Availability
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### Test case 1 – solution (one possible)

disturbances	<b>to clarify</b>			
costs for availability	<b>In</b>			
interactivities rail - ballast	purchase costs rail	maintenance - grinding		
<b>Out of calc.</b>				
				<b>In/Out-frame</b>

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### Product tree (PBS) and cost breakdown structure (CBS)

#### Product tree

- 1 TRACK
  - 1.1 Rail
    - 1.1.1 R260/ R350HT
    - 1.2 Rail Pad ZW700

#### Cost breakdown structure

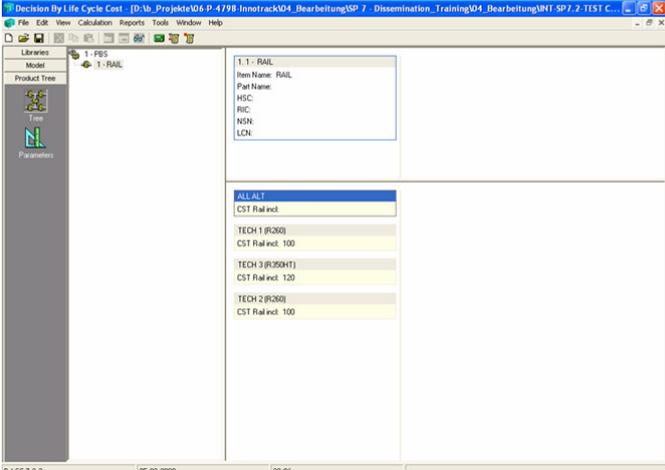
- 1 LCC
  - 1.1 PURCHASE
    - 1.1.1 INVESTMENT
      - 1.1.1.1 rail incl. freight
      - 1.1.1.2 installation cost
      - 1.1.1.3 rail renewal
    - 1.1.2 DISPOSAL/ RECYCLING
      - 1.1.2.1 calc<sup>1</sup>. disposal value rail
      - 1.1.2.2 Disposal rail
  - 1.2 MAINTENANCE
    - 1.2.1 rail grinding
  - 1.3 NON-AVAILABILITY
    - 1.3.1 planned maintenance
      - 1.3.1.1 rail grinding
      - 1.3.1.2 rail renewal

- real Discount rate 3-6%
- Study period over 40 years

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### PBS reduced to rail



Item Name	Item No.	Cost
ALL-ALT		
CST Rail incl.		
TECH 1 (R260)		
CST Rail incl.	100	
TECH 3 (R350HT)		
CST Rail incl.	120	
TECH 2 (R260)		
CST Rail incl.	100	

suggested solution: MTN x 3

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**Example: all values are defined as globals**

#	Global Variable Name	Distribution	Value
1	TIME_CHANGE	Constant	0
2	TIME	Period	
3	Period 40 years	Period	
5	Alt 1 / Alt 2	Alternative	
6	NA installation shift (m)	Constant	1000
10	TLT (a) - R260	Constant	16
11	CST - rail R260(C/m)	Constant	100
12	CST - installation (C)R26	Constant	100
13	screw (C/m)R260	Constant	20
14	grinding shift R26(m)	Constant	2000
20	TLT (a) - R350HT	Constant	40
21	CST - rail R350 (C)	Constant	120
22	CST - installatio (C)R350	Constant	100
23	screw (C/m)R350HT	Constant	20
24	NA-shift grinding R35(m)	Constant	2000
30	grinding (C/shH)	Constant	20000
31	INTER grinding (a)R260	Constant	1
32	INTER grinding (a)R350HT	Constant	
40	N-A grinding (min) KONV	Constant	300
41	N-A renewal rail (min)	Constant	300
200	choice P 300	Constant	0
201	C M 230	Constant	0
202	C M 230	Constant	0

suggested solution: MTN x 3  
start value (1)

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**Potential LCC reduction of a route**

1. potential radius curve  
calculation range e.g. test sites

2. potential route  
assessment of ratio radii to route  
(amount as factor)

3. potential network  
results assignes to network

NPV/ annuity

radius curve length - sum

aggregation

calculation potential of network

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### TEST CASE 2

- S & C – switch pointers
- CASE description

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### Switch point machine (Växeldriv)

- Traditional rodding (technology 1)
- Inbuilt rodding/ hollow sleeper (technology 2)



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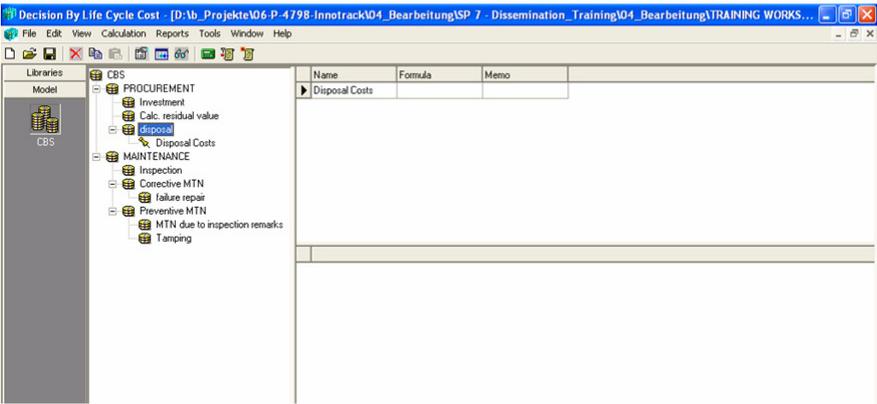
### Input data (estimated)

Input	Tech 1	Tech 2
Investment €	12 856	23 160
Failure repair €/ Year	171	86
Inspection €/Year	100	100
Maintenance due to inspection remarks €/Year	2 368	1 071
Tamping €/ 2 Year	129	100
Technical life time [year]	25	40

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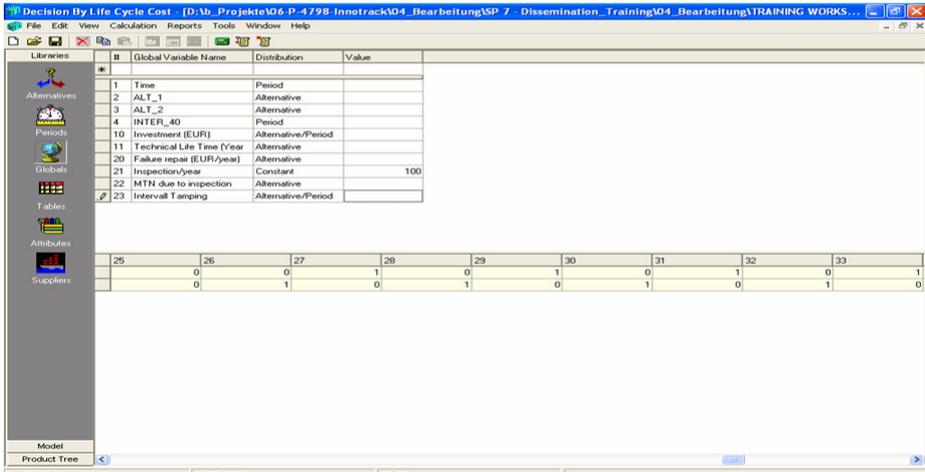
### CBS test case 2



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## Be aware after renewal!



The screenshot shows a software window titled "Decision By Life Cycle Cost" with a menu bar (File, Edit, View, Calculation, Reports, Tools, Window, Help). On the left is a "Libraries" pane with categories: Alternatives, Periods, Global, Tables, Attributes, and Suppliers. The main area contains a table with columns: Global Variable Name, Distribution, and Value.

Global Variable Name	Distribution	Value
1 Time	Period	
2 ALT_1	Alternative	
3 ALT_2	Alternative	
4 INTER_40	Period	
10 Investment (EUR)	Alternative/Period	
11 Technical Life Time (Year)	Alternative	
20 Failure repair (EUR/year)	Alternative	
21 Inspection/year	Constant	100
22 MTN due to inspection	Alternative	
23 Intervall Tamping	Alternative/Period	

	25	26	27	28	29	30	31	32	33
	0	0	1	0	1	0	1	0	1
	0	1	0	1	0	1	0	1	0

At the bottom of the window, the date "25.02.2008" is displayed on the left, the name "Nicole Kumpfmüller (DB AG), Ulla Espling (BV)" is in the center, and the number "76" is on the right.



## TEST CASE 3 (self study)

- S & C – Frog
- CASE description

At the bottom of the slide, the date "25.02.2008" is displayed on the left, the name "Nicole Kumpfmüller (DB AG), Ulla Espling (BV)" is in the center, and the number "77" is on the right.



### Case 3

- Traditional frog
- Mn frog
- Movable frog ECR





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### Indata

S&C Type	SJ50-12-1:15	UIC60-760-1:15 Mn frog	UIC60-760-1:15 Moveable frog, EVR
Investment cost	10 000	14 000	25 000
Surface welding cost per year	4 280	2 142	215
Technical life time	8	10	25
Replacement moving parts in EVR			2150 every fifth year
Grinding manual	670	280	150
Grinding machine	3 140	3 140	

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