C4R

Capacity for Rail

Towards an affordable, resilient, innovative and high-capacity European Railway System for 2030/2050

Dataset of costs and RAMS data for analysis

Submission date: 23/11/2017

Deliverable 52.3

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 605650








Collaborative project SCP3-GA-2013-60560
Increased Capacity 4 Rail networks through enhanced infrastructure and optimised operations
FP7-SST-2013-RTD-1

Lead contractor for this deliverable:

- DB AG

Project coordinator

- Union Internationale des Chemins de fer, UIC

Acronyms and Abbreviations

The following list provide definitions for acronyms and abbreviations and for terms used in this document:

CBA	Cost-Benefit Analysis
EC	European Commission
IMs	Infrastructure managers
LCC	Life-Cycle Costs
p·km	Passenger km
RAMS	Reliability, Availability, Maintainability and Safety
RFC	Rail Freight Corridor
T·km	Ton km
tkm	km of track
tm	m of track
Train load	Freight train with a single type of cargo
TRL	Technology Readiness Level
Wagon load	Freight train combining wagons with its own type of cargo

Table of content

Executive Summary

The aim of this deliverable is to provide a compendium of baseline data that can be used for the cost benefit analysis which have to be carried out in WP5.4.

Baseline data are necessary to calculate the reference situation or scenario and to compare the results with scenarios where C4R innovations are applied. The baseline data presented in this deliverable are reduced to the data which are required for the CBA.

As the innovations like the slab track in SP1 are novel required detailed data are not available with sufficient reliability. To overcome this approach only “top level” data for costs and lifespan are considered and collected. This means the data structure for the baseline data is much simpler than the templates for LCC and RAMS described in D5.2.2.

The benefit of this approach is to get more confidence in the calculation. The CBA can calculate target costs for the innovation where the benefit of the innovative solution is higher than the reference case. These target costs can be used in the optimization of the innovative solution. In this case the detailed cost structure is necessary for the technical and financial optimization and therefore outside the CBA. This top down approach makes the assessment much easier, as unknown costs are eliminated.

The data collected are from different sources but mostly from the European projects InnoTrack and AutoMain. In both projects technical and economic data are collected and normalized.

The data presented in this deliverable are divided into

- boundary and system parameters,
- investment and lifespan data,
- maintenance and renewal data and
- data about rolling stock

and include only baseline information. Corridor specific data are given in the deliverable D5.4.2/3.

1 Objectives

Task 5.2.3 is to gather baseline data for the models in WP5.4. This includes cost for maintenance and renewal activities, reliability, carbon cost, societal impact, capacity and publically available cost rate data. Sources for the data are infra-managers, design and construction companies and publicly available sources.

The data collected in this task shall allow the evaluation of the baseline scenarios, against which the innovations will be assessed.

The structure of the collected data strongly depends on the progress and results achieved in C4R.

As SP2 will do their own assessment inform of business cases and SP3 will base on the results of existing projects like Mainline the focus of this task is on the assessment that will be carried out in SP5. WP5.4 will do a cost benefit analysis to assess the innovations of SP1, SP2 and SP4 with respect to social impacts and benefit of the society, customers, IM’s and railway undertakers. The scenarios and the corridors which are the base for the CBA and the related data are described in deliverable D5.3.2 and the combined deliverable D5.4.2/3. The deliverable D5.2.3 can be considered as a compendium of the data used for the CBA.

2 Data structure and assumptions

Task 5.2.2 was among others to develop templates for the analysis of scenarios. These templates are also about technical and economic parameter to use in RAMS and LCC analyses. During the project it became clear, that SP1 to SP4 are not able to provide the requested data as the innovations are not proven and partly totally new. Therefor it was tried to simplify the data and reduce the uncertainty by using more condensed values.

The following sections describe the data structure and the assumption which were made. The collected data are oriented at the assessment of the innovations in WP5.4.

The main innovations considered are the following:

- new slab track,
- new switches and crossings (S&C) with enhanced tolerance to failure and higher availability leading to less delay minutes,
- new freight wagons with higher axle loads, 25 T/axle,
- terminal upgrades and
- new monitoring systems.

Beside generic data which were used for the base line scenarios and summarized in this deliverable detailed data are collected with respect to the analysed corridors or section. These data are not part of this deliverable and can be found in D5.4.2/3.

Normalisation or harmonization of data is absolute necessary to compare and assess innovations on a European level. In the EU project InnoTrack one important and challenging task was to collect and harmonize data for cost and RAMS of track systems and components. Therefore, most of the data are based on the InnoTrack project.

2.1 Sources

Among information gathered within C4R the following sources are used for the base line data.

Main sources for baseline data	
Statistisches Bundesamt	https://www.destatis.de/DE/ZahlenFakten/Indikatoren/Konjunkturindikatoren/Preise/bpr210.html?cms_gtp=145850_list%253D1&https=1
InnoTrack	www.innotrack.eu
AutoMain	www.automain.eu
D-Rail	www.d-rail-project.eu
STAIRRS	www.stairrs.org
Transport Research	http://www.transport-research.info/web/projects/project_details.cfm?id=13764
DB	Gathered data from internal projects or data bases
Arne Nissen	Development of Life Cycle Cost Model and Analyses for Railway Switches and Crossings

2.2 Boundaries and System Parameters

As the CBA carried out in WP5.4 is based on life cycle costs parameters like

- time horizon,
- base year,
- discount rate or
- inflation rate

need to be defined.

The discount and inflation rates strongly influence the financial results. Especially in times of low inflation rates the discount rate should be selected very carefully to avoid negative impacts from higher investments which are mostly necessary in case of innovations. **Figure 1** illustrates the calculation of the net present value (NPV) using the discount rate *i*. The most important cost block is the investment in the year of installation. The saving of costs due to innovations, which may occur after several years are discounted and therefore not as high as the annual savings.

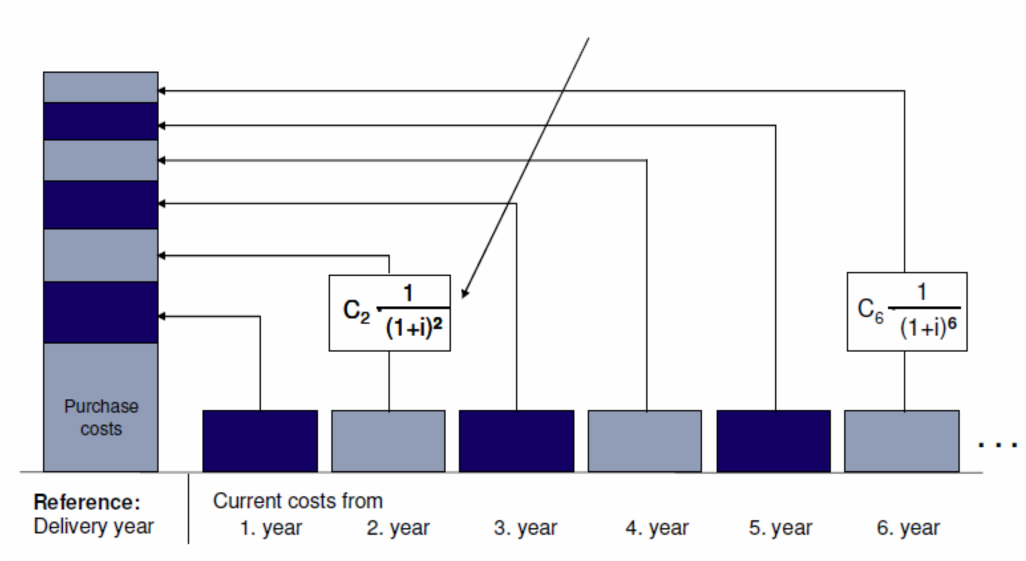

FIGURE 1 ANNUAL COSTS AND NPV, SOURCE: INNOTRACK

This effect is shown in **Figure 2**.

Here the related NPV is shown for rates of 3 and 6% for a payment or saving of 1000€ as a function of time. For a payment of 1000 € in the first year the NPV is 1000€. For a payment or saving of 1000€ in year 20 the related NPV is 554€ for 3% and 312€ for 6%. This means for example, if a higher investment will increase the life span of a system from 40 to 60 years or reduce maintenance costs after several years the NPV, which is the parameter for LCC, may be negative for high discount rates.

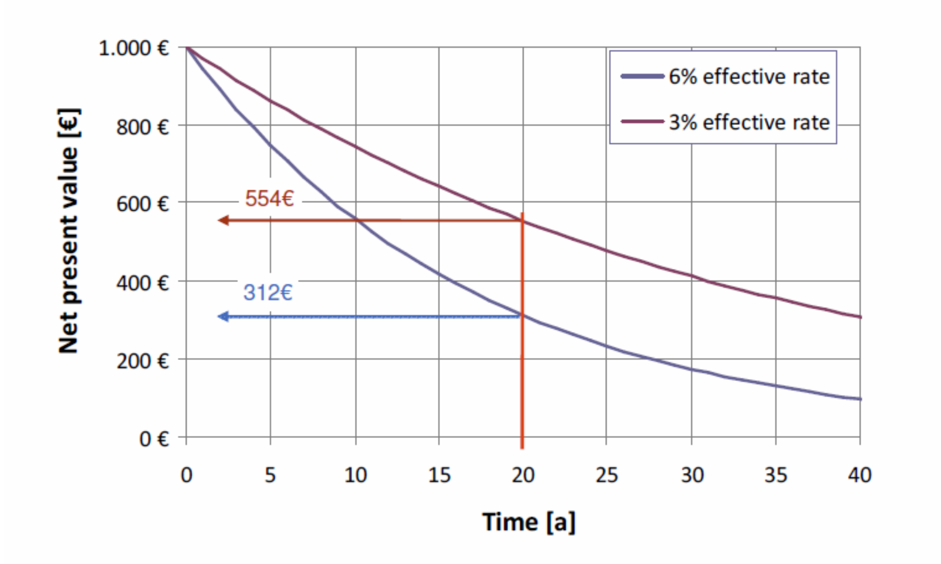

FIGURE 2 EFFECT OF DISCOUNT RATE ON NPV, SOURCE: INNOTRACK

To reduce this effect for long lasting railway assets the following values for the discount rate, shown in **Figure 3**, are recommended in the InnoTrack Guideline for LCC and RAMS analysis

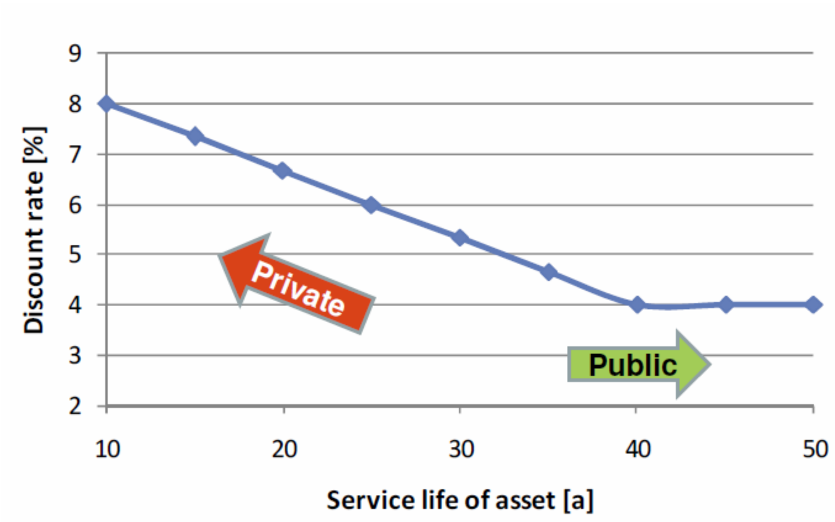

FIGURE 3 RECOMMENDED DISCOUNT RATE AS A FUNCTION OF ASSET LIFE, SOURCE: INNOTRACK

Table 2 in the appendix summarizes the parameter mentioned above. The table also contain base line values for the shadow price conversion factor, values of time which are divided for rail freight and road freight. Value of greenhouse gas and the switch density is given too.

2.3 Investment and Maintenance

The task for SP1 is to compare conventional ballasted track with the slab track developed in C4R.

Figure 4 shows the different phases of a life cycle and the cost categories used in C4R. The initial or investment costs like development, construction or installation are summarized in procurement costs. This cost block also considers decommissioning and disposal.

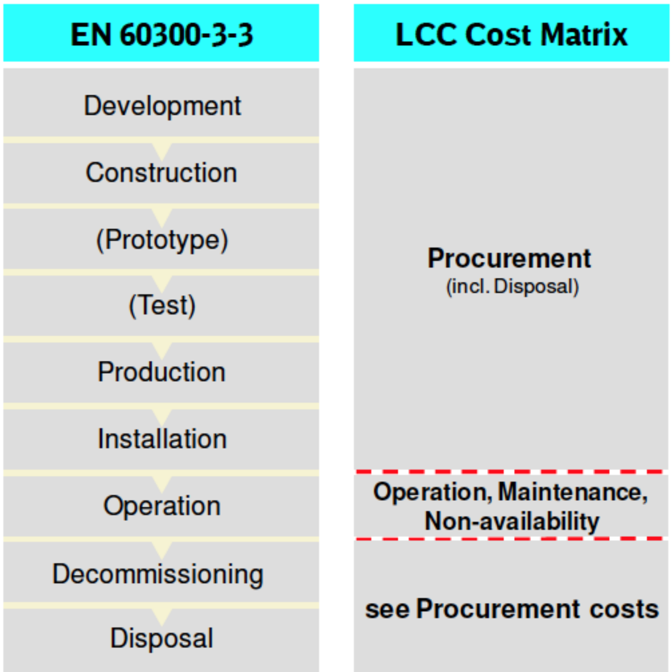

Figure 4 Life cycle phases according to EN 60300-3-3 [InnoTrack]

A more detailed cost structure is only necessary if the compared systems need detailed analysis. For example, for the comparison of LCC of a slab track in and ballasted tracks, the necessary soil improvements to reduce settlements must be considered. It is now possible to create a detailed cost break down structure or include all costs in one global value. For a new construction like the slab track developed in C4R, the global value is much more convenient as detailed data are not available. A CBA gives the possibility to estimate the target costs for a new construction or innovation in relation to the reference one considering the benefits. This estimated target costs can then be used to optimize the new construction looking at more detailed cost categories.
During the operation of an asset the costs for

- Operation,
- Maintenance and
- Non-availability

must be considered.

Like for the investment it is meaningful to summarize these costs to reduce uncertainties.

With respect to the innovations in SP1 and SP4 detailed information about costs and technical performance are not available and not gathered during the project. Therefore, the costs are deduced from existing systems. In case of the slab track a proven system, which is already in operation is used for comparison with the reference system ballasted track.

The baseline data for the investment and maintenance are summarized in the appendix in **Table 3** and **Table 4**. Mean values for possible possession time are given in **Table 5**.

2.4 Rolling Stock

Most of the data about rolling stock are directly related to the specific corridor. Like for other data these specific data can be found in the deliverable D5.4.2/3. From the corridor independent baseline data can be found in the appendix.

For all analysis the same types of freight trains or wagons are considered. The reference freight trains are build form the following types

- Train load
- Wagon load
- Intermodal Container
- Intermodal Trailer and
- Wagon load Feeder

The share of these types depends on the specific corridor or section.

For other parameters related to the rolling stock or operation like

- Tare weight,
- Axle load,
- Cargo capacity,
- Load factor,
- Gross weight,
- Train length,
- Operation and terminal costs or
- GHG emission

no base line data are given as these parameters depend on the specific corridor.

Also, it was obviously, especially for the train length, that C4R innovations of SP2 partly already used on other sections of RFCs. This means the base line case depend on the corridor.

Even if the CBA concentrate on freight transport the passenger transport is considered as a fixed system component. The parameters of the reference passenger train and road vehicle can be found in the appendix in Table 6 and Table 7.

2.5 Traffic Data and Delays

During the CBA horizon, the rail demand is expected to grow according to each of the scenarios' performance. This variation will respond to the elasticity of the demand to a set of parameters to be evaluated:

- Annual GDP Growth: 1.5%;
- Freight Demand Elasticity with GDP: 1;
- Freight Demand Elasticity with Operating Costs: -0.42.

Since passenger traffic is kept constant throughout the analysis period, its elasticities are set at 0.

As delays of trains have a noticeable impact on the results of the CBA the values given in **Table 1** are assumed for the baseline case.

TABLE 1. BASELINE VALUES FOR TRAIN DELAYS [D5.4.2/3]

Variable	Passenger Trains	Freight Trains
Punctual trains – arrival on schedule	73.0%	65.0%
Cancelled trains	1.0%	1.0%
Delayed trains – arrival over 1 min. after schedule	26.0%	34.0%
Average delay per delayed train per travelled 100 km	2.1 minutes	6.6 minutes

3 Conclusions

The compendium presented here summarizes the baseline data which were used in the cost benefit analysis carried out in WP5.4. The baseline data describe the reference configuration which is independent on the specific corridor.

The templates for RAMS and LCC data that were developed in Task 5.2.2 and described in D5.2.2 should be the basis for the collection of the baseline data. But the response from the SPs showed that the data structure was too complex, and the requested information was not available for the innovations. Also, it is nearly impossible to harmonize very detailed data to use them on a European level. This leads to the requirement to reduce the detailing of data structure. The data presented in this deliverable therefore use a simplified structure and concentrate mainly on top level values.

The data given in the tables correspond with the assessment carried out in C4R. Mainly data for the infrastructure are collected as SP2 already assessed their innovation developing business cases and other data are more corridor specific.

4 References

[1] European Commission, “Guidelines for Project Appraisal,” 2014.

[2] “INNOTRACK (Innovative Track Systems) Project,” 2006.

[3] AutoMain, European Project, 2014.

[4] “Network Statement 2016, Trafikverket, Swedish Transport Administration”.

[5] “Scandinavian-Mediterranean Core Newtwork Corridor Study - Final Report,” 2014.

[6] STAIRRS, European Project, 2003.

[7] Arne Nissen, "Development of Life Cycle Cost Model and Analyses for Railway Switches and Crossings", Thesis, Lulea 2009; https://www.diva-portal.org/smash/get/diva2:990370/FULLTEXT01.pdf

Appendix – Baseline Data

The following section summarizes the data used for the baseline scenario in the CBA.

Boundaries and System Parameters

Table 2 Baseline data – Boundaries and System Parameters

Parameter	Value	unit	Area	Quality	Source	Note
Time horizon	40	year	Generic	Recommendation	InnoTrack: LCC and RAMS Guideline	At least the longest life time of system
Base year	2015		C4R			
Discount rate	4	%	Europe	Recommendation / Project result	InnoTrack: D 6.2.1 Unique Boundary Conditions	Discount rate should be selected depending on lifespan of asset 8% - 10 years lifespan 4% - 40 years lifespan
Inflation rate	2	%	Germany	calculated	Statistisches Bundesamt	Mean value for last 10 years for civil engineering (road)
Shadow price conversion factor	0,95		C4R		EC Guidelines	
Value of Time						
Rail freight	1,66	€/h	Generic	Estimation		Mean value
Road freight	4,05	€/h	Generic	Estimation		Mean value
Value of greenhouse gas	0,031	€/kg	Generic	Estimation	Diff. investigations	
Switch density	0,14	km	Sweden	Estimation	TRV	Mean value

Investment and Lifespan

Table 3 Baseline data – Investment and Lifespan

System/modul/component	Cost	Unit	Lifespan	Area	Quality	Source	Note
Track							
Ballasted track	650	€/m track	40 years	Generic / Germany	validated	InnoTrack	
Slab track	1017	€ /m track	60 years	Generic / Germany	validated	InnoTrack	
Rail 60E2 R260	255	€ /m track	600 MGT	Generic / Germany	validated	InnoTrack	
Rail 60E2 HT 350	268	€ /m track	1000 MGT	Generic / Germany	validated	InnoTrack	
Rail fastening - ballasted track	50	€/m track	20 years	Generic / Germany	validated	InnoTrack	
Rail fastening - slab track	117	€/m track	30 years	Generic / Germany	validated	InnoTrack	
Sleeper	50	€/unit	40 years	Europe	validated	Innotrack	Mean value
S&C							
UIC 60-300	258	T€ /Unit	≥ 24 years	Generic	validated	Innotrack	without point machine
UIC 60-500	366	T€ /Unit	≥ 24 years	Generic	validated	Innotrack	without point machine
noise measure							
noise barrier 1 m heigt	933	€ / m	25 years	Europe		STAIRRS	Average values
noise barrier 2 m heigt	1215	€ / m	25 years	Europe		STAIRRS	Average values
noise barrier 3 m heigt	1475	€ / m	25 years	Europe		STAIRRS	Average values
Rolling stock brakes type 1	9881	€ / car	40 years	Europe		STAIRRS	Average values
Rolling stock brakes type 2	4996	€ / car	40 years	Europe		STAIRRS	Average values
Rolling stock optimised wheels	11557	€ / car	10 years	Europe		STAIRRS	Average values
Absorber on track	500	€ / m	30 years	Europe		STAIRRS	Average values
Safety measure							
barrier	2000	€/m track	20 years	Generic	estimated	InnoTrack	

MAINTENANCE AND RENEWAL

TABLE 4 BASELINE DATA – MAINTENANCE AND RENEWAL

Maintenance/renewal activity	Cost Unit	mean interval	Area	Quality	Source	Note
Track	15600 €/tkm 309 €/(MGT km)	1 year	generic	Validated	AutoMain	mean value for all maintenance activities
Renewal of ballested track	550 €/tm	40	generic	Validated	Innotrack	
Renewal of slab track	850 €/tm	60	generic	estimated		
Conventional grindig of rail - TPG	5 €/tm	1 to 2 years	generic / Germany	Validated	InnoTrack	
High speed grinding of rail	4 €/tm	2 to 4 time a year	generic	estimated	AutoMain	
Reneval of rail 60E2 R260	330 €/tm	1000 MGT	generic / Germany	Validated	InnoTrack	
Reneval of rail 60E2 R350 HT	380 €/tm	1800 MGT	generic / Germany	Validated	InnoTrack	
Tamping of Ballast	22 €/tm	3 to 8 years	generic / Germany	Validated	Innotrack	
Possession time						
S&C						
UIC 60-300	1850 €/unit	1 year	generic	validated	Innotrack	mean value for this type
	193 €/unit	MGT	generic	validated	InnoTrack	mean value for this type
UIC 60-500	2250 €/unit	1 year	generic	validated	Innotrack	mean value for this type
	205 €/unit	MGT	generic	validated	InnoTrack	mean value for this type
Noise measure						
maintenance of noise barrier 1 m heigt	19 €/m	1 year	Europe	estimated	STAIRRS	Average values
maintenance of noise barrier 2 m heigt	24 €/m	1 year	Europe	estimated	STAIRRS	Average values
maintenance of noise barrier 3 m heigt	30 €/m	1 year	Europe	estimated	STAIRRS	Average values
removal of noise barrier 1 m heigt	93 €/m	25 years	Europe	estimated	STAIRRS	Average values
removal of noise barrier 2 m heigt	122 €/m	25 years	Europe	estimated	STAIRRS	Average values
removal of noise barrier 3 m heigt	148 €/m	25 years	Europe	estimated	STAIRRS	Average values
Removal of optimised wheels	11557 € / car	10 years	Europe	estimated	STAIRRS	Average values
Maintenance of absorber on track	10 €/m	1 year	Europe	estimated	STAIRRS	Average values
Removal of absorber on track	50 €/m	30 years	Europe	estimated	STAIRRS	Average values

Note: tkm means km of track
tm means m of track

TABLE 5 BASELINE DATA – POSSESSION TIME

Parameter	Value Unit
Posession time	
freight line	3 h/(night line)
passenger line	5 h/(night line)

PASSENGER TRAIN AND ROAD VEHICLE

TABLE 6 BASELINE DATA – PASSENGER TRAIN

Parameter	Value Unit	Note
Tare weight	348 t	
Maximum axle load	17,5 t	
Number of seats	250	
Load factor	45 %	Average
Operating cost	0,1 €/(p·km)	Average
CO2 emission	0,02 kg/(p km)	Average

TABLE 7 BASELINE DATA – PASSENGER ROAD VEHICLE

Parameter	Value	Unit	Note
Load	1,21	p/car	Average
Operating cost	0,35	€/(p·km)	Average
CO2 emission	0,1	kg/(p km)	Average
Traffic mix			
Business	50	%	
Leisure	40	%	
Commuter	10	%	
Value of Time			HEATCO study, Euros/2002
Business	30	€/h	
Leisure	10	€/h	
Commuter	15	€/h	
Average	22	€/h	