Project no. TIP5-CT-2006-031415

INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

D 1.2.4 Populated data base of track section characteristics for general modelling for design and LCC and specific problem segments

Due date of deliverable: 2007/12/31

Actual submission date: 2008/07/04

Start date of project: 1 September 2006 Duration: 36 months

Organisation name of lead contractor for this deliverable:
Deutsche Bahn AG

Final

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
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

The terms *section,* used in this report, should be interpreted as follows:

Section section means a part of a system that is described by a special *long-term behaviour and set of parameters.* A system is divided into a sequence of sections.

E.g.: a straight line with same parameters and boundary conditions and different long-term behaviour is divided into several sections.

SECTION = FUNCTION OF (BAD LONG-TERM BEHAVIOUR AND STRONG MAINTENANCE WITH ECONOMICAL IMPACT)

1. Executive Summary

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

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

In this version data from DB site 1 are included.

2. Introduction

This report contains the description of selected example sections for DB track sites.

The basis for the selection of the following typical sections is the analysis of the DB tracks, which is described in the deliverable D1.2.2, which includes also former deliverable D1.2.3.

According to detailed cost and failure analysis, selected track sections are typical examples for maintenance cost drivers or alternatively for failures of track construction, which cause maintenance cost drivers.

3. Typical sections with failure

3.1 Sections of DB track site 1

The analysis of the high-speed track No.1 was done according to the modified "bottom-up" approach (see report D1.2.2). After identification of maintenance cost drivers, the failures of track construction – which cause track maintenance activities - have been analysed.

Failures which cause maintenance cost drivers on main track of the high-speed track site 1 are:

- rail failures Belgrospi,
- short-wavelength rail corrugation,
- rail failures Head Checks,
- white spots in ballast,
- differential settlements of ballast (mostly in transition areas).

For each failure type one or more typical sections has been selected. Detailed information for all selected example sections - as much information as possible - has been collected: data about track construction elements, subgrade, line routing, traffic data and geometry measurement data. The data sets have been systematically collected and described especially for further detailed analysis and modelling of maintenance issues in the project InnoTrack.

Examples for cost drivers in switches and crossings have been also selected and are described in the report D3.1.2 of subproject 3 Switches and Crossings.

To make the searching easier the information is presented in standardized tables for all sections with typical failures.

3.1.1 Short-wavelength rail corrugation

Selected section is a 3 km long section with typical short-wavelength rail corrugation in straight line as well as in transition curves (clothoid) and in curves in both directions. Maximal speed in this section is 280 km/h in both directions and the subgrade is made of very stiff soil with protective layer (except one 5m long bridge).

The amplitude of corrugation waves is between 8/100 mm and 10/100 mm. The development of short-wavelength corrugation areas and corrugation wave depth in this section is given through annual rail surface measurements (available measurements for the time period 2001 – 2007).

Site	DB Site No.1

Example_Corrugation / Table 1

Issue	Corrugation	in track sections with high speed (v>200 km/h) in straight line segments as well as in curves, with consequence of rail failures Belgrospi
Directory with data files	Example_Corrugation	

Selected example section		
	Direction	1 and 2
	Start km	278
	End km	281

Segments with corrugation		Seg. No.1	Seg. No.2	Seg. No.3
	Direction	1	2	2
	Start km	278,145	278,615	279,300
	End km	280,755	279,215	280,330
	Lenght [m]	2610	600	1030
	Corrugation Amplitude	10/100 mm	8/100 mm	8/100 mm

Corrugation Measurements
Data file
Exp_Corrugation_Rail_Surface_Measurements_2001-2007.xls
Notice: Measurements 2001-2007 for selected section in both directions D1 and D2

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
278 - 281	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
278 - 281	Zw 700	medium	Basalt/Diabas	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Subgrade

Soil		Bridge		Soil	
Direction	1 and 2	Direction	1 and 2	Direction	1 and 2
Section 1	278,000	Start km	280,039	Section 1	280,044
Section 2	280,039	End km	280,044	Section 2	281,000
Lenght	2039 m	Lenght	5 m	Lenght	956 m
Protective layer	yes	Type	frame structure	Protective layer	yes
Ev_2	very stiff	Material	reinforced concret	Ev_2	very stiff

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Site	DB Site No.1

Example_Corrugation / Table 2

Issue	Corrugation	in track sections with high speed (v>200 km/h) in straight line segments as well as in curves, with consequence of rail failures Belgrospi
Directory with data files	Example_Corrugation	

Line routing

Direction 1 (for example)								Data files
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_Corrugation_Line_Routing_Data_D1.xls*
								Exp_Corrugation_Line_Routing_Data_D2.xls
1	straight line	277.526	278.567	0	0	increasing max	3,0	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) for both directions (D1 and D2) is given in data files*
2	clothoid	278.567	278.843	0 - 5937,5	0 - 75			
3	curve	278.843	280.481	5937,5	75	decreasing max	-12,5	
4	curve	280.481	281.546	5597,65	75			
5	clothoid	281.546	281.821	5597,65 - 0	75 - 0	***Notice:*** *gradient is bound to direction 1*		
6	straight line	281.821	283.157	0	0			

Traffic data

	Direction of traffic	Max speed [km/h]	Load [t/week]	Data file
Direction 1	km-upwards	280	256452	*Exp_Corrugation_Traffic_Data.xls*
Direction 2	km-downwards	280	217422	
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data

Diagramms	Data file	*Exp_Corrugation_Track_Geometry_Diagramms.ppt*
Data	Data file	In Directory: *Geometry Measurements Data*
Parameter description	Data file	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for both directions D1 and D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.2 Belgrospi – Section 1

The first example section for rail failures Belgrospi is a section, which had rail renewal of both rails (right and left rail) in both directions in autumn 2007. The length of section with rail failures Belgrospi and required rail renewal was 2020 m in direction 1 and 1145 m in direction 2.

The number of rail failures Belgrospi on this section was about 30 per each direction; the failures have been placed in groups (nests) with 3 to 4 single Belgrospi rail failures.

A 733m long bridge is situated in the middle of the example section. On both sides of the bridge are short transition areas to tunnel constructions. The rail failures Belgrospi were found only outside of tunnels, but according to the constructions the rail renewal had to be done also in the neighbouring first tunnel sections.

Maximal speed of this section is 280 km/h and the line routing consists of two curves with transition curves (clothoid) and short straight line between the curves.

Example_Belgrospi_1 / Table 1

Site	**DB Site No.1**	
Issue	**Belgrospi**	Rail renewal due to rail failures Belgrospi
Directory with data files	**Example_Belgrospi_1**	

Selected example section		
	Direction	1 and 2
	Start km	197,935
	End km	199,955

Segments with Belgrospis	**Segment No.1**	
	Direction	1
	Start km	197,935
	End km	199,955
	Length [m]	2020

Segment No.2	
Direction	2
Start km	197,995
End km	199,100
Length [m]	1145

Track construction elements

	Rail				**Sleeper**			**Rail fastening**	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
197,935 - 199,955	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		**Ballast**			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
197,935 - 199,955	Zw 700	medium	Basalt	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Subgrade

Tunnel		**Bridge**		**Tunnel**		**Soil (two short sections)**	
Direction	1 and 2	Direction	1 and 2	Direction	1 and 2	Direction	1 and 2
Start km	197,155	Start km	198,127	Start km	199,035	Section 1	km197,993 - km198,127
End km	197,993	End km	198,860	End km	202,855	Section 2	km198,860 - km199,035
Lenght	838 m	Lenght	733 m	Lenght	3820 m	Lenght	134 m and 175 m
Type	flat bottom slab	Type	box girder bridge	Type	flat bottom slab	Protective layer	yes
Material	reinforced concret	Material	reinforced concret	Material	reinforced concret	Ev_2	very stiff

Site	DB Site No.1

Example_Belgrospi_1* / *Table 2

Issue	Belgrospi	Rail renewal due to rail failures Belgrospi

Directory with data files	Example_Belgrospi_1

Line routing

Direction 1 (for example)

Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]	
1	straight line		197,938	0	0	increasing max	/
2	clothoid	197,938	198,245	0 - -5102,35	0 - 90		
3	curve	198,245	198,493	-5102,35	90	decreasing max	-12,5
4	clothoid	198,493	198,800	-5102,35 - 0	90 - 0		
5	straight line	198,800	199,172	0	0	***Notice:*** *gradient is bound to direction 1*	
6	clothoid	199,172	199,479	0 - 5097,65	0 - 90		
7	curve	199,479	201,434	5097,65	90		

Data files

Exp_Belgrospi_1_Line_Routing_Data_D1.xls
Exp_Belgrospi_1_Line_Routing_Data_D2.xls

Notice:
detailed routing data with horizontal position elements, gradients and superelevation (cant) for both directions (D1 and D2) is given in data files

Traffic data

	Direction of traffic	Max speed [km/h]	Load [t/week]
Direction 1	km-upwards	280	457396
Direction 2	km-downwards	280	406840

Data file

Exp_Belgrospi_1_Traffic_Data.xls

Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data

Diagramms	**Data file**	*Exp_Belgrospi_1_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*

Notice: *there is one measurement data set respectively for years 2006 and 2007 for both directions D1 and D2*

Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.3 Belgrospi – Section 2

The second example section with rail failures Belgrospi is a section without any constructions.

This section is situated in direction 2 direct after exit of a station, which has a possibility of bifurcation of the track line. Maximal line speed is 280 km /h and the line routing in the area with rail failures Belgrospi contents a curve with radius 5500 m and a suitable transition curve (clothoid).

Example_Belgrospi_2 / Table 1

Site	**DB Site No.1**	
Issue	**Belgrospi**	Rail failures Belgrospi in a section without any constructions
Directory with data files	**Example_Belgrospi_2**	

Selected example section		
	Direction	2
	Start km	301,375
	End km	300,723

Segments with Belgrospis	**Segment No.1**
Direction	2
Start km	301,375
End km	300,723
Length [m]	652

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
301,375 - 300,723	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
301,375 - 300,723	Zw 700	medium	Basalt/Diabas	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Subgrade	
Soil	
Direction	2
Section 1	301,375
Section 2	300,723
Lenght	652
Protective layer	yes
Ev_2	very stiff

Notice: Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Site	DB Site No.1		***Example_Belgrospi_2 / Table 2***
Issue	**Belgrospi**	Rail failures Belgrospi in a section without any constructions	
Directory with data files	**Example_Belgrospi_2**		

Line routing

Direction 2								**Data files**
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_Belgrospi_2_Line_Routing_Data_D2.xls*
1	curve	299,493	300,904	5502	80	increasing max	1,5	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
2	clothoid	300,904	301,190	5502 - 0	80 - 0			
3	straight line	301,190	303,750	0	0	decreasing max		
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	Max speed [km/h]	Load [t/week]	Data file
Direction 2	km-downwards	280	254307	*Exp_Belgrospi_2_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data		
Diagramms	**Data file**	*Exp_Belgrospi_2_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.4 Head Checks - Section 1

This example section is typical section for development of rail failures Head Checks. The section is situated in a curve with radius 1600 m (in tunnel) and their transition curves (clothoid) on neighboured bridges on both sides of the tunnel in direction 2 of the DB track site 1. The maximal speed in this section is 160 km/h.

The rail failures Head Checks had been reason for some maintenance activities in this section in the past and have again achieved a damage degree, which require new rail grinding within the next year.

Example_Headchecks_1 / Table 1

Site	**DB Site No.1**	
Issue	**Headchecks**	Rail failures Head Checks in a curve with radius 1600m; low damage degree (depth 0,5 mm)
Directory with data files	**Example_Headchecks_1**	

Selected example section	**Direction**	2
	Start km	324,900
	End km	325,800

Segments with Head Checks	**Segment No.1**	
	Direction	2
	Start km	324,900
	End km	325,800
	Length [m]	900

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
324,900 - 325,800	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
324,900 - 325,800	Zw 700	medium	Basalt / Diabas	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Subgrade

Bridge Construction 1		Tunnel 2		Bridge Construction 3		Soil in two short sections 1/2 & 2/3	
Direction	2	Direction	2	Direction	2	Direction	2
Start km	324,842	Start km	325,042	Start km	325,637	Section 1/2	km324.970 - km325.042
End km	324,970	End km	325,621	End km	325,791	Section 2/3	km325.621 - km325.637
Lenght	128 m	Lenght	579 m	Lenght	154 m	Lenght	72 m and 16 m
Type	box girder bridge	Type	bottom plate	Type	box girder bridge	Protective layer	yes
Material	reinforced concret	Material	jetcrete	Material	reinforced concret	Ev_2	very stiff

Site	**DB Site No.1**	***Example_Headchecks_1 / Table 2***
Issue	**Headchecks**	Rail failures Head Checks in a curve with radius 1600m; low damage degree (depth 0,5 mm)
Directory with data files	**Example_Headchecks_1**	

Line routing

Direction 2								**Data files**
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_Headchecks_1_Line_Routing_Data_D2.xls*
1	clothoid	324,778	325,048	0 - -1600	0 - 95	increasing max	5,0	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
2	curve	325,048	325,669	-1600	95			
3	clothoid	325,669	325,939	-1600 - 0	95 - 0	decreasing max	-12,5	
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	**Max speed [km/h]**	**Load [t/week]**	**Data file**
Direction 2	km-downwards	160	390902	*Exp_Headchecks_1_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data

Diagramms	**Data file**	*Exp_Headchecks_1_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.5 Head Checks - Section 2

The second example section had rail renewal of both rails due to rail failures Head Check in year 2007. This section is situated in direction 2 in a tunnel and the line routing consists of a curve with radius 2500 m and their neighbouring transition curves (clothoid). Along this section trains increase the speed from 100 km/h up to 220 km/h. The gradient in direction 2 is increasing and with 11.2 ‰ relative high.

Example_Headchecks_2 / Table 1

Site	**DB Site No.1**	
Issue	**Headchecks**	Rail renewal due to rail failures Head Checks in a curve with radius 2500m, acceleration section with large increasing gradient in tunnel
Directory with data files	**Example_Headchecks_2**	

Selected example section	**Direction**	2
	Start km	231,250
	End km	229,300

Segments with Head Checks	**Segment No.1**	
	Direction	2
	Start km	231,250
	End km	229,300
	Length [m]	1950

Track construction elements

	Rail				**Sleeper**			**Rail fastening**	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
231,250 - 229,300	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		**Ballast**			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
231,250 - 229,300	Zw 700	medium	Basalt / Diabas	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Subgrade

Soil		**Tunnel**	
Direction	2	Direction	2
km	231,250	Start km	231,050
km	231,050	End km	223,675
Length	200 m	Length	7375 m
Protective layer	yes	Type	flat bottom slab
Ev_2	very stiff	Material	reinforced concret

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Site	DB Site No.1

Example_Headchecks_2* / *Table 2

Issue	Headchecks	Rail renewal due to rail failures Head Checks in a curve with radius 2500m, acceleration section with large increasing gradient in tunnel
Directory with data files	Example_Headchecks_2	

Line routing

Direction 2							Data files
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]	*Exp_Headchecks_2_Line_Routing_Data_D2.xls*
1	curve	222,867	227,632	7002,35	65	increasing max /	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
2	clothoid	227,632	227,855	7002.35 - 0	65 - 0		
3	straight line	227,855	229,749	0	0	decreasing max -11,22	
4	clothoid	229,749	229,940	0 - 2502.35	0 - 115		
5	curve	229,940	231,028	2502,35	115	***Notice:*** *gradient is bound to direction 1*	
6	clothoid	231,028	231,219	2502.35 - 0	115 - 0		
7	straight line	231,219	232,184	0	0		

Traffic data

	Direction of traffic	Max speed [km/h]	Load [t/week]	Data file
Direction 2	km-downwards	220	422238	*Exp_Headchecks_1_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data		
Diagramms	Data file	*Exp_Headchecks_2_Track_Geometry_Diagramms.ppt*
Data	Data file	In Directory: *Geometry Measurements Data*
Parameter description	Data file	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.6 White spots in ballast on a bridge

The following example describes a bridge with 24 white spots in ballast in direction 1. The white spots occur mostly in joints areas of bridge piers. The bridge has two expansion joints with under ballast mat in each direction (on both ends of the bridge). Sleeper type on the bridge is B 93.1.

Maximal speed on the bridge is 280 km/h. The line routing consists of a curve with radius 7000 m and the suitable transition curve (clothoid).

Example_White_Spots_1 / Table 1

Site	**DB Site No.1**	
Issue	**White Spots**	24 white spots in ballast on the bridge (in joints areas of bridge piers)
Directory with data files	**Example_White_Spots_1**	

Selected example section	**Direction**	1
	Start km	173,716
	End km	175,174

Segments with white spots	**Segment No.1**	
	Direction	1
	Start km	173,716
	End km	175,174
	Length [m]	1458

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
173,716 - 175,174	UIC 60	880	E2 *)	1:40	B 93.1	60 cm	none	W14	Skl14

*)since 2004 before grinding E1

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
173,716 - 175,174	Zw 700	medium	Basalt	37 cm	200 MN/m²	none *)

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

*) UBM only under 2 expansion joints of the bridge

Subgrade

Soil		Bridge Construction		Soil	
Direction	1	Direction	1	Direction	1
Start km	173,468	Start km	173,707	Start km	175,174
End km	173,707	End km	175,174	End km	175,348
Length m	239	Length m	1467	Length m	174
Protective layer	yes	Type	box girder bridge	Protective layer	yes
Ev_2	very stiff	Material	prestressed concret	Ev_2	very stiff

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Site	**DB Site No.1**	***Example_White_Spots_1 / Table 2***

Issue	**White Spots**	24 white spots in ballast on the bridge (in joints areas of bridge piers)

Directory with data files	**Example_White_Spots_1**

Line routing

Direction 1								**Data files**
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_White_Spots_1_Line_Routing_Data_D1.xls*
1	curve	172,546	174,948	6997,650	65	increasing max	/	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
2	clothoid	174,948	175,171	6997,65 - 0	65 - 0	decreasing max	-11,22	
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	**Max speed [km/h]**	**Load [t/week]**	**Data file**
Direction 1	km-upwards	280	457259	*Exp_White_Spots_1_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data

Diagramms	**Data file**	*Exp_White_Spots_1_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D1*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.7 White spots in ballast on a transfer line – Section 1

White spots occur frequently in station areas, which are not the stop stations for the high-speed traffic of the track site 1, but can be used as transfer line for changing of track routs.

The selected example section is a transfer line station with four white spots in the direction 2.

The line speed of the track site 1 in this section is also 280 km/h. The line routing is a straight line and with increasing gradient of 12.5 ‰ in the direction 2.

Example_White_Spots_2 / Table 1

Site	**DB Site No.1**	
Issue	**White Spots**	White spots in ballast in a station, which has been used as transfer line; v_max for the track site 1 is here 280 km/h
Directory with data files	**Example_White_Spots_2**	

Selected example section	**Direction**	2
	Start km	179,640
	End km	179,020

Segments with white spots	**Segment No.1**	
	Direction	2
	Start km	179,640
	End km	179,020
	Length [m]	620

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
179,640 - 179,020	UIC 60	880	E2	1:40	B 70	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
179,640 - 179,020	Zw 700	medium	Diabas	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft *≤ 100 kN/mm*
medium *> 100 and ≤ 400 kN/mm*
stiff *> 400 kN/mm*

Notice:
UBM *under ballast mat*

Subgrade	
Soil	
Direction	2
Start km	179,640
End km	179,020
Length m	620
Protective layer	yes
Ev_2	very stiff

Notice:
Ev_2 - modulus of static deformation
soft *≤ 60 MN/m²*
medium *> 60 and < 100 MN/m²*
stiff *≥ 100 and < 120 MN/m²*
very stiff *≥ 120 MN/m²*

Site	**DB Site No.1**

Example_White_Spots_2* / *Table 2

Issue	**White Spots**	White spots in ballast in a station, which has been used as transfer line; v_max for the track site 1 is here 280 km/h
Directory with data files	**Example_White_Spots_2**	

Line routing

Direction 2								**Data files**
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_White_Spots_2_Line_Routing_Data_D2.xls*
1	straight line	178,665	180,469	0	0	increasing max	12,5	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
						decreasing max	/	
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	**Max speed [km/h]**	**Load [t/week]**	**Data file**
Direction 2	km-downwards	280	407126	*Exp_White_Spots_2_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data

Diagramms	**Data file**	*Exp_White_Spots_2_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.8 White spots in ballast on a transfer line - Section 2

The following example section is the second example for transfer line (station) with white spots in ballast.

The selected section needs frequently ballast tamping due to track geometry faults and white spots in ballast. There are currently four white spots only in direction 2 of the selected section.

The maximal section speed is 280 km/h. The line routing is straight line with a small decreasing gradient 1,089 ‰ in direction 2.

Example_White_Spots_3 / Table 1

Site	**DB Site No.1**	
Issue	**White Spots**	White spots in ballast in a station, which has been used as transfer line; v_max for the track site 1 is here 280 km/h
Directory with data files	**Example_White_Spots_3**	

Selected example section	**Direction**	2
	Start km	160,32
	End km	160,75

Segments with white spots	**Segment No.1**	
	Direction	2
	Start km	160,32
	End km	160,75
	Length [m]	430

Track construction elements

	Rail				Sleeper			Rail fastening	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
160,750 - 160,320	UIC 60	880	E2	1:40	B 70 W	60 cm	none	W14	Skl14

Notice:
USP under sleeper pad

	Pad		Ballast			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
160,750 - 160,320	Zw 700	medium	Basalt	37 cm	200 MN/m²	none

Notice:
Dynamical pad stiffness
soft *≤ 100 kN/mm*
medium *> 100 and ≤ 400 kN/mm*
stiff *> 400 kN/mm*

Notice:
UBM *under ballast mat*

Subgrade

Soil	
Direction	2
Start km	160,320
End km	160,750
Length m	430
Protective layer	yes
Ev_2	very stiff

Notice:
Ev_2 - modulus of static deformation
soft *≤ 60 MN/m²*
medium *> 60 and < 100 MN/m²*
stiff *≥ 100 and < 120 MN/m²*
very stiff *≥ 120 MN/m²*

Site	**DB Site No.1**

Example_White_Spots_3* / *Table 2

Issue	**White Spots**	White spots in ballast in a station, which has been used as transfer line; v_max for the track site 1 is here 280 km/h
Directory with data files	**Example_White_Spots_3**	

Line routing

Direction 2								**Data files**
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_White_Spots_3_Line_Routing_Data_D2.xls*
1	straight line	157,841	161,787	0	0	increasing max	1,08957	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
						decreasing max	/	
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	**Max speed [km/h]**	**Load [t/week]**	**Data file**
Direction 2	km-downwards	280	407125	*Exp_White_Spots_3_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data		
Diagramms	**Data file**	*Exp_White_Spots_3_Track_Geometry_Diagramms.ppt*
Data	**Data file**	In Directory: *Geometry Measurements Data*
Parameter description	**Data file**	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

3.1.9 White spots in ballast on a bridge counter bearing

The last example describes a bridge with white spot on counter bearing construction only on one side of the bridge. The bridge has embedded under ballast mats since the beginning of operation of the track site.

On the opposite side of the white spot in ballast, the bridge has one expansion joint in each direction.

The white spot occurs directly on the counter bearing construction of the bridge on the side without expansion joint in the transition area to the neighbouring soil and tunnel construction. The length of the white spot is about 8.5 m (14 sleepers). The maximal line speed in this section is 280 km/h.

Site	**DB Site No.1**	***Example_White_Spots_4 / Table 1***
Issue	**White Spots**	White spot in ballast on a bridge counter bearing (on the side without expansion joint)
Directory with data files	**Example_White_Spots_4**	

Selected example section		
	Direction	2
	Start km	120,412
	End km	120,853

Segments with white spots	**Segment No.1**
Direction	2
Start km	120,850
End km	8,5
Number of sleepers	14

Track construction elements

	Rail				**Sleeper**			**Rail fastening**	
Start km - End km	Type	Quality grade	Profile	Inclination	Type	Mean span	USP	Type	Wegde clamp
120,412 - 120,853	UIC 60	880	E2*)	1:40	B 70 W	60 cm	none	W14	Skl14

*) since 2004 before grinding E1

Notice:
USP under sleeper pad

	Pad		**Ballast**			
Start km - End km	Type	Dynamical stiffness	Rock	Thickness	E-modulus	UBM
120,412 - 120,853	Zw 700	medium	Basalt	37 cm	200 MN/m²	yes

Notice:
Dynamical pad stiffness
soft ≤ 100 kN/mm
medium > 100 and ≤ 400 kN/mm
stiff > 400 kN/mm

Notice:
UBM under ballast mat

Subgrade

Bridge Construction		**Soil**		**Tunnel**	
Direction	2	Direction	2	Direction	2
Start km	120,412	Start km	120,853	Start km	120,974
End km	120,853	End km	120,974	End km	
Length m	441	Length m	121	Length m	long tunnel
Type	box girder bridge	Protective layer	yes	Type	flat bottom slab
Material	composite bridge	Ev_2	very stiff	Material	reinforced concret

Notice:
Ev_2 - modulus of static deformation
soft ≤ 60 MN/m²
medium > 60 and < 100 MN/m²
stiff ≥ 100 and < 120 MN/m²
very stiff ≥ 120 MN/m²

Site	DB Site No.1

Example_White_Spots_4 / Table 2

Issue	White Spots	White spot in ballast on a bridge counter bearing (on the side without expansion joint)
Directory with data files	Example_White_Spots_4	

Line routing

Direction 2								Data files
Element	Type	Start km	End km	Radius [m]	Superele-vation[mm]	Gradient [‰]		*Exp_White_Spots_4_Line_Routing_Data_D2.xls*
1	straight line	116,803	120,778	0	0	increasing max	0	***Notice:*** *detailed routing data with horizontal position elements, gradients and superelevation (cant) is given in data files*
2	clothoid	120,778	121,001	0 - 7004,7	0 - 65	decreasing max	0	
						Notice: *gradient is bound to direction 1*		

Traffic data

	Direction of traffic	Max speed [km/h]	Load [t/week]	Data file
Direction 2	km-downwards	280	428914	*Exp_White_Spots_4_Traffic_Data.xls*
				Notice: *detailed traffic data with number of trains and load/week in data file - for weeks: 15/2005, 43/2005, 14/2006, 43/2006, 16/2007*

Geometry measurements data		
Diagramms	Data file	*Exp_White_Spots_4_Track_Geometry_Diagramms.ppt*
Data	Data file	In Directory: *Geometry Measurements Data*
Parameter description	Data file	*Description_of_Parameter_from_Track_Geometry_ Measurements.xls*
		Notice: *there is one measurement data set respectively for years 2006 and 2007 for direction D2*
		Notice: *not all data channels from track coach measurements are stored in the data files, only the most important geometry data are saved*

4. Vehicle data

Due to the fact, that the vehicles are manufactured by external companies the exact data of the vehicle are often unknown.

The subsequent tables summarize the existing data for typical vehicles running on DB site 1. The data will be extended, if data of other vehicles or additional data are available. This first version includes the data for a typical high speed train.

Table 1 shows the definition of the coordinate system used in the data tables of the vehicles.

Table 1: Definition of coordinate systems

Direction		Coordinate
Longitudinal	traveling direction	x
Lateral		y
Vertical		z

4.1 High speed train

4.1.1 Data of coach

Table 2: Modelling data of high speed coach

Vehicle definition file	**HST-coach.def**	
Type	High speed coach, bogie MD 530, wheel distance in bogie 2.50 m	
Abbreviated designation	HST/MD530	
Mass of car body	with inventory	$4.76\ 10^4$ kg
Moment of inertia of car body	arround y-axis	$2.44\ 10^6$ kg/m^2
Mass of bogy frame		$2.98\ 10^3$ kg
Moment of inertia of bogy frame		$1.60\ 10^3$ kg/m^2
Unsprung mass of wheelset		$1.76\ 10^3$ kg
Secondary stiffness, 4 per bogy	vert. direction	$3.52\ 10^5$ N/m
Secondary damping, 2 per bogy	vert. direction	2.00 104 Ns/m
Primary stiffness, 4 per bogy	vert. direction	$9.72\ 10^5$ N/m
Primary damping, 4 per bogy	vert. direction	1.20 104 Ns/m
Distance bogy - car body (center-center)	long. direction	9.50 m
Distance between wheelsets	long. direction	2.50 m
Distance between bassinet springs	long. direction	0.56 m
Diameter of wheel		0.92 m
Length of vehicle		26.4 m

4.1.2 Data of power car

Table 3: Modelling data of high speed coach

Vehicle definition file	**HST-Powercar.def**	
Type	3.00 m	
Abbreviated designation	HST/PC	
Mass of car body		$6.08\ 10^4$ kg
Moment of inertia of car body	arround y-axis	$1.34\ 10^6$ kg/m^2
Mass of bogy frame		$5.60\ 10^3$ kg
Moment of inertia of bogy frame	arround y-axis	$2.18\ 10^4$ kg/m^2
Unsprung mass of wheelset		$2.00\ 10^3$ kg
Secondary stiffness, 4 per bogy	vert. direction	$4.44\ 10^5$ N/m
Secondary damping, 2 per bogy	vert. direction	7.60 104 Ns/m
Primary stiffness, 4 per bogy	vert. direction	$2.40\ 10^6$ N/m
Primary damping, 4 per bogy	vert. direction	5.40 104 Ns/m
Distance bogy - car body (center-center)	long. direction	5.75 m
Distance between wheelsets	long. direction	3.00 m
Distance between bassinet springs	long. direction	0.56 m
Length of vehicle		20.9 m
Diameter of wheel		1.04 m
Wheel arrangement		Bo'Bo'

4.1.3 Wheel profile after different mileages

Figure 1 shows the measured wheel profiles of a high speed train after different mileages and the resulting differences to a new profile. The diagram shows the mean profiles, which were calculated from 20 measured profiles for the different mileages.

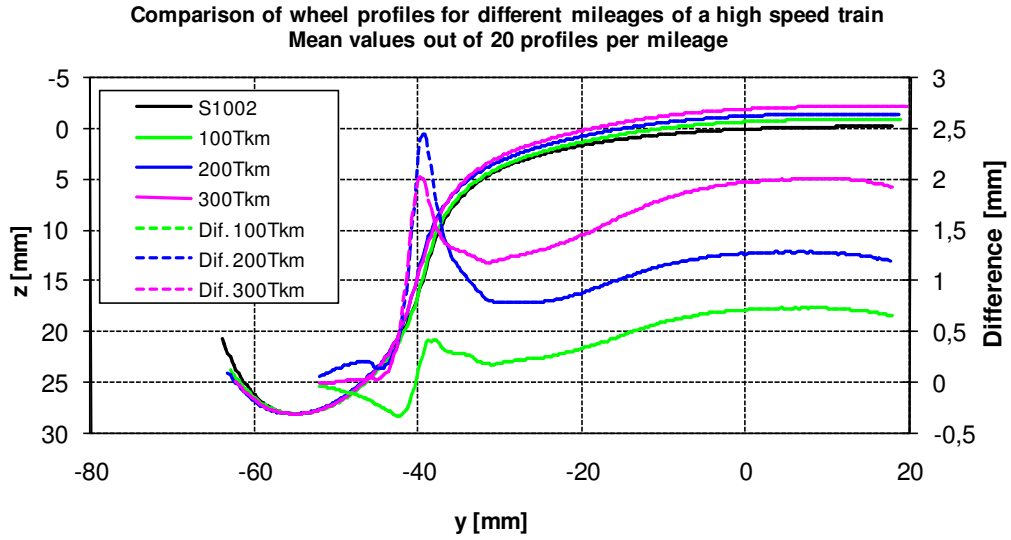

Figure 1: Wheel profiles of a high speed train for a mileage of 100.000 km, 200.000 km, 300.000 km in comparison to a new wheel (S1002)

In general the wheel profile of a high speed train will be profiled after 200.000 to 300.000 km.

4.2 Out-of-round wheels

At DB several measured out-of-round wheels were analysed in the past. It was found, that the shapes of the out-of-round wheels can be classified and clustered. Due to the fact, that the wheel is a “closed” system, the unwind for the out-of-roundness can be described in a Fourier series with the circumferences of the wheel as longest wavelength.

In a first step the measured radius of an out-of-round wheel $r(\varphi)$ will be transformed in Cartesian coordinates.

With $x = r_0 \varphi$, $\varphi = 0, ..., 2\pi$

$$\Delta z(x) = (r_0 - r(\varphi)) \qquad \varphi = 0, ..., 2\pi$$

In these equation means r_0 the nominal radius and $r(\varphi)$ the measured radius of the wheel.

To improve the subsequent performed Fourier transformation the transformed out-of-roundness $\Delta z(x)$ was periodically extended to $\Delta z_n(x)$.

$$\Delta z_n(x) = \{\Delta z(x_1), \Delta z(x_2), \Delta z(x_3), ... \Delta z(x_n)\}, \qquad x = 0, ..., n\ 2\pi\ r_0$$

The clustering approach enables a fast and standardized calculation of the vehicle track dynamics and ensures the comparability of different analyses.

Figure 2 shows the Fourier coefficients (amplitudes of harmonics) for three different clusters of out-of-round wheels. The mode numbers, according wavelengths, amplitudes and phases are given in **Table 4** in detail.

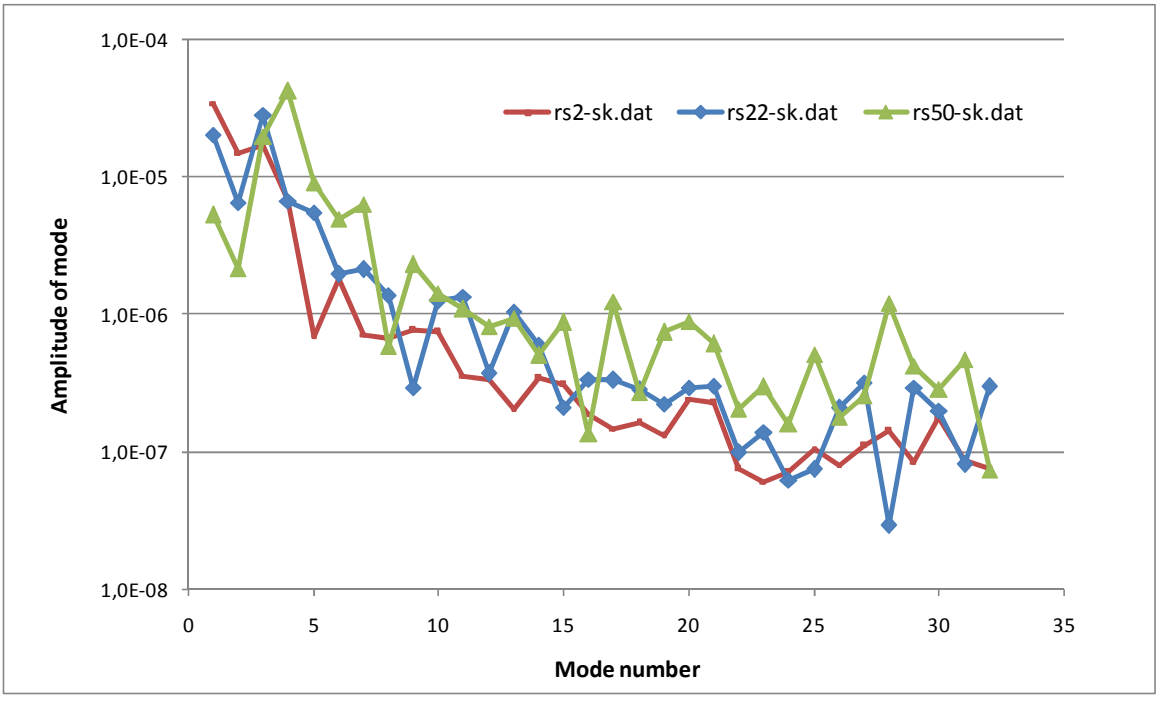

Figure 2: Fourier coefficients (amplitudes of harmonics) for three typical out-of-round wheels

Table 4: Amplitudes and phases of harmonics for 3 typical of out-of-round wheels

File		rs2-sk.dat		rs22-sk.dat		rs50-sk.dat	
Mode	Wavelength	Amplitude	Phase	Amplitude	Phase	Amplitude	Phase
1	3,00E+00	3,43E-05	2,75E+02	2,01E-05	1,86E+01	5,28E-06	2,62E+02
2	1,50E+00	1,49E-05	4,30E+02	6,50E-06	3,13E+02	2,14E-06	1,44E+01
3	1,00E+00	1,70E-05	6,06E+02	2,83E-05	5,95E+02	1,97E-05	2,26E+02
4	7,50E-01	6,86E-06	4,37E+02	6,66E-06	4,55E+02	4,20E-05	1,75E+02
5	6,00E-01	6,81E-07	6,24E+02	5,53E-06	4,61E+02	9,03E-06	2,67E+02
6	5,00E-01	1,80E-06	4,57E+02	1,94E-06	4,88E+02	4,95E-06	2,68E+01
7	4,29E-01	7,12E-07	4,21E+02	2,12E-06	4,23E+02	6,33E-06	1,41E+02
8	3,75E-01	6,63E-07	6,08E+02	1,38E-06	5,60E+02	5,81E-07	3,35E+02
9	3,33E-01	7,64E-07	4,37E+02	2,92E-07	4,68E+02	2,29E-06	7,16E+02
10	3,00E-01	7,40E-07	6,65E+02	1,25E-06	7,04E+02	1,41E-06	1,05E+03
11	2,73E-01	3,58E-07	9,18E+02	1,35E-06	8,90E+02	1,09E-06	1,32E+03
12	2,50E-01	3,38E-07	1,01E+03	3,71E-07	8,21E+02	8,16E-07	1,33E+03
13	2,31E-01	2,05E-07	1,12E+03	1,05E-06	7,80E+02	9,33E-07	1,41E+03
14	2,14E-01	3,43E-07	1,35E+03	5,97E-07	9,49E+02	5,02E-07	1,71E+03
15	2,00E-01	3,04E-07	1,58E+03	2,11E-07	8,03E+02	8,74E-07	1,65E+03
16	1,88E-01	1,89E-07	1,76E+03	3,34E-07	7,31E+02	1,34E-07	1,76E+03
17	1,77E-01	1,48E-07	1,94E+03	3,32E-07	8,69E+02	1,22E-06	1,87E+03
18	1,67E-01	1,63E-07	1,91E+03	2,81E-07	7,81E+02	2,70E-07	2,00E+03
19	1,58E-01	1,31E-07	2,10E+03	2,21E-07	8,68E+02	7,36E-07	2,12E+03
20	1,50E-01	2,41E-07	2,30E+03	2,90E-07	8,48E+02	8,90E-07	2,20E+03
21	1,43E-01	2,25E-07	2,51E+03	3,02E-07	7,47E+02	6,10E-07	2,52E+03
22	1,36E-01	7,51E-08	2,70E+03	9,75E-08	9,74E+02	2,03E-07	2,57E+03
23	1,30E-01	6,06E-08	2,68E+03	1,39E-07	8,34E+02	2,98E-07	2,74E+03
24	1,25E-01	7,12E-08	2,85E+03	6,21E-08	1,07E+03	1,59E-07	2,56E+03
25	1,20E-01	1,05E-07	3,04E+03	7,40E-08	1,25E+03	5,04E-07	2,60E+03
26	1,15E-01	8,02E-08	2,88E+03	2,07E-07	1,15E+03	1,76E-07	2,56E+03
27	1,11E-01	1,10E-07	3,03E+03	3,17E-07	1,24E+03	2,55E-07	2,55E+03
28	1,07E-01	1,42E-07	3,21E+03	2,89E-08	1,15E+03	1,19E-06	2,59E+03
29	1,03E-01	8,39E-08	3,31E+03	2,94E-07	1,14E+03	4,18E-07	2,62E+03
30	1,00E-01	1,75E-07	3,58E+03	1,97E-07	1,42E+03	2,83E-07	2,83E+03
31	9,68E-02	8,63E-08	3,84E+03	8,08E-08	1,77E+03	4,67E-07	2,90E+03
32	9,38E-02	7,40E-08	3,69E+03	2,97E-07	1,89E+03	7,26E-08	2,97E+03

4.3 Freight train

If available and validated, data for common freight trains, running on the DB site will be provided in the next version.

4.4 Regional train

If available and validated, data for common regional trains, running on the DB site will be provided in the next version.

5. Conclusions

This document describes the collected data of the DB site. These data were already provided to the project in data files (data base).

Among others it contains the following data:

- Failure description
- Track design (super and substructure)
- Line routing
- Traffic data
- Track geometry measurements
- Vehicle data
- Worn profile
- Out-of round wheels

At the moment the data of the vehicles are incomplete. The tables will be extended when more validated data are available.