The sustainable freight railway: Designing the freight vehicle – track system for higher delivered tonnage with improved availability at reduced cost

SUSTRAIL

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Leader of this deliverable:	Francis Franklin, UNEW, *on behalf of NRIC*
Prepared by:	Francis Franklin, UNEW Andrew Jablonski, NR Mirena Todorova, VTU, *in cooperation with NRIC* Enrique Mario García Moreno, ADIF
Verified by:	Paul Richards, NR

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1. INTRODUCTION

Work Package 1 of the SustRail project seeks to establish a 'zero state' benchmark for subsequent use in comparisons, and as a basis for enhancement activities and the evaluation of key system parameters. Within this work package, Task 1.2 gathers the data for the following routes:

- the Mediterranean Corridor in Spain, which is a mixed traffic electrified line in the east of Spain;
- the Bulgarian route from the Serbian border to Turkey, an intermodal connection which is part of the European "Corridor 10" project; and
- two key intermodal freight routes in the UK, from the ports of Southampton and Felixstowe to the North West of England, part of Network Rail's "Strategic Freight Network".

SustRail Deliverable D1.5 *Route summary: Logistics, local freight market and whole system economics* provides an overview and analysis of freight operations on these routes. This deliverable (D1.2) provides some complementary data on the routes. In addition, SustRail Deliverable D1.4 *Route summary: track characteristics, condition and economic data* provides a selection of more detailed infrastructure data.

The test track at Faurei, Romania, is described in detail in SustRail Deliverable D1.6 *Test track assessment and performance benchmark of key vehicle components and track and infrastructures*.

This report presents details of the principal routes including topology and additional factors which may influence freight operation. The data requested from infrastructure manager partners included:

- Core route geometry
- Track and loading gauge
- Track diagrams and coordinate systems
- Train paths and stations
- Freight loading points
- Speeds limits and restrictions
- Environmental restrictions (e.g., crosswinds, track contaminants)

The data presented here focuses on the whole routes, or significant sections of the routes, rather than looking in detail at specific points.

Additional route data: InnoTrack

In the Framework 6 project InnoTrack, Deutsche Bahn presented details of a 327km-long double-track mixed passenger/freight route. The report (Deliverable D1.2.2) covers track structure and construction, track condition (failures and faults), and an analysis of costs. It is available to the public for download from the InnoTrack website here:

http://www.innotrack.net/IMG/pdf/d122-f2p-track_sections_irregularities_analysis.pdf

2. UK ROUTE

The UK rail network has a restrictive loading gauge, compared to most of the rest of Europe, and routes are designated from W6A (the smallest) to W12 (the largest). The W10 loading gauge is particularly relevant because it allows the movement of 9½ foot (2.9m) "Hi-Cube" shipping containers using standard flat bed wagons.

Figure 2.1 shows the main freight routes in the south of England. The current high-gauge freight routes for 2011, and the expected status for the end of Control Period 4 (April 2014) is shown in Figure 2.2, and the full topographic map of the U.K. is shown in Figure 2.3. Maps of the bedrock geology near Felixstowe and Southampton are given in Figure 2.4 and Figure 2.5 respectively.

The freight traffic on these routes, forecast for 2020, is shown in Figure 2.6.

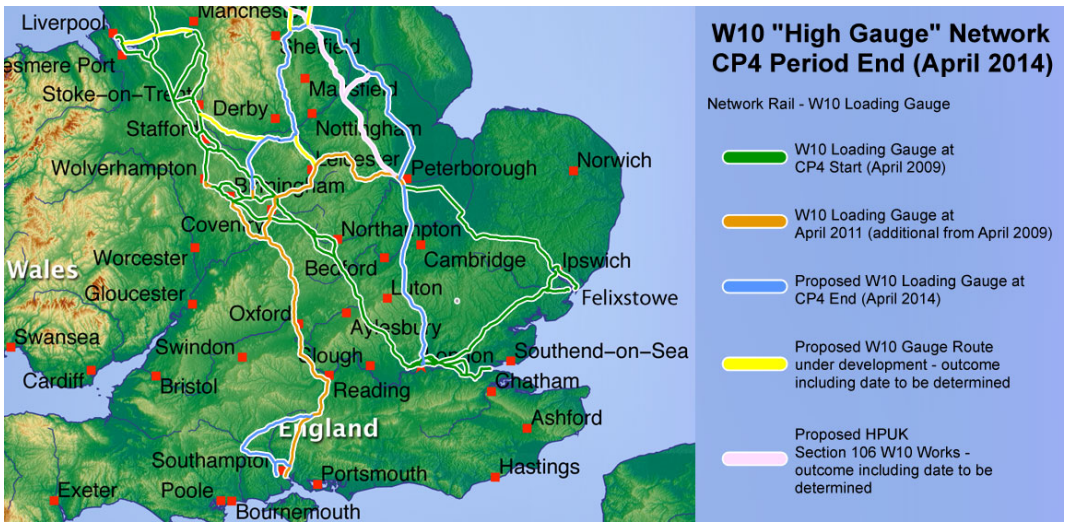


Figure 2.1 Topographic map of the UK showing planned Network Rail route status by April 2014.

Rail section:

A variety of rail sections are in use on the routes, primarily BS113A (est. 48-65%) and 60E1 (est. 16-20%).

Track gauge	1435 mm
Ballast / Subgrade	Ballast
Train control	Train Protection & Warning System (TPWS)
Signalling system	Four aspect signalling / Track circuit block
Access charges	Variable, but approx. 3 Euro/train-km for a 960 tonne freight train

Costs:

Maintenance and renewal costs for the whole of the Southampton-Nuneaton-Warrington route are approximately £18,000/km/yr and £35,000/km/yr respectively; and for the Felixstowe-Nuneaton-Warrington route the maintenance and renewal are approximately £14,000/km/yr and £24,000/km/yr respectively.

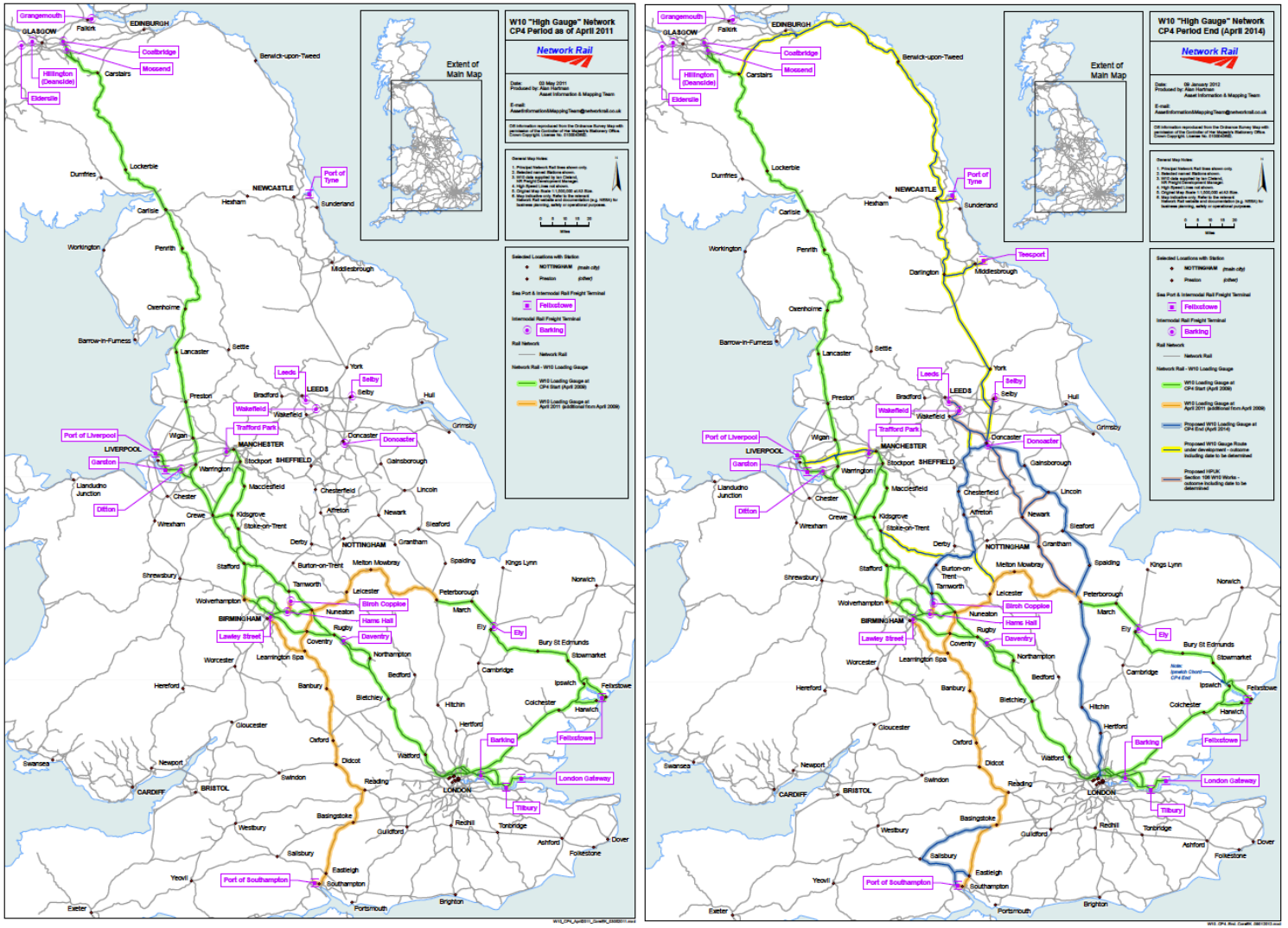


Figure 2.2 **Network Rail: Left: Routes cleared for W10 by April 2011; Right: Planned route status by end of CP4 (April 2014).**

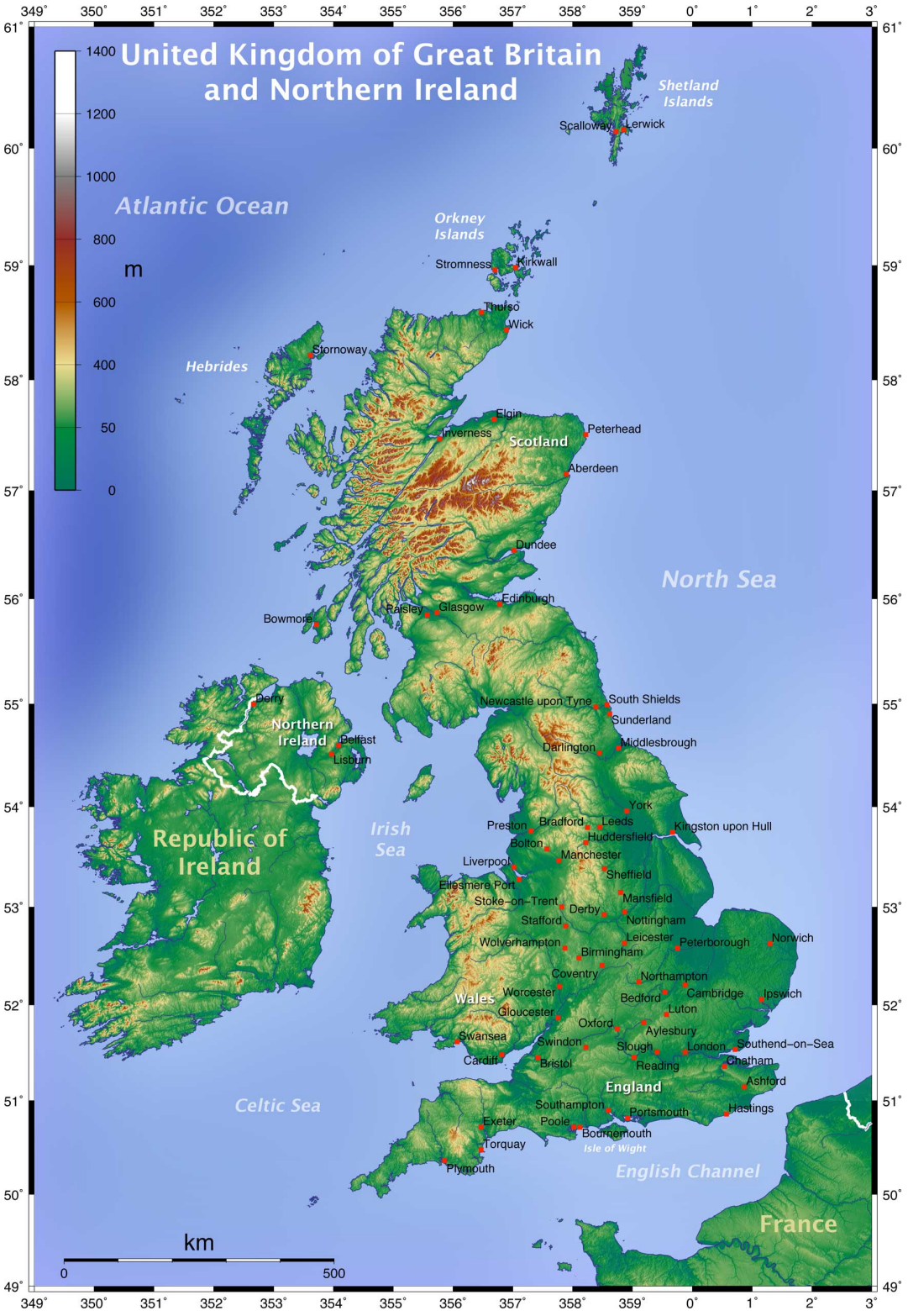


Figure 2.3 Topographic map of the UK.
[Original topographic map by **Equestenebrarum**, licensed under **Creative Commons Attribution 3.0 Unported**; see http://commons.wikimedia.org/wiki/File:Topographic_Map_of_the_UK_-_English.png.]

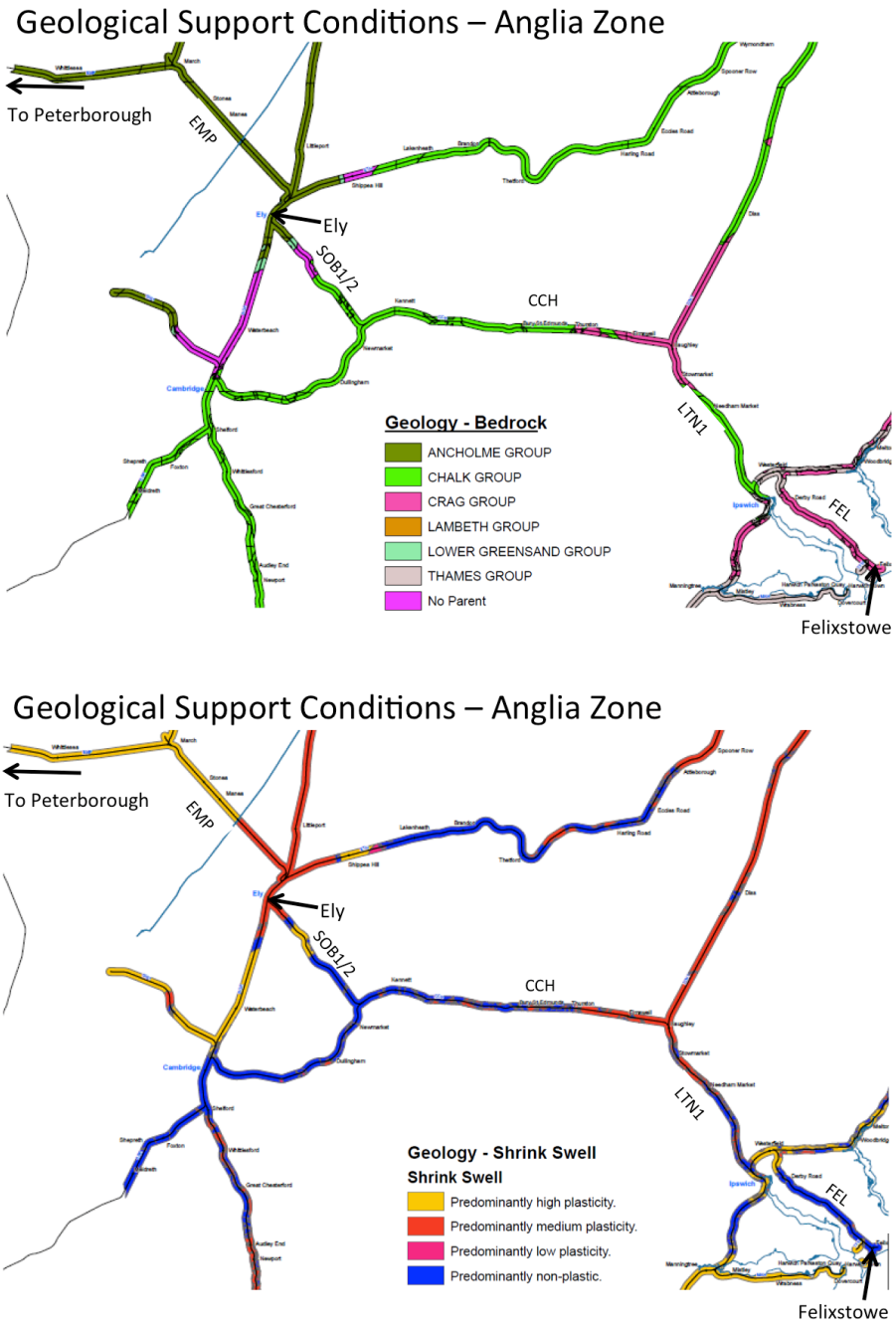


Figure 2.4 Geological support conditions – bedrock and shrink swell – near Felixstowe.

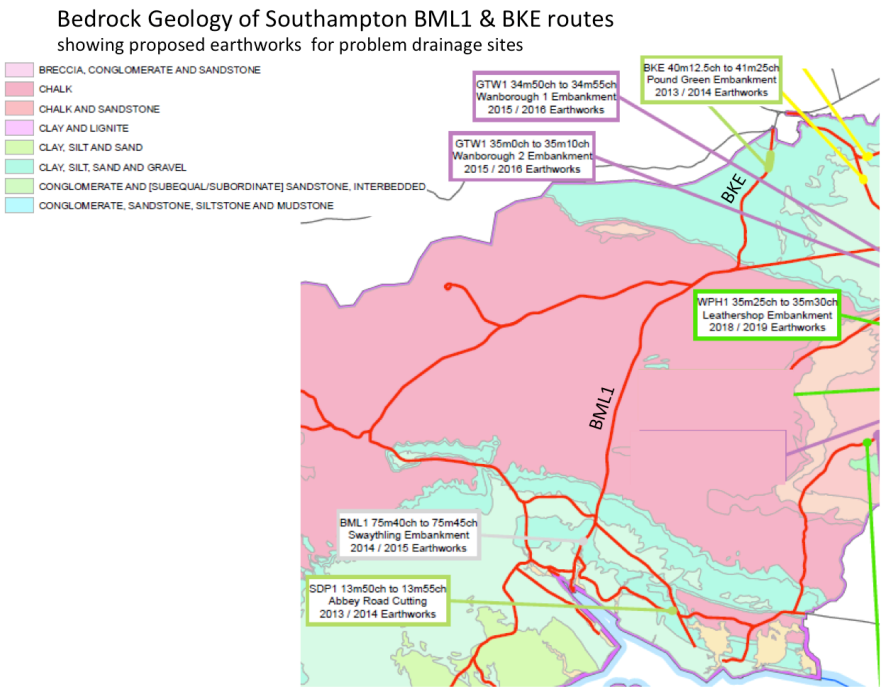


Figure 2.5 Geological support conditions – bedrock – near Southampton.

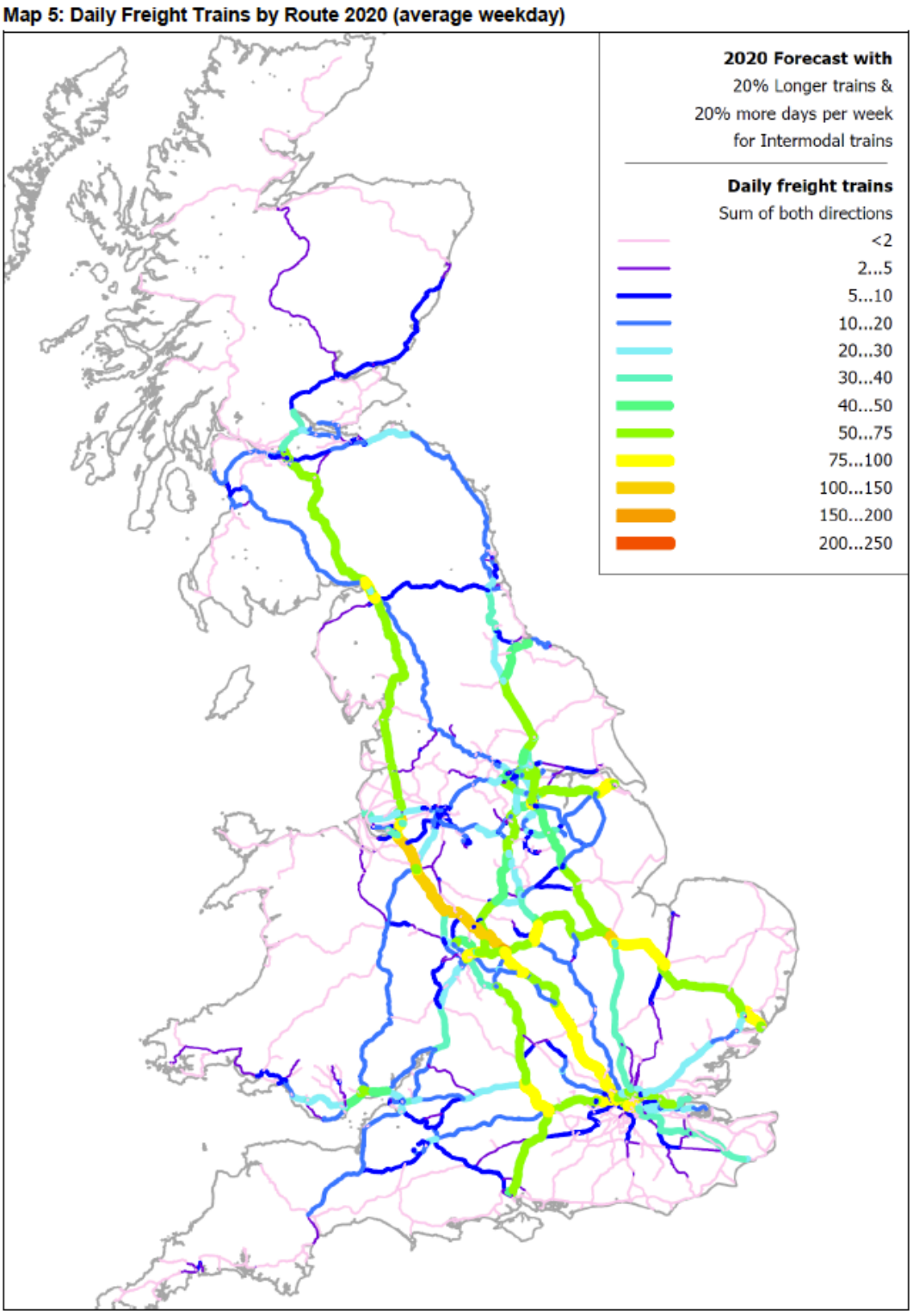


Figure 2.6 Forecast for 2020: Number of freight trains per day.
'Rail freight demand forecasts to 2030,' MDS Transmodal Limited, 2011.

2.1 Felixstowe to Nuneaton

Felixstowe is the largest container port in the UK and the deep sea container market dominates the rail freight traffic market in the area (i.e., East Anglia). Intermodal trains from Felixstowe are either bound for the North West and West Midlands via the Cross Country route, or head north once they reach the East Coast Mainline at Peterborough. However, many operators still choose to go via the North London Line which runs across the north side of London to gain access to the West Coast Mainline. Network Rail cannot force operators to use the Cross Country route, and currently every third night the Cross Country route to Nuneaton is closed for maintenance. This means that all trains to the North West are diverted south via the North London Line.

An overview of route characteristics is given in Table 2.1. Route profile is shown in Figure 2.7, and histograms of gradient, curvature and cant are given in Figure 2.8, Figure 2.9 and Figure 2.10.

Table 2.1 Overview of route characteristics, between Felixstowe and Nuneaton.

Length	256.6 km
Number of tracks	2 (Double track) - except 21 km of single track in two sections at Port and near Ely.
Minimum curve radius	400 m (at SOB2 near Ely dock Jnct)
Maximum cant	153.7 mm
Maximum gradient	1.25% (Near Westerfield Jnct 12 m from Felixstowe FEL 73.5 m)
Minimum loading gauge	W10
Maximum axle load	22.8 t (RA8 throughout)
Ground conditions	Much of the route has clay and glacial deposits making it quite soft along the way and prone to weak embankments and soft spots.
Traffic mix	Averages around 22% passenger; 78% Freight along the route; Intermodal wagons are currently 85% of total traffic near Felixstowe and 11% near Narborough.
Typical line speed	120 km/h
Electrified	Mostly not (the first 30 km is under 25kVAC overhead)
Track maintenance quality	Good
Speed restrictions:	Some stretches at 80 and 96 km/h; with 30 km/h on the 1 km out of the port.
Local environment:	Urban at port but mostly rural.
Climate conditions:	Mean daytime temperatures range from 6°C in the winter to 22°C in the summer with the highest temperature recorded of 37°C. Rainfall of around 500 mm per year.
Accidents reported:	Derailment of aggregate train on SOB2 near 12 mile at Ely dock junction on single line to Soham - 22 Jun 2007.

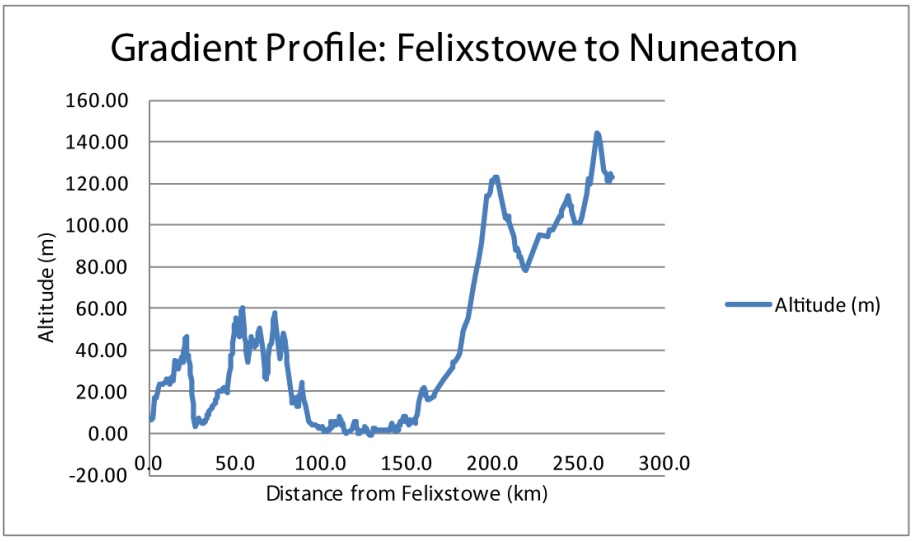


Figure 2.7 Felixstowe to Nuneaton: Altitude of route.

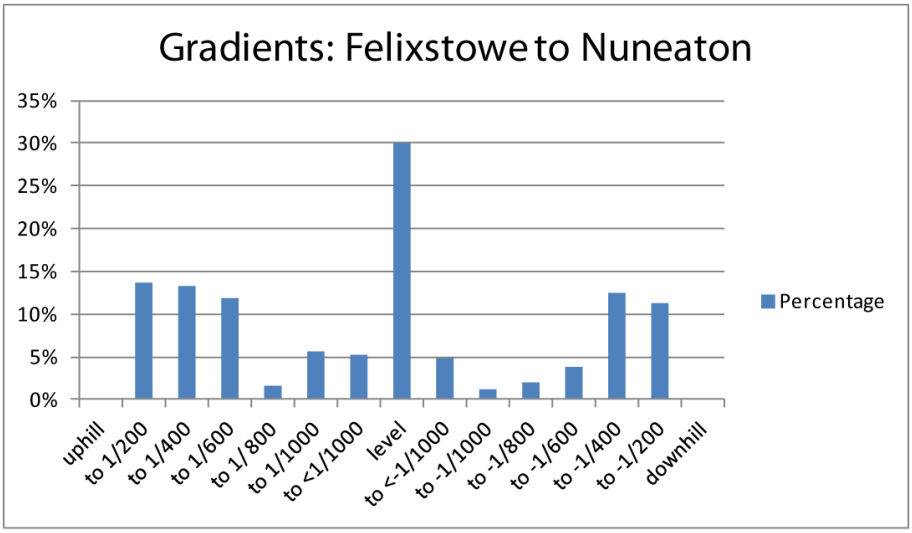


Figure 2.8 **Felixstowe to Nuneaton: Histogram of route gradient.**

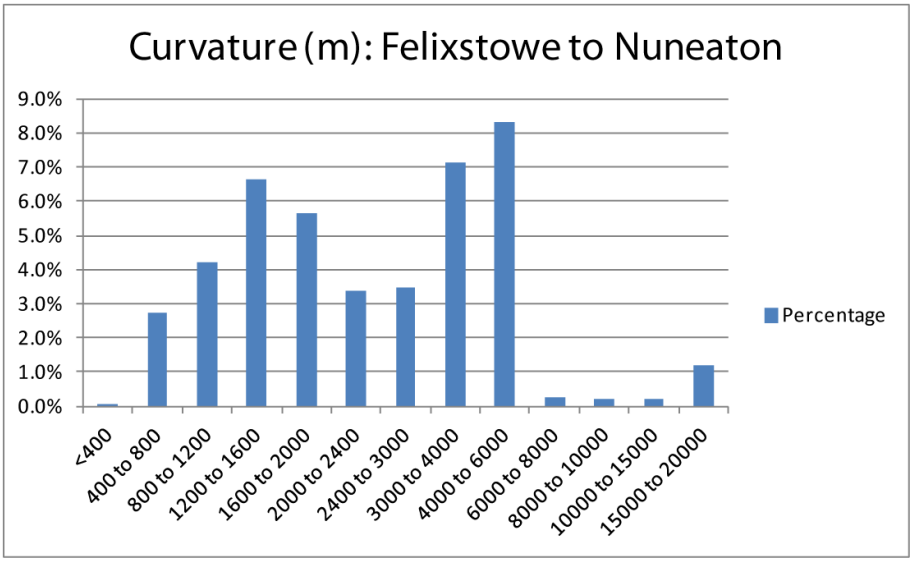


Figure 2.9 **Felixstowe to Nuneaton: Histogram of route curvature.**

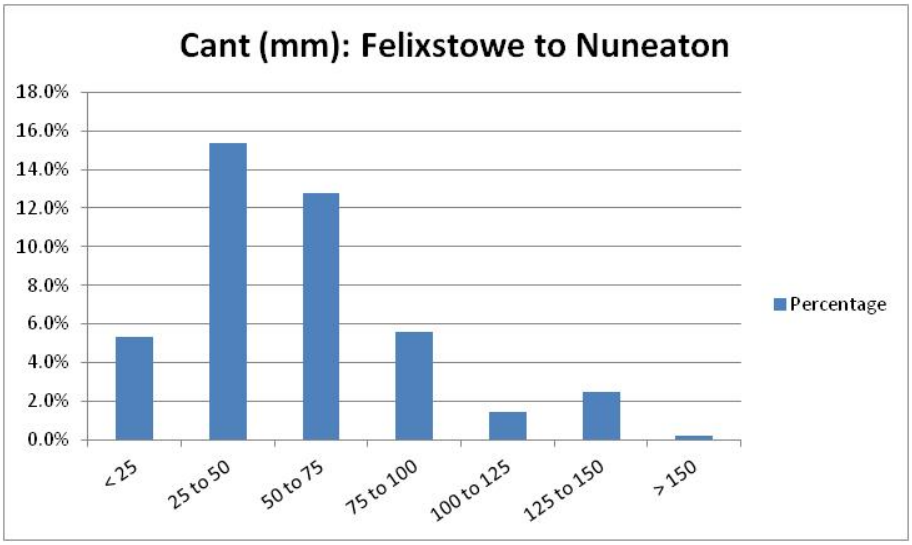


Figure 2.10 **Felixstowe to Nuneaton: Histogram of route cant.**

2.2 Southampton to Nuneaton

The sea port at **Southampton** is the UK's second largest port for container traffic and it handled 19% of the total number of container units in 2010. The port has 1,350m of quayside and handled just under 1 million containers in 2010. The traffic from Southampton generally heads northwards towards Reading on lines shared with passenger services, and it then continues on mainly shared tracks north towards Birmingham. Approximately 75% of services then go on to the West Coast Main Line and 25% go to the East Coast Main Line, splitting just west of Birmingham. Freight traffic on this line is typically container traffic travelling to Daventry, Ditton, Liverpool, Manchester, Coatbridge, Birch Coppice, Birmingham and Hams Hill.

An overview of route characteristics is given in Table 2.2. Also, overviews of the Southampton-Basingstoke and Didcot-Leamington Spa sections on this route are given in Table 2.3 and Table 2.4 respectively; profiles of these sections are given in Figure 2.11 and Figure 2.12 respectively. Histograms of gradient, curvature and cant along the Southampton-Nuneaton route are given in Figure 2.13, Figure 2.14 and Figure 2.15.

Table 2.2 Overview of route characteristics, between Southampton Port and Nuneaton on the West Coast Mainline (WCML).

Length	211.2 km	
Number of tracks	2	Double track
Minimum curve radius	300 m	On LSC2 near Coventry.
Maximum gradient	1.22%	Near Kenilworth LSC2 gradients of 1/82 for 2 km.
Minimum loading gauge	W10	
Maximum axle load	25 t	
Ground conditions	Mostly chalk, but sands near coast. Along the coast is the "Hampshire Basin", an area of relatively non-resistant Eocene and Oligocene clays and gravels; the Southern England Chalk Formation of the South Downs.	
Traffic mix	58% EMU commuter stock; 42% Freight; 26.5% of total trains are intermodal.	
Typical line speed	160 km/h	
Electrified	Mostly not	first 48km is electrified at 750V dc
Track maintenance quality	Good	
Speed restrictions:	40 km/h on first mile from the docks to the junction	
Local environment:	Urban at port with rural up to Basingstoke	
Climate conditions:	Much of the route has a mild or maritime climate which is protected against the more extreme weather of the Atlantic coast. Average annual rainfall of around 800mm is evenly distributed throughout the year. Average annual temperatures of around 10 deg C with min of -5 and max around 30 deg C.	
Contaminants:	Wooded along much of the route of the railway so prone to leaf problems in winter.	
Accidents reported:	Basingstoke, December 2008, RAIB report 21/2009: Container struck overbridge - High cube had been loaded onto the wrong flat (FIA)	

Table 2.3 Overview of BML1 section characteristics, between Southampton Port and Basingstoke.

Length	48.42 km
Number of tracks	2 (Double track)
Minimum curve radius	1300 m
Maximum gradient	0.46% (From Southampton ascending 27.6 km and descending 5.1 km at steeper than 1:400; descending.)
Minimum loading gauge	W10
Maximum axle load	25 t
Ground conditions	Mostly chalk, but sands near coast. Along the coast is the "Hampshire Basin", an area of relatively non-resistant Eocene and Oligocene clays and gravels; the Southern England Chalk Formation of the South Downs.
Traffic mix	58% EMU commuter stock; 42% Freight; 26.5% of total trains are intermodal
Typical line speed	160 km/h
Electrified	yes: 750V dc
Track maintenance quality	Good
Speed restrictions:	40 km/h on first mile from the docks to the junction
Local environment:	Urban at port with rural up to Basingstoke
Climate conditions:	Hampshire has a milder climate than most areas of the British Isles, being in the far south with the climate stabilising effect of the sea, but protected against the more extreme weather of the Atlantic coast. Hampshire has a higher average annual temperature than the UK average at 9.8 to 12 °C (50 to 54 °F), average rainfall at 741–1060 millimetres (29.2–42 in) per year, and higher than average sunshine at over 1541 hours per year.
Contaminants:	Wooded along the railway so prone to leaf problems in winter
Accidents reported:	Basingstoke - December 2008- RAIB report 21/2009 Container struck overbridge - High cube had been loaded onto the wrong flat (FIA)

Table 2.4 Overview of DCL section characteristics, between Didcot and Leamington Spa.

Length	85.55 km
Number of tracks	2 (Double track)
Minimum curve radius	400 m
Maximum gradient	0.89% (From Didcott ascending 20.05 km and descending 19.85 km at steeper than 1:400; descending.)
Minimum loading gauge	W12
Maximum axle load	22.5 t
Ground conditions	Mostly chalk, but sands near coast. The escarpment and plateau of the Cotswold Hills dominates the north-west of Oxfordshire through which DCL passes. These are formed in Jurassic shallow coastal limestones, shales and sands. The plateau surface gradually shelves southwards to Oxford, which is floored by the heavy clays of the Jurassic Oxford Clay. South of Oxford there is a low ridge of Upper Jurassic limestones and clays.
Traffic mix	33% passenger 67% Freight up to Anyho Jnct. Beyond this, 44% Passenger trains; 56% Freight.
Typical line speed	144 km/h
Electrified	No
Track maintenance quality	Good
Speed restrictions:	120 km/h through some stations.
Local environment:	Rural but passing through some towns.
Climate conditions:	The Oxfordshire and surrounding area has a maritime climate with uniform rainfall averaging 644 mm/year and average annual temperatures between 6 deg C and 14 deg C.
Contaminants:	Wooded along parts of the railway so prone to leaf problems in winter.
Accidents reported:	1. Fatality of pedestrian at Tackley level crossing. [31/03/2008 RAIB report] 2. An incident on 05/01/2006 when a JNA NLU 'Falcon' aggregate wagon from Meldon Quarry with a severe wheel flat caused two rails to break at Kennington at 61miles on DCL route just south of Oxford. Unfortunately the Wheelchex at Cholsey was switched off as ballast maintenance was taking place! [RAIB report 27/2006]

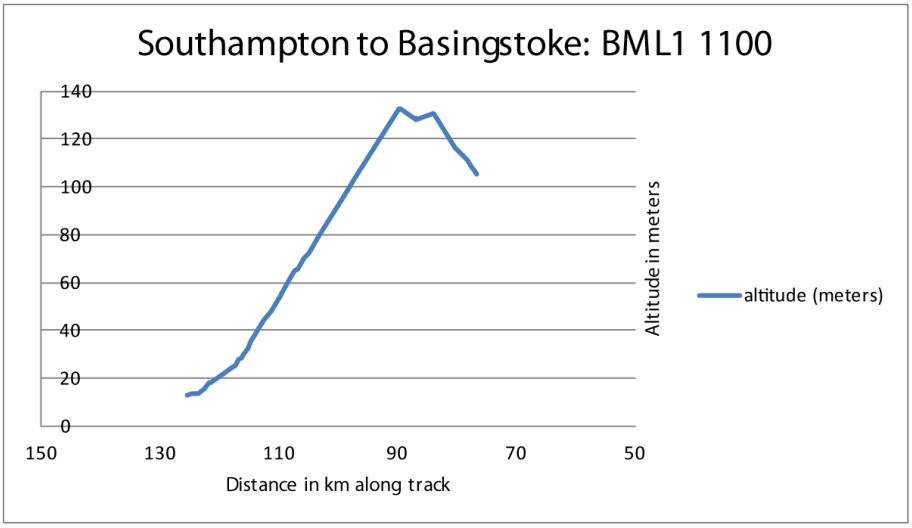


Figure 2.11 Southampton to Nuneaton: Altitude of route between Southampton and Basingstoke (from left to right).

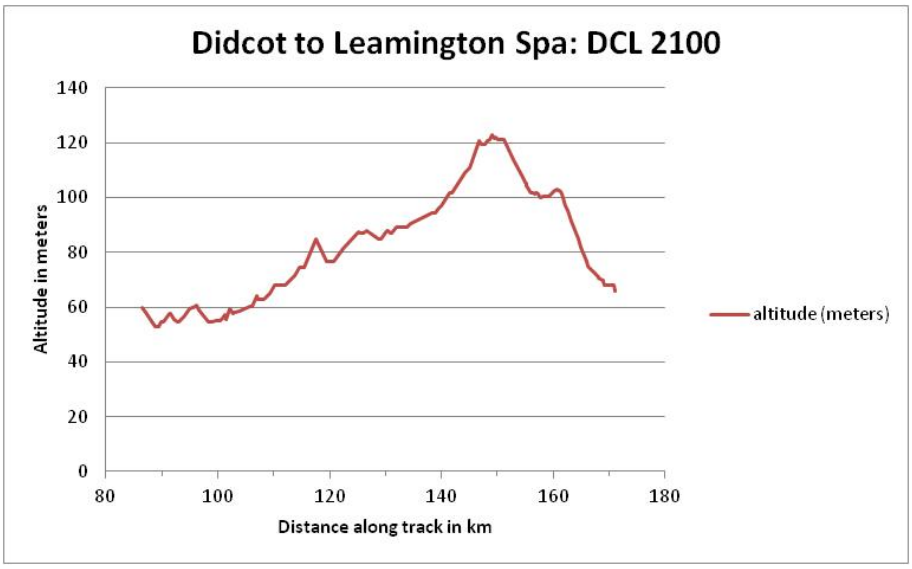


Figure 2.12 Southampton to Nuneaton: Altitude of route between Didcot and Leamington Spa.

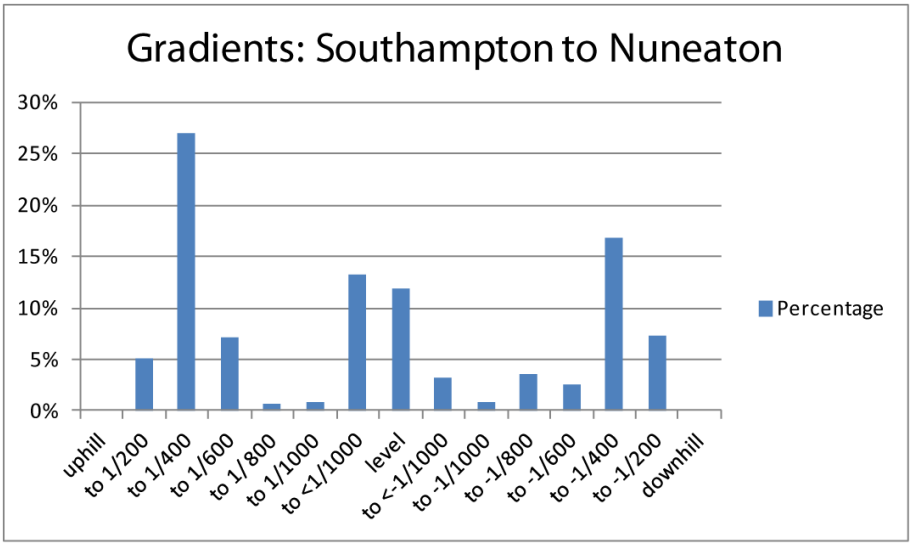


Figure 2.13 Southampton to Nuneaton: Histogram of route gradient.

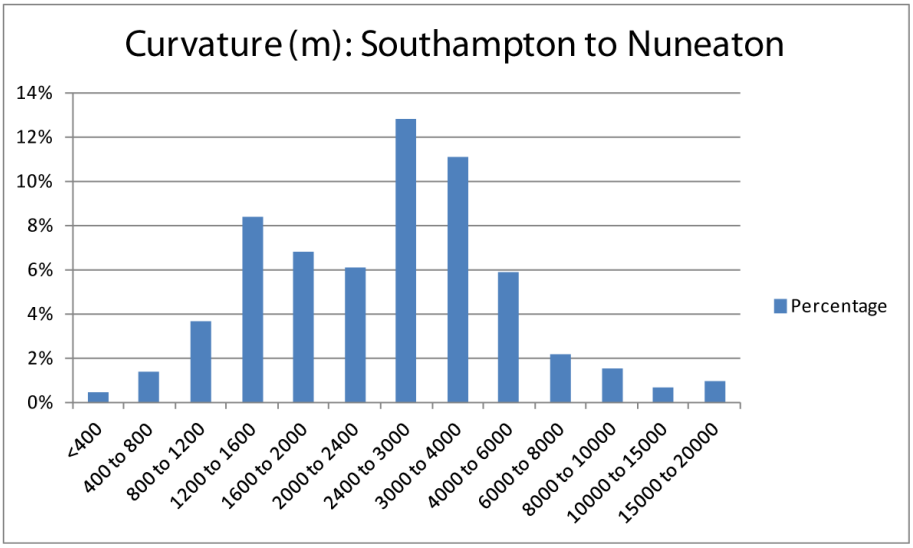


Figure 2.14 Southampton to Nuneaton: Histogram of route curvature.

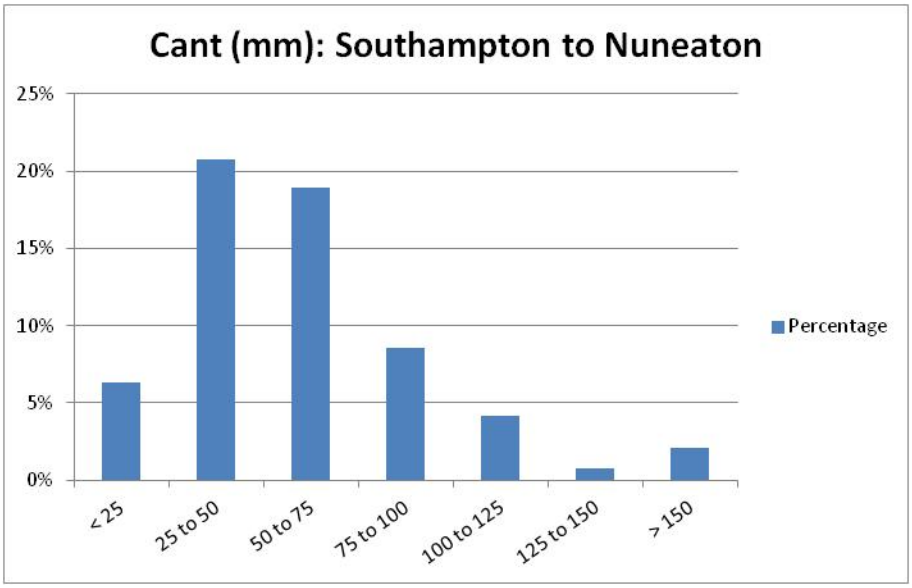


Figure 2.15 Southampton to Nuneaton: Histogram of route cant.

2.3 Ely to Peterborough (EMP)

Ely is situated to the south-east of Peterborough; both towns lie on the Felixstowe to Nuneaton route, which crosses the East Coast Mainline (ECML) just north of Peterborough. An overview of section characteristics is given in Table 2.5. Route altitude and gradient histogram are given for this section in Figure 2.16 and Figure 2.17.

Table 2.5 Overview of EMP section characteristics.

Length	45.4 km	
Number of tracks	2	Double track
Minimum curve radius	600 m	Near March
Maximum gradient	0.71%	On the approach to Peterborough
Minimum loading gauge	W10	
Maximum axle load	25 t	
Traffic mix	76% freight 24% passenger; Intermodal wagons are 37.5% of total traffic	
Typical line speed	160 km/h	
Electrified	No	
Track maintenance quality	Good	

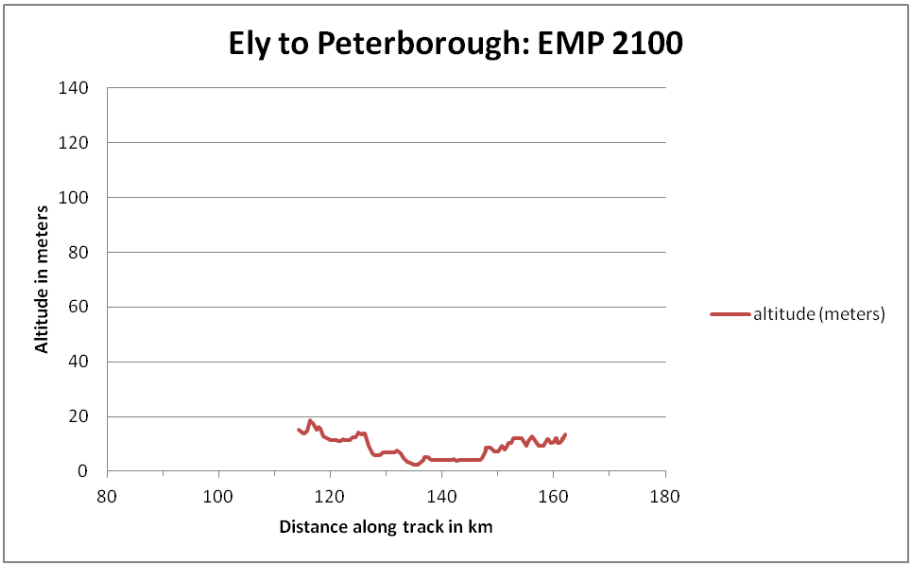


Figure 2.16 Ely to Peterborough: Altitude of route.

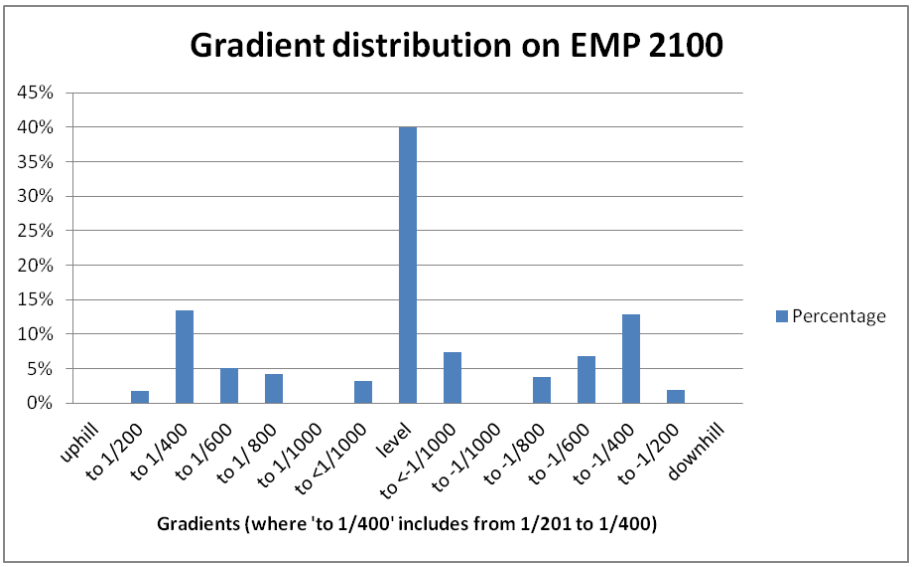


Figure 2.17 Ely to Peterborough: Histogram of route gradient.

2.4 Nuneaton to Crewe

The Southampton-Warrington and Felixstowe-Warrington routes meet at Nuneaton, where they join the West Coast Mainline (WCML) and head north via Crewe to Warrington. An overview of section characteristics is given in Table 2.1. The profile of the section between in Nuneaton and Crewe is shown in Figure 2.18, and histograms of gradient and curvature are given in Figure 2.19 and Figure 2.20.

Table 2.6 Overview of WCML section (Nuneaton to Crewe) characteristics

Length	101.62 km
Number of tracks	4 (Freight is mainly on the two slow lines)
Minimum curve radius	600 m (near 132 miles 35 ch near Trent Valley Junction)
Maximum cant	6.05 mm
Maximum gradient	0.56% (between 150 miles and 153 miles near Betley Road)
Minimum loading gauge	W10
Maximum axle load	22.8 t (RA8 throughout)
Ground conditions	The geology of Staffordshire comprises a swathe of Permian and Triassic sandstones and mudstones, which occupy much of the central and southern part of Staffordshire and older Carboniferous rocks which outcrop in the Potteries area of Stoke and form the south-west corner of the Peak District. In south and east Staffordshire the landscape becomes more undulating and is dominated by arable farming on the fertile floodplain soils of the upper Trent River. To the North of this, Cheshire covers a boulder clay plain. The bedrock of the northern region is almost entirely Triassic sandstone.
Traffic mix	Averages around 14% passenger; 84% Freight along the route; Intermodal wagons are currently 58% of total traffic
Typical line speed	120 km/h
Electrified	Yes (25 kV AC overhead)
Track maintenance quality	Very Good
Speed restrictions:	Slow Line between 120 km/h and 160 km/h
Local environment:	Mixture of rural and urban
Climate conditions:	Mean daytime temperatures range from 1°C in the winter to 21°C in the summer with the highest temperature recorded of 37°C. Rainfall of around 675mm per year.

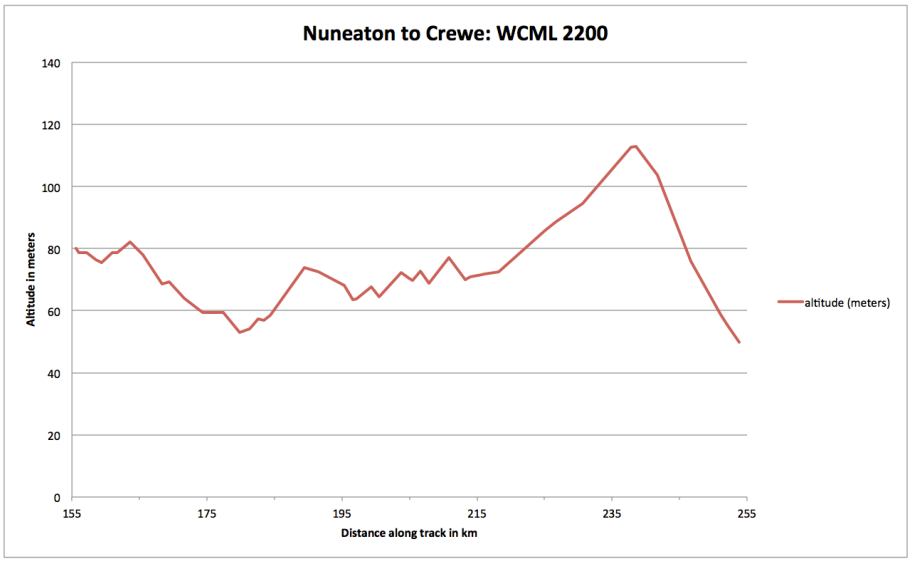


Figure 2.18 Section on WCML between Nuneaton and Crewe: Altitude of route.

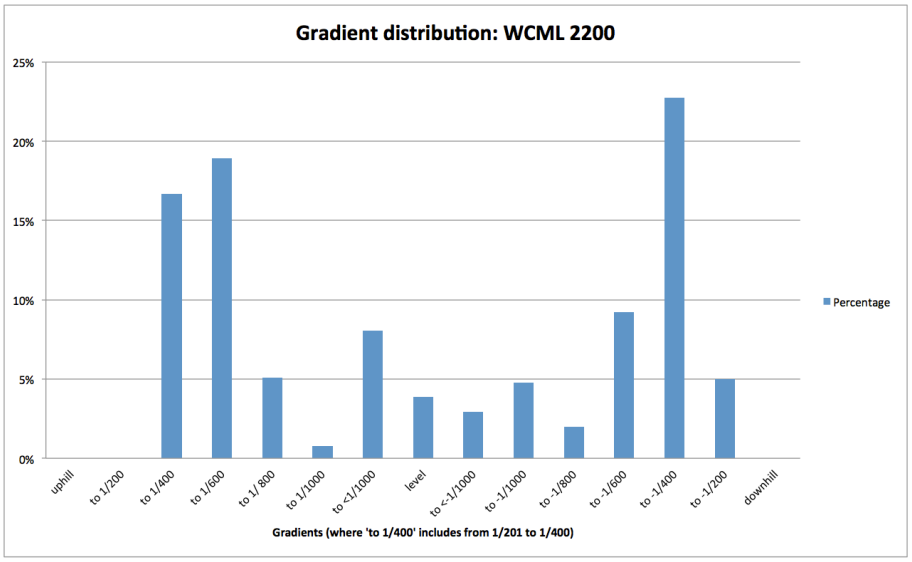


Figure 2.19 Section on WCML between Nuneaton to Crewe: Histogram of route gradient.

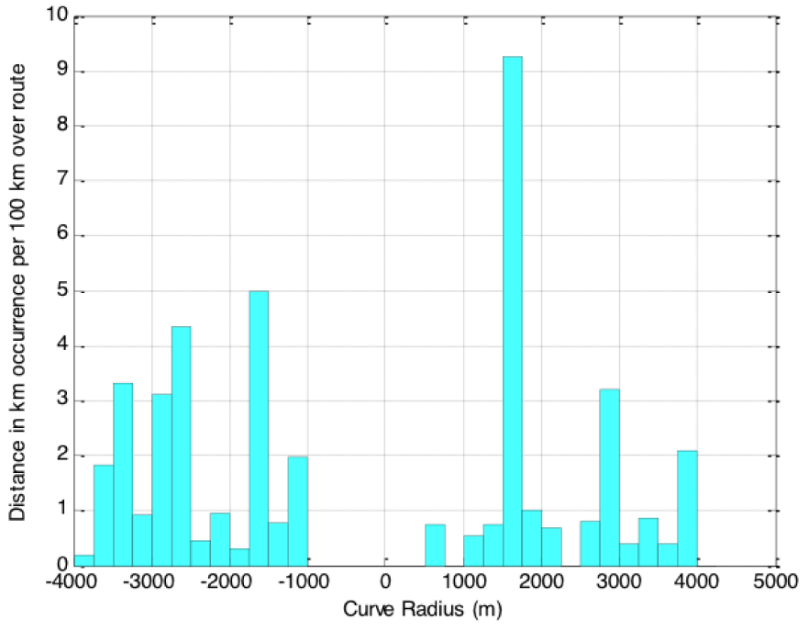


Figure 2.20 Section on WCML between Nuneaton to Crewe: Histogram of curvature.

3. BULGARIAN ROUTE

The Bulgarian route runs between the Serbian border (Kalotina in Bulgaria, by Dimitrovgrad in Serbia; note: there is another Dimitrovgrad on the route in Bulgaria just north of Haskovo) and the Turkish border (Svilengrad in Bulgaria, by Kapikule in Turkey). The traffic mix on this line is freight and passenger; freight traffic has a typical line speed of 75km/h apart from the section between Parvomaj and Jabalkovo during which freight can travel at up to 120km/h; the speed for passenger traffic on this line ranges from 65-130km/h. The line is electrified west of Plovdiv and has a combination of single and double track. The signalling on this route is controlled by colour light and cab radio, while train control is managed by automatic blocks. The freight on this line is a combination of local and international traffic. It has an operational pattern of both liner and multi-stopping services and intermediate services are carried out along the line. There are two marshalling yards on this line, one each at Poduyane and Plovdiv; Sadovo is an intermediate station where only freight operations are carried out.

As part of the European TEN-T project, intermodal terminals are planned for construction at Sofia and Plodviv, initially followed by terminals at Svilengrad and Dragoman. Plodviv is the second city in Bulgaria after Sofia and the centre of rapidly increasing commercial and agricultural trade and activity.

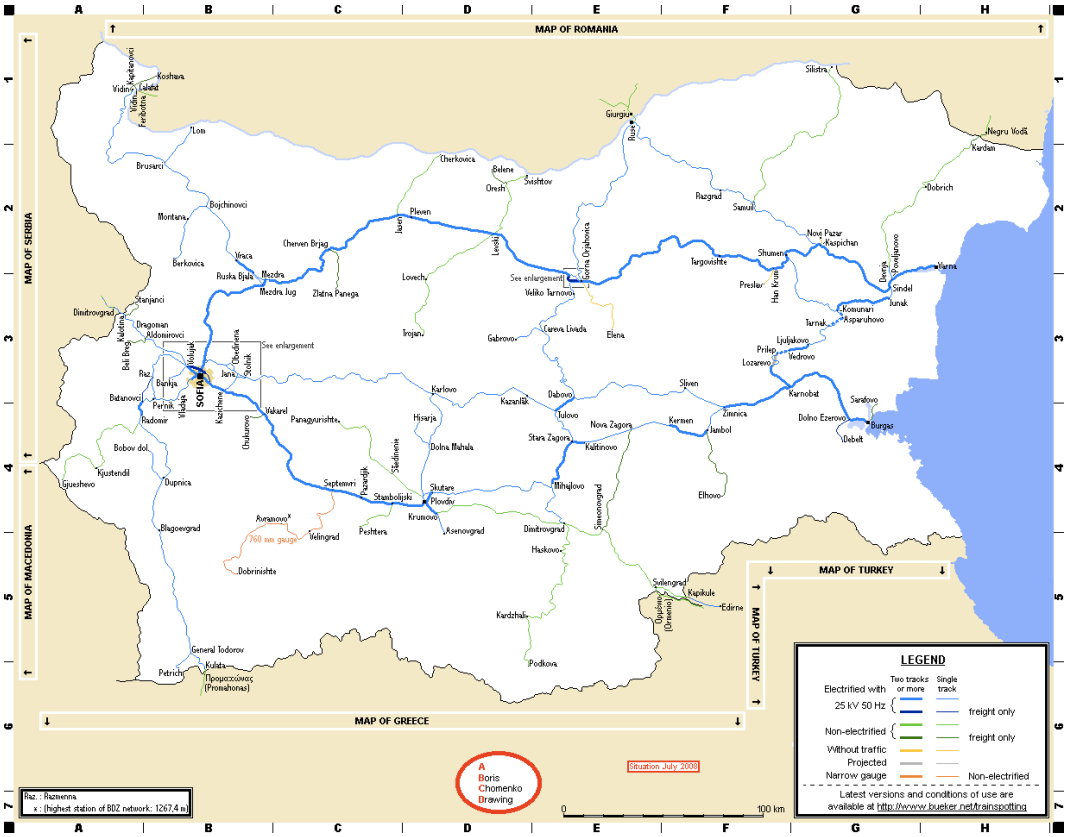


Figure 3.1 Map of Bulgarian railways.
[Map available from http://www.bueker.net/trainspotting/maps_bulgaria.php; free for non-commercial use – see webpage for details.]

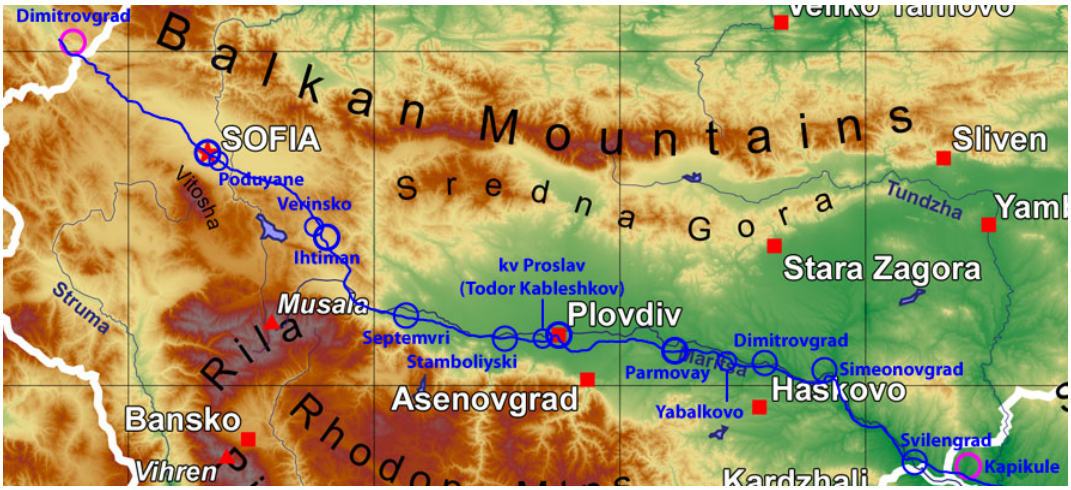


Figure 3.2 Close-up of Bulgarian route and key locations.

General characteristics for the selected route:

Track gauge	1435 mm
Rail section	49 E 1
Subgrade	ballast
Tunnels	no
Traffic mix	freight + passenger
Maximum axle load	22.5 tonnes (wagons and locomotives)

Electrification: *between Dmitrovgrad (at the Serbian border) and Krumovo (near Plovdiv)*

Nominal voltage	25 kV
Frequency	50 Hz
Maximum current permissible for trains	500 A

Signalling system:

Dimitrovgrad S – Sofia	colour light
Sofia – Krumovo	colour light & cab radio
Krumovo – Svilengrad	colour light

Train control:

Dimitrovgrad S – Sofia	relay semi automatic block system
Sofia – Podujane	direct connection with interlocking
Podujane – Krumovo	automatic block system
Krumovo – Dimitrovgrad	automatic block system with axle-counters
Dimitrovgrad – Svilengrad	relay semi automatic block system



Figure 3.3 Topography of Balkan region showing key locations on Bulgarian route between Serbian and Turkish borders.
[Original topographic map by **Equestenebrarum**, licensed under **Creative Commons Attribution 3.0 Unported**; see http://commons.wikimedia.org/wiki/File:Topographic_Map_of_Bulgaria_English.png.]

Table 3.1 Track charges

		Reservation Fee	Passing			
			Track	Signalling & communication	Traction power network	Traffic control
		Leva / train-km	Leva / (gross-)tonne-km	Leva / train-km	Leva / train-km	Leva / train-km
passenger trains	fast, regional and suburban	0.2654	0.0016	0.2283	0.1305	0.7284
	international trains	0.531	0.0031	0.4566	0.2609	1.4567
freight trains	freight	0.9997	0.0033	0.4678	0.3668	2.0534
	container block trains	0.6998	0.0023	0.3275	0.2567	1.4375
	vehicle block trains	0.3392	0.0011	0.1587	0.1244	0.6968

Using exchange rate 1 Euro = 1.95583 Leva:

		Reservation Fee	Passing			
			Track	Signalling & communication	Traction power network	Traffic control
		Euro / train-km	Euro / (gross-)tonne-km	Euro / train-km	Euro / train-km	Euro / train-km
passenger trains	fast, regional and suburban	0.1357	0.0008	0.1167	0.0667	0.3724
	international trains	0.2715	0.0016	0.2335	0.1334	0.7448
freight trains	freight	0.5111	0.0017	0.2392	0.1875	1.0499
	container block trains	0.3578	0.0012	0.1674	0.1312	0.7350
	vehicle block trains	0.1734	0.0006	0.0811	0.0636	0.3563

Table 3.2 Stations on Bulgarian route – Sofia division

NAME	Type of station	Number IOT	Number IT, OT,CT	Possibility of loading and unloading	Connection with industrial branches	Crossing near the station	Border station with the transition	Type of safety equipment in the station
KALOTINA - ZAPAD	FO	2		NO	NO	NO	Serbia	RRI
KALOTINA	FO	2		NO	NO	YES		EMI
DRAGOIL	FO	2		NO	NO	NO		EMI
DRAGOMAN	SO	5	0,2,0	YES	NO	YES	Serbia	EMI
ALDOMIROVCI	FO	3		NO	NO	NO		EMI
SLIVNICA	FO	3	0,1,0	YES	YES	YES		EMI
PETARCH	FO	2		NO	NO	YES		EMI
KOSTINBROD	FO	4		YES	YES	YES		EMI
VOLUJAK	SO	7	0,2,0	YES	YES	NO		RRI
SOFIA	Passenger	14		NO	YES	NO		RRI
PODUJANE	FO	2		NO	YES	NO		RRI
PODUJANE -	Marshalling yard	5	7,5,33	YES	YES	NO		RRI
ISKAR	SO	6		YES	YES	NO		RRI
KAZICHENE	FO	4	0,1,0	YES	YES	YES		RRI
ELIN PELIN	FO	4		YES	YES	NO		RRI
POBIT KAMAK	PII	2		NO	NO	NO		RRI
VAKAREL	FO	7		NO	NO	YES		RRI
VERINSKO	FO	4		NO	NO	YES		RRI
IHTIMAN	FO	4		YES	YES	YES		RRI
KOSTENEC	FO	4		YES	YES	NO		RRI
BELOVO	FO	3	0,1,0	YES	YES	YES		RRI

Legend	IOT	Inbound-outbound a tracks	EMI	electro mechanical interlocking
	IT	Inbound tracks	RRI	route relay interlocking
	OT	Outbound tracks	RCI	route computing interlocking
	CT	Classification tracks	SO	station with shunting operation
	TMTSO	Traffic management, train and station operations	FO	station few load/upload operation

Table 3.3 Stations on Bulgarian route – Plovdiv division

NAME	Type of station	Number IOT	Number IT, OT,CT	Possibility of loading and unloading	Connection with industrial branches	Crossing near the station	Border station with the transition	Type of safety equipment in the station
SEPTEMVRI	SO end station	6(3)		YES	YES	YES		RCI/ NO
PAZARDZHIK	FO	4		YES	YES	NO		RRI
OGNJANOVO	SO	4		YES	YES	NO		RRI
STAMBOLIJSKI	SO	6	0,1,0	YES	YES	YES		RRI
TODOR KABLESHKOV	FO	4	0,3,0	NO	NO	YES		RRI
PLOVDIV	Passenger	10		YES	YES	NO		RRI
PLOVDIV -	Marshalling yard	10	0,0,15	YES	YES	NO		RRI
KRUMOVO	SO	4		YES	NO	YES		RRI
KATUNICA	FO	1		NO	YES	YES		EMI
POPOVICA	FO	2		NO	NO	YES		EMI
PARVOMAJ	FO	2		YES	YES	YES		EMI
SKOBELEVO	FO	2		NO	NO	YES		EMI
JABALKOVO	FO	2	0,1,0	YES	YES	YES		EMI
DIMITROVGRAD	SO - Marshalling yard	7	4,0,12	YES	YES	NO		RRI
NOVA NADEZHDA	FO	3		NO	NO	YES		EMI
SIMEONOVGRAD	FO	4		NO	NO	YES		EMI
HARMANLI	FO	3		YES	YES	NO		EMI
LJUBIMEC	FO	2		YES	YES	YES		EMI
SVILENGRAD	SO	5	0,1,0	YES	YES	NO	Turkey and Greece	EMI

Legend				
	IOT	Inbound-outbound a tracks	EMI	electro mechanical interlocking
	IT	Inbound tracks	RRI	route relay interlocking
	OT	Outbound tracks	RCI	route computing interlocking
	CT	Classification tracks	SO	station with shunting operation
	TMTSO	Traffic management, train and station operations	FO	station few load/upload operation

Table 3.4 Bulgarian route (Sofia division): trains operating on route

Railway section	Distance	Trains passed	All		Fast Trains (FT)		Regional Trains (RT)		Suburban Trains (ST)		International Fast Trains (IT)		Freight Trains (FrT)		Local Freight Trains (LFT)		Shunting Trains (SHT)		Working Trains (WT)	Labour Service Trains (LST)		International Freight Trains (IFT)	
DIMITROVGRAD JS | KALOTINA ZAPAD	6.5	66	33	33	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	2	2	26	26
KALOTINA ZAPAD | KALOTINA	1.8	66	33	33	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	2	2	26	26
KALOTINA | ДРАГОИЛ	4.4	71	36	35	0	0	0	0	0	0	5	5	3	2	0	0	0	0	0	2	2	26	26
DRAGOIL | DRAGOMAN	7.4	71	36	35	0	0	0	0	0	0	5	5	3	2	0	0	0	0	0	2	2	26	26
DRAGOMAN | ALDOMIROVCI	7.1	84	43	41	0	0	1	2	6	4	5	5	3	2	0	0	1	1	0	0	0	27	27
ALDOMIROVCI | SLIVNICA	7.6	87	44	43	0	0	1	2	6	4	5	5	4	4	0	0	1	1	0	0	0	27	27
SLIVNICA | PETARCH	6	87	44	43	0	0	1	2	6	4	5	5	4	4	0	0	1	1	0	0	0	27	27
PETARCH | KOSTINBROD	6.9	87	44	43	0	0	1	2	6	4	5	5	4	4	0	0	1	1	0	0	0	27	27
KOSTINBROD | VOLUJAK	6.9	87	44	43	0	0	1	2	6	4	5	5	4	4	0	0	1	1	0	0	0	27	27
VOLUJAK | SOFIA	7.8	95	45	50	0	1	1	2	17	14	5	5	0	6	0	0	1	1	0	0	1	21	20
SOFIA | PODUJANE	3.4	103	50	53	14	14	7	8	0	0	4	4	2	6	0	0	1	1	0	1	0	21	20
PODUJANE | ISKAR	6.1	104	51	53	14	14	7	8	0	0	4	4	3	5	1	1	2	2	0	1	0	19	19
ISKAR | KAZICHENE	4.9	100	49	51	14	14	7	8	0	0	4	4	3	5	1	1	0	0	0	1	0	19	19
KAZICHENE | ELIN PELIN	9.5	91	46	45	11	11	7	8	0	0	4	4	3	2	1	1	0	0	0	1	0	19	19
ELIN PELIN | POBIT KAMAK	6.1	91	46	45	11	11	7	8	0	0	4	4	3	2	1	1	0	0	0	1	0	19	19
POBIT KAMAK | VAKAREL	9.3	91	46	45	11	11	7	8	0	0	4	4	3	2	1	1	0	0	0	1	0	19	19
VAKAREL | VERINSKO	8.8	89	45	44	11	11	7	8	0	0	4	4	2	1	1	1	0	0	0	1	0	19	19
VERINSKO | IHTIMAH	8.4	89	45	44	11	11	7	8	0	0	4	4	2	1	1	1	0	0	0	1	0	19	19
IHTIMAH | NEMIROVO	9.1	89	45	44	11	11	7	8	0	0	4	4	2	1	1	1	0	0	0	1	0	19	19
NEMIROVO | KOSTENEC	8.7	89	45	44	11	11	7	8	0	0	4	4	2	1	1	1	0	0	0	1	0	19	19
KOSTENEC | SESTRIMO	10.6	90	45	45	11	11	7	8	1	1	4	4	2	1	1	1	0	0	0	0	0	19	19
SESTRIMO | BELOVO	8	90	45	45	11	11	7	8	1	1	4	4	2	1	1	1	0	0	0	0	0	19	19
БЕЛОВО | SEPTEMVRI	9.9	90	45	45	11	11	7	8	1	1	4	4	2	1	1	1	0	0	0	0	0	19	19

Table 3.5 Bulgarian route (Plovdiv division): trains operating on route

Railway section	Distance	Trains passed	All		Fast Trains (FT)		Regional Trains (RT)		Suburban Trains (ST)		International Fast Trains (IT)		Freight Trains (FrT)		Local Freight Trains (LFT)		Shunting Trains (SHT)		Working Trains (WT)	Labour Service Trains (LST)		International Freight Trains (IFT)	
SEPTEMVRI | PAZARDZHIK	16.1	85	43	42	11	11	3	4	3	2	4	4	2	1	1	1	0	0	0	0	0	19	19
PAZARDZHIK | OGNJANOVO	9.1	87	44	43	11	11	3	4	4	3	4	4	2	1	1	1	0	0	0	0	0	19	19
OGNJANOVO | STAMBOLIJSKI	10.1	90	46	44	11	11	3	4	4	3	4	4	4	2	1	1	0	0	0	0	0	19	19
STAMBOLIJSKI | TODOR KABLESHKOV	9.1	102	52	50	11	11	3	4	10	9	4	4	4	2	1	1	0	0	0	0	0	19	19
TODOR KABLESHKOV | PLOVDIV	8.6	102	52	50	11	11	3	4	10	9	4	4	4	2	1	1	0	0	0	0	0	19	19
PLOVDIV | POR	3.7	108	54	54	2	2	3	4	23	24	4	4	2	1	0	0	0	1	1	0	0	19	18
POR | KRUMOVO	4.6	74	37	37	2	2	3	4	6	7	4	4	2	1	0	0	0	1	1	0	0	19	18
KRUMOVO | KATUNICA	4.9	73	36	37	2	2	3	4	6	7	4	4	1	1	0	0	0	1	1	0	0	19	18
KATUNICA | POPOVICA	16.7	73	36	37	2	2	3	4	6	7	4	4	1	1	0	0	0	1	1	0	0	19	18
POPOVICA | PARVOMAJ	15.4	73	36	37	2	2	3	4	6	7	4	4	1	1	0	0	0	1	1	0	0	19	18
PARVOMAJ | KARADZHALOVO	6.2	63	32	31	2	2	3	4	3	2	4	4	1	1	0	0	0	0	0	0	0	19	18
KARADZHALOVO | JABALKOVO	13.4	63	32	31	2	2	3	4	3	2	4	4	1	1	0	0	0	0	0	0	0	19	18
JABALKOVO | DIMITROVGRAD	13	63	32	31	2	2	3	4	3	2	4	4	1	1	0	0	0	0	0	0	0	19	18
DIMITROVGRAD | NOVA NADEZHDA	12.1	65	33	32	0	0	3	4	1	0	4	4	1	1	1	1	0	0	0	0	0	23	22
NOVA NADEZHDA | SIMEONOVGRAD	10.8	65	33	32	0	0	3	4	1	0	4	4	1	1	1	1	0	0	0	0	0	23	22
SIMEONOVGRAD | HARMANLI	15.2	65	33	32	0	0	3	4	1	0	4	4	1	1	1	1	0	0	0	0	0	23	22
HARMANLI | LJUBIMEC	16.4	65	33	32	0	0	3	4	1	0	4	4	1	1	1	1	0	0	0	0	0	23	22
LJUBIMEC | SVILENGRAD	11.1	65	33	32	0	0	3	4	1	0	4	4	1	1	1	1	0	0	0	0	0	23	22
SVILENGRAD | KAPIKULE	20.7	65	33	32	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	2	2	27	26

Table 3.6 Infrastructure overview (track type, curves, gradients)

station	station	Length (km)	Number of tracks	Track	Track type JT = Jointed	Sleepers	Minimum curve radius	length	number	Maximum gradient ‰	length (m)	Minimum gradient	length (m)	GTW gradient
DIMITROVGRAD S	KALOTINA - ZAPAD	0.8	1	1	JT	CT 4	400	223	1	-7.2	175	-7.2	175	11/0
KALOTINA - ZAPAD	KALOTINA	2	1	1	JT	CT 4,wood	301	504	1	-20.0	2030	-20.5	380	23/0
KALOTINA	DRAGOIL	4.251	1	1	JT	CT 4,wood	303	180	1	-10.0	180	-20.0	3890	23/10
DRAGOIL	DRAGOMAN	7.469	1	1	JT	CT 4,wood	300	635	10	8.5	650	-21.0	630	16/19
DRAGOMAN	ALDOMIROVCI	7.052	1	1	JT	CT 4,wood	300	539	1	18.5	1020	-14.0	1100	16/21
ALDOMIROVCI	SLIVNICA	7.653	1	1	JT, CWR	CT 4,wood	495	328	1	20.5	320	0.0	740	0/7
SLIVNICA	PETARCH	5.966	1	1	JT, CWR	CT 4	1000	425	2	6.6	800	0.0	660	0/8
PETARCH	KOSTINBROD	6.85	1	1	JT	CT 4,wood	725	540	1	7.0	770	0.0	1120	0/6
KOSTINBROD	VOLUJAK	6.966	1	1	JT	CT 4,wood	1000	412	1	6.2	500	-11.0	400	3/4
VOLUJAK	SOFIA	7.793	2	1	JT	CT 4T	550	248	2	9.7	344	-7.6	349	3
				2	JT	CT 4T	600	250	3	9.2	366	-8.2	325	8
SOFIA	PODUJANE	3.265	2	1	JT	CT 4	650	380	1	2.2	300	-9.6	238	1
				2	JT	CT 4,wood	650	371	1	2.2	300	-9.6	238	2
PODUJANE	ISKAR	6.041	2	1	JT	CT 4	1000	295	1	5	470	-1	312	5
				2	JT, CWR	CT 4, CT 6	1000	593	1	5.1	721	-0.7	521	2
ISKAR	KAZICHENE	5.047	2	1	JT, CWR	CT 4	10000	78	2	3	400	-3	600	2
				2	JT, CWR	CT 4	1550	181	1	3	400	-3	300	1
KAZICHENE	ELIN PELIN	9.321	2	1	JT, CWR	CT 4	5000	115	4	4.6	650	-1	1200	5
				2	JT, CWR	CT 4				4.6	650	-1	1200	0
ELIN PELIN	POBIT KAMAK	6.314	2	1	JT, CWR	CT 4, CT 6	1085	232	1	19.9	477	0	655	21
				2	JT, CWR	CT 4	1075	233	1	18.2	300	0	700	1
POBIT KAMAK	VAKAREL	9.284	2	1	JT	CT 4, CT 4T, CT 6, wood	290	578	1	25	1015	-0.4	244	29
				2	JT	CT 4, CT 4T, CT 6	300	838	1	25	975	13.5	200	26

station	station	Length (km)	Number of tracks	Track	Track type JT = Jointed	Sleepers	Minimum curve radius	length	number	Maximum gradient ‰	length (m)	Minimum gradient	length (m)	GTW gradient
VAKAREL	VERINSKO	8.881	2	1	JT, CWR	CT 4, CT 6, wood	496	761	1	0	840	-24.9	1320	0
				2	JT, CWR	CT 4, CT 6	500	765	2	0	840	-24.9	1320	11
VERINSKO	IHTIMAN	8.361	2	1	JT, CWR	CT 4,wood	800	1,656	2	0	400	-12	260	0
				2	JT, CWR	CT 4	800	1,656	2	0	400	-12	260	5
IHTIMAN	NEMIROVO	9.153	2	1	JT, CWR	CT 4, CT 6	800	458	1	20.6	200	-3.4	504	20
		9.153		2	JT, CWR	CT 4, CT 6	800	458	1	20.6	292	-3.4	504	29
NEMIROVO	KOSTENEC	8.7	2	1	JT	CT 4, CT 6, wood	295	383	2	0	735	-25	2065	0
				2	JT	CT 4, CT 4T, CT 6, wood	295	383	2	0	735	-25	2065	24
KOSTENEC	SESTRIMO	10.675	2	1	JT	CT 4, CT 4T, wood	275	796	3	3	480	-20	2100	0
		10.675		2	JT	CT 4, CT 4T, wood	275	820	2	3	480	-20	2059	21
SESTRIMO	BELOVO	8	2	1	JT	CT 4, CT 4T, CT 6	300	210	1	0	253	-20	580	0
				2	JT	CT 4, CT 4T, CT 6	370	450	1	0	253	-20	580	15
BELOVO	SEPTEMVRI	9.816	2	1	JT, CWR	CT 4, CT 6, wood	700	1,100	2	6	260	-14	850	0
		9.816		2	JT, CWR	CT 4, CT 6, wood	700	1,100	2	6	260	-14	850	5
SEPTEMVRI	ZVANICHEVO	9.2	2	1	JT, CWR	CT 4	2750	643	1	6	411	-5.5	300	2
				2	JT, CWR	CT 4, wood	1900	84	1	5.5	246	-2.6	600	4
ZVANICHEVO	PAZARDZHIK	6.969	2	1	JT, CWR	CT 4, MP 94	1800	479	1	5.8	410	0	130	0
				2	JT, CWR	CT 4, wood	1800	478	1	5	680	0.6	795	3
PAZARDZHIK	OGNJANOVO	9.036	2	1	JT, CWR	CT 4, wood	1500	966	1	4.5	280	-7.5	430	5
				2	JT, CWR	CT 4	1500	967	1	3	700	-6.5	600	7
OGNJANOVO	STAMBOLIJSKI	10.169	2	1	JT, CWR	CT 4	1500	1,404	3	8	840	-2.5	881	3
		10.169		2	JT, CWR	CT 4	1500	1,390	3	4	800	-2.5	800	4

station	station	Length (km)	Number of tracks	Track	Track type JT = Jointed	Sleepers	Minimum curve radius	length	number	Maximum gradient ‰	length (m)	Minimum gradient	length (m)	GTW gradient
STAMBOLIJSKI	TODOR KABLESHKOV	8.719	2	1	JT, CWR	CT 4	1800	587	1	5	320	-3	320	3
		8.719		2	JT, CWR	CT 4	1640	196	1	5	320	-2	350	4
TODOR KABLESHKOV	PLOVDIV	8.436	2	1	JT, CWR	CT 4	3020	888	1	5.5	380	-1	687	2
		8.436		2	JT, CWR	CT 4	1600	148	1	5.5	380	-2	170	0
PLOVDIV	KRUMOVO	8.173	2	1	JT	CT 4,wood	475	187	1	2.5	300	-2.5	840	1
				2	JT	CT 4,wood	400	190	1	2.5	300	-2.5	840	2
KRUMOVO	KATUNICA	4.9	1	1	JT	CT 4	850	513	1	2	550	-2	300	1/2
KATUNICA	SADOVO	6.3	2	1	JT	CT 4	900	276	1	5	410	-2	400	1
				2	JT	CT 4	900	276	1	5	410	-2	400	3
SADOVO	POPOVICA	10.4	2	1	JT	CT 4	560	728	1	9	825	-9	230	1
				2	JT	CT 4	560	728	1	9	825	-9	230	5
POPOVICA	PARVOMAJ	15.4	1	1	JT	CT 4	592	337	1	10	660	-10	600	5/5
PARVOMAJ	SKOBELEVO	12.4	1	1	JT, CWR	CT 4	410	330	1	9	200	-2.5	300	2/5
SKOBELEVO	JABALKOVO	7.2	1	1	JT	CT 4	100	312	1	8	300	-8	435	2/5
JABALKOVO	DIMITROVGRAD	13	1	1	JT	CT 4	400	716	1	10	260	-6.6	530	2/5
DIMITROVGRAD	NOVA NADEZHDA	12.1	1	1	JT	CT 4	400	548	1	9.8	280	-9.3	200	5/6
NOVA NADEZHDA	SIMEONOVGRAD	10.8	1	1	JT	CT 4	350	354	1	4.5	630	-7.5	290	7/3
SIMEONOVGRAD	HARMANLI	15.2	1	1	JT, CWR	CT 4	350	544	4	12.5	380	-9.7	300	8/8
HARMANLI	LJUBIMEC	16.4	1	1	JT	CT 4	350	368	1	12	325	-12	200	8/0
LJUBIMEC	SVILENGRAD	11.1	1	1	JT, CWR	CT 4	345	499	1	11.5	200	-10	280	8/7
SVILENGRAD	KAPIKULE	19.4	1	1	JT, CWR	CT 4	800	700	12	7	500	-6.3	959	
SVILENGRAD	DIKEA		1	1	JT, CWR	wood	495	697	1	8.5	200	-7.7	220	

Table 3.7 Infrastructure overview: speed restrictions and reasons

station	station	Track	Typical line speed, km/h	Speed: passenger	Speed: freight	Reason of change	Bridges	Level crossings	Weaknesses	Repairs: year, type
DIMITROVGRAD S	KALOTINA - ZAPAD	1	70	70	70		1	1		2009, mechanised renewal
KALOTINA - ZAPAD	KALOTINA	1	70	70	70	Disinfection frame	1	1		2009, mechanised renewal
KALOTINA	DRAGOIL	1	70	70	70	Bad technical condition of railway	5	1	Rock Stones fall	2009, mechanised renewal
DRAGOIL	DRAGOMAN	1	65	65	65	Bad technical condition of the 3rd track in Dragoman station	3	2	Rock Stones fall	2009, mechanised renewal
DRAGOMAN	ALDOMIROVCI	1	90	70	70	Bad technical condition of the 3rd track in Dragoman station	1	2		1983, renewal
ALDOMIROVCI	SLIVNICA	1	75	60	60		1	2		1983, renewal
SLIVNICA	PETARCH	1	100	80	80		1	2		1983, renewal
PETARCH	KOSTINBROD	1	100	80	80		1	2		
KOSTINBROD	VOLUJAK	1	100	100	80		3	1		
VOLUJAK	SOFIA	1	100	90	70	Switches in Sofia station	3	3		1961, renewal
		2	100	90	70	Switches in Sofia station	3			
SOFIA	PODUJANE	1	75	75	65	Switches in Sofia station	4			1980, renewal
		2	75	75	65	Switches in Sofia station				1980, renewal
PODUJANE	ISKAR	1	120	120	80	A double switch in a transition curve in Iskar station	2			
		2	130	130	80	Switches in a horizontal curve in Iskar station				
ISKAR	KAZICHENE	1	80	80	70	A worn out double switch in Kazichene station	1	1		1979, renewal
		2	80	80	70	Switches in a horizontal curve in Iskar station and a bad technical condition of railway on a steel bridge				1979, renewal
KAZICHENE	ELIN PELIN	1	80	80	70	A worn out double switch in Kazichene station		1		1978, renewal
		2	80	80	70	Bad technical condition of continuous welded track				1978, renewal
ELIN PELIN	POBIT KAMAK	1	130	130	80	Switches in Elin Pelin station	1			
		2	80	80	70	Bad technical condition of continuous welded track				1978, renewal
POBIT KAMAK	VAKAREL	1	65	65	60		1		Collapse of rock mass	1979, renewal
		2	65	65	60				Collapse of rock mass; changes by axis and level	1979, renewal
VAKAREL	VERINSKO	1	100	100	80		1	1	Railroad bed subsidence	
		2	100	100	80				Railroad bed subsidence	

Station	station	Track	Typical line speed, km/h	Speed: passenger	Speed: freight	Reason of change	Bridges	Level crossings	Weaknesses	Repairs: year, type
VERINSKO	IHTIMAN	1	80	100	80		1	3		1980, renewal 1989, rehabilitation
		2	80	80	70	Bad technical condition of sleepers				1980, renewal 1989, rehabilitation
IHTIMAN	NEMIROVO	1	100	80	70		1	1		1979, renewal 1990, rehabilitation
		2	80	80	70					1979, renewal 1990, rehabilitation
NEMIROVO	KOSTENEC	1	65	60	50		3			1980, renewal 1991, rehabilitation
		2	50	50	50					1980, renewal 1991, rehabilitation
KOSTENEC	SESTRIMO	1	65	70	70	Track undergoing mechanised renewal	6	2	Sliding of rocks together with trees and shrubs after weathering Self-excavating of boulders	1979, renewal
		2	50	50	50	Track undergoing mechanised renewal				1979, renewal
SESTRIMO	BELOVO	1	80	80	80	Horizontal curves R300 with short transition curves	4	2		
		2	80	80	80	Horizontal curves R300 with short transition curves				
BELOVO	SEPTEMVRI	1	80	80	80		3	3		1980, renewal 1991, rehabilitation
		2	80	80	80					1980, renewal 1991, rehabilitation
SEPTEMVRI	ZVANICHEVO	1	130	110	80	Dirty ballast on the 1st track in Septemvri station	3	1		1995, renewal
		2	130	110	80	Dirty ballast on the 2st track in Septemvri station				1994, rehabilitation
ZVANICHEVO	PAZARDZHIK	1	130	130	80	Switches in Pazardjik station	1			1997, renewal
		2	130	110	80	Switches in Pazardjik station				2004, rehabilitation
PAZARDZHIK	OGNJANOVO	1	120	100	80		2		Poor track	2002, rehabilitation
		2	60	60	60	Bad technical condition of railway			Poor track	
OGNJANOVO	STAMBOLIJSKI	1	130	110	80	Switches in Ognjanovo and Stambolijski stations	1	2	Poor track	2004, rehabilitation
		2	130	110	80	Switches in Ognjanovo and Stambolijski stations			Poor track	2005, rehabilitation

Station	station	Track	Typical line speed, km/h	Speed: passenger	Speed: freight	Reason of change	Bridges	Level crossings	Weaknesses	Repairs: year, type
STAMBOLIJSKI	TODOR KABLESHKOV	1	130	110	80	Switches in Todor Kableshkov and Stambolijski stations	1	1		1994, rehabilitation
		2	130	110	80	Switches in Todor Kableshkov and Stambolijski stations				2005, rehabilitation
TODOR KABLESHKOV	PLOVDIV	1	130	110	80	Switches in Todor Kableshkov station	3			1990, rehabilitation
		2	130	110	80	Switches in Todor Kableshkov station				1993, rehabilitation
PLOVDIV	KRUMOVO	1	80	100	80	Dirty ballast, bad technical condition of sleepers in Plovdiv iztok post	1	3		1993, rehabilitation
		2	80	100	80	Dirty ballast, bad technical condition of sleepers in Plovdiv iztok post				
KRUMOVO	KATUNICA	1	160	160	80		1	1		1988, rehabilitation
KATUNICA	SADOVO	1	160	160	80	Railway crossing	1	2		1986, rehabilitation
		2	160	160	80	Railway crossing				
SADOVO	POPOVICA	1	160	160	80	Railway crossing	1	5		1986, rehabilitation
		2	160	160	80	Railway crossing				
POPOVICA	PARVOMAJ	1	160	160	80	Railway crossing	3	2		1995, rehabilitation
PARVOMAJ	SKOBELEVO	1	160	160	120	Railway crossing	7	5		1987, renewal
SKOBELEVO	JABALKOVO	1	160	160	120	Railway crossing	4	1		1995, rehabilitation
JABALKOVO	DIMITROVGRAD	1	160	160	120	Railway crossing	4	3	Poor railroad bed	1996, rehabilitation
DIMITROVGRAD	NOVA NADEZHDA	1	85	85	80	Railway crossing	5	4		1997, rehabilitation
NOVA NADEZHDA	SIMEONOVGRAD	1	85	85	80	A horizontal curve R350 and bad technical condition of sleepers in Simeonovgrad station	2	1	Unfit wooden sleepers	1994, rehabilitation
SIMEONOVGRAD	HARMANLI	1	80	80	80	Bad technical condition of wooden sleepers in Simeonovgrad station	6	3	Unfit wooden sleepers	1996, renewal
HARMANLI	LJUBIMEC	1	80	80	80		3	4		1996, renewal
LJUBIMEC	SVILENGRAD	1	80	80	80		5	4		1996, renewal
SVILENGRAD	KAPIKULE	1	80	130	80	Reconstruction and electrification of the line between Svilengrad and Kapikule	11	5		1990, rehabilitation
SVILENGRAD	DIKEA	1	80	75	75		2	1		1990, rehabilitation

Table 3.8 Capacity, maintenance and renewal costs

station	station	Capacity of the section between the neighbouring stations	Capacity of the section including more than two stations	Maintenance costs: track with stations [Euro *]	Maintenance costs: only track [Euro *]	Renewal costs [Euro *]
DIMITROVGRAD S	KALOTINA - ZAPAD	79		35413.98	19774.72	35664.99
KALOTINA - ZAPAD	KALOTINA	153		88534.94	49436.81	89162.47
KALOTINA	DRAGOIL	126		188181.01	105077.93	189514.83
DRAGOIL	DRAGOMAN	82		330633.73	184621.75	332977.25
DRAGOMAN	ALDOMIROVCI	81	78	312174.20	174314.18	314386.87
ALDOMIROVCI	SLIVNICA	78		338778.95	189169.94	341180.19
SLIVNICA	PETARCH	117		264099.72	147469.99	265971.65
PETARCH	KOSTINBROD	105		303232.17	169321.06	305381.46
KOSTINBROD	VOLUJAK	100		308367.19	172188.40	310552.89
VOLUJAK	SOFIA	96		344976.39	192630.51	347421.57
SOFIA	PODUJANE	256		356003.98	212694.77	145557.73
PODUJANE	ISKAR	257		658689.13	393534.19	269315.24
ISKAR	KAZICHENE	257	137	550306.91	328781.17	225001.49
KAZICHENE	ELIN PELIN	187		1016328.65	607206.12	415541.69
ELIN PELIN	POBIT KAMAK	229		688456.08	411318.47	281485.92
POBIT KAMAK	VAKAREL	137		1012294.31	604795.80	413892.19
VAKAREL	VERINSKO	158		394511.75	251795.98	395925.95
VERINSKO	IHTIMAN	206		371412.31	237052.83	372743.71
IHTIMAN	NEMIROVO	206		406594.53	259507.79	408052.05
NEMIROVO	KOSTENEC	158	137	386471.37	246664.23	387856.75
KOSTENEC	SESTRIMO	137		474204.81	302659.85	475904.69
SESTRIMO	BELOVO	206		355375.97	226817.69	356649.88
BELOVO	SEPTEMVRI	182		436046.32	278305.30	437609.41

*** 1 Euro = 1.95583 Leva**

station	station	Capacity of the section between the neighbouring stations	Capacity of the section including more than two stations	Maintenance costs: track with stations [Euro *]	Maintenance costs: only track [Euro *]	Renewal costs [Euro *]
SEPTEMVRI	ZVANICHEVO	229		604037.46	261828.60	410147.37
ZVANICHEVO	PAZARDZHIK	229		457558.38	198335.17	310686.63
PAZARDZHIK	OGNJANOVO	206	187	593269.84	257161.22	402836.04
OGNJANOVO	STAMBOLIJSKI	187		667658.36	289405.98	453346.58
STAMBOLIJSKI	TODOR KABLESHKOV	229		572456.81	248139.52	388703.79
TODOR KABLESHKOV	PLOVDIV	206		553876.09	240085.44	376087.30
PLOVDIV	KRUMOVO	99		305614.76	70402.85	364362.44
KRUMOVO	KATUNICA	143		183226.76	42208.98	218448.05
KATUNICA	SADOVO	229		235577.26	54268.69	280861.78
SADOVO	POPOVICA	163	50	388889.45	89586.40	463644.85
POPOVICA	PARVOMAJ	52		575855.53	132656.79	686551.02
PARVOMAJ	SKOBELEVO	64		463675.88	106814.56	552807.32
SKOBELEVO	JABALKOVO	64		269231.16	62021.36	320984.89
JABALKOVO	DIMITROVGRAD	50		486111.81	111983.00	579556.06
DIMITROVGRAD	NOVA NADEZHDA	67		177390.01	51009.45	539432.95
NOVA NADEZHDA	SIMEONOVGRAD	71		158331.58	45529.09	481477.34
SIMEONOVGRAD	HARMANLI	64	54	222837.04	64077.98	677634.78
HARMANLI	LJUBIMEC	54		240429.44	69136.77	731132.26
LJUBIMEC	SVILENGRAD	76		162729.68	46793.79	494851.71
SVILENGRAD	KAPIKULE			284410.43	81783.74	864875.97
SVILENGRAD	DIKEA					

Table 3.9 Track state by expert inspection in 2008 (Sofia division): Risk zone according to three indices (railway track, railway bed, inclines) and one generalised.

		Risk			
Section	**Track**	**Track**	**Bed**	**Inclines**	**General**
Dimitrovgrad S -> Kalotina zapad	1	C	C	D	C
Kalotina zapad -> Kalotina	1	C	C	D	C
Kalotina -> Dragoil	1	B	D	D	C
Dragoil -> Dragoman	1	C	C	D	C
Dragoman -> Aldomirovci	1	B	C	D	C
Aldomirovci -> Slivnica	1	C	C	D	C
Slivnica -> Petarch	1	C	C	D	C
Petarch -> Kostinbrod	1	C	C	D	C
Kostinbrod -> Volujak	1	C	C	D	C
Volujak -> Sofia	1	C	C	D	C
Sofia -> Podujane	1	C	D	D	D
Sofia -> Podujane	2	C	D	D	D
Podujane -> Iskar	1	D	D	D	D
Podujane -> Iskar	2	D	D	D	D
Iskar -> Kazichene	1	C	D	D	D
Iskar -> Kazichene	2	C	D	D	D
Kazichene -> Elin Pelin	1	C	D	D	D
Kazichene -> Elin Pelin	2	C	D	D	D
Elin Pelin -> Pobit kamak	1	C	C	D	C
Elin Pelin -> Pobit kamak	2	D	D	D	D
Pobit kamak -> Vakarel	1	C	C	D	D
Pobit kamak -> Vakarel	2	D	C	D	C
Vakarel -> Verinsko	1	D	D	D	D
Vakarel -> Verinsko	2	D	D	D	D
Verinsko -> Ihtiman	1	C	D	D	D
Verinsko -> Ihtiman	2	C	D	D	D
Ihtiman -> Nemorovo	1	C	D	D	D
Ihtiman -> Nemorovo	2	C	D	D	D
Nemorovo -> Kostenec	1	B	D	D	C
Nemorovo -> Kostenec	2	B	D	D	C
Kostenec -> Sestrimo	1	A	D	D	C
Kostenec -> Sestrimo	2	A	D	D	C
Sestrimo -> Belovo	1	B	D	D	C
Sestrimo -> Belovo	2	B	D	D	C
Belovo -> Septemvri	1	C	D	D	D
Belovo -> Septemvri	2	C	D	D	D

Risk zone "A" unacceptably high risk level
Risk zone "B" comparatively high risk level
Risk zone "C" comparatively low risk level
Risk zone "D" acceptable low risk level
Risk zone "E" slight / low risk level

Table 3.10 Track state by expert inspection in 2008 (Plovdiv division): Risk zone according to three indices (railway track, railway bed, inclines) and one generalised.

		Risk			
Section	**Track**	**Track**	**Bed**	**Inclines**	**General**
Septemvri -> Pazardjik	1	D	D	D	D
Septemvri -> Pazardjik	2	C	D	D	D
Pazardjik -> Ognjanovo	1	C	D	D	D
Pazardjik -> Ognjanovo	2	C	D	D	C
Ognjanovo -> Stambolijski	1	D	D	D	D
Ognjanovo -> Stambolijski	2	D	D	D	D
Stambolijski -> Todor Kableshkov	1	D	D	D	D
Stambolijski -> Todor Kableshkov	2	D	D	D	D
Todor Kableshkov -> Plovdiv	1	D	D	D	D
Todor Kableshkov -> Plovdiv	2	C	D	D	D
Plovdiv -> Plovdiv iztok	1	C	D	D	D
Plovdiv -> Plovdiv iztok	2	C	D	D	D
Plovdiv iztok -> Krumovo	1	C	D	D	D
Plovdiv iztok -> Krumovo	2	C	D	D	D
Krumovo -> Katunica	1	E	E	E	E
Katunica -> Popovica	1	E	E	E	E
Katunica -> Popovica	2	E	E	E	E
Popovica -> Parvomaj	1	E	E	E	E
Parvomaj -> Karadjalovo	1	E	E	E	E
Karadjalovo -> Jabalkovo	1	E	E	E	E
Jabalkovo -> Dimitrovgrad	1	E	E	E	E
Dimitrovgrad -> Nova Nadejda	1	C	D	D	D
Nova Nadejda -> Simeonovgrad	1	C	D	D	D
Simeonovgrad -> Harmanli	1	C	D	D	D
Harmanli -> Ljubimec	1	C	D	D	D
Ljubimec -> Svilengrad	1	C	D	D	D
Svilengrad -> Kapikule	1	E	E	E	E
Svilengrad -> Dikeja	1	C	D	D	D

Entries marked in green are new construction and will correspond to class "E"

Risk zone "A" unacceptably high risk level
Risk zone "B" comparatively high risk level
Risk zone "C" comparatively low risk level
Risk zone "D" acceptable low risk level
Risk zone "E" slight / low risk level

Table 3.11 Track state (Quality Index, QI) by geometry measurement, in 2008: Sofia division.

Section	Track	Work Length, km	QI 2008	Class by QI at Project Speed	Class by QI at Maximum Admissible Speed for 2008	State of Track	Substate of Track
Dimitrovgrad S -> Kalotina zapad	1	0.4	3.718	C	C	bad	bad
Kalotina zapad -> Kalotina	1	1.8	3.559	C	C	bad	bad
Kalotina -> Dragoil	1	3.8	4.152	over C	over C	bad	worst
Dragoil -> Dragoman	1	7.0	3.969	over C	C	bad	worse
Dragoman -> Aldomirovci	1	6.6	3.474	over C	C	bad	worse
Aldomirovci -> Slivnica	1	7.0	3.625	C	C	bad	bad
Slivnica -> Petarch	1	4.4	2.686	C	C	bad	bad
Petarch -> Kostinbrod	1	6.4	2.511	C	C	medial	sufficient
Kostinbrod -> Volujak	1	6.2	2.600	C	C	medial	sufficient
Volujak -> Sofia	1	7.0	3.077	C	C	bad	bad
Sofia -> Podujane	1	2.2	3.002	C	C	medial	sufficient
Sofia -> Podujane	2	2.2	3.086	C	C	medial	sufficient
Podujane -> Iskar	1	5.2	2.411	C	C	medial	sufficient
Podujane -> Iskar	2	4.8	1.414	A	A	good	best
Iskar -> Kazichene	1	4.2	2.225	C	C	medial	sufficient
Iskar -> Kazichene	2	4.2	2.504	C	C	bad	bad
Kazichene -> Elin Pelin	1	8.4	2.027	C	B	good	good
Kazichene -> Elin Pelin	2	8.6	2.245	C	C	medial	sufficient
Elin Pelin -> Pobit kamak	1	5.6	1.612	B	B	good	better
Elin Pelin -> Pobit kamak	2	5.8	2.803	C	C	bad	bad
Pobit kamak -> Vakarel	1	8.8	2.976	C	C	medial	sufficient
Pobit kamak -> Vakarel	2	8.8	2.629	C	C	good	good
Vakarel -> Verinsko	1	8.2	1.884	B	B	good	better
Vakarel -> Verinsko	2	8.2	1.599	A	A	good	best
Verinsko -> Ihtiman	1	8.0	2.646	C	C	bad	bad
Verinsko -> Ihtiman	2	7.6	2.378	C	C	medial	sufficient
Ihtiman -> Nemorovo	1	8.8	2.598	C	C	bad	bad
Ihtiman -> Nemorovo	2	9.0	2.559	C	C	bad	bad
Nemorovo -> Kostenec	1	8.4	3.437	C	C	bad	bad
Nemorovo -> Kostenec	2	8.4	3.393	C	C	bad	bad
Kostenec -> Sestrimo	1	10.6	3.310	C	C	bad	bad
Kostenec -> Sestrimo	2	10.4	3.253	C	C	medial	sufficient
Sestrimo -> Belovo	1	7.6	2.783	C	C	bad	bad
Sestrimo -> Belovo	2	7.4	2.707	C	C	bad	bad
Belovo -> Septemvri	1	9.0	2.515	C	C	bad	bad
Belovo -> Septemvri	2	8.8	2.453	C	C	bad	bad

QI 2008 Mean value of QI (quality index) from geometry measurement by a motorailer EM-120 "Plasser&Theurer" in 2008

Class by QI Class of distances based on geometry measurement according to project speed/ maximum admissible speed for 2008
Class "A" - new constructions or repairs must correspond to it
Class "B" - railway track does not need maintenance when correspond to it
Class "C" - railway track must correspond to it for safe operation
(if does not correspond to its criteria - "over C", geometric troubles must be eliminated or speed should be decreased)

State of Track State of station distances by track geometry according to project speed

Substate of Track Substate of station distances by track geometry according to project and maximum admissible speeds
The "bad" and "good" states are subdivided in three sub states each – "worst", "worse", "bad"; "good", "better", "best".

Table 3.12 Track state (Quality Index, QI) by geometry measurement, in 2008: Plovdiv division

Section	Track	Work Length, km	QI 2008	Class by QI at Project Speed	Class by QI at Maximum Admissible Speed for 2008	State of Track	Substate of Track
Septemvri -> Zvanichevo	1	8.8	1.985	C	B	good	good
Septemvri -> Zvanichevo	2	9.0	2.214	C	C	medial	sufficient
Zvanichevo -> Pazardjik	1	6.4	1.386	A	A	good	best
Zvanichevo -> Pazardjik	2	6.4	2.318	C	C	medial	sufficient
Pazardjik -> Ognjanovo	1	8.6	2.390	C	C	medial	sufficient
Pazardjik -> Ognjanovo	2	8.2	2.195	C	B	medial	sufficient
Ognjanovo -> Stambolijski	1	9.4	2.165	C	C	medial	sufficient
Ognjanovo -> Stambolijski	2	9.4	2.109	C	C	good	good
Stambolijski -> Todor Kableshkov	1	7.8	2.294	C	C	medial	sufficient
Stambolijski -> Todor Kableshkov	2	8.0	2.057	C	C	good	good
Todor Kableshkov -> Plovdiv	1	7.4	2.234	C	C	medial	sufficient
Todor Kableshkov -> Plovdiv	2	7.2	2.354	C	C	medial	sufficient
Plovdiv -> Plovdiv iztok	1	3.2	2.886	C	C	bad	bad
Plovdiv -> Plovdiv iztok	2	3.0	3.275	over C	C	bad	worse
Plovdiv iztok -> Krumovo	1	3.6	2.302	C	C	medial	sufficient
Plovdiv iztok -> Krumovo	2	3.6	2.264	C	C	good	good
Katunica -> Popovica	1			A	A	good	best
Katunica -> Popovica	2			A	A	good	best
Krumovo -> Katunica	1			A	A	good	best
Popovica -> Parvomaj	1			A	A	good	best
Parvomaj -> Karadjalovo	1			A	A	good	best
Karadjalovo -> Jabalkovo	1			A	A	good	best
Jabalkovo -> Dimitrovgrad	1			A	A	good	best
Dimitrovgrad -> Nova Nadejda	1	10.4	3.383	over C	over C	bad	worst
Nova Nadejda -> Simeonovgrad	1	10.6	3.175	over C	over C	bad	worst
Simeonovgrad -> Harmanli	1	14.2	3.398	C	C	bad	bad
Harmanli -> Ljubimec	1	16.0	2.944	C	C	medial	sufficient
Ljubimec -> Svilengrad	1	10.8	2.772	C	C	good	good
Svilengrad -> Kapikule	1			A	A	good	best
Svilengrad -> Dikeja	1	3.2	3.208	C	C	medial	sufficient

Entries marked in green are new construction and will correspond to class "A"

QI 2008 Mean value of QI (quality index) from geometry measurement by a motorailer EM-120 “Plasser&Theurer” in 2008

Class by QI Class of distances based on geometry measurement according to project speed/ maximum admissible speed for 2008
Class "A" - new constructions or repairs must correspond to it
Class "B" - railway track does not need maintenance when correspond to it
Class "C" - railway track must correspond to it for safe operation
(if does not correspond to its criteria - "over C", geometric troubles must be eliminated or speed should be decreased)

State of Track State of station distances by track geometry according to project speed

Substate of Track Substate of station distances by track geometry according to project and maximum admissible speeds
The “bad” and “good” states are subdivided in three sub states each – “worst”, “worse”, “bad”; “good”, “better”, “best”.

4. SPANISH ROUTE

The Castellbisbal-Silla Corridor is located on the east coast of Spain. The Castellbisbal-Silla route is an electrified line, with a typical line speed of 100 km/h (75 km/h for freight). The majority of the route is double track, apart from a 57 km section between Vilarreal and Tarragona, which is single track. A combination of freight and passenger traffic uses the line, which has a signalling system of cab radio and colour light signals. Train control is managed by automatic blocks. All of the freight on this line runs from rail yard to rail yard without intermediate service activity on the line. Bulk commodities such as iron and steel are transported along the line, as well as many cars and intermodal traffic.

Maps showing rail routes in Spain, and a close-up of the region near Barcelona showing Castellbisbal, are given in Figure 4.1. The 272 km section between Valencia (just north of Silla) and Tarragona (just south of Castellbisbal and Barcelona) is described here.

General characteristics for the selected route:

Track gauge	1668 mm
Maximum axle load	25 t
Ballast / Subgrade	ballast
Ground conditions	rocky
Traffic mix	freight + passenger
Typical line speed	100 km/h
Track maintenance quality	poor
Local environment	Suburban & Industrial
Contaminants	No contaminants

Electrification:

Electrified	yes: 3000 cc

Signalling system:

Signalling system	cab radio + colour light signals

Train control:

Train control	automatic block

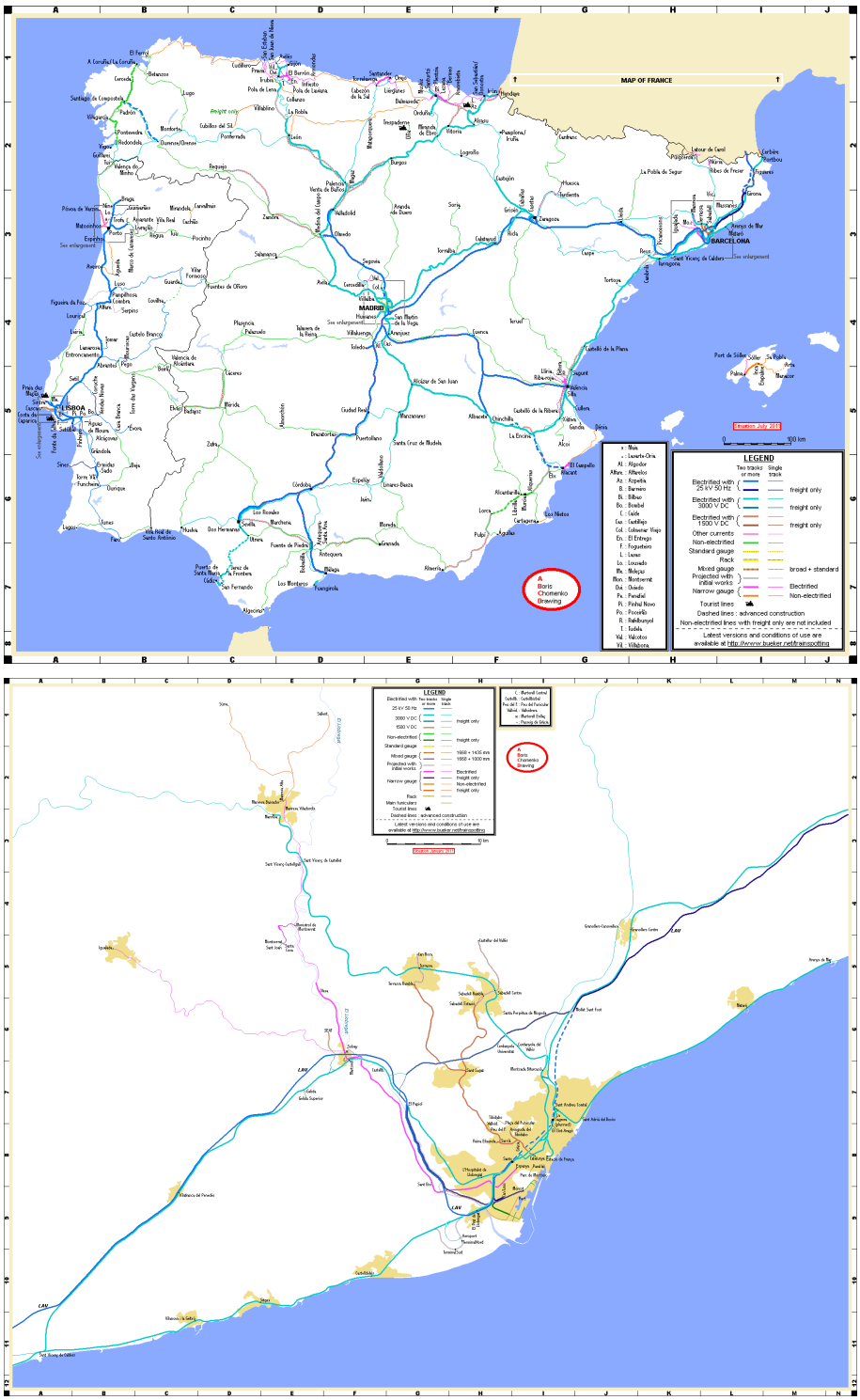


Figure 4.1 Top: Map of Spanish railways; Bottom: Close-up of Barcelona area and Castellbisbal.
[Maps available from http://www.bueker.net/trainspotting/maps_iberian-peninsula.php and http://www.bueker.net/trainspotting/maps_barcelona-area.php;
free for non-commercial use – see webpage for details.]

4.1 Valencia Fuente de San Luis to Sagunto-Cargas

Length	29 km
Number of tracks	2 (Double track)
Minimum curve radius	354 m
Maximum gradient	1:400
Overpasses	20
Underpasses	6
Level Crossings	2
Bridges	4
Tunnels	1

A histogram of curvature on this route section is shown in Figure 4.2.

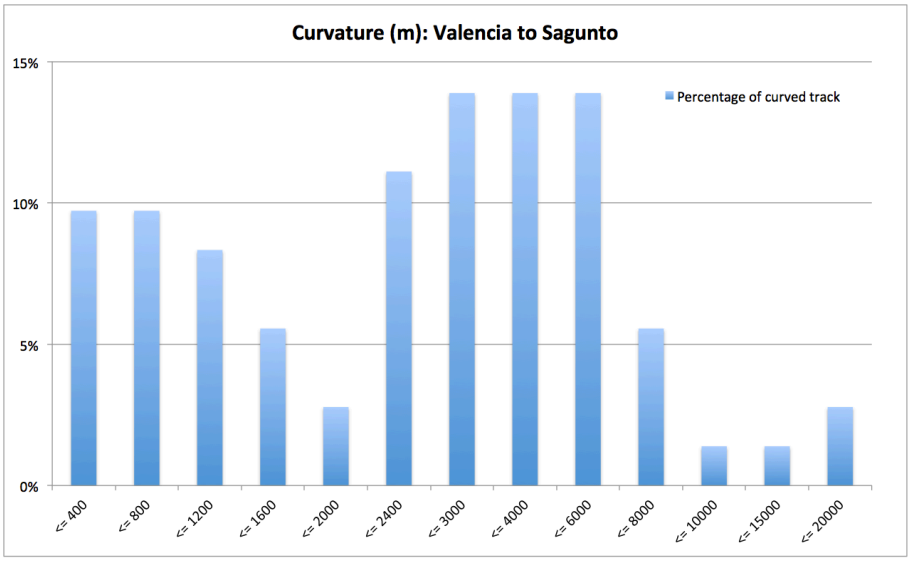


Figure 4.2 Section Valencia to Sagunto: Histogram of route curvature.

4.2 Sagunto-Cargas to Vila Real

Length	33 km
Number of tracks	2 (Double track)
Minimum curve radius	848 m
Maximum gradient	1:400
Overpasses	28
Underpasses	31
Level Crossings	1
Bridges	5
Tunnels	-

A histogram of curvature on this route section is shown in Figure 4.3.

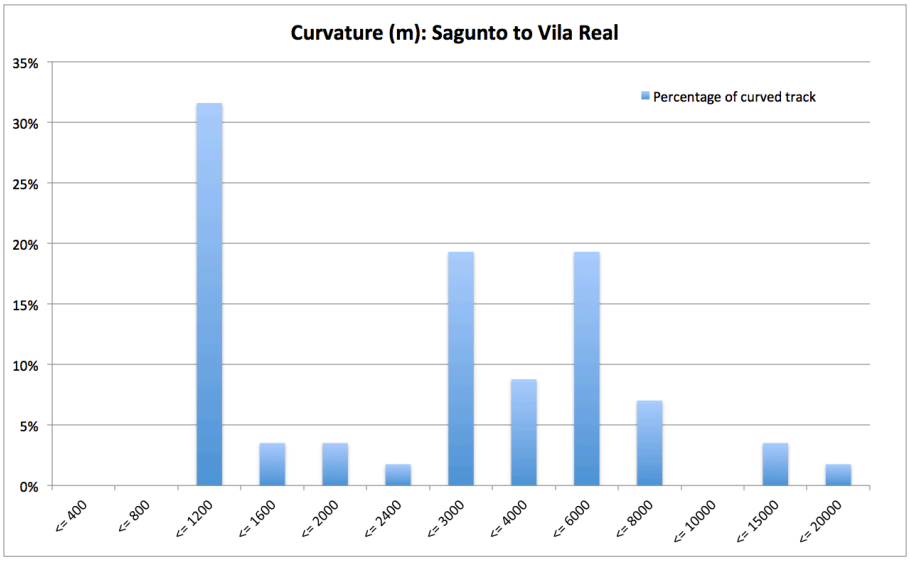


Figure 4.3 Section Sagunto to Vila Real: Histogram of route curvature.

4.3 Vila Real to Tarragona

Length	210 km	
Number of tracks	2 (Double track)	km 62.2 - km 215
	1 (Single track)	km 215 - km 272
Minimum curve radius	890 m	
Maximum gradient	1:400	
Minimum loading gauge	galibo	
Overpasses	62	
Underpasses	127	
Level Crossings	16	
Bridges	25	
Tunnels	5	

A histogram of curvature on this route section is shown in Figure 4.4.

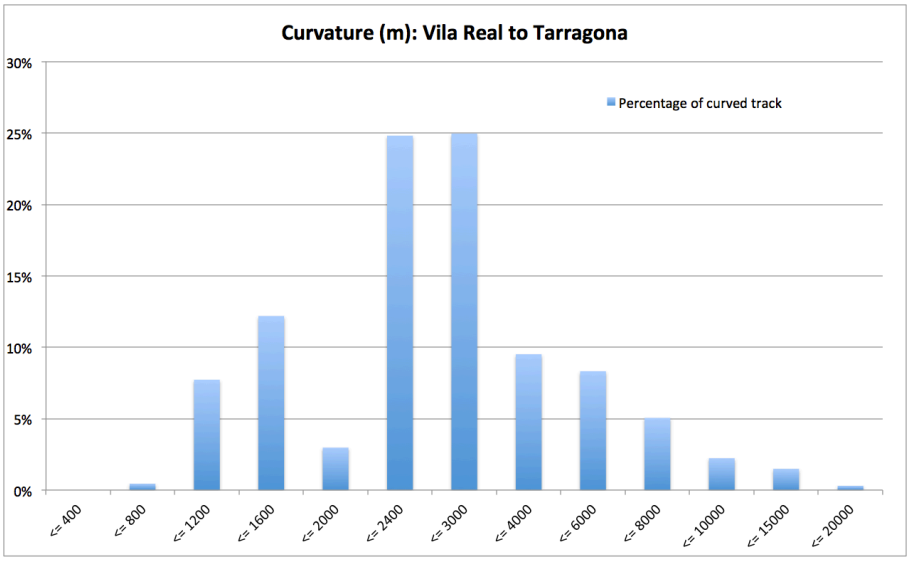


Figure 4.4 Section Vila Real to Tarragona: Histogram of route curvature.