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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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 1.5 gathers the benchmark data for Operations and Logistics 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".

The report addresses Sub-Tasks 1.5.1 and 1.5.2, covering:

- a description of the movement of freight on these routes and of the loading and unloading facilities;
- a description of the overall system capacity, both current and including developments that are already underway;
- details of competition from alternative modes of transport for each route;
- restrictions along each route that may prevent increased capacity or competitiveness;
- details on the security arrangements that are in place, with a view to preventing terrorist attack;
- details of track access charges; and
- whole system infrastructure costs, primarily relating to those components that go into the track access charge, which includes track maintenance, renewals and operations.

The report also describes a capacity modelling exercise has been undertaken to provide a base model of the above routes using event based simulation software. This uses a "mesoscopic simulation methodology" based on real world data provided by ADIF, BDZ and Network Rail but including some estimates where necessary to examine the following measures of performance:

- travel times & average speed;
- line utilisation;
- station utilisation; and
- percentage utilisation using a time-weighted average.

The information presented in this report was predominantly gathered from the following sources:

- partner organisations within the SustRail project;
- directly from the internet;
- interviews with key players within various railway administrations;
- analysis of raw data provided by relevant railway administrations; and
- responses to questions sent to participants.

A summary and additional commentary is provided in the final chapter.

2. UNITS AND TERMINOLOGY

Throughout the report, reference will be made to various units of measure and terminology as described in the following text.

2.1 Standard container sizes and TEU

Intermodal freight services use standard container sizes which due to the US influence on the world market are in imperial sizes. Standard containers are 8 feet (2.44m) in width and are traditionally been 8½ feet (2.6m) in height. However, "Hi-Cube" containers which are 9½ feet (2.9m) high are becoming increasingly common as the higher volume means they are more economical.

It is common to refer to the volume of freight moved in terms of not only the total number of containers moved, but also "TEU" or Twenty-foot Equivalent Units. This refers to the standard length deep sea containers, which are commonly 20 feet (6.1m) or 40 feet (12.2m) in length, although larger sizes exist of 45, 48 and 53 foot containers are also increasingly used.

2.2 Freight moved vs freight lifted

There are two key statistics used in the evaluation of how much freight is transported by rail, fright lifted and freight moved:

- freight lifted – the overall mass of goods carried on the network as measured in tonnes (i.e., it excludes the weight of the locomotives and wagons), and this measure takes no account of the distance that the freight travels; and
- freight moved – the overall mass of goods carried multiplied by the distance travelled (again excluding the weight of the locomotives and wagons, which does take into account the distance freight travels and with units of NTKm (net tonne kilometres).

For the purposes of this deliverable, key statistics will be presented in terms of freight moved.

2.3 Capacity

The overall capacity of a freight railway line can be measured in a number of ways, potentially including:

- tonnes per direction per hour / day / month / year – appropriate for bulk haulage;
- TEU per direction per hour / day / month / year – appropriate for intermodal traffic; and
- trains per direction per hour – appropriate when talking about signalling systems and line capacity.

In terms of intermodal freight, capacity is determined by:

- the number of trains that can be operated per day;
- the number of days per year trains can be run (for example track maintenance can reduce overall capacity particularly at night when many freight services operate);
- the maximum train length;
- the loading gauge;
- the maximum axle load of the trains operating (although this is typically less of a constraint for intermodal container traffic); and
- the efficiency with which the space available on the train is used, which can be greatly affected by wagon design considerations and the lengths of the containers to be transported at that time.

In relation to the last point, although vehicles are the subject of a separate work package (WP3), it is important to note that wagon design can have a significant impact on capacity, particularly in the case of intermodal freight:

- with well wagons, the containers sit in a well between the bogies which restricts the proportion of the wagon that can be used for carrying containers;
- for flat bed wagons, the bogies sit beneath the vehicle and these are more efficient as almost the entire length of the wagon can be used to carry containers;
- double stack wagons, where two layers of shipping containers sit one on top of the other, dramatically increase overall capacity (increasingly used in the USA, but require a very large loading gauge); and
- articulated wagons where adjacent vehicles share a bogie mean that containers on adjacent wagons effectively sit closer together, thereby increasing overall train capacity.

An investigation of the different wagon types is provided in deliverable D1.3, however, it should be borne in mind that where a capacity in terms of TEU is stated for a given route, the figures provided are based on a particular wagon design.

2.4 Clearance

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.

3. OVERVIEW OF ROUTES

3.1 Spanish Route: Mediterranean Corridor

The Castellbisbal Silla Corridor is located on the East coast of Spain Figure 3.1. The Castellbisbal Silla route is an electrified line, with a typical line speed of 100km/h (75km/h for freight). The majority of the route is double track, apart from a 57km 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. The total number of freight trains per day is indicated in Table 3.1.

Bulk commodities such as iron and steel are transported along the line, as well as many cars and intermodal traffic.

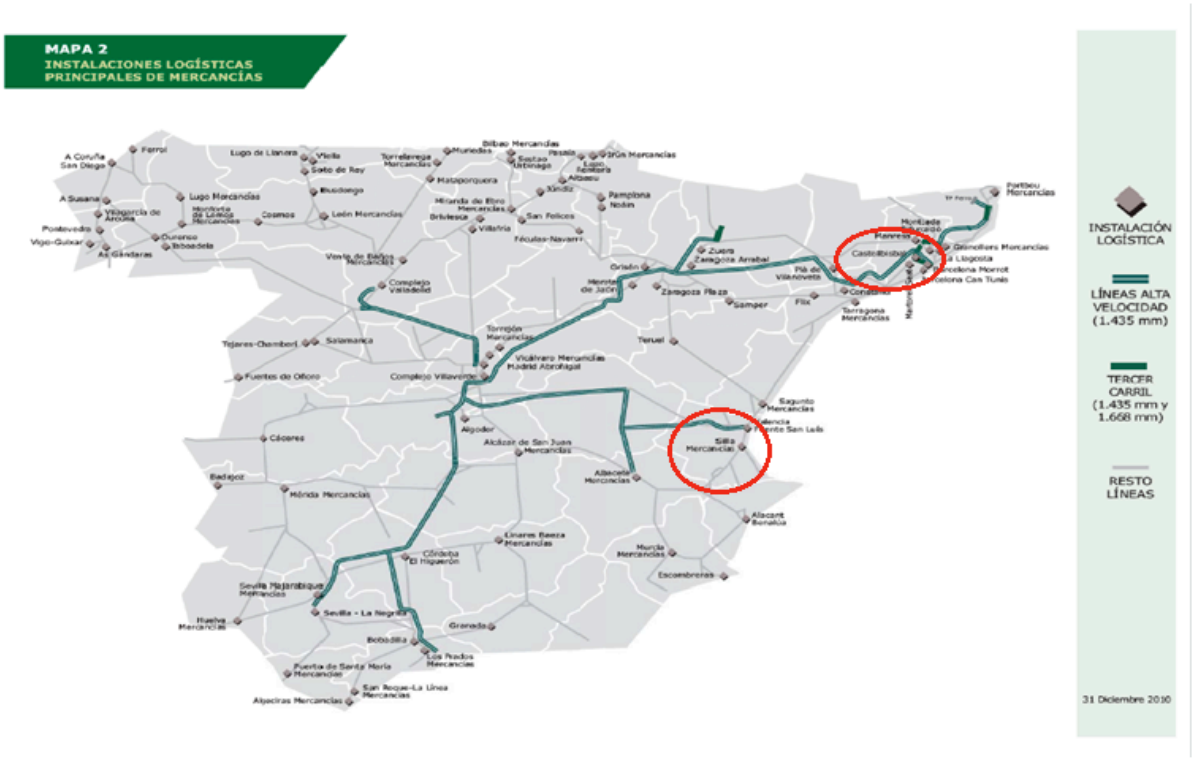


Figure 3.1 Map of Mediterranean Corridor

Table 3.1 Total Freight Tarragona – Valencia (total trains per day)

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
15	18	17	14	17	3	2

3.2 Bulgarian Route: Dimitrovgrad S – Kapikule

3.2.1 Bulgarian Route Analysis

Rail freight in Bulgaria has approximately a 10 per cent share of total goods carried by surface transport. This is shown in Figure 3.2. The trend in goods carried tonnes per 1000 indicates a small decrease from 2008, in line with the economic recession.

Figure 3.3 indicates international rail freight transport in Bulgaria, this suggests a trend which increased from 2002, with a peak in 2007. International rail freight then decreased in 2009, there is an indication that it may increase in the future.

The main markets for rail freight in Bulgaria are:

- Agricultural products and animals
- Foodstuffs and fodders
- Solid mineral fuels
- Petroleum and petroleum products
- Ores and metal scrap
- Ferrous and non ferrous metallurgy produce
- Elaborated and non elaborated non metallic raw materials
- Fertilisers
- Chemical substances and products

The main product carried is indicated in

Table 3.2, where in 2010 solid mineral fuels had the highest volume. Note: The second highest market for freight in Bulgaria is petroleum and petroleum products.
The operator along this line is BDZ EAD,

Table 3.3 indicates trends in freight traffic along the line from 2005-2010. Tonnes carried (see

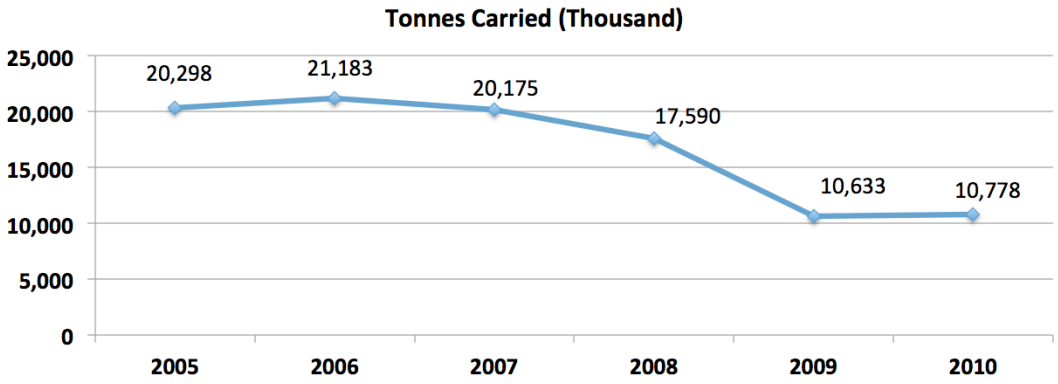


Figure 3.4) demonstrates a steady decrease, with the steepest decrease between 2008 and 2009 with a loss of approximately 7 million tonnes in one year. Data for tonne-kilometres (see Figure 3.5) indicates a pattern in line with tonnes carried. Note: The steepest decrease was 2008-2009. Data for average hauling distance (see Figure 3.6) demonstrates a small decrease in comparison to tonnes carried and tonne-kilometres.

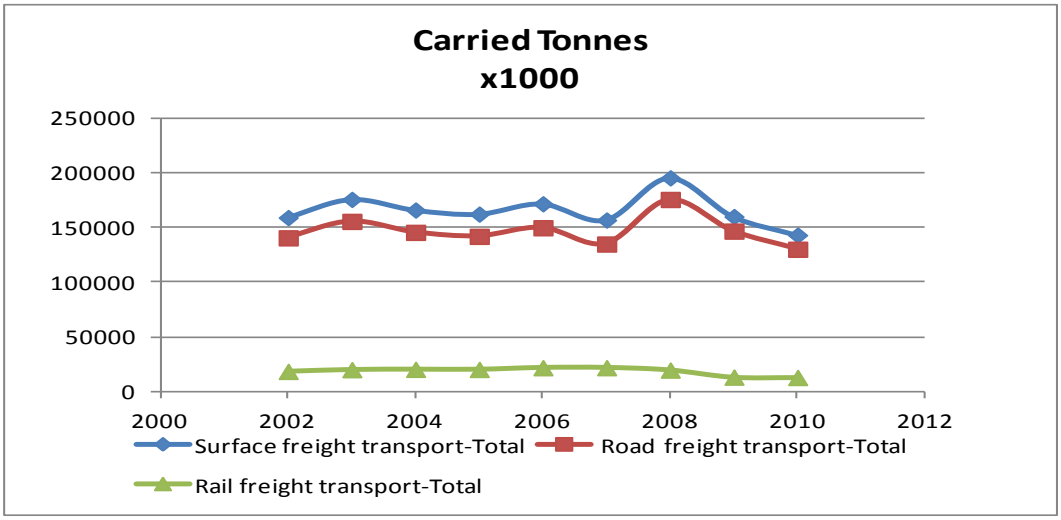


Figure 3.2 Goods carried surface transport total: Bulgaria

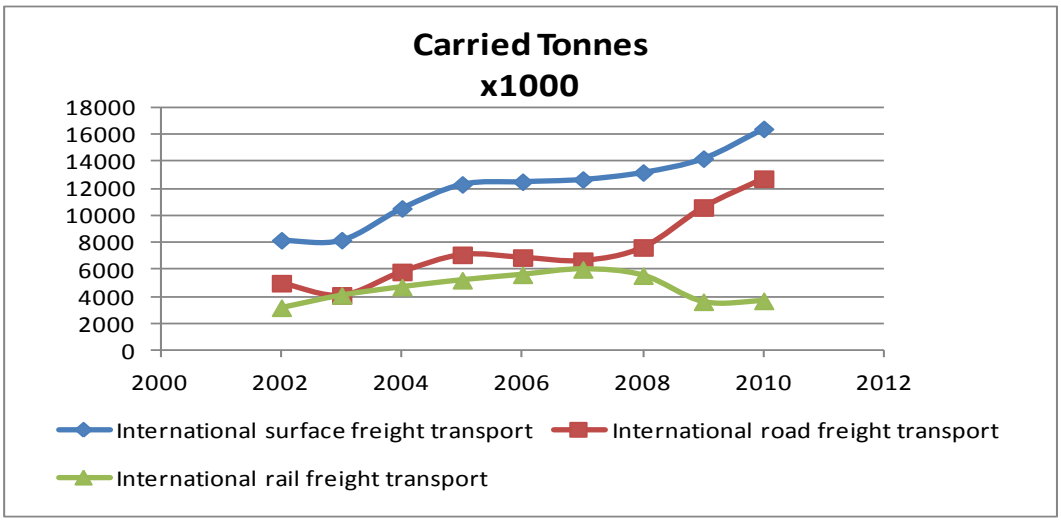


Figure 3.3 Goods carried: International surface transport: Bulgaria

Table 3.2 Rail Freight Markets in Bulgaria [Carried tonnes × 100 000]

code	Name	2010	2009	2008	2007	2006
0	Agricultural products and animals	158,00	237,90	418,06	200,00	212,00
1	Foodstuffs and fodders	314,00	374,30	458,79	433,00	495,00
2	Solid mineral fuels	3 381,90	3 453,70	4 458,00	5 030,00	4 652,00
3	Petroleum and petroleum products	2 020,40	1 922,60	2 201,40	1 754,00	1 959,00
4	Ores and metal scrap	1 332,50	1 050,20	2 132,67	3 738,00	4 414,00
5	Ferrous and non-ferrous metallurgy produce	764,90	856,70	2 030,18	2 730,00	2 690,00
	Elaborated and non-elaborated non-metallic raw materials	885,60	1 130,40	3 116,15	3 272,00	3 484,00
7	fertilizers	201,70	72,40	371,84	379,00	461,00
8	Chemical substances and products	385,00	420,70	730,88	906,00	1 425,00
9	Machines , Transport means, etc.	1 333,90	1 114,40	1 672,45	1 733,00	1 391,00
	TOTAL	**10 777,90**	**10 633,30**	**17 590,42**	**20 175,00**	**21 183,00**

Table 3.3 Freight Traffic Totals: Bulgaria

Freight traffic in total –BDZ EAD						
	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Tones carried (thousand)	20 298	21 183	20 175	17 590	10 633	10 778
Tone kilometres (mil)	5 163	5 225	4 710	4 031	2 277	2 352
Average hauling distance (km)	254	247	233	229	214	218

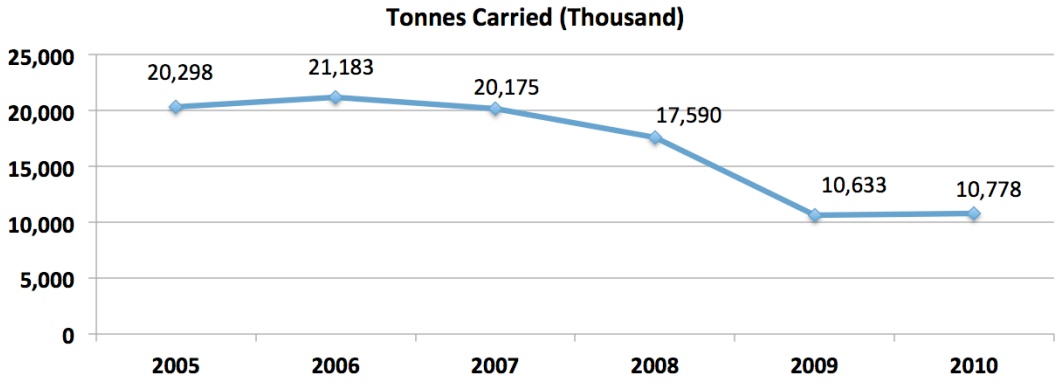


Figure 3.4 Tonnes carried (Thousand): Bulgaria

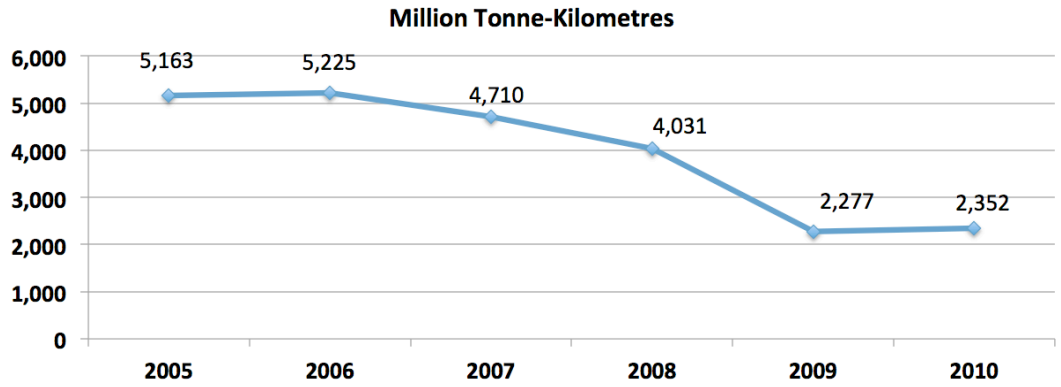


Figure 3.5 Tonne Kilometres: Bulgaria

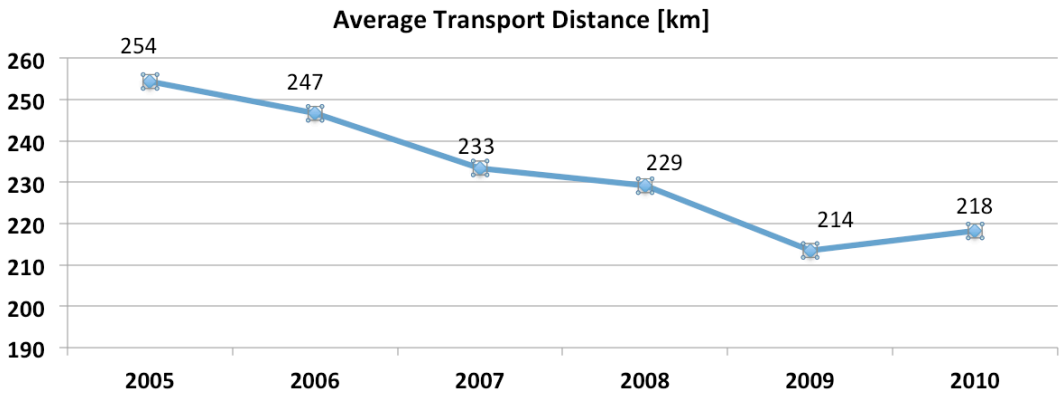


Figure 3.6 Average transport distance (km): Bulgaria

From 2005-08, rail freight held approximately 25% of the surface freight market by tonne kilometres. Figure 3.7 indicates a clear pattern of decreasing rail freight from 2006-2010 and now rail freight holds about 10% of the surface freight market. During this period, surface freight transport (in particular road freight transport) has increased; this indicates that the main competition to rail freight in Bulgaria is road transport.

The capacity for this route, which will be analysed in further detail in Section 5, is expected to increase in the next ten years, as a result of a number of projects currently under implementation which, when completed, will affect capacity along the whole route.

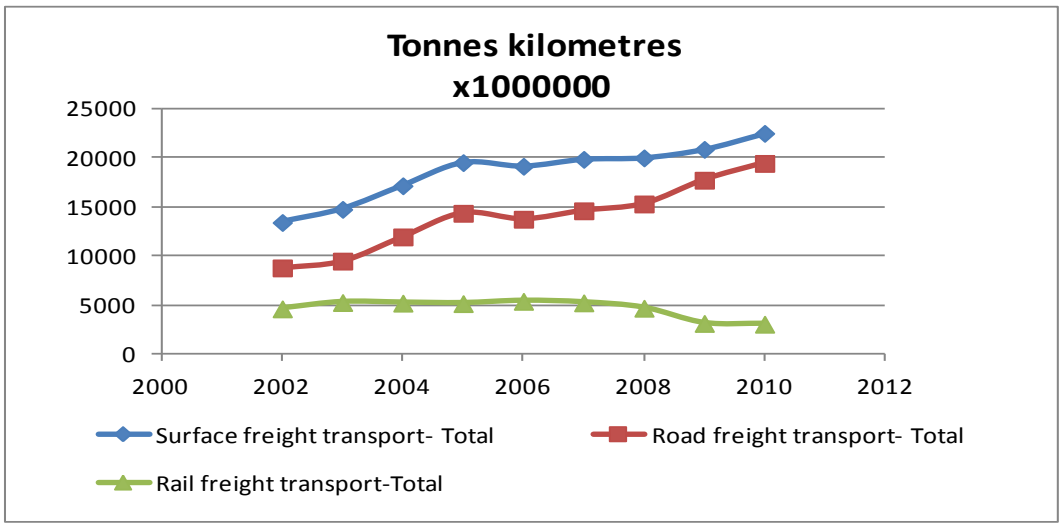


Figure 3.7 Tonne-Kilometres, Surface Transport: Bulgaria

3.2.2 Bulgarian Route Description

The Dimitrovgrad S – Kapikule (Turkey) line runs through Bulgaria from West to East (Figure 3.8) 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 – 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 throughout 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.

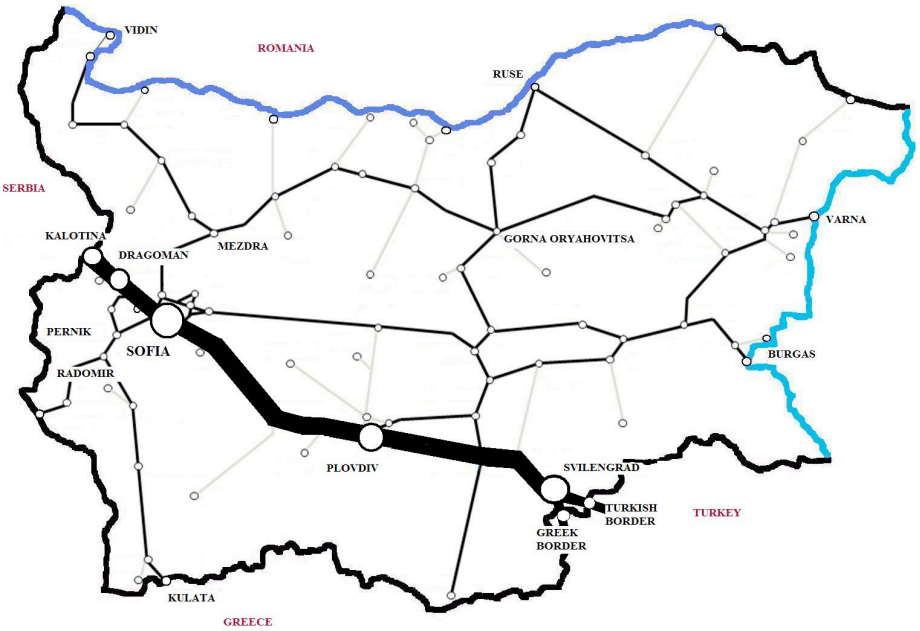


Figure 3.8 Map of the Bulgarian Route

3.3 UK Route: Southampton and Felixstowe

The UK's railways have approximately an 11% share of surface freight transport[1] and the amount of rail freight carried has generally been increasing since the mid 1990s. As shown in Figure 3.9, there has been a slight fall in recent years due to the recession, but rail freight transport is predicted to continue its upward trend once economic recovery is underway:

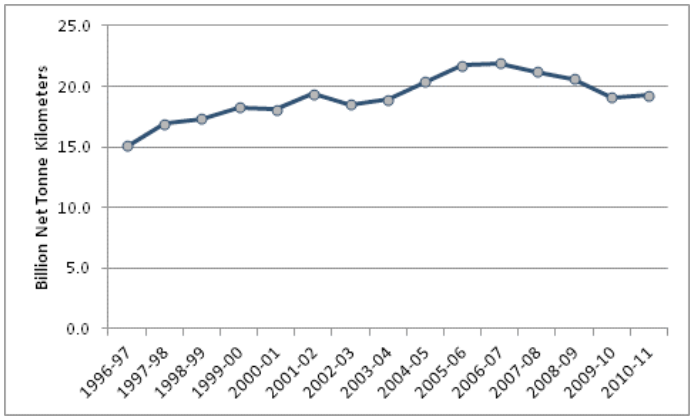


Figure 3.9 UK Rail Freight Moved[2]

There are 4 main markets for rail freight in the UK:

- bulk commodities including coal, metals, construction traffic, oil and petroleum
- international traffic
- domestic intermodal
- railway infrastructure related

Traditionally, coal was the main freight carried on the UK network, but this is likely to decrease in coming years, although this will be offset by an increase in the transportation of biomass, predicted to take 1/3 to 2/3 of the coal market over the next 15 years[3]. However, intermodal freight is set to see the largest growth as shown in Figure 3.10, and in 2010-11, it overtook coal traffic in term of Net Tonne Kilometres (5.68 billion NTKm vs 5.46 billion)[4].

Looking to the future, container traffic in the UK is forecast to increase, on average, by around 4% per between 2005 and 2030[5]. For this reason, important intermodal routes with the potential for significant future growth in traffic were selected for further analysis.
The bulk of intermodal freight traffic enters and leaves the UK via one of several deep sea ports, as shown in

Table 3.4. Felixstowe and Southampton are the largest in the UK, and are the sixth and eleventh largest container ports in Europe respectively[6]. The so-called "Haven Ports" of Felixstowe, Ipswich and Harwich are set to see a substantial increase in traffic flows. This will be particularly so for Felixstowe if the development of new facilities at Bathside Bay on the opposite side of the estuary goes ahead.

[1] Network Rail, Value and Importance of Rail Freight, July 2010

[2] Based on data from ORR National Rail Trends Yearbook 2010-11

[3] Interview with Ian Cleland, Network Rail, 2 November 2011

[4] ORR National Rail Trends Yearbook 2010-11

[5] DfT, Container End To End Journey December 2008

[6] DfT, The Container Freight End-To-End Journey, December 2008

The choice of route was further influenced by a government White Paper[7] which describes the need to develop a number of routes designated as strategically important for UK rail freight traffic. Both lines from Felixstowe (west towards Birmingham via Ipswich and line south towards London) and from Southampton north towards Birmingham via Reading are part of this Strategic Freight Network. Of the two lines from Felixstowe, it is the "cross country" line to the west that was selected for this analysis as it has greatest scope for expansion as it avoids the congested London area.

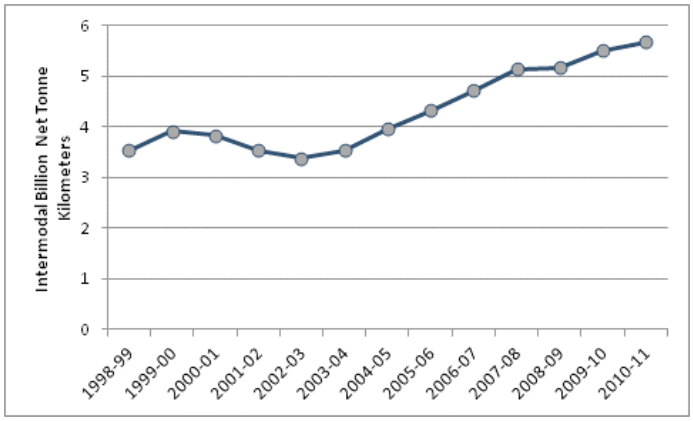


Figure 3.10 UK Intermodal Rail Freight Moved[2]

Table 3.4 UK Container Traffic by Port[8]

UK Port	Thousand Containers (2010)
Felixstowe	2,074
Southampton	945
London	425
Liverpool	400
Medway	263
Tees & Hartlepool	146
Forth	129
Belfast	125
Hull	105
Grimsby & Immingham	61

[7] DfT, Delivering a Sustainable Railway July 2007

[8] DfT, Port Freight Statistics, 2010

4. CASE STUDY: DETAILED ANALYSIS OF THE UK ROUTE

4.1 General Description of Rail Routes

It is estimated over 25% of freight containers originating from the Far East shipped into ports like Southampton Felixstowe are now transported onwards by rail[9]. General characteristics that apply to both the Felixstowe and Southampton routes include the following:

- on the West Coast Main Line or other lines shared with passenger services, freight runs at up to 120km/h, but on other sections, freight runs at well below its potential speed (often around 30mph) due to going into loops or slow lines and because of being stopped for passenger services[10]
- at peak times there are very few freight trains, but in off-peaks periods, both routes have 2 paths/hour each way[10]
- generally intermodal trains run directly from the port to their inland freight terminal and the Freight Operating Companies (FOCs) will usually try to use a single driver for the journey if working hours allow[11]

A map showing UK's W10 cleared routes (existing and planned) is shown in Figure 4.1.

The so-called "Cross Country" route runs west from Felixstowe, initially along the green line, then swapping to the orange line that crosses towards Birmingham. This route section is approximately 257km in length. The route from Southampton is shown by the red line that heads north towards Birmingham via Reading, and this route is approximately 212km in length. The two routes meet just east of Birmingham at a town called Nuneaton, and they then run north for a further 136km on the slow line of the West Coast Main Line (the blue line originating in London) via Crewe towards Warrington, just to the west of Manchester.

4.2 Route Description – Felixstowe Route

Felixstowe is the largest container port in the UK and the deep sea container market dominates the rail freight traffic market in the area[12] (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[13].

[9] Network Rail, Value and Importance of Rail Freight, July 2010

[10] Interview with Ian Cleland, Network Rail, 2 November 2011

[11] email from Ian Cleland, Network Rail, 16 November 2011

[12] Network Rail, Network Specification 2011 – Anglia

[13] Interview with Ian Cleland, Network Rail, 2 November 2011

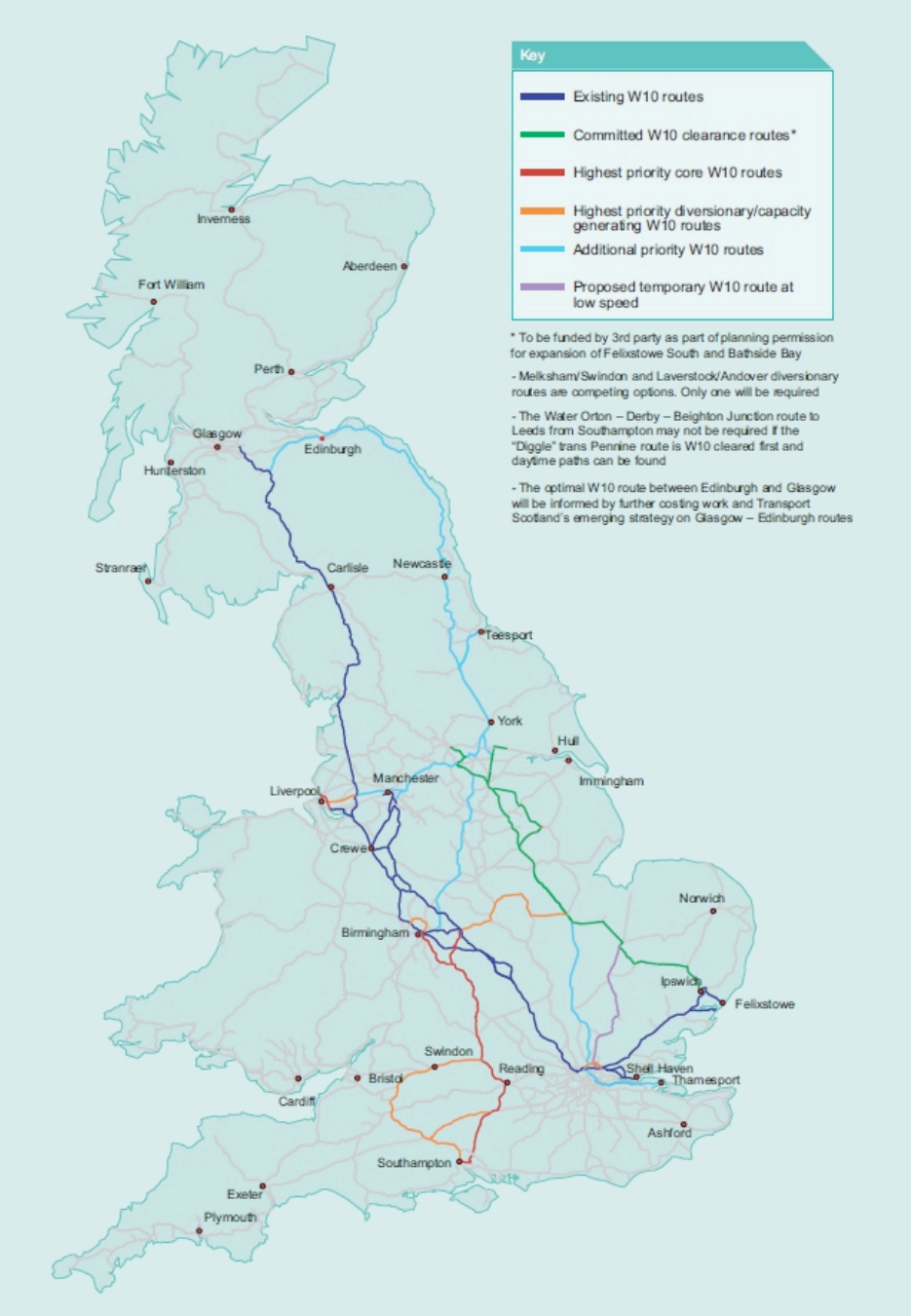


Figure 4.1 W10 Clearance Routes[14]

4.2.1 Freight Movement

While the majority of onward transportation is with road haulage, there is a significant proportion transported by rail (27% in 2010[15]). There are currently 28 train services per direction per day (30 by 2012), with services to and from the port operated by Freightliner, GB Railfreight and DB Schenker.

[14] Network Rail, Freight Route Utilisation Strategy March 2007

[15] Port of Felixstowe Publications, Port Journal – Rail Services, accessed 23 November 2011

There are plans to develop new port facilities at Bathside Bay on the other side of the estuary which would further increase the demand for rail freight capacity. But these plans are dependent on upgrades to the local road network, which have yet to be implemented. Should Bathside Bay be given the go ahead, the number of trains from the combination of Felixstowe and Bathside Bay is expected to increase to 56 trains per day in 2030[16].

4.2.2 Loading and Unloading Facilities

The key locations are the port at Felixstowe, and the intermodal depots including Daventry and Hams Hall in the West Midlands, Warrington/Trafford Park and Ditton in the North West and Coatbridge in Scotland.

Felixstowe

The port at Felixstowe is the largest container port in the UK and it currently handles 42% of the total UK intermodal container traffic[17]. The port currently handles over 2 million containers (equivalent to over 3 million TEU) per annum, and recent investment means it is capable of accommodating the largest 18,000 TEU container ships. Other key statistics relating to intermodal freight traffic are as follows:

- storage capacity of 118,000 TEU
- 1,806 reefer points (i.e., for refrigerated containers)
- 96 rubber tyred gantry cranes and 34 quayside cranes
- 12 high stacking container fork lifts and 3 top loading fork lifts

There are two rail terminals currently the following facilities (totals):

- 6 rail mounted gantry cranes
- 4 “reach-stackers”
- 2 shunting locos

The rail freight handling capacity at Felixstowe is over 750,000 TEU per annum, but the rail terminal currently only deals with 200,000 TEU. Current maximum train length is limited to 24 wagons, but future planned expansion includes:

- a third terminal capable of taking trains up to 30 wagons in length due for 2012
- doubling the line to enable up to 40 trains per day per direction by 2020

So the port handles very large volumes of containerised freight, and it is expanding as evidenced by recent and planned investment. The use of rail transport is also set to increase with the construction of the third rail terminal, capable of taking significantly longer freight services.

UK Freight Terminals

The main intermodal freight terminals served by Felixstowe are shown below in Figure 4.2.

The terminals are generally similar, with typically two overhead gantry cranes, plus a number of other container handling vehicles such as stacking container fork lifts. As an example, of one of the main terminals is Hams Hall Railfreight Terminal, 8 miles east of the centre of Birmingham. The terminal services trains from both Felixstowe and Southampton and handles over 170,000 TEU per annum, with storage for over 5000 TEU at any one time. It has four working sidings with 2 reception roads capable of receiving trains up to 750m in length.

[16] Network Rail, Network Specification 2011 – Anglia

[17] DfT Maritime Statistics Factsheet Q2 2011



Figure 4.2 Primary Intermodal Flows from Felixstowe[18]

4.2.3 Rail System Capacity

There are currently 30 intermodal trains a day from Felixstowe, of which 22 are destined for the North West, although many of these currently go via the North London Line. Network Rail and the port owners are investing heavily in upgrading the capacity of the Cross Country line including additional loops and chords at Ipswich and Nuneaton, as well as re-gauging for larger vehicles[19]. Trains are currently 24 wagons in length, but work is underway to increase this to 30 wagons, and the route will be upgraded to W10 loading gauge by the end of Network Rail's current Control Period[20] (i.e., by 2014). It is then expected that most of the freight traffic will take this cross-country route whereas only 3 intermodal trains/day currently use the section from Peterborough to Nuneaton.

4.2.4 Competition

The main competition for the transportation of intermodal freight is road haulage, which currently carries 80% of container freight to and from the port.

4.2.5 Restrictions

There are a number of restrictions on increasing the capacity of the Cross Country route. One of the primary ones that the route is mostly section shared with passenger services, and the

[18] Freightliner Limited website, accessed 28 November 2011

[19] Network Rail, Network Specification 2011 - Anglia

[20] Interview with Ian Cleland, Network Rail, 2 November 2011

demand for passenger travel is increasing. As far as loading gauge is concerned, the route is currently being upgraded to W10, by the end of the current Network Rail Control Period (i.e., by 2014), but there are currently no plans to increase it further than this. A map showing gauge clearances for the UK's intermodal freight routes is shown in Figure 4.1. As far as axle loads are concerned, the whole route is cleared for RA8, which equates to a maximum axle load of 22.8 tonnes. Part of the route is actually cleared for RA10, 25.4 tonnes, but there is much of it not cleared for this higher loading.

The route from Felixstowe to Ipswich is electrified with 25kV overhead (as is the West Coast Main Line), but in the main the route is not electrified and freight services are typically hauled by Class 66 diesel locomotives. These produce 2.46MW of power, and while adequate for the current services, should train length be increased as is planned, more tractive effort will be required to maintain timings along this line. It would be possible to double head container services (i.e., use two locomotives), but this would greatly reduce the profitability and therefore viability of transportation by rail.

The maximum train length on the route is currently 487m including locomotive. This is dictated by the length of passing loops and sidings. In addition, until an additional chord is built at Ipswich which is planned for the current Network Rail Control Period (i.e., by 2014), trains from Felixstowe typically have a dwell time of 1 hour in the freight yard at Ipswich[21].

There are no severe gradients on the line, and the signalling is currently mostly standard UK 4-aspect signalling with AWS and TPWS with some semaphore signalling in places. One of the most significant restrictions is the single line between Soham and Ely, and at night there are often problems with engineering works and single-line working[21].

4.3 Route Detail – Southampton Route

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[21]. Freight traffic on this line is typically container traffic travelling to Daventry, Ditton, Liverpool, Manchester, Coatbridge, Birch Coppice, Birmingham and Hams Hill.

4.3.1 Freight Movement

On average there are 22 to 23 intermodal freight trains per day per direction from Southampton. These trains are currently 23 wagons in length, but there is work underway to increase maximum train length to 775m. The recent upgrading of the line to W10 gauge is expected to further improve the utilisation[22], benefitting Freightliner and DB Schenker who currently operate this route.

4.3.2 Loading and Unloading Facilities

Southampton

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[23]. The port has 1,350m of quayside and handled just under 1 million containers in 2010. The port facilities include over

[21] Interview with Ian Cleland, Network Rail, 2 November 2011

[22] e-mail from Ian Cleland, Network Rail, 16 November 2011e

[23] DfT Maritime Statistics Factsheet, Q2 2011

100+ straddle carrier cranes, 6 “sprinter” straddle carriers, 4 reach stackers and 8 empty container handlers. In terms of rail capacity, the rail terminals at Southampton has 2 overhead gantry cranes spanning four tracks.

Terminals

The main intermodal freight terminals served by Southampton are shown in Figure 4.3.

As mentioned previously for Felixstowe, these terminals are generally similar in nature, typically having two overhead gantry cranes, plus a number of other container handling vehicles such as stacking container fork lifts.



Figure 4.3 Primary Intermodal Flows from Southampton[24]

4.3.3 Rail System Capacity

Capacity is set to increase in coming years, with record levels of throughput being recently achieved thanks to the recent rail infrastructure project to increase the loading gauge from Southampton to Nuneaton which allows “Hi Cube” containers to be transported.

4.3.4 Competition

Rail caries approximately 25% to 30% of container movements to and from the port[25], the rest being by road haulage.

[24] Freightliner Limited website, accessed 28 November 2011

[25] DP World Southampton Newsletter, June 2011

4.3.5 Restrictions

There are several restrictions on increasing the capacity of the Southampton to Nuneaton Route, one of the primary ones being that, like Felixstowe, many sections of the route area also used extensively by passenger traffic.

As for the loading gauge, work was completed in April this year to increase the loading gauge to W10 from Southampton to Nuneaton[25]. This has resulted in an increase in the number of containers transported by rail from 30% to 36% in the space of 4 months[26]. There are currently no plans to increase this further.

In terms of axle load, the route is cleared for RA8 (i.e., a maximum of 22.8 tonnes) and much of the route is non-electrified except for the section from Southampton to Basingstoke which is 750Vdc third rail. Freight services are typically hauled by Class 66 diesel locomotives.

The maximum train length is currently 557m which is dictated by the length of passing loops and sidings. The signalling used is standard UK 4-aspect signalling with AWS and TPWS and there are no severe gradients on the line.

One further current restriction is that the port of Southampton is unable to accommodate the very largest container ships.

4.4 Security

4.4.1 Ports

Ports are secure sites and have features including CCTV and security fences. Both Felixstowe and Southampton meets the standards outlined in the International Ship and Port Facility Security (ISPS) Code. This code was introduced following the attacks on the USA in 11th September 2001[27]. This has meant that ports such as Felixstowe and Southampton have enhanced their security arrangement to include stricter access control and identification requirements, increased searching of personnel and cargo, continuous patrolling and monitoring of the port[28].

4.4.2 Terminals

In addition to the usual arrangements for a secure site (secure boundary fence, CCTV etc.), the security at terminals that handle international cargo such as Hams Hall are increasingly strict, with compliance to standards such as Security Assured Channel Tunnel Freight Forwarder (SACTFF), which included the ability to screen cargo.

4.4.3 Running Lines

Railway networks are difficult to defend against terrorism due to their extensive network that is relatively easily accessible. The current security measures include the widespread removal of safety bins from across the passenger network (although some stations have introduced clear rubbish bags) and the widespread use of CCTV. There are also regular patrols by security staff (armed police in many cases) at key locations such as stations. There are also regular announcements warning the public to be vigilant and report anything deemed suspicious, and unattended luggage can be removed without notice.

[26] DP World Southampton Newsletter, September 2011

[27] DfT website, UK National Maritime Security Programme, accessed 22 November 2011

[28] Port of Felixstowe website, Port Protection, accessed 22 November 2011

In the UK, the security and safety of rail services is the responsibility of the British Transport Police, a national force consisting of approximately 1000 officers and 500 civilian support staff[29]. The force is also linked to the Anti-Terrorist Branch of the Metropolitan Police Service of London and the UK Security Services. However, this force must project the entire UK network including London Underground.

One of the key methods used to counter the threat is the gathering of good intelligence in order to intercept any planned attacks. However, improved staff training and the development of trust with the community, as well as the use of trained "sniffer" dogs[30] are additional effective measures that are employed.

It has also been recommended that there be increased screening of railway staff and increased training in recognising and dealing with potential threats[29]. As for freight services, recommendations have been made to make hazardous materials less easy to identify (they currently have warning signs on the side plates of such vehicles), and the possibility of routing hazardous trains away from areas of dense population. More secure driving cabs and GPS are other possibilities.

[29] Ozonelink White Paper on Railway and Train Security, May 2004

[30] Railway Technology, Terrorism, The Ever Evolving Threat, June 2010

5. TRACK CHARGES AND COSTS

This section gives a high level overview of the access charge regime in each of the three case study countries with a focus on freight charges, and provides some overall system cost information.

5.1 Track Access Charge Regimes

For each case study country we outline the key features of the access charging system. Figure 5.1 also presents a comparison as to the level of freight access charges across a number of European countries. As can be seen Spain (SP) generally has lower access charges for a given weight of train, while Great Britain (UK) has roughly average charges and Bulgaria (BG) has relatively high charges.

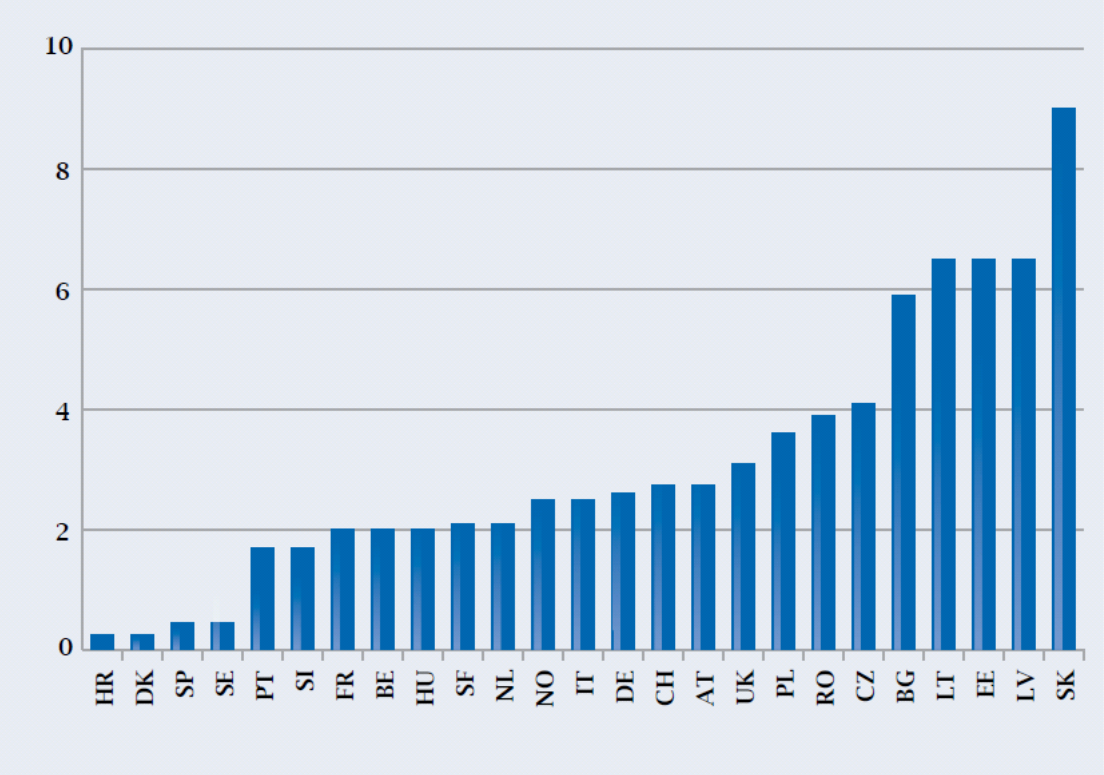


Figure 5.1 2008 access charges for a typical 960 gross tonne freight train (Euros/Train-Km)

Source: ITF (2008)[31]

[31] International Transport Forum, Charges for the Use of Rail Infrastructure, 2008. Paris.

Bulgaria

Source: ECMT (2005)[32] and ITF (2008)

- Charges comprise three core elements: A path reservation fee, a fee per train-km and a fee per gross tonne-km
- Charges are different for freight and passenger trains
- Freight charges: € 0.65/train path plus € 1.9/train-km plus € 0.0020/gross ton-km in 2003
- From 2007, freight charges were reduced by 10%
- Overall 65% of infrastructure costs are recovered from levying access charges on both passenger and freight traffic in 2003

Great Britain

Source: ECMT (2005) and ITF (2008) and Network Rail

- The principle of freight access charges is to recover the additional wear and tear costs associated with the infrastructure from running the freight service
- This is different to (franchised) passenger traffic which also pay a contribution to fixed charges
- Charges are levied per vehicle-km. However each vehicle has a different charge rate depending on its characteristics and how these influence infrastructure damage
- Damage determined by relative vertical forces applied by vehicles
- This factor is now being extended to take account of the propensity of the bogie to cause lateral rolling contact fatigue damage. Vehicles are divided between 7 different bands, according to bogie type, which affects the level of charging.

Spain

Source: ADIF Network Statement (2011)[33] and ITF (2008)

- Freight charges different to passenger charges
- Charges comprise of a reservation charge per train path and then a train-km charge
- Charges differ by time of day

5.2 Whole System Costs

Table 5.1 provides an overview of the cost of each of the case study railways in 2008. The overall cost of the three railways is very different, largely due to the size and intensity of their operations (see Table 5.2). Therefore UK railways have costs over 30 times that of Bulgaria and just under 3 times that of Spain.

As part of the detailed economic data collection exercise we have investigated the availability of cost data at the case study route level. This is described in more detail in Section 7. Estimates of the infrastructure maintenance and renewal costs for specific route sections from Network Rail for the GB case study are given in Table 5.3.

[32] Nash, Chris, Bryan Matthews and Louis S. Thompson, "Railway Reform and Charges for the Use of Infrastructure," ECMT, 2005, Paris.

[33] ADIF (2011). Network Statement Update 2011. Available at http://www.adif.es/es_ES/index.shtml

The lack of data for the other routes is not deemed to be problematic at this stage since the focus of effort has been to understand whether the data exists and how, once we know exactly which innovation options are to be considered in the project, we can obtain it to input into any economic appraisal.

Table 5.1 Total system costs for each case study country

Country Organisation	Cost (€ million 2008 prices)
Bulgaria	
BDZ	276
BRC	12
NRIC	202
Total	*489*
Great Britain	
Network Rail	8,112
Passenger Operators	6,132
Freight Operators	977
Total	*15,222*
Spain	
ADIF	2,571
FEVE	172
FGC	135
RENFE	2,599
Total	*5,477*

Source: Table 72 of UIC (2008)[34] except for Great Britain where data is UNILEEDS analysis of GB accounts (using UIC (2008) exchange rate).

Table 5.2 Whole-system utilisation – freight and passenger operations

	Passenger-km billions	Freight tonne-km million 2010	Freight tonne-km million
Spain	22.3	6973	9737
Bulgaria	2.3	2352	4031
UK	54	19000	21000
	Ratios	**Ratios**	**Ratios**
UK/Spain	2.4	2.7	2.2
Spain/Bulgaria	9.7	3.0	2.4
UK/Bulgaria	23.5	8.1	5.2

Table 5.3 Route cost estimate summary

Item	Felixstowe to Warrington (£ / km / year)	Southampton to Warrington (£ / km / year)
Renewals & Refurbishment	£24000	£35000
Maintenance	£14000	£18000
TOTAL	£38000	£53000

[34] UIC (2008). International Railway Statistics.

6. CAPACITY MODELLING

6.1 Modelling Methodology

To enable a comparison to be made of the capacity utilisation on the specified freight routes in the three countries, simulation modelling was carried out. A decomposition approach was used wherein rail networks are broken down into individual components. This is a practical approach which is used to increase model accuracy and is well established within operations research. When carrying out decomposition, the level of decomposition must be considered as this will have the greatest impact on model accuracy. If the system is broken down into small components the model will be able to provide a more detailed representation of its performance; however, breaking down a network into miniscule detail may lead to a very complex model and have a negative effect on model accuracy. It would be inappropriate where detailed information is not readily available. These issues must be deliberated when deciding on the level of decomposition, along with the consideration that when modelling individual components within the decomposition approach the components must still be regarded as part of the network.

In order to carry out event simulation modelling a mesoscopic simulation modelling methodology as presented below was employed on the three routes. The mesoscopic simulation modelling methodology allows the flow of freight trains moving within the components of the rail freight network to be captured. As a result of this, the global impact of freight train movement within a network can also be analysed. As the network has been decomposed into components to allow modelling to occur, it was possible to examine individual components which are believed to influence freight operations in greater detail.

The elements which were needed to construct a mesoscopic simulation modelling methodology are listed below. This process allowed the levels of performance to be assessed and the evaluation of freight traffic along the three routes. The event based simulation package Arena was used to carry out this process.

i) The freight trains are generated within the replication at the beginning of the model. The creation pattern of freight trains is controlled to replicate the required freight train arrivals subject to the objectives of the conducted experiment.

For the objectives of this experiment, the generation patterns were controlled in line with scheduled freight in N–S direction on the Mediterranean Corridor, W-E direction on Dimitrovgrad S – Kapikule route and S–N direction on the UK route. The measure of performance objective is the number of freight trains generated over the route for a certain period of time, i.e., 24 hours.

ii) As stated above, a decomposition approach was applied to allow the three routes to be represented in greater detail. Each route was decomposed into lines (represented by blocks), rail freight terminals, rail passenger stations and rail freight yards. Within the model, in order to allow straightforward identification, each component was provided with a name (rail freight yards, rail freight stations, rail passenger stations) or a code (lines, trains).

iii) Each of the routes has different characteristics and functions. To allow the replication to be as realistic as possible, detailed data collection describing the characteristics and functions of each component was required.

iv) To indicate the entry of a train into the system as stated a create module was used. To monitor the point where the train leaves the system a dispose module was used.

v) The Dimitrovgrad S – Kapikule line includes two marshalling yards. These were decomposed into receiving yard, classification yard and departure yard, with each component represented by a process module. Process modules will be discussed in more depth in the 'Modelling in Arena' section.

vi) Rail lines were represented by blocks for further details – see Section 5.2.

The implementation of the mesoscopic simulation modelling methodology allows the creation of an event based simulation model to analyse and evaluate operational processes with freight trains in a rail network.

Once created the event based simulation model must be calibrated and validated. If possible, this should be done through the comparison of the output from the model with data collected from the real system.

6.2 Modelling in Arena

The event simulation package Arena (Rockwell Software) was used to produce simulation models. Arena is a visual event simulation package, with different modules used to replicate the network under investigation.

The entities represent the trains within the Arena environment, with the focus on the flow of the entities through the system. The entities are created by **create** modules, each entity created represents a new freight service entering the network. The **create** module includes a number of variables which can be altered to suit the network being represented: arrival pattern, number of entities per arrival and maximum number of arrivals.

As the focus of the model is around entity flow, this is captured as the entity passes through each module. Each module has an input and output port which allows a smart connection to be made to the next module see Figure 6.1. The **create** module only has an output port as it represents the beginning of the system, likewise the **dispose** module only has an input port as it represents the end of the system. When the entity reaches the **dispose** module this is the equivalent of a freight train reaching its final destination and leaving the network.

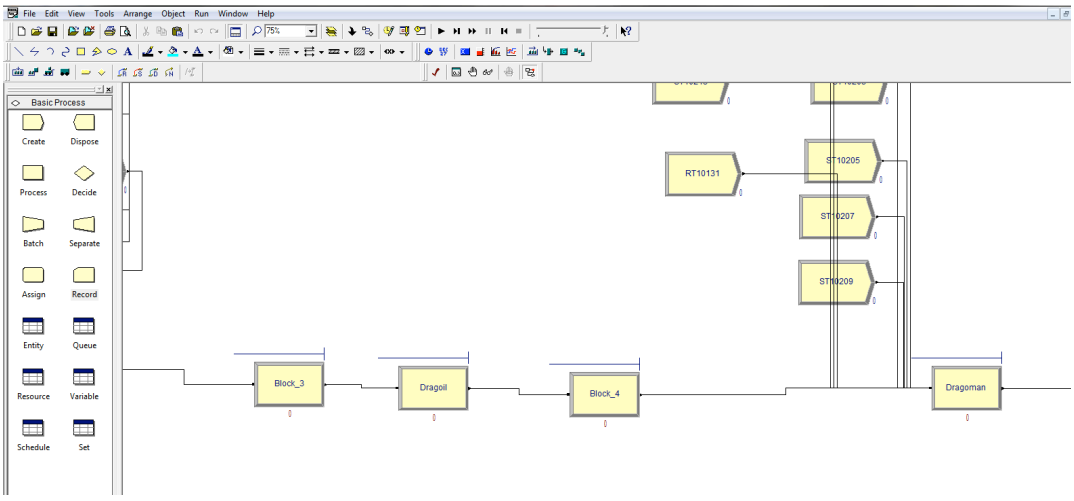


Figure 6.1 Input & Output Ports in Arena

When travelling through the system, the entities seize the resources in the system to be served. The resources represent the rail freight stations, passenger stations, rail freight yards and rail lines they are represented by the **process** module.

The interaction between the entity and the server represents the relationship between the stations and the trains. Similar to the **create** module the **process** module includes a number of pre-programmed variables to allow close replication of the system: Logic Action, Resource capacity and process time.

Potential queues within the network are also represented by the **process** module. Once the **process** module has been edited, potential queues within the system will appear automatically; these are represented by a blue line above the module. A queue will form if the number of entities is too high for the resource to process in the given time. If this situation occurs the entities will queue at the previous module.

If the network under replication includes rail freight yards and stations used only by freight traffic a **decide** module will be used. The **decide** module includes variables to split the entities with options to split them by chance or condition. Splitting the entities by condition will split the entities by entity type and name, to ensure that only freight trains flow through the freight station while passenger trains continue to the next station.

Entities exit the system through a **dispose** module. A **dispose** module records the number of entities leaving the system and this data is presented in the model report.

Once the network has been replicated within Arena the run parameters must be set using the run tool. The run tool allows the following variables to be edited: number of replications, replication length and statistics collection.

On completion of the simulation, Arena produces a number of reports the data from which are key to assessing the rail routes in question.

6.3 Route Simulation

A decomposition approach has been employed in order to replicate the three rail routes within Arena. Each route was decomposed into: rail line, rail freight stations, rail passenger stations and, in the case of the Bulgarian line, rail freight yards. (See Figure 6.2.) Detailed data regarding these components was provided by Adif, BDZ and Network Rail along with timetable data for the route.

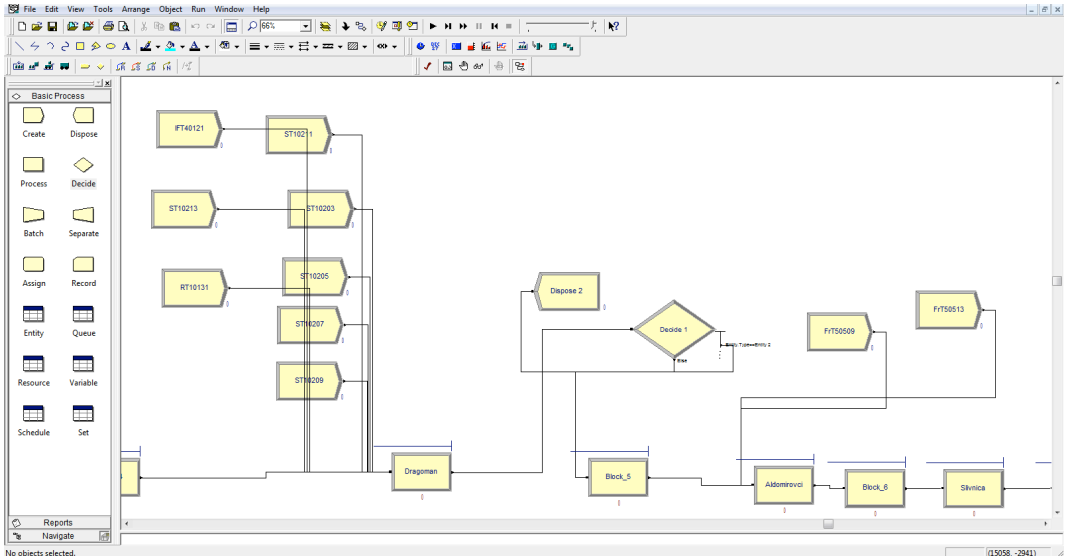


Figure 6.2 Decomposition of Railway Routes in Arena

Each line was replicated using a combination of **create**, **process**, **decide** and **dispose** modules. The freight represented in these models is scheduled freight, this was replicated using the create modules which create the entities or trains.

The rail line was represented by a **process** module initially the idea was to replicate each 2.5km block by one **process** module but due to restrictions with the software the total distance between each station was represented by one **process** module. The logic of the **process** module was edited to seize, delay, release wherein the entity/train seized the **process** module, is served by the resource and then releases the resource after a set parameter of time in line with the process time.

The rail freight stations and rail passenger stations were also represented by **process** modules. The **process** logic was edited to seize, delay, release as explained above the entity could then seize the resource within the server, be served by the resource in line with the process time and be released see Figure 6.3.

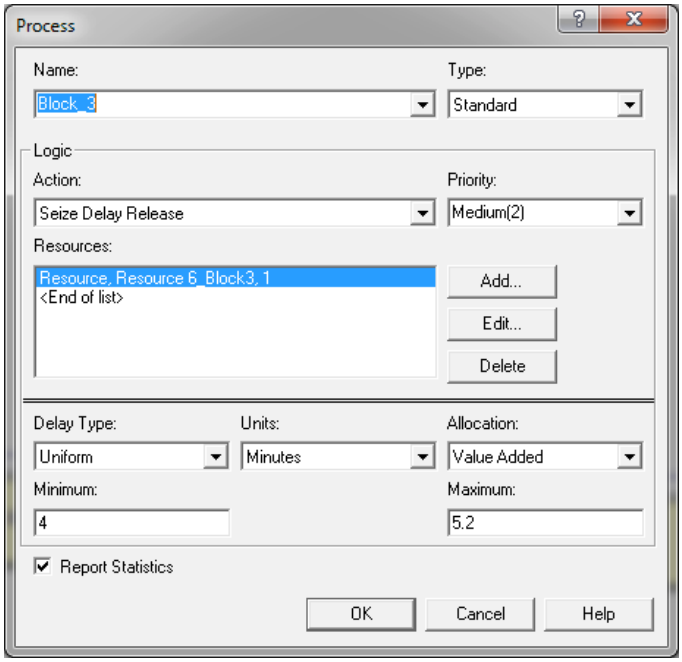


Figure 6.3 Process Module in Arena

Rail freight yards were decomposed into receiving yards, classification yards and departure yards with each yard represented by a separate **process** module. Rail freight yards were only included in the Bulgarian route. These **process** modules were edited to contain the same logic as rail lines and rail stations, i.e., seize-delay-release.

Decide modules were used to replicate the line where passenger trains and freight trains were served at separate stations or yards. This module provides the option to split the entities by type and name. In this way it was possible to give freight trains and passenger trains different entity names.

To ensure that the results produced by the simulation model are as accurate as possible, on completion the model must be calibrated and validated. As timetable data for these routes was available this was done through the comparison of the model with real world data.

6.4 Results

The models replicate reality reasonably well. Although the focus is on freight train movement scheduled passenger trains have been incorporated into the models and hence the global impact of freight train movement and vice versa is captured. To ensure a robust set of averages and results after reproducing each line within Arena, 150 replications of the model were run. Several measures of performance were collected for each line on completion of the simulation:

- Travel times & average speed
- Line utilisation – this is calculated through analysing the total number of entities seized by each block section.
- Station utilisation – this is calculated by analysing the total number of entities seized by each block section.
- Scheduled utilisation – this is calculated from taking the utilisation at each instant in time and then calculating a time-weighted average.

6.4.1 Spanish Route: Mediterranean Corridor

For the purposes of this analysis, due to low freight flows along the route initially in question from Valencia – Tarragona to allow for more critical analysis, the route in question has been extended from Castellbisbal to Silla.

The following services have been observed on the Mediterranean corridor:

- Nine direct freight trains
- Average line speed 75km/h
- Average train length 420m
- Average number of wagons per train 18

Figure 6.4 indicates line utilisation from Castellbisbal – Silla, this has been calculated using the total number of entities seized by each block section. Note the highest line utilisation from Tarragona – Sagunto (5) and the lowest utilisation between Sagunto and Valencia (2). This suggests that a number of freight services leave the line at Sagunto.

Figure 6.5 indicates station utilisation along the Mediterranean corridor, this has been calculated using the total number of entities seized by each station. The highest station utilisation at Valencia (6) suggests a number of freight services enter the line here.

Percentage utilisation from Castellbisbal – Silla is shown in Figure 6.6. This was calculated through taking the utilisation at each instant in time and then calculating a time-weighted average. These data suggest the highest utilisation rate is between Tarragona and Sagunto, which is in line with the highest line utilisation.

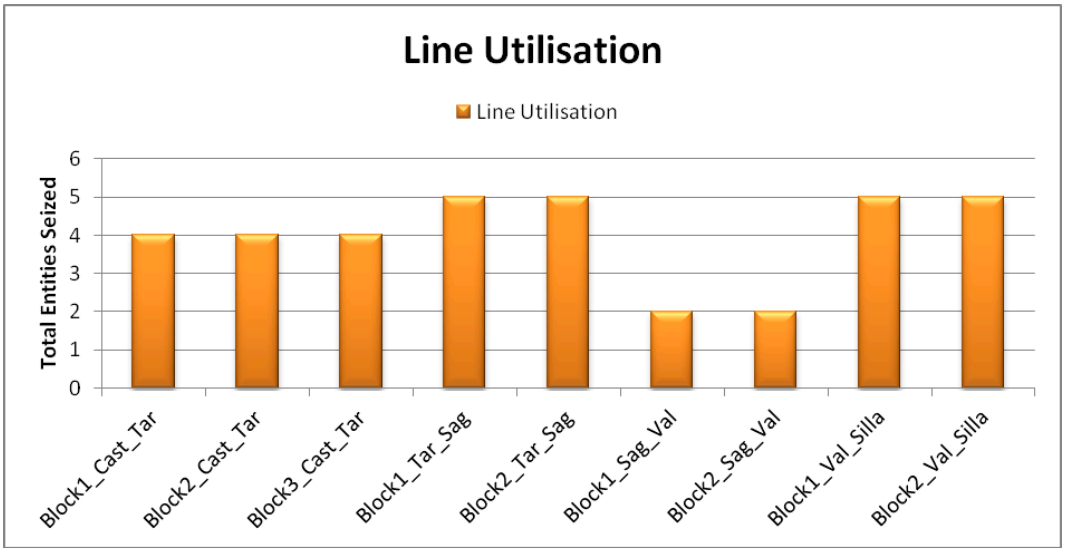


Figure 6.4 Line Utilisation – Castellbisbal – Silla

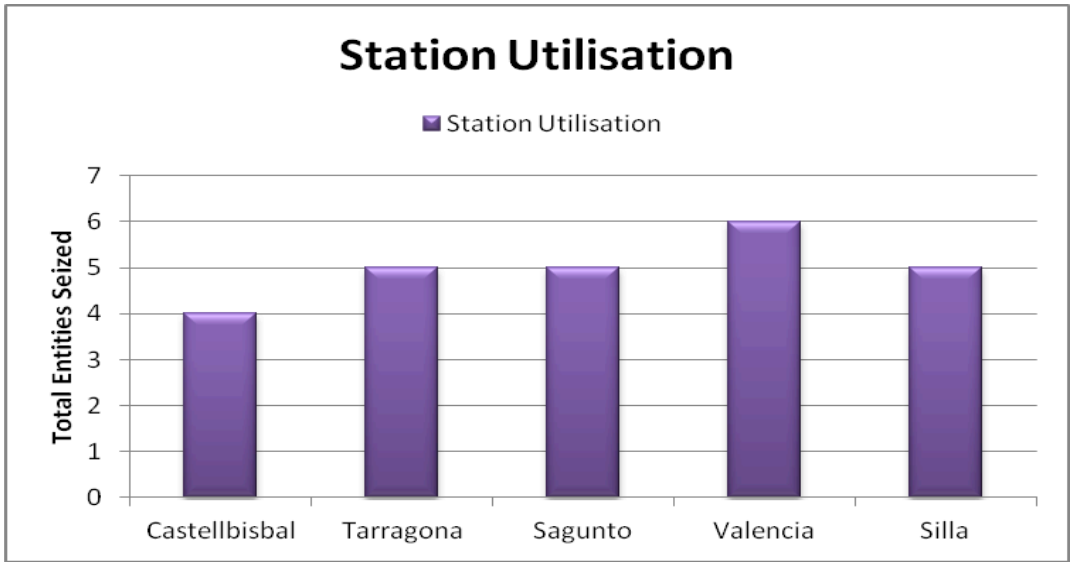


Figure 6.5 Station Utilisation – Castellbisbal – Silla

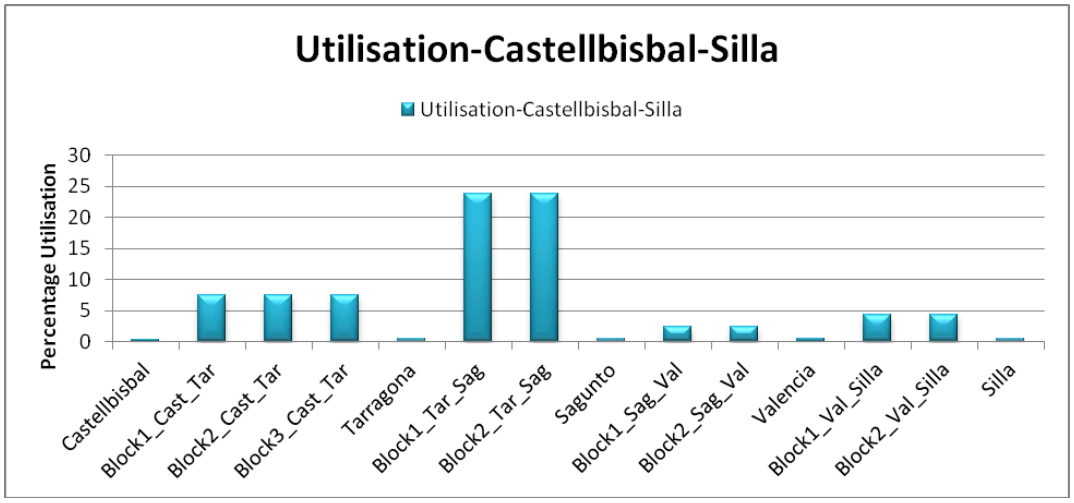


Figure 6.6 Utilisation – Castellbisbal – Silla

6.4.2 Bulgarian Route

The Bulgarian route is 367.5km long. Because of software restrictions, it was split into five sections as shown below and each section was modelled individually:

- Dimitrovgrad S – Sofia
- Poduyane – Verinsko
- Ihtiman – Todor Kableshkov
- Plovdiv R – Parvomaj
- Jabalkovo – Kapikule

The measures of performance are presented for each section individually.

Dimitrovgrad S – Sofia

For the purposes of this analysis the following services have been observed on the section Dimitrovgrad S – Sofia, shown in Figure 6.7 indicated in red.

- Twenty multi-stopping freight trains
- Average speed 71km/h
- Average train length 500 metres
- Average number of wagons per train 17-24



Figure 6.7 Dimitrovgrad S – Sofia

Data regarding the condition of the track for this section suggests the track is in bad condition. A section between Petarch and Volujak is ranked as medium state; the overall conclusion for this section of track is that speeds may have to be reduced from the maximum speed of 100km/h by up to 30% in order to counteract the condition of the track.

Figure 6.8 shows line utilisation, which has been calculated using the total number of entities seized by each block section. Note, the block Aldomirici – Volujak demonstrates the highest level of line utilisation (30), while Dimitrovgrad S – Kalotina Zapad shows the lowest line utilisation (18).

Figure 6.9 indicates station utilisation, which has been calculated using the total number of entities seized by each block section. In line with line utilisation the stations of Aldomirici, Slivinca, Petarch, Kostinbrod and Volujak demonstrate the highest level of utilisation. The lowest station utilisation is at Dimitrovgrad S and Kalotina Zapad. This indicates that freight services join the line at Dragoil and leave at Volujak.

Figure 6.10 below indicates percentage utilisation for the section Dimitrovgrad S – Sofia. This was calculated through taking the utilisation at each instant in time and then calculating a time-weighted average. These data indicate the highest utilisation in this section occurs at Kalotina Z, Dragoman and Block 6 Aldomirici – Slivinca. Low percentage utilisation can be viewed at Kalotina and Sofia. After exploring the model outputs and additional data further, improvements may be considered at these stations.

Both Figure 6.8 and Figure 6.9 indicate that there is an increase in freight traffic to the line at Dragoil, some of which leaves the line at Volujak. This suggests a clear freight flow along this section of the line.

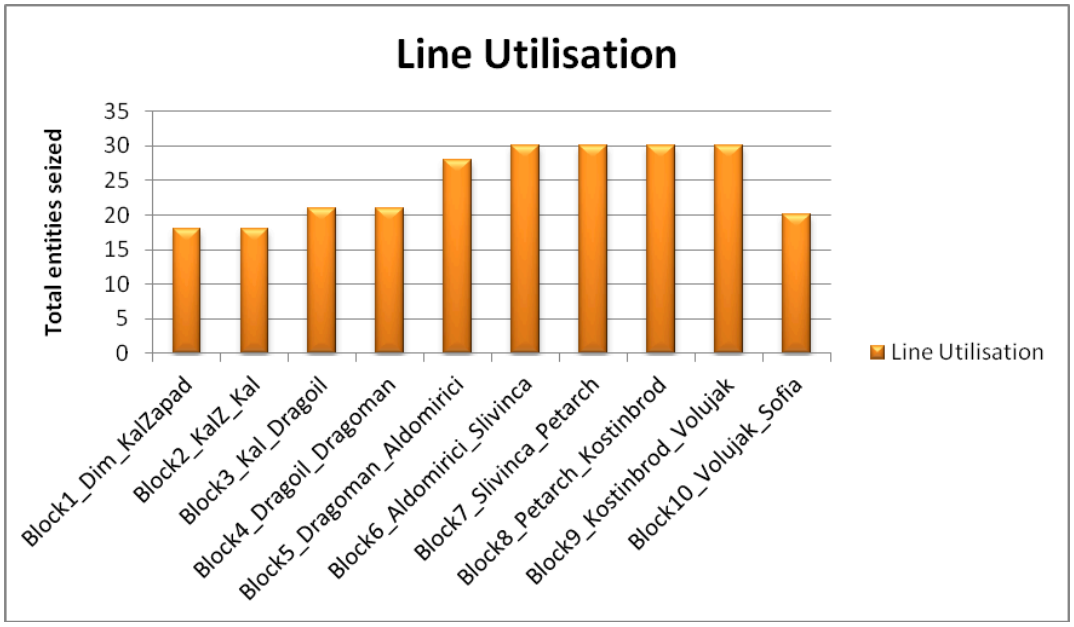


Figure 6.8 Line Utilisation – Dimitrovgrad S – Sofia

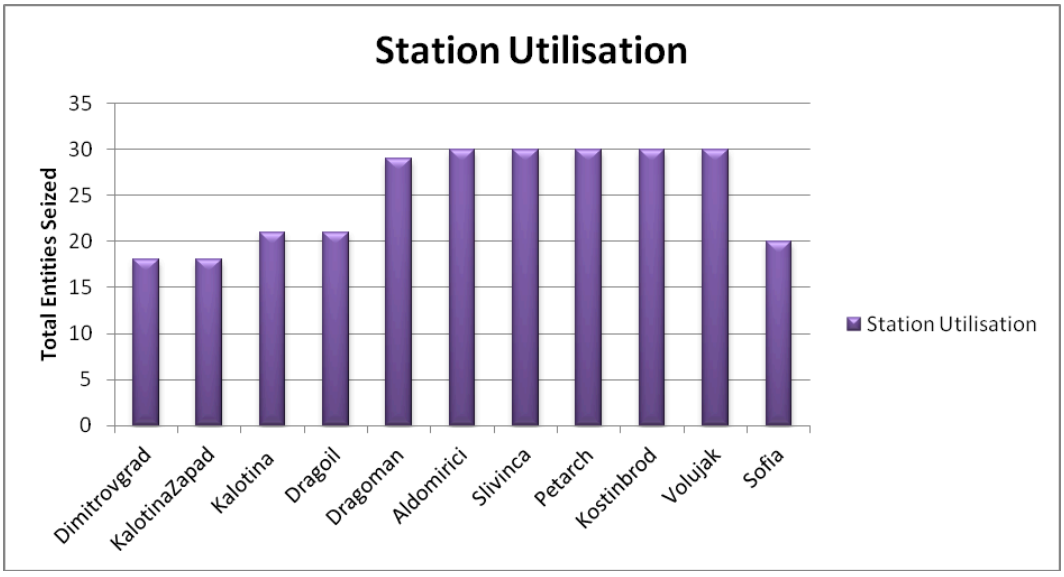


Figure 6.9 Station Utilisation – Dimitrovgrad S – Sofia

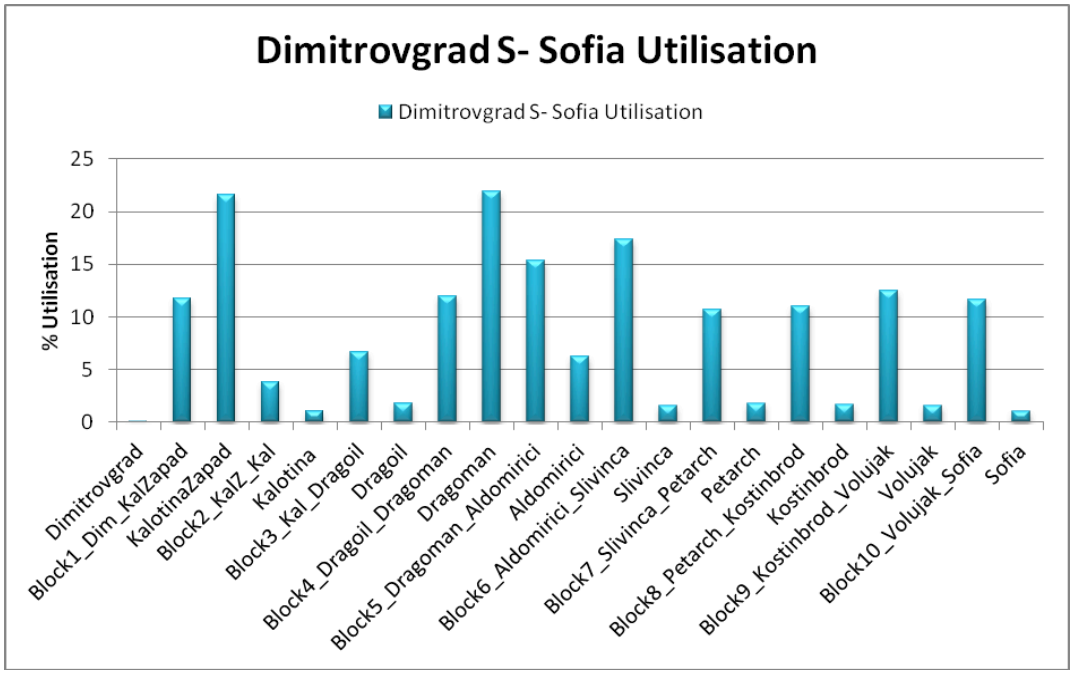


Figure 6.10 Dimitrovgrad S – Sofia Utilisation

Poduyane-Verinsko

For the purposes of this analysis the following services have been observed on the section Poduyane – Verinsko:

- Thirteen multi-stopping freight trains
- Average speed 72.5km/h
- Average train length 500 metres
- Average number of wagons per train 17-24
- Capacity of the Poduyane marshalling yard is 100 trains overnight. Currently the yard only works at 10% of its capacity due to a decrease in the demand for freight traffic.

The Poduyane – Verinsko section of the route is indicated in Figure 6.11, highlighted in red.



Figure 6.11 Poduyane – Verinsko

Data regarding the condition of the track for this section suggests the track is in medium-good condition. Sections from Elin Pelin – Pobit Kamak and Vakarel – Verinsko are in good condition, while the rest of the track in this section has been ranked as medium.

Figure 6.12 indicates line utilisation; note the blocks from Iskar – Vakarel demonstrate the highest level of line utilisation (25), while Poduyane – Iskar demonstrates the lowest level of line utilisation (22). This decrease in services between Vakarel and Verinsko indicates that some freight services leave the line at Vakarel.

Figure 6.13 indicates station utilisation, in concordance with line utilisation, stations from Iskar – Vakarel demonstrate the highest level of utilisation. Note the utilisation of the marshalling yard is currently only working at 10% capacity. This indicates that not all the freight on this section of the route passes through the marshalling yard.

Figure 6.14 indicates percentage utilisation for the section Poduyane marshalling yard – Verinsko. These data indicate the highest utilisation in this section occurs at Poduyane marshalling yard and on the line between Pobit Kamak and Vakarel. Significantly low percentage utilisation can be viewed at Poduyane and Kazichene. Figure 6.12, Figure 6.13 and Figure 6.14 suggest that freight traffic enters the route at Poduyane where line and station utilisation increases and leaves the line at Vakarel where line and station utilisation then decreases.

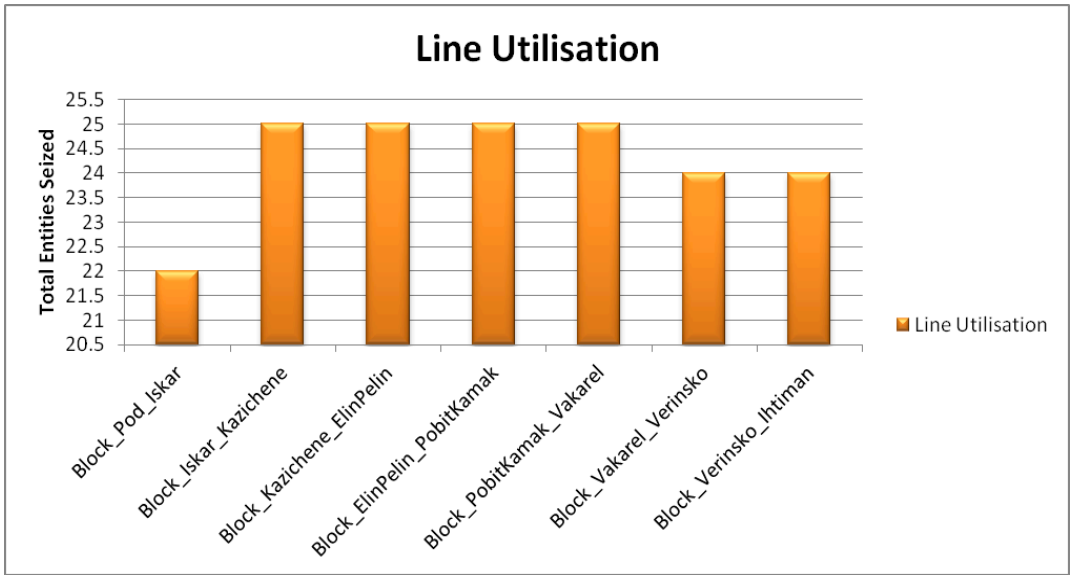


Figure 6.12 Line Utilisation – Poduyane – Verinsko

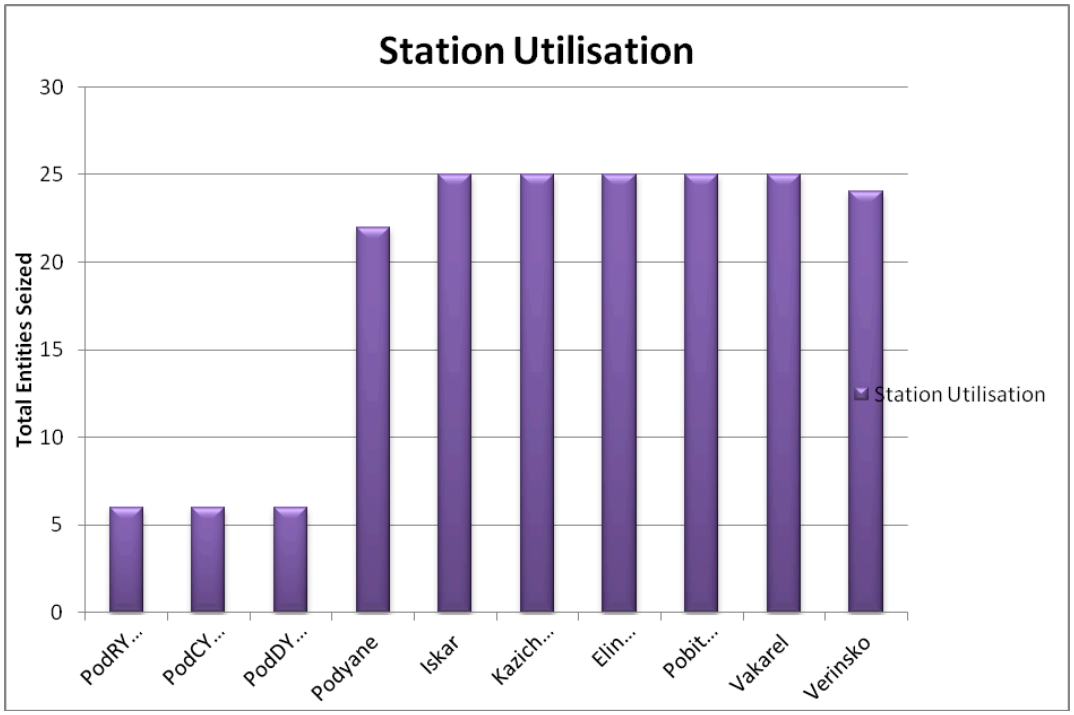


Figure 6.13 Station Utilisation – Poduyane – Verinsko

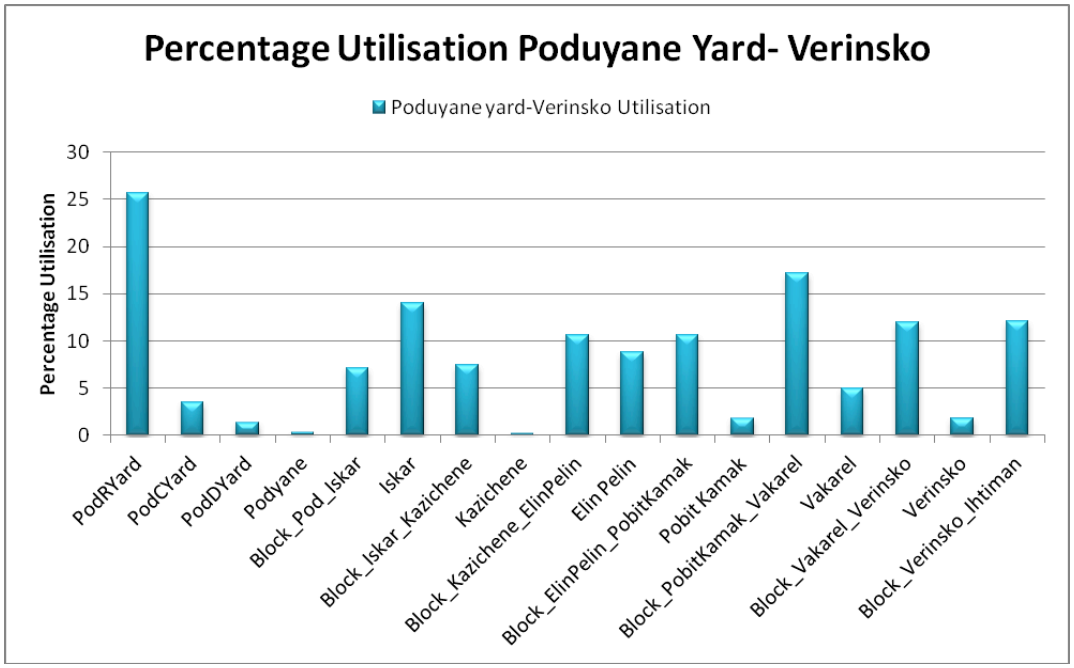


Figure 6.14 Utilisation – Poduyane – Verinsko

Ihtiman – Todor Kableshkov

For the purposes of this analysis the following services have been observed on the section Ihtiman – Todor Kableshkov shown in Figure 6.15:

- Fifteen multi-stopping freight trains
- Average speed 77km/h
- Average train length 500 metres
- Average number of wagons per train 17-24



Figure 6.15 Ihtiman – Todor Kableshkov

Data for the condition of the track in this section indicates that there is a combination of track conditions from Ihtiman – Todor Kableshkov. Data for stations from Ihtiman – Septemvri demonstrates that the track condition here is poor, while data for stations from Septemvri-Pazardzhik suggest good track conditions. For the remainder of this section the data indicates the track is of medium condition.

Figure 6.16 indicates line utilisation, the highest level of line utilisation is demonstrated between Ihtiman and Septemvri (23), line utilisation decreases sharply from Septemvri – Pazardzhik, note this block demonstrates the lowest line utilisation of 12.

Figure 6.17 indicates station utilisation. In accord with line utilisation the highest level of station utilisation can be viewed from Ihtiman – Septemvri. Septemvri has the highest station utilisation of 24. Station utilisation also follows the trend of line utilisation in that station utilisation decreases at Pazardzhik. This suggests a significant volume of freight leaves the line at Septemvri.

Figure 6.18 indicates percentage utilisation for the section Ihtiman – Todor Kableshkov. These data indicate the highest utilisation in this section is between Kostenec – Sestrimo, several stations and blocks in this section indicate significantly low percentage utilisation. To allow this section to be better utilised these may need to be addressed.

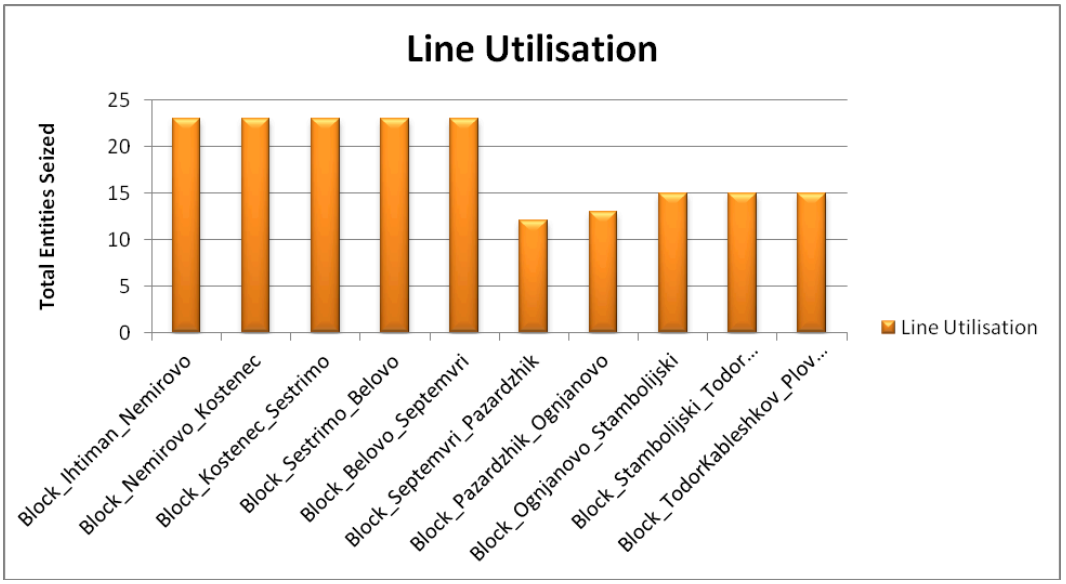


Figure 6.16 Line Utilisation Ihtiman – Todor Kableshkov

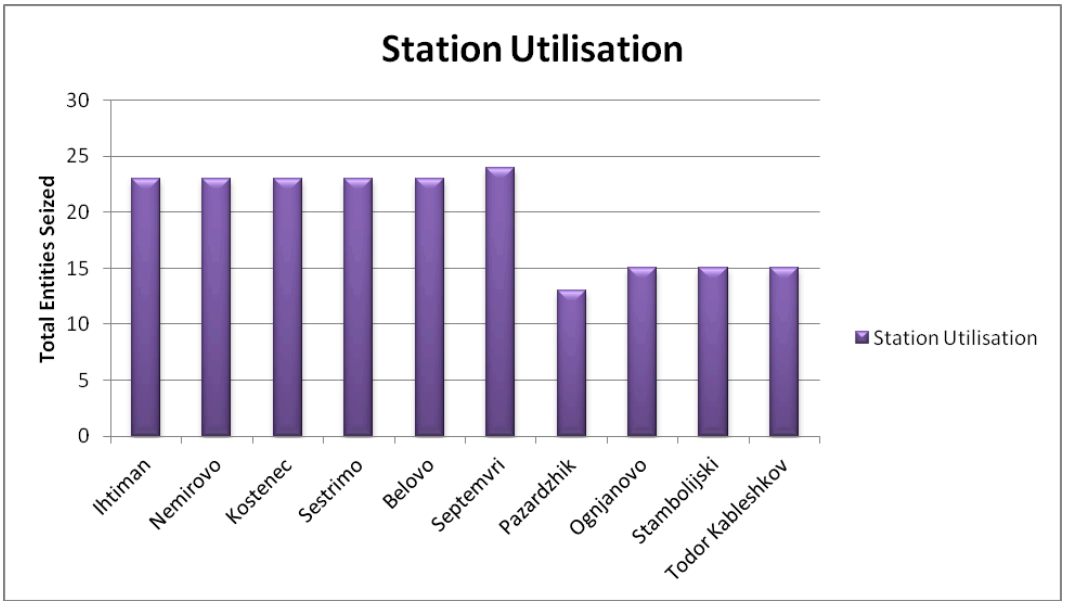


Figure 6.17 Station Utilisation Ihtiman – Todor Kableshkov

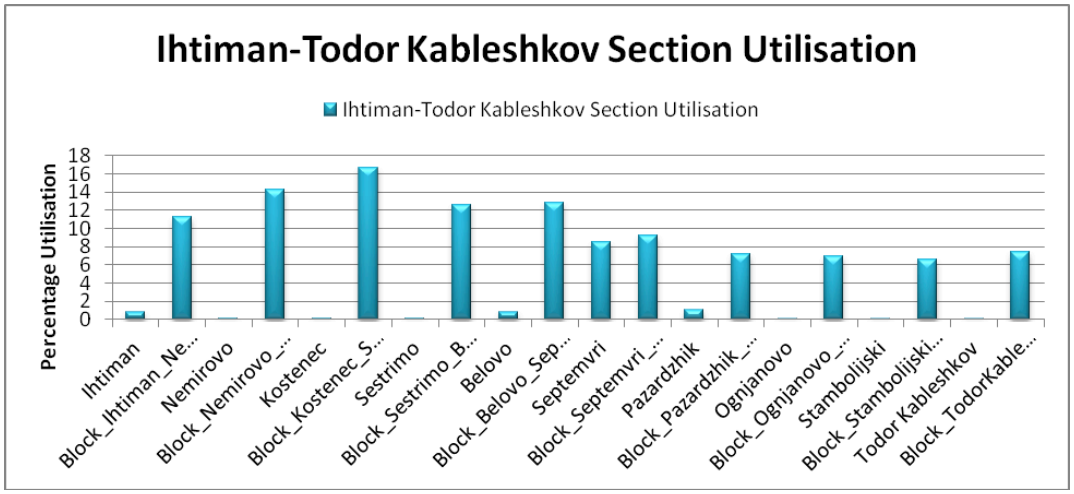


Figure 6.18 Utilisation – Ihtiman – Todor Kableshkov

Plovdiv R – Parvomaj

For the purposes of this analysis the following services have been observed on the section Plovdiv R – Parvomaj, indicated in Figure 6.19:

- Eleven multi-stopping freight trains
- Average Speed 80km/h
- Average train length 500 metres
- Average number of wagons per train 17-24

Data regarding the condition of the track for this section suggests for a large proportion of this section the track is in good condition. However the track condition from Plovdiv – Plovdiv marshalling yard is bad and from Plovdiv marshalling yard – Krumovo is medium.

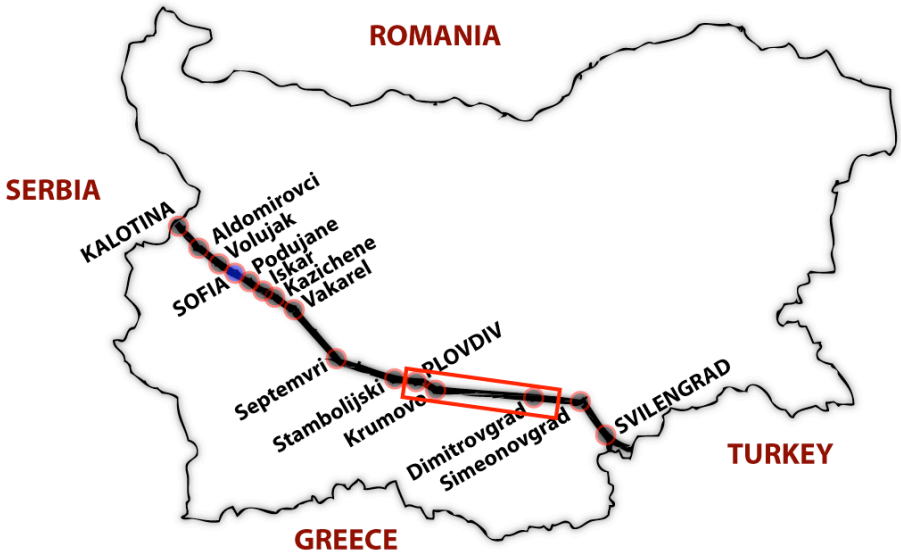


Figure 6.19 Plovdiv R – Parvomaj

Figure 6.20 indicates line utilisation, which indicates a clear pattern, as the line has a higher rate of utilisation in the blocks which serve passenger and freight services. Plovdiv Yard and Sadovo serve only freight services.

Figure 6.21 indicates station utilisation, which suggests a pattern in concordance with line utilisation, note the lower utilisation of 10 at Plovdiv yard and Sadovo.

Figure 6.22 indicates percentage utilisation for the section Plovdiv R – Parvomaj. These data suggest a pattern of a higher rate of utilisation in the blocks and stations where only freight trains are served. This can be explained through a lower number of services passing through these stations and blocks leading to a higher percentage utilisation.

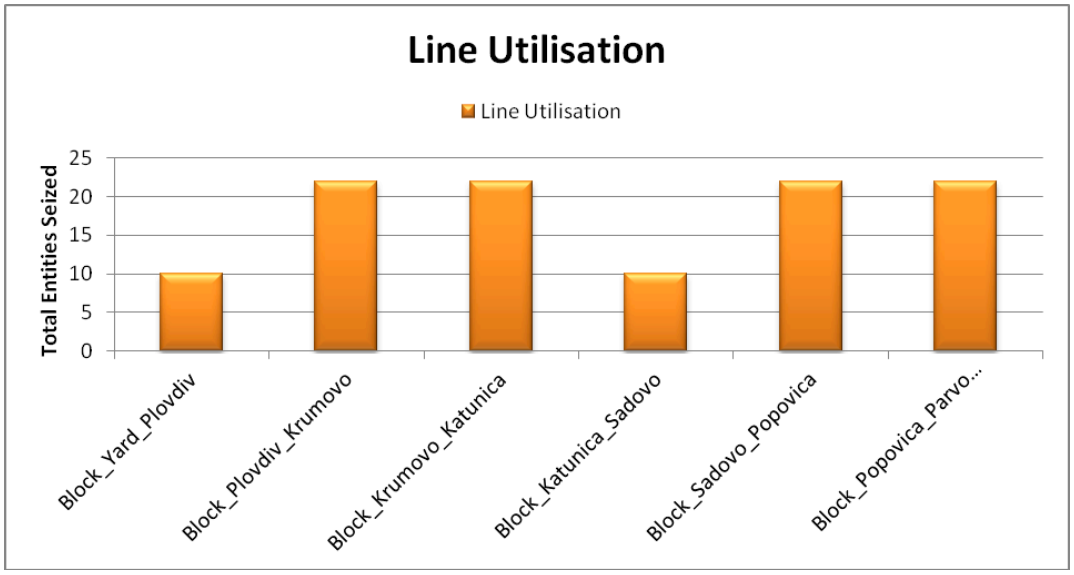


Figure 6.20 Line Utilisation – Plovdiv R – Parvomaj

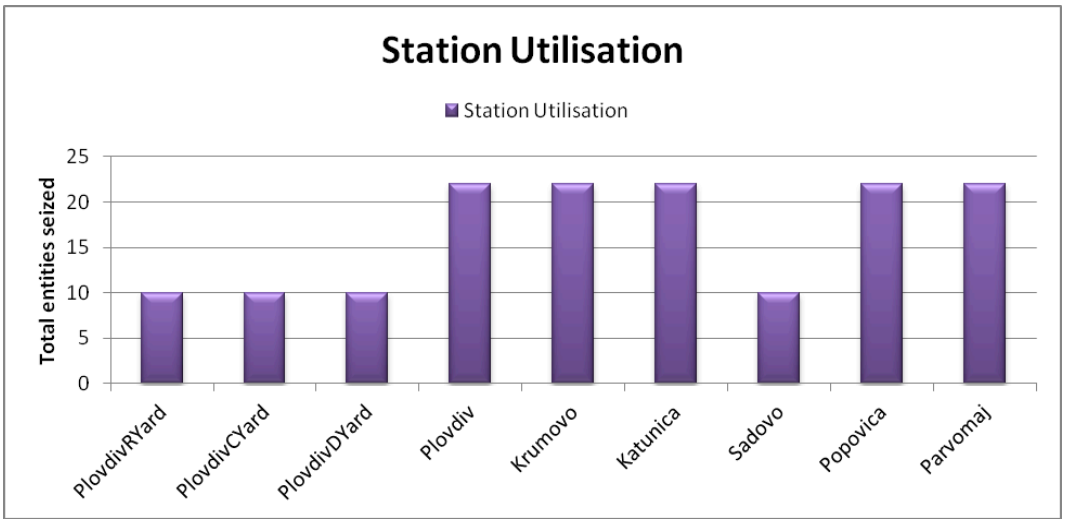


Figure 6.21 Station Utilisation – Plovdiv R – Parvomaj

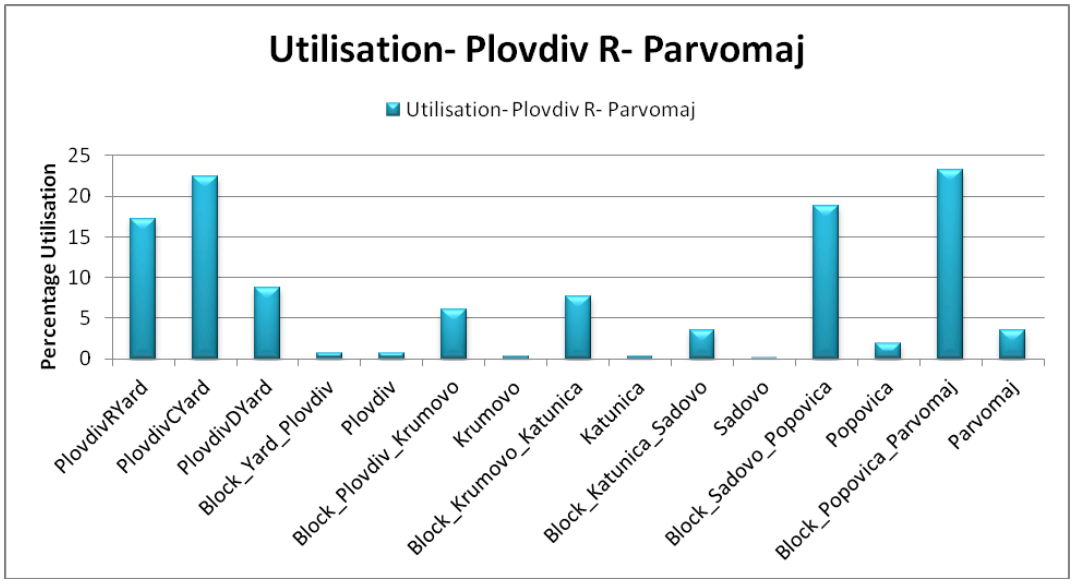


Figure 6.22 Utilisation – Plovdiv R – Parvomaj

Jabalkovo – Kapikule

For the purposes of this analysis the following trains have been observed on the section Jabalkovo – Kapikule, indicated in Figure 6.23.

- Twelve multi-stopping freight trains
- Average Speed 85km/h
- Average train length 500 metres
- Average number of wagons per train 17-24

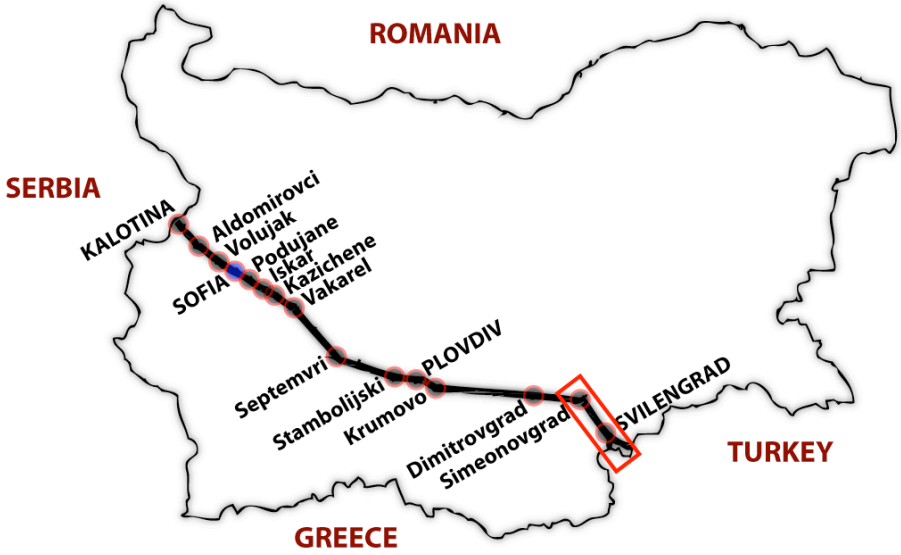


Figure 6.23 Jabalkovo – Kapikule

Data regarding the condition of the track suggests that there is a combination of track conditions between Jabalkovo and Kapikule. Data from stations Dimitrovgrad-Harmanli indicate poor track conditions, while track conditions from Jabalkovo-Dimitrovgrad and Ljubimec-Kapikule are in good condition. Track for the remainder of this section can be considered in medium condition.

Figure 6.24 indicates line utilisation between Parvomaj and Kapikule. These data indicate there is little variation between the utilisation rates, note the lowest utilisation in block Ljubimec – Svilengrad (18).

Station utilisation between Jabalkovo and Svilengrad is indicated in Figure 6.25 . These data suggest a level of variance between stations; note the highest utilisation Dimitrovgrad (24), and the lowest utilisation (20) at Nova Nadezhda.

Figure 6.26 demonstrates percentage utilisation between Block Parvomaj-Jabalkovo – Block Svilengrad – Kapikule. These data do not suggest a clear pattern, the highest utilisation should be noted at Svilengrad, this may be explained through a number of freight services joining the line here, while Ljubimec and Simeonovgrad both indicate significantly low levels of utilisation.

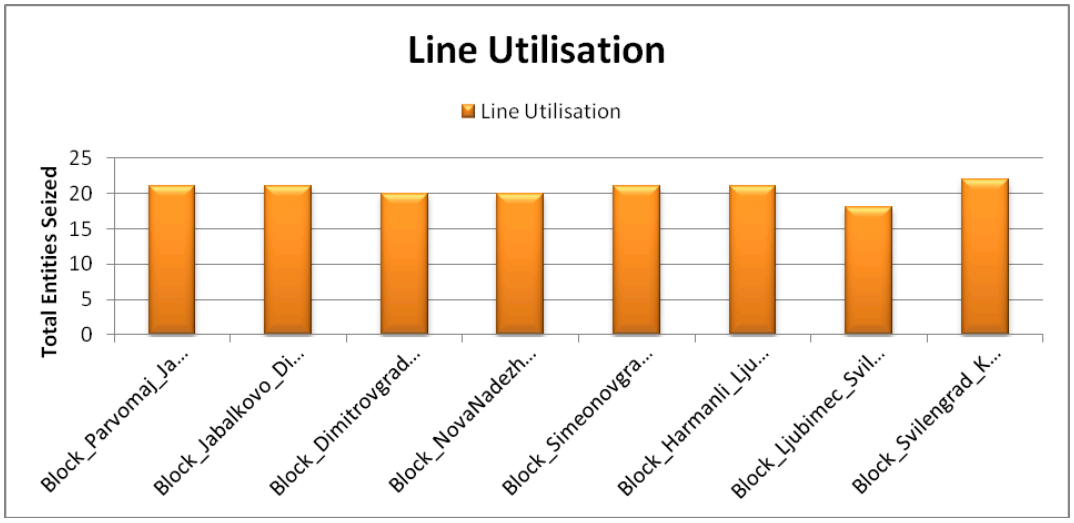


Figure 6.24 Line Utilisation – Parvomaj – Kapikule

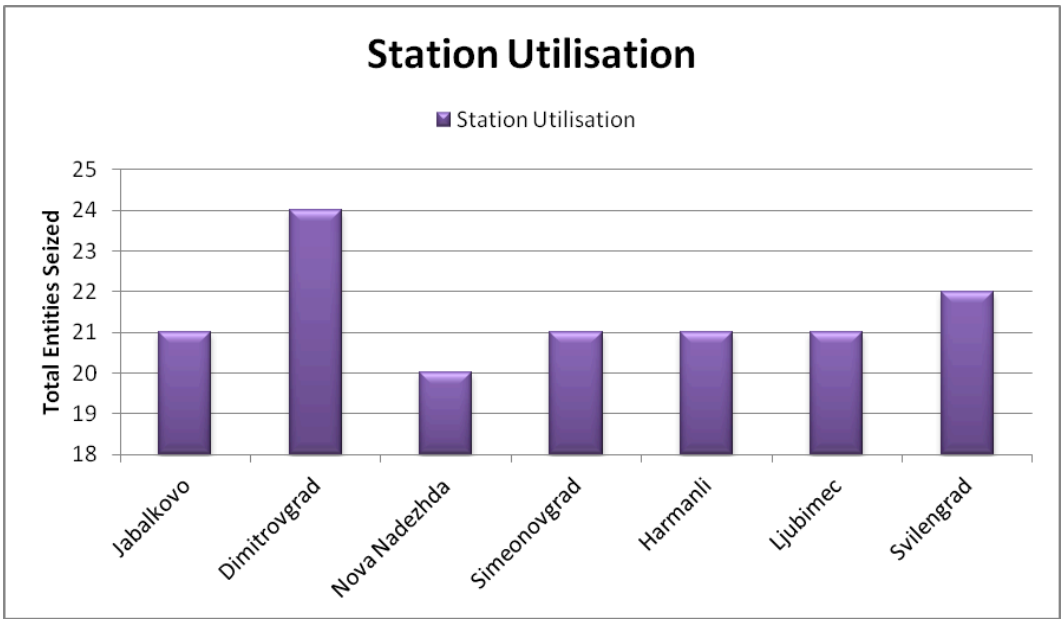


Figure 6.25 Station Utilisation – Jabalkovo – Svilengrad

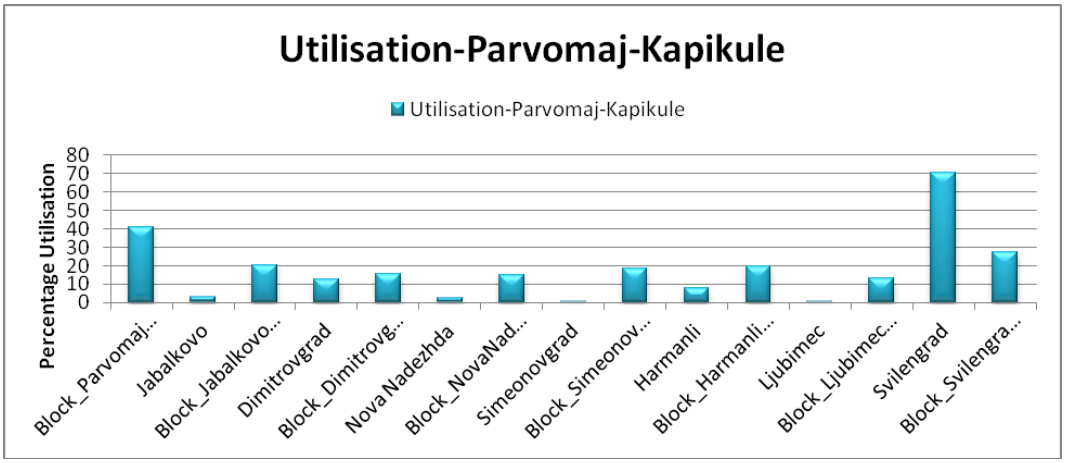


Figure 6.26 Utilisation – Parvomaj – Kapikule

6.4.3 UK Route: Southampton – Warrington

Due to software restrictions the route was split into four sections as detailed below and each section was modelled individually:

- Southampton Harbour East – Basingstoke
- Bramley – Chester Line Junction
- Appleford – Leamington Spa Junction
- Milverton – Warrington

The measures of performance are presented for each section individually.

Southampton Harbour East – Basingstoke

- 22 direct freight trains per day
- Average speed 80km/h
- Average train length 557 metres
- Average number of wagons per train 23

Figure 6.27 indicates line utilisation between Southampton Harbour East and Basingstoke. This has been calculated using the total number of entities seized by each block section. A clear pattern is visible from Block 3-9 between St Denys and Basingstoke after an increase in the total number of services on the line at St Denys.

Figure 6.28 demonstrates station utilisation between Southampton Harbour East and Basingstoke. This has been calculated using the same method as line utilisation. These data indicate the pattern for station utilisation is in concordance with line utilisation, note the highest utilisation of 29 from Southampton Airport Parkway to Basingstoke.

Percentage utilisation between Southampton Harbour East and Basingstoke has been calculated through taking the utilisation at each instant in time and then calculating a time weighted average. This is demonstrated in Figure 6.29. Note the highest percentage utilisation in Block 8 between Micheldever and Basingstoke and the lowest utilisation at St Denys of 2.5.

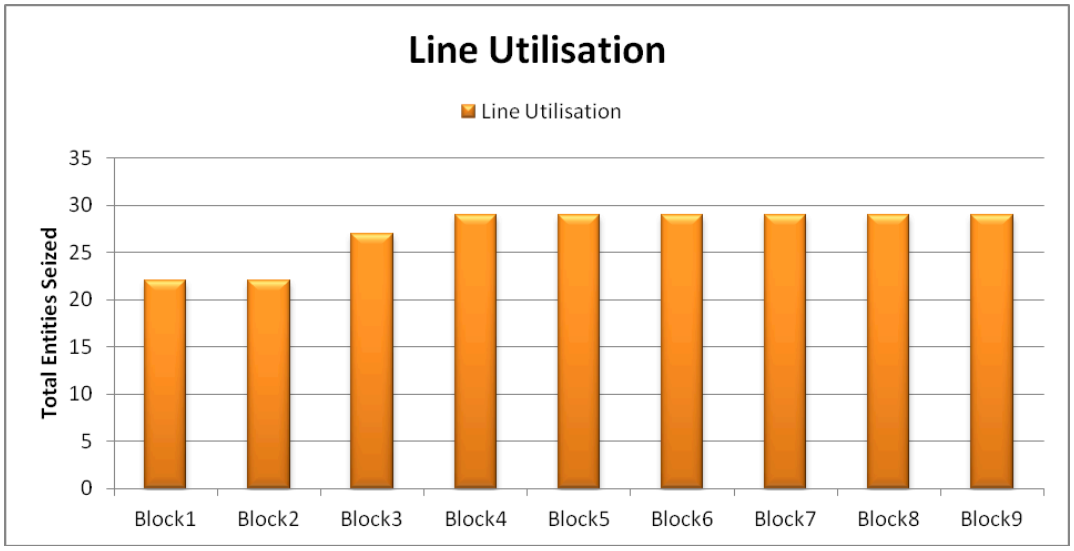


Figure 6.27 Line Utilisation SHE – Basingstoke

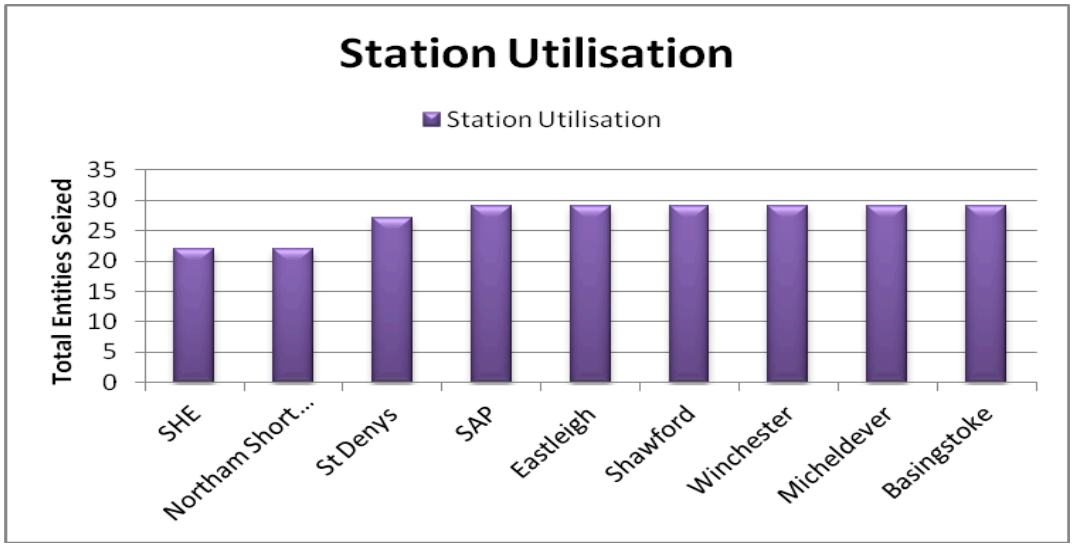


Figure 6.28 Station Utilisation: SHE – Basingstoke

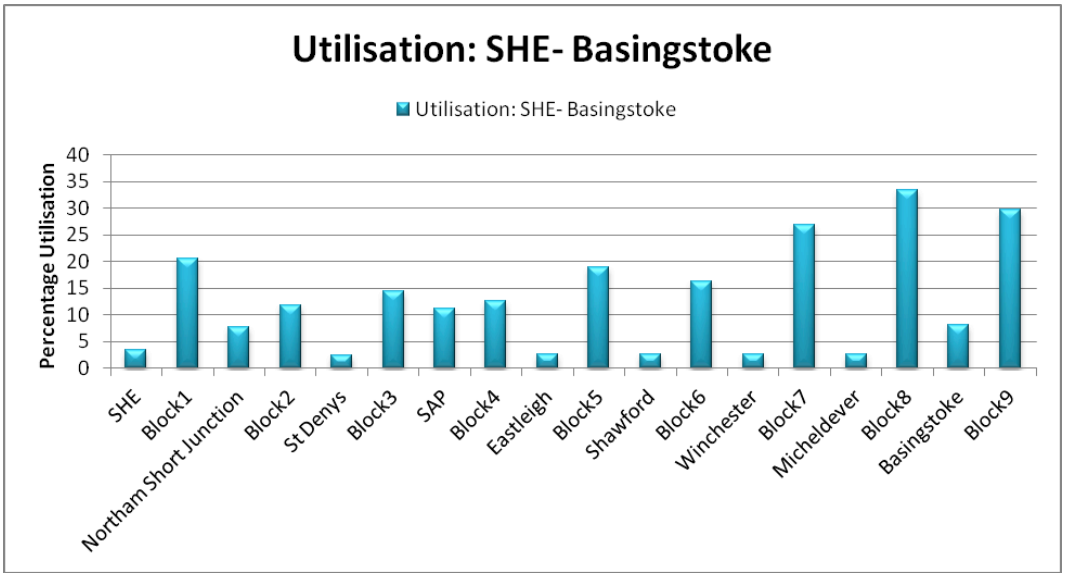


Figure 6.29 Utilisation: SHE – Basingstoke

Bramley – Chester Line Junction

- 22 direct freight trains
- Average speed 80km/h
- Average train length 557 metres
- Average number of wagons per train 23

Figure 6.30 below demonstrates line utilisation from Bramley – Chester Line Junction, a clear pattern is visible; every block except block 19 from Didcot – Chester Line Junction indicate the same utilisation of 29, while block 19 indicates a utilisation of 24. This may be explained through a number of services leaving the line at Didcot. This is a major junction with trains diverting from the GWR mail line and on lines to the Midlands. The GWR main line is an intensively used high-speed passenger and regional passenger service route. The Cross Country passenger route supports 4-6 trains per hour together with regional and commuter operations.

Figure 6.31 indicates station utilisation from Bramley – Chester Line Junction, this follows a pattern in concordance with line utilisation, note the lowest utilisation of 24 at Chester Line Junction.

Figure 6.32 indicates percentage utilisation between Junction 1 and Chester Line Junction, these data do not suggest any clear pattern, note a significant highest percentage utilisation at block 12 between Mortimer and Reading West. Significantly low percentage utilisation is demonstrated at Bramley, Mortimer, Westbury Junction, Tilehurst, Pangbourne, Goring, Cholsey and Didcot. The freight trains operate over lines occupied by intensive Inter-city services, bulk aggregate flows and other traffic around the Reading-Didcot section. Most container traffic leaves the GWR main line at Didcot. This line operates as the link between the LSWR route and the GWR line for block container and tanker trains with no train consist adjustment at any of the stations passed in transit.

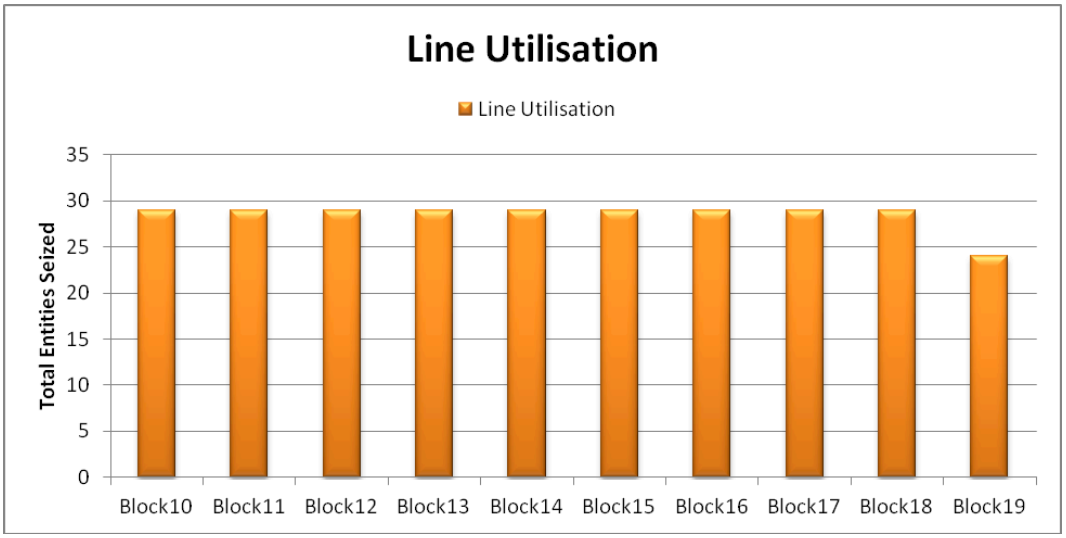


Figure 6.30 Line Utilisation: Bramley – Chester Line Junction

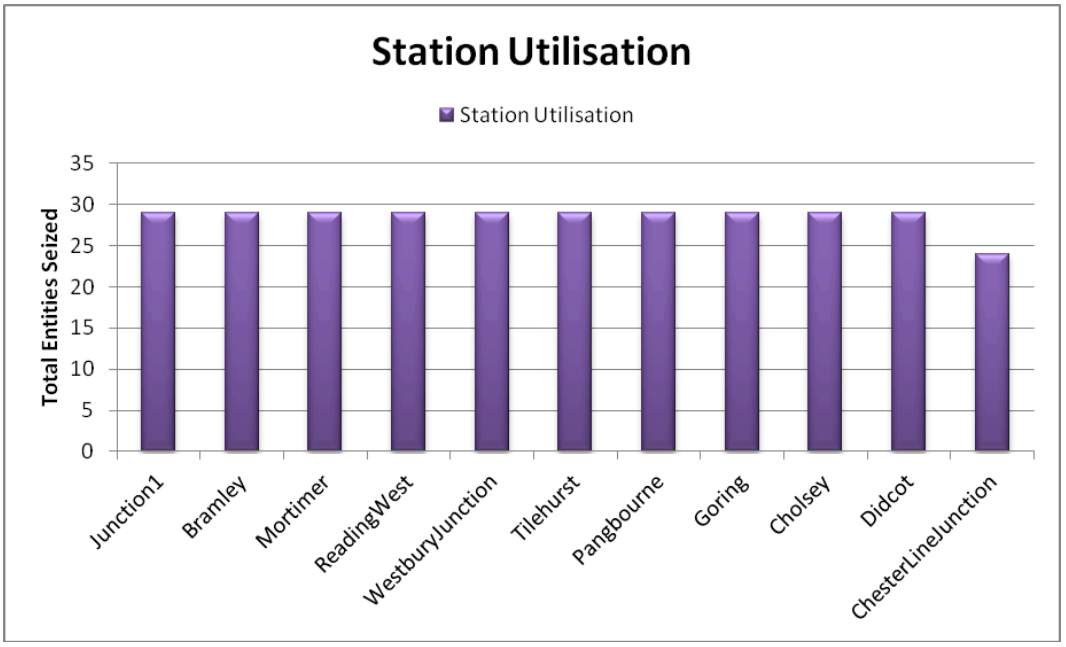


Figure 6.31 Station Utilisation: Bramley – Chester Line Junction

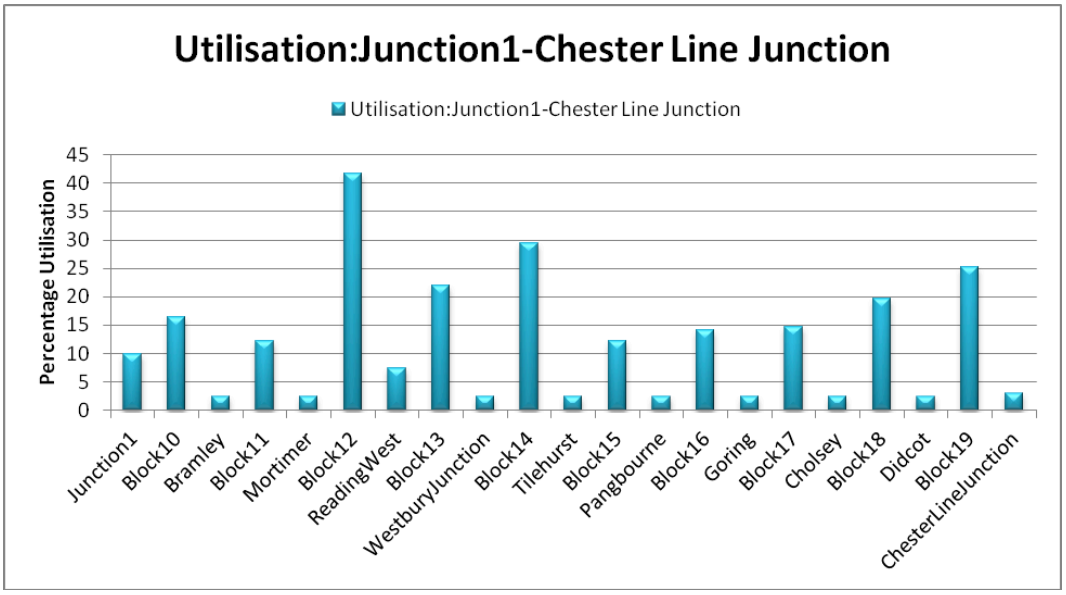


Figure 6.32 Utilisation: Junction1 – Chester Line Junction

Appleford – Leamington Spa Junction

- 22 direct freight trains
- Average speed 80km/h
- Average train length 557 metres
- Average number of wagons per train 23

Line utilisation between Appleford and Leamington Spa Junction is indicated in Figure 6.33 as with Figure 6.30 these data follow a clear pattern. Every block except block 29 has a utilisation of 28, while block 29 which represents from Leamington Spa-Leamington Spa Junction has a utilisation of 23. This can be explained through a number of freight services leaving the line at Leamington Spa, with a final destination of Birmingham or beyond.

Station utilisation between Appleford and Leamington Spa Junction indicated in Figure 6.34 suggests a pattern in accord with line utilisation for this section. Note the highest line utilisation of 28 and the lowest utilisation of 23 Leamington Spa Junction.

Figure 6.35 indicates percentage utilisation along this section, this has been calculated through taking the utilisation at each instant in time and calculating a time weighted average. Block 21 between Appleford and Culham indicates a significantly high utilisation of 60%. Note significantly low utilisation occurs at Appleford, Radley, Oxford, Tackley, Kings Sutton and Banbury.

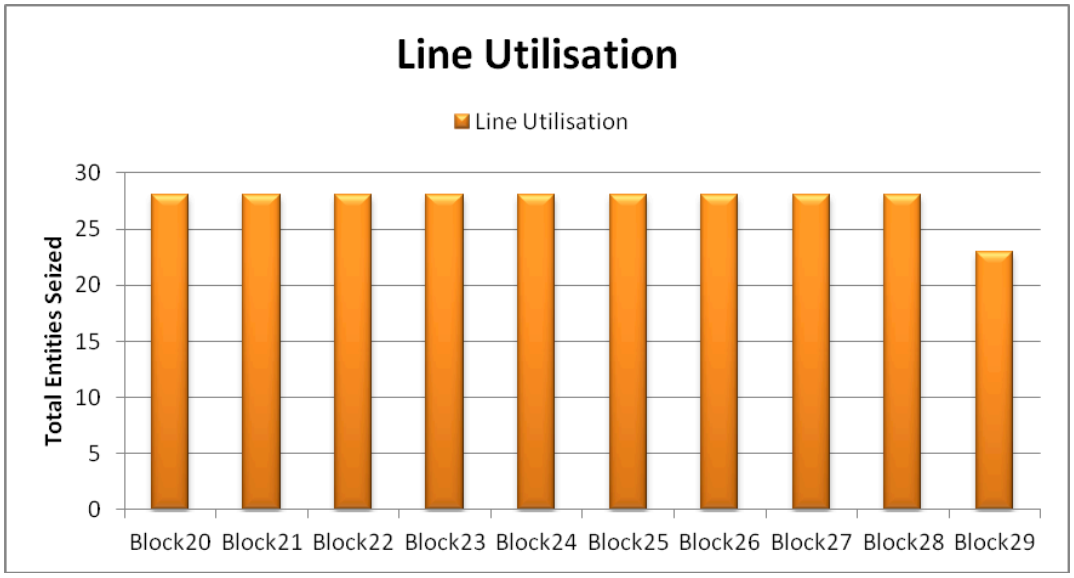


Figure 6.33 Line Utilisation: Appleford – Leamington Spa Junction

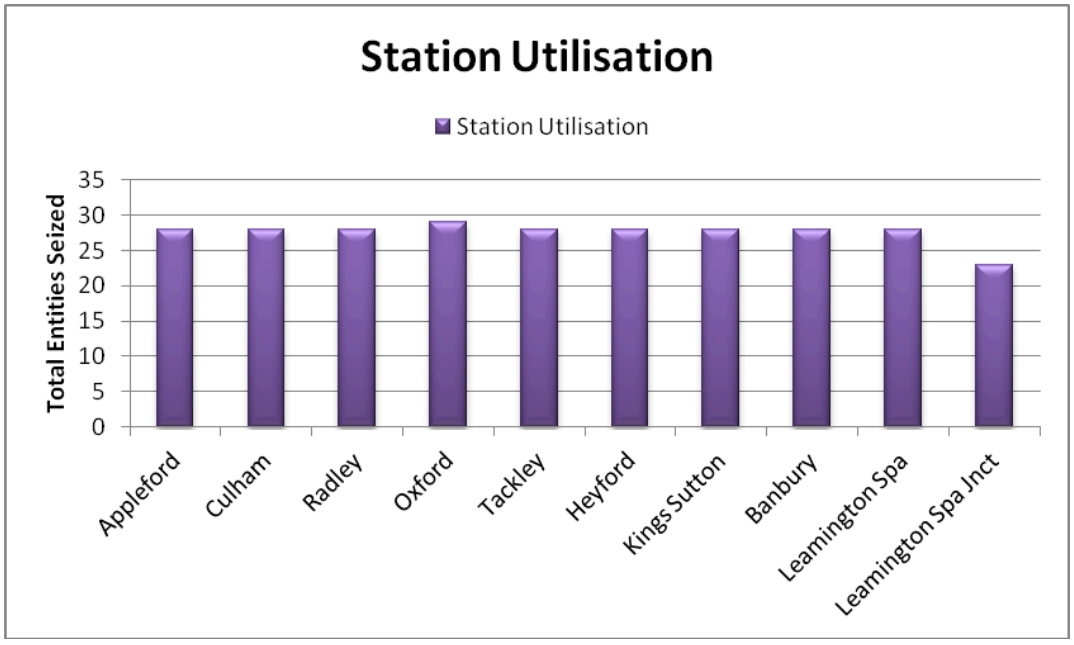


Figure 6.34 Station Utilisation: Appleford – Leamington Spa Junction

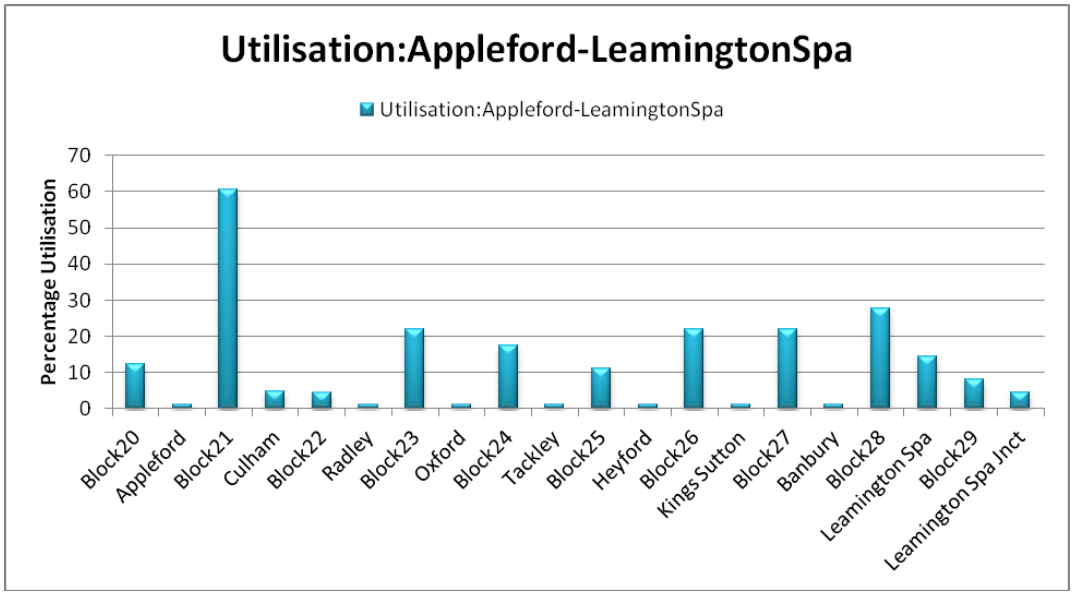


Figure 6.35 Utilisation: Appleford – Leamington Spa Junction

Milverton – Warrington

- 17 direct freight trains
- Average speed 80km/h
- Average train length 557 metres
- Average number of wagons per train 23

Line utilisation between Milverton and Warrington is demonstrated in Figure 6.36. The model included an estimate of the number of trains thought to be leaving the line at Coventry and at Nuneaton and this is shown in the output data and in the steady decrease in line utilisation after these stations.

Station utilisation is indicated in Figure 6.37, these data suggest a pattern in concordance with line utilisation. Note the highest utilisation (24) between Milverton and Coventry and the lowest utilisation (11) Warrington.

Figure 6.38 suggests there is a significantly high percentage utilisation between Tamworth and Crewe, this may be explained through the high travel time between these stations. Significantly low utilisation is demonstrated at Milverton, Coventry South Junction, Coventry, Coventry North Junction and Bedworth.

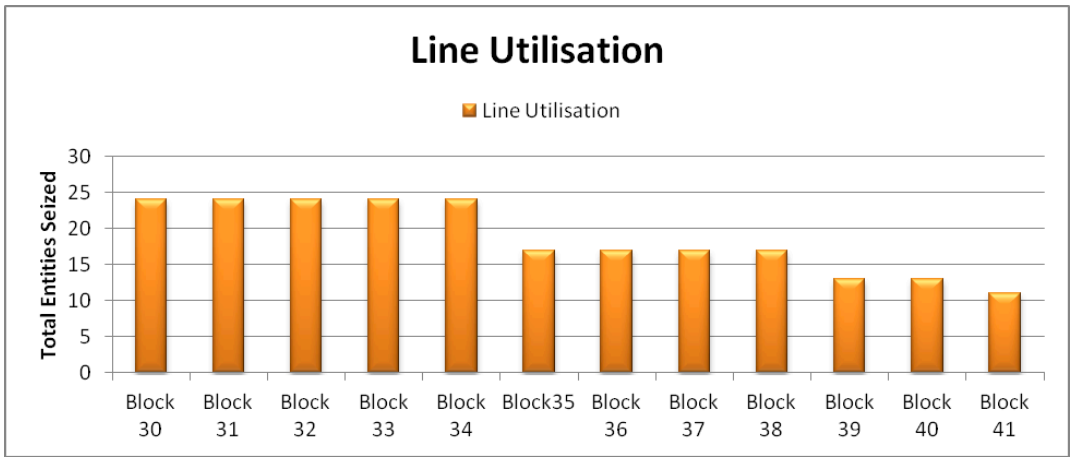


Figure 6.36 Line Utilisation: Milverton – Warrington

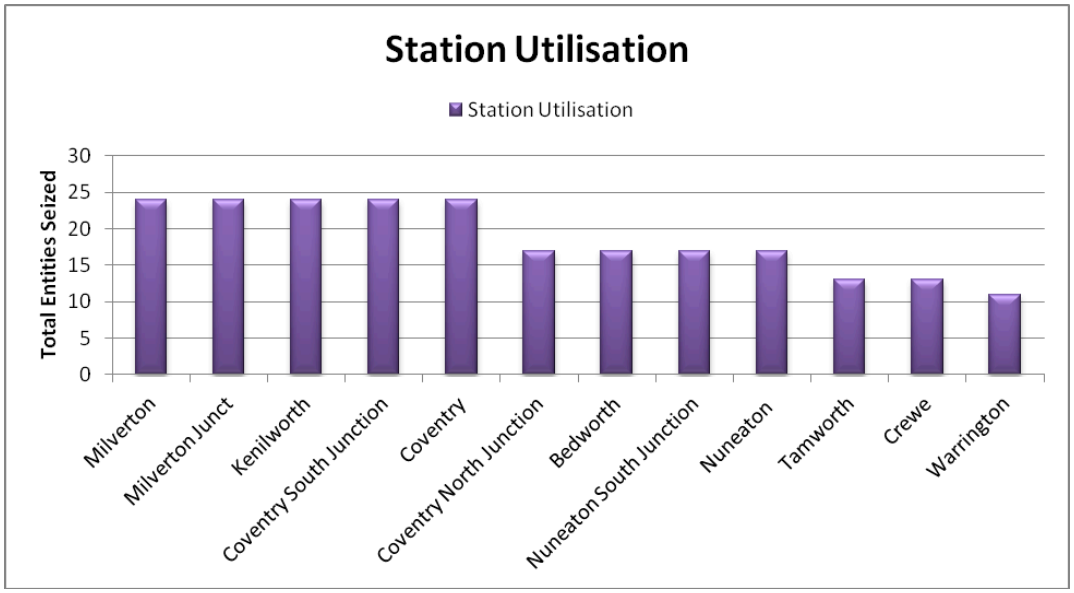


Figure 6.37 Station Utilisation: Milverton – Warrington

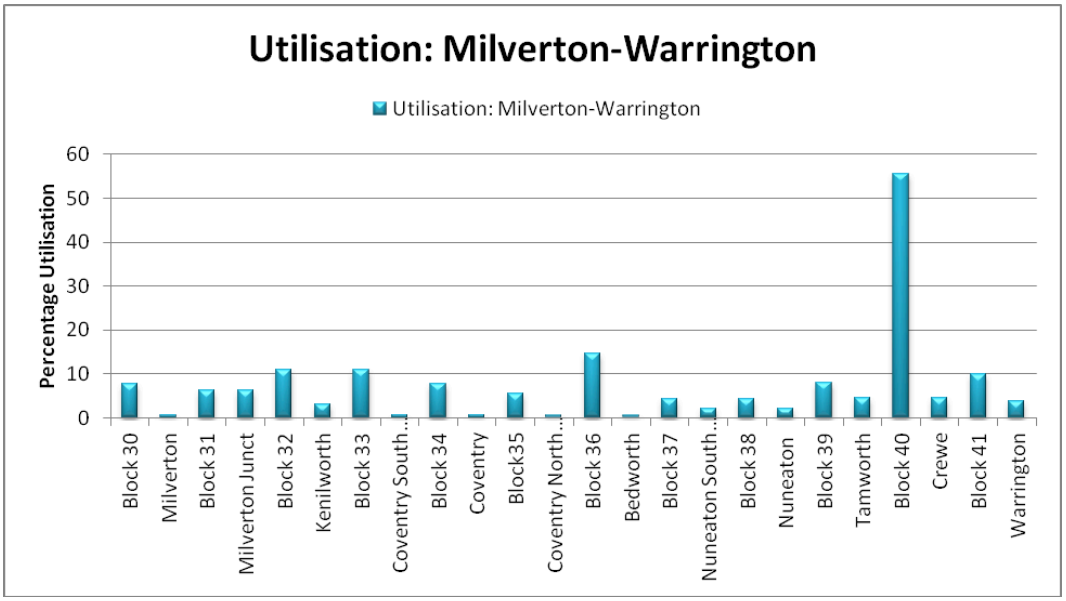


Figure 6.38 Utilisation: Milverton – Warrington

7. ECONOMICS: DATA FOR LCC/RAMS

Data collection methodology for economic assessment of whole system effects

A key element of the overall assessment of innovations proposed in the SustRail project is the assessment of their economic impact on the whole system (i.e., rail infrastructure, freight operations and passenger operations) and on all major system stakeholders. This will require comparative assessment of existing and novel vehicles in terms of their whole system economic impact.

SustRail will conduct these analyses in Work Package 5 using a variety of relevant approaches, most particularly the Life Cycle Costing (LCC) approach and an assessment of Reliability, Availability, Maintainability and Safety (RAMS), but also a comprehensive economic evaluation which will take into account impacts of the innovation on key stakeholder groups.

RAMS assessment is fundamental to the evaluation and information on how RAMS is conducted is set out in SustRail Deliverable D1.3. Essentially, both LCC and RAMS analyses need to take into consideration impacts throughout the entire life cycle of the developed system 'from cradle to grave' (i.e., from conception and design, through manufacturing, testing and operation until end-of-life, disposal or recycling). In SustRail, LCC and RAMS will be conducted at an appropriate level of detail and disaggregation, and will as far as possible adhere to the EN 50126-1:1999 standard *"Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)"*. This standard entails that RAMS assessment operates at various distinct levels:

- System level (locomotive, wagon)
- Sub-system level (e.g., bogie, braking system, bodywork, engine, etc.)
- Component level (frame, wheels, springs, etc.)

An initial assessment of the availability and accessibility of relevant data has been conducted for the three case study routes. The three countries have different organisational structures and levels of vertical separation, and relevant data (if and when available) are held within diverse organisations within the rail industry, such as infrastructure operators, train operating companies, maintenance providers, wagon manufacturing and leasing companies and regulatory bodies.

The national rail infrastructure organisations are the primary points of contact within SustRail for the purposes of obtaining data. While these organisations do not themselves hold all data that will be required, by the nature of their responsibilities, their operations and their relationships with other industry stakeholders, they have a broad knowledge of which other organisations hold such data. The infrastructure organisations were therefore asked to provide information regarding availability, ownership and accessibility of the data required for RAMS, LCC and economic evaluation of the whole system effects (infrastructure, freight operations and passenger operations), pertaining to their own country.

The responses identify that much of the data is held by a relevant organisation in the rail industry, or else that sufficient information will be available to build up some form of modelled cost estimate for the parameters that will be required. The precise location of data varies and, as might be expected, is particularly widely dispersed in countries such as the UK where vertical separation of the rail industry is more advanced. In some instances, data may be held by more than one organisation. Where the infrastructure organisation itself does not hold the data, it is not always clear at this stage how much detail and disaggregation of data can be obtained, and further investigation into this will be required. Apart from the UK case,

it appears that systematic data on rail infrastructure network reliability may be difficult to obtain, as may data on specific aspects of rail environmental performance. In Work Package 5, SustRail will need to engage with a wider range of stakeholders in each country beyond the infrastructure organisation.

Table 7.1, Table 7.2 and Table 7.3 provide overviews of the availability and ownership of data required for RAMS, LCC and economic evaluations, for infrastructure operations, freight operations and passenger operations respectively, for each of the 3 case studies / countries under investigation.

Table 7.1 Availability of data for LCC/RAMS: Infrastructure

INFRASTRUCTURE		BULGARIA	SPAIN	UK
RELIABILITY				
	Failure rates	X	X	O
	Critical items and functions	X	X	Y
	Boundary conditions	X	X	Y
AVAILABILITY		Y	Y	V
MAINTENANCE				
	Preventive (either condition-based or time-based)	Y	Y	Y
	Corrective	Y	Y	Y
SAFETY				
	Incident numbers	V	Y	V
	Accident numbers	V	Y	O
LCC COST DRIVERS				
	R&D	Y	M	Y
	Investments/disposals	Y	M	V
	Maintenance costs – preventive	Y	M	V
	Maintenance costs – corrective	Y	M	V
	Operating costs	Y	M	V
REVENUE AND USER BENEFIT DRIVERS				
	Track Access Charges	Y	X	Y
	Service quality	Y	X	O
	Capacity	Y	X	Y
	Availability	X	X	O
	Demand	Y	X	O
	'Zero state' revenue	Y	X	Y
ENVIRONMENTAL PERFORMANCE				
	Noise	U	X	V
	CO_2	U	X	V

CODES

Y Infrastructure Organisation has the data
T Infrastructure Organisation advises that train operating companies possess the data
M Infrastructure Organisation advises that train operating companies *may* have the data
O Infrastructure Organisation advises that another organisation possesses the data
P Infrastructure Organisation advises that another organisation *may* have the data
X Infrastructure Organisation understands that the data does not exist
U unknown / not ascertained to date
V more than one organisation holds relevant data

Suffix /I indicates that whilst some data exists, it may be incomplete

Table 7.2 Availability of data for LCC/RAMS: Freight operations

FREIGHT OPERATIONS		BULGARIA	SPAIN	UK
RELIABILITY				
	Failure rates	M	P	V
	Critical items and functions	M	P	V
	Boundary conditions	M	P	V
AVAILABILITY		V	P	V
MAINTENANCE				
	Preventive (either condition-based or time-based)	M	P	V
	Corrective	M	P	V
SAFETY	Incident numbers	V	P	O
	Accident numbers	V	P	V
LCC COST DRIVERS				
Technical	Track standards	Y	P	V
	Maintenance regime	T	P	V
	Speeds	T	P	V
	Freight flows	T	P	V
	Timetable	V	P	Y
	Rolling stock	T	P	Y
	Train lengths	V	P	V
	Axle loads	V	P	Y
	Track/train interface	Y	P	V
	Technologies employed	V	P	V
Economic	R&D	T	P	V
	Investments/disposals	T	P	V
	Maintenance costs – preventive	U	P	V
	Maintenance costs – corrective	U	P	V
	Operating costs	T	P	V
REVENUE AND USER BENEFIT DRIVERS				
	Track Access Charges	V	P	Y
	Service quality	U	P	V
	Capacity	Y	P	V
	Availability	U	P	V
	Demand	T	P	V
	'Zero state' revenue	T	P	T
ENVIRONMENTAL PERFORMANCE				
	Noise	U	P	V
	CO_2	U	P	V

Y Infrastructure Organisation has the data
T Infrastructure Organisation advises that train operating companies possess the data
M Infrastructure Organisation advises that train operating companies *may* have the data
O Infrastructure Organisation advises that another organisation possesses the data
P Infrastructure Organisation advises that another organisation *may* have the data
X Infrastructure Organisation understands that the data does not exist
U unknown / not ascertained to date
V more than one organisation holds relevant data

Suffix /I indicates that whilst some data exists, it may be incomplete

Table 7.3 Availability of data for LCC/RAMS: Passenger operations

PASSENGER OPERATIONS		BULGARIA	SPAIN	UK
RELIABILITY				
	Failure rates	U	P	V
	Critical items and functions	U	P	V
	Boundary conditions	U	P	V
AVAILABILITY		V	P	V
MAINTENANCE				
	Preventive (either condition-based or time-based)	U	P	V
	Corrective	U	P	V
SAFETY				
	Incident numbers	V	P	O
	Accident numbers	V	P	V
LCC COST DRIVERS				
Technical	Track standards	Y	P	V
	Maintenance regime	Y	P	V
	Speeds	Y	P	V
	Timetable	V	P	Y
	Rolling stock	T	P	Y
	Track/train interface	Y	P	V
	Technologies employed	V	P	V
Economic	R&D	T	P	V
	Investments/disposals	T	P	V
	Maintenance costs – preventive	U	P	V
	Maintenance costs - corrective	U	P	V
	Operating costs	T	P	V
REVENUE AND USER BENEFIT DRIVERS				
	End User Pricing	V	P	V
	Service quality	U	P	V
	Capacity	Y	P	V
	Availability	U	P	V
	Demand	T	P	V
	'Zero state' revenue	T	P	T
ENVIRONMENTAL PERFORMANCE				
	Noise	U	P	V
	CO_2	U	P	V

Y Infrastructure Organisation has the data
T Infrastructure Organisation advises that train operating companies possess the data
M Infrastructure Organisation advises that train operating companies *may* have the data
O Infrastructure Organisation advises that another organisation possesses the data
P Infrastructure Organisation advises that another organisation *may* have the data
X Infrastructure Organisation understands that the data does not exist
U unknown / not ascertained to date
V more than one organisation holds relevant data

Suffix /I indicates that whilst some data exists, it may be incomplete

8. CONCLUSIONS

8.1 Spanish Route

Spanish rail freight is only taking 5% of the land freight market. The main traffic on the Castellbisbal – Silla Corridor currently is cars and bulk freight with some intermodal. If improvements can be made both locally, to double-tracking the whole route, and to its integration with the European network, then a significant increase in utilisation might be expected from the current 16 trains/day which is just on week days.

8.2 Bulgarian Route

Although there has been a decline in rail freight to carry only 10% of land transport freight there are plans to invest in the main freight corridors. The selected line connects key locations within Bulgaria and internationally and the EU has identified it as an important transport route with a wide variety of freight that can be transported. The current average speeds are relatively low but with improvements to the line and the rolling stock the increases in capacity and potential are very significant. The freight services on this line could benefit very significantly from the innovations proposed in SustRail.

8.3 UK Route

The greatest increase in rail freight traffic in the foreseeable future will be intermodal container traffic via the UK's sea ports. There are plans to increase the capacity of several major UK ports and to carry a greater proportion of onward traffic on the railway network. The UK government has outlined the strategically important UK rail freight lines, and Network Rail is implementing change as part of their Freight Route Utilisation Strategy. This includes various loading gauge improvements on key routes, and removing key bottlenecks from the network.

However, there are other restrictions to the expansion of freight, and primary amongst these is the need to accommodate ever increasing numbers of passenger services.

8.4 Capacity Modelling

Even at this early stage with only initial outline information, the output from the modelling has been shown to provide a means of easily comparing the capacity utilisations on the three lines. Once innovations are proposed in the project such a modelling method should provide a means of quantifying potential improvements in capacity and utilisation. To allow for ease of comparison between routes and benchmarking, it has been shown to be effective to summarise each of the routes using the same parameters:

- Average freight train speed
- Average freight train length
- Line utilisation by freight services

As the Bulgarian and UK routes have been broken down into sections to allow a more representative model to be produced, one section from each route of comparable length to the Mediterranean Corridor has been chosen. From the Bulgarian route the section Poduyane – Verinsko from the UK route Milverton – Warrington.

8.4.1 Spanish Route

The parameters in Table 8.1 indicate that this line is not heavily utilised by freight traffic as line utilisation suggests a maximum utilisation of five trains see Figure 6.4. An average speed of 75km/h demonstrates that the condition of the infrastructure is reasonable. The average train length is the lowest of the three and indicates the average number of wagons per train has the potential to increase. Further research is needed to clarify restrictions regarding train length along this route.

Table 8.1 Spanish Route: Mediterranean Corridor

Parameter	Value
Average Speed	75km/h
Average Train Length	420m
Line Utilisation	Maximum 5 Minimum 2

8.4.2 Bulgarian Route

The parameters for Poduyane – Verinsko indicated in Table 8.2 below, demonstrate a maximum line utilisation of 25 see Figure 6.12 and a minimum line utilisation of 22. Information regarding infrastructure for this section suggests that the track is in medium/good condition, this is demonstrated by an average speed of 72.5km/h. Average train length of 500m the same as the Mediterranean Corridor indicates there is potential for the average number of wagons per train to increase, however further research is needed to clarify any restrictions regarding train length along this route.

Table 8.2 Bulgarian Route: Poduyane – Verinsko

Parameter	Value
Average Speed	72.5km/h
Average Train Length	500m
Line Utilisation	Maximum 25 Minimum 22

8.4.3 UK Route

Parameters from Milverton – Warrington, shown in Table 8.3, indicate an average speed of 80km/h. The maximum train length for this section is 557m and this was used as the average for this initial modelling to see how this might affect capacity. However, the average is nearer to 440m. The range between maximum line utilisation and minimum line utilisation is quite high, see Figure 6.36, because freight services enter and leave the line at different stations along this section. This remains to be corroborated with freight operating companies and their use of this section of the route and any frequently used diversionary lines.

Table 8.3 Milverton – Warrington

Parameter	Value
Average Speed	80km/h
Average Train Length	557m
Line Utilisation	Maximum 24 Minimum 11

8.4.4 Comparisons

The low average speed for the route in Bulgaria suggests that, compared to the Mediterranean Corridor and UK routes, the Bulgarian route has poor technical conditions. The data indicates that the Bulgarian route has the highest rate of line utilisation compared to the Mediterranean and UK routes but line and rolling stock improvements could significantly increase the line capacity.

In comparison to the Bulgarian and UK routes, the parameters indicate that the Mediterranean Corridor has the shortest train length and is experiencing the lowest levels of line utilisation. However the Mediterranean Corridor has the highest average speed, which suggests this line could be better utilised.

Data for the UK route indicates that compared to the Bulgarian and Mediterranean routes it has the longest train length this suggests it has the potential for a higher level of capacity than the other two routes. The UK route has a similar maximum level of line utilisation to the Bulgarian route although the minimum level of line utilisation on the UK route is significantly lower than that of the Bulgarian route. This is explained by the operation of freight services within a densely occupied fast passenger corridor including direct services to London, stopping services and Cross Country services. Freight trains have to be able to use available train paths and move along track sections to passing loops or yards without inflicting delay on following trains. Passenger and freight trains join and leave the route sections under scrutiny at various key parts of the network. There are no freight train services that are handled for cargo additions or removal between Southampton and the West Midlands, Manchester or the North West.

Further research and the generation of alternative and further scenarios may lead to a better understanding of the routes under scrutiny and the current pattern of operations along the three routes.