Finished Vehicle Logistics by Rail in Europe

Version 3
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Foreword

The project to produce this book on 'Finished Vehicle Logistics by Rail in Europe' was initiated during the ECG Land Transport Working Group meeting in January 2014, Frankfurt am Main. Initially, it was suggested by the members of the group that Oleh Shchuryk prepares a short briefing paper about the current *status quo* of rail transport and FVLs by rail in Europe. It was to be a concise document explaining the complex nature of rail, its difficulties and challenges, main players, and their roles and responsibilities to be used by ECG's members. However, it rapidly grew way beyond these simple objectives as you will see.

The first draft of the project was presented at the following Land Transport WG meeting which took place in May 2014, Frankfurt am Main. It received further support from the group and in order to gain more knowledge on specific rail technical issues it was decided that ECG should organise site visits with rail technical experts of ECG member companies at their railway operations sites. These were held with DB Schenker Rail Automotive in Frankfurt am Main, BLG Automotive in Bremerhaven, ARS Altmann in Wolnzach, and STVA in Valenton and Paris. As a result of these collaborations, and continuous research on various rail issues, the document was extensively enlarged.

The document consists of several parts, namely a historical section that covers railway development in Europe and specific EU countries; a technical section that discusses the different technical issues of the railway (gauges, electrification, controlling and signalling systems, etc.); a section on the liberalisation process in Europe; a section on the key rail players, and a section on logistics services provided by rail. A substantial part of the document is also dedicated to types of FVL wagons, various types of locomotives and their technical specifications. It also includes a section that tackles the question of European regulation of rail. It briefly presents the current EU projects and initiatives for rail transport. There is a section that discusses the key railway organisations and associations, and, finally, the additional supportive materials, such as maps, glossary, various tables and charts, useful links, etc. have been added.

This document has been reviewed several times since its first publication. The current version 3 of the 'Finished Vehicle Logistics by Rail in Europe' was revised and complemented with a new chapter on "Transport documents in rail" and prepared for publication in December 2017.

This detailed document on 'Finished Vehicle Logistics by Rail in Europe' is relevant not only to ECG's members, but also to the whole FVL sector in Europe. It represents a unique undertaking to approach the rail transport sector from the perspective of FVL, taking into account the complexity of European rail. It can be used as an instructive manual for those who wish to understand the European rail complexity from the standpoint of FVL even if they have no prior knowledge.

It is sincerely hoped that this document will be supported by everyone active in FVL in Europe whether as LSP, customer or any other capacity.

It will require regular updating and improving so we welcome your input in helping us to achieve this.

Oleh Shchuryk 06.12.2017

Finished Vehicle Logistics

by Rail

in Europe

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Abbreviations

A	Additive (*in measurement of noise*)
ABs	Allocation Bodies
ABCL	Automatic Barrier Crossing Locally monitored
ABS	Automatic Block Signalling
AC	Alternative current
ACS	Automatic Cab Signal System
ADD	Automatic Detection and Dropping Devices
ADIF	Railway Infrastructure Manager - *Administrador de Infrestructuras Ferroviarias* (ES)
AEIF	European Association for Railway Interoperability
AERA	Association of European Rail Agents
AFC	Automatic Fare Collection
AHB	Automatic Half Barrier crossing
ALE	*Autonome Machinistenbond Europa*
ALSN	Continuous Automatic Train Signalling (RU)
AOCL	Automatic Open Crossing, Locally monitored
AOCR	Automatic Open Crossing, Remotely monitored
ARS	Automatic Route Setting (System)
ASFA	Automatic Braking and Announcement of Signals (ES)
ATB	Automatic Braking and Announcement of Signals - *Automatische TreinBeïnvloeding* (NL)
ATC	Automatic Train Control
ATM	Automatic Train Monitoring
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATR	Automatic Train Regulation
ATS	Automatic Train Supervision
AVI	Automatic Vehicle Identification
AWS	Automatic Warning System
BACCC	Automatic Block System with Codified Currents *Blocco automatico a correnti codificate* (IT)
BBÖ	*Österreichische Bundesbahnen* (before WWII and after renamed into ÖBB)
BDŽ	Bulgarian State Railways - *Balgarski darzhavni zheleznitsi* (BG)
CAWS	Continuous Automatic Warning System
CBB	Composite brake blocks
CBTC	Communications-Based Train Control
ČD	Czech Railways - *České dráhy* (CS)
CEF	Connecting Europe Facility
CER	Community of European Railways and Infrastructure Companies
CFL	Luxembourg Railways - *Chemins de Fer Luxembourgeois* (LU)
CFM	Moldovan Railway - *Calea Ferată din Moldova* (MD)
CFR	State Railway Company - Căile Ferate Române (RO)
CIM	Uniform Rules concerning the Contract of International Carriage of Goods by Rail
CIT	International Rail Transport Committee
CLECAT	European Association for Forwarding, Transport, Logistics and Custom Services
CMK	Central Trunk Line
COTIF	Convention concerning International Carriage by Rail
CP	Portuguese Railways - *Caminhos de ferro portugueses* (PT)
CT	Combined Transport
CTC	Centralised Traffic Control
DB	German Railway - *Deutsche Bundesbahn* (DE)
dB	Decibel (*measurement of noise*)
DC	Direct current
DEMU	Diesel-Electric Multiple Unit
DG ENV	Directorate-General Environment

DG MOVE	Directorate-General for Mobility and Transport
DGPS	Differential Global Positioning by Satellite
DMI	Driver Machine Interface
DMU	Diesel Multiple Unit
DR	German State Railway - *Deutsche Reichsbahn* (DE)
DRA	Driver Reminder Appliance
DRG	German State Railway Company - *Deutsche Reichsbahn-Gesellschaft* (DE)
DSB	Danish State Railways - *Danske Statsbaner* (DK)
DTC	Direct Traffic Control
EAD	Bulgarian State Railways (BG)
EC	European Commission
ECM	Entity in Charge of Maintenance
EEA	European Environmental Agency
EIM	European Rail Infrastructure Managers
EIRENE	European Integrated Railways Radio Enhanced Network
EMU	Electric Multiple Unit
END	Environmental Noise Directive
EP	European Parliament
EPTTOLA	European Passenger Train and Traction Operating Lessors' Association
ERA	European Railway Agency
ERC	European Rail Circle
ERFA	European Rail Freight Association
ERFCP	European Rail Freight Customers Platform
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
FCR	Forwarders' Certificate of Receipt
FCT	Forwarders' Certificate of TRansport
FGC	Railway of the Generalitat of Catalunya - *Ferrocarrils de la Generalitat de Catalunya* (ES)
FGV	Railways of the Generalitat of Valencia - *Ferrocarrils de la Generalitat de Valenciana* (ES)
FIATA	International Federation of Freight Forwarders Associations
FOCs	Freight Operating Companies
FRA	Federal Railroad Administration
FTE	Forum Train Europe
FP7	European Union Seventh Framework Programme
FS	*Ferrovie dello Stato* (IT)
FVL	Finished Vehicle Logistics
HSH	Albanian Railways - *Hekurudha Shqiptare* (AL)
Hz	Herz (*in measurement of noise*)
HŽ	Croatian Railways - *Hrvatske željeznice* (HR)
IARO	International Air Rail Organisation
IC	Inter City
ICE	Inter City Express
IECC	Integrated Electronic Control Centre
IMs	Infrastructure Managers
ISO	International Standards Organisation
GEPGIS	Geographic and Infrastructure Systems
GIS	Geographic Information System
GKW	Upper Silesian Narrow Gauge Railways - *Górnośląskie Koleje Wąskotorowe* (PL)
GPRS	General Purpose Radio System
GPS	Global Positioning by Satellite
GSM-R	Global System for Mobile Communications – Railway
KsOd	Kaschau-Oderberg Railway
KVB	*Contrôle de Vitesse par Balises* (FR)
LDz	Latvian Railway - *Latvijas dzelzceļš* (LV)

LEU	Lineside Electronics Unit
LG	Lithuanian Railways - *Lietuvos geležinkeliai* (LT)
LHS	Polish abbreviation for Broad Gauge Metallurgy Line
LOA	Length over all
LRV	Light rail vehicles
LS	Continuous System - *Liniový Systém* (CS)
LSPs	Logistic Service Providers
LZB	*Linienzugbeeinflussung*
MA	Movement Authority
MÁV	Hungarian State Railways - *Magyar Államvasutak* (HU)
MT	Main Track
MU	Multiple unit
NDTAC	Noise Differentiated Track Access Charges
NMBS	National Belgian Railway Company - *Nationale Maatschappij der Belgische Spoorwegen* (NL)
NOI	Noise TSI
NS	Dutch Railways - *Nederlandse Spoorwegen* (NL)
NSA/NSARE	National Skills Academy for Railway Engineering
NSB	Norwegian State Railways - *Norges Statsbaner AS* (NO)
NVR	*National Vehicle Register*
ÖBB	Austrian State Railway - *Österreichische Bundesbahnen* (renamed from BBÖ to ÖBB after WWII)
OLE/OHLE	Overhead line
OTIF	Intergovernmental Organization for International Carriage by Rail
OSE	Greek Railways Organization - *Hellenic Railways Organisation* (EL)
OSJD/OSShD	Organization for Co-operation of Railways
OSSB	*Oberschlesische Schmalspurbahn*
OTIF	Intergovernmental Organization for International Carriage by Rail
PKP	Polish State Railway - *Polskie Koleje Państwowe* (PL)
PSS	Packet Switch System
RBC	Radio Block Centre
REF	*Réseau Ferré de France*
REFE	*Ferrocarriles de Vía Estrecha* (IT)
RENEFE	National Network of Spanish Railways - *Red Nacional de los Ferrocarriles Españoles* (ES)
RhB	Rhaetian Railway
RFCs	Rail Freight Corridors
RFE	Rail Forum Europe
RFF	French Rail Network - *Réseau ferré de France* (F)
RFI	Italian Rail Network - *Rete Ferroviaria Italiana* (IT)
RID	Regulation concerning the International Carriage of Dangerous Goods by Rail
RNE	Rail Net Europe
RSSB	Railway Safety and Standards Board
RU	Rail Undertaking
RZhD	Russian Railway - *Российские железные дороги, Rossiyskie zheleznye dorogi* (RU)
SAD	Single Administrative Document
SBB	Swiss State Railway - *Schweizerische Bundesbahnen* (DE)
SCB	*Schweizerische Centralbahn*
SCMT	*Sistema di Controllo della Marcia del Treno* (IT)
SFAI	*Società per le strade ferrate dell'Alta Italia* (IT)
SFR	Swiss Federal Railways
SFR	*Società per le strade ferrate romane* (IT)
SFM	*Società per le Strade Ferrate Meridionali* (IT)
SJ	Swedish State Railways - *Statens Järnvägar* (SE)
SHP	*Samoczynne Hamowanie Pociągu* (PL)
SIRTS	Association for Rail Transport Interoperability and Development

SMGS	Agreement on Direct International Goods Transport by Rail and Procedure Instruction
SNB	*Schweizerische Nationalbahn* (Swiss National Railway)
SNCB	National Railway Company of Belgium - *Société nationale des chemins de fer belges* (FR)
SNCF	*Société Nationale des Chemins de fer Francais* (FR)
SWL	Single Wagon Load
SŽ	Slovenian Railways - *Slovenske železnice* (SI)
SŽD	*Správa železniční dopravní* (CS)
SŽDC	Railway Infrastructure Administration, state organization - *Správa železniční dopravní cesty* (CS)
T&E	European Federation for Transport and Environment
TAF	Telematics Applications for Freight services
TAP	Telematics Applications for Passenger services
TBL	Transmission Beacon Locomotive - *Transmissie Baken Locomotief* (NL)
TEN-T	Trans-European Transport Network
TGV	*Train à Grande Vitesse*
TOR	Top of rail
TOPS	Total Operations Processing System
TPWS	Train Protection & Warning System
TSI	Technical Specifications for Interoperability
TVM	Track-to-train transmission - *Transmission Voie-Machine* (FR)
TWC	Train Warrant Control
UIC	International Union of Railways - *Union Internationale des Chemins de Fer* (FR)
UIP	International Union of Private Wagon Keepers
UIRR	International Union for Road-Rail Combined Transport
UITP	International Association of Public Transport
UTI	Intermodal Transport Unit
UZ	Ukrainian Railways - *Ukrzaliznytsia* (UK)
UNIFE	Association of the European Rail Industry
VBS	Voice Broadcast Services
VGC	Voice Group Call
VR	State Railway of Finland
VSB	*Vereinigte Schweizerbahnen*
ZSSK	Slovenian State Railway - *Železničná spoločnosť Slovensko* (SL)
ŽFBH	Railways of the Federation of Bosnia and Herzegovina - *Željeznice Federacije Bosne i Hercegovine* (BA)
ŽRS	Railways of Republika Srpska - *Željeznice Republike Srpske* (BA)
ŽS	Serbian Railways - *Železnice Srbije* (RS)
ŽSR	The Railways of the Slovak Republic - *Železnice Slovenskej Republiky* (SK)

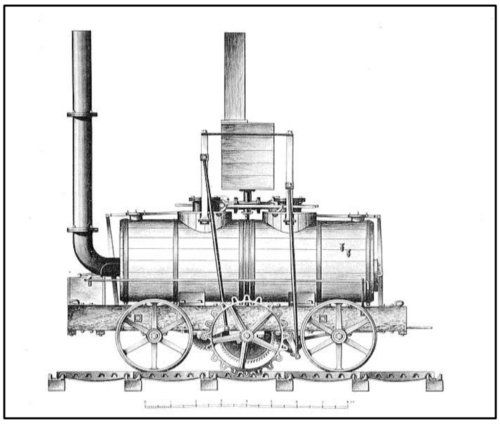
1. Brief History of the European Railways

The history of rail transport in Europe dates back to Greco-Roman[1] times where the first prototypes of the modern railway system were created. The use of wagons in Europe became common from about 1500 through 1800. They were mainly used for transportation of coal in the mining industry. The first mechanised rail transport system that employed steam locomotives dates back to the 1820s in the UK.

Diolkos wagonway, Greece

Talking about the early wagonways (or 'tramways') they are believed to have been developed in Germany in the 1550s and were used for transportation in mining facilities. The first wagonways were made of wood and were used on wooden rails.[2]

The first real railway appeared before 1605 in the UK and was a funicular railway at Broseley in Shropshire. Another of the earliest documented railways in the UK was the Wollaton Wagonway that was completed in 1604. It ran from Strelley to Wollaton near Nottingham. Another railway constructed at that time was a wagonway of Huntingdon Beaumont[3] that was laid down near Newcastle upon Tyne.



Salamanca

By the 18th century such wagonways already existed in many places and they were spreading rapidly. Due to the fact that a stiff wheel rolling on a rigid rail requires less energy to move loads than road transport, railways became very efficient for bulk goods and it became a main reason for further development of rail.

In 1760 the Coalbrookdale Company[4] introduced a fixed plate of cast iron to the upper surface of the wooden rails. It used wagons that had flanged wheels as in modern railways. This composite iron/wood rail was later replaced by all metal rails, which made them durable, safer and stiffer.

[1] The earliest evidence of a wagonway, a predecessor of the railway (6 to 8.5 km long), is found in Diolkos, Greece. This railway was used for transportation of boats across the Isthmus of Corinth in Greece from around 600 BC. Trucks pushed by slaves ran in grooves in limestone, which provided the track element. The Diolkos wagonway ran for over 600 years. Other examples of the pre-rail are found on the islands of Malta and Gozo.
http://en.wikipedia.org/wiki/History_of_rail_transport

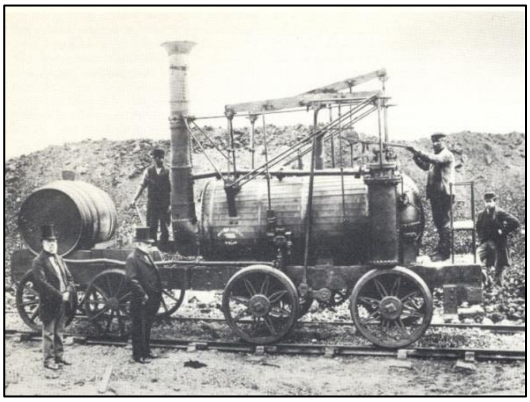
[2] http://en.wikipedia.org/wiki/History_of_rail_transport

[3] http://www.eoearth.org/view/article/150461/

[4] http://www.gracesguide.co.uk/Coalbrookdale_Co

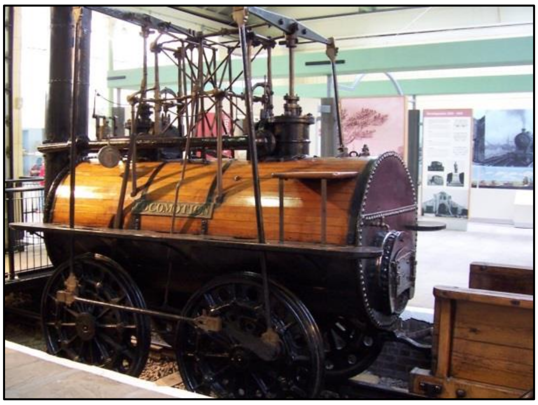
The invention of a steam engine by James Watt in 1784 revolutionised the whole railway system. The first steam rail locomotive was constructed by John Fitch in the United States in

1794. However, the first working locomotive railway system was built in the UK in 1804 by Richard Trevithick in Cornwall. The first commercial steam locomotive was designed by Matthew Murray and was called *Salamanca*. It was built for the narrow gauge Middleton Railway in 1812. In 1813 Christopher Blackett and William Hedley built *Puffing Billy* for the Wylam Colliery Railway. It was first successful locomotive running by adhesion only. [5]



Blücher

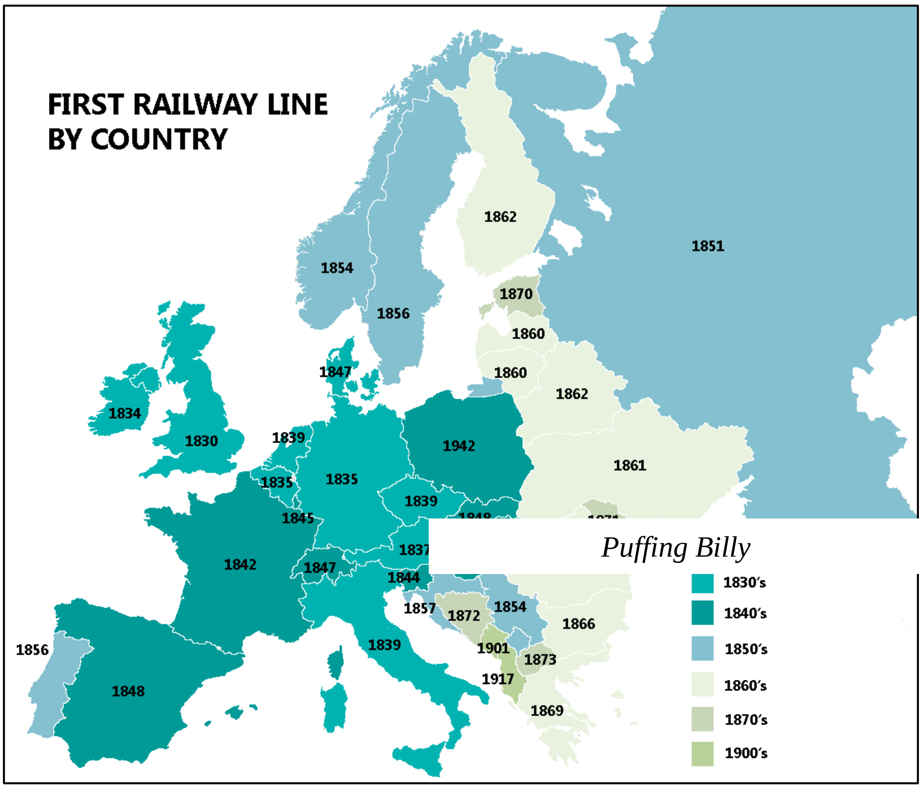
In 1815 a first steam-powered machine prototype of the modern locomotive was built by George Stephenson. The machine was called *Blücher* (*see picture*).[6] It was a flanged-wheel adhesion locomotive. In 1825 he constructed *Locomotion* (*see picture*) for the Stockton and Darlington Railway, the first public steam railway in the world.[7]



Locomotion

In the beginning there were two types of locomotive, namely a light fast passenger loco and slower more powerful goods engines. All of them had four wheels.

Alongside the changes in design of locos that became lighter and quicker, the rail network was quickly expanding, not only in the UK but also in other European countries. Construction of the rails and locomotives required large quantities of heavy materials, which in its turn stimulated coal-mining, iron-production and construction industries. It reduced the costs of travelling and increased personal mobility.



Puffing Billy

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[5] C. Hamilton Ellis, The Pictorial Encyclopaedia of Railways, New York, NY, 1968, pp. 20-22.
[6] http://www.steamindex.com/cyberspine/media/reed14.jpg
[7] http://en.citizendium.org/wiki/Railway_history

Spread of Railways in Ten EU Countries[8]

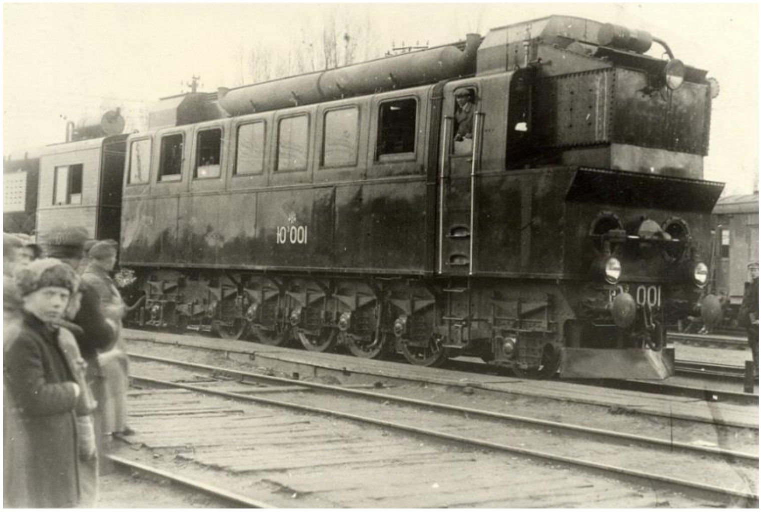
	1840	1860	1880	1900
Austria-Hungary	144	4,543	18,507	36,330
Belgium	334	1,730	4,112	4,591
France	496	9,167	23,089	38,109
Germany	469	11,089	33,838	51,678
Great Britain	2,390	14,603	25,060	30,079
Italy	20	2,404	9,290	16,429
Netherlands	17	335	1,846	2,776
Russia	27	1,626	22,865	53,234
Spain	-	1,917	7,490	13,214
Sweden	-	527	5,876	11,303

This table represents the length of railway in km by countries in different years

One of the leading countries in the construction of railways was Belgium, which was a major contributor to early rail development in Europe and became an important railway hub. After the separation of Belgium from the Netherlands in 1830, the Belgian government decided to stimulate the industry by introducing a rail network. Its rail system connected major cities, industrial areas, ports and neighbouring countries. The first railway in Belgium was constructed from Brussels to Mechelen and the line was completed in May 1835. It was the first railway in continental Europe. (*The map opposite shows the dates of the first railway lines in each European country*).

The first electric tram line was introduced in Lichterfelde, near Berlin in 1881 and it was built by Werner von Siemens. The electric railways became popular in many large cities of Europe. In the course of time the urban electric railways grew beyond metropolitan areas. This brought development of the intercity network connections. One of the most elaborate electric rail systems that connected every town and city was developed in Belgium.

The first diesel-electric locomotives were low-powered machines, yet they were cleaner, more efficient, and needed less maintenance than steam locomotives. They became very popular after World War II and by the 1970s they had completely replaced steam power on most of the world's railroads. (*See the picture of the World's first diesel locomotive for long distances SŽD Eel2, 1924 in Kyiv*).[9]



Talking about the development of the railway network in Europe, it is worth focusing here on two countries; Germany

[8] http://www.fordham.edu/halsall/mod/indrev6.asp
[9] http://www.ipukr.com/?cat=717

and France. It is important to show what features of both rail networks are shared by the two countries and at the same time what are the characteristics of these networks that differentiate them from one another. It can be stated that both countries have the most complex rail network systems in the whole of Europe on one hand. On the other hand these networks differ from one another by their structures: France has a centralised system, or capital-oriented, whereas Germany has a decentralised or regionalised one. It is also crucial to understand the socio-economic-political settings that lay at the root of both rail systems and that caused the development of two such different models.

1.1. History of Rail in France

The history of rail in France dates back to the 19th century. The first rail line in France became operational in 1832 not long after the first line launched in the UK.[10] It connected Rouen with Paris. However, the development of the French railway was not as rapid as it was in Belgium, Germany or Switzerland and the main French railway system started to be built only after 1942. There were several obstacles that hindered rail development in France, among them were economic issues, poor iron industry, destruction of the Napoleonic Wars (1803-1815), and strong national opposition to the changes that railways would bring, that it would be detrimental to agriculture and impinge upon the business of the canals and rivers. (There were serious investments into water-borne transport and rail was regarded as dangerous competition. Moreover, the government's sluggish involvement also slowed down the process. It took decades to start railway construction on a national scale. After a period of inaction, the French government managed to combine two models to construct its railway, on one hand a free-market system (*laissez-faire*) that existed in the UK, and on the other hand a government controlled and built railway, similar to that of Belgium. Finally the government took control of it.

In 1842 the state issued a law that allowed private companies to plan and engineer work for the new lines. It subsidised these companies to construct railways linking Paris with other major cities in France. The French government ensured that the land was available and agreed to pay infrastructure costs, building bridges, track bed and tunnels. At the same time the private companies had to furnish the tracks, stations and rolling stock and pay the operational costs. The most successful companies, such as *Compagnie du Nord* would build the lines, avoiding governmental complications. The original agreement of 1842 leased the railway lines to the companies for only 36 years, extended to 99 years by Napoleon III (1808–1873). Under the social government of the 1930s, the French rail lines became nationalised.

Under heavy bureaucracy and various overlapping influences, the French rail system had failed to grow and required government intervention. The government guaranteed the dividends of the railway operating companies and in exchange it took 2/3 of any profits. The governmental department of the *Ponts et Chaussées* had close control over the construction of transport infrastructure in France and took rail under its control.

[10] A. Mitchell, *The Great Train Race: Railways and the Franco-German Rivalry*, 1815-1914, New York, NY, 2000, p. 4.

The first completed railway lines streamed out of Paris and connected major cities with the French capital. The major back-bone of the French rail infrastructure was completed by the 1860s, but the minor lines were still being constructed. By 1855, a number of small firms coalesced into six large companies with regional monopolies (*Chemin de Fer de l'Est*, *Chemin de Fer de l'Ouest*, *Chemin de Fer du Nord*, *Chemins de Fer de Paris à Lyon et à la Méditerranée*, *Chemin de Fer Paris-Orléans* and *Chemin de Fer du Midi*). These lines divided the nation into strict corridors of control. However the arrangements of the French lines were not very efficient, which hurt the economy. It led to inflation of shipping costs between regional centres. All lines were leading to the heart of France, Paris, yet there were many places that either did not have railway infrastructure or the connection had to be done through Paris, prolonging the route and increasing costs.

By 1914 the French railway system had become one of the densest and most highly developed in the world with 1/3 of it comprising narrow gauge.

By the 1930s many narrow gauge lines were closed and by the 1950s they became extinct. On 1st January 1938 the socialist government completely nationalised the railway system and formed the *Société Nationale des Chemins de fer Francais* (SNCF) with its headquarters in the Parisian suburb of Saint-Denis.[11]

Since 1981 the high-speed TGV (*Train à Grande Vitesse*) lines were constructed, linking the most important areas with the capital, starting with Paris-Lyon. In 1994 the Channel Tunnel was opened. Now the French railway system is the second largest one in Europe, comprising 29,901 km of railway and rail transport in France is mostly operated by SNCF.[12]

The French railway network is administered by *Réseau Ferré de France* (RFF),[13] which became government-owned and controlled in 1997. It comprises a network of commercially usable lines of 29,901 km, out of which 15,140 km is electrified at 1,500 V DC (5,905 km).[14] 1,876 km of those are high speed lines '*lignes à grande vitesse*' (LGV); 16,445 km is comprised of two or more tracks. 5,905 km are supplied with 1,500 V DC; 9,113 km with 25 kV AC at 50 Hz. 126 km are electrified by a third rail or other means.[15]

As can be seen on the map, historically the French railway network is Paris-centric. This capital-oriented rail system has certain advantages as well as disadvantages. The key advantage is that there is a direct connection between the capital and other main cities of France. The big disadvantage is that in order to travel from one city to another, the route often has to pass through Paris, which prolongs the trip and increases the costs.

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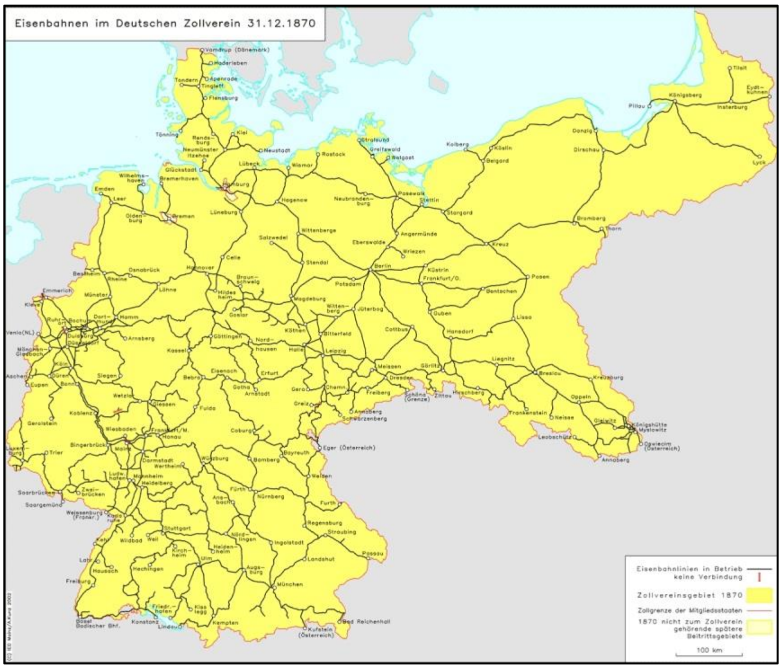
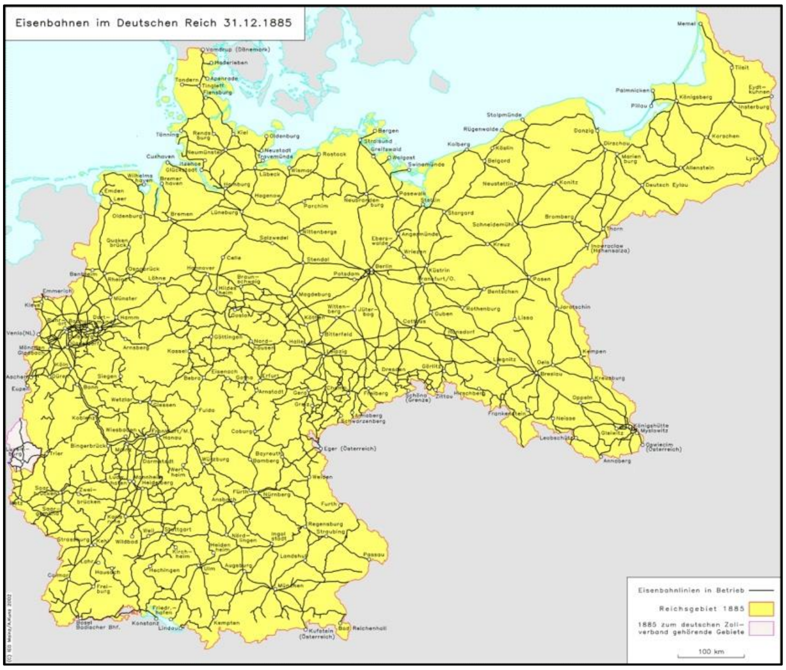
11 http://en.wikipedia.org/wiki/SNCF
12 http://fr.wikipedia.org/wiki/Groupe_SNCF
13 http://en.wikipedia.org/wiki/R%C3%A9seau_Ferr%C3%A9_de_France
14 http://en.wikipedia.org/wiki/Rail_transport_in_France
15 http://www.rff.fr/en/the-network/the-network-today/a-wide-reaching-network

1.2. History of Rail in Germany



The history of German railway starts with the launching of the steam-hauled *Bavarian Ludwig Railway*, going from Nuremberg to Fürth on 7th December 1835 with the Adler (Eagle) locomotive running between Nuremberg and Fürth. The first long railway was the Leipzig-Dresden line[16], which was finished on 7th April 1839.[17]

The period between 1835 and 1870 is marked by political disunity that hindered construction of the railways. In 1840 major links between big cities were constructed. Each German state took responsibility for building the line within its borders. The initiative was largely supported by the middle class who saw the benefits from rail infrastructure for the development of trade. In the 1840s government companies copied many of the private companies' methods and structures.



The first specialists who built the rail infrastructure were British, yet the skills and experience were quickly acquired by the Germans. By the 1850s Germany was self-sufficient in meeting various railroad construction demands. Railway became a key factor for the growth of the new steel industry.

By the middle of the 1850s several railway lines became operational in Germany, such as the *Prince William Railway* was a horse-hauled narrow gauge (82 cm) railway that ran for a Prussian mile (7,532 metres) along the Deilbach valley from Hinsbeck near Essen to Nierenhof. It was opened on 20 September 1831 and operated as a horse-drawn railway carrying coal until 1844, but from 1833 it also carried passengers. In 1847, it was converted to standard gauge and became a steam-hauled railway.

16 http://en.wikipedia.org/wiki/List_of_the_first_German_railways_to_1870
17 http://en.wikipedia.org/wiki/History_of_rail_transport_in_Germany

The third German railway was the *Leipzig-Dresden* railway, opened from Leipzig to Althen on 24th April 1837 and completed to Dresden on 7th April 1839. It was the first long-distance line in Germany with a length of 120 km and it also included the first railway tunnel in Germany.

By 1845, there were already more than 2,000 km of railroads in Germany, ten years later that number was above 8,000km. The majority of German states had state-owned railway companies, but there were several large private companies as well. One of these private companies, the Rhenish Railway (*Rheinische Eisenbahn*) constructed the first ever international railway line, connecting Cologne to Antwerp in Belgium. It was opened in 1843.

After unification of Germany in 1871, the German railway grew rapidly. The impetus for this quick expansion of the railway system was a need to support industrialisation. Heavy lines crisscrossed the Ruhr and other industrial districts, providing good connections to the major ports of Hamburg and Bremen. By 1880 Germany had increased its number of locomotives to 9,400 with 43,000 carriages and 30,000 tons of freight, and forged ahead of France.

With consolidation of the railway system, the network was expanded into the hinterland. It was a time of the branch line or *Nebenbahn*, called '*Sekundärbahn*' ("secondary line"), '*Vizinalbahn*' ("neighbourhood line") or '*Lokalbahn*' ("local line") depending on local laws and usage. Some states operated their own railways, known as the '*Länderbahnen*' ("state railways").

After WWI the '*Länderbahnen*' were united to form the '*Deutsche Reichsbahn*.'[18] According to the 'Dawes Plan,' from 30th August 1924 it was transformed into '*Deutsche Reichsbahn-Gesellschaft*' (DRG, German State Railway Company),[19] a private company.

The German *State Railway Wagon Association*, responsible for the standardisation of goods wagons, that had produced the *Verbandsbauart* ('Association design') wagons, continued and new designs using interchangeable components were introduced from about 1927. These were the *Austauschbauart* ('interchangeable design') wagons. In the 1930s many changes in design took place, e.g. the introduction of welded construction and solid wheels replacing spoked wheels on new goods wagons. New types and designs of wagons were dictated by time and needs, e.g. '*Kriegsbauart*' or wartime designs for the transportation of large quantities of tanks, vehicles, troops and supplies and standard passenger coaches called '*Donnerbüchsen*'.

After WWII Germany (and the DRG) was divided into 4 zones: US, British, French and Soviet. The first three eventually combined to form the *Federal Republic of Germany* (the West) and the Russian zone became the *German Democratic Republic* (the East). German territories beyond the Oder were ceded to Poland except for the northern part of East Prussia, which was ceded to the Soviet Union in 1945. The DRG's successors were named *Deutsche Bundesbahn* (DB, German Federal Railways) in West Germany, and *Deutsche Reichsbahn* (DR, German State Railways) in East Germany kept the old name to hold tracking rights in western Berlin. Both the DB and the DR were federal state institutions, directly controlled by their respective transportation ministries. Railway service between East and West was restricted; there were around five well-controlled and secure checkpoints between West and East Germany, and about the same number between East Germany and West Berlin. Four transit routes existed between West Germany and West Berlin.

[18] http://en.wikipedia.org/wiki/Deutsche_Reichsbahn
[19] http://www.franken-online.de/stefan.arold/bahn-drg.html

In 1968 DB started to use locomotive and passenger car serial numbers according to the UIC norm. In 1970 DR did the same.

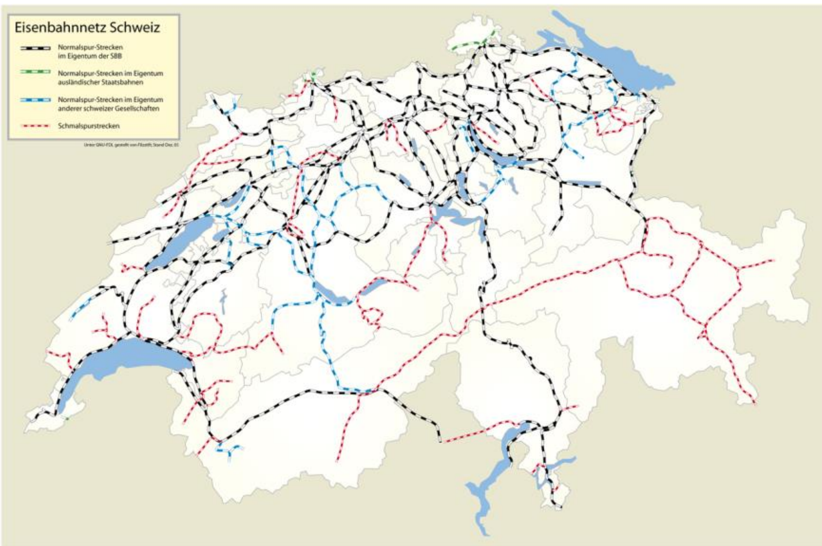
After the reunification of Germany on 3rd October 1990, Germany faced a challenging problem of how to turn two systems into one. There were many administrative and organisational problems which led to a complete re-organisation of Germany's railways. The well-known '*Bahnreform*' (Railway Reform) came into effect on 1st January 1994, when the State railways '*Deutsche Bundesbahn*' and '*Deutsche Reichsbahn*' were formally reunited to form the current German Railway Corporation (*Deutsche Bahn*).

Since 2005 the German railway network comprised approximately 41,315 km of which 34,211 km belonged to the national railway and 19,857 km was electrified. Today the total track length constitutes approximately 76,476 km.[20]

In contrast to the French rail network which is centralised, the German rail network system developed from the local or regional level into a vast state network combining various regions. It has advantages as all the big cities are interconnected which makes this system very efficient for freight transportation.

1.3. History of Rail in Switzerland

The first rail line in Switzerland was opened in 1847 and it run from Zürich to Baden.[21] It was 16 km in length. Already by 1860 railways connected western and northern parts of Switzerland. The first Alpine railway line was opened under the Gotthard Pass in 1882, and the second one was operational under the Simplon Pass since 1906. By 1913 the construction of railway lines in the western Alps, the Lötschberg railway line, was completed. However it was not a federal project, but it was an initiative of the canton of Bern. The *Rhaetian Railway* (RhB) opened the Albula line in 1903 and the *Bernina Railway* completed the Bernina line in 1910, providing a link to Italy. These lines were initially built for tourists, but they were later also used for freight.



The first Railway Act of 1852 issued by the Swiss government passed responsibility for administering policy in relation to the construction and operation of railways to the cantons, including licensing of companies, co-ordination of lines, technical specifications and pricing policy. Railways were to be built by private limited-liability companies. This Act also mandated the 1,435 mm standard gauge.

In 1853 the Swiss Central Railway (German: *Schweizerische Centralbahn*, SCB) began to build the Basel-Olten line through the Hauenstein pass, with branches from Olten to Aarau and Lucerne, Bern and Thun and from Herzogenbuchsee to Solothurn and Biel. At the same time the Swiss Northeastern Railway (*Schweizerische Nordostbahn*, NOB) concentrated on eastern Switzerland in the

[20] http://en.wikipedia.org/wiki/Rail_transport_in_Germany
[21] http://en.wikipedia.org/wiki/History_of_rail_transport_in_Switzerland

cantons of Zürich and Thurgau; its network covered the lines from Zürich to Lake Constance and to Schaffhausen and later to Lucerne. The United Swiss Railways (VSB) built lines from Winterthur to Rorschach and from Wallisellen to Rapperswil, Sargans and Chur. There were contracts for sharing the interlinked VSB line between Weesen and Glarus and the NOB line between Ziegelbrücke, Näfels, Glarus and Linthal.[22]

During the time of financial difficulties, many of the original companies merged with the Swiss North-eastern Railway (*Schweizerische Nordostbahn*) and with the United Swiss Railways (*Vereinigte Schweizerbahnen*, VSB) in the east and with the Jura–Simplon Railway (French: *Compagnie du Jura–Simplon*, JS) in the west. Despite the financial difficulties, by 1860 a continuous line extended from Geneva to Lake Constance, and by 1870 other main routes were completed.

The second Railway Act of 1872 that was issued right after the Franco-Prussian War (1870-71), transferred control of construction, operation, tariffs and accounting of the railways and the licensing of railway companies from the cantons to the federal government. The possibility of the federal government nationalising the railways also became part of the political agenda.[23] This document allowed local and mountain railways to be built with different gauges.

Rhaetian Railway, Albula/Bernina

In 1879 the federal government established a new Department of Post and Railways which had power over the railways together with the postal sector. The bankruptcy of several railway companies during the 1870s, rail strikes and opposition to foreign ownership of the railways led to support for the nationalisation of the railways. In 1891, the nationalisation of the SCB was rejected in a referendum, but it was approved by the Federal Council in 1897. Between 1900 and 1909, the Swiss Confederation acquired the five big railway companies, Jura–Simplon Railway (JS, 937 km), Swiss Northeastern Railway (NOB, 771 km), Swiss Central Railway (SCB, 398 km), United Swiss Railways (VSB, 269 km) and the Gotthard Railway (273 km), forming the *Schweizerische Bundesbahnen* (SBB) (Swiss Federal Railways). In 1903 the SBB network took over the metre gauge Brünig Railway (German: *Brünigbahn*) opened in 1888 and the Swiss shipping line on Lake Constance. It acquired another four small private railways between 1913 and 1948.[24]

In the 1870s, branch lines began to be built. Two-thirds of them were built as narrow gauge lines to reduce costs. Fifty branch lines were built in the period from 1874 to 1877, including the Gäu Railway (German: *Gäubahn*) between Solothurn and Olten (completed in 1876) and the Broye valley lines near Freiburg (1877), both originally planned by the *Schweizerische Nationalbahn* (SNB) (Swiss National Railway). Also built during this period were the Emmental railway (German: *Emmentalbahn*) from Solothurn to Burgdorf and Langnau im Emmental (opened 1875-81) and the Wädenswil–Einsiedeln Railway ("*pilgrim railway*", opened

[22] Hans-Peter, Bärtschi (1998–2009). Eisenbahnen, 2 - Die Bauperiode 1850-1870 (Railways, construction period 1850-1870).
[23] Ibid.
[24] Hans-Peter, Bärtschi; Dubler, Anne-Marie (1998–2009). Konzentrationsprozess im Bereich der Hauptlinien (Merging of the mainlines).

1877). Also opened between 1874 and 1881 was the Aargau Southern Railway, from Rupperswil to Rotkreuz, which later became a freight feeder line to the Gotthard railway.[25]

In 1901 the major railways were nationalised by SBB.[26] The electrification and upgrading of the lines took place in the first half of the twentieth century. The majority of the railway network was single track and its equipment and rolling stock was mostly in poor condition and unable to cope with increasing traffic. The difficult financial situation during the first half of the 20th century limited the modernisation of the Swiss rail network. The main work carried out was electrification, duplication and safety improvements. Electrification started on an experimental basis in 1888 and was completed in 1960.

Regarding private railways, they were built to connect cities with suburbs, beginning with the metre gauge Bern-Muri-Worb Railway opened in 1898 (now part of Bern-Solothurn Regional Transport). Additional standard gauge suburban lines were built to connect Bern with Thun via the Gürbe Valley (the Gürbe Valley Railway) and with Schwarzenburg and the metre gauge lines were extended to Zollikofen and Solothurn.[27]

After many investments in roads in the post-war period, the share of rail in the total passenger market in Switzerland had been significantly reduced by the end of the 1960s. SFR decided to increase train frequencies. In 1972 it introduced a regular time table, so that the trains arrive and leave each station at the same minute past every hour. Services at Zurich station were reorganised so that trains arrived on each line before the hour or half-hour and left after the hour or half-hour, making it easier to change to trains on other lines.

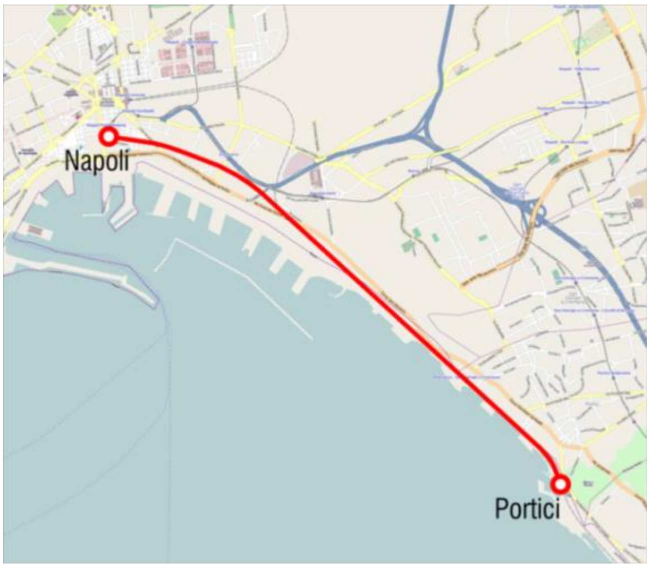
Total length of the Swiss railway system constitutes 5,063 km (including all gauges: standard, metre, 800 and 750 mm gauges), 3,652 km of standard gauge; 3,641 km of railway lines are electrified (standard gauge) with 15 kV 16.7 Hz.

Rail links to other countries:[28]
Austria — same voltage 15 kV, 16.7 Hz AC
France — voltage change 15 kV, 16.7 Hz AC / 25 kV, 50 Hz AC or 1,500 V DC
Germany — same voltage 15 kV, 16.7 Hz AC
Italy — voltage change 15 kV, 16.7 Hz AC / 3 kV DC
Liechtenstein — same voltage 15 kV, 16.7 Hz AC.

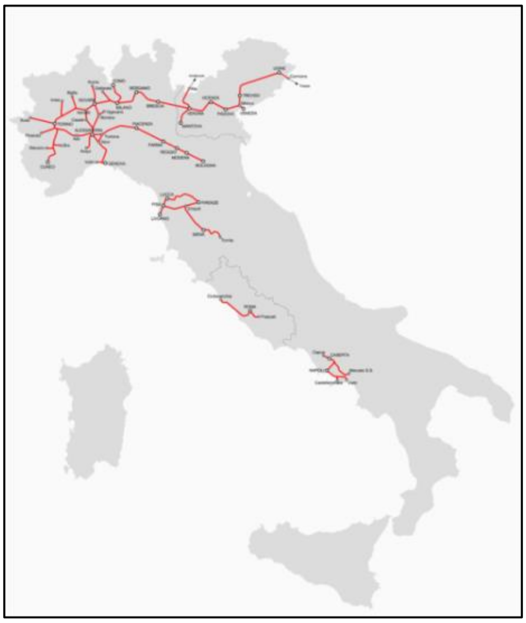
[25] Hans-Peter, Bärtschi; Dubler, Anne-Marie (1998–2009). Konzentrationsprozess im Bereich der Hauptlinien (Merging of the mainlines).
[26] http://en.wikipedia.org/wiki/Swiss_Federal_Railways
[27] Kräuchi, Christian; Stöckli, Ueli (2004). *Mehr Zug für die Schweiz. Die Bahn-2000-Story (More train for Switzerland. The Rail 2000-Story)* (in German). Zürich: AS-Verlag, p. 14
[28] http://en.wikipedia.org/wiki/Rail_transport_in_Switzerland

1.4. History of Rail in South Europe

1.4.1. Italy



The history of rail in Italy dates back to times when the country was still divided. The first rail line was the Naples-Portici (the Kingdom of the Two Sicilies 1816-1860),[29] which was built by the Bayard Company and it was a double track line of 7.25 km. It was opened on 3rd October 1839.[30] In the following year the Holzammer company from Bolzano obtained permission to build the Milano-Monza line (12 km) (the Kingdom of Lombardy-Venetia). Then the Milan-Venice line was constructed. The Padua-Mestre line was 32 km, which was constructed in 1842, then Milan-Treviglio at 32 km (1846) and Padua-Vicenza at 390 km (1846). In the Kingdom of Sardinia the Turin-Genoa railway was completed in 1853. Later on the lines connecting Italy with France, Switzerland and Lombardy-Venetia were constructed. The Ansaldo locomotive factory was opened in Genoa in 1853 to avoid an English monopoly of rail transport. In Tuscany the Lucca-Pisa line was inaugurated and then two other lines towards Piacenza and Modena. In the Papal State the first lines appeared under Pius IX (pope between 1846-1878): there were the Rome and Frascati Rail Road and the Rome and Civitavecchia Rail Road.



Network as of 17 March 1861

After the unification of Italy (1815) there were 5 main lines constructed Piedmont (850 km), Lombardy-Venetia (522 km), Tuscany (257 km), Papal State (317 km-1870) and Kingdom of the Two Sicilies (128 km) with a total of 2,064 km. To promote the industrial development of the country, the government entrusted the existing lines to five concessions: SFAI (*Società per le strade ferrate dell'Alta Italia*), SFR (*Società per le strade ferrate romane*), SFM (*Società per le Strade Ferrate Meridionali*), Società Vittorio Emanuele, Società Reale delle ferrovie sarde. In 1872 there were about 7,000 km of rail tracks. Many small lines were operated by private companies. The unification of Italy brought rapid growth in the railway sector and many other lines were opened.

In 1884 the Italian Parliament issued a document '*Convencioni*' (concessions), according to which 3 main private companies obtained rail concessions for 60 years. SFM was assigned the lines on the Adriatic Sea (*Rete Adriatica, Italian for Adriatic Network*), while the *Società per le Strade Ferrate del Mediterraneo* and the *Società delle Ferrovia della Sicilia* received, respectively, the *Rete Mediterranea* (Mediterranean Network, lines facing the Ligurian, Ionian and

[29] http://en.wikipedia.org/wiki/Kingdom_of_the_Two_Sicilies
[30] http://en.wikipedia.org/wiki/Naples%E2%80%93Portici_railway#mw-navigation

Tyrrhenian Seas) and the *Rete Sicula* (Sicilian Network). The companies received in total 8,510 km of railways[31]. This movement did not help to resuscitate the situation of the Italian railway. In 1905 the state bought the private companies and created the *Ferrovie dello Stato* (FS). Italian rail at that time had 10,557 km in total length.

Network as of 20 September 1870

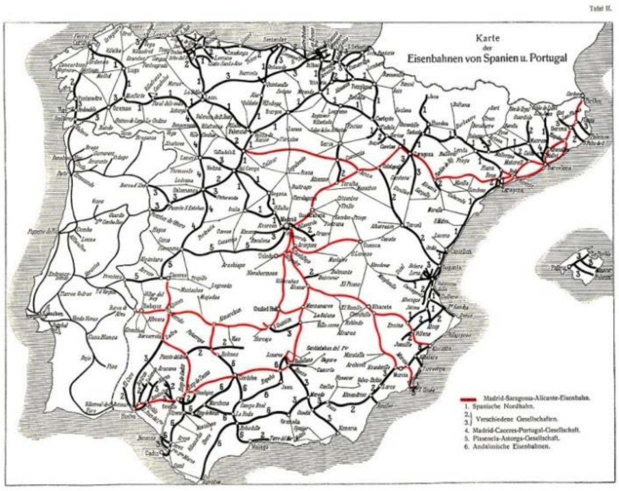
Under the Piedmontese engineer Riccardo Bianchi, who was appointed a General Director of the FS, the Italian railway was quickly modernised. He introduced a semaphore system and centralized hydrodynamic switches and signals were added in the main stations. He also expanded electrification of the railways, particularly in the north of Italy, using the three phase AC system.

During the Fascist era (1922-1939) electrification of 3,000 V DC was introduced, which later supplanted the existing three-phase system. Other improvements included automatic blocks, light signals, construction of numerous main stations (Milan Central, Napoli Mergellina, Roma Ostiense and others) and other technical modernisations.

After WWII the Italian railway was in a dilapidated state. Thanks to the Marshall Plan it was rebuilt in the following years. The three-phase lines were gradually turned into standard 3,000 V DC lines. The steam locomotives were replaced by electric or diesel ones.

In the 1960s the FS started an innovative project for high speed trains and introduced the FS E.444 electric locomotives. They were the first standard locomotives capable of 200 km/h, while a FS ALe 601 EMU reached a speed of 240 km/h during a test. Other EMUs, such as the ETR 220, ETR 250 and ETR 300 were also updated for speeds up to 200 km/h. The braking systems of cars were updated to fit the increased travelling speeds. On June 25th, 1970, works for the Florence–Rome *Direttissima*, the first high-speed line in Italy, were started.

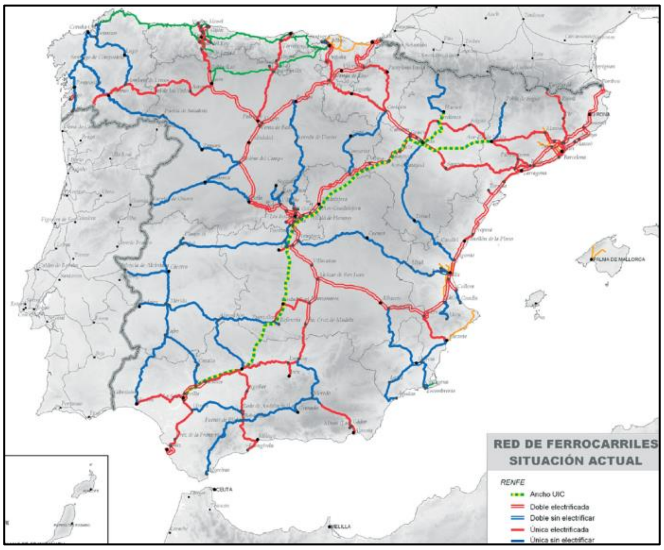
1.4.2. Spain



The history of rail transport in Spain starts in 1848 with the opening of the line between Barcelona and Mataró.[32] The main railway developments arrived quite late to Spain. It was due to economic difficulties in the country and geographical complications (*i.e.* mountainous terrain did not allow to easily construct railway in these territories. The Spanish railway was built with an unusual broad track gauge of 1,672 mm, or six Castilian feet). It is believed that the choice of gauge was influenced by Spain's hostility to neighbouring France during the 1850s. Making the Spanish railway network incompatible with that of France would hinder any French invasion. Others say that the decision was taken to allow bigger engines that

[31] http://en.wikipedia.org/wiki/History_of_rail_transport_in_Italy
[32] http://en.wikipedia.org/wiki/History_of_rail_transport_in_Spain

would have enough power to climb the steep passes in the second most mountainous country in Europe. As a result, Portuguese railways were also built to a broad gauge (roughly the same, 1,664 mm, but rounded to a Portuguese unit). In 1955 Spain and Portugal decided to halve this difference of 8 mm, and defined their gauge to be 1,668 mm, called *Iberian gauge*. Apart from the widespread broad-gauge lines, a large system of narrow gauge railways was built in the more mountainous parts of Spain, especially on the north coast of the country, where narrow gauge was the most suitable option. The main lines were completed in the 1870s.



In 1852 the first narrow gauge line was constructed. In 1863 a line reached the Portuguese border. Also by 1864 the Madrid-Irun line was opened, which reached the French border. In 1911 the first electrified line the Gergal-Santa Fe line became operational. The last steam locomotive was removed from use in 1975 and in 1986 the maximum speed on the Spanish railway was raised to 160 km/h. In 1992 the Madrid-Seville high speed line was opened.

During the civil war in the 1930s many lines were severely damaged. Franco's regime nationalised the broad gauge network and in 1941 RENFE (*Red Nacional de los Ferrocarriles Españoles*—National Network of Spanish Railways)[33] was founded. Narrow gauge lines were nationalized in the 1950s, later being grouped to form FEVE (*Ferrocarriles de Vía Estrecha*, Spanish for 'Narrow-gauge railways').[34]

During the decentralisation of Spain after 1978 those narrow gauge lines which did not cross the limits of autonomous communities of Spain were taken out of the control of FEVE and transferred to the regional governments, which formed, amongst others, *Eusko Trenbideak* and *Ferrocarrils de la Generalitat de Catalunya* (FGC). Madrid (Madrid Metro), Barcelona, Valencia and Bilbao (Metro Bilbao) all have autonomous metro services.

The Railway Sector Act of 2003 separated the management, maintenance and construction of rail infrastructure from train operation. A new public company, *Administrador de Infrestructuras Ferroviarias* (ADIF) is responsible for management, while Renfe (*Renfe Operadora*) owns the rolling-stock and remains responsible for the planning, marketing and operation of passenger and freight services.

[33] http://en.wikipedia.org/wiki/Renfe_Operadora
[34] http://en.wikipedia.org/wiki/FEVE

In 1992, a standard gauge high-speed rail line (AVE) was built between Madrid and Seville. In 2003, a high-speed service was inaugurated on a new line from Madrid to Lleida and extended to Barcelona in 2008. The same year, the lines from Madrid to Valladolid and from Córdoba to Málaga were inaugurated.

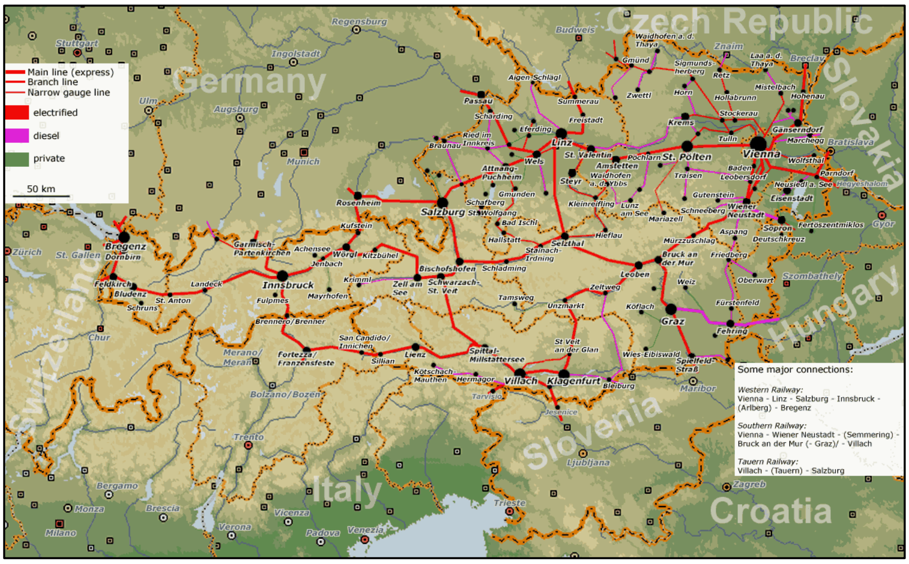
Major operators in the Spanish railways are: RENEFE, FEVE, EuskoTren, FGC and FGV. Total length of railway network constitutes 15,288 km, of which 8,847 km is electrified; the broad gauge (1,668 mm) - 11 829 km, Standard gauge (1,435 mm) - 998 km, Metre gauge (1,000 mm) – 1,926 km and Narrow gauge (914 mm) - 28 km. The main network is electrified with 3 kV DC and high-speed lines 25 kV AC. The longest tunnel is Sierra de Guadarrama of 28.4 km.[35]

1.5. History of Rail in Central and Eastern Europe

In this section we will focus on several countries from Eastern and Central Europe, such as Austria, Poland, Ukraine, Romania, Bulgaria and Russia.

1.5.1. Austria

The history of rail in Austria starts with a 22 km long horse-drawn line that was built in 1810 at the Eisenerz mine in Styria for the transport of iron stones.[36] In 1832 a wagonway between Austrian Linz and *České Budějovice* (Budweis) in Bohemia was opened. It stretched for 128.8 km and was the second interurban railway in continental Europe (after the French Saint-Étienne to Andrézieux Railway line opened in 1827). The first section of a new steam locomotive railway from the Austrian capital Vienna to Kraków in the Kingdom of Galicia and Lodomeria operated by the Emperor Ferdinand Northern Railway Company opened in 1837, designed by Franz Xaver Riepl.



In 1854, 994 km out of 1,443 km of railway lines were state owned (ca. 70%). The Southern Railway from Vienna to the seaport at Trieste via the Semmering Pass opened in 1857 and was operated by the private Austrian Southern Railway company.

During the financial crisis in 1854, many Austrian railway lines were sold to foreign investors. For instance the Imperial Royal Privileged Austrian State Railway Company to French investors. After the Austro-Hungarian Compromise of 1867, the *Transleithanian* (Hungarian) lines were nationalized as the Hungarian State Railways (MÁV). The Long Depression, started by the Vienna stock market crash in 1873, resulted in the bankruptcy of several Austrian railways, and the state took them over. In 1882 the nationalisation of the

[35] http://en.wikipedia.org/wiki/Rail_transport_in_Spain
[36] http://en.wikipedia.org/wiki/Imperial_Royal_Austrian_State_Railways

railway network of the Austro-Hungarian Monarchy into the Imperial Royal Austrian State Railways (*Kaiserlich-königliche österreichische Staatsbahnen*) started. In 1923 the independent, commercial enterprise, the Austrian Federal Railways (*Österreichische Bundesbahnen*) (BBÖ) was founded. After the *Anschluss* of Austria into the German Empire in 1938, BBÖ was taken over by the *Deutsche Reichsbahn*. During WWII about 41% of the Austrian railway network was destroyed. In 1947 BBÖ were reformed as a state-owned company and it changed name to ÖBB.

In 1969 ÖBB became a non-independent, economic entity that was run as a branch of the government's industrial programme and remained entirely within the Federal budget. In 1992 the ÖBB was broken out of the federal budget and turned into a company with its own legal status (a cross between a *GmbH* and an *AG* in Austrian commercial terms). It was aiming at conforming to EU rules on the admission of Austria into the European Union as well as improving efficiency and the pressure of competition.

In 2004 another reorganisation took place: the company was reorganised into ÖBB Holding AG and a number of operating subsidiaries. The holding company was to oversee the operations of the companies assigned to it, coordinate a coherent strategic approach and allocate tasks for the whole enterprise. And in 2005 it became autonomous and independent operationally.

The Austrian rail system is largely electrified. Electrification of the system began in 1912 but did not reach an advanced state until the 1950s. The last steam locomotive in regular service on the standard gauge network was retired in 1978.

According to the Annual Report 2013, ÖBB Holding AG employs 39,513 people. The ÖBB has 4,859 km, 72% electrified; 1,128 train stations, 1,093 locomotives, 2,799 passenger cars, and 26,518 freight wagons.

1.5.2. Czech Republic

Rail transport in the territory of the present day Czech Republic dates back to the Austro-Hungarian Monarchy.[37] The first locomotive-hauled railway from Vienna to Břeclav opened in 1839. After WWI and the independence of Czechoslovakia, the company *Československé státní dráhy* (Czechoslovak state railways) was founded. In the aftermath of the Velvet Revolution in 1948 the crossing points with Austria and West Germany became strictly controlled. Following the fall of communism the railways with the West were reopened.

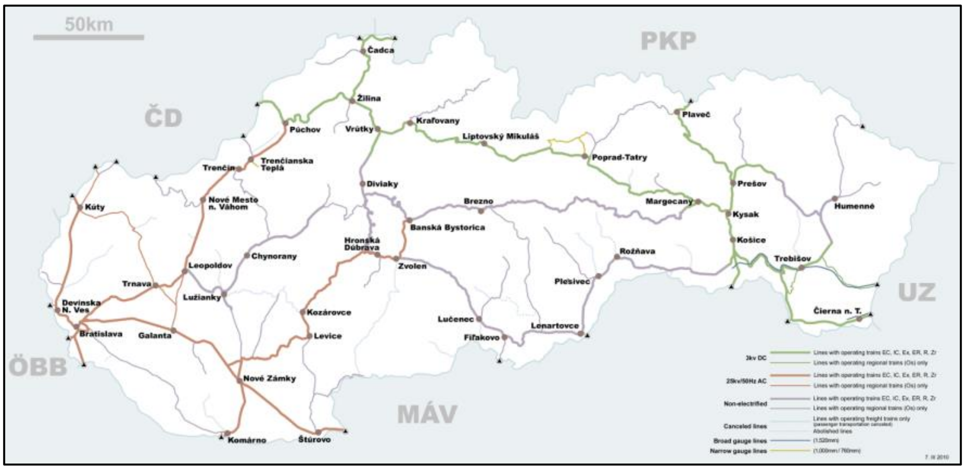
[37] http://en.wikipedia.org/wiki/Rail_transport_in_the_Czech_Republic

The majority of passenger services nowadays are operated by the state company *České dráhy* (Czech Railways), which until 2007 also managed cargo services, which are now run by ČD Cargo. In 2009 the country had 9,420km of standard gauge track, 3,153km of which was electrified. The railway network has same gauge links to all four countries bordering the Czech Republic (Slovakia, Austria, Germany and Poland).

The company that was responsible for the infrastructure in the country was *Správa železniční dopravní cesty* (SŽDC). In 2011 the Czech government proposed merging SŽDC and *České dráhy* to a single company. In 2011, RegioJet, a subsidiary of Student Agency, became the first company to actively compete with *České dráhy* on a route, launching a service between Prague and Havířov. Other private companies own exclusive rights to run services on certain lines.

The rail in Czech Republic has links to adjacent countries of the same gauge, yet sometimes with a different voltage system: Austria – voltage change 25 kV AC/15 kV AC, Germany – voltage change 3 kV DC/15 kV AC, Poland – same voltage 3 kV DC, Slovakia – same voltage 3 kV DC (north) and 25 kV AC (south)
The Czech Republic is a member of the UIC.

1.5.3. Slovakia



The first railway line in Slovakia dates back to 1848. It connected Bratislava with Vienna. The modern *Železnice Slovenskej republiky* company was established in 1993 as a successor of the *Československé státní drahy* in Slovakia. Until 1996 it held a monopoly on railroad transport in the country. The private operators entered the network only in the early 2010s. Private passenger service operators include RegioJet, which operates trains between Prague (Czech Republic) and Žilina and on the Komárno - Dunajská Streda - Bratislava route.[38] Since 2002 the company was divided: ŽSR was left with infrastructure maintenance while passenger and cargo transport was moved into company "*Železničná spoločnos*', a. s." (ZSSK). In 2005 it was split into "*Železničná spoločnosť Slovensko, a. s.*" (ZSSK) providing passenger transport services and "*Železničná spoločnosť* Cargo Slovakia, a. s." (ZSSK Cargo) providing cargo services. Freight transport is operated by ZSCS and around 30 private companies. Slovakia is a member of the UIC.

In 2006 total length of lines constituted 3,658 km, of which single track: 2,639 km, double or more track: 1,019 km. Regarding the gauges: 1,520 mm broad gauge had 99 km and 1,435 mm standard gauge: 3,509 km; narrow gauge: 50 km, 45 km of 1,000 mm gauge; 5 km of 750 mm gauge. It had 1,577 km of electrified lines. Since December 2010 it has 75 tunnels measuring 43 km, 2,321 railway bridges measuring 52 km and 8,529 sets of points.

[38] http://en.wikipedia.org/wiki/Rail_transport_in_Slovakia

Slovakia has links with adjacent countries: same gauge 1,435 mm: Austria – voltage change 25 kV AC/15 kV AC, Czech Republic – same voltage 3 kV DC or 25 kV AC, Hungary – same voltage 25 kV AC and Poland – same voltage 3 kV DC.

1.5.4. Hungary

The history of rail in Hungary dates back to the middle of the 19th century. The first steam locomotive railway was launched on 15th July 1846 between Pest and Vác.[39] In the 1850s as a result of the Austro-Sardinian War all Hungarian lines were sold to Austrian private companies. During this time the company of Ábrahám Ganz invented a method of 'crust-casting' to produce cheap yet sturdy iron railway wheels, which greatly contributed to railway development in Central Europe. After the Austro-Hungarian Compromise of 1867 transport issues became the responsibility of the Hungarian Government, which also inherited duties to support local railway companies. This led the Hungarian Parliament to consider founding a State Railway in 1868. Hungarian State Railways (Hungarian: Magyar Államvasutak or MÁV) is the Hungarian national railway company, with divisions "MÁV START Zrt." (passenger transport), "MÁV-Gépészet Zrt." (maintenance). In 2014 the "MÁV Cargo Zrt" (freight transport) was sold to ÖBB. The purpose of it was to take over and operate the Hungarian main lines. The small branches were constructed by private companies, but they did not own locomotives or the rolling stock which belonged to MÁV. MÁV gave contracts to the private companies only if their equipment and buildings were constructed to MÁV standards. This helped to build standard station buildings, sheds, and accessories, all to the MÁV rules. In 1890 most large private railway companies were nationalized as a consequence of their poor management, except the strong Austrian-owned Kaschau-Oderberg Railway (KsOd) and the Austrian-Hungarian Southern Railway (SB/DV).

MÁV Class M44

In 1910 MÁV became one of the largest European railway companies regarding both its network and its finances.

After the peace treaty of Trianon that followed the end of WWI and which reduced Hungarian territory by 72%, the railway network was cut from around 22,000 km to 8,141 km (the 7,784 km long MÁV-owned

[39] http://en.wikipedia.org/wiki/Hungarian_State_Railways

network decreased to 2,822 km). During WWII the Hungarian railway suffered great destruction, but by 1948 most of the railway network was restored. The first electrified section came into use in October 1945.

During Soviet times the rail system was dilapidated, overloaded trains were hauled by badly maintained locomotives on poor quality tracks. In 1958 steam locomotive manufacturing stopped in Hungary. 600 HP diesel-electric locomotives (Class M44) and 450 HP diesel hydraulic switchers (Class M31) were manufactured. To this day 120 km/h remains the maximum railway speed in Hungary, but EU funds became available to upgrade the network, especially tracks that form part of the Trans-European Transport Networks (TEN-T).

In the period 2000-2010 many lines were abandoned or closed by the government. However since 2010 when the new government came to power, ten rural railway lines, previously closed due to low revenues, were reopened. In February 2013, for the first time in its history, the railway started to train women drivers.[40]
The Hungarian railway network has 7,606 km and it operates on the standard track gauge of 1,435 mm.

1.5.5. Poland

The history of Polish railway dates back to the first half of the 19th century. It was built under Prussian, Russian and Austrian rule. After the proclamation of Polish independence on 11th November 1918, the independent Polish state administered its own railways until control was surrendered to German and Soviet occupiers during WWII. During the war major changes took place in the Polish railway, with shifting of the Polish borders westward in 1945, when many parts of the German railways came under Polish control.[41]

Under Prussian rule, two of the oldest Polish railways were launched in 1842: the Upper Silesian Railway Company, licensed since 1839, opened the first two sections of its main line: Breslau (Wrocław) to Ohlau (Oława) on 22th May and Ohlau to Brieg (Brzeg) in August. These two lines were progressively extended, joining with Katowice, Mysłowice. Then in 1856 the Upper Silesian Railway Company built a line from Breslau (Wrocław) to Posen (Poznań). In 1851 inside its standard gauge main line, the Upper Silesian Railway Company started to build a narrow gauge network, connecting local mining trams. This *Oberschlesische Schmalspurbahn* (OSSB) survived the nationalization of the standard gauge lines, and in two steps 1920 and 1945 became present day *Górnośląskie Koleje Wąskotorowe* (GKW). At the same time other lines were constructed including the Lower Silesian-Mark Railway (1843), William Railway (1846-1848), Silesian Mountain Railway from Görlitz via Lauban (Polish: Lubań) and Hirschberg (1880), the Prussian Eastern Railway was planned from Berlin to Königsberg (present day Kaliningrad) (ca. 1848), Öls–Adelnau–Ostrów line / Oleśnica–Odolanów–Ostrów Wielkopolski (1910), the Warsaw-Vienna Railway (1845), Kraków and Upper Silesian Railway (1847) etc. The first link to the 1,524 mm system was the Saint Petersburg – Warsaw Railway, completed in 1862.

[40] http://www.bbj.hu/life/hungary-starts-training-women-to-be-engine-drivers_64719
[41] http://en.wikipedia.org/wiki/History_of_rail_transport_in_Poland

In 1893, the Prussian state railways introduced the first modern fast trains using the new steam locomotives (S2/PKP class Pd1) which could reach a speed of 100 km/h (62 mph). The trains also included 4-axle bogie coaches with compartments and side corridors and covered gangways (Corridor trains, in German "D-Zug"). After annexing Polish areas, the German railway army re-adjusted the railway from Russian (broad gauge) to 1,435 mm. In 1915, the German and Austrian armies completed adapting a significant portion of broad gauge track to standard gauge.

PKP class Ok1, former Prussian P8

In 1918 the Regency Council transferred the management of the state railway from the former Congress Poland (*Królestwo Kongresowe*)[42] to the Ministry of Business and Industry. On 31th October 1918, Polish railwaymen took over the Railway Directorate in Kraków and railways in Galicia and *Śląsk Cieszyński*, beginning the takeover of railways in the former Russian and Austrian sectors. Polish railwaymen took over the management of railways in the Warsaw district on the same day.

After the independence of Poland on 11th November 1918 Poland reclaimed the former Russian and Austrian sectors from military railways. The Railway Department in the Ministry of Communication was created and the Polish railways were officially named *Polskie Koleje Państwowe* (Polish State Railways), known as PKP. In 1922 Polish railway administration took over the railways in Upper Silesia and it was decided to divide railway in Poland into nine administrative districts.

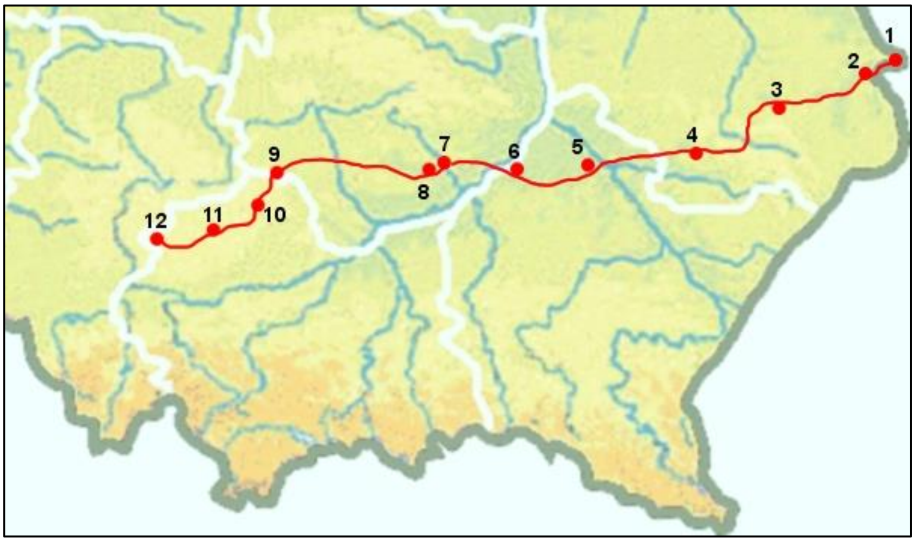
The government of Paderewski purchased 150 Consolidation type steam locomotives from the USA in 1919. The same year the French authorities offered one hundred captured German steam locomotives and two thousand cargo vehicles. Twenty-five items of PKP class Tr20 locomotives were ordered from the USA in 1920. In 1923 the First Polish Locomotive Factory in Chrzanów was constructed. The same year, local production began in the Warszawa Steam Locomotive Joint Stock Company. The first Polish steam locomotives in Germany and Belgium (PKP class Tr21, PKP class Ok22, PKP class Ty23) were ordered.

In 1945, the Ministry of Transport was created, as well as the Regional Directorate of National Railways. Many pre-war locomotives were sent to the Soviet Union. Poland received many German locomotives as a compensation for war losses. Polish railways regained pre-war locomotives from Hungary, Czechoslovakia and Yugoslavia (in 1947), but units from the eastern parts of Poland were taken over by USSR and rebuilt to operate on a wide gauge.

The Polish railway network consists of 19,599 km of track as of 2008, of which the vast majority is electrified at 3 kV DC overhead. Large parts of the Polish rail network were built before WWII when its territory belonged to different countries, where it was a part of the *Deutsche Reichsbahn* and Russian Imperial State Railways or by the Communist authorities from 1946 onwards. Due to the age of the lines and bad maintenance of them many sections are limited to speeds below 100 km/h even on trunk lines. There are no high-speed lines and some 500 km allow 160 km/h, most notably the Central Trunk Line (CMK), which links Warsaw to Katowice and Kraków, with some sections which could permit 200 km/h but are not operated at that speed. In 2000 the

[42] http://en.wikipedia.org/wiki/Congress_Poland

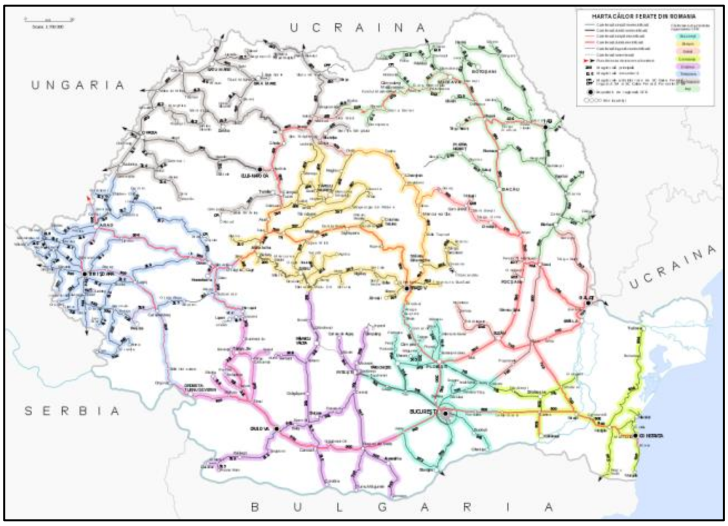
Polish government launched the construction of a dedicated high speed line based on the French TGV model and using TGV style train sets. The project is planned to be completed by 2020.



PKP is a state-owned corporate group, which is the main provider of railway services, holding an almost complete monopoly in rail services as it is both supported and partly funded by the government. There are three main PKP companies: PKP PLK (owns and maintains infrastructure including lines and stations), PKP Intercity (provides long-distance connections on the most popular routes) and PKP Cargo (provides cargo rail transport).

Polish railway has standard gauge (1,435 mm). The Broad Gauge Metallurgy Line (known by its Polish abbreviation LHS) is broad gauge (1,520 mm) with a few short stretches near border crossings. The LHS to Sławków is the longest line, single track for almost 400 km from the Ukrainian border just east of Hrubieszów. It is the westernmost broad gauge line connected to the system of the former Soviet Union (*see the map*).

1.5.6. Romania



The first railway in the Kingdom of Romania was constructed in 1869[43] and linked Bucharest and Giurgiu. The first railway on current Romanian territory opened in 1854, between Oraviţa and Baziaş in Banat, however that region was part of the Austro-Hungarian Empire at the time. Since that time the Romanian rail network has gradually expanded. Now it is the fourth largest railway network in Europe by total track length of 22,298 km, out of which 8,585 km are electrified.

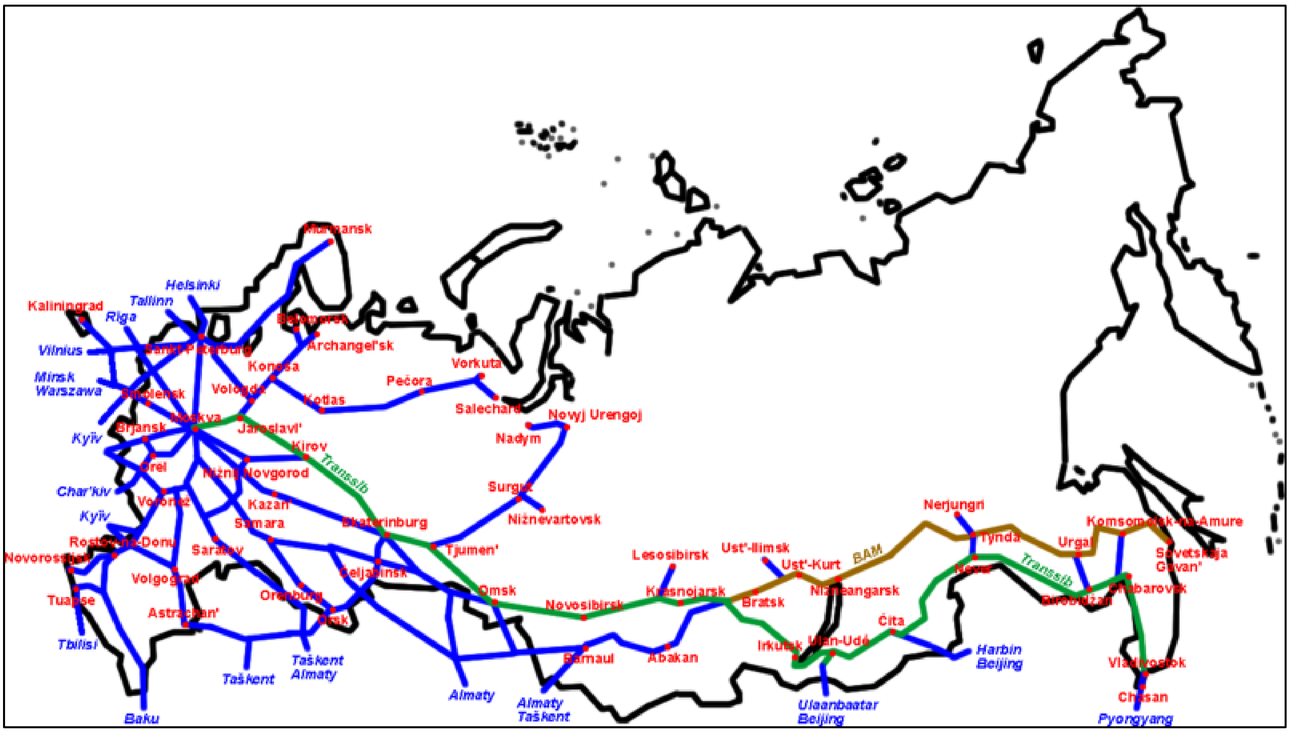
[43] http://en.wikipedia.org/wiki/Rail_transport_in_Romania

As for the operators of the Romanian railways, the network was previously monopolized by *Căile Ferate Române*, the state railway company, but since 1998, a number of private companies began operations, both in passenger and/or freight transport: *Regiotrans*, *Grup Feroviar Român*, *Servtrans*, *Transferoviar Grup* and *Unifertrans*. Romania is a member of the UIC.

CFR Class 60 Diesel electric locomotive

1.5.7. Russian Federation

In the early 1830s Russian inventors father and son Cherepanovs built the first Russian steam locomotive. The first railway line was built in Russia in 1837 between Saint-Petersburg and Tsarskoye Selo.[44] It was 17 km long and linked the Imperial Palaces at Tsarskoye Selo and Pavlovsk. The track gauge was 1,830 mm. The first major railway in the Russian Empire appeared in 1851 under the Russian tsar Nicholas I. The first railway connected St Petersburg and Moscow with a track gauge of 1,524 mm and since that time it became known as the 'Russian standard gauge.'



In the 1880s and 1890s the Trans-Caspian railway was built; by 1906 Central Asia was connected by the Trans-Aral Railway with European Russia via Kazahstan. The Trans-Siberian Railway connecting European Russia with the Russian Far East provinces on the Sea of Japan was built between 1891 and 1916. The Russian-built system included the Chinese Eastern Railway, short-cutting across China's Manchuria; later on, its southern branch was connected with other Chinese railways.

[44] http://en.wikipedia.org/wiki/History_of_rail_transport_in_Russia

By 1880 all railways were private companies, but after having had financial difficulties, the government took over some of them. It resulted in a mixed system of private and government railways. The government had guaranteed payment of interest and dividends on the securities of the private railroads resulting in a strong incentive for government takeover of failing railways. The result was that the Russian railways became the most economically operated in the world, the profit of which was over 100 million gold rubles. However, it was not until 1917 that rail traffic boomed rapidly under the Soviet Union. After the revolution railways became completely owned by the Soviet state. The USSR rebuilt its rail system and industrialized with five-year plans.

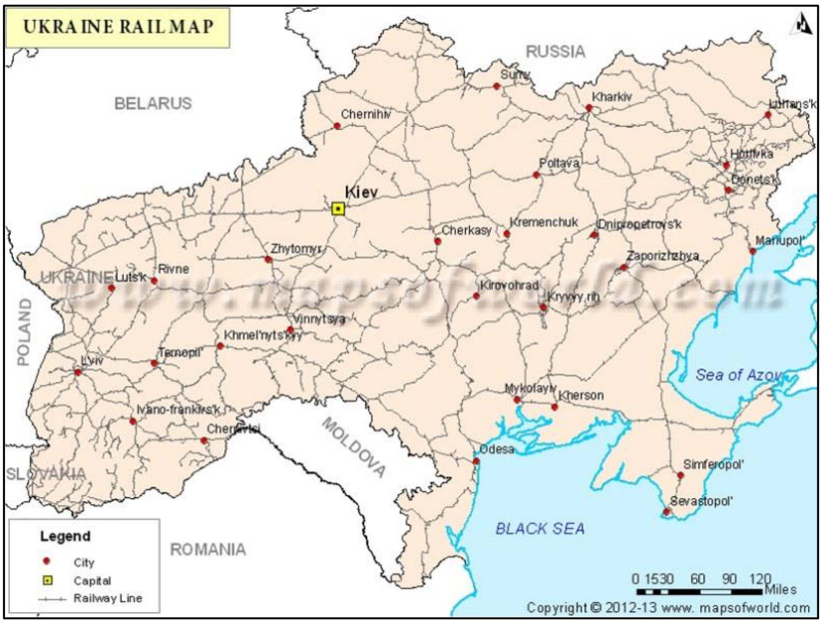
During Soviet times the rail system was electrified, new lines were built, double-tracking and automatic couplers, brakes and signalling were introduced. During this period the Railway University was founded as well. The railway system declined after the collapse of the Soviet Union, when the Russian Federation declared it to be its main inheritor, the other parts of the railroads broke up into national railway systems of various Soviet republics.

Nowadays the Russian system is the biggest railway in the world with 950,000 employees and it is state owned. The total length of it constitutes 85,500 km, exceeded only by the United States.

In 2003 vast structural reforms were introduced by the Russian Government to preserve the unity of the railway network and separate the functions of state regulation from operational management. It was done by Decree №585 of the Russian Government which established the Russian Railways Public Corporation with the state holding 100% of the shares. In 2007 Russian Railways established the First Freight Company which holds a large number of freight wagons; in 2010, it was announced that the Second Freight Company would be established, and the remaining freight wagons were transferred to that. In July 2010, Russian Railways (*Российские железные дороги, Rossiyskie zheleznye dorogi*) (RZD) signed an agreement with Siemens to provide rolling stock (240 EMUs) and upgrade 22 marshalling yards.[45]

1.5.8. Ukraine

Ukrzaliznytsia (Ukrainian: *Укрзалізниця*), also known as Ukrainian Railways, is the State Administration of Railroad Transportation in Ukraine, a monopoly that controls the vast majority of the railroad transportation in the country.[46] It has a total length of track of over 23,000 km. It is the 14th largest rail network in the world. Ukrzaliznytsia is also the world's 6th largest rail passenger transporter and world's 7th largest freight transporter.



[45] http://www.railjournal.com/newsflash/siemens-signs-multi-billion-euro-russian-rail-deal.html
[46] http://en.wikipedia.org/wiki/Ukrainian_Railways

State Administration of Railroad Transportation is subordinated to the Ministry of Infrastructure, administering the railways through the 6 territorial railway companies: Donetsk Railway, Lviv Railway, Odessa Railway, Southern Railway (Kharkiv), South-western Railway (Kyiv) and Near-Dnipro Railway (Dnipropetrovsk).

The first rail line was built under the rule of the Austrio-Hungarian Monarchy (western territories) and later under Russian Empire territories. Since the moment of breaking up of Ukraine from the Soviet Union in 1991, all railroads located on the territory of the country became the property of Ukraine. On 14th December 1991 the Cabinet of Ministers of Ukraine issued declaration No. 356 "In creation of the State Administration of Railroad Transportation in Ukraine" which proclaimed *Ukrzaliznytsia* a government body in administering railroad transportation uniting the six state railroad companies.[47]

The Ukrainian railway system accounts for 23,000 km of which 9,752 km (44.3%) is fully electrified with the use of overhead wire. The network is fully interconnected, central-dispatched and consists of 1,648 stations of all sizes spread throughout the country. The largest stations are Nyzhnodniprovsk-Vuzol (in the city of Dnipropetrovsk) and Darnytsia (in the capital Kiev) – both freight.

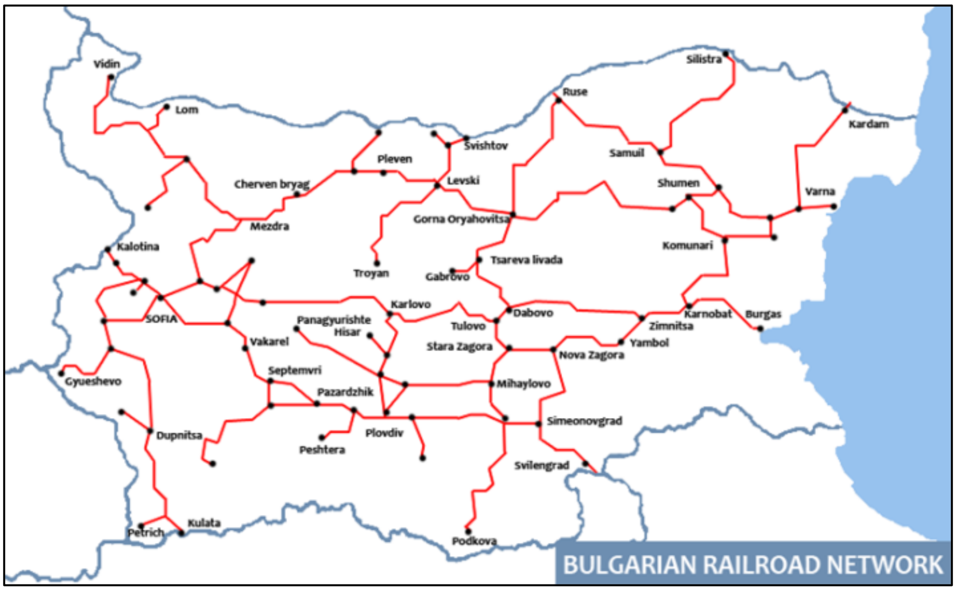
Ukrzaliznytsia possesses: 174,939 freight wagons, 8,429 passenger wagons, 2,718 locomotives, 1,796 electric locomotives, 1,443 electric multiple units, 186 diesel multiple units, 375,900 employees, 62 specially branded passenger trains.

1.5.9. Bulgaria

The largest railway carrier in Bulgaria is the Bulgarian State Railways (Bulgarian: *Български държавни железници*, Balgarski darzhavni zheleznitsi, abbreviated as БДЖ, BDZ or BDŽ), which is a state company

[47] See the document issued by the Cabinet of Ministers of Ukraine: http://zakon0.rada.gov.ua/laws/show/356-91-%D0%BF

with headquarters in Sofia. It was founded in 1885.[48] During the period 1994 to 2010 there was a significant drop in the market share in the passenger and freight services. In 2002 a new state company, the National Railway Infrastructure Company, was founded and became the owner of the infrastructure. Bulgaria is a member of UIC.



In 1864 construction of the Ruse-Varna railway line begun. It was commissioned by the Turkish government to an English company managed by William Gladstone and the Barkley brothers to build the line. The whole line was officially opened in 1866. In 1870 Baron Maurice de Hirsch started construction of the Constantinople – Belovo railway line, which was opened in 1873. In 1885 the national Assembly passed the Railway Act, according to which railways in Bulgaria were state property and are operated by the state. In 1912 an independent Ministry of Railways, Post Offices and Telegraphs was established. In 1952 the sub-Balkan railway line was launched. The first electrified line, Sofia-Plovdiv was built by Škoda and it became operational in 1963. In 1964 the first double track line between Sindel and Varna was finished. On 1 January 2002, the new Railway Transport Act entered into force, passed by the National Assembly, according to which the National Company Bulgarian State Railways is split into two separate enterprises – a railway carrier (Bulgarian State Railways EAD) and an infrastructure enterprise (Railway Infrastructure National Company). In October 2010 further restructuring was announced, with BDŽ EAD becoming a holding company, and all rolling stock allocated to passenger and freight subsidiaries.

Bulgarian Railways BDŽ Class 46
Electric locomotive

[48] http://en.wikipedia.org/wiki/Bulgarian_State_Railways

Since 2007 a new organisational structure appeared DŽ Inc. (a holding company with one shareholder, the Republic of Bulgaria). There is *BDŽ Putnicheski Prevozi Ltd*. - responsible for the passenger services. The company carried 31.36 million passengers in 2009; *BDŽ Tovarni Prevozi Ltd*. - freight operations and expedition with subsidiary *BDZ SPED Ltd*. The company carried 13.3 million tonnes of freight in 2009. Privatisation was attempted in 2012, but called off in 2013 due to financial problems; *BDŽ Traktzionen Podvizhen Sustav Ltd*. - locomotive management and servicing; *BDŽ-Koncar Inc*. - joint venture between BDŽ EAD and KONČAR Group from Croatia with as main scope of work locomotive repairs and modernization.

There are many problems with the organizational structure of the holding. The main goal of the Ministry of Transport, Information Technologies and Telecommunication is to make the company profitable.

There are several narrow gauge railways in Bulgaria: Septemvri-Dobrinishte narrow gauge line was finished in 1945. The line is 760 mm gauge, unelectrified, and is primarily served by diesel power locomotives. It has the highest railway station in the Balkans at 1,267 m. Bulgaria has track gauge of 1,435 mm and 1,520 mm with Ukraine – voltage 3 kV DC.

1.6. Rail Links with Adjacent Countries

Crossing points between countries with the same gauge:[49]

Bulgaria – Romania: crossings at Calafat, Giurgiu and Negru Vodă. Daily passenger service to Sofia and beyond (Athens and Istanbul) from Bucharest. No voltage issues (currently no electrified crossings, Calafat-Vidin crossing electrification is planned, same voltage, 25 kV, 50 Hz AC.

Hungary – Romania: multiple crossings from North to South - Carei, Valea lui Mihai, Episcopia Bihor, Salonta, Curtici. Multiple daily passenger frequencies to Budapest and beyond (Vienna, Prague) from Bucharest and from many cities within Transylvania. No voltage issues, railroad systems electrified at 25 kV, 50 Hz AC (electrified crossing at Curtici/Lokoshaza only).

Serbia – Romania: crossings at Jimbolia and Stamora Moraviţa. Daily service from Bucharest to Belgrade via Timişoara. No voltage issues (crossings are not electrified).

Ukraine – Romania: dual gauge crossing at Halmeu. No voltage issues (crossing is not electrified). Currently freight only.

Ukraine – Slovakia/Hungary: a dual gauge line enables standard gauge connections with Hungary and Slovakia through Chop.

Crossing points between countries with break-of-gauge:

Ukraine – Romania: break-of-gauge 1,435 mm/1,520 mm. Crossings at Vicşani, Valea Vişeului and Câmpulung-la-Tisa (including bogie conversion systems). Dual gauge (4 rail) track exists between Tereseva (Ukraine)/Câmpulung-la-Tisa - Sighetu Marmaţiei - Valea Vişeului, going back into Ukraine. Ukrainian trains (both freight and passenger services) occasionally use this route without stopping within Romania. International passenger services exists between Bucharest and Kiev (and onwards to Moscow) via Vicşani

[49] http://en.wikipedia.org/wiki/Rail_transport_in_Romania

(operated by CFR, with UZ and RZD cars) and between Sighetu Marmaţiei and Teresva (operated by UZ). No voltage issues (crossings are not electrified).

Moldova – Romania: break-of-gauge 1,435 mm/1,520 mm. Crossings and bogie changers exist at Ungheni-Prut and Galaţi-Reni. No voltage issues. None of the tracks of the Moldovan Railways are electrified. Daily passenger service to Chişinău from Bucharest. Multiple daily services from Iaşi.

2. European Railways Technical Specifications

2.1. Introduction

One of the most complex aspects of rail in Europe is its technical specifications. Historically the first real European railway appeared in the UK. It was created to facilitate the transportation of coal in the mining industry and had a very strong impact on the economy of the country. Since the first appearance of rail, it became one of the important factors that stimulated industrialisation. The railways not only boosted economic development, but also played an important role in the construction of the new modern world.

After the appearance of railways in the UK, they spread very quickly across Europe. In less than three decades the network covered all major parts of continental Europe. However, each country, depending on its economic needs, geographic specifications, and certain ideologies, developed their own railway systems and infrastructure, preserving original technical specifications to a certain degree. As a result, the national railways differ from one another in several technical aspects. The most significant differences between the national railway systems are: traffic direction; various types of gauges; electrification systems; train protection systems, etc. This makes the European railway system very heterogeneous. Therefore, to make the European rail network work as one consolidated mechanism without interruption is one of the most challenging tasks on the EU agenda. Let us have a quick look at these rail technical specifications.

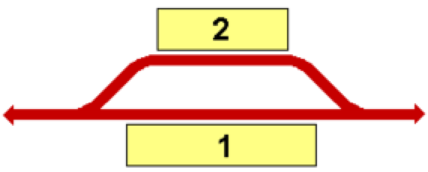
2.1.1. The Tracks

There are different types of tracks to serve different purposes.[50] A track with a spot at the station to board and disembark trains is called *station track* or *house track* regardless of whether it is a *main line* or *loop line*. If such track is served by a platform, the track may be called *platform track*. A *loop line* without a platform which is used to allow a train to clear the main line at the station only, it is called *passing track*. A track at the station without a platform which is used for trains to pass the station without stopping is called *through track*.

There may be other *sidings* at the station which are *lower speed tracks* for other purposes. A *maintenance track* or a *maintenance siding*, usually connected to a *passing track*, is used for parking maintenance equipment, trains not in service, autotracks or sleepers. A *refuge track* is a dead-end siding that is connected to a station track as a temporary storage of a disabled train.

2.1.1.1. Single / Double track

There two types of railways: a *single-track railway* and a *double-track railway*.



The *double-track railway* involves one track in each direction, whereas the *single-track* means that a train uses the same track in both directions.[51] The single track is usually used on lesser-used lines (branch lines), where the traffic is not dense.[52] The single tracks have *passing loops*, or *passing siding / crossing loops*, to allow trains running in different directions to pass each other, or to overtake trains in the same direction (*see the picture*: 1-*main line* and 2-*passing loop*). In some places only one train operates in the single track. One of the biggest

[50] http://en.wikipedia.org/wiki/Train_station
[51] http://en.wikipedia.org/wiki/Double_track
[52] http://en.wikipedia.org/wiki/Single_track_(rail)

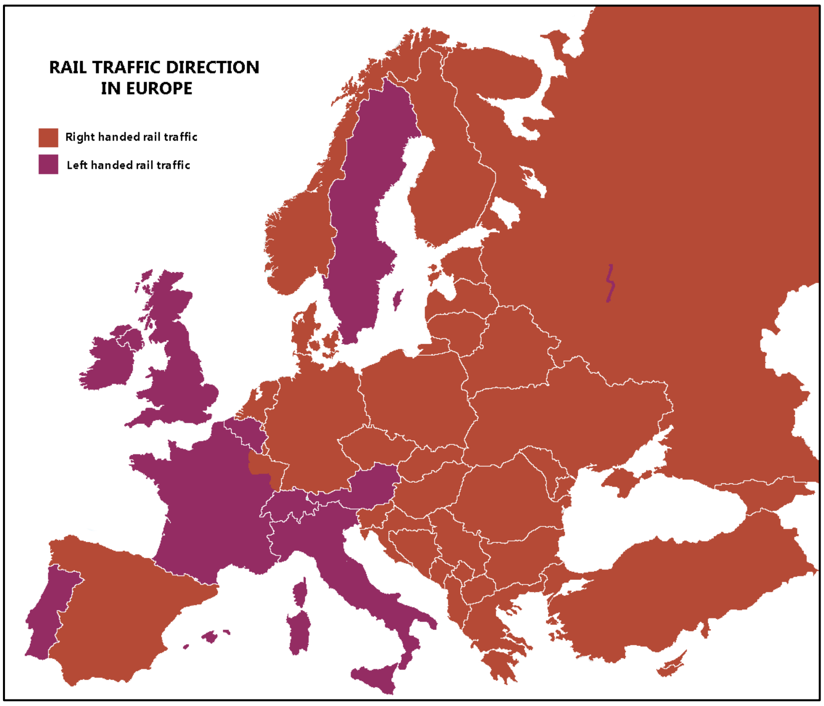
risks in the traffic on the single tracks is *head-on collisions*. A special form of signalling system is required (like a token system).[53]

In the USA, however, since early days the lines were built as single-track for reasons of cost. At the same time, a working timetable system was managed in such a way that any collision on the lines was avoided.

2.1.1.2. Track Centres

Another important measure that is used in a double-track line is *track centres*. It is the distance between the centres of each of the two tracks. It makes a difference in cost and performance of a double-track line. Narrow track centres can be as narrow and as cheap as possible, yet the maintenance must be done on the side. In this case the signals for bi-directional working cannot be placed between the tracks, so it has to be mounted on the 'wrong' side of the line or on a signal bridge. The track centres are wider on high speed trains, because of pressure waves that knock each other when the train pass. The distance between the narrow track centres might be 4 m or even less.

2.1.2. Traffic Direction



Generally speaking rail traffic on a double-track line is left-handed, as the first railways were built by British engineers, keeping the same system as it was for the road in the UK. In other words trains 'drive on the left' in the UK.[54]

Initially most steam engines were right-handed, with the engineer sitting on the right and the fireman on the left (as it is easier for the fireman to shovel coal from the right to the left) and it was never converted, even when trains switched to right-hand drive running. However, some railways adopted the left-handed traffic which became common on the UK mainline railways. Both left-and right-handed rail systems were adopted by European countries.

The countries that are using the **left-handed line** system in continental Europe are: Austria, Belgium, France (except the former German Alsace-Moselle and Lorraine), Ireland, Italy, Portugal, Sweden, Switzerland, and UK.

Countries using the **right-handed** rail traffic: Denmark, Estonia, Finland, Georgia, Germany, Greece, Hungary, Latvia, Lithuania, Netherlands, Norway, Poland, Romania, Russia, Slovakia, Spain, Serbia, Turkey, and Ukraine.

[53] http://en.wikipedia.org/wiki/Token_(railway_signalling)
[54] http://en.wikipedia.org/wiki/Right-_and_left-hand_traffic

To switch from one side to another one at the crossing point between two countries with different traffic systems, for instance, Germany-France, special infrastructure was developed. They are called *flyovers* which help the train moving on the right in Germany to switch to the left side in France and vice versa.

It is important that road traffic be consistently on the same side of the road, but since railways are highly controlled and don't always interconnect, there are many exceptions to the general rules of train operation.

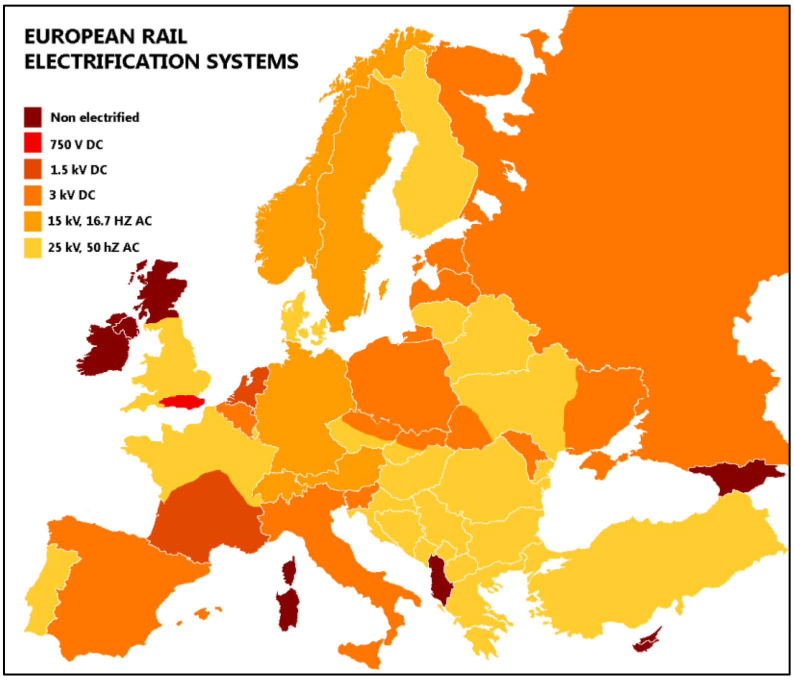
Most trains in the UK operate on the left, and the driver sits on the left, allowing a better view of trackside signals and the possibility of sticking one's head out the window without it getting knocked off by a train on the other track.

In France, trains run on the left as a legacy from the days when they were first constructed by English engineers with equipment imported from England.

In Russia, most trains run on the right, except for the line between Moscow and Ryazan, which was designed and built by British engineers. (*See the map above*).

2.1.3. Electrification System

One of the most varied specifications that is found amongst EU national railway systems is the electrification system. Almost every EU country uses its own electrification system with its own specific constraints. It is one of the most challenging barriers to making the European rail network operate as one system.[55]



Electrification systems are classified by three main parameters: *voltage*, *current* and *contact system*.

There are six commonly used voltage systems in Europe and they are independent of the contact system used. (*See the table below*).

There are also two current systems; *direct current* (DC) and *alternating current* (AC) (*see the map*). In order that trains pass easily between countries with different systems without interruption, they have two options. They either need to change the locos, but this procedure is very costly and time consuming, or another solution is that the locos are equipped with multi-system units that allow them to switch between various electrification systems without stopping the train and losing precious time.

There are three contact systems commonly used in Europe, namely: *overhead system*, *third* and *fourth rails*.

[55] http://en.wikipedia.org/wiki/Railway_electrification_system

Third and fourth rail contact systems use voltage below 1 kV for safety reasons, while overhead wires usually use high voltage for efficiency. DC has often less loss of power than AC. DC avoids the electromagnetic radiation inherent with AC, which can interfere with signalisation and communication. It also avoids the power factor problems of AC. DC can supply constant power with a single ungrounded wire.

Electrification system	Voltage				
	Min. non-permanent	Min. permanent	Nominal	Max. permanent	Max. non-permanent
600 V DC	400 V	400 V	600 V	720 V	800 V
750 V DC	500 V	500 V	750 V	900 V	1,000 V
1,500 V DC	1,000 V	1,000 V	1,500 V	1,800 V	1,950 V
3 kV DC	2 kV	2 kV	3 kV	3.6 kV	3.9 kV
15 kV AC, 16.7 Hz	11 kV	12 kV	15 kV	17.25 kV	18 kV
25 kV AC, 50 Hz	17.5 kV	19 kV	25 kV	27.5 kV	29 kV

Constant power with AC requires three-phase transmission with at least two ungrounded wires.

Overhead systems use 1,500 V DC and are used in the Netherlands, Republic of Ireland, France (also using 25 kV 50 Hz AC). In Portugal, it is used on the Cascais Line and in Denmark on the suburban S-train system. 3 kV DC is used in Belgium, Italy, Spain, Poland, the northern Czech Republic, Slovakia, Slovenia, western Croatia, and former Soviet Union countries (also using 25 kV 50 Hz AC).[56]

Third rail is an option up to about 1,200 V. DC and can carry approximately 41% more power than an AC system operating at the same peak voltage. Third rail is more compact than overhead wires and can be used in smaller-diameter tunnels, an important factor for subway systems. DC systems (especially third rail systems) are limited to relatively low voltages and this can limit the size and speed of trains and cannot use low-level platforms and also limit the amount of air-conditioning that the trains can provide. This may be a factor favouring overhead wires and high voltage AC, even for urban usage. Fourth rail contact system was introduced because of the problems of return currents, intended to be carried by the earthed (grounded) running rail, flowing through the iron tunnel linings instead. This can cause electrolytic damage and even arcing if the tunnel segments are not electrically bonded together.

Fourth rail is the additional rail carrying the electrical return that, on third rail and overhead networks, is provided by the running rails. On the London Underground, a top-contact third rail is beside the track, energized at +420 V DC, and a top-contact fourth rail is located centrally between the running rails at −210 V DC, which combine to provide a traction voltage of 630 V DC.

Because AC implies very high voltages, it is only used on overhead wires, never on third rails. Power is voltage times current (Watts = Volts x Amps), so the higher the voltage, the lower the current for the same power. Lower current means lower line loss and/or the ability to use lighter and less expensive conductors.

The issue of electrification of the rail networks remains one of the most challenging ones. It still needs more time and extra investments to make it function as one system.

[56] http://en.wikipedia.org/wiki/List_of_current_systems_for_electric_rail_traction

2.1.4. Gauges

Gauge means the distance between the inner running faces (gauge lines) of the two rails, on the same track. Also used to describe the “envelope” through which trains’ profiles must fit – this is the structure gauge (US-spelling gage).[57]

There are three major types of gauges that are used in rail terminology:

- **loading gauge**: maximum dimensions of the wagon;
- **track gauge** (width of track);
- **structure gauge**: constraint dimension of infrastructure (*e.g.* tunnel and bridge).

2.1.4.1. Loading Gauge

Loading gauge is the cross-section profile within which rail vehicles and their loads must be contained. It defines the maximum height and width for rail wagons and their loads to pass safely through tunnels, bridges, railway station platforms and other structures on the network.

The loading gauge is the maximum size of loaded rolling stock, whereas the structure gauge is the minimum size of infrastructure (tunnels, bridges, etc.)[58] which has to be larger to allow for engineering tolerance. The difference between both gauges is called *clearance*.

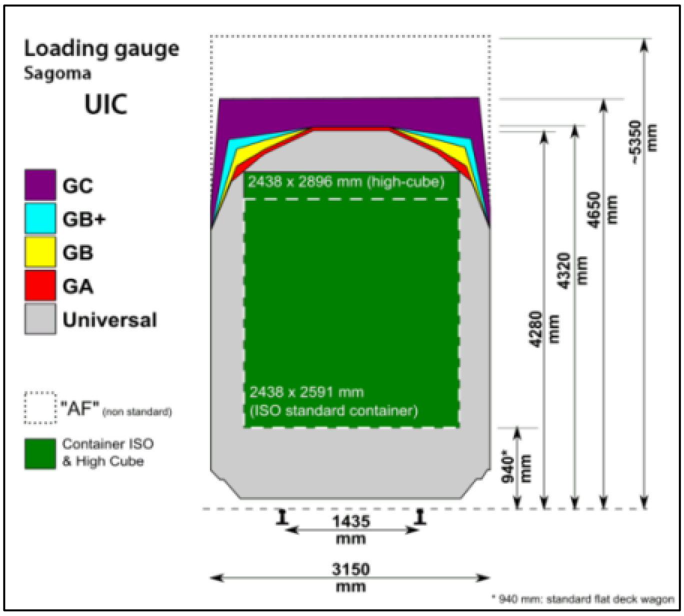
The terms *dynamic envelope* or *kinematic envelope* are used instead of loading gauge, which mean suspension travel, overhead on curves, lateral motion on track.

While carrying larger *out-of-gauge* loads, other measures are taken into account, such as operation at low speed, crossover from track with inadequate clearance to another one with greater clearance, preventing operation of other trains on adjacent tracks, using refuge loops to allow trains to operate on other tracks, using of *Schnabel cars* (*see the picture*) that manipulate the load up and down or left and right to clear obstacles, removing/replacing obstacles, using *gauntlet track* to shift the train to side or centre.

[57] http://www.railway-technical.com/Rail-Lexicon-Mk24.pdf
[58] http://myweb.tiscali.co.uk/gansg/2-track/02track3.htm

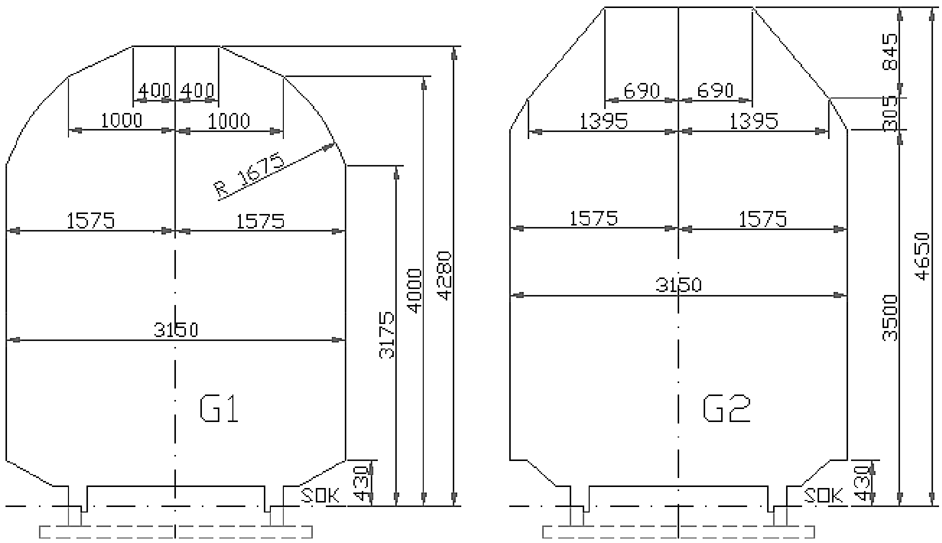
The UIC[59] has developed a standard series of loading gauges named:

- **PPI** (the predecessor of the UIC gauges with max. dims. width 3.15 by height 4.28 m)
- UIC **A** (max. dims 3.15 by 4.32 m)
- UIC **B** (max. dims. 3.15 by 4.32 m)
- UIC **B+** (max. dims. 4.28 m by 2.50 m)
- UIC **C** (max. dims. 3.15 by 4.65 m)



In Europe, the UIC directives were supplanted by ERA Technical Specifications for Interoperability (TSI) of the European Union in 2002. It embraced a number of recommendations to harmonise the train system[60]. The TSI Rolling Stock (2002/735/EC) has taken over the UIC Gauges definitions defining Kinematic Gauges with a reference profile such that Gauges **GA** and **GB,** both having a height of 4.35 m (they differ in shape) with Gauge **GC** rising to 4.70 m allowing for a width of 3.08 m of the flat roof. All wagons must fall within an envelope of 3.15 m wide on a 250 m radius curve. The TGVs, which are 2.9 m wide, fall within this limit.

All covered wagons featuring the **G1** (3.15 m by 4.28 m) profile (international profile) can be used freely throughout Europe. Large-volume wagons featuring the **G2** (3.15 by 4.65 m) profile do not have a permit for being used in France, Italy, Belgium and Switzerland and so they cannot be deployed there.



The designation of a **GB+** loading gauge refers to the plan to create a pan-European freight network for ISO containers and trailers with loaded ISO containers.

These container trains (*piggy-back trains*) fit into the B envelope with a flat top so that only minor changes are required for the widespread structures built to loading gauge B in continental Europe.

There are **GA**, **GB**, **GB1**, **GB2**, **GB+**, **GC** and **G13**.

[59] UIC is the International Union of Railways. It includes 197 members across all 5 continents. It promotes rail transport at world level and addresses the challenges of mobility and sustainable development. See: www.uic.org

[60] http://www.era.europa.eu/Document-Register/Pages/HS-RST-TSI-repealed.aspx

Sweden uses a similar gauge to the Central European loading gauge but trains are wider. There are three main classes in use (width × height):[61]

- Class **SE-A** is 3.40 by 4.65 m.
- Class **SE-B** is 3.40 by 4.30 m.
- Class **SE-C** is 3.60 by 4.83 m.

In **UK** a W loading gauge classification of freight transport is used, which runs from W6A (smallest) through W7, W8, W9, W9Plus, W10, W11 to W12 (largest). There are also C1 for standard coach stock, C3 for longer MkIII coaching stock and UK1 for high-speed rail.

Depending on the size of the load that can be conveyed and the design of the rolling stock, the British system for load gauge distinguish several types:

- **W6a** (the majority of the British rail network)
- **W8** (2.6 m high shipping containers to be carried on standard wagons)
- **W9** (2.9 m high Hi-Cube shipping containers to be carried on "Megafret" wagons which have lower deck height with reduced capacity. At 2.6 m wide it allows for 2.5 m wide Euro shipping containers which are designed to carry Euro-pallets efficiently)
- **W10** (2.9 m high Hi-Cube shipping containers to be carried on standard wagons and also allows 2.5 m wide Euro shipping containers. Larger than UIC A)
- **W11** (larger than UIC B)
- **W12** (slightly wider than W10 at 2.6 m to accommodate refrigerated containers. Recommended clearance for new structures, such as bridges and tunnels)
- **UIC GC** (Channel Tunnel and Channel Tunnel Rail Link to London; with proposals to enable GB+ northwards from London via an upgraded Midland Main Line).

Height and width of containers that can be carried on GB gauges:

- **W9** (2.74 m by 2.6 m)
- **W10** (2.90 m by 2.5 m)
- **W11** (2.90 m by 2.55 m)
- **W12** (2.90 m by 2.6 m)

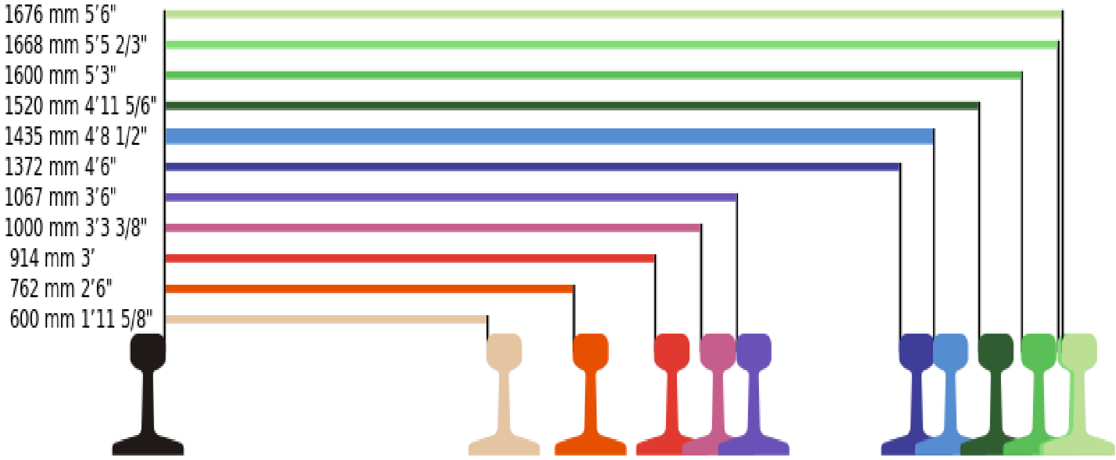
British Rail code	Rail track code	UIC height equivalent	Height above rail	Width
W6	W6		3320	2700
W6A (Freightliner 8')	W7		3448	2500
W6A (Freightliner 8' 6")	W8		3600	2500
SB1c	W9		3715	2600
n/a	W10	> UIC "A"	3896	2500
n/a	W10w	> UIC "A"	3896	2600
n/a	W11	> UIC "B"	4130	2500
n/a	W11w	> UIC "B"	4130	2600

[61] http://www.transportstyrelsen.se/Global/Jarnvag/Vagledning/Godkannande/bilaga_7_bvf_586_20.pdf

In the **Netherlands** a similar shape to the UIC C is used that rises to 4.70 m in height. The trains are wider allowing for 3.40 m width, similar to Sweden. About one third of the Dutch passenger trains use double-decker railcars.

2.1.4.2. Track Gauge

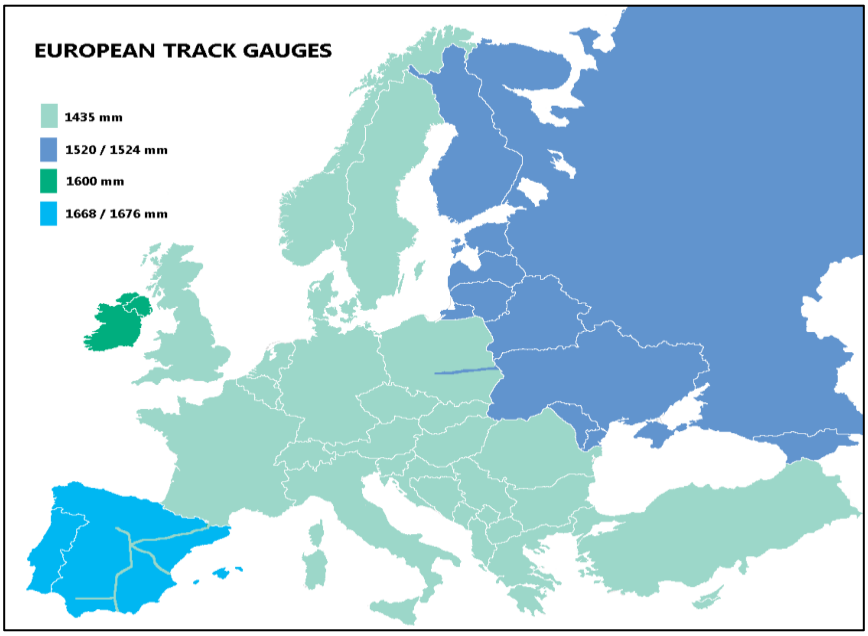
The 'track gauge' is the distance between the inner running faces (gauge lines) of the two rails, on the same track.[62]



There are different rail track widths between the lines.
They are divided into three main groups:

- **Broad**
- **Standard**
- **Narrow**.

All three types are present in Europe.



Broad: Iberian – 1.668m (Spain and Portugal); Irish (including Northern Ireland) – 1.6m; Russian – 1.524m (Finland) and 1.52m (Russian Federation and post-Soviet Countries)

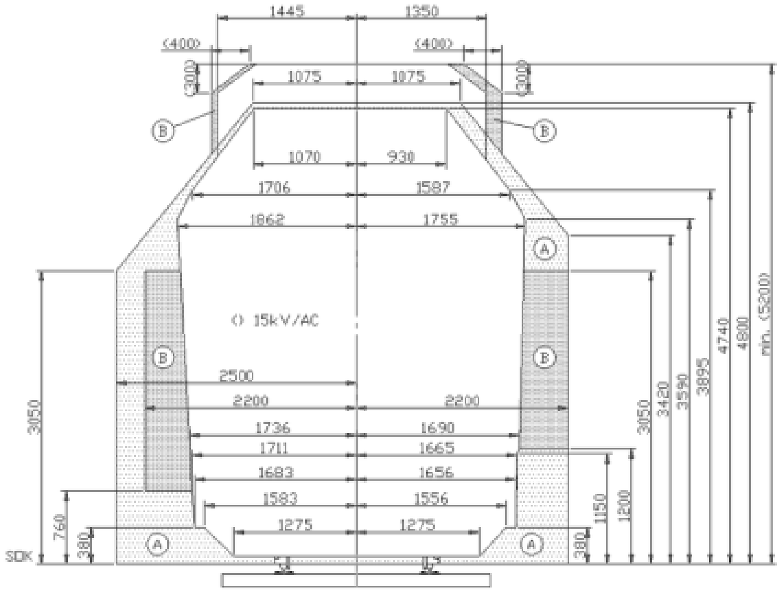
Standard: 1.435m (most of EU countries including UK)

Narrow: Scottish – 1.372m.

[62] http://www.railway-technical.com/Rail-Lexicon-Mk24.pdf

2.1.4.3. Structure Gauge

Structure gauge or as it is also called the ***minimum clearance outline*** describes the cross-section envelope into which new or altered structure (bridge, inside equipment etc.) must not encroach.



It is the minimum height and width of tunnels and bridges as well as the minimum height and width of doors that allow a rail siding access into a warehouse.

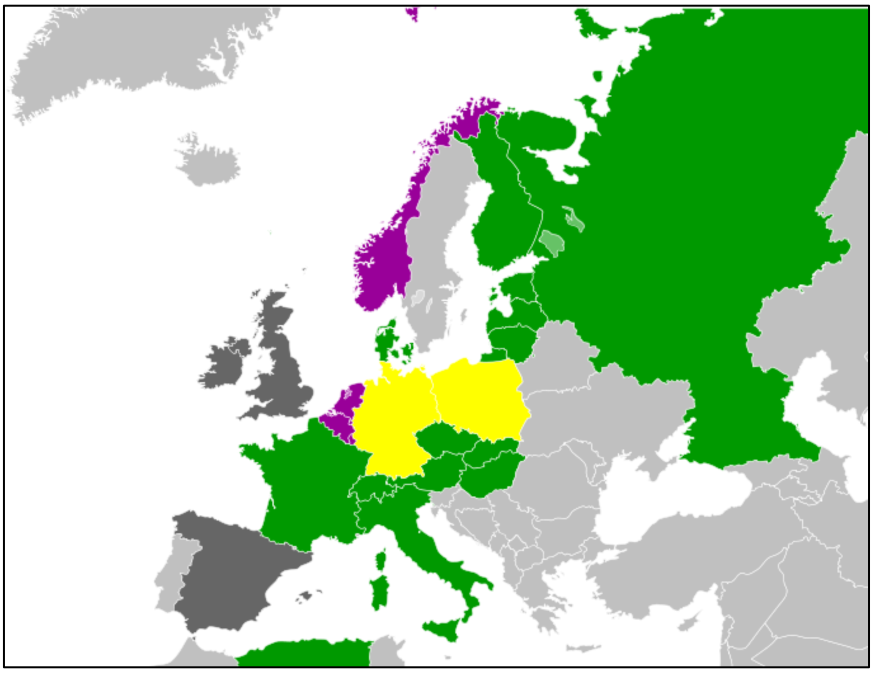
This term may also apply to the minimum distance to rail platforms (passenger or freight), buildings, electrical equipment boxes, railway signal equipment, third rail or to support for overhead catenaries or overhead lines from track.

Oversized load permissions can be requested from rail networks in case of transport of cars above the normal gauge limit, depending on the route used.

2.1.5. Additional Parameter

2.1.5.1. Platform Height

The height of platform is another important parameter which is taken into consideration together with the loading gauge. Platform height refers to the height of a railway platform Above Top of Rail (ATR).



Another important term is '*train floor height*,' which indicates the height of the floor of the rail vehicle. When the two are not compatible then steps or platform ramps are required to be placed for loading-unloading.

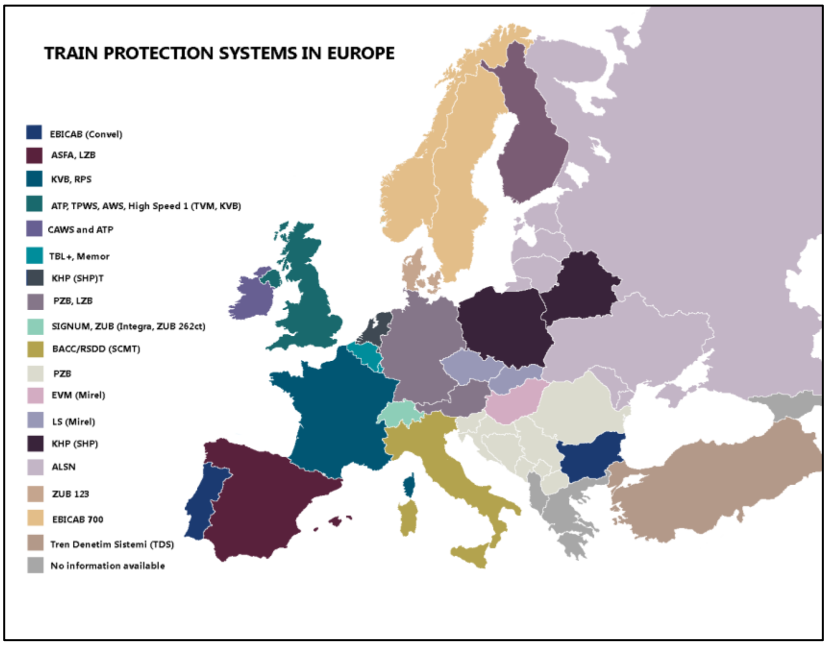
The width of a wagon is also an important dimension. To avoid both large gaps and mechanical interference this parameter has to be considered as well. (Platform height impacts both the loading gauge and must be within structure gauge. Many train systems employ a lower platform and steps on the train to the train's floor).

Application of the EU standard heights for new construction; Green = 550 mm, Pink = 760 mm, Yellow = both, dark grey = New builds in other heights than the EU standards.

On 30th May 2002 (2002/735/EC)[63] the European Commission issued TSI (Technical Specification for Interoperability) which sets standard platform heights for passenger steps on high-speed rail. They are 550 mm and 760 mm. The minimum platform length shall be 400 m. In Germany EBO standard (Ordinance on the Construction and Operation of Railways) set an allowable range of 380 mm to a maximum 960 mm. In Ireland all platforms are 915 mm above the rail. In the Netherlands the platform height is 760 mm. In Poland a typical platform is 550 mm high, as it is in France, Denmark, Austria, Switzerland and Czech Republic. In Spain older platforms are 680 mm above rail. Sweden generally has 380 to 580 mm platforms for mainline trains, yet it also has 1150 mm platform height with floor at platform level. In the UK the standard height is 915 mm, yet new platforms are expected to be built to dimensions conforming to EU technical standards for interoperability for high-speed rail (EU Directive 96/48/EC),[64] which is either 550 mm or 760 mm.

2.1.5.2. Train Protection Systems

Another complex issue in the European rail network is the train protection system, which is a railway technical installation that ensures safe operation by preventing accidents due to a human failure. There are more than 20 incompatible train protection systems existing in the European rail network today, which include:[65]



Train stop

The earliest system was the 'train stop' system. Beside every signal is a moveable clamp, which touches a valve on a passing train if the signal is red and opens the brake line, applying the emergency brake. If the signal shows green, the clamp is turned away.

Inductive system

The system data is transmitted magnetically between the track and locomotive by magnets mounted beside the rails and on the locomotive. In the *Integra-Signum* system the trains are influenced only at given locations, the emergency brakes are applied and the locomotive's motors are shut down. They often require the driver to confirm distant signals (e.g. CAWS, *see the table after this section*) that show stop or caution – failure to do so results in the train stopping. This gives sufficient braking distance for trains following each other, however

[63] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:245:0402:0506:EN:PDF
[64] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0048:en:HTML
[65] http://en.wikipedia.org/wiki/Train_protection_system

it cannot always prevent accidents in stations where trains cross paths, because the distance from the red signal to the next obstacle may be too short for the train to brake to a halt.

There are more advanced systems (e.g. PZB, and ZUB) that calculate a braking curve that determines if the train can stop before the next red signal, and if not they brake the train. They require that the train driver enter the weight and the type of brakes into the on-board computer. One disadvantage of this kind of system is that the train cannot speed up before the signal if the signal has switched to green, because the on-board computer's information can only be updated at the next magnet. To overcome that problem, some systems allow additional magnets to be placed between distant and home signals, or data transfer from the signalling system to the on-board computer is continuous (e.g. LZB).

Radio-based system

Prior to a standard train protection system in Europe being developed, there were many incompatible systems. Locomotives crossing the boarders needed to be equipped with multiple systems, or the locomotive needed to be replaced. The European Train Control System standard was developed which offered different levels of functionality. This has been in operation since 2002 and uses GSM digital radio with continuous connectivity.

Cab signalling

The system is based on the principle that the trains constantly receive information regarding their position relative to the other trains. An on board computer indicates how fast the train can move, instead of relying on exterior signals. This system is commonly used in France and Germany. These systems are automatic, they not only prevent accidents, but also support the train driver with necessary information.

Control systems used by EU countries:

System	Definition	Country
ALSN	It is Continuous Automatic Train Signalling (АЛСН - автоматическая локомотивная сигнализация непрерывного действия) used widely on the main lines of the ex-Soviet states. It uses modulated pulses inducted into rails similar to the Italian RS4 Codici and American Pulse Code Cab Signaling. On high-speed lines the variant ALS-EN (АЛС-ЕН) is used which takes advantage of a double phase difference modulation carrier frequency. Use of several distinct pulse train patterns of alternating current flowing through a track circuit to convey an aspect of the next signal. The circuit comprises the feedpoint at the next signal, one running rail, first locomotive axle, another running rail and back to the signal feedpoint. The resulting electromagnetic field is picked up by receiver coils located just front of the first axle of the locomotive. The signal is then amplified, filtered and evaluated.[66]	Russian Federation, Belarus, Estonia, Latvia, Lithuania, Ukraine
ASFA	Anuncio de Señales y Frenado Automático (Automatic Braking and Announcement of Signals) is an Automatic Warning System. It consists of a mechanism that stops a train if the driver does not properly heed signals.[67]	Spain

[66] http://en.wikipedia.org/wiki/ALSN
[67] http://en.wikipedia.org/wiki/Anuncio_de_Se%C3%B1ales_y_Frenado_Autom%C3%A1tico

ATB	Automatische TreinBeïnvloeding or ATB is a Dutch train protection system developed in the 1950s. Its installation was spurred by the Harmelen train disaster of 1962.[68]	Netherlands
ATC	Automatic Train Control is the term for a general class of train protection systems for railways that involves some sort of speed control mechanism in response to external inputs. ATC systems tend to integrate various cab signalling technologies and use more gradual deceleration patterns in lieu of the rigid stops encountered with the older Automatic Train Stop technology. ATC can also be used with Automatic train operation (ATO) and is usually considered to be the safety-critical part of the system.[69]	Sweden, Denmark, Norway
ATP	Automatic train protection refers to either of two implementations of a train protection system installed in some trains in order to help prevent collisions through a driver's failure to observe a signal or speed restriction. ATP can also refer to automatic train protection systems in general, as implemented in other parts of Europe and elsewhere.[70]	UK and Ireland
AWS	The Automatic Warning System is a form of limited cab signalling and train protection system introduced in 1956 in the UK to help train drivers observe and obey signals. It was based on a 1930 system developed by Alfred Ernest Hudd and marketed as the "Strowger-Hudd" system. An earlier contact system, installed on the Great Western Railway since 1906 and known as Automatic Train Control (ATC), was gradually supplanted by AWS within the Western Region of British Railways.[71]	UK
BACC	It is a train protection system used in Italy on railway lines using 3kV DC electrification. The term is an abbreviation of *Blocco automatico a correnti codificate* (automatic block system with codified currents).[72]	Italy
CAWS	The Continuous Automatic Warning System is a form of cab signalling and train protection system used in Ireland to help train drivers observe and obey lineside signals.[73]	Ireland
CBTC	Communications-Based Train Control is a railway signalling system that makes use of the telecommunications between the train and track equipment for the traffic management and infrastructure control. By means of the CBTC systems, the exact position of a train is known more accurately than with the traditional signalling systems. This results in a more efficient and safe way to manage the railway traffic.	Spain
CONVEL	EBICAB comes in two versions, EBICAB 700 in Sweden, Norway, Portugal and Bulgaria and EBICAB 900 installed in the Mediterranean Corridor (vmax= 220 km/h). The EBICAB 900 is also used in Finland under the name ATP-VR/RHK. In Portugal it is known as Convel (the contraction of *Controlo de Velocidade*, meaning Speed Control).[74]	Portugal
Crocodile/Memor	A crocodile is a component of a train protection system used in France, Belgium and Luxembourg. It is functionally similar to the Automatic Warning System (AWS) used in United Kingdom.	Belgium, France and Luxemburg

[68] http://en.wikipedia.org/wiki/Automatische_treinbe%C3%AFnvloeding
[69] http://en.wikipedia.org/wiki/Automatic_Train_Control
[70] http://en.wikipedia.org/wiki/Automatic_Train_Protection
[71] http://en.wikipedia.org/wiki/Automatic_Warning_System
[72] http://en.wikipedia.org/wiki/Blocco_Automatico_a_Correnti_Codificate
[73] http://en.wikipedia.org/wiki/Continuous_Automatic_Warning_System
[74] http://en.wikipedia.org/wiki/CONVEL

EBICAB	EBICAB is a trade mark registered by Bombardier for the equipment on board a train used as a part of an Automatic Train Control system. EBICAB was originally derived from Ericsson's SLR system in Sweden. Most trains in Sweden and Norway use a similar on-board system, Ansaldo L10000 (more known as ATC-2) from Bombardiers competitor Ansaldo. ATC-2 was also developed in Sweden. These on-board systems use pairs of balises mounted on the sleepers. The pairs of balises distinguish signals in one direction from the other direction with semicontinuous speed supervision, using a wayside to train punctual transmission using wayside transponders.[75]	Bulgaria, Finland, Norway, Portugal, Spain, Sweden
EVM 120	*Information is not available*	Hungary
HKT	*Information is not available*	Denmark
Integra-Signum	Integra-Signum is a Swiss train protection system introduced in 1933. Originally it was called Signum; the name Integra was added later. It transmits data inductively and is simple, robust and reliable even in snow.[76]	Switzerland
KVB	KVB or Contrôle de Vitesse par Balises (it could be translated as Speed control by beacons) is a train protection system used in France and in London St Pancras station. It checks and controls the speed of moving trains.[77]	France
LZB	Linienzugbeeinflussung is a cab signalling and train protection system used on selected German and Austrian railway lines as well as the AVE in Spain. In Germany, the system is mandatory on all lines where trains exceed speeds of 160 km/h (99 mph) (200 km/h or 120 mph in Spain), but it is used on some slower lines to increase capacity. The German Linienzugbeeinflussung translates to continuous train control, literally: linear train influencing. It is also called linienförmige Zugbeeinflussung.[78]	Germany, Austria and Spain
LS	LS (stands for “Liniový Systém” in Czech, “continuous system” in English) is a cab signalling and a train protection system used on the main lines of the Czech and Slovak railways (on all lines which track speed exceeds 100 km/h in the Czech republic or 120 km/h in Slovakia). This system continuously transmits and shows a signal aspect of the next main signal in driver’s cabin and when the driver’s activity is needed (e.g. reduction of train’s speed), it periodically checks the driver’s vigilance (he has to press the “vigilance” button; else the emergency brake is applied). This is the main function of the on-board part of the LS-system (continuous cab signalling and checking the driver’s vigilance when needed).[79]	Czech republic and Slovakia
PZB Indusi	PZB or Indusi is an intermittent cab signalling system and train protection system which was developed in Germany and the historic short name Indusi was derived from German Induktive Zugsicherung (“inductive train protection”). Later generations of the system were named PZB short for German Punktförmige Zugbeeinflussung (“intermittent automatic train running control”) as PZB/Indusi is a family of intermittent train control systems and it is a predecessor of the German Linienzugbeeinflussung (LZB, “continuous train protection”) system. Originally Indusi provided warnings and enforced braking only if the warning was not acknowledged (similar	Germany, Austria, Romania, Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Montenegro,

[75] http://en.wikipedia.org/wiki/EBICAB
[76] http://en.wikipedia.org/wiki/Integra-Signum
[77] http://en.wikipedia.org/wiki/KVB
[78] http://en.wikipedia.org/wiki/LZB
[79] http://en.wikipedia.org/wiki/LS_90

	to traditional automatic train stop) but current developments of PZB provide more enforcement.[80]	and Macedonia
SHP	SHP (Samoczynne Hamowanie Pociągu)	Poland
SCMT	Sistema di Controllo della Marcia del Treno (SCMT) is a discontinuous train Cab signalling system used in Italy. It shares many features with the Ripetizione Segnali (RS) system, the two systems co-existing and working together. The main purpose of SCMT is to control the respect of the speed limit imposed by the signal aspect and the line condition. SCMT is divided in two parts: SSB: Sottosistema di bordo ("Onboard Subsystem") SST: Sottosistema di terra ("Ground Subsystem")[81]	Italy
TBL	Transmission balise-locomotive (Dutch: Transmissie Baken Locomotief) (TBL) (English "Transmission Beacon Locomotive") is a train protection system.[82] There are TBL1, TBL2+ and TBL2/3. The TBL system is designed to stop a train passing a red signal, with operating speeds of up to 160 km/h. In 2006 13% of the Belgium train network used the original TBL system, introduced in 1982. The system requires the train driver to manually acknowledge a warning when passing a double yellow signal (similar to the Memor/Le Crocodile system), as well as stopping a train automatically if it passes a red signal.	Belgium
TPWS	The Train Protection & Warning System (TPWS) is a train protection system throughout the two UK passenger main-line railway networks, and in Victoria, Australia. It automatically activates brakes on a train that has passed a signal at danger or is overspeeding. It is fitted at selected sites, including some lines where automatic train protection (ATP) is installed.	UK
TVM	Transmission Voie-Machine (TVM, English: track-to-train transmission) is a form of in-cab signalling originally deployed in France and used on high-speed railway lines. TVM-300 was the first version, followed by TVM-430. TVM-300 was developed in the 1970s as part of the TGV project. At speeds of above 220 kilometres per hour, TGV trains run only on dedicated tracks designated as lignes à grande vitesse (LGV). At high-speeds it is not possible for a driver to accurately see colour-light based railway signals along the track-side. Signalling information is instead transmitted to the train and displayed as part of the train controls. The driver is shown the safe operating speed, displayed in kilometres per hour. The 1980s-developed TVM-430 system transmits more information than traditional signalling would allow, including gradient profiles and information about the state of signalling blocks further ahead. This high degree of automation does not remove the train from driver control, although there are safeguards that can safely bring the train to a stop in the event of driver error.	France
ZUB 123	*Information is not available*	Denmark
ZUB 262	*Information is not available*	Switzerland

The various rail technical specifications that exist in Europe seriously hinder the movement of trains. Only the traffic direction, electrification systems, various types of gauges, or train protection systems constitute

[80] http://en.wikipedia.org/wiki/PZB
[81] http://en.wikipedia.org/wiki/SCMT
[82] http://en.wikipedia.org/wiki/Transmission_Beacon-Locomotive

obstacles, but also different local and national regulations hamper movement between the EU Member States. Therefore, the European rail network with its numerous technical specifications represents one big mechanism which needs more work towards synchronisation, not only on the level of regulations but also from the side of technical adjustments in order that it may eventually function in a consolidated way.

3. Rail Network and its Liberalisation

3.1. Brief history of Rail Liberalisation in Europe

In the 1980s many railway companies became gradually dependent on public funding. European national governments felt a pressure to introduce reforms in the national railway networks that were heavily subsidised.

As Vinh Phan says in his thesis on 'The Liberalisation of Rail Transport in the European Union' the first changes in terms of national rail transport liberalisation took place in **Sweden**.[83] It started with the adoption of the Transport Policy Act in 1988. The Swedish government established Banvekert as national infrastructure manager. SJ AB became a service operator, paying infrastructure usage fees to Banvekert. Local transport authorities took over SJ AB's ownership of regional routes so that they were able to offer competitive tendering on these routes. These changes brought a lower level of public subsidies and a price reduction in the operations of regional lines.

This separation between infrastructure management and service operations in Sweden and the increase of competition in other Member States provided the regulatory framework for an EU reform aiming at liberalisation of national railway networks in Europe.

The Swedish model of liberalisation of railways in which the ownership of infrastructure management is separated from network services is also found in the national railways of Bulgaria, Denmark, Spain, Finland, Greece, the Netherlands, Norway, Portugal, Romania, Slovakia and the UK.

There is **another scheme of liberalisation which features a legal and functional separation of infrastructure and services, where both parts exist under one umbrella**.[84] This model is found in such EU countries as Austria, Belgium, Switzerland, Denmark, Germany, Estonia, Hungary, Ireland, Italy, Latvia, Luxembourg, Lithuania, Poland and Slovenia.

The **third model, which is a combination of the other two, is called a 'hybrid' one** and exists in France and the Czech Republic. Here an independent infrastructure manager delegates its tasks back to the incumbent train service operator as part of an agency agreement.

The separation between infrastructure management and service operations, and the increase of competition in other Member States provided the regulatory framework for an EU reform aiming at the liberalisation of national railway networks in Europe. Several EU directives were issued by the European Commission to pave the way for the liberalisation of the whole EU railway network. This process is still ongoing as the European Commission proposed, in January 2013, a Fourth Railway Package.[85]

The EU Directive 1991/405[86] set out the framework and requirements for railways in the EU. It permits open access operations on railway lines by companies other than those who own the rail infrastructure. It was further supplemented by directives that included cross border transit of freight. The European Commission is

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[83] Pham, Vinh, *The Liberalization of Rail Transport in the European Union. An Honors Thesis to the Economics Department of Connecticut College in partial fulfillment of the requirements for Honors in the Major Field*, Now London, Connecticut, 2013, p. 1.
[84] Vinh Pham, The Liberalization of Rail Transport in the European Union, p. 33.
[85] For more detailed information on the EU Rail Packages see the ECG briefing paper on 'Finished Vehicle Logistics by Rail.'
[86] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0440

convinced that opening the rail transport market and privatising existing monopolies will promote rail networks' efficiency. Privatisation of public monopolies such us railways is aimed at generating revenues for the public sector and reducing public subsidies in the future.

It is supposed to involve a separation between infrastructure management and service operations. The European Commission requires separation of accounting systems between both levels, which is supposed to enhance competition in the sector by providing equal rail capacity allocation, fair infrastructure charging and easy licensing for new rail operators, which has to be separated from the operation of transport services in a neutral fashion to give new rail operators access to the market.[87]

Directive 1991/440/EC was complemented by three reform packages and services legislations. Directive 1995/18/EC[88] specified a universal licensing process for new railway undertakings.

Directive 1995/19/EC[89] provided the framework for fair allocation and infrastructure capacity charging for railway undertakings.

The subsequent Directives 2001/12/EC[90] (extended the original Directive 1991/440/EC, focused on breaking down the vertical bound by establishing clear requirements for the relationship between the state and the infrastructure manager, and between the infrastructure manager and service operation), 2001/13/EC[91] (additional license requirements introduced by 1995/18/EC) and 2001/14/EC[92] (discussed advancing the framework for non-discriminatory allocation and charging of infrastructure in 1995/19/EC; infrastructure access fees to be set and collected by an independent entity)[93] which are known as the First Railway Package. In September 2010 a process of merging of the Directives into one piece of legislation was started.

Thus a process of liberalisation of European railways was initiated in the 1980s to eliminate the monopoly of the national states over the railways, boost competition, and make the rail market more open for new funding and more efficient in providing its services. It is expected that liberalisation will bring long-term economic benefits for the European railways.

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[87] European Commission, Modern rail, modern Europe: towards an integrated European railway area. Directorate-General of Energy and Transport, Brussels, 2008.
http://ec.europa.eu/transport/media/publications/doc/modern_rail_en.pdf

[88] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0018:EN:HTML

[89] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0019:EN:HTML

[90] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0012:EN:HTML

[91] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:075:0026:0028:EN:PDF

[92] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0014:en:HTML

[93] Pham, Vinh, *The Liberalization of Rail Transport in the European Union. An Honors Thesis to the Economics Department of Connecticut College in partial fulfillment of the requirements for Honors in the Major Field*, Now London, Connecticut, 2013, pp. 5-6.

3.2. The networks

3.2.1. National Rail Networks

The European Rail network consists of national railways which are state-owned. These companies are responsible for national rail infrastructures.

Country	Name of the company[94]	Length of network (km)[95]
Albania	**HSH** (Hekurudha Shqiptare - Albanian Railways)	423
Austria	**ÖBB** (Österreichische Bundesbahnen - Austrian Federal Railways)	5,919
Belarus	**BCh** (Belarusian: Беларуская чыгунка, Belaruskaya chyhunka, БЧ; Russian: Белорусская железная дорога - Belarusian Railway)	5,512
Belgium	**NMBS/SNCB** (Dutch: Nationale Maatschappij der Belgische Spoorwegen, French: Société nationale des chemins de fer belges, German: Nationale Gesellschaft der Belgischen Eisenbahnen)	3,513
Bosnia-Herzegovina	**ŽFBH** (Railways of the Federation of Bosnia and Herzegovina - Željeznice Federacije Bosne i Hercegovine) and **ŽRS** (Railways of Republika Srpska - Željeznice Republike Srpske)	1,103
Bulgaria	**BDZh** (Bulgarian State Railways - Български Държавни Железници, Bălgarski Dărzhavni Zheleznitsi)	4,159
Croatia	**HŽ** (Croatian Railways - Hrvatske željeznice)	2,974
Czech Republic	**SŽDC** (Správa železniční dopravní cesty, s.o. - Railway Infrastructure Administration, state organization)	9,487
Denmark	**DSB** (Danish State Railways - Danske Statsbaner)	2,667
Estonia	**Eesti Raudtee** (Estonian Railways, national raylway company; privatized 2001, re-nationalized 2006–2007)	816
Finland	**VR** or **VR Group** (Finnish: VR-Yhtymä Oy, Swedish: VR-Group Ab)	5,919
France	**RFF** (Réseau ferré de France; French: French Rail Network)	29,640
Germany	**DB Netze** (DB Network)	41,981
Greece	**OSE** (Greek Railways Organization - Οργανισμός Σιδηροδρόμων Ελλάδας, Organismós Sidirodrómon Elládas)	2,552
Hungary	**MÁV** (Hungarian State Railways - Magyar Államvasutak)	7,942
Italy	**RFI** (Rete Ferroviaria Italiana, Italian Rail Network)	24,179
Latvia	**LDz** (Latvian Railway - Latvijas dzelzceļš - infrastructure manager)	2,269
Lithuania	**LG** (Lithuanian Railways - Lietuvos geležinkeliai)	1,766
Luxembourg	**CFL** (Luxembourg Railways - Chemins de Fer Luxembourgeois)	274
Moldova	**CFM** (Moldovan Railway - Calea Ferată din Moldova)	1,156
Netherlands	**NS** (Dutch Railways - Nederlandse Spoorwegen)	2,896
Norway	**NSB** (Norges Statsbaner AS - Norwegian State Railways)	4,114
Poland	**PKP** (Polish State Railways - Polskie Koleje Państwowe SA)	19,627
Portugal	**CP** (Portuguese Railways - Caminhos de ferro portugueses)	2,794
Romania	**CFR** (Căile Ferate Române - State Railway Company)	22,298
Russian Federation	**RZhD** (Russian Railways - Российские железные дороги, Rossiskiye Zheleznye Dorogi)	128,000
Serbia	**ŽS** (Serbian Railways - Železnice Srbije	3,809
Slovakia	**ŽSR** (Železnice Slovenskej Republiky - The Railways of the Slovak Republic)	3,658
Slovenia	**SŽ** (Slovenian Railways - Slovenske železnice)	1,228

94 http://en.wikipedia.org/wiki/List_of_railway_companies
95 http://en.wikipedia.org/wiki/List_of_countries_by_rail_transport_network_size

Spain	**Adif** (Railway Infrastructure Manager - Administrador de Infraestructura Ferroviaria)	15,947
Sweden	**SJ** (Statens Järnvägar - Swedish State Railways)	12,821
Switzerland	**SBB/CFF/FFS** Swiss Federal Railways (German: Schweizerische Bundesbahnen, French: Chemins de fer fédéraux suisses, Italian: Ferrovie federali svizzere)	5,232
Turkey	**TCDD** (Turkiye Cumhuriyeti Devlet Demiryolları - Turkish State Railways)	12,000
Ukraine	**UZ** (Ukrainian Railway - Укрзалізниця, Ukrzaliznytsya)	22,300
UK	**Network Rail**	17,732

3.2.2. Rail Infrastructure

The fundamental part of the railway infrastructure is the ***track*** which distinguishes railway from other forms of land transport and provides a fixed guidance system. It represents the steering base for the train. The modern railway is based on a steel wheel running on a steel rail.

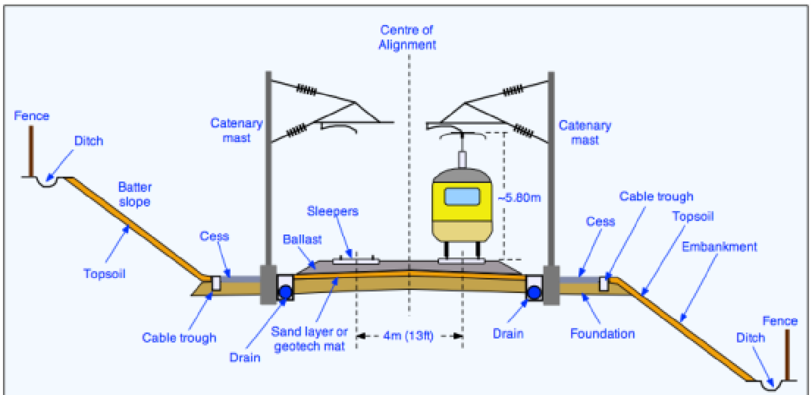
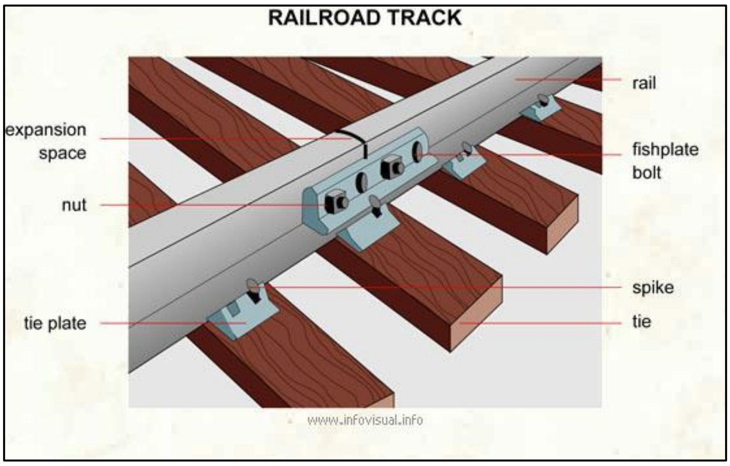


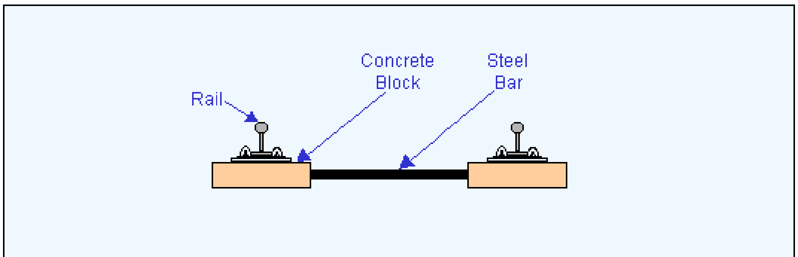
Diagram showing cross section of double track railway alignment including an overhead power supply system

The track is the main part of the ***railway route***, and it is supported by a ***sub-structure***, which ensures a safe and comfortable ride of the train and its freight.



The total width across a two-track line is about 15 m for a modern design. The ***cess*** on each side of the alignment is the area available for a walkway or refuge for staff working on the track.[96]

This part of the track consists of three main elements: the ***formation***, the ***sub-ballast*** and the ***ballast***. The formation is the ground upon which the track will be laid. The formation under the track has a ***camber*** rather like that seen on roads. The track itself is supported on ***ballast***, made up of stone (basalt), below which is a layer of sand, which separates it from the formation. ***Catenary masts*** are located outside the ***drains*** and, beyond them, there is a ***walkway area***. Next to it there is a ***cable trough***. Ballast is used to



Twin block track form using a sleeper with two cast concrete blocks held to gauge by a steel bar. The system is favoured by the French and is also known by the names Sonneville block or Stedef track. It has the advantage of being lighter than standard concrete sleepers and the four faces of the two blocks resist movement better.

[96] http://www.railway-technical.com/track.shtml

provide support, load transfer and drainage to the track and it keeps water away from the rails and sleepers. It also supports the weight of the track and considerable cycling loading of passing trains. Individual loads on rails can be as high as 50 tonnes and around 80 short tonnes on a heavy haul freight line.

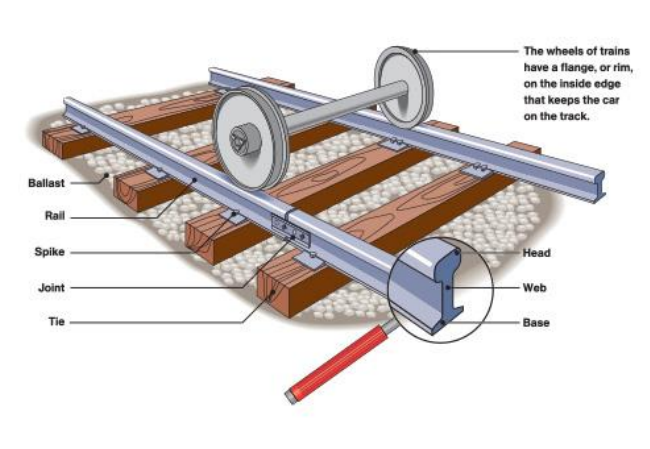
The track consists of the two ***steel rails***, secured on ***sleepers*** so as to keep the rails the correct distance apart and capable of supporting the weight of trains. There are various types of sleepers and methods of securing the rails to them. Sleepers are normally spaced at 650 mm to 760 mm intervals.

Mixed concrete and wooden sleepers used on the Sheffield Supertram LRT system. The concrete sleepers are of the twin block type. Note that the steel bar connecting the two blocks is normally covered by the ballast. Wooden sleepers are used for the crossover because the timber is easy to cut to the required size.

Sleepers are traditionally wood impregnated with preservative (life span of 25 years). Nowadays, concrete and steel sleepers are used. Yet in some cases concrete sleepers (up to 320 kg) do not perform well under the loads of heavy haul freight trains. They are less flexible than wooden ones. The spacing of concrete sleepers is about 25% greater than wooden sleepers.

There also ***twin block sleepers*** (*see picture*). They consist of two concrete blocks joined by a steel bar. They are 30% lighter than the regular concrete sleepers, and can be easily moved manually.

The standard form of rail used around the world is the ***flat bottom rail***. It has a wide base or ***foot*** and narrower top or ***head***. In the UK ***Bullhead*** rail is used. Originally it was designed with the idea to reuse them. Bullhead rail is mounted in a specific ***chair*** made of cast iron and secured by a ***key*** wedged between the rail ***web*** and the ***chair***. The chairs are secured to the sleepers by ***coach screws***. The rail is attached to the plate by a system of clips or clamps.



Rail is welded into long lengths, which can be up to several hundred metres long. Adjustment switches are also provided to protect turnouts and at locations where a change in the rail design or size occurs. Rail tends to creep in the main direction of travel so ***rail anchors*** (***anti-creepers*** in the US) are installed at intervals along the track. They are fitted under the rail against a base plate to act as a stop against movement. Nowadays track-work uses long welded rail length, which ensures a better ride, reduces wear, reduces damage to trains and eliminates the noise associated with

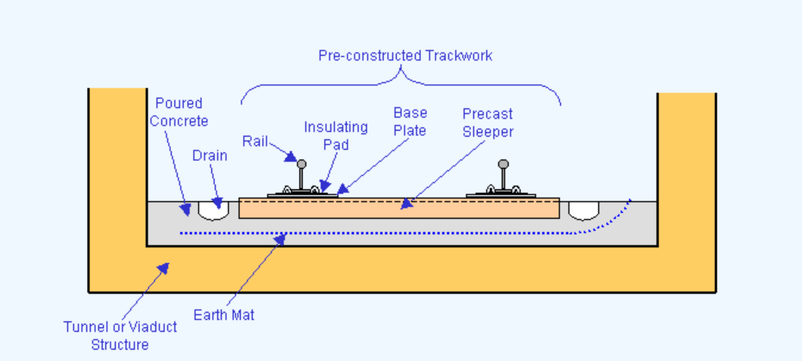


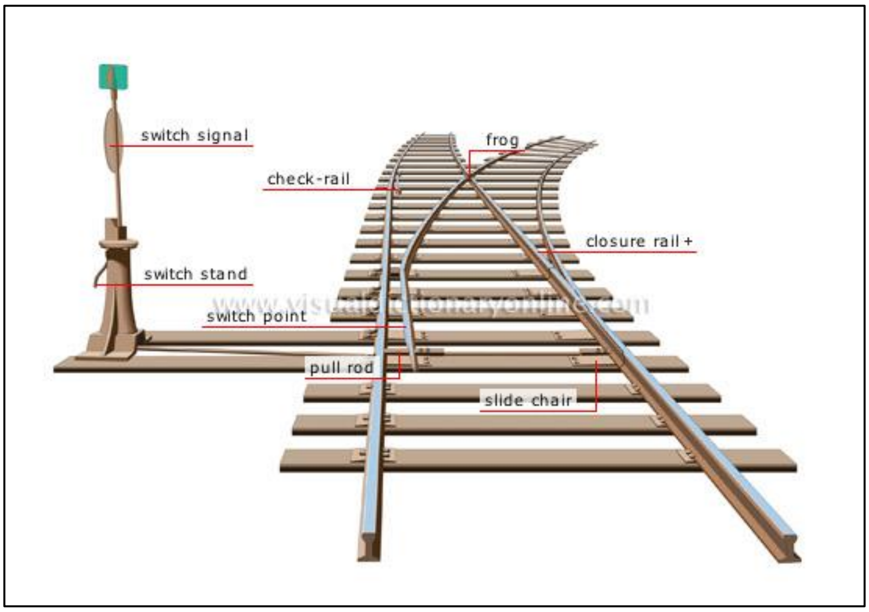
Diagram of modern slab track system, showing the pre-constructed track which is suspended in the tunnel (or viaduct structure) while concrete is poured around it. The earth mat is used to reduce stray current corrosion.

rail joints. There are two main types of welding used for rails: ***Thermit welding*** and ***Flash Butt welding***. Rails are put in concrete base, which is called ***slab track*** or ***non-ballasted*** track.

Slab track System "FF Bögl" on Nuremberg-Munich high-speed rail line

Along the line various locations are marked by a fixed post in the track or a plate on a nearby structure to indicate the correct level or position of the track. These are called ***monuments*** or ***datum plates***. Measurements are taken from these to confirm the correct position of the track.

Cant is the name used to describe the cross level angle of track on a curve, which is used to compensate for lateral forces generated by the train as it passes through the curve. The sleepers are laid at an angle so that the outer rail on the curve is higher than the inner rail. In the US, it is known as ***superelevation***. Cant is measured either in degrees or in linear dimensions. On standard gauge track (1435 mm) 150 mm of cant is equal to 6 degrees. The maximum amount of cant deficiency allowed is 110 mm.



Turnouts are referred to as ***switches*** and ***crossing work***. They describe the junctions in track-work where lines diverge or converge, known as ***points*** (UK) or ***switches*** (US). The moving part of the turnout is called the ***switch blade*** or ***point***, one for each rail. The two blades are fixed to each other by a tie bar to ensure that when one is against its stock rail, the other is fully clear and will provide room for the wheel flange to pass through cleanly. Either side of the crossing area, wing and check rails are provided to assist the guidance of the wheel-sets through the crossing.

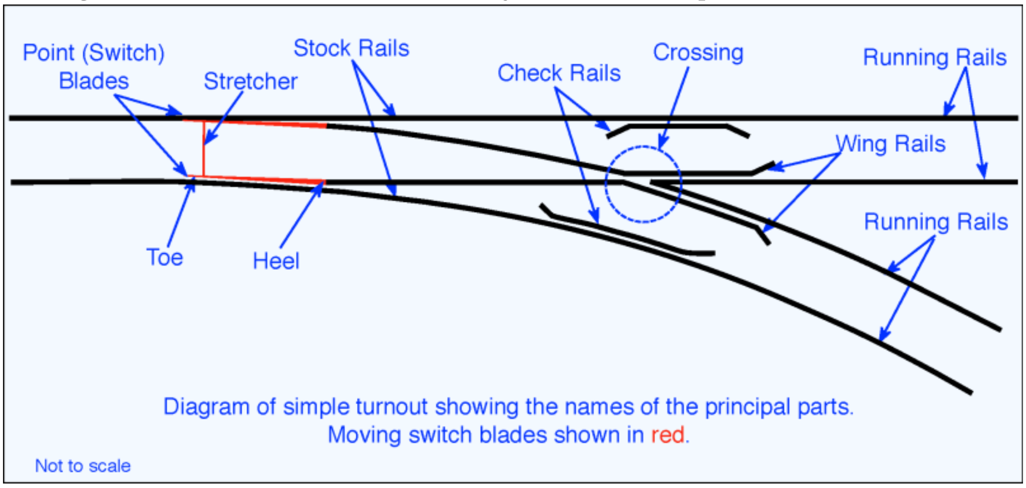
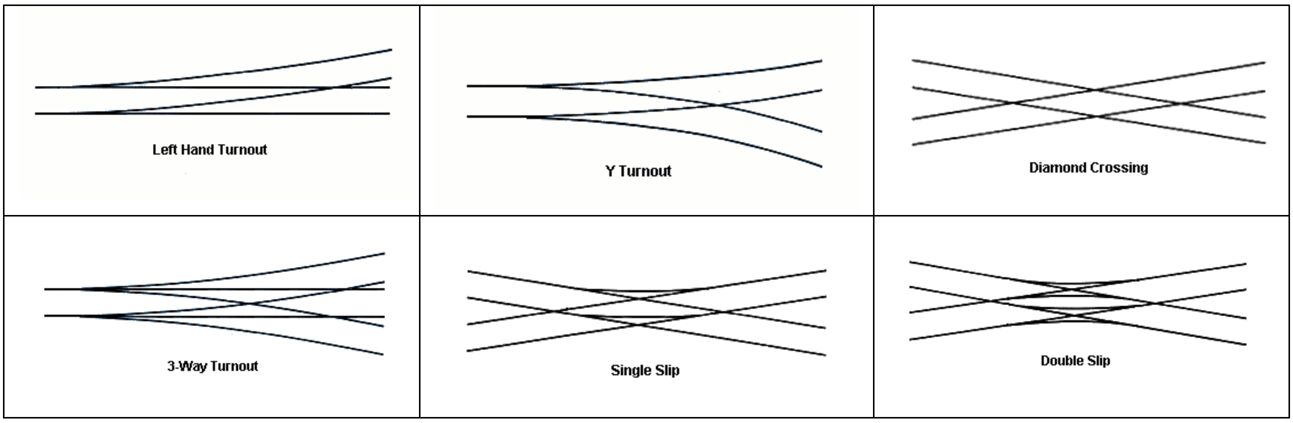


Diagram of simple turnout showing the names of the principal parts.
Moving switch blades shown in red.

A ***crossing*** can be cast or fabricated. Rails are usually made of steel with large iron content but a little manganese is added to crossings and some heavily used rails to increase resistance to wear. There are several types of turnouts:



3.2.2.1. Stations

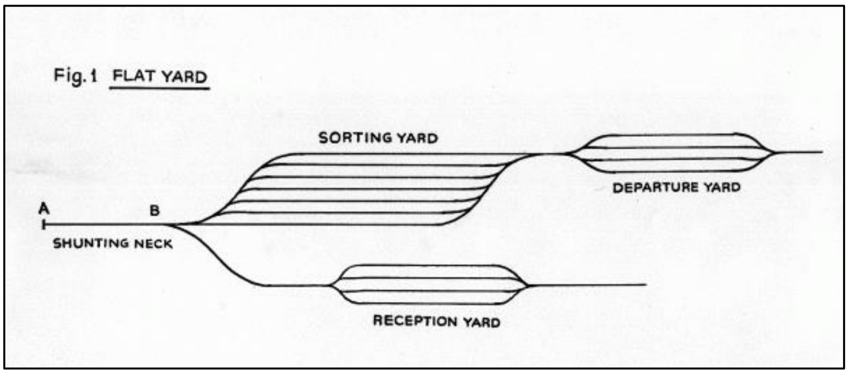
A *train station*, or a *railway station* or a *railroad station* (US)[97] or simply station, is a railway facility where trains regularly stop to load or unload passengers and/or freight. It generally consists of at least one track-side platform and a station building (depot) providing such ancillary services as ticket sales and waiting rooms. If a station is on a single-track line, it often has a passing loop to facilitate traffic movements. The smallest stations are most often referred to as 'stops' or, in some parts of the world, as 'halts' (flag stops).

3.2.2.2. Marshalling and switch yards

Marshalling or classification yards can be classified into three types, depending on the kind of shunting they employ, namely:

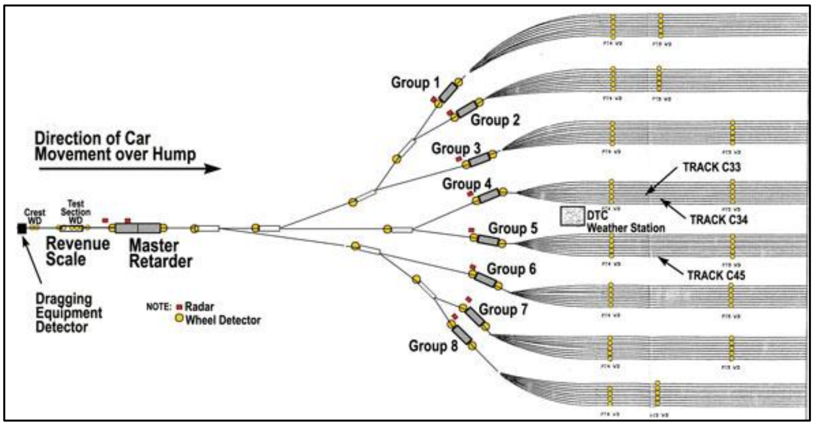
- ***Flat yards***
- ***Gravity yards***
- ***Hump yards***

Each marshalling yard consist of three main components: the *reception yard*, the *classification* or *sorting yard* and *departure yard*.



[97] http://en.wikipedia.org/wiki/Train_station

In the ***flat yard*** a train is received in the *reception yard* and the engine is sent to the *loco shed*.[98] Adjacent to the reception yard, there is the sorting yard, where each line is reserved for wagons going in a particular direction. During the process of sorting, a train is broken up and the wagons are deposited in the sorting yard on lines nominated for various destinations. To sort a train that has arrived a shunting engine attaches to the train from the left end and draws it out of the reception yard onto the shunting neck AB. The first wagons remote from the engine have to be deposited on a certain line of sorting yard. The engine pushes the train towards the sorting yard after which it draws back into the shunting neck. The 'first cut' of wagons at the front have been set rolling move into the nominated line where they are brought to rest by brake porters who run alongside the wagons pinning down the handbrakes. A second push-pull operation will deposit another set of wagons on the appropriate line in the sorting yard. The push-pull method is employed in flat yards where the whole layout is built on level ground.



In the ***gravity yard*** a gentle slope on the shunting neck falling towards the sorting lines assists wagon groups in rolling down by themselves without engine assistance. Gravity yards are considered ideal, but topographical features often do not favour such an arrangement in which case hump yard can be created. In such yards lines join up into a single line which slowly begins to ascend an artificially made 'hump' or hill. When the track has risen to a height of around 2.5 - 3m it levels off and begins to descend towards the sorting yard. The descent grade could be anywhere from 1 in 25 to 1 in 35 up to the first point of divergence which is known as the King point. Beyond this is a gentler grade (1 in 80 to 1 in 200) which eases off into a still gentler grade of 1 in 400 to 1 in 600 where the fans of lines commence. The

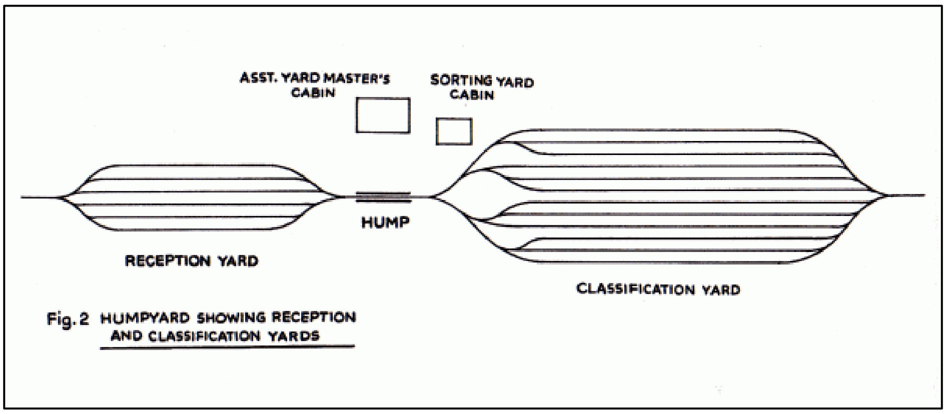


Fig. 2 HUMPYARD SHOWING RECEPTION AND CLASSIFICATION YARDS

98 http://www.irfca.org/docs/marshalling-yards.html

entire sorting yard is thus laid on a downward grade. The yard doesn't have a shunting neck as in the flat yard shown earlier. The shunting neck is not needed in this case as the reception and sorting yards are in continuation and a train can be directly pushed from the reception area onto the hump for sorting work.

The ***hump yard*** is the largest and most effective type of yard, with the largest shunting capacity.[99] The heart of these yards is the hump: a lead track on a hill (hump) over which an engine pushes the cars. Single cars, or some coupled cars in a block, are uncoupled just before or at the crest of the hump, and roll by gravity onto their destination tracks in the classification bowl (the tracks where the cars are sorted). Hump yard sorting can be quite a slow process, but it is still quicker and requires less engine movement when compared to a flat yard. The hump yard design is thus ideally suited for places which deal with a substantial number of wagons each day.

3.2.2.2.1. Single and multiple marshalling yards

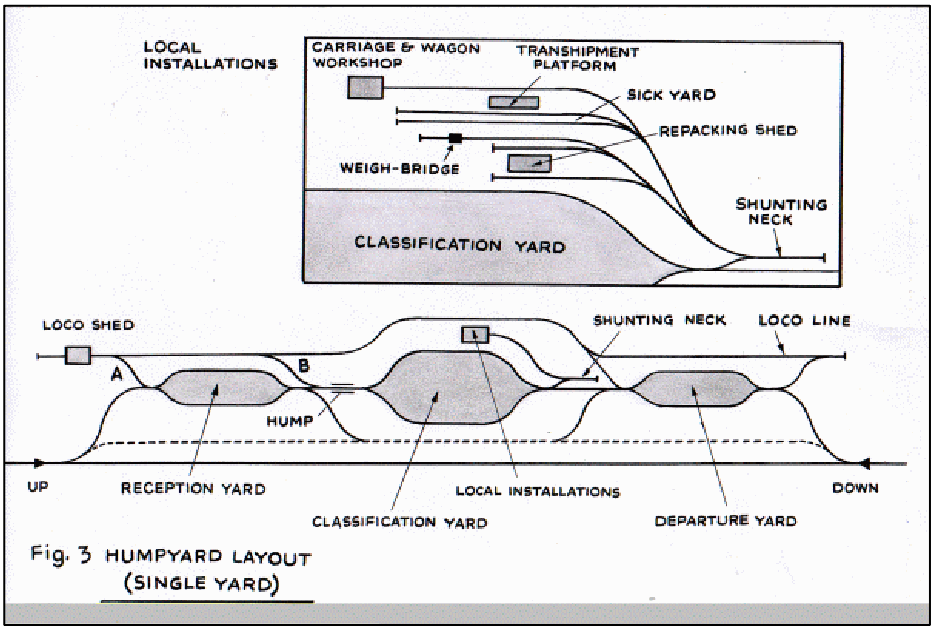


Fig. 3 HUMPYARD LAYOUT (SINGLE YARD)

There are two ways in which a marshalling yard layout can be planned. There are *single* and *multiple yards*. In a multiple yard there are two sets of reception, classification and departure yards, one for the up direction and the other for the down direction, lying side by side. From the 1930s most European countries abandoned the idea of multiple yards and changed over to the single yards. A single yard has just one set of reception, classification and departure yards which serve for both up and down directions. It requires less space to construct, and saves not only on capital cost but also on staff.


© www.f1online.de Bildnr./image no: 5631335

A single or unitary yard has reception, sorting and departure yards in series (*see diagram*). An up train arriving from the left enters the reception area where the engine detaches and returns to the loco shed using connection B. For a train arriving from the right, the entry will be via the dotted line, the engine leaving for the shed using crossover A. To the right of the sorting yard is a shunting neck which allows wagons to be drawn out of the sorting yard and

[99] "ABC's of Railroading: Terms of the trade". Trains (Waukesha, WI: Kalmbach Publishing): p 22. June 1991.

placed at 'local installations' such as the *repacking shed*, *sick yard* and *weighbridge*. The *shunting neck* is usually a short piece of track since only a few wagons have to be drawn out at a time.

The first and foremost of these local installations is the *sick yard*, the place where wagons are brought in for repairs.[100] On arrival in the reception yard, a train is first examined and wagons needing repairs are marked out. During sorting operations on the train, defective wagons are put on one or more lines in the sorting yard which are specially reserved for this purpose. Light repairs can also be carried out in the sorting yard itself, whereas wagons needing more extensive work are drawn out via the *shunting neck* and placed in the *sick yard*. As repair work in the carriage & wagon workshop may take some time, the usual procedure is to shunt these wagons to a platform known as the *transhipment platform* where the content of defective wagons on one side of the platform is transferred to another set of wagons lined up on the other side. Following transhipment of goods, the newly loaded wagons are returned to the *sorting yard* whilst those which needed repairs, now empty, are shunted away to the workshop.

At *break-of-gauge junctions* a *transhipment platform* of another kind may also be found having tracks of different gauges alongside, this facility allowing goods arriving on one gauge to be transferred to wagons of the other gauge before they can resume their onward journey to their final destination. A *weighbridge* is also illustrated, the position indicated being suitable for occasional wagons that need weighing. However, at places where each wagon entering the yard needs to be weighed, a more suitable location for the weighbridge would be somewhere on the hump itself. Wagon cuts deposited on sorting lines are generally separated by gaps of varying lengths. Once a train-load of wagons has accumulated on a line, the cuts are coupled, a guard's brake van added, and the train is shunted to the departure yard. For an up train (proceeding towards the right), an engine from the *loco shed* makes its way along the *loco line* entering the *departure yard* from the right hand end, attaches to the train, and draws out. An analogous procedure exists for a down departing train which is left as an exercise for the reader.

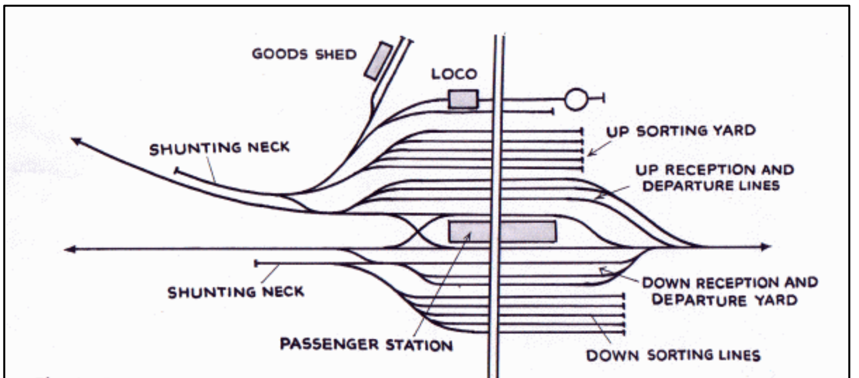


Fig. 4 FLAT YARD WITH SEPARATE UP & DN SORTING AND RECEPTION-CUM-DEPARTURE LINES

A *goods shed* is essentially a loading - unloading point: a place where consignments arriving by road transport are unloaded, booked, stored and finally loaded into railway wagons, facilities also being provided for the reverse process, namely, unloading of wagons and handing over the material to the consignee. The railway goods shed which serves this function is usually situated in the vicinity of the passenger station area. During hump-shunting, goods shed wagons (for the town in question) are collected on a line in the sorting yard, and at the appointed time, an engine picks up these wagons and proceeds towards the passenger station area, often without a brake van, to deposit them at the goods shed for unloading. Then picking up loaded wagons from the shed, it returns to the yard where the wagons are hump-sorted and placed on the appropriate lines in the sorting yard.

[100] http://www.irfca.org/docs/marshalling-yards.html

3.2.2.2.2. Multiple yards

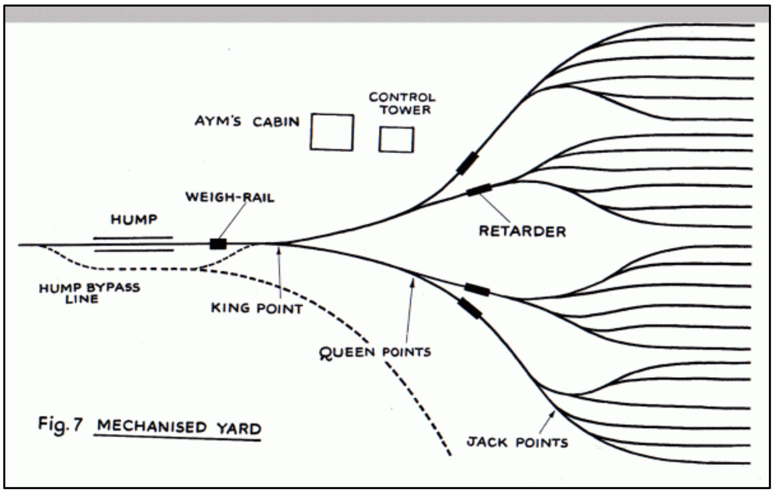


Fig. 7 MECHANISED YARD

A multiple yard will consist of the following key elements : (1) *Up reception*, *sorting* and *departure yards* laid usually in continuation, (2) *Down reception*, *sorting* and *departure yards* laid alongside and parallel to the up yard, and pointing the other way, (3) *separate humps* for up and down yards, (4) connections between the two yards for the movement of cross-traffic and, (5) various auxiliary installations such as *locoshed*, *sick yard*, *transhipment platform*, *repacking shed*, *weighbridge*, *goods shed*, etc., each of these having suitable connections with the yard.

Marshalling yards can show an almost infinite variation in the way the constituent elements can be grouped together. The example in the diagram shows a *flat yard* that has separate *up* and *down yards*, each made up of *reception-cum-departure lines*, and *sorting lines* which are *dead end sidings*. Once a train is formed in the sorting area it is moved to the *reception-cum-departure yard* where it awaits departure. The yard is attached to the passenger station.

3.2.2.2.2.a. Mechanised yards

A *mechanised yard* is a term used to describe a hump yard that has been upgraded by the addition of appropriate electrical and electro-pneumatic control devices so as to speed up the rate of sorting of a train. Mechanisation can thus be looked upon as a refinement that allows more trains to be sorted in a given period than would be possible in a yard of conventional design.

The retarders grip the sides of the wheels
on passing cars to slow them

How does the mechanised yard work? A *hump* has a height ranging from 3 to 6 m. Increasing the height of the hump means that wagons will roll down towards the sorting yard at faster speed.

A *weigh-rail* is placed a little beyond the apex of the hump and has *coil springs* and *pressure transducers* below it which give a visual indication to the control cabin of the weight of the wagons passing over the hump.

A *set of retarders* are used to slow down wagon cuts rolling down the hump. A *retarder* is an electro-pneumatic device operated from the control cabin and consists of two pairs of *horizontal brake beams* at track level, one pair for each rail. When operated, beams of each pair draw closer gripping the wheels of a passing wagon at their lower extremity in a nutcracker fashion, thereby slowing down the movement of the vehicle.

Hydraulic 'Dowty retarders' allow fine adjustment of speed

The points are set electro-pneumatically. Switches on a panel in the control cabin allow routes to be set individually for each successive shunt as it comes rolling along. (Alternatively, a perforated tape is prepared which (when fed into a machine) sets the routes automatically without the need for intervention from the operator).

In a mechanised yard, wagons are not uncoupled as they go over the hump. Instead, the train is split up while it is still in the reception yard.

3.2.2.2.2.b. Sorting process

The hub of every marshalling yard is the classification yard where trains are broken up routewise. Each line is set aside for a certain purpose. A train arrives in the reception area, waiting for sorting. A shunting engine attaches to the train from the rear and begins to push it up the hump. The *Assistant Yard Master* has full details of the train, and he has prepared the *cut-list* so that, for instance, (a) section wagons for route 1 are sent to line 4, (b) section wagons for route 2 are sent to line 5, (c) any long distance wagons go to line 1, 2, or 3, as the case may be, (d) goods shed wagons are dispatched to line 10, (e) sick wagons, if any, are sent to 12 or 13 as the case demands, and (f) the guard's brake van rolls into line 14.

When enough section wagons have accumulated on a line, the next thing to do is to arrange them in station-order. Making its way to the sorting yard the shunting engine picks up these wagons and draws back into the reception yard using a line which bypasses the hump, for a second round of hump shunting. Five or six (or even more) 'humping operations' may be required to juggle these wagons (using various lines) before they are all on one line in geographical order. This secondary sorting is usually done in the main classification yard itself but in some cases a separate yard is built for detailed classification work of this kind. This is known as a subsidiary yard.

3.2.2.3. Private Railway Siding

By definition a *private railway siding* is track or set of tracks which do not belong to the railway enterprise but are linked up with the track of a railway enterprise so that an industrial, establishment, port, etc. can be served by rail without trans-shipment.[101]

It is important to keep in mind a clear distinction between railway property, *industrial sites* and *private lines*.

[101] http://stats.oecd.org/glossary/detail.asp?ID=3920

Industrial sites could have their own track and/or their own railway system. Track between the railway company and the site would be either railway company track or private track.

On both private and industrial tracks there might well be signs prohibiting staff from riding on anything on the track without authorisation. Before the move to road transport any company that needed a lot of transport would try to locate as close to rail access as possible. Where appropriate (cost effective) they would get right alongside and get direct access in one way or another. Both the railway companies and the industry would want to minimise transhipment costs including both labour and losses through spillage/pilfering etc. The railways also do not want industries to put anything onto a lorry to get it to them because, increasingly, once on a lorry, it might stay there for its entire journey. This means that railways may accept a joint boundary of the industry's wall with appropriate doors (or gates) and a platform putting the railway right up against the industry. One side would be able to be completely secure from the other. Then again where track ran in pavement, the railway companies tended to not want the hassle. In those cases the track could belong to a consortium, the "trading estate" or some other arrangement. Sidings have to have trap points between them and running tines.

3.2.3. Slots

To run a train between two places on the rail route, rail operators need to secure timeslots, which they obtain from the appropriate rail infrastructure manager.

In rail transport, a train slot is a permission or licence that gives the right for a rail company to run a train on a specific section of track, at a specific time.[102] Many tracks and stations across Europe are owned by rail infrastructure companies, e.g. *Eurotunnel*, *HS1* and *Network Rail* in UK, *DB Netz* in Germany, *Infrabel* in Belgium, *ProRail* in the Netherlands, etc.[103]

The rail infrastructure companies sell train slots to various companies which operate freight and passenger services. There are night and day rail slots.

There are three different types of slots (in Germany):
- **Safe slots** with fixed timing, e.g., by master contract
- **Optional slots** with relatively safe timing, e.g. system slots
- **Requested (or *ad hoc*) slots** with desired timing, e.g. chartered or extra train (slots).[104]

To obtain slots and use a national rail network is subject to the payment of fees to the relevant rail infrastructure manager. These fees are also called *rail tolls*.

Each EU country has its own system of charging. The highest common fee is charged for the reservation of capacity (slots).[105] The fees are paid by each *rail operator* (=railways company) and are calculated on the basis of a unit rate per kilometre, subject to the addition of a variable element applied as a ratio to reflect:

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[102] April Kuo, Elise Miller-Hooks, Kuilin Zhang, and Hani Mahmassani (2008). "Train Slot Cooperation in Multicarrier, International Rail-Based Intermodal Freight Transport". *Transportation Research Record: Journal of the Transportation Research Board* (2043): 31–40. http://www.iti.northwestern.edu/publications/mahmassani/Kuo_et_al-2008-Train_Slot_Cooperation_in_Multicarrier_International_Rail-Based_Intermodal_Freight_Transport.pdf
[103] http://www.eurocarex.com/carex-technique.php?cat=19&sscat=39
[104] file:///C:/Users/OSK/Downloads/schlechte_thomas%20(2).pdf
[105] http://www.eurocarex.com/carex-technique.php?cat=19&sscat=39

- Type of line used (the cost for a high-speed or light-traffic line is higher than for a low-speed and/or local traffic line);
- Time of use (the rates charged at off-peak times, and particularly during the night, are lower than those charged at peak times);
- The nature of the train for which the slot is reserved;
- The type and speed of the rolling stock used.

In France the reservation fees are referred to as *des redevances pour prestations minimales* (minimum service fees), which also comprise network access and usage fees. Other fees are requested by rail infrastructure operators, such as access to electrical power equipment and installations. In various EU countries the rate charged for freight slots may differ significantly from those charged for passenger slots.

In many EU countries slots are distributed via *auctioning procedures*. For instance, in Germany slots are allocated according to priority rules, though, railway law and regulation also provide for the application of a 'highest price procedure' in case of a conflict between equally ranked slot requests.[106]

However, when a particular bottleneck slot is allocated, it might block other parts of the network. This can lead to inefficient allocations, so insulated bidding for bottlenecks is not appropriate for railway network allocation. To avoid this situation, a so-called *combinatorial auction* is used, which allocates a multitude of interdependent slots simultaneously. The efficient use of a railway network hinges not only on departures and arrivals, but also on the combination of routes and speeds taken by individual trains in the network.

There are several factors that influence slot allocation in the rail network.

One of them is railway scheduling, which is based on a detailed model of the railway network, *i.e.* a model that includes all tracks, switchers, and signals. This model is used for planning on the principle of exclusive use of block sections. It means that a *block section* may be occupied by, at most, one train at a time. Various characteristics of the individual train need to be taken into account, such as maximum speed, acceleration and braking distance, as well as characteristics of track segments, such as allowed speed and signalling system, determining the blocking time, i.e. the time that a block section is occupied, and the headway, *i.e.* the minimum time interval between two trains.[107]

Other important factors in slot allocation are train types which are defined by several properties, such as driving characteristics, train protection system, intermediate, service type (passenger vs. freight, local vs. long distance). For instance, there are InterCityExpress ICE, InterCity IC, RegionalExpress, RegionalTrain, and InterCargoTrain.

To request a slot, three main components need to be considered, namely a *monetary bid* (a sum which the operator is willing to pay for a slot), a *train type* (it specifies the technical characteristics like maximum speed, acceleration, braking distance, weight, *etc*.), *route of the train*, which is given by a sequence of stations and times.

When all these components are considered, the slot is allocated to a train. However, the train slot requests submitted by competing railway undertakings are likely to conflict. For instance in Germany the number of

[106] https://www.zib.de/Publications/Reports/ZR-05-45.pdf
[107] https://www.zib.de/Publications/Reports/ZR-05-45.pdf

conflicting train slot requests climbed from 10,000 to 12,000 from 2008 to 2009. In the same period the number of conflicting slots in Switzerland increased from 103 to 127.[108]

The main issues targeted by the EU regulations are:

- The working train timetable shall be established annually.
- Infrastructure managers have to declare a specific date and time when the shift of one train timetable to the new one takes places.
- The final date for receipt of annual train slot requests must not be earlier than 12 months before the new timetable is operated.
- Not later than 11 months before the new timetable is operated the infrastructure managers shall ensure that the international train slot requests have been allocated provisionally.
- Four months after the deadline for submission of the annual train slot requests by railway undertakings, a draft timetable shall be prepared.

There are four different types of slot request to be distinguished:

- long term train slot requests,
- international train slot requests,
- annual train slot requests,
- and *ad hoc* train slot requests

Long term slot requests are from 5 up to 15 years. The term *planning time horizon* is the time period the between the date when a train request is submitted and the date when the train path request is included into the working timetable.

International slot requests require capacity from at least two different international railway infrastructure providers.

Annual train path requests are submitted annually in order to be included into the annual timetable. It takes approximately 8 months before the new timetable is operated.

RailNetEurope was set up to facilitate co-operation between the national infrastructure managers and independent organisations. International train slot requests are directly submitted to *RailNetEuro*, which is responsible for co-ordination between the national infrastructure managers.

There are *ad hoc* train slot requests which are submitted at short notice. This applies to cargo trains which are planned in a much more flexible way than passenger trains. Such slots are requested from 2 weeks to 24 hours in advance. Most infrastructure managers already plan in advance suitable train slots, calling them *system slots*, without allocating them to a specific railway undertaking. In the case of *ad hoc* or individual slot requests in the course of the year such system slots can be assigned.

In practice, all passenger trains have priority over freight trains. Trains operating in regular slots have priority over the trains with *ad hoc* slots, and all high speed trains, including TGV (in some places using their own tracks that are not used by freight trains), have priority over slower trains.
How does the logistics operator manage all those parameters for FVL?

[108] file:///C:/Users/OSK/Downloads/schlechte_thomas%20(2).pdf

3.2.4. Slot allocation scheme for FVL

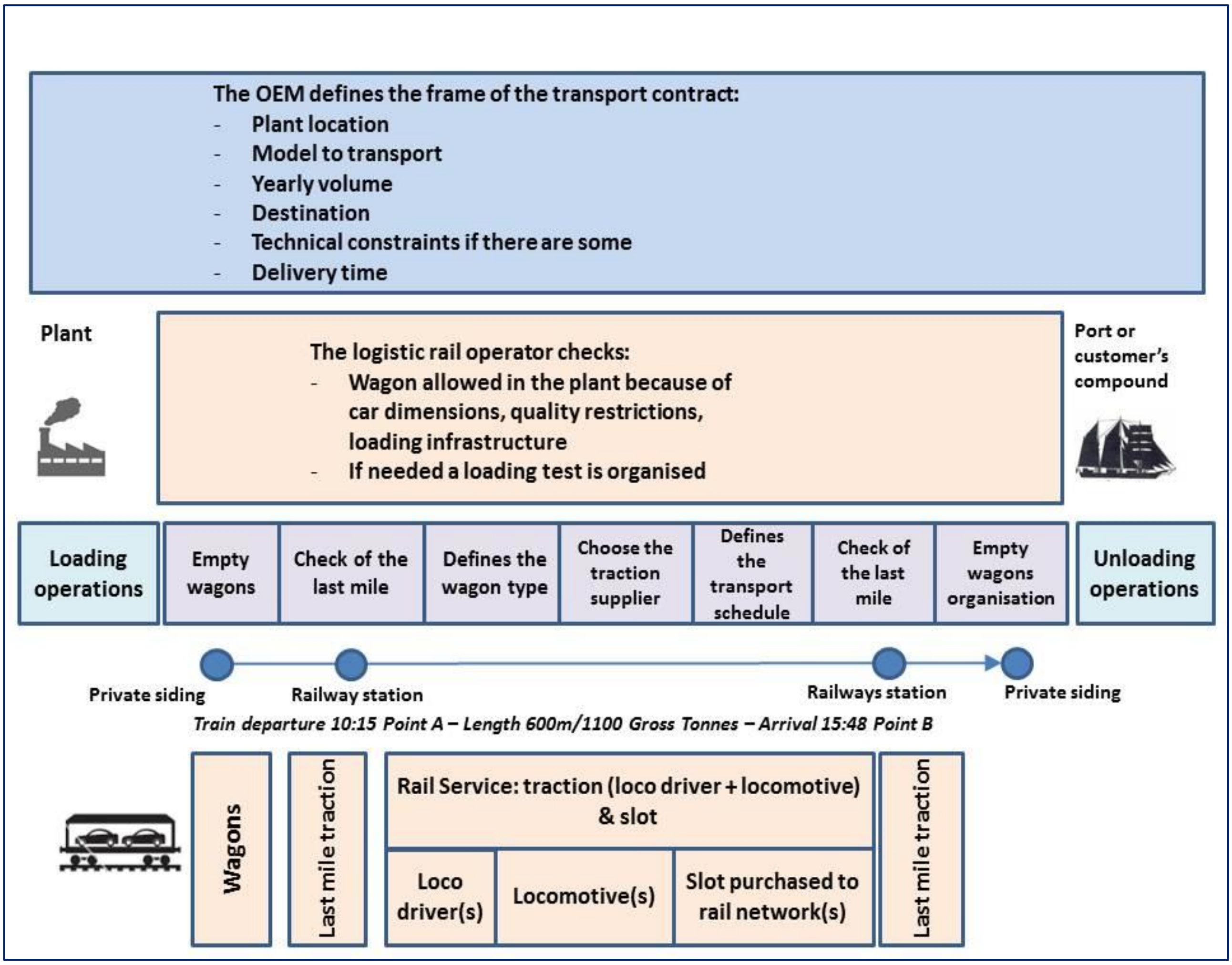
Here we would like to present a theoretical scheme for slot allocation for FVL in several steps.

1. Request from OEM (Model of car, volume, planning, delivery time, where the cars need to be transported).
2. The LSP defines the scheme: transport line and transport format (train, single wagons).
3. The LSP also defines the wagon type suitable for the specific models, from the types available in his fleet and checks the compatibility of the wagons with the loading/unloading infrastructure on the customer's sites.

   There are 2 main transport formats:
   - Single wagons
   - Block train
4. In any case, the LSP has to define the way to supply empty wagons inside the transport scheme and tries to optimize those empty costs.
5. LSP launches a *traction purchasing tender*, in order to choose the railway company, which will provide the traction service.
6. LSP has also to define the size of the wagon fleet necessary for the transport, and the wagon type adapted to the model dimensions and the quality prescriptions.
7. Railway companies offer traction price, including the technical description of the service: time schedule, possible length of train and maximum weight.
8. LSP checks with the sending station and receiving station that the train length fits the infrastructure.
9. Logistics operator builds its price offer on those technical items.

In case of reaching an agreement – how does the LSP provide the service:

1. The logistics operator defines with the OEM the practical conditions of the service:
   - Presentation of the wagon, loading test to validate the loading factor;
   - Listing of the practical constraints: preferred departure time, and arrival time (in case of ports, the logistics operator has often to negotiate unloading slots with the Port authorities.
2. On this basis, the LSP starts the discussion with the designated railway company:
   - Transport schedule: the RU will try to find a free slot finding a compromise with the constraint of the OEM and also demanding the smallest fleet of wagons. Most of the time, it is too late to order regular slots on the transport line. The transport will start with *spot slots,* until we reach the schedule of regular slots. In fact, the RU will contract with the Network the slot programme, and organize its own means to provide a locomotive and a driver on a regular basis.
   - Traction cost.
   - Negotiation of the last miles.



This example allocation scheme was prepared by STVA

3.3. Trains

3.3.1. Types of Trains

There are various types of trains that are designed for particular purposes. A train can consist of a combination of one or more locomotives and attached railway wagons, or a self-propelled multiple unit (or occasionally a single or articulated powered coach). In the early 1890s trains were powered by steam locomotive and only from 1950s onwards they began to be replaced by less labour-intensive and cleaner (but more complex and expensive) diesel and electric locomotives.

Special kinds of trains running on corresponding special 'railways' are *atmospheric railways*,[109] *monorails*,[110] *high-speed railways*,[111] *maglev*,[112] *rubber-tired underground*,[113] *funicular*[114] and *cog railways*.[115] A passenger train may consist of one or several locomotives and coaches. There are several types of passenger trains. They can be divided into three main groups: inter-city trains, fast trains and regional trains.

A *freight train* (also known as *goods train*) uses freight wagons (also known as trucks or goods wagons) to transport goods or materials (cargo) – essentially any train that is not used for carrying passengers.

There are many different types of freight trains, which are used to carry many different kinds of freight, with many different types of wagons. In Europe the *sliding wall wagon* has taken over from the ordinary covered goods wagon. In some countries '*piggy-back*' trains or rolling highways are used: In the latter case trucks can drive straight onto the train and drive off again when the end destination is reached. A system like this is used through the Channel Tunnel between England and France, and for the trans-Alpine service between France and Italy (this service uses *Modalohr* road trailer carriers). Containers are lifted onto the train via a crane or other loading mechanism, which greatly speeds up the loading and unloading process. This style of freight train has largely replaced wagonload and boxcar freight trains, in which cargo is loaded and unloaded by hand.

Freight trains can be divided into three major groups depending on a way the cargo is transported:[116]

- *Unit train*: used to carry a large quantity of a specific product from one location to another in a short amount of time. Unit trains are useful for quick delivery turnarounds because they can return to their destination on the same track they arrived and be reloaded. Unit trains do not require switching tracks or remaining in the station any longer than necessary to offload their cargo. They are fast and cost-efficient for the sender.
- *Mixed freight trains*: Mixed freight trains are also known as *manifest trains*. Unlike unit trains, which carry just one type of cargo in a single type of train wagon, mixed freight trains bring numerous

[109] An atmospheric railway uses differential air pressure to provide power for propulsion of a railway vehicle. A static power source can transmit motive power to the vehicle in this way, avoiding the necessity of carrying mobile power generating equipment. The air pressure or partial vacuum (i.e. negative relative pressure) can be conveyed to the vehicle in a continuous pipe, where the vehicle carries a piston running in the tube.
http://en.wikipedia.org/wiki/Atmospheric_railway

[110] Monorail railways that are not using maglev design are today most often used in urban environments, with slow trains and trams that transport usually only people. http://www.trainhistory.net/train-facts/train-types/

[111] Advances in railway and train technologies enabled technicians to design new type of railway that is optimized for high speeds and smooth driving. These railways can be found in many high-speed train networks, especially in Japan, France and Spain. http://www.trainhistory.net/train-facts/train-types/

[112] In distant 1937 German inventor Hermann Kemper patented railway system that uses power of the magnets to provide support for traveling locomotive and its trains. Today this system is often used for very expensive and high-speed railway lines. http://www.trainhistory.net/train-facts/train-types/

[113] A rubber-tyred metro is a form of rapid transit system that uses a mix of road and rail technology. The vehicles have wheels with rubber tyres which run on rolling pads inside guide bars for traction, as well as traditional railway steel wheels with deep flanges on steel tracks for guidance through conventional switches as well as guidance in case a tyre fails. Most rubber-tyred trains are purpose-built and designed for the system on which they operate. Guided buses are sometimes referred to as 'trams on tyres', and compared to rubber-tyred metros. http://en.wikipedia.org/wiki/Rubber-tyred_metro

[114] A funicular, also known as an inclined plane or cliff railway, is a cable railway in which a cable attached to a pair of tram-like vehicles on rails moves them up and down a steep slope; the ascending and descending vehicles counterbalance each other. http://en.wikipedia.org/wiki/Funicular

[115] A rack railway (also rack-and-pinion railway, cog railway) is a steep grade railway with a toothed rack rail, usually between the running rails. The trains are fitted with one or more cog wheels or pinions that mesh with this rack rail. This allows the trains to operate on steep grades above 7%, which is the maximum for friction-based rail. Most rack railways are mountain railways, although a few are transit railways or tramways built to overcome a steep gradient in an urban environment. http://en.wikipedia.org/wiki/Rack_railway

[116] http://www.ehow.com/list_7606612_three-types-modern-freight-trains.html

different wagons and cargo to their destination. They do not move as smoothly from one point to another as unit trains, but they are able to carry a greater amount of varied cargo.

- *Intermodal trains*: Intermodal transportation involves the transport of cargo by several different forms of transportation. The goods are shipped in intermodal containers. Intermodal transportation is often not cost-effective for cargo that needs to be shipped short distances.

3.3.2. Train Systems

There are two train systems: block train and single wagon load (SWL) systems.

3.3.2.1. Block Trains

A *block train*, also called a *unit train* or *train load service*, is a railway train in which all the wagons making it up are shipped from the same origin to the same destination, without being split up or stored on route. This saves money, time and confusion with assembling and dissembling trains at rail yards near the origin and destination. Unit trains are considered to be economically efficient only when they are used for high-volume customers. It happens very often that unit trains carry one commodity, wagons are of all the same type and very often they are all identical apart from possible variations in livery. Block trains are mainly used for the transportation of bulk goods, such as solid substances (ballast, gravel, iron, coal, steel, etc.), bulk liquids (crude oil, mineral oil, ethanol, molten sulphur, etc.), food (corn, fruit juice, etc.), shipping containers, cars, aggregate, waste, potash, taconite, mail, etc. A block train consists of goods from one customer, whereas the single wagon load trains can have multiple shippers. The length of the block train can be between 400 and 700 m. However, there are tests conducted in Europe with a view to increase the maximum length of a block train up to 1,000 m.

3.3.2.2. Single Wagons Load System

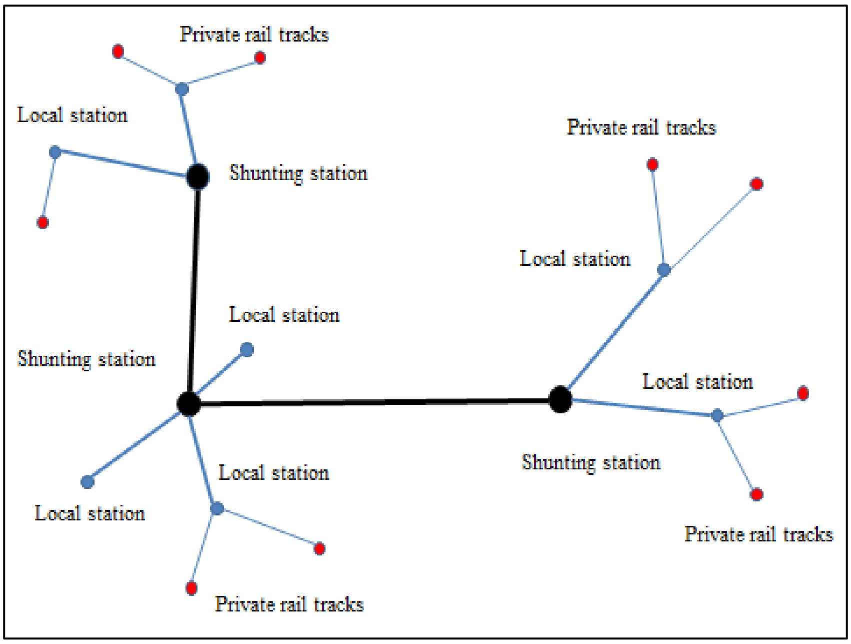
The single wagon load (SWL) system is used in cases when one or several wagons need to be dispatched at a time to a certain place, yet the total quantity of these wagon(s) does not make a full train/block train.[117] SWL system can be compared with a 'hub and spoke system' (where all goods are brought into a central point (*hub*) for sorting and are distributed from the centre in all directions). It is a network system which consists of *customer sidings*, *stations* and *marshalling yards*, or *switch yards* (*see: marshalling yards*):

- If the customer has railway tracks, the operator will send a *feeder service* to collect the wagons (and give the customer empty wagons to fill). These are then hauled or pulled to a *marshalling yard*.
- If the client does not have railway track access, he will transport the goods to a terminal by truck where the goods are loaded onto a railway wagon and then brought to the marshalling yard.
- In the marshalling yard further wagons (from other customers) are added and the train is built up for departure to the next hub/marshalling yard in the network. All departures within the network are scheduled and depart at predefined times (*see: slots*).
- The wagons are transported from one hub/marshalling yard to another and wagons are added and taken away at each stop.
- Once the wagon has reached the hub nearest to its destination, it is taken off the train and is transported either by truck or by track to the final destination.

In the SWL system every customer has a private rail track, which is linked to the national rail network. Each track depends on a regional station, where deliveries are organised. All these local stations are linked with

[117] http://www.railfreightportal.com/Single-wagon-load

bigger shunting stations. There is a different number of trains that run between the stations every day. Each wagon is brought from a local station(s) to bigger hubs of shunting stations where the wagons are re-organised into new trains to be moved onwards to their destination point. The only problem is that formation of a train that includes different wagons with different destination takes time (e.g. 4-5 day needed to cross France). In many cases wagons are moved from one shunting station to another and re-organised, which normally takes time. However, the big advantage of the SWL system is that it works with a small quantity of goods (cars) that need to be transported. The most efficient and cost saving method is a block train, but this requires a sufficient number of cars to have a complete train. However, there are requests from the OEMs to transport cars in smaller quantities, then the SWL system is used for such requests.



The SWL system provides the customer with adaptability of dispatch volatility. Here the number of wagons is chosen by the client to be dispatched to a certain destination. This number can be changed any time. A client can decide as well when to load them, or when to add new wagons to a train. In Europe, the SWL accounts for approx. 50% of the total rail market (with annual freight volume of around 100bn t/km).[118] SWL system is used mainly for midsized and geographically dispersed industry and for agriculture. It is also known, however, that many EU RUs lose money with SWL operations.

The term *wagonload* or *wagonload freight* refers to trains made up from single wagon consignments of freight. Rail freight transport is increasingly operated as trainload or "unit trains," with wagonload less able to compete with road haulage.

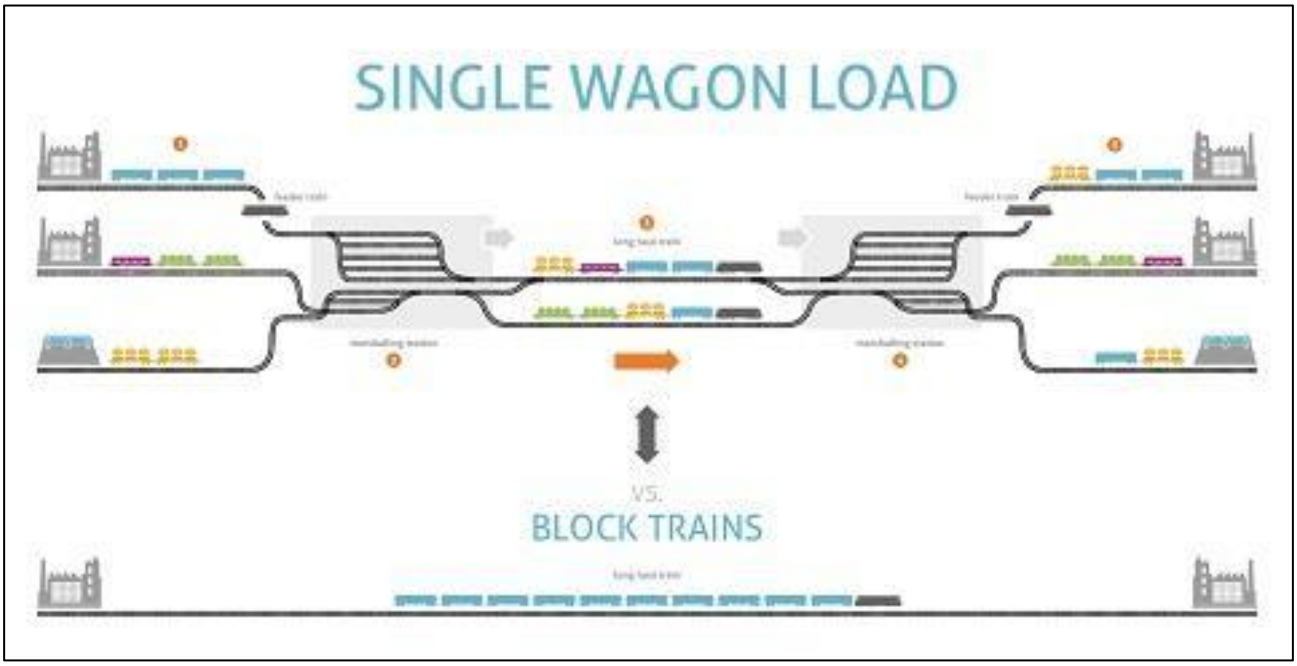
Since 2012, in Europe wagonload freight represents 30% to 40% of freight carried in many countries including France, Italy, Germany and Belgium. In other countries, including the UK and Romania, wagonload freight is a very minor aspect of rail freight transport, representing less than 5% of total rail freight.[119]

Comparing SWL traffic and block trains, the latter ones are less complex because the train does not need to be stopped for shunting procedures. In Western Europe operators have supported SWL transport by signing the new Xrail Alliance in Zurich in February 2010 to improve SWL transport. The founding members of the Xrail Alliance are CD Cargo, CFL Cargo, DB Schenker Rail, Green Cargo, Rail Cargo Austria, SBB Cargo and SNCB Logistics.[120] Since SWL was not profitable, the European Commission decided to support this type of transport and is working on a strategy to simplify the customs control in Member States and to remove the bureaucratic and technical procedures in SWL transport. Therefore, in order to operate at maximum efficiency,

118 http://www.railfreightportal.com/Single-wagon-load
119 http://en.wikipedia.org/wiki/Wagonload_freight
120 http://www.railfreightportal.com/Single-wagon-load

trains need to carry as much freight as possible, within the technical capability of the track and traction. The principle ‘the longer the train the better’ prevails.

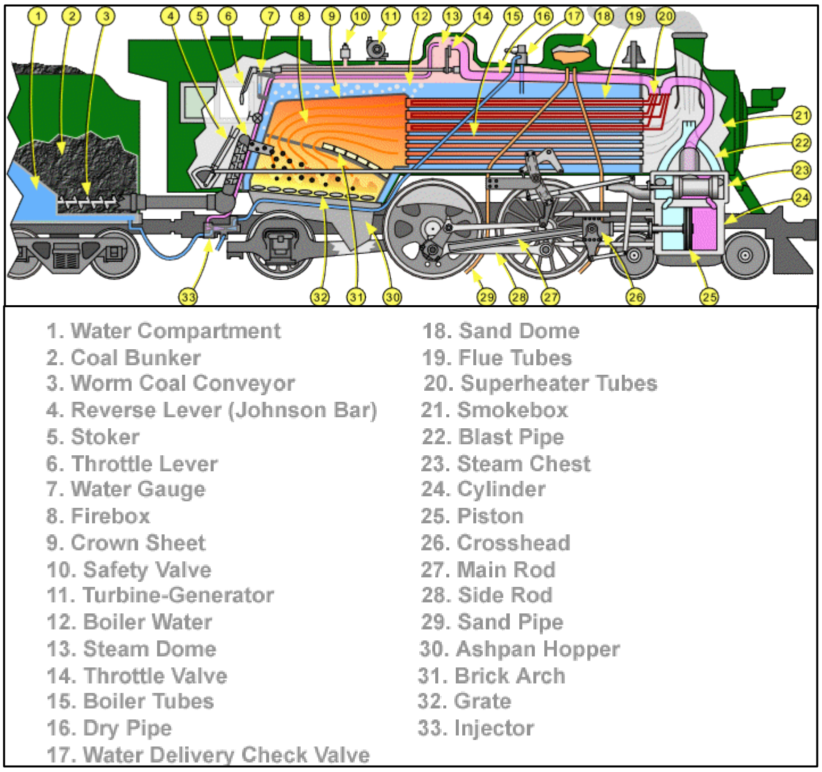
There are two types of wagons that are used to carry non-bulk goods: *intermodal* and *wagon load*. The difference between them lies in the means of loading and unloading. Intermodal loads need lifting equipment such as cranes, whereas wagon load is loaded and unloaded often with fork lift trucks, and from a platform



level with the floor of the wagon. Wagons are shunted into smaller trains for haulage to the ultimate destination by rail. It involves a main line locomotive being used to haul just one or two wagons many kilometres, which makes it uneconomic. One of the solutions is to store goods in wagons at the shunting yards until there is enough to form a whole train. This reduces costs and makes SWL more efficient. The biggest difference between a block train and SWL is that the former is now open to competition in many Member States and the efficiency of the private sector helped to boost the growth in intermodal traffic across Europe. The only obstacles are operating, safety and access restrictions which are imposed to protect the incumbent operators. (*For more information on EU initiatives for SWL traffic, see EU Regulations and Initiatives in Chapter 6*).

3.4. Locomotives

Before starting to discuss the types of locomotives it is necessary first to define what a locomotive is. Locomotive – a self-propelled rail vehicle designed to convert electrical or mechanical energy into tractive effort to haul trains of non-powered carriages and freight wagons.[121]



Trains can be sorted in several distinct categories, separated by the way their locomotives are powered, their use, and by the design of their tracks.

There are several types of locomotives: *steam locomotives*, *diesel locomotives*, *electric locomotives*, *combined engines*, and *maglev locomotives*.[122]

3.4.1. Steam Locomotives

Now effectively obsolete, a steam locomotive is a self-contained power unit consisting essentially of a steam engine and a boiler with fuel and water supplies. Superheated steam, controlled by a throttle, is admitted to the cylinders by a suitable valve arrangement, the pressure on the pistons being transmitted through the main rod to the driving wheels.[123] The driving wheels, which vary in number, are connected by side rods. Steam locomotives are usually classified under the *Whyte system*, that is, by the number and arrangement of the wheels; for example, an engine classified as 2–6–0 has one pair of wheels under the front truck, three pairs of coupled or driving wheels, and no wheels under the trailing truck. In some cases the truck wheels of the tender (fuel carrier) are added.[124]

					
The NKP 500-series 2-8-2 'Mikado'	Norfolk and Western No. 475 is a 4-8-0 steam locomotive	Passenger train 4-6-0 steam locomotive 5972 OLTON HALL (built at Swindon in 1937)	Bavarian S 3/6 class, later Class 18.4-5 of the Deutscher Reichsbahn	The LNER Class A3 Pacific steam locomotive No. 4472 Flying Scotsman (originally No. 1472)	Steam engine VHX 40-308

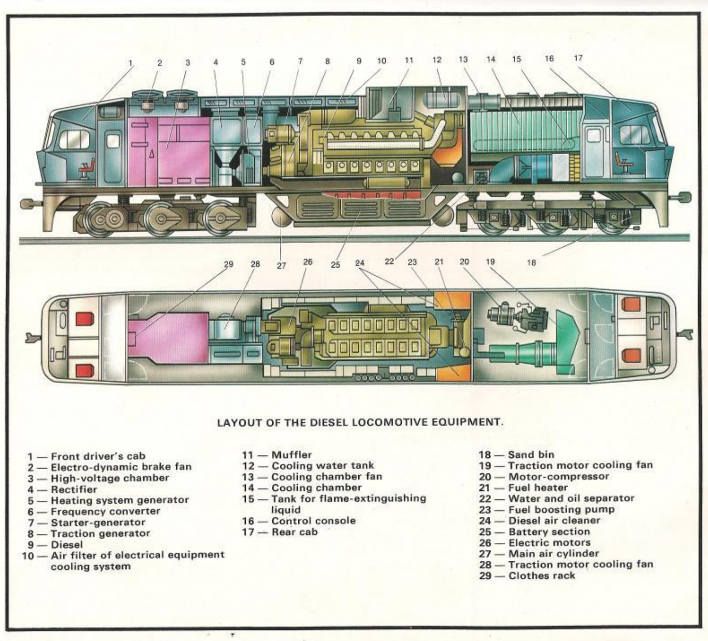
[121] http://www.railway-technical.com/Rail-Lexicon-Mk24.pdf
[122] http://www.trainhistory.net/train-facts/train-types/
[123] http://www.enselsoftware.com/article/train_sim.html
[124] http://www.infoplease.com/encyclopedia/science/locomotive-types-locomotives.html

3.4.2. Electric Locomotives

Electric locomotives range from the small types used in factories and coal mines for local hauling to the large engines used on railways. Electric locomotives generally have two or more motors. Power is collected from a pantograph running on an overhead wire or from a third rail at one side of the track. Battery locomotives, used only for local haulage, carry electric storage batteries that act as their primary source of power. Electric railway locomotives are used chiefly on steep grades and on runs of high traffic density; although highly efficient, they are not more widely used because of the cost of electric substations and overhead wires or third rails.[125]

					
Taurus ES64U2/U4 locomotive	El16 of CargoNet	El18 of NSB	Rc4 of Green Cargo	DB E18/ÖBB	Soviet 2TE10U locomotive

3.4.3. Diesel Locomotives

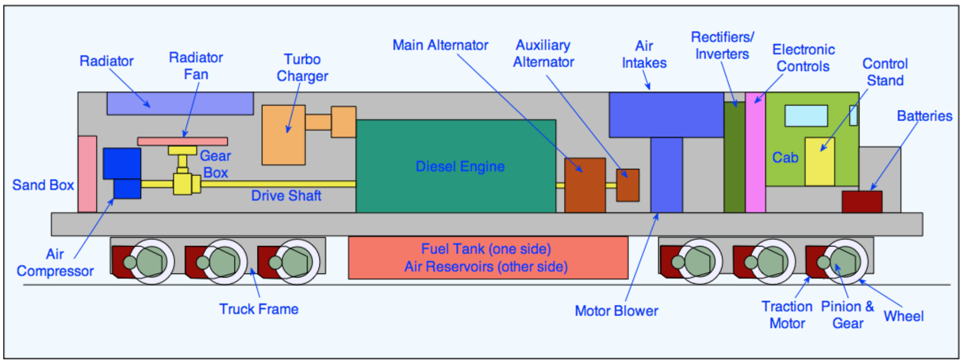


The modern diesel locomotive is a self-contained version of the electric locomotive. Like the electric locomotive, it has electric drive, in the form of traction motors driving the axles and controlled with electronic controls. It also has many of the same auxiliary systems for cooling, lighting, heating, braking and hotel power (if required) for the train. It can operate over the same routes (usually) and can be operated by the same drivers. It differs principally in that it carries its own generating station around with it, instead of being connected to a remote generating station through overhead wires or a third rail. The generating station consists of a large diesel engine coupled to an alternator producing the necessary electricity. A fuel tank is also essential. It is interesting to note that the modern diesel locomotive produces about 35% of the power of an electric locomotive of a similar weight.[126]

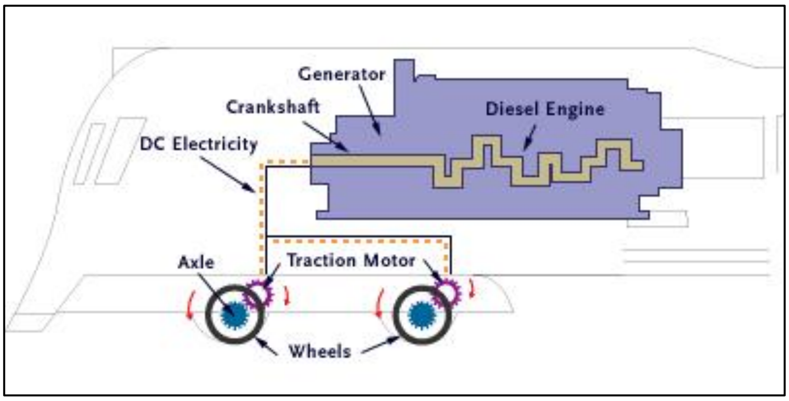
					
The UK Class 47 is typical of the general purpose diesel-electric locomotives introduced in the 1960s.	MAV Diesel locomotive M62 Taigatrommel	HGK JT42CWR number DE672 in Ulm Germany	Class 66 number 403 used by CargoNet	Class 233 of DB	Class 203 of NBE Rail

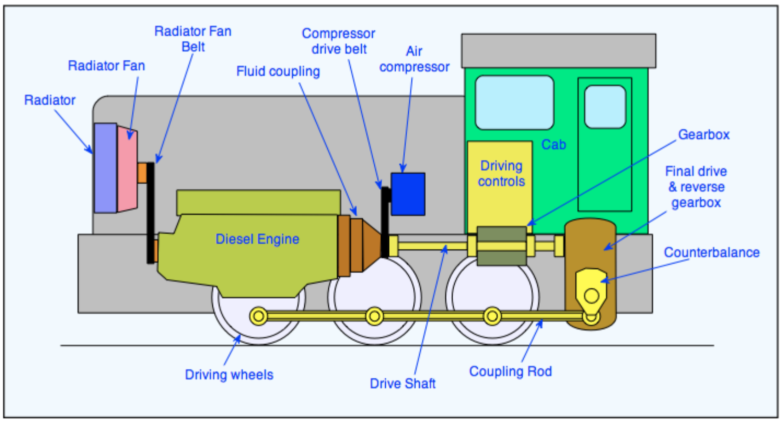
[125] http://www.infoplease.com/encyclopedia/science/locomotive-types-locomotives.html
[126] http://www.railway-technical.com/diesel.shtml

3.4.4. Combined Locomotives



Diesel-electric locomotives were introduced in the United States in 1924, and have become the most widely used type of locomotive. The modern diesel-electric locomotive is a self-contained, electrically propelled unit. Like the electric locomotive it has electric drive in the form of traction motors driving the axles and controlled with electronic controls. It also has many of the same auxiliary systems for cooling, lighting, heating, and braking. It differs principally in that it has its own generating station instead of being connected to a remote generating station through overhead wires or a third rail. The generating station consists of a large diesel engine coupled to an alternator or generator that provides the power for the traction motors. These motors drive the driving wheels by means of spur gears. The ratio of the gearing regulates the hauling power and maximum speed of the locomotive. A modern diesel-electric locomotive produces about 35% of the power of an electric locomotive of similar weight.[127]





Diesel-mechanical locomotives have a direct mechanical link consisting of a clutch and a series of gears and shafts between the engine and the wheels, similar to the transmission in an automobile. Because mechanical drives deliver less power to the wheels than electric and diesel-electric systems, they are only used with the smallest locomotives.

In *diesel-hydraulic locomotives* the engine drives a torque converter, which uses fluids under pressure to transmit and regulate power to the wheels. Hydraulic drives are widely used in some countries, such as Germany.

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[127] http://24coaches.com/locomotive-working-india/

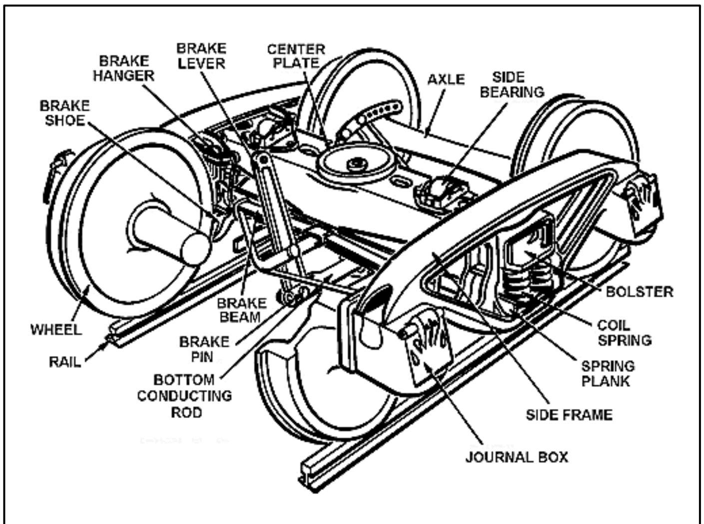
Gas turbine–electric locomotives are similar to the diesel-electric but use a gas turbine to drive the generator. The technology is used primarily on turbotrains, high-speed passenger trains that do not have locomotives but instead are powered by units built into one or more of their cars.[128]

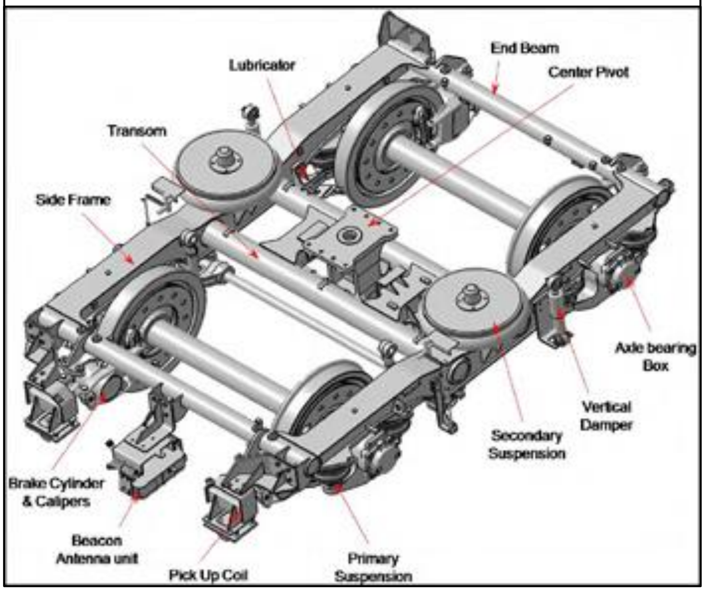
					
Diesel-electric locomotive: MLW model S-3 produced in 1957	Diesel-electric locomotive: ER20s	Class 56 Romanian-built diesel-electric locomotive 56006 at RailFest 2004	Co-Co diesel-electric locomotive Class 47 D1705 SPARROWHAWK	Diesel-Electric Locomotive 1Co-Co1 Class 40	Diesel-Electric Co-Co Locomotive Class 50

3.5. Wagons

3.5.1. General Features of Wagons

Most railway freight and passenger wagons sit on top of ***bogies*** (or 'trucks' US).[129] Most bogies have two ***wheel sets*** so rollingstock can manoeuvre around curves while supporting heavy loads. The ***two side frames*** contain two wheel sets (each wheel set is two wheels and a solid axle mounted together as one piece). ***Roller bearings*** are used between the axles and the side frames to permit the wheel sets to turn freely. Usually, wagon bodies are not fastened to the bogies but rest on and pivot around, a centre support. Generally, bogies on passenger rolling stock support a suspension system that isolates them from the wheels and infrastructure. Bogies also support the ***braking systems***. Most passenger and freight rail cars use brakes operated by air pressure. Freight braking systems use air pressure to press brake pads to each wheel tread. Some passenger systems use the same type of braking system, but most high-speed trains are equipped with ***disk brakes*** attached directly to wheelset axles in addition to tread brake systems.



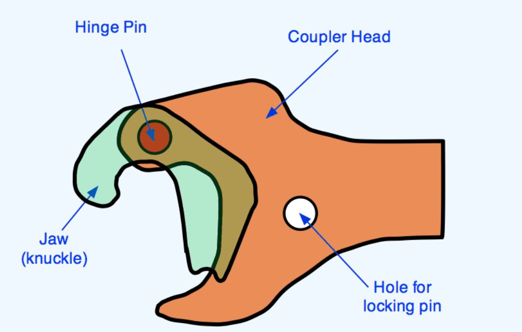


[128] http://www.infoplease.com/encyclopedia/science/locomotive-types-locomotives.html
[129] http://www.ppiaf.org/sites/ppiaf.org/files/documents/toolkits/railways_toolkit/ch1_3_2.html

Couplers are designed to allow railway cars to be joined together quickly and easily while draft gears provide the mechanism to transmit the longitudinal forces that propel the train through the car body to the next car, without interfering with the workings of the bogies. Some couplers have top and bottom extensions (shelf couplers) to ensure that cars stay coupled even if one car leaves the tracks. Draft gear and coupler system strength determine the safe weight at which a train can operate on a railway. Many rail systems use ***buffer pads*** alongside coupler mechanisms to reduce 'slack action', the tendency of a group of wagons to elongate or contract when in motion.

3.5.2. Wagon Classification

The UIC (International Union of Railways) has established systems for the classification of locomotives and their axle arrangements, coaches and goods wagons. This classification of goods wagons was agreed in 1965 and it was introduced into the member countries (in 1968 by Germany, replacing an old classification system adopted as early as 1905). A few countries use national classification schemes in addition to, or instead of the UIC classification, for instance: the State Railway of Finland (VR) which uses similar to UIC classification, the State Railways of the Czech Republic (CD) use alongside the UIC system a national classification, British Rail use TOPS (Total Operations Processing System) widely instead of the UIC system and the Railways of Spain (RENFE) use alongside the UIC system a specific classification.



Plan view of standard Buckeye or Knuckle coupler. The coupler is made of cast steel and the jaw moves about the hinge pin for coupling and uncoupling action

The UIC classification code consists of letters (in upper case) as well as several index letters (in lower case). Some capital letters are reserved only for coaches (A, B, C, D, P, and W),[130] the others indicate goods wagons. The letters in capital are followed by letters in lower case, which are international index letters. The index letters indicate the technical size/capacity of the wagons. They are followed by 12 digits. The first digit forms the fifth digit of the 12-digit UIC wagon number and the last digit is a check number.[131]

For instance, DB Schenker uses wagon 'Laaeks' 25-80-43-6-6678-7 (*see the photo*):
L = flat wagon
aa = double wagon with 4 axles
e = with decks for the transport of motor cars (double decker)
k = with maximum load on class C route: m < 20 t
s = permitted in trains up to 100 km/h.

[130] http://en.wikipedia.org/wiki/Goods_wagon
[131] Digits 1-2 indicate a type of vehicle and international utilization modus; digits 3-4 indicate country code; digits 5-6 – vehicle type information; digit 7 denotes sub-type of the above (freight); 8-11 – individual running number (serial number) and final one is a redundancy self-check digit. http://en.wikipedia.org/wiki/UIC_wagon_numbers

25 = type of vehicle and indication of the interoperability capacity
80 = country code (Germany)
43 = vehicle type information
6 = sub-type
6678 = individual running number
7 = check number
(*For full explanation of the letters, please see table on p. 84*).

There are two types of wagons that are used for vehicle logistics in Europe: ***open wagons*** which are designated by the letter **L** and ***closed wagons*** marked by the letter **H** according to the UIC classification.

Cars are lighter than most other freight. Therefore, wagons that are used for transportation of cars are lighter and have two decks. Providing their great length, they have at least three axles. Where there are three axles, the centre one rests on a swivel and the wagon has an articulated joint in the middle. The cars can be loaded over the joint. These wagons are open as a rule and are thus classified as flat wagons of Class L.[132]

During the development of car transporting wagons, the end walls of standard open wagons were removed and pairs of wagons were permanently coupled which improved the capacity. Then the second deck was fitted to these wagons, which doubled the capacity. German engineers at Volkswagen and Deutsche Bundesbahn jointly designed an extra-long wagon for the transport of factory-new vehicles. The result was a wagon that could carry ten cars from the factory to the ports.

Flat wagons, as classified by the UIC, are railway goods wagons that have a flat, usually full-length deck (or 2 decks on car transporters) and little or no superstructure. By contrast, open wagons have high sides and end walls and covered goods wagons have a fixed roof and sides. Flat wagons are often designed for the transportation of goods that are not weather-sensitive. Though some flat wagons are able to be covered completely by tarpaulins or hoods and are therefore suitable for the transport of weather-sensitive goods. Unlike a "goods wagon with opening roof," the loading area of a flat wagon is entirely open and accessible once the cover is removed.

3.5.2.1. Open Wagon: L class: special flat wagons with separate axle

This class of wagon is used for the transportations of cars. It contains three and four-axle car transporters with one or two decks.

The class of L wagons that are used by most of the automotive Rail operators DB Schenker, BLG, ARS Altmann, STVA, SITFA, GEFCO, etc., for instance, Laekks 552, Laaeks 553, Laaes 556, Laes 559, Laaers 560 and Laadrs 557.

[132] http://en.wikipedia.org/wiki/Flat_wagon

UIC wagon classification code and DB-specific type number		Laekks 552	Laaeks 553	Laaes 556	Laes 559	Laaers 560	Laadrs 557
Loading length	upper deck m	25,73	26,5	26,5	26,64	30,55	no upper deck
	lower deck m	25,43	26,1	26,1	26,16	30,07	30
Loading width	upper deck m	2,8	2,91	2,91	2,794	2,75	-
	lower deck m	2,948	3	3,1	2,926	2,95	2,8
Height of floor above TOR	at headstock m	1,155	1,2	1,155	1,201	1,2	1,165
	between the axles m	0,64	0,98	0,98	0,64	0,82	-
Loading height	upper deck m	min. 1,665/max. 2,205	min. 1,48/max. 1,85	min. 1,482/max. 1,852	min. 1,462/max. 2,302	min. 1,305/max. 2,09	-
	lower deck m	min. 1,27/max. 2,165	min. 1,57/max. 1,75	min. 1,589/max. 1,684	min. 1,153/max. 2,141	min. 1,308/max. 2,1	max. 3,485
Height of wagon m		3,241	3,4	3,403	3,4	3,578	2,276
Number of axles		3	4	4	3	4	4
Distance between outer axles m		20	22,3	22,3	20	25,16	24,24
Length over buffers m		26,24	27	27	27	31	31
Average tare weight of wagon t		25,2	26,5	28,8	28,2	29,6	28
Load limits t		Line category: A, B, C for all load limit is 17; lower deck: 12 upper deck 10	Line category: A, B, C for all load limit is 18; lower deck: 12 upper deck 10; 120km/h when empty	Line category: A, B, C for all load limit is 24; lower deck: 13 upper deck 11	Line category: for A is 19,5; for B and C is 20 lower deck: 12 upper deck 12; 120km/h when empty	Line category: A, B, C, D is 34; for B and C is 20 lower deck: 18 upper deck 18; 120km/h when empty	Line category: A, B, C is 24; for per wagon: 12; 120 km/h when empty
Special features		Removable wagon: accessories: 4 hand cranks	Removable wagon: accessories: 4 hand cranks	Removable wagon: accessories: 4 hand cranks	Removable wagon: accessories: 2 hand cranks	Removable wagon: accessories: 4 hand cranks	-

Rail load limit:

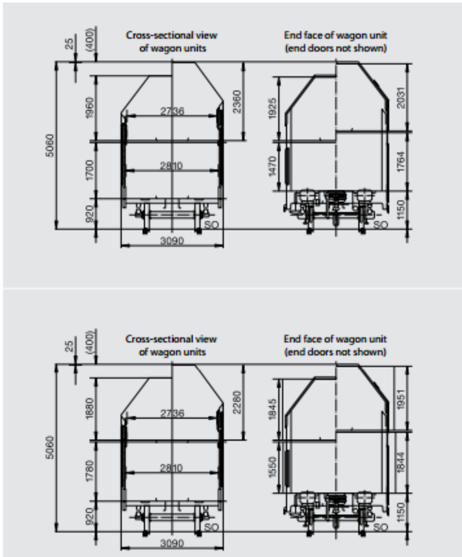
Classification → Axle load = P ↓ Vehicle mass per unit length = p	A 16 t	B 18 t	C 20 t	D 22.5 t	E 25.0 t	F 27.5 t	G 30 t
5.0 t/m	A	B1					
6.4 t/m		B2	C2	D2			
7.2 t/m			C3	D3			
8.0 t/m			C4	D4	E4		
8.8 t/m					E5		
10 t/m							

			
Laekks 552	**Laaeks 553**	**Laaes 556**	**Laes 559**
			
Laaers 560	**Laadrs 557**	**Laaers 700**	**Laaers 800**
			
Laaers	**Laaers**	**Laaers**	**Laaers**

STVA also uses Roco Car carrier, IPA Double-Deck Twin Car Carrier.

	
Roco Car carrier	**IPA Double-Deck Twin Car Carrier**

3.5.2.2. Closed Wagon: H class: special covered wagons



The H class[133] covered wagons are used for high-volume rail freight shipment, including finished vehicles. (A closed wagon is used for high-volume rail freight shipment. It is a completely closed unit with end doors and a full-width gangway at the inner coupling ends).

For instance, DB Schenker is using Hcceerrs 330 for finished vehicle logistics purposes. This wagon has 8 axles and two decks. The length of the upper deck is 52.5m and of the lower deck is 52.68m. The loading width of the upper deck is 2.74m and of the lower deck is 2.82m. The height of wagon is 4.7m and the average tare weight of the wagon is 65t. ARS Altmann uses Hccrrs for the transportation of cars.

UIC wagon classification code and DB-		Hcceerrs 330
Loading length	upper deck m	52,5
	lower deck m	52,68
Loading width	upper deck m	2,738
	lower deck m	2,810
Height of floor above TOR	at headstock m	1,15
	between the axles m	0,92
Loading height	upper deck m	min. 1,960/max. 2,36
	lower deck m	min. 1,74/max. 1,7
Height of wagon m		5,064
Number of axles		4
Distance between outer axles m		20
Length over buffers m		26,24
Average tare weight of wagon t		64,1
Load limits t		load limit is 48; lower deck: 24 upper deck 24
Special features		100 km/h when loaded; 120 km/h when empty
Companies using the wagons		DB

GEFCO uses a wagon, designated TAL 499, which is designed to cater for the trend towards higher and wider vehicles which is presenting “gauge” problems for traditional rolling stock. The 4-axle wagon has a length over all of 33m and can be adapted for the Iberian gauge for transports to/from Spain and Portugal.

133 http://en.wikipedia.org/wiki/Flat_wagon

			
Hcceerrs 330	**Hccrrs 4780**	**Hccrrss 23**	**Hccrrs 4780**

Explanation for the lower case letter used in combination with L and H types of wagons:[134]

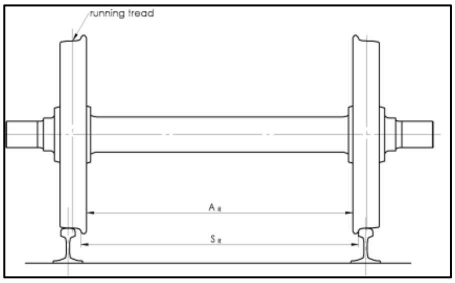
Extension	Class	Meaning
a	H, L	3 wheel sets
aa	H	$\geq$3 wheels sets
	L	$\geq$ 4 wheel sets
b	H	wagon with separate axles and of length 12–14 m, 70 m^3 volume, may be less for ferry boat wagons
	L	transporter for medium-sized containers
bb	H	wagon with separate axles and loading length of 14 m or more
c	H	door in front wall
	L	cradle
cc	H	door in end wall and interior equipment for the transportation of motor vehicles
d	H	floor trap
	L	for transportation of motor vehicles on one level
e	H	two levels
	L	double-decker wagon for motor vehicles
ee	H	more than 2 levels
f	H, L	Great Britain loading gauge, suitable for ferries and channel tunnel
ff	H, L	Great Britain loading gauge, suitable for channel tunnel only
fff	H, L	Great Britain loading gauge, suitable for ferries only
g	H	for grain
	L	for container transportation
i	H	opening side walls (sliding walls)
	L	fixed front wall, movable top cover
k	Laa, Haa	maximum load on class C route: $m < 40$ t
	H, L(a)	maximum load on class C route: $m < 20$ t
kk	H, Ha, L(a)	maximum load on class C route: 20 t $\leq m <$ 25 t
	Laa	maximum load on class C route: 40 t $\leq m <$ 50 t
l	H	with movable partitions (from 1 May 1994)
	L	no stakes
ll	H	with lockable partitions (from 1 May 1994)
m	H	loading length*14: $l < 9$ m
	Ha(a)	loading length: $l < 15$ m

[134] http://en.wikipedia.org/wiki/UIC_classification_of_goods_wagons

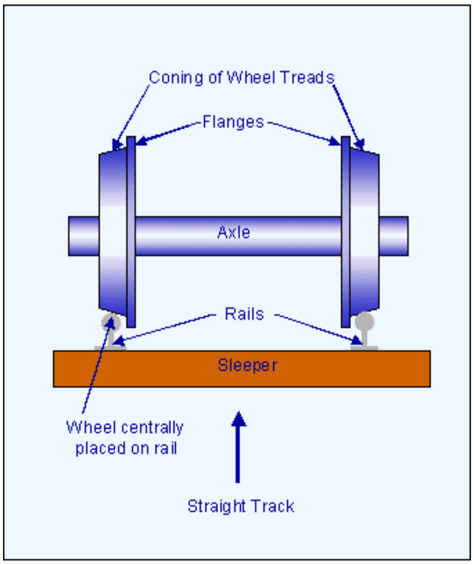
	L	loading length*14: 9 m ≤ l < 12 m
	La(a)	loading length: 18 m ≤ l < 22 m
mm	L	loading length*14: l < 9 m
	La(a)	loading length*14: l < 9 m
n	H	maximum load on class C route: m > 28 t
	L	maximum load on class C route: m > 30 t
	La	maximum load at limit of load C: m > 40 t
o	H	twin-axled with loading length under 12 m and more than 70 m^3 loading area
p	L	no end wall
q	H, L	electrical heating pipes for all permitted types of power
qq	H, L	electrical heating pipes and heating equipment for all permitted types of power
r	H, L	steam heating pipes
rr	H, L	steam heating pipes and equipment
s	H, L	permitted in trains up to 100 km/h
ss	H, L	permitted in trains up to 120 km/h
For wagons with country code 80: DB		
t	H	*Daberkow* transport protection equipment (to 30 April 1994)
	L	inside loading width at the ends under 2.45 m
tt	H	lockable partitions (to 30 April 1994)
u	H, L	steam heating pipes
v	H, L	electrical heating pipes for 1,000 or 1,500 volts
vv	H, L	electrical heating pipes and heating equipment for 1,000 or 1,500 volts
w	H	full spark protection covering
ww	H, L	spark protection plate to UIC standard 543
z	H	wagons for *Leig-Einheit* units
For wagons with country code 85: SBB		
t	H, L	line feeder (10 bar)
u	H	cooling system
v	H, L	electrical heating pipes 1000v 16⅔ ~
ww	H	spark protection plate to UIC standard 543
x	H	2-axled drum brake
	L	ACTS rotating frame
y	H	insulated
z	H	with 12-core UIC cable

3.5.3. Wagon Wheels and Axle Load

All rail wheels[135] have different diameters of the wheel running circle, which range from 550mm to 2,500mm. The wagon wheels have various diameters, such as: 630, 680, 730, 760, 840, 920 and 1000mm diameters. The most common wheels have a diameter of 980mm. The wheels[136] that are used for the wagons that transport cars are with 680mm.



Wheel tread diameter (mm)	Axle load (t)	Vehicle type	Areas of use
1 000	20	Goods wagon	DB
950	20	Passenger coach	DB
920	16; 18; 20; 22,5; 25; 30	Goods wagon	DB, ÖBB
900	30	Goods wagon	DB
850	20	Car transport	DB
840	18; 20	Goods wagon	DB, UK
760	16; 18	Locomotive transport	DB, SBB
730	16	Goods wagon	DB, SBB, IK, NL
680	14; 16	Car transporting wagon	DB, STVA,
630	14	Goods wagon	

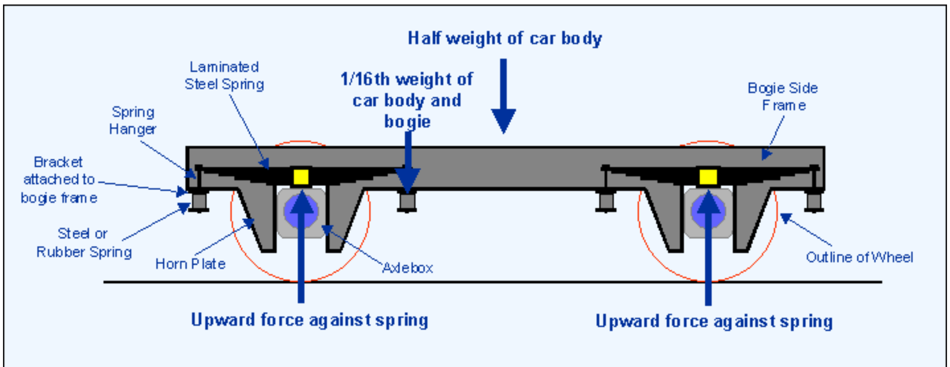


On railways, a given section of track is designed to a maximum axle load. The maximum axle load is related to the strength of the track, which is determined by the weight of the rails, the density of sleepers and fixtures, the train speeds, the amount of ballast, and the strength of bridges.

If the track is overloaded by trains that are too heavy, it can be destroyed in a short time. It is convenient for the steelworks that rails are made in a limited number of sizes, so that a perfect match of rail weight and axle load is rarely achieved.

There are light and heavy branch lines.

The absolute maximum axle load for railways is about 40 tonnes (39.4 long tons; 44.1 short tons), above which the rails start to be pulverised by the passage of trains.



Simplified Diagram of Plate Frame Bogie Suspension
Primary Suspension Only Shown

[135] http://en.wikipedia.org/wiki/Train_wheel
[136] http://www.railway-technical.com/whlbog.shtml

3.5.4. Weight and Length of a Train

In most European countries the allowed maximum length of train is between[137] 600m and 750m, though 600m is more common. However, all countries are moving towards 750m for main freight routes.

The iron trains that run from Rotterdam can have 4000 metric tonnes. The railway lines that have Russian gauge and using Russian designed equipment can be longer and heavier. These lines are available in Baltic States, there is one line in Poland and Slovakia. The route from Kiruna, Sweden to Luleå, Sweden and Narvik, Norway also sees longer and heavier iron ore trains. As for doublestacks, the line from the port of Helsinki, Finland to Tampere, Finland has clearances and sees limited operations of doublestacked containers (ISO marine boxes). These are the only doublestacks operated in Europe, but, the Dutch built the new Betuwe Route freight line out of the port of Rotterdam with clearances under the catenary for doublestacked marine containers.

In the former USSR countries (Baltic States, Belarus, Ukraine, Russian Federation, etc.) the length of train can be over a kilometre and weigh in at 6000t.

For the FVL companies it is very important to know the maximum allowed length of loaded train because a company can calculate how many cars can be transported per train and this number varies depending on the wagon type and its length. To give an example: if the allowed length is 740m, where the length of 1 engine is ca. 19m (normally two engines are needed, so the total length of two engines is roughly ca. 40m). 700m is available for wagons. There are 2 types of wagons with length of 27m and 32m. So, 25 wagons with length of 27m equals ca. 675m and 26 wagons is 702m. In a 700m train only 22 (21.9) wagons of 32m length can be used. However, in this calculation it is also crucial to take into account the capacity of each wagon, namely how many cars of the same brand can fit on a 27m wagon and on a 32m wagon. For some brands of cars it is more efficient to send 26 wagons each of 27m in length, in other cases 22 wagons of 32m in length.

[137] http://www.trainorders.com/discussion/read.php?17,1564189

4. Loading and Unloading Operations

One of the most important and at the same time very complex processes in finished vehicle logistic by rail is the loading or unloading of the cars. It is possible to say that there is one unified process for loading or unloading that is strictly observed by the companies who provide logistic services. However, there are many other small elements that differentiate these operations in different places. There are several factors that can influence this process and make loading and unloading different, such as length of the siding (whether train needs to be split or not), available facilities, closeness of the compounds where the cars need to be stored, etc.

Case study: *BLG in Bremerhaven*

Bremerhaven is a point where four modes of transport meet together, namely rail, road, river and sea transports. Yearly it handles approximately 2.2m. cars, which constitutes more than 6,000 cars per day. 90% of cars in Bremerhaven are transported by rail: approximately 25-30 trains arrive per day. This is what makes Bremerhaven one of the most important automotive port in Europe and a leading place in FVL by rail.

Regarding the rail network available in the port, it is one of the most elaborate rail systems that exist in any European port. The port can be accessed by rail from several sides. Inside the port there are 5 terminals where the loading or unloading is taking place, and 2 or 3 marshal/classification yards for shunting and storing the trains. One of the marshal yards is being extended. The construction of the new rail lines and branches are made by the ports authority, which owns the land of the port and is responsible for the infrastructure inside the port.

Each terminal has its own supervisor who is responsible for handling of cars from/on trains. He manages several teams, each team consisting of 2-4 people, for preparing the train for loading or unloading, another team consists of professional drivers who are responsible for driving cars on/off the wagons.

Before the process of unloading starts, the supervisor receives a document called the ‘Discharge window’ (*Entladefenster*) for each day with an indication of how many trains are expected that day, and at what time they will arrive. It also indicates their final destination, where they come from, slots, the number of wagons, the name of the locomotive that will bring wagons to the platform, the start and end times for the discharging, the name of a shunting locomotive that takes away the wagons, the hour of departure, the number of the train.

Another document that is dispatched to the supervisor is the list of wagons (*Wagenlist*). It contains information about the total number of wagons. This list also provides detailed information about each wagon, its number, wagon owner (*Wagoneinsteller*), the type of the wagon, destination, instruction how it has to be discharged, number of cars per wagon, their direction (‘front’ means towards locomotive), number of axles, the length of the wagon, tonnage, etc.

When a train arrives, it is placed by a shunting locomotive to the siding. Each train contains approximately 220 cars. Each wagon typically has the capacity to contain from 8 (4 per deck), 10 cars (5 per deck), or 12 cars (6 per deck) depending on the size of the cars. Depending on the type of wagon, whether it is closed (H-type) or open (L-type) preparatory work is differently organised. In the case of closed type of wagons, the first team prepares the wagons and cars inside for unloading. They open the gates between the wagons; connect the power/electricity supply to light the interior of the wagons and lifting the wagon ramps. If wagons’ gates and ramps are lifted up by the pneumatic facilities, they need to be connected to the air supply. The first team removes the lashings from the wheels of the cars, if necessary, and checks the cars for damage. (In some cases checks are done after discharge).

Regarding lashing, not all closed wagons contain lashings for the cars. In some new wagons designed for transportation of Mercedes or Porsches, lashings are not necessary. The reason why they are not needed is that the suspension is locked during the transportation and prevents the cars from moving.

In case of H-type wagons (used by ARS Altmann, DB Schenker), the roof of each wagon is lifted up which gives easy access for the cars. The lifting of the roof can be either electric or pneumatic. At the end of the train the ramp is attached to the wagons.

Once the wagons are prepared for unloading, the second team of professional drivers starts unloading of wagons. The team consists of 6-8 people who are transported by a bus to the places in the port where their work is needed.

All cars in the wagons shall be directed towards the ramp. There are cases when the cars were directed backwards to the ramp. In this case the whole train needed to be put in the reverse direction so that the cars are directed towards the ramp. It is very important to know beforehand the direction of the cars in the wagons in order to avoid mistakes which takes extra time and costs.

Unloading of the train starts from the upper deck. There are several accesses to the cars in the wagons, so that the drivers can reach the cars in the needed section of the train. When the unloading from the upper deck is finished, the unloading of the lower deck starts in the same way as it was done for the upper deck. When a car leaves the train a person scans its VIN number (Vehicle Identification Number), checking its departure place and destination. The scanning is done automatically and the data from each car is stored on the server. The same procedure is done during the loading of the cars on a train. Management of the terminal knows about each car when it arrives and when it leaves as well as its location in the compound.

When the train is completely unloaded, the loading procedure starts. When loading is over, the cars are lashed in the wagons by the first team and the ramps are removed from the train. Shunting locomotive removes the wagons from the siding and brings them to the marshalling yard to be prepared for departure from the port.

There is a practice in Bremerhaven to indicate the direction of the cars in the train by sticking an arrow on the side of the wagon.

After unloading each car from the train and before going to a compound for temporary storage, they pass through the damage control premises. When any damage is identified, it is immediately reported in the system and the car stops its journey.

There are two more parties that are important for the process, i.e. the planning department and the controlling department. One person is in permanent contact with the shunting companies and decides (based on the plan made by the planning department) which train should be shunted to which siding and when the wagons can be removed again. The person in the controlling department gets information about when the wagons are going to be ready (when all cars unloaded and wagons in transport mode) from the operation. Via radio communication he stays in contact with the people working at the wagons.

5. Key Players in the Rail Industry

In order to understand who is responsible for what in the rail industry, it is first necessary to understand how the rail freight industry operates.

There are various industry economic and safety regulators, such as the Office of Rail Regulation (ORR) in the UK which protect the interests of all rail users of the railway network. These bodies consider applications for freight train operator licences and consider track access agreements (slots in the rail network to run freight trains) and establish a list of track access agreement prices or conditions.

National rail networks are still often the property of the State and under the responsibility of an Infrastructure Manager (RFF, DB Netz, etc.) Some parts of the network are private to owned (private sidings, but also private small network like most of the Port properties).

Railways undertakings are the railway operating companies. Since the liberalization of the market, there are two types of RU: state-owned companies and private owned companies.

Logistic Service Providers (LSPs) often intermediate between shippers and Railways undertakings. FVL is a specific case inside the rail industry, because LSPs own the wagon fleets and offer complete services to their customers. In lots of industries, wagons are directly provided by RU or they are lease directly to the shipper (chemical industry).

Another stage in the rail freight operation is *rail freight interchanges*. There are three types of interchanges:

> *Private sidings*: these can be at a factory, works, warehouse or distribution depot, often owned or leased by the shipper or operator.
>
> *Large strategic rail freight interchanges*: capable of handling intermodal or conventional wagons – these strategic interchanges include other facilities such as wagon repair, fork-lift and mechanical handling, storage facilities, personnel hire and canteen facilities: sometimes known as a 'freight village'.
>
> *Smaller road/rail interchanges/ Intermodal compounds*: where the trans-shipment between road and rail takes place, for example, the transfer of containers.

5.1. Infrastructure Managers

After the implementation of Directive 1991/440/EC in all EU countries the entities in charge of the management of the rail infrastructure are separate from the companies operating rail transport services. This was done in order to give all the interested rail undertakings transparent and neutral access to use the rail network[138] for both international and national services so that the rail infrastructure was put at the disposal of any qualified transporter without discrimination.

Regarding pricing of the rail infrastructure and certification in respect of safety Directive 2001/14/EC makes provision for the Member States authorising granting of train paths not only to railway undertakings (RUs), but also to (authorised) applicants who want to have direct access.

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[138] http://www.uirr.com/en/road-rail-ct/players/infrastructure-managers.html

The infrastructure managers belong to a group called Rail Net Europe (RNE).[139] The main mission of this group is to co-ordinate the awarding of international train paths.

RNE was created in 2004 and it is a non-profit making association of a majority of European Rail Infrastructure Managers and Allocation Bodies (IMs/ABs) that aims at enabling fast and easy access to European rail and increasing the quality and efficiency of international rail traffic. RNE has 35 members who are working on harmonising conditions and procedures in the field of international rail infrastructure management for the benefit of the entire industry. It has four standing working groups and *ad-hoc* project groups that are co-ordinated by the RNE Joint Office, based in Vienna. In 2010 it received the mandate to become the service provider of choice and expert support provider for corridor organisations to develop methods, processes and operating tools. RNE endeavours to simplify, harmonise and optimise international rail processes, such as: Europe-wide timetabling, common marketing and sales approaches, co-operation between IMs in the field of operations, train information exchange in real time across borders, and after-sales services.

There are other associations of Infrastructure Managers, such as European Rail Infrastructure Managers (EIM), established in 2002. Their main mission is to provide a single voice to represent the interests of IMs vis-à-vis all relevant European institutions and stakeholders, help members develop their businesses through the sharing of experiences, and contribute through its members to the technical and safety activities of the European Rail Agency (ERA). Today its members cover 53% of European rail lines, 68% rail passengers and 42% of all rail freight within the EEA. In total, EIM counts 11 full members and 2 associate members in 11 countries.[140]

5.2. Rail Undertakings

The process of liberalisation in European railways implies that the *railway undertakings* receive more autonomy in their daily management. They become commercial enterprises with full responsibility.

At the same time the Member States need to take care that the measures of restructuring are applied at national level and they guarantee the transparency of relations between railway operation and administration of the railway infrastructure.

As a result of this process the railway undertakings enter the market as private enterprises. They levy charges relative to the distance, the composition of train, and other criteria (speed, axle load, etc.).[141]

Restructuring also means that trains are not stopped at national borders – this needs greater interoperability at technical level and a high level of maintenance of specific forms of co-operation between the operators of the rail services and the managers of the infrastructure. Some railway undertakings have made authorised co-operation agreements, for instance ÖBB (AT), DB (D), SNCF (F) and SNCB (B), etc. The Cargo divisions of certain companies have merged, for example Railion (DB Cargo, Railion Denmark, Railion Benelux). These alliances do not create new monopolies and do not infringe the rules of the competition.

The RUs who are responsible for taking the train in, out and for movements inside the last mile area are called *shunting operators*.

[139] http://www.rne.eu/
[140] http://www.europeanrailcongress.com/sponsors.php/European-Rail-Infrastructure-Managers-EIM-17/
[141] http://www.uirr.com/en/road-rail-ct/players/railway-undertakings.html

Shunting is a rail operation which includes the process of sorting items of rolling stock into complete train sets, or the reverse.

They provide their services either with their own locomotives and staff, or by a local service provider. It depends on the technical accessibility of the terminal tracks by long distance locomotives, availability of shunting service, quantity of trains and their timing over the day and the expected quantity of shunting operations on wagons.

5.3. Rail Operators. Responsibilities and Roles

In order to understand how FVL by rail operates, it is necessary first to identify the key players in the sector and to understand their tasks and responsibilities.

Several models of Rail Operators exist in Europe, depending mostly o the industry sector:

- Rolling stock managers or wagon owners: those companies are investing in wagon equipment and lease them directly to the shippers (e.g. chemical industry, building industry) or to logistics providers (e.g. FVL) who operate them. Most of the time the wagons are designed for special needs (dangerous goods, out of gauge transport, etc…).
- Some RUs are also rolling stock managers and provide the wagon and the traction to their customers.
- Combined transport operators
- Rail services providers: Freight services are provided by various companies that provide traction and rolling stock and in some cases also modal transfer and product loading/unloading facilities. FVL is one big exception in the family of rail services providers, because they operate their own transport scheme and sell a complete service (traction + wagon supply).

Service is therefore managed by the terminal operator entirely on its own or in co-ordination with the railway undertaking or a local shunting service provider.[142]

[142] http://www.intermodal-terminals.eu/content/e3/e18/e128/e235/2.2GoodPracticesManual-actions-shuntingservices2010-04-22_eng.pdf

6. EU Regulations, Initiatives and Projects for the Rail Transport Sector

6.1. Railway Noise – Wagon Brake Systems

Railway is considered to be the cleanest means of transportation with very little influence on the environment, except for its noise nuisance. According to EU Member State reports that were collected by the European Environmental Agency (EEA) in 2010, rail noise affects approximately 12m EU citizens in day time, with a noise exposure of about 55 dB(A) and approximately 9m people at night time, with noise exposure of about 50 dB(A). However, it is believed that the real figures are much higher, as the noise mapping initiative for rail noise mainly concentrated on the agglomerations with over 250,000 inhabitants and main railway lines with over 60,000 trains per year.[143]

6.1.1. Sources of Rail Noise

As identified by the European Commission in its study, there are three key sources of rail noise, i.e. engine noise, rolling noise and aerodynamic noise. The first two are of a great concern for freight trains and the last one is mainly of high speed trains. It was also highlighted that rail noise is mainly a problem of freight trains and trains that contain older wagons or engines, whereas rolling noise is generally higher from poor conditions and maintenance of rail wagons and rail infrastructure, interaction of which increase rail noise. Regarding engine noise, it is relevant mostly for trains with old engines running at lower speeds up to about 30 km/h. As for rolling noise it is the most intense at a speed of about 30 km/h and aerodynamic noise peaks at about 200 km/h. However, rolling noise affects all types of trains to different degrees.

6.1.2. Factors of Rail Noise

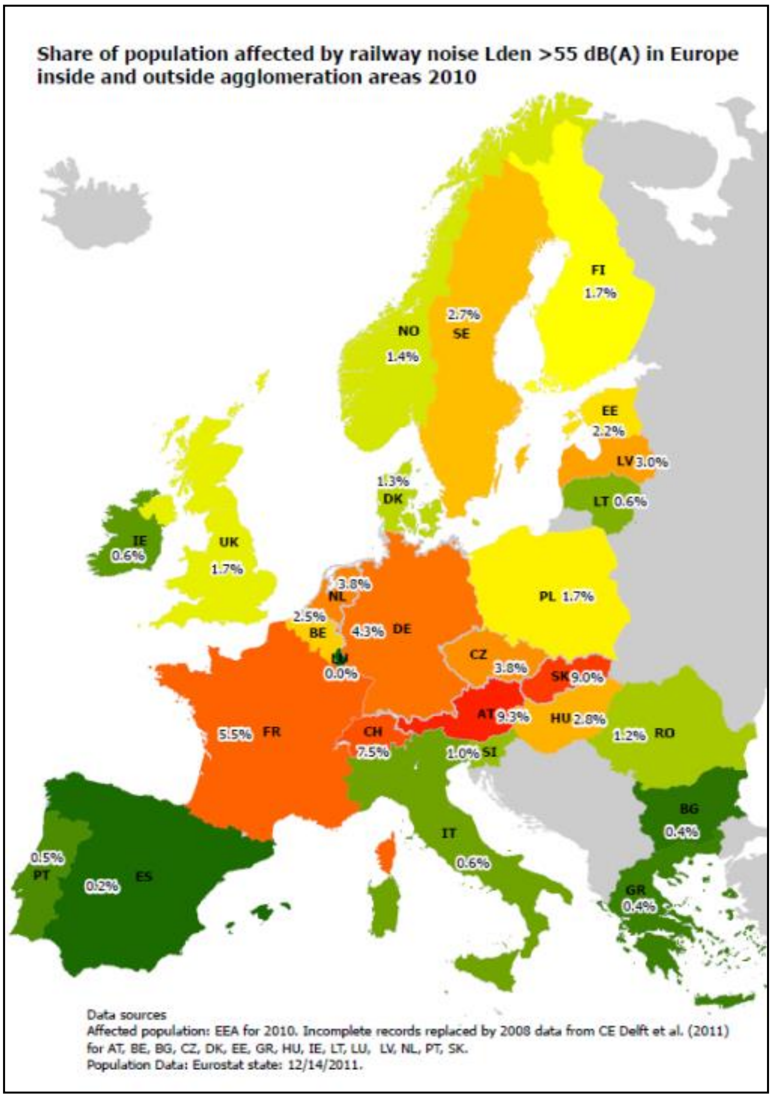
There are two factors that determine railway noise, the *technical* ones; depending on the type of wagon; brake system used; weight of the wagon; speed at which it is moving; condition of the tracks (poor track maintenance can cause rough rails which increase noise levels), and *geographic* ones depending on landscape that can intensify the noise (resonance issue); closeness to the urban areas (freight trains are mostly operated at night and they pass through highly populated areas); and infrastructure (noise from steel bridges, for instance).

6.1.3. Rail Noise in European Countries

Regarding rail noise in Europe, it differs from country to country. In Western Europe, including Italy, where the population density is very high and the volume of transit traffic is very intensive, railway noise is of concern in these areas. The map overleaf shows the share of affected people in each EU country according to the figures delivered by the states to EEA to fulfil the requirements of Directive 2002/49/EC.

There is strong pressure on the authority to decrease railway noise by imposing restrictions such as limit speed restriction, operational time or train cadence.

[143] U. Clause, C. Doll, F. J. Franklin, G. V. Franklin, H. Heinrichmeyer, J. Kochsiek, *Reducing Railway Noise Pollution*, European Commission, Directorate-General for Internal Policies, Policy Departmen B: Structural and Cohesion Policies, Transport and Tourism, Brussels, 2012, p. 11.



Regarding rail noise in different parts of Europe, Central Europe is marked by high levels of rail noise emitted mainly from rail freight transport. A proposed retrofit of the freight rolling stock is a difficult way to reduce noise. Many freight wagons have types of wheels which prevent composite brake blocks from being fitted due to overheating of the wheels. In Northern Countries (Denmark, Norway and Sweden) rail noise is less of a problem, because these countries have little freight traffic. In North-Eastern Europe (Latvia, Estonia and Lithuania), which are using a wide Russian gauge (1,524mm) rail noise is perceived as a smaller problem than in the Western regions of Europe. In the UK rail noise is not a big problem, because freight traffic is already made silent by using either composite brake blocks or disc brakes, which does not comply with the specification in the rest of Europe. In Spain and Portugal which are using the Iberian gauge (1,668mm), rail noise is not an acute problem, for these countries are excluded from cross border traffic with the rest of Europe because of their track gauge. As a result, no freight wagons from other parts of Europe can circulate in these countries, and vice versa. Spain and Portugal have chosen braking systems without European homologation. Therefore, they opted for an introduction of composite brake blocks, which do not comply with the requirements necessary for the rest of Europe. In other countries such as Greece, Cyprus or Malta, they have either little rail freight movement or no railways at all. Therefore, the issue of rail noise and its abatement is not discussed here. As can be seen from this analysis the problem of rail noise in the different zones of Europe varies. The most problematic is in Central and Western parts of Europe.

6.1.4. EU Legislative Framework for Rail Noise

Regarding EU legislation, a departure point in the EU regulation to reduce rail noise is the identification of rail noise sources. The principal source is the rail-wheel interaction and it concerns both passenger and freight transport. This issue is addressed in interoperable directives and corresponding technical specifications for interoperability (TSI)[144] under the responsibility of DG MOVE (Directorate-General for Mobility and

[144] TSI define the technical and operational standards which must be met in order to satisfy the ‘essential requirements’ (it includes safety, reliability and availability, health, environmental protection, technical compatibility and accessibility) and to ensure the ‘interoperability’ of the European railway system. They also set out expected performance levels. http://www.rssb.co.uk/standards-and-the-rail-industry/technical-specifications-for-interoperability

Transport) or specific directives such as the Environmental Noise Directive (END) under the responsibility of DG ENVI (Directorate-General Environment).

All EU legislation can be divided into two main groups, i.e. for high-speed traffic and conventional speed traffic. The Interoperability of the trans-European high-speed rail system, Directive 1996/48/EC has two corresponding TSIs:[145] TSI relating to high-speed rolling stock – Commission Decision 2002/735/EC[146] and TSI relating to high-speed railway infrastructures – Commission Decision 2002/732/EC.[147]

The Interoperability of the conventional Trans-European rail system - Directive 2001/16/EC[148] has three corresponding TSIs: Commission Decision 2004/446/EC of 29 April 2004 specifying the basic parameters of the 'Noise,' 'Freight Wagons' and 'Telematic applications for freight' Technical Specifications for Interoperability referred to in Directive 2001/16/EC; Directive 2004/50/EC[149] of 29 April 2004 amending Council Directive 96/48/EC150 and Directive 2001/16/EC; Commission Decision 2006/66/EC[151] adopted on 23 December 2005 concerning the technical specification for interoperability relating to the subsystem "rolling stock – noise."

The TSIs specify the noise limits both for new rolling stock and for renewed or upgraded rolling stock. There are different limits for various types of rolling stock (i.e. freight wagons, multiple units, locos, coaches) as well as for different operating situations (*i.e.* pass-by, stationary and interior noise). Limits for passing-by noise came into force in June 2006. It includes a noise emission limit for wagons with retrofitted braking systems.

The examples for limits values in the TSIs:[152]

Wagon type	Limit value
New freight wagons pass-by noise at 80 km/h	82-85 dB(A) depending on number of axles per length
Renewed freight wagons pass-by noise at 80 km/h	84-87 dB(A) depending on number of axles per length
Locomotive pass-by noise at 80 km/h	80 dB(A)
Stationary noise of locomotive	85 dB(A)
Stationary noise of Electric Multiple Unit (EMU)	75 dB(A)
Stationary noise of Diesel Multiple Unit (DMU)	68 dB(A)
Stationary noise for high speed trains	73 dB(A)
Noise level in high speed service	< 87 dB(A) at 250 km/h, <91 dB(A) at 300 km/h and <92 dB(A) at 320 km/h at 25m and height of 3.5m

The Environmental Noise Directive (END) 2002/49/EC[153] of 25 June 2002 (now replaced by Directive 2008/57/EC[154]) requires Member States to submit noise maps and action plans for its reduction.[155] New EU requirements concern mainly new and upgraded lines. Some countries (such as Switzerland and Italy) have

[145] http://ec.europa.eu/environment/noise/sources.htm
[146] http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=WTh1JnqpfP140w7snRLDQ2Dpv8l8Qbc2TynLQhgV1BcCGC9ZmHqq!1646143431?uri=CELEX:32002D0735
[147] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:245:0143:0279:EN:PDF
[148] http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32001L0016
[149] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:220:0040:0057:EN:PDF
[150] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0048:en:HTML
[151] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32006D0066
[152] *Railway Noise in Europe. A 2010 report on the state of the art*, 2010, Brussels, 2010, p. 8.
[153] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0049
[154] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0057
[155] http://ec.europa.eu/transport/modes/rail/interoperability/environment_en.htm

maximum allowed noise limits. The noise control measures most often implemented are noise barriers or insulated windows.[156] TSI requires new rolling stock to be quieter.[157]

In order to reduce rail noise at its source, the Commission adopted Decision 2006/66/EC.[158] It concerns the technical specification for interoperability relating to the noise of rolling stock (TSI Noise). It introduced for the first time noise limits for conventional rolling stock used in the EU. These limits apply to new and renewed rolling stock including freight wagons. New freight wagons have to be equipped with low-noise brake blocks reducing noise by up to 50%. This TSI was repealed by a new TSI Noise, Decision 2011/229/EU.[159] Noise of high-speed vehicles is covered by Commission Decision 2002/735/EC[160] on technical specification for interoperability relating to the rolling stock sub-system of the trans-European high-speed rail system.

However, taking into account a long life span of rolling stock, it will take several years before the overall noise emissions from freight transport can be reduced if no additional measures addressing the existing fleet are introduced. In this respect the European Commission has adopted a Communication on rail noise abatement measures addressing the existing fleet as part of the 'Greening Transport'[161] package where the concept of noise differentiated track access charges (NDTAC) was put forward as the main tool to help to reduce railway noise.

The purpose of NDTAC is to serve as an enticement to retrofit freight wagons with low noise brake blocks. It can be considered as the first step to internalisation of the cost of noise. This measure is reflected in Directive 2012/34/EC[162] ("recast of the first railway package").

The next step was adoption by the European Commission of a proposal for a Regulation establishing the Connecting Europe Facility (COM (2011) 665/3)[163] with €31.7bn earmarked for transport projects. It allowed to co-fund retrofitting of existing freight wagons with quieter brake blocks by the EU (proposed at max 20% of eligible costs). The proposal was adopted by the Parliament and the Council in 2013.

In 2013 the European Commission launched a study to analyse the "Effective reduction of noise generated by railway freight wagons in use in the European Union"[164] in order to explore all possibilities for noise reduction without hindering the competitive position of the railway sector.

The latest revision of TSI by the European Commission that was adopted on 26 October 2014 (1304/2014/EU) (known as Noise TSI - NOI) entered into force on 1 January 2015. The Regulation sets new measurements for pass-by, stationary and starting conditions for locos, coaches and wagons. According to NOI, the limit value for stationary noise for wagons is 65 dB; the pass-by limit is 83 dB.[165]

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156 https://www.google.be/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CCwQFjAC&url=http%3A%2F%2Fwww.uic.org%2Fdownload.php%2Fpublication%2F516E.pdf&ei=HZtTVNqvGse4OPvwgMgL&usg=AFQjCNH6F0FvgzAbry05_ZizIsWRGG9vAw&sig2=5yp5GgIqtL8zK2nN6Srk3Q&bvm=bv.78677474,d.ZWU&cad=rja
157 http://www.era.europa.eu/Document-Register/Documents/TSIs-chronology-201404.pdf
158 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32006D0066
159 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32011D0229
160 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002D0735
161 http://ec.europa.eu/transport/themes/strategies/2008_greening_transport_en.htm
162 http://ec.europa.eu/transport/modes/rail/packages/2008_en.htm
163 http://ec.europa.eu/transport/modes/rail/interoperability/doc/com_2011_665_3_-_connecting_europe_facility.pdf
164 http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2014_move_008_noise_reduction_rail_fraight_wagons_en.pdf
165 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2014_356_R_0006&qid=1418658301848&from=EN

6.1.5. EU National Legislation

Talking about various strategies and regulations on a national level, all EU countries have their own noise limit values for newly constructed railway wagons. Many countries use a *noise bonus* in their calculation schemes. Some of the countries have additional requirements in the legislation which concern rail noise limits. In Italy, Switzerland and Norway, for example, there are noise reception values for existing lines. Norway, for instance, have thresholds for indoor noise or for gardens. Some countries developed schemes for financing or incentives, e.g. Dutch legislation includes noise differentiated track access charges as an incentive; the Swiss government finances the noise abatement programme to promote public transport, it also has noise differentiated track access charges; in Italy this issue is solved through a fixed percentage of the infrastructure charges. Countries like Germany, France, Austria, Denmark or Sweden invest a large amount of money in various projects to decrease noise levels on existing lines.

One of the biggest concerns remains a decision of the Swiss government to ban cast-iron brake blocks by 1st January 2020. It will cause serious problems for rail freight traffic through or within Switzerland. It will most likely be negatively affected, with a massive impact not only on customers and foreign undertakings but also on Swiss railway companies which operate trains and foreign wagons. It is very unlikely that enough wagons and type of wagons will be equipped with composite brake blocks by 2020 in order to compose trains within, to, from and through Switzerland containing quieter wagons.[166]

6.1.6. Measurement of Rail Noise

It was agreed by the Working Group Railway Noise of the European Commission that railway noise can be described in terms of the daily average noise emission of the traffic flow, but also in more detail in terms of the noise characteristics of individual trains, vehicles and tracks. Most national legislation sets limits for daily noise levels, which for railways is based on calculations of noise emission from the traffic flow at a given location.[167]

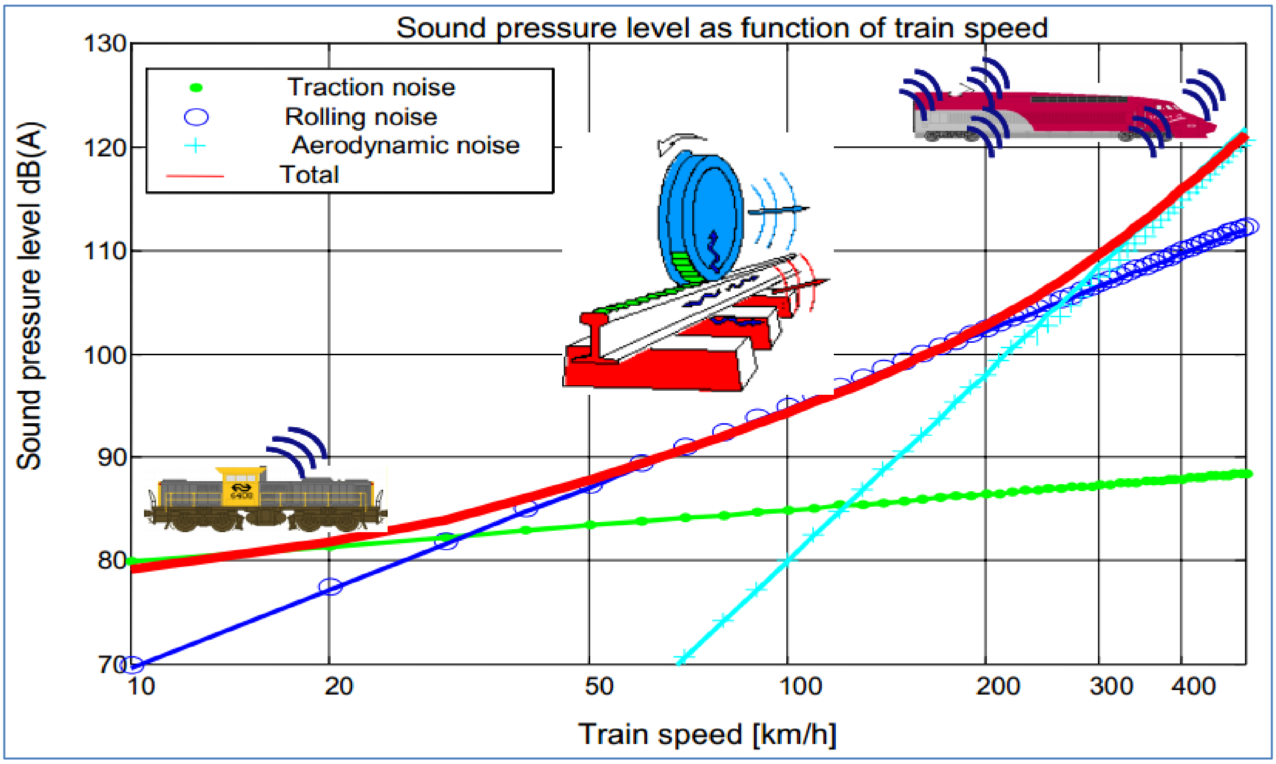
There are several factors that influence measurements of rail noise, among them is the management of the traffic flow, i.e. train types, composition, timetables and speeds. This is indispensable information to identify the daily noise emission, for the noise emission characteristics of individual trains and tracks are an important factor in reducing noise at the source. When noise emissions from an individual train are considered there are many major noise sources which need to be taken into account. There are several aspects which are relevant for the management of railway noise, these are pass-by situations, which includes constant speed, acceleration and deceleration, stationary noise (in and around stations), and shunting noise, which includes a variety of noise sources. Therefore, there are several major noise sources, which are relevant to any particular situation:

Noise situation	Pass-by noise: constant speed and acceleration/deceleration	Stationary noise	Shunting and other
Noise source	Rolling Traction/auxiliary Aerodynamic (squeal, impact, bridges)	Traction/auxiliary	Squeal/impact Traction/auxiliary Rolling

[166] http://www.uiprail.org/documents/20120829_NOISE_Swiss_Ban_CER_UIP_ERFA%20Position_final.pdf
[167] *Position Paper on the European strategies and priorities for railway noise abatement*, WG Railway Noise of the European Commission, Brussels, 2003, p. 14.

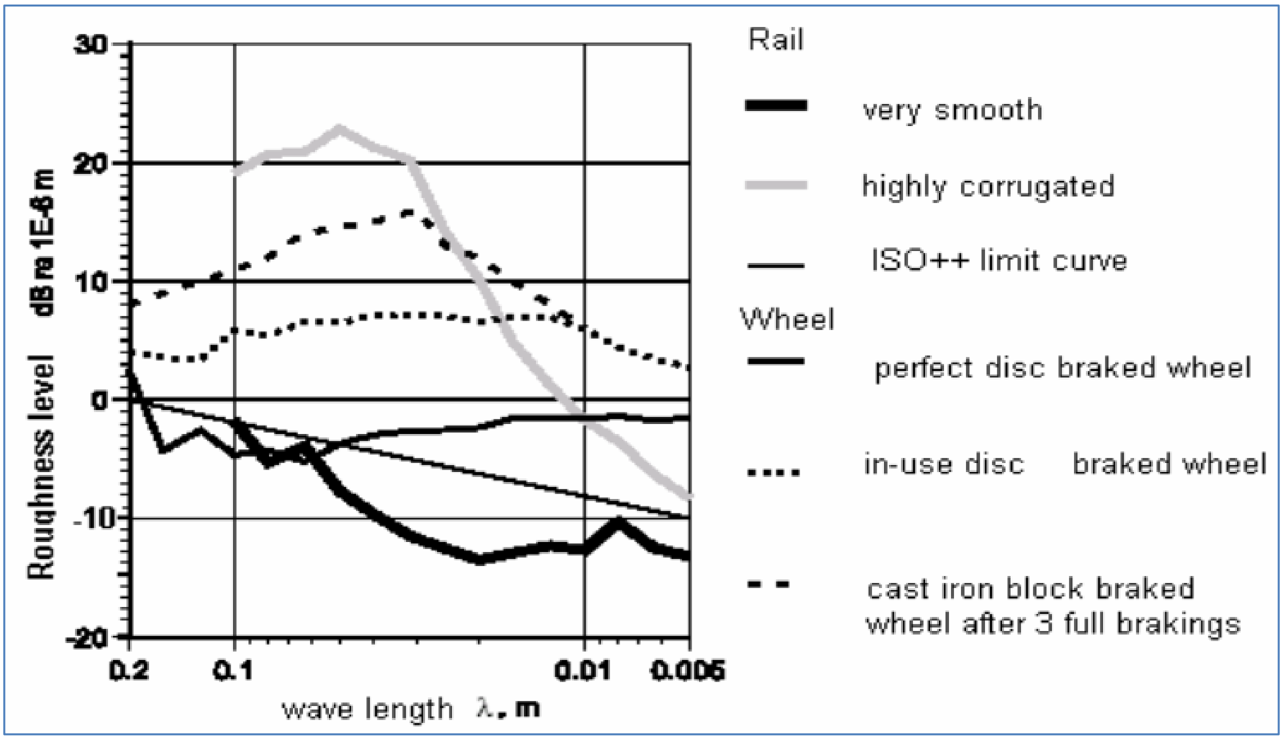
The predominant type of noise source for freight trains as it was identified by the research is rolling noise, which is of significant relevance, and noise from traction and auxiliary systems which is of somewhat less relevance. Aerodynamic noise for freight trains is not of significant importance.

Another important observation made during the research was that train speed is a major influence parameter for noise emission.[168] It was also identified that the noise due to traction and auxiliary systems (diesel units, electrically driven powertrains, cooling equipment, compressors) tends to be predominant at low speeds, up to around 60 km/h. Regarding wheel-rail rolling noise, it is dominant up to speeds around 200-300 km/h, after which aerodynamic noise takes over as a dominant factor. The transition speeds from traction noise to rolling noise and from rolling noise to aerodynamic noise depend entirely on the relative strength of these sources. The rolling noise, for example, depends strongly on the surface condition (roughness) of wheels and rails, whereas aerodynamic noise depends on the streamlining of the vehicle. The graph below clearly shows dependence of rail noise on the speed at which the train is moving.



Another important factor that influences rail noise is surface roughness levels of rail and wheels even. As it was noticed there is a significant increase in roughness levels between smooth and corrugated rails. More corrugated rails increase rail noise. The difference between extreme situations can be as much as +20 dB(A).

[168] *Position Paper on the European strategies and priorities for railway noise abatement*, pp. 16-17.



It was identified that after a number years when the rails have been acoustically ground, the rail noise increases and it depends on the vehicle type in use on the track following the grinding. For the quietest wagons, which use disc brakes with smoother wheels, the increase is 0.9 dB(A)/year. For cast iron braked freight wagons it is 3 times less for the same period of time.[169]

6.1.7. Solutions to Reduce Rail Noise

In order to reduce rail noise and implement noise control measures, it is important first to locate the noise source areas and then the parameters that influence them.

There are three main approaches in identification of the areas of rail noise. The first one focusses *at the source* where it is emitted. It is caused by small irregularities on both the wheel and the track in the contact area between the two (rolling noise). In this case the reduction of noise can be achieved by either reducing this roughness and/or preventing it, which is achieved by improving the contact surface between the wheel and the rail. The second approach concentrates on *the area between the source and neighbouring buildings*. One of the solutions for this is to diminish noise by installing noise barriers. The third approach focuses on *the areas near the neighbouring buildings*. In this case noise can be reduced in the vicinity of the inhabitant, on the building itself by insulating windows or with façade insulation.

To reduce the level of rail noise various *active* and *passive measures* were developed. A good example of passive measures is protecting walls and insulating windows. Concerning the active measures, many solutions were proposed and developed such as special acoustic grinding, disk brakes, composite brake blocks, wheel-tuned absorbers, aerodynamically optimised pantographs, rail dampers, etc.

During many years of research several technical possibilities were developed to control railway noise emissions. These solutions do not include rail maintenance or additional methods to be used for specific

[169] *Position Paper on the European strategies and priorities for railway noise abatement*, pp. 17-18.

situations (*e.g.* friction modifiers against curve squeal or absorbers against steel bridge noise). As indicated above poor maintenance may also lead to noise increase of up to 20 dB. Here are some methods for reduction of rail noise which are enumerated in the table below:[170]

Noise reduction method	Source of noise	Effect	Impact	Costs	Comments
Retrofitting with K-blocks		8 – 10 dB	Network		K-blocks are homologated yet require adaptation of the braking system
Retrofitting with LL-blocks		8 – 10 dB	Network		LL-brake blocks are only provisionally homologated
General grinding of bad track	Rolling noise	10 – 12 dB (A) (up to 20 dB (A) at very bad track)	Local	Established in normal maintenance	
Wheel tuned-absorbers	Wheel-noise	2 – 7 dB	Network	3,000 – 8,000 € per wheel (24,000 – 64,000 per 4-axle wagon)	Effect strongly dependent on local conditions. Wheel maintenance difficulties may occur
Disc brakes	Rolling noise	10 dB	Network	Meanwhile mostly established in passenger cars	
Bogie Shrouds together with low height barriers	Wheel-noise	8 – 10 dB	Local		
Rail absorbers and dampers	Rail noise	3 – 7 dB dB(A) (mostly around 3 dB(A) attended)	Local	300 – 400 € per metre (two rails)	Track maintenance difficulties may occur, effect strongly dependent on local conditions, not homologated in most countries
Acoustic rail grinding	Rolling noise	1 – 4 dB	Local		Effect strongly dependent on local rail roughness conditions, smooth wheels are a precondition for effect
Slab tracks	Rolling noise	5 dB (A)	Local		
Rail pads	Rail noise	Up to 20 dB(A) depending on local conditions	Local		

[170] *Railway Noise in Europe. A 2010 report on the state of the art*, p. 12.

Noise reduction method	Source of noise	Effect	Impact	Costs	Comments
Shielding of pantograph	High speed trains	5 – 10 dB(A)	Global but only at high speed from 200 km/h up		
Noise barriers	All sources	5 – 15 dB	Local	1,000 €/m	Effect dependent on height and local geography, negative effect on landscape, influence on railway maintenance procedures
Barriers 3-4 metre high	All sources	15 dB(A)	Local	1,350 €/m (3 metres high) 1,700 €/m (4 metres high)	
Noise insulated windows	All sources	10 – 30 dB	In house only	3,000 – 8,000 € per house (4 windows)	Effect is only achieved when windows are closed

6.1.7.1. Wheel noise and vibration absorbers

Noise arises through wheel-on-rail contact, on the one hand as a result of the rolling and microscopic sliding movements by the wheels on the rails and, on the other hand, through intensive slipping and sliding in tight curves. Wheel and rail roughness is the main source of noise. In most cases rail roughness is a result of the mechanic movement of wheels on rails and the corrugation process which increase noise level by 20 dB.[171] For both cases wheel vibration absorbers were developed to absorb and dissipate the vibration energy. There are two technical approaches in tackling wheel noise and vibrations, namely *radial vibration absorbers* are

Ring absorber

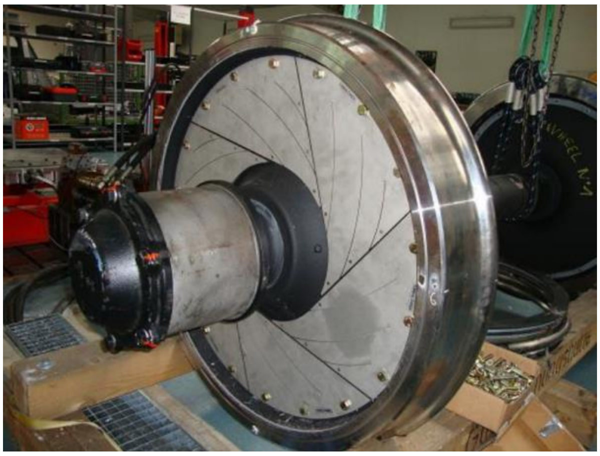


Plate absorber

[171] U. Clause, C. Doll, F. J. Franklin, G. V. Franklin, H. Heinrichmeyer, J. Kochsiek, *Reducing Railway Noise Pollution*, European Commission, Directorate-General for Internal Policies, Policy Departmen B: Structural and Cohesion Policies, Transport and Tourism, Brussels, 2012, p. 53.

designed to attenuate rolling noise and *axial vibration absorbers* which are mainly to eradicate screeching noises in tight curves, particularly in local, short-distance traffic applications.[172]

Ring damper and perforated wheel

The installation of the absorbers requires special preparation of the wheels. There are also other types of wheel absorbers,[173] such as *constrained-layer absorbers* which are mounted directly on the wheel web. Other designs include *mass-spring systems* that are tuned to particular frequencies. Using resilient materials with high damping coefficient, these absorbers also introduce some damping beyond their tuning frequency. A further evolution of this absorber type is the *multi-layer damper* involving sheets of rubber and steel of different stiffness and mass, leading to a broadband effect. Besides dispersion of energy in a resilient material, dry friction can add damping. This principle is exploited using *friction rings* that are clamped to the inner side of the wheel rim. It was also proved over time that perforation of wheels is ineffective in reducing rail noise and vibrations from wheels significantly. However *wheel web shields* proved to be efficient in reduction of noise by up to 9 dB.

Wheel web shields

To avoid surface curve squeal noise, design solutions were proposed which allow wheels to roll tension free through the curve. It was achieved by using independent wheels instead of wheel sets. Due to missing centering mechanism of independent wheels on straight track section, the wear of the wheels is higher than with wheel sets. With radial steering wheel sets, the minimal curve radius, which a wheel set can roll through tension free, can be reduced. This design solution for the wheel sets reduced curve squeal noise.[174]

6.1.7.2. Tuned rail vibration absorbers

Rail vibration absorbers are resonant mechanical elements that are attached to the rail base and web to absorb vibration energy and reduce noise radiation by the rail. Theses absorbers can consist of multiple elements that can be tuned to a number of frequencies.[175] Vibration absorbers may be impractical on ballasted track unless they can be positioned clear of the ballast to maintain electrical isolation. If this is not the case, piling the ballast above the rail base should provide substantial absorption without vibration absorbers. They are effective where the track exhibits little damping, *i.e.* at ballasted track with concrete cross ties, resilient rail pads, and

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[172] http://www.bochumer-verein.de/uk/products/wheel-vibration-absorbers.html

[173] https://hal.archives-ouvertes.fr/hal-00810782/document

[174] B. Schulte-Werning, D. Thompson, P.-E. Gautier, C. Hanson, B. Hemsworth, J. Nelson, T. Maeda, P. de Vos (eds.), *Noise and Vibration Mitigation for Rail Transportation Systems. Proceedings of the 9th International Workshop on Railway Noise, Munich, Germany, 4-8 September 2007,* in Note on Numerical Fluids Machanics and Multidisciplinary Design (vol. 99), Berlin, 2008, pp. 407-408.

[175] https://books.google.be/books?id=04z0Lw1qKiIC&pg=SA9-PA31&lpg=SA9-PA31&dq=rail+track+absorbers&source=bl&ots=rOakYY0nzW&sig=WzoL7GZMY58ADCrS1Pa6tcUbBr8&hl=en&sa=X&ei=XCvrVIO3N4L6UsnzgfAC&ved=0CDcQ6AEwBQ#v=onepage&q=rail%20track%20absorbers&f=false

clips or at direct fixation track. Research shows that reduction of noise with vibration absorption can be reduced by about 3 to 5 dB at band frequencies between 300 and 2,000 Hz for 11km/h on tangent track with absorbers mounted on each rail, one between each rail fastener. It was also proved that the quantitative noise reduction attributed to rail vibration absorber may be nil where wheel and vehicle auxiliary equipment dominate the wayside noise. Rail vibration absorbers might be placed on the rails with chronic corrugation at curves or another problematic section of track. A major disadvantage of rail vibration absorbers is increased maintenance costs related to clips, nuts, and bolts required to clamp the absorbers to the rail. Water retention and possible corrosion is also of concern. As for the cost of rail vibration absorbers, it may be compared with that of resilient direct fixation fasteners.

6.1.7.3. Rail Vibration Dampers

Rail vibration dampers are elastomer pads or sheets that bear against the rail flange, web, or both and some types also have a part under the rail. They are placed on the rail at periodic distances, usually between every sleeper. This is a continuous rail damper, which is placed along the whole length of the rail.[176] Rail vibration dampers do not have to be tuned to specific frequencies, unlike rail vibration absorbers, and they do not have a vibration mass. They are used to control high-frequency distortional mode resonances of the rail, including specifically the base and web. They are proven to be effective in controlling the bending resonances of the rail, especially the pinned-pinned mode. Similar to vibration absorbers, the quantitative noise reduction attributed to rail vibration dampers may be nil if the wheel-radiated noise and vehicle auxiliary equipment noise dominate the wayside noise. They are mainly used in reducing the perception of noise and improving the acceptance of transit by the public. They are also good for controlling rail corrugation, with obvious long-term cost benefits.

[176] E. Scorssa-Romano, J. Oertli, Rail Dampers, *Acoustic Rail Grinding*, *Low Height Noise Barriers*, Bern, 2012, p. 10.

The disadvantages of rail vibration dampers include the obstruction of the rails for inspection purposes. They are most effective in dry areas with little moisture or sufficient drainage to avoid significant corrosion. If dampers collect water against the rail and promote corrosion, they are ineffective.

There are several manufacturers of rail dampers, using different construction principles with slightly different functioning mechanisms. The most commonly used dampers are the products of TAT (CORUS) and Schrey & Veith, Vossloh and STRAIL, Edilon and Tiflex (for CDM dampers).

CDM-ABSO-RAIL system designed to damp the 'pin-pin'resonance peak in balasted

6.1.7.4. Acoustic rail grinding

A smooth rail is an important element in reducing railway noise. Rail grinding aims at achieving a smooth rail. Regular maintenance grinding is performed to remove corrugation and to restore the transverse profile of the rail. For acoustical roughness to be removed as well a special procedure called 'acoustic grinding' must be used, usually undertaken separately from regular grinding. It is important to keep in mind that the roughness (corrugation) grows with time, thus noise reduction effects due to acoustic grinding are limited in time. The acoustic grinding consists of two steps, namely the monitoring of the roughness (acoustical) and the grinding itself which must be repeated as soon as the roughness reaches a critical value. Maximum effect of grinding will last between 2 to 4 weeks. The monitoring procedure for corrugation is performed with a diagnostic train. In the direct method a small device rolls on the surface of the rail and measures all irregularities. This a slow but precise method, used for short distances. In the indirect method roughness is either calculated based on noise measurements or on axle acceleration. These methods are less precise, but because they can be mounted on a moving train they are suitable for network wide measurements.[177] In general grinding can reduce noise level by 10-12 dB and special acoustic grinding can achieve a further 3-4 dB reduction.[178]

Only two countries in Europe, Germany and the Netherlands have implemented acoustic rail grinding procedures. In Germany the procedure allows a legal noise reduction of 3 dB, regardless of whether this is achieved in practice or not while in the Netherlands specific noise reduction aims are defined.[179]

6.1.7.5. Noise barriers

It is well known that ballasted track produces about 5 dB less wayside noise than direct fixation track due to the sound absorption provided by the ballast and differences in the track support characteristics. Acoustic absorber or glass-fiber panels placed very close to the rail may reduce noise by ca. 3 dB when installed on

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[177] E. Scorssa-Romano, J. Oertli, Rail Dampers, *Acoustic Rail Grinding*, *Low Height Noise Barriers*, pp. 25-26.
[178] *Reducing Railway Noise Pollution*, p. 54.
[179] E. Scorssa-Romano, J. Oertli, Rail Dampers, *Acoustic Rail Grinding*, *Low Height Noise Barriers*, p. 3.

direct fixation track. These panels have no effect on ballasted track because the ballast already provides substantial acoustic absorption.[180]

There is another type of noise barriers, called '*low height noise barrier*.' These barriers are normally placed closer to the railway and have a lower height than normal. Normal barriers are usually constructed at a distance of about 4 m from the rail axis and have a height which varies between 1.5 m to 4 m above the railhead.[181] The low height barriers are installed at about 1.70 m distance from the axis of the nearest track and have a height of about 0.5 m to 1m. One of the main disadvantages of low height barriers is that they lose their efficiency when they are installed in a place with many parallel tracks. It will work only for the closest one, but not for the tracks further from the barrier. The problem can be solved when there is sufficient space to place low height barriers between the tracks, then they are more efficient than the higher ones. However this increases instalment costs. The average of the noise reduction of a low height barrier is between 5 and 11 dB, which can be increased by covering the wheels. In this case the total noise reduction then depends on the gap between the shroud and the low height barrier. There are some difficulties with low height barriers, namely, that even with the small foundation there may be conflict with drainage and certain construction elements close to the track. It also makes maintenance more difficult and time consuming. Another problem can occur in the case of accident, for instance it will increase evacuation time. They also cause an obstruction for the staff working on the rail track. It is a difficult obstacle to cross in case of a passing train. Regarding the cost, they can be the same as for normal height barriers if low height barriers are required between tracks.

[180] https://books.google.be/books?id=04z0Lw1qKiIC&pg=SA9-PA31&lpg=SA9-PA31&dq=rail+track+absorbers&source=bl&ots=rOakYY0nzW&sig=WzoL7GZMY58ADCrS1Pa6tcUbBr8&hl=en&sa=X&ei=XCvrVIO3N4L6UsnzgfAC&ved=0CDcQ6AEwBQ#v=onepage&q=rail%20track%20absorbers&f=false

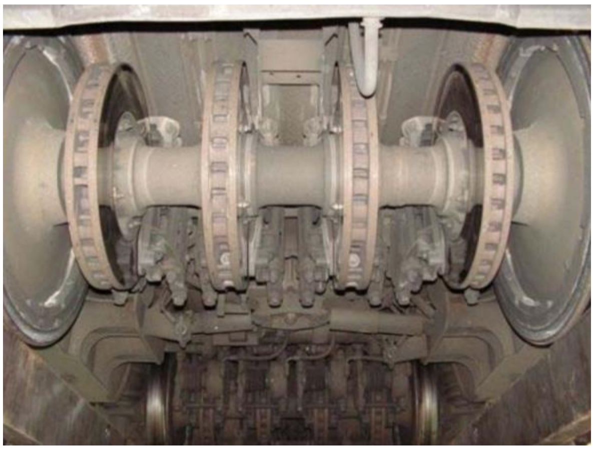
[181] E. Scorssa-Romano, J. Oertli, Rail Dampers, *Acoustic Rail Grinding*, *Low Height Noise Barriers*, pp. 29-31.

6.1.7.6. Noise insulated windows

To reduce rail noise pollution, passive measures at the place of disturbance can be distinguished from active measures at the noise source. The most important passive methods used to diminish the impact of rail noise on the environment are noise protection walls and insulating windows. In densely populated areas with high frequencies of trains, noise protection walls or insulating windows are considered to be the best solutions. Their potential to reduce noise is between 10 to 30 dB.[182] This is the most effective method to diminish rail noise, but works only on a limited area.

6.1.8. Wagon Block Brake Systems

The most common brakes that are used in European freight wagons are *cast-iron brake blocks*, also called *tread brakes*. With time these brakes are proven to roughen the wheel surface and induce corrugation in the wheels. All this increases the noise level very significantly. There is another type of brake which is used mainly in passenger wagons which is about 8 dB quieter than iron-cast brakes. These are *disk brake blocks*. The difference between both is that with tread brakes, the brake block presses against the wheel directly on the running surface (the tread), *i.e.* the wheel surface which is in contact with the rail; whereas with disc brakes an extra disc is placed on the axle and brake blocks press against this to brake the wagon. Because tread brakes damage the wheel, the running surface becomes rough and can develop out-of-roundness, increasing the rolling noise. Disc brakes are also very expensive and can be introduced only on new freight wagons. Their retrofitting on old wagons is also very expensive as the whole bogie needs to be changed.



Iron brake blocks vs. disc brake blocks

There are other possibilities for retrofitting existing wagons with low-noise replacements for cast-iron brake blocks. A solution was found in composite brake blocks with friction characteristics similar to cast-iron brake blocks, and suitable for retrofit. They are called ‘LL-blocks.’ ‘K-blocks’ are also composite brake blocks and are used in new designs.[183] The difference between both lies in the variation in the co-efficient of friction at different speeds for different brake blocks. K-blocks are already available and the homologation of LL-blocks is in progress. LL-blocks simulate the braking performance of cast-iron brake blocks and only minor adaptations of the braking system are required.

[182] E. Scorssa-Romano, J. Oertli, Rail Dampers, *Acoustic Rail Grinding, Low Height Noise Barriers*, p. 68.
[183] *Ibid*., pp. 25-26.

There were many scientific projects conducted that analysed both retrofitting of freight wagons with K- and LL-blocks shown below. It has been proven that total noise reduction potential is around 8-10 dB for both K- and LL-blocks, yet K-blocks require adaptation of the braking system. Comparing this with other methods to reduce rail noise, overall wheel, track and acoustic absorbers can reach a noise reduction between 1-3 dB, noise barriers by 5-15 dB, composite brake blocks by 10 dB and noise insulated windows by 10-30 dB.

Several EU countries provide incentives to promote retrofitting with new composite brake blocks. For instance, Switzerland gives subsidies for retrofitting of the freight fleet in addition to using noise differentiated track access charges. The Netherlands have also introduced noise differentiated track charges. The biggest difficulties appear with homologation of the LL-brake block which requires appropriate funding and suitable schemes so that the railway sector is not harmed.

6.1.8.1. K-brake Blocks

K-brake blocks have a higher co-efficient of friction (2.5 times higher) than that of cast-iron brake blocks, as previously mentioned. This type of brake requires a complex technical modification of a vehicle's brake system. The whole braking system has to be changed and recalibrated.

Regarding the cost of retrofitting with K-brake blocks on the wagons: there are several options for performing this change, yet all these changes involve relatively high up-front costs. Additional costs are generated by homologation of the whole wagon after the retrofitting. In their turn high up-front costs lead to higher uncertainty with regard to the return on investment and might make it unviable. There are additional costs as the wagon cannot be used during the retrofitting process. However, these costs can be reduced when the retrofitting is done at the same time as routine maintenance (every 6-7 years).

K-brake blocks are used only for twagon wheels with a diameter of 920, 840, 760, and 730mm, but not smaller. It was proven that the K-brake blocks destroy the surface of the wagon wheel very quickly. This increases the cost of using this type of brakes.

6.1.8.2. LL-brake Blocks

LL-brake blocks (short for "Low noise, Low friction")[184] are composite or sintered blocks, like K-brake blocks, yet they differ essentially from them. They do not damage the surface of the wheels and they have approximately 10 dB noise reduction potential which means a 50% decrease of noise. They do not usually require the technical modification of the wagons, which implies simpler retrofitting. For some wagons an additional specific valve is needed. There are no fixed retrofitting costs apart from time and effort plus opportunity costs. This type of brake block has a longer life time, yet imposes higher wear and tear costs on the wheels. Thus, the costs per axle-km are higher for LL-blocks.

[184] http://www.dbschenker.com/ho-en/news_media/press/news/4083560/whisper_brakes_.html?start=0&itemsPerPage=25

LL brake blocks have a co-efficient of friction similar to that of cast-iron brake blocks. They can replace cast-iron blocks on existing wagons without requiring major modification.

Retrofitting wagons in the existing fleet with the K-brake block, however, requires extensive modifications to the vehicle's brake system, followed by recertification of the brake system for each type of car. Replacing the cast-iron brake blocks of freight cars of the existing fleet with the newly approved LL-brake blocks, in contrast, is possible with no costly modifications required; only the brake blocks themselves are replaced. The costs for retrofitting with LL-brake blocks amount to around €1,700 per wagon, which is approximately one third of the sum required to retrofit wagons of the existing fleet with K-brake blocks.[185]

The LL-brake blocks can be used with wagon wheels ranging from 760 to 920mm, but it is not allowed by the ERA to be used with wheels that have a diameter of 680mm, which are typical for wagons that transport cars. There are two companies in Europe that produce LL-brake blocks: Becorit[186] and Honeywell.[187] Furthermore, their authorisation is still pending and a full life-cycle analysis has not yet been done.[188]

Since the life span of a wagon is approximately 40 years there has not been enough time to test how the LL-brake blocks influence the wheels and whole braking system over their life. To assess the effect of LL-brake blocks on wheels a consortium of brake manufacturers and wagon operators was established which launched the EuropeTrain project. The main idea of this project was to have a real train travelling around Europe to speed up testing of LL-blocks. This test has already shown that the wheels' equivalent conicity increases over time, affecting the dynamic stability of the wagon.

6.2. ECM Certification

The Railway Safety Directive 2004/49/EC, which was amended by Directive 2008/110/EC, established an *Entity in Charge of Maintenance* (ECM). ECM requires that all wagons assigned to it in the *National Vehicle Register* (NVR) are serviced in accordance with the regulations in force. The Directive specifies that railway traffic providers, infrastructure operators or vehicle owners can assume the function of ECMs. Notwithstanding the responsibility of rail traffic providers and infrastructure operators for safe operation of a train, ECM provides for a system guaranteeing that the vehicles are in a safe operating state. The certification of ECM, according to the Regulation EU/445/2011,[189] provides evidence of responsibility and traceability of the maintenance undertaken on freight wagons. This regulation also aims at ensuring consistency of ECM

185 http://www.dbschenker.com/ho-en/news_media/press/news/4083560/whisper_brakes_.html?start=0&itemsPerPage=25
186 http://www.becorit.de/
187 http://honeywell.com/Pages/Home.aspx
188 http://www.uiprail.org/documents/20120829_NOISE_Swiss_Ban_CER_UIP_ERFA%20Position_final.pdf
189 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:122:0022:0046:EN:PDF

requirements[190] throughout the European Union and in all OTIF (Intergovernmental Organisation for International Carriage by Rail) Member States. As indicated in the regulation, all Entities in Charge of Maintenance for freight wagons using the EU and OTIF railway network must obtain certification.

The *certification of maintenance workshop* (MW)[191] sets a certification process that ensures a transparent and structured management system for all workshops and helps to reduce the burden and duplication of controls and/or audits across the rail sector. Therefore, all of the freight wagon maintenance competent authorities and workshops need certification as evidence that they have implemented a maintenance system and that this implementation is performed according to the requirements of Annex III of the Commission Regulation 2011/445/EC[192] and ERA Safety Units. These facilities have to submit an application in line with Annex IV of the Regulation 2011/445/EG to the accredited certification body. After proofing the specific, complete records the certifier has to complete the certification within four months.[193]

There are other standards, such as ISO 9001: 2008,[194] SMS railway safety according to EU Directive 2004/49/EC[195] or, for instance, the Railway Act §39 in Austria, EN 13816 'Transport – Logistics and services – Public passenger transport – Service quality definition, targeting and measurement.'[196] Quality Austria is accredited as a certification body for ECM since 12.12.2012 and is listed as ECM Certification Body at ERA in the ERADISD database.

There are several certification schemes which outline how to conduct the certification activities. The ERA has launched the *Network on Co-operation of Certification bodies* to facilitate the harmonised implementation of the accreditation and certification processes. In an application for an ECM certificate the Certification body assesses the ability to manage maintenance activities and to deliver the operational functions of maintenance either by itself or through contracts with other bodies (maintenance workshops, charged with delivering these functions or parts of these functions).[197] The ECM certificate is valid for 5 years.

A railway operator can request information for operation at purposes on the maintenance of a freight wagon. The entity in charge of the maintenance of the freight wagon shall respond to such requests either directly or through other contracting parties. An entity in charge of maintenance has to have procedures to establish, identify, supply, register and keep available the right equipment which permit it to deliver maintenance services in conformity with the orders and other applicable specifications. Railway freight transport operators or IMs have to ensure the control of all risks related to its activity, including the use of such wagons. RU should rely on contractual arrangements involving entities in charge of maintenance for all wagons it operates. The entity

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[190] http://www.bureauveritas.com/wps/wcm/connect/bv_com/group/services+sheet/certification+of+entities+in+charge+of+maintenance

[191] http://www.era.europa.eu/Core-Activities/Safety/Regulatory-Framework/Pages/Certification-of-entities-in-charge-of-maintenance.aspx

[192] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2011.122.01.0022.01.ENG

[193] http://www.qualityaustria.com/index.php?id=3596&L=1

[194] http://www.iso.org/iso/catalogue_detail?csnumber=46486

[195] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:220:0016:0039:EN:PDF

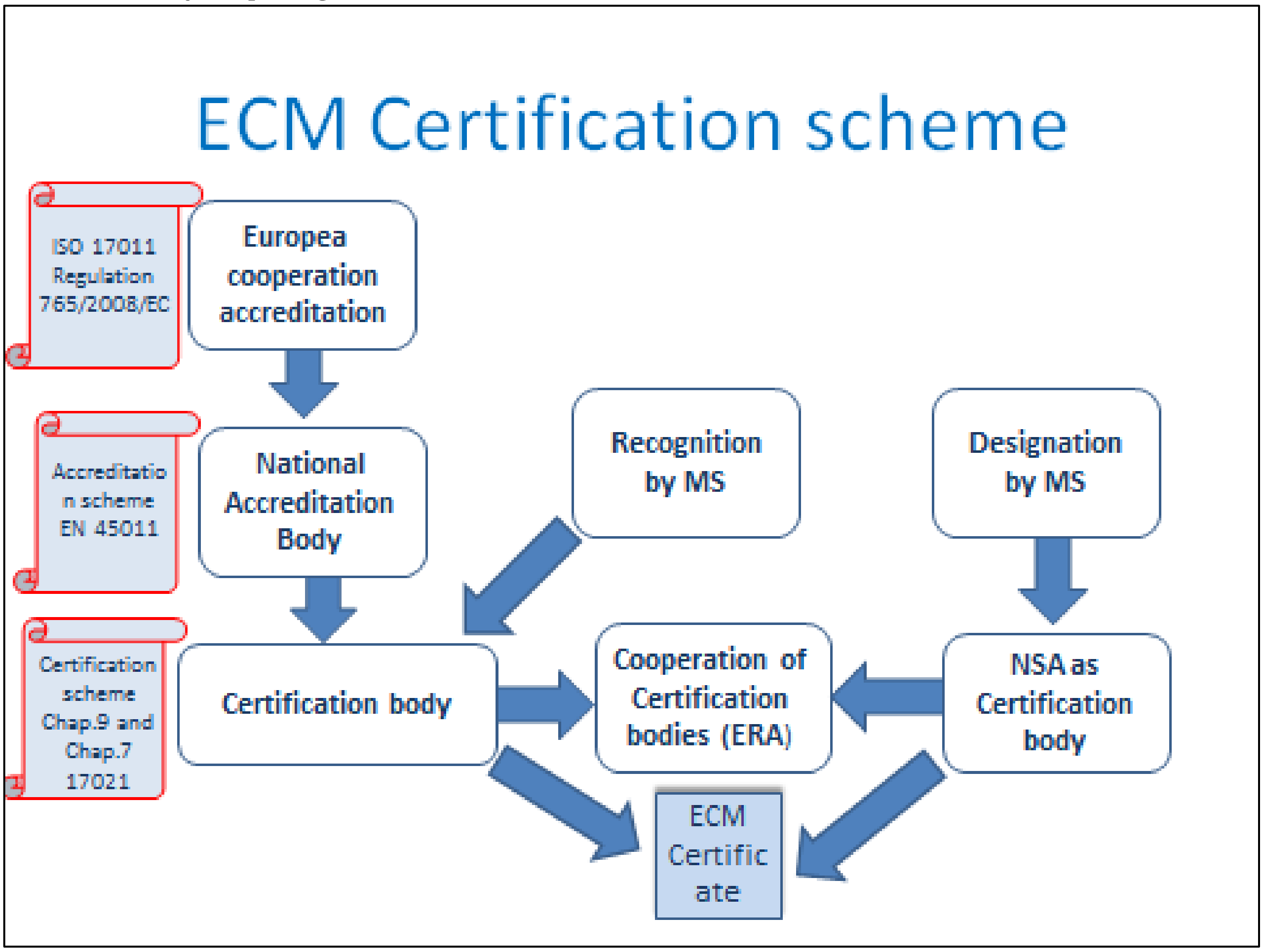
[196] http://www.transportbenchmarks.eu/groups/documents/MEETING2-EN13816.pdf

[197] To consult the guide on the application of the "Commission Regulation (EU) No 445/2011 of 10 May 2011 on a system of certification of entities in charge of maintenance for freight wagons" as referred to in Article 14(a) of the Safety Directive, follow the link:http://www.era.europa.eu/Document-Register/Documents/ECM-guide%20V1%20-%20ERA-GUI-100.pdf

To consult ECM certification Application guide including explanations ECM certification scheme, please follow the link: http://www.transportstyrelsen.se/Global/Jarnvag/ERA-GUI-09-2011-SAF-%20ECM%20certification%20-%20guide%20ECM%20certification%20scheme%20v1%200.pdf

in charge of maintenance has to make sure, with the help of a maintenance system that freight wagons are in good operating condition.
According to the EU Regulation, the maintenance system has four functions:

- a management function which supervises and co-ordinates maintenance functions;
- a maintenance development function, in charge of managing the documents which refer to maintenance, including configuration management, based on design and operating data and on gained experience;
- fleet maintenance function managing the maintenance of the cars;
- the actual maintenance for a freight wagon or part of it, including the supply of the documents necessary for putting the vehicles back into service.



Examples of companies that provide wagon maintenance:

GATX Rail Europe: provides technical maintenance, repairs, overhauls and cleaning of tank cars.[198]

Gemco Rail: provides a custom maintenance, modification, retrofit and upgrade facility for all types of railway wagons and rail associated equipment.[199]

[198] http://www.gatx.eu/en/content/our-services
[199] http://www.gemcorail.com.au/default.aspx?MenuID=294

VTG and ***VTG Group***: provides Repair and maintenance of bodywork, chassis and bogies, wheel set reconditioning, overhauls/tank inspections, and modernizations and conversions.[200]

AWT: provides ordinary upkeep of freight wagons, such as lubrication, calibration, repainting etc.; repair or replacement of freight wagons parts (draw gear and buffer gear, wheel assemblies, brake etc.); welding on freight wagons, repairs to freight wagons casings up to complete overhaul level; repair of wagons at their current location, preparation for transportation to a repair shop.[201]

Rail Service Net: provides repair, maintenance, parts/base materials for locomotives and wagons.[202]

[200] http://www.vtg.com/v/s/content/132266;jsessionid=1DE72A2429590D9BC13CCF08256FF964
[201] http://www.awt.eu/en/freight-wagon-rental/freight-wagon-maintenance-and-repair
[202] http://www.rsn.be/index.php

6.3. EU Railway Packages

In 1998 the European Commission came up with a proposal to make existing legislation more effective. On 26 February 2001, the Council adopted three Directives, which are known now as[203] the "***rail infrastructure package***" or ***"first railway package"***. It enabled rail operators to have access to the trans-European Network on a non-discriminative basis. In order to improve the EU's rail freight options, the European Commission came up with a proposal to establish a one-stop-shop to market freeways. The proposal stressed the need to improve the distribution of train paths, establish a tariff structure which reflects relevant costs, reduce delays at borders and introduce quality criteria. The European Commission indicated the actions to be taken in order to set up freeways.

The assessment of the implementation of the first rail package that took place in middle of 2006 showed that although the practical implementation of its provisions was still ongoing, the results were already visible and encouraging. The railways' position in regard to other transport modes was improved, the high level of rail transport safety was safeguarded and increased, new jobs were created and rail traffic performance was increased where the rail freight market had been open for completion relatively early. All these achievements were confirmed by the Commission in its communication in October 2007. It was also proved that rail freight traffic performance in the Member States became significantly better than in Member States where the market was still dominated by a monopoly.

On 23 January 2002, the European Commission[204] came up with a new proposal (known as the "***second railway package***"),[205] aiming at renewing the railways by means of quick creation of an integrated European railway area. The proposal was targeting improvement in safety, interoperability and opening up of the rail freight market. It was also proposed to establish the European Rail Agency (ERA) to be responsible for providing technical support for the safety and interoperability work. The package caused quick liberalisation of rail freight services after opening the market to competition as from 1 January 2007. ERA has representation in all EU Member States (except Malta and Cyprus). The key aim of the ERA is to align technical regulations in the Member States and set safety objectives which all Europe's railways must achieve.

In 2004 the European Commission[206] came with a new proposal, called the ***"third railway package."*** This document contained measures to revitalise the railways in Europe. It proposed to open up the international passenger transport market by 2010 and to regulate passenger rights and certification of train crew.[207]

The third package was adopted in October 2007. It introduced open access rights for international rail passenger services including cabotage by 2010. Operators may pick up and set down passengers at any station on an international route, including at stations located in the same Member State. The package has introduced a European driver licence allowing train drivers to circulate on the entire European network. The drivers will have to meet basic requirements concerning their educational level, age, physical and mental health, specific knowledge and practical training of driving skills. The package also strengthened the rail passengers' rights. While long-distance travellers will enjoy a wider range of rights, minimum quality standards (non-discrimination of handicapped travellers or persons with reduced mobility, liability in case of accidents,

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[203] http://ec.europa.eu/transport/modes/rail/packages/2001_en.htm
[204] http://ec.europa.eu/transport/modes/rail/packages/2004_en.htm
[205] Pham, Vinh, *The Liberalization of Rail Transport in the European Union. An Honors Thesis to the Economics Department of Connecticut College in partial fulfillment of the requirements for Honors in the Major Field*, Now London, Connecticut, 2013, pp. 6-7.
[206] http://ec.europa.eu/transport/modes/rail/packages/2007_en.htm
[207] Pham, Vinh, p.7.

availability of train tickets and personal security of passengers in stations) will have to be guaranteed to all passengers on all lines.

In March 2011 the European Commission[208] published the White Paper, proposing to revitalise the Community's railways by creating a sound financial basis, ensuring freedom of access to all traffic and public services and promoting the integration of national systems and social aspects. In January 2013 the European Commission adopted its proposal for the fourth railway package. It is a set of six legislative documents which aims at establishing the Single European Area. It intends to increase the efficiency of rail transport in Europe by bringing competition to the railway sector. To achieve it, the measures proposed to lower administrative, technical as well as operational barriers to improve efficiency. The proposal tackles several issues such as rail governance, market opening for domestic passenger rail transport, competitive tendering for Public Service Obligations contracts and a new role for the ERA.

The "***fourth railway package"*** aims to improve the quality of passenger rail services and reduce fragmentation of the internal market in passenger rail services. The package was not only to provide more independent infrastructure managers, but also to make concrete steps towards the establishment of a Single European Railway Area, with the completion of rail market opening and with a heavy revision of the Interoperability and Safety Directives and of the Regulation establishing the European Rail Agency.

The fourth rail package consists of two pillars, namely market pillar and technical pillar. The market pillar aims at strengthening the criteria for the financial and managerial independence of the rail infrastructure managers, without at the same time disrupting the widely used governance models currently in place. The infrastructure manager is today even more than yesterday at the centre of each Member State's railway system, equally close to all infrastructure users. Domestic rail passenger markets will have to be opened to competition, and that, at the same time, the entrance of new operators will not be to the detriment of all the operators that serve regional markets via public service contracts.[209]

The *technical pillar* of the package addresses the essential question of authorisation procedures in Europe. For the moment these authorisation procedures are very costly and hinder the completion and growth in the rail sector. Therefore, the package proposes to change it by establishing a European authorisation process with the ERA as a one-stop-shop for authorisation, making multi-country authorisation simpler and more predictable. The new measures seek to ensure that all operators have access to rail infrastructure, give new operators more opportunities to compete for public service contracts and harmonize safety certification and vehicle authorisation procedures in order to cut costs and save time. It plans to improve standards and authorisation for rolling stock; workforce skills; independent management of infrastructure; and the liberalisation of domestic passenger services. This package is another attempt to reform a rail sector still dominated by state-owned railway businesses that control both the tracks and the trains; they have repeatedly resisted attempts to separate the two parts of the business, which would allow more competition.

The package has been watered down. Instead of requiring infrastructure and train operators to be completely separated businesses, it permits them to be owned by a single company. It would boost competition to allow regulators to place sanctions on parts of a vertically integrated rail business that put obstacles in the way of competitors trying to provide services on their network, it would boost competition.

[208] http://ec.europa.eu/transport/modes/rail/packages/2007_en.htm
[209] http://www.cer.be/publications/4th-railway-package-overview

6.4. SHIFT^{2}RAIL

On 16th December 2013 the European Commission adopted a new private-public partnership called 'SHIFT^{2}RAIL'[210] to triple funding for rail innovation. It is the initiative that aims at bringing Research & Innovation[211] and market-driven solutions into innovative rail product solutions, which meet the key objectives of the EU 2020 Strategy. The Commission proposes €450m of funding to be matched by €470m from the rail industry, bringing the total budget to just under €1bn. In the framework of the 7-year work programme, the European Commission is planning to increase passenger and freight flow on European railways. The multiannual budget of SHIFT^{2}RAIL is commonly supported by the private sector and the European Union. The initiative intends to reinforce the attractiveness of rail transport towards passengers and business. It intends to increase the competition of the European rail industry in the world as well as create and preserve high-quality jobs in Europe.

There are three major objectives of this Joint Undertaking: to increase capacity of the European rail system up to 100% in order to meet increased passenger and freight demand; to increase reliability and quality of services and to reduce the life-cycle cost of railway transport by up to 50%, which includes costs of building, operating, maintaining and renewing infrastructure as well as rolling stock.

There are five key focus areas in which research and innovation will be conducted: development of a new generation of high capacity trains which will improve the quality of the services; development of the intelligent traffic management and control systems, which is aiming at increasing the capacity of railways; improvement of rail infrastructure which will include reduction of track noise, development of intelligent maintenance; introduction of IT solution and services to provide integrated tickets and journey planners and, finally, development of effective logistics and inter-modal freight solutions so that rail may become competitive in various markets and can easily connect with other forms of transport.

The result of the four-year investigation period is a long-term strategy plan which combines five Innovation Programmes (IPs).

IP1 – ***Energy and mass efficiency technologies for high capacity trains***. This Innovation Programme intends to boost capacity, efficiency, and sustainability of all types of passenger rolling stock. It includes traction systems, wireless train control and management systems, doors and PRM solutions, brake systems, carbodyshell, running gear of high capacity trains.

IP2 – ***Advanced traffic management and control systems***. It foresees building on existing ERTMS/ETCS specifications, interoperability across the EU network – including urban rail networks (CBTC) – is increased and research is dedicated to keeping ERTMS technology ahead of the competition. The advanced traffic management and control systems include capacity and efficiency surge, a dependable safe signalling system and smart procurement and testing.

IP3 – ***Cost efficient, high capacity infrastructure***. It proposes a comprehensive and systematic approach to improving the durability, capacity and efficiency of track and energy systems to cope with increased train traffic and speeds. Cost efficient high capacity infrastructure includes tracks, tunnels and bridges, intelligent maintenance, energy efficiency and switches and crossings.

[210] http://europa.eu/rapid/press-release_IP-13-1250_en.htm
[211] http://www.unife.org/uploads/UNIFE_Annual_Report_2013.pdf

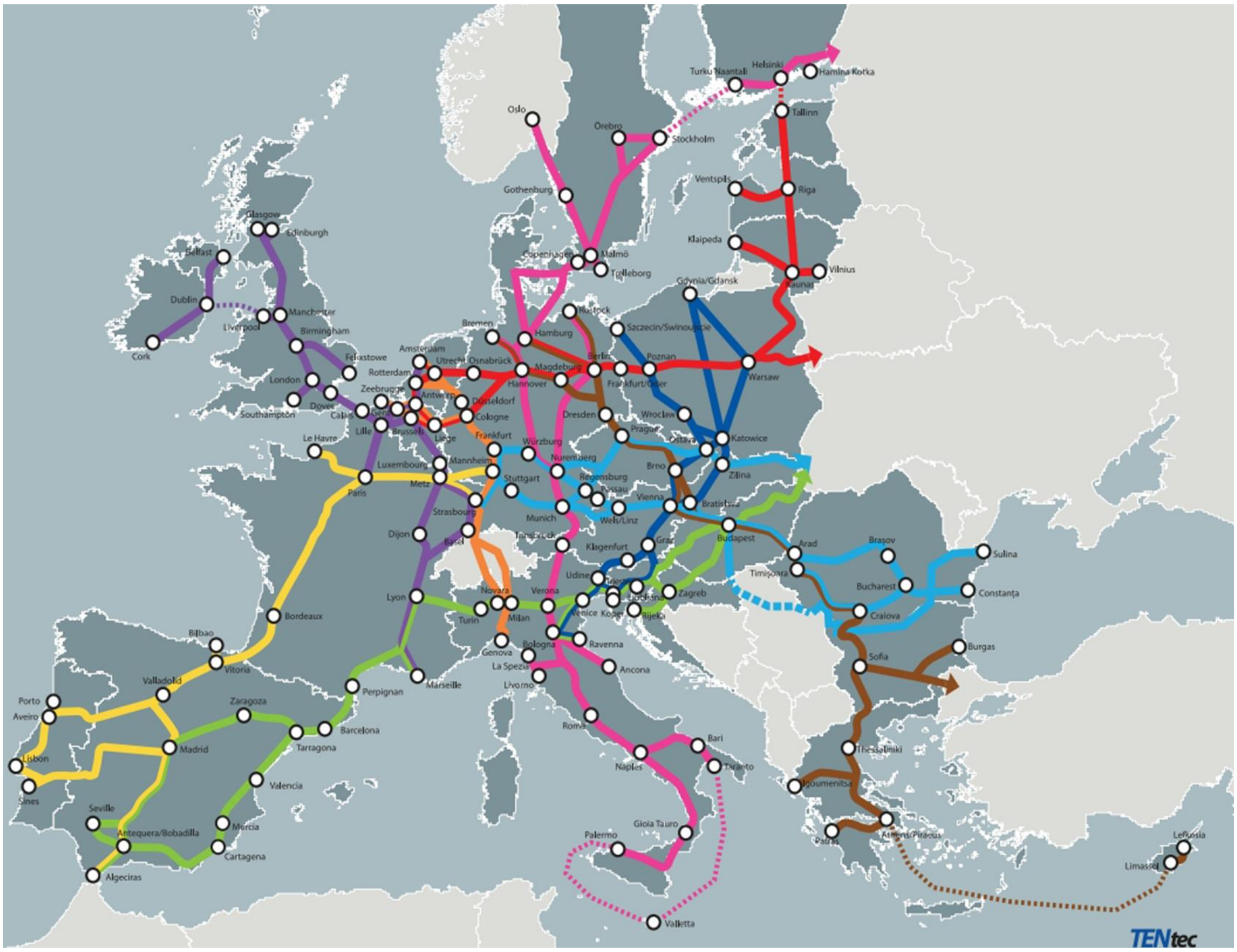
IP4 – ***Attractive Rail***. It promotes inter-modal passenger transit across Europe with an efficient conventional and urban rail network, as well as smart connections to road and aviation networks. Attractive railways includes co-ordination and demonstration, business analytics, travel companion, triptracker, ticketing, travel shopping and interoperability framework.

IP5 – ***Technologies for sustainable and attractive European Freight***. It improves door-to-door transport time, security, and traceability, thereby demonstrating a real business case for smart interoperable rail freight that offers reliable, competitive, sustainable, flexible transport services that are efficiently interfaced with other modes. This programme embraces propulsion, access and operations, terminals and marshalling, wagon and electric control line, brakes control.

More than 70 rail operating companies, which include industrial partners or railway undertakings, infrastructure managers or urban operators together with 17 research organisations have joined the initiative and have been bringing their expertise in the framework of the technical preparatory phase.

6.5. TEN-T

In June 2013 the Council of Ministers and the European Parliament came to an agreement regarding the new guidelines for the Trans-European Transport Network (TEN-T). The new regulation is intended to replace the existing guidelines (last update to the guidelines was made in 2010) by introducing the core network as a priority and a comprehensive network to be completed at a later stage.

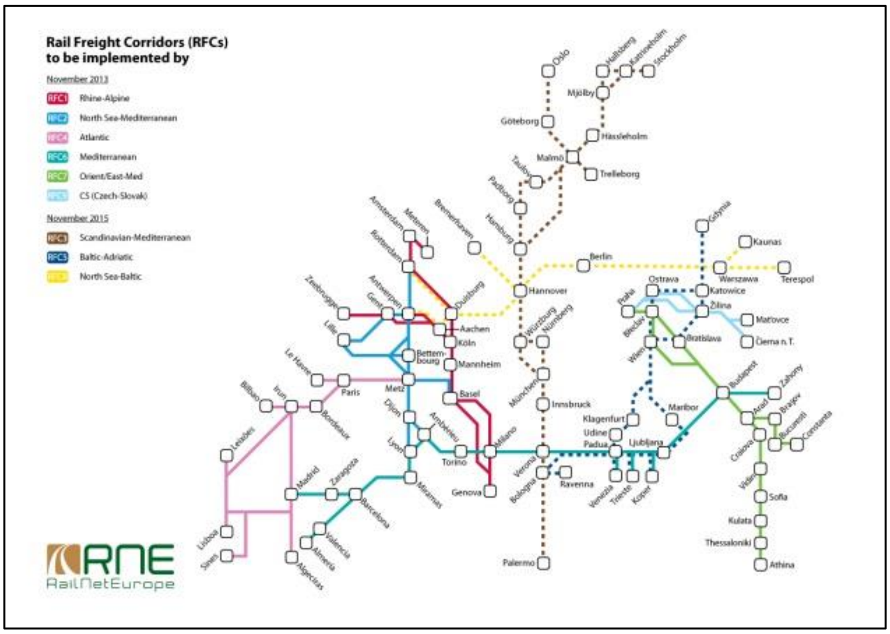


The institutional agreement sets a deadline of 2030 for the completion of the core network and 2050 for the comprehensive network. The idea of the EU rail corridors stands as an instrument for the implementation of the core network. It foresees exemption from the core network infrastructure requirements for railways in regard to the ERTMS and line electrification.

In June 2013 the TEN-T agreement was followed by a compromise on the text for the Connecting Europe Facility (CEF), which complemented the previous agreement. The CEF belongs to the next MFF (Multiannual Financial Framework). The CEF explains the general rules for granting the Union financial aid in the field of the trans-European transport, energy and telecommunication network, replacing the existing legal basis. Both documents received support from the European Parliament in November 2013. According to the CEF agreement, the financing of the transport infrastructure is tripled, which means that €26bn support for the new TEN-T core network development is foreseen for the period of 2014-2020. The CEF's financing for the transport infrastructure will encourage further investments from the Member States to complete difficult cross-border connections as well as links which might not otherwise be constructed. The first financing phase for the TEN-T core network to be implemented constitutes €260bn for the period 2014-2020. 80 to 85% of CEF financing will be used for core network projects, which include the 9 implementing corridors on the TEN-T core network. CEF financing will also include horizontal IT related projects, such as SESAR (the technological dimension of the Single European Sky Air Traffic Management System), or ERTMS (the European Rail Traffic Management System).

6.6. EU Rail Freight Corridors

The Regulation regarding the European Rail Network for Competitive Freight (Rail Freight Regulation No. 913/2010)[212] entered into force on 9 November 2010. It aims to make the European rail network competitive for freight, setting rules for the Member States to establish international market-oriented Rail Freight Corridors (RFCs). The annex to the regulation indicates 9 initial freight corridors which have to become operational by either November 2013 or November 2015.



The main purpose of this regulation is to strengthen the co-operation between Infrastructure Managers on several key aspects such as allocation of paths, deployment of interoperable systems and infrastructure development. It also aims at finding the right balance between freight and passenger traffic along the RFCs, giving appropriate capacity for freight in line with market needs. Another key objective of the regulation is promotion of intermodality between rail and other transport

[212] http://www.rne.eu/rail-freight-corridors-rfcs.html

modes by integrating terminals into the corridor management process (maritime and inland ports, marshalling yards, etc.). It also promotes non-discriminatory access to these corridors for all operators, with provision for transparency of information

For each corridor an executive and management board was established, made up of EU Member States representatives. Each management board has to present an implementation plan, which should contain an investment plan, of measures foreseen to implement the corridor. Two advisory bodies are set up for each corridor. The first one consists of managers and owners of the terminals of the freight corridor and the second advisory group is composed of railway undertakings interested in the use of the freight corridor. The management board will establish a joint body as a 'one-stop shop' to provide authorised applicants with a single place to both request and receive answers related to infrastructure capacity for freight trains crossing at least one border along the freight corridor. It will also take decisions on applications for prearranged train paths and reserve capacity for international freight trains.[213] The created advisory groups and consultation mechanisms will foster co-operation between Infrastructure Managers and corridor users.

The corridor approach has been confirmed also by the new TEN-T guidelines regulation which is a powerful European transport network across 28 Member States. The main purpose of the approach is to promote growth and competitiveness; to connect East with West and replace today's transport patchwork with a network that is genuinely European. The new policy establishes a core transport network which is built on 9 major corridors: 2 North-South corridors, 3 East West corridors; and 4 diagonal corridors. It was decided to prioritise East-West connections, almost half of the total transport infrastructure funding (€11.3bn from the Connecting Europe Facility, CEF) will be ring-fenced just for cohesion countries.

9 EU rail freight corridors:

1. **Rhine-Alp Corridor** (Zeebrugge-Antwerp/Rotterdam-Duisburg-Basel-Milan-Genova) by 10 Nov 2013
2. **Benelux-France Corridor** (Rotterdam-Antwerp-Luxemburg-Metz-Dijon-Lyon) by 10 Nov 2013
3. **Central North-South Corridor** (Stockholm-Malmö-Copenhagen-Hamburg-Innsbruck-Verona-Palermo) by 10 Nov 2015
4. **Atlantic Corridor** (Sines-Lisboa/Leixões) by 10 Nov 2013
5. **Balt-Adria Corridor** (Gdynia-Katowice-Ostrava/Zilina-Bratislava/Vienna-Klagenfurt-Udine-Venice-Trieste-Bologna/Ravenna) by 10 Nov 2015
6. **Mediterranean Corridor** Almeria-Valencia/Madrid-Zaragoza/Barcelona-Marseille-Lyon-Turin-Milan-Verona-Padua/Venice-Trieste/Koper-Ljubljana-Budapest-Zahony-Hungarian-Ukrainian border) by 10 Nov 2013
7. **Orient Corridor** Prague-Vienna/Bratislava-Budapest-Vidin-Sofia-Thessaloniki-Athens) by 10 Nov 2013
8. **Central East-West Corridor** (Bremerhaven/Rotterdam/Antwerp-Aachen/Berlin-Warsaw-Terespol (Poland-Belarus border)/Kaunas by 10 Nov 2015
9. **Eastern Corridor** (Prague-Horni Lide-Žilina-Košice-Ierna nad Tisou-Slovak/Ukrainian border) by 10 Nov 2013

Since 10th November 2013 six rail freight corridors have become operational. The six corridors are the Rhine–Alp Corridor, the Benelux–France Corridor, the Atlantic Corridor, the Mediterranean Corridor, the Orient Corridor and the Eastern Corridor. The six new corridors will be complemented by three further corridors that are set to become operational by 10 November 2015. Rail freight corridors form the rail backbone of the future Trans-European Transport Network.

[213] http://europa.eu/legislation_summaries/transport/rail_transport/tr0048_en.htm

6.7. ERTMS

The European Railway Traffic Management System (ERTMS)[214] is the project aimed at enhancing cross-border interoperability through Europe, creating a single standard for railway signalling. (Currently there are over 20 various national signalling speed control systems in the European rail system). In 1996 the Council agreed that ERTMS[215] should be a key part of European rail interoperability (Council Directive 1996/48/EC on the interoperability of the trans-European high-speed rail system).

It was decided to create six legally binding ERTMS corridors. The purpose of the corridors is to ensure the successful deployment of the system. Over 2,700 km of lines and more than 1,000 units of rolling stock equipped with ERTMS were in commercial operation in Europe by the end of 2011. ERTMS received not just European but also global recognition. Since 2012 more than 62,000 km of railway tracks and 7,500 vehicles are already either running or are equipped with ERTMS in 38 countries around the world.

ERTMS aims at increasing traffic capacity, reduction of maintenance costs, increase of safety, increase of maximum speed up to 500 km/h. ERTMS aims at increasing capacity of rail by 40% without any extra infrastructure advancements.

In 1990s the role to develop the ERTMS was given to the European Association for Railway Interoperability (AEIF) that brought together the representatives of Infrastructure Managers, railway companies and the industry. In the later stages the role of AEIF was taken up by the European Railway Agency (ERA). In 2000 the industrial consortium UNISING, led by ERA finalised the technical specification of the ERTMS. The team constantly reviews the specifications and endeavours to adapt ERTMS to the railways' needs.

ERTMS contains three basic elements: **ETCS** (European Train Control System) the automatic control system that helps to control speed limits of a train, **GSM-R** (Global System for Mobiles - Railway), a radio system for enabling communication between the driver and the traffic management centre and **ETML** (European Traffic Management Layer) which intends to optimise train movements by the 'intelligent' interpretation of timetables and train running data. It includes the improvement of real-time train management and route planning – rail node fluidity – customer and operating staff information.

Function of ERTMS

The main functions of ERTMS are[216]:

- The transmission of movement permission;
- Signalling;
- Automatic train control;

[214] http://www.railway-technology.com/projects/european-rail-traffic-management-system-ertms/
[215] http://ec.europa.eu/transport/modes/rail/interoperability/ertms/doc/ertms_10_questions_en.pdf
[216] http://nl.wikipedia.org/wiki/European_Rail_Traffic_Management_System

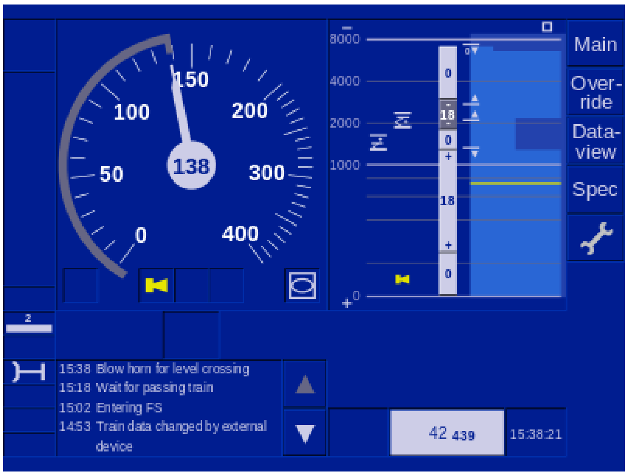
- Position reports;
- Transmission of track occupation.

Transmission of movement permission

ERTMS movement permission is transmitted via GSM-R or via ERTMS transponders or Eurobalises. The transmission of movement permission via GSM-R can be continuous, so it can be at any place and at any time, regardless of the position of the train. There are a number of GSM channels reserved only for GSM-R, so the communication for rail cannot be overloaded by public GSM channels. The transmission of movement permission via Eurobalises happens only when the train antenna moves over the Eurobalise. Eurobalises also have a function for determining the position of the train.

Signalling

ERTMS movement permission gives information about the distance that the train may still take and pass the speed limit. Where it is necessary it adjusts the ERTMS computer to the train speed limit, at the approach of the end of the permission zone, or when approaching a point of a lower speed limit. If a train approaches the end of the movement permission zone, the on-board computer calculates maximum speed down, until finally 0 km/h at the end of the movement permission. In this manner, a braking curve is created by series of decreasing speed limits. The calculated braking curve is always adapted to the train because the ERTMS computer takes into account the braking system and the weight of the train. At the same speed a long, heavy freight train will have to start braking much earlier than a light passenger train.



Driver Machine Interface (DMI)

A calculated maximum speed is shown to the train driver on a display, the driver machine interface. The permission in the cabin is sent either by electronic message called ‘cab signalling’ or ‘send mail signalling.’ The driver machine interface is part of the ERTMS on-board equipment. It displays the maximum speed which the ERTMS computer has calculated. The actual speed of the train is indicated by a sharp needle. The colour of the needle and the band around the clock rate play an important role in the cab signal, because the colours are considered to be a signal. The colours have the following meanings:

Grey: driving allowed with maximum speed
White: to slow down
Yellow: to slow down to the speed indicated on the screen

Train control

ERTMS offers train control that is fully integrated with the movement permissions. If a train is moving faster than the calculated maximum speed, then the on-board warns. In case a train driver does not react then the on-board ERTMS takes control and slows down or stops the train. Two additional colours are used:

Orange: the train is moving too fast, there is an additional speed warning.
Red: the train brakes automatically because the speed rate was greater than the maximum allowed.

Position report

The position of the train is important information for traffic control of a train. ERTMS sends information about the train position periodically, for example, every six seconds, and after passing specific points.

Information regarding track occupation

Only when the on-board equipment is in a position to establish with certainty that the train is complete, it informs that the train with this specific length can be driven safely. In each ERTMS position report it is explicitly stated that the train integrity is established. As long as there are no checks on train integrity in the ERTMS-position report.

The ERTMS as a component of the control chain of rail traffic

The information circuit in the control chain of the rail contains two major information flows which together form a control loop. These information flows are: (*see the diagram below*):
- Control information (indicated with green arrows);
- Feedback information (indicated with red arrows).

In the control chain of the track movement the ERTMS looks after a small part of the control information and the feedback information. Within the control information the ERTMS passes on file authorisations or movement authorities (MAs). This is called signalling. ERTMS checks whether the train observes the movement permission. This is known as a train control. Within the feedback information the ERTMS provides position reports from the train.

The control chain of the rail traffic

There are six elements of the control chain of the rail:

1. **Traffic control**
   The information cycle starts with the traffic. The traffic control takes decisions about the train schedule. In a situation without disturbances and without sudden drop or sudden demand for transport carries traffic from the timetable. In other cases it sends to the timetable. The decisions of the traffic control eventually lead later in the control chain, movement authorities to the driver, train driver or train.

   For a safety control of the rail traffic it is essential to know the position of each train to avoid collisions. For this reason, information about the position of each train goes to the movement control centre[217].

[217] http://nl.wikipedia.org/wiki/European_Rail_Traffic_Management_System

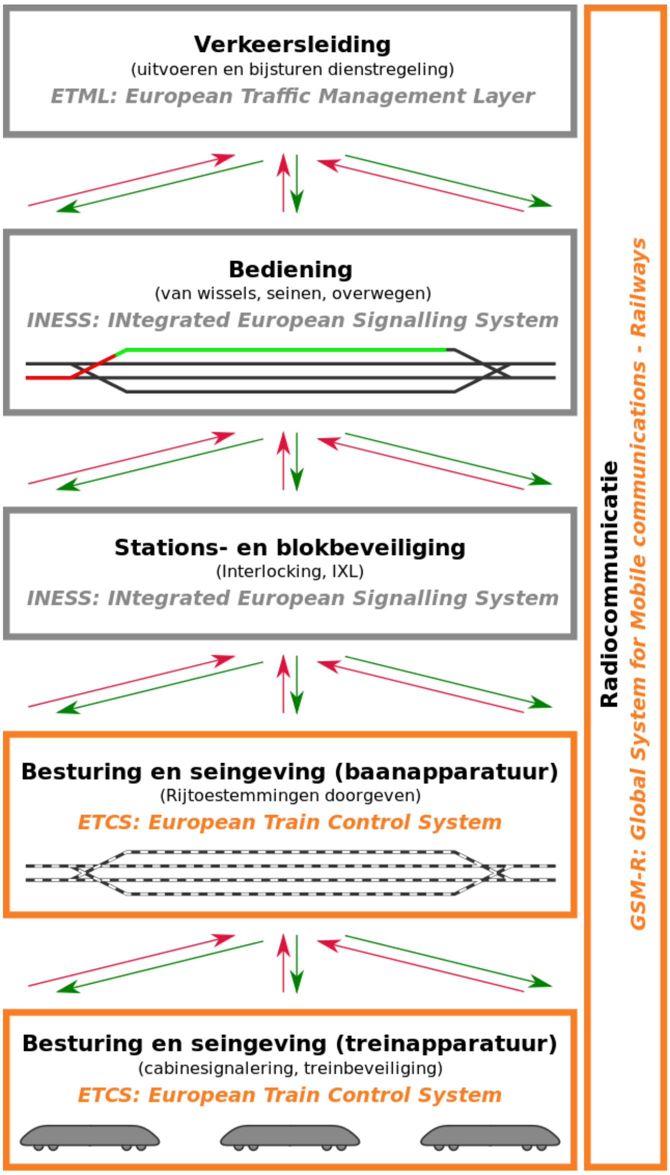
2. **Service**
   The traffic control requests a line for a train. The line is a specific track of a route of the train on the track and signals. Service of signals is performed by a specific computer programme, after checking whether the line is safe for movement of the train.

3. **Stations and block-system security**
   The stations and block-system security check a line for safety. If the route is safe, then the interlocking sets the line. It passes an authorisation file to the train.

4. **ETCS work equipment**
   The ETCS work equipment translates the authorisation file from the interlocking in standardised ERTMS movement authorisation and send it to the train.

5. **GSM-R**
   GSM-R is the radio connection which is used to transfer the authorisation file to train equipment, and to transfer the position reports of the train in the reversed direction. The authorisation files can be also passed on by means of Eurobalises to the train. (*for more explanation about GSM-R see below*).

6. **ETCS train equipment**
   The ETCS train equipment receives the authorisation file. It calculates the associated speed limit and shows all information on a screen. If the train goes faster than the file authorisation allows, then train equipment will slow down the train.



ERTMS applications

There are four various levels of ERTMS/ETCS application.
Level 0, Level 1, Level 2 and Level 3 (for the explanation, see ETCS below).

The six corridors that were identified by the European Commission for the deployment of ERTMS include:
Corridor **A**: from Rotterdam to Genoa
Corridor **B**: from Stockholm to Naples
Corridor **C**: from Antwerp to Basel
Corridor **D**: from Budapest to Valencia
Corridor **E**: from Dresden to Constanta
Corridor **F**: from Aachen to Terespol.

It is planned to install ERTMS on more than 10,000 km of railway lines by 2015 and 25,000 by 2020. Many key European freight lines were also identified for ERTMS deployment. €5bn was allocated to invest for the deployment of ERTMS in Europe during 2007-2013.

There are cross border lines that run with ERTMS: these are the Vienna-Budapest line, ERTMS (level 2) High Speed Line between Liege (Belgium) and the German border, and the Thalys line between Amsterdam (Netherlands) and Antwerp (Belgium). There are also contracts signed to deploy ERTMS in Denmark, Switzerland and Belgium.

6.7.1. GSM-R

GSM-R[218] is the communication element containing both a voice communication network between driving vehicles and line controllers and a bearer path for ETCS. The system is based on the public standard GSM with specific rail features for operation e.g. Priority and Pre-emption (eMLPP) – Functional Addressing Location Department Addressing – Voice Broadcast Services (VBS) – Voice Group Call (VGC) – Shunting Mode – Emergency Calls – General Packet Radio Services (GPRS option) – Fast call set-up.

In 2000 the GSM-R Industry Group (GSM-R IG)[219] was created to promote GSM-R technology and ensure successful deployment of the GSM-R project across Europe. The group was constituted by a private initiative of the GSM-R industry suppliers. Currently there are 32 countries that joined the group and decided to work together on the specification of a European standard for a train control and communication system. GSM[220] was selected as the technology for railway communication as the GSM-R platform offers enhanced functionalities and improved performance in terms of quality of service whilst guaranteeing data and voice communication at speeds up to 350 km/h.

6.7.2. ETCS

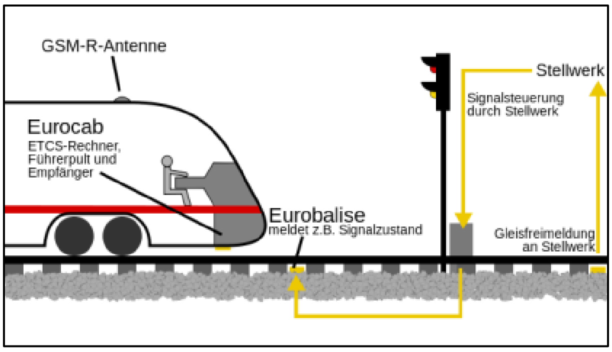
The European Train Control System (ETCS)[221] is a signalling, control and train protection system that is used in Europe.[222] It was introduced in order to replace the many incompatible systems that were used in European countries. This system requires standard trackside equipment and a standard controller within the train cab. The information is transmitted electronically to the driver. The need for ETCS came from the 1991 Council Directive (91/440/EC) and the 1993 EC Directive (93/38/EC), which laid down the necessary requirements. In 1995 the creation of the European Rail Traffic Management System (ERTMS) was mentioned in the development plan. The specification for ERTMS was developed in 1996 in response to Council Directive 96/48/EC.

ETCS has four levels:

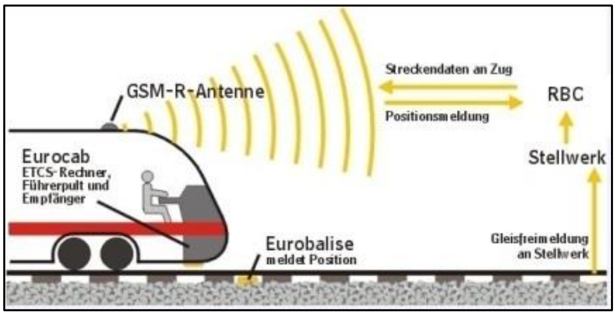
Level 0: when train is used on a non-ETCS route. Train equipment monitors the train for maximum speed of that type of train. The train driver observes the trackside signals. Since signals can have different meanings on different railways, this level restricts drivers to one railway. If the train has left a higher level ETCS, it might be limited in speed globally by the last balises encountered (*see the picture*).

[218] http://www.uic.org/spip.php?article381
[219] http://www.gsm-rail.com/drupal/gsmrig
[220] http://www.gsm-rail.com/drupal/technology
[221] http://www.navipedia.net/index.php/Rail_Traffic_Management_and_Signaling
[222] http://www.uic.org/spip.php?article381

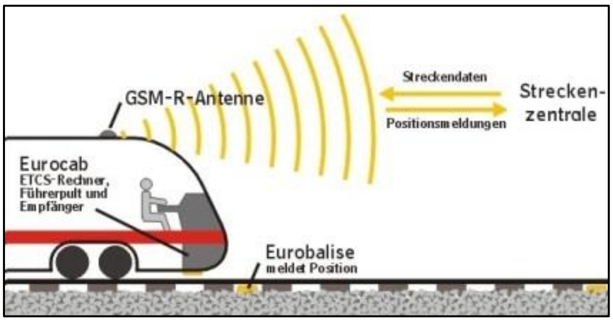
Level 1: is an add-on designed for conventional line with line-side signals and train detectors. Balises are installed on the trackside adjacent to the line side signals to transmit the information to control centre and train. ETCS on-board equipment receives the information from the balise and calculates the maximum speed for the train, which indicates when and where the train needs to brake. The system works such that a balise radio receives signals from the trackside signal via signal adapters and telegram codes (Lineside Electronics Unit - LEU) and transmits them to the train. The computer in the cab processes the data and calculates the maximum speed and the braking curve from this data.



Level 2: does not require line-side signals. The movement authority communication occurs directly from the Radio Block Centre (RBC) to the on-board unit using. GSM-R (Global System for Mobile Communications – Railway) together with speed information and route data. In this case balises are employed as passive positioning beacons. This level allows the train to reach its optimum or maximum speed while maintaining a safe braking distance.

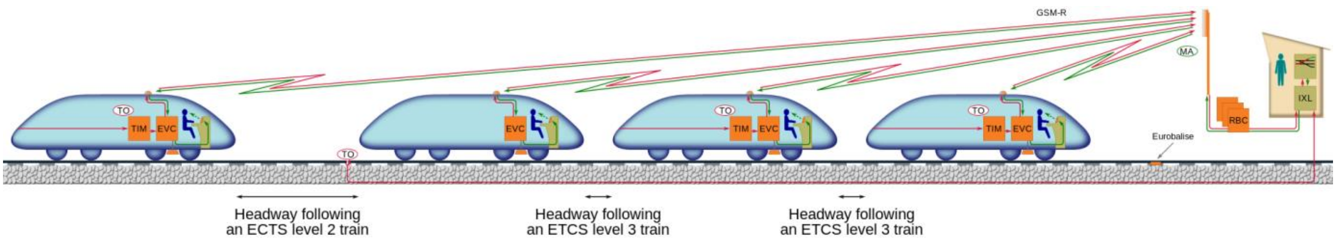


Level 3: This level is still under development. It is based on moving block technology. It involves use of special equipment on the train that constantly supplies data on the train's position to the control centre, rather than by track based detection equipment. The train constantly monitors its own position. In Level 3 the position of the train is determined by means of positioning beacons and via sensors (axle transducers, accelerometers and radar).



Combination of ERTMS levels and its variations

It is possible to control trains with different ERTMS levels to drive on the same line. For example, mixed rail traffic possible for trains to train Integrity riding in ERTMS Level 3, and trains without train integrity monitoring in ERTMS level 2. Another example is a station where trains arrive coming from a railway with ERTMS level 1, and trains of a railway with ERTMS level 2. Also 'dual signalling' is possible here. Two systems are used simultaneously for the trains with ERTMS equipment and trains with a national train security system, such as the combination of lights with ATB (for ATB, see the Control System table used in various EU countries).

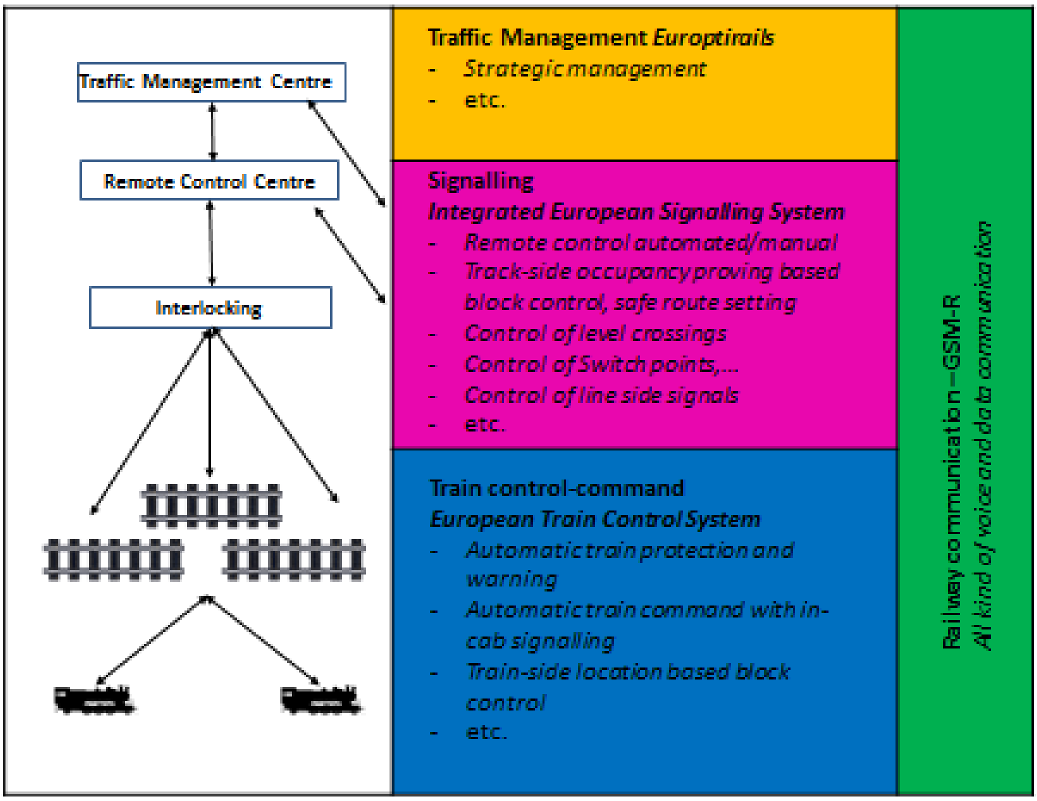


6.7.3. ETML

ETML (European Traffic Management Layer)[223] – the operation management level intended to optimise train movements by the "intelligent" interpretation of timetables and train running data. It involves the improvement of: real-time train management and route planning - rail node fluidity - customer and operating staff information.[224]

The deployment of a unique harmonised train command/control and telecommunication systems and the creation of trans-European traffic management facilities constitute crucial elements toward the achievement of a real integrated rail network.

Railways, as guided ground systems, use a dedicated infrastructure. Their attractiveness and efficiency depend, to a large extent, on the underlying means and methods for traffic management and on the ability to maximise the capacity and throughput of different types of traffic in a consistently safe and reliable manner. The typical functional structure of a rail traffic management system is displayed in the figure below:[225]



[223] http://www.uic.org/spip.php?article381
[224] http://en.wikipedia.org/wiki/European_Rail_Traffic_Management_System
[225] http://www.uic.org/spip.php?article381

Train control-command systems are very much linked to specific railway requirements from a functional and technical point of view. They therefore demand rail-specific solutions and are covered by legislative requirements, which dictate that the signalling systems in general and the underlying train control-command systems are designed to very stringent safety standards. The technical ability of trains, of a given operator, to run on a particular infrastructure is basically determined by the control-command subsystems, which bridge the gap between the ground and the moving trains.

The train communication between the ground and the moving trains requires, by definition, a wireless radio-link. Basically, the same methods and technologies can be applied, as those which are developed for other modes of transport with far bigger market size, especially the general radio mobile communication used by road vehicles and private individuals. These state of the art mobile communication systems are based on geographical cells which are interlinked by a dedicated fixed network. In a railway-owned communication system, it is possible to exploit the fixed network part for other telecommunications applications. Contrary to the past, one integrated communication system with a central technical platform can satisfy all railway communication needs either with voice or data transmission. The one of most particular interest for this report is the data transmission for the control-command of trains.

Rail traffic management is a key area for the medium-term optimisation of rail services. Increasingly, rail traffic management systems employ more "intelligent," highly computerised technology. The technical life cycle of these installations is generally shorter than the more durable parts of railway infrastructure and rolling stock. A considerable amount of the cost lies in the decentralised part, *i.e.* in the external signalling installations, as well as in the distributed devices for train control-command and train communication. A well-planned strategy for procurement and maintenance of these systems, covering the whole life cycle, is therefore of crucial importance.

6.8. RFE

The Rail Forum Europe (RFE) is a platform created by MEPs who have a genuine interest in transport policy and railway.

The platform was created in Febbruary 2011 in order to have constructive dialogue between the European Parliament and the European rail sector representatives to discuss and improve the understanding of rail-related issues and foster the development of common strategies and initiatives. RFE endeavours to create professional and personal ties between its members to work in full compliance with European and national law. It aims as well at the co-operation with different scientific, technical, economic, industrial and professional organisations that are active in the rail sector and can influence various issues related to rail transport. It organises conferences, debates where the European policy-makers and experts from the sector are brought together. To raise the understanding of the important rail issues RFE organises technical visits to rail transport-related facilities. To increase the awareness about recent developments in the sector RFE publishes any information that is or might be of interest for its members.

RFE is governed by a Managing Board of MEPs. An Advisory Committee composed of rail stakeholders assists MEPs in the definition of the activity programme and the preparation of the organisation's budget.

7. Transport documents in rail

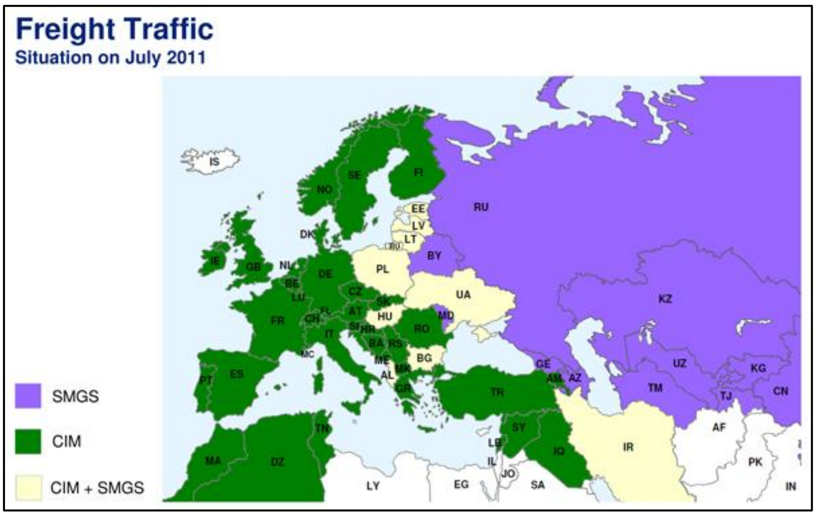
7.1. Introduction

There are different types of documents that are required for transportation of goods by rail. A key document that provides information about transported goods, their description, weight, origin and destination etc. is the rail freight bill or rail consignment note. For cross-border transportation of goods by rail, customs documents are required which are provided by the shipper. Another set of documents that are required are the documents that inform about technical conditions of wagons and traction.

7.2. Rail Consignment Note

A rail consignment note is required for transportation of any type of goods by rail. There are several types of freight bill, depending on the origin and destination of goods:

- CIM consignment note is used in international traffic among railways who are the members of the CIM-COTIF agreement.
- SMGS consignment note is used in former soviet countries, plus additionally in China, Iran and Mongolia among countries that are members of the SMGS agreement. Some EU countries such as Poland, Latvia, Lithuania and Estonia use both CIM and SMGS documents for international rail transportation.
- Common CIM/SMGS consignment note.
- National freight bill used only for domestic transportations.



One consignment note must be prepared for each wagon. The exception to this rule is one consignment note for the wagons that are forwarded in a block train, or a group of wagons (usually min. 10 wagons), or a UTI (Intermodal Transport Unit). If several wagons or if three or more UTI are consigned with a single consignment note, then the number of wagon lists required must be shown on the consignment note and the wagon lists attached to it.[226] A wagon list then forms an integral part of the consignment note. For SWL each wagon needs to be accompanied by an individual consignment note. If a train is forwarded by a state company then it also needs a preliminary permission for using one consignment note for more than one wagon.

[226] The International Rail Transport Committee (CIT) is an association of some 216 railway undertakings and shipping companies which provide international passenger and/or freight services. 126 organisations are members in their own right, 80 organisations are linked indirectly by being members of CIT associate members. It has prepared several types of manuals on how to use various consignment notes in rail. It also describes the procedures to be followed for international freight traffic by rail. http://www.cit-rail.org/en/freight-traffic/manuals/

7.2.1. CIM consignment note

Railway contract law ensures legal certainty by defining liability regimes in international traffic. A majority of the EU Member States use the CIM consignment note for transportation of goods by rail. CIM belongs to and is regulated by the COTIF Protocol[227] (Convention concerning International Carriage by Rail). The COTIF Protocol was signed by OTIF[228] members in 9 June 1999, Vilnius. The Protocol contains seven Appendices. A rail transport document prepared according to Appendix B of the COTIF Convention is called a ***CIM Rail Consignment Note***. In 2011, the European Union accepted COTIF 1999.[229] There are 7 appendices of the COTIF Protocol, where Appendix B provides rules for the CIM consignment note:

Appendix A: Uniform Rules concerning the Contract for International Carriage of Passengers by Rail (CIV)
Appendix B: Uniform Rules concerning the Contract of International Carriage of Goods by Rail (CIM)
Appendix C: Regulation concerning the International Carriage of Dangerous Goods by Rail (RID)
Appendix D: Uniform Rules concerning the Contract of use of vehicles in international rail traffic (CUV)
Appendix E: Uniform Rules concerning the Contract of use of infrastructure in international rail traffic (CUI)
Appendix F: Uniform Rules concerning the Validity of Technical Standards and Adoption of Uniform Technical Prescriptions applicable to Railway Material intended to be used in International Traffic (APTU)
Appendix G: Uniform Rules concerning the Technical Admission of Railway Material used in International Traffic (ATMF).

A document prepared in accordance with the requirement of Appendix B is called a "CIM consignment note" (green colour) and it certifies that the rail carrier has received the goods and that a contract of carriage exists between consignor and carrier. This document does not give its holder rights of ownership or possession of the goods. A CIM consignment note is to be completed in one or more languages of which one must be either English, French or German.

The key information that is included in CIM:

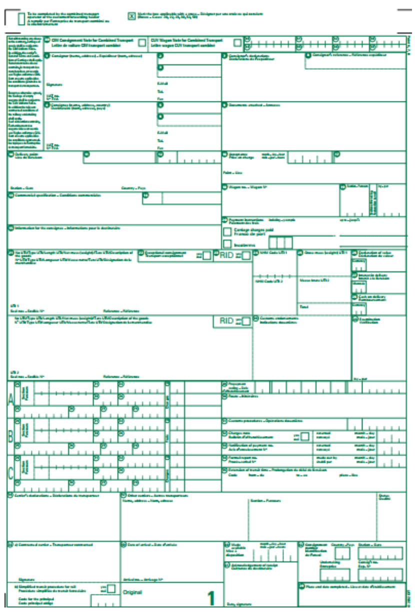
- a description of the goods
- the number of units and their weight
- the names and addresses of the sender and recipient.

The document must:

- indicate the name of the carrier and:
  - be signed by the carrier or a named agent for or on behalf of the carrier, or
  - indicate receipt of the goods by signature, stamp or notation by the carrier or a named agent for or on behalf of the carrier
- indicate the date of shipment or the date the goods have been received for shipment, dispatch or carriage at the place. Unless the transport document contains a dated reception stamp, an indication of the date of receipt or a date of shipment, the date of issuance of the transport document will be deemed to be the date of shipment
- indicate the place of shipment and the place of destination.

[227] http://otif.org/fileadmin/user_upload/otif_verlinkte_files/04_recht/03_CR/03_CR_24_NOT/COTIF_1999_01_12_2010_e.pdf
[228] The Intergovernmental Organisation for International Carriage by Rail (OTIF) was set up on 1 May 1985. 48 States are Members of OTIF at the present time (Europe, Asia and North Africa) and one State is an Associate Member (Jordan). OTIF has developed the uniform systems of law which apply to freight in international traffic by rail. These systems of law are known as the Convention concerning International Carriage by Rail (COTIF) of 9 May 1980 (1999 Protocol).
[229] http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52014PC0338

A CIM consignment note provides proof that the goods have been deposited at the railway for transportation. It also serves as a commitment to transport the goods and deliver them to the consignee. It provides evidence of the conditions of carriage.



The consignor is responsible for the accuracy of CIM notes and is liable for any loss or damage suffered by the carrier due to inaccurate information.

There is also a CIM consignment note for combined transport. In 2006 CIT (The International Rail Transport Committee)[230] introduced a "CIM Consignment Note for Combined Transport," to facilitate the combined transport in Europe and the electronic trade, as the new document can be processed in electronic format.

7.2.1.1. Paper and electronic consignment notes

7.2.1.1.1. Paper consignment note

A paper consignment note consists of 5 A4 sheets:

Sheet		Retention of the sheet
No.	**Title**	
1	Original of the consignment note	Consignee
2	Invoice	Carrier at the destination
3	Arrival note/customs	Customs or carrier at the destination
4	Duplicate of the consignment note (green)	Consignor
5	Duplicate invoice	Forwarding carrier

7.2.1.1.2. Electronic consignment note

The consignment note and its duplicate may be created in the form of an electronic data record which can be transformed into legible written symbols. The procedures used for data storage and processing must be functionally equivalent to those for the paper system particularly in so far as the evidential value of the consignment note represented by that data is concerned.

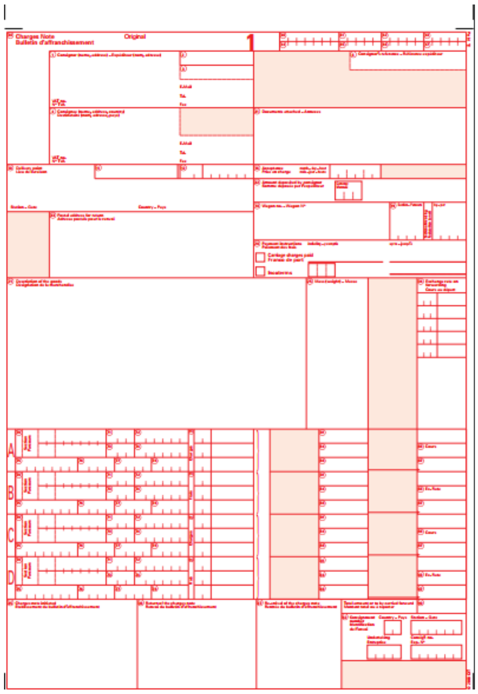
The carrier and the customer are to set down the messages to be exchanged and the ways in which electronic consignment note data will be exchanged in a contract.

In anticipation of comprehensive implementation, a mixed system may be agreed in order to be able to use the electronic consignment note on sections of the journey. It will allow different data media to be used for one and the same consignment (paper consignment note, electronic consignment note, printout used as a paper consignment note). If necessary, the electronic consignment note is to be printed out.

[230] http://www.lcviews.com/index.php?page_id=18

7.2.2. Accompanying CIM consignment note documents

7.2.2.1. Wagon List



A wagon list (red colour) accompanies the CIM document. Customer agreements are to set down what data wagon lists are to contain and how they are to be used. The wagon list must at least contain this information:

- Name of document
  - Wagon list
- Reference to the consignment note to which it is appended:
  - Consignment identification number
  - Date of acceptance
  - Forwarding station
  - Destination station
  - Route
  - Consignor
  - Consignee
  - Customs procedures
- Details of the wagons, the UTI and the goods:
  - Wagon number
  - UTI number
  - UTI type code
  - Gross mass [weight] of UTI
  - Net mass [weight] of UTI
  - Tare of UTI
  - Identity numbers of the seals on the UTI
  - Reference number of number on the transfer note
  - Loaded/empty status of the UTI
  - Customs documents
  - Description of the goods
  - NHM code
  - Details which the RID requires to be put on the consignment note when dangerous goods are carried
  - Mass [weight] of the load
  - Movement Reference Number (MRN)
  - Administrative Reference Codes (ARC)
  - Export
- Details of the escorst(s)
  - Family and first name(s)
- Preparation of the wagon list
  - Address of the undertaking
  - Place and date
  - Signature

Except where specially agreed otherwise, six copies of the wagon list are to be made out (one per sheet of the consignment note, plus an additional one in case wagons have to be detached from a block train or group of wagons).
For those consignments which pass over the customs territory of the European Community or the territory on which the common transit procedure is applied, separate wagon lists must be made out for community goods and non-community goods.

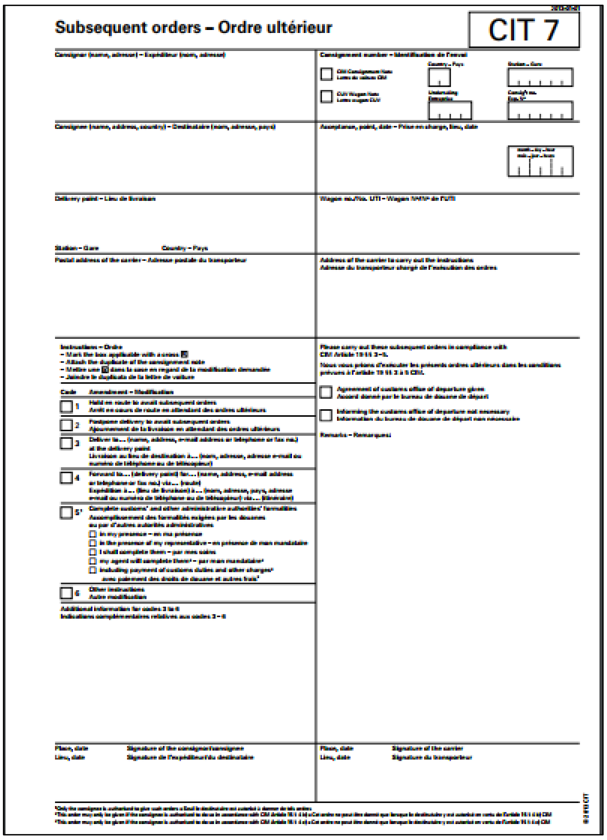
7.2.2.2. Charges note

A rail consignment note contains a list of charges, called a "Charges note" (red colour) which include carriage charge, ancillary charges, customs duties and other charges. If the total of the charges to be accepted by the consignor cannot be determined exactly when the goods are accepted, these charges are to be entered on charges note. This document is to form the basis of the settlement with the consignor, at the latest thirty days after the expiry of the transit period.

The charges are to be paid by the consignor to the forwarding carrier or by the consignee to the destination carrier in accordance with the instructions. Instructions expressed as a three letter code are taken from Incoterms 2010.[231] The use of Incoterms on the consignment note refers only to the payment of charges and has no other legal consequences for the contract of carriage (*e.g.* DAF "Delivered At Frontier (… *named place*)" means that all charges (carriage charges plus ancillary charges, customs duties and other charges) up to the tariff break point shown on the consignment note paid by the consignor).

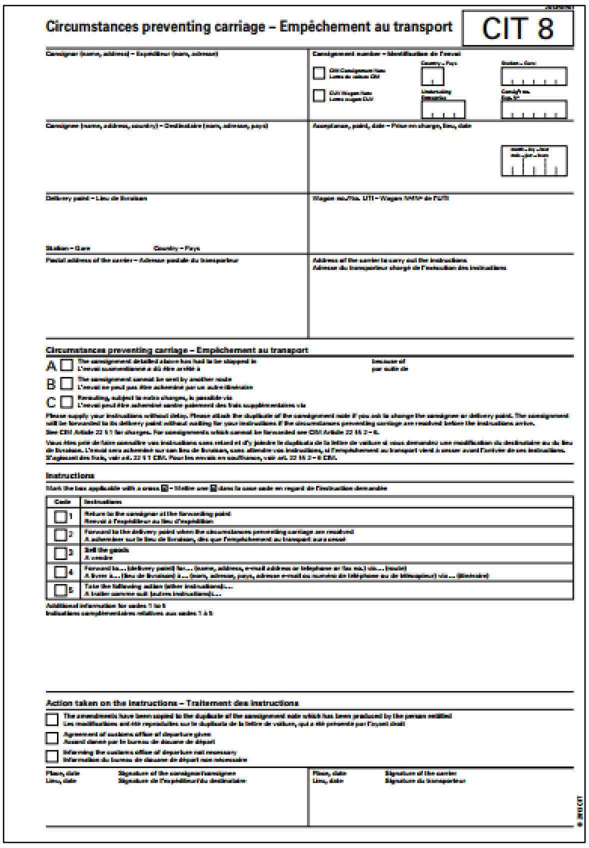
7.2.2.3. Subsequent orders

The consignor and consignee may amend the contract by subsequent orders. Subsequent orders are to be given in an appropriate written form. Electronic methods such as the internet or e-mail are to be preferred to allow the flow of information to be speeded up. The form needs to be downloaded, completed, printed-out and sent electronically. Where subsequent orders are given by means of a document which is not pre-printed, the amendment required should be given both in code and in plain text. The signature may be replaced by a stamp, an accounting machine entry or in any other appropriate manner. In parallel, the duplicate of the consignment note is to be given to the carrier. The same amendments are to be entered on it.


Subsequent orders – Ordre ultérieur
CIT 7

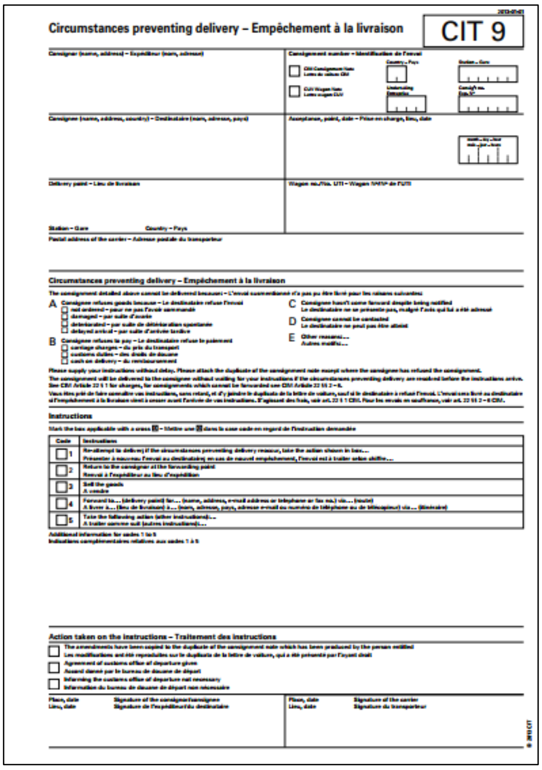
[231] https://www.incotermsexplained.com/

7.2.2.4. Notification of circumstances preventing carriage


Circumstances preventing carriage – Empêchement au transport CIT 8

In the case of circumstances preventing carriage in the sense of CIM Article 20, of his own accord the carrier is to take action to alleviate the circumstances or shall ask for instructions from the person entitled. The carrier is to ask for instructions in an appropriate written form from the person entitled (the consignee, except that it will be the consignor where the consignor has entered "consignee not authorised to take control of the goods"). Electronic methods such as the internet or e-mail are to be preferred to allow the flow of information to be speeded up. The signature may be replaced by a stamp, an accounting machine entry or in any other appropriate manner.

7.2.2.5. Notification of circumstances preventing delivery


Circumstances preventing delivery – Empêchement à la livraison CIT 9

In case of circumstances preventing delivery, the carrier is to ask for instructions from the consignor, unless an endorsement on the consignment note requires the goods to be returned without further formality. When the circumstances preventing delivery occur after the consignee has amended the contract of carriage, the carrier must notify the consignee.

The carrier is to ask for instructions in an appropriate written form from the consignor or, if appropriate, consignee. Electronic methods such as the internet or e-mail are to be preferred to allow the flow of information to be speeded up. A form for seeking instructions needs to be downloaded, completed, printed-out and sent electronically. It is recommended that the layout be the same. The signature may be replaced by a stamp, an accounting machine entry or in any other appropriate manner.

7.2.2.6. Dangerous goods

Europe-wide rules govern the transportation of dangerous goods by rail. These are known by the letters 'RID' (Appendix C of the COTIF agreement).

Any dangerous goods must be marked with their name, description and UN number (the UN number states which of the following nine categories your dangerous goods come under).

UN Class	Dangerous Goods	Classification
1	Explosives	Explosive substances and articles
2	Gases	Flammable gas Non-flammable, non-toxic gas Toxic gas
3	Flammable liquids	Flammable liquids
4	Flammable solids	Class 4.1 Flammable solids, self reactive substances and solid desensitised explosives Class 4.2 Substances liable to spontaneous combustion Class 4.3 Substance which emits flammable gas in contact with water
5	Oxidising substances	Class 5.1 Oxidising substance Class 5.2 Organic peroxide
6	Toxic substances and infectious substances	Class 6.1 Toxic substances Class 6.2 Infectious substances
7	Radioactive material	Radioactive material
8	Corrosive substances	Corrosive substances
9	Miscellaneous dangerous substances and articles	Miscellaneous dangerous substances and articles

In case of transportation of dangerous goods, the information that is required by the by Annex C on RID, needs to be indicated in the consignment note as well as in the wagon list.

7.2.2.7. Document of carriage for empty uncleaned means of containment as defined by the RID

The following provisions are applicable to the return of empty uncleaned means of containment,[232] containing the residues of dangerous goods which are not accompanied by a consignment note or a wagon note.

The consignee for the loaded journey must supply the carrier with two copies of a declaration for each means of containment. For this purpose, two sheets from a consignment note are to be used. The following information must be entered in the appropriate spaces in the written declaration:

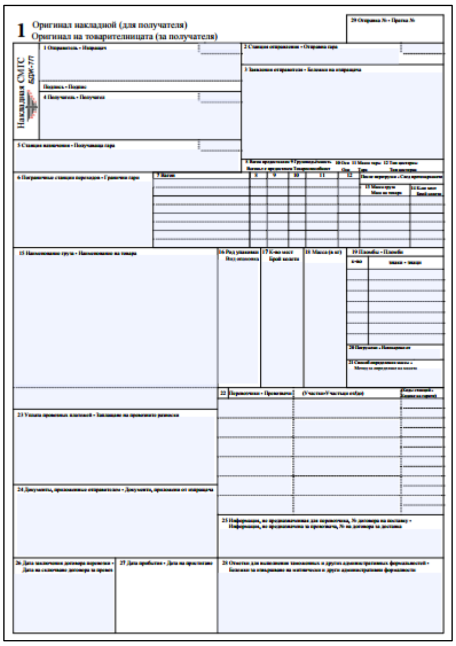
- consignor (consignee of the loaded journey),

[232] 1 In accordance with paragraph 5.4.1.1.6.2.1 RID, the following means of containment are considered as packaging: "empty packaging", "empty receptacle", "empty IBC", "empty large packaging". In accordance with paragraph 5.4.1.1.6.2.2 RID, the following means of containment must be considered as means other than packaging "empty tank vehicle", "empty tank wagon", "empty demountable tank", "empty tank container", "empty portable tank", "empty battery-vehicle", "empty battery-wagon", "empty MEGC", "empty vehicle", "empty wagon", "empty container", "empty receptacle".

- wagon number or designation of the means of containment,
- information required for empty uncleaned means of containment.

The other provisions of the RID applicable to packaging and to empty uncleaned means of containment containing residues of dangerous goods must also be observed by the consignee of the loaded journey.

7.2.3. SMGS consignment note



The Agreement on International Goods Transport by Rail (SMGS) governs railway activities between countries. The countries that have entered into the agreement belong to the Organization for Co-operation of Railways (OSJD).[233] The working languages of the OSJD are Russian and Chinese.

Transport between Europe and Asia is controlled by different regulations from Western Europe, such as

- Agreement on Direct International Carriage of Passengers and Luggage by Rail and Procedure Instruction attached thereto (SMPS),
- Agreement on Direct International Goods Transport by Rail and Procedure Instruction attached thereto (SMGS),
- Rules of Reciprocal Use of Wagons in International Traffic (PPW),
- Agreement on Direct International Carriage of Passengers and Luggage by Rail (MPS)
- Agreement on Direct International Goods Transport by Rail (MGS).

The SMGS consignment note consists of 5 A4 sheets:[234]

Sheet	
No.	**Title**
1	Original of the railway consignment note (accompanies the cargo to the destination station and is issued to the consignee with sheet 5 and cargo)
2	Road list (accompanies the cargo to the destination station and remains on the destination road)
3	Duplicate of the railway consignment note (issued to the sender after the conclusion of the contract of carriage)

[233] The Organization for Cooperation of Railways (OSJD or OSShD) was established at a conference in Sofia, Bulgaria on 28 June 1956, the governmental ministers managing railway transport of Eastern bloc countries Albania, Bulgaria, Hungary, Vietnam, East Germany, China, North Korea, Mongolia, Poland, Romania, the USSR, and Czechoslovakia decided to establish a special inter-governmental organization, the executive body of which started operations in Warsaw, Poland on 1 September 1957. It is the equivalent of the International Union of Railways (UIC) to create and improve the coordination of international rail transport. Concerning especially the transports between Europe and Asia, it has helped develop cooperation between railway companies and with other international organisations. The members of this organisation created an international transport law.

[234] http://economylit.online/predprinimatelstvo-biznes_728/321-nakladnaya-smgs-27188.html

4	Sheet of delivery of cargo (accompanies the cargo to the destination station and remains on the destination road)
5	Sheet of notification of the arrival of the goods (accompanies the cargo to the destination station and is issued to the consignee together with sheet 1 and cargo)

As well as the necessary number of additional copies of the road list intended for the way of departure and transit railways.

The sheets 1, 2, 4 and 5 of the SMGS consignment note accompany the goods to the destination station. Sheet 3 of the invoice (duplicate of the waybill) is returned to the shipper after the conclusion of the contract of carriage. This sheet does not have the power of the original invoice (sheet 1 consignment note).[235]

7.2.4. Common CIM/SMGS consignment note

It is an alternative to the classic system of consignment with re-transcription of an SMGS consignment note to a CIM consignment note or from a CIM consignment note to an SMGS consignment note at the reconsignment point. The common CIM/SMGS consignment note may be used as a CIM consignment note in the area in which the CIM applies and as an SMGS consignment note in the area in which the SMGS applies. The same principle also applies to the use of the CIM/SMGS consignment note as a customs document.

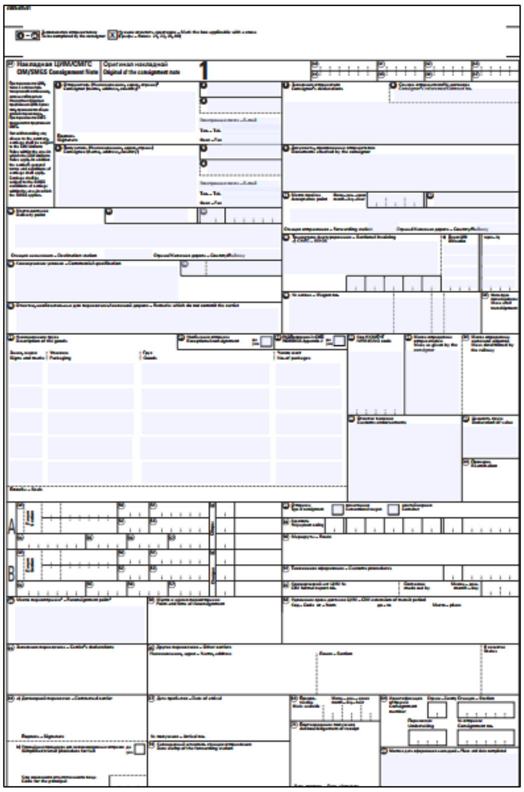
Descriptions of the boxes are to be printed in two, or as appropriate three, languages of which one must be Russian and another either English, French or German. For consignments to or from the People’s Republic of China, descriptions of the boxes are additionally to be printed in Chinese.

The common CIM/SMGS consignment note consists of 6 A4 sheets:

Sheet		**Retention of the sheet**
No.	Description	
1	Original of the consignment note	Consignee
2	Invoice	CIM carrier at the destination or SMGS destination railway
CIM 5 SMGS 3	Duplicate of the consignment note	Consignor
4	Delivery note	CIM → SMGS traffic: destination railway SMGS → CIM traffic: not used
CIM 5 SMGS 3	Arrival note/Customs	CIM → SMGS traffic: consignee/customs SMGS → CIM traffic: destination carrier/customs
6	Duplicate invoice	CIM → SMGS traffic: forwarding carrier SMGS → CIM traffic: not used

235 http://p.bdz.bg/0/0/00-nakladnaja-smgs-ot-01072015-ru-bg-v2016-5793.pdf

Block trains, groups of wagons and groups of containers may be consigned with a single CIM/SMGS consignment note and a CIM/SMGS wagon list/container list provided there has been prior agreement between the consignor and the carriers taking part and provided the following conditions are satisfied:



- same consignor and consignee,
- same acceptance point/forwarding station,
- same delivery point/destination station,
- same commodity (unless agreed otherwise).

With the CIM/SMGS consignment note the necessary CIM and SMGS conveyance contracts are condensed into a single document.[236] This enables non-stop rail freight transport with a single consignment document between Europe, Russia and Asia. It also applies as a T1 transit declaration (*see below*) in the customs area of the EU/EFTA. It applies as a national customs (transit) document in each instance in the area of the SMGS regime and it can be used both in wagon loading and Combined Traffic.

A common CIM/SMGS consignment note has several advantages, *i.e.* export formalities/commercial verification can be dealt with as soon as the consignment has been dispatched in the EU/EFTA. No amendments to the documents at the place of reconsignment between two legal areas and it guaranties thus minimal wagon stoppage times. A common CIM/SMGS consignment note is used voluntarily, when agreed between the sender and the carrier.

7.2.4.1. Common CIM/SMGS electronic consignment note

CIM – Functional equivalence as the legal basis

The consignment note and its duplicate may be created in the form of an electronic data record which can be transformed into legible written symbols. The procedures used for data storage and processing must be functionally equivalent to those for the paper system particularly in so far as the evidential value of the consignment note represented by that data is concerned.

SMGS – Agreement between railways, consignors and consignees who apply the SMGS as the legal basis

The contract of carriage may be concluded using an electronic consignment note. The electronic consignment note is an electronic data record which is regarded as a paper consignment note supporting a contract of carriage. The arrangements for entering data into the electronic data record are to be agreed between the railway and the consignor. If necessary, this electronic consignment note and any supplementary sheets may be printed on paper. The original data is to be retained in addition to any altered data where data input to the electronic data record is altered in accordance with the provisions of the SMGS.

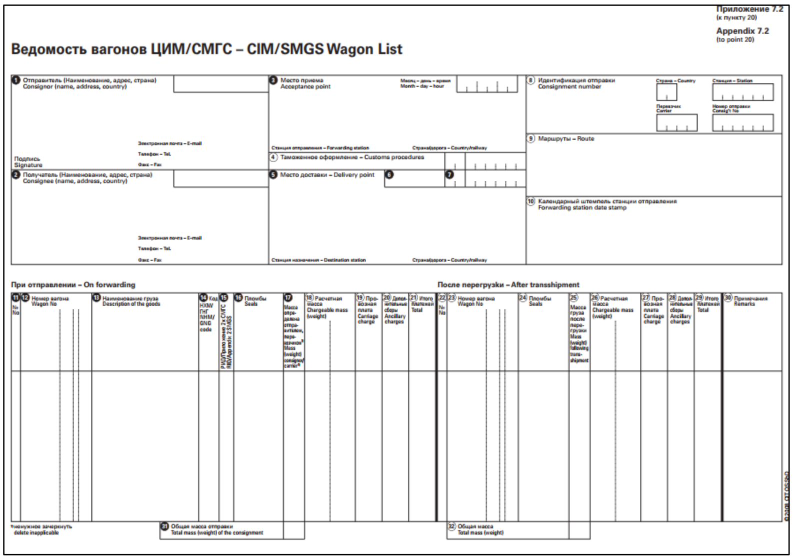
[236] http://www.dbcargo.com/rail-deutschland-en/info-service/international_provisions/CIM_SMGS_consignment_note.html

Agreement for the use of electronic data interchange for international freight traffic by rail (EDI agreement)

The carriers (railways) and the customers (consignors and consignees) are to set down the messages to be exchanged and the ways in which electronic consignment note data will be exchanged in a contract.

7.2.4.2. Wagon List

Except where otherwise agreed, the consignor is to make out the CIM/SMGS wagon list and give it to the forwarding carrier with the CIM/SMGS consignment note. As many copies of the CIM/SMGS wagon list must be attached as the CIM/SMGS consignment note has sheets. This must include the additional copies of the invoice.



Приложение 7.2
(к пункту 20)
Appendix 7.2
(to point 20)

Ведомость вагонов ЦИМ/СМГС – CIM/SMGS Wagon List

1 Отправитель (Наименование, адрес, страна) Consignor (name, address, country)
Электронная почта – E-mail
Телефон – Tel.
Факс – Fax
Подпись Signature
3 Место приема Acceptance point
Месяц – день – время Month – day – hour
Станция отправления – Forwarding station
Страна/дорога – Country/railway
4 Таможенное оформление – Customs procedures
8 Идентификация отправки Consignment number
Страна – Country
Станция – Station
Перевозчик Carrier
Номер отправки Consig't No
9 Маршруты – Route
2 Получатель (Наименование, адрес, страна) Consignee (name, address, country)
Электронная почта – E-mail
Телефон – Tel.
Факс – Fax
5 Место доставки – Delivery point
6
7
Станция назначения – Destination station
Страна/дорога – Country/railway
10 Календарный штемпель станции отправления Forwarding station date stamp

При отправлении – On forwarding

После перегрузки – After transshipment

11 № No	12 Номер вагона Wagon No	13 Наименование груза Description of the goods	14 Код ГНГ NHM/GNG code	15 РИД/Приложение 2 к СМГС RID/Appendix 2 SMGS	16 Пломбы Seals	17 Масса определена отправителем, перевозчиком* Mass (weight) consignor/carrier*	18 Расчетная масса Chargeable mass (weight)	19 Провозная плата Carriage charge	20 Дополнительные сборы Ancillary charges	21 Итого платежей Total	22 № No	23 Номер вагона Wagon No	24 Пломбы Seals	25 Масса груза после перегрузки Mass (weight) following transshipment	26 Расчетная масса Chargeable mass (weight)	27 Провозная плата Carriage charge	28 Дополнительные сборы Ancillary charges	29 Итого платежей Total	30 Примечания Remarks

*ненужное зачеркнуть delete inapplicable
31 Общая масса отправки Total mass (weight) of the consignment
32 Общая масса Total mass (weight)

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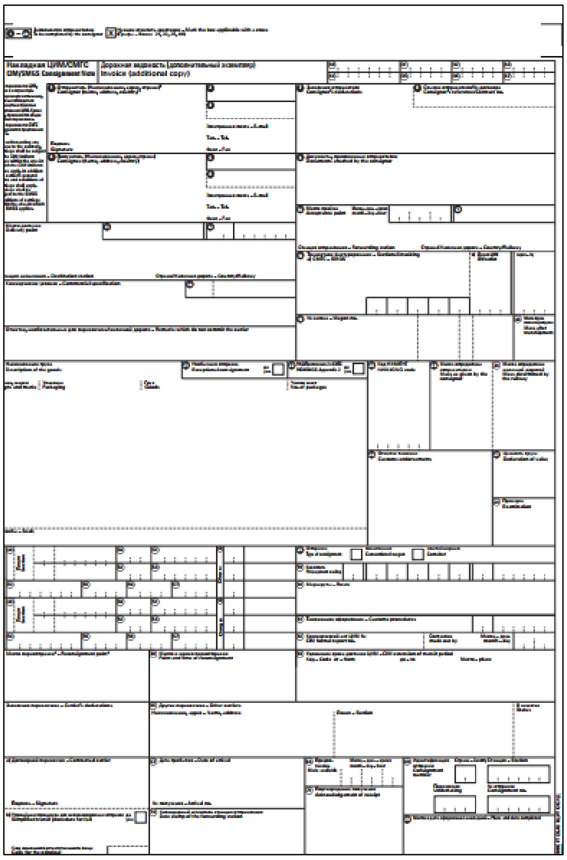
7.2.4.3. Specimen of the additional invoice forming

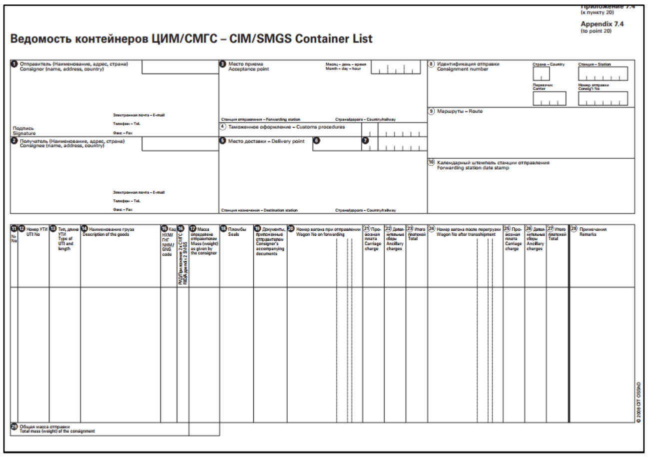
A common CIM/SMGS consignment note also contains specimen of additional invoice forming.



Накладная ЦИМ/СМГС CIM/SMGS Consignment Note
Дорожная ведомость (дополнительный экземпляр) Invoice (additional copy)

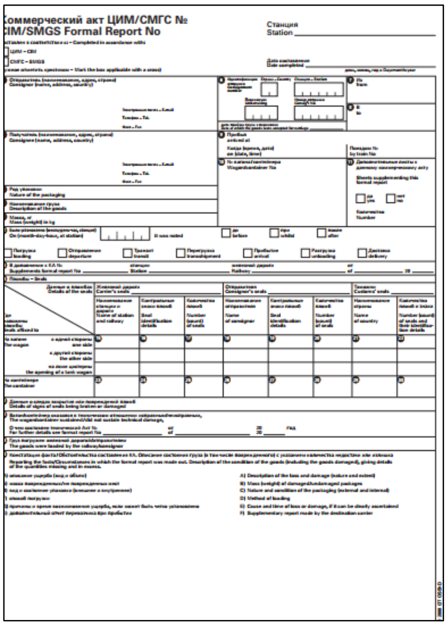
7.2.4.4. CIM/SMGS container list

Except where otherwise agreed, the consignor is to make out the CIM/SMGS container list and give it to the forwarding carrier with the CIM/SMGS consignment note. As many copies of the CIM/SMGS container list must be attached as the CIM/SMGS consignment note has sheets to include the additional copies of the invoice.


Ведомость контейнеров ЦИМ/СМГС – CIM/SMGS Container List

7.2.4.5. CIM/SMGS formal report

The purpose of the CIM/SMGS formal report is to record the condition of the goods and the extent of loss or damage. The CIM/SMGS formal report is to be made out in at least two copies. One copy is to be attached to the CIM/SMGS consignment note. Descriptions of the boxes on the CIM/SMGS formal report are to be printed in two, or as appropriate three, languages of which one must be Russian and another either English, French or German. For consignments to or from the People's Republic of China, descriptions of the boxes may additionally be printed in Chinese.


Коммерческий акт ЦИМ/СМГС №
CIM/SMGS Formal Report No

7.2.5. National freight bill

A national consignment note or domestic freight bill is very similar in format to the CIM consignment note. However, it can have a different official name. Sometimes the CIM consignment note is used in domestic rail freight transportation.

7.2.6. Other documents

7.2.6.1. Forwarders' certificates

If goods are send intermodally, it is unlikely that the same train will transport them the whole way. This is what the Forwarders' Certificate of Receipt (FCR) is needed. It provides a proof that a forwarder has collected goods with irrevocable instructions to deliver them to the consignee indicated on the FCR.[237]

[237] http://www.secondhand4business.com/transport/moving-goods-by-rail/key-rail-transport-documents/

The FCR can be presented for payment, rather than having to wait until a non-negotiable or negotiable transport document (the proof of the goods having been loaded onto the transport conveyance for the main international carriage, if any) is issued, which may be some time later.

While the FCR is non-negotiable, another similar document, the Forwarders' Certificate of Transport (FCT), is negotiable. This means that the forwarder accepts responsibility to deliver to a specified destination - not to an unchangeable destination as with the FCR.

7.2.6.2. Insurance for international rail transport

As with any commercial transaction, there are risks associated with trading internationally. Before moving goods by rail, insurance for international rail transport needs to be issued.

Three main risks arise in international trade. These are loss, damage and delay, including detention at customs. The contracts should use Incoterms to specify exactly how these risks are shared between buyer and seller.

Incoterms are an internationally recognised set of trading terms that spell out exactly when responsibility for the costs and risks of a transaction shift from seller to buyer. The greater the costs are, the greater the insurance cover needs to be arranged. Incoterms 2010 cover freight security obligations and new types of container transport.

Traders frequently under-insure themselves, so it is recommended to add 10% to the amount of cover needed. Cover for contingencies such as the buyer refusing to accept goods when they arrive can be also arranged.

7.3. Train document

A train document[238] is a list containing the necessary information for the safe operation of the train. The list can be manually prepared or produced by a computer system containing information on train services and wagons. It is prepared by railway undertaking (RU).

A train document contains information about:

- **the train identification number and destination**
- **the class and number of the locomotive(s)**
- **formation of the train from the locomotive**
- **authorised length limit**
- **actual length of the train**
- **actual load of the train** (the gross laden weight (in tonnes) of each wagon making up the train, including the weight of the locomotive and the weight of any wagon),
- **Route Availability** (RA) (RA of wagons and locomotives must not exceed the RA number for the route over which the train is to run unless this is permitted by the application of special conditions. If the RA figure is to be exceeded, each movement must be authorised by the issue of an exceptional load form)
- **highest route availability of any vehicle in the train**
- **maximum speed of the train** (the maximum speed at which a freight train can run is determined by the lowest permissible speed of any vehicle making up the train. This is subject to compliance with

[238] https://www.rssb.co.uk/rgs/rulebooks/GORT3056%20Iss%204.pdf

any emergency, temporary, or permanent speed restrictions. The maximum speed of any vehicle is contained in the wagon file for vehicles registered by Network Rail),

- **minimum brake force required in tonnes**
- **actual brake force available in tonnes**
- **actual number of vehicles**
- **dangerous goods** and their position in the train, or a **statement that no dangerous goods are being conveyed.**

The train document must be registered in the IT system of the railway infrastructure companies in each country. A loco driver must retain the train document during the journey. A train document must be provided for the guard if one is present for any part of the journey.

7.4. Documents for customs clearance in rail

7.4.1. Commercial invoice

The commercial invoice is a record or evidence of the transaction between the exporter and the importer.[239] Once the goods are available, the exporter issues a commercial invoice to the importer in order to charge him for the goods.

The commercial invoice contains the basic information on the transaction and is always required for customs clearance. Although some entries specific to the export-import trade are added, it is similar to an ordinary sales invoice. The minimum data generally included are the following:

- Information on the exporter and the importer (name and address)
- Date of issue
- Invoice number
- Description of the goods (name, quality, etc.)
- Unit of measure
- Quantity of goods
- Unit value
- Total item value
- Total invoice value and currency of payment. The equivalent amount must be indicated in a currency freely convertible to Euro or other legal tender in the importing EU country
- The terms of payment (method and date of payment, discounts, etc.)
- The terms of delivery according to the appropriate Incoterm
- Means of transport

No specific form is required. The commercial invoice is to be prepared by the exporter according to standard business practice and it must be submitted in the original along with at least one copy. In general, there is no need for the invoice to be signed. In practice, both the original and the copy of the commercial invoice are often signed. The commercial invoice may be prepared in any language. However, a translation into English is recommended.

[239] http://exporthelp.europa.eu/thdapp/display.htm?page=rt/rt_DocumentsForCustomsClearance.html&docType=main&languageId=EN

7.4.2. Custom Value Declaration

A Customs Value Declaration must be presented to the customs authorities where the value of the imported goods exceeds €10,000. The Customs Value Declaration must be drawn up conforming to form DV 1[240] of which a specimen is provided in Annex 8[241] to Regulation (EU) 2016/341[242] the UCC Transitional Delegated Act.[243] This form must be presented with the Single Administrative Document (SAD) (see further).

The main purpose of this requirement is to assess the value of the transaction in order to fix the customs value (taxable value) to apply the tariff duties.

The customs value corresponds to the value of the goods including all the costs incurred (e.g.: commercial price, transport, insurance) until the first point of entry into the European Union. The usual method to establish the Customs value is using the transaction value (the price paid or payable for the imported goods).

7.4.3. T1 transit declaration

In order to bring the goods under the regulations of external Community customs transport, a T1 declaration to Customs[244] needs to be submitted. Goods are not cleared as such, but they can be transported from customs depot to customs depot under the supervision of Customs.

A T1 is a transit document used to transport goods from the customs office at the place of departure to the customs office at the destination without paying customs duties and taxes within the territories of the countries included in the transit agreement.[245]

A T-document has restricted validity and must be settled in time by means of a subsequent document or be cleared into free circulation by means of clearance, or exported outside the EU again.

7.4.4. Freight documents

The following documents are to be filled in and presented to the customs authorities of the importing EU country upon importation in order for the goods to be cleared:

7.4.4.1. Bill of Lading (B/L)

Issued by the shipping company to the operating shipper, confirming that the goods have been received on board. The Bill of Lading serves as proof of receipt of the goods by the carrier obliging him to deliver the goods to the consignee. It contains the details of the goods, the vessel and the port of destination. It evidences the contract of carriage and conveys title to the goods, meaning that the bearer of the Bill of Lading is the owner of the goods.

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240 http://exporthelp.europa.eu/update/requirements/ehir_eu16_04v001/eu/auxi/eu_gen_valuedec_dv1.pdf
241 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32016R0341
242 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R0341
243 https://ec.europa.eu/taxation_customs/business/union-customs-code/ucc-legislation_en
244 http://www.logisticsglossary.com/term/t1/
245 http://www.f1express.fi/en-gb/node/66

The Bill of Lading may be a negotiable document. A number of different types of bills of lading can be used. “Clean Bills of Lading” state that the goods have been received in an apparent good order and condition. “Unclean or Dirty Bills of Lading” indicate that the goods are damaged or in bad order, in this case, the financing bank may refuse to accept the consignor's documents.

7.4.4.2. FIATA Bill of Lading

A document designed to be used as a multimodal or combined transport document with negotiable status. Developed by the International Federation of Freight Forwarders Associations (FIATA).[246]

7.4.4.3. CIM consignment note

A CIM consignment note (discussed earlier) required for the transportation of goods by rail and regulated by the Convention concerning International Carriage by Rail 1980 (COTIF-CIM). The CIM is issued by the carrier in five copies, the original accompanies the goods, the duplicate of the original is kept by the consignor and the three remaining copies by the carrier for internal purposes. It is considered to be the rail transport contract.

7.4.4.4. ATA Carnet

Temporary Admission carnets are international customs documents issued by the chambers of commerce in the majority of the industrialized world to allow the temporary importation of goods, free of customs duties and taxes. ATA carnets can be issued for the following categories of goods: commercial samples, professional equipment and goods for presentation or use at trade fairs, shows, exhibitions and the like.

7.4.5. Freight insurance

Insurance covers common risks during handling, storing, loading or transporting cargo, but also rare risks, such as riots, strikes or terrorism.

There is a difference between the goods transport insurance and the carrier’s responsibility insurance. The covered risks, fixed compensation and indemnity of the contract of transport insurance are left to the holder’s choice. Nevertheless, the hauler’s responsibility insurance is determined by different regulations. Depending on the means of transport, indemnity is limited by the weight and value of the goods and is only given in cases where the transporter cannot be held responsible. The insurance invoice is required for customs clearance only when the relevant data do not appear in the commercial invoice indicating the premium paid to insure the merchandise.

International transport of goods by rail is regulated by the Convention concerning Intercarriage by Rail (CIM Convention), signed in Bern in 1980. The rail carrier is not responsible for losses of or damages to the goods if he proves that they arise from:

- the merchandise’s own defect(s);
- force majeure;

[246] http://fiata.com/home.html

- a fault by the loader or consignee.

There is no EU regulation regarding compensation. Indemnification is normally limited to a maximum amount per gross kilo lost or damaged. In the majority of cases, therefore, the company is unlikely to receive anything approaching the value of its goods.

7.4.6. Packing list (P/L)

The packing list (P/L) is an inventory of the incoming cargo required for customs clearance and accompanying the commercial invoice and the transport documents.

It generally includes the following:
- the exporter, the importer and the transport company
- date of issue
- number of the freight invoice
- type of packaging (drum, crate, carton, box, barrel, bag, etc.)
- number of packages
- content of each package (description of the goods and number of items per package)
- marks and numbers
- net weight, gross weight and measurement of the packages

No specific form is required. The packing list is to be prepared by the exporter according to standard business practice and the original along with at least one copy must be submitted. Generally, there is no need for it to be signed. However, both the original and the copy of the packing list are often signed. The packing list may be prepared in any language, although a translation into English is recommended.

7.4.7. Single Administrative Document (SAD)

All goods imported into the EU must be declared to the customs authorities of the respective EU country using the Single Administrative Document (SAD),[247] which is the common import declaration form for all EU countries.

The SAD may be presented either by:
- using an approved computerised system linked to Customs authorities; or
- lodging it with the designated Customs Office premises.

The main information to be declared is:
- identifying data of the parties involved (importer, exporter, representative, etc.)
- customs-approved treatment (release for free circulation, release for consumption, temporary importation, transit, etc.)
- identifying data of the goods (Taric code, weight, units), location and packaging
- the means of transport
- data about country of origin, country of export and destination
- commercial and financial information (Incoterms, invoice value, invoice currency, exchange rate, insurance etc.)
- list of documents associated with the SAD (Import licenses, inspection certificates, document of origin, transport document, commercial invoice etc.)

[247] http://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/sad_text_en.xls

- declaration and method of payment of import taxes (tariff duties, VAT, Excises, etc)

The SAD set consists of eight copies; the operator completes all or part of the sheets depending on the type of operation.

For imports, generally three copies are used: one is retained by the authorities of the EU country in which arrival formalities are completed, another is used for statistical purposes by the EU country of destination and the last is returned to the consignee after being stamped by the customs authority.

7.4.7.1. Documents associated with the SAD

According to the operation and the nature of the imported goods, additional documents must be declared with the SAD and presented together with it. The most important documents are:

- documentary proof of origin, normally used to apply a tariff preferential treatment
- certificate confirming the special nature of the product
- transport document
- commercial invoice
- customs value declaration
- inspections certificates (health, veterinary, plant health certificates)
- import licenses
- community surveillance document
- cites certificate
- documents to support a claim of a tariff quota
- documents required for Excise purposes
- evidence to support a claim for VAT relief.

7.5. Summary

Rail documents required for international and domestic transportation of goods by rail:

	A block train	**SWL/wagon group**
National transportation	- Domestic consignment note - Wagon list - Dangerous goods (RID) - Train documents	- Domestic consignment note for each wagon or wagon group - Wagon list - Dangerous goods (RID) - Train documents
International transportation	- CIM/SMGS consignment note - Wagon list - Dangerous goods (RID) - Train documents - Custom documents	- CIM/SMGS consignment note for each wagon or wagon group - Wagon list - Dangerous goods (RID) - Train documents - Custom documents

8. Main Organisations and Associations

8.1. EU rail organisations and associations

Abbreviation	Full name	Missions/activities	Link
AEIF	European Association for Railway Interoperability	The AEIFy is the representative body mandated by the EU Commission to lay down the Technical Specifications for Interoperability of the Trans-European high speed railway system	www.aeif.org
ALE	Autonome Machinistenbond Europa	The ALE unites autonomous European trade unions and professional associations, which unionise locomotive drivers and other on-board staff.	www.ale.li
CER	The Community of European Railways and Infrastructure Companies	CER represents the interests of 81 railway undertakings, infrastructure companies and vehicle leasing companies from the European Union, the Western Balkan countries, Turkey, Norway, and Switzerland. The main objective is to contribute to a regulatory environment enhancing business opportunities for European railway and railway infrastructure companies	www.cer.be
CLECAT	European Association for Forwarding, Transport, Logistics and Custom Services	It represents the interests of 22 national organisations of European freight related service providers. The main objective is to strengthen and improve the representation of the transport-logistics sector and customs services industry in Europe. It represents its members vis-à-vis the institutions of the European Union; it promotes the transport-logistics and customs services sectors to representatives of the European Union as well as to society in general; it advises and informs Members about the effects of European Union developments on their sector.	www.clecat.org
EFRTC	European Federation of Railway Trackworks Contractor	EFRTC was founded in 1997. Membership consists of national federations, or where these do not exist national co-ordinators, representing the majority of specialist trackwork contractors for countries that are members of the European Union (EU), or the European Free Trade Area (EFTA). National federations and coordinators from other countries may be admitted as associate members. The principal objective of the EFRTC is to promote the common interests of its members - the specialist European trackwork contractors.	www.efrtc.org
EIA	European Intermodal Association	Its mission is to develop, improve and promote sustainable intermodal mobility combining innovative rail, waterway, road, air and maritime transport solutions. It aims at using every mode of transport in the most optimal way by improving their links with each other (also called “co-modality”).	www.eia-ngo.com
EIM	European Rail Infrastructure Managers	EIM was established in 2002 following the liberalisation of the EU railway market to promote the interests of independent rail infrastructure managers in the EU and the EEA. Based in	www.eimrail.org

		Brussels, EIM is registered as an international, non-profit association under Belgian law. It is one of 10 European railway organisations recognised by the European Commission as a 'representative body from the railway sector.' As such, EIM supports the work of the European Railway Agency (ERA) in various working groups and occupies a seat on its Administrative Board. The role of EIM is to provide a single voice to represent its members (independent infrastructure managers (IMs) vis-à-vis to the relevant European institutions and sector stakeholders. EIM also assists members to develop their businesses through the sharing of experiences and contributing to the technical and safety activities of the European Rail Agency (ERA).	
EPTTOLA	The European Passenger Train and Traction Operating Lessors' Association	Its objectives are to be a representative body for European passenger train and traction operating lessors that: examines those activities of European authorities which impact on the interests of its Members and communicates those activities to its Members; and works with such European authorities so as to ensure that its Members' interests are represented in those activities. EPTTOLA is recognised by the European Commission as an official stakeholder representative body for train leasing companies.	www.epttola.eu
ERA	European Rail Agency[248]	The European Railway Agency was set up to help create this integrated railway area by reinforcing safety and interoperability. The Agency also acts as the system authority for the European Rail Traffic Management System (ERTMS) project, which has been set up to create unique signalling standards throughout Europe.	www.era.europa.eu
ERFA	European Rail Freight Association	ERFA represents new entrants, i.e. all those operators who want open access and fair market conditions, and sustains their role of pushing forward the development of the railway market. The members of ERFA represent the entire value chain of rail transportation: rail freight operators, wagon keepers, service providers, forwarders, passenger operators and national rail freight associations. ERFA works towards a competitive and innovative single European railway market by promoting attractive, fair and transparent market conditions for all railway companies.	www.erfarail.eu
ERFCP	The European Rail Freight Customers Platform	It is an initiative of European and national associations of industries and groupings. The aim of the platform is the realisation of a single, customer-oriented rail freight market in Europe.	www.erfcp.org

[248] Following the entry into force of the technical pillar of the 4th EU Railway Package, the European Union Agency for Railways replaces and succeeds the European Railway Agency (ERA). The "Agency" refers as from now to the European Union Agency for Railways. However depending on the context, some parts of the text still refer to the former ERA.

ERRAC	The European Rail Research Advisory Council	ERRAC was set up by, and is responsible to, the European Commission. It was established in 2001 to help create a single European body with both the competence and capability to help revitalise the European rail sector and make it more competitive, by fostering increased innovation and guiding research efforts at European level.	www.errac.org
ERWA	European Railway Wheels Association	ERWA is the UNIFE Railway Wheels and Wheelsets Committee. It supports the Railway Industry in the promotion of railway by contributing to improvements in wheels and wheel sets through a focus on safety, reliability and economic efficiency. The activity of the Committee also includes the definition, adaptation and implementation of advanced technologies.	www.unife.org
ETF	Européenne de Travaux Ferroviaires (European Railway Works)	ETF, a subsidiary of EUROVIA (VINCI Group) is one of the world's leading players in the rail industry. The company specializes in the construction and maintenance of national railway networks, urban transport networks and industrial sidings. The company's broad range of technical expertise encompasses all railway works, from railway civil engineering, overhead contact lines, railway safety, and power supply to signalling. Active both in France and abroad, ETF has contributed to the development of railway infrastructure in recent decades: high-speed lines, concrete-slab tracks, metal and rubber-wheeled tramway systems, automated metros.	www.etf.fr
EUROFIMA		EUROFIMA European Company for the Financing of Railroad Rolling Stock is a supranational organization located in Basel, Switzerland. It was established in 1956 based on an international treaty signed by 25 European sovereign States so far. EUROFIMA fulfils a non-profit maximizing mission to support the development of rail transportation in Europe. It supports its shareholder railways as well as other railway bodies in renewing and modernizing their equipment.	www.eurofima.org
FTE	Forum Train Europe	It is a pan-European forum for international production, planning, timetable co-ordination and harmonisation of train paths for allocation in European rail traffic.	www.forumtraineurope.org

FIATA	International Federation of Freight Forwarders Associations	The main objectives are to unite the freight forwarding industry worldwide; to represent, promote and protect the interests of the industry by participating as advisors or experts in meetings of international bodies dealing with transportation; to familiarise trade and industry and the public at large with the services rendered by freight forwarders through the dissemination of information, distribution of publications, etc.; to improve the quality of services rendered by freight forwarders by developing and promoting uniform forwarding documents, standard trading conditions, etc.; to assist with vocational training for freight forwarders, liability insurance problems, tools for electronic commerce including electronic data interchange (EDI) and barcode	www.fiata.com
NSA/NSARE	The National Skills Academy for Railway Engineering	It was established with wide railway industry support to help tackle current and future skills needs within the railway engineering industry. NSARE doesn't deliver training. It works with employers to understand their skills needs, with training providers to ensure they are delivering what the industry needs and with other stakeholders, such as sector skills bodies	www.nsare.org
RFE	Rail Forum Europe	It is an international non-profit making association that aims at bringing together EU decision-makers and the rail sector to achieve a better understanding of rail-related issues. It intends to establish and strengthen professional and personal ties between its members in full compliance with European and national Law; co-operation with various scientific, technical, economic, industrial and professional groups and organisations whose activities affect the various issues that concern rail transport.	www.rail-forum.eu
RNE	Rail Net Europe	RNE is an association set up by a majority of European Rail Infrastructure Managers and Allocation Bodies to enable fast and easy access to European rail, as well as to increase the quality and efficiency of international rail traffic. It has 35 members.	www.rne.eu
T&E	The European Federation for Transport and Environment	A European umbrella for non-governmental organisations working in the field of transport and the environment, promoting sustainable transport in Europe.	www.transportenvironment.org
UEEIV	Union of European Railway Engineer Associations	The UEEIV is the umbrella organization of the European railway engineers. Its core competence is the certification of European railway engineer. So in addition to the EURAILING qualified railway engineer thus offer new opportunities and prospects in the international labour market. Currently over 300 railway engineers in 18 countries are already certified by the UEEIV.	www.ueeiv.eu

UIRR	International Union For Road-Rail Combined Transport	It counts 19 members (18 active and 1 associated) in 14 different countries. The active members are all private operators and the majority of their capital is detained by road hauliers, shippers or their associations. All UIRR's activities are directed towards the development of road-rail CT in Europe as well as to represent and defend the interests of its members.	www.uirr.com
UIP	International Union of Private Wagon Keepers	It was founded in 1950. Its main office is located in Brussels. UIP is the umbrella association of national associations from fourteen European countries, thus representing more than 250 keepers with approximately 180,000 freight wagons, performing 50 % of the rail freight tonne-Kilometres throughout Europe. The UIP represents the members' concerns at international level. By means of research, lobbying and focused cooperation with all stakeholders and organisations interested in rail freight transportation, the UIP wants to secure on the long term the future of rail freight transport.	www.uiprail.org
UNIFE	Association of the European Rail Industry	Promoting European policies favourable to rail; shaping a European interoperable and effective railway system; ensuring European rail supply industry leadership through advanced research, innovation and quality; providing members with market, technical and political intelligence	www.unife.org

8.2. National Organisations and Associations

EU Country	Abbreviation	Full name	Missions/activities	Link
France	**AFFI**	Railway Engineers & Executives Association	*Information is not available*	
	AIF	Railway Industry Association	It has more than 130 member companies, representing about 10,000 jobs in the sector, we work on a daily basis to achieve these various goals.	www.aifonline.com
	FIF	Railway Industry Association	FIF has 280 member companies representing the whole spectrum of railway equipment industries, ranging from rolling-stock builders to engineering firms, railway equipment manufacturers to track & signalling industries, designing to testing.	www.fif.asso.fr
	GART	Association of Transport Authorities	It was created in 1980. The main mission is to promote and increase the use of public transport as alternative to private car.	www.gart.org
Germany	**VDEI**	German Association of Railway Engineers	It is the professional association for engineers in the area of track-guided transport (railways) operate. It has approximately 4,500 members. It offers a wide professional and social network. Its goal is strengthening and the development of rail transport. It is committed to the economic and transport policy interests of engineers and their professional development.	www.vdei.de
	VDV	Association of Transport Operators	About 600 companies performing public passenger transport and rail freight transport in Germany are organised in the "Verband Deutscher Verkehrsunternehmen" (VDV = Association of German Transport Companies). The VDV advises and supports its member companies and politicians, supports the exchange of experience and know-how between the members and prepares technical, operational, legal and economic principles.	www.vdv.de
Italy	**ASSIFER**	Italian Association of Railway Electrical Industries	It represents companies operating in Italy in the field of rail transport and urban public transport electrified (metro, tram, and trolley-bus), for the construction of vehicles, components and systems for the sectors: Rolling Stock, Signalling and Electrification & TLC. ASSIFER is the association of a strategic industrial sector for the development of the country. ASSIFER is part of ANIE Federation, the Federation of Confindustria that represents the	www.assifer.anie.it

			electrotechnical and electronic sectors of the most strategic and innovative national industrial scenario.	
Poland	**SIRTS**	Association for Rail Transport Interoperability and Development	Polish association for rail transport interoperability and development. The main goals are to inform about the AU law and EU standardization for Polish railway industry; to represent the Polish railway industry opinion in UNIFE works; to promote the Polish railway industry in the EU; to co-operate with Polish railway authorities and non-governmental organisations; to co-operate with international authorities and organisations involved in railway transport legislation, standardisation, research and development; to participate in Polish and international railway related projects dealing with legal and standardisation issues; to organise conferences, seminars and workshops	www.sirts.eu
Spain	**MAFEX**	Spanish Railway Association	MAFEX is a non-profit association whose main objective is to serve the Spanish railway sector, by supporting their businesses in their promotional activities abroad and by defending the general interests of their companies associated. For this it relies on the experience and prestige of over 35 years of GRUPO AGEX as well as agencies and public institutions with which it collaborates.	www.mafex.es
Sweden	**SWERIG**	Swedish Rail Industry Group	The Swedish National Team of Rail Competence the SWERIG group is an independent organisation with some 50 member companies representing the very best of what Sweden can offer within the railway sector. The member companies cover the complete range of railway products and services – from planning, technical consulting, systems design and installations along the rail track, rolling stock including components, and railway software.	www.swerig.se
Switzerland	**SWISSRAIL**	SWISSRAIL Industry Association	SWISSRAIL Industry Association is the export promotion organisation of the Swiss industry and Swiss commerce in the field of guided transport systems founded in 1977. It is a private, legally independent non-profit organisation with more than 100 member companies. SWISSRAIL is mainly a marketing organisation whose primary function is communication. It is active worldwide as well as in Switzerland and includes the foremost consultants and industrial companies and a high number of	www.swissrail.com

			innovative medium and small size enterprises. SWISSRAIL has the support of the Swiss Federal Railways, the public transport authorities including the associated privately-owned rail- ways, urban transport operators and cableways, the Federal Office of Transport and the Institute of Transportation, Traffic, Highway and Railway Engineering.	
The Netherlands	**Railforum**		Railforum exists since 1992 and it is the independent network of more than 85 companies and organizations active in the broad rail sector.	www.railforum.nl
UK	**ATOS**	Association of Train Operating Companies	ATOC's mission is to work for passenger rail operators in serving customers and supporting a prosperous railway. It was set up after privatisation in 1993, the Association brings together all train companies to preserve and enhance the benefits for passengers of Britain's national rail network.	www.atoc.org
	RFG	Rail Freight Group	Rail Freight Group is the leading representative body for rail freight in the UK, with a membership which includes some of the biggest names in logistics along with many smaller companies, all of whom contribute to the success of rail freight. Its members include ports, terminal operators, property developers, equipment suppliers and support services.	www.rfg.org.uk
	RIA	Railway Industry Association	The Railway Industry Association is the representative body for UK-based suppliers of equipment and services to the world-wide industry. It has around 180 member companies, active across the whole range of railway supply. RIA members represent the greater part of the UK railway supply industry by turnover. Most large firms are members, as well as a wide range of smaller companies.	www.riagb.org.uk
	YRP	Young Rail Professionals	It was founded in 2009, brings together young people from across the UK railway industry, covering all aspects of the industry from engineering, to asset management, train operations, strategic planning, rolling stock design, maintenance, franchising, regulation, marketing, etc.	www.youngrailpro.com

8.3. International Organisations and Associations

Abbreviation	Full name	Missions/activities	Link
	Arab Union of Railways	In 1979, representatives of some Arab railways met in Amman and decided to establish the Arab Union of Railways to assist in development of relations between neighbouring networks, to establish international cooperation between railway organizations, and to obtain an increased share of the transport market. The Union membership is comprised of most Arab railways and is based in Aleppo, Syria. The Union: Organizes scientific conferences on important subjects by holding bi-annual international symposia. The eighth one will be held in Beirut, Lebanon, in autumn this year. Special seminars on subjects of interest to Arab railways have been held in Aleppo in 1994 and in Cairo in 1996. Organizes training courses to raise the professional level of railways staff Conducts studies and presents proposals on unified regulations and technical specifications. Unifies railway terms in Arab countries by issuing six dictionaries of 25,000 railway terms in Arabic, French and English Publishes Arab Railways, a railway quarterly in three languages, Arabic, French and English. The Union also publishes annual statistics on the Arab railways.	www.unescwa.org/arab-union-railways
ALAMYS	Latin American Association of Underground Networks & Subways	The Association was founded in 1986, Caracas. ALAMYS represents rail passenger and freight companies from Latin America and Iberian Peninsula.	www.alamys.org
ARA	Australasian Railway Association	The Australasian Railway Association (ARA) is the peak body for rail in Australia, representing all sectors of the rail industry. It represents an array of rail organisations, including private and public, passenger and freight operators, track owners and managers, manufacturers of rolling stock, construction companies and all other organisations supplying and contributing to the Australasian rail sector. It provides a coordinated and unified voice on relevant issues of national importance. The ARA engages political leaders at both the state and federal level in forward-looking discussions around industry potential. It brings about key policy reform to effectively enhance Australia's productivity, economic and social prosperity, as well as its international competitiveness.	www.ara.net.au

CIT	The International Rail Transport Committee	It is an organisation of 200 railway undertakings which provide international transport of passengers and/or freight. It is an association under Swiss law with its headquarters in Bern and its task is to provide all necessary juridical documents and instruments for international traffic at railroad level. The CIT helps railways implement international rail transport law, standardises the contractual relationships between the various players (customers, carriers, infrastructure managers, wagon keepers, customs authorities) and represents the interests of carriers by rail vis-à-vis legislators and authorities. In addition, it provides regular briefings for its members and provides members with training courses and legal advice.	www.cit-rail.org
IARO	International Air Rail Organisation	It shares world-class best practice and good workable ideas among people interested in rail links to airports and air-rail intermodality. It includes organisations planning, developing, building and operating rail air links. It represents, a unique community within Air/Rail, facilitating the exchange of experience, ideas and information, offering genuine insight and sector intelligence to its membership	www.iaro.com
IHHA	International Heavy Haul Association	The International Heavy Haul Association, Inc. is a non-profit, non-political entity organized to facilitate and participate in the development or acquisition and distribution of knowledge germane to heavy haul railroad technology and operations. Membership is open to any heavy haul railroad regardless of country of origin.	www.ihha.net
	International Transport Forum	The International Transport Forum at the OECD is an intergovernmental organisation with 54-member countries. It acts as a strategic think tank for transport policy and organises an Annual Summit of ministers. Its goal is to help shape the transport policy agenda on a global level, and ensure that it contributes to economic growth, environmental protection, social inclusion and the preservation of human life and well-being.	www.internationaltransportforum.org
OSShD/OSJD	Organisation for Co-operation between Railways	OSJD is an international organization established at the Railway Ministers Conference in Sofia, Republic of Bulgaria, by the ministers, responsible for the railway transport on 28 June 1956. The OSJD activities are undertaken according to the OSJD Statute, which is of an international treaty nature. Main objectives of OSJD include development of international freight and passenger traffic, creation of common railway transport environment in the Eurasian region, higher competitiveness and an increase in transcontinental railway routes as well as promotion of technological progress and technical-scientific cooperation in the field of railway transport. 28 countries take part in activities of OSJD as an intergovernmental organization.	www.en.osjd.org

RAC	Railway Association of Canada	RAC represents more than 50 freight and passenger railway companies—railways that transport close to 82m passengers and more than $280bn worth of goods across our country each year. RAC also counts a growing number of industrial railways and railway supply companies in its associate membership. As part of the fifth largest rail network in the world, RAC members are the backbone of Canada's transportation system.	www.railcan.ca
SARA	Southern African Railways Association	SARA is a 'Non-profit Organisation' domiciled in Zimbabwe formed in April 1996 in terms of its Constitution in response to increasing road competition. At its formation, SARA was to originally provide the SADC railways with a strong lobbying association to pursue advocacy for fair surface transport competition to be achieved through– "levelling of the playing field" between road and rail in terms of policy and regulations. Modal equity was to be achieved by enforcing the User Pays Principle where the road pays the full cost of road infrastructure or infrastructure support to railways by Governments. Members of SARA are predominantly railways in the SADC region, some major railway customers and suppliers, and other organisations with special interest in railways.	www.sararail.org
UIC	International Union of Railways	Includes 197 members across all 5 continents. It promotes rail transport at world level and meets the challenges of mobility and sustainable development. Promotes sharing of the best practices among members; support members to develop new business and areas of activities; propose new ways to improve technical and environmental performance; promotes interoperability, new world standards for rails; develops centres of competence (high speed, safety, security, e)business, etc.)	www.uic.org
UIP	International Union of Private Wagon Keepers	It is the umbrella association of national associations from fourteen European countries, thus representing more than 250 keepers with approximately 180,000 freight wagons, performing 50% of the rail freight tonne-Kilometres throughout Europe. The UIP represents the members' concerns at international level. By means of research, lobbying and focused co-operation with all stakeholders and organisations interested in rail freight transportation, the UIP wants to secure the long term future of rail freight transport.	www.uiprail.org/about_the_uip.php
UITP	The International Association of Public Transport	The international network for public transport authorities and operators, policy decision-makers, scientific institutes and the public transport supply and service industry.	www.uitp.org

Glossary of Rail Freight Terminology

Accompanied/combined transport – also known as the "Rolling Road." A truck shuttle system whereby the entire vehicle is transported by rail.[249]

Absolute Block – a railway signalling system which is based on the principle of dividing a railway line into a sequence of individual sections or blocks, allied to the principle of never having more than one train on the same line in the same section at the same time. The acceptance of a train by the signaller at the signal box in advance is necessary before a train is allowed to proceed into the Absolute Block Section.

Access Charge – the charge paid by railway operators for access to rail facilities which are the subject of an access agreement.

Adjacent Line – a line or siding next to the line you are on (Rule Book definition).

Adjustment Switch – a device which allows longitudinal rail movement to dissipate thermal forces when CWR is adjacent to jointed track or other features not designed to withstand thermal forces. Adjustment switches are also used when thermal forces, additional to those in CWR, may be encountered such as at long underbridges which are themselves subject to expansion and contraction. (US term: Breather Switch.)

Ancillary Movement – movements of locomotives and rolling stock directly in association with normal day-to-day train services.

Apron – an area of roadway, loading and/or parking land by a railway station, often larger than a forecourt.

Articulation – the core feature of a rolling stock design where two adjacent railway vehicle ends are mounted on a common bogie. Nowadays much favoured by tramcar or light rail vehicle (LRV) designers. Also used for some European high-speed train designs, namely, TGV and Eurostar carriages. It has the benefit of reducing the number of bogies required for a train. Generally, only suitable for lighter weight vehicles since the load on each axle is proportionately increased. Usually requires that special lifting systems or bogie drop-pits are provided in maintenance workshops.

Automatic Barrier Crossing Locally monitored (ABCL) – type of level crossing with warning lights and half barriers, for use on railway lines where train speeds are no greater than 60 mph (96 km/h). The operation of these is controlled by the approaching train, potentially using a level crossing predictor system. It differs from the AHB system in that there is a white light, at braking distance from the crossing, to indicate to the train driver that the crossing has engaged the closing sequence correctly.

Automatic[250] **Block Signal (ABS)** – a train control subsystem based on a series of consecutive blocks governed by block signals which are controlled by the movement of trains and certain other conditions (e.g., detection of level crossing closure) rather than by a signaller or train describer driven route setting system. The installation includes automatic line side signals, cab signals or both, actuated by a train or light engine by means of axle counters or track circuits. This is a very basic form of automatic route setting (ARS).

Automatic Cab Signal System (ACS) (US) – a system that automatically operates a display of signal aspects in the cab of a train as well as the cab warning whistle.

Automatic Code Insertion – the means by which, when a train terminates, the next working of its stock is automatically picked up by the signalling in IECC areas.

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[249] http://www.dbschenker.com/file/2964714/data/dbschenkerrailog_brochure.pdf

[250] 'Automatic' Systems: see the comment under the heading 'Automatic Systems' and the associated diagram concerned with Train Control Systems.

Automatic Coupler – an automatic coupler allows two vehicles to be attached to each other merely by pushing the two vehicles together. There are various types and systems in use, which range from a simple automatic mechanical coupler (like the 'buckeye coupler' of US origin) to one which is remotely controlled and can connect and secure air and electrical connections in one operation. In Europe only used for Multiple Unit trains and specialised types of rolling stock. The proposed UIC auto-coupler was shelved in the 1970s due to cost but Germany and France are currently carrying out trials of a traction-only auto-coupler.

Automatic Dropping Device – mechanism which causes a damaged or displaced pantograph to drop automatically to limit (further) damage to the overhead line equipment.

Automatic Half Barrier crossing (AHB) – type of level crossing with warning lights and half barriers, for use on railway lines where train speeds are no greater than 100 mph (160 km/h). The operation of these is controlled by the approaching train, potentially using a level crossing predictor system where trains operate at several different speeds. The crossing sequence must start a minimum of 27 s before the arrival of the train at the crossing. The barriers are raised immediately after the passage of the train, unless another train is approaching.

Automatic Level Crossing – includes AHB, ABCL, AOCL and AOCR level crossings plus those protected by miniature red/green warning lights**.**

Automatic Open Crossing, Locally monitored (AOCL) – a type of level crossing without barriers on the Network Rail system where operation of the warning lights is triggered by the train. It also differs from the AHB system in that there is a white light, at braking distance from the crossing, to indicate to the train driver that the crossing has engaged the closing sequence correctly.

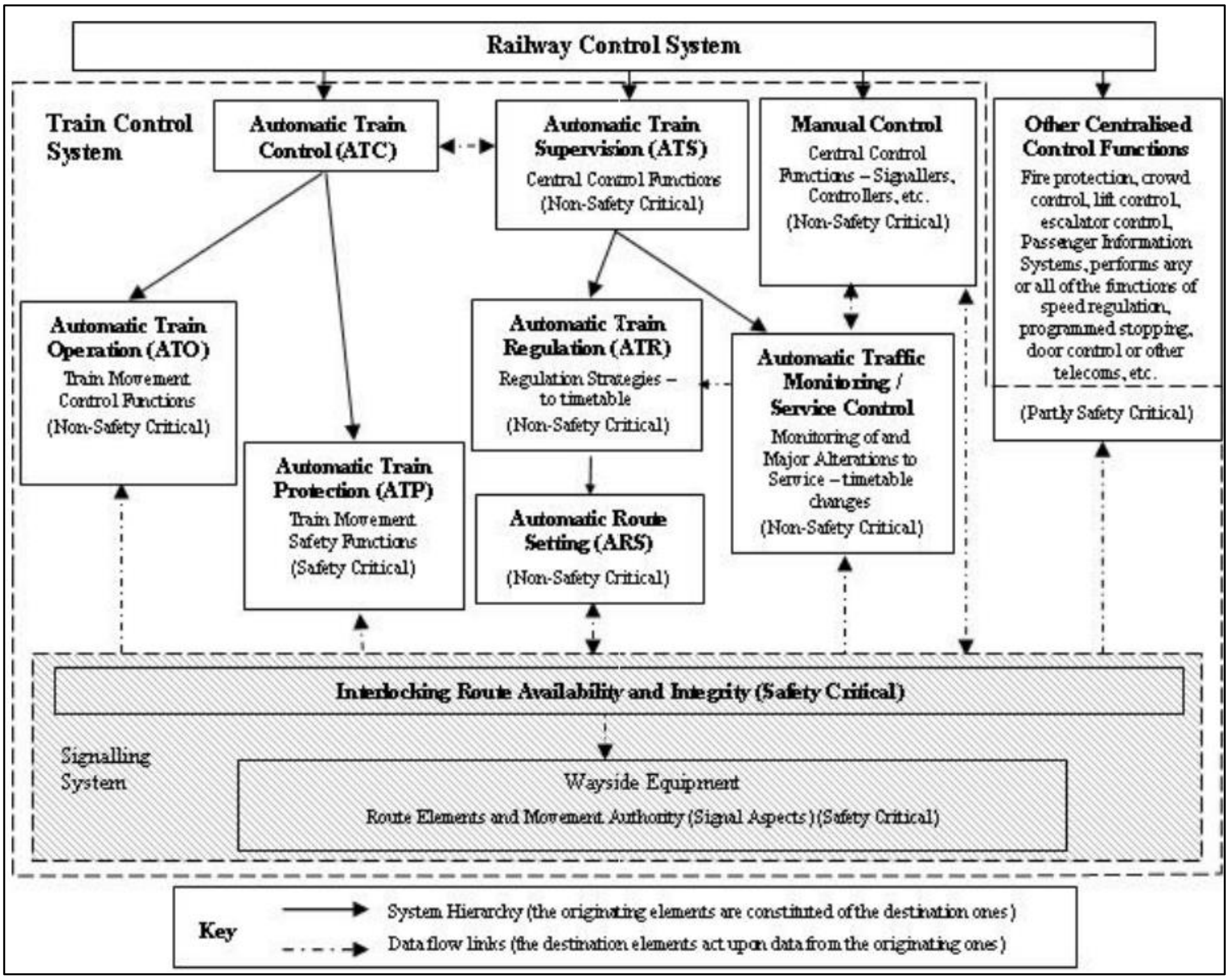
Automatic Open Crossing, Remotely monitored (AOCR) – now only one left on the Network Rail system (in Scotland). Here the operation of the crossing is monitored in the signal box but not interlocked with the signalling of the line. Automatic Railway Inquiry Systems in Europe – a prototype system to provide passenger timetable information.

Automatic Route Setting (System) (ARS) – electronic or relay based system which sets routes using information from a train describer and the timetable without the need for intervention by a signaller.

Automatic Signal – a colour light signal which operates automatically as trains travel onto and off track circuits ahead.

Automatic Stop Arm (US) – see (Automatic) Train Stop (UK).

Automatic Systems – the hierarchy of the components of automatic assistance to the operation of trains is not clear-cut. Different authors advocate different structures. The structure presented on the diagram below is based on a study of railway automation system by D. Woodland.



Automatic Train Control (ATC) – the system for automatically controlling train movements and directing train operations. ATC requires automatic train operation (ATO) and automatic train protection (ATP) subsystems and has features which enhance operational safety, e.g., through the separation of trains by implementing a conflict free timetable, train detection and interlocking of routes. ATC allows the automatic control of trains throughout a railway network, obviating the need for train drivers. The Docklands Light Railway in London provides a good example of this type of operation. (Australians use this acronym to describe automatic train protection.)

Automatic Train Monitoring (ATM) – subsystem to monitor the train service by means of train describers, track circuit occupation or balise based data collection. ATM is normally a subsystem of automatic train supervision (ATS) and is sometimes also referred to as train service monitoring.

Automatic Train Operation (ATO) – the subsystem within the automatic train control (ATC) system which performs functions otherwise assigned to the train operator (driver). ATO is not generally considered to be safety critical since interlockings and automatic train protection (ATP) ensure that trains' routes and movements cannot conflict. Driverless operation of trains requires the transmission of control data using track circuits, inductive loops, balises or radio signals. Radio signals can be diffused by broadcast or leaky cable feeders.

Automatic Systems – the hierarchy of the components of automatic assistance to the operation of trains is not clear-cut. Different authors advocate different structures. The structure presented in Figure 1 is based on a study of railway automation system by D. Woodland.

Automatic Train Protection (ATP) – the subsystem within the overall train control system which automatically ensures compliance with or observation of some or all speed restrictions or movement authorities'. Normally, the term ATP refers to the provision of fail-safe protection against collisions, excessive speed, and other hazardous conditions which may arise during train movements by preventing trains from ignoring control commands. This definition covers what could be described as 'Comprehensive ATP' (see below). Less effective systems (such as TPWS, AWS and Trainstops) are sometimes also classified as ATP. As a result, the following hierarchy of functionality is proposed, with ATP as the 'global' term:

Warning Systems	'systems assisting observation of movement authorities, based upon manual activation', e.g., the Driver Reminder Appliance (DRA);
Automatic Warning Systems	'systems automatically assisting observation of movement authorities', e.g. the standard British AWS system;
Automatic Train Stop	'a system automatically enforcing compliance with the limits of movement authorities';
Partial ATP	'a system automatically enforcing compliance with speed restrictions and movement authorities at some locations or for some vehicles';
Comprehensive ATP	'a system automatically enforcing compliance with all speed restrictions and movement authorities (for all vehicles) within a given area'. This type of system is often divided into two sub-categories, Intermittent ATP and Continuous ATP.

There are many different types of implementation, but all require the transmission of control data using track circuits, inductive loops, balises or radio signals. Radio signals can be diffused by broadcast or leaky cable feeders.

Automatic Train Regulation (ATR) – subsystem to ensure that the train service returns to timetabled operation or to regular, fixed headways, following disruption. ATR subsystems adjust the performance of individual trains to maintain schedules. ATR is normally a subsystem of automatic train supervision (ATS).

Automatic Train Reporting – electronic system for reporting train movements based on the passing of train identities using a signal panel train describer.

Automatic Train Stop – a wayside system that works in conjunction with equipment installed on the vehicle to apply the brakes at designated speed restrictions, block signals or on a dispatcher's signal, should the driver not respond. Once actuated, the brakes are applied until the train has been brought to stop. See Train Stop.

Automatic Train Supervision (ATS) – the top-level system in real time train control which regulates performance levels, monitors the trains in service and which provides data to controllers to adjust the service to minimise the inconvenience otherwise caused by irregularities. The ATS subsystem also typically includes automatic train regulation functions which are implemented through an automatic routing system (ARS). ATS requires automatic train monitoring (ATM) and service monitoring to be able to adjust the timings of trains appropriately. ATS supports automatic train control by managing the routes or network.

Automatic Vehicle Identification – semi-automatic mechanism for reporting of train movements based on the location of freight rolling stock and subsequent translation to actual train identities/activities reported to TOPS (generally limited to electricity coal services).

Automatic Vehicle Identification (AVI) – transponder based system to identify the number and other useful information of any vehicle in a train using a trackside interrogating unit. The passive UIC standard system is low-cost (about US$40 per unit for the hardware). AVI components are also being used for low-cost ATP applications.

Automatic Warning System – used to give advance warning to drivers of a signal aspect, a temporary speed restriction or a permanent speed restriction at least 30% slower than the previous limit.

Automatic Warning System (AWS) – British system for alerting the driver to a signal aspect which requires action (horn for danger) or indicating a clear signal ahead (bell for green). Based on a track-mounted permanent magnet with an electro-magnet to cancel the warning.

Autonomous Traction – a form of traction where the power source is contained wholly on the vehicle (Diesel, gas turbines, battery, flywheel, coal, wood) allowing the vehicle to travel a design range between refuelling. Auxiliary Wayside System – a back-up or secondary train control system, capable of providing full or partial automatic train protection for trains not equipped with train borne CBTC equipment, and/or trains with partially or totally inoperative train borne CBTC equipment. The auxiliary wayside system generally includes train borne equipment and may also provide broken rail detection.

Axle Arrangement – the way in which powered and non-powered axles are arranged under a vehicle. The most commonly used description distinguishes between powered and non-powered axles where the letter "A" stands for a single powered axle, "B" for two, etc. while numbers stand for the non-powered axles:

- A1A-A1A is the axle arrangement of a locomotive with two bogies, each of which has two powered axles with an non-powered axle in between;
- C0-C0 or Co-Co is the axle arrangement of a locomotive with two bogies with three powered axles. Other well-known arrangements are B0-B0-B0 (Bo-Bo-Bo) for heavy locomotives and 1A-A1 for EMU cars.

Axle – the part of a wheelset which links the two wheels. Normally, wheels are pressed onto shoulders machined onto the axle. Axles normally have outside bearings which sit in axle-boxes. Inside bearings are more difficult to install and maintain but reduce the unsprung mass acting on the track.

Balise – track mounted device for communicating with passing trains. Most are mounted on a sleeper in the middle of the track (4 foot). We distinguish inductive and radio based balises, active and passive balises and intelligent and dumb balises. All balises transmit or transmit and receive information in the form of telegrams, e.g., one of the ERTMS standards allows the transmission of up to 512 bits of information three times while a train is passing at up to 250km/h.

- *inductive balises* operate at low frequencies and use inductive coupling between a fixed coil (antenna) and a moving coil on board the vehicle;
- *radio based balises* operate at several hundred MHz and use aerials embedded in the balise and suspended underneath the front end of the vehicle;
- *passive balises* must be powered up by the passing train, usually using a 100kHz signal coupled inductively. The balise detects the presence of a train and automatically transmits the stored data. This is the most common type of balise;
- *active balises* use an external supply to transmit data and are often used to power track loops (EUROLOOP) where data is transmitted continuously;
- *dumb balises* simply transmit fixed information such as the balise number, number and position of the next balise(s), gradients and speed restrictions etc.;
- *intelligent balises* transmit a combination of fixed and variable information such as the aspects of signals associated with the balise. In some cases, they can also receive and process information from the train.

It is possible to have most combinations of the types, e.g., active intelligent inductive balises.

Ballast – selected material placed on the sub grade (US: roadbed) to support and hold the track with respect to its alignment within the bounds of specified top (vertical) and line (horizontal). Ballast preferably consists of accurately graded hard particles, normally stone, easily handled in tamping, which distribute the load, provide elasticity, drain well and resist plant growth. Generally, ballast must consist of broken stones. Granite is a very suitable material thanks to its toughness.

Bi-Directional Lines – rail lines which are fully signalled to take trains in both directions.

Bi-Directional Signalling – allows trains to run in either direction over the same section of track under the control of an interlocking (built-in safety system) which prevents collisions. Bi-directional signalling is very useful in releasing for maintenance a single track of a two-track railway but it is more complex and expensive to install than single direction signalling. Single-track lines always have bi-directional signalling. (Swiss Term: *banalised track*.)

Bill of loading or **consignment note -** Legal certificate stating that a contract of carriage has been drawn up and signed, documenting the ownership of cargo and acknowledging that specified goods have been received.

Block (Section) – a length of track of defined limits onto which one train only is usually allowed at any one time (exceptions include the joining of trains, split platforms and breakdown recovery). The access to and use of the block section is governed by verbal instruction, track warrant, token or track circuit controlled block (section) signals or by some other type of signalling. Older type block signalling requires the presence of block instruments to communicate with adjoining signal boxes.

Bogie – a four or six-wheeled frame, normally used in pairs under long-bodied railway vehicles and on locomotives or individually in-between two sections of an articulated vehicle. The bogie has a central pivot point, which allows it to turn as the track curves and it thus guides the vehicle into the curve. The pivot point can be real or it can be created by links and flexibility in the suspension. There are almost as many bogie designs as there are bogies. All-welded box-frame bogies with some steering capability are currently the fashion in Europe. Good design is crucial to achieve a good ride quality, although track condition is also very important in assuring this.

Block train or full train – railway train in which all the wagons contain the goods of one customer, and are shipped from the same origin to the same destination, without being split up or stored on route.

Bo-Bo (EU) – a locomotive with a 4 wheel per bogie configuration, each individually powered, as opposed to a 6-wheel "Co-Co" configuration**.**

Bowl yard, bowl track – a classification yard with an ascending grade at both ends, which thus prevents free-rolling cars from running out the opposite end during switching operations.

Brake Van - any vehicle with a brake compartment.

Braking Distance – the distance a train needs in which to stop (or to reduce speed) from travelling at a given speed.

Branch (Line) – track carrying trains from the mainline to destinations on lower priority routes than the mainline.

Bump Stop – hard rubber suspension component which stops a movement close to the end of the spring travel of a lateral or vertical suspension.

Butt Weld – a weld joining two abutting surfaces by depositing weld metal within an intervening space or by melting both rail ends and then pushing them together. This weld serves to unite the abutting surfaces of the elements of a member or to join members by their elements abutting upon or against each other. Butt rail welding of one rail to another can be accomplished in-plant or on site by electric resistance fusion (Flash Butt Welding) or by an alumino-thermic process in the field.

Cab – the space in the power unit or driving unit of the train containing the operating controls and providing shelter and seats for the driver or engine crew.

Cargo rail station, freight depot/yard - Cargo traffic location where goods are handled and prepared for upcoming transportation.

Carriage (UK) – passenger carrying rail vehicle, also referred to as Coaching Stock. (US: Coach)

Carriage Line – a line used to move empty rolling stock / carriages only.

Carrier - The company engaged in transporting the goods (e.g. by rail).

Carrier Drain – an impervious drain designed to carry water from place to place instead of collecting water from the surface or surrounding soil directly.

Category A Platform – a platform on LUL where the driver cannot see the entire platform train interface from the normal driving position in the cab without using mirrors or monitors. If this equipment is defective at a category A platform, assisted despatch must be provided.

Category B Platform – a platform on LUL where the driver can see the entire platform train interface from the normal driving position in the cab without using mirrors or monitors. If this equipment is defective at a category B platform, the driver can despatch the train by looking back from the cab to make sure no person or article is trapped in the doors.

Catenary – (1) the catenary wire or cable (also known as the messenger wire) carries the contact wire by means of dropper wires. The term was chosen because the catenary wire assumes more or less the shape of the curve adopted by a suspended chain or wire. (2) Generic term used for a power supply arrangement incorporating at least a contact wire and a catenary wire connected by droppers. See Overhead Line.

Centralised Traffic Control (CTC) – remotely controlled system of signals and points under which train movements are authorised by station and block signals whose indications determine the precedence of trains. The manipulation of automatic and/or cab signals and power-operated turnouts is effected from a central location where indications on panels or displays indicate the position of trains and the state of signals and points. (UK: Power Box or Integrated Electronic Control Centre IECC)

Centre Siding – a length of track laid between two running lines for the purpose of reversing trains, usually beyond a station. It allows a train to reverse direction without crossing a track carrying through trains. Sometimes referred to as a "reversing siding." (US: *pocket track* or *turnback track*).

Cess – the area either side of the railway immediately off the ballast shoulder. This usually provides a safe area for workers to stand when trains approach.

Chair – the cast steel fixture on a sleeper, which secures rail (particularly bullhead rail) in the correct position. Depending on the design, of which there are many, the rail is secured to the chair by a form of clip, key or spike.

Class of Train – there are 10 classes of trains:

Class 0 – Light locomotive (locomotive running on its own);
Class 1 – Express passenger trains, mail trains and some emergency trains;
Class 2 – Stopping passenger trains;
Class 3 – Express parcel trains;
Class 4 – Express freight trains – 75mph maximum speed;
Class 5 – Empty coaching stock trains (passenger vehicles running empty);
Class 6 – Express freight trains – 60mph maximum speed;
Class 7 – Freight trains with 45mph maximum speed;

Class 8 – Freight trains with 35mph maximum speed;
Class 9 – Eurostar trains.

Clockface Timetable – a timetable where trains run at regular intervals (e.g., every 10 minutes.)

Co-Co (EU) – a heavier duty locomotive with 6 wheels per bogie (all axles being separately driven) configuration as opposed to a 4-wheel "Bo-Bo" configuration. The correct classification is Co'Co', but Co-Co is used more often

Combined transport or **intermodal transport** – This method involves the transportation of cargo in a container or swap body or trailer, using various means of transportation (rail, ocean vessel and truck), without any handling of the freight itself when changing modes.

Conductor Rail – an additional rail (or rails) provided on those electric railways where power is transmitted to trains from the track. Often referred to as the 'third rail' or 'current rail', it is normally at positive potential and is mounted on insulators to the outside of and slightly higher than the running rails. The return of the circuit is via the running rails. The current is collected by the train through 'shoes', attached to the bogies, which slide on top, along or under the rail. The continuity of conductor rails must be broken at junctions in the track to allow continuity of the running rails. Such 'gaps' may cause momentary loss of power to the train. There are cases from time to time of trains becoming 'gapped' at complex junctions, i.e. they stall over a gap and have to be rescued by another train. London Underground has a fourth rail (negative) for a completely insulated circuit. This is known as a four-rail system and the running rails are at an offset potential between the contact rails. Modern 3rd rail systems are under – pinning to allow the installation of protective (insulating) covers.

Contact Wire – hard-drawn copper, silver or (in Russia) aluminium wire, which is normally suspended from a catenary wire by droppers and is swept by the stainless steel contact strip (Japan) or aluminium contact piece (France – DC electrified lines) of the pantograph.

Contact Wire – the overhead wire touched by an electric train's pantograph in order to draw power.

Cow and calf – a diesel locomotive with a crew cab permanently coupled to and acting as a controller for a similar slave diesel locomotive without a crew cab, primarily used for switching/shunting duties for large groups of rolling stock. Also known as master and slave, as in the British Rail Class 13 shunters at Tinsley Marshalling Yard.

Derail – a track safety device to guide non-authorised train movements off the rails at a selected spot, as a means of protection against collisions or other accidents. Modern day equivalent for catch-points in areas with slow moving traffic. Usually linked to a point giving access to a main line or through track.

Detonator – a small disc shaped warning device, designed to be placed on the railhead for protection and emergency purposes. It explodes when a train passes over, thus alerting the driver. Detonators are being phased out. Correctly known as a fog signal

Diamond Crossing – arrangement of a line where one track crosses another, without connection, at an angle of less than 90º, at grade. Named after the pattern formed by the ails.

Differential Global Positioning by Satellite (DGPS) – navigation based on signals received from four or five satellites with a correction factor received from a fixed position reference transmitter via terrestrial FM.

Direct Traffic Control (DTC) – system of traffic control with sections of track identified with clear boundaries, where permission to proceed is granted remotely by a dispatcher. Ordinarily, only one train may occupy a DTC block at a time. Similar to train warrant control (TWC) except that the section entry timings are fixed by timetable rather than granted case by case. DTC may be used in conjunction with track signalling in APB, ABS, or over "dark territory".

Distant Signal (AU, CH, D etc.) – fixed signal which indicates the state of the main signal on the approach to a block signal, station entry or exit signal etc. It will not convey information as to conditions affecting the use of the track between the distant signal and main signal. Distant signals are necessary where a train driver can not react fast enough once he or she sees the main signal. Often combined with the previous main signal.

Dual Voltage Locomotive (Train) – locomotive or multiple unit train designed to operate over lines having two different electric traction power supply systems. Locomotives have been designed to operate with up to four different voltages covering both AC and DC systems. Some trains can operate on lines with either overhead or third rail current collection, as in the case of Eurostar Trains and UK Class 92 Channel Tunnel locomotives and some North East Corridor trains in New York. Eurostar trains can handle 750Vdc (England) 1500Vdc (Holland + France), 3000Vdc (Belgium) and 25kVac (Belgium and France).

Dwell Time – the time a vehicle or train spends at a station or stop to allow passengers to board and alight, measured as the interval between time of stopping and starting.

Dynamic Braking – a train braking system using the traction motors of the power vehicle(s) to act as generators with the energy dissipated in brake resistors (rheostatic braking) or supplied to other trains via the supply system (regenerative braking).

Dynamic Track Stabiliser – a self propelled on-track machine for consolidating track ballast by inducing high frequency vibration into the ballast through the rails and sleepers. This treatment allows resumption of operations at line speed after a maintenance intervention (tamping etc.).

Eco TransIT – Internet tool used by several European rail companies. Determines and compares the ecological balance of freight shipments with various other modes of transport.[251]

Electric Multiple Unit (EMU) – the generic term for an electrically powered suburban or metro train where a separate locomotive is not required because the traction drive and control system is contained under or in the roof space of various cars in the train (*see also* Multiple Unit).

Electrification – a term used to describe the installation of overhead wire or third (or 4th) rail power distribution facilities to enable operation of EMU trains or trains hauled by electric locomotives.

Electro Magnetic Interference – interference in the signalling system caused by inductive coupling with traction motors, transformer stray fields, radio waves being generated by electronic equipment etc.

Electromagnetic Compatibility – the ability of electronic devices to function satisfactorily in the presence of magnetic and electric fields.

Electronic Data Interchange – a computer network enabling suppliers and customers to pass orders, invoices, and payments electronically.

Equivalent Million Gross Tons Per Annum – a measure of the damage effect on the track caused by different types of trains running at different speeds and with different axle loads.

EROS – (1) Emergency Restriction of Speed: a reduction of normal speed which has to be applied in an emergency or (2a) Efficiency by the Rationalisation of Signalboxes and (2b) Early Rationalisation of

[251] www.ecotransit.org

Signalling, Railtrack's accelerated programme of closing small signal boxes and concentrating work at fewer, larger signal boxes.

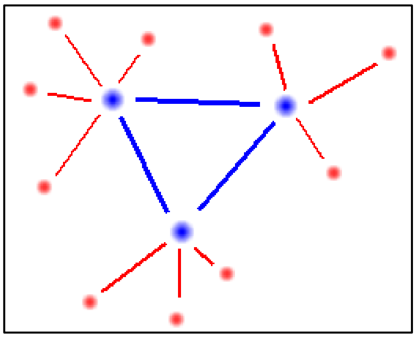
European Integrated Railways Radio Enhanced Network (EIRENE) – pan-European development project for a train radio system suitable for transmitting the information required by ERTMS. Uses GSM in the 900MHz band allocated to railways.

European Rail Traffic Management System (ERTMS) – high level set of standards to allow interoperability and effective management of Trans European railway operations. Previously, there was no distinction between the management aspects and the technical solution, European Train Control System (ETCS).

European Train Control System (ETCS) – the signalling equipment aspect of ERTMS with its three levels of train control. The Level 1 is effectively a standardised ATP system with line side signals. Levels 2 and 3 require output from project EIRENE to assure transmission of movement authority by radio.

Event recorder – a device that continuously captures analog and digital train systems information and stores that data for a minimum of 48 hours. This data is used to evaluate incidents and accidents. Typical stored data includes speed, brake pressure, dynamic brake, horn activation, track signal, etc. In the U.S., event recorders are mandated by the Federal Railroad Administration (FRA) for freight, passenger and commuter rail. Regulations for railroad outside the U.S. vary by country. Transit operations are not generally required to have event recorders, but have begun to add them voluntarily.

Feeder line – is a peripheral route or branch in a network, which connects smaller or more remote nodes with a route or branch carrying heavier traffic. The term is applicable to any system based on a hierarchical network.



A diagram of a hierarchical communications network. Feeder lines (in red) provide communication with important nodes.

Feeder service – a locomotive which fetches the full wagons to be added to the train and brings empty ones to be filled.

Flyovers – is a special infrastructure that allows to switch from one side traffic to another one at the crossing point between two countries with different traffic systems, for instance, Germany-France.

Freight car or **freight wagon** – Vehicles used for the transportation of goods (from all-round to special-purpose types) for rail transportation.

Freightways – European cross-border tracks for freight transportation used by all European train operators.

Full train – synonym for a 'block train.'

Gauge – the distance between the inner running faces (gauge lines) of the two rails of a track. Also used to describe the "envelope" through which trains' profiles must fit – this is the structure gauge (US-spelling "gage".

Overview of Common Track Gauges:

Broad gauge (Spain):	1674 mm	5'5 9/10th"
Broad gauge (Portugal):	1665 mm	5'5 11/20th"
Broad gauge (Ireland):	1600 mm	5'3"
Broad gauge (Finland):	1524 mm	5' exactly
Broad gauge (former USSR):	1520 mm	5'
Standard gauge (World-wide Application):	1435 mm	4'8 1/2"
Narrow gauge (Cape gauge – Africa, Japan):	1067 mm	3'6"
Narrow gauge (metre gauge):	1000 mm	3'3 37/100"

Narrow gauge (Latin America)	950 mm	
Narrow gauge (Austria):	750 mm	

Gauge Line – a line five-eighths of an inch, about 15mm below the running surface of a rail on the side of the head nearest the track centre; the line from which measurements of gauge are made.

Gauntlet track or **interlaced track** (also **gantlet track**) – an arrangement in which railway tracks run parallel on a single track bed and are interlaced (i.e. overlapped) such that only one pair of rails may be used at a time. Since this requires only slightly more width than a single track, all rails can be carried on the same crossties/sleepers. Trains run on the discrete pair of rails appropriate to their direction, track gauge or loading gauge.

General Purpose Radio System (GPRS) – implementation of PSS using mobile radio communications.

Geographic and Infrastructure Systems (GEOGIS) – a major database of railway infrastructure assets containing information on the physical location of track, buildings and structures.

Geographic Information System (GIS) – high quality database for assets using exact geographic information for object location, in most cases referenced to a national grid system. It may include full mapping information. Generally of a relational type and based on a standard software such as ORACLE or ARCINFO.

Global Positioning by Satellite (GPS) – navigation based on measuring time delays of signals received from four or five satellites. See also DGPS.

Global System for Mobile Communications (GSM) – internationally agreed standard and protocols for mobile radio (telephone type) communications using cellular arrangements to maximise use of the frequency spectrum. European standard.

Global System for Mobile Communications for Railways (GSM-R) – specialised GSM cellular Personal Mobile Radio (PMR) implementation for railways using the 900MHz band and with a higher level of reliability and safety and more features than GSM.

Headshunt (UK), Shunting neck (US) – length of track feeding a number of sidings that permits the sidings to be shunted without blocking the main line, or where two lines merge into one before ending with a buffer, to allow a run-round procedure to take place.

Headway – the time interval between the passing of the front ends of successive multiple units or trains moving along the same lane or track in the same direction.

Hunting (UK), Boxing (US) – the sinusoidal oscillation of a bogie or wheelset at speed caused by wheelset conicity and yaw stiffness and initiated by irregularities in the track or wheels. Different designs "hunt" in different ways and under different conditions. Below a critical speed, the oscillations decay away. Above the critical speed the oscillations increase, and this can have a damaging effect on rails or may lead to the train being derailed. Suspension design often affects ride as much as anything and the whole science of bogie design can be a bit of a black art.

Independent brake – the common name for the braking system that applies or releases the brakes of a locomotive independently from its train; sometimes called the locomotive brake in layman's terms.

Intermodal freight – moving goods by more than one type of vehicle. Intermodal freight can be transported using shipping containers which can easily be transferred among railroad flatcars, ships, and trucks.

Intermodal traffic – Freight transportation involving several different Types of transport mode (e.g. rail, truck, aircraft etc.)

Interlocking – is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as junctions or crossings. The signalling appliances and tracks are sometimes collectively referred to as an *interlocking plant*. An interlocking is designed so that it is impossible to display a signal to proceed unless the route to be used is proven safe.[252]

Junction – a point at which two tracks diverge from each other.

Kunden Service (KS) – European cross-border tracks for freight transportation used by all European train operators.

Level Crossing (UK) – the point where a railway line and a motor vehicle road intersect at the same level. Protection levels include (i) signage, (ii) road traffic signals, (iii) flashing lights, (iv) automatic half barriers, (v) automatic full barriers, (vi) manually operated barriers. Level crossings may be monitored locally or remotely using CCTV etc.

Licensed Operator – a company or organisation who is granted a licence by the Rail Regulator to operate rail services, and to operate vehicles on the track, under terms and conditions defined by the Rail Regulator.

Light Loco – term used to describe a locomotive running on its own without a train (usually to or from a depot for maintenance etc. (sometimes called a Light Diesel or Light Electric, according to type)

Light rail – a city-based rail system based on tram design standards that operates mostly in private rights-of-way separated from other traffic but sometimes, if necessary, mixed with other traffic in city streets. Light rail vehicles (LRV) generally have a top speed of around 55 mph (89 km/h) though mostly operating at much lower speeds, more akin to road vehicles. Light rail vehicles usually run on trackage that weighs less per foot (due to a smaller track profile) than the tracks used for main-line freight trains; thus they are "light rail" due to the smaller rails usually used.

Loading Gauge – the dimensions of height and width which must not be exceeded by a rail vehicle or its load, so as not to foul lineside fixtures or structured. Similarly, the dimensions in respect to the rails which must not be infringed by such structures (structure gauge). See also Kinematic Envelope

Loading yard – European cross-border tracks for freight transportation used by all European train operators.

Local train – a train that stops at most, if not all, stations along its route. Often referred to in North America as a “milk train” or “milk run”.

Locomotive – a self-propelled, non-revenue rail vehicle designed to convert electrical or mechanical energy into tractive effort to haul trains of non-powered carriages and freight cars.

Loop/loop line – is a low-speed track section distinct from a running line or through route such as a main line or branch line or spur. It may connect to through track or to other sidings at either end. Sidings often have lighter rails, meant for lower speed or less heavy traffic, and few, if any, signals. Sidings connected at both ends to a running line are commonly known as *loops*; otherwise they are known as *single-ended sidings* or *dead end sidings*, or (if short) *stubs*.

Maglev – magnetically-levitated vehicle or train of vehicles with guidance and propulsion provided by magnetic forces. Support can be provided by either an electro-dynamic system (EDS) whereby a moving

[252] http://en.wikipedia.org/wiki/Interlocking

vehicle is lifted by magnetic forces induced in the guideway, or an electromagnetic system (EMS) where the magnetic lifting forces are created by actively energising magnets in the guideway.

Main Line (UK+US) – the principal line or lines of a railway as opposed to branch lines (UK: also known as trunk routes). Sometimes used to refer to the fastest line(s) in a multiple track area.

Main Track (M.T.) (US) – a track extending through yards and between stations upon which trains are operated by timetable or train order or both, or the use of which is governed by block signals. (UK: Main Line)

Maintenance – the activity of returning an asset to a condition where it can safely and reliably perform its function.

Maintenance Depot – a location defined in a Train Operator's contingency plan with the facilities to repair or replace specified items of defective on-train equipment (Rule Book definition).

Marshalling yard (classification yards-US) – is a railroad yard found at some freight train stations, used to separate wagons on to one of several tracks. First the wagons are taken to a track, sometimes called a *lead* or a *drill*. From there the wagons are sent through a series of switches called a *ladder* onto the classification tracks. Larger yards tend to put the lead on an artificially built hill called a *hump* to use the force of gravity to propel the wagons through the ladder. There are three types of classification yards: *flat-shunted yards* (constructed on flat ground), *hump yards* (heart of these yards is the hump: a lead track on a hill (hump) that an engine pushes the cars over. Single wagons, or some coupled cars in a block, are uncoupled just before or at the crest of the hump, and roll by gravity onto their destination tracks in the classification bowl (the tracks where the wagons are sorted)) and *gravity yards* (operated similarly to hump yards but, in contrast to the latter, the whole yard is set up on a continuous falling gradient and there is less use of shunting engines).

Modalsplit – the amount of total traffic volume (tonnage) according to the transportation mode (road, rail, ship).

Multi-modal traffic – Freight transportation involving several different Types of transport mode (e.g. rail, truck, aircraft etc.)

Multiple unit – a self-propelled rail vehicle that can be joined with compatible others and controlled from a single driving station. The sub-classes of this type of vehicle; Diesel Multiple Unit (DMU), Diesel-Electric Multiple Unit (DEMU) and Electric Multiple Unit (EMU) are more common terms.

Narrow Gauge – a gauge narrower than standard gauge. A gauge of 24 inches or less is commonly employed for industrial railways. Meter gauge is often used in territories at some time under the influence of Germany and France while UK influenced areas would be dominated by 3ft6in tracks (1067mm).

Network Rail – the not-for-profit company that maintains and enhances most railway (not Metro) wayside infrastructure in UK, created when Railtrack was put into railway administration. Network Rail bought the assets of Railtrack in spring 2003. Some harbour railways are also responsible for their own track.

Open wagon (UIC, UK) – a form of freight wagon for bulk goods.

Overhead – generic term (as in "the overhead") referring to electric traction supply wires suspended over the track for current collection by trains. Also known as "overhead line, OLE or OHLE (overhead line equipment) or catenary after the contact wire suspension system. Current is collected by a pantograph on the roof of the train or locomotive, although trolley poles are still used on some tramways (e.g., Melbourne, AU).

Overlap – the section of line in advance of a stop signal which must be cleared by the preceding train before the next signal in rear of the stop signal can display a proceed aspect. Practically, a short (about 200m) additional braking distance beyond a signal, provided in case the train fails to stop at the signal when it is showing a danger aspect. On metros using the equiblock system, the overlap is usually a full block section long.

P-train – an NMBS/SNCB commuter train.

Packet Switch System (PSS) – transmission of information (voice, data, *etc*.) over one or several routes, using short packages, each with a unique identifier, which are combined by the receiver to make up the full message.

Pantograph (see picture) – variable height traction current collection device mounted on the roof of a railway vehicle fed from an overhead supply system, usually featuring a carbon contract strip. Nowadays, pantographs are sophisticated aerodynamically designed devices which can operate at high speeds and on tilting trains without loss of contact and with built-in safety devices which reduce the risk of damage to overhead wires in the event of a fault. Under certain circumstances (high winds etc.) a pantograph may rise above the wire and can pull it down for considerable distances before this is noticed by the train crew and the train can be stopped. Modern pantographs are fitted with automatic detection and dropping devices (ADD), such a device can be created by using a hollow carbon collector strip on the pantograph. This is connected to a pneumatic circuit which will trigger a switch if the air escapes when the contact strip fractures due to an impact. Alternatively, the horns (curved ends) of the pantograph may be equipped with frangible pneumatic sensors which, if broken by a wire support, cause the detector system to lower the pantograph.

Private wagon owner – companies that hire freight cars out for freight operations on a commercial basis.

Private siding – track directly linking company to rail network.

Rail – a rolled steel shape designed to be laid end-to-end in two parallel lines on sleepers (US: ties), to form a track for railway rolling stock, travelling cranes and the like. There are two main types of rail in use in the UK. Flatbottom rail is the most common, while Bullhead rail is still in use in sidings and on branch lines. Network Rail has adopted UIC60 rail (which weighs 60 kg/m or 125 lb/yd) as its standard for high speed lines. The previous standard, which is still being installed, is equivalent to the UIC 54 rail, and weighs about 113 lbs/yd or 54 kg/m.

Railcar – a powered single unit or articulated passenger car, usually “railroad-derived” light DMU or EMU, with a driver's cab at one or both ends.

Rail Foot – the flat bottomed part of the rail, held down by the fastenings.

Rail Head – the top portion of the rail that the wheels run on.

Railroad car – a railroad vehicle that is not a locomotive.

Railtrack – the privately owned company (plc) that bought the railway infrastructure at the time of privatisation. Railtrack was put into Railway Administration by the UK government in autumn 2001, partly as a result of the Hatfield railway accident. The company was dissolved and its assets were bought by Network Rail.

Railway Safety and Standards Board (RSSB) – railway industry group owned not-for-profit company in charge of setting Group Standards, auditing performance and pushing forward the safety agenda through research and development.

Refuge siding – a siding used as a passing place on a main line, where slow trains may be held whilst an express passes. A simpler, but less convenient, form of the passing loop.

REV (rev) – found on international registered wagons to denote date of overhaul.

Rolling Road – Also known as accompanied combined traffic.

Rolling stock (UK) – passenger and freight vehicles, locomotives, multiple units, any vehicle in revenue service.

Running track – an other-than-main track, typically providing access to a yard or industry and governed by the requirements of restricted speed.

Running Round – transferring a locomotive from one end of a train to the other by means of a loop.

Schnabel car – is a specialized type of railroad freight car. It is designed to carry heavy and oversized loads in such a way that the load makes up part of the car. The load is suspended between the two ends of the cars by lifting arms; the lifting arms are connected to an assembly of pivots and frames that distribute the weight of the load and the lifting arm over a large number of wheels.

Schnabel car with transformer travels parallel to a road

Seaport Hinterland traffic – Describes the transportation process from seaports by rail, road or inland waterway (e.g. Rhine or Elbe) into the hinterland.

Section – the division of the track for security (occupation).

Semaphore Signals – such signals are usually worked mechanically by wire from a signal box lever frame, but can be electrically operated. They use mechanical arms rather than coloured lights to display aspects. Traditional types are “upper quadrant and lower quadrant” position where the “clear” positions are at approximately 45^{o} to the horizontal.

Set – a complete train, including loco and carriages or a multiple unit train.

Shipper (consignor) – the party requiring carriage and logistics services (generally the end user).

Shunting – is the process of sorting items of rolling stock into complete train sets or consists, or the reverse.

Siding – a track auxiliary to a main or secondary track for the meeting or passing of trains.

Single Line – one line which is available for movement in both directions.

Sleeper – wood, concrete or steel object that holds the rails apart and supports the track on the ballast.

Sleeper (UK) – in the US known as "ties," short for "crossties." The transverse members of track (-work), made of wood, concrete or steel, or even plastic composite, which are used to secure the rails at the correct gauge. Cast steel chairs fixed to the sleepers hold the rails in place by means of clips or keys.

Slot - is a license that allows its holder, usually a railway company, to run a train on a specific section of track at a specific time, similar to an airport slot in civil aviation. Rail infrastructure companies such as Network Rail in Great Britain and DB Netze in Germany own the tracks and stations in their area of responsibility and make money by selling train slots to companies which operate freight and passenger services.[253]

Switching Yard (US) – (*see* Marshalling Yard (UK)).

Terminal – an assemblage of facilities provided by a railway at a terminus or at an intermediate point for the handling of passengers or freight and the receiving, classifying, assembling and dispatching of trains.

Third Rail – an additional rail besides the two running rails which carries electric current for trains which operate on electrical system.

Third Rail System – traction current supply system which uses an additional rail to transmit the electrical supply from where it is collected by collector shoes attached to the train. *See fourth rail system and conductor rail*.

Track – an assembly of rail, fastenings and sleepers over which railway carriages, wagons, locomotives and trains are moved. The track is usually defined as the area covered by the rails, rail fastenings and sleeper hardware and the roadbed.

Track Circuit – means by which the passage of trains is detected and the information used to control signals provided for train safety and control. This method of train detection (train location) uses a voltage which is applied at one end of a track section and detected at the other end. An electric current must flow in the rails of the track which therefore requires insulation of the rails with respect to each other. Rail joints between track circuit sections must be specially bonded at rail joints used by the signalling system. When a vehicle enters the track circuit section the detection occurs when its wheelsets (wheels and axles) short-circuit the rails together and interrupt the flow of electricity to the receiver. Track circuits can be based on High voltage, Pulse, DC, Audio Frequency signals etc. The simplest track circuit consists of a relay energised by a low voltage circuit fed through the running rails of a section of track.

Traction Current – term used for the electric power supply used on electric railways for trains. Normally supplied by overhead wire or third rail and collected by a pantograph on the roof of the train in the former case or by shoes attached to the bogies in the latter.

Traction Motor – electric motor used to provide the driving or braking torque to a locomotive or multiple unit axle. Used in diesel-electric and electric systems. The traction motor is mounted close to the axle and transmits power through a reduction a final drive gearbox or final drive.

Traction Unit – generic term for a railway vehicle which can move under its own power. It includes locomotives, multiple units, self-propelled rail vehicles and road rail vehicles operating in rail mode.

Train – is a form of rail transport consisting of a series of vehicles that usually runs along a rail track to transport cargo or passengers although magnetic levitation trains that float above the track exist too. Motive power is provided by a separate locomotive or individual motors in self-propelled multiple units.

Train Control System (US) – American designed software tool for managing train operations. English, Welsh and Scottish railways intended to use TCS to control its freight operations as a successor of TOPS.

[253] Paolo Beria, Emile Quinet, Gines de Rus, and Carola Schulze (September 2012). "A comparison of rail liberalisation levels across four European countries." Research in Transportation Economics 36 (1): pp. 110–120.

Train Operator – an organisation authorised and licensed to operate trains over the Network Rail network infrastructure that holds an accepted Railway Operator's Safety Case and a Rail Operator's Licence.

Train Set – a group of coupled cars including at least one power unit.

UIC – *Union Internationale des Chemins de Fer*, or International Union of Railways. The European railway regulating body which sets engineering and operating standards for railways. Equivalent to the AAR in the United States.

Web of Rail (UK) – space between head and base of a rail occupied by the fish plate at rail joints.

Welded Vee – two pieces of rail with parts of the head and foot removed by machining placed either side of a filler plate so as to form a weld preparation, welded using the electroslag welding process and subsequently machined to the drawing requirements.

Wheel Flat – a localised flat area on a steel wheel of a rail vehicle, usually caused by skidding on steel rails, causing a discontinuity in the wheel radius.

Wheel Set – a fixed formation of an axle with two wheels set at the correct gauge for the track. The wheels are pressed onto the axle and rotate with it as a unit. It is mounted into the bogie (or vehicle) frame with using axle boxes.

Wheel Slide – synonymous with skidding and usually caused by over braking during poor adhesive conditions. It is a common cause of wheel damage, as it produces a flat spot (called a "flat") on the wheel where the skid occurred. Severe flats have been known to derail a train.
Modern rolling stock is equipped with various systems to assist with the elimination of wheel slide. These include load control, automatic brake "dumping" if a slide is detected, cosmetic rail applications like Sandite to improve adhesion and attention to maintenance of correct mechanical brake settings. See also our brakes section.

Wheel Slip – the phenomenon caused on a locomotive or power vehicle by over application of power to the drive system relative to the available adhesion. It can cause damage to electric motors and is normally automatically detected to immediately eliminate or reduce the power being applied. A modern system recently developed using microprocessors is known as creep control and permits a certain degree of slip as this has been proven to improve torque transmission efficiency.

Wheel Squeal – the noise produced by wheel-rail interaction, particularly on a curve where the radius of curvature is smaller than allowed by the separation of the axles in a wheel set.

Yard – a system of tracks within defined limits provided for making up trains, storing cars, and other purposes, over which movements not authorised by time table or by train-order may be made, subject to prescribed signals and rules, or special instructions.

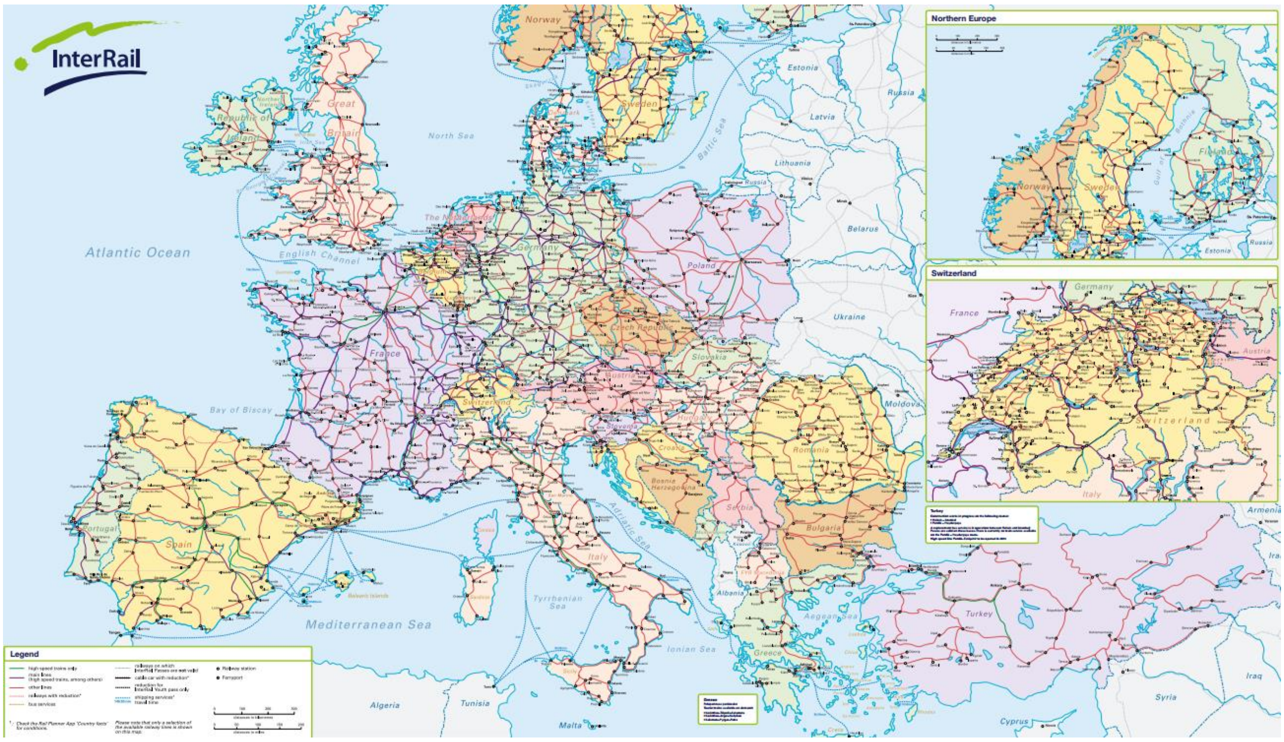
UK versus US Terminology

UK	US	Comment
Apply	Set	… of brakes
Brake Controller	Brake Stand	In Cab
Brake Pipe	Train Line	… train line on LUL
Brake Van	Caboose	
Bogie	Truck	Bogie
Buffer stop	Stubbing post	… see bump stop
Buffer Stop (marks end of line)	Bump Stop	Buffer Stop (marks end of line)
Cant	Superelevation	… of track
Carriage	Couch	Trailer in some countries
Carriage Line	Side Track	
Carriage Shed	Car Barn	
Clear	Highball	… signal
Controller	Dispatcher	… of Route or area
Couple	Add	Vehicle to a train
Crossing	Frog	
Depot	Maintenance Facility	Depot
Double-Deck	Bi-Level	Passenger vehicle
Draw Gear	Draft Gear	
Driver	Engineer	
Engine under tow	Dead Head	In US, sometimes called 'unsked' light running
Fishplate	Joint bar	
Fitter	Maintainer	
Front	Head end	… of train
Goods wagon	Freight car	
Guard	Conductor	Guard
Head-on collision	Cornfield Meet	…in clear, open country
Hunting	Boxing	
Level Crossing	Grade Crossing	
Lineside	Wayside	Lineside
Main Track	Main Line	
Marshalling Yard	Switching Yard	
Notching up	Hooking up	… locomotive power
Overhead line	Catenary	
Pantograph	Electric trolley	
Permanent Way Maintenance	Maintenance of Way	
Points	Switch	Points
Points	Turnout	… see also 'switch'
"Point & Xing" work (P&C)	Special Trackwork	In UK, also Switch and Xing (S&C)
Railway	Railroad	
Railway Station	Train Station	Railway Station
Rake/Formation	Consist	…of train
Reversing siding/bay road	Pocket Track	

Shunt Signal	Dummy	ground signal
Sleeper	Tie	… from term ‘cross tie’
Stabling	Lay Up	To put a train out of service...depot
Timetable	Schedule	
Train Stop	Automatic Stop Arm	
Transition Curve	Spiral	… trackwork
Underground rail	Subway	
Uncouple	Cut	…vehicles from train
Wagon	Car, rail-car	
Workshop	Shop	

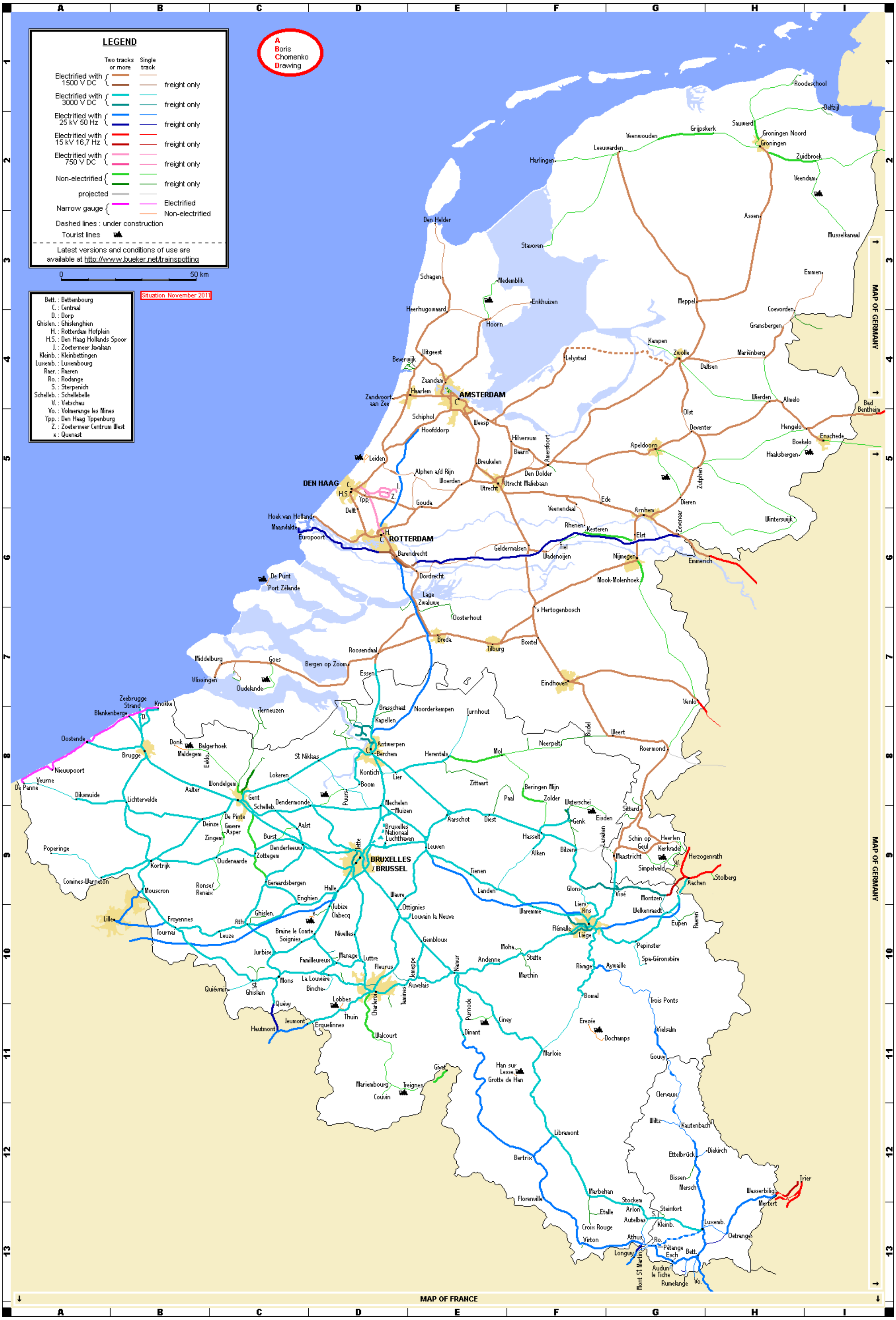
Railway maps

Map of Europe

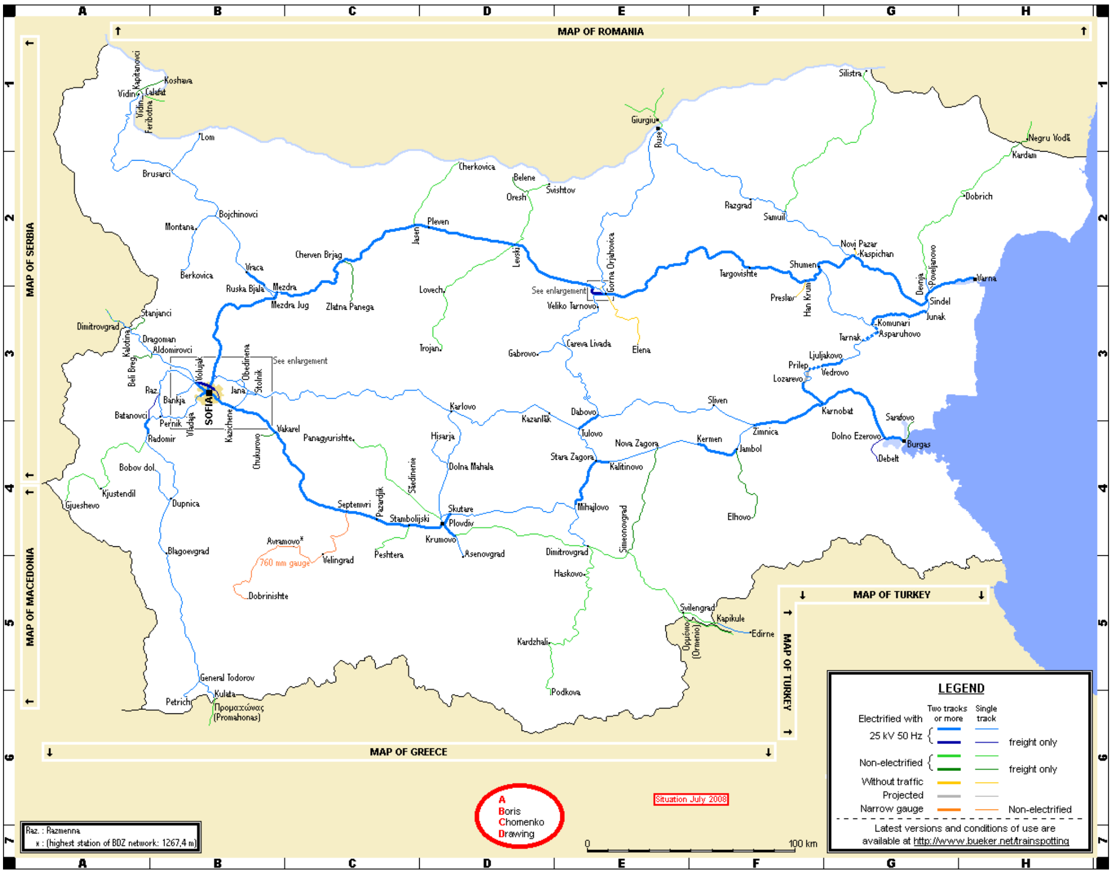


Austria

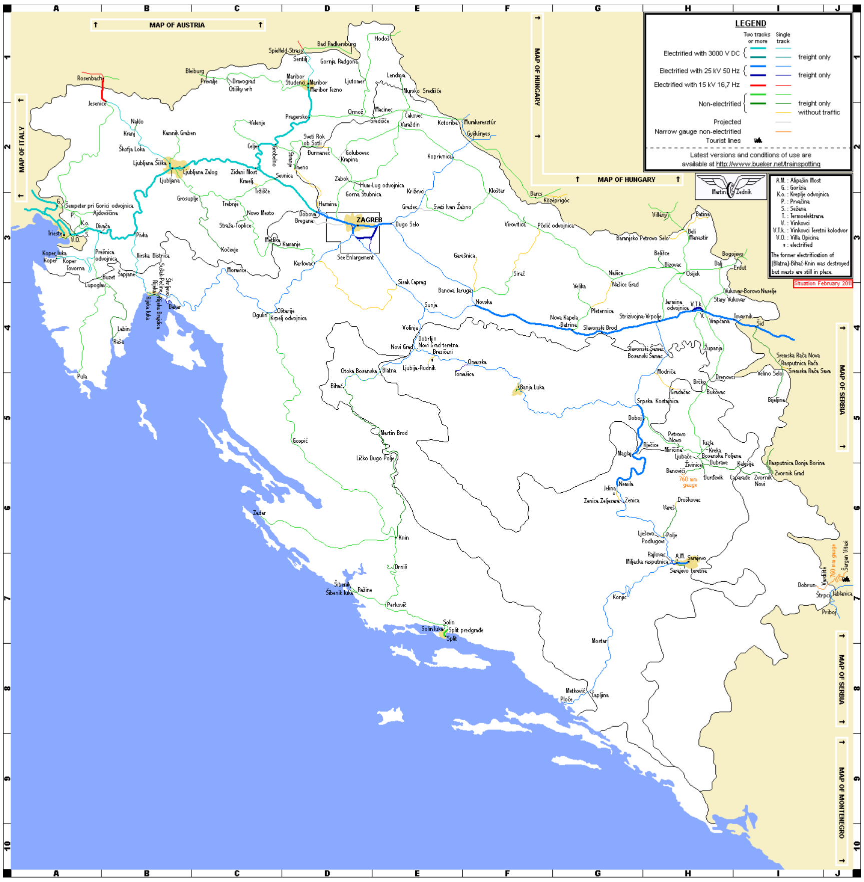
Belgium, Luxemburg and the Netherlands



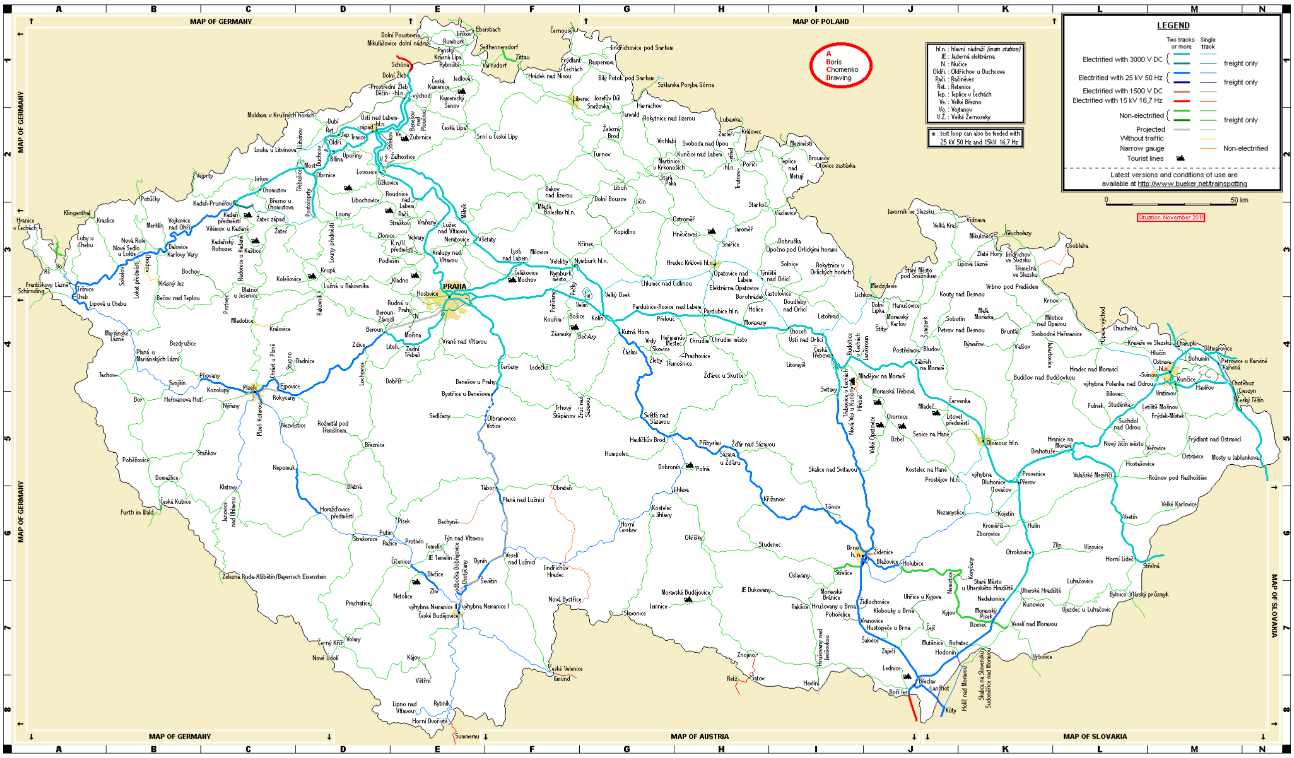
Bulgaria



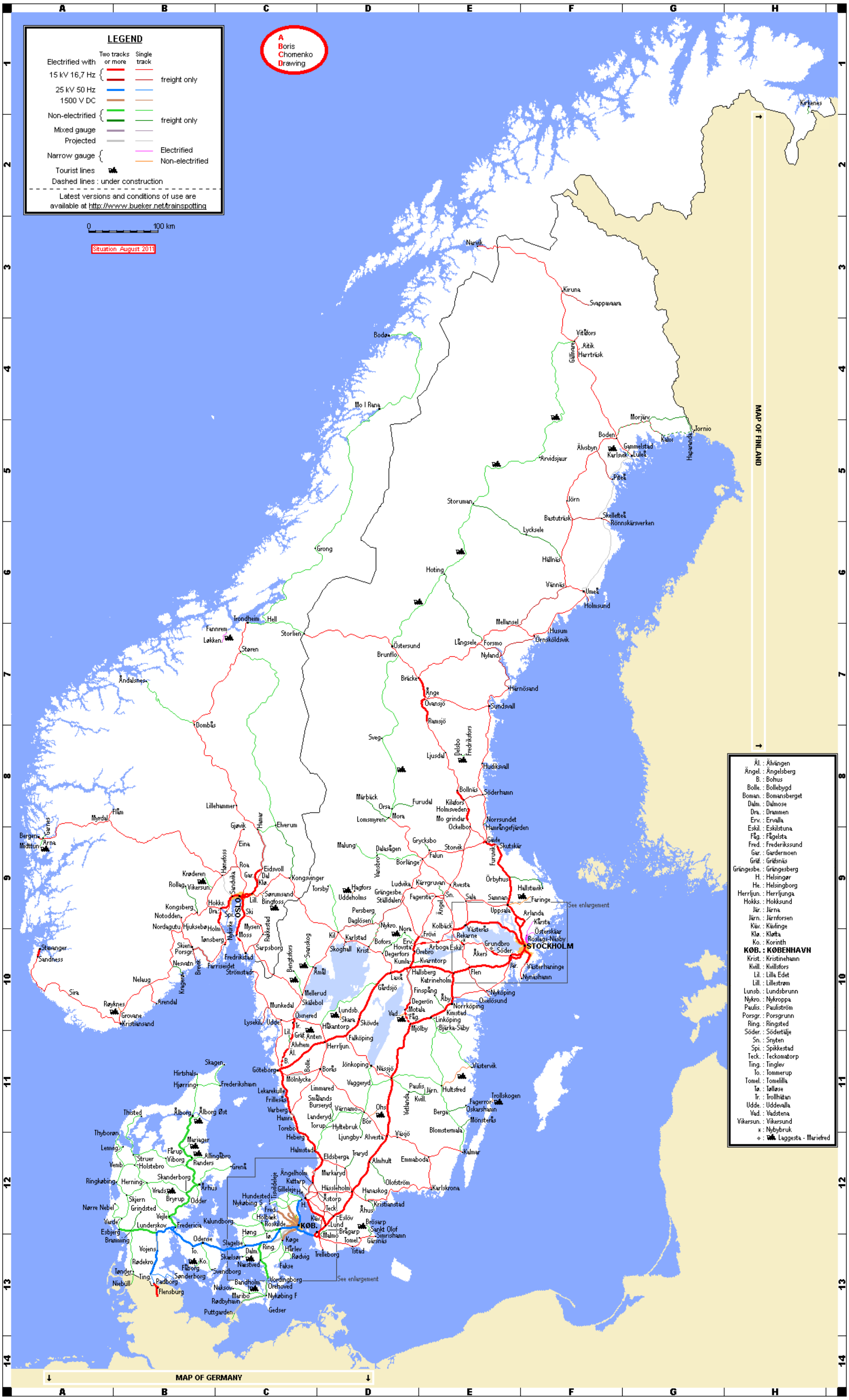
Croatia, Slovenia and Bosnia-Hercegovina



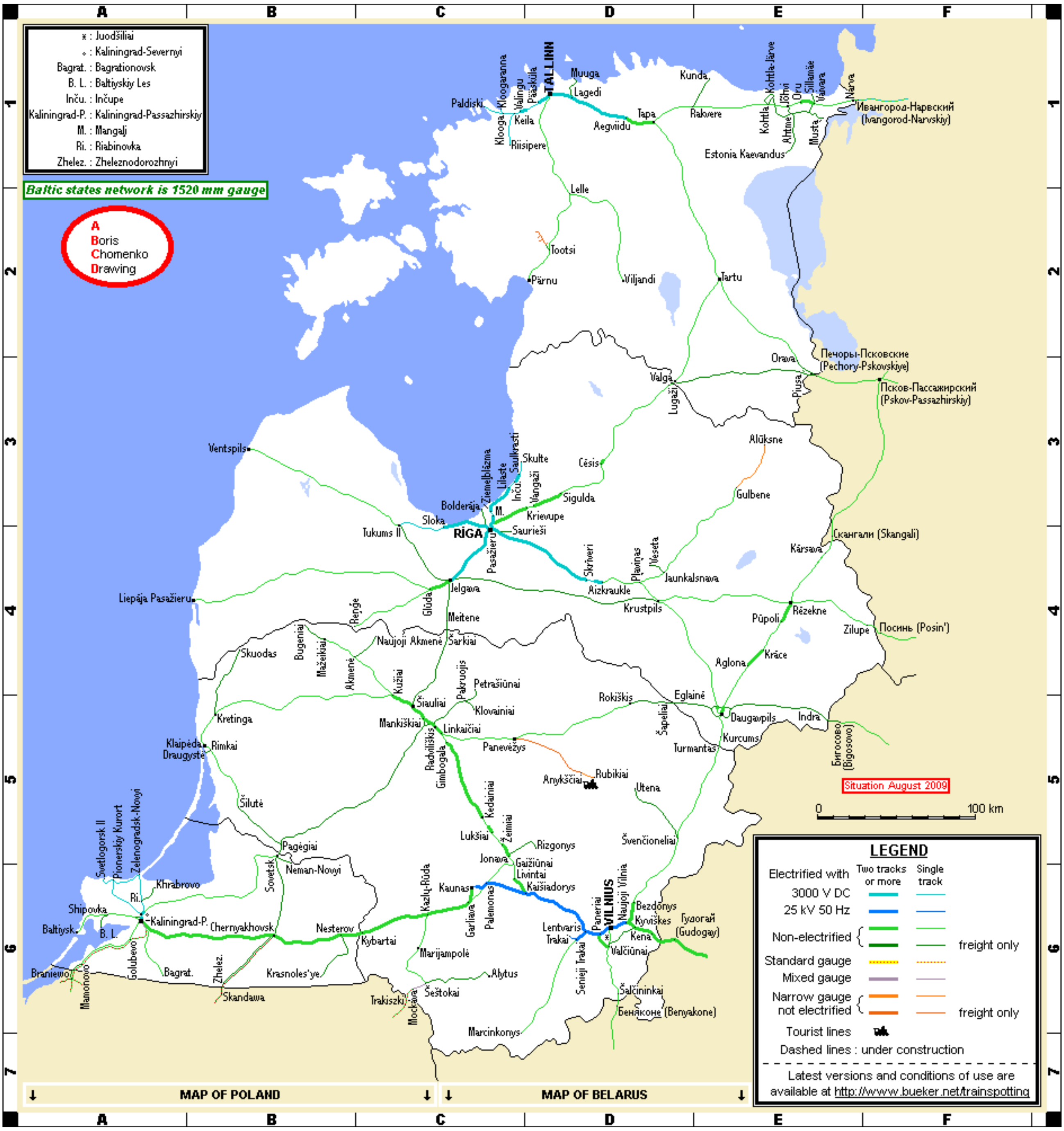
Czech Republic



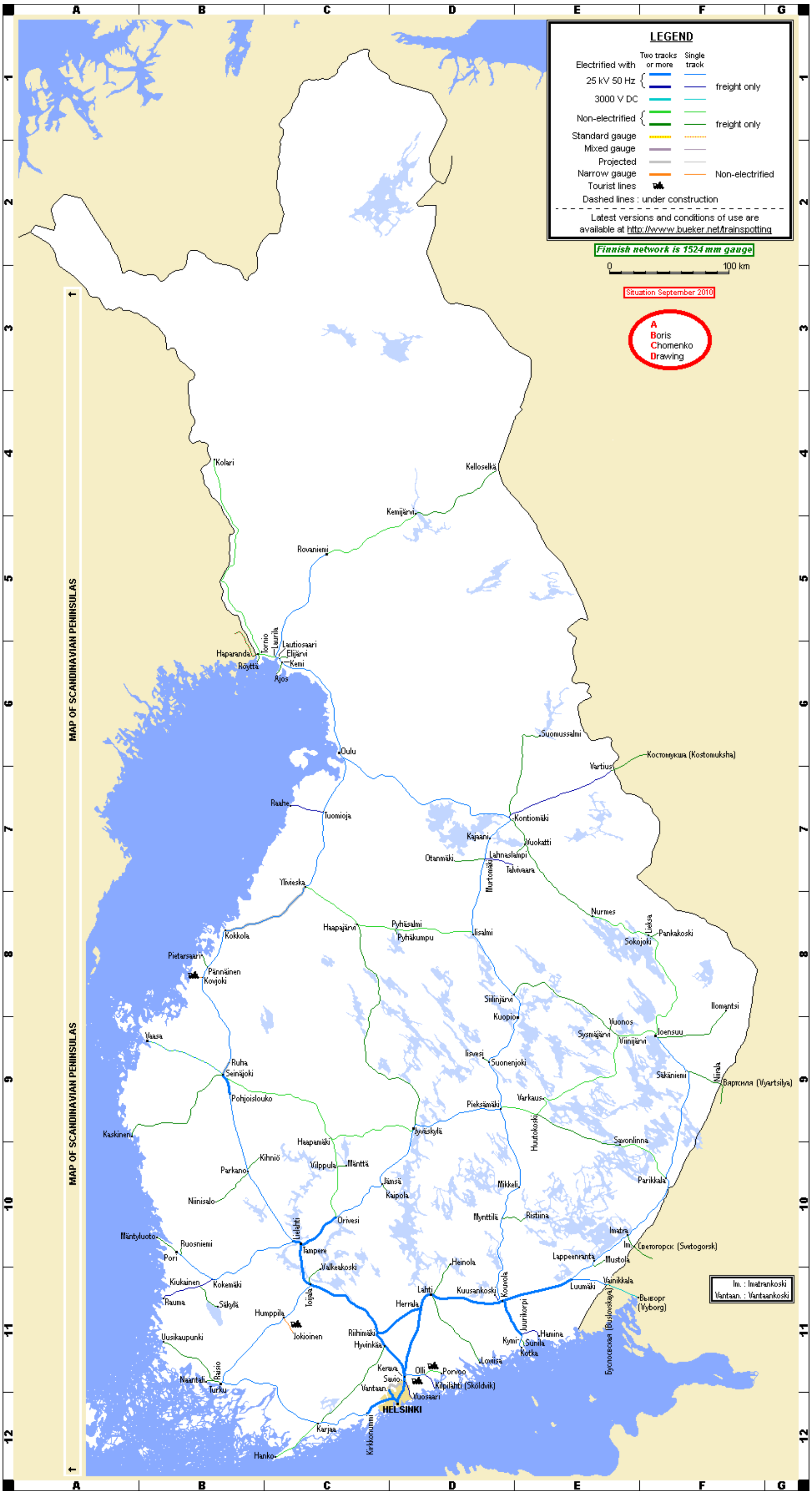
Denmark, Norway and Sweden



Estonia, Latvia and Lithuania



Finland

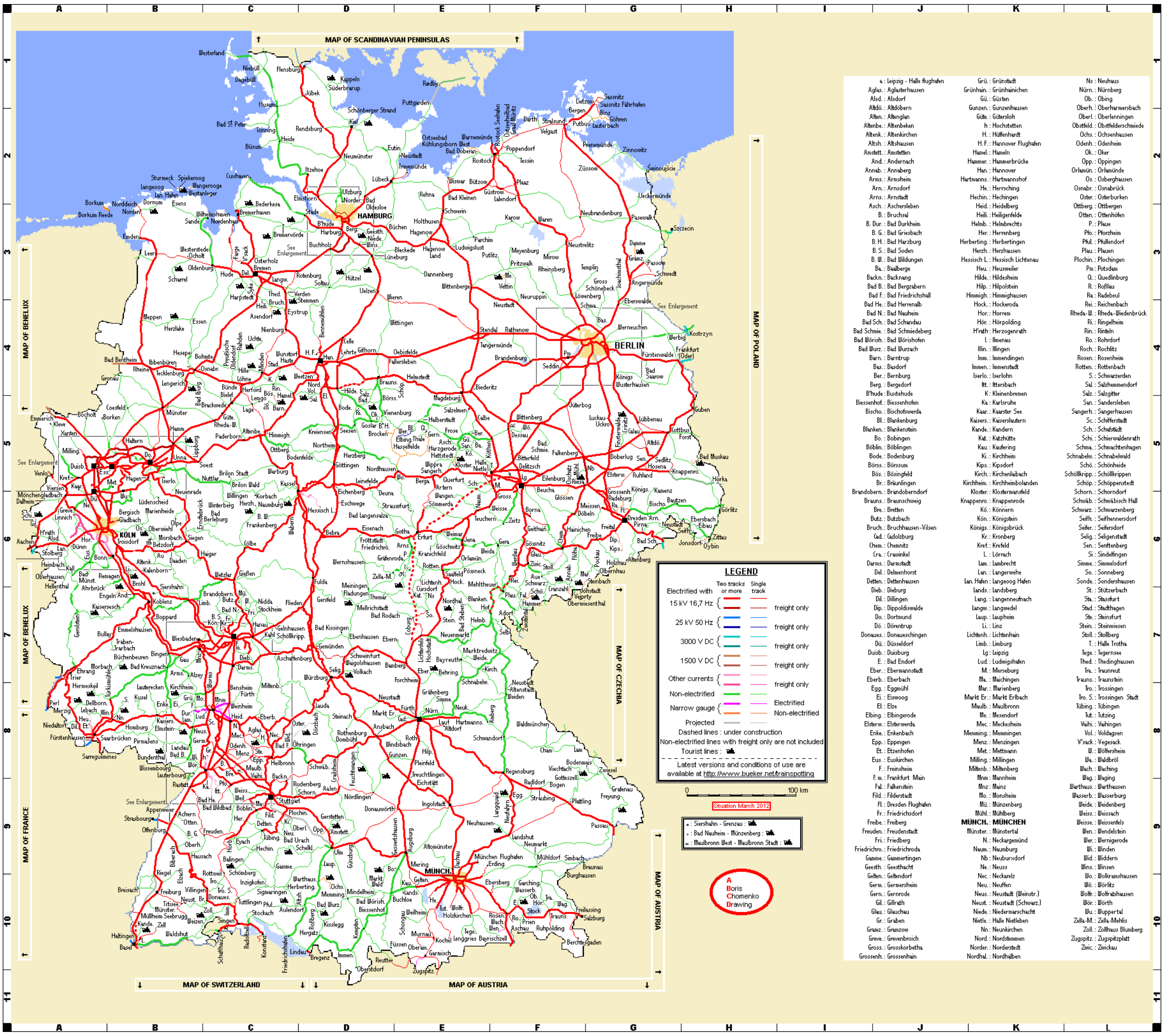

LEGEND
Two tracks or more
Single track
Electrified with
25 kV 50 Hz
freight only
3000 V DC
Non-electrified
freight only
Standard gauge
Mixed gauge
Projected
Narrow gauge
Non-electrified
Tourist lines
Dashed lines : under construction
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting
Finnish network is 1524 mm gauge
0
100 km
Situation September 2010
A Boris Chomenko Drawing
MAP OF SCANDINAVIAN PENINSULAS
Kolari
Kelloselkä
Kemijärvi
Rovaniemi
Tornio
Laurila
Lautiosaari
Elijärvi
Kemi
Haparanda
Röyttä
Ajos
Oulu
Suomussalmi
Костомукша (Kostomuksha)
Vartius
Raahe
Tuomioja
Kontiomäki
Kajaani
Vuokatti
Otanmäki
Lahnaslampi
Talvivaara
Murtomäki
Ylivieska
Nurmes
Lieksa
Pankakoski
Sokojoki
Haapajärvi
Pyhäsalmi
Pyhäkumpu
Iisalmi
Kokkola
Pietarsaari
Pännäinen
Kovjoki
Siilinjärvi
Kuopio
Ilomantsi
Vuonos
Sysmäjärvi
Viinijärvi
Joensuu
Vaasa
Iisvesi
Suonenjoki
Säkäniemi
Niirala
Вяртсиля (Vyartsilya)
Ruha
Seinäjoki
Pohjoislouko
Pieksämäki
Varkaus
Huutokoski
Kaskinen
Jyväskylä
Savonlinna
Haapamäki
Kihniö
Vilppula
Mänttä
Parkano
Jämsä
Kaipola
Mikkeli
Parikkala
Niinisalo
Orivesi
Mynttilä
Ristiina
Imatra
Im.
Светогорск (Svetogorsk)
Mäntyluoto
Ruosniemi
Pori
Lielahti
Tampere
Valkeakoski
Heinola
Lappeenranta
Mustola
Kiukainen
Kokemäki
Rauma
Säkylä
Toijala
Lahti
Kuusankoski
Kouvola
Luumäki
Vainikkala
Выборг (Vyborg)
Im. : Imatrankoski
Vantaan. : Vantaankoski
Humppila
Jokioinen
Herrala
Juurikorpi
Hamina
Бусловская (Buslovskaya)
Uusikaupunki
Riihimäki
Hyvinkää
Kymi
Sunila
Kotka
Loviisa
Paimio
Naantali
Turku
Kerava
Savio
Olli
Porvoo
Kilpilahti (Sköldvik)
Vantaan.
Vuosaari
HELSINKI
Karjaa
Kirkkonummi
Hanko
A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
9
10
11
12

France


LEGENDE
Deux voies ou plus
Voie unique
Electrifié en 1500 V CC
marchandises
Electrifié en 25 kV 50 Hz
marchandises
Electrifié en 3000 V CC
marchandises
Electrifié en 15 kV 16,7 Hz
marchandises
Autres courants
Non électrifié
En projet
Voie étroite
Electrifiée
Non électrifiée
Ligne touristique
Tiretés : en construction
Lignes marchandises non électrifiées non représentées
Dernière version et conditions d'utilisation disponibles à :
http://www.bueker.net/trainspotting
Situation décembre 2011
Dessin
Boris
Chomenko
0
100 km
CARTE DES ILES BRITANNIQUES
CARTE DU BENELUX
CARTE D'ALLEMAGNE
CARTE DE LA SUISSE
CARTE D'ITALIE
CARTE DE LA PENINSULE IBERIQUE
Voir agrandissement
Ab. : Abancourt
Ande. : Andelot
B. : Breuilpont
Blain. : Blainville-Damelevières
C. : Corbeil
Cha. : Chamonix
Co. : Cocherel
Comp. : Compiègne
Dn : Dourdan
Dou. : Douai
Es. : Estivareilles
Fontvi. : Fontvieille
H. : Hagondange
H.B. : Hombourg Budange
Hag. : Haguenau
Liv. : Livron
Lour. : Lourches
Luné. : Lunéville
M. : Marcenais
Moir. : Moirans
Niederb. : Niederbronn
Pont A. : Pont Audemer
S. : Somain
Sarre-U. : Sarre-Union
Sarreb. : Sarrebourg
Semb. : Sembadel
St R. : St Rambert d'Albon
St Quen. : St Quentin
Tara. : Tarascon
Thi. : Thionville
V. : Valence
Valenci. : Valenciennes
Ven. : Vendenheim
Vézel. : Vézelise
Vi. : Villars les Dombes
PARIS
LYON
MARSEILLE
Dunkerque
Calais
Boulogne sur Mer
Lille
Amiens
Rouen
Le Havre
Cherbourg
Caen
Rennes
Brest
Quimper
Nantes
Le Mans
Tours
Orléans
Poitiers
La Rochelle
Bordeaux
Toulouse
Montpellier
Nîmes
Avignon
Toulon
Nice
Grenoble
Dijon
Strasbourg
Metz
Nancy
Reims
Luxembourg
Basel
Genève
Perpignan
Bayonne
Limoges
Clermont-Ferrand
St Etienne
Besançon
Mulhouse
Ventimiglia
Portbou
Irún
Bastia
Ajaccio

Georgia and Abkhazia

Germany



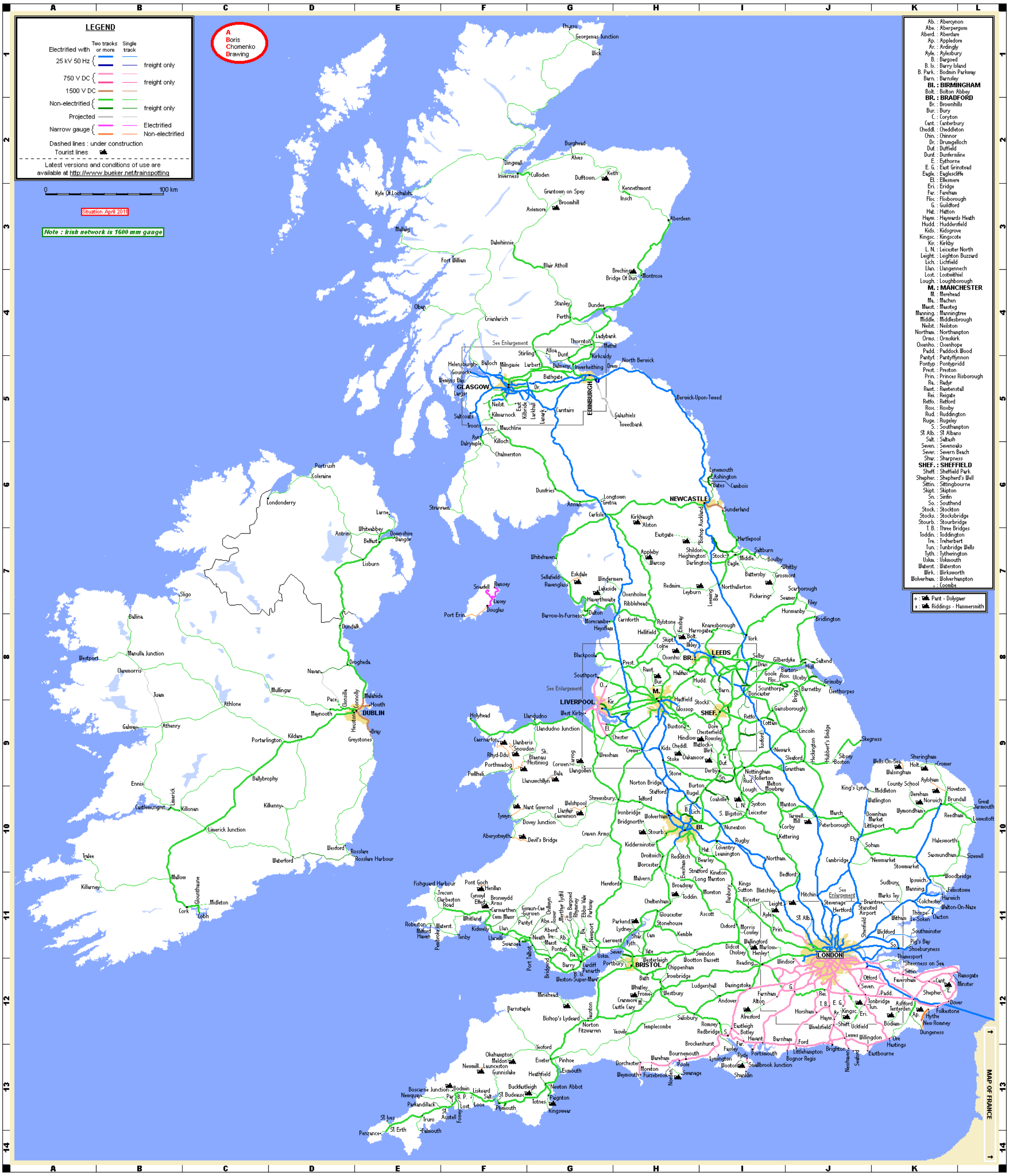
MAP OF SCANDINAVIAN PENINSULAS
HAMBURG
BERLIN
KÖLN
MÜNCHEN
MAP OF BENELUX
MAP OF FRANCE
MAP OF SWITZERLAND
MAP OF AUSTRIA
MAP OF CZECHIA
MAP OF POLAND
LEGEND
Electrified with
15 kV 16,7 Hz
25 kV 50 Hz
3000 V DC
1500 V DC
Other currents
Non-electrified
Narrow gauge
Projected
Dashed lines : under construction
Non-electrified lines with freight only are not included
Tourist lines :
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting
Situation March 2012
Boris Chomenko Drawing

Greece

Hungary

MAP OF SLOVAKIA
MAP OF UKRAINE
MAP OF AUSTRIA
MAP OF SLOVENIA
MAP OF ROMANIA
MAP OF CROATIA
MAP OF SRBIA
Situation December 2010
BUDAPEST
GYŐR
MISKOLC
NYÍREGYHÁZA
DEBRECEN
SZÉKES-FEHÉRVÁR
KECSKEMÉT
SZEGED
PÉCS
LEGEND
Two tracks or more
Single track
Electrified with 25 kV 50 Hz
freight only
Electrified with 15 kV 16,7 Hz
Electrified with 3000 V DC
freight only
Electrified with 3000 V DC (1520 mm gauge)
freight only
Electrified with 1000 V DC (Budapest HÉV network)
Non-electrified
freight only
Without traffic
Normal gauge
Narrow gauge
Broad gauge (1520 mm)
Mixed gauge
Non-electrified
Narrow gauge
Non-electrified
Projected
Industrial tracks are not included
Dashed lines : under construction
Tourist lines
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting

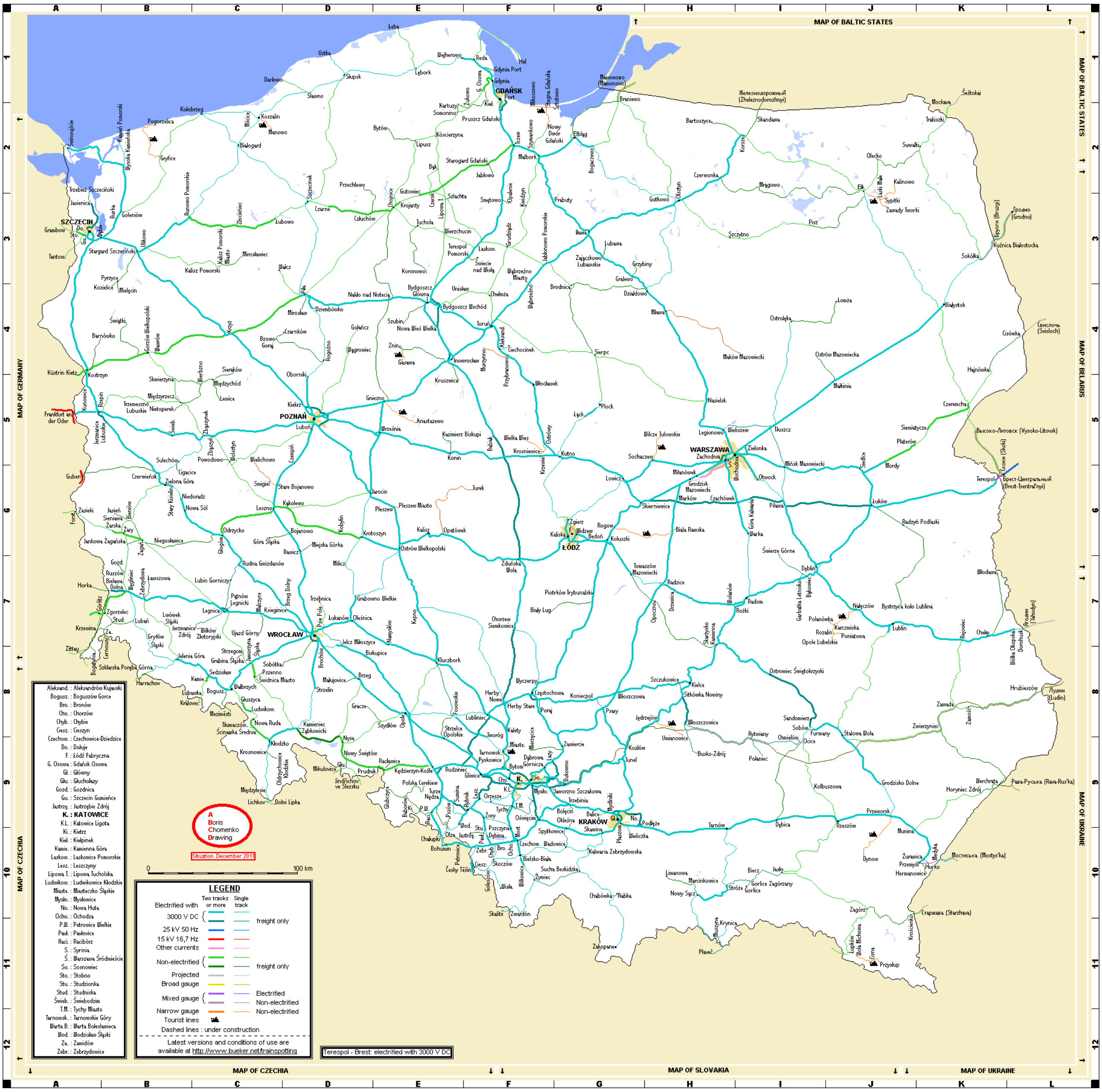
Republic of Ireland and UK



Italy

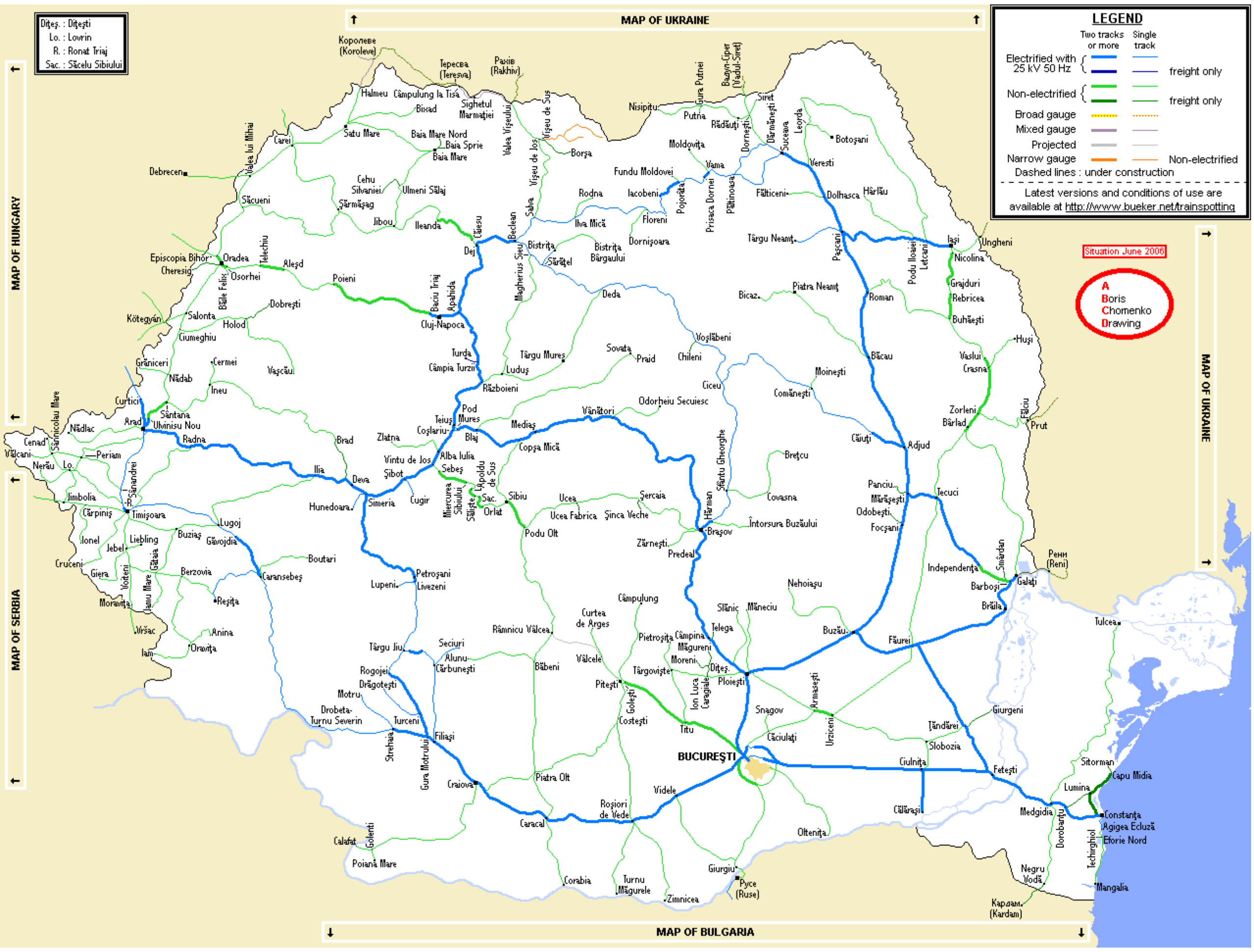

MAP OF SWITZERLAND
MAP OF AUSTRIA
MAP OF SLOVENIA
MAP OF FRANCE
Situation March 2012
LEGEND
Electrified with 3000 V DC
Electrified with 15kV 16,7Hz
Electrified with 25 kV 50 Hz
Electrified with 1500 V DC
non-electrified
projected
Narrow gauge
freight only
Electrified
Non-electrified
non-electrified lines with freight only are not included
Dashed lines : under construction
Tourist lines
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting
A Boris Chomenko Drawing
Milan.
Torino
Genova
Venezia
Bologn.
Fir.
Roma
Napoli
Bari
Palermo
Cagliari

Poland


MAP OF BALTIC STATES
MAP OF BELARUS
MAP OF UKRAINE
MAP OF SLOVAKIA
MAP OF CZECHIA
MAP OF GERMANY
GDAŃSK
SZCZECIN
POZNAŃ
WARSZAWA
ŁÓDŹ
WROCŁAW
KRAKÓW
A Boris Chomenko Drawing
100 km
LEGEND
Two tracks or more
Single track
Electrified with
3000 V DC
25 kV 50 Hz
15 kV 16,7 Hz
Other currents
freight only
Non-electrified
freight only
Projected
Broad gauge
Mixed gauge
Electrified
Non-electrified
Narrow gauge
Non-electrified
Tourist lines
Dashed lines : under construction
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting
Terespol - Brest: electrified with 3000 V DC

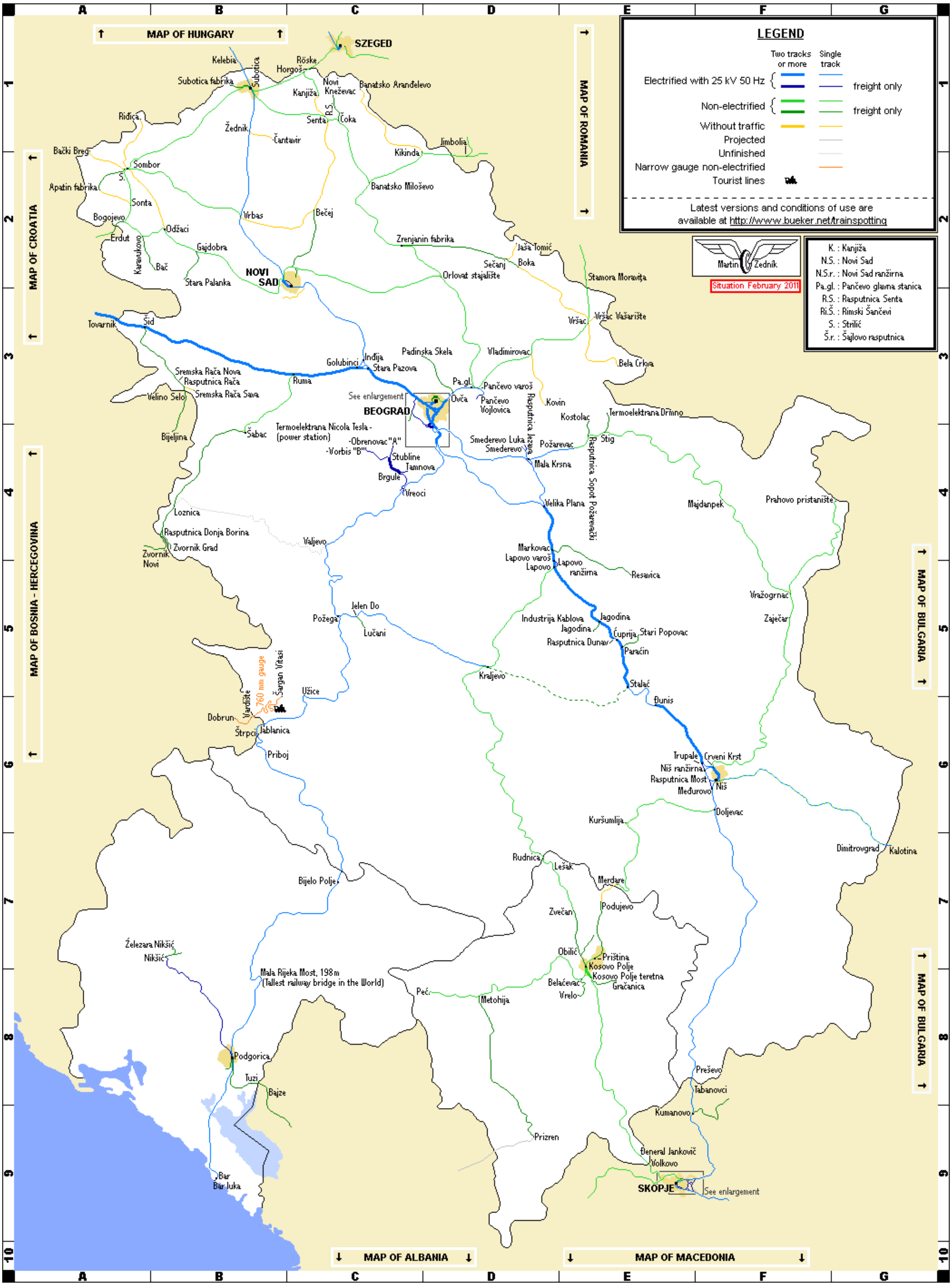
Portugal and Spain

Romania

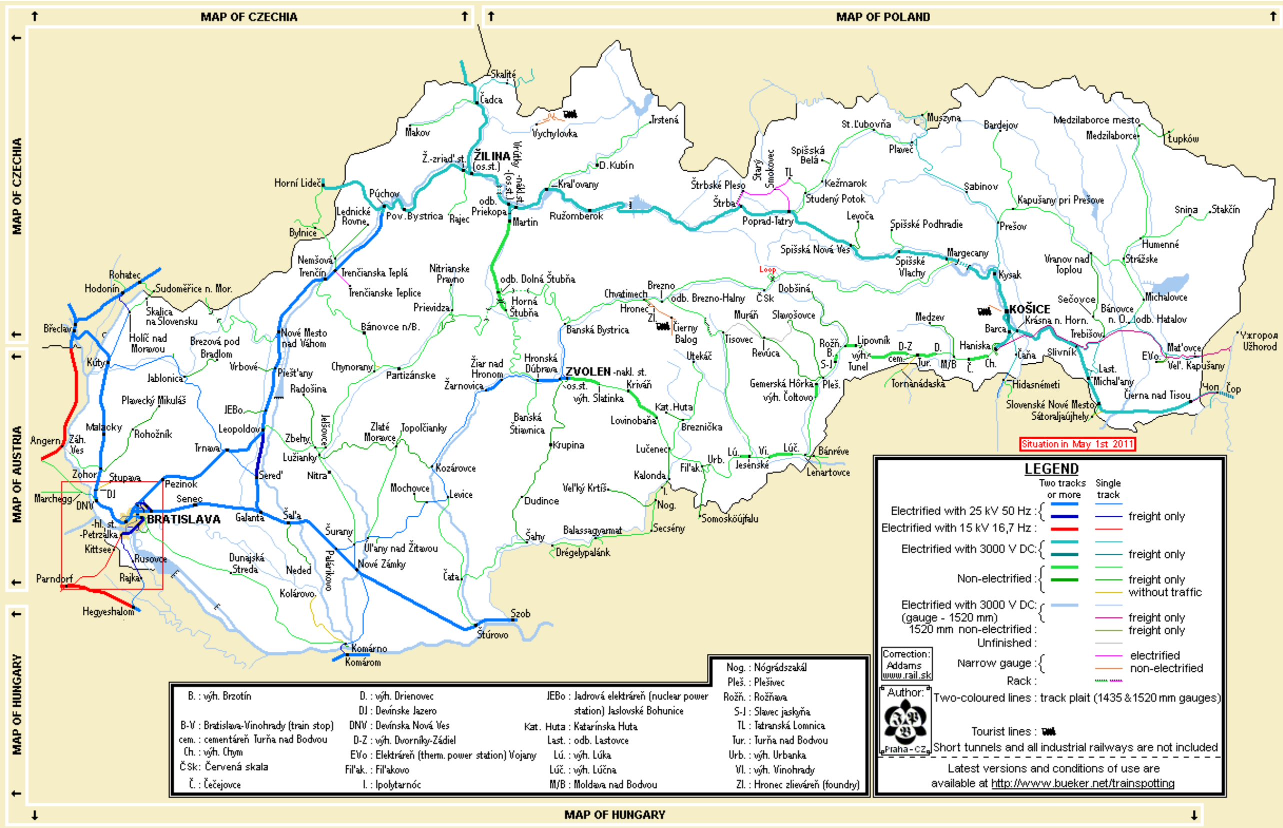


MAP OF UKRAINE
MAP OF HUNGARY
MAP OF SERBIA
MAP OF BULGARIA
LEGEND
Two tracks or more
Single track
Electrified with 25 kV 50 Hz
freight only
Non-electrified
freight only
Broad gauge
Mixed gauge
Projected
Narrow gauge
Non-electrified
Dashed lines : under construction
Latest versions and conditions of use are available at http://www.bueker.net/trainspotting
Situation June 2006
A Boris Chomenko Drawing
BUCUREŞTI

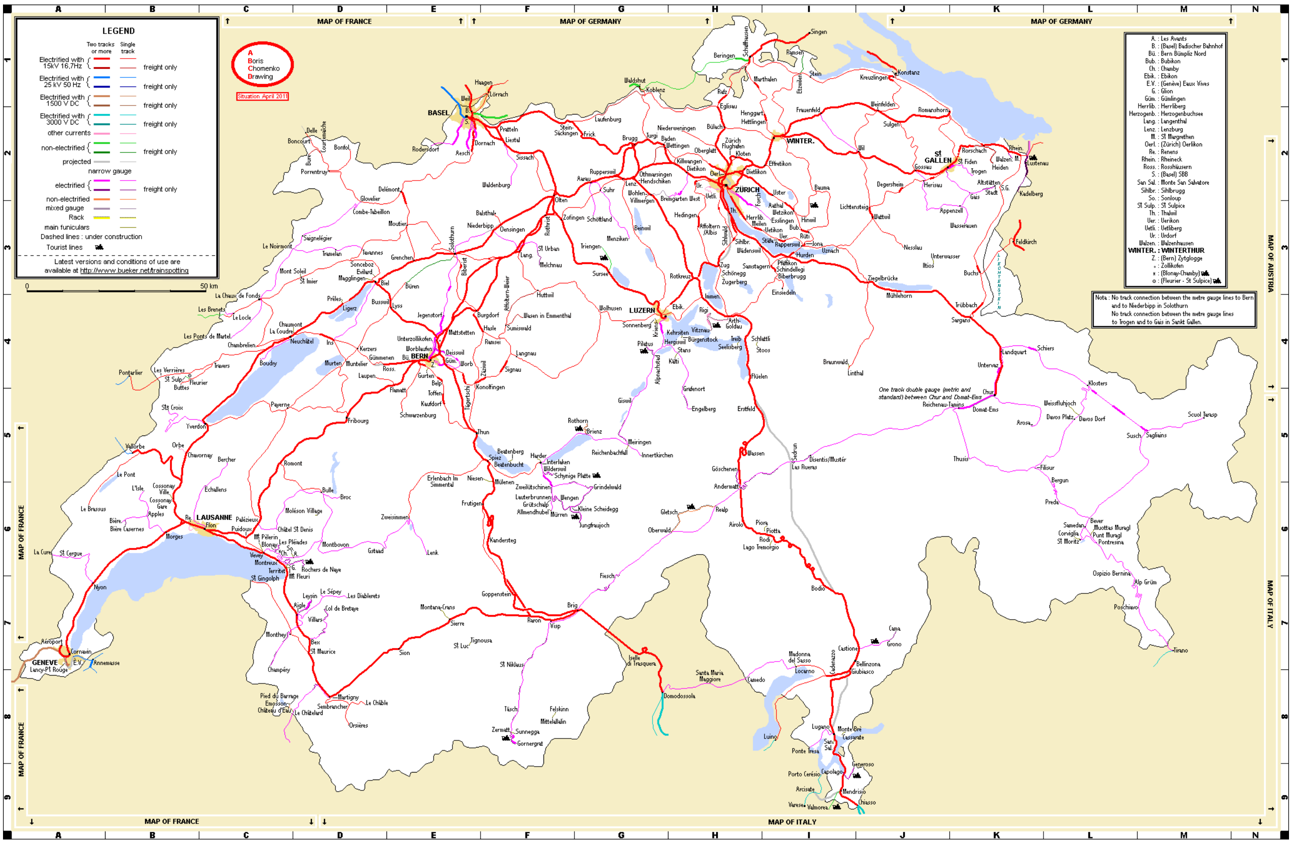
Serbia and Monte Negro



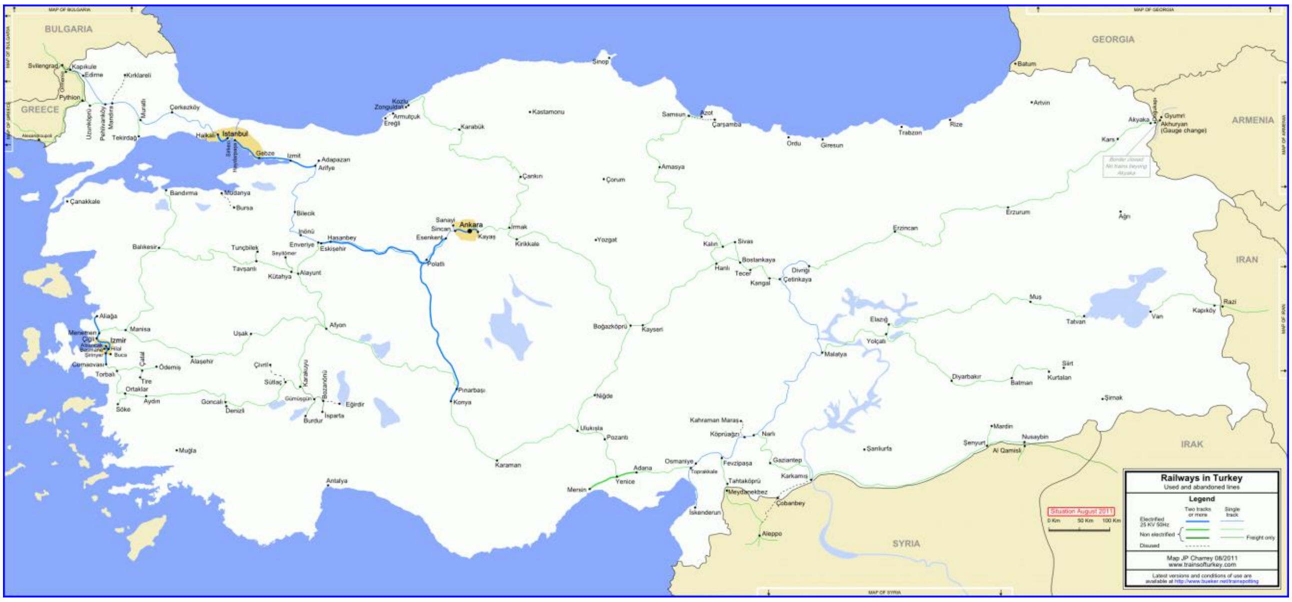
Slovakia



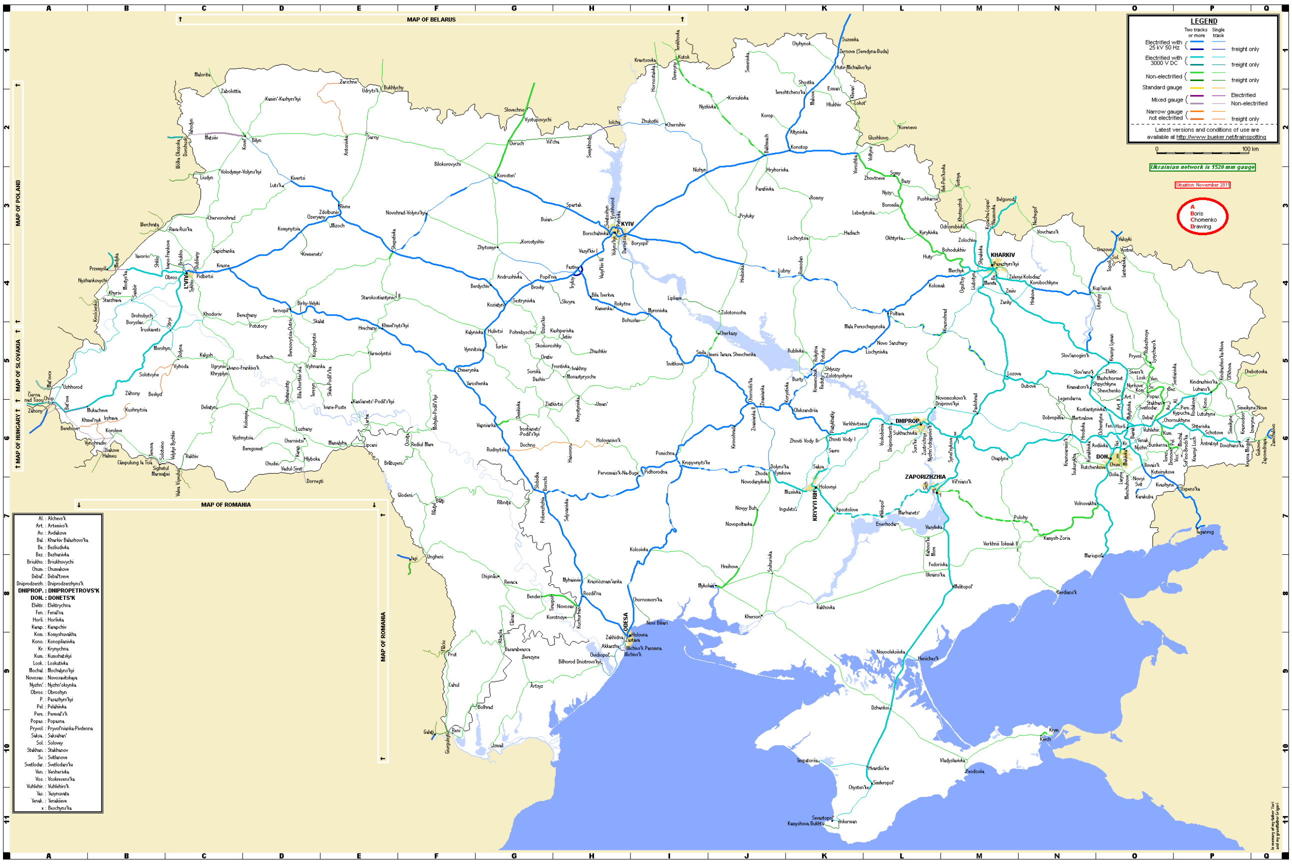
Switzerland



Turkey



Ukraine and Moldova



Useful links

History of rail in Europe:
http://www.azg.org.uk/
http://en.wikipedia.org/wiki/History_of_rail_transport
http://www.gracesguide.co.uk/Coalbrookdale_Co
http://en.citizendium.org/wiki/Railway_history
http://www.fordham.edu/halsall/mod/indrev6.asp
http://en.wikipedia.org/wiki/SNCF
http://en.wikipedia.org/wiki/Rail_transport_in_France
http://en.wikipedia.org/wiki/List_of_the_first_German_railways_to_1870
http://en.wikipedia.org/wiki/History_of_rail_transport_in_Germany
http://www.franken-online.de/stefan.arold/bahn-drg.html
http://en.wikipedia.org/wiki/Deutsche_Reichsbahn
http://en.wikipedia.org/wiki/Rail_transport_in_Germany
http://en.wikipedia.org/wiki/History_of_rail_transport_in_Switzerland
http://en.wikipedia.org/wiki/Swiss_Federal_Railways
http://en.wikipedia.org/wiki/Rail_transport_in_Switzerland
http://en.wikipedia.org/wiki/Kingdom_of_the_Two_Sicilies
http://en.wikipedia.org/wiki/Naples%E2%80%93Portici_railway#mw-navigation
http://en.wikipedia.org/wiki/History_of_rail_transport_in_Spain
http://en.wikipedia.org/wiki/Renfe_Operadora
http://en.wikipedia.org/wiki/FEVE
http://www.greeceathensaegeaninfo.com/getting-around-greece-train-history.htm
http://en.wikipedia.org/wiki/Decauville
http://en.wikipedia.org/wiki/History_of_rail_transport_in_Russia
http://en.wikipedia.org/wiki/History_of_rail_transport_in_Poland
http://en.wikipedia.org/wiki/Congress_Poland
http://en.wikipedia.org/wiki/Imperial_Royal_Austrian_State_Railways
http://en.wikipedia.org/wiki/Hungarian_State_Railways
http://www.bbj.hu/life/hungary-starts-training-women-to-be-engine-drivers_64719
http://en.wikipedia.org/wiki/Bulgarian_State_Railways
http://en.wikipedia.org/wiki/Rail_transport_in_Romania
http://en.wikipedia.org/wiki/Rail_transport_in_the_Czech_Republic
http://en.wikipedia.org/wiki/Rail_transport_in_Slovakia
http://www.globalrailnews.com/2014/02/27/ukraine-withdraws-hyundai-rotem-trains/

European Railways technical specifications:

Tracks:
http://en.wikipedia.org/wiki/Double_track
http://en.wikipedia.org/wiki/Single_track_(rail)

Traffic direction:
http://en.wikipedia.org/wiki/Right-_and_left-hand_traffic

Railway electrification systems:
http://en.wikipedia.org/wiki/List_of_current_systems_for_electric_rail_traction
http://en.wikipedia.org/wiki/Railway_electrification_system

Gauges:
http://myweb.tiscali.co.uk/gansg/2-track/02track3.htm
http://www.transportstyrelsen.se/Global/Jarnvag/Vagledning/Godkannande/bilaga_7_bvf_586_20.pdf

Railway signalling and protection systems:
http://en.wikipedia.org/wiki/Token_(railway_signalling)
http://en.wikipedia.org/wiki/ALSN
http://en.wikipedia.org/wiki/Anuncio_de_Se%C3%B1ales_y_Frenado_Autom%C3%A1tico
http://en.wikipedia.org/wiki/Automatische_treinbe%C3%AFnvloeding
http://en.wikipedia.org/wiki/Automatic_train_control
http://en.wikipedia.org/wiki/Automatic_train_protection
http://en.wikipedia.org/wiki/Automatic_Warning_System
http://en.wikipedia.org/wiki/Blocco_Automatico_a_Correnti_Codificate
http://en.wikipedia.org/wiki/Continuous_Automatic_Warning_System
http://en.wikipedia.org/wiki/EBICAB
http://en.wikipedia.org/wiki/Integra-Signum
http://en.wikipedia.org/wiki/Contr%C3%B4le_de_vitesse_par_balises
http://en.wikipedia.org/wiki/Linienzugbeeinflussung
http://en.wikipedia.org/wiki/LS_90
http://en.wikipedia.org/wiki/Punktf%C3%B6rmige_Zugbeeinflussung
http://en.wikipedia.org/wiki/Sistema_Controllo_Marcia_Treno
http://en.wikipedia.org/wiki/Transmission_balise-locomotive

Liberalisation of European railway:
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0440
http://ec.europa.eu/transport/media/publications/doc/modern_rail_en.pdf
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0018:EN:HTML
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0019:EN:HTML
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0012:EN:HTML
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:075:0026:0028:EN:PDF
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0014:en:HTML

Rail infrastructure:
http://www.railway-technical.com/track.shtml
http://en.wikipedia.org/wiki/Train_station
http://www.irfca.org/docs/marshalling-yards.html

Railway slots:
http://www.iti.northwestern.edu/publications/mahmassani/Kuo_et_al-2008-Train_Slot_Cooperation_in_Multicarrier_International_Rail-Based_Intermodal_Freight_Transport.pdf
http://www.eurocarex.com/carex-technique.php?cat=19&sscat=39
https://www.zib.de/Publications/Reports/ZR-05-45.pdf

Railway undertakers:
http://www.modeshiftcentre.org.uk/railfreight/how_the_rail_freight_industry_works/
http://www.uirr.com/en/road-rail-ct/players/railway-undertakings.html
http://www.intermodal-terminals.eu/content/e3/e18/e128/e235/2.2GoodPracticesManual-actions-shuntingservices2010-04-22_eng.pdf
http://www.uirr.com/en/road-rail-ct/players/infrastructure-managers.html
http://www.europeanrailcongress.com/sponsors.php/European-Rail-Infrastructure-Managers-EIM-17/
http://www.uirr.com/en/road-rail-ct/players/ct-operators.html
http://www.uirr.com/en/road-rail-ct/players/customers.html
http://www.uirr.com/en/road-rail-ct/players/rolling-stock-managers.html
http://www.uirr.com/en/road-rail-ct/players/terminal-managers.html
http://books.google.be/books?id=PmHz81oV250C&pg=PA36&lpg=PA36&dq=logistics+Wagon+Owners&source=bl&ots=jUSTs74z-z&sig=J2HBcZfQoKnQcYwgOt5zGeAYZkA&hl=en&sa=X&ei=UucbVKesJ8v3O_vlgcAP&ved=0CB8Q6AEwAA#v=onepage&q=logistics%20Wagon%20Owners&f=false

European Cargo Railway Undertakings:
http://www.raildata.coop/About.htm

Database of rail network operators, managers, services providers, etc.
http://www.railwaydirectory.net/

Database for locomotives:
http://www.bahnbilder.de/name/zeitachse/jahr/2010/monat/juli/seite/17.html

ECM certification:
http://www.era.europa.eu/Document-Register/Documents/ECM-guide%20V1%20-%20ERA-GUI-100.pdf
http://www.transportstyrelsen.se/Global/Jarnvag/ERA-GUI-09-2011-SAF-%20ECM%20certification%20-%20guide%20ECM%20certification%20scheme%20v1%200.pdf
http://www.rsn.be/index.php

Locomotives:
http://www.trainhistory.net/train-facts/train-types/
http://www.infoplease.com/encyclopedia/science/locomotive-types-locomotives.html
http://www.railway-technical.com/diesel.shtml
http://magnetbahnforum.de/index.php?barriers-and-paradigms
http://english.swjtu.edu.cn/public/viewNews.aspx?ID=154
http://www.trainhistory.net/train-facts/train-types/
http://www.ehow.com/list_7606612_three-types-modern-freight-trains.html
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Amendment proposal

The form can be sent by fax to +32 2 7068281 or by email to info@ecgassociation.eu

Amendment proposed by:

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COMPANY

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E-MAIL

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Current wording...

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