



DB Manual

EXTRACT

# Railway system knowledge

1st edition

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to minimise environmental disturbances and land consumption. The new Cologne-Frankfurt line construction for instance, runs alongside the motorway over long stretches. As the air along electrified train path lines is not polluted, around two thirds of the area required for a new line construction are preserved as biologically valuable habitats.



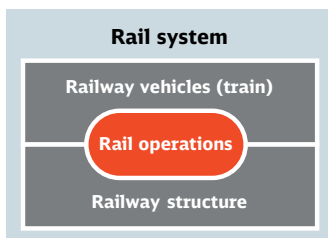
**Fig. 1-9:**  
A double railway track has the same capacity as a six-lane motorway.  
Photo: DB AG/Bartłomiej Banaszak

### 1.1.3 Structure of the rail system

The term system generally describes a structure composed of various parts which are related to each other. Due to their complexity, systems are often difficult to comprehend, and require precise knowledge of their underlying mechanisms as well as high control and monitoring effort.

The railway system is no different; it encompasses numerous technical and functional components whose interaction is very complex due to diverse technical system considerations – such as track guidance, for example. There are a variety of links and dependencies between the individual system components.

The rail system's fundamental component is the infrastructure, which determines the essential framework for the rolling stock subsystem. For instance, the track gauge and carrying capacity of the tracks, and the width of the track, are the basis for the characteristics and dimensions of the rolling stock to be used.



**Fig. 1-10:**  
Rough breakdown of the rail system  
Figure: Jürgen Janicki

## System components

The railway system essentially consists of the components of railway vehicles and the railway infrastructure, with rail operations acting as the link.

The train formed from railway vehicles is the production unit in rail transport. Depending on transport task and intended use, the designs and characteristics of trains differ extensively in some cases. While passenger trains transport comparatively low "loads" at high speed, with high starting acceleration and braking deceleration, and with maximum running stability and comfort, freight trains are used to transport heavy loads at medium speeds and with accordingly lower acceleration and deceleration.

In addition to plots of land, the railway infrastructure comprises all structures and facilities required to directly process rail transport. In many cases, the term railway land is also used for this. Railway infrastructure is subdivided into track infrastructure such as tracks, tunnels and bridges, and the infrastructure used for rail operations in the stations. Railway stations also perform essential tasks as transport stations and interfaces to passengers.

The term rail operations sums up all of the activities and equipment required to move railway vehicles and to guarantee the safety, control and monitoring of train movements. Besides the movement of trains, rail operations also include the formation of trains and emergency management. The importance of the rail operations subsystem deserves particular emphasis, as it has significant effects on the infrastructure, the timetable and rolling stock. One of this subsystem's tasks involves influencing the movement of vehicles through signals. Signal boxes are used to intervene into and secure the vehicle movement control process, and to ensure that these proceed smoothly.

## Interface between the wheel and rail

The connection between the vehicle (wheel) and track (rail) is the essential interface in the railway system. Here, the wheelset undertakes rolling stock track guidance, supports the vehicle weight and transfers the tractive and brake forces required for vehicle movement. Safe and smooth running is not only determined by a vehicle's running gear but also by the track which is driven on. The wheel-rail system therefore represents a technological unit which responds extremely sensitively to unilateral changes due to its very complex interactions. This is the reason why both components always underwent further development together in the past. For instance, coordinated wheel-rail profiles are essential for achieving good driving characteristics and minimising wear.

The railway system is exposed to environmental influences. For example, certain weather conditions influence the friction between the wheel and rail, and thus also the driving and braking characteristics.



Fig. 1-11: S-Bahn train at the stop in Leipzig MDR

Photo: DB AG/Wolfgang Klee

## Interface to the customer

Railway stations are the gateway to the railway, the transport hub which links various modes of transport and the marketplace for purchasing consumer goods and services. Railway stations have both transport and operational tasks. The German Railway Construction and Operating Regulations define railway stations as railway facilities with at least one set of points where trains can begin, end, pass or turn. Depending on their importance in transport terms, a distinction is made between passenger and freight stations.

### 1.1.4 Rail operations

The fact that rail vehicles are track-bound not only places particular requirements on railway safety systems, but also enables technical safeguards which are foreign to other means of transport. During train movement, the simultaneous use of a route by several trains has to be ruled out through technical means. Before a journey takes place, a check is performed to determine whether the route is clear and passable. In comparison with other transport systems, the railway system offers extensive protection against accidents.

The railway system places particular requirements on operations planning. This not only includes the establishment of timetables and the creation of turnaround cycle and staff assignment plans, but also the definition of operating regimes and the development of dispatching rules.



Fig. 1-12: Two trains meet on entering or exiting the station throat.

Photo: DB AG/Wolfgang Klee

## Train paths

To use the track, applications for so-called train paths are submitted to the railway infrastructure undertaking (RIU). In this case, a train path refers to the scheduled time-related and spatial assignment of a route section for a train movement. Train paths must be allocated without discrimination. This is monitored by the German Federal Network Agency. A track access charge is paid to the appropriate RIU for the use of a train path. This is joined by further charges for additional services such as the use of passenger transport facilities.

The rail companies submitted over 60,000 orders – so-called path requests – for DB's working timetable in 2014. Extensive construction measures are already taken into consideration in the working timetable, and can therefore be scheduled-in by customers.

## Timetable

So that train movements are coordinated, a timetable is established for each train movement during the planning stage. It represents the production chains in passenger and freight transport. The trains' routes, the nominal journey times between the individual operating locations and their hold times at the stations are taken into consideration during timetable planning. The timetable is therefore not only one of the core elements of the rail system, but is also extremely important for freight and tourist traffic customers. Irregularities during current rail operations lead to the fact that the scheduled timetable cannot always be adhered to.

## Signal-controlled operation

A distinctive feature of rail operations is control and protection through signals. Signals are generally visible or audible signs with specified information. They are used to communicate information and guarantee that railway vehicles move safely. Either trackside signals or driver's cab displays are used for this. As a fall-back level or in the event of deviations from scheduled operations, train movement approval is issued through written or oral orders.



*Fig. 1-13:*  
Dispatcher signal box and main light  
signal (left)

Photo: DB AG/Uwe Miethe

## Operating regime

Railway vehicle operations on railway infrastructure necessitate an operating regime. The trains' route is formed by the tracks in the stations and their continuation on the open track. Points enable track changes. To ensure that distances are maintained, trains are usually moved with fixed spacings. Here, the route is subdivided into block sections, which a train may only approach when they are clear. In signal-controlled operation with trackside signals, the block sections are limited by main signals. The route is approved through the proceed aspect of the main signal. Technical safeguards and dependencies prevent the route from being changed during a train movement or from being used by another train movement. This operating regime was introduced by a number of railway administrations back in the second half of the 19th century, and has since become the standard in train separation. Today, it is used almost exclusively in rail operations.

## Signal boxes

The routes for train and shunting movements are set and secured centrally by signal boxes. These are operated from a local control room or are remotely controlled from an "operations centre".



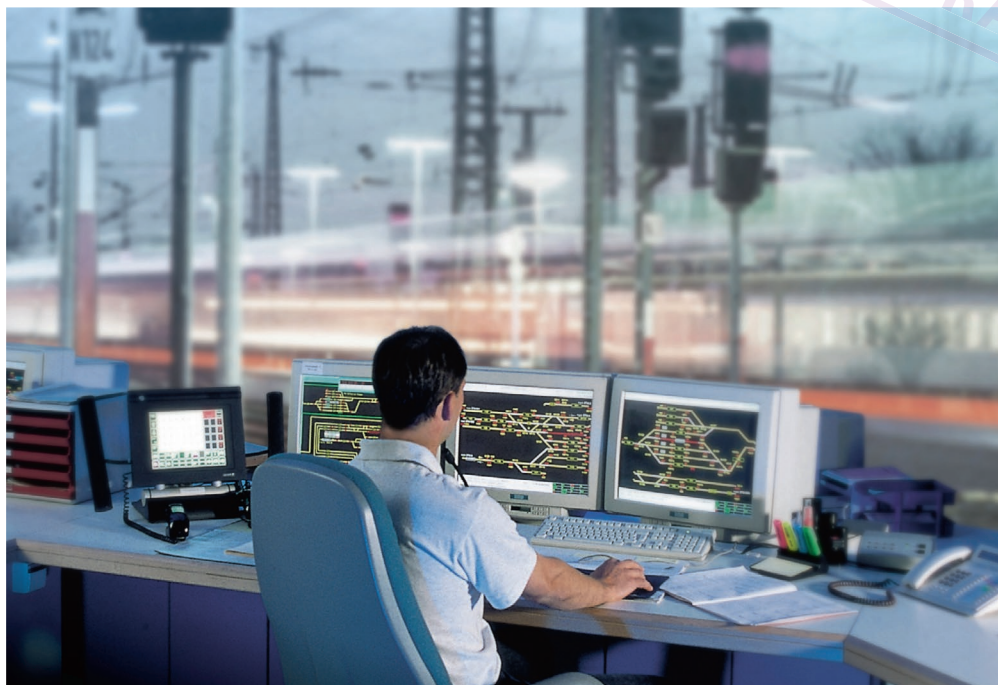


Fig. 1-14: In the electronic signal box, the dispatcher controls the rail traffic by computer. His monitors show the execution of signal commands and the current track occupation.

Photo: Siemens press photo

### 1.1.5 The railway network

Substantial development of the rail network in Germany ended during the Second World War. Apart from the construction of a few S-Bahn lines, the rail network was not significantly extended in subsequent years. It was not until 1970 that what was then Deutsche Bundesbahn presented its network expansion plans with numerous new lines and line upgrades; these plans were implemented in the ensuing years. In 1986, Deutsche Bundesbahn put the initial sections of a new line into operation.

Following reunification in 1990, the DB and DR networks had to be linked again through gap closure measures. In subsequent years, some new lines were also commissioned between the western and eastern German states. In 1991, the German Federal Government decided to implement the German Unity Transport Projects (VDE). In addition to various motorway projects and a waterway project, nine rail projects constitute the basic framework of high-performance and modern traffic links between the western and eastern German states. At present, six projects have been completed and are in operation; the other projects are in an advanced stage of construction.

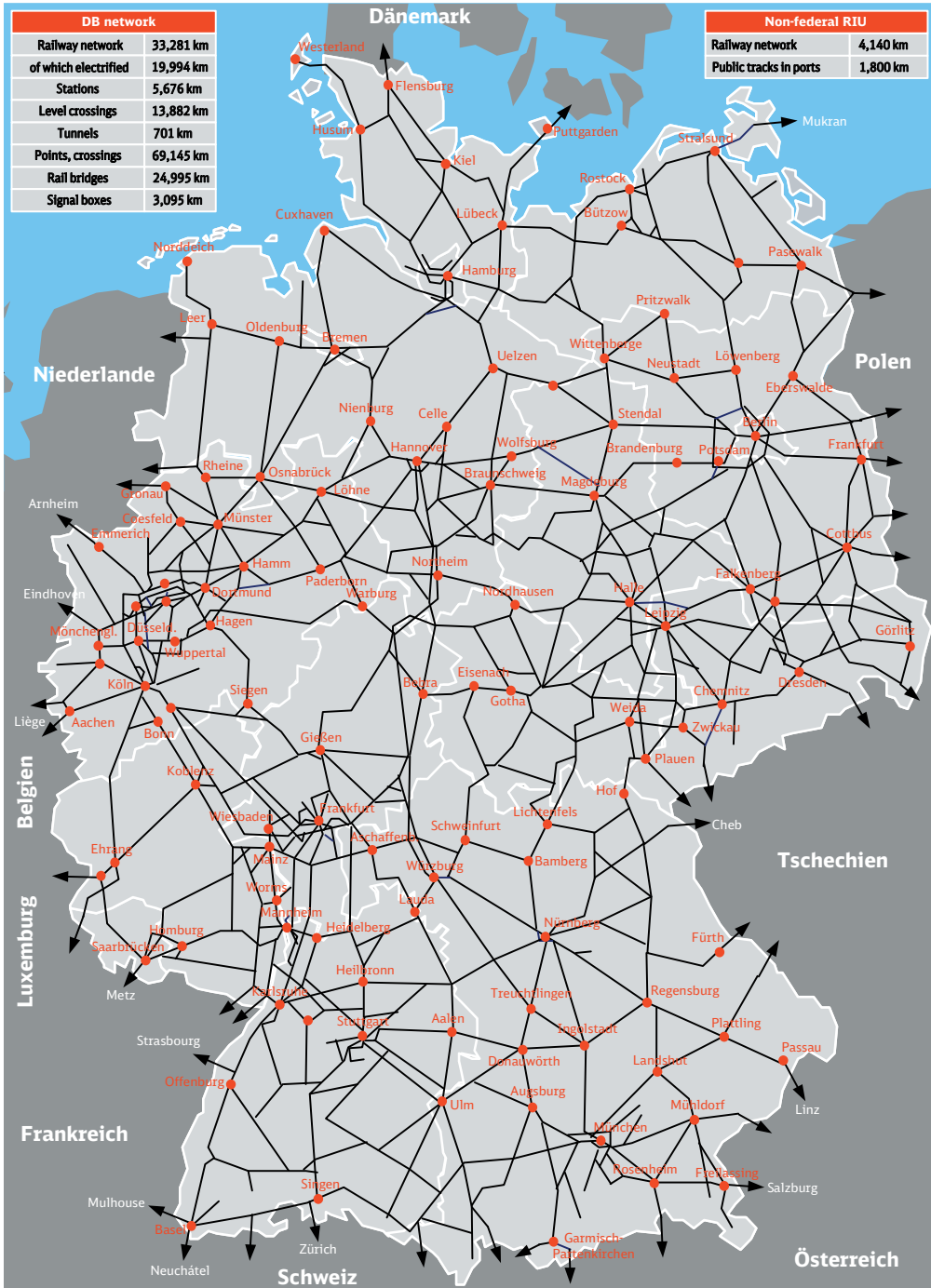


Fig. 1-15: Railway network in Germany

When the new Cologne–Frankfurt line construction came into service in 2002, Germany acquired its first 300-km/h rail line. When vast swathes of German Unity Transport Project No. 8 (VDE 8) are completed in 2017, high-speed trains will also be able to run at speeds of up to 300 km/h between Berlin and Munich. A partial section of this service, the new Erfurt–Leipzig/Halle line construction, entered operation with the timetable change in December 2015.

The present situation is that round 60% of train services are being provided on approximately one quarter of the rail network. With the exception of a few high-speed and S-Bahn lines, both fast and slow passenger and freight trains operate in mixed mode. The capacity of the rail network is crucial to the future role of rail transport in the competitive market.

### **Federal Transport Infrastructure Planning**

In view of increasingly tight financial restraints, the prioritisation of investments – i.e. the selection of projects and the specification of the sequence in which they are implemented – is crucial. The current prioritisation strategy gives precedence to maintaining the existing transport network infrastructure over new construction and upgrades. New construction and upgrade projects are focussed primarily on eliminating bottlenecks, predominantly along the main transport axes and freight corridors. In this, consideration is given to climate and environmental protection, noise control and traffic safety requirements as important framework conditions.

The German Federal Government's Federal Transport Infrastructure Planning defines the investment framework for maintaining and upgrading infrastructures and transshipment terminals in Germany for a period of 10 to 15 years. The Federal Transport Infrastructure Plan (BVWP) itself has no immediate legal effect. However, it is the basis for the laws and requirements plans adopted by Parliament which regulate the expansion of the rail, road and waterway networks. Expansion of the federally-owned rail companies' railway tracks therefore conforms to the Federal Railway Infrastructure Development Act and the German equivalent of the High-Level Output Specification, which is an appendix to this act.

Since 1973, the various German Federal Governments have adopted five Federal Transport Infrastructure Plans. Based on multimodal forecasts, the German Federal Cabinet determines the investment volume required to maintain and upgrade the existing transport infrastructure. According to the expected, available investment framework, the planned new construction and upgrade projects are then classified into the urgency levels of "Urgent requirement" and "Further requirement" based on their benefit-cost ratio as well as network concept and ecological considerations. New construction and upgrade projects which concern cross-border infrastructures or transit routes of significance to other international traffic are allocated to the category of "International projects".

At the time of revising this manual, Federal Transport Infrastructure Plan 2015 is in the participation and coordination phase. It is to be anticipated that it will be adopted during the course of 2016.

## 1.1.6 Occupations in the integrated railway system

There are various occupation groups in the integrated railway system. The employees advise customers and sell transport services, ensure the safety of passengers and goods, look after track facilities and rolling stock, drive the traction units and control train movements at the signal boxes. They all guarantee the smooth operation of the integrated rail system, and thus provide customers with reliable and high-quality mobility and logistics services.

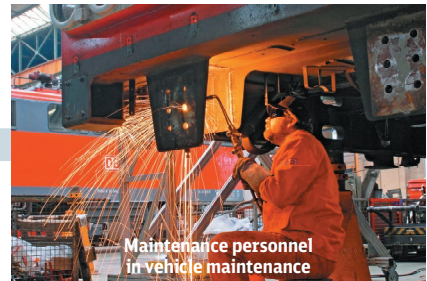
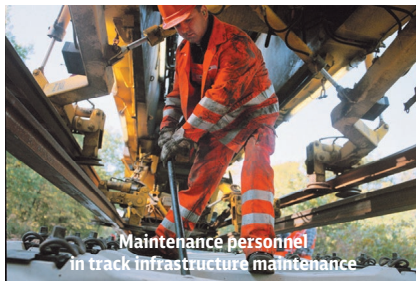


Fig. 1-16: Occupations in the integrated railway system

Photos: DB AG/H. Reiche, M. Lautenschläger, B. Banaszak, Jet-Foto Kranert, M. Neuhaus, C. Bedeschinski

Depending on their training background, the most important occupations within a rail company can be broken down into railway operation, administrative service-oriented and industrial-technical activities. However, this allocation is not always clear cut. For example, the work of a train attendant is mainly administrative service-oriented, but also includes some railway operation elements.

### **Railway operation activities**

There are a variety of employees whose work mainly involves train movement operations. These primarily include the employees in the trains, at operating locations and in operations centres, i.e. train drivers, train attendants, dispatchers and pointsmen.

- Train drivers drive self-propelled rolling stock (traction units) and trains on public rail infrastructure companies' railway tracks. Their other tasks include the preparation and completion service on the vehicle and establishment of the train's readiness to depart. In the shunting service, train drivers compile individual trains, and ensure that wagons are coupled to the traction units in a specific sequence, for example.
- Together with the other employees in the railway control centre, dispatchers ensure that operations are safe, punctual and economically viable. With the aid of the interlocking system, they perform train and shunting movements by controlling the sequence of trains and the execution of train movements according to the timetables, submitting and receiving train messages, setting points and signals, and securing level crossings. In the event of disruptions and dangerous incidents, they close certain tracks or initiate emergency stops.
- Pointsmen are involved in the execution of train movements, and perform shunting movements as part of their responsibility. Crossing keepers secure level crossings by closing the barriers in good time.
- Employees in a control room or traffic regulation centre monitor the route and can therefore detect disruptions to the scheduled operations. In the event of deviations from operations, they initiate corresponding countermeasures, with the objective of minimising the impact of a disruption.
- The persons who prepare and plan rail transport and the related operations are also crucial to rail transport. The railway operation functions also include the rail infrastructure and operations managers and supervisors as well as further monitoring functions in rail operations.

These employees have particularly specific rail operations skills. High safety standards lead to the fact that these employees are qualified to a uniformly high level, usually through vocational training or a specific railway degree. The two biggest railway-specific occupation groups in rail operations are the train drivers and the employees at the signal boxes. The vocational training typically undergone for these two activities is rail operations staff (EiB) training, with the special subject area of train driver/transport or the special subject area of track infrastructure.

## Administrative service-oriented activities

These employees work at the interface to the customers, e.g. by looking after passengers as train attendants or customer advisors, providing customers with information, providing timetable and price information, managing disruptions and irregularities and, in part, also undertaking railway operation tasks. This job family also includes those employees who look after freight transport customers. The typical vocational training for this includes the occupations of transport service specialist and freight forwarding and logistics service manager.

## Industrial-technical activities

Infrastructure and rolling stock are the key technical system components of the railway. Their care, maintenance and repair are the task of professions in the industrial-technical area.

In the track infrastructure area, numerous activities ensure that trains are able to run at all. These include the employees who lay tracks and points, and therefore construct and improve traffic infrastructures. These employees have normally undergone vocational training as structural engineering technicians/track makers. The industrial electronics technician, who works as a maintenance technician for signal box and electrical power equipment, for instance, is also important.

Vehicle maintenance employees are responsible for the safety and reliability of the railway vehicles. They ensure light maintenance in the local maintenance shops, whereas extensive maintenance work – such as overhauling major components or the elimination of accident damage, for instance – is carried out locally in the large heavy maintenance depots. To do this, the vehicle maintenance employees usually require initial vocational training in the technical field, e.g. as mechatronics technicians, industrial electronics technicians or industrial mechanics. Maintenance shops also exist for signals and for constructing or overhauling points.

By means of regular and special inspections, wagon inspectors ensure that passenger train and freight wagons can and may be used in rail transport. To do this, wagons are checked or inspected to ensure that they are in a safe and reliable condition, and brake tests are performed. The wagon inspectors' technical training is such that they can redress minor technical problems directly on the spot.



*Fig. 1-17:*  
The railway is a team effort which closely intermeshes various vocational and occupation groups. To perform its tasks, each occupation group is reliant on other occupation groups.

Photo: DB AG/Christoph Busse

This reference book describes the German railway system in its entirety and explains the interrelationships between its various subsystems. It explains how the main system components – railway operations, rolling stock and railway infrastructure – work, and describes different modes of transport. This first English edition is based on the second German edition of Systemwissen Eisenbahn, which includes numerous updated illustrations and new chapters on maintenance, railway braking technology and trams. It also reflects the changes in European railway legislation and operating regulations.

Railway system knowledge is an essential reference book for all rail employees and a practical tool for young professionals and career changers.

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