8 THE DUAL-MODE RAILWAY SYSTEM: THE KARLSRUHE MODEL

8.1 THE (KEY) ISSUES ADDRESSED BY THIS CASE STUDY

The Karlsruhe model case study addresses the following key topics:

- **TramTrains as an emerging mobility solution.** The use of TramTrain vehicles overcomes the change otherwise necessary between regional trains and local tramways. This is the (technical) nucleus of the Karlsruhe Model. Nevertheless its overall success has only been possible due to several other components which were implemented as well. For that reason the case study also deals with all these components.
- **Improved Links,** Interchanges **and services**. The inauguration of TramTrains in the Karlsruhe area was accompanied by multiple additional measures:
  - Existing links of regional railway lines were upgraded (electrified, upgraded for higher speed, equipped with additional tracks, etc.)
  - Interchanges between TramTrains and feeding bus lines were built or modernised.
  - Services were enhanced through higher frequencies, longer operating hours, rerouting of bus lines to complement and feed the TramTrains instead of formerly bus services parallel to railway lines.
- **Legal and Organisational Arrangements.** Multiple legal and organisational arrangements had to be made not only for running TramTrains on classical railways and local tram lines, but also for the implementation of the regional transport authority.
- **Effective integration of (public) transport services**. A regional transport authority was founded, targeting the harmonisation and synchronisation of all public transport services.
- **Integrated Ticketing and Pricing**. One core issue of the founded transport authority was the implementation of a common tariff for all public transport modes in the area.
- **Consistent travel information across modes**. One issue of the regional transport authority was the common publishing of timetables and the implementation of common information services.
- **Infrastructure Pricing**. The massive increase of services made it necessary to implement new schemes concerning the prices to be paid for the use of rail infrastructure.

8.2 GENERAL DESCRIPTION OF THE CASE STUDY

The target to be achieved was the revitalisation of public transport to maintain the quality of life in the cities served, with the provision of integrated networks and services, but avoiding confrontation with individual road transport.

The Karlsruhe Model can be considered as a blue print to revitalise public transport between medium sized urban and rural areas. The core of the model is that instead of the passengers changing vehicles, a bimodal vehicle changes between the modes at the system borders from classic rural railway lines to the urban tramway system.

8.2.1 Background and Current Situation

Urban transport (local trams) and regional transport (rail) were existing alongside each other, both more or less connected at interchange points, but not interwoven. This led to some problems in attracting additional passengers, as it was necessary to change between train and tram and vice versa thus discouraging potential passengers onto public transport, especially as car ownership expanded. For this reason in major cities (like, Frankfurt, Stuttgart or Munich) new networks for commuter railway systems were implemented, allowing direct trains between the countryside and the inner cities, but they showed a significant disadvantage: Building such networks was very expensive as the new lines had to tunnel into the inner city and upgrading the existing lines outside the city to

the necessary standard was almost as costly as building the lines new. Classical tramways on the other hand were not part of such concepts, in consequence their network shrunk or wholly disappeared (e.g. like in Hamburg or West-Berlin).

At Karlsruhe the development was different. In the 1960s the local authorities decided to stick with the tramway system and later to upgrade it. Several new tram lines with a layout independent from road traffic were built and where applicable this was also implemented for existing lines. At the end of this process 80% of the whole tram network had an alignment separated from car traffic.

In spite of these measures the usage of public transport stagnated in the town of Karlsruhe (meaning constant passenger figures of about 40 million p.a. from 1950 until the mid of the 1980s, but a decreasing market share), and the passenger numbers on the local trains connecting Karlsruhe with its surrounding area declined. As a consequence less frequent train services and earlier closing hours were implemented and some links were even shutdown, at least partly on weekends. Despite these measures the deficits spent in total for public transport still increased slightly, but when counted per passenger trip went up enormously.

In the meantime car ownership figures rose from year to year (from about 350 cars per 1,000 inhabitants in the early 1970s to 550 cars per 1,000 inhabitants in the late 1980s in the administration district of Karlsruhe), and individual transport took full utilisation of road capacities, although these were increased continuously. The process of suburbanisation was ongoing, meaning that the traffic volumes between town and vicinity still grew.

To halt this development it was decided to revitalise public transport not only within the town of Karlsruhe but especially concerning the transport patterns with its hinterland, since a regulation or limitation of individual motor car traffic was politically not welcomed.

8.2.2 Geographic Coverage

The geographic coverage of the Karlsruhe Model originally was the town of Karlsruhe and the surrounding county Karlsruhe Land, but it was increased to seven cities and counties (Landkreise, NUTS 3) in the larger vicinity now covering an area of 3,550 km² with 120 cities and municipalities and 1.3 million inhabitants.

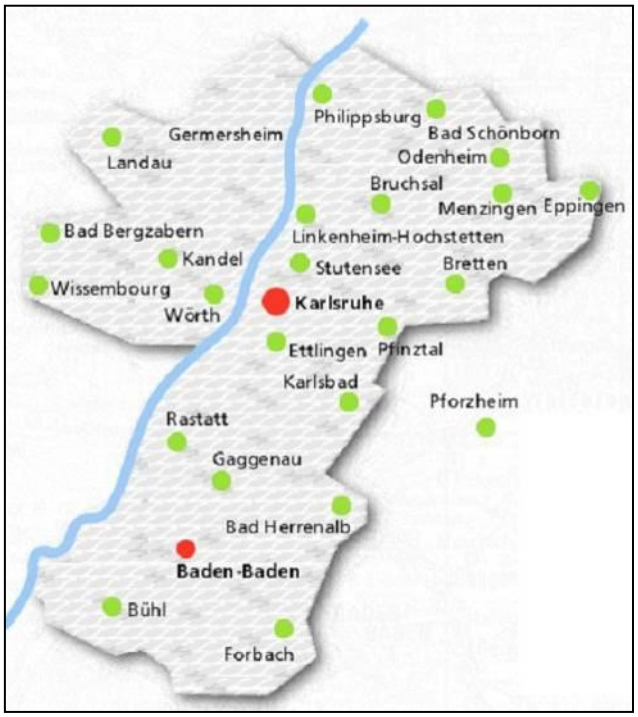


Figure 8-1 Area covered by the "Karlsruhe Modell"

8.3 SPECIFIC CHARACTERISTICS OF THE CASE STUDY

8.3.1 Modes and Infrastructure Involved

The central railway station in Karlsruhe is situated outside the inner city of the town since moving to its current location about 100 years ago. This location requires a necessary change from all passengers travelling to Karlsruhe by train at the central station or another railway station in Karlsruhe to a connecting tramway service.

Each means of transport in the area previously had its own tariff, meaning that people using a combination of train and tram for the trip into Karlsruhe always had to use two tickets. In the case where a bus service was used to reach the origin train station this meant having to pay three times for a trip to the town. This also applied for people commuting and holding season tickets for that reason. There was no kind of harmonised pricing at all.

Figure 8-2 Typical railway station before TramTrain inauguration

Railway stations in the countryside were still situated where they were originally built when the railway lines were opened more than 100 years ago, not taking into account that villages spread out or new settlements were founded since that time. Due to a lack of investment on some of these railway lines, their operational management remained unchanged since the 1960s, meaning multiple staffed stations (ticket selling, signalling, railway crossing gates, local instead of remote traffic control, ...), and loco-hauled diesel trains instead of EMU's. The only "innovation" on some single track lines was the move to unstaffed stations, removing the possibility to have train crossings there any longer and meaning the technical capacity of these lines was reduced over the years. But still the high costs of service compared to the poor passenger figures made them candidates for a closedown.

Figure 8-3 DMUs used on heavy rail links before the implementation of the TramTrain system

Train schedules were mainly oriented to the needs of commuters, meaning they were of no use for leisure traffic, which has grown above average of total transport demand. Timetable brochures existed only for each specific mode of transport or each town.

All these components (enforcement of changing modes, unattractive tariffs, inappropriate location of train stops, poor schedules poor information policy) meant serious disadvantages for public transport when competing with car usage for trips between the countryside and the town.

8.3.2 Existing Institutional and Regulatory Barriers

Tramways and or buses in the towns outside Karlsruhe were operated by municipal authorities, trains by the national German Railways or on some lines by non federal railway companies owned by the Federal State Baden-Württemberg or the counties. Bus lines in the countryside were either operated by independent regional bus companies owned by the national German Railways, by the non-federal railway companies mentioned before or by more than a dozen private companies whose core business is coach tourism. In total there were 20 companies running the public transport services in the area.

Tramways and railways follow different regimes concerning legal and technical issues. In addition different regulations apply and different authorities are responsible for the controlling for tracks / trains on the lines of Deutsche Bahn and of other non-federal railway companies.

Technical standards differ significantly for tramways and railways, although in the Karlsruhe area both systems have the same gauge (1,435 mm). This means vehicles which are supposed to run on railway lines as well as on tramway lines have to fulfil all regulations / technical standards applying to both.

8.3.3 Intermodal and Interconnection Opportunities

A first experience of improving town – hinterland services was the revitalisation of the Albtalbahn, connecting Karlsruhe with Bad Herrenalb. Until the end of the 1950s this route was served by a narrow gauge line with worn-out infrastructure and vehicles. The line terminated at its own terminal, the Abtalbahnhof, which is located close to the central railway station of Karlsruhe, but quite apart from the city centre, where all passengers had to either walk about 10 minutes to the central station to interchange to long distance trains or about 5 minutes to the local city tram system.

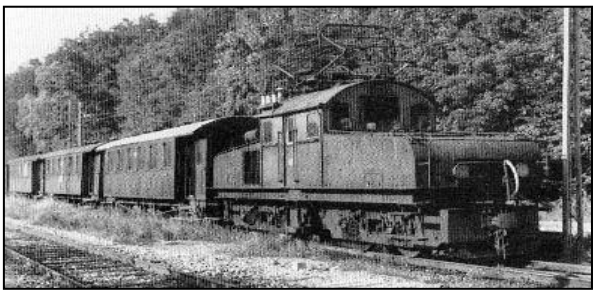


Figure 8-4 Loco hauled train of narrow gauge Albtalbahn until 1960

As this line also served the town of Ettlingen which has close relations to Karlsruhe, in principal this line had a great potential for additional passengers. For this reason, the decision was taken to re-gauge this line and to serve it with tramway vehicles directly to and from Karlsruhe city centre. The new gauge of this line (1,435 mm) is identical to the gauge of the Karlsruhe tramway system, which is also the standard gauge in Germany on heavy rail lines.

This service upgrade also incorporated an increase of the top speed (now up to 80 km/h) and a higher frequency on the line. At a later stage a shut down branch line (to Ittersbach) of the Albtalbahn was reopened and served in the same way, that is with high frequency trams to Karlsruhe city centre.

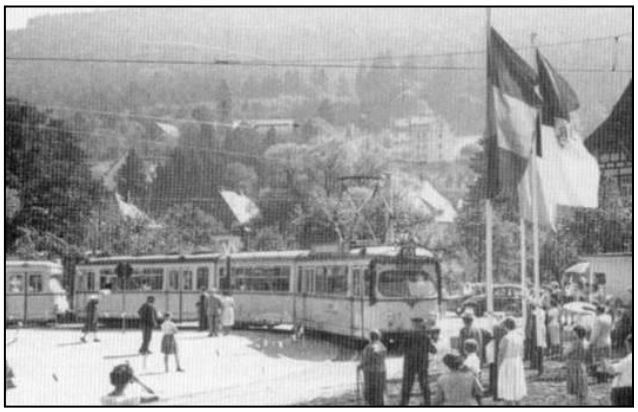


Figure 8-5 Tramway for the direct services of Albtalbahn to city centre Karlsruhe in 1961

As the company which formerly ran the Albtalbahn went bankrupt, in 1961 the town of Karlsruhe founded a new company responsible for the infrastructure and the services of this "new" line, the Albtalbahn Verkehrsgesellschaft, AVG. This company is in close connection with the local transport authority of Karlsruhe (Verkehrsbetriebe Karlsruhe, VBK), which made it easy to implement a common tariff scheme for the Albtalbahn and with other public transport services in Karlsruhe.

A second step towards the "Karlsruhe Model" was the opening of the Hardtbahn. The line from Nordweststadt to Neureut was inaugurated in 1979 and included 1.5 km of track sharing with DB. In 1989 this line was extended to Hochstetten, integrating 4.4 km of additional track sharing with DB. Track sharing safety required additional signalling system modification. The line from Bad Herrenalb via Ettlingen and Karlsruhe to Hochstetten is today the S1, one of Karlsruhe's main transport lines.

Figure 8-6 Mono voltage TramTrain used on Albtal- and Hardtbahn since 1983

The lessons learned from these two steps were:

- Abolishing necessary changes of vehicles at interchange points, meaning more comfort and shorter travel-times, led to a dramatic increase of passenger figures.
- The technical adaptations needed for track sharing of heavy rail trains and tramways are feasible and available for reasonable costs.
- Those measures gave an excellent cost-benefit ratio, much better than what applies for completely new built lines.

From the experience made with the Albtalbahn and the Hardtbahn the question arose: Why shouldn't this be possible for all the other heavy rail lines in the Karlsruhe area?

8.4 CHARACTERISTICS OF THE SOLUTIONS ALREADY IN PLACE

The key issue in the Karlsruhe Model is the use of bimodal vehicles as an emerging mobility solution so that the intermodal connection between the railway and the tramway system is done by the vehicle and not by the passenger. This means that there are connection points where the vehicles switch from one network to the other. Some railway lines have been electrified and modernised first to allow TramTrain services. The solutions shown are all in use, and their technical, financial, organisational and legal feasibility is proven.

8.4.1 The Connection Points

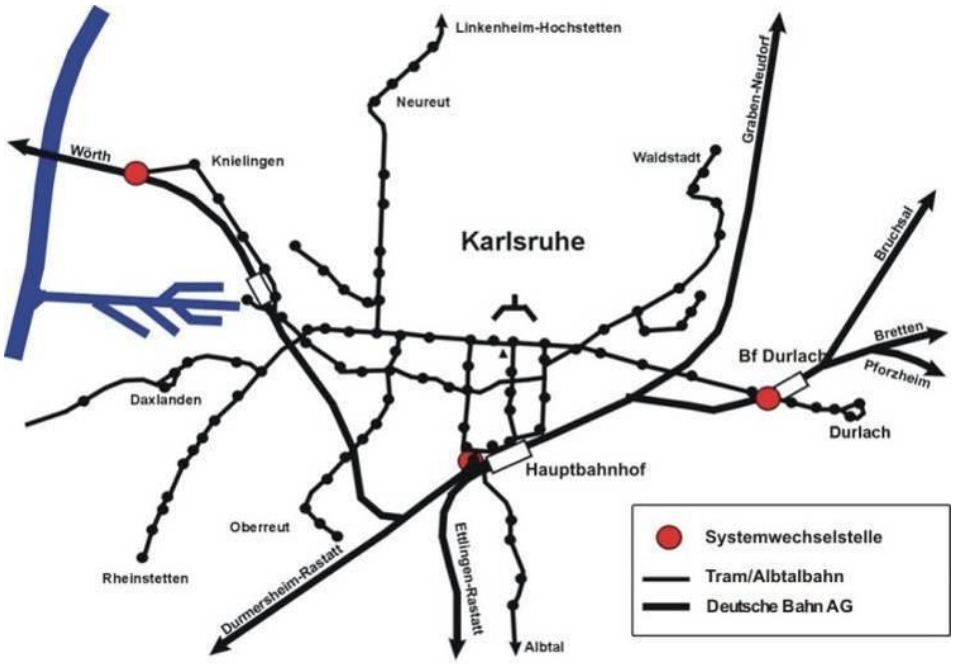


Figure 8-7 Karlsruhe tramway network with interchanges to heavy rail lines

The figure above shows the Karlsruhe tramway network (extract) and the three changing points ("Systemwechselstelle", red bullets in the map) where TramTrain vehicles can switch from the heavy rail network of Deutsche Bahn to the tramway network: in the east at the railway station of Karlsruhe-Durlach, in the west at Karlsruhe-Knielingen, and in the south close to the central railway station at the Albtalbahnhof, where a ramp connects the tramway system with the tracks of Deutsche Bahn.

The interchange just consists of a short isolated part of the catenary, where the power supply of the vehicle switches automatically between the different voltages. While the tramway lines have 750 Volt DC, the heavy rail lines are equipped with 15,000 Volt AC, as the connection points are an essential prerequisite for TramTrains.

Figure 8-8 Ramp at Albtalbahnhof with interchange from 750 V DC to 15kV AC

8.4.2 The TramTrain Vehicles

To enable the vehicle to run under two different voltages it is equipped with additional electrical components all situated in the middle part of the TramTrain.

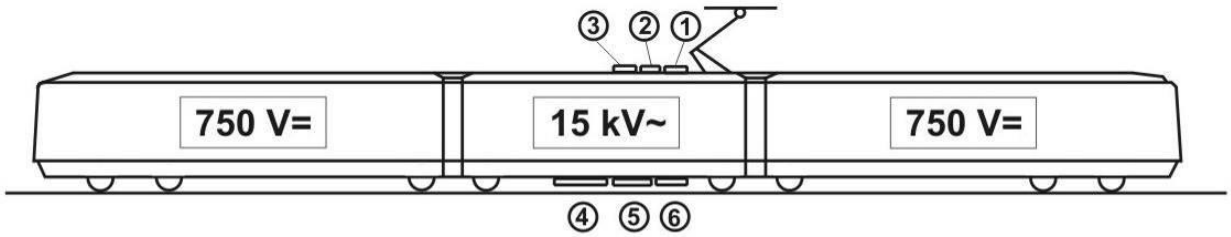


Figure 8-9 Electric components of TramTrain vehicles

1 = Disconnector
2 = Sensing device (feeler to identify current voltage)
3 = Circuit breaker
4 = Transformer (to bring 15 kV to 750 V)
5 = Rectifier (to bring AC to DC)
6 = Condenser

The TramTrain vehicles furthermore must cope with the profiles of the different tracks used for tramway lines and heavy rail. In addition their dimensions and sketch must follow the rules applying for tramways (BOStrab), which limits maximum width and length, as well as the rules for railways (EBO, Eisenbahnbau- und Betriebsordnung). Concerning these topics some experience was gained when introducing tram train services at the Hardtbahn (see section 8.3).

The TramTrains are categorised as light motorised unit, “leichter Nahverkehrstriebwagen, LNT”. This classification means a number of implications for regular operations:

- Allowed top speed is 100 km/h (90 km/h on tracks of Deutsche Bahn)
- Breaking power (deceleration) must be in line with the regulations which apply for construction and operation for tramways (BOStrab)
- Vehicles must be equipped with home signals, signal dependent switches, sectors and inductive train protection
- In addition, on main tracks with top speed higher than 160 km/h, check-ins and checkout in stations are required
- TramTrain vehicles are generally not permitted on tracks with top speeds exceeding 160 km/h
- The velocity on double tracks with tunnels is limited to 120 km/h

Before the TramTrain vehicles got permanent permission to be used in regular services on heavy rail lines, numerous test runs were undertaken. The following picture shows a block train composed of two units of TramTrain vehicles combined with a monitoring car of Deutsche Bahn during a stop at Rastatt station situated on the main line Karlsruhe – Basel.

Figure 8-10 Block train with monitoring car for test runs

The current TramTrain vehicles have close to 100 seats, a space for strollers / wheelchairs / bicycles, and are equipped with a ticket vending machine, stop request buttons, ticket validating machines and those which are dedicated to run on the long routes also have a restroom. The visible axis from one end to the other of a TramTrain unit between the driver and the passengers increases their personal security when compared with classical trains.

Figure 8-11 Interior of a TramTrain

The newly ordered series of 30 vehicles to be delivered from summer 2011 will cost about € 4.3M each, while in 1992 the TramTrains of the first generation were available for € 2.3M per unit.

8.4.3 Improvement of Links

This section is twofold. The first part deals with the specific measures to improve a link, while the second summarises the development of the whole network year by year.

Specific improvements

The improvement of links covers several aspects. In some cases the first step was the electrification of heavy rail lines according to German-wide standard with 15 kV, 16.7 Hz DC. If there were tunnels on links to be electrified the increased clearing profile necessary due to the catenary usually caused

immense costs. These costs could be reduced significantly by combining two technical solutions: replacement of the standard contact wire by a third rail system with a height of five metres in the tunnels and the usage of Y-sleepers which reduces the construction height by 11 cm. The following figures show these construction elements.

Figure 8-12 Third rail system for electrification in tunnels

Figure 8-13 Y-sleepers allowing a reduction of the clearance profile

In addition elements such as signalling, train control, railway, and crossing gates, that were formerly handled locally at staffed stations, were centralised and run from just one railway control centre.

A further step was the implementation of additional stops (blue bullets in the figure below) for the TramTrains, in comparison to the situation before, where the trains used to serve those stations which already existed when the rail line was opened 100 years ago. The figure below shows what has been done at the very first line, Bretten – Karlsruhe, comparing the situation before and after 1992, the year of inauguration of TramTrain services. At Karlsruhe the new layout of the line on the tramway tracks allowed TramTrain to serve all the stopping points of the tramways between the central station, which is located in the south of the town, and Karlsruhe-Durlach in the east, including those in the very city centre. East of Karlsruhe the smaller villages received one additional stop which reduces the access distance to the system for major parts of the local population. Finally the town of Bretten (13,000 inhabitants in the city itself) got five additional stops. The following figure shows where these stops are situated.

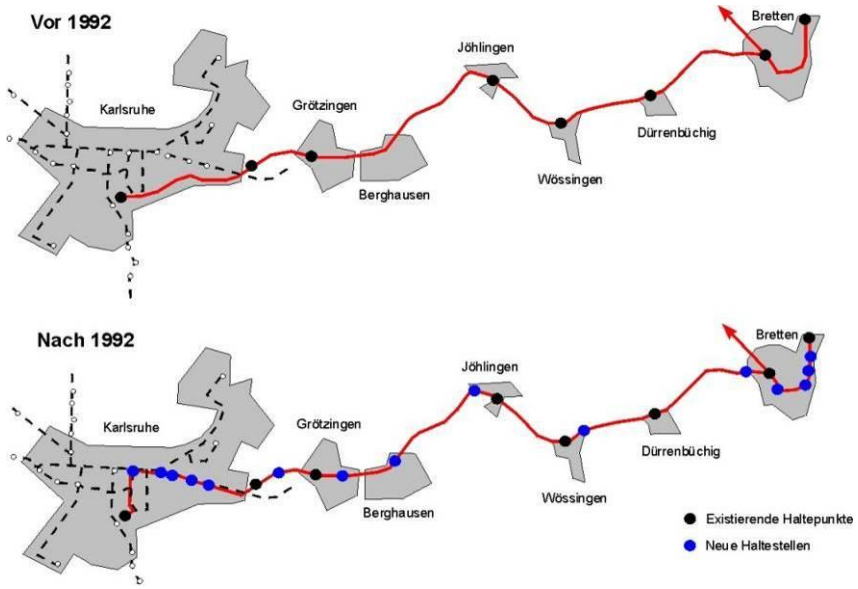


Figure 8-14 Development of stops on the Karlsruhe – Bretten line

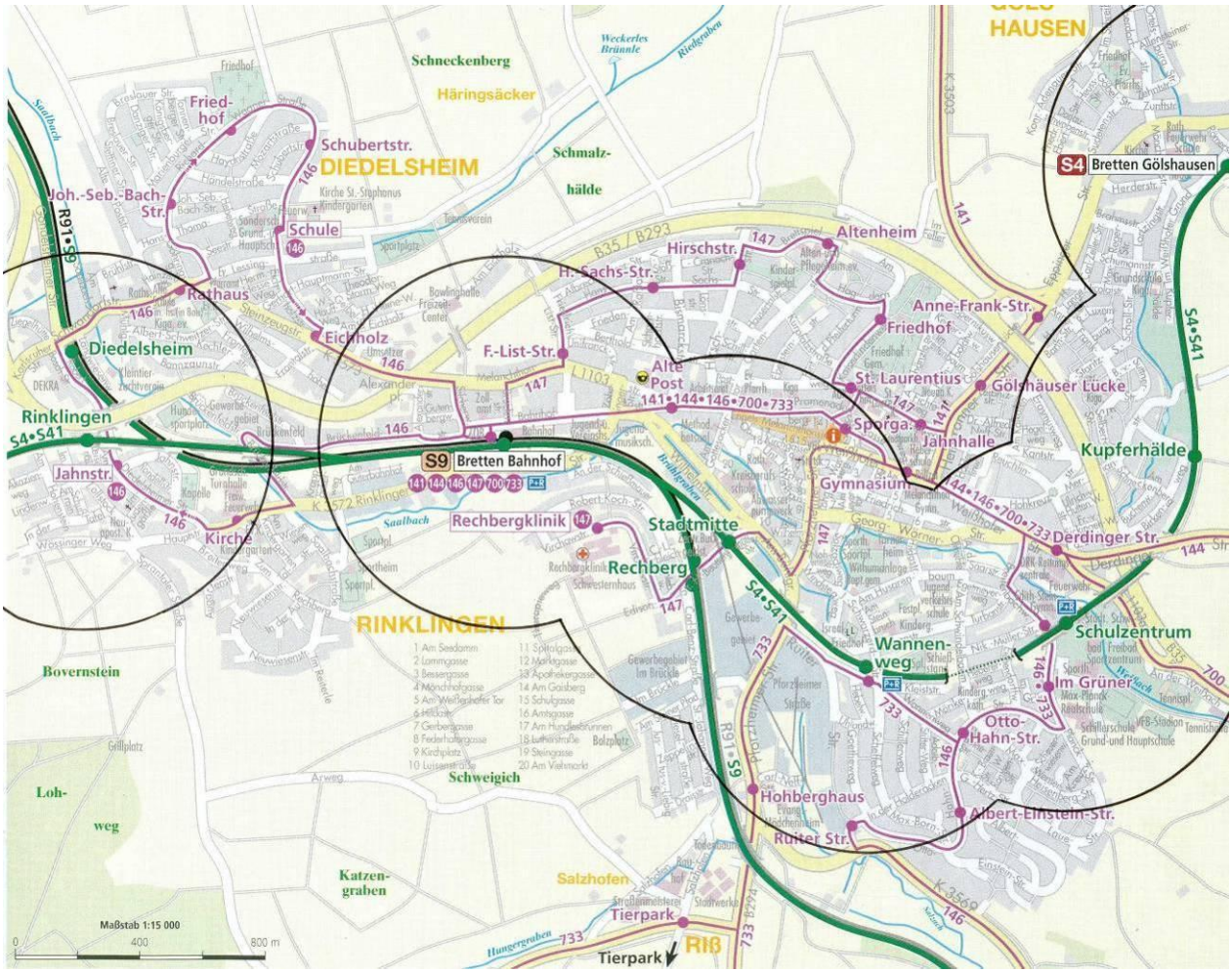


Figure 8-15 New stops for the TramTrains at Bretten

The only stops for conventional trains in the area have been the railway station of Bretten (Bretten Bahnhof) in the centre and Bretten-Gölshausen displayed on the right side of the figure above. The villages of Rinklingen and Diedelsheim on the left side, belonging to Bretten had never had a train stop before, although the railway lines directly pass them.

Together with the other new stops (Stadtmitte, Wannenweg, Schulzentrum, Kupferhälde, Rechberg) this allows access to the TramTrain within walking distance (see the circles with a radius of 500 metres) from most parts of the town. This includes the city centre, with multiple shops and a pedestrian zone, as well as the business park area in the south of the town. In this way using public transport becomes not only more attractive for passengers commuting to Karlsruhe, but also for those passengers who are heading towards Bretten. The purple lines in Figure 8-15 reflect bus services feeding the tram system and providing transport within the town.

In some cases existing tram stations which did not really meet passenger demand were closed and replaced by stations which meet the current demand from the urban land uses that have developed within the last century. For example the former station of Hörden-Ottenau, serving the two villages Hörden and Ottenau on the Karlsruhe – Freudenstadt line, was replaced by two new stops in each of these two settlements, allowing shorter access for inhabitants.

Finally in some cases, the relocation of a stop meant a short extension of the link. This applied for the Pforzheim – Bad Wildbad line. Bad Wildbad, a famous spa, originally had a quite massive railway station in the very outskirts of the town, where the line from Pforzheim ended. To improve accessibility with public transport it was decided to extend the line by a few hundred metres (including new stops) right through the town to the very centre. The following picture shows the new situation.

Figure 8-16 TramTrain on the extended line to the city centre of Bad Wildbad

Furthermore bus lines were newly organised avoiding services parallel to TramTrain routes but enforcing feeder services to existing or newly built intermodal nodes bus <-> TramTrain to offer an integrated network.

Network development

The original nucleus of the Karlsruhe TramTrain network was the Albtalbahn line to Bad Herrenalb in 1961 which later was complemented with a branch to Ittersbach and an extension to the north to Hochstetten, which formed the base network for (at that time only mono-voltage) TramTrains of 60 kilometres (including the path within the communal tram network).

In 1992 the first real dual-voltage TramTrain line from Karlsruhe to Bretten with was inaugurated adding another 24 km. The success of this prototype was followed by an intensive extension of the TramTrain network:

- In 1994 the lines from Karlsruhe to Baden-Baden (only serving a remote station) and Bruchsal + Bretten – Bruchsal (all exclusively on tracks of Deutsche Bahn) were opened.
- In 1996 Bruchsal to Menzingen (upgrade of formerly diesel-hauled secondary line) was put into service and the city centre of Karlsruhe was connected to the Baden-Baden line (new built).
- In 1997 the lines connecting Karlsruhe with Pforzheim and Wörth (on tracks of Deutsche Bahn) were opened plus the extension of the Bretten line to Eppingen (upgrade of formerly diesel-hauled line) was inaugurated.
- In 1998 the TramTrains reached Odenheim (upgrade of formerly diesel-hauled line).
- In 1999 the extensions from Pforzheim to Bietigheim-Bissingen (partly on new built tracks, partly on tracks of Deutsche Bahn) and from Eppingen to Heilbronn Central station (upgrade of formerly diesel-hauled line) came into service.
- In 2001 the Heilbronn line was extended to the city centre of Heilbronn (new built).
- In 2002 the Murgtalbahn from Rastatt to Forbach opened (upgrade of formerly diesel-hauled line).
- In 2003 the Murgtalbahn got TramTrain services on its full length up to Freudenstadt and the line from Pforzheim to Bad Wildbad was inaugurated (both upgrades of formerly diesel-hauled line, to Bad Wildbad combined with a short new built completion).
- In 2004 the Baden-Baden line was extended to Achern (on tracks of Deutsche Bahn).
- In 2005 the Heilbronn line was extended to Öhringen (partly new built, partly upgrade of formerly diesel-hauled line).
- In 2006 the (mono-voltage) line from Mörsch to Spöck came into full service after some parts of the line had already been set into service earlier. In addition the Freudenstadt line was extended to Eutingen im Gäu.

This development, all within 15 years, brought the network for TramTrains to a total length of more than 400 kilometres. Further extensions (from Wörth to Germersheim to be finished in the end of 2010) and in the Heilbronn area are under construction. Additional links are in a planning stage. The map below shows the lines which exist, and those which are under construction.

Starting from eight TramTrains in 1992 for the Bretten line, their number rose to more than 120 TramTrains which are in service at the present time. This fleet of dual-voltage trainsets is accompanied by 60 sets for the mono-voltage lines.

Figure 8-17 Current status of the TramTrain network

8.4.4 Improvement of Stations and Interchanges

Stops on lines exclusively served by tram trains in regular passenger transport have a number of standards implemented to increase the passengers' comfort in general, but especially for passengers with reduced mobility. Their application at existing stops depends on the ownership of those lines and the type of other trains serving these stops or just using the tracks.

The standard layout of the stations consists of platforms with a length of 80 metres, adequate for train sets composed of two TramTrain vehicles. The access to the platform in general is via level crossings accompanied by signalling where required, while underpasses or bridges are avoided. Level crossings are in line with the applicable regulations for railways which are run under the supervision of the Federal State of Baden-Württemberg, while the construction standards of Deutsche Bahn require less cost effective solutions. In combination with a tram-like deceleration level-crossings mean the same users' safety as for an underpass. The height of the platforms is at 55 centimetres which allows barrier-free access to TramTrain vehicles at least of the second generation (lowered floor). The platforms are equipped with timetable information, waiting booth, ticket vending machines (where justified by the number of passengers) and tactile stripes.

Figure 8-18 Standard layout of platforms for TramTrains

Finally, existing train stops had to be modernised (e.g. with new platforms for level access to vehicles, ticket machines, passenger information systems, rearrangement of bus stops and new stops to be implemented must follow the existing standards. For stations at links which are not exclusively used by TramTrains deviations on the layout principles as mentioned above may apply, especially concerning platform height or platform access.

Figure 8-19 Standard layout for interchange points TramTrain <-> bus

8.4.5 Improvement of Services

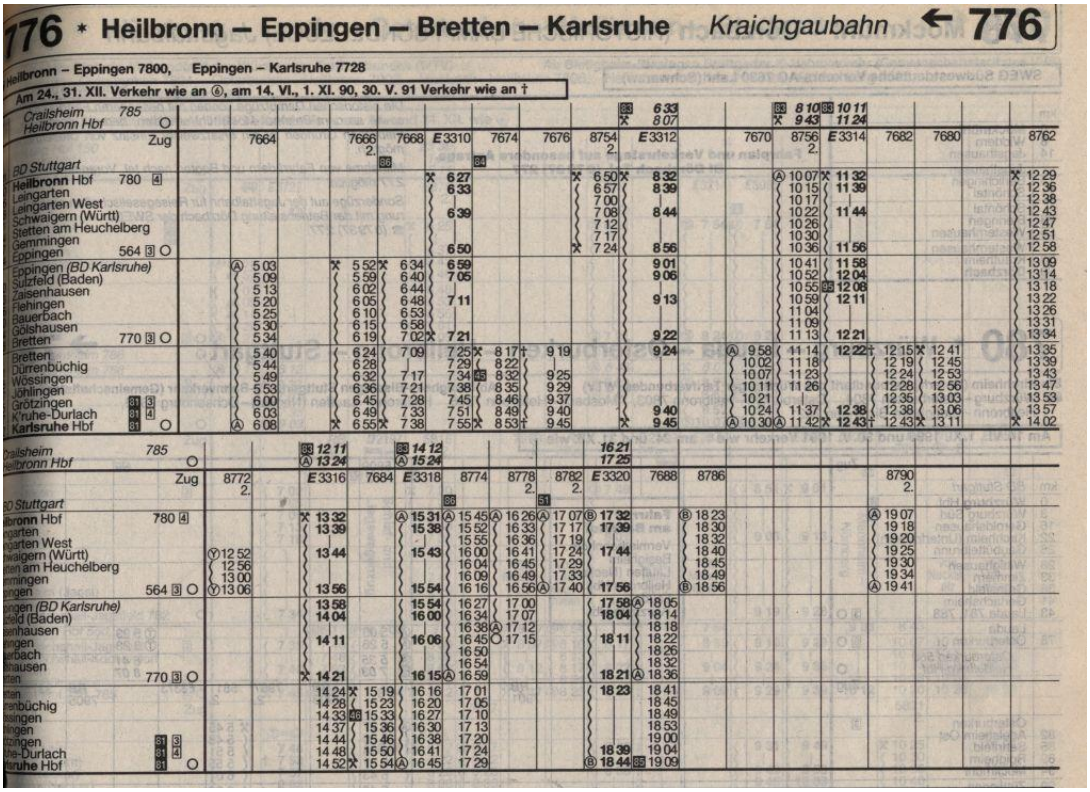
One major component of the overall success of the system comes from the increased number of services. Before the instalment of TramTrain services the timetable of those lines run by classical trains was demand oriented with special focus on commuters, negating the needs of other trip purposes.

The following three figures show the timetable of the year 1990 on the first line where the TramTrain system was implemented, and the timetable the TramTrains follow on this line today for daytime and night-time.

In 1990 there were:

- No regular interval timetables,
- Major parts of the line without any services between Saturday afternoon and Sunday evening,
- No more trains after eight o'clock in the evening,

- No segments of the line with more than 17 trains per day and direction,
- Travel-times for the whole line varying between 71 minutes (8 intermediate stops) and 104 minutes (all 17 intermediate stops) between Heilbronn and Karlsruhe (between central stations).



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Heilbronn – Eppingen 7800, Eppingen – Karlsruhe 7728

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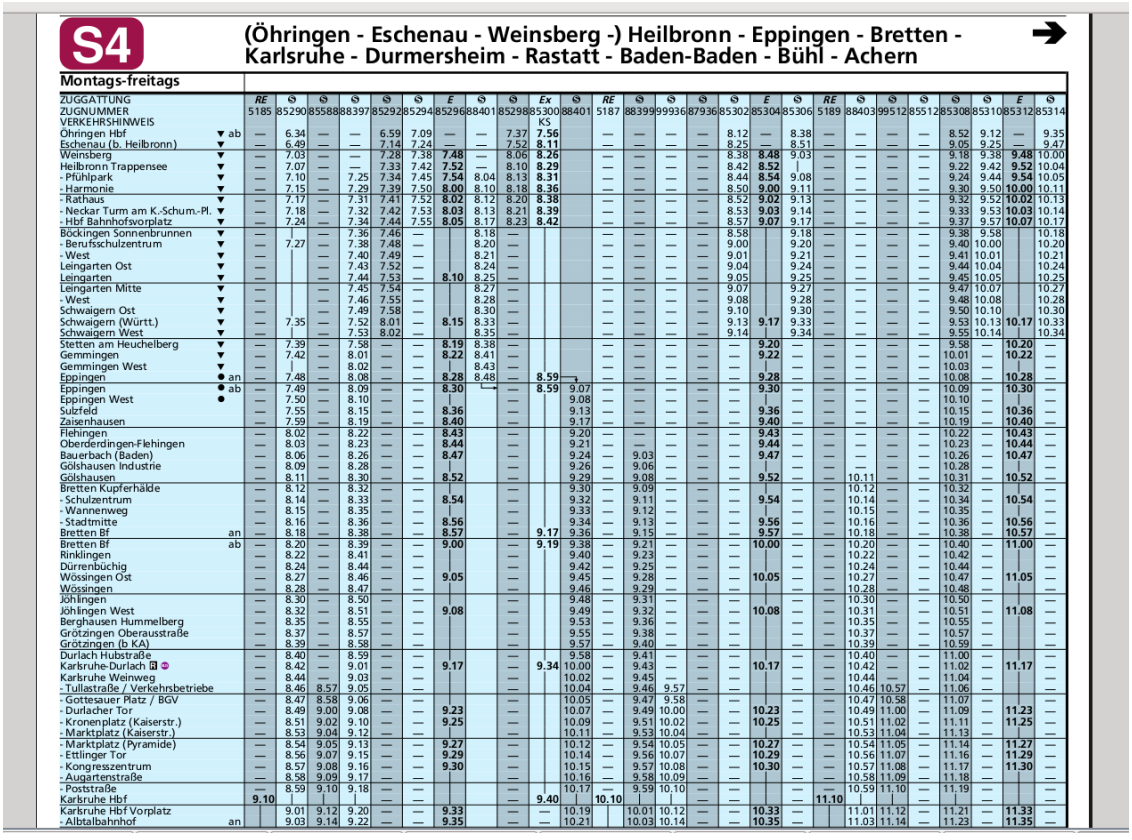
Heilbronn Hbf									8 07		9 43	11 24			
BD Stuttgart															
Heilbronn Hbf 780 4					6 27			6 50	8 32		10 07	11 32			12 29
Leingarten					6 33			6 57	8 39		10 15	11 39			12 36
Leingarten West								7 00			10 17				12 38
Schwaigern (Württ)					6 39			7 08	8 44		10 22	11 44			12 43
Stetten am Heuchelberg								7 12			10 26				12 47
Gemmingen								7 17			10 30				12 51
Eppingen 564 3					6 50			7 24	8 56		10 36	11 56			12 58
Eppingen (BD Karlsruhe)		Ⓐ 5 03			6 59				9 01		10 41	11 58			13 09
Sulzfeld (Baden)		5 09			7 05				9 06		10 52	12 04			13 14
Zaisenhausen		5 13									10 55	12 08			13 18
Flehingen		5 20			7 11				9 13		10 59	12 11			13 22
Bauerbach		5 25									11 04				13 26
Gölshausen		5 30									11 09				13 31
Bretten 770 3		5 34			7 21				9 22		11 13	12 21			13 34
Bretten		5 40		7 09	7 25	8 17†	9 19		9 24	Ⓐ 9 58	11 14	12 22†	12 15	12 41	13 35
Dürrenbüchig		5 44			7 29	8 22				10 02	11 18		12 19	12 45	13 39
Wössingen		5 49		7 17	7 34	8 32	9 25			10 07	11 23		12 24	12 53	13 43
Jöhlingen		5 53		7 21	7 38	8 35	9 29			10 11	11 26		12 28	12 56	13 47
Grötzingen 81 3		6 00		7 28	7 45	8 46	9 37			10 21			12 35	13 03	13 53
Karlsruhe-Durlach 81 4		6 03		7 33	7 51	8 49	9 40		9 40	10 24	11 37	12 38	12 38	13 06	13 57
Karlsruhe Hbf 81		Ⓐ 6 08		6 55	7 38	7 55	8 53†	9 45	9 45	Ⓐ 10 30	Ⓐ 11 42	12 43†	12 43	13 11	14 02

	Zug	8772 2.	E 3316	7684	E 3318	8774	8778 2.	8782 2.	E 3320	7688	8786	8790 2.
Crailsheim 785			12 11		14 12				16 21			
Heilbronn Hbf			Ⓐ 13 24		Ⓐ 15 24				17 25			
BD Stuttgart												
Heilbronn Hbf 780 4			13 32		Ⓐ 15 31	Ⓐ 15 45	Ⓐ 16 26	Ⓐ 17 07	Ⓑ 17 32		Ⓑ 18 23	Ⓐ 19 07
Leingarten			13 39		15 38	15 52	16 33	17 17	17 39		18 30	19 18
Leingarten West						15 55	16 36	17 19			18 32	19 20
Schwaigern (Württ)		Ⓨ 12 52	13 44		15 43	16 00	16 41	17 24	17 44		18 40	19 25
Stetten am Heuchelberg		12 56				16 04	16 45	17 29			18 45	19 30
Gemmingen		13 00				16 09	16 49	17 33			18 49	19 34
Eppingen 564 3		Ⓨ 13 06	13 56		15 54	16 16	16 56 Ⓐ	17 40	17 56		Ⓑ 18 56	Ⓐ 19 41
Eppingen (BD Karlsruhe)			13 58		15 54	16 27	17 00		17 58	Ⓐ 18 05		
Sulzfeld (Baden)			14 04		16 00	16 34	17 07		18 04	18 14		
Zaisenhausen						16 38 Ⓐ	17 12			18 18		
Flehingen			14 11		16 06	16 45	17 15		18 11	18 22		
Bauerbach						16 50				18 26		
Gölshausen						16 54				18 32		
Bretten 770 3			14 21		16 15 Ⓐ	16 59			18 21	Ⓐ 18 36		
Bretten			14 24	15 19	16 16	17 01			18 23	18 41		
Dürrenbüchig			14 28	15 23	16 20	17 05				18 45		
Wössingen			14 33	15 33	16 27	17 10				18 49		
Jöhlingen			14 37	15 36	16 30	17 13				18 53		
Grötzingen 81 3			14 44	15 46	16 38	17 20				19 00		
Karlsruhe-Durlach 81 4			14 48	15 50	16 41	17 24			18 39	19 04		
Karlsruhe Hbf 81			14 52	15 54 Ⓐ	16 45	17 29			Ⓑ 18 44	85 19 09		

Figure 8-20 Timetable before inauguration of TramTrains on Heilbronn – Karlsruhe 1990

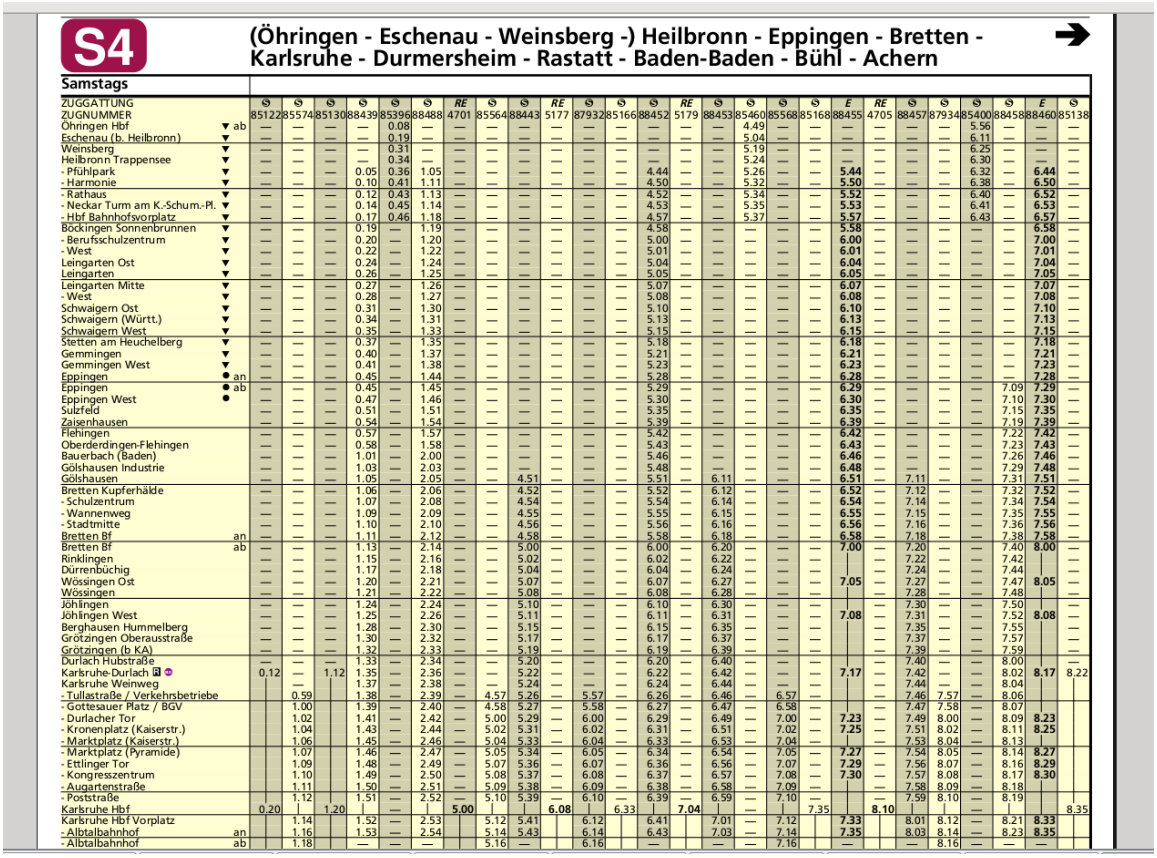


S4 (Öhringen - Eschenau - Weinsberg -) Heilbronn - Eppingen - Bretten - Karlsruhe - Durmersheim - Rastatt - Baden-Baden - Bühl - Achern

Montags-freitags

ZUGGATTUNG		RE	S	S	S	S	S	E	S	S	Ex	S	RE	S	S	S	S	E	S	RE	S	S	S	S	S	E	S
ZUGNUMMER		5185	85290	85588	88397	85292	85294	85296	88401	85298	85300 KS	88401	5187	88399	99936	87936	85302	85304	85306	5189	88403	99512	85512	85308	85310	85312	85314
VERKEHRSHINWEIS																											
Öhringen Hbf	▼ ab	—	6.34	—	—	6.59	7.09	—	—	7.37	7.56		—	—	—	—	8.12	—	8.38	—	—	—	—	8.52	9.12	—	9.35
Eschenau (b. Heilbronn)	▼	—	6.49	—	—	7.14	7.24	—	—	7.52	8.11		—	—	—	—	8.25	—	8.51	—	—	—	—	9.05	9.25	—	9.47
Weinsberg	▼	—	7.03	—	—	7.28	7.38	7.48	—	8.06	8.26		—	—	—	—	8.38	8.48	9.03	—	—	—	—	9.18	9.38	9.48	10.00
Heilbronn Trappensee	▼	—	7.07	—	—	7.33	7.42	7.52	—	8.10	8.29		—	—	—	—	8.42	8.52	|	—	—	—	—	9.22	9.42	9.52	10.04
- Pfühlpark	▼	—	7.10	—	7.25	7.34	7.45	7.54	8.04	8.13	8.31		—	—	—	—	8.44	8.54	9.08	—	—	—	—	9.24	9.44	9.54	10.05
- Harmonie	▼	—	7.15	—	7.29	7.39	7.50	8.00	8.10	8.18	8.36		—	—	—	—	8.50	9.00	9.11	—	—	—	—	9.30	9.50	10.00	10.11
- Rathaus	▼	—	7.17	—	7.31	7.41	7.52	8.02	8.12	8.20	8.38		—	—	—	—	8.52	9.02	9.13	—	—	—	—	9.32	9.52	10.02	10.13
- Neckar Turm am K.-Schum.-Pl.	▼	—	7.18	—	7.32	7.42	7.53	8.03	8.13	8.21	8.39		—	—	—	—	8.53	9.03	9.14	—	—	—	—	9.33	9.53	10.03	10.14
- Hbf Bahnhofsvorplatz	▼	—	7.24	—	7.34	7.44	7.55	8.05	8.17	8.23	8.42		—	—	—	—	8.57	9.07	9.17	—	—	—	—	9.37	9.57	10.07	10.17
Böckingen Sonnenbrunnen	▼	—	|	—	7.36	7.46	—		8.18	—			—	—	—	—	8.58		9.18	—	—	—	—	9.38	9.58		10.18
- Berufsschulzentrum	▼	—	7.27	—	7.38	7.48	—		8.20	—			—	—	—	—	9.00		9.20	—	—	—	—	9.40	10.00		10.20
- West	▼	—	|	—	7.40	7.49	—		8.21	—			—	—	—	—	9.01		9.21	—	—	—	—	9.41	10.01		10.21
Leingarten Ost	▼	—		—	7.43	7.52	—		8.24	—			—	—	—	—	9.04		9.24	—	—	—	—	9.44	10.04		10.24
Leingarten	▼	—		—	7.44	7.53	—	8.10	8.25	—			—	—	—	—	9.05		9.25	—	—	—	—	9.45	10.05		10.25
Leingarten Mitte	▼	—		—	7.45	7.54	—		8.27	—			—	—	—	—	9.07		9.27	—	—	—	—	9.47	10.07		10.27
- West	▼	—		—	7.46	7.55	—		8.28	—			—	—	—	—	9.08		9.28	—	—	—	—	9.48	10.08		10.28
Schwaigern Ost	▼	—		—	7.49	7.58	—		8.30	—			—	—	—	—	9.10		9.30	—	—	—	—	9.50	10.10		10.30
Schwaigern (Württ.)	▼	—	7.35	—	7.52	8.01	—	8.15	8.33	—			—	—	—	—	9.13	9.17	9.33	—	—	—	—	9.53	10.13	10.17	10.33
Schwaigern West	▼	—	|	—	7.53	8.02	—		8.35	—			—	—	—	—	9.14		9.34	—	—	—	—	9.55	10.14		10.34
Stetten am Heuchelberg	▼	—	7.39	—	7.58	—	—	8.19	8.38	—			—	—	—	—	—	9.20	—	—	—	—	—	9.58	—	10.20	—
Gemmingen	▼	—	7.42	—	8.01	—	—	8.22	8.41	—			—	—	—	—	—	9.22	—	—	—	—	—	10.01	—	10.22	—
Gemmingen West	▼	—	|	—	8.02	—	—		8.43	—			—	—	—	—	—		—	—	—	—	—	10.03	—		—
Eppingen	● an	—	7.48	—	8.08	—	—	8.28	8.48	—	8.59		—	—	—	—	—	9.28	—	—	—	—	—	10.08	—	10.28	—
Eppingen	● ab	—	7.49	—	8.09	—	—	8.30		—	8.59	9.07	—	—	—	—	—	9.30	—	—	—	—	—	10.09	—	10.30	—
Eppingen West	●	—	7.50	—	8.10	—	—	|		—		9.08	—	—	—	—	—	|	—	—	—	—	—	10.10	—	|	—
Sulzfeld		—	7.55	—	8.15	—	—	8.36		—		9.13	—	—	—	—	—	9.36	—	—	—	—	—	10.15	—	10.36	—
Zaisenhausen		—	7.59	—	8.19	—	—	8.40		—		9.17	—	—	—	—	—	9.40	—	—	—	—	—	10.19	—	10.40	—
Flehingen		—	8.02	—	8.22	—	—	8.43		—		9.20	—	—	—	—	—	9.43	—	—	—	—	—	10.22	—	10.43	—
Oberderdingen-Flehingen		—	8.03	—	8.23	—	—	8.44		—		9.21	—	—	—	—	—	9.44	—	—	—	—	—	10.23	—	10.44	—
Bauerbach (Baden)		—	8.06	—	8.26	—	—	8.47		—		9.24	—	9.03	—	—	—	9.47	—	—	—	—	—	10.26	—	10.47	—
Gölshausen Industrie		—	8.09	—	8.28	—	—	|		—		9.26	—	9.06	—	—	—	|	—	—	—	—	—	10.28	—	|	—
Gölshausen		—	8.11	—	8.30	—	—	8.52		—		9.29	—	9.08	—	—	—	9.52	—	—	—	10.11	—	10.31	—	10.52	—
Bretten Kupferhälde		—	8.12	—	8.32	—	—			—		9.30	—	9.09	—	—	—		—	—	—	10.12	—	10.32	—		—
- Schulzentrum		—	8.14	—	8.33	—	—	8.54		—		9.32	—	9.11	—	—	—	9.54	—	—	—	10.14	—	10.34	—	10.54	—
- Wannenweg		—	8.15	—	8.35	—	—	|		—		9.33	—	9.12	—	—	—	|	—	—	—	10.15	—	10.35	—	|	—
- Stadtmitte		—	8.16	—	8.36	—	—	8.56		—		9.34	—	9.13	—	—	—	9.56	—	—	—	10.16	—	10.36	—	10.56	—
Bretten Bf	an	—	8.18	—	8.38	—	—	8.57		—	9.17	9.36	—	9.15	—	—	—	9.57	—	—	—	10.18	—	10.38	—	10.57	—
Bretten Bf	ab	—	8.20	—	8.39	—	—	9.00		—	9.19	9.38	—	9.21	—	—	—	10.00	—	—	—	10.20	—	10.40	—	11.00	—
Rinklingen		—	8.22	—	8.41	—	—			—		9.40	—	9.23	—	—	—		—	—	—	10.22	—	10.42	—		—
Dürrenbüchig		—	8.24	—	8.44	—	—			—		9.42	—	9.25	—	—	—		—	—	—	10.24	—	10.44	—		—
Wössingen Ost		—	8.27	—	8.46	—	—	9.05		—		9.45	—	9.28	—	—	—	10.05	—	—	—	10.27	—	10.47	—	11.05	—
Wössingen		—	8.28	—	8.47	—	—			—		9.46	—	9.29	—	—	—		—	—	—	10.28	—	10.48	—		—
Jöhlingen		—	8.30	—	8.50	—	—			—		9.48	—	9.31	—	—	—		—	—	—	10.30	—	10.50	—		—
Jöhlingen West		—	8.32	—	8.51	—	—	9.08		—		9.49	—	9.32	—	—	—	10.08	—	—	—	10.31	—	10.51	—	11.08	—
Berghaus Hummelberg		—	8.35	—	8.55	—	—			—		9.53	—	9.36	—	—	—		—	—	—	10.35	—	10.55	—		—
Grötzingen Oberausstraße		—	8.37	—	8.57	—	—			—		9.55	—	9.38	—	—	—		—	—	—	10.37	—	10.57	—		—
Grötzingen (b KA)		—	8.39	—	8.58	—	—			—		9.57	—	9.40	—	—	—		—	—	—	10.39	—	10.59	—		—
Durlach Hubstraße		—	8.40	—	8.59	—	—			—		9.58	—	9.41	—	—	—		—	—	—	10.40	—	11.00	—		—
Karlsruhe-Durlach		—	8.42	—	9.01	—	—	9.17		—	9.34	10.00	—	9.43	—	—	—	10.17	—	—	—	10.42	—	11.02	—	11.17	—
Karlsruhe Weinweg		—	8.44	—	9.03	—	—			—		10.02	—	9.45	—	—	—		—	—	—	10.44	—	11.04	—		—
- Tullastraße / Verkehrsbetriebe		—	8.46	8.57	9.05	—	—			—		10.04	—	9.46	9.57	—	—		—	—	—	10.46	10.57	11.06	—		—
- Gottesauer Platz / BGV		—	8.47	8.58	9.06	—	—			—		10.05	—	9.47	9.58	—	—		—	—	—	10.47	10.58	11.07	—		—
- Durlacher Tor		—	8.49	9.00	9.08	—	—	9.23		—		10.07	—	9.49	10.00	—	—	10.23	—	—	—	10.49	11.00	11.09	—	11.23	—
- Kronenplatz (Kaiserstr.)		—	8.51	9.02	9.10	—	—	9.25		—		10.09	—	9.51	10.02	—	—	10.25	—	—	—	10.51	11.02	11.11	—	11.25	—
- Marktplatz (Kaiserstr.)		—	8.53	9.04	9.12	—	—			—		10.11	—	9.53	10.04	—	—		—	—	—	10.53	11.04	11.13	—		—
- Marktplatz (Pyramide)		—	8.54	9.05	9.13	—	—	9.27		—		10.12	—	9.54	10.05	—	—	10.27	—	—	—	10.54	11.05	11.14	—	11.27	—
- Ettlinger Tor		—	8.56	9.07	9.15	—	—	9.29		—		10.14	—	9.56	10.07	—	—	10.29	—	—	—	10.56	11.07	11.16	—	11.29	—
- Kongresszentrum		—	8.57	9.08	9.16	—	—	9.30		—		10.15	—	9.57	10.08	—	—	10.30	—	—	—	10.57	11.08	11.17	—	11.30	—
- Augartenstraße		—	8.58	9.09	9.17	—	—			—		10.16	—	9.58	10.09	—	—	—	—	—	—	10.58	11.09	11.18	—		—
- Poststraße		—	8.59	9.10	9.18	—	—			—		10.17	—	9.59	10.10	—	—	—	—	—	—	10.59	11.10	11.19	—		—
Karlsruhe Hbf		9.10	|	|	|	—	—	—		—	9.40	|	10.10	|	|	—	—	—	11.10	|	|	|	—	—	—	—
Karlsruhe Hbf Vorplatz			9.01	9.12	9.20	—	—	9.33		—	—	10.19		10.01	10.12	—	—	10.33	—			11.01	11.12	11.21	—	11.33	—
- Albtalbahnhof	an		9.03	9.14	9.22	—	—	9.35		—	—	10.21		10.03	10.14	—	—	10.35	—			11.03	11.14	11.23	—	11.35	—

Figure 8-21 Weekday timetable on Heilbronn – Karlsruhe today (daytime extract)



S4 (Öhringen - Eschenau - Weinsberg -) Heilbronn - Eppingen - Bretten - Karlsruhe - Durmersheim - Rastatt - Baden-Baden - Bühl - Achern

Samstags

ZUGGATTUNG	S	S	S	S	S	S	RE	S	S	RE	S	S	S	RE	S	S	S	S	E	RE	S	S	S	S	E	S
ZUGNUMMER	85122	85574	85130	88439	85396	88488	4701	85564	88443	5177	87932	85166	88452	5179	88453	85460	85568	85168	88455	4705	88457	87934	85400	88458	88460	85138
Öhringen Hbf ▼ ab	—	—	—	—	0.08	—	—	—	—	—	—	—	—	—	—	4.49	—	—	—	—	—	—	5.56	—	—	—
Eschenau (b. Heilbronn) ▼	—	—	—	—	0.19	—	—	—	—	—	—	—	—	—	—	5.04	—	—	—	—	—	—	6.11	—	—	—
Weinsberg ▼	—	—	—	—	0.31	—	—	—	—	—	—	—	—	—	—	5.19	—	—	—	—	—	—	6.25	—	—	—
Heilbronn Trappensee ▼	—	—	—	—	0.34	—	—	—	—	—	—	—	—	—	—	5.24	—	—	—	—	—	—	6.30	—	—	—
- Pfühlpark ▼	—	—	—	0.05	0.36	1.05	—	—	—	—	—	—	4.44	—	—	5.26	—	—	**5.44**	—	—	—	6.32	—	**6.44**	—
- Harmonie ▼	—	—	—	0.10	0.41	1.11	—	—	—	—	—	—	4.50	—	—	5.32	—	—	**5.50**	—	—	—	6.38	—	**6.50**	—
- Rathaus ▼	—	—	—	0.12	0.43	1.13	—	—	—	—	—	—	4.52	—	—	5.34	—	—	**5.52**	—	—	—	6.40	—	**6.52**	—
- Neckar Turm am K.-Schum.-Pl. ▼	—	—	—	0.14	0.45	1.14	—	—	—	—	—	—	4.53	—	—	5.35	—	—	**5.53**	—	—	—	6.41	—	**6.53**	—
- Hbf Bahnhofsvorplatz ▼	—	—	—	0.17	0.46	1.18	—	—	—	—	—	—	4.57	—	—	5.37	—	—	**5.57**	—	—	—	6.43	—	**6.57**	—
Böckingen Sonnenbrunnen ▼	—	—	—	0.19	—	1.19	—	—	—	—	—	—	4.58	—	—	—	—	—	**5.58**	—	—	—	—	—	**6.58**	—
- Berufsschulzentrum ▼	—	—	—	0.20	—	1.20	—	—	—	—	—	—	5.00	—	—	—	—	—	**6.00**	—	—	—	—	—	**7.00**	—
- West ▼	—	—	—	0.22	—	1.22	—	—	—	—	—	—	5.01	—	—	—	—	—	**6.01**	—	—	—	—	—	**7.01**	—
Leingarten Ost ▼	—	—	—	0.24	—	1.24	—	—	—	—	—	—	5.04	—	—	—	—	—	**6.04**	—	—	—	—	—	**7.04**	—
Leingarten ▼	—	—	—	0.26	—	1.25	—	—	—	—	—	—	5.05	—	—	—	—	—	**6.05**	—	—	—	—	—	**7.05**	—
Leingarten Mitte ▼	—	—	—	0.27	—	1.26	—	—	—	—	—	—	5.07	—	—	—	—	—	**6.07**	—	—	—	—	—	**7.07**	—
- West ▼	—	—	—	0.28	—	1.27	—	—	—	—	—	—	5.08	—	—	—	—	—	**6.08**	—	—	—	—	—	**7.08**	—
Schwaigern Ost ▼	—	—	—	0.31	—	1.30	—	—	—	—	—	—	5.10	—	—	—	—	—	**6.10**	—	—	—	—	—	**7.10**	—
Schwaigern (Württ.) ▼	—	—	—	0.34	—	1.31	—	—	—	—	—	—	5.13	—	—	—	—	—	**6.13**	—	—	—	—	—	**7.13**	—
Schwaigern West ▼	—	—	—	0.35	—	1.33	—	—	—	—	—	—	5.15	—	—	—	—	—	**6.15**	—	—	—	—	—	**7.15**	—
Stetten am Heuchelberg ▼	—	—	—	0.37	—	1.35	—	—	—	—	—	—	5.18	—	—	—	—	—	**6.18**	—	—	—	—	—	**7.18**	—
Gemmingen ▼	—	—	—	0.40	—	1.37	—	—	—	—	—	—	5.21	—	—	—	—	—	**6.21**	—	—	—	—	—	**7.21**	—
Gemmingen West ▼	—	—	—	0.41	—	1.38	—	—	—	—	—	—	5.23	—	—	—	—	—	**6.23**	—	—	—	—	—	**7.23**	—
Eppingen ● an	—	—	—	0.45	—	1.44	—	—	—	—	—	—	5.28	—	—	—	—	—	**6.28**	—	—	—	—	—	**7.28**	—
Eppingen ● ab	—	—	—	0.45	—	1.45	—	—	—	—	—	—	5.29	—	—	—	—	—	**6.29**	—	—	—	—	7.09	**7.29**	—
Eppingen West ●	—	—	—	0.47	—	1.46	—	—	—	—	—	—	5.30	—	—	—	—	—	**6.30**	—	—	—	—	7.10	**7.30**	—
Sulzfeld	—	—	—	0.51	—	1.51	—	—	—	—	—	—	5.35	—	—	—	—	—	**6.35**	—	—	—	—	7.15	**7.35**	—
Zaisenhausen	—	—	—	0.54	—	1.54	—	—	—	—	—	—	5.39	—	—	—	—	—	**6.39**	—	—	—	—	7.19	**7.39**	—
Flehingen	—	—	—	0.57	—	1.57	—	—	—	—	—	—	5.42	—	—	—	—	—	**6.42**	—	—	—	—	7.22	**7.42**	—
Oberderdingen-Flehingen	—	—	—	0.58	—	1.58	—	—	—	—	—	—	5.43	—	—	—	—	—	**6.43**	—	—	—	—	7.23	**7.43**	—
Bauerbach (Baden)	—	—	—	1.01	—	2.00	—	—	—	—	—	—	5.46	—	—	—	—	—	**6.46**	—	—	—	—	7.26	**7.46**	—
Gölshausen Industrie	—	—	—	1.03	—	2.03	—	—	—	—	—	—	5.48	—	—	—	—	—	**6.48**	—	—	—	—	7.29	**7.48**	—
Gölshausen	—	—	—	1.05	—	2.05	—	—	4.51	—	—	—	5.51	—	6.11	—	—	—	**6.51**	—	7.11	—	—	7.31	**7.51**	—
Bretten Kupferhäldle	—	—	—	1.06	—	2.06	—	—	4.52	—	—	—	5.52	—	6.12	—	—	—	**6.52**	—	7.12	—	—	7.32	**7.52**	—
- Schulzentrum	—	—	—	1.07	—	2.08	—	—	4.54	—	—	—	5.54	—	6.14	—	—	—	**6.54**	—	7.14	—	—	7.34	**7.54**	—
- Wannenweg	—	—	—	1.09	—	2.09	—	—	4.55	—	—	—	5.55	—	6.15	—	—	—	**6.55**	—	7.15	—	—	7.35	**7.55**	—
- Stadtmitte	—	—	—	1.10	—	2.10	—	—	4.56	—	—	—	5.56	—	6.16	—	—	—	**6.56**	—	7.16	—	—	7.36	**7.56**	—
Bretten Bf an	—	—	—	1.11	—	2.12	—	—	4.58	—	—	—	5.58	—	6.18	—	—	—	**6.58**	—	7.18	—	—	7.38	**7.58**	—
Bretten Bf ab	—	—	—	1.13	—	2.14	—	—	5.00	—	—	—	6.00	—	6.20	—	—	—	**7.00**	—	7.20	—	—	7.40	**8.00**	—
Rinklingen	—	—	—	1.15	—	2.16	—	—	5.02	—	—	—	6.02	—	6.22	—	—	—	—	—	7.22	—	—	7.42		—
Dürrenbüchig	—	—	—	1.17	—	2.18	—	—	5.04	—	—	—	6.04	—	6.24	—	—	—	—	—	7.24	—	—	7.44		—
Wössingen Ost	—	—	—	1.20	—	2.21	—	—	5.07	—	—	—	6.07	—	6.27	—	—	—	**7.05**	—	7.27	—	—	7.47	**8.05**	—
Wössingen	—	—	—	1.21	—	2.22	—	—	5.08	—	—	—	6.08	—	6.28	—	—	—	—	—	7.28	—	—	7.48		—
Jöhlingen	—	—	—	1.24	—	2.24	—	—	5.10	—	—	—	6.10	—	6.30	—	—	—	—	—	7.30	—	—	7.50		—
Jöhlingen West	—	—	—	1.25	—	2.26	—	—	5.11	—	—	—	6.11	—	6.31	—	—	—	**7.08**	—	7.31	—	—	7.52	**8.08**	—
Berghausen Hummelberg	—	—	—	1.28	—	2.30	—	—	5.15	—	—	—	6.15	—	6.35	—	—	—	—	—	7.35	—	—	7.55		—
Grötzingen Oberausstraße	—	—	—	1.30	—	2.32	—	—	5.17	—	—	—	6.17	—	6.37	—	—	—	—	—	7.37	—	—	7.57		—
Grötzingen (b KA)	—	—	—	1.32	—	2.33	—	—	5.19	—	—	—	6.19	—	6.39	—	—	—	—	—	7.39	—	—	7.59		—
Durlach Hubstraße	—	—	—	1.33	—	2.34	—	—	5.20	—	—	—	6.20	—	6.40	—	—	—	—	—	7.40	—	—	8.00		—
Karlsruhe-Durlach R	0.12	—	1.12	1.35	—	2.36	—	—	5.22	—	—	—	6.22	—	6.42	—	—	—	**7.17**	—	7.42	—	—	8.02	**8.17**	8.22
Karlsruhe Weinweg		—		1.37	—	2.38	—	—	5.24	—	—	—	6.24	—	6.44	—	—	—		—	7.44	—	—	8.04		
- Tullastraße / Verkehrsbetriebe		0.59		1.38	—	2.39	—	4.57	5.26	—	5.57	—	6.26	—	6.46	—	6.57	—		—	7.46	7.57	—	8.06		
- Gottesauer Platz / BGV		1.00		1.39	—	2.40	—	4.58	5.27	—	5.58	—	6.27	—	6.47	—	6.58	—		—	7.47	7.58	—	8.07		
- Durlacher Tor		1.02		1.41	—	2.42	—	5.00	5.29	—	6.00	—	6.29	—	6.49	—	7.00	—	**7.23**	—	7.49	8.00	—	8.09	**8.23**	
- Kronenplatz (Kaiserstr.)		1.04		1.43	—	2.44	—	5.02	5.31	—	6.02	—	6.31	—	6.51	—	7.02	—	**7.25**	—	7.51	8.02	—	8.11	**8.25**	
- Marktplatz (Kaiserstr.)		1.06		1.45	—	2.46	—	5.04	5.33	—	6.04	—	6.33	—	6.53	—	7.04	—		—	7.53	8.04	—	8.13		
- Marktplatz (Pyramide)		1.07		1.46	—	2.47	—	5.05	5.34	—	6.05	—	6.34	—	6.54	—	7.05	—	**7.27**	—	7.54	8.05	—	8.14	**8.27**	
- Ettlinger Tor		1.09		1.48	—	2.49	—	5.07	5.36	—	6.07	—	6.36	—	6.56	—	7.07	—	**7.29**	—	7.56	8.07	—	8.16	**8.29**	
- Kongresszentrum		1.10		1.49	—	2.50	—	5.08	5.37	—	6.08	—	6.37	—	6.57	—	7.08	—	**7.30**	—	7.57	8.08	—	8.17	**8.30**	
- Augartenstraße		1.11		1.50	—	2.51	—	5.09	5.38	—	6.09	—	6.38	—	6.58	—	7.09	—		—	7.58	8.09	—	8.18		
- Poststraße		1.12		1.51	—	2.52	—	5.10	5.39	—	6.10	—	6.39	—	6.59	—	7.10	—		—	7.59	8.10	—	8.19		
Karlsruhe Hbf	0.20		1.20		—		**5.00**			**6.08**		6.33		**7.04**		—		7.35		**8.10**			—			8.35
Karlsruhe Hbf Vorplatz		1.14		1.52	—	2.53		5.12	5.41		6.12		6.41		7.01	—	7.12		**7.33**		8.01	8.12	—	8.21	**8.33**	
- Albtalbahnhof an		1.16		1.53	—	2.54		5.14	5.43		6.14		6.43		7.03	—	7.14		**7.35**		8.03	8.14	—	8.23	**8.35**	
- Albtalbahnhof ab		1.18		—	—	—		5.16	—		6.16		—		—	—	7.16		—		—	8.16	—	—	—	

Figure 8-22 Weekend timetable on Heilbronn – Karlsruhe today (night time extract)

Today there are:

- Regular interval timetables (slight deviations may apply for some trains),
- Through service 7 days per week, 20 - 22 hours per day,
- Two trains per hour (one with all stops, one accelerated serving selected stops) as standard during day-time, hourly services at night time,
- One or two additional trains per hour in the vicinity of the two big towns at each end of the line (Heilbronn and Karlsruhe),
- Stopping-trains serve 49 intermediate stops (of which the majority is “on demand”) between Karlsruhe and Heilbronn central station with a travel-time of 104 minutes,
- Accelerated -trains serve 22 intermediate stops between Karlsruhe and Heilbronn central station with a travel-time of 86 minutes,
- Some complementary express-trains run the whole line within 58 minutes and only 3 intermediate stops.

Concerning bus services the schedules were adjusted to regular interval and also to allow minimal transfer times at intermediate stops to the TramTrains. Bus routes were arranged avoiding parallel routings to the TramTrain lines in favour of feeder services with increased frequency (at least hourly during weekdays and every two hours on the week-end) and operating hours.

For trips with low demand for public transport services, at least during off-peak hours complementary taxi or bus services exist, i.e. taxis serve fixed routings on request (to be ordered by phone at least 30 minutes before scheduled departure). These services can be used with all sorts of tickets plus a minor surcharge.

All these measures together caused a significant reduction of travel-time for passengers: not only by using vehicles with higher acceleration and speed, but also by decreasing pedestrian routes to access points and average waiting times. The extension of the operating times and the frequencies also means more convenience in using public transport.

8.4.6 Integrated Ticketing and Pricing

Based on the experience with the Albtalbahn in the 1960s a common tariff regime was implemented so that instead of separate tickets for buses in the countryside, the regional trains to the cities and for the urban transport systems, one ticket allows the use of all transport modes available. This common tariff is based on a zoning system, with a declining ticket price according to the number of zones passed. This principle applies for season tickets as well as for tickets for single trips. In addition 24-hour-tickets for one town and a neighbouring zone, the whole area and the whole areas plus extensions are available for one person and for small groups up to five people at discounted cost to compete best with private car usage for excursions, shopping, etc. Furthermore the railcard of Deutsche Bahn allows purchase of single tickets with a reduction 25%.

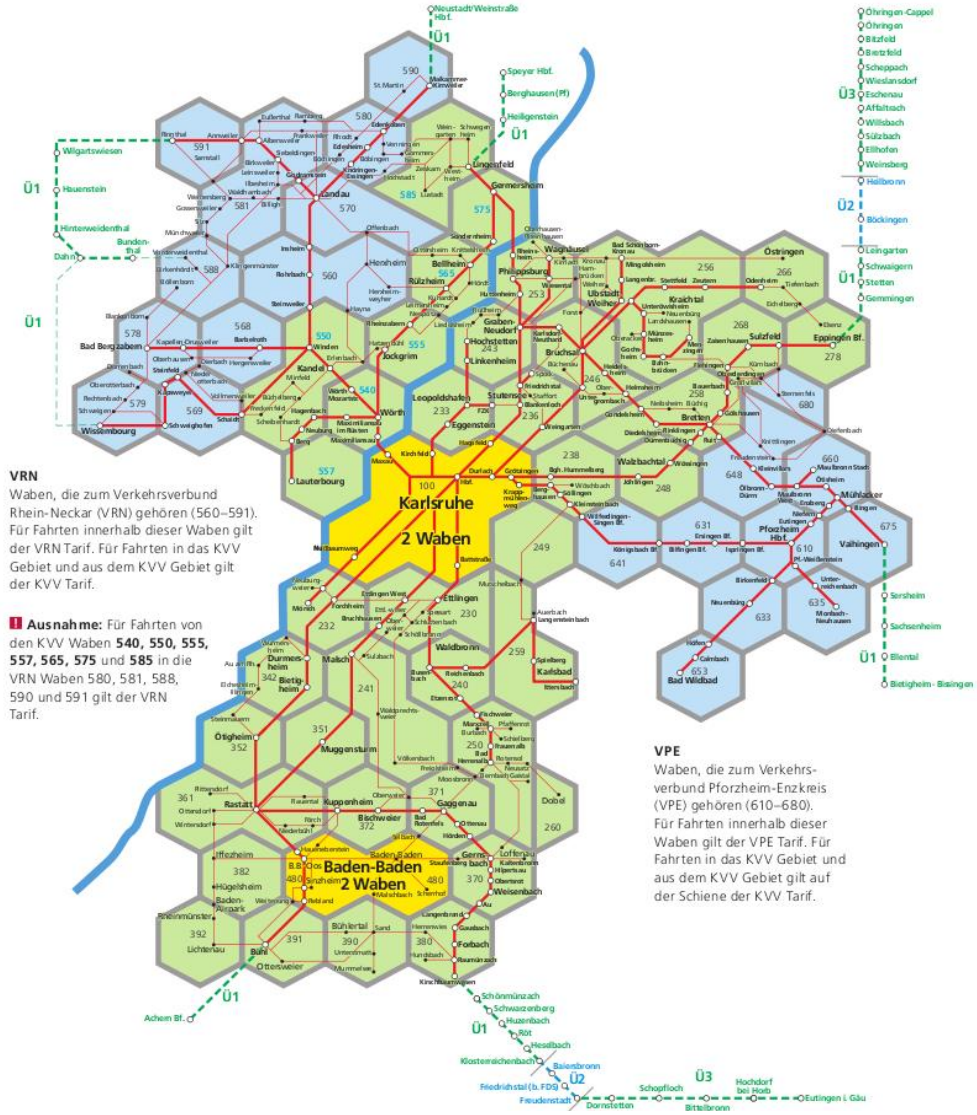


Figure 8-23 Zoning system for integrated ticketing

Figure 8-24 shows the types of available tickets and gives information how many trips were undertaken with them in 2003.

The development of tailored season tickets encouraged many people to switch from occasional usage of public transport to become regular customers; e.g. for trainees, students, pupils, elderly persons, month and year ticket for employees.

For nearly all trips where two modes where involved before the inauguration of TramTrains and the corresponding integrated ticketing, the costs per trip decreased. In this way mobility, especially for people with low income, has been improved.

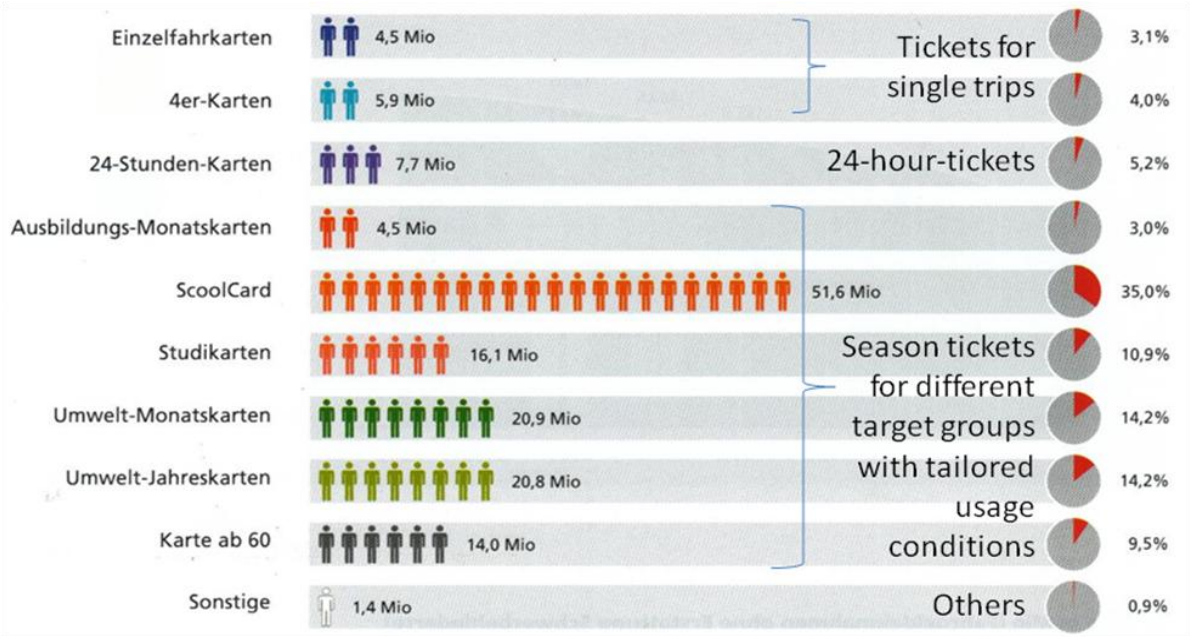


Figure 8-24 Ticket types and breakdown of usage

Tickets are sold:

- At staffed points of the of the regional transport authority
- In ticket offices of Deutsche Bahn at railway stations
- At ticket vending machines at stations
- At ticket vending machines in trams / TramTrains
- In buses by the driver
- At kiosks etc. by third partners

Nearly all different ticket types are available at all different points of sale allowing the customer freely to decide on the spot to make use of public transport

8.4.7 Consistent Travel Information across Modes

A printed timetable containing the schedules of all trains, TramTrains, tramways, buses and special services (night bus lines, on request services, ferries across River Rhine, rack railways, etc.) is available at all staffed points of sale for a nominal fee. Tariff information is covered, as well as the departure plans of long-distance trains from the bigger stations in the area. In addition pocket timetables covering just one distinct link are available freely.

Furthermore, a telephone information service covering all transport modes within the area is offered. And online schedule information between stations as well as between addresses or points of interest is available via the internet at http://www.kvv-efa.de/, and all printed timetables mentioned above are offered as downloadable puff-files for free.

Finally, schedule information is accessible by mobile phone, after sending from/to information by SMS.

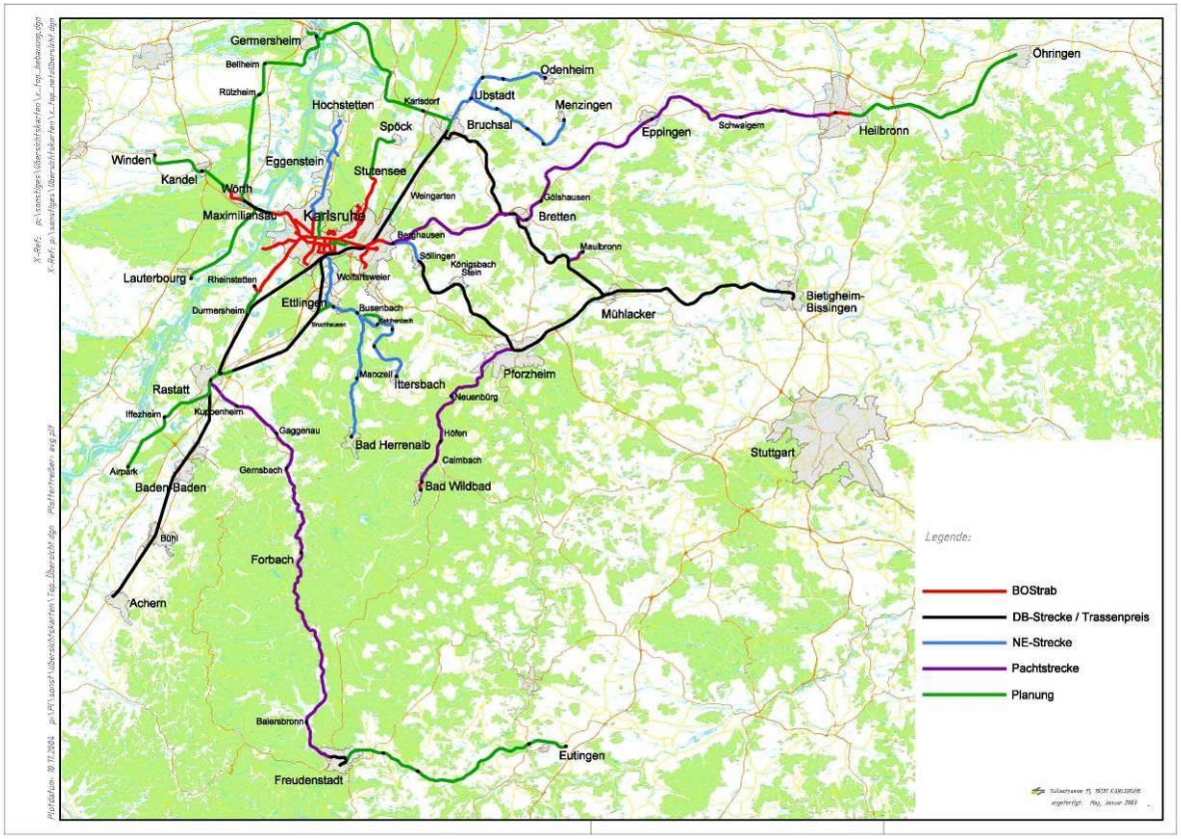
8.4.8 Legal and Organisational Arrangements

Multiple legal and organisational arrangements applied for the implementation of the TramTrain system.

As mentioned in sections 8.3 and 8.4.2 the technical provisions to run the TramTrain vehicles on tramway lines and classical heavy rail links had to be met.

Stakeholders involved: ownership of infrastructure

For the use of the infrastructure different solutions were found, according to the ownership of the distinct links. There are links owned by the Albtalbahn or the urban transportation services (Verkehrsbetriebe Karlsruhe, VBK) marked blue or red respectively on the map below, while other links are rented (violet) from Deutsche Bahn. For all these links the local transport authority is fully responsible for construction, upgrade and maintenance. The long term rental solution applies for links where Deutsche Bahn expects the line not to be used by trains other than TramTrains for regular services and where it has no interest in running freight services of its own. The advantage is that such lines neither have to be operated under the nationwide rules valid for Deutsche Bahn nor apply costly standards for construction in favour of the regulations for secondary lines run by third parties (NE-Bahnen).



(some of the lines marked green („planned“) are already in service or under construction)

Figure 8-25 Ownership structure of the TramTrain network

The last category of lines (marked black) is owned by Deutsche Bahn, i.e. these lines are used mostly by long-distance and/or freight trains and therefore fees apply for the use of these lines for each and every single ride of the TramTrains.

Stakeholders involved: the regional transport association

The organisation of the regional transport association ("Karlsruher Verkehrsverbund", KVV) is threefold:

- Towns and counties as shareholders are functional responsible of the
- Regional transport association ("Karlsruher Verkehrsverbund", KVV, which orders and co-ordinates the transport services from the:
  - Transport operators ("Betreiber") Deutsche Bahn (regional train division, regional bus divisions)
  - Enterprises belonging to the Federal State of Baden-Württemberg,
  - Enterprises under regime of the towns
  - Private (bus) operators

The following figure illustrates this organisational scheme.

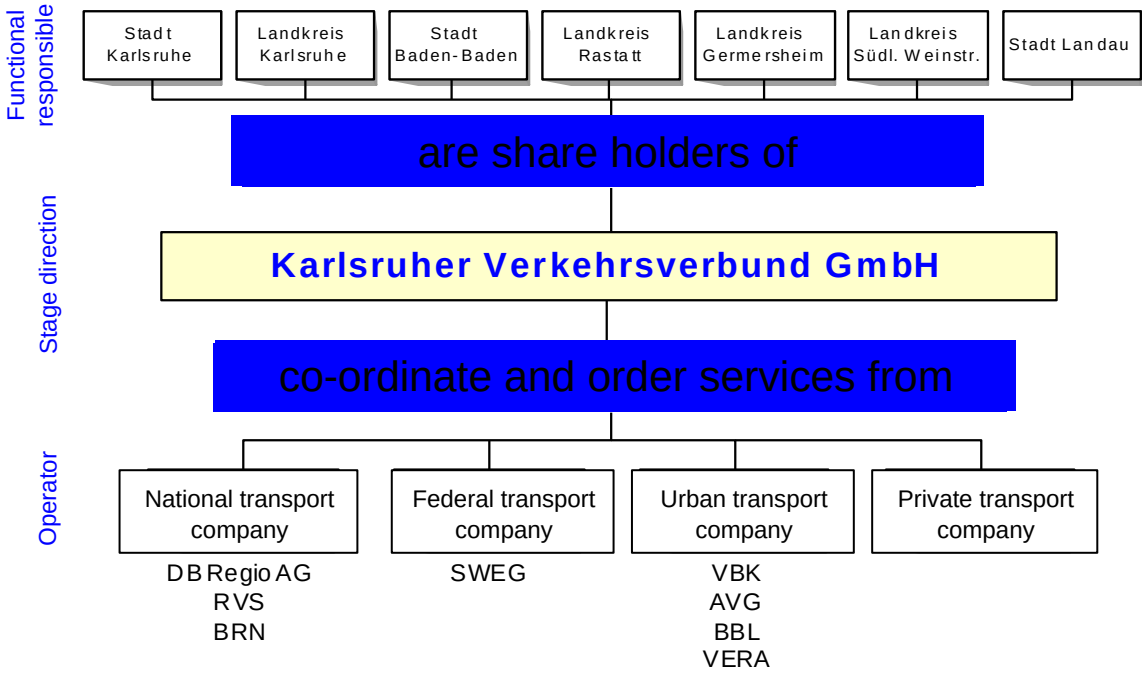


Figure 8-26 Organisational scheme of regional transport association (KVV)

Operators get paid for their transport services by the transport association, which is the tariff authority and receives all income from the ticket sales and gets the corresponding deficit financing from the stakeholders.

Stakeholders involved: Financing the infrastructure

The financing of the infrastructure (construction and upgrade of links, buying of vehicles) is based on the national law for financing communal traffic (Gemeindeverkehrsfinanzierungsgesetz, GVFG) http://bundesrecht.juris.de/gvfg/ (in German only). A total amount of € 844M per year is given from the national Ministry of Transport to the Federal States for financing public transport infrastructure following the principle of subsidiarity, i.e. the Federal States have to complement the national financing with their own funds. This fund must be used for financing regional infrastructure by 75% - 90%, while the missing 25% - 10% have to come from the communes. Furthermore a positive ratio from a standardised cost-benefit analysis must apply for each investment. For most of these investments the decision to fund is the responsibility of the Federal States.

8.4.9 Assessment Against Toolkit Criteria

Costs

The subsidiarity principle as mentioned in 8.4.8 (section "Stakeholders involved: Financing the infrastructure") enabled the regions and communes to implement the TramTrain system, which otherwise would have not been affordable for them. The following table shows line length and corresponding costs for selected projects. If not specially mentioned, the costs are for upgrade of existing lines. The costs for vehicles (see 8.4.2) are not included. They are borne by the operator of the TramTrains (AVG).

Table 8-1 Costs for TramTrain lines

Line	Length (km)	costs (mill. €)	Measures exceeding pure upgrade
Karlsruhe Hbf - Bretten	26	40	incl. electrification and connection to tramway network
Bretten - Eppingen	19	27,5	incl. electrification
Eppingen - Heilbronn-Harmonie	28	93,2	incl. electrification and 3 km new track in Heilbronn City
Heilbronn-Harmonie - Öhringen	26	97,9	incl. electrification and 2 km new track in Heilbronn and Öhringen
Karlsruhe Grötzingen - Pforzheim	24	35	incl. 5 km with 3rd track for TramTrain
Rastatt - Freudenstadt	83	100	incl. electrification
Pforzheim - Bad-Wildbad	25	27	incl. electrification and 2 km new track in Bad Wildbad
Freudenstadt - Eutingen	34	75	incl. electrification

The costs per kilometre vary significantly, depending on:

- the existing conditions of a link (good / bad condition of roadbed, track etc.)
- the density of stations to be upgraded / new built
- the ownership of the line (Deutsche Bahn / Albtalbahn)
- the usage profile of the line (exclusively TramTrains, mixed usage with freight / passenger trains)
- the geography and topography (e.g. number of tunnels or bridges on the line)
- the necessity of building additional tracks

Technical, organisational and political feasibility

The technical feasibility is given and proven every day by more than 100 TramTrains providing 13 million train kilometres per year. It has to be stated that the regional status quo situation implies which technical solutions have to be applied (see section 8.5, the examples of Kassel or Chemnitz) or if the introduction of a TramTrain system is prior instead of the implementation of classic heavy rail commuter lines or a bus system.

The organisational feasibility is proven as well. While the implementation of a regional transport association can be considered as relatively easy, as numerous examples for that exist in many countries all over the world, for the application of TramTrains for services on classic heavy rail lines a serious opposition from the Deutsche Bundesbahn in the early 1990s had to be overcome. With the reorganisation of this fully state owned monopoly company responsible for all aspects of train services and the rail infrastructure in 1994, accompanied by the instalment of a separated authority (Eisenbahnbundesamt) responsible for all legal aspects concerning rail transport and the appointment of authorities responsible for the regional rail transport in each distinct Federal State, these issues were much easier to handle.

The political feasibility has been proven as well, as these successful systems have been working since 1992. Nevertheless it has to be stated that the declared intention to implement such a system must exist in all political levels. The two towns of Baden-Baden and Rastatt, where the local policy neglected the chance of having a TramTrain directly to the city centres, although financial support from the Sate of Baden-Württemberg and the Federal Government has been available, can be mentioned as an example for that. The deep fear concerning the absorption of purchase power towards the city of Karlsruhe has been the driving factor in these towns for this decision, although the example of Bretten showed opposite effects. In the case of Baden-Baden it is believed that the financial burden caused by the instalment of the Festspielhaus (festival hall) did also influence the decision.

User acceptance and system take-up

The Karlsruhe – Bretten line was the first real tram-line with dual-voltage vehicles. The passenger figures on this line quadrupled within the first year and are today with 16.000 passengers per day eight times as high as before the inauguration of the new system.

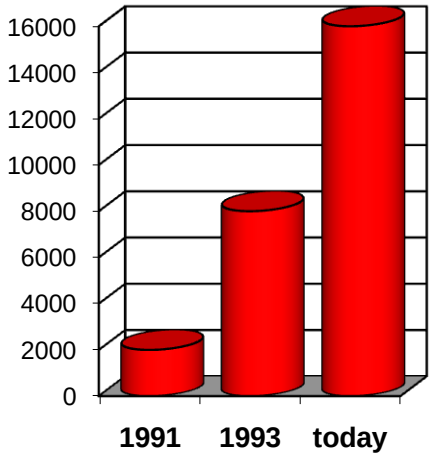


Figure 8-27 Development of passenger figures on the Karlsruhe – Bretten line

This success is based on the mode shift from other modes to TramTrain usage. The following figure illustrates the change in traveller behaviour.

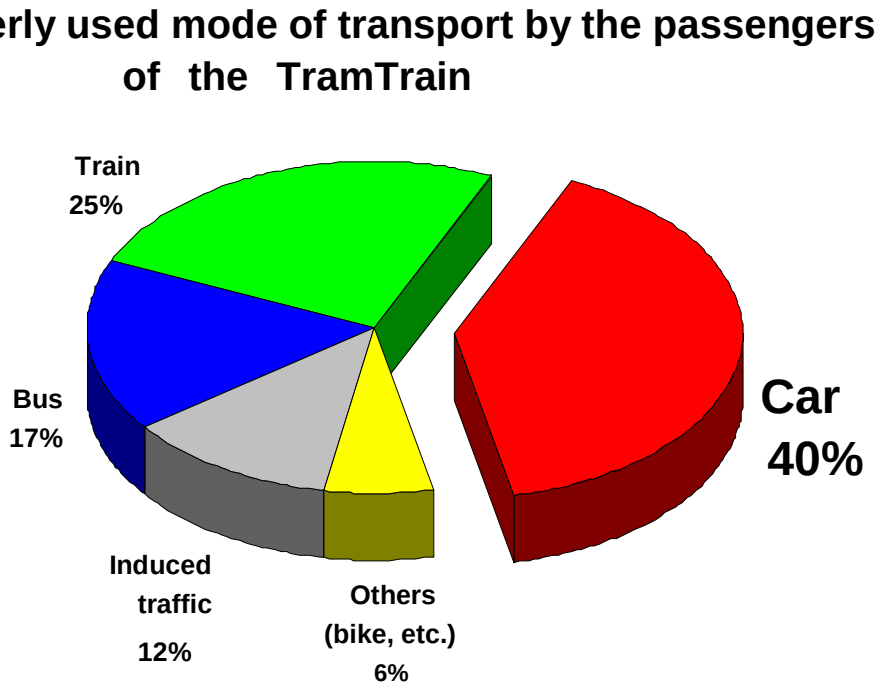


Figure 8-28 Change in mode transport by TramTrains

The majority of TramTrain riders used the car before (40%), while 32% were already public transport users. This high shift from private car usage shows the higher acceptance of rail systems over buses as a form of public transport. From existing bus lines in the Karlsruhe area it is known that passengers with car ownership only make 5% of the bus users, suggesting that the acceptability of the TramTrain system is eight times higher than using the bus for people who are not captive riders.

In a later stage the passenger figures of the line also changed because of the development in settlement and employment patterns which took place in the Bretten area:

- The number of inhabitants of Bretten increased by 17% from 24,000 to 28,000 in 1988 – 2004.
- The land prices rose between +50% in the city centre of Bretten (230 €/m^2) and +200% in the village of Bauerbach which is part of Bretten commune (120 €/m^2) from 1988 to 2004. “Close to TramTrain stop” has become a top selling point for real estate agents.
- The number of employees in Bretten rose by 28% to 11,000 within the same period of time, while the unemployment rate decreased from 20% down to 7%.
- The number of pupils in secondary schools increased by 92% to 2,800 and finally
- The total tax purchase power income (Steuerkaufkraftsumme) in the town of Bretten developed from below € 14 million in 1998 to € 25 million in 2004, of which the local business tax development formed the greatest part: (€ 4.8 million in 1998 -> € 14.1 million in 2004).

Similar effects have been observed for the mono-voltage line from Karlsruhe to Hochstetten which was inaugurated in the late 1980s.

The development caused by the TramTrain system exceeds just mode choice effects, as it furthermore increased the prosperity of a whole region.

Financial feasibility and overall development

The passenger figures on other lines which were upgraded to TramTrain services developed in a similar way to the Karlsruhe – Bretten line. The following figure shows the development of seven lines by pointing out the figures of daily passenger usage before and after the introduction of TramTrains.

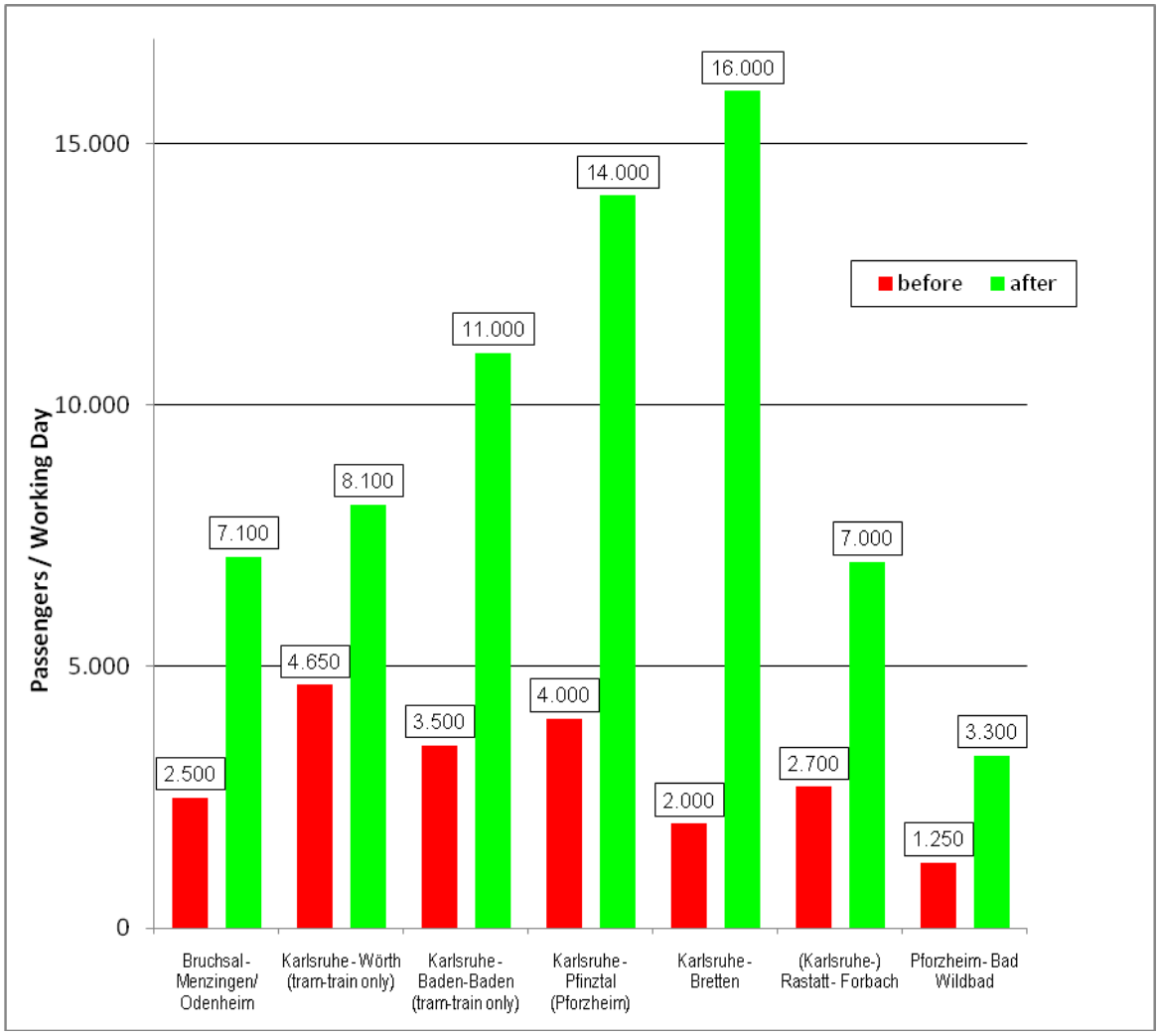


Figure 8-29 Development of passenger figures for selected TramTrain lines

The passenger shift in absolute figures varies between +2,050 on Pforzheim – Bad Wildbad, the line with the lowest basic figures and +14,000 on the very first TramTrain line to Bretten now operating for 18 years and showing a remarkable long term development. The Bad Wildbad line shows a remarkable detail: for the weekend the passenger figures raised from 550 to 2,350 (quadrupling of demand), i.e. the acceptance of this line especially for leisure trips (excursion to the Black Forest, shopping at Pforzheim, etc.) is very high.

The relative change varies between +74% on the line from Karlsruhe crossing the River Rhine towards Palatinate where two parallel trains per hour take the majority of demand and +700% on the Bretten line, where the long-term effects already mentioned apply.

A complementary picture is revealed by looking at the development of the total figures for public transport in the Karlsruhe area (the area covered by the regional transport organisation, KVV). For the first period from 1995 (102 million passengers) until the year 2000, when the majority of TramTrain lines were inaugurated, the numbers increased between 5% and 10% per year, reaching a total demand of 144 million in 2000. In the following period the numbers still rose by 1% to 3% per year, so that in 2009 the total demand was at 175 million passengers. These figures are based on passengers travelling within the area covered by the regional transport organisation; passengers using more than one mode of transport (e.g. feeder bus and TramTrain) for their trip are counted just once.

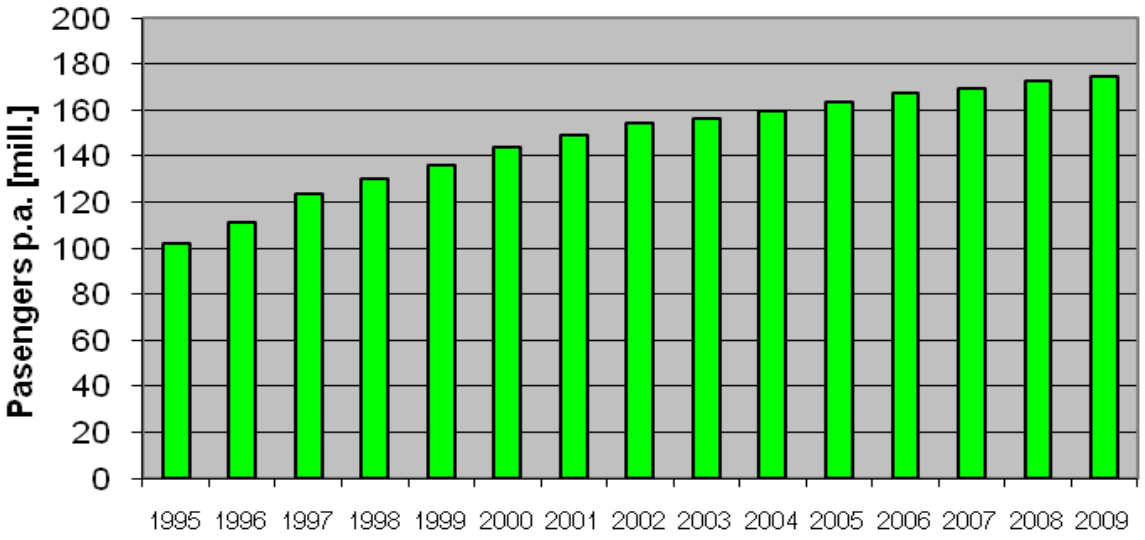


Figure 8-30 Development of total public transport demand in the Karlsruhe area

Achieving a mode shift from road transport and improving the development of the areas as benefits are one side of the positive assessment, which also includes less **congestion** (a reduction of traffic of 6% on the parallel class A road by 6% applied) on the regional road system and due to the limited growth in road transport a corresponding development concerning **green house gas emission**. But what is the picture concerning the deficit applying when offering such an innovative transport system?

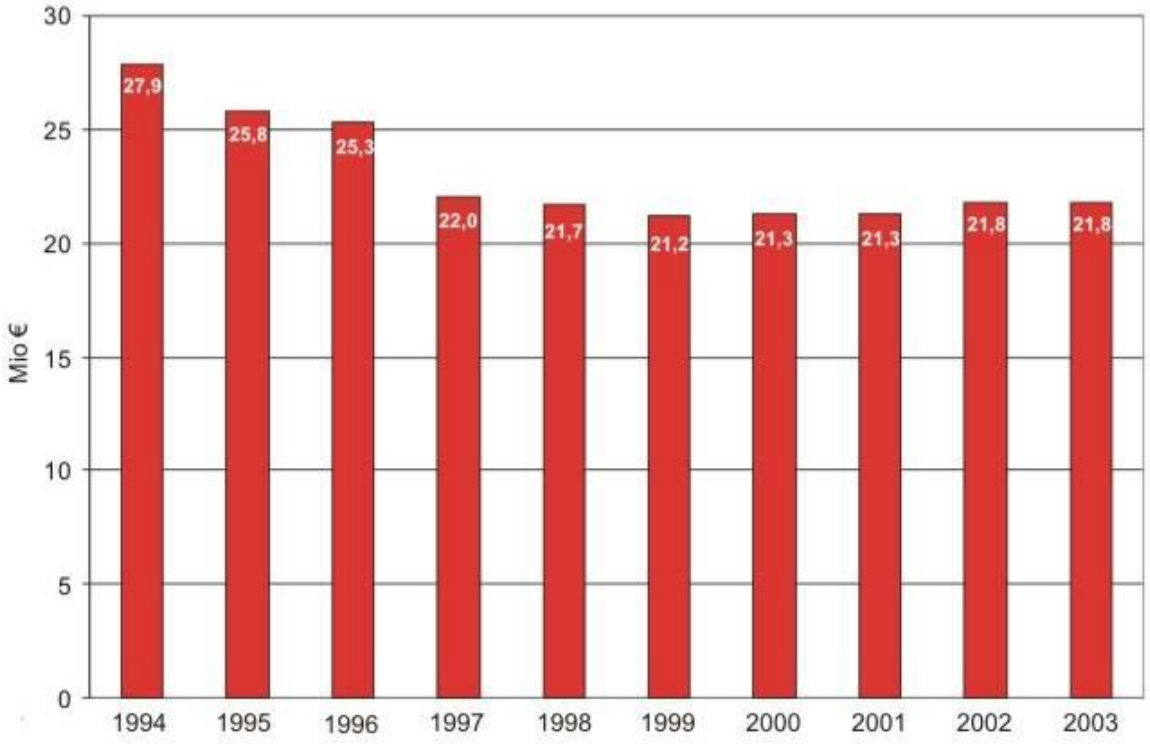


Figure 8-31 Deficit development of public transport in the Karlsruhe area

The figure above shows what has happened: Although the supply of public transport increased strongly, as did ticket sales, the implementation of the transport association brought significantly less revenues from all trips with different transport modes for which before more than one ticket was necessary. The reduction of the deficit from nearly € 28 million in 1994 to less than € 22 million in 2003 (and later years) means a decrease of more than 20%. When also taking into account the

increasing passenger figures this results in a trip specific deficit below 14 Cent/trip today, while this was at more than 25 Cent/trip in 1994.

Other Assessment Criteria

Impact on users' door to door travel time

As described above the improvement of services caused a significant reduction of travel-times.

Impact on users' door to door travel cost / Access for people with low incomes

As described above the common tariff regime implemented reduced the travel-costs for all trips, where more than one mode of transport is involved. The tariffs implemented especially improve mobility for people with low incomes.

Initial impact on comfort or convenience

All measures as described in section 8.4 and subsections led to a strong increase in convenience and comfort for the passenger.

Users' safety

As the user's safety is higher when travelling by public transport instead of private car etc. the mode shift applying with the introduction of TramTrains resulted in an increase in safety.

Personal security

Concerning this topic TramTrains bring an advantage over classical trains (see section 8.4.2, interior of a TramTrain).

Region's prestige

The overall success concerning transport mode change as well as positive financial figures especially in the long run made Karlsruhe a shining example of local public transport and this has increased the region's prestige and brought many visitors to the area to see the operation of the Karlsruhe Model.

Access for people with physical disabilities

The consequent implementation of barrier-free access to TramTrain vehicles accompanied by access to stations via level-crossing and tactile stripes on all platforms allows easy access for people with physical disabilities (see section 8.4.4).

8.5 TRANSFERABILITY OF SOLUTIONS

The situation in the Karlsruhe area is clearly an example of good practice. It is so successful that similar systems have been established in several other towns/areas not only in Germany, but also in other countries.

The usage of vehicles switching between originally separated networks of (urban) tramways and railway lines can be implemented in principal everywhere. It qualifies best for an application in medium sized areas, especially when the very centres of towns are not reachable directly by rail.

Many other cities have implemented rail-bound public transportation systems in the manner of the "Karlsruhe Model".

- The City of Saarbrücken (190,000 inhabitants in the city and 280,000 in the region) has the most advanced scheme. The implementation started in 1995, and the operation of the first route started in 1997. The project includes 15 km of newly constructed inner city tracks and the total investment is 540 million DM.

- In Heilbronn (122,000 inhabitants in the city and 415,000 in the region) there are limited new tracks but the light rail system gains access to approximately 220 km of regional heavy rail tracks. As the city is only 80 km from Karlsruhe, the plan has been to connect both networks in order to set up a direct connection from Karlsruhe to Heilbronn via Bretten.
- The City of Kassel (195,000 inhabitants in the city and 550,000 in the region) has started to operate a 3.5 km light rail track in the district of Baunatal which also uses the heavy rail track of the regional rail, the Kassel-Naumburger Eisenbahn. In Kassel a special solution is the use of four-rail tracks at stops to allow low-floor platforms outside heavy rail clearances.
- The City of Chemnitz (270,000 inhabitants and 600,000 in the region) will also use low-floor light rail vehicles with a power-pack for use on five non-electrified regional German Rail lines. The power pack system is a test case which could become a model for cities with a non-electrified regional rail network.

Cities in other parts of Europe also have an interest in the implementation of the "Karlsruhe Model". The map below documents the current development: green marks towns where such a system is running; blue spots identify cities where TramTrain systems are planned or under construction, while cities where a feasibility study has been executed are marked in red.

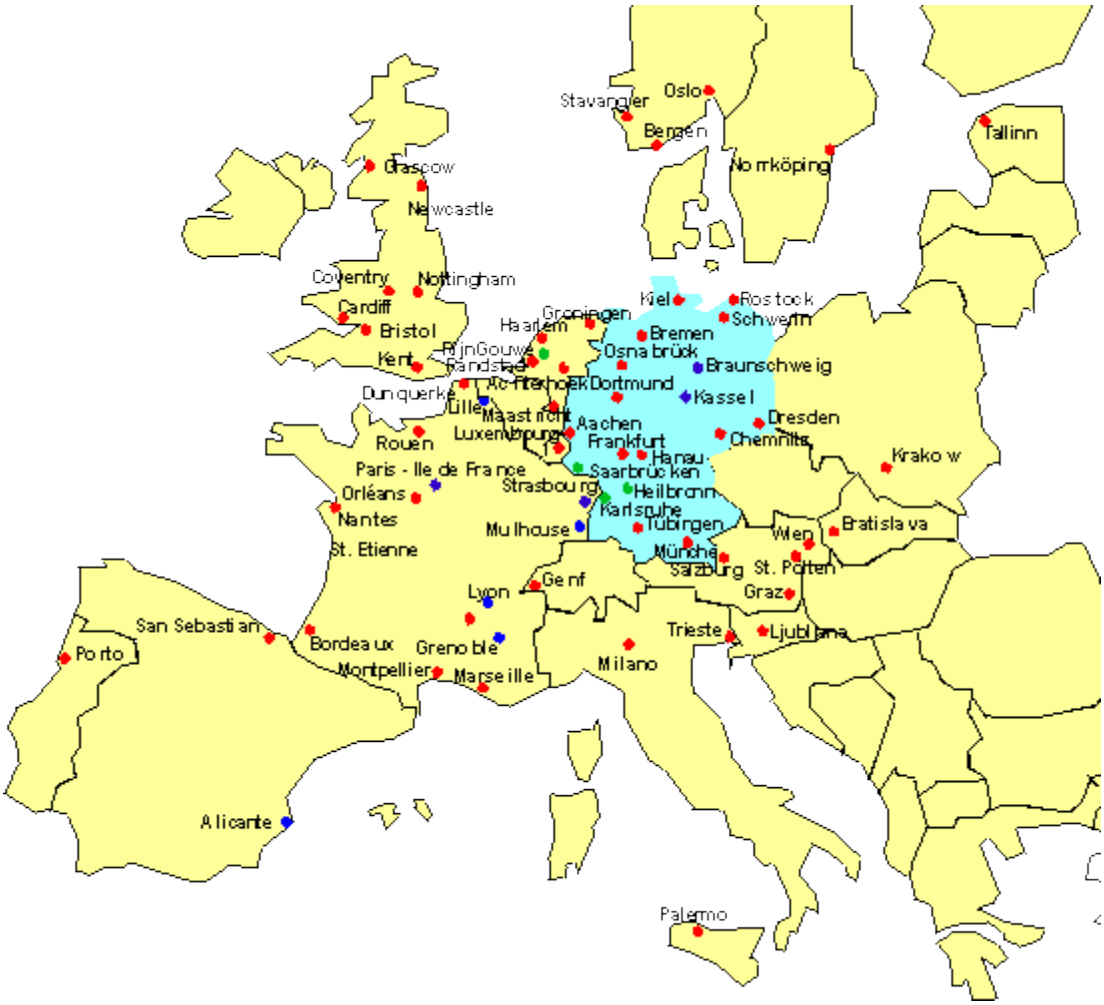


Figure 8-32 TramTrain systems in Europe

8.6 SUMMARY OF CONCLUSIONS

The dual-mode railway system of Karlsruhe is widely regarded as the model of a high-quality and well patronised local public transport system. It has earned the city the nickname ”The Mecca of local public transport.” The successful track-sharing experience of the various Karlsruhe rail systems has

revolutionised urban and regional public transport: Karlsruhe trams run on the urban light rail system and on the heavy rail tracks of the German Railways. The Karlsruhe model of a dual-mode railway system is an outstanding example of best practice for the following reasons:

- continuous extension of an environmentally compatible transport system from the urban area to the surrounding region,
- excellent facilitation of commuter movement between railway and tramway,
- a massive mode shift from individual to public transport,
- limitation of deficits for public transport spending,
- introduction of innovative technology,
- revitalisation of urban life in the city centre by supporting pedestrian districts,
- increased mobility for all social groups including disabled persons,
- higher attractiveness of the area through integrated high frequency public transport services,
- dissemination of expertise.