Light rail transit system of Karlsruhe

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1 Introduction

In congested urban areas problems caused by transportation have increased continuously for many years. This is evident due to the increasing noise and air pollution as well as an overloaded road network. To decrease the negative effect of road transport on the environment and to maintain the functionality of road networks, alternatives to the motorised individual are necessary. For these reasons the greatest emphasis is placed on regional public passenger transport, as the demands of the private car are more likely to be met by selectional service of public transport. The alternatives "on foot" and "bicycle" are of great importance for short distance travelling and for bringing passengers to public transport vehicles. Amongst the different regional transport systems, rail transport is at the centre of attention. When considering the amount of motorised individuals today, it is evident that a lot needs to be done to decrease them. As the financial situation of the public sector is very strained, solutions, obtained by reasonable effort and lasting improvements, must be found. A new solution has been found to combine urban and regional traffic so that the advantages of both systems are used. Light rail transit (LRT) vehicles coming from the regional areas use existing rail lines and are subsequently tied up with the urban traffic at existing junctions or junctions that have still to be developed. This enables the passenger to save time and reach the city without having to change vehicles.

This is a considerable solution as it provides a service improvement in public transport and a gain in market value, whilst the value of the private car is hard to recede. As a comparatively smaller financial burden is achieved, this is the solution for the future. This solution also meets the political demands of the communities and regions. Because it was developed for the city and region of Karlsruhe, it has been given the name "Karlsruhe Model".

In the following elaborations, the Karlsruhe Model is discussed shortly, whereas emphasis is placed on a description of the initial situation which applies to many other cities and regions. The main objective of the presentation is to give an insight view of potentials to combine urban and regional traffic by applying the Karlsruhe Model. The effects of this advanced solution will be assessed by travel

demand and costs. Lastly, the potentials from the political side and regionalisation will be discussed.

2 The Karlsruhe Model

The city Karlsruhe with its 280 000 inhabitants is the main centre for the middle upper Rhine region. More than often it is the rule that the railway stations of the DB lie far away from the city centre. Shuttling passengers between the regions and the city centre, specifically business people and students, are forced to change from the DB train to the LRT vehicle (figure 1). For the passenger this costs time, money and a loss in the quality of transport. To lure inhabitants of a region with an attractive public transport system, the service is gradually extended into the region. For a number of years city LRT vehicles are already travelling on the previous DB lines to Bad Herrenalb and Ittersbach in the south as well as to Linkenheim-Hochstetten in the north. On these lines the LRT vehicles fall under the Eisenbahn-Bau- und Betriebsordnung (EBO): a German act for railway construction and service. These lines were built up for the use of LRT vehicles as they had been closed to passenger transport of the DB and some of these lines were only occasionally used for goods transport. The advantage of not having to change vehicles at junctions between the region and the city of Karlsruhe brought forward the idea of using the DB lines for a city passenger service with a direct tie up to the city centre.

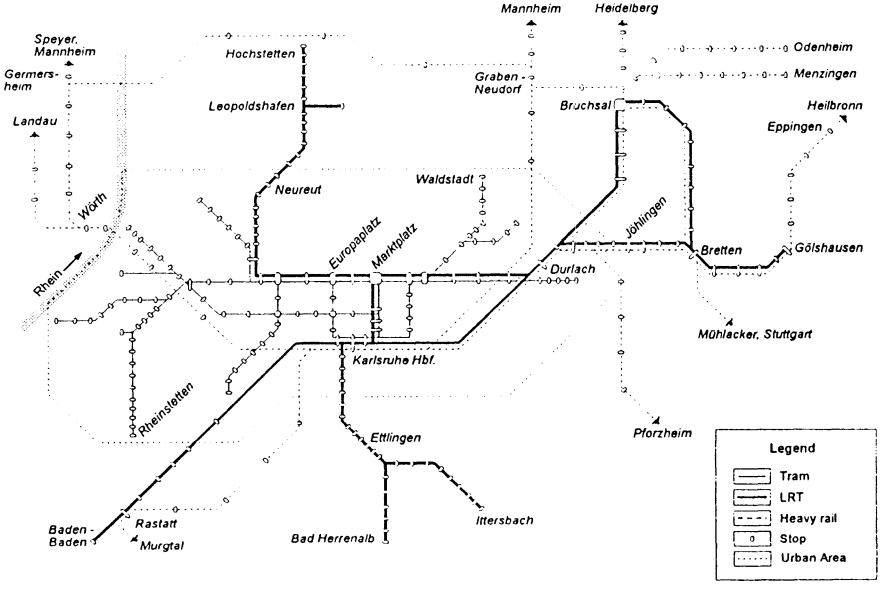

Figure 1: Public transport area of Karlsruhe

The initial situation was difficult to master as the demands of the DB service on DB lines and the LRT service on city lines had to be fulfilled. Demands of the passenger, the transport services and simply general demands are summarised in a catalogue of criteria as follows:

- The user would like to reach his destination quickly, comfortably and affordably.

- The passenger transport service would like cost-saving vehicles, a railway infrastructure and running methods that reduce fixed and variable costs as well as providing a good quality of service to improve its income.

- It is in everybody´s interest to get a functional transformation from car traffic to pollution-free transport methods as well as an economical public passenger transport system.

The biggest problem was finding a vehicle that could be used on the DB and LRT lines and that could use different energy systems. The LRT vehicle of Karlsruhe was transformed so that it could use the DB lines in the region (figure 2). Their outer appearance changed only slightly, but from a technical point of view they are a new development under the following aspects:

- The vehicle functions in the LRT (750 V Direct Current) as well as in the DB (15.000 V Alternating Current) electrical net.

- The wheel profile is a mix profile and allows for the use of switches on LRT and DB lines.

- The vehicle, in the contrary to the vehicles used in Karlsruhe until now, can now operate on a two directional basis.

Because the boarding height of platforms on DB lines differs considerably from that of the city centre, compromises had to be found.

In a test period the vehicle was put into DB service between the railways stations of Karlsruhe and Pforzheim during the autumn of 1992. A regular city service could be started after the tie up of the DB line, Karlsruhe-Bretten, with the LRT lines at the railway station Karlsruhe-Durlach had been constructed. The new LRT line S4 connects the city of Bretten to the main railway station of Karlsruhe in that when the city area is approached, a turn-off from the DB line is made and the LRT continues on LRT lines and reaches the Albtalbahnhof (A LRT stop in close proximity to the main railway station of Karlsruhe).

The LRT connection between Karlsruhe and Bretten fulfils only the first stage in the implementation of the "Karlsruhe Model". In the coming years further stages will follow:

- During the summer of 1994 a LRT service was started between the main railway station of Karlsruhe and the cities of Bruchsal and Rastatt as well as on the DB line between Bruchsal an Bretten.

- A LRT connection from Pforzheim through the city centre of Karlsruhe is planned in the next two years.

- During this same period a new LRT line will be started between Wörth and Karlsruhe. In the city district of Knielingen a tie up will be made with the LRT net.

Figure 2: Bimodal LRT vehicle of Karlsruhe

3 Effects of the Karlsruhe Model

The LRT lines have become very popular and all the new LRT lines have experienced a considerable increase in passenger numbers. This development is due to a number of measures that were implemented simultaneously:
The not having to change vehicles, the reduction in travelling time and the modern look of the vehicles play a role. A uniform fare system was developed that in most cases made travelling cheaper for the passenger. In the outlying regions a tie up by bus was made with the LRT stops as well as providing parking facilities for bicycles and cars at these stops. A concentrated timetable was introduced for daytimes and an extension was made to after midnight.

To illustrate the effects which come with the implementation of the Karlsruhe Model, the Karlsruhe-Bretten line is taken as an example here.

Constructional changes
The city line Karlsruhe-Bretten runs from the main station of Karlsruhe on LRT lines through the city centre (pedestrian zone) and is tied up with the DB lines at the station of Durlach. In order to achieve the tie up a ramp was necessary at the station. There it is possible to change to the long distance trains of the DB on the same platform. To continue in the direction of Bretten, the LRT line runs over the DB railway line that heads for Heidelberg on bridges built for this purpose and turns into the DB line to Bretten. The main constructional changes that took place were the tie up at the Durlach station and the building of a new 2.4 km connecting line. In addition to these, 7 new stops were constructed so that more areas could benefit from the line.

Servicing program
A considerable change in the services offered results from the dual system. The following table shows important numbers:

Table 1: Time Table Change

	before	after
Amount of trains per workday and direction	19	38
- of the DB direct service to the main station	19	9
- of the LRT service to the city centre	0	29
Rhythmic timetable	no	yes
Start of last trip in Karlsruhe on workdays	8:00 p.m.	0:53 a.m.
Start of last trip in Karlsruhe on weekend	8:00 p.m.	1:53 a.m.

Fares

With the introduction of the LRT line to Bretten, the regional fare system was applied to it. This means that the trains of the DB and the LRT vehicles could be used with one single ticket. Furthermore, this ticket enables the user to change vehicles as often as he/she likes as well as to use the connecting bus lines.

Table 2: Fare Change

	before	after
Monthly ticket Bretten-Karlsruhe/City Centre	200 DM	105 DM
Regio ticket (2 adults, 2 children) for 24 hours	---	12 DM

Demand

The implementation of the LRT service on the Bretten line led to extensive changes in demands. This is primarily due to changes in the selection of transport means offered.

Table 3: Demand Change

	before	after	today
Number of passengers per workday	2200	7500	10 340
- of the DB service	2200		1840
- of the LRT service	0		8500

Costs

Investment in the constructional changes amounted to 80 million DM. Service costs are made up of costs attributed to the vehicles (depreciation, servicing, energy), staff and track usage. The variable costs per kilometre are about 12 DM for the LRT vehicle (in double traction), 18 DM for the Light Rail Vehicle of the DB and 25 DM for the electric or diesel units of the DB. At least 80% of the costs are covered. At the moment a loss of 700.000 DM per year is made.

4 Investigations in other regional transport areas

LRT systems are presently experiencing a global renaissance. It should however be noted that the new LRT systems have little in common with the conventional systems of the past. The vehicles, the carefully designed transport facilities and the study of traffic flows offer a far more attractive alternative. The direct tie up of a LRT system with the DB is however not appropriate for all cities. Because there is a lack of experience in this field and because conditions in the area may be unsuitable, the decision of how and in which combination regional

traffic is to be financed, must be done individually. Competitive systems must be compared critically, as for example the tram system and the regional main line system.

Previous experience has shown that investment in the successful implementation of a Karlsruhe Model on a city should be justified. Sometimes a transport system for bigger masses, like the S-Bahn in Germany or rapid transit in the UK is a more efficient alternative. Furthermore, the existence of infrastructure with expansion possibilities and financing are necessary.

The principle initial situation of the region Karlsruhe can be found in many other urban areas. For this reason, the VCK, which is a subsidiary of the Karlsruhe transport services, is active throughout Germany and also internationally.

Cities and regional areas, that are considering the tie up of a LRT system with main lines are Saarbrücken and Aachen (cross border services), Heilbronn, Ulm, Wiesbaden, Osnabrück, Rostock, Halle and Dessau in Germany, Graz and St. Pölten in Austria, Ljubljana in Slovenia, Kent in the UK and L'Ile de France. In many of these cities the old tramway system had been shut down and now an introduction of the old system into the new LRT system is being considered.

5 Transference by taking into consideration regionalisation

Regionalisation of rail passenger transport will bring considerable changes into the structure of public transport. Regionalisation means that authorities in the fields of planning, organisation and finance will be passed from a national level to the federal states and districts. Apart from road and LRT services, the regional passenger rail transport is almost completely in the hands of the Deutsche Bahn AG (DB). Only in a few cases the federal states or districts have authority. Examples here are the regional railways of the federal state of Baden-Württemberg (AVG, SWEG, HZL, WEG) and also the district railway of Düren.

Furthermore, regionalisation means that communities and regional districts express their wishes at a regional transport service.

Regionalisation offers big changes for a customer friendly and economical functioning of regional traffic, but may also contain unforeseen risks. The service that the DB offers for regional traffic today is only indirectly influenced by communities and districts. This is achieved by holding time table conferences regularly at which

representatives for the respective regions are present. However, the final design for services to be offered, for all components (rail line network, time table, vehicle, stops, etc.), lies in the hands of the DB. It must also be mentioned that the end product is not paid for by the communities and regional districts.

Because local and regional authorities only have a slight influence in deciding which services should be offered, the result is a lack of interest for collaborating work. The lack of financial support is also a reason. Only with the start of proceedings for the closing down of a rail line, regional authorities were made aware of their responsibilities in their area. The DB is primarily interested in feeder traffic to the main lines and local and regional needs have only secondary priority.

Regionalisation gets the regional authorities involved in the design for services to be offered. They are also interested in doing this economically. A positive aspect is that conflicts in the politics of transport are discussed in the respective area.

Dangers may also come with regionalisation. The new person in authority must develop structures to avoid these. They must also make sure that capital is used efficiently for regional passenger rail transport. The balancing of this capital will be problematic on the credit as well on the debit side of the balance sheet. It must also be noted that DB enterprises have a uniform fare structure and passenger information which can be put to good use. The big variety in service and information structures for busses and deregulation in Great Britain are an excellent example.

Regionalisation should therefore be implemented very carefully so that institutions of authority, users and operators achieve optimum results.