

Making Regional Railroads More Attractive— Research Studies in Germany and Patronage Characteristics

*Dietmar Bosserhoff,
Hessian Office for Roads and Transportation, Germany*

Abstract

This article summarizes current research on regional rail passenger service in Germany. The aim of the research was to help rail operators, municipalities along the rail lines, and transportation planners identify the most effective strategies for improving rail service and patronage. The article outlines study contents and purpose and then summarizes the most important study findings. It also presents action and research recommendations. In addition, current rail developments in Germany and methods for increasing patronage and reducing costs with special focus on the separation of infrastructure and operations are described. Finally, patronage data for different rail segments are compared to help determine whether improvement measures should be applied and what impacts they could have on patronage.

Introduction

In 1994, competition was introduced into railway operation in Germany. The former national railway (Deutsche Bundesbahn) was separated into the Deutsche Bahn (DB) network company (DB Netz), which operates the tracks; DB Station&Service, which operates the stations; and three other DB companies,

which operate the trains on the DB Netz network (long-distance trains, regional trains, and freight trains). DB Regio is the company that operates regional trains. Among the main aims of the strategy were to enable private railway companies to use the national railway network, to create a better railway service by competition, and to reduce costs for railway service. Complementary former federal subsidies to the national railway company for operating deficit-producing regional lines were diverted to the regional authorities. The regional authorities were allowed to decide for themselves what to do with the money (e.g., improve railway service, maintain service, replace railway lines by bus service, or even reopen railway lines). Federal funding (collected from gasoline taxes) is possible to facilitate infrastructure measures (e.g., building new stops, track improvement, building new lines, or introducing new vehicles). The result of these changes was better train service with less operating costs on many regional and rural passenger lines.

This article summarizes the results of 12 recently completed research studies on regional passenger rail operations in Germany. The first part of the article outlines the main focus and results of each research study examined. The research is divided into three sections: studies financed by the German Ministry of Transport, studies financed by the German Ministry of Research, and important third-party research. The second part summarizes the most important findings of all the studies, proposes needed actions, and describes areas for additional research. The last part compares the results of passenger demand surveys of different types of regional rail segments. The article is based on a lecture on behalf of the German Ministry of Transport at the Railway Transportation in the Region conference (Bosserhoff 2004a) and two publications about regional rail transit (Bosserhoff 2003; 2005).

Research Funded by the Federal Ministry of Transport

Study 1: Standardized Evaluation of Public Transportation System Investments and Calculation of Subsequent Costs (Intraplan and University of Stuttgart 2000)

In Germany, federal funding for public transportation system investments is granted only if a standardized procedure of evaluation of the investment shows that the overall benefits of the project exceed its costs. The principal purposes of Study 1 were to update the existing procedure of the evaluation, to extend the appraisal procedure developed for rail segments in urban centers to regional rail segments, and to adapt the passenger demand model accordingly. Ten example railway segments from throughout Germany served as a basis for the adjustment.

On two segments, urban rail vehicles operate over streets in the city center and on existing general rail infrastructure outside the city (tram-train system). This concept was first introduced by the German city of Karlsruhe (Figures 1 and 2). The studies considered in this article underscore the fact that tram-train service induces a high patronage increase because of fast connections from the region into the city center without having to transfer between systems.



Source: Karlsruher Verkehrsverbund 2005.

Figure 1. Light Rail Vehicle and Intercity Express Train on Heavy Rail Infrastructure

The main results regarding regional rail were:

- Patronage increases are generally the result of several different variables. It is difficult to isolate the impacts of single variables.
- No specific mathematical relationship could be developed between the particular improvements and increased patronage based on the segments investigated in the study.



Figure 2. Light Rail Vehicle on Local Road Close to Housing Areas

Nevertheless, to obtain “comparable evaluation results” for different investment projects, a pragmatic formula based on the difference in travel time between car and rail, number of transfers necessary, number of trains per day, and comfort (vehicles, stops) was developed for estimating the increased patronage. This formula was calibrated using data from the segments investigated.

Study 2: Impact of Improvement Measures on Regional Rail Patronage (Bosserhoff et al. 2003)

The principal goal of Study 2 was to examine in detail the impact of improvement measures on regional rail patronage to determine whether a mathematical formula can be derived for the estimation of these impacts and to provide business recommendations for helping local authorities or rail service operators determine when an improvement is sensible and therefore justified. Additionally, the study identified the costs of regional rail passenger and freight transportation improvement measures.

The study considered 20 railway segments from throughout Germany, two of which had tram-train linkages. This study had the largest sample size of all those mentioned in this article. All types of improvement measures (integration of

transportation and land-use planning, railway service, railway infrastructure, customer comfort, security, fares, and marketing) were considered. The study determined the extent of improvement measures for each segment investigated and the extent of missing measures. As a result it was possible to identify the connection between improvement measures and patronage impact for each segment. Figure 3 presents an example of a regional railway near Frankfurt.

The study's most important results were (Bosserhoff 2003):

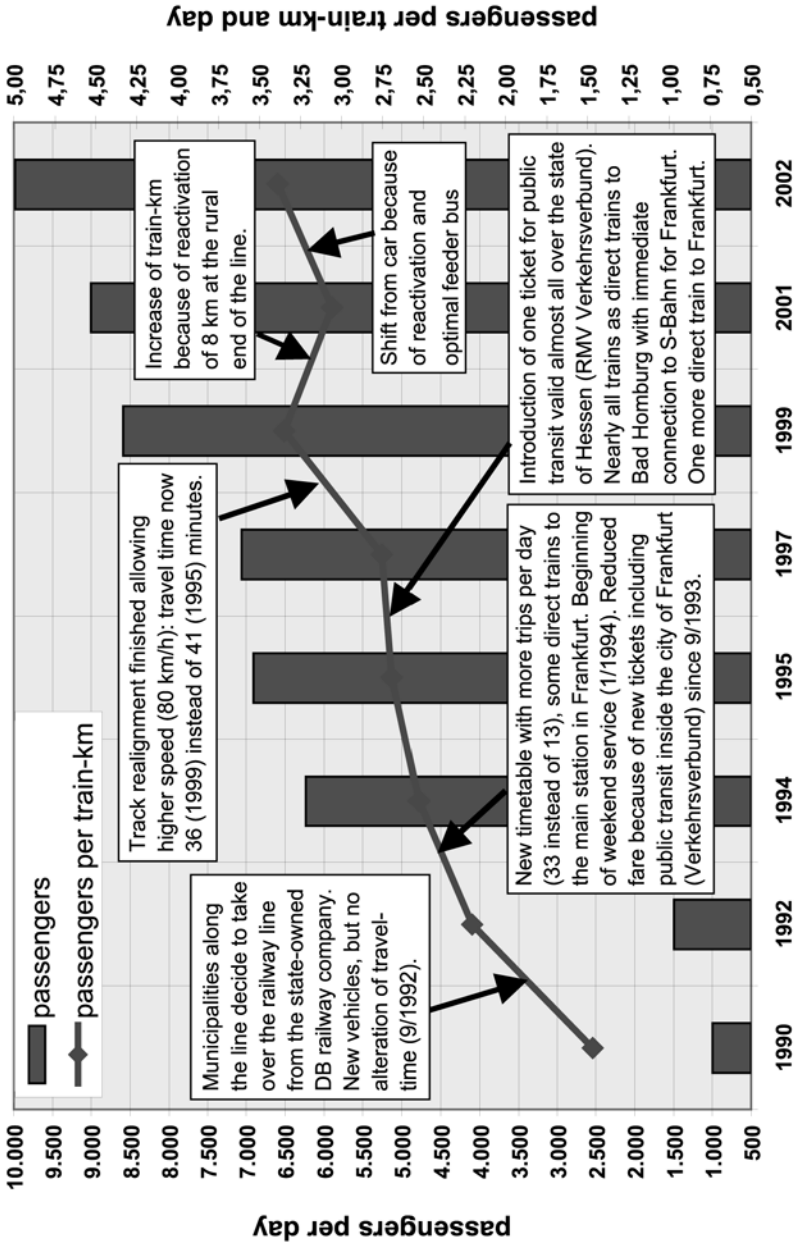
- Much time is needed to make patronage data from different segments comparable because there is no uniform data collection procedure.
- A mathematical formula could not be derived between improvement measures and their patronage impact because, among other reasons, the local conditions (e.g., the amount of transit service operated) and the level of improvement measure implementation are crucial.
- Patronage increases are generally the result of several different improvement measures; implementing sets of improvement measures cause the largest patronage increase.
- A long-term view of an improvement measure's patronage impact is necessary.
- In the long-term patronage increases are almost always at least proportional to the increase in service (e.g., train-km).
- The highest values for the measure "persons boarding per train-kilometer" are achieved with tram-train linkages.

The study developed a pragmatic procedure that allows users to estimate the patronage impact of improving a segment by comparing the proposed improvement to results found on the segments considered in the study. A checklist was prepared to help evaluate a potential improvement measure (measure selection, patronage effect, costs, etc.). The criteria used are the competitive situation with respect to automobiles (WCO), potential land-use development, comfort/security, marketing/ information, and investment/costs.

Study 3: Integration of Regional Railway Lines into the Regional Public Transportation System with Special Consideration of Effective Operation (Planungsbüro für Verkehr and KMPG Consulting 2003)

Study 3 examined the integration of regional rail networks into the regional transit system and developed a manual with practical examples for improving regional

Figure 3. Connection between Improvement Measures and Patronage (Passengers Boarding and Alighting per Day: Monday–Friday).



railway service. The possibilities and limits of increasing the attractiveness of regional rail segments and the regional-specific as well as the transferable basic conditions and success factors were identified.

The study examined six railway segments in Germany. Its main findings were:

- Impacts on different segments were not always comparable because different data were available.
- Patronage increases often exceeded the increase in demand projected before implementation of the improvement measures.
- Local municipalities must be committed to the regional rail system for it to be successful.
- Bus lines must be integrated into the concepts and should not compete with the rail lines.

The study identified success factors for improving the attractiveness of regional rail transportation on basis of the evaluations and prepared an action catalog with the topics organization, conception, infrastructure, economy, and other. The result is a manual for local decision makers, planners, and interested citizens (Johannsmeier and Markgraf 2003).

Study 4: Development of Land Use Based on Railway Lines (Planungsgemeinschaft Theine et al. 2003)

The principal purpose of Study 4 was to examine whether current public transportation land-use planning techniques (designed to promote development along one of the regional rail corridors) are sufficient and what additional strategies (incentives, promotions) are necessary to improve coordination. The study also determined positive and negative factors in the linking of land-use and public transportation planning, measured the patronage effects of improvements at railway stations, and evaluated the developed strategies and measures in terms of their implementation practicability.

The study examined six examples and the strategies were tested using railway stations on a segment near Bremen. The results were:

- Settlement development patterns must be coordinated with station orientation.
- Short station access times are particularly effective for high patronage.

- A new planning and implementation instrument called the “station-oriented outline plan” is recommended in addition to the general zoning plan.
- The study identified and described components for this outline plan including station functions, location appreciation, and neighborhood/city linkages.

Study 5: Model Project of Area Planning: Regional Railway Lines (SCI Verkehr 2004)

This project consisted of a two-phase research study on land-use and regional railway planning. The first phase outlines possible solutions for maintaining the operation and increasing the efficiency of passenger and freight transportation on secondary rail segments. It also identifies success factors and obstacles for increasing rail transportation. Finally, it provides a list of action recommendations needed for sustainable transportation development. In contrast to the other studies, the goal of phase two was to implement and test, working with regional participants, the land use-planning conceptual measures identified in the first phase in two different rural regions.

The main results of this study are action recommendations in the areas of sustainability and stabilization of passenger and freight transportation on regional rail segments. The study identified the following factors for success:

- The larger the amount of floor space oriented to the rail line and/or of trade areas with track connections the better.
- Bus transportation must be integrated into the concepts and competition with rail avoided.
- Local governments must be committed to regional rail service and provide financial support.
- It is difficult to finance rail infrastructure without regular passenger rail service.

Specific recommendations were given for optimizing rail transportation for both example regions and suggestions were made for implementing these recommendations. However, these met differing success. While service improvements succeeded in increasing passenger patronage and freight transportation on one segment, passenger service was discontinued on parts of the other segment in 2004.

Study 6: Strategies for Developing the Market Potential of Railways (Universities of Karlsruhe, Kassel and Stuttgart 2004)

The goal of Study 6 was to describe strategies for developing the market potential of railways and conditions for their success. The study considered a regional railway in a tourist region and a diesel regional railway extended on tramway tracks to the city center.

The study results regarding passenger transportation were:

- In Germany, the strongest market potential for rail service is for region-connecting (interregional) rail passenger transportation (i.e., travel distance of 50-150 km) and for intraregional rail service.
- Regional rail in rural areas and tram-train linkages have an important supplementary function for interregional transportation.
- The rail share for these market segments can be increased by implementing appropriate improvement measures.

The research also describes success factors for the two regional rail market segments as well as concepts and recommendations for political action and for actions by service operators.

Research Funded by the Federal Ministry of Research

Study 7: Optimizing Regional Rail System Operations and Infrastructure in the Transition from Urban Centers to the Region (Fachhochschule Gelsenkirchen 2003)

Study 7 analyzed regional rail improvement measures accomplished since 1994 and examined them for additional potential and mutual combinability. The study also identified further possibilities for increasing patronage and reducing costs in regional rail operations and made action recommendations. Three example segments were closely examined, one from each of the three types of regional rail operation: “general railway standard” (operated by the federally owned DB Netz network company), “branch line standard” (operated by private railway companies), and “urban rail service” (electric tram-train service).

The research study points out that a very broad spectrum of measures has been completed throughout Germany to improve regional rail segments. These measures can be grouped into four main categories: track, vehicle, organization, and

rail service, as well as land–use development/planning. The majority of these measures can be combined. The study identifies possibilities for optimization and cost reduction in each of the four categories. Substantial cost reduction potential exists in the track category. Performing construction and maintenance work to branch-line standards can save slightly more than 50 percent of the costs compared with the same work performed under the general railway standards. In the organization and rail service category, the study recommends promotion of competition, with all railway infrastructure and rail service separated completely from the publicly owned infrastructure (segments with long-distance transportation should be controlled by the federal government, while segments with predominantly regional service should be controlled by the state or region). Transportation services should be awarded via competition. The study also identifies obstacles for the optimization (e.g., no real separation of infrastructure and rail service by the DB railway company) and suboptimal funding methods.

Study 8: Bahn.Ville—Railway-Based Land-Use Development and Modal Interchange (ISB Hochschule Aachen et al. 2005)

Study 8 is a joint French-German project that examined the interaction between land use and transportation as well as the coordination processes and organizational aspects. The study considered a series of case study examples from German and French regions.

The project used the case studies to examine the ideas, strategies, and potential for integrated land-use and transportation planning to reduce sprawl-type urbanization. The objective was to determine the pros and cons of the example strategies, as well as their benefits in relation to the impacts and the coordination processes. On the one hand, the study describes how railroad lines generate development patterns (forms, density, variety); on the other hand, it describes the laws that control development to implement more purposefully and more successfully public transportation policies (equipment, vehicles, organization). In Germany six best practice examples were analyzed, two of which included a tram-train service.

The following variables were considered:

- Rail service: Upgrading the regional rail service.
- City: Increases in development along the rail line and around stations.
- Station: Revaluation of railway stations as transportation and community centers.

The main results of the study were the assessment of the pros and cons of different basic approaches used in the planning process, an estimation of the qualitative and quantitative developments, and a manual with recommendations for local decision makers, planners, and rail operators. The manual describes meaningful strategies for improving the integration of land-use and transportation planning and their implementation. The research study found that focusing settlement development at railroad lines is possible but has limits because of increasing land prices along railroad lines.

Study 9: Regional Importance of Railway Lines—Development and Test of an Evaluation Method in the State of Thuringia (Fachhochschule Erfurt 2003)

Study 9 developed a decision-assistance tool to help answer questions about the elimination of regional rail service, for temporarily suspending service, and/or to protect the rail infrastructure. The starting point of the study was that often regional rail service was simply replaced by bus service and the railway line shut down without considering the regional effects of these actions because there was no procedure with objective decision criteria in existence to evaluate this decision. The study included a literature search on arguments for and against rail segment service suspension, collection of available data on the regional effects of railway structures, and developing a methodology to estimate the regional impacts of railroad lines. The applicability of the method was tested by examining 20 example segments in the state of Thuringia. The main findings were:

- Substitution of regional rail service by bus led almost without exception to worse public transportation service.
- The following factors were determined to be relevant and they were quantified for the evaluation procedure: development function, regional economy, safety, travel time, network effect, environmental effect, tourism, and connecting function.
- The evaluation procedure developed in the study supplies plausible results for the importance of regional segments. However, the ranking of segments using this procedure was partially surprising. Some of the segments where regional rail service has been cancelled have higher values than other segments where there is not even any discussion of eliminating regional rail service.
- The evaluation procedure developed represents a meaningful addition to the standardized evaluation process (Intraplan and University of Stuttgart)

2000) used for investments in public transportation systems because while the regional rail segments are subject to the service elimination, to date there have been no objective decision criteria for evaluating these decisions.

The study recommended that the regional rail infrastructure be recognized as a public responsibility. Only then would its long-term economic use become relevant to the evaluation; otherwise only short-term economics (e.g., direct revenues and costs) enter into the decision over cancellation of regional rail services.

Important Third-Party Research

Study 10: Areas of Application for Regional Railway Lines (Zöllner 2002)

Study 10 developed a procedure for objectively evaluating reactivation of, or improvement measures on, regional railroad lines, which requires only simple input data. In contrast to the other research studies mentioned in this article, this study derived a mathematical formula to estimate the patronage impacts of improvement measures on the basis of 14 example segments. However, this formula is not generally accepted.

The study also examined the cost and revenue situation for regional rail and bus transportation under two alternative scenarios: operating regional rail service or replacing rail service with bus transportation. The patronage demand model showed that the examined railroad lines that were converted from rail to bus operation experienced an average patronage decrease of about 45 percent. This loss could be reduced to a decrease of 9 percent by doubling the bus frequency (i.e., buses that operate twice as frequently as trains formerly did). Based on these results, it is possible to identify a rail bonus of 35 to 45 percent in relation to bus transportation. Rail transportation exhibits advantages in particular with respect to patronage, travel time, road safety, and its effect on regional structure. In terms of cost, bus transportation—even with twice as high a service frequency—is less expensive; rail transportation is only cost effective if track and station costs are not included (e.g., regarded as part of the overall government economic responsibilities).

Study 11: Procedure for Estimating the Effects of Improvement Measures in Public Transit and Rank Listing of the Measures Investigated (University of Kassel et al. 2001; Arndt et al. 2002)

Study 11 developed a procedure for comparing improvement measures for railway service in the central part of Hessen including the Frankfurt region. It examined the connection between individual measures, their associated costs, and their respective effects on passenger demand.

The study developed a procedure that helped rank improvement measures in terms of efficiency (i.e., comparison between additional revenues from passenger increases and associated additional costs) using examples from the region. It used this procedure to examine groups of improvement measures and place them in a rank listing, which can serve as a guideline for investment decisions. The study found that the most favorable projects were new and upgraded S-Bahn (regional rail rapid transit) segments and the building of new railway stations. In the middle category were the modernization of stations as well as new park-and-ride facilities and reactivation and/or improvement of regional railroad lines.

Study 12: Estimation of the Patronage Potential of Regional Railway Lines Based on Several Examples (Schuler 2001)

Study 12 determined how rural area rail segments operated by DB Regio (successor of the former federally owned passenger company operating regional railways) can be operated more economically and whether these segments could obtain similar patronage increases by implementing best practices of other rail operators. In this study, 35 segments of the DB regional network owned by the federal infrastructure company (DB Netz) were compared with structurally similar best practice segments of five private railway companies and one regionally operating subsidiary of the DB with integrated infrastructure and operations. Using these data, the patronage potential of the regional lines was derived on the basis of population, employment, overnight accommodations, and number of students.

The study result was that DB Regio segments show a lower demand, although in 81 percent of these segments similar conditions are present as with the best practice segments, and therefore patronage increases from 22 percent to 700 percent compared to the starting level are possible if DB Regio adopts these best practices. The most important factors for these increases are service frequency and number of the stops. The segments operated by private companies were substantially better with respect to these factors than those operated by DB Regio.

Summary Evaluation of the Research Projects

Examined Railway Segments

Extensive research and many case studies have examined the topic of making regional rail service more attractive. The segments considered in the studies outlined above were from throughout Germany. Figure 4 illustrates regional rail studies financed by the German federal government. While many regional rail

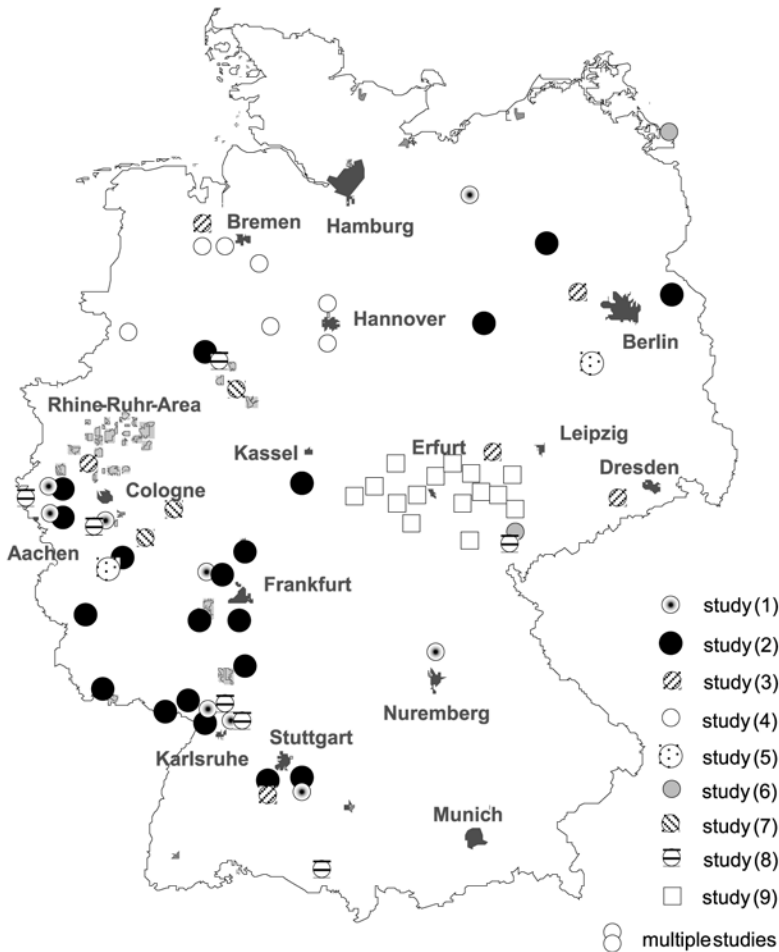


Figure 4. Case Examples in Regional Rail Studies Financed by the German Federal Government

segments were considered in the studies, only four examples for linking urban rail segments and railroad lines (tram-train) were analyzed because there were insufficient time series data to measure the patronage changes, although particularly high passenger increases were observed on these systems.

Main Findings

Methodology. Decision makers should consider all the referenced research studies relevant for a particular question, especially those that are based on the largest sample size and a careful data analysis, before deciding which specific improvement measures to implement. To evaluate high cost improvement measures, detailed cost benefit studies are also necessary, especially if federal funds are needed.

Local Commitment. A central finding of the research studies considered in this article is that local commitment is crucial for the success of regional rail lines. The municipalities in the region must consider the railway segment as theirs and strongly support continued operation and improved service. A local rail service provider is optimal for obtaining good rail service; private rail operators have proved this for many routes formerly served by the national railway company DB. However, it appears not crucial whether the local proximity is provided by a private rail operator or a DB regional subsidiary. For example, patronage per kilometer on a DB subsidiary once threatened with closing (Figure 5) rose almost 880 percent between 1992 and 2002 (Allianz pro Schiene 2005). The four existing DB regional subsidiaries reported passenger increases of 15 percent in their two first years (Göbel 2004).

Cost Reduction Through Competition. Competition should be used more consistently to reduce the cost of regional rail service. One study shows that competition provides a possible cost savings of approximately 18 percent with small and 38 percent with large services (Private Sector Participation Consult 2004). However, there is still substantial need for improving the basic conditions for competition in Germany, given that the private operator market share for regional rail service amounts to only 9 percent and the DB Regio's dominance with more lucrative products is even larger.

Infrastructure Finance. The general railway rules need to be examined for cost-reduction possibilities. On regional lines, rail service should be operated based on branch-line standards. Also, private operators should be able to receive federal



Figure 5. The Usedomer Bäderbahn, a Subsidiary of DB AG, Exhibits High Patronage Increases

funds for infrastructure. It is favorable when the federal railway infrastructure operator (DB Netz) is not responsible for the improvements because branch-line standards are more economical, high cost increases in the planning and building phase occur less often, and the construction time is reduced. Similarly, construction work at stops is more economical and completed more quickly when the federal railway station operator (DB Station & Service) is not responsible: the costs are on average about 40 percent lower with private operators (Agentur Bahnstadt 2004). The most favorable model (particularly for regional rail line infrastructure) is where the DB-owned infrastructure is leased to private companies that are responsible for both maintenance and service. There are examples, however, where DB Netz has rejected leasing of track segments that are experiencing increasing number of trains (Naumann 2004).

Eliminating Regional Rail Services. The replacement of regional rail service with bus service led nearly without exception to the degradation of public transportation service. The regional economic impacts of railroad lines were not considered in the decision over the cancellation of regional rail service or reactivation of rail routes.



Figure 6. Rhineland-Palatinate Systematically Improved Regional Rail Service throughout the State, Leading to a High Increase in Passenger Patronage

Patronage Effects. The patronage increases after making improvements are often larger than predicted. With only one exception it was not possible to derive a mathematical formula for estimating the patronage change due to improvements. To determine the total effect of an improvement measure, a long-term view is necessary. Two important measures for increasing patronage are increasing service frequency and linking urban rail and regional railway segments (tram-train). Rail-oriented land-use planning has special meaning. The bundling of the settlement development along the rail is possible, however it has limits because of increasing land prices. Increasing service almost always boosts patronage at least proportionally to the increase of the service miles. For all the DB Regio served segments, service miles grew by 23 percent between 1993 and 2003, while the number of the person kilometers grew by 30 percent (DB Regio 2004). Many of the private operator-served segments registered substantially higher increases. In Rhineland-Palatinate (Figure 6) the number of train-kilometers grew by 50 percent between 1994 and 2004 on all segments (DB Regio and private operators), while the number of person-kilometers rose around 90 percent (Ministerium Rheinland-Pfalz 2004).

Identification of Efficient Measures for More Attractive Regional Rail Traffic

To identify the most efficient measures for increasing patronage on a rail line, it is necessary to evaluate fully the current service level and quantities as well as deficiencies. The potential demand depends substantially on the type and extent of the train service. Therefore, a detailed analysis of the surrounding field conditions has to be completed, especially to judge the current competitive situation between rail and private car traffic as the main competitor. The analysis should include:

- Investigation of the major traffic flows and an estimate of passengers who could be attracted to rail
- Examination of the current and the desired competition situation to private car traffic including comparison of travel times and decision-relevant costs
- Evaluation of the current comfort situation for passengers (trains and stations)

Deficiencies in these areas have to be eliminated to the maximum extent feasible to reach a high degree of attractiveness and big patronage increases. The quality of train service should be as equivalent as possible to or better than car traffic. This requires:

- Competitive travel times to destinations with high passenger flows
- Sufficient train capacity
- High reliability of train service
- High schedule availability (long period of operation during the day, dense timetable, regular clock-face schedule)
- High spatial availability (stations close to high concentration of settlements and destinations with high traffic flows)
- Safe and comfortable railway stations (e.g., protected waiting shelters, transparent design, close to housing areas)
- Direct and safe access routes, which can be used by persons with mobility problems (e.g., persons with physical handicaps, persons with buggies)

- Comfortable trains, matching to platform levels that enable fast boarding and alighting without problems
- Parking facilities for cars and bikes close to the stations
- Good public transit connections with short transfer times

Furthermore, it is important to pay attention to image factors, which can highly influence patronage. Examples of image factors include well-maintained appearance of the trains and stations and attractive surroundings of the stations.

Action and Additional Research Recommendations

Action Recommendations

The following list outlines specific urgently needed actions:

- Uniform regulations should be provided for preparing patronage projections and collecting patronage data. One goal must be making data collected from different segments comparable.
- Regular passenger patronage surveys should be made on regional rail segments to compare with results on other segments, to determine causes for deviations, and to develop improvement measures if necessary. A good example is the annual survey program in the state of Baden-Württemberg (Landtag Baden-Württemberg 2004), which includes the number of passengers per segment-kilometer and the required subsidy per person-kilometer, the number of passengers compared to population potential, and the difference of travel time between rail and private car. These data are used to compare rail segments in terms of transportation and economics.
- A detailed estimate of potential passenger demand should be prepared. This estimate should include all types of trips including leisure and shopping.
- Regional service should be planned from the customer's point of view. To attract choice customers, it is important to offer rail service that competes with the automobile by providing short travel times and high frequency service.
- The federal government must improve the ability for competition in the rail transport market.
- A balance must be created between too much (and too little) detailing of requests for bids and business concepts.

- The “infrastructure” and “service” sections of the DB railway company must be truly separated into independent companies to avoid discrimination against private rail companies.
- Transportation policy must support development and promotion of regional rail service.
- Regulations for railroad infrastructure, construction, and service must be standardized with the goal of “cost reduction.”
- Solutions must be found for the financing of railway infrastructure (e.g., segment reorganization, providing federal funds for private company operated segments, requiring acceptable prices for the purchase of segments from the federal railway company, and new models for the regional rail infrastructure).
- Funding regulations and incentives for architects and engineers should be changed to provide incentives for economical solutions.
- The integration of transportation and land-use planning should be improved and railroads should be more strongly considered as a location factor in future planning. A rail-orientated settlement plan and providing financial incentives for rail-oriented settlement patterns are important; however, it is also necessary to provide a good railway service (Bosserhoff 2004b).
- The regional rail infrastructure should be recognized as a public responsibility.
- The long-term economical value of railroad lines should be considered in the decision over the cancellation of regional rail service. The appraisal procedure mentioned in this article can be used for this purpose (Fachhochschule Erfurt 2003).

Recommendations for Additional Research

Additional research is particularly needed on the following subjects:

- The impact of linking urban rail and general railway segments (tram-train) and the possibilities for cost reduction (e.g., rail service without overhead lines). The largest patronage impacts were obtained for tram-train service.
- The impact of measures for increasing the passenger demand not yet suf-

ficiently considered in literature, such as fare measures that effect trips by people who do not normally use the regional rail system.

- The question of a common financing scheme for regional rail and other regional public transportation service.
- More economical possibilities for the financing of regional rail infrastructure.
- Suitable ways to separate the infrastructure from rail service.

In the state of Hessen, a study was recently completed on the future of regional rail service to maintain rail service in the middle to long term (ETC Consultants 2005). Alternative possibilities for infrastructure ownership, operation, and maintenance were examined. The study compares these possibilities using a concrete example and considering the different expectations of the public transit operator, the state, DB Netz with respect to regional rail financing, high infrastructure availability, improved infrastructure quality, regionalization of the decision-making process, economy, cost transparency, faster project realization, and implementation. One solution for maintaining regional rail service is to transfer the operation of regional infrastructure to a regional operator without simultaneous transfer of the property. Three models were examined all of which consider an integration of tracks and stations. The regional network model represents the strategy currently being pursued by the DB with its regional subsidiaries integrating infrastructure and service. In the cooperative model a close co-operation takes place between the regional rail service provider and the DB Netz in a joint enterprise. The lease model is characterized by having a private company lease the segments from DB Netz and provide both service and infrastructure.

Results of Patronage Data Studies

Regional Segments

Figure 7 illustrates the development of the parameter “daily persons boarding and alighting per segment-kilometer (work days)” for different segments after the implementation of improvement measures. Broken curves were used, when no values were available for intermediate years.

Figure 7 shows fairly substantial passenger increases in all but two cases. The two exceptions can be explained by problems with new tilting vehicles used on these segments. The number of passengers boarding and alighting continues to increase

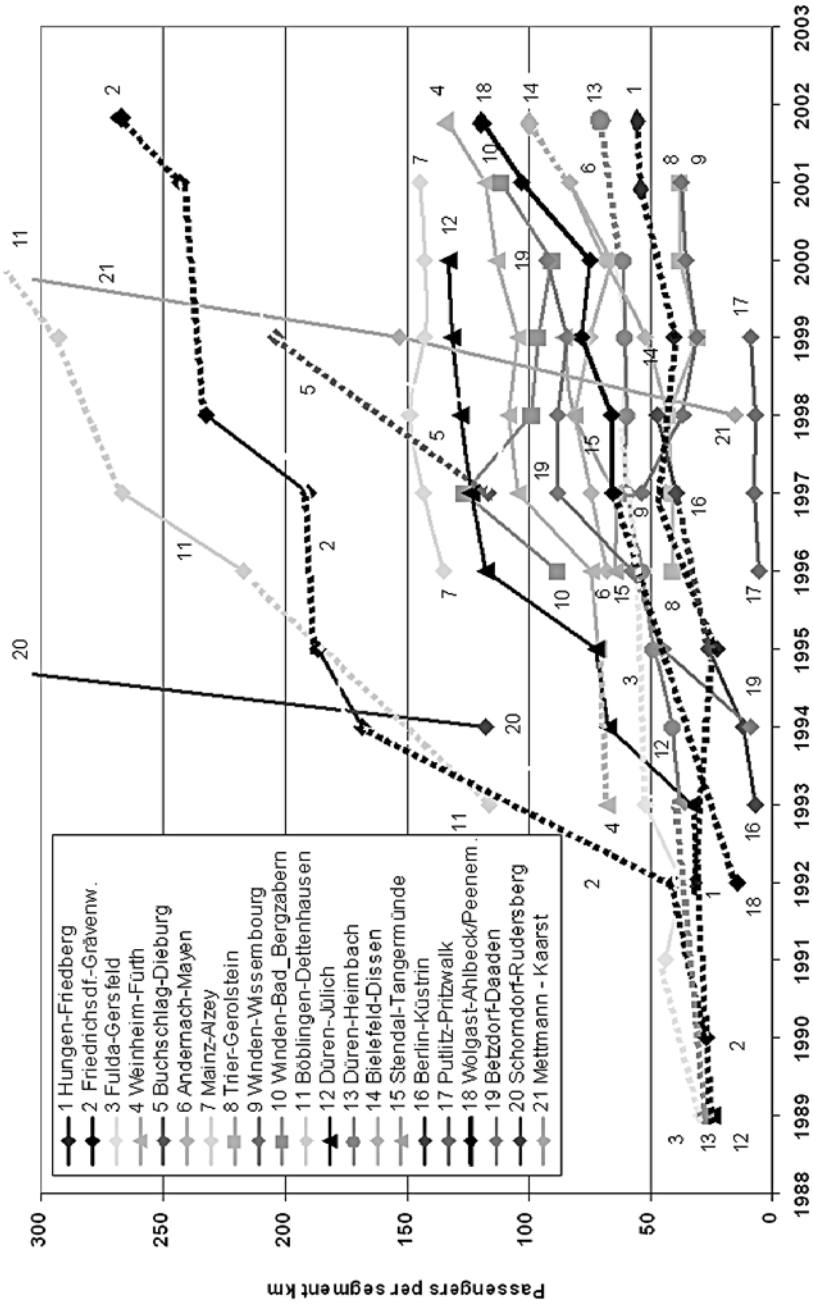


Figure 7. Increase of Daily Patronage per Segment-Kilometer Over Time

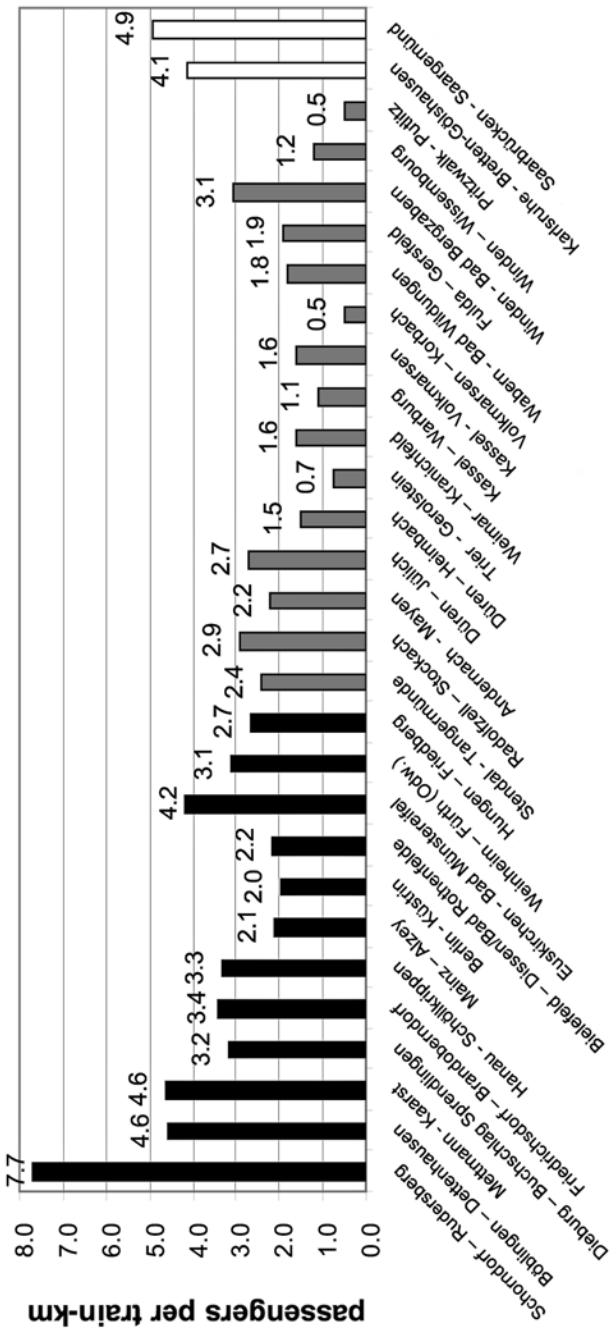


Figure 8. Passengers Boarding and Alighting per Train-Kilometer (Daily)

on the majority of segments after improvement into the range of between 50 and 150 persons boarding per kilometer; higher values are observed for a few segments in the catchment areas of larger cities.

Figures 8, 9, and 10 show different parameters of patronage per day (Monday–Friday): passengers boarding and alighting per train-kilometer (Figure 8) and per inhabitant (Figure 9). In these figures the segments are distinguished by type (black, located in agglomeration areas; grey, located in rural areas; white, tram-train service). The values displayed correspond to the most current published patronage data (see Figure 7).

Figures 8 and 9 show that high patronage is achieved where urban rail segments are linked to general railroad lines. Each criterion can be meaningful (e.g., economically the measure “persons boarding per train kilometer” is the most important, while when considering potential demand the measure “persons boarding per inhabitant” is most important).

Figure 10 illustrates the increase in patronage (passengers boarding and alighting) per segment-kilometer after improvements for selected regional segments in rural areas and Figure 11 for selected regional segments in agglomeration areas. Comparing Figures 10 and 11 shows the absolute increase in patronage per segment-kilometer generally results in higher values for segments in agglomeration areas. The average value before improvement is approximately 40 passengers per segment-kilometer for rural areas, and approximately 80 for agglomeration areas (neglecting the segment Mettmann-Kaarst which operates with an S-Bahn standard and is therefore a special case). The average values after improvement are 85 passengers per segment-kilometer for rural areas and 200 for agglomeration areas. This is equal to increases on average of 240 percent and 260 percent, respectively. With only four exceptions the patronage increase was at least two thirds for all segments considered.

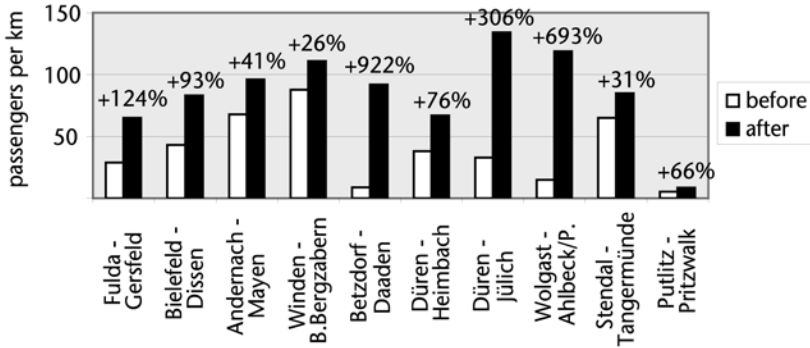


Figure 10. Increase of Daily Patronage per Segment-Kilometer Before and After Improvement of Regional Railway Segments in Rural Areas

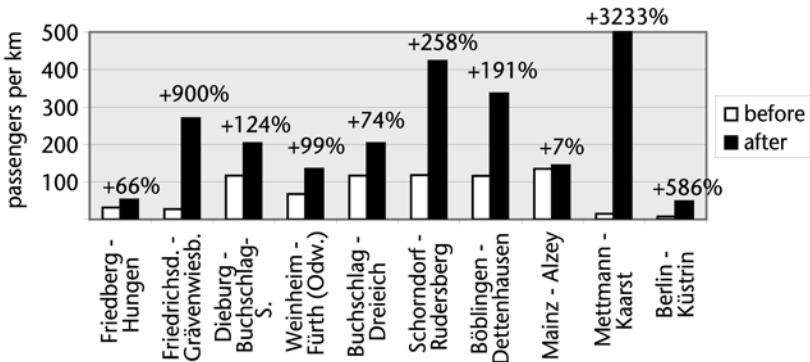


Figure 11. Increase of Daily Patronage per Segment-Kilometer Before and After Improvement of Regional Railway Segments in Agglomeration Areas

Linkage between Urban and Regional Railroad Lines

Figure 12 shows the increase of patronage per segment-kilometer for segments in the area of Karlsruhe (Karlsruher Verkehrsverbund 2005) after linking urban rail and general railway segments (tram-train service). The average value of the passenger demand before the linkage was approximately 130 passengers per segment-kilometer. The absolute increase in segments using the tram-train linkage is substantially larger than the patronage increases for the regional segments. The increase on segments with the linkage averaged 410, highest for all segment types.

The middle proportional increase of 290 percent is even higher than the increase for regional segments in agglomeration areas.

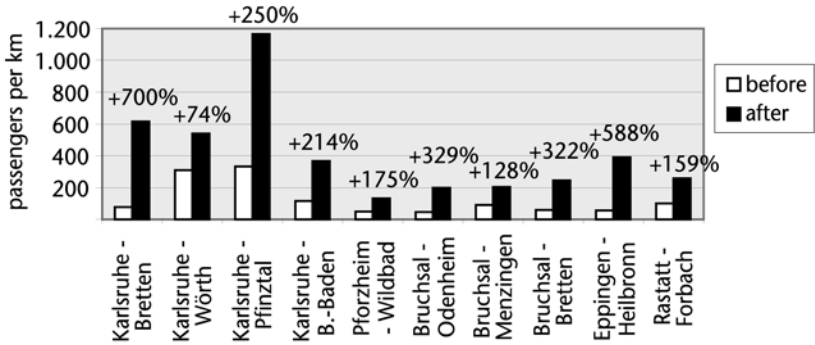


Figure 12. Increase of Daily Patronage per Segment-kilometer Before and After the Beginning of Tram-Train Service



Source: Menzel 2006.

Figure 13. Kassel Vehicle for Tram-Train Service on Diesel Sections



Source: Menzel 2006

Figure 14. Kassel Vehicle for Tram-Train Service on Electric Sections

It is expected that tram-train service will become much more widespread as hybrid vehicles that can be used on tracks with catenary and tracks for diesel use have been developed (Alstom 2005; van der Bijl and Kühn 2006). This technology allows direct connections from the region into the city center, avoiding the high cost for electrification of sections outside the cities. The first hybrid vehicle for regular gauge (Figures 13 and 14) has been in service since 2005 in the city of Kassel (Menzel 2006).

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About the Author

DIETMAR BOSSEHOFF (Dietmar.Bosserhoff@hsvv.hessen.de) studied civil engineering at the University of Karlsruhe with emphasis on transportation and land-use planning. He received his doctorate in 1985 after working as a scientific assistant in Karlsruhe. After a year of research at the University of California—Berkeley's Institute of Transportation Studies, Dr. Bosserhoff worked in the area of the transportation planning and technology at the engineering company GEVAS in Munich. Since 1992 he has worked in the Hessian Office for Roads and Transportation. He is responsible for the integration of transportation and land-use planning, rail transportation, as well as quality improvement of traffic signals. He is a member of several working committees of the German Road and Transportation Research Association.