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Demographic change in Germany will lead to a remarkable change in the composition of the population, particularly in terms of the ageing of society with the prospect of a population decrease. These factors are the main determinants for future travel demand. This chapter describes the procedure of modelling transport for 2030 and illustrates the results with regard to the infrastructure. The findings of the Rostock Center serve as the main basis for the data in the transport model, belonging to the family of microscopic activity-based demand models.

The future passenger transport demand will decrease in most areas. The workload of the road infrastructure will decrease correspondingly. Differences of the impact between the two demographic scenarios are low. Findings show significant spatial differences. The western part of Mecklenburg-Western Pomerania, for example, will experience some trip increases, but most of the regions will face a decrease in transport demand. Public transport in Mecklenburg-Western Pomerania will not gain any more passengers in the future.

We therefore conclude that the planning process for infrastructure should include a proper approach that assesses the options of disassembling streets and restructuring them. Criteria for making this decision should not be the workload of the road, but rather accessibility questions. Future land use management will also play an important role.

4.0 Introduction

Demographic change in Germany will lead to a remarkable change in the composition of the population, particularly in terms of the ageing of society with the prospect of a population decrease. Furthermore, economic development will cause changes in the work force, contributing further to the demographic change. These aspects are major determinants of trends in the transportation sector. The task of the DLR - Institute of Transport Research in this project was to prepare future trends of travel demand by applying a method suitable for the relevant aspects of InfraDem. The findings of the Rostock Center regarding the demographic and economic projections had to be integrated into our transport model.

Changes in the composition of the population lead to a change in transport demand, as each population group is characterised by a specific mobility demand. Here, we concentrate on school and university students, the work force, and elderly people. This chapter focuses on changes in these groups and discusses the respective future transport demand in two model regions. We conclude with the subsequent workload and demand of transport infrastructure.

The extent and manner of the impact of demographic change will not be the same throughout Germany. The InfraDem project selected the federal states of Hamburg and Mecklenburg-Western Pomerania as examples of two diverging regions. Hamburg (HH) is a densely populated city with a comparatively young population. Its population is expected to continue growing over the coming years. In contrast, the already sparsely populated federal state of Mecklenburg-Western Pomerania (MV) with a comparatively old population is expected to experience a further decline in population in the future.

Transport demand is the essential determinant of future infrastructure planning. Increasing or declining transport demand has to be considered when restructuring old roads or dimensioning new roads, and hence, when designing the road network. Renaturalization may be another option in regional planning, as the burden of maintaining the network is not viable considering the few people who will use it.

We have estimated future transport demand in the two model regions by applying the microscopic activity-based demand model TAPAS (**T**ravel **A**ctivity **Pa**tterns **S**imulation). Furthermore, these demand projections will be used to outline recommendations for future infrastructure planning.

This chapter comprises four main parts. Section 4.1 elaborates on the relevance of demographic change for transport demand. A description of the applied transport demand model TAPAS is then given in section 4.2. The results of the transport model are presented in section 4.3. The chapter closes with a conclusion of the findings with respect to future infrastructure usage.

4.1 The relevance of demographic change for future transport demand

Changes in the composition of the population within a certain area can cause significant changes in the demand for transport. Two dominant processes that influence the transport demand must be distinguished (see Fig. 4-1): the shrinking of the population in general and the change in the age structure, or more precisely the proportional increase of the older population (see chapter 8). The first process, the “shrinking” of the population, primarily leads to “quantitative” changes in transport demand, assuming a stable proportional composition of the population, as well as persistence in travel behaviour on a general level: less people use the existing infrastructure to an overall lower extent. The ageing of a population, on the other hand, goes along with a “qualitative” change in transport demand caused by a changed population structure that is potentially accompanied by a change in travel behaviour on the individual level. The main aspects of the ageing of the population comprise the increasing proportion of elderly people, as well as the proportional decline of the labour force and young people.

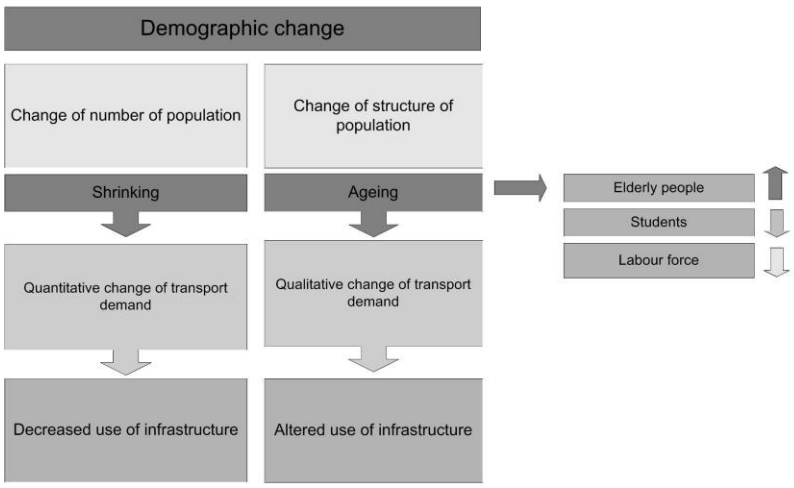

Fig. 4-1: Relevance of demographic change for transport demand and its impact on transport infrastructure

In recent decades, the development of the passenger transport demand can be summarised and characterised by a relatively stable volume of transport considering the number of trips per person, as well as by a relatively constant time budget for mobility per person. Furthermore, a modal shift from non-motorised means of transport to motorised individual transport and increasing lengths of trips travelled is noticeable.

For the upcoming decades, expectations are different. The German Plan for Federal Traffic Routes includes a traffic forecast for 2015. The prognosis presumes that previous developments will continue in the future with already familiar tendencies; motorised individual transport will continue to rise (Scheiner 2006). Other empirical findings and the analysis of surveys and model calculation methods show that in the long run the transport demand will stagnate and even decline in shrinking regions. Even the German automobile association ADAC assumes that the average annual mileage will remain constant after 2010 before decreasing after 2015 (Zumkeller et al. 2004, ADAC 2003).

All studies on future travel demand consider certain assumptions on general economic and demographic development, as well as the transport-related framework such as transportation costs or the availability of public transportation. The focus in InfraDem lies on the impact of the demographic aspects mentioned above, in other words changes in transport costs that go beyond the business-as-usual assumptions (e.g. due to new taxes) are not included in the modelling. Detailed descriptions of the demographic changes can be found in chapter 1, as well as in chapter 8 with specific emphasis on the mobility of the elderly. Concerning the modelling of the overall travel demand, the following aspects are crucial in the two model regions:

The elderly as a group is, as already mentioned, growing. With respect to traffic development, this increase has different impacts. This group will have more driving licences than seniors in the past. The share of households with a car will also increase. Each individual, reaching retirement age, will be better equipped with cars and driving licences and will thus influence passenger transport demand (Scheiner 2006, Beckmann et al. 2005).

Connected with these demographic developments, changes in the household structure with a growing share of one-person households are also expected. The increase in one-person households will bring with it an increase in car ownership, even if mobility budgets remain more or less stable. This will lead to a decreasing number of passengers per car. More and longer trips might therefore compensate for population losses (Ahrens 2005).

The decreasing number of employed people will lead to a diminishing number of work and business trips. Employed persons make the most trips and travel the highest number of kilometres per day.

Scheiner (2006) analysed the daily variation of transport according to age and proved that the problematic peak during the afternoon rush hour is mainly caused by persons of working age. In future, when these people retire from 2020 to 2050, this peak will diminish, as will the morning peak. Therefore, with a stagnating or slightly growing transport demand, further expansion of the infrastructure should be reconsidered critically.

Another undesirable consequence is caused by the shrinking of the group of children and adolescents. This leads to a decreasing demand for public transport. In many areas of Germany, up to 90% of local public transport is to and from schools. Local public transport is hence mainly dependant on school students.

The impact on infrastructures differs according to the regional characteristics. For a stable or even slightly growing metropolitan area like Hamburg, no relief is expected on the urban infrastructure. In addition, suburbanisation processes might compensate for the diminishing transport demand of the shrinking group of employed persons (Scheiner 2006). Sparsely populated Mecklenburg-Western Pomerania is fundamentally different. Characterised by a larger population loss, shrinking populations pervade throughout the whole federal state. Cities and municipalities suffer from bad public finances and the development of infrastructures is – compared to the number of inhabitants – over proportionately expensive (ibid.).

4.2 Estimating the passenger travel demand 2030

In order to evaluate the impact of demographic change on travel demand, an activity-orientated demand modelling approach was pursued for the two regions under evaluation within InfraDem. The model applied was developed by the DLR Institute of Transport Research and originally emanated from a thesis written by Hertkorn (2005). Known as TAPAS (**T**ravel **A**ctivity **Pa**tterns **S**imulation), the model belongs to the family of microscopic activity-based demand generation approaches in transport modelling.

Activity-based demand generation (ABDG) is based on the perception of travel behaviour resulting from an interdependent sequence of activities and trips. Interest has grown in this method over recent years. Currently, a lot of different ABDG implementations exist, sharing the common conceptual understanding of activity-based analysis but pursuing quite different methods and approaches (see Balmer et al. 2005, Bowman and Ben-Akiva 2000, Jonnalagadda et al. 2001, Punjari et al., 2008; Rilett 2001, Timmermans 2001).

Other than the widely used traditional 4-step models (e.g. Emme/3, Viseva/Visum, see Lohse et al. 1997, Vrtic et al. 2006), research and model development with an ABDG approach are not as standardised or well-established. They are based on a very detailed representation of the population within the region of interest and can account for a more individual- and household-centred perspective on demand emergence. TAPAS provides a detailed daily spatiotemporal activity programme for each individual in the population within the region analysed. Furthermore, especially temporal aspects and budget restrictions of individuals, both with respect to time and money, seem to be better addressed by the more detailed approach provided by ABDG.

TAPAS focuses on the complex process of demand generation, comprising the steps of trip chain generation for individuals in a synthetic population, trip distribution and destination choice. Route assignment is not yet part of TAPAS, therefore state-of-the-art software is used (e.g. PTV VISUM).

4.2.1 Modelling approach of TAPAS

An overview of the main elements of the passenger transport demand model TAPAS is given below (see also Fig. 4-2). A more comprehensive description can be found in Justen and Cyganski (2008).

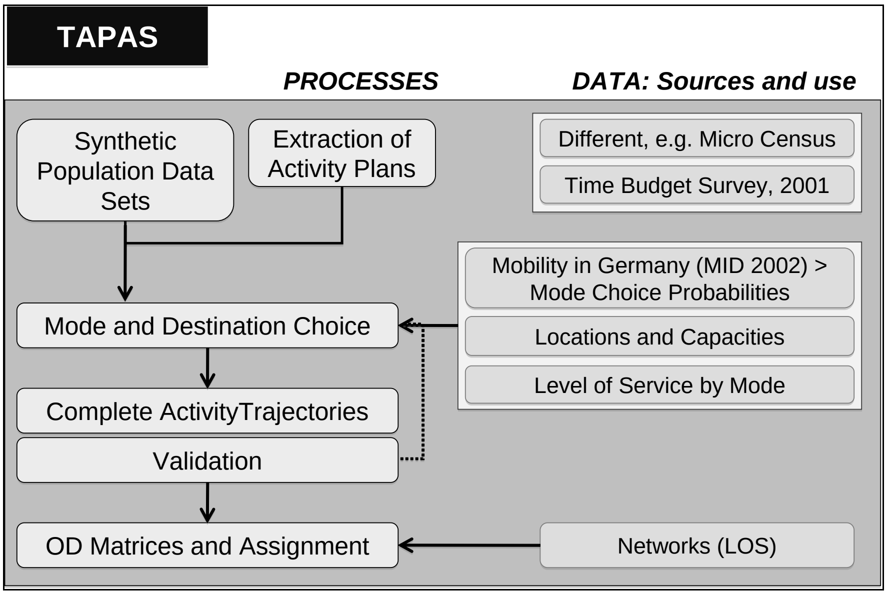

Fig. 4-2: Data sources and structure of the travel demand model TAPAS

4.2.1.1 Generation of a synthetic population

As the modelling approach focuses on individuals, one of the major prerequisites for precise modelling results is the detailed representation of the people living in the area under investigation with respect to their demographic and socioeconomic characteristics.

The generation of this input was primarily based on the established and documented procedure known as the creation of a synthetic population (see Beckman et al. 1996, Simpson and Tranmer 2005, Hobeika 2005). By combining official statistics on demography and socioeconomics, multiple-attributed individual and household data sets were created, which match the distributions given by official statistics. The InfraDem project considers two different population forecasts based on the work packages of the Rostock Demographic Center (see chapter 1, for further data used, see Table 4-1). A synthetic population was created composed of individuals equipped with different attributes such as sex, age, employment status (full or half-time), driving licence and the possession of a annual public transport ticket. As travel behaviour is strongly influenced by constraints imposed by the household context, individuals were aggregated to households. Hence, income, monetary budget for travel-related expenditure, car availability, household type (e.g. presence of children) were attributed on a household level. Last not least, a geocoded place of residence was assigned. Urban blocks were used to the greatest possible extent as spatial resolution for the place of residence and other locations used in the simulation. When this was not possible, traffic analysis zones (TAZ) were used as spatial units of reference.

4.2.1.2 Generation and assignment of activity plans

Another prerequisite of an activity-based analysis of transport demand is the consideration of the interdependent choices of activities and trips during a day. Hence, a set of activity plans (referring to number, type, order, start and duration of activities) had to be provided for each individual in the synthetic population. The activity plans used in TAPAS were based on an analysis of a time budget survey conducted in Germany in 2001/2002 (Federal Statistics Office 2004). For InfraDem, activity diaries were selected that were reported on workdays during the week (Tuesday to Thursday) and within the corresponding settlement structures of the region according to the categories defined by the Federal Office for Building and Regional Planning (BBR).

To relate activity plans to travellers in the area, a concrete diary was assigned to each of the individuals in the demographic data set. To do so, a combination of sequenced and cluster analysis was applied, thus grouping plans with similarities in number, type, durations and order of activities. With this procedure, 23 different groups of diaries with internal structural similarities were identified, while each “diary group” contained a different number of activity plans. According to the individuals’ attributes (primarily age, sex, employment status and car availability), the population was divided into 32 groups. For each group, the choice probabilities were calculated und used to first assign a diary group and finally a specific diary to each of the individuals. To account for the increasing mobility of the elderly, the selection of diaries for persons aged 75 and older was modified so that the diary probabilities of the younger retirees (aged 65-74) were used.

4.2.1.3 Destination and mode choice

Subsequently, a destination and a mode had to be chosen for each of the activities contained in a selected diary. Both decisions were strongly interrelated in TAPAS. Destination choice was based on the model of intervening opportunities[1] and accounts for the preceding location of stay, as well as for the attractiveness or capacity of the available alternatives. Mode preferences of the individual with respect to the type of activity, the accessibility of the location of each mode, and the respective travel times and expenditures were also considered. Destinations were determined hierarchically in correspondence to the importance of each activity. Thus, interdependencies of choices within trip chains were considered.

Mode choice probabilities were based on a CHAID[2] decision tree built from regional adequate subsamples of the German National Mobility Survey "Mobility in Germany – MiD 2002" (see Table 4-1, Infas and DIW 2004). The decision tree was defined using the sociodemographic attributes of the trip maker (e.g. age, sex, car availability), as well as attributes of the trip (e.g. purpose, distance). Respectively, the empirical mode choice probabilities at each leaf on the decision tree represented the basis for estimating an incremental multinomial logit model (see Ortúzar and Willumsen 2006) to predict variances of mode choices due to changes in cost structures. Estimation parameters of the utility function were adopted from a study based on the analysis of a six-week travel survey: the Mobidrive data set (König and Axhausen 2001).

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[1] The concept of *intervening opportunities* assumes that an alternative to all decision options is refused with a certain probability, e.g. because the location is not known or not preferred by the individual.

[2] Chi-Squared Automatic Interaction Detectors

Table 4-1: Database for travel demand modelling in InfraDem

Category	Data Source	Function	Characteristics
Demographics	Land Use Planning 2025 (study of the Federal Office for Building and Regional Planning (BBR); Rostock Center for the Study of Demographic Change (InfraDem); Different public statistics	Number of inhabitants by sex and age/projections for population and household	Information of BBR e.g. concerning number of households by size for 2025
Persons and Household Characteristics	Rostock Center for the Study of Demographic Change (InfraDem); Infas Geodaten; Specific data provided by the Federal Office for Building and Regional Planning (BBR)	Calculation of cross-tables, e.g. concerning household structure and income or employment status	German-wide household surveys
Household Budget for Mobility	Income and consumption sample 2003 (Federal Statistical Office)	Calculation of household expenditures for mobility issues (public transport, fuel and vehicles)	German-wide household survey with 60,000 households
Travel Behaviour	Mobility in Germany 2002 (Infas & DIW, 2004)	Generation of parameters for model calibration, e.g. travel distances and modal split/number of cars per household	German-wide household and travel survey with approximately 25,000 households, 62,000 persons and 167,000 trips
	Time Budget Survey 2001/2002 (Federal Statistical Office, 2004)	Generation of activity plans/variances of activity time durations and starting times	German-wide household survey with approximately 5,400 households, collecting about 38,000 diaries
Transport Development	Transportation Forecast 2025 (Federal Ministry of Transport, Building and Urban Development)	Analysis of the general transport development concerning trip generation rates, average distances travelled	Forecast for transportation performance in passenger and commercial transport (e.g. vehicle miles travelled, modal split)

4.2.2 TAPAS: summing up

Within the simulation process, a full activity trajectory was calculated for each of the individuals. This trajectory or day plan comprised information on the number, type, start, end and duration of each of the activities performed, as well as the mode and destination of all trips. Each day plan was finally evaluated with respect to financial and temporal feasibility and iteratively improved where necessary.

A statistical analysis of the resulting plans allows the derivation of the number of departures and arrivals per spatial analysis area, as well as the distribution of travel distances, modes chosen and the number of trips undertaken. Route assignment of the resulting origin-destination matrices for the car mode permits the calculation of the vehicle kilometres travelled according to the day plans. Each of the statistical parameters can hereby be differentiated by person group when appropriate.

4.3 Results of travel demand modelling

In order to describe and assess the effects of the demographic development on transport demand, three indicators have been selected:

- Originating trips: The number of trips with an origin in a certain cell made by the inhabitants. Trips by tourists or other people from outside the area are not included. The effect of demographic change in this region is therefore dominant and it can be attributed to a local area.
- Kilometres travelled by car: All trips for which cars are used linked to destinations and assigned to the network result in the total traffic volume, described by vehicle kilometres travelled.
- Workload of the road network: Here, the vehicle kilometres are set in relation to the road capacity.

To model future transport demand, general assumptions have been taken over from the Federal Transportation Forecast 2025 (BVU 2007), except in the case of assumptions on demographic development, which have been provided by the Rostock Center. The general assumptions in the Federal Forecast 2025 are a constant budget for travelling according to household income, increasing motorisation and increasing transportation costs of 1% per year (without inflation).

The results of the transport modelling will provide general information about trends of future transport demand. The project does not intend to give recommendations with regard to individual road sections, bridges or other infrastructure facilities. Therefore, a general trip assignment was performed for passenger car traffic to gain the indicator values only. A comprehensive and balanced trip assignment for the total network was not carried out in this project. The number of daily trips was calculated for public transportation only.

4.3.1 Expected changes in the origin of passenger trips

The origin of trips reflects the number of inhabitants in a certain area and their activities. If the number and structure of the population changes, the activities will also change because the travel patterns are closely linked to the age and the phase of life of the people. Therefore, the average number of trips per person will not stay the same as for 2005, but will develop in line with the assumptions made in the population scenarios.

Mecklenburg-Western Pomerania

The development of the number of trips shows a large spread in general, as well as large differences within the state. Areas can be found in the western part of Mecklenburg-Western Pomerania between Wismar and Lübeck with a high increase of trips of about 20% and more (Fig. 4-3). A few smaller areas in the southwest also have high rates of increase. However, according to our modelling, the majority of Mecklenburg-Western Pomerania will experience heavy decreases of 20 to 30% in the number of trips made between 2005 and 2030.

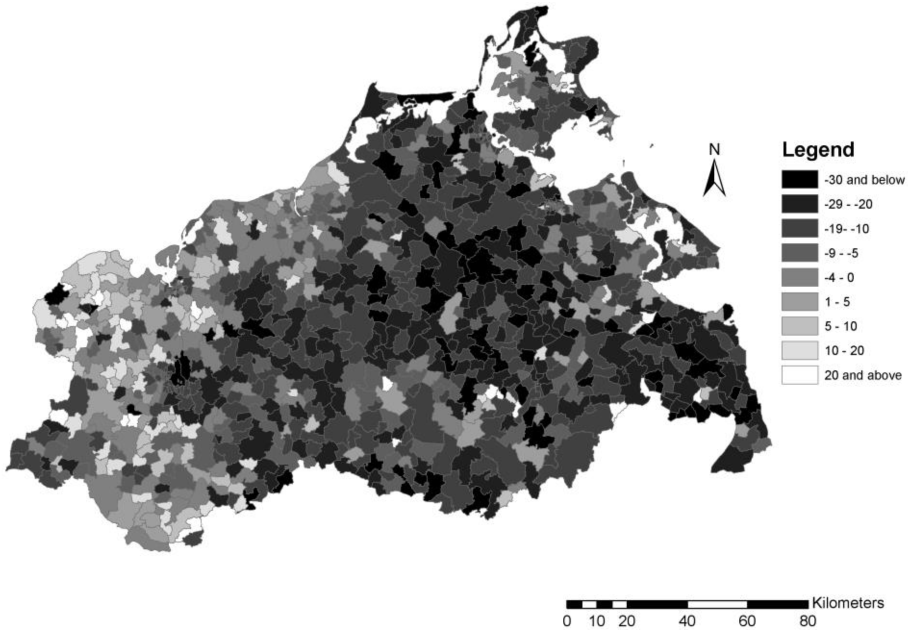

Fig. 4-3: Development of trips originating in Mecklenburg-Western Pomerania from 2005 to 2030 in the low scenario

In the high scenario (Fig. 4-4), some more areas displayed a high increase in trips during the 25 years investigated. In the western area, more trips were made, especially in the district of Ludwigslust (5 to 20%) and the coastal region around Wismar and Rostock, as well as some eastern parts near the city of Anklam. The districts of Güstrow, Demmin, Mecklenburg-Strelitz and Uecker-Randow do not benefit from the different assumptions in the high scenario, and show nearly the same decrease rates as in the low scenario.

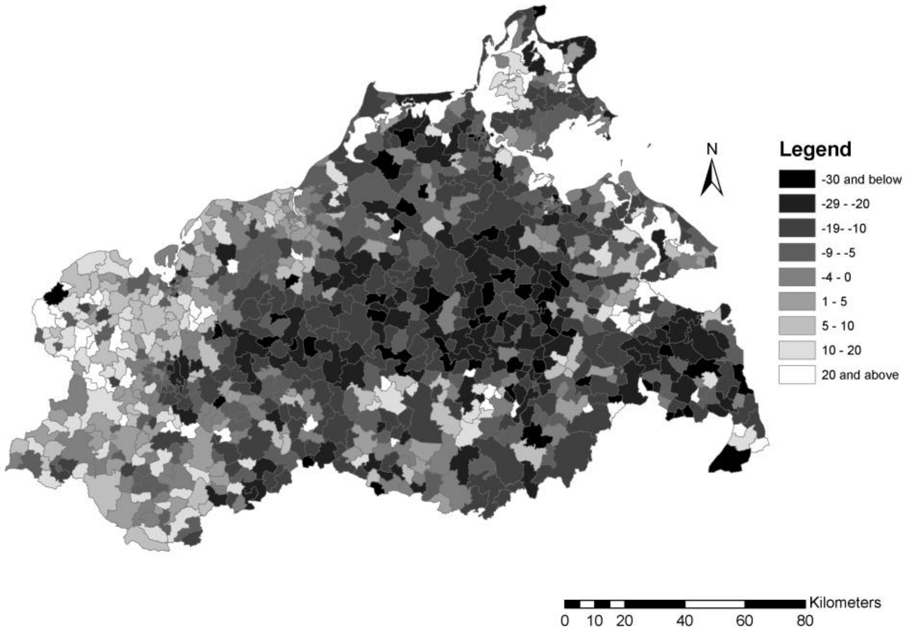

Fig. 4-4: Development of trips originating in Mecklenburg-Western Pomerania from 2005 to 2030 in the high scenario

Looking at the trip development of age groups, very large differences were revealed. Trip increases can be reported for students and those retired. The number of trips made by people aged 74 years and older nearly tripled in the time period investigated. In all other age groups, the number of trips decreased.

In addition to some general assumptions, e.g. those concerning mobility costs, the number of trips is mainly influenced by the underlying population scenario. As Mecklenburg-Western Pomerania will lose 9.5% of its population in the low scenario and 12.9% in the high scenario, which will simultaneously age by about 7 years, the results of the transport model are not surprising. Furthermore, the 30% decline in the labour force must also be considered, as the specific trips per day made by this group differ to those made by the other groups.

Hamburg

In the case of Hamburg, a very uniform picture was revealed by the calculation of the future transport demand. The number of originating trips will grow in all districts until 2030 by 13 to 15% in the high scenario (Fig. 4-5). The low scenario results in slight changes, but the number of trips stays more or less the same.

These findings are not unexpected when considering the weak demographic changes in the low scenario for Hamburg. The high scenario includes a population growth of approximately 15%, which is reflected by the higher mobility demand. The labour force will increase by 13%.

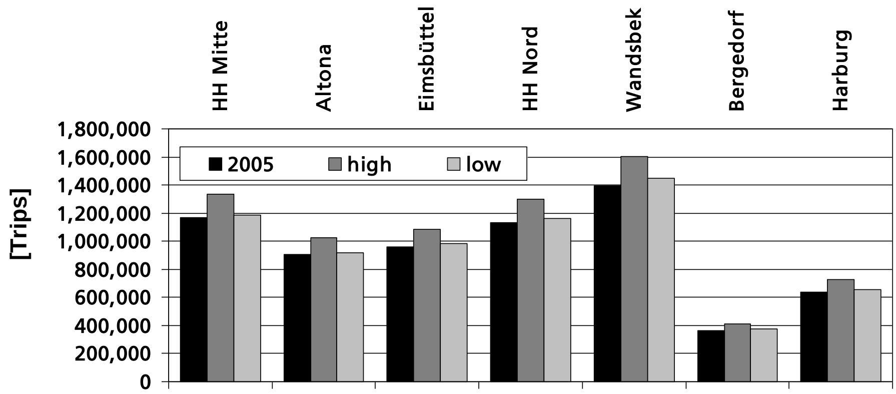

Figure 4-5: Average daily trips originating in Hamburg

4.3.2 Expected changes in kilometres per year

In order to determine the total transport demand and hence the resulting workload of the infrastructure, the originating trips were supplemented with the arriving trips. For the origin-destination matrices, the routes were assigned to the network. By adding up all assigned trips, the kilometres travelled per year were calculated.

In contrast to other projects, the passenger kilometres (pkm) which include the number of passengers per car, is irrelevant for the purposes of this project. As the workload of the infrastructure is a key indicator, the kilometres driven per year are important.

In Mecklenburg-Western Pomerania (Fig. 4-6), the vehicle kilometres decline significantly in both scenarios by about 16%. This means that the difference between the two scenarios only has a minor influence on the vehicle kilometres. Moreover, the increase in the activities of retired people in 2030 compared to 2005 cannot compensate for the general decrease in mobility demand in that state.

In Hamburg, constant or even decreasing vehicle kilometres (up to 12%) are expected in 2030 compared to 2005. As this accompanies the stable or increasing number of total trips caused by the increasing use of public transport, the modal split shares in Hamburg clearly change from car to public transport.

Having calculated the kilometres driven per year, the assignment of the trips to the road network will be of interest, especially for Mecklenburg-Western Pomerania, in order to gain information on the usage of the infrastructure in the future. This is carried out in the following section.

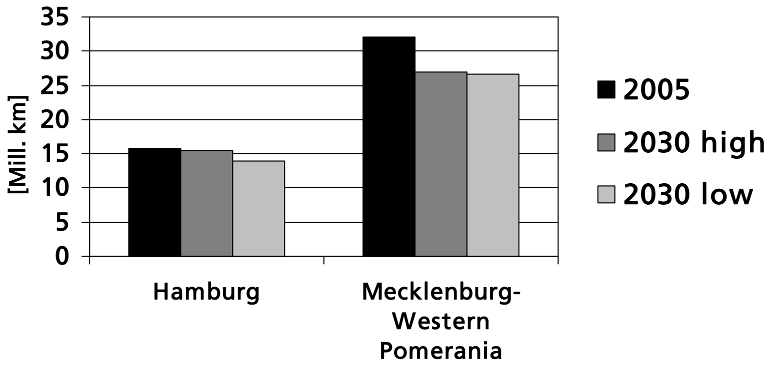

Figure 4-6: Average daily trips originating in Hamburg and Mecklenburg-Western Pomerania

4.3.3 Resulting workload of the road infrastructure

The emerging traffic as described above is set in relation to the road capacity in this step. The capacity is determined by factors such as the number of lanes, the width of lanes and the speed limit. The daily average workload will not provide information on congestion at certain places. However, the daily figures allow for a general assessment of the suitability of the infrastructure.

Mecklenburg-Western Pomerania

The state shows a decrease in the workload in nearly all districts. The workload, which is low to start with, will fall further by approximately 5% on average. A constant workload was found for very few districts. The whole state was divided into two parts: the very rural areas with a workload between 5 and 10% and the cities of Greifswald, Neubrandenburg, Schwerin, Stralsund, Wismar and Bad Doberan with a workload of about 15 to 20%. As an exception, Rostock shows a stable workload of nearly 40% in all scenarios.

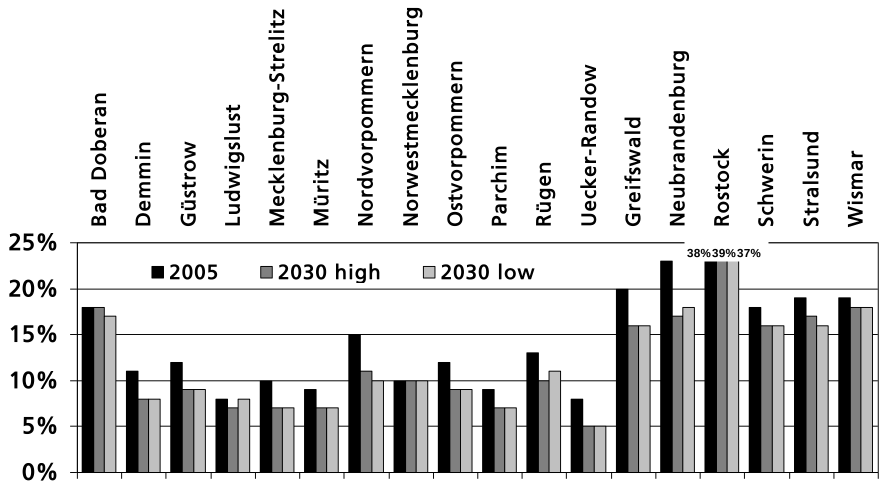

Figure 4-7: Average workload of the main road network in Mecklenburg-Western Poerania

Hamburg

In the area of Hamburg, the workload of the road infrastructure is not significantly affected by demographic change. The trend shows a slight decrease from 2005 to 2030. In 2030, Bergedorf and Harburg will have a workload of 20% on average, Mitte and Altona about 40% and Eimsbüttel, Nord and Wandsbeck about 50%.

4.3.4 Public Transportation

For public transport in Mecklenburg-Western Pomerania, a remarkable decrease of about 20% was ascertained in daily trips from 2005 to 2030 (see Fig. 4-8). This reflects the lower numbers of school and university students, as well as the growing motorisation of older people. The differences between the two scenarios only have a minor influence. Since the public transport service in this rural area is only moderate, more passengers are not expected in the future.

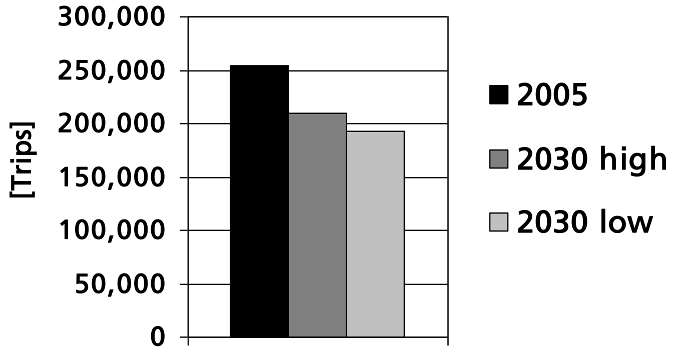

Figure 4-8: Average daily trips by public transport in Mecklenburg-Western Pomerania

In Hamburg, trips by public transportation will increase in both scenarios: by 24% in the high scenario and 11% in the low scenario. These results are not only influenced by demographic change. The general trend of increasing transportation costs also has a significant impact. People have the choice of using their own car or using a well-developed public transportation system in Hamburg. Therefore, increase rates were ascertained for public transportation that were well above the population growth.

4.4 Conclusion

When calculating the future passenger transport demand under the given demographic assumptions, a demand decrease can be found for most areas. The workload of the road infrastructure will decrease correspondingly. Therefore, the available infrastructure is satisfactory in general. However, in a few tourist and urban areas, congestion may occur during the peak hours. This is more a matter of traffic organisation than of infrastructure in general. Hamburg in particular has streets with very dense traffic; however, this initial situation will not be affected by the demographic change in the future.

Moreover, the following results can be concluded:

- The differences between the two demographic scenarios in terms of impact on passenger transport demand are low. A higher impact was observed in general for the development from 2005 to 2030.
- Findings with regard to the transport demand show significant spatial differences. The western part of Mecklenburg-Western Pomerania, in particular, will experience some trip increases, but most of the regions will face a decrease in transport demand.

Concerning public transportation in Mecklenburg-Western Pomerania, the situation will become more problematic. New affordable approaches for public transportation must be introduced.

In Hamburg, public transportation will face an increasing passenger volume due to demographic change. Here, a thorough analysis is necessary to assess the sufficiency of available capacities.

Bearing the forecast results in mind, the planning process for infrastructure must be questioned. The establishment of an approach that assesses the options of disassembling streets and restructuring them in a proper way will become very relevant. Criteria for the decision to invest in infrastructure may not necessarily be the workload of the road, but rather the accessibility of all houses. Lots of minor streets connect the destinations directly, but not all of them can be restructured and maintained. The question in the future will therefore be: how big is the imposition for the inhabitants, i.e. how long a detour will they have to make when direct connections are no longer available? Future land use management will also play an important role here.

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