Structures of Traffic Management and Control in German Cities

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Abstract

The paper presents selected results of a questionnaire distributed to all 187 cities in Germany larger than 50,000 inhabitants to analyse most typical and most common structures of Traffic Management and Control. The identified results are part of a first outcome of a methodology developed for the German research project UR:BAN-VV to transfer and extrapolate the impacts of cooperative advanced driver assistant systems developed in the project to other German cities. With the high overall return rate of 42% the questionnaires offer a basis to identify most relevant conditions in German cities and to restrict the number of considered scenarios within the impact assessment or by future system developments in the urban area. Amongst others, results document the high relevance of the prioritisation of the public transport at intersections and adaptive local signal control in German cities, which have a significant impact on signal state prediction.

Keywords: Survey, German Cities, Impact Assessment

Introduction

The German research project UR:BAN-VV (urban space: user oriented assistance systems and network management – networked traffic system) aims to develop cooperative advanced driver assistance and traffic management systems for the different areas of the urban road network (signalised intersection, road segment and network) to improve traffic safety, efficiency and in order to reduce harmful environmental effects. One of the major focus areas of the developed systems is the optimisation of the approaching and crossing of signalised intersections via an active signal time provision [1].
Besides the development of the systems, one of the main goals of UR:BAN-VV is to transfer and scale up the impacts of the systems which will be identified specifically in the projects' test sites in Düsseldorf, Brunswick and Kassel with a limited number of test vehicles to other German cities. As a basis for the extrapolation, microscopic traffic simulation is used in order

to reproduce the situations and the observed impacts at the test sites and to modulate the performance of the systems in different surrounding conditions with different equipment rates. Since in reality every city, network, road and intersection is unique regarding its static and dynamic attributes, it is obvious that a very high number of variations is available.

Approach

To limit the scenarios for the impact assessment as well as to improve the transferability of the results, the most typical and common structures in German cities must be identified. This identification is based on an approach, which includes a survey on general structures of traffic management and control in German cities on the one hand and a more detailed statistical analysis of the road network of all 187 German cities on the other hand.

For the survey, the representatives of all cities larger than 50,000 inhabitants (inh.) were asked to answer a questionnaire, which included questions like the general concepts of signal control or the prioritisation of public transport. This survey provides a solid overview on typical macroscopic structures to be considered for the impact assessment, microscopic simulation environments and the development of systems like in UR:BAN-VV.

Additionally, to obtain a more detailed picture of the area in which systems should have an impact, the road network of the 187 cities on the level of the designated network elements signalised intersection and road segment is analysed. The combination of the two elements helps to identify most relevant structures and with this set-ups for the microscopic traffic simulation to reconstruct and extrapolate the impacts of the UR:BAN-VV systems. Detailed information concerning this approach and more detailed analysis of signalised intersection and road segments can be found in “Scaling up of ADAS’ Traffic Impacts to German Cities” [2]. In the following, major outcomes of the questionnaire-based survey are presented.

Survey structures

The survey aimed for a better understanding of “what is typical for German urban road networks” in order to reflect these conditions in the microscopic traffic simulation. Similar surveys have been conducted in recent years to analyse typical structures of traffic management in European and German cities, i.e. [3], [4]. Nevertheless, while often being very detailed, mostly the results are restricted to a few big cities which do not provide a significant basis for the UR:BAN-VV goal to provide transferable results for “all” German cities.

Therefore, it was decided to initiate a questionnaire-based survey, predominantly based on multiple-choice answers, to collect relevant information to reduce the number of traffic simulation scenarios. The survey was sent to representatives of all German cities with more than 50,000 inh., which were identified on the basis of DER ELSNER [5], a German almanac on road transport. The questionnaire is divided into two chapters:

The **Traffic planning/Traffic management** part contains questions on the length of the road network, modal split, presence of commuting/internal traffic, yearly budget for the transport sector, definition of congestion, main reasons and extent of congestion, focus of traffic optimisation (from complete network to single intersection), focus of optimisation at intersections (all directions/main directions only), indicators used to identify/select/assess traffic problems and countermeasures.
In the context of the traffic simulation, especially the focus of traffic optimisation and main indicators used to identify traffic problems and countermeasures are relevant.

The **Traffic control** part includes questions on the number of traffic lights, signal control interfaces used, other interfaces for traffic control/management, availability and degree of prioritisation of public transport, ratio of approaches of signal control (fixed/actuated/model based), age of traffic signals/computer, availability of infrastructure based sensors and measures of traffic management implemented (e.g. parking control, variable message signs)
In the context of the traffic simulation, especially the influence of public transport and the approaches of signal control are relevant.

Selected results of the survey

The selected results, which are presented consecutively, document typical macroscopic structures of traffic management and control for German cities with more than 50,000 inh. These information should be considered for the impact assessment, microscopic simulation environments and the development of systems like in UR:BAN-VV. The results are analysed separately according to the categories[1] of city sizes used in Germany into "big medium-sized city" (50,000-100,000 inh.), "small major city" (100,000-300,000 inh.), "big major city" (300,000-1 Mio. inh.) and "metropolis" (>1 Mio. inh.). The selection of results presented is related to their relevance for the UR:BAN-VV systems and the traffic simulation as well as the completeness and soundness of the information.

1. Return rates of the survey

The overall return rate of the questionnaires is 42%. Figure 1 shows the distribution of the 79 questionnaires returned according to the city size. The high return rates of cities larger than 100,000 inh. and larger than 300,000 inh. are regarded as positive, because they represent the size of the projects' partner cities Düsseldorf (~580,000 inh.), Kassel (~190,000 inh.) and Brunswick (~240,000 inh.). The return rates also largely correlate with the density of cities in the respective Federal states of Germany.

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[1] Definition according to International Statistics conference (1887) and German Reichsstatistik (1871)

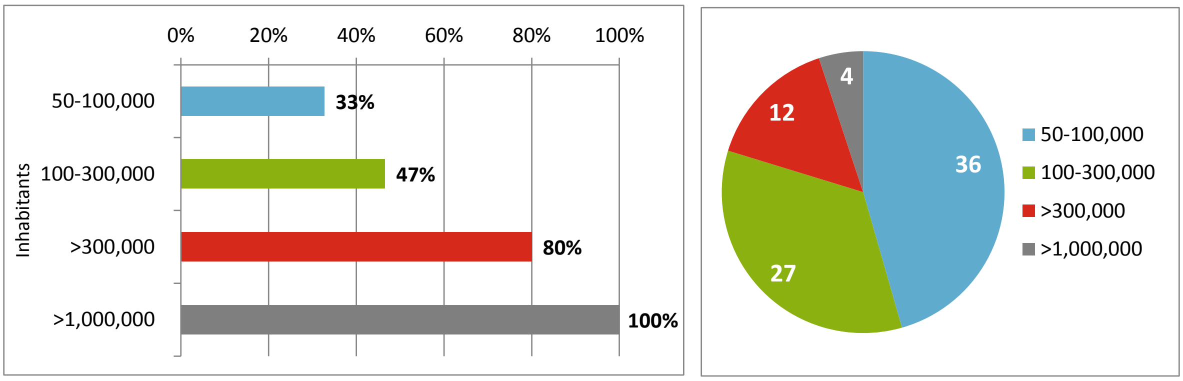

Figure 1 – Return rate of survey according to city size

2. *Origin of traffic demand*

To optimise traffic flow via traffic signals, knowledge of the traffic demand and predominant directions is important. As expected, Figure 2 shows that all cities larger than 100,000, 300,000 and 1 Mio. inh. have a strong influence on the surrounding areas with a high ratio of in-commuter traffic with a maximum for the four German cities larger than 1 Mio. inh. (Berlin, Hamburg, Cologne and Munich). For cities larger than 100,000 inh. it can be assumed that traffic peaks into town in the morning and out of town in the evening represent the most typical direction of traffic demand.

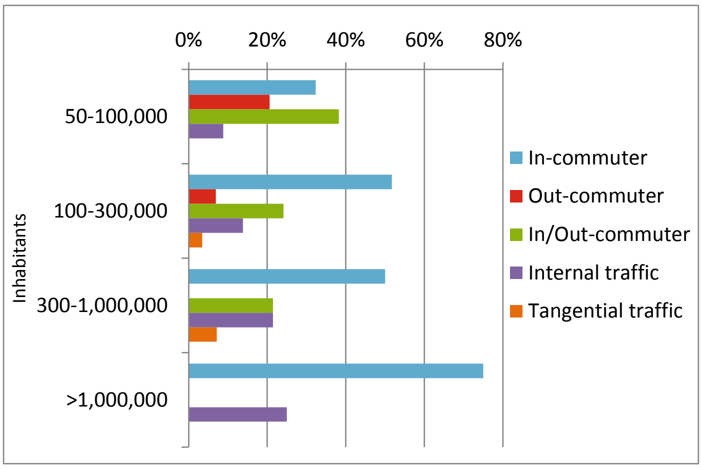

Figure 2 – Source/direction of traffic demand

3. *Definition and main reasons for congestion on urban road network*

A very important topic is the definition of traffic congestion. Meanwhile the terms to define a congested situation are largely concerted. In contrast, according criteria and thresholds to define that situation are still not harmonised, which is a precondition to create a common understanding of traffic events and countermeasures needed to overcome these situations. 44% of the returned questionnaires state that there is no general definition of congestion in their city.

9% of the cities use a definition based on the German HBS-Manual [6] for congestions at traffic light signalised intersections. Other definitions vary, using different thresholds for traffic signal cycles/stops to cross an intersection, waiting times, queuing lengths, average speeds, etc.
The main reasons nominated by the cities for congestion on the urban road network are shown in Figure 3. A lack of road capacity is the stated number one reason for congestion followed by road works. Most "other" reasons stated by the cities are diverted traffic, i.e. from neighbouring motorways in case capacity overload or events/incidents. The most effective UR:BAN-VV systems can be derived from these stated problems.

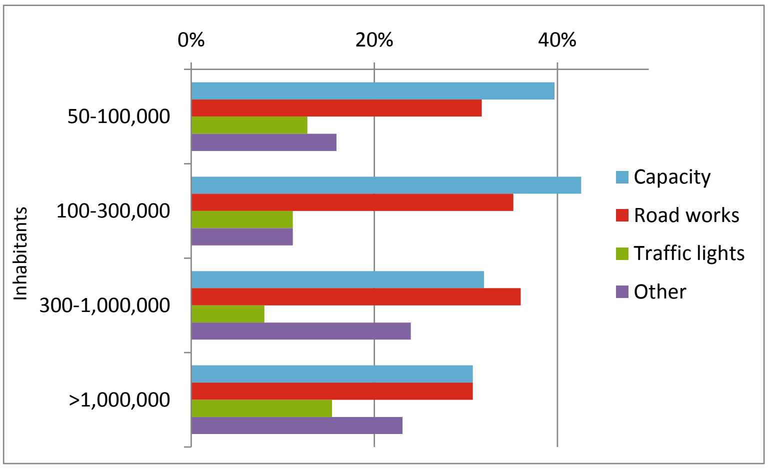

Figure 3 – Stated reasons for congestion on urban road network

4. *Focus of optimisation at the intersection*

Figure 4 presents how cities strategically adjust the traffic signal control at intersections.

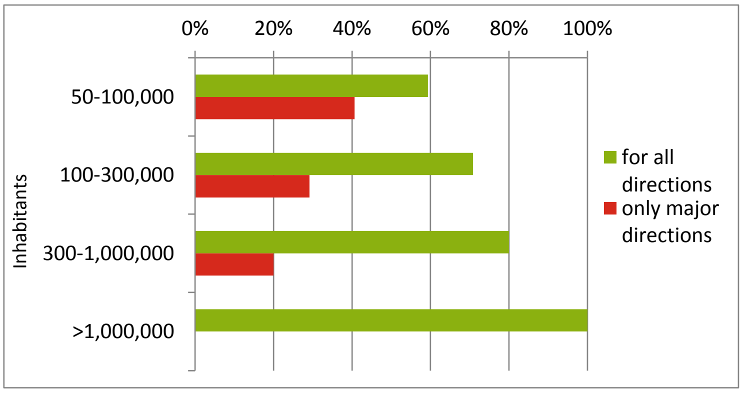

Figure 4 – Focus of optimisation at intersection

In general, most signal plans focus on an overall optimisation of waiting times for all turning directions. This is also in line with the HBS-Manual [6], which considers the overall quality rate as the worst single rate of a turning direction. However, 40% of the smaller sized cites state that an optimum for the major directions is intended. For the traffic simulation this implies that not only an improvement for vehicles in the main directions, e.g. equipped with the UR:BAN-VV systems, is to be considered but for all traffic relations of the intersection.

5. Approaches of signal control

Figure 5 shows an analysis of prevalent approaches of signal control favoured by German cities. The majority of signal control is based on traffic-actuated control and partly on fixed-time control. The dominance of highly dynamic signal times is very significant for ITS-systems that need reliable information of the current signal times and even more for a prognosis for upcoming intersection as foreseen for some UR:BAN-VV systems, by having a signal state prediction component.

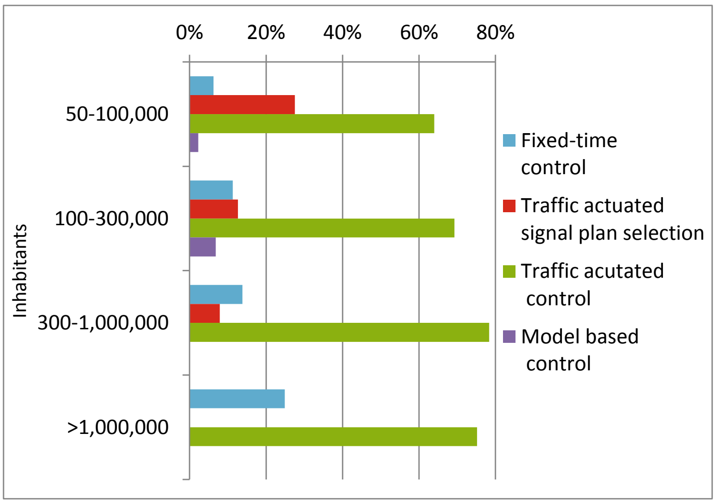

Figure 5 – Approaches of signal control

6. Prioritisation of the public transport

Figure 6 illustrates that practically every city in Germany supports a prioritisation of the public transport. Nevertheless, the concepts vary from absolute prioritisation to prioritisation only in case of delay or if it matches to the current green period. The survey also shows that the tram, if available in a city, is mostly operated with a strong/absolute prioritisation, while busses predominantly face a weaker prioritisation, depend on the intersection or a delay of the bus. For the UR:BAN-VV systems this means that subject to the level of prioritisation this information is highly important for reliable information on the current signal times and their prognosis.

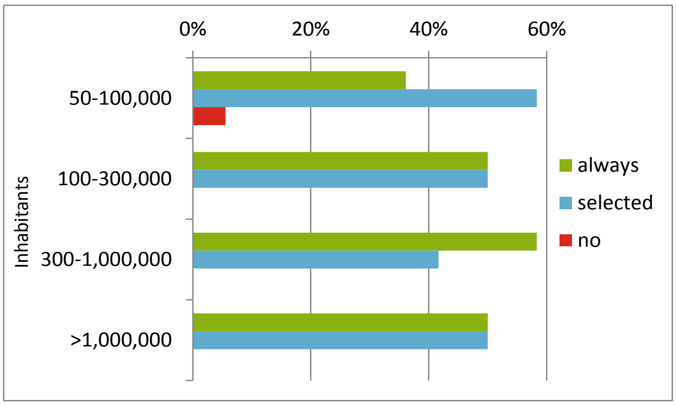

Figure 6 – Prioritisation of public transport (bus/tram)

7. Coverage road network with infrastructure based traffic detection

A reliable picture of the traffic state on the road network is a basic pre-condition to optimise sufficiently the urban traffic. Figure 7 states that about a quarter of the cities reported of having a full vision of the traffic condition based on their infrastructure-based detection. However, the majority has sensors only at strategic points in the road network or have no detection at all; the latter in particular for cities smaller than 100,000 inh. This outcome underlines the relevance of alternative means on data collection, like based on floating car (FCD) or phone data (FPD).

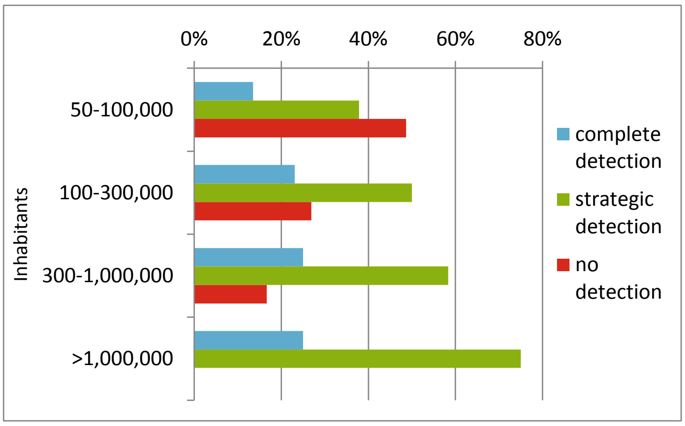

Figure 7 – Coverage road network with infrastructure based traffic detection

8. Age of traffic computers and availability of central data on traffic signals

Figure 8 gives an impression of the age of traffic computers used in the cities. 32% of the cities smaller than 100,000 inh. have no traffic computer. All other cities operate mostly one or partly several traffic computers. The majority of cities smaller than 1 Mio. inh. has computers, which are younger than 2001. This enables the deployment cooperative V2I/ I2V systems and ITS systems (traffic computers starting from 2005 and younger are generally capable to support the functions, for 2001-2005 it has to be checked in individual cases).

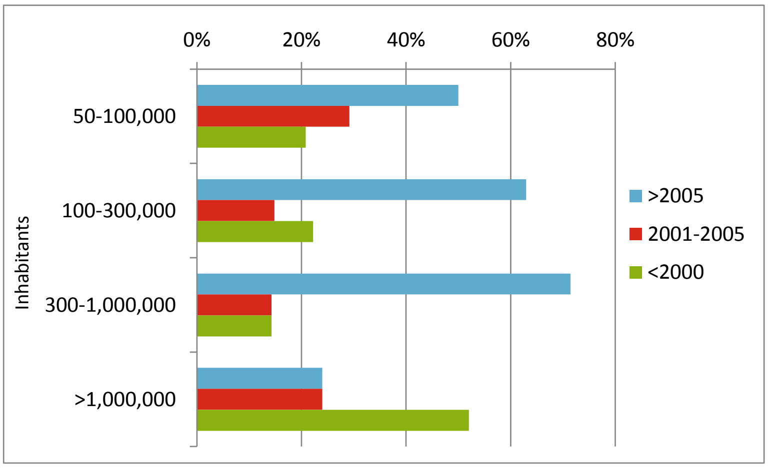

Figure 8 – Age of traffic computers

Moreover the survey states that 52% of the light signal systems (incl. pedestrians light signal systems) of cities smaller than 100,000 inh., 70% of the cities with 100-300,000 inh., 75% of the cities with 300-1 Mio. inh. and 84% of the cities larger than 1 Mio. inh. are connected to the traffic computers. This means that their signal times are available centrally, which is highly suitable for traffic light based systems with mobile phone communication.

9. *Criteria to identify a deficit and to verify a measure*

Figure 9 presents predominant criteria stated by the cities to identify and prioritise problems to be solved in an urban network as well as to assess the impact of the countermeasures applied. For the identification and prioritisation/selection of a deficit, in particular at signalised intersections, mainly the number and severity of accidents followed by capacity are used.

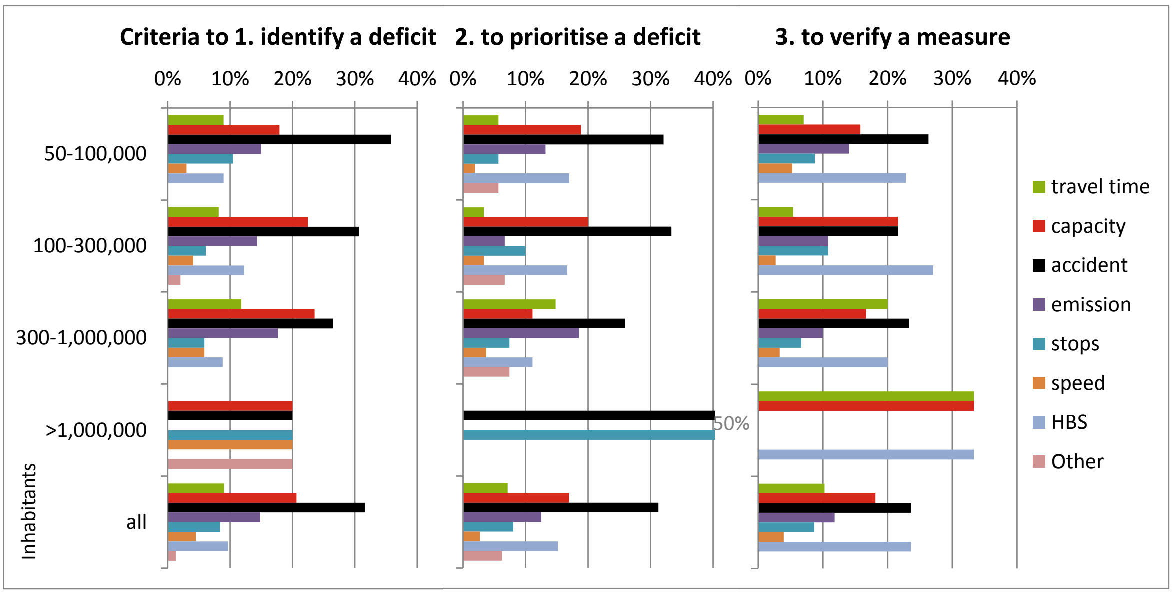

Figure 9 – Criteria to identify/prioritise a deficit and to verify a measure

For the verification after a measure has been applied also criteria defined by the HBS-Manual [6] was indicated, which is mainly based on travel/waiting times and the number of stops. Other mentioned criteria refer to political intent or complaints. An adjusted definition of these criteria is important to create the information needed by the cities during the assessment.

Conclusion

With an overall return rate of 42% the survey provides a good basis to identify typical and common structures of Traffic Management and Control in German cities. Results e.g. show that the traffic light control in German cities is mostly traffic actuated including a prioritisation of the public transport. This is considered by systems dealing with signal state prediction as developed in UR:BAN-VV. For the simulation studies to validate the UR:BAN-VV systems this is recognised by the definition of relevant scenarios to model the impacts in microscopic simulation environments. For the scaling up of the simulation results, the categories found will be used [2]. However, to extract the full information included in the questionnaire, additional and more detailed analyses will be made in the future.

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