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On-demand mobility meets scheduled services: Data-based analysis of the relative advantages of area- and scheduled services in cities

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inspiring
smart
mobility

Content

Keywords

- Quality of services
- On-demand transport
- Bus
- Data
- Digital platforms
- Efficiency
- Flexibilisation
- Costs
- Customer benefits
- Mobility analyses
- On-demand mobility
- City bus systems
- Urban transport systems
- Traffic planning
- Economic efficiency

Summary

The mobility market is changing constantly: The drivers of these dynamic changes are among other things, digitisation and individualisation as well as the increased use of data. Digital platforms make it possible to create individual forms of operation to innovate public transport and to improve the quality of service. These forms of mobility are currently discussed intensively under the term 'on-demand mobility' and increasingly integrated into urban transport systems. The discussion about the advantages and disadvantages of line and area traffic is however often more emotional than rational. The objective comparison of systems in this discussion paper is based on facts and figures, using the example of a small town, showing the relative efficiency of the respective systems. The results underline once again the need for a data-based approach for the optimization of both the cost as well as the quality side. Since mobility is a complex and fundamentally individual construct, analyses such as these cannot be applied as a blueprint to any territories, but require a case-specific adaptation.

Changing mobility

The mobility market is undergoing a **dynamic change**. Keywords such as 'smart mobility' or 'new mobility' as well as 'digital platforms' stand for this change. Digitisation, the increased use of data and the increasing consideration of individual needs of users of mobility services should be mentioned here (cf. Fischer 2018: 11 f., cf. ADAC 2017: 6 ff.). Innovations such as the development and provision of digital mobility platforms lead to a growing importance of flexible and **individual forms of operation** in public transport (see Digital Summit 2019: 6 ff., see Rödl & Partner 2019: 6 f., cf. Rodi et al. 2019: 1, Münchner Kreis 2017: 9 ff.) Although individual forms of operation such as call-gathering or call-line taxis are not a new phenomenon in public transport, digital solutions and data-based planning will make them more convenient for users and more economical for transport companies and public transport operators (cf. Schönberg et al. 2019: 5, 11, 13).

In this context, the term **'on-demand mobility'** has been used for some time as a synonym for modern forms of individualised forms of service in public transport. However, these can only play their strengths to the fullest if they are sensibly integrated into the existing public transport system. In this way, cannibalisation of existing public transport can be avoided, and optimised for users, transport companies and public authorities. This is particularly noteworthy against the background of the central role of public transport in the transformation of traffic and climate. Public transport must be developed more efficiently and effectively as well as in a more customer-centred manner and latent **potential for optimisation** must be exploited (cf. Schönberg et al. 2019: 6 et seq., Sommer et al. 2016: 12). This is not only a question of economic viability, but rather to optimise the cost recovery ratio and to use financial resources sensibly to improve the quality of the overall public transport system. In this context, existing **urban bus systems** as an essential component of public transport, especially in small and medium-sized cities, should be strengthened and made more attractive. The on-demand mobility solutions can contribute to this and meaningfully supplement public transport with individual public transport, thus contributing to a flexibilization of existing public transport systems.

The question now arises to what extent the **flexibilization** of existing city bus systems in the direction of flexible line systems makes sense regarding the overall urban public transport system and what role the new on-demand mobility offers play in this context.

Public transport must be developed more efficiently, effectively and customer-centred and latent potential for optimisation must be exploited. This is not just a question of economic viability, but rather of optimising the cost recovery ratio and using financial resources sensibly to improve the quality of the overall public transport system.

Relative advantages of line and area traffic

Line and area traffic are often presented as opposites and less of an attempt is made to view them as integrative. The discussion about the advantages and disadvantages as well as the degree of innovation of on-demand transport is often discussed by both proponents and opponents more emotionally than fact-based. While proponents emphasize the many possibilities of digitalization, sceptics see classic scheduled services as the best approach to efficiently bundle transports.

Scheduled services have various central **advantages**. So, they assign a high bundling capacity with a clearly directed demand structure. They have, through a communicated and stable timetable, usually a high degree of temporal reliability. Especially in settlement structures with a clear orientation towards the next middle centre (e.g. in valleys) they show a great development performance.

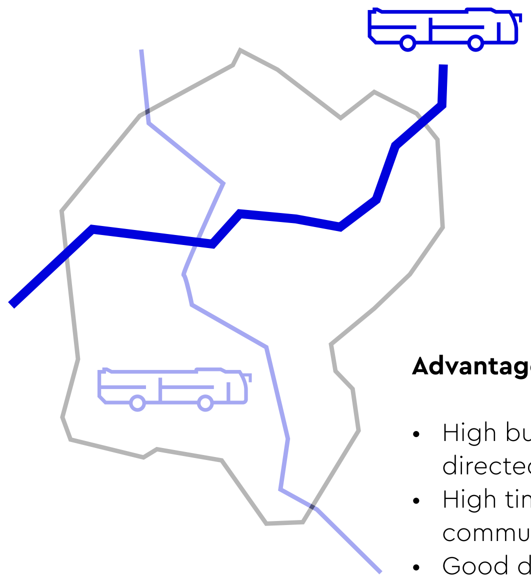
Different **advantages** can be cited for area transport ('on-demand transport'). They thus enable direct, transfer-free service on many routes. They enable the targeted supply to the higher-level public transport system. They are able to bundle demand. Furthermore, they show a high degree of flexibility and benefit orientation (needs-based).

In principle, it cannot be said that one system is better than the other. The assessment of the systems is much more complex, since a multitude of specific characteristics of the respective traffic areas must be considered. Thus, the following questions are of central importance for the **evaluation of the systems:**

- What is the **settlement structure** and thus the natural ability of the systems to bundle?
- What is the **volume** of **transport** demand?
- How is the demand for transport structured **spatially and temporally** dispersed?

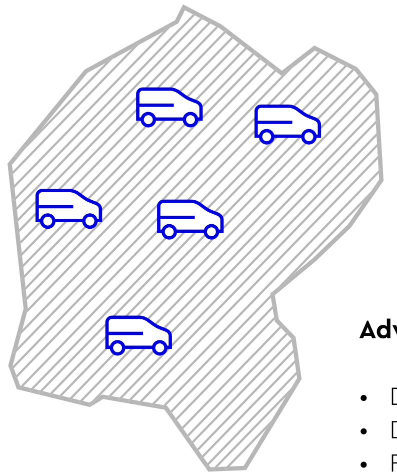
In addition, different objectives in terms of costs, quality and efficiency must be considered when planning offers. In general, it can therefore be stated that, depending on planning objectives and market structure, either scheduled or surface transport can be advantageous.

Advantages of line and area traffic



Advantages of scheduled services

- High bundling capability with clearly directed demand structure
- High time reliability through communicated timetable
- Good development performance in settlement structures with clear orientation to the nearest middle centre



Advantages of area traffic

- Direct service of many relations
- Demand pooling
- Flexibility in terms of space and time and thus stronger user orientation (needs-based)

A possible use case is, for example, the **tendering of an urban bus network or sub-network** and the related question regarding the most cost-effective option. The assessment of the advantageousness of the transport systems should always be data-based.

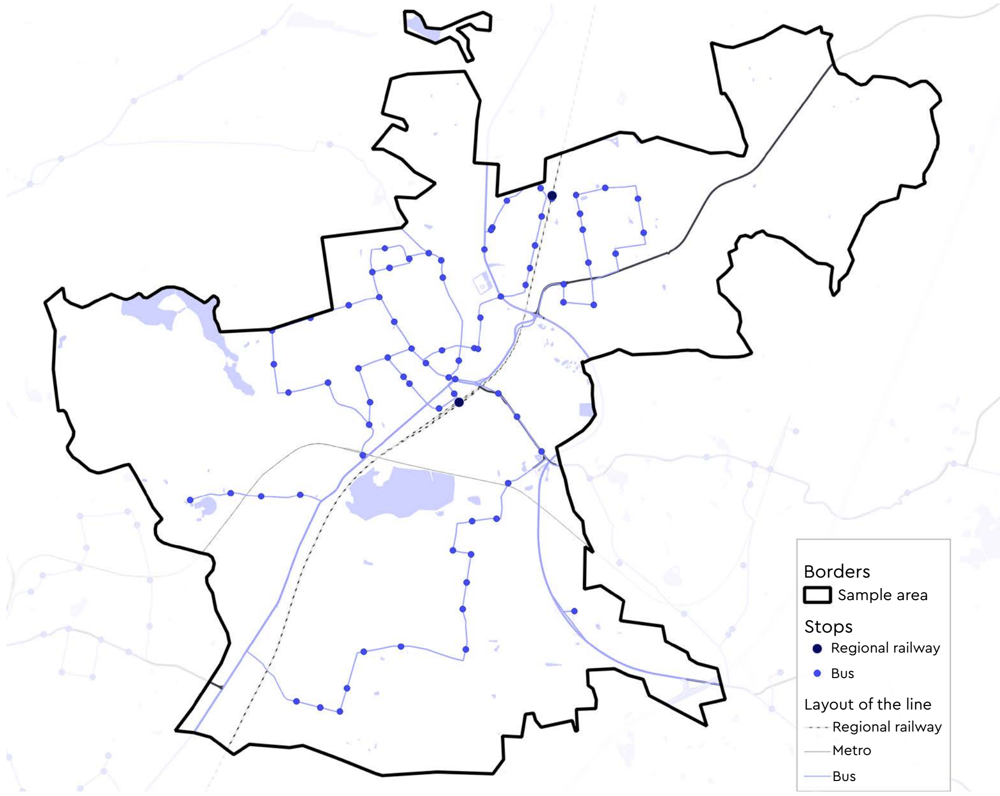
Using the example of a representative small town, the analytical approach pre- and evaluation of line and area systems is shown.

Data-based analysis of line and area traffic

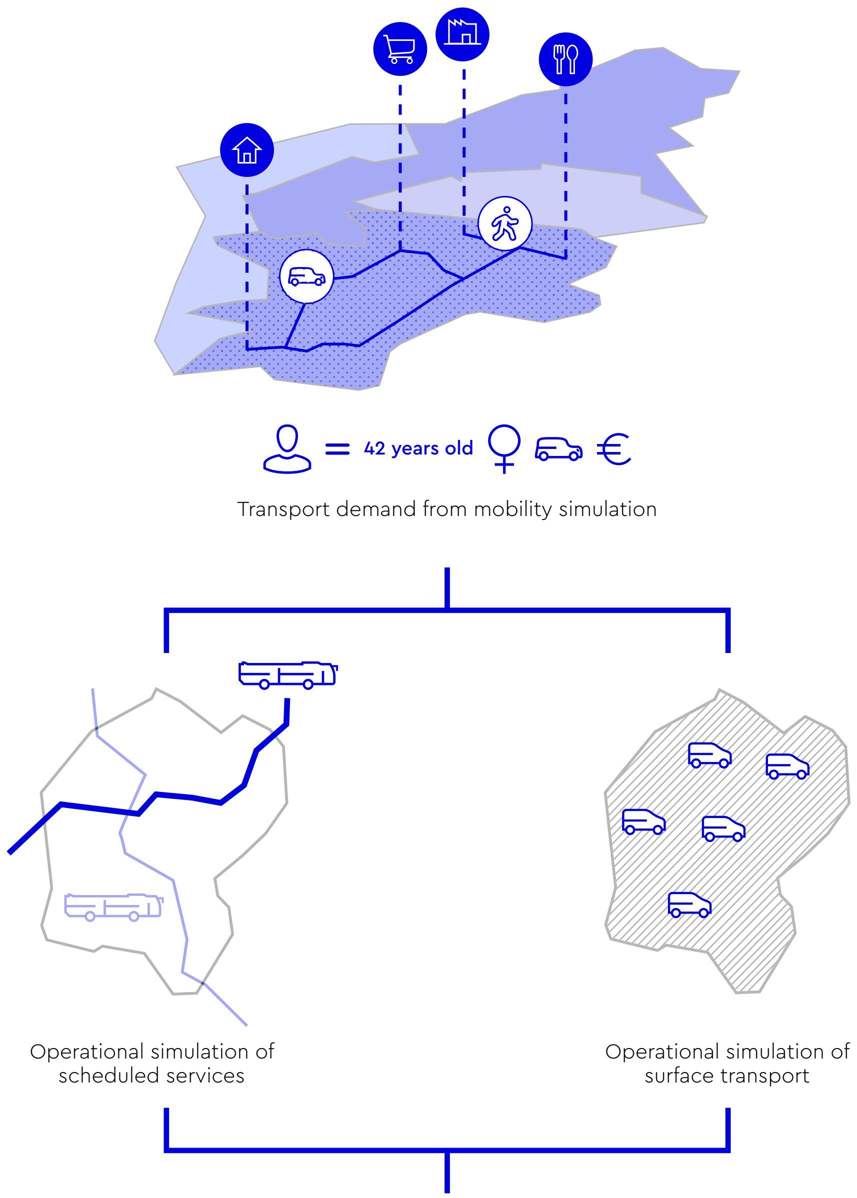
The data-based assessment of the relative advantages of land and line systems is carried out based on a **representatively selected small German town**. The city has a population of about 30,000 inhabitants and is the largest city in the county. It is a middle centre, which is adjacent to a large compression space, with a strong economy and many utilities.

The fulfilment of the main activities takes place in the city centre. Commuting to the nearby metropolis is essentially via a regional train station and a subway. Besides breaking in and out regional bus lines have their own urban bus system. The bus system connects the city districts and serves the inner-city traffic demand mainly every half hour. The seven bus lines meet at the train station as the central hub in the city ('rendezvous concept'). There are 78 stops spread over the city. Further is used in rush hours as an additional amplification line for school traffic. The bus system comprises over 350 daily trips with up to 13 vehicles at peak times.

Example area with current public transport stops



Schematic representation of the analysis model



- Operating figures
- Quality of services
- Costs

The analysis model provides a **system comparison** between the classical bus and more recent on-demand traffic. Many determinants remain constant in this model. These are the stop infrastructure and the underlying transport demand, in individual scenarios, also the number of drivers and vehicles used. The essential difference is that the bus can move flexibly in the traffic area. It's like 'letting him off the line.'

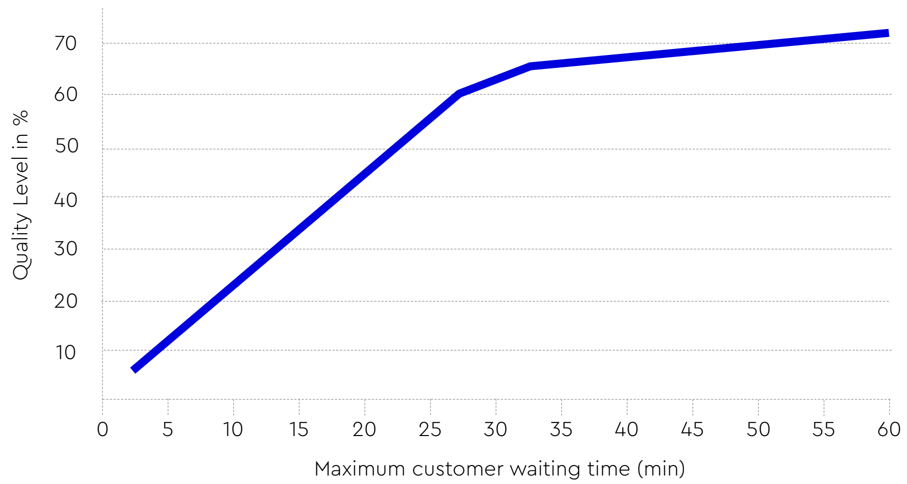
The analysis takes place in five steps. Firstly, within the framework of a mobility simulation **today's mobility needs** are determined. Thereupon follows an assessment of the quality of the **current bus service** in the city. The central question here is what quality of supply, including in the form of travel time and waiting time, for how many citizens is available and what mobility needs cannot be satisfied with the current offer. In the next step, an **on-demand offer is calculated**, which is based on the following key questions: Will this, compared to the current situation achieve a higher customer benefit with the same number of vehicles? Can the same level of safety be achieved with fewer vehicles or vehicle hours? Can customer benefits be achieved at lower costs?

Variations of the required on-demand offer are then by consideration of the **factors of market share and traffic volume** calculated to reflect the development of costs as market acceptance increases to be able to simulate. Finally, the variation takes place via different **quality criteria**. Regarding the necessary data, the following are required for the implementation this analysis of door-to-door mobility needs, the public transport timetable, the bus stops, stop-specific changeover times and road infrastructure are necessary as input variables.

The **daily, motorised transport demand** comprises about 60,000 routes, which are derived from a highly detailed microscopic traffic demand model. Incoming and outgoing paths will be determined, if reasonable, to or from the nearest underground or regional train station.

Depending on the accepted waiting time, the current bus system offers a different **quality level**. It increases due to the current 30-minute cycle only significantly with higher average waiting times. This cannot be offered to nearly 30% of the population – this is among other things due to a too low density of stops.

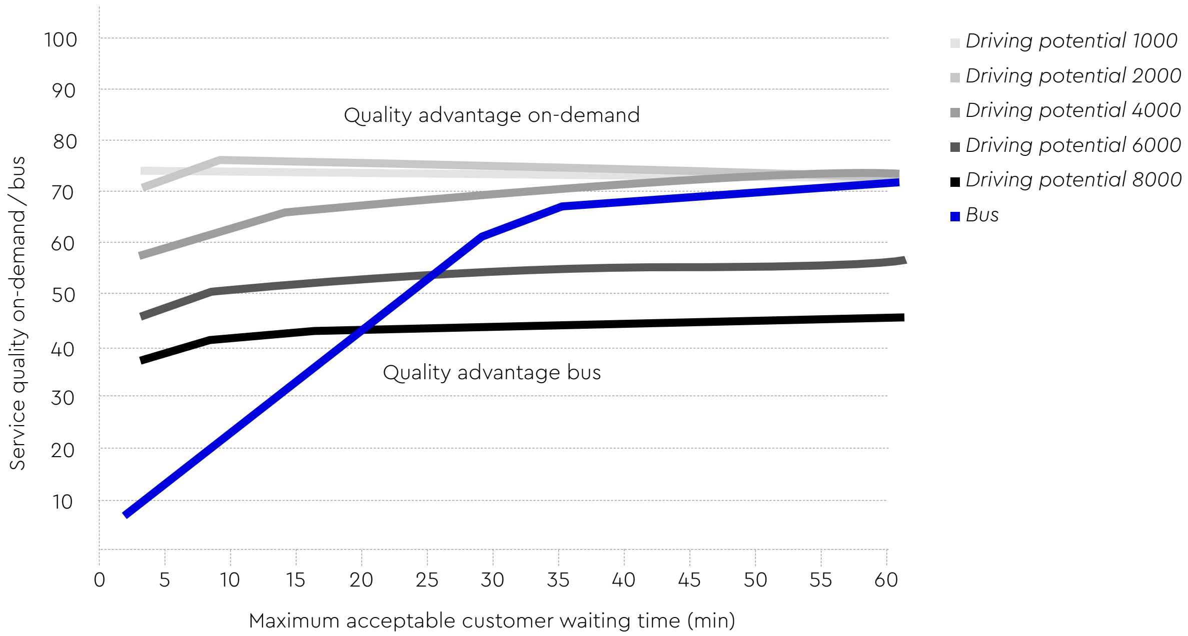
Proportion of fulfilled customer promises in the bus after waiting time



The transport system can be considered in two scenarios. On the one hand the quality can be analysed while maintaining the same cost structures. Hereby, the number of vehicles in area traffic corresponds with the current bus service. On the other hand, the costs can be reduced while maintaining the same level of quality compare. In this case, the quality of the area traffic corresponds with today's bus service.

In the **first scenario**, **higher quality values** can be achieved with the **same number of vehicles** in on-demand traffic, depending on demand and the demand for permitted waiting time. The following figure illustrates this.

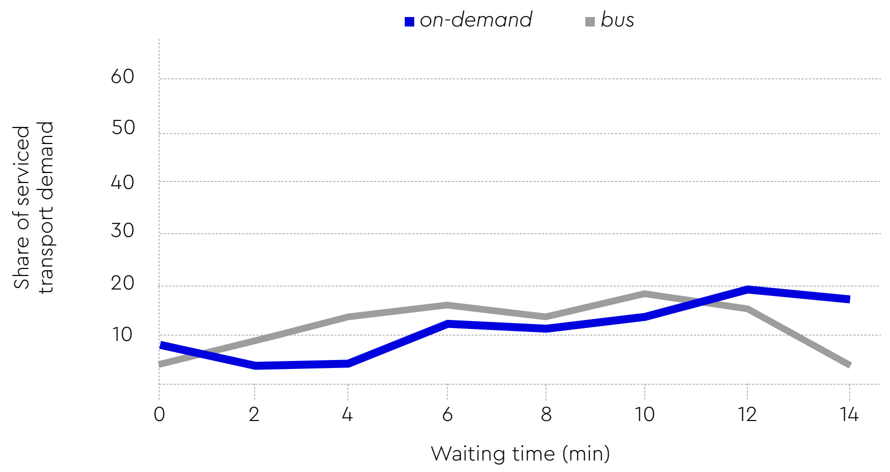
First scenario: Quality advantages in comparison

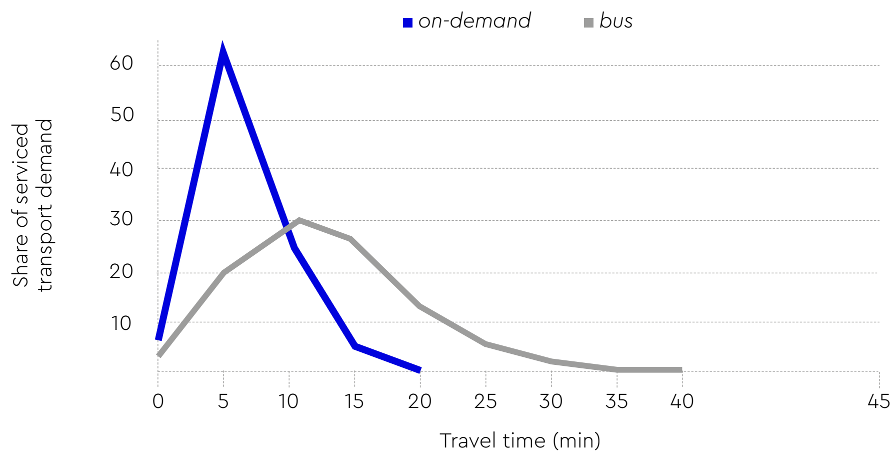


The analysis shows that with an accepted waiting time of 20 minutes and 4,000 accepted passengers, a service level of 45% can be achieved in today's bus traffic, whereas in on-demand traffic with the same number of vehicles the service level is 68%.

Comparing the distribution of waiting and travel times in the scenario with 2,000 passengers, it is shown that with the same number of vehicles and comparable waiting times, passengers reach their destination much faster with surface transport. Although on-demand traffic also creates detours due to so-called pooling, there are no changeover procedures and the transport is comparatively direct on many routes.

Distribution of waiting and travel time to the served traffic demand





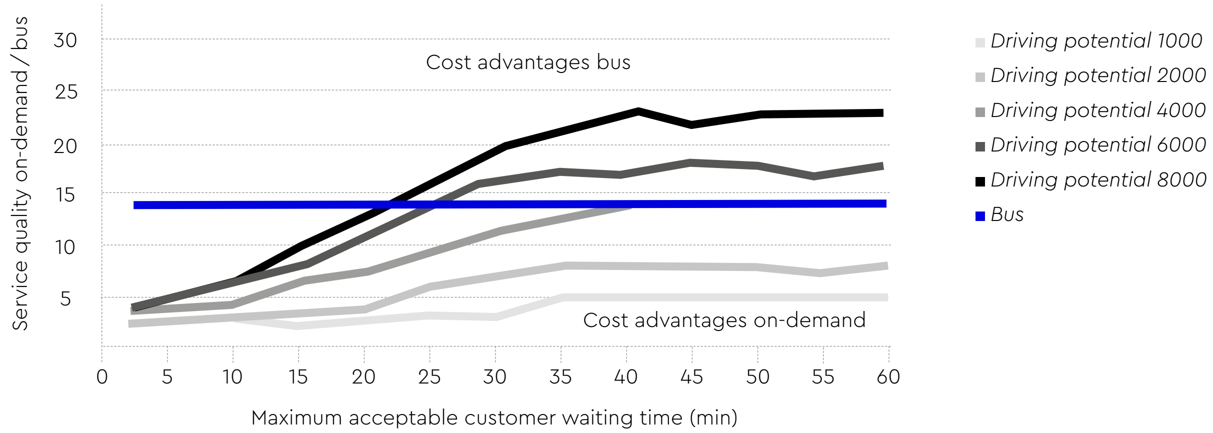
The following diagram shows an analysis on which door-to-door relations the travel time advantage of an on-demand system is particularly large, which at the same time provides inspiration for the optimization of the overall system. **It becomes clear that mobility wishes are not oriented along lines but are based on numerous points of possible activity.** With the help of an area system, these relations 'beyond the lines' can be served noticeably better.

Relationships, which are determined by an on-demand system especially benefit

The **second scenario** shows that, while **maintaining the same quality** depending on the demand for transport, an on-demand system can **save costs** in terms of the vehicles required compared to the bus. The basic assumption is that with increasing, accepted waiting times, the demands on the quality level (analogous to the service rate of buses) also increase.

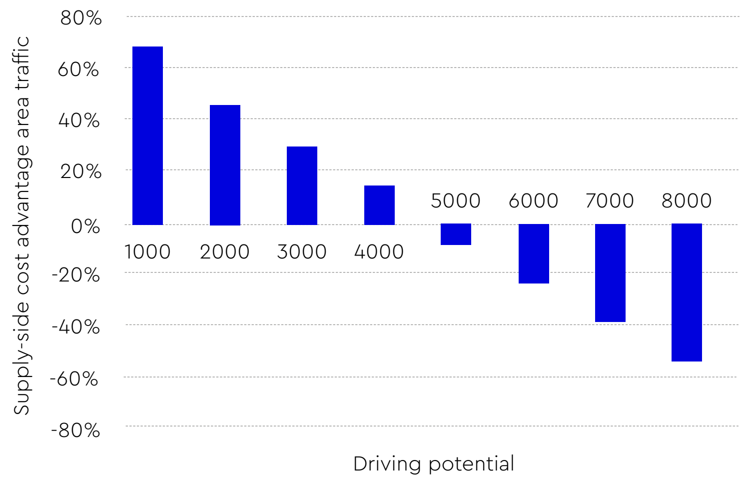
The costs of the systems are determined by their efficiency in terms of space development (supply) and their specific cost rates (production costs). While production costs depend on vehicle and driver costs, supply-side costs are determined by the amount of capacity required (vehicles/seats).

Second scenario: Cost advantages in comparison



Regarding the small town described above, with a passenger potential of 4,000 passengers, supply-side cost advantages of up to 15% can be achieved with an on-demand system. The following figure shows the cost advantages for a waiting time of 30 minutes and a service quality of 62%. Further opportunities are offered by more cost-effective production possibilities, which can be realised in the case of a new tender for an urban public transport system (fleet renewal). Particularly at these times, it is therefore essential to take a close look at the future supply structure.

Cost comparison bus and on-demand system



In summary, the central **result of the analysis** for the representative city described above is the fundamental statement that both systems have their raison d'être. Scheduled services are particularly useful where demand can be bundled well with good travel times, without a fine-meshed service of e.g. individual settlements. On-demand transports are particularly suitable for a dispersed mobility demand at a lower level. Within a city, there are strong spatial and temporal differences in the relative advantage of the respective system. **Looking at the bus systems in small towns today, they are often oversized.** Here there are opportunities regarding the mixed use of scheduled and surface transport. Significant **cost savings** are possible if the settlement structure and disperse demand in cities favour on-demand transport. At the same time, there is an opportunity to **improve the quality** of mobility services by making the existing urban bus system more flexible. The decisive aspect is the joint, data-based planning of the systems in the sense of a strengthening integration of the on-demand services into the existing public transport structure of the city.

Action recommendations for the optimisation of urban bus line systems

If small and medium-sized towns and cities want to plan a new bus system or optimise the existing system, this should generally be done on the basis of a **data-based analysis**, as presented in this discussion paper using a representative medium-sized centre.

In addition to the **'classic' regular bus service**, new forms of so-called 'smart mobility', such as on-demand transport, but also **offers** from the field of micro-mobility, should be considered.

The analytical, data-based approach makes it possible, adapted to the respective traffic area, to show **opportunities** for urban mobility by means of simulations and to perspectively optimize the traffic system in terms of quality of supply and economic efficiency by means of **on-demand offers**. This optimisation of the bus system can range from an approach that complements the existing system (integration approach) to a complete system change in the sense of a more flexible urban bus system (substitution approach). In principle, no generally valid statements can be made here, as the respective transport demand, settlement structure and the respective conditions and municipal requirements and interests are different. Therefore, a **case-specific** analysis is always necessary to find out which system can best exploit its advantages, whether planned jointly or individually, in order to strengthen urban public transport in terms of economy and quality of service.

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