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Automated vehicles in a major European city – a technical perspective on urban transport policy options: the case of Vienna

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Abstract

Introducing automated vehicles to the urban mobility system will certainly bring changes for mobility behavior and will thus impact the effects of traffic in the city. The development path is very uncertain from a current perspective but several opportunities and risks can be envisioned. Several experts in the Vienna City Administration have seized the opportunity to reflect on the City's objectives for urban and transport development matching them with expected risks and opportunities in this formative phase. In addition, instruments at the disposal of an urban municipal administration were collected in the areas of "public spaces and street infrastructure", "land use and settlement patterns" and "traffic system management", which could help gearing developments towards the transport policy goals. It is expected that the findings are valid and applicable to a large extent to other large European Cities.

Keywords: Transition to Automation; Regulatory Framework; Spatial Planning; Mobility as a Service; ITS and Traffic Management; Mobility in Smart Cities; Political and Legal Framework.

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1. Introduction

Taking the recent advancements in development of automated vehicles into account, it is likely that such vehicles will be part of the traffic in urban areas, even if expectations about the time of introduction and increasing market penetration vary in the expert community (see e.g. ITF 2015B; Chase, R. 2016; DCI 2017; REUTERS 2017). First test scenarios such as the Sion “SmartShuttle” are being implemented (PostBus 2015), and more are under preparation; see e.g. the case of a large car manufacturer in Munich (Muenchen.de 2016) or minibusses in Vienna (Wienerlinien.at 2017). Several conceivable scenarios indicate that this will lead to a significant change of urban mobility.

In comparison to the work done with the aim of solving technological challenges or focusing on motorway or rural road implementation of automated vehicles, only a few studies have selected effects of automated vehicles in urban areas as their field of study or looked at systemic effects, a conclusion similar to the one reached by Gruel, W. and Stanford, J.M. (2017) in their literature review. Internationally recognized were, amongst others, the work of the OECD International Transport Forum for Lisbon (ITF, 2015A) or Friedrich, M. and Hartl, M. (2016) for the Stuttgart region. The conclusions of both are highlighting the importance of ridesharing to gain benefits on a systematic level and show possible effects of unguided developments.

Urban administrations have a specific responsibility towards their constituents, their quality of life and the assets within the territory. Changes in mobility behavior can strongly affect these areas of responsibility. To manage the change, very different dimensions and plans may be addressed. International agreements, standardization or national laws (e.g. vehicle approval, road code, regulation on insurance) will have a tremendous impact. Can urban administrations play a role in that framework? Are they limited to lobbying interests at e.g. national level? So far municipal administrations have been hesitant in taking up the topic, even in long term strategic documents (see e.g. Vienna City Administration 2015; Guerra, E., 2016). This paper attempts to describe in particular the measures urban administrations can take independently to unlock potentials and mitigate risks of a future urban mobility system with automated vehicles.

The items presented in this paper were gathered mainly in the course of a working group within the Vienna City Administration, bringing together experts from different fields such as urban planning, transport system planning, roads infrastructure, traffic management, public transportation, transport law and ITS. The expertise is based on the knowledge of day-to-day operational requirements of a city’s transport system, includes the strategic planning goals and is enriched by exchange of experience in (international) networks and desk research. The expressed views collected in this paper are those of individual technical experts and do not reflect an official policy. Policies of public sector institutions are usually based on a broader societal consensus and are strongly oriented along the priorities of elected political representatives. The topic of automated mobility has so far not matured sufficiently in either dimension but

2. Automation in the transport system from the perspective of an urban administration

2.1. Focusing efforts

Automated driving touches a broad variety of domains. An initial screening quickly showed that technology development is and has been borne by the industry together with universities and research institutes (vehicle technology, connectivity, HMI, technology acceptance, etc.). The framework for application will most likely be determined by international standardization and regulation in the competence of the national and European level (interoperability, regulation of natural monopolies, classical road safety, IT security, liability, etc.). The receding of the debate after the publication of the BMVI (2017) on ethical questions may be indicative also in other areas. City administrations do not have the resources to parallel this work nor does this seem to be a necessity. What is vital is that the various stakeholders in research and development hear the voice of cities and include considerations for a sustainable and livable urban environment.

Urban municipal administrations can provide a setting for automated vehicle testing and development. This paper does not look further into industrial or R&D policy and test beds. It is focused on technical transport and urban planning questions. It is structured along three dimensions: “public spaces and street infrastructure”, “land use and settlement patterns” and “traffic system management”.

Transport service provision is an important topic in the context of autonomous vehicles. On the one hand, it may be expected that there is no alternative to high volume public transport in dense European cities, on the other hand, automation could provide the opportunity for a blurring of definitions of private and public transport. In the present paper it was not possible to include further elaboration on the field of transport services. Due to the high consciousness of the City of Vienna for public services and the ample opportunities to shape the future together with the City’s public transport company “Wiener Linen”, this topic would merit a proper paper but exceeds the possibilities available here. On the contrary, this paper addresses, even more exclusively, instruments that are directly at the disposal of the municipal administration. Irrespective of this, the major role of public transport and an increased sharing of vehicles and rides is included as an assumption for most of the opportunities described further below.

2.2. Strategic objectives of the City of Vienna

In strategic processes the City of Vienna has identified, adopted and published its vision and goals for future development (Vienna City Administration 2014 A & B, Vienna City Administration 2015). The top objective is to maintain and improve the high standard of the quality of living. In a modern pluralistic society, based on the division of labor, many relations exist leading to trips of persons and transport of goods. Traffic is the result of the needs and desires of people. Making mobility possible, is thus a contribution to the quality of life and may even be seen as part of public service provision. In this light, it is necessary to balance the equally present negative effects of traffic (use of space, emissions, use of energy, accidents, congestion, etc.). It is the task of urban and transport planning to achieve this balance for a city. A future introduction of automated vehicles does not change the task, but the challenges encountered. For example, Crayton, T., Meier, B., (2017) emphasize the public role in relation to public health. Similar reasoning is applicable in other fields. Following an expert assessment, it has been determined that the strategic objectives for urban transport planning could be maintained independent of the level of automation or autonomy of vehicles. A condensed version of the Viennese objectives with continued validity is:

- Mobility serves economic and personal development.
- Mobility is thus a factor for the quality of life in a city, but traffic should be controlled to not impair quality.
- Traffic operations must be balanced between personal benefits and external costs.
- Traffic must be shifted to space-efficient transport modes.
- Health can be improved via physical activity in daily routines, traffic safety and protection against harmful emissions.
- Mobility forms part of public service responsibilities (social inclusion).
- Taking life-cycle costs into account as well as a generally prudent and efficiency-based approach to public spending.

These objectives set the frame for an appraisal of chances resulting from the introduction of autonomous vehicles in the transport system. Only based on this set of objectives and the values reflected therein, is it possible to determine whether developments and effects are actually considered opportunities or threats. It is also the first step to determine which actions must be taken. It shows that it is an important public task to shape the future traffic system by setting a sensible regulatory framework.

3. Activity spheres of an urban administration in relation to the introduction of autonomous vehicles

3.1. Public spaces and street infrastructure

Management, maintenance and development of public streets and squares are a responsibility of municipalities. The design of public spaces and roads has direct effects on traffic and mobility behavior. Automated vehicles, will have to be able to adapt to the existing infrastructure on public streets like all other street users. Thus the infrastructure design sets requirements for the vehicle technology and, in addition, determines maximum traffic volumes. It may even determine the extent to which certain transport services can be delivered in case they depend on the allocation of public space.

3.1.1. Opportunities and threats in the dimension of public spaces and street infrastructure

Automated vehicles could introduce a major change in public space allocation. In scenarios based on intense ridesharing, studies e.g. by ITF (2015A), Friedrich, M. and Hartl, M. (2016) or Huß, S., Frick, C., Keck, M. (2016) concordantly assume tremendous decreases in required parking space. Some assumptions went as far as formulating "on-street parking spots could be totally removed from the streets, whatever the scenario considered" (ITF 2015 A).

Given the fact that on weekdays Austria has an average of 1.3 persons per car (BMVIT 2016) and – especially in peak hours – many people have similar trips, ridesharing obviously is a leverage for reducing car traffic.
However there are two main obstacles for ridesharing today: a lack of information (who has a similar trip at a similar time?) and security concerns. Technological progress might help to overcome these problems. People might hail autonomous vehicles with their smartphones. A platform operator would manage the fleet of AVs and the trips requests by the customers.

Applying the above mentioned results concerning decreases in parking space to the street system in Vienna's inner districts (1 and 3-9), calculations showed that up to 400,000m² of public space could become available. This equals more than 3 times the area of one of Vienna's main parks "Stadtpark". These are excellent news for urban planners. Especially considering that Vienna grew by 201,000 persons in the last 9 years and 2/3 of this growth took place in existing parts of the city (internal research, not published). Assuming that not all existing infrastructure have considerable over-capacities, an increase of population density in existing structures puts some additional pressure on them. Especially for infrastructure which need a lot of space (parks, schools) it is challenging to keep up with this additional demand.

Allocation of the potentially unlocked on-street parking space will be a determining factor: If it is used for more green spaces in cities, places for stopovers and sojourning, space used by businesses, etc., significant quality of life and productivity gains for urban locations could be the result. More attractive infrastructure for walking and cycling may lead to a boost of these transport modes and the benefits associated with them.

The space could also be used for motorized traffic. Obviously there will be a strong need for pick-up/drop-off and loading/unloading areas. Such areas will be instrumental for maintaining the functioning of the city and maybe even unlocking potentials of automated vehicles. Compared to current on-street parking this utilization is characterized by very short occupancy and thus also a reduction of absolute space required.

A claim for additional motorized vehicle lanes is also a realistic scenario. In case of space and cost-efficient ways of travelling such as public transport or ride sharing, this might unlock additional benefits for mobility such as quicker travel times or a higher total capacity. However, any reallocation of current on-street parking space towards driving lanes would lead to more energy consumption, emissions, less public space available and separation of urban quarters. Thus an allocation of additional public space for low occupancy or individually used vehicle traffic, whether automated or conventional, is not in line with the current transport policy and urban development objectives in Vienna.

The extent to which public spaces will be claimed by elements belonging to new digital infrastructure for transport is currently unknown. Primary planning considerations in this regard must depart from the needs of non-motorized road users and non-traffic related public space uses.

Infrastructure maintenance, including street surfaces and road markings, signs and electric equipment, burdens local public authorities with high running cost already today. The roughly 2,800 km length of Vienna's road network – nearly the driving distance from Madrid to Warsaw, and 1,300 traffic signals are indicative of the volumes involved. Increased quality standards with the need for increased efforts in monitoring or maintenance intervals could significantly increase these costs. Taking into account that budgets of local public administrations are already strained by many different tasks and requirements, a cautious approach should be taken in accepting further burdens.

Traditional elements of street infrastructure were the main focus of the paragraph above. Connectedness of vehicles obviously adds an additional dimension to the discussion: digital roadside infrastructure and new elements required for vehicle to infrastructure (and vice versa) communication (V2I). Certainly, officials and technical experts within city administrations recognize the potential benefits of these technological additions. If the quality and standards for the abovementioned traditional infrastructure elements are already strongly debated in the light of costs and burdens on public budgets, it is obvious that this debate is even more intense around new responsibilities. So far a conclusion is not achievable as there is too little information on the technical options, benefits and costs. One major consideration are potentially very short maintenance cycles of electronic/digital infrastructure compared to built infrastructure. Also, the awareness about a high risk of sunken costs due to technological evolution is present.

Several of the principles mentioned in sections 2.2 and 3.1 will be relevant in the valuation of the technological options. Because of the need for self-sufficiency of autonomous vehicles and cost as well as public space design arguments, the current debate leans towards the position that a complete retrofitting of urban streets with V2I may not be the future. From today's position, an outfitting of selected points (e.g. intersections where significant efficiency gains can be unlocked or street sections with high potentials for safety increases) seems most likely. Similar views are concisely presented in NACTO (2017).

Modern approaches to traffic management may be closely related to digital roadside infrastructure, but also the use of alternatives, which are initially independent of traffic infrastructure (e.g. cellular networks), are solutions that are being developed. It is quite certain that digital infrastructure will be required at the backend, which may, however, be centralized (see also subsection 3.3.2.). For both this topic and the aforementioned V2I considerations, there is an ongoing discussion on opportunities and threats.

Finally, a recurrent topic is that of specially protected street areas for automated vehicles to avoid potential conflicts with conventional vehicles and non-motorized road users. Such exemptions could be possible for a short phase of testing for technological development, and as such would also be limited to a small area. On a larger scale, for example a whole metropolitan area, and as a regular feature this would most likely lead to great inefficiencies in the allocation of the resource "public space". Also, as it would introduce further barriers, it contradicts urban planning goals of highly interconnected urban quarters. Both aspects are not desirable from a societal point of view and could significantly impair the quality of urban life.

3.1.2. Key measures in the field of public space and street infrastructure design

To unlock potentials of a mobility system with automated vehicles and prevent negative impacts, the following infrastructure and public space design measures in the responsibility of a local public administration appear most effective at the current state of knowledge:

- Application of design principles prioritizing the needs of pedestrians, cyclists and high volume public transport.
- When the need for on-street parking decreases, reallocating on-street parking spaces to create inviting, high quality urban public spaces focusing on the needs of local users.
- When the need for on-street parking decreases, reallocating on-street parking spaces to create structured hop-on/hop-off bays and loading zones.
- Conscious, if necessary restrictive, approach regarding new infrastructure elements (on-street controller boxes, masts, cables, etc.).
- Generating a clear picture on the benefits and costs of individual digital (roadside) infrastructure and V2I solutions, focusing on their contribution to managing traffic volumes on a large scale (see also subsection 3.3.2.; second paragraph).
- Reserved lanes for low occupancy automated vehicles are not compatible with objectives for urban public space.
- Requiring automated vehicles to be able to cope with today's infrastructure service level.

3.2. Land use and settlement patterns

There is a close link between traffic volumes and land use patterns. Effects of measures in the respective fields can travel both ways. Municipalities have powerful tools to structure settlement patterns and influence land use. Due to the Austrian federal constitution, where legislation for zoning and building is at the level of provinces and the fact that Vienna is both a province and a city, there is great freedom to design powerful and effective measures.

3.2.1. Opportunities and threats for settlement patterns from automation in mobility

Empirical research based on mobile phone location data shows that a population living in dense urban quarters with a huge variety of facilities actually travels shorter paths (internal research, not published). As the population in these quarters has a socio-economic status slightly above average, it seems likely that they manage to satisfy their needs in a relatively small catchment area (Peters-Anders, J., et al., 2017). This means that they produced fewer km travelled by choice, not due to (economic) restraints.

Considering a transport system where automated shared vehicles as a transport service play a significant role, it seems possible that trips in the (urban) periphery and along less frequented relations become more easily accessible (customized times of departure, more direct, shorter routes, affordability of such services, …). Essentially, this means the benefits of individual motorized mobility may be enjoyed by an even larger group of persons. Also the individual use of vehicles may become more attractive as the need to actively drive vehicles decreases (see also assumptions on cost of travelling by Trommer, S., et.al., (2016)). Several personal preference dependencies have been noted in the discussion on expert level. Both of the described changes may increase accessibility of locations in the urban periphery and thus positively impact their attractiveness.

Although better accessibility in the periphery is a desirable effect, it can also comprise undesirable consequences. It may lead to reduced efficiency of land use compared to urban centers, and thus urban sprawl and an overconsumption of green and natural spaces. After all, car traffic requires at least 10 times, in peak times at least 20 times more space per person than mass transit (Randelhoff, M. 2014). This is why mass transit helps to preserve non built-up areas and avoid massive car traffic congestion at the same time.

AVs may lead to longer trips and thus more traffic volume with the well-known problematic implications (energy consumption, emissions, etc.). Due to interdependencies between possibilities in mobility and settlement patterns, urban structures may develop in a way that proliferates captivity within motorized mobility options, leading to associated problems such as private household expenses, physical activity levels, etc. In a longer term, ample development possibilities at the urban periphery and less resistance for mobility could also threaten the functionality of urban centers, which draw their qualities from density and diversity which may decrease as it is increasingly located in the periphery.

Section 3.1.1 describes expected opportunities resulting from the decreased need for on-street parking. Some of the studies cited above go beyond that and expect that in favorable scenarios, even a significant amount of off-street parking capacities would not be needed any longer (ITF 2015A). This space could be used differently, and potentially allow an increase of high value uses in cities. Also the costs of building/providing off-street parking facilities are finally paid by users of buildings, sometimes irrespective of whether they actually need them. Reducing the costs is desirable for any kind of user in the building and should abe an objective.

3.2.2. Key urban and spatial planning measures to manage developments driven by a mobility system with automated vehicles

Settlement patterns are managed and shaped to a great extent through zoning plans and the building code. The paradigm of spatial planning is of a conservational, protective nature. Spatial planning measures therefore seem especially suitable for preventing the incidence of the risks as described above. In addition, some cities actively develop new or renewed urban quarters, mostly with partners in the private sector and can thus influence via contracts or technical decisions:

- Settlement boundaries could prove especially effective to control urban sprawl.
- A conscious management of the quantities of available land for urban development through zoning is recommendable to ensure that an adequate level of efficiency (often hand in hand with density) of land use is met, even considering a framework of improved accessibility at the urban periphery. Feedback loops with developers and monitoring of market prices provide essential information to achieve a good balance.
- Cooperation and agreements across administrative borders could reinforce these instruments to ensure stringent urban development in functional urban areas.
- Currently the building code in Vienna, similar to many other cities, requires developers to build parking spaces. Taking into account that current amounts might not be functionally required in a mobility system with automated vehicles and innovative transport services, a revision of such requirements could unlock the abovementioned potentials.

3.3. Traffic system management

In an urban setting, with the often manifold mobility options and a dense network of streets, a large variety of incentives for medium and short term mobility behavior must be considered in the framework of traffic management, going beyond (local) road capacity management.

3.3.1. Opportunities and threats for urban surface traffic in scenarios with automated vehicles

Monitoring the discussion at EU level, the assumption that automated vehicles will also boast a high level of connectedness seems a likely scenario. This paves the way to unlock benefits from highly up-to-date traffic information and active routing guidance to vehicles. Schedulable capacity restrictions (e.g. road maintenance), recurrent bottlenecks or also congestion resulting from unperceivable events (e.g. accidents) could be covered.

High vehicle connectedness could allow for more comprehensive information of urban authorities about traffic flows and volumes. This information could be used to improve planning decisions or the above mentioned active capacity management, see also Van de Weijer, C.J.T., (2017). A higher coverage of reported vehicles and close to real time monitoring would cater to this. The main improvement compared to the current situation is expected to be a significant cost reduction for gathering information and at the same time an unparalleled increase of precision. Increased expectations and thus costs for urban administrations could be perceived as a threat but should be balanced against societal benefits.

Traffic calming for residential areas relies amongst others on information concentrating traffic on specific routes. This information is given to drivers in maps and signs, on the one hand, and, on the other hand, also through infrastructure design (more or less generous street space and straight lanes for motorists). In some cases, as already perceivable when using independent routing applications, the shortest or quickest route – even though not the easiest to drive – may not be along main roads but through traffic calmed areas. Should automated vehicles rely exclusively on internal optimization factors, increased traffic volumes may be found in traffic calmed areas. Additionally the sum of individual route optimizations does not necessarily lead to a system wide optimum (congestion, travel times).

3.3.2. Key measures in the field of urban traffic system management

A core assumption, embedded in section 3.1.1 and section 3.2.1, is that the need to have vehicles close to the points of origin and destination of trips will decrease with automation of vehicles, and thus also the need for on-street and off-street parking. Today parking management is probably the most powerful traffic system management tool in Vienna and is based on the desire and value to park close to origins and destinations of trips. A reduced need for this also raises questions about the effectiveness of the management instrument and its effects on mobility decisions:

- A further development of parking management and conception of potential replacement instruments with similar effects on traffic volumes independent of infrastructure design seems in order.
- Localized restrictions (and exemptions from these) are a continuous powerful instrument and may be based on vehicle types, trip purpose or time of day.
- Various financially based incentives for efficient use of transport infrastructure and services are in place in different European cities and could prove effective to control automated vehicles. Administration could also be automated and digitalized and thus avoid transaction costs (time for the person making the journey, control by the authority, etc.).
- Independently, parking management and parking restrictions must be maintained to continuously manage where vehicles may be stored.

In traffic information, the following tools could benefit from developments associated with autonomous vehicles:

- Real time information on traffic provided by the authorities. A pivotal question will be to establish standards for the interpretation of such information by autonomous vehicles. Depending on the developments, C-ITS steering signals, (dynamic) positive and negative incentives might be transmissible to vehicles directly and automatically. There is the need to work on several topics to develop a clearer picture of possibilities, benefits and costs. Amongst others, this addresses the relationship between OEM-clouds and city administration’s C-ITS and traffic management systems, the relationship between HD-

maps and city administration’s GDI (geodata infrastructure) and finally also with a link to public space and, as mentioned in the section above, V2I and electronic devices such as road-side-infrastructure (beacons, sensors, etc.) and their integration with traffic management centers. From the current point of view, several synergies could be unlocked.
- To improve the information available for municipal traffic managers, it is important to ensure access to anonymized traffic data generated by vehicles.

4. Conclusions and recommendations

In the overview of responsibilities and objectives of an urban administration, matched with the resources and competencies, a large spectrum of measures could be identified which may be used to manage mobility, even under modified conditions which will develop as automated vehicles are introduced. Many of the measures are taken from the existing repertoire of urban and transport planners. The assumptions on future scenarios including autonomous vehicles indicate a need to proactively and strictly implement these measures in the future.

The presence of several risks as described above means that a scenario with only positive developments cannot be taken for granted. Constructing an incentive system, where the total vehicle distance travelled remains constant or decreases, appears central from today’s viewpoint and when taking continuously valid objectives for urban mobility into account. Otherwise, developments could also lead to a decreasing quality of life in cities, mainly due to increased vehicle emissions, congestion, less available public space and separation of urban quarters. Success will strongly be based on efficiency gains. Key success factors are: effective public mass-transit and dense, high quality and multi-purpose ridesharing in urban quarters.

In most cases, the identified instruments must be further developed and appropriately fine-tuned to ensure that they will be able to achieve the intended effects. To this end, more research is required. The development of measures should be a priority before automated vehicles are introduced to the transport system in significant numbers. Based on this immediate action is recommended.

A task beyond the technical transport planning instruments of an urban municipal authority, but also of high relevance, is to communicate the expected changes, benefits and possible necessary new behaviors in the traffic system to the citizens. This may be necessary in particular with regard to new mobility services focusing on vehicle and ridesharing.

Finally, outside the scope of this paper, but in combination with the importance of efficiency identified also from the point of view of a municipality, the conception of new transport services (both for the mobility of persons and goods) also presents itself as a “must”. While it may be driven and implemented by private companies, there may be benefits and synergies for both sides from cooperation between providers of future services and authorities in municipal administrations. For cities such as Vienna, with a strong public transport provider, there might be additional possibilities to shape the future.

Protection of the population and public interests is a main task of urban authorities. There is currently no indication of a passive approach to these tasks or regarding the achievement of strategic objectives. It is likely that, within the described portfolio of measures, and maybe even beyond that, municipalities will be active players in shaping the future. Based on the solutions achieved with standardization issues, between governmental strata and in cooperation with the industry, the implementation of municipal measures may involve transaction costs and thus create a more or less seamless and smooth mobility for people. Involvement of municipalities at the current stage can most likely lead to better results in the future.

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