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## **Automated Vehicles and Valet Parking: Game Changer for the Future of Residential Areas?**

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### **Abstract**

In this paper, we discuss impacts of parking that can improve the land use of future cities. We identify and discuss opportunities for future development of urban residential areas resulting from vehicle automation through innovative parking management systems. A central idea here is the implementation of central parking depots, where autonomous vehicles are heading autonomously after dropping the vehicle owners at their destination. This paper highlights the resulting land use opportunities and thus can feed into future plans for low-car residential areas. We discuss two types of possible future scenarios and have a special view on innovative automated parking concepts. We also discuss examples of measures that could have a positive impact on traffic development. Thus, the paper contributes to advising local authorities, administrations and policy makers on the future development of cities through automated vehicles.

### **Keywords:**

Connectivity, Parking

### **Introduction**

The development of automation in road traffic is creating new opportunities for shaping traffic and mobility in the future. Accordingly, there are diverse and high expectations associated with this, but there are also uncertainties and unanswered questions facing users and providers of mobility, but also, for example, urban planners, municipalities and politicians. The A.R.T.-Forum research project addresses these aspects and attempts to develop recommendations and guidelines in order to make use of the opportunities arising from automated road traffic.

One scenario mentioned by various stakeholders in this context is the possibility of making the streetscape in urban areas more liveable in the future. For example, more efficient traffic could lead to less road space in total and autonomously driving vehicles could be able to perform manoeuvres such

as finding parking spaces on their own. Since many experts assume that automation alone cannot bring about such significant changes, the question also arises as to which other new mobility concepts and possibly also regulatory interventions automated driving must be combined with and accompanied by in order to bring about sustainable changes in mobility behaviour and thus provide a basis for mobility transformation.

The question is discussed whether and under what conditions it is possible, for example, to ban stationary traffic from a residential area. In this specific case, it is about a typical neighbourhood in which there is a high vehicle availability due to grown structures, but the capacity of the street-side parking space is exhausted. This leads to a high traffic volume, especially in the evening, due to parking search traffic, poses risks and obstructions, e.g. for pedestrians, and negatively affects the streetscape, since every available space is occupied by parked vehicles. Banning parking at the roadside and setting up central parking depots could be a measure to change this situation. At the same time, however, this would create new effects that need to be investigated. Since, as mentioned, automation alone can shift but not yet reduce traffic, further steps could include measures such as a combination with car sharing or ride pooling to ensure mobility but reduce traffic. The purpose of this paper is to discuss this specific aspect of changing land use in urban areas with the help of automated driving.

### **Land use in Residential Areas in Change**

The space required for traffic takes up a large part of the total land use in urban areas. In addition to space used by moving traffic (roads), large areas are also taken up by stationary traffic (parking vehicles). This aspect is particularly important in residential areas, where roadside parking is very common. This fact shows that the inclusion of motorized individual traffic was often in the focus when these types of residential areas were planned.

Today, new approaches are attempting to give urban space back to the people to create a more liveable and human centric perspective to urbanization. In many cities such as Copenhagen, Cologne, Darmstadt, Bern etc. there are already residential areas that were planned as low-car areas. With valet parking of autonomous cars there is an opportunity to support and advance this development.

### **Valet Parking - Parking Concepts for Autonomous Vehicles**

Automated vehicles open up new chances for parking concepts. Intelligent parking technology can enable autonomous vehicles to drive to a free parking lot by themselves. People could thus get out of the vehicle at their destination and instruct the vehicle to store itself (valet parking). With connected vehicles and infrastructures, vehicles have information about where free parking spaces are located. This could reduce the traffic caused by parking space search. As a consequence, new approaches to parking space management can be discussed. For example, parking space can be shifted to a location outside a residential area or the city center, thus creating central parking depots.

### **Discussion of Possible Future Scenarios**

Automated vehicles have the potential to cause significant changes in terms of traffic and urban planning. However, it is unclear how traffic will develop in the future. One aspect is that central parking facilities in combination with valet parking of autonomous vehicles can have an impact on the land consumption of stationary traffic.

In this context, two types of scenarios are expected to have a special view on impacts of valet parking and parking garages. In this context, we refer to the city types Endless City, Regenerative and Intelligent City and Hypermobility City, that Heinrichs [1] uses for his description of autonomous driving and land use. These thoughts are developed further with regards to the impacts of valet parking and parking garages. The creation of scenarios can be helpful to simulate possible developments.

#### *Dystopia: Motorised Individual Transport*

The *endless city* according to Heinrichs describes a car-dominated city. In this future scenario, the urban planning paradigm of the “car-oriented city” is still up to date. Vehicles are mainly privately owned and conventional as well as highly connected automated cars are on the road. Sharing and ridepooling remain a niche concept and also public transport is not well developed. The whole implementation of autonomous driving is theoretically possible, but fails due to acceptance of the society. The drivers want to steer the car instead of giving up the control. There also is no change in behaviour and paradigm and as a consequence also no change of the mobility system and the modal split. Level 5-vehicles are permitted in geo-fenced residential areas and parking garages. In single-family residential areas where the parking space is located on the residential property, no change is expected. In areas of higher density, such as inner-city districts, it may be assumed that central parking garages will appear or develop. The autonomous vehicle will be a luxury good that only financially well-off people can afford. Due to the high cost of parking garages and cars, socioeconomic segregation will occur within cities. The use of valet parking garages will depend on the district. This could create gated communities where entry is only possible with the autonomous vehicles. It can be assumed that when intelligent vehicles take over the transportation of people, the real estate market will change. This scenario presupposes a continuation of the suburbanization tendencies that can currently be observed around the world.

#### *Utopia: Integrated Multi-Modal Transportation*

Shifting stationary traffic to central parking garages or areas on the periphery of residential areas seems to be a good approach in the first instance to improve the quality of stay as well as the use of space within the residential area. However, a combination of several accompanying measures is required to bring about sustainable and comprehensive improvements. New concepts of parking management should not make private car ownership more attractive which in turn leads to an increase of the overall number of vehicles. Rather, it is necessary to plan for other mobility services as well. One approach here can be the introduction of collectively used mobility systems. This includes vehicle sharing (e.g. car sharing, bike sharing, scooter sharing) as well as pooling concepts, in which the travel requests of several people are combined to form a shared route.

The *Utopia concept* comprises a flexible, multimodal and connected public transport system. Intermodal mobility hubs serve to link different mobility systems. The expansion of collective mobility systems is expected to reduce the number of private cars and reduce current traffic problems. As a prerequisite for the scenario, it must first be assumed that the technology for highly automated driving will be developed to such an extent in the future that the vehicles will be able to drive independently, learn, communicate with each other and coordinate with traffic infrastructures. In principle, this corresponds to a blend of the *Regenerative City* and *Hypermobile City* scenarios described by Heinrichs.

As a result, this means that there will be fewer private cars, less parking space in streets, trips will be shared with other people, less energy used and the infrastructure relieved. The unnecessary and environmentally harmful traffic searching for a parking space would be eliminated. The reclaimed space could be used and designed by urban planning in the interests of the residents and for a higher quality of living in the city.

Finally, fewer vehicles will be necessary to fulfil the transport needs, which in turn creates the opportunity to dismantle existing traffic infrastructure and put the space gained to other uses that improve the quality of stay. Moreover, people with limited mobility could be given access to mobility and thus to social participation again. In addition, drivers are promised that they will be able to drive stress-freely in the future and make better use of the (shortened) travel times because they will be relieved of the task and responsibility of driving the vehicle in fully automated operation.

#### *Possible effects*

Both previously described scenarios are based on expectations and extrapolations. The real development could be somewhere in between the two extremes.

Fully autonomous pick-up and drop-off services in the sense of valet parking areas seem obviously tempting at a first glance. The use appears to be associated with a clear benefit for urban planners, road users and residents in residential areas. There is no need to park or find parking space. The vehicle does not have to be owned. Passengers do not need a driving license. This allows vehicles to be used by a wider range of people, including children, the elderly, and people with sensory, cognitive, or physical impairments, for example. Without a driver, this convenient door-to-door service could be offered quite cheaply and has low barriers.

This is a good concept in its theory. No matter where you are, such a service enables everyone to get around individually, cheaply and very comfortably. And exactly that is the problem: Instead of improving our cities, valet parking also has the potential to ruin them. It can even worsen the situation if it is used for conventional cars or for further developed, even more convenient sharing services. Humans always go for what is convenient. Internet shopping is the best example of this. Convenience and the comfortability to purchase anything at any time are huge reasons that online shopping has boomed over the last few years. This convenient mobility thus created can also induce traffic.

So, what would happen if everyone who used to take the bus, train or bike now calls an autonomous vehicle and everyone who was previously unable to drive also does so? Experience shows that the

efficient bundling of such flexible offers is difficult to achieve. The consequences: a collapse of traffic systems with significantly more cars on the roads, significantly more kilometres driven than before, additional empty trips to pick up the passengers and an existential threat to local public transport and ecomobility. In this way more could be destroyed than gained.

### **Shaping the future**

The potential of valet parking is enormous if service providers and cities get the services in the right way. However, the cities must steer developments in the right direction. Autonomous sharing systems and valet parking systems should be planned as an advantageous addition to an integrated mobility concept and not in isolation from competition with local public transport.

Implementing only valet parking falls short of bringing about a long-term improvement in traffic. Rather, a combination of several accompanying measures is required to bring out improvements. Therefore, here follows a description of examples of measures that could have a positive impact on traffic development.

#### *City-toll as regulation*

Debated many times congestion pricing and city tolls are key tools for moderating demand and incentivizing more socially and environmentally friendly travel choices. They are designed to ensure that commuters refrain from their cars. Cities like London, Stockholm, Milan or Bergen have been using them for years to regulate traffic. This incentive system should also be considered for autonomous vehicles and could work here as well.

#### *As a solution for the last mile*

The so-called last mile proves to be particularly problematic. For long-distance connections, there are often good public mobility services, but the close-range accessibility development, i.e. the last part of the journey to the actual destination, can be time-consuming. For many people this is the reason to take their own car for the entire route. Where economic operation in the suburban or rural areas or on the last mile from the station to the actual destination is not feasible today, valet parking with shared autonomous vehicles, in which several passengers share a vehicle, could be a real alternative to the relatively expensive taxi or private car. The vehicles would be part of the overall system here and would strengthen public transport.

#### *Improving conditions for pedestrians and cyclists*

As a special aspect of coping with the last mile, the possibility to cover short distances on foot, by bicycle or with Micro Mobility Systems is mentioned here. Especially in combination with public transport, better conditions for pedestrians and cyclists can influence the choice of means of transport. This can also avoid an increase in induced traffic with autonomous vehicles.

#### *Parking management and urban integration*

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For the architectural design of the parking spaces, classic vertical construction methods are just as conceivable as underground approaches. With the classical vertical parking garage, it will be important to make it multifunctional and architecturally sophisticated. Additional services such as food, services or leisure can be offered. Furthermore, attention should be paid to climate-neutral construction with urban gardening projects. Also parking space can be relocated to underground garages. On the surface, green spaces could be created between the residential buildings for the residents. The use of autonomous vehicles requires new options for the design of building regulations and parking space statutes for the planning of new as well as existing residential areas. Parking spaces do not necessarily have to be located near apartments.

### *More and improved space for living and housing*

In the context of the current pressure on space in conurbations, an innovative view on spaces for living and housing would be an interesting development. The freed-up space could, for example, be used for the urgently needed housing development, but also provide space for high-quality open spaces. Local living, recreation and work could then take place in previously unhealthy spaces, e.g., along main roads or intersections, because these become attractive spaces.

### *Mobility and Service Hubs*

Valet parking in parking depots should not be viewed in isolation from the entire transport system. Parking garages just for valet parking do not solve mobility problems even with autonomous vehicles. In addition to vehicle parking, parking garages could become the heart for various sorts of mobility as well as mobility-related and supply services: as a location for "shared mobility" means of transport, bicycles, scooters, automated vehicles - as a starting point for covering the last mile or as a pick-up station for goods. Passengers should be able to switch seamlessly between different transport modes and at best they should use the services of the environmental network. If switching from the autonomous vehicle to the train and then to the electric scooter to get to the office is too complicated, a commuter will of course use the more convenient travelling option from point to point. To prevent this situation, urban and transport planning should invest more in mobility hubs with micromobility pick-up solutions.

## **Conclusion**

Automated driving enables the development of new concepts in mobility and thus in the development of urban environments. Specific features, such as automatic passenger pick-up and parking, can be used in this context, but must be set in the context of further traffic and regulatory measures in order to lead to meaningful results. Otherwise, the uncontrolled automation of traffic can lead to disadvantageous developments. This is discussed here using the example of valet parking.

Therefore, bundles of measures will lead to desired effects. However, in order to be able to use these in a controlling manner, it seems reasonable to first examine the effects of individual measures in order to understand their mechanism and to reasonably combine them with other measures. For this

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reason, the A.R.T.-Forum project is preparing simulative studies on the effects of the valet parking described above in residential areas and their combination with car sharing and ride pooling. The results will form a basis for the subsequent discussion on the use of this option for urban planning concepts.

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