1 Introduction

1.1 Expectations concerning autonomous driving

Autonomous driving is on everyone’s lips. In public discussions in Germany most people agree, that autonomous driving will make traffic safer as it is today. They also agree, that autonomous driving will offer more mobility options for people and that it has the potential to make traffic more sustainable, as well.

Figure 1: Expectations mentioned in interviews
Figure 2: Picture search autonomous driving
Figure 3: Picture search smart city

1.2 Expectations concerning smart city

Concerning the term “smart city” the association with safety / security, more options and sustainability can be recognized, too – even if not that strong as concerning autonomous driving.

Risks associated with autonomous driving and smart city are less seen. If at all, it is most likely in connection with the protection of personal data.

An image search on google for “autonomous driving” produces a similar image as the direct talk to people: Car-users are visible who are engaged in other activities while driving a car. In order to be mobile with your car, you don’t necessarily have to have a driver’s license in today’s sense. Groups of people who are not able to drive a car today (more options) can also be mobile.

Also present are images showing the detection ranges of the sensors of autonomous vehicles. They point to the safety potential of autonomous vehicles (--> More safety).
Finally, pictures can be seen that point to the necessary networking of autonomous vehicles with other vehicles and the infrastructure. A connection between autonomous driving and sustainability is not recognizable in the pictures.

Concerning “smart city” the google search mainly points out several pictures that show the symbols of connectivity. Opportunities and chances like in the autonomous driving are not present. It is an interesting parallel, that the same indifference as in the pictures can be discovered in the discussion with people.

Anyway, smart city is omnipresent in media, news and scientific papers. Large technology companies are promoting “smart city” as the goal of the future: terms such as “safe”, “clean”, “worth living” and “environmentally friendly” are linked to the vision of the smart city.

Smart cities are already a reality in Korea: Daejeon, for example, offers an impressive scenery (especially at night). The term "smart city" is omnipresent: from the roofs of houses to the manhole covers - not to mention the numerous surveillance cameras, which also give a feeling of security.
The same goes for the smart city Songdo, which is currently one of the world's best-known examples.

1.3 Smart = Sustainable?

In Germany, on the other hand, the Smart City is still the subject of planning rather than reality. Cities are investing in the development of their communications infrastructure and are currently digitizing numerous administrative processes in particular.

But both in Korea and in Germany, at least the transport sector does not yet offer a picture of sustainability: congestion. If autonomous driving should improve the situation to make traffic more sustainable, there is a long way to go.

2 Effects of autonomous driving on mobility behavior

2.1 Research project AutoRICH

The following chapter describes the questions that are examined in the research project "AutoRICH" (Autonomous Driving – Risks and Chances), which has just started at the Karlsruhe University of applied sciences and which is funded by the research ministry of the federal state of Baden-Württemberg, Germany. Main goal of the project is to describe and quantify possible chances and possible risks of autonomous driving. Two possible scenarios are defined in order to model the impact of autonomous driving on mobility behavior of the people. The traffic performance will be modeled and – if necessary – possibly measures to be taken by governments are figured out, so that negative side effects of autonomous driving on urban traffic can be avoided.

On three examples the possible impact of autonomous driving on people’s mobility behavior will be discussed:
Example 1: Parking

Many households live without a car in the densely built-up inner cities. In the city center of Karlsruhe, for example, about 300 cars are registered for every 1000 inhabitants. On the other hand, more than 600 cars per 1000 inhabitants are registered in the peripheral areas with predominantly detached and semi-detached houses with garages.

A major reason for the relatively low car ownership in the inner cities is the shortage of parking spaces. Autonomous vehicles would also be able to drive to more distant parking spaces. The reason for not having a car due to a lack of parking space could be eliminated for many households. This raises two further questions:

1. How should parking then be organized?
2. What additional distances would the vehicles drive in empty condition when driving from the car park to the owner?
3. Already with this consideration it becomes clear that the form of ownership of autonomous cars will be of enormous importance:

Private cars are expected to cover numerous empty trips: From and to the (far) distant parking lot, but also to drive back to the house after a family member has driven and to transport another family member.

Example 2: Excluded groups of persons

Many groups of people are currently excluded from (auto)mobility: Old, sick, disabled, etc. For example, for the visit of a pub people would probably choose public transport or bicycle or the would walk to avoid getting into trouble by drinking and driving back. An autonomous car would solve this problem, driving car would be a very comfortable solution.

In order to better estimate changes in the mobility behavior of different groups of people and purposes of travel, the mobility survey of the city of Karlsruhe offers a very good data basis.
The survey examined the city of Karlsruhe and the surrounding countryside districts. 7,800 people out of 450,000 inhabitants were interviewed. The result is a very comprehensive database which enables several analysis and proper definition of scenarios. As a first result basic values like the modal split are reported.

For the development of scenarios, the today’s daily trip patterns (e.g. home – work – home – leisure – home) are of special importance. It can be easily assumed that more options for driving will lead to a generation of trips, that today are not possible at all.

Going more into detail, a first qualitative estimation of the change of trips for the purpose “leisure” is possible: Several trips for this purpose are done by foot. Some of there trips could in future be replaced by car, some others could be done over longer distances and some new trips could be additionally generated.
Example 3: Trips for purpose “work”

In Karlsruhe there are 100,000 incoming commuters and 40,000 outgoing commuters. While the inhabitants of the city districts are doing a lot of trips by bike, most trips still are done by car in the range of 10 km.

In the countryside districts – expectedly – less jobs are available in the neighborhood. Most trips are done by car with a distance of about 20 km. It can be easily expected, that autonomous cars would lead to more and longer trips done by car for work-purpose: Driving-time is no longer “dead” time and can be used as work-time.

In a first internal study two scenarios were developed, that set different estimations for parameters like car occupancy (private / share / ride-share), modal split, trip lengths etc. As a result, in the best-case scenario the traffic performance could be slightly reduced in comparison to the baseline scenario. In the worst-case scenario, however, the traffic performance doubled.
3 Integration in urban planning and energy management

3.1 Urban Planning:

First urban planners in Germany deal with the effect of autonomous driving on future urban planning. One approach is to reduce parking opportunities in housing rapidly to force a traffic system based on ride-share-services.

As a consequence of the ride-sharing-system parking opportunities have to be provided for the cars in times of less traffic demand. To keep the distances to upcoming users short, the idea of quarter-garages comes to a renaissance: Following the idea of "mobility-stations" decentralized garages in the neighborhood are planned.

3.2 Energy:

Assuming that the vehicle fleet will be predominantly electrified in the future, the question of their energy supply arises. The provision of high charging currents already means great challenges for the network operators of the municipalities. It cannot be assumed that the electrical network will be completely expanded in the coming decades to meet these requirements.
Therefore, a decentralized energy management and the local and regenerative generation of electrical power seems to be necessary.

Some start-ups already have innovative ideas:

- The sono-motors-company developed an electric car with integrated solar cells in the car body. On a sunny day it charges energy for 30 km by itself. Production starts in 2019.
- The company “homepowersolutions” sells a hydrogen-based storage system. It stores excess solar energy during summer in hydrogen and re-creates electrical power during winter. Production of the system already started, first installations were done in 2018.

4 Conclusion

- Autonomous driving has the potential to make traffic safer.
- But autonomous driving potentially causes significantly more traffic, too.
- To make the smart city (including autonomous driving) liveable, more car-traffic should be avoided. Therefore, (ride)-sharing systems seem to be a solution.
- To make the smart city (including autonomous driving) sustainable, a decentralized energy system based on renewable energy seems to be necessary.
- Last not least: Planning cities walkable and cyclable makes them sustainable, too.