Mobility as part of the solution?

Governments today are broadly faced with two main challenges when it comes to mobility. 200 years ago there were less than 1 billion humans on planet earth. Today the world population is over 7 billion and is expected to grow. Growth in population is accompanied by rapid urbanization as more people move to cities in search of economic opportunities. And more people in cities means more demand for mobility. If we continue as usual (private car ownership of ICE vehicles), our cities will run out of space and soon become very congested. Further adding fuel to the fire is the problem of climate change and air pollution in cities to which IC engine vehicles are major contributors.

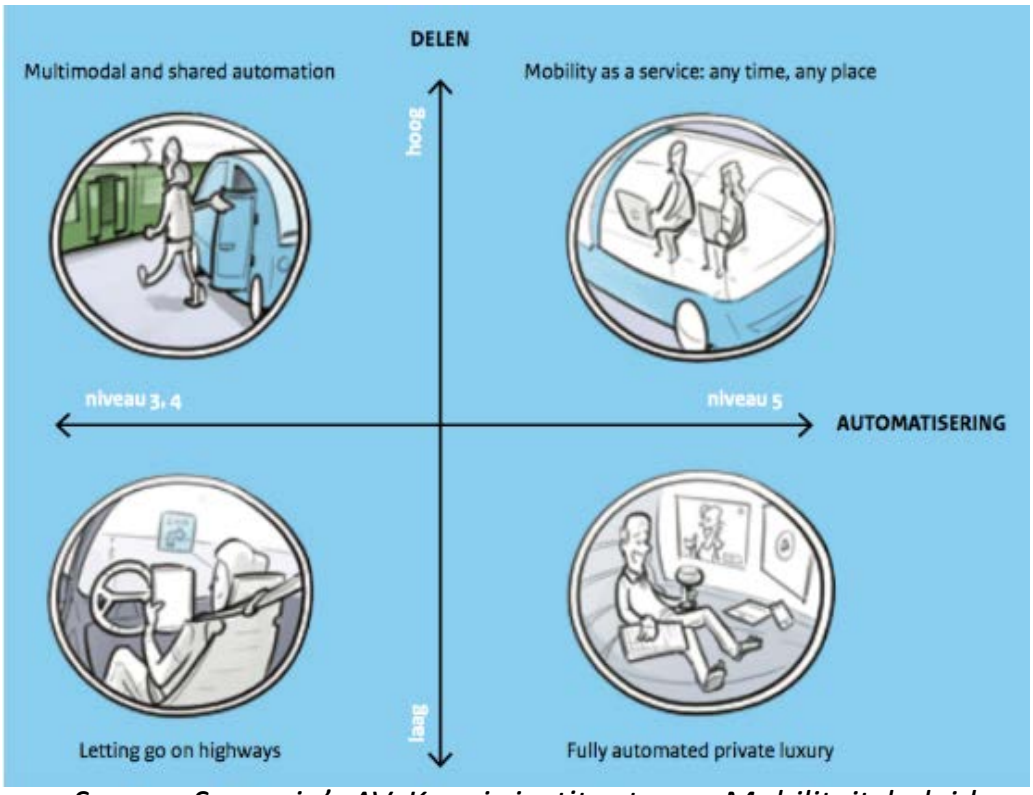
So what can be a solution to these twin challenges in mobility?

- Firstly, private vehicle ownership will be discouraged by governments. Autonomous vehicles which can be shared more easily and can be parked more freely will help reduce congestion in our cities.
- Secondly, electric vehicles fuelled by sustainable energy sources, which are clean and more efficient than IC engine vehicles can help mitigate air pollution and greenhouse gas emissions. Combine these two, and we find that autonomous electric vehicles can be an important part of the solution.

AEV: Foresights for the future

How would a future with large scale automation look like? Well we can't say for sure, but here are four possible manifestations with varying levels of automation and car sharing. Check here what the 5 levels of autonomy entail.

DC-DC converter: driving and regenerative braking



Source: Scenario's AV, Kennis instituut voor Mobiliteitsbeleid

The x-axis in this figure tells you how far is the technology automated, and the y-axis how much it is shared. Imagine, autonomous driving on highways where the driver can intervene when he wants. The driver is all alone, so no sharing. This is the case of limited automation, limited sharing (image in the left bottom half). Now look at the image in the right bottom half, the driver is fully relaxed all by himself so complete automation but still no sharing. A good example of this is a car that is currently on the market and is equipped with automatic lane detection, automatic parking and so on. Now coming to the top half, on the left we have limited automation with advanced sharing. An example of this is shared driving on highways (think of ride-sharing and public transport) where a high level of automation is not re-

quired. And finally, imagine autonomous driving everywhere in the form of shuttles with pick-up and drop-off service. Here sharing is ubiquitous; and every vehicle is a shared one. This is shown in the top right corner.

AEV is no universal proposition : location dependent

It is important to understand that no one of the four scenarios will be in place everywhere at the same time. In fact, research shows these scenarios are highly location dependent. Driving on highways is not so difficult. Lower level of automation such as cruise control and automatic lane control will be enough. So we expect this to be implemented first (2020 onwards). Driving in cities is very complicated. Imagine trying to cross a busy street in your city with 100 pedestrians passing by, the autonomous EV will never take off. So this scenario will take many more years to realize. The situation for suburban and rural areas is somewhere in between. While it is more complex than driving on highways but we have more space and lower population density. So it is easier to implement than in cities but there is still many a times interaction between road users. So not all the scenarios look so positive.

Adoption of AEV per location

Now, as we learnt, the adoption of EVs is expected to differ between locations. So what will be the impact of autonomous EVs on transport and spatial planning in these different locations?

Location		Highways	Cities	Suburbs and rural areas
Expected adoption of AEV		Short term	Long term	Mid term
Impact	**Transport**	Autonomous highways, first hybrid then solely AEVs	• Less car ownership • Modal shift to MaaS, cycling and walking	Gradual transition • Car ownership prevails • Public transport automated and on demand
	Spatial planning	Acceptance of longer travel distances and traffic jams → possible demographic changes	Infrastructural adaptations needed for AEV • Car-free zones • Hubs for 'park & ride' with MaaS	Traditional public transport under pressure Parking at own property
	Charging infrastructure	Fast charging stations along highways, but mostly 'destination charging'	Parking hubs with wireless charging infrastructure • AC with smart charging • DC without smart charging	Destination charging at own property with smart charging

'Autonomous highways' with level 5 AEVs are first expected. This could result in the acceptance of longer travel distances and even of traffic jams. Therefore, this might cause demographic changes with people living further away from their work. In cities a further reduction of car ownership is foreseen. This is expected to cause a shift towards automated mass transport (AE buses and AE pods), cycling (increasingly on electric bikes) and walking. To make AEV possible infrastructural adaptions are needed. Most experts at least foresee more car-free zones in cities and hubs for park & ride, especially to facilitate automated mass transport services. Now coming to suburban and rural areas, we expect private car ownership to prevail for at least a while. People will have their own AEV or will use automated mass mobility services as a form of public transport. The latter will put traditional public transport under pressure in these areas, especially because of the associated costs.

Charging AEV

Along highways there will be (ultra) fast charging stations to extend the range of AEVs, but most charging will be done at the destination (when being parked). In a futuristic city with AEV there will be parking hubs where AEVs will charge wireless, either AC with smart charging or DC (to be on the run immediately) without smart charging. As for rural areas, people with an AEV will charge their vehicle at home and can use this as part of a smart energy system, being largely self-sufficient at household or neighbourhood level. How people use the AEV has a big impact on the business models.

Business models

In the earlier slides we talked about the possibility of automated mass transportation systems in cities and sub-urban/rural villages. We call it Mobility as a service (MaaS). This would take the form of AE buses and single person AE pods. To cater to different economic and social segments of the population, users can choose on the basis of time taken to travel, reliability (that is guarantee of no time delays) and different onboard services (like internet, food) and comfort levels (1st class, 2nd class travel).

For charging we envisage centralized charging depots where you park your car and the vehicle is automatically charged. These charging depots may function based on wireless charging and will be optimized to match electricity supply with demand and manage peak loads. Users will have a choice between two basic types of charging – faster but more expensive DC charging and the cheaper but slower AC smart charging.

Conclusion

So as mentioned earlier, the AEV is no universal proposition. At different places and times, it will manifest itself in different forms. To conclude this lecture we must ask what is to be expected from AEVs in the short term (say next 10 years) and the long term (say next 50 years)? The answer is that in the short term we expect AEVs to become increasingly visible on highways. Charging will largely be limited to homes and offices, while limited growth in charging facilities along highways can be expected. In urban areas, small pilot projects may be run to study the feasibility of AEVs, to further improve the technology and remove bottlenecks. In rural areas, public transport by MaaS may take off in the form of autonomous electric buses.

Looking at the long-term prospects of AEV we expect radical changes. The way we think about cars itself might change. Large scale private ownership, on-street parking and charging will disappear. This will be replaced by the concept of hubs for park and ride. So vehicle ownership could be shared or private companies will provide you vehicles to use and charge you as per your usage.

In terms of charging technology, wireless charging (could be AC or DC) will become common. As vehicle utilization patterns develop (just as we have set patterns for electricity usage) smart charging will become increasingly feasible. Users will have a variety of mobility options to choose from – AE segways, AE pods, AE buses, etc. And we expect to see a hybridization of private and public transport: vehicles can be both private or shared.