**“The Urban Mobility Challenge”**

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Tech: The Challenges of Innovation

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Introduction

This analytic report will start in the future of urban mobility, 30 years from now. It will project the reader into a future that hopefully most of us will experience ourselves – and into a future that we can shape right now by taking the right decisions and action.

It’s our and our children’s future cities that are at stake.

A comparison with past developments in urban mobility will be surprising. We think that we move always forward, but it seems that in urban mobility, under different circumstances, we make the same choices – and maybe the same mistakes - as decades before. How is that possible? Who are the players and what are the interests in urban mobility change processes?

The second part or the report will provide insights into the underlying forces that are shaping urban mobility and will probably continue to do so during the next three decades.

We are living a unique era in urban mobility development, because three ongoing technological revolutions happen almost at the same time. The first overall revolution is digitization: of our communication, our transportation, our work, our cities. The other two revolutions are interrelated with each other as well as with digitization: the electric and the autonomous revolution.

These developments represent huge changes for improvement of urban mobility. And improvement is needed, because cities are suffocated by air pollution and congestion. These developments mean big changes in technology and business. New ethical questions arise. And as with all big technological changes, it will depend on our society what we make of them; if we use them for the better or for the worse.

1. A Journey into the Future: Utopian and dystopian Scenarios

The base of the utopias and dystopias of urban mobility in this chapter are conversations with urban planning scientists and technologists, economists, consultants and city activists. Particular inspiration to the chosen examples of utopias and dystopias are an interview with Molly Turner, lecturer at University of California, Berkeley, Haas School of Business and a presentation by Lars Zimmermann, activist at The City open Source Lab, at the digital conference re:publica 2018.

1.1. Urban mobility Dystopias

San Francisco 2049

There is no public transportation anymore, just autonomous car services. The introduction of the autonomous rideshare services had killed public transport decades ago. Without the driver, riding an autonomous car became so cheap that no one wanted to use the subway and busses any more. The rideshare services are no shared services, because riding without sharing has become affordable. Now huge uninterrupted lane of autonomous cars is moving forward slowly but steadily. In each car there is one passenger in front of his devices, surfing through the web, swiping through social media; mobile without moving; connected without human interaction - and comfortable, maybe too comfortable. One is reminded of the film Wall-E, where the passengers of AV’s become fatter and lonelier.

Taxi drones cruise above the skyscrapers and get the wealthiest from A to B. On the surface and subsurface, huge car infrastructure has been built: tunnels for autonomous cars under the city and the San Francisco Embarcadero Freeway seems to have risen out of the past.

Paris 2049

Paris’ Marais neighborhood has disappeared. Instead of the little medieval streets and picturesque houses, 18 glass towers rise on a rectangular grid surrounded by wide boulevards. Walls on the left and right side of the boulevards prevent that cyclists or pedestrians can interfere with the autonomous cars, which are highly efficiently coordinated by algorithms. Every few kilometers there is a small bridge or tunnel to cross, but there is no need for those anymore because there are neither pedestrians nor cyclists. Instead of them, autonomous delivery drones on the sidewalks steered by algorithms are heading towards their programmed destinations. Paris’ infrastructure in 2049 looks as if Le Corbusier’s vision had become reality. Around 125 years after his *Plan Voisin* was rejected, Paris has become the automotive and aviation friendly city Le Corbusier and the industry had dreamed of.

Will the Paris of 2049 have sacrificed its beauty to become a business case for car and aviation manufacturers?

1.2. What if…?

The victory of autonomous cars and drones over pedestrians and cyclists in our cities, will it be an inevitable global trend like it’s observable at the end of the 2010s in Asia and Arabia?

Or could the future also be different?

What if Paris just succeeded to remain an impressionist painting?

What if… is the attempt to think out of the box, out of our own Locked-In-Effect.

Locked-In-Effect means that we perceive and think like we have learned is. For example, our society values cars a lot, so solutions for mobility will mostly include cars. And: As children, we have learned to pay attention to cars, because they are the more powerful participants of our streets, so we remember that we have to respect cars and that cars are more powerful than pedestrians and cyclists. The thought of chasing the cars out of our streets seems rather unusual, rather out of the box.

Hacking the City activists imagine exactly this for our future cities. According to them, hacking means breaking a city’s limitations, working with what is already there. They see in the victory of cars one of those limitations. And they predict that cars will become even more omnipresent in cities as soon as they become autonomous. For Hacking the City activists, cars are targets, because they steal space, pollute air, kill pedestrians and cyclists. Their city hacking begins imagining: What if the City was...a botanical garden, a playground, a farm…an impressionist painting.

1.3. Two Urban Mobility Utopias

Paris 2049

Arrival on the river Seine. The city seems like a painting by Eduard Manet. “Paris always wanted to remain like an impressionist painting,” says NYU Marron Institute‘s urban planner Alain Bertaud, who studied at École Nationale des Beaux Arts in Paris. In this scenario, the city succeeded. Strolling along the river, you meet lots of pedestrians, cyclists on their own lanes and even horses. No flying drone taxis, no package drones, no cars. Those who want to get faster from A to B choose public transportation, which is completely train based and has been significantly upgraded. The new Metro trains are cleaner, faster and take more passengers than 30 years before. The RER for bigger distances is almost unrecognizable to its version of the 2010s. But there is another change: in mobility habits. Commuting has decreased significantly, because people work much more from home now and log themselves into virtual reality conferences. Errors are done in the neighborhood; online sale has become unattractive. This Paris 2049 seems like in the film Wakanda. This Paris 2049 is social, healthy and playful; it’s digital, modern and productive, but in another way; and first of all, it‘s more human.

New York City 2049

What if New York City was…?

...a museum. Not one of those dusty ones with just insects pinned on paper, but a lively one, a science, nature adventure museum, full of action and conversation, of colors and curiosity and the most different sweet noises. With creative commuting, a powerful modernized subway system and creatively designed pedestrian and cyclist zones.

...or a playground, with all the different mobility possibilities that are sustainable, sporty and healthy. With perfectly organized changes from bike to pedal boat to scooter to skates. What if the bridges and tunnels that had once determined NYC’s destiny of an auto friendly city in the future belonged to bikes, trams and subways?

During the gathering of these scenarios, it was interesting that the perspectives on what is a utopian and what a dystopian vision are very different – sometimes even opposite. What is presented above as utopias are pedestrian and cyclist friendly utopias – that would be dystopias for automotive industry and consulting companies. The different perspectives are not only found between activists and business players, but also among researchers and they are not always predictable. There are urban planners who share the auto-friendly position – and technologists who share the pedestrian friendly position. The different visions and perspectives on future urban mobility are already a sign of how vividly urban mobility is discussed. That makes it even more important to take a closer look at the underlying forces of the ongoing processes. What is shaping our urban mobility right now and what will shape it in the next 30 years?

2. Global Trends that will shape Urban Mobility until 2049

This part will provide insights into the underlying forces and global trends that shape urban mobility and will probably continue to do so within the next 30 years. It will focus on urban mobility development in the context of the three ongoing revolutions that open new horizons: of digitization and of the electric and autonomous car revolution.

2.1. The System’s perspective: Urban Mobility seen by the Complexity approach

Before taking a closer look on selected trends, a system’s perspective provided by the complexity approach will open up the broader context.

According to Prof. David Teece, a US-based organizational theorist and the Professor in Global Business and an authority on the economics of technological change, new forms of urban mobility can be seen as a systems issue with several interrelated factors such as technology, regulation, acceptance and integration.

Right now, in our western democracies, he sees technology ahead of public acceptance, bureaucracy and legal frameworks. In 2049, Teece predicts, the questions that now are still discussed will be sorted out and the reshaped system will be running in a new flow.

Criteria for changes in a system like urban mobility are safety, connection, access, speed, cost, convenience and environmental factors such as reduction of noise and air pollution.

Nowadays, there are a lot of open questions concerning regulation and public acceptance of new forms of urban mobility. Also, still open is question who the systems integrator will be. There is a race of the companies to set the standard – and there’s a lot in stake, because systems that will make save us time by providing efficient urban mobility solutions will be a good investment.

Seen from the perspective of the complexity approach, in the reshaped system of urban mobility the winners of this race and thus the money makers will be the one who owns the data and the one who manages to be the manages to integrate the different technologies. In former times in the computer sector the systems integrators were Microsoft and Intel: Microsoft managed to integrate the software and Intel managed to integrate the hardware.

According to Prof. Teece, autonomous vehicles are game changers in the System of urban mobility, because they cause disruptive innovation that is related to other factors of the System. This point of view is shared by several researchers from different disciplines. Especially in the context of autonomous vehicles, a determining question for the German car manufacturers is if they will be able to stay the systems integrators in a reshaped system of urban mobility. Their advantage compared to the Tech companies and startups is that they are able to build cars, which is, and probable will continue to be an important hardware of mobility. But it’s hard for the automotive industry to keep up with the process of disruptive industrial change, because they are stock market based and have longer production cycles.

2.2. AV’s in the City – key questions for future urban mobility

This part gives special attention to the trend of the autonomous vehicles, because they are widely seen as game changers in urban mobility.

The three revolutions that urban mobility is going through right now are all determining the future presence of vehicles in the city: digitization, the electric and the autonomous revolution. Some key questions of AV’s in the city will be raised and answered in a short overview.

When will the technology be ready – and when will it work well enough?

The answer is complex. Accidents like the one of the Uber cars in Tempe, Arizona in March 2018 show to the public that there are still considerable obstacles to surmount.

As the Uber CEO pointed out, those accidents show to the developers that they were proceeding too quickly. The question of when the technology work will well enough refer mainly to the context of security and is very important to trust and public acceptance of the new technology. For the innovation by the autonomous car, the same rule can be applied as for the innovation by the electric light bulb: In order to introduce it successfully into a society, you have to prove that it is safe. The questions when AV’s will work well enough to be safe depends not only on the engineers, but also on the use that we imagine for AV’s. The most difficult use will be the interaction between the autonomous cars and humans in city traffic, because there is a lot of communication that is based on human mimics and gesture. It’s very difficult for a machine to understand the unwritten communication rules between humans: the waving to a pedestrian, a cyclist or another driver, combined with a smile and a nodding for example. It has not been decided yet if this kind of city traffic will be needed in the future. For example, if autonomous cars get their own lanes, separated from the rest of urban traffic, as the companies try to negotiate with state and urban authorities in the United States right now, the algorithms won‘t have to learn the nuances of human city traffic communication, because they will be able to communicate in their own car to car way - which is technologically much easier to achieve. The question of when the technology will work well enough also depends on how we imagine the transition from human driven to autonomous vehicles. Google/Waymo for example wants to skip the phase of highly automated vehicles, which need the driver to interfere in dangerous situations. The company has good reasons to do so. Latest research by insurance companies reveals that a driver who doesn’t actively participate in road traffic needs more time to understand and react to a dangerous situation – more time than he has when he is warned by the car in the time span provided by the regulatory framework. If more automation were associated with more accidents, the acceptance of autonomous vehicles would diminish.

Who will implement the technology – and take the lead?

The race between automotive companies, tech companies and rideshare companies is still open. Each type of company has its advantages based on the knowledge and experience of the system it comes from, but in order to be the systems integrator, it has to provide more than that. The automotive companies have the hardware advantage; they know how to build cars – but this huge advantage diminishes, because the cars of the future won’t have a combustion engine any more. Electric cars need much less parts, so the automotive companies have to adapt their production cycles and the competitors can keep up with them more easily. The tech companies have the software advantage but are lacking the hardware knowledge. Even if the knowledge gap diminishes with the electric revolution, Tesla’s difficulties of delivering their Model 3 show clearly that a successful structure is needed to deliver a bigger number of cars on time.

Who will program and know the algorithms?

With the introduction of autonomous vehicles, algorithms will make more and more decisions and will replace humans at the steering wheel. The decisions that we as humans make when we are driving a car are a combination of our driving skills and our ethical behavior. The driving skills can be learned by machines quite easily. The ethical setup that we humans take in while we grow up is more complex to program into algorithms. This means a big responsibility for the algorithms’ creators - and opens up questions that go way beyond engineering. An autonomous car sees, decides and takes action. The Uber car that killed a woman in Tempe, Arizona in March 2018 saw her on its cameras. But its decision-making algorithms were programmed in a way that they interpreted the woman as an interfering object with no importance that could be neglected. The car drove on, the woman died.

In key situations with autonomous cars, the question how algorithms are programmed can decide over life and death. In order to make society worldwide participate easily in this discussion, the MIT Scalable Cooperation’s Group has developed *The Moral Machine*, a website that puts users into emergency situations of city traffic that are at the same time key questions for ethical behavior and society’s values. In these key situations the users must decide between bad options such as: Should the car rather overrun the CEO or the old lady? Should it run over the mother with the child or the delinquent. Or even: Should it run over five pedestrians or kill its own driver?

The results, the moral decisions that have been made by millions of participants worldwide, vary between cultures, ages and between male and female participants. Some sets of answers differ from the political framework – when the elderly or delinquents are less important as the young and wealthy. The decisions to kill the car driver in order to save five pedestrians are taken – but at the same time, the participants refuse to buy or use such a car.

Most of us won’t be able to program the algorithms of autonomous cars, but we should know and discuss how they are programmed so that important ethical questions for society won’t be decided just in the lab of tech or rideshare companies.

Will drivers let go of the steering wheel – and will we trust AV’s?

As with every technological innovation, important for its implementation into society is the demonstration that it’s safe. Edison had to demonstrate that the light bulb was safe before people got it for their households. The companies that are racing to be the winners of the autonomous revolution must prove that AV’s are safe before AV’s will be frequent in our streets. Statistics seem to be on their side. Most of the car accidents are caused by the human factor, which is by the driver who is not concentrated on driving, because he or she is writing messages, is emotionally stressed or just distracted. AV innovators like Uber promise that with autonomous vehicles the bad human influence on car traffic is eliminated and Mc Kinsey predicts considerable influences on hospital infrastructure, because there will be so much less car accidents. After the accident with an AV in Tempe, Arizona in March 2018, the media were criticized for reporting that accident but not reporting all the car accidents with human drivers. But they had good reasons to do so. For sure, every car accident that can be prevented by introducing AV’s should be prevented. AV’s won’t make the same mistakes that human drivers make, which is a huge advantage. But might there be also mistakes that only algorithms make? We should look closely enough not only at the strengths but also at the weaknesses of the new technology. And as we deal with a large-scale innovation, we should be prepared to surprise and expect the unexpected. In order to create transparency, to be able to prove that the technology can be safe and to build trust and acceptance.

2.3 Effects of AV’s on the city

Will AV’s be EV’s? The electric and autonomous revolution

The electric car revolution got a boost by the *Dieselgate*. The scandal that the big German car companies had cheated on the authorities as well as on millions of customers and that they had put the city inhabitants’ health at risk, was a wakeup call for more sensitivity about air pollution in the cities. Since *Dieselgate,* the problem of air pollution in the cities has risen in public political and juridical attention. In Germany, environmental activists like the organization *Deutsche Umwelthilfe* are pushing the city authorities to ban diesel cars from the city centers. Although the negative effects of petrol cars are – by now – rather neglected, it is clear that the age of the combustion engine is finishing; the future of cars will be electric. However, although a number of countries reward car owners who buy electric cars, the rise of the private electric cars is rather modest. The breakthrough of the EV revolution is expected with the introduction of autonomous car fleets.

The recent Stanford University study “Rethinking Transportation 2020-2030” for example, claims that the EV of the future will be an AV. The author, the economist Tony Seba and his thinktank RethinkX say that by 2030, 95 percent of all passenger miles will be driven in autonomous electric vehicles.

Whoever will own the car fleets: car manufacturers like Mercedes or BMW, rideshare companies like Uber or Lyft or tech companies like Google/Waymo; the car fleets are expected to be the future of urban automotive transportation. The main factor to this development, predicts RethinkX, will be the costs. That means we will not own a car any more but use mobility services. The mobility services will be provided by car fleets. Those will be electric, because electric cars are much cheaper to produce and maintain; and they will be autonomous, because the main cost factor of a mobility service, the human driver, will be replaced by algorithms.

Will our cities be healthier? Effects on air pollution and greenhouse gas emissions

The predicted effects on air pollution of the EV-AV revolution is positive; even if the EV’s are not yet powered by renewable energy. A recent study from Belgium’s VUB University states that switching from diesel to electric cars reduces emissions by 25 percent over the course of a vehicle’s life; even in countries that depend on coal power. If the power can be generated by renewable energy, the greenhouse gas emissions will also be reduced significantly. To bring it to the point: EV’s will make the cities healthier, EV’s powered by renewable energy will make the city and the planet healthier. The problem that the cities’ grid will have to provide more power can be solved by charging the EV’s during non-peak overnight hours - thanks to intelligent charging algorithms in the cars.

Urban mobility based on EV’s and AV’s will provide a relief for the air of our cities - but should these EV’s/AV’s be cars or trains?

What happens to public transport? Effects on congestion

Regarding the effects on congestion, the question is what kind of electric autonomous vehicles will be the main preferred means of urban transportation. The more people a vehicle can transport the better its effects on congestion. Electric autonomous tramways, subways and trains help to reduce congestion. Urban planners worry that they could get competition by fleets of electric autonomous cars – in the worst case with only one passenger per car. The question is if fleets of cars replace just the private owned cars or if they kill public transport. When people shift their habits from taking the subway to taking an autonomous car service, both the cities’ public transport system and the cities’ road infrastructure system have a problem.

Who will get the green light and own the space? Effects on pedestrians and cyclists

Algorithms at the steering wheel of cars are already imaginable on highways, but lively city traffic with its many different spontaneous situations is a huge obstacle for algorithms. That’s why autonomous car developing companies are negotiating with city authorities about autonomous car lanes in cities. Those lanes would be separated from cyclists and pedestrians and human driven cars so that the autonomous cars would be able to communicate among each other and would not be disturbed by the many unpredictable human actions. Consultants’ calculations promise that thanks to the separation from the rest of city traffic, the cars could drive faster, be more efficient and thus reduce congestion even if they are numerous on the streets. Urban planners however are warning that with those measures, the city could transform itself into a car-friendly city – again. In order to see what happens when a city prioritizes cars over pedestrians, cyclists and public transportation, a look into the past can provide insights – and surprising parallels. When cars get space in a city, they become more numerous – and want even more space. The discussion about parking spaces follows the same logic. In the age of autonomous cars, parking spaces will not be needed any more, because the cars will just drop off their passenger or and return on the street, on duty. But who will benefit from the new free space? What will it become; a bike lane, sidewalk or park – or another autonomous car lane?

Conclusion

Tech: The Challenges of Innovation

Digitization, the EV and the AV revolution open new horizons for the development of our urban mobility. Thanks to smart electric and autonomous vehicles, we will be able to reduce air pollution in our cities significantly. In order to successfully implement the technological innovation, the developing companies must prove that it is safe and must make transparent how they program the algorithms. In society it’s important that we raise and discuss the open ethical questions and that we actively participate in the change process instead of accepting it or claiming to be the victims. The reshaping of our urban mobility thanks to technological innovation is also a chance to question long learned certainties and to think urban mobility out of the box. Right now, while determining questions of our urban mobility are not answered yet, we have the chance to interfere in order to prevent dystopian scenarios and to participate and be creative in order to get closer to our urban mobility utopias.

And the City: Policy strategies for handling future urban mobility

With the rising interests of the private sector, the city authorities must take action to preserve or get back their power over public space. But how? The cities are pressured from two sides. On the one side by the negotiations with the private companies, on the other side by the framework that is developed on the national and federal level.

The TUT pol project, a study at Harvard Graduate School of Design led by Prof. Diane Davis, provides some strategies for city policy based on a comparative case study in eight democratic cities worldwide. TUT pol seeks to analyze how, when and where political leadership has been critical to the successful implementation of urban mobility policies. In each city, the authors describe the special situation and highlight the authorities’ initiatives that in their eyes were successful. According to the TUT pol project, the situation in San Francisco is unique, because it was the first city that experienced the emergence of commercial rideshare in 2012. The city authorities were caught by surprise and then began to develop a regulatory framework. Among the German speaking countries in Europe, the city of Vienna stands out, because it was the city that had most transformed its urban transportation system during the 1990s and early years of the 21st century giving priority to public transport and local communities. The TUT pol study points out that the circumstances for city policy have become much more complex. But if the cities take these circumstances into account and develop agile strategies, they do have impact – to change our future urban mobility for the better.