PUBLIC TRANSPORT IN THE ERA OF AUTOMATISATION AND SHARING ECONOMY

[1]Iveta VOZNAKOVA, [2]Sabina KAUF

[1]VSB - Technical University of Ostrava, Faculty of Materials Science and Technology, Ostrava, Czech Republic, EU, Iveta.voznakova@vsb.cz

[2]University of Opole, Faculty of Economic, Opole, Poland, EU, skauf@uni.opole.pl

Abstract

Background. Over half of the world's population lives in urbanized areas, cities emit over 75 % of global greenhouse gases [1]. One of the sources of pollution is transport. Therefore, striving for the development of sustainable transport systems in cities is crucial. Observing global trends in mobility allows noting the development of economy, automation and electrification of the automobile. These tendencies seem to have enormous potential to improve the functioning of transport systems and to maximize economic and environmental effects. Therefore, the aim of this article is to identify the benefits of using low-carbon autonomous vehicles, to spread the sharing mobility and to identify possible development scenarios in this area.

Method. The article is theoretical in nature and is based on a literature review.

Result. Automation of vehicles, their electrification and sharing mobility offer numerous opportunities to improve the functioning of transport systems in urban areas. The integration of these technologies is becoming more and more popular. However, it is not entirely sure whether these modern concepts will revolutionize ways of moving within the city, or will only result in changes in individual mobility.

Keywords: Public transport, automated mobility, vehicle electrification, sharing mobility

1. INTRODUCTION

Our world is a subject of enormous changes. The growth rate of cities is huge (**Figure 1**). At the beginning of the 19th century, less than 1 % of the population lived in cities. In one hundred years this percentage increased to 13 %, and at the turn of the century it amounted to 47 %. It is predicted that it will reach 68 % by 2050 (ESA 2018). Such a rapid rate of growth of the city population will cause the huge overcrowding and also very negative effects on the natural environment. One of them is the growing demand for mobility and availability of (public) transport. Along with the increase in the number of urban populations, mobility needs are growing. There are a lot of travels carried out in large urban agglomerations. Only in Warsaw, there are over 3.5 million per day [2]. Such a large number makes citizens experience stress in the city, resulting from the awareness of the loss of time that they must devote to moving around. For many years it seemed that the panacea for improving the quality of life in the city and reducing its congestion is to expand the communication infrastructure and increase its capacity. However, the increasing number of roads does not improve the situation, but only leads to a vicious circle - the development of infrastructure increases the residents' tendency to use individual forms of movement. Therefore, in order to improve the conditions of the city's functioning and to reduce congestion, it is necessary to look for other, alternative forms of overcoming space and ways to change the mobility habits of the residents.

In this context, the automation of transport means and the dissemination of the sharing mobility concept seem to have great potential [3,4]. Although fully automated vehicles are not yet available for general use, it can be expected that this is the prospect of the next 10-15 years. But already today, there are known many examples of their use in public transport. We mean solutions like Personal Rapid Transit (PRT), Group Rapid Transit (GRT), Automated Transit Networks (ATNs), and Automated People Movers (APMs), that are deployed at

most major airports in the world. The PRT system combines comfort with the availability of public transport. This system has already been applied in Masdar City. Changes in the area of mobility have an impact on the perception of the distance and availability of a particular place. Bearing this in mind, the aim of this study is to identify the benefits of using autonomous vehicles in urban transport and to spread the sharing mobility.

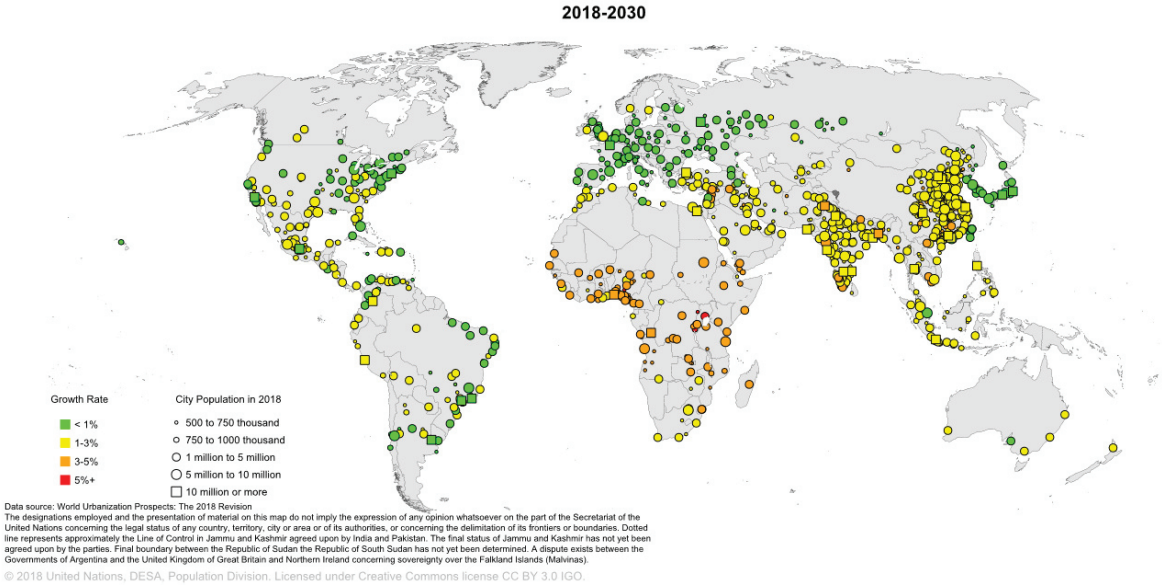

Figure 1 Growth rates of urban agglomerations [5]

2. SHARING MOBILITY AND ITS POTENTIAL TO REDUCE THE CITYCONGESTION

Sharing economy has become popular due to the inhabitants' knowledge about IT techniques and their readiness for interactivity. Generation Y, so-called Millenials are looking at the world differently, and they adapt and perfectly understand peer-to-peer systems. In addition, raising the awareness of residents and striving to limit consumerism means that they need and they are looking for alternatives to their properties, and thus are open to sharing economy. The internet platforms are an important element connecting the sharing economy and the city, allowing to share large amounts of data. Thanks to the possibilities of offering access to large data sets, cities can offer a wide range of services tailored to the expectations of residents. Because of them, sharing mobility can be developed [3].

Due to the residents' tendency to move cars, sharing mobility seems to be the natural direction of transport system development in the city. However, sharing does not have to be limited only to the shared use of the vehicles, but may also involve the use of other low-carbon modes of transport. We mean solutions like carsharing, bike-sharing, ridesharing (carpooling/vanpooling), public transit services, on-demand ride services, scooter sharing, and alternative transit services such as shuttles and microtransit [3]. The number of sharing operators is constantly growing, and it is expected that it will grow even more rapidly. This is confirmed by a study conducted in 2017 by McKinsey's which shows that among the current users of nontaxi ride-hailing services, 63 percent expect to increase their usage “a lot” in the next two years, and even more (67 %) say that they will do the same concerning car sharing [6].

According to the Boston Consulting Group report, 20 million people will benefit from car-sharing services until 2021, which will use cars for 1.5 billion a month, which will allow the annual value of the global market to be estimated at EUR 4.7 billion. The global car sharing market included at the end of 2015 86 thousand of cars, of which 22 thousand in North America vehicles, in Europe 31 thousand vehicles, and in Asia and the Pacific 33 thousand vehicles. At the same time, 5.8 million users used global car-sharing systems including 1.5 million

in North America, 2.1 million in Europe, and 2.3 million in Asia and the Pacific. In total, all users have used car sharing during 2.5 billion minutes per year, and all car-sharing revenues totaled 650 million euros per year [5].

Sharing allows users to have short-term access to the means of transport and can appear in several models. The most popular is the free-floating system, under which cars can be collected and returned in any places within the scope of the service. Other models are stationary systems in which the client collects and returns the car to one of the databases provided by the operator and P2P system relies on hiring private vehicles. There are also concepts that do not require prior reservation, deposit or membership fees. "Free" cars can be found online from PC, smartphone or just passing by. Sharing mobility not only contributes to the reduction of the number of cars on the roads, which allows to "regain" the city space - especially in places where parking spaces are the most lacking. Sharing mobility (bike sharing, car sharing) allows the reduction of congestion, leads to reduction of greenhouse gas emissions, and opens up new mobility opportunities for people with limited financial resources. The experience of cities in which sharing has already been widespread shows that one car sharing can replace from 9 to 14 individual cars. This is confirmed by research carried out in 2016 on the one-way car sharing operator car2go in five North American cities [3]. The large sharing potential induces more and more people, especially the younger generation to use this form of communication. Positive perception encourages, in turn, to expand the offer. In many cities, even mobility stations are created, being a kind of transfer stops, where most sharing options are available, e.g. scooters or bicycles. Ease of an access to them is undoubtedly a factor which positively influences the use of alternative means of transport or the choice of low-emission vehicles, reducing environmental problems [7].

Discussions on sharing mobility are increasingly accompanied by the issue of electrification and automation of vehicles. They are increasingly becoming a component of the fleet available to users as part of sharing mobility.

3. SHARING MOBILITY AND VEHICLE AUTOMATISATION - SCENARIOS FOR THE FUTURE

Automation is a common phenomenon of modern civilization. Automation supports, among others, mobility of people and goods, and is supported by satellite navigation, automatic multi-level car parks, automated container terminals, mentioned Group Rapid Transit (GRT), or Intelligent Transportation Systems (ITS). As a result of the development of Information and Communication Technologies (IST), the phenomenon of sudden and unrecognized change is revealed - automatic systems gain the ability to independently make decisions in conditions that have so far required human response. As a result, we observe evolutionary (and maybe even revolutionary) changes in the ways people are moving around the cities. The so-called new mobility is borning. It consists of several interpenetrating elements; (1) e-mobility and using alternative fuels, (2) sharing mobility, (3) connected mobility, i.e. vehicles exchanging information on road safety with each other and with road infrastructure. The condition for success, however, is the cooperation and integration of all these elements, because e-mobility only makes sense if it is related to the right strategy in the field of electricity generation. Moreover, the spread of electric vehicles must be connected to the sharing economy. Because of it, it is possible to develop new business models that allow reconciling the three challenges of contemporary cities at the same time: (1) growing demand for transport services, (2) overcoming of increasing ecological barriers (environmental pollution, congestion of roads, depletion of fossil fuel resources) and (3) rising development costs. The above means that new mobility in the near future may become an alternative to conventional forms of movement. Today, the sharing operators, thanks to modern technologies, have become a significant competitor to traditionally operating taxi services, public transport and even an individual car. And with the dissemination of individual solutions, is increasing their impact on the transport system as well as on the use and shaping of space. This is to be expected because the main players - automotive manufacturers, develop sharing mobility services and cooperate by combining their functionalities together to counter the threat of transport startups, such as Uber or Lyft.

The shared mobility with the use of autonomous vehicles will be an especially important factor affecting spatial development in the future. The most important feature will be the unmanned, extending coverage that users will be able to overcome during their daily trips. This, in turn, affects the decision of relocating the place of residence. In the near future, many scenarios may occur, characterized by a different share of the three methods of movement: individual mobility with personal vehicles, with a significant degree of automation and autonomy (owned), car sharing with autonomous vehicle and collective transport. Gruel and Stanford envisage three scenarios: (1) nothing will change; (2) there will be a significant increase in traffic, further urban sprawl and public transport that do not meet public needs; (3) there will be fewer cars, but more carriages (up to 30 %), than in the first scenario, carried out using various means of transport [8]. Mc Kerracher et. al. claim that the share of car-sharing and car-on-damond journeys will definitely increase, which will be supported by the drop in the costs of sharing autonomous vehicle fleets. It will be possible thanks to the elimination of professional drivers, generating up to 50 % of overheads [9]. However, the increase in the number of vehicle kilometres travelled can cause congestion at critical points in cities. As a result, sharing mobility and autonomous vehicle will not necessarily revolutionize movement within the cities, but will only change individual motorization. A similar conclusion can be drawn with regard to e-mobility. It is estimated that by 2030, electric vehicles will account for three-fifths of all cars, of which vehicles with self-steering capabilities can exceed 40 % share in selected cities [9]. Bearing the above in mind, the earlier mentioned authors distinguished three directions of development of city mobility: (1) sustainability sharing mobility in poorer, densely populated urban areas. (2) individual autonomous vehicle mobility in the rich suburbs and (3) mobility on demand for richer populations, densely populated urban areas.

The report on automated mobility in United Kingdom, developed at the request of KPMG, shows that by 2026 the production level will be reached 100 % of connected vehicle, i.e. vehicles exchanging information about the traffic situation between them (vehicle-to-infrastructure). In addition, it is predicted that by 2030 as much as 75 % of vehicles will reach 3.4 and 5 level of automation (**Table 1**) [10].

Table 1 SAE Vehicle Automation Level Definitions [11]

SAE Level	Name	Description
Level 0	No Automation	No automation
Level 1	Driver Assistance	Automation of one primary control function, e.g. adaptive cruise control, self - parking, lane - keep assist or autonomous braking
Level 2	Partial Automation	Automation of two or more primary control functions “designed to work in unison to relieve the driver of control of those functions”
Level 3	Conditional Automation	Limited self driving; driver may “cede full control of all safety critical functions under certain traffic or environmental conditions,” but it is “expected to be available for occasional control” with adequate warning
Level 4	High Automation	Full self - driving without human controls within a well - defined Operational Design Domain, with operations capability even if a human driver does not respond appropriately to a request to intervene
Level 5	Full Automation	Full self - driving without human controls in all driving environments that can be managed by a human driver

Fraedrich and Lenz present different scenarios, focusing on four technical and organizational solutions: (1) Pilot using the driver for extended availability: on motorways or similar roads the driver can give control to the vehicle. The driver does not have to pay attention to another movement or driving task at this time and can perform other activities; (2) Autonomous parking of the car: after leaving the vehicle, all passengers can drive to the previously determined parking space, and from there to the delivery address; (3) Full automation with the driver for extended availability: Whenever it is desired or required, the driver can give control to the vehicle.

The driver does not have to pay attention to another movement or driving task at this time and can perform other activities; (4) Vehicle on demand: a vehicle on demand drives passengers without the presence of any human driver. The people themselves can no longer drive such vehicles - the interior of the vehicle will therefore have neither steering wheel nor pedals [12]. From the research carried out by the authors, the smallest level of social acceptance is characterized by the fourth scenario, i.e. mobility on demand. The reasons may be attributed to the lack of respondents' experience in using such a solution and their natural fears about technology innovation. Despite the scepticism of users regarding technological novelties, it should be assumed that in the perspective of the next 10-20 years, we will observe an increasingly frequent resignation of residents of urban areas from owning a car, for the benefit of car sharing and car on demand. We believe that the number of individual vehicles may decrease by up to 30 %. The thesis can be confirmed by calculations made by Bischoff and Maciejewski. In their opinion, 1.1 million private vehicles currently moving in Berlin can be replaced by 90 to 110 thousand autonomous taxibus [13].

An unambiguous definition of what will be the acceptability of autonomous vehicles in the near future is still not possible today. Although the observation of communication behaviours, especially of the generation Y, allows us to hope that sharing mobility together with vehicle automation will become popular, leading to the relieve of infrastructure and reduction of congestion. The most optimistic solution would be the complete resignation of urban residents from individual communication to sharing autonomous mobility. The worst is the dominance of autonomous individual vehicles, which encourages the deterioration of the transport situation in cities, and at the same time the increase in environmental pollution and, as a result, the quality of life of residents.

4. CONCLUSION

The growth of cities around the world means that transport service providers have to cope with the growing demand for displacement and adapt infrastructure and public transport models to create sustainable mobility solutions. Sharing concepts, combined with the autonomy and electrification of vehicles have the huge potential for improving the quality of public transport systems in cities. Sharing autonomous vehicle can significantly optimize travel time (among others by saving time searching for a parking space). It can be expected that sharing mobility will significantly reduce the use of individual vehicles and thus reduce congestion. Autonomisation of vehicles (from level 2) will allow them to increase their self-service and facilitate their movement, which in turn may reduce the tendency of residents to use public transport. Sharing autonomous vehicles bring in the possibility of increasing vehicle capacity and lowering overall transport costs (environmental pollution, road accidents and civil liability, etc.). Thus, sharing mobility can facilitate the revitalization of cities, e.g. by reusing parking structures - "giving away" to their residents for housing or entertainment. It is difficult to say today whether and to what extent sharing autonomous mobility will affect the functioning of public transport in the city. It results not so much from the still little popularization of sharing mobility, but of sharing autonomous mobility. Therefore, it seems important to analyse the dynamics of the evolution of transport systems and technological innovations in transport on a current basis, based, among others, on an analysis of good practices. With appropriate knowledge about the adaptability of innovative solutions, cities could be able to adequately control the pace of autonomous vehicle implementation and automotation of fleet.

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