

## URBAN TRANSPORT AS AN IMPORTANT ELEMENT OF „THE SMART CITY”

Radosław KORNEC<sup>1\*</sup>, Wioletta WEREDA<sup>2</sup>

<sup>1</sup> University of Natural Sciences and Humanities, Faculty of Economic and Legal Sciences Department of Logistic, Siedlce; [radoslaw.kornec@uph.edu.pl](mailto:radoslaw.kornec@uph.edu.pl)

<sup>2</sup> Military University of Technology, Faculty of Cybernetics, Institute of Organization and Management, Warsaw; [wereda.wioletta@tlen.pl](mailto:wereda.wioletta@tlen.pl)

\* Correspondence author

**Abstract:** The concentration of population in urban centres and the progressing economic development are the one of the fundamental causes of problems of functioning of contemporary cities. One of these issues is the urban transport causing environmental losses and a lower quality of life. The concept that limits the adverse phenomena may be the smart city, and intelligent solutions in the way of moving the urban community. The purpose of this article is to show how urban transport can influence the shaping of intelligent solutions in cities with the help of various factors and components.

**Keywords:** smart city, transport, mobility, ICT solutions.

## TRANSPORT MIEJSKI JAKO ISTOTNY ELEMENT “SMART CITY”

**Streszczenie:** Koncentracja ludności w ośrodkach miejskich oraz postępujący rozwój gospodarczy stanowią jedne z zasadniczych przyczyn problemów funkcjonowania współczesnych miast. Jednym z tych zagadnień jest transport miejski powodujący straty w środowisku naturalnym oraz niższą jakość życia. Koncepcją ograniczającą niekorzystne zjawiska może być smart city, a w tym inteligentne rozwiązania w sposobie przemieszczania się miejskiej społeczności. Celem niniejszego artykułu jest ukazanie jak transport miejski może wpłynąć na kształtowanie inteligentnych rozwiązań w miastach przy pomocy różnych czynników i komponentów.

**Słowa kluczowe:** smart city, transport, mobilność, rozwiązania ICT.

## 1. Introduction

Over the last few decades, a significant increase in the urbanization rate on a global scale has been observed. In 2007, for the first time, the population living in urban areas predominated on the rural population. In 2014, the urban community accounted for 54% of the world's population. According to UN estimates, by 2050, 66% of the world's population will live in urban areas (United Nations, 2015). The progressive process of urbanization of the world, although it is a symbol of social evolution, raises numerous challenges related to intensive energy consumption, overloaded transport networks, water and air pollution, waste, social inequality or decline in the quality of life. On the basis of many international organizations such as the European Union or the UN, ambitious goals in the field of energy and climate are set, taking into account the urgent need to develop intelligent solutions in the area of meeting the challenges of increasing urbanization.

Cities play an important role in the fight against environmental pollution, and the implementation of new technologies is seen as a key factor in reducing greenhouse gas emissions, pollution and improving the efficiency of cities. These technologies must be smart, slim, integrated, and cost-effective. They should play an important role not only in the field of environmental sustainability, but also with regard to the well-being of citizens and financial stability. One of the key areas shaping smart cities, where modern technologies should be implemented is transport. This is one of the aspects of the functioning of urban areas, which is also an element and condition for economic growth. Effective transport operates in well-developed areas, equipped with the necessary elements. The economy stimulated by transport generates ever greater needs resulting from the growing production capacities and greater consumption of the society. An efficient transport system often determines the attractiveness of countries, regions and cities. However, its organization in urban space, where there is a high population density, is an extremely difficult task.

The aim of the article is to show transport as an important element in the construction of a smart concept in urban space.

## 2. Smart concept in cities

Currently, urbanization is one of the fundamental socio-economic processes taking place around the world. Concentration of the population as well as various and countless relationships between various entities results in a high degree of complexity of life in the urban space. Hence the characteristics of modern cities refer not only to the physical structure, but also to virtual networks optimizing processes occurring in agglomerations.

Along with the concept of sustainable development, technological progress, increased ecological awareness and the shaping of a knowledge-based economy, many models of urban space management have also been created. All of these models are aimed at the rational use of resources, taking into account the ecological, social and economic spheres. One of such ideas is smart growth, which in relation to cities assumes spatial planning and transport network, whose task is to minimize costs resulting from the growth of cities. For some time, technologically advanced cities striving to save resources have been distinguished. Such centres are called smart cities (Stawasz, and Sikora-Fernandez, 2015). The very concept of smart city appeared for the first time in 1994, however, by 2010 it was not a subject of scientific and economic interest.

The beginnings of this concept have a technological character. Smart city in the initial period of development referred to the use of modern technologies, primarily in the area of communication and information in the space of high density, which is the city. It was noticed that effective gathering and management of information is able to improve the efficiency of functioning of various measurable areas of the city, from water supply systems and heating network to public transport. This was simultaneous with the implementation of IT tools to manage the enterprise, from where the city managers could derive knowledge and experience (Przybylski, 2015).

Wider interest in this concept also results from the activities and regulations of the European Union. With the advent of the *Strategy for smart and sustainable and inclusive growth – EUROPA 2020*, research aimed at developing a knowledge-based economy and innovation began to be promoted, supporting an environmentally friendly, efficient and more competitive economy.

The *smart city* concept in the EU documents originally concerned only development in the field of energy and climate objectives (European Commission, 15.11.2017). Currently, attention is also focused on the use of digital technologies to increase efficiency and improve living conditions, save resources and social activation. The complex nature of this concept causes a heterogeneous understanding of the term. There are various approaches in the subject literature; various areas of application of modern methods of management and use of technology are exposed. On the one hand, smart city researchers focus on technical and environmental aspects of city management. They emphasize the use and importance of modern technologies in everyday urban life. As a result, innovative transport systems are created, logistics processes are optimized, green and efficient energy systems are created. The authors investigating this aspect of the functioning of cities based on the smart concept in modern technologies see the possibility of increasing the efficiency of services and raising the quality of life and reducing pressure on the environment. However, these elements defining the concept of smart city only in a direct context with information and communication technologies are insufficient. Therefore, apart from the aspect of modern technologies, attention is paid to the role of human capital, education and creativity in the development of smart cities. Participating

management is very important in this respect (Ahyenniemi, et al., 2017). As noted by Caragliu, a smart city is when investments in human capital, information and communication technologies, transport, and infrastructure are carried out through wise and sustainable participatory management of available natural resources (Caragliu, et al., 2011). Lombardi's social aspect of building smart cities also involves an adequate level of security and preservation of cultural identity. Lombardi describes these elements as "soft factors" for shaping smart cities (Lombardi, et al., 2011). According to the Correia and Wüstel approach, a smart city is capable of combining physical capital with human capital and developing better services and infrastructure. It makes it possible to combine technologies, information and political ideas into an organized city improvement program and services (Correia, and Wüstel, 14.12.2017).

There are many definitions of smart city in the literature on the subject, stressing different aspects of functioning of smart cities. However, in each of them modern technologies are important elements affecting the efficiency of urban centres? This element improves infrastructure performance, leading to cost minimization. The development of smart city also requires management that stimulates innovation and creativity, which develops cooperation with stakeholders, because the participation of residents in the public management process is an essential element of the smart city concept.

The development of contemporary technologies in the information and communication area and their implementation in the area of modern cities management is very important for the functioning of cities and its inhabitants. The most important issues in this regard should include (Stawasz, and Sikora-Fernandez, 2016):

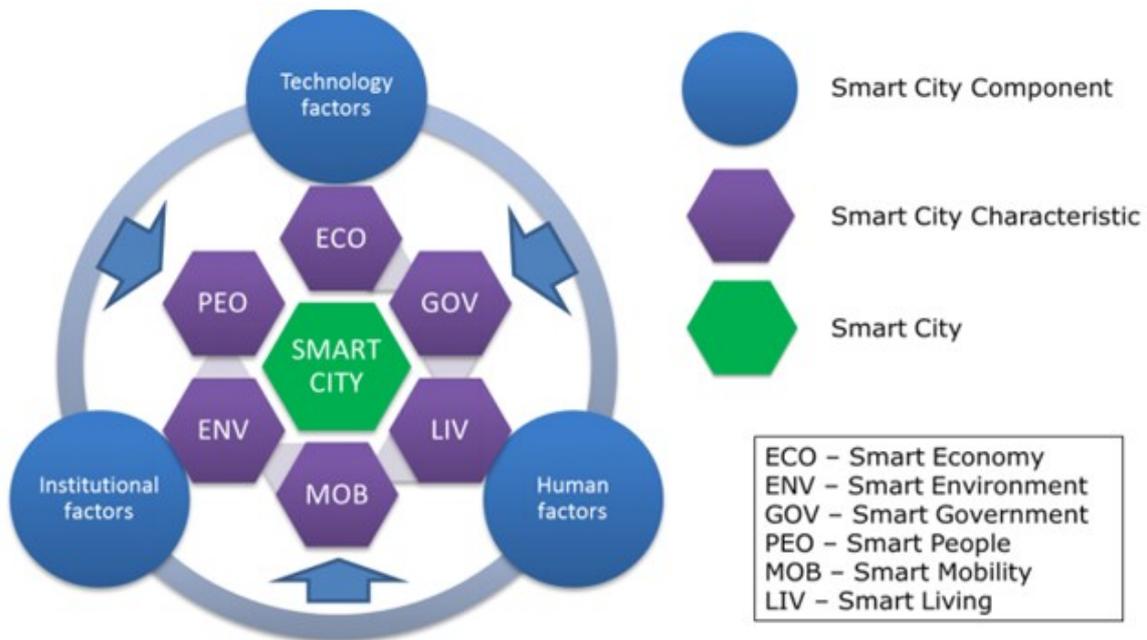
1. Cloud computing.
2. The presence of various types of sensors and meters.
3. The universality of social media.
4. Big Data analysis.

Shaping an intelligent city is a long-term process and requires a well-thought-out way of operating its individual system areas. In the literature on the subject, many spheres of shaping a smart city can be found. One of the most common approaches is the model developed by the University of Vienna, in which six basic areas of smart city have been distinguished, they are (Sikora-Fernandez, 2013):

1. Economy (smart economy).
2. Transport and communication (smart mobility).
3. Environment (smart environment).
4. People (smart people),
5. Management and governance (smart governance).
6. Quality of life (smart living).

City centres recognized as smart cities must therefore have appropriate features, the importance of which depends on the direction of development in a given spatial area. Creating smart cities in the above spheres results directly from the postulates proposed by contemporary

urban communities that deal with unfavourable phenomena on a daily basis. These are mainly road traffic, noise, security or weakening of social ties.



**Figure 1.** The relationship between components and characteristics of Smart Cities. Source: *Mapping smart cities in the EU*, European Parliament, Bruksela 2014, [http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE\\_ET\(2014\)507480\\_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf), 14.12.2017.

The pace and level of solving these problems depends mainly on the financial resources owned by the city authorities. In addition, the ability of a system approach in city management and long-term forecasting of the effects of decisions is important. At the same time, the concept of smart is the search for own, unique identity that will allow the city to build a competitive advantage. The centres that find the best way to attract investors, innovators and entrepreneurs succeed in this competition.

According to *Mapping Smart Cities in the EU* (European Parliament, 14.12.2017), smart city areas proposed by the University of Vienna are also a ground for measuring urban intelligence. According to this document, the presence of at least one smart area allows the urban centre to be included in the group of smart cities. The basis for smart city measurement, carried out by the European Parliament, is the qualitative analysis and assessment of the implemented and developed strategies for the functioning and development of cities.

Local governments implementing smart concepts in city management can also use tools that attempt to systematize this process. This is about *ISO 37120 Sustainable social development – indicators of urban services and quality of life*, published in 2014 by the International Organization for Standardization. The idea of this document is consistent with the concept of integrated progress based on reliable information. The ISO 37120 standard defines a set of measures that can be used by cities of various sizes and specificity to measure and control the level of development in the environmental, social and economic context. The authors of the standard propose measurement of urban development through 100 indicators, divided into

17 relevant thematic groups (including fire safety and crisis management, security, communication, transport, energy, education, environment, public involvement) (Polski Komitet Organizacyjny, 2017). The implementation of the standard is not obligatory and raises some kind of challenges related to with obtaining data that will be monitored on an ongoing basis. At the same time, ISO 37120 provides a number of benefits, in particular the framework for sustainable urban development or strategic planning. Thanks to the indicators adopted in the standard, it is also possible to monitor the development of cities on a general urban scale, allowing comparisons with other cities on the national, continental and global scale (important cities close to each other, for example with similar population, density or wealth) (Ciupa, and Podkowik, 14.12.2017).

Thanks to this, on the basis of benchmarking, it is possible to analyze processes and practices operating in cities of a similar nature and to implement the best existing solutions.

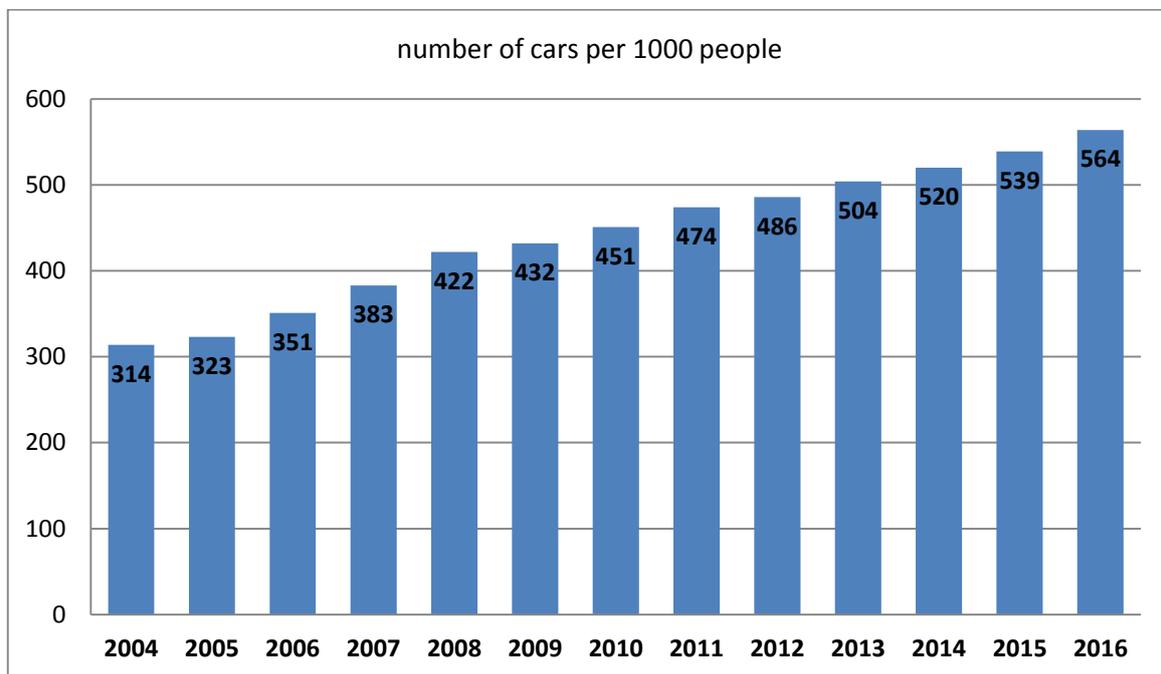
### **3. Transport in the smart city**

Transport is one of the most important elements that determine the level of social, economic and technical development of the city. One of the functions of urban transport is taking care of the internal development of the city, as well as linking all its spheres of functioning, such as production, trade, services, recreation or housing (Kiba-Janiak, and Witkowski, 2014).

Urban mobility also plays a key role in the process of shaping smart cities that are capable of implementing environmental demands and adapting to a dynamic environment. In particular, these undertakings should take into account the need to maintain appropriate proportions between the social, environmental and economic aspect, constituting the fundamental pillars of sustainable development, which is one of the conditions for shaping smart city.

Currently, urban mobility is one of the biggest problems in shaping smart cities, generating increasingly larger environmental and economic losses. Together with the chaotic development of urban transport and its impact on the quality of life in cities, there is a visible reorientation of actions for smart solutions in the field of urban mobility. However, individual communication remains an unresolved problem. As a means of transport, it allows relatively easy movement and convenient access to various destinations. A car performing the function of a particularly valuable good, especially in Poland, is a determinant of social position. This means of transport is an essential factor shaping the spatial and functional layout of cities. It is also an element hampering the development of mobility of residents in the smart system. Personal communication as a factor of spatial development and changes in the city structure is at the same time a reason for the increase in the costs of functioning of urban centres. In Poland, there is an upward trend in the change in the level of motorization. Every year, more and more

cars are coming, in 2016 there were 564 cars per 1000 inhabitants of our country, which is a 4.5% increase compared to 2015, and as much as 45% increase compared to 2004.



**Figure 2.** Number of cars per 1000 people in Poland. Source: own elaboration based on the Central Statistical Office data.

Significant traffic in cities has an undesirable impact on the economy and society, also negatively affects the health of residents and the natural environment. The main ecological problems in urban centres concern the increase of CO<sub>2</sub> emissions, air, soil and water pollution, noise and vibrations. Although these problems are local, their effects affect a large number of populations and go beyond urban areas. Among them climate change, diseases or bottlenecks in supply chains are included (Motowidlak, 2015).

The size of issues related to the nuisance of transport activity in urban space induces actions to minimize its impact on the quality of life. It should be remembered that mobility is one of the key and necessary elements of human life; it is one of the great achievements of our civilization. Therefore, the reduction of the use of individual communication implied by the smart city concept cannot restrict the freedom of movement.

Bearing in mind the lack of possibility to completely eliminate individual transport, one should strive for qualitative solutions allowing for effective use of its advantages. Intelligent development of transport in a smart city is also conditioned by the use of modern communication and information technologies. Innovative solutions allow for even greater integration of elements of the transport system thanks to which it is possible to determine the behaviour and preferences regarding the mobility of the urban community. More and more cars are connected to the Internet, but also to other vehicles and the surrounding infrastructure. For this purpose, apart from the commonly used geolocation, the Internet of Things is being developed and the transfer and analysis of data in the cloud.

Ericsson is one of the pioneers of using these technologies in the automotive industry. The company proposed the concept Connected Vehicle Cloud, which is a proposal to connect all the electronic systems of the car with the management of them in the cloud. One of the assumptions of this concept is the permanent submission of reports on road conditions to the cloud, which is available to other drivers using this technology. It gives the possibility of quick and easy access to information on traffic, weather conditions or random events in real time (Ericsson, 18.12.2016).

Thanks to advanced technology and many connections between elements of the urban transport system, the implementation of the *green wave* concept, i.e. synchronization of traffic lights, is more and more real. However, the very setting of lights in such a way that they change at specific intervals is not difficult and commonly used. The challenge is to adjust the cycle of light changes from constantly changing traffic. The throughput of arteries and intersections is limited, so when there are too many vehicles on the road, some of them are not able to cross the route on the so-called green wave. Full adjustment of the change of lights to the current intensity requires analysis of the traffic situation and cooperation of drivers. Moving away from traditional light control at individual intersections, in favour of more innovative methods, creates much greater opportunities for the overall formation of communication streams.

The automotive concerns are also involved in the improvement of the green wave, which already in the design and production phase of vehicles, equip them with the necessary sensors. One of these companies is Ford, which as part of a British project researching autonomous driving and communication between cars – UK Autodrive, tests the Green Light Optimal Advisory System (the system of advising optimal speed for green light). This system uses information about the time of the high-beam cycle obtained with the use of roadside sensors, to show the driver the information about the optimal speed, which will ensure the continuity of driving on green light.

The use of modern technologies in the economic, social and environmental sphere can also effectively reduce transport needs using a car. Communication and information technology can successfully replace everyday business trips, official matters (bank, administrative matters, etc.), stationary shopping or personal meetings. Bearing in mind the aspect of "necessary mobility", local self-governments should try to limit the need to use cars with such solutions as: better communication, attractive public transport or modern land development (Malasek, 2016).

Attractive public transport is, above all, the sphere of activity that implements the demands of society so far met only by a car. This type of transport should in particular be: comfortable, safe and quick, while taking into account environmental aspects. These assumptions can be achieved not only thanks to modern and intelligent technologies, but also by intelligent organizational and construction activities, which include short waiting times at public transport stops, well-organized transfer hubs, priority in servicing public transport at intersections and crossings, and also call-and-ride services.

Intelligent spatial planning is of great importance for intelligent mobility and relocation within urban centres. It should be done taking into account in particular the relatively small distance between the place of work, home and large shopping centres. In addition, places that generate a high level of traffic (high office buildings, shopping centres, sports halls, etc.) should be located near the main corridors of public transport and interchange transport hubs.

Public transport is ecologically and economically efficient, as compared to individual transport it needs much less space, which is especially important in the compact development of existing cities. Public communication is much safer, less accidental and less noisy (Szołtysek, and Twaróg, 2012).

An important issue in building intelligent mobility is skilful shaping of residents' preferences and behaviour. This applies not only to the transition from a personal car to public communication, but also solutions based on car-sharing and car-pooling use. The proper availability of means of transport in these systems in time and space is essential in the dissemination of these issues (Pieriegud, 2017). Recently, the car-sharing service is available in the largest Polish cities. The car rental offer for minutes meets the requirements of many city residents, especially where the use of own car is more and more onerous, especially through problems with finding parking spaces. Undoubtedly the very concept of car-sharing will not solve the problems of the lack of free parking spaces or will not eliminate congestion in urban space. However, it undoubtedly favours limiting the number of vehicles in the city.

## Summary

The priority in the activities of local authorities should be, above all, to raise the level of efficiency of the functioning of urban centres. Striving to achieve the result, which allows determining the city as smart, local authorities are forced to a specific resource management policy in such a way as to fully coordinate all aspects of the city's operations. In the field of intelligent mobility, one should remember not only about the need to develop intelligent forms of transport, but also the needs of residents should be taken into account, because it is possible to make huge investments in smart technologies that will not bring tangible results. An intelligent city transport system is one that satisfies primarily local transport needs in an economically, socially and ecologically effective way. Modern technologies can only be effective if their users can use them efficiently. Therefore, the priority in the aspect of building smart mobility should be system consultations with residents, in which technologies will play a supporting role. The smart city concept, including smart mobility, will continue to be developed in the near future. It seems that the issues of discrepancies between the technological and human factors are slowly disappearing, now the need for a holistic approach to smart city is visible, which main goal is to increase the quality of life of the inhabitants of urban centres.

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