Intelligent Transport Systems (ITS) in Smart City

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Abstract Contemporary cities are areas with diverse functions on which economic and social activities are concentrated. The concept of a Smart City as a progressive city of the future assumes sustainable urban development based on innovative technologies, the application of which is aimed at increasing the functionality of cities by economical, effective and ecological management. The purpose of intelligent technologies used in the city is to support the residents and provide them with comfortable, economical and safe lives. This concept covers economic, infrastructural, organizational and social issues. One of the elements of the Smart City concept is smart mobility in the sense of safe, effective and efficiently integrated management systems of transport, logistics, public transportation, bicycle traffic and parking—due to the use of intelligent transport systems, which constitute a wide collection of various tools based on information and telecommunications technology. The aim of the paper is to present selected ITS solutions that increase the efficiency and integration of the urban transport system.

Keywords Smart City · Smart mobility · Intelligent transport systems

1 Introduction

Contemporary cities are areas with diverse functions on which economic and social activities are concentrated. Decision-making, administrative, economic, political, educational, cultural, health care and others functions are concentrated in multi-million cities, agglomerations and metropolises. The issue of urban development is a very important and complex one, especially from the point of view of sustainable development because [37]:

- half of the world's population—3.5 billion people—live in cities today,
- by 2030, almost 60% of the world's population will live within urban areas,

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- cities in the world occupy only 3% of the Earth's surface and account for 60–80% of energy consumption and 75% of carbon emissions,
- rapidly progressing urbanization processes exert excessive pressure on freshwater resources, sewage systems, living conditions and public health care.

Eradication of unfavourable phenomena related to the expansion of urban centres is one of the priorities of global development, recognized in a number of international documents, including the Agenda 21 (i.e. a document showing an approach to implementing sustainable development in local life), adopted at the First Earth Summit in Rio de Janeiro (1992); the Territorial Agenda of the European Union (the so-called Leipzig Charter), created at an informal meeting of ministers of EU Member States on Territorial Cohesion and Urban Development (2007); the Treaty of Lisbon (2007), as well as the renewed EU sustainable development strategy (2006); Declaration from Marseille (2008); or the Declaration of Toledo (2010). These documents clearly state that the management of urban areas should be regarded as a priority and that it should be based on the strategy of coherent and sustainable development conducive to achieving greater economic competitiveness, environmental effectiveness, social cohesion and strengthening civic attitudes [29]. The most common issues covered by urban strategies for sustainable development are [29]:

- economic development, including job creation,
- creation of conditions for new business investments,
- enhancement of the intellectual capital of the city,
- increase in the quality of life in the city (condition of the natural environment, level and quality of medical services and social assistance, level of public safety),
- modernization and extension of the city's technical infrastructure system,
- revitalization of the area,
- increase in the recreation and leisure offer as well as the tourist attractiveness of the city.

Smart City as a modern city of the future optimizes sustainable urban development based on innovative technologies which are aimed at increasing the functionality of cities by economical, effective and ecological management. Intelligent technologies used in the city enhance the quality of urban services and improve the quality of life. The concept of a Smart City covers a wide range of economic, infrastructural, organizational and social issues. One of the most important elements of the Smart City concept is smart mobility understood as safe, effective and efficiently integrated systems monitoring and managing traffic and transportation systems, using intelligent transport systems, consisting of many various tools based on information and telecommunications technology.

The aim of the article is to review and analyse theoretical issues related to the definition and evolution of the Smart City concept as a direction of urban development. Hypothesis that without the implementation of innovative technological solutions modern, especially multi-million cities will not be able to solve their growing problems (among others in the area of economic and social urban mobility) can be put forward. For the purposes of the article, methods of descriptive and comparative

analysis were used to present and evaluate selected ITS solutions that increase the efficiency and integration of the city's transport system.

2 The Smart City Concept

The concept of a Smart City appeared in year 1992 to signify the turn in urban developments towards technology, innovation and globalization [6]. The concept of Smart City as an urban area of sustainable development is the subject of serious consideration in the literature. There are many definitions that differ from each other. The Smart City concept is commonly used in different nomenclatures and contexts and with different meanings. Apart from the Smart City concept, it is possible to indicate other similar concepts relating to modern urban areas such as [5]:

- Intelligent City,
- Knowledge City,
- Sustainable City,
- Talented City,
- Wired City,
- Digital City,
- Eco-City.

Many publications review the definition of smart cities [2, 14, 19, 22, 23], pointing to changes that have occurred in them as a result of the development of the concept.

Among the definitions of the Smart City, one can find those that emphasize technical, social, institutional or environmental aspects, e.g.:

- "The Smart City is a new way of leaving and considering the cities. The optimization of available and new resources as well as of possible investments is required. The achievement of Smart City objective can be reached through the support of various information and communications technologies. These can be integrated in a solution considering the electricity, the water and the gas consumptions, as well as heating and cooling systems, public safety, wastes management and mobility" [18].
- "The Smart Cities concept is connected to notions of global competiveness, sustainability, empowerment and quality of life, enabled by broadband networks and modern ICTs. Its implementation requires the development of migration paths regarding Internet infrastructures, test bed facilities, networked applications and stakeholder partnerships" [13].
- "Key conceptual components of Smart City are three core factors: technology (infrastructures of hardware and software), people (creativity, diversity and education) and institution (governance and policy). Given the connection between the factors, a city is smart when investments in human/social capital and IT infrastructure fuel sustainable growth and enhance a quality of life, through participatory governance" [23].

The more complex concept of the Smart City factors is presented by Chourabi et al. [2]. They list eight clusters of factors including (1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure and (8) the natural environment.

Mosannenzadeh and Vettorato [22] analysed existing Smart City definitions and concluded that the concept of Smart City was mostly developed in three areas: academic, industrial and governmental. The review of the literature also allowed to identify that the Smart City concept itself is not fixed but usually assigns ICTs a significant role in Smart urban development. In addition, one should pay attention to the differences occurring in the above-mentioned three areas (academic, industrial and governmental) on the semantic interpretation of the word "Smart". In the academic area, it usually refers to the features of technological solutions, in the industrial area to the characteristics of intelligent products and services [23], and in the governmental documents to the concept of "Smart Growth" that is an urban planning theory originating from USA and dealing with prevention of urban sprawl [8].

It is generally believed that a city can be treated as "intelligent" when it invests in human and social capital and communication infrastructure in order to actively promote sustainable economic development and high quality of life, including wise management of natural resources, through civic participation.

For the purpose of the article, it was assumed that Smart City is a concept focused on sustainable urban development based on innovative technologies, primarily IT and communication. It aims to improve the functionality of cities by economical, effective and ecological management. It is a concept that covers economic, infrastructural, organizational and social issues. It is possible to identify six basic components that make up a Smart City [3, 7, 12, 27]:

- smart governance as a transparent exchange of information between residents, a city, central units and municipal services units, police, fire brigades, emergency medical services,
- smart economy (e-business and e-commerce) enabling efficient flow of goods, services and knowledge at the city level and between cities,
- smart mobility as safe, effective and efficiently interconnected systems for management of transport, logistics, public transport, bicycle traffic, parking,
- smart environment as intelligent management of environmental resources (smart meters, devices supporting energy storage, devices supporting the reduction in energy consumption, rational management of electricity, intelligent lighting systems, implementation of renewable energy sources, waste management),
- smart people—smart education/residents information (access to training, education through modern communication and information technologies; support of resources, creativity and human potential, enabling active participation of residents in the life of the urban community),
- smart living—smart lifestyle enabling to raise the quality of lifestyle based on ICT: a wider, more diverse cultural and service offer, better insight into the offer of healthcare facilities, housing offer.

Currently, the attractiveness and quality of life in cities are assessed using a series of complex indicators and indices—the so-called Urban Indicators, which are tools for monitoring sustainable urban development. Among them, there are the following: City Development Index (CDI), the Sustainable Cities Index, the Green City Index, the Smart City Index, the Quality of Life Index, the IESE Cities in Motion Index, etc. They differ in the choice of indicators to calculate subindices, the number of subindices and the method of selecting cities for comparison. Therefore, the rankings of cities based on individual indicators are often incomparable. In addition, even within one index, there are problems in comparing the position of the city in subsequent years, because the number of indicators to be assessed for particular subindices, the number of cities assessed or the introduction of new indicators change. Only formulation of relatively stable models for the assessment in a given timeframe will allow for a full comparative analysis.

To indicate the position of Polish cities, IESE Cities in Motion Index (CIMI) [9–11] were chosen. In the 2016 edition of the CIMI, 181 cities (including 72 capitals) were assessed from 80 countries in 10 areas: economy, human capital, technology, the environment, international outreach, social cohesion, mobility and transportation, governance, urban planning and public management (overall 77 indicators). In the 2017 edition of the CIMI, 180 cities (including 73 capitals) from 80 countries (overall 79 indicators) were assessed. In 2018 edition of the CIMI, there are 165 cities (including 74 capitals) from 80 countries. In 2018, changes were introduced expanding the number of indicators (altogether 83 indicators), including levels of compliance with ISO 37120 (known as a Smart City standard) and combining two areas of governance and public management into one called governance.

In the 2016 edition, the following cities were at the top of the ranking (first 5) New York, London, Paris, San Francisco and Boston. In the 2017 edition, the first 5 cities were almost the same, only San Francisco and Boston changed places: New York, London, Paris, Boston and San Francisco. In 2018 edition, the first 5 cities were: New York, London, Paris, Tokyo and Reykjavik (in the previous editions Reykjavik was not evaluated).

Table 1 presents data from CIMI in 2016–2018 for two Polish cities: Warsaw and Wroclaw. However, Wroclaw was not included in the CIMI 2018 edition. Due to changes in the calculations of individual subindices, it is difficult to unequivocally assess changes in particular areas, which is most evident for Warsaw for the environmental subindex. Nevertheless, it can be noticed that the worst values for these two cities are found in economy, public management and technology subindices. Wroclaw is also low in human capital and international outreach areas, while both cities have the best values in urban planning (in 2017 both cities were positioned in the top ten).

The aforementioned ISO 37120: 2014 standard, Sustainable development of communities—Indicators for city services and quality of life measures the development of cities from a social, economic or environmental perspective, the quality of urban services and the standard of living of residents through 100 indicators, of which 46 are considered basic and 54 additional ones. All indicators were divided into 17 main thematic groups describing the concept of sustainable development and qual-

Table 1 Position of Polish cities according to CIMI in 2016–2018 [9–11]

Index	Warsaw			Wroclaw		
	2016	2017	2018	2016	2017	2018
Cities in motion	74	54	64	94	95	–
Economy	113	95	108	121	127	–
Human capital	121	59	65	146	123	–
Social cohesion	34	29	58	77	68	–
Environment	66	16	83	71	19	–
Public management	140	142	–	170	169	–
Governance	78	93	50	94	108	–
Urban planning	12	6	15	14	10	–
International outreach	87	83	30	116	105	–
Technology	68	70	114	53	68	–
Mobility and transportation	61	41	58	126	155	–

ity of life. These are: economy, education, energy, environment, recreation, safety, shelter, solid waste, telecommunications and innovation, finance, fire and emergency response, governance, health, transportation, urban planning, wastewater, water and sanitation. Certification is carried out on five levels: aspiring, brown, silver, gold and platinum, and the level of certification depends on the number of indicators reported by the city. In Poland, the certificate of compliance with the ISO 37120 standard has been awarded to three cities: Gdynia and Gdansk in 2017 and Kielce in 2018.

The implementation of the ISO 37120 standard aims at more efficient city management, including provision of higher-quality urban services and support for informed decision-making based on data and verified information. It is a tool that allows for objective assessment of the compliance with the standards of a modern management in the city.

In 2016, the next standard ISO 37101:2016 Sustainable development in communities—Management system for sustainable development—Requirement with guidance for use was published.[1]

3 Intelligent Transport Systems (ITS)

Smart mobility as one of the elements of the Smart City concept is essential for the functioning and development of the city and the quality of life of the residents. The efficient transport system of the city based on the use of intelligent transport systems, which depend on information technology and telecommunications, is a

[1] ISO 37101:2016 Sustainable development in communities—Management system for sustainable development—Requirements with guidance for use, https://www.iso.org/standard/61885.html.

factor influencing decisions regarded as decisive for the competitiveness of cities and regions, such as investment location, both from perspective of investors and people seeking a place to live.

Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport [4] has defined Intelligent Transport Systems (ITS) as information and communication systems to provide services related to different modes of transport and traffic management, allowing better information for different users and ensuring safer, more coordinated and "smarter" use of transport networks. They are used in traffic management and mobility management, and they can cooperate with similar systems used in other modes of transport. In addition, the Directive provides a common framework for the coordinated implementation of ITS in the EU, with particular emphasis on the cross-border cooperation between Member States. The application of ITS in road transport and its interactions with other modes of transport is the main concern of this document. The Directive sets the necessary conditions and specifies the directions of activities in the priority areas with the development of appropriate standards when needed. This applies in particular to areas such as:

- optimization of the road, traffic and travel data usage,
- continuity of ITS services related to traffic management and freight transport,
- ITS applications related to road safety and security,
- connection of the vehicle with the used transport infrastructure.

Intelligent Transport Systems (ITS) constitute a wide range of various tools based on information technology, telecommunications and vehicle electronics used to increase the efficiency and integration of the entire transport system of the city. ITS implementation aims to improve traffic efficiency by reducing travel time, reducing nuisances such as pollution and noise, and increasing safety in transport [28].

The main areas supporting Intelligent Transport Systems are as follows [1, 16, 20, 21, 25, 28, 31, 35, 38, 39]:

- traffic management,
- management of public transport,
- management of cargo transport and fleet of vehicles,
- traffic safety management and monitoring system for regulations' violation,
- management of road incidents and emergency services,
- information services for travellers,
- electronic payment services [15] and electronic systems for collecting toll for road use.

ITS operation is based on the processes of collecting a lot of different information about the status of individual subsystems and then their processing and analysis in order to take the best decision in a given situation. Various entities may be the recipients of the information, e.g. traffic management authorities, public transport managers, local government units, infrastructure users, emergency services, passengers, etc.

From the point of view of urban mobility management, the subsystems related to transport management play an important role in [27]:

- central gathering of information on traffic flows; control of traffic lights and flows depending on the current traffic situation, road events in real time, improving the capacity of the city's road transport system,
- collective transport management, enabling rolling stock monitoring, effective passenger information, building dynamic schedules allowing more comfortable use of public transport, better resource planning and savings associated with more efficient use of rolling stock,
- managing parking spaces together with a guidance system for road users, enabling efficient guidance on free parking spaces, detection of exceeding the set parking time, reservation of seats.

Thanks to the ITS application, the benefits can be achieved by both residents and entrepreneurs conducting business activities in the city. The basic benefits of using Intelligent Transport Systems in the city include increasing street capacity, reducing time losses in the street network and improving traffic safety [16].

Benefits of using Intelligent Transport Systems are as follows [25]:

- increase in the capacity of the street network by 20–25%,
- improvement in road traffic safety (reduction in accidents by 40–80%),
- reduction in travel times and energy consumption (by 45–70%),
- improvement in the quality of the natural environment (reduction in exhaust emissions by 30–50%),
- improvement in the comfort of travel and traffic conditions for drivers, travellers and collective transport,
- reduction in the costs of road fleet management,
- reduction in expenses related to maintenance and renovation of the surface,
- increase in the economic benefits in the region.

Today, Polish agglomerations, following the example of European cities, implement modern traffic management systems, including Intelligent Transport Systems that bring many benefits related to improving the local quality of life. Intelligent Transport Systems contribute to the optimization of transport mobility of the society and the quality of transport services, which in turn gives positive economic effects, reduction in pressure on the environment and improvement in road safety [36].

The ITS projects currently implemented in Poland are usually large and complex solutions, consisting of many subsystems. The most common domain subsystems are as follows [30]:

- area motion control by means of traffic lights,
- information on traffic conditions, transmitted via various media—electronic text tables and variable message signs (VMS), Web portals and mobile applications,
- electronic boards, guiding parking lots and informing about the number of vacancies,

- supervision of compliance with road traffic regulations—measurement of instantaneous and part speed, entry at red traffic light, exceeding the permissible total weight of the vehicle,
- video traffic monitoring and event detection through automatic image analysis,
- dynamic stop information on electronic boards about the estimated time of departure of public transport vehicles,
- supervision of transport traffic: location of vehicles while driving, deviations in running in relation to the timetable, dedicated dispatch communication systems,
- charging for road tolls, using public transport, parking.

The most activities that could be considered as implementation of intelligent solutions were undertaken by the following cities in Poland: Bialystok, Bydgoszcz, Czestochowa, Gdynia, Gdansk, Gliwice, Lodz, Poznan, Rzeszow, Sopot, Szczecin, Kraków, Warsaw, Wroclaw and Zielona Góra. However, these cities mainly carry out activities related to the construction of infrastructure, in particular intelligent traffic management systems at intersections (assigning priority to the public transport vehicles), parking spaces occupancy monitoring systems, systems "smart transition" that increase the visibility of pedestrians, intelligent stops, as well as dynamic passenger information systems, etc.

Implemented electronic city cards enabling payments for various types of public services in the cities (many Polish cities, both large and small, already have such cards) or Open Payment Systems which operate in Jaworzno, Lodz and Wroclaw are examples of modern solutions. In addition, various types of mobile applications allowing access to timetables, dynamic passenger information or purchasing tickets for travel can be indicated as further examples of modern technological solutions employed.

Although many cities undertake various initiatives, they cannot be classified as systematic and orderly. As far as the implementation of extensive programs is concerned, local authorities are most often limited by the lack of financial resources.

4 Conclusion

In recent years, the concept of "Smart City" has become very popular. Many cities in the world and in Poland implement innovative, modern solutions to improve the quality of life of their residents.

The concept of Smart City as a modern city of the future assumes sustainable urban development based on innovative technologies, the application of which is aimed at increasing the functionality of cities in the aspect of economical, effective and ecological management.

Currently, the attractiveness and quality of life in cities are assessed using a series of complex indicators and indices—the so-called Urban Indicators, which are tools for monitoring sustainable urban development. Among them, City Development Index (CDI), the Sustainable Cities Index, the Green City Index, the Smart City Index,

the Quality of Life Index, the IESE Cities in Motion Index, etc., and ISO 37120:2014 and ISO 37101:2016 norms can be included. When analysing the position of Polish cities, it should be stated that despite many initiatives, they still have much to do to be recognized as modern cities in accordance with the models used as a base for the various assessments. Nevertheless, the fact that three Polish cities were able to obtain a certificate of compliance with the ISO 37120:2014 standard gives hope for further development of Polish smart cities.

The use of ICT systems in transport in urban areas is part of the concept of smart mobility, which is one of the Smart City components. From the point of view of creating smart mobility, available resources, financial, personal and information resources should be involved in order to properly shape attitudes and communication behaviours of city dwellers towards more frequent use of public transport, walking and cycling, and joint use of individual vehicles [17, 24, 26, 33, 34].

In Polish conditions, the mobility management process should aim at providing city residents with high-quality public transport services [32], transport interchange, an adequate network of safe bicycle paths, extensive, well-marked and safe pedestrian routes that will retain current public transport users and encourage other residents to undertake more pro-ecological journeys, in particular the resignation from the use of passenger cars for urban travel. But despite many initiatives undertaken by cities, it is still hard to classify these activities as systematic and orderly actions.

References

1. Barwiński, S., Kotas, P.: Inteligentne Systemy Transportowe w wybranych miastach Polski. Autobusy: technika, eksploatacja, systemy transportowe **10**, 26–29 (2015)
2. Chourabi, H., Nam, T., Walker, S., Ramon Gil-Garcia, J., Mellouli, S., Nahon, K., Pardo, T.A., Jochen Scholl, H.: Understanding smart cities: an integrative framework. In: 45th Hawaii International Conference on System Sciences, pp. 2289–2297. CPS, Los Alamito (2012)
3. Czupich, M., Kola-Bezka, M., Ignasiak-Szulc, A.: Czynniki i bariery wdrażania koncepcji Smart City w Polsce. Studia Ekonomiczne **276**, 223–235 (2016)
4. Directive 2010/40/EU of the European parliament and of the council of 7 July 2010 on the framework for the deployment of intelligent transport systems in the field of road transport and for interfaces with other modes of transport, 14 Mar 2018. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0040 (2010)
5. Directorate general for internal policies policy department a economic and scientific policy: mapping smart cities in the EU, 14 Mar 2018. European Union Internet: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf (2014)
6. Gibson, D.V., Kozmetsky, G., Smilor, R.W.: The Technopolis Phenomenon, Smart City, Fast Systems, Global Networks. Rowman & Littlefield Publishers, Washington D.C. (1992)
7. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Milanoviü, N., Meijers, E.: Smart Cities Ranking of European Medium-Sized Cities. Centre of Regional Science (SRF), Vienna UT (2007)
8. Herrschel, T.: Competitiveness and Sustainability: Can 'Smart City Regionalism' Square the Circle? Urban Studies **50**, 2332–2348 (2013)
9. IESE Business School: IESE Cities in Motion Index 2016, 9 Aug 2018. https://www.iese.edu/research/pdfs/ST-0396-E.pdf (2016)

10. IESE Business School: IESE Cities in Motion Index 2017, 9 Aug 2018. https://www.iese.edu/research/pdfs/ST-0442-E.pdf (2017)
11. IESE Business School: IESE Cities in Motion Index 2018, 9 Aug 2018. https://www.iese.edu/research/pdfs/ST-0471-E.pdf (2018)
12. Jankowska M.: Smart City jako koncepcja zrównoważonego rozwoju miasta – przykład Wiednia. Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania Uniwersytetu Szczecińskiego **42**(t. 2), 174–175 (2015)
13. Komninos, N., Schaffers, H., Pallot, M.: Developing a policy road map for smart cities and the future internet. In: eChallenges e-2011 Conference Proceedings, IIMC International Information Management Corporation (2011)
14. Komninos, N.: The Age of Intelligent Cities. Smart Environments and Innovation-for-All Strategies. Routledge, London and New York (2014)
15. Kos, B.: Development of electronic payments in Poland using the example of local and regional collective transport. In: TST 2015 Tools of Transport Telematics, CCIS 531, pp. 352–361. Springer, Berlin Heidelberg (2015)
16. Koźlak, A.: Inteligentne systemy transportowe jako instrument poprawy efektywności transportu. Logistyka **2**, CD (2008)
17. Koźlak, A.: Kierunki zmian w planowaniu rozwoju transportu w miastach jako efekt dążenia do zrównoważonego rozwoju. Transport Miejski i Regionalny **7/8**, 39–43 (2009)
18. Lazaroiu, G.C., Roscia, M.: Definition methodology for the smart cities model. Energy **47**, 326–332 (2012)
19. Marolla, C.: Climate Health Risks in Megacities, Sustainable Management and Strategic Planning. CRC Press, Boca Raton (2016)
20. Mikulski, J.: Wizja rozwoju Inteligentnych Systemów Transportowych w Polsce. Przegląd ITS **17**, s. 8–9 (2009)
21. Modelewski, K.: Czym jest ITS?, 14 Mar 2018 http://www.itspolska.pl/?page=11
22. Mosannenzadeh, F., Vettorato, D.: Defining Smart City. A conceptual framework based on keyword analysis. TeMA, Journal of Land Use, Mobility and Environment, Special Issue, 683–694 (2014)
23. Nam, T., Pardo, T.A.: Conceptualizing Smart City with dimensions of technology, people, and institutions. In: Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, ACM, pp. 282–291 (2011)
24. Nosal, K., Starowicz, W.: Wybrane zagadnienia zarządzania mobilnością. Transport Miejski i Regionalny **3**, 26–31 (2010)
25. Oskarbski, J., Jamroz, K., Litwin, M.: Inteligentne Systemy Transportu - zaawansowane systemy zarządzania ruchem, 14 Mar 2018. http://docplayer.pl/4094310-Inteligentne-systemy-transportu-zaawansowane-systemy-zarzadzania-ruchem.html (2006)
26. Osyra, B.: Zarządzanie mobilnością miejską – Instrumenty i podstawowe etapy wdrażania zrównoważonych planów zarządzania (SUMP). Zeszyty Naukowe Politechniki Częstochowskiej Zarządzanie **22**, 218–229 (2016)
27. Polskie miasto przyszłości: Inteligentne rozwiązania w Twoim mieście, 14 Mar 2018. http://polskiemiastoprzyszlosci.pl/ (2014)
28. Proper, K., Allen, T.: Intelligent Transportation System Benefits: 2000 Update. U.S. Department of Transportation, Washington D.C. (2001)
29. PWC: Miasta na drodze do zrównoważonego rozwoju. Najlepsze praktyki polskich miast nagrodzonych w Konkursie "Miasto Szans-Miasto Zrównoważonego Rozwoju", 14 Mar 2018. https://www.pwc.pl/pl/biuro-prasowe/assets/miasto_szans_opisy_dobrych_praktyk.pdf (2013)
30. Qumak: Inteligentne systemy transportowe, 14 Mar 2018. http://www.qumak.pl/wp-content/uploads/2014/01/Qumak_ITS_2015.pdf (2015)
31. Siergiejczyk, M., Tatar, K.: Koncepcja wdrażania usług Inteligentnych Systemów Transportowych w obszarze miejskim. Prace Naukowe Politechniki Warszawskiej. Transport **113**, 443–453 (2016)

32. Starowicz, W.: Jakość usług w miejskim transporcie publicznym. Wydawnictwo Politechniki Krakowskiej, Kraków (2008)
33. Starowicz, W.: Zarządzanie mobilnością wyzwaniem polskich miast. Transport Miejski i Regionalny **1**, 42–47 (2011)
34. Szołtysek, J.: Kreowanie mobilności mieszkańców miast. Wolters Kluwer, Warszawa (2011)
35. Świderski, A., Kamiński, T., Zelkowski, J.: Aspekty Inteligentnych Systemów Transportowych w miastach. Gospodarka Materiałowa i Logistyka **5**, 697–707 (2016)
36. Tomaszewska, E.J.: Inteligentny system transportowy w mieście na przykładzie Białegostoku. Zeszyty Naukowe Uniwersytetu Szczecińskiego, Problemy Zarządzania, Finansów i Marketingu **41**(t. 2), 317–329 (2015)
37. UN GLOBAL COMPAKT: Zrównoważone miasta. Życie w zdrowej atmosferze. Network Poland (2016)
38. Wałek, T.: Inteligentne Systemy Transportowe jako instrument poprawy bezpieczeństwa. Security, Economy & Law **2**(XI), 67–73 (2016)
39. Wojewódzka-Król, K., Rolbiecki, R.: Inteligentne systemy transportowe w świetle europejskiej polityki transportowej. Zeszyty Naukowe Uniwersytetu Szczecińskiego, Ekonomiczne Problemy Usług **57**, 65–72 (2010)