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SMART MOBILITY SOLUTIONS IN PUBLIC TRANSPORT BASED ON ANALYSIS CHOSEN SMART CITIES

MOBILNOŚĆ INTELIGENTNA W TRANSPORCIE PUBLICZNYM NA PODSTAWIE ANALIZY WYBRANYCH MIAST INTELIGENTNYCH

Summary: The term smart city is increasingly used in media and across society. Every city wants to have the status of a smart city, because it means using smart solutions to help the city with contemporary problems related to, inter alia, public transport. For the inhabitants of these cities, the implementation of the smart city concept may mean a higher level of quality of life and greater comfort of life. The main goal of this paper is the presentation of the results of the conducted study on what cities should do and how, in order to improve the quality of public transport in their city to become a smart city. Based on comparative analysis of public transport of the best smart cities in the world i.e. London, San Francisco and Singapore, this research aims at pointing out the development direction of implementing smart mobility for cities. The selected cities will be examined and compared according to the following criteria: availability of transport in the city, applied technologies in transport solutions, and the strategy for the development of transport services in the city.

Keywords: smart city, smart mobility, public transport, information and communication technologies (ICT).

Streszczenie: Pojęcie miasta inteligentnego jest coraz częściej stosowane w mediach i spo-łeczeństwie. Każde miasto chce mieć status miasta inteligentnego, ponieważ oznacza to sto-sowanie inteligentnych rozwiązań, które mają pomóc eliminować współczesne problemy dotyczące m.in. transportu publicznego. Dla mieszkańców tych miast realizacja koncepcji *smart city* może oznaczać wyższy poziom jakości życia i większy komfort życia. Głównym

celem tego artykułu jest prezentacja wyników przeprowadzonego badania na temat tego, co miasta powinny realizować i jak powinny to robić, aby poprawić jakość komunikacji zbiorowej i aby stać się miastem inteligentnym. Opierając się na analizie porównawczej transportu publicznego najlepszych miast inteligentnych na świecie, tj. Londynu, San Francisco i Singapuru, wskazano działania istotne dla rozwoju miasta inteligentnego. Wybrane miasta zbadano i porównano ze względu na następujące kryteria: dostępność transportu w mieście; zastosowane technologie w rozwiązaniach transportowych i strategię rozwoju usług transportowych w mieście.

Słowa kluczowe: *smart city*, miasto inteligentne, mobilność inteligentna, transport publiczny, technologie informacyjno-komunikacyjne.

1. Introduction

Modern cities are developing very quickly. Fast and dynamic urban development is caused by several factors, among which we can mention urbanization and globalization.

Urbanization means the process of a large concentration of people in specific places which are urban areas. This process is associated with very fast population growth in cities. Inextricably linked to this process is also the expansion of city borders and incorporating smaller towns around them into the cities. Due to the widespread development of cities, modern cities face various problems, the main ones being: problems with optimization and the effective organization of public urban transport; popularization of cars as a means of communication (a large number of urban residents choose a car instead of public transport); traffic congestion occurring during the rush hour which prevents citizens from reaching their place of residence smoothly; the city center becomes an increasingly less desirable place to live; high pollution of cities [*Smart City. What is a smart city* 2017]. In connection with the aforementioned problems of the city, the managers of these cities should take steps to make them a friendly living environment. The smart cities concept can help these cities.

The main goal of this paper is the presentation of the results of the conducted study on what cities should do and how they should do it in order to improve the quality of public transport in their city to become a smart city. We will try to establish if there is a generic development direction that aspiring cities could adopt, based on the current leaders in the world.

The paper is structured as follows: the next section focuses on the definition of a smart city. Then the meaning of smart mobility in public transport in the smart city concept is discussed. Following that, we present the assumptions of our research and the obtained results. The paper closes with a summary.

2. Review of the smart city definitions

There are numerous definitions of a smart city in the literature. A smart city is described as "a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure" [Smart City, 2017]. According to S. Dirks and M. Keeling, a smarter city "is one that uses technology to transform its core systems and optimize the return from largely finite resources. By using resources in a smarter way, it will also boost innovation, a key factor underpinning competitiveness and economic growth. Investments in smarter systems is also a source of sustainable employment" [Dirks, Keeling 2009]. Another definition of a smart city is: "Smart cities are cities built on 'Smart' and 'Intelligent' solutions and technology that will lead to the adoption of at least five of the following eight smart parameters–smart energy, smart building, smart mobility, smart healthcare, smart infrastructure, smart technology, smart governance and smart education, smart citizen" [Frost, Sullivan 2011]. A more extensive review of the definitions of smart city is presented, among others, in the following publications: [Anthopoulus 2017; ITU-T Focus Group on Smart Sustainable Cities 2014; Lazaroiu, Roscia 2012].

Probably the most accurate definition of smart city is the one given by the International Telecommunication Union, based on the analysis of over 100 independent definitions: "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" [ITU-T Focus Group on Smart Sustainable Cities 2014].

The presented examples prove that there is no one truly correct definition of the term "smart city". Some sources emphasise the role of soft skills - citizens who need to develop awareness and social abilities (like the sense of supporting community), whereas others highlight the importance of ICT and infrastructure solutions. Another inconsistency can be observed in the terms of defining the specific parameters of a smart city. Some sources do not refer to them at all and in others the number of components ranges between five and eight. However, all sources agree on the core of the definition, which is a more efficient and sustainable environment for humankind.

3. Smart mobility in public transport in the smart city concept

Regardless of the chosen interpretation of a smart city, none of the definitions contains information about public transport, instead the term smart mobility appears.

Mass transport is still the backbone of the presented definition but with a strong dependence on ICT components: cloud computing, software, hardware, raw data, transactions, communication and internet access all integrated into one system. From the report on smart cities and infrastructure: "Smart mobility is best described as approaches that reduce congestion and foster faster, greener and cheaper transportation options. (...) Smart mobility systems include mass transit systems as well as individual mobility systems that feature bicycle sharing, ride sharing (or carpooling), vehicle sharing and, more recently, on-demand transportation" [Smart cities and infrastructure. Report of the Secretary-General 2016].

The given definition of smart mobility does not include the term smart public transport per se, but it shares two of its main aspects – traffic optimization through the analysis of the collected data and the fact that it comprises of transport for the masses. The conclusion is that public transport is part of the smart mobility approach.

To understand the capabilities and trends of smart mobility it is essential to get familiar with the technologies used in vehicles, infrastructure and supporting systems as well as the required policies. Firstly, to determine the area of impact of these technologies there must be identified their purpose of use. According to C. Benevolo, R. P. Dameri and B. D'Auria, smart mobility objectives "(…) are summarized in the following six categories: reducing pollution, reducing traffic congestion, increasing people safety, reducing noise pollution, improving transfer speed, reducing transfer costs" [Benevolo, Dameri, D'Auria 2015].

The performed analysis of the definitions may raise the question – will the term public transport become obsolete? According to S. Bouton, S. M. Knupfer, I. Mihov, and S. Swartz from the consulting firm McKinsey & Company, in the smart future this can be true: "Our view is that (…) the lines between private and public transport will be increasingly blurred". The United Nations seems to share a similar view: "Intelligent transport systems integrate the entire array of multimodal transport options in a city, including both individual mobility and mass transit, in an efficient manner" [Bouton et al. 2015].

The next section will present the research procedure applied in the study.

4. Assumptions of the research

4.1. The goal of research and research questions

The goal of this research is to outline what cities should do and how they should do it, in order to improve the quality of public transport in their city to become a smart city. Based on comparative analysis of public transport of the best smart cities in the world, this research aimed to point out the development direction of the smart mobility realization for cities. The research question is: what are the trends in adopting smart mobility solutions in public transport in the smart city concept?

In order to find the answer to the formulated research questions, firstly it was essential to define the scope, then to gather suitable and reliable resources and lastly, to find a common denominator between the different solutions and compare them to each other. The applied research procedure consisted of three stages:

1. Defining the scope. To find answers to the research questions, firstly the area of this study by geographical field was specified. We decided to pick three cities from different continents in order to explore if there is a contrast between the regions. In the second step, criteria for comparing the cities were developed.

2. Gathering resources and specifying the scope. In the first step of gathering resources, we had to find and choose a ranking of cities that best meets the previously established requirements. In the second step, cities were chosen based on the conditions from defining the scope. In the last step, we found and analyzed good quality data from official sources (i.e. reached out to local governments, departments of transport or those responsible for handling public transport affairs) and also research papers.

3. Comparing solutions. Firstly we analyzed and compared similarities between available data, checking if the same statistics are measured. In the second step, we decided to compare only relative indicators and descriptive features. This allowed avoiding abnormalities resulting from the different characteristics of the cities, because the analyzed solutions from those cities were not measured in the same, straightforward way. In the last step, the conclusions from the research were presented.

It was assumed in the study that three cities from three different continents will be selected based on reports evaluating the best smart cities. The selected cities will be examined and compared according to the following criteria:

- Availability of transport in the city. This criterion focuses on types of transport solutions present in the city.
- Applied technologies in transport solutions. This criterion compares the intelligent solutions already implemented in the cities.
- Strategy for the development of transport services in the city. This criterion checks what type of initiatives are planned in a ten-year timespan which is considered to be medium to long-term in smart city design, as suggested by Buro Happold [Happold 2016], and what impact cities are hoping to achieve by then. Therefore, the threshold of cities strategies considered in this research is set for 2030.

In this section, the research procedure and defining the scope were described. The next section presents the selection of cities that were subject to research.

4.2. Choosing the most smart cities

To provide the most accurate and meaningful sample of smart cities we compared different smart cities' rankings, looking specifically for mobility solutions. Then we picked the most suitable report; lastly, we identified cities for this study.

Creating a smart city ranking is a subjective and ambiguous task. There are no official guidelines of what makes a city smart, or how remarkable a given solution is. Portals emphasise different technologies as those that are key factors of a smart city. To gain a broad view of possible results, we compared four rankings with a different approach: EasyPark [Smart Cities Index 2017], Juniper Research [*Smart Cities – What's in it for Citizens?* 2017], Wireless Design & Development [*Top 10 Smartest Cities in the World* 2017] and Responsible Business [*Top 10 Smart Cities of 2017* 2017].

All those papers classified cities by their own methodology, stressing subjective focal points. After reading the arguments of all reports, we selected the Juniper Research ranking [*Smart Cities – What's in it for Citizens*? 2017], because it is the most comprehensive one, taking a holistic approach that is built from a granular examination of each parameter, stating clearly what causes the particular city to be marked higher than the other ones.

The Juniper Research report [*Smart Cities – What's in it for Citizens?* 2017] comprises twenty cities from seven designated regions: Asia Pacific, West Europe, North America, Latin America, Far East and China, Middle East and Africa, and the Indian Subcontinent. The report is divided into four parts and each of them contains a description of one of the following categories: Mobility, Health, Safety, and Productivity. The main theme, a common denominator of the review, is the amount of time saved per inhabitant that result from adopting the given smart solution. According to the Juniper's investigation, the potential for time savings in the mobility sector is the highest. The authors define mobility as urban transport systems, including public and private transport, as well as non-motorised transport solutions.

Summarizing, the Juniper Research report presents twenty cities from all over the world and identifies Singapore as the leader, followed by San Francisco, London, New York and Barcelona in descending order [*Smart Cities – What's in it for Citizens?* 2017]. We chose the three best cities from different regions of the world i.e. Singapore, San Francisco and London.

5. Results of comparing the chosen smart cities

5.1. Description of chosen cities

The analysed solutions from the different cities could not be measured in the same, straightforward way. To present the results of our research, we decided to compare only relative indicators and descriptive features. This will allow to avoid abnormalities resulting from the different characteristics of the cities. The results of this study will be described in the following way:
• A brief characterization of the chosen cities. This is a general description that includes population, affluence, the average age of society.

- Description of the smart solutions implemented in the chosen cities.
- Description of these cities strategy regarding smart solutions for the future.

Each subsection consists of three parts describing the cities in alphabetical order. As a result, the first city described is London, the second San Francisco, and the last one is Singapore.

In this subsection, the chosen cities are briefly described, covering basic facts important from a transport perspective.

London is the capital city of the United Kingdom. GDP per capita equals 83,086 USD [*GDP per capita in 276 EU regions* 2017] and the median age range of citizens is 30-34 years old [*London's population by age* 2017]. The total number of registered vehicles is estimated to be higher than 2.6mln [*How many cars are there in London and who owns them?* 2012]. London will spend 27.2 bln USD on transport services in 2018.[1] Based on the report presented by Transport for London, "Travel in London" [Travel in London 2016], the car is the preferable means of transport in day to day journeys, but commuting around the city is not dominated by it. Moreover, public transport combined (bus, tram, underground, DLR and rail) adds up to 45% of modal share and beats car usage (Figure 1). There are eight different types of public transport vehicles available for the users: bus, underground, river bus, local trains, trams, city bikes, taxi, and cable car.
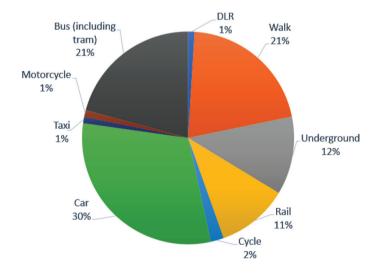

Fig. 1. Means of transport to work in London

Source: own elaboration based on [*How we are funded* 2017]; see also [Piątkowski 2018].

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[1] Based on the government's analysis of planned central government transport investment [*London transport investment…*2018] and Transport for London (TfL) spending [*How we are funded* 2017].

San Francisco is a city located in Northern California, on the West Coast of the United States. GDP per capita is 87,943 USD [GDP per capita 2017] and the median age range of citizens is 36-40 years old [San Francisco 2015]. The total number of registered vehicles within the city is estimated to be around 500 thousand [SFMTA Factsheet 2015]. Spending on transport services in San Francisco is expected to reach 1.1 bln USD in 2018 [*Balancing the Transportation…* 2018], according to the Municipal Transportation Agency budget. In reference to the 2015 factsheet presented by San Francisco MTA, the car is the most commonly used source of transport on a daily basis, but public transport does not fall far behind with only a 1% difference in share (Figure 2). San Francisco offers ten different transportation means inside its borders: hybrid buses, metro, cable cars, trolley coaches, streetcars (trams), bike share, moped share, car share, commuter shuttle, and taxi.
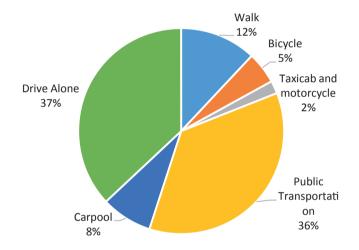

Fig. 2. Means of transport to work in San Francisco

Source: own elaboration based on [SFMTA Factsheet, 2015]; see also [Piątkowski 2018].

Singapore is a sovereign city-state and island country located in South-East Asia. GDP per capita equals 52,962 USD [*GDP per capita* (US$) 2016] and the median age range of citizen is 40-44 years old [Age Pyramid of Resident Population, 2017]. There are over 970 thousand vehicles registered in Singapore, with the vast majority of cars and station wagons (62%) (Figure 3). Singapore will spend 13.7 bln USD on transport services in 2018 [Tan 2018]. There are five types of public transport available in Singapore: train, bus, city bikes, cable car, and taxi.

The presented descriptions show the general contrast between cities in the scope of this study. In the next subsection, we analyze the smart solutions implemented in these cities.
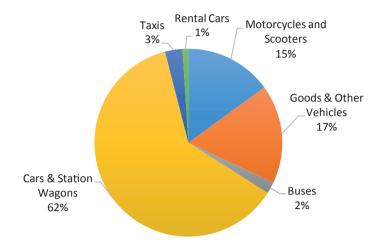
Fig. 3. Types of transport vehicles in Singapore

Source: own elaboration based on [*Smart Mobility 2030. ITS Strategic Plan for Singapore* 2014; see also [Piątkowski 2018].

5.2. Smart solutions implemented in the analyzed cities

In this subsection, a description of the smart solutions implemented in London, San Francisco, and Singapore are presented. For each city we present five important solutions for the development of public transport in the smart city concept.

The following intelligent solutions have been implemented in London:[2]

- London Datastore – The London Datastore is a free and open data-sharing portal where anyone can access data relating to the capital. Access to public data has created new markets, encouraging the development of products and services for Londoners. The Datastore receives over 30,000 visits a month, with over 450 transport apps alone having been created.

- Santander Cycles – public bicycle hire scheme in London. There are more than 11,500 bikes at over 750 docking stations across London, first set up in 2010 in a cooperation between TfL and Barclays Bank.

- Countdown service – provides live bus arrival information for all bus stops in London's network via the web, SMS and via roadside signs. The system provides not only live bus arrival times but also service disruption information and links to London Underground service updates. Live information is transmitted using TfL's state-of-the-art Automatic Vehicle Location, radio and on-bus passenger

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[2] The solutions described below are based on the Smart London Plan [*Smart London Board…* 2013] introduced in cooperation by the Smart London Board and Boris Johnson, a former Mayor of London. It is described in more detail in: [Piątkowski 2018].

information display and announcement system known as iBus, which is installed on all its buses.

- Oyster card – a form of electronic ticket used on public transport in London. Oyster card works with radio-frequency identification (RFID) technology. The reader sends energy to the card via radio waves, generating power via electromagnetic induction. This powers up the microchip in the Oyster card and allows the reader access the data stored inside the card. In December 2012, TfL began offering customers the option of using their contactless debit, credit or charge card to pay the journey fare.
- Legible London – a way-finding system for pedestrians developed by TfL to support walking journeys around London. It uses accessible maps of different scales to convey quickly the immediate surroundings and to show how the area connects to those around it. Simple 3D images of landmark buildings have been incorporated into the maps to fix given points in people's minds. Pedestrian and public transport flow data provide an insight into where people are moving and how frequently.

Summarizing, the presented solutions in London heavily support the development of public transport services. Access to information was not restricted but there are difficulties in finding updated files from official sources. Although there is a number of smart solutions implemented in London, there is no portal storing aggregated information about them.

The following intelligent solutions have been implemented in San Francisco[3]:

- SFpark – The San Francisco Municipal Transportation Agency (SFMTA) established SFpark to use new technologies and policies to improve parking in San Francisco. Reducing traffic by helping drivers find parking benefits everyone. SFpark works by using smart pricing so that drivers can quickly find open spaces. Demand-responsive pricing encourages drivers to park in underused areas and garages, reducing the demand in overused areas.
- DataSF – a portal with open data gathered from across the whole city of San Francisco. The mission of the initiative is to deliver quality data to improve citizens' life quality.
- MuniMobile – a comprehensive application to facilitate moving around the city by public transport. Examples of the features available in the application include: ability to purchase, store and use single or multiple Muni fares on one mobile device and ability to pay for single-ride fares, cable car rides, and one-day, three-day and seven-day passports.
- Clipper card – Clipper is the all-in-one transit card for the San Francisco and all Bay Area. The Clipper card can hold transit passes, cash value or any

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[3] There is no consolidated document describing San Francisco's ongoing smart mobility initiatives, therefore the solutions described in this place were found in independent research, described in more detail in: [Piątkowski 2018].

combination. The cash value works on all participating transit systems, including bike sharing services.

- SFMTA Alerts – the SFMTA offers a free electronic subscription service that allows to receive real-time alerts regarding public transport service as well as general news on transport agency topics and incoming projects. Messages are available via SMS or email.

San Francisco's initiatives are, similarly to London's, not restricted but hard to find in independent online research. There is no official source that explains the ongoing smart solutions implemented in the city.

The following intelligent solutions have been implemented in Singapore:[4]

- Mass Rapid Transit (MRT) – fully automated underground driverless train with suitable ICT infrastructure – VMS displaying real-time arrival times in the train and train stations, providing commuters with helpful information to optimize their journey plan.
- Contactless e-Purse Application Standard (CEPAS) – a national standard that makes it possible for different card issuers to access integrated payment services with implemented in Singapore information system that handles public transport services (MRT etc.). To create an even more integrated and equitable environment, distance-based fares were introduced. Thanks to complex algorithms, the entry and exit point of public transport commuters are linked and, in effect, an individually tailored fare fee is collected. Another huge benefit of introducing CEPAS is a rich source of anonymised data for analysis that allows for improving services through observing commute patterns.
- Dedicated MyTransport.SG ecosystem – an initiative started in 2008 as a website to help passengers plan their journeys, with an interactive map of bus and train stops, and a calculator to compute fares. In 2011 a dedicated and integrated web portal was introduced. New functions included traffic information, taxi-stand location, and vehicle and bicycle related information. With the increasing demand and capabilities, Singapore has launched a mobile version of the MyTransport. SG web portal.
- DataMall@MyTransport web portal – an innovative idea to create a hub to share real-time public transport data with interested third parties.
- Expressway Monitoring and Advisory System (EMAS) – almost 600 video detection cameras and radar-based traffic data collection system deployed in more than 60 locations connected to strategically placed VMS's to support decision-makingprocess for participants of the road traffic and help them to avoid congestion or incident-affected intersections.

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[4] Developed based on [*Smart Mobility 2030…* 2014]. This is a document describing current progress as well as strategies for the city's future, jointly developed by the LTA and the Intelligent Transportation Society Singapore (ITSS). It consolidates the perspectives from the Authority and the industry, paving the way for a more comprehensive and sustainable ITS ecosystem in Singapore in the coming years up to 2030, described in more detail in: [Piątkowski 2018].

The Singapore information was easy to find, stored in a single document explaining both the advancement of current initiatives and strategies for the city's future.

To sum up, all the cities have established amazing smart solutions so far. Based on the presented points, two concepts seem to be common across the cities – open data portal and electronic method of payment for transport services. San Francisco is the only city that does not share a consolidated document with the technologies implemented in the city.

5.3. Cities' strategy regarding smart solutions for the future

In this section, strategies for the development of transport services in the chosen cities i.e. London, San Francisco, and Singapore, are presented. This analysis contains the comparison of the answers for third criterion of solutions in these cities.

Description of London's strategy

London's top officials share exhaustive documentation regarding plans for city's transport future. The Mayor's Transport Strategy [Mayor of London 2018] is available to download from the main TfL site. The d presents the key strategies, describes a tailored approach for each city area and finally, emphasizes the importance of the "Healthy Streets Approach" initiative. The central aim of this strategy is to create a city that is a better place for all of its inhabitants. The most important elements of this strategy regardin transport are:[5]

1. Planning London's streets – this comprises four initiatives that focus on activity on the city streets:
- Increase all Londoner's physical activity by doing at least 20 minutes of active travel they need to stay healthy each day.
- Safer commute on the roads. The Mayor's aim is for no one to be killed in or by a London bus by 2030, and for deaths and serious injuries from all road collisions to be eliminated from the streets by 2041.
- Improving the efficiency of freight and commercial traffic. The Mayor aims to reduce freight traffic in the central London morning peak by 10 percent on current levels by 2026 and to reduce total London traffic by 10-15 percent by 2041.
- Decrease air pollution. The Mayor aims consistently and step by step move London's entire transport system to zero emissions by 2050.

2. Improving public transport – the main conviction is that public transport is the most efficient means of moving people over distances that are too long to walk or cycle. The statement is supported by three strategies:

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[5] Prepared on the basis of the following document: [Mayor of London 2018], described in more detail in: [Piątkowski 2018].

- Create new connections. The Mayor aims to reduce overcrowding by opening new train lines.
- Service expansion. The Mayor aims to create a London suburban metro to improve the experience for Londoners living outside current TfL-run lines.
- Improve accessibility. The Mayor aims to decrease the number of barriers that disabled people face during making trips inside the city.

The generic impact expected from introducing the above strategies can be summarized as a shift away from using cars as the primary means of transportation in the city. London aims to decrease car, taxi, and private hire vehicles share from 37% to 20% in 2041 [Mayor of London 2018].

Description of San Francisco's strategy

San Francisco created a website with a smart city strategy, heavily occupied with mobility matters [*Smart city challenge…* 2016]. The strategy is described by three steps and instead of presenting solutions it informs about current issues:[6]

1. Current system challenges – this strategy draws attention to the inefficiency of the transportation system. There are four main perspectives that comprise this issue:
- Private car ownership – the average car is 80 percent empty when driven and is parked 95 percent of the time. Moreover, the city's infrastructure is optimized for private cars
- Traffic burden – San Francisco was rated the third worst city in the United States for traffic. Public transport buses are extremely slow, and drivers are circling for parking creating not only additional traffic but also increase air and greenhouse gas pollution.
- Walking and cycling – while cycling is the most efficient and affordable way to get around the city, the city's bicycle network is fragmented, and these gaps deter a broader range of people from cycling every day. Cycling and walking are also considered to be very dangerous when sharing the space with cars.
- Public transit – in peak hours the system is overwhelmed but has lots of spare capacity between peaks. The lower numbers of connections in late hours impact on a certain group of citizens.

2. Sharing culture – this strategy emphasizes the benefits of initiatives like ride sharing, car sharing, bike sharing and public transport:
- Shared vehicles – car sharing, ridesharing and transit dramatically increase the number of people moved per vehicle, using the 80 percent of vehicle occupancy currently wasted in the majority of auto trips.

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[6] Prepared on the basis of the following document: [*Smart city challenge…* 2016], described in more detail in: [Piątkowski 2018].

- Traffic relief – redesigning deliveries to have them move away from large trucks to smaller vans and cargo bikes means that people get access to their goods with less impact on traffic.
- Better streets – bike sharing has grown in popularity, and as an effect, people tend to try to use other forms of sustainable modes as well.
- Public transit – sharing services play a perfect role as a first or last-mile connection for people travelling by public means.

3. Connected city – this strategy outlines the perspective for embracing different types of vehicles connected with each other to create efficient and affordable, city--wide net of intelligent transport solutions.

- Shared, electric, connected, automated vehicles – shifting towards autonomous vehicles in sharing services to increase availability for all citizens.
- Smart traffic management – connected vehicles, through multiple sensors, will be able to detect each other and avoid collisions.
- Integrated streets – owing to implementing the previous initiatives, the share of private cars on the streets will decrease, increasing the space available for cycling and walking.
- City for everyone – the goal of this point is to release the space currently occupied by parking lots to pedestrians.

In conclusion, the overall impact expected from introducing those strategies can be interpreted as shifting away from private car traffic share. Clearly, San Francisco's goal is very similar to London's.

Description of Singapore's strategy

Singapore, when creating a vision for its future, defined three main strategies and four focal areas of development. The strategies are as follows:[7]

1. Implement innovative and sustainable smart mobility solutions. A strategy that targets commute solutions dedicated to all citizens. It includes using advanced analytics for forecasting citizen trends and needs.

2. Develop and adopt ITS standards. Standardizing operations structure, data formats and introducing consistent protocols for all interested parties to improve overall efficiency.

3. Establish close partnerships and co-creation. Improve the connection between the public and private sector. Envisaging and working side by side on a clear, common goal to ensure better co-operation for the betterment of mobility services.

The four focal areas that will lay the foundation for initiatives and programmes to support and steer Singapore towards achieving it's ITS vision, are as follows:[8]

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[7] Prepared on the basis of the following document: [*Smart Mobility 2030. ITS Strategic Plan for Singapore* 2014], described in more detail in: [Piątkowski 2018].

[8] Prepared on the basis of the following document: [*Smart Mobility 2030…* 2014], described in more detail in: [Piątkowski 2018].

1. Informative – this area focuses on the development of sensor technologies, ease of collecting and processing the data. There is no longer a problem with quantity, but with the quality of gathered data. Users' need for more information has increased, therefore the importance of real-time analysis of relevant data is amongst the top priorities. Data processing and analytics include managing Big Data, as the amount and frequency of collecting data is constantly increasing. To satisfy current but also future demand, Singapore has put the emphasis on systems and methods which can be categorized into two groups, i.e. data collection technologies and data processing and analytics. Singapore plans to leverage visualisation tools to analyse huge quantities of available data and with more precise predictive analytics, improve their response to citizens demands.

2. Interactive – this area focuses on improving interactions between citizens via a net of connected devices and improving dialogue between people who express their needs and an information system that delivers a tailored solution.

3. Assistive – this area focuses on increasing safety and satisfaction with the journey. Thanks to technological advancement, Singapore plans to develop a co-operative transport system environment and decrease congestion in the city.

4. Green Mobility – this area focuses on increasing public transport usage and zero-emission vehicles. Singapore places a strong emphasis on maintaining good air quality and sees motorized traffic as a challenge.

Singapore has a comprehensive implementation strategy of smart mobility for supporting public transport.

In conclusion, each city takes a different approach to define its strategy. London's top officials describe the actual actions that they plan to take in order to meet the strategic goal, San Francisco's strategy is based on provoking thinking about current issues in the city, and Singapore outlines a detailed description of each area that it plans to innovate.

6. Conclusions

As a result of the research carried out, the following answers to the formulated research questions were obtained. The governments of these cities focus on answering to local needs, yet there are initiatives that are common across the cities. This may lead to the conclusion that developing those overlapping solutions is core for introducing innovations in cities. There are two initiatives that are present in all three cities and definitely outline a global trend: open data portal and ticketless payment system. Analysis of the selected cities has also shown that there is no smart city without technology. Very important, it needs to be acknowledged that technology should not be treated as a goal in itself but as a tool to reach the goal – which is the overall betterment of citizens.

Smart mobility is a broad field of original solutions that increase the capacity and efficiency of public transport services. This impacts not only on citizens' satisfaction

but also on economic growth, and therefore cities that are looking for improvement in public transport can gain a huge advantage from adopting the steps taken by leaders of smart cities.

Each of the chosen cities took a different approach to developing their city and finding its own way to the top of the Juniper Research smart cities ranking [*Smart Cities – What's in it for Citizens*? 2017]. After examining all available data and synthesizing an insight from the conducted study we can say that Singapore stands at the forefront of improving public transport services and should be considered the example to follow.

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