RUGGEDISED
Designing smart, resilient cities for all

Brno’s review of practices: Mobility

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Contents

Introduction

Mobility is an important part of a critical infrastructure and for habitants is an inherent part of everyday life. With development of society, there are also increasing demands on traffic and transport capacity, effectiveness, loaded, speed, safety etc. In accordance with concept of smart cities is important to find the appropriate measures for completion of requirements (Adamec et al. 2016).

Traditionally, urban mobility is about moving people from one location to another location within or between urban areas. Policy makers, urban and transport planners, and engineers spend huge amounts of time and money to improve urban mobility, based on two basic assumptions. People need to move in order to access housing, jobs and urban services, such as education and entertainment. People prefer motorized mobility to non-motorized mobility, because the former is economically more efficient than the latter, especially as cities grow and the society becomes more affluent. Those assumptions have already been challenged.

Rising public awareness about the environmental and other costs of motorized mobility, coupled with the surging popularity of biking and walking all over the world, is also challenging those assumptions. In fact, in the developing world – despite the fact that more and more people can afford to own private vehicles – more than half of all daily trips are still carried out on foot or using bicycles in most cities. Mobility is no longer just about moving people around by motorized vehicles. What people really need is the accessibility to various urban services. Numerous examples from different cities have demonstrated that better accessibility doesn't have to be achieved by generating motorized traffic, particularly by private vehicles (Fang, 2015).

1 Dynamic Traffic Signs and Light Signalization

Due to a great number of cars on the roads in cities, the road capacity is often fully utilized and traffic jams frequently occur during rush hours. The number of these problematic situations may be reduced by applying a suitable combination of modern methods of car movement identification and tools allowing computer predictions of car movement. Using these tools enables the optimization of car movement control with regard to reaching the highest road permeability.

High traffic intensity significantly reduces the speed of transportation of persons/goods and contributes to an increased production of pollutants produced by road traffic. Monitoring the production of pollutants does not only concern the amount of exhaust gases emitted when driving slowly or standing. It also concerns the production of fine particles emitted from the brakes and clutches of cars which accelerate and stop repeatedly within a short period of time. To identify the pollution load in the vicinity of roads, automatic monitoring stations are used as well as advanced computational models enabling the creation of planar concentration maps of pollutants.

For road traffic control in cities, prediction models are used enabling the optimization of traffic control with regard to:

- the maximization of traffic permeability,
- the minimization of the pollution load in the surroundings.

1.1 Optimizing Crossroads Cycle

Traffic-light intersections constitute a critical element affecting the traffic flow and road permeability. Traffic-light intersections constitute a significant local source of pollution in urban areas. It is in their vicinity where the maximum pollution concentration is often reached in an urban area. For this reason, it is appropriate to pay extra attention to traffic-light intersections, especially to optimizing their traffic cycle. The amount of emission substances does not change significantly with the change of the cycle. However, the traffic cycle has a significant impact on the maximum immediate pollution concentration in the vicinity of the intersection.

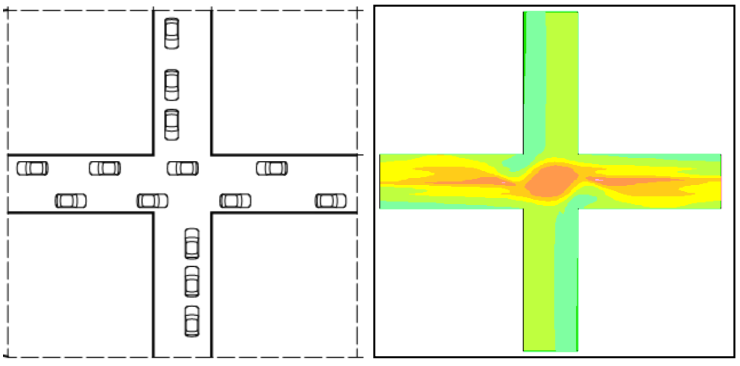

Fig. 1 A diagram of the position of cars and a pollution map at an intersection

Optimizations aiming for the maximization of traffic permeability as well as the minimization of the pollution load lead to close but not the same requirements for the control of light signalization. Simulation models are able to implement parametric studies enabling the optimization of signalization at traffic-light intersections. For these purposes, detailed computer modelling based on numerical description of the problems of thermos-fluid mechanics is used. Detailed computer modelling enables simultaneous monitoring of the movement of air in the intersection area caused by the cars passing through and the immediate production of pollutants emitted by the cars. The conclusions based on the results of numerical modelling make it possible to determine an optimal traffic cycle of light signalization for a particular traffic load at an intersection.

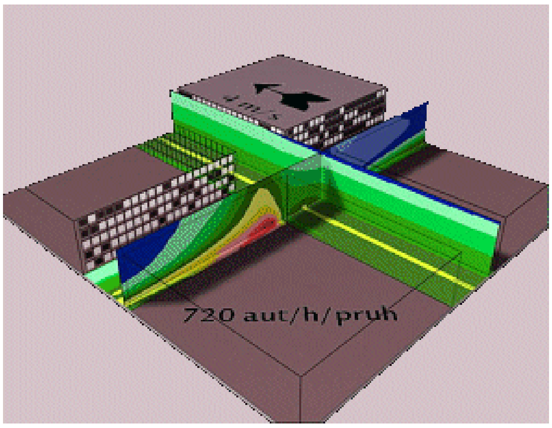

Fig. 2 Example of a model solution of concentration fields of pollutants produced by road traffic

A commercial solution of light intersection control enabling maximum permeability is offered by e.g. Siemens as „Plus+ traffic control“. This system uses dedicated failsafe controllers, signal heads, and pedestrian indicators as well as new smartloop modules ensuring that the overall system is tolerant of individual component and cable damage, resulting in higher intersection availability and reduced disruption to the travelling public. Find more on this product at https://www.siemens.com/uk/en/home/products/campaigns/plus-plus.html.

Another manufacturer dealing with “smart” intersections is Ford. Their activities are focused on the communication between cars and the elements of transport infrastructure. This way of communication is supposed to ensure an increase in transport hub permeability and at the same time to increase the traffic safety. Similar activities are dealt with in Europe within the simTD (Safe and Intelligent Mobility) project.

Fig. 3 Example of a Smart intersection by Ford (Source:Hybrid.cz)

1.2 The impact of car speed

Moving cars generate an intensive flux in their surroundings and create a complex structure of disintegrating vortices. This vortex structure influences the speed of pollution dispersion from the linear road into the surroundings. A higher car speed generates a more intensive turbulent nature of the stream and the pollution dispersion from the road to the surroundings is more intensive. Faster driving also causes a higher production of pollutants. A combination of both of these facts causes a greater pollution load of the road surroundings when the car speed is higher. Also, significantly greater aerodynamic noise is generated at a higher speed.

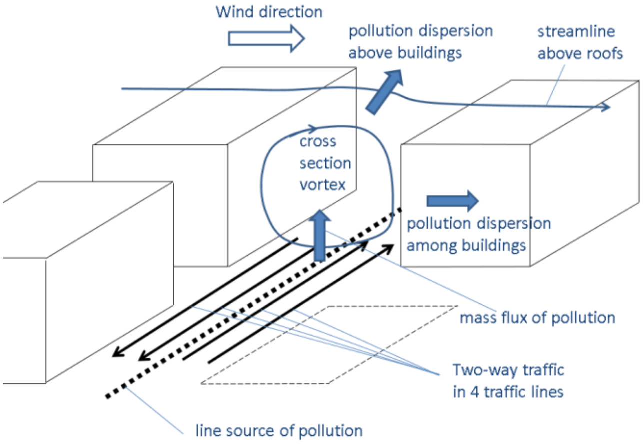

Fig. 4 An example of pollution dispersion from the road in an urban built-up area

To reduce these negative phenomena, the speed limit on some roads is restricted. The reason is not to deal with technical issues but to minimize the impact of traffic on the surroundings (e.g. in Austria).

1.3 The impact of tree alleys along roads

Tree alleys are a significant aesthetic and functional element in an urban built-up area. With regard to air exchange, however, they constitute an obstacle slowing down the flow. This may, in certain situations, contribute to an increase in concentrations of pollutants. The importance of tree alleys must therefore be considered in a wider context.

1.4 The impact of one-way vs. two-way traffic

A turbulent flow generated in close proximity of cars is the result of the aerodynamic properties of cars. This causes intensive air turbulence resulting in increased effective viscosity. A turbulent air flow is decelerated by surfaces and obstacles influencing the movement of the air. The turbulence is more intensive in two-way traffic compared with one-way traffic. Washing out street canyons with fresh air is, therefore, lower for two-way traffic compared with one-way traffic.

1.5 Identifying traffic flow using cameras

Another type of model uses active identification of a real traffic situation by evaluating a recording made by a traffic camera monitoring the intersection area. Based on the discovered circumstances, it modifies the management of the traffic flow using given algorithms.

1.6 Use of an array of affordable pollution sensors

A new emerging trend in traffic flow management uses online measuring of pollutant concentrations at a great number of checkpoints located in the surroundings of intersections and important roads. This way of measuring uses new types of sensors, which are affordable and which monitor concentrations of pollutants with sufficient accuracy.

1.7 Eco-driving in urban built-up areas using information from traffic control elements

The authors of (De Nuzio et al, 2015) deal with eco-driving in urban built-up areas. They describe an algorithm which may be used for car ride control minimizing the consumption of drive power. For this purpose, the vehicle control unit evaluates the signals from the traffic system and tries to optimize the ride to make it as fluent as possible. There is an effort to always drive through the green light at intersections without unnecessary stopping.

2 Smart monitoring of transportation

The smart traffic management is necessary part of smart city conception. Most often are use the measures such as Internet of Things (IoT), big-data techniques, wireless sensor networks (WSNs), mobile apps etc. A smart IoT system automatically notifies necessary information of passengers after triggering of shock detector sensors to lowering loss rates in accidents and alert nearby local public safety organization about the physical location of accident suggest (Nasr et al. 2016). Smart traffic management carries alternate routing to avoid traffic blocking and increase traffic flow through IoT and lower traffic density, offers predictive analytic techniques (Rizwan et al., 2016).

Intelligent mechanisms are able to control traffic flow, reduce traffic jam occurrences and travel times in connection with reduction of air pollution. On the other hand, the smart application fields are able to benefit from monitoring systems and information about traffic flow. For example, smart parking or toll monitoring systems can aggregate such data about the type of a vehicle for providing information about the parking space capacity or for calculating correct toll fees (Haferkamp et al., 2017). The data of an increasing number various detection systems is aggregated building a multifunctional data-driven ITS (Zhang et al. 2011)

For this purpose, a wide range of different sensor and detection techniques with specific advantages and disadvantages is used. A widespread approach for vehicle detection and classification are camera based systems, which achieve a high classification success rate. Normally, several cameras are needed in those systems to analyze the scenario from different angles and perspectives. In contrast, an enhanced visual system which is able to categorize vehicles into various vehicle classes using a single camera is presented in (Hsieh et al. 2006).

2.1 Smart monitoring in world cities

Automotive traffic monitoring using probe vehicles with Global Positioning System were applied at U.S.A. The system, also solving the problem with privacy concern of drivers and monitoring of their traffic position. There were proposed virtual trip lines are geographic markers that indicate where vehicles should provide location updates. These markers can be placed to avoid particularly privacy sensitive locations. They also allow aggregating and cloaking several location updates based on trip line identifiers, without knowing the actual geographic locations of these trip lines. Thus, they facilitate the design of a distributed architecture, where no single entity has a complete knowledge of probe identities and fine-grained location information. There is implemented the system with GPS smartphone clients and conducted a controlled experiment with 20 phone-equipped drivers circling a highway segment. Results show that even with this low number of probe vehicles, travel time estimates can be provided with less than 15% error, and applying the cloaking techniques reduces travel time estimation accuracy by less than 5% compared to a standard periodic sampling approach (Hoh et al, 2008).

2.2 Smart monitoring in European cities

In Spain was applied Smart Tech Solutions system for traffic flow monitoring. The information on travel times collected and processed by the platform goes directly to the Traffic Management Centre (TMC) of the City Councils, where it is displayed on a web interface conceived especially for management purposes. The analysis of the data collected by the sensors improves understanding of the complexity of roads, neighbourhoods and events. Thus, local authorities can intervene in traffic flows by diverting traffic to secondary arteries, by adjusting phase positions and the timing of signal lights at road crossings and by sending patrol officers to control and manage the situation. Travel time information is provided as well. The platform offers daily, real-time information on origin-destination matrices, which is useful for urban planning policies. It is possible to identify a city's hot and cold areas, the most congested paths and patterns, as well as to control entrances and exits. From there, route optimization can be performed for better management of existing resources (Smart Tech Solution, 2008).

3 Smart City Logistic

To create a Smart City logistic strategy is difficult aims because there are many factors, like data points and stakeholders intertwined within this unique challenge. The best strategy is to create collaborations between city government, multiple businesses, academia, environmental organization, transportation operators etc.(Prest, 2017)

The city logistic is a part of supply chain management that plans, implements and controls the efficient, effective forward and reverses flow and storage of goods, services, related information etc. (Nowicka, 2014)

The Smart Logistic ensures that traffic routs remain open through the utilization of intelligent infrastructures and thus enhance faster movement of goods. Smart logistics are associated with modern tools that improve the efficiency of an organization through information and communications systems in the transportation network. The connection in real time can utilize smart technologies such as tablets, laptops, smartphones etc. The real-time monitoring of the movements of vehicles and goods is able through the internet and so called Internet of Things (IoT). In addition, smart logistics enables employees to work from remote regions and communicate directly with their colleagues without having to be physically present in the office. Smart logistics have therefore played an instrumental role in enabling an organization to communicate with customers and handle any queries on time thus leading to the delivery of efficient and quality services (Shulenbayeva, 2017).

Smart city logistic projects are usually focused on unimodal, relying exclusively on motor vehicles to move freight. There is important the focusing on the type of truck most appropriate to the particular application or system layout, a constant preoccupation being the utilization of environment-friendly vehicles (Bektas et al., 2015).

Currently, in U.S.A. were applied any applications for improvement the efficiency of logistic system. For example:
Freight-Specific Dynamic Travel Planning and Performance bundle seeks to include all of the traveler information, dynamic routing, and performance monitoring elements that users need. Enhances traveler information systems to address specific freight needs. Provides route guidance to freight facilities, incident alerts, road closures, work zones, routing restrictions (hazmat, oversize/overweight), and performance monitoring. The application is builds on the Cross-Town Improvement Project (C-TIP) Real Time Traffic Monitoring (RTTM) and Dynamic Route Guidance (DRG) applications for best route between freight facilities. Provides intermodal connection information, container disposition and schedule Leverages existing data in the public domain, as well as emerging private sector applications to provide benefits to both sectors (Transportation.gov, 2016).

Another is Drayage Optimization application bundle seeks to combine container load matching and freight information exchange systems to fully optimize drayage operations, thereby minimizing bobtails/dry runs and wasted miles, as well as spreading out truck arrivals at intermodal terminals throughout the day. The application reduces freight delays at key facilities that overbook their capacity to ensure uninterrupted operations within the terminal/warehouse and optimize drayage operations so that load movements are coordinated between freight facilities. There is possible that the individual trucks are assigned time windows within which they will be expected to arrive at a pickup or drop-off location. There is possible to monitoring early or late arrivals and also, there is a web-based forum for load matching provided to reduce empty moves (USDOT, 2016).

The emphasis is also placed on reduce the emission from transport. For example, in California will be testing experimental system E-Highway Catenary System. A road design project dubbed the e-highway is aiming to reduce and maybe even eliminate the pollution problems caused by all this truck traffic near the ports of Los Angeles and Long Beach. The experimental system is being built along a mile of the corridor to test how highly polluting diesel truck traffic could instead run on emission-free electric power. The e-highway consists of an overhead catenary system that will run along the outside lanes of both sides of the road, sort of like the overhead wires that provide power to electric buses, trolleys, and trains in cities. Specially outfitted hybrid or all-electric trucks can attach to the system using automated current-transfer devices called pantographs. Once connected, the trucks will pull all their power from the overhead lines, effectively becoming emission-free vehicles.
Part of logistic system is also issue of parking. In U.S.A. is tested Smart Truck Parking, also such as safety measure. The application proposes information about parking places via websites, mobile apps, through connected vehicle technologies and dynamic message signs.

There are projects focusing on problems with ineffective and inefficient management of urban freight distribution. For example, it was a project SUGAR promoted basic actions for the exchange, discussion and transfer of policy experience, knowledge and good practices through policy and planning levers in the field of urban freight management. The SUGAR partnership brought together 17 institutions from 10 countries working on enhancing capabilities in terms of infrastructures and the design of urban mobility (Nowicka, 2014)

One from the European platform is Smart City Logistics. It is a decision support platform for urban logistics for European cities. The platform is focused on supporting of urban freight transportation plans by wide range of easy-to-understand information. The Smart City Logistics platform maps users' information on transportation networks, access restrictions, traffic measures, delivery and transport facilities, administrative units, population, land use and emission situations.
http://civitas.eu/tool-inventory/smart-city-logistics-platform
Last Mile Logistic (LaMiLo) is North West Europe project with aim to create a step change in freight deliveries by fully considering the 'last mile' of a supply chain when planning a freight logistics journey, ensuring a more efficient and integrated logistics approach. The project brings together experts from all sectors of the freight transport industry to change behavior of private companies, the public sector and consumers to make better use of existing transport infrastructure and networks (EURIFT, 2018).

Another project is Smart Urban Logistic in Austria where is the aim to build the Austrian networking platform to boost and promote intelligent solutions in the field of urban logistic. There is solution including free phases. The first on this development of a strategic roadmap concept and implementation of a stakeholder platform. The second one is elaboration of supporting topics in order to evaluate framework conditions and to prepare information for implementation activities (requirements analysis of cities, best practice toolbox, framework conditions and policies, management of the stakeholder process). The third one is set-up of coaching and implementation activities in cities with the goal to initiate pilot projects (Schrampf, 2016).

In Spain was applied the SMILE project (Smart green Innovative Urban Logistics Models for Energy Mediterranean cities project) aims to improve the energy efficiency of Mediterranean cities through the promotion of innovative green and cost effective solutions for urban freight logistics, addressing the target of green and smart urban development.

One of the cities is Barcelona, where the city council has recently approved the Sustainable Urban Mobility Plan (2013-2018), which focuses specifically on logistic activities. In particular, it contains one of the strategic objectives "to give priority to public transport and goods and to oversee the correct operation of different modes of transport, giving priority to public transport and the movement of goods" in particular, inside the optimization of urban goods, it specifies a way: "Establish a network of multi-use vehicle parks and mini trans-shipment platforms in neighborhoods from which goods deliveries can be realized by trolleys, electric vehicles and tricycles/cargo-bikes". The pilot was designed to provide some space to operate a transshipment center with e-tricycles covering the Ciutat Vella district. The transshipment point was designed to be dynamic and flexible to accommodate future services and changes. Mainly, the service was orientated towards parcel services and similar shipments (i.e. fashion shops), the size and the weight of the packages are limited by the total capacity of the tricycles. The aim was oriented to transport operators that cover last mile deliveries inside area. Transport carries visited the transshipment point at an agreed time and shipment was transferred to electric tricycles and to the final destination. The similar system was applied also in Valencia (Navarro et al. 2015).

Fig. 5 Transshipment terminal and electric Tricycle in Barcelona (Source: Navarro et al., 2015)

In Great Britain were applied for better city logistic and delivery system any measures using GPS data system. There are for example (Allmapdata, 2018):

Better Scheduling system

The widespread use of sensor technology in Smart Cities means that a series of on road circumstances can be monitored and taken into account before and after the routing process. Any number of issues can cause a delivery to be late, ranging from extreme weather conditions to traffic accidents to failing infrastructure.
In a Smart City, these issues are immediately recorded and transmitted to all relevant parties, meaning that these can be accounted for both before and during the delivery process so that the fastest and most cost-effective route can be planned with this wealth of information.
Problems with infrastructure also become less widespread in the context of a Smart City. Smart City data used in tandem with GPS technology allows for traffic flow to be redirected to avoid congestion and frustrating delays. In addition to this, infrastructure is also better maintained in this type of urban sprawl. Indeed, the proliferation of sensors means that if a road or a bridge is about to become compromised, the feature itself can autonomously book an engineer for a swift bespoke solution.

Better Delivery Services

The knock-on effect caused by better scheduling to home and commercial deliveries is always better customer service. With routes being scheduled more efficiently and unforeseen circumstances being reacted to more swiftly due to the extensive data collated by the Smart City ecosystem, delays are made significantly reduced in both volume and length. Fewer delays result in better stocked commercial branches and more home deliveries made on time. Additionally, special deliveries to businesses and homes can be allocated tighter and more accurate windows for deliveries, meaning that individuals won't need to wait around for deliveries that never arrive.

AddressAnalytix Home Delivery
It is an enhanced database for all of Great Britain which provides details of every address, residential and commercial, including extra information specifically designed to be useful for planning home delivery applications.

AddressAnalytix Logistics

System provides full address details of every property (residential and commercial) in Great Britain. It comes complete with premise-level geographical coordinates and extra information to enhance planning logistics applications.

4 Residential areas

New transport systems and logistic improve the urban traffic and the inhabitant's mobility. Smart mobility can contribute to the design of smart cities in order to answer to user request in terms of transport network efficiency and social sustainability. Because of urban traffic congestion and public transport policy, parking is becoming an expensive resource in almost any major city in the world, and its limited availability is a concurrent cause air pollution and detriment of the quality urban mobility (Giuffré et al, 2012).

Residential areas are highly loaded by traffic and lack of parking places. One of the measures is focusing on parking system for these areas. Example is introduction of so-called "Limited Traffic Zone (LTZ)" in the central parts of the urban areas.

In Helsinki (N) are designed as a test laboratory for intelligent solutions, the district is set to become resource-wise in all aspects of living and habitation, giving residents an extra hour every day to do other things than just moving from place to place or shopping for groceries. And when everyday life becomes practical and flexible and electric appliances are interconnected it will also mean greater energy efficiency (Manas, 2016).

In London (GB) is planning Transport Strategy includes an ambitious timeline to phase-in new zero emission sites in the busiest, most polluted areas. From 2020, town centre across the city will be emission-free, extending to central London by 2025. This will reach larger zones within inner London by 2040, until the whole city is covered by the zones by 2050. Taxis and private hire companies, such as Uber, will be upgraded to be zero emission capable by 2033 and all buses by 2037. City Hall will also invest billions into new schemes to encourage walking, cycling and public transport. This includes transforming some of London's most busiest and congested areas, such as Oxford Street and Old Street, to become partly pedestrianised. From 2019, vehicles which do not meet tough new emission standards will have to pay a charge, which will also directly fund new green transport schemes. The ULEZ will run 24 hours a day, all year round (Climateactionprogramme, 2017).

Mechelen (B) city is almost car free from 2011. Vehicles access to numerous street was prohibited during day or another day periods. A few minor adjustments were made to respond to the main remarks. Both the procedure and the online application have now been simplified, access for the disabled made easier and an additional car park provided. Some one hundred icar cameras together with M³ are supporting the city's mobility policy (Macq, 2017).

5 Smart city failure risk management

5.1 Risk analysis methods and risk assessment

Risk Analysis in connection with mobility is a very complex problem for the selection of a suitable methodology. The aim of the analysis is to obtain relevant information describing the identified risks and their importance for the given area. Therefore, it is important to use a combination of methods based on qualitative, semi-quantitative and quantitative approach.

The identification of risks should never been underestimated, and so-called black swans that in the case of their full expression may have the fatal consequences should be taken into account. Although it is not easy to predict precisely the occurrence and extent of the impact of events, it is important to ensure sufficient functional background work is undertaken, which is based on the creation of a communication network in preparedness for an immediate response with primary and secondary measures with regard to protecting the human society. It should also include an adequate analysis and assessment of undesirable events with the objective approach, which includes external experiences and the assessment (Adamec et al., 2016).

5.2 Smart Cities projects – resilience and risk management

The challenge discussed earlier and the focus on near-term security measures creates an environment that is not conducive to thinking about what it will take to ensure a more resilient Smart City. Moreover, it creates an environment that fixates on new projects and developments, overlooking the essential role that maintenance and upkeep play in long-term infrastructure security and resilience. The increase in Smart Cities projects presents an opportunity to incorporate risk management principles that result in more resilient cities. Holistic risk management can be a lever for building resilience in Smart Cities projects—specifically through assessments and analysis, partnerships, information sharing, capacity building, and situational awareness. For example, through cross-domain, cross-sector assessments and analysis we can move away from a focus on individual assets to a systems-based approach. Through cross-domain, cross-sector information sharing and capacity building, we can begin to merge data collection. Strong partnerships developed prior to incidents, and ample situational awareness during incidents, will ensure more cross-network, cross-jurisdiction coordination of cascading incidents. Incorporating risk management at the outset improves the ability of Smart Cities to ensure long-term resilience, both in developing new projects and maintaining and operating existing components. Resilience planning builds the partnerships and information sharing frameworks needed to prepare for new challenges in the dynamic world of Smart Cities. It helps support the analysis and assessments needed to have a comprehensive situational awareness of new capabilities, the interconnections between them, and the emerging risks that Smart Cities face. And it makes it possible to build resilience capacity throughout the Smart City and its systems (Gordon and McAleese, 2017)

5.3 Security designs

Smart cities are constantly evolving with connectedness in cyber space between people, buildings, transport, energy, water, communications, commercial operations, media and the multitude of activities cities generate. The boundaries of smart cities are in cyber space which creates global linkages in the connections to systems and this brings a different threat horizon that has to be monitored for business operations, safety and continuity of activities. Cyber events whether accidental from failures to integrate rapidly changing technologies or intentional from individuals, terrorists or nation states are rapidly creating disruptions and uncertainty because there is no international legal agreement between countries on boundaries, behavior, criminal investigation or compensation when systems fail. Cyber space is not geographically bounded except where services and companies are located but virtual space with cloud and the speed of electronic connectedness means that cyber space creates unbounded and ungoverned threat landscape. Risk work requires

evaluation of the threat landscape and safety, security and integrity of systems and people within this landscape.
Newrisk Limited's early experience in smart city security design evolved from tender work on security design for a new build of a smart city in the Middle East where the continuity of security, safety and mass population movement from airport and sea ports, rail links and technology parks as hubs of productivity and the new design of accommodation, leisure and community support services, retail services and government infrastructure required a security framework based on the threat horizons for the smart city. The dynamic changing threats evolving from the specification through design, commissioning, operation and change management stages in such a city all require solutions and risk based decisions within a coherent and harmonious security framework (Leivesley, 2017).

5.4 Minimizing of IoT security risks

In the case of cyber-attacks on smart cities, millions of devices are potentially threatened by manipulations or malware infections. Therefore, a well thought out security strategy is indispensable. This starts with identifying and then prioritizing the critical infrastructure. Only those who can identify and clear away vulnerabilities, security flaws, malicious environments, outdated operating systems, etc. in time are able to prevent serious failures and manipulations.
The best possible protection against hacking attacks is a security solution that is embedded within the IoT application itself. Instead of constructing a fence around the device and its software, applications need to be hardened with effective protection solutions such as obfuscation or Whitebox cryptography as well as with advanced RASP (Runtime Application Self-Protection) technologies. Being protected in such a manner, the applications are able to protect themselves against all kinds of attacks with individually defined activities e.g. informing the provider of the IoT device that the software has been modified. Thanks to these application hardening technologies the application´s sensitive binary code – its crown jewels so to speak – is proactively protected.
Smart cities offer great opportunities, especially for rapidly growing cities which have to deal with population growth and increasing traffic loads. Nonetheless, in terms of IoT innovations security, data protection and privacy have to be top priority if they should be profitable in the long run. An important factor here is education. The issue of security must be top priority in all companies and organizations. Suppliers and vendors of IoT devices and technologies need to be better skilled and should dedicate time to discussing risks and informing their customers about possible threats (Brander, 2017).

In the study of Chia, J. et al. (2016) are proposed measures for risk management and cyber security, such as:

- surveillance system and equipment (cameras collect data in image or video format),
- video analytics (analyzing videos to detect certain objects, behavior, spatial and temporal events),
- data center (centralized storage space for all the data collection from the multiple sensors in the network. The center provides real time data to monitoring center for effective operations),
- command center (provides an infrastructure that can assess the integrated information provided by the data center such as live video for incident response),
- Knowledge transfer (dissemination of the required knowledge and skills for the smooth operation and implementation of the smart city initiatives. The staff need to be trained in operating the new and redesigned services and efficiently deliver the outputs).

6 Smart bus stop

Digital kiosks give information about restaurants, retail stores, and events in the immediate area. It also provides mapping for visitors, and can sync with a mobile phone to give additional data as needed. For example, Citymapper pulls in public transport information and provides multi-modal transport options to get users to their chosen destinations. It really saves time and make it easy for travellers to find information without actually reading many articles and visiting many sites (Apiumhub, 2018).

6.1 Solar Smart Bus Stop

Some reasons why not to travel by public transport are based on the fact that waiting for a connection is often long, because the connections do not have to arrive on time, they are full and last but not least, the stay at the passenger stop is uncomfortable. Waiting for a bus never needs to be frustrating again with the advent of smart bus stops. Often made from repurposed metals and other recycled materials, these bus stops respond in real time to customer queries, changes in bus schedules, and traffic conditions to keep customers informed about the status of their journey. The smart solar power bus station uses PV power generation for energy needs. As long as there is sunlight, the station will be able to generate electricity, and does not emit any pollutants; the bus station is therefore low-carbon, energy-saving and environment-friendly. The smart solar power bus stop has settings according to the needs of PV power generation, electronic monitoring, LED lighting, mobile phone charging, Wi-Fi, and switches between solar power and the grid to meet the diverse needs of public travel (Energo mobil, 2016).

6.2 Enhanced communication

Most smart bus stops are integrated with real time communication systems which enable customers to press a call button to either hear an automated message providing information about the next buses, or to talk to a human operative. Electronic displays providing details of upcoming bus journeys are a common feature of smart bus stops, and these digital displays usually have the capacity to change automatically if a bus will be arriving more quickly than expected, if the bus is delayed, or if a route has to be changed at short notice (for instance, due to unexpected traffic in the area) (Zizla, 2017).

6.3 Climate monitoring

EverImpact discover the origins of greenhouse gas emissions in your city. It is the climate monitoring app for cities, which measures and monetizes Cities' CO_2 emission by combining Satellites and Ground Sensors' data. Cities get a real-time map of their emissions at street and building level. It really helps to control the environmental situation in the cities.

6.4 Smart Cooler

The smart bus stop has been initiated to address the dual problems of urban heat and air pollution (PM2.5). The Airbitat Oasis Smart Bus Stop delivers energy-efficient, sustainable cooling with no waste heat generation, using water to cool air to as low as 24°C to address urban heat. Air purification technology removes harmful airborne particles such as PM2.5. The filtration system can also trap up to 90% of harmful air particles in the air like debris, dirt and PM 2.5 particles, offering commuters cleaner air. Embedded sensors in the panels of the bus stop help collect real-time data on pollution levels and ambient temperature, which will be displayed to commuters on digital screens (Metering, 2018).

6.5 Examples case studies

Barcelona

The city has installed smart streetlights, and sensors for monitoring air quality and noise. It is also expanding a network of free Wi-Fi in bus stop. These bus stops offer wireless connectivity, free USB charging points and regularly updated local information including traffic news and headlines. Barcelona's smart bus stops are not just used by citizens and tourists who are waiting for buses: they are also used by anyone seeking a free wifi point, a place to charge their phone, or a tourist information point (as these bus stops almost all contain comprehensive tour guides for the city) (Zizla, 2017).

Croatia

Fully autonomous Energomobil bus stop facilitate our daily journey giving us the possibility of charging cell phones and tablets, and use Wi-fi while waiting for the bus. Energomobil has developed a new product that is entirely designed and manufactured in Croatia. Lighting on bus stops is powered by photovoltaic modules.

Singapure

The prototype bus stop aims at redefining our transport system as part of the larger social infrastructure. This looks into the aspects of how do we make transitional points like this fun and enjoyable. How do we make waiting at bus stops fun? The product sees an integration of various hardware such as interactive smart boards, a swing, bicycle parking station, USB charging station, book exchange corner and also some artwork showcase along the rear of the bus stops (Japhethlim, 2016).

Sydney

Anyone who has waited for a bus this summer will know bus shelters in Sydney can get very hot and uncomfortable. In high-traffic, high-heat suburbs that miss out on the sea breeze and where trees are being lost to development, the temperature of surfaces, such as seats, inside bus shelters can exceed 60°C. Technical innovations could allow improved responsiveness of the shelter to environmental conditions or user needs, or as communication platforms for the delivery of information services to users such as displays of latent capacity from transport services, or forecasts of demand or travel time. Visionect intelligent signs run on solar power and have been developed on energy-saving electronic paper technology to ease the daily commute in the bustling Australian metropolis (Primozic, 2018).

7 Multimodal transport mobile application

In addition to technology-enabled carsharing, ridesharing and bikesharing services, and new technology options to help make public transportation easier to use, a number of new apps are being developed that knit the entire transportation experience together—taking a multi-modal approach to helping people get places in the fastest, cheapest, most convenient way possible.
This is particularly important because specific services may only be convenient for people under certain circumstances, when they are traveling to certain neighborhoods, or in certain weather. The broader the spectrum of overlapping choices available to travelers—and the easier it is to find the best potential option—the easier it is for people to consider a car-free or carlight lifestyle (Dutzik and Madsen, 2013).

7.1 Multimodal transport in world cities

Portland's TriMet transit agency, for example, introduced a multi-modal trip planning tool on its website in 2011. The tool enables users to plan trips that could include a mix of walking, cycling, buses, trains, bikesharing and carsharing. It even allows cyclists to choose routes based on personal preferences such as speed, availability of bike trails or bike lanes, or minimizing hill climbing.137 Bibiana McHugh, Director of Information Technology at TriMet, says multimodal planning is crucial for commuters, who sometimes need extra guidance about how to travel the last mile from their transit stop to their place of work.138 She has also been working with Zipcar and car2go to put information into the planner about where carsharing vehicles can be picked up. Because the trip planning tool is opensource, other developers have begun to build on TriMet's work to create multimodal trip planning tools in cities around the country. As of February 2013, such tools are being deployed in Florida, Tennessee, Washington D.C. and New York City—as well as in 11 other countries around the world Other app developers have taken on the challenge of helping consumers navigate the wide array of new transportation options available. RideScout is a mobile app that aggregates information about all of the various transportation options available in a given city. A RideScout user simply enters in his or her destination and is provided with a menu of real-time transportation options—including transit, taxi service, carsharing or ridesharing (Dutzik and Madsen, 2013).

Columbus, Ohaio

Smart Corridor: In order for employees to get to work efficiently, Columbus will have a pathway with concentrated transit services that focus on those last mile connections to the workplace.
Smart Logistics: Columbus is a major freight hub, so the city plans to help trucks via real-time and integrated data. We've seen how big data can have an effect on transit – being able to improve reliability and the efficiency of operating is a huge boost.
Connected Visitors and Citizens: Columbus is working on a private sector app for events and activities happening in the city, with real-time updates on traffic, parking, and alternative transit choices. The city will also partner with local private and public social services providers to improve mobility options.
Sustainable Transportation: As many smart cities do, Columbus is planning an infrastructure centered around car-sharing, vehicle use, and grid mobility patterns in order to make itself not just more sustainable, but more mobile, too.

Santa Monica, CA

Travellers can find upcoming events and specials – such as free rides – as well as maps of local businesses nearby the Expo stations, with detailed information on how long it would take to walk, bike, or bus to those businesses from each station. People can ask questions and receive free TAP cards – durable, reusable smart cards that riders can load with money and simply “tap” as they board the bus. Obtaining TAP or similar smart cards are a major barrier for riders to use transit options. This gives riders an easy way to access them other than retail or light rail stations. As a way to engage the public, for the more photogenic travelers, the city is planning to place photo booths around transit stations, where riders can share stories of why they ride via pictures.

U.S.A. – HopStop

Free available app that give all information for choice destination and quickest possible ways. The app uses GPS, maps and real-time data. There is possible to cooperate with alternatives such as public transport (buses, subway, train schedules), cycling and walking times including for example burned calories, taxi costs, closest station, transit maps. Currently, is the app available also in Europe (Narboneta and Teknomo, 2017).

Richmond, Australia – Rome2Rio

The app searches city, town, landmark, attraction or address across the globe with thousands of multi-modal routes to easily get from point A to B. Compare possible options such as plane, train, bus, car, ferry, bikesharing, driving and walking. The app allows works offline, when view previous searches offline. The app cooperates with partnerships companies for flight tickets, booking accommodation etc. The app is available for more than 160 countries including Czech Republic (Rome2Rio, 2017).

Manila – OpenTripPlanner

The basic set-up of the system is able to produce multimodal public transport routes when the user selects the origin and destination point with using of the provided map. OTP’s web API was configurated to run the web application. Some modifications were employed such as activation of the „To“ and „From“ (Narboneta and Teknmo, 2016).

Singapore –Integrated Mobility Platform (Siemens)

The application was created for all modes of transport which suggest feasible and economic options for commuters. Operators can easily cosine complementary mobility services with their own portfolio. The unify platform facilitates the planning, boxing and billing of multimodal travel. Travelers get information about possible modes of transportation, available fares, real-time information and mobile payment system of the platform. Also, there is possible to switch to alternative modes of travel in the event of delays. The app combines public transport system and for example private services like car rental, taxi services (priority boxing, Peking up a car from a neighboring car park etc.) (Eco Business, 2013).

7.2 Multimodal transport in European cities

The Whim app was developed by Finnish company MaaS Global and the test version launched officially in Helsinki on June 13th. The mobile app allows users to plan their route and pay for their tickets for bus, train, bike, taxi or car (Whim, 2018). The app gives users access to transport packages on a pay-as-you-go or monthly subscription basis. Also, the system was applied in Birmingham, UK and will be applied in Antwerp, Belgium and Singapore (MOBiNET, 2016; Strasburg, 2017).
The Bobby app was developed during a hackathon in 2014 for the EU Commission funded platform MOBiNET, an open business-to-business platform for mobility data and service providers to create new mobility value propositions. MOBiNET's aim is to have an open multi-vendor platform across Europe. There is possible to create automated actions based on mobility needs for a specific place and time. The app uses geo-fencing Android system for real-time mobility solutions, also with parking and sends SMS or e-mail notifications when passing close to a selected place, show the next passing bus and tram in the vicinity, display. The app was applied in Bordeaux, Toulouse, Glasgow (MOBiNET, 2016; Sustainia, 2018; Civitas 2013).

Sustania app in Hannover making multimodal trips fast and easy and discouraging private car use. The app integrates routing, booking, and billing for all public transit options as well as taxis, carsharing, bikesharing, and parking. There is possible to enter starting point and destination, the app offers all options organized by cost and duration journey, allowing the user to select their preferred modes of transit. The app allowing users a number of different purchasing options including single rides and long-term subscriptions, all under a single account (Cityway, 2016).
The OPTIMUM app was developed as free of charge multimodal route planning application. The app includes a personal profile that can be enabled to give greener transport recommendations. Based on start location and destination inputs, the app can plan routes to meet specific individual needs - e.g. time and date of arrival or departure, transport modes or vehicle locations. Users can also add "via points" along the route proposed by the application. In addition, the app can suggest alternative routes, along with information on modes of transport, time of travel and CO2 emissions for each trip alternative. Routing optimization can then be personalized to fit the user's travel profile. Also, the app allowing sending messages accompanies each specific alternative, greener transportation choice. The app contains crediting system, supports the storage of current and future trips, allows quick access to planned trips and informs about potential incidents such as congestions, road accidents, road works etc. Currently the app supports route planning in Birmingham, Ljubljana and Vienna [9].
The TUeTO app was applied in Torino, Italy. The app takes into account the real-time transit information, road work, traffic congestion, parking and bike availability, bikesharing stations and suggests alternative trips adapting for users. TUeTO is based on its ability to mix traffic data coming from different local partners, bikesharing data and trains (Cityway, 2016).
MyWay app was applied in Barcelona (Spain), Berlin (Germany), Trikala (Greece). The app includes a meta planning concept which combines the different modes of transport found in cities, including train, bus and tram public transport, plus cars, taxis, bikes and even e-scooters. The app allows to organize the trips, interacting with specialized planner and checking resource availability, also include the information such as timetables, parking availability (Myway, 2018).
The Reisplanner Xtra is app for planning of trips in Netherlands. It shows real-time information and has a map of the trains running in the country at the moment and bikes availability (NS, 2018).
The 9292.nl is journey planner app for public transport in Netherlands. The app provides various options for choosing of departure location and destination (current location) with using GPS, a known location (like a shopping mall, station or landmark), a bus stop, an address or a location which is created. It doesn't have network maps (Amsterdam, 2018).
The SmartCity is free app for public transport in Budapest (Hungary). The app contains a vector based map with address search, route planner, timetables of all public transport lines (bus, metro, tram, train, suburban train, night lines). The SmartCity app could be used offline (maps are based on

OpenStreetMap data). There is visualization of planned routes on the map with vehicles types and connections and public transport lines with stops (SmartCity, 2018).

The MOVE-ME app was applied in Porto (Portugal). Allows users to integrate information from different operators, modes of transport and establishes intermodal route planning in real time. The information is from cooperating companies and 13 private operators (Civitas, 2012).

8 Smart Parking systems

8.1 Smart parking system in world

American drivers spend an average of 17 hours per year looking for parking. In large cities, this number is even higher. Drivers in Los Angeles and San Francisco spend about 85 hours annually seeking out parking, while New Yorkers spend a staggering 107 hours per year searching for spaces. Smart parking technology could be the key to solving this ongoing problem. Creating more parking spaces won't necessarily solve traffic congestion in heavily populated cities. Instead, we need better management of the spaces we currently have. Smart parking technology can improve this process, both for drivers and city planners alike. Smart parking isn't just a matter of having enough spaces for drivers who need to park, it's about whether drivers can locate those empty spaces so that they can get off the road quickly. Additionally, drivers searching for available parking spaces are more likely to get into a collision. About one in every five traffic accidents occurs in or around a parking lot. Often, it's a result of distracted driving and congested lots. Drivers will pay closer attention to the side of the road or the parking lot, rather than what's in front of them or behind them—all because they're trying to see whether a space is available. Smart parking technology increases parking safety, but its greatest impact on traffic congestion comes from the fact that it makes parking much faster. If city planners install sensor lights on every space, this gets drivers off the road more quickly because they can see whether a street or lot has parking available blocks in advance. In parking garages, you can even list the number of spaces available at the entrance, before drivers pull into the garage. This information receives constant updates from the sensors, ensuring that drivers always have the latest information. For instance, if a driver sees that there are no available parking spaces on a particular road and that the closest parking garage is full, rather than travelling along on the same road for blocks and blocks, they can turn onto a parallel street that does have parking available. This saves time on the driver's commute. Smart parking technology can go even further than sensors and lighted spaces. Using the latest advances in the Internet of Things (IoT), we can sync these sensors to a cloud platform that feeds the information into mobile apps or online parking websites. In theory, a driver could have a GPS app on their phone providing audio directions to the next available parking space or garage. The driver can keep their eyes on the road and spend far less time driving around looking for spaces. Another way that smart parking technology will reduce traffic volume in cities is making it easier for drivers to pay for parking. Technology that syncs with a mobile app allows drivers to pay for parking on their phones instantly, which saves time. A parking space might become available to the next driver more quickly when the first driver can pay for parking digitally—they're not wasting minutes looking for a ticket machine (Marcotorchino, 2018).

Dahau

With increasing automobiles on the roads, how to enhance the parking efficiency and improve user experience has been set with high priority by parking owners. Dahau innovative parking solution integrates ANPR and video analytics which enable automatic driving in/out without manual interference to improve parking efficiency. Furthermore, vehicle guidance and vehicle locating via embedded E-map is set to enhance user experience (DAHAU, 2017).

Singapore

A cloud-based end-to-end parking management system with various payment methodologies. Flexible occupancy reporting, Smart City cloud feeding. The solution results in less air pollution generated by traffic searching for free parking space. The system provides information on available parking lots and flexible payment methodologies – e.g. Credit Card, City Card, Mobile phone payment (Paypal, Alipay, Wechatpay, etc.) (IPI, 2018).

Dubai

Drivers cannot find a parking space or it takes them too long to find a parking space because of inefficiency of parking monitoring methods. And every moment a parking spot is empty, potential revenue evaporates and can never be recovered. Cleverciti's parking app enables drivers/customers to find the nearest available parking space quickly and efficiently. Other benefits are a carfinder showing the way back to the parked car, a mobile payment solution and voucher pay-back options for parking costs (Cleverciti Systems, 2015).

Sydney

Looking for a way to improve the parking experience for motorists, Mosman Council have begun work with Smart Parking Limited (ASX:SPZ) in installing bay sensor technology, which is already being used by a number of other Sydney councils, in off-street and on-street locations across the precinct that will help motorists find a parking space quickly and conveniently. The installation of more than 1000 SmartEye sensors has begun for the first stage of deployment, enabling infrared technology to detect when a vehicle has occupied a parking space. The real-time data captured through the sensors will feed into parking guidance app, SmartApp. Motorists can download SmartApp via their iPhone or Android device to view a real-time map of parking spaces near to their desired location. Using GPS navigation, they are then guided to the nearest unoccupied bay. Intelligent traffic signs quickly point the way towards car parks with available spaces. Inside the car parks, overhead green and red-light indicators will guide motorists to available spaces (Smart parking, 2016).

8.2 Smart parking in European cities

The functionality means that motorists now have a much better chance of finding an available and suitable parking space quickly and easily, reducing the amount of time spent idling / circling; increasing occupancy in previously under-used bays; ensuring a better driver experience and reducing the number of parking overstays. Parking and traffic congestion are constant sources of frustration for drivers, merchants, employers and public officials in most cities around the world. It is no surprise that smart parking services are top of mind with public officials, city information technology (IT) and innovation executives when planning smart cities. Sensors embedded in the ground, or cameras mounted on light poles or building structures, determine whether the parking spaces are occupied or available. This data is routed wirelessly to a gateway, and relayed to a central cloud-based smart parking platform. It is aggregated with data from other sensors to create a real-time parking map.

To drivers, parking is often seen as a necessary lead to frustration. At best, it causes drivers to utilize alternate transportation options (walk, bike, bus taxi, or ride-sharing) to reach their destination. At worst, they will avoid going to those places and go to other destinations with easier parking (Chan, 2017).

The global market for smart parking technology solutions and applications reached $13.1 billion in 2016. The market should reach $15.5 billion in 2017 and $35.3 billion by 2022, increasing at a compound annual growth rate of 17.9% during 2017-2022. Smart parking is defined as a vehicle parking system where a set of hardware devices and software assist the driver finding a parking spot, signaling available locations and assisting the driver in parking the vehicle. Smart parking includes both driver assistance systems (mentioned as automotive park assist throughout the report) that are inside the vehicle (such as sensors, display systems, etc.) as well as smart parking equipment and solutions (such as cameras, sensors, etc.) installed in the parking lot (both on-street and off-street) (this is mentioned as assisted parking throughout the report) (Research and Markets, 2017).

Smart Parking’s SmartPark

Formed in 1993, Smart Parking is now one of the largest and fastest-growing bay sensor technology companies in the world. Smart Parking’s SmartPark solution has already been successfully deployed in capital cities across the globe in London, UK; Cardiff, Wales and Cape Town, South Africa with the deployment of over 3,500 sensors shortly to commence in Wellington, New Zealand. Smart Parking specializes in some of the most technically innovative real-world solutions available within the market and continually leads the way in the development and application of these technologies, under the 'Smart' systems brand. They develop industry-leading technology and provide their clients with the very best parking management solutions (Smart parking, 2017).

Siemens parking solution

Every car driver wastes on average about 100 hours a year looking for a parking space, which accounts for one third of city center traffic. Siemens has developed a sensor-controller parking management system that helps optimize the use of urban parking facilities and substantially reduce the congestion caused by motorists searching for a space: our Intelligent Parking Solutions. Siemens' Intelligent Parking Solutions use of the full potential of digitalization: smart sensors, intelligent software and clever analysis of the available data. The system eliminates unnecessary parking-related traffic and ensures optimum utilization of urban parking facilities. This saves time, reduces the environmental impact of traffic and improves the quality of life in the city. In-pavement or overhead detectors (e.g. mounted on or in street lights) monitor the parking spaces. Microwaves transmitted by the sensor's circuit board across a predefined space bounce back to the sensor when they hit an obstacle. The sensor uses an algorithm to calculate whether an object is in the parking space and, if so, how big it is and how it is positioned. The collected data provide a transparent overview of occupancy and parking duration for the monitored parking facilities. Moreover, the tool supplies data on street spaces where parking is not allowed, e.g. cycle paths or lanes reserved for emergency vehicles (SIEMENS, 2017).

Nwave

Nwave's smart city parking solution utilizes state-of-the-art ultra-narrow band radio technology and advanced de-modulation techniques, which ensure efficient transmission of data without the risk of collisions, capacity issues or security breaches. This scalable, long-range, low-power system can effortlessly be integrated with various mobile apps for vacant spot way-finding and financial transactions, ensuring high user adoption and data privacy. Moreover, the intelligence derived from the system can substantially facilitate decision-making and help optimize operators' policies and pricing in the future (Nwawe, 2018).

London

With over 500,000 vehicles traveling through the central London Borough of Camden on a daily basis the demand for the use of limited space - for moving traffic, for servicing and for parking - considerably exceeds capacity and finding a parking space is not always easy. Parking spaces which are part of the trial are at Caversham Road, Charlotte Street, Fortess Road, Gaisford Street, Grangeway, Greenland Road, Islip Street, Mornington Crescent, Percy Street and Plender Street. Real-time occupancy data is fed into RingGo, the cashless parking application available on iPhone devices with an Android release expected in early January 2016. Drivers can download the app to view a current picture of parking spaces near to them which then guides them to the nearest unoccupied bay ultimately reducing the time taken looking for a parking place. Using the same application, they can then pay for their parking session with a credit card (Smart parking, 2015).
In October 2014 Westminster City Council went live with Smart Parking's SmartPark solution, an integrated package of leading edge technology that provides drivers with real-time information on unoccupied car parking spaces. The deployment includes a network of over 3,400 RFID equipped in-ground vehicle detection sensors which register whether each parking bay is occupied or vacant. This information is relayed live to SmartRep, Smart Parking's powerful car parking management software tool, which collates and analyses the data. The information is fed instantaneously to the council's ParkRight, a simple to use app which drivers can install on their smartphone. The driver then uses ParkRight to identify the best available space and receive clear, precise, GPS-based directions to get them to it (Smart parking, 2018).

Amsterdam

The Dynamic guided parking solution (DGPS) developed by ARS T&TT collects and maintains real-time information about the occupation and availability of parking spaces in off-street parking premises. At each intersection within the car park, up-to-date information is given on the number of available parking places, for each row, section or floor. The DGPS provides assistance with capacity management and incident management, and dynamically guides all vehicles to the nearest, most convenient places available using smart routing. Up to 50% of the traffic in city centres consists of vehicles searching for a convenient parking place. ARS T&TT has successfully implemented an integrated solution combining route navigation and parking facilities with which people attending specific events are able to combine route navigation to the event with booking a parking place in advance. By integrating knowledge of the event location and the available parking capacity, the amount of traffic seeking parking can be reduced. ARS T&TT successfully applied this concept during SAIL 2015, an event during which more than a million people visited the centre of Amsterdam (ARS, 2018).

Mureaux

The wireless vehicle detection system SENSIT not only “sees” whether or not a single parking bay is occupied, it also detects how long a space has been occupied. The status information (e.g. available, occupied and overstay) is wirelessly relayed to a parking officer, working with dedicated software. In order to get to know the real-time status of hundreds of parking spots in Les Mureaux, the SENSIT system was installed by the French company TTS (Trafic Technologie Système). Nedap is the developer and manufacturer of SENSIT: a network of wireless parking sensors which detect vehicle occupancy at every single parking space. SENSIT collects parking data and shares that information with third party parking guidance, enforcement and intelligent transport systems. This smart parking technology decreases search traffic, improves utilization of parking capacity and reduces of CO_2-emissions. Nedap currently works with partners and cities worldwide to implement the SENSIT system (Nedap, 2017).

9 Sharing system

9.1 Bike sharing system

The first systems of public bicycle sharing appeared in the 1960s, but it still lasted many years before they gained worldwide popularity today. To their wider spread has only occurred at the time of the boom of modern technologies, which have been substantially simplified and made more transparent borrowing systems to the wider public. The historically first bike sharing system was launched on 28 July 1965 in Amsterdam. These were 50 standard bikes (most commonly urban types) of uniform color, which were made available in the public space. The wheels were unlocked and could be borrowed for free and without limitation by anyone who needed it. Unfortunately, a number of systems of this kind were forced to end their operations in just a few days of operation - due to theft and vandalism (Valeska, 2008). Smart cities are urban areas that make use of information technology to address social, economic and environmental issues, creating sustainable economic development and a high quality of life. Bike sharing systems can be an ideal element of a smart city as they have the potential for impact on multiple levels. The most obvious bicycle sharing benefits are environmental and social: dealing with carbon emissions and poor air quality in cities. The latter is already having a clear and direct impact on public health. In China for example, outdoor air pollution contributed to 1.2 million premature deaths in 2010, and an estimated 80% of pollution in Asian cities is attributed to private passenger vehicles (Bike sharing, 2012). Another health benefit of biking is its contribution to an active lifestyle. In the first six years of its existence, Vélib' users were estimated to have burnt over 19 billion calories. Bike sharing systems also have the potential to contribute to economic development. Accessible and efficient personal transportation is a key condition of economic development within cities. Recent years have seen rapid development and implementation of public bicycle systems (PBS). PBS as a convenient and green form of public transport for nations both rich and poor, represents a strategic choice for urban sustainable development (Graham at al., 2015). The city has introduced clever cyclists that can be controlled by mobile applications and can retrieve payment and other cards. About 65 percent of people do not go to work by bike because they are afraid of their theft. Of course, replacing every car with a (shared) bicycle overnight is not a realistic scenario. Barriers for bicycle adoption include a lack of safe parking spaces, vandalism and theft, and inconvenience and cost of owning and maintaining a bike. These issues are addressed by bike sharing systems (Vinke, 2015). Nonetheless, the success of bike sharing systems depends on other aspects, such as station accessibility (how far a commuter has to walk to reach a station) and of bike-availability (the likelihood of finding a bike at the station). Adaptive bike-sharing systems, focus on riders with special needs. Rather than simply offering traditional bikes, the stations have options like adult-sized tricycles and hand-operated cycles (Smart Cities Dive, 2015).

Bike sharing aims to make cycling available to people who do not have a lap at a given moment available. The whole system is actually a kind of city bike rent, scattered around the city, with the opportunity to borrow (free of charge or for a fee) a bicycle in one place and return it on the spot another. The advantage, however, lies in the simplicity and speed of the lending process that they allow special stands. Some systems allow you to use it to pay for a customer card that also works in urban public transport. This option seems appropriate for city residents and frequent users of Bike sharing. For tourists and other people who do not regularly use this service is a quick option internet signup and mobile phone payments. If bike rental is free, only access to the Internet is sufficient. This is because of the ubiquity of the Internet in bigger cities, this service is really available to everyone.

Compared to traditional systems built on docking stations, dockless bike sharing brings none of the implementation costs and slow government approval processes, but all the flexibility in distribution and the benefit for the users – who can leave the bike directly at their destination, and don't need to find an empty dock. Dockless systems are not all the same, however. The ones that grew the fastest in 2017 are completely free-floating, meaning you can leave GPS-tracked bikes literally anywhere you want. While Chinese companies Mobike and ofo are the main purveyors of this model, we also saw notable developments from Singapore-based oBike, Gobee from Hong Kong, and Limebike and Spin in the US (Martinek, 2008).

9.2 Car sharing system

Carsharing is an easy, convenient and considerate alternative to car ownership that saves both finances and worries for users. Surveys say the average car is driving only one hour a day. Efficiency does not make much difference when it is 23 hours. Carsharing, or car sharing, helps to make better use of cars in cities so that one car can meet the transport needs of more people or businesses. It's easy: every user can book any shared car at any time online after the initial registration by computer or phone. Then he only opens it with a smart card or smartphone. Reservations may be needed for an hour, but also a half-day or weekly holiday as needed. Everything is fully self-service and the car can be picked up at any time, 24 hours a day (Akademie městské mobility, 2017).

9.3 Bike sharing system

Copenhagen

Since the early 20th century, the bicycle has been a symbol of freedom for people in Denmark. Government of Copenhagen planned and balanced very well spaces given to cars, bikes, public transport and pedestrians. Today, around half of the people who live in Copenhagen ride a bicycle to work. It’s not just the culture that encourages this, but an infrastructure plays a critical role here. Traffic lights are timed for bicycle speeds. And in terms of urban design for bikes, Copenhagen’s 240-mile network is impressive. Then there are dock less, but not free-floating bike shares. We call this system hub-centric at Donkey Republic, Hello-Bike in Amsterdam calls it hybrid, while SG Bike uses the term geostations. That’s because these systems don’t use docking stations, but rather virtual parking zones defined though geo-fencing. Virtual parking zones are needed in dock less bike-shares to ensure optimal control over bike fleets for both operators and city authorities and to avoid the chaos created by free-floating bikes being parked in unsuitable places. Schemes using a hub-centric model also require less bikes to operate efficiently thanks to a higher predictability in bike availability at specific locations and lower levels of bike loss. Cities across Europe woke up flooded in thousands of brightly colored shared bikes and didn’t know what to do with them. Because most of these were dock less, things got messy pretty fast. If you tell people they can park a bike anywhere, they park it EVERYWHERE. Including here, or here. Even if bikes don’t purposely end up in very weird places, they still naturally crowd in high traffic areas, or scattered in people’s courtyards, and rarely get redistributed. In China alone, by August 2017 there were more than 20 million shared bikes from 50 companies (Fratila, 2017).

India

In city of Bengaluru which is riddled with traffic jams and parking issues, Kerberon Automations, a green technology start-up came up with bicycle sharing system known as ATCAG (Automated Tracking and Control of Green Assets), an automated unit which automatically issues and accepts bicycles electromechanically. Compared to other public transportation projects, cycle sharing systems are very inexpensive, fun and people friendly (Smart Cities Dive, 2017).

Paris

Parisian residents are losing an annual average of € 2,883 due to traffic congestion, and it’s costing the French economy € 17 billion every year. Bicycles address traffic congestion as they form a valid substitution for cars on short trips, contribute to the use of public transport by providing effective last-mile connectivity and simply take up less space on the road. The INSEAD & Chicago Booth study investigates these issues with empirical research on the Parisian Vélib’ system. Based upon calculations using a dataset of 22 million snapshots from 349 bike stations, the authors suggest that by splitting existing stations into smaller stations, which decreases availability but increases the accessibility, ridership can be increased by almost 30% – with the same amount of bicycles (Vinke, 2015). Female-focused ride-share services, such as Paris' Women Drive, employ women drivers and are aimed at female passengers. They're intended to boost women's safety and sense of security when getting into a vehicle with strangers (Smart Cities Dive, 2017).

San Francisco

Scoot has been operating a fleet of 700 electric two-wheelers in San Francisco for five years serving tens of thousands of riders who have logged more than 3.9 million miles. During that time, Scoot’s riders have collectively eliminated over 1000 metric tons of CO_2 from entering the atmosphere in San Francisco while simultaneously reducing congestion on city streets (Rodriguez, 2017).

Singapore
Application PopScoot for e-scooter will run on a bluetooth app-based unlocking system, releasing the e-scooters from their docks via mobile phones. The in-app GPS also lets users locate available scooters, and tracks their travelling routes (The New paper, 2017).

Hangzhou
The city of Hangzhou, with a population of around 7 million, boasts the world's largest bike share program. In fact, no other bike share on earth touches the sheer numbers they have. Let's take a tally. There are somewhere between 66,500 and 78,000 bicycles in their program, scattered across around 2700 stations. There are so many city bikes that, in the downtown of the city, you can't go 5 minutes without seeing one (Hiles, 2015).

10 Smart Cycling

10.1 Smart cycling in world cities

Smart Mobility is one of the main directions of transportation systems development in Smart Cities. In this case along with intellectualization of management the issue of transition to “green”, safe and sustainable modes of transport, such as bicycle, should be solved. Democracy and availability, cheapness and environmental friendliness, promotion of healthy lifestyle are the reasons for the growing popularity of this mode of transport all over the Word (Makarova et al, 2017). Many solutions are focused on the using of bike sharing system to make city smarter and analyze the bicycle sharing data for generating insights into sustainable transport system. The bike sharing system can use various technologies to make it smart and real-time example, advances sensors, collaborative agents and ontologies for storing user’s and heterogenous station details (Rani et al, 2017; Rani et al. 2016). In U.S.A., the bike share is particularly powerful because it integrates with public transport, increasingly with combined ticketing and journey planning – so called Mobility as a Service.
Similar work has been done in cities like California and San Francisco (Cervero et al. 2016; Maurer, 2012). For the simulation, we referenced the standard tutorial for NS2 by MarcGreis (Greis, 2018).
Baltimore’s new system will eventually include 200 bikes with electric pedal assistance, known as “pedelec” systems, making it the largest public electric bike-share fleet in both North and South America (look for the rides with white lightning bolt icons on the back fender) (Baltimore, 2016).
Idaho-based Solar Roadways has been working on a similar goal – paving roads and other surfaces with solar panels. And the company has plenty of supporters. Solar Roadways secured an $850,000 Federal Highway Administration grant for a pilot project, and it managed to raise $2.2 million in a crowdfunding effort in 2015 (SCC, 2015).
In Atlanta the ongoing construction of the Beltline, 22 miles of urban rail being rebuilt as a transformative pedestrian and biking loop—is taking shape, sparking real estate speculation and civic pride while helping locals re-imagine how they traverse their city.
First cycling lines in U.S. city Loop were build the protected cycling lanes. Part of the larger Loop Link transit upgrade, the new, safer system will help riders avoid some of the dangers of rush-hour traffic in a congested neighborhood. Even with the addition of new lanes this spring, there’s still a ways to go. But the groundwork is laid to start untying the city’s congested commuter traffic with dedicated lanes [9].
Portland’s Tilikum Crossing, a 1,720-foot-long cable-stayed bridge across the Willamette River, gives bikers, pedestrians, and public-transit riders a new way to get across town. The first major bridge in the country specifically designed to exclude vehicular traffic (its name is a Chinook word meaning “people, tribe, or family”), the bridge provides a model for multimodal transport, separate paths for walkers and cyclists, designated places to stop and chat, and a new means to extend the city’s light-rail and streetcar lines. It’s also an aesthetically pleasing model for a new type of car-free infrastructure, with a slim profile (no cars mean fewer lanes) and an interactive light display that reacts to the speed and depth of the river (Trimetm 2018; Sisson, 2017).
Seattle founded the PeopleForBikes foundation and built Westlake Avenue protected bike trail for better bike infrastructure, green city and health of habitants (Sisson, 2017).

10.2 European Smart Cycling

10.2.1 Data sharing

A Smarter Cycling is the shared, real-time collaborative application of data, communication technologies, products and services through both private and public actors that helps better move people individually and collectively, across the urban environment. Akin to smartphones today, Smarter Cycling’ vision is that everyone will have a bicycle in his or her pocket (figuratively), always at reach, and on-demand, combining private cycling and public access - with other forms of urban mobility (Strrata, 2018).

10.2.2 Bike sharing

The StadtRAD in Germany has bike sharing programs in many cities, including Aachen, Berlin, Cologne, Düsseldorf, Frankfurt, Hamburg. The program proposes many hire stations throughout the entire city offer facilities round the clock for hiring and returning. There are possible ways how to hire bikes such as via terminal (with using customer card) or by phone. It is possible to hire more bikes (Stadtrad, 2018). Popular are also e-bikes and their on-board battery makes their integration with networked technologies easier than on traditional bicycles.

Another program in Germany (Karlsruhe) is public bicycle scheme with 50 hire stations with about 500 bikes. The bikes hire is possible by register phone number, ID card number and credit card for free online, via the app. Also, there are another three touchscreen terminals at the train stations. There is possible to rent out two bikes at a time (Kassel, 2018).

The MVGmeinRad system in Mainz is web application available also for smartphones via Android and iOS system (MVGmyRad). This system, allow to hire bike 24-hours per day on more than 100 stations by chip card. The mobile application, allow overview of stations and number of bikes (Mainzer, 2018).

Another possible measure of Smart City solutions in bicycle system is ride monitoring, where throw the apps can riders see their trip (lenity, durative, start and end time), a map visualization of trips, select a data range for this etc. These apps are currently available not only for smart city solution. But in connection with smart velomobility are these apps apply for smart e-bikes (Behrendt, 2016).

Station based System Metropolradruhr is located in the Ruhr Area. Bike-sharing stations are also located in over 50 ICE railway stations (Malovrh, 2018). French cities offering a sharing system include Marseille, Lyon, Bordeaux, Nice, Toulouse, Rennes, Rouen, La Rochelle, Orléans, Montpellier, Nantes, Lille, Strasbourg, Clermont-Ferrand, Avignon, Saint-Étienne, ChalonsurSaône, Belfast, and Aix-en-Provence.

Electric cycling is supported by Europe policies. The integration of electric components in an e-bike is still considerably easier and less expensive compared to big e-vehicle development, which can be quite challenging: batteries are smaller, require less time to be charged, and guarantee a good performance; furthermore, efficient infrastructures have already been created to implement bike-sharing systems in many cities worldwide (some of which are also electric). To have an idea of current BSSs (Bike Share Schemes) in the world, give a glance at the Bike-Sharing World Map (Malovrh, 2018).

10.2.3 Secure parking

The Smart Biking platform was applied in Barcelona (Spain). The platform is focused on secure bicycle parking. Parking places include anti-theft system that consist of three anchoring points and anti-cutting materials with three different lock. There is possible to pay for service per year and maximum parking time allowed is 72 hours (Barcelona, 2018).

10.2.4 Smart paths

In Copenhagen was used the bike footrest. The city installed simple, inexpensive railings at intersections so that cyclists have a place to lean while waiting for the light to change. Taken together, all of these are smart behavioral nudges and minor adjustments that encourage more riders and good cycling behaviors (SCC, 2015).

10.2.5 Cycle paths

In Amsterdam (Neatherland), was built SolaRoad. The concept is to propose pave roads with solar panels that could eventually provide power for street lights and traffic controls, and maybe even homes and electric vehicles. The 230-foot stretch has produced 3,000 kilowatt-hours of power, enough to keep the juice flowing in a single-person residence (Artefactgroup, 2017).

Utrecht (Neatherland) has improved main routes, built cycle streets, bicycle bridges, bicycle subways and roundabouts. It has also improved bicycle parking facilities. The city has invested large amounts of money in a long list of projects (Bicycle Dutch, 2016).

11 Pedestrian zone

A thousand-mile journey begins with a first step and walking is our first means of transport: every trip begins and ends with walking. As a fish needs to swim, a bird to fly, a deer to run, we need to walk, not in order to survive, but to be happy. Pedestrian sites are diminishing at the expense of parking spaces, advertising stands and crowding road networks for motor vehicles. Cities at the cutting edge of the sustainability movement are constantly trying to provide a greener and more live able environment for their residents. At the same time, economic growth creates added pressure for more transportation, which leads to crowded roads, stress, wasted time and air pollution. For well over half a century, city planners have focused on crafting car-friendly cities – to the detriment of people. But before cars, our city streets served as social gathering spaces, where neighbors could congregate, street vendors could sell their wares, and children could play. The main thrust of the pedestrianization movement is that we need to re-think urban planning, and start designing cities for people, not cars. Proponents of pedestrianization say that fewer cars would mean less stress and more effective use of people's time, not to mention cleaner air and more attractive cities.

Countless cities around the world already have pedestrian zones, but usually just one in the center. Pedestrianization, however, calls for many more such zones, to the point where cities are once again visibly dominated by human activity, and not vehicular traffic. Some cities have already witnessed great success: Ghent now has a 30-hectare pedestrian zone. Still others are planning ahead. Oslo (Norway) and Madrid (Spain) both plan to ban cars entirely from the city center by 2019 and 2020, respectively (Urban hub, 2018). More vehicle traffic on a street, more robust biking and walking infrastructure needed. Pedestrians need a flat band of sidewalk—called a "pedestrian zone"—free of obstructions. Wider sidewalks can also accommodate commercial activity and community interaction without becoming a nuisance to moving pedestrians. Sidewalks are inherently social, and should be thought of as public spaces that happen to have a transportation function, rather than simply a way to get from one building to another. Streets with high traffic or fast-moving vehicles need barriers that separate and protect pedestrians and cyclists from traffic. Especially where on-street parking is not permitted, sidewalks should be protected by strips of greenery, whose permeable surfaces also help with drainage during storms.

To ensure the comfort and efficiency of non-motorized mobility as a means for transportation, the spaces needed for bicycle and pedestrian track must be designed. To guarantee uninterrupted pedestrian flows, the sidewalk must be divided into three zones or segments:

A. One segment is for services, where urban furniture and vegetation are placed, and where the underground infrastructure is located for the network of urban services.

B. A pedestrian flow segment, where continuous pedestrian flow occurs without the invasion (or presence) of barriers, such as urban furniture, vegetation, lamp posts, ramps, steps, stations or buildings. C. A segment in front of the buildings, which marks the transition between privately built spaces and the unbuilt public space (EMBARQ, 2018).

Smart waste bins in pedestrian zone

The first smart waste bins have been installed in the pedestrian zone of the City of Brussels. A solar battery allows the bin to compress the waste and to warn the Cleanliness service when it's full. The compression of the waste is carried out inside the container after each closure. The capacity of the volume of 125 liters without compression is thus increased to 600 liters after the compression. Moreover, the waste bin is equipped with a computer system that warns the central office when it is full. Thus, the collection can be scheduled faster. The computer system also groups all bins together on an interactive map, gives statistics about filling and emptying, or technical problems. Bigbelly is a smart waste and recycling system that has been implemented in main cities of the US and in more than 50 countries around the globe. Bigbelly provides a solar-powered compacting waste bin that allows for up to five times the amount of waste as in a traditional bin. What is also good about it and I would say the best and the most demanded feature of it is that it alerts the appropriate city department when it needs to be emptied. This means that the number of trash bins in a city can be reduced by 70-80%, which makes the streets more aesthetically appealing. Also, it reduces traffic jams and ensures that the cars take full rubbish bins instead of coming twice for half-full bins (Smartcity.breussels.be, 2016).

Smart crosswalk reacts to cars and pedestrians in real time

Responsive road surface reacts in real time to different traffic and pedestrian conditions by modifying the patterns, layout, configuration, and the size and orientation of pedestrian crossings in order to prioritize pedestrian safety. he road, a full-scale prototype of which has been installed in South London, is made from LED-embedded plastic panels that display crossing markings, warnings, and other indications that are meant to direct and alert both drivers and pedestrians. Cameras monitor the crosswalk at all times and feed the computer-controlled LEDs with data that in turn illuminates the crossing. sing a neural network framework, cameras track objects that are moving across the road surface, distinguishing between pedestrians, cyclists and vehicles, calculating their precise locations, trajectories and velocities and anticipating where they may move to in the next moment. Crossing also takes into account the time of day. At night and during the early morning, when there are virtually no people on the road, the crosswalk may "disappear" altogether. On the other hand, during rush hour, for example, the image of the crosswalk may expand in width to accommodate more pedestrians (Curbed, 2017).

Smart lights

LED streetlights have numerous benefits. One of the main benefits is reduced crime, because the lights automatically brighten when there are multiple people in the area and dim when no one is around (Apiumhub, 2018).

Barcelona

Smart LED streetlamps activate only when movement is detected, producing 30% energy savings, and are equipped with sensors to collect data from the environment. Municipal smart bins monitor waste levels and are cleared only when they are full, optimizing waste collection operations. Smart city became another buzz word these years but we are going to be hearing a lot more of in the coming years. By 2020 we will be spending $400 billion a year building smart cities. Barcelona's new plan consists of creating big superilles through a series of gradual interventions that will repurpose existing infrastructure, starting with traffic management through to changing road signs and bus routes. Superblocks will be smaller than neighborhoods, but bigger than actual blocks (EMBARQ, 2018).

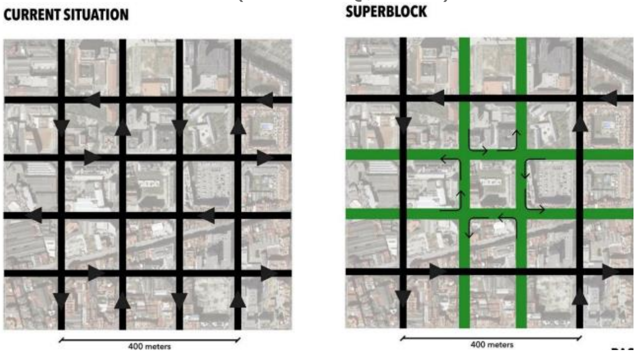

Fig. 6 Pedestrian zone in Barcelona

Stockholm

If Stockholm is to be more pedestrian-friendly, it should provide an intricate pedestrian network that enables more people to walk instead of driving their cars. he city's public spaces should provide every resident and visitor with the opportunity, the desire, the know-how and the courage to walk. Several projects that correspond with the Pedestrian Plan's strategic objective have been implemented or are currently ongoing in Stockholm. Pedestrian thoroughfares should exist, be wide enough and accessible for everyone. The pedestrian network should be direct, provide alternative routes and not be obstructed by obstacles that make it difficult or impossible to navigate. Pedestrian thoroughfares should be safe for traffic populated, well lit, and visible from the surrounding area and perceived as safe. The City of Stockholm's road safety program has set goals and policies for the City's commitment to safety in traffic. The goals that are directly related to pedestrian safety include managing the speed of motor vehicles, ensuring that main roads are safe, and enhancing standards of street management and maintenance. The pedestrian network should be navigable, visible and signposted in such a way that it is easy to understand where thoroughfares lead and the destinations along the route (Part of the mobility strategy, 2017).

Singapore

The city-state's island territory means it is already densely-developed and has naturally limited road links outside its borders. It's also far from being car-friendly; the cost of car ownership is high. However, a more likely future for Singapore is to become 'car-lite' rather than emptying the roads altogether of private vehicles. One of the keys to encouraging the use of public transport, walking and cycling, is to improve first and last mile connections. Ang Mo Kio, one of the most established housing estates in Singapore has become the first "walking and cycling" town. When fully completed in 2020, the cycling network in Ang Mo Kio will span 20km and will be the longest in any residential town. The cycling network will include a 2.6km-long walking and cycling corridor. Pedestrian priority zones are created in areas where pedestrians and cyclists need to share the space, such as behind bus stops. These pedestrian priority zones will include rumble strips to slow cyclists down and contrast markings to guide pedestrians and cyclists on where they should travel to enhance the safety for both users (Land transport, 2017).

12 Electromobility

12.1 Requirements for car power sources

The DAFI directive

The obligation of EU member states to support sustainable (ecological and clean) mobility is a challenge for seeking new solutions in transportation. An important milestone is the *2014/94/EU* directive also known as DAFI (DAFI Directive 2014/94/EU) (Directive on deployment of alternative fuels infrastructure), which focuses on distributing the alternative fuel infrastructure in the European Union and should be implemented by national political structures. The aim of this directive is to reduce the dependence on oil and to reduce the impact of transportation on the environment. The directive defines the minimal requirements for the infrastructure of alternative fuels such as electricity and hydrogen, from which energy is not released by burning.

The COP 21 climatic conference

At the COP 21 (Conference of Parties) conference in Paris in December 2015, the international contracting parties of the United Nations Framework Convention on Climate Change pledged to take measures necessary to prevent the increase in global temperatures by more than 2°C to prevent possible natural disasters caused by climate change. In Europe, this means reducing greenhouse gas emissions by 80-95% by the year 2050 compared with the levels from 1990.
The commitments which not only European countries have decided to apply at the national political level are evident in specific strategies of each country. The following section offers an overview of non-emission vehicles (electrical as well as hydrogen), their key aspects and examples of their practical application.

12.2 Electric vehicles

Electric vehicles can help to reduce greenhouse gas emissions, improve the air quality in cities and therefore the health of the inhabitants because they only release natural by-products and not exhaust gases. However, it must be pointed out that since it is a long-term challenge, it is necessary, in the short-term and medium-term horizon, to take radical measures to deal with the current environmental and energy-related problems.
An electric vehicle is therefore an optimal solution for clean urban mobility.

Low emission zones

Some cities have had to introduce severe restrictions in transport such as low emission zones (LEZ) in the city centre, where combustion engine cars are not allowed. However, in London, the air quality has not improved in the first three years since the introduction of such zone, or rather, no significant positive progress has been observed in the impact on the health of the inhabitants. That is why there is a need for stronger measures for reducing transport emissions (Wood et al. 2015).
On the other hand, in Munich, Germany, introducing LEZ has led to a significant reduction in the concentration of PM_{10} particles in the city environment, which is evident in the air quality (Fensterer et al, 2014).

Switzerland

Vehicles in Switzerland constitute 17% of the total use of energy and 28% of the total CO_2 emissions. According to numerous scenarios, the CO_2 emissions from transport in 2050 will only decrease by

23-63% compared with 40-60% being the aim of the Swiss energy strategy. For comparison, the aim of the EU concerning mobility in 2030 is to reduce the greenhouse gas emissions by 40% (EU, 2014). In Switzerland, electromobility has the potential for decarbonizing 30-93% of the vehicle fleet. (Kannan and Hirschberg, 2016).

Spain

According to an analysis by *José M.Cansino et al.*, at the end of 2012 there were 12,425 electric vehicles (EV) on Spanish roads, which is an increase by 148.3% compared with the year 2007. However, it is still only about 0.02% of all the vehicles, which is far from the 10% limit established by some European countries (e.g. Ireland) to be reached by 2020 (Cansino and Yňlguer, 2018).

Sale of electric cars

From the total number of new cars sold in the first half of 2017 the proportion of electric cars was over 2% in very few European countries, for example in Sweden (3.8%) and Belgium (2.1%), (The World Vehicle World Sales Database, 2017). In Holland, this proportion fell from 3.87% in 2014 to 1.5%. Norway, although not an EU member, reaches a proportion of 28.9% thanks to tax concessions.

Although the visions of the European Commission and the member states are ambitious, the real increase in the proportion of electric vehicles in the market still lags behind the goals. These examples show low demand for electric cars in the EU. Therefore, to deal with the factors which impede the spreading of EV, governments and other institutions need to consider and take more action (Biresselioglu et al. 2018).

An efficient coordination is necessary between the numerous parties involved in the ecosystem of EV including customers, operators of energy systems and distribution networks, manufacturers and providers of services, mobility and urban plans.

A Europe-wide attitude to electromobility

Low emission mobility is an issue in all of Europe. It means that all the countries must have a common vision at the political level. This requires comprehensive, international understanding of the issue of reducing emissions from transport, not only dealing with the problems specific to the particular country. This concern, for example, charging road tolls, introducing a tax on vehicles or the infrastructure of charging stations (Newbery at al. 2016).

The biggest challenges in the transition to electromobility

- **Missing infrastructure of charging stations.** If there is a lack of charging infrastructure, the flexibility and comfort of electric power supply is not ensured, which lowers the attractiveness of electromobiles. Studies show that the key factors of the charging stations is the timing of charging EV and the location of the charging station (Azadfar et al. 2014)
- **Economy –** The prices of EV are considerably higher compared to conventional cars and the clean way of mobility does not bring the users any compensation benefits. On the other hand, the total costs are lower for an owner of an EV than in the case of conventional vehicles thanks to fuel saving and lower maintenance costs. However, not many potential users of EV are familiar with these benefits and most of them compare EV with regular vehicles solely in terms of the purchase price (Haddadian, 2015).

- **Technical limits of batteries –** The cost of the battery is often unreasonably high, its lifespan is not certain and the charging time is rather long. The batteries also occupy much more space than a fuel tank and a sufficient amount of raw materials (e.g. lithium) is also needed for the production of electromobile batteries (Cabeza et al, 2015)
- **Public awareness of environmental benefits –** A lot of potential buyers of EV, based on the surveys undertaken in some parts of Europe, still do not have enough information on electric vehicles and their benefits (Barisa et al., 2016) and moreover, the potential buyers of EV are not sure to what extent using EV really leads to reducing CO_2 emissions in the environment. Many claims that electric mobility leads to an increase in the demand for electrical energy, which, on the contrary, increases CO_2 emissions (Barisa et al, 2016). Others consider the disposal of used batteries to be harmful to the environment (Winslow et al. 2018).
- **Higher demands for the production of electrical energy.** Many countries are planning to gradually eliminate nuclear energy and replace it with renewable resources. However, it is expected that decentralized production of electrical energy from renewable resources will be insufficient for the future demand for electrical energy. Nevertheless, electromobility supports the decarbonisation of the car fleet even if electrical energy is supplied by big gas power plants. Another obstacle is the fact that cheap excess electrical energy may not always be available and there may be problems with the energy distribution at the charging peak. This will have to be eliminated by the right timing of the charging and by applying smart elements in the distribution network and at the charging stations (Zawieska and Pieriegud, 2018).

Almost all the key car manufacturers invest in the development and production of electromobiles. This indicates that EV could constitute a considerable part of the vehicle fleet in Europe in the future. Besides the benefits of almost non-emission mobility mentioned above, there are other benefits which could be brought by the arrival of electric cars:

- Reducing the consumption of oil and reducing the dependence on imported oil products.
- The number of smart elements to be integrated into new concepts of transport control such as automatic car rent systems, smart distribution of goods or small buses for services in city centres. An electric vehicle also enables silent access to historic city centres and contributes to a reduction in the overall noise level (De Nuzio et al. 2015).

Electromobility and smart city in Poland

Zawieska et al. (2018) examined the relation between the implementation of the smart city concept and the idea of sustainable transport, especially in terms of the reduction in CO_2 emissions caused by transport in Warsaw. They offer various potential development scenarios for the Warsaw transport system by the year 2050 and they analyse a further impact of CO_2 emissions on smart city elements related to mobility. The results show that reaching the goals of reducing the emissions requires a depth transformation of the fields of transportation and power industry. This study also confirms that the smart-city solutions may play a key role in reducing the emissions from transport and reaching the established goals.

In spite of the improvement in the electromobile technology, further progress is necessary, especially for lorries. Among the main challenges are energy storage, battery performance and charging speed. In the case of electric buses, the current technology only enables their use for short distances with frequent charging (Zawieska and Pieriegud, 2018).

In Poland, as well as in other countries, where the power industry still depends on coal burning, a growing demand for electrical energy could even lead to an increase in greenhouse gas emissions.

Hydrogen and hydrogen mobility

Article 5 of the DAFI directive refers to „a supply of hydrogen in road transportation“. The member states which decide to include hydrogen filling stations accessible to the public in their national policy frameworks will ensure that, by December 31 2025, there will be an appropriate number of these places and enough fuel for ensuring the functioning of hydrogen cars (*FCEV - fuel cell electric vehicle*).

13 Hydrogen for car propulsion

13.1 Renewable resources and electrical energy accumulation

With the emerging trend of renewable sources of energy such as wind and solar energy, the imbalance in the distribution network and the fluctuation in the electrical energy production is increasing. Since we cannot predict the immediate performance of these sources sufficiently in time, it is necessary to ensure a sufficient balance between the production and consumption of electricity. Besides pumping hydroelectric power stations, mainly batteries, accumulators and supercapacitors are used for short-term accumulation. For long-term storage of a large amount of energy, it is suitable to use the Power-to-Gas technology. It is about transferring electrical energy to chemical energy. The most widespread chemical carrier of energy is hydrogen. It is produced by electrolysis from water and then it is stored. If needed, its chemical form of energy is transformed back to electrical energy via a fuel cell. This technology does not produce any CO_2 and the only product of using hydrogen is water.

13.2 Hydrogen Mobility Italy (MH2IT)

National Hydrogen Infrastructure Rollout Plan is a plan for the development of hydrogen fuel cells, mobility and infrastructure by the year 2025 in Italy. This plan was launched in 2016 by the Italian Ministry of Economy on the basis of the above mentioned DAFI Directive 2014/94/EU. MH2IT is an association founded in June 2015 which unites the main Italian parties involved in the hydrogen sphere.

This plan includes a detailed map of Italy including the materials, methods and results describing the prospects for the development of hydrogen mobility by 2050. According to the authors, this strategy is economically sustainable and it is in compliance with the main European objectives of decarbonisation and clean mobility in an urban environment. Hydrogen vehicles proposed by Scenario MobilitàH2IT do not release harmful pollutants and they may ensure a decrease in CO_2 emissions and clean and healthy air in cities.

The strategy proposes 1,000 personal fuel cell vehicles and 100 hydrogen buses by 2020. By 2025, their number should increase to 27,000 cars and 1,100 buses. By 2050, there should be 20% hydrogen mobility (which means 8.5 million cars) and 25% of buses (23,100 units) (Mobilitah, 2018). During the initial phase of the transitional period in 2020 – 2030, low-cost centralized production of hydrogen in existing Italian plants is proposed. After this phase, the H_2 production capacity should be increased by installing electrolysers in places with sources of renewable energy. In this way, the following will also be accomplished:

- reducing CO_2 emissions by implementing renewable resources and hydrogen fuel cells,
- increasing the national energy independence,
- greater integration of unpredictable renewable sources (such as solar and wind energy).

From the consumer's point of view, if hydrogen was not subject to taxation, competitiveness could quickly show as early as the initial phase and even more after the extension of the filling station network. The price of hydrogen as fuel would not include the national taxation of hydrogen, which is currently applied to oil and petrol (Viesi et al. 2017).

The cost of producing 1kg of hydrogen by electrolysis ranges from 4 to 23 USD/kg depending on the source of energy used.

Fig.7 The number of hydrogen filling stations in different areas all over the world in 2017 (Wixstatic, 2018)

13.3 Hydrogen Mobility Australia

With the aim of developing a power industry based on clean and renewable energy technologies including hydrogen transportation, a new body was established in Australia consisting of car manufacturers, energetic companies, research institutions and the government. Its founders say that hydrogen is the most important carrier of energy, which may cover Australia's future energy needs in a clean way. The organization is trying to achieve its goal related to hydrogen technology through commercializing new hydrogen technologies and fuel cells in the entire chain including the production, transport and storage for transport and stationary applications in Australia and overseas (Hydrogen Mobility Australia, 2018).

The following are the goals of Hydrogen Mobility Australia:

- accelerating the commercialization of new hydrogen technologies and fuel cells for transport, production, export, storage and stationary applications in Australia,
- provoking a discussion and cooperation among all the parties involved in hydrogen related issues and energy,
- helping with Australia's future transition to hydrogen society based on clean and renewable energy technologies.

In the transportation sector, the Australian government has also designed a strategy aimed at supporting the use of vehicles with zero emissions called Ministerial Forum into Vehicle Emissions and led by Josh Frydenberg, the Minister for the Environment and Energy, and others. They have declared that although electric batteries for vehicles constitute one technological option, fuel cell vehicles, also powered by electrical energy, constitute another real alternative for reducing the emissions from transport in Australia. Among the members of the Hydrogen Mobility Australia group are BOC, BP Australia, Caltex Australia, CNH Industrial, Coregas, Hyundai Australia, ITM Power, Siemens, Toyota Australia and Viva Energy Australia (Nuzio et al. 2015).

14 Best cases for Brno

14.1 Dynamic traffic signs

One of a possible solution is the system uses dedicated failsafe controllers, signal heads, and pedestrian indicators as well as new smartloop modules ensuring that the overall system is tolerant of individual component and cable damage, resulting in higher intersection availability and reduced disruption to the travelling public (https://www.siemens.com/uk/en/home/products/campaigns/plus-plus.html)

Also, there is possible system focused on the communication between cars and the elements of transport infrastructure. This way of communication is supposed to ensure an increase in transport hub permeability and at the same time to increase the traffic safety. Similar activities are dealt with in Europe within the simTD (Safe and Intelligent Mobility) project.

Important is also to apply new emerging trend in traffic flow management uses online measuring of pollutant concentrations at a great number of checkpoints located in the surroundings of intersections and important roads. This way of measuring uses new types of sensors, which are affordable and which monitor concentrations of pollutants with sufficient accuracy.

14.2 Smart monitoring

A wide range of different sensor and detection techniques with specific advantages and disadvantages is used. A widespread approach for vehicle detection and classification are camera based systems, which achieve a high classification success rate. Normally, several cameras are needed in those systems to analyze the scenario from different angles and perspectives. In contrast, an enhanced visual system which is able to categorize vehicles into various vehicle classes using a single camera is presented in (Hsieh et al. 2006).

One of the solution is to use system with collecting and processing the information on travel times with displayed on a web interface conceived especially for management purposes. The analysis of the data collected by the sensors improves understanding of the complexity of roads, neighborhoods and events. Thus, local authorities can intervene in traffic flows by diverting traffic to secondary arteries, by adjusting phase positions and the timing of signal lights at road crossings and by sending patrol officers to control and manage the situation. Travel time information is provided as well. The platform offers daily, real-time information on origin-destination matrices, which is useful for urban planning policies. It is possible to identify a city’s hot and cold areas, the most congested paths and patterns, as well as to control entrances and exits. From there, route optimization can be performed for better management of existing resources (Hsieh et al., 2006; Smart Tech Solution, 2008).

14.3 Smart City Logistic

The platform is focused on supporting of urban freight transportation plans by wide range of easy-to-understand information. The Smart City Logistics platform maps users’ information on transportation networks, access restrictions, traffic measures, delivery and transport facilities, administrative units, population, land use and emission situations (Civitas, 2013).

The pilot was designed to provide some space to operate a transhipment center with e-tricycles covering the Ciutat Vella district. The transhipment point was designed to be dynamic and flexible to accommodate future services and changes. Mainly, the service was orientated towards parcel services and similar shipments (i.e. fashion shops), the size and the weight of the packages are limited by the total capacity of the tricycles. The aim was oriented to transport operators that cover last mile deliveries inside area. Transport carries visited the transshipment point at an agreed time and shipment was transferred to electric tricycles and to the final destination (Navarro et al. 2015).

14.4 Residential areas

Taxis and private hire companies, such as Uber, could be upgraded to be zero emission such as in London (2037), also busses. There are also includes transforming some of the most busiest and congested areas, to become partly pedestrianised. From 2019, vehicles which do not meet tough new emission standards will have to pay a charge, which will also directly fund new green transport schemes. The ULEZ will run 24 hours a day, all year round (Climateactionprogramme, 2017).

14.5 Smart bus stop

The smart bus stops propose a lot of possible ways how to apply smart measures not only in connection with public transport. The appropriate measure is to apply system provides multi-modal transport options to get users to their chosen destinations (Apiumhub, 2018). With characteristic of climate condition on the region is also possible to propose solar smart bus stop. The smart solar power bus station uses PV power generation for energy needs. As long as there is sunlight, the station will be able to generate electricity, and does not emit any pollutants; the bus station is therefore low-carbon, energy-saving and environment-friendly. The smart solar power bus stop has settings according to the needs of PV power generation, electronic monitoring, LED lighting, mobile phone charging, Wi-Fi, and switches between solar power and the grid to meet the diverse needs of public travel (Energo mobil, 2016). Similar system was applied for example in Spain or Croatia.

Multimodal Transport Mobile Application

The most experience and wide use in European cities in multimodal transport is the Whim app and its similar modification. The mobile app allows users to plan their route and pay for their tickets for bus, train, bike, taxi or car (Zizla, 2017). The app gives users access to transport packages on a pay-as-you-go or monthly subscription basis. Also, the app MyWay applied in Spain, Germany and Greece which includes a meta planning concept which combines the different modes of transport found in cities, including train, bus and tram public transport, plus cars, taxis, bikes and even e-scooters. The app allows to organize the trips, interacting with specialized planner and checking resource availability, also include the information such as timetables, parking availability (Whim, 2018).

14.6 Smart Parking systems

It is possible to use the combination of systems using sensor-controller parking and dynamic signs or mobile apps. Example is Siemens' Intelligent Parking Solutions use of the full potential of digitalization: smart sensors, intelligent software and clever analysis of the available data.

Good experience is from London with app RingGo when drivers can can download the app to view a current picture of parking spaces near to them which then guides them to the nearest unoccupied bay ultimately reducing the time taken looking for a parking place (SmartParking, 2015). Another is SmartPark solution an integrated package of leading edge technology that provides drivers with real-time information on unoccupied car parking spaces. The information is fed instantaneously to the council's ParkRight, a simple to use app which drivers can install on their smartphone. The driver then uses ParkRight to identify the best available space and receive clear, precise, GPS-based directions to get them to it (Smart parking, 2018).

14.7 Bicycle sharing system and smart cycling

A Smarter Cycling is the shared, real-time collaborative application of data, communication technologies, products and services through both private and public actors that helps better move people individually and collectively, across the urban environment (Strrata, 2018; Rani et al, 2017)

German cities have a good bike sharing system, such as Karlsruhe, where is possible to hire more than one bicycle. The terminals witch bicycles are located around train stations, in the city centre and

around. The hire of bicycle is possible by register phone number, ID card number, credit card, mobile phone app, via terminal or with using customer card (Tadtrad, 2018; Mainzer, 2018).
Electric cycling is supported by Europe policies. The cities proposing to hire e-bikes by simile system such as bicycles sharing system (e.c. MVGmeinRad). Another possible measure of Smart City solutions in bicycle system is ride monitoring, where throw the apps can riders see their trip (lenity, durative, start and end time), a map visualization of trips, select a data range for this etc. These apps are currently available not only for smart city solution. But in connection with smart velomobility are these apps apply for smart e-bikes (Malovrh, 2018).)
The Smart Biking platform was applied in Barcelona (Spain). The platform is focused on secure bicycle parking. Parking places include anti-theft system that consist of three anchoring points and anti-cutting materials with three different lock. There is possible to pay for service per year and maximum parking time allowed is 72 hours (Barcelona, 2018)
In Copenhagen was used the bike footrest. The city installed simple, inexpensive railings at intersections so that cyclists have a place to lean while waiting for the light to change. Taken together, all of these are smart behavioral nudges and minor adjustments that encourage more riders and good cycling behaviors (Artefactgroup, 2017).

14.8 Pedestrian Zone

In Barcelona was applied the Smart LED streetlamps activate only when movement is detected, producing 30% energy savings, and are equipped with sensors to collect data from the environment. Another solution there are municipal smart bins monitor waste levels and are cleared only when they are full, optimizing waste collection operations. Similar system is in Brussel where bins work on solar battery system. The capacity of the volume of 125 liters without compression is thus increased to 600 liters after the compression. Moreover, the waste bin is equipped with a computer system that warns the central office when it is full. Thus, the collection can be scheduled faster (Smartcity.breussels.be, 2016).
Another solution for pedestrian is system from Stockholm. The City of Stockholm's road safety program has set goals and policies for the City's commitment to safety in traffic. The goals that are directly related to pedestrian safety include managing the speed of motor vehicles, ensuring that main roads are safe, and enhancing standards of street management and maintenance. The pedestrian network should be navigable, visible and signposted in such a way that it is easy to understand where thoroughfares lead and the destinations along the route (Part of the mobility strategy, 2017).

14.9 Electro mobility and hydrogen mobility

In Warsaw is planned the new transport system by the year 2050. The results show that reaching the goals of reducing the emissions requires a depth transformation of the fields of transportation and power industry. This study also confirms that the smart-city solutions may play a key role in reducing the emissions from transport and reaching the established goals. In spite of the improvement in the electromobile technology, further progress is necessary, especially for lorries. Among the main challenges are energy storage, battery performance and charging speed. In the case of electric buses, the current technology only enables their use for short distances with frequent charging (Zawieska et al, 2018).
European objectives of decarbonisation and clean mobility in an urban environment. Hydrogen vehicles proposed by Scenario MobilitàH2IT do not release harmful pollutants and they may ensure a decrease in CO_2 emissions and clean and healthy air in cities. During the initial phase of the transitional period in 2020 – 2030, low-cost centralized production of hydrogen in existing Italian plants is proposed. After this phase, the H_2 production capacity should be increased by installing electrolysers in places with sources of renewable energy. The hydrogen mobility is important future solution such as show the example from Australia strategy – Hydrogen Mobility Australia. The biggest challenge for the electromobility and hydrogen mobility are missing infrastructure of charging stations, economy etc.

15 Conclusion

Smart city mobility is an important part, not only current status but also future development of critical infrastructure and also society. There are challenges where is necessary to start plan and to build the smart infrastructure. Also, there is neccessery to conscious, that new technologies and another smart measures have advatages and disadantages where is important to include the risk management system and preventive measures with the aim to ensure the safety and security mobility (Adamec et al. 2017; Adamec et al. 2016). It is big challenge that is important for future society with respect on environmental friendly transport, increasing traffic load, minimizing of health risk, increasing of effectivness of mobility etc.Smart measures for Brno where propose with considering of the experiences from the world and european cities.

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