City logistics: a case study from Minsk

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Abstract

Worldwide, there is a steady increase in urban populations. Urban agglomerations are currently developing. This brings with it greater demands on ensuring high-quality transport services and on building new traffic communication. The most serious problems for urban residents are caused by the high intensity of road traffic. Road transport brings with it negative consequences (noise, vibration, exhalation, pollution of the atmosphere, etc.), which brings further problems and the associated decrease in the quality of life of the population. City Logistics is a way to improve the traffic situation in urban and metropolitan areas.
Minsk is the capital, largest and industrial city of Belarus, located in the center of Belarus. Transport problems in Minsk are deteriorating the environment and lowering people's satisfaction and quality of life. Nowadays, there are about two million people living in Minsk, which brings with it many traffic complications. The aim of this article is to propose appropriate measures for the capital city of Belarus – Minsk based on an analysis of current approaches to city logistics.
KEY WORDS: *city logistics, mobility, bike sharing, hub and spoke, public transport*

1. Introduction

Nowadays, solving the problem of population satisfaction in modern cities is quite complicated, because the high growth of motorization and urbanization brings with it transport and environmental problems that are solved by city logistics [1]. Population is increasing every year in the cities and the number of different organizations and companies is also increasing with a higher urban population [2]. One of the problems of city logistics is, for example, insufficient parking areas. Today, because of the high use of individual car transport, parking areas are very busy, forcing cities to address the lack of additional car parking areas [3]. However, parking problems can occur not only in individual car transport, but also in cycling transport [4]. This problem may be influencing factor in determining population use some kind of transport.

Another problem is the more frequent traffic congestion, which negatively affects the mobility of the population within the city and the agglomeration as a whole [3]. Cities are also struggling with poor public transport organization. The authors perceive this problem, especially in poor utilization of transport systems [3]. Lines that are economically disadvantageous and misuse the fleet capacity of rush hour transport companies are problematic [3]. The authors see the main problems of transport companies in the poor organization of routes within large cities, which leads to unnecessary lengthening of public transport times [5].

Another problem is the state of the environment and the ecological situation in the cities. The increasing intensity of individual car traffic has a major impact on the deteriorating ecological situation in the cities [6]. Another problem of city logistics is the increasing number of traffic accidents. Some authors mention in addition to traffic accidents also explosions in factories and accidents associated with aviation (airports nearby cities) [7]. Use of freight transport in cities is increasing, which implies the need to optimize traffic flow in cities [8].

The problems of city logistics can be solved using various methods. According to the authors, these include, for example, improving the quality of transport and transport networks, creating distribution centers, optimizing traffic for cyclists, using integrated transport systems, optimizing the number of parking lots, applying Park and Ride systems, etc. [3, 9]

City logistics solves not only cities and agglomerations problems but also the flow of material and goods in the cities and whole agglomerations. There are two ways to optimize the flow of goods, which are “Gateways” and “Hub and Spoke” [10]. Hub and Spoke is a logistics technology that consists of collecting shipments in a special location and then transporting those shipments to recipients who deliver shipments to final consumers [11].

Modern cities need to address how to protect the environment, for example by building new cycle paths [12]. Integrated transport systems are starting to use large cities. Within the integrated transport system, there are links

between the different modes of transport, which allow seamless traceability between the different modes of transport and also the tariff is unified [13].

2. Theoretical background of city logistics

There are many definitions of city logistics. One of the latest versions of the city logistics definition is as follows: the city logistics is the summary of the processes within the city logistics system, in accordance with the needs of the population and the requirements of the environmental protection, taking into account the fact that the main objective is to meet the needs of the population [14].

Voženílek and Strakoš [15] states that: city logistics is the process of optimizing logistics and transport processes in the city with the participation of private companies and support for information systems. In logistics, transport carries material flow. City logistics involves the transport of goods and materials, the operation of an internal transport system, the operation of warehouses and the commercial network, the transport services of small and medium-sized enterprises and passenger transport [15]. Crainic [16] emphasizes the need for a systematic view of issues related to the movement of goods within an urban area, that is, a system characterized by optimized consolidation of the load of different carriers and shippers within the same vehicles and coordination of cargo and intra-city transportation activities. Pernica [17] understands city logistics as justifying the requirements in urban transport, taking into account environmental requirements and economic framework conditions.

The basic tasks of city logistics were formulated by Chernyak and Konyukhov [1]: connecting the city as a whole, improving and increasing the intensity of urban transport, using city logistics by all city organizations, reducing carbon dioxide emissions and improving the urban environment, enhancing city material flows, quality education, high level of health and the adoption of cultural leisure time by the population. Ajtbahin [18] introduces other tasks of city logistics, which are the right choice of place to build a warehouse in the city, improve transport infrastructure with less traffic congestion, and use more environmentally friendly vehicles in the city.

City logistics can achieve success according to Witkowski and Kiba-Janiak [2] when focusing on three areas: mobility, sustainability and viability. Mobility is based on finding a balance between sufficient transport capacities and reducing traffic [2]. Mobility plays an important role in determining traffic flows, choosing the right means of transport and places to store in the city [19]. Sustainability is about saving energy and protecting the environment [2]. Yiftachel and Hedgcock [20] add that sustainability must be based not only on environmental protection, but also on improving the complex planning of the entire agglomeration. Viability refers to the quality of life of the population (for example, health, peace and security) [2]. The aim of this article is to propose appropriate measures for the capital city of Belarus – Minsk based on an analysis of current approaches to city logistics.

3. The analysis of city logistics in Minsk

The issue of city logistics in Minsk was explain on the case study which is the method of the qualitative research based on the study of one or a small amount of situations for application of the findings for the similar cases according to Nielsen, Mitchell and Nørreklit [21]. The analysis was based on a review of available resources and interviews with experts in the field.

Problems encountered by the inhabitants of Minsk in everyday life are, for example, ecology and environmental problems. The majority of the population is dissatisfied with the existence of landfills and pollution of the atmosphere and water [22]. Vargasov [23] sees the problem in the wrong use of the tram because the depot is available for 130 trams, but the operation goes out every day, only 70 of them. Poor traffic lights at the main intersections in Minsk, according to Petrovich [24], cause huge traffic congestion and delays in public transport by more than 60 minutes. Traffic accidents at intersections are a frequent cause of traffic congestion [25]. As a crossroads, the author considers: intersection Romanovská Sloboda street / Niamiha street, Masherova street / Pobediteley street, Gvardeiskaya street / Pobediteley street, Zakcharov street / Plošča Pieramohi street, Červany street, circle intersection Vaneeva, circle intersection Pritytskogo [25].

Another problem for the inhabitants of Minsk and for bike path users is that there is no bike sharing service. Danilov [26] emphasized the problem of developing satellite cities without infrastructure. The Rudensk satellite city should be a full-fledged city to transport to the capital, Minsk. Danilov [26] confirms the problem that satellite city residents do not use public transport services but use individual car traffic, causing additional traffic congestion problems. In a satellite city like Rudensk, where a new housing estate is located on the outskirts of the city, ongoing construction work is underway, says Zhuravlevich [27]. Infrastructure is not yet sufficiently built up and residents are forced to use unpaved roads, which is especially unpleasant in bad weather.

Nagepetyan [28] presents another problem that concerns the organization of waste collection from housing estates. In Minsk, according to the author, more than 1,000 containers for sorted waste were placed, but they are not comfortable for the use of residents and municipal waste collection services do not bind waste in time, which forces residents to leave waste next to containers. There are few bicycle parking spaces in Minsk; it is another problem of city logistics in Minsk. Currently in Minsk, a B+R car park is located near the metro station Uračča, Malinaúka and Kamennaja horka [29].

The analysis showed that the people of Minsk face the following problems in their daily lives: bad environmental condition in Minsk, lack of parking for bicycles, outdated way in bike rental organization, poor mobility of the

population and state of transport infrastructure of satellite city Rudensk.

4. Results and discussion

City logistics proposals will be based on the analysis results. The biggest problems in city logistics in Minsk are: bad environmental condition in Minsk, lack of parking for bicycles, outdated way in bike rental organization, poor mobility of the population and state of transport infrastructure of satellite city Rudensk.

The inhabitants of Minsk are dissatisfied with the state of the environment. Every day a huge number of cars are moving in Minsk, and the problem of frequent traffic congestion in the city is growing. From the analysis of the current situation, it was concluded that in Minsk all the car parks in the city center are free of charge. To reach the goal of making people more use of public transport, it is necessary to charge all the car parks located in the city center. Thereafter, the use of public transport will increase and will contribute to improving the city's environment. The health of the population will also improve, leading to a higher quality of life.

Another proposal to improve the environment in Minsk will be to use more environmentally friendly means of transport, both in public transport and in individual car transport. There are currently two electric buses in Minsk, which is absolutely negligible in the context of the whole city. In order to improve the urban environment and improve the quality of life of the inhabitants, Minsktrans must increase the number of operated electric buses. The design is based on the use of electric buses on the main classes in Minsk, which are most affected by emissions. On some roads, the amount of emissions exceeds 1000 tonnes per year. These are the following roads: Pushkina, Pobediteley, Partizanskiy, Derzhinskogo and Nezavisimosti and Bagdanovicha, Pritytskogo and Mayakovskogo.

The electric buses should also be used on today's trolleybus line 53, which connects the Derzhinskogo class and Bagdanovicha street, on trolleybus line number 10, which passes through the Pushkina and Derzhinskogo class, on the bus line 100 passing Mayakovskogo street and the Nezavisimosti class and on the trolleybus line the number 34 stopping on Partizanksy Avenue and Bagdanovich Street. Furthermore, the electric buses should be used on Partizanskiy and Nezavisimosti, where line 1 goes and on Pritytskogo, line 13.

Another option to reduce city emissions is by electric cars. From the analysis it can be stated that today there are only six charging stations in Minsk, which does not fit the current situation, and the lack of infrastructure attracts people to buy an electric car. The solution to this problem will be to increase the promotion of electric vehicles and to build additional charging stations. The charging station could be placed in a housing estate in Minsk, where residents will be able to charge their car, for example, upon arrival from work. P + R parking is another convenient location for charging stations.

Trams are one of the favorite modes of transport in Minsk, and above all, it is an environmentally friendly means of transport. The problem is that the Minsktrans transport company does not make sufficient use of the entire tram fleet. The solution to this problem is to use the fleet capacity in the rush hour to reduce the interval between connections. Increasing the capacity of trams will also contribute to improving the traffic situation and it will be possible to reduce the number of buses in public transport. For residents, tram is the best way to get to the city center or to the nearest metro station such as Sierabranka, Zialiony luh, Trakratny or Staravilienski. Other modes of public transport are not able to get to the city center as quickly as a tram, which uses its own transport infrastructure and is also an environmentally friendly means of transport that does not contribute to the creation of emissions in the city center.

Waste collection has a significant impact on the state of the environment in Minsk. Nowadays there are many modern smart technologies for collecting, sorting and collecting waste that do not harm the environment. It is important that the people of Minsk begin to understand the need for waste sorting, and what environmental impacts have poor waste management. The problem of waste collection in Minsk is that municipal services do not collect waste on time. Problems relate to the center of Minsk, but also to adjacent housing estates. Communal services are not able to estimate the time at which waste needs to be exported and it often happens that bins and baskets are overcrowded.

The best option in the center of Minsk will be the installation of smart garbage bins, which use the information system to show the amount of waste in them. The Smart Basket works with solar panels that also contribute to environmental protection. A stylish and modern waste bin not only saves the environment, reduces the cost of communal services to waste collecting unnecessarily in the city, reduces traffic congestion, reduces access to rodents and other animals, but also decorates Minsk with its beautiful design.

Cycling is developed in Minsk, but the infrastructure includes only modern cycling routes and there is no parking space for bicycles. Parking tents or cycloboxes are limited and often so crowded. Building sites where residents will be able to safely park their bikes will reduce the number of people using cars, and this will also contribute to a better urban environment, so new cycloboxes or bicycle tents must be built.

The solution to this problem is also in continuing the construction of the B+R car parks. Good places to build these car parks, for example, are the final subway station Mahilioúskaja where people can go to their home by bike. Furthermore, at Niamiha Metro Station, as the main cycle path passes by this subway station. Other suitable metro stations in Minsk are Uručča, Mahilioúskaja, Kamennaya Gorka and Malinaúka. Additional parking spaces could be placed at Minsk-Pasažyrski's main railway station, where the residents of other cities arrive by train, and could continue cycling on their way through Minsk. Such a solution would be appropriate for those who, for example, commute to work or school every day. Another option where B+R car parks could be located are the Minsk train stops such as Minsk-Paŭnočny, Minsk-Uschodni, Lošica, Masiukoŭščyna, Kurasoŭščyna and Karbyšava, Paŭdniova-Zachadu and Zachad bus stations. These bus stations were chosen because there are bike paths nearby.

Business centers are another place to build bicycle infrastructure. It is not necessary to build a B+R car park, just place modern bike racks or cycloboxes in front of the entrance that are safer than normal racks, for example in the center of Minsk, at the Plošča Lieninaje metro station, where residents like to spend their free time. There are five shopping centers, restaurants, cinemas, a park and an entertainment center.

Nowadays, bike sharing is very popular and the people of the cities where this service is provided are very satisfied, especially because people don't have to worry about their own bike and can return it anywhere, anytime. However, such a service is not offered throughout Belarus. The analysis showed that there are bike rentals in Minsk, but it is necessary to present a passport and carry cash when borrowing. The rented bicycle must be returned at a specific time and in the same place where it was borrowed. This way of renting bikes is not suitable for tourists or for residents of Minsk. It does not give you the option to freely set the length of a bicycle rental and the rental customer must constantly watch the time to return the bike within the deadline.

The solution to this problem is to create a bike sharing service. This service will provide free of charge or a small fee for the residents of Minsk and also for tourists. Bike sharing is a good alternative to public transport, and especially to cars. Developing bike sharing will help reduce CO_2 emissions, improve city traffic and improve the quality of life of the population.

Bike sharing rental stations can be located along the main bike path, next to metro stations, both in the city center and on the outskirts of the city, close to public transport stops, the main railway station and close to Minsk's parks. Suggested stations in the city center are: Niamiha, Kastryčnickaja / Kupalauskaja, Pieramohi Platform and Čaluskincau Park. On the outskirts of the city there are the stations: Uručča, Kamennaya Gorka, Piatroúščyna and Mahilioúskaja.

A good place to place a bike sharing rental station is the main railway station and the central bus station, as these are places with a high concentration of people and are also the gateways of tourists to Minsk. Bike sharing service is offered to tourists in many countries of the world and is known to them. They will be able to experience and travel in an environmentally friendly way. Another suitable place for new bike sharing stations is in the parks: Losycki Park, Pieramozcaŭ Park and Druzhba Narodaŭ Park.

Furthermore, it would be advisable to deploy stations at tourist sites of interest in the city center. The following stations are proposed in the center: Niamiha, Kastryčnickaja / Kupalauskaja, Pieramohi Platform and Čaluskincau Park. Near these stations, tourists will find many attractions such as the Holy Trinity Church, Independence Square, Belarusian State Circus, Victory Square, Kolas Yakubovo Square and the National Library. Also nearby are Gorky Central Children's Park, Čaluskincau Park and Central Botanical Garden of the National Academy of Sciences of Belarus.

In Minsk, people experience traffic congestion daily. Waiting in a vehicle worsens people's mood, tears them and consequently reduces their quality of life. Information boards are available as a solution to the problem, informing car drivers about the situation at the nearest intersection. These boards will provide drivers with the necessary, and most importantly up-to-date information about the traffic situation at the next intersection or adjacent area, so that drivers will be able to respond in a timely manner to traffic conditions and avoid traffic congestion by, for example, using other traffic for their journey. Another advantage of the information system is that traffic congestion will not increase as cars split into multiple roads, thereby reducing the likelihood of accidents and reducing CO_2 emissions from cars in the column. Installing whiteboards would be useful at problem intersections: Romanovská Sloboda street / Niamiha street, Masherova street / Pobediteley street, Gvardeiskaya street / Pobediteley street, Zakcharov street / Plošča Pieramohi street, Červany street, circle intersection Vaneeva, circle intersection Prityts kogo.

A smart traffic light is another way to tackle traffic congestion. The new advanced technology of smart traffic lights ensures traffic management and reduces traffic congestion. Smart traffic lights can also be used to check compliance with traffic rules. The smart traffic light will provide increased crossroads. Based on sensor sensing, the central server instructs the dispatcher to turn on the red or green traffic light to minimize the time spent at the intersections. For example, if traffic congestion is generated in one of the directions, the interval with green light is extended.

Other ways to increase the mobility of the population of Minsk are also possible, for example by installing information boards for public transport passengers. The boards will be deployed at bus, trolleybus and tram stops. Information boards will show which means of transport and how long they will arrive and will also report any delays. The board will consist of two parts, where the map will be displayed on the second part. On the map, passengers will find information about the location of the line.

Another option is a smart stop that has a touch screen installed. Through the touch screen, passengers will be able to search for a connection or look at the list of stops through which the link travels. The location of such stops would be convenient in the center of Minsk, where foreign tourists are located.

The traffic situation in the satellite city of Rudensk is not good and for this reason the inhabitants are not interested in buying houses in this locality. The proposal to solve this problem is to provide public transport for commute to the railway station from this satellite city, where passengers will be allowed to switch to train services. The access road to the train station is not built in the satellite town of Rudensk and the residents are forced to walk through the unpaved road. For this reason, the inhabitants of the satellite city mainly use their cars for transport, which does not contribute to the already poor transport and environmental situation in the center of Minsk. New residential blocks, especially multi-storey buildings, a shopping center, parks, recreational areas, major and minor roads and public networks should be built in Rudenska.

The proposal to improve the transport infrastructure consists in the implementation of a bus line whose connections will be linked to trains to Minsk. The bus line will start at the new housing estate in Rudensk and continue to the railway station. This line will make it easier for residents who now have to use individual car traffic or have to walk to the railway station. Furthermore, in the design, the green paths show cycle paths that will enable residents to commute to the railway station by bicycle, thereby contributing to environmental protection. Building cycle paths is in line with the city logistics concept and supports the idea of improving the environment. The bike paths are designed in two routes, the first of which runs through the center of the village and will also be used for city dwelling trips, for example to drive to the shop or to the doctor, and the second to the first-class road where the bike path will be on the road separately. A B+R car park will be built near the railway station.

5. Conclusions

The aim of this article was to propose appropriate measures for the capital city of Belarus – Minsk based on an analysis of current approaches to city logistics. Suggestions for solving city logistics problems in Minsk were based on theoretical basis and examples of approaches to city logistics abroad. The improvement of the environment in Minsk can be achieved by using electric buses and electric vehicles, by developing cycling and by optimizing the collection of waste from housing estates and the city center.

Another approach of the city logistics to solve traffic problems is the realization of specific car parks (for example park and ride systems). These car parks are used all over the world and reduce the intensity of traffic in the city, and this is also related to the decline in traffic accidents and the reduction of negative environmental impacts. Problems with the lack of parking spaces in cities are addressed by Smart City elements within the city logistics. Smart parking brings many benefits and improves the quality of life of the population. The development of cycling is another possible solution to the problems of city logistics.

The creation of bike sharing services in Minsk will bring many benefits for both the city's residents and tourists. Bike sharing will provide a modern and convenient way to rent bicycles, and cycling, as a more friendly way of transport, will contribute to improving the air and environment as a whole in the city.

Population mobility is an important factor in city logistics. Mobility in Minsk could be solved by smart city tools, by installing smart traffic lights and signboards to provide drivers some information about the current traffic situation at the next intersection, which will increase traffic flow and reduce traffic congestion. In the area of public transport, for example, smart stops can be introduced in Minsk. All presented designs address the area of city logistics and meet its goals.

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