CITY LOGISTICS - SUSTAINABLE URBAN MOBILITY

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Abstract

Problems related to congestion, pollutants emitted by road transport and decreased road safety are increasingly grave issues of present-day cities. To address these problems, literature and strategic EU documents propose measures aimed at an implementation of sustainable urban mobility. These measures need to be based on the new urban mobility culture context. A concurrent proposal includes measures related to broadly interpreted city logistics. The purpose of the present article is to develop guidelines for the formulation of an urban logistics system in the aspect of sustainable urban mobility. The system proposed constitutes a combination of the two aforementioned areas, which can be used to address transport issues in urban areas.

Keywords: City logistics, sustainable urban mobility, system

1. INTRODUCTION

City logistics as a town's management conception constitutes the whole of activities and processes related to the management of the flows of people, cargo and information inside an urban logistics system [8, 11]. The superior objective of the conception presented herein is to satisfy those needs that are the result of the activity of the users of urban areas, which are manifested in the need to travel, the effect being travels in towns.

In the European Union, over 60 per cent of the population live in urban areas; therefore, travels realized in these areas constitute a great challenge to urban logistics. In order to limit the negative social, environmental and economic impacts generated by urban travels, the European Union presented in the year 2007 a proposal of a new urban mobility culture [6]. An action plan for urban mobility [1] and an urban mobility package constitute [9] an extension of this proposal. Sustainable urban mobility is the common indicator of the proposals presented.

It was accepted in the article that sustainable urban mobility is such communicational behaviours of the users of urban areas that are formed by town's spatial planning and an availability of the urban transport system, where the length and numbers of travels are rationalized, individual car transport does not degrade public transport or non-motorised transport, while the functioning of the urban transport systems allows one to maintain harmony with the urban environment [10].

The purpose of the present article is to develop guidelines for the formulation of an urban logistics system in the aspect of sustainable urban mobility.

2. SIGNIFICANCE OF CITY LOGISTICS IN EU STRATEGIC DOCUMENTS

In the twenty first century, urban logistics continues one of the primary challenges for the EU. A reduction of road traffic in urban areas, which is responsible for congestion and a continuous increase of the amounts of pollution in the environment in the form of solid, liquid and gaseous substances, requires long-term solutions oriented onto the formation of urban mobility.

In view of the above, the European Union has introduced the CIVITAS initiative, which is probably the best known tool that is to offer aid to European cities in the implementation of sustainable urban transport strategies.

It has also undertaken activities aimed at a development of guidelines for a new interpretation of urban mobility through the realization of joint measures in relation to innovative solutions oriented onto urban transport. These guidelines were presented in the year 2007 in the Green Paper entitled: „Towards a new culture for urban mobility" [6]. It is emphasized in the document that urban mobility should facilitate an economic development of cities, to ensure adequate living standards for the residents, and to lead to a reduced pollution of the natural environment and an increased safety of road users. It was accepted that mobility has an influence on a sustainable development of cities and it is justifiable to analyse mobility in social, environmental and economic aspects. While taking the above interpretation into consideration, it was indicated in the document that measures undertaken in relation to urban mobility need to be integrated and realized under five challenges referred to, i.e.: improve fluidity in towns, reduce pollution, intelligent urban transport, accessible urban transport, safe and secure urban transport.

In the year 2009, another document was formulated: „Action Plan on Urban Mobility" [1]. An integral part of the plan is the programme of actions to support mobility in towns under sustainable development rules. When analysing the measures introduced under the action plan, it is true to state that a creation of urban mobility constitutes a system approach that combines at the same time actions in the area of infrastructure, means of transport, management in the areas of knowledge, partnership, education, trainings, raising awareness, influence on changes in mentality and formation of communicative behaviours.

The issues of mobility were also emphasized in the White Paper from the year 2011 [12]. It was observed that mobility is of a great importance to the internal market and the quality of citizens' lives. In the context of the initiatives that are covered by the Paper, the Future Initiative is noteworthy; its objectives include promotion of behaviours in line with the sustainable development principle and integrated urban mobility.

An opinion has also been published entitled „Urban Mobility Package" [9]. Through this package, local authorities are encouraged to undertake more comprehensive activities in relation to the formation of mobility in urban areas. The structure of this Package is to follow this objective and it covers primary priorities, i.e. availability of urban areas to individual vehicle types, urban logistics, intelligent urban transport systems and road safety in towns [9]. Plans concerning urban mobility in compliance with sustainable development principles are to constitute an element that integrates the individual issues.

An evolution of the EU approach to the issues of the formation of urban mobility is presented in **Fig. 1**.

3. GUIDELINES FOR THE DEVELOPMENT OF A CITY LOGISTICS SYSTEM IN THE ASPECT OF SUSTAINABLE URBAN MOBILITY

The city logistics system is a service system for users, institutions and companies that pursue their objectives in urban areas. It is important that the system formulated in this manner realizes objectives in line with the sustainable development idea. For the needs of the research, the system analysed was narrowed down to passenger transport.

The primary resources of a system interpreted in this way basically cover its three elements, i.e. an assessment of transport needs in an urban area, an urban transport system and organization of travels in an urban area.

3.1. Assessment of transport needs in urban area

Transport needs in an urban area can be determined based on the volume of the effective and potential demand. The effective demand is determined based on the number of passengers that travel using public transport over a specific period of time. An assessment of the demand can be carried out if we have at our disposal data on the effective demand in the area of the communications network, the individual territorial units, days of the week (weekdays, Saturday, Sunday) and the individual routes that are available in a given urban area [7].

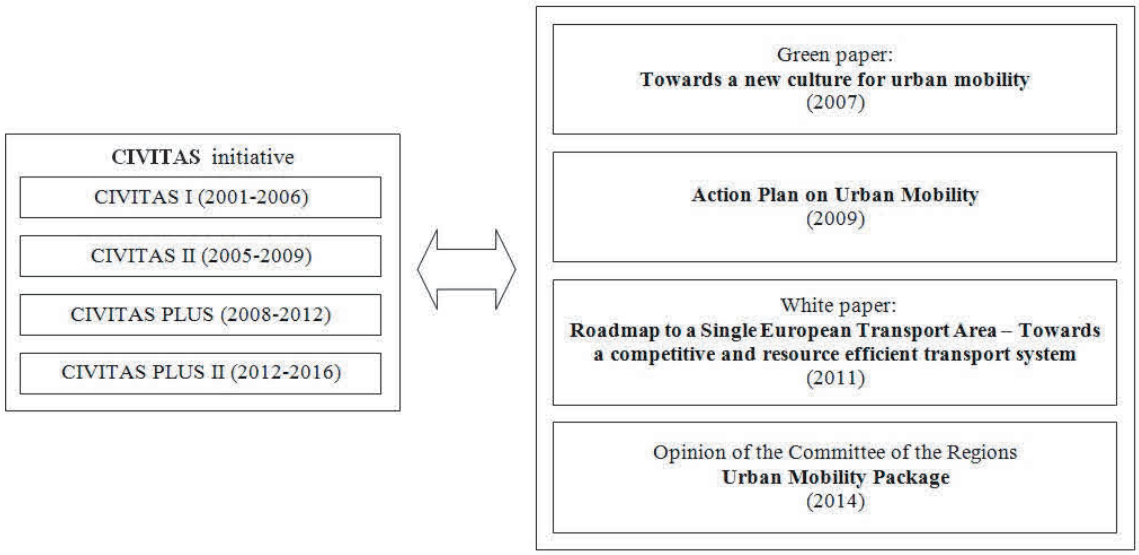

Fig. 1 European activities for urban mobility

The potential transport takes into account those travels that are realized with those means of transport that are different from public ones as well as those transport needs that are not realized for various reasons. An assessment of the potential demand is significantly more difficult and it is burdened with a high error risk as it is based on declarations from respondents that are related to their possible communicational behaviours, which may differ substantially from real behaviours. The data from surveys needs to be supplemented with information obtained from traffic analyses carried out in an urban area.

For the needs of the analyses of the city logistics system in the aspect of sustainable urban mobility, an assessment of transport needs in an urban areas includes the following components cf. (**Fig. 2**): the volume and distribution of the demand in relation to travels in an urban area, the demand for urban transport subsystems, traffic flows related to the elements of the urban transport network.

The volume and distribution of the demand in an urban area presents the number of travels that are generated or absorbed by a given area. When identifying the distribution of the demand in an urban area, we need to make references to travel motivation. What makes someone take certain activities or decisions in relation to a travel is travel motivations that constitute a particularly important factor that has an influence on mobility. In this context, travel motivation is the determination of the purpose of the travel with the aid of needs (e.g. home, work, study, shopping, entertainment etc.) and not in a spatial aspect.

A demand for the individual urban transport subsystems follows from the realization of travels for specific motivations and in the configurations of travel chains. The system is a complex object where, depending on the criterion accepted, a number of characteristic subsystems can be distinguished. In the research, two criteria were accepted, i.e. the way in which one travels and what type of the means of transport they use. Considering the criterion of the way in which one travels, we identify the subsystem of travels on foot and the subsystem of travels by the means of transport. As regards the other criterion, we define the individual transport subsystem, the group transport subsystem, the public transport subsystem and other subsystems (Park and Ride, Bike and Ride, carpooling, carsharing).

Traffic flows on the elements of the urban transport network reflect the volume and distribution of the demand for travels and of the demand for transport subsystems. The users of urbanized areas take various decisions in relation to travels realized in the everyday life cycle. A measurable effect of the decisions made is integrated traffic flows on the elements of the urban transport network that include pedestrians and the means of transport that carry people.

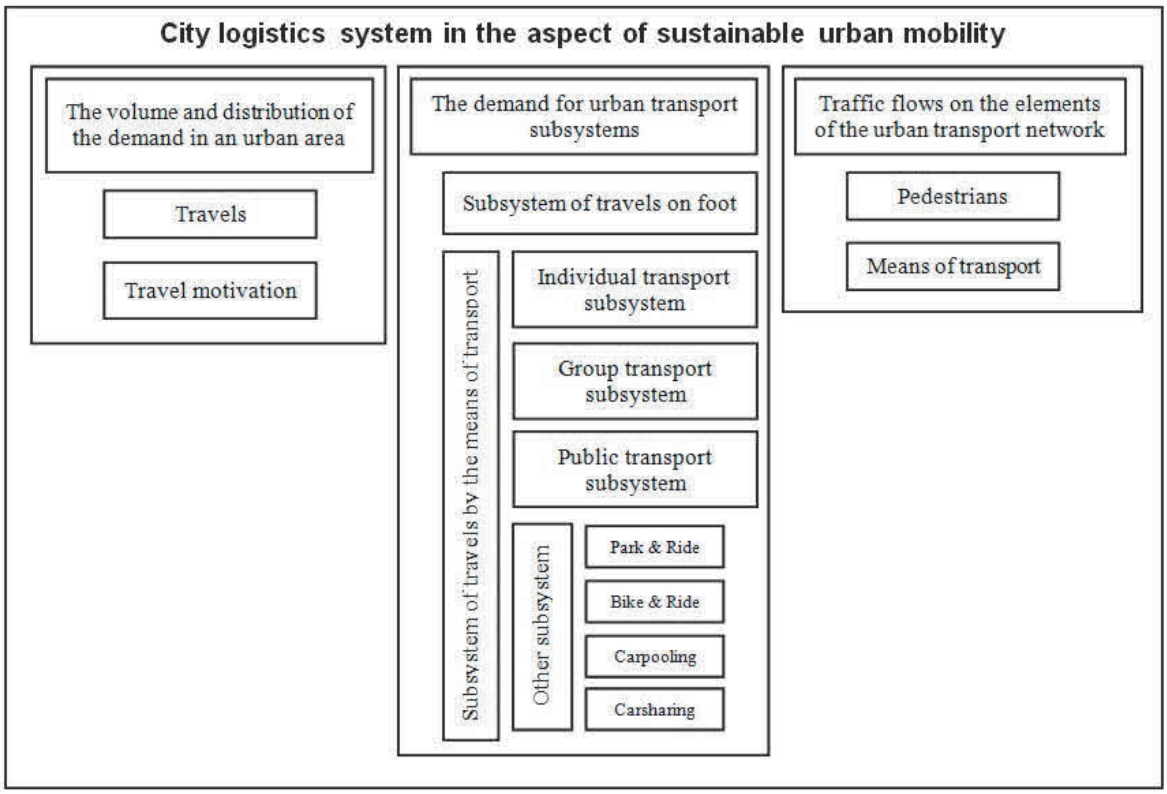

Fig. 2 Components of an assessment of transport demands in urban areas

3.2. Urban transport system

The urban transport system is a compound object where R transport subsystems can be distinguished. The set $\boldsymbol{R}$ of the numbers of transport subsystems is a set in the following form:

$$\boldsymbol{R} = \{r\colon\ r = 1, 2, \dots, r', \dots, R\} \tag{1}$$

where: r - the number of the transport subsystem, R - the number of transport subsystems in urban areas.

We accept that the structure of each r-th transport subsystem can be presented in the form of a graph $\boldsymbol{G}^r$, i.e.:

$$\boldsymbol{G}^r = \langle \boldsymbol{Z}^r, \boldsymbol{LM}^r \rangle,\ r \in \boldsymbol{R} \tag{2}$$

where: $\boldsymbol{Z}^r$ - the set of the numbers of the intermediate points of r-th transport subsystem:

$$\boldsymbol{Z}^r = \{z^r\colon\ z^r = 1, 2, \dots, z'^r, \dots, Z^r\},\ r \in \boldsymbol{R} \tag{3}$$

$\boldsymbol{LM}^r$ - the set of transport connections between the intermediate points from the set of $\boldsymbol{Z}^r$:

$$\boldsymbol{LM}^r = \{(z^r, z'^r)\colon\ z^r \neq z'^r\} \tag{4}$$

3.3. Organization of travels in an urban area

The organization in the city logistics system presents connections between the elements of the system and the quantity of the transport needs realized. For the established transport demand and supply, an organization is a division of the needs into the elements of the system. The division of the needs in the city logistics system determined the manner of the use of the transport offer of urban areas for the realization of trips in a given relation (p, k).

The set $\boldsymbol{PR}$ of relation of the trips is a set in the following form:

$$\boldsymbol{PR} = \{(p,k)\colon (p,k) \in \boldsymbol{P} \times \boldsymbol{K}\} \tag{5}$$

The relation of the trip determines where from and where to the town user will be travelling, while it does not result from it in what way he/she will realize the trip, e.g. what ways they will travel and what means of transport they will use. Therefore, the objective of organization in a city logistics system is to define the methods of trips for a given relation, of course when given conditions and limitations are met. We accept that for each trip relation $(p,k) \in \boldsymbol{PR}$, there exists a possibility to realize at least one trip. A trip is defined as the chain of relocations, and every relocation is a stage in the trip. The trip formulated in this manner can be presented in the form of a way, where each of its segments represents the individual stages of the trip connected with the relocation method.

We assume that a walking trip in the relation $(p,k) \in \boldsymbol{PR}$ is a way in the form:

$$d(p,k) = \langle (p,k) \rangle \tag{6}$$

where the beginning of the way is in the point $p, (p \in \boldsymbol{P})$, and the end is in the point $k, (k \in \boldsymbol{K})$, $p \neq k$. The way includes only one segment (trip stage).

A non-walking trip in the relation $(p,k) \in \boldsymbol{PR}$ realized with the use of one transport subsystem is a way in the form:

$$d(p,k) = \langle (p,z^r), (z^r, z'^r), (z'^r, k) \rangle \tag{7}$$

where the beginning of the way is in the point $p, (p \in \boldsymbol{P})$, and the end is in the point $k, (k \in \boldsymbol{K})$, $p \neq k$, and the points $z^r \neq z'^r \in \boldsymbol{Z}$ are intermediate points. The way defined in this manner includes three stages, i.e. the first $(p,z^r), p \neq z^r$ and third $(z'^r, k), z'^r \neq k$ stages are walking relocations, and the second $(z^r, z'^r), z^r \neq z'^r$ stage is relocation with any means of transport from one transport subsystem (e.g. by car, by tram etc.).

A non-walking trip in the relation $(p,k) \in \boldsymbol{PR}$ realized with the use of two transport subsystems is a way in the form:

$$d(p,k) = \langle (p,z^r), (z^r, z'^r), (z'^r, z^{r\prime}), (z^{r\prime}, z'^{r\prime}), (z'^{r\prime}, k) \rangle \tag{8}$$

where the beginning of the way is in the point $p, (p \in \boldsymbol{P})$, and the end is in the point $k, (k \in \boldsymbol{K})$, $p \neq k$, and the points $z^r, z'^r, z^{r\prime}, z'^{r\prime} \in \boldsymbol{Z}$ are intermediate points. The way includes five stages i.e. the first $(p,z^r), p \neq z^r$, third $(z'^r, z^{r\prime}), z'^r \neq z^{r\prime}$ and fifth stages $(z'^{r\prime}, k), z'^{r\prime} \neq k$ are walking relocation, the second stage $(z^r, z'^r), z^r \neq z'^r$ is relocation with the a means of transport from the first transport subsystem (e.g. by car) and the fourth stage $(z^{r\prime}, z'^{r\prime}), z^{r\prime} \neq z'^{r\prime}$ is relocation with the means of transport from the second transport subsystem (e.g. by underground).

Taking the above into consideration, we accept that we define the way that is a representation of a trip in the relation (p,k) in the mobility system as a finished series of transport connections:

$$d(p,k) = \langle (p,z^r), (z^r, \dots), \dots, (\dots, z'^r), (z'^r, z^{r\prime}), (z^{r\prime}, \dots), (\dots, z'^{r\prime}), (z'^{r\prime}, k) \rangle \tag{9}$$

In a given trip relation (p,k), many trips (ways) can be determined. The set of the numbers of all the trips in the relation (p,k) can be described as:

$$\boldsymbol{H}(p,k) = \{h\colon \exists d(h(p,k)), h = 1, \dots, H(p,k)\} \tag{10}$$

where: $\boldsymbol{H}(p,k)$ - the set of numbers trips in the relation (p,k), h - the current trip number, H - the number of elements in the set $\boldsymbol{H}(p,k)$.

Taking into consideration the assumption that the point k is achieved from the point p the condition below can be formulated:

$$\forall(p,k) \in \boldsymbol{PR} \quad \boldsymbol{H}(p,k) \neq \emptyset \tag{11}$$

The set of all the trips in the mobility system is a set in the form:

$$\boldsymbol{H} = \cup_{(p,k)\in \boldsymbol{PR}} \boldsymbol{H}(p,k) \tag{12}$$

4. CONCLUSIONS

Various issues in the area of city logistics pose a substantial challenge to the functioning and development of urban areas. These may include purposes related to a limitation of negative social, environmental and economic impacts that are generated on the stage of the realization of transport needs. The realization of these goals is possible by undertaking activities aimed at the formation of urban mobility.

The system proposed in the present study of city logistics in the aspect of sustainable urban mobility constitutes an offer of a system approach to the issue of city logistics and sustainable urban mobility. A combination of these two areas will make it possible to carry out studies aimed at a limitation of a negative impact of travels realized in urban areas. This will be reflected by a limitation of the congestion phenomenon, a reduction of the numbers of travels realized with cars, increased numbers of travels realized with the means of public transport etc. The author presents an extended interpretation of the issues referred to in the present study in other studies [2, 3, 4, 5].

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