Archives of
Transport System Telematics

Volume 12

Issue 1

February 2019

Utilization of Portable Traffic Detectors as the Support for the Data Collection Process in City Logistics Systems

K. KIJEWSKA, S. IWAN
MARITIME UNIVERSITY OF SZCZECIN, Pobożnego 11, 70-507 Szczecin, Poland
EMAIL: k.kijewska@am.szczecin.pl

ABSTRACT

One of the most important problem in the analysis of city logistics systems is data collection. The solution, which could support this process is utilization of independent, easy to use devices. The paper is focused on the example of utilization the portable road traffic detectors. These devices are easy to use tools, which can help to collect traffic data including the vehicles classification. The Authors will introduce an example of practical utilization of this kind of device, Sierzega SR4, as well as the advantages related to that.

KEYWORDS: data acquisition, traffic detection, portable detectors, city logistics, urban freight transport, vehicles classification

1. Introduction

Due to the cities growth rate combined with the increasing needs of their inhabitants, issues connected with freight transport operations within urban areas become more and more important. This results from, among other things [1]:

- the growing significance of total transport costs of goods and logistics and their direct impact on city budgets;
- the role UFT plays for the industry and commerce sectors which are the main sources of income;
- the fact that UFT itself provides a considerable number of jobs;
- its contribution to raising the industry competitiveness in any given region;
- the fact that it is necessary to sustain the life style and comfort that people have become used to;
- its negative impact on the natural and social environment.

Delivering goods in urban areas becomes particularly important in view of the development of information societies and the dominating role of the knowledge-based economies that apply digitisation and network technologies. The ubiquitous presence of the internet on the one hand contributes to improving the communication and data transfer effectiveness, consequently affecting the quality of transport organisation, and on the other hand it becomes a catalyst of market changes, implicating an increased demand for transport as a result of e-commerce growth [2]. Therefore, more and more deliveries of goods are made directly to individual customers, which in consequence generates considerable difficulties regarding the delivery process, e.g. efficient use of cargo space, reducing the fleet operation costs or ensuring quick deliveries.

In view of the above, application of telematics solutions to support urban freight transport has become an urgent necessity. Urban logistics is aimed at comprehensive optimisation of this kind of transport, while taking into account the costs and benefits for both the society and the private sector [3]. Given that the realities are becoming more and more complex, it is practically impossible to implement this proposal. The ever increasing transport congestion effect observed in cities leads to considerable hindrances in carrying out any transport tasks, and the aspects of negative environmental impact of urban transport and its adverse effect on the urban environment and in particular its inhabitants, put an extra emphasis on the importance of that issue. It is also important to note that freight transport within a city is considerably different in terms or functioning and organisation from transport taking place outside built-up areas. More often than not, urban freight transport requires more complex planning, supervision and application of sometimes very advanced optimisation methods. Due to that, effectiveness of this system depends largely on the proper data and information flows and knowledge acquisition allowing for effective management of processes occurring in this system.

2. Data acquisition in Urban Freight Transport Systems

In recent years, the use of intelligent transport systems to support freight management is becoming increasingly important both in terms of theoretical as well as practical examples [4]. The need to support the transport and distribution of goods in urban areas with telematics solutions results mainly from the complexity of these processes and different expectations of the stakeholders in UFT. However, in order for these systems to operate effectively, it is necessary to provide adequate data resources on the transport, which would form the basis for their control, optimization and management of various processes in UFT. However, providing these data resources faces considerable difficulties. Major obstacle to its effective management and implementation of intelligent transport systems is the difficulty in data acquisition.

Identification of data sources should take into account the following criteria [5]:

- the availability of data:
  - the ability to collect - not all of the necessary data are collected;
  - availability - not all of the data that are collected are available; this particularly applies to data held by private companies;
  - universality - there is often a lack of information about data that have already been collected;
  - the way of utilization - available data are not always used in the right way;
  - interpretation - data can be interpreted in the wrong way, usually there are problems with their accuracy and comparability;
- data quality:
  - accuracy – it is of particular importance in the case of small differences in the results or when the analysis covers value changes over time; it must be able to properly reflect the trends;
  - comparability - differences may occur in the process of defining, grouping and presenting data;
  - complexity - data do not have to reflect all aspects of the analysed system; it is necessary to collect a wide range of data associated closely with the analysed part of the system, specified as a key factor for its effectiveness;
  - timeliness – data should be up to date to reflect current changes.

In the area of UFT, data can be classified according to three basic criteria [5]:

- variability: static (fixed) and dynamic (variable);
- reliability: deterministic (certain), probabilistic (random) and diffused (ambiguous);
- sources from: public sector (road and area administrators) and private sector (carriers or customers).

The major problems in obtaining data within the urban freight system is not the identification of data sources but availability of them. It results from two key facts [6]:

- urban deliveries involve mainly private companies, which usually do not want to share data on their transactions, supplies and transported goods with their competitors and the public sector (it is, of course, observed not only in the case of transport within cities, but also in interurban, national, or international transport);
- there are no standardized research methods in the field of urban freight deliveries.

3. General classification of road traffic counting methods

The solution to solve problems mentioned above is independent road traffic counting, which will help to identify the number and categories of the vehicles in taken point in a time. This measurement could be realized on the basis of two major approach – manual counting and utilization of telematics tools (like traffic detectors).

The first one is the simplest but accurate way. However, the manual counting is directly related to the human perception and due to that it's human-barriers' sensitive system. Moreover, it's impossible to calculate the speed of the vehicles. Also this approach is inefficient in the case of high traffic. Finally, it possible to identify two major types of errors in manual road traffic analysis [7]:

- counting errors – can be defined as the difference between the number of vehicles counted and the true number of vehicles in the same time interval;
- classification errors – can be defined as the number of vehicles which have been classified in wrong classes.

A solution, which does not address all of the difficulties in the respect above, is the use of telematics technologies based on traffic detection and classification of vehicles. These systems allow for making measurements, which are non or less intrusive, undetectable for drivers and independent of freight companies. It is possible to divide telematics-based road traffic detectors into few categories [11]:

- video vehicle detection – Systems are now available that will automatically analyse the video pictures as cars are passing underneath, detecting cars with a similar accuracy to that of people watching the video;
- pneumatic road tube counting – This has for many years been a popular method of vehicle sensing. Here one or more rubber hoses are stretched across the road and connected at one end

to a data logger. The other end of the tube is sealed. When a pair of wheels hits the tube, air pressure in the squashed tube activates the data logger which records the time of the event;

- piezoelectric sensor – Piezoelectric sensors collect data by converting mechanical energy into electrical energy. The piezoelectric sensor is mounted in a groove cut into road's surface. When a car drives over the piezoelectric sensor, it squeezes it and causes an electric potential - a voltage signal. The size of the signal is proportional to the degree of deformation. When the car moves off, the voltage reverses.
- inductive loop – An inductive loop is a square of wire embedded into or under the road. The loop utilizes the principle that a magnetic field introduced near an electrical conductor causes an electrical current to be induced. In the case of traffic monitoring, a large metal vehicle acts as the magnetic field and the inductive loop as the electrical conductor. A device at the roadside records the signals generated.
- magnetic sensor – This detects vehicles by measuring the change in the earth's magnetic field as the vehicles pass over the detector. The sensor is either buried in the road, or enclosed in a box by the side of the road.
- acoustic detector – This detects vehicles by the sound created as the vehicle passes. The sensor is mounted on a pole pointing down towards the traffic. It can collect counts for one or more travel lanes.
- passive infrared – Passive infrared devices detect vehicles by measuring the infrared energy radiating from the detection zone. When a vehicle passes the energy radiated changes and the count is increased. Slow changes in road surface temperature, caused by changing weather conditions, are ignored. Lane coverage is limited to one to two lanes.
- doppler and radar microwave sensors – Doppler microwave detection devices transmit a continuous signal of low-energy microwave radiation at a target area and then analyse the reflected signal. The detector registers a change in the frequency of waves occurring when the microwave source and the vehicle are in motion relative to one another. This allows the device to detect moving vehicles. Radar is capable of detecting distant objects and determining their position and speed of movement. With vehicle detection, a device directs high frequency radio waves at the roadway to determine the time delay of the return signal, thereby calculating the distance to the detected vehicle.

Taking to the account the utilization of telematics technology for detection of the Table 1 introduces the strengths and weaknesses of the telematics detection systems mentioned above.

Table 1. The comparison of traffic detection technology [own study]

Technology	Level of installation intrusiveness	Multi-lane detection
Video vehicle detection	Low	Yes
Pneumatic road tube counting	Medium	Yes (2 lines)
Piezoelectric sensor	High	No
Inductive loop	High	No
Magnetic sensor	Medium	No
Acoustic detector	Low	Yes
Passive infrared	Low	Yes (2 lines)
Doppler and radar microwave sensors	Low	Yes

Mostly, the road traffic detectors are installed in the permanent way. This approach is used among others as the data acquisition subsystems in intelligent transportation systems. For instance, it makes it possible to collect data for traffic management processes. However, not always this approach is suitable for the specificity of the chosen traffic data analysis. Especially at the city areas, where the structure of the road systems are very complicated. It's very costly to install devices at each road section. Also, in the case of one-line detectors, it's hard to install detectors per each traffic line on each section.

Additionally, it should be underlined that many times it's not necessary to collect data on each section on the permanent way. Very often it's enough to detect the traffic during some shorter or longer time periods only. In this cases the best solution for data acquisition is utilization of portable systems.

4. The utilization of portable road traffic detectors

4.1 The expectations for portable use of road traffic counters

The portable road traffic detector should be defined as the device, which is installed and deinstalled in the simple way and can be used at different road sections, it means that it is not permanently installed. This kind of device helps to collect data in the independent way considering the road infrastructure. However, there are not too many technical solutions, which could be used in this way.

The major expectation is the simple, easy from technical point of view and fast installation process. This process shouldn't be based on utilization of different technical equipment, like lifts or ladders. Due to that many of non-intrusive traffic counter (especially radar or microwave detectors as well as video detectors) can't be used as a portable solutions. Mostly these devices have to be placed on the height of 2,5 or more meters. Moreover, this kind of devices have to be powered by capacious batteries, which make it possible to use them for a longer time and independently to the power sources.

The most popular and often utilize systems are based on the traditional approach. These devices are better for permanent installation or at least utilization at the same place for longer time period. Nevertheless, in recent years some road traffic counters producers delivered the solutions, which are suitable for utilization as a portable systems. Also some interesting technical ideas have been published as the results of research and development works [8, 9].

4.2 Wavetronix's Portable SmartSensor HD Radar

The Portable SmartSensor HD Radar (Fig. 1) is the device produced by Wavetronix company. It is a special version of

SmartSensor HD Radar, delivered in a weatherproof case that also contains the battery, protective equipment and accessories required for quick drum installations. According to the technical specification, this is a high-definition radar detector that accurately measures and classifies vehicles [12]:

- up to 22 lanes simultaneously,
- up to 8 length classes and 14 speed classes,
- classify vehicles by direction of movement.

This device can work in two modes [12]:

- vehicle detection mode – it determines the spot speed, length, class, distance, lane and passing duration;
- lane detection mode – it measures the volume of traffic (number of vehicles) by direction of movement and classification (length and speed), the occupation rate, the average spacing and interval between vehicles, the average speed, speed by category and speed of the 85th percentile (speed below which 85% of roadway users are driving) during a period set by the user.

Fig. 1. Radar traffic detector Wavetronix's Portable SmartSensor HD Radar [12]

4.3 Sierzega SR4

The device SR4 by Sierzega (Fig. 2) is a radar road traffic detection system. It combines easy and quick mounting at the roadside with unbiased, accurate and straightforward acquisition of traffic data. No need for any construction work, no interruption of the flow of traffic. Due to its low energy consumption the SR4 is able to gather traffic data at the roadside for a period of more than 2 weeks continuously. The collected data can be retrieved wirelessly with an Android Smartphone, a Laptop or Tablet using Bluetooth. Included in delivery is the Sierzega Analysing Software SRA, which offers a user friendly, in-depth way to filter, analyse and evaluate data using meaningful charts.

According to the technical specification, this is a high-definition radar detector that accurately measures and classifies vehicles [13]:

- 2 lanes simultaneously,
- up to 4 length classes,
- speed analysis,
- classify vehicles by
- direction of movement.

Fig. 2. Radar traffic detector SR4 by Sierzega [13]

4.4 MetroCount RoadPod® VT 5900

MetroCount RoadPod® VT 5900 (Fig. 3) is a portable traffic counter with robust rubber tubes. Designed for short-term surveys on multiple locations or long-term data collection on low volume roads. RoadPod VT is the first MetroCount unit to operate in Zombie Mode. This keeps the counter completely inert between passing vehicles, drawing one fifth the power required by the previous 5600 model, while using the same alkaline battery pack. The Time-up feature in the latest MTE software (v5 onwards) provides a dynamic projection of battery life, based on specific patterns of counter usage [14].

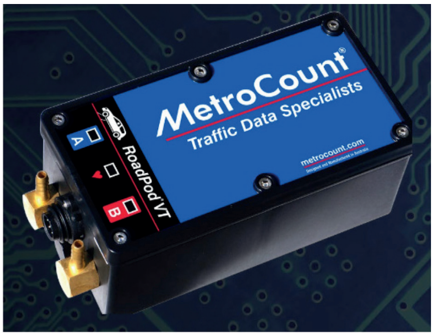


Fig. 3. Pneumatic traffic detector MetroCount 5600 [14]

The RoadPod VT can be amplified by the FieldPod remore access add-on. Through the mobile network, FieldPod enables data download, sensor checks and site diagnostics.Combining RoadPod VT with FieldPod provides access to the latest data at the click of a button [14].

4.5 NC350 BlueStar Portable Traffic Analyzer

The NC350 BlueStar Portable Traffic Analyzer from MH Corbin (Fig. 4) provides the accurate measurements of vehicle count, speed, and vehicle length. The NC350 BlueStar Portable Traffic Analyzer sensor is placed directly in the traffic lane to measure data, and can be installed and removed quickly and easily without damage to the road surface.

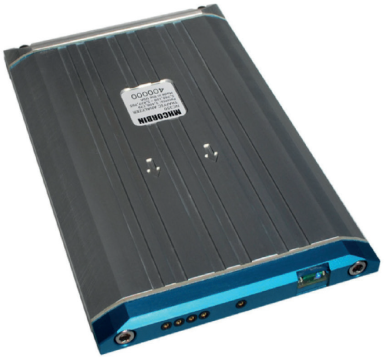


Fig. 4. Magnetic traffic detector NC350 BlueStar Portable Traffic Analyzer [15]

The specificity of this device includes [15]:

- communicates wirelessly via Bluetooth™ Technology,
- can be installed and removed in minutes,
- inconspicuous design blends in with road surface,
- individual vehicle recording allows infinite binning capabilities,
- durable extruded aluminium housing,
- long life, rechargeable, Lithium-Ion battery,
- easy to use software for viewing data.

4.6 Comparison of introduced solutions

The Table 2 introduces short comparison of chosen analysed portable detectors parameters. It should be underlined that all of them work with battery power supply. It makes them very easy to use on each road sections. Moreover, all devices are light and easy to carry. It should be noted, that in two cases – Sierzega SR4 and MetroCount 5600 – the capacity to simultaneously control lanes is very limited (both of these devices can control only 2 lanes). On the other hand, they allow for flexibility in terms of the measurement points and adaptation of areas of analysis to current needs.

Table 2. The comparison of chosen portable road traffic detector systems [own study]

Device	Portable SmartSensor HD Radar	Sierzega SR4	MetroCount 5600	NC350 BlueStar Portable Traffic Analyzer
Counting technology	Radar	Radar	Pneumatic	Magnetic
Multiline detection	Yes (up to 22 lines)	Yes (2 lines)	Yes (2 lines)	No
Battery supply	Yes	Yes	Yes	Yes
Dimensions (cm)	33,5 x 26,9 x 8,4	20 x 30 x 17	35 x 12,4 x 9,5	18,1 x 11,8 x 1,27
Classification by direction of movement	Yes	Yes	Yes	No
Weight (kg)	1,9	3	4,13	0,59
Operating temperature	-40 to 74°C	-25°C to 60°C	-10°C to 60°C	-20°C to 60°C

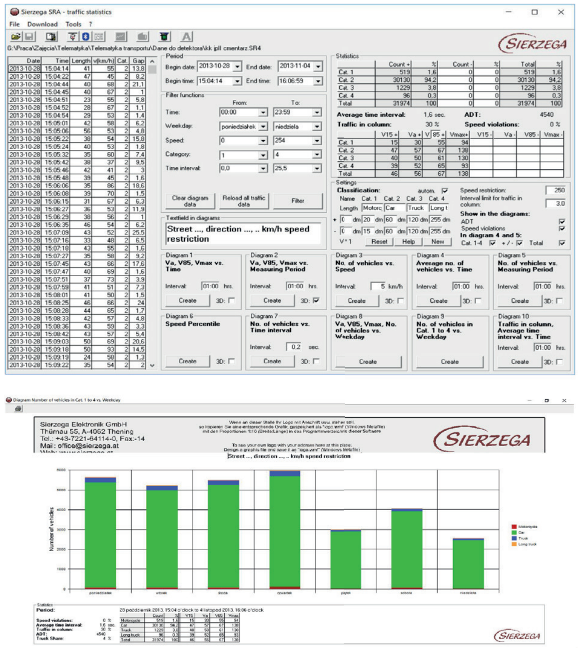
5 The example of utilization of Sierzega SR4 for city logistics analysis

One of the most important challenge for city logistics analysis is an identification of the environmental impact of the implemented measures. Mostly, it's realized on the basis of general models and simulations with utilization of estimated data only compare [16]. In recent years some more real-data-based approaches have been proposed compare [17].

5.1 Comparison of introduced solutions

The example introduced below, shows the usefulness of portable traffic detector for this kind of analysis. It's based on the experiences from analysis realized under GRASS project. This work helped to establish some assumptions and expectations for efficient work with the device Sierzega SR4.

Sierzega SR4 seemed to be very efficient tool considering easy to use and readable software (Fig. 5a), which can help to analyse collected data (Fig. 5b) as well as make it possible to transfer them to external software, like MS Excel.



a)

b)

Fig. 5. Sierzega SR4 software: a) general working window, b) example of graph [own study]

The important strength of Sierzega SR4 device is the possibility of installation without any additional technical equipment, like lift or ladder. For efficient work, tt can be placed on the height of 1,5-1,8 meters. Also not any actions are needed, which can influence on the traffic flows (realized directly on the road). The Fig. 6 introduces the installation expectations, which are needed for proper work of the device.

SR4 device helps to divide vehicles into four categories: motorcycles (length to 20 dm), passenger cars (length between 20 and 60 dm), trucks (length between 60 and 95 dm) and long trucks (length between 95 and 255 dm). However, the parameters of classification can be changed.

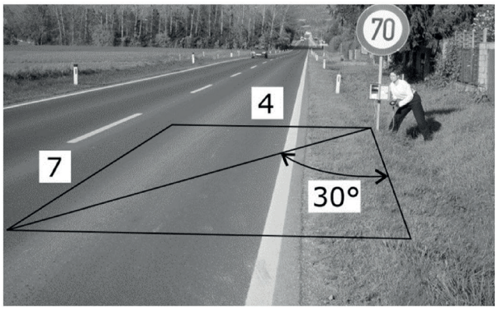


Fig. 6. The proper Sierzega SR4 installation [own study]

5.2 The analysis of the environmental efficiency of unloading bays

In the studied area, two unloading bays were taken to the account.(Fig. 7). The analysed street is placed in the city centre. There are located 41 retail entities, 37 service entities, 4 HoReCa and 3 production plants. Due to that the total number of weekly deliveries at this street is very high.

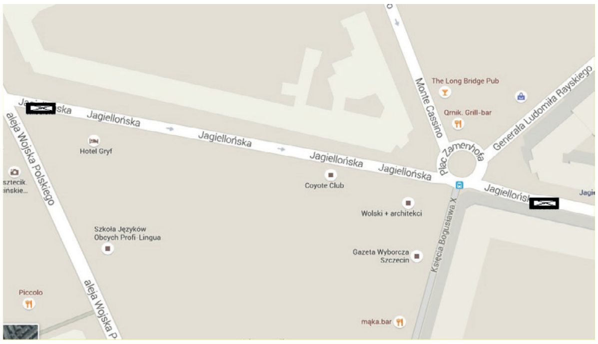


Fig. 7. Analysed unloading bays locations [own study]

To analyse the efficiency of unloading bays, the traffic data acquisition has been made. During this work two portable traffic detectors Sierzega SR4 were used. The data include vehicles categories and their speed. In order to simplify the analysis, modelling was performed for a constant average speed of vehicles in a road section. Data collection process was realized through one week from Monday to Friday, between 4 AM and 7 PM. In the next step the data have been summarized in five three-hours' time periods (Table 3).

Data collected during traffic analysis were used as the input for the emissions models. Next, based on the simulation with utilization of cellular automata, the analysis showed that application of unloading bays in the studied sections increased the traffic fluidity by 8% on average. This allows reduction of pollutant emissions on average by:

- 4% in the case of carbon monoxide (CO),
- 5% in the case of hydrocarbons (HC),
- 4% in the case of nitrogen oxides (NOX).
- More details regarding the models and analysis are available in [10].

Table 3. The traffic data for the analysed road sections [own study]

Time period	4.00-6.59			7.00-9.59			10.00-12.59			13.00-15.59			16.00-18.59		
Vehicle category	PC	LDV	HDV	PC	LDV	HDV	PC	LDV	HDV	PC	LDV	HDV	PC	LDV	HDV
Road section 5A															
Mon	389	24	1	1454	99	33	1324	66	37	1552	5	0	957	1	0
Tue	360	40	5	1490	52	43	1559	62	2	1442	41	52	712	45	5
Wed	309	11	7	1465	75	23	1502	109	58	1397	104	53	811	37	21
Thu	373	26	9	1490	102	26	1408	144	5	1386	112	43	707	58	50
Fri	353	27	12	1454	119	56	1344	152	14	1392	119	50	796	59	27
Total	1784	128	34	7353	447	181	7137	533	116	7169	381	198	3983	200	103
Road section 5B															
Mon	262	7	1	1550	51	4	1495	53	8	1315	54	5	849	22	1
Tue	267	27	7	1355	81	6	1515	150	7	1301	109	5	708	56	3
Wed	318	19	7	1464	62	8	1488	102	8	1445	82	2	763	50	8
Thu	252	24	7	1360	98	5	1382	102	7	1478	94	15	721	45	13
Fri	189	48	5	1407	79	5	1542	104	38	1057	95	15	634	48	12
Total	1288	125	27	7136	371	28	7422	511	68	6596	434	42	3675	221	37

6. Conclusion

One of the key factors necessary for taking control over the increasing disorder in urban freight transport as well as the implementation and efficiency of sustainable UFT measures implementations are the data resources. Lack of knowledge about freight flows, their direction and structure contributes to the difficulty in controlling and guiding them in a way that minimizes the negative impact on the urban organism, in particular, on the environment and residents. Moreover, in recent years, the use of intelligent transportation systems to support urban freight transport management is becoming increasingly important both in terms of theoretical as well as practical examples.

The major problem in UFT data collection process is the lack of the cooperation wiliness between different stakeholders, especially the business ones. The reason of this situation is mostly the competition between deliverers (especially Courier, Express and Parcel Operators – CEP) as well as shops and HoReCa (hotels, restaurants, catering) sector. The solution to solve this problem is utilization of stakeholder-independent devices, which can help to collect data according to the present needs and expectation. Nevertheless, the fundamental difficulty resulting from the specificity of delivering goods in the city is the need to deploy a large number of detectors, allowing for acquiring data in a wide area.

The Authors introduced the idea and example of utilization of portable traffic detectors, which can be used on the simple way and at every road section. This approach make it possible to collect data in shorter time periods but in the infrastructure-independently way. The device Sierzega SR4 have been used by Authors in the practice and helped to analyse the environmental influence of chosen UFT measure. It proofed the usefulness of portable traffic detectors for UFT analysis support. Nowadays, two devices of SR4 are used under the work of Faculty of Economics and Engineering of Transport in few project as well as under the cooperation with local and regional authorities.

Acknowledgments

The paper has been prepared as the activity of the project Low Carbon Logistics, founded under Interreg South Baltic Programme.

Bibliography

[1] ALLEN J., THORNE G., BROWNE M.: BESTUFS. Good Practice Guide on Urban Freight Transport, 2007
[2] IWAN S.: Wdrażanie dobrych praktyk w obszarze transportu dostawczego w miastach, Wydawnictwo Naukowe Akademii Morskiej w Szczecinie, Szczecin (in polish), 2013
[3] TANIGUCHI E., THOMPSON R. G., YAMADA T.:Recent Advances in Modelling City Logistics [in:] Eds. E. Taniguchi, R. G. Thompson, City Logistics II, Institute of Systems Science Research, Kyoto, pp. 3-34, 2001
[4] GATTUSO D., PELLICANÒ D.S.: Advanced Methodological Researches Concerning ITS in Freight Transport, Procedia - Social and Behavioral Sciences, Volume 111, Elsevier, pp. 994–1003, 2014
[5] KASZUBOWSKI D.: Zastosowanie benchmarkingu w logistyce miejskiej, Logistyka 5/2011, ILiM, Poznań, 2011
[6] TANIGUCHI E., THOMPSON R.G., YAMADA T.: Data Collection for Modelling, Evaluating and Benchmarking City Logistics Schemes. In: Taniguchi E., Thompson R.G. (Eds.) Recent Advances in City Logistics, Elsevier, 2006
[7] ZHENG P.J., MCDONAD M.: An Investigation on the Manual Traffic Count Accuracy. Procedia - Social and Behavioral Sciences. 43. pp. 226–231, 2012
[8] TAGHVAEEYAN S., RAJAMANI R.: Portable Roadside Sensors for Vehicle Counting, Classification, and Speed Measurement, IEEE Transactions on Intelligent Transportation Systems, Vol. 15, No. 1, 2014
[9] USHAKIRANMAI M., SAI THIRUMAL G.: Design Portable Sensors System for Vehicle Counting, Classification, and Speed Measurement in Traffic Junctions, International Journal of Professional Engineering Studies, Volume V, Issue 5, 2015
[10] IWAN S., et al.: Analysis of the environmental impacts of unloading bays based on cellular automata simulation, Transportation Research Part D: Transport and Environment, Vol. 61, Part A, pp. 104-117, 2018
[11] www.windmill.co.uk/vehicle-sensing.html [date of access: 2.02.2019]
[12] www.wavetronix.com [date of access: 2.02.2019]
[13] www.sierzega.com [date of access: 2.02.2019]
[14] metrocount.com [date of access: 2.02.2019]
[15] mhcorbin.com [date of access: 2.02.2019]
[16] www.c-liege.eu [date of access: 2.02.2019]
[17] grassproject.eu [date of access: 2.02.2019]
[18] novelog.eu [date of access: 2.02.2019]