TRANSPORT PROBLEMS 2022 Volume 17 Issue 1
PROBLEMY TRANSPORTU DOI: 10.20858/tp.2022.17.1.04

Keywords: transport process efficiency; indicators of transport vehicle utilisation; systematic and integrated evaluation of the productivity

Ljupko ŠIMUNOVIĆ[1]*, Veselko PROTEGA[2], Mario ĆOSIĆ[3], Davor BANDOV[4]

VEHICLE RELOCATION EFFICIENCY – A CASE STUDY OF THE PARKING COMPANY IN THE CITY OF ZAGREB

Summary. There is a need for vehicle relocation, whether for delivering new vehicles to their selling destinations, pulling inoperative or damaged vehicles out of traffiic, or removing illegally parked vehicles from the street. The relocation of illegally parked vehicles in the City of Zagreb is done by constantly monitoring parked vehicles or through citizen telephone alerts. The paper analyses the vehicle relocation service of the Zagrebparking company, which, in addition to overseeing car park management in public car parks and garages, is in charge of removing illegally parked vehicles. Due to the cyclic nature of its operations, a high share of empty rides, high vehicle investment costs, small quantities of cargo transported, high fuel prices, and high fuel consumption in the urban environment, Zagrebparking's Vehicle Relocation Department operates with unnecessarily high costs. In this paper, vehicle relocation efficiency is analysed by presenting indicators of vehicle utilisation as part of a systematic evaluation of the company. Improvements to the current service are also provided.

1. INTRODUCTION

Monitoring vehicle parking in large urban areas is essential for a just and efficient process in which traffic flow is stable and efficient, risk of road accidents is minimised, and freeing blocked entrances improves the reliability of the infrastructure, both for drivers and pedestrians. While cruising urban areas, tow trucks search for illegally parked vehicles on the streets and then intervene if necessary by relocating the vehicle from the parking violation site to a car park for illegally parked vehicles located in the southern part of the city. In this manner, drivers are discouraged by inconvenience and financial costs from violating parking regulations in the future.

Despite the importance of vehicle relocation services, these services must be efficient to be justified. If not performed effectively, vehicle relocations can create financial burdens for the operator, which are usually subsidised by the local authority. The service mostly includes a vehicle fleet and drivers, and the process must be coordinated optimally. Therefore, financial burdens are the result of poor vehicle utilisation, poor driver utilisation, and a lack of knowledge about route optimisation, as the nature of operations requires vehicles to drive empty for some percentage of the total time or distance that they are in operation.

This paper is motivated by the fact that the vehicle relocation process, as with any other transport process, can be described in terms of supply and demand, with the goal being to adjust the supply

[1] University of Zagreb, Faculty of Transport and Traffic Sciences; Vukelićeva 4, 10000, HR-Zagreb, Croatia; email: ljsimunovic@fpz.unizg.hr; orcid.org/0000-0003-2626-8390
[2] University of Zagreb, Faculty of Transport and Traffic Sciences; Vukelićeva 4, 10000, HR-Zagreb, Croatia; email: vprotega@fpz.unizg.hr; orcid.org/0000-0002-4779-3007
[3] University of Zagreb, Faculty of Transport and Traffic Sciences; Vukelićeva 4, 10000, HR-Zagreb, Croatia; email: mcosic@fpz.unizg.hr; orcid.org/0000-0003-4044-1567
[4] Zagrebparking, Vehicle Relocation Department; Šubićeva 40/III, Zagreb, Croatia; email: davorbandov1201@gmail.com; orcid.org/0000-0001-8105-6038
* Corresponding author. E-mail: ljsimunovic@fpz.unizg.hr

according to the demand while minimising costs and travel time. In the present case, supply is represented by vehicle fleet and drivers, and the effectiveness of running the service is represented by coefficients that demonstrate the extent to which supply is meeting the demand.

In a traditional vehicle relocation company, activities are typically conducted based on staff experience, and the required numbers of drivers and vehicles to cover all critical parts of the city are limited by the availability of financial assets. Although the experience and peak period conditions are enough to predict demand most of the time, in the long term, costs can increase due to a lack of specialised knowledge. Therefore, this paper covers the gap created by the lack of a sound methodology for improving vehicle relocation services.

In previous research, most authors have emphasised the importance of relocating illegally parked vehicles, mostly for improving road safety and ensuring stable traffic flow. Aapan et al. [1] stated that detecting illegally parked vehicles in places where urban traffic occurs is necessary to prevent unwanted road incidents such as vehicle collisions, traffic jams, and road accidents. Wenneman [2] established a correlation between on-street parking (increased limitations on streets) and the number of illegally parked vehicles. In other research, Chou, Wen-Sheng, Lin, and Pi [3] used data envelopment analysis to establish a performance measurement model for towing illegally parked vehicles.

Traditional vehicle relocation services are highly dependent on the resources of staff and vehicles, which creates high costs because of salaries, fuel, and maintenance. And although advanced video surveillance technologies have been developed, most research is focused on smart detection methods to check whether vehicles are illegally parked with as much accuracy as possible. For example, Tang et al. [4] proposed a real-time illegal parking detection method based on contextual information transmission using a Single Shot MultiBox Detector based on deep learning, resulting in 97.3% precision, which was superior to the other tested methods for illegal parking detection. Chungyang et al. [5] proposed an algorithm based on a Gaussian mixture model and morphological processing to detect illegally parked vehicles. By providing the exact steps of the procedure, the authors showed that the algorithm could achieve proper surveillance. Wahyono et al. [6] proposed an adaptive dual background model for vehicle detection with a robust framework based on statistical information about pixel intensity, and their results showed a 0% false detection rate. Thus, compared to traditional vehicle relocation, these methods are almost 100% precise; however, they require considerable investments because the technology can only be applied locally, which is not always suitable.

This paper proposes indicators that could be used when evaluating vehicle relocation services, thus improving such services. These indicators are related to vehicle operations by both time and space, regardless of whether vehicles are in operation or stationary. After the description of the indicators, the paper presents the results for each indicator and draws conclusions regarding the efficiency of the service. This paper also introduces fleet performance indicators based on the available data to further support conclusions. These results are used to make proposals for the company in terms of reduced costs and empty rides.

2. MEANS OF RELOCATING ILLEGALLY PARKED VEHICLES

The Zagrebparking company was established in 1993 as a former Centar company, which provided parking management services in public car parks and garages. Within the Zagrebparking company, the Vehicle Relocation Department oversees illegally parked cars. The name of the department explains its function, which is to carry out the continuous surveillance of illegally parked vehicles in public areas in the City of Zagreb, to relocate such vehicles with a mass below 2500 kg, and block illegally parked buses, trucks, work machines, and trailers [7 – 10]. The department officials must be present in public spaces for two reasons. The first reason has a preventive nature – to remind the public of their obligations to comply with traffic regulations and the rights granted to privileged groups. The second reason has a corrective nature – to react quickly to relocate vehicles that violate the regulations [11].

Vehicle relocation or blocking in the City of Zagreb is done by tow trucks that cruise the roads that have a relatively high potential for parking violations. Further, according to the order issued by a traffic warden, communal warden, police officer, or citizen telephone alerts, they relocate illegally parked vehicles [7]. The relocation site is a vehicle depot located near the Vehicle Relocation Department in the southern part of the City. The owner of an illegally parked vehicle can retrieve his or her vehicle at the site if he or she proves vehicle ownership. Fine payment can be made at the site up to eight days after the violation. The City of Zagreb is currently working on equipping public spaces with surveillance cameras, which will ease operations and reduce costs for the department. Cameras connected to the network will enable dispatchers to monitor parking violations from a central point, and this will reduce staff costs and unnecessary rounds made by tow trucks.

The vehicle fleet of the company consists of Iveco trucks, which are primarily utilised for transporting illegally parked private cars, vans, light-duty vehicles, and motorcycles (Fig. 1). However, they can also pull machinery and kiosks in the City of Zagreb. They differ from towing vehicles, as they are equipped with a stable platform and cargo crane with a special yoke and devices for grabbing the vehicle (cuffs). Non-movable platforms are fixed on the vehicle's undercarriage, and they do not have a system for moving or adjusting according to the cargo installed. The cargo is put onto the platform by a crane installed on the vehicle. Additional equipment on the vehicle consists of a hydraulic stabilizer, wheel pincers, additional lighting (working reflectors), signals, a ramp, and a toolbox [12].

Fig. 1. Zagrebparking – loading an illegally parked vehicle

Illegally parked vehicles can be relocated in two different ways:

1) During regular vehicle monitoring, the vehicles of the Vehicle Relocation Department every location where people, potentially parking their vehicles, violate the Law on Road Safety or decisions made by the city administration. An illegally parked vehicle, once identified, is then relocated according to the written instructions by police or a traffic utility officer. This kind of monitoring applies on every workday and Saturday but not on Sundays or at night – during these periods, the illegally parked vehicles are identified exclusively through citizen telephone alerts or public service alerts.
2) Illegally parked vehicles are identified by a traffic warden, communal warden, police officer, or citizen telephone alert using the publicly known telephone number. After the department receives such a telephone call, the department sends the nearest available vehicle to the location. The employees on the field then take photos of the illegally parked vehicle and send them to the person in charge for approval using the video surveillance infrastructure. If the legal conditions for relocating the vehicle are fulfilled, the person in charge sends written instructions for removing the vehicle from the site. After getting the instructions, the employees remove the illegally parked vehicle (Fig. 2).

Fig. 2. Sideways vehicle loading using hydraulic stabilisers

3. THE EFFICIENCY OF THE PROCESS

The existing means of operating depend on traffic and utility police because tow truck drivers are the ones who find illegally parked vehicles, and by sending the pictures to the traffic and utility police, they expect a warranty for vehicle relocation. Therefore, the seamlessness of car park employees sending pictures of potential violations and the seamlessness of sending the picture of the violation to the police are essential. In both cases, dispatchers must have the information about the illegally parked vehicle's location to send a tow truck to the location as quickly as possible.

Every vehicle of the department is included in the fleet management system and equipped with a mobile unit to track vehicle movement, named CVS Mobile. The basic component of every fleet management system is a mobile unit that gives them information about vehicle location. It can collect (using various sensors) and send different kinds of data about the vehicle dynamics to the end-user. Applying these systems can result in significant savings for the company [13]. Fig. 3 shows the movement route of one tow truck with the alarms on April 16th, 2020 by the CVS Mobile.

The collected and analysed data includes driving time, movement speed, counter state, engine RPMs, the fuel level in the tank, fuel consumption, engine temperature, total driving time, driving route, power voltage, state of the hydraulic pump, speed limit violations, maintenance data, distance covered since the last maintenance, cost per vehicle, name and surname of the driver, and every other piece of information that can be requested by the alarm.

All the data that is collected by a mobile unit and additional sensors is sent via the internet and stored on the server by General Packet Radio Service. Based on the collected data, reports are accessible over the computer interface. Installation is not required for a computer interface because all the data are visible on the webpage, which provides access to standardised reports about vehicle tracking, location/driver/user administration, fuel consumption, routes, travel invoices, errors, and other information. All data is normally encrypted by a password. The reports serve as a basis for analyses of efficiency, fuel consumption, and vehicle movement. The analysis of the particular processes in one cycle is shown in detail in Tab. 1.

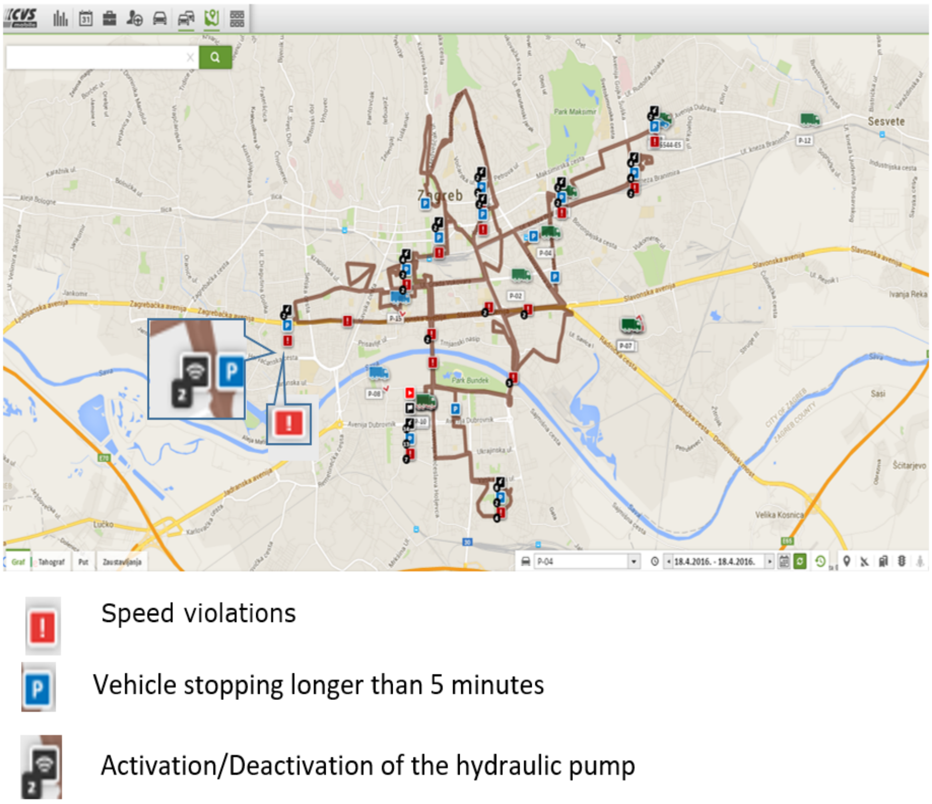

Fig. 3. Movement route by one tow truck on April 16th, 2020 with alarms by CVS Mobile unit

Table 1

Analysis of the process – cycle To1

Location – route	Activity [V_n, v, u, p, i]	Time period [t]	Cargo mass [q]	Total distance covered [L]	Speed [V_p]	Time	Distance	Utilisation [U]
/	/	min	kg	km	km/h	min	km	t km
Garage (empty ride)	V_n	19		9,0	28,4	19	9,0	
Source 1 (loading)	u1	9	1500			56	53,5	
Route 1 (transport)	p1	27	1500	10,5	23,3	159	31,0	15750
Destination 1 (loading)	i1	5	1500					
Route 1-2 (transport)	v1-2	19		8,0	25,4			0
Source 2 (loading)	u2	8	1500					
Route 2 (transport)	p2	23	1500	16,0	41,7			24000
Destination 2 (unloading)	i2	7	1500					
Route 2-3 (transport)	v2-3	18		9,0	30,0			0
Source 3 (loading)	u3	9	1500					
Route 3 (transport)	p3	24	1500	11,0	27,5			16500
Destination 3 (unloading)	i3	4	1500					
Route 3-4 (transport)	v3-4	27		114,0	31,1			0
Source 4 (loading)	u4	10	1500					
Route 4 (transport)	p4	21	1500	16,0	45,7			24000
Destination 4 (unloading)	i4	4	1500					
TOTAL		**234**	**6000**	**93,5**				**80250**

V_n – empty ride speed (km/h); V_p – travel speed (km/h); q – average vehicle mass (1.500 kg); u – loading; i – unloading; p – transport.

4. VEHICLE PRODUCTIVITY INDICATORS

To analyse the process, expenses and activities for the Vehicle Relocation Department, vehicle fleet monitoring is established in this paper by implementing the following coefficients [7, 14, 15]:

- α_{is} – Correctness coefficient;
- α_a – General engagement coefficient;
- α_a' – General engagement coefficient of the correct vehicles;
- β – Distance covered coefficient;
- α_v – Driving time coefficient;
- Driver efficiency.

4.1. Correctness coefficient α_{is}

The correctness coefficient (**α_{is}**) is an indicator of vehicle correctness and depends on many factors, such as years in operation, means of maintenance, time required to repair the vehicle, and the reliability of the company in charge of vehicle maintenance. The closed contracts have to include all (regular and extraordinary) maintenance segments. The company's reliability is foreseen in the time required to put a faulty vehicle in operation, especially in cases of extraordinary maintenance.

$$\alpha_{is} = \frac{DPS_{is}}{DPS_K} \qquad (1)$$

Where: DPS_{is} – available vehicle-days in operation; DPS_k – total registered vehicle-days

For the observed period, the coefficient was 0.68; however, a value equal to or greater than 0.9 is required in order for the number of vehicles to adjust to driver requirements.

Table 2

Correctness coefficient by garage number in 2019

2019																
Garage number	1	3	4	6	7	8	9	10	12	15	16	17	18	19	20	21
DPS_{is}	280	202	314	184	250	204	187	233	295	233	274	256	267	244	312	236
DPS_k	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365
α_{is} 2019	0,77	0,55	0,86	0,50	0,68	0,56	0,51	0,64	0,81	0,64	0,75	0,70	0,73	0,67	0,85	0,65

TOTAL 2019	0,68

The maintenance system is based on maintenance after breakdowns and ignores regular planned services. The maintenance has to be done in a systematic manner, although maintenance after a vehicle breaks down cannot be avoided. The number of vehicle breakdowns can be reduced by monitoring the costs of each vehicle. Such monitoring can indicate when there is no justification for the vehicle to be further invested in due to the vehicle's age and correlated increase in extraordinary maintenance costs. These indicators should guide further actions. One of the possibilities for reducing the maintenance costs is a successive vehicle procurement, starting by replacing the oldest vehicles or those for which maintenance would result in increased costs. The procurement of new vehicles results reduces extraordinary maintenance costs and increases vehicle reliability.

4.2. General engagement coefficient α_a

The general engagement coefficient (**α_a**) is an indicator of vehicle presence in the process itself.

$$\alpha_a = \frac{DPS_R}{DPS_K} \tag{2}$$

where: DPS_R – active vehicle-days, DPS_K – total registered vehicle-days.

For the observed period, the coefficient was 0.52. By monitoring driver efficiency and analysing the number of interventions per hour, the maximum value of the general engagement coefficient was determined to be 0.80.

Table 3

General engagement coefficient by garage number in 2019

2019																
Garage number	1	3	4	6	7	8	9	10	12	15	16	17	18	19	20	21
DPS_R	100	153	303	89	211	145	100	161	285	198	154	213	228	182	289	211
DPS_K	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365
α_a 2019	0,27	0,42	0,83	0,24	0,58	0,40	0,27	0,44	0,78	0,54	0,42	0,58	0,62	0,50	0,79	0,58

TOTAL 2019 **0,52**

The general engagement coefficient is an indicator of the state of the average vehicle engaged in the process (i.e. the presence rate of the homogenous vehicle fleet during the observed period in the process). Possible reasons for which vehicles are not in operation include, on the one hand, vehicle breakdowns, and on the other hand, vehicles being assigned for backup.

4.3. General engagement coefficient of correct vehicles α_a'

The general engagement coefficient of correct vehicles (**α_a'**) is an indicator of the proportion of vehicles in operation compared to the total number of vehicles in operation (i.e. disposable vehicles for the process).

$$\alpha_a' = \frac{DPS_R}{DPS_{IS}} \tag{3}$$

Where: DPS_R – active vehicle-days; DPS_{IS} – total available vehicle-days.

Table 4

General engagement coefficient by vehicle garage number

2019																
Garage number	1	3	4	6	7	8	9	10	12	15	16	17	18	19	20	21
DPS_R	100	153	303	89	211	145	100	161	285	198	154	213	228	182	289	211
DPS_R + $DPS_{R'}$	282	205	311	182	252	206	190	237	297	236	273	256	271	244	313	238
$\alpha_{a'}$ 2019	0,35	0,75	0,97	0,49	0,84	0,70	0,53	0,68	0,96	0,84	0,56	0,83	0,84	0,75	0,92	0,89

TOTAL 2019 **0,74**

For the observed period, the coefficient was 0.74; however, the coefficient should be as high as possible in practice. The value of 0.74 indicates that the vehicle fleet has to be available every day of the week; however, not every available vehicle is operated on Saturdays and Sundays.

4.4. Distance covered coefficient β

The distance covered coefficient (**β**) is the proportion of the distance covered loaded compared to the total distance covered.

$$\beta = \frac{PSL_T}{PSL} \tag{4}$$

Where: PSL_T – distance covered while loaded; PSL – total distance covered.

Table 5

Distance covered coefficient by month in 2019

2019												
Months	1	2	3	4	5	6	7	8	9	10	11	12
Loaded	6648	5677	7762	7074	7377	6544	4144	3404	7792	9211	8561	9241
Total	28236	24156	31855	29028	29622	26119	19277	16338	29310	31587	29812	29548
β per months	0,24	0,24	0,24	0,24	0,25	0,25	0,21	0,21	0,27	0,29	0,29	0,31

TOTAL 2019	0,25

For the observed period, the proportion of distance covered loaded compared to the total distance covered was 0.25. The efficiency of tow trucks would be optimal if the value was 0.50 (the mode of operation cannot allow values greater than 0.50).

An increase in the distance covered coefficient (i.e. the achievement of the loaded vehicle-kilometres proportion of 0.50 compared to the total kilometres covered) could be achieved through better cooperation with the traffic police and the utility police. With the physical presence of the police on the field, video surveillance, and the engagement of the parking control officers, empty rides of tow trucks could be reduced.

4.5. Driving time coefficient α_v

The driving time coefficient (**α_v**) is an indicator of the proportion of time spent driving compared to the total working time.

$$\alpha_V = \frac{HPS_V}{HPS_R} \tag{5}$$

where: HPSv – driving hours; HPSr – working hours.

For the observed period, the proportion of time spent driving to the total working time was 0.44. Such a small coefficient is a consequence of the means of operation in the department (duty hours at the vehicle relocation site during night shifts or paid duty hours in the field).

5. TRANSPORT PROCESS EFFICIENCY IN THE SCOPE OF EVALUATING THE ZAGREBPARKING COMPANY

Income and expenses are unavoidable elements of every business activity in the company. They are important for determining the results of the business activities of the company, which are conducted to determine the level of achievement. Tab. 6 shows the data related to the analysis of driver performance and utilisation in the department. Driver utilisation is defined as the average number of driver interventions (i.e. the number of loaded vehicles in violation during a typical eight-hour shift on an annual basis).

Table 6

Driver utilisation in the department

Driver	Number of shifts	Driving	Activities	Breaks	Driving time / business hours	Registered business hours	Business hours without service	Average kilometres	Utilization
Driver 1	142	3:00	3:07	0:51	43,06%	6:58	7:11	62	4,32
Driver 2	211	3:31	3:09	0:42	47,74%	7:22	7:29	78	4,11
Driver 3	116	2:59	3:18	1:04	40,59%	7:21	7:33	60	5,50
Driver 4	223	3:17	2:55	0:54	46,24%	7:06	7:27	74	4,05
Driver 5	227	3:09	3:23	0:52	42,57%	7:24	7:30	70	5,55
Driver 6	169	3:20	2:24	1:19	47,28%	7:03	7:19	66	4,35
Driver 7	95	2:39	3:23	1:06	37,15%	7:08	7:41	51	4,10
Driver 8	189	3:27	3:03	0:42	47,92%	7:12	7:22	67	4,16
Driver 9	172	3:07	3:13	0:52	43,29%	7:12	7:31	66	3,94
Driver 10	225	3:09	3:18	0:47	43,55%	7:14	7:34	69	5,05
Driver 11	221	3:35	3:00	0:41	49,31%	7:16	7:31	78	4,41
Driver 12	209	3:02	3:21	0:48	42,23%	7:11	7:33	72	4,80
Driver 13	193	3:06	3:12	0:58	42,66%	7:16	7:33	72	4,68
Driver 14	213	3:33	3:08	0:48	47,44%	7:29	7:44	74	5,44
Driver 15	198	3:22	3:02	0:52	46,33%	7:16	7:23	70	4,28
Driver 16	231	2:56	2:53	1:22	40,84%	7:11	7:27	59	6,12
Driver 17	215	3:13	3:05	1:04	43,67%	7:22	7:29	64	6,02
Driver 18	194	3:09	3:15	0:48	43,75%	7:12	7:26	67	5,35
Driver 19	203	3:19	2:57	1:05	45,12%	7:21	7:28	75	4,23
Driver 20	207	3:00	3:27	0:42	41,96%	7:09	7:31	66	4,76
Driver 21	17	3:06	3:02	0:53	44,18%	7:01	7:52	67	2,80
Driver 22	228	3:29	3:04	0:51	47,07%	7:24	7:32	66	5,94
Driver 23	132	2:38	3:09	1:16	37,35%	7:03	7:21	52	4,30
Driver 24	121	3:09	3:23	0:47	43,05%	7:19	7:42	68	4,19
Driver 25	220	3:28	3:08	0:40	47,71%	7:16	7:43	74	5,88
Driver 26	144	2:55	3:30	0:47	40,51%	7:12	7:34	71	4,35

Due to the importance assigned to income and expenses, an analysis and comparison of the numbers of relocations and started interventions in particular months (Fig. 4) and years in total (Fig. 5) is presented.

Fig. 6 shows total number of vehicle relocations from 2005 to 2019. Green line shows total number of relocations, and the blue line shows the number of relocations due to violations, indicating most of relocations due to violations. The number of vehicle relocations reached its maximum in 2014 and has been declining until present. This is due to the parking surveillance cameras and parking prohibition poles installed.

Fig. 7 shows utilization (average number of illegally parked vehicles in one driver shift) of tow trucks from 2006 to 2019. The maximum utilisation of vehicles was in 2010 (nine interventions per vehicle), due to lack of measures preventing drivers to park their cars illegally.

Fig. 8 shows total distance covered by the fleet in kilometres. From 2010 to 2014, the number of illegal parking declined due to introduced measures for preventing illegal parking, but the number of vehicles in the fleet remained the same. After 2014, total distance covered is reduced because the number of vehicles in the fleet reduces to adjust to the reduced demand for vehicle relocations.

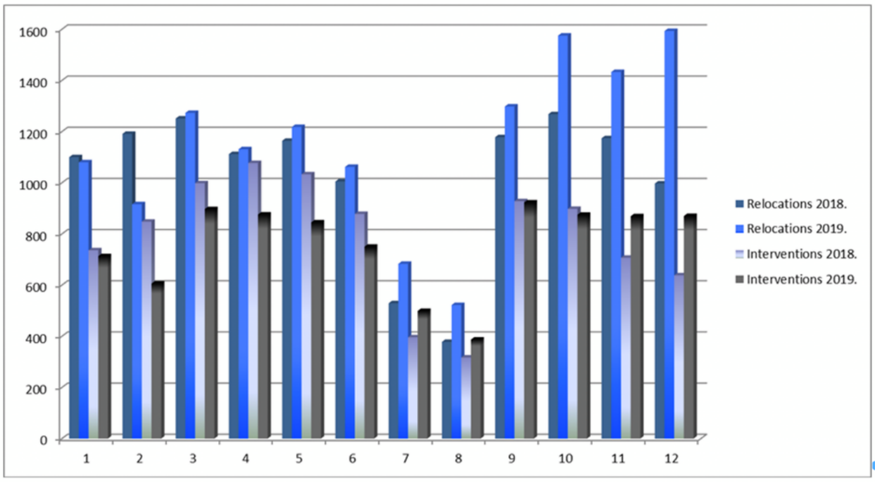

Fig. 4. Efficiency in 2018 and 2019 by month

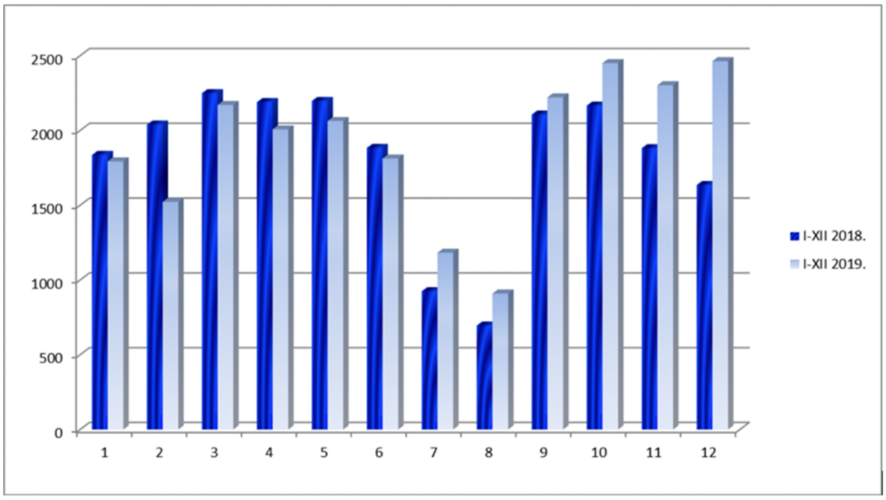

Fig. 5. Efficiency in 2018 and 2019 – total by year

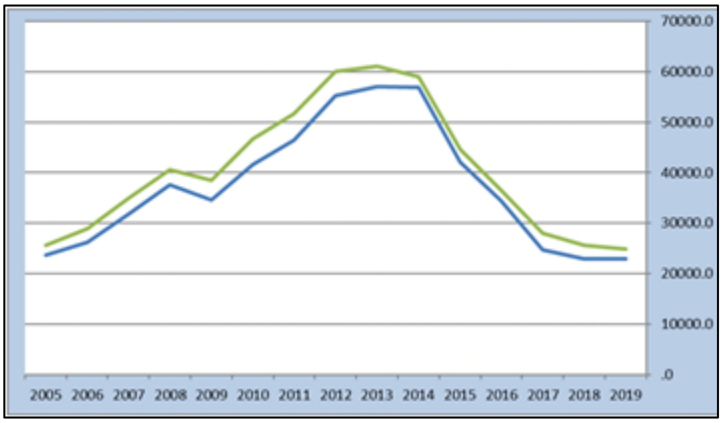

Fig. 6. The number of relocated vehicles, 2005 – 2019

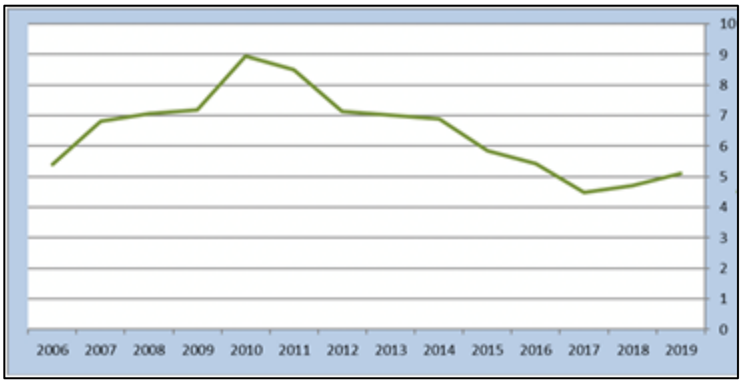

Fig. 7. Utilization of tow trucks, 2006 – 2019

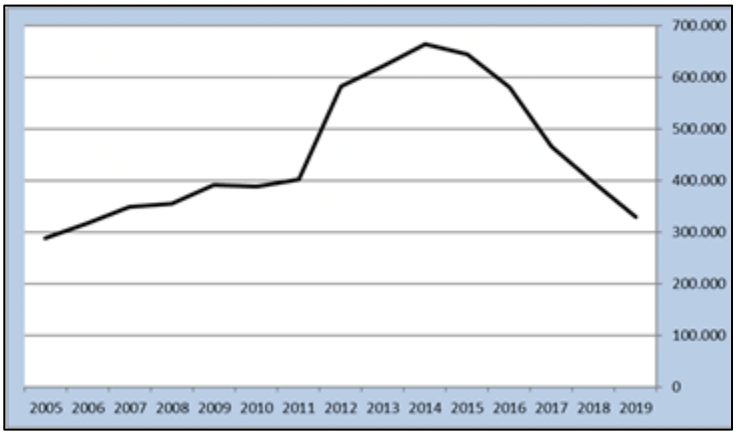

Fig. 8. Total distance covered, 2005 – 2019

6. CONCLUSION

By observing and monitoring performance indicators of the Vehicle Relocation Department, the actions described below are suggested:

- Consecutively renew the vehicle fleet.
- Achieve a higher degree of cooperation with the utility and traffic police by unifying and harmonising the utility personnel and the company personnel according to the stated models. This would increase the number of relocations while maximising the utilisation of the distance covered by tow trucks, which ultimately puts the current number of tow trucks (as well as the number of personnel) in question.
- Manage efficiently by ensuring an optimal number of vehicles required to perform the vehicle relocation service are in operation. Thus way, the general vehicle fleet engagement would be satisfactory, with coefficients between 0.8 and 1.0.
- Monitor the expenses per vehicle as a starting point for analysing the proportion of the particular cost type in total costs (e.g. pneumatics, lubricants, fuel, maintenance, wear and tear, taxes, insurance, interest).
- Completely implement a fleet management system. The proposition is to implement automatic driver detection because only manual driver registration is currently present, and human factors are important to keep the system updated.
- Redefine the procedure of issuing requests for vehicle procurement and the procedure for issuing receiving orders, thus shortening the time taken to get the vehicle back into operation. Each vehicle creates additional costs after breaking down, primarily manifested by the impossibility to engage all personnel in the process.

- Introduce new technologies for detecting illegally parked vehicles based on video surveillance and smart detection.

References

1. Aapan, M. & Kaushik, D. & Tasmina, K. & Kang-Hyun, J. Illegaly parked vehicle detection based on Haar-Cascade classifier. In: *15th International Conference, ICIC 2019*. Nanchang, 2019.
2. Wenneman, A. *Commercial Vehicle Operations in Urban Areas: Identifying Policies to Reduce Negative Impacts*. MSc thesis. University of Toronto.
3. Wen-Sheng, C. & Pei-Yi, L. A Comparative Study of Towing Performance of Illegally Parked Vehicles. *Journal of the Eastern Asia Society for Transportation Studies*. 2013. Vol. 10. P. 376-391.
4. Tang, H. & Peng, A. & Dongming, Z. & Liu, T. SSD Real-Time Illegal Parking Detection Based on Contextual Information Transmission. *Computers, Materials & Continua*. 2020. Vol. 62. No. 1. P. 293-307.
5. Chunyang, M. & Xing, M. & Panpan, Z. *Smart Detection of Vehicle in Illegal Parking Area by Fusing of Multi-features*. In: *9th International Conference on Next Generation Mobile Applications, Services and Technologies*. Cambridge, 2015.
6. Wahyono & Filonenko, A. & Jo, K.-H. *Illegally parked vehicle detection using adaptive dual background model*. In: *41st Annual Conference of the IEEE Industrial Electronics Society – IECON 2015*. Yokohama, 2015.
7. Ministry of Internal Affairs. *Pravilnik o uvjetima i načinu obavljanja poslova nadzora nepropisno zaustavljenih ili parkiranih vozila te uvjetima za obavljanje poslova premještanja nepropisno zaustavljenih ili parkiranih vozila*. [In Croatian: *Ordinance on the conditions and manner of performing activities of supervision of improperly stopped or parked vehicles and conditions for performing activities of moving improperly stopped or parked vehicles*]. Zagreb: Narodne novine 134/2008.
8. Ministry of Internal Affairs. *Zakon o sigurnosti prometa na cestama*. [In Croatian: *Road Traffic Safety Act*]. Zagreb: Narodne novine 67/2008, 48/2010, 74/2011, 80/2013, 158/2013, 92/2014, 64/2015, 108/2017, 7020/19, 42/2020.
9. Croatian Parliament. *Zakon o prijevozu u cestovnom prometu*. [In Croatian: Road Transport Act]. Zagreb: Narodne novine 41/2018, 98/2019, 30/2021, 89/2021.
10. Ministry of the Sea, Transport and Infrastructure. *Pravilnik o posebnim uvjetima za vozila kojima se obavlja javni cestovni prijevoz i prijevoz za vlastite potrebe*. [In Croatian: Ordinance on special conditions for vehicles used for public road transport and own-account transport]. Zagreb. 2018.
11. Županović, I. *Tehnologija cestovnog prijevoza*. [In Croatian: *Road transport technology*]. Zagreb: Faculty of Transport and Traffic Sciences. 2002. 140 p.
12. Jazar, R. N. *Vehicle Dynamics: Theory and applications*. New York: Manhattan College – Dept. of Mechanical Engineering. 2008. 582 p.
13. Rogić, K. & Šutić, B. & Kolarić, G. Methodology of introducing Fleet Management System. *Promet – Traffic&Transportation.* 2008. Vol. 20. P. 105-111.
14. Rajsman, M. *Tehnologija prijevoza putnika u cestovnom prometu*. [In Croatian: *Road passenger transport technology*]. Zagreb: Faculty of Transport and Traffic Sciences. 2017. 75 p.
15. Rajsman, M. Mogućnost racionalizacije poslovanja cestovnoga transportnog poduzeća. *Promet*. 1994. Vol. 26. P. 161-167.

Received 07.01.2021; accepted in revised form 09.03.2022