UDC 658.13 https://doi.org/10.23947/2541-9129-2020-2-53-59

Using adaptive traffic lights for improvement of environmental situaiton at metropolis crossroads

G. A. Galchenko[1], M. V. Byrnysheva[2], D. S. Drozdov[3]

[1,2]Don State Technical University (Rostov-on-Don, Russian Federation)
[3]Southern Federal University (Rostov-on-Don, Russian Federation)

Introduction. Jams at crossroads lead to emissions in atmosphere of great volumes of pollutants. The problem of unloading of a transport artery can be decided partially by means of usage of an adaptive mode of switching of a light signal. The analysis of a transport situation should be executed previously by means of various means and program complexes.

Problem statement. The task of the given research is the analysis of a transport situation at crossroads of Rostov-on-Don on the basis of full-scale supervision and theoretical calculations, development of advisories on the enhancement of organisation of traffic.

Theoretical part. The main mathematical method on which basis the computer program is developed, the method of electrodynamic modelling is. The analysis of the given full-scale supervision, theoretical calculations and present-position sensors of availability of the car is carried out.

Conclusions. Full-scale supervision and mathematical calculations showed significant degree of intensity of traffic on the given crossroads. Installation of an adaptive light signal will promote improvement of a transport situation. For realisation of an adaptive mode of switching of a light signal it is offered to use TrafiCam - the sensor of availability of the car.

Keywords: methods, modelling, software product, vehicles, crossroads, ecology.

For citation: Galchenko G. A., Byrnysheva M. V., Drozdov D. S. Using adaptive traffic lights for improvement of environmental situaiton at metropolis crossroads: Safety of Technogenic and Natural Systems. 2020;2: 53−59. https://doi.org/10.23947/2541-9129-2020-2-53-59

Introduction. Transport problems in megacities, such as congestion at intersections, lead to a large amount of air-polluting emissions when the car engine is idling or running slowly. The problem of relieving pressure on roads is acute for departments of major cities. One of the solutions to this problem is the organization of traffic light regulation, taking into account the current transport situation. The decision to install an adaptive traffic light system should be based on the analysis of traffic situation at the intersection [1]. For the analysis, such approaches as field observations are widely used, which allow determining the structure and number of vehicles, software systems and technical tools.

Problem Statement. The initial objective of this study was to analyze traffic situation at intersections in Rostov-on-Don. Based on field observations and theoretical calculations, the recommendations for improving the organization of traffic are developed.

Theoretical Part. In this paper, we propose to use the developed software package "Material flow" [2-3] to analyze traffic situation at problematic intersections in order to determine the need to install an adaptive traffic light. The software package is developed using the method of electrodynamic modeling [4], which allows you to calculate the main characteristics of the transport situation (traffic intensity, tension and resistance) at a particular intersection.

As an example we used this program for evaluating and improving traffic management at the intersection of Voroshilovskiy ave. – Varfolomeeva street, Rostov-on-Don (Fig. 1). Traffic density is heavy at this intersection and congestions are frequent.

Fig. 1. Map of the intersection of Voroshilovskiy ave. – Varfolomeeva street, Rostov-on-Don

Field observations were made. The traffic congestion at the intersection was analyzed on different days of the week: during morning and evening peak traffic congestions (tables 1-3).

Table 1

Diagram of the number of passenger cars

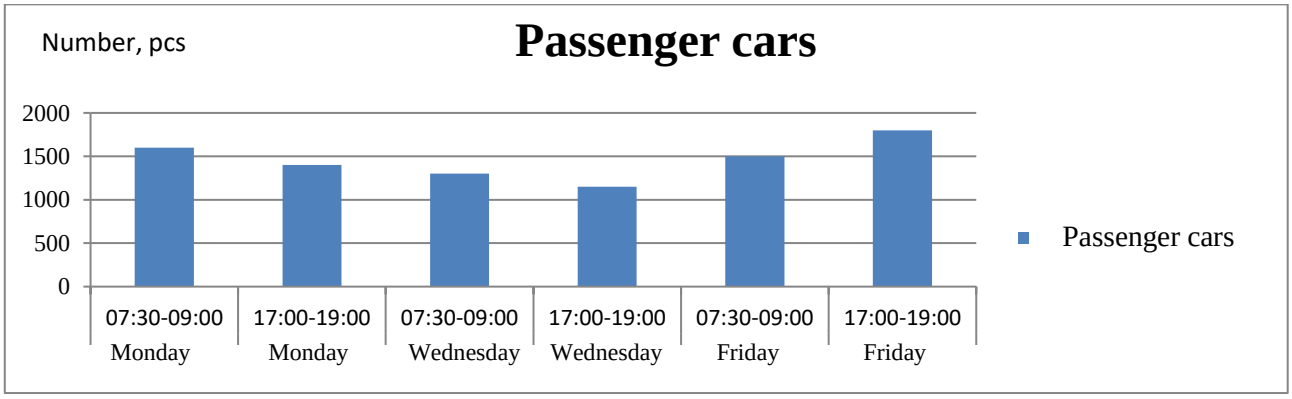


Table 2

Diagram of the number of trucks

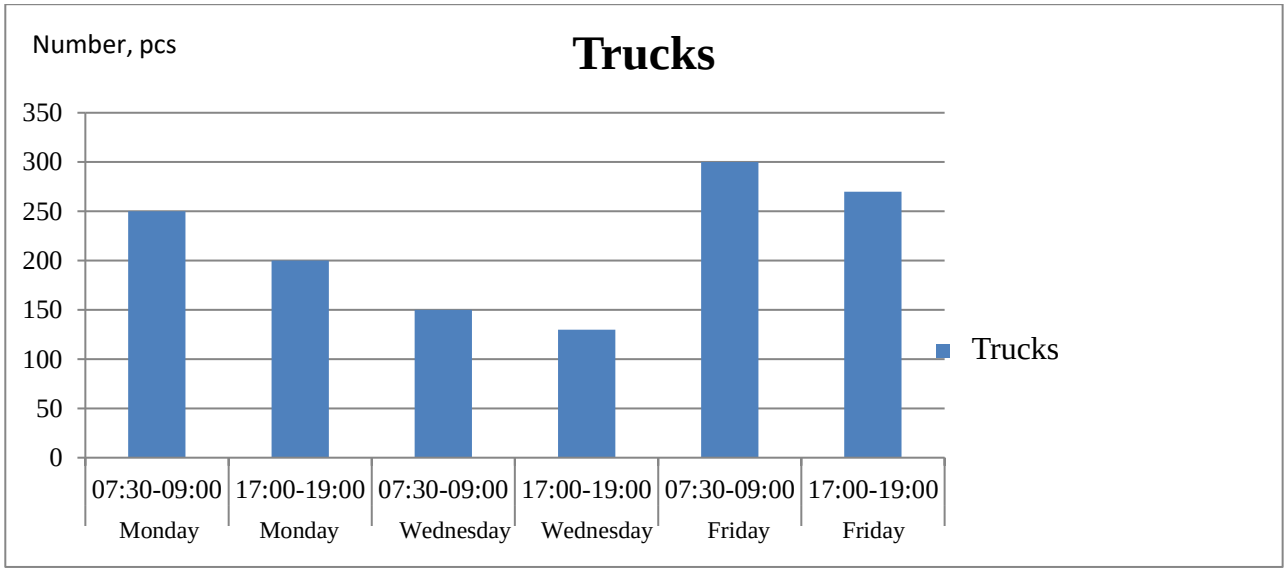
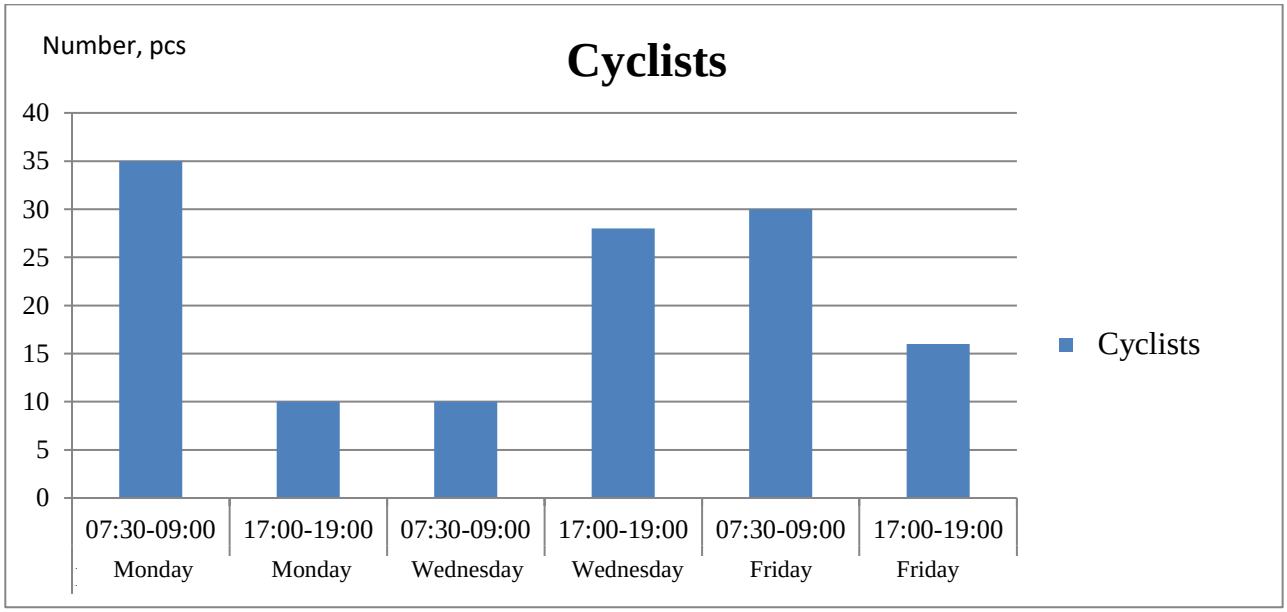


Table 3

Diagram of the number of cyclists



To calculate the main transport characteristics of the intersection Voroshilovskuy ave. – Varfolomeeva street, Rostov-on-Don, the method of electrodynamic modeling was used [5-7].

Calculations of the influence of vehicle speed on traffic intensity (I) were made (Fig.2) and resistance to movement (R) (Fig.3-4) at different values of the number of vehicles at the intersection and different values of grip of wheel (ψ) - different weather conditions.

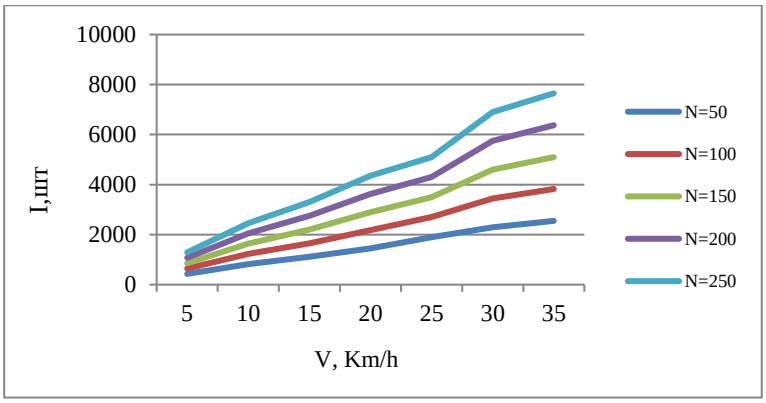


Fig. 2. Influence of vehicle speed on traffic intensity for different values of the number of vehicles (N) at the intersection

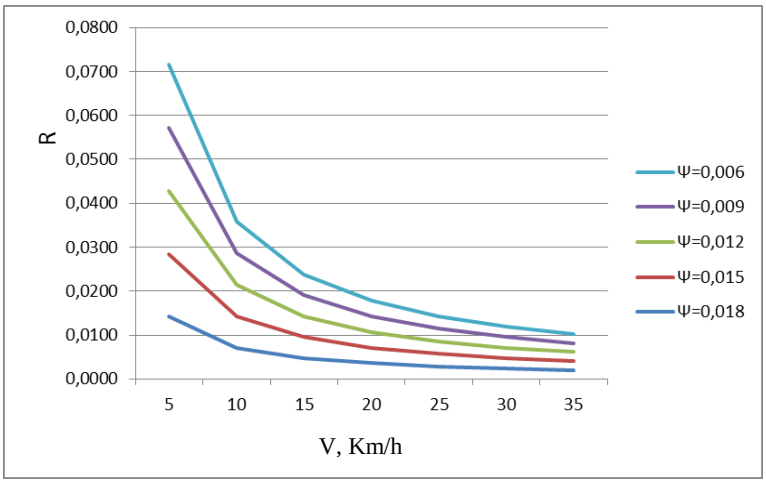


Fig. 3. Influence of vehicle speed on traffic resistance with a flow density of q = 100 and various weather conditions (ψ)

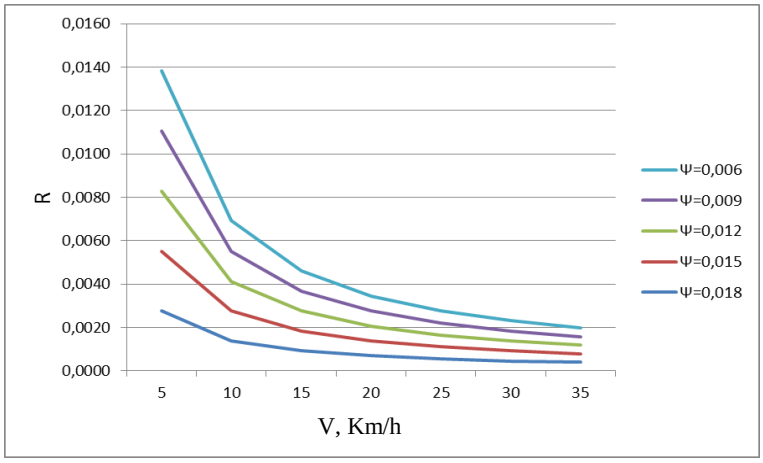


Fig. 4. Influence of vehicle speed on traffic resistance with flow density of q = 150 and various weather conditions (ψ)

The analysis of these dependencies allows us to conclude that there is heavy traffic at this intersection, the speed of the vehicle decreases with the increase in the number of cars, and the resistance to traffic increases, especially when weather conditions worsen. An adaptive traffic light can help improve traffic situation at this intersection. The adaptive traffic light is always accompanied by various types of sensors that are located before (D1) and after (D2) the intersection. The D1 sensor reads the identification number of the car approaching the intersection and enters it in the computer memory, while counting the number of cars approaching (N). As soon as N reaches a certain set maximum of Nmax, the green light turns on. A car that leaves the intersection is counted by the D2 sensor, which deletes the identification numbers of cars that passed through the intersection. The traffic light switches to a different phase and the traffic light cycle control program returns to the beginning of the cycle. This operation of the traffic light cycle is performed for both roads. The conventional layout of the sensors is shown in Fig. 5, and for the intersection in question, Figure 1 shows the arrows.

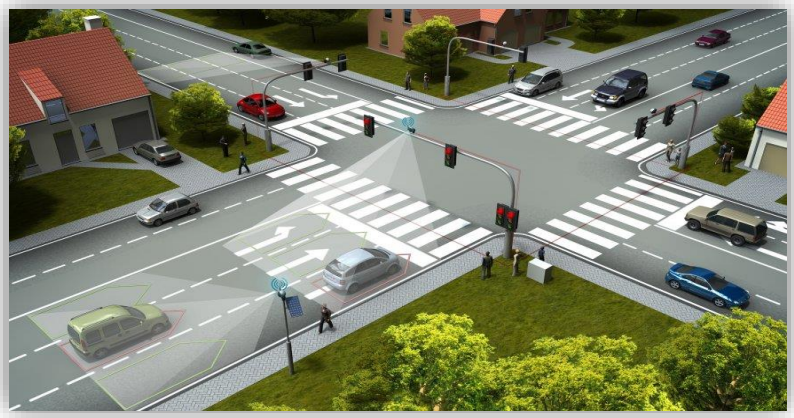


Fig. 5. Layout of sensors at a conditional intersection

There are a large number of sensors that can be used to implement this algorithm. The TrafiCam car presence sensor series is a combination of cameras with CMOS memory chips and video detectors. This series includes two products: the autonomous Traficam car presence sensor and the TrafiCam x-stream sensor with the function of collecting data from the video stream. Both TrafiCam and TrafiCam x-stream sensors are used to detect and monitor moving and stationary vehicles at controlled intersections. The user-friendly web interface allows users of TrafiCam x-stream sensors to manage their video sources ONLINE .

Fig. 6.a) TrafiCam Sensor

Fig. 6.b) Location of the sensor

Traffic violations are recorded using automatic video recording cameras. Today in Russia, the traffic police use the following types of cameras and radars:

Arena is a stationary complex. This system is designed to measure the speed of a vehicle and has software that allows you to recognize the registration number. It is usually installed at a height of no more than 8 meters and controls only one lane of traffic.

Arena 2 is a stationary complex. It is installed at a certain angle to the road and can control two lanes of traffic. The complex has sufficient memory in which information about violations is accumulated and transmitted to the appropriate post of the road patrol service.

Arena is a mobile complex, which is an easily moved device that can be placed on a tripod at a short distance from the road. Power is provided by a battery. Speed violations on this section of the highway are photographed and stored in the memory of the complex.

Speed camera "Berkut-Visa" - knowledge of the computer allows you to work with this device, using the capabilities of a video camera. The road situation is displayed on the device screen in real time. Information about violations, if the speed limit is exceeded on this section of the route, is stored in a file and in the computer memory.

TrafiCam car presence sensor series is a combination of cameras with CMOS memory chips and video detectors. This series includes two products: an autonomous car presence sensor that collects information from video stream data. Information about the presence of vehicles is transmitted via the corresponding outputs or via IP Protocol

to the traffic light controller, and thus the duration of traffic light signals is dynamically adjusted. In this way, traffic flow is optimized by reducing waiting at intersections. The information is transmitted in full frame format, but can also be compressed in the appropriate formats. The interface of this series of sensors is convenient and allows you to work in ONLINE mode.

Conclusion. To simulate the optimal distribution of traffic light control modes, you can use the PTV VISTRO software product. This software allows you to work simultaneously with several intersections, optimizing and coordinating traffic. However, the cost of this product is very high, which limits its widespread use.

The proposed approach with the use of the developed software package "Material flow" allowed us to collect a fairly large database of problematic intersections in Rostov-on-Don [8], where adaptive traffic lights need to be installed. Of all these sensors, it is proposed to install TrafiCam - a car presence sensor, since this sensor counts cars and thus will relieve the road. If there is a traffic jam at an intersection that impedes traffic flow, the TrafiCam sensor can send information about the presence of cars to the system, which allows the system to change the switching pattern of traffic signals.

Adaptive traffic lights are widely used in many countries around the world. In Moscow, adaptive traffic lights are installed at more than 500 intersections. The above mentioned approach to traffic management on busy roads allows you to significantly increase the average speed of traffic and reduce tension of the entire transport system. For cities and regions of Russia, the use of an adaptive traffic light control approach will have a noticeable social effect [9-10], as it will reduce harmful emissions from cars and improve the overall environmental situation.

References

1. Popov S.I. et al. Modelirovanie transportnykh potokov [Modeling of transport flows]. Rostov-on-Don, 2018. 284 p. (In Russ.)

2. Galchenko G.A., Drozdova O.N., Mishchenko D.A. Primenenie metoda elektromodelirovaniya k raschetu osnovnykh kharakteristik transportnykh potokov [Application of the method of electric modeling to the calculation of the main characteristics of transport flows]. Materialy foruma "Bezopasnost', doroga, deti" [Materials of the forum "Safety, road, children"]. 2015, p.141-145. (In Russ.)

3. Marchenko Yu.V., Galchenko G.A. Programmnyy kompleks modelirovaniya dvizheniya avtotransportnykh sredstv v gorodskikh usloviyakh [Complex of programs for modeling of movement of vehicles in city conditions] University News North-Caucasian Region. Technical Sciences Series. 2018;1(197):132-136. (In Russ.)

4. Kushchenko S.V. Povyshenie effektivnosti organizatsii dvizheniya na osnove modelirovaniya transportnykh potokov. Disser. [Improving the efficiency of traffic management based on traffic flow modeling. Author's abstract]. Kursk, 2012. 134 p. (In Russ.)

5. Popov S.I., Galchenko G.A., Drozdov D.S. Ispol'zovanie matematicheskikh metodov i prikladnykh programmnykh produktov dlya rascheta optimizatsii dorozhnogo dvizheniya [Use of mathematical methods and software products for the optimization calculation of road traffic]. V sb.: Issledovanie i proektirovanie intellektual'nykh sistem v avtomobilestroenii, aviastroenii i mashinostroenii ("ISMCA' 2019") Materialy III Vserossiyskoi nauch.-prakt. konf. s mezhdunar. uchastiem [In: Research and design of intelligent systems in the automotive, aircraft and mechanical engineering ("ISMCA' 2019") Proceedings of the III all-Russian scientific and practical conference with internat. participation]. 2019, p. 117-121. (In Russ.)

6. Korotkiy A.A. et al. Programmnyy kompleks postroeniya optimal'nogo marshruta pri karavannom dvizhenii transportnykh sredstv [Software package for building an optimal route for caravan traffic]. V sb.:

Innovatsionnye tekhnologii v nauke i obrazovanii (ITNO-2019) sb. trudov VII Mezhdunar. nauch.-prakt. konf., posvyashchennoi 90-letiyu DGTU [In: Innovative technologies in science and education (ITNO-2019) Proceedings of the VII international scientific-practical conference dedicated to the 90th anniversary of DSTU]. Rostov-on-Don. 2019, p. 68-71. (In Russ.)

7. Korotkiy A.A., Galchenko G.A., Drozdov D.S. Optimizatsii gruzoperevozok v logisticheskoy strukture APK. [Optimization of cargo transportation in the logistics structure of the agro-industrial complex]. V sb.: Sostoyanie i perspektivy razvitiya agropromyshlennogo kompleksa. Sb. nauch. trudov XII Mezhdunar. nauch.-prakt. konf. v ramkakh XXII Agropromyshlennogo foruma yuga Rossii i vystavki «Interagromash». Donskoy gosudarstvennyy tekhnicheskiy universitet. Agrarnyy nauch. tsentr «Donskoy». 2019, p. 721-723. (In Russ.)

8. Galchenko G.A., Popov S.I., Marchenko Yu.V. Ispol'zovanie baz dannykh na transporte. Teoriya sozdaniya: ucheb. posobie [Use of databases in transport. Theory of creation: texbook]. Rostov-on-Don: DSTU Publishing center, 2018. 111 p. (In Russ.)

9. Korotkiy A.A., Galchenko G.A., Ivanov V.V. Informatsionno-kommunikatsionnaya logisticheskaya sistema dlya optimizatsii transportnykh marshrutov v urbanizirovannoy srede [Information and communication logistics system for optimizing transport routes in an urban environment]. Vestnik Bryanskogo gos. tekh. un-ta. 2018;4(65):63-67. (In Russ.)

10. Galchenko G.A., Ostanin O.A., Ivanov V.V. Digitalizatsiya i modelirovanie optimal'nogo puti dostavki gruzov k stantsii Rostov-Tovarnaya [Digitalization and modeling of the optimal way of cargo delivery to the Rostov-Tovarnaya station]. Ekonomika i upravlenie innovatsiyami. 2018;4:61-70. (In Russ.)

Submitted 20.03.2020
Scheduled in the issue 14.04.2020

Information about the authors:

Galchenko, Galina A., Senior Researcher, Department of Operation of Vehicles and Logistics, Don State Technical University (1, Gagarin sq., Rostov-on-Don, 344000, RF), candidate of physical and mathematical Sciences, Associate Professor, ORCID: https://orcid.org/0000-0001-5966-0423, ggalchenko@inbox.ru

Burnyasheva, Mariya V., Master's degree student, Department of Operation of Vehicles and Logistics, Don State Technical University (1, Gagarin sq., Rostov-on-Don, 344000, RF), ORCID: https://orcid.org/0000-0001-6707-6198, m.burnyasheva@yandex.ru

Drozdov, Dmitriy S., Student, Department of Computer Science and Computational Experiment, Southern Federal University (105, Bolshaya Sodovaya street, Rostov-on-Don, 344006, RF), ORCID: https://orcid.org/0000-0003-0381-1012, ds-drozdov@yandex.ru

Contribution of the authors:

G. A. Galchenko — scientific supervision, formation of the main concept, goals and objectives of the research, correction of conclusions. M. V. Burnyasheva — field observations, preparation of the text, formation of conclusions. D. S. Drozdov — development of a software package, calculations, analysis of research results, revision of the text.