

Improving the Organization of Traffic in the Framework of the Development of Integrated Schemes for the Organization of Traffic for Small Cities (by the Example of Isilkul)

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Abstract— The increase in the level of motorization in the country leads to an increase in the intensity of traffic on the main highways of settlements. At the intersections of the road network, there are unacceptable, in terms of safety, conflicts of traffic and pedestrian flows. Therefore, the development of integrated traffic management schemes for small cities is an urgent task today. The article presents the features of the organization of traffic, which must be taken into account when developing complex schemes of traffic management for small cities. Reducing the total conflict load at the intersections of the road network is considered as one of the activities aimed at improving road safety. The results of studies aimed at determining the number of conflict points, as well as the results of theoretical studies confirming the validity of the proposed measures are reflected. The results of modeling of possible transport delays are presented both in the current traffic management and in the implementation of the proposed measures.

Keywords—small cities, complex traffic management scheme, conflict loading, traffic intensity, traffic delays.

I. INTRODUCTION

In accordance with Federal Law No. 443 "On the Organization of Road Traffic in the Russian Federation and on Amendments to Certain Legislative Acts of the Russian Federation" dated December 29, 2017, the development of complex traffic management schemes (CTMS) is a mandatory

component of urban planning documentation and should be periodically updated. Exactly how the availability of approved urban planning documentation (master plans, CTMS) allows municipal administrations to ensure the sustainable development of their territories. The document is equally valid both for the largest cities (with a population of over 1 million people) and for small cities whose population does not exceed 50 thousand people [1, 2].

A small part of the country's population lives in small cities, and indicators of the socioeconomic development of the regions, as well as the country as a whole, largely depend on the level of development of small cities [3]. It is the small cities that carry out the economic and sociocultural interrelation between the countryside and the large cities [2].

Developed and approved by the CTMS for a period of at least fifteen years or, for the duration of the strategic planning documents in the territory in respect of which the development of these complex schemes is carried out [1].

II. TASK ASSIGNMENT

The task of the work is to substantiate the legitimacy of applying the total conflict load as the main evaluation indicator of measures to improve the organization road traffic.

Let us conduct a simulation of possible transport delays in the current organization road traffic and after the implementation of the proposed activities.

III. THEORY

Currently, representatives of the authorities of municipalities of different levels are implementing policies aimed at shaping the strategic development of their territories. The development of the CTMS of cities in the period of total automobilization of the population becomes a priority. It is necessary to note the fact that in recent years the number of cars in cities is increasing regardless of the number of inhabitants and is not associated with the growth of population in these cities [5].

So, for example, fig. 1 shows that the number of vehicles in the city of Isilkul, over the past 5 years has increased by approximately one and a half thousand units, mainly due to passenger transport. At the same time, according to ROSSTAT, the number of residents of Isilkulsky District, over the past 5 years, has decreased from 41689 to 40125 people.

It follows from the above that, taking into account the growth rate of motorization of small cities, the intensity of traffic increases, therefore, the danger level at traffic intersections (by the number of conflicts) increases, which consequently influences the increase in the likelihood of road traffic accidents (RTA). That is why, at the stage of the development of the CTMS, it is necessary to introduce measures, primarily aimed at reducing the number of conflicts.

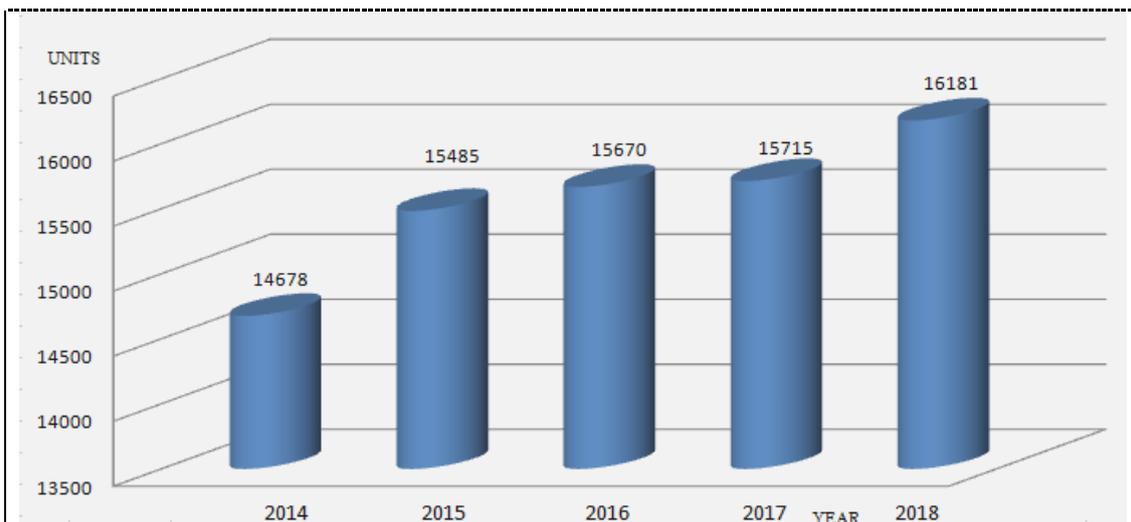


Fig. 1. The number of registered vehicles funds in Isilkulsky municipal district.

When developing the CTMS for small cities, it is necessary to take into account their following features:

1. Small cities have a rather small territorial composition.
2. As a rule, in the territory of small towns there are only 2-3 main streets, on which the main objects of mass violence are concentrated and along which the main traffic inside the city passes. The streets are usually two-lane, one lane in each direction [5].
3. The increase in the intensity of traffic and pedestrian traffic on the street road network (SRN) in small towns is observed during the lunch period of the working days of the week, on Friday and on pre-holiday days in the evening time of day.
4. RSN of small cities is practically not equipped with the necessary parking space.
5. When organizing road traffic (ORT) at intersections with traffic lights, there are unacceptable conflicts between pedestrians and vehicles in the general phase of traffic.
6. The behavior and mentality of road users (drivers and pedestrians flows) differs from residents of large cities:

pedestrians massively move the roadway in unauthorized places, while drivers take this violation for granted [6].

The above features are typical of many cities that fall under the category of "small". The improvement in the ORT, associated with the implementation of measures to reduce the number of conflicts in the development CTMS for small cities, is illustrated by the example of the town of Isilkul, Omsk Region.

IV. RESEARCH

In the city of Isilkul at three intersections (Communist street - Lenin Avenue; Communist street – street first may Day; Communist street – Telman Avenue) (fig. 2.) traffic and pedestrians are regulated by means of traffic lights of type T.1. At all intersections, a two-phase scheme traffic road organization was implemented (pedestrians move to “seeping” through traffic lights). The current level of loading approaches is in the range of 0.15-0.40.



Fig. 2. Fragment of the street road network Isilkul.

Evaluation of the effectiveness of the existing and proposed ORT at the regulated intersections of the city of Isilkul was made on the basis of calculating the conflict load of the SRN and comparing traffic delays between them.

The total conflict load of the main SRN (taking into account the conflicts of transport and pedestrian flows between each other) was calculated by the formula [7]:

$$R = 5 \sum \frac{N_{in}N_{jn}}{(N_{in} + N_{jn})^2} + 3 \sum \frac{N_{ic}N_{jc}}{(N_{ic} + N_{jc})^2} + 1 \sum \frac{N_{io}N_{jo}}{(N_{io} + N_{jo})^2}, \quad (1)$$

where $N_{ip}N_{jp}$ – intensity of movement of the flows i and j , which form the conflict point of intersection, units/day;
 $N_{ic}N_{jc}$ – intensity of the movement, respectively, of the flows i and j , which form the conflict point of the confluence of the flows, units/day;
 $N_{io}N_{jo}$ – intensity of movement of the flows i and j , forming the conflict point of the branch of the flows, units / day.

During the calculations, there are data from the survey of traffic and pedestrian traffic flow rates at the intersections of Isilkul city, carried out in accordance with the method "Investigation of peak traffic intensity (according to method C)" p.8.1. ODM 218.2.020-2012 "Guidelines for assessing the capacity of highways" [5].

V. RESULTS AND DISCUSSION

It is proposed to reduce the degree of danger at intersections of the SRN by introducing the third traffic light phase, highlighting pedestrians in a separate regulated direction, and thereby reducing the number of conflicts, eliminating the conflict «car - pedestrian» [8].

The results of the calculation of the total conflict load for three intersections with its phase separation are presented in Table 1.

Also from table 1 it is clear how much the risk indicator of conflicts decreases if one of the measures to reduce conflict points to introduce a separate (third) phase into the work of traffic lights.

The results of studies conducted at the regulated intersections of Communist street with: Lenina Avenue, street first may Day, Telman Avenue made it possible to conclude that the total conflict load at all intersections will decrease by an average of 50%, thus ensuring increased traffic safety and compliance of the scheme ORT at intersections with traffic lights to the requirements of GOST R-52289 -2004 [9].

With the achieved positive effect of the introduction of the third phase in the work of traffic lights, inevitably there will be a problem associated with an increase in traffic delays at the intersections of the city of Isilkul. Such a pattern is characteristic of sketching with the three-phase operation of traffic lights.

TABLE 1 - TOTAL CONFLICT LOADING OF INTERSECTIONS ON COMMUNIST STREET, CITY ISILKUL

Street	1 phase		2 phase	
	Before events (Phase 2)	after events (3 phases)	Before events (Phase 2)	after events (3 phases)
Lenin Avenue	2.46	0.21	4.03	1.784
street first may Day	10.41	6.01	8.14	4.09
Telman Avenue	8.97	4.87	7.33	3.28

Partially to solve this problem is proposed by:

1. Reducing the intensity of traffic flows at the approaches to intersections by outputting a part of traffic flows to the bypass road.
2. Optimization of the program of work of traffic lights.
3. Implementing off-center coordination of the work of traffic lights on the principle of the Green Wave, the key principle of which is a reference to traffic at a certain average speed and the connection of traffic lights to each other, ensuring the inclusion of green signals at the time the vehicle groups approach.

The simulation was carried out in the software product Avenue App 2.0 (Prospect 2.0) which allows you to simulate the movement of traffic, to calculate the optimal duration of cycles, phases and their shifts. In addition, the program allows to obtain information on the status of all directions of traffic on the SRN [10,11].

Fig. 3 presents the working view of the Avenue App 2.0 service, reflecting the elements of the designed SRN [10,12]. The results of experimental studies aimed at modeling traffic flows in order to optimize the coordination of traffic light regulation on the studied sections of the SRN Isilkul cities are presented in Tables 2 and 3 [10,13].

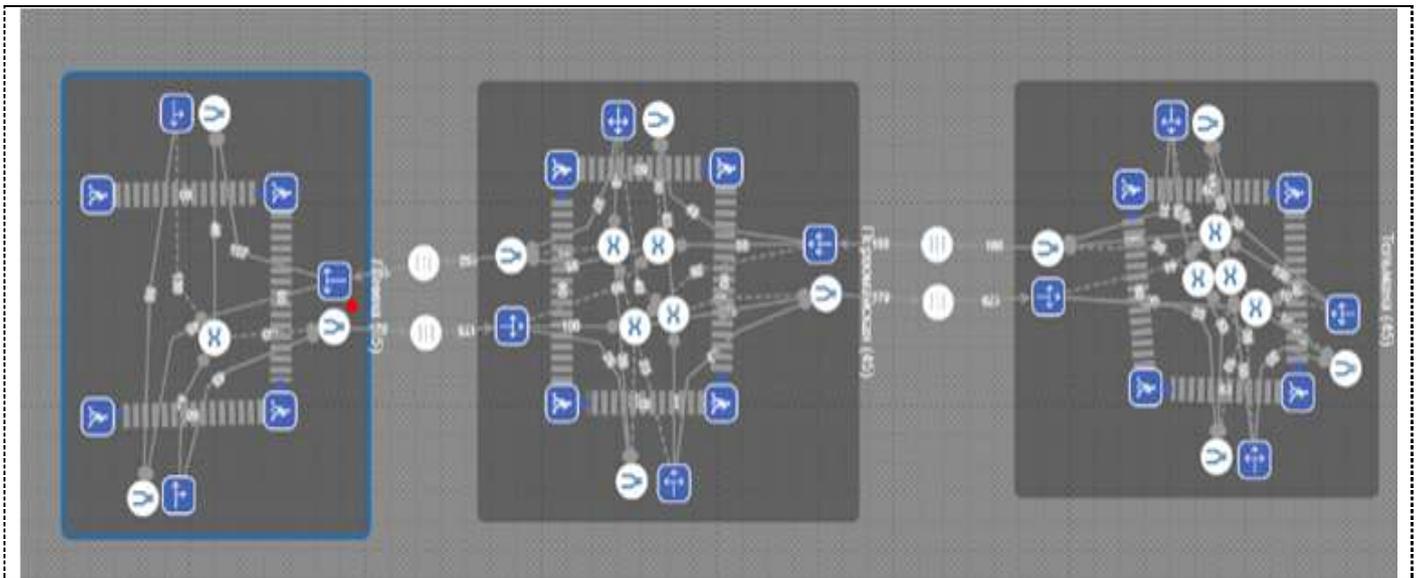


Fig. 3. Model of the SRN study area in the Avenue App 2.0 program

TABLE 2. VALUES OF TRANSPORT DELAYS AT THE EXISTING AND PROPOSED OPTION OF THE ORT AT THE INTERSECTIONS OF COMMUNIST STREETS CITY ISILKUL

Street	Average delay, auto / sec			
	Experiment (existing delay, with 2 phases)	Modeling		
		Present situation (2 phases)	With the introduction of pedestrian phase (3 phases)**	Optimized cycle (3 phases)***
Lenin Avenue	8.9	10.76	17.47	14.82
street first may Day	9.92	9.3	15.5	12.49
Telman Avenue	13.6	12.96	19.94	11.53

Note: * - the average delay was compared on the second approach
 ** - pedestrian phase = 14s.
 *** everywhere cycle = 45c.

TABLE 3. VALUES OF TRANSPORT DELAYS AT LOCAL AND COORDINATED CONTROL AT THE INTERSECTIONS OF COMMUNIST STREETS CITY ISILKUL

Street	Average delay, auto / sec			
	Without the Green Wave		Green Wave	
	Straight	Back	Straight	Back
Lenin Avenue	10.91	11.53	10.91	11.53
street first may Day	10.50	12.79	9.57	11.42
Telman Avenue	12.76	14.16	11.09	12.93

From the tables we can conclude about the effectiveness of the complex of measures proposed in the framework of the development CTMS for the city of Isilkul.

VI. CONCLUSION

When developing CTMS for small cities, it is proposed to use the total conflicting load as the main evaluation indicator of measures to improve the ORT. In the development of schemes ORT in small cities, this indicator provides objectivity in comparing transport solutions.

One of the options for reducing conflict points at intersections of the SRN with traffic lights is to add a third (pedestrian phase) to the traffic lights.

To minimize the negative consequences associated with the introduction of the pedestrian phase, it is proposed to introduce coordination of the work of traffic lights on the principle of the Green Wave and to bring some of the traffic to the street doublers.

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