References

1. Sidorovich, A. A. Gorodskie poseleniya Belarusi: formirovanie seti i sovremen-nyj social'no-ekonomicheskij profil' : monografiya / A. A. Sidorovich ; M-vo ob-razovaniya Resp. Belarus', Brest. gos. un-t im. A. S. Pushkina. – Brest : BrGU, 2024. – 263 s.

2. Administrativno-territorial'noe ustrojstvo BSSR : spravochnik : v 2 t. / Glav-noe arhivnoe upravlenie pri Sovete ministrov BSSR, Institut filosofii i pra-va Akademii nauk BSSR ; otv. sost.: A. I. Karpacheva. – Minsk : Belarus', 1985. – T. 1. – S. 86–87.

3. Ob obrazovanii Baranovichskoj, Belostokskoj, Brestskoj, Vilejskoj i Pinskoj oblastej v sostave Belorusskoj SSR [Elektronnyj resurs] : Ukaz Prezidiuma Verhovnogo Soveta SSSR, 4 dek.1939 g. // Elektronnaya biblioteka istoricheskih dokumentov. – Rezhim dostupa: https://docs.historyrussia.org/ru/nodes/131068-ob-obrazovanii-baranovichskoy-belostokskoy-brestskoy-vileyskoy-i-pinskoy-oblastey-v-sostave-belorusskoy-ssr-ukaz-ot-4-dekabrya-1939-g. – Data dostupa: 22.11.2023.

4. Sbornik zakonov Belorusskoj SSR i ukazov Prezidiuma Verhovnogo Soveta Belorusskoj SSR / Sost. E. Ya. Burdzevickij [i dr.]. – T. 1 : 1938–1973 gg. – Minsk : Prezidium Verhovnogo Soveta BSSR, 1974. – 670 c.

5. Dogovor mezhdu Soyuzom Sovetskih Socialisticheskih Respublik i Pol'skoj Res-publikoj o sovetsko-pol'skoj gosudarstvennoj granice [Elektronnyj resurs] : [zaklyuchen v g. Moskva 16.08.1945 g.] // ETALON-ONLINE. Zakonodatel'stvo Res-publiki Belarus' / Nac. centr pravovoj inform. Resp. Belarus'. – Minsk, 2024.

6. Elizarov, S. A. Formirovanie i funkcionirovanie sistemy administrativno-territorial'nogo deleniya BSSR (1919–1991 gg.) / S. A. Elizarov. – Gomel' : GGTU im. P. O. Suhogo, 2009. – 222 s.

7. V agrogorodke Molotkovichi postroili pervyj v Pinskom rajone sborno-monolitnyj zhiloj dom [Elektronnyj resurs] // Mediaholding «Varyag». – Rezhim dostupa: https://varjag.net/v-agrogorodke-molotkovichi-postroili-pervyj-v-pinskom-rajone-sborno-monolitnyj-zhiloj-dom/. – Data dostupa: 30.05.2024.

УДК 656

INTRODUCTION OF A SEPARATE PEDESTRIAN REGULATION PHASE AS A MEANS OF REDUCING EMERGENCY LOSSES IN ROAD TRAFFIC

D. P. Khodoskin, *Ph.D. (Eng.), Associate Professor of the Department of "Automobile Transportation and Road Traffic Management"*
A. S. Atamanenko, *Master's student Belarusian State University of Transport, Gomel, Republic of Belarus, e-mail: dlya_moih_studentov@mail.ru*

Abstract

The annual growth of the intensity of transport and pedestrian flows in the Republic of Belarus also directly affects road safety. In most countries, accidents in motor transport have become one of the most important socio-economic problems. It is no coincidence that the UN Road Safety Regulations characterize it as a global crisis.

More than 270 thousand pedestrians die on the roads of the world every year. Globally, pedestrians account for 22 % of the total number of deaths as a result of road accidents, and in some countries - up to two thirds of such cases. In addition, millions of pedestrians are injured in accidents, and some of the victims become disabled for life. These accidents, in addition to personal "losses", also lead to emergency (and other!) losses, for which the state "pays" [1]. An effective measure aimed at improving pedestrian safety is the optimization of the traffic light regulation cycle, with a separate phase for pedestrian movement.

Keywords: pedestrian regulation phase; regulated intersection; pedestrian crossing; accidents; traffic delays.

ВВЕДЕНИЕ ОТДЕЛЬНОЙ ПЕШЕХОДНОЙ ФАЗЫ РЕГУЛИРОВАНИЯ КАК СРЕДСТВО СНИЖЕНИЯ АВАРИЙНЫХ ПОТЕРЬ В ДОРОЖНОМ ДВИЖЕНИИ

Д. П. Ходоскин, *к. т. н, доцент кафедры управления автомобильными перевозками и дорожным движением, Белорусский государственный университет транспорта, Гомель, Республика Беларусь*

А. С. Атаманенко, *магистрант, Белорусский государственный университет транспорта, Гомель, Республика Беларусь, e-mail: dlya_moih_studentov@mail.ru*

Реферат

Ежегодный рост в Республике Беларусь интенсивности транспортных и пешеходных потоков непосредственно сказывается также на безопасности дорожного движения. В большинстве стран аварийность на автомобильном транспорте превратилась в одну из важнейших социально-экономических проблем. Не случайно положение о безопасности дорожного движения ООН характеризует как глобальный кризис.

Ежегодно на дорогах мира погибают более 270 тыс. пешеходов. В глобальных масштабах на долю пешеходов приходится 22 % общего числа случаев смерти в результате ДТП, а в ряде стран – до двух третей таких случаев. Кроме того, миллионы пешеходов получают в ДТП ранения, причем некоторые из пострадавших становятся инвалидами на всю жизнь. Эти несчастные случаи кроме личной «потери», а также приводят к возникновению аварийных (и не только!) потерь, за которые «расплачивается» государство [1]. Действенным мероприятием, направленным на повышение безопасности пешеходов, является оптимизация цикла светофорного регулирования, с выделением отдельной фазы для движения пешеходов.

Ключевые слова: пешеходная фаза регулирования; регулируемый перекресток; пешеходный переход; аварийность; задержки движения.

Introduction

The most vulnerable and unprotected road users are pedestrians and cyclists. Conflict situations (and, unfortunately, road accidents) on the streets involving pedestrians occur both due to the fault of the pedestrians themselves and due to the fault of car drivers, which often ends in death.

Improving the conditions of motor transport in modern cities requires the use of a whole range of architectural, planning and technical measures. While the implementation of road and architectural planning measures requires, in addition to significant capital investments, a fairly long period of time, measures related to the organization of road traffic can provide a quick effect, and in some cases act as the only means of solving transport problems.

Very often, at regulated pedestrian crossings, pedestrians cross the road together with parallel moving (turning) vehicles. In this case, conditionally permissible conflicts arise between turning vehicles and pedestrians, i. e. there is a risk of an accident involving turning vehicles and pedestrians. The organization of a separate pedestrian phase reduces the number of such conflicts and, as a consequence, accidents. Additionally, it becomes possible to organize a diagonal pedestrian crossing, where pedestrians have the opportunity to cross the controlled intersection diagonally.

Main part. The article considers an example of calculation for the implementation of a separate pedestrian phase at the controlled intersection of Uralskaya Street - Frolikova Street in Minsk (a satellite image of the design site is shown in figure 1) in order to reduce the number of conflicts with pedestrians and, accordingly, the number of accidents.

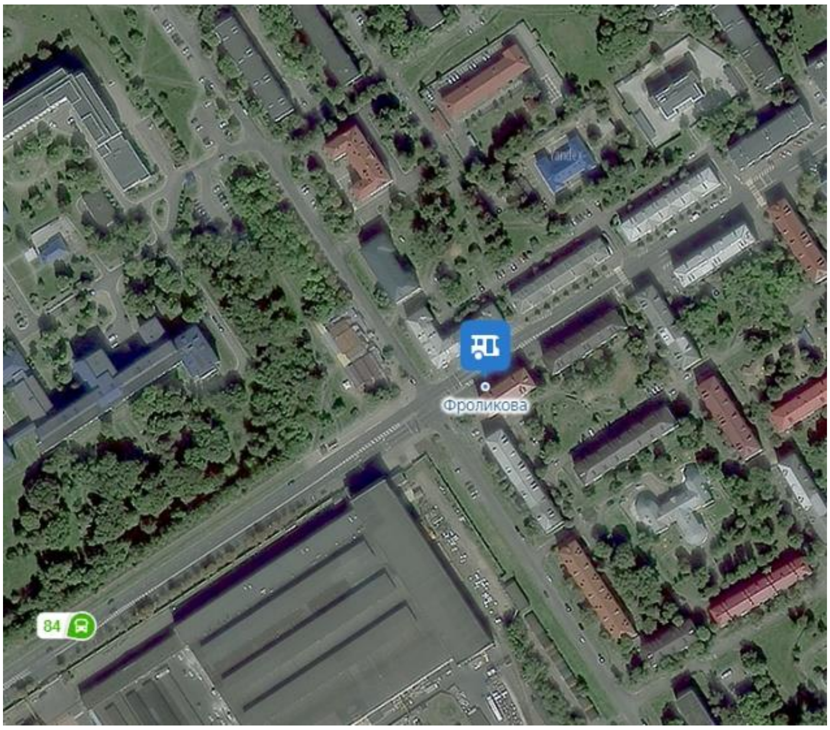

Figure 1 – Satellite image of the object under study

To perform calculations and subsequent assessment, a number of data about the object are required: a scale plan of the intersection (figure 2), the existing phased traffic scheme (figure 3), the existing traffic light control diagram (figure 4).

The assessment of the introduction of an additional pedestrian phase was carried out using the traffic light cycle optimization in the TRANSYT program. This is a computer simulation macroscopic modeling tool that is used to design, model and optimize both individual isolated intersections and large and complex transport networks. Due to the international wide expediency of using TRANSYT, it is currently one of the most widely used programs in the world related to the optimization of the duration of traffic light cycles.

The main capabilities of the TRANSYT program are the following [1]:

– the ability to use various research techniques (neural networks and other algorithms);

– a large number of objective functions used for optimization: combinations of progression capabilities, delays, stops, fuel consumption, throughput, queue accumulation;

– the ability to orient the optimization process to achieve specific goals;

– the ability to optimize the parameters of traffic light objects (cycle duration, phase sequence, phase duration, offset).

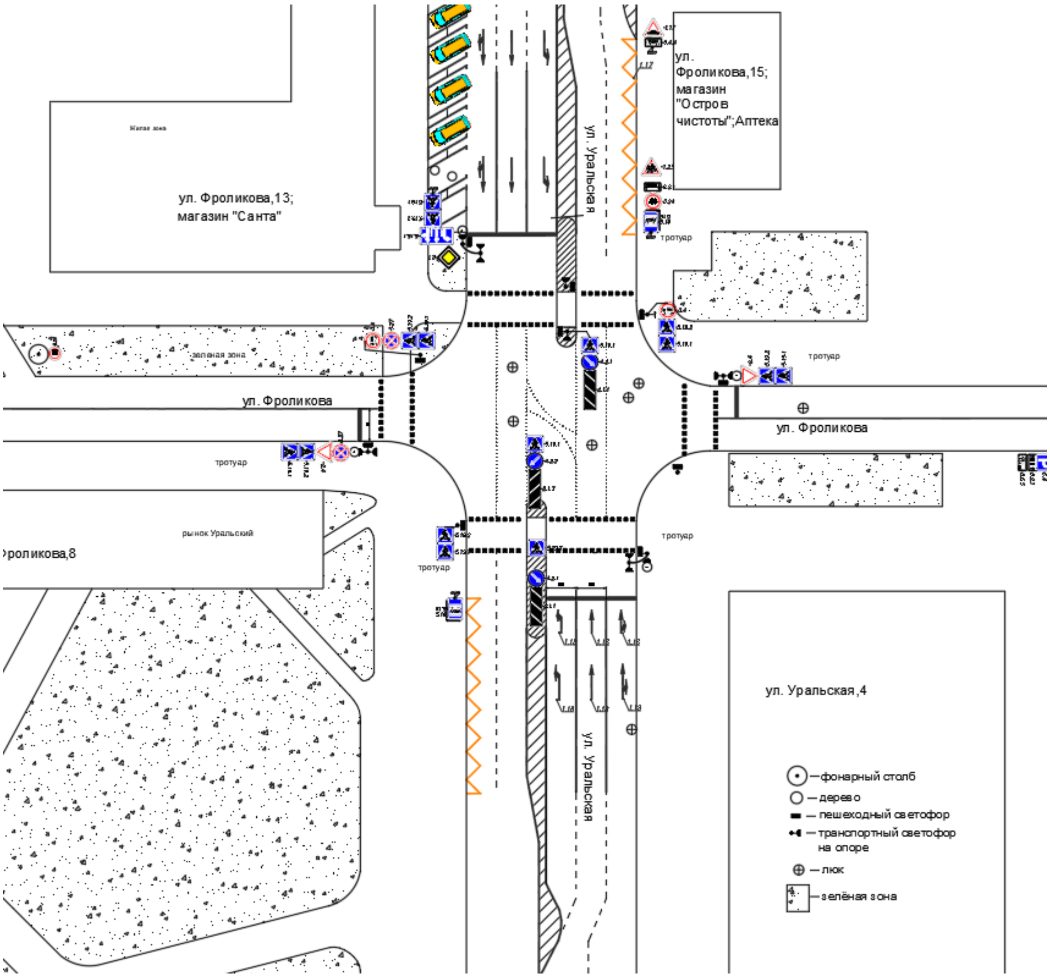

Figure 2 – Traffic management scheme at the site under study

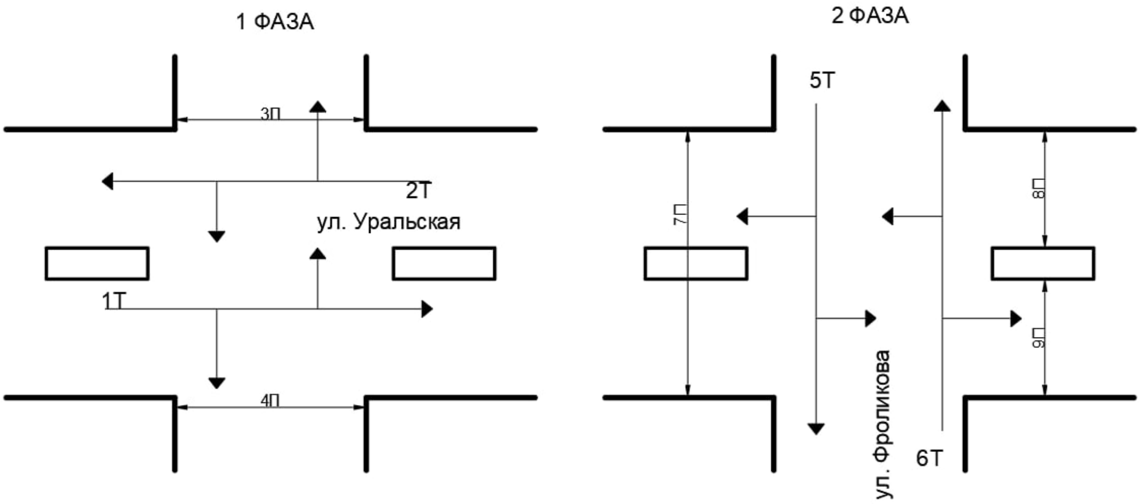

Figure 3 – Existing scheme of phased movement at the intersection

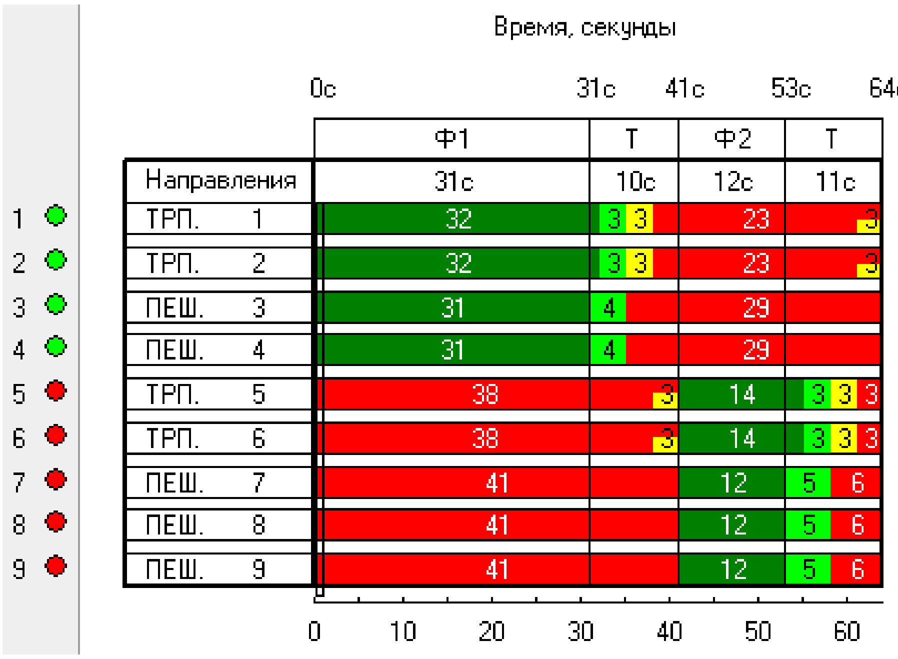

Figure 4 – Existing traffic light control diagram

TRANSYT-7FR optimizes the operation modes of traffic light objects by performing macro-modeling of the TP over small time intervals taking into account the possibility of varying the plan parameters. Important properties of the TRANSYT-7FR optimization process are the wide possibilities of using various search techniques (associated with the shortest descent method and genetic algorithm), the diversity of target functions to be optimized in various combinations (for example, combinations of the functions of unimpeded movement, delay, stop, fuel consumption, throughput and queue accumulation), the possibility of adapting the process within wide limits and the ability to optimize the parameters of the cycle duration and the choice of sequence, duration and phase offset.

Optimization of traffic light control parameters and adjustment of the phased passing were performed using the ArteryLite (TRANSYT) software package according to the following algorithm.

The first step is to create a new TRANSYT model.

The second step is to create traffic lanes.

Menu "Edit" – "Lanes". We create lanes in all directions: north, south, west, east. You can also select the menu command "Edit" – "Lanes" – "All approaches", which leads to the automatic opening of four copies of the window, one for each of the approaches to the intersection.

Figure 5 shows the initial window "Configuration of lanes at the intersection".

Window parameters (figure 5):

Lane Usage: the drop-down list contains a list of options for using the lane whose number is selected in the adjacent field: L – left turn, T – straight ahead, R – right, LT – left and straight ahead, LR – left and right, TR – straight ahead and right, LTR – left, straight ahead and right.

Analysis Type: the radio button allows you to select one of the analysis options – «Lane Group» or (more precise) «By Lanes».

Approach Direction: the approach to the intersection is selected in the drop-down list.

Distance: the input field specifies the distance on the current approach to the intersection from the previous intersection.

Intensity: the traffic intensity in each direction of the segment is indicated (vehicles per hour).

Rush Hour Factor: the input field is designed to set the rush hour factor (PHF) for the three standard directions of travel.

Turn Zone Capacity: The input field defines the capacity of the car queue in the left and right turn directions.

Add/Delete: The button allows you to create and delete lanes similar to the above-mentioned option in the diagram context menu.

Node Number: The menu for switching between intersection nodes.

The third step is to use the Intersection Traffic window. The Edit – Traffic menu to view and edit the flow rates and other traffic parameters (figure 6).

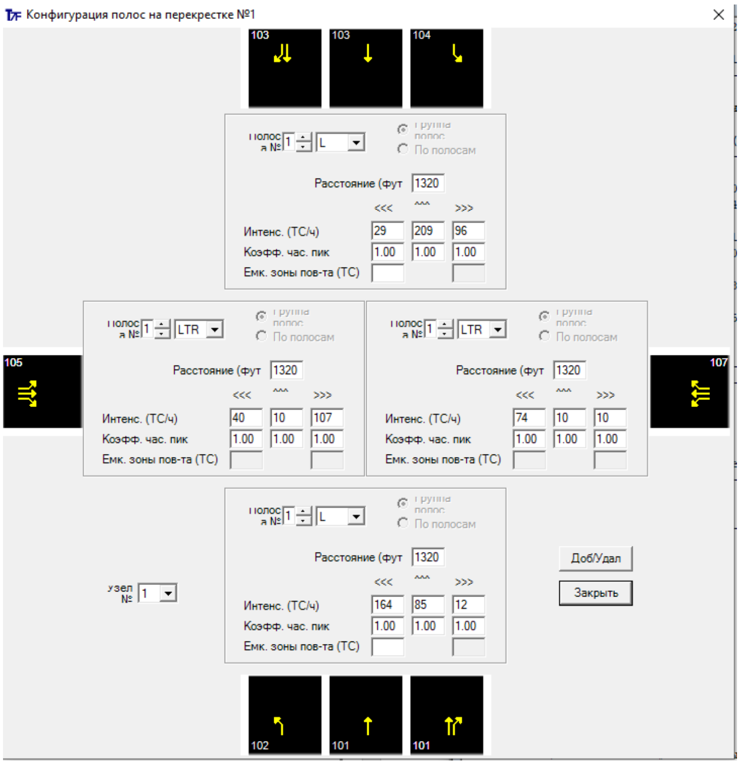

Figure 5 – «Intersection Lane Configurations»

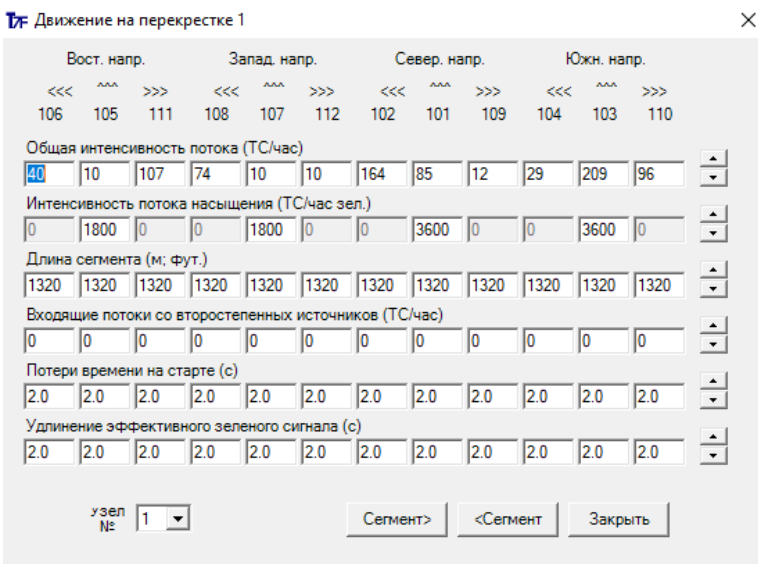

Figure 6 – Editing flow intensity and other movement parameters

The fourth step is setting phase tables (figure 7).

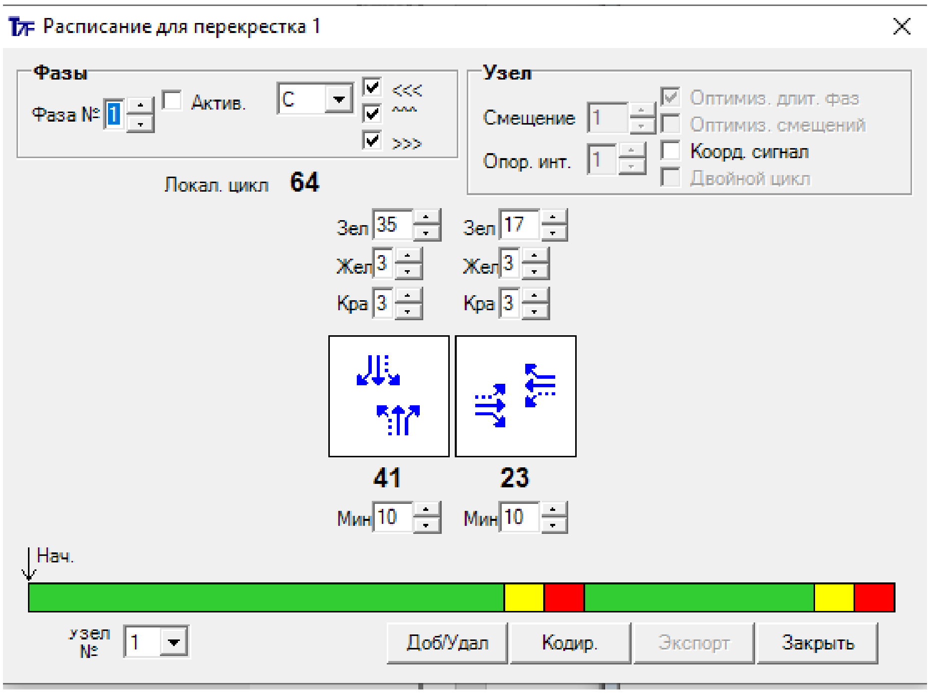

Figure 7 – Creating Phase Tables

Window parameters (figure 7):

Phase #: the content of the field indicates which phase is subject to editing.

Active: the checkbox determines whether the phase is active. The TRANSYT model assumes that if a specific direction of movement allows a phase to be updated or terminated, such a phase is considered active.

N / S / W / E: the approach (north/south/west/east) to be edited is selected from the list.

<<< (left) / ^^^ (straight) / >>> (right): the checkboxes are used to indicate which directions are active during the current phase, as well as to add or remove phases from the schedule.

Coordinated signal: set if the node is part of a coordinated network.

Minimum: the field is used to set the minimum duration of the phase (where the phase duration is equal to the sum of the lengths of the green, yellow and common red signal intervals).

Node number: Menu for switching between intersection nodes.

Phase diagram: The phase diagram is a graphical representation of the schedule. Inactive phases are indicated by blue arrows, while active phases are gray. Solid arrows correspond to preferred directions, while dashed arrows correspond to permitted directions.

Line diagram: The line diagram, along with the phase diagram, is one of the most important components of the Schedules window. When viewed from left to right, the diagram provides a space-time representation of the schedule. The horizontal axis represents the duration of the cycle and intervals. The width of each interval in the diagram is proportional to its duration. The line diagram is consistent with the phase diagram: the initial intervals on the left are associated with the first phase, while the final intervals, located on the right, are associated with the last phase.

Offset: The difference in seconds between the start times of green signals at adjacent signalized intersections.

Reference interval: Changing the value results in an offset of the start of the cycle. Add/Delete: Clicking on the button allows you to easily add or delete any phase for the active intersection.

Export: The button allows you to export data including cycle length, offsets and phase durations for the corresponding node to a CORSIM input file (*.TRF) (CORSIM is a microscopic traffic simulation program that compares candidate schedules obtained from TRANSYT-7FR optimization in its own simulation system).

Step 5 – Calculation of saturation flows.

This screen is designed to help the user adjust the saturation flow intensity values. If the adjusted saturation flow intensity values are already known, they can be entered directly on the Traffic screen and the calculator window is not needed at all. The pedestrian influence on turning traffic (none / minor / moderate / major) is also specified on this screen (figure 8).

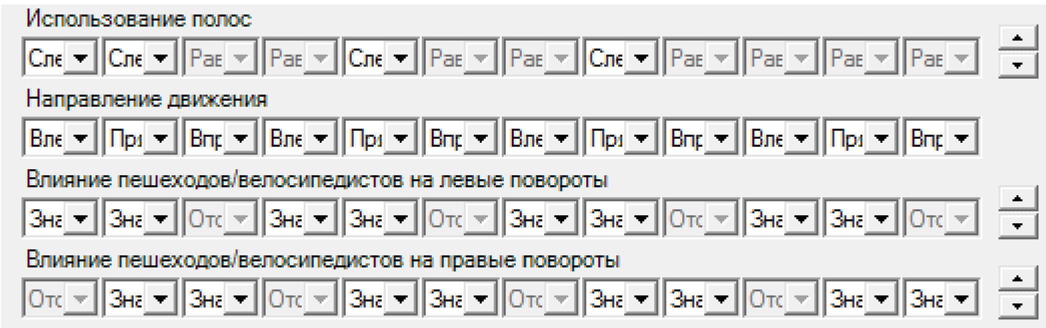

Figure 8 – "Saturation Flow" Window

The "Calculation Parameters" window opens after pressing the "OK" button in the "Create TRANSYT Input File" window or is called up via the "Edit" – "Analysis" menu (figure 9).

After entering all the data, if no errors were detected, a report on the current transport data will appear on the screen.

Системные характеристики :для всех узлов

Основные показатели	единицы	Системное значение
Полн.пробег	а-мл/ч	211
Время полн.пробега	а-ч/ч	9
Полн.стан. з-жка	а-ч/ч	4
Полн.случ.з-жка	а-ч/ч	1
Общая з-жка	а-ч/ч	5
Сред.з-жка	сек/а	22.5
З-жка пассжр.	рах-а/ч	6
Станд.ост-ки:	а/ч	614
	%	73
Случ.ост-ки:	а/ч	86
	%	10
Полн.ост-ки:	а/ч	700
	%	83
Степ.насыщ. > 1	# Сегменты	0
Удлин.оч-ди	# Сегменты	0
Время в пробке	%	0
Длина периода	сек	900
Сист. Ск-сть	mph	24.0
Расх. Топл.	гал/ч	25
Опер.затраты	$/ч	241
Индекс невыгодности	DI	5.3
Индекс эф-сти	Thru/DI	647.9

Figure 9– Window "Results of the existing regulation"

Calculation of the pedestrian phase:

At intersections and pedestrian crossings, the duration of the main beats must be checked for the possibility of passing pedestrians in the corresponding directions across the roadway. In accordance with the methodological recommendations, the time required for pedestrians to cross the roadway is calculated using the following formula [1]

$$t_{пш} = \frac{B_{пч}}{V_{пш}} + 5,$$

where $B_{пч}$ – is the width of the roadway crossed by pedestrians, m;

$V_{пш}$ – is the speed of pedestrians, $V_{пш}$ = 1,3 m/s.

The width of the roadway of pedestrian crossings at entrances I, II, III and IV is 19, 7.5, 20 and 8 meters, respectively.

Let us determine the duration of the permissive signal for pedestrians in each direction:

$$t_{пш1} = \frac{19}{1,3} + 5 = 19,6 \text{ с};$$
$$t_{пш2} = \frac{7,5}{1,3} + 5 = 20,3 \text{ с};$$
$$t_{пш3} = \frac{20}{1,3} + 5 = 10,7 \text{ с};$$
$$t_{пш4} = \frac{8}{1,3} + 5 = 11,2 \text{ с}.$$

Since pedestrians will cross any of the 4 pedestrian crossings (simultaneously), we select the maximum time. Thus, the duration of the pedestrian phase is 21 s.

Conclusion. The results of the work in the TRANSYT "Optimization" program are presented in figures 10 and 11.

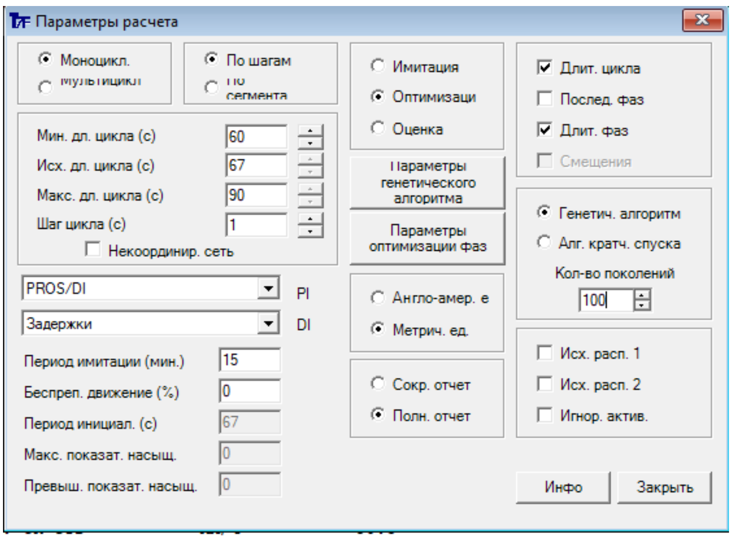

Figure 10 – "Calculation Parameters Optimization" window

Системные характеристики :для всех узлов

Основные показатели	единицы	Системное значение
Полн.пробег	а-мл/ч	211
Время полн.пробега	а-ч/ч	8
Полн.стан. з-жка	а-ч/ч	4
Полн.случ.з-жка	а-ч/ч	1
Общая з-жка	а-ч/ч	5
Сред.з-жка	сек/а	19.5
З-жка пассжр.	pax-а/ч	6
Станд.ост-ки:	а/ч	592
	%	70
Случ.ост-ки:	а/ч	80
	%	9
Полн.ост-ки:	а/ч	672
	%	79
Степ.насыщ. > 1	# Сегменты	0
Удлин.оч-ди	# Сегменты	0
Время в пробке	%	0
Длина периода	сек	900
Сист. Ск-сть	mph	26.1
Расх. Топл.	гал/ч	24
Опер.затраты	$/ч	233
Индекс невыгодности	DI	4.6
Индекс эф-сти	Thru/DI	756.6

Figure 11 – Result of work in the TRANSYT program "Optimization"

Similar calculations in the program were carried out for each time period, the results are given in table 1.

Table 1 – Delays of vehicles with existing and proposed regulation

Time period	Existing delays, s/a	Delays in the implementation of the pedestrian phase, s/a
07:00-08:00	22,5	19,1
09:00-10:00	17,1	15,4
11:00-12:00	17,0	14,8
13:00-14:00	17,0	14,2
15:00-16:00	18,2	15
17:00-18:00	22,9	19,8
19:00-20:00	18,3	16,3
Average	19,0	16,4

Thus, as a result of the introduction of an additional pedestrian phase, the average delays of vehicles will change by 14% from 19.0 s to 16.4 s.

As a result of the calculations, a new traffic light control diagram was proposed, as well as a phased passing scheme with the organization of a separate pedestrian phase (figures 12, 13).

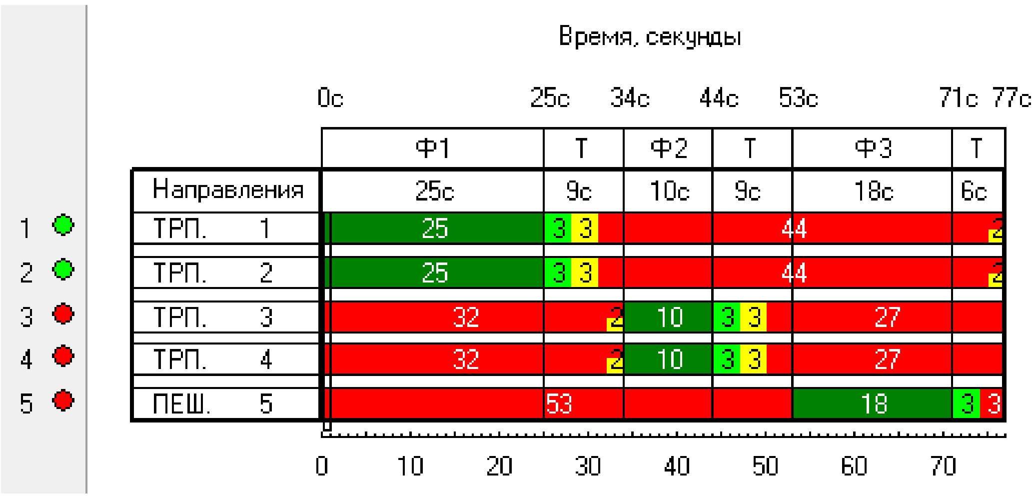

Figure 12 – Proposed traffic light control diagram

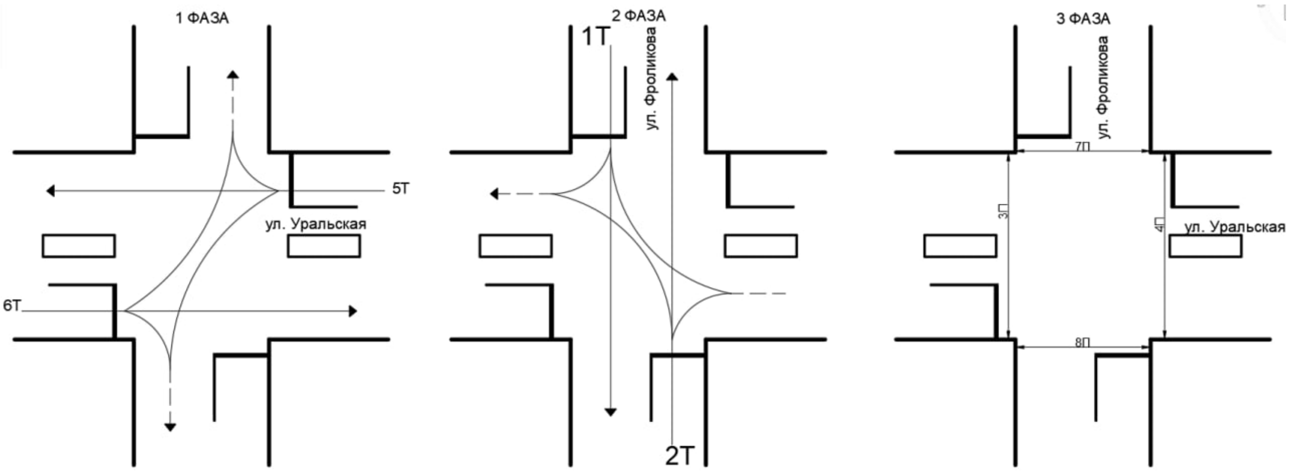

Figure 13 – Proposed scheme of phased passing

Table 2 shows the results of calculating the total delays for the existing and proposed control options.

Table 2 – Results of calculating delays

Time	Existing regulation, transport delays, sec.	Proposed regulation, transport delays, sec.	Effect, %	Existing regulation, pedestrian delays, sec.	Proposed regulation, pedestrian delays, sec.	Effect, %
07:00-08:00	18544,0	17669,4	5	5830,9	5904,8	-1
09:00-10:00	16205,2	14123,3	13	5508,1	5649,3	-3
11:00-12:00	16489,2	14506,4	12	4206,8	4061,8	3
13:00-14:00	17959,8	16635,6	7	5988,8	5822,4	3
15:00-16:00	15315,3	13387,5	13	5488,9	5622,8	-2
17:00-18:00	25600,4	22785,8	11	6858,5	6835,7	0
19:00-20:00	12840,7	12254,3	5	4166,5	4289,0	-3
Среднее	17564,9	15908,9	9	5830,9	5654,2	3

Thus, based on the analysis of the data in Table 2, the introduction of a separate pedestrian phase will reduce traffic delays by an average of 9%, and pedestrian delays by an average of 3%.

Thus, to increase the level of road safety in accidents between pedestrians and turning vehicles at controlled intersections with intense pedestrian traffic, the introduction of separate pedestrian phases is a fairly effective measure. However, in the event of design flaws or errors in the implementation of such a project, the number of collisions with pedestrians may, on the contrary, increase.

References

1. Arterylite / Arterylite: a unique tool for optimizing the operating modes of traffic lights. – 2024. – URL: http://www.arterylite.ru (date of access: 23.04.2024).