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SIMULATION MODELING OF ADJUSTABLE RAILWAY CROSSINGS

ИМИТАЦИОННОЕ МОДЕЛИРОВАНИЕ РЕГУЛИРУЕМЫХ ЖЕЛЕЗНОДОРОЖНЫХ ПЕРЕЕЗДОВ

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Abstract. *A simulation model of the movement of vehicles through adjustable railway crossings on Saltanovka – Zhlobin section in GPSS World simulation system is proposed. The developed simulation model makes it possible to determine the characteristics of crossings and can be used to justify the choice of an option to improve traffic conditions through railway crossings – the installation of additional traffic lanes, the construction of an overpass, the closure of one of the crossings.*

Keywords: *adjustable railway crossing, simulation modeling, queuing systems, GPSS modeling system.*

Introduction.

Railway crossings are the places of greatest danger for the movement of road and rail transport. Taking into account the great inertia of railway transport, the preferential right of movement at crossings is granted to railway transport. Its unhindered movement along the railway crossing is excluded only in case of an emergency. In this case, a barrier alarm of automatic or non-automatic action is provided.

The intersection of highways with railway tracks at the same level is the most difficult and dangerous element of the road network, which has a significant impact on efficiency of operation of road and railway transport in general.

The problem of railway crossings is also very important because more than half of total numbers of crossings are located on the routes of main passenger traffic.

Over the many years that have passed since the opening of crossings, as a result of reconstruction, the parameters of highways on the approaches to crossings have changed. The daily traffic intensity of cars has increased significantly, the number of trains by railway has raised with a simultaneous increase in traffic speeds. Currently, the traffic intensity in the Republic of Belarus exceeds 5 thousand cars per day by more than 30% of crossings.

Due to the limited capacity of intersections of roads and railways at the same level, because of the frequency and duration of the closure of crossing at high traffic density, long queues at the approaches to the crossings, which sharply exacerbates the problem of costs in road transport. In these conditions, the number of violations of traffic rules by drivers at railway crossings increases, which rises the likelihood of a risk of road accidents.

The high coefficient of severity of the consequences of accidents is caused by the incommensurability of the masses of train and vehicles. Road traffic accidents at crossings are usually accompanied by a large number of victims.

The urgency of the problem of improving road safety at intersections of highways with railways requires the development and approval of a long-term strategy for eliminating intersections of roads and railways at the same level.

Statement of basic materials.

The number of railway crossings in the Republic of Belarus, as well as throughout the world, tends to gradually decrease due to the construction of interchanges at different levels or the closure of inactive crossings. Replacing a railway crossing with a transport interchange at different levels is the best way, especially in places where intersections at the same level cannot provide sufficient capacity and security. However, the implementation of such events is everywhere constrained by economic problems and long deadlines for their implementation.

Consider the railway section of Saltanovka - Zhlobin (Gomel region, Republic of Belarus) on which three adjustable railway crossings are located.

The characteristics of crossings on Saltanovka - Zhlobin section are presented in Table 1.

Table 1

Characteristics of crossings of Saltanovka - Zhlobin section

km+m	Number of trains per day	Number of vehicles per day	Running time, min	v_{fr} / v_{pas}	Location	Type of alarm
264+7	66	163	3	80/140	Embankment, curve	Automatic
277+9	66	94	7	80/140	Embankment, straight	Automatic, traffic light
280+7	66	5717	2	80/100	Embankment, curve	Automatic, traffic light

Authors` development

When considering the indicators of road traffic through adjustable railway crossings, it is necessary to highlight those that are the most important. These include the traffic intensity of vehicles, the composition of traffic flow, the existing traffic management scheme and the operation of traffic lights. The railway crossings have 2 entrances. Traffic lights and barriers are used to regulate the movement of vehicles at adjustable railway crossings. Barriers and traffic lights are installed at both entrances. The traffic pattern through railway crossings is shown in Figure 1.

The purpose of the work is to develop simulation model of movement of vehicles through adjustable railway crossings on Saltanovka – Zhlobin section to analyze the operation of crossings and substantiate options for improving traffic conditions through railway crossings and closing one of crossings.

Model of movement of vehicles through adjustable railway crossing can be presented as a queuing system. Its graphic image is shown in Figures 2.

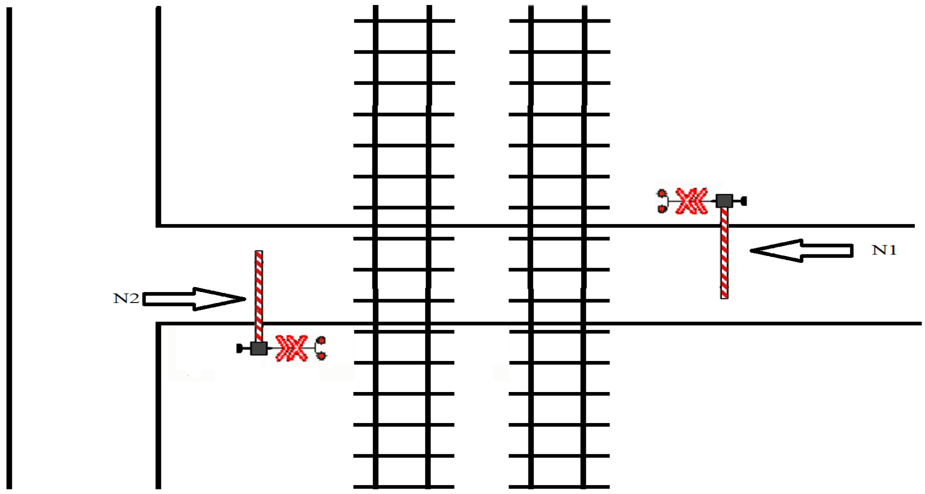

Fig. 1 Traffic flow diagram on adjustable railway crossing

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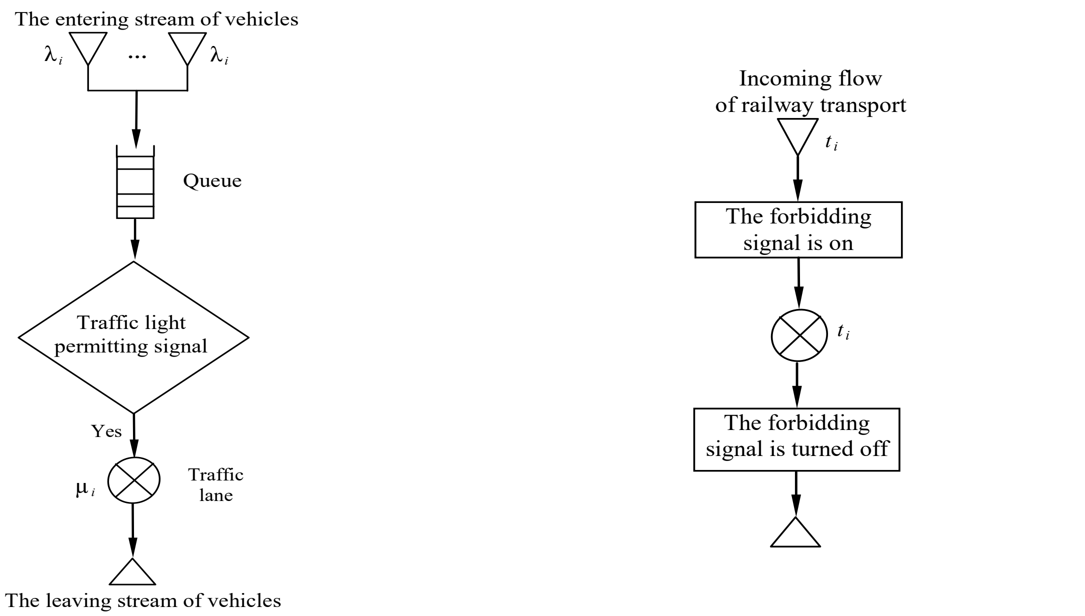

a) the movement of vehicles through adjustable railway crossing

b) Organization of traffic light operation

Fig. 2 Model of adjustable railway crossing

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As modeling criteria, the following are considered:

– the average travel time through a railway crossing by vehicle, including the average downtime of vehicles in the queue before moving;
– the number of motor vehicles that have passed the railway crossing without stopping;
– the maximum and average lengths of queues of vehicles before the railway crossing.

Since railway crossings are represented by a queuing system in which all events are associated with the movement of vehicles – dynamic objects, in this case it is advisable to use a transactional method of formalizing the components of the simulation model.

The GPSS World simulation automation package is used as a means of automating the simulation of adjustable railway crossings on Saltanovka – Zhlobin section [2-4].

Simulation results the movement of vehicles through railway crossings in the time period 7:00 - 10:00 are presented in Table 2.

Table 2

Simulation results of railway crossings

Characteristics / km + m	Crossing №1 (264+7)	Crossing №2 (277+9)	Crossing №3 (280+7)
Forward direction			
Average queue length of vehicles, η	0,704	0,659	0,296
Queue downtime, ω sec.	21,190	26,366	17,707
Number of vehicles that have passed the crossing without stopping, %	38	32	46
Reverse direction			
Average queue length of vehicles, η	0,349	0,580	0,379
Queue downtime, ω sec.	21,012	26,348	17,105
Number of vehicles that have passed the crossing without stopping, %	38	32	47
Railway crossing load factor, ρ	0,498	0,564	0,406
Time of passage by train of a road section	15 min		

As a result of the simulation, it was decided to close the second crossing (km 277+9). Simulation results the movement of vehicles through railway crossings are presented in Table 3.

Table 3

Simulation results of railway crossings after the closure of the second crossing

Characteristics / km + m	Crossing №1 (264+7)	Crossing №3 (280+7)
Forward direction		
Average queue length of vehicles, η	0,708	0,468
Queue downtime, ω sec.	21,247	20,980
Number of vehicles that have passed the crossing without stopping, %	37	38
Reverse direction		
Average queue length of vehicles, η	0,347	0,530
Queue downtime, ω sec.	20,892	21,239
Number of vehicles that have passed the crossing without stopping, %	38	38
Railway crossing load factor, ρ	0,499	0,495
Time of passage by train of a road section	14 min	

Conclusions.

The developed simulation model of the movement of vehicles through adjustable railway crossings allows to determine the characteristics of crossings (average queue length and queue downtime of vehicles, number of vehicles that have passed the crossing without stopping, railway crossing load factor, time of passage by train of a road section) and can be used to justify the choice of an option to improve traffic conditions through railway crossing – the device of additional traffic lanes, the construction of an overpass, the closure of one of crossings.

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Аннотация. *Железнодорожные переезды являются «узким местом», так как не справляются с возрастающими транспортными потоками, резко ограничивающими пропускную способность автомобильной дороги. Рост интенсивности движения транспорта через железнодорожные переезды приводит к увеличению числа дорожно-транспортных происшествий в местах их расположения. Предложена имитационная модель движения транспортных средств через регулируемые железнодорожные переезды на участке Салтановка – Жлобин в системе имитационного моделирования GPSS World. Разработанная имитационная модель позволяет определять характеристики переездов и может быть использована при обосновании выбора варианта улучшения условий движения через железнодорожные переезды – устройства дополнительных полос движения, строительства путепровода, закрытия одного из переездов.*

Ключевые слова: *регулируемый железнодорожный переезд, имитационное моделирование, системы массового обслуживания, система моделирования GPSS.*

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