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METHOD OF DYNAMIC TRAFFIC MANAGEMENT AT A RAILWAY CROSSING

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Abstract. *The method of dynamic traffic control for complex and dangerous road sections implies a vehicle speed reduction in order to increase the road capacity. The use of speed reduction method on the approach to the railway crossing to improve the road safety and increase the crossing area by installing additional controlled traffic signs to display the speed mode along with time of railway crossing closing for road vehicles.*

Key words: *controlled traffic signs, vehicle speed mode, road capacity, access to the railway crossing, the risk of accidents, drivers' informational support, dynamic traffic management.*

СПОСОБ ДИНАМИЧЕСКОГО УПРАВЛЕНИЯ АВТОМОБИЛЬНЫМ ДВИЖЕНИЕМ НА ЖЕЛЕЗНОДОРОЖНОМ ПЕРЕЕЗДЕ

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Аннотация. *Рассмотрены вопросы повышения безопасности движения автомобильного транспорта через железнодорожные переезды. Предложено управление скоростным режимом автотранспортных средств на подходе к переезду с учетом времени закрытия переезда и места установки дополнительных средств регулирования – информационных дорожных знаков.*

Ключевые слова: *безопасность дорожного движения, управления дорожным движением, технические средства регулирования.*

СПОСІБ ДИНАМІЧНОГО КЕРУВАННЯ АВТОМОБІЛЬНИМ РУХОМ НА ЗАЛІЗНИЧНОМУ ПЕРЕЇЗДІ

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Анотація. *Розглянуті питання підвищення безпеки руху автомобільного транспорту через залізничні переїзди. Запропоновано керування швидкісним режимом автотранспортних засобів на підході до переїзду з урахуванням часу закриття переїзду та місця встановлення додаткових засобів регулювання – інформаційних дорожніх знаків.*

Ключові слова: *безпека дорожнього руху, керування дорожнім рухом, технічні засоби регулювання.*

Introduction

Improvement of road safety at railway crossings in different countries all over the world receives much attention, this fact evidenced by increasing in funding for the multilevel crossing construction, technical improvement of safety devices and their management systems. Largely, the effectiveness of regulation and road safety level depends on the perception of crossing signal information by vehicles (VH) drivers.

Analysis of traffic accidents at railway crossings shows that in some cases the information is insufficient or distorted. This underlines the need of study of functioning crossings peculiarities as informational and controlled systems in terms of maximum reducing of traffic accident risks.

Content analysis

The main terms of reliable and safe passage of transport at railway crossings are [1, 2]: a) compliance with the order of passage of transport in the area of crossing; b) sufficient amount of signal information for the safe movement of VH.

The first condition involves the existing priority of rail transport against road VH, because of difference of velocities of rail and road transport as well as the length of braking distances.

The second condition is based on a purely technical means of information and discipline of VH's drivers. In general, the amount of signal information, which prohibits movement ($I_{guard.cr}$) for vehicles and pedestrians at crossings and at approaching to them is [3]

$$I_{guard.cr} = I_{bar} + I_{ls} + I_{sa} , \qquad (1)$$

where I_{bar} – the amount of information from barriers and road signs; I_{ls} – the amount of light signaling information (traffic lights); I_{sa} – the amount of information from sound alarm.

However, this amount of information for vehicles is inadequate in the conditions of limited visibility and insufficient distance to change the traffic mode. Recognition, processing and decision of vehicle drivers depend on the efficiency of signal information. Therefore, it is appropriate with the help of technical regulation means to supply the drivers with traffic information for operational speed choosing on the approach to the crossing.

It is known [3] that extra information signs installing increases the amount of signal information for motor vehicles:

$$I_{guard.cr} = I_{bar} + I_{ls} + I_{sa} + I_{as} , \qquad (2)$$

where I_{as} – amount of information from the additional information signs.

It is therefore necessary to increase the amount and quality of management information, which allows overcoming existing information amount in case of proper problem solution

$$I_{as} > I_{bar} + I_{ls} + I_{sa} . \qquad (3)$$

Thus, in terms of existing signaling information in automatic or manual mode, the driver must take this information in a very small time period and switch the vehicle to the modes of moving or stopping. Therefore, there is a need to develop of additional controls for vehicles, as well as to increase controlling information for the driver at a reasonable distance from the crossing to change the traffic mode at the approaching up to a complete stopping the vehicle.

The purpose and task of the article

Based on the analysis the need to develop of methods and elements of informational and controlling traffic system on the approaches to the railway crossing to improve road safety. To achieve the goals and the task method of dynamic traffic management was chosen, which allowed determining the necessary velocity of VH approaching the railway crossing with the operational displaying of traffic mode information on the road signs, the location of which is determined by the control algorithm [4].

Dynamic traffic management

In further studies, the analysis of the traffic interaction parameters allowed to determine that the major controllable elements of the system «car–driver–road–environment» (C-D-R-E) are the road conditions and traffic stream as well as their interaction because parameters of subsystem «driver – car» are changing less dynamically in the long-term period and at some point may be adopted as average statistical. Therefore, subsystem «Traffic Conditions – Transport Stream» (TC–TS) was selected as the main form of functioning C-D-R-E, for which three-level management system is proposed, due to possibility to take into account the demand of road using by traffic stream and by other environmental influences. Thus, the road throughput is offered to select as generalizing parameter, which depends on the TC–TS parameters.

This scheme of system «TC–TS» management (fig. 1) shows the parameters' relationship on three levels of management in the traffic process.

In the three-level management, first level of strategic management is carried out at the design stage or stage of reconstruction – it's a process of choosing and determination of traffic parameters and freight-operational road characteristics

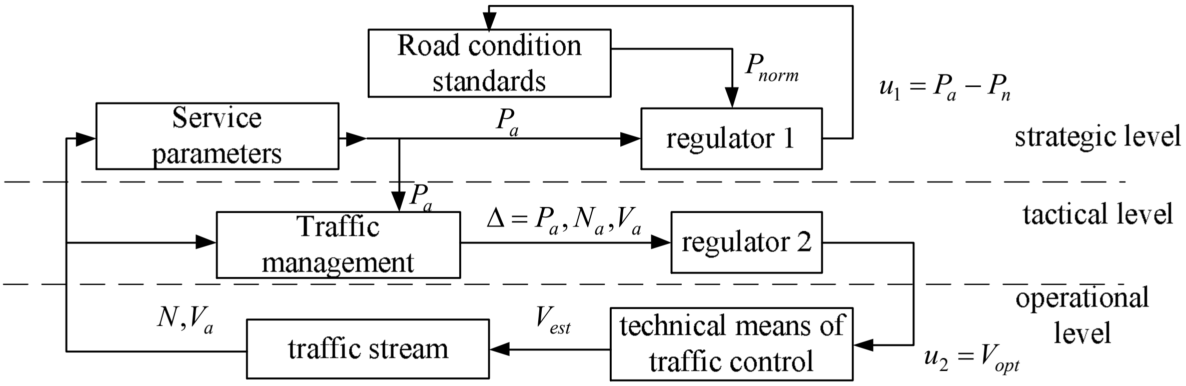

Fig. 1. The general scheme of dynamic traffic management

The second level solves the problem of tactical control, which is carried out at the stage of the traffic process servicing (road conditions must match the parameters of traffic) and implemented by methods of road maintenance and traffic control. Efficient traffic management on the third level is done by control actions on traffic. It provides determined vehicles speed establishing on the current road section with the help of information signs.

The principle of the dynamic control is as follows. Road conditions are major managed subsystems of C-D-R-E complex, while the rules of road conditions can change during reconstruction and repair of the road network, also traffic conditions depend on the service level and the service options impacting on traffic stream. Taking into account the demand for the highway traffic using, control actions are generated: u_1 – for vehicle maintenance and u_2 – directly to the traffic stream. In this case, the control action u_1 is defined as the value of nonconformity of actual TS parameters to their normative meanings (on the design stage and in operational road using). By the actual parameters of traffic streams the standard service process parameters values can be determined with changing in time (t).

$$u_1(t) = \int_0^t f\left[P_a(t), P_n(0)\right]dt, \quad (4)$$

where P_a – actual carrying capacity, vehicles/hour; P_n – normative carrying capacity, vehicles/hour.

The definition of control actions u_2 directly to the transport stream is based on the respective dependency:

$$u_2(t) = \int_0^t f\left[V_a(t), P_a(t), V_{est}(t)\right]dt. \quad (5)$$

where V_a – actual movement speed, km/hour; V_{est} – the estimated movement speed, km/hour.

With the increasing intensity, negative consequences of growth are gradually accumulating – correspondingly to inconsistencies of u_1 and u_2, which do not provide optimal functioning of «TC–TS» subsystem.

At the design stage, determining of the parameters is made by selecting of the road category and appointing of the road technical parameters (width of the roadway, availability and the options of curb) as well as methods and forms of road maintenance. Parameters of road conditions, taken at the design stage are the input parameters for traffic service process. This fact explains the essential connection of settings in the subsystem «TC–TS». With a given demand amount for road used by transport stream (N – intensity of traffic) and with a given service level (P_a) by developed standards (P_n) the control parameters in controller 1 can be determined as a value of mismatch, which affects the traffic in general.

$$u_1 = P_a - P_n. \quad (6)$$

At the same time with the same intensity of traffic (N), and with given constant parameters the road traffic management parameters can be defined. By comparing existing output parameters and required (V_a) the inconsistencies in the controller 2 as control action may be determined.

$$u_2 = V_{opt}. \quad (7)$$

In reality self-controlling or self-regulation of traffic exists, which is reflected on changes of the traffic speed and of the road capacity level. When traffic is increased, changes in the mode of traffic stream can take place, such situation leads to the need of major road repair or reconstruction, or the traffic management parameters must be changed to correlate demands of increased traffic coordination with the required quality of service. The studies found that traffic management parameters can be divided into groups of four types (fig. 2).

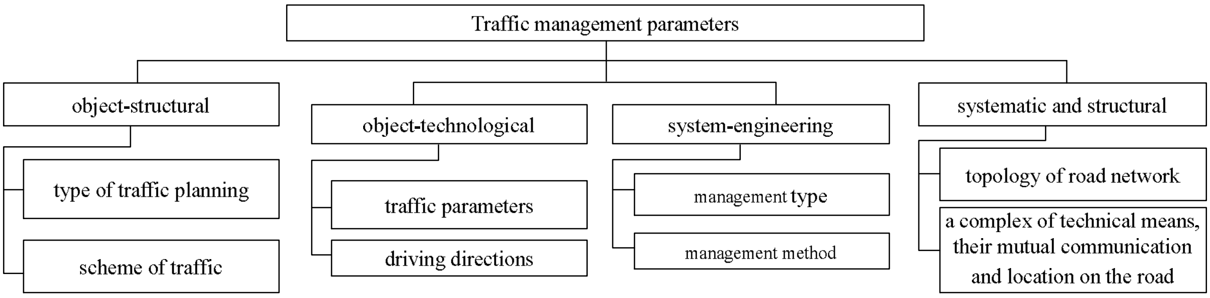

Fig. 2. Traffic management parameters

In dynamic management developing were applied the following parameters: 1) object-technological – the parameters of traffic; 2) object-structural – scheme of traffic; 3) system-engineering – the method of administration; 4) systematic and structural – a complex of technical means, their mutual communication and location on the road.

Improving the TC–TS subsystem can be done in different directions, the main part of which is efficient traffic management to improve the road transport efficiency and to improve the safety of road users in real road conditions. In this regard, the task of traffic management, in general, can be formulated as follows. With the given parameters of traffic, machine maintenance settings (fixed and variable road parameters), parameters of the service (characteristics of the maintenance of the road and traffic management), repair resources and road maintenance considering perturbations (presence of complex sectors, e.g.) and depending on the climatic conditions, it is necessary to determine the parameters of traffic along with the road capacity and traffic safety conditions.

The using of this method in the road traffic streams management on the approaches to railway crossings will allow to change the vehicles' parameters of movement promptly and effectively on the basis of the regulation parameters for rail transport and to increase the amount and quality of signal information in front of crossing for drivers of motor vehicles (3). According to the traffic control scheme (fig. 1), the value of non-compliance of road conditions (6) should be determined at the strategic level in the functioning railway crossing Control Center and traffic controller (regulator 2) will form a control action (7) to the parameters of traffic with their reflection on controlled road signs at the entrance to railway crossing. Taking this into account, the improved block scheme of rail and road transport regulating on crossing is as follows (fig. 3).

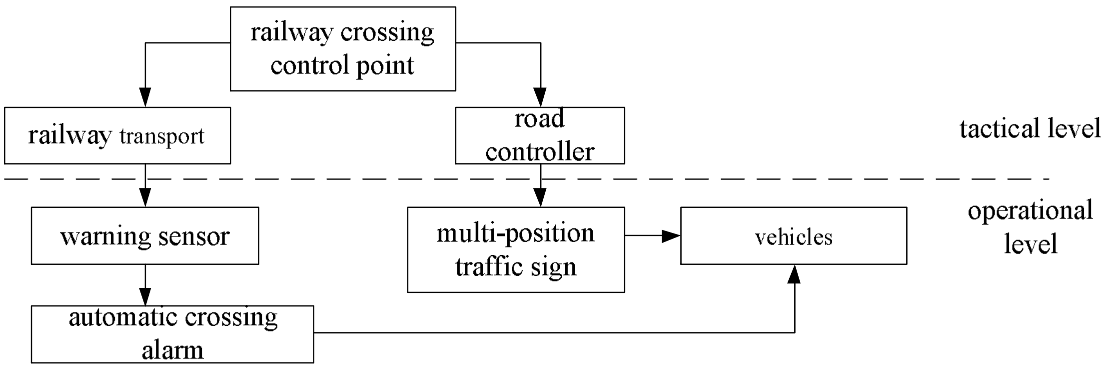

Fig. 3. Structure of regulation means on a railway crossing in motor vehicles driving management

Thus, the application of reducing speed method for the VH in the approaching zone of the railway crossing improves road safety and road capacity.

Conclusions

The block diagram is developed to implement the method of dynamic traffic management and to provide connection of railway crossing control point not only with the rail transport, but also with motor vehicles at the entrance to the railway crossing. In this case the controlled road sign will display required traffic stream speed on the approach to the dangerous sections of the road – the crossing, it will increase the safety of passing across and railway crossing capacity, since operating range of technical means of regulation will increase and VH quantity in queue will be reduced.

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