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DEVELOPMENT OF THE SYSTEM OF ROAD TRAFFIC SAFETY IMPROVEMENT IN ACCIDENT SEATS OF URBAN AREAS

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The analysis of the developed system of increase of road traffic safety in the city centres of road accidents is resulted. The block diagram of the given system has been received; lacks of the existing position are reflected. The description of necessary actions for creation of methodological base of increase of road safety of traffic in the city centres of road accidents in Byelorussia is performed.

In the article substantive provisions on the road traffic organisation in the city centres the road accidents, which are based on the account of all kinds of losses in road traffic and an estimation of quality of accepted decisions are resulted. Practical, scientific and scientifically-methodical problems on creation the system of safety increase of road traffic are defined.

Keywords: losses in road traffic, methodology of accident forecasting, accident losses, forecasting methods

1. Problem Solving

Works made by the methods of road traffic arrangement on the constant basis are fulfilled just episodically in the Republic of Belarus. As the result together with rather a high rate of auto-mobilization it is a speedy growth of rate of accidents in seats (places) of cities especially [1, 2]. To overcome this situation it is essential to develop scientific-methodical system of traffic safety improvement in accident places in cities, which should be based on the up-to-date methods of accident forecasting and optimisation of the decisions taken.

2. A Structure of Road Safety

A structure of road safety improvement system in cities is on Figure 1.

The whole complex of operations for road traffic safety improvement can be divided into 4 periods:

- obtaining the initial data;
- defining the accident reasons and preliminary decisions producing;
- evaluation of the effectiveness and optimization of the taken decisions;
- measures development and implementation.

The initial data include not only accident statistic, but the other parameters of road traffic in a place that are necessary to forecast the rate of accidents, to calculate the losses and optimise the decisions.

The problem of the initial data obtaining is extremely critical. Present statistics is not suitable for works providing road safety improvement in accident places in cities just because it doesn't take into account (ignores) the so-called non-registered accidents (all the accidents with material damage and about 17% of accidents with pedestrians that have not lead to serious injures), that makes up more than 90% of all accidents in cities. As regards other initial data, which are necessary for accident forecasting, evaluation of the affectivity and optimisation of the decisions taken, such data are not being defined at all because of lack of their need.

There are unsatisfactory road conditions, vehicle damage, human mistakes (traffic rules violation) among the accident reasons, but there is no any reason concerning road traffic arrangement. It is obvious that defining accident reason by using such initial data and decision-making on the basis of these reasons can't be optimal.

The evaluation of the complex effectiveness with taking into account the main constituencies of road traffic as it is claimed in the Conception of road traffic safety providing is not being made in the Republic of Belarus [3].

At the best research of accident effectiveness by the statistical method of accident forecasting is being conducted, which is not connected to economy, ecology, sociology, and it is appropriate just to preliminary evaluation during decision-making.

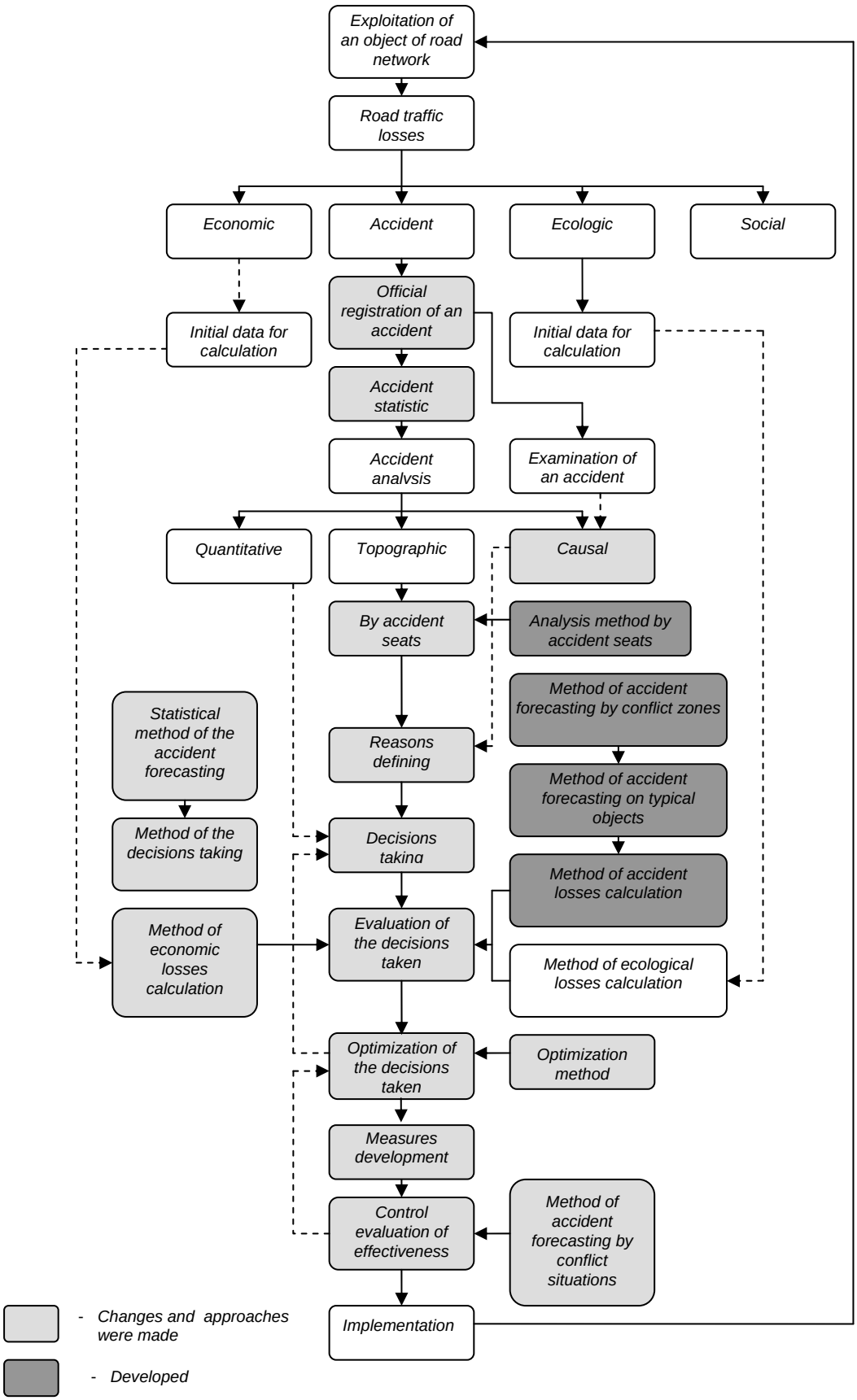

Figure 1. Traffic safety improvement system in accident places in cities

It is obvious that if the taken decisions are not optimal and the decisions do not undergo to evaluation of effectiveness and optimisation, then measures developed on the basis of such decisions can not be optimal. More over the decisions do not undergo the control checking even to define whether they have accident effectiveness.

As the statement indicates on every stage of works there are serious problems and as the result the rate of accident places in cities is unwarranted high.

The term "accident place (seat) in cities" means the place where not less than 3 accidents occur annually [2, 15, 14]. The accident seats in cities include intersections, pedestrian crossings, bus stops, railroad crossings, exits from adjacent territories, places with speed bumps, popular places of crossing violations by pedestrians. Accidents in accident place in cities are the consequences of conflict manoeuvres what is caused by different reasons. The peculiarities of these places are relatively slow traffic speed and large quantity of conflicting members.

The signalised intersections have a special place among accident places in cities as a place of powerful manoeuvred traffic flows. Beside it there is also interaction (crossing) of powerful traffic and pedestrian flows. These interactions are being made in limited area and in limited time, because all flows "compressed" in time since they move not during all traffic light cycle but in limited time of green signal of a traffic light.

As the result, signalised intersections most every have become the main places of the accident, economic and ecological losses. More over signalised intersection define road capacity of streets in cities that leads to appearance of great social losses beside the losses mentioned above. Of course owing to this signalised intersection has become the main object of street road network which indicates the quality of road traffic in cities including safety. That is why signalised intersections have been chosen as the main object to be researched.

The signalised intersections are divided to standard and non-standard conditionally. The standard intersections have 4 or 3 entrance which are directed at a right angle to each other and have one carriageway on each side. Controlling of standard intersections is simpler and depends on movement intensiveness and correlation of transit (direct) and turning traffic flows and on the presence and intensiveness of pedestrian flows.

Non-standard intersections differs from standard by displacement of one or several sides from the centre, by presence of dividing strips, by presence of different from 90° angle of joining, by presence of 5 sides and etc. Non-standard intersections are very individual and they are more difficult to be controlled.

Traffic light controlling at signalised intersections is composed of two main classes – system and local [2, 16, 17, 18]. Local controlling take place at an isolated intersection the controlling of which is not coordinated with controlling at the other intersections. As a rule it is used when intersections are detached from each other (more than 800 m) and the operation of one of them doesn't influent the operations of others. The system's controlling means a coordinated control under several adjacent objects, which are located either along a street (highway) or on several (crossed possibly) streets (network). As a rule, in cities, especially in large, the coordinated control is used.

The structure of traffic light cycle is subdivided into two-phase and poly-phase. The two-phase signalising means that in the first phase all traffic and all pedestrian flows of one of the crossing streets move and in the second phase flows move on the other of the crossing streets.

The peculiarity of poly-phase signalising is that one can single out separate phases for turning flows, pedestrians, traffic flows of every entrance and etc. that allows to create a lot of control combinations taking into account the peculiarities of a separate intersection. Two-phase cycles are simpler, more economic and more ecologic but sometimes they have very dangerous conflicts inside the phase (in-phase), for instance, left-turning traffic flow – opposite transit traffic flow, that is why such cycles are inadmissible by safety conditions. Poly-phase signalising takes off the most dangerous and inadmissible conflicts and it would seem to be safer. But it is not economic, not ecologic and it is often accompanied by overload that causes great quantity of violations (social losses), that causes the accident rate growth.

As it is following from premises, selecting the parameters of traffic light cycle at signalised intersection, especially if it is loaded, is an extra difficult and delicate matter which depends on an engineer's experience and intuition and it is not efficient. Because of absence of workable methods of quality evaluation of road traffic arrangement and optimisation of the taken decisions it is possible to affirm that road traffic arrangement at signalised intersections is far from optimal. Namely, this circumstance is the main reason of inadmissible high losses of every kind including accident losses.

To solve the situation it is essential to do the following:

- to develop the method of accident forecasting on the conflict objects which is useful for obtaining appropriate forecasting by accuracy on both existing object and the stage of designing of an object;
- to develop the methods of accident forecasting for the main typical conflicts: vehicle-vehicle and vehicle – pedestrian that take place at signalised intersections (4 methods);
- to develop the method for accident losses calculation;
- to develop the method of selection and optimisation of the decisions taken on road traffic arrangement on the basis of the developed method of accident losses calculation and existing methods of ecological and economical losses calculation;
- for implementation of the developed methods of accident forecasting and also of methods of accident losses calculation and optimisation the decisions taken to create a complex of computer programs which are available for road traffic engineers;
- for control checking of adequacy of implemented measures effectiveness on the real objects to modify the existing accident forecasting method by making it appropriate for practical use in road traffic engineering.

Speed hump – is a specially organized on the constant basis obstacle for traffic made as jut of the carriage way with radial or trapezoid section which is made of asphalt-concrete or another durable materials and installed across the road (street) without a possibility of driving around which forces the drivers by threat of accident or car breaking to limit velocity distinctly independently on road traffic situations.

Appearance and use of speed humps are connected to great growth of accidents in the second half of previous century that become a national problem for some countries [4, 5, 6]. Especially it concerns on the West-European countries with high population density and specialties of settlements' design with narrow streets of ancient building. Searches of the problem solution, which often have been made on "fresh tracks" and were not fundamental and systematically made, have led to requirements of abrupt reduction of traffic speed. At the beginning it tried to realize by installation of set of traffic signs for speed limitation, however it has not given special effect, because the more limitations were established and the more severe were these limitations, the more drivers broke them. In the different countries the share of infringes was various; however the order of figures remained stable – approximately 75-95 % of drivers broke requirements of abrupt speed limitations.

Then it was started searching and finding ways of compulsory speed limitation. One of them, psychological compulsion, includes the various devices, which create the driver's psychological need to reduce the speed – the effect of narrowing or a curvature of movement trajectory; effect of break of movement trajectory, a special marking, which becomes more frequent; chokers; rumble strips with increasing frequency of sound influence, etc.

The second way is physical compulsion. It includes different kind of devices causing physical need of speed reduction under threat of loss of controllability or breakage of the automobile with an opportunity of accident occurrence. It includes roundabouts with small diameter of central island (or different inside road pavement); physical narrowing or a curvature of a lane by application of protected safety islands for pedestrians with an opportunity of pedestrians movement "on a curve"; an abrupt physical curvature roads ("zigzag", chicane) by application of the ledges protected by an onboard stone; raised above a carriage way pedestrian crossings across a street; cross-section deepening on a surface of carriage way and, at last, prominent obstacles (speed humps) of diversified designs and the sizes [5,6,7,8]. The last appeared the cheapest and easy applicable to various conditions and consequently have become widespread.

It seemed that the decision of a problem of speed reduction has been found at last - cheap, effective, not demanding the control – and in Europe it was started the real boom of speed hump's application. A lot of new modifications have been developed, process of their interaction with traffic was investigated, their efficiency in increasing of traffic safety was advertised, etc. However, there has soon come sobering up – it is appeared that application of speed humps, except for positive influence on traffic safety, also has a wide area of negative influences in the field of economy, ecology and social relations. Application of speed humps conflicts to fundamental tasks of road transport – improvement of quality and reduction of the cost price of transport service, which is based on the balanced ratio of such properties of traffic as safety, profitability, ecological compatibility and influence on society, and not just based on safety as it seemed before. Not having an opportunity to estimate this balanced ratio precisely – as far as it is known (anyway, we did not manage to find), such method of traffic quality estimation in Europe has not been present yet – they have started to limit application of speed humps in "obvious" typical situations. In particular, in many countries, certainly, with different variations, installation of speed

humps is forbidden on country roads, in city streets with intensive and moderate movement, on roads with bus movement, in streets with trucks movement, etc. Gradually the scope of speed humps is being narrowed and limited by streets of ancient building, domestic territories, areas of schools, etc. It is considered, that ”speed humps – last tool from a tooling, intended for increase of traffic safety” [9, 10, 11]. Therefore Europeans today search for other, less unhealthy ways of traffic safety increasing, including speed reduction in the necessary places, in the necessary limits and during necessary time, for example, by means of flexible traffic light controlling with the obligatory automatic video control.

In the Republic of Belarus the first speed humps appeared on the beginning of the present century. In some years the great growth of speed humps had began and appropriate organizations has got the planned indicators of installation of speed humps with or without the need. The same practice still has been continuing, unfortunately, sobering has not started. It is necessary to study constantly and to use the foreign experience of speed humps application. However, it should be applied with extra accuracy, taking into account our conditions and features. Also it is necessary to have an effective method of traffic quality evaluation; in particular, evaluation of efficiency of speed humps application that will allow taking more sensible decisions and balancing all basic properties of road traffic. It is necessary also to use available now domestic experience received as a result of application and research of speed humps. Thus one should be guided by positions of ”Concepts of providing of road traffic safety in the Republic of Belarus”, developed according to the Decree of the President of the Republic of Belarus №551 on the 28th of November, 2005 and authorized by the Council of Ministers Decision of the Republic of Belarus on the 14th of June, 2006 № 757 [3].

In the Concept it is pointed out that the road traffic has not one but four main threats (dangers) – accident, ecologic, economic and social. That is why quality improvement of road traffic means reducing of losses of all kinds of dangers, but not reducing of losses of one kind of danger by great increasing dangers of other kinds.

Taking into account the premises it was decided to choose speed humps as a second (after signalised intersection) object for research and to develop a complex evaluating method of evaluation of implementation effectiveness. To achieve these purposes the following tasks must be solved:

- to develop the accident forecasting method on the basis of statistical method for preliminary selection of decisions;
- to develop the accident forecasting method on the basis of conflict zones method for accident effectiveness evaluation and optimisation of the decisions taken;
- to develop the method of accident, economic, ecologic losses calculation for evaluation of social-economic effectiveness and optimisation of the decisions taken.;

Thus, the researches undertaken are based on the main objects of conflict interaction of traffic flows and traffic-pedestrian flows.

3. Methodology of the Road Traffic Engineering

The main methodical clauses of road traffic engineering in accident places of cities in the Republic of Belarus must include the following items: terminology, methodology and ideology, technology, norms, structure, control and financing. Let’s consider all these items.

The special terms that are used in road traffic system, in particular, in subsystem of road traffic arrangement must be developed, coordinated and approved. Here the international coordination must be fulfilled. The approximate quantity of unified terms is not less than 500.

Methodology of road traffic must be based on the following aspects:

1. Initial data defining for evaluation of road traffic quality on the basis of the methods which are developed and proved by established order.
2. Calculation of all kinds of losses (including social).
3. Analysis of sources of losses in road traffic of higher level.
4. Evaluation of road traffic quality and its constituents by the losses rate.
5. Optimisation of all managing supposed impacts by the minimization criterion.
6. Development of operative measures for the road traffic arrangement.
7. Optimisation by the minimization criterion of losses of possible impacts on the road traffic process.
8. Development of prospect measures for the road traffic arrangement.
9. Development of propositions for the norm correction (traffic lows and norm of a direct impact – traffic rules).

For efficient implementation of all clauses of the road traffic safety system in accident places in cities the ideology must be developed, which should include the main purposes and tasks, role and place of the ”Road traffic arrangement” item in the road traffic system; the main road traffic arrangement principle and the chapter “Responsibility” of course.

There are the basic clauses of Technology of road traffic arrangement developed in BNTU. The technology includes collecting and processing of the information concerning quality (characteristics) of road traffic and its constituents; evaluation of present road traffic arrangement quality; analysis of present state of accident places; the methodical aid of operative measures implementation; the methodical aid of prospect measures implementation; and also the clause concerning the control under fulfilment of managing decisions. All norms in road traffic arrangement must be ordered. That is why it is necessary to develop the hierarchy of norms in road traffic arrangement system where juridical norms, methodical norms, technical norms responsibility and the rules of their change must be clearly defined. Also it is necessary to develop Guidance for the road traffic arrangement in cities – the main unitary methodological document concerning road traffic arrangement.

The structure of managing in the system of road traffic arrangement can be simply represented by the following way (Fig.2).

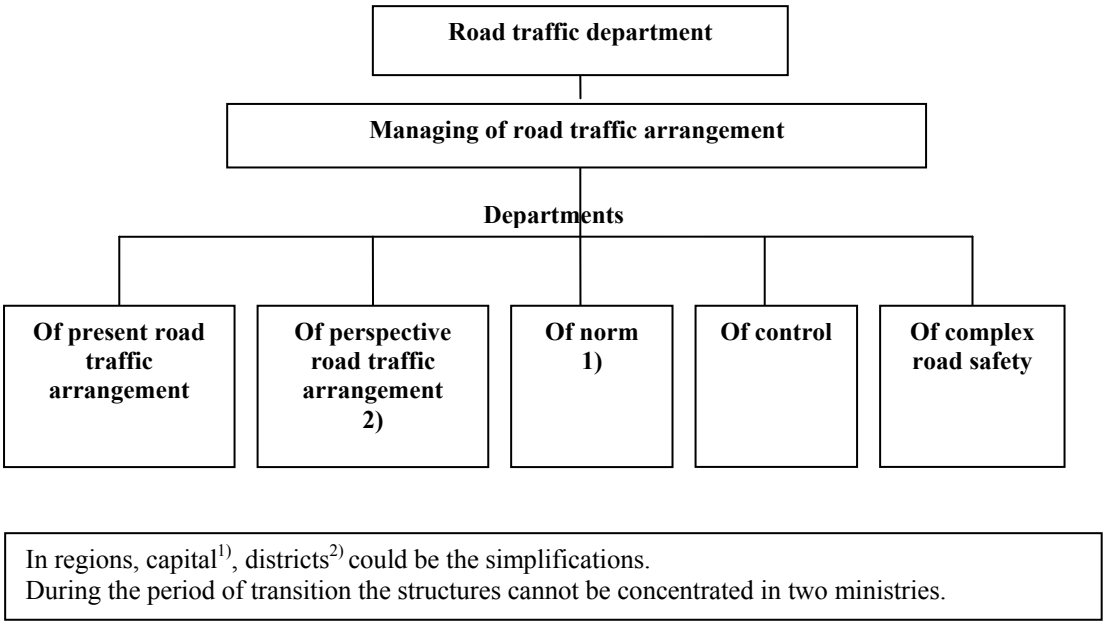

Figure 2. Structure of managing of road traffic arrangement

The control in road traffic can be represented by the following way.

$$\left.\begin{array}{l}\text{over the condition of road traffic arrangement - d + s}\\ \text{over directions implementation - s + d}\\ \text{over designing condition - d + s}\\ \text{over scientific researches - d + s}\\ \text{over training of specialists - d + s}\end{array}\right\}\text{- p}$$

where d – departmental, s – state, p – public

Financing in the system of road traffic arrangement can be both state-financed (as the main on the first stage) and at the expense of other incomes. Here it is necessary to provide the system of encouragement at the cost of reducing of accident, economic, ecological and social losses. A part of finances stays among people, a part can be used for the development of road traffic arrangement and a part is used for the encouragement of specialists worked on road traffic arrangement. Here part and

correlation of the effect of losses reduction can be changed while trends are discovered. The return of the effect in state use is possible by enlarging the taxes for road vehicles, increasing the part of contributions of compulsory insurance, increasing fuel price, increasing transit payment (in central parts of cities, within a parking and so on), increasing of ecological tax and etc.

4. Conclusions

Thus, to solve these problems and to develop useful scientific-methodic system of traffic safety improvement it is essential to solve a set of practical, scientific and scientific-methodical tasks. Among them there are:

- to make compulsory statistical reporting about all accidents including accidents without injured;
- to give to accident seat (place) appropriate status which would claim reviewed reporting, evaluation of effectiveness, optimisation of the decisions and measures implementation;
- to develop the method of accident place analysis;
- to adapt the statistical accident forecasting method to conditions of the Republic of Belarus in usage of speed humps;
- to develop the method of accident forecasting by potential danger of higher precision which could be used for practical implementation for effectiveness evaluation and optimization of the decisions taken for both existing and being designed conflict objects (conflict zone method);
- to develop the methods of accident forecasting by the method of conflict zones for speed humps and four typical conflicts at the signalised intersections: vehicle-vehicle (side impact, turning, head on impact, impacts in one directions), vehicle-vehicle (rear-end accidents), vehicle-pedestrian (transit vehicle-pedestrian) and vehicle-pedestrian (turning vehicle – pedestrian);
- to develop a section of the methodical aid for accident losses calculation concerning specific cost of accident of different consequences' weight;
- to develop the method of economic losses calculation for speed humps;
- to develop the method of optimisation of the decisions taken concerning road traffic safety increasing by the road traffic arrangement methods at signalised intersections, controlled pedestrian crossings and speed humps;
- to perfect the accident forecasting method for conflict situations with purpose to increase forecast precision for control evaluation of accident effectiveness measures during their implementation;
- to develop the method of control evaluation of accident effectiveness measures during their implementation;
- to develop the program package for accident forecasting, evaluation of effectiveness and optimisation of the decisions taken with purpose to implement the system of road traffic safety improvement developed;
- to develop propositions for perfection of norm base in road traffic.

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