TRAFFIC FLOWS. MODELLING, CONTROL AND EVALUATION OF INFLUENCE ON THE ENVIRONMENT

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INTRODUCTION

The evaluation of many researchers and experts shows that the road transport causes about 80 % of pollutant emissions (such as CO, CO_2, etc.). Such an influence of the road transport on the environment concerned with general using of cars in the daily human activity. In the most developed countries the number of vehicals per thousand inhabitants (the level of automobilization) reaches 500-700. In general it can be mentioned that the number of vehicles in the world increases. In average the global automobilization is 100 vehicles per 1000 inhabitants (620 million vehicles per 6 milliards of inhabitants in the world).

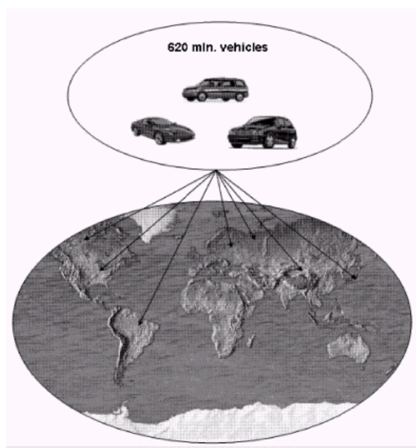

Figure 1. Territory and automobilization.

So far as the square of territories on which the mentioned occurrences take place is constant, but the level of motorization of the territory (the number of cars attributed to a unit of territory) increases.

Rapid growth of automobilization causes the problems with population safety and environment. For example in Russia where the population is about 140 million yearly 30000 die and 100000 are injured in traffic accidents. Transport emissions are ruining the natural balance of environment but the scale of damage is poorly studied and the consequences are hardly forecasted.

A traffic flow is a form of co-existence of a large group of vehicles. The mail local characteristics of the traffic flow are its density, intension and composition. The manner of transference of vehicle within the flow determines the energy ecological parameters such as kinematics, the energy consumption and the road transport emissions. For setting regimes of the traffic flow it is very significant to have the fundamental diagram (Figure 2) which shows the dependence of the flow intensity on the flow density.

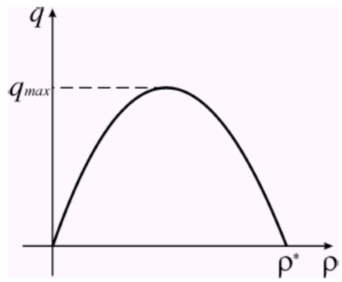

Figure 2. Fundamental traffic diagram.

In many investigations this dependence is presented empirically by two monotonous components and describes the behavior of a stationary homogeneous traffic flow on one lane quite satisfactorily.

For instance the stable and unstable regimes of traffic flow can be defined on the base of analysis of the main diagram.

The behavior of different vehicles on a multilane road proves to be more difficult. One of the main problems of the intended research is modeling of such behavior with the purpose of control and optimization. And more difficult problem is investigation of traffic flows on network with complex geometry.

TRAFFIC FLOW MODELS

The mixed simulation model of traffic on a multilane road is founded on the composition of collective and individual properties of traffic flow.

This model is used for determination of the dependence of the traffic flow speed on density of the traffic flow, the number of road lanes and the percentage of lorries (slow vehicles) in the traffic flow. In that way the fundamental diagram is reduced. The model in particular can show that even a small portion of slow vehicles decreases considerably the average vehicle speed.

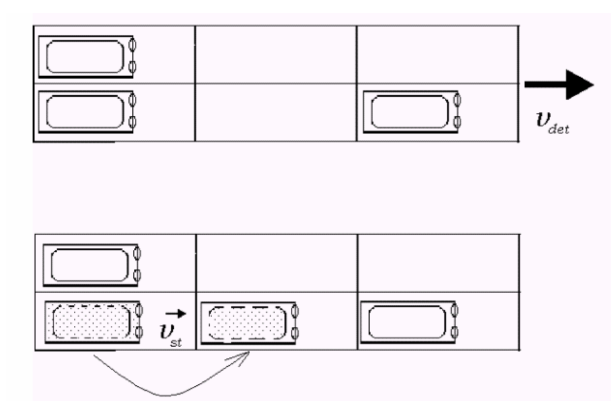

Figure 3. Determined and stochastic flow components.

With the help of the model it is established the effectiveness of the method giving increase of the traffic intensity with the help of the ban of going by slow vehicles on left line (or two left lanes). So the model gives the ground for using this ban.

This simulation model can be also used for investigation of the appearance of an obstacle on the road lane caused for example by a traffic accident. By means of the simulation model it is investigated the effectiveness of the manner the traffic control used in the case of appearance of such obstacle. The rule proposes the decrease of the vehicle speed at some distance of the place of the obstacle and change of lane by vehicles from the lane where the obstacle occurs.

Percolation. Theoretical and simulation models of the movement of special (very fast) vehicles.
What are the abilities of moving for very fast vehicles inter the flow of ordinary vehicles? How they depend on traffic flow characteristics? How to optimize the perculation?

Segregation (grading)
The traffic flow model on the two lanes road before of the separation.

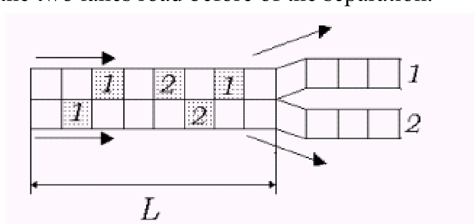

Figure 4. Traffic flow segregation.

Evaluate traffic flow characteristics. There L is the length of the active zone of lane changes. How do the characteristics depend on L, value of separated parts of flow and its density?

Crossroads model
On the based of mixed approach and a simulation model the cases of controlled and uncontrolled crossroads are considered. In the case of the controlled crossroads it is investigated the dependence of average delay of vehicle at the crossroads on the durations of the traffic-light phases.

The results of the investigations can be used for the elaboration of the recommendations on optimization of the phase.

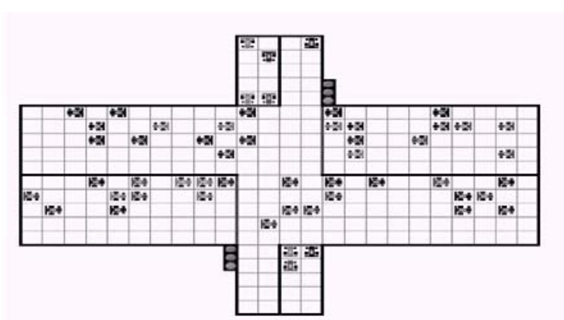

Figure 5. Traffic flow at the crossroads.

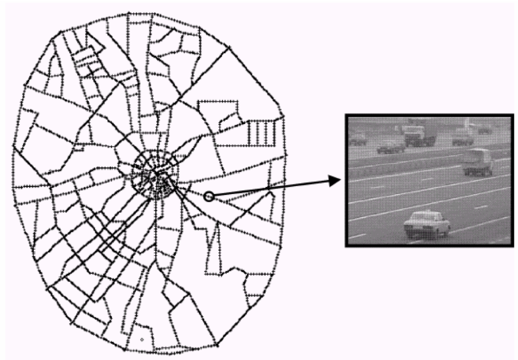

Figure 6. Traffic flows on network (Moscow)

It is well known that the traffic flow characteristics are depend on not only local parameters of road, but on configuration of network, in particular quantity of light signals, the length of road section between them. The more density of traffic flows, the more geographically the large fragments of networks are correlated.

Forecasting of traffic accidents

The safety problem in Russian Federation becomes more urgent. The analysis of statistical data per last ten years shows that at relative constancy of population and spread of road network the fleet grows quickly. From 1995 to 2001 the fleet increased at one half time (37 million vehicles). On the territory of Russia with 145559.2 thousands of people 29718 perished and 182123 were injured as a result of traffic accidents in 1999.

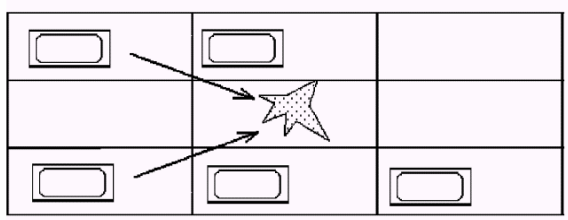

Figure 7. Conflict scheme on multilane road.

The flow statistical data confirm the actuality of our approach allowed to take into account the individual driver behavior in flow. The main reason of traffic accident is driver infringement of traffic rules (63 % in Moscow in 1999). The other reasons are distributed as follows: 25 % are caused by the infringement of rules of the road pedestrians, 10 % are caused by the substandard of road pavement, 2% are caused by technical faultiness of vehicles.

The classification of traffic accidents by types in Moscow in 1999 is: 48% - run over pedestrians, 25 % - crash of vehicles, 13 % - upset of vehicles, 6% - collision with obstacle, 5% - collision of stationary cars, 3% - others (Figure 8).

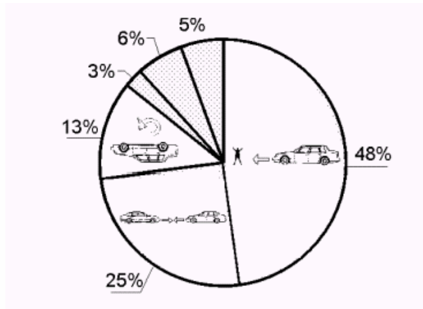

Figure 8. Traffic accidents structure.

The formalization of local driver behavior in flow enables to investigate the main traffic accident scenarious, collision of vehicles and obstacles and so on. The aim is to evaluate the influence of main parameters.

The development of methods of the energy and ecological parameters of the traffic flow
The energo-ecological balance of the traffic flows is based on estimation of fuel consumption and emission getting into account the unstationarity behavior of vehicles on road. The main concept is the Fuel Ecological Characteristics (FEC) of traffic flow and its analogy in kinetic parameters of movement.

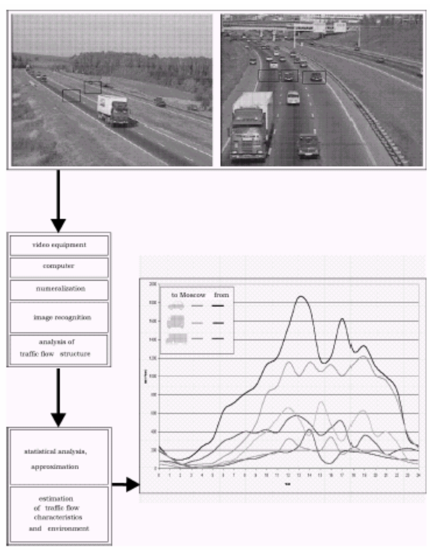

Figure 9. Video-monitoring scheme.

Using these methods and simulation models gives the manner of defining the traffic flow FEC and find the optimal regime with minimum harmful emission.

The corresponded computer program has on the input the meanings of the intensity of the traffic on the roads and the information on the character of the locality, predominant wind directions etc. The program has on the output the distribution of the considered pollutant on the city territory.

The investigation of optimization of FEC measuring of traffic flow on highway (monitoring)

The parameters of the mathematical model are intended tobe defined more precisely with help of the results of the measurements of the concentrations of the pollutants. The problem is in calculation of measuring duration and its frequency for the purpose of accuracy maintenance at minimal inputs on the monitoring.

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