LEGAL AND SCIENTIFIC BASIS OF ROAD SAFETY MANAGEMENT SYSTEMS

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Abstract; *In developing countries, the rapid growth in the number of vehicles, the slow modernization of road infrastructure, the lack of traffic culture and the outdatedness of existing management systems pose a serious threat to road safety. Each country has traffic rules and laws aimed at regulating traffic, ensuring safety and protecting the rights and interests of citizens. Over the past decade, almost all major cities in the world have seen an increase in vehicle density, increased traffic jams in city centers, and an increase in the number of road accidents. In particular, the number of road accidents related to the human factor remains one of the highest in the world. These problems have not gone unnoticed in the Republic of Uzbekistan.*

Keywords; *traffic light, youth, incident, driver, pedestrian, passenger, school, incident, event;*

Analysis and results; Mathematical modeling methods play an important role in the effective management of modern urban transport systems and ensuring road safety. The mathematical foundations of road traffic management are understood as mathematical formulas, probability theory, statistical modeling and optimization methods used to determine and analyze traffic parameters - namely, flow rate, vehicle density, average speed, traffic light operation frequency, the probability of traffic jams and other factors.

The main goal of traffic management is to ensure that vehicles move smoothly, safely, and quickly on the roads. This is achieved by using mathematical methods that calculate the number of vehicles, their speed, and how busy the road is.

The transport flow relies on 3 core values.

Table 1.3

Traffic flow

Density	ρ	Car/km
Speed	V	km/h
Flow	q	Car/hour

They are interconnected by the following formula:

$q = \rho \times V(1)$

Let's assume that 30 cars are moving on 1 km of road ρ= 30 cars/km, cars are moving at an average speed of 60 km/h. Now let's calculate the flow.

$$q = \rho \times V = 30 \times 60 = 1800 \frac{avt}{soat} \quad (2)$$

This means that 1,800 cars travel on this road per hour.

Usually, when cars are densely packed on the road, traffic slows down. For example: If the density is 100 cars/km, the speed drops to 20 km/h. Flow q=100 · 20=2000 cars/h. Another case Density 50 cars/km, speed 40 km/h →2000 cars/h. It is clear that for the flow to be the highest, a balance between density and speed is needed. Too many cars - traffic jams, too few cars - useless gaps.

This formula determines the distance between cars, taking into account the driver's reaction time and stopping distance:

$$d = v \times t_r + \frac{V^2}{2a} \quad (3)$$

d – safe distance (in meters)

V – speed (m/s)

t_r – driver reaction time (usually 1–1.5 s)

a – braking acceleration (m/s^2)

For example: Speed 20 m/s (72 km/h), reaction time 1.5 s, a=4a = 4a=4 m/s^2:

$$d = 20 \times 1.5 + \frac{20^2}{2 \times 4} = 80\, metr \quad (4)$$

This determines the distance based solely on braking :

$$d_s = \frac{v^2}{2a} \quad (5)$$

For example, speed V=25 m/s, braking acceleration a=5 m/s^2:

$$d_s = \frac{25^2}{2 \times 5} = 62.5\, metr \quad (6)$$

Mathematical determination of traffic light timing (simple model)

Let's assume:

- When the traffic light is green, 1 car passes every second.
- 40 cars pass by every 1 minute (60 seconds)
- So, 40 seconds of green light is enough (for 40 cars to pass)

Mathematical approaches are also important in traffic light control. The time interval between green and red lights is determined based on the average speed and flow density of the traffic flow. This reduces vehicle congestion and increases the efficiency of road use.

In general, mathematical models and calculations allow for in-depth analysis of traffic parameters, proper traffic light control, early detection of traffic jams, reduction of the risk of traffic accidents, and efficient organization of the road network. Therefore, mathematical foundations play an important role in the design and implementation of traffic management systems.

Road safety is one of the most pressing issues in modern urban planning and transport management. Population growth, increasing car ownership, underdeveloped infrastructure, and the human factor are leading to an increase in the number of road accidents (RAs). Therefore, it is necessary to use a systematic approach and scientifically based analytical methods to ensure road safety.

To this end, mathematical and statistical methods are used to identify, analyze, and evaluate factors affecting road safety. This allows for a deeper understanding of existing problems, identification of dangerous areas, and development of effective measures in the future.

1. Determining traffic flow density

It is used to calculate the number of cars passing by a road at a given time.

$$q = \frac{n}{t} \tag{7}$$

- q – traffic flow (cars/hour)
- n – number of vehicles during the observation period
- t – time (in hours)

For example: if 900 cars pass in 1 hour,

q=900/1=900 cars/hour (8)

2. Determining the probability of an accident.

The probability of a traffic accident occurring is calculated using a statistical method:

$$P = \frac{A}{N} \tag{9}$$

-P – probability of accident

-A – Number of accidents

-N – total number of cases (observations, number of cars, distance traveled in km)

For example: If there were 20 accidents involving 10,000 cars in 1 year:

$$P = \frac{20}{10000} = 0.2\% \tag{10}$$

3. Whether the number of cars increases or not, the relationship between the number of accidents and the number of vehicles can be determined by r. ($-1 \le r \le 1$)

-r > 0: strong positive correlation

-r=0: no dependency

-r < 0: inverse relationship

4. Determining the density of traffic jams (relative to distance)

$$k = \frac{A}{L} \tag{11}$$

- k – the number of accidents corresponding to 1 km

-A – Number of accidents

- L – road length (km)

For example: if there are 10 traffic accidents on a 5 km road section:

$$k = \frac{10}{5} = 2\frac{YTH}{km} \tag{12}$$

These analyses identify the main factors that negatively affect traffic safety. These serve as an important basis for modernizing road infrastructure, managing traffic flow, and developing preventive measures. In addition, complex assessment methods such as the road safety index are used to assess the level of safety in modern transport systems. This takes into account road lighting, the presence of signs, pedestrian infrastructure, video surveillance systems, and other factors.

Conclusions and suggestions; Thus, the mathematical-statistical approach to analyzing road safety allows not only to assess the current situation, but also to predict dangerous situations in advance.

The two-point radar system works on the basis of the formula speed = distance / time. This system calculates the average speed of the vehicle during the movement interval and compares it with the maximum permitted speed:

$$V_{o\prime rtacha} = \frac{S}{t_{real}} \quad va \quad t_{min} = \frac{S}{V_{max}} \tag{13}$$

If:

$$t_{real} < t_{min} \Rightarrow V_{o\prime rtacha} > V_{max} \tag{14}$$

If so, it means the driver is exceeding the speed limit.

2. Substantiating efficiency through a mathematical model

a) Model for reducing the number of accidents

Let's say:

N_o – the number of traffic accidents occurring on a road section in 1 year.

R is the accident reduction coefficient after the introduction of two-point radar.

N – number of TDIs after implementation.

Equation:

$$N = N_o(1 - R) \tag{15}$$

If, based on international practice, R=0.30 (i.e. 30%), for example:

- If N_0=100 YTH,
- N=100 · (1−0.30)= N=100 · (1−0.30)=70 .

This means that 30 traffic accidents are prevented in this area per year.

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