Improving the level of traffic service on the road network of cities

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Abstract. The problems associated with the formation of congestion and the low quality of transport service continue to be relevant for modern megacities. One of the parameters that evaluates the effectiveness of the organization of traffic is the level of service traffic. The article provides foreign experience of using this parameter. The need to improve the level of traffic service on the road network by using a set of measures is noted as the main problem. The authors give a classification of event types. The paper notes that only the integrated application of the measures specified in the classification, taking into account the restrictions imposed and the existing traffic conditions, has the greatest effect.

1. Introduction
Problems of organization and road safety in large cities are becoming increasingly relevant due to the continuous growth of motorization and the lack of development of urban transport infrastructure. Congestions that happen everywhere on the road network cause the need to improve traffic and road management, and the use of technologies that provide a designated level of service in key urban areas with an appropriate level of road safety for road transport.

Systemic congestion leads to a highly time-consuming travel of citizens both on individual and on public transport. The level of comfort and safety of these trips is low [1]. One of the parameters that evaluates the effectiveness of the organization of road traffic is the level of service of road traffic, which is the ratio of the average vehicle speed to the speed of vehicles in free traffic conditions [2]. This provision is enshrined by the Decree of the Government of the Russian Federation dated November 16, 2018 N 1379 “On approval of the rules for determining the main parameters of road traffic and keeping their records”, which was developed pursuant to Federal Law No. 443-FZ “On the Organization of Road Traffic in the Russian Federation and on amendments to certain legislative acts of the Russian Federation”.

Abstract. The problems associated with the formation of congestion and the low quality of transport service continue to be relevant for modern megacities. One of the parameters that evaluates the effectiveness of the organization of traffic is the level of service traffic. The article provides foreign experience of using this parameter. The need to improve the level of traffic service on the road network by using a set of measures is noted as the main problem. The authors give a classification of event types. The paper notes that only the integrated application of the measures specified in the classification, taking into account the restrictions imposed and the existing traffic conditions, has the greatest effect.
2. **The main part**

In foreign sources, in particular [3], the level of service (LOS) is an indicator describing traffic conditions in a traffic flow, as a rule from the point of speed of movement and travel time, freedom to maneuver, comfort, and convenience.

Level of Service is a concept introduced to relate the quality of transport service to a given flow speed, used to determine how well a vehicle works from the perspective of the traveler [4], [5], [6], and also from the position of drivers, transit passengers, cyclists and pedestrians - the so-called multi-modal level of service [7]. Usually there are six service levels, and each is assigned a letter from A to F, where service level A represents the best working conditions, and service level F is the worst.

Level of service in urban areas on the streets and roads with regulated traffic is significantly different from the level of service on countryside roads or during unregulated traffic [8, 9]. There is a following procedure for measuring the level of service on a section of city street:

- determination of the study area;
- determination of peak hourly volume and peak hourly ratio;
- determination of the speed of free flow;
- classification of the type and class of a city street;
- determination of operating time, delay time and, therefore, determination of the average speed of movement during rush hours and hours of the lowest network load;
- data analysis to determine the level of service

The criteria for determining the level of service of a city street are based on the class of a city street and the average speed of movement. If the demand at any point exceeds the capacity of the segment, then the calculated average speed of movement may not be a good indicator of the level of service. The above stages describe the determination of the city street type and the average speed of movement, and using the Table 1, we can determine the level of service of an urban street [10].

| Urban street class | Level of service | Average Travel Speed (km/h) |
|--------------------|-----------------|----------------------------|
| I                  | >72             | >59                        | >50                        | >41                        |
| II                 | >56-72          | >46-59                     | >39-50                     | >32-41                     |
| III                | >40-56          | >33-46                     | >28-39                     | >23-32                     |
| IV                 | >32-40          | >26-33                     | >22-28                     | >18-23                     |
| V                  | >26-32          | >21-26                     | >17-22                     | >14-18                     |
| VI                 | ≤26             | ≤21                        | ≤17                        | ≤14                        |

The definition of the level of service is completely based on the average speed of movement, delay time, travel time, type and class of an urban street. For urban streets, a ‘C’ level of service is required as a minimal, according to Highway Capacity Manual 2010. This means that for different urban streets the average speed varies from 40-56 km/h for streets of class I to 23-32 km/h for streets of type IV.

Regarding the level of service for the urban streets in the Russian Federation, the Ministry of Transport of the Russian Federation signed the Order No. 114 “On Approval of the Road Traffic Monitoring Procedure” on April 18, 2019. This document provides the gradation of average vehicle speeds in accordance with the level of service for different categories of streets (see Table 2).
Table 2. Level of service for different categories of RF urban streets.

| Urban street class | Main streets of citywide value of regulated traffic (2nd and 3rd class) | Main streets of district value | Streets and local roads | Streets and local roads in production areas |
|--------------------|---------------------------------------------------------------------|-------------------------------|-------------------------|-------------------------------------------|
| Level of service   | Average Travel Speed (km/h)                                         |                               |                         |                                           |
| A                  | 60-50                                                               | >85                           | 40-34                   | 50-43                                     |
| B                  | 50-40                                                               | 85-67                         | 34-27                   | 43-34                                     |
| C                  | 40-30                                                               | 67-50                         | 27-20                   | 34-25                                     |
| D                  | 30-24                                                               | 50-40                         | 20-16                   | 25-20                                     |
| E                  | 24-18                                                               | 30-40                         | 16-12                   | 20-15                                     |
| F                  | <18                                                                 | <30                           | <12                     | <15                                       |

Nowadays the Russian Federation urgently needs to develop methodological approaches to determining the main parameters of road traffic, namely the level of service, to comply with the provisions and standards enshrined in the above regulatory documents.

Important task is to increase the level of traffic service on the road network. For this purpose the authors have developed a method for increasing the level of service for road traffic in urban conditions, taking into account the probabilistic characteristics of the traffic flow and a combination of various factors influencing traffic conditions. The use of the proposed method provides an increase in the efficiency of functioning of the urban road network (URN) by implementing a set of measures for improvement of the transport infrastructure elements, organization and traffic management in large cities.

The first step is to determine the core network of city streets, which is the main area for the task of raising the level of road traffic service. To determine the possibility of including a street in the core network, we propose an algorithm for the formation of the street road network (see Figure 1). The selection criteria are the correspondence and traffic intensity of URN [9-12].

For each city street (or street section) claiming to be included in the core road network, we should determine the proportion of correspondences to the main streets of city-wide significance (by SP 42.13330.2016) and when this share is more than 30% - the street is included for further consideration.

The next stage calculates the coefficient of intensity of movement of the core network $K_{oc}$ (1). The value of the specified coefficient for each city street is compared with the weighted average traffic intensity of a large city $N_{cp,vz}$.

$$K_{oc} = \frac{k \cdot N_i}{N_{cp,vz}}$$  (1)

Where $N_i$ – traffic intensity on the sections of the considered route, vehicles/day; $k$ – correction factor (1.2-1.5); $N_{cp,vz}$ – weighted average traffic intensity, vehicles/day.
Thus, the core network of streets and roads is formed. First of all, the list of city streets included in the core network is checked for compliance with the assigned level of service.

If the level of service complies with the assigned for each category of city street - the city network is functioning properly and does not require additional adjustments or measures to reorganize the traffic. The values of the service level that do not comply with the designated ones indicate the need to identify areas that limit the speed of movement on the considered network. The algorithm for increasing the level of traffic service for each element of the core network is following: (see Figure 2).

**Figure 1.** Algorithm for the formation of the core road network.
Figure 2. Algorithm for improving the level of traffic service.

Identification of problem areas is based on the analysis of the graph of the speed of movement on the specific route. First of all, it is necessary to include areas with a significant reduction in the speed of movement.

For problem areas, we should carry out a detailed analysis of the existing traffic conditions and its organization and factors that limit the possibility of using these or other measures. The following conditions and limitations are considered:

- spatial (territorial) restrictions;
- the intensity of movement of the various participants;
- change in traffic intensity;
- the demand for turning maneuvers in various directions;
- the existing traffic organization in the considered section of the street;
existing methods of traffic control at the intersections of the considered section of the street;
the organization of public transit stops;
organization of parking space;
economic restrictions;
the time of implementation of the proposed activities.

Taking into account the above factors, we can develop measures to improve the level of traffic
service, which can be divided into three groups (see. Figure 3):
1. Development of transport infrastructure;
2. Organization of traffic;
3. Movement control.

| Classification of types of activities to improve the level of traffic service |
|-----------------------------|----------------|----------------|
| Transport infrastructure development | Traffic organization | Traffic management |
| Construction of new transport infrastructure | Allowed maneuvers | Introduction of traffic light regulation |
| Reconstruction of existing infrastructure | Motion channeling | Optimization of work of traffic lights |
| Local planning activities | One-way traffic | Creating ATCS |
| | Reverse movement | Change management technology |
| | Restriction on travel | Creation and development of ITS |
| | Organization of parking a vehicle | |
| | Orienteering | |

**Figure 3.** Classification of types of activities to improve the level of traffic service.

The biggest limitations and influence on subsequent decisions come from the measures for the
development of transport infrastructure. Since the proposed methodology is focused on increasing the
level of service for the movement on the existing URN, local planning measures were taken for
consideration, as well as the measures to improve the organization of traffic and its management. If it is
impossible to ensure a given level of service for road traffic by the specified set of measures, a transition
to reconstructive measures of the URN elements is necessary.

The greatest effect is provided by the complex application of these measures. The choice of a
complex of measures depends on the existing conditions, the factors listed above and restrictions.

The development of measures and the assessment of their effectiveness should be carried out with
the use of transport modeling. The development of measures is carried out for each haul and the
intersection of the considered route (a section of a street, a complex of streets).
After identifying areas that limit traffic speed, we advise to prepare recommendations for improving the level of service.

The sequence of the development of activities:

- analysis of factors and restrictions on the choice of types of activities to improve the level of traffic service;
- development of local planning activities;
- development of measures to improve the organization of traffic, taking into account local planning activities;
- development of measures to improve traffic management, taking into account the proposed changes in traffic management and local planning activities.

The proposed measures should serve as a basis for improving the level of service of the urban network; for this purpose, it is vital to make an assessment using transport modeling.

If the assigned level of road traffic service is reached, the proposed set of measures is accepted and a feasibility study of its use is made.

If the assigned level of traffic service is not reached, the cycle of development of a set of measures is repeated. If it is impossible to ensure the assigned level of road traffic service due to a set of measures, including local planning activities, measures to improve traffic organization and management, it is necessary to reconstruct the URN elements.

3. Conclusion

The complex of the developed techniques and algorithms allows to carry out a research of the conditions of road transport movement and will contribute to the solution of an important task - to increase the level of service and the quality of functioning of the traffic movement on the road network of large cities.

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