A unified approach for measuring the level of service of transport infrastructure

Timofei Radionov1*, Anton Mikhailov1, Aleksandr Kuznetsov1, and Denis Mityukhin2

1Institute of space and information technologies, Siberian Federal University, Krasnoyarsk, 660074, Russia
2Modular Control Systems LLC, Krasnoyarsk, 660099, Russia

Abstract. This article aims to discuss the problem of road traffic management and the criteria for its measurement. The article uses the concept of service level as the most important characteristic in the assessment of transport infrastructure. The differences in approaches to determining the level of service in the world practice are considered. The problem is outlined of non-uniform metrics used to measure the level of service for various road elements in existing methodologies. A comparison is made of the assessment of the level of service of a traffic lane in the Russian and foreign approaches in the choice of coefficients and the method of their calculation. Changes are proposed to the existing Rosavtodor methodology for assessing the capacity of a lane, a roundabout, an unregulated and regulated intersection, which can simplify the assessment of the level of service. As a result, an example of the application of the proposed unified approach in calculating the capacity of a controlled intersection is given. Finally, a conclusion is drawn about the need for a new approach, the advantages of using unified metrics for the level of service assessment are highlighted, and the vector of future research on this problem is also outlined.

1 Introduction

The main objective of road services is to create and maintain conditions that ensure safe road trafficking [1]. To assess the efficiency of organizations in maintaining transport infrastructure facilities the following factors are used: absence of traffic interruptions, reduced number of traffic accidents, compliance with applicable regulations, etc. [2]. The vast road network of Russia and numerous government agencies involved in road maintenance served as the basis for the creation of various work management structures.

The efficiency of traffic management is defined by the ability to minimize the time spent by road users and pedestrians to move [3]. To assess the efficiency it is first need to establish certain criteria/metrics to measure the quality of traffic management.

For the purpose of measuring the traffic management quality authors use such a basic metric as the level of service (LOS) [4]. The LOS defines the quality of traffic flow that provides specific comfort conditions to the drivers. One of the key traffic flow metrics used

* Corresponding author: tradionov-a21@stud.sfu-kras.ru
in modern foreign literature to design different traffic control modes is the ideal saturation flow rate which stands for the saturation flow achieved under ideal traffic conditions [5]. The Russian literature on traffic flows uses the concept of maximum traffic capacity of a road.

The key factors that define the level of service include: load rate, speed and travel time, traffic interruptions, freedom to maneuver, traffic safety, driving convenience or comfort, and operating cost [6].

Drivers assess the LOS of motor roads based on their individual experience. Some factors (e.g., driving comfort) are largely ignored and some are not measurable at all [7].

However, the assessment of the LOS gives an idea of the state of the transport infrastructure and how well it meets the needs of end users and what should be changed in the first place [8].

There are many existing criteria to assess the LOS. This article describes the problem of non-harmonised approaches to the assessment of transport infrastructure and proposes methods to solve the problem by analysing the existing approaches and giving recommendations as to the selection and calculation of various criteria for road traffic assessment.

2 Related works

After reading the subject-matter works by authors from different countries, it can be concluded that the concept of saturation flow rate varies everywhere. Over several decades, a saturation flow rate has been understood to be the established rate of movement through the stop line from a long queue [9].

However, some experts have their own understanding of the saturation flow rate. Yu.A. Kremenets [10] defines the saturation flow rate as the maximum intensity of queue dissipation in a fully saturated phase. Yu.A. Vrubel [11] suggests that the saturation flow rate is the maximum capacity of continuous traffic flow from the stop line during the green time.

There is also a more unconventional definition: according to the Urban Streets and Roads Design Guidelines the saturation flow rate is the capacity of a lane with continuous flow at a speed of 15 km/h [12].

There are also differences in the definition of saturation flow rate in foreign literature. According to F. Webster, a pioneer of traffic theories, the saturation flow is achieved when there is an infinite queue of vehicles with green time equal to 100% of the regulation cycle time [13]. W. McShane defines the capacity of an approach entry to an intersection as the maximum rate of traffic flow at the intersection during a given time period under prevailing traffic and roadway geometric conditions [14].

The U.S. Highway Capacity Manual (1985) investigates the intermediate intervals between vehicles entering an intersection, and only then calculates the saturation flow rate at the approach entry to the intersection. A later version of HCM 2000 offers a methodology almost identical to that of HCM 1985. However, there are still some differences: according to HCM 2000, a saturation flow rate is the maximum discharge rate of vehicles leaving the queue during the green time. It is usually achieved after about 10 to 14 seconds of green, which corresponds to the front axle of the fourth to sixth car crossing the stop line after the beginning of green.

The German HBS 2001 (Handbuch fuer die Bemessung von Strassenverkehrsanlagen, 2001) [15] defines the saturation flow rate as the maximum possible number of vehicles that can pass a lane group during the green time. According to this methodology, the saturation flow rate is based on the number of vehicles that, in fully saturated condition, have time to leave the queue during the green and yellow signals. The research is carried out during the peak period.
According to the Canadian Capacity Guide for Signalized Intersection (1995) [16] the saturation flow is defined as the traffic rate at which vehicles that have been waiting in a queue during the red interval cross the intersection approach lane during the green interval. Also, this manual introduces the concept of cumulative saturation flow rate, which defines the value of the average saturation flow rate by a certain point in time.

The Australian Manual (Akcelik 1981) [17] methodology is somewhat different. Those differences result in different measured saturation flow rate. The research includes only those vehicles that enter the intersection after the tenth second of the green time. The saturation flow rate in this case is defined as the average value of time intervals, for vehicles, starting from the tenth second of green time.

3 Problem

From the above-mentioned definitions of saturation flow rate it becomes evident that there are different methods to calculate the saturation flow rate based on the values used in those definitions.

The RF Government Decree No. 1379 "On Approval of the Rules for Determining and Keeping Records of the Key Metrics of Road Traffic" dated 16 November 2018 defines the traffic quality metrics to measure the efficiency of road traffic management. There are many guidelines for assessing various road elements. The Federal Road Agency of the Ministry of Transport of Russia (Rosavtodor) approved a road industry standard ODM 218.2.020-2012 for use by road maintenance organizations and enterprises when assessing the road conditions.

The saturation flow rate serves as one of the key metrics to measure the level of road service [18]. Level of service is a comprehensive metric to measure cost efficiency, traffic convenience and safety and characterise the traffic flow conditions. The above-mentioned methodological guidelines use different metrics to calculate the LOS for each road element. For example, for traffic lanes, it is calculated based on three metrics (table 1). For unsignalized intersections, only the first metric from the above-mentioned table is used for assessment. For signalized intersections, the LOS is assessed based on the control delay value (Table 2).

<table>
<thead>
<tr>
<th>LOS</th>
<th>Load rate Z</th>
<th>Velocity V</th>
<th>Saturation rate S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt; 0.20</td>
<td>&gt; 0.90</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>B</td>
<td>0.20–0.45</td>
<td>0.70–0.90</td>
<td>0.10–0.30</td>
</tr>
<tr>
<td>C</td>
<td>0.45–0.70</td>
<td>0.55–0.70</td>
<td>0.30–0.07</td>
</tr>
<tr>
<td>D</td>
<td>0.70–0.90</td>
<td>0.40–0.55</td>
<td>0.70–1.00</td>
</tr>
<tr>
<td>E</td>
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<td>&lt; 0.40</td>
<td>1.00</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 1.00</td>
<td>0.30</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOS</th>
<th>Control delay (seconds per passenger car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤10</td>
</tr>
<tr>
<td>B</td>
<td>10–20</td>
</tr>
<tr>
<td>C</td>
<td>20–35</td>
</tr>
<tr>
<td>D</td>
<td>35–55</td>
</tr>
<tr>
<td>E</td>
<td>55–80</td>
</tr>
<tr>
<td>F</td>
<td>&gt;80</td>
</tr>
</tbody>
</table>
Therefore, there is no single approach to assessing the level of service: different metrics are used to measure different road elements.

Also, the assessment of a single road element does not show how it affects other elements before or after it. Even if a work is done to increase the LOS of one element, it is difficult to predict how it influences the LOS for other elements.

Hence the need to develop a universal methodology for determining the LOS for any type of road element. And further assessment of the LOS for larger groups, streets, districts will be based on individual LOS assessment of their components.

### 4 Solution

Integrated quantification of a road section comprised of several more simple components requires consistency in all relevant measurable quantities. The quantities chosen by the authors are essential and sufficient for the purpose:

- traffic intensity $N$;
- traffic capacity $P$;
- load rate $Z$.

The intensity rate $N$ usually can be measured with motion detectors. The traffic capacity $P$ is a theoretical value and depends on the road parameters. The congestion rate $Z$ shows how $N$ relates to $P$, i.e. $Z = N / P$. If, for example, $N = P$, then $Z = 1$, which means that the road is congested (the traffic intensity has reached the traffic capacity).

There are many ways to measure traffic intensity $N$ and their choice depends on the approach and equipment. When there is no way to measure traffic intensity on certain road segments, a probabilistic approach is proposed.

Throughput capacity $P$ analysis is essentially based upon maximum ideal (unobstructed) throughput capacity factored (by obstructions) down to its design value. The reducing factors values and calculation practices may vary or coincide among various analysis procedures.

Factor $Z$ depends on throughput capacity $P$ in terms of value and represents quantification of level of service $LOS$: the higher throughput capacity $P$ is the lower is $Z$ and the higher is level of service. Traffic intensity $N$ is generally more or less stable and understandable. Furthermore, level of service increase through decreased traffic intensity $N$ does not belong to transport infrastructure improvement field as such.

The procedure suggested by the authors is consistent since level of service quantification $LOS$ is based upon a sole variable i.e. load factor $Z$. The latter in turn can be derived for each simple component from throughput capacity $P$ using known analysis methods, and from measured traffic intensity $N$. The existing method (Table 1) can be used to convert $Z$ into $LOS$.

Prior to level of service quantification, a complex transport infrastructure facility must be split into more simple components analyzable with known methods. A sample average can be then derived for the road components with equation:

$$Z = \frac{1}{n} \sum_{i=0}^{n} Z_i$$  \hspace{1cm} (1)

where $Z$ – sample average i.e. resultant load factor for a considered road section;

$Z_i$ – i-component load factor;

$n$ – number of components in a considered road section.

Equation 1 can be used for integrated load quantification for any road section with only possible limitations caused by lack of data, if any. $Z$ can be then converted into $LOS$. A road section quantification for example would require quantification of all lanes. A street roadway
quantification would require quantification of all relevant road sections and crossroads. A district quantification would require all its components quantified in turn.

Below authors discuss the most important road elements in any city, the methods to assess their LOS, and how they can be improved and simplified based on the above-mentioned metrics $N, P$ and $Z$.

### 4.1 LOS of a lane

A road is a set of lanes accommodating various road elements such as turns, crosswalks, stops, intersections, etc. No matter which method is chosen, the traffic capacity and the saturation flow rate are defined by common factors:

- lane width;
- condition of the road surface;
- lane geometry;
- number of changing lanes;
- left and right turns;
- quantity of freight vehicles;
- approach grade;
- availability of parking lots;
- availability of stops;
- availability of crosswalks;
- restrictions;
- availability of a traffic light.

Most of these factors are given as rates in the HCM 2000 formula that is widely used in many countries with a developed transport infrastructure:

$$
S = S_0 \cdot N \cdot f_w \cdot f_g \cdot f_{HV} \cdot f_p \cdot f_{bb} \cdot f_{LU} \cdot f_a \cdot f_{LT} \cdot f_{RT} \cdot f_{Lpb} \cdot f_{Rpb}
$$

(2)

where $S_0$ is the intensity of the ideal saturation flow rate assumed to be 1900 passenger cars per hour;

- $N$ is number of lanes;
- $f_w$ is adjustment factor for lane width;
- $f_g$ is adjustment factor for approach grade;
- $f_{HV}$ is adjustment factor for heavy vehicles;
- $f_p$ is adjustment factor for parking activity;
- $f_{bb}$ is adjustment factor for bus-passing activity;
- $f_{LU}$ is adjustment factor for lane utilization;
- $f_a$ is adjustment factor for area type;
- $f_{LT}$, $f_{RT}$ are adjustment factors for right and left turns;
- $f_{Lpb}$, $f_{Rpb}$ are bicyclist/pedestrian adjustment factors for left and right turn movements.

According to ODM 218.2.020-2012, the formula 2 has been changed: saturation flow rate is replaced with traffic capacity, and there are differences in some adjustment factors, but the approach is similar. The formula for calculating the ultimate traffic capacity of the direction in question is as follows:

$$
P_\Delta = P_{max} \cdot \prod_{n=1}^{17} \beta_n
$$

(3)

where $P_{max}$ is the maximum traffic capacity in passenger cars per hour;

- $\beta_1$ is adjustment factor for lane width;
- $\beta_2$ is adjustment factor for curb width;
- $\beta_3$ is adjustment factor for side interference;
- $\beta_4$ is adjustment factor for heavy vehicles in the flow;
- $\beta_5$ is adjustment factor for road trains in the flow;
\( \beta_6 \) is adjustment factor for visibility distance;  
\( \beta_7 \) is adjustment factor for curve radius;  
\( \beta_8 \) is adjustment factor for speed limits;  
\( \beta_9 \) is adjustment factor for intersections (type, number of intersections);  
\( \beta_{10} \) is adjustment factor for curb surface type;  
\( \beta_{11} \) is adjustment factor for road surface type;  
\( \beta_{12} \) is adjustment factor for stops (gas stations, bus stops, parking lots, etc.);  
\( \beta_{13} \) is adjustment factor for marking type;  
\( \beta_{14} \) is adjustment factor for passenger cars in the flow;  
\( \beta_{15} \) is adjustment factor for the length of urban location;  
\( \beta_{16} \) is adjustment factor for stationary obstacles;  
\( \beta_{17} \) is adjustment factor for crosswalks.

The formula 2 uses mostly dynamic metrics, of which the most significant are trucks, parking and bus-passing activity, right and left turns, and crosswalks. For these calculations it is necessary to know the number of objects under study (by acquisition of statistical data from observations or special instruments).

The formula 3 mostly relies on static metrics, which are usually of tabular type, but still they are acquired as statistical data from observations: type of road, radius of curvature, road grade, speed limits, etc.

The above-mentioned formulas contain the same metrics, but they are calculated in different ways and they are not interchangeable (needs further research). However, both formulas do not take into account weather conditions that can be quite significant, even temporarily (only formula 3 uses some adjustment factors for snow cover).

Thus, based on all the significant adjustment factors in formulas 2 and 3 and with due account for weather conditions, it is possible to construct a single measure for assessing the lane capacity. The factors values can be either implemented into the existing methods or used to establish a new method based upon available statistics, data analysis and derived interaction between the chosen variables and factor values. In this case, it is only need to use the load rate (Table 1) in order to calculate the level of service. This would provide a more complete picture to assess the road situation and simplify the calculations by reducing/omitting the adjustment factors that have minimum impact on the traffic capacity of a lane in a particular place.

### 4.2 LOS for unsignalized intersections

At unsignalized intersections, the LOS is determined based on their traffic rates. Otherwise, in the absence of traffic, the LOS is considered equal to the main road. To determine the LOS for an unsignalized intersection, you have to calculate the maximum traffic capacity of main road (consisting of the traffic capacity of its lanes). Then apply the load rate of the main road according to ODM 218.2.020-2012 (Table 3) based on its flow rate and maximum traffic capacity. The LOS for a secondary road at an unsignalized intersection may not exceed that for a main road, and the same LOS must be ensured. If the flow intensity \( N \) of the secondary road exceeds its measured congestion \( P \) (the secondary road traffic capacity at the intersection under study obtained from the main road traffic capacity multiplied by adjustment factor \( K \)), then such an unsignalized intersection will not work efficiently and the LOS of the secondary road should be increased until the condition is met \( N_{\text{secondary}} \leq P_{\text{secondary}} \). This would show the actual LOS of the unsignalized intersection.
Table 3. Maximum traffic loads at intersections.

<table>
<thead>
<tr>
<th>Main road LOS</th>
<th>Main road load factor $Z_{\text{main}}$</th>
<th>Secondary road load factor $P_{\text{secondary}} = K \cdot P_{\text{main}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt; 0.20</td>
<td>0.11 \cdot P_{\text{main}}</td>
</tr>
<tr>
<td>B</td>
<td>0.20–0.45</td>
<td>0.22 \cdot P_{\text{main}}</td>
</tr>
<tr>
<td>C</td>
<td>0.45–0.70</td>
<td>0.37 \cdot P_{\text{main}}</td>
</tr>
<tr>
<td>D</td>
<td>0.70–0.90</td>
<td>0.56 \cdot P_{\text{main}}</td>
</tr>
</tbody>
</table>

Here it is more correct to call $P_{\text{secondary}}$ not the secondary road load factor, but the maximum traffic capacity at an unsignalized intersection of a secondary road because this metric is calculated by applying an adjustment factor to the main road traffic capacity.

Here it is necessary to expand the gradation of the levels of service to F inclusive (Table 3). This would give a more accurate assessment and would correlate the lane LOS. The calculation methodology just reviewed tells us how to calculate the LOS for the main and secondary roads, but it does not tell us how to assess the LOS for the entire unsignalized intersection.

The overall LOS for an unsignalized intersection can be obtained as the average assessment of each entry lane (towards the intersection). This would allow us to more accurately identify problem intersections and determine the cause (which entry lanes are congested).

### 4.3 LOS for circle traffic intersections

There are no provisions on the LOS for circle traffic intersections in ODM 218.2.020-2012. However, the formula for calculating the capacity of a circle traffic approach entry is based on the circle diameter and applies adjustment factors $A$ and $B$, which are tabular values and depend on the circle traffic intensity $N_{\text{ring}}$:

$$P_{\text{ring}} = \frac{c}{k} \cdot (A - B \cdot N_{\text{ring}}),$$

where $P_{\text{ring}}$ is the traffic capacity at the traffic circle approach in passenger cars per hour;

- $k$ is adjustment factor for traffic composition;
- $c$ is adjustment factor for the central island diameter;
- $A, B$ are adjustment factors for the entry layout that depend on the number of traffic lanes at the approach and at the entry;
- $N_{\text{ring}}$ is the circle traffic intensity.

Here authors suggest that the circle LOS should be considered in the same way as the unsignalized intersection LOS. For this purpose, it is necessary to know the circle traffic intensity (main road) along with its maximum traffic capacity and the approach entry flow intensity (secondary road). Then, by analogy with the previously described methodology for an unsignalized intersection, check the condition $N_{\text{secondary}} \leq P_{\text{secondary}}$ and determine the approach entry LOS. Accordingly, the circle traffic LOS will be defined as the average LOS values of the circle traffic approach entries.

### 4.4 LOS for signalized intersections

The traffic capacity of a lane at a signalized intersection is determined by the following formula:
\[ P_i = \frac{P_i \cdot g_i}{C}, \quad (5) \]

where \( P_i \) is the saturation flow during phase \( i \) in passenger cars per hour;
\( g_i \) is the effective duration of the control phase \( i \) in seconds;
\( C \) is the control cycle duration in seconds.

There is no need to change anything in this approach, but it is worth noting that the LOS here is considered only for the entry lanes of a signalized intersection, which means that the LOS for the intersection itself would be defined as the average LOS value of those lanes.

A signalized intersection reduces traffic capacity due to loss of effective time when phases and flow velocity change. Also, the traffic capacity at the lane exit would change as phases change at the lanes towards the exit.

5 Discussion and use cases

Once the existing approaches are studied and the amendments they propose are substantiated, authors come to a need for a new reduction factor establishment and road network assessment method.

Authors propose the lane sections between crossings and controlled crosswalks as an assessment basis. The crossing capacity should be assessed independently.

Proposed reduction factor classification system:

- static;
- dynamic;
- combined;
- temporary.

The static factors are those which affect traffic behaviour albeit independent from it. They are not self-altered, and impact throughput capacity notwithstanding traffic availability. Their traffic intensity dependence is minimized too. Typical examples are the road geometry specifics: width, turning radius, pavement type, speed limitations, parking areas if any.

The dynamic factors are those dependent from traffic variables and ceasing to affect road capacity in traffic absence. These factors may only be quantified if traffic intensity data and type details are available. Turns, lane changes, pull ins and outs, lane travel stops, zebra walkways etc. are the examples. The dynamic factors can be converted into static ones if ranged similarly to Rosavtodor recommended practices.

The combined factors are essentially combinations of static and dynamic factors, and their impact on throughput capacity in traffic absence becomes even higher as traffic intensifies over certain thresholds. Impact of a draw-in public transport stop on general traffic for example is minimized. Should, however, bus traffic intensify, the transport stop overall impact becomes much greater. The turning lanes, road gradients etc. can be represented in a similar way.

The temporary factors affect throughput capacity in an irregular manner. The category include various seasonal, weather and road factors such as snow and ice storms, ongoing maintenance works, traffic accidents, potholes etc.

The Russian assessment method for road throughput capacity resolves into static factors only (even dynamic quantities are converted into static ones). If 5 vehicles are considered for example, factor for 0-40 vehicles should be chosen from the table. HCM factor however varies with every vehicle considered. Rosavtodor’s establishment approach to the reductions factors is more streamlined and clear since it obtains values from regression analysis of throughput capacity as a function of the considered factors. Some amendments thereto are however required as discussed below.
Additional corrections should be implemented to improve static factors accuracy since many of them affect a part of a considered road section rather than its whole. The examples are road width variations limited to a certain range, short gradient, distance-specific speed limitations etc.

E. g. when dynamic factors related to vehicle manoeuvres are considered, a percentage of manoeuvring vehicles and assessed against a factor dependency with due respect to a manoeuvre type. These factors require analysis of traffic intensity and direction. Then again, if such details are unavailable, recommended case-by-case values can be established.

The basic equation for the combined factors should be supplemented with an additional one to address a reduction factor in case of “overloads”. E. g. a case correction would be required for a public transport stop sized to 60 buses per hour with actual load as high as 80 buses per hour. Indeed, the stop factor is static as such but as long as actual load remains below design capacity.

The temporary factors would require regression analysis of their impact on throughput capacity, and conversion into numerical tables.

The described approach to the reduction factors would improve actual lane capacity calculation accuracy and allow to assess service level for the relevant road components thereupon.

Let’s take a signalized crossing (Figure 1) of four road sections as an example of throughput capacity analysis. According to ODM 218.2.020-2012, traffic saturation time must be measured to quantify the considered road crossing type (table 2). In their conceptual method, the authors suggest to quantify level of service of a controlled road crossing through load factors $Z_i$ of its components. In our example, throughput capacity $P_i$ must be derived for every inbound (green square on Figure 1) road section from the reducing factors (orange round on fig. 1) obtained with known methods. Then, we obtain throughput capacity of the road sections considering controlled crossing effect $P_i^r$ with equation 5 (yellow triangle on Figure 1). A section load factor may only be obtained with known relevant traffic intensity $N_i$. Load factor $Z_i$, which is essentially quantification of $LOS_i$, is derived as traffic intensity to lane throughput capacity ratio (with due respect to traffic lights effect). Using equation 1 for integrated quantification of road section load factors, we derive resultant level of service $LOS$ from calculated $Z$ for a controlled road crossing.

![Fig. 1. Signalized crossing capacity analysis.](image-url)
Since the paper disregards reducing factors calculation methods, the factor values, initial maximum lane throughput capacity and traffic intensity in the following example (Table 4) are chosen randomly. For the purpose of analysis, each lane capacity $P_{\text{max}}^\text{lane}$ is considered equal to 1000 vehicles per hour, section 1 $P_{\text{max}}^\text{section}$ and lane capacities are similar, and section 2-4 capacities $P_{\text{max}}^{\text{section}2-4}$ are 2000 vehicles per hour each (two lanes). Once the reducing factors are applied, capacity of the road sections up to the crossing becomes as follows: section 1 $P_1$ - 400 vehicles per hour, section 2 $P_2$ - 1500 vehicles per hour, section 3 $P_3$ - 1100 vehicles per hour and section 4 $P_4$ - 1700 vehicles per hour. Since the crossing is signalized, phase timing is similar and numbers of phases and sections are equal (1/4 for each direction), $P_{\text{section}}^{\text{reduced}}$ capacity for every road section (1-4) would then decrease fourfold with due respect to crossing control effect. Level of service quantification would require comparison of calculated throughput capacity $P_{\text{section}}^\text{calculated}$ and actual traffic intensity $N_i$ to obtain section-specific load factors $Z_i$. The factors then would be subject to integrated quantification to derive resultant load factor $\bar{Z}$, which is essentially quantification of $\overline{\text{LOS}}$, for the considered cross section.

<table>
<thead>
<tr>
<th>$i$</th>
<th>$P_i^\text{a}$</th>
<th>$P_i$</th>
<th>$P_i^\text{r}$</th>
<th>$N_i$</th>
<th>$Z_i \to \text{LOS}_i$</th>
<th>$\bar{Z} \to \overline{\text{LOS}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>400</td>
<td>100</td>
<td>30</td>
<td>0.30 $\to$ B</td>
<td>0.56 $\to$ C</td>
</tr>
<tr>
<td>2</td>
<td>2000</td>
<td>1500</td>
<td>375</td>
<td>200</td>
<td>0.53 $\to$ C</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2000</td>
<td>1100</td>
<td>275</td>
<td>200</td>
<td>0.72 $\to$ D</td>
<td></td>
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<tr>
<td>4</td>
<td>2000</td>
<td>1700</td>
<td>425</td>
<td>300</td>
<td>0.70 $\to$ C</td>
<td></td>
</tr>
</tbody>
</table>

6 Conclusion

Based on the above analysis of different methodologies authors have found that different concepts are used to determine the level of service in foreign countries and in Russia: saturation flow vs traffic capacity. Also, there are differences and similarities in adjustment factors used to determine the true traffic flow characteristics of a lane. The foreign methodologies use mostly dynamic metrics based on the exact number of vehicles. In Russian practice, all adjustment factors are determined statistically and are summarized in reference tables.

The Rosavtodor standard ODM 218.2.020-2012 also uses different metrics to assess the level of service for various road elements and even at their absence (in case of circular traffic): average flow velocity for lanes, the time of traffic delay for signalized intersections, and the main roads traffic capacity for unsignalized intersections.

Authors propose to use same metrics for all road elements: intensity, traffic capacity and load. Authors give some recommendations and amendments for the existing Rosavtodor methodology as to the assessment of various road elements based of uniform metrics. When determining the traffic capacity of a lane, it is also proposed to use the foreign methods for calculation of some factors when each vehicle unit matters.

The proposed changes will greatly simplify the LOS assessment for various road elements and will allow us to assess it in the aggregate (the level of service for section, street, neighbourhood, district, etc.). To this effect, it is only necessary to measure the traffic intensity for different types of vehicles and the technical parameters of the lanes. This approach will also allow us to recreate a program model with real data simulations. That model will be able to change road elements and analyse the level of service for the related road elements that will have a positive economic effect.

In the future, authors plan to conduct detailed studies of traffic capacity reduction factors, compile our own methodology for their calculation taking into account only significant
metrics, and propose new factors that are absent in existing methods but still have a significant impact on the road situation including weather, frequency of lane changes, etc.

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