Identification of the Composition of Transport Streams for Remote Satellite Monitoring

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Abstract. The necessary condition for the successful conduct of project, construction and management activities in the field of road and transport infrastructure is the availability of information about the intensity and composition of TA. To determine the transport demand in urban street networks from the perspective of resource cost minimization, it is most expedient to use the method of remote satellite monitoring, which was tested in previous studies by the authors. The method is based on deciphering the satellite image by visual determination of density and subsequent determination of the intensity of motion through the functional dependence of the theory of transport flows. In the development of the method, the article investigates the possibility of identifying the composition of transport flows on the basis of resources provided by map service providers through information and telecommunication networks of General access. Under existing classifications identified visual, outline dimensional and constructive identity of the signs of motor vehicles of the different groups. The developed requirements for the spatial resolution of satellite images based on the analysis of its correlation dependencies and the scale of the image, allowed to determine the boundary values at which it is possible to recognize vehicles by composition. The estimation of accuracy of results of remote identification showed statistical reliability of the received values for streets and roads with a regular mode of movement.

1. Introduction

During the planning the development of urban transport infrastructure, representative information about primary indexes of vehicular flow [1-4] is needed, such as intensity and composition of traffic. This information is used in methods of improving public transport correspondence, choosing a street category, grounding project decisions, road safety and maintenance of urban roads and streets.

As has been proven by the authors in previous studies, the method of remote satellite monitoring is the most justified for determining the transport demand on urban street-road networks, from the point of diminishing resource costs [5]. This method of obtaining information can be used in solving tasks related to design, construction and management activities. The basis of the method is interpretation of online images with visual determination of density and following calculation of traffic intensity through functional mono dependencies within the framework of vehicular flow theory [6]. The presented model is developed by taking into account transport, road and meteorological factors:

\[ N = k_1 \cdot \frac{f(\rho \cdot k_2 \cdot k_3 \cdot k_4)}{k_2 \cdot k_3 \cdot k_4} \]  (1)
\[ N \] – traffic intensity, vehicle/hour;
\[ \rho \] – traffic density, vehicle/km;
\[ k_1 \] – coefficient of determination of traffic intensity during rush hours;
\[ k_2 \] – coefficient of meteorological factors;
\[ k_3 \] – coefficient of transport conditions;
\[ k_4 \] – coefficient of driving factors

During solving the tasks of the project activity, a high correlation between the actual intensity, determined by the method of remote monitoring was noted. Currently, within this method the possibility of obtaining information about the primary parameter (traffic intensity through flow density [6]) has been already investigated and tested. At the same time, the revealed stable distribution of traffic intensity according to composition of vehicular flow during the day, allowed to put forward a hypothesis about the possibility to identify the composition of vehicular flow within the considered method.

2. Main part
At the first stage of present study, the domestic and foreign vehicle’s classifications were analyzed by type, which were reflected in government standards and regulatory legal acts. According to the regulatory legal acts [7], transport flows are differentiated by composition, overall dimensions (length, width) and the structural features of its layout [8]. Characteristic features of the transport image were taken into account to make it possible for identification. The satellite images were enlarged to the scale, so that this allows recognition of each transport by type (table 1).

The individual features of vehicles that contribute to their identification can be attributed to the following specific characteristics, particularly, cars have smaller size, more extensive color scheme and a large quantity in comparison with other vehicles. A distinctive feature of all freight vehicles is the presence of a clearly recognizable driver's cab. Buses of small capacity have a clearly marked convex windshield, which is not visible in other types of road transport. Medium, large, articulated buses and trolleybuses have from one to three sections of rectangular shape and a certain color range (green, yellow, blue or white).

The above-mentioned types of public transport are characterized by the operating time, which should be taken into account when investigating traffic flow at different times of the day. Previously, the paid and free cartographic resources have been analyzed to identify the most relevant and regularly updated databases [6]. The enquiries were sent to the domestic and foreign online providers of cartographic services for detailed study of provided information [10]. Received information formed the basis for the assessment of satellite technical capabilities and quality of images, for the purpose of identification of vehicular flow composition (table 2).

Table 1. Technical capabilities of satellites (Table fragment)

| №  | Satellite     | Launch date | Estimated period of operation, years | Frequency of shooting, day | Spatial resolution, m/mm |
|----|---------------|-------------|--------------------------------------|----------------------------|--------------------------|
| 1  | GF-4          | 20.12.2015  | 8                                    | 1                          | 50                       |
| 2  | Landsat-8     | 11.02.2013  | 10                                   | 16                         | 15                       |
| 3  | AlSat-2B      | 26.09.2016  | 5                                    | 3                          | 10                       |
| 4  | CBERS-4       | 7.12.2014   | 3                                    | 2-3                        | 10                       |
| 5  | Deimos-2      | 19.06.2014  | 7                                    | 4                          | 10                       |
| 6  | ALOS-3        | 2019        | 5                                    | 60                         | 5                        |
| 7  | Formosat-5    | 24.08.17    | 5                                    | 2                          | 2                        |
| 8  | DubaiSat-2    | 21.10.2013  | 5                                    | 1                          | 1                        |
| 9  | BlackSky      | 26.09.2016  | 3                                    | 1                          | 1                        |
| 10 | ASNARO-1      | 6.11.2014   | 3-5                                  | 1                          | 0,5                      |
Table 2. Division of vehicles by composition of vehicular flow.

| №  | Type of vehicle           | Characteristic | Features | Vehicle’s Scheme | Satellite image |
|----|---------------------------|----------------|----------|-----------------|-----------------|
| 1  | Light Vehicles, t         | 1-3            | 2.0-5.0  | 1.5-2.0         | Small sizes in comparison with other vehicles. |
| 2  | Freight vehicles, t       | Дп 2           | 2.0-4.0  | 1.6-2.0         | 2 axes Weight 1.5-3 tons |
| 3  | 2-6                       | 3.0-5.0        | 2.0-2.5  | 1.9-2.6         | 2 axes Weight 5.7 tons |
| 4  | Freight vehicles, t       | 6-8            | 4.0-8.0  | 2.0-2.5         | 2-3 axes Weight 5.7 tons |
| 5  | 8-14                      | 6.0-10.0       | 2.0-2.5  | 2.3-2.7         | 3-4 axes |
| 6  | More than 14              | More than 14   | 12.0-16.0| 2.3-2.6         | 4-8 axes |
| 7  | Small capacity            | 4.5-7.5        | 2.0-2.5  | 2.2-2.6         | 2 axes |
| 8  | Medium capacity           | 8.0-9.5        | 2.2-2.8  | 2.2-2.8         | 2 axes |
| 9  | Large capacity            | 10.5-12.0      | 2.2-2.8  | 2.2-3.0         | 2-3 axes |
| 10 | Articulated buses and trolleybuses | 16.5-24.0  | 2.4-3.0  | 2.4-3.2         | 2-4 axles, distinct parts |

Marks: *a – length, b – width, h – height
The quantitative evaluation of the graphic content, expressing the actual number of meters represented in one millimeter of the image, was carried out through the spatial resolution. During the studying of this parameter, there was found its dependence on the scale of image, in view of this the issue of changing the image quality with a multiple magnification of the satellite image (Figure 1).

![Figure 1. Multiple magnification of satellite image taken from satellite Landsat-8 scale: a – 1:600; b – 1:300; c – 1:200](image)

Analysis showed, when the scale of image was zoomed, it’s complicated to define vehicles. Detailed study of satellite images revealed that there is an additional possibility to identify a vehicle using its shadow projection. Boundary values of spatial resolution and scale, in which it is possible to identify the composition of vehicle by type, were determined on the basis of the developed schedule (Figure 2).

![Figure 2. Graphic dependence of scale and resolution](image)

On the basis of obtained data, we can make a conclusion that the critical scale at which the identification of traffic flow by vehicle composition becomes impossible is 1:1500, and corresponding maximum spatial resolution 1/15 m/mm with scale 1:600.

In order to confirm the representativeness of the results, the accuracy of the identification of traffic flow for different types of streets was evaluated. The comparison consisted of comparing actual intensity values of different types of vehicles, obtained from field observations and identified from satellite image. Actual accounting was performed by video surveillance from 12 to 13 o’clock in the afternoon, to meet the conditions of shooting in remote satellite monitoring. The diagrams of the results comparison are shown in Figure 3.

The analysis of the obtained results showed their discrepancy in the interval from 1 to 10%. Fixed deviations in the individual types of vehicles can be attributed to the irregularity of the daily work.
Due to traffic irregularity, there are no trucks identified on the streets of the first, third and fourth types. The difference between results for these groups was 1 and 2%, respectively.

3. Conclusion
In general, the research showed the possibility of obtaining representative values during the identification of the transport flow by remote satellite monitoring. In the development of the methodology it is planned to develop a method of accounting for uncommitted groups of vehicles on the basis of mathematical modelling methods, and the ability to recognize the type of vehicle in automatic mode by software DiSMID.

Figure 3. Chart of quantity comparison of vehicles’ composition, received from field researches and during remote satellite monitoring

* - the number is taken from the table 1
References

[1] Silyanov V.V. 1977 *Theory of traffic flows in the design of roads and traffic management*. Textbook. M. *Transport* 1977 p. 303.

[2] Trofimenko Yu., Yakimov M.R. 2013 *Transport planning: Formation of efficient transport systems of large cities* Moscow: Logos p. 464.

[3] Gorev A. E., Böttger, Prokhorov A., Steven R. R. 2015 *Transport modeling* SPSUACE p. 168.

[4] Khomyak Ya.V. 1986 *Designing optimal networks of highways*. Textbook for high schools K.: Higher School, General Publishing House p. 271.

[5] Testeshev, A.A., Timohovetz, V.D. 2017 Methodology of traffic flows remote monitoring in the Ural Federal District largest cities using satellite monitoring data *AIP Conference Proceedings* Vol 1800(1) Retrieved March 30. from [http://aip.scitation.org/doi/pdf/10.1063/1.4973066](http://aip.scitation.org/doi/pdf/10.1063/1.4973066).

[6] Testeshev, A.A., Timohovetz, V.D., Mikeladze T.G. 2018 Development of multiparameter equations for satellite monitoring analysis of traffic flow *MATEC Web of Conferences* vol. 143 04009, from [https://doi.org/10.1051/matecconf/201814304009](https://doi.org/10.1051/matecconf/201814304009)

[7] JV 34.13330.2012 roads. Updated version of Snip 2.05.02-85 * (with change N 1)

[8] Blatnov M.D. 1973 *Passenger Road transport*. The second edition, revised and updated. M. *Transport* p. 304.

[9] [Electronic resource]/satellite imagery from various cartographic resources. – Access mode: [https://sovzond.ru/](https://sovzond.ru/). Date of inquiry: 10.04.2018-11.05.2018

[10] [Electronic Resource]/Landsat satellite. – Access mode: [https://landsatlook.usgs.gov/viewer.html](https://landsatlook.usgs.gov/viewer.html). Date of inquiry: 8.02.2018-16.05.2018

[11] Timohovetz, V.D., Sysuev D.A. 2017 Typesis of streets and city roads of the largest cities of the russian federation source: new technologies - oil and gas region *Materials of the International scientific-practical conference of students, graduate students and young scientists*. 2017 Publisher: Tyumen Industrial University (Tyumen) pp. 335-338

[12] Vuchik, W. R. 2011 *Transport in cities convenient for life*. Publisher: The Territory of the future p. 551.