Improvement of organization and functioning of taxi transportation through the introduction of digitalization

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Abstract. The article provides a brief retrospective of the development of taxi activity. The key characteristics of the changes in the quality of services provided, including the average time flow, average check, etc. The carried out researches and the analysis allowed determining relevance and expediency of usage of technologies for digitalization of the taxi market to solve "classical" problems of the system how to organize transportation by taxis. The possibility of using the Unified Regional Navigation and Information System of Moscow (ERNIS) was analyzed, as well as registers of issued permits on passenger and luggage transportation by taxis in Moscow and Moscow region to solve the problems of location of taxi stands and determine the optimal taxi car. The studies and analysis made it possible to determine the relevance and appropriateness of existing taxi cabs and the future ones, taking into account the requirements for rational location, in terms of ensuring a quick approach for passengers, as well as reducing the time for car delivery. The article concludes that it is necessary to revise the approach to solve "classical" problems how to improve the functioning of the taxi market.

1. Introduction

The first mention of a taxi in Moscow was in 1907. The formation of the Soviet taxi began in 1924, when the Moscow city Council decided to buy 200 taxi cars (minutes No. 35 of the meeting of the Presidium of the Moscow Council of RK and KD dated December 23, 1924) [1]. The first GAZ-A taxi cars produced in the USSR appeared in 1933.

The current stage of taxi development in the Russian Federation begins with the adoption on April 21, 2011 of Law No. 69-FL “On Amending Certain Legislative Acts of the Russian Federation”. One of the most important achievements in passenger taxi transportation in recent years has been the reduction of the average delivery time to 4-6 minutes. This indicator is one of the most important in taxi transportation. Taxis in the capital have one of the leading positions in the world in terms of service level. The legalization and transformation of the taxi market has reduced travel prices and made taxis more attractive for Muscovites. These changes were made possible through the digitalization of the industry.
According to the data of the Department of transport and development of road infrastructure of Moscow, the average taxi delivery time decreased by 6 times compared to 2011 (figure 1). The cost of taxi services in the capital decreased by 2.4 % compared to 2017. For 2018, the average check for a taxi ride in Moscow amounted to 473 rubles. There has been a decrease in the average check for several years in a row due to an increase in the share of short trips. According to forecasts for 2019, the average check will be 495 rubles.

Taking into account the current trends in technology development, we can conclude that it is necessary to use the possibilities of digitalization of the industry to solve the classical problems of development and improvement of the system, organization and management of taxi transportation [2, 3, 4].

2. Planning for the organization of taxi stops based on geographic information

One of the "classic" tasks facing the system of organization of transportation by taxi cars is the issue of minimizing idle mileage, from the point of view of economic entities and minimizing the waiting time and emissions of exhaust gases into the environment. One of the approaches to solve this problem can be the optimization of the network of locations of taxi stands.

On the basis of the modern level of digital technologies, it is expedient to use large amounts of data obtained with the help of the GLONASS/GPS system when solving the problem of taxi parking arrangement. For the purposes of urban planning, it is possible to use the data transmitted in accordance with the Regulations on Information Interaction from the largest passenger taxi dispatcher orders to the Unified Regional Navigation and Information System of Moscow (ERNIS) [5,6].

The analysis of statistical data on the number of transferred statuses free/occupied allowed determining the most frequent points of start and end of taxi trips by districts on average per day (Table 1).
Table 1. Top 10 districts of Moscow to begin travel by taxi

| №  | Area          | Number of trips started, u. | % of the total number | Total % |
|----|---------------|------------------------------|-----------------------|---------|
| 1  | Tverskoj      | 8009                         | 5.85                  |         |
| 2  | Presnenskij   | 7249                         | 5.3                   |         |
| 3  | Taganskij     | 5477                         | 4.01                  |         |
| 4  | Basmannyj     | 5231                         | 3.83                  |         |
| 5  | Hamovniki     | 4410                         | 3.22                  |         |
| 6  | Krasnosel'skij| 4373                         | 3.19                  | 36.52   |
| 7  | Ramenki       | 4146                         | 3.03                  |         |
| 8  | Dorogomilovo  | 3846                         | 2.81                  |         |
| 9  | Meshhanskij   | 3597                         | 2.63                  |         |
| 10 | Danilovskij   | 3576                         | 2.61                  |         |
|    | Other areas (average) | 1484                        | 1.86                  | 63.48   |

In order to solve the problem of using geoinformation data, it is necessary to determine the following information structure according to the starting and ending points of the route of passenger taxis (Table 2).

Table 2. Information on the start and end points of travel by taxi

| №  | Name          | Data type | Note                                                                 |
|----|---------------|-----------|----------------------------------------------------------------------|
| 1  | Date and time | Date      | Date and time of data creation (to the nearest millisecond)          |
| 2  | Latitude      | Numerical | In the WGS84 projection, decimal degrees accurate to 3 decimal places (+ - 50 m) |
| 3  | Longitude     | Numerical | In the WGS4 projection, decimal degrees accurate to 3 decimal places (+ - 50 m) |
At the first stage of planning it is necessary to divide the data set containing information on the starting
and ending points of the passenger taxi route into blocks of hours with an interval of one hour in the
section of the district. The second step is to construct ranked tables (Table 3) on the number of
boarding/disembarkation points of passengers.

Table 3. Top 5 coordinates for the period from 00 to 1 a.m..

| №   | Coordinates          | Number of orders per hour |
|-----|----------------------|---------------------------|
| 1   | 55.758 37.612        | 27                        |
| 2   | 55.761 37.620        | 23                        |
| 3   | 55.756 37.614        | 22                        |
| 4   | 55.759 37.611        | 18                        |
| 5   | 55.757 37.613        | 17                        |

The final step is an analysis of the potential and modelling of the specific location of the universal taxi
stations, taking into account the changes in the concentration of taxi cars in the context of hours of day,
days of the week and seasonality.

3. Determining optimal taxi car

Taxi companies regularly face the problem of choosing the type of vehicle when renewing their rolling
stock. Often the choice is made through subjective assessment of the company's managers and the
possibility of more profitable purchase of cars of a particular manufacturer.

The analysis of ERNIS data and the register of issued permits can help solve the problem of choosing
the optimal type of vehicle, similarly to the problem of choosing locations for taxi cabs.

The analysis of 19621 vehicles for which "Permits" were obtained by the Department of Transport
and Road Infrastructure Development of Moscow in 2017 shows that the vehicle brands were distributed
as follows (Table 4, Figure 2):

Table 4. Distribution of permits by car brands

| Car model | Hyundai Solaris | Ford Focus | Škoda Rapid | Volkswagen Polo | Škoda Octavia | Kia Rio | Ford Galaxy | Others |
|-----------|-----------------|------------|-------------|-----------------|---------------|---------|-------------|--------|
| Quantity, units | 4179           | 3041       | 2148        | 1863            | 1774          | 1539    | 1386        | 3691   |

Figure 2. Distribution of passenger taxis by brand
The analysis of the fleet of passenger taxis used in the city of Moscow will allow identifying the 4 most popular brands / models, which account for about 60% of the entire sample (Figure 3).

Of the 19,621 vehicles for which permits were received in the Department of Transport of the city of Moscow in 2017, the most popular vehicle brand is Hyundai Solaris (4,179 vehicles), which is 21.2%. The second most popular vehicle brand is Ford Focus 15.5%, followed by Skoda Rapid (10.9%) and Volkswagen Polo (9.5%) [7].

On the other hand, for the selected car brands it is necessary to understand the interest (attractiveness) of passengers in each of them. Such information can be obtained by analyzing the data sets from the ERNIS system. The totality of information about the choice of taxi rolling stock allows determining the most accurate definition of the most popular taxi car for all market participants.

Table 5. Car parking areas for taxis

| Offered parking areas for taxi cabs                              | Existing taxi parking areas                                  |
|-----------------------------------------------------------------|----------------------------------------------------------------|
| Mohovaja street, Manezh;                                        | There's an active parking lot                                 |
| The intersection of Tverskaya street with the Gazetniy and Nikitsky lanes; | There's an active parking lot in the immediate vicinity: Tverskaya Street, 3 |
| Crossing of Bol'shaja Dmitrovka Street and Kamergersky Lane;     | No active parking, pedestrian zone                            |
| Neglinnaja Street, TSUM department store;                       | There is an active parking lot                                 |
| Slavjanskaja and Staraja Squares;                              | There is an active parking lot in the immediate vicinity: Lubyansky passage, 25s2 |
| Tverskoj zastavy square, Belorusky railway station;             | There's an active parking lot                                 |
| The intersection of Teatraln passage and Nikolskaya street;     | There's an active parking lot (the sign 3.27 with the inscription 8.4.14 "Except for taxis" is set) |
| Triumphal square, 2, Mayakovskaya metro station;                | There's an active parking lot                                 |
| The intersection of Novoslobodskaya street and Sushevsky Val.    | No active parking                                              |
4. Conclusion
The use of ERNIS databases and information on issued permits makes it possible to apply fundamentally new methods and approaches to solving various problems in the field of passenger transportation by taxi cars, which were previously unavailable. In particular, for the Tverskoy district of Moscow, potential taxi parking areas have been identified based on and analysis of the data (Table 5).

Similarly, by means of the industry’s digitalization, the tasks of choosing the optimal taxi car are solved, both for its owner and passenger.

The proposed approaches and methods for solving the "classical" problems of improving the functioning of the taxi market are impossible without a significant level of digitalization of the industry. It should be especially noted that the market of taxi services is currently one of the most advanced in terms of implementation of the concept of digital transformation of the transport industry.

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